Advanced Networks

Dr. Sara Hebal

Assistant professor

Computer sciences department

Faculty of sciences

Ferhat Abbas Setif university 1

Algeria

Email: sara.hebal@univ-setif.dz

1.0 March 2026

Attribution - NonCommercial : http://creativecommons.org/licenses/by-nc/4.0/fr/

Table of contents

Objectives 3

Introduction 4

I - Requirements 5

II - Quiz : Pre-test 6

III - Introduction to Computer Networks 8

1. Chapter Objectives 8

2. What is a Network? 8

3. Fundamental Objectives of Computer Networks....9

4. Network Components 9

5. Networks Classification....9

5.1. Based on Communication Pattern (transmission techniques)....10

5.2. Based on Geographical Scope (distance covered) 10

5.3. Based on Host role 11

5.4. Based on Fields of application 12

5.5. Based on Mobility....12

6. Networking Models....13

7. Quiz....15

IV - Bibliography 17

Objectives

By the end of this course, students will be able to:

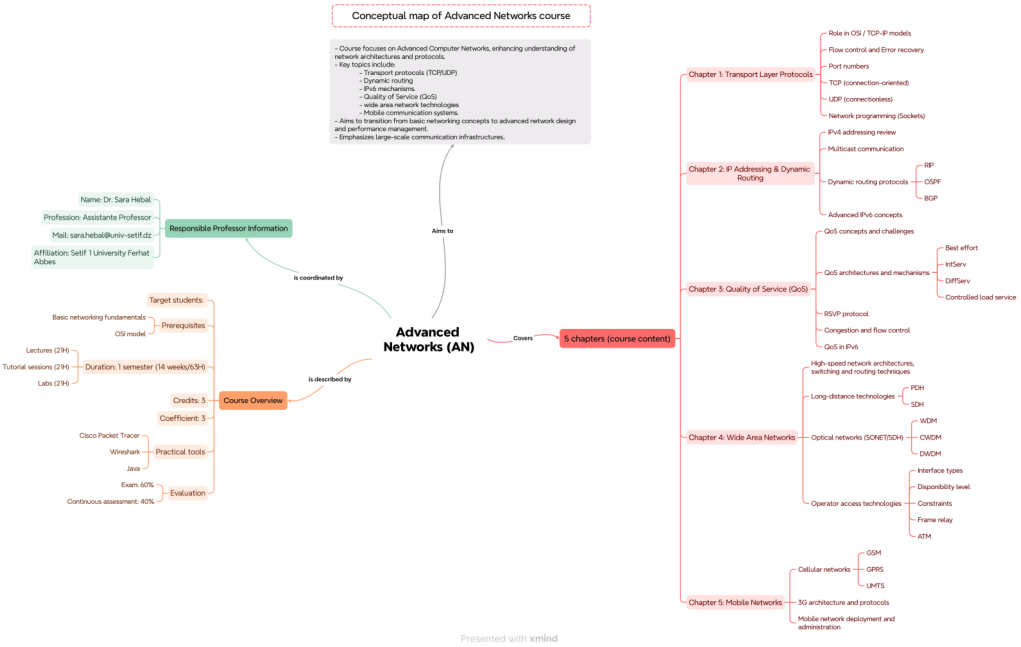
- Explain core networking concepts, including network architectures, components, topologies, and the OSI/TCP-IP models.
- Analyze and apply IP addressing schemes and routing mechanisms, including IPv4/IPv6 and dynamic routing protocols.
- Evaluate the behavior and performance of transport protocols (TCP and UDP), including connection management, flow control, and reliability.
- Assess QoS mechanisms and select appropriate strategies to ensure network performance under different traffic conditions.
- Describe and analyze WAN technologies and architectures, including MPLS and optical networks.
- Explain the architecture and functioning of mobile communication systems (GSM, UMTS, 3G/4G).

Introduction

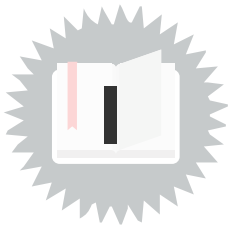
Modern computer networks form the backbone of today's digital world, enabling communication, data exchange, and service delivery across local and global infrastructures. This course on Advanced Computer Networks builds upon fundamental networking concepts to provide a deeper understanding of how complex communication systems operate and are managed.

The course begins with a review of essential concepts, including network components, architectures, and reference models such as OSI and TCP/IP. It then focuses on key layers of network communication, particularly the network and transport layers, exploring addressing mechanisms, routing strategies, and transport protocols.

In addition, the course introduces advanced topics such as Quality of Service (QoS), wide-area network (WAN) technologies, and mobile communication systems. Emphasis is placed on both theoretical understanding and practical application, enabling students to analyze network behavior, configure network services, and evaluate performance in real-world scenarios.



Requirements



Before starting this course, students should have the following basic competencies:

- Be comfortable using a computer, including file management and basic software tools.
- Have introductory knowledge of computer science concepts from a previous course or equivalent background.
- Be familiar with the basics of operating systems, especially command-line usage.
- Understand elementary mathematical ideas such as binary numbers and simple algebraic operations.
- Have general awareness of Internet usage and how data is exchanged over networks.
- Possess introductory knowledge of computer networks, including the concept of IP addresses (IPv4) and basic communication between devices.
- Be able to understand simple technical explanations and follow structured problem-solving steps.

Note: Key foundational networking concepts will be briefly reviewed at the beginning of the course to ensure a common starting level for all students

Quiz : Pre-test



Quiz

What is the most efficient way to organize a project containing documents, images, and code files?

- Keep all files in the desktop folder
- Store all files in a single directory
- Separate files into structured folders by type
- Rename all files with random names for uniqueness

Quiz

Describe the steps you would take to move a file from one folder to another using a file manager.

Quiz

Which option best defines an algorithm?

- A programming language used to build applications
- A sequence of instructions designed to solve a problem
- A hardware component that processes data
- A network communication protocol

Quiz

Which environment represents a command-line interface?

- Windows Explorer
- Terminal / Command Prompt
- Desktop icons
- Web browser

Quiz

A command-line interface allows users to interact with a computer by entering commands through a text-based environment.

- True
- False

Quiz

Write one basic command used in a terminal and explain its function.

Quiz

Which of the following are valid binary numbers?

- [ ] 10101
- [ ] 10201
- [ ] 11100

Quiz

What happens when you send data over the Internet?

- ○ It is sent as one complete block without changes
- ○ It is divided into small packets for transmission
- ○ It is stored in the router permanently
- ○ It is converted into a physical signal only at the destination

Quiz

Which of the following are valid IPv4 addresses?

- [ ] 192.168.1.10
- [ ] 10.0.0.300
- [ ] 172.16.5.4
- [ ] 255.255.255.255

Quiz

Which of the following are Internet services?

- [ ] Email
- [ ] File Transfer (FTP)
- [ ] Offline text editor
- [ ] Web browsing

Introduction to Computer Networks



1. Chapter Objectives

By the end of this chapter, the student will be able to:

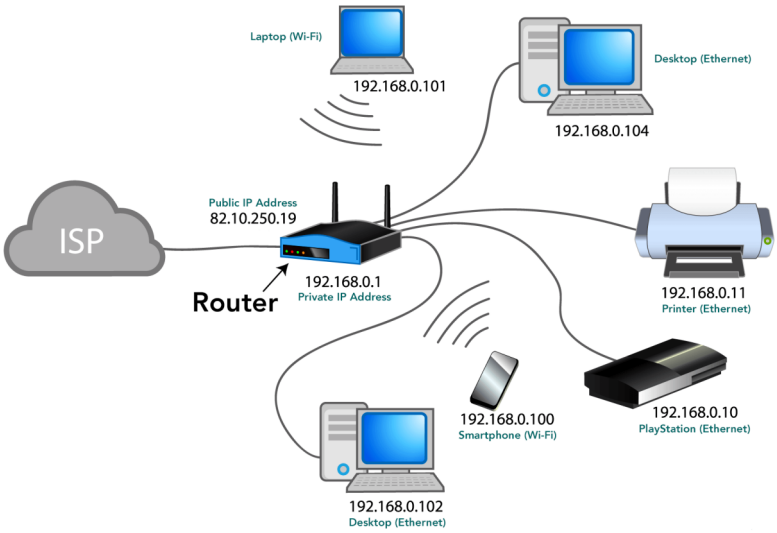
- Define the fundamental concepts of computer networks and their components.
- Classify different types of networks and network topologies.
- Differentiate between the OSI and TCP/IP reference models.

2. What is a Network?

Definition

A computer network is a set of interconnected autonomous devices that communicate and share resources using standardized rules called communication protocols.

- A network could be as large as the Internet or as small as your two computers at home, sharing files and printers
- Two computers are interconnected if they are capable of exchanging information.



Warning

- Autonomy excludes master/slave-type systems.
- A system composed of one unit that controls several slave units is not a network

3. Fundamental Objectives of Computer Networks

- **Data Communication:** efficient and reliable information exchange between geographically distributed entities (email, video conferencing platforms).
- **Resource Sharing:** hardware, software, storage
- **Increase collaboration:** collaborative engineering platforms
- **Reliability and Fault Tolerance:** backup systems.
- **Scalability:** ability to grow without redesign Cost Optimization
- **Distributed Processing:** Distributed databases, cloud computing platforms and Parallel AI model training
- **Mobility and Remote Access:** access resources from different locations and enable devices to remain connected while moving.

Example

AI platforms, IoT ecosystems, cloud computing, and financial systems are examples of modern infrastructures that are essentially network-dependent.

4. Network Components

1. **End Devices (Hosts)**
    - Computers / Workstations
    - Smartphones / Tablets
    - Servers (Web, DNS, Database)
    - IoT Devices (sensors, cameras)
2. **Intermediate Devices**
    - Routers
    - Hubs
    - Switches
    - Access Points
    - Firewalls
3. **Communication Media**
    - Copper cables
    - Fiber Optical cables
    - Wireless channels

5. Networks Classification

Networks lack a standard classification and are typically categorized by various criteria:

- Communication Pattern (transmission techniques)
- Geographical scope (distance covered)
- Host role
- Fields of application

- Mobility

5.1. Based on Communication Pattern (transmission techniques)

Broadcast Networks

- Shared communication medium
- All connected devices receive the transmitted frame Each message contains its destination address
- Devices check upon reception to determine if they should process the message or disregard it.
- A broadcast network allows a message to be sent to all devices in the network.
    - **Limited broadcast:** broadcast in the same network
    - **Direct broadcast:** broadcast from a device to all devides in another network
- Medium access control required (one at a time)
- Typical Topology: Bus topology

Note

In some networks, a message can be sent only to a selected group of devices. This type of transmission is known as Multicasting.

- one-to-many (not all)

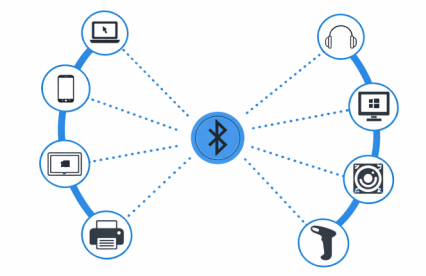
Point-to-Point Networks

- Dedicated link between two devices
- No shared medium
- Data is only delivered to the designated receiver.
- Data is typically forwarded by intermediate devices from source to destination, with routing algorithms determining the optimal path when multiple paths are available.
- Often full-duplex
- Common in WANs
- Typical Topology: Mesh topology

5.2. Based on Geographical Scope (distance covered)

Personal Area Network (PAN)

- Short-range network (few meters 1-10m)
- Centered around one person that links their devices
- Use wireless technologies (Bluetooth, NFC, ZigBee)
- Low data rate

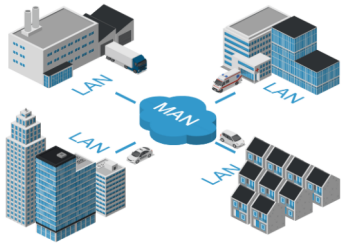


Local Area Network (LAN)



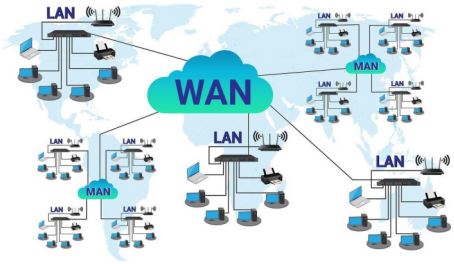
- Interconnects devices within a limited geographical area, such as a building or campus
- Several kilometres, typically use wired connection efficient communication & data transfer, high data rate, Low latency

Metropolitan Area Network (MAN)



- Covers a wider geographical area than a LAN
- Connects multiple sites across a metropolitan area (city or a large campus)
- Several kilometers to tens of kilometers, High data rate

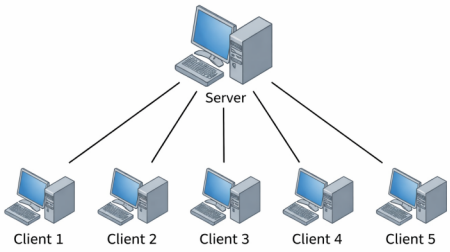
Wide Area Network (WAN)



- Connects networks over large geographic areas (LANs, MANs)
- Mesh topology
- Point-to-Point links
- Global connectivity & High scalability

5.3. Based on Host role

Client-server Network

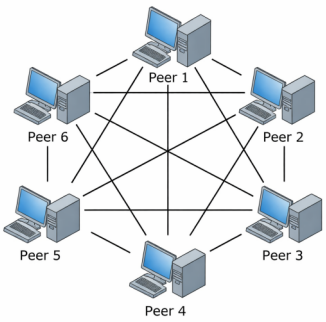


- Centralizes services on dedicated servers
- Clients send requests to the servers
- Servers provide services to clients
- Centralized control
- High scalability
- Easier management
- Security control

Warning

- Single point of failure (without redundancy)

Peer-to-Peer Network (P2P)



- A device can be a client or a server
- Decentralized architecture
- Distributed resource sharing
- Easy to set up
- Less complex
- Lower cost for simple tasks & small networks

Warning

- Not as secure
- Not scalable
- Slower performance

5.4. Based on Fields of application

Networks are designed differently depending on their operational domain.

- **Telecommunication Networks:** used for voice communication (2G, 3G, 4G, 5G,etc)
- **Home networks:** used for communication in houses and apartments (TVs, Mobiles, heating system, lighting system . . .)
- **Offices networks:** used for data communication within a company, university or administration, for exchanging information or sharing resources (documents, printers . . .)
- **Industrial networks:** used to exchange data between control systems in an industrial setup
- **Military networks:** used by military command systems

5.5. Based on Mobility

Wired Network

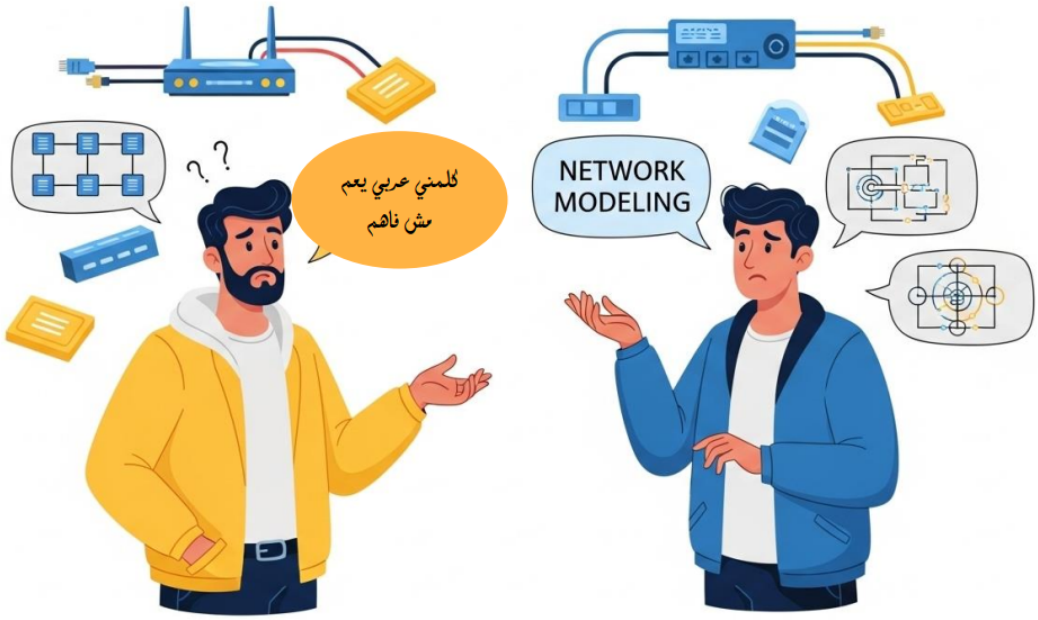
- Wired infrastructure (use cables to connect equipment to the network)
- Minimal mobility
- Predictable topology

Wireless Network

- Radio-based transmission (use antennas to send and receive data)
- Supports device movement while maintaining communication continuity.
- Two categories
    - Networks with infrastructure (those networks using access points)
    - Ad hoc networks

6. Networking Models

How can computers from different organizations communicate with each other despite using different systems and technologies?



Netwoking models *Definition*

Categorise and provide a structure for Network Protocols and Standards

Networking protocols *Definition*

Are a set of rules defining how network devices and software should work to connect and communicate to a network

Note

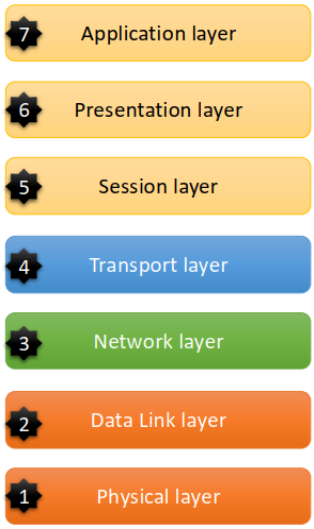
In the beginning the development of networks was chaotic.

- Each vendor had its own proprietary solution.
- The bad part was that one vendor's solution was not compatible with another vendor's solution.

This is where the idea for the standardized networking models such as OSI-model was born, having a layered approach to networks our hardware vendors would design hardware for the network, and others could develop software for the application layer.

Using an open model which everyone agrees on means we can build networks that are compatible with each other.

OSI (Open System Interconnection) Model



- A conceptual architecture that standardizes the functions of a telecommunications or computer system into seven layers
- Each layer has a number, name, functions and communicates with the layers directly above and below it
- The first four layers are important for networking, while the upper three layers are important for applications.

- The seven layers of this model, from the lowest (Layer 1) to the highest (Layer 7), are as follows:
  1. **Physical Layer**
     - Define physical characteristics of the used medium (voltage, connectors, . . .)
     - Convert digital bits to electrical or radio signals (encoding)
     - Bit transmission
  2. **Data Link Layer**
     - Provides node-to-node connectivity and data transfer
     - Define how data is formatted for transmission over a physical media
     - Error detection
     - Physical addressing
     - Two sublayers
       - **Logical Link Control (LLC)**
       - **Media Access Control (MAC)**
  3. **Network Layer**
     - Provide connectivity between end hosts in different networks
     - Logical addressing (IP)
     - Data routing and forwarding (routing protocols) between devices on different networks
  4. **Transport Layer**
     - Ensures reliable end-to-end communication
     - Split large data into smaller segments and handling error detection and correction
     - The most common transport layer protocols are:
       - **TCP (Transmission Control Protocol)** for reliable communications
       - **UDP (User Datagram Protocol)** for connectionless communications
  5. **Session Layer**

- Establishes, maintains and terminates sessions or connections between applications on different devices
- Provides synchronization and control mechanisms to ensure orderly data exchange

6. **Presentation Layer**
   - Translates data between the application layer data and lower layers into appropriate format
   - Data encryption, decryption, compression and formatting
7. **Application Layer**
   - The closest layer to the user interacting directly with end-user applications (web browser)
   - It provides network services directly to end-users or applications, and includes protocols such as HTTP, FTP, SMTP

7. Quiz

Quiz

Which of the following are **functions/objectives** of computer networks?

- ☐ Resource sharing
- ☐ Data encryption
- ☐ Communication between devices
- ☐ Centralized processing

Quiz

Which statement best describes a computer network topology?

- ○ The physical and logical arrangement of devices in a network
- ○ The type of operating system used in devices
- ○ The physical arrangement of devices in a network

Quiz

Differentiate between LAN and WAN in terms of scope and performance.

Quiz

Explain why the TCP/IP model is more widely used than the OSI model in real-world networks.

Quiz

Which of the following are advantages of layered network models (OSI/TCP-IP)?

- ☐ Simplifies troubleshooting
- ☐ Makes systems independent of hardware changes
- ☐ Removes the need for protocols

- ☐ Standardizes communication

Quiz

Which of the following are true characteristics of a LAN?

- ☐ High data transfer rate
- ☐ Covers a large geographical area
- ☐ Low latency communication
- ☐ Usually privately managed

Bibliography



- Tanenbaum, A. S., Feamster, N., Wetherall, D. J., Computer Networks, 6th Edition, Pearson,2021.
- Kurose, J. F., Ross, K. W., Computer Networking: A Top-Down Approach, 8th Edition, Pearson, 2021.
- Comer, D. E., Internetworking with TCP/IP, Volume 1: Principles, Protocols, and Architecture, 6th Edition, Pearson Education, 2014.
- Stallings, W., High-Speed Networks and Internets: Performance and Quality of Service, 2nd Edition, Prentice Hall, 2002.