

— DUT · SEMESTER 3 · COMPUTER SCIENCE

Network Administration

Session 01 · Linux servers and a virtual lab

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Today's session

- 01 From CCNA 1 to network administration
- 02 Linux on the server
- 03 Working in the terminal
- 04 Virtual machines for the lab
- 05 First boot: a Fedora Server VM

TODAY'S FOCUS

In CCNA 1 you configured routers and switches. Here you configure the servers that give the network its services.

Today you learn enough Linux to install a server in a virtual machine and give it an address.

Learning objectives

1. Explain what a server does and which services this module will configure
2. Move around a Linux system and read, copy and edit files from the terminal
3. Explain what each VirtualBox network mode lets a VM reach
4. Give a Linux server a fixed IPv4 address with nmcli and check it

PREREQUISITES

- CCNA 1: IPv4 addresses, masks, default gateway, TCP/UDP ports
- Basic idea of an operating system
- A laptop with virtualization enabled in the BIOS/UEFI

What we will build this semester

01

Linux server

A Fedora
Server VM
with a fixed
address

02

DHCP

Hosts receive
their network
settings
automatically

03

DNS

Names
resolve to
addresses
inside the lab
domain

04

Web server

A site
published on
the lab
network

05

Full network

DHCP, DNS
and web
working
together

The target: a small company network

Every server is a VM on your laptop. Today we build the first Fedora server.

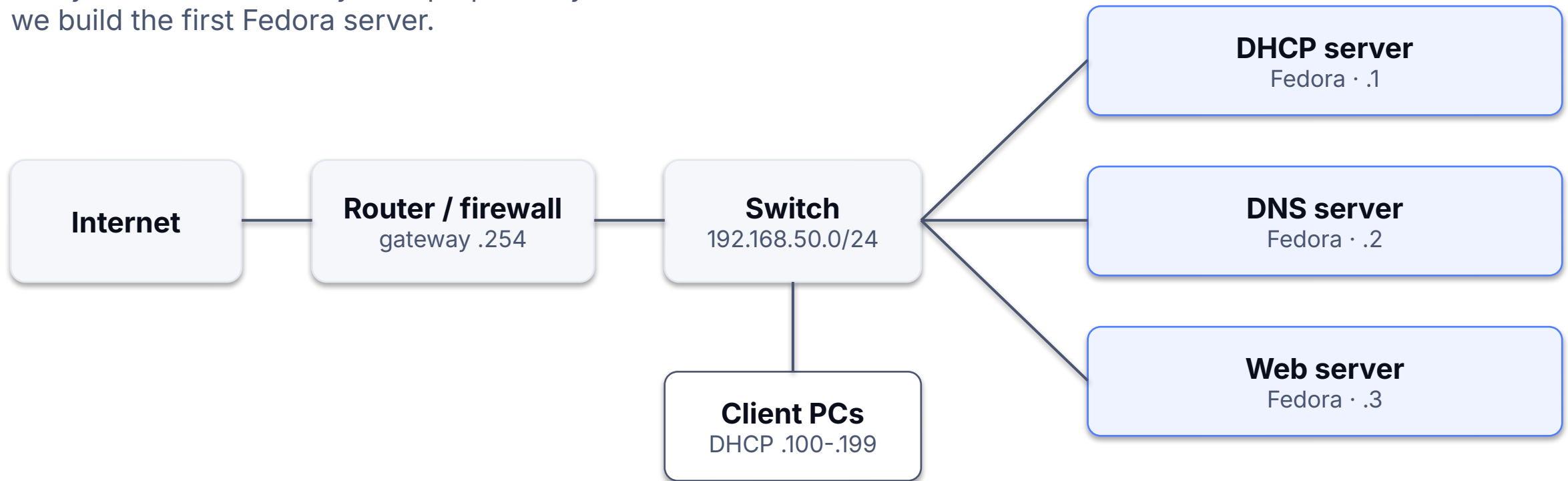


Figure 1. Target lab architecture, built step by step in the practical sessions. Legend: blue = Linux server, grey = clients and network devices.

01

— CHAPTER

From CCNA 1 to network administration

What you already know, and what a network administrator adds to it

What a network administrator does

DEFINITION

Network administration means keeping the devices and services of a network configured, available and secure for its users.

EXAMPLE

Giving every PC an address, making names like intranet.lab work, publishing an internal website, and finding out why "the network is down".

TYPICAL TOOLS

Linux servers, the services they run, the command line, and logs that record what happened

From CCNA 1 to this module

What you learned in CCNA 1

- IPv4 addresses, masks and default gateways
- Switches and routers configured with Cisco IOS
- TCP, UDP and port numbers
- DHCP and DNS as ideas: what they are for

What this module adds

- Servers that provide those services
- Linux servers instead of Cisco IOS
- Installing, configuring and testing services
- Building everything in virtual machines

Clients and servers

DEFINITION

**A server is a program that waits for requests on a port and answers them.
A client is the program that sends the request.**

EXAMPLE

Your browser (client) sends a request to TCP port 443 of a web server; the server sends back the page.

ONE MACHINE, MANY SERVERS

A single Linux machine can run a web server, a DNS server and SSH at the same time. Each one listens on its own port.

The services of this module and their ports

Service	Protocol and port	What it does	Session
SSH	TCP 22	Remote administration of a server	Today
DHCP	UDP 67 (server), 68 (client)	Gives hosts their network settings	DHCP
DNS	UDP and TCP 53	Translates names into addresses	DNS
HTTP / HTTPS	TCP 80 / 443	Publishes web pages	Web server

Table 1. Well-known ports registered with IANA (Service Name and Transport Protocol Port Number Registry).

The four settings every host needs

Setting	Example	What fails without it
IP address	192.168.50.10	The host cannot communicate at all
Subnet mask (prefix)	255.255.255.0 (/24)	The host cannot tell local from remote destinations
Default gateway	192.168.50.254	Nothing outside the local subnet is reachable
DNS server	192.168.50.2	Addresses work, but names (www.example.com) do not

Table 2. Review of CCNA 1. These four values are what we type by hand today and what the DHCP server will distribute later.

Knowledge check

QUESTION

A PC can ping 8.8.8.8 but cannot open www.example.com. Which setting is most likely wrong?

A

IP address

B

Subnet mask

C

Default gateway

D

DNS server

02

— CHAPTER

Linux on the server

What an operating system does, what a distribution adds, and which one we use

What an operating system does

DEFINITION

An operating system shares the hardware (processor, memory, disk, network card) between programs. Its core part is called the kernel.

EXAMPLE

When a web server sends a page, it asks the kernel; the kernel passes the data to the network card.

KERNELS YOU KNOW

Windows uses the NT kernel, macOS uses XNU, Android and Linux distributions use the Linux kernel.

Kernel and distribution are not the same thing

DEFINITION

The Linux kernel alone cannot do much. A distribution adds the tools, the software packages and the update policy that make it usable.

EXAMPLE

Fedora Server 44 = Linux kernel +
systemd + dnf + NetworkManager +
firewalld + Cockpit

SECOND EXAMPLE

Ubuntu Server 26.04 LTS = Linux kernel +
systemd + apt + netplan, with a different
release and support policy

Server distributions in 2026

Distribution	Family	Packages	Release and support	Typical use
Fedora Server 44	Red Hat	dnf	New release about every 6 months; each one supported about 13 months	Learning, labs, newest tools
CentOS Stream	Red Hat	dnf	Continuous preview of the next RHEL minor release	Testing what RHEL will ship
RHEL, Rocky Linux, AlmaLinux	Red Hat	dnf	Long life cycles (about 10 years per major version)	Enterprise production
Debian 13 "trixie"	Debian	apt	Stable release about every 2 years (13.0: August 2025)	Servers that change rarely
Ubuntu Server 26.04 LTS	Debian	apt	5 years of standard support (to April 2031)	Cloud and general servers

Table 3. Sources: Fedora Project download page (F44, 28 Apr 2026); Red Hat, CentOS Linux EOL; debian.org/releases; Ubuntu 26.04 LTS release notes. Checked 5 Oct 2026.

Older tutorials still recommend CentOS Linux

✗ INCORRECT APPROACH

Following a guide that installs CentOS Linux 7 or 8 as a "free RHEL" for a new server

✓ CORRECTION

Use Rocky Linux or AlmaLinux for RHEL compatibility, or Fedora for a lab. CentOS Stream is a development preview of RHEL.

WHY IT FAILS

CentOS Linux 8 reached end of life on 31 December 2021 and CentOS Linux 7 on 30 June 2024. A server on either version no longer receives security updates.

Why we use Fedora Server in this module

- It uses the same tools as RHEL, Rocky Linux and AlmaLinux
 - dnf for packages, systemd for services, firewalld for the firewall, NetworkManager for interfaces
- It ships recent versions of the services we study
 - BIND for DNS, Apache httpd for the web
- It is free, and has no graphical desktop to slow the VM down

KEY TAKEAWAY

What you practise on Fedora works almost unchanged on the enterprise servers of the Red Hat family.

Knowledge check

QUESTION

A company needs a DNS server that will run for six years with security updates. Which choice fits best?

A

Fedora Server 44

B

CentOS Linux 7

C

Rocky Linux or AlmaLinux

D

Any distribution, because they all use the same kernel

03

— CHAPTER

Working in the terminal

Reading the prompt, moving around, editing files, and the commands you will use in every lab

Why servers are managed from a command line

- Servers usually have no graphical desktop
 - Less memory used, fewer programs that could contain security flaws
- You often manage them remotely, over SSH
 - The server may be in a data centre or in the cloud, far from you
- Commands can be written down, repeated and scripted
 - A lab report is simply the list of commands you ran and what they printed

KEY TAKEAWAY

You already did this on Cisco routers. The Linux terminal works on the same principle: type, read, verify.

Reading the prompt

BASH · SRV1

```
[admin@srv1 ~]$ ls -l /etc
```

```
[admin@srv1 ~]$ cd /var/log  
[admin@srv1 log]$
```

```
[admin@srv1 log]$ sudo -i  
[root@srv1 ~]# exit
```

LINE 1

admin = user, srv1 = machine,
~ = current directory. ls is the
command, -l an option, /etc an
argument

LINES 3-4

After cd, the prompt shows the
new directory

LINES 6-7

\$ = normal user, # = root. Read
the prompt before typing

Paths: how to name a file

DEFINITION

An absolute path starts from the root, /. A relative path starts from the directory you are in.

EXAMPLE

/etc/hostname is absolute and works from anywhere. If you are already in /etc, hostname alone is enough.

THREE SHORTCUTS

~ is your home directory (/home/admin), . is the current directory, .. is the parent directory

Basic file commands

Command	What it does	Example
<code>pwd</code>	Shows the current directory	<code>pwd</code>
<code>ls -l</code>	Lists files with details	<code>ls -l /etc</code>
<code>cd</code>	Changes directory	<code>cd /var/log</code>
<code>mkdir</code>	Creates a directory	<code>mkdir backups</code>
<code>cp</code>	Copies a file	<code>cp notes.txt notes.bak</code>
<code>mv</code>	Moves or renames a file	<code>mv notes.bak backups/</code>
<code>rm</code>	Deletes a file (no recycle bin)	<code>rm backups/notes.bak</code>

Table 4. Every command has a manual page: type `man` followed by the command name (for example `man cp`). Press `q` to leave it.

Reading and editing a configuration file

BASH · SRV1

```
cat /etc/hostname  
less /etc/services  
grep -w 53 /etc/services  
  
# keep a copy before editing  
sudo cp /etc/hosts /etc/hosts.bak  
sudo nano /etc/hosts
```

LINES 1-3

Show a short file, scroll a long one (q to quit), find the lines that mention port 53

LINES 6-7

Back up, then edit with nano: Ctrl+O saves, Ctrl+X quits

Where to look on a Linux server

Directory	What it contains	Example in this module
/etc	System and service configuration (text files)	<code>/etc/hostname</code> , <code>/etc/named.conf</code>
/etc/NetworkManager/system-connections	Saved network connection profiles	<code>labnet.nmconnection</code>
/var/log and the journal	Logs from the system and services	<code>journalctl -u named</code>
/home and /root	User home directories; root has its own	<code>/home/admin</code>
/usr/bin and /usr/sbin	Programs (/bin and /sbin now point here)	<code>/usr/sbin/named</code>

Table 5. Selected parts of the Filesystem Hierarchy Standard as applied on Fedora. Older systems kept separate /bin and /sbin directories.

First look at a server

BASH · SRV1

```
whoami
hostnamectl
cat /etc/os-release
ip -br address
ls -l /etc | less

# read the manual of any command
man hostnamectl
```

LINES 1-3

Who am I, which machine is this, which distribution and version

LINE 4

One line per network card: name, state, addresses

LINE 5

The | sends the output of ls into less, page by page

root and ordinary users

DEFINITION

root is the administrator account and can change anything. Ordinary users can change only their own files.

EXAMPLE

As admin, `sudo nano /etc/hosts` works after you type your password; `nano /etc/hosts` alone cannot save the file.

SUDO

Runs one command as root, after asking your own password. On Fedora, members of the wheel group may use it.

Reading permissions with ls -l

BASH · EXAMPLE OUTPUT

```
ls -l /etc/hostname  
-rw-r--r--. 1 root root ... /etc/hostname
```

#	type		owner		group		others
#	-		rw-		r--		r--

FIRST CHARACTER

- is a regular file, d a directory

NEXT THREE GROUPS

r read, w write, x execute, for the owner, the group, then everyone else

ROOT ROOT

The owner and the group of the file

Creating a user with administrator rights

BASH · ADMIN USER

```
# create a user with a home directory
sudo useradd -m -G wheel student1
sudo passwd student1

# check the result
id student1
getent passwd student1
```

LINE 2

-m creates /home/student1; -G wheel allows the user to use sudo

LINE 3

Sets the password (nothing is shown while you type)

LINES 6-7

id shows the groups; getent shows the account line from /etc/passwd

Working as root all the time

× INCORRECT APPROACH

Opening a root shell with `sudo su` at the start of the lab and doing everything in it

✓ CORRECTION

Work as a normal user and put `sudo` only in front of the commands that change the system

WHY IT FAILS

In a root shell, a typing mistake (`rm -rf` in the wrong directory) has no safety net, and `sudo` no longer records which commands you ran.

Packages and repositories

DEFINITION

A package contains a program, its files and the list of other packages it needs. A repository is an online collection of packages.

EXAMPLE

`sudo dnf install bind` downloads the DNS server and everything it needs, checks the signatures, then installs it.

COMPARE

It works like an app store, but from the command line, and every package is signed by the distribution.

Installing software: dnf and apt

Task	Fedora and RHEL family (dnf)	Debian and Ubuntu (apt)
Refresh and upgrade everything	<code>sudo dnf upgrade --refresh</code>	<code>sudo apt update && sudo apt upgrade</code>
Install a package	<code>sudo dnf install bind</code>	<code>sudo apt install bind9</code>
Remove a package	<code>sudo dnf remove bind</code>	<code>sudo apt remove bind9</code>
Search by name or description	<code>dnf search dhcp</code>	<code>apt search dhcp</code>
Show details of a package	<code>dnf info httpd</code>	<code>apt show apache2</code>

Table 6. Since Fedora 41 the dnf command runs DNF5; yum remains only as a compatibility link. Source: Fedora Project wiki, Changes/SwitchToDnf5.

Services: programs that run in the background

DEFINITION

A service (or daemon) is a program that starts with the system, runs in the background and waits for requests, usually on a port.

EXAMPLE

sshd is the SSH service. It listens on TCP port 22 so that you can log in remotely.

WHO MANAGES SERVICES

systemd starts, stops and watches services. You give it orders with the systemctl command.

Services: start, enable, inspect

BASH · SYSTEMD

```
systemctl status sshd
```

```
# start now and at every boot  
sudo systemctl enable --now \  
cockpit.socket
```

```
# why did a service fail?  
journalctl -u sshd --since today  
  
sudo firewall-cmd --list-all
```

LINE 1

Shows whether SSH is running (active) and starts at boot (enabled)

LINES 4-5

enable = start at boot; --now = also start immediately. \
continues a long command

LINES 8-10

Read one service's logs; list what the firewall allows

Knowledge check

QUESTION

You install httpd, start it and the website works. After a reboot the site is down. What is the most likely cause?

A

The firewall blocks port 80

B

The service was started but not enabled

C

The package was removed during the reboot

D

The server lost its IP address

04

— CHAPTER

Virtual machines for the lab

Why each server is a VM, and how a VM's network card decides who it can reach

Virtual machines and the hypervisor

DEFINITION

A hypervisor shares one physical computer between several virtual machines, each with its own virtual processor, memory, disk and network card.

EXAMPLE

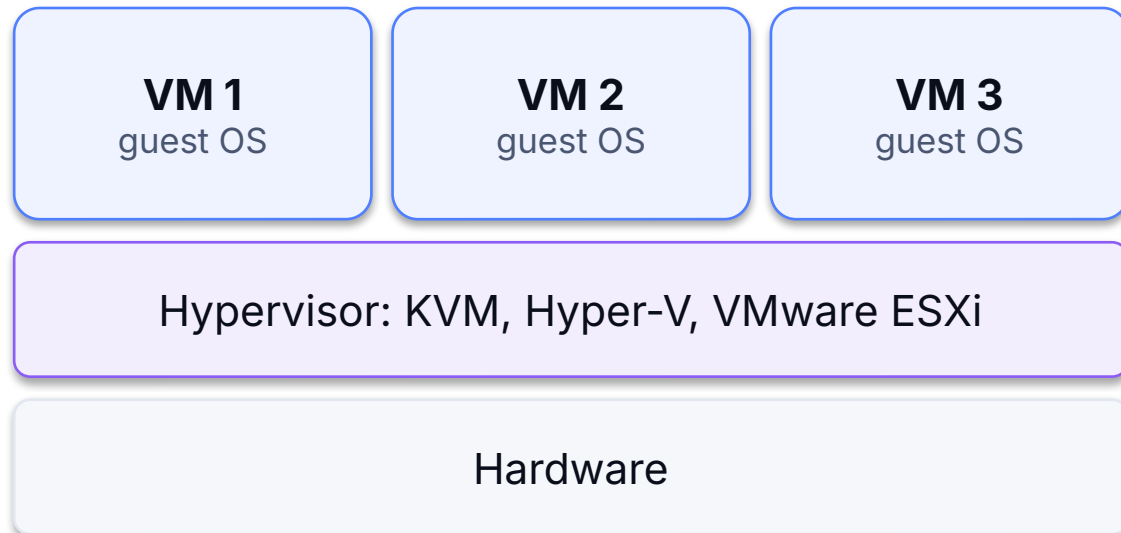
Your laptop runs VirtualBox. Inside it, a Fedora server VM and a client VM each believe they are separate computers.

WHY IT SUITS A LAB

Snapshots let you return to a working state in seconds; cloning gives you a second server without a new installation.

Two ways to run a hypervisor

Type 1 · bare metal (data centres)



Type 2 · hosted (your laptop)

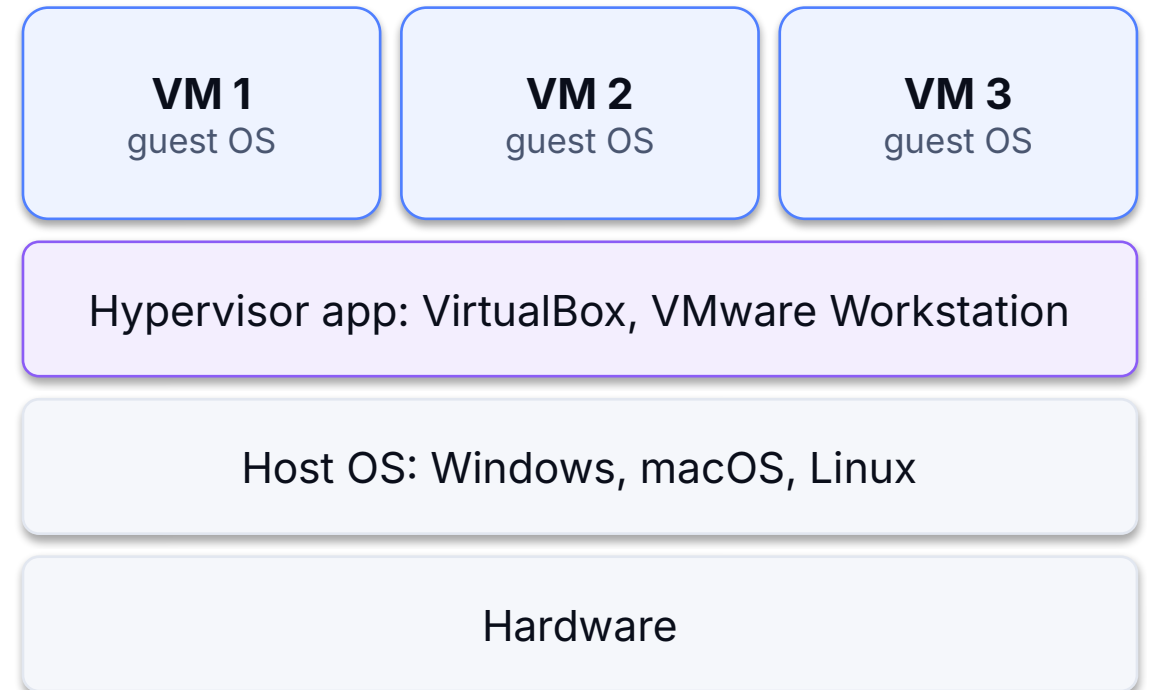


Figure 2. Type 1 (bare-metal) and type 2 (hosted) hypervisors. Legend: blue = guest VMs, violet = hypervisor, grey = host layers.

Physical server, virtual machine, container

Physical server

Runs: one operating system

Isolation: full, separate hardware

Start-up: minutes

In this module: not used

Virtual machine

Runs: its own kernel and OS

Isolation: strong, through the hypervisor

Start-up: tens of seconds

In this module: every server and client

Container

Runs: one application, sharing the host kernel

Isolation: lighter, through the kernel

Start-up: about a second

In this module: not required

VirtualBox NAT works like your home router

DEFINITION

With NAT, the VM uses a private address and goes out through the host's address. Replies come back, but nobody outside can start a connection to the VM.

EXAMPLE

The VM gets 10.0.2.15, gateway 10.0.2.2. It can install packages from the Internet, but other VMs cannot reach it.

SAME IDEA AT HOME

Your phone has a private address like 192.168.1.20; the box translates it to the single public address of your connection.

Network modes decide who a VM can reach

Mode	VM to host	Host to VM	VM to VM	VM to Internet	Use in this module
NAT	Yes	Port forwarding	No	Yes	Install packages and updates
NAT Network	Yes	Port forwarding	Yes	Yes	Several VMs sharing Internet
Bridged	Yes	Yes	Yes	Yes	Avoid for DHCP labs on campus
Host-only	Yes	Yes	Yes	No	Reach a VM from the host (SSH)
Internal network	No	No	Yes	No	Isolated lab LAN for DHCP and DNS

Table 7. Connectivity per mode. Source: Oracle VirtualBox 7.2 User Guide, Virtual Networking (VirtualBox 7.2.20, 22 Sep 2026).

Choosing network cards for the DHCP lab

PROBLEM

srv1 will run a DHCP server for client1. srv1 needs the Internet to install packages. DHCP traffic must never reach the campus network.

REASONING

1. Bridged would expose the DHCP server to campus machines: excluded.
2. srv1 and client1 need a network only they can see: internal network.
3. srv1 also needs the Internet: a second card in NAT mode.

RESULT

srv1: card 1 NAT, card 2
internal network
"labnet"

client1: one card,
internal network
"labnet"

05

— CHAPTER

First boot: a Fedora Server VM

From the installation image to a server with a name and a fixed address on the lab network

Installing Fedora Server in VirtualBox

01

Get the ISO

Fedora Server
DVD image,
checksum
verified

02

Create the VM

Suggested: 2
vCPU, 2-4 GB
RAM, 20 GB
disk, 2
network cards

03

Install

Automatic
partitioning;
admin user
with
administrator
rights

04

Update

dnf upgrade
--refresh,
then reboot

05

Snapshot

Name it
"clean install"

How Linux names network cards

Reading a name like enp0s3

- en = Ethernet, wl = Wi-Fi
- p0 = bus 0, s3 = slot 3: where the card sits in the machine
- lo = loopback, the machine itself (127.0.0.1)

Why it matters

- The name stays the same after a reboot or when you add a card
- Tutorials that use eth0 will not match your VM
- In VirtualBox, card 1 is usually enp0s3 and card 2 enp0s8: check with `ip -br address`

First checks after the first login

BASH · SRV1

```
sudo hostnamectl set-hostname \
    srv1.lab.internal
```

```
ip -br address
```

```
ip route
```

```
nmcli device status
```

```
nmcli connection show
```

```
ping -c 3 fedoraproject.org
```

LINES 1-2

Name the server; .internal is reserved for private networks

LINES 4-7

enp0s3 (NAT) has 10.0.2.15 and a default route; enp0s8 (labnet) has no address yet

LINE 9

Three pings to a name: tests DNS and Internet access

NetworkManager: devices and connections

DEFINITION

A device is the network card (enp0s8). A connection is a named set of settings (labnet) that NetworkManager applies to a device.

EXAMPLE

Your laptop's Wi-Fi card is one device, but it has one saved connection for home and another for the campus.

THE TOOL

nmcli is the command-line client of NetworkManager. Settings saved with it survive reboots.

A fixed address on the lab network

BASH · SRV1 · NMCLI

```
sudo nmcli connection add type ethernet \
    ifname enp0s8 con-name labnet \
    ipv4.method manual \
    ipv4.addresses 192.168.50.1/24 \
    ipv6.method disabled
sudo nmcli connection up labnet

ip -br address show enp0s8
nmcli connection show labnet | grep ipv4
```

LINES 1-5

Create a connection named labnet for enp0s8, with a fixed address and no gateway

LINE 6

Activate it now; it also comes back at every boot

LINES 8-9

Check the live address, then the saved settings

nmcli settings and their CCNA 1 equivalents

nmcli setting	Meaning	Cisco IOS equivalent
ifname enp0s8	Which network card	interface g0/1
ipv4.method manual	Fixed address, no DHCP	ip address ... (not ip address dhcp)
ipv4.addresses 192.168.50.1/24	Address and mask	ip address 192.168.50.1 255.255.255.0
ipv4.gateway 192.168.50.254	Default gateway	ip default-gateway 192.168.50.254
ipv4.dns 192.168.50.2	DNS server	ip name-server 192.168.50.2
connection up labnet	Apply the settings	no shutdown

Table 8. srv1's labnet connection sets no gateway and no DNS today. Clients will need all four settings, given later by DHCP.

Troubleshooting: client1 cannot ping srv1

PROBLEM

client1 has 192.168.50.10/24 on labnet. ping 192.168.50.1 fails. Where do you look, and in which order?

REASONING

1. Layer 1-2: in VirtualBox, are both cards on the same internal network name?
2. Layer 3: on both VMs, ip -br address: card UP, expected address?
3. Same subnet? .1/24 and .10/24 are both in 192.168.50.0/24

RESULT

Check from the bottom layer up. In practice, the usual cause is a misspelt network name (labnet vs Labnet).

Command line first, web console when it helps

Command line (SSH, nmcli, systemctl)

- Works on any server, even over a slow connection
- Every step can be copied into a lab report
- Required in the practical sessions and the exam

Cockpit web console

- Installed by default on Fedora Server
- Open `https://<server address>:9090` in a browser that can reach the VM
- Useful to view logs, services and network settings at a glance

Knowledge check

QUESTION

client1 must reach srv1, but neither the laptop nor the campus network. Which mode for client1's card?

A

NAT

B

Bridged

C

Internal network

D

Host-only

Recap

KEY TAKEAWAYS

- Servers are programs waiting on ports
- A distribution is the kernel plus tools and a support policy
- Configuration is in /etc; services are managed with systemctl
- The network mode of each VM card decides who can talk to whom
- nmcli: add, then up, then verify with ip

NEXT

- Session 02 (masterclass): DHCP, how hosts receive their four settings
- Week 4 practice: build srv1 and client1. Install VirtualBox 7.2 and download Fedora Server before coming

References

- (1) Fedora Project. Download Fedora Server 44 (released 28 April 2026). fedoraproject.org/server/download
- (2) Fedora Project. Changes/SwitchToDnf5 (Fedora 41). fedoraproject.org/wiki/Changes/SwitchToDnf5
- (3) Red Hat. What to know about CentOS Linux EOL. redhat.com/en/topics/linux/centos-linux-eol
- (4) Debian Project. Debian releases (Debian 13 "trixie", 9 August 2025). debian.org/releases
- (5) Canonical. Ubuntu 26.04 LTS release notes. documentation.ubuntu.com/release-notes/26.04
- (6) Oracle. VirtualBox 7.2 User Guide, Virtual Networking. virtualbox.org/manual
- (7) NetworkManager. nmcli reference manual. networkmanager.dev/docs/api/latest/nmcli.html
- (8) IANA. Service Name and Transport Protocol Port Number Registry. iana.org/assignments
- (9) Cockpit Project. Running Cockpit. cockpit-project.org/running.html



Course page:
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Thank you - Questions?

Before Week 4: install VirtualBox 7.2 and download Fedora Server

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