Frame Relay Networks

- **Frame Relay is designed to provide lower delay and higher throughput than traditional packet switched networks.**
- **Frame Relay originated as part of ISDN standardization.**
- **Frame Relay service can be provided by both ISDN and non-ISDN networks.**

Traditional X.25 Packet Switching:

- **Call control packets, used for setting up virtual circuits, are carried on the same channel and the same virtual circuit, as data packets. In effect, in-band signaling is used.**
- **Multiplexing and switching of virtual circuits takes place at layer 3.**
- **Both layer 2 and layer 3 include flow control and error control.**

Frame Relay Approach:

- **Call control signaling is carried on a separate logical connection from user data. Thus, intermediate nodes need not maintain state tables or process messages relating to call control on an individual per-connection basis. (Common channel signaling.)**
- **Multiplexing and switching of logical connections takes place at layer 2, (instead of layer 3,) eliminating one entire level of processing.**
- **There is no hop-by-hop flow control and error control. End-to-end flow control and error control, if they are employed at all, are the responsibility of a higher layer.**

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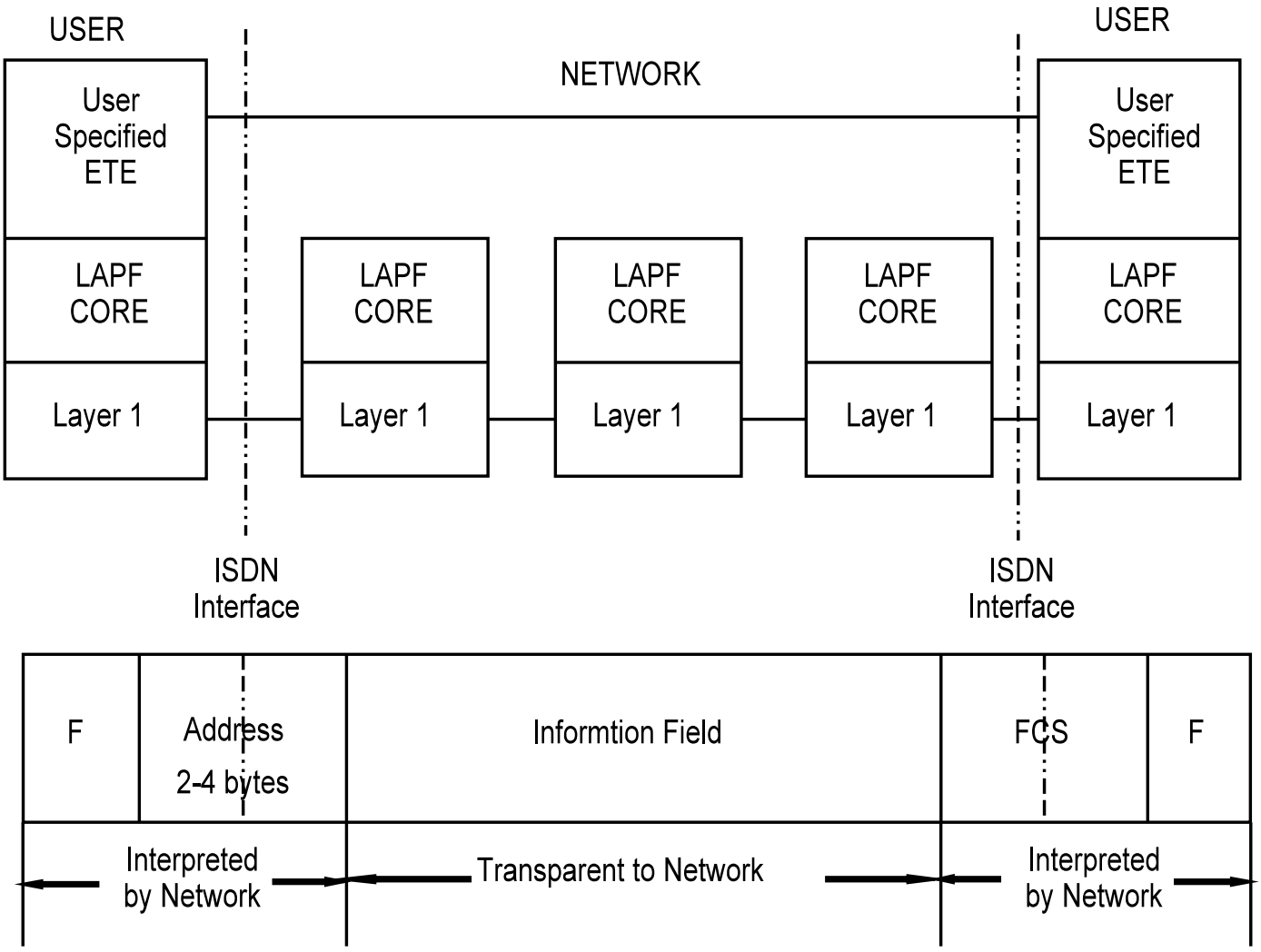
Frame Relay Data Transfer Operation



Only the LAP core functions are performed during data transfer.

LAP core functions:

- **Flag Detection**
- **FCS calculation**
- **Address Recognition**

If FCS is correct:

- **change address for next link**
- **recalculate FCC**
- **relay to next node**

If FCS is incorrect:

- **discard frame**

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Frame Relay Address Field Formats

! **2-byte**

8	7	6	5	4	3	2	1
DLCI (high order)						C/R	EA0
DLCI (low order)				FECN	BECN	DE	EA1

! **3-byte**

8	7	6	5	4	3	2	1
DLCI (high order)						C/R	EA0
DLCI				FECN	BECN	DE	EA0
DLCI (low order) or DL Core Control						D/C	EA1

! **4-byte**

8	7	6	5	4	3	2	1
DLCI (high order)						C/R	EA0
				FECN	BECN	DE	EA0
DLCI							EA0
DLCI (low order) or DL Core Control						D/C	EA1

C/R - Command/Response bit
EA - Address Field Extension bit
DE - Discard Eligibility bit
FECN - Forward Explicit Congestion Notification
BECN - Backward Explicit Congestion Notification
DLCI - Data Link Connection Identifier
D/C - DLCI or CORE Control Indicator bit

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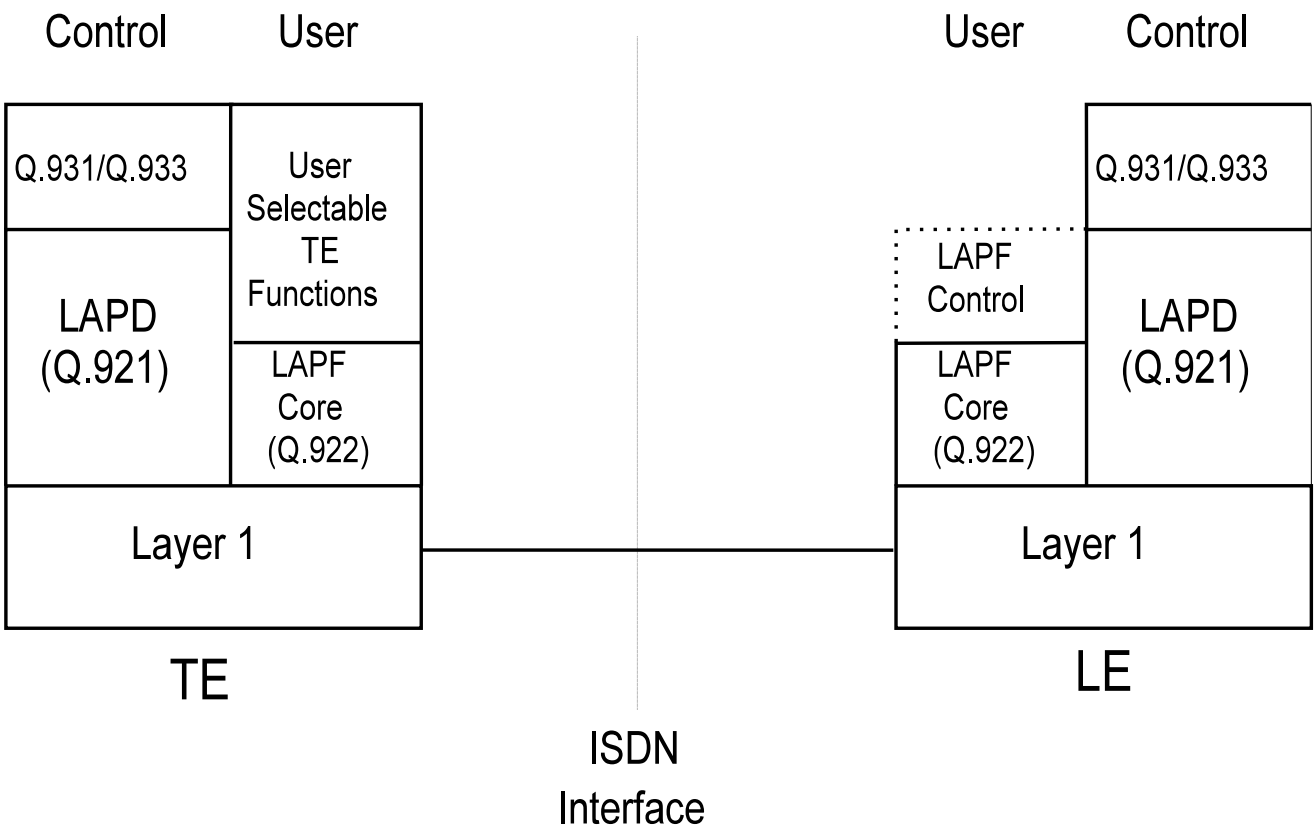
Frame Relay Protocol Architecture



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Q.931/Q.933 Frame Relay Message Repertoire

- **Call Establishment Messages:**
  - **ALERTING**
  - **CALL PROCEEDING**
  - **CONNECT**
  - **CONNECT ACKNOWLEDGE**
  - **PROGRESS**
  - **SETUP**

- **Call Clearing Messages:**
  - **DISCONNECT**
  - **RELEASE**
  - **RELEASE COMPLETE**

- **Miscellaneous Messages:**
  - **STATUS**
  - **STATUS ENQUIRY**

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Frame Relay Call Control

- **The establishment and release of a frame relay connection is accomplished by the exchange of Q.931/Q.933 messages over a logical connection dedicated to call control (DLCI = 0). A frame with DLCI=0 has a call control message in the information field.**

- **Either side may request the establishment of a logical connection by sending a SETUP message.**

- **The other side must reply either with a CONNECT message to accept the connection or with a RELEASE COMPLETE message to refuse the connection.**

- **The side sending the SETUP message may choose the DLCI for the connection by choosing an unused value; otherwise, the accepting side assigns the DLCI within the CONNECT message.**

- **After the connection is established, data transfer can proceed.**

- **Clearing a connection is accomplished by the exchange of DISCONNECT, RELEASE, and RELEASE COMPLETE messages.**

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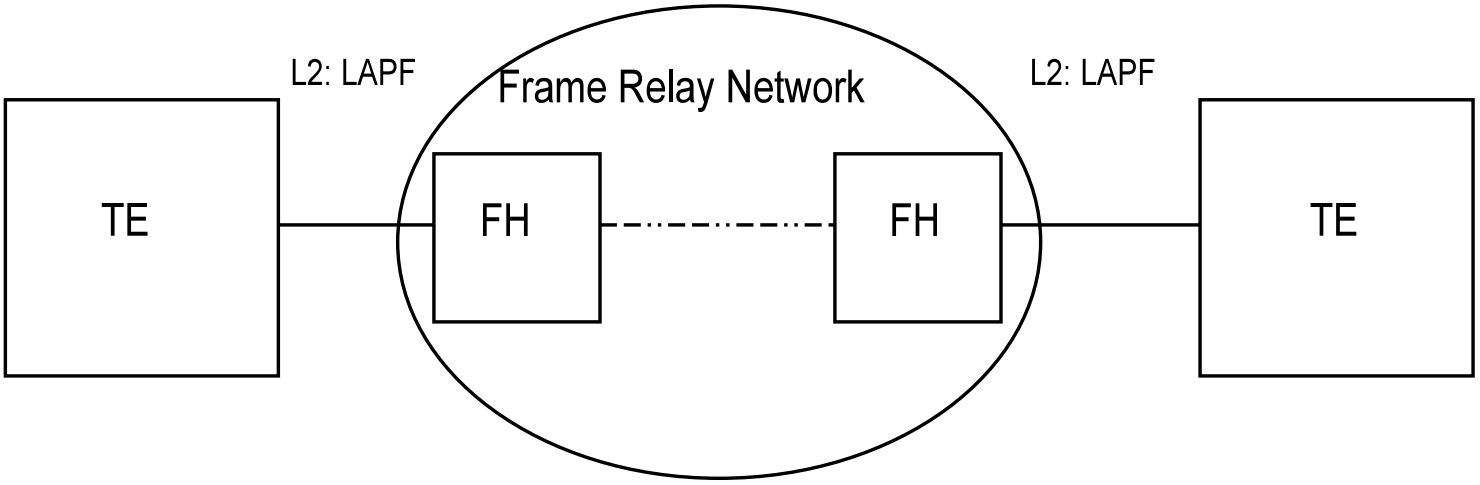
Frame Relay Data Transfer



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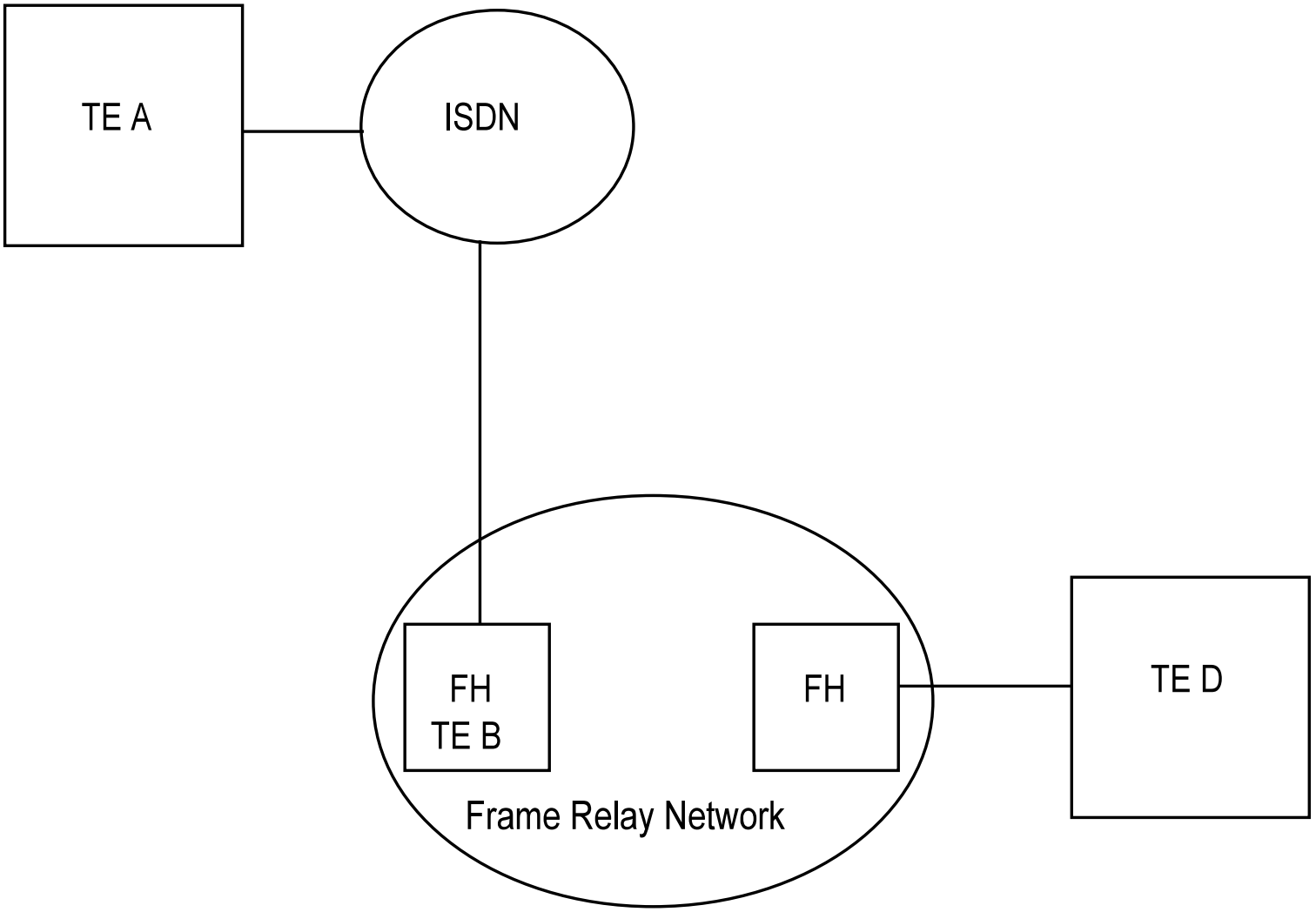
Frame Relay Connection Setup: Example 1



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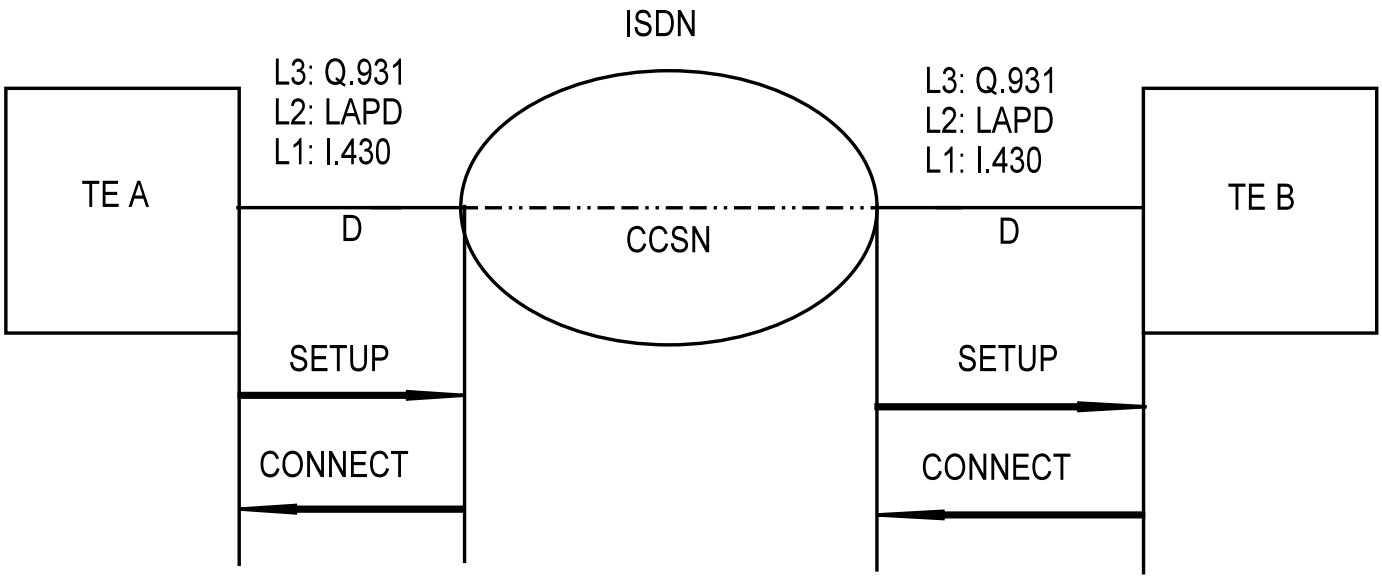
! Stage 1: CM Connection across the ISDN using Q.931

- Call Setup: Q.931



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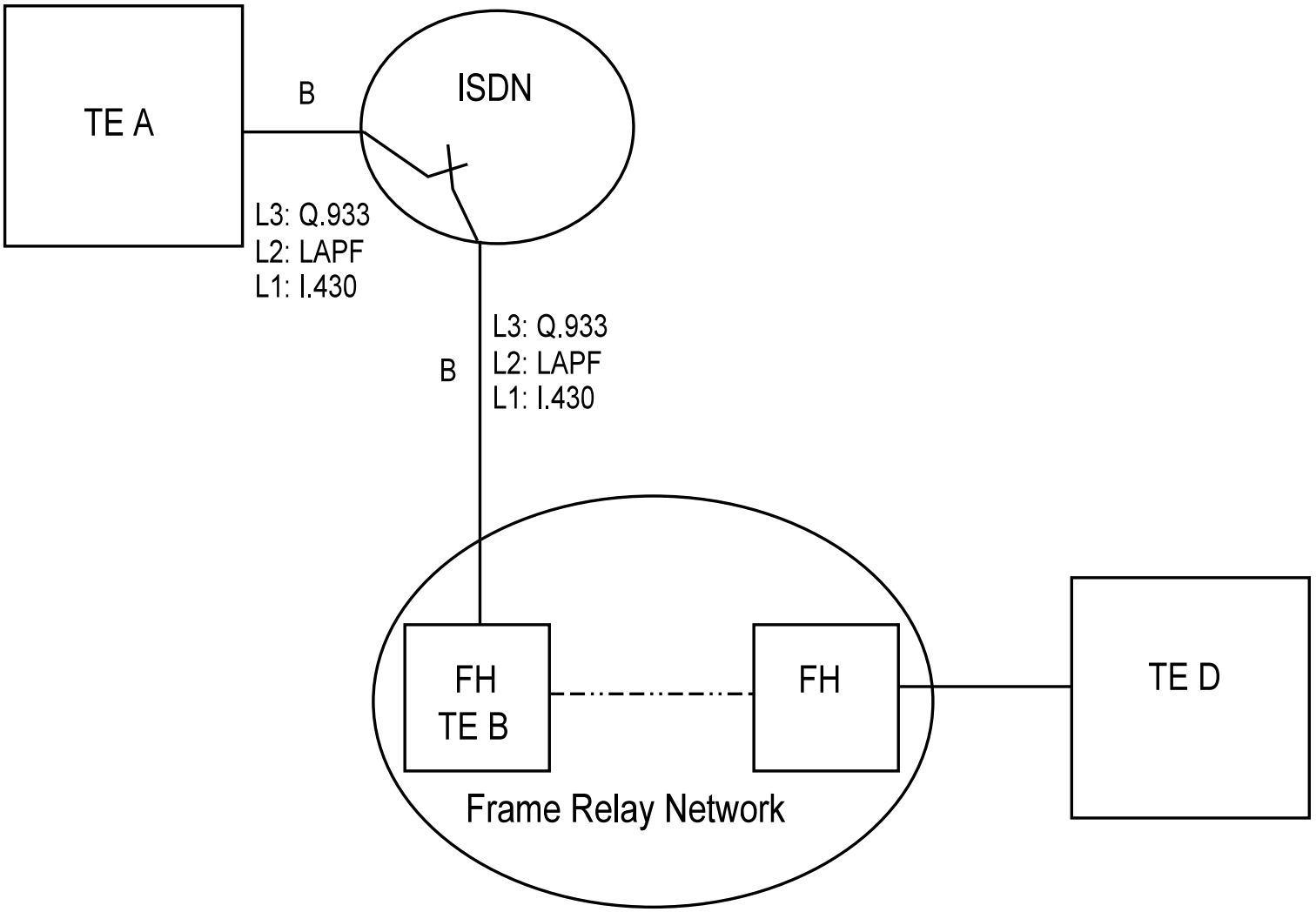
! **Stage 2: Frame Relay Connection using Q.933**



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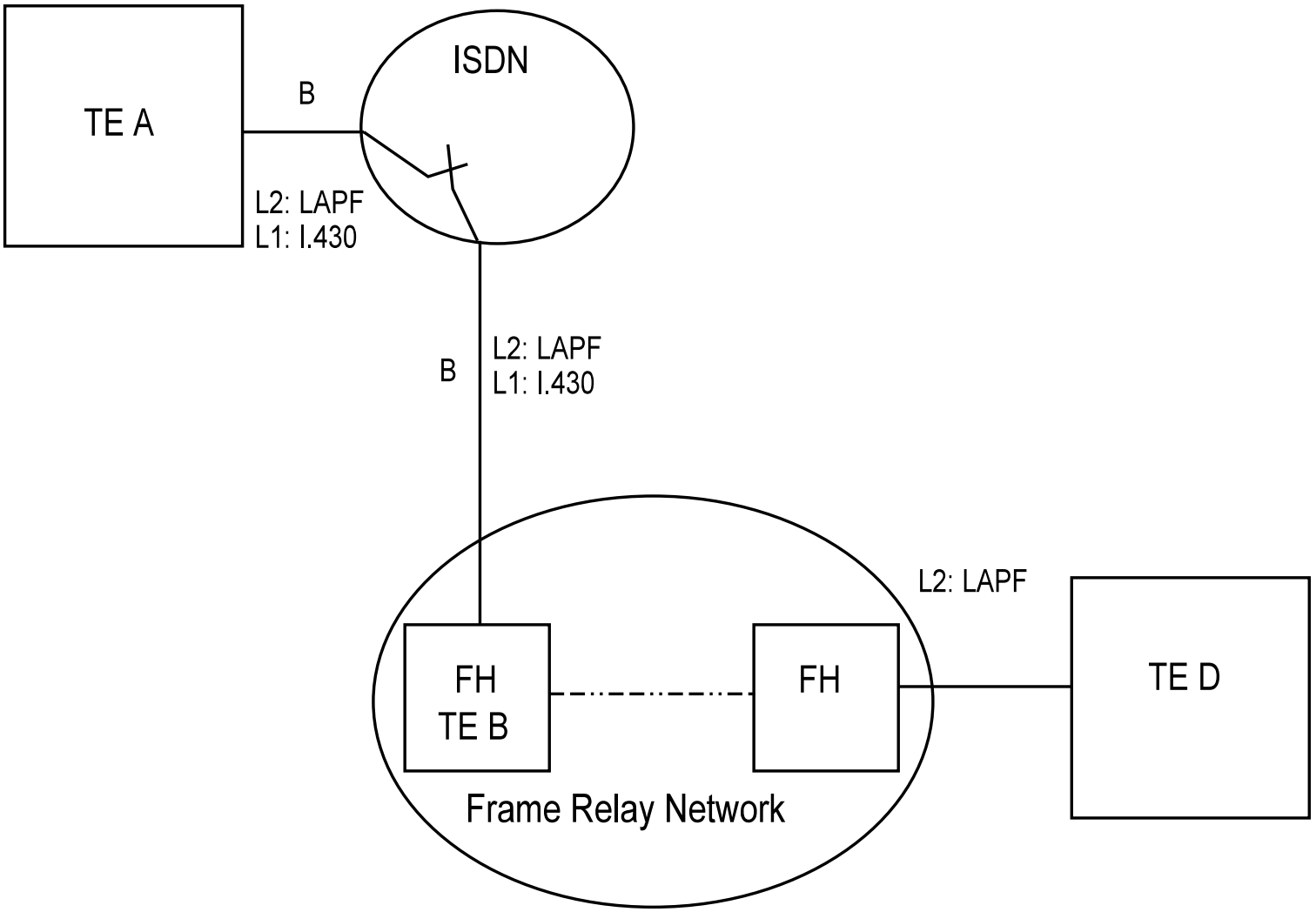
! **Stage 3: Frame Relay Logical Connection for Data Transfer**



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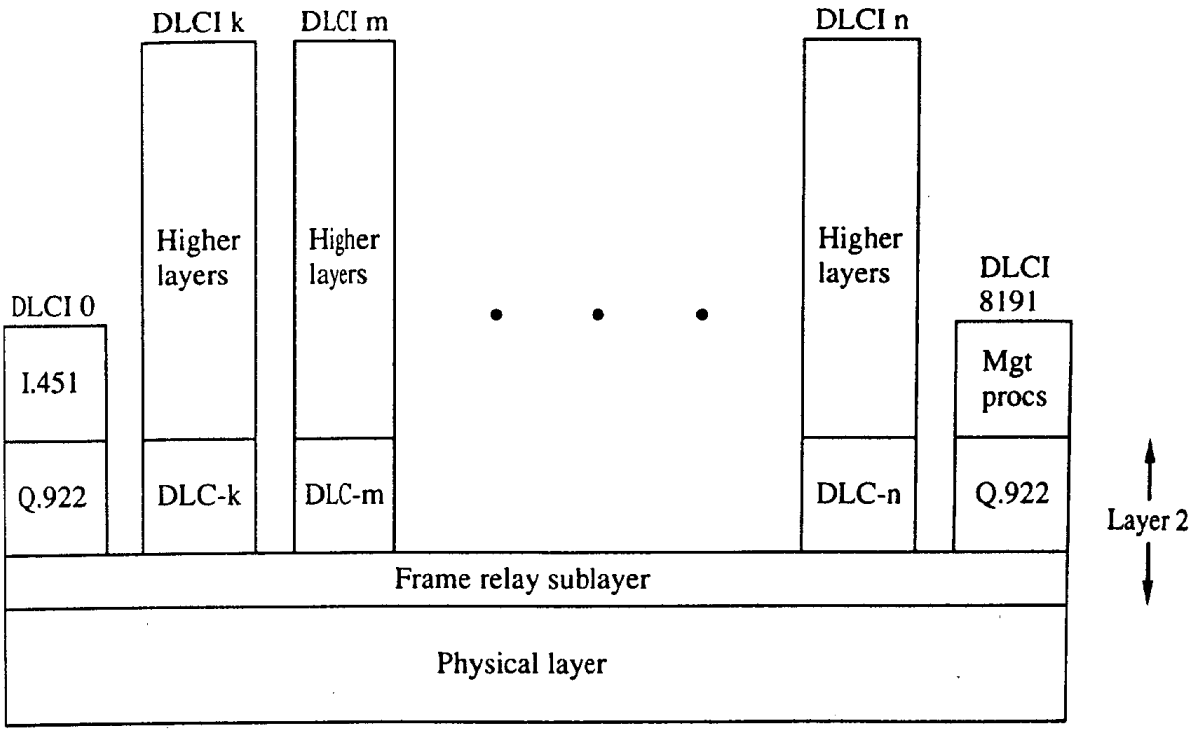
Frame Relay Multiplex Function



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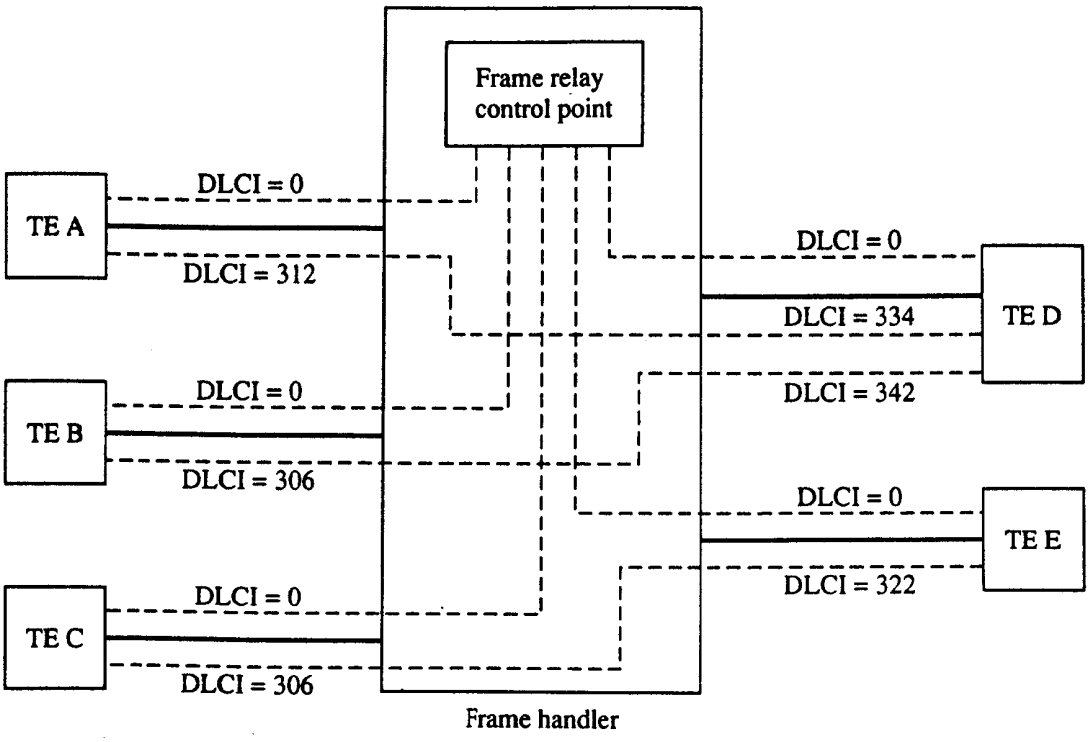
Frame Handler Operation



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Frame Relay Congestion Control

! **Frame Relay Congestion Control Techniques:**

Technique	Type	Function	Key Elements
Discard Control	Discard Strategy	Provide guidance to network as to which frames to discard	DE bit
Backward Explicit Congestion Notification	Congestion Avoidance	Provide guidance to ESs about congestion in network	BECN bit
Forward Explicit Congestion Notification	Congestion Avoidance	Provide guidance to ESs about congestion in network	FECN bit
Implicit Congestion Notification	Congestion Recovery	ES infers congestion from frame loss	Sequence numbers in higher layer PDUs

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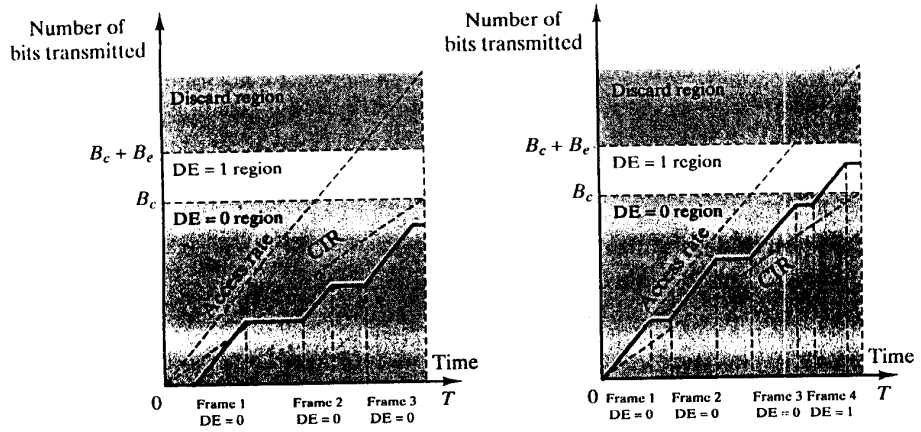
Discard Strategy (Use of DE bit)

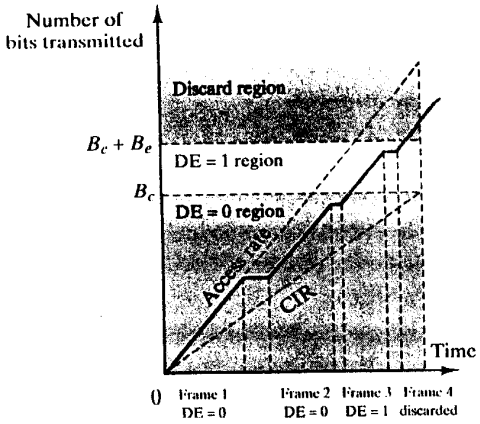
Definitions:

- **Access Rate:**
  The data rate of the user access channel.
- **Committed Information Rate (CIR):**
  The rate (in bps) that the network agrees to support a particular frame mode connection.
- **Committed Burst Size (B_c):**
  The maximum amount of data that the network agrees to transfer, under normal conditions, over an interval T. (Note: $T = B_c/CIR$).
- **Excess Burst Size (B_e):**
  The maximum amount of data in excess of B_c that the network will attempt to transfer, under normal conditions, over an interval T.



(a) All frames within CIR

(b) One frame marked DE



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Collision Avoidance Technique

- **Each frame handler monitors its congestion and sets BECN and/or FECN as appropriate.**

- **Backward Explicit Congestion Notification (BECN):**
  Notifies the user that congestion avoidance procedures should be initiated where applicable for traffic in the opposite direction of the received frame. The notification indicates that frames transmitted by the user on this logical connection may encounter congested resources.

  User Response:
  Reduce transmitted frame rate until the signal ceases.

- **Forward Explicit Congestion Notification (FECN):**
  Notifies the user that congestion avoidance procedures should be initiated where applicable for traffic in the same direction as the received frame. The notification indicates that this frame, on this logical connection, has encountered congestion.

  User Response:
  Notify its peer user of this connection to restrict its flow of frames. This must be done at a higher layer of protocol.

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