Frame Relay

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Frame Relay

- *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

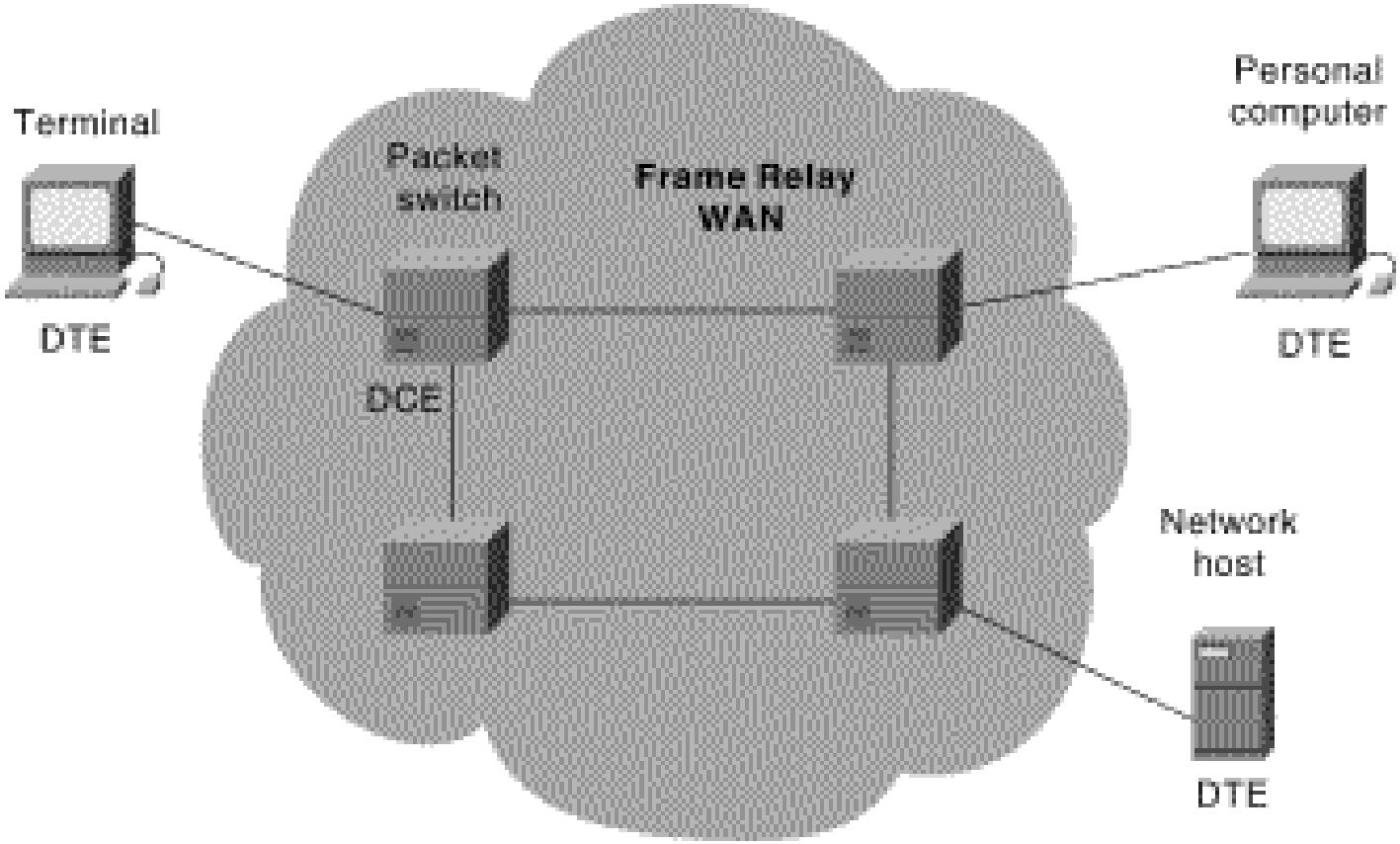
Packet Switching

- Frame Relay is based on packet-switched technology.
- The following two techniques are used in packet-switching technology:
  - Variable-length packets
  - Statistical multiplexing

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)
- 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

Frame Relay Devices



Frame Relay Virtual Circuits

- Frame Relay provides connection-oriented data link layer communication.
- 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.
- A virtual circuit can pass through any number of intermediate DCE devices (switches) located within the Frame Relay PSN.
- Frame Relay virtual circuits fall into two categories: **switched virtual circuits** (SVCs) and **permanent virtual circuits** (PVCs).

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.
  - **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.

Switched Virtual Circuits

- **Few manufacturers** of Frame Relay DCE equipment support switched virtual circuit connections. Therefore, their actual deployment is minimal in today's Frame Relay networks.
- **Previously not widely supported** by Frame Relay equipment, SVCs are now the norm.
- Companies have found that SVCs save money in the end because the circuit is not open all the time

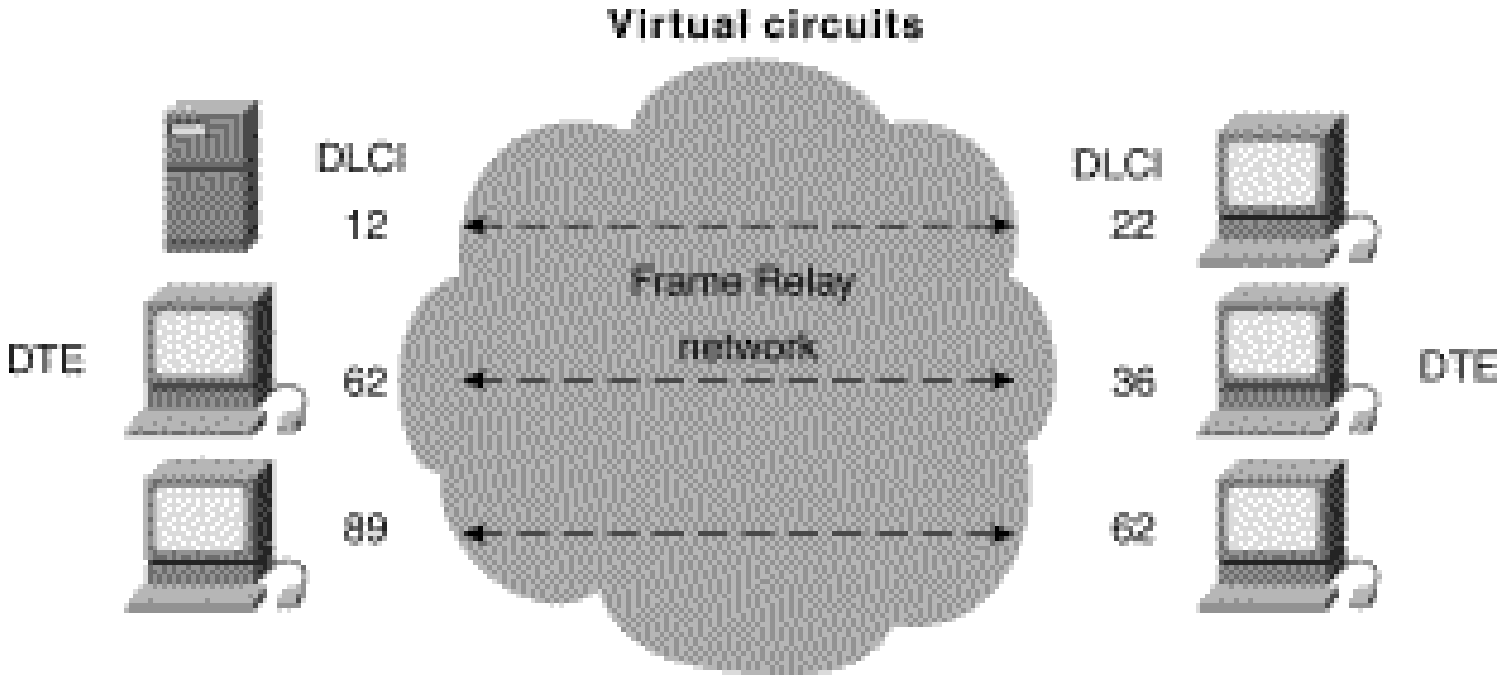
Permanent Virtual Circuits

- *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 a PVC does not require the call setup and termination states that are used with SVCs.
    - **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.

Data-Link Connection Identifier

- 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

Data-Link Connection Identifier



A Single Frame Relay Virtual Circuit Can Be Assigned Different DLCIs on Each End of a VC

Congestion-Control Mechanisms

- Frame Relay reduces network overhead by implementing simple congestion-notification mechanisms rather than explicit, per-virtual-circuit flow control.
- Frame Relay implements two congestion-notification mechanisms:
  - Forward-explicit congestion notification (FECN)
  - Backward-explicit congestion notification (BECN)
- FECN and BECN each is controlled by a single bit contained in the **Frame Relay frame header**.
- The Frame Relay frame header also contains a Discard Eligibility (DE) bit, which is used to identify less important traffic that can be dropped during periods of congestion.

Congestion-Control Mechanisms

- The *FECN bit* is part of the Address field in the Frame Relay frame header.
- The FECN mechanism is initiated when a DTE device sends Frame Relay frames into the network.

If the network is congested, DCE devices (switches) set the value of the frames' FECN bit to 1. When the frames reach the destination DTE device, the Address field (with the FECN bit set) indicates that the frame experienced congestion in the path from source to destination. The DTE device can relay this information to a higher-layer protocol for processing. Depending on the implementation, flow control may be initiated, or the indication may be ignored.

Congestion-Control Mechanisms

- The *BECN bit* is part of the Address field in the Frame Relay frame header.
- DCE devices set the value of the BECN bit to 1 in frames traveling in the opposite direction of frames with their FECN bit set.
- This informs the receiving DTE device that a particular path through the network is congested.
- The DTE device then can relay this information to a higher-layer protocol for processing. Depending on the implementation, flow-control may be initiated, or the indication may be ignored

Frame Relay Discard Eligibility

- The DE bit is part of the Address field in the Frame Relay frame header.
- The *Discard Eligibility (DE) bit* is used to indicate that a frame has lower importance than other frames.
- DTE devices can set the value of the DE bit of a frame to 1 to indicate that the frame has lower importance than other frames.
- When the network becomes congested, DCE devices will discard frames with the DE bit set.

Frame Relay Error Checking

- Frame Relay uses a common error-checking mechanism known as the cyclic redundancy check (CRC).
- The CRC compares two calculated values to determine whether errors occurred during the transmission from source to destination.
- Frame Relay reduces network overhead by implementing error checking rather than error correction.

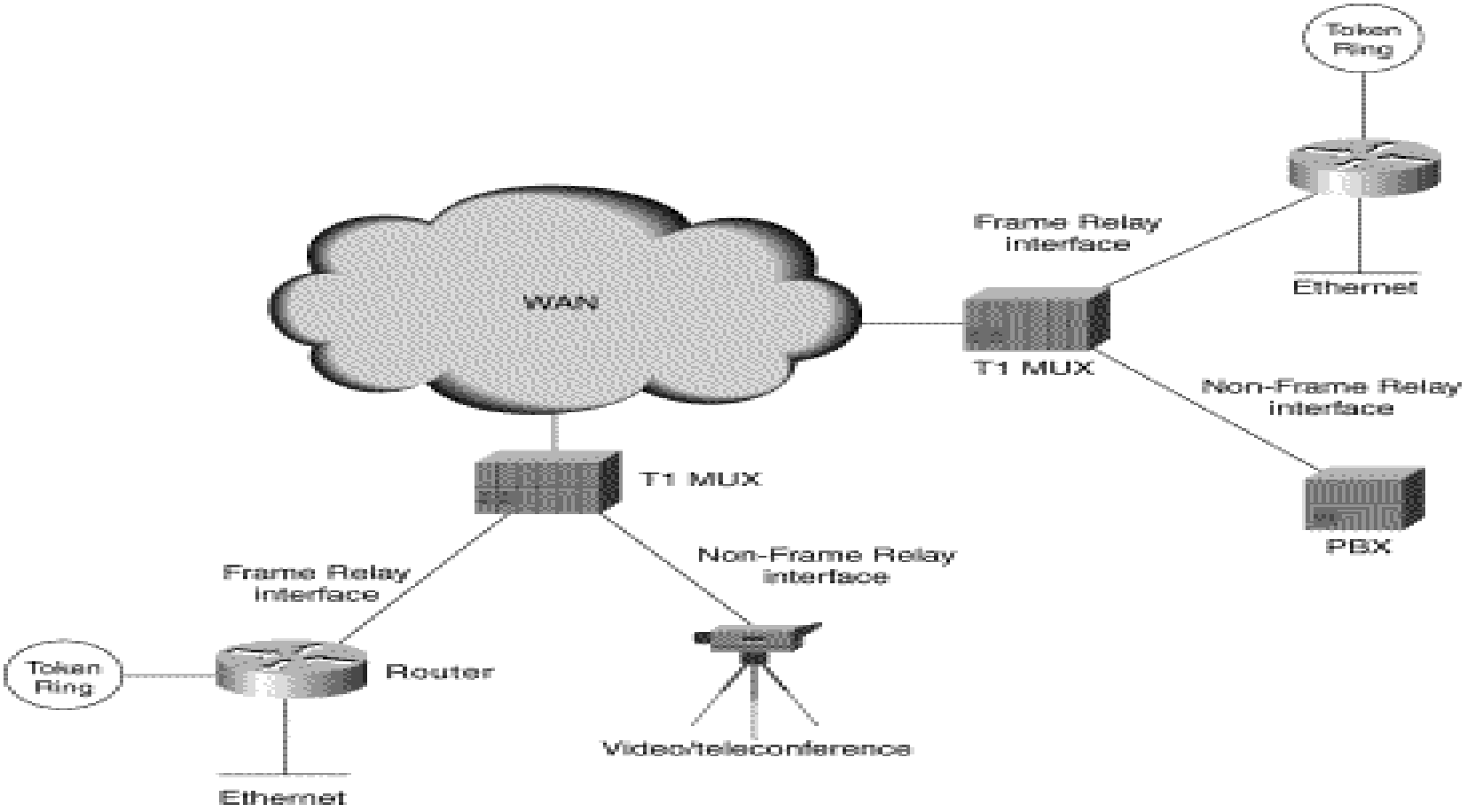
Frame Relay
Local Management Interface

- The *Local Management Interface (LMI)* is a set of enhancements to the basic Frame Relay specification
- The LMI global addressing extension gives Frame Relay (DLCI) values global rather than local significance. DLCI values become DTE addresses that are unique in the Frame Relay WAN.
- LMI virtual circuit status messages provide communication and synchronization between Frame Relay DTE and DCE devices. These messages are used to periodically report on the status of PVCs, which prevents data from being sent into black holes (that is, over PVCs that no longer exist).

Frame Relay Network Implementation

- A common private Frame Relay network implementation is to equip a T1 multiplexer with both **Frame Relay** and **non-Frame Relay** interfaces.
- Frame Relay traffic is forwarded out the Frame Relay interface and onto the data network.
- Non-Frame Relay traffic is forwarded to the appropriate application or service, such as a private branch exchange (PBX) for telephone service or to a video-teleconferencing application.

Frame Relay Network Implementation



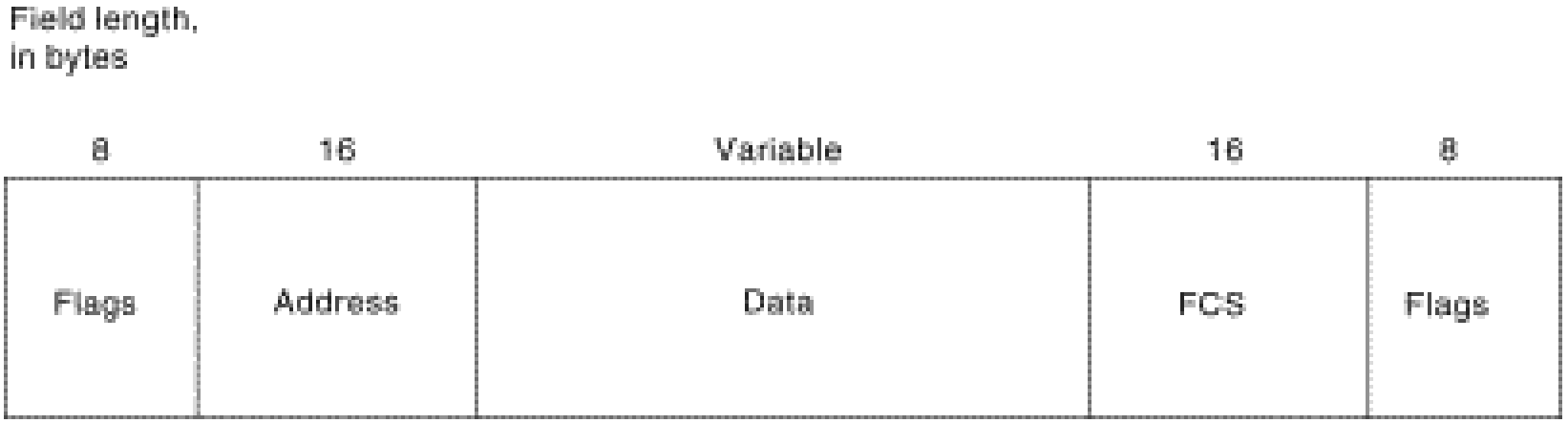
Public Carrier-Provided Networks

- In public carrier-provided Frame Relay networks, the Frame Relay switching equipment is located in the central offices of a telecommunications carrier.
- Subscribers are charged based on their network use but are relieved from administering and maintaining the Frame Relay network equipment and service.
- DCE equipment either will be customer-owned or perhaps will be owned by the telecommunications provider as a service to the customer. Generally, the DCE equipment also is owned by the telecommunications provider.
- The majority of today's Frame Relay networks are public carrier-provided networks.

Private Enterprise Networks

- More frequently, organizations worldwide are deploying private Frame Relay networks.
- In private Frame Relay networks, the administration and maintenance of the network are the responsibilities of the enterprise (a private company).
- All the equipment, including the switching equipment, is owned by the customer

Frame Relay Frame Formats



- 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).

Frame Relay Frame Formats

- **Flags**—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**
  - **Extended Address (EA)**
  - **C/R**
  - **Congestion Control**
    - *(FECN)*
    - *(BECN)*
    - *Discard eligibility (DE)*

Frame Relay Frame Formats

- **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.

Frame Relay Frame Formats

- **Extended 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.

Frame Relay Frame Formats

- **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.

Frame Relay Frame Formats

- *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. 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.*

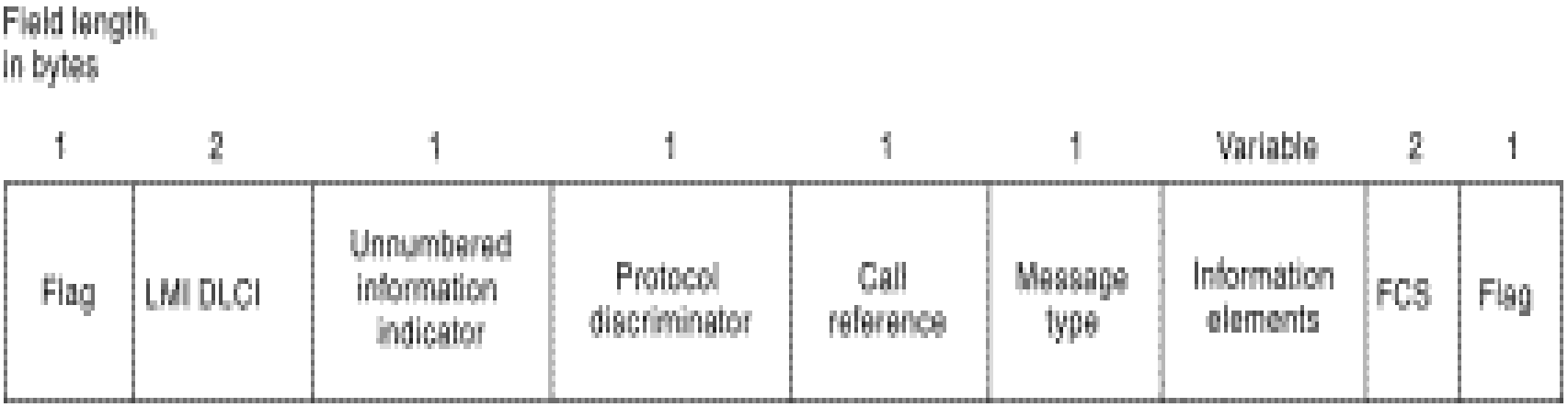
Frame Relay Frame Formats

- *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.*

Frame Relay Frame Formats

- **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.

LMI Frame Format



- **Flag**—Delimits the beginning and end of the frame.
- **LMI DLCI**—Identifies the frame as an LMI frame instead of a basic Frame Relay frame. The LMI-specific DLCI value defined in the LMI consortium specification is DLCI = 1023.

LMI Frame Format

- **Unnumbered Information Indicator**—Sets the poll/final bit to zero.
- **Protocol Discriminator**—Always contains a value indicating that the frame is an LMI frame.
- **Call Reference**—Always contains zeros. This field currently is not used for any purpose.
- **Message Type**—Labels the frame as one of the following message types:
  - **Status-inquiry message—**Allows a user device to inquire about the status of the network.
  - **Status message—**Responds to status-inquiry messages. Status messages include keepalives and PVC status messages.

LMI Frame Format

- **Information Elements**—Contains a variable number of individual information elements (IEs). IEs consist of the following fields:
  - **IE Identifier**—Uniquely identifies the IE.
  - **IE Length**—Indicates the length of the IE.
  - **Data**—Consists of 1 or more bytes containing encapsulated upper-layer data.
- **Frame Check Sequence (FCS)**—Ensures the integrity of transmitted data.