UNIT - 2

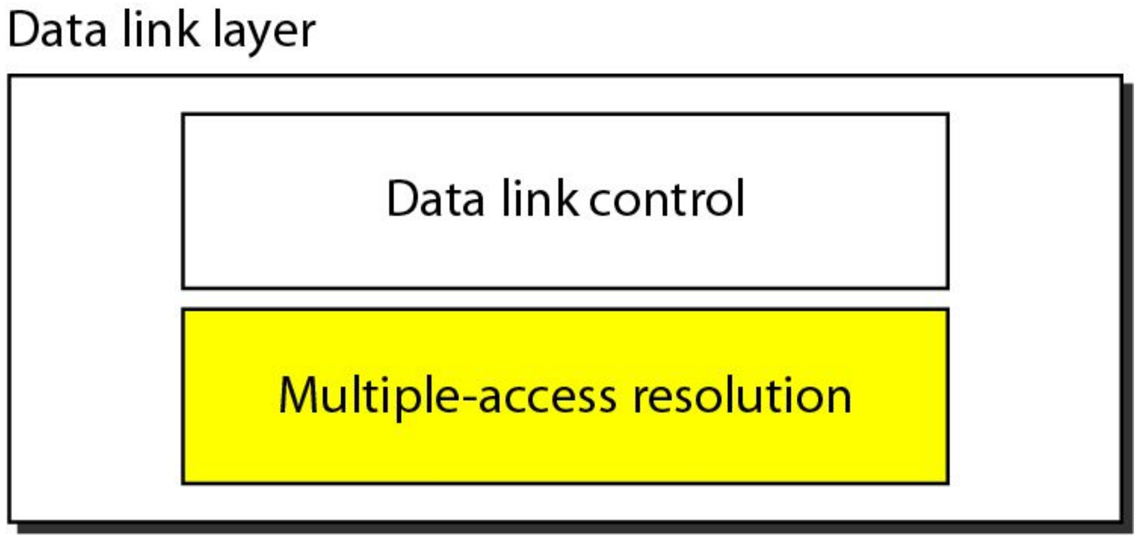
Multiple Access Protocols:

- Pure ALOHA
- Slotted ALOHA
- CSMA/CD
- CDMA/CA

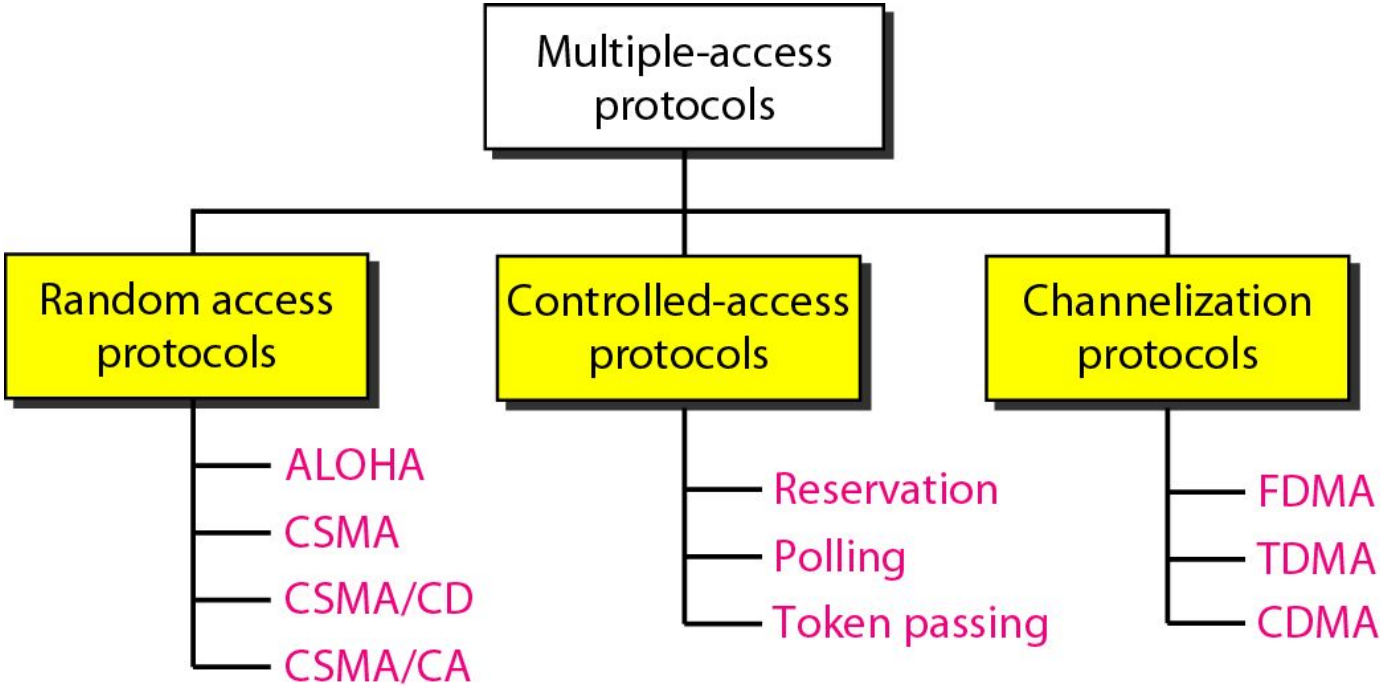
MULTIPLE ACCESS PROTOCOLS

Data link layer divided into two functionality-oriented sublayers

- Data Link Control
- Multiple access resolution



1.Taxonomy of multiple-access protocols



2.ALOHA:

In the 1970s, Norman Abramson and his colleagues at the University of Hawaii devised a newand elegant method to solve the channel allocation problem.

- ❖ Their work has been extended bymany researchers since then (Abramson, 1985).

Although Abramson's work, called the ALOHA system, used ground-based radio broadcasting,the basic idea is applicable to any system in which uncoordinated users are competing for the useof a single shared channel.

- ❖ There are two versions of ALOHA: pure and slotted. They differ withrespect to whether time is divided into discrete slots into which all frames must fit.
- ❖ Pure ALOHA does not require global time synchronization; slotted ALOHA does

Pure ALOHA:

The basic idea of an ALOHA system is simple: let users transmit whenever they have data to be sent. There will be collisions, of course, and the colliding frames will be damaged.

However, due to the feedback property of broadcasting, a sender can always find out whether its frame was destroyed by listening to the channel, the same way other users do.

With a LAN, the feedback is immediate; with a satellite, there is a delay of 270 msec before the sender knows if the transmission was successful.

If listening while transmitting is not possible for some reason, acknowledgements are needed.

If the frame was destroyed, the sender just waits a random amount of time and sends it again. The waiting time must be random or the same frames will collide over and over, in lockstep.

Systems in which multiple users share a common channel in a way that can lead to conflicts are widely known as contention systems

The throughput for pure ALOHA is

$S = G \times e^{-2G}$.

The maximum throughput

$S_{max} = 0.184$ when G= (1/2).

Example 12.3

A pure ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is 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

The frame transmission time is 200/200 kbps or 1 ms.

a. If the system creates 1000 frames per second, this is 1 frame per millisecond. The load is 1. In this case $S = G \times e^{-2G}$ or $S = 0.135$ (13.5 percent). This means that the throughput is $1000 \times 0.135 = 135$ frames. Only 135 frames out of 1000 will probably survive.

Example 12.3 (continued)

b. If the system creates 500 frames per second, this is (1/2) frame per millisecond. The load is (1/2). In this case $S = G \times e^{-2G}$ or $S = 0.184$ (18.4 percent). This means that the throughput is $500 \times 0.184 = 92$ and that only 92 frames out of 500 will probably survive. Note that this is the maximum throughput case, percentagewise.

c. If the system creates 250 frames per second, this is (1/4) frame per millisecond. The load is (1/4). In this case $S = G \times e^{-2G}$ or $S = 0.152$ (15.2 percent). This means that the throughput is $250 \times 0.152 = 38$. Only 38 frames out of 250 will probably survive.

Figure 12.3 Frames in a pure ALOHA network

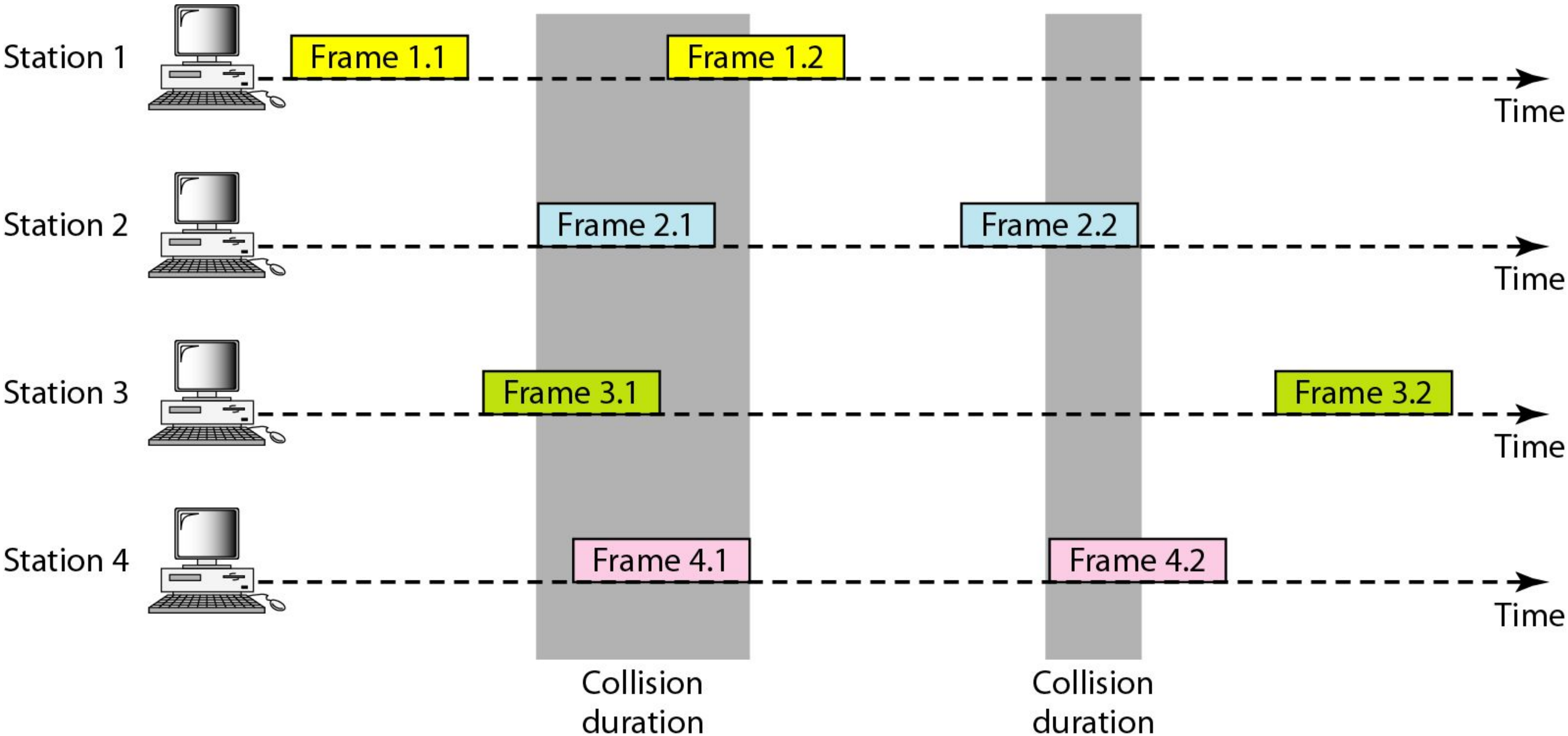
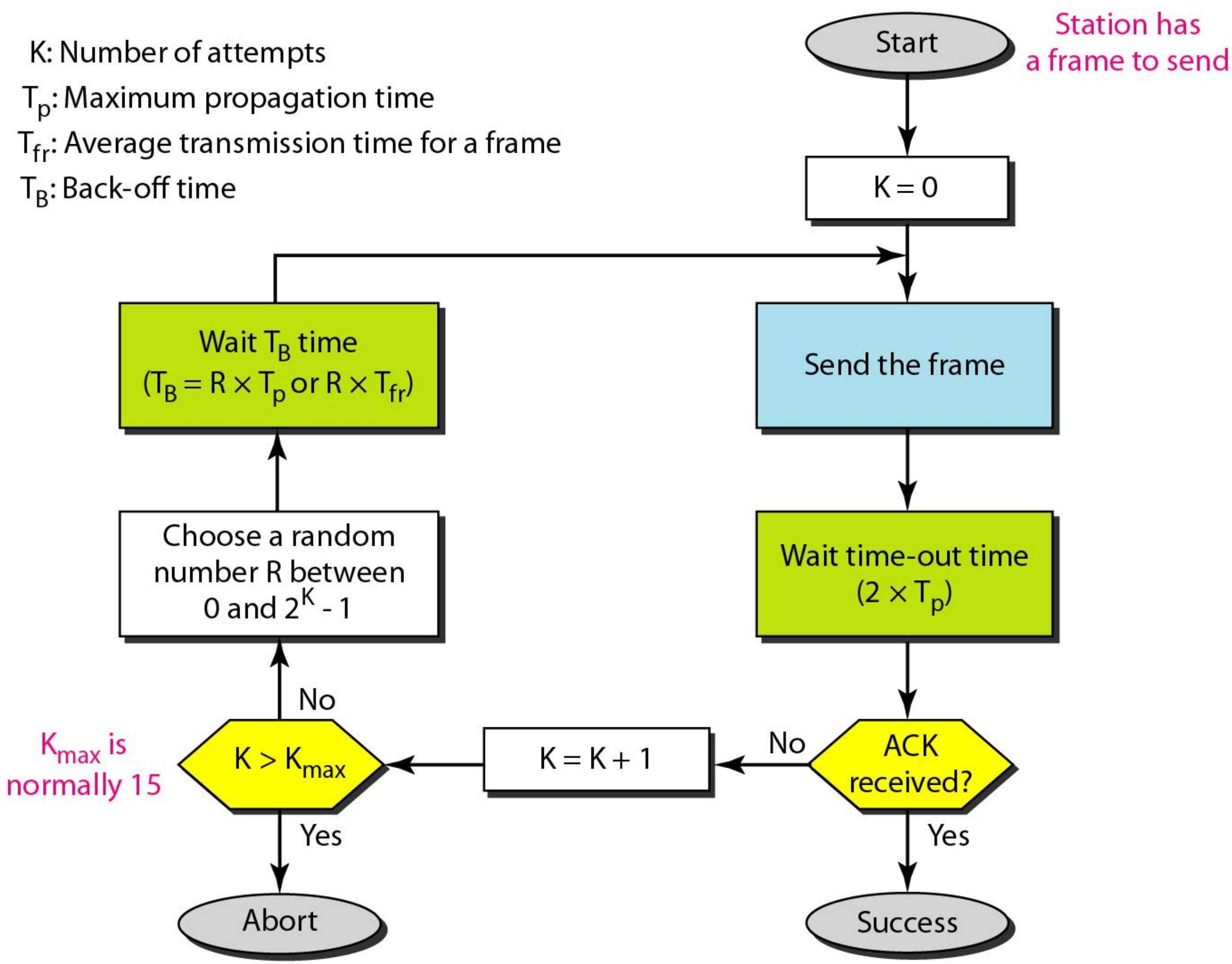


Figure 12.4 Procedure for pure ALOHA protocol



Slotted ALOHA:

In 1972, Roberts published a method for doubling the capacity of an ALOHA system . His proposal was to divide time into discrete intervals, each interval corresponding to oneframe. This approach requires the users to agree on slot boundaries.

One way to achieve synchronization would be to have one special station emit a pip at the start of each interval, like aclock.

In Roberts' method, which has come to be known as slotted ALOHA, in contrast to Abramson'spure ALOHA, a computer is not permitted to send whenever a carriage return is typed.

Instead, it

is required to wait for the beginning of the next slot. Thus, the continuous pure ALOHA is turned into a discrete one.

Since the vulnerable period is now halved, the probability of no other traffic during the same slot as our test frame is e-G which leads to

\Equation

As you can see from Fig.3, slotted ALOHA peaks at G = 1, with a throughput of S=1/e or about 0.368, twice that of pure ALOHA. If the system is operating at G = 1, the probability of an empty slot is 0.368. The best we can hope for using slotted ALOHA is 37 percent of the slots empty, 37 percent successes, and 26 percent collisions. Operating at higher values of G reduces the number of empties but increases the number of collisions exponentially.

To see how this rapid growth of collisions with G comes about, consider the transmission of a test frame. The probability that it will avoid a collision is e-G, the probability that all the other users are silent in that slot. The probability of a collision is then just 1 – e-G. The probability of a transmission requiring exactly k attempts, (i.e., k – 1 collisions followed by one success) is

Fig.3 Throughput versus offered traffic for ALOHA systems.

The expected number of transmissions, E, per carriage

Since the vulnerable period is now halved, the probability of no other traffic during the same slot as our test frame is e-G which leads to the following equation

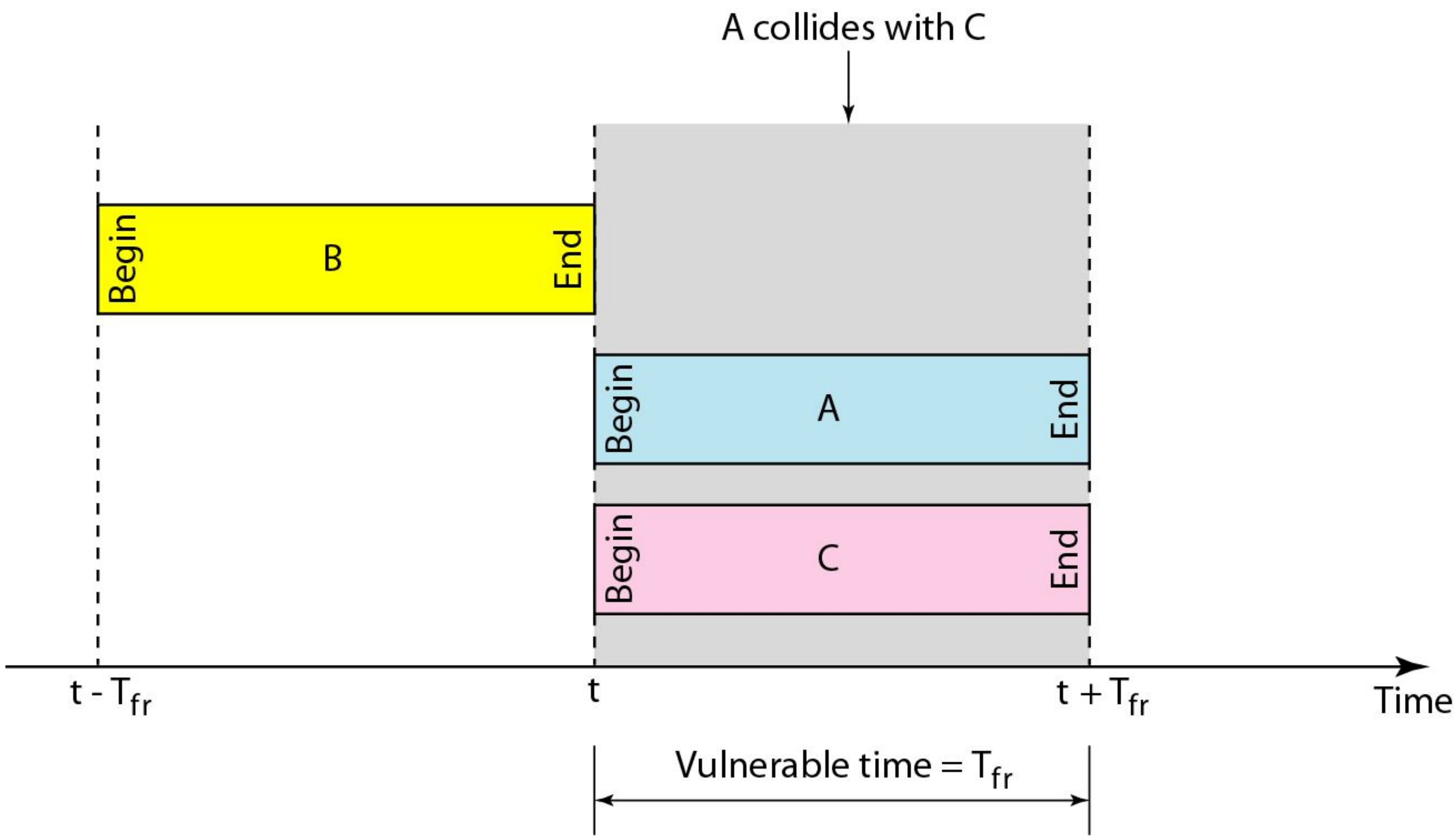
The throughput for slotted ALOHA is

$S = G \times e^{-G}$.

The maximum throughput

$S_{max} = 0.368$ when G = 1.

Figure 12.7 Vulnerable time for slotted ALOHA protocol



Example 12.4

A slotted ALOHA network transmits 200-bit frames on a shared channel of 200 kbps. What is 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

The frame transmission time is 200/200 kbps or 1 ms.

a. If the system creates 1000 frames per second, this is 1 frame per millisecond. The load is 1. In this case $S = G \times e^{-G}$ or S = 0.368 (36.8 percent). This means that the throughput is 1000 × 0.0368 = 368 frames. Only 386 frames out of 1000 will probably survive.

Example 12.4 (continued)

b. If the system creates 500 frames per second, this is (1/2) frame per millisecond. The load is (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. If the system creates 250 frames per second, this is (1/4) frame per millisecond. The load is (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.

CSMA(Carrier Sense Multiple Access Protocols):

With slotted ALOHA the best channel utilization that can be achieved is 1/e. This is hardly surprising, since with stations transmitting at will, without paying attention to what the other stations are doing, there are bound to be many collisions.

In local area networks, however, it ispossible for stations to detect what other stations are doing, and adapt their behaviour accordingly.

These networks can achieve a much better utilization than 1/e. In this section we will discuss some protocols for improving performance. Protocols in which stations listen for a carrier (i.e., a transmission) and act accordingly are called carrier sense protocols.

A number of them have been proposed. Kleinrock and Tobagi (1975) have analysed several such protocols in
detail. Below we will mention several versions of the carrier sense protocols.

i)persistent CSMA:

The first carrier sense protocol that we will study here is called 1-persistent CSMA (CarrierSense Multiple Access).

When a station has data to send, it first listens to the channel to see ifanyone else is transmitting at that moment.

If the channel is busy, the station waits until it becomes idle. When the station detects an idle channel, it transmits a frame.

 If a collision occurs,the station waits a random amount of time and starts all over again.

The protocol is called 1-persistent because the station transmits with a probability of 1 when it finds the channel idle

ii) Non-persistent CSMA:

A second carrier sense protocol is nonpersistent CSMA. In this protocol, a conscious attempt ismade to be less greedy than in the previous one.

- Before sending, a station senses the channel. Ifno one else is sending, the station begins doing so itself.

- However, if the channel is already inuse, the station does not continually sense it for the purpose of seizing it immediately upondetecting the end of the previous transmission.

- Instead, it waits a random period of time and then repeats the algorithm.

- Consequently, this algorithm leads to better channel utilization but longerdelays than 1-persistent CSMA.

iii)P-persistent CSMA:

- The last protocol is p-persistent CSMA. It applies to slotted channels and works as follows.
When a station becomes ready to send, it senses the channel. If it is idle, it transmits with aprobability p.
- With a probability q = 1 - p, it defers until the next slot. If that slot is also idle, It
either transmits or defers again, with probabilities p and q. This process is repeated until either the frame has been transmitted or another station has begun transmitting.
- In the latter case, the unlucky station acts as if there had been a collision (i.e., it waits a random time and starts again).

- If the station initially senses the channel busy, it waits until the next slot and applies the above
algorithm. Figure 4 shows the computed throughput versus offered traffic for all three protocols,
as well as for pure and slotted ALOHA.

Figure 12.8 Space/time model of the collision in CSMA

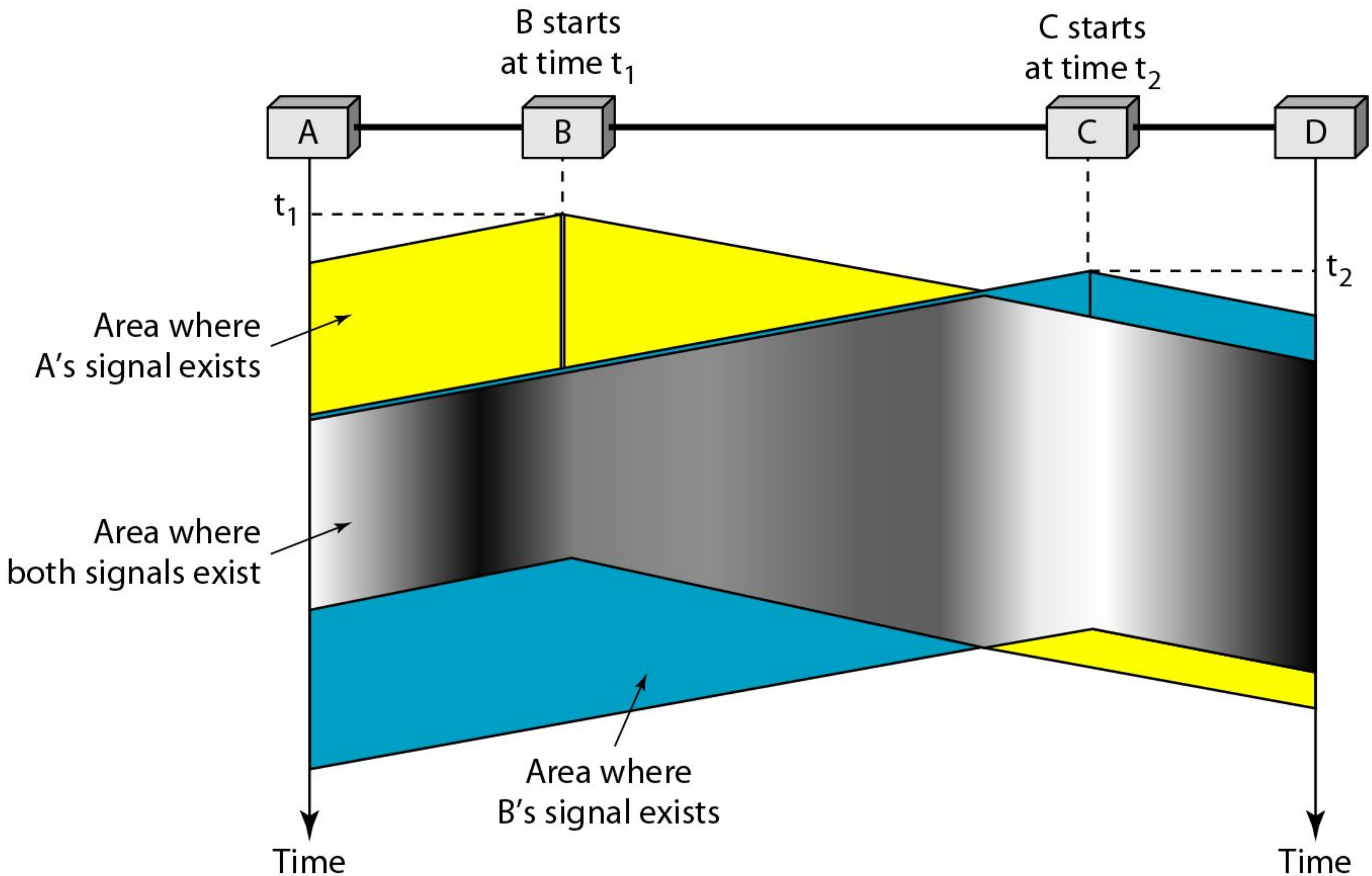


Figure 12.9 Vulnerable time in CSMA

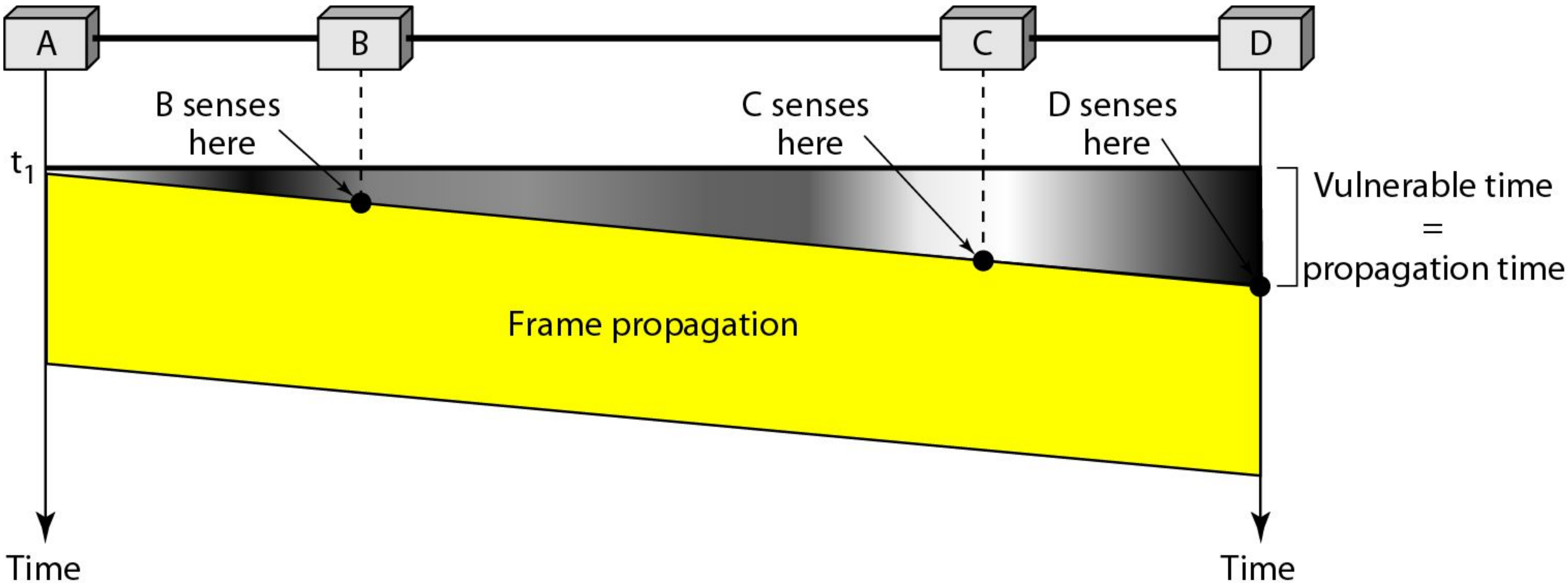
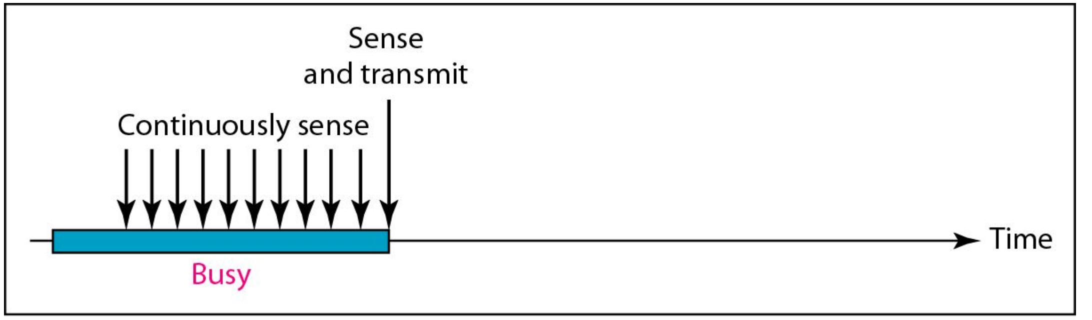
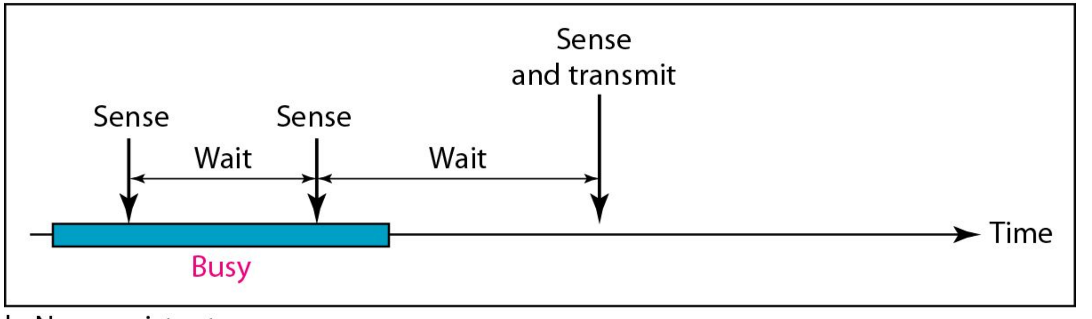


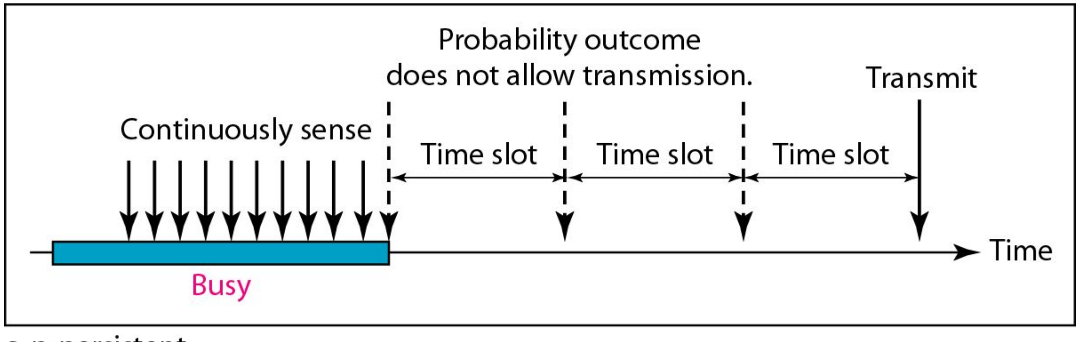
Figure 12.10 Behavior of three persistence methods



a. 1-persistent

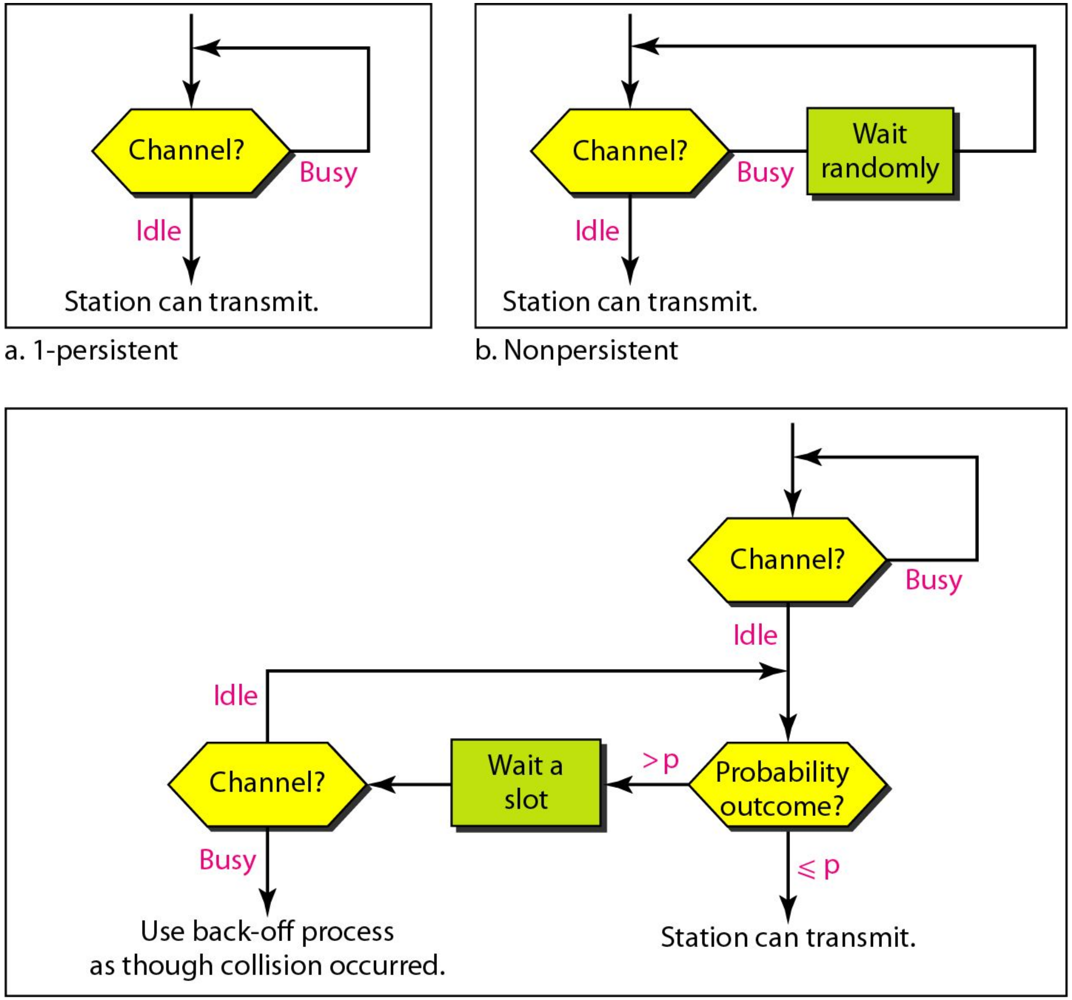


b. Nonpersistent



c. p-persistent

Figure 12.11 Flow diagram for three persistence methods



a. 1-persistent

b. Nonpersistent

c. p-persistent

Figure 12.12 Collision of the first bit in CSMA/CD

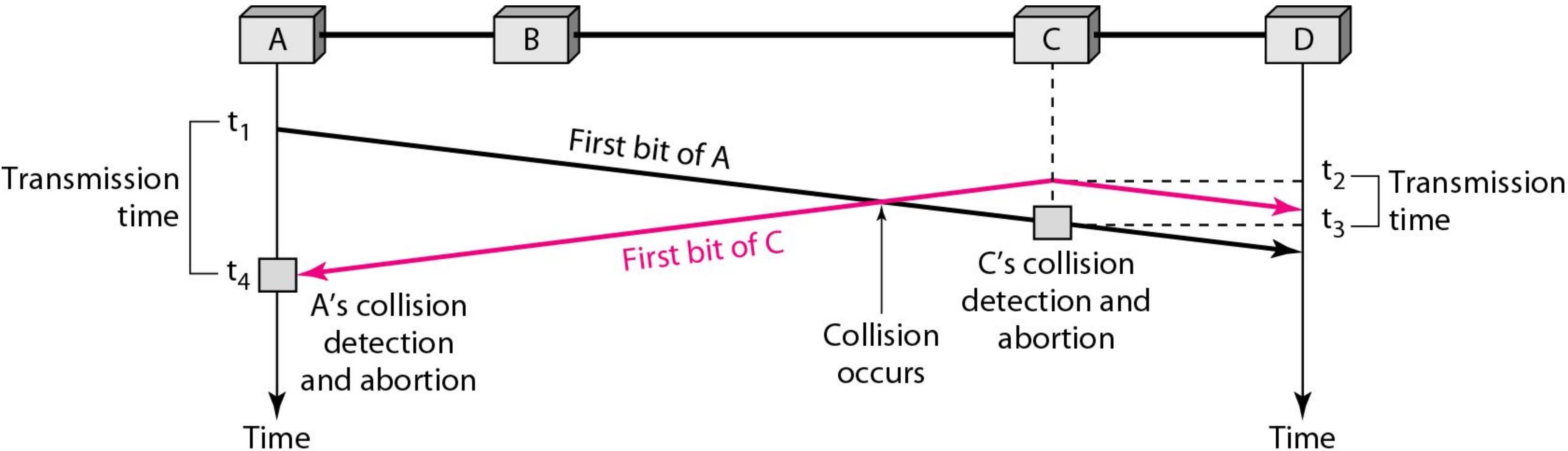


Figure 12.13 Collision and abortion in CSMA/CD

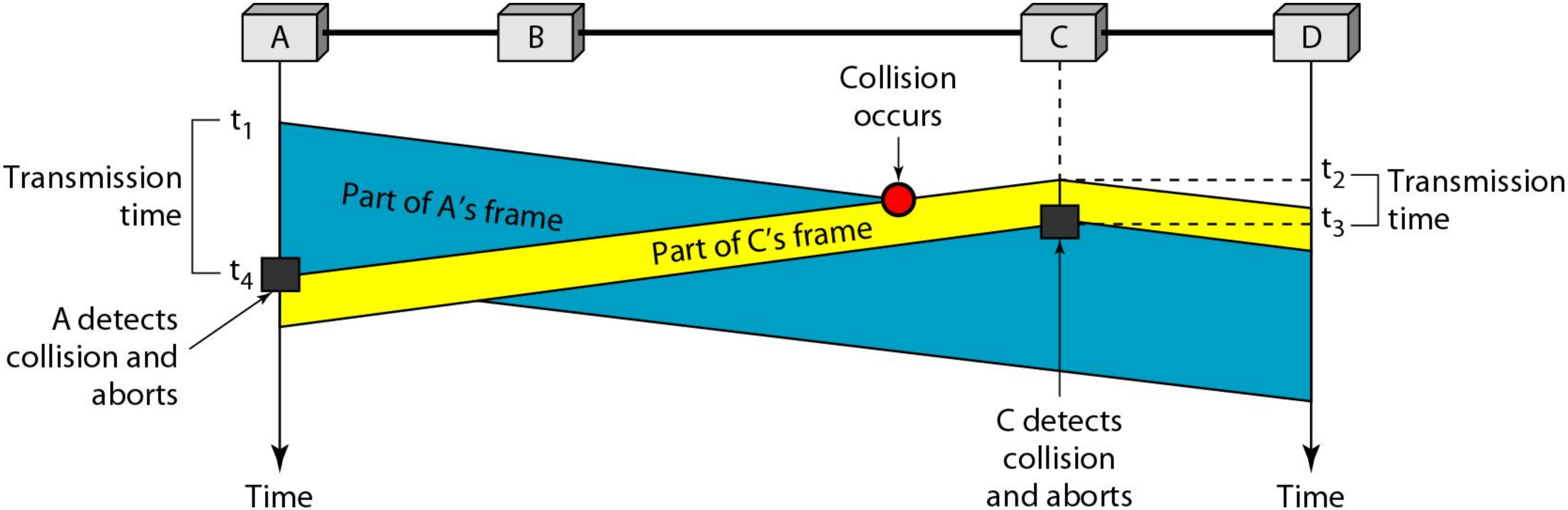


Figure 12.14 Flow diagram for the CSMA/CD

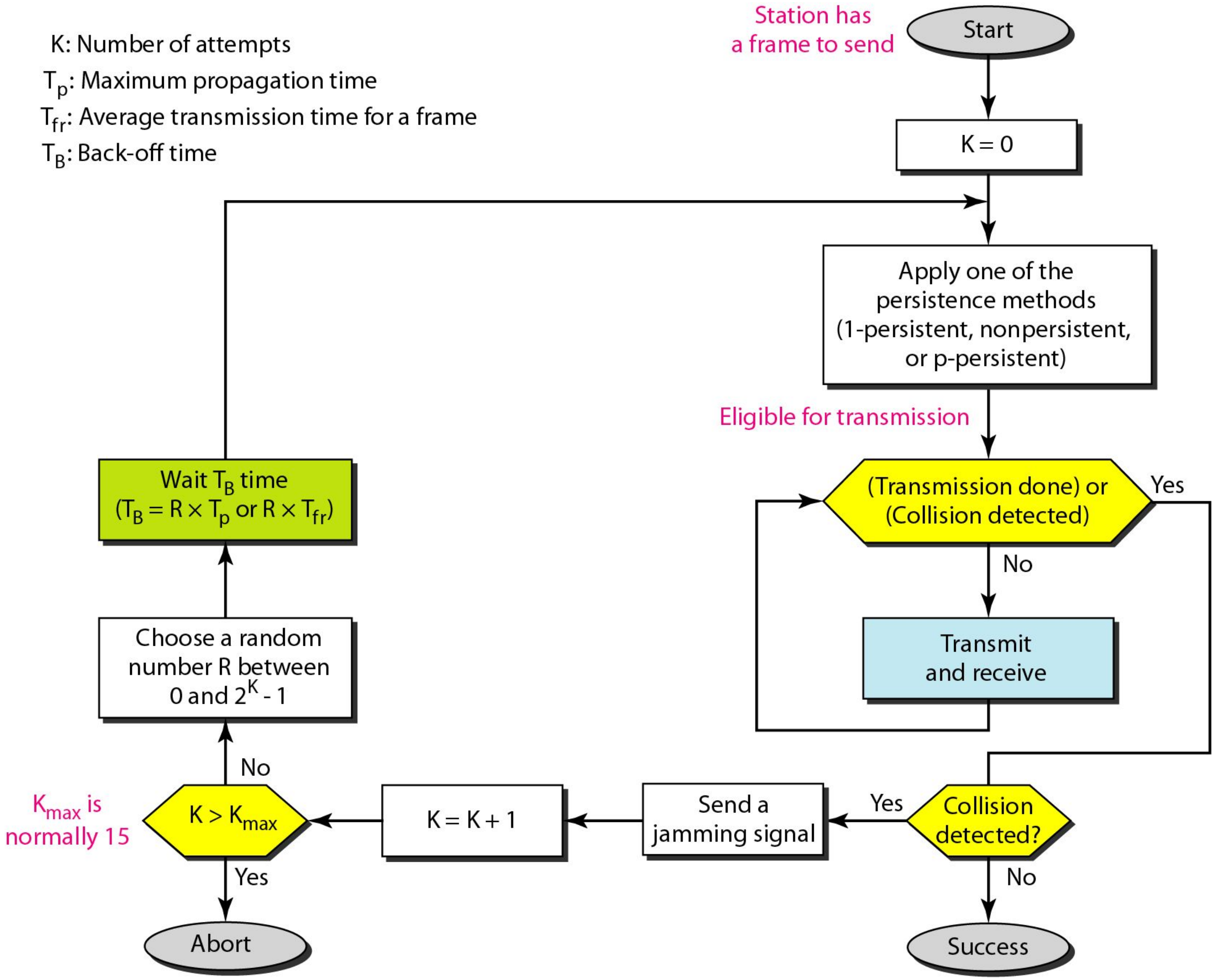
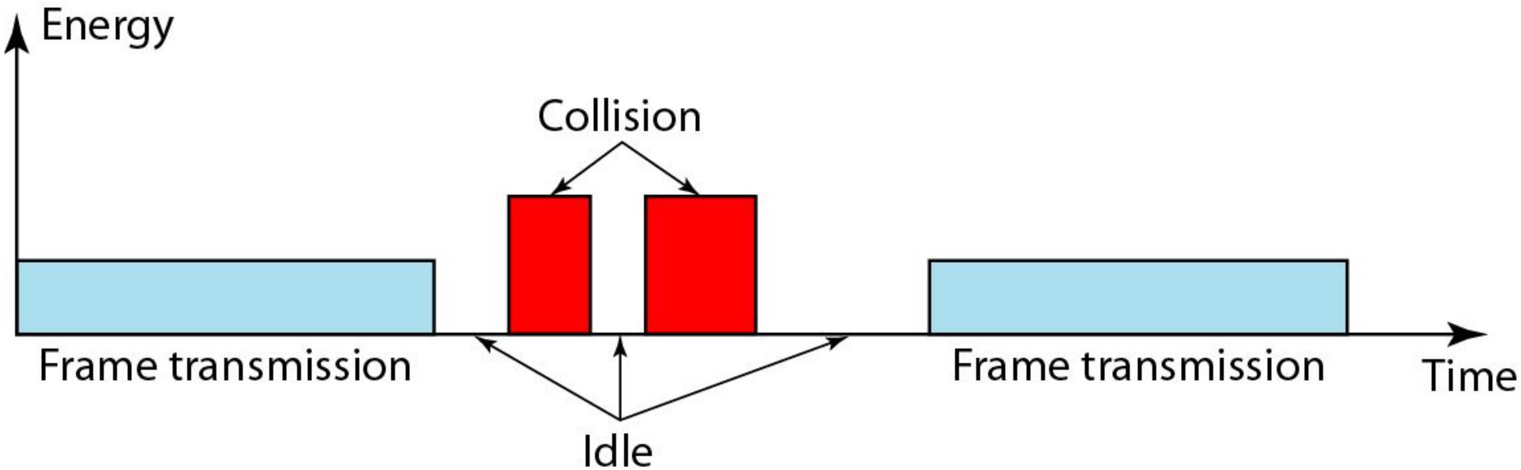


Figure 12.15 Energy level during transmission, idleness, or collision

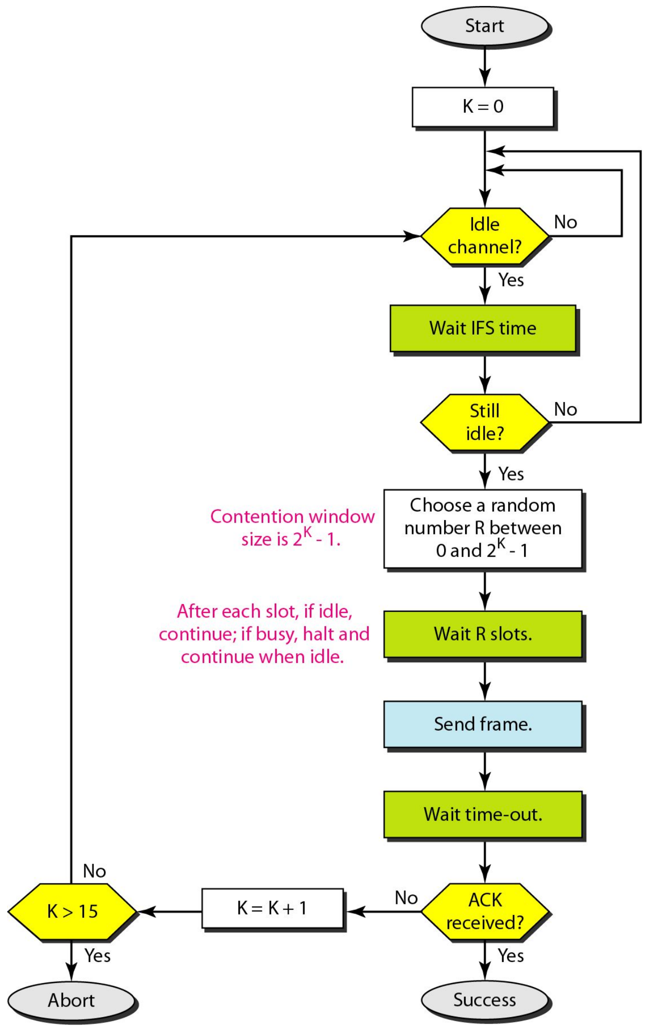


In CSMA/CA, the IFS can also be used to define the priority of a station or a frame.

Note

In CSMA/CA, if the station finds the channel busy, it does not restart the timer of the contention window;
it stops the timer and restarts it when the channel becomes idle.

Figure 12.17 Flow diagram for CSMA/CA



- **CSMA with Collision Detection:**

- Persistent and nonpersistent CSMA protocols are clearly an improvement over ALOHA because they ensure that no station begins to transmit when it senses the channel busy.
- Another improvement is for stations to abort their transmissions as soon as they detect a collision.
- In other words, if two stations sense the channel to be idle and begin transmitting simultaneously,they will both detect the collision almost immediately.
- Rather than finish transmitting their frames, which are irretrievably garbled anyway, they should abruptly stop transmitting as soon as the collision is detected. Quickly terminating damaged frames saves time and bandwidth. This protocol, known as CSMA/CD (CSMA with Collision Detection) is widely used on LANs in the MAC sublayer

CSMA/CD, as well as many other LAN protocols,uses the conceptual model At the point marked t0, a station has finished transmitting its frame.Any other station having a frame to send may now attempt to do so.
If two or more stations decide to transmit simultaneously, there will be a collision.
Collisions can be detected by looking at the power or pulse width of the received signal and comparing it to the transmitted signal