Computer networks

Grado en Ingeniería Informática

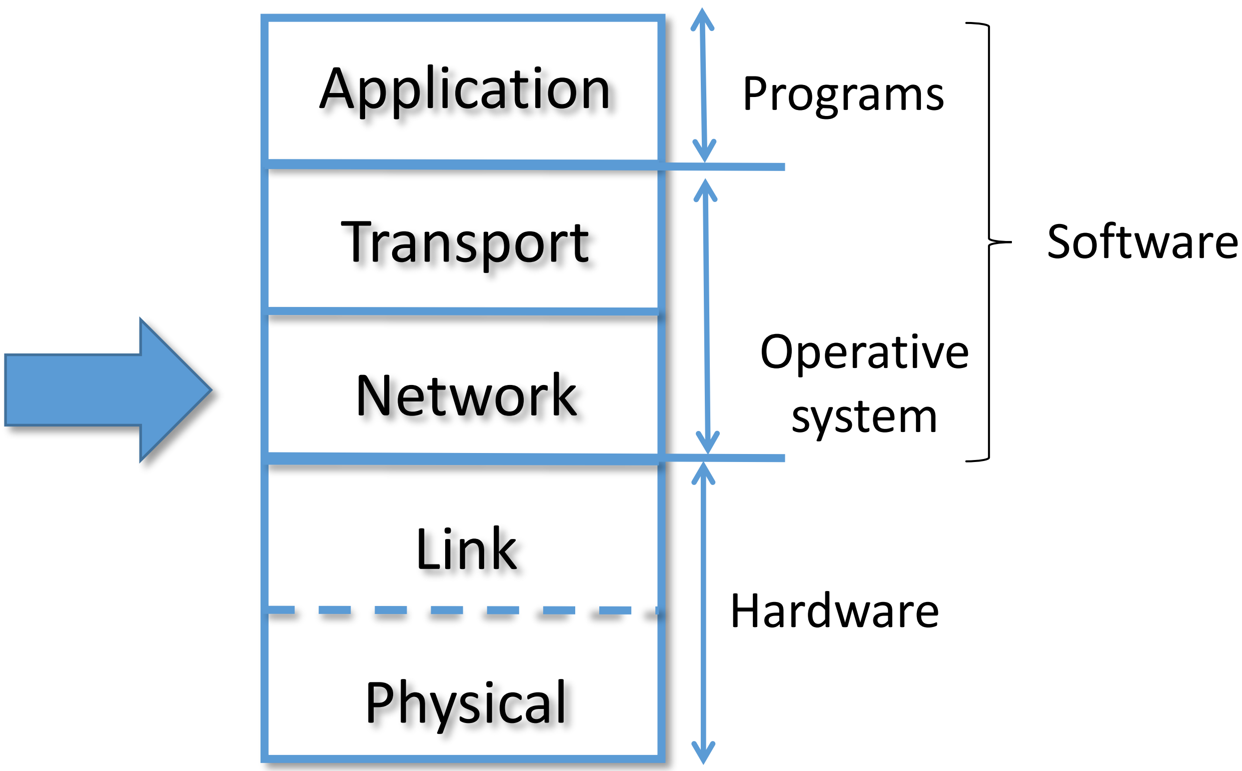
UNIVERSIDAD DE SEVILLA

Departamento de
Tecnología Electrónica

Computer Networks
Lesson 4

The Internet or Network Layer

Departamento de
Tecnología Electrónica


Application
Transport
Network
Link
Physical
Programs
Operative system
Hardware
Software

Lesson 4: Network layer

Objectives

- Understand the principles behind Network Layer services:
- Network Level Service Models
  - Forwarding versus routing
  - The inside of a router
- Discuss an example: Internet

Content

1. **Introduction**
2. Router in datagram networks
3. IP: Internet Protocol
   - IPv4 datagram format
   - IPv4 addressing
   - Introduction to ICMP
   - Operation

Introduction
Network Layer

- Sends segments (T_PDUs) from a final source system to a destination system.
- In the sender encapsulates each T_PDU in a datagram (N_PDU)
- At the receiver, it delivers the T_PDU to the transport level.
- The Network layer is present in both the end systems and the routers.
- Routers examine the header (N_PCI) of all N_PDUs that pass through them.

Introduction
Network Service Model

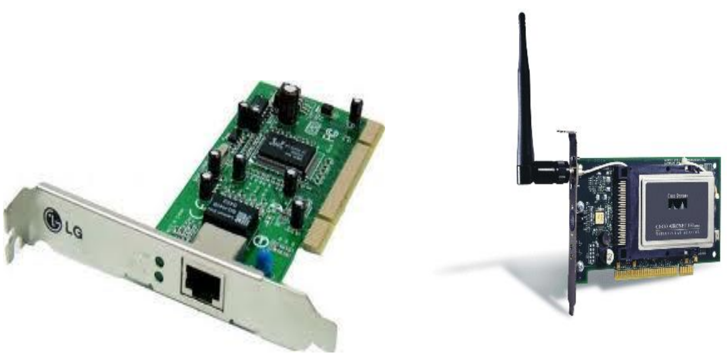
Some of the services that a network layer of the OSI model could provide are:

- Guaranteed delivery.
- Guaranteed delivery with limited delay.
- Delivery of packets in order.
- Guaranteed minimum bandwidth.
- Security.

However, the TCP/IP Network layer provides only one: best effort service, which does not include any of the above services.

Introduction
Network Layer – Link Communication

- Each network interface implements a certain link-level and physical protocol, known as link technology, network technology, or simply technology.
- Each network interface has an associated link-level address, known as a physical address or 48-bit MAC address, that identifies it. For example, 00:BF:3C:23:45:30

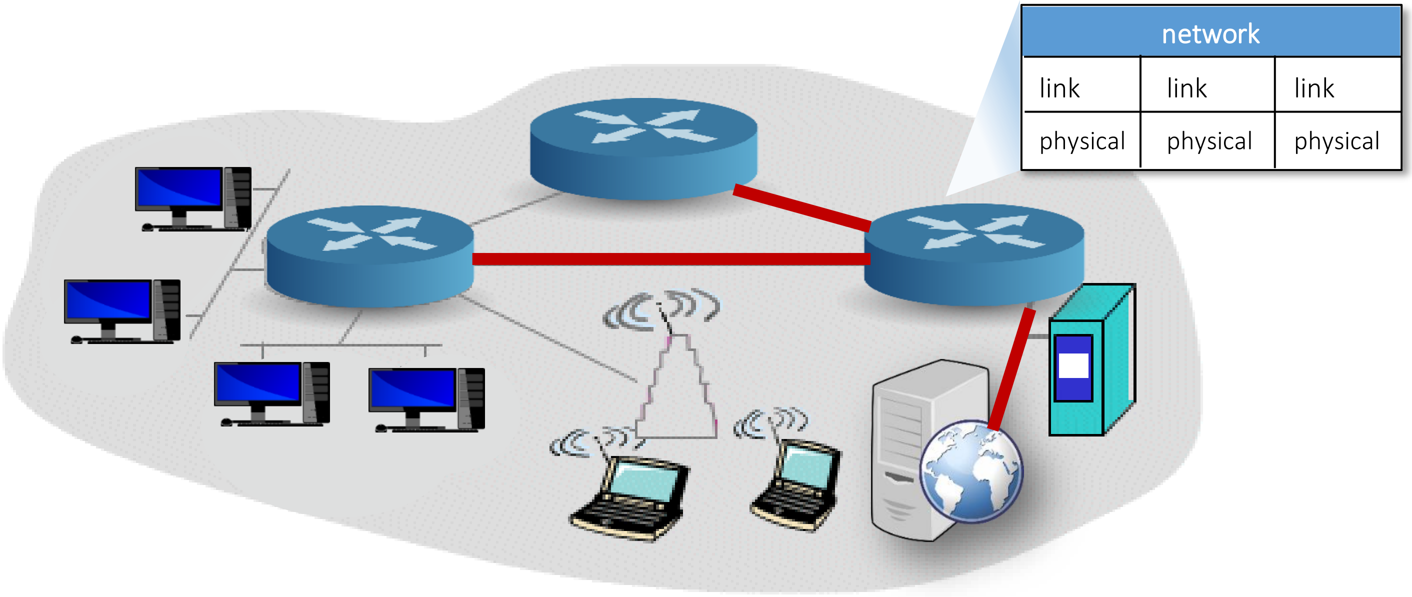


NIC (Network Interface Card).

More about physical addresses at the link level...

Introduction
Network Layer - Interfaces

- In general, only one network interface is used in end systems, although there may be several (for example, Ethernet and Wi-Fi).
- On routers there are several network interfaces.
  - Each of these interfaces will take you to other routers or to end systems.



Introduction
Network Layer – Broadcast domain boundaries

- The Link Layer, through the network interface, offers the Network Layer an unreliable service of N_PDUs delivery between routers or end systems that are connected by physical media and devices that implement, at most, up to the link layer.
- Routers and end systems connected in this way are said to be in the same broadcast domain.

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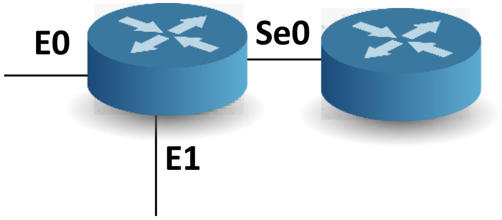
Routers in datagram networks
Router interfaces

- The technology used in each interface of a router is independent.
- For example, the border router of a home network usually has an Ethernet or WI-FI interface and another ADSL, cable modem...
- The interfaces of a router are identified
  - with a letter according to the technology and
    - For example, E: Ethernet 10 Mbps, Fa: Fast Ethernet, Gi: Gigabit Ethernet, To: Token Ring, Se: Serial...
  - a number to distinguish interfaces with the same technology
    - For example, E0, Fa0, Fa1, Se0...



Routers in datagram networks
Router interfaces and logical networks (I)

- At each interface of a router, using the appropriate transmission medium, end systems or other routers can be connected.
- It is possible to use other devices that deploy at most up to the link layer to make this connection. For example switch, access point or hub.
- All will be in the same broadcast domain, that is, all of them will process all the frames (L_PDUs) that in the L_PCI have a physical address destination broadcast or multicast.
- In general, they will all belong to the same logical network.
  - Their IP addresses will share the same network identifier.

Notes

1. A broadcast or multicast physical address is used to identify a group of network interfaces.
2. IP addresses are hierarchical. The bits that compose it are structured in such a way that one part (network identifier) identifies the logical network, and the other part (host identifier) identifies the final system or router. In generic mode we can say that an IP address=Network.Host.
3. More shortly...

Routers in datagram networks
Router interfaces and logical networks (II)

- Each interface of a router will belong to a different logical network.
  - You will have a different IP address.
    - The part that identifies the network will necessarily be different in each interface. (For example, 1, 2,...)
    - Each interface of a router is a different broadcast domain.
    - A router is not a transparent device.
    - The IP address of the router must be known by the end systems of a given broadcast domain.
    - For example, in home networks, end systems must know the IP address of the Ethernet or WI-FI interface of the border router.
    - The router's IP address must be known by other routers that are forwarding a N_PDU (directly connected routers).

Routers in datagram networks
Destination-Based Forwarding - Forwarding Table (I)

- The two key functions of the network layer make use of the forwarding or routing (RT) table.
- The routing function can modify its contents.
  - The forwarding function checks the RT to know the output interface to reach its destination.
  - Both end systems and routers have a forwarding table.
  - In the process of forwarding the RT entries serve to know the next gateway to follow along the way.
  - An ENTRY in the RT contains at least:

Network	Next hop	Interface
Network Identifier	Level 3 address of the next hop	Output network interface

Routers in datagram networks
Destination-Based Forwarding - Forwarding Table (II)

How are the RT entries filled in?

Automatically

Assigning IP addresses to network-layer devices includes an entry for the logical network to which the device belongs

Manually

Administration commands to fill the entries with the networks that can be reached in the RT.

Dynamically

Through routing protocols that implement algorithms that determine the best path to a certain logical network.

Specific to routers.

Typical Internet protocols are OSPF and BGP.

In addition, the RT usually includes a special entry, known as the default path, which will be used in the case of no specific entry for a certain logical network. A reserved network identifier is used.

Routers in datagram networks
Destination-Based Forwarding - Forwarding Table (III)

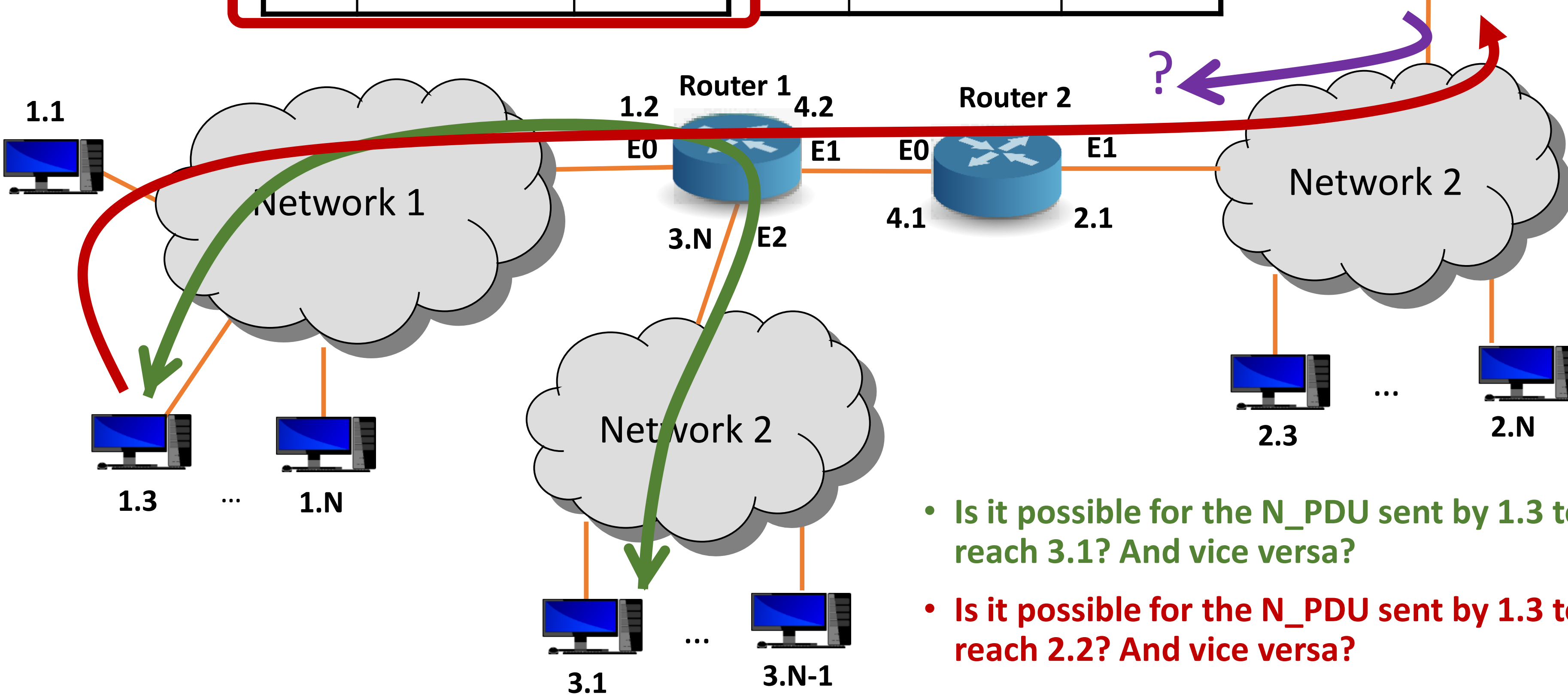
- When the Network Layer has to send a N_PDU, the only information it needs to use from the N_PCI to find out the next hop, is the destination IP address.
- The network layer will check the RT for an entry whose network field has a network identifier that matches the network identifier of the destination.
  - In case of finding that entry in the RT, it will deliver the N_PDU, without modifying in the N_PCI the source and destination IP addresses in the case of routers, to the next jump indicated in the input and through the interface indicated in the entry.
  - If the input found does not specify the next hop, it is because the destination is directly connected to the indicated interface. In that case it will deliver the N_PDU directly to the destination through the indicated interface.
  - If it does not find a suitable entry, it will discard the N_PDU.

Routers in datagram networks

Destination-Based Forwarding - Forwarding Table: Example

RT Router 1		
Net	**Next hop**	**Interface**
1	-	E0
3	-	E2
4	-	E1
2	4.1	E1

RT Router 2		
Net	**Next hop**	**Interface**
4	-	E0
2	-	E1
3	4.2	E0



- Is it possible for the N_PDU sent by 1.3 to reach 3.1? And vice versa?
- Is it possible for the N_PDU sent by 1.3 to reach 2.2? And vice versa?

Routers in datagram networks
Destination-Based Forwarding - Routing Table Principles

- Each network-layer device makes its own decisions, based on the information it has in its routing table.
- Just because a network-layer device has certain information in its routing table doesn't mean others have the same information.
- The fact that routing tables contain information capable of getting a N_PDU from a source network to a destination does not guarantee that they contain information necessary for the N_PDU to make the reverse path.

Lesson 4: Network layer

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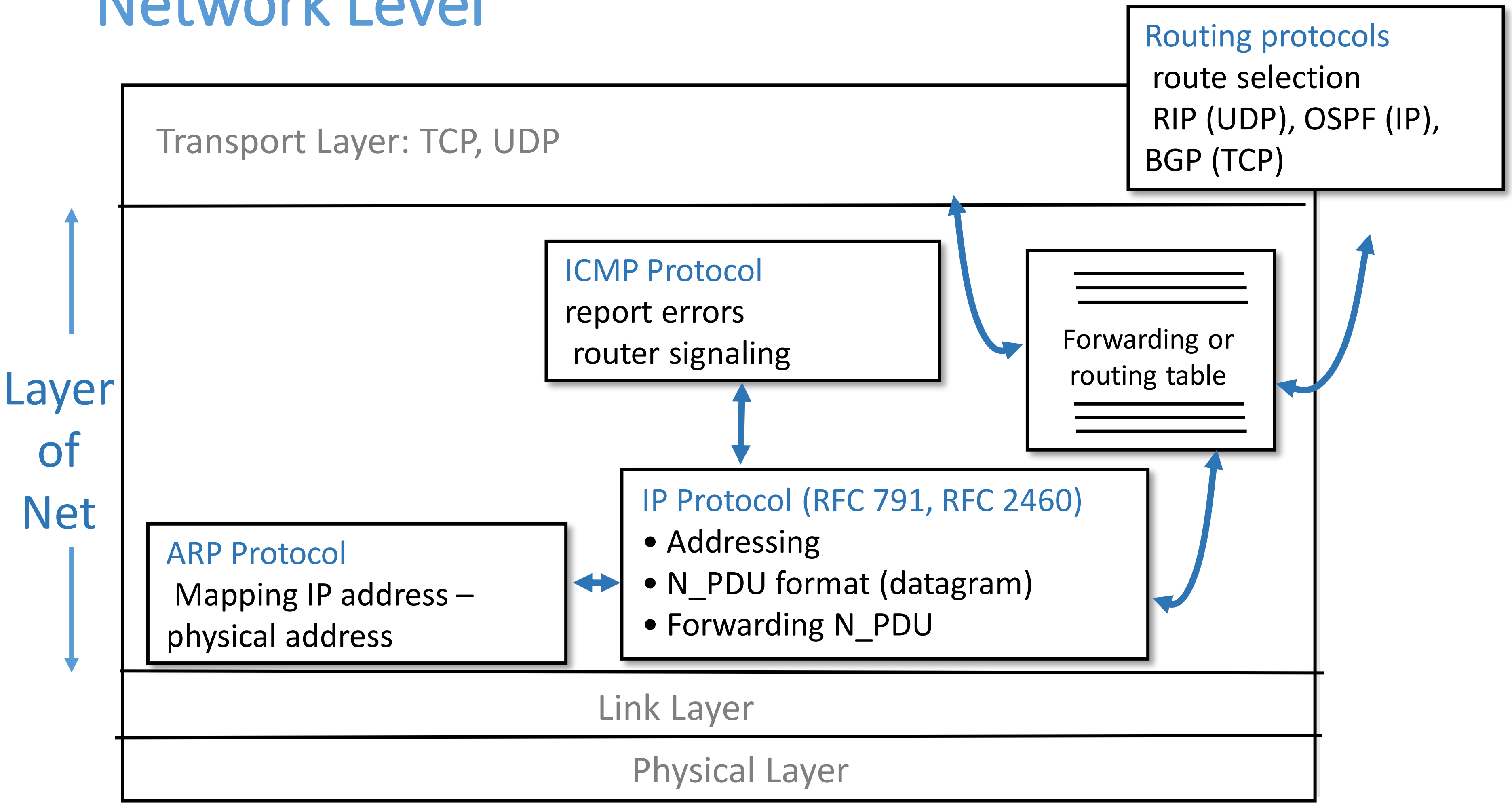
IP: Internet Protocol
Network Level



- There are several protocols at the Network layer that are present in both end systems and routers.
- The routing protocols in the traditional approach are in routers. Not all routing protocols operate at the Network Layer.

Lesson 4: Network layer

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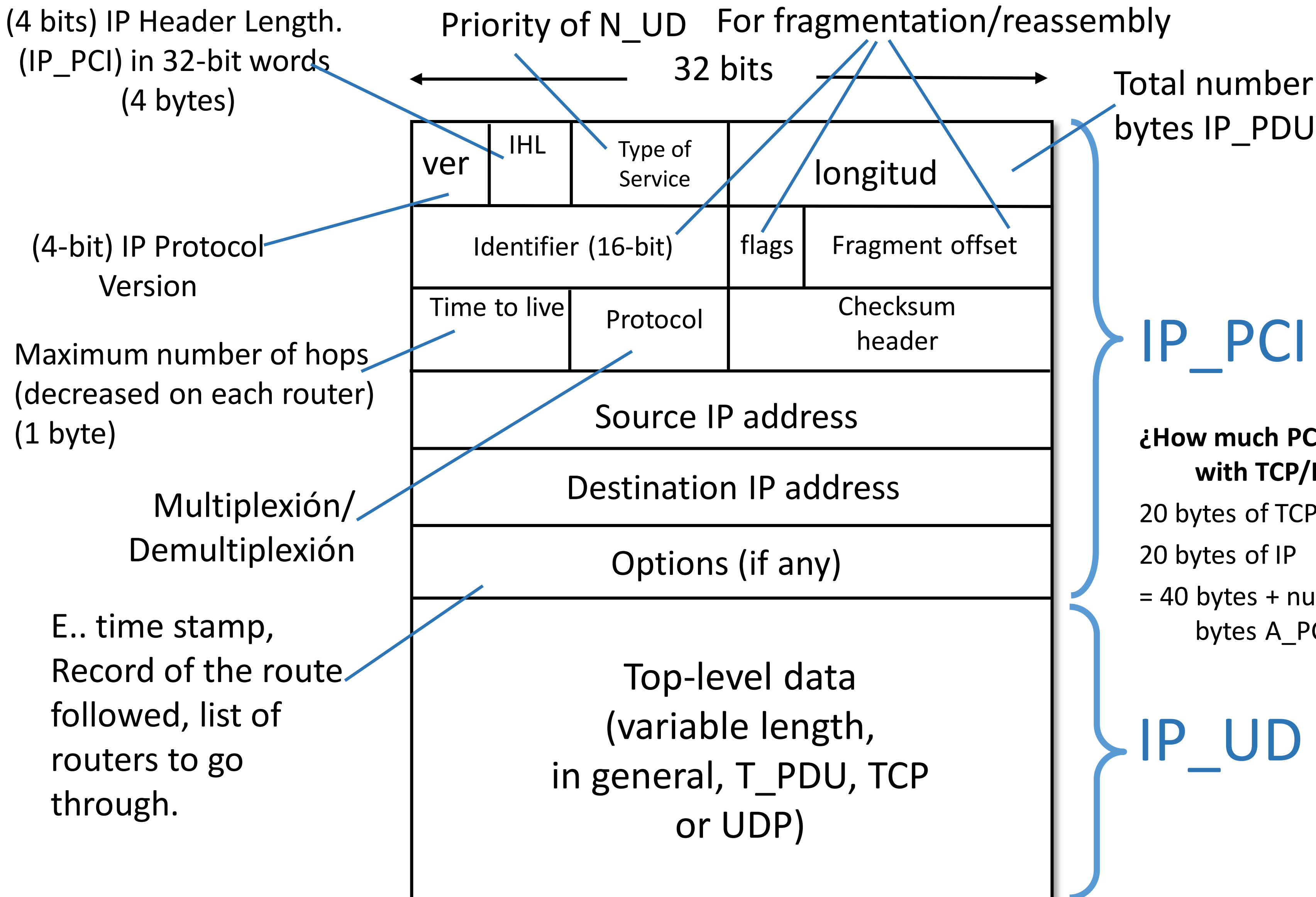
IP: Internet Protocol

IPv4 datagram format (IP_PDU or N_PDU)



¿How much PCI is added with TCP/IP to A_UD?

20 bytes of TCP

20 bytes of IP

= 40 bytes + number of bytes A_PCI

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IP: Internet Protocol
IPv4 addressing (I)

- This network-layer function allows you to define a mechanism to uniquely identify devices that are connected to a network.
- Known as a Level 3 address, logical address, or IP address for the TCP/IP architecture.
- Every device that has a network level has a network-level address (e.g. end systems, routers,...).
- Hierarchical addressing schemes (Red.Host) are used
  - A part of the N_PCI for addressing identifies the network (subnet). (Network)
  - Common to all devices on the same network.
  - Another party identifies the device with level 3 within the network (subnet). (Host)
  - It is often called host.

IP: Internet Protocol
IPv4 Addressing (II)

- Known as IP address or IPv4
- 32 bits (4 bytes) are used with a hierarchical addressing scheme:

Network ID	**Host ID**

  - The number of bits that identify the network and the number that identifies the host will depend on the addressing scheme used.
  - The notation used to represent an IPv4 address is:
  - 32-bit address:

    11001000001010001000000000100000
    - They group in bytes:
    - 11001000 00101000 10000000 00100000
    - Each byte is written in decimal and separated by dots: 200.40.128.32
  - Configurable manually or automatically.
  - In the final systems you have to configure IP address and border router IP address (more shortly).
  - Routers one IP address per interface.

IP: Internet Protocol
Direccionamiento IPv4 – Tipos direcciones IPv4

There are three types of ipv4 addresses:

- **Unicast**: IP_PDUs to a single destination.
  - All routers and end systems must have at least one unicast address.
- **Broadcast**: IP_PDUs to all devices (hosts and routers) on a logical network.
- Each logical network has a broadcast address.
- **Multicast**: IP_PDUs to a group of devices (host and routers) of the same or different logical network.
  - All devices in the same group must have the same multicast address configured.

IP: Internet Protocol
IPv4 Addressing – Special Addresses

	Address format		Meaning
Two meanings	Todos 0s		**This host**: Used as the source IP address when you don't have one (e.g. device without configuration). ***Identifier of any network*** *(Default path in the TE)*
Network address	Network ID	All 0s	***Logical network identifier*** *(Used in RT)*
Broadcast – Directed	Network ID	All 1s	Identifies all devices on a network.
Broadcast – Limited	All 1s		Identifies all devices on the network to which the source belongs
Loopback address *(localhost)*	127	Any digit	Used to communicate internal processes from the same team.

IP: Internet Protocol

IPv4 Addressing – Addressing Schemes

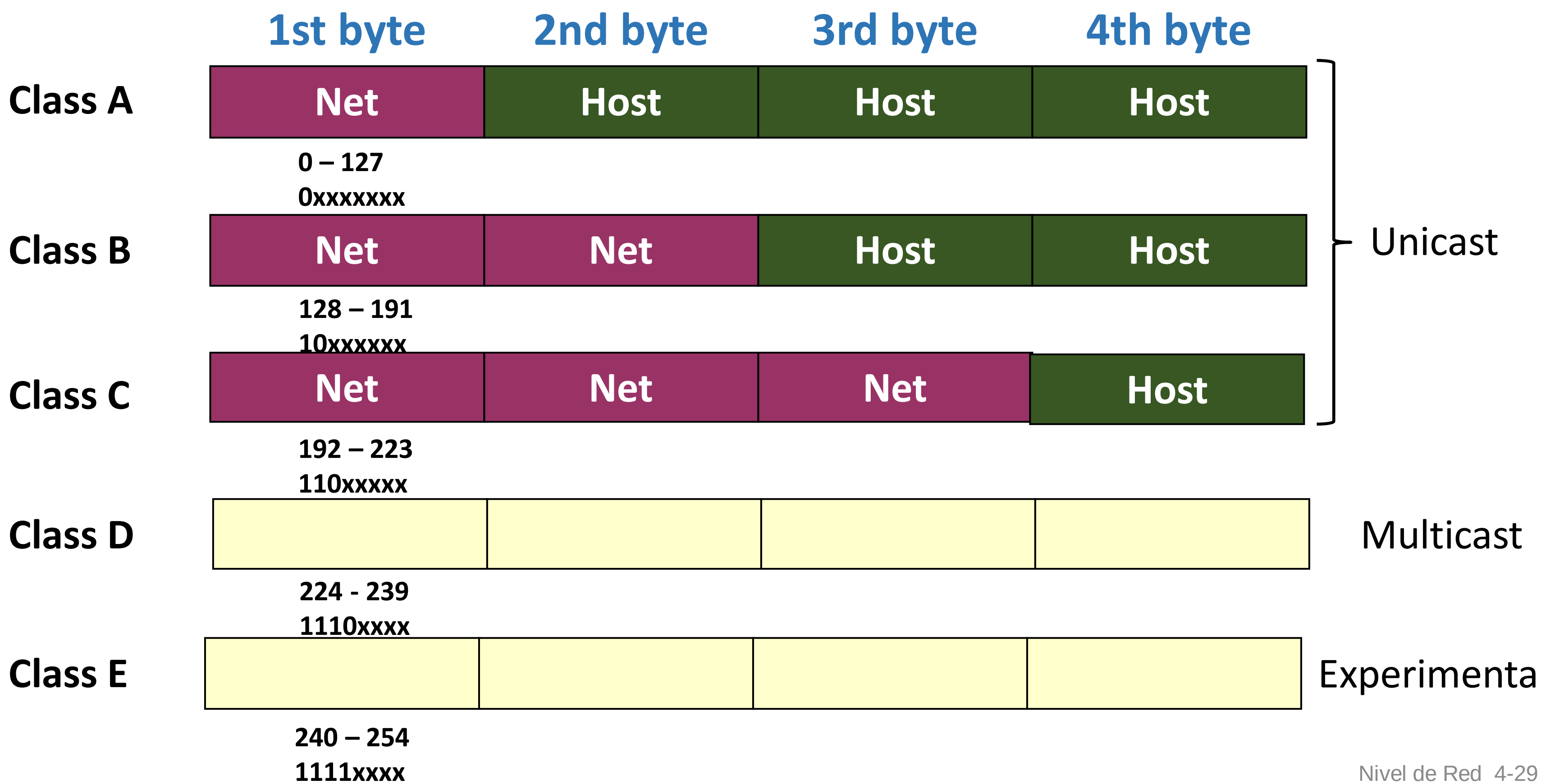
To determine which part of the IPv4 address identifies the network and which part identifies the host are used:

- Classful addressing (deprecated).
- Classless addressing (mechanism used today).

IP: Internet Protocol

IPv4 Addressing – Classful Addressing (I)

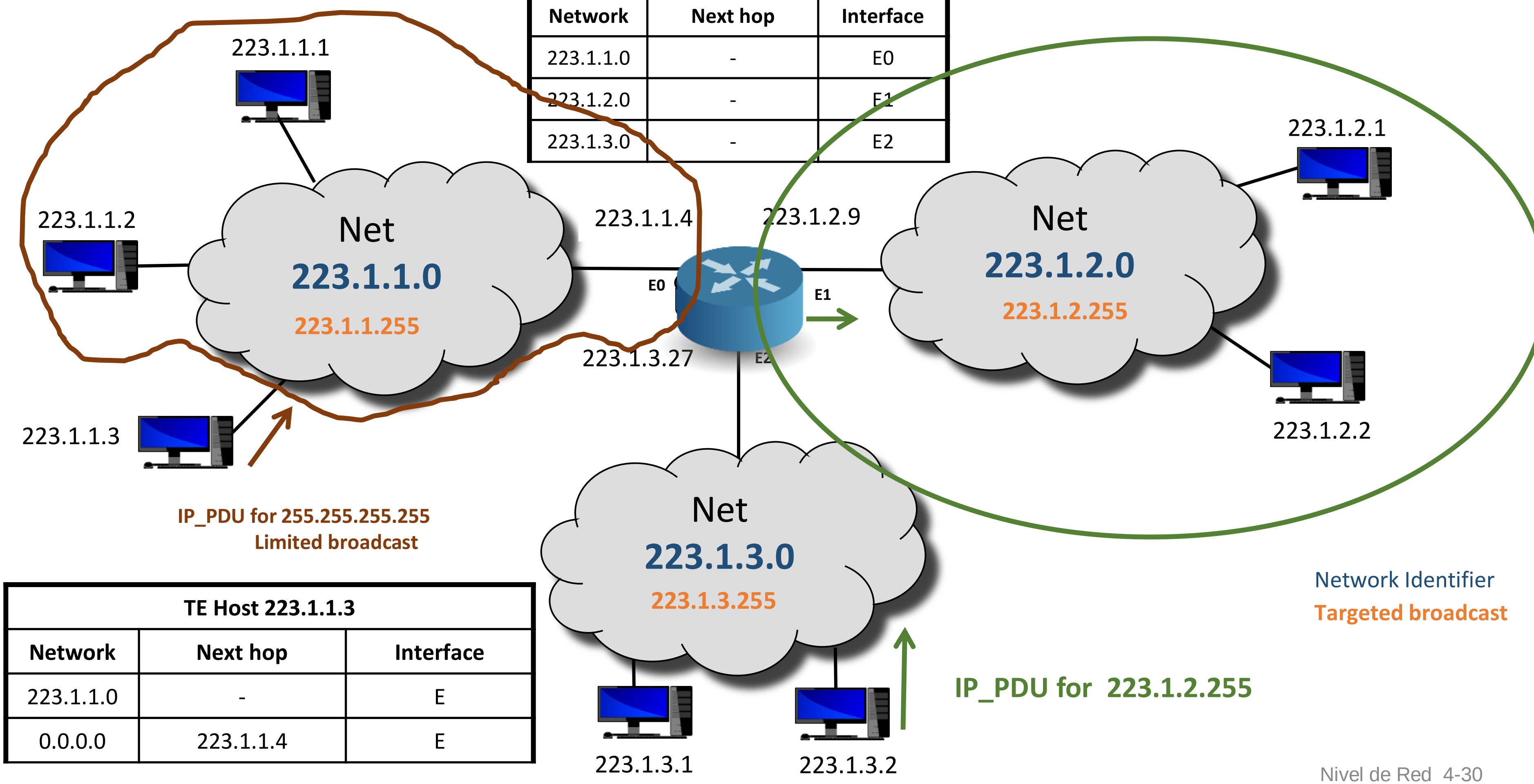
- It uses the first byte of the IP address to determine which party identifies the network and which part identifies the host.
- There are 5 address classes:



IP: Internet Protocol

IPv4 Addressing – Classful Addressing (II) – Example

- Class C, the last byte identifies the host and the rest the network.
- ¿How many devices with a maximum network level can be identified in each logical network?
-



TE Router		
Network	**Next hop**	**Interface**
223.1.1.0	-	E0
223.1.2.0	-	E1
223.1.3.0	-	E2

TE Host 223.1.1.3		
Network	**Next hop**	**Interface**
223.1.1.0	-	E
0.0.0.0	223.1.1.4	E

IP: Internet Protocol

IPv4 Addressing – Classful Addressing (III)

- Networks 1.0.0.0 – 126.0.0.0. Class A.
- Network 0 has a special use.
- 0.0.0.0 is the address that is used as the source if a network-level device is not configured.
- 0.0.0.0 is used to identify any network.
- It appears in the entry of the routing table that represents the default path.

Example of default route in RT		
Net	**Next hop**	**Interface**
0.0.0.0	223.1.3.27	E0

  - The 127 network has a special use. Used in internal communications.
  - 2^7 – 2 networks of 224 -2 addresses assignable to devices
- Networks 128.0.0.0 – 191.255.0.0. Class B.
- 2^{14} 216 – 2 host networks
- Networks 192.0.0.0 – 223.255.255.0. Class C.
  - 2^{21} 28-2 host addresses assignable to devices

IP: Internet Protocol
IPv4 Addressing – Classless Addressing (I)

To determine which party identifies the network and which part identifies the host at an IPv4 address, a bar is added to the network followed by a number (/x) indicating the number of bits of the network identifier (bar notation).

X can take values from 0 to 32.

For example, 223.234.0.0/16 would be the identifier of a logical network of equivalent size to a class B network.

Given a network prefix /x (2^{32-x}-2) network-level devices. can be addressed

For example, 223.234.0.0/16 would be a network identifier where:

- the broadcast address would be 223.234.255.255
- the range of IPs assignable to devices would be 223.234.0.1 to 223.234.255.254.

IP: Internet Protocol

IPv4 Addressing – Classless Addressing (II)

- When configuring network-level devices, the bar notation is typically used to specify the number of bits the network IDENTIFIER has.
- The /x is replaced by the netmask or subnet mask (name used interchangeably).
- It is a 32-bit number in which:
- The first X bits are at 1.
- The last 32-X bits are at 0.
  - The mask is represented the same as an IPv4 address.
  - for example a device with a network level that was assigned the ip 223.234.0.25/16 would be configured as:
  - IP Address: 223.234.0.25
  - Netmask: 255.255.0.0
- 0.0.0.0/0 is used to identify any network.
-

With netmask

Example of default route in RT		
Net	**Next hop**	**Interface**
0.0.0.0 – 0.0.0.0	223.1.3.27	E0

Network identifier - netmask

With bar notation

Example of default route in RT		
Net	**Next hop**	**Interface**
0.0.0.0/0	223.1.3.27	E0

IP: Internet Protocol
IPv4 Addressing – Classless Addressing (III)

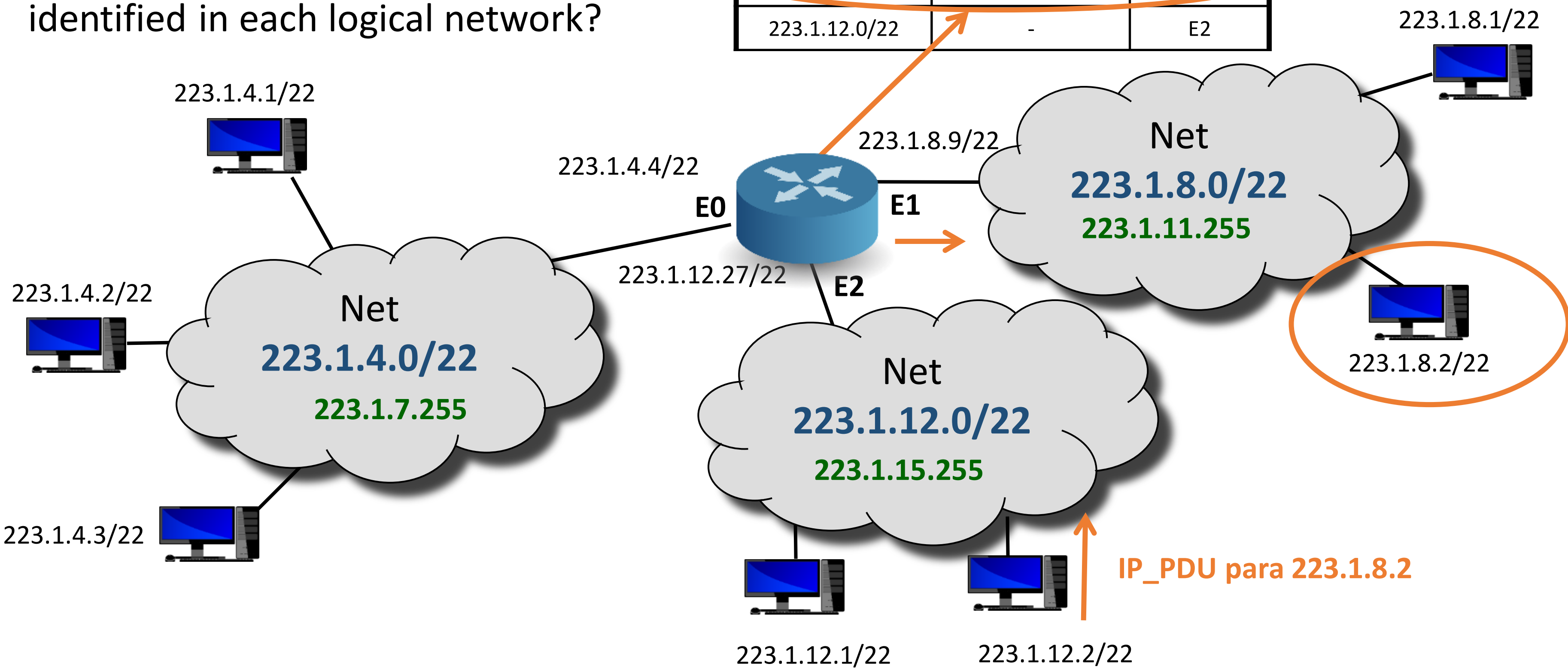
- This addressing scheme is known as **CIDR** (Classless InterDomain Routing) (RFC 4692).
- It allows you to assign IPv4 address blocks (known as CIDR blocks) according to real needs.
- No IPv4 addresses are wasted.
  - Example: If a company requires 2000 IPv4 addresses.
    - With classy addressing requires a complete class B network.
    - 2^{16} – 2002 addresses are wasted.
    - With CIDR with a network prefix /21 you would have 2^{11} – 2 addresses, 2046, which are sufficient.

IP: Internet Protocol

IPv4 Addressing – Example of Classless Addressing

- What is the netmask to configure on the devices?
- How many devices with a maximum network level can be identified in each logical network?

TE Router		
Net	**Next hop**	**Interface**
223.1.4.0/22	-	E0
223.1.8.0/22	-	E1
223.1.12.0/22	-	E2



note

TE Host 223.1.12.2/22		
Net	**Next hop**	**Interface**
223.1.12.0/22	-	E
0.0.0.0/0	223.1.12.27	E

Network Identifier
Directed broadcast

IP: Internet Protocol
IPv4 Addressing – Creating Subnets with CIDR

- From a CIDR block, it allows to address smaller logical networks, subnets, that fit the number of IP addresses required.
- All subnets created do not have to be the same size.
- To create the subnets, you have to borrow some of the bits that identify the host so that they can be identified to the subnet.
- Given a network with x bits of network prefix, if n bits are borrowed, with n being ≤ 32-x-2, then:
    - 2^n subnets of 2^{32-x-n}-2 are created – 2 IP addresses assignable to devices
    - x+n being the number of bits that identify the network within each subnet.

IP: Internet Protocol

IPv4 Addressing – Creating Subnets with CIDR - Example

- Let be the network prefix 200.23.16.0/23
- Network part | Host part

  11001000 00010111 0001000 | 0 00000000

- Borrowing one bit creates two subnets.
- Network part | Host part

Network part	Host part	
11001000 00010111 00010000	00000000	200.23.16.0/24
11001000 00010111 00010001	00000000	200.23.17.0/24

- If one of the new networks, e.g., 200.23.16.0/24 borrows a bit again, two other new subnets would be created.

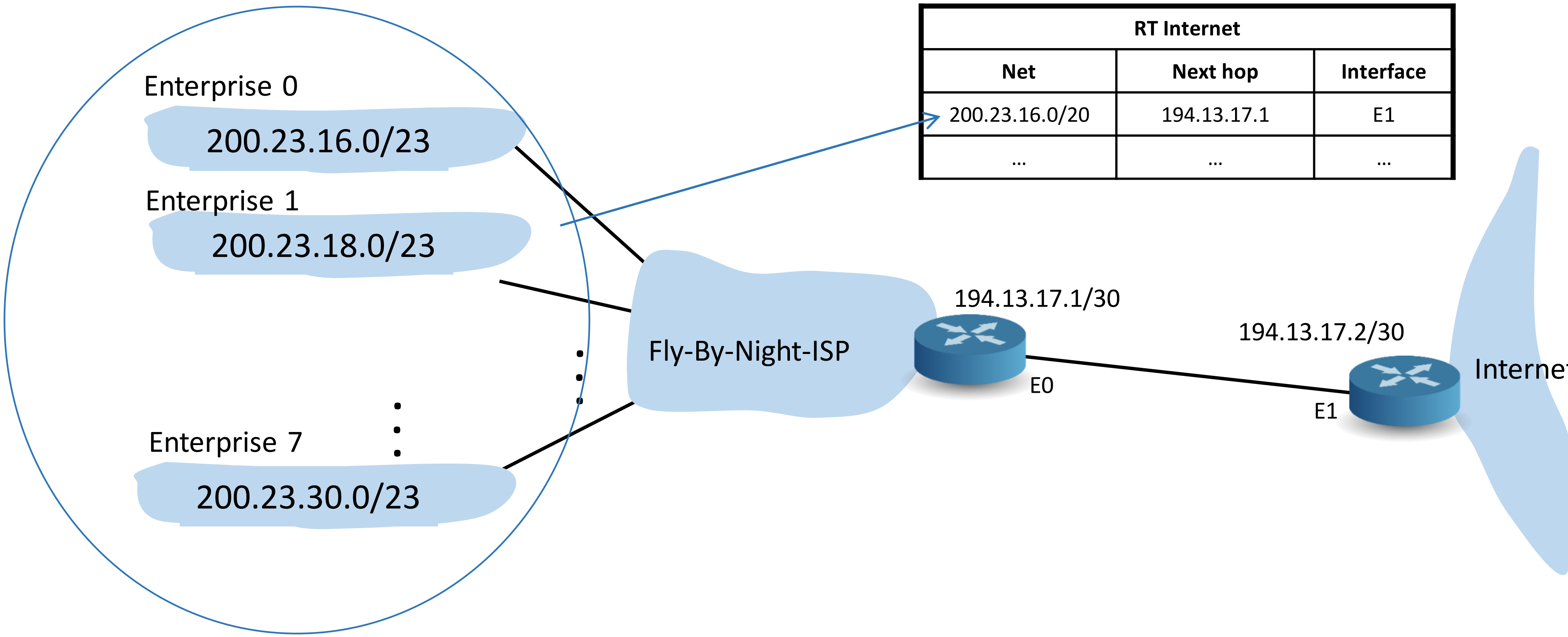
Network part	Host part	
11001000 00010111 00010000 0	0000000	200.23.16.0/25
11001000 00010111 00010000 1	0000000	200.23.16.128/25

- Then from the CIDR block 200.23.16.0/23 three networks have been created, the 200.23.16.0/25 and the 200.23.16.128/25 of 2^7-2 assignable addresses and the 200.23.17.0/24 with 2^8-2 assignable addresses.

IP: Internet Protocol

IPv4 Addressing – Benefits of Subnets with CIDR

- Allows routes to be added to routing tables.
- when you create subnets from a starting network prefix (cidr block) if all those subnets are accessible by the same interface they can be summarized by the starting network prefix.



RT Internet		
Net	**Next hop**	**Interface**
200.23.16.0/20	194.13.17.1	E1
…	…	…

IP: Internet Protocol
IPv4 Addressing – How are CIDR blocks assigned?

- There are no free blocks left.
  - The last one was assigned in February 2011.
  - Mobile devices.
    - Inefficient use of available address space.
    - High number of users on the Internet.
- ISPs distribute among their clients the CIDR blocks they are assigned.
  - It is no longer usually assigned fixed IP.
- If there are no free IPv4 addresses, how are the devices identified?
- Private addressing and NAT.
- IPv6
    - Progressive migration.
    -

IP: Internet Protocol
IPv4 Addressing – Private Addressing

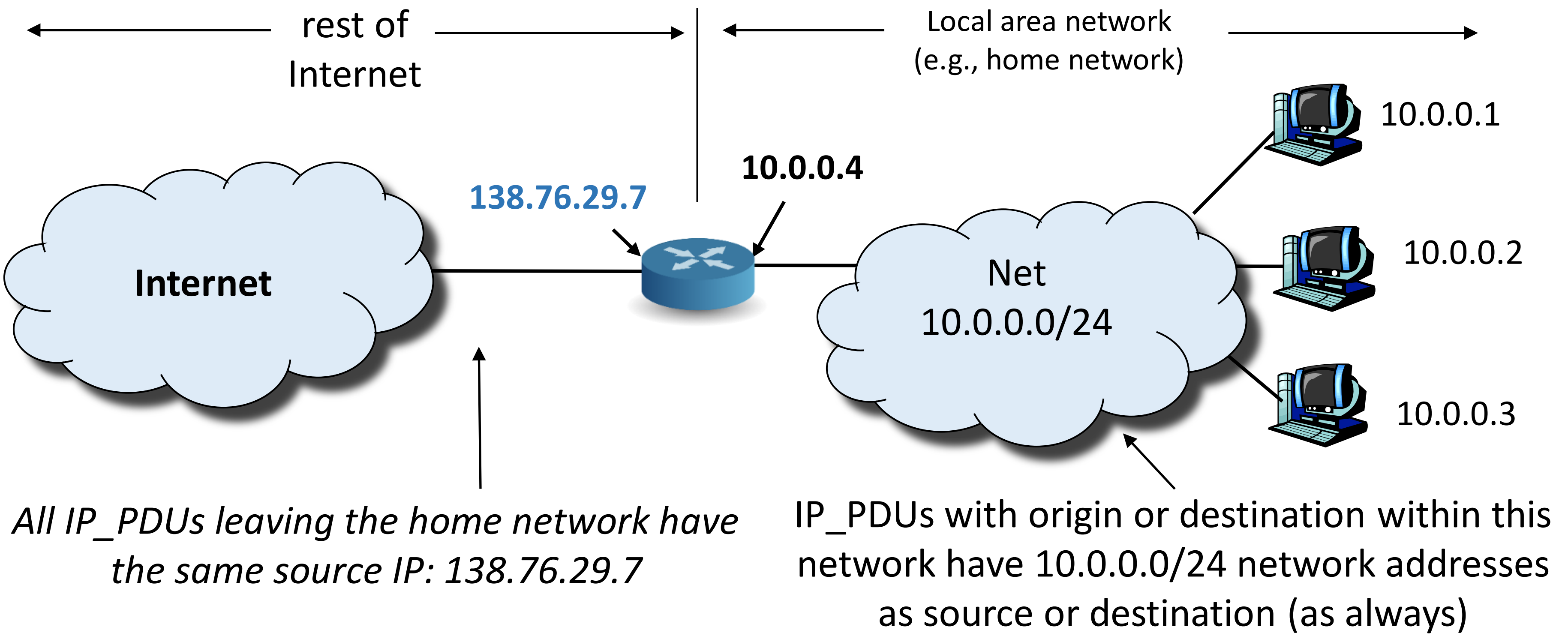
In 1996 a set of IPv4 addresses called private addresses were reserved (RFC 1918):

- It is nothing more than a range of IP addresses reserved to be used only in private networks (these IP addresses cannot appear in the core of the Internet).
- For example, addressing an Intranet that is not public, a laboratory, a home network...
- Reserved ranges:
-

"Class"	Address Range	CIDR prefix
A	**10.0.0.0 –10.255.255.255**	**10.0.0.0 /8**
B	**172.16.0.0 – 172.31.255.255**	**172.16.0.0 /12**
C	**192.168.0.0 – 192.168.255.255**	**192.168.0.0 /16**

IP: Internet Protocol
IPv4 Addressing – Private and NAT Addressing

- Private addresses along with NAT (Network Address Translation, RFC 3022) are used so that an entire network addressed with private IP addresses can access the Internet.
- NAT is typically implemented on routers.



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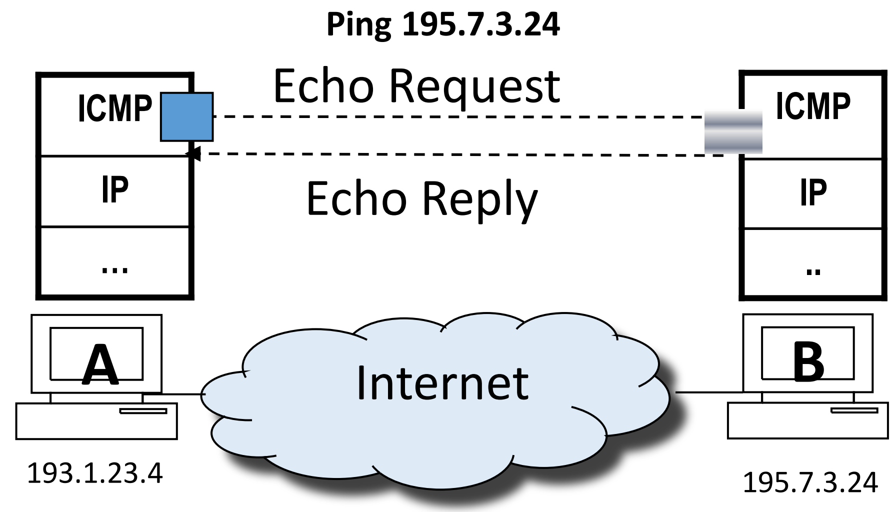
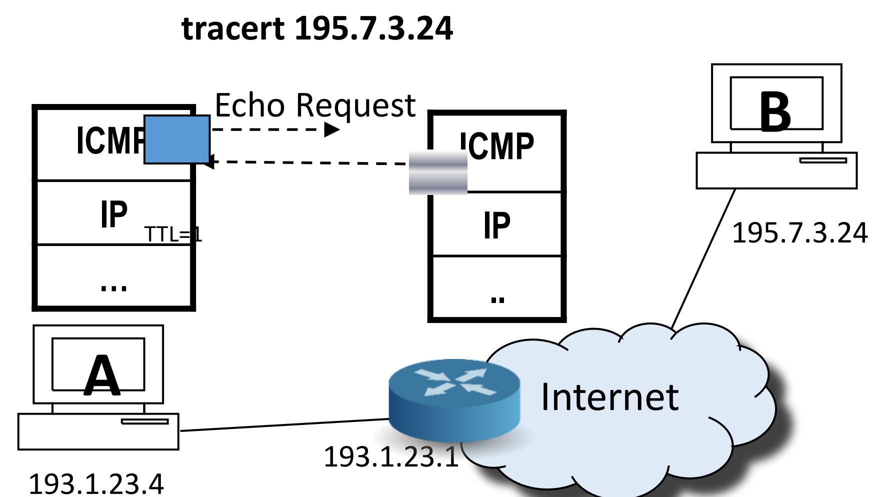
   - IPv4 addressing
   - **Introduction to ICMP**
   - Operation

IP: Internet Protocol
Introduction to ICMP

- **ICMP = Internet Control Message Protocol (RFC 792)**
- Used by end systems and routers to communicate network-level information
- Error reporting: unreachable host, or network, or port, or protocol, etc.
- Works "over" IP (network level):
  - The ICMP_PDUs (known as ICMP messages) are encapsulated in the IP_PDUs (IP datagrams).
- ICMP Messages:
  - Echo request/Reply (used by ping)
  - Expired TTL (used by tracert)





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IP: Internet Protocol
IPv4 (I) Operation

The internet network layer requires that network-level devices are configured and have the routing table populated:

- On the final systems at least you must configure IP address, mask and default router (border router). There are two ways to do this:
  - Manually using the operating system interface.
  - Automatically using some protocol, e.g. DHCP (Dynamic Host Configuration Protocol).
- In routers you have to configure the IP address of each interface that has active and its corresponding netmask.

note

In the final systems it is also convenient to configure the address of one or more name servers (DNS) to be able to translate names to IP addresses.

IP: Internet Protocol
IPv4 Operation (II)

The internet network layer requires that network-layer devices are configured and have the routing table populated:

- The RT of a final system has at least two inputs (automatically included).
- That of the logical network to which it belongs (does not need a next hop).
  - Default route, whose next hop is the border router.
- A router’s RT must have an input to each network achievable by it:
  - Entered manually.
    - E.g. default path.
  - Dynamically learned by a routing protocol.
  - At least the table includes directly connected networks, i.e. those that are accessed directly through their interfaces (they are entered automatically).

IP: Internet Protocol
IPv4 operation (III)

Before it can send a IP_PDU with a particular destination ip the ip protocol looks for an entry in the RT with a network to which that destination ip belongs:

- If that entry does not exist, it will not send the IP_PDU.
- if there is input, it will send the IP_PDU through the interface indicated in the RT, using the link-level services...
  - ...directly to the destination, if directly connected .
  - ... to the device (router) whose IP address matches the one indicated in the TE as the next hop.

Note

Before requesting the sending of the IP_PDU to the link level, it will be necessary to translate from IP address to MAC address using ARP protocol. More about it in the next lesson...

If the MTU of the data link level is not adequate, it would have to be fragmented.

IP: Internet Protocol
IPv4 (IV) Operation

When you receive a IP_PDU the network level checks whether the destination ip address is one of those that you have configured:

- If it matches, it will process the IP_PDU, uncapsulating it.
- If it doesn't match, then:
  - If it is a final system, it will discard the IP_PDU.
  - If it is a router, it will forward it, doing the following:
    - Check the value of the TTL field in the IP_PDU.
      - if it is 1, discard the IP_PDU (do not forward it).
      - otherwise, decrease the value of the TTL field by one unit.
      - Repeat the actions that the network level performs to send a IP_PDU.

IP: Internet Protocol

IPv4 Operation – Example sending IP_PDUs

De 223.1.8.2 a 223.1.8.1

De 223.1.8.2 a 223.1.16.1

What will be the value of the TTL when the IP_PDU 223.1.16.1 arrives to its destiny.

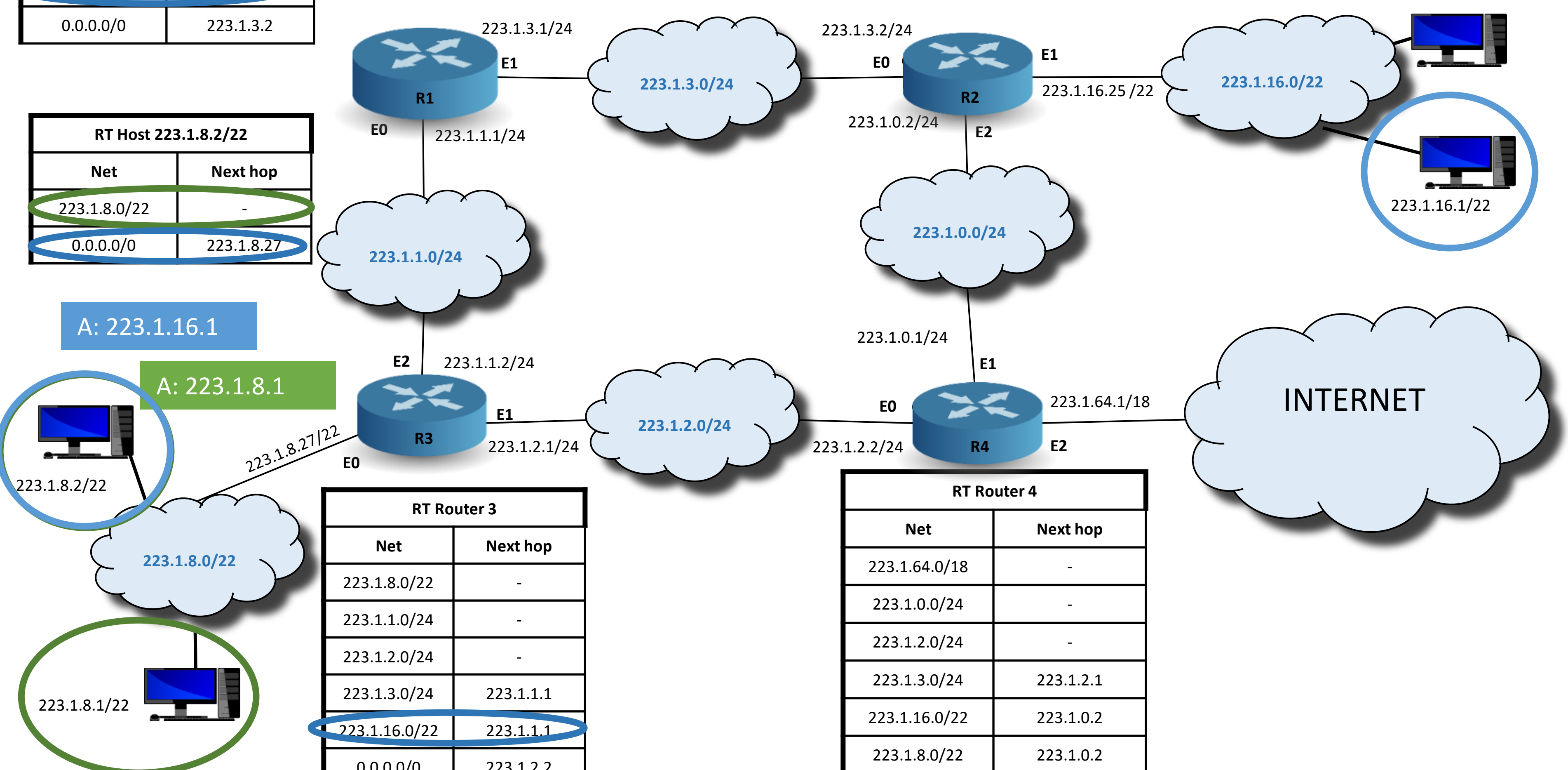
RT Router 1	
Net	**Next hop**
223.1.3.0/24	-
223.1.1.0/24	-
223.1.2.0/24	223.1.1.2
223.1.8.0/22	223.1.1.2
223.1.16.0/22	223.1.3.2
0.0.0.0/0	223.1.3.2

RT Router 2	
Net	**Next hop**
223.1.3.0/24	-
223.1.0.0/24	-
223.1.16.0/22	-
223.1.1.0/24	223.1.3.1
223.1.8.0/22	223.1.3.1
0.0.0.0/0	223.1.0.1

RT Host 223.1.8.2/22	
Net	**Next hop**
223.1.8.0/22	-
0.0.0.0/0	223.1.8.27

A: 223.1.16.1

A: 223.1.8.1



RT Router 3	
Net	**Next hop**
223.1.8.0/22	-
223.1.1.0/24	-
223.1.2.0/24	-
223.1.3.0/24	223.1.1.1
223.1.16.0/22	223.1.1.1
0.0.0.0/0	223.1.2.2

RT Router 4	
Net	**Next hop**
223.1.64.0/18	-
223.1.0.0/24	-
223.1.2.0/24	-
223.1.3.0/24	223.1.2.1
223.1.16.0/22	223.1.0.2
223.1.8.0/22	223.1.0.2
0.0.0.0/0	223.1.96.255

Nota: En las TR no aparece la interfaz

Computer Networks
Lesson 4

The Network Layer

Problems

Departamento de
Tecnología Electrónica

Problem 1

A router has received through one of its interfaces a IP_PDU without options of 2400 bytes that must be forwarded by another output interface whose MTU is 700 bytes. How many IP_PDUs will you forward through that interface? Indicate in your response the value of the IP_PCI identification, flag, offset of the fragment and length of each of these IP_PDUs

Problem 2

Suppose a company is assigned the CIDR block 200.1.0.0/24, determine in a reasoned manner how many subnets it could create within the company, what network prefix, broadcast address and assignable IP address range each would have, if the number of final systems to connect in each subnet is 20. Would your answer change if there were 30 end systems?

Figure 1 shows the network of a company that is connected to the Internet through the R1 E2 interface and is assigned the CIDR 200.1.2.0/24 block. (Rext does not belong to the company.)

How many broadcast domains are there?

a) Write the routing table of Rext.
b) Assign network prefixes to the subnets of the company, if in the subnet of PC A there are 30 PCs and in that of PC D there are 90 PCs. You should leave the largest number of IPs unallocated for future expansions of the company's network.
c) Indicate the IPv4 configuration, according of PC A, PC D and the contents of the R1 routing table if all end systems must have access to the Internet and the rest of the company's end systems.

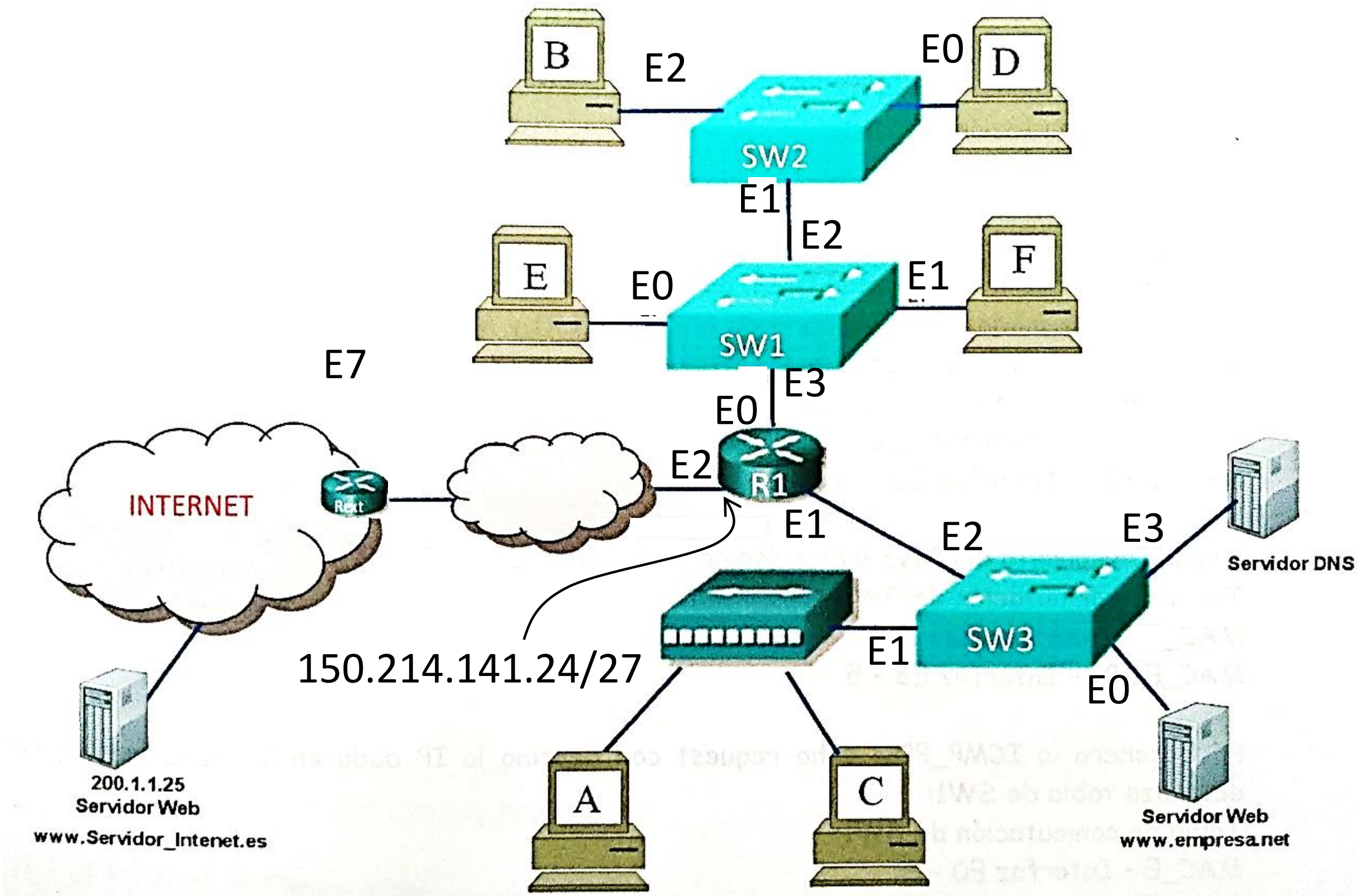
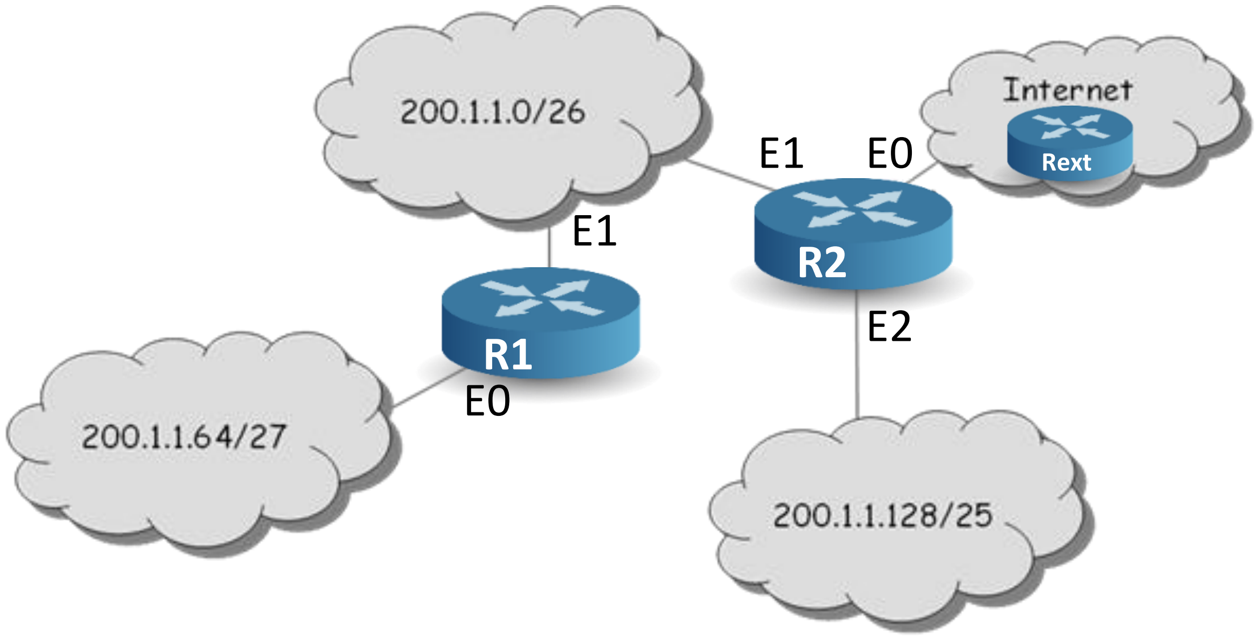


Figura 1

Problem 3

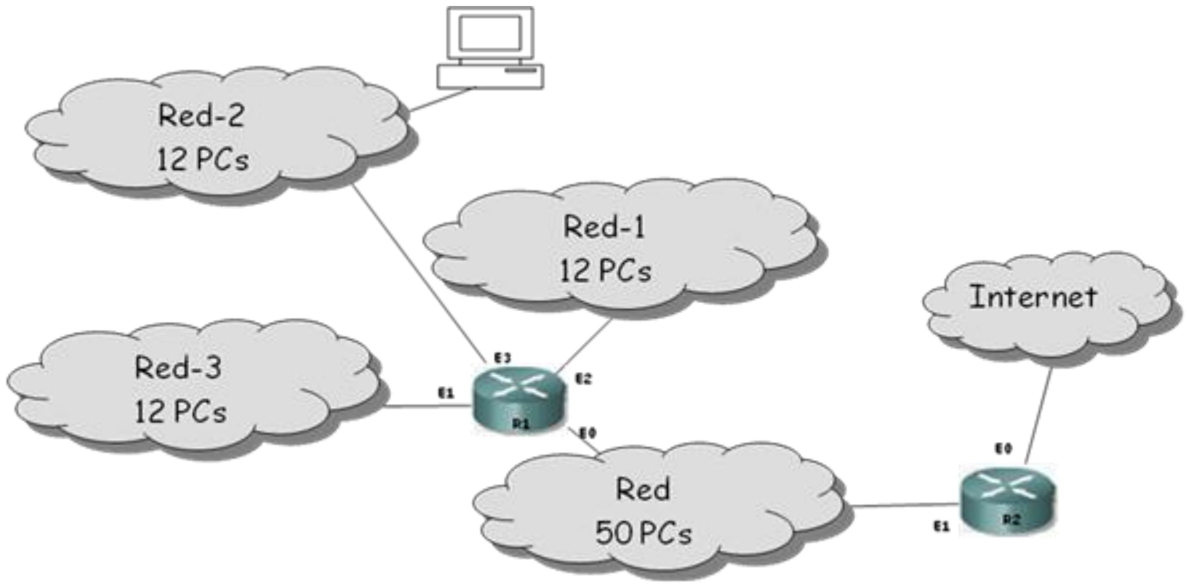
The following figure shows the network of a public company that accesses the Internet through an R2 router and is assigned a single CIDR block. Determine:



a) How many end systems at most can be connected in each subnet of the company?
b) Do router R2 need to implement NAT?
c) Assume that R2 does not implement NAT. What network prefix would appear in the routing table of an Internet router, for example RI, to identify this company's network?
d) Could the company address a new subnet? How many end systems could I connect at most?
e) Assume that the R2 E0 interface has the following configuration IP address=223.14.15.1, mask=255.255.255.252, and that all end systems must have access to the Internet and communicate with other end systems in the enterprise. Indicate the configuration of the interfaces of the R1 and R2 routers, the minimum content of the routing tables of R1 and R2, as well as that of a final system of each subnet of the company.

Problem 6

The following figure shows the network of a public company that accesses the Internet through R2 router. Determine:



a) Would it be possible to address all the subnets of the company from the CIDR block 200.1.1.0/25?, if so perform the assignment of network identifier for each of the subnets of the company.

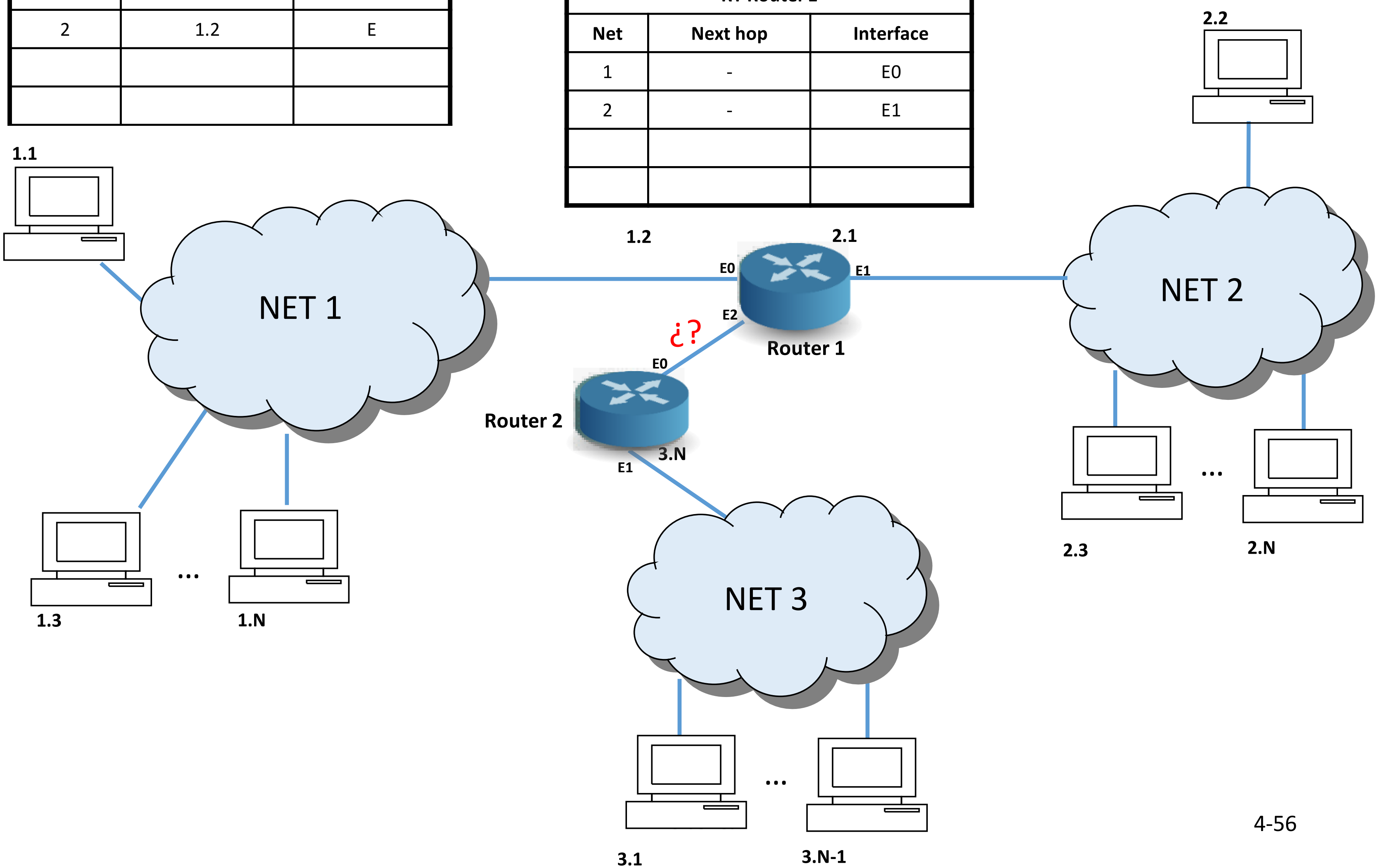
b) Would it be possible to connect a new subnet of 13 PCs to a free R1 interface?, if yes, indicate the contents of the R2 routing table that makes the number of entries in it minimal. (Note: The R2 E0 interface has the following configuration IP address=223.14.15.1, mask=255.255.255.252. All of the company's PCs have access to the Internet.)

c) Would you change your response to question B, if the subnet is connected to a free interface of R2 instead of R1?

Example routing table

RT Host 1.1		
Net	**Next hop**	**Interface**
1	-	E
2	1.2	E

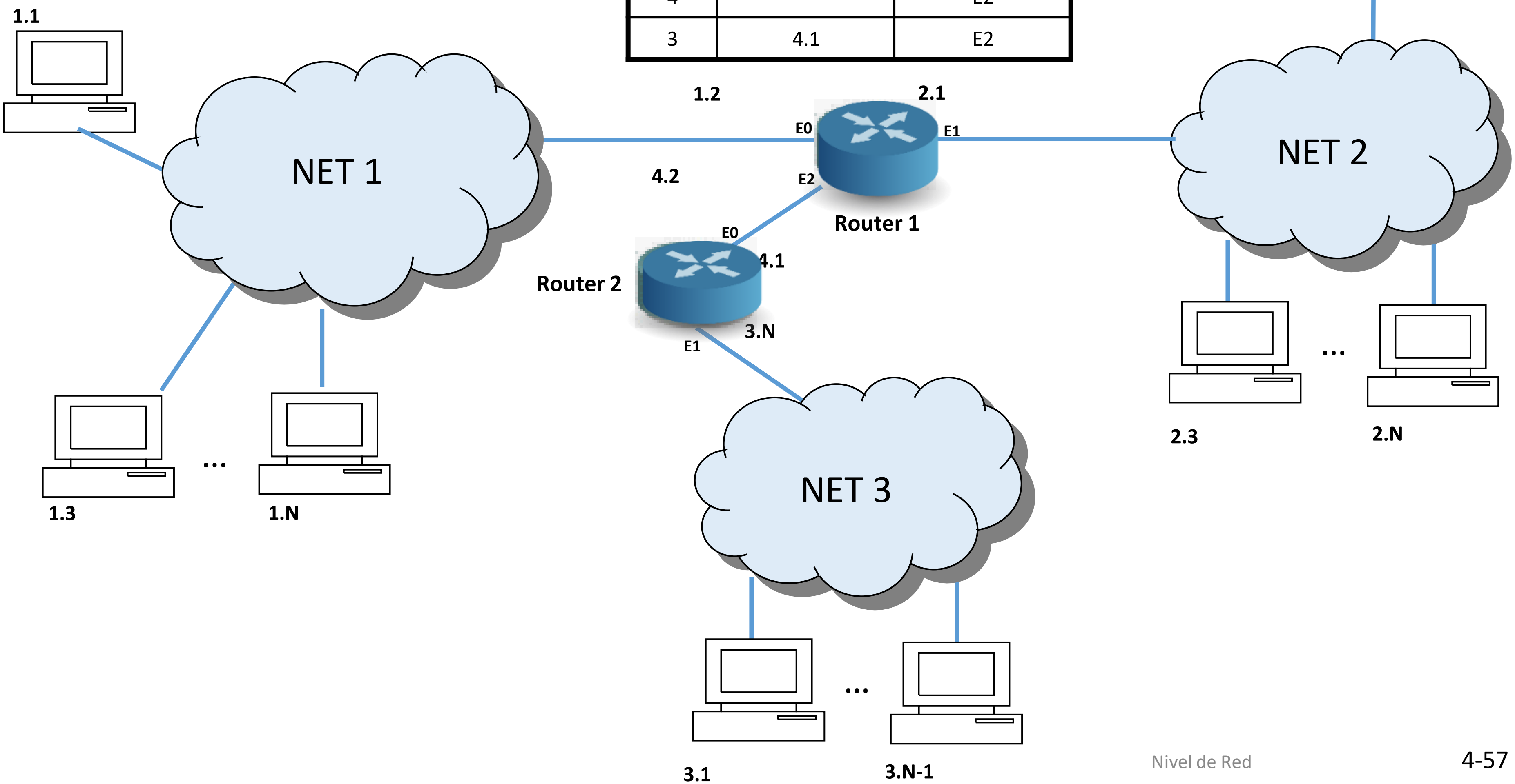
RT Router 1		
Net	**Next hop**	**Interface**
1	-	E0
2	-	E1



Example routing table

RT Host 1.1		
Net	**Next hop**	**Interface**
1	-	E
2	1.2	E
3	1.2	E
4	1.2	E

RT Router 1		
Net	**Next hop**	**Interface**
1	-	E0
2	-	E1
4	-	E2
3	4.1	E2



Example routing table

RT Host 1.1		
Net	Next hop	Interface
1	-	E
RedC	1.2	E

RT Router 1		
Net	Next hop	Interface
1	-	E0
2	-	E1
4	-	E2
3	4.1	E2