USN											CMRIT

Internal Assessment Test 2 – April 2018

Sub:	Data Communication				Sub Code:	15CS46	Branch:	CSE
Date:	18/04/2018	Duration:	90 min's	Max Marks: 50	Sem / Sec:	IV A and B		OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1 a.	Explain multiplexing and demultiplexing process applied in FDM	08	CO2	L2
b.	Assume that a voice channel occupies a bandwidth of 4KHz. We need to multiplex 10 voice channels with guard bands of 500Hz using FDM. Calculate the required Bandwidth.	02	CO2	L3
2 a.	Differentiate between synchronous TDM and statistical TDM	06	CO2	L2
b.	We need to use synchronous TDM and combine 20 digital sources, each of 100 Kbps. Each output slot carries 1 bit from each digital source, but one extra bit is added to each frame for synchronization. Answer the following questions: i. What is the input bit duration? ii. What is the size of an output frame in bits? iii. What is the output frame rate? iv. What is the output data rate?	04	CO2	L3
3	Define FHSS. With relevant diagrams, explain how it achieves bandwidth spreading?	10	CO3	L2

USN											CMRIT

Internal Assessment Test 2 – April 2018

Sub:	Data Communications				Sub Code:	15CS46	Branch:	CSE/ISE
Date:	18/04/2018	Duration:	90 min's	Max Marks: 50	Sem / Sec:	IV-A and B		OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1 a.	Explain multiplexing and demultiplexing process applied in FDM	08	CO2	L2
b.	Assume that a voice channel occupies a bandwidth of 4KHz. We need to multiplex 10 voice channels with guard bands of 500Hz using FDM. Calculate the required Bandwidth.	02	CO2	L3
2 a.	Differentiate between synchronous TDM and statistical TDM	06	CO2	L2
b.	We need to use synchronous TDM and combine 20 digital sources, each of 100 Kbps. Each output slot carries 1 bit from each digital source, but one extra bit is added to each frame for synchronization. Answer the following questions: i. What is the input bit duration? ii. What is the size of an output frame in bits? iii. What is the output frame rate? iv. What is the output data rate?	04	CO2	L3
3	Define FHSS. With relevant diagrams, explain how it achieves bandwidth spreading?	10	CO3	L2

4	With relevant diagrams, explain the working of 3 phases in Virtual Circuit Networks	10	CO3	L2
5 a.	Design encoder and decoder for CRC-3	06	CO3	L2
b.	Given the data word 101001111 and the generator $x^4 + x^2 + x^1 + 1$, i. Show the generation of the CRC codeword at the sender site (using binary division). ii. Prove that the received data is error-free.	04		L3, L4
6.	With specific frame formats and control fields, explain the working of HDLC.	10	CO3	L2
7	With the help of FSM and Flow Diagram, explain the working of Stop and wait protocol	10		L2
8 a.	Explain the working procedure of Pure ALOHA protocol for multiple access	6	CO3	L2
b.	Stations in a pure Aloha network send frames of size 1000 bits at the rate of 1 Mbps. What is the vulnerable time for this network? 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.	4	CO3	L3

4	With relevant diagrams, explain the working of 3 phases in Virtual Circuit Networks	10	CO3	L2
5 a.	Design encoder and decoder for CRC-3	06	CO3	L2
b.	Given the data word 101001111 and the generator $x^4 + x^2 + x^1 + 1$, i. Show the generation of the CRC codeword at the sender site (using binary division). ii. Prove that the received data is error-free.	04	CO3	L3, L4
6.	With specific frame formats and control fields, explain the working of HDLC.	10	CO3	L2
7	With the help of FSM and Flow Diagram, explain the working of Stop and wait protocol.	10		L2
8 a.	Explain the working procedure of Pure ALOHA protocol for multiple accesses.	6	CO3	L2
b.	Stations in a pure Aloha network send frames of size 1000 bits at the rate of 1 Mbps. What is the vulnerable time for this network? 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.	4	CO3	L3

2.4.1 Frequency Division Multiplexing (FDM)

- FDM is an analog multiplexing technique that combines analog signals (Figure 6.3).
- FDM can be used when the bandwidth of a link is greater than the combined bandwidths of the signals to be transmitted. (Bandwidth measured in hertz).

Figure 6.3 *Frequency-division multiplexing*

2.4.1.1 Multiplexing Process

- Here is how it works (Figure 6.4):
  1) Each sending-device generates modulated-signals with different carrier-frequencies (f1, f2, & f3).
  2) Then, these modulated-signals are combined into a single multiplexed-signal.
  3) Finally, the multiplexed-signal is transported by the link.

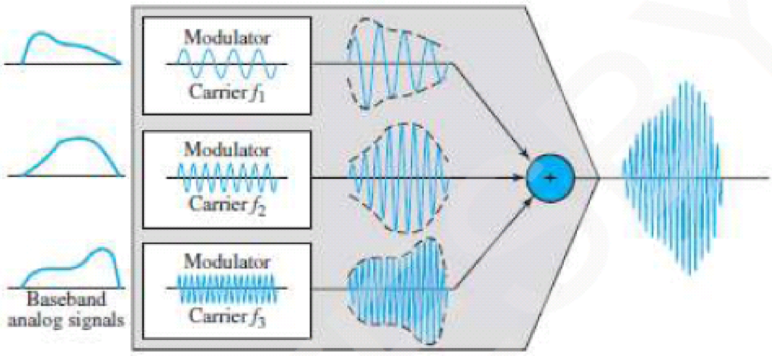


Figure 6.4 *FDM process*

Demultiplexing Process

- Here is how it works (Figure 6.5):
  1) The demultiplexer uses filters to divide the multiplexed-signal into individual-signals.
  2) Then, the individual signals are passed to a demodulator.
  3) Finally, the demodulator
     → separates the individual signals from the carrier signals and
     → passes the individual signals to the output-lines.

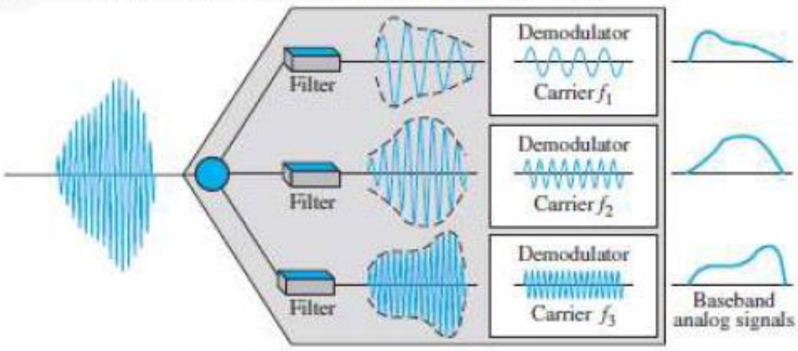


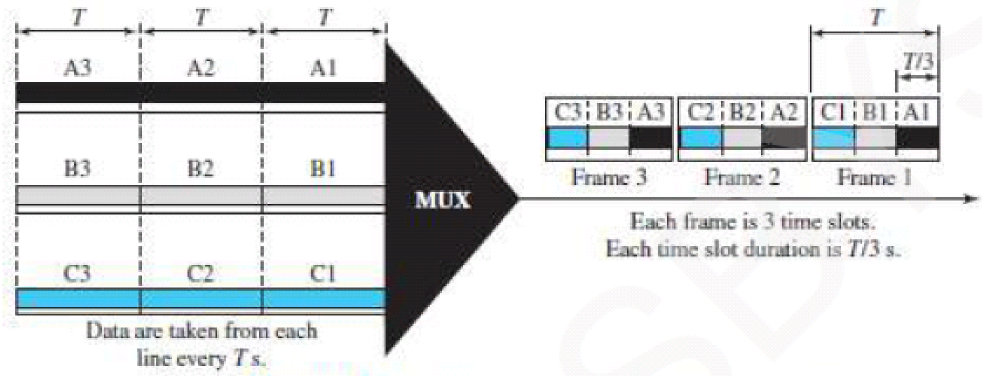
Figure 6.5 *FDM demultiplexing example*

1 b). Answer: Total bandwidth occupied by 10 voice channels=4*10=40 KHz
Bandwidth occupied by 9 guard bands=500*9=4.5KHz
Hence total bandwidth of the channel=44.5KHz.

2. Difference between Synchronous TDM and Statistical TDM

Synchronous TDM

- Each input-connection has an allotment in the output-connection even if it is not sending data.
- The data-flow of input-connection is divided into units (Figure 6.13).
- A unit can be 1 bit, 1 character, or 1 block of data.
- Each input-unit occupies one input-time-slot.
- Each input-unit
  → becomes one output-unit and
  → occupies one output-time-slot.
- However, duration of output-time-slot is 'n' times shorter than duration of input-time-slot.
- If an input-time-slot is T s, the output-time-slot is T/n s
  where n = No. of connections.
- In the output-connection, a unit has a shorter duration & therefore travels faster.



- Problem: Synchronous TDM is not efficient.
  For example: If a source does not have data to send, the corresponding slot in the output-frame is empty.

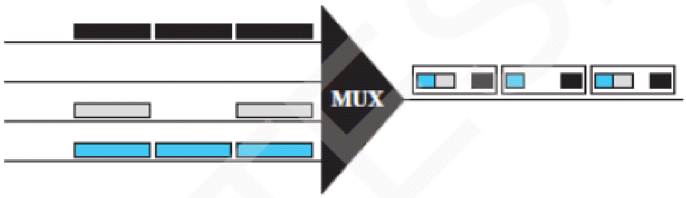
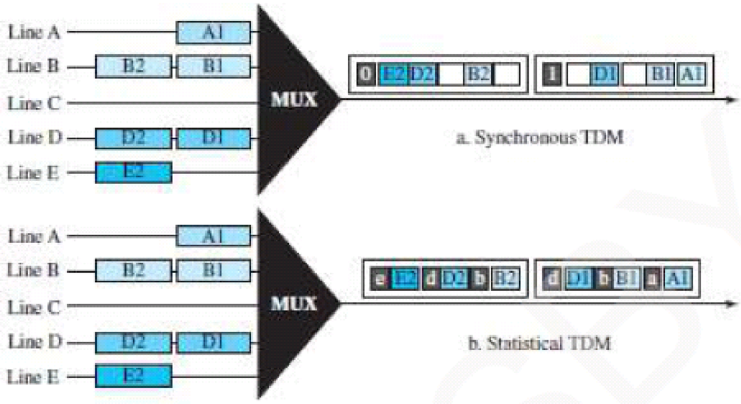


Figure 6.18 *Empty slots*

- As shown in Figure 6.18,
  Second input-line has no data to send
  Third input-line has discontinuous data.
- The first output-frame has 3 slots filled.
  The second frame has 2 slots filled.
  The third frame has 3 slots filled.
  No frame is full.
- Solution: Statistical TDM can improve the efficiency by removing the empty slots from the frame.

- Problem: Synchronous TDM is not efficient.
  For ex: If a source does not have data to send, the corresponding slot in the output-frame is empty.
  Solution: Use statistical TDM.
  Slots are dynamically allocated to improve bandwidth-efficiency.
  Only when an input-line has data to send, the input-line is given a slot in the output-frame.
- The number of slots in each frame is less than the number of input-lines.
- The multiplexer checks each input-line in round robin fashion.
  If the line has data to send;
  Then, multiplexer allocates a slot for an input-line;
  Otherwise, multiplexer skips the line and checks the next line.



2 b). i. Input bit duration=10μs

ii. Size of the output frame=21 bits

iii. Frame rate=100K frames /sec

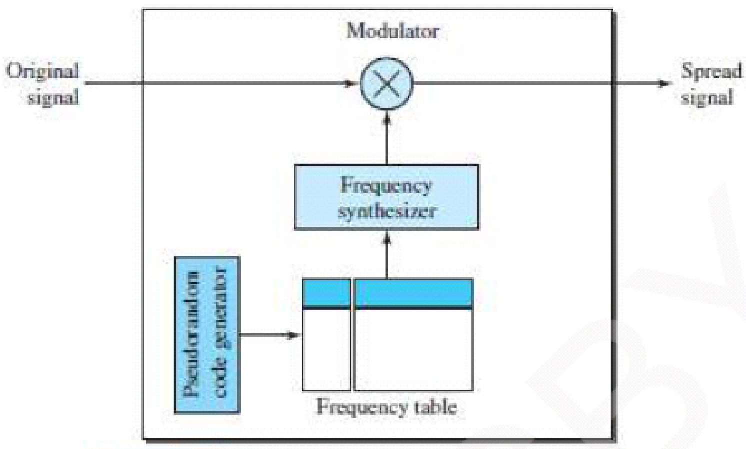
iv. Output Link rate=2000Kbps

3. FHSS:

Frequency Hopping Spread Spectrum (FHSS)

- This technique uses 'M' different carrier-frequencies that are modulated by the source-signal.
- At one moment, the signal modulates one carrier-frequency.
  At the next moment, the signal modulates another carrier-frequency.
- Although the modulation is done using one carrier-frequency at a time, 'M' frequencies are used in the long run.
- The bandwidth occupied by a source is given by

$$B_{FHSS} >> B$$



- A pseudorandom code generator (PN) creates a k-bit pattern for every hopping period T_h.
- The frequency-table
  → uses the pattern to find the frequency to be used for this hopping period and
  → passes the frequency to the frequency-synthesizer.
- The frequency-synthesizer creates a carrier-signal of that frequency.
- The source-signal modulates the carrier-signal.

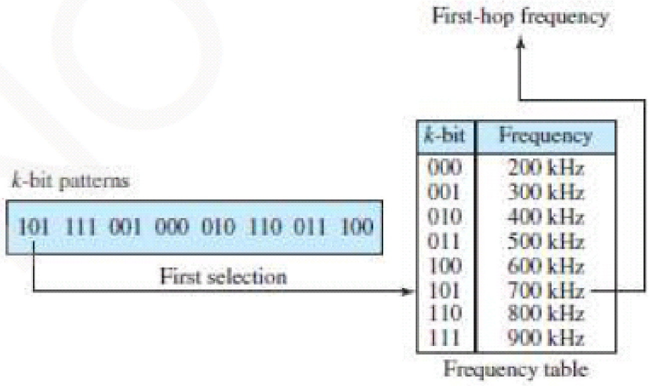


Figure 6.29 *Frequency selection in FHSS*

- As shown in Figure 6.29, assume we have 8 hopping frequencies.
  - Here, M = 8 and k = 3.
  - The pseudorandom code generator will create 8 different 3-bit patterns.
  - These are mapped to 8 different frequencies in the frequency table (see Figure 6.29).
  - These are mapped to 8 different frequencies in the frequency table (see Figure 6.29).
  - The pattern for this station is 101, 111, 001, 000, 010, 111 & 100.
    1) At hopping-period 1, the pattern is 101.
       The frequency selected is 700 kHz; the source-signal modulates this carrier-frequency.
    2) At hopping-period 2, the pattern is 111.
       The frequency selected is 900 kHz; the source-signal modulates this carrier-frequency.

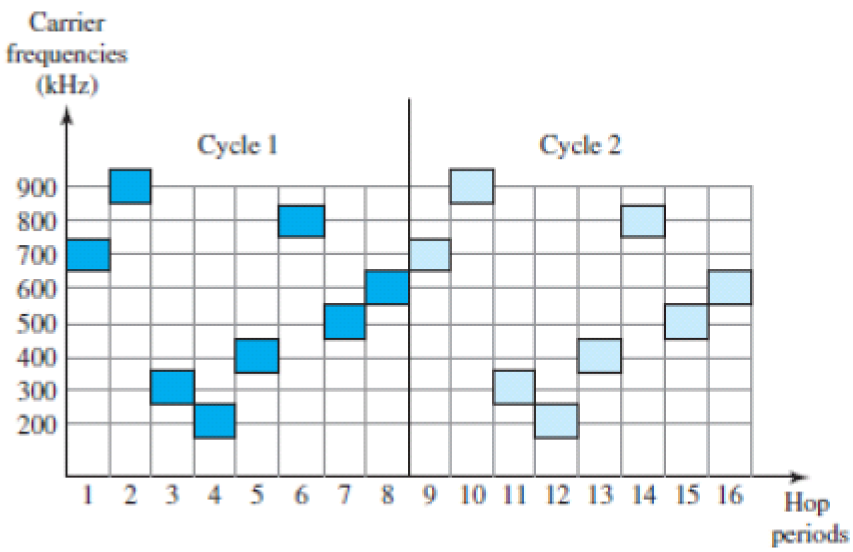


Figure 6.30 *FHSS cycles*

- If there are many k-bit patterns & the hopping period is short, a sender & receiver can have privacy.
  If an attacker tries to intercept the transmitted signal, he can only access a small piece of data because he does not know the spreading sequence to quickly adapt himself to the next hop.
- The scheme has also an anti-jamming effect.
  A malicious sender may be able to send noise to jam the signal for one hopping period (randomly), but not for the whole period.

4) With relevant diagrams, explain the working of 3 phases in Virtual Circuit Networks

2.8.2 Virtual Circuit Network (VCN)

- This is similar to telephone system.
- A virtual-circuit network is a combination of circuit-switched-network and datagram-network.
- Five characteristics of VCN:
  1) As in a circuit-switched-network, there are setup & teardown phases in addition to the data transfer phase.
  2) As in a circuit-switched-network, resources can be allocated during the setup phase.
     As in a datagram-network, resources can also be allocated on-demand.
  3) As in a datagram-network, data is divided into packets.
     Each packet carries an address in the header.
     However, the address in the header has local jurisdiction, not end-to-end jurisdiction.
  4) As in a circuit-switched-network, all packets follow the same path established during the connection.
  5) A virtual-circuit network is implemented in the data link layer.
     A circuit-switched-network is implemented in the physical layer.
     A datagram-network is implemented in the network layer.

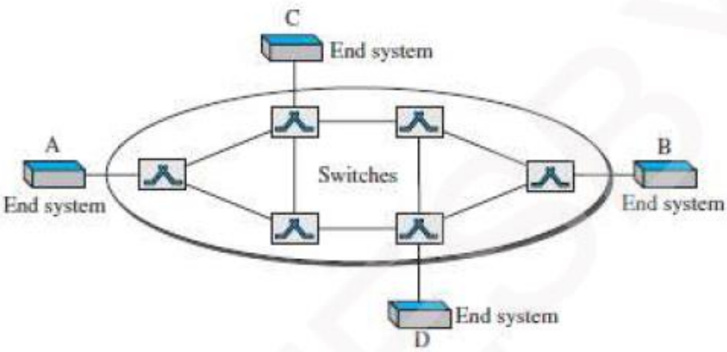


Figure 8.10 *Virtual-circuit network*

- ➢ The Figure 8.10 is an example of a virtual-circuit network.
- ➢ The network has switches that allow traffic from sources to destinations.
- ➢ A source or destination can be a computer, packet switch, bridge, or any other device that connects other networks.

2.8.2.2 Three Phases

- A source and destination need to go through 3 phases: setup, data-transfer, and teardown.
  1) In setup phase, the source and destination use their global addresses to help switches make table entries for the connection.
  2) In the teardown phase, the source and destination inform the switches to delete the corresponding entry.
  3) Data-transfer occurs between these 2 phases.

2.8.2.2.1 Data Transfer Phase

- To transfer a frame from a source to its destination, all switches need to have a table-entry for this virtual-circuit.
- The table has four columns.
- The switch holds 4 pieces of information for each virtual-circuit that is already set up.

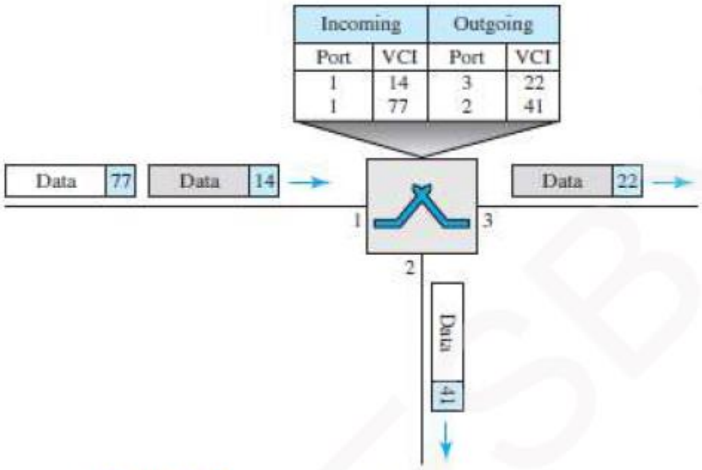


Figure 8.12 *Switch and tables in a virtual-circuit network*

- As shown in Figure 8.12, a frame arrives at port 1 with a VCI of 14.
- When the frame arrives, the switch looks in its table to find port 1 and a VCI of 14.
- When it is found, the switch knows to change the VCI to 22 & send out the frame from port 3.

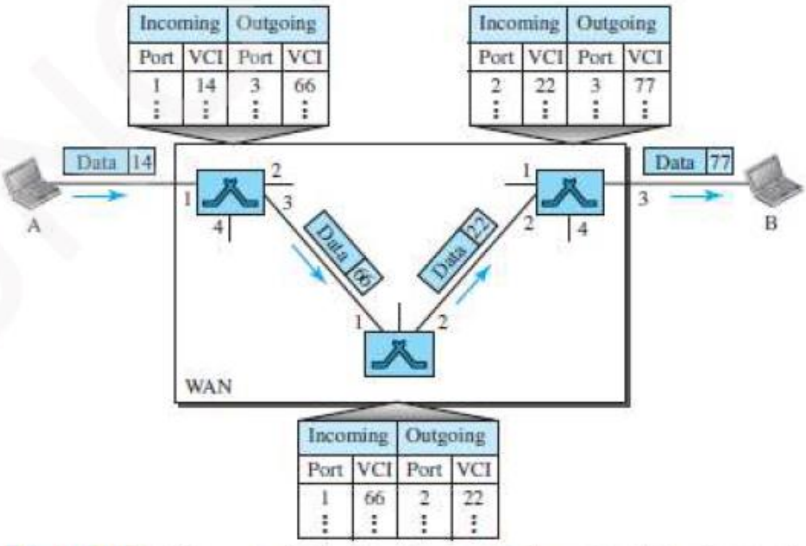


Figure 8.13 *Source-to-destination data transfer in a virtual-circuit network*

- As shown in Figure 8.13, each switch changes the VCI and routes the frame.
- The data-transfer phase is active until the source sends all its frames to the destination.
- The procedure at the switch is the same for each frame of a message.
- The process creates a virtual circuit, not a real circuit, between the source and destination.

2.8.2.2.2 Setup Phase

• A switch creates an entry for a virtual-circuit.
• For example, suppose source A needs to create a virtual-circuit to B.
• Two steps are required: 1) Setup-request and
2) Acknowledgment.

1) Setup Request

➢ A setup-request frame is sent from the source to the destination (Figure 8.14).

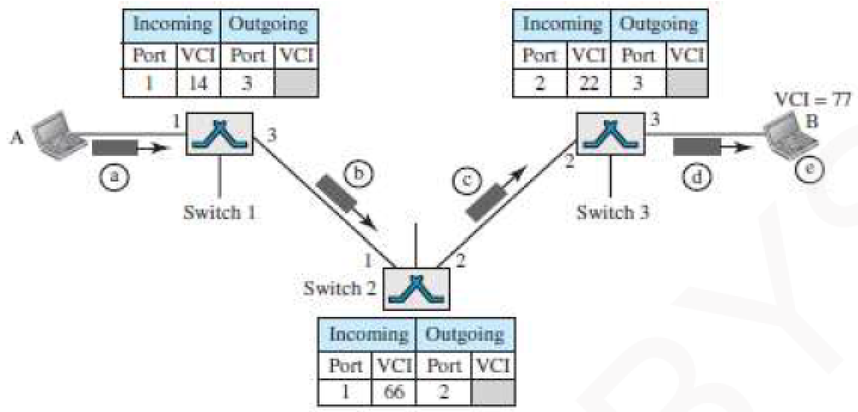


Figure 8.14 *Setup request in a virtual-circuit network*

➢ Following events occurs:

a) Source-A sends a setup-frame to switch-1.

b) Switch-1 receives the setup-frame.

¤ Switch-1 knows that a frame going from A to B goes out through port 3.
¤ The switch-1 has a routing table.
¤ The switch
→ creates an entry in its table for this virtual-circuit
→ is only able to fill 3 of the 4 columns.
¤ The switch
→ assigns the incoming port (1) and
→ chooses an available incoming-VCI (14) and the outgoing-port (3).
→ does not yet know the outgoing VCI, which will be found during the acknowledgment step.
¤ The switch then forwards the frame through port-3 to switch-2.

c) Switch-2 receives the setup-request frame.

¤ The same events happen here as at switch-1.
¤ Three columns of the table are completed: In this case, incoming port (1), incoming-VCI (66), and outgoing port (2).

d) Switch-3 receives the setup-request frame.

¤ Again, three columns are completed: incoming port (2), incoming-VCI (22), and outgoing-port (3).

e) Destination-B
→ receives the setup-frame
→ assigns a VCI to the incoming frames that come from A, in this case 77.
¤ This VCI lets the destination know that the frames come from A, and no other sources.

2) Acknowledgment

➢ A special frame, called the acknowledgment-frame, completes the entries in the switching-tables (Figure 8.15).

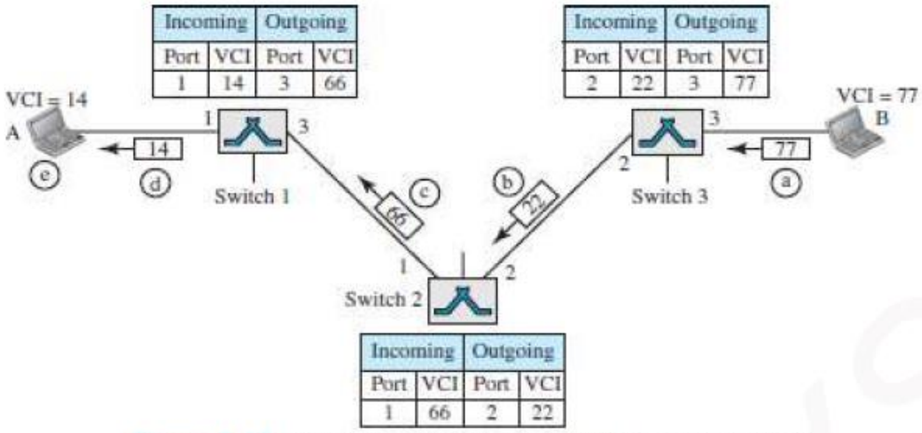


Figure 8.15 *Setup acknowledgment in a virtual-circuit network*

Figure 8.15 Setup acknowledgment in a virtual-circuit network

a) The destination sends an acknowledgment to switch-3.

¤ The acknowledgment carries the global source and destination-addresses so the switch knows which entry in the table is to be completed.

¤ The frame also carries VCI 77, chosen by the destination as the incoming-VCI for frames from A.

¤ Switch 3 uses this VCI to complete the outgoing VCI column for this entry.

b) Switch 3 sends an acknowledgment to switch-2 that contains its incoming-VCI in the table, chosen in the previous step.

¤ Switch-2 uses this as the outgoing VCI in the table.

c) Switch-2 sends an acknowledgment to switch-1 that contains its incoming-VCI in the table, chosen in the previous step.

¤ Switch-1 uses this as the outgoing VCI in the table.

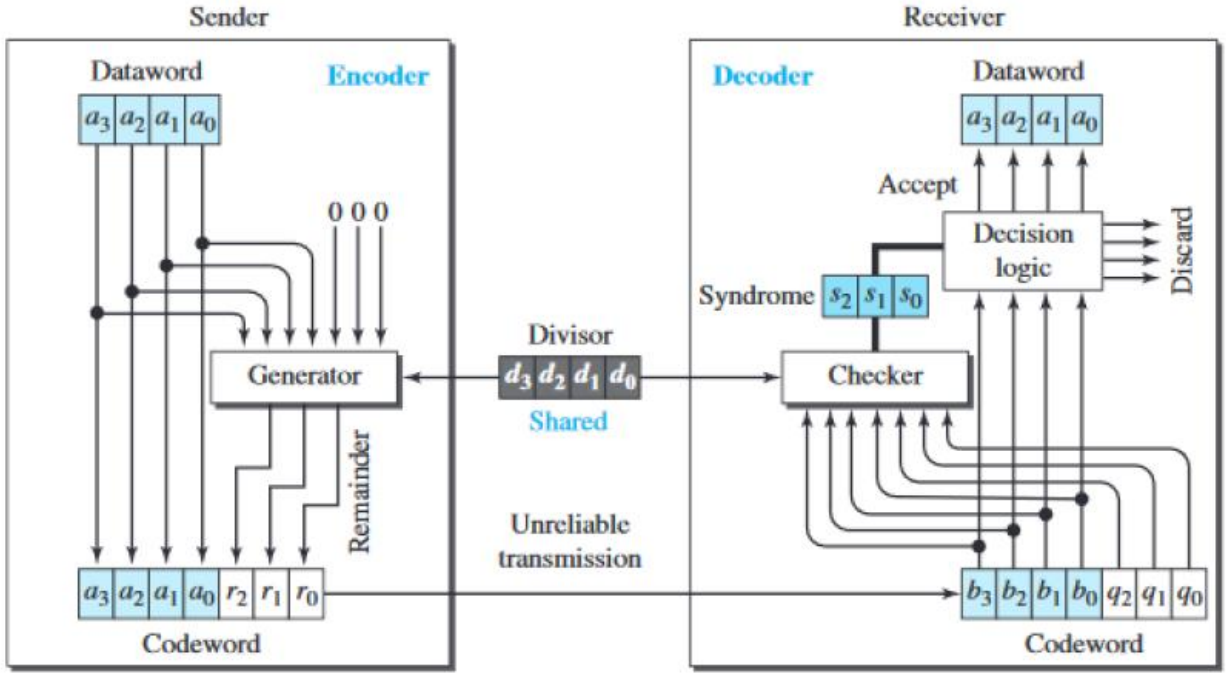
d) Finally switch-1 sends an acknowledgment to source-A that contains its incoming-VCI in the table, chosen in the previous step.

e) The source uses this as the outgoing VCI for the data-frames to be sent to destination-B.

2.8.2.3 Teardown Phase

- Source-A, after sending all frames to B, sends a special frame called a teardown request.
- Destination-B responds with a teardown confirmation frame.
- All switches delete the corresponding entry from their tables.

5 a) Design encoder and decoder for CRC



Cyclic Redundancy Check Encoder and decoder

- In the encoder, the data word has *k* bits (4 here); the codeword has *n* bits.
- The size of the data word is augmented by adding *n - k* (3 here) Os to the right-hand side of the word.
- The n-bit result is fed into the generator.
- The generator uses a divisor of size *n - k* + I (4 here).
- The generator divides the augmented data word by the divisor (modulo-2 division).
- The quotient of the division is discarded; the remainder *(r2 r1 r0)* is appended to the data word to create the codeword.
- The decoder receives the possibly corrupted codeword.
- A copy of all *n* bits is fed to the checker which is a replica of the generator.
- The remainder produced by the checker is a syndrome of *n - k* (3 here) bits, which is fed to the decision logic analyzer.
- The analyzer has a simple function. If the syndrome bits are all as, the 4 leftmost bits of the codeword are accepted as the data word (interpreted as no error); otherwise, the 4 bits are discarded (error).

5b) Given the data word 101001111 and the generator $x^4 + x^2 + x^1 + 1$,

i. Show the generation of the CRC codeword at the sender site (using binary division).

ii. Prove that the received data is error-free.

Sol: Given Data word = 1010011110

generator $x^4 + x^2 + x^1 + 1$ (10111)

Augmented Data word = 10100111100000

Sender's side:

```
10111)10100111100000(1001101110
      10111
      000111
       00000
       001111
        00000
        011111
         10111
         010001
          10111
          001100
           00000
            11000
            10111
            011110
             10111
             010010
              10111
              001010
```

Code word: 10100111101010

Receiver's side:

```
10111)10100111101010(1001101110
      10111
      000111
       00000
       001111
        00000
        011111
         10111
         010001
          10111
          001100
           00000
            11001
            10111
            011100
             10111
             010111
              10111
                0
```

6) With specific frame formats and control fields, explain the working of HDLC. (10)

3.8.2 Framing

- To provide the flexibility necessary to support all the options possible in the modes and configurations, HDLC defines three types of frames:
    1) Information frames (I-frames): are used to transport user data and control information relating to user data (piggybacking).
    2) Supervisory frames (S-frames): are used only to transport control information.
    3) Unnumbered frames (U-frames): are reserved for system management.
        Information carried by U-frames is intended for managing the link itself.
- Each type of frame serves as an envelope for the transmission of a different type of message.

3.8.2.1 Frame Format

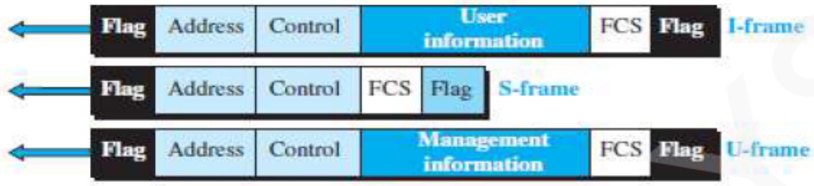


Figure 11.16 *HDLC frames*

- Various fields of HDLC frame are:

1) Flag Field

- This field has a synchronization pattern 01111110.
- This field identifies both the beginning and the end of a frame.

2) Address Field

- This field contains the address of the secondary station.
- If a primary station created the frame, it contains a to-address.
- If a secondary creates the frame, it contains a from-address.
- This field can be 1 byte or several bytes long, depending on the needs of the network.

3) Control Field

- This field is one or two bytes used for flow and error control.

4) Information Field

- This field contains the user's data from the network-layer or management information.
- Its length can vary from one network to another.

5) FCS Field

- This field is the error-detection field. (FCS → Frame Check Sequence)
- This field can contain either a 2- or 4-byte standard CRC.

3.8.2.1.1 Control Fields of HDLC Frames

- The control field determines the type of frame and defines its functionality (Figure 11.17).

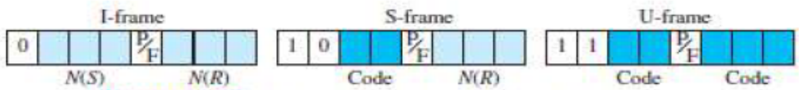


Figure 11.17 *Control field format for the different frame types*

1) Control Field for I-Frames

- I-frames are designed to carry user data from the network-layer.
- In addition, they can include flow and error-control information (piggybacking).
- The subfields in the control field are:
    1) The first bit defines the type.
        If the first bit of the control field is 0, this means the frame is an I-frame.
    2) The next 3 bits N(S) define the sequence-number of the frame.
        With 3 bits, we can define a sequence-number between 0 and 7
    3) The last 3 bits N(R) correspond to the acknowledgment-number when piggybacking is used.
    4) The single bit between N(S) and N(R) is called the P/F bit.
        The P/F field is a single bit with a dual purpose. It can mean poll or final.
        i) It means poll when the frame is sent by a primary station to a secondary (when the address field contains the address of the receiver).
        ii) It means final when the frame is sent by a secondary to a primary (when the address field contains the address of the sender).

2) Control Field for S-Frames

- Supervisory frames are used for flow and error-control whenever piggybacking is either impossible or inappropriate (e.g., when the station either has no data of its own to send or needs to send a command or response other than an acknowledgment).
- S-frames do not have information fields.
- The subfields in the control field are:
  1) If the first 2 bits of the control field is 10, this means the frame is an S-frame.
  2) The last 3 bits N(R) corresponds to the acknowledgment-number (ACK) or negative acknowledgment-number (NAK).
  3) The 2 bits called code is used to define the type of S-frame itself.
     With 2 bits, we can have four types of S-frames:

     1) Receive Ready (RR) = 00
     ¤ This acknowledges the receipt of frame or group of frames.
     ¤ The value of N(R) is the acknowledgment-number.
     2) Receive Not Ready (RNR) = 10
     ¤ This is an RR frame with 1 additional function:
       i) It announces that the receiver is busy and cannot receive more frames.
     ¤ It acts as congestion control mechanism by asking the sender to slow down.
     ¤ The value of N(R) is the acknowledgment-number.
     3) ReJect (REJ) = 01
     ¤ It is a NAK frame used in Go-Back-N ARQ to improve the efficiency of the process.
     ¤ It informs the sender, before the sender time expires, that the last frame is lost or damaged.
     ¤ The value of N(R) is the negative acknowledgment-number.

3) ReJect (REJ) = 01
¤ It is a NAK frame used in Go-Back-N ARQ to improve the efficiency of the process.
¤ It informs the sender, before the sender time expires, that the last frame is lost or damaged.
¤ The value of N(R) is the negative acknowledgment-number.

4) Selective REJect (SREJ) = 11
¤ This is a NAK frame used in Selective Repeat ARQ.
¤ The value of N(R) is the negative acknowledgment-number.

3) Control Field for U-Frames

- Unnumbered frames are used to exchange session management and control information between connected devices.
- U-frames contain an information field used for system management information, but not user data.
- Much of the information carried by U-frames is contained in codes included in the control field.
- U-frame codes are divided into 2 sections:
  i) A 2-bit prefix before the P/F bit
  ii) A 3-bit suffix after the P/F bit.
- Together, these two segments (5 bits) can be used to create up to 32 different types of U-frames.

7) With the help of FSM and Flow Diagram, explain the working of Stop and wait protocol. (10)

3.7.2 Stop & Wait Protocol

- This uses both flow and error control.
- Normally, the receiver has limited storage-space.
- If the receiver is receiving data from many sources, the receiver may
  → be overloaded with frames &
  → discard the frames.
- To prevent the receiver from being overloaded with frames, we need to tell the sender to slow down.

3.7.2.1 Design

1) At Sender

➢ The sender
  → sends one frame & starts a timer
  → keeps a copy of the sent-frame and
  → waits for ACK-frame from the receiver (okay to go ahead).

➢ Then,
  1) If an ACK-frame arrives before the timer expires, the timer is stopped and the sender sends the next frame.
     Also, the sender discards the copy of the previous frame.
  2) If the timer expires before ACK-frame arrives, the sender resends the previous frame and restarts the timer

2) At Receiver

➢ To detect corrupted frames, a CRC is added to each data frame.
➢ When a frame arrives at the receiver-site, the frame is checked.
➢ If frame's CRC is incorrect, the frame is corrupted and discarded.
➢ The silence of the receiver is a signal for the sender that a frame was either corrupted or lost.

3.7.2.2 FSMs

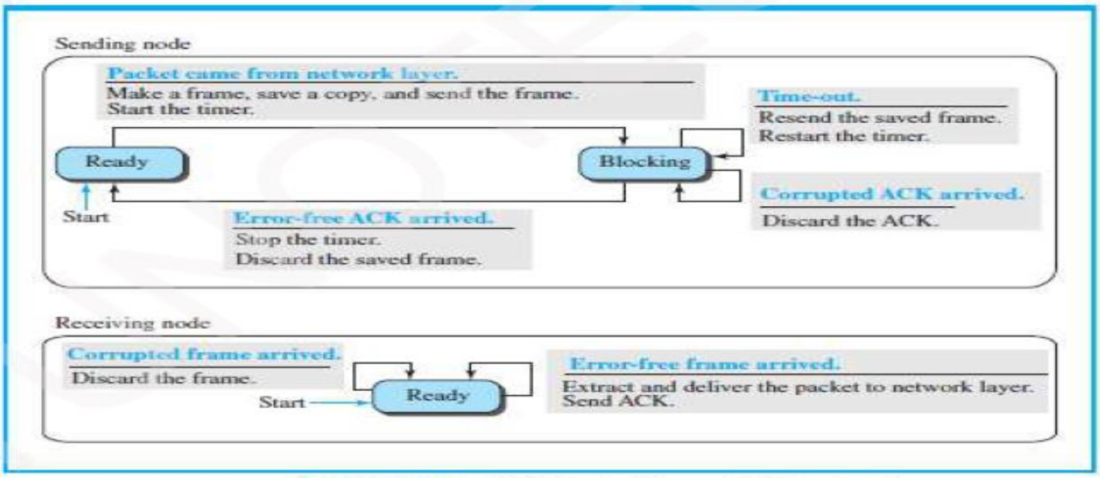


Figure 11.11 *FSM for the Stop-and-Wait protocol*

- Here is how it works (Figure 11.11):
  1) Sender States
  - Sender is initially in the ready state, but it can move between the ready and blocking state.
    i) 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 only timer and sends the frame. The sender then moves to the blocking state.

Figure 11.12 shows an example. 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. However, there is a problem with this scheme. The network layer at the receiver site receives two copies of the third packet, which is not right. In the next section, we will see how we can correct this problem using sequence numbers and acknowledgment numbers.

ii) Blocking State: When the sender is in this state, three events can occur:
a) If a time-out occurs, the sender resends the saved copy of the frame and restarts the timer.
b) If a corrupted ACK arrives, it is discarded.
c) 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.

2) Receiver
- The receiver is always in the ready state. Two events may occur:
  a) If an error-free frame arrives, the message in the frame is delivered to the network layer and an ACK is sent.
  b) If a corrupted frame arrives, the frame is discarded.

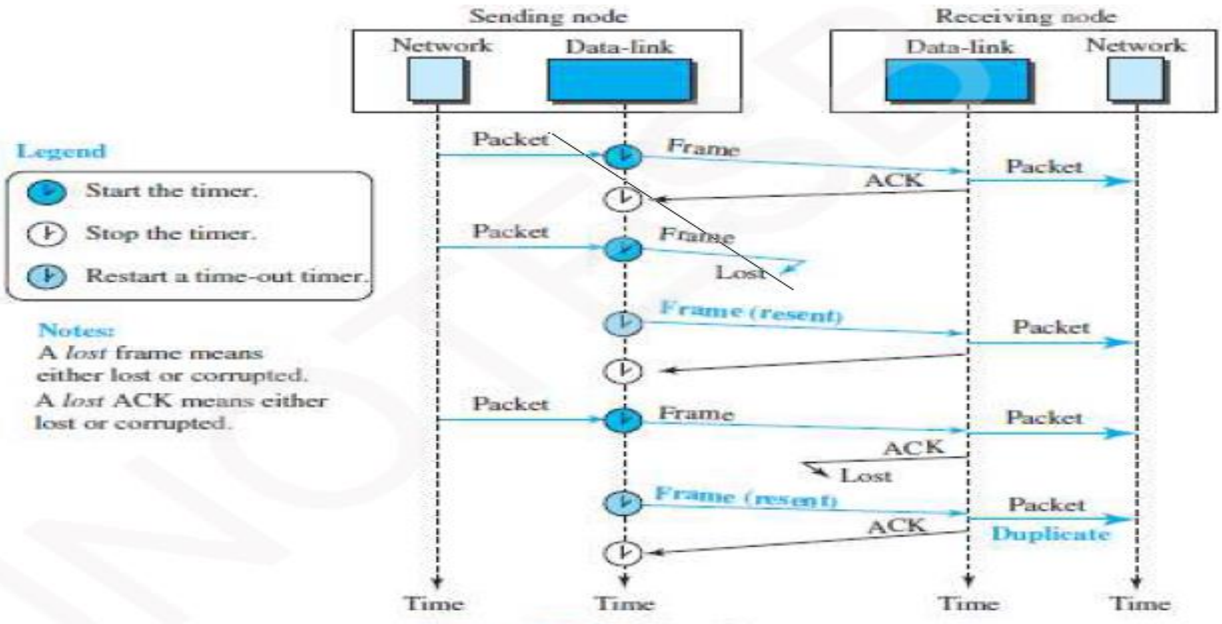


Figure 11.12 *Flow diagram*

3.7.2.3 Sequence and Acknowledgment Numbers

- Q: How to deal with corrupted-frame?

  Ans: If the corrupted-frame arrives at the receiver-site, then the frame is simply discarded.
- Q: How to deal with lost-frames?

  Ans: If the receiver receives out-of-order data-frame, then it means that frames were lost. .'. The lost-frames need to be resent.
- Problem in Stop and Wait protocols:

  1) There is no way to identify a frame.

  2) The received-frame could be the correct one, or a duplicate, or a frame out of order.

Solution: 1) Use sequence-number for each data frame.

2) Use Acknowledgment-number for each ACK frame.

Sequence Numbers

- Frames need to be numbered. This is done by using sequence-numbers.
- A sequence-number field is added to the data-frame.

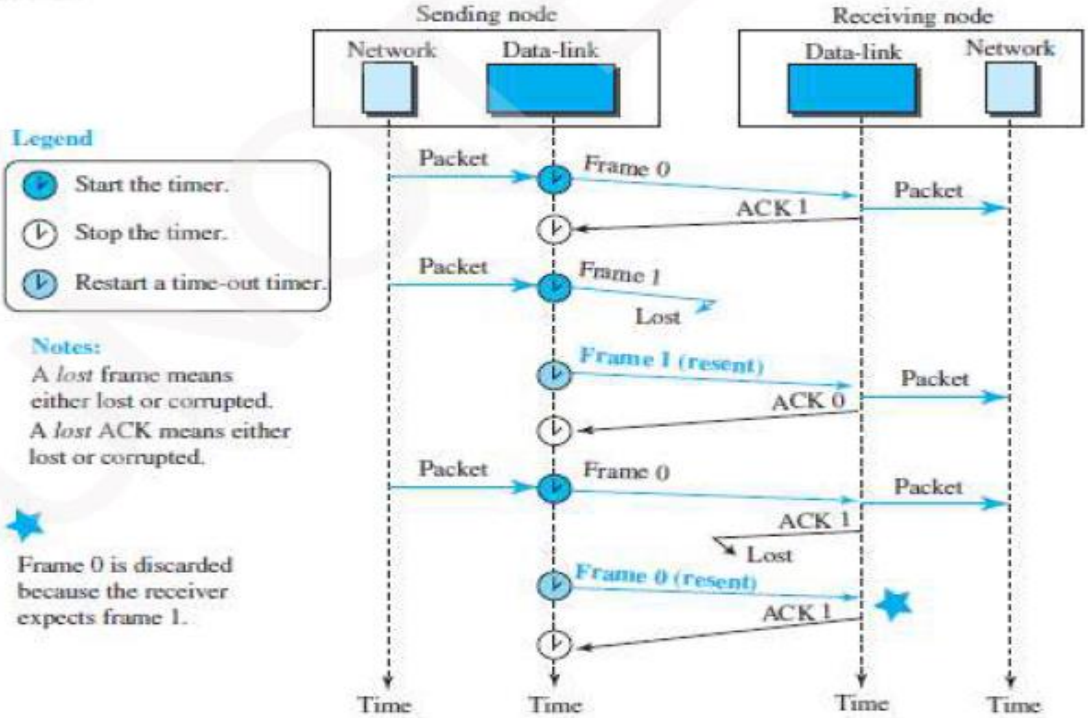
Acknowledgment Numbers

- An acknowledgment-number field is added to the ACK-frame.
- Sequence numbers are 0, 1, 0, 1, 0, 1, . . .

  The acknowledgment numbers can also be 1, 0, 1, 0, 1, 0, …
- The acknowledgment-numbers always announce the sequence-number of the next frame expected by the receiver.
- For example,

  If frame-0 has arrived safely, the receiver sends an ACK-frame with acknowledgment-1 (meaning frame-1 is expected next).

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.



8)a) Explain the working procedure of Pure ALOHA protocol for multiple accesses. (6)

4.2.1 ALOHA

- ALOHA was designed for a wireless LAN, but it can be used on any shared medium.
- Since the medium is shared between the stations, there is possibility of collisions.
- When 2 or more stations send the data simultaneously, there is possibility of collision & data loss.

4.2.1.1 Pure ALOHA

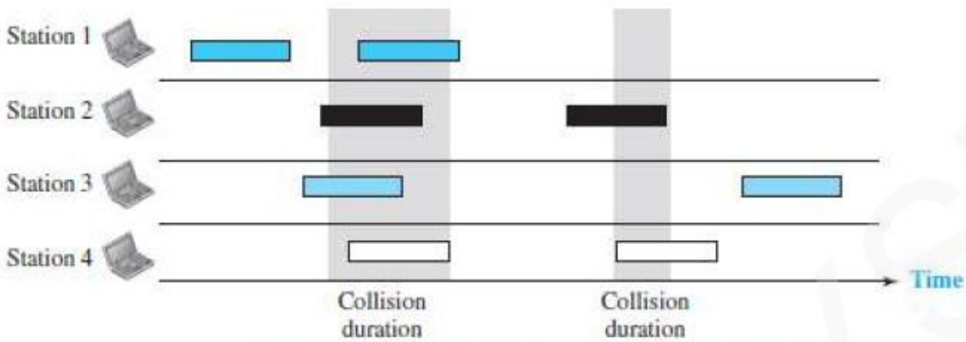


Figure 12.2 *Frames in a pure ALOHA network*

• Here is how it works (Figure 12.2):

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

1) 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.

2) 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 (Figure 12.3).

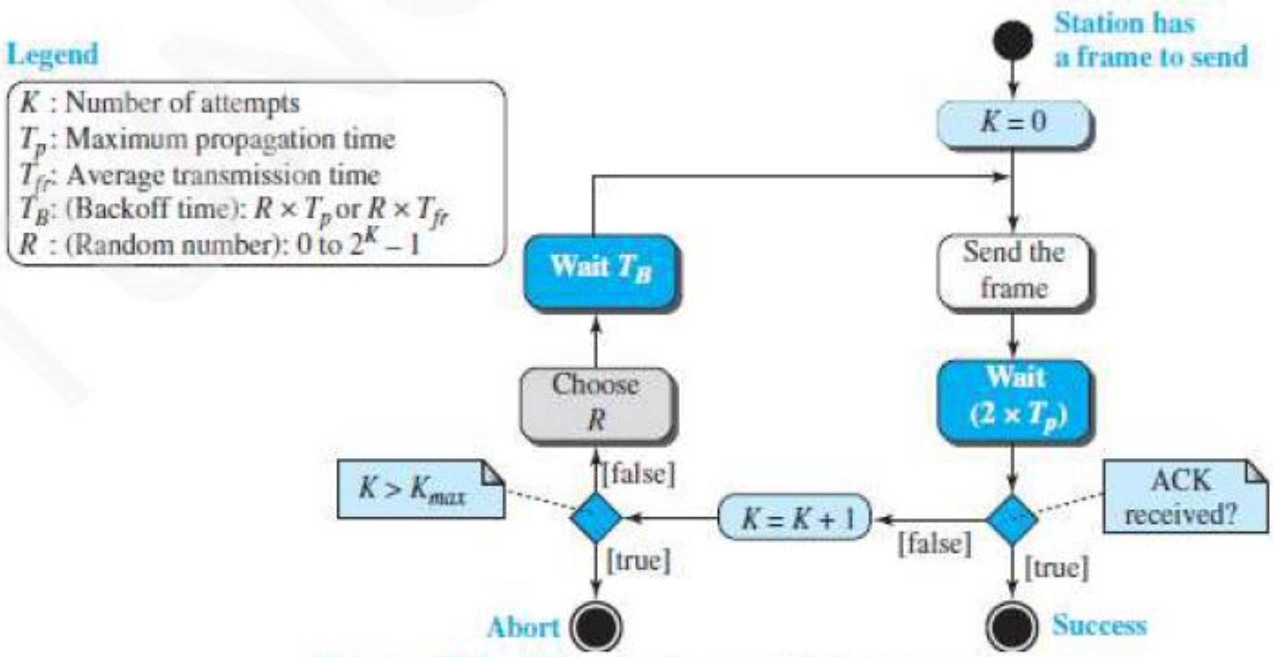


Figure 12.3 *Procedure for pure ALOHA protocol*

4.2.1.1.1 Vulnerable Time

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

Pure ALOHA vulnerable time = 2 × T_{fr}

where T_{fr} = Frame transmission time

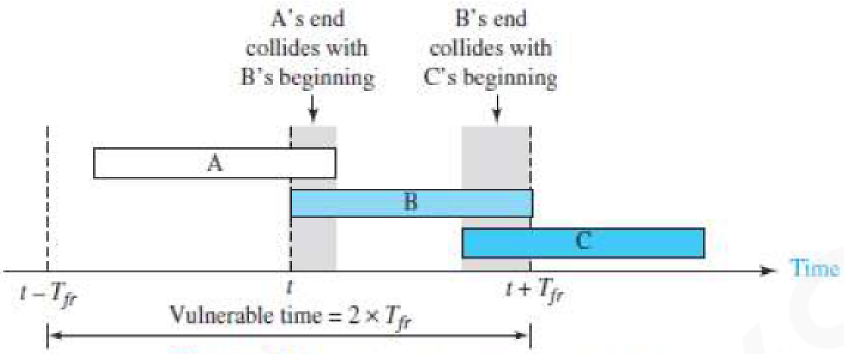


Figure 12.4 *Vulnerable time for pure ALOHA protocol*

- In Figure 12.4,
  - ➢ 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.

b) Stations in a pure Aloha network send frames of size 1000 bits at the rate of 1 Mbps. What is the vulnerable time for this network? 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

Frame transmission time=1ms.
Hence vulnerable time=2ms.

a.

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

b.

If the system creates 500 frames per second, or 1/2 frames per millisecond, then $G = 1/2$. In this case $S = G \times e^{-2G} = 0.184$ (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, or 1/4 frames per millisecond, then $G = 1/4$. In this case $S = G \times e^{-2G} = 0.152$ (15.2 percent). This means that the throughput is $250 \times 0.152 = 38$. Only 38 frames out of 250 will probably survive.