



Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Communication Networks course Physical Layer

Pr A. DJEFFAL

2nd licence year

2023-2024

www.abdelhamid-djeffal.net



Physical layer

Physical Layer Role

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Transform a sequence of bits into signals (and vice versa)
- Determine how bits are transported on physical media.
- Introduce bits 0 and 1 on the medium in a specific form, recognizable by the receiver.



Physical layer

Used Components

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Cables, fibers, ...
- Sockets, connectors, ...
- Network Cards
- Repeaters, multiplexers, ...
- Modems, hubs, ...



Physical layer

Chapter Objective

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Study of transmission media and their characteristics,
- Study of the methods used for the transmission of information



Modes of transmission

Parallel transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

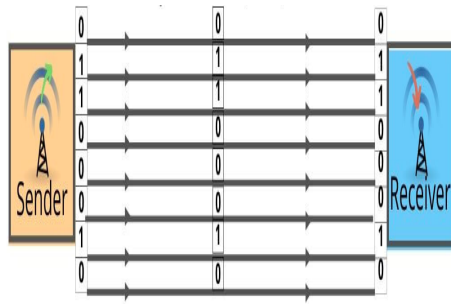
Characteristics
of a commu-
nication
line

Transmission
media

Information
coding

Multiplexing

Bits sent on separate wires



- Synchronization problems !!
- Suitable for short distances



Modes of transmission

Serial transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

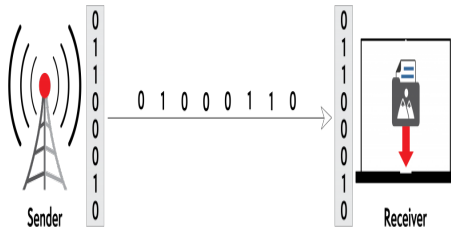
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Bits sent one after the other
- Used in computer networks
- Asynchronous or synchronous.





Modes of transmission

Asynchronous Serial Transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

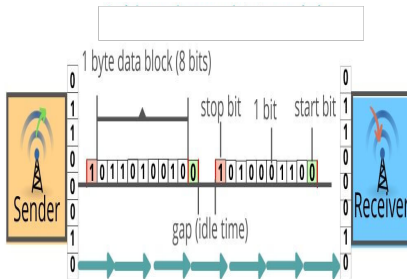
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Transmit Anytime
- Does not depend on specific time intervals
- START bit and STOP bit





Modes of transmission

Synchronous Serial Transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

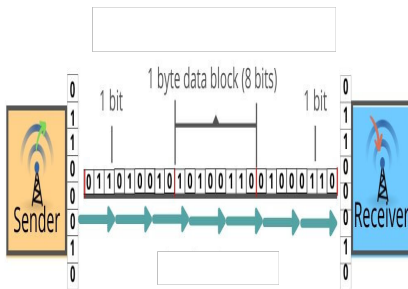
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Convention on a constant elementary time interval
- Transmit at the beginning of the interval for a duration of one interval per information
- Broadband





Modes of transmission

Simplex transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- One part is always sending and the other is always receiving
- Data always flows in the same direction

Simplex:





Modes of transmission

Half duplex transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

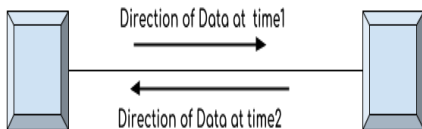
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Channel operated on the alternator for the emission
- Transmitter and receiver transmit but not at the same time





Modes of transmission

Full Duplex Transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

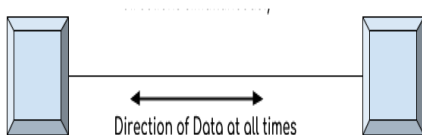
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Full Duplex
- Bandwidth Sharing





Transmitted signal

Signal

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Information Vehicle
- Propagation in the form of a wave resulting from the propagation of a vibratory phenomenon.
- 3 types of waves :
 - electric waves (cables, wires, ...),
 - radio waves (microwave, satellite),
 - light waves (fiber optics, infrared).



Transmitted signal

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

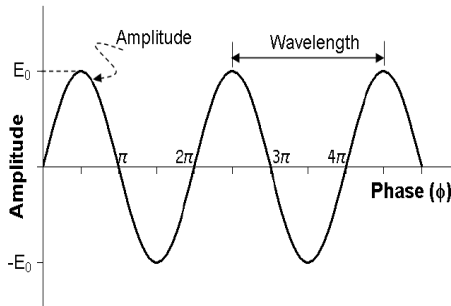
Information
coding

Multiplexing

Forme sinusoidale

$$y(t) = A \sin(2\pi ft + \varphi)$$

A : amplitude, f : frequency, φ : phase.





Transmitted signal

Analog signal

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

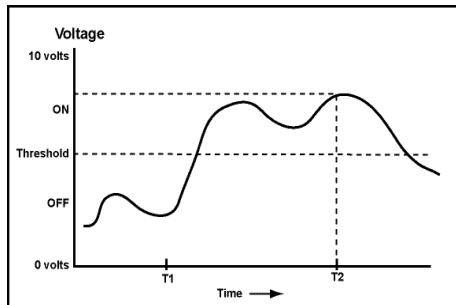
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Continuous variation
- Levels of values proportional to the values of the information (sound, image)
- Long distances





Transmitted signal

Digital signal

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

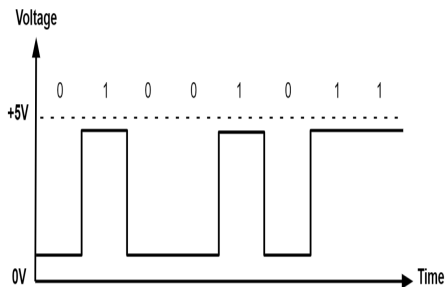
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Square shape
- Discontinuous variation
- Low number of fixed value levels
- Short distances





Characteristics of a communication line

Bandwidth

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communication
line

Transmission
media

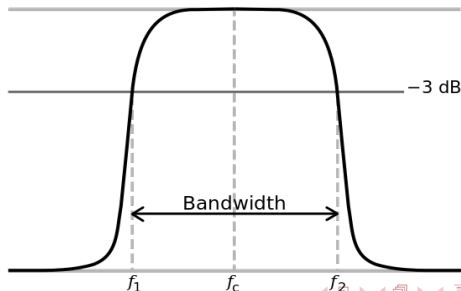
Information
coding

Multiplexing

The bandwidth of a channel is the frequency range over which the channel is able to transmit signals without their attenuation being too great.

$$W = f_{max} - f_{min}$$

f_{min} : fréquence plus basse , f_{max} plus haute





Characteristics of a communication line

R modulation speed

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Number of symbols transmitted per unit time

$$R = \frac{1}{\Delta} \text{ baud}$$

Δ duration of the interval separating two significant values

Nyquist criterion :

$$R_{max} = 2F_{max}$$



Characteristics of a communication line

Transmission Capacity C

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer
Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

$$C = 2W \text{ (bauds)}$$

Shannon (1949) : C depends on the Signal/Noise ratio

$$C = W \log_2 \left(1 + \frac{S}{N} \right)$$

Often the Signal to Noise ratio is given in decibels such as :

$$(S/B)_{db} = 10 \log_{10} \left(\frac{S}{B} \right)$$



Characteristics of a communication line

Error rate

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Probability of loss or alteration of information (1 bit). Example 10^{-9}



Characteristics of a communication line

Bitrate D

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Number of bits transmitted per unit of time (512 Kbits/s, 1 Gigabit/s)

$$D = R \times \log_2(V)$$

V valence of the signal : number of significant states

Exercise : If the duration of a bit is 20ms, what is the bit rate ?



Characteristics of a communication line

Propagation delay T_p

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Time required for a signal to travel a medium from one point to another



Transmission media

Two Families

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Physical Guide Supports
 - Electric currents : twisted pairs, coaxial cables
 - Light : Fiber Optics
- Supports without physical guide
 - Electromagnetic Waves : Hertzian Beams, Radio Waves
 - Light : Laser, infrared



Physical Guide Transmission Media

Twisted Pairs (1)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

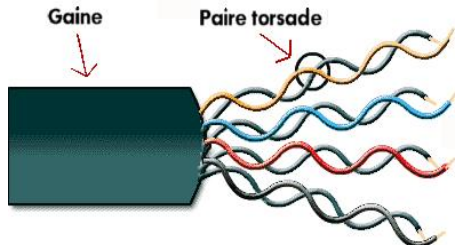
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

RJ11 : telephone, RJ45 : computer networks





Physical Guide Transmission Media

Twisted Pairs (2)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

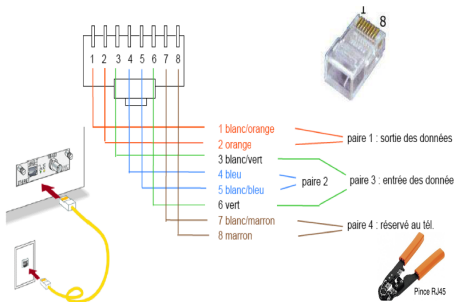
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Connection : RJ45 connectors, RJ45 clip





Physical Guide Transmission Media

Twisted Pairs (3)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Disadvantages :

- Current Attenuation,
- Use of repeaters

Benefits :

- Technique mastered,
- Ease of connection,
- Added new equipment,
- Low cost,
- Point-to-Point and Broadcast



Physical Guide Transmission Media

Twisted Pairs (4)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

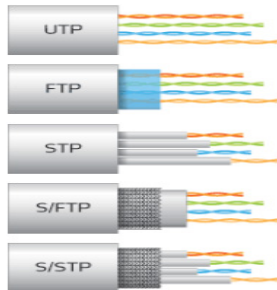
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Types :





Physical Guide Transmission Media

Twisted Pairs (5)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Catégories :

- Category 3 : 16MHz bandwidth, used for telephony.
- Category 5 : Bandwidth 100MHz, Speed 100MB/s over 100m used for telephony and networks
- Category 6 : Bandwidth 250MHz, Speed GB/s over 100m used for networks
- Category 6a : Bandwidth 500MHz, Speed 10GB/s over 100m
- Category 7 : Bandwidth 600Mhz, Throughput 10GB/send



Physical Guide Transmission Media

Coaxial cable (1)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

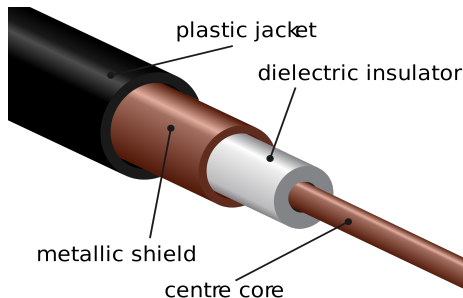
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Two cylindrical conductors on the same axis separated by an insulator, the whole being protected by a plastic sheath.





Physical Guide Transmission Media

Coaxial cable (2)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Kinds :

- Cable 75Ω , known as "broadband" (broadband) used for analog transmission : it's television cable !
- 50Ω cable, called "baseband" (baseband) generally used to transmit digital signals. It allows a bandwidth of a few hundred MHz and speeds of up to 2Gbit/s.



Physical Guide Transmission Media

Coaxial cable (3)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

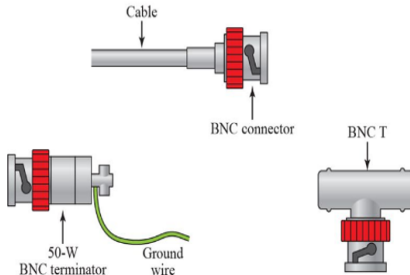
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Connection : vampire sockets for large cables and BNC plugs (British Naval Connector) for thin cables.



Disadvantage : a little expensive.



Physical Guide Transmission Media

Optical Fiber (Composition)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

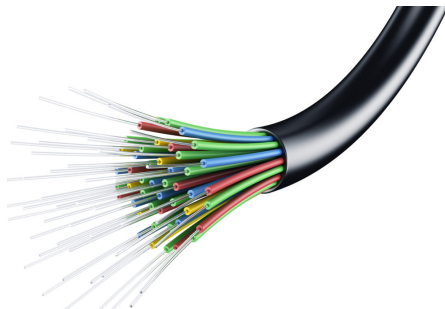
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Physical Guide Transmission Media

Optical Fiber (Composition)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

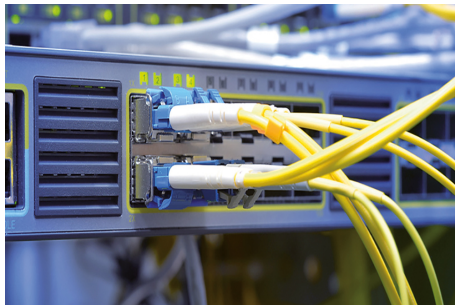
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Physical Guide Transmission Media

Optical Fiber (Composition)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

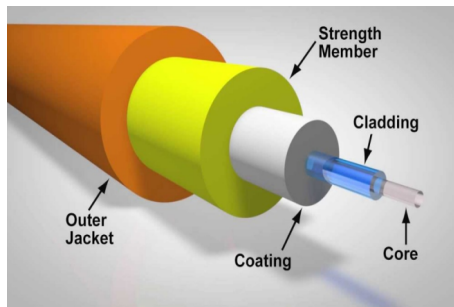
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Consists of a core, in which the light emitted by a light-emitting diode or a laser source propagates, and an optical cladding whose refractive index ensures that the light signal remains in the fiber.





Physical Guide Transmission Media

Optical fiber (Principle)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Optical fiber transmission system :

- a light emitter (transmitter), consisting of a light emitting diode (LED, Light Emitting Diode) or a LASER diode (Light Amplification by Stimulated Emission of Radiation), which transforms electrical impulses into light impulses ;
- a light receiver, consisting of a PIN (Positive Intrinsic Negative) type photodiode which translates light pulses into electrical signals ;
- an optical fiber.



Physical Guide Transmission Media

Optical fiber (Principle)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

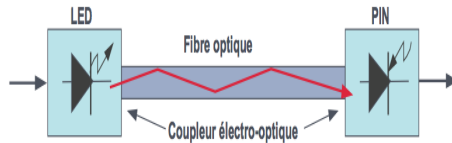
Transmission
media

Information
coding

Multiplexing

Fiber optic transmission system :

Unidirectional system : 2 fibers for 1 connection.



Fiber optic transmission system :

Unidirectional system : 2 fibers for 1 connection.



Physical Guide Transmission Media

Fiber Optics (Types)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communication
line

Transmission
media

Information
coding

Multiplexing

1. Multimode step-index fiber :

- The core of refractive index n_1 is surrounded by a sheath of index n_2 .
- The index variation between the core and the sheath is sudden (index jump).
- Propagation is by total reflection at the core/cladding interface.
- The diameter of the core is large which allows it to admit several rays which propagate on different paths or modes of propagation.
- The range of the rays being 10 km.



Physical Guide Transmission Media

Fiber Optics (Types)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

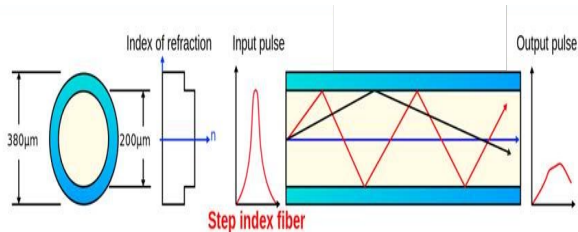
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Physical Guide Transmission Media

Fiber Optics (Types)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

2. Gradient index multimode fiber :

- The core index decreases continuously, from the center of the core to the core/sheath interface following a parabolic law.
- All the rays are focused at the center of the fiber, they have a trajectory close to the sinusoid.
- Dispersion is reduced which allows ranges of about 50 km.



Physical Guide Transmission Media

Fiber Optics (Types)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

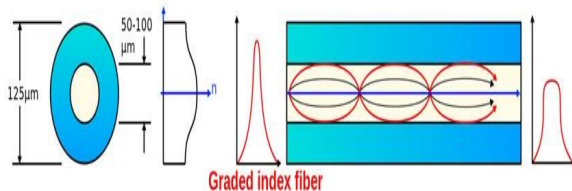
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Physical Guide Transmission Media

Fiber Optics (Types)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

3. Single mode fiber :

- Core diameter reduced to $8\mu m$.
- This reduction can be such that, for a given wavelength, the fiber only admits one ray.
- The fiber is then said to be monomode and the distance that can be covered is of the order of 100 km.



Physical Guide Transmission Media

Fiber Optics (Types)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

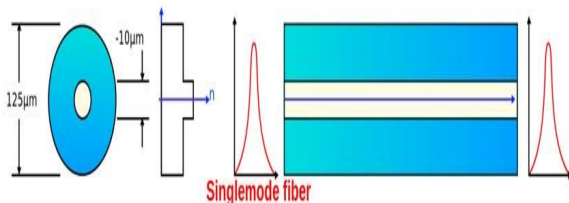
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Physical Guide Transmission Media

Fiber Optics (Connectors)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Connection : SC (Subscriber Connector), ST (Straight Tip), FC (Fiber Connector), LC (Lucent Connector) connectors.



SC



LC



FC



ST



Physical Guide Transmission Media

Fiber Optics (Advantages)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Optical fiber Pt to Pt, but :

- Speeds up to 50 GBit/s (theoretical speed 50 TBit/s),
- Simultaneous transmission of many television channels, telephone,...
- Insensitive to electromagnetic interference,
- Outer diameter is around 0.1mm,
- Weight of a few grams per kilometre.
- Difficult to hack.



Supports without physical guide

Electromagnetic waves (1)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Spread through the atmosphere,
- Flexibility of movement,
- No cable laying cost.

Principle :

- Antenna radiates energy
- Collected by another antenna.

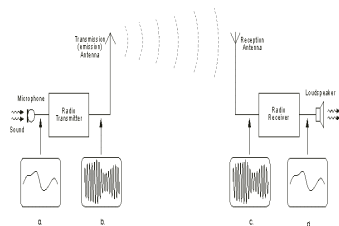


Fig. 2.1. Radio Transmission Block-Diagram



Supports without physical guide

Electromagnetic waves (2)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

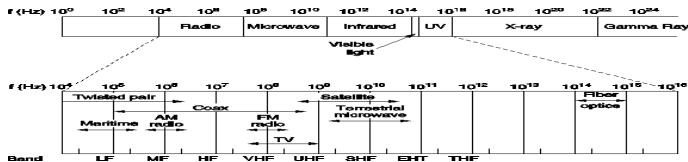
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Each type of application \Rightarrow different frequency band \Rightarrow Frequency space managed by national and international organizations.



- High frequencies : long distances,
- low frequencies : geographically dispersed receivers.



Supports without physical guide

Electromagnetic waves (3)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Radio beam :

- Use of very high frequencies (from 2 GHz to 15 GHz and up to 40 GHz)
- Stations placed at height : direct visibility,
- Transmission by satellite, television channels or long-distance transmission arteries



Supports without physical guide

Electromagnetic waves (4)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Electric Radio waves () :

- Frequencies between 10 kHz and 2 GHz,
- Diffuse transmitter, geographically dispersed receivers,
- Interferences



Supports without physical guide

Light waves

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

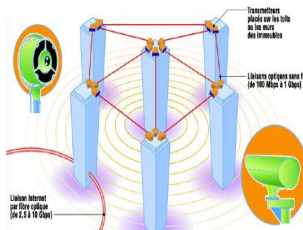
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Infrared and lasers,
- Special case of microwave links, similar to fiber optics,
- Interconnect 2 private networks over a short distance,
- Speeds that can exceed 1 GBit/s





Information coding

Data circuit

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

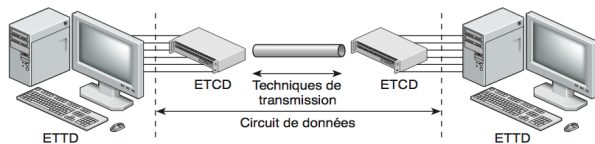
Characteristics
of a communication
line

Transmission
media

Information
coding

Multiplexing

- A device is placed at the ends to transmit the data,
- Manufacture and recovery of signals,
- Transparent to the user
- 2 Codecs (modems) + Transmission medium = Data circuit





Information coding

Data circuit

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

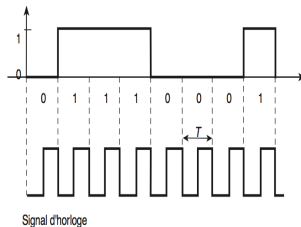
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- UTI standard designations
- Modem and codec DCTE (Data Circuit Termination Equipment)
- Computer TDPE (terminal data processing equipment)
- TDPE periodically sends 0s and 1s to the DCE
- DCTE converts to signal and sends **Synchronous message**





Information coding

Data circuit

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

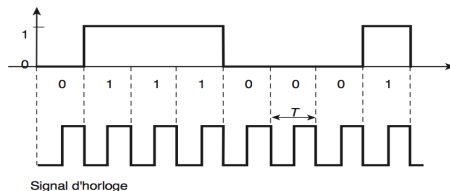
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- DCE converts to signal and sends **Synchronous message**,
- Equal intervals for all symbols,
- Matches transmitted clock,
- If short distance : digital transmission (in baseband)
- If long distance : Analog transmission (in transposed band or wideband)





Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Digital signal (speed $\uparrow + 1$ Mbit/s , range \downarrow A few hundred meters (LAN))
- Twisted Pairs, Coaxial Cable, Fiber
- Use of repeaters
- Long sequences 0 and 1 (rests) \Rightarrow Loss of synchronization
- Coding : introduce frequent state changes to avoid silences



Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

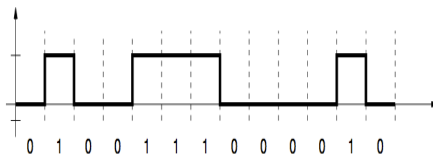
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Unipolar code : The signal is transmitted without any change.



Problem : distinguish the case of 0 from the case of absence of information



Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

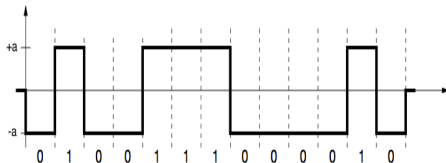
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

NRZ code (No return to zero) : $+a : 1$; $-a : 0$



Problem : rests



Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

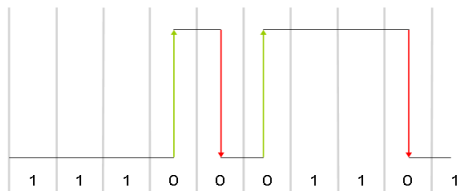
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

**NRZI code (No return to zero inverted) : same state : 1 ;
change state : 0**





Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

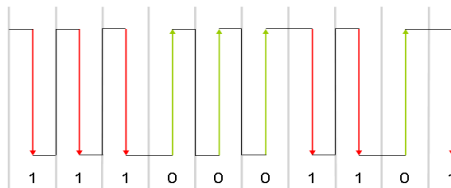
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Manchester code (biphase) : XOR between clock and data (\uparrow : 0 ; \downarrow : 1)





Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

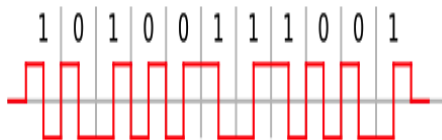
Transmission
media

Information
coding

Multiplexing

Differential Manchester code :

- systematic transition in the middle of each bit,
- at end of bit :
 - 1 : no transition,
 - 0 : transition





Information coding

Baseband transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

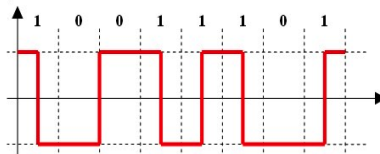
Transmission
media

Information
coding

Multiplexing

Miller code :

- 1 : mid-bit transition ;
- 0 : no transition in the middle of the bit ;
- transition at the end of a 0 bit if the next bit is 0





Information coding

Modulation (wideband)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Distance + hundreds of meters \Rightarrow Unreliable baseband,
- The signal must be **modulated** : sine wave (carrier)
- Neither rising nor falling edges : greater range
- DCE : Modem (modulator-demodulator)



Information coding

Modulation (wideband)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Types of modulation :

- amplitude modulation, or ASK (Amplitude-Shift Keying) ;
- phase modulation, or PSK (Phase-Shift Keying) ;
- frequency modulation, or FSK (Frequency Shift Keying).
- Combined modulation.



Information coding

Amplitude Modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

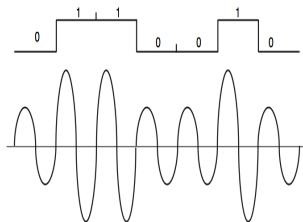
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

ASK (Amplitude-Shift Keying) : change amplitude





Information coding

Phase modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

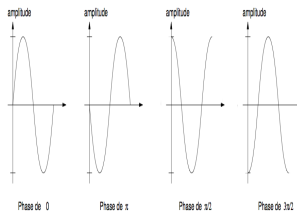
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

PSK (Phase-Shift Keying) : signal starts at different phases





Information coding

Phase modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

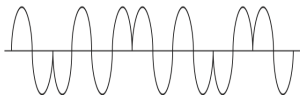
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

PSK (Phase-Shift Keying) : signal starts at different phases





Information coding

Frequency modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

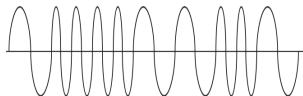
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

FSK (Frequency Shift Keying) : change the frequency





Information coding

Combined modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Phase and amplitude modulation (PSK + AM) : combine phase and amplitude

- 00 : phase of π and amplitude of 3
- 01 : phase of π and amplitude of 6
- 10 : phase of 0 and amplitude of 3
- 11 : phase of 0 and amplitude of 6



Information coding

Combined modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

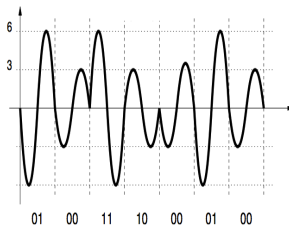
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Modulation by phase amplitude (PSK + AM) : combine phase and amplitude





Information coding

Combined modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

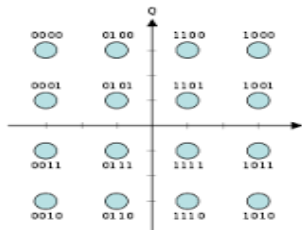
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Phase and amplitude modulation (PSK + AM) :
quadrature carrier amplitude modulation (QAM, or QAM
Quadrature Amplitude Modulation)





Information coding

Combined modulation

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

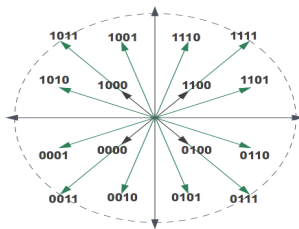
Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Trellis



- High throughputs,
- Resistance to errors by Gray coding (2 adjacent codes \Rightarrow 1 different bit)



Information coding

ADSL Transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communication
line

Transmission
media

Information
coding

Multiplexing

ADSL transmission :

- RTC : limited bandwidth, poor signal-to-noise ratio \Rightarrow throughput tens of kbit/s
- Asymmetric Digital Subscriber Line : several Mbit/s over 5 km
- Voice and data simultaneously
- \neq frequency bands : 1.1 MHz band subdivided into 4KHZ channels
- Upstream : 640 kbit/s & Downstream : 2 Mbit/s



Information coding

ADSL Transmission

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

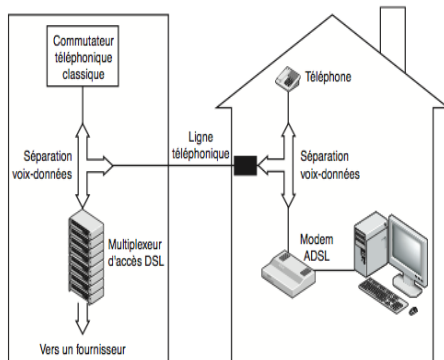
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing



Speed can reach 20 Mbits/s with versions such as ADSL2 and ADSL2+



Information coding

Modems

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

Standardized modems : ITU has set the standards for modems

standard	modulation	rate
V.21	frequency	300 bit/s
V.26	phase	2400 bps
V.32	phase/amplitude	9600 bit/s
V.32bis	phase/amplitude	14 400 bit/s
V.34	phase/amplitude	28,800 bit/s
V.34bis	phase/amplitude	33 600 bit/s
V.90	phase/amplitude	56,000 bit/s



Multiplexing

Principle

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- Transmit on a single link (high speed), communications from several transmitters and receivers
- Multiplexer - Demultiplexer



Multiplexing

Time Division Multiplexing Access (TDMA) Time Multiplexing

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

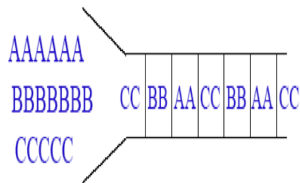
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Multiplexing

Frequency Division Multiplexing (FDM)

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

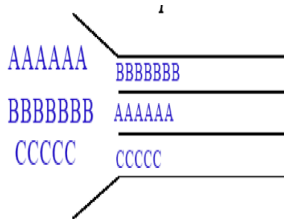
Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing





Multiplexing

Asynchronous Time Division Multiplexing (ATDM) Statistical Multiplexing

Communication
Networks
course
Physical Layer

Pr A.
DJEFFAL

Physical Layer

Modes of
transmission

Transmitted
signal

Characteristics
of a communi-
cation
line

Transmission
media

Information
coding

Multiplexing

- assign high speed channel only to low speed channels that actually have something to transmit
- not bass rests