LESSON E9_EN. INTERNET BASIC STRUCTURES AND ARCHITECTURES. THE BRICKS AT THE BASIS OF THE INTERNET. THE LANS. THE ETHERNET.

Parent Entity: IPA SA, Bucharest, Romania, 167 bis, Calea Floreasca; Fax: + 40 21 316 16 20
Authors: Professor Gheorghe Mincu Sandulescu, PhD, IPA SA, Bucharest, Romania, 167 bis, Calea Floreasca,
Mariana Bistran, Principal Researcher, IPA SA, Bucharest, Romania, 167 bis, Calea Floreasca, e-mail: san@ipa.ro. Consultations: Every working day between 9.00 a.m. and 12.00 p.m.

After learning this lesson you will acquire the following knowledge:
- The features of LANs.
- Ethernet as the main type of LANs.
- The Ethernet practice. The bus and the Hub / Switches topologies.
- How to construct the Ethernet LANs. Ethernet coaxial cables and coaxial cabling.
- How to use the IEEE coaxial cables for the Ethernet LANs.
- The main troubleshooting in the use of the Ethernet LANs.

CONTENT OF THE LESSON

1. THE LANs IN THE WORLD OF NETS.
2. THE CHARACTERISTICS OF LANs.
3. THE ETHERNET LAN.
4. THE ETHERNET PRACTICE.
5. THE ETHERNET NETWORK TOPOLOGIES. THE HUBS. THE SWITCHES.
6. CABLING RULES. COAXIAL CABLES.

LEARNING OBJECTIVES:
After learning this lesson, you will have the ability to:
- know and understand the LANs and the main type of LANs, the Ethernet LAN, .
- construct Ethernet LANs and accomplish the Ethernet practice. To understand the bus and the Hub / Switches topologies. To achieve essential Ethernet LAN configurations.
- to understand and select the types of architectures and cabling of the Ethernet LANs. To troubleshoot Ethernet LAN.

1. THE LANs IN THE WORLD OF NETS.

1.) Remembering the types of networks.
As you remember, the networks may be divided into the following categories (The categories of networks are presented in Lesson 1):
- LAN – Local Area Networks, and
- WAN- Wide Area Networks
- The super-networks: such as very fast backbones.

Types of WAN:

Public Networks. Public Networks are, obviously, wide area telecommunication facilities. They are owned by common carriers. Public Networks sell services, especially carrier services for the subscribers.
Private networks Private networks are obviously LANs.
A private network is a network built, maintained and controlled by one organization for their personal use.

2.) Essential types of carrier services for WANs.

a.) Old, Switched Analogue Lines:
- Dial up lines, normal telephone lines. For operation, first of all the connection is achieved and after that the Data is transmitted, normally in a theoretical bandwidth of 43 Kbps (56 Kbps reduced by the FCC norms to 53 Kbps),
- Dedicated lines. Dedicates lines display the same performances as the Dial up lines. The lines are always available to the customer, in accordance with the carrier–customer contract.

b.) Circuit Switched Services.
In this case, a connection (possibly a virtual connection) is established before the Data transfer.
Example: ISDN – Integrated Service Digital Network. The ISDN permits a speed of 64 Kbps or 124 Kbps.

c.) Packet- Switched Services.
At the Packet-Switched Service (used in the Internet), a pre-established connection is not necessary.
The Data Packets find the path towards the destination.

d.) Cell-Switched Services
This service sends Packets of the fixed size, the cells.
Example of networks using Cell-Switched Services: ATM- Asynchronous Transfer Mode.

e.) Dedicated Digital Services.
They obviously carry voice, video and data with a speed of over 45 Mbps.
Examples of networks using Dedicated Digital Services: T1, T3.

f.) Networks of the T1 type.
T1 works at up to 1.544 Mbps and carries both voice and Data.
Normally, T1 is divided into 24 channels, each of 64 kbps.

g.) Networks of the T3 type.
T3 works up to about 45 Mbps. It may be divided into 28 divisions of the T1 type, each T1 divided into 24 channels of 64 kbps.

3.) Type of networks: connection oriented and connectionless oriented.

a.) The connection oriented networks .

A connection-oriented network works based on creating the clear transmission channel (possibly virtual) before establishing the transmission.
The channel (virtual or non-virtual), which is created before the achievement of the transmission, is **maintained** during the transmission.

Examples of **connection oriented networks**, for WANs for instance, are:
- **X.25**, which was used between 1970 and 1980, for transferring Data, based on the pre-established connection.
- **Frame Relay**, which replace the X25 and which also ensure the delivery of the Packets in the order of the packets' number.
- **ATM (Asynchronous Transfer Mode),** used intensively since 1990. The ATM communication first of all solves the establishment of the channel of transmission.
  With the aim of establishing the channel of communication, the ATM systems initially send one Data Packet which registers all the Routers from the path. This path becomes the established path.
  After establishing one channel for the connection, the 2 partners of the communication may transfer Data in one direction or another. The speeds are up to: 155 Mbps or 622 Mbps.

b.) The connectionless oriented networks.

Connectionless communications are those where no connection is established, before the data is transferred, between the transmitting and receiving parties.

In the connectionless oriented networks, the serialized Data Packets may arrive at the Destination through the **non pre-established connection.**
The procedure may also be interpreted in the sense that **the Data Packet finds the path**, based on the help given by the software of routers and by the tables of the Routers.

The channel of transmission of the Data Packets may be different from time to time. The path of transmission of the Data Packets may be changed under the pressure of congestion, faults, events and the environment.

In principle, the Data Packets used by the Internet work based on **the connectionless technology**: the Data Packets find on their own (with the help of the Routers) the paths to the Destinations.

4.) The position of the LANs

The Internet is a hierarchy of extremely numerous networks, including public and private networks, WANs and, at a lower level, LANs.
This extremely complex configuration of networks is illustrated in fig. 1.1.
Despite this unimaginable complexity, the Internet super-system is working favourably, including by following the separations and isolations generated by:

- The Internet concepts of **separation and isolation** of the networks. The TCP / IP standards and architectures help the separation and the virtual isolation,
- The IP addressing procedure which permits the simple isolation of networks, by maintaining the transfer possibilities towards the exterior of the network.

Because the TCP /IP protocols permit the connection to different types of networks, basically all types of networks can be connected to the Internet.

The LANs are the bricks at the basis of the Internet network.
The LANs may work by being connected or not connected to the Internet.

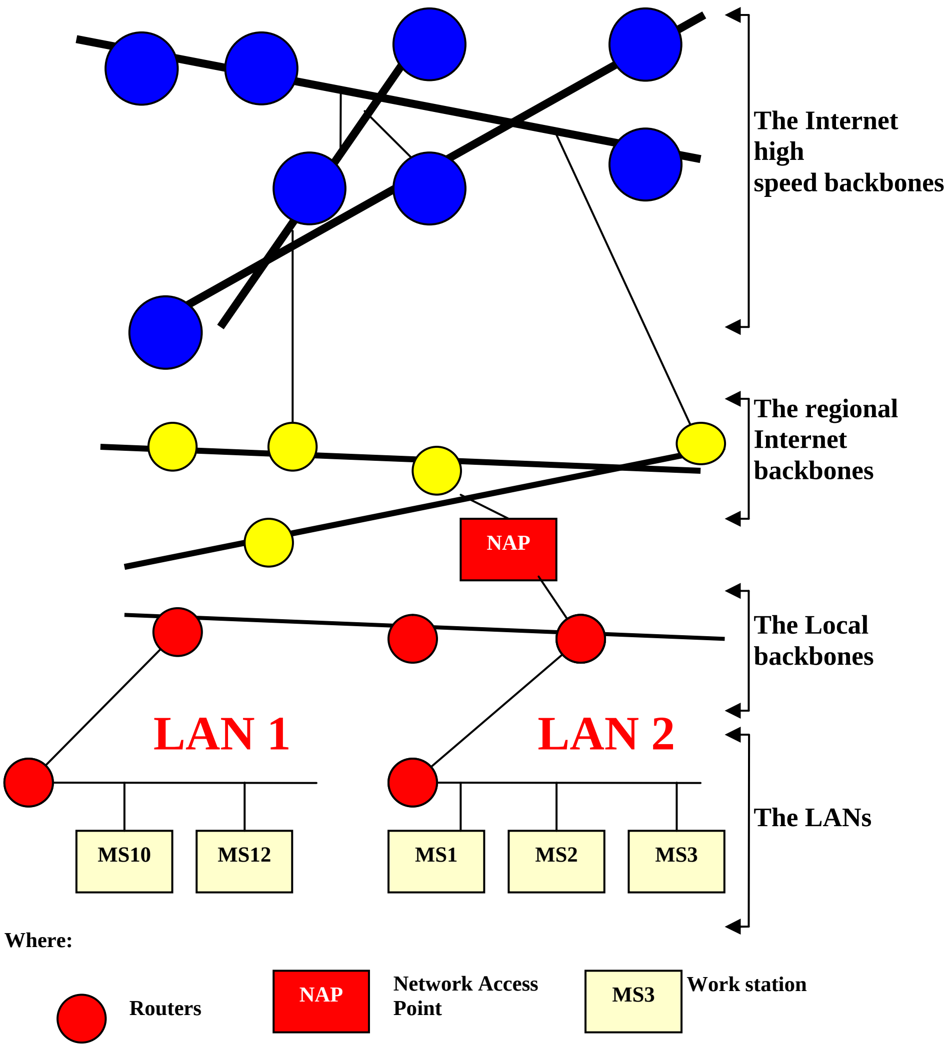


Fig. 1.1. The position of LAN as the Internet brick.

2. THE CHARACTERISTICS OF LANs.

<u>1.) Types of LAN.</u>

Two important aspects take place in the world:
- the networks' protocols have converged towards the TCP / IP,
- the LAN networks have converged towards the Ethernet.

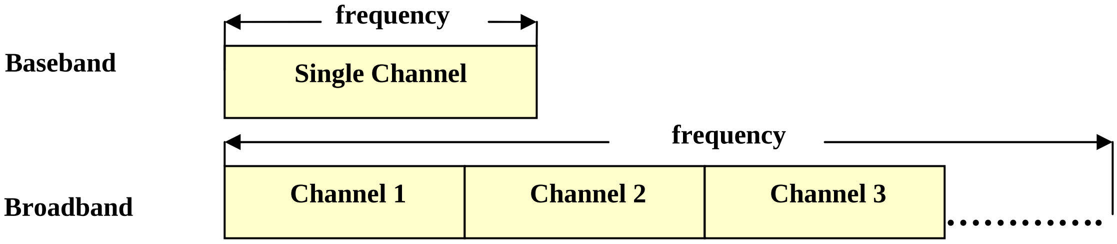
As the TCP /IP are the winners among the protocols, similarly, the Ethernet LAN is a winner among the LANs.

The Ethernet is the most popular LAN (Other LANs: Token Ring, FDDI and different LANs, generated by firms, have smaller quantity extensions as compared to the Ethernet).

At the basis of the Internet are extremely numerous individual LANs. The Ethernet LANs are the most used type of LANs.

2.) The Broadband and Baseband LANs.

In the Baseband signalling, only **one signal** is transmitted (in all time intervals)**.**
In the Broadband signalling, many sub-channels are simultaneously used. This means that in the broadband signalling the bandwidth of transmission is subdivided into multiple sub-bands.



It must be emphasized that the Ethernet LAN normally works in the Baseband frequency, respectively the signals occupy the base of the band, respectively the entire allocated frequency bandwidth.
There are also the Ethernet LANs which can work in broadband systems [11.].

3.) The features which identify a LAN.

The Intranets, LANs Local Area Networks:

- operate on a limited geographical area, are localised in one building or group of buildings or relatively small areas (see below the maximum lengths of the Ethernet connections) and usually they:
  - are monitored locally,
  - are private,
- are in operation 24/7 (seven days),
- permit the multi-access (the access of different partners connected to the respective network).
- The LANs (such as the Ethernet LAN) work with Layer 1 of the stack of the communication model and in correspondence with the Physical Addresses.
- The use of the Switching Packets Technology. The Data is transmitted in the form of Data Packets.
- The Data routing: the Ethernet normally uses a fixed route, with no modification of the path. As compared to the LANs, the WANs work with the possible and frequent modifications of the paths of the Data Packets.
- The speed (bandwidth): typical for the respective LAN technology: 10 Mbps, 100 Mbps, 1Gbps, 10 Gbps.

If the LAN -Local Area Net is also connected to the exterior (of the respective LAN), such as to the Internet (for instance through one Gateway), then
the respective LAN becomes one of the bricks placed at the basis of the Internet.

4.) The standards related to the LANs (excerpt):

The essential standards related to the Ethernet LAN or including adjacent aspects are:

IEEE 802.1 -LANs: General concepts and architecture.
IEEE 802.3-
ETHERNET Version 2.0 (there are differences between the Ethernet specifications and IEEE 802.3).
IEE 802.8- Optical fibre.
IEEE 802.9 - LANs for the real time applications.
IEEE 802.10- Virtual LANs and security.
IEEE 802.11- Wireless LANs.
IEEE 802.15- Bluetooth.
IEEE 802.16- Wireless BB (Broad Band).
EIA/TIA Specifications for cables. EIA/TIA (EIA- Electronic Industry Association; TIA- Telecommunications Industries Associations) such as **EIA /TIA -568 UTP 9** (for UTP cables).
Other.

Today, the following are used for the Ethernet:

- the specifications for the Ethernet Version 2.0 named Ethernet II and
- the IEEE standards 802.3.

3. THE ETHERNET LAN.

1.) Essential aspects.

Launched mainly based on the works of Bob Metcalfe, in the 1970's, and becoming the standard IEEE 802.3, the Ethernet technology, standards and procedures permit the installation and use of the most widely used LANs in the world.

The Ethernet concepts are also extended to the wireless Internet.

The Ethernet is based on the linear (bus) network (converted by the Hub in star). The network's partners are connected to this network: different devices which process Data according to the Ethernet protocols. The NICs –Network Interface Cards interfaces are used by all the partners.

The NICs interfaces of PCs or of quasi-NIC interfaces (for instance at LAP-TOPs) work only with the MAC –Media Access Control / Physical Address.

The operation of the LAN is achieved at the physical level of the stack of the communication model and is related to the Physical Addresses.

2.) The functioning of the Ethernet LAN.

The basic concept of the Ethernet uses the in-line connection at the bus (converted, by the Hub, in star).
The bus ensures the medium of transmission and may be achieved as:

- Twisted pair wire,
- Coaxial cable,
- Fibre-optic cable.

The basic (and starting) Ethernet LAN configuration is illustrated in the fig. 3.1.

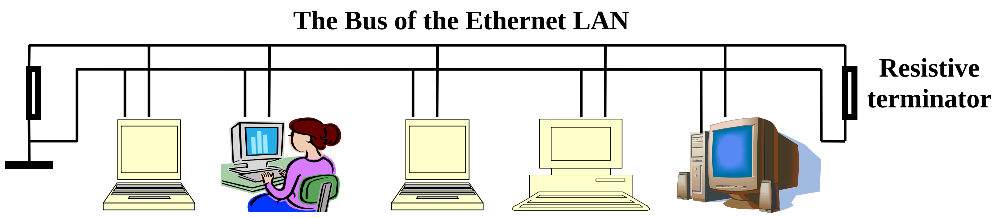


Fig. 3 .1. The initial bus of the Ethernet LAN.

As illustrated in fig. 3.1., the cable is adapted by resistive terminators at both ends. But the connection to the ground is achieved (from considerations of electronic compatibility) only at one end.

The resistive terminators avoid the electrical signal reflections on the cable and reduce the electromagnetic interference.
The connection to the ground only at one of the extremities reduces the electromagnetic interference and diminishes the possibility of damages.

All the Ethernet LAN partners have equal rights and the Ethernet LAN does not have one coordinator.
The Ethernet is a democratic LAN.

The Ethernet LANs may work connected or not connected to the exterior (to the external network).
Therefore, the LANs may work:

- only as an isolated network (not connected to the Internet) or
- as a separate local net, connected through one Gateway (or other device) to the external networks, frequently to the Internet.

The Power of a LAN not connected to the external networks is very low.
By the connection to the external networks (mainly to the Internet), the power of the LAN is growing in an extraordinary manner.
At the same time, the security of the LAN diminishes.

The operating manner of Ethernet also inspires the connection of separate wireless cells, by using the revolutionary 802.11 wireless standard.
In this case, fig.3.2, the Access Points are the elements connected to the Ethernet bus.

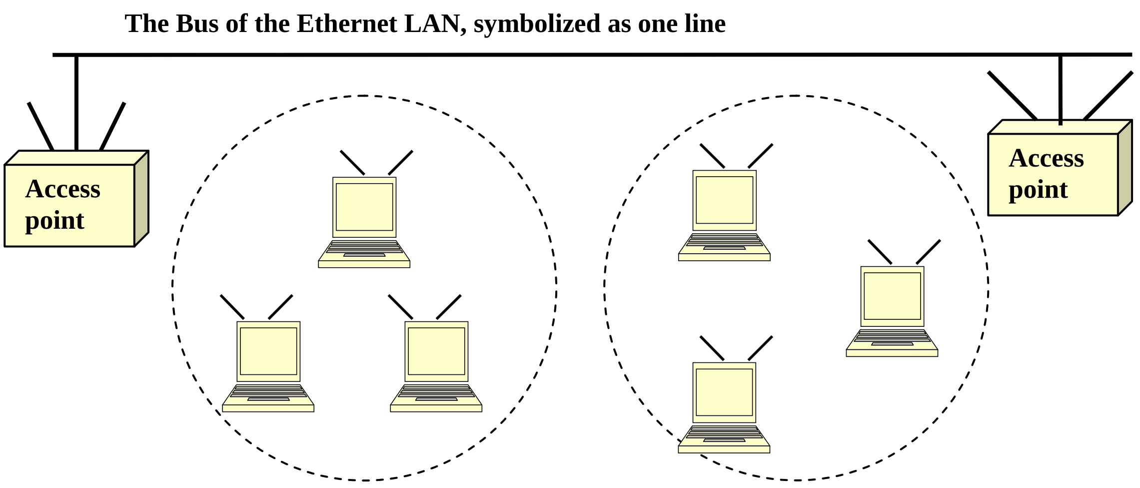


Fig. 3.2. The functioning of one Ethernet LAN including wireless devices.

The Ethernet LAN functions on the basis of the principles: **CSMA/CD Carrier Sense Multiple Access with Collision Detection.**

<u>3.) CSMA / CD Carrier Sense Multiple Access with Collision Detection.</u>

The operation of the Ethernet is based on the 2 types of behaviour of the devices:

- As **Listener**, devices which in the respective time interval listen to the bus and
- As **Talker**, devices which, in the respective time interval, talk to the bus.

A **Listener** device may become a **Talker** device.

Initially, in the incipient times, the Ethernet operated by being based only on the CSMA Carrier Sense Multiple Access.
For the Ethernet II, which is used today, the CD (Collision Detection) was introduced near the CSMA.

The CSMA / CD procedure operates in the following manner:

1. All the partners / stations, connected to the respective Ethernet bus, listen continuously to the situation on the bus. The listening is accomplished through the personal NIC (Network Interface Card) of each machine.
Through this listening, each station knows if the bus is occupied with the transmission of another message (generated by other stations) or not.

2. When one station intends to send a Data Packet to the bus, it sends this Packet only when the bus is not occupied with the transmission of another Packet. The fact that the bus is not occupied with another dialogue (other transmission of a Data Packet) is detected by each machine by listening to the bus.

3. <u>The intervention of the CD-Collision Detection</u>. It is possible that 2 (or more) stations send the Data Packets, quit simultaneously, thinking that the bus is not occupied (and not knowing the intention of another device to send, quite simultaneously, other packets). **This situation is named collision.**

4. If a collision is generated, the NICs of each sending stations detect the **collision state**.

5. If the collision state is detected, then both stations which have emitted quite simultaneously enter in the regime of the collision treatment.

6. After the treatment of the collision state, if no other collision state is detected, then one of the two stations will restart the transmission of its own Data Packet suggested for transmission.
The time intervals for the re-launching of emissions are different, established probabilistically, depending on the machine, so that a new collision is not generated.

The time interval for the re-launching of the Data Packet by each respective machine, on the bus, is established by each machine involved, based on the internal routine of evaluation of these time intervals.

If a new collision is detected, possibly with a Data Packet from a third machine, the newly involved machines stop the emissions and enter in the collision treatment state.

If a machine detects the second successive bus-collision, then **it doubles the time interval** up to the re-entering in emission, respectively up to the launching of the Data Packet on the bus.

4.)- When the sending conditions are met, the sending of the Data Packet is achieved.
5.)- After each serialized Tram (Data Packet) transmission, the emitting machine waits for 9.6 microseconds, before the new Tram transmission.

The analogy of the Ethernet concepts with the human behaviour
It is considered that the behaviour of the Ethernet in case of collision is similar to the behaviour of 2 polite persons:

- when both persons detect that they are trying to discuss simultaneously, then both persons stop speaking.
- after some time, depending on the temperament, one of the 2 persons re-launches the conversation.

<u>The detection of the collision.</u>
The principle of the practical detection of collisions is based on the identification of the existence of signal transitions on the bus. After the disappearance of the detection of the signal transitions (indicating transmission) on the bus, a one time reserve is used up to the first new sending.

The signals, coded under the form of the **Manchester encoding, are used on the** Ethernet LANs.
The Manchester encoding allows the detection of each bit (0 and 1) from the train of impulses which form the Data Packet.

The use of other forms of encoding, for instance the simple:
Voltage A Volts (12Volts for instance) for the bit **1**
Voltage zero for the bit **0**
leads to confusions, for instance when the Data includes the repeated string of **1**.
For instance, confusions may be generated if the 2 tensions of 12 Volts correspond at the string **11**. Because a pause is necessary to be introduced for 2 values of **1** to be detected, the string may be interpreted as: **101**.

The unipolar encoding, illustrated in the fig. 3.3., **does not permit the detection of the situation in which one bit ends** (for strings such as 1111…).

The Manchester encoding (Biphasic code) avoids this confusing situation by using the following signals on the bus:
- the **transition (in specified conditions) from 0 to 1** (for instance between -12 Volts to + 12 Volts) represents the bit 0,
- the **transition (in specified conditions) from 1 to 0** (for instance between +12 volts and - 12 Volts) represents the bit 1.

In the Manchester code, the data is signified by at least one transition and therefore the Manchester encoding:

- is self-clocking. Each bit is transmitted over a pre-defined time period.
- enables the synchronization of the data stream. The Manchester encoding is a synchronous encoding technique. (http://www.erg.abdn.ac.uk/users/gorry/course/phy-pages/man.html)
  A receiver may be synchronized, at the rate of received bits, through the use of the Phase-Look-Loop procedure, for instance.

The functioning based on the Manchester encoding is illustrated in the following fig. 3.3.

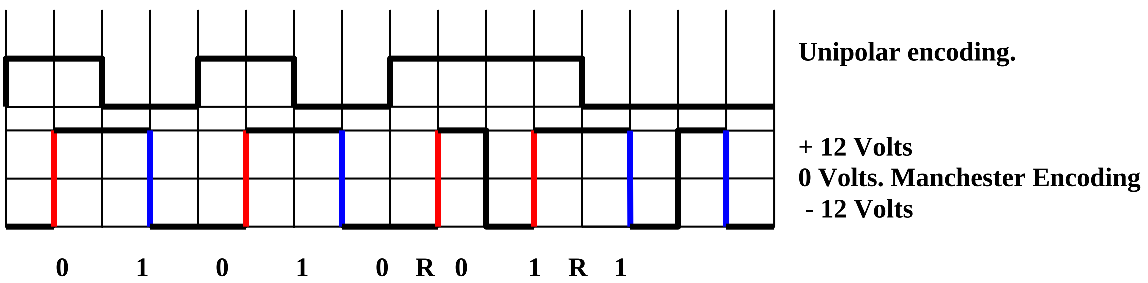


Fig. 3 .3. The unipolar and the Manchester encoding.

In the case of the Manchester encoding, the network devices know the transmitted frequency (rate) of the string of bits of the Data Packet and based on this, the duration allocated for a **‘1’,** respectively for a **‘0’**.

Following this information, the receiver devices may detect the phenomena which are produced (for instance in the middle of the time period) and reject the transitions (to value 0 or 1) which are placed inside the **predefined time period after one valid transition**. The situation is illustrated in the fig. 3.3., where the transitions noted with R (rejected) are rejected.

Example of Manchester Encoding: The pattern of bits " 0 1 1 1 1 0 0 1 " encodes to " 01 10 10 10 10 01 01 10".

Based on the above considerations, the detection of the collision seems to be simple: the machines may measure the voltage on the bus and detect the transitions occurred.
Also, the collision leads to the modification (at the time of the collision) of the voltage on the bus.

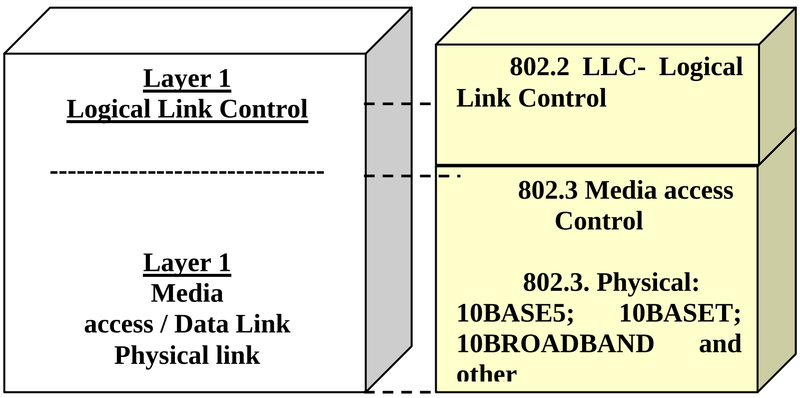
It must be emphasized that after a machine "takes the bus", the respective machine occupies the bus and, when the transmission is finished, communicates this situation, on the bus, to all the other machines.

The Ethernet protocol position inside the TCP / IP.

The Ethernet protocol belongs (if it is installed) to Layer 1, Network Access, to the TCP /IP protocols.

This Layer is hiding two floors:
- LLC- Logical Link Control, in this case based on the IEEE 802-3, and
- Media Access Control formed, obviously, from cables.

The actual positions of the IEEE sub-levels described in the Ethernet standards, related to the TCP /IP layers, are illustrated in the following fig. 3.4.



3.4. The composition of TCP /IP Layer 1 from the point of view of Ethernet standards and specifications.

4. THE ETHERNET PRACTICE.

4.1. CABLES FOR THE ETHERNET

1.) Types of cables for Ethernet buses.

Many types of cables are available for supporting buses for the Ethernet LANs.
For the Ethernet, special Ethernet cables were developed.

The pallet of connections for the Ethernet includes:
- a.)- coaxial copper cables,
- b.)-twisted pairs cables,
  - UTP - unshielded twisted pairs,
  - STP – shielded twisted pairs,
- c.)-fibre-optic cables,
- d.)-wireless connections.

2.) The features of the cables.
The main features of the cables include:
- a.)-Bandwidth, which denotes the possible speed through the cable.
- b.)-Attenuation, which denotes the loss of signal power as a signal propagates on the specified portion of cable.

$$\text{Attenuation} = 20 \log \frac{\text{Emitted Voltage (in the point of emission)}}{\text{Received Voltage (in the point of reception)}}$$; (where log is decimal logarithm).

- c.)- Costs.

The costs grow in the direction: Twisted pair cables → coaxial cables → fibre-optic cables.
Twisted pair cables are low cost cables.
The fibre-optic cables require special skills and specific hardware at the installation.

- d.) Maximum segment length.

One segment length represents the length (metres) of the cable after which the signal must be regenerated.
If the maximum segment length is surpassed, then the attenuation of the signals may lead to the loss of Data.

- e.) Maximum number of nodes per segment.

A node is the place where a machine is connected, through the personal machine NIC (Network Interface Card), to the cable of the Ethernet bus.
Each connection of a machine to the cable brings about mechanical and electrical modifications of the respective cable.
For instance, the connectors do not simulate the perfect continuity of the cables' parameters, the input impedances of NICs are not infinite, etc.
Therefore, with the growing number of nodes at the cable, the admissible length of the segments diminishes.

- f.) The level of electromagnetic compatibility.

This feature represents the resistance to electromagnetic interferences.
The level of resistance to the electromagnetic interferences (EMI) grows in the following direction:

UTP (poor resistance to EMI) → STP (fair to good resistance to EMI) → fibre-optic (best resistance to EMI).

- g.) The characteristic impedance of cables.

The copper Ethernet cables must be adapted at the ends of the transmission physical supports (end of the cables), in order to avoid the electromagnetic reflections.

The impedance of adaptation is for some EIA/TIA 586 BackBone Cabling (with some possible variations for the specific types of cables) and may be of about [11.]:

- For the 100-ohm UTP cable: 100 ohms;
- For the 150-ohm STP cable: 150 ohms;
- For the 50-ohm thick coaxial cable: 50 ohms (other values, 75 ohms for instance, are possible, depending on the specifications of the cables).

- h.) NEXT represents the level of electromagnetic interference generated by one pair of wires in another pair of wires of the same Ethernet cable.

$$\text{Attenuation} = 20 \log \frac{\text{Emitted Voltage (in the point of emission)}}{\text{Coupled Voltage (in the point of reception)}}$$ (where log is decimal logarithm).

- The speed / signalling rate.

The EIA / TIA -568 emphasize that the cables must be selected for the required signalling rates.
Based on the correspondence between the signalling rate and the type of cable, the EIA/TIA-568 (EIA- Electronic Industry Association; TIA- Telecommunications Industries Associations) classify the UTP cables into 5 categories [11.]:

EIA/TIA-568 category	Essential cable applications
Category 1	Not for LAN. Data up to 56 Kbps.
Category 2	Data up to 1 Mbps
Category 3	Transmission up to 16 Mbps
Category 4	Transmission up to 20 Mbps
Category 5	Transmission up to 100 Mbps.

3.) Examples of the values for some cables specifications:
For cables of **Category 5**, of the cables **EIA /TIA -568 UTP**:
Frequency range: 1-100 MHz; Attenuation 24 dB; NEXT 27,1 dB, propagation delay: 548 ns (nanoseconds) and other.

4.) The detailed types of Ethernet cables.

The Ethernet cables are of different types.
The cables for the Ethernet applications are selected according to the required speed (signalling rate), costs and other requirements.

The following are produced for the Ethernet applications:

A.) Different variants of UTP (Unshielded Twisted Pairs) and of STP (Shielded Twisted Pairs) cables.
- Depending on the type of Ethernet technology used, specific cables, **for each range of speed,** may be selected. The pallet of speeds (divided into categories) is between 10 Mbps and 1000 Mbps,
- The maximal length of segments is indicated as **100 metres** (for the **UTP 10BASE-T**), (with possible exceptions in the specifications of the producers,[11.]).

The UTP- twisted pair cable is the most popular Ethernet cable, being very flexible and easy to be installed.
Despite the fact that it is vulnerable to electromagnetic perturbations and it has a high level of signal attenuation, the UTP is intensively used.

B.) Different types of coaxial cables.
- **Ethernet/ thick: 10BASE-5/thick** for segments of up to **500 metres** (maximum 5 segments through repeaters).
- **Ethernet thin: 10Base-2/thin** for segments of up to **185 metres** (maximum 5 segments through Hubs).

Different types of fibre-optic cables for 100 Mbps up to 10000 Mbps, for maximum length (depending on the type of technology) of up to 80 Km (these big lengths are referred to for applications other than Ethernet applications).

5.) Notations related to the Ethernet Cables. Clarifications related to the notations.

- a.)-First notation: such as 10 (in 10BASE-5, for instance) indicates the maximum normal Data speed, in Mbps, for which the cable is constructed (in the case of the 10BASE-5, the maximum Data speed is of 10 Mbps).

- b.)-The end notation, such as 5 (in 10BASE-5, for example), indicates the maximal length of the segment, in units of (100 metres), of the transmission, in this case 500 metres (multiple cable segments can be connected through the repeaters, so that the total maximum distance may reach 2500m).

For the coaxial cables (**10BASE-n**, for instance, where **n** may be **5** or **2**), **n** indicates the maximum accepted length of the cable segment, in units of (100 metres),
The coaxial cable is constructed with a single central conductor, which is surrounded by the insulation layer, by the external conductive foil and by the exterior isolation and protection material.

10BASE5 is thick coaxial cable (normally obsolete),
10BASE2 is thin coaxial cable, with the characteristic impedance of 50 ohms, also named thin Ethernet or **Cheaper-net**.

- c.)- **BASE** signifies that the cable is destined for the transmission in the base-band (only by a single channel for the transmission). **BROAD** signifies that the cable may support broadband communications.

- d.) **10BASE-F** is **10 Mbps** Ethernet, optical fibre cable. 10BASE-FB is for the synchronous Ethernet connections and 10BASE-FL for asynchronous connections.

- e.) **10Base-T** is **10 Mbps** Ethernet cable, of the UTP -unshielded twisted pairs type.
  For low distances (under 100m), T cables, UTP-Unshielded Twisted Pairs cables are used.
- …………………………………………………………………………………….

- f.) Name exceptions. The new types of high speed Ethernet networks do not observe the rules for naming the Ethernet cables exactly, for instance:
  100BASE-TX
  100BASE-T4
  100BASE-FX
  They operate at 100 Mbps, baseband, but the suffix indicates the type of media and not the length of the segment.

- g.) RG (referring to the connectors and cables) signifies Radio Government.
  - The RG -58A/U and RG 58C/U cables have an impedance of 50 ohms and the speed of transmission:
    - RG -58A/U 68% to 78% of the speed of light (300.000 km/s),
    - RG- 58C/U 68% of the speed of light (300.000 km/s).

Clarifications regarding the most popular cable: the UTP (Unshielded Twisted Pairs) cable.

IEEE 802 has created 5 categories of UTP cables. (Categories 1 and 2 are not used for networking):

- Category 3, the four-pair cable in accordance with the **10BASET** standard, respectively working up to **10 Mbps**,
- Category 5, the four-pair cable, **100BASETX,** working up to **100 Mbps** and **1000BASETX**, working up to **1000 Mbps.**
- Category 6, referring to the cables of up to **1 Gigabit per second**.

The optical fibre cables.
The optical fibres permit, generally speaking (depending on the type), up to 40 Gigabits per second and up to 80 Km in length.
This length of 80 Km is not referred to for Ethernet use.
In Ethernet, the maximum length of the optical fibre (depending also on the local specifications and conditions) is of 2000 m.

In the following Table, an informative pallet of the possibilities of Ethernet cables is presented:
Note: The Data of the following table are informative. The exact specifications and performance of these types of cables must be taken from the documentations of the suppliers of the respective cables.

IEEE name of the cable / elements of construction	**Achieved for the Data frequency**	**Remarks**	**Maximal Length of one segment / maximum length of the network**	**Maximal number of nodes per segment**	**Advantages and other remarks**	**Compatible connectors**	**Cable Material**	**Name of the connector (couple)**
10BASE5 **(coaxial)**	10 Mbps	Standard Ethernet (Thick Ethernet)	500m / 2500m	100	Not used	Vampire	Thicknet **coaxial**	
10 BASE2 **(coaxial)**	10Mbps	Fine cable for Ethernet	185m / 925 m	30	Working without a hub.	Standard BNC For the junctions of the T type	Thinnet **coaxial**	
10BASET (T signifies twisted) **UTP**	10Mbps	4 wires, 2 Pairs, each pair with torsions	100 m / 500 m	2 per segment as star arm, total 1024	Low cost		**UTP (unshielded twisted pairs)**	**RJ45**
10BASES **STP**	10Mbps	4 wire, 2 Pairs, each pair with torsions	100 m	2 per segment as star arm, total 1024	STP may be used up to 1000Mbs, for instance the 1000BASES type		**STP (shielded twisted pairs)**	
100BaseX	100Mbps	Four Wire Fast Ethernet	In accordance with the Specifications of the producer	2				
100BASET4	100Mbps		In accordance with the specifications of the producer	2				

100BASETX	100 Mbps Fast Ethernet		100 m / 200 m	2				
1000BaseTX	1 Gigabyte per second	Twisted pair cable	In accordance with the specifications of the producer.	2	Gigabit Ethernet (GbE)			
10BASEF **OPTICAL FIBRE**	10 Mbps	Optical Cable (optical fibre)	(10BASEFL: 2000 m / 4000 m) Depending on the signal technology and medium used, generally up to 2000m in Ethernet	2	To be preferred between buildings		MMF Fibre-optic	
100BASEFX **OPTICAL FIBRE**		Optical Cable (optical fibre)	412 m / 2000m	2	Fast Ethernet using two strand fibre-optic cable			
100BASEVG (voice grade)	100 Mbps		In accordance with the specifications of the producer		100 Mbps over category 3 cable			

5. ETHERNET NETWORK TOPOLOGIES. HUBS. SWITCHES.

1.) The Ethernet topologies.

The Ethernet topologies may be interpreted from 2 points of view:
- physical topologies, related to the physical organization and construction of the network,
- logical (virtual) topologies, related to the virtual (logical) way between the Source and the Destination.

The physical topologies (network architectures) usually used for the Ethernet are:

- **bus topologies**,
- **star topologies**,
- **hybrid topologies** (especially in separate configurations).

2.) The Hub and the important similarity between the Hub and the bus.

The kernel, the central point, of each star network is practically the Hub.
The cables from all the beams of the star which achieves the network are connected to the Hub.
The segments of the local network are connected to the Hub.

The Hub offers the following facilities:

a. - multiple ports for connection,
b. - at the arrival of the Data at the Hub (on one of the Hub connections), the Hub copies the Data and offers the respective Data (in the form of serialized Data packets, respectively trams) on all the ports of the Hub,
c. so that all the machines are connected to the same bus, in the star connected machines,
d. - the Hub achieves the separation of the outputs, so that a short-circuit on one output does not generate a short-circuit to the entire network. The Hub confers on level of separation.

As it results from the above point 2.), the fact that the hub simultaneously offers the data to all the machines connected to the star is equivalent to the behaviour of a bus.

The Hub behaviour is equivalent to the functioning bus: the hub copies the Data arriving at one port to all the output ports and consequently, delivers the Data simultaneously to all the machines of the star.

The Hub may be imagined as a bus which has supported the metamorphoses illustrated in the following fig. 5.1.:

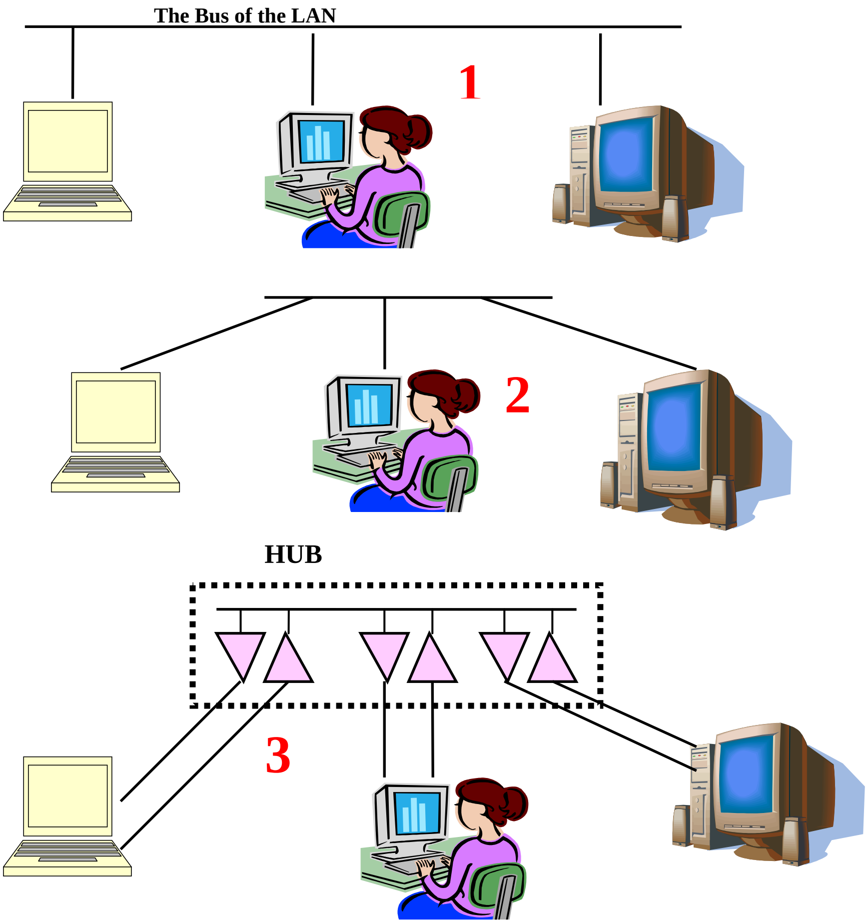


Fig. 5.1 .The schematic conversion from bus to Hub.
The triangles inside the Hub represent the local separators.

<u>One step in advance: **Switching hub. The Switch**.</u>

The hub creates copies of the arrived Data (sequential components of the Data Packet) and offers, quite synchronously, these Data to all the ports, emulating a bus.

However, the ports connected to the one star arm are not interested in the respective Data, because the respective Data do not address the respective machines.

The normal Hub places the Data in useless mode, at the entries of all the machines connected to the Hub, including the machines which are not of interest for the transmission.

It is more convenient to send a Data Packet only towards the arm which includes the addressed machines (by the respective Data Packet).

Through this procedure, the security, separation and even the speed may grow and some connections are not occupied with Data of no interest to the respective machines.

The use of the switch is illustrated in the following fig. 5.2.

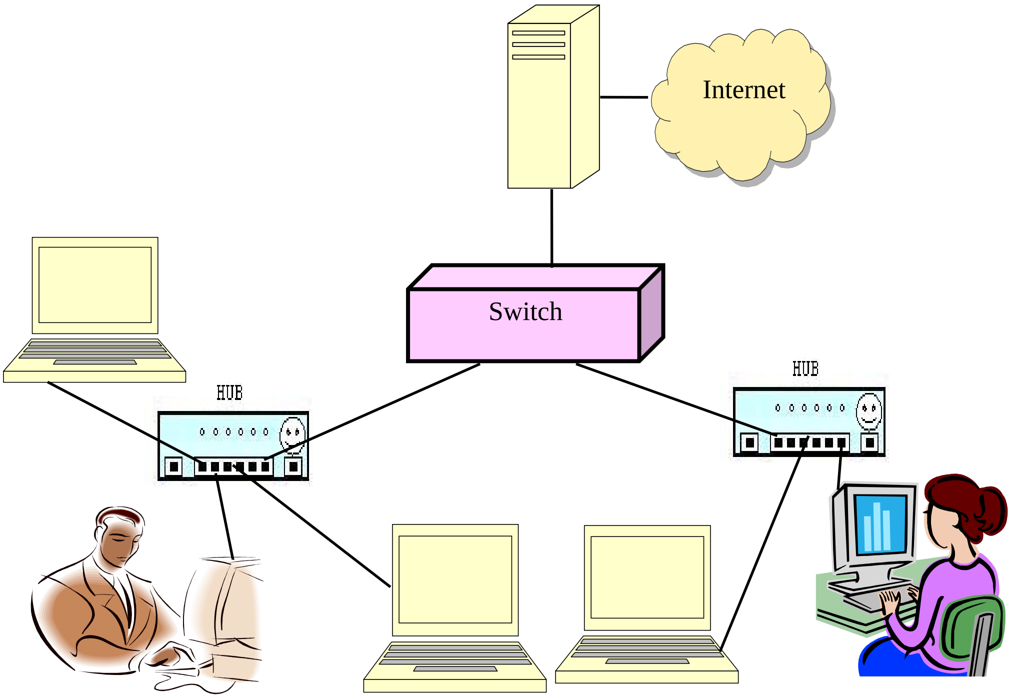


Fig.5.2. The Switch directs the data packets only towards the zone (arm) with addresses of interest.
(The Switch may be directly connected, at one Router, to the Internet).

The above positive improvements are achieved by the **Switching Hub** (or **Switch**).

The **Switch** forwards specific Data to specific ports, respectively in connection to the address of the machine which is placed at the end of the arm.
The **Switches** are intelligent devices which have the possibility to select and store the path towards the specific addresses. Related to the configuration illustrated in the fig. 5.2., the operation may also be achieved without the Hubs (by the use of only one switch).

5.2. THE ACHIEVEMENT OF ETHERNET NETWORKS.

Examples of the characteristics of the IEEE 802.3., Ethernet networks, for low transmission rates: 1 Mbps and respectively 10 Mbps, are illustrated in the following table [11.]
(Note: The Data of the following table are informative. The exact specifications and performances of these types of cables must be taken from the documentations of the suppliers of the respective cables):

Type of network (bus and cable)	**Ethernet**	**10BASE-5**	**10BASE-2**	**10BROAD-36**	**10BASE-T**
Type of transmission medium	**Coaxial Thick**	**Coaxial Thick**	**Coaxial Thin**	**Coaxial**	**UTP**
The operating speed Mbps	10	10	10	10	10
Topology/ Type of communication	Bus/ Baseband	Bus/ Baseband	Bus/ Baseband	Bus/ Broadband	Star based on Hub/ Baseband
The maximum segment length	**500 metres**	**500 metres**	**185 metres**	**1800 metres**	**100 metres**
The maximum number of nodes /	100	100	30	100	12/ Hub
Adaptation Impedance ohms	50	50	50	75	100 (see specifications)

Significant conclusions result from the above table:
- The coaxial cable is used in the bus configurations,

- The UTP cable is used in the Hub or Switch based star configurations.
- The length of the segments achieved with the UTP cable (for 10Mbps) may only be of 100 metres.
- Other.

6. THE CABLING RULES. COAXIAL CABLES.

6.1. GENERAL CONSTRAINTS.

The cabling rules are under the constraints generated by:

- the maximum accepted length of one segment (distances after which the signal must be regenerated),
- the maximum accepted total length,
- the maximum admissible number of segments,
- the maximum speed permitted by the physical connection (cables),
- constraints imposed by the features of the involved devices such as the Repeater
- the maximum number of machines connected to one segment,
- other constraints.

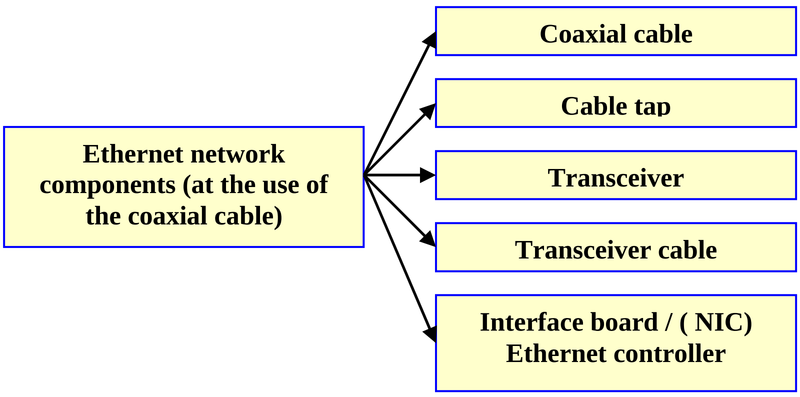
These constraints are generated firstly by the delay times during the Data transmission.
The delay time may interconnect with the Ethernet principles of functioning (CSMA CD) and generate troubles.
Also, constraints are generated by the cables' attenuation and possible interferences.

The Repeaters.
The signals on the cables are re-constructed by the devices named Repeaters.
At the extremity of one segment, the signal may be so attenuated that it does not offer the correct levels (amplitude, form, spectral components, timing, etc.). The Repeaters re-construct the signal and resend the signal to another segment.

Obsolete cables.
The 10Base5 (coaxial, thick) cable is obsolete (not in use today).

6.2. ETHERNET LAN ACHIEVED WITH COAXIAL CABLES. THE BUS TOPOLOGY. CONFIGURATIONS AND FEATURES.

1.) The Ethernet network components.
The Ethernet network components are the following



The Ethernet LANs based on **the coaxial cables** serve for achieving **the bus** network topologies.
The use of coaxial cables may generate difficulties (at the disconnection of one machine), in comparison with the case of using twisted pairs cables.
But the lengths accepted by the coaxial cables surpass the lengths accepted by the twisted pairs cables.

The solution with the coaxial cables in the Bus Physical Topology is applied when the simple solution with the Hub and UTP cables in star is not possible.

2.) The use of coaxial cables for the Ethernet.

Also, the coaxial cable is used as the network of hierarchical level in the tree topologies, such as that illustrated in the following fig. 6.1 or in the topology illustrated in fig. 6.2..:

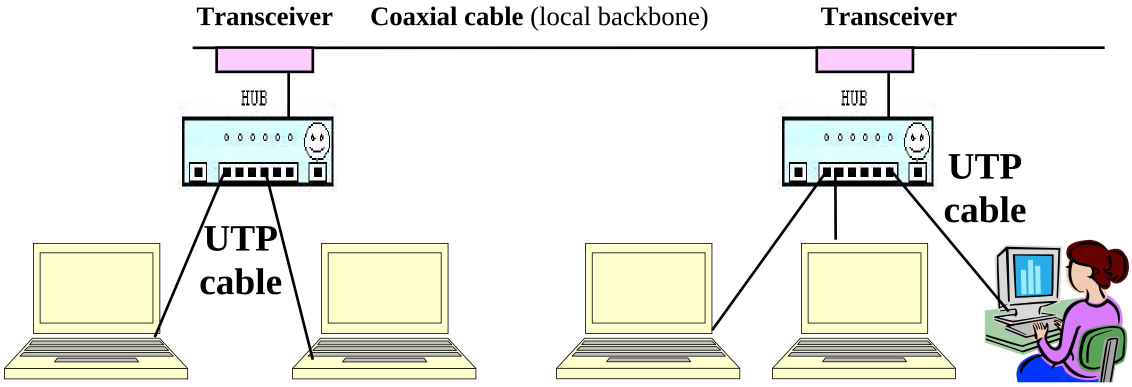


Fig.6.1. Ethernet LAN achieved with coaxial cable as local backbone.
The LAN is completed with sub-hierarchical trees achieved with the UTP cables

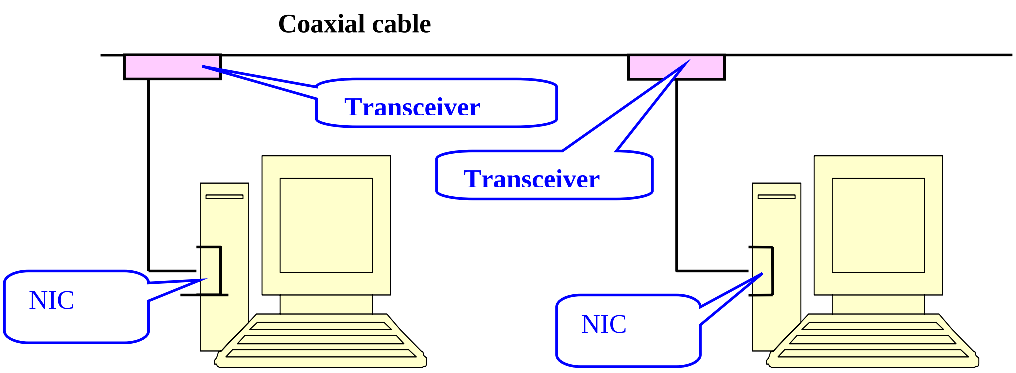


Fig.6.2. Machines connected to the coaxial cable

Also, the machines may be connected to the coaxial cables:

- If the thick coaxial cable (now obsolete) is used (at the configuration from fig. 6.2.), 10BASE5 for instance, special boxes must be used (transceivers, respectively MAUs), placed in the marked points on the cable.

- If the thin coaxial cable, 10BASE2 for instance, is used, special BNC connectors must be used, in T form, placed directly on the machine, and performing 2 functions:
  - The connection to the NIC of the station (machine),
  - The transfer of the connection towards the next machine (This transfer may generate troubles).

3.) The 5-4-3 rule.

1.) The "5-4-3" rule stated that in one Ethernet network (constructed with coaxial cable):
- **maximum 5 segments (segments separated by the Repeaters) may be used,**
- **maximum 4 Repeaters may connect the above segments,**
- **maximum 3 segments (from the above 5 segments) may be populated with machines.**

2.) At the application of the "5-4-3" rule, the following aspect must be taken into consideration for a compound network:
- **If a connection is made with another network through a Bridge or a Router, then the "5-4-3" rule must be applied in each network**

3.) The 5-4-3 rule may also be applied in the case of the Hub based Ethernet LANs, such as at the use of the 10 BASET [11.].

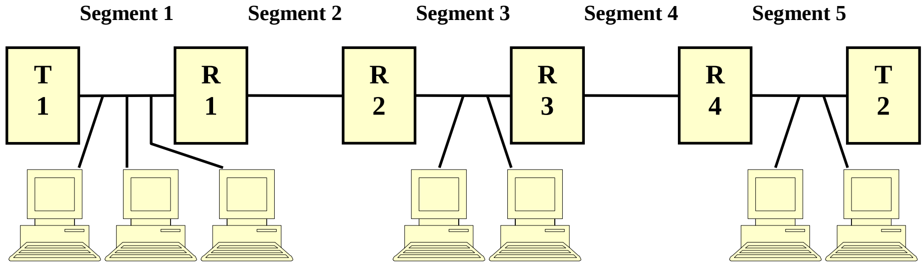


Fig. 6.2. The Ethernet coaxial cable (simplified scheme without the illustration of the transceivers): The application of the 5-4-3 rule: maximum 5 segments, with maximum 4 Repeaters, with maximum 3 segments with nodes connections at users).

4.) The 10BASE5 thick coaxial cable.

The 10BASE5 thick coaxial cable has the big advantage that it offers the possibility for LANs to be achieved with a maximum length of

5 segments x 500 metres /segments = 2500 metres.

Performances of the 10BASE5 thick coaxial cable.

- Maximum rate: 10Mbps.
- The maximum number of Repeaters: 4 (the 5-4-3 rule).
- Maximal **segment length**: **500 metres**. Maximum configuration length: 5x500m=2500m.
- The maximal number of connection cables (respectively segments without stations): 2 (this is the result of the application of the 5-4-3 rule: 3 segments of cable accept connections to the machines. 2 segments of cables do not accept connections to the machines. These 2 are connection cables).
- The maximal number of stations / machines per segment: **100** (the maximum number of machines connected to the segments which, in accordance with the 5-4-3 rule, accept the machines' connections: only 3. 2 are only connection segments. Therefore, 2 segments do not accept the connections of machines).
- The minimum distance between the connection towards 2 successive machines: 2,5 metres, marked on the cable.
- **The 10BASE5 thick coaxial cable works with the transceivers placed on the cable**. The maximum distance from the station to the cable: 50 metres.
- The 10BASE5 thin coaxial cable has an impedance of **50 ohms**.

With the purpose of connecting the machine to the thick coaxial cables (for instance, 10BASE5), the following are used:

A.) **The Transceiver (MAU).**

The following differences are related to the names of the interfacing box placed on the 10BASE5 thick coaxial cable, between the Ethernet specifications and the IEEE 802.3 standards, for the 10BASE5 network:

- In the Ethernet specifications, the interfacing box is named **transceiver** and the cable between the transceiver and the controller of the Ethernet station is called **transceiver cable**
- In IEEE 802.3, the interfacing box is named **MAU**- **Medium Attachment Unit** and the cable between MAU and NIC is called **AUI**-**Attachment Unit Interface**.

In case of using the thick coaxial cable (10BASE-5, for instance) for the connection of each machine: **the transceiver** (transmitter-receiver) and the cable between the transceiver and the NIC of the machine.
The Transceiver is a device placed in the small box, including electronics and mechanics components, which ensures the contact with the thick coaxial cable.
The small box of the transceiver has a special mechanical system. This mechanical system includes a tap which penetrates the coaxial cable and achieves the contact with the core of the coaxial cable.

The transceiver solves the CSMA CD aspects of the respective machine connected to the coaxial cable.
The electronics of the transceiver informs the machine through the NIC about the situations regarding the collision.

The thick 50 ohms Ethernet cable, which works with the transceiver, has at each length of 2,5 metres an indication of the place where a tap should occur.
The **cable tap (AUI)** of the transceiver assures the connection between the transceiver's own electronics and the NIC.

B.) The connection (AUI) between the Transceiver / MAU and NIC for the 10BASE5 thick cable.

The maximum length of this connection cable (for connecting the NIC to the 10BASE5 thick coaxial cable) is of **50 metres** and is achieved with the special cable**.**
The AUI cable includes the 4 pairs of shielded twisted wires:

- 3 pairs for the signals:

  - 1 pair for the transmission (send) signals
  - 1 pair for the reception signals,
  - 1 pair for the signal indicating the collision
- 1 for the 12 volts DC for the transceiver supply.

<u>C.) **The NIC connection to the 10BASE-5 cable.**</u>

The NIC (included in the machine / work station) is connected to the transceiver through the **cable tap (AUI).**

In view of connecting to the cable tape (AUI), the NIC's (of the types complying with the thick coaxial table) are equipped with the DB-15 connector.

For the connection to the thick coaxial cables, the following structure is achieved:

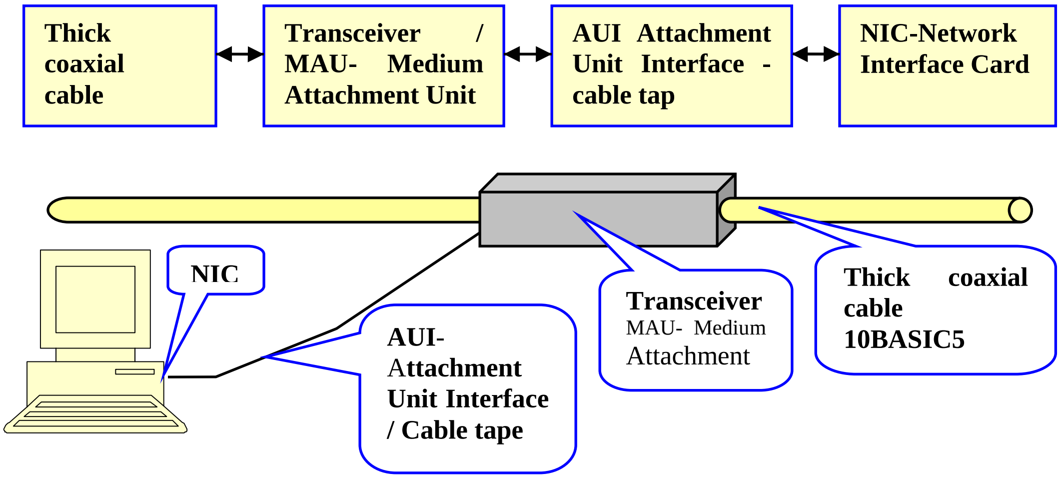


Fig. 6.3. Connecting the work station to the 10BASIC5 thick coaxial

The 10BASE 5 specification requires that the coaxial cable should be grounded at one and only one point.

<u>5.) The 10BASE2 thin coaxial cable.</u>

The 10BASE2 (thin coaxial) is less expensive than 10BASE5 (thick coaxial), but the maximum length accepted by the 10BASE2, through the segments' concatenation, is of about 5 times less than in the case of the10BASE5 thick coaxial.

<u>**Performances of the 10BASE2 coaxial cable**</u>

- The 10BASE2 thin coaxial cable, type RG-58, has the impedance of **50 ohms** and a diameter of **o,5 centimetres**.
- Maximum rate: 10Mbps.
- The maximum number of Segments: 5. The maximum number of repeaters: 4 (the 5-4-3 rule).
- Maximal **segment length**: 185 metres.
- The maximal number of connection cables: 5 (this results from the 5-4-3 rule): 3 segments of cable accept connections to the machines. 2 segments of cables do not accept connections to the machines. These 2 are connection cables, respectively segments without stations).
- The maximal number of stations / machines per segment: 30 (the maximum number of machines, connected at the segments which accept machines, in accordance with the 5-4-3 rule: only 3 segments accept machines and 2 are only connection segments, therefore 2 segments do not accept machines).
- The maximum number of machines per each segment: 30

The thin coaxial cables (10BASE-2, for instance) use the special **BNC (Bayonet Nut Connector) connectors** achieved in the mechanical T form (the T geometrical form), which has 3 elements:

  - 2 connections to the Cable (one side and the opposite side) and
  - 1 connection to the machine.

The BNC is connected directly on the machine.

The BNC in T connector does not only achieve the connection of one machine. Additionally, the cable continuity towards the following machine is accomplished through the same connector.

If a T connector, from the chain: connector (machine)→ cable →connector (machine)→cable…
is not fastened or has defects, then it may disturb or trouble the entire network.

<u>The rules of cabling with the **thin coaxial Ethernet cable**</u>

The rules of cabling the **thin coaxial Ethernet cable** [also named Thinnet or Cheapnet (cheaper among the coaxial cables' price)], with the technical name 10BASE2 (version IEEE), (type RG-58) are synthesized below.
10 BASE2 is permitting the transmission with the speed of up to 10 Mbps at the maximum **segment length** of 185 m (therefore below 200m).

The 5 segments, from which the machines are accepted only on 3 segments length, lead to the maximum length of under 900 metres.

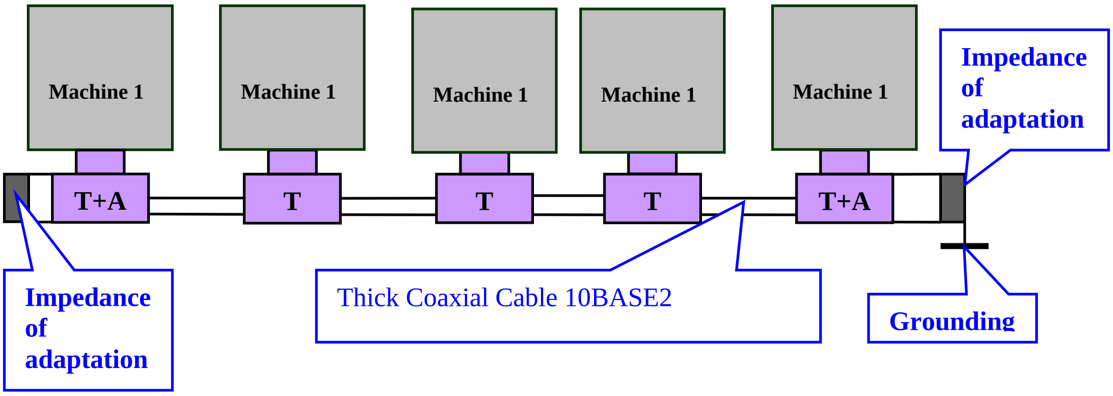


Fig. 6.4 The thick coaxial cable based network.

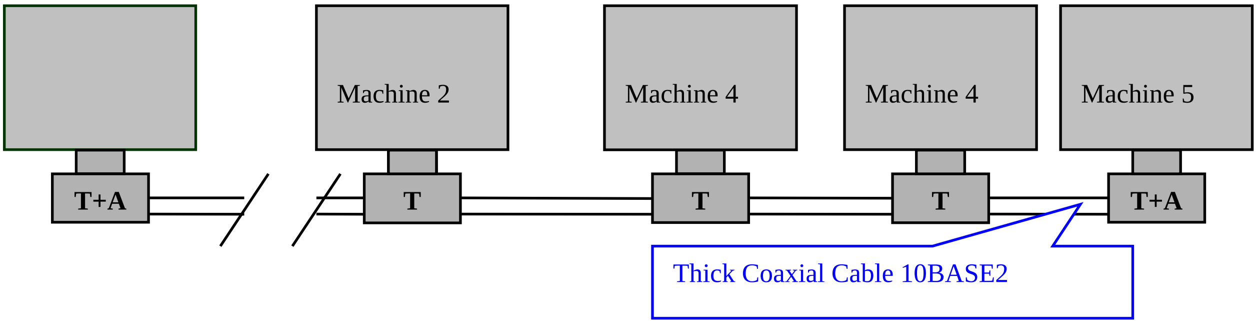


Fig. 6.5 The case of failure.

In fig. 6.4., the manner of connecting is illustrated, through BNC connectors and the thin coaxial cable, of one chain of the Work Stations.
A trouble-inducing situation is illustrated in fig. 6.5. The cable failure or a defection of the connector of machine 2 may lead to the failure of the connection between machine 1 and all the work machines.

The 10BASE2 (coaxial thin cable) segment may accept a maximum number of 30 machines, with the minimum distance between the machines of: 0.5 m.

<u>The following must be accomplished in all types of networks:</u>
A. The continuity of the ground,
B. The isolation: excluding the contacts between the conductive elements of the coaxial cables and the conductive parts of the equipments,
C. The adaptation of the cable impedance at both ends of the entire coaxial cable.
D. The connection to the ground (at the screw of the electrical outlet) of one of the grounds of one of the 2 terminators. The connection to the ground is only done at one of the ends.
The 10BASE 5 specification requires that the coaxial cable should be grounded at one and only one point.
Also, the 10BASE 2 specification requires that the coaxial cable should be grounded at one and only one point.

"…multiple grounds on an Ethernet segment can result in a risk to the equipment, shock to people, and network errors" [11].

Connecting the multiple segments of network lengths.
Based on the 5-4-3 rules, 5 network segments may be connected, out of which 3 populated work stations.
A maximum number of 29 stations will be on each segment, because 1 Repeater is equivalent to one station.
This means that each repeater sends signals towards another maximum 29 stations + 1 repeater.

Each segment must be ended with adaptors (impedance of adaptation) at the end of the respective segment and one of the adaptors (and only one of each segment) of the segment must be grounded.

In the configuration illustrated in fig. 6.6., an example of the Ethernet network is presented, based on thin coaxial cable, 10BASE2 and constructed from 2 segments connected through one repeater.

Each segment has the adapting impedance at both ends and each segment has one and only one personal segment grounding.

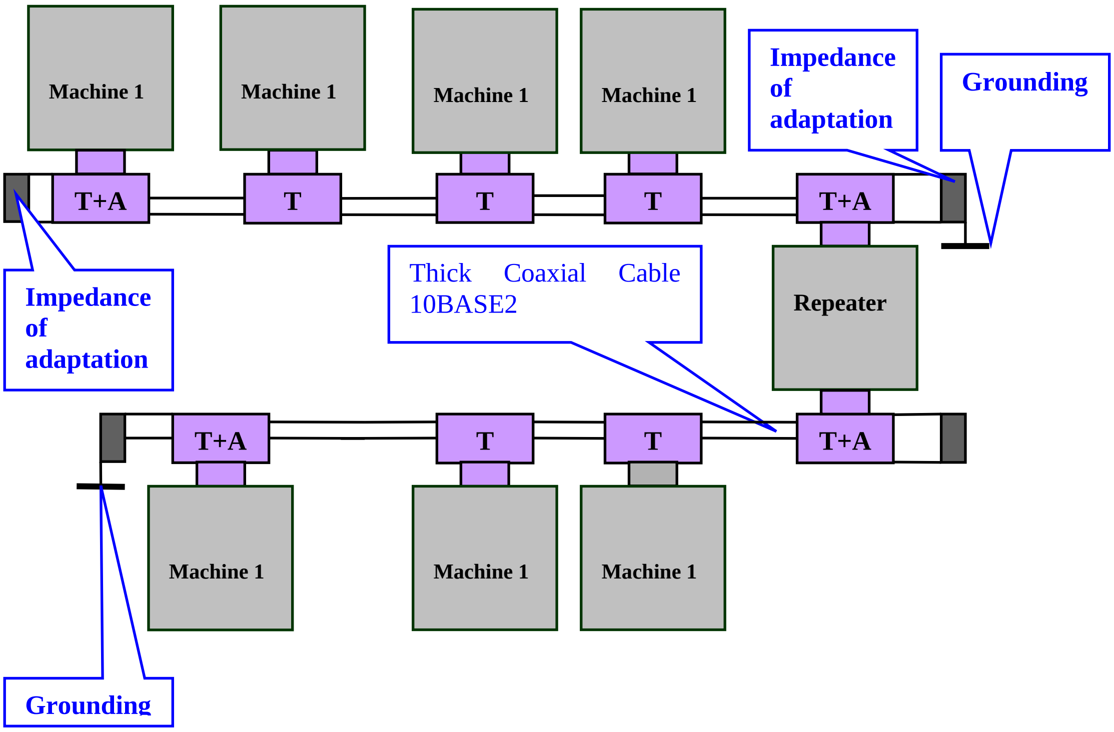


Fig. 6.6. The connection of the 2 thin coaxial cable-based network using one repeater.

In the same manner in which the configuration from fig. 6.6 is achieved, other configurations are created, for instance the networks from 5 segments length.

In this case, in accordance with the 5-4-3 rule, 4 repeaters are used, from which only 3 populated segments and 2 connecting segments (without clients / work stations).

Each segment is adapted, at both ends, at the impedance of the line.
Only one adaptation terminator is grounded for each segment.

In the following Table, examples of configurations achieved with the 10BASE2 coaxial cable are illustrated.

No.	Description of the network based on the 10BASE2 coaxial cable
1.	Speed: 10 Mbps Repeaters : 0 Maximal length of the segment: 185 Maximal machines per segment: 30 Minimal distance between 2 machines: 0.5 m Total maximum length: 185m
2.	Speed: 10 Mbps Repeaters : 1 Segments with possible machines: 2 Number of the inter-segments (with zero machines): 0

	Maximal length of one segment: 185 Maximal machines per segment: 30 Minimal distance between 2 machines: 0.5 m Total maximum length: 370 m (respectively 2x185m)
3.	Speed: 10 Mbps Repeaters : 2 Segments with possible machines: 2 Number of inter-segments (with zero machines): 1 Maximal length of one segment: 185 Maximal machines per segment: 30 Minimal distance between 2 machines: 0.5 m Total maximum length: 555 m (respectively 3x185m)
4.	Other configurations, up to 5x185m=925m.

6.) Elements of maintenance and troubleshooting of the networks with Bus Physical Topology

A big disadvantage of the BUS Physical Topology configurations consists in the fact that a trouble or failure of one connection, at one machine, may influence and trouble the entire bus of the network (practically the entire network).

Another disadvantage consists in the fact that the identification of the causes of the troubles is more difficult.
For instance:

- a defective connector at one node or
- a break in the cable or
- the lack of a terminator

may lead to the fall of the entire bus and network.

The numerous troubles at the bus physical topology consist in the disconnection, in one point of the network, of one connector at one machine.
Example: moving the position of a machine may lead to breaking the cables, in which case the entire network is falling.

Key Point Summary Conclusions and Recommendations

1. Cabling the Ethernet networks, by observing the rules, is essential for the correct operation.
2. 2 philosophies and topologies of cabling are developed and are applicable:
a.) The bus cabling based on the coaxial cables,
b.) The Hub and / or Switch based cabling, based especially on the UTP cables.
3. The types of Ethernet cables initially used, such as the thick coaxial cable, for instance the 10BASE5 (up to 10 Mbps, up to 500 metres of **segment length**) are now obsolete.
Among the types of coaxial cables, the coaxial thin cable may be used, such as 10BASE2 (up to 10Mbps, up to 183 metres of **segment length, maximum 5 segment lengths**) or other.
Through the application of the 5-4-3 rule, up to 5 segments of the thin coaxial cable may be concatenated and, with the 10BASE2 thin coaxial cable, one length of about maximum 900 metres may be accomplished.
4. The configurations with UTP cables, Hub and / or Switch based, are presented in the following lesson.
5. It is essential to observe the rules of adapting the cable impedance at both ends, and of grounding the cable ground (conductive cover of the kernel of the coaxial cable and isolated towards the kernel and towards the exterior) only at one end.

Study Guide

ESSENTIAL QUESTIONS FOR THE VERIFICATION OF THE KNOWLEDGE ACQUIRED

1. What is a LAN and where are the LANs placed in the Networks?
2. Which are the principal features of LAN?
3. Which is the difference between the Hub and the Switch?
4. In what consists the 5-4-3 rule?
5. What is the signification of the 10BASE5?
6. Which are the principal advantages and disadvantages of the 10BASE5 coaxial cables?
7. Which are the principal troubleshooting generated when using the 10BASE2 cables?
8. Which is the maximum length of the network accomplished with the 10BASE 5 and with the 10BASE 2? Which are the essential differences between the respective 2 types of coaxial cables?
9. Where is it necessary for a network which uses repeaters to be adapted?
10. What signifies one segment length and where is it necessary to ground a network with multiple repeaters?

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[Supplem. 2.] www.cisco.com/univercd/cc/td/doc/cisintwk/idg4
[Supplem. 2.] www.cramsession.com
[Supplem. 4.] http://uga.edu/~ucns/lans/docs/ethernet/faq Ethernet Network Questions and Answers. Summarized from UseNET group… .
[Supplem. 5.] http://www.erg.abdn.ac.uk/users/gorry/course/phy-pages/man.html

SUPPLEMENTARY INDICATIONS ABOUT THE CONTENTS OF THE LESSON

It is recommended to also consult the documentations from: www.cisco.com; www.cramsession.com; and other.

ANSWERS TO QUESTIONS

1. The LAN – Local Area Network represents a net on a limited area, normally one building or several buildings. The LAN works independently or may be connected to other networks. The LANs are the bricks at the basis of the Internet.
2. The principal features of LANs are: they operate on a limited geographical area, are monitored locally, are private, are in operation 24/7 (seven days), allow the multi-access (the access of different partners connected to the respective network), The LANs (such as the Ethernet LAN) work with Layer 1 of the stack of communication model and with Physical addresses. Also: The use of the Switching Packets Technology. The Data is transmitted under the form of Data Packets. The speed (bandwidth): typically (for the respective LAN, depending on the type of Ethernet technology used) 10 Mbps, 100 Mbps, 1Gbps, 10 Gbps.
3. The Hub offers on all of the ports the Data coming on one of the ports. The switch offers the Data only on the ports which include the address of the clients connected to the respective ports.
4. A network may be achieved from 5 segments, separated by 4 repeaters and only with 3 populated segments.
5. 10BASE5 signifies: the maximum rate 10 Mbps, working in the Baseband, the segment length of maximum 500 metres and respectively the total length of about 2500 metres. 10BASE5 is a thick coaxial cable.
6. The principal advantages of the 10BASE5 cable are: long length segment, high immunity to electromagnetic perturbations, possibility to be achieved with 5 length segments, big Ethernet length of up to 2500 m. Disadvantages: very difficult to re-configure the network in situ, difficulties to work with this cable, big diameter, requires supplementary devices (transceivers), expensive, the fall of the entire network due to the failures of the bus cable, requires mechanical interventions for the achievement of the connection and other.
7. The principal troubleshooting generated when using the 10BASE2 (thin coaxial cable) consists in the fall of the entire network due the breakdown at one BNC connector.
8. 2500 metres with 10BASE5. 925 metres with 10BASE2. Differences between the 2 types of cables: electrical and mechanical performance, construction, the segment lengths, price, diameter, the manner of physical connection, possibilities of manipulation and replacement.
9. At the ends of all of the segments. For instance: if a repeater will be used, then 4 adaptations must be achieved (at both ends of each of the 2 segments).
10. A segment length represents the maximum length acceptable for a cable used without repeaters. Each segment must be individually grounded in one single point, respectively at one of the adaptation impedances.

WORDS TO THE LEARNER: ***"Do not wait for opportunities.*** Create them." (After Bernard Shaw)