Module 4

Switched Communication Networks

Lesson 5

Frame Relay

Special Instructional Objective

- On completion of this lesson, the student will be able to:
- State the limitations of X.25
- Explain the key features of Frame Relay
- Specify the Frame relay frame format
- Explain how congestion control is performed in Frame relay network

4.5.1 Introduction

Frame Relay is a high-performance WAN protocol that operates at the physical and data link layers of the OSI reference model. Frame Relay originally was designed for use across Integrated Services Digital Network (ISDN) interfaces. Today, it is used over a variety of other network interfaces as well. Frame Relay is a simplified form of Packet Switching, similar in principle to X.25, in which synchronous frames of data are routed to different destinations depending on header information. The biggest difference between Frame Relay and X.25 is that X.25 guarantees data integrity and network managed flow control at the cost of some network delays. Frame Relay switches packets end to end much faster, but there is no guarantee of data integrity at all.

As line speeds have increased from speeds below 64kbps to T1/E1 and beyond, the delays inherent in the store-and-forward mechanisms of X.25 become intolerable. At the same time, improvements in digital transmission techniques have reduced line errors to the extent that node-to-node error correction throughout the network is no longer necessary. The vast majority of Frame Relay traffic consists of TCP/IP or other protocols that provide their own flow control and error correction mechanisms. Much of this traffic is fed into the Internet, another packet switched network without any built-in error control.

Because Frame Relay does not 'care' whether the frame it is switching is error-free or not, a Frame Relay node can start switching traffic out onto a new line as soon as it has read the first two bytes of addressing information at the beginning of the frame. Thus a frame of data can travel end-to-end, passing through several switches, and still arrive at its destination with only a few bytes' delay. These delays are small enough that network latency under Frame Relay is not noticeably different from direct leased line connections. As a result, the performance of a Frame Relay network is virtually identical to that of a leased line, but because most of the network is shared, costs are lower.

Frame Relay is an example of a packet-switched technology. Packet-switched networks enable end stations to dynamically share the network medium and the available bandwidth. The following two techniques are used in packet-switching technology:

- Variable-length packets
- Statistical multiplexing

Variable-length packets are used for more efficient and flexible data transfers. These packets are switched between the various segments in the network until the destination is reached.

Statistical multiplexing techniques control network access in a packet-switched network. The advantage of this technique is that it accommodates more flexibility and more efficient use of bandwidth. Most of today's popular LANs, such as Ethernet and Token Ring, are packet-switched networks.

4.5.2 Frame Relay Devices

Devices attached to a Frame Relay WAN fall into the following two general categories:

- Data terminal equipment (DTE)
- Data circuit-terminating equipment (DCE)

DTEs generally are considered to be terminating equipment for a specific network and typically are located on the premises of a customer. In fact, they may be owned by the customer. Examples of DTE devices are terminals, personal computers, routers, and bridges.

DCEs are carrier-owned internetworking devices. The purpose of DCE equipment is to provide clocking and switching services in a network, which are the devices that actually transmit data through the WAN. In most cases, these are packet switches.

The connection between a DTE device and a DCE device consists of both a physical layer component and a link layer component. The physical component defines the mechanical, electrical, functional, and procedural specifications for the connection between the devices. One of the most commonly used physical layer interface specifications is the recommended standard (RS)-232 specification. The link layer component defines the protocol that establishes the connection between the DTE device, such as a router, and the DCE device, such as a switch.

4.5.3 Virtual Circuits

Frame Relay is a virtual circuit network, so it doesn’t use physical addresses to define the DTEs connected to the network. Frame Relay provides connection-oriented data link layer communication. This means that a defined communication exists between each pair of devices and that these connections are associated with a connection identifier. However, virtual circuit identifiers in Frame relay operate at the data link layer, in contrast with X.25, where they operate at the network layer. This service is implemented by using a Frame Relay virtual circuit, which is a logical connection created between two data terminal equipment (DTE) devices across a Frame Relay packet-switched network (PSN).

Virtual circuits provide a bidirectional communication path from one DTE device to another and are uniquely identified by a data-link connection identifier (DLCI). A number of virtual circuits can be multiplexed into a single physical circuit for transmission across the network. This capability often can reduce the equipment and network complexity required to connect multiple DTE devices.

A virtual circuit can pass through any number of intermediate DCE devices (switches) located within the Frame Relay PSN. Before going into the details of DLCI let us first have a look at the two types of Frame Relay Circuits, namely: switched virtual circuits (SVCs) and permanent virtual circuits (PVCs).

4.5.3.1 Switched Virtual Circuits

Switched virtual circuits (SVCs) are temporary connections used in situations requiring only sporadic data transfer between DTE devices across the Frame Relay network. A communication session across an SVC consists of the following four operational states:

- **Call setup—**The virtual circuit between two Frame Relay DTE devices is established.
- **Data transfer—**Data is transmitted between the DTE devices over the virtual circuit.
- **Idle—**The connection between DTE devices is still active, but no data is transferred. If an SVC remains in an idle state for a defined period of time, the call can be terminated.
- **Call termination—**The virtual circuit between DTE devices is terminated.

After the virtual circuit is terminated, the DTE devices must establish a new SVC if there is additional data to be exchanged. It is expected that SVCs will be established, maintained, and terminated using the same signaling protocols used in ISDN.

4.5.3.2 Permanent Virtual Circuits

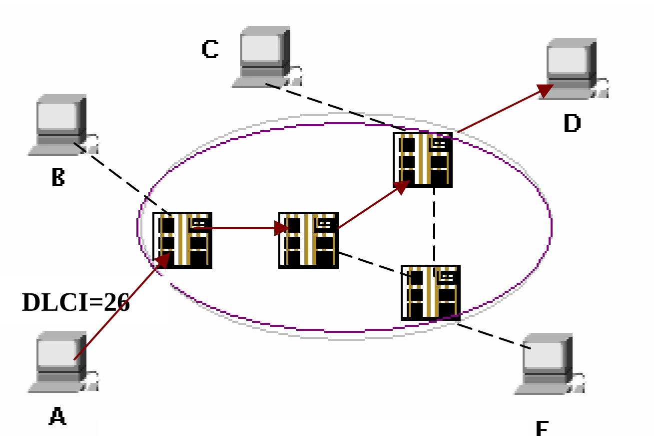
Permanent virtual circuits (PVCs) are permanently established connections that are used for frequent and consistent data transfers between DTE devices across the Frame Relay network. Communication across PVC does not require the call setup and termination states that are used with SVCs. PVCs always operate in one of the following two operational states:

- **Data transfer**: Data is transmitted between the DTE devices over the virtual circuit.
- **Idle**: The connection between DTE devices is active, but no data is transferred.

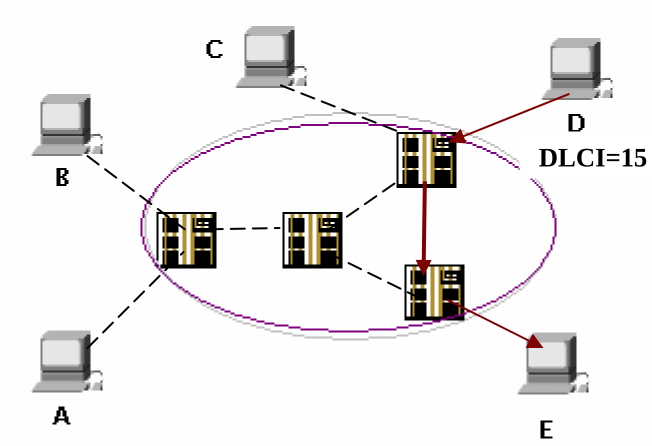
Unlike SVCs, PVCs will not be terminated under any circumstances when in an idle state. DTE devices can begin transferring data whenever they are ready because the circuit is permanently established.

4.5.3.3 Data-Link Connection Identifier (DLCI)

Frame Relay virtual circuits are identified by *data-link connection identifiers (DLCIs)*. DLCI values typically are assigned by the Frame Relay service provider (for example, the telephone company). Frame Relay DLCIs have local significance, which means that their values are unique in the LAN, but not necessarily in the Frame Relay WAN. The local DTEs use this DLCI to send frames to the remote DTE.

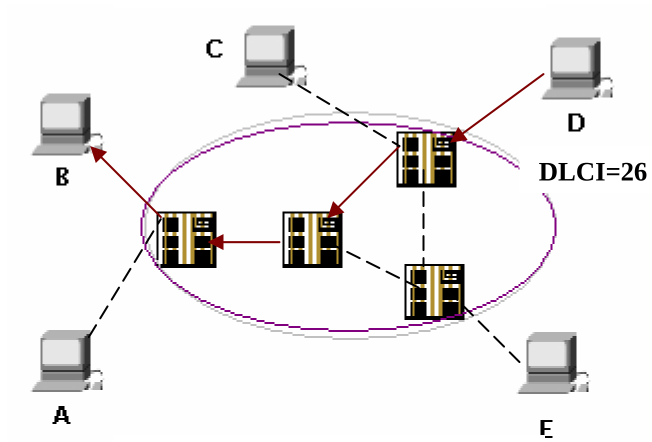


(a). Connection from A to D



(b). Connection from D to E

Figure 4.5.1 shows the assignments of DLCIs, 3 connections have been shown namely, between A to D, D to E, and D to B. Point Here to be noted is that connection in fig.(a) and in fig.(c) uses the same DLCI, this can be done because these DLCIs are used by local DTEs. Bothe the connectons are valid as they define different virtual circuits originating from different DTEs.

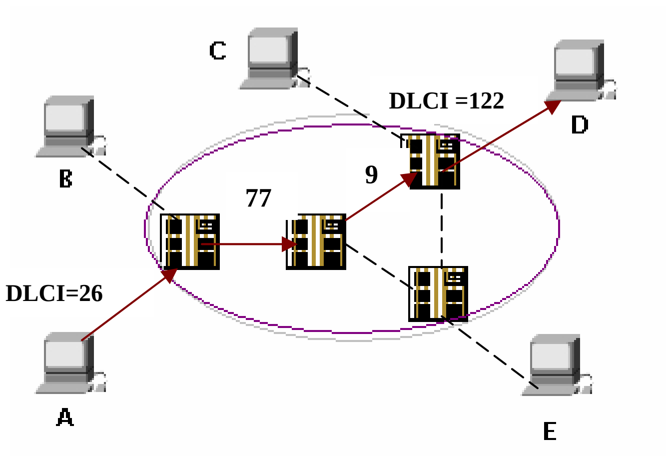


(c). Connection from D to A

Figure 4.5.1 DLCIs connection between different DTEs

4.5.3.4 DLCIs inside the network

DLCIs are not only used to define the virtual circuit between a DTE and a DCE, but also to define the virtual circuit between two DCEs (switches) inside the network. A switch assigns a DLCI to each virtual connection in an interface. This means that two different connections belonging to two different interfaces may have the same DLCIs (as shown in the above figure). In other words, DLCIs are unique for a particular interface.



A connection between DTE A and DTE D has been shown in this figure, DLCI assigned inside the Frame Relay network is also shown in the network. DCEs inside the network use incoming interface – DLCI combination to decide the outgoing interface – DLCI combination to switch out the frame, from that DCE.

Figure 4.5.2 DLCIs inside Frame relay network

Each switch in a Frame relay network has a table to route frames The table matches the incoming interface- DLCI combination with an outgoing interface-DLCI combination. Figure 4.5.3 shows two frames arriving at the switch on interface2, one with DLCI=11 and other with DLCI= 213.

Incoming		**Outgoing**	
Interface	DLCI	Interface	DLCI
1	122	1	41
2	213	1	158
2	11	2	111
1	151	2	210

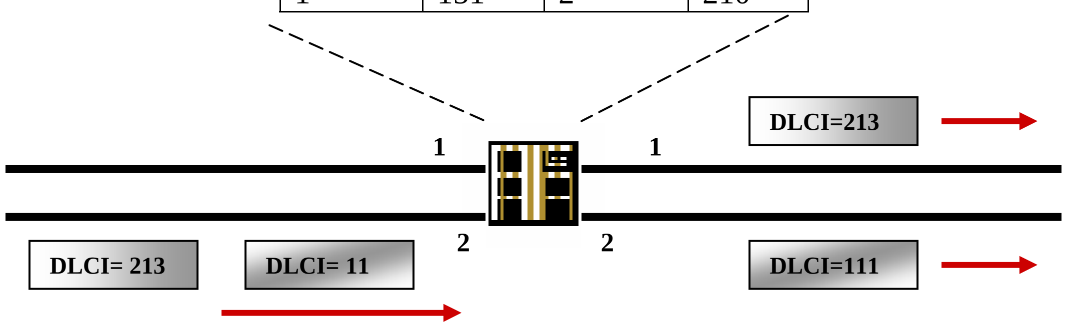


Figure 4.5.3 Frame Relay switch table

4.5.4 Frame Relay Layers

Frame Relay has only 2 layers, namely Physical layer and Data Link layer. And as compared to other layer of packet switching network such as X.25, frame relay has only 1.5 layers whereas X.25 has 2 layers. Frame Relay eliminates all network layer functions and a portion of conventional data-link layer functions.

Physical Layer

No specific protocol is defined for physical layer in frame relay. Frame relay supports any one of the protocols recognized by ANSI, and thus the choice of physical layer protocol is up to the implementer.

Data Link Layer

At Data-link Layer Frame employs a simpler version of HDLC. Simpler version is used because HDLC provides extensive error and flow control fields that are not needed in frame relay.

To understand much of the functionality of Frame Relay, it is helpful to understand the structure of the Frame Relay frame. Figure 4.5.4 depicts the basic format of the Frame Relay frame. Flags indicate the beginning and end of the frame. Three primary components make up the Frame Relay frame: the header and address area, the user-data portion, and the frame check sequence (FCS). The address area, which is 2 bytes in length, is comprised of 10 bits representing the actual circuit identifier and 6 bits of fields related to congestion management. This identifier commonly is referred to as the data-link connection identifier (DLCI).

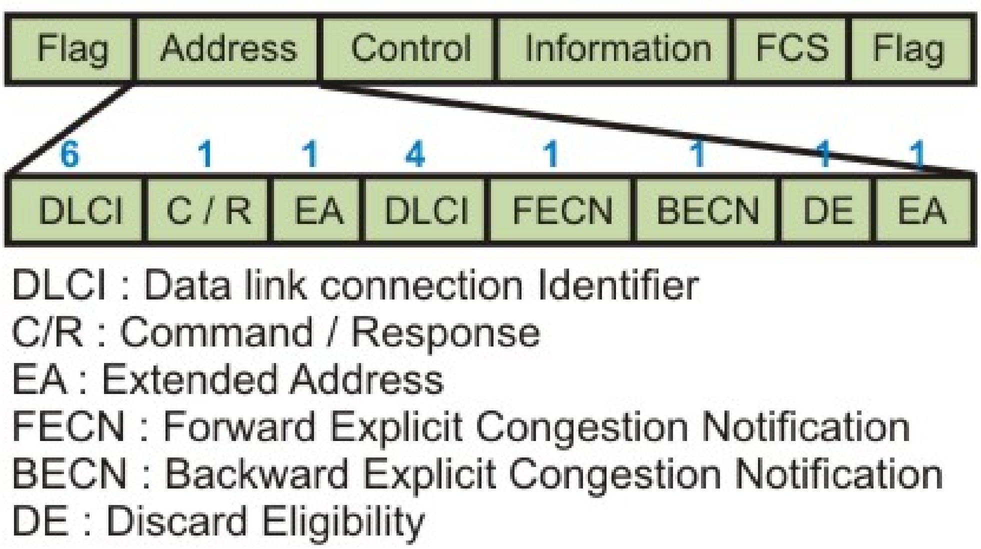


Figure 4.5.4 Frame Relay frame format

- F**lags**—Delimits the beginning and end of the frame. The value of this field is always the same and is represented either as the hexadecimal number 7E or as the binary number 01111110.
- **Address**—Contains the following information:

DLCI—The 10-bit DLCI is the essence of the Frame Relay header. This value represents the virtual connection between the DTE device and the switch. Each virtual connection that is multiplexed onto the physical channel will be represented by a unique DLCI. The DLCI values have local significance only, which means that they are unique only to the physical channel on which they reside. Therefore, devices at opposite ends of a connection can use different DLCI values to refer to the same virtual connection. The first 6-bits of the first byte make up part 1 of the DLCI, and second part of DLCI uses the first 4-bits of second byte.

E**xtended Address (EA)—**The EA is used to indicate whether the byte in which the EA value is 1 is the last addressing field. If the value is 1, then the current byte is determined to be the last DLCI octet. Although current Frame Relay implementations all use a two-octet DLCI, this capability does allow longer DLCIs to be used in the future. The eighth bit of each byte of the Address field is used to indicate the EA.

C/R—The C/R is the bit that follows the most significant DLCI byte in the Address field. The C/R bit is not currently defined.

Congestion Control—This consists of the 3 bits that control the Frame Relay congestion-notification mechanisms. These are the FECN, BECN, and DE bits, which are the last 3 bits in the Address field.

Forward-explicit congestion notification (FECN) is a single-bit field that can be set to a value of 1 by a switch to indicate to an end DTE device, such as a router, that congestion was experienced in the direction of the frame transmission from source to destination as shown in Fig. 4.5.5. The primary benefit of the use of the FECN and BECN fields is the capability of higher-layer protocols to react intelligently to these congestion indicators. Today, DECnet and OSI are the only higher-layer protocols that implement these capabilities.

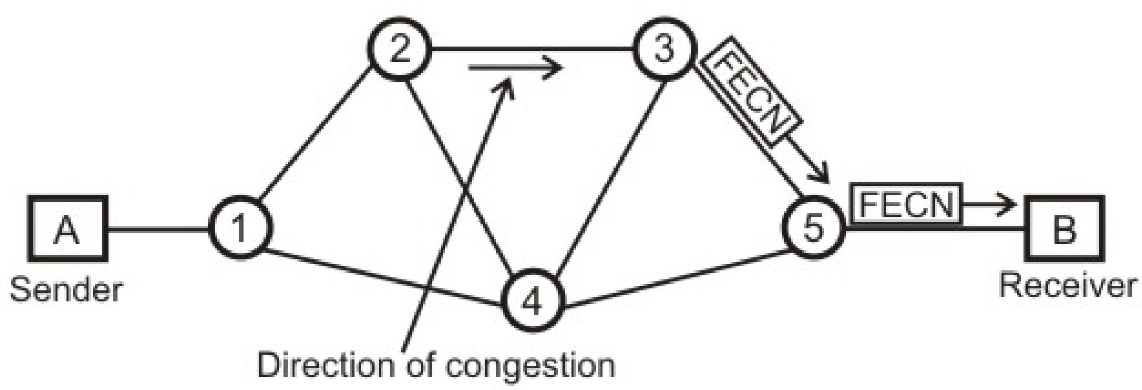


Figure 4.5.5 Forward-explicit congestion notification

Backward-explicit congestion notification (BECN) is a single-bit field that, when set to a value of 1 by a switch, indicates that congestion was experienced in the network in the direction opposite of the frame transmission from source to destination.

Discard eligibility (DE) is set by the DTE device, such as a router, to indicate that the marked frame is of lesser importance relative to other frames being transmitted. Frames that are marked as "discard eligible" should be discarded before other frames in a congested network. This allows for a basic prioritization mechanism in Frame Relay networks.

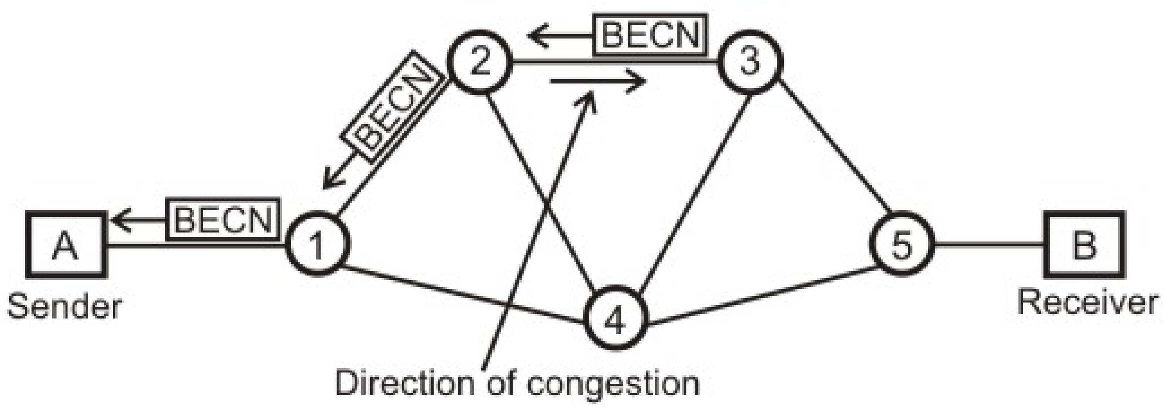


Figure 4.5.6 Backward-explicit congestion notification

• **Data**—Contains encapsulated upper-layer data. Each frame in this variable-length field includes a user data or payload field that will vary in length up to 16,000 octets. This field serves to transport the higher-layer protocol packet (PDU) through a Frame Relay network.

• **Frame Check Sequence**—Ensures the integrity of transmitted data. This value is computed by the source device and verified by the receiver to ensure integrity of transmission.

4.5.5 Summary

- Frame relay operates only in data link and physical layer.
- Frame Relay allows bursty traffic.
- It allows frame size of 9000 bytes, which can accommodate all local area network frames.
- Frame relay is less expensive then other traditional WANs.
- Frame relay provides both Permanent and switched connections.
- Frame relay allow variable-length frames, this may create varying delays for different users. Due to variable delay it is not suitable for real-time communication

Fill in the blanks:

1. **1.** Frame Relay is a high-performance ______ protocol.
2. **2.** Frame Relay operates at the __________ and _____________ layers of the OSI reference model.
3. **3.** Frame Relay requires Error Checking at the _________ layer.
4. **4.** Frame Relay is a simplified form of ______________ switching, similar in principle to _______.
5. **5.** Frame Relay is a ___________________ network.
6. **6.** Frame Relay virtual circuits are identified by ___________.
7. **7.** ______ bit in address field in frame relay is set to one to signify the last address bit.
8. **8.** Routing and switching in Frame Relay is performed by ________ layer.
9. **9.** ________ data are allowed on a Frame Relay Network.
10. **10.** Frame relay is not suited well for ______ due to the delay resulting from varying sizes of Frame.

Answers fill in the blanks

1. WAN
2. Physical, data link
3. Data link
4. Circuit, X.25
5. Virtual switched
6. DLCIs.
7. Extended Address (EA)
8. Data link layer
9. Encapsulated upper layer
10. Real time traffic

Short Answer Questions:

1. Explain few devices used in Frame relay.

Ans: Devices attached to a Frame Relay WAN fall into the following two general categories:

- **Data terminal equipment (DTE)** : DTEs generally are considered to be terminating equipment for a specific network and typically are located on the premises of a customer
- **Data circuit-terminating equipment (DCE)**: DCEs are carrier-owned internetworking devices. The purpose of DCE equipment is to provide clocking and switching services in a network, which are the devices that actually transmit data through the WAN. In most cases, these are packet switches.

2. Distinguish between permanent virtual and switched virtual connections used in Frame relay protocol.

Ans: In permanent virtual connection, the path is fixed and data transfer occurs as with virtual calls, but no call setup or termination is required. On the other hand, in switched virtual connection, the path is a dynamically established virtual circuit using a call set up and call clearing procedure. Many other circuits can share the same path.

3. What are the various states in a Switched virtual circuit connection in Frame Relay?

Ans:

A communication session across an SVC consists of the following four operational states:

- **Call setup—**The virtual circuit between two Frame Relay DTE devices is established.
- **Data transfer—**Data is transmitted between the DTE devices over the virtual circuit.
- **Idle—**The connection between DTE devices is still active, but no data is transferred. If an SVC remains in an idle state for a defined period of time, the call can be terminated.
- **Call termination—**The virtual circuit between DTE devices is terminated.

4. Describe Permanent Virtual switched connection in Frame Relay.

Ans: *Permanent virtual circuits (PVCs)* are permanently established connections that are used for frequent and consistent data transfers between DTE devices across the Frame Relay network. Communication across PVC does not require the call setup and termination states that are used with SVCs. PVCs always operate in one of the following two operational states:

- **Data transfer—**Data is transmitted between the DTE devices over the virtual circuit.

- **Idle—**The connection between DTE devices is active, but no data is transferred.

Unlike SVCs, PVCs will not be terminated under any circumstances when in an idle state. DTE devices can begin transferring data whenever they are ready because the circuit is permanently established.

5. Write a short Note on Data-Link Connection Identifier (DLCI).

Ans: Frame Relay virtual circuits are identified by *data-link connection identifiers (DLCIs)*. DLCI values typically are assigned by the Frame Relay service provider (for example, the telephone company). Frame Relay DLCIs have local significance, which means that their values are unique in the LAN, but not necessarily in the Frame Relay WAN. The local DTEs use this DLCI to send frames to the remote DTE.

DLCIs are not only used to define the virtual circuit between a DTE and a DCE, but also to define the virtual circuit between two DCEs (switches) inside the network. A switch assigns a DLCI to each virtual connection in an interface. This means that two different connections belonging to two different interfaces may have the same DLCIs. In other words, DLCIs are unique for a particular interface.

6. What does extended address field in Frame Relay frame Format specifies?

Ans:
Extended Address (EA) is used to indicate whether the byte in which the EA value is 1 is the last addressing field. If the value is 1, then the current byte is determined to be the last DLCI octet. Although current Frame Relay implementations all use a two-octet DLCI, this capability does allow longer DLCIs to be used in the future. The eighth bit of each byte of the Address field is used to indicate the EA.