ITMC412

MAC Protocols and Techniques

PAN

L2

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Shared Medium Frame Transmission

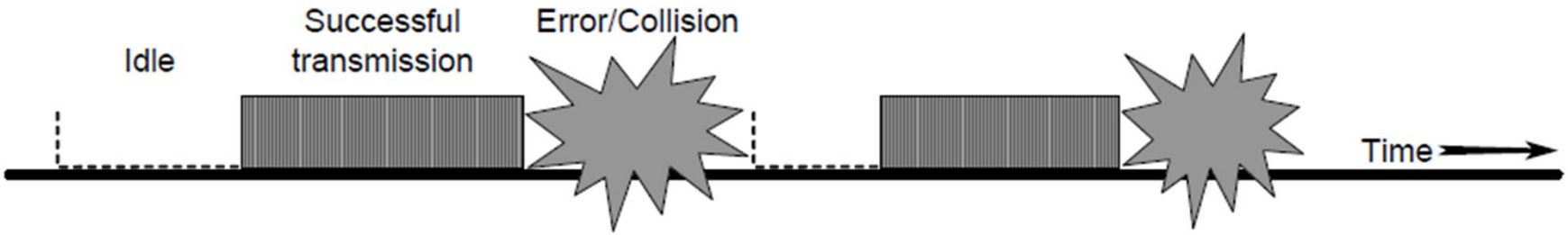

Figure 2.1. Broadcast communication channel can be in one of the three possible states. Assuming that at least one station always needs to transmit, the design objective is to maximize the fraction of the "Successful transmission" state.

- A common means of improving a protocol's performance is to shorten the possible collision period (vulnerable period) by introducing the constraints on packet transmission start time

Shared Medium Frame Collisions

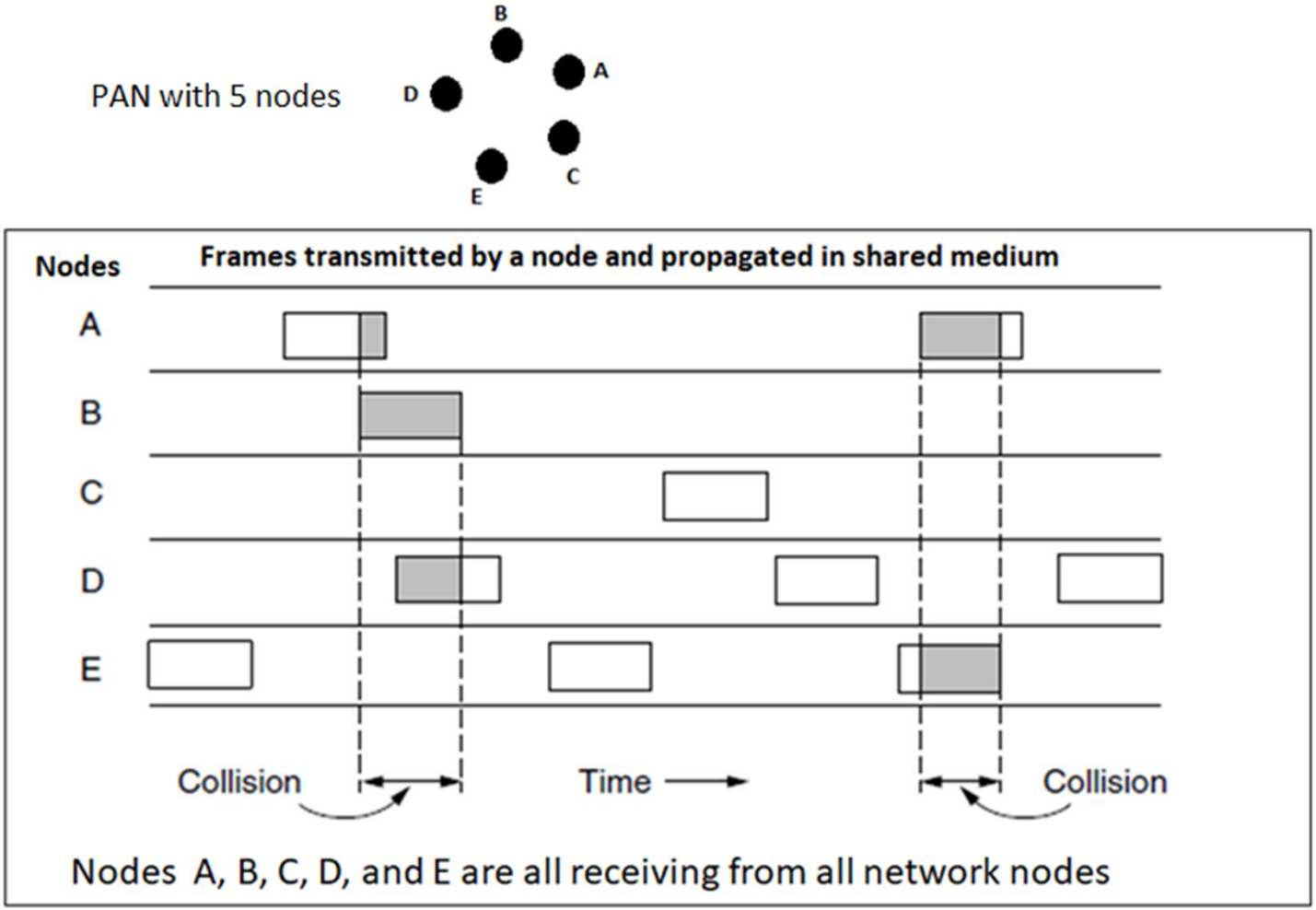

Fig (2.1) Four wireless node transmitting in shared medium with frame collisions

Vulnerable Period

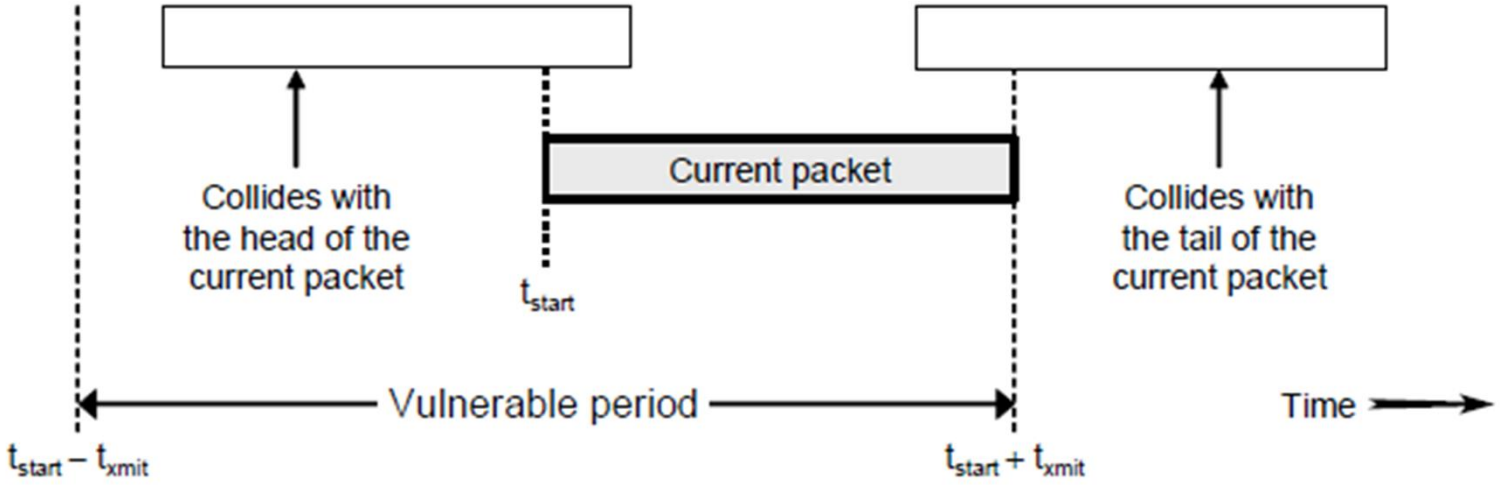

Fig (2.2) how to measure the vulnerable period [2]

$$t_{xmit} = \frac{L}{R}$$

t_{xmit} is the frame/packet transmission time

L is the frame/packet size in bits

R is transmission rate in bit per second

MAC Protocol Classification

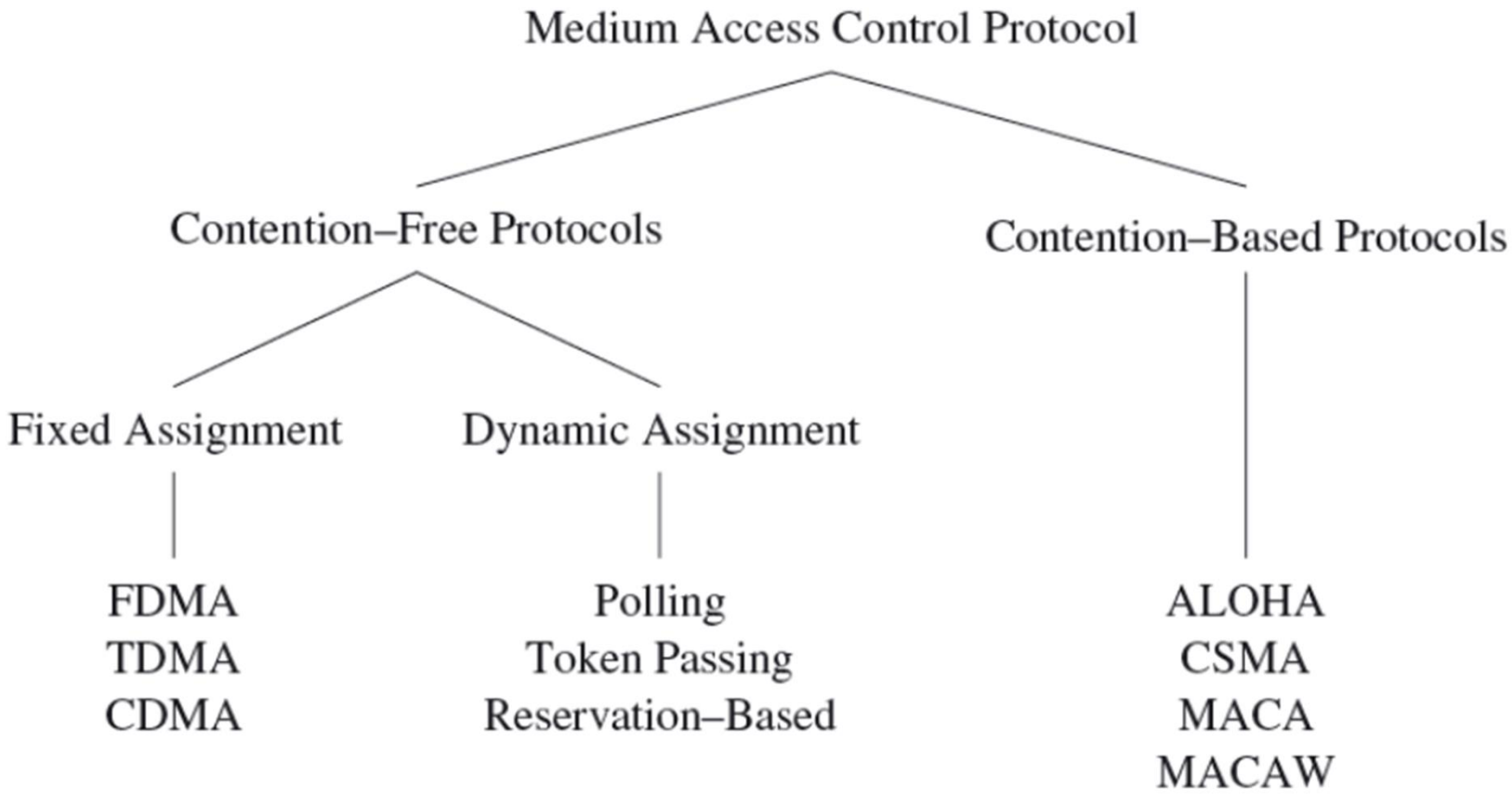

Fig (2.3) classifying depending on shared medium contention

Multiple Access Mechanisms

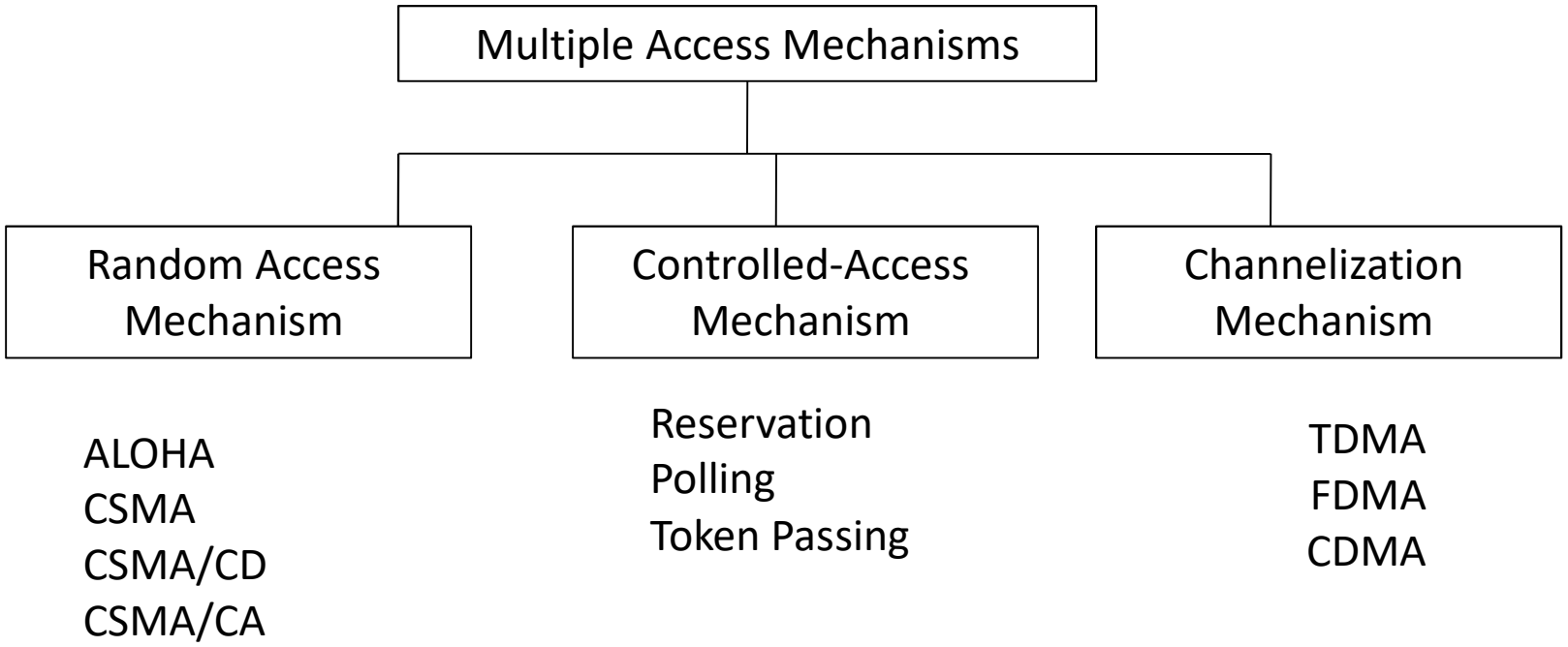

Fig (2.4) classifying depending on control mechanisms

Access Methods

Two different channel access methods (in MAC Protocols):

- Beacon-Enabled duty-cycled mode
- Non-Beacon Enabled mode (aka Beacon Disabled mode)

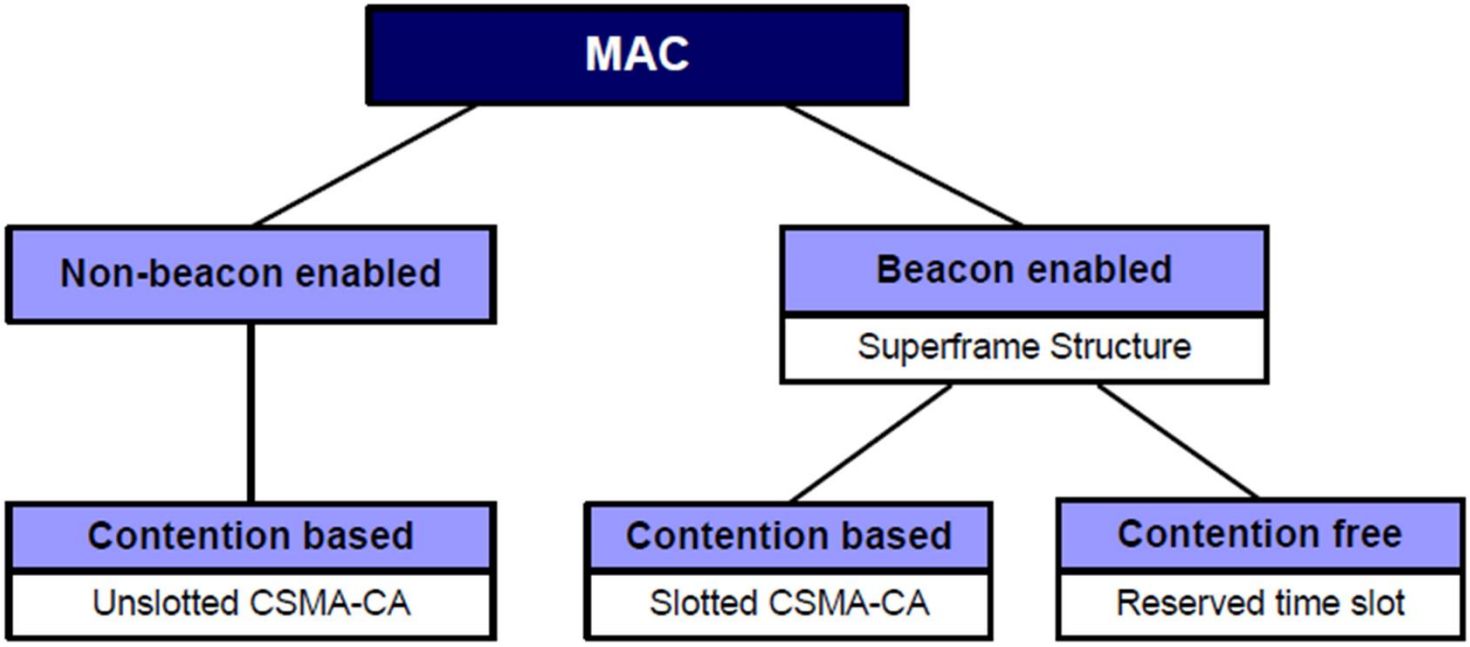

Fig (2.5) classifying depending on channel access and network beacon

Shared medium Problems

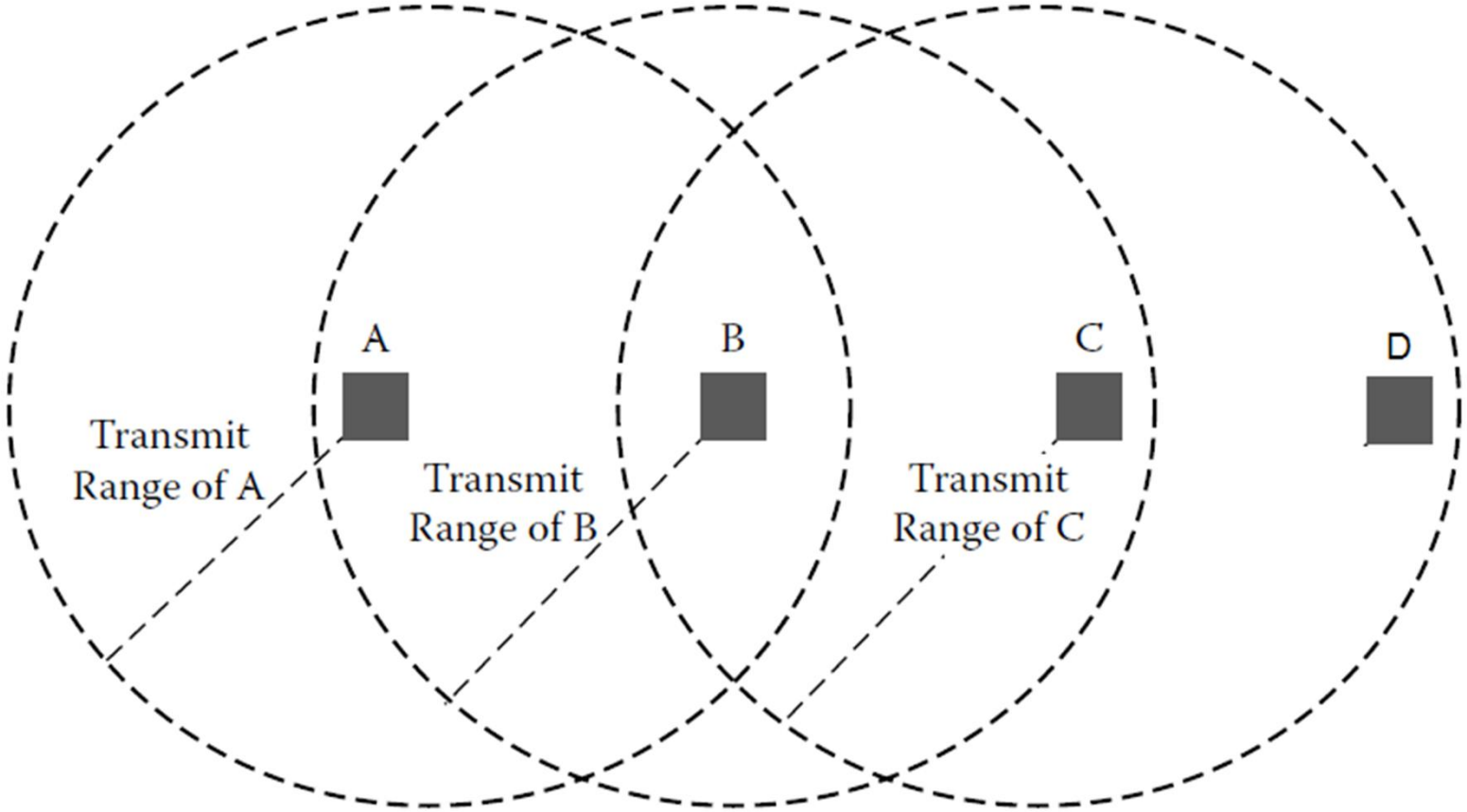

Fig (2.6) Example of a wireless network of 4 nodes not receiving from all nodes

Hidden-terminal

- The hidden-terminal problem occurs when two (or more) terminals, A and C, cannot detect each other's transmissions (due to being outside of each other transmission range) but their transmission ranges are not disjoint.
- As shown in Figure (2.6) collision may occur, for example, when terminal A and C start transmitting toward the same receiver, terminal B in the figure, see also (2.7 a).

Exposed-terminal

- The exposed-terminal problem results from situations in which a permissible transmission from a mobile station (sender) to another station has to be delayed due to the irrelevant transmission activity between two other mobile stations within sender's transmission range.
- As in Figure (2.7 b), B transmits to A, but C wants to transmit to D, so it delays while receiving from B.

Link Layer Interference: Hidden and Exposed Stations

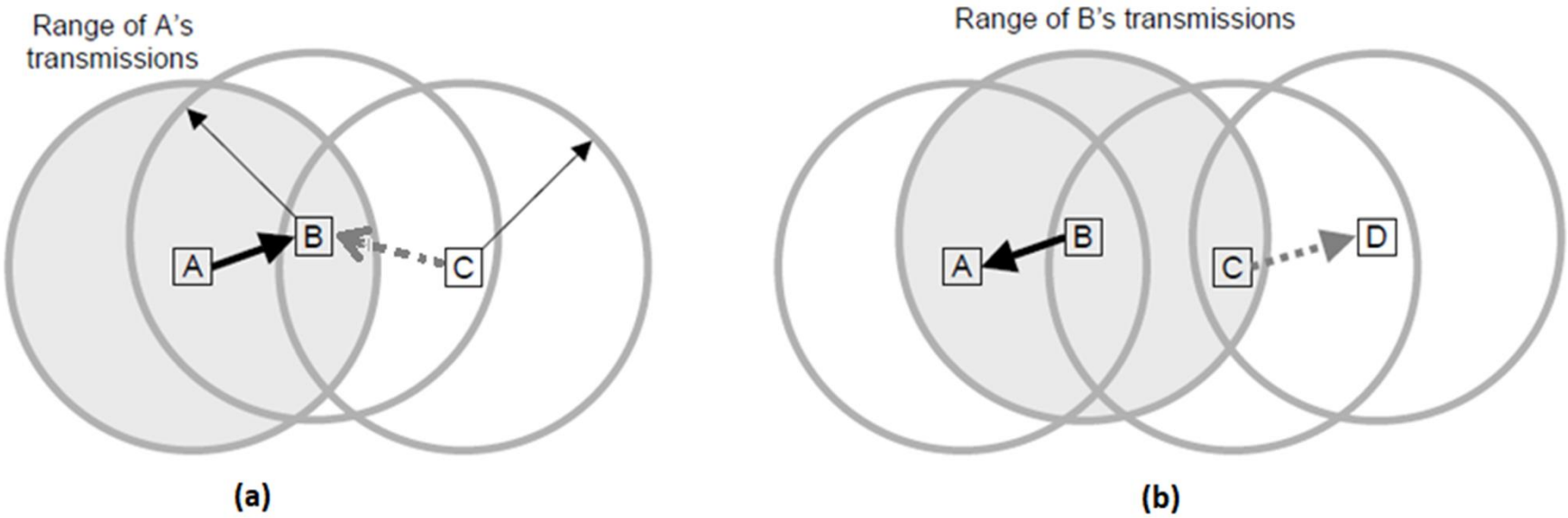

Fig (2.7) The hidden and exposed problem Examples, **a)** hidden station A from C, **b)** exposed station C deferred transmission to D

This Course Focus on

- ALOHA
- CSMA
- CSMA/CA
- TDMA

This presentation includes the three contention based.

Improve the MAC protocol

- Receiving acknowledgement for all transmissions.
- Reduce Collisions between senders, by reducing vulnerability period.
- Limit transmission start time to the beginning of discrete time slices (Slots).
- Listen before talking to avoid having a collision with an ongoing packet transmission.

Contention based Medium Access

- Nodes may initiate transmissions at the same time.
  - requires mechanisms to reduce the number of collisions and to recover from collisions

Using ALOHA techniques and CSMA techniques

- Nodes may initiate transmissions at the same time
  - requires mechanisms to reduce the number of collisions and to recover from collisions
- Example 1: ALOHA protocol
  - uses acknowledgments to confirm the success of a broadcast data transmission
    - allows nodes to access the medium immediately
    - addresses collisions with approaches such as exponential back-off to increase the likelihood of successful transmissions
- Example 2: slotted-ALOHA protocol
  - requires that a station may commence transmission only at predefined points in time (the beginning of a time slot)
  - increases the efficiency of ALOHA
  - introduces the need for synchronization among nodes

- Carrier Sense Multiple Access (CSMA)
  - CSMA with Collision Detection (CSMA/CD)
    - sender first senses the medium to determine whether it is idle or busy
      - if it is found busy, the sender refrains from transmitting packets
      - if the medium is idle, the sender can initiate data transmission
  - CSMA with Collision Avoidance (CSMA/CA)
    - CSMA/CD requires that sender aware of collisions
    - instead, CSMA/CA attempts to avoid collisions in the first place

Aloha

- uses acknowledgments to confirm the success of a broadcast data transmission.
- allows nodes to access the medium immediately.
- addresses collisions with approaches such as exponential back-off to increase the likelihood of successful transmissions!

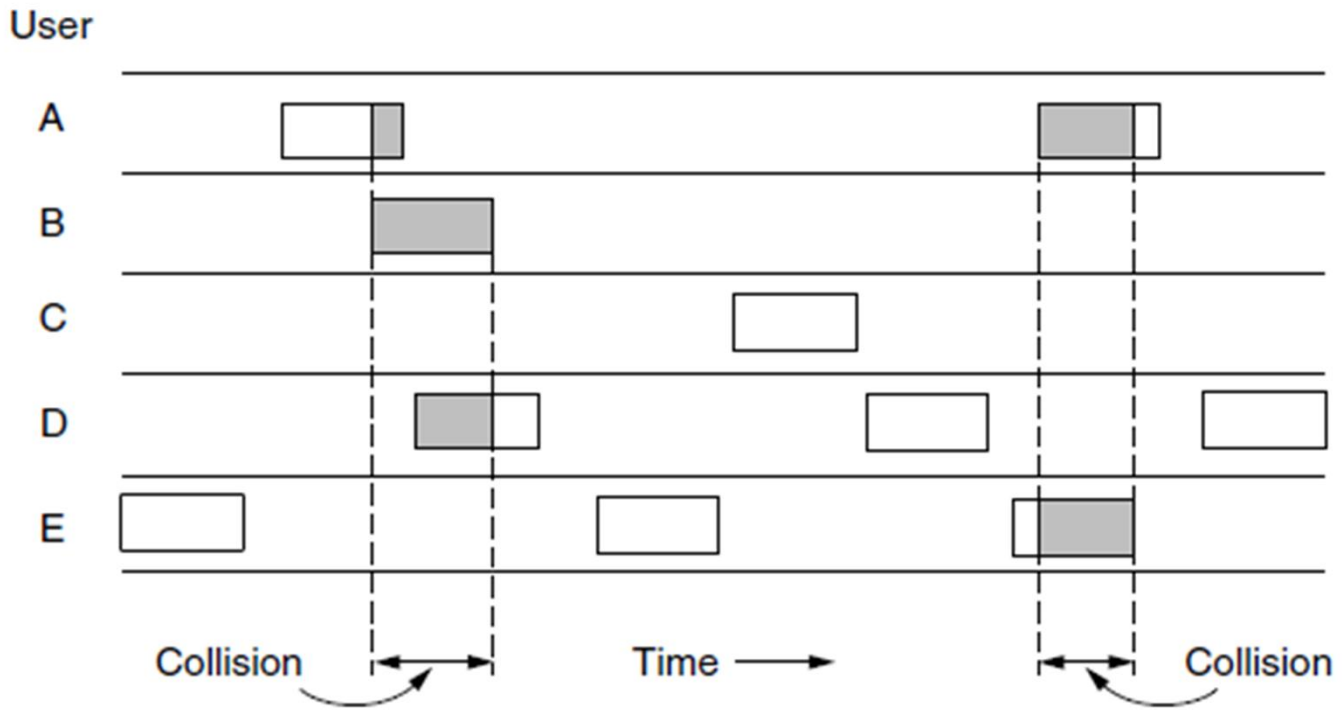

Fig (2.8) In pure ALOHA, frames are transmitted at completely arbitrary times.

Nodes A, B, C, D, and E are all receiving from all network nodes

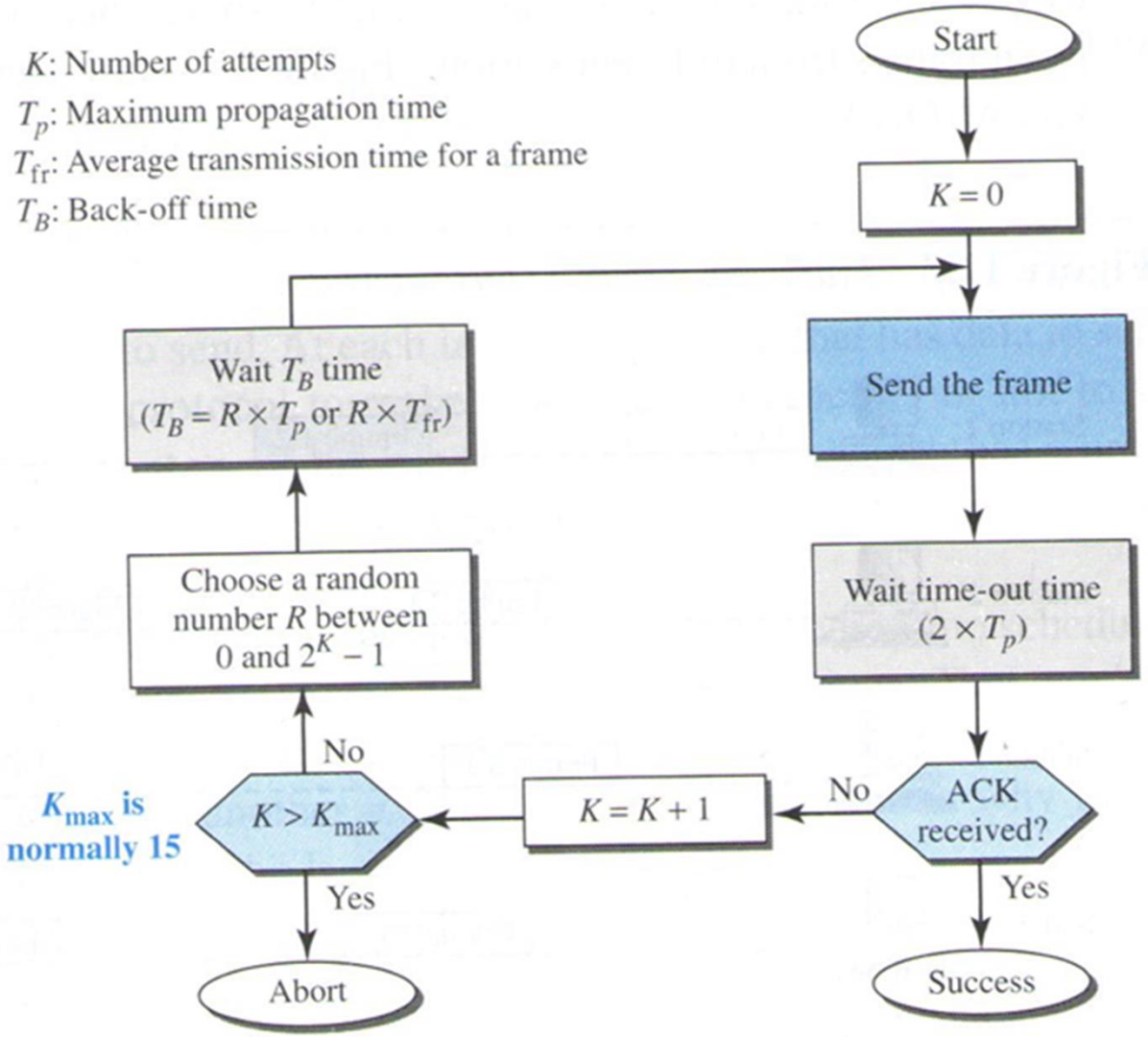

Fig (2.9) Pure ALOHA procedure [1]

Slotted- Aloha

- requires that a station may commence transmission only at predefined points in time (the beginning of a time slot).
- increases the efficiency of ALOHA!
- introduces the need for synchronization among nodes.

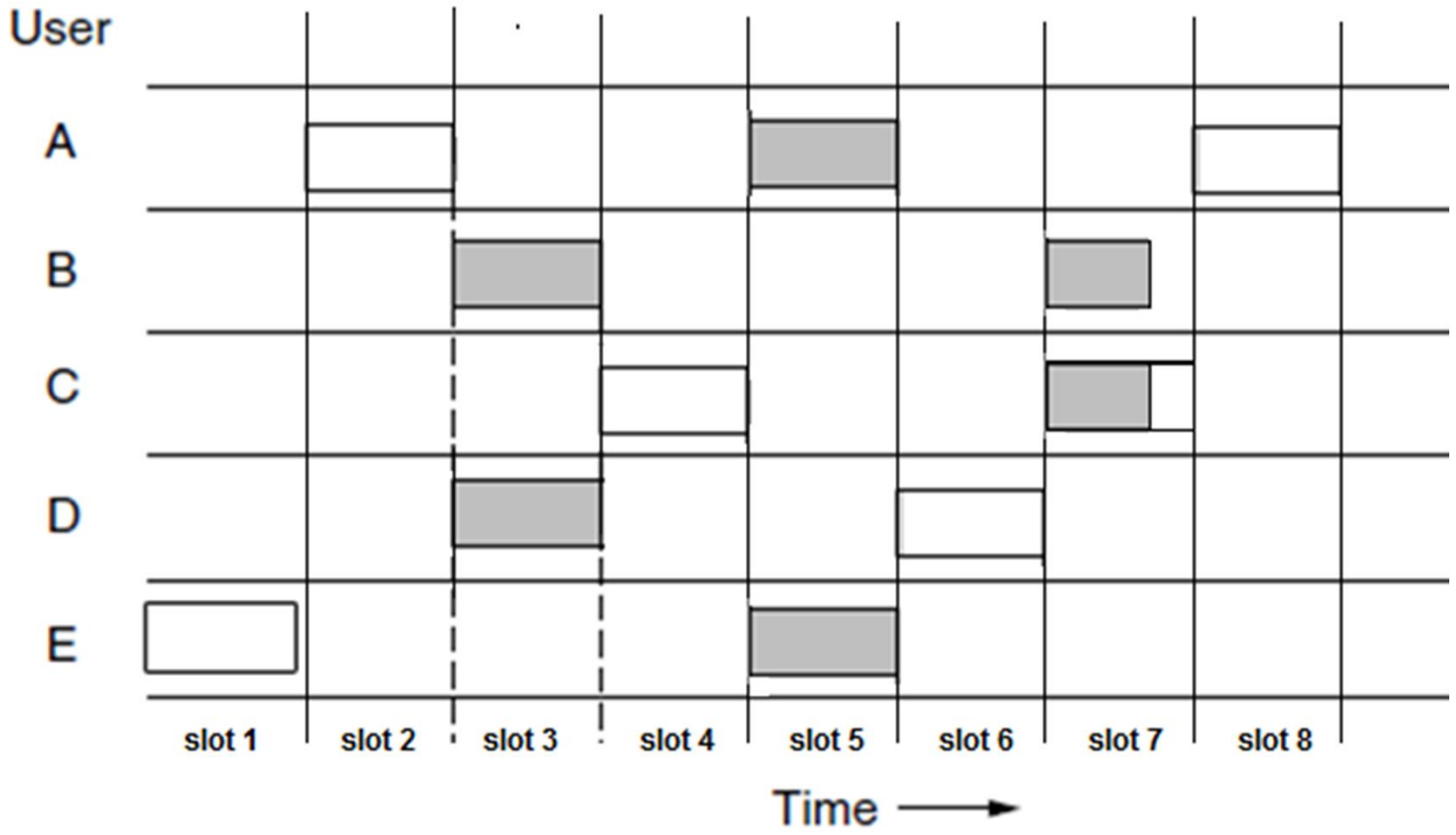

Fig (2.10) Slotted Aloha frames from the network nodes at slotted times
All nodes A, B, C, D, and E are receiving from all network nodes

Comparing packet arrivals and departures

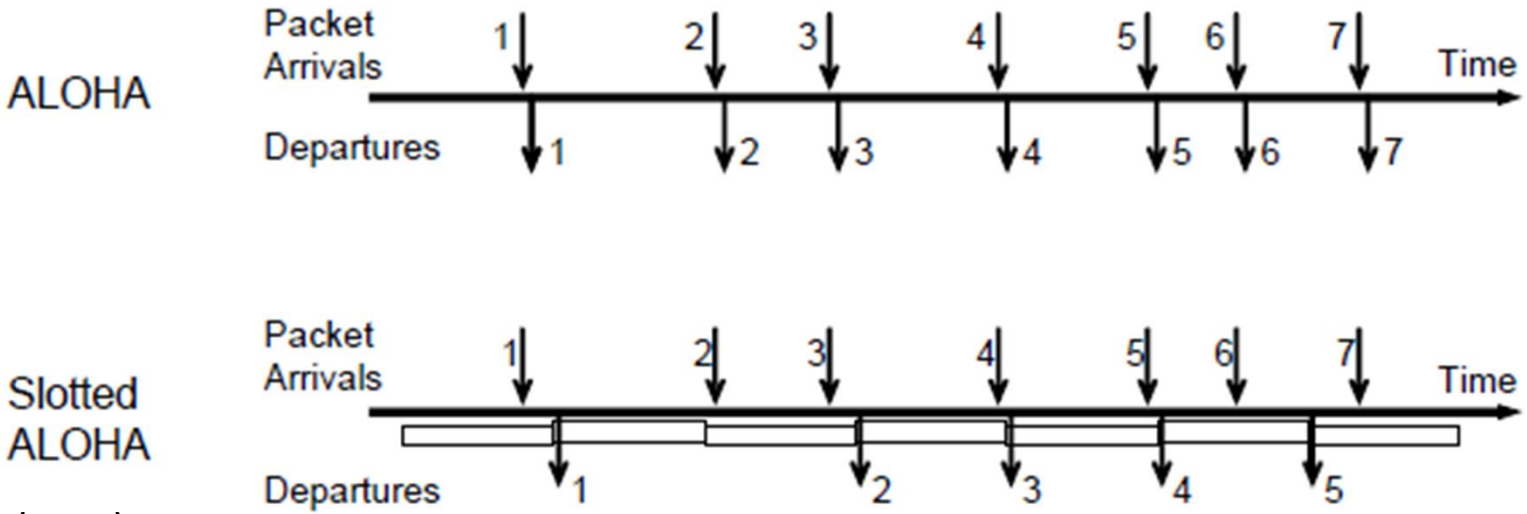

Fig (2.11)

Packet arrivals and departures for pure ALOHA and Slotted ALOHA MAC protocols. In Slotted ALOHA, a packet is transmitted only at the beginning of a slot.

Questions

- Make the procedure for slotted ALOHA?
- Compare between pure and slotted ALOHA?
- What is the vulnerability period for both ALOHA protocols?

- A station holding a packet that must be retransmitted is said to be *backlogged*. *After too* many failures, the link is declared down and transmission is aborted.

Pure ALOHA has a vulnerable time of $2 \times T_{fr}$.

Slotted ALOHA vulnerable time = T_{fr}

The throughput for slotted ALOHA is $S = G \times e^{-G}$.
The maximum throughput $S_{max} = 0.368$ when $G = 1$.

Questions and Answers [1]

Q1- The stations on a wireless ALOHA network are a maximum of 600 km apart. If we assume that signals propagate at 3×10^8 m/s, we find $T_p = (600 \times 10^5) / (3 \times 10^8) = 2$ ms. Now we can find the value of T_B for different values of K.

a. For $K = 1$, the range is $\{0, 1\}$. The station needs to generate a random number with a value of 0 or 1. This means that T_B is either 0 ms (0×2) or 2 ms (1×2), based on the outcome of the random variable.

b. For $K = 2$, the range is $\{0, 1, 2, 3\}$. This means that T_B can be 0, 2, 4, or 6 ms, based on the outcome of the random variable.

c. For $K = 3$, the range is $\{0, 1, 2, 3, 4, 5, 6, 7\}$. This means that T_B can be 0, 2, 4, . . . , 14 ms, based on the outcome of the random variable.

d. We need to mention that if $K > 10$, it is normally set to 10.

Vulnerable time Let us find the length of time, the **vulnerable time,** in which there is a possibility of collision. We assume that the stations send fixed-length frames with each frame taking T_{fr} s to send. Figure 12.5 shows the vulnerable time for station A.

Questions and Answers [1]

Q2- A slotted ALOHA network transmits 200-bit frames using a shared channel with a 200-kbps bandwidth. Find the throughput if the system (all stations together) produces

a. 1000 frames per second
b. 500 frames per second
c. 250 frames per second

Solution

This situation is similar to the previous exercise except that the network is using slotted ALOHA instead of pure ALOHA. The frame transmission time is 200/200 kbps or 1 ms.

a. In this case G is 1. So $S = G \times e^{-G}$ or $S = 0.368$ (36.8 percent). This means that the throughput is $1000 \times 0.0368 = 368$ frames. Only 368 out of 1000 frames will probably survive. Note that this is the maximum throughput case, percentagewise.
b. Here G is $\frac{1}{2}$. In this case $S = G \times e^{-G}$ or $S = 0.303$ (30.3 percent). This means that the throughput is $500 \times 0.0303 = 151$. Only 151 frames out of 500 will probably survive.
c. Now G is $\frac{1}{4}$. In this case $S = G \times e^{-G}$ or $S = 0.195$ (19.5 percent). This means that the throughput is $250 \times 0.195 = 49$. Only 49 frames out of 250 will probably survive.

References

[1] Fozan, Data Communication and Networks

[2] Marsic, I., Wireless Networks, Local and ad hoc networks, Rutger University.