

Exercise series no. 1

Part I: Network categories, Network Topologies, Throughput, and Delays

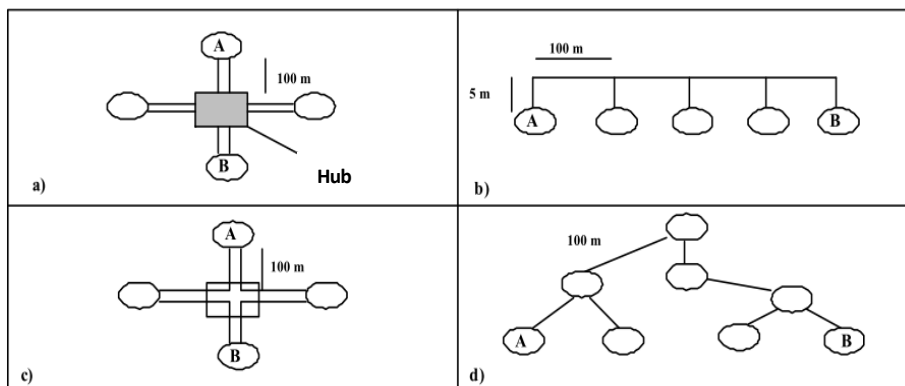
Definitions:

- **Hierarchical topology** (also known as **tree topology**) is a network structure in which devices are arranged in a layered, tree-like hierarchy. It consists of multiple levels, with a **root node** (often a central server or switch) at the top, followed by intermediary nodes (such as switches or routers) that connect to lower-level devices (like computers or other endpoints).
- A **VPN (Virtual Private Network)** is a technology that creates a secure and encrypted connection over a public network, such as the internet. It allows users to send and receive data as if their devices were directly connected to a private network, enhancing security, privacy, and anonymity.
- A **SAN (Storage Area Network)** is a high-speed, specialized network that provides access to consolidated, block-level storage. It connects storage devices, such as disk arrays and tape libraries, to multiple servers, allowing them to access shared storage as if it were directly attached to their own systems.

Exercise 01

I.

1. For each of the networks represented in the following figure, specify:
 - a. The physical and logical architecture.
 - b. The distance between station A and station B.



2. What is the total length of circuit c?

II. For n devices in a network, what is the number of cable links required for a mesh, star, ring, and bus topology?

Exercise 02

Ahmed works at the Algiers office and needs to connect to the company network in Bejaia. The information he needs to access is highly confidential. Security is therefore a major consideration. What type of network should he use?

- a. A WAN (Wide Area Network).
- b. A LAN (Local Area Network).
- c. A SAN (Storage Area Network).
- d. A VPN (Virtual Private Network).

Exercise 03

1. List some types of information transmitted over computer networks.
2. In a computer, what is the fundamental unit of information?
3. What are its multiples, and how much data do they represent?
4. How much information does a black-and-white digital image of an A4 sheet (210 × 297 mm) represent, given that the resolution is 600 dots per square inch? (1 inch = 25.4 mm)

Exercise 04

An image has a size of 1920 x 1080 pixels (Full HD) with true color, which means that 3 Bytes per pixel are used for the color information.

1. How long does it take to transmit the uncompressed image via a:
 - 10 Mbps connection?
 - 100 Mbps connection?
 - 1 Gbps connection?
2. Assume the image is compressed with a compression algorithm that reduces the image size by 85%. How long does it take to transmit the image via a :
 - 10 Mbps connection?
 - 100 Mbps connection?
 - 1 Gbps connection?

Exercise 05

A MP3 file with a size of $30 * 10^6$ bits must be transferred from terminal device A to terminal device B. The signal propagation speed is 200000 km/s. A and B are directly connected by a link with a length of 5000 km. The file is transferred as a single message that has a size of $30 * 10^6$ bits. No network protocol headers or trailers exist.

We assume that:

The data rate of the computer network between both terminal devices is 56 kbps.

Waiting time (Queuing Time) = 0 s

Processing Delay = 0 s

1. Calculate the transfer time (latency) of the file.
2. What is the maximum number of bits that can reside inside the line between the sender and receiver?

Exercise 06

Imagine, NASA sent a spacecraft to planet Mars, which landed there. A 128 kbps (kilobit per second) point-to-point link is set up between planet Earth and the spacecraft.

The distance between Earth and Mars fluctuates between approx. 55000000 km and approx. 400000000 km. For the further calculations, we use the 55000000 km, which is the distance from Earth to Mars, when they are closest together.

The signal propagation speed is 299792458 m/s, which is the speed of light.

1. Calculate the bandwidth-delay product for the link to find out what is the maximum number of bits that can reside inside the line between the sender and receiver, considering that:

Processing delay = 0 s

Waiting time = 0 s

2. A webcam at the surface of planet Mars sends pictures to Earth. Each image has a size of 20MB. How quickly, after a picture is taken, can it reach Mission Control on Earth?

Part II: OSI Model, TCP/IP Model

Exercise 07

1. Provide the architecture of the OSI model.
2. A network card is considered a device of which layer in the OSI model?
3. How can two layers of the same level communicate virtually without knowing the implementation of the lower layers?
4. What is encapsulation?
5. In the context of the OSI model, what is a PDU?
6. What is the protocol data unit (PDU) of the OSI model layers: transport, network, data link, and physical?
7. Given that $|PDU_i|$ represents the size of the PDU used by layer i , which of the following statements is true?
 - a. $|PDU_i| < |PDU_{i+1}|$.
 - b. $|PDU_i| = |PDU_{i+1}|$.
 - c. $|PDU_i| > |PDU_{i+1}|$.
8. What is the role of a PCI added by a layer?
9. Which of the following statements is true?
 - a. $N_PDU = L_PDU + N_PCI$.
 - b. $N_PDU = N_SDU + N_PCI$.
 - c. $N_PDU = T_PDU + N_PCI$.
 - d. $N_PDU = N_SDU + L_PCI$.
10. Compare the OSI model layers to the TCP/IP protocol stack.