USN :

CMR Institute of Technology, Bangalore
DEPARTMENT OF INFORMATION SCIENCE AND ENGINEERING
III - INTERNAL ASSESSMENT

Semester: 4-CBCS 2018
Subject: DATA COMMUNICATION (18CS46)
Faculty: Ms Dhanya Viswanath

Date: 2 Aug 2021
Time: 01:00 PM - 02:30 PM
Max Marks: 50

Instructions to Students :

Answer any 5 FULL questions

Answer any 5 question(s)

Q.No			Marks	CO	PO	BT/CL
1	a	Explain the Stop-and-Wait protocol used in the data link layer with the help of FSM and flow diagram.	6	CO3	PO1,PO4	L2
	b	How is the issue of duplicate packets overcome in the Stop-and-Wait protocol?	4	CO3	PO1,PO4	L3
2	a	Illustrate the flow diagram for pure ALOHA and obtain an expression for vulnerable time with necessary explanation and diagrams.	6	CO3	PO1,PO4	L2
	b	A slotted ALOHA network transmits 300-bit frames using a shared channel with a 600 kbps bandwidth. Find the throughput if the system produces (i) 1000 frames per second (ii) 250 frames per second.	4	CO3	PO1,PO4	L3
3	a	Discuss how collisions are avoided in CSMA/CA.	6	CO3	PO1,PO4	L2
	b	Explain the frame exchange time line and mention the significance of the NAV timer.	4	CO3	PO1,PO4	L2
4		Explain the features of the different Standard Ethernet implementations with necessary diagrams.	10	CO4	PO1	L2
5	a	Draw and label the MAC layer frame format structure.	2	CO4	PO1	L2
	b	Explain the IEEE 802.11 addressing mechanism in detail.	8	CO4	PO1	L2
6		Explain the baseband layer in Bluetooth with emphasis on the access method and frame format.	10	CO4	PO1	L2

Question #	Description	Marks Distribution	Max Marks
1	(a) Explain the Stop-and-Wait protocol used in the data link layer with the help of FSM and flow diagram. • Explanation with block diagram • FSM for sender and receiver sides with explanation • Flow diagram	2 M * 3	10 M
	(b) How is the issue of duplicate packets overcome in the Stop-and-Wait protocol? • Sequence and acknowledgement numbers concept • Modified flow diagram	2 M * 2	
2	(a) Illustrate the flow diagram for pure ALOHA and obtain an expression for vulnerable time with necessary explanation and diagrams. • Flow diagram with explanation • Vulnerable time calculation diagram & expression	3 M * 2	10 M

	(b) A slotted ALOHA network transmits 300-bit frames using a shared channel with a 600 kbps bandwidth. Find the throughput if the system produces (i) 1000 frames per second (ii) 250 frames per second. • Calculation of T_{fr} • Obtain value of G • Expression for throughput • Calculating how many frames actually survive	1 M * 4	
3	(a) Discuss how collisions are avoided in CSMA/CA. • Explain concept of IFS, contention window and acknowledgement • Flow diagram of CSMA/CA	3 M * 2	10 M
	(b) Explain the frame exchange time line and mention the significance of the NAV timer. • Frame exchange time line with explanation • NAV timer concept explanation	2 M * 2	
4	Explain the features of the different Standard Ethernet implementations with necessary diagrams. • 4 implementations – 10Base5, 10Base2, 10Base-T and 10Base-F • Include diagrams, type of medium, encoding, medium length and explanation	2.5 M * 4	10 M
5	(a) Draw and label the MAC layer frame format structure. • Frame structure with each field labelled	2 M	10 M
	(b) Explain the IEEE 802.11 addressing mechanism in detail. • Explain the 4 cases of To DS and From DS values and how the values of the 4 Address fields change for each case. • Diagrams for each case	2 M * 4	
6	Explain the baseband layer in Bluetooth with emphasis on the access method and frame format. • Access method – TDMA – explanation of SSC and MSC with diagrams	5 M * 2	10 M

	• Frame format – 3 types based on slots, frame structure with each field labelled		

1a. Explain the Stop-and-Wait protocol used in the data link layer with the help of FSM and flow diagram.

Stop-and-Wait Protocol

1. Second protocol is called the Stop-and-Wait protocol, which uses both flow and error control.
2. In this protocol, the sender sends one frame at a time and waits for an acknowledgment before sending the next one.
3. To detect corrupted frames, we need to add a CRC to each data frame.
4. When a frame arrives at the receiver site, it is checked. If its CRC is incorrect, the frame is corrupted and silently discarded.
5. The silence of the receiver is a signal for the sender that a frame was either corrupted or lost.
6. Every time the sender sends a frame, it starts a timer. If an acknowledgment arrives before the timer expires, the timer is stopped and the sender sends the next frame (if it has one to send).
7. If the timer expires, the sender resends the previous frame, assuming that the frame was either lost or corrupted.
8. This means that the sender needs to keep a copy of the frame until its acknowledgment arrives.
9. When the corresponding acknowledgment arrives, the sender discards the copy and sends the next frame if it is ready.
10. Figure shows the outline for the Stop-and-Wait protocol.
11. Note that only one frame and one acknowledgment can be in the channels at any time.

Figure 11.10 *Stop-and-Wait protocol*

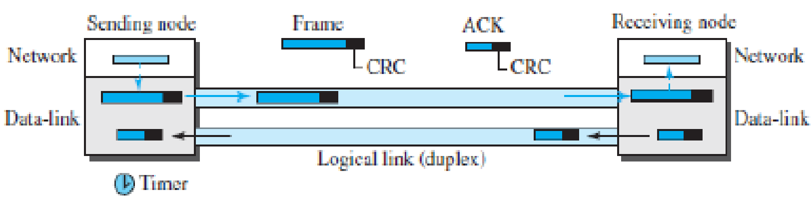
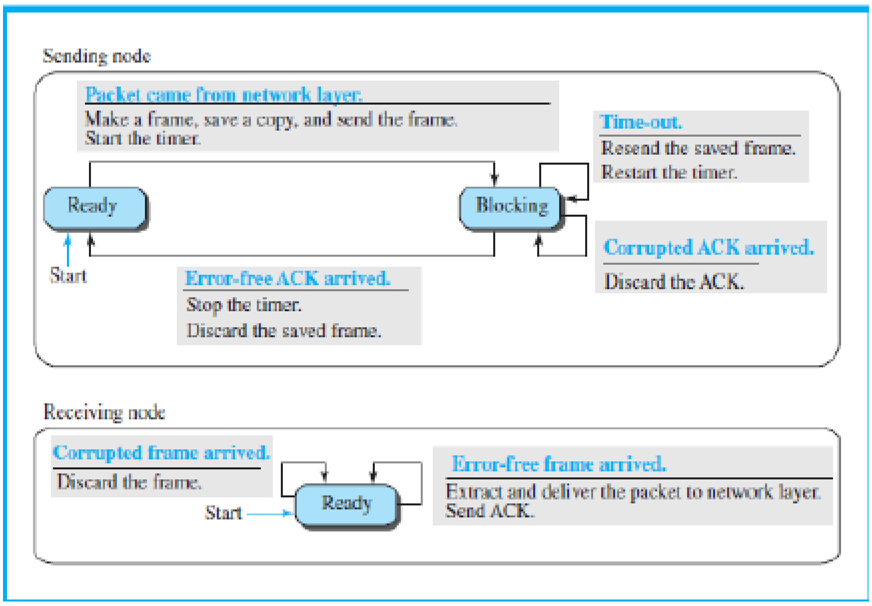


Figure 11.11 *FSM for the Stop-and-Wait protocol*



We describe the sender and receiver states below.

Sender States

The sender is initially in the Ready state, but it can move between the Ready and Blocking state.

1. **Ready State**

   - When the sender is in this state, it is only waiting for a packet from the network layer.
   - If a packet comes from the network layer, the sender creates a frame, saves a copy of the frame, starts the timer and sends the frame.
   - The sender then moves to the Blocking state.

2. **Blocking State:** When the sender is in this state, three events can occur

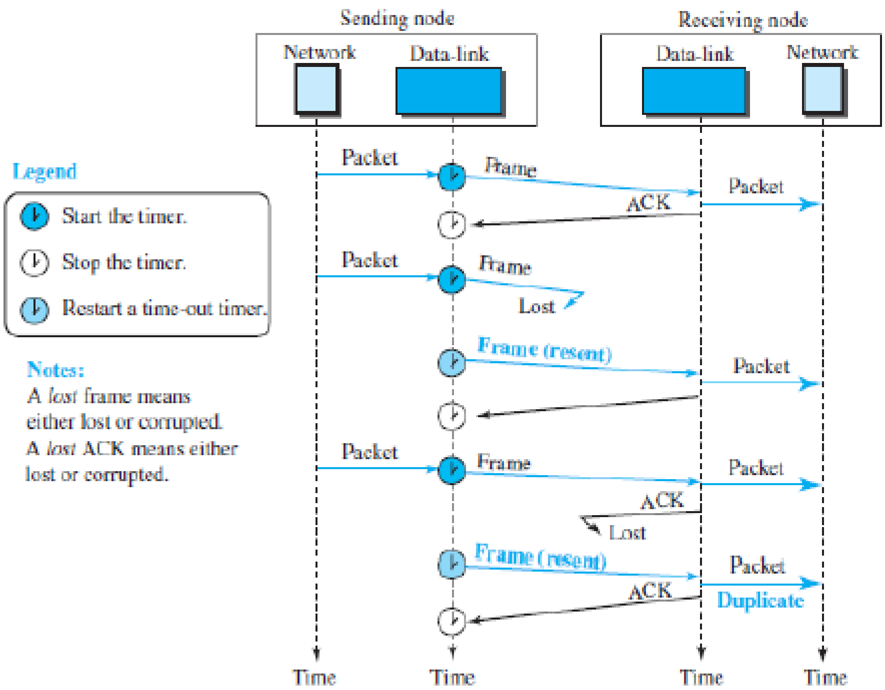
   - If a time-out occurs, the sender resends the saved copy of the frame and restarts the timer.
   - If a corrupted ACK arrives, it is discarded.
   - If an error-free ACK arrives, the sender stops the timer and discards the saved copy of the frame. It then moves to the Ready state.

Receiver States

The receiver is always in the Ready state. Two events may occur:

• If an error-free frame arrives, the message in the frame is delivered to the network layer and an ACK is sent.

• If a corrupted frame arrives, the frame is discarded.

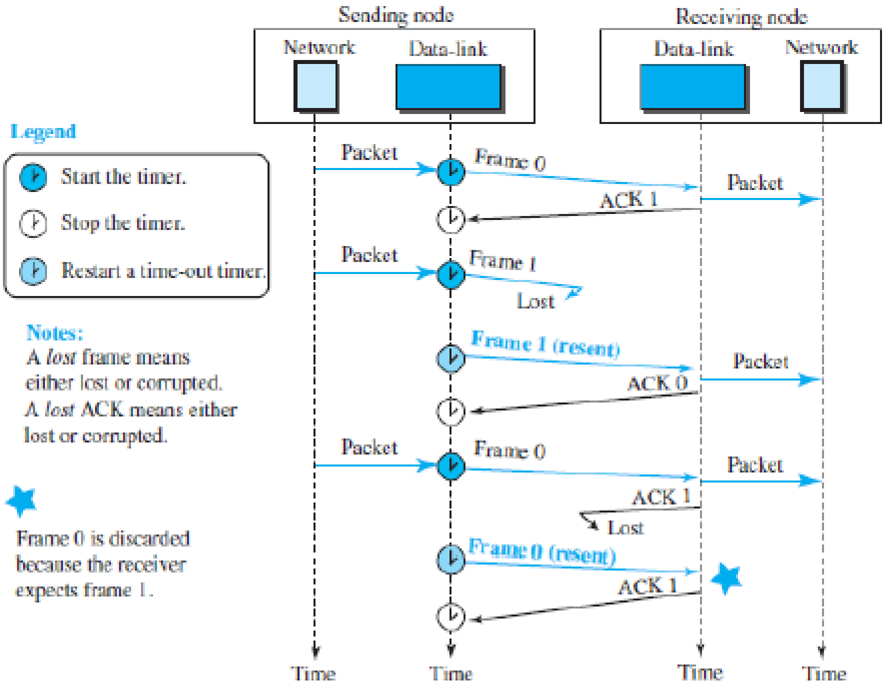


1b. How is the issue of duplicate packets overcome in the Stop-and-Wait protocol?

Sequence and Acknowledgment Numbers
The problem of duplicate packets needs to be addressed and corrected. Duplicate packets, as much as corrupted packets, need to be avoided. To correct the problem in the above example, we need to add sequence numbers to the data frames and acknowledgment numbers to the ACK frames. However, numbering in this case is very simple. Sequence numbers are 0, 1, 0, 1, 0, 1,.. .; the acknowledgment numbers can also be 1, 0, 1, 0, 1, 0, … In other words, the sequence numbers start with 0, the acknowledgment numbers start with 1. An acknowledgment number always defines the sequence number of the next frame to be received.

Figure 11.13 shows how adding sequence numbers and acknowledgment numbers can prevent duplicates. The first frame is sent and acknowledged. The second frame is sent, but lost. After time-out, it is resent. The third frame is sent and acknowledged, but the acknowledgment is lost. The frame is resent.

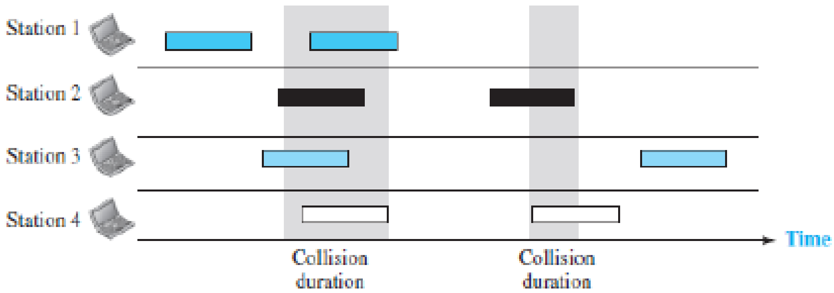
Figure 11.13 *Flow diagram for Example 11.4*



2a. Illustrate the flow diagram for pure ALOHA and obtain an expression for vulnerable time with necessary explanation and diagrams.

Pure ALOHA

The idea is that each station sends a frame whenever it has a frame to send (multiple access). However, since there is only one channel to share, there is the possibility of collision between frames from different stations.



For example, consider the above example of a pure ALOHA network.
There are four stations that contend with one another for access to the shared channel. The figure shows that each station sends two frames; there are a total of eight frames on the shared medium. Some of these frames collide because multiple frames are in contention for the shared channel. The figure shows that only two frames survive: one frame from station 1 and one frame from station 3. (We need to mention that even if one bit of a frame coexists on the channel with one bit from another frame, there is a collision and both will be destroyed.) So, it is obvious that we need to resend the frames that have been destroyed during transmission.

Here is how Pure ALOHA works:

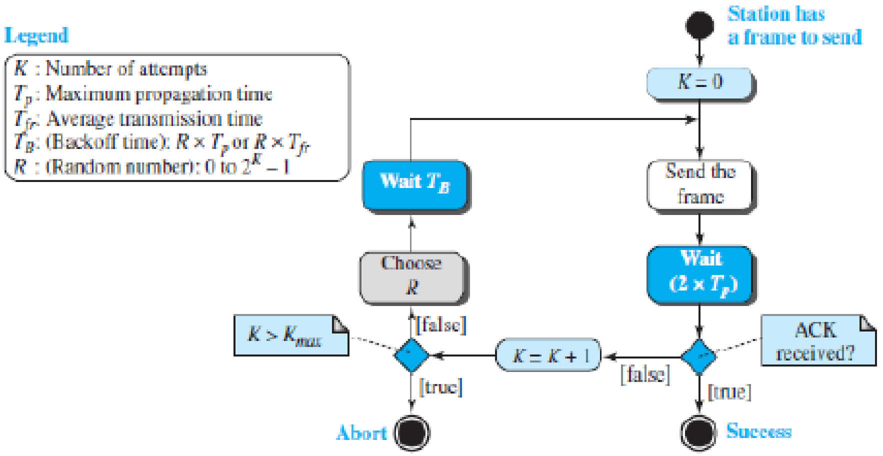
- The sender sends a frame & starts the timer.
- The receiver receives the frame and responds with an acknowledgment.
- If the acknowledgment does not arrive after a time-out period, the sender resends the frame as the sender assumes that the frame (or the acknowledgment) has been destroyed.
- Since the medium is shared between the stations, there is the possibility of collisions.
- If two stations try to resend the frames after the time-out, the frames will collide again.
- There are two methods to deal with collision:

  Randomness

  When the time-out period passes, each station waits a random amount of time before resending the frame. This time is called back-off time T_B. The randomness will help avoid more collisions.

  Limit Maximum Retransmission

  This method prevents congestion by reducing the number of retransmitted frames. After a maximum number of retransmission attempts K_{max}, a station must give up and try later.

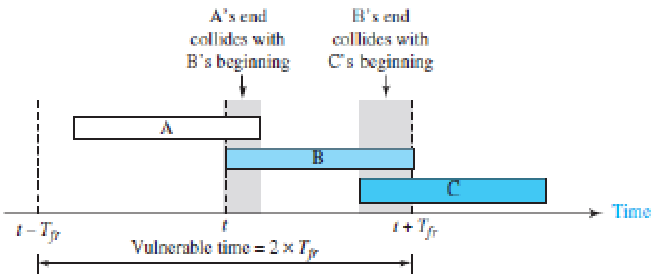


Vulnerable time

- The vulnerable-time is defined as a time during which there is a possibility of collision.

Pure ALOHA vulnerable time = $2 \times T_{fr}$

where T_{fr} = Frame transmission time



In Figure,

If station B sends a frame between $t-T_{fr}$ and t, this leads to a collision between the frames from station A and station B.

If station C sends a frame between t and $t+T_{fr}$, this leads to a collision between the frames from station A and station C.

2b. A slotted ALOHA network transmits 300-bit frames using a shared channel with a 600 kbps bandwidth. Find the throughput if the system produces (i) 1000 frames per second (ii) 250 frames per second.

2b. 300 bit frames → 600 kbps bandwidth.

∴ Frame transmission time, $T_{fr} = \frac{300 \text{ bits}}{600 \text{ kbps}}$

$= 0.5$ ms.

① 1000 frames per second.

1000 frames → in 1 sec.

⇒ 1 frame → in 1 ms.

⇒ 0.5 frame → in 0.5 ms.

⇒ $G = 0.5$

∴ Throughput, $S = G \times e^{-G} = 0.5 \times e^{-0.5}$

$S = 0.303 = 30.3\%$.

⇒ Only 30.3% of 1000 frames will survive.

⇒ 30.3% of 1000 = 0.303 × 1000

= 303 frames.

② 250 frames per second.

250 frames → in 1 sec.

⇒ 0.25 frames → in 1 ms.

⇒ 0.125 frames → in 0.5 ms.

⇒ $G = 0.125$

∴ Throughput, $S = G \times e^{-G} = 0.125 \times e^{-0.125}$

$S = 0.1103 = 11.03\%$

⇒ Only 11% of 250 frames will survive

⇒ 11% of 250 = 0.11 × 250 = 27 frames.

3a. Discuss how collisions are avoided in CSMA/CA.

CSMA/CA

Here is how it works:

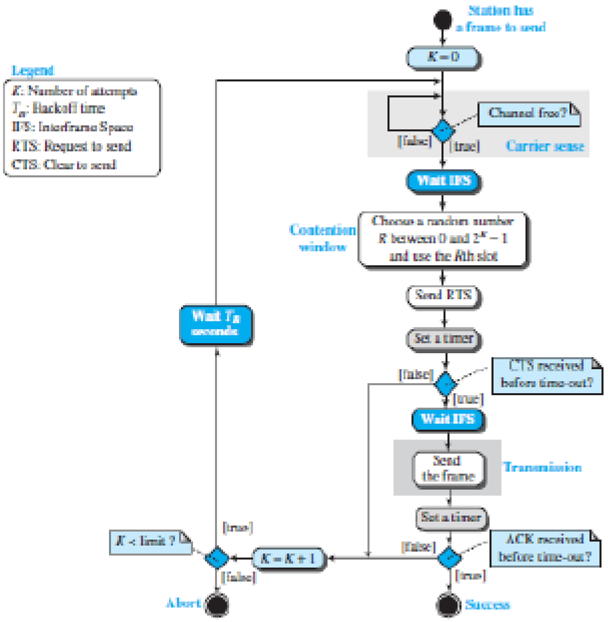
A station needs to be able to receive while transmitting to detect a collision.

When there is no collision, the station receives one signal: its own signal. When there is a collision, the station receives 2 signals:

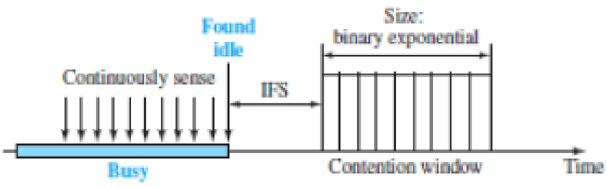
Its own signal and

Signal transmitted by a second station.

To distinguish b/w these 2 cases, the received signals in these 2 cases must be different.



Collisions are avoided through the use of CSMA/CA's three strategies: the interframe space, the contention window, and acknowledgments.



1) Interframe Space (IFS)

Collisions are avoided by deferring transmission even if the channel is found idle. When the channel is idle, the station does not send immediately.

Rather, the station waits for a period of time called the inter-frame space or IFS.

- After the IFS time,
  if the channel is still idle, then, the station waits for the contention-time & finally, the station sends the frame.
- IFS variable can also be used to prioritize stations or frame types.
  For example, a station that is assigned a shorter IFS has a higher priority.

2) Contention Window

The contention-window is an amount of time divided into time-slots. A ready-station chooses a random-number of slots as its wait time.

In the window, the number of slots changes according to the binary exponential back-off strategy. For example:

At first time, number of slots is set to one slot and

Then, number of slots is doubled each time if the station cannot detect an idle channel.

3) Acknowledgment

There may be a collision resulting in destroyed-data.

In addition, the data may be corrupted during the transmission.

To help guarantee that the receiver has received the frame, we can use Positive acknowledgment and Time-out timer

3b. Explain the frame exchange time line and mention the significance of the NAV timer.

Frame Exchange Time Line

- Two control frames are used: 1) Request to send (RTS) 2) Clear to send (CTS)
- The procedure for exchange of data and control frames in time (Figure 12.17):

1) The source senses the medium by checking the energy level at the carrier frequency. If the medium is idle,

then the source waits for a period of time called the DCF interframe space (DIFS); finally, the source sends a RTS.

The destination

receives the RTS

waits a period of time called the short interframe space (SIFS)

sends a control frame CTS to the source.

CTS indicates that the destination station is ready to receive data.

The source

receives the CTS

waits a period of time SIFS

sends a data to the destination

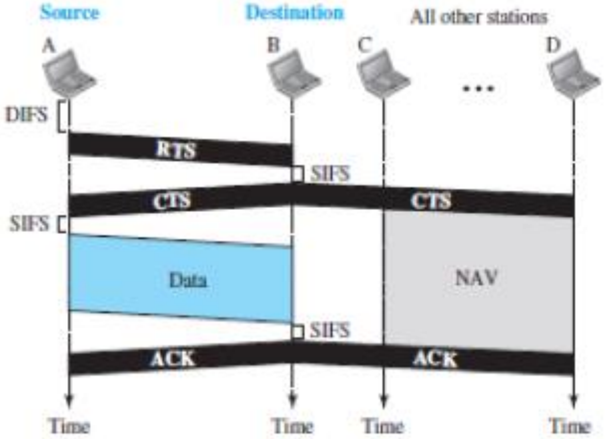
The destination

receives the data

waits a period of time SIFS

sends a acknowledgment ACK to the source.

ACK indicates that the destination has been received the frame.



Network Allocation Vector

- When a source-station sends an RTS, it includes the duration of time that it needs to occupy the channel.
- The remaining stations create a timer called a network allocation vector (NAV).
- NAV indicates waiting time to check the channel for idleness.
- Each time a station accesses the system and sends an RTS frame, other stations start their NAV.

4. Explain the features of the different Standard Ethernet implementations with necessary diagrams.

Implementation	Medium	Medium Length	Encoding
10Base5	Thick coax	500 m	Manchester
10Base2	Thin coax	185 m	Manchester
10Base-T	2 UTP	100 m	Manchester
10Base-F	2 Fiber	2000 m	Manchester

Encoding and Decoding

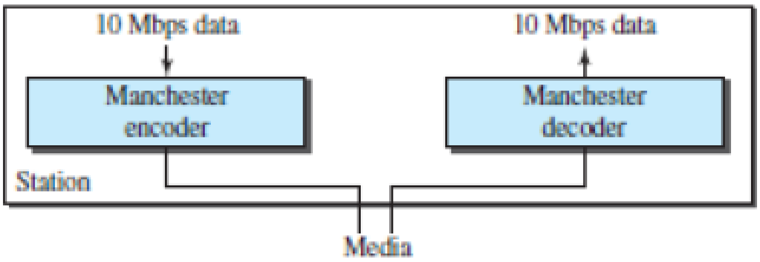
All standard implementations use digital-signaling (baseband) at 10 Mbps (Figure 13.6).

At the sender, data are converted to a digital-signal using the Manchester scheme.

At the receiver, the received-signal is

interpreted as Manchester and

decoded into data.



10Base5: Thick Ethernet

10Base5 uses a bus topology.

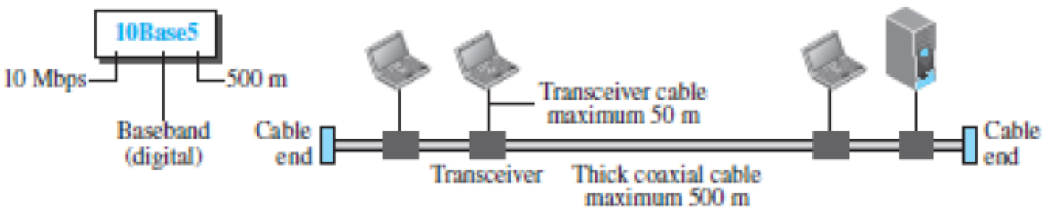
A external transceiver is connected to a thick coaxial-cable. (transceiver - transmitter/receiver)

The transceiver is

- responsible for
- transmitting
- receiving and
- detecting collisions.

The transceiver is connected to the station via a coaxial-cable. The cable provides separate paths for sending and receiving.

The collision can only happen in the coaxial cable.



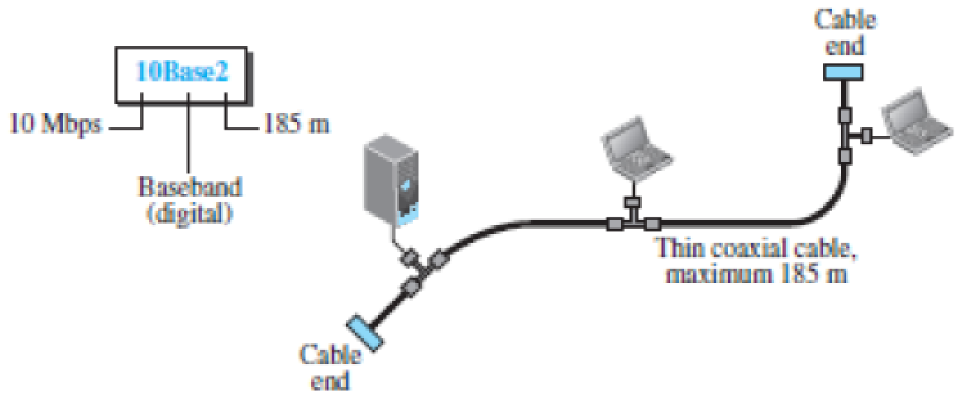
The maximum-length of the cable must not exceed 500m.

If maximum-length is exceeded, then there will be excessive degradation of the signal.

If a length of more than 500 m is needed, up to five segments, each a maximum of 500 meters, can be connected using repeaters.

10Base2: Thin Ethernet

10Base2 uses a bus topology (Figure 13.8). The cable is much thinner and more flexible than 10Base5.
Flexible means the cable can be bent to pass very close to the stations. The transceiver is part of the NIC, which is installed inside the station. The collision can only happen in the coaxial cable.



Advantages:

Thin coaxial-cable is less expensive than thick coaxial-cable.

Tee connections are much cheaper than taps.

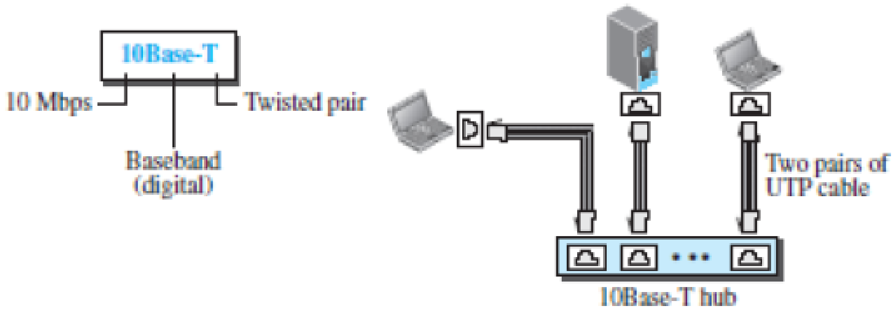
Installation is simpler because the thin coaxial cable is very flexible.

Disadvantage:

Length of each segment cannot exceed 185m due to the high attenuation in the cable.

10Base- T: Twisted-Pair Ethernet

10Base-T uses a star topology to connect stations to a hub. The stations are connected to a hub using two pairs of twisted-cable.



Two pairs of twisted cable create two paths between the station and the hub.

First path for sending.

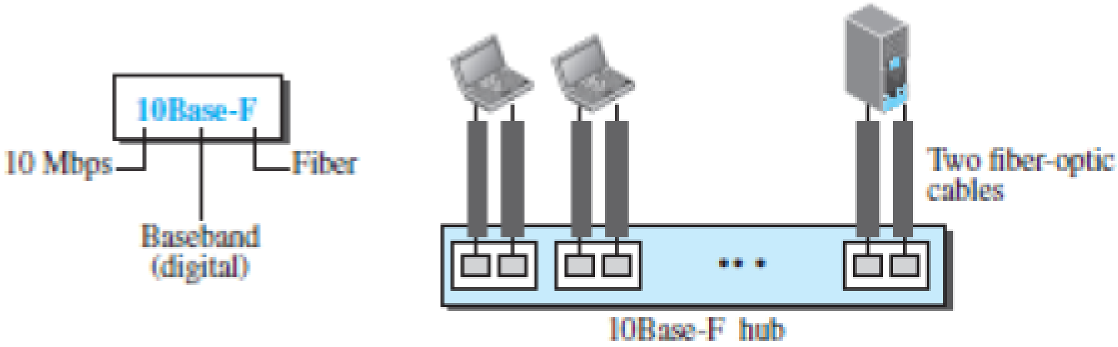
Second path for receiving.

The collision can happen in the hub.

The maximum length of the cable is 100 m. This minimizes the effect of attenuation in the cable.

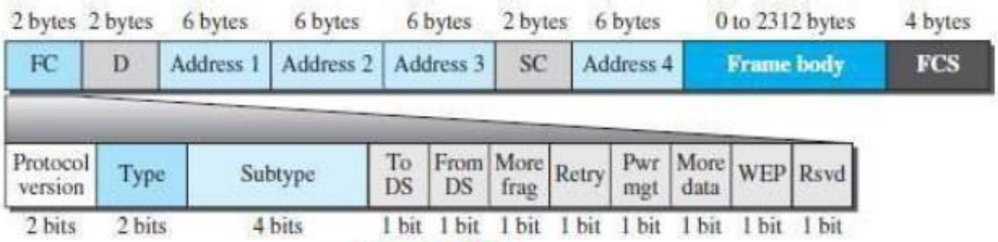
10Base-F: Fiber Ethernet

10Base-F uses a star topology to connect stations to a hub. The stations are connected to the hub using two fiber-optic cables.



5a. Draw and label the MAC layer frame format structure.

Frame Format



5b. Explain the IEEE 802.11 addressing mechanism in detail.

The IEEE 802.11 addressing mechanism specifies 4 cases, defined by the value of the 2 flags in the FC field, To DS and From DS. (DS stands for Distribution System).

Each flag can be either 0 or 1, resulting in 4 different situations.

The interpretation of the 4 addresses (address 1 to address 4) in the MAC frame depends on the value of these flags, as shown in the Table.

To DS	*From DS*	*Address 1*	*Address 2*	*Address 3*	*Address 4*
0	0	Destination	Source	BSS ID	N/A
0	1	Destination	Sending AP	Source	N/A
1	0	Receiving AP	Source	Destination	N/A
1	1	Receiving AP	Sending AP	Destination	Source

Address 1 is always the address of the next device. Address 2 is always the address of the previous device.

Address 3 is the address of the final destination-station if it is not defined by address 1. Address 4 is the address of the original source-station if it is not the same as address 2.

Case-1: 00

In this case, To DS = 0 and From DS = 0 (Figure a).

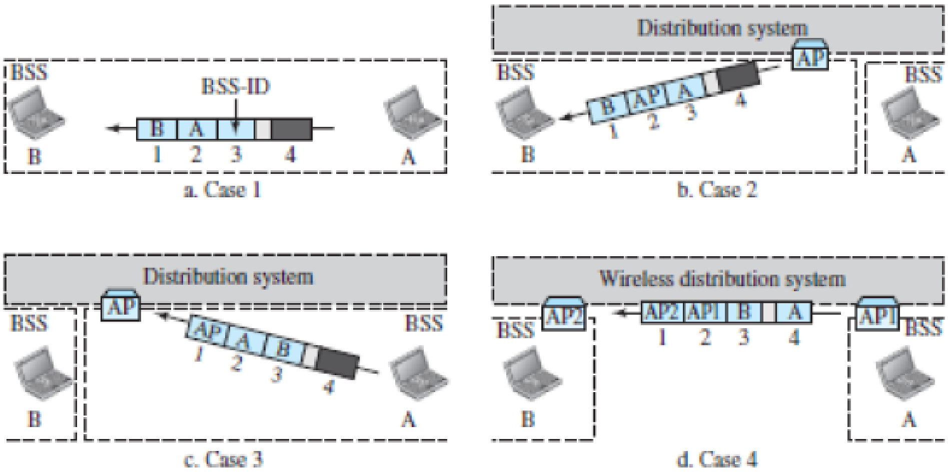
This means that the frame is

not going to a distribution-system (To DS = 0) and is

not coming from a distribution-system (From DS = 0).

The frame is going from one station in a BSS to another without passing through the distribution-system.

The ACK frame should be sent to the original sender.



Case-2: 01

In this case, To DS = 0 and From DS = 1 (Figure b).

This means that the frame is coming from a distribution-system (From DS = 1). The frame is coming from an AP and going to a station.

The ACK should be sent to the AP.

The address 3 contains the original sender of the frame (in another BSS).

Case-3: 10

In this case, To DS = 1 and From DS = 0 (Figure c).

This means that the frame is going to a distribution-system (To DS = 1).

The frame is going from a station to an AP. The ACK is sent to the original station. The address 3 contains the final destination of the frame (in another BSS).

Case-4: 11

In this case, To DS = 1 and From DS = 1 (Figure 15.11d).

This is the case in which the distribution-system is also wireless.

The frame is going from one AP to another AP in a wireless distribution-system.

We do not need to define addresses if the distribution-system is a wired LAN because the frame in these cases has the format of a wired LAN frame (for example: Ethernet.).

Here, we need four addresses to define

original sender, final destination, and two intermediate APs.

6. Explain the baseband layer in Bluetooth with emphasis on the access method and frame format.

The baseband layer is roughly equivalent to the MAC sublayer in LANs. The access method is TDMA.

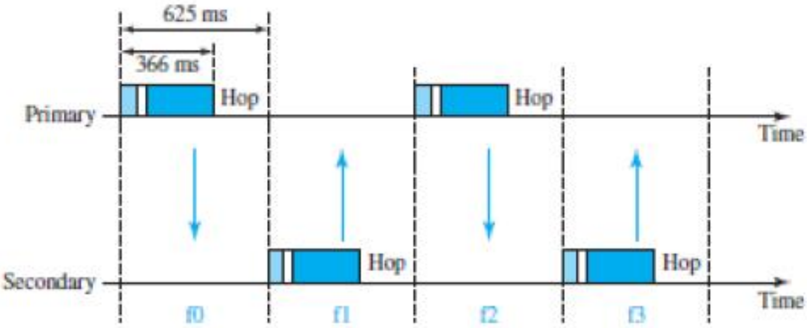
The primary and secondary communicate with each other using time slots. The length of a time slot is exactly the same as the dwell time, 625 µs.

This means that during the time that one frequency is used, a sender sends a frame to a secondary, or a secondary sends a frame to the primary. The communication is only between the primary and a secondary; secondaries cannot communicate directly with one another.

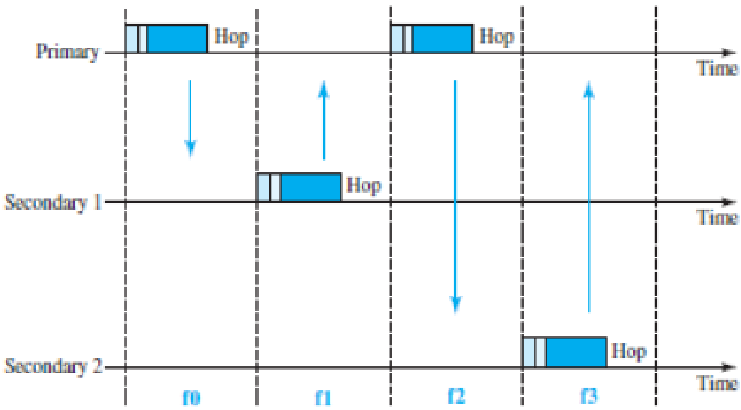
TDMA

Bluetooth uses a form of TDMA that is called ***TDD-TDMA (time-division duplexTDMA).*** TDD-TDMA is a kind of half-duplex communication in which the sender and receiver send and receive data, but not at the same time (half-duplex); however, the communication for each direction uses different hops.

Single-Secondary Communication If the piconet has only one secondary, the TDMA operation is very simple. The time is divided into slots of 625 μs. The primary uses even-numbered slots (0, 2, 4, . . .); the secondary uses odd-numbered slots (1, 3, 5, . . .). TDD-TDMA allows the primary and the secondary to communicate in half-duplex mode. In slot 0, the primary sends and the secondary receives; in slot 1, the secondary sends and the primary receives. The cycle is repeated.



Multiple-Secondary Communication The process is a little more involved if there is more than one secondary in the piconet. Again, the primary uses the even-numbered slots, but a secondary sends in the next odd-numbered slot if the packet in the previous slot was addressed to it. All secondaries listen on even-numbered slots, but only one secondary sends in any odd-numbered slot. Figure 15.22 shows a scenario.



Let us elaborate on the figure.

1. In slot 0, the primary sends a frame to secondary 1.
2. In slot 1, only secondary 1 sends a frame to the primary because the previous frame was addressed to secondary 1; other secondaries are silent.
3. In slot 2, the primary sends a frame to secondary 2.
4. In slot 3, only secondary 2 sends a frame to the primary because the previous frame was addressed to secondary 2; other secondaries are silent.
5. The cycle continues.

We can say that this access method is similar to a poll/select operation with reservations. When the primary selects a secondary, it also polls it. The next time slot is reserved for the polled station to send its frame. If the polled secondary has no frame to send, the channel is silent.

Frame Types

- A frame in the baseband layer can be one of 3 types: 1) one-slot 2) three-slot or 3) five-slot.

1) One-slot frame

A slot is 625 μs.

However, in a one-slot frame exchange, 259 μs is needed for hopping & control mechanisms.

This means that a one-slot frame can last only 625 - 259, or 366 μs.

With a 1-MHz bandwidth and 1 bit/Hz, the size of a one-slot frame is 366 bits.

2) Three-slot frame

A three-slot frame occupies 3 slots.

However, since 259 μs is used for hopping, the length of the frame is 3 x 625 - 259 = 1616 μs or 1616 bits.

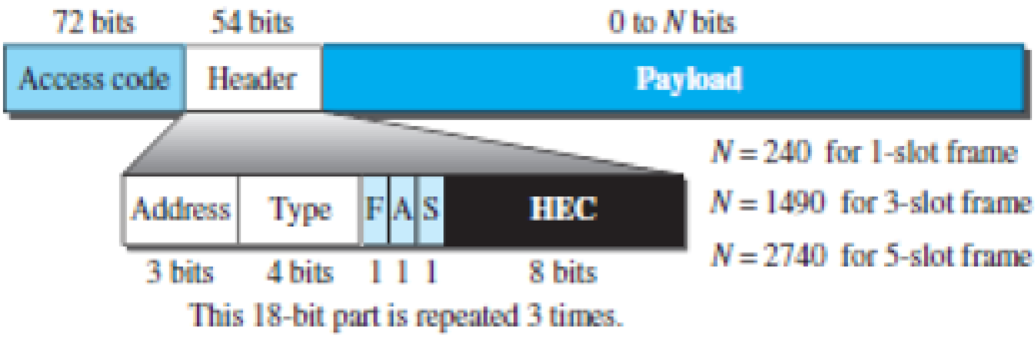
A device that uses a three-slot frame remains at the same hop (at the same carrier frequency) for 3 slots.

Even though only once hop number is used, 3 hop numbers are consumed.

That means the hop number for each frame is equal to the first slot of the frame.

3) Five-slot frame

A five-slot frame also uses 259 bits for hopping, which means that the length of the frame is 5 x 625 - 259 =2866 bits.



Frame Format

- The following describes each field:

4) Access code

This field contains synchronization bits and the identifier of the primary to distinguish the frame ofone piconet from anothe

5) Header

This field is a repeated I8-bit pattern. Each pattern has the following subfields:

i)Address

This subfield can define up to 7 secondaries (1 to 7).

If the address is zero, it is used for broadcast communication from the primary to all secondaries.

ii) Type

This subfield defines the type of data coming from the upper layers.

iii) **F**

This subfield is for flow control.

When set (1), it indicates that the device is unable to receive more frames (buffer is full).

iv) **A**

This subfield is for acknowledgment.
Bluetooth uses Stop-and-Wait ARQ.

- 1 bit is sufficient for acknowledgment.

v) **S**

This subfield holds a sequence number. Bluetooth uses Stop-and-Wait ARQ
1 bit is sufficient for sequence numbering.

vi) HEC (header error correction)

This subfield is a checksum to detect errors in each 18-bit header section.

The header has three identical 18-bit sections.

The receiver compares these three sections, bit by bit.

If each of the corresponding bits is the same, the bit is accepted; if not, the majority opinion rules.

This is a form of forward error correction (for the header only).

This double error control is needed because the nature of the communication, via air, is very noisy.

There is no retransmission in this sublayer.

6) Payload

This subfield can be 0 to 2740 bits long.

It contains data or control information coming from the upper layers.