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# Chapter 6. Enumerating Target

Enumerating target is a process that is used to find and collect information about ports, operating systems, and services available on the target machines. This process is usually done after we have discovered that the target machines are available. In penetration testing practice, this task is conducted at the time of the discovery process.

In this chapter, we will discuss the following topics related to the target enumeration process:

- A brief background concept describing port scanning and various port scanning types supported by the port scanning tools
- The tools that can be used to carry out network scanning task
- The tools that can be used to do SMB enumeration on the Windows environment
- The tools that can be used to do SNMP enumeration
- The tool that can be used to enumerate the IPsec VPN server

The goal of performing the enumeration process is to collect information about the services available on the target systems. Later on, we will use this information to identify vulnerabilities that exist on these services.

## Introducing port scanning

In its simplest definition, port scanning can be defined as a method used to determine the state of the **Transmission Control Protocol** (**TCP**) and **User Datagram Protocol** (**UDP**) ports on the target machines. An open port may mean that there is a network service listening on the port and the service is accessible, whereas a closed port means that there is no network service listening on that port.

After getting the port's state, an attacker will then check the version of the software used by the network service and find out the vulnerability of that version of software. For example, suppose that server A has web server software Version 1.0. A few days ago, there was a security advisory released. The advisory gave information about the vulnerability in web server software Version 1.0. If an attacker finds out about server A's web server and is able to get the version information, the attacker can use this information to attack the server. This is just a simple example of what an attacker can do after getting information about the services available on the machine.

Before we dig into the world of port scanning, let us discuss a little bit of the TCP/IP protocol theory.

### Understanding the TCP/IP protocol

In the TCP/IP protocol suite, there are dozens of different protocols, but the most important ones are TCP and IP. IP provides addressing, datagram routing, and other functions for connecting one machine to another, while TCP is responsible for managing connections and provides reliable data transport between processes on two machines. The IP is located in the network layer (layer 3) in the **Open Systems Interconnection** (**OSI**) model, whereas TCP is located in the transport layer (layer 4) of OSI.

Besides TCP, the other key protocol in the transport layer is UDP. You may ask what the differences between these two protocols are.

In brief, TCP has the following characteristics:

- **This is a connection-oriented protocol**: Before TCP can be used for sending data, the client and the server that want to communicate must establish a TCP connection using a three-way handshake mechanism as follows:

    1. The client initiates the connection by sending a packet containing a SYN (synchronize) flag to the server. The client also sends the **initial sequence number** (**ISN**) in the **Sequence number** field of the SYN segment. This ISN is chosen randomly.
    2. The server replies with its own SYN segment containing its ISN. The server acknowledges the client's SYN by sending an ACK (acknowledgment) flag containing the client's ISN + 1 value.
    3. The client acknowledges the server by sending an ACK flag containing the server ISN + 1. At this point, the client and the server can exchange data.
    4. To terminate the connection, the TCP must follow the given mechanism:

        1. The client sends a packet containing a FIN (finish) flag set.
        2. The server sends an ACK (acknowledgment) packet to inform the client that the server has received the FIN packet.
        3. After the application server is ready to close, the server sends a FIN packet.
        4. The client then sends the ACK packet to acknowledge receiving the server's FIN packet. In a normal case, each side (client or server) can terminate its end of communication independently by sending the FIN packet.

- **This is a reliable protocol**: TCP uses a sequence number and acknowledgment to identify packet data. The receiver sends an acknowledgment when it has received the packet. When a packet is lost, TCP will automatically retransmit it if it hasn't received any acknowledgment from the

receiver. If the packets arrive out of order, TCP will reorder them before submitting it to the application.

Applications that need to transfer files or important data use TCP, such as **Hypertext Transport Protocol** (**HTTP**) and **File Transfer Protocol** (**FTP**).

UDP has characteristics opposite to TCP, which are stated as follows:

- This is a connectionless protocol. To send data, the client and the server don't need to establish a UDP connection first.
- It will do its best to send a packet to the destination, but if a packet is lost, UDP will not automatically resend it. It is up to the application to retransmit the packet.

Applications that can bear the loss of some packets, such as video streaming and other multimedia applications, use UDP. The other well-known applications that use UDP are **Domain Name System** (**DNS**), **Dynamic Host Configuration Protocol** (**DHCP**), and **Simple Network Management Protocol** (**SNMP**).

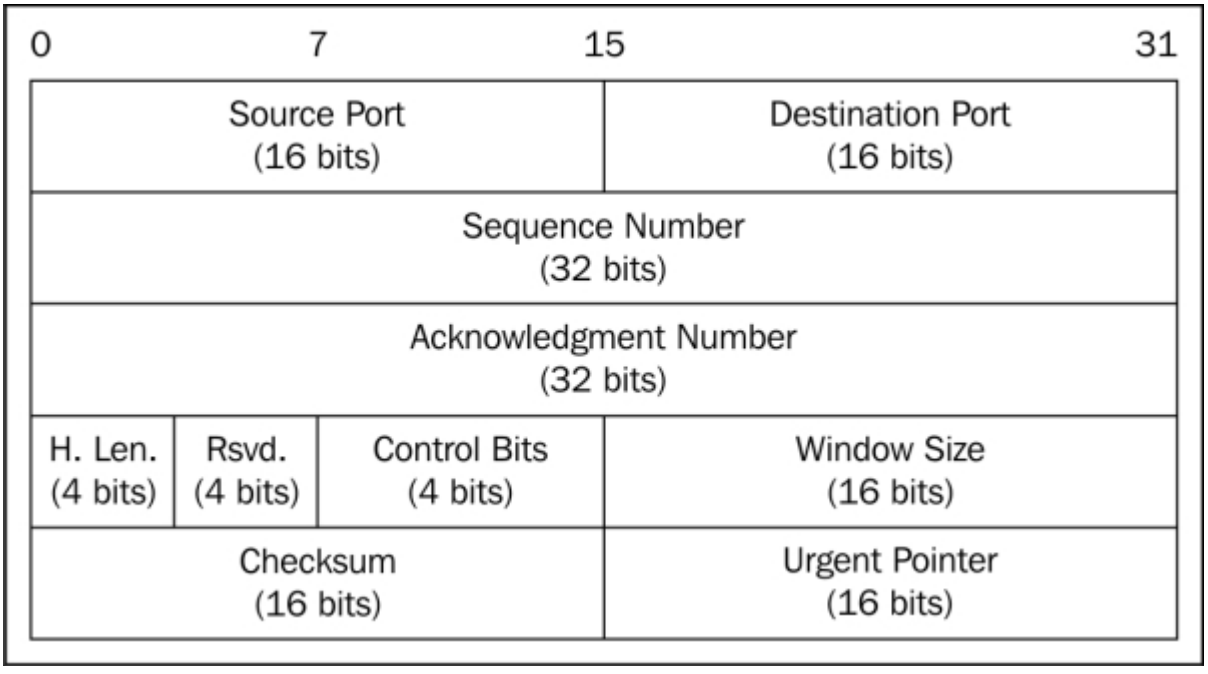
For applications to be able to communicate correctly, the transport layer uses addressing called ports. A software process listens on a particular port number on the server side, and the client machine sends data to that server port to be processed by the server application. The port numbers have a 16-bit address, and it can range from 0 to 65,535. To avoid a chaotic usage of port numbers, there are universal agreements on the port numbers' ranges as follows:

- **Well-known port numbers** (0 to 1023): Port numbers in this range are reserved port numbers and are usually used by the server processes that are run by a system administrator or privileged user. The examples of the port numbers used by an application server are SSH ( `port 22` ), HTTP ( `port 80` ), HTTPS ( `port 443` ), and so on.
- **Registered port numbers** (1024 to 49151): Users can send a request to the **Internet Assigned Number Authority** (**IANA**) to reserve one of these port numbers for their client-server application.
- **Private or dynamic port numbers** (49152 to 65535): Anyone can use port numbers in this range without registering themselves to IANA.

After discussing the differences between TCP and UDP in brief, let us describe the TCP and UDP message format.

## Understanding the TCP and UDP message format

The TCP message is called a segment. A TCP segment consists of a header and a data section. The TCP header is often 20 bytes long (without TCP options). It can be described using the following figure:




Following is a brief description of each field:

- The **Source Port** and the **Destination Port** have a length of 16 bits each. The source port is the port on the sending machine that transmits the packet, while the destination port is the port on the target machine that receives the packet.
- The **Sequence Number (32 bits)**, in normal transmission, is the sequence number of the first byte of data of this segment.
- The **Acknowledgment Number (32 bits)** contains the sequence number from the sender increased by one.
- **H.Len. (4 bits)** is the size of the TCP header in 32-bit words.
- **Rsvd**. is reserved for future use. It is a 4-bit field and must be zero.

- The **Control Bits** (control flags) contains eight 1-bit flags. In the original specification (RFC 793; the RFC can be downloaded from http://www.ietf.org/rfc/rfc793.txt), the TCP only has six flags as follows:
    - **SYN**: This flag synchronizes the sequence numbers. This bit is used during session establishment.
    - **ACK**: This flag indicates that the **Acknowledgment** field in the TCP header is significant. If a packet contains this flag, it means that it is an acknowledgement to the previously received packet.
    - **RST**: This flag resets the connection.
    - **FIN**: This flag indicates that the party has no more data to send. It is used to tear down a connection gracefully.
    - **PSH**: This flag indicates that the buffered data should be pushed immediately to the application rather than waiting for more data.
    - **URG**: This flag indicates that the **Urgent Pointer** field in the TCP header is significant. The urgent pointer refers to important data sequence numbers.
- Later on, the RFC 3168 (the RFC can be downloaded from http://www.ietf.org/rfc/rfc3168.txt) added two more extended flags as follows:
    - **Congestion Window Reduced** (**CWR**): This is used by the data sender to inform the data receiver that the queue of outstanding packets to be sent has been reduced due to network congestion
    - **Explicit Connection Notification-Echo** (**ECN-Echo**): This indicates that the network connection is experiencing congestion
- **Window Size (16 bits)** specifies the number of bytes the receiver is willing to accept.
- **Checksum (16 bits)** is used for error checking of the TCP header and data.

The flags can be set independent of each other.

> **Note**
>
> To get more information on TCP, consult RFC 793 and RFC 3168.

When performing a port scanning on the TCP port by using a SYN packet to the target machine, an attacker might face the following behaviors:

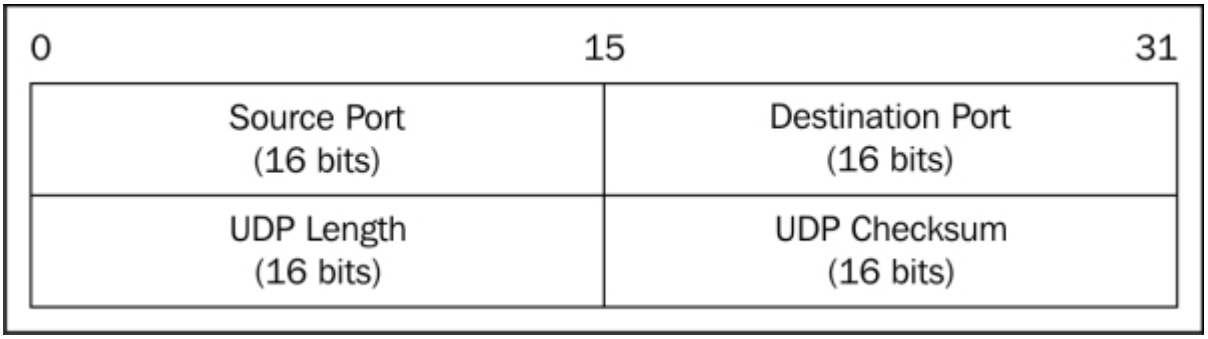
- The target machine responds with the SYN+ACK packet. If we receive this packet, we know that the port is open. This behavior is defined in the TCP specification (RFC 793), which states that the SYN packet must be responded with the SYN+ACK packet if the port is open without considering the SYN packet payload.
- The target machine sends back a packet with the RST and ACK bit set. This means that the port is closed.
- The target machine sends an ICMP message such as `ICMP Port Unreachable`, which means that the port is not accessible to us most likely because it is blocked by the firewall.
- The target machine sends nothing back to us. It may indicate that there is no network service listening on that port or that the firewall is blocking our SYN packet silently.

From a pentester's point of view, interesting behavior is when the port is open because this means that there is a service available on that port that can be tested further.

If you conduct a port scanning attack, you should understand the various TCP behaviors listed in order to be able to attack more effectively.

When scanning for UDP ports, you will see different behaviors, as will be explained later on.

Before we go to see various UDP behaviors, let's see the UDP header format first as shown in the following figure:




The following is a brief explanation of each field in the UDP header depicted in the preceding figure:

- Just like the TCP header, the UDP header also has the **Source Port** and the **Destination Port**, each of which has 16-bits length. The source port

is the port on the sending machine that transmits the packet, while the destination port is the port on the target machine that receives the packet.

- **UDP Length** is the length of the UDP header.
- **UDP Checksum (16 bits)** is used for error checking of the UDP header and data.

Note that there are no Sequence Number, Acknowledgement Number, and Control Bits fields in the UDP header.

During a port scanning activity to the UDP port on the target machine, an attacker might face the following behaviors:

- The target machine responds with a UDP packet. If we receive this packet, we know that the port is open.
- The target machine sends an ICMP message such as `ICMP Port Unreachable`. It can be concluded that the port is closed. However, if the message sent is not an ICMP unreachable message, it means that the port is filtered by the firewall.
- The target machine sends nothing back to us. This may indicate one of the following situations:
    - The port is closed
    - The inbound UDP packet is blocked
    - The response is blocked

UDP port scanning is less reliable when compared to TCP port scanning because sometimes, the UDP port is open but the service listening on that port is looking for a specific UDP payload. Thus, the the service will not send any replies.

Now that we have briefly described the port scanning theory, let's put this into practice. In the following sections, we will look at several tools that can be used to help us perform network scanning.

For the practical scenarios in this chapter, we will utilize a Metasploitable virtual machine, as explained in Chapter 1, *Beginning with Kali Linux*, as our target machine. It has an IP address of `192.168.56.103`, while our attacking machine has an IP address of `192.168.56.102`.

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# The network scanner

In this section, we will look at several tools that can be used to find open ports, fingerprint the remote operating system, and enumerate the services on the remote machine.

Service enumeration is a method that is used to find the service version that is available on a particular port on the target system. This version information is important because with this information, the penetration tester can search for security vulnerabilities that exist for that software version.

Some system administrators often change the port number, a service is listening on. For example, an SSH service may be bound to port `22` (as a convention), but a system administrator may change it to be bound to port `2222`. If the penetration tester only does a port scan to the common port of SSH, it may not find that service. The penetration tester will also have difficulties when dealing with proprietary applications running on non-standard ports. By using the service enumeration tools, these two problems can be mitigated, so there is a chance that the service can be found, regardless of the port it binds to.

## Nmap

Nmap is a very comprehensive, feature- and fingerprint-rich, and widely used port scanner by all of the IT security community. It is written and maintained by Fyodor. It is a must-have tool for a penetration tester because of its quality and flexibility.

Besides being used as a port scanner, Nmap has several other capabilities as follows:

- **Host discovery**: Nmap can be used to find live hosts on the target systems. By default, Nmap will send an ICMP echo request, a TCP SYN packet to port `443`, a TCP ACK packet to port `80`, and an ICMP timestamp request to carry out the host discovery.
- **Service/version detection**: After Nmap has discovered the ports, it can further check for the service protocol, the application name, and the version number used on the target machine.
- **Operating system detection**: Nmap sends a series of packets to the remote host and examines the responses. Then, it compares these responses with its operating system fingerprint database and prints out the details if there is a match. If it is not able to determine the operating system, Nmap will provide a URL where you can submit the fingerprint to update its operating system fingerprint database. Of course, you should submit the fingerprint if you know the operating system used on the target system.
- **Network traceroute**: It is performed to determine the port and protocol that is most likely to reach the target system. Nmap traceroute starts with a high value of **Time to Live** (**TTL**) and decrements it until the TTL value reaches zero.
- **Nmap Scripting Engine**: With this feature, Nmap can be extended. If you want to add a check that is not included with the default Nmap, you can do so by writing the check using the Nmap scripting engine. Currently, there are checks for vulnerabilities in network services and for enumerating resources on the target system.

It is good practice to always check for new versions of Nmap. If you find the latest version of Nmap available for Kali Linux, you can update your Nmap by issuing the following commands:

```
apt-get update
apt-get install nmap
```

To start Nmap, go to the console to execute the following command:

```
nmap
```

This will display all of the Nmap options with their descriptions.

A new user to Nmap will find the available options quite overwhelming.

Fortunately, you only need one option to scan for the remote machine. That option is your target IP address or hostname if you have set up the DNS correctly. This is done with the following command:

```
nmap 192.168.56.103
```

The following is the result of the scan without any other options:

```
Nmap scan report for 192.168.56.103
Host is up (0.0046s latency).
Not shown: 977 closed ports
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
111/tcp  open  rpcbind
139/tcp  open  netbios-ssn
445/tcp  open  microsoft-ds
512/tcp  open  exec
513/tcp  open  login
514/tcp  open  shell
1099/tcp open  rmiregistry
1524/tcp open  ingreslock
2049/tcp open  nfs
2121/tcp open  ccproxy-ftp
3306/tcp open  mysql
5432/tcp open  postgresql
5900/tcp open  vnc
6000/tcp open  X11
6667/tcp open  irc
8009/tcp open  ajp13
8180/tcp open  unknown
MAC Address: 08:00:27:43:15:18 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 13.49 seconds
```

From the preceding result, we can see that the target machine is very vulnerable to attack because it has many open ports.

Before we continue to use Nmap, let's take a look at the port states that can be identified by Nmap. There are six port states that are recognized by Nmap as follows:

- **Open**: This means that there is an application accepting a TCP connection, UDP datagram, or SCTP association.
- **Closed**: This means that although the port is accessible, there is no application listening on the port.
- **Filtered**: This means that Nmap can't determine whether the port is open or not because there is a packet-filtering device blocking the probe to reach the target.
- **Unfiltered**: This means that the port is accessible, but Nmap cannot determine whether it is open or closed.
- **Open|Filtered**: This means that Nmap is unable to determine whether a port is open or filtered. This happens when a scan to open ports doesn't give a response. It can be achieved by setting the firewall to drop packets.
- **Closed|Filtered**: This means Nmap is unable to determine whether a port is closed or filtered.

After describing the port states, we will describe several options that are commonly used during penetration testing, and after that, we will use those options in our practice.

### Nmap target specification

Nmap will treat everything on the command line that isn't an option or option argument as target host specification. We suggest that you use the IP address specification instead of the hostname. By using the IP address, Nmap doesn't need to do DNS resolution first. This will speed up the port scanning process.

In the current version, Nmap supports the following IPv4 address specifications:

- A single host such as `192.168.0.1` .
- A whole network of adjacent hosts by using the CIDR notation such as `192.168.0.0/24` . This specification will include 256 IP addresses ranging from `192.168.0.0` to `192.168.0.255` .
- An octet range addressing such as `192.168.2-4,6.1` . This addressing will include four IP addresses: `192.168.2.1` ,

`192.168.3.1` , `192.168.4.1` , and `192.168.6.1` .

- Multiple host specifications such as `192.168.2.1 172.168.3-5,9.1`

For the IPv6 address, Nmap only supports the fully qualified IPv6 format and hostname such as `fe80::a8bb:ccff:fedd:eeff%eth0` .

Besides getting the target specification from the command line, Nmap also accepts target definition from a text file by using the `-iL <inputfilename>` option. This option is useful if we already have the IP addresses from another program.

Make sure that the entries in that file use the Nmap-supported target specification format. Each entry must be separated by spaces, tabs, or a new line.

The following code is a sample of that file:

```
192.168.1.1-254
192.168.2.1-254
```

Now let's scan a network of `192.168.56.0/24` . We want to see the packets sent by Nmap. To monitor the packets sent, we can use a packet capture utility such as `tcpdump` .

Open a console and type the following command:

```
tcpdump -nnX tcp and host 192.168.56.102
```

The `192.168.56.102` IP address belongs to our machine, which launches Nmap. You need to adjust it to your configuration.

Open another console on the same machine and type the following command:

```
nmap 192.168.56.0/24
```

In the `tcpdump` console, you will see the following packet:

```
22:42:12.107532 IP 192.168.56.102.49270 > 192.168.56.103.23: Flags [S],
seq 239440322, win 1024, options [mss 1460], length 0
  0x0000:  4500 002c eb7f 0000 3006 ad2e c0a8 3866  E..,....0.....8f
  0x0010:  c0a8 3867 c076 0017 0e45 91c2 0000 0000  ..8g.v...E......
  0x0020:  6002 0400 4173 0000 0204 05b4            `...As......
```

From the preceding packet information, we know that the attacking machine sent a packet with a SYN flag set from port `49270` to the target machine port `23` (Telnet). The SYN flag is set by default if Nmap is run by the privileged user, such as `root` in Kali Linux.

The following screenshot shows other packets sent by the attacking machine to other machines and ports on the target network:

```
22:31:01.766788 IP 192.168.56.102.39755 > 192.168.56.101.22939: Flags [S], seq 340921615,
win 1024, options [mss 1460], length 0
        0x0000:  4500 002c 1714 0000 3506 7c9c c0a8 3866  E..,....5.|...8f
        0x0010:  c0a8 3865 9b4b 599b 1452 0d0f 0000 0000  ..8e.KY..R......
        0x0020:  6002 0400 8bc2 0000 0204 05b4            `...........
22:31:01.769945 IP 192.168.56.102.39754 > 192.168.56.100.1216: Flags [S], seq 340987150, w
in 1024, options [mss 1460], length 0
        0x0000:  4500 002c 40b8 0000 3406 53f9 c0a8 3866  E..,@...4.S...8f
        0x0010:  c0a8 3864 9b4a 04c0 1453 0d0e 0000 0000  ..8d.J...S......
        0x0020:  6002 0400 e09f 0000 0204 05b4            `...........
22:31:01.777222 IP 192.168.56.102.39755 > 192.168.56.100.22939: Flags [S], seq 340921615,
win 1024, options [mss 1460], length 0
        0x0000:  4500 002c e034 0000 3b06 ad7c c0a8 3866  E..,.4..;..|..8f
        0x0010:  c0a8 3864 9b4b 599b 1452 0d0f 0000 0000  ..8d.KY..R......
        0x0020:  6002 0400 8bc3 0000 0204 05b4            `...........
22:31:01.786871 IP 192.168.56.102.39755 > 192.168.56.101.99: Flags [S], seq 340921615, win
 1024, options [mss 1460], length 0
        0x0000:  4500 002c c6c1 0000 3106 d0ee c0a8 3866  E..,....1.....8f
        0x0010:  c0a8 3865 9b4b 0063 1452 0d0f 0000 0000  ..8e.K.c.R......
        0x0020:  6002 0400 e4fa 0000 0204 05b4            `...........
```

If the remote machine responds, the response packet will look like the following code:

```
22:36:19.939881 IP 192.168.56.103.1720 > 192.168.56.102.47823: Flags [R.],
seq 0, ack 1053563675, win 0, length 0
  0x0000:  4500 0028 0000 4000 4006 48b2 c0a8 3867  E..(..@.@.H...8g
  0x0010:  c0a8 3866 06b8 bacf 0000 0000 3ecc 1b1b  ..8f........>...
  0x0020:  5014 0000 a243 0000 0000 0000 0000       P....C........
```

Note the flag sent—it is denoted by the character `R` which is reset. It means that port `1720` in the target machine is closed. We can verify this with the previous Nmap result.

However, if the port is open, you will see the following network traffic:

```
22:42:12.108741 IP 192.168.56.103.23 > 192.168.56.102.49270: Flags [S.],
seq 1611132106, ack 239440323, win 5840, options [mss 1460], length 0
  0x0000:  4500 002c 0000 4000 4006 48ae c0a8 3867  E..,..@.@.H...8g
  0x0010:  c0a8 3866 0017 c076 6007 ecca 0e45 91c3  ..8f...v`....E..
  0x0020:  6012 16d0 e1bf 0000 0204 05b4 0000
```

You can see that the packet in the preceding code is to acknowledge the sequence number from the previous packet displayed. This packet has an acknowledgement number of `239440323`, while the previous packet had a sequence number of `239440322`.

## Nmap TCP scan options

To be able to use most of the TCP scan options, Nmap needs a privileged user (a root-level account in the Unix world or an administrator-level account in the Windows world). This is used to send and receive raw packets. By default, Nmap will use a TCP SYN scan, but if Nmap doesn't have a privileged user, it will use the TCP connect scan. The various scans used by Nmap are as follows:

- **TCP connect scan** (`-sT`): This option will complete the three-way handshake with each target port. If the connection succeeds, the port is considered open. As a result of the need to do a three-way handshake for each port, this scan type is slow and it will most likely be logged by the target. This is the default scan option used if Nmap is run by a user who doesn't have any privileges.
- **SYN scan** (`-sS`): This option is also known as **half-open** or **SYN stealth**. With this option, Nmap sends a SYN packet and then waits for a response. A SYN/ACK response means that the port is listening, while the RST/ACK response means that the port is not listening. If there is no response or an ICMP unreachable error message response, the port is considered to be filtered. This scan type can be performed quickly and because the three-way handshake is never completed, it is unobtrusive and stealthy. This is the default scan option if you run Nmap as a privileged user.
- **TCP NULL scan** (`-sN`), **FIN scan** (`-sF`), and **XMAS scan** (`-sX`): The NULL scan doesn't set any control bits. The FIN scan only sets the FIN flag bit, and the XMAS scan sets the FIN, PSH, and URG flags. If an RST packet is received as a response, the port is considered closed, while no response means that the port is open/filtered.
- **TCP Maimon scan** (`-sM`): The TCP Maimon scan was discovered by Uriel Maimon. A scan of this type will send a packet with the FIN/ACK flag bit set. BSD-derived systems will drop the packet if the port is open, and it will respond with RST if the port is closed.
- **TCP ACK scan** (`-sA`): This scan type is used to determine whether a firewall is stateful or not and which ports are filtered. A network packet of this type only sets the ACK bit. If RST is returned, it means that the target is unfiltered.
- **TCP Window scan** (`-sW`): This scan type works by examining the **TCP Window** field of the RST packet's response. An open port will have a positive **TCP Window** value, while a closed port will have a zero window value.
- **TCP Idle scan** (`-sI`): Using this technique, no packets are sent to the target by your machine, instead the scan will bounce off to a zombie host you specify. An IDS will report the zombie as the attacker.

Nmap also supports you in creating your own custom TCP scan by giving you the option of **scanflags**. The argument to that option can be numerical, such as `9` for PSH and FIN, or symbolic names. Just put together any combination of URG, ACK, PSH, RST, SYN, FIN, ECE, CWR, ALL, and NONE in any order; for example, `--scanflags URGACKPSH` will set the flags URG, ACK, and PSH.

## Nmap UDP scan options

While the TCP scan has many types of scans, the UDP scan only has one type and that is the UDP scan (`-sU`). Even though the UDP scan is less reliable compared to the TCP scan, as a penetration tester you should not ignore this scan because there may be interesting services located on these UDP ports.

The biggest problem with the UDP scan is how to perform the scan quickly. A Linux kernel limits the sending of the `ICMP Port Unreachable` message to one message per second. Doing a UDP scanning of 65,536 ports to a machine will take more than 18 hours to complete.

To help mitigate this problem, there are several ways that can be used as follows:

- Running the UDP scan in parallel
- Scanning the most popular ports first
- Scanning behind the firewall
- Setting the `--host-timeout` option to skip slow hosts

These methods can help to decrease the time required for doing UDP port scans.

Let's see a scenario where we want to find which UDP ports are open on the target machine. To speed up the scanning process, we will only check for ports `53` (DNS) and `161` (SNMP). The following is the command used to do this:

```
nmap -sU 192.168.56.103 -p 53,161
```

The following is the result of this command:

```
Nmap scan report for 192.168.56.103
Host is up (0.0016s latency).
PORT    STATE  SERVICE
53/udp  open   domain
161/udp closed snmp
```

## Nmap port specification

In the default configuration, Nmap will only scan the 1000 most common ports for each protocol randomly. The `nmap-services` file contains a popularity score for the selection of top ports.

To change that configuration, Nmap provides several options as follows:

- `-p port_range` : Scan only the defined ports. To scan port `1` to `1024` , the command is `-p 1-1024` . To scan port `1` to `65535` , the command is `-p-`
- `-F` (fast): This will scan only 100 common ports
- `-r` (don't randomize port): This option will set sequential port scanning (from lowest to highest)
- `--top-ports <1 or greater>` : This option will only scan the *N* highest-ratio ports found in the nmap-service file

To scan for ports `22` and `25` using the TCP NULL scan method, you can use the following command:

```
nmap -sN -p 22,25 192.168.56.103
```

The following command lines are the result:

```
Nmap scan report for 192.168.56.103
Host is up (0.00096s latency).
PORT     STATE         SERVICE
22/tcp   open|filtered ssh
25/tcp   open|filtered smtp
80/tcp   open|filtered http
3306/tcp open|filtered mysql
MAC Address: 08:00:27:43:15:18 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 14.38 seconds
```

The following are the packet's dumped snippets:

```
23:23:38.581818 IP 192.168.56.102.61870 > 192.168.56.103.22: Flags [], win
1024, length 0
  0x0000:  4500 0028 06e4 0000 2f06 92ce c0a8 3866  E..(..../.....8f
  0x0010:  c0a8 3867 f1ae 0016 dd9e bf90 0000 0000  ..8g............
  0x0020:  5000 0400 2ad2 0000                      P...*...


23:23:38.581866 IP 192.168.56.102.61870 > 192.168.56.103.25: Flags [], win
1024, length 0
  0x0000:  4500 0028 1117 0000 3106 869b c0a8 3866  E..(....1.....8f
  0x0010:  c0a8 3867 f1ae 0019 dd9e bf90 0000 0000  ..8g............
  0x0020:  5000 0400 2acf 0000                      P...*...

23:23:39.683483 IP 192.168.56.102.61871 > 192.168.56.103.25: Flags [], win
1024, length 0
  0x0000:  4500 0028 afaf 0000 2706 f202 c0a8 3866  E..(....'.....8f
  0x0010:  c0a8 3867 f1af 0019 dd9f bf91 0000 0000  ..8g............
  0x0020:  5000 0400 2acc 0000                      P...*...

23:23:39.683731 IP 192.168.56.102.61871 > 192.168.56.103.22: Flags [], win
1024, length 0
  0x0000:  4500 0028 5488 0000 3506 3f2a c0a8 3866  E..(T...5.?*..8f
  0x0010:  c0a8 3867 f1af 0016 dd9f bf91 0000 0000  ..8g............
  0x0020:  5000 0400 2acf 0000                      P...*...
```

From the packets displayed in the preceding code, we can see that:

- In the first and second packet, the attacking machine checks whether port `22` on the target machine is open. After a period of time, it checks port `25` on the target machine.
- In the third and fourth packet, the attacking machine checks whether port `25` on the target machine is open. After a period of time, it checks port `22` on the target machine.
- After waiting for some time, as there is still no response from the target machine, Nmap concludes that those two ports are open or filtered.

## Nmap output options

The Nmap result can be saved to an external file. This option is useful if you want to process the Nmap result with other tools.

Even if you save the output to a file, Nmap still displays the result on the screen.

Nmap supports several output formats as follows:

- **Interactive output**: This is a default output format, and the result is sent to the standard output.
- **Normal output** ( `-oN` ): This format is similar to the interactive output, but it doesn't include the runtime information and warnings.
- **XML output** ( `-oX` ): This format can be converted to an HTML format, parsed by the Nmap graphical user interface, or imported to the database. We suggest you use this output format as much as you can.
- **Grepable output** ( `-oG` ): This format is deprecated, but it is still quite popular. Grepable output consists of comments (lines starting with a pound ( `#` )) and target lines. A target line includes a combination of six labeled fields separated by tabs and followed by a colon. The fields are `Host` , `Ports` , `Protocols` , `Ignored State` , `OS` , `Seq Index` , `IP ID Seq` , and `Status` . We sometimes use this output if we want to process the Nmap output using the UNIX commands such as `grep` and `awk` .

> **Note**

You can use the `-oA` option to save the Nmap result in three formats at once (normal, XML, and grepable).

To save a scan result to an XML file ( `myscan.xml` ), use the following command:

```
nmap 192.168.56.103 -oX myscan.xml
```

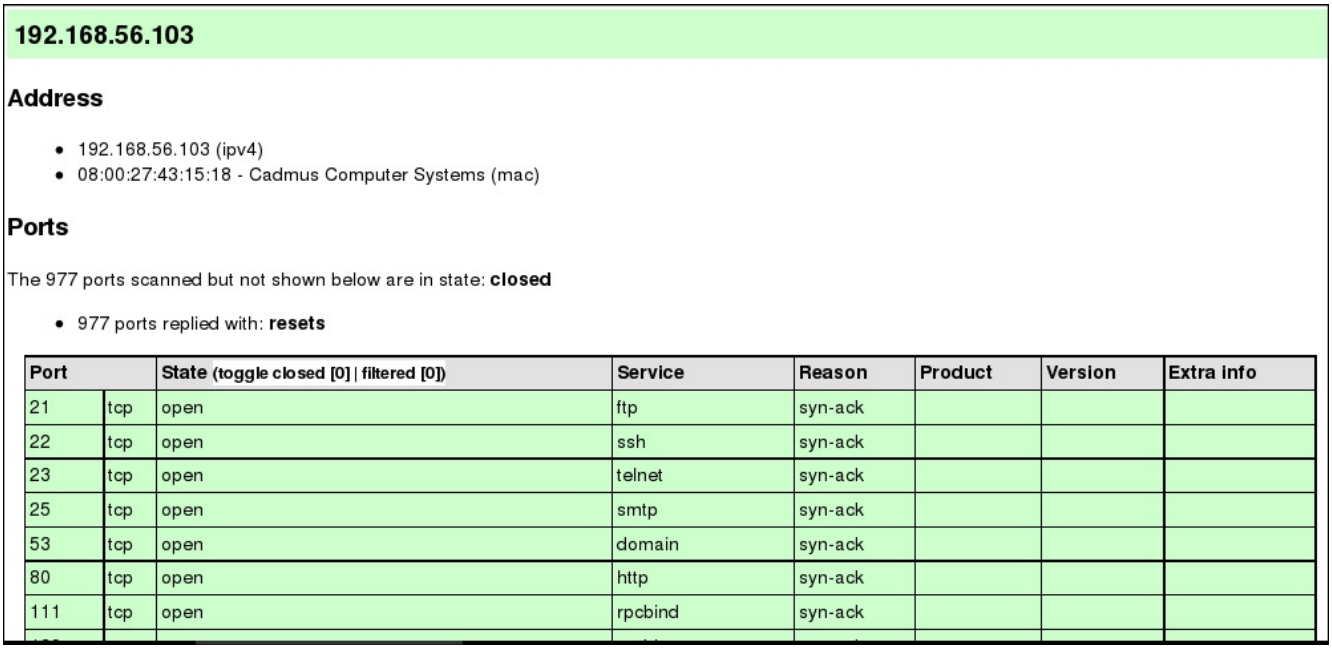
The following is a snippet of the XML file:

```
<?xml version="1.0"?>
<?xml-stylesheet href="file:///usr/bin/../share/nmap/nmap.xsl"
type="text/xsl"?>
<!-- Nmap 6.25 scan initiated Sat Jul 20 23:50:25 2013 as: nmap -oX
myscan.xml 192.168.56.103 -->
<nmaprun scanner="nmap" args="nmap -oX myscan.xml 192.168.56.103"
start="1374339025" startstr="Sat Jul 20 23:50:25 2013" version="6.25"
xmloutputversion="1.04">
<scaninfo type="syn" protocol="tcp" numservices="1000"
services="1,3-4,6-7,9,13,17,19-26,30,32-33,37,42-

<some port numbers are deleted for brevity>

50003,50006,50300,50389,50500,50636,50800,51103,51493,52673,52822,52848,528
69,54045,54328,55055-55056,55555,55600,56737-56738,57294,57797,58080,60020,
60443,61532,61900,62078,63331,64623,64680,65000,65129,65389"/>
<verbose level="0"/>
<debugging level="0"/>
<host starttime="1374339025" endtime="1374339038"><status state="up"
reason="arp-response" reason_ttl="0"/>
<address addr="192.168.56.103" addrtype="ipv4"/>
<address addr="08:00:27:43:15:18" addrtype="mac" vendor="Cadmus Computer
Systems"/>
```

It is easier to read the HTML file instead of the XML file, so we'll convert the XML format to HTML. You can use the `xsltproc` program to do the conversion. The following command is used to convert the XML file to an HTML file:

```
xsltproc myscan.xml -o myscan.html
```

The following is the HTML report as displayed by the Iceweasel web browser included in Kali Linux:



192.168.56.103

Address

- 192.168.56.103 (ipv4)
- 08:00:27:43:15:18 - Cadmus Computer Systems (mac)

Ports

The 977 ports scanned but not shown below are in state: **closed**

- 977 ports replied with: **resets**

| Port | | State (toggle closed [0] \| filtered [0]) | Service | Reason | Product | Version | Extra info |
|---|---|---|---|---|---|---|---|
| 21 | tcp | open | ftp | syn-ack | | | |
| 22 | tcp | open | ssh | syn-ack | | | |
| 23 | tcp | open | telnet | syn-ack | | | |
| 25 | tcp | open | smtp | syn-ack | | | |
| 53 | tcp | open | domain | syn-ack | | | |
| 80 | tcp | open | http | syn-ack | | | |
| 111 | tcp | open | rpcbind | syn-ack | | | |

If you want to process the Nmap XML output to your liking, there are several programming language generic XML libraries that you can use for this purpose. Also, there are several libraries specifically developed to work with an Nmap output:

- **Perl**: Nmap-Parser (http://search.cpan.org/dist/Nmap-Parser/)
- **Python**: python-nmap (http://xael.org/norman/python/python-nmap/)
- **Ruby**: Ruby Nmap (http://rubynmap.sourceforge.net/)
- **PowerShell**: PowerShell script to parse nmap XML output (http://www.sans.org/windows-security/2009/06/11/powershell-script-to-parse-nmap-xml-output)

### Nmap timing options

Nmap comes with six timing modes that you can set with options ( `-T` ):

- `paranoid (0)` : In this timing mode, a packet is sent every 5 minutes. The packets are sent in serial. This mode is useful to avoid IDS detection.
- `sneaky (1)` : This mode sends a packet every 15 seconds, and there are no packets sent in parallel.
- `polite (2)` : This mode sends a packet every 0.4 seconds and there is no parallel transmission.
- `normal (3)` : This mode sends multiple packets to multiple targets simultaneously. This is the default timing mode used by Nmap. It balances between time and network load.
- `aggressive (4)` : Nmap will scan a given host only for 5 minutes before moving on to the next target. Nmap will not wait more than 1.25 seconds for a response.
- `insane (5)` : In this mode, Nmap will scan a given host for only 75 seconds before moving on to the the next target. Nmap will not wait for more than 0.3 seconds for a response.

In our experience, the default timing mode usually works great unless you want to have a more stealthy or faster scan.

### Nmap useful options

In this section, we will discuss several Nmap options that are quite useful when doing a penetration testing job.

## Service version detection

Nmap can also be asked to check the service version when doing port scanning. This information is very useful when you do the vulnerability identification process later on.

To use this feature, give Nmap the `-sV` option.

The following is an example for this feature's usage. We want to find the software version used on port `22` :

```
nmap -sV 192.168.56.103 -p 22
```

The following is the result of this command:

```
Nmap scan report for 192.168.56.103
Host is up (0.0016s latency).
PORT   STATE SERVICE VERSION
22/tcp open  ssh     OpenSSH 4.7p1 Debian 8ubuntu1 (protocol 2.0)
```

From the preceding information, we know that on port `22`, there is an SSH service using the `OpenSSH` software Version `4.7p1` and the SSH protocol is `2.0`.

## Operating system detection

Nmap can also be asked to check the operating system used on the target machine. This information is very useful when you do the vulnerability identification process later on.

To use this feature, give Nmap the `-O` option.

The following is an example for this feature's usage. We want to find the operating system used on the target machine:

```
nmap -O 192.168.56.103
```

The following command lines are the result of this command:

```
Host is up (0.0037s latency).
Not shown: 977 closed ports
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
111/tcp  open  rpcbind
139/tcp  open  netbios-ssn
445/tcp  open  microsoft-ds
512/tcp  open  exec
513/tcp  open  login
514/tcp  open  shell
1099/tcp open  rmiregistry
1524/tcp open  ingreslock
2049/tcp open  nfs
2121/tcp open  ccproxy-ftp
3306/tcp open  mysql
5432/tcp open  postgresql
5900/tcp open  vnc
6000/tcp open  X11
6667/tcp open  irc
8009/tcp open  ajp13
8180/tcp open  unknown
MAC Address: 08:00:27:43:15:18 (Cadmus Computer Systems)
Device type: general purpose
Running: Linux 2.6.X
OS CPE: cpe:/o:linux:linux_kernel:2.6
```

```
OS details: Linux 2.6.9 - 2.6.33
Network Distance: 1 hop
```

Based on the preceding information, we can see that the remote system is a Linux operating system using Linux kernel Version `2.6.9 - 2.6.33` . If there are vulnerabilities on those Linux kernels, we can exploit them.

## Disabling host discovery

If a host is blocking a ping request, Nmap may detect that the host is not active; so, Nmap may not perform heavy probing, such as port scanning, version detection, and operating system detection. To overcome this, Nmap has a feature for disabling host discovery. With this option, Nmap will assume that the target machine is available and will perform heavy probing against that machine.

This option is activated by using the `-Pn` option.

## Aggressive scan

If you use the `-A` option, it will enable the following probe:

- Service version detection ( `-sV` )
- Operating system detection ( `-O` )
- Script scanning ( `-sC` )
- Traceroute ( `--traceroute` )

It may take some time for this scan type to finish. The following command can be used for aggressive scanning:

```
nmap -A 192.168.56.103
```

The following is the result of this command:

```
PORT     STATE SERVICE     VERSION
21/tcp   open  ftp         vsftpd 2.3.4
|_ftp-anon: Anonymous FTP login allowed (FTP code 230)
22/tcp   open  ssh         OpenSSH 4.7p1 Debian 8ubuntu1 (protocol 2.0)
| ssh-hostkey: 1024 60:0f:cf:e1:c0:5f:6a:74:d6:90:24:fa:c4:d5:6c:cd (DSA)
|_2048 56:56:24:0f:21:1d:de:a7:2b:ae:61:b1:24:3d:e8:f3 (RSA)
80/tcp   open  http        Apache httpd 2.2.8 ((Ubuntu) DAV/2)
|_http-methods: No Allow or Public header in OPTIONS response (status code
200)
|_http-title: Metasploitable2 - Linux
...
Host script results:
|_nbstat: NetBIOS name: METASPLOITABLE, NetBIOS user: <unknown>, NetBIOS
MAC: <unknown>
| smb-os-discovery:
|   OS: Unix (Samba 3.0.20-Debian)
|   NetBIOS computer name:
|   Workgroup: WORKGROUP
|_  System time: 2013-07-21T09:20:22-04:00

TRACEROUTE
HOP RTT     ADDRESS
1   1.66 ms 192.168.56.103
```

### Nmap for scanning the IPv6 target

In the previous section, we discussed that you can specify an IPv6 target in Nmap. In this section, we will discuss this in depth.

For this scenario, the following is the IPv6 address of each machine involved:

- Target machine: `fe80::a00:27ff:fe43:1518`

To scan an IPv6 target, just use the `-6` option and define the IPv6 target address. Currently, you can only specify individual IPv6 addresses. The following is a sample command to do port scanning to the IPv6 address:

```
nmap -6 fe80::a00:27ff:fe43:1518
```

The following is the result of this command:

```
Nmap scan report for fe80::a00:27ff:fe43:1518
Host is up (0.0014s latency).
Not shown: 996 closed ports
PORT     STATE SERVICE
22/tcp   open  ssh
53/tcp   open  domain
2121/tcp open  ccproxy-ftp
5432/tcp open  postgresql
MAC Address: 08:00:27:43:15:18 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 0.34 seconds
```

We can see that in IPv6 testing, the number of ports open are lesser compared to the IPv4 testing. This may be caused by the services on the remote machine that do not support IPv6 yet.

## The Nmap scripting engine

Although Nmap itself has already become a powerful network exploration tool, with the additional scripting engine capabilities, Nmap becomes a much more powerful tool. With the **Nmap Scripting Engine** (**NSE**), users can automate various networking tasks, such as checking for new security vulnerabilities in applications, detecting application versions, or other capabilities not available in Nmap. Nmap has already included various NSE scripts in its package, but users can also write their own scripts to suit their needs.

The NSE scripts utilize the Lua programming language (http://www.lua.org) embedded in Nmap, and currently, the NSE scripts are categorized into the following:

- `auth` : The scripts in this category are used to find the authentication set on the target system such as using the brute force technique.
- `default` : These scripts are run by using the `-sC` or `-A` options. A script will be grouped in the default category if it satisfies the following requirements:
    - It must be fast
    - It needs to produce valuable and actionable information
    - Its output needs to be verbose and concise
    - It must be reliable
    - It should not be intrusive to the target system
    - It should divulge information to the third party
- `discovery` : These scripts are used to find the network.
- `doS` : The scripts in this category may cause **Denial of Service** (**DoS**) on the target system. Please use them carefully.
- `exploit` : These scripts will exploit security vulnerabilities on the target system. The penetration tester needs to have permission to run these scripts on the target system.
- `external` : These scripts may divulge information to third parties.
- `fuzzer` : These scripts are used to do fuzzing to the target system.

- `intrusive` : These scripts may crash the target system or use all of the target system resources.
- `malware` : These scripts will check for the existence of malware or backdoors on the target system.
- `safe` : These scripts are not supposed to cause a service crash, **Denial of Service** (**DoS**), or exploit target system.
- `version` : These scripts are used with the version detection option ( `-sV` ) to carry out advanced detection for the service on the target system.
- `vuln` : These scripts are used to check for security vulnerabilities on the target system.

In Kali Linux, these Nmap scripts are located in the `/usr/share/nmap/scripts` directories, and currently, Nmap Version 6.25 included with Kali Linux contains more than 430 scripts.

There are several command-line arguments that can be used to call NSE as follows:

- `-sC or --script=default` : This performs scan using default scripts.
- `--script <filename> | <category> | <directories>` : This performs scan using the script defined in filename, categories, or directories.
- `--script-args <args>` : This provides script argument. An example of these arguments are username or password if you use the auth category.

To do port scanning to the host `192.168.56.103` and utilize the default script categories, we can give the following command:

```
nmap -sC 192.168.56.103
```

The following is the result snippet:

```
Nmap scan report for 192.168.56.103
Not shown: 977 closed ports
PORT     STATE SERVICE
21/tcp   open  ftp
|_ftp-anon: Anonymous FTP login allowed (FTP code 230)
22/tcp   open  ssh
| ssh-hostkey: 1024 60:0f:cf:e1:c0:5f:6a:74:d6:90:24:fa:c4:d5:6c:cd (DSA)
|_2048 56:56:24:0f:21:1d:de:a7:2b:ae:61:b1:24:3d:e8:f3 (RSA)
25/tcp   open  smtp
|_smtp-commands: metasploitable.localdomain, PIPELINING, SIZE 10240000,
VRFY, ETRN, STARTTLS, ENHANCEDSTATUSCODES, 8BITMIME, DSN,
| ssl-cert: Subject: commonName=ubuntu804-
base.localdomain/organizationName=OCOSA/stateOrProvinceName=There is no
such thing outside US/countryName=XX
| Not valid before: 2010-03-17T14:07:45+00:00
|_Not valid after:  2010-04-16T14:07:45+00:00
|_ssl-date: 2013-07-21T08:40:20+00:00; -4s from local time.
53/tcp   open  domain
| dns-nsid:
|_  bind.version: 9.4.2
111/tcp  open  rpcbind
| rpcinfo:
|   program version   port/proto  service
|   100000  2            111/tcp  rpcbind
|   100000  2            111/udp  rpcbind
|   100003  2,3,4       2049/tcp  nfs
```

```
|   100003  2,3,4       2049/udp  nfs
|   100005  1,2,3      35075/udp  mountd
|   100005  1,2,3      59685/tcp  mountd
|   100021  1,3,4      37466/tcp  nlockmgr
|   100021  1,3,4      60726/udp  nlockmgr
|   100024  1          36880/udp  status
|_  100024  1          38557/tcp  status
3306/tcp open  mysql
| mysql-info: Protocol: 10
| Version: 5.0.51a-3ubuntu5
| Thread ID: 7
| Some Capabilities: Connect with DB, Compress, SSL, Transactions, Secure
Connection
| Status: Autocommit
|_Salt: !`BijWW-x7HCVi,<*[l-
5900/tcp open  vnc
| vnc-info:
|   Protocol version: 3.3
|   Security types:
|_    Unknown security type (33554432)
6667/tcp open  irc
| irc-info: Server: irc.Metasploitable.LAN
| Version: Unreal3.2.8.1. irc.Metasploitable.LAN
| Lservers/Lusers: 0/1
| Uptime: 0 days, 0:15:26
| Source host: 50388A6E.97684684.FFFA6D49.IP
|_Source ident: OK nmap
8180/tcp open  unknown
|_http-favicon: Apache Tomcat
|_http-methods: No Allow or Public header in OPTIONS response (status code
200)
|_http-title: Apache Tomcat/5.5
MAC Address: 08:00:27:43:15:18 (Cadmus Computer Systems)

Host script results:
|_nbstat: NetBIOS name: METASPLOITABLE, NetBIOS user: <unknown>, NetBIOS
MAC: <unknown>
| smb-os-discovery:
|   OS: Unix (Samba 3.0.20-Debian)
|   NetBIOS computer name:
|   Workgroup: WORKGROUP
|_  System time: 2013-07-21T04:40:20-04:00

Nmap done: 1 IP address (1 host up) scanned in 46.87 seconds
```

From the preceding information, you can see that now the Nmap result is more thorough. This is because it utilizes the NSE default scripts.

However, if you only want specific information on the target system, you can use the script by itself. If we want to collect information about the HTTP server, we can use several HTTP scripts in NSE, such as `http-enum`, `http-headers`, `http-methods`, and `http-php-version` using the following command:

```
nmap --script http-enum,http-headers,http-methods,http-php-version -p 80
```

```
192.168.56.103
```

The following is the result of this command:

```
Nmap scan report for 192.168.56.103
Host is up (0.0010s latency).
PORT   STATE SERVICE
80/tcp open  http
| http-enum:
|   /tikiwiki/: Tikiwiki
|   /test/: Test page
|   /phpinfo.php: Possible information file
|   /phpMyAdmin/: phpMyAdmin
|   /doc/: Potentially interesting directory w/ listing on 'apache/2.2.8
(ubuntu) dav/2'
|   /icons/: Potentially interesting folder w/ directory listing
|_  /index/: Potentially interesting folder
| http-headers:
|   Date: Sun, 21 Jul 2013 08:45:07 GMT
|   Server: Apache/2.2.8 (Ubuntu) DAV/2
|   X-Powered-By: PHP/5.2.4-2ubuntu5.10
|   Connection: close
|   Content-Type: text/html
|
|_  (Request type: HEAD)
|_http-methods: No Allow or Public header in OPTIONS response (status code
200)
| http-php-version: Versions from logo query (less accurate): 5.1.3 -
5.1.6, 5.2.0 - 5.2.17
| Versions from credits query (more accurate): 5.2.3 - 5.2.5
|_Version from header x-powered-by: PHP/5.2.4-2ubuntu5.10
MAC Address: 08:00:27:43:15:18 (Cadmus Computer Systems)

Nmap done: 1 IP address (1 host up) scanned in 24.47 seconds
```

By utilizing four NSE scripts related to HTTP, we gain more information regarding the target system's web server:

- There are several interesting directories to check: `Tikiwiki` , `test` , and `phpMyAdmin`
- We have an interesting file: `phpinfo.php`
- We know the server is using PHP Version `5.2.3 -5.2.5`

After discussing Nmap, let's discuss another port scanner tool.

There is a useful NSE script called Nmap NSE Vulscan (http://www.computec.ch/mruef/software/nmap_nse_vulscan-1.0.tar.gz) that can help you to map the version information you obtain from a target machine with the vulnerability database, such as CVE (http://cve.mitre.org/), OSVDB (http://www.osvdb.org/), scip VulDB (http://www.scip.ch/?vuldb), SecurityTracker (http://securitytracker.com/), and SecurityFocus (http://www.securityfocus.com/).

The following screenshot shows the sample result of the CVE script:

```
PORT      STATE    SERVICE         REASON      VERSION
22/tcp    open     ssh             syn-ack     OpenSSH 5.8p1 Debian 1ubuntu3
(Ubuntu Linux; protocol 2.0)
| vulscan: scipvuldb - http://www.scip.ch/en/?vuldb (12 findings):
| [7775] Red Hat Linux/Fedora 6 OpenSSH glibc error() privilege escalation
| [4584] OpenSSH up to 5.7 auth-options.c information disclosure
| [4282] OpenSSH 5.x Legacy Certificate Handler buffer overflow
| [2667] OpenBSD OpenSSH up to 4.5 Separation Monitor Designfehler
| [2578] OpenBSD OpenSSH up to 4.4 Signal Handler race condition
| [1999] OpenBSD OpenSSH up to 4.2p1 scp system() Designfehler
| [1724] OpenBSD OpenSSH up to 4.2p1 GSSAPIDelegateCredentials Designfehler
| [1723] OpenBSD OpenSSH up to 4.2p1 Dynamic Port Forwarding Designfehler
| [1083] Nokia IPSO 3.x OpenSSH Designfehler
| [299] OpenBSD OpenSSH 3.7p1/3.7.1p1 PAM Handler Konfigurationsfehler
| [287] OpenBSD OpenSSH up to 3.7.1 buffer_append_space() buffer overflow
| [100] OpenSSH Client IP Restrictions weak authentication
|
| cve - http://cve.mitre.org (69 findings):
| [CVE-2012-6066] freeSSHd.exe in freeSSHd through 1.2.6 allows remote
attackers to bypass authentication via a crafted session, as demonstrated
by an OpenSSH client with modified versions of ssh.c and sshconnect2.c.
| [CVE-2012-5975] The SSH USERAUTH CHANGE REQUEST feature in SSH Tectia
Server 6.0.4 through 6.0.20, 6.1.0 through 6.1.12, 6.2.0 through 6.2.5, and
6.3.0 through 6.3.2 on UNIX and Linux, when old-style password
authentication is enabled, allows remote attackers to bypass authentication
via a crafted session involving entry of blank passwords, as demonstrated
by a root login session from a modified OpenSSH client with an added
input_userauth_passwd_changereq call in sshconnect2.c.
| [CVE-2012-5536] A certain Red Hat build of the pam_ssh_agent_auth module
on Red Hat Enterprise Linux (RHEL) 6 and Fedora Rawhide calls the glibc
error function instead of the error function in the OpenSSH codebase, which
allows local users to obtain sensitive information from process memory or
possibly gain privileges via crafted use of an application that relies on
this module, as demonstrated by su and sudo.
| [CVE-2012-0814] The auth_parse_options function in auth-options.c in sshd
in OpenSSH before 5.7 provides debug messages containing authorized_keys
command options, which allows remote authenticated users to obtain
potentially sensitive information by reading these messages, as
```

## Nmap options for Firewall/IDS evasion

During penetration testing, you may encounter a system that is using firewall and IDS to protect the system. If you just use the default settings, your action may get detected or you may not get the correct result from Nmap. The following options may be used to help you evade the firewall/IDS:

- `-f` (fragment packets): This purpose of this option is to make it harder to detect the packets. By specifying this option once, Nmap will split the packet into 8 bytes or less after the IP header.
- `--mtu` : With this option, you can specify your own packet size fragmentation. The **Maximum Transmission Unit** (**MTU**) must be a multiple of eight or Nmap will give an error and exit.
- `-D` (decoy): By using this option, Nmap will send some of the probes from the spoofed IP addresses specified by the user. The idea is to mask the true IP address of the user in the logfiles. The user IP address is still in the logs. You can use `RND` to generate a random IP address or `RND:number` to generate the `<number>` IP address. The hosts you use for decoys should be up, or you will flood the target. Also remember that by using many decoys you can cause network congestion, so you may want to avoid that especially if you are scanning your client network.
- `--source-port <portnumber>` or `-g` (spoof source port): This option will be useful if the firewall is set up to allow all incoming traffic that comes from a specific port.
- `--data-length` : This option is used to change the default data length sent by Nmap in order to avoid being detected as Nmap scans.
- `--max-parallelism` : This option is usually set to one in order to instruct Nmap to send no more than one probe at a time to the target host.

- `--scan-delay <time>` : This option can be used to evade IDS/IPS that uses a threshold to detect port scanning activity.

You may also experiment with other Nmap options for evasion as explained in the Nmap manual (http://nmap.org/book/man-bypass-firewalls-ids.html).

## Unicornscan

`Unicornscan` is an information gathering and correlation engine tool. It is useful for introducing stimulus and measuring the response from a TCP/IP device. `Unicornscan` has the following features:

- Asynchronous stateless TCP port scanning
- Asynchronous stateless TCP banner grabbing
- Asynchronous UDP port scanning
- Active and passive remote OS and application identification

Unfortunately, `Unicornscan` is not included in the default installation of Kali Linux; you need to install it from the repository by giving the following command:

```
apt-get install unicornscan
```

To start `Unicornscan`, use the console to execute the following command:

```
# unicornscan -h
```

This will display all the options with their descriptions.

The main difference between `Unicornscan` and other similar tools is that it is a very fast and scalable port scanner. From our experience, the scanning of UDP ports will take a long time to finish, especially if you want to test all the ports for a network. `Unicornscan` can help you with this problem.

In `Unicornscan`, you can define how many packets you want to send per second. The higher the **packets per second** (**PPS**) value, the faster the scan process; but this may cause an overload on the network, so be careful when using this capability. The default PPS is `300`.

Let's scan the target using the default options in `Unicornscan`. The following is the command and the result.

To carry out a UDP scan ( `-m U` ) for the ports `1-65535` on machine `192.168.56.103`, display the result immediately, and to be verbose ( `-Iv` ), the command is as follows:

```
# unicornscan -m U -Iv 192.168.56.103:1-65535
```

The following is the reply from `Unicornscan` :

```
adding 192.168.56.103/32 mode `UDPscan' ports `1-65535' pps 300
using interface(s) eth0
scaning 1.00e+00 total hosts with 6.55e+04 total packets, should take a
little longer than 3 Minutes, 45 Seconds
```

From the preceding information, we know that by using the default PPS, this scan will take more than 3 minutes. To speed up the scanning process, let's change the packet sending rate to 10,000 ( `-r 10000` ):

```
unicornscan -m U -Iv 192.168.56.103/24:1-65535 -r 10000
```

The following is the response from `Unicornscan` :

```
adding 192.168.56.103/32 mode `UDPscan' ports `1-65535' pps 10000
using interface(s) eth0
scaning 1.00e+00 total hosts with 6.55e+04 total packets, should take a
little longer than 13 Seconds
```

The scanning is much faster after we change the packet sending rate. Note that you may only use this rate in a fast network, if not you don't overwhelm the network with your UDP packets.

The following is the scan result:

```
UDP open 192.168.56.103:137  ttl 64
UDP open 192.168.56.103:53  ttl 64
UDP open 192.168.56.103:41250  ttl 64
UDP open 192.168.56.103:2049  ttl 64
UDP open 192.168.56.103:111  ttl 64
sender statistics 7586.6 pps with 65544 packets sent total
listener statistics 14 packets recieved 0 packets dropped and 0 interface
drops
UDP open            domain[   53]    from 192.168.56.103  ttl 64
UDP open             sunrpc[  111]    from 192.168.56.103  ttl 64
UDP open         netbios-ns[  137]    from 192.168.56.103  ttl 64
UDP open              shilp[ 2049]    from 192.168.56.103  ttl 64
UDP open            unknown[41250]    from 192.168.56.103  ttl 64
```

## Zenmap

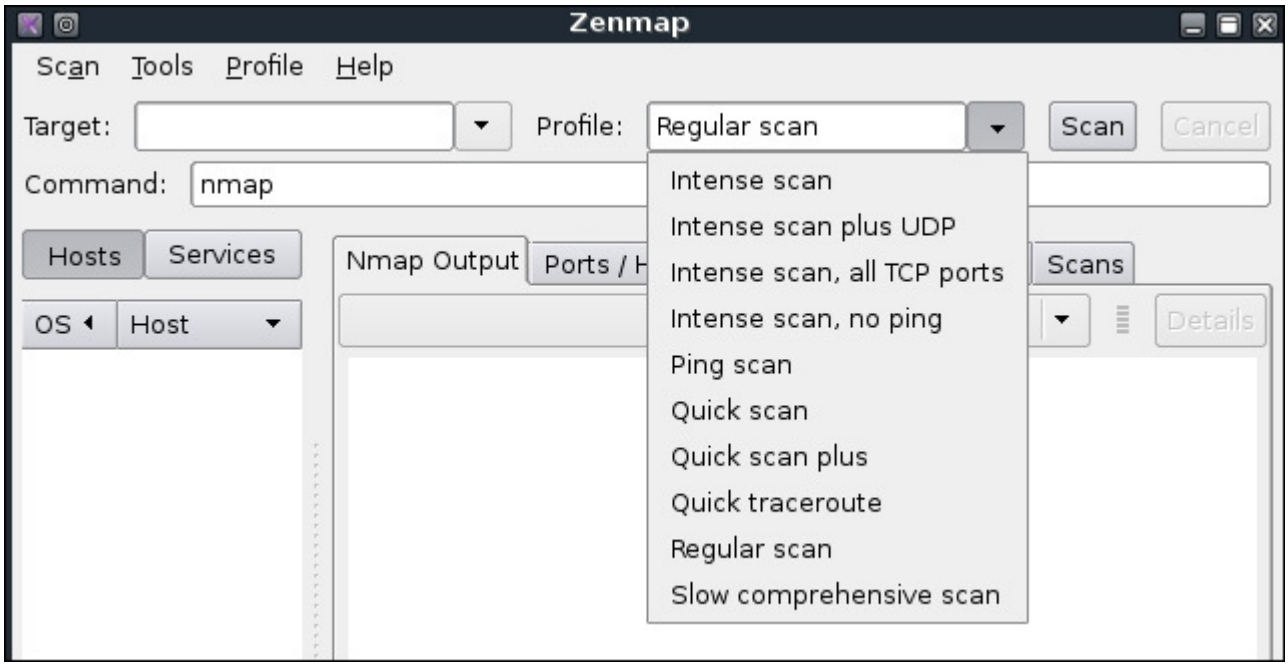
Zenmap is the graphical interface of Nmap. The advantages of Zenmap compared to Nmap are as follows:

- Zenmap is interactive; it arranges the scan results in a convenient way. It can even draw a topological map of the discovered network.
- Zenmap can do a comparison between two scans.
- Zenmap keeps a track of the scan results.
- To run the same scan configuration more than once, the penetration tester can use a Zenmap profile.
- Zenmap will always display the command that is run, so the penetration tester can verify that command.

To start Zenmap, navigate to **Kali Linux** | **Information Gathering** | **Network Scanners** | **Zenmap**, or use the console to execute the following command:

```
#zenmap
```

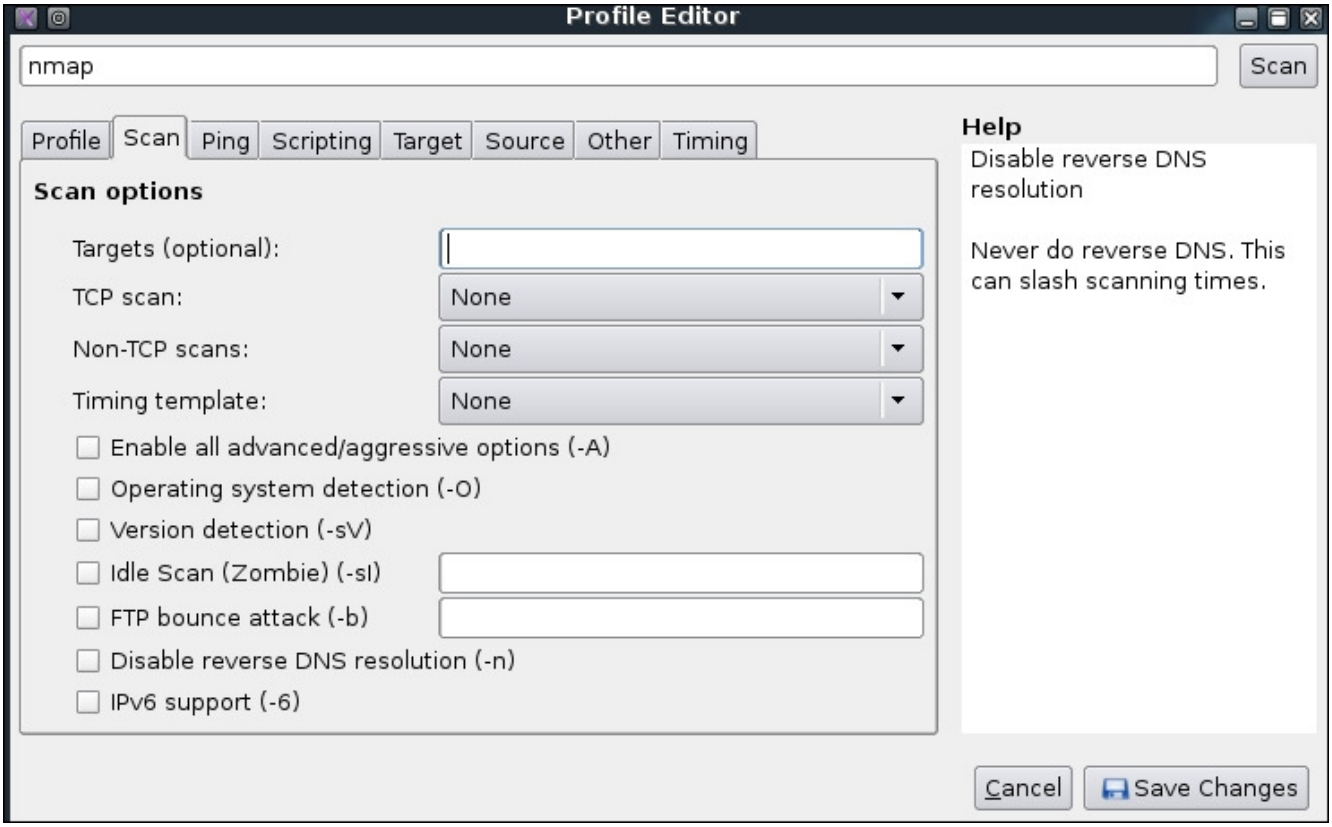
This will display the main Zenmap window. Zenmap comes with 10 profiles that can be chosen. To find which command options are used on each profile, just click on **Profile** and the command options will be displayed in the **Command:** box as shown in the following screenshot:



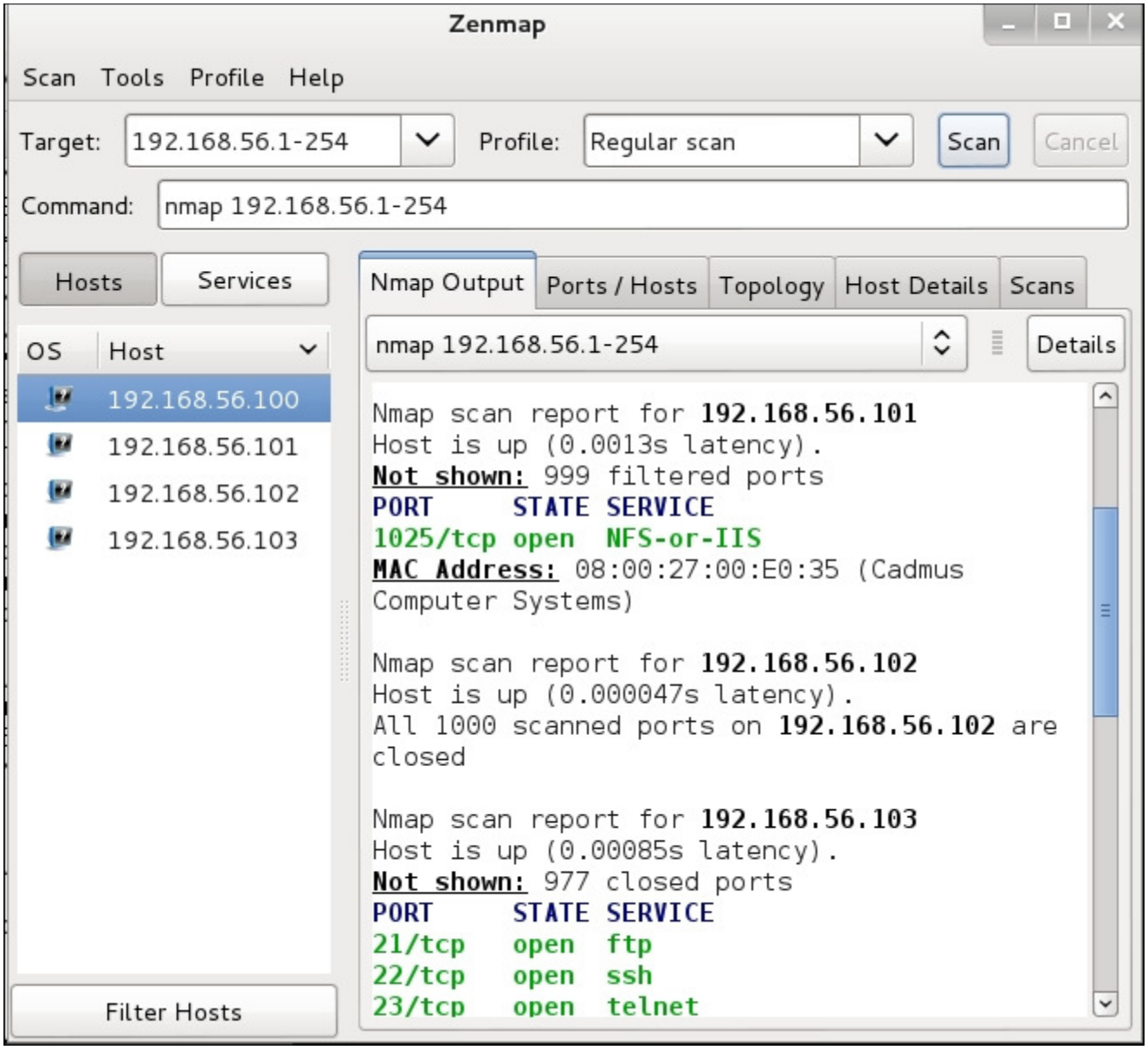

If the provided profiles are not suitable for our needs, we can create our own profile by creating a new profile or editing the existing ones. These tasks can be found under the **Profile** menu.

To create a new profile, select the menu **New Profile** or **Command** or you can press the keys *Ctrl* + *P*. To edit an existing profile, select the **Edit Selected Profile** menu or press *Ctrl* + *E*.

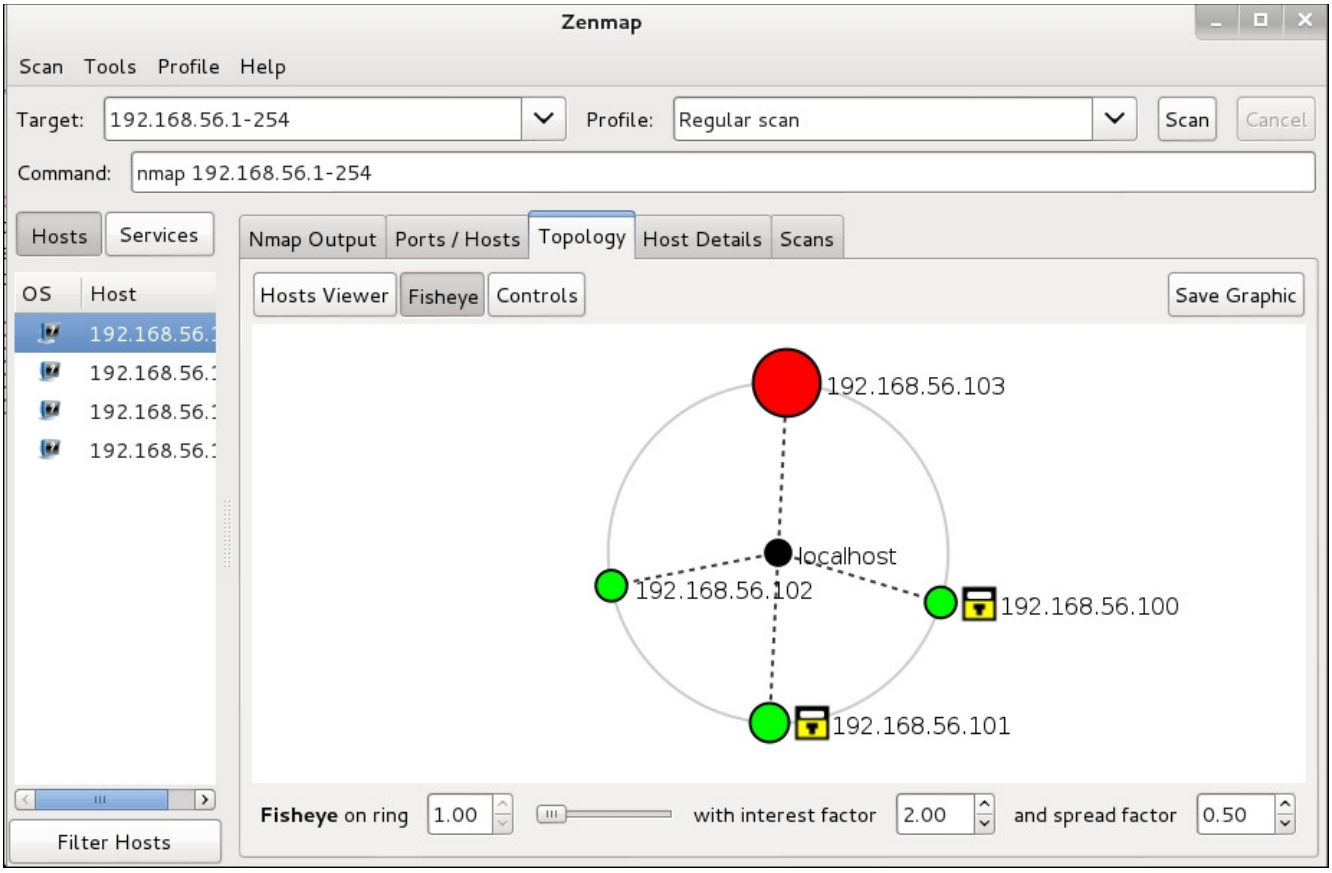
Select each tab (**Profile**, **Scan**, **Ping**, **Scripting**, **Target**, **Source**, **Other**, and **Timing**) and configure it according to your needs. If you have finished configuring the profile, save the profile by clicking on the **Save Changes** button as shown in the following screenshot:



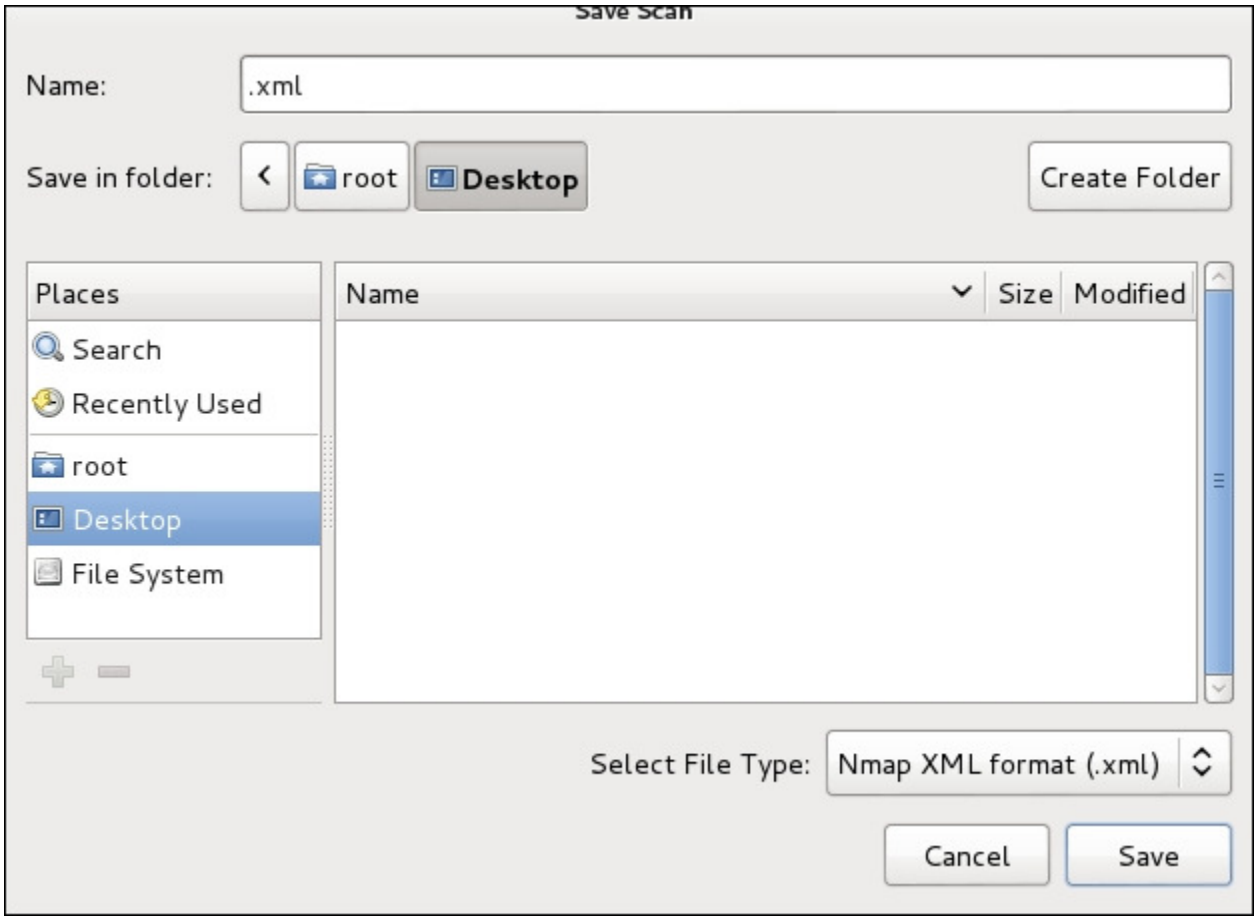

Let's scan the host **192.168.56.1-254** using the **Regular scan** profile as shown in the following screenshot:




If you want to see the network topology, click on the **Topology** tab and you will be able to see the details as shown in the following screenshot:



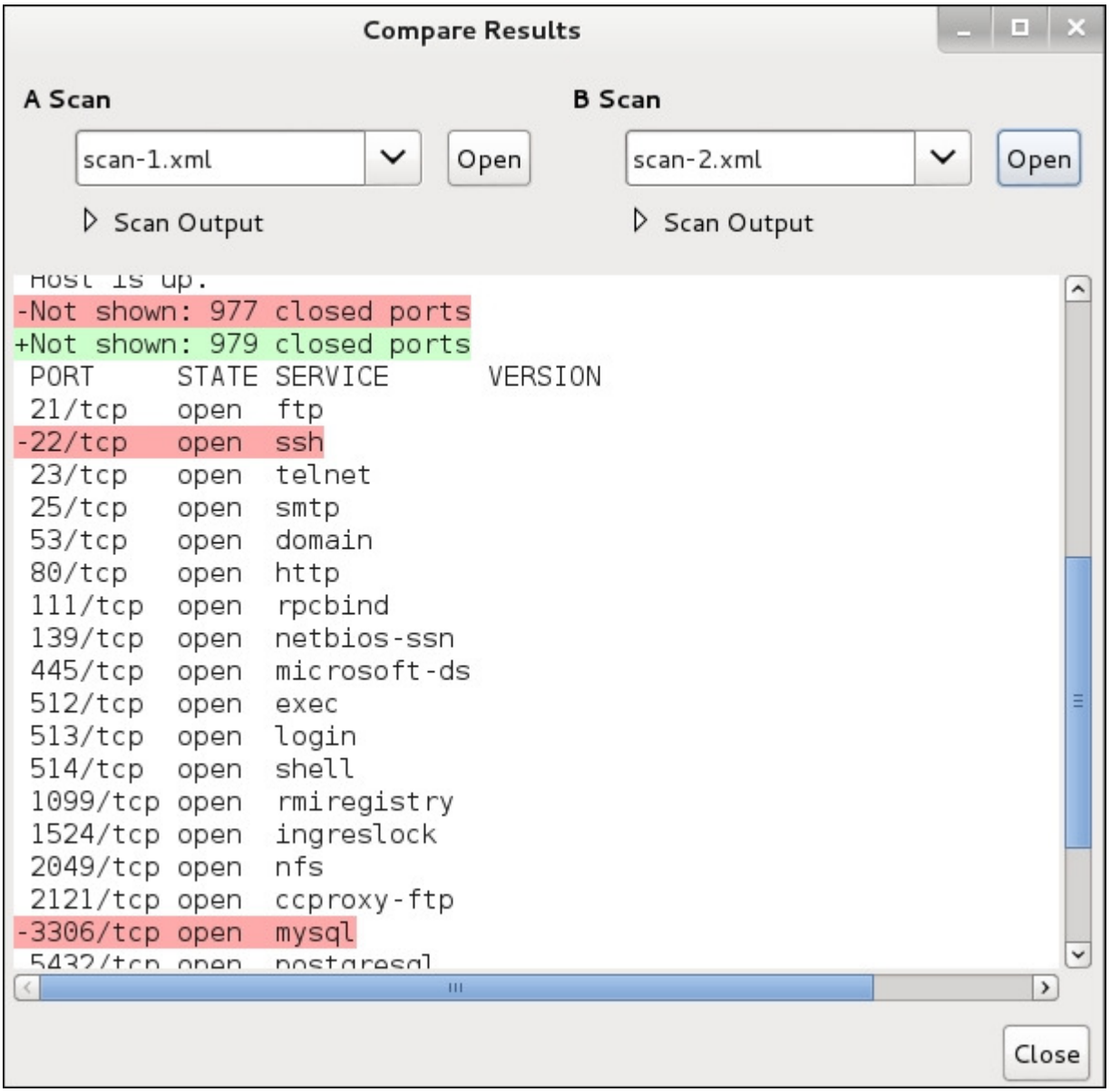

To save the Zenmap result, go to the **Scan** menu and choose **Save Scan**. Zenmap will then ask you where you want to save the result. The default format is XML as shown in the following screenshot:




To find the differences between the scans, perform the first scan and then save the result. Then, make changes to the scan targets. Next, do the second scan

and save the result. Later, compare the scan results by going to the **Tools** menu and select **Compare Results**.

For **A Scan**, you can select the XML file of the first scan result by clicking on the **Open** button, while for **B Scan**, you can select the XML file of the second scan result as shown in the following screenshot:




The **-** character denotes that this line is removed in the **B Scan** result, while the **+** character means that this line is added in the **B Scan** result.

We noticed that the SSH and MySQL ports are not open anymore in the second scan and the number of closed ports has increased from **977** to **979** to adjust with the number of closing ports during the second port scanning process.

## Amap

`Amap` is a tool that can be used to check the application running on a specific port. `Amap` works by sending a trigger packet to the port and comparing the response with its database. It will print the application information if the application's response matches the database information.

In Kali Linux, the `Amap` trigger file is located in `/etc/apmap/appdefs.trig`, whereas the response file is available in `/etc/amap/appdefs.resp`.

To start `Amap`, go to the console and execute the following command:

```
amap
```

This will display a simple usage instruction and example on your screen.

For our exercise, we will analyze the application that runs on the target system's port `22`. We will use the `-b` and `-q` options to get banner information without reporting the closed or unidentified ports as given in the following command:

```
amap -bq 192.168.56.103 22
```

The following is the result of this command:

```
Protocol on 192.168.56.103:22/tcp matches ssh - banner: SSH-2.0-
OpenSSH_4.7p1 Debian-8ubuntu1\n
Protocol on 192.168.56.103:22/tcp matches ssh-openssh - banner: SSH-2.0-
OpenSSH_4.7p1 Debian-8ubuntu1\n
```

Using `Amap`, we can identify the application used on a specific port and the version information too.

To identify more than one port, define the ports on the command line separated by a space as follows:

```
amap -bq 192.168.56.103 80 3306
```

The following is the result of this command:

```
Protocol on 192.168.56.103:3306/tcp matches mysql - banner: >\n5.0.51a-
3ubuntu5/?,`~yel,nd,M~Ti3ap/5Bad handshake
Protocol on 192.168.56.103:22/tcp matches ssh - banner: SSH-2.0-
OpenSSH_4.7p1 Debian-8ubuntu1\n
Protocol on 192.168.56.103:22/tcp matches ssh-openssh - banner: SSH-2.0-
OpenSSH_4.7p1 Debian-8ubuntu1\n
```

`Amap` is able to identify the service that is running on port `3306`, but it gives several matches when identifying the service running on port `22`.

`Amap` is useful if you want a quick way to find out the application service information.

---

# SMB enumeration

If you are testing a Windows environment, the easiest way to collect information about that environment is by using the **Server Message Block** (**SMB**) enumeration tool such as `nbtscan`.

The `nbtscan` tool can be used to scan the IP addresses for the NetBIOS name information. It will produce a report that contains the IP address, NetBIOS computer name, services available, logged in username, and MAC addresses of the corresponding machines.

This information will be useful in the penetration testing steps. The difference between `nbtstat` and `nbtscan` of Windows is that `nbtscan` can operate on a range of IP addresses. You should be aware that using this tool will generate a lot of traffic, and it may be logged by the target machines.

> **Note**
>
> To find the meaning of each service in the NetBIOS report, you may want to consult Microsoft Knowledge Based on *NetBIOS Suffixes (16th Character of the NetBIOS Name)* located at http://support.microsoft.com/kb/163409.

To access `nbtscan`, go to the console and type `nbtscan`.

If you are connected to a `192.168.56.0` network and want to find the Windows hosts available in the network, you can use the following command:

```
nbtscan 192.168.56.1-254
```

The following is the result of this command:

```
Doing NBT name scan for addresses from 192.168.56.1-254

IP address       NetBIOS Name     Server    User             MAC
address
------------------------------------------------------------------------------
---
192.168.56.103   METASPLOITABLE   <server>  METASPLOITABLE
00:00:00:00:00:00
```

From the preceding result, we are able to find out one NetBIOS name, `METASPLOITABLE`.

Now let's find the service provided by that machine by giving the following command:

```
nbtscan -hv 192.168.56.103
```

The following is the result of this command:

```
Doing NBT name scan for addresses from 192.168.56.103

NetBIOS Name Table for Host 192.168.56.103:

Incomplete packet, 281 bytes long.
Name             Service          Type
----------------------------------------
METASPLOITABLE   Workstation Service
METASPLOITABLE   Messenger Service
METASPLOITABLE   File Server Service
METASPLOITABLE   Workstation Service
```

```
METASPLOITABLE   Messenger Service
METASPLOITABLE   File Server Service
WORKGROUP        Domain Name
WORKGROUP        Browser Service Elections
WORKGROUP        Domain Name
WORKGROUP        Browser Service Elections

Adapter address: 00:00:00:00:00:00
----------------------------------------
```

From the preceding result, we can see that there are various services available on `METASPLOITABLE` such as `File Server Service` and `Messenger Service` .

---

# SNMP enumeration

This section will cover the tools that can be used to check for the **Simple Network Monitoring Protocol** (**SNMP**). Even though the information from a SNMP device may not look important, as pen-testers, we have seen misconfigured SNMP devices which allow us to read the configuration, get important information, and even have a privilege to modify the configuration.

We suggest you also check the SNMP devices when you encounter a penetration testing job; you may be surprised with what you find.

## onesixtyone

The `onesixtyone` tool can be used as a SNMP scanner to find whether the SNMP string exists on a device. The difference with respect to other SNMP scanners is that this tool sends all the SNMP requests as fast as it can (10 milliseconds apart). Then it waits for the responses and logs them. If the device is available, it will send responses containing the SNMP string.

To access `onesixtyone`, go to the console and type `onesixtyone`.

### Note

By default, Metasploitable 2 does not have the SNMP daemon installed. To install it, just type the following command after you are connected to the Internet:

```
apt-get install snmpd
```

Then, you need to change the configuration file, `/etc/default/snmpd`:

```
sudo vi /etc/default/snmpd
```

In the `SNMPDOPTIONS` line, remove the localhost address (`127.0.0.1`) and restart SNMPD:

```
sudo /etc/init.d/snmpd restart
```

Beware that you need to isolate the Metasploitable 2 machine from the network connected outside. If not, you will get attacked easily.

Let's try `onesixtyone` to find the SNMP strings used by a device located at `192.168.1.1`. The following is the appropriate command:

```
onesixtyone 192.168.56.103
```

The following is the scanning result:

```
Scanning 1 hosts, 2 communities
192.168.56.103 [public] Linux metasploitable 2.6.24-16-server #1 SMP Thu
Apr 10 13:58:00 UTC 2008 i686
192.168.56.103 [private] Linux metasploitable 2.6.24-16-server #1 SMP Thu
Apr 10 13:58:00 UTC 2008 i686
```

The SNMP strings found are `public` and `private`.

If we want the scanning to be more verbose, we can give the `-d` option:

```
onesixtyone -d 192.168.56.103
```

The result is as follows:

```
Debug level 1
Target ip read from command line: 192.168.56.103
2 communities: public private
Waiting for 10 milliseconds between packets
Scanning 1 hosts, 2 communities
```

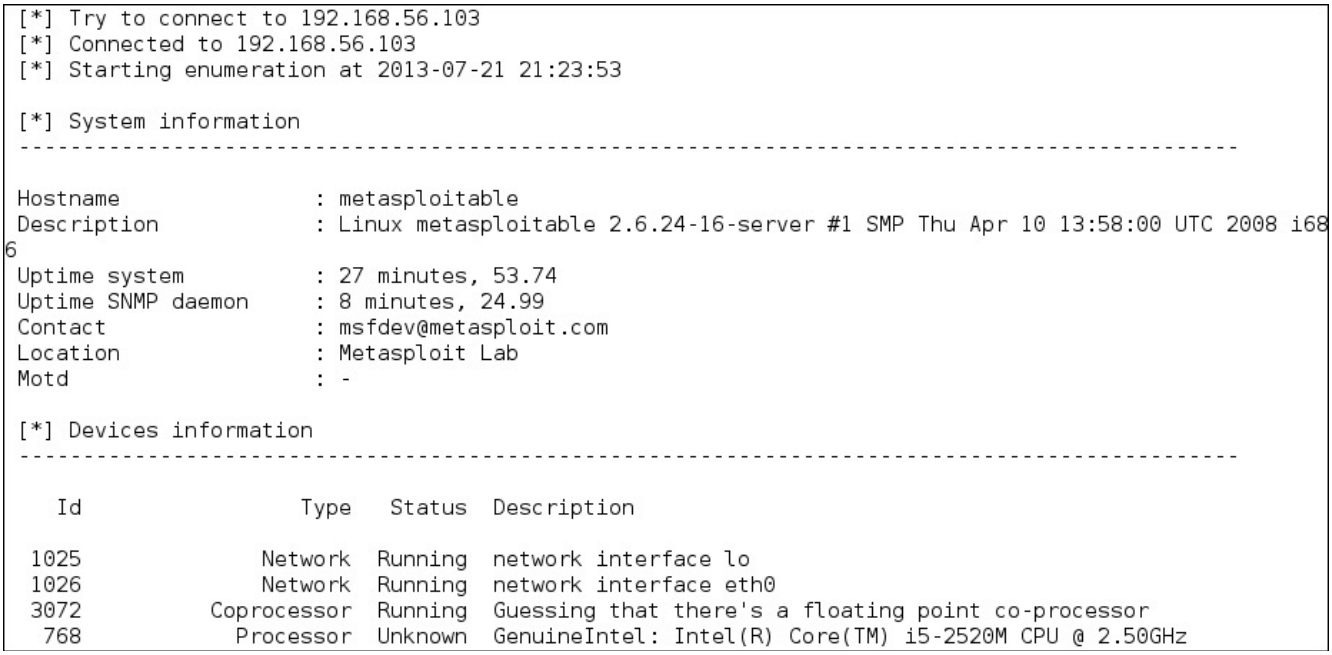
```
Trying community public
192.168.56.103 [public] Linux metasploitable 2.6.24-16-server #1 SMP Thu
Apr 10 13:58:00 UTC 2008 i686
Trying community private
192.168.56.103 [private] Linux metasploitable 2.6.24-16-server #1 SMP Thu
Apr 10 13:58:00 UTC 2008 i686
All packets sent, waiting for responses.
done.
```

## snmpcheck

You can use `snmpcheck` to collect more information about the SNMP device using the following command:

```
snmpcheck -t 192.168.56.103
```

The following screenshot shows the information obtained from the preceding command:



```
[*] Try to connect to 192.168.56.103
[*] Connected to 192.168.56.103
[*] Starting enumeration at 2013-07-21 21:23:53

[*] System information
-------------------------------------------------------------------------------

Hostname              : metasploitable
Description           : Linux metasploitable 2.6.24-16-server #1 SMP Thu Apr 10 13:58:00 UTC 2008 i68
6
Uptime system         : 27 minutes, 53.74
Uptime SNMP daemon    : 8 minutes, 24.99
Contact               : msfdev@metasploit.com
Location              : Metasploit Lab
Motd                  : -

[*] Devices information
-------------------------------------------------------------------------------

   Id                Type   Status  Description

 1025             Network  Running  network interface lo
 1026             Network  Running  network interface eth0
 3072         Coprocessor  Running  Guessing that there's a floating point co-processor
  768           Processor  Unknown  GenuineIntel: Intel(R) Core(TM) i5-2520M CPU @ 2.50GHz
```

---

# VPN enumeration

In this section, we will discuss about discovering and testing the **Virtual Private Network** (**VPN**) systems.

Several years ago, when a branch office wanted to connect to the head office, it needed to set a dedicated network line between the branch and head offices. The main disadvantage of this method was the cost; a dedicated network line is expensive.

Fortunately, there is a solution for this problem: a VPN. A VPN allows a branch office to connect to the head office using the public network (Internet). The cost of using a public network is much cheaper than using a dedicated line. With the VPN, the branch office will be able to use the application in the headquarters as if the branch office is located in the **Local Area Network** (**LAN**). The connection established is protected by encryption.

Based on the method used, VPN can be divided into at least three groups:

- **IPsec-based VPN**: This type is a popular VPN solution for connecting the branch office to the head office's LAN. The branch office will install an IPsec VPN client on the network gateway, while the head office will install an IPsec VPN server on its network gateway. It is not a popular method to connect a user to the head office's LAN due to the complexity of configuring the method. The user that uses this method is called a road warrior.
- **OpenVPN**: This type is a very popular VPN solution for road warriors. In OpenVPN, a user needs to install an OpenVPN client before being able to connect to the VPN server. The advantage of this mode is that it is very easy to set up and doesn't need an administrator-level privilege to run.
- **SSL-based VPN**: In this category, the user doesn't need a dedicated VPN client but can use a web browser to connect to the VPN server as long as the web browser supports an SSL connection.

## ike-scan

The `ike-scan` tool is a security tool that can be used to discover, fingerprint, and test the IPsec VPN systems. IPsec is the most commonly used technology for LAN-to-LAN and remote access VPN solutions.

IPsec uses three major protocols as follows:

- **Authentication Headers** (**AH**): This provides data integrity
- **Encapsulating Security Payloads** (**ESP**): This provides data integrity and confidentiality
- **Internet Key Exchange** (**IKE**): This provides support for the negotiation of parameters between endpoints; it establishes, maintains, and terminates the **Security Association** (**SA**)

IKE establishes security association through the following phases:

- **IKE phase 1**: This sets up a secure channel between two IPsec endpoints by the negotiation of parameters, such as the encryption algorithm, integrity algorithm, authentication type, key distribution mechanism, and lifetime. To establish the bidirectional security association, IKE phase 1 can either use the main mode or aggressive mode. The main mode negotiates SA through three pairs of messages, while the aggressive mode provides faster operations through the exchange of three messages.
- **IKE phase 2**: This is used for data protection.
- **IKE phase 1.5** or **the extended authentication phase**: This is an optional phase and is commonly used in the remote access VPN solutions.

The `ike-scan` tool works by sending IKE phase 1 packets to the VPN servers and displaying any responses it receives.

The following are several features of `ike-scan` :

- Ability to send the IKE packets to any number of destination hosts
- Ability to construct the outgoing IKE packets in a flexible way
- Ability to decode and display any response packets
- Ability to crack the aggressive mode pre-shared keys with the help of the `psk-crack` tool

In short, the `ike-scan` tool is capable of two things:

- **Discovery**: Finding hosts running the IKE by displaying the hosts that respond to the IKE request.
- **Fingerprint**: Identifying the IKE implementation used by the IPsec VPN server. Usually, this information contains the VPN vendor and the model of the VPN server. This is useful for later use in the vulnerability analysis process.

The reason why you need a tool like `ike-scan` is that in general, port scanner will not be able to find an IPsec VPN server because these servers doesn't listen on any TCP ports. And, they also don't send ICMP unreachable error message, so UDP scans will not find them either. Also, if you try to send random garbage data to the UDP port `500` or IP protocols `50` and `51`, you will not receive any response. So, the only way to find the IPsec VPN server is by using a tool that can send a correctly formatted IKE packet and display any responses that are received from that server.

To start the `ike-scan` command line, you can use the console to execute the following command:

```
ike-scan
```

This will display a simple usage instruction and example on your screen.

As our exercise, we are going to discover, fingerprint, and test an IPsec VPN server using the following command:

```
ike-scan -M -A -Pike-hashkey 192.168.0.10
```

Here:

- `-M` : This splits the payload decoded across multiple lines to make the output easier to read
- `-A` : This uses the IKE aggressive mode
- `-P` : This saves the aggressive mode pre-shared key to this file

The following screenshot shows the result:

```
root@kali:~# ike-scan -M -A -Pike-hashkey 192.168.0.10
Starting ike-scan 1.9 with 1 hosts (http://www.nta-monitor.com/tools/ike-scan/)
192.168.0.10    Aggressive Mode Handshake returned
        HDR=(CKY-R=5fe7eb4afa630434)
        SA=(Enc=3DES Hash=SHA1 Auth=PSK Group=2:modp1024 LifeType=Seconds LifeDu
ration(4)=0x00007080)
        KeyExchange(128 bytes)
        Nonce(16 bytes)
        ID(Type=ID_IPV4_ADDR, Value=192.168.0.10)
        Hash(20 bytes)
        VID=afcad71368a1f1c96b8696fc77570100 (Dead Peer Detection v1.0)

Ending ike-scan 1.9: 1 hosts scanned in 0.034 seconds (29.27 hosts/sec).  1 retu
rned handshake; 0 returned notify
```

The interesting information is contained in the SA payload as follows:

- **Encryption**: **3DES**
- **Hash**: **SHA1**
- **Auth**: **PSK**
- **Diffie-Hellman group**: **2**
- **SA life time**: **28800 seconds**

The pre-shared key is saved in the `ike-hashkey` file.

The next step is to crack the hash to get the password to connect to the VPN server. For this purpose, we can use the `psk-crack` tool as follows:

```
psk-crack -d rockyou.txt ike-hashkey
```

Here, `-d` is the wordlist file.

The following screenshot shows the result of this command:

```
root@kali:~# psk-crack -d rockyou.txt ike-hashkey
Starting psk-crack [ike-scan 1.9] (http://www.nta-monitor.com/tools/ike-scan/)
Running in dictionary cracking mode
key "123456" matches SHA1 hash 74948c512be7950157e6b925f9c426e3e12cc151
Ending psk-crack: 1 iterations in 0.030 seconds (33.34 iterations/sec)
```

From the output, we notice that the key is **123456**. You can then use this key to connect to the VPN server.

The next task is to fingerprint the VPN server. For this purpose, we need to define the transform attributes until we find one which is acceptable.

> **Note**
>
> To find out which transform attributes to use, you can go to http://www.nta-monitor.com/wiki/index.php/Ike-scan_User_Guide#Trying_Different_Transforms.

The following is the command to fingerprint the IPsec VPN server based on the previous SA payload:

```
ike-scan -M --trans=5,2,1,2 --showbackoff 192.168.0.10
```

The following screenshot shows the result of this command:

```
root@kali:~# ike-scan -M --trans=5,2,1,2 --showbackoff 192.168.0.10
Starting ike-scan 1.9 with 1 hosts (http://www.nta-monitor.com/tools/ike-scan/)
192.168.0.10    Main Mode Handshake returned
        HDR=(CKY-R=8cb7b6369d11ae81)
        SA=(Enc=3DES Hash=SHA1 Auth=PSK Group=2:modp1024 LifeType=Seconds LifeDuration(4)=
0x00007080)
        VID=4f45755c645c6a795c5c6170
        VID=afcad71368a1f1c96b8696fc77570100 (Dead Peer Detection v1.0)

IKE Backoff Patterns:

IP Address      No.     Recv time               Delta Time
192.168.0.10    1       1386775276.209957       0.000000
192.168.0.10    2       1386775286.214992       10.005035
192.168.0.10    3       1386775306.236889       20.021897
192.168.0.10    Implementation guess: Linux FreeS/WAN, OpenSwan, strongSwan

Ending ike-scan 1.9: 1 hosts scanned in 90.086 seconds (0.01 hosts/sec).  1 returned hands
hake; 0 returned notify
```

The `ike-scan` tool is able to guess the remote VPN server software used: **FreeS/WAN**, **OpenSwan**, or **strongSwan**.

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## Summary

In this chapter, we discussed the target enumeration process and its purpose. We also discussed port scanning as one of the target enumeration methods. You learned about several types of port scanning, and then we looked at several tools, such as Nmap, `Unicornscan`, and `Amap`. Next, we talked about SMB enumeration using `nbtscan` and SNMP enumeration using `onesixtyone` and `snmpcheck`. Lastly, we talked about VPN enumeration and `ike-scan` as the tool to carry out this process.

In next chapter, we will look at vulnerability identification, a process of identifying and analyzing the critical security flaws in the target environment.