Computer Network

November 29, 2023

1 Lesson 1

Let's introduce the two most imported network models:

- TCP/IP: it describes the functions performed in particular layers by popular set of network protocols (TCP and IP)
- ISO/OSI: it describes all stages of communication in various computer networks (descrive cosa accade perfettamente nella comunicazione)

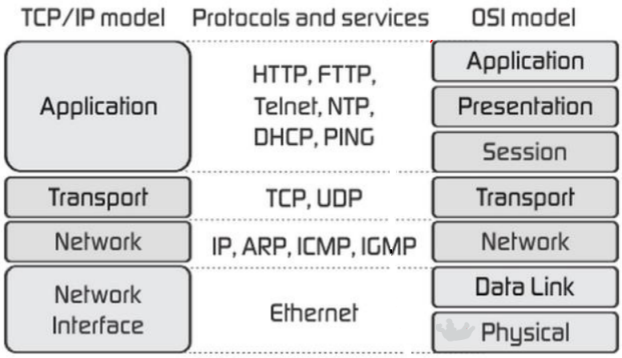


Figure 1: Models

Two important words used in the word of computer network are:

1. **Encapsulation**
   - On the transmitting side before sending the telecomunications packet over the network
   - Packing data from a higher layer to a lower layer
2. **Decapsulation**
   - On the receiving side after receiving the package
   - Decompressing data from a lower layer to a higher one

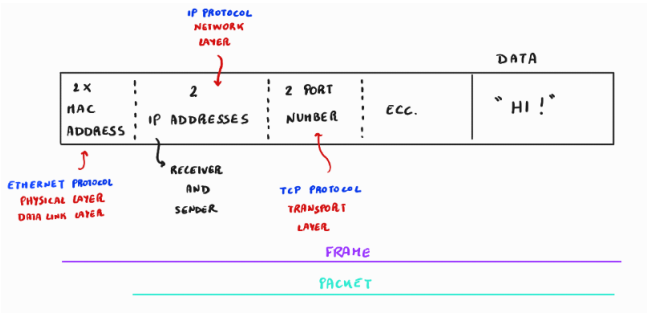


Figure 2: Schema alla lavagna

Ogni model ha due dei layers e si parte dall'analisi dal basso:

- Physical layer: è come un walky-talky (non posso verificare l'integrità dei dati). I bits del physical layer sono per sincronizzazione (ethernet contiene sia physical layer che data link layer)
- Data link layer: i MAC-address sono univoci e caratteristici per ogni device (identifica il device)
- Network layer: caratteristica di questo layer sono gli indirizzi ip
- Transport layer: ogni applicazione ha una porta diversa: posso usare più applicazioni contemportaneamente

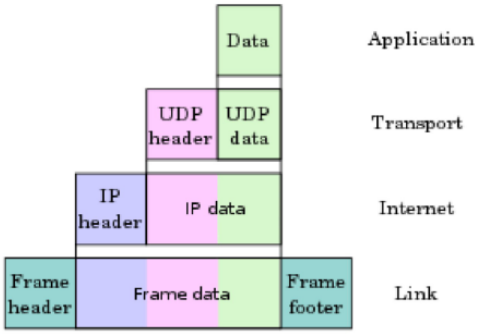


Figure 3: Example of decapsulation

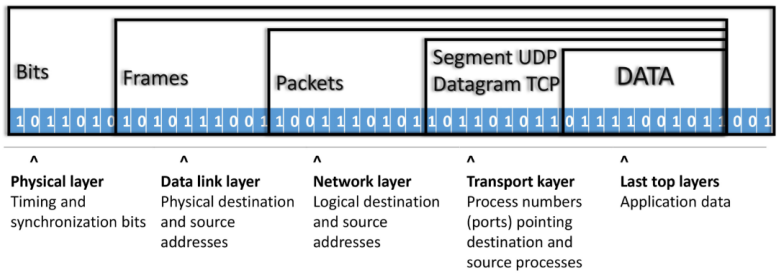
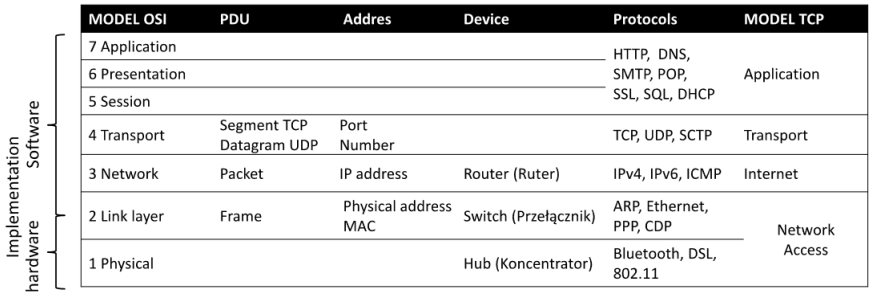


Figure 4: Inside the encapsulation



MODEL OSI	PDU	Addres	Device	Protocols	MODEL TCP
7 Application				HTTP, DNS, SMTP, POP, SSL, SQL, DHCP	Application
6 Presentation					
5 Session					
4 Transport	Segment TCP Datagram UDP	Port Number		TCP, UDP, SCTP	Transport
3 Network	Packet	IP address	Router (Ruter)	IPv4, IPv6, ICMP	Internet
2 Link layer	Frame	Physical address MAC	Switch (Przełącznik)	ARP, Ethernet, PPP, CDP	Network Access
1 Physical			Hub (Koncentrator)	Bluetooth, DSL, 802.11	

Figure 5: Network protocols

2 Lesson 2

Who connects to the network? Network devices:

- Client (workstation) / Server
- Network nodes (Hub, Switche, Router)

It's important the definition of **Hosts**: network devices with an ip-address (router-workstation).

The **Hub** works at the I layer of the ISO/OSI model.
Hubs form collision domain and it have the problam that if I send a mail from PC3 to PC1, all the other devices connected to the hub will recive the same mail.
Se mando 2 messaggi contemporanemente -> COLLISIONE :(

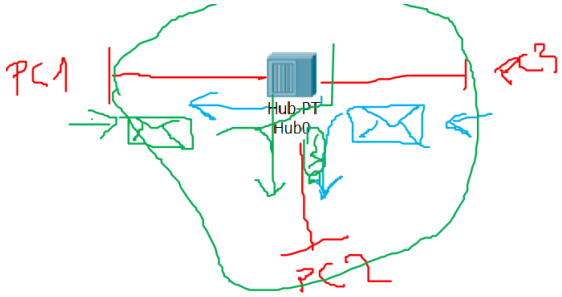


Figure 6: Collision domain in the hub

The **Switch** works at the II layer of the ISO/OSI model.
It is characterised from the MAC-address (if I want to send a mail from PC3 to PC1, i need to insert the MAC-addresses of PC1 and PC3).

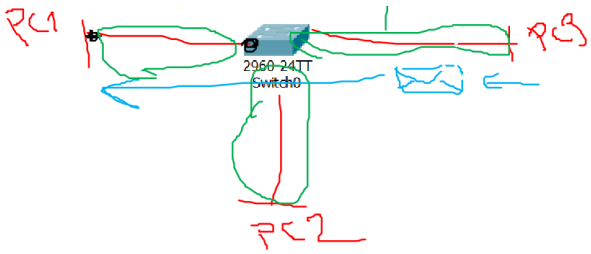


Figure 7: Collision domanin in the switch

The **Router** works at the III layer of the ISO/OSI model.
In this case for sending the mail, i need to insert the two MAC-addresses of PC3 an PC1 but the two IP-addresses of the same PC too.
The collision domains are the same of the switch.

A question of the exam is finding the broadcast and the collision domains in a network, like in the example behind.

Un dominio di broadcast è un insieme di dispositivi in una rete che possono scambiare dati a livello datalink (Wikipedia)

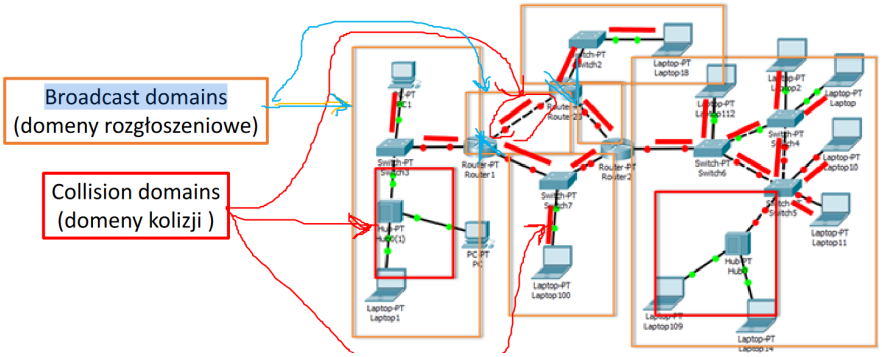


Figure 8: Distinction beet-wen broadcast and collision domains

Devices working as routers used in home or SOHO (Small Office / Home Office) they combine a router, switch, access point (wi-fi), firewall, ...
The networks supporting companies and institutions are built in network cabinets and consist of devices dedicated to each task separately.

The operating system used in the CISCO devices is IOS (Internetwork Operating System).

Ways of gaining access to CISCO network devices:

- Access via the **console port**
- Access via **Telnet** or **SSH**
- Access via the AUX port
- Access via USB
- ...

3 Lesson 3

There are 3 tipes of area network:

- Wide area network (**WAN**): It covers a larger area
- Metropolitan area network (**MAN**): Area "city"
- Local Area Network (**LAN**): A small area

SWITCHING is a method of forwarding frames on local networks.

- Switch operates in layer II of the ISO / OSI model - the data link layer
- PDUs (protocol data units) are called "**frames**"

ROUTING IS finding the best routes on the web.

- Router operates in layer III of the ISO / OSI model - the network layer
- PDUs (Protocol Data Units) are called "**packets**"

A question of the exam can regards the knowledge of packets and frame.
An example of network connections can be the ones in the behind figure:

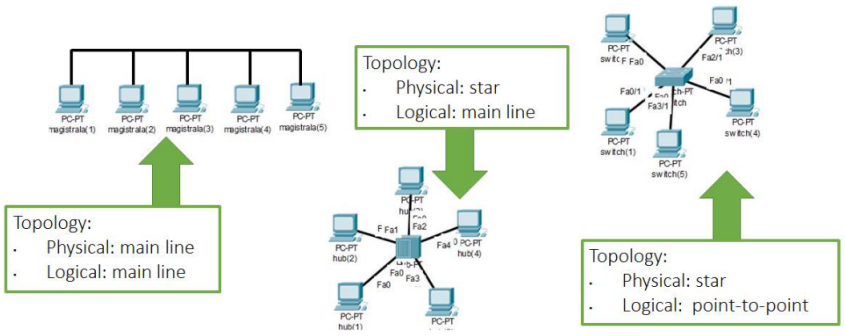
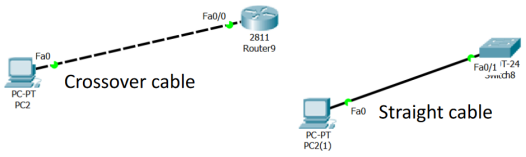


Figure 9: Example of network connections

The ways of data transmission in networks are:

- Unicast transmission: the frame is only sent to one device
- Multicast transmission: the message is directed only to a selected group of hosts
- Broadcast transmission: a special address is used that allows all nodes to receive and process the frame

A question that I can find in the exam, regards the following image. It's important to know when I need to use a straight cable and when I need to use a crossover cable.



	Hub	Switch	Router	Working station
Hub	crossover	crossover	straight	straight
Switch	crossover	crossover	straight	straight
Router	straight	straight	crossover	crossover
Working station	straight	straight	crossover	crossover

Figure 10: Straight and crossover cable

3.1 Ethernet in link layer

Ethernet è lo standard al livello più basso della pila (usato nelle local area network).
Ethernet is defined by **Data Link** layer and **Physical** layer protocols.

Let's watch how a ethernet frame is composed:

- Preamble: 56 bit combination (10101010...) allows devices in the network to easily synchronize receiver clocks, ensuring bit-level synchronization.
- SFD start frame tag 10101011 that marks the end of a preamble and indicates the start of an Ethernet frame. The SFD is designed to interrupt the preamble bit pattern and signal the start of an actual frame
- Field Etherype or length: 0-1500 - describes the maximum length of the datagram (Ethernet 802.3) and ¿1536 - describes the EtherType value (Ethernet II DIX)
- Pole FCS: checksum in accordance with CRC-32
- IPG (interpacket gap): the minimum required interval between network frames

Layer	Preamble	Start frame delimiter	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interpacket gap
	7 octets	1 octet	6 octets	6 octets	(4 octets)	2 octets	46-1500 octets	4 octets	12 octets
Layer 2 Ethernet frame	← 64–1522 octets →								
Layer 1 Ethernet packet & IPG	← 72–1530 octets →								← 12 octets →

Figure 11: Caption

A separate discussion must be made for the addressing, just because it's important to know that each device in the ethernet network has its own unique address and it is 48 bit.

What about the CISCO addressing? There is a fixed part that represent the producer and a variable part, like in the figure behind:

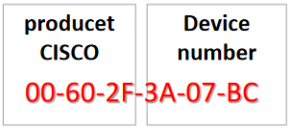


Figure 12: CISCO addresses

Frame addresses can be:

- **Unicast**: specify a transmission linking one receiver and one sender. Most of adresses in MAC pool
- **Multicast**: use Ethernet frames with MAC addresses in the range 01:00:5e:00:00:00 - 01:00:5e:7f:ff:ff
- **Broadcast** Layer 2 devices (switches) pass to all interfaces. FFFF.FFFF.FFFF

3.2 Cut-Through vs Store-and-Forward

This will be a little subsection in which we find the differces beetween:

Store-and-Forward Switching

- Uploading will wait for the entire frame to arrive before transmitting it
- The LAN switch will write every complete frame to the switch's memory buffers and check for errors before making a forwarding decision (CRC)
- If there are no errors, the frame will be sent to the destination address. Otherwise, the damaged frame will be rejected

Cut-Through Switching

- The switch searches the first 6 bytes of the received frame (after the preamble)
- Based on the read MAC address, the switch will check the destination MAC address in its switch table, determine the port of the outgoing interface, and redirect the frame to the destination
- No CRC error checking in the switching process

3.3 Switch association table (MAC table)

It is a table linking the switch port numbers to the MAC address and the basic switch operation control table is: **Switch> show mac address-table**

```
Switch>
Switch>show mac ?
  address-table  MAC forwarding table
Switch>show mac add
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    0001.430a.76da    DYNAMIC     Fa6/1
   1    0001.64a1.8537    DYNAMIC     Fa6/1
   1    0001.9619.4ec0    DYNAMIC     Fa6/1
   1    00d0.ba17.2dd6    DYNAMIC     Fa6/1
   1    00d0.baed.b04a    DYNAMIC     Fa6/1
```

Figure 13: MAC table

The ARP protocol provides two basic functions:

- Mapping IPv4 addresses to MAC addresses
- Maintaining a mapping in ARP table

The **ARP table** is an array in RAM that connects network layer (IPv4) addresses with host hardware (MAC) addresses. It is stored in layer 3 devices (network), so if I want to check the ARP table I need to use the command: **Router> show arp**

```
Router>
Router>
Router>show arp
Protocol  Address          Age (min)  Hardware Addr   Type   Interface
Internet  192.168.20.2           -   00D0.FF6B.CE01  ARPA   FastEthernet0
Router>
Router>
```

Figure 14: ARP table

4 Lesson 4

Ethernet is the protocol used for the switches.
IPv4 and IPv6 are the protocols used for the routers.

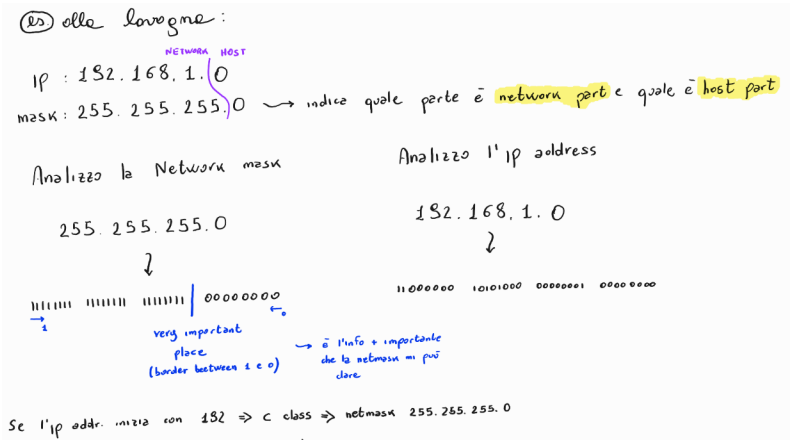


Figure 15: Esempio alla lavagna

Up to 40 years ago, the net-masks were fixed and standard:

Class	First octet	IP address range	Net mask	Number of networks	Number of hosts
A	0 _ _ _	0.0.0.0 - 127.255.255.255	255.0.0.0	127	16.777.214
B	1 0 _ _	128.0.0.0 - 191.255.255.255	255.255.0.0	16.382	65.534
C	1 1 0 _	192.0.0.0 - 223.255.255.255	255.255.255.0	2.097.150	254
D	1 1 1 0	224.0.0.0 - 239.255.255.255	for broadcast transmission		
E	1 1 1 1	240.0.0.0 - 255.255.255.255	Reserved for IETF		

Figure 16: Net-masks 40 years ago

There are ip addresses that are not public. They are called local addresses:

Class	IP address range	Net mask	CIDR notation
A	10.0.0.0 – 10.255.255.255	255.0.0.0	10.0.0.0/8
B	172.16.0.0 – 172.31.255.255	255.240.0.0	172.16.0.0/12
C	192.168.0 .0 – 192.168.255.255	255.255.0.0	192.168.0.0/16

Figure 17: Local addresses

Let's analyse, now, what is a routing table:

- Table in the memory of a network device (es. router)
- Stores information about routes for specific purposes on the web
- It helps the router determine where to send packets

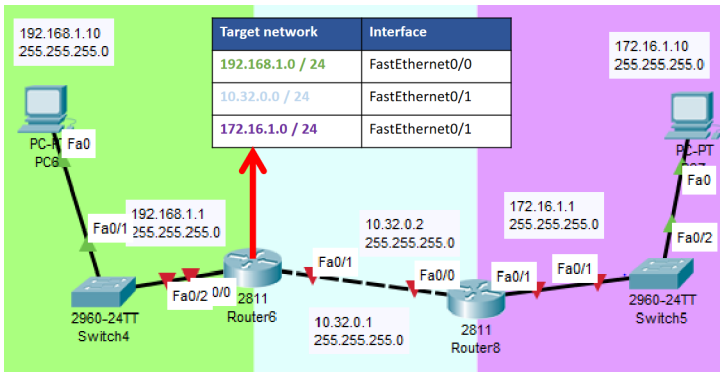


Figure 18: Routing table

All'esame saranno presenti esercizi riguardo questo capitolo.
Sono presenti nelle note scritte su tablet.