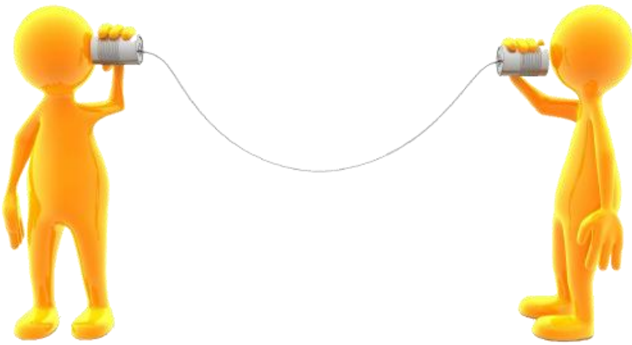
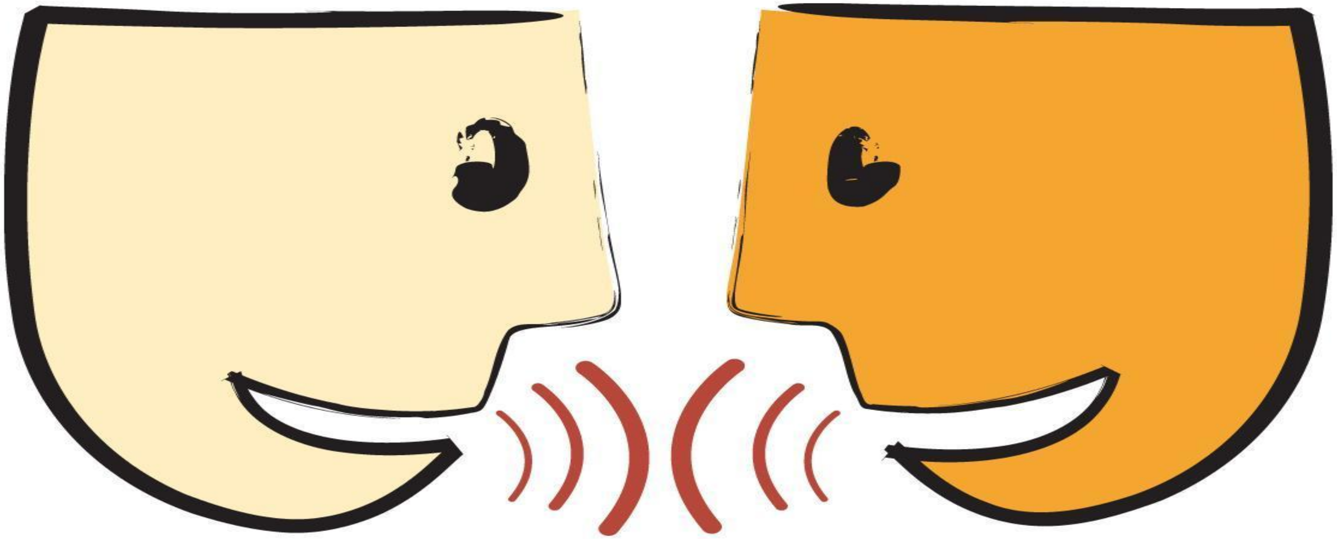
DCWSN - UNIT – I
BASICS OF COMMUNICTAION

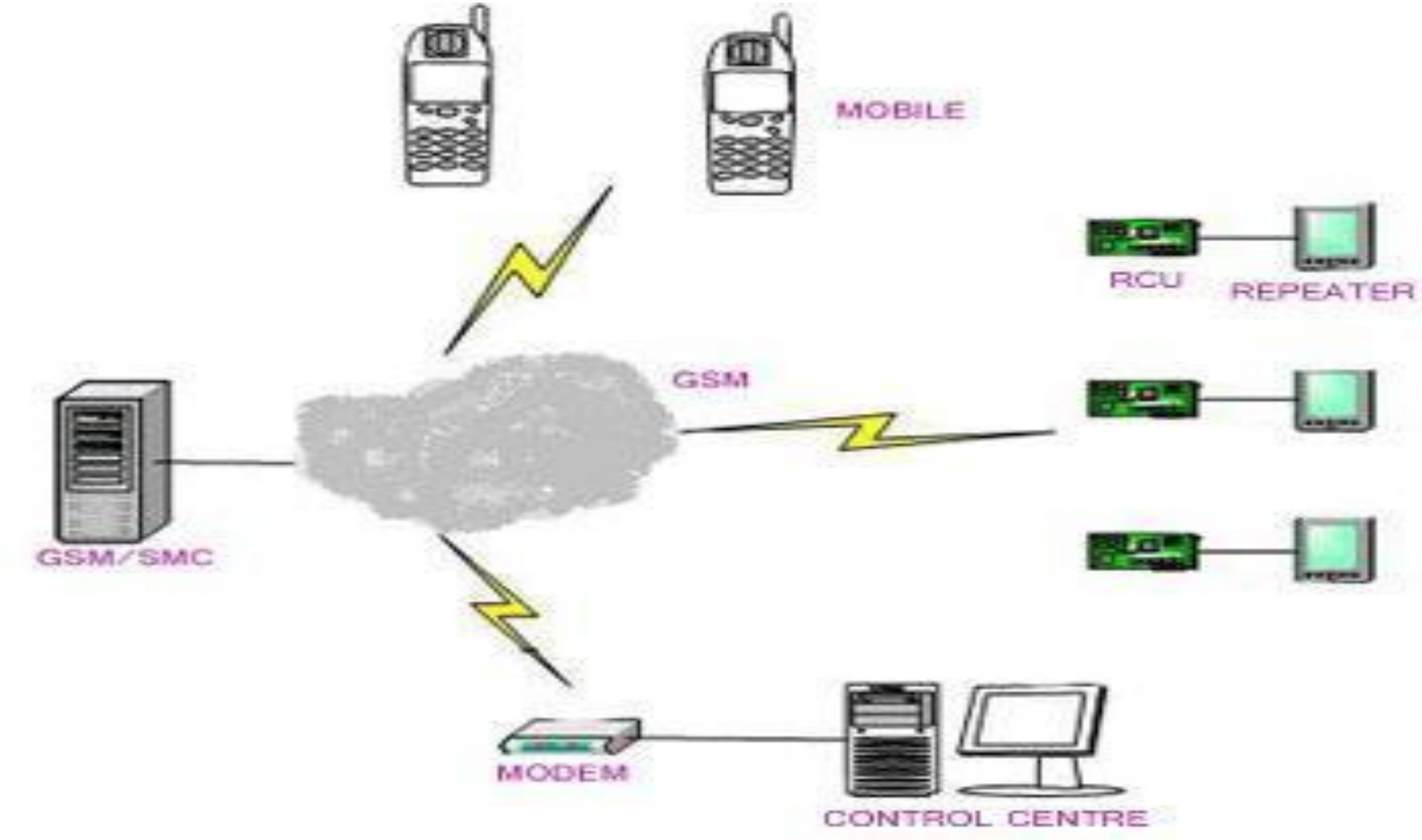


Department of Computer Engineering, Neminagar, Chandwad

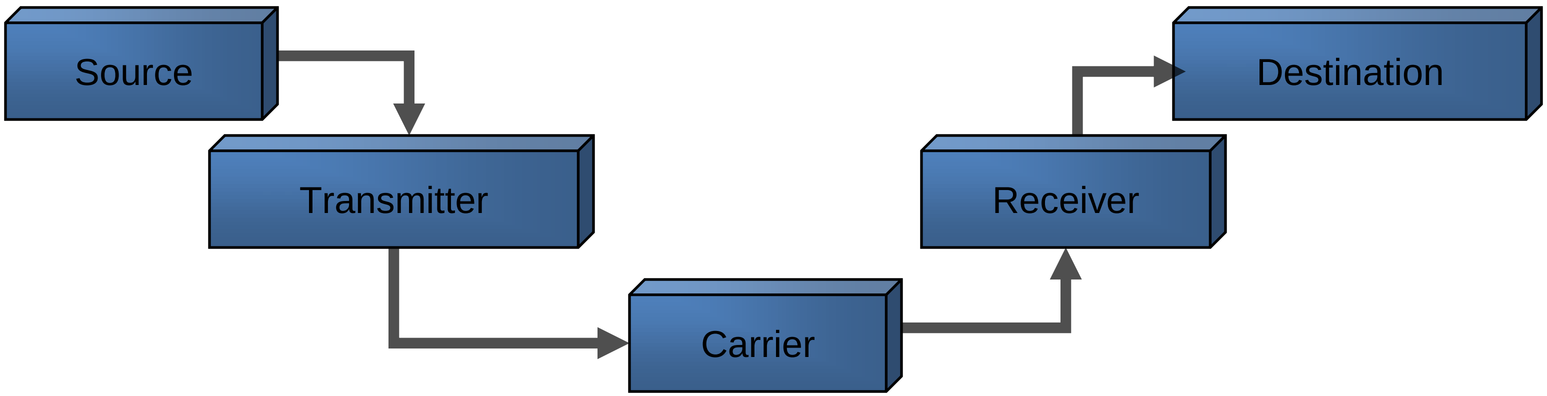
Local Communication

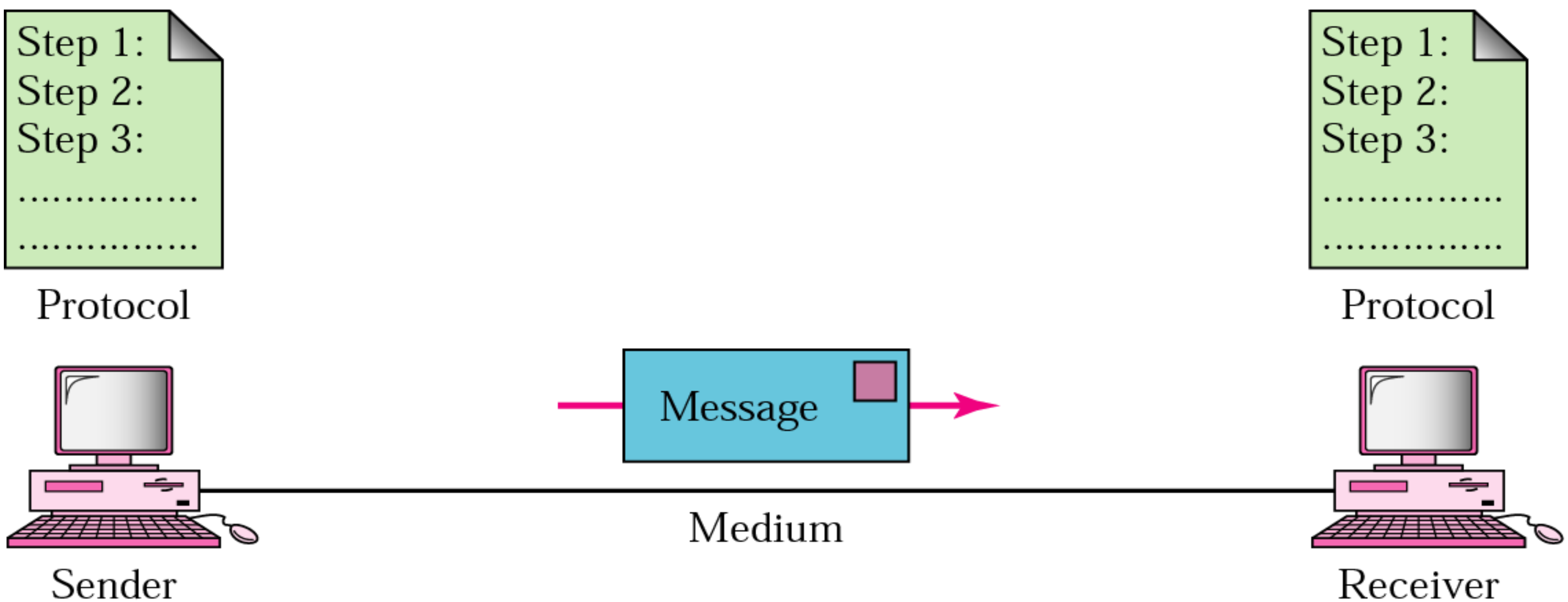


Remote Communication



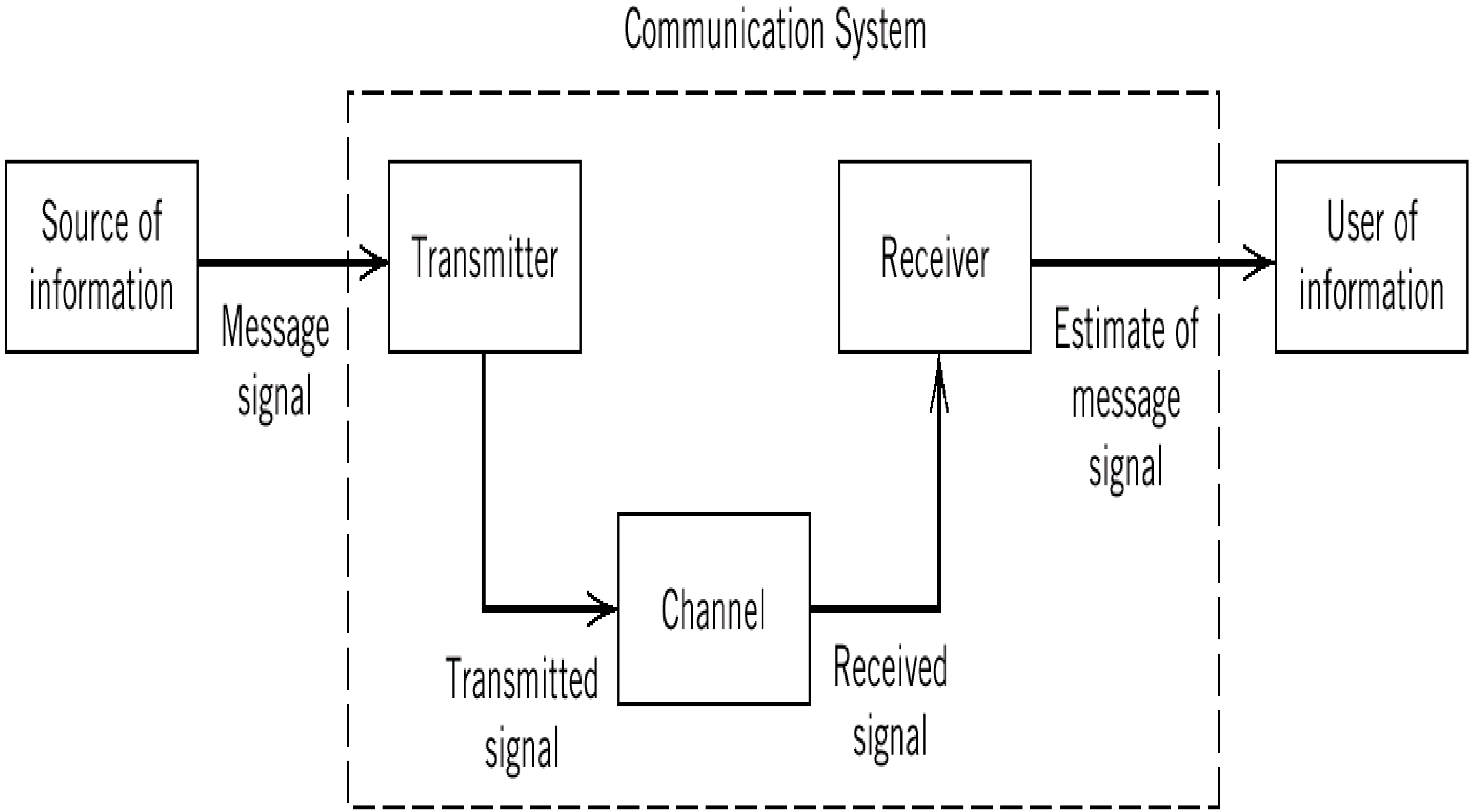
A Communication system Model





VUW, 2004.

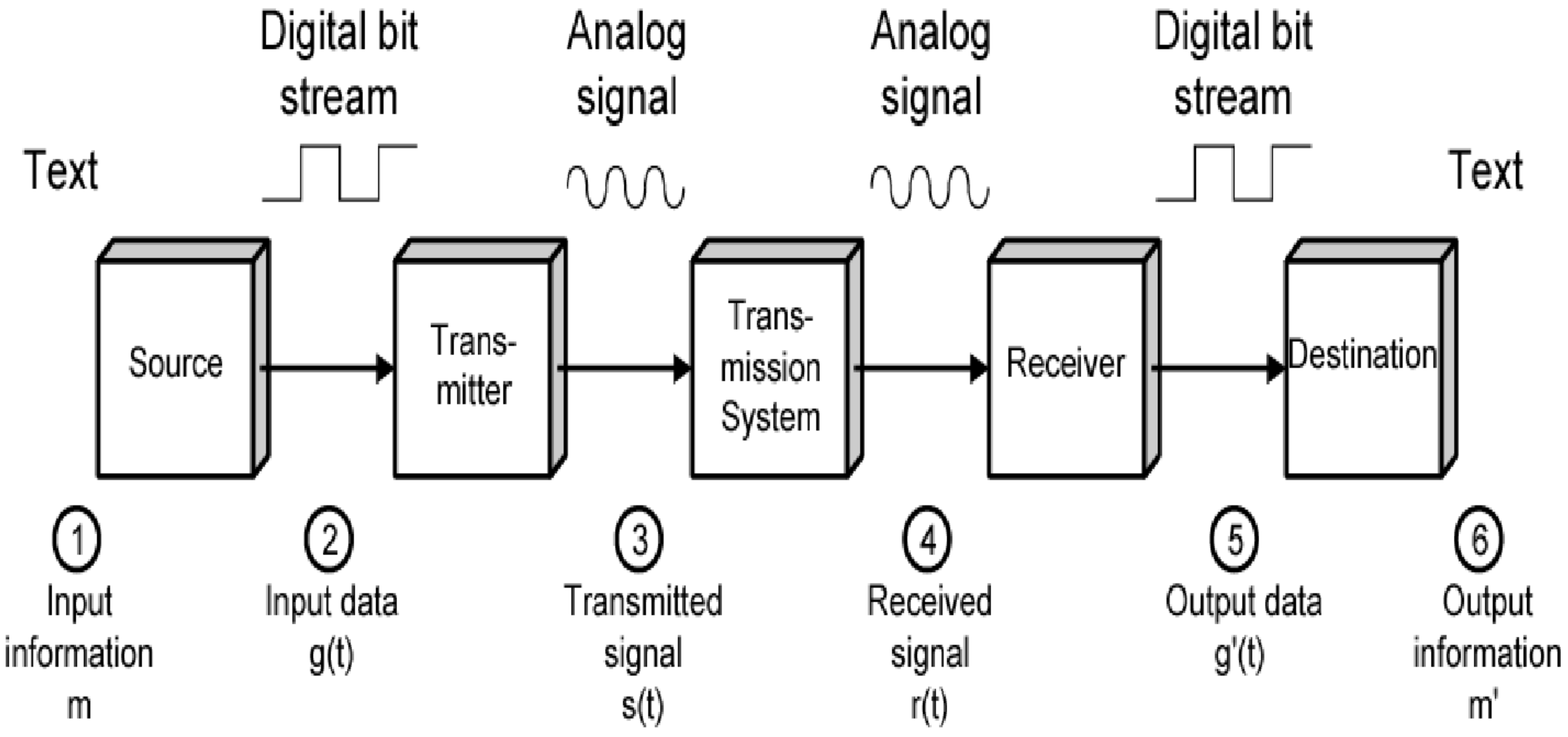
A Communication system Model



Elements of A Communication system

- **Source of information**
- **Transmitter**
- **Channel (transmission medium)**
- **Receiver**
- **User of information (sink)**
- **Noise source**

Simplified Data Communications Model



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Two Basic Modes of Communication

- **Broadcasting:** **single powerful transmitter and numerous receivers, one direction. Such as radio, television.**
- **Point-to-point communication: a pair transmitter and receiver, usually bi-direction, such as telephone.**

Base band

- The original band of frequencies of a signal before it is modulated for transmission at a higher frequency.
- A type of data transmission in which digital or analog data is sent over a single unmultiplexed channel, such as an Ethernet LAN. Baseband transmission use TDM to send simultaneous bits of data along the full bandwidth of the transmission channel.

Broadband

- The term broadband is used to describe a type of data transmission in which a single medium (wire) can carry several channels at once. Cable TV, for example, uses broadband transmission. In contrast, baseband transmission allows only one signal at a time.

- Most communications between computers, including the majority of local-area networks, use baseband communications

Data transmission modes

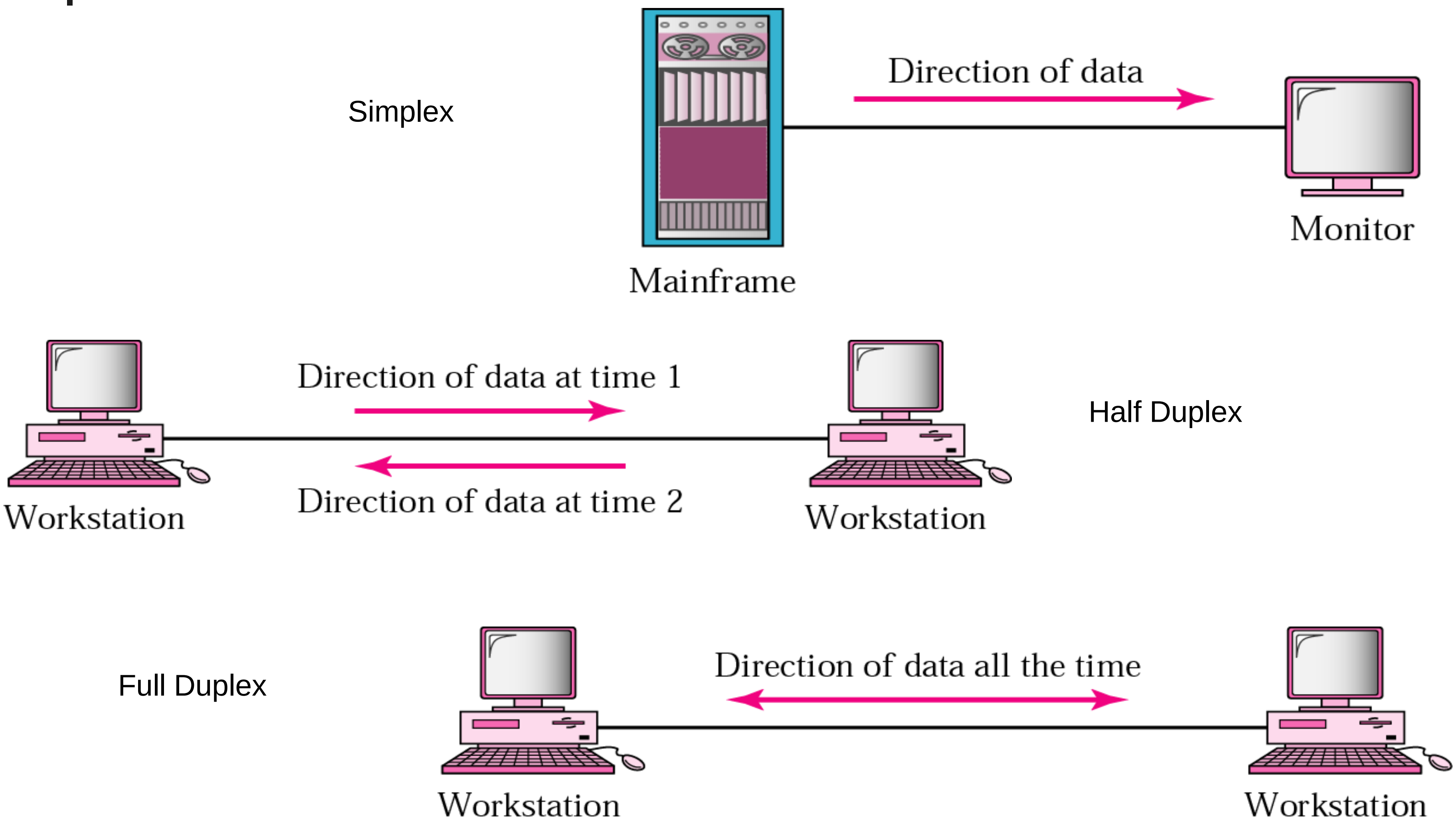
The transmission is characterized by:

1. The direction of the exchanges.
2. The transmission mode: the number of bits sent simultaneously.
3. Synchronization between the transmitter and receiver.

There are 3 transmission modes characterised according to the direction of the exchanges:

- **A simplex connection**
- **A half-duplex connection**
- **A full-duplex connection**

Transmission Modes



A simplex connection

Data flows in only one direction, from the transmitter to the receiver.
E.g. - computer to the printer or mouse to your computer.

half-duplex connection(*alternating connection* or *semi-duplex***)**

- Data flows in one direction or the other, but not both at the same time.
- Each end of the connection transmits in turn.
- It is possible to have bidirectional communications using the full capacity of the line.

A full-duplex connection

- Data flow in both directions simultaneously.
- Each line can thus transmit and receive at the same time.
- Bandwidth is divided in two for each direction of data transmission if the same transmission medium is used for both directions of transmission.

Synchronous and asynchronous transmission

- **An asynchronous connection**
  - in which each character is sent at irregular intervals in time.
  - To remedy this problem, start and stop bits are used.
- **synchronous connection**
  - the transmitter and receiver are paced by the same clock.
  - transmitter and receiver are paced at the same speed

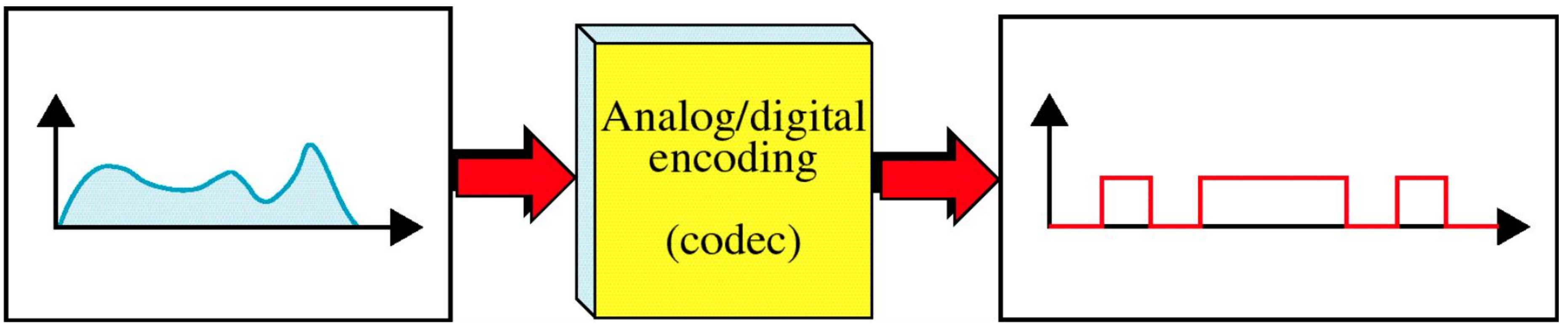
Digital Transmission

- PCM
- DM
- ADM
- DPCM
- ADPCM

ANALOG-TO-DIGITAL CONVERSION

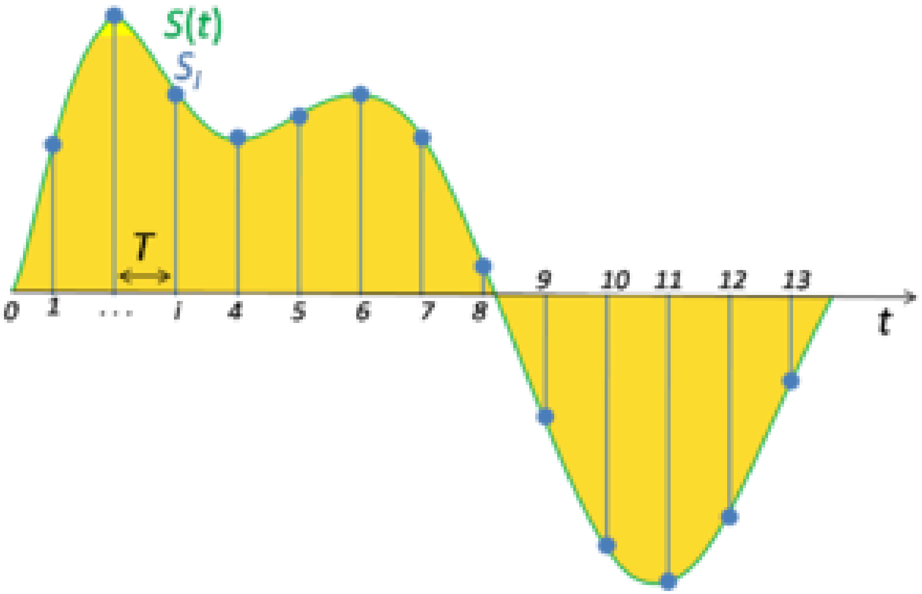
A digital signal is superior to an analog signal because it is more robust to noise and can easily be recovered, corrected and amplified. For this reason, the tendency today is to change an analog signal to digital data. In this section we describe two techniques, pulse code modulation and delta modulation.

Analog to Digital Encoding



What is Sampling

- In signal processing sampling is the reduction of a continuous signal to a discrete signal

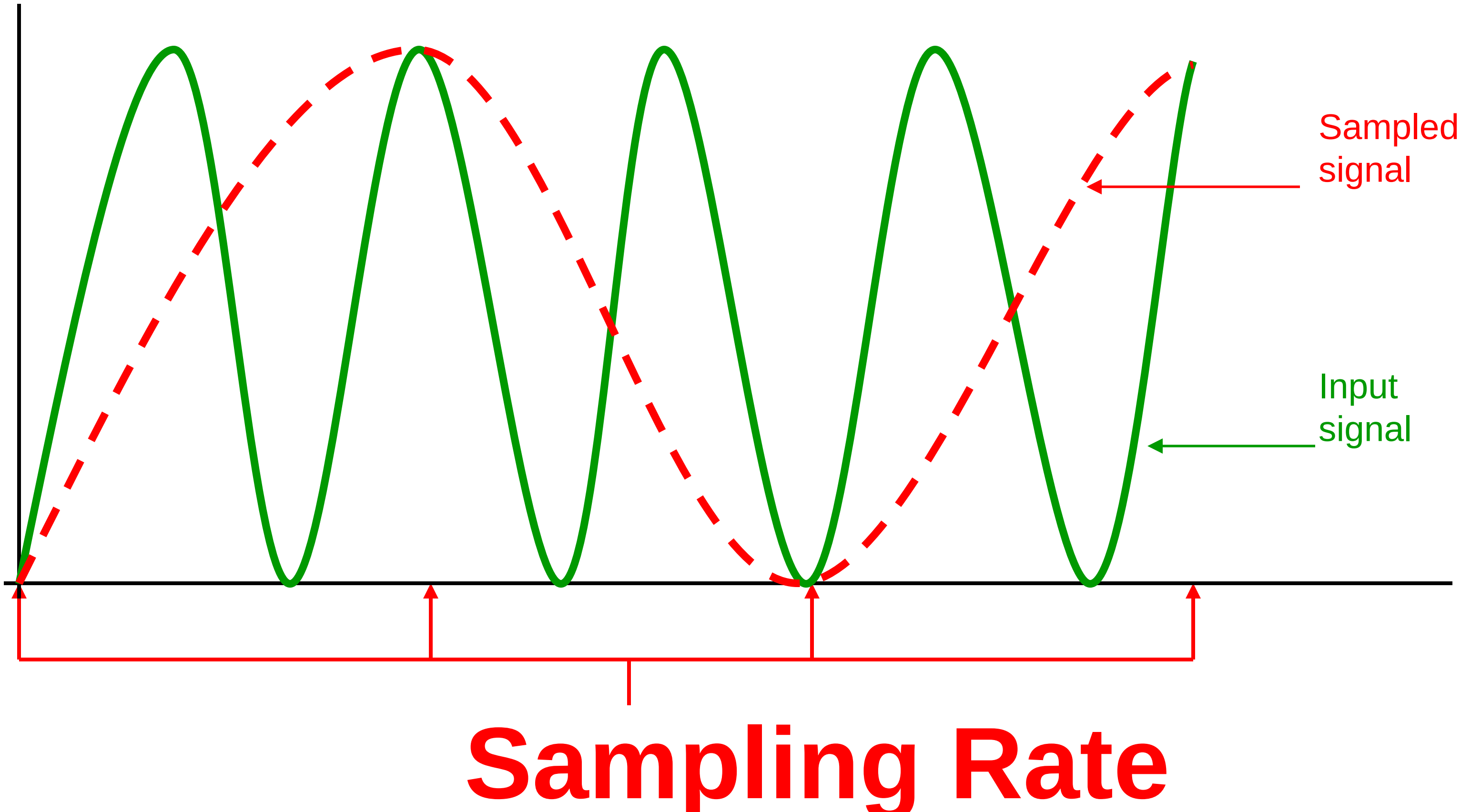


Aliasing

- **aliasing** refers to an effect that causes different signals to become indistinguishable (or *aliases* of one another) when sampled.
- It also refers to the distortion

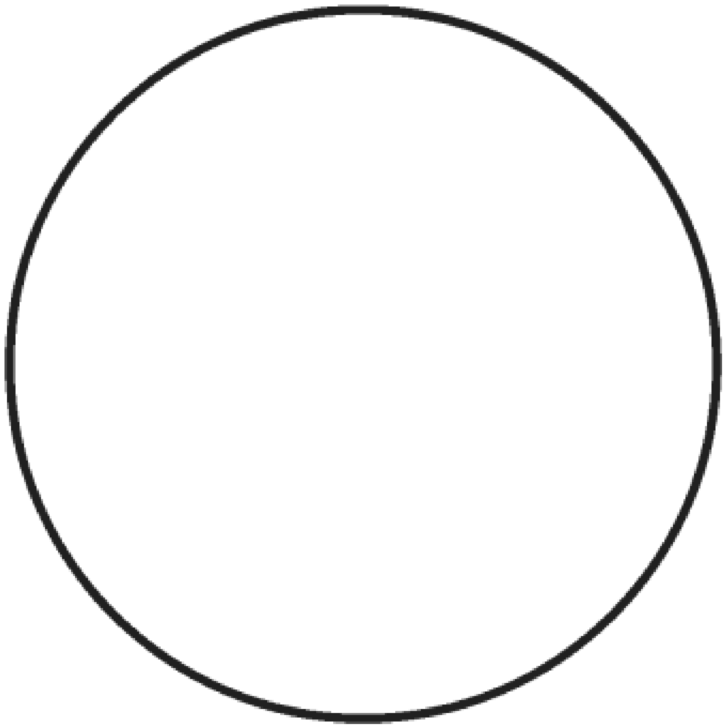
What is Aliasing?

- False frequencies created by poor sampling of an input signal.

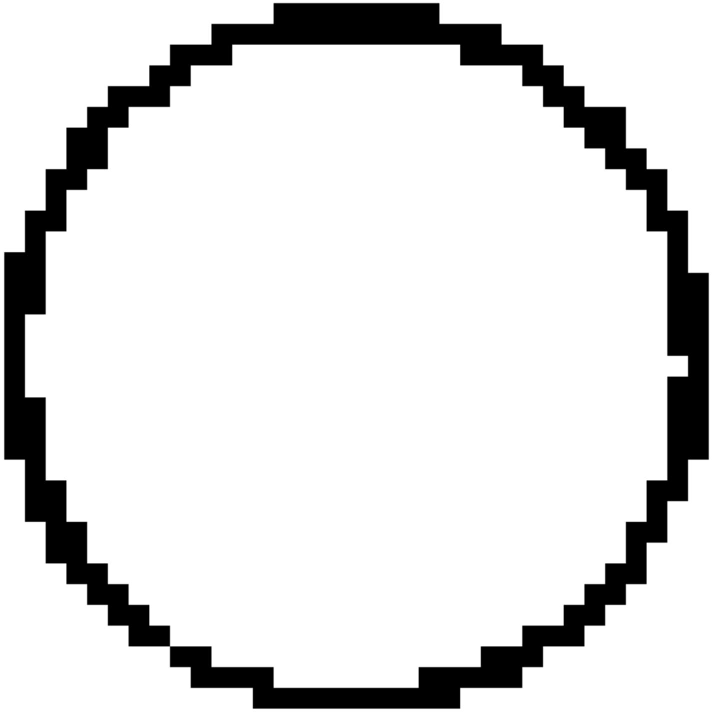


Effects of Aliasing in Graphics

- Jagged effect in rasterised graphics:



Vector representation of a circle



Jagged edges due to aliasing during the rasterisation process

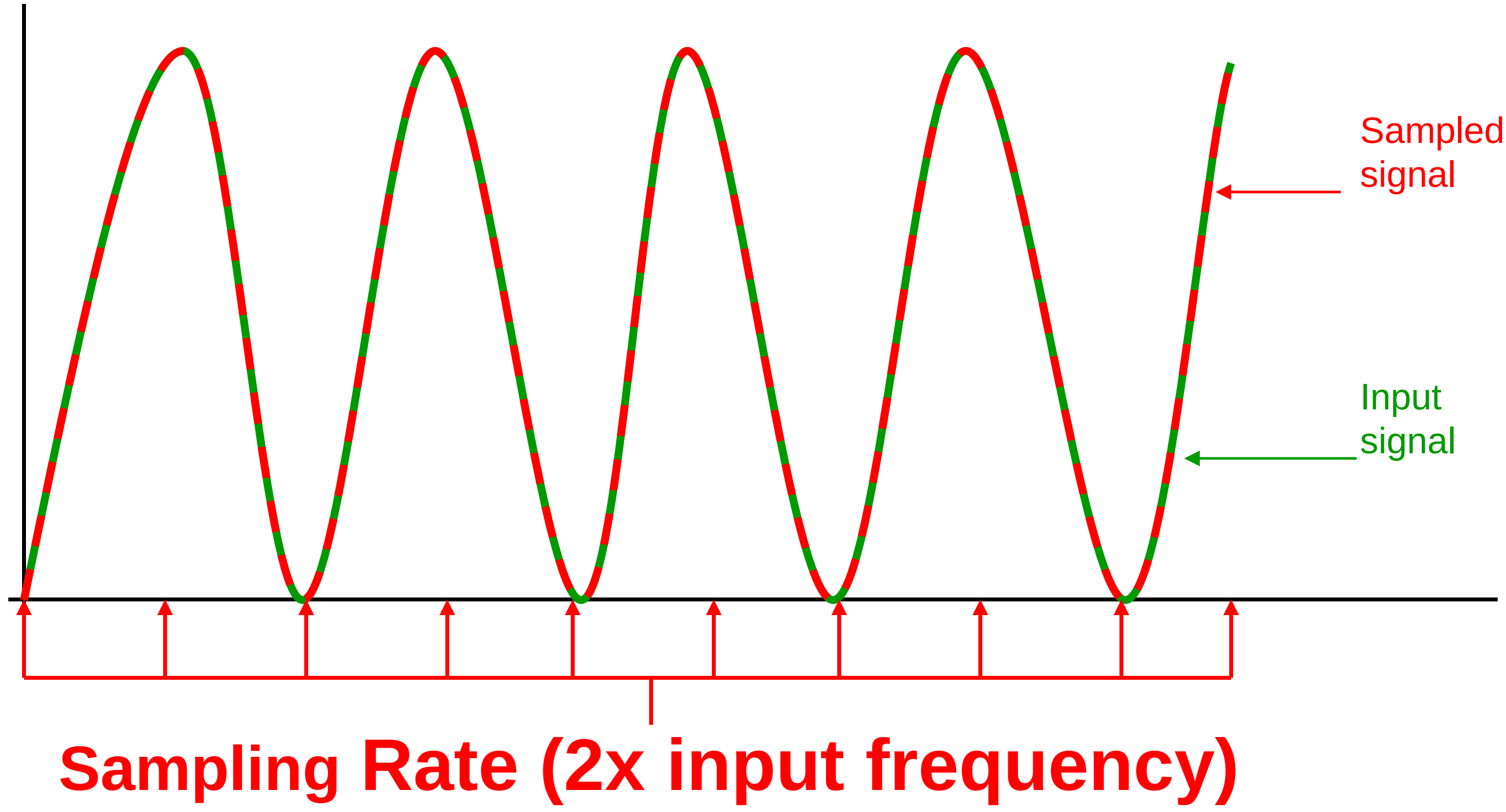
Avoiding Aliasing?

- The aliasing problem can be avoided when sampling audio by applying *Nyquist's Theorem.*

- Sampling should be done at TWICE the rate of the maximum frequency present in the original signal.

Avoiding Aliasing?

- Use of Nyquist's theorem produces a mathematically identical output signal.



Sampling rate (Frequency)

- The **sampling rate**, or **sampling frequency** () defines the number of samples per unit of time (usually seconds) taken from a continuous signal to make a discrete signal

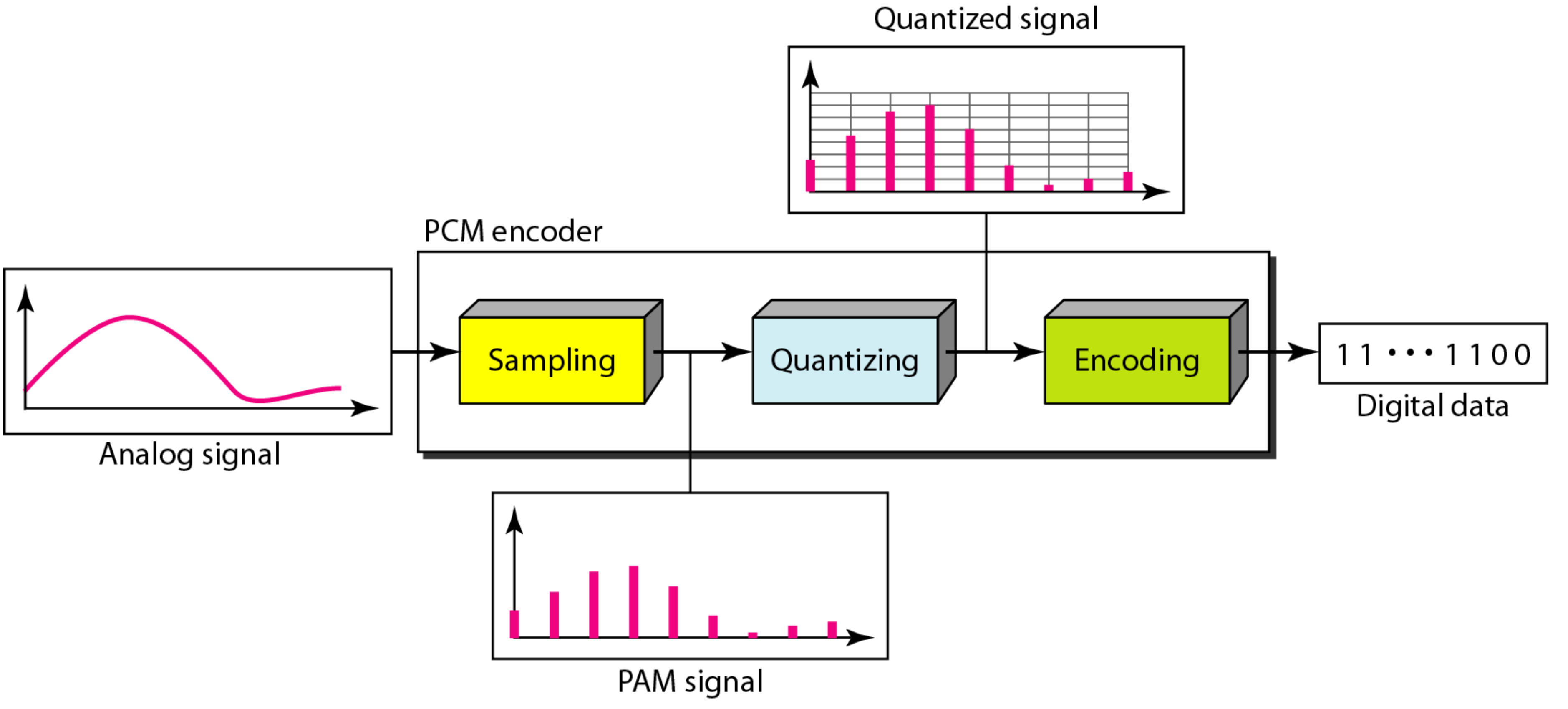
Nyquist rate & Nyquist Interval

- In signal processing, the **Nyquist rate**, is two times the bandwidth(W).
- i.e. = 2W
- **Nyquist Interval,** is the time interval between ant two adjacent samples when sampling rate is Nyquist rate
- =1/2W

PCM (Pulse Code Modulation)

- PCM consists of three steps to digitize an analog signal:
  1. Sampling
  2. Quantization
  3. Binary encoding
- Before we sample, we have to filter the signal to limit the maximum frequency of the signal as it affects the sampling rate.
- Filtering should ensure that we do not distort the signal, ie remove high frequency components that affect the signal shape.

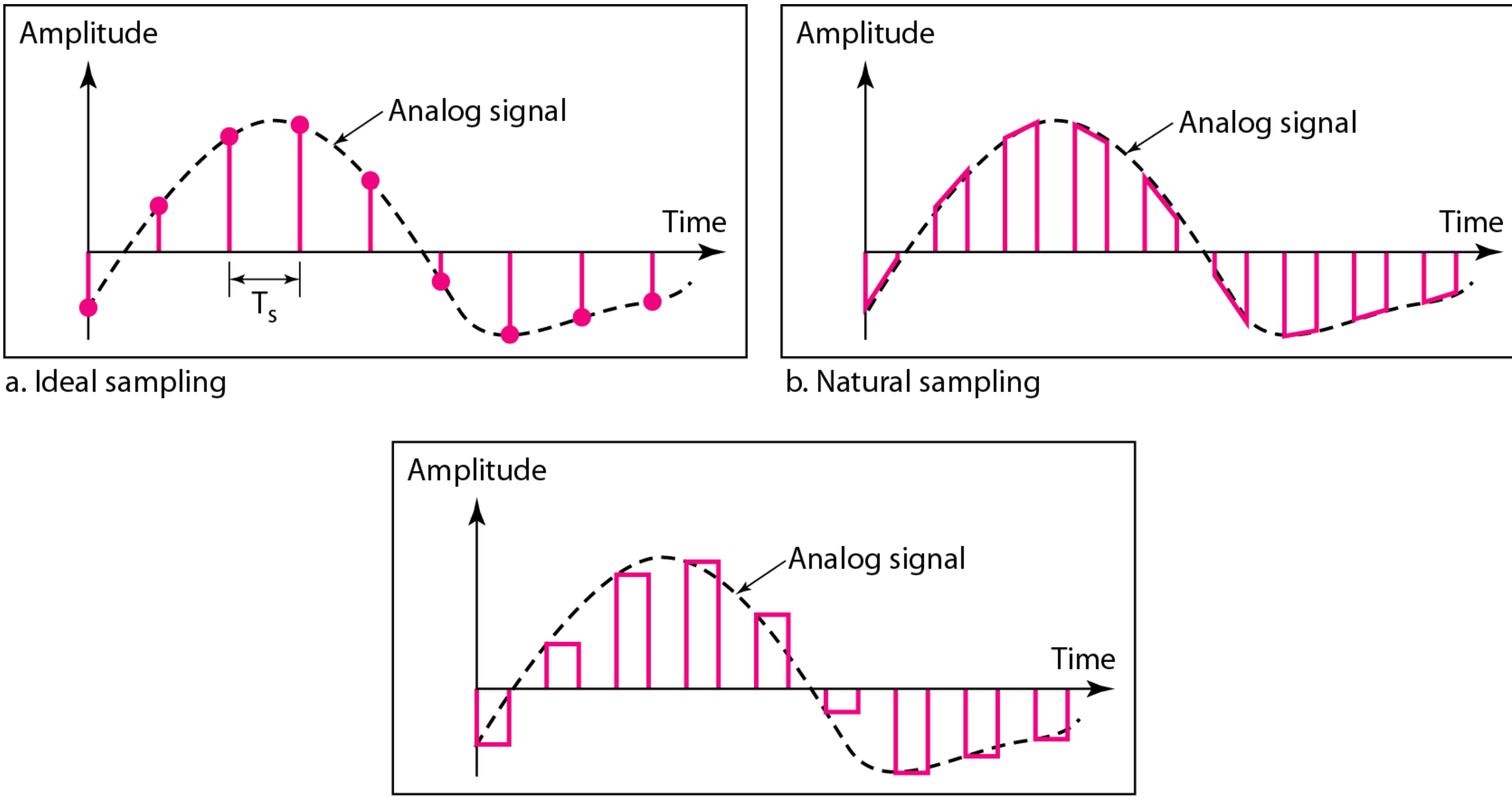
Figure *Components of PCM encoder*



Sampling

- Analog signal is sampled every T_S secs.
- T_s is referred to as the sampling interval.
- $f_s = 1/T_s$ is called the sampling rate or sampling frequency.
- There are 3 sampling methods:
  - Ideal - an impulse at each sampling instant
  - Natural - a pulse of short width with varying amplitude
  - Flattop - sample and hold, like natural but with single amplitude value
- The process is referred to as pulse amplitude modulation PAM and the outcome is a signal with analog (non integer) values

Figure *Three different sampling methods for PCM*



a. Ideal sampling

b. Natural sampling

c. Flat-top sampling

Quantization

- Sampling results in a series of pulses of varying amplitude values ranging between two limits: a min and a max.
- The amplitude values are infinite between the two limits.
- We need to map the *infinite* amplitude values onto a finite set of known values.
- This is achieved by dividing the distance between min and max into L zones, each of height Δ.

$$\Delta = (\text{max} - \text{min})/L$$

Quantization Levels

- The midpoint of each zone is assigned a value from 0 to L-1 (resulting in L values)
- Each sample falling in a zone is then approximated to the value of the midpoint.

Quantization Zones

- Assume we have a voltage signal with amplitutes V_{min}=-20V and V_{max}=+20V.
- We want to use L=8 quantization levels.
- Zone width Δ = (20 - -20)/8 = 5
- The 8 zones are: -20 to -15, -15 to -10, -10 to -5, -5 to 0, 0 to +5, +5 to +10, +10 to +15, +15 to +20
- The midpoints are: -17.5, -12.5, -7.5, -2.5, 2.5, 7.5, 12.5, 17.5

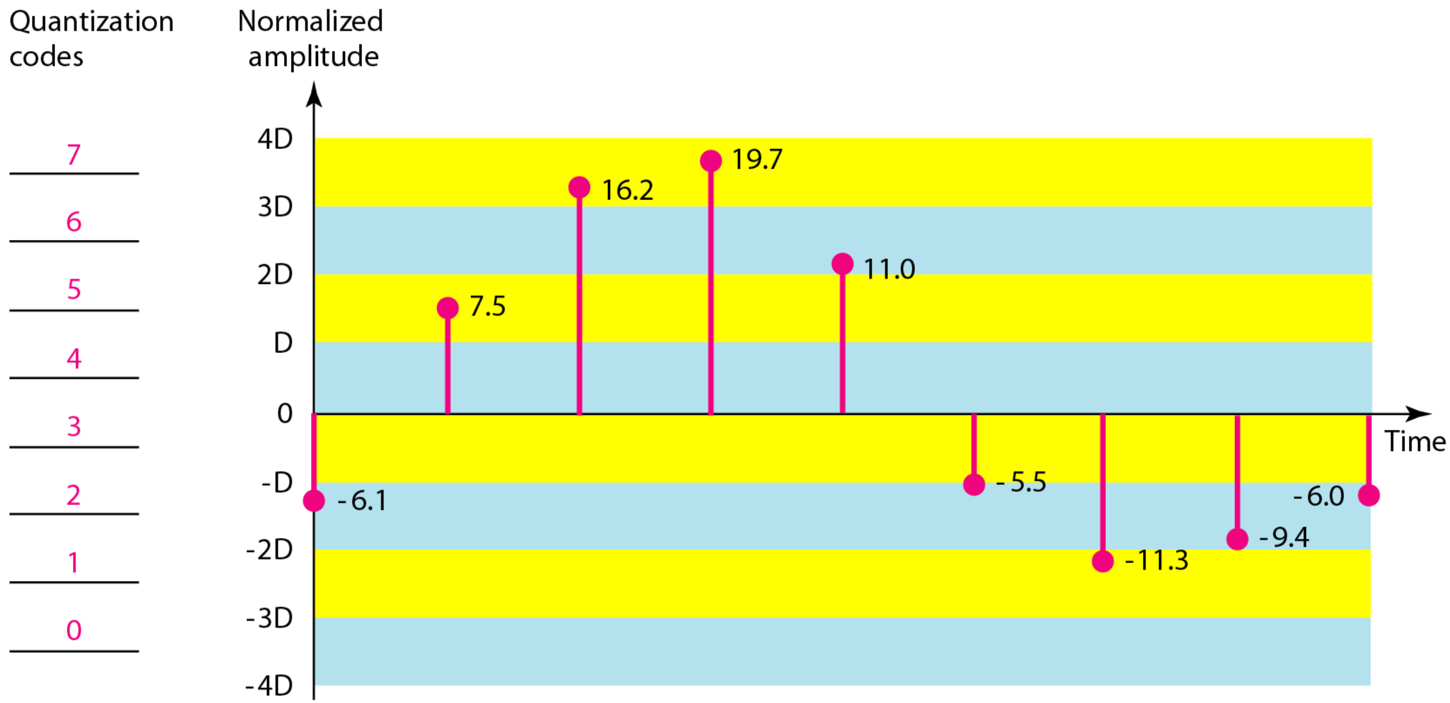
Assigning Codes to Zones

- Each zone is then assigned a binary code.
- The number of bits required to encode the zones, or the number of bits per sample as it is commonly referred to, is obtained as follows:

$$n_b = \log_2 L$$

- Given our example, $n_b = 3$
- The 8 zone (or level) codes are therefore: 000, 001, 010, 011, 100, 101, 110, and 111
- Assigning codes to zones:
  - 000 will refer to zone -20 to -15
  - 001 to zone -15 to -10, etc.

Figure *Quantization and encoding of a sampled signal*

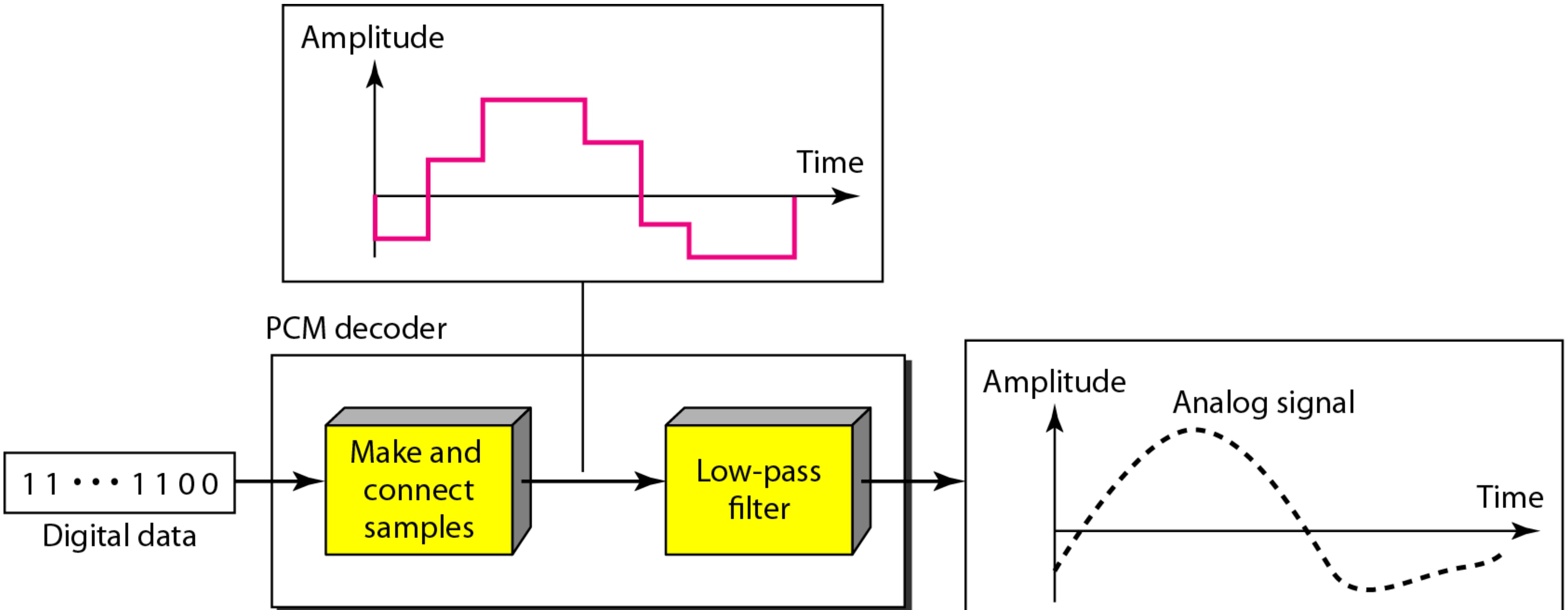


Normalized PAM values	-1.22	1.50	3.24	3.94	2.20	-1.10	-2.26	-1.88	-1.20
Normalized quantized values	-1.50	1.50	3.50	3.50	2.50	-1.50	-2.50	-1.50	-1.50
Normalized error	-0.38	0	+0.26	-0.44	+0.30	-0.40	-0.24	+0.38	-0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010

PCM Decoder

- To recover an analog signal from a digitized signal we follow the following steps:
  - We use a hold circuit that holds the amplitude value of a pulse till the next pulse arrives.
  - We pass this signal through a low pass filter with a cutoff frequency that is equal to the highest frequency in the pre-sampled signal.

Figure *Components of a PCM decoder*



(DM) Delta Modulation

- This scheme sends only the difference between pulses, if the pulse at time t_{n+1} is higher in amplitude value than the pulse at time t_n, then a single bit, say a “1”, is used to indicate the positive value.
- If the pulse is lower in value, resulting in a negative value, a “0” is used.
- This scheme works well for small changes in signal values between samples.
- If changes in amplitude are large, this will result in large errors.

Figure *The process of delta modulation*

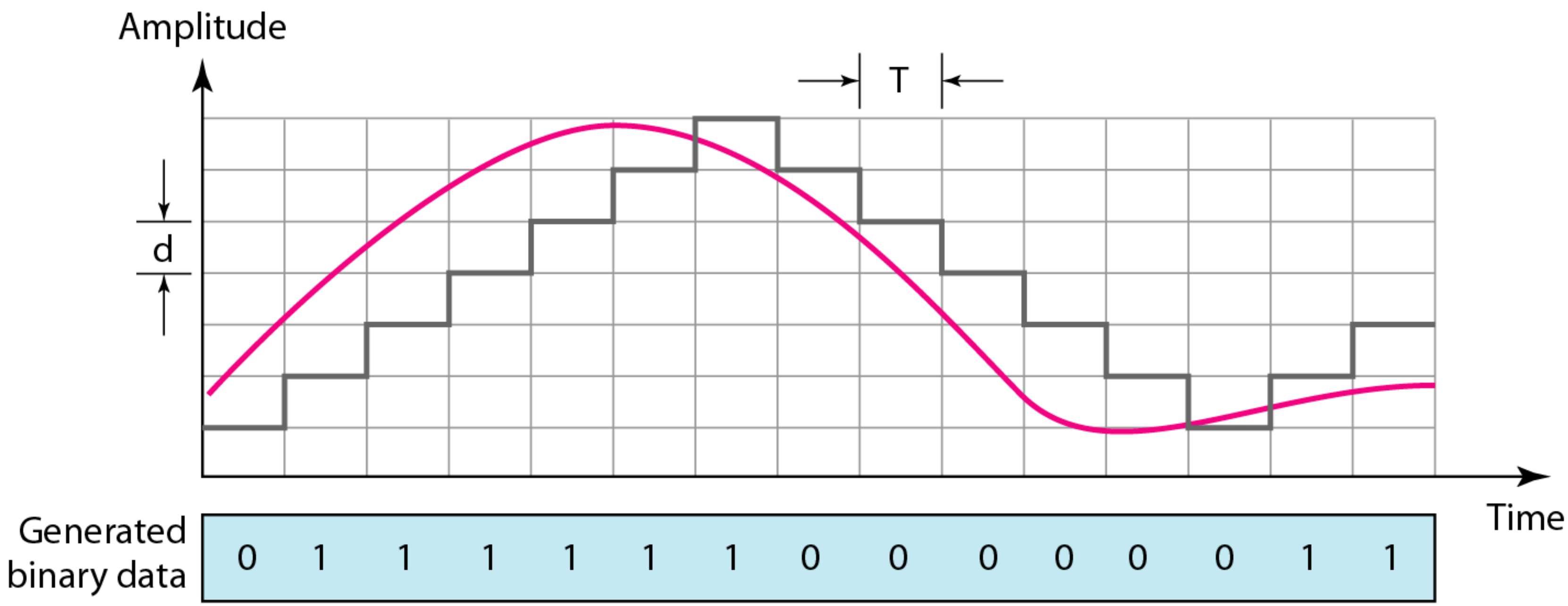


Figure *Delta modulation components(Transmitter)*

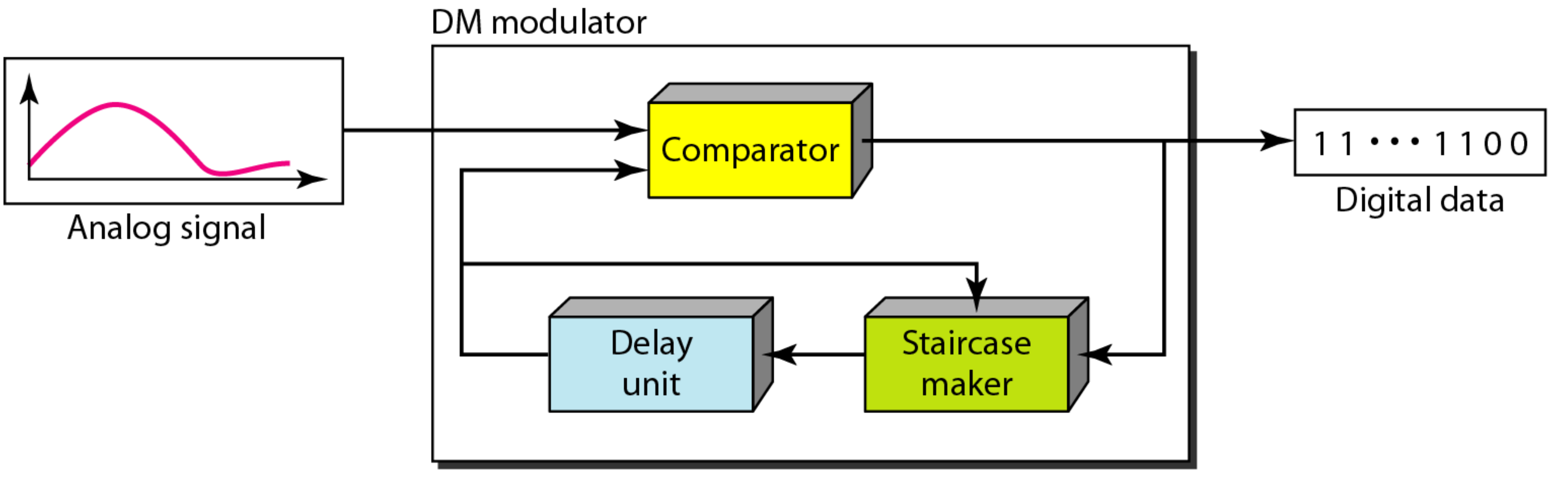
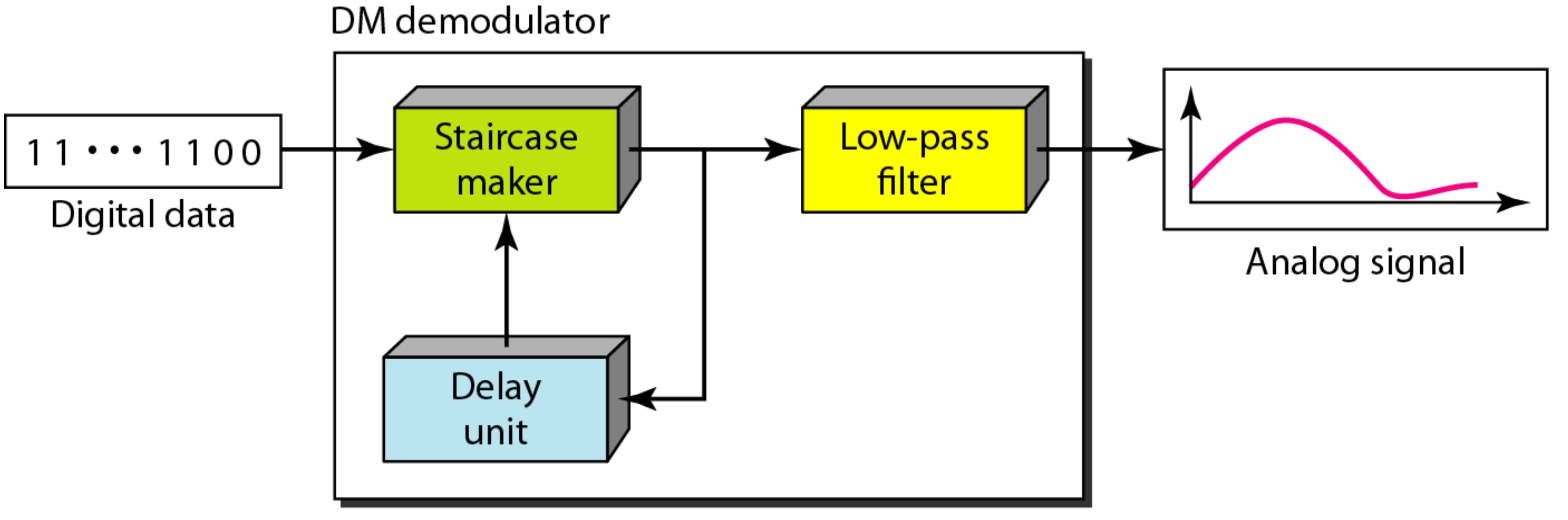


Figure *Delta demodulation components(Receiver)*

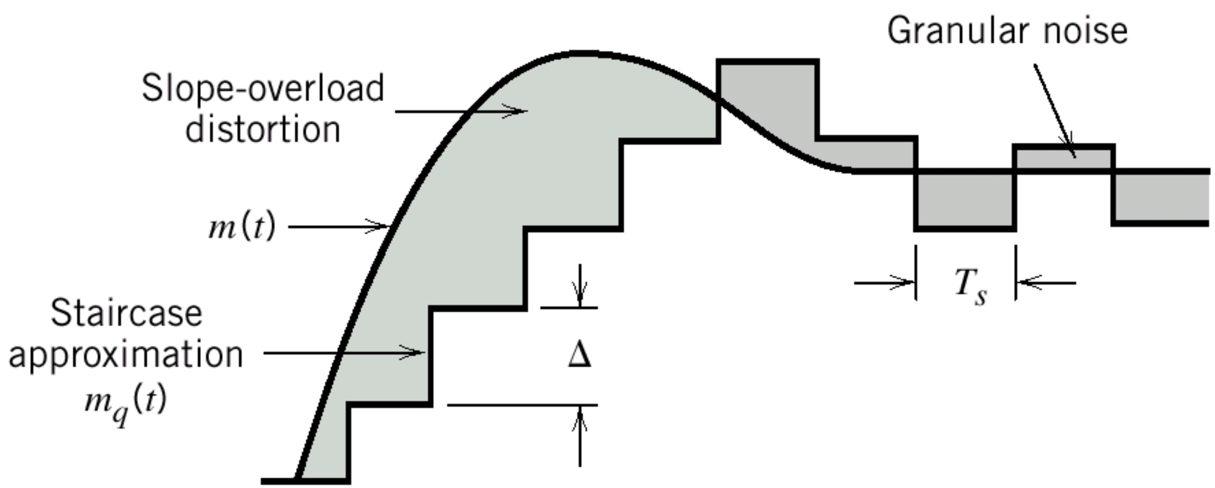


Pros and cons of Delta Modulation (DM)

- Main advantage – simplicity
- Sampled version of the message is applied to a modulator (comparator, quantizer, accumulator)
- delay in accumulator is “unit delay” = one sample period (z^{-1})

Noise in Delta Modulation Systems

- slope overhead distortion
- granular noise



Adaptive DM

- Adaptive delta modulation
  - A better performance can be achieved if the value of δ is not fixed.
  - The value of δ changes according to the amplitude of the analog signal.
- Quantization Error
  - DM is not perfect.
  - Quantization error is always introduced in the process.
  - Much less than that for PCM.

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Delta PCM (DPCM)

- Instead of using one bit to indicate positive and negative differences, we can use more bits -> quantization of the difference.
- Each bit code is used to represent the value of the difference.
- The more bits the more levels -> the higher the accuracy.

DPCM - How it works

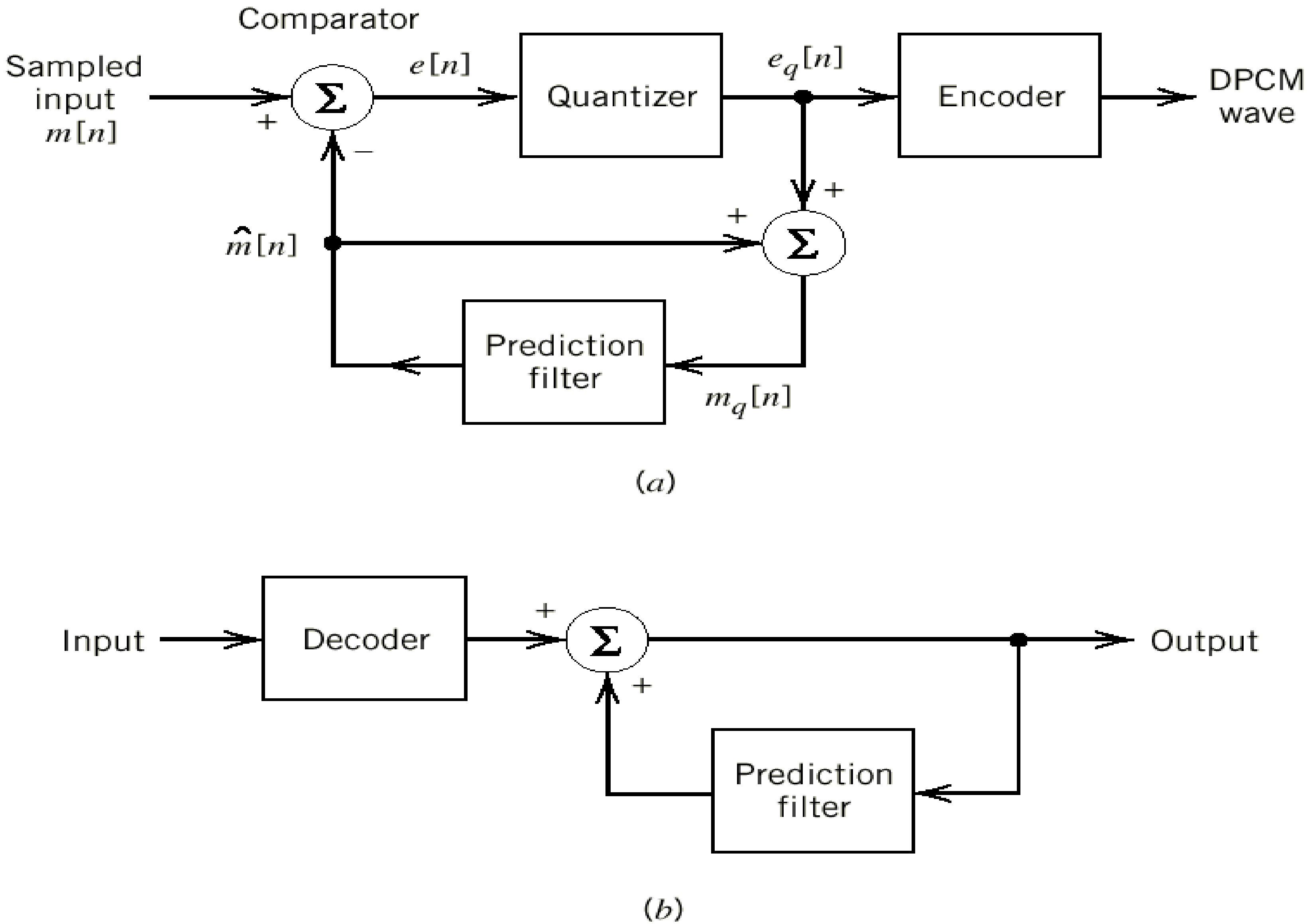
- We know the signal up to a certain time
- Use prediction to estimate future values
- Signal sampled at $f_s = 1/T_s$; sampled sequence – $\{m[n]\}$, where samples are T_s seconds apart
- Input signal to the quantizer – difference between the unquantized input signal *m(t)* and its prediction:

$$e[n] = m[n] - \hat{m}[n]$$

prediction of the input sample

DPCM

- Predicted value – achieved by linear prediction filter whose input is the quantized version of the input sample m[n].
- The difference e[n] is the prediction error (what we expect and what actually happens)
- By encoding the quantizer output we actually create a variation of PCM called differential PCM (DPCM).



DPCM system. (a) Transmitter. (b) Receiver.

Comparison DPCM and DM

- DPCM and DM
  - DPCM includes DM as a special case
  - Similarities
    - subject to slope-overhead and quantization error
  - Differences
    - DM uses a 1-bit quantizer
    - DM uses a single delay element (zero prediction order)
- DPCM and PCM
  - both DM and DPCM use feedback while PCM does not
  - all subject to quantization error

Adaptive Differential PCM (ADPCM)

- PCM for speech coding requires high bandwidth
- some applications (secure transmission over radio channel – low capacity)
- requires speech coding at low bit rates but preserving acceptable reliability
- possible using special coders that utilize statistical characteristics of speech signals and properties of hearing

ADPCM Design Objectives

- **Adaptive differential pulse-code modulation** (**ADPCM**) is a variant of differential pulse-code modulation (DPCM) that varies the size of the quantization step, to allow further reduction of the required bandwidth for a given signal-to-noise ratio.

ADPCM

- Adaptive prediction in ADPCM
  - adaptive prediction with forward estimation (APF); uses unqunatized samples of the input signal to calculate prediction coefficients; disadvantages similar to AQF
  - adaptive prediction with backward estimation (APB); uses samples of the quantizer output and the prediction error to compute predictor coefficients; logic for adaptive prediction – algorithm for updating predictor coefficients

Digital-Digital Conversion

Line Coding
Line Coding Schemes
Block Coding

DIGITAL-TO-DIGITAL CONVERSION

In this section, we see how we can represent digital data by using digital signals. The conversion involves two techniques: line coding, block coding.
Line coding is always needed;
block coding may or may not be needed.

Topics discussed in this section:

Line Coding
Line Coding Schemes
Block Coding

Signal Element versus Data Element

- Data element
  - The smallest entity that can represent a piece of information: this is **bit**.
- Signal element
  - The shortest unit (timewise) of a **digital signal**.
- In other words
  - Data element are what we need to send.
  - Signal elements are what we can send.

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Figure *Line coding and decoding*

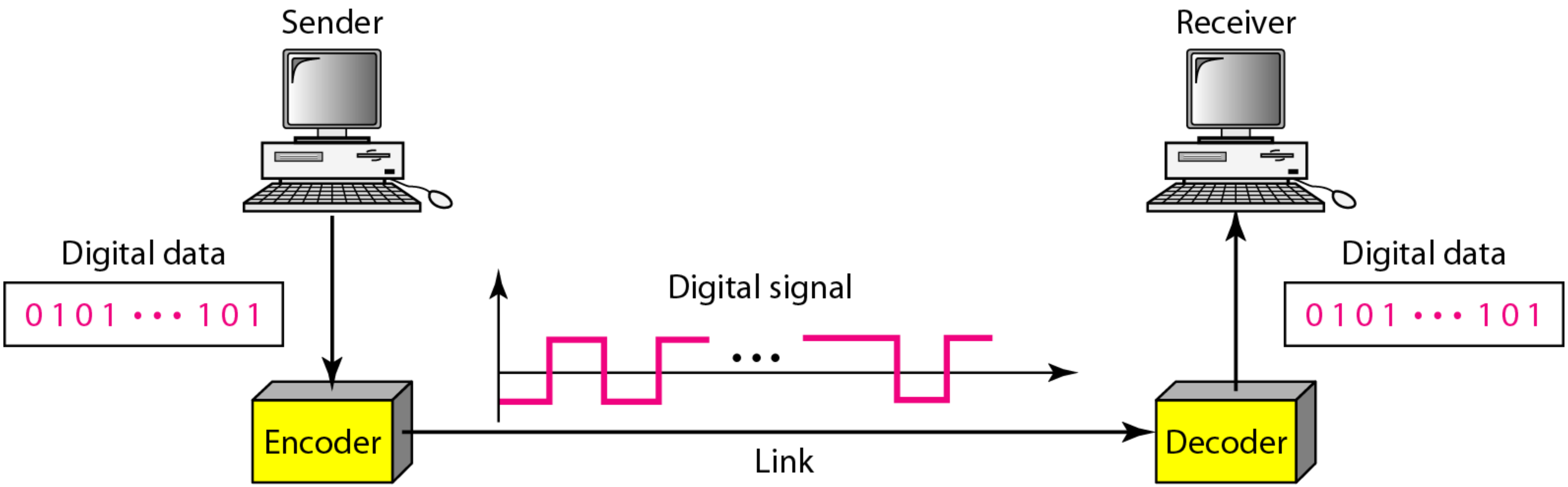

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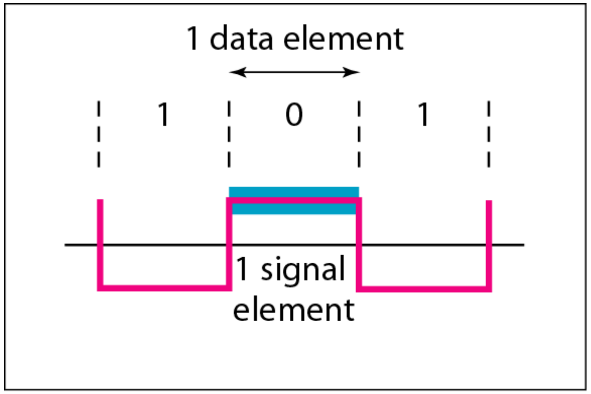
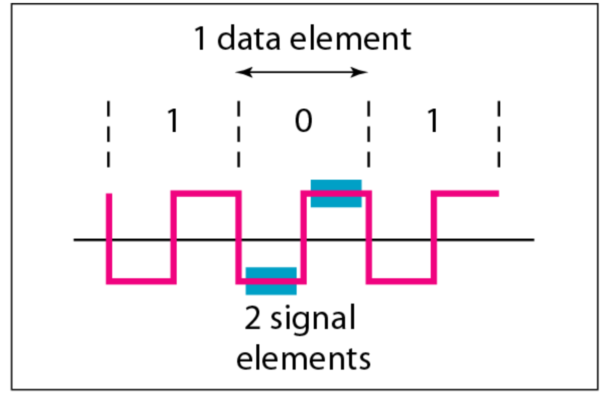
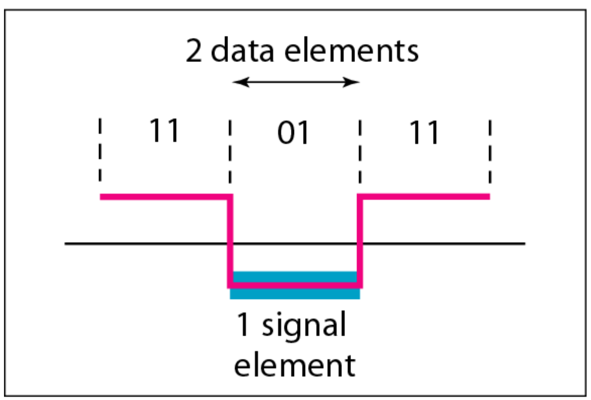
Figure *Signal element versus data element*



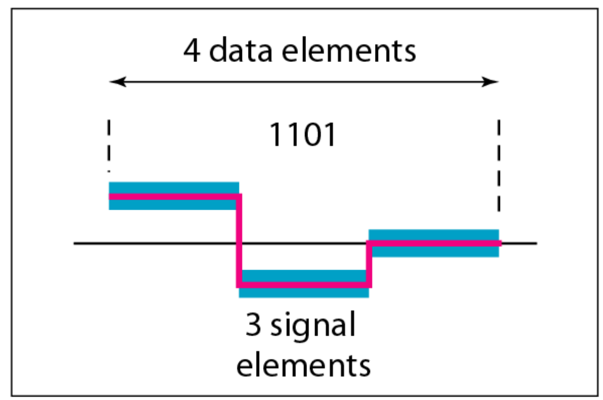
a. One data element per one signal element (r = 1)



b. One data element per two signal elements $\left(r = \frac{1}{2}\right)$



c. Two data elements per one signal element (r = 2)



d. Four data elements per three signal elements $\left(r = \frac{4}{3}\right)$

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Data Rate versus Signal Rate(Bit and Baud rate)

- **Data rate**
  - The number of data elements (bits) sent in 1s
  - The unit is bits per second (bps)
  - Called **bit rate**
- **Signal rate**
  - The number of signal elements sent in 1s
  - The unit is the **baud**
  - Signal rate is sometimes called the **pulse rate**, the **modulation rate**, or the **baud rate**
- Relationship between data rate and signal rate

$$S = c \times N \times \frac{1}{r} \quad \text{baud}$$

- *S*: number of signal elements, *c*: the case factor, *N*: data rate (bps), *r*: data elements per signal elements

Figure *Line coding schemes*

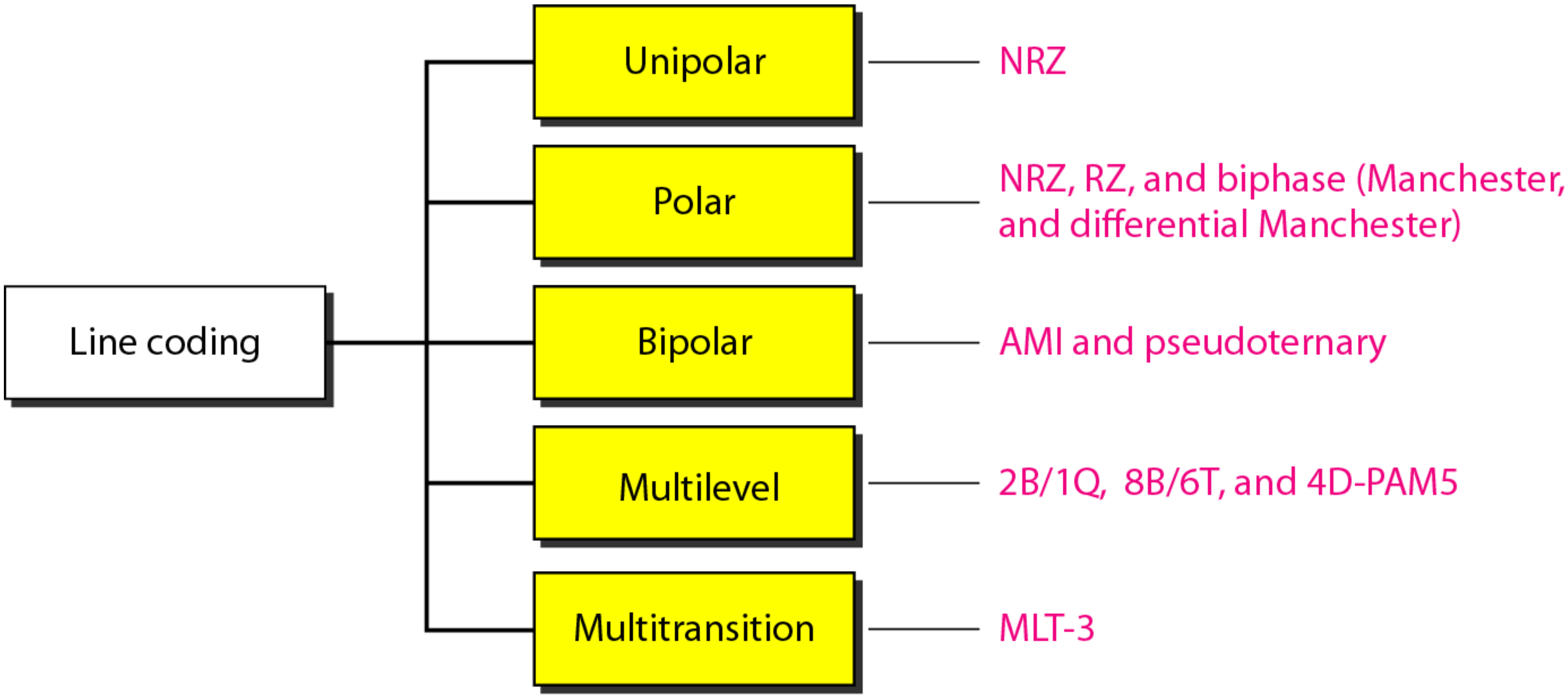

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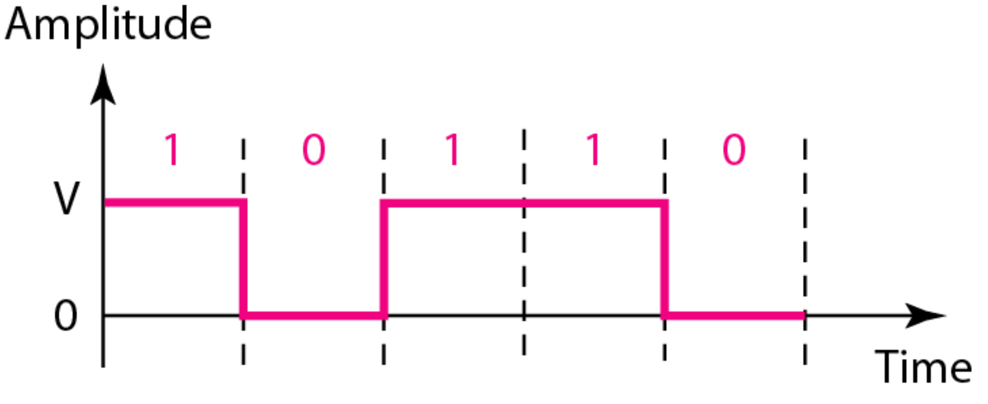
Figure *Unipolar NRZ scheme*

Non-Return-to-Zero (NRZ)



$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

Normalized power

It is called NRZ because the signal does not return to zero at the middle of the bit.

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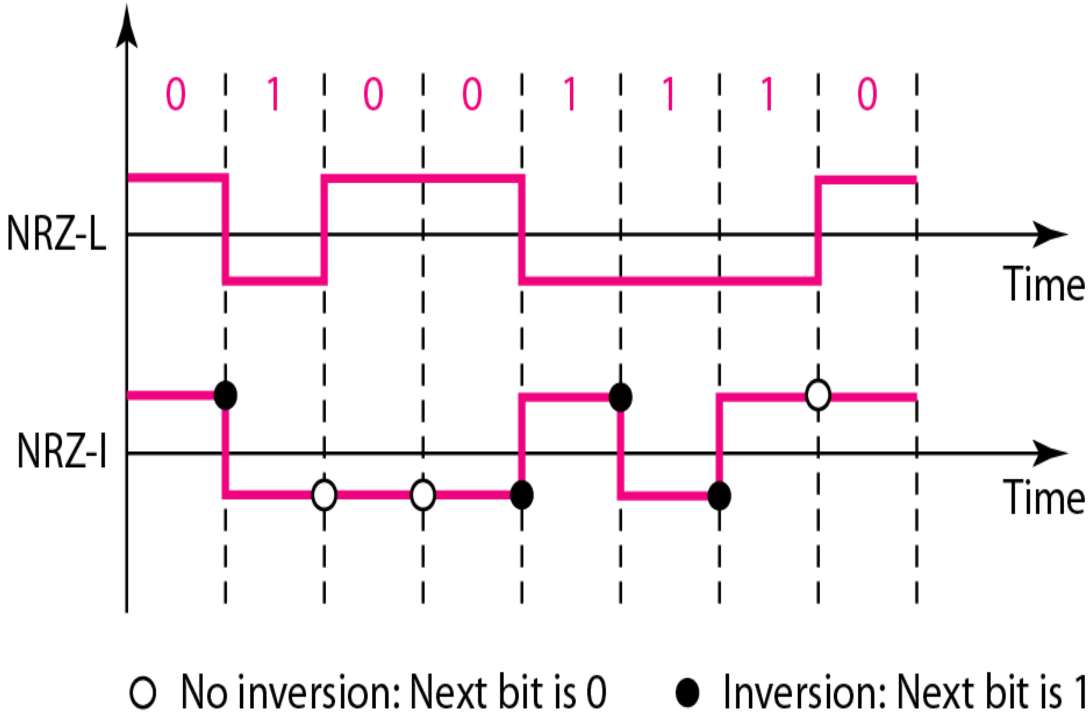
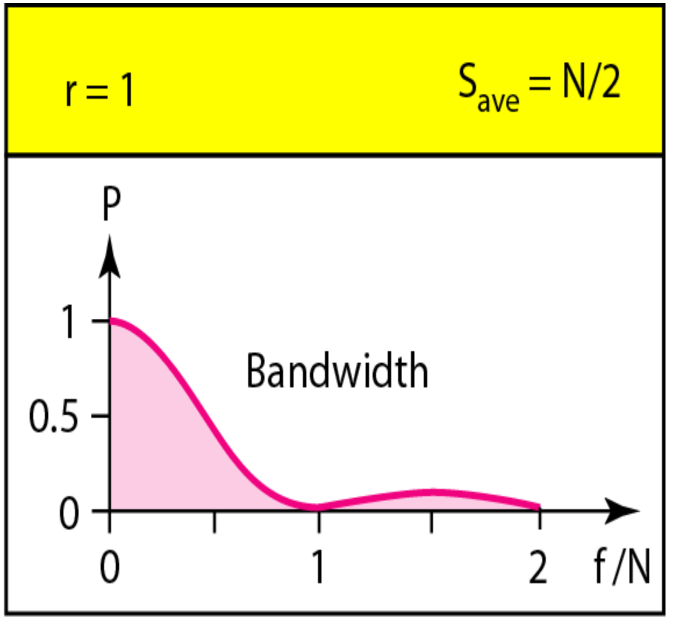
Figure *Polar NRZ-L and NRZ-I schemes*

NRZ-L (NRZ-Level), NRZ-I (NRZ-Invert)





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Note

In NRZ-L the level of the voltage determines the value of the bit.
In NRZ-I the inversion or the lack of inversion determines the value of the bit.

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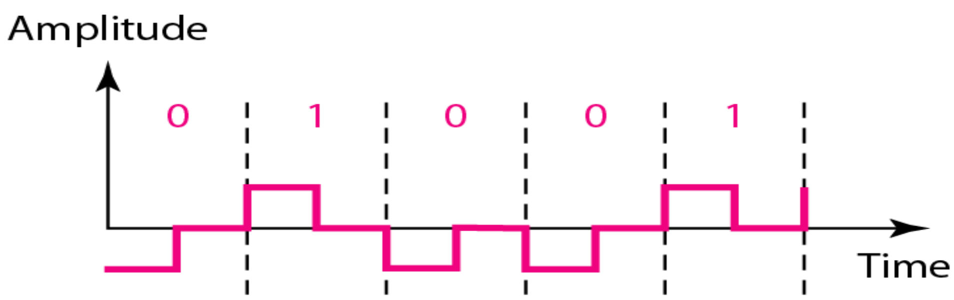
Return to Zero (RZ) :

The **main problem** with NRZ encoding occurs when the sender and receiver clocks are not synchronized. The receiver does not know when one bit has ended and the next bit is starting. One solution is the return-to-zero (RZ) scheme, which uses three values: positive, negative, and zero. In RZ, the signal changes not between bits but during the bit. In Figure 4.7 we see that the signal goes to 0 in the middle of each bit. It remains there until the beginning of the next bit. The main **disadvantage** of RZ encoding is that it requires two signal changes to encode a bit and therefore occupies greater bandwidth. The same problem we mentioned, a sudden change of polarity resulting in all Os interpreted as is and all Is interpreted as Os, still exist here, but there is no DC component problem. Another problem is the complexity: RZ uses three levels of voltage, which is more complex to create and discern. As a result of all these deficiencies, the scheme is not used today. Instead, it has been replaced by the better-performing Manchester and differential Manchester schemes (discussed next).

Figure 4.7 ***Polar RZ scheme***



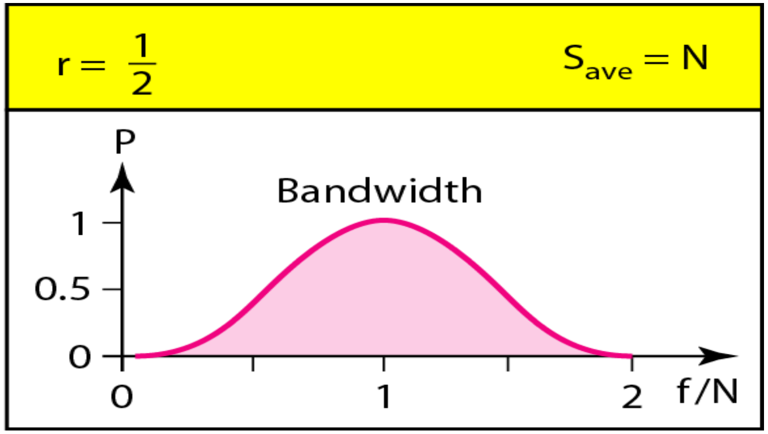
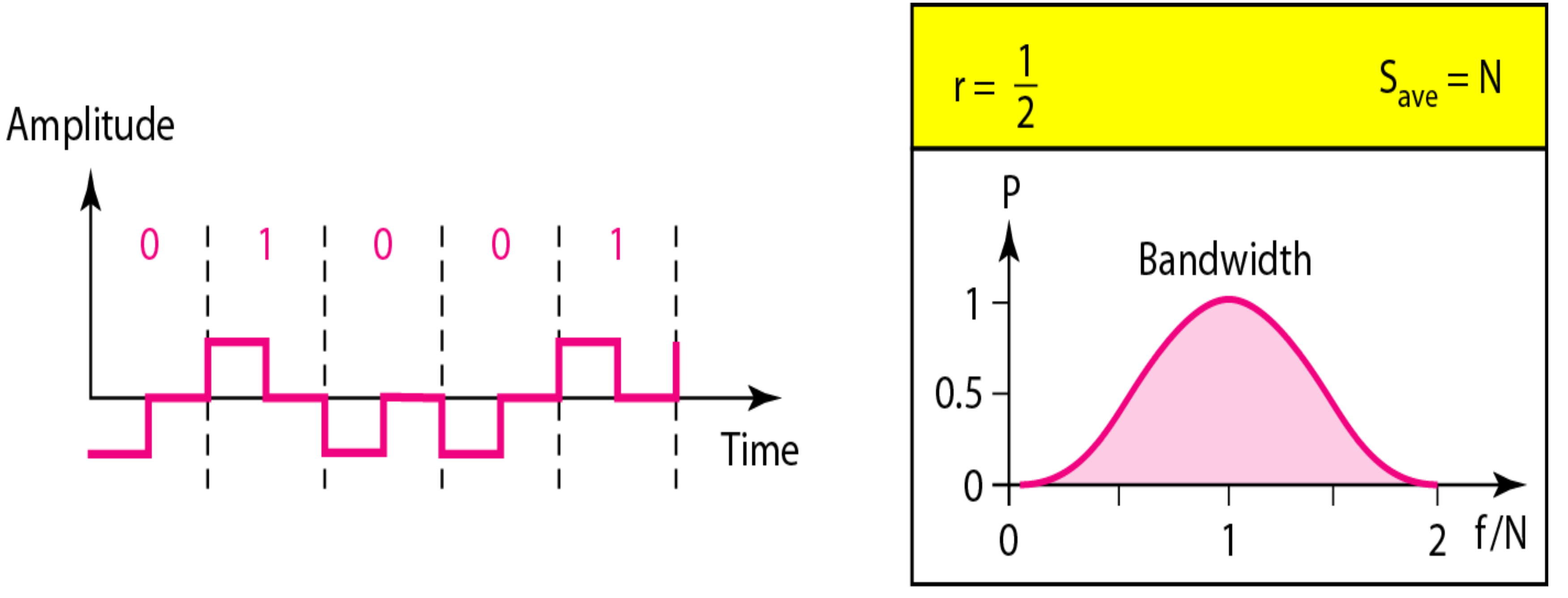


Figure *Polar RZ scheme*

RZ: Return-to-Zero



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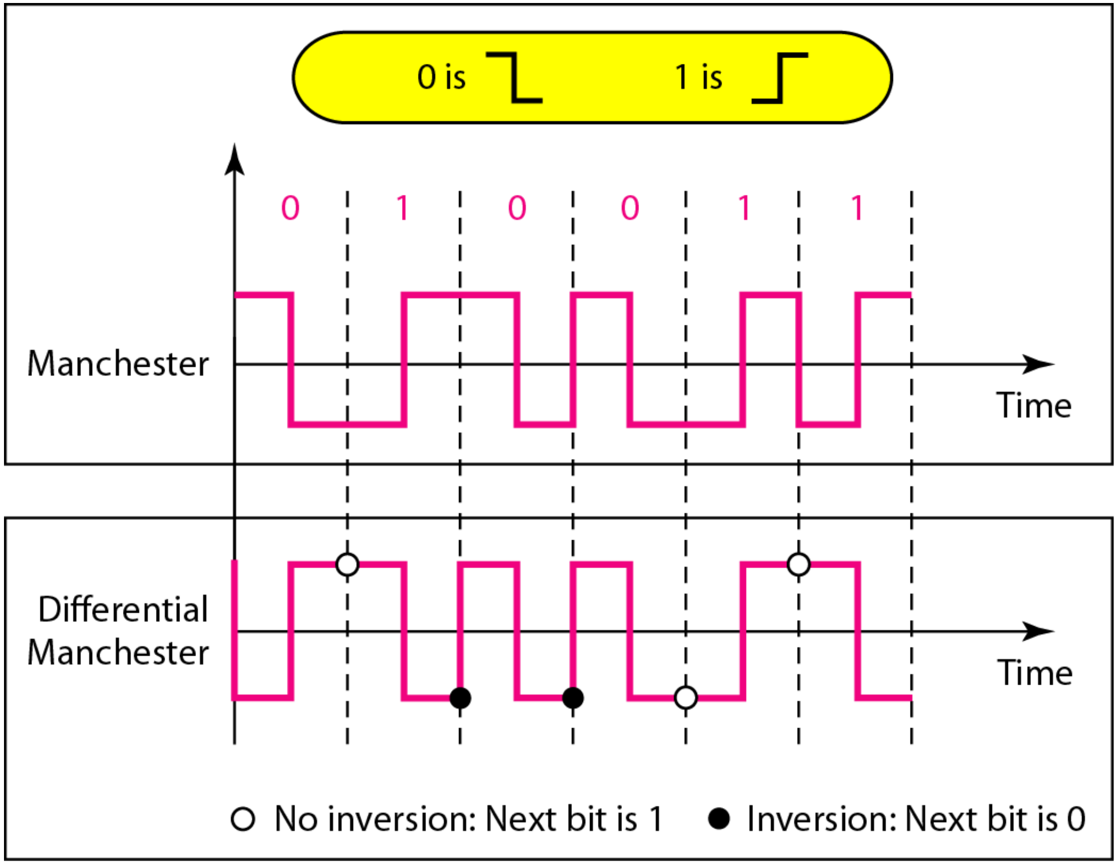
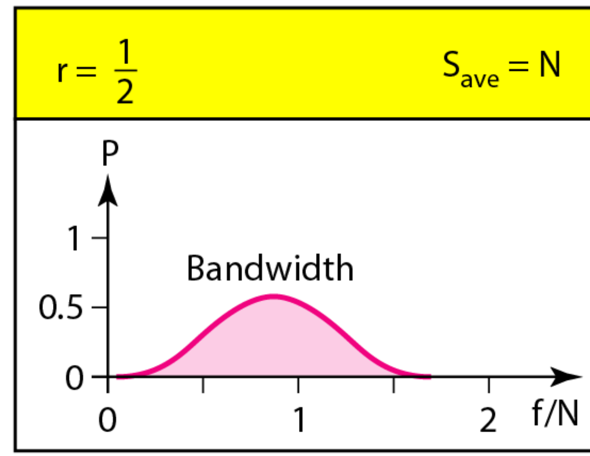
Polar biphase: Manchester and differential Manchester schemes

• In Manchester and differential Manchester encoding, the transition at the middle of the bit is used for synchronization.
• The minimum bandwidth of Manchester and differential Manchester is 2 times that of NRZ.

The Manchester scheme **overcomes** several problems associated with NRZ-L, and differential Manchester **overcomes** several problems associated with NRZ-I. First, there is **no** baseline wandering. There is **no** DC component because each bit has a positive and negative voltage contribution. The only **drawback** is the signal rate. The signal rate for Manchester and differential Manchester is double that for NRZ. The **reason** is that there is always one transition at the middle of the bit and maybe one transition at the end of each bit.

Figure ***Polar biphase: Manchester and differential Manchester schem***





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Note

In Manchester and differential Manchester encoding, the transition at the middle of the bit is used for synchronization.

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Bipolar Schemes

- Bipolar encoding (sometimes called multilevel binary)
  - Three voltage levels: positive, negative, and zero
- variations of bipolar encoding
  - AMI (alternate mark inversion)
    - 0: neutral zero voltage
    - 1: alternating positive and negative voltages

NDSL Copyright@2008

Note

In bipolar encoding, we use three levels: positive, zero, and negative.

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AMI

- **AMI** (alternate mark inversion)
  - The work ***mark*** comes from telegraphy and means **1**.
  - AMI means alternate 1 inversion
  - The neutral zero voltage represents binary 0.
  - Binary 1s are represented by alternating positive and negative voltages.

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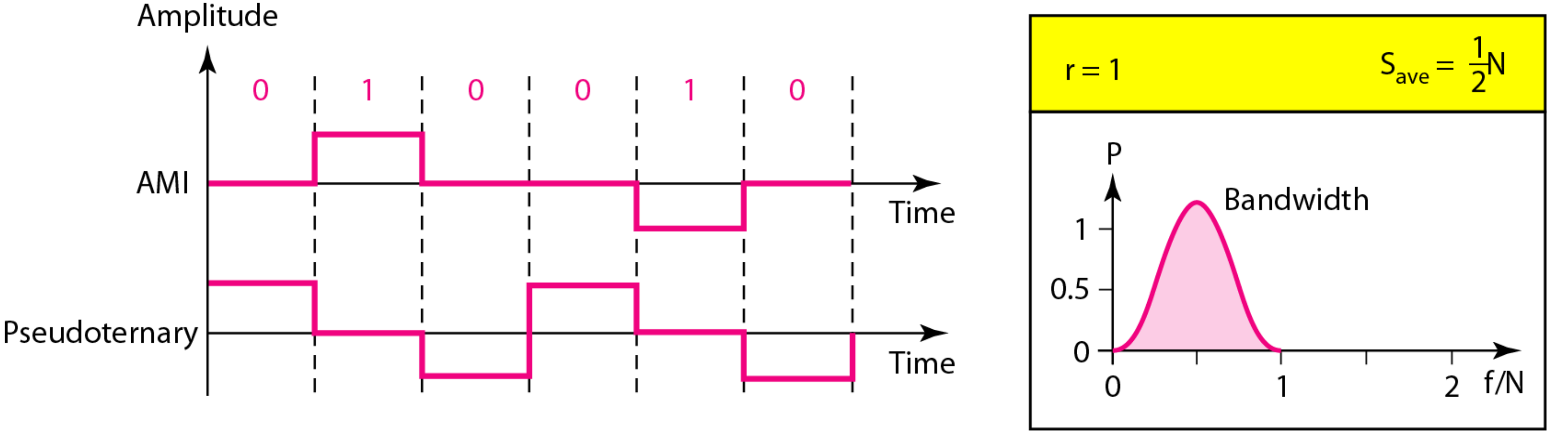
Figure 4.9 *Bipolar schemes: AMI and pseudoternary*



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B8ZS

- Bipolar with 8-zero substitution (B8ZS)
  - Commonly used in North America
  - Eight consecutive zero-level voltages are replaced by the sequence **000VB0VB**.
  - The V in the sequence denotes violation; that is a nonzero voltage that breaks an AMI rule of encoding (opposite polarity from the previous).
  - The B in the sequence denotes bipolar, which means a nonzero level voltage in accordance with the AMI rule.

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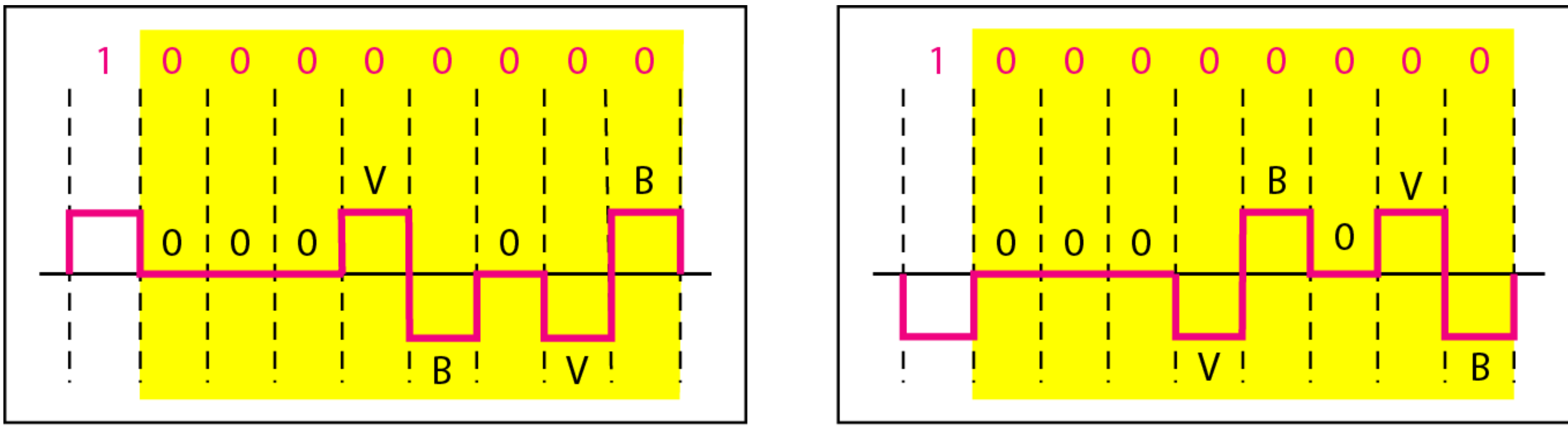
Figure *Two cases of B8ZS scrambling technique*



a. Previous level is positive.

b. Previous level is negative.

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Block Coding

- Use redundancy to ensure synchronization and to provide some kind of inherent error detecting.
- In general, **block coding** changes a block of *m* bits into a block of *n* bits, where *n* is larger than *m*.
- Block coding is referred to as an *m*B/*n*B encoding technique.
- For example:
  – 4B/5B encoding means a 4-bit code for a 5-bit group.

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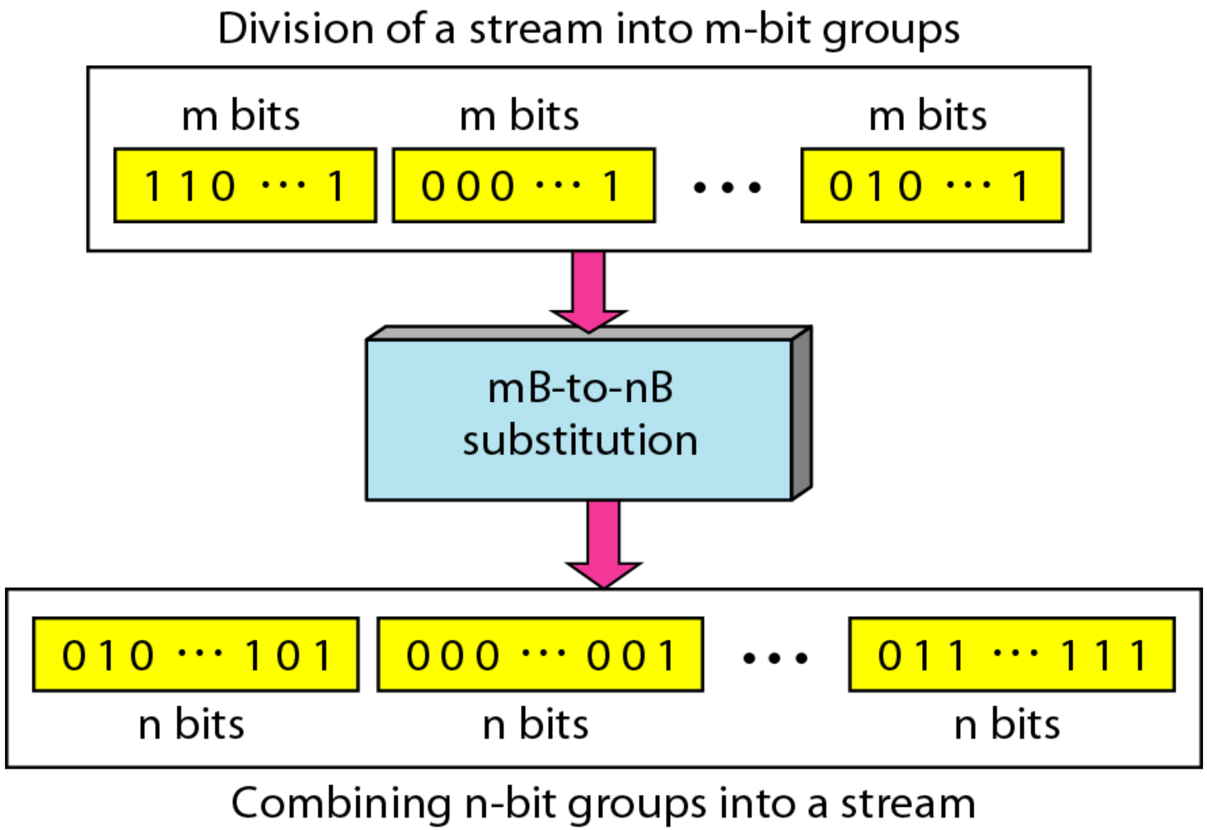
Block Coding

We need redundancy to ensure synchronization and to provide some kind of inherent error detecting. Block coding can give us this redundancy and improve the performance of line coding. In general, block coding changes a block of m bits into a block of n bits, where n is larger than m. Block coding is referred to as an mB/nB encoding technique.

Block coding is normally referred to as *m*B/*n*B coding; it replaces each *m*-bit group with an *n*-bit group.

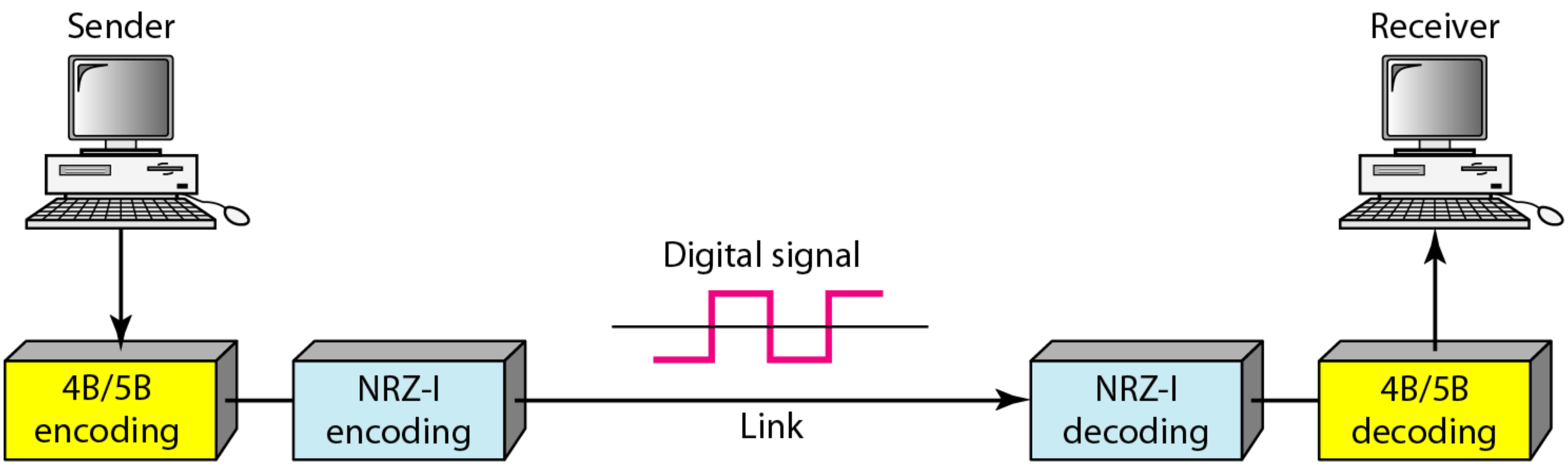
Figure ***Block coding concept***



Block Coding

Block coding normally involves three steps: division, substitution, and combination. In the division step, a sequence of bits is divided into groups of m bits. For example, in 4B/5B encoding, the original bit sequence is divided into 4-bit groups. The heart of block coding is the substitution step. In this step, we substitute an m-bit group for an n-bit group. For example, in 4B/5B encoding we substitute a 4-bit code for a 5-bit group. Finally, the n-bit groups are combined together to form a stream. The new stream has more bits than the original bits.

Figure ***Using block coding 4B/5B with NRZ-I line coding scheme***



4B/5B Encoding

- 5-bit output that replaces the 4-bit input
- No more than one leading zero (left bit) and no more than two trailing zeros (right bits).
- There are never more than **three consecutive 0s**.
- If a 5-bit group arrives that belongs to the unused portion of the table, the receiver knows that there is an error in the transmission.

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Table 4.2 *4B/5B mapping codes*

Data Sequence	*Encoded Sequence*	*Control Sequence*	*Encoded Sequence*
0000	11110	Q (Quiet)	00000
0001	01001	I (Idle)	11111
0010	10100	H (Halt)	00100
0011	10101	J (Start delimiter)	11000
0100	01010	K (Start delimiter)	10001
0101	01011	T (End delimiter)	01101
0110	01110	S (Set)	11001
0111	01111	R (Reset)	00111
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

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Figure 4.16 *Substitution in 4B/5B block coding*

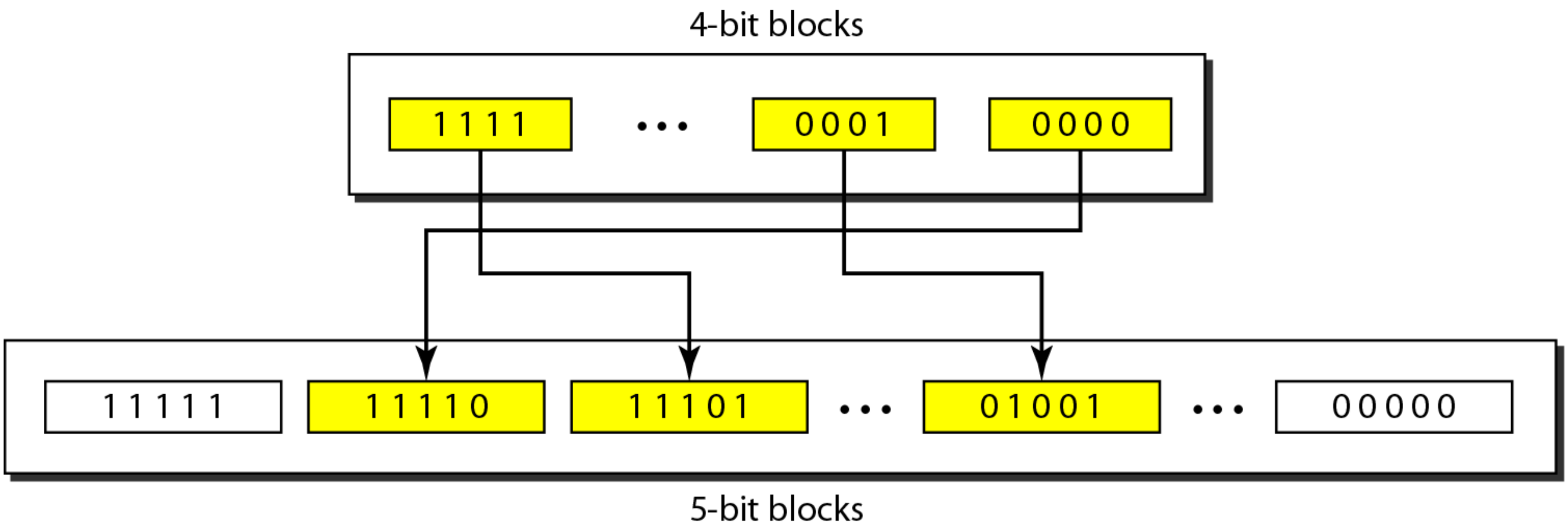

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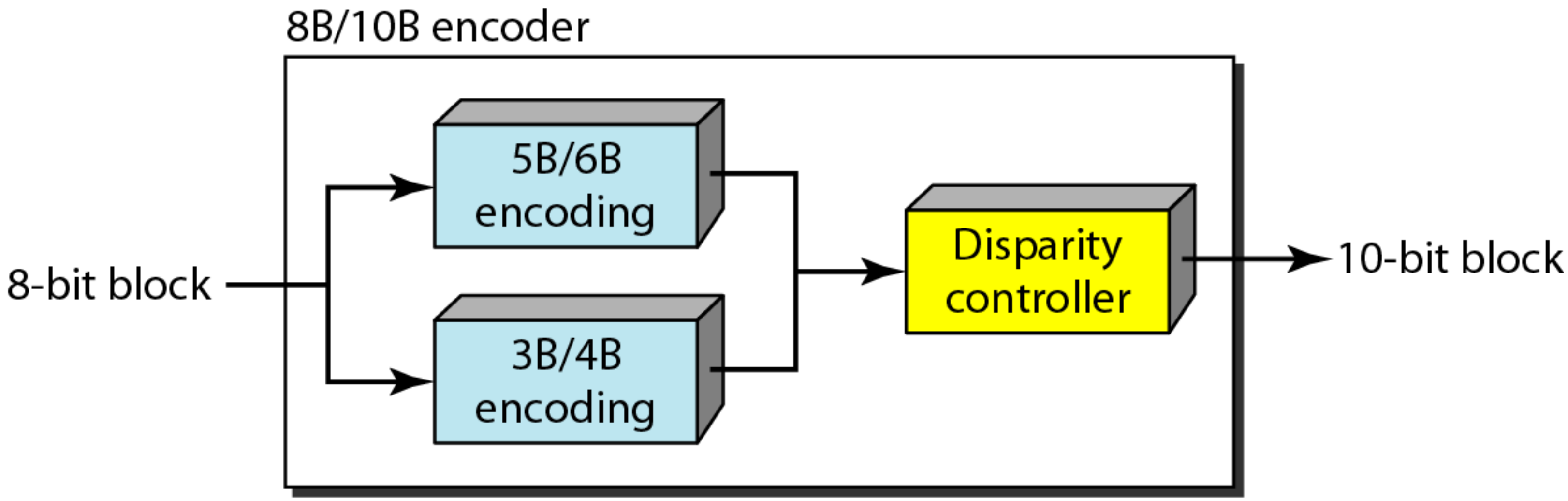
Figure *8B/10B block encoding*



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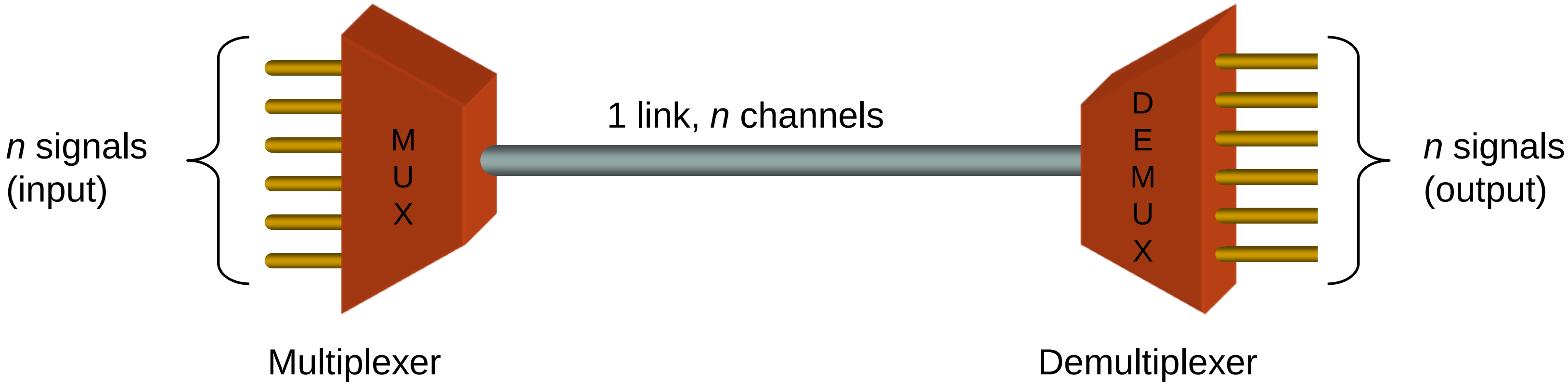
Multiplexing

Multiplexing: Sharing Medium

- A link is divided into channels

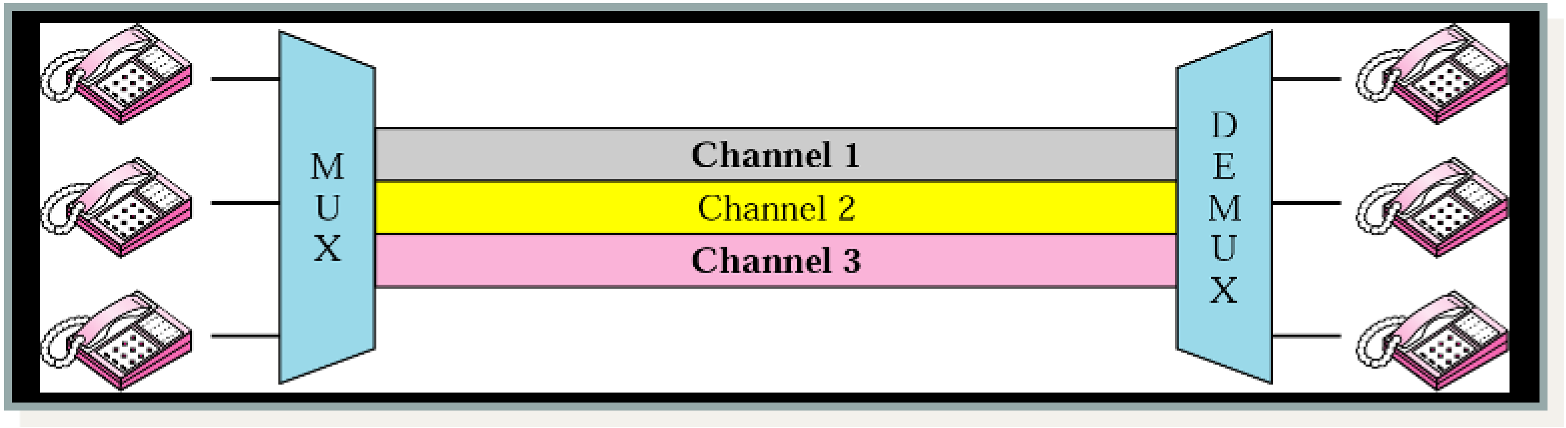


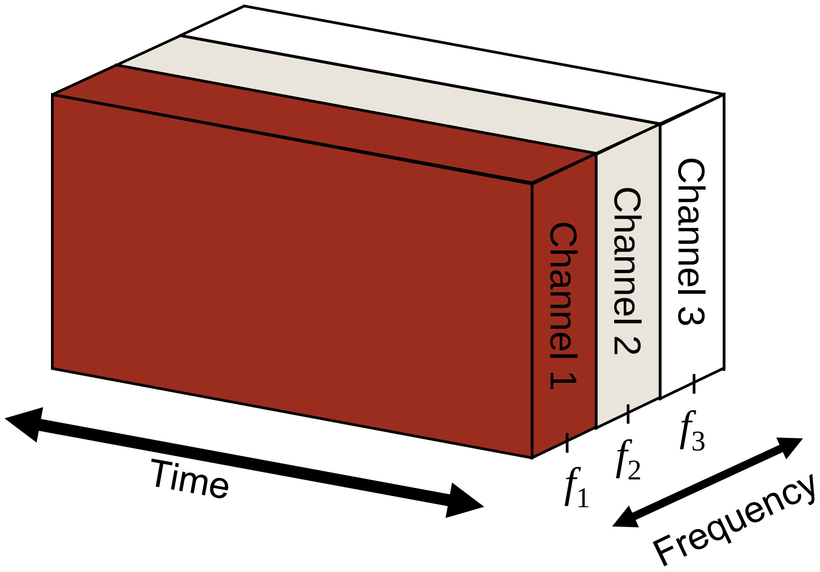
Frequency Division Multiplexing (FDM)

An analog multiplexing technique to combine signals

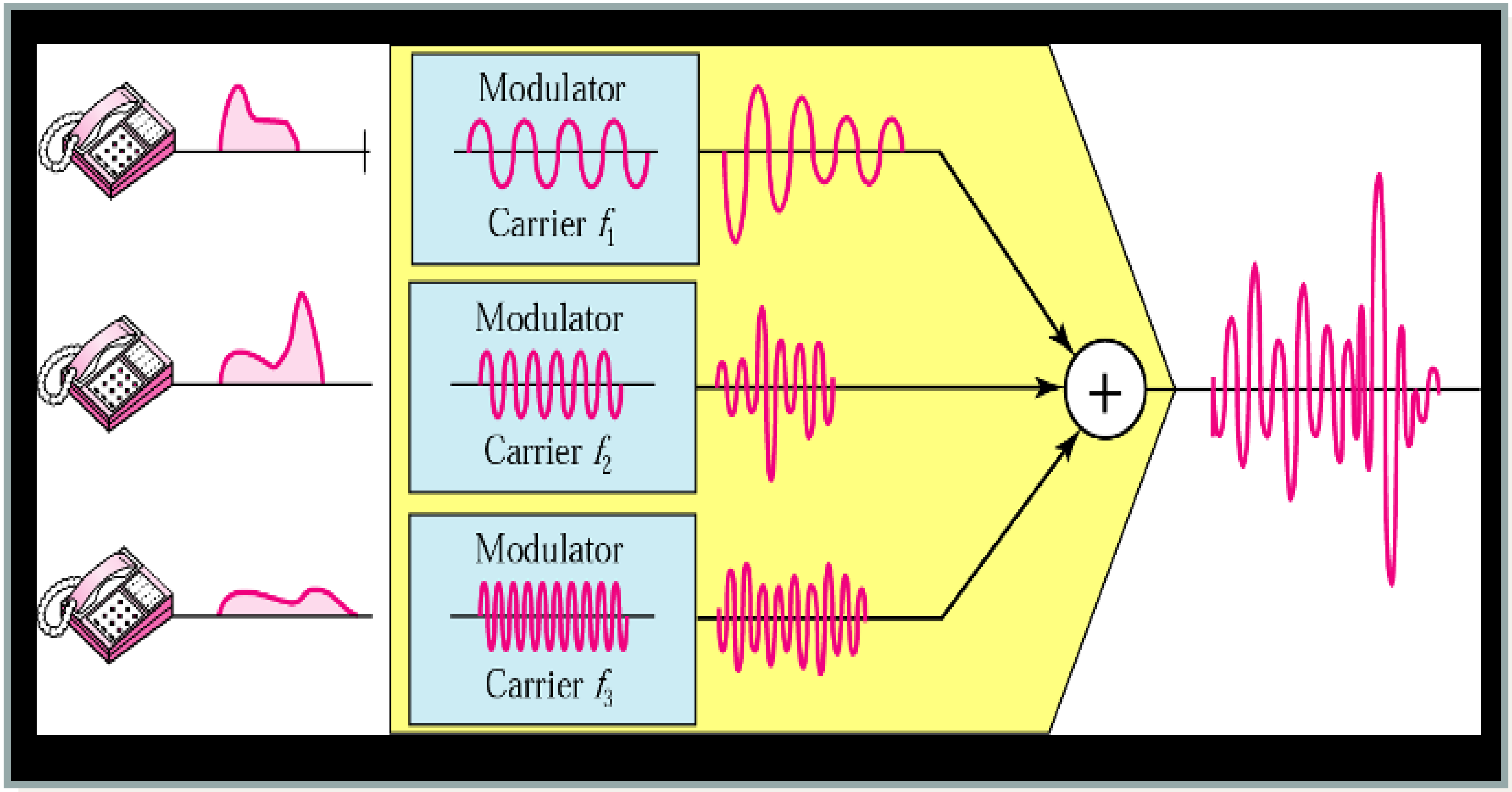
- Medium BW > Channel BW
- Each signal is modulated to a different carrier frequency
- E.g., broadcast radio
- Channel allocated even if no data

Conceptual View of FDM

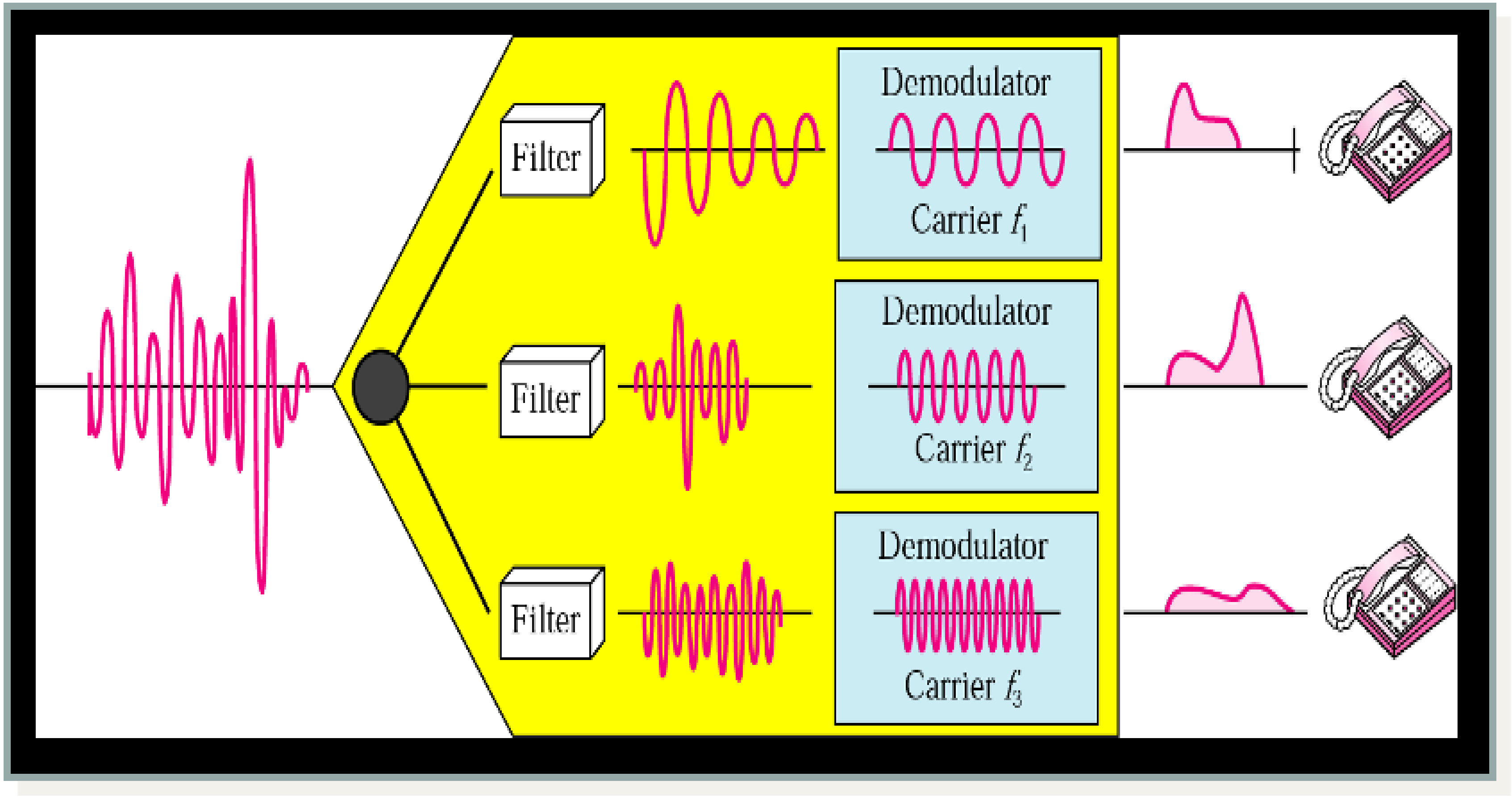




FDM: Multiplexing Process



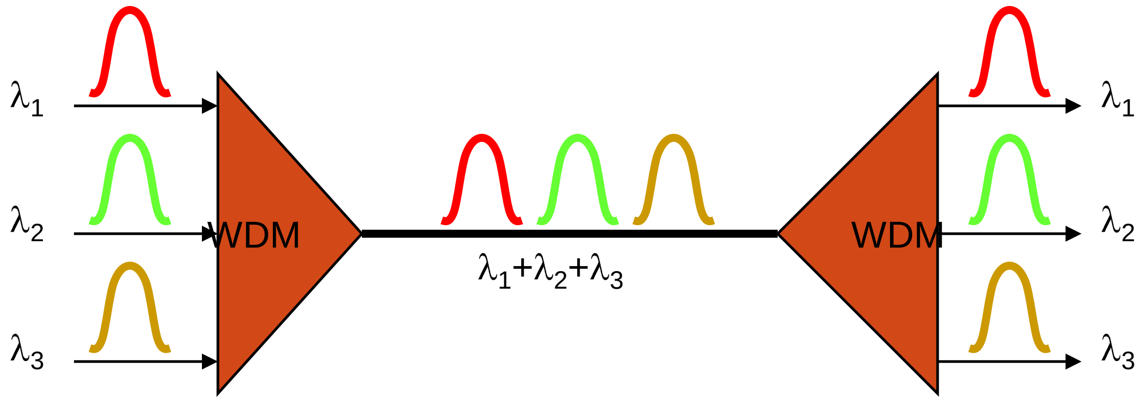
FDM: Demultiplexing Process

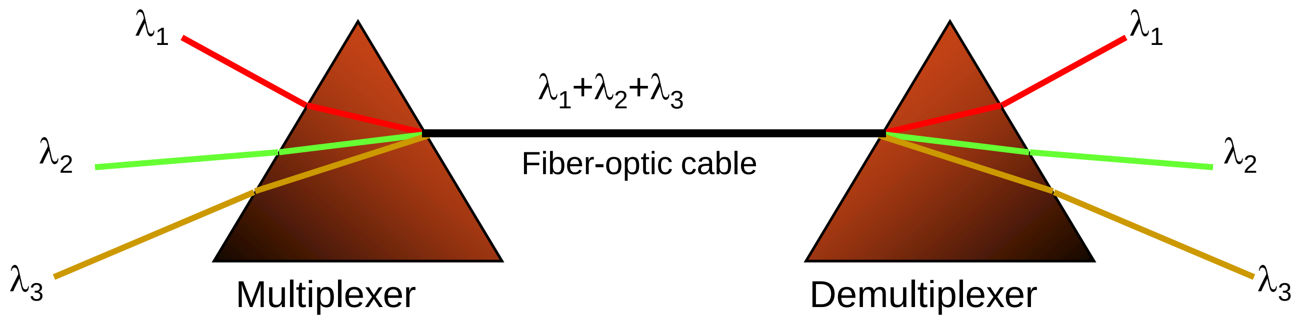


Wavelength Division Multiplexing (WDM)

An analog multiplexing technique to combine optical signals

- WDM is a special case of FDM

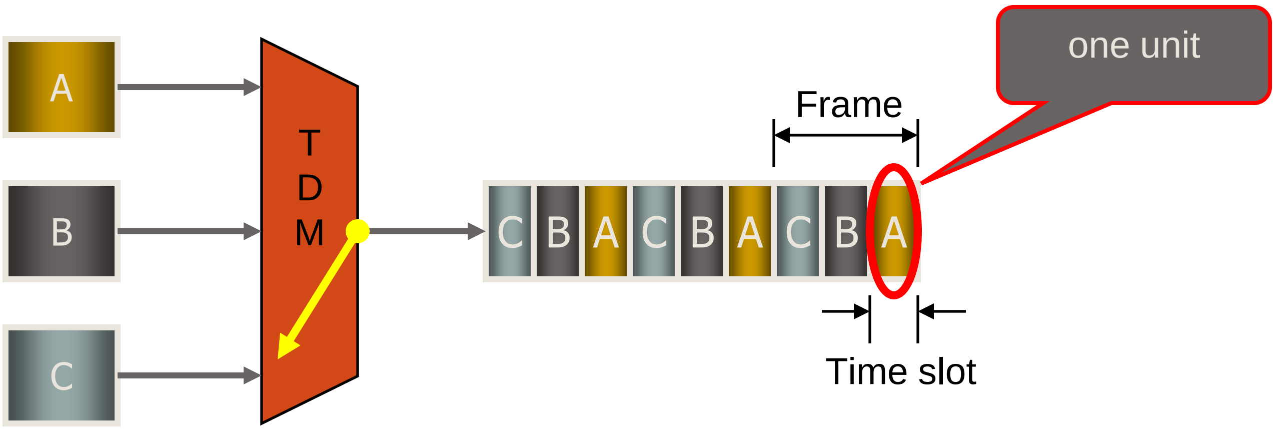




Time Division Multiplexing (TDM)

A digital multiplexing technique to combine data

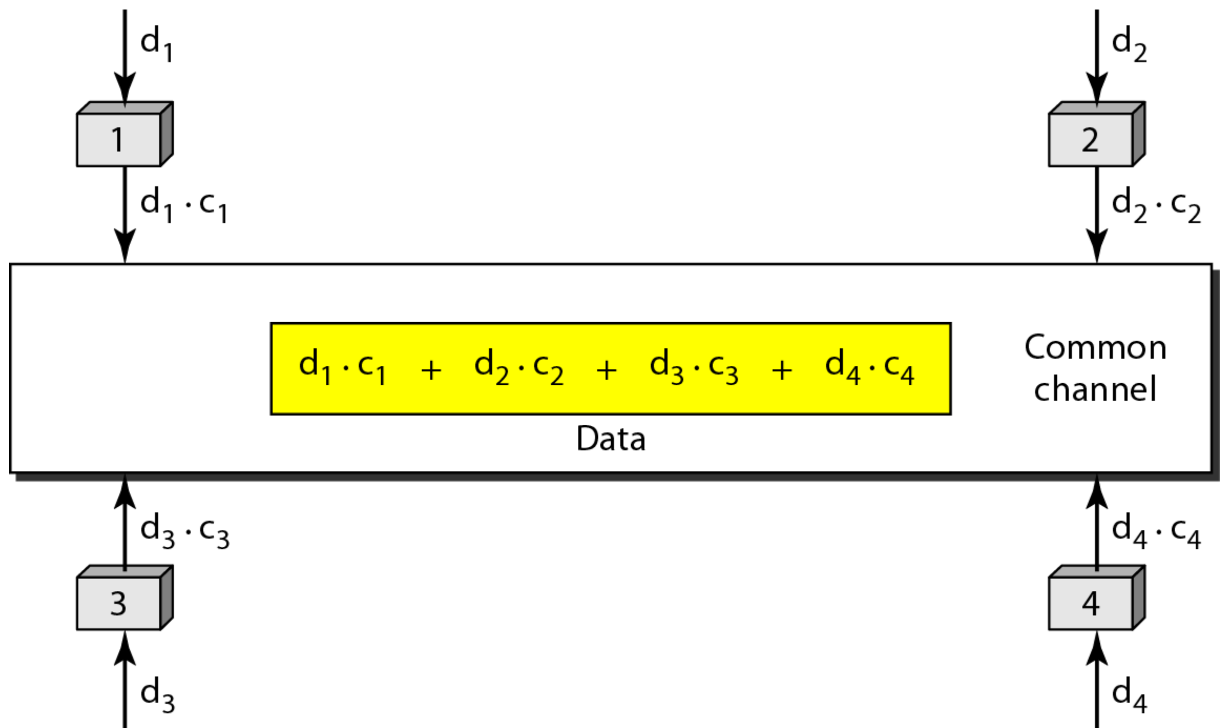
- Medium Data Rate > Signal Data Rate
- Multiple digital signals interleaved in time



- Time slots
  - are preassigned to sources and fixed
  - are allocated even if no data
  - do not have to be evenly distributed among sources

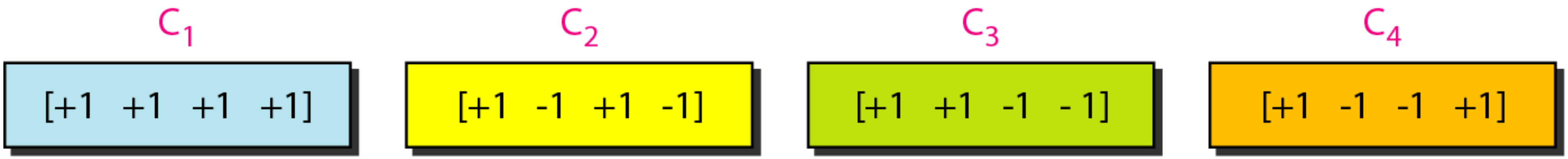
CDMA (Code Division Multiple Access)

- One channel carries all transmissions at the same time
- Each channel is separated by code



CDMA: Chip Sequences

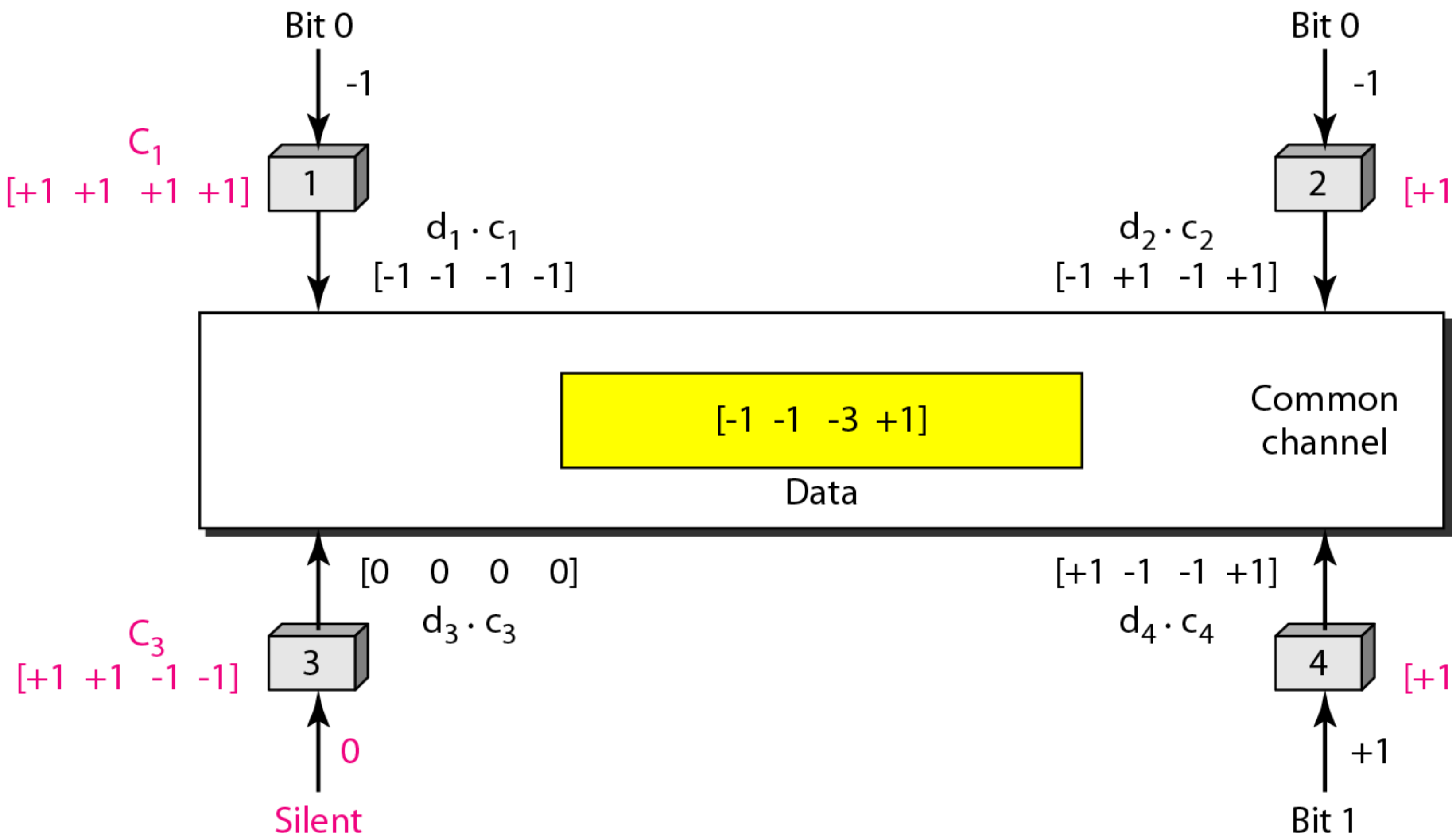
- Each station is assigned a unique chip sequence



- Chip sequences are orthogonal vectors
  - Inner product of any pair must be zero
- With N stations, sequences must have the following properties:
  - They are of length N
  - Their self inner product is always N

CDMA: Bit Representation

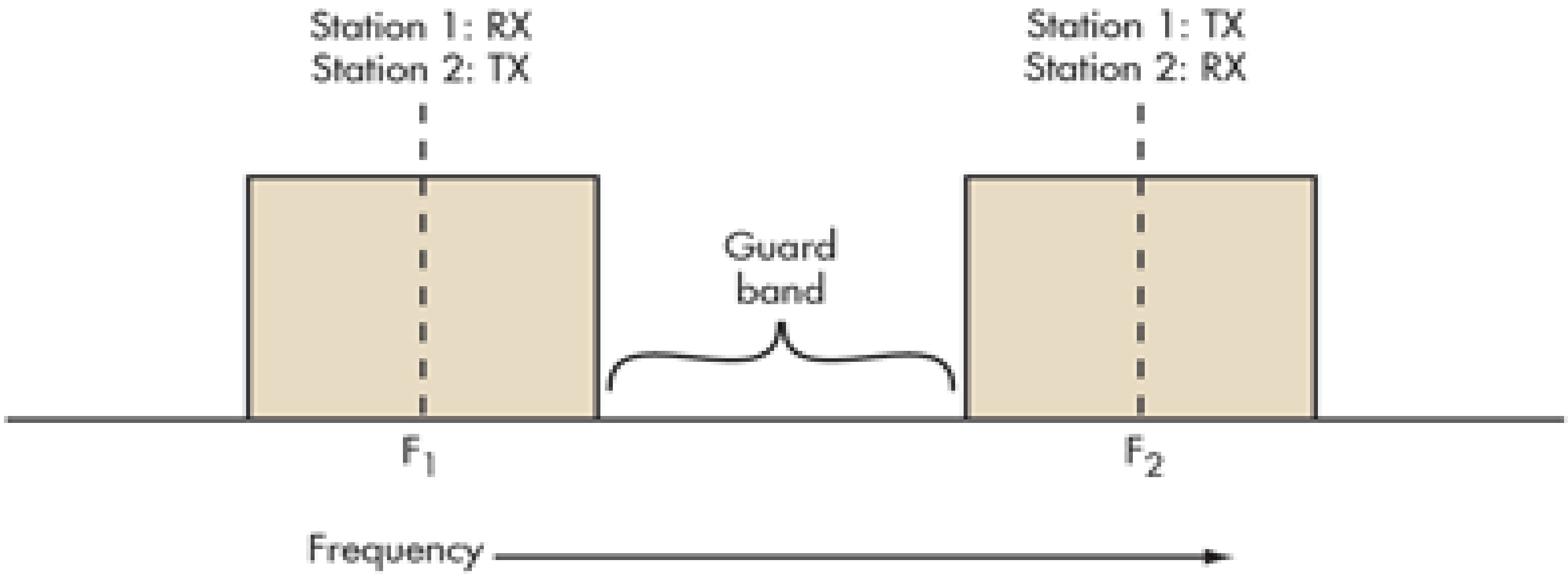
Transmission in CDMA



FDD (Frequency Division Duplexing)

- FDD requires two separate communications channels. In networking, there are two cables. Full-duplex Ethernet uses two twisted pairs inside the CAT5 cable for simultaneous send and receive operations.
- Wireless systems need two separate frequency bands or channels A sufficient amount of guard band separates the two bands so the transmitter and receiver don’t interfere with one another.

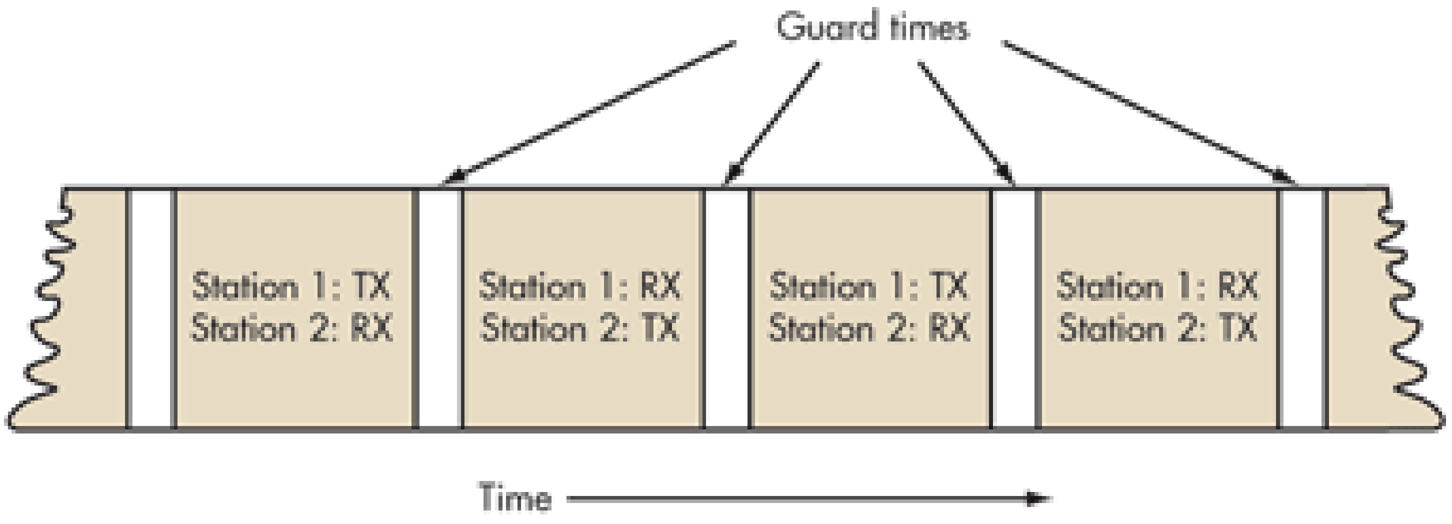
FDD (Frequency Division Duplexing



TDD- Time Division Duplex

- TDD uses a single frequency band for both transmit and receive. Then it shares that band by assigning alternating time slots to transmit and receive operations
- The information to be transmitted—whether it's voice, video, or computer data—is in serial binary format. Each time slot may be 1 byte long or could be a frame of multiple bytes.
- The real advantage of TDD is that it only needs a single channel of frequency spectrum

TDD- Time Division Duplex



Difference between FDD & TDD

FDD AND TDD METHODS		
Characteristic	FDD	TDD
Spectrum usage	High including guard bands	Less
Complexity	High	Low but needs accurate timing
Cost	Higher	Lower
Latency	Little or none	Depends on range, TX-RX switching times
Range	Unlimited	Shorter, depends on guard time
UL/DL symmetry	Usually 50/50	Asymmetrical as required
Dynamic bandwidth allocation	None	Can be implemented
MIMO and beamforming	More difficult	Easier

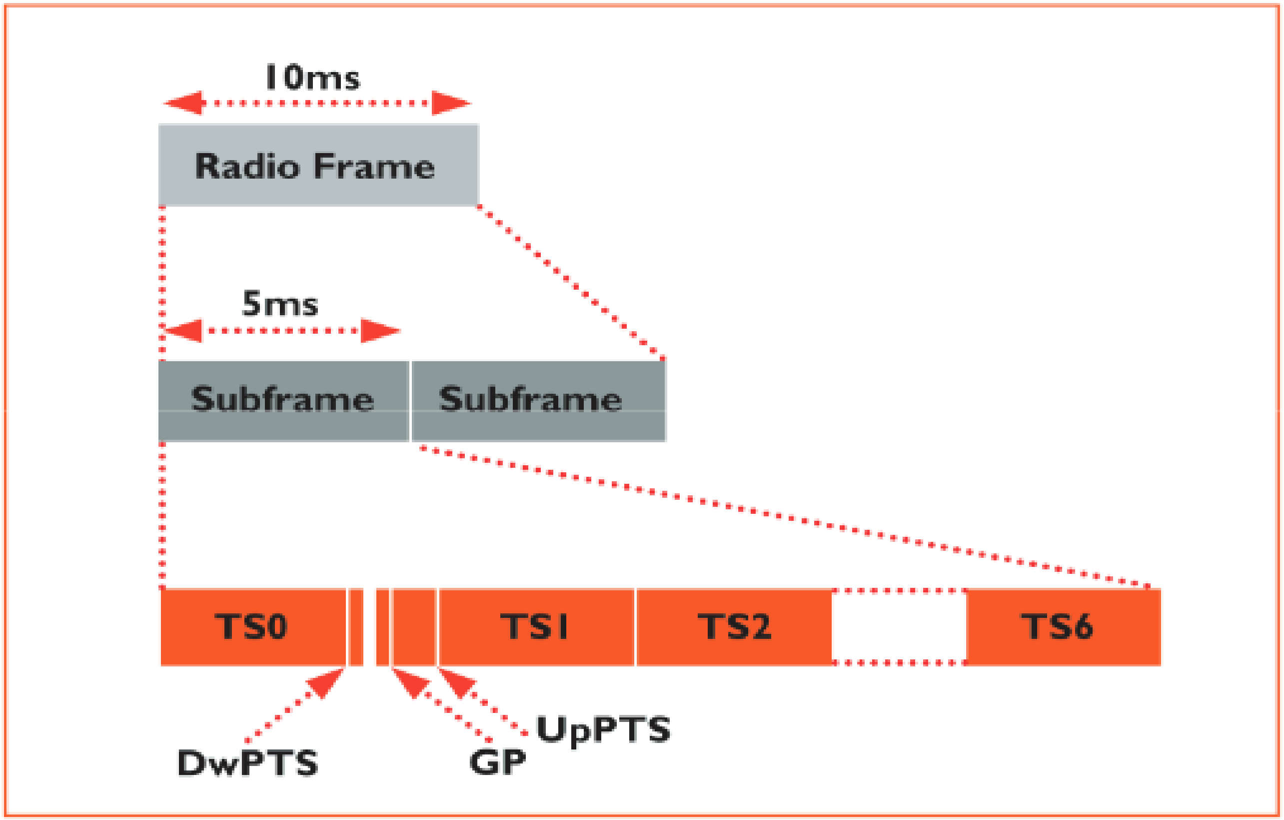
TD-SCDMA (Time Division Synchronous Code Division Multiple Access)

- TD-SCDMA (time division synchronous code division multiple access) is a mobile telephone standard for wireless network operators who want to move from a second generation (2G) wireless network to a third-generation (3G) one.
- Supporting data transmission at speeds up to 2 Mbps, TD-SCDMA combines support for both circuit-switched data, such as speech or video, and also packet-switched data from the Internet.
- The standard combines time division multiple access (TDMA) with an adaptive, synchronous-mode code division multiple access (CDMA) component.
- TD-SCDMA was developed by the China Academy of Telecommunications Technology (CATT) in collaboration with Datang and Siemens.

TD-SCDMA (Time Division Synchronous Code Division Multiple Access)

- TD-SCDMA uses TDD, in contrast to the FDD scheme used by W-CDMA. By dynamically adjusting the number of timeslots used for downlink and uplink, the system can more easily accommodate asymmetric traffic with different data rate requirements on downlink and uplink than FDD schemes. Since it does not require paired spectrum for downlink and uplink, spectrum allocation flexibility is also increased

TD-SCDMA Frame Structure



LTE(Long Term Evaluation)

- **LTE**, an acronym for **Long-Term Evolution**, commonly marketed as **4G LTE**, is a standard for wireless communication of high-speed data for mobile phones and data terminals
- The LTE specification provides downlink peak rates of 300 Mbit/s, uplink peak rates of 75 Mbit/s and QoS provisions permitting a transfer latency of less than 5 ms in the radio access network

LTE(Long Term Evaluation)

- LTE has the ability to manage fast-moving mobiles and supports multi-cast and broadcast streams. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz
- supports both frequency division duplexing (FDD) and time-division duplexing (TDD).
- The IP-based network architecture, called the Evolved Packet Core (EPC) and designed to replace the GPRS Core Network,
- supports seamless handovers for both voice and data
- The simpler architecture results in lower operating costs

LTE-TDD and LTE-FDD

- LTE has been defined to accommodate both paired spectrum for Frequency Division Duplex, FDD and unpaired spectrum for Time Division Duplex, TDD operation.
- There are a number of the advantages and disadvantages of TDD and FDD that are of particular interest to mobile or cellular telecommunications operators. These are naturally reflected into LTE.

LTE-TDD and LTE-FDD

Parameter	LTE-TDD	LTE-FDD

LAN Standards

LAN Standards

- Ethernet
- Wireless LAN
- WiMax
- Zigbee
- Bluetooth
- Infrastructure Based
- Infrastructure less
- Wireless topology

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LAN Standards

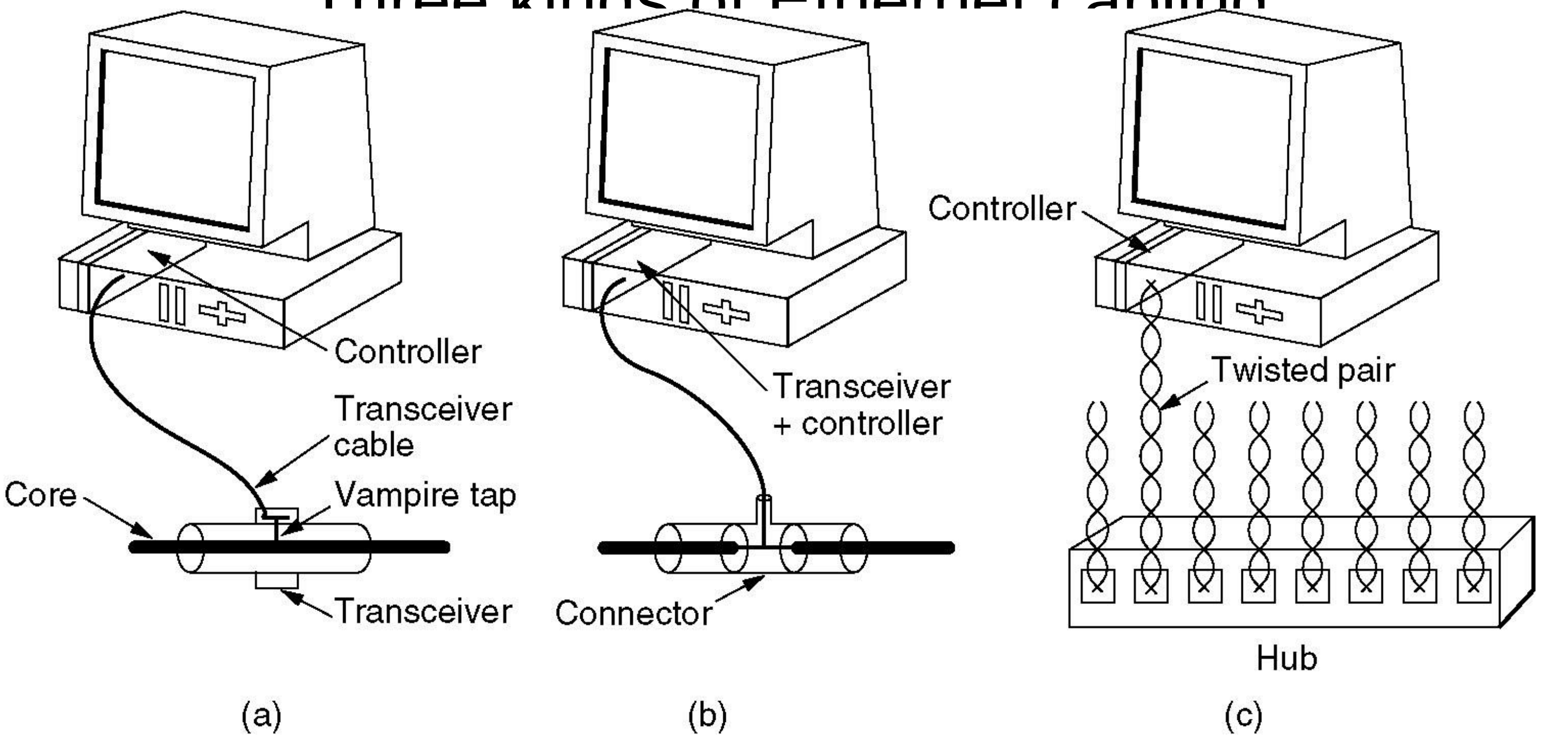
IEEE 802 standards	Used For
IEEE 802.1	High Level Interface(MAC Bridges)
IEEE 802.2	Logical Link Control(LLC)
IEEE 802.3	CSMA/CD(Ethernet)
IEEE 802.4	Token Bus
IEEE 802.5	Token Ring
IEEE 802.6	Metropolitan Area Network(MAN)
IEEE 802.7	Broadband LAN
IEEE 802.8	Fiber Optic LAN
IEEE 802.11	Wireless LAN
IEEE 802.15	Bluetooth
IEEE 802.16	Broadband Wireless (WIMAX)

Ethernet Specifications (Cabling)

Medium Option	Transmission Media	Signaling Technique	Data Rate(Mbps)	Maximum Segment Length
10BASE 5	Coaxial Cable(Thick)	Baseband	10	500
10BASE2	Coaxial Cable(Thin)	Baseband	10	185
10BASET	Unshielded Twisted Pair	Baseband	10	250
10BASEF	Fiber Optics	Baseband	10	2000

Ethernet Cabling (2)

Three kinds of Ethernet cabling.



ZIGBEE PROTOCOL

- The IEEE 802.15.4 covers the physical layer and the MAC layer of low-rate WPAN.

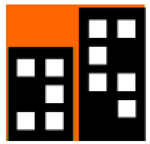
- The ZigBee is “an emerging standard that is based on the IEEE 802.15.4 and adds network construction (star networks, peer-to-peer/mesh networks, and cluster-tree networks), application services, and more”.

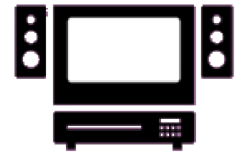
ZIGBEE features

- Standards based
- Low cost
- Can be used globally
- Reliable and self healing
- Supports large number of nodes
- Easy to deploy
- Very long battery life
- Secure

ZIGBEE APPLICATIONS

security
HVAC
AMR
lighting control
access control



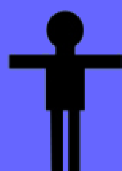


TV
VCR
DVD/CD
remote

ZigBee

Wireless Control that Simply Works

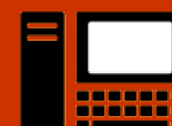
patient monitoring
fitness monitoring



PERSONAL HEALTH CARE

TELECOM SERVICES

m-commerce
info services
object interaction
(Internet of Things)

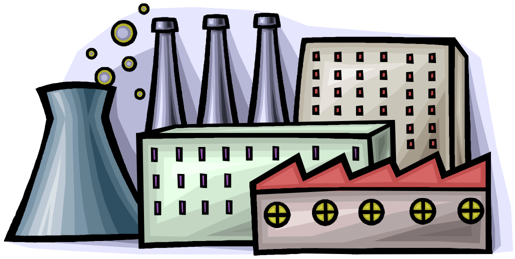


PC & PERIPHERALS

security
HVAC
lighting control
access control
irrigation

asset mgt
process control
environmental
energy mgt

ZigBee- SOME APPLICATION PROFILES



- Home Automation [HA]
  - Defines set of devices used in home automation
    - Light switches
    - Thermostats
    - Window shade
    - Heating unit

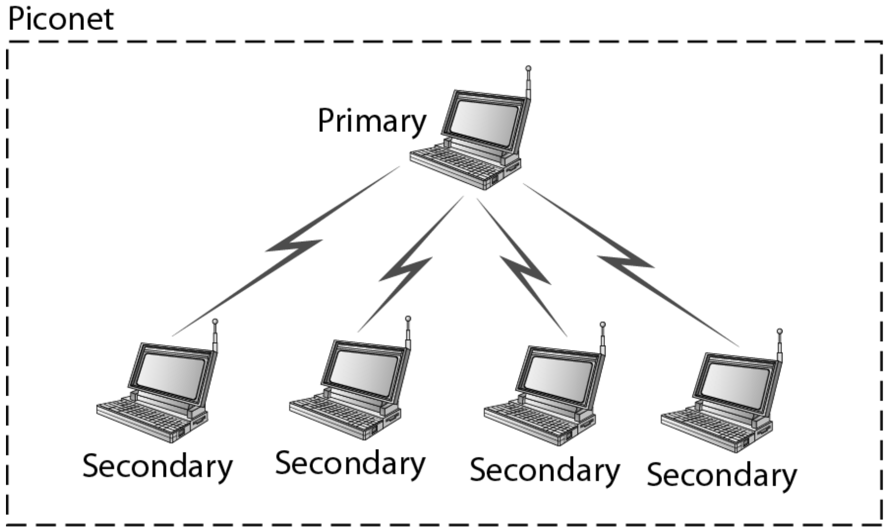
- **Industrial Plant Monitoring**
  - **Consists of device definitions for sensors used in industrial control**
    - **Temperature**
    - **Pressure sensors**
    - **Infrared**
    - **etc.**

Zigbee Application In-Home Patient Monitoring

- Patients receive better care at reduced cost with more freedom and comfort
  - Patients can remain in their own home
    - Monitors vital statistics and sends via internet
    - Doctors can adjust medication levels
  - Allows monitoring of elderly family member
    - Sense movement or usage patterns in a home
    - Turns lights on when they get out of bed
    - Notify via mobile phone when anomalies occur
    - Wireless panic buttons for falls or other problems
  - Can also be used in hospital care
    - Patients are allowed greater movement
    - Reduced staff to patient ratio

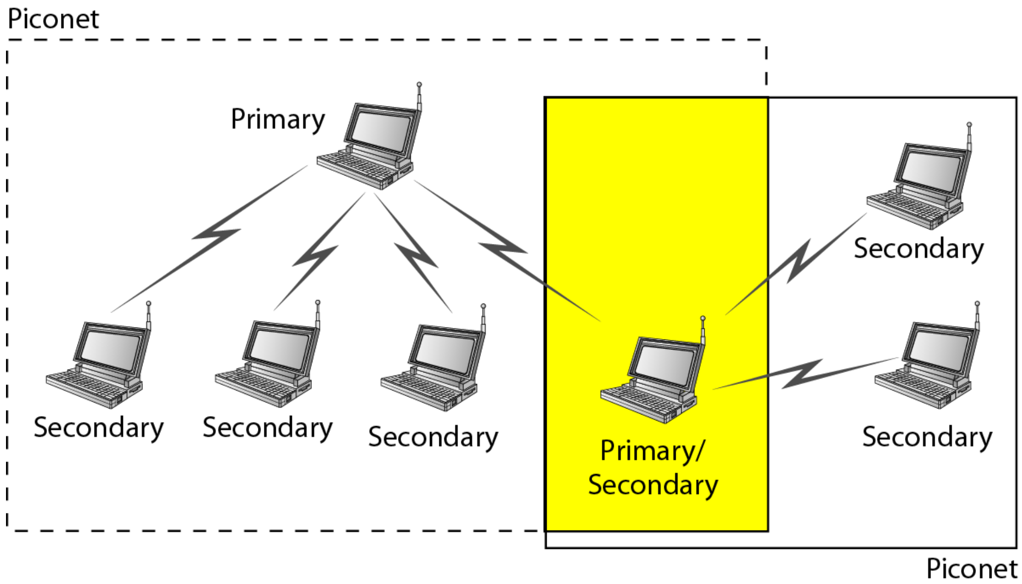
Bluetooth: *Piconet*

- Bluetooth is a wireless LAN technology designed to connect devices of different functions such as telephones, notebooks, computers, cameras, printers, coffee makers, and so on. A Bluetooth LAN is an ad hoc network, which means that the network is formed spontaneously
- Bluetooth network is called piconet, or a small net



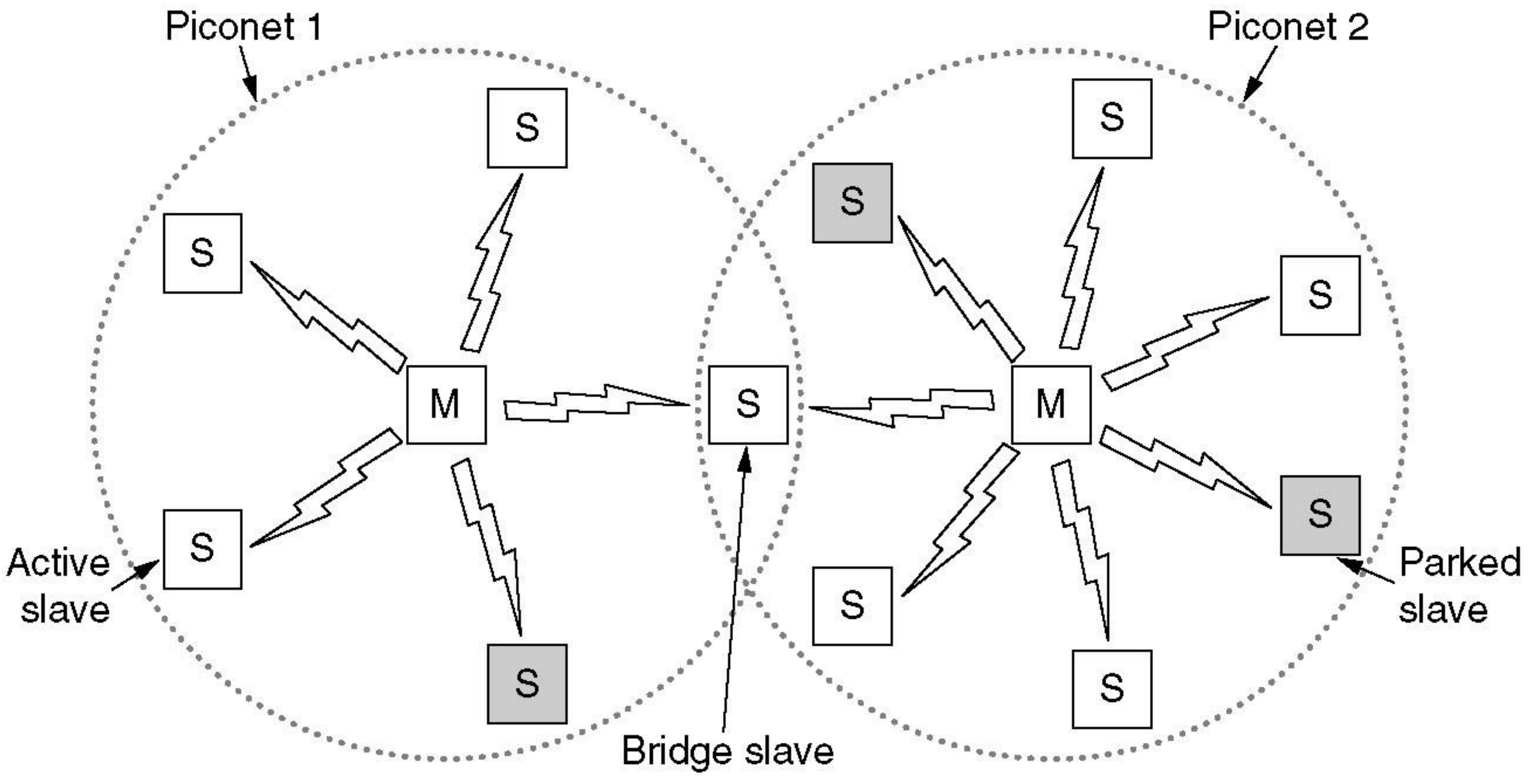
Bluetooth: *Scatternet*

- Piconet can be combined to form what is called a scatternet.



- Bluetooth device has a built-in short range radio transmitter with 2.4 GHz bandwidth. A possibility of interference with IEEE 802.11b

Bluetooth Architecture

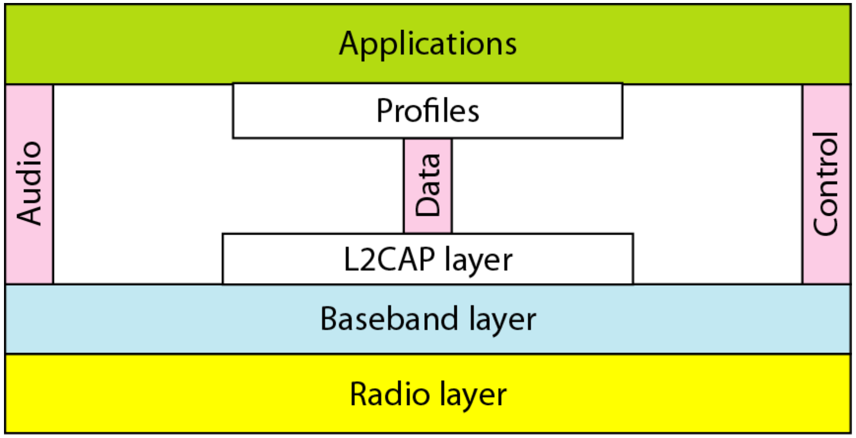


Bluetooth Applications

Name	Description
Generic access	Procedures for link management
Service discovery	Protocol for discovering offered services
Serial port	Replacement for a serial port cable
Generic object exchange	Defines client-server relationship for object movement
LAN access	Protocol between a mobile computer and a fixed LAN
Dial-up networking	Allows a notebook computer to call via a mobile phone
Fax	Allows a mobile fax machine to talk to a mobile phone
Cordless telephony	Connects a handset and its local base station
Intercom	Digital walkie-talkie
Headset	Intended for hands-free voice communication
Object push	Provides a way to exchange simple objects
File transfer	Provides a more general file transfer facility
Synchronization	Permits a PDA to synchronize with another computer

Bluetooth Layers (Protocol Architecture)

- Radio layer
  - 2.4 GHz ISM band divided into 79 channels of 1 MHz each
  - FHSS: Bluetooth hops 1600 times per second, dwell time is 625 μsec (= 1/1600 sec)
  - Modulation: GFSK (FSK with Gaussian bandwidth filtering)



Wireless Components

- Access Point

  -- Wireless transmitter/receiver that bridges between wireless nodes and a wired network

  --IEEE 802.11 + Wired Ethernet connection

- Wireless clients

  – Any computer with a wireless network adapter card that transmits and receives RF signals

  – Laptop, PDA, surveillance equipment, VoIP phone

Two Basic Wireless Modes

- 1. Ad Hoc (IBSS)
- 2. Infrastructure (BSS)

Mode 1: Ad hoc (Peer-to-peer)

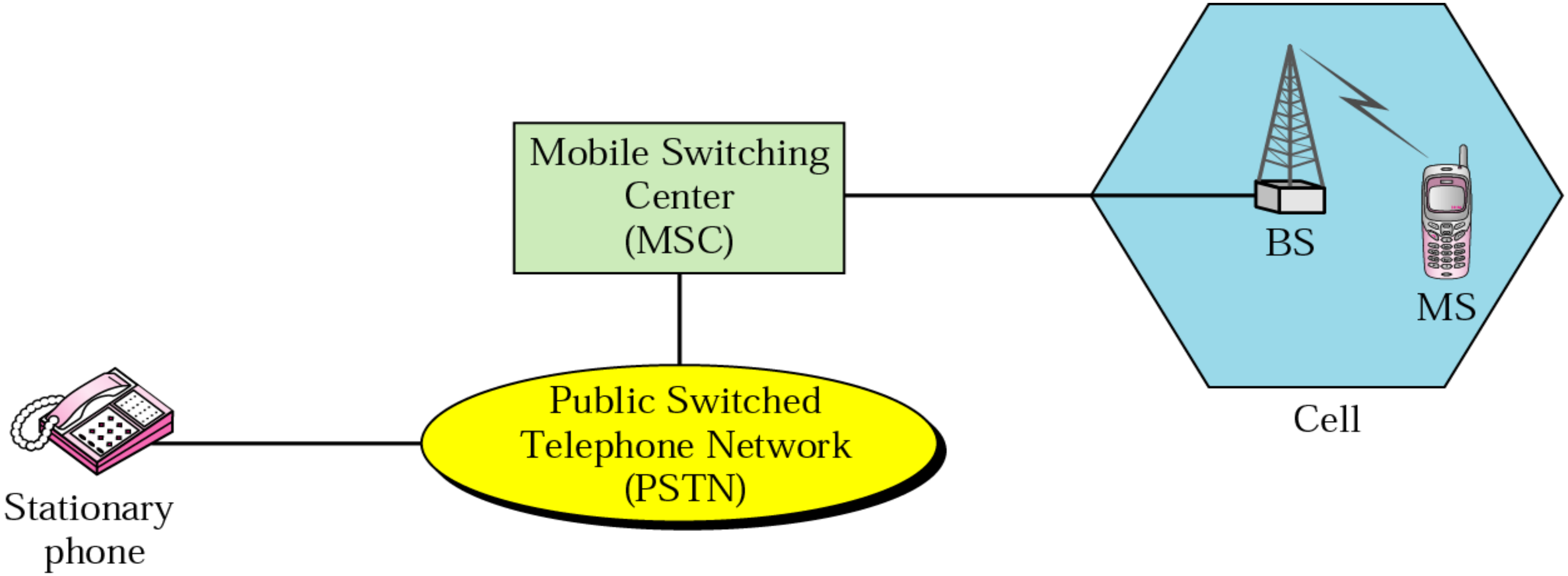
- Independent Basic Service Set (IBSS)
- No need of central access point
- All nodes need to use the same SSID and channel
- Not scalable

Mode 2: Infrastructure

- Extended Service Set (ESS)
- Central access point is needed
- “Connects“ a WLAN to an Ethernet network
- Clients and AP's must use the same SSID
- Channel is set in AP and discovered by clients
- Scalable

Infrastructure based Cellular and Satellite N/W

Cellular system



System Components of Cellular system

- Mobile Stations
  - Transceiver
  - Antenna
  - Control circuitry
  - Moves at pedestrian or vehicle speeds
- Base Transceiver Station (BTS)
  - Several transmitters and receivers
  - Tower that supports several transmitting and receiving antennas
- Base Station (BS)
  - Control one or more BTS
  - Bridge between all mobile users of the BTSs and a Mobile switching center
- Mobile Switching Center(MSC)
  - Connects MSs to the PSTN (public-switched telephone network)
  - Coordinates activities of all BSCs
  - Controls all billing and system maintenance functions
  - Several MSCs in large cities

Cellular system Concept

- Idea: replace high power transmitter with several lower power transmitters to create small “cells”
- Multiple cells cover a geographic area
- Each cell assigned a set of frequencies
- Neighboring cells assigned different group of frequencies to reduce adjacent-cell interference

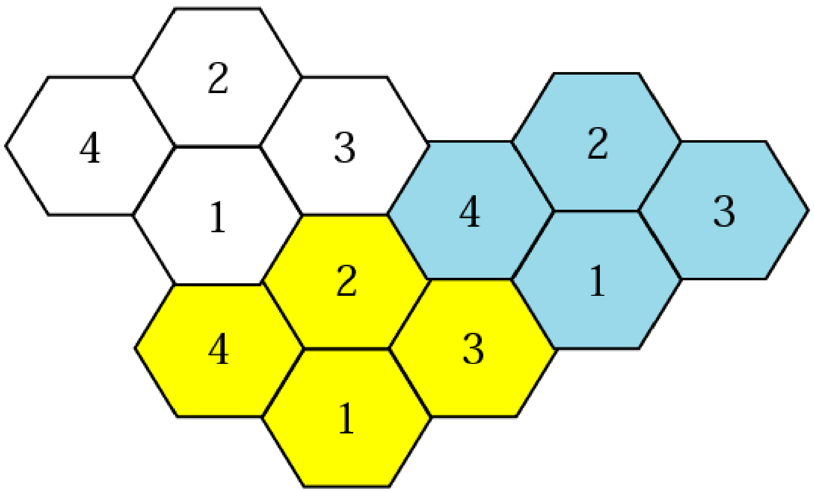
Cellular system Concept…

- Enables spatial frequency reuse
- Increase capacity by increasing number of transmitters and decreasing transmit power
- Enables fixed bandwidth to serve arbitrarily large number of subscribers
- Users within a cell communicate with the cell BS
- As users move between cells, calls go through "hand-off" when switching to new cell BS

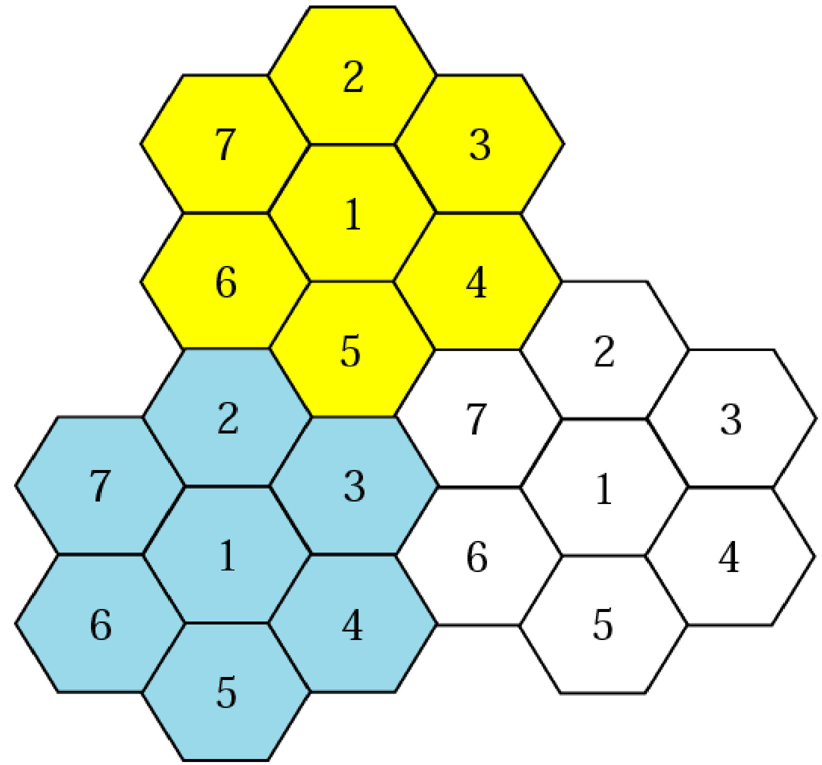
Cellular telephony :Frequency Reuse

- Design cells to be non-overlapping and cover entire region
- Cells depicted as hexagons
  - Conceptual design allowing easy analysis of system
  - Close to circular shape achieved by omnidirectional antennas
- "Cells that use same frequencies must be separated by distances large enough to keep interference levels low
- Frequencies assigned to different cells using frequency reuse plan
- Adjacent cells assigned different frequencies to avoid interference or crosstalk

Frequency reuse patterns



a. Reuse factor of 4



b. Reuse factor of 7

Satellite Networks

Orbits

Three Categories of Satellites

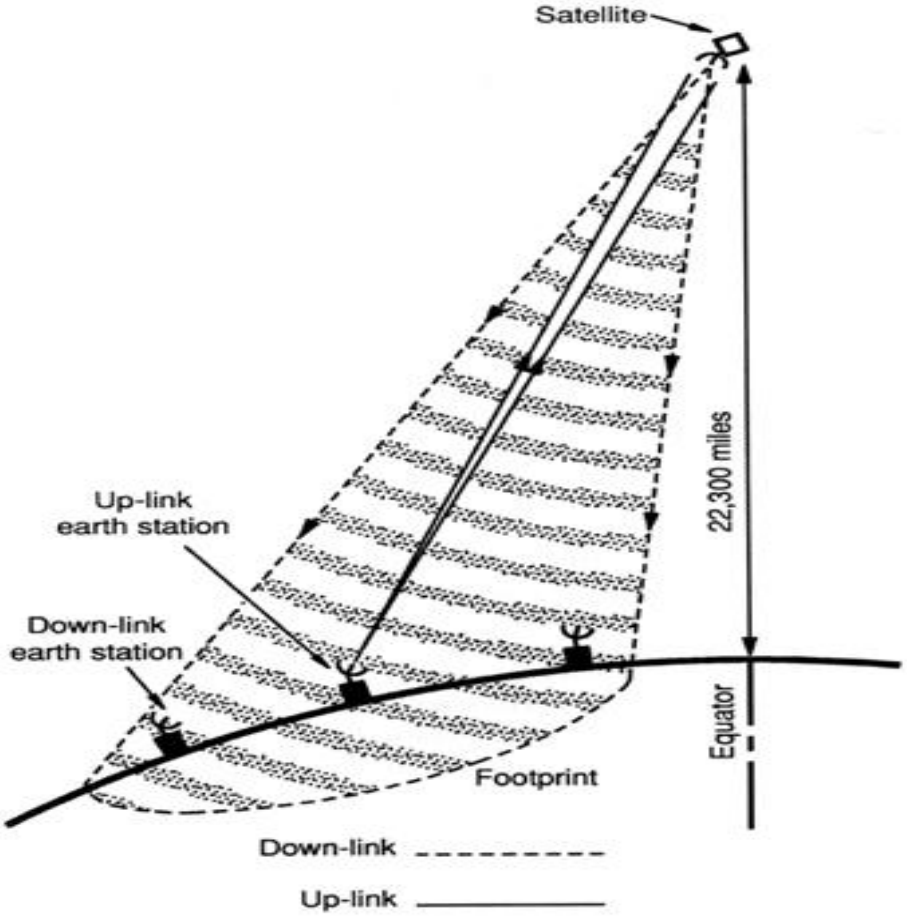
GEO Satellites

MEO Satellites

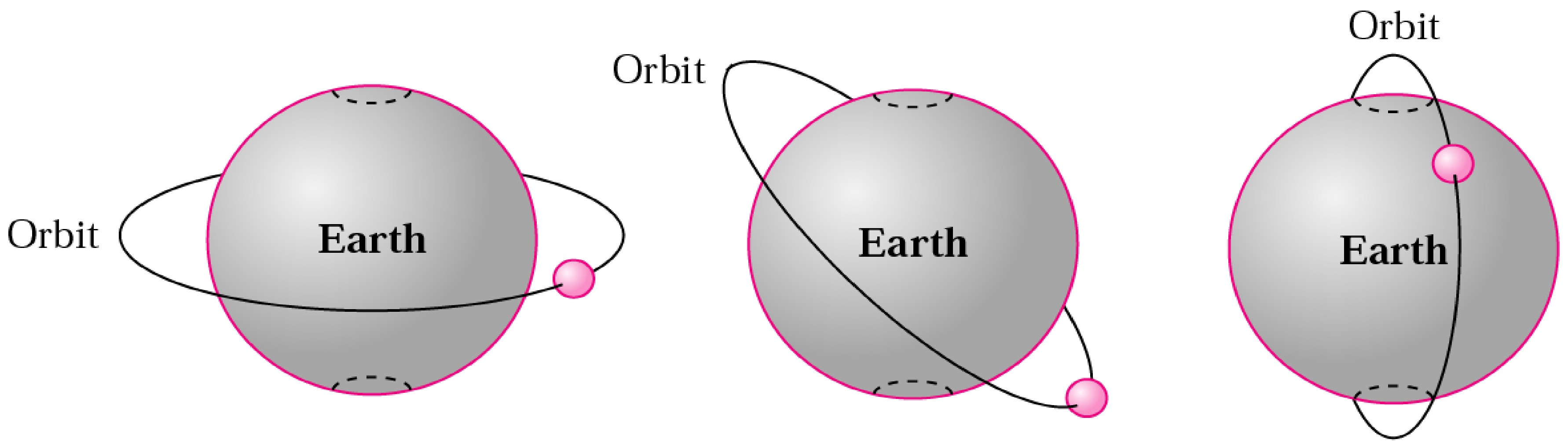
LEO Satellites

How Satellites Work

1. A Earth Station sends message in GHz range. (Uplink)
2. Satellite Receive and retransmit signals back. (Downlink)
3. Other Earth Stations receive message in useful strength area. (Footprint)

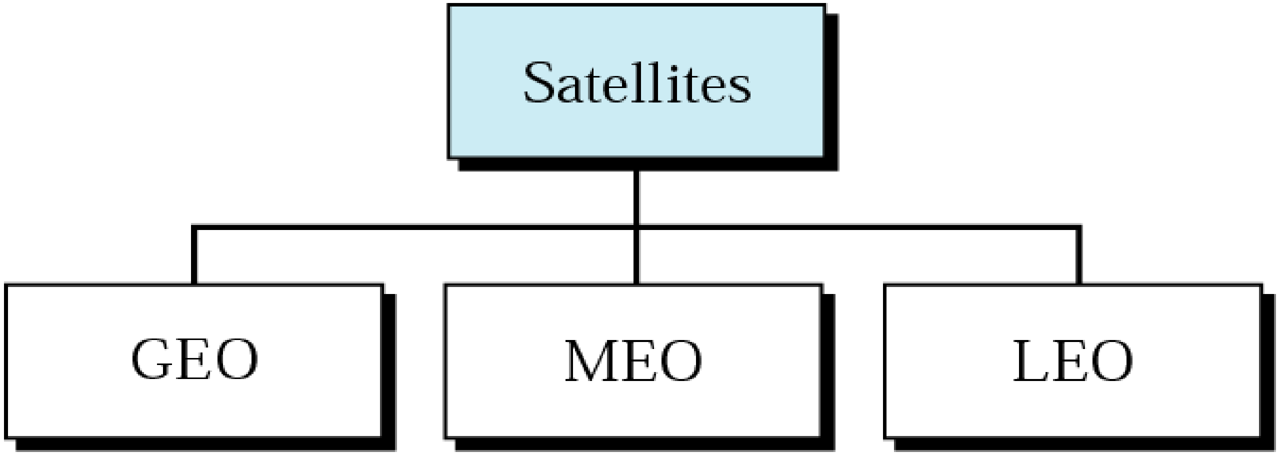


Satellite orbits

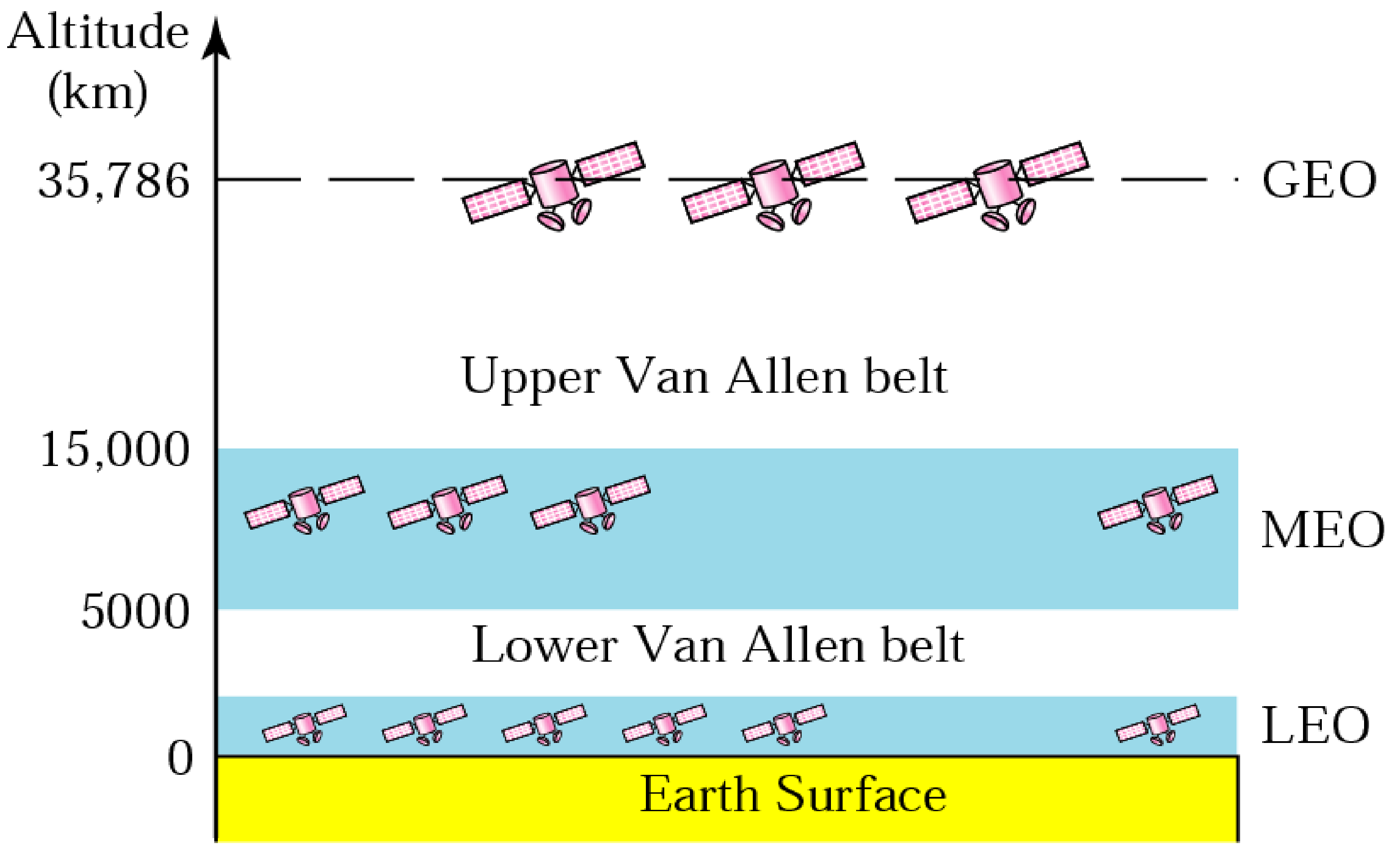


a. Equatorial-orbit satellite b. Inclined-orbit satellite c. Polar-orbit satellite

Satellite categories

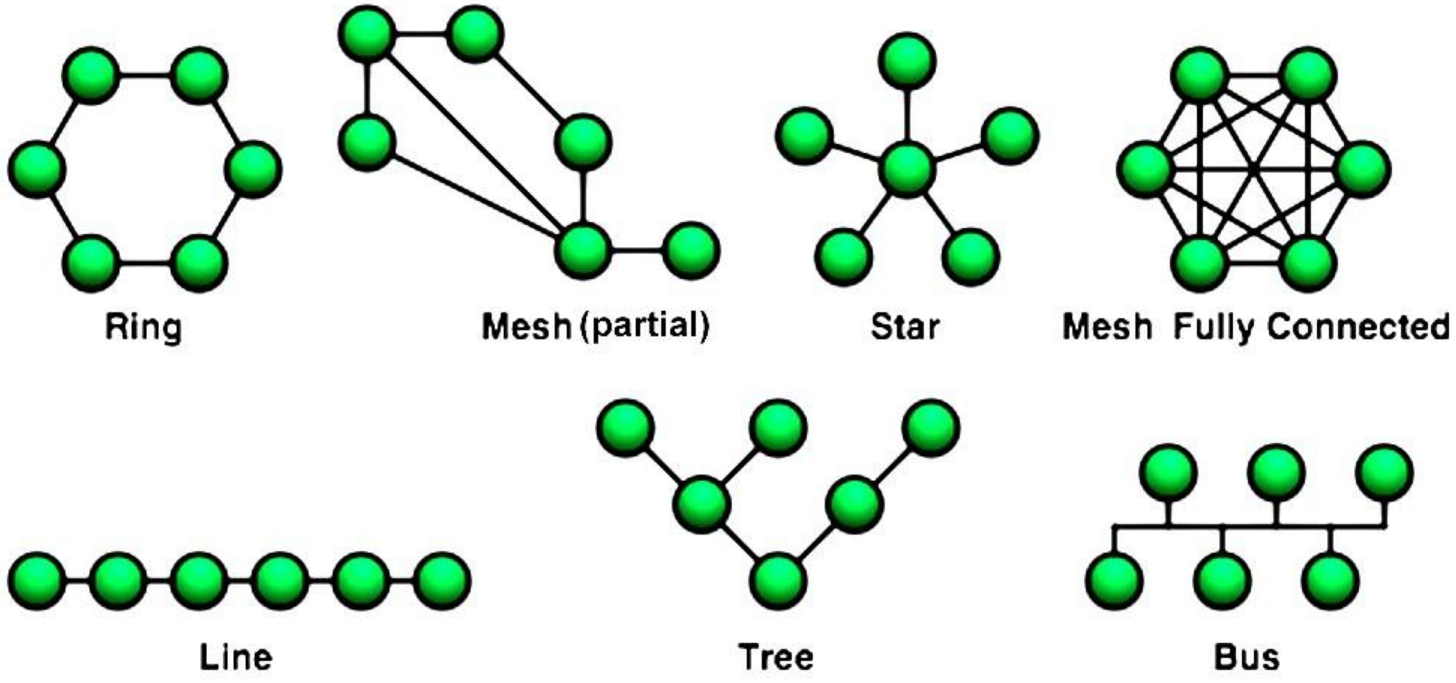


Satellite orbit altitudes



Wireless Topology

Basic Network Topologies



Topologies Relevant for Wireless Networking

- Star Yes, standard wireless topology
- Tree Yes (a combination of star and line)
- Mesh Yes, mainly partial mesh
- Ring Possible, but rarely found
- Bus Not applicable. Why?

Two Basic Wireless Modes

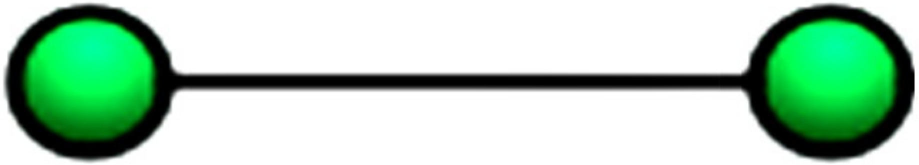
- 1.Ad Hoc (IBSS)
- 2.Infrastructure (BSS)

Ad hoc case 1: Point-to-point

- Connecting two wireless clients directly

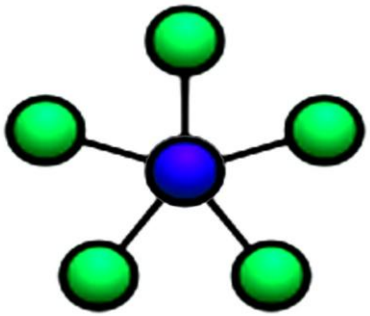
    Building to building (when one has Internet connection and the other one does not)

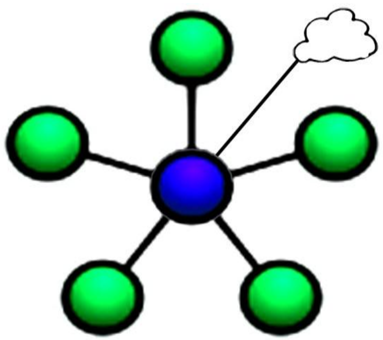
    Inside an office



Infrastructure Case 1: Star

- Hotspots, Telecenters, Offices and WISP's
  - Point to Multi-point
  - The most common infrastructure in wireless networking



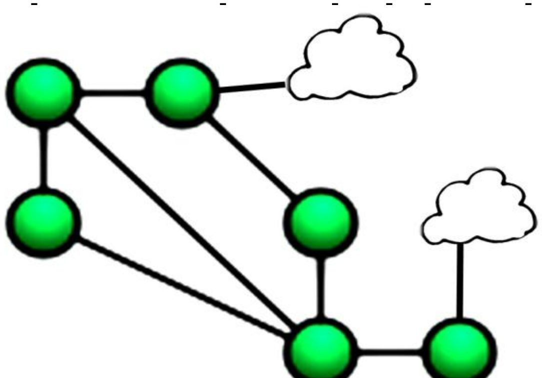


Infrastructure Case 2: Point to Point

- Standard element of wireless infrastructure
  - A PtP link may be part of
    - – a star, a tree, a two point line or other topology

Infrastructure Case 4: Mesh

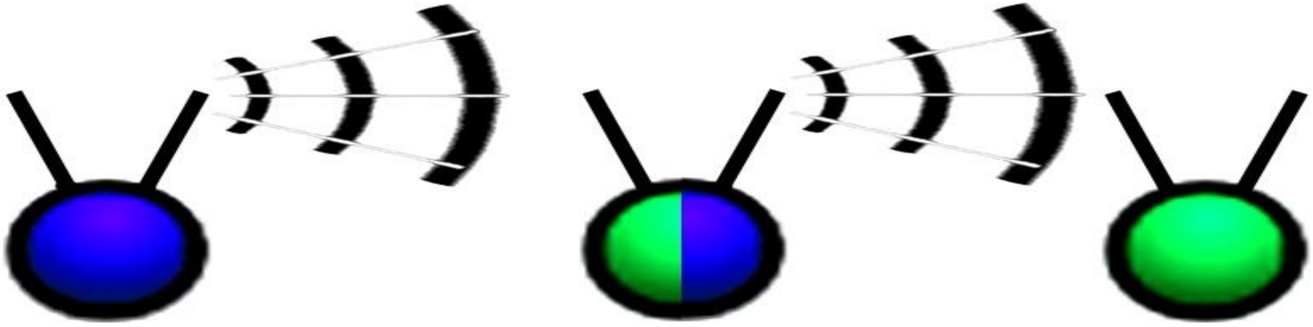
- Mesh topologies are an interesting option mainly in
  – dynamic environments (urban areas)
  – where central infrastructure is hard to implement
  – when redundancy is desired
    - Typical cases are: municipal networks, campus netw[illegible]ood communities



Infrastructure Case 3: Repeating

The repeating unit consist of

- One or two physical devices
- Two radios or one radio and “isolated antennas”
- Can be seen as a “receiving client and a re-transmitting access point”



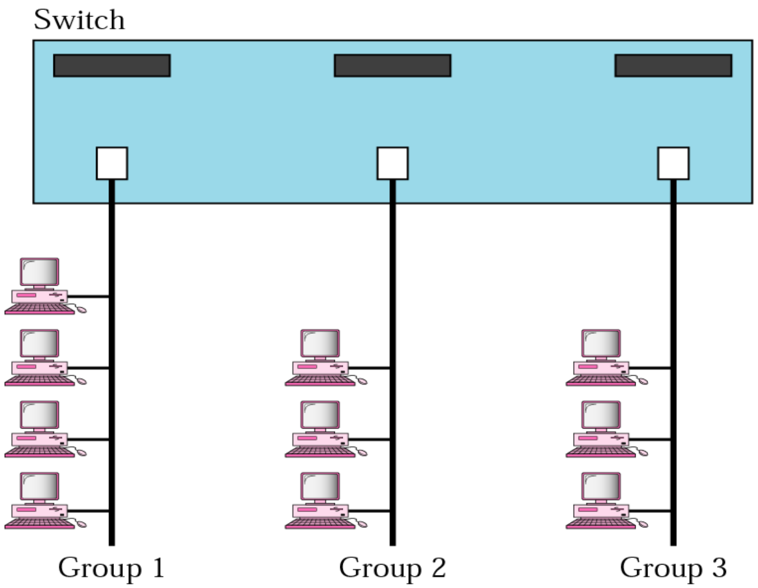
Virtual LAN (VLAN)

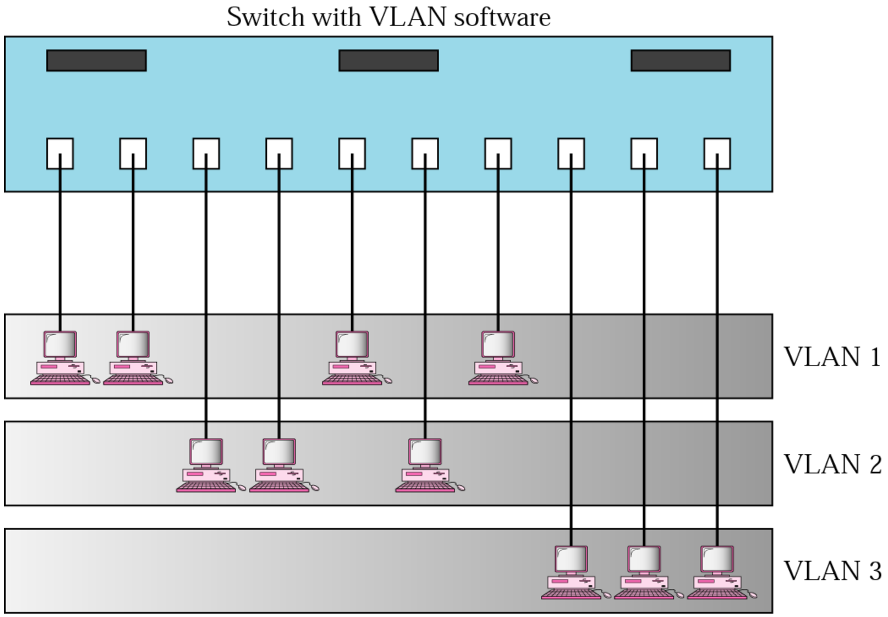
Virtual LAN (VLAN)-Introduction

- VLAN stands for Virtual Local Area Network.
  - viewed as a group of devices on different physical LAN
    - can communicate with each other as if they were all on the same physical LAN
  - Configured through software rather than hardware
    - extremely flexible.

Virtual LANs

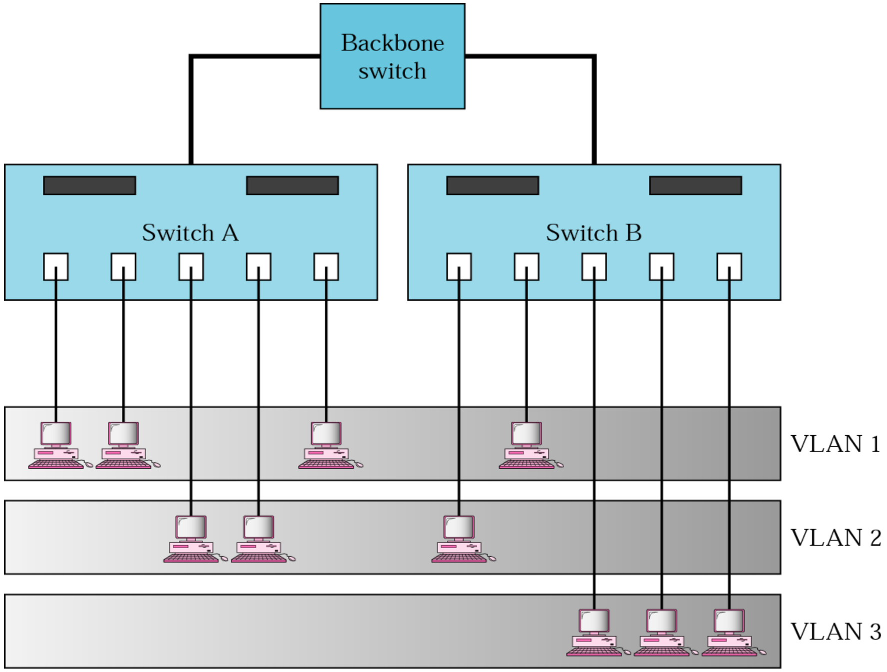
- LAN configured by *software*, not by physical wiring
- VLANs create broadcast domains





Virtual LAN (VLAN) - Example

- Membership is characterized by port numbers, MAC addresses, IP addresses, multicast IP addresses or a combination of the above



Virtual LAN (VLAN)…Continue

Advantages

- Increased performance
- Improved manageability
- Physical independence
- Increased Security Option

Disadvantages

- Costly
  - Software based
    - Human labor to program
  - Depending on variety switches
- Management complexity