# LABORATORY WORK NO. 3b
STRUCTURED CABLING

## 1. Objectives

The objective of this paper is the knowledge of structured cabling, networks topology and the function of the different network devices.

## 2. Theoretical considerations

### 2.1 Physical media analysis

In the physical media analysis, we may choose several factors of performance such as: the speed of transfer, bandwidth, reliability or the error rate, the duration of service, the average duration between the two defects, defects tolerance, direct costs, indirect costs, the cost per port or equipment connected, the cost per bandwidth or the total cost per port per bandwidth. The bandwidth, $L_B$ is a factor of intrinsic performance particular to each medium. The reliability, F, is also a factor of intrinsic performance of each medium and shall be the ratio of the number of bits erroneously transmitted to the total number of bits transmitted. The service duration, $D_{e,}$ is the length of time after the environment should be replaced, due to aging phenomena. The average duration between two faults, DMDD, is the statistical average time between two successive malfunctions of the environment for the standardised period of life. Defects tolerance, $T_{d,}$ is a factor of performance induced on the physical environment by the technology and network architecture used, but in many cases a given environment does not allow a error tolerance architecture or only one limited. Direct costs, $C_d$, are represented by the actual cost of the environment along with connectors, the auxiliary materials necessary for correct posing, and the cost of labour for communication environment realisation and environment testing. The cost per port, $C_p$, it is a synthetic factor which has a greater decision value, being a global decision criterium and reflecting the total costs for carrying out physical infrastructure related to the total number of ports or equipment connected. The cost per port per speed of transfer, $C_{pv}$, is a factor performance more usefull which alleviates taking a correct decision in the implementation of a local area network, including the possibility of future extension without the need for change the environment. The total cost per port per speed, $C_{tpv}$, is a complex factor of performance which characterizes a local area network at global level also including the equipment or technology costs. Characterization of performance factors above referred of the physical communication media previously presented is summarized in the following table. Performance factors, and in particular the type of cost, shall be classified relatively without giving absolute values which may be affected very rapidly in time.

**Table 2.1** *Performance factors*

| Medium | $L_b$ Gbps | Reliability | $D_e$ years | DMDD | $T_d$ | $C_d$ | $C_p$ | $C_{pv}$ | $C_{tpv}$ | Recomanded in usage | Further use |
|---|---|---|---|---|---|---|---|---|---|---|---|
| UTP Cat 6,7 | >1 | Medium | 15 | years | Yes | Medium | Small | Small | Small | Yes | Yes |
| Multimode OF | >1 | Large | 30 | years | Yes | Large | Medium | Medium | Medium | Yes | Yes |
| Single-mode OF | >1 | Large | 30 | years | Yes | V. Large | V. Large | Large | Large | Yes | Yes |

## 2.2 Structured cabling

There are three standard network topologies bus, star and ring:

- **Bus topology** is the oldest method of interconnecting computers in a network. Data is transmitted to all the stations but is accepted only by the destination station, and the reflection of the signal is stopped using terminators. Figure 2.1 a. represents the bus topology;
- **Star topology** has replaced the bus topology, the main feature is that it has a central component called hub through this component data is transmitted from one station to all the others. The star topology offers the resources and means for central administration. Figure 2.1 b. represents the star topology;
- **Ring topology** stations are connected through a cable shaped as a ring and every station is acting as a repeater amplifying the signal. Figure 2.1 c. represents the star topology.

Today most of the topologies used are combinations of star, ring and bus topologies. The bus-star topology supposes connecting networks with star topology through linear branches (bus). Problems of connectivity appear when a concentrator fails. The ring-star topology also known as ring cabled as a star. In this case there is a central concentrator that connects all the other concentrators to which the stations are connected.

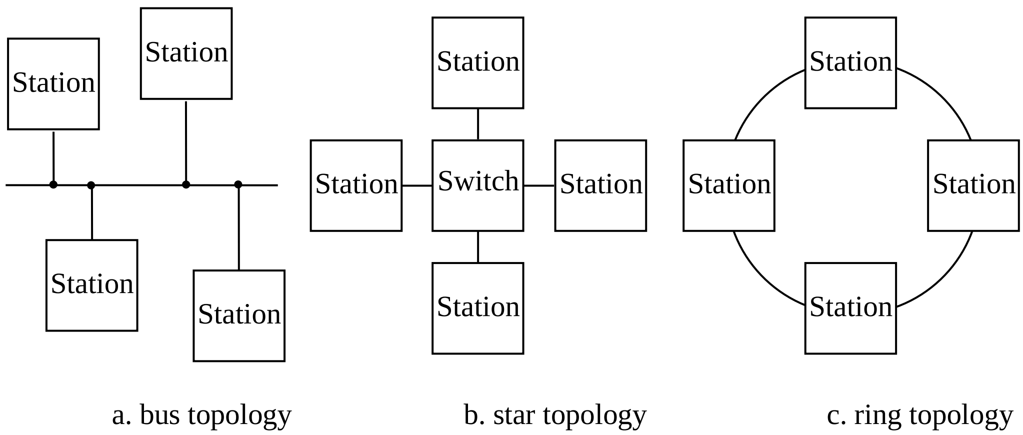


**Figure 2.1** *Standard network topologies*

Under the generic name of active elements are grouped all of the network components that need a power supply and can work with electric, optic signals or both. **Network interface cards** are active elements of layer 2 providing the stations with the network connectivity. Every network interface card has its own 48 bits MAC address assigned from fabrication. This address is unique for every network card and it is composed of 2 parts: the 24 most significant bits identifies the producer, and the 24 least significant bits are assigned by the producer. The network interface cards used in PC's need an I/O address space and a hardware interrupt. The interrupt is activated every time an event (a frame reception in most of the cases) appears requiring software attention, and the I/O address space represents the address region in which the card registers are accessible (written, read, by its driver). Usually both the interrupt and the I/O space are configurable to avoid conflicts with other devices.

The overcome of the length limitations of cables is done by using **repeaters**. These are simple devices, connected at many network segments amplifying the signal that passes through them. Repeaters operate at the physical layer (they don't have the frame notion or package transmitted through the network) and they broadcast the amplified signals on all their outputs.

With the growth of the network dimensions, problems will appear if there are used only repeaters. The limitation for the stations that create such a network is the fact that repeaters/hubs(multiport repeaters) split the bandwidth, being situated in a single **collision domain**. In order to solve this problem we use **bridges**, equipments that operate at the second layer in the OSI hierarchy, and they represent devices much more complex than repeaters because they perform frame filtering based on MAC addresses and a separation of collision domains. Bridges don't forward the frames that are local for a network, but only the ones that have destination addresses located in other networks. They store the frames and realize a retransmission only to the network in which the destination is situated. When the bridges are powered-up they know nothing about the network configuration and the addresses of the computers connected to it, but they learn the network topology while they forward the frames. Initially they allow all the frames to pass in all directions. But in time, as frames pass through, the bridge inspects the source address of each frame and completes the MAC tables, with the station address and the port at which the station is connected. Based on these tables they decide on which port the frames must be retransmitted. Frames sent at broadcast or multicast addresses will be retransmitted further away on all ports. **Switches** are layer 2 equipments that take frames forwarding decisions based on the MAC address, so to direct the data only on the port corresponding to the destination host. These devices can be seen as devices capable to offer the connectivity of a hub and they manage the traffic like a bridge. Designing networks with complex topologies is done using switches.

**Routers** are layer 3 equipments that route the packets based on the address used by routable protocols (for example Internet Protocol-IP or Internetwork Packet Exchange – IPX) with the help of the routing protocols (for example Routing Information Protocol RIP, Interior Gateway Routing Protocol – IGRP, Enhanced Interior Gateway Routing Protocol – EIGRP or Open Shortest Path First - OSPF). There are two main router types: dedicated routers and routers built from general purpose computers that have more interfaces. The computer routers have the advantage of cost and simplicity and can be used for other jobs. Dedicated routers are much more efficient and flexible, have much more interfaces and support more protocols and medium access types. Dedicated routers are devices specialized for the routing job. Due to the specialized hardware and powerfully optimized software, they achieve superior performance. They offer a wide range of speeds, physical interfaces and communication protocols. Usually these are manufactured by specialized firms (Cisco, Juniper, HPE etc.) their operating system is specific and has all the software need for the router to function properly. Dedicated routers support almost any transmission medium, used with any communication protocol, with a large range of sockets and adaptors.

Taking in consideration the costs for realizing or modifying a network cabling it has been proved that once a network has been set in place is better to stay in use as long as possible and that it should be able to be used with novel communication technologies. The solution for this problem was in the elaboration of the **structured cabling** concept, defined later through several international standards.

The ISO/IEC 11801 (Europe) and ANSI/TIA-568-C (USA and Canada) standard refer to the ways of cabling commercial edifices, specifying the cabling structure, the necessary minimal configuration, the categories of cables and components that must be used, ways of installation, performance requests that have to be met, acceptable distance limits and other parameters, and also ways and methods for testing them. Another problem that is approached is the problem of designing the cabling for a much more complex building group, in this way a complex project needs to be configured in a hierarchic (tree-like) structure, allowing the possibility to add redundant links. The standard specifications refer to some of the following aspects:

- Minimal request for realizing the cabling of a building
    - The cabling topology and allowed distances;
    - Component elements of the cabling;
    - Transmission media used with the needed parameters specification;
    - Vertical and horizontal cabling realization mode;
    - Ways of identifying the cables used;
    - Project documentation.
- Subsystems and components of the structured cabling system
    - The subsystem from the entrance in the building;
    - The equipment room;
    - The backbone cabling;
    - The telecommunication closet;
    - Horizontal cabling;
    - The work area components.

**The cabling topology** specified in the ISO/IEC or ANSI/TIA standard is a star, hierarchically organized (extended star). The topology center is main distribution facility, the second hierarchic level is the intermediary distribution facility afferent to one area edifice, and at the lower level is the telecommunication closet related to a floor or a group of rooms. The constitutive elements are:

- *The main distribution facility* – the distribution center to the other edifices;
- *The intermediary distribution facility* – are local to edifices;
- *The telecommunication closet* – is represented by the local distribution closets for the cables that connect the stations or related to the vertical cabling;
- *The inter-edifice section* – identifies the main cables that interconnect the main distribution center;
- *The internal section* – connects the intermediate commuter with the distribution offices;
- *The equipment room* – related to a cabling plan with passive and active equipments;
- *The entrance infrastructure* – for the interfacing of the exterior cabling system with the interior one;
- *The work area* – the working stations, interconnection cables, external adaptors between cables;
- *Intermediate panels* – identifies the connection panels for the transmission mediums;
- *Terminator blocks* – represent the cable mechanical terminators;
- *Communication outlets, cabling adaptors.*

The usual transmission media are:

- Twisted cable (category 6 and above);
- Multimode or single-mode optical fiber;

Types of the connectors used are:

- RJ-45 connectors for TP cables;
- LC, SC or ST type connectors for optical fiber;

So, in order to accommodate a much easier and efficient way to manage the network, the cabling is structured using concentrators (on different levels). At each level a concentrator must be implemented, and if the covered area is too large than several concentrators can be used. At the working stations the UTP cable is ended in RJ-45 connectors, and at the concentrator in boxes or patch panels. The cumulative length of the cable and UTP patch cord used for connecting a computer at the equipment from the concentrator is not allowed to be greater than 100m. In the floor concentrator the switches or other equipments are situated.

The advantages concentrators offer (and also the topologies based on concentrators) are:

- possibility to extend or modify the cable system;
- usage of different ports, adapted at different types of cables;
- possibility of a central monitoring of the activity and the network traffic.

Types of concentrators:

- **Active concentrators** – that regenerates and transmits the signal;
- **Passive concentrators** – can be considered the cabling panels or the connection blocks representing only connection points without any signal amplification. Also there are hybrid concentrators that allow the usage for connection of different cable types.

The cables must be labeled according to the standard, the ventilation must be sufficient to prevent equipment overheating, security measures must be set and fire protection must be provided. The floor concentrator is connected to the building concentrators, link that can be realized with a category 6 cable or with multi-mode optical fiber. Additionally, redundant links can be added between the floor concentrators and between the buildings. The building group concentrator is connected to the buildings concentrators with multimode or single-mode optical fiber. Installation standards are referring to the cable installation (maximum tension allowed on the cable, mechanical connection type), masked horizontal cabling, ground protection, and the specific protection of the optical fibers cables.

## 3. Lab activity

3.1 The topologies of the computer networks are going to be discussed underlining their advantages and disadvantages.
3.2 The function of the following network devices will be discussed: network interface card, concentrator, repeater, bridge, switch and router.
3.3 Aspects of the structured cabling and ISO-IEC/ANSI-TIA standard will be discussed.
3.4 Floor cabling will be analyzed, and the elements of the structured cabling will be pointed out.
3.5 Identify and analyze the structured cabling design at your workplace/home. How is your network connected to the WAN/ISP (what type of cable, device, etc)? How is your device connected to the internal network?

**Notes**