

Chapter I – Introduction to Communication Systems and Networks

ENEL 471 – Introduction to Communications Systems
and Networks

Chapter Objectives

- At the end of this chapter, you will be able to:
 - Define communication systems and networks
 - Define the basic feature and characteristics of the elements of a communication system
 - Distinguish between the different types of communication systems

Outline

- Definition of a communication system
- Elements of a communication system
 - Information source
 - Transmitter
 - Channel
 - Receiver
 - Information sink
- Communication networks
 - Definition of a communication network
 - Standardization

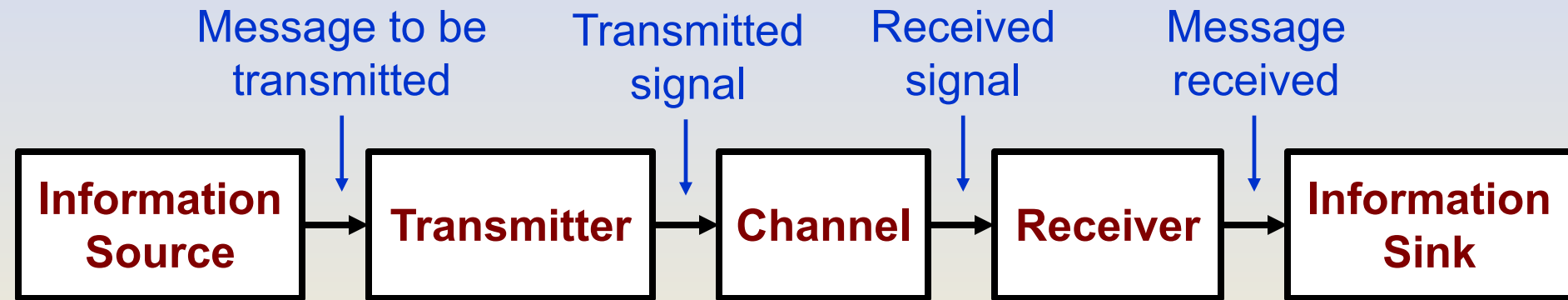
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Definition of a Communication System

- Communication system (or communication link) is a **set of elements** that transmit useful **information from one point to another**
- Information :
 - message to be transmitted (audio, video, picture, text, data,...)
- Set of elements:
 - Information source: generates the message to be transmitted
 - Transmitter: converts the message to be transmitted to an appropriate format for transmission (signal)
 - Transmission medium or channel: carries the signal from the transmitter to the receiver
 - Receiver: converts back the received signal (the reverse operations of the transmitter + channel effects compensation)
 - Information sink: user of the received message

Definition of a Communication System



Block diagram of a communication system

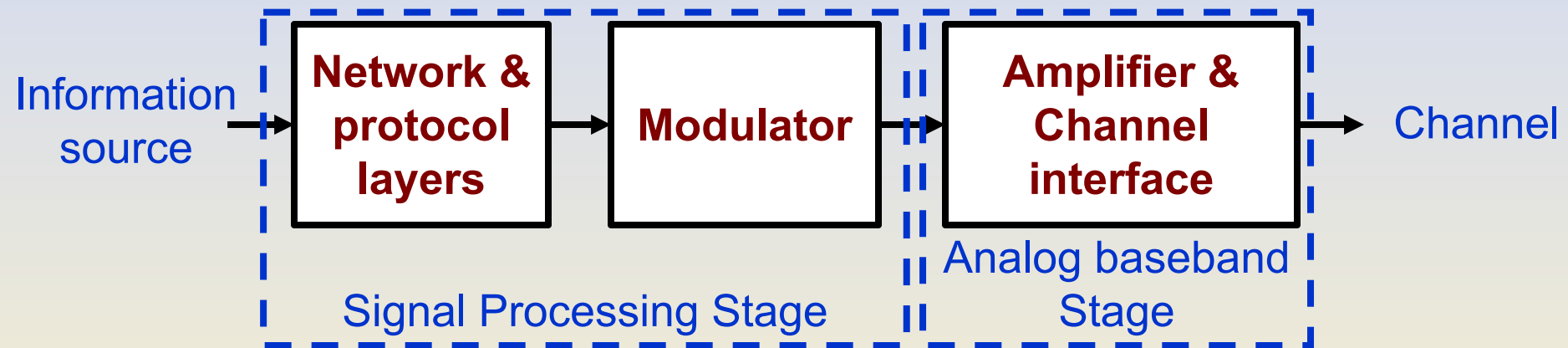
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Information Source

- Two types of information source: digital and analog
- Digital information source
 - Generates digital message
 - The digital message has a finite set of possible values
 - Examples: keyboard (text message), digital camera, “microphone + audio encoder”
- Analog information source
 - Generates analog message (infinite set of possible values)
 - Examples: microphone, VHS recorder
- A communication system is characterized by the type information source:
 - Digital communication systems use digital information sources
 - Analog communication systems use analog information sources

Baseband Transmission

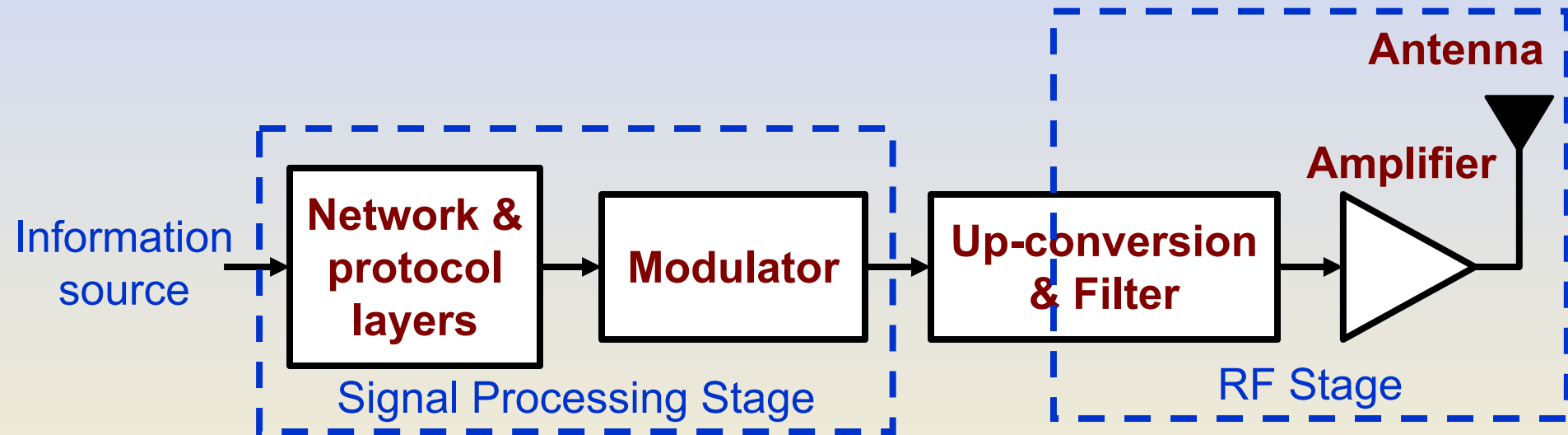


Block diagram of a baseband transmitter

Baseband Transmission

- Baseband transmission is used in the case of wired channel. The transmitted signal is in baseband.
- Network and protocol layers: allow sharing the same channel between different users and package the information (label its characteristics: start, end, type of modulation, length, address of the source and destination,...)
- Modulator: the information is impressed within a certain bandwidth in a manner that can be suitably recovered by the receiver
- Amplifier and channel interface: increases the power of the signal and change its shape or form to adapt it to the transmission medium (for example transform the electrical signal to a light signal in the case of fiber optic transmission)

Bandpass Transmission



Block diagram of a bandpass transmitter

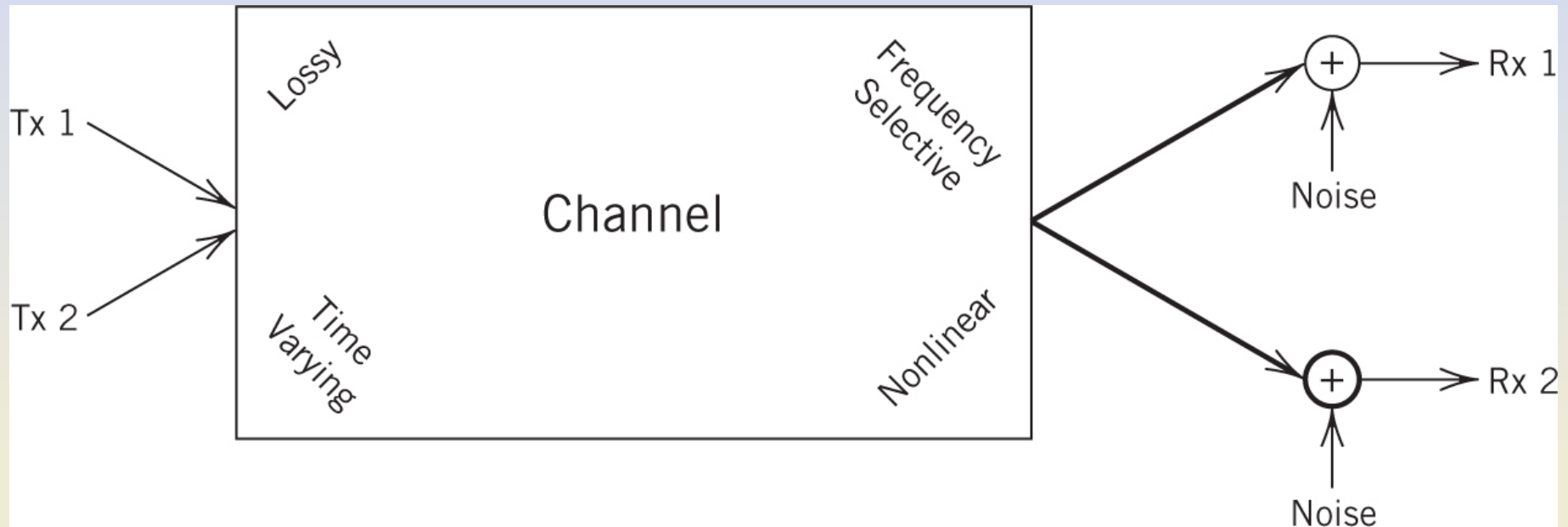
Bandpass Transmission

- Bandpass transmission is used in the case of wireless channel. The transmitted signal is converted from baseband to a carrier frequency at RF in order to allow the wireless propagation.
- Network and protocol layers: this block has similar functions as in baseband transmission.
- Modulator: has similar functions as in baseband transmission
- Up-conversion and filter: this block converts the baseband signal at the output of the modulator to bandpass signal around a RF carrier frequency
- In analog communications, the modulator block and up-conversion block may be combined
- Amplifier : increases the power of the RF signal
- Antenna: transforms the RF signal to an electromagnetic wave to be transmitted through the channel (air)

Communication Channel

- Wired and wireless channels have a number of properties:
- Loss: there is a loss of signal strength (signal power) with increasing distance. In wireless channels, the loss increases proportionally to the square of the distance. In wired channel, the loss increases linearly with distance
- Frequency selectivity: the channel generally have a non-flat frequency response (there is a difference on how well a frequency is transmitted compared to another)
- Time varying: the channel (especially in the case of wireless communication) is a time varying system. Its behaviour changes versus time
- Nonlinearity: when a repeater or relay station is used (very long distance communication), for example in satellite communication
- Noise: is mainly introduced by the random motion of electron in circuits. It is significant in the receiver side because the signal power is very low

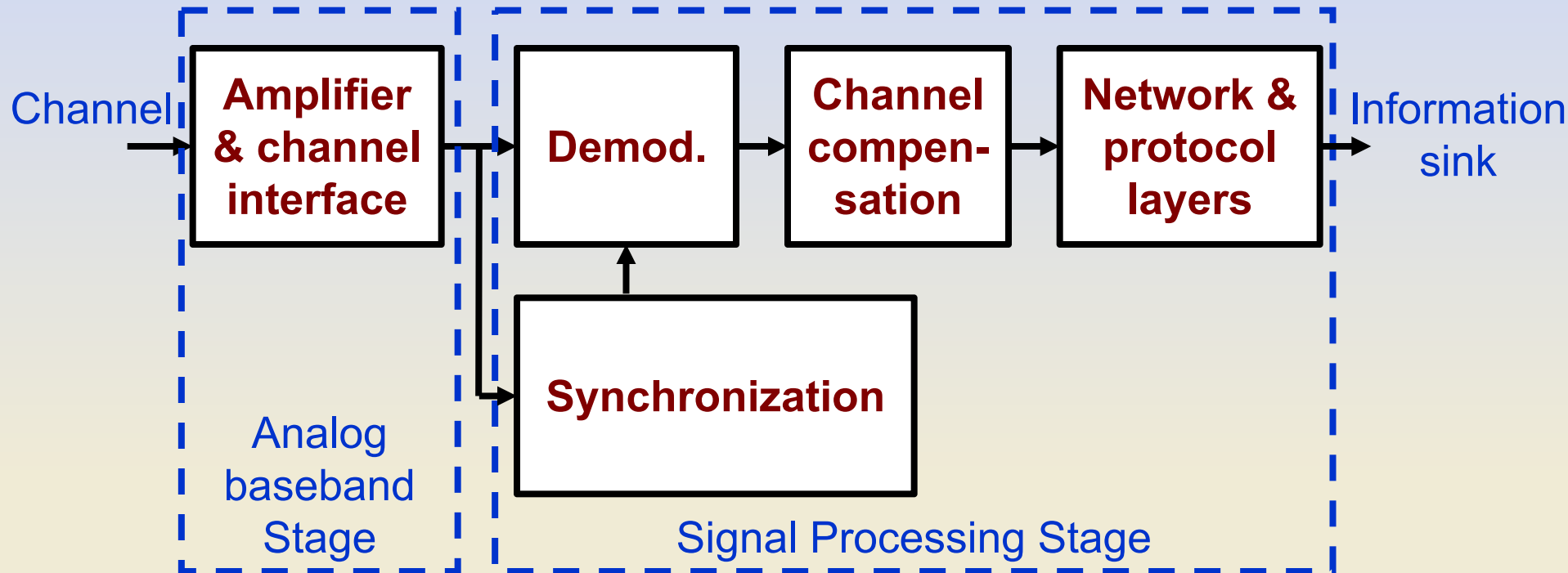
Communication Channel



Receiver

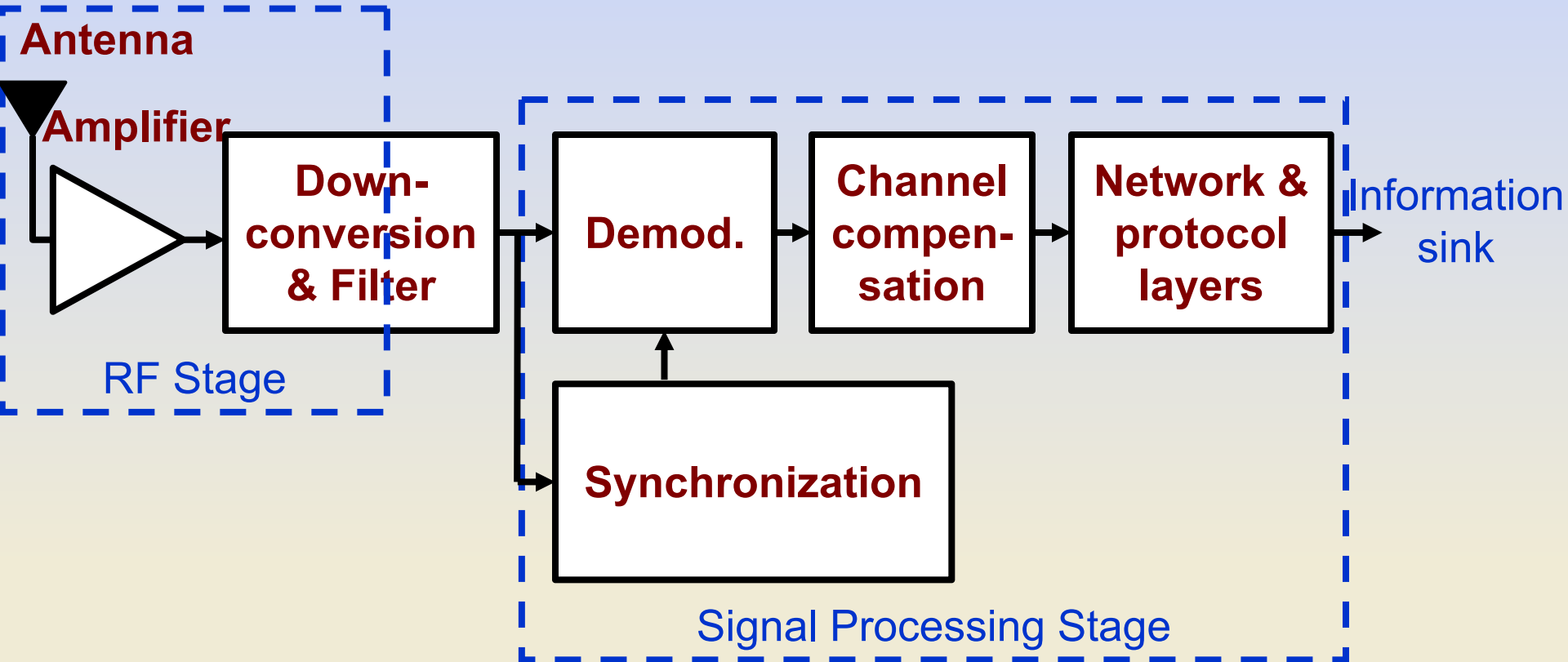
- The receiver performs the reverse operations of the transmitter
- In addition, it performs:
 - Amplifier: is a low noise amplifier that will amplify the power of the received weak signals without introducing too much noise
 - Synchronization: it uses a known transmitted training sequence to synchronize the time and frequency between the transmitter and receiver clocks
 - Channel compensation: it generally uses a known transmitted training sequence to estimate the channel distortions (frequency selectivity and nonlinearity)

Baseband Receiver



Block diagram of a baseband receiver

Bandpass Receiver



Block diagram of a bandpass receiver

Information Sink

- Destination of the information sent by the source
 - Uses the received information
 - Examples: speaker, screens, TV, ...

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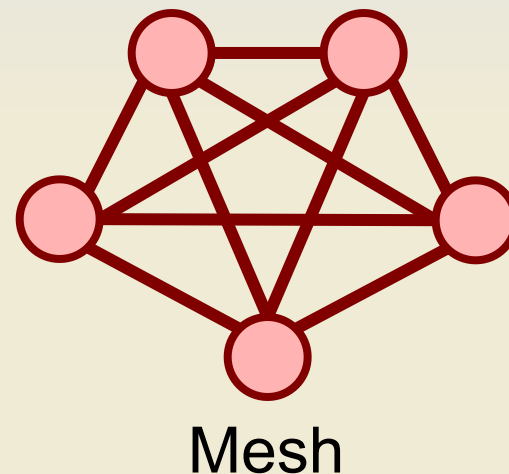
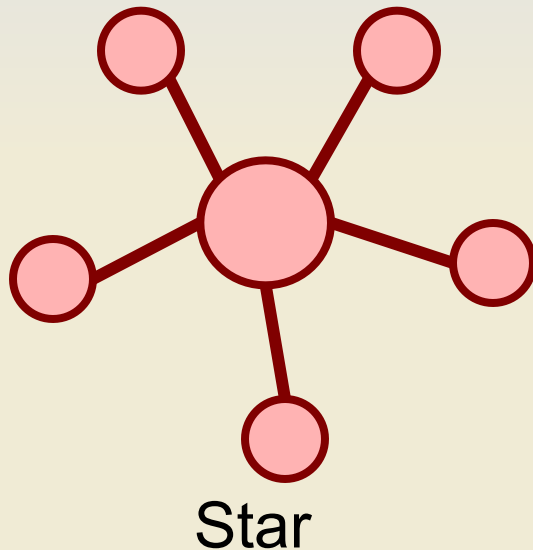
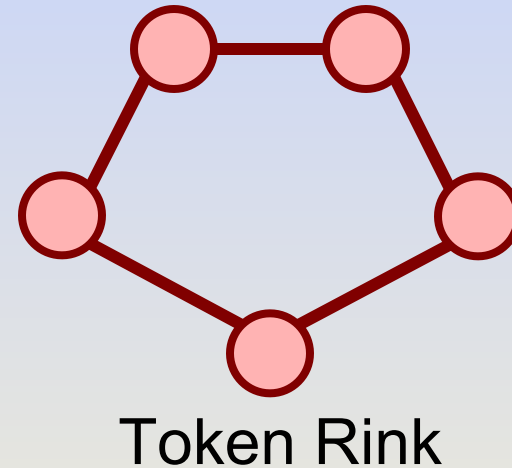
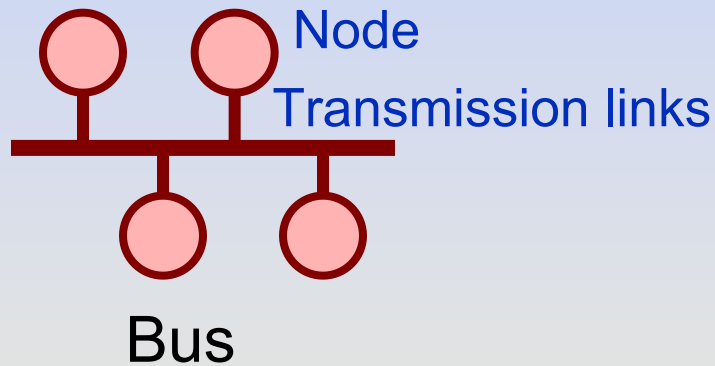
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Definition of a Communication Network

- The network is a set of several nodes (users, transmitters, receivers) interconnected by a transmission links
 - nodes: users, transmitters, receivers
 - Transmission link: channel that provides information exchange between two or more nodes
- The information exchange over the network is governed by a set of rules or communication protocols
- The communication protocols ensures effective use and sharing of the channel and proper communication
- There are different network topologies; e.g.: Bus, Star, Token ring, Mesh ...

Examples of Communication Network Topologies



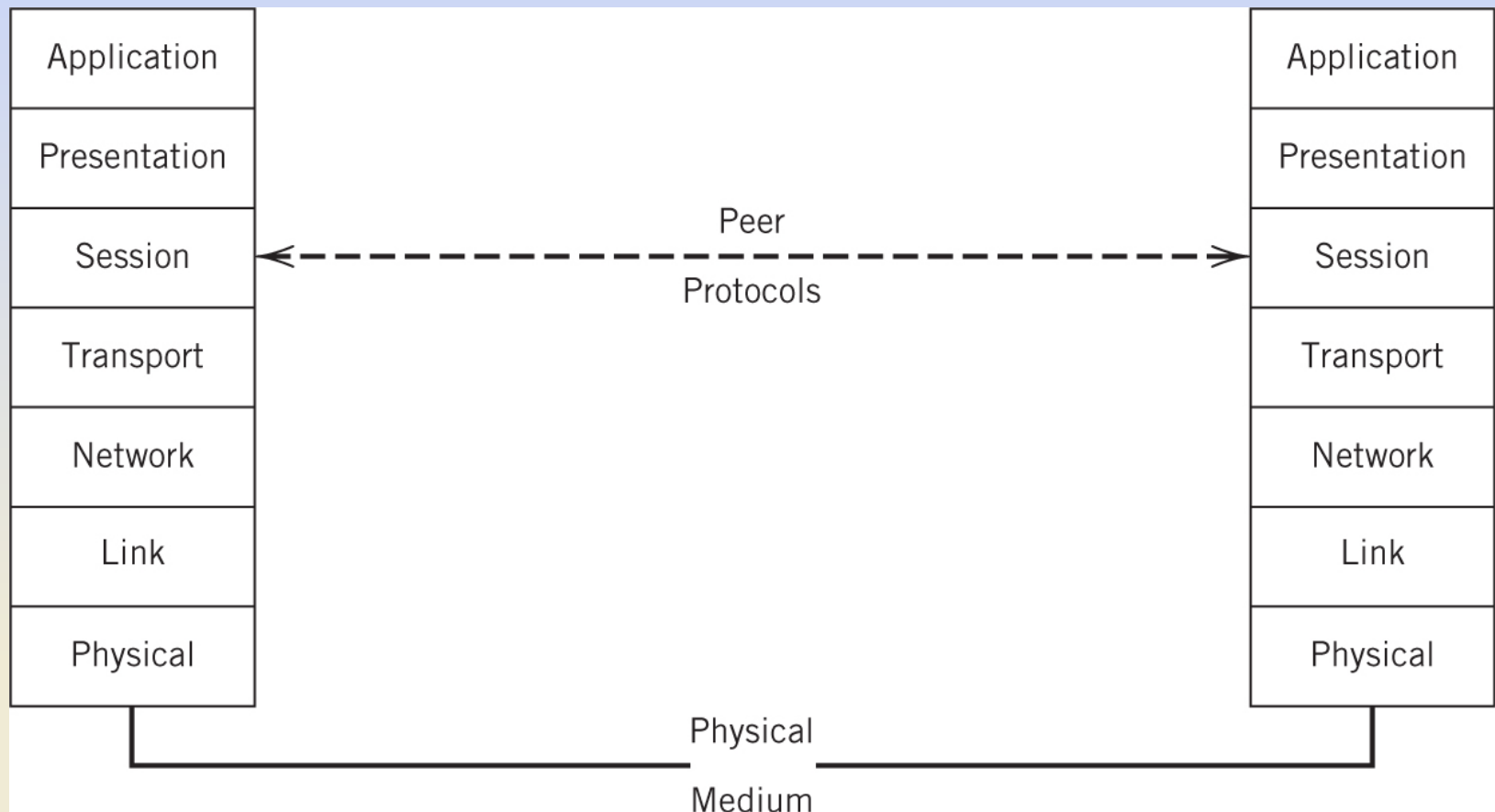
Deployment of a Communication Networks

- Objective: information transfer between different nodes
 - This objective should be met while satisfying different Criteria:
 1. Reliability: reliable information exchange between the nodes
 2. Cost-effectiveness: by sharing resources when possible
 3. Quality of service:
 - data rate: quantity of information transmitted by time unit
 - Latency: time between transmission and reception of information
 - Error rate: the number of erroneous information unit (bits, frames, packets...) per time unit
- Need for organizing mechanism: communication standards set by standards organizations

Standards and Standards Organizations

- Need for standards
 - Allow interoperability: equipment from different vendors to interwork
 - Speed the growth of the communication industry
- Important standard organizations
 - International Standards Organization (ISO)
 - International Telecommunication Union (ITU)
 - Institute of Electrical and Electronics Engineering (IEEE)
 - Federal Communication Commission (FCC)
 - Industry Canada Radio, Spectrum and Telecommunications

Open System Interconnection (OSI) Model



- In ENEL 471, we will focus on :
 - Physical layer: transmitter, channel and receiver
 - Link layer: rules for gaining access to the channel