Computer Networks Basic Protocols

Assoc. Prof. Dr. Berk CANBERK

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Modulation, MAC Addresses, Wireless MAC

References:

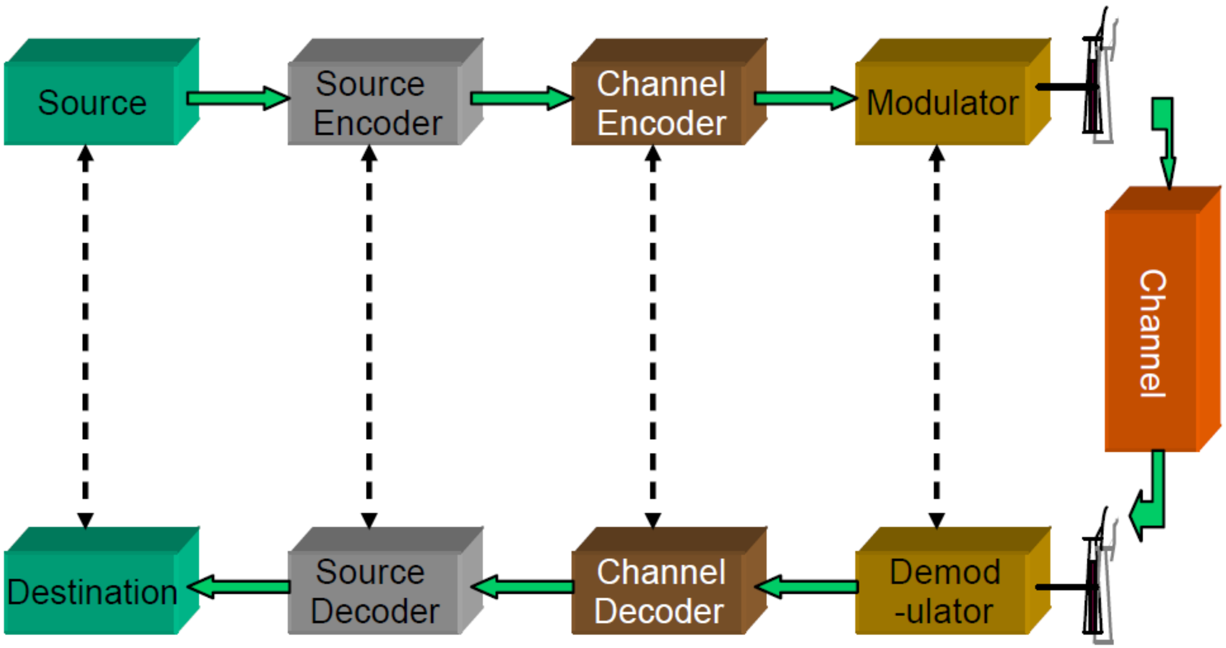
-*Data and Computer Communications*, William Stallings, Pearson-Prentice Hall, 9th Edition, 2010.

-*Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.

Shannon Model and Modulation

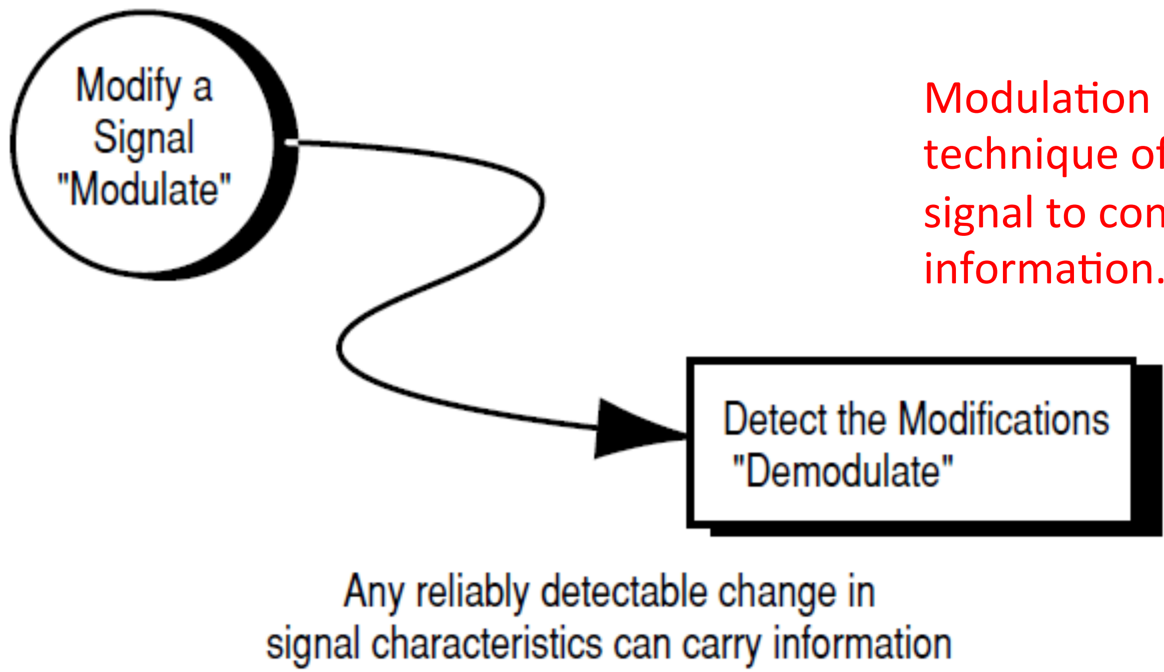
Digital data can be transmitted via an analog carrier signal by modulating one or more of the carrier's three characteristics:

- amplitude
- frequency
- phase



What is modulation ?

- Modulation = Adding information to a carrier signal
- The sine wave on which the characteristics of the information signal are modulated is called a carrier signal



Modulation is the general technique of shaping a signal to convey information.

Modulation

The carrier signal is usually just a simple, single-frequency sinusoid (varies in time like a sine wave).

The basic sine wave :$V(t) = Vo \sin (2 \pi f t + \phi)$

V(t) ->the voltage of the signal as a function of time.

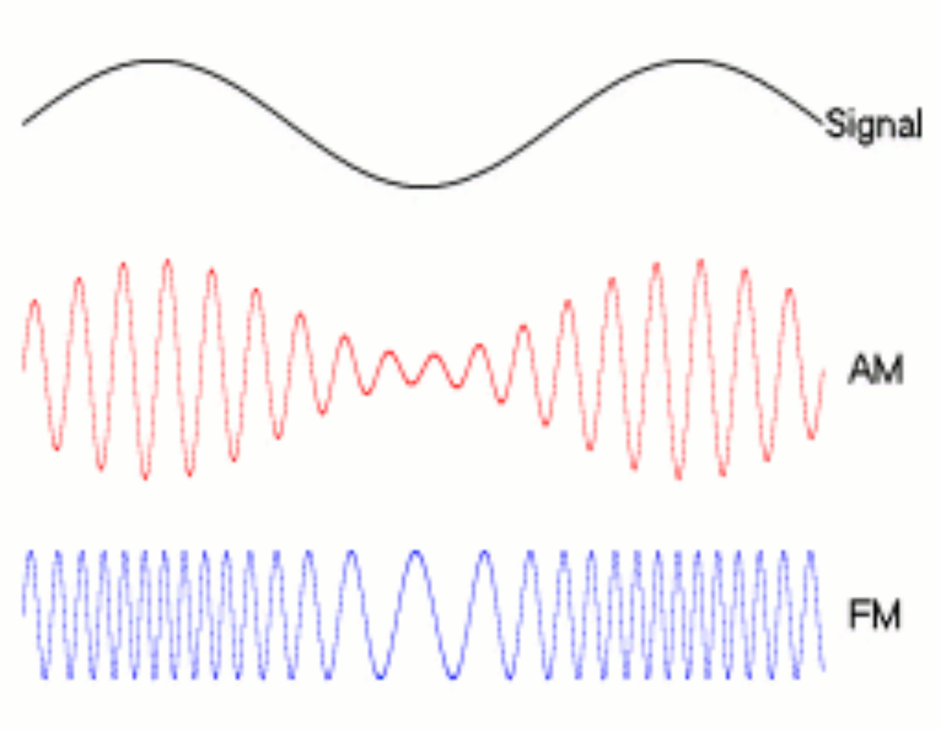
Vo-> the amplitude of the signal (represents the maximum value achieved each cycle)

f-> frequency of oscillation, the number of cycles per second

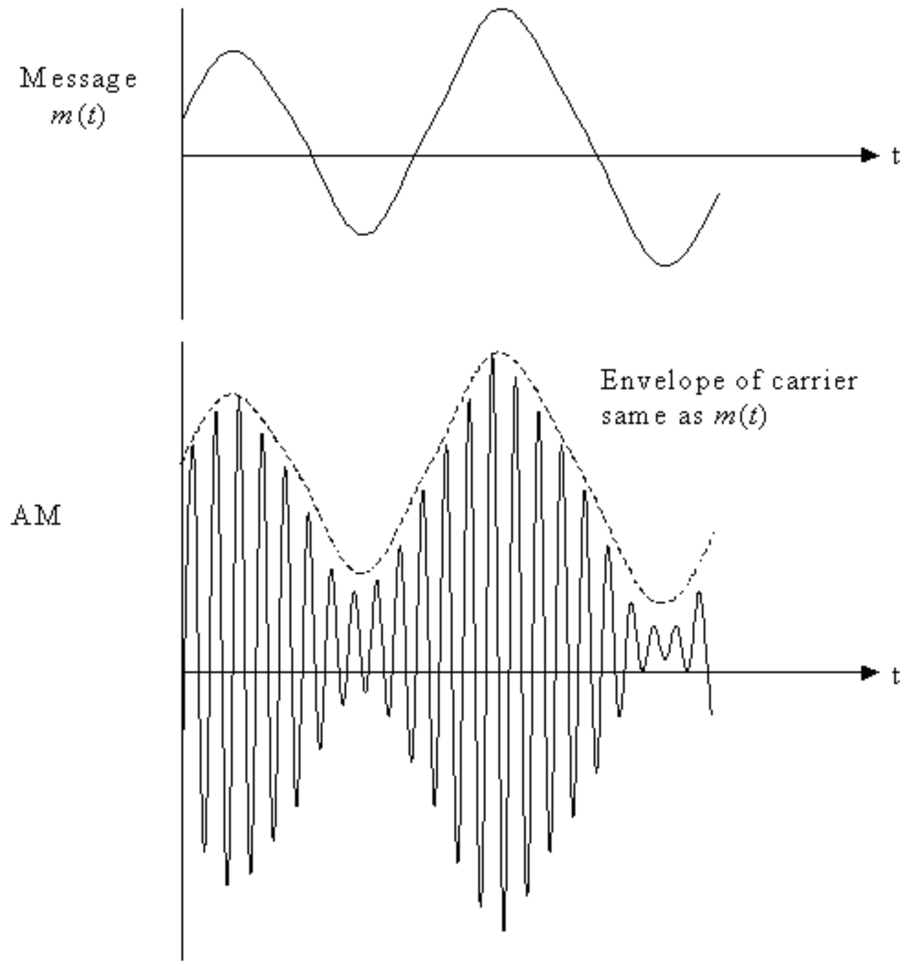
Φ −> phase of the signal, representing the starting point of the cycle.

To modulate the signal just means to systematically vary one of the three parameters of the signal: amplitude, frequency or phase.

Analog modulation



Modulation Types AM, FM, PAM



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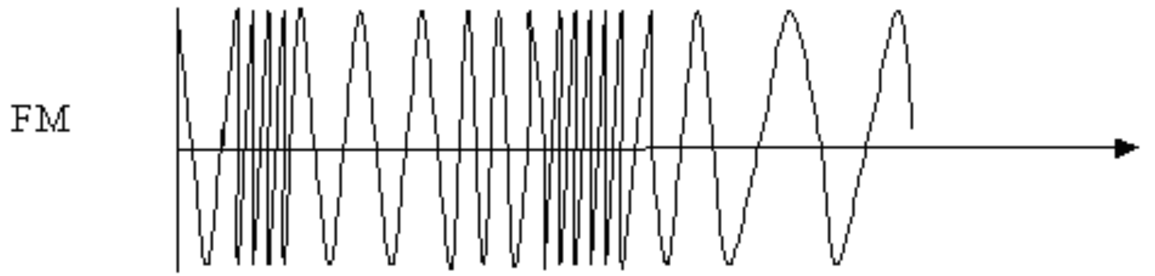
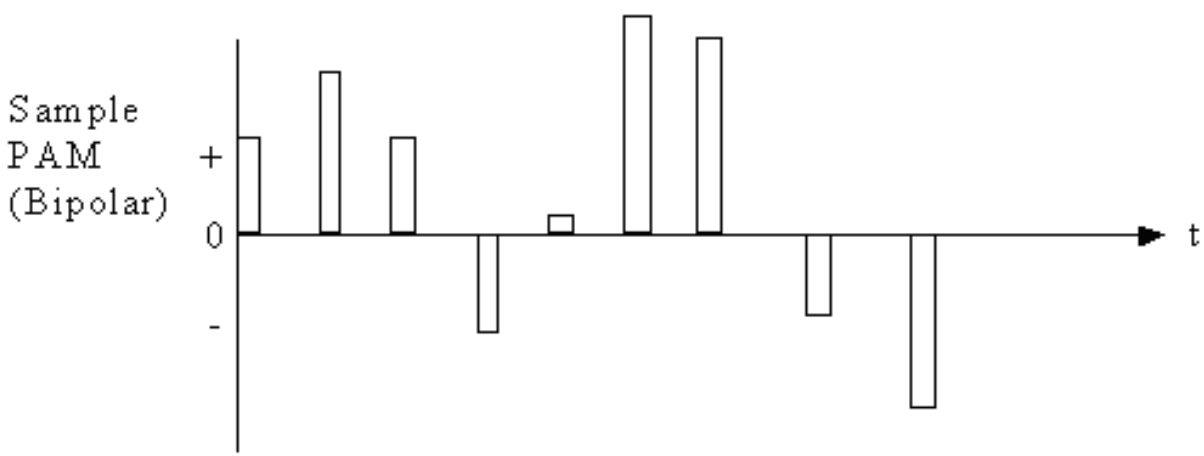
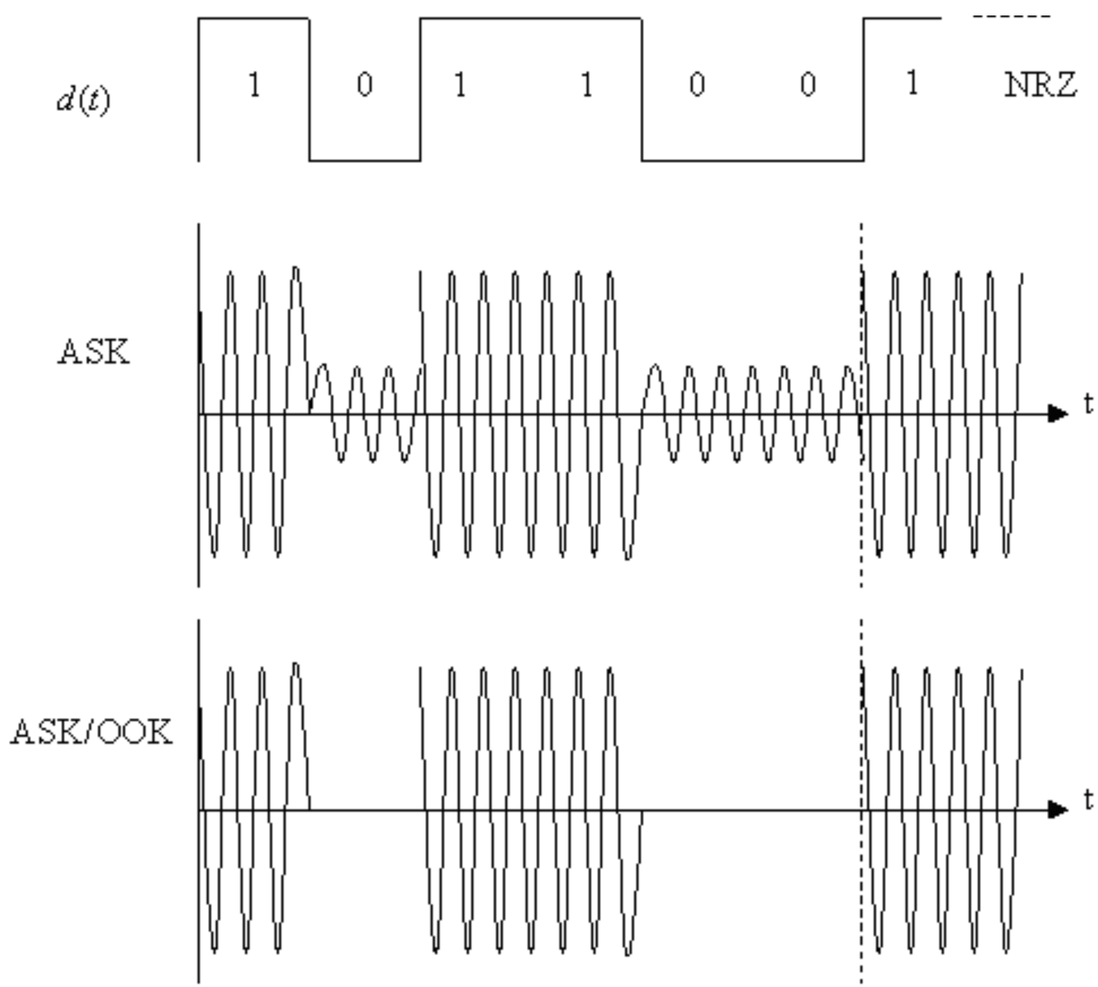


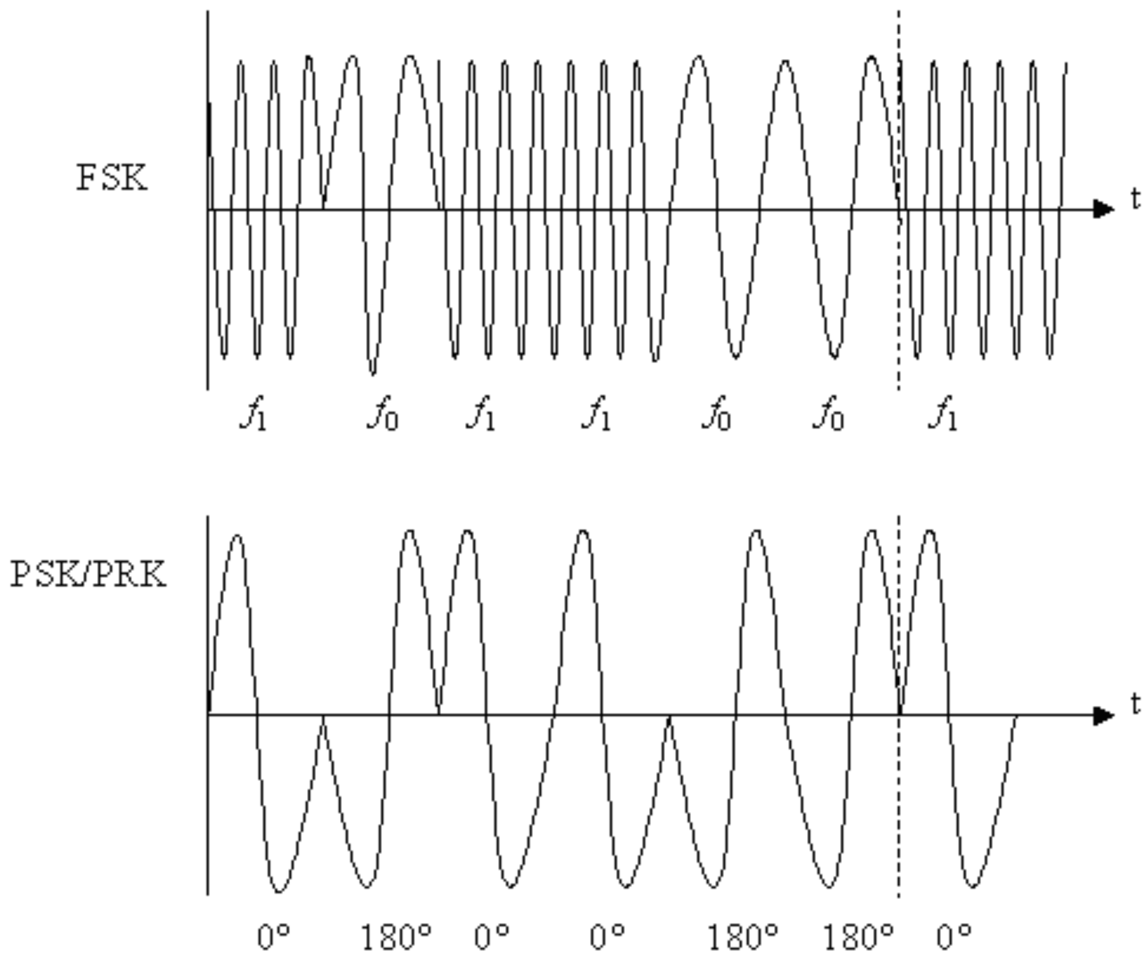


Pulse-Amplitude modulation

Modulation Types (Binary ASK, FSK, PSK)

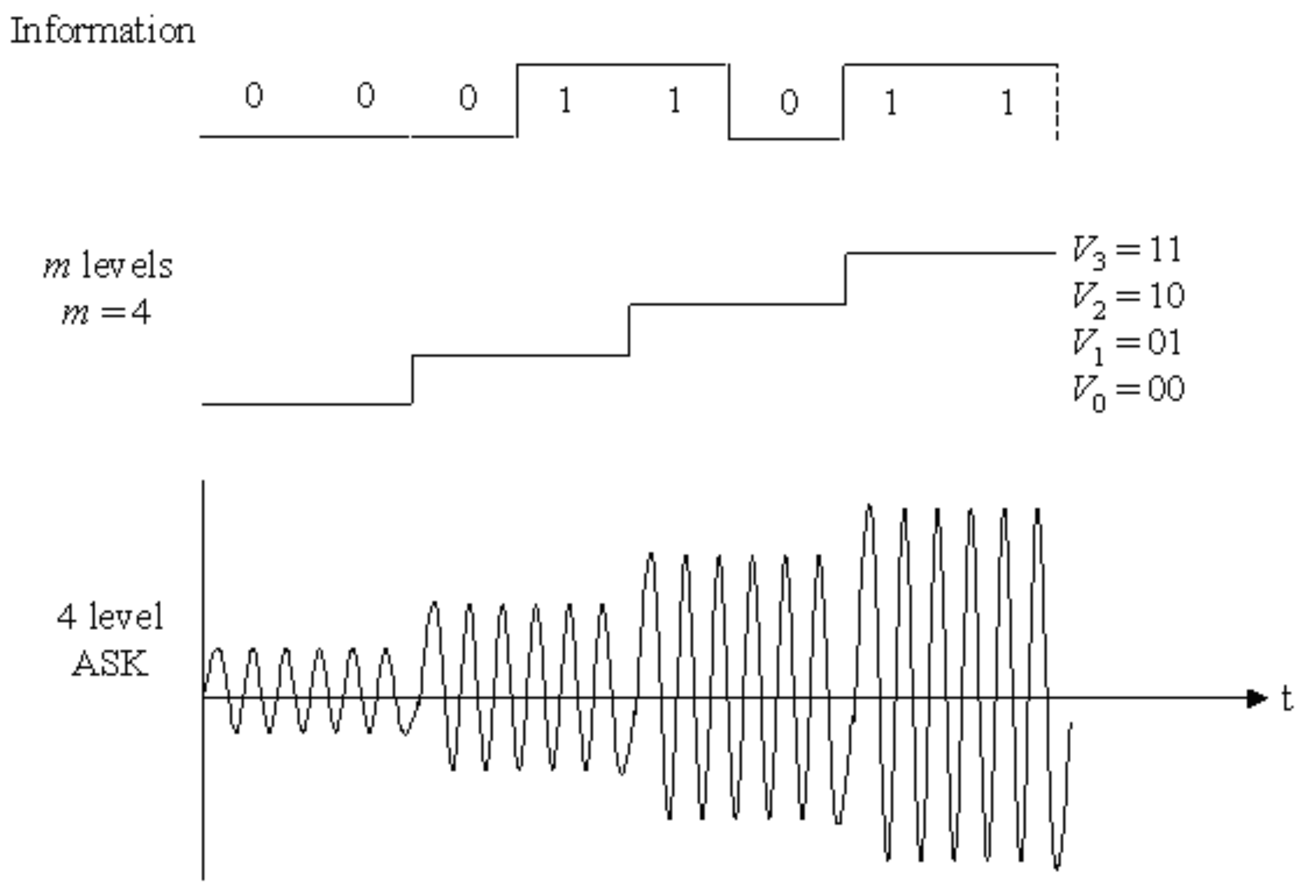


Modulation Types (Binary ASK, FSK, PSK) 2

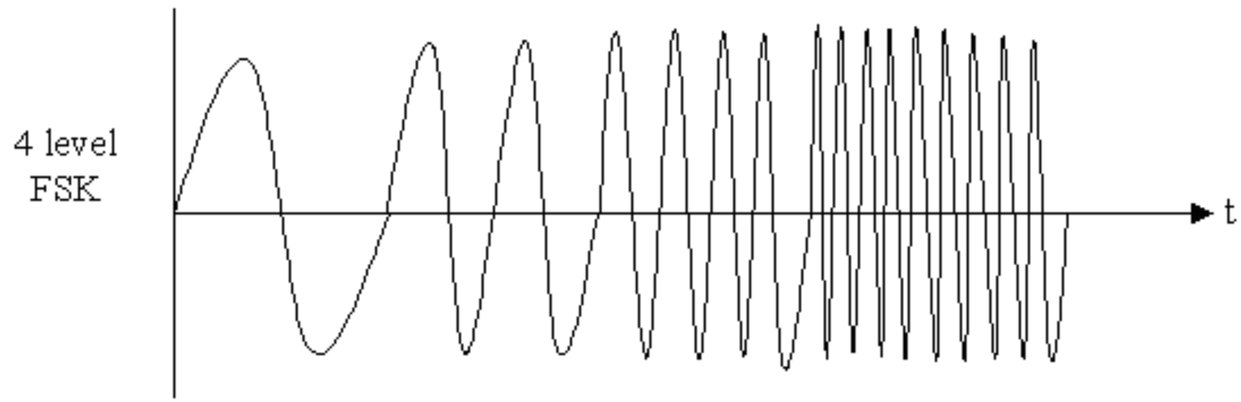


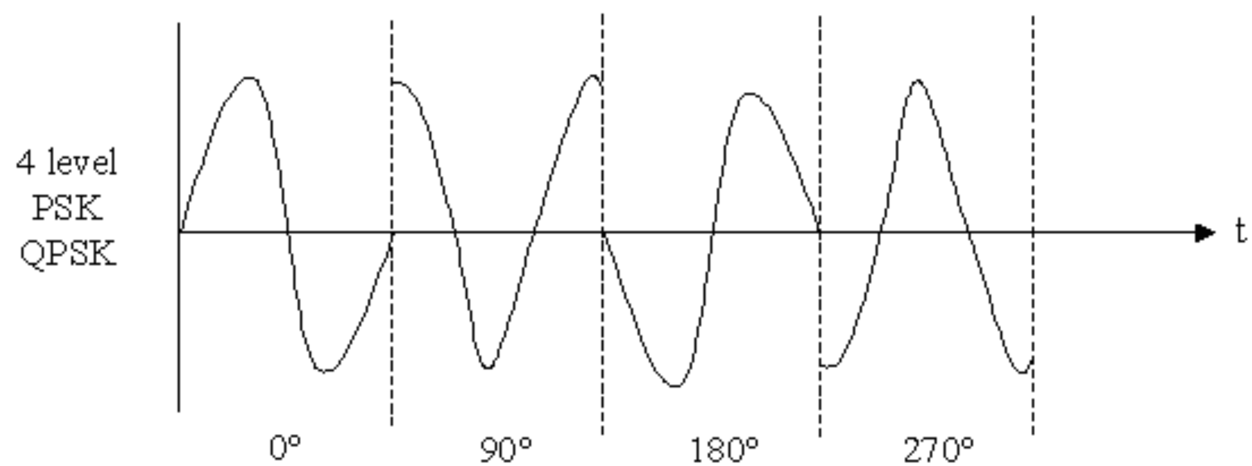
Phase Shift Keying (PSK)
Phase Reverse Keying (PRK)

Modulation Types – 4 Level ASK, FSK, PSK



Modulation Types – 4 Level ASK, FSK, PSK 2





Demodulation

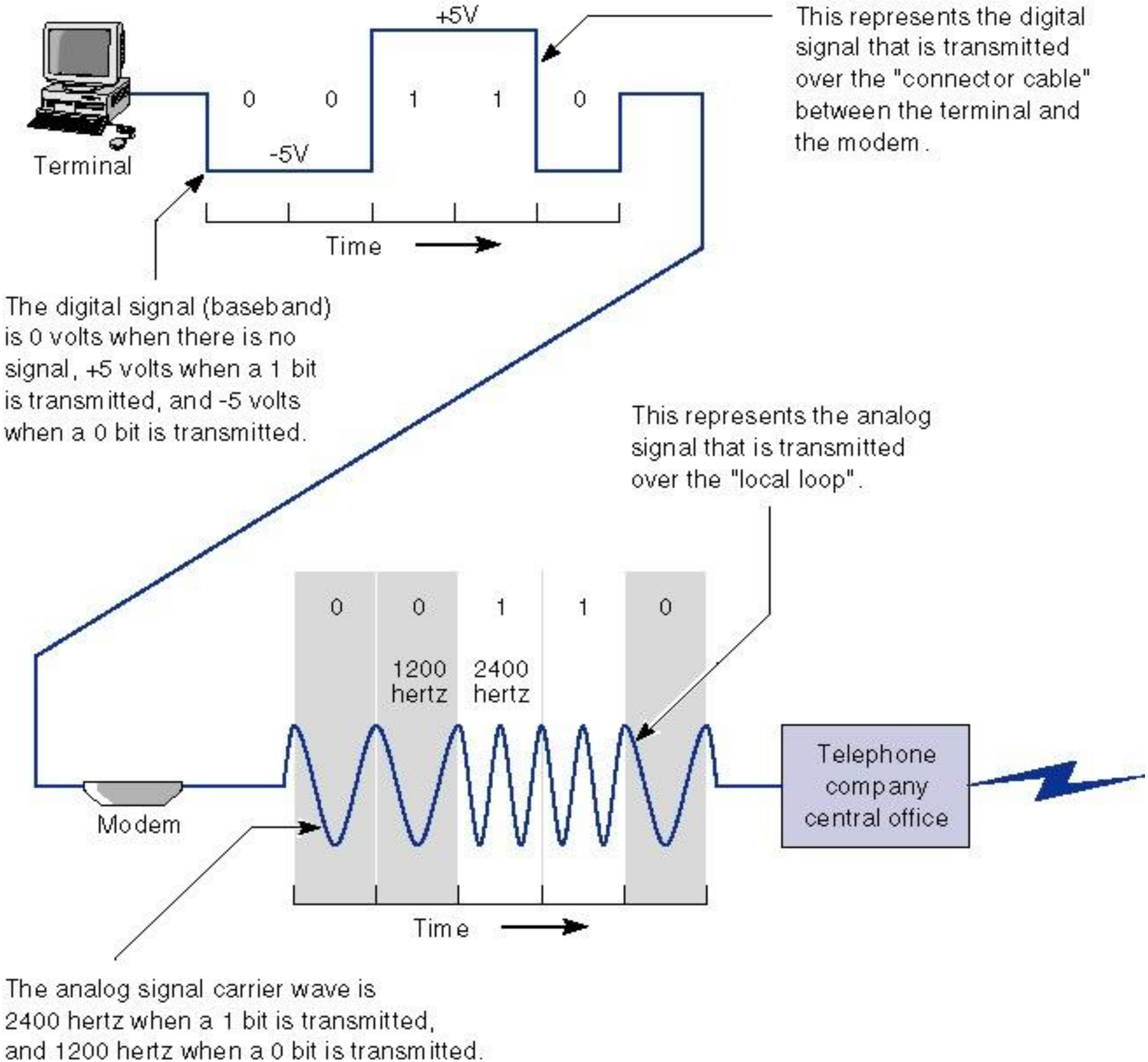
Demodulation is the process of extracting the digital information from the carrier.

ANALOG TRANSMISSION OF DIGITAL DATA

Analog Transmission occurs when the signal sent over the transmission media continuously varies from one state to another in a wave-like pattern.

e.g. telephone networks, originally built for human speech rather than data.

Advantage for long distance communications: much less attenuation for analog carrier than digital

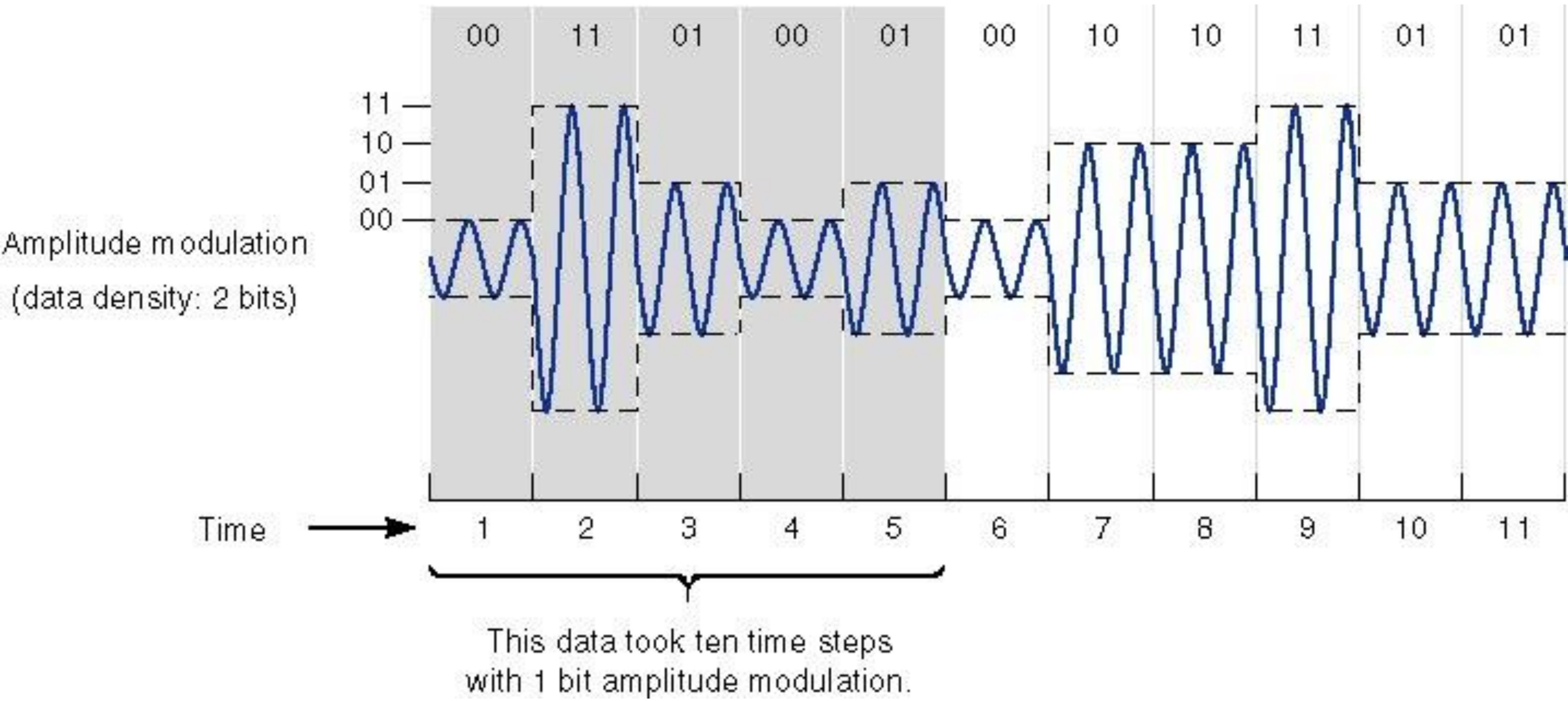

+5V
This represents the digital signal that is transmitted over the "connector cable" between the terminal and the modem .
0
0
1
1
0
-5V
Terminal
Time
The digital signal (baseband) is 0 volts when there is no signal, +5 volts when a 1 bit is transmitted, and -5 volts when a 0 bit is transmitted.
This represents the analog signal that is transmitted over the "local loop".
0
0
1
1
0
1200 hertz
2400 hertz
Telephone company central office
Modem
Time
The analog signal carrier wave is 2400 hertz when a 1 bit is transmitted, and 1200 hertz when a 0 bit is transmitted.

Sending Multiple Bits Simultaneously

Each of the three modulation techniques can be refined to send more than one bit at a time. It is possible to send two bits on one wave by defining four different amplitudes.

This technique could be further refined to send three bits at the same time by defining 8 different amplitude levels or four bits by defining 16, etc. The same approach can be used for frequency and phase modulation.

Sending Multiple Bits Simultaneously



MAC Address

The Media Access Control (MAC) address is just as important as the IP address. The MAC address is a unique value associated with the network adapter (NIC). MAC addresses are known as the hardware addresses or physical addresses. They uniquely identify the adapter on the LAN.

MAC Address

Format of the MAC address:

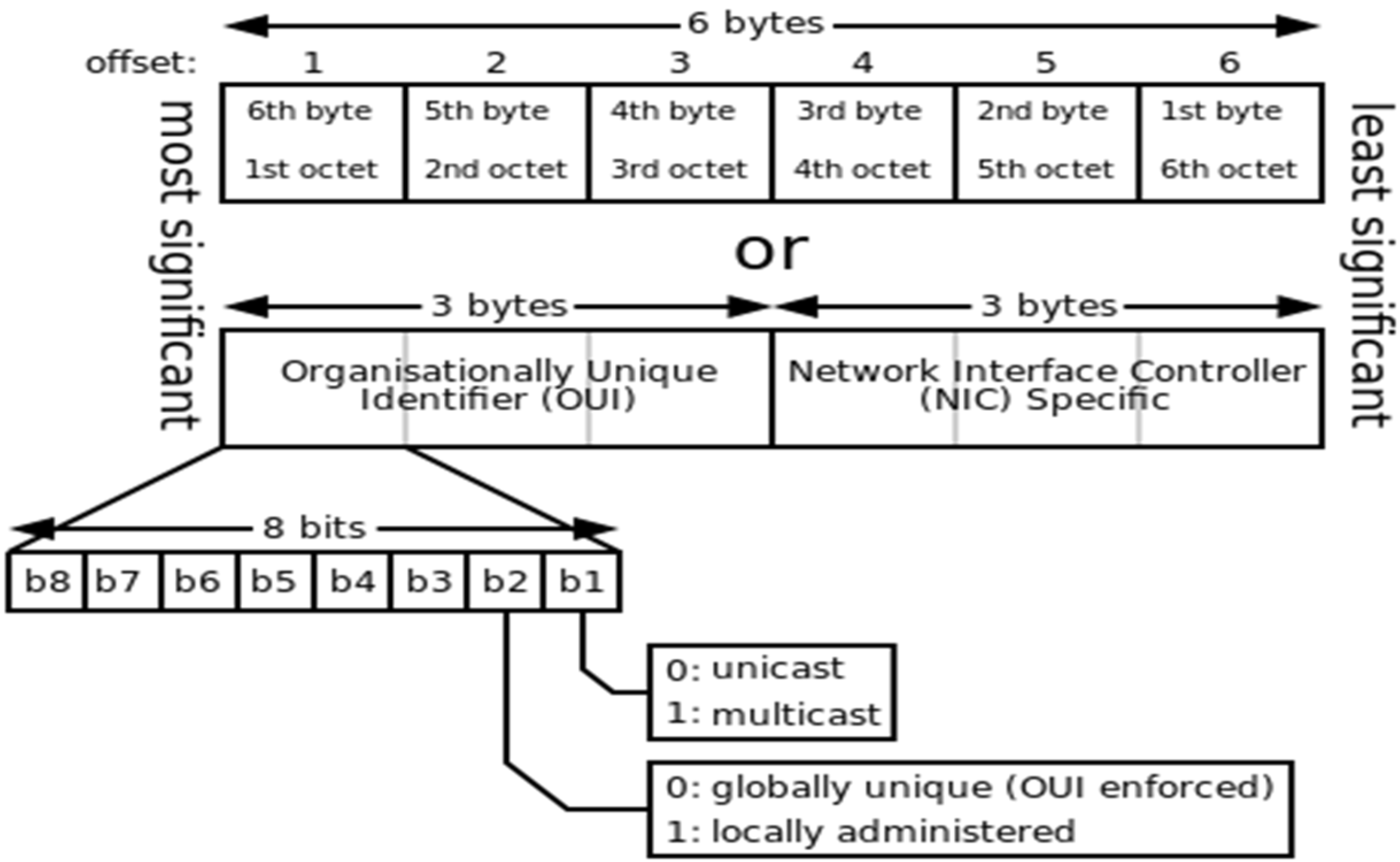
MM:MM:MM:SS:SS:SS

or

MM-MM-MM-SS-SS-SS

The first half of the MAC address contains the ID number of the adapter manufacturer. These IDs are regulated by an Internet standards organization. The second half of the MAC address represents the serial number assigned to the adapter by the manufacturer.

MAC Address



6 bytes
offset:
1
2
3
4
5
6
6th byte
1st octet
5th byte
2nd octet
4th byte
3rd octet
3rd byte
4th octet
2nd byte
5th octet
1st byte
6th octet
most significant
least significant
or
3 bytes
3 bytes
Organisationally Unique Identifier (OUI)
Network Interface Controller (NIC) Specific
8 bits
b8
b7
b6
b5
b4
b3
b2
b1
0: unicast
1: multicast
0: globally unique (OUI enforced)
1: locally administered

MAC Address

C8	60	00	BA	95	65

OUI [Organizationally Unique Identifier]
Identitas Organisasi/Vendor NIC
Seperti Network Portion pada IP Address

UAA/Extended Identifier/Device Identifier
Unique Address assigned by vendor
Seperti Host Portion pada IP Address

MAC Address

MAC and IP address functionality:

The MAC addresses function at the data link layer (layer 2) and the IP addresses function at the network layer (layer 3).

The IP addresses support the software implementation and the MAC addresses support the hardware implementation of the network stack (OSI model).

The MAC address generally remains fixed and follows the network device, but the IP address changes as the network device moves from one network to another.

MAC Address

ARP table :

IP address	MAC address
192.168.2.122	00:03:47:96:E0:6B
192.168.2.123	00:03:47:96:7F:EB
192.168.2.1	00:90:0B:01:1D:F4
192.168.2.111	BA:BE:69:BA:BE:69
192.168.2.235	00:04:E2:9C:C4:43
192.168.2.111	00:1A:92:3A:99:D9

ahoss.wordpress.com

MAC Layer Protocols for Wireless Networks

What is MAC?

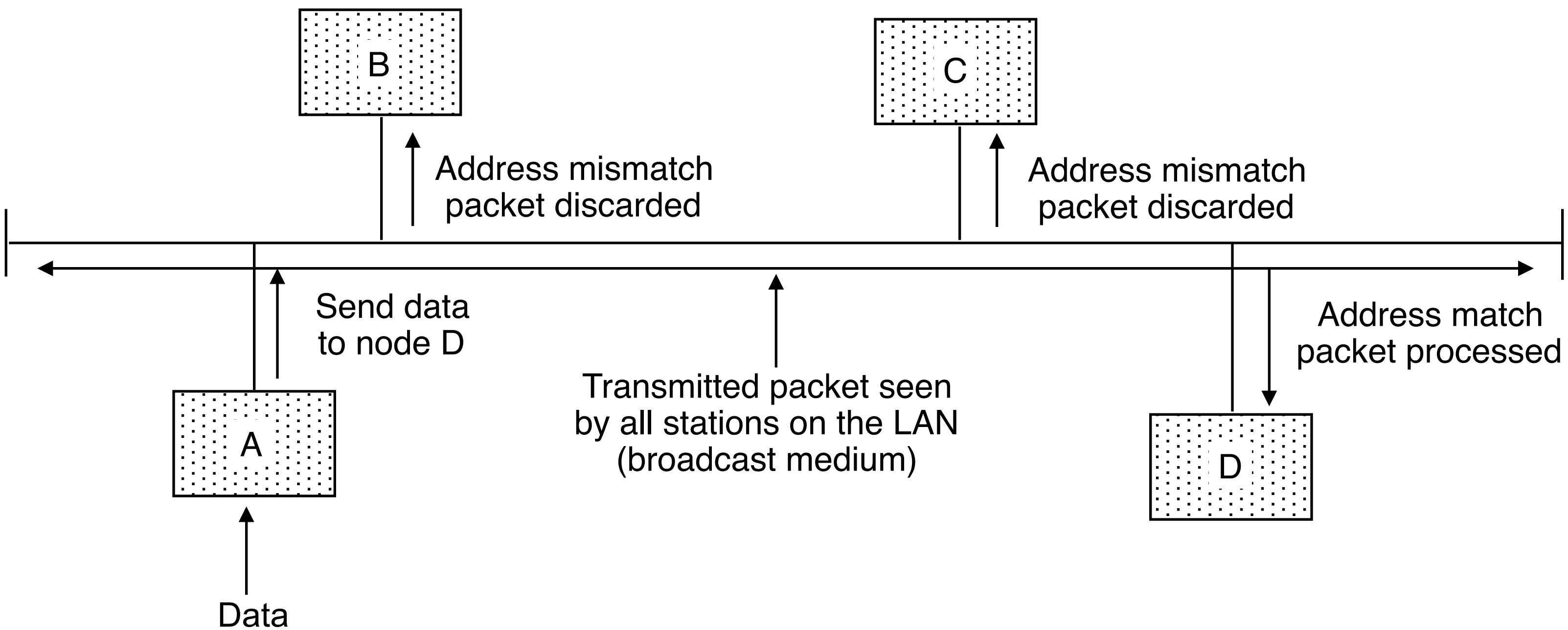
- MAC stands for **M**edia **A**ccess **C**ontrol. A MAC layer protocol is the protocol that controls access to the physical transmission medium on a LAN.
- It tries to ensure that no two nodes are interfering with each other's transmissions, and deals with the situation when they do.

CSMA/CD MAC

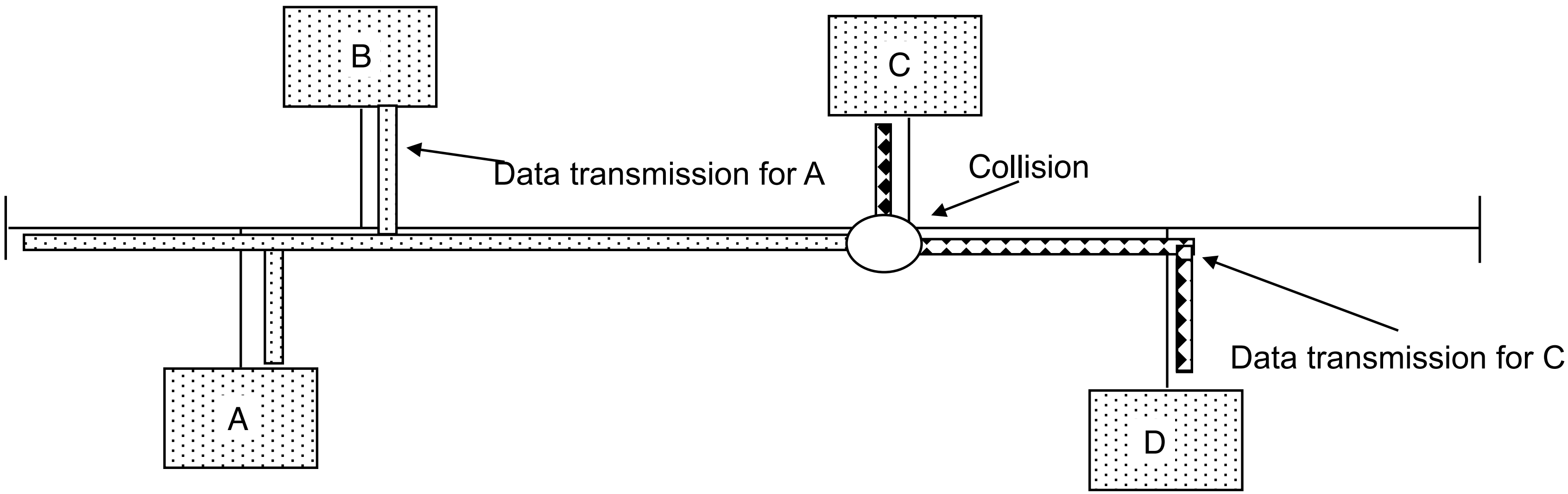
- CSMA/CD architecture used in Ethernet is a common MAC layer standard.

- It acts as an interface between the Logical Link Control sublayer and the network's Physical layer.

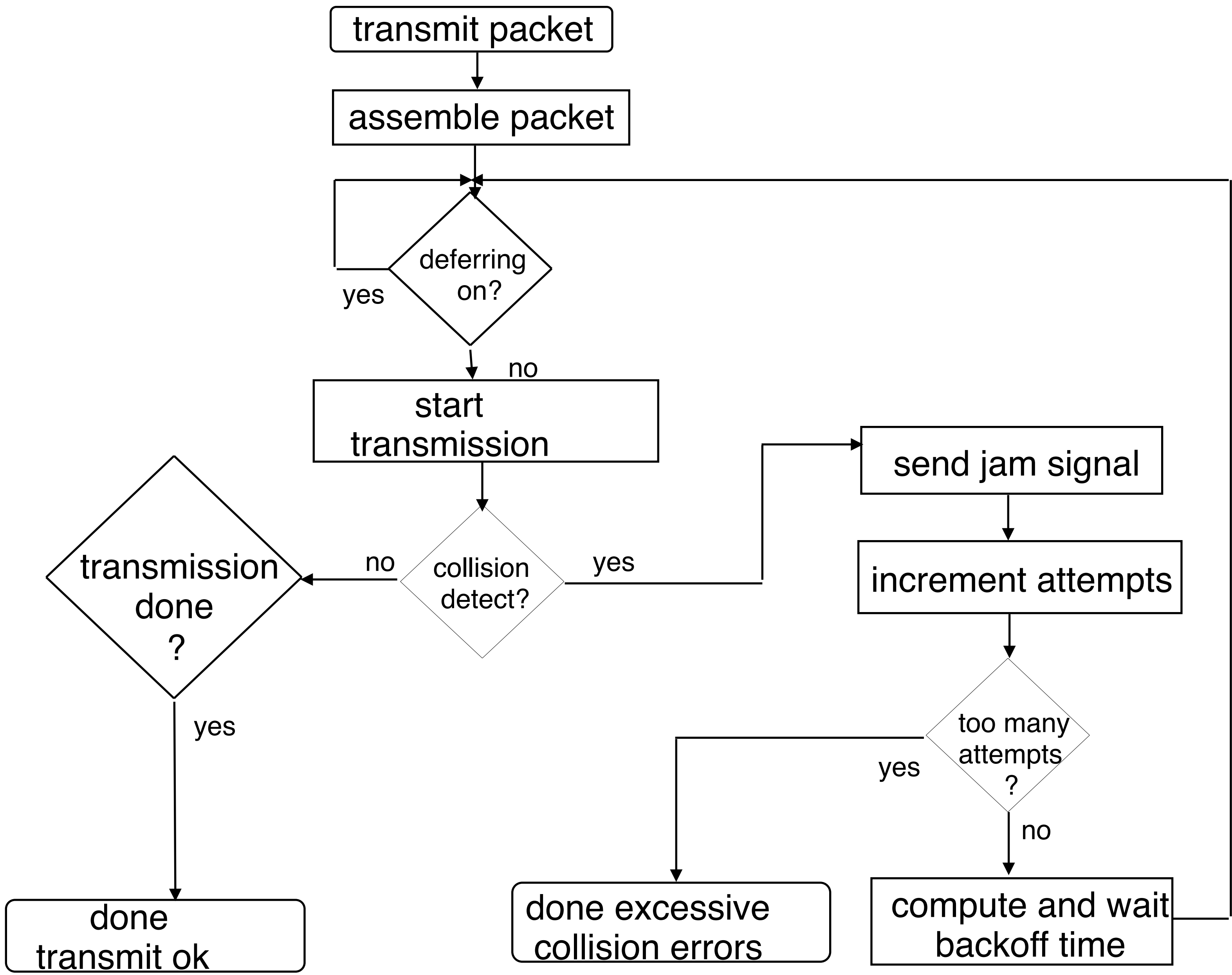
Normal Ethernet Operation



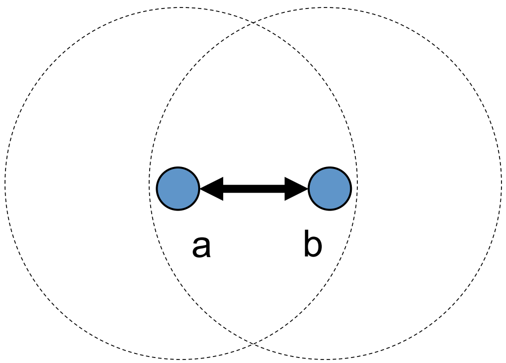
Ethernet Collisions



Ethernet Transmission Flowchart



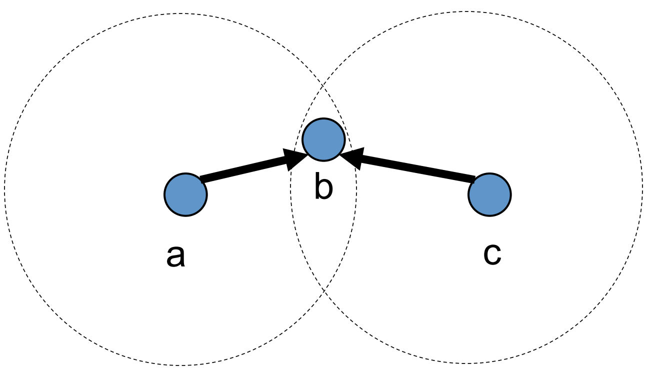
Interference / Collisions



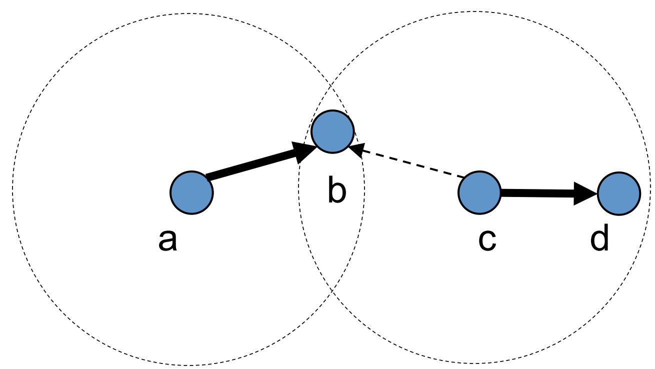
a and ***b*** interfere and hear noise only

Packets which suffered collisions should be re-sent.

Ideally, we would want all packets to be sent collision-free, only once…

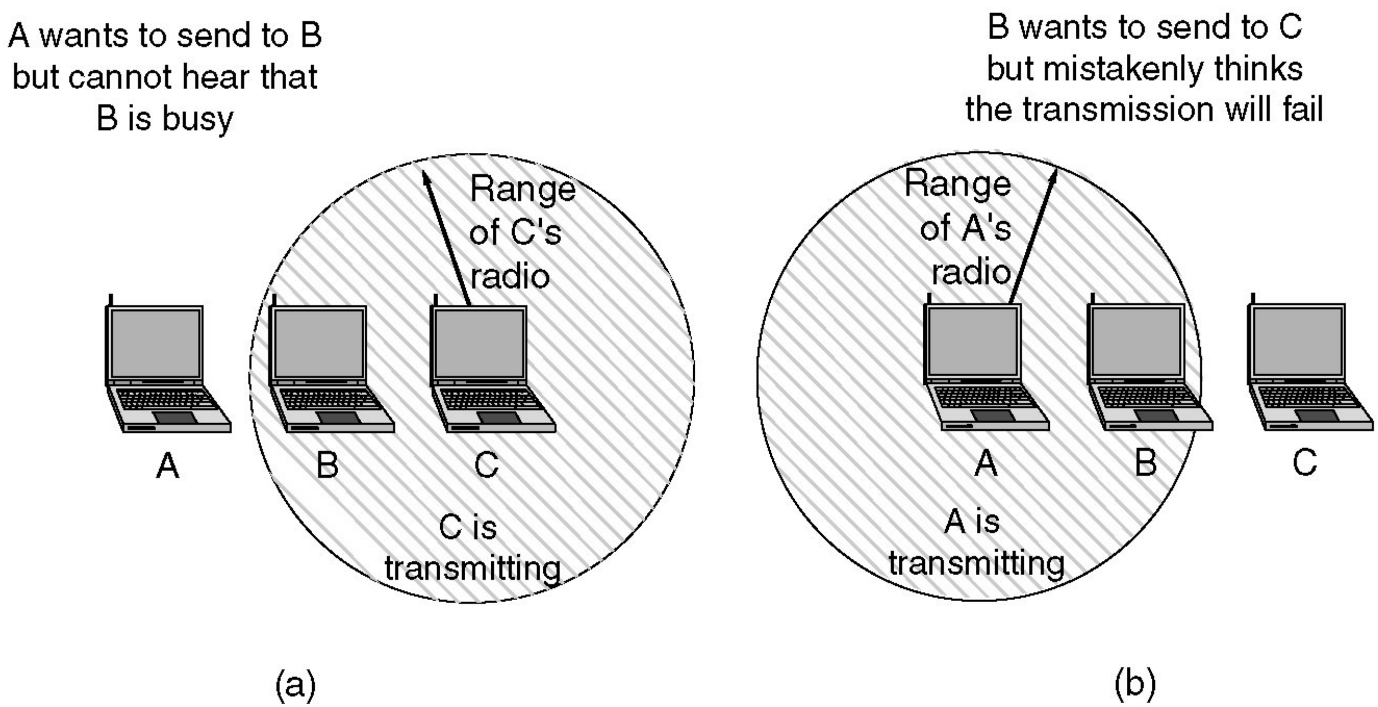


Interference on node ***b***
("hidden terminal problem")



Interference on node ***b***

("exposed terminal problem")

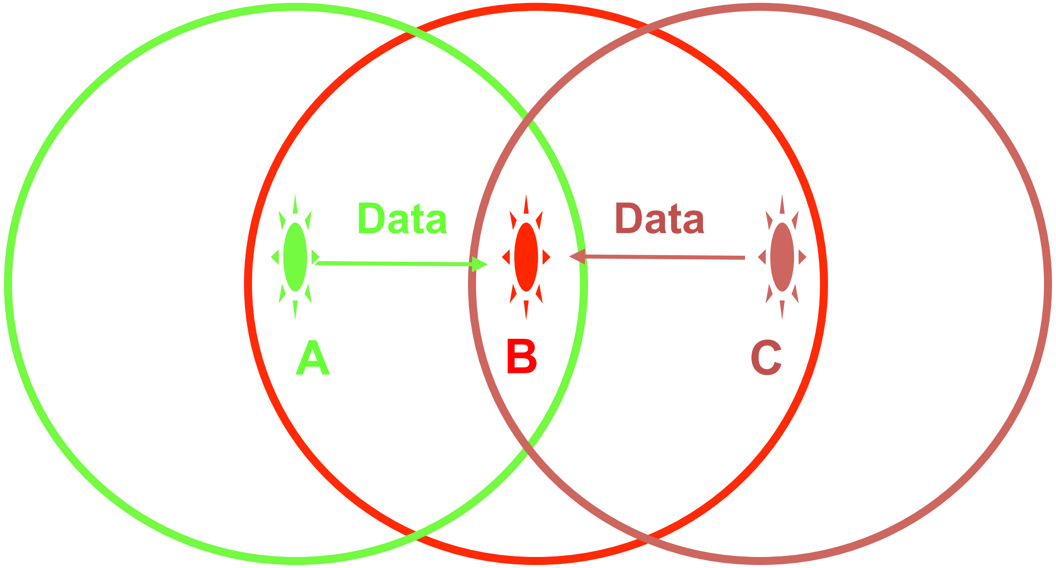


(a)The hidden station problem. (b) The exposed station problem.

The Hidden Terminal Problem

- Wireless stations have transmission ranges and not all stations are within radio range of each other.
- Simple CSMA will not work!
- C transmits to B.
- If A "*senses*" the channel, it will not hear C's transmission and falsely conclude that A can begin a transmission to B.

Hidden Terminal Problem



A and C want to send data to B

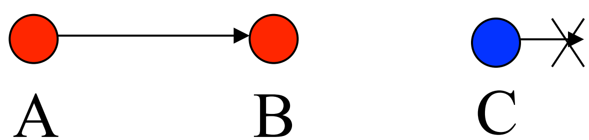
1. **A senses medium idle and sends data**
2. **C senses medium idle and sends data**
3. **Collision occurs at B**

The Exposed Station Problem

- The inverse problem.
- B wants to send to C and listens to the channel.
- When B hears A's transmission, B falsely assumes that it cannot send to C.

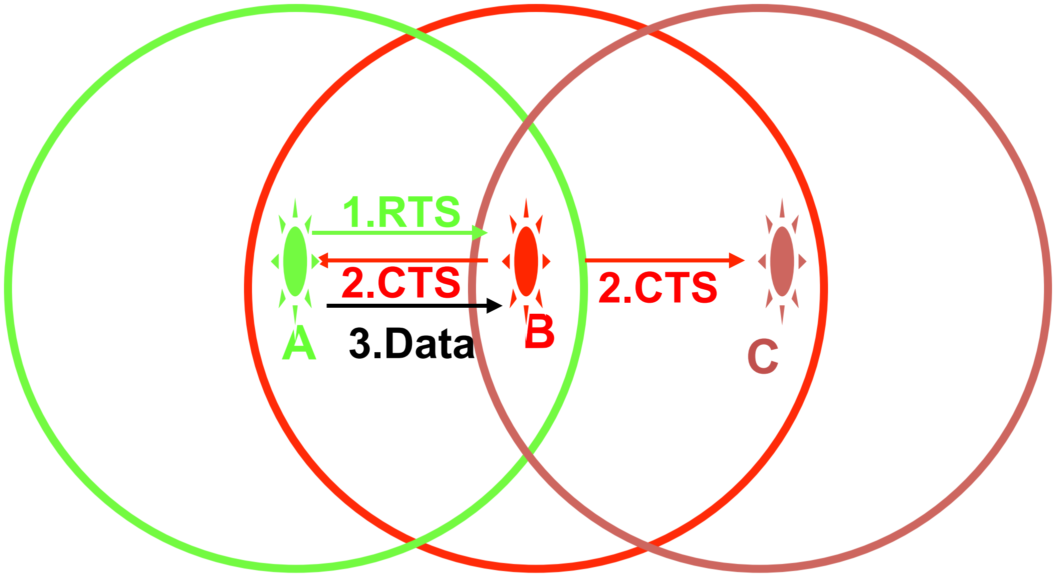
MACA Protocol

- Contention-based protocols
  - CSMA — Carrier Sense Multiple Access
    - Ethernet (CSMA/CD) is not enough for wireless (collision at receiver cannot detect at sender)



Hidden terminal: A is hidden from C's CS

Collision Avoidance w/ RTS/CTS



A and C want to send to B

1. **A sends RTS (Request To Send) to B**
2. **B sends CTS (Clear To Send) to A**
   C "overhears" CTS from B
3. **C waits for duration of A's transmission**

802.11 DCF (Distributed Coordinate Function)

- Station listens before transmission
- If medium is free for more than DIFS: transmits
- Otherwise, uses exponential backoff mechanism

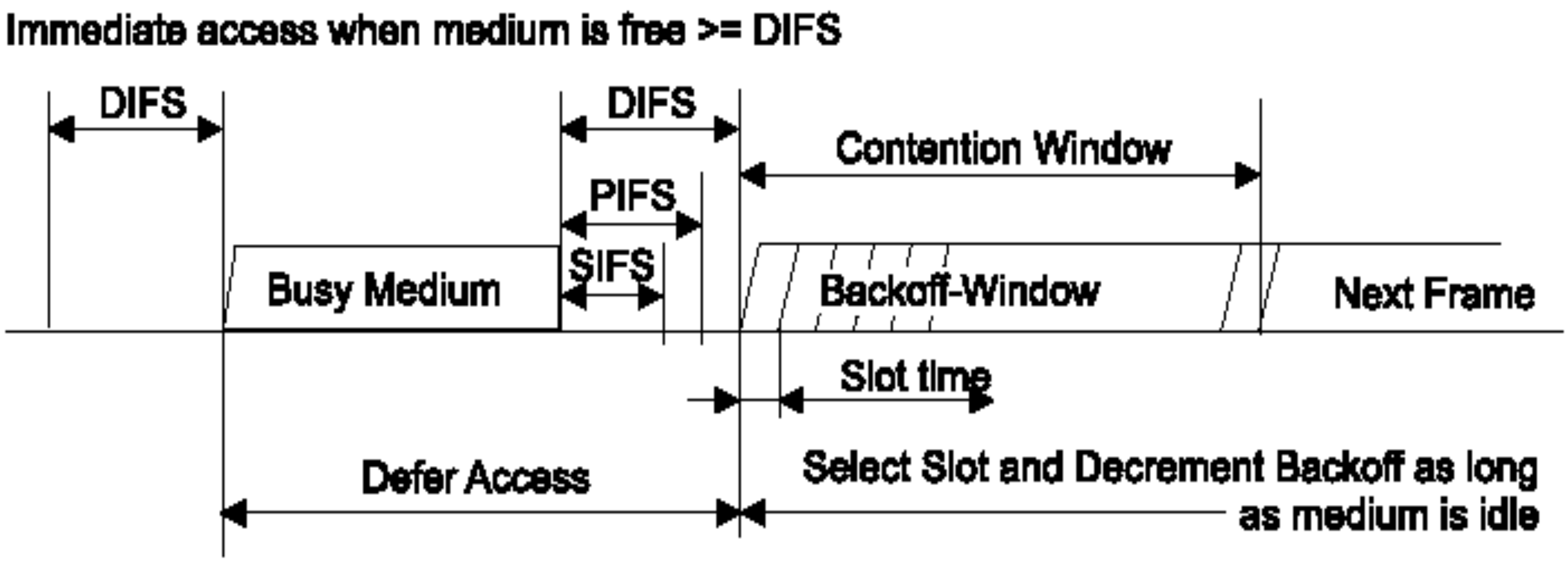


Figure 49—Some IFS relationships

Interframe space (IFS)

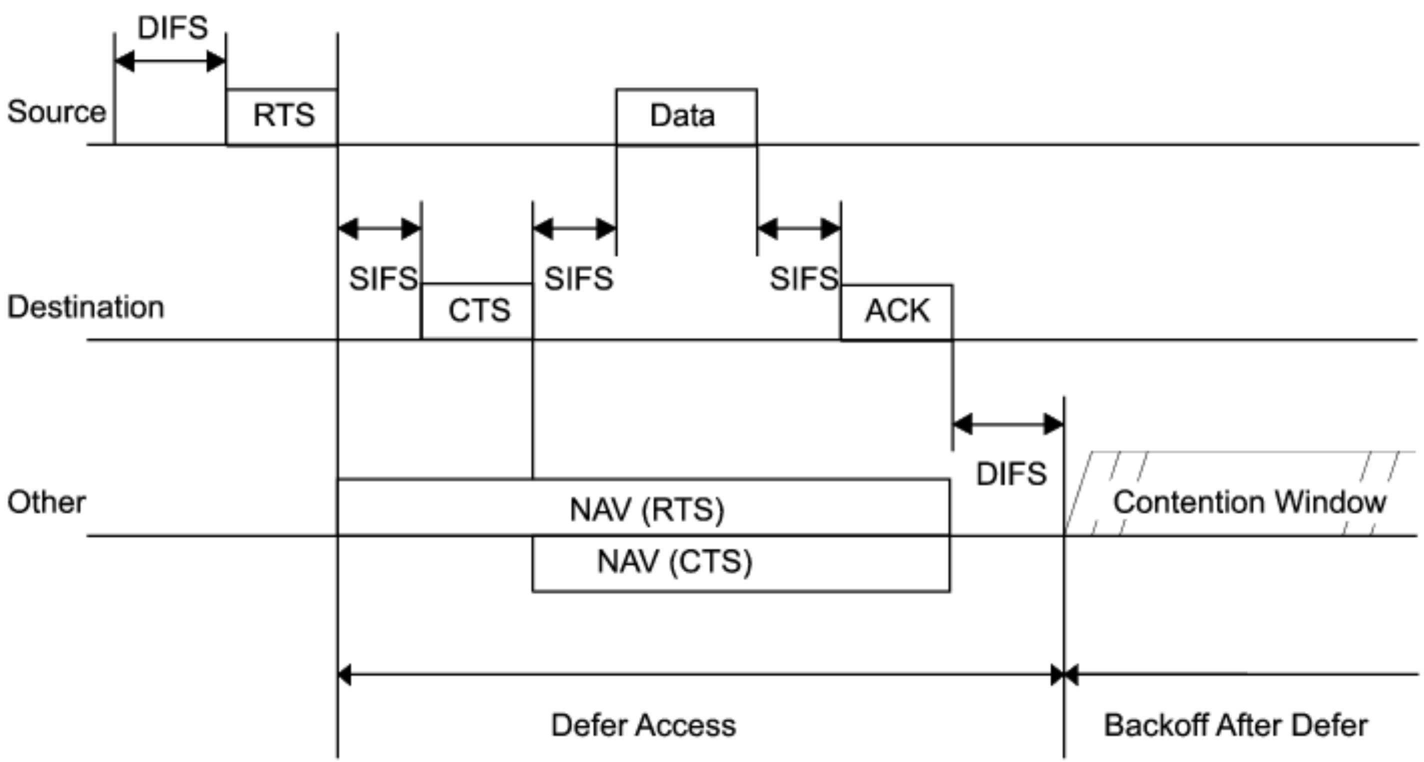
- SIFS : used by ACK, CTS, poll response (short)
- PIFS : used by PC (point coordinator) when issuing polls
  (point)
- DIFS : used by ordinary asynchronous traffic (distributed)

IEEE 802.11 DCF

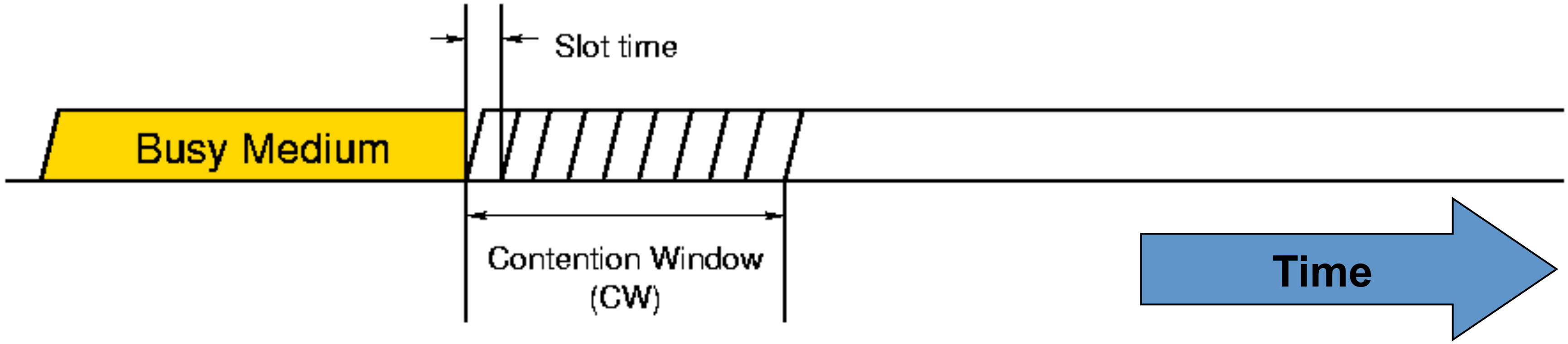
- Distributed coordinate function: ad hoc mode
  - Virtual and physical carrier sense (CS)
    - Network allocation vector (NAV), duration field
  - Binary exponential backoff
  - RTS/CTS/DATA/ACK for unicast packets
  - Broadcast packets are directly sent after CS

Virtual Carrier Sense

- Timing relationship



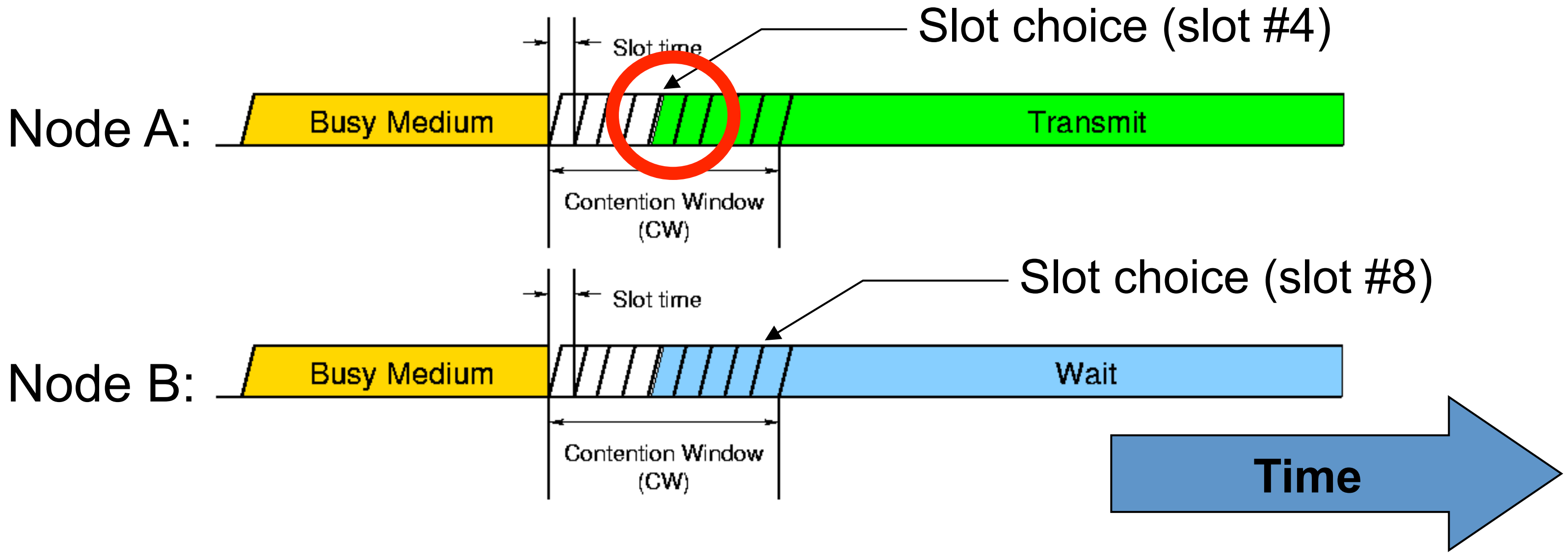
Random Backoff



- Pick a timeslot chosen ***uniformly*** in [0, CW]
- **Listen** up to chosen slot
  - **Transmit** if nobody else started transmitting
  - **Wait** if somebody else started transmitting

Example: A Successful Transmission

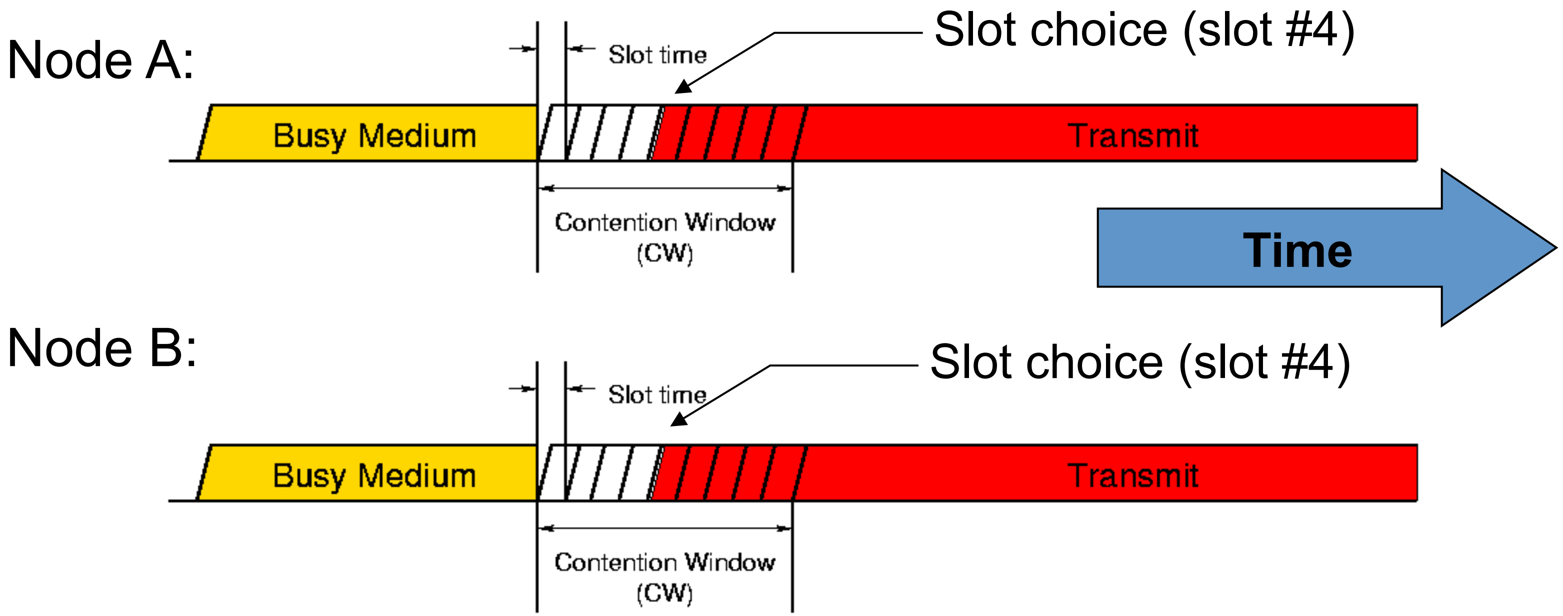
- A and B happened to choose different slots
  - Node A chooses slot 4, hears nothing, **transmits**
  - Node B chooses slot 8, hears Node A, **waits**



Success: exactly one node in ***first non-vacant slot***

Example: A Collision

- A and B happened to choose slot 4
  - Both **listen and hear nothing**
  - Both **transmit simultaneously**



*Collision: ≥ 2 nodes in **first non-vacant slot***

Binary Exponential Backoff (BEB)

- Creating more slots for solving the collision problem