Global Information Assurance Certification Paper

Fingerprinting Windows 10 Technical Preview

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Abstract

Understanding the intricacies of a network is powerful information for security professionals and malicious attackers alike. Operating system (OS) fingerprinting is the process of determining the OS of a remote computer. This can be primarily accomplished by passively sniffing network packets between hosts or actively sending crafted packets to the ports of a target host in order to analyze its response. This paper attempts to fingerprint Windows 10 Technical Preview for the purpose of OS identification and to improve Nmap's OS detection database.

1. Introduction

There are five phases in the ethical hacking methodology, and they begin with reconnaissance, scanning, gaining access, maintaining access, and covering tracks (EC-Council, 2015). Reconnaissance is the preliminary phase where a malicious attacker attempts to gather as much information as possible about the target. The use of this information will assist in determining if any vulnerability exists on any of the live hosts. The next phase will attempt to exploit the vulnerable host in order to gain access. Once a malicious attacker gains access to the target host then she/he will attempt to install a backdoor or rootkit to maintain access for future entry. Finally, the malicious attacker will begin covering their tracks by destroying evidence of their presence.

In relation to this paper, the tools and methods used will primarily fall under the reconnaissance and scanning phases. "For attackers, network scanning is an initial reconnaissance to locate hosts running vulnerable network services" (Alsaleh, Oorschot, 2012). The malicious attacker must know the target host's OS in order to have a high success rate of gaining access. As such, a malicious attacker will be meticulous when performing OS fingerprinting because this information will greatly affect each phase of their operation. "For example, the dbot worm invokes GetUserName() to check if the user is in its blacklist of user names. Windows operation system provides several API functions for gaining system-level information, which can be misused for identifying the running environment" (Xie, Lu, Wang, Su, 2013). OS fingerprinting isn't limited to only conducting scans against a remote host. A malicious attacker might attempt multiple avenues to acquire this type of information, like reviewing publicly available information, social engineering, dumpster diving, or viruses.

Yet there also multiple reasons to perform OS fingerprinting that would be for the benefit of an IT security professional. OS fingerprinting can assist in determining if a remote host is susceptible to a particular vulnerability. Through OS detection scanning, an IT security professional can focus their efforts on patching a particular set of hosts that would be vulnerable to an OS-specific exploit. Yet, OS fingerprinting can also assist in tailoring OS-specific exploits. "Buffer overflows, format-string exploits, and many other vulnerabilities often require custom-tailored shellcode with offsets and assembly payloads generated to match the target OS and hardware architecture" (Lyon, 1997). There are also administrative reasons where OS fingerprinting scans can provide additional information such as network

inventory. These scans will be able to locate what is running on a particular network to keep an inventory of a company's assets. In addition, these scans will be able to assist in detecting unauthorized and potential dangerous devices for investigation and containment. "With the ubiquity of mobile devices and cheap commodity networking equipment, companies are increasingly finding that employees are extending their networks in undesirable ways" (Lyon, 1997). A company's corporate network may be opened up to potential attackers who may be in a close proximity if an employee installs an unauthorized wireless access point.

2. Fingerprinting Windows 10 Technical Preview

For the purpose of this exercise, all scanning activity was conducted in an isolated virtual environment. A virtual machine (VM) running OS Kali Linux version 3.18.0 with Nmap version 6.47 was utilized to probe another virtual machine running Windows 10 Technical Preview version 10.0.10041. "All the scanning tools fall into one of two major categories: Active or Passive" (Budhrani, Sridaran, 2015). Nmap is an active scanning tool as it will send out packets to a target host rather than passively sniff traffic to be analyzed. The configuration for each virtual machine's network adapter was set to host only and with no port forwarding in order to create an isolated, clean environment between source and destinations addresses. The IP address of the Kali Linux virtual machine is 192.168.56.102 and the IP address for the Windows 10 Technical Preview virtual machine is 192.168.56.101. These versions and system information can be seen in Figure 1-6.

Each type of scan was performed twice. The first set of scans probed the default configuration of Windows 10 Technical Preview. While the second set of scans probed Windows 10 Technical Preview with its host-based firewall turned off for both public and private networks. The host-based firewall disrupted all of the first set of scans. This rendered the outcome to be inadequate for analysis. As such, all forthcoming analysis with be derived from the second set of scans.

Figure 1 – Network Diagram

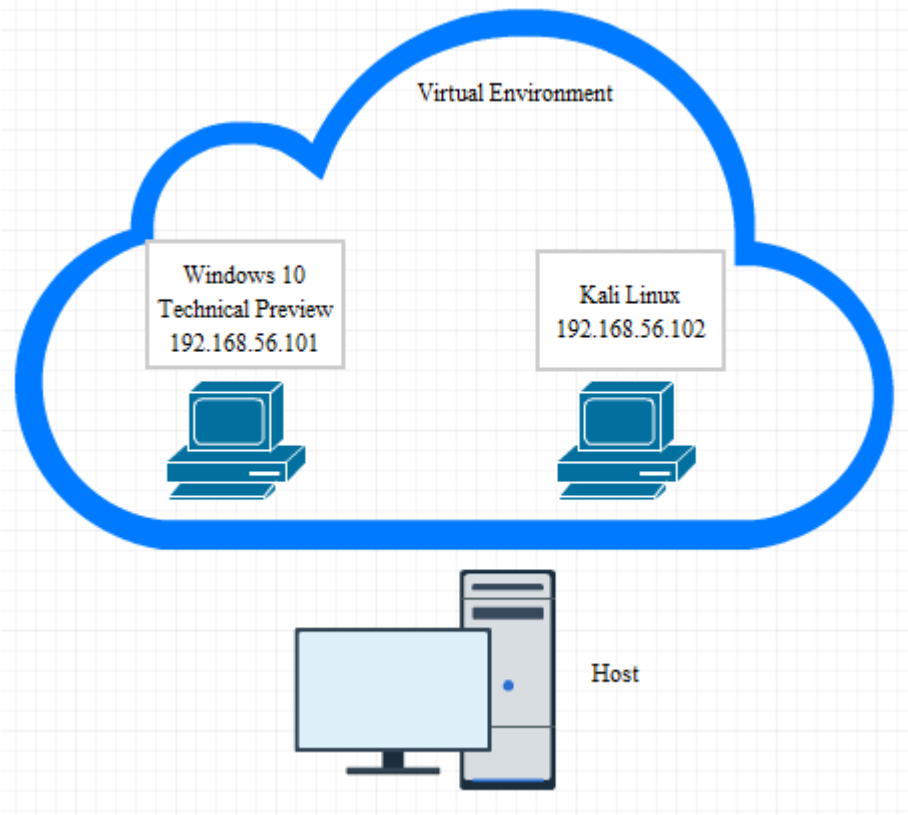

Figure 2 – Kali Linux Virtual Machine Overview

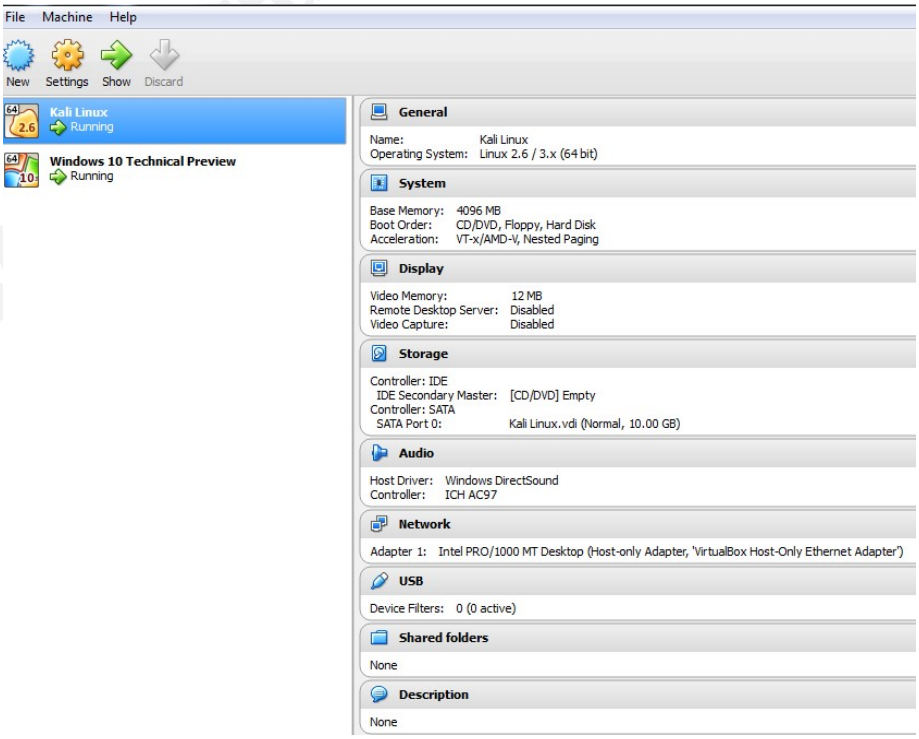

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Figure 3 – Windows 10 Technical Preview Virtual Machine Overview

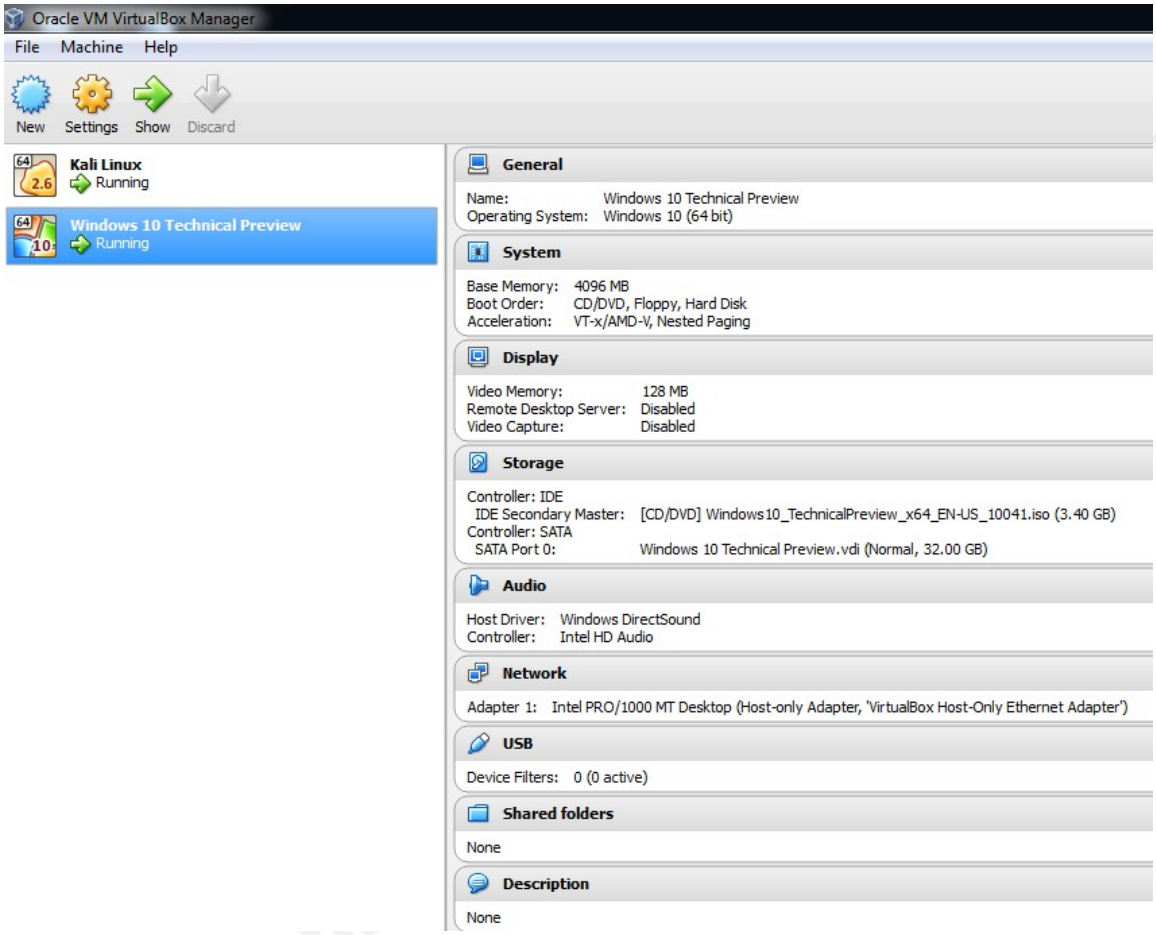

Figure 4 – Kali Linux version and IP address

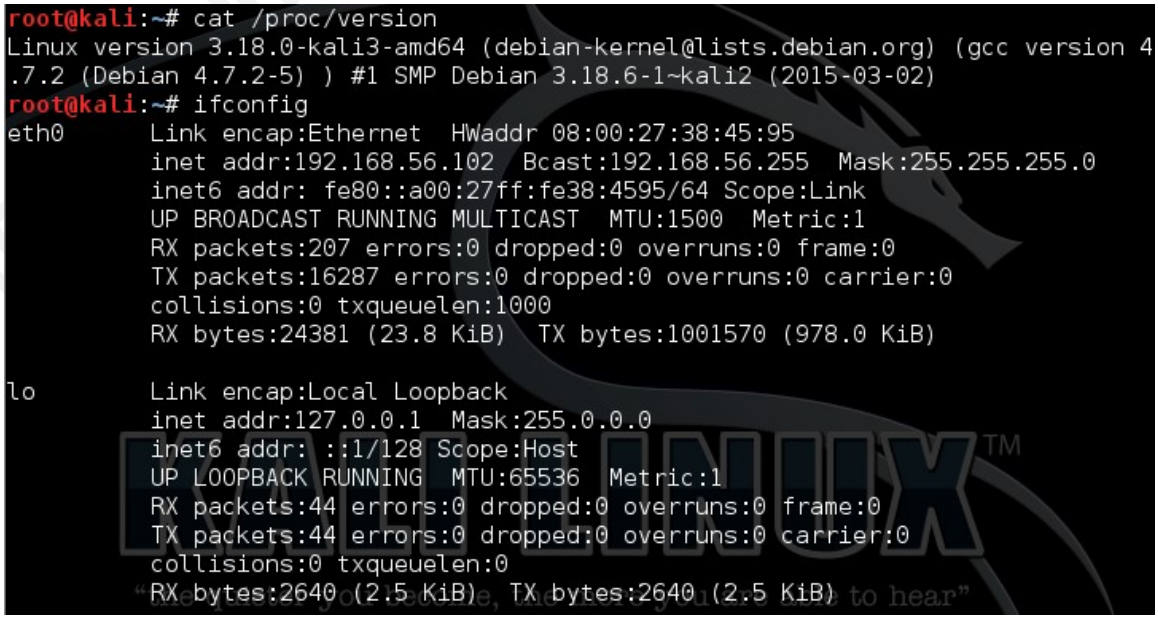

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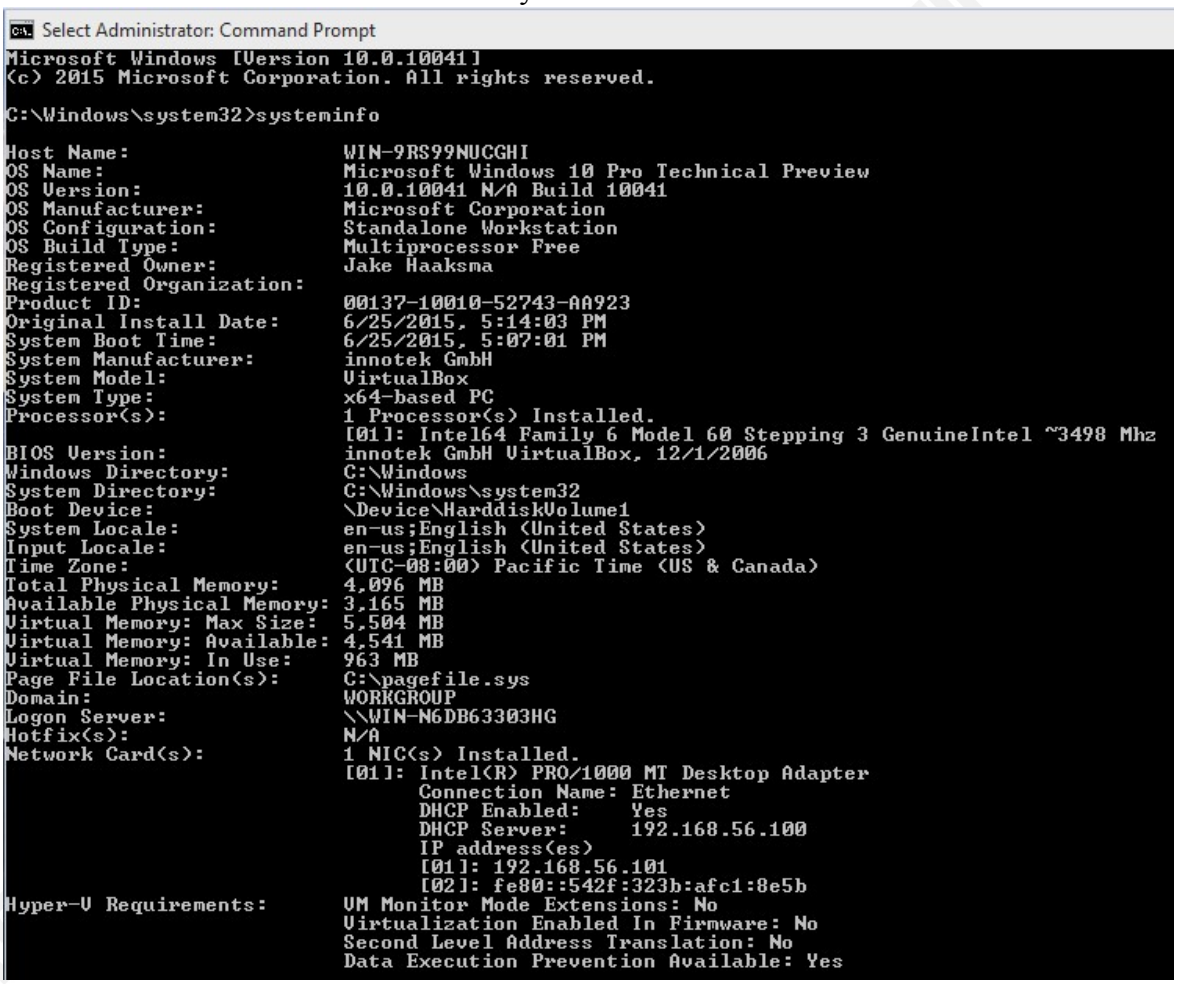
Figure 5 – Nmap version

Figure 6 – Windows 10 Technical Preview system information



2.1 Scanning for Ports/Services/Protocols

The reconnaissance phase begins with target definition. This is where an attacker specifies a target IP address, hostname, or a range of IP addresses of interest. The attacker's objective is to reduce a range of IP addresses into a list of active hosts, which is known as host discovery. Nmap contains a variety of options to perform this step such as TCP Connect option (-sT). This option will send a TCP packet with the SYN flag set. If the destination

host's port is open, a SYN/ACK packet is sent back as the second step of a TCP three-way handshake. However, if the destination host's port is closed, a RST packet is sent back. If a SYN/ACK packet is received, Nmap will complete the TCP three-way handshake with a final ACK packet. In Figure 7 and 8, tcpdump has captured both a successful and unsuccessful TCP connection. However, in this situation, the only target of interest is 192.168.56.101.

Figure 7 - SYN and RST/ACK

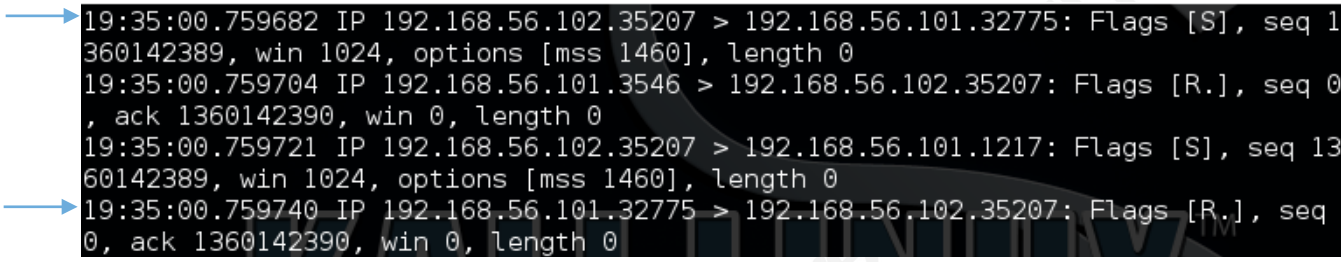
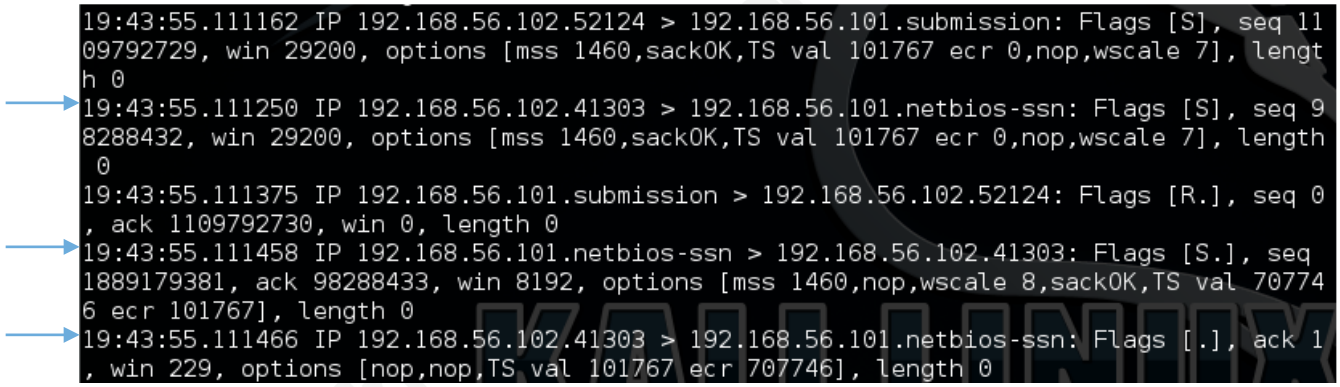


Figure 8 - SYN, SYN/ACK, and ACK



After the attacker has compiled a list of active hosts, then the next course of action is to determine what ports, protocols, services, and the version of those services are open on each host. This information can potentially become the avenue for the attacker's exploit if a vulnerability is present. "Various ports and IP addresses may lead to the same type of attack" (Sultana, Charles, Govardhan, 2013). Nmap allows a user to be quite flexible because of the variety of scans to choose from. Each Nmap's scan option will probe 1,000 ports of the destination host. The response will be recognized into six port states, which are open, closed, filtered, unfiltered, open|filtered, and closed|filtered.

1. An open port denotes that an application is actively accepting TCP connections and UDP datagrams (Lyon, 1997).
2. A closed port is accessible but no application is listening on it (Lyon, 1997).

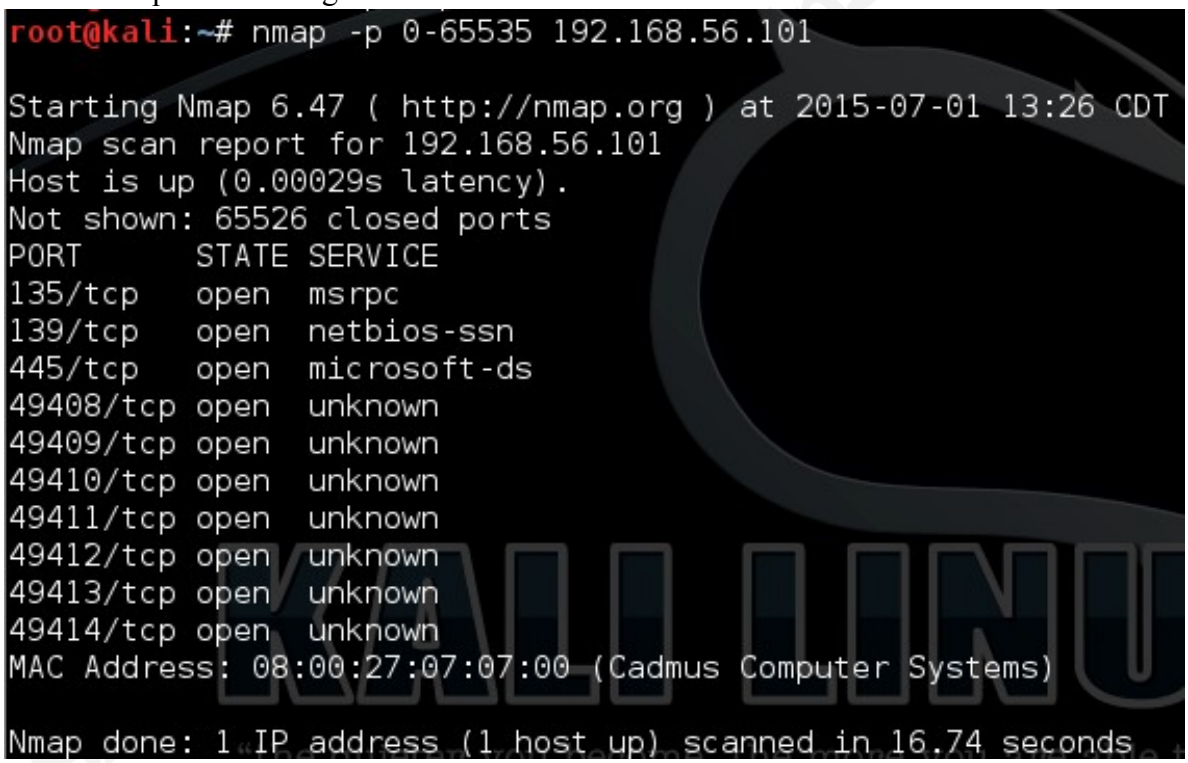
3. A filtered port state indicates that Nmap cannot determine whether the port is open because packet filtering prevents the probe from reaching the port (Lyon, 1997).
4. An unfiltered port state represents the port is accessible, but Nmap is unable to determine whether it is open or closed. “Only the ACK scan, which is used to map firewall rulesets, classifies ports into this state. Scanning unfiltered ports with other scan types such as Window scan, SYN scan, or FIN scan, may help resolve whether the port is open” (Lyon, 1997).
5. The open|filtered port state signifies that the port could be open or filtered because no response from the port was received. “The lack of response could also mean that a packet filter dropped the probe or any response it elicited. So Nmap does not know for sure whether the port is open or being filtered. The UDP, IP protocol, FIN, NULL, and Xmas scans classify ports this way” (Lyon, 1997).
6. Lastly, the closed|filtered port state implies that the port could be closed or filtered. “It is only used for the IP ID idle scan” (Lyon, 1997).

An attacker can continue to study a particular host by querying for an accurate service version number. This piece of information can determine which exploits a host might be vulnerable to. “Nmap’s service and version detection scans determine the service protocol (e.g. FTP, SSH, Telnet, HTTP), the application name (e.g. ISC BIND, Apache httpd, Solaris telnetd), the version number, hostname, device type (e.g. printer, router), the OS family (e.g. Windows, Linux)” (Lyon, 1997). When a malicious attacker knows their target host’s open and closed ports, supported protocols, running services and the version of those services, then she or he can begin to anticipate a high chance of compromising the host.

As seen in Figure 9, the initial scan against 192.168.56.101 was to analyze the state of each port. Nmap has revealed that 192.168.56.101 has 10 open TCP ports but was only able to specify 3 services: Microsoft Remote Procedure Call (MSRPC), Netbios-ssn, and Microsoft- directory services (ds). This information could indicate that the target resembles a host running some type of Windows OS. MSRPC is an interprocess communication mechanism that enables data exchange and functionality residing in a different process (What is RPC?, 2003). Netbios provides services to allow applications on separate computers to communicate over a LAN. These services include a name service, datagram distribution service, and a session service. Netbios-ssn is a session service for connection-oriented

communication (NetBIOS Over TCP/IP, 2005). Microsoft-ds allow Server Message Block (SMB) to run over TCP for session-oriented communication (NetBIOS Over TCP/IP, 2005). "Port scanning can be conducted using special TCP scanning tools, such as NMAP, where the attacker usually attempts to connect to the target computer via various TCP ports" (Anbar, Manasrah, Manickam, 2012). If the host's firewall were up, then the results would have been quite limited. All possible ports were probed with a TCP SYN packet, but the host's firewall prevented the packet from reaching the port. Therefore, the host could not respond.

Figure 9 – Nmap Port Scan against firewall turned off



The next type of scan is Nmap's SYN scan, which can be executed by the –sS switch in one's Nmap command. This popular scan can be performed quickly and is relatively unobtrusive and stealthy. The SYN scan will start the three-way handshake of a TCP connection to only see if the target host will reply with a SYN/ACK or a RST/ACK. Nmap will record the response and will not attempt to complete the three-way handshake, which can be seen in Figure 10. Figure 11 showcases the results of the scan. The second set of scans concluded that 3 registered TCP ports were open along with the same listening services from the previous scan.

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Figure 10 - SYN and RST/ACK

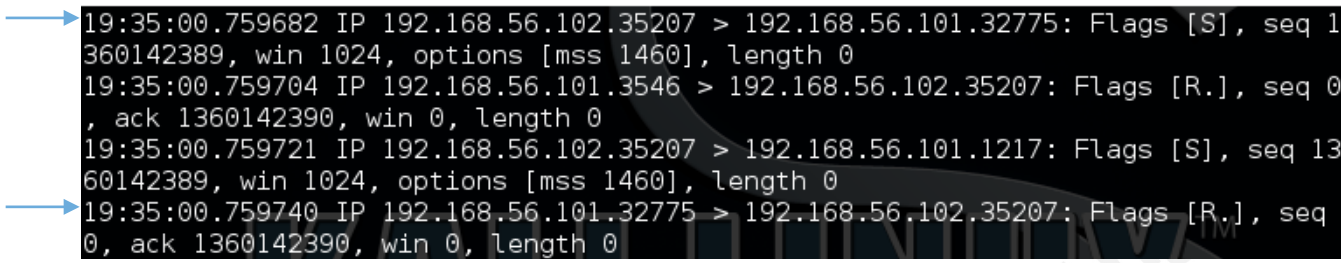
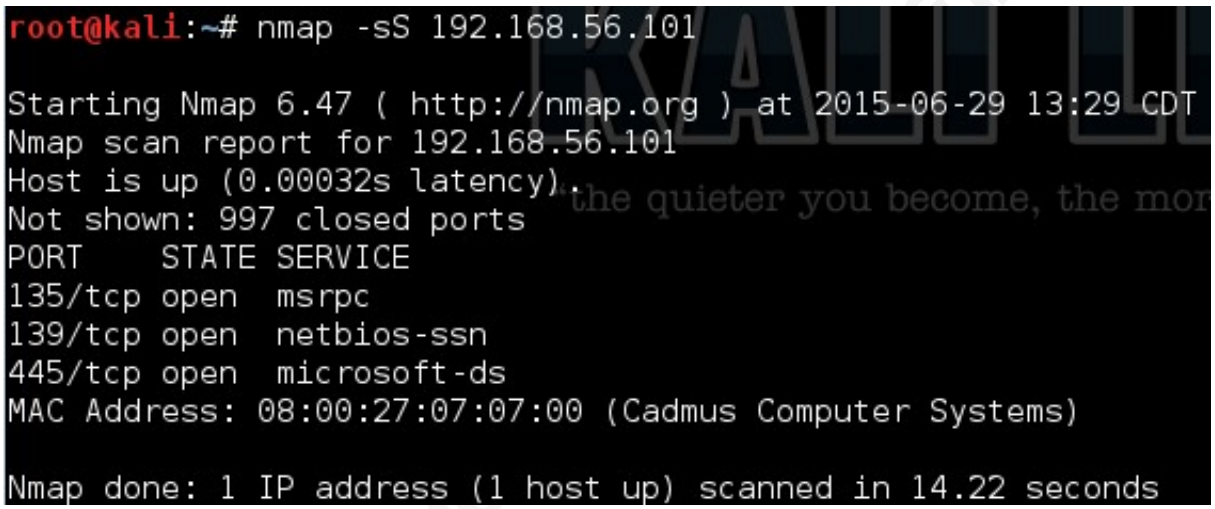


Figure 11 – Nmap SYN Scan against firewall turned off



A generally slower, more difficult scan such as the UDP scan tend to be overlooked, but there are exploitable UDP services. “UDP scanning is not commonly used compared to TCP scanning, but it is still used and gives accurate results for scanners” (Elejla, Jantan, Ahmed, 2014). A UDP scan (-sU) can be quite customized due to the number of options available. The conclusions shown in Figure 12 reveal new information about
192.168.56.101. Nmap is able to determine that UDP port 137 is open, but the other ports could be open or filtered.

1. UDP port 123 could be running the Network Time Protocol (NTP), which is for clock synchronization between computer systems.
2. UDP port 137 is running Netbios-ns. This service is another one of the Netbios distinct functions specifically for name registration and resolution.
3. UDP port 138 could be running Netbios-dgm, which is the final service of Netbios used for datagram distribution service for connectionless communication.

4. UDP port 500 could be running the Internet Security Association and Key Management Protocol (ISAKMP). “Port 500 is used by the Internet key exchange (IKE) that occurs during the establishment of secure VPN tunnels. Users of VPN servers and clients may encounter this port” (Gibson, 2008).
5. UDP Port 1900 is Simple Service Discovery Protocol. “This UDP port is opened and used by Universal Plug N' Play (UPnP) devices to receive broadcasted messages from other UPnP devices. UPnP devices broadcast subnet-wide messages to simultaneously reach all other UPnP devices” (Gibson, 2008).
6. UDP port 4500 could be running Network Address Translation – Traversal – IKE (NAT-T-IKE).
7. The zeroconf service on UDP port 5353 is associated with Mac OS X Bonjour/Zeroconf, which on Windows, allows for communication between Windows and Mac OS.
8. Finally, UDP port 5355 could be running Link-Local Multicast Name Resolution (LLMNR). This service provides name resolution services for hosts on an ad-hoc network (Posey, 2006).
9. UDP port 137, 5355, and 138 are another set of services typically seen on Windows machines. It appears that this host uses the Internet Key Exchange (IKE) protocol in the IPsec protocol suite when establishing a VPN tunnel or performing NAT traversal” (Gibson, 2008).

Figure 12 – Nmap UDP Scan against firewall turned off

```
root@kali:~# nmap -sU 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 13:31 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00067s latency).
Not shown: 992 closed ports
PORT     STATE         SERVICE
123/udp  open|filtered ntp
137/udp  open          netbios-ns
138/udp  open|filtered netbios-dgm
500/udp  open|filtered isakmp
1900/udp open|filtered upnp
4500/udp open|filtered nat-t-ike
5353/udp open|filtered zeroconf
5355/udp open|filtered llmnr
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 1085.67 seconds
```

This next Nmap scan is not technical a port scan. An IP protocol scan (-sO) allows a user to determine which IP protocols are supported by the target host. “Rather than cycling through the target’s ports it tries all 256 possible IP protocol numbers in the IP header” (Lyon, 1997). Figure 13 showcases that 192.168.56.101 supports fairly common IP protocols and even two members of the IPsec protocol suite, Encapsulating Security Payload (ESP) and Authentication Header (AH).

Figure 13 – Nmap IP Protocol Scan against firewall turned off

```
root@kali:~# nmap -sO 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 17:55 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00027s latency).
Not shown: 248 closed protocols
PROTOCOL STATE         SERVICE
1        open          icmp
2        open|filtered igmp
4        open|filtered ip
6        open          tcp
17       open          udp
41       open|filtered ipv6
50       open|filtered esp
51       open|filtered ah
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 315.07 seconds
```

Nmap’s Service/Version Detection Scan (-sV) can been enhanced through the following options: --allports and --version-all. The option --allports informs Nmap to not exclude a ports from this scan and the option --version-all increases the intensity of the scan to the maximum level of 9 (Lyon, 1997). The intensity level changes the number of probes Nmap will send to accurately identify running services. Although the results in Figure 14 are similar to several of the previous port and SYN scans, it differs in that Netbios-ssn is listening on both TCP port 139 and 445. The port/SYN/TCP-connect scans concluded that Microsoft-ds is listening on TCP port 445 rather than Netbios-ssn. These results provide indication that the target host’s OS is some version of Windows and not

UNIX because of the MSRPC and Netbios services as these services were developed by Microsoft.

Figure 14 – Nmap Service Version Detection Scan against firewall turned off

```
root@kali:~# nmap -sV --allports --version-all 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 18:01 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00027s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE     VERSION
135/tcp open  msrpc       Microsoft Windows RPC
139/tcp open  netbios-ssn
445/tcp open  netbios-ssn
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)
Service Info: OS: Windows; CPE: cpe:/o:microsoft:windows

Service detection performed. Please report any incorrect results at http://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 20.25 seconds
```

The default IP version for Nmap's scan is version 4; however, Nmap can conduct an IPv6 scan (-6) against a target host. The IPv6 scan is identical to the SYN scan where instead IPv6 SYN packets are sent to the target host. Nmap will look for a SYN/ACK or RST/ACK to judge whether the port is open or not. In Figure 15, Nmap was able to detect through the IPv6 scan that TCP port 135 and 445 are open. Again, the same services can be seen before in the previous scans and reinforce the suspicious that the target host's OS is some version of Windows.

Figure 15 – Nmap IPv6 Scan against firewall turned off

```
root@kali:~# nmap -6 fe80::542f:323b:afc1:8e5b

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-30 06:43 CDT
Nmap scan report for fe80::542f:323b:afc1:8e5b
Host is up (0.000081s latency).
Not shown: 998 closed ports
PORT    STATE SERVICE
135/tcp open  msrpc
445/tcp open  microsoft-ds
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 0.09 seconds
```

2.2 Windows 10 Technical Preview Ports/Protocols/Services

The results, particularly from the second set of Nmap scans, provided a great deal of information regarding the host's port and service activity. The next series of

screenshots (Figure 16-19) were taken from the Windows 10 Technical Preview VM to display the actual open ports, protocols, processes, and running services. This information will also act as the benchmark to verify how accurate the scan results were.

Figure 16 shows that a default installation of Windows 10 Technical Preview has 10 open TCP ports and 12 open UDP ports. Nmap scans were able to correctly detect all 10 TCP ports, however was only able to identify 8 UDP ports. The enumerate UDP ports of 57455, 57456, 57457, 57458, and 546 were not revealed through the Nmap scans conducted in this experiment. Nmap may not be at fault for not determining the other 4 UDP ports because of the nature of the protocol. UDP provides no guarantee of delivery or anticipate a response from the given port.

Figure 17 correlates each port's PID to a more detailed view of the process and Figure 18 lists all of the started services for Windows 10 Technical Preview. There are some tactics available to the IT security professional to thwart such reconnaissance attempts such as port hopping. "In this way, port hopping disrupts the static associations between port numbers and services, which can be used to mitigate reconnaissance attacks because the attacker often identifies services of a given system by network probes, and then breaks in the target system by exploiting a known vulnerability of the service identified" (Luo, Wang, Cai, 2015). This concept of port hopping is a proactive cyber defense technology to mislead a potential attacker.

Figure 16 – Windows 10 Technical Preview open ports

```
C:\Windows\system32>netstat -aon | more

Active Connections

  Proto  Local Address          Foreign Address        State           PID
  TCP    0.0.0.0:135            0.0.0.0:0              LISTENING       652
  TCP    0.0.0.0:445            0.0.0.0:0              LISTENING       4
  TCP    0.0.0.0:49408          0.0.0.0:0              LISTENING       436
  TCP    0.0.0.0:49409          0.0.0.0:0              LISTENING       912
  TCP    0.0.0.0:49410          0.0.0.0:0              LISTENING       1112
  TCP    0.0.0.0:49411          0.0.0.0:0              LISTENING       816
  TCP    0.0.0.0:49412          0.0.0.0:0              LISTENING       516
  TCP    0.0.0.0:49413          0.0.0.0:0              LISTENING       524
  TCP    0.0.0.0:49414          0.0.0.0:0              LISTENING       1268
  TCP    192.168.56.101:139     0.0.0.0:0              LISTENING       4
  TCP    [::]:135               [::]:0                 LISTENING       652
  TCP    [::]:445               [::]:0                 LISTENING       4
  TCP    [::]:49408             [::]:0                 LISTENING       436
  TCP    [::]:49409             [::]:0                 LISTENING       912
  TCP    [::]:49410             [::]:0                 LISTENING       1112
  TCP    [::]:49411             [::]:0                 LISTENING       816
  TCP    [::]:49412             [::]:0                 LISTENING       516
  TCP    [::]:49413             [::]:0                 LISTENING       524
  TCP    [::]:49414             [::]:0                 LISTENING       1268
  UDP    0.0.0.0:500            *:*                                    816
  UDP    0.0.0.0:4500           *:*                                    816
  UDP    0.0.0.0:5353           *:*                                    636
  UDP    0.0.0.0:5355           *:*                                    636
  UDP    127.0.0.1:1900         *:*                                    920
  UDP    127.0.0.1:57458        *:*                                    920
  UDP    192.168.56.101:137     *:*                                    4
  UDP    192.168.56.101:138     *:*                                    4
  UDP    192.168.56.101:1900    *:*                                    920
  UDP    192.168.56.101:57457   *:*                                    920
  UDP    [::]:500               *:*                                    816
  UDP    [::]:4500              *:*                                    816
  UDP    [::]:5353              *:*                                    636
  UDP    [::]:5355              *:*                                    636
  UDP    [::1]:1900             *:*                                    920
  UDP    [::1]:57456            *:*                                    920
  UDP    [fe80::542f:323b:afc1:8e5b%3]:546  *:*                                912
  UDP    [fe80::542f:323b:afc1:8e5b%3]:1900  *:*                               920
  UDP    [fe80::542f:323b:afc1:8e5b%3]:57455  *:*                              920
```

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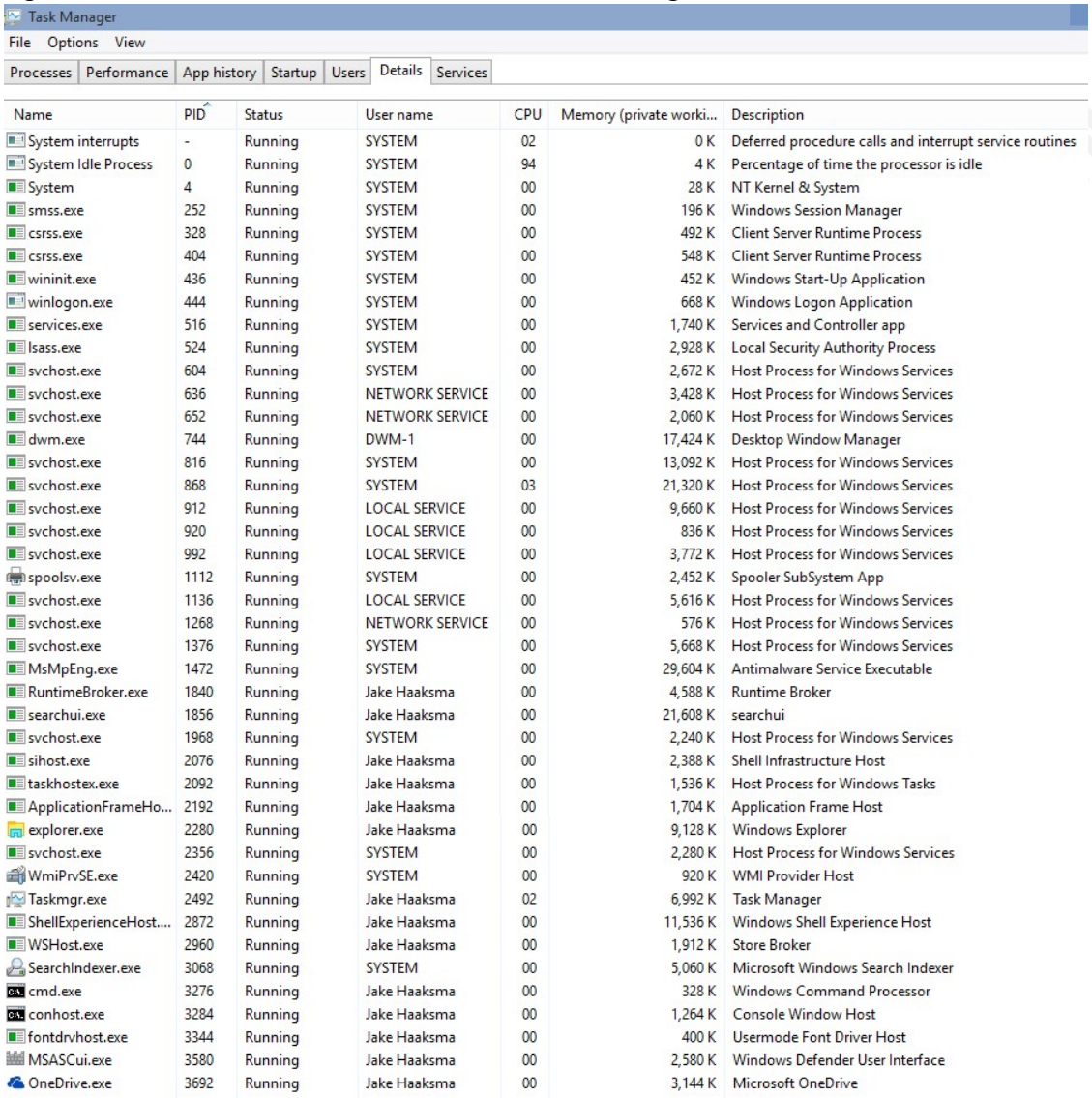
Figure 17 Windows 10 Technical Preview Task Manager



Name	PID	Status	User name	CPU	Memory (private worki...	Description
System interrupts	-	Running	SYSTEM	02	0 K	Deferred procedure calls and interrupt service routines
System Idle Process	0	Running	SYSTEM	94	4 K	Percentage of time the processor is idle
System	4	Running	SYSTEM	00	28 K	NT Kernel & System
smss.exe	252	Running	SYSTEM	00	196 K	Windows Session Manager
csrss.exe	328	Running	SYSTEM	00	492 K	Client Server Runtime Process
csrss.exe	404	Running	SYSTEM	00	548 K	Client Server Runtime Process
wininit.exe	436	Running	SYSTEM	00	452 K	Windows Start-Up Application
winlogon.exe	444	Running	SYSTEM	00	668 K	Windows Logon Application
services.exe	516	Running	SYSTEM	00	1,740 K	Services and Controller app
lsass.exe	524	Running	SYSTEM	00	2,928 K	Local Security Authority Process
svchost.exe	604	Running	SYSTEM	00	2,672 K	Host Process for Windows Services
svchost.exe	636	Running	NETWORK SERVICE	00	3,428 K	Host Process for Windows Services
svchost.exe	652	Running	NETWORK SERVICE	00	2,060 K	Host Process for Windows Services
dwm.exe	744	Running	DWM-1	00	17,424 K	Desktop Window Manager
svchost.exe	816	Running	SYSTEM	00	13,092 K	Host Process for Windows Services
svchost.exe	868	Running	SYSTEM	03	21,320 K	Host Process for Windows Services
svchost.exe	912	Running	LOCAL SERVICE	00	9,660 K	Host Process for Windows Services
svchost.exe	920	Running	LOCAL SERVICE	00	836 K	Host Process for Windows Services
svchost.exe	992	Running	LOCAL SERVICE	00	3,772 K	Host Process for Windows Services
spoolsv.exe	1112	Running	SYSTEM	00	2,452 K	Spooler SubSystem App
svchost.exe	1136	Running	LOCAL SERVICE	00	5,616 K	Host Process for Windows Services
svchost.exe	1268	Running	NETWORK SERVICE	00	576 K	Host Process for Windows Services
svchost.exe	1376	Running	SYSTEM	00	5,668 K	Host Process for Windows Services
MsMpEng.exe	1472	Running	SYSTEM	00	29,604 K	Antimalware Service Executable
RuntimeBroker.exe	1840	Running	Jake Haaksma	00	4,588 K	Runtime Broker
searchui.exe	1856	Running	Jake Haaksma	00	21,608 K	searchui
svchost.exe	1968	Running	SYSTEM	00	2,240 K	Host Process for Windows Services
sihost.exe	2076	Running	Jake Haaksma	00	2,388 K	Shell Infrastructure Host
taskhostex.exe	2092	Running	Jake Haaksma	00	1,536 K	Host Process for Windows Tasks
ApplicationFrameHo...	2192	Running	Jake Haaksma	00	1,704 K	Application Frame Host
explorer.exe	2280	Running	Jake Haaksma	00	9,128 K	Windows Explorer
svchost.exe	2356	Running	SYSTEM	00	2,280 K	Host Process for Windows Services
WmiPrvSE.exe	2420	Running	SYSTEM	00	920 K	WMI Provider Host
Taskmgr.exe	2492	Running	Jake Haaksma	02	6,992 K	Task Manager
ShellExperienceHost....	2872	Running	Jake Haaksma	00	11,536 K	Windows Shell Experience Host
WSHost.exe	2960	Running	Jake Haaksma	00	1,912 K	Store Broker
SearchIndexer.exe	3068	Running	SYSTEM	00	5,060 K	Microsoft Windows Search Indexer
cmd.exe	3276	Running	Jake Haaksma	00	328 K	Windows Command Processor
conhost.exe	3284	Running	Jake Haaksma	00	1,264 K	Console Window Host
fontdrvhost.exe	3344	Running	Jake Haaksma	00	400 K	Usermode Font Driver Host
MSASCui.exe	3580	Running	Jake Haaksma	00	2,580 K	Windows Defender User Interface
OneDrive.exe	3692	Running	Jake Haaksma	00	3,144 K	Microsoft OneDrive

Figure 18 – Windows 10 Technical Preview default started services

```
C:\Windows\system32>net start
These Windows services are started:

   Application Information
   Background Intelligent Transfer Service
   Background Tasks Infrastructure Service
   Base Filtering Engine
   Client License Service (ClipSVC)
   COM+ Event System
   CoreMessaging
   Cryptographic Services
   DCOM Server Process Launcher
   Device Setup Manager
   DHCP Client
   Diagnostic Policy Service
   Diagnostic Service Host
   Diagnostics Tracking Service
   Distributed Link Tracking Client
   Distributed Transaction Coordinator
   DNS Client
   Geolocation Service
   Group Policy Client
   IP Helper
   Local Session Manager
   Microsoft Account Sign-in Assistant
   Network Connection Broker
   Network List Service
   Network Location Awareness
   Network Store Interface Service
   Plug and Play
   Power
   Print Spooler
   Program Compatibility Assistant Service
   Remote Procedure Call (RPC)
   RPC Endpoint Mapper
   Security Accounts Manager
   Security Center
   Sensor Monitoring Service
   Sensor Service
   Server
   Shell Hardware Detection
   SSDP Discovery
   Superfetch
   System Event Notification Service
   System Events Broker
   Task Scheduler
   TCP/IP NetBIOS Helper
   Themes
   tiledatamodelsvc
   Time Broker
   TP AutoConnect Service
   User Manager
   User Profile Service
   VMware Tools
   Windows Audio
   Windows Audio Endpoint Builder
   Windows Connection Manager
   Windows Defender Service
   Windows Driver Foundation - User-mode Driver Framework
   Windows Event Log
   Windows Firewall
   Windows Font Cache Service
   Windows Management Instrumentation
   Windows Search
   Windows Time
   WinHTTP Web Proxy Auto-Discovery Service
   Workstation
```

2.2 OS Detection Scanning

When Nmap begins to perform OS fingerprinting, it does this through a series of probes that are sent to the target. "These TCP, UDP, and ICMP probes are crafted to exploit various ambiguities for Nmap to analyze each response or lack thereof to generate a fingerprint for a particular OS. The supported methods for TCP/IP fingerprint by Nmap are split into two categories, probes sent and response tests" (Lyon, 1997). Below are the probes that are sent:

1. Sequence generation (SEQ, OPS, WIN, and T1). This test involves sending a series of 6 crafted TCP SYN packets to analyze the target's sequence algorithms, which include initial sequence numbers (ISN), IP IDs, and TCP timestamps. The results of each response are contained into 4 category lines. The SEQ line will showcase the sequence analysis of the packets. The OPS line contains the TCP options received for each of the packets. The WIN line covers the window sizes for the packet responses. The T1 line will contain various test values based on the response of the first TCP SYN packet sent (Lyon, 1997).
2. ICMP echo (IE). This test will send 2 crafted ICMP echo request packets to the target host. The IE line will contain the results of each ICMP echo reply (Lyon, 1997).
3. TCP explicit congestion notification (ECN). This tests the target's TCP/IP stack for ECN support. If a response is received, then the ECN line will record its response (Lyon, 1997).
4. TCP (T2-T7). This test will send 6 crafted TCP packets with various characteristics then each response is recorded in the T2-T7 lines.
5. UDP (U1). This final probe test will send a UDP packet to a closed port to verify if the port is truly closed and there is no packet-filtering device in place. This result will be displayed in the U1 line (Lyon, 1997).

The response tests are along with the Windows 10 Technical Preview responses:

1. TCP ISN greatest common divisor (GCD). This response test is to determine the smallest number by which the target host increments their ISN, GCD=1 (Lyon, 1997).

2. TCP ISN counter rate (ISR). This response test reports the average rate of increase for the target host's ISN, ISR=1 (Lyon, 1997).
3. TCP ISN sequence predictability index (SP). This response test, combined with GCD and ISR, attempts to estimate how difficult it would be to predict the target host's next ISN, SP=100 (Lyon, 1997).
4. IP ID sequence generation algorithm (TI, CI, II). These tests will examine the responses in the IP header ID field. These tests come from the SEQ, T5-T7, and IE probes, TI=I, CI=I, II=I (Lyon, 1997).
5. Shared IP ID sequence Boolean (SS). This response test will record whether the target host shares its IP ID sequence between the TCP and ICMP protocols, SS=S (Lyon, 1997).
6. TCP timestamp option algorithm (TS). This response test will attempt to determine OS characteristics by the TCP timestamp options in the SEQ responses, TS=A (Lyon, 1997).
7. TCP options (O, O1-O6). This response test will record what TCP options are set in the response packets, O1=M5B4NW8ST11, O2=M5B4NW8ST11, O3=M5B4NW8ST11, O4=M5B4NW8ST11, O5=M5B4NW8ST11, O6=M5B4ST1 (Lyon, 1997).
8. TCP initial window size (W, W1-W6). This response test will record the 16-bit TCP window size of the received packets, W1=2000, W2=2000, W3=2000, W4=2000, W5=2000, W6=2000 (Lyon, 1997).
9. Responsiveness (R). This response test will simply record whether or not the target host has responded to a given packet, R=Y (Lyon, 1997).
10. IP don't fragment bit (DF). This response test will record if the don't fragment bit is set or not, DF=Y (Lyon, 1997).
11. Don't fragment ICMP (DFI). Similar to the DF test, it will look for the don't fragment bit from the IE packets, DFI=N (Lyon, 1997).
12. IP initial time-to-live (T). This response test will record how many hops away it is from the target host, T=1 (Lyon, 1997).
13. IP initial time-to-live guess (TG). This response test will attempt to estimate the target host's initial TTL value, nothing set (Lyon, 1997).

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14. Explicit congestion notification (CC). This response test will record if ECN is supported or not, CC=N (Lyon, 1997).
15. TCP miscellaneous quirks (Q). This response test will examine and record oddities in the target host's TCP stack such as if the reserved field in the TCP header is nonzero, Q=(nothing set) (Lyon, 1997).
16. TCP sequence number (S). This response test will examine the 32-bit sequence number field in the TCP header and compare it to the 32-bit acknowledge number field, for each TCP probe sent S=0|Z|Z|A|Z|A|Z (Lyon, 1997).
17. TCP acknowledge number (A). This particular test is just the opposite of the TCP sequence number response test, for each TCP probe sent A=S|S|O|O|S|S|S (Lyon, 1997).
18. TCP flags (F). This response test will records what TCP flags were set in the response packets from the target host, for each TCP probe sent F=A|AR|AR|R|AR|R|AR (Lyon, 1997).
19. TSP RST data checksum (RD). If the target host returns ASCII data in RST packets then that data is recorded, for each TCP probe sent RD=0|0|0|0|0|0|0 (Lyon, 1997).
20. IP total length (IPL). This response test will record in the total length of an IP packet, IPL=164 (Lyon, 1997).
21. Unused port unreachable field nonzero (UN). This response test will view the last 4 bytes of an ICMP port unreachable message header and record its value, UN=0 (Lyon, 1997).
22. Returned probe IP total length value (RIPL). This response test will examine if the IP header is returned as it was received in an ICMP port unreachable message, RIPL=G (Lyon, 1997).
23. Returned probe IP ID value (RID). This response test will examine if the IP ID value is returned as it was received in an ICMP port unreachable message, RID=G (Lyon, 1997).
24. Integrity of returned probe IP checksum value (RIPCK). This response test will verify if the IP packet's checksum is valid when it is received, RIPCK=G (Lyon, 1997).

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25. Integrity of returned probe UDP checksum (RUCK). This response test will verify if the UDP packet's checksum is valid when it is received, RUCK=G (Lyon, 1997).
26. Integrity of returned UDP data (RUD). This response test will check the integrity of the UDP's payload, RUD=G (Lyon, 1997).
27. ICMP response code (CD). This final response test will examine the ICMP response code from the target host, CD=Z (Lyon, 1997).

This combination of probing and testing the target's responses are the hidden workings for Nmap OS detection (Lyon, 1997). There are two types of OS fingerprints that Nmap creates. "The fingerprints of known operating systems that Nmap reads in are called *reference fingerprints*, while the fingerprint Nmap displays after scanning a system is a *subject fingerprint*" (Gibson, 2008). The following OS scans have produce subject fingerprints. The TCP/IP fingerprint is prefixed with 'OS:' and for a subject reference is comprised of two sections, the scan line and then the values from the probes sent/response test. The scan line is a series of conditions to describe the environment for the Nmap scans. These conditions are:

1. the Nmap version number (V),
2. Date of scan (D),
3. Open and closed TCP ports (OT and CT),
4. Closed UDP port (CU),
5. Private IP space (PV),
6. Network distance (DS),
7. Distance calculation method (DC),
8. Good results (G),
9. Target MAC prefix (M),
10. OS scan time (TM),
11. Platform Nmap was compiled in (P).

Nmap's OS detection scans (-O) can be augmented by 2 options which are -osscan-limit and --osscan-guess. The --osscan-guess option will offer up near matches as possibilities and provide a percentage to display its assurance for that guess. However the

second set of scans came back with several guesses as seen in Figure 19. It first makes an initial guess of 97% that the OS is either Microsoft Windows 7|2008|Vista|Longhorn|2012|8.1. None of these initial guesses are correct but all of the guesses were in the Microsoft Windows family. Secondly, Nmap begins to aggressively print its assurance level on each OS guess. Thirdly, Nmap states that no exact OS match can be derived from this particular OS detection scan. Finally, Nmap prints its own TCP/IP fingerprint for the OS.

Figure 19 – Nmap OS Detection Guess Scan against firewall turned off

```
root@kali:~# nmap -O --osscan-guess 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 18:05 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00031s latency).
Not shown: 997 closed ports
PORT    STATE SERVICE
135/tcp open  msrpc
139/tcp open  netbios-ssn
445/tcp open  microsoft-ds
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)
Device type: general purpose
Running (JUST GUESSING): Microsoft Windows 7|2008|Vista|Longhorn|2012|8.1 (97%)
OS CPE: cpe:/o:microsoft:windows_7 cpe:/o:microsoft:windows_server_2008::sp1 cpe:/o:microsoft:windows_8 cpe:/o:m
icrosoft:windows_vista::sp1 cpe:/o:microsoft:windows_vista::sp2 cpe:/o:microsoft:windows cpe:/o:microsoft:window
s_2012 cpe:/o:microsoft:windows_8.1
Aggressive OS guesses: Microsoft Windows 7 Professional (97%), Microsoft Windows 7 SP0 - SP1, Windows Server 200
8 SP1, or Windows 8 (97%), Microsoft Windows 7 Ultimate (97%), Microsoft Windows 7 or Windows Server 2008 (97%),
 Microsoft Windows Vista SP1 - SP2, Windows Server 2008 SP2, or Windows 7 (96%), Microsoft Windows 7 or Windows
Server 2008 R2 (96%), Microsoft Windows Longhorn (96%), Microsoft Windows Server 2008 SP2 (95%), Version 6.1 (Bu
ild 7601: Service Pack 1) (94%), Microsoft Windows 7, Windows Server 2012, or Windows 8.1 Update 1 (94%)
No exact OS matches for host (If you know what OS is running on it, see http://nmap.org/submit/ ).
TCP/IP fingerprint:
OS:SCAN(V=6.47%E=4%D=6/29%OT=135%CT=1%CU=30143%PV=Y%DS=1%DC=D%G=Y%M=080027%
OS:TM=5591CF70%P=x86_64-unknown-linux-gnu)SEQ(SP=100%GCD=1%ISR=10D%TI=I%CI=
OS:I%II=I%SS=S%TS=A)OPS(O1=M5B4NW8ST11%O2=M5B4NW8ST11%O3=M5B4NW8NNT11%O4=M5
OS:B4NW8ST11%O5=M5B4NW8ST11%O6=M5B4ST11)WIN(W1=2000%W2=2000%W3=2000%W4=2000
OS:%W5=2000%W6=2000)ECN(R=Y%DF=Y%T=80%W=2000%O=M5B4NW8NNS%CC=N%Q=)T1(R=Y%DF
OS:=Y%T=80%S=O%A=S+%F=AS%RD=0%Q=)T2(R=Y%DF=Y%T=80%W=0%S=Z%A=S%F=AR%O=%RD=0%
OS:Q=)T3(R=Y%DF=Y%T=80%W=0%S=Z%A=O%F=AR%O=%RD=0%Q=)T4(R=Y%DF=Y%T=80%W=0%S=A
OS:%A=O%F=R%O=%RD=0%Q=)T5(R=Y%DF=Y%T=80%W=0%S=Z%A=S+%F=AR%O=%RD=0%Q=)T6(R=Y
OS:%DF=Y%T=80%W=0%S=A%A=O%F=R%O=%RD=0%Q=)T7(R=Y%DF=Y%T=80%W=0%S=Z%A=S+%F=AR
OS:%O=%RD=0%Q=)U1(R=Y%DF=N%T=80%IPL=164%UN=0%RIPL=G%RID=G%RIPCK=G%RUCK=G%RU
OS:D=G)IE(R=Y%DFI=N%T=80%CD=Z)

Network Distance: 1 hop

OS detection performed. Please report any incorrect results at http://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 24.17 seconds
```

Nmap's second OS detection option --osscan-limit is a more effective guess because of the required condition a target host must met. The target host must have at least one and one closed TCP port otherwise Nmap will move on to the next host if one has been specified. When 192.168.56.101's firewall is turned off then the --osscan-limit scan provides nearly the same information as the --osscan-guess option. Such as an identically TCP/IP fingerprint, the statement that says no exact OS matches has been found, but didn't make any sort of OS guesses. Figure 20 will display these results.

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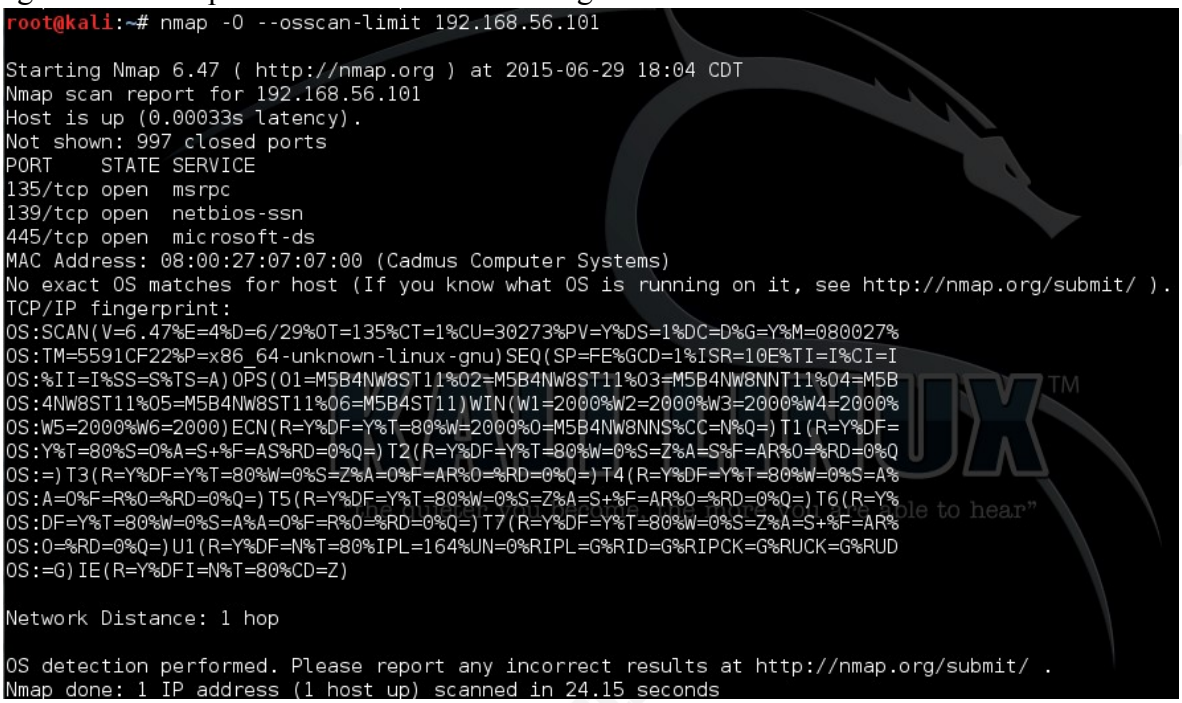
Figure 20 – Nmap OS Detection Limit Scan against firewall turned off



Thus, both OS detection scans were unable to correctly guess that the target's OS is running Windows 10 Technical Preview. There was not one exact fingerprint match in Nmap's OS database, nmap-os-db. The next screenshot is an attempt to generate a suitable fingerprint for Windows 10 Technical Preview. In order to create a fingerprint, Nmap requires the command to be 'nmap –O –sV –T4 –d <target>'. This particular command starts nmap, enables OS detection, probes open ports to determine service/version information, set the timing template to 4 seconds, and increases the debugging level. The scan was able to successfully create a TCP/IP fingerprint for the target host's OS. In order to further improve Nmap's OS database, the fingerprint in Figure 21 has been sent to Nmap's fingerprint submitter webpage.

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Figure 21 – Nmap generate own fingerprint against firewall turned off

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```
OS:%A=O%F=R%O=%RD=0%Q=)T5(R=Y%DF=Y%T=80%W=0%S=Z%A=S+%F=AR%O=%RD=0%Q=)T6(R=Y
OS:%DF=Y%T=80%W=0%S=A%A=O%F=R%O=%RD=0%Q=)T7(R=Y%DF=Y%T=80%W=0%S=Z%A=S+%F=AR
OS:%O=%RD=0%Q=)U1(R=Y%DF=N%T=80%IPL=164%UN=0%RIPL=G%RID=G%RIPCK=G%RUCK=G%RU
OS:D=G)IE(R=Y%DFI=N%T=80%CD=Z)

Uptime guess: 4.068 days (since Thu Jun 25 17:07:00 2015)
Network Distance: 1 hop
TCP Sequence Prediction: Difficulty=259 (Good luck!)
IP ID Sequence Generation: Incremental
Service Info: OS: Windows; CPE: cpe:/o:microsoft:windows
Final times for host: srtt: 315 rttvar: 67  to: 100000

Read from /usr/bin/../share/nmap: nmap-mac-prefixes nmap-os-db nmap-payloads nmap-service-probes nmap-services.
OS and Service detection performed. Please report any incorrect results at http://nmap.org/submit/ .
Nmap done: 1 IP address (1 host up) scanned in 30.32 seconds
           Raw packets sent: 1090 (51.514KB) | Rcvd: 1081 (46.690KB)
```

3.0 Future Work

This experiment allows for future work to extend the knowledge of the Windows 10 OS fingerprint. A proposal of conducting this experiment with the official Windows 10 OS could produce additional information. Windows 10 for customer PCs and tablets is set to be officially released on July 29, 2015. It would be interesting to discover if the default open ports, services, and the OS fingerprint would differ from Windows 10 Technical Preview; also if having the OS runs on a virtual machine as opposed on a standard workstation.

4.0 Conclusion

The process of conducting network exploration and security auditing will yield a vast amount of information about a particular network. This information is currently what a malicious attacker will attempt to acquire. “A host that runs a sniffer can easily embezzle private and confidential information of network users. Hence detection of a sniffer is an essential task to maintain network security” (Khan, Qureshi, Khan, 2012). A security professional must understand their environment in order to properly defend their network(s) and a large part of the picture is to know what operating systems are running within a network. While Nmap was unable to precisely identify the target’s OS it was able to determine the target’s open/closed ports, running services, and protocols. The fingerprint for Windows 10 Technical Preview was created to improve the accuracy of Nmap’s OS database and for the benefit of the security community.

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5.0 Appendix A – Additional Scans against Host's firewall OFF

Nmap TCP NULL Scan against firewall turned off

```
root@kali:~# nmap -sN 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 17:48 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00023s latency).
All 1000 scanned ports on 192.168.56.101 are closed
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 14.14 seconds
```

Nmap FIN Scan against firewall turned off

```
root@kali:~# nmap -sF 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 17:50 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00025s latency).
All 1000 scanned ports on 192.168.56.101 are closed
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 14.14 seconds
```

Nmap Xmas Scan against firewall turned off

```
root@kali:~# nmap -sX 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 17:51 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00015s latency).
All 1000 scanned ports on 192.168.56.101 are closed
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 14.14 seconds
```

Nmap ACK Scan against firewall turned off

```
root@kali:~# nmap -sA 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 17:52 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00020s latency).
All 1000 scanned ports on 192.168.56.101 are unfiltered
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 14.14 seconds
```

Nmap Window Scan against firewall turned off

```
root@kali:~# nmap -sW 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 18:24 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00030s latency).
All 1000 scanned ports on 192.168.56.101 are closed
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 14.14 seconds
```

Nmap Maimon Scan against firewall turned off

```
root@kali:~# nmap -sM 192.168.56.101

Starting Nmap 6.47 ( http://nmap.org ) at 2015-06-29 17:53 CDT
Nmap scan report for 192.168.56.101
Host is up (0.00018s latency).
All 1000 scanned ports on 192.168.56.101 are closed
MAC Address: 08:00:27:07:07:00 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 13.09 seconds
```

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