

ECE 567: Project Report Part 2

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Phase 1: Intrusion Detection

For this Phase, we decided to utilize the vulnerability shown to us through the Nessus Vulnerability Scanning tool depicted in Figure 1.

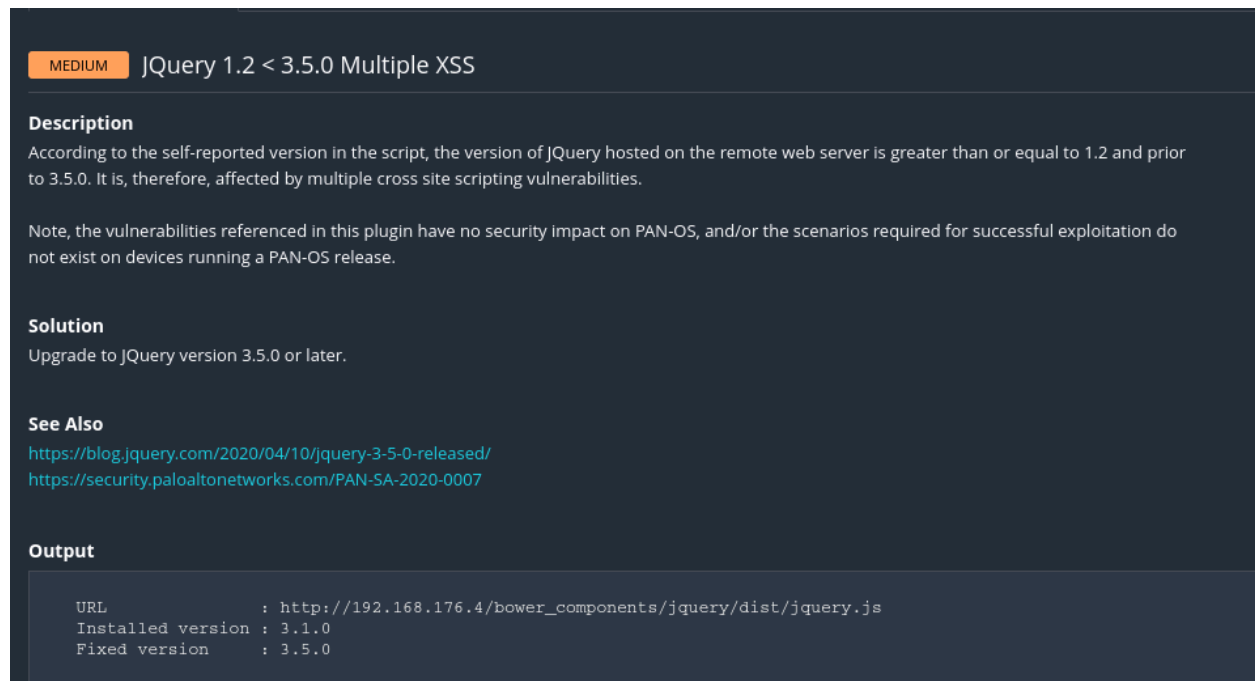


Figure 1: Cross-site Scripting Vulnerability on HTTP.

The following vulnerability depicts that given the outdated version of JQuery, the HTTP web server is susceptible to multiple Cross-Site Scripting attacks. We have examined the Mars webpage and determined an area on the page that is susceptible to the attacks, which we will describe in our general attack scenario. These attacks require deeper packet inspection levels, making for slightly more complex inspection and rule parameters. Thus, implementing SNORT rules to detect these general scenario XSS attacks is a nice challenge.

Part 1: Attack Scenario

Cross-site scripting can be categorized under Three possible attack vectors: Persistent, Reflected or DOM-based cross-site scripts. While investigating the susceptibility of the MARS website, we determined that the general attack scenario to explore is the Persistent XSS. In this case, the attacker must find a section embedded within the site that allows information to be posted or saved. Persistent XSS completely depends on the scripting attack originating from the website. In this general attack scenario, the attacker will find the area of the site that can store user input, such as comment sections of forum posts and write a script embedded within it; these scripts can use simple `<script></script>`, `<img...src...onerror>` or more. These scripts will be saved in the website database. If another user visits the site, the server loads the comments or forums that are improperly sanitized and will load and run the associated commands/payload. These scripts can contain various commands, implement objects such as keyloggers, steal session cookie data, and

send the information to a server the attacker is running. The information can reveal sensitive data such as session data, key inputs for usernames and passwords and more. Figures 2 and 3 below show a brief graphical sketch of this attack's attacker and user sides.

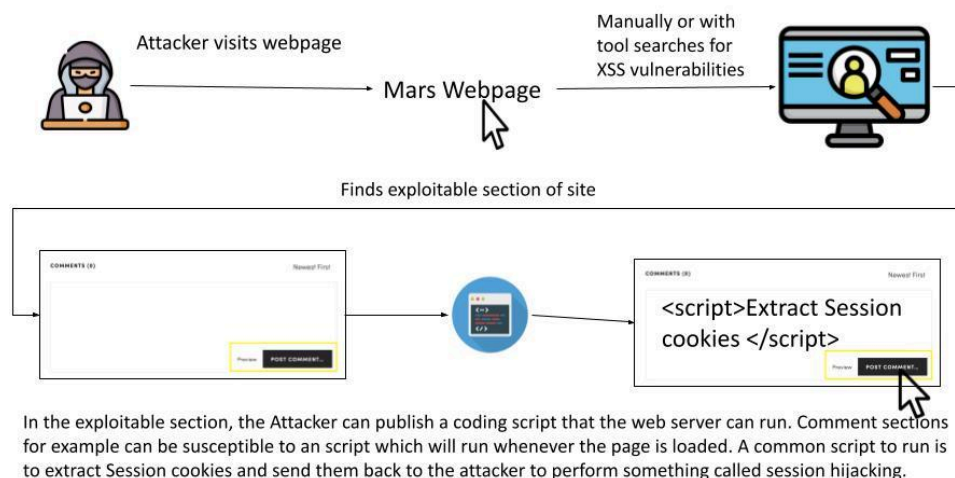


Figure 2: Attacker Side of XSS.

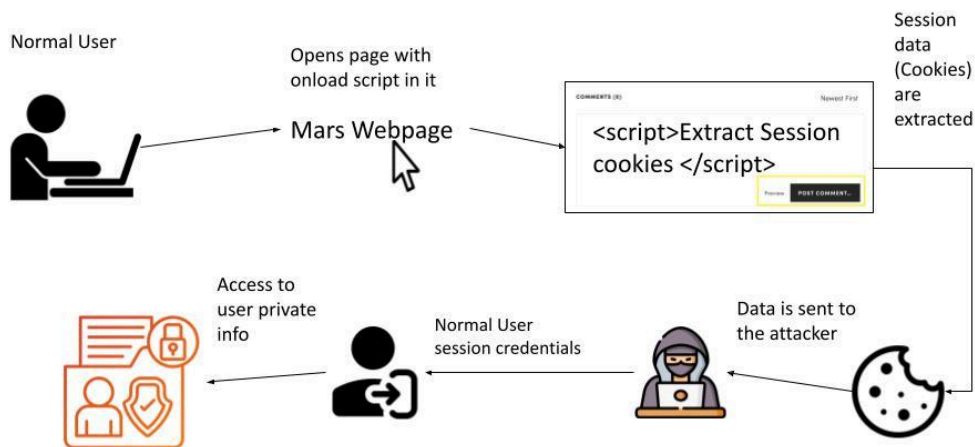


Figure 3: User side of XSS.

Concerning the specific susceptibility of the MARS webserver, we know through inspection and extensive testing that each article page embedded within the site has a comments section susceptible to Persistent XSS attacks embedded within a bolded, underlined or URL-embedded section. One of the pages referenced is shown below in Figure 4. Furthermore, through general trial and error, we decided to focus on XSS attacks with the ‘<...onerror=’script’>’ flag, which narrows down the requirements for the Snort rules.

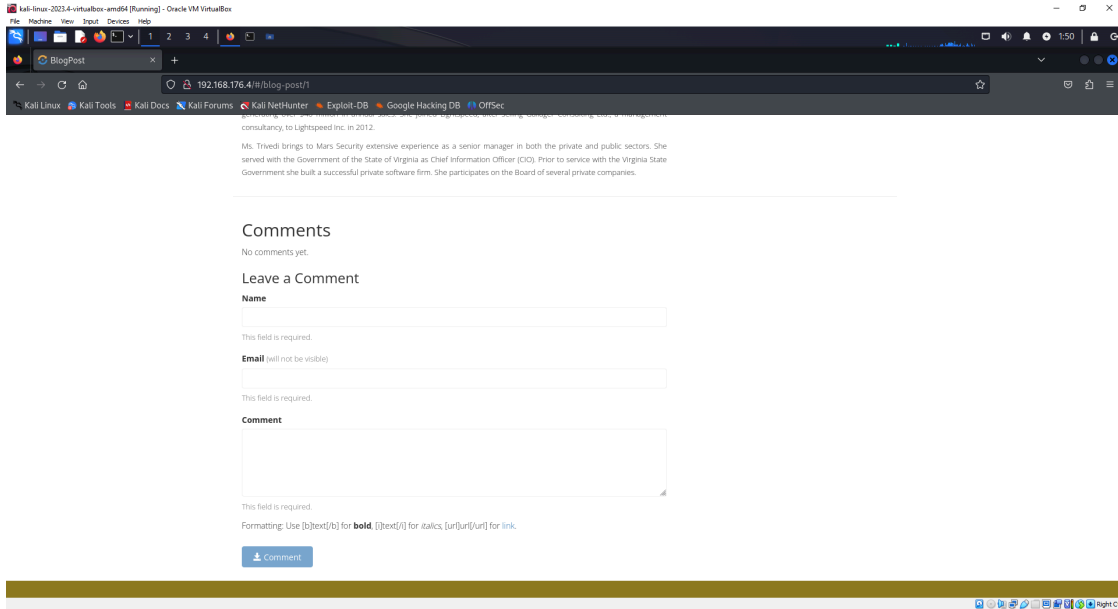


Figure 4: Exploitable XSS field on Mars Website.

Part 2: Snort Rules

Before setting up the Snort rules to attempt to detect XSS vulnerabilities, we must determine and configure the interface so that the Detection system on MarsR2.0 can trigger on the exploitation attempt. As we know, the webserver runs on the MarsN2.0 machine, which, in our case, is listed at IP 192.168.176.4. As such, we need to make sure that the snort.conf file on MarsR2.0 has additional logic implemented to surveil the neighbouring IPs within its network. To ensure this, we will open the /etc/snort/snort.conf file using VI and change the initial ipvar HOME_NET to the appropriate network, and we change the HTTP_SERVERS variable to match MarsN2.0, as shown in Figure 5.

```

# Setup the network addresses you are protecting
ipvar HOME_NET 192.168.176.0/24

# Set up the external network addresses. Leave as "any" in most situations
ipvar EXTERNAL_NET any

# List of DNS servers on your network
ipvar DNS_SERVERS $HOME_NET

# List of SMTP servers on your network
ipvar SMTP_SERVERS $HOME_NET

# List of web servers on your network
ipvar HTTP_SERVERS {192.168.176.4}

# List of sql servers on your network
ipvar SQL_SERVERS $HOME_NET

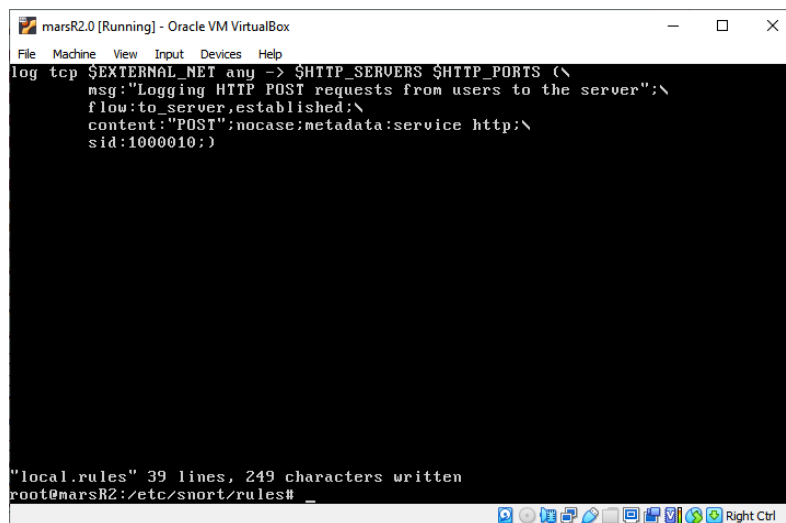
# List of telnet servers on your network
ipvar TELNET_SERVERS $HOME_NET

"snort.conf" 695 lines, 27084 characters written
root@marsR2:/etc/snort#

```

Figure 5: snort.conf on MarsR2.0 with proper HOME_NET variable.

It is important to note the various rules we attempted to implement before arriving at the final rule set, which detects the XSS attack. The first hurdle we encountered while trying to create snort rules was that Snort starts examining packets at the network level. That said, one needed to do more than add HTTP in the protocol field and immediately receive results. We had to begin with the TCP level, develop a snort rule that parses the HTTP content within it, and take it one step further; we wanted to specifically detect the HTTP post command as this signifies that something had been written to the server. Therefore, after looking through snort manuals [1], our initial rule, shown in Figure 6, is simply to log HTTP traffic with post content within it going into the server.

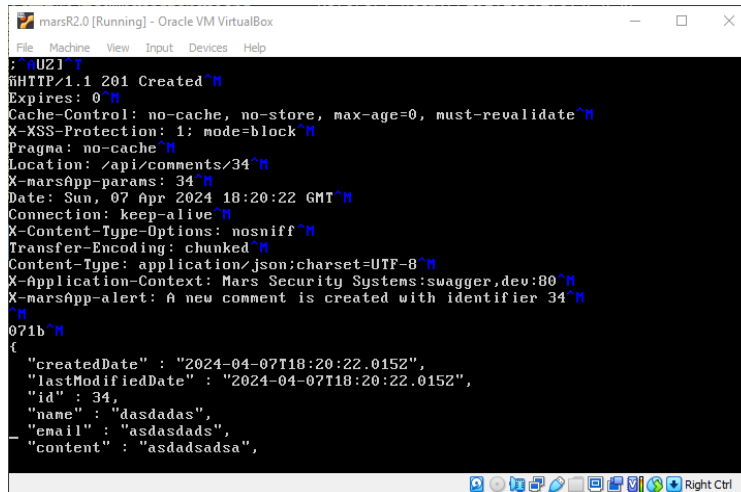


```
marsR2.0 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
log tcp $EXTERNAL_NET any -> $HTTP_SERVERS $HTTP_PORTS (\
  msg:'Logging HTTP POST requests from users to the server';\
  flow:to_server,established;\
  content:'POST';nocase;metadata:service http;\
  sid:1000010;)

"local.rules" 39 lines, 249 characters written
root@marsR2:/etc/snort/rules# _
```

Figure 6: Log snort rule for all HTTP inbound traffic with ‘post’ content.

Unfortunately, this did not yield the correct results, as the only traffic flagged were HTTP GET commands, as the content ‘post’ is embedded in the website header in the logs. Furthermore, upon inspection with general snort rules to log all inbound traffic at the network level, we found no HTTP POST commands. Thus, we needed to switch methods and instead log bidirectional general HTTP traffic while posting a comment through the attacker to see how the snort logs the network information. By deleting all the additional flow and content conditions and switching the arrow to ‘<>’ when we posted the comment on the site with snort running for the following log in Figure 7.



```
File Machine View Input Devices Help
marsR2.0 [Running] - Oracle VM VirtualBox
.:^U21^M
HTTP/1.1 201 Created^M
Expires: 0^M
Cache-Control: no-cache, no-store, max-age=0, must-revalidate^M
X-XSS-Protection: 1; mode=block^M
Pragma: no-cache^M
Location: /api/comments/34^M
X-marsApp-params: 34^M
Date: Sun, 07 Apr 2024 18:20:22 GMT^M
Connection: keep-alive^M
X-Content-Type-Options: nosniff^M
Transfer-Encoding: chunked^M
Content-Type: application/json;charset=UTF-8^M
X-Application-Context: Mars Security Systems:swagger,dev:80^M
X-marsApp-alert: A new comment is created with identifier 34^M
^M
071b^M
{
  "createdAt" : "2024-04-07T18:20:22.015Z",
  "lastModifiedDate" : "2024-04-07T18:20:22.015Z",
  "id" : 34,
  "name" : "dasdadas",
  "email" : "asdasdads",
  "content" : "asdasadsa",
}
```

Figure 7: Snort log of general comment post on Mars Site.

This gives us all the information necessary to create our final snort rules for XSS detection. As we can see, stat code 201 is associated with making the new comment. Therefore, this will be the first condition for isolating the traffic. Additionally, this shows us that the traffic originates from the HTTP server and is going to the client utilizing it. Thus, we can switch the \$HTTP_SERVERS and \$EXTERNAL_NET vars and return the arrow to ‘->’ so that snort does not need to over-examine the bi-directional traffic. Next, we must consider the different types of XSS scripts the system is vulnerable to for the alerts. Through general experimentation on the website through the attacker machine, we determined that the system is susceptible to scripts that feature ‘onerror.’ We will expand this to a few more generalized scripts with common elements. With all this in mind, we will use pcre and the information above to create snort alerts which flag general expressions utilized in XSS.[2] As shown in Figure 8, you can see the resulting rules. After many attempts, it was logical to simply flag regex, which contains common script elements such as ‘<script>...</script>’, ‘<...onerror...>’, ‘<...onload...>’ and ‘<...javascript...>’ hopefully isolating particular XSS attempts. Any ‘[^\\n]+’ signifies one or more repetitions of any character besides a new line, which can generally denote non-significant information to the regex.

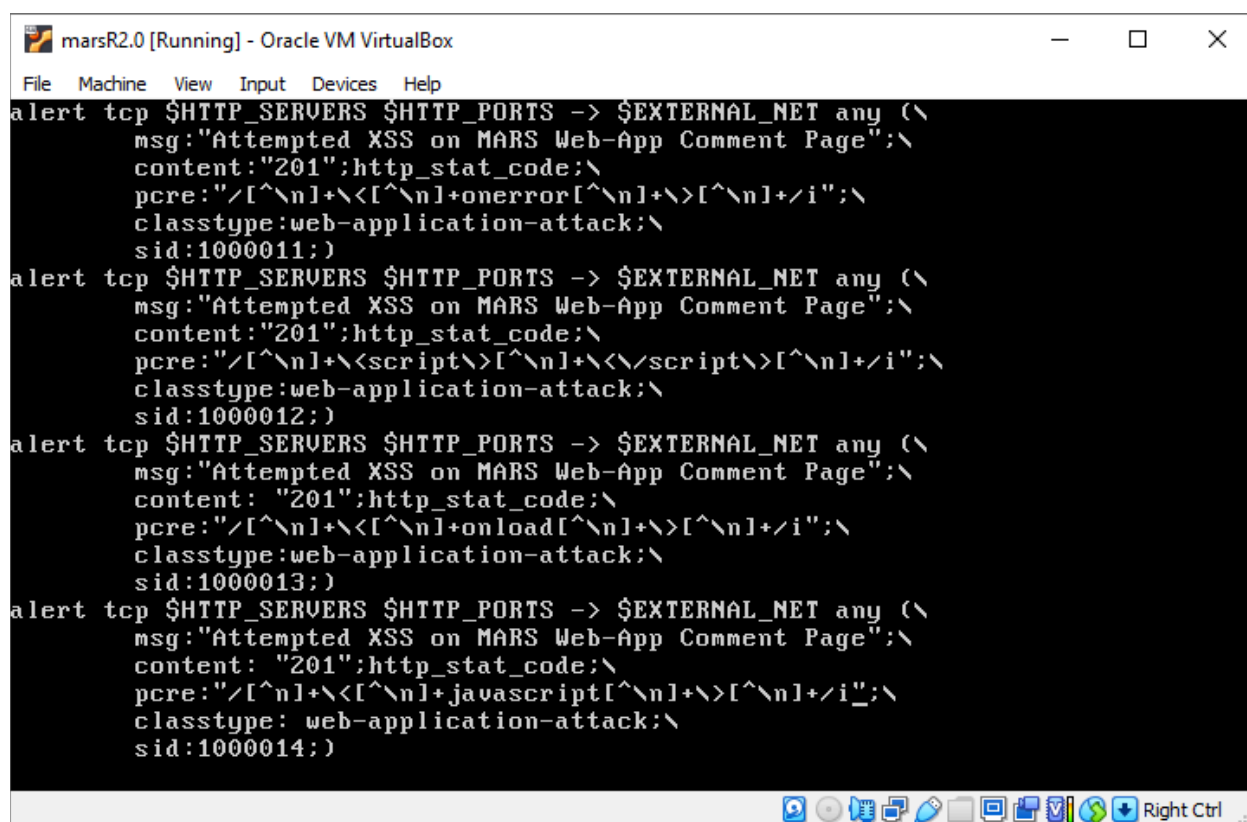
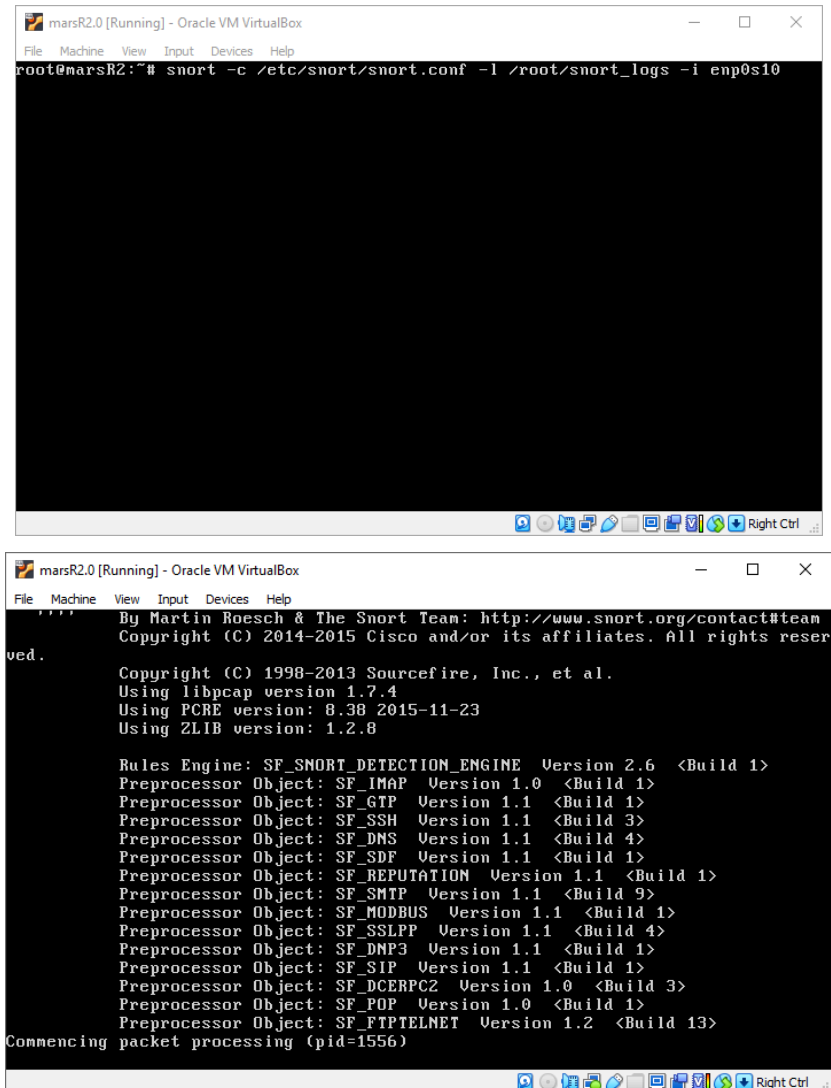


Figure 8: Snort Rules for XSS Detection.

This only covers some possible scripts within the realm of XSS, as there are thousands. Unfortunately, we do not have the time to compute thousands of rules. Furthermore, as stated in the project parameters, we do not want to overfit our rules. Thus, these rules will detect the generic attack vector we proposed, and since we tested and know that 'onerror' XSS attacks work on the MARS site, we want to test against those specifically.

Part 3: Snort Detection

To run snort in Intrusion Detection mode, we run the command shown in the first image in Figure 9. We have initialized the home network HTTP server and rules in the snort.conf file, it will operate with all the general rules in place. Therefore, the second image shows it running with no errors.



```
marsR2.0 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
root@marsR2:~# snort -c /etc/snort/snort.conf -l /root/snort_logs -i enp0s10

By Martin Roesch & The Snort Team: http://www.snort.org/contact#team
Copyright (C) 2014-2015 Cisco and/or its affiliates. All rights reserved.

Copyright (C) 1998-2013 Sourcefire, Inc., et al.
Using libpcap version 1.7.4
Using PCRE version: 8.38 2015-11-23
Using ZLIB version: 1.2.8

Rules Engine: SF_SNORT_DETECTION_ENGINE Version 2.6 <Build 1>
Preprocessor Object: SF_IMAP Version 1.0 <Build 1>
Preprocessor Object: SF_GTP Version 1.1 <Build 1>
Preprocessor Object: SF_SSH Version 1.1 <Build 3>
Preprocessor Object: SF_DNS Version 1.1 <Build 4>
Preprocessor Object: SF_SDF Version 1.1 <Build 1>
Preprocessor Object: SF_REPUTATION Version 1.1 <Build 1>
Preprocessor Object: SF_SMTP Version 1.1 <Build 9>
Preprocessor Object: SF_MODBUS Version 1.1 <Build 1>
Preprocessor Object: SF_SSLPP Version 1.1 <Build 4>
Preprocessor Object: SF_DMP3 Version 1.1 <Build 1>
Preprocessor Object: SF_SIP Version 1.1 <Build 1>
Preprocessor Object: SF_DCERPC2 Version 1.0 <Build 3>
Preprocessor Object: SF_POP Version 1.0 <Build 1>
Preprocessor Object: SF_FTPTELNET Version 1.2 <Build 13>

Commencing packet processing (pid=1556)
```

Figure 9: Initializing snort on IDS mode.

Moving on to Figure 10, we go to the Kali machine and find pages on the website with comment boxes. We will visit different media pages and add comments on each page, some of which will be embedded with XSS. Each of the XSS embedded commands will use one of the [b],[i], or [url] commands as a wrapper, as this will cause the server to run it in an attempt to transform it into the designated text type whether it be italics, bolded or added as a link. Thus, we must run snort for those three cases when considering XSS.

Part 4: Analysis of Results

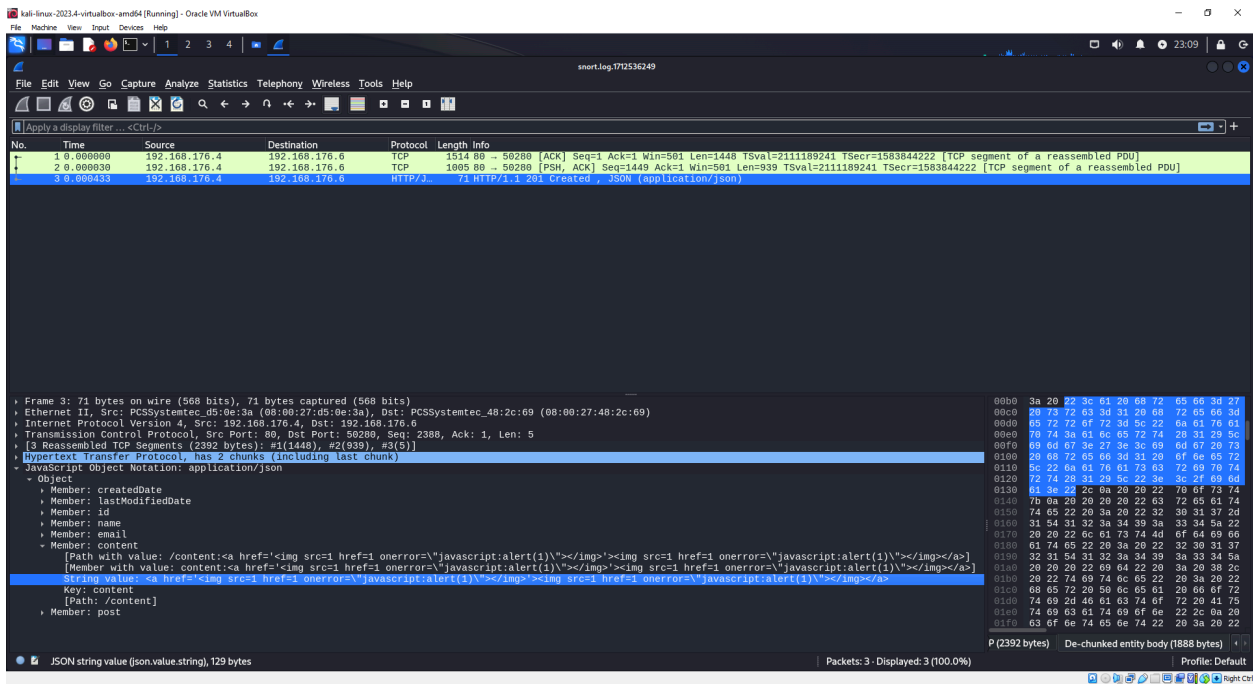
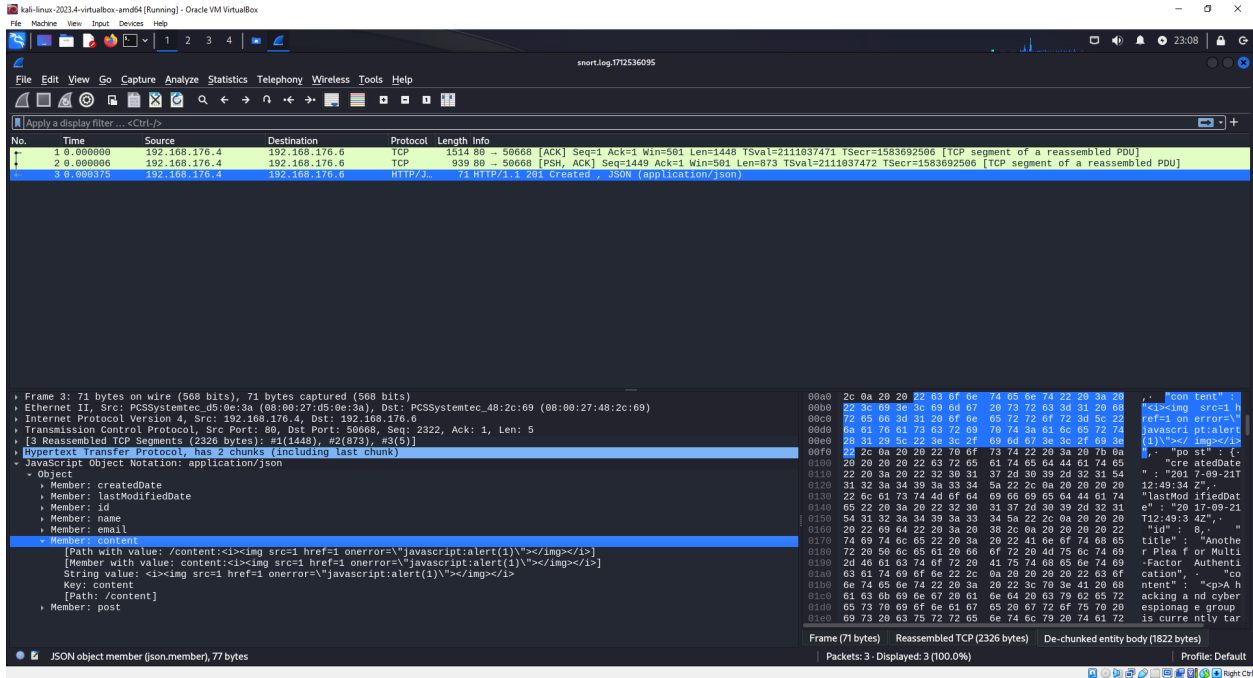
While this specific example yields the correct results by only flagging the comments with ‘<...onerror...>’ embedded within them, as shown in Figures 13 to 16, it is important to consider the cases where false positives and negatives can occur. As stated in the prior paragraph, these snort rules only detect specific XSS variations. Thus, any script outside the variations included may run if no other protections exist in the server’s code. Furthermore, we must consider false positives. This specific variation of an XSS holds with it a very peculiar combination of characters. Thus, it is relatively rare for a normal user to type this combination of characters in a normal sentence, albeit not impossible. Furthermore, a series of relatively false positives could not run properly but could indicate an attempted XSS attack by those without sufficient knowledge. By all means, the snort rules we implemented are susceptible to evasion. However, we hope that our willingness to tackle an attack of such a complex nature shows our motivation to learn all about snort and its advantages. The rules developed suffice for cases dependent on mishandled loading errors in the code, a general script or comments embedded with javascript, but not additional XSS cases as it is a massive field as denoted by the list in [3].

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	0407-17:26:45.439574	1	1000011	0	Attempted XSS on MARS Web-App Comment Page	TCP	192.168.176.4	80	192.168.176.6	37180	08:00:27:05:0E:3A	08:00:27:48:2C:69	0x036	***A***	0x4F69C0B	0xF5083336		0xFAB0	64	0	51822	2344	40996			
2	0407-17:28:46.406955	1	1000011	0	Attempted XSS on MARS Web-App Comment Page	TCP	192.168.176.4	80	192.168.176.6	50668	08:00:27:05:0E:3A	08:00:27:48:2C:69	0x958	***A***	0x80E72135	0x1894A360		0xFAB0	64	0	36490	2378	75812			
3	0407-17:31:20.177661	1	1000011	0	Attempted XSS on MARS Web-App Comment Page	TCP	192.168.176.4	80	192.168.176.6	50280	08:00:27:05:0E:3A	08:00:27:48:2C:69	0x98A	***A***	0x4946043A	0xF34427EF		0xFAB0	64	0	53700	2444	143396			

Figure 13: Three Alerts generated by SNORT.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.176.4	192.168.176.6	TCP	1514	80 → 37180 [ACK] Seq=1 Ack=1 Win=501 Len=1448 TSval=2110914506 TSecr=1583569603 [TCP segment of a reassembled PDU]
2	0.000058	192.168.176.4	192.168.176.6	TCP	905	80 → 37180 [PSH, ACK] Seq=1449 Ack=1 Win=501 Len=839 TSval=2110914506 TSecr=1583569603 [TCP segment of a reassembled PDU]
3	0.000011	192.168.176.4	192.168.176.6	HTTP/3	71	HTTP/3.1 201 Created, JSON (application/json)

Figure 14: [b][b] wrapped XSS lists document cookies for session theft.



Phase 2: Intrusion Prevention

Part 1: Define the IPTables rules and provide the rationale for each.

In this part, we were given MarsN2.0 credentials of root/Jum!@4217 to set the IPTables firewall directly. The basic ideal to mitigate and prevent attacks is to find out what services MarsN2.0 provides and to give each service proper accessibility.

1. We used Nmap to scan how many ports and services MarsN2.0 is providing:

```
File Actions Edit View Help
(root@kali)-[~]
# nmap 192.168.56.104
Starting Nmap 7.94SVN ( https://nmap.org ) at 2024-04-09 14:06 EDT
Nmap scan report for 192.168.56.104
Host is up (0.0011s latency).
Not shown: 989 closed tcp ports (reset)
PORT      STATE SERVICE
21/tcp    open  ftp
22/tcp    open  ssh
23/tcp    open  telnet
25/tcp    open  smtp
53/tcp    open  domain
80/tcp    open  http
110/tcp   open  pop3
143/tcp   open  imap
993/tcp   open  imaps
995/tcp   open  pop3s
3306/tcp  open  mysql
MAC Address: 08:00:27:DD:BF:25 (Oracle VirtualBox virtual NIC)
Nmap done: 1 IP address (1 host up) scanned in 0.52 seconds
```

Figure 17: MarsN2.0 ports scan

We also find there is a GUI interface MarsN2.0 Ubuntu provided:

```
startx
```

Figure 18: Go into the GUI of Ubuntu

2. We back up the Iptables at the beginning to mitigate unnecessary mistakes and ensure every change can be recovered.

```
sudo apt-get install iptables
sudo iptables-save > /root/iptables.backup
```

Figure 19: Install and Backup IPTables

3. To start, the default policy is to drop INPUT and FORWARD and to accept OUTPUT.

```

sudo iptables -P INPUT DROP
sudo iptables -P FORWARD DROP
sudo iptables -P OUTPUT ACCEPT

```

Figure 20: Default Policies

4. After scanning MarsN2.0, no TCP port is open under the default policies.

```

Not shown: 989 closed tcp ports (reset)
PORT      STATE SERVICE
21/tcp    open  ftp
22/tcp    open  ssh
23/tcp    open  telnet
25/tcp    open  smtp
53/tcp    open  domain
80/tcp    open  http
110/tcp   open  pop3
143/tcp   open  imap
993/tcp   open  imaps
995/tcp   open  pop3s
3306/tcp  open  mysql
MAC Address: 08:00:27:DD:BF:25 (Oracle VirtualBox virtual NIC)

Nmap done: 1 IP address (1 host up) scanned in 0.52 seconds

(root@kali)-[~]
# nmap 192.168.56.104
Starting Nmap 7.94SVN ( https://nmap.org ) at 2024-04-09 14:51 EDT
Nmap scan report for 192.168.56.104
Host is up (0.00050s latency).
All 1000 scanned ports on 192.168.56.104 are in ignored states.
Not shown: 1000 filtered tcp ports (no-response)
MAC Address: 08:00:27:DD:BF:25 (Oracle VirtualBox virtual NIC)

Nmap done: 1 IP address (1 host up) scanned in 21.63 seconds

```

Figure 21: Using Nmap from Kali to test the status of ports on MarsN2.0

5. We'll allow incoming traffic on their respective ports for each public-facing service. Given that the inside IP '192.168.56.104' is for internal use and '10.0.2.15' is the outside IP, we'll focus on rules applicable to the outside interface. We do not allow port 21 for FTP and port 23 for Telnet. Instead, port 22 is allowed for SSH and SFTP.

```

# HTTP and DNS (domain)
iptables -A INPUT -p tcp --dport 80 -j ACCEPT
iptables -A INPUT -p tcp --dport 53 -j ACCEPT

# Email services (SMTP, POP3, IMAP, IMAPS, POP3S)
iptables -A INPUT -p tcp --dport 25 -j ACCEPT

```

```

iptables -A INPUT -p tcp --dport 110 -j ACCEPT
iptables -A INPUT -p tcp --dport 143 -j ACCEPT
iptables -A INPUT -p tcp --dport 993 -j ACCEPT
iptables -A INPUT -p tcp --dport 995 -j ACCEPT

# Secure channels (SSH, for remote access and file transfer)
iptables -A INPUT -p tcp --dport 22 -j ACCEPT

# Database access, consider limiting to specific IPs if possible
iptables -A INPUT -p tcp --dport 3306 -j ACCEPT

```

Figure 22: Allow service's Ports

6. In this part, we limited new TCP connections to mitigate DDoS attacks. Limiting new connections to 5 per minute.

```

iptables -A INPUT -p tcp -m connlimit --connlimit-above 5
--connlimit-mask 32 --connlimit-saddr -j DROP

```

Figure 23: Mitigate DDoS

7. Incoming mail traffic must be restricted to the internal mail server. We only allow mail traffic to the internal mail server IP 192.168.56.104.

```

# Allow SMTP (25),POP3(110),IMAP(143),IMAPS(993),POP3S(995) for the
internal mail server
iptables -A INPUT -p tcp --dport 25 -d 192.168.56.104 -j ACCEPT
iptables -A INPUT -p tcp --dport 110 -d 192.168.56.104 -j ACCEPT
iptables -A INPUT -p tcp --dport 143 -d 192.168.56.104 -j ACCEPT
iptables -A INPUT -p tcp --dport 993 -d 192.168.56.104 -j ACCEPT
iptables -A INPUT -p tcp --dport 995 -d 192.168.56.104 -j ACCEPT

# Block these email service ports for other destinations
iptables -A INPUT -p tcp --dport 25 -j DROP
iptables -A INPUT -p tcp --dport 110 -j DROP
iptables -A INPUT -p tcp --dport 143 -j DROP
iptables -A INPUT -p tcp --dport 993 -j DROP
iptables -A INPUT -p tcp --dport 995 -j DROP

```

Figure 24: Allow mail server ports and drop other destinations.

8. Accept incoming traffic that is a response to legitimate requests initiated by the server itself


```
iptables -A INPUT -m conntrack --ctstate ESTABLISHED,RELATED -j ACCEPT
```

Figure 25: Related Incoming Connections

9. Save IPtables:

```
sudo iptables-save > /etc/iptables/rules.v4
```

Part 2: Test the firewall rules and provide screenshots documenting the results.

We use Kali to test the firewall policy we set in the previous part.

10. Using the browser to access the website on MarsN2.0 through port 80. This step is to make sure the website is working well to access.

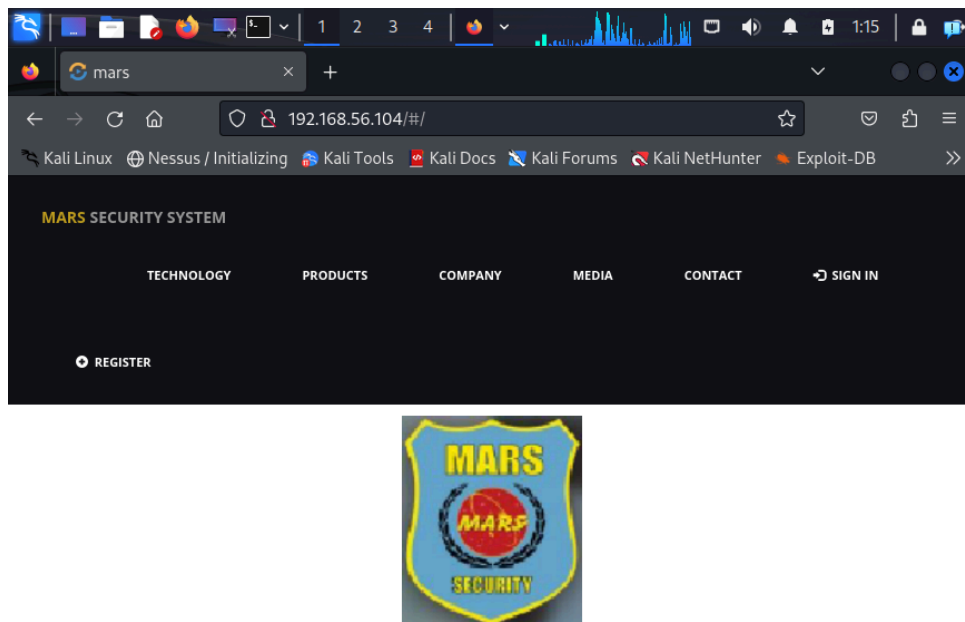


Figure 26: Testing public HTTP service

11. We use Nmap to scan if the ports related to email service are achievable.

```
root@kali: ~  
File Actions Edit View Help  
ost)  
NSE: Script scanning 192.168.56.104.  
Initiating NSE at 01:27  
Completed NSE at 01:27, 0.04s elapsed  
Initiating NSE at 01:27  
Completed NSE at 01:27, 0.01s elapsed  
Nmap scan report for 192.168.56.104  
Host is up (0.00045s latency).  
  
PORT      STATE SERVICE VERSION  
25/tcp    open  smtp    Postfix smtpd  
110/tcp   open  pop3     Dovecot pop3d  
143/tcp   open  imap     Dovecot imapd (Ubuntu)  
993/tcp   open  ssl/imap Dovecot imapd (Ubuntu)  
995/tcp   open  ssl/pop3 Dovecot pop3d  
MAC Address: 08:00:27:DD:BF:25 (Oracle VirtualBox virtual NIC)  
Service Info: Host: marsouin.telus; OS: Linux; CPE: cpe:/o:linux:  
linux_kernel  
  
Read data files from: /usr/bin/./share/nmap  
Service detection performed. Please report any incorrect results a  
t https://nmap.org/submit/ .  
Nmap done: 1 IP address (1 host up) scanned in 14.76 seconds  
Raw packets sent: 6 (248B) | Rcvd: 6 (248B)  
  
(root@kali)-[~]  
#
```

Figure 27: Testing SMTP, POP3, IMAP, IMAPS and POP3s services

12. The server should allow remote access and file transfer. We can use SSH for control and SFTP for file sharing. Logging from the Keli machine, two services work properly.

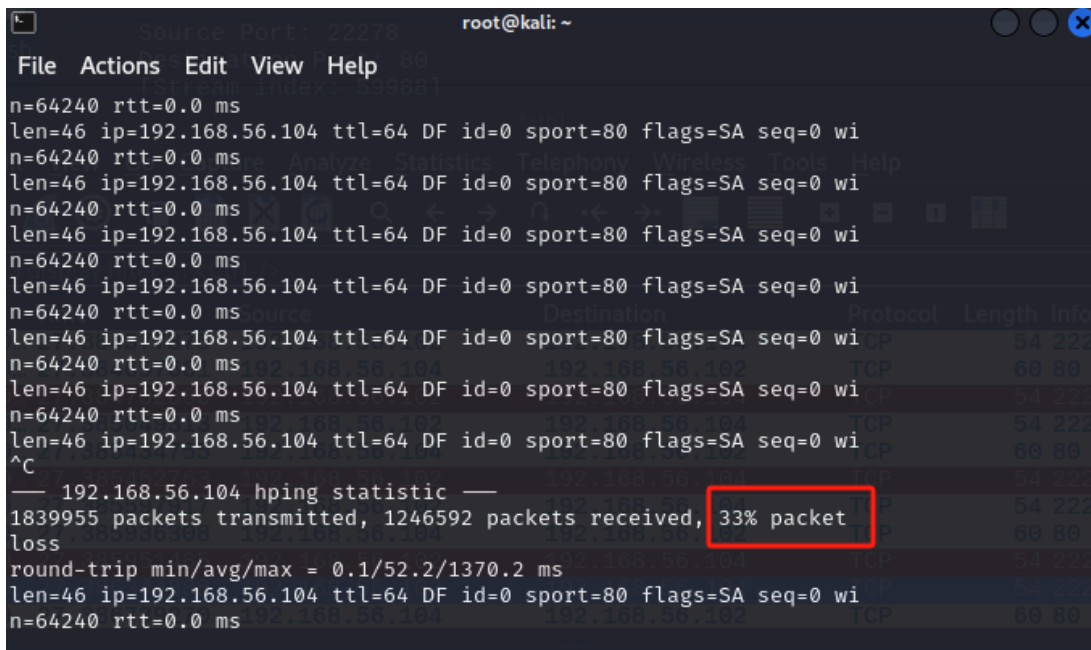
```
root@kali: ~  
File Actions Edit View Help  
root@192.168.56.104's password:  
Permission denied, please try again.  
root@192.168.56.104's password:  
Connection closed by 192.168.56.104 port 22  
  
(root@kali)-[~]  
# ssh root@192.168.56.104  
root@192.168.56.104's password:  
Welcome to Ubuntu 18.04.1 LTS (GNU/Linux 4.15.0-213-generic x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/advantage  
  
System information as of Thu Apr 11 05:10:51 UTC 2024  
  
System load:  0.16           Processes:      110  
Usage of /:   72.0% of 10.04GB Users logged in: 1  
Memory usage: 65%           IP address for enp0s3: 10.0.2.  
15  
Swap usage:   0%             IP address for enp0s10: 192.168  
.56.104  
  
* Strictly confined Kubernetes makes edge and IoT secure. Learn h  
ow MicroK8s  
just raised the bar for easy, resilient and secure K8s cluster  
  
root@kali: ~  
File Actions Edit View Help  
deployment.  
  
https://ubuntu.com/engage/secure-kubernetes-at-the-edge  
  
* Canonical Livepatch is available for installation.  
- Reduce system reboots and improve kernel security. Activate a  
t: https://ubuntu.com/livepatch  
  
185 packages can be updated.  
2 updates are security updates.  
  
New release '20.04.6 LTS' available.  
Run 'do-release-upgrade' to upgrade to it.  
  
You have mail. After you become, the more you are able to hear  
Last login: Thu Apr 11 05:04:56 2024  
root@marsouin:~# exit  
logout  
Connection to 192.168.56.104 closed.  
  
(root@kali)-[~]  
# sftp root@192.168.56.104  
root@192.168.56.104's password:  
Connected to 192.168.56.104.  
sftp>
```

Figure 28: Testing SSH and SFTP

13. We use 'hping3' to generate network traffic to test firewall rules for the DDoS Mitigation test: start a TCP flood towards MarsN2.0. Sending a large number of SYN packets, simulating multiple attempts to establish a TCP connection:

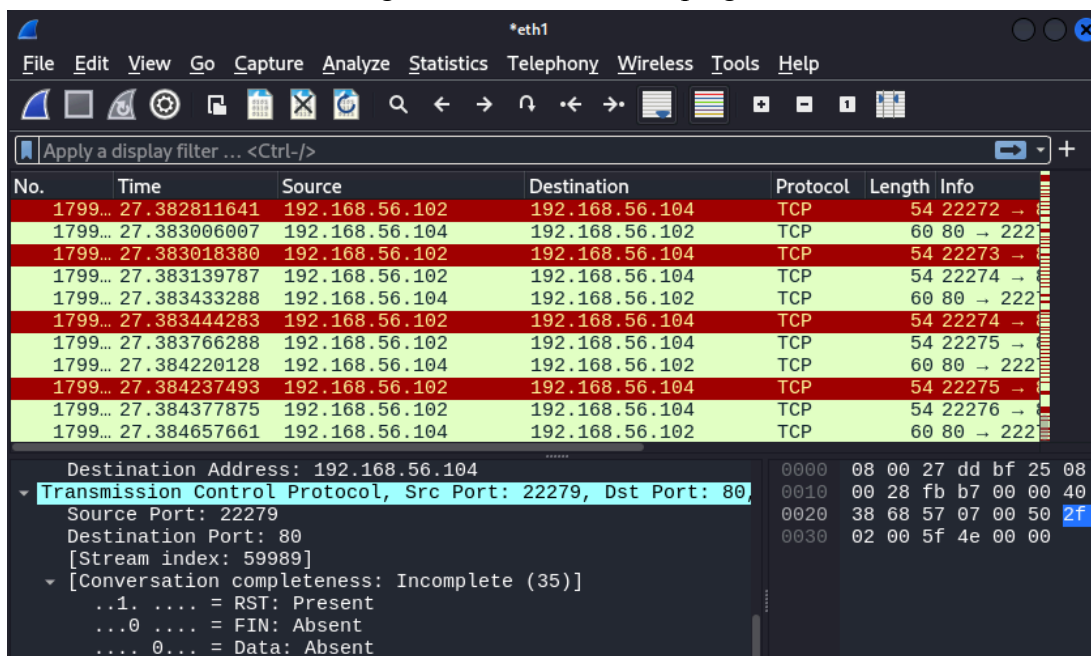
```
hping3 -S -p 80 -i u1 --rand-source 192.168.56.104
```

Thanks to the IPTables, 33% of packets are dropped by the server.



```
root@kali: ~  
File Actions Edit View Help  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
^C  
— 192.168.56.104 hping statistic —  
1839955 packets transmitted, 1246592 packets received, 33% packet  
loss  
round-trip min/avg/max = 0.1/52.2/1370.2 ms  
len=46 ip=192.168.56.104 ttl=64 DF id=0 sport=80 flags=SA seq=0 wi  
n=64240 rtt=0.0 ms
```

Figure 29: The result of hping3



Wireshark interface showing a packet capture on eth1. The packet list displays multiple TCP packets from 192.168.56.102 to 192.168.56.104. The selected packet (No. 1799) is a TCP SYN packet with Source Port 22279 and Destination Port 80. The packet details pane shows the Transmission Control Protocol section with Src Port: 22279, Dst Port: 80, and Conversation completeness: Incomplete (35).

No.	Time	Source	Destination	Protocol	Length	Info
1799...	27.382811641	192.168.56.102	192.168.56.104	TCP	54	22272 →
1799...	27.383006007	192.168.56.104	192.168.56.102	TCP	60	80 → 222
1799...	27.383018380	192.168.56.102	192.168.56.104	TCP	54	22273 →
1799...	27.383139787	192.168.56.102	192.168.56.104	TCP	54	22274 →
1799...	27.383433288	192.168.56.104	192.168.56.102	TCP	60	80 → 222
1799...	27.383444283	192.168.56.102	192.168.56.104	TCP	54	22274 →
1799...	27.383766288	192.168.56.102	192.168.56.104	TCP	54	22275 →
1799...	27.384220128	192.168.56.104	192.168.56.102	TCP	60	80 → 222
1799...	27.384237493	192.168.56.102	192.168.56.104	TCP	54	22275 →
1799...	27.384377875	192.168.56.102	192.168.56.104	TCP	54	22276 →
1799...	27.384657661	192.168.56.104	192.168.56.102	TCP	60	80 → 222

Figure 30: The traffic captured by Wireshark

Phase 3: Anomaly Intrusion Detection

From a high-end view, our code is split into two files, ‘Train.py’ simply trains the ML model on relevant data that we will describe below and ‘Test.py,’ which looks into the input data file to discern if it has valid labels and then predicts and validates the data with the loaded ML model. Luckily, a lot of research has been cited concerning these models. In [4], we gained more insight and decided to implement the Random Forest ML classifier model, which was mentioned to have a very high accuracy rate. Furthermore, we learned from [5] that embedded within the random Forest module in Scikit exists a module called `.feature_importances_`, which allows us to visualize the weights associated with training data to determine which vectors have minimal influence on the models’ predictions. With this in mind, we outputted a visual representation of these features during model construction and determined which columns could be pruned from the training sets. After many test attempts, we pruned the information concerning forward and backward URG, RST, ECE, CWE flags, and bulk packet and byte rates. Aside from those, we incorporated all other data points, as they had some influence on the Random Forests. When considering the classes for this project, we wanted to simplify the data into simple binaries; therefore, we generalized all benign data as 0 and any DoS data as 1. We cite the Figure below to understand better how random forests work, which was taken from [6].

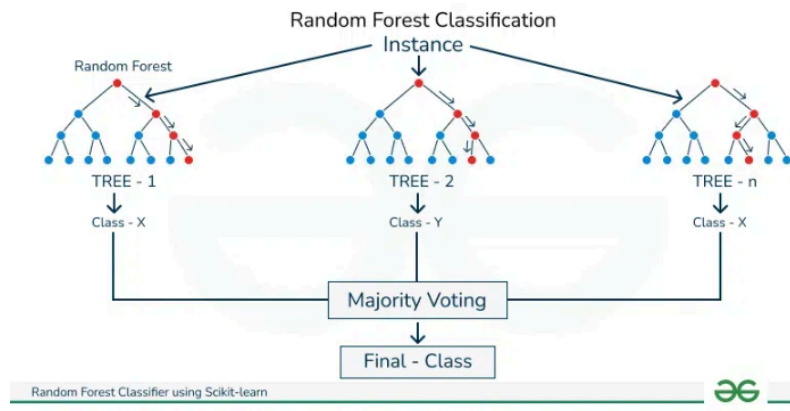


Figure 31: Random Forest Classifier from [6].

Figure: Random Forest Classifier from [6]. This model incorporates a series of randomized decision trees that consider input variables. Each results in a class designation. These classifications are amalgamated, and the majority is the resulting prediction.[6] With this in mind, we conducted thorough experiments on Random Forests regarding estimator parameters. We were determined to ensure that the forest was trained very thoroughly, as differences in DoS data and normal data are relatively minor. Therefore, we implemented the system with 50 estimators. Concerning our test parameters, to distinguish easily between the true values of the traffic and the estimations, we conducted SSH traffic while employing slowhttptest so that we could record any dest port which is not 80 as normal traffic. The result is shown in the Figure

The screenshot displays a Windows desktop environment. In the foreground, a terminal window titled "kali@kali:~/Desktop" shows the execution of a Python script. The script outputs the accuracy score (0.994972486243121) and the False Positive Rate (FPR) and Detection Rate (DR) for a specific model configuration. The output is as follows:

```

File Actions Edit View Help
(kali@kali) ~/Desktop
$ python Train.py flows_benchmark_and_DoS.csv
Accuracy score: 0.994972486243121

(kali@kali) ~/Desktop
$ python Test.py ml_model.joblib Test_Data.pcap_Flow.csv

False Positive Rate: 0.0%
Detection Rate: 94.73684210526315%

(kali@kali) ~/Desktop
$ python Test.py ml_model.joblib Test_Data.pcap_Flow.csv

False Positive Rate: 0.0%
Detection Rate: 94.73684210526315%

```


In the background, a Jupyter Notebook titled "Figure 1" is open, displaying a confusion matrix and an ROC curve. The confusion matrix is as follows:

	Actual Neg	Actual Pos
Predicted Neg	10136, 0.0, 2880, 0.1467	0.2880, 0.0, 2880, 0.8534
Predicted Pos	0.0, 0.0, 4038, 0.0	0.4038, 0.0, 4038, 0.5555

The ROC curve shows the True Positive Rate (Y-axis) versus the False Positive Rate (X-axis). The curve is a solid blue line, and the Area Under the Curve (AUC) is 0.97.

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References

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<https://www.labellerr.com/blog/ddos-attack-detection/> (accessed Apr. 12, 2024).
- [6] GfG, “Random Forest classifier using Scikit-learn,” GeeksforGeeks,
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