

WAN Technology

- Operates at 3 layer OSI model as below:
- 1. PHY
- 2. Data Link
- 3. Network
- Most of WAN technology are packet-switched network categorized as Switched Virtual circuit Network (3-phase, connection oriented)

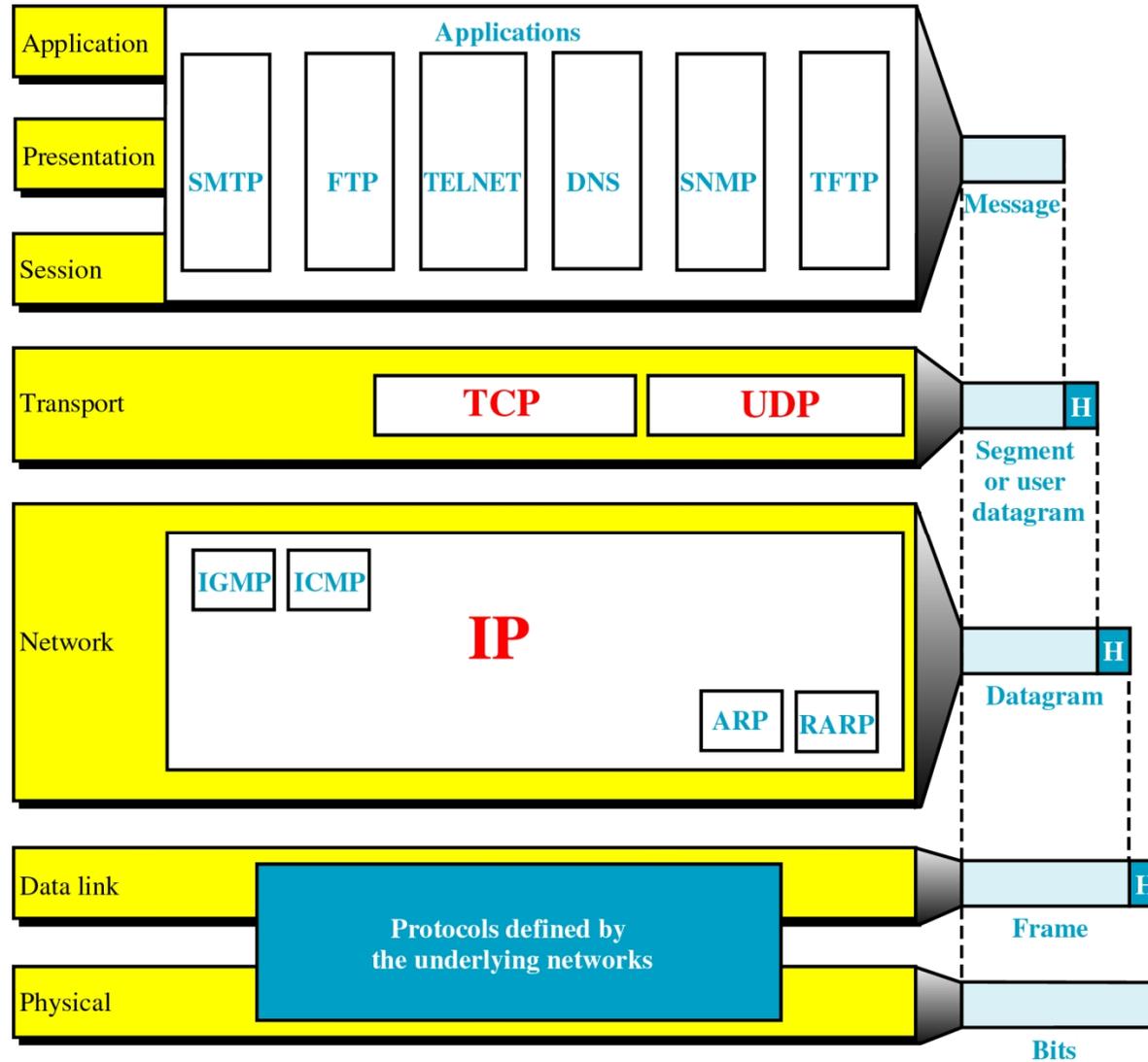
WAN technology which are to be discussed:

- PPP-ADSL (Point-to-point protocol) for ADSL
- ISDN (PPP-ADSL took place)
- X.25
- Frame Layer
- ATM (famous in Malaysia/Singapore)
- MPLS (multi-protocol label switched)
- Sonet – as WAN backbone

Term of packets used at each 3 layer

- PHY layer – bits
- Data link layer – frame or PDU
- Network layer – packet or datagram

Term of Packet used at each layer

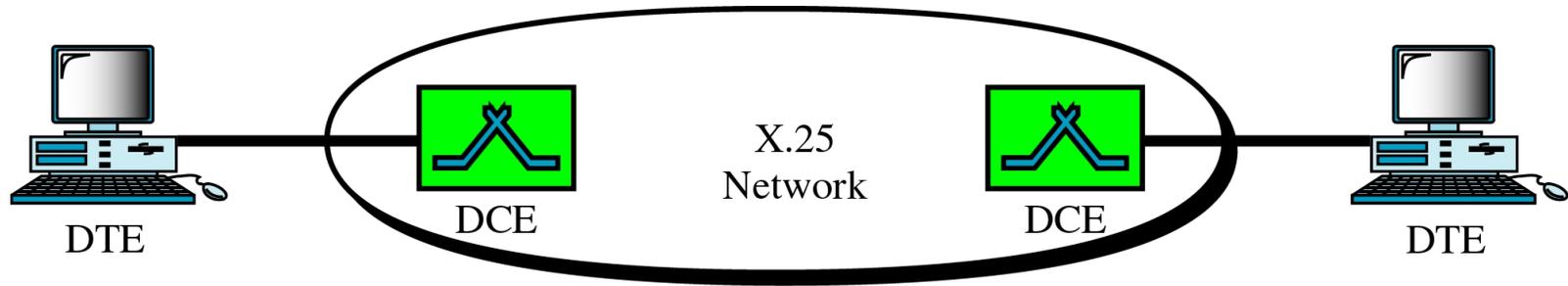


X.25 and Frame relay

X.25

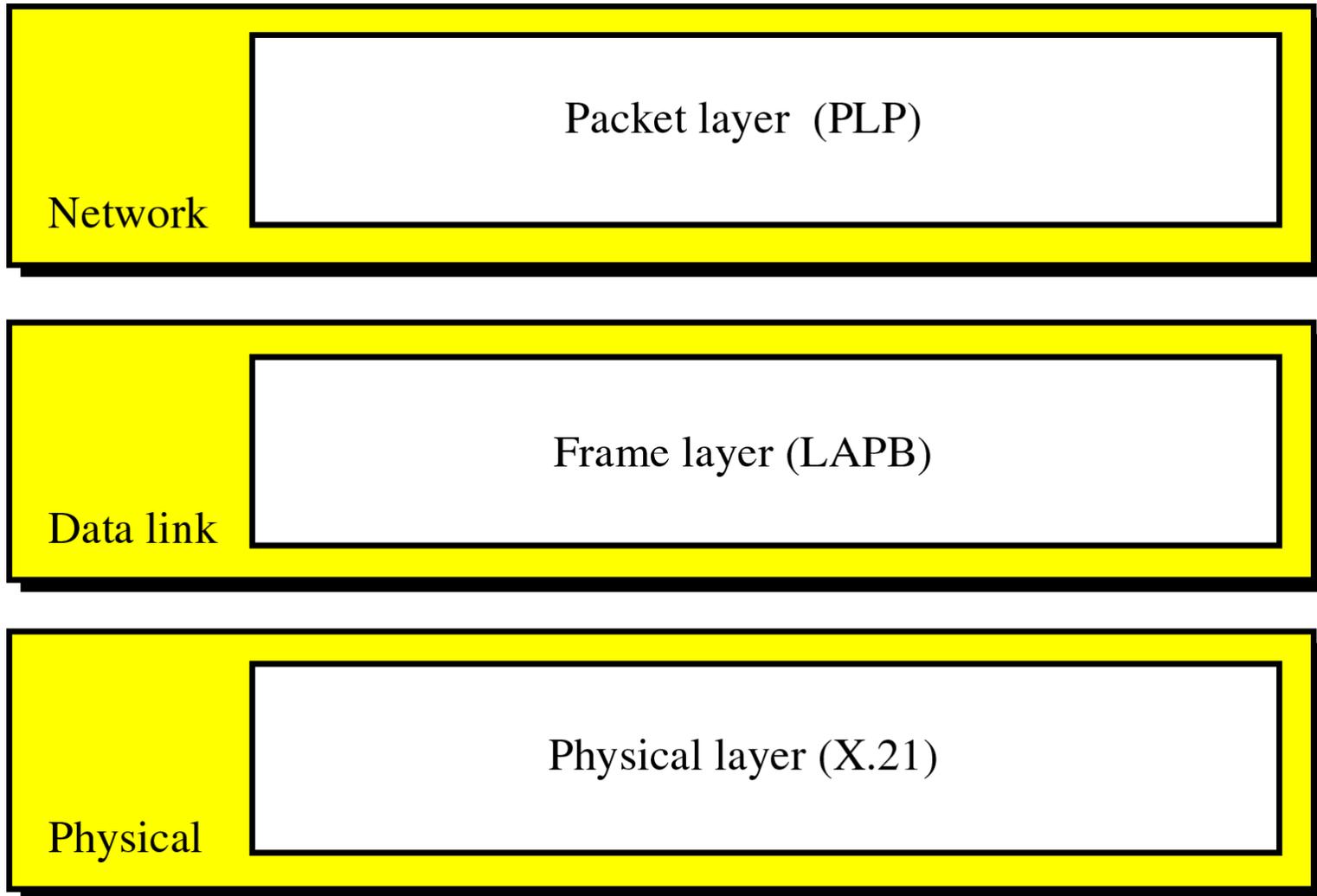
- X.25 is a packet-switching wide area network developed by ITU-T in 1976.
- X.25 defines how a packet-mode terminal can be connected to a packet network for the exchange of data.
- X.25 is what is known as subscriber network interface (SNI) protocol.
- It defines how the user's DTE communicates with the network and how packets are sent over that network using DCEs.

X.25



- X.25 network is a packet switching network that used X.25 protocol.
- X.25 is a standard packet switching protocol that has been widely used in WAN.
- X.25 is a standard for interface between the host system with the packet switching network in which it defines how DTE is connected and communicates with packet switching network.
- It uses a virtual circuit approach to packet switching (SVC and PVC) and uses asynchronous (statistical) TDM to multiplex packets.

X.25 Layers in Relation to the OSI Layers



X.25 Layers

X.25 protocol specifies three layers:

- i. **Physical Layer (X.21)**
- ii. **Frame Layer (LAPB)**
- iii. **Packet Layer (PLP) (Packet Layer Protocol)**

X.25 – Physical Layers

- specifies the physical interface between the node (computer, terminal) and the link that connected to X.25 network.

- specifies a protocol called X.21 or X.21bis (interface).

- similar enough to other PHY layer protocols, such as EIA-232.

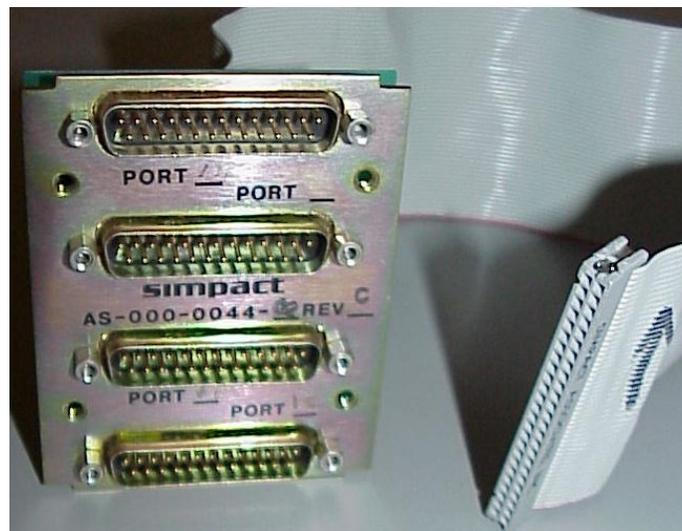
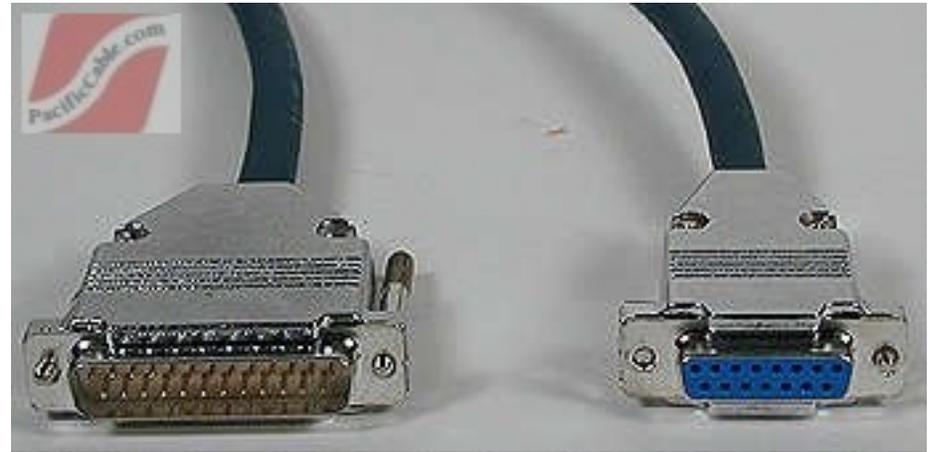
X.21 in PHY layer of X.25

- X.21, sometimes referred to as X21, interface is a specification for differential communications introduced in the mid 1970's by the [ITU-T](#). X.21 was first introduced as a means to provide a digital signaling interface for telecommunications between carriers and customer's equipment. This includes specifications for [DTE/DCE](#) physical interface elements, alignment of [call control](#) characters and [error checking](#), elements of the call control phase for [circuit switching](#) services, and test loops.
- When X.21 is used with V.11, it provides synchronous data transmission at rates from **100 kbit/s to 10 Mbit/s**. There is also a variant of X.21 which is only used in select legacy applications, "circuit switched X.21". X.21 normally is found on a 15-pin D Sub connector and is capable of running full-duplex data transmissions.
- The Signal Element Timing, or clock, is provided by the carrier (your telephone company), and is responsible for correct clocking of the data. X.21 was primarily used in Europe and Japan, for example in the Scandinavian [DATEX](#) and German [DATEX-L](#) circuit switched networks during the 1980s.

X.21 hardware interface



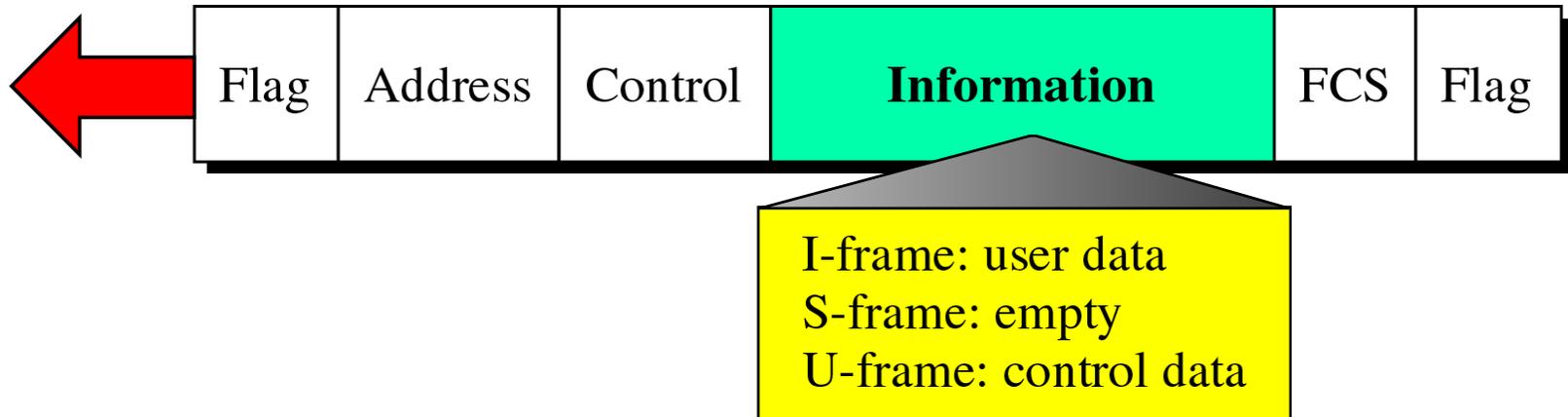
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X.25 Frame Layer

- provides a reliable data transfer process through data link control which used link access procedure, balanced (LAPB) protocol.
- there are 3 categories of frame involved in the LAPB frame format:
 - I-Frames** – encapsulate PLP packets from the network layer and before being passed to the physical layer

Format of a Frame in X.25



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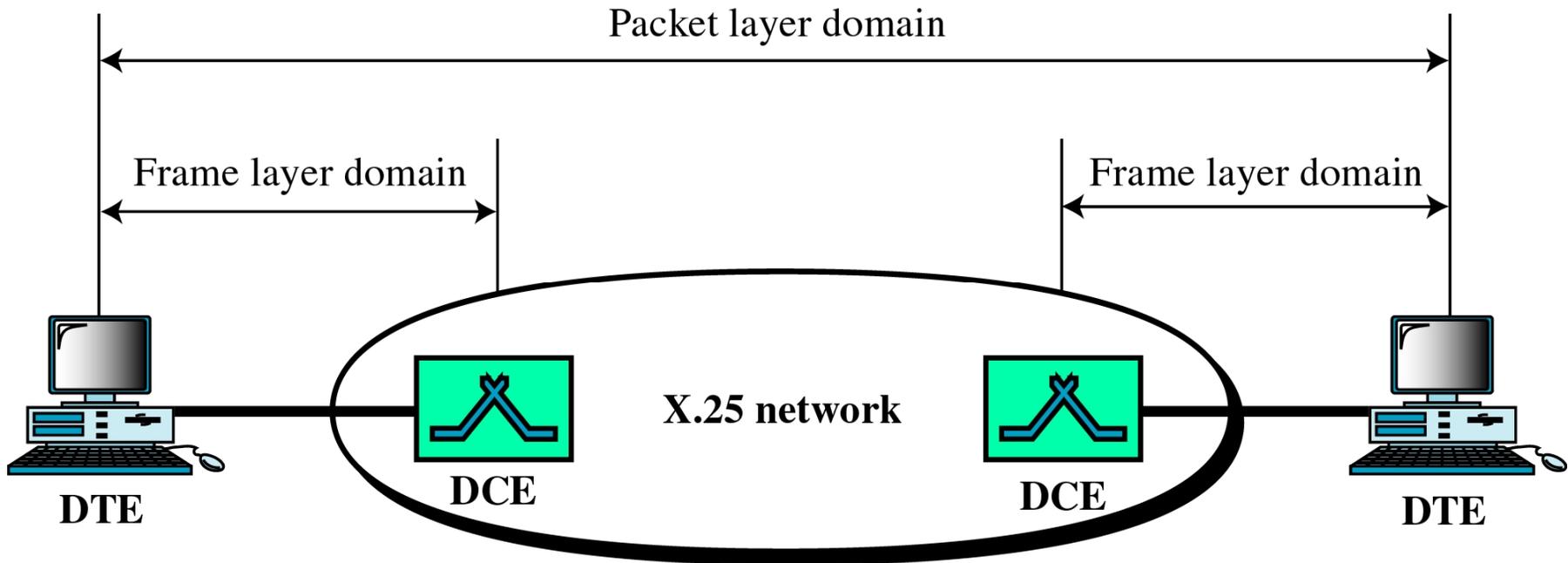
S-Frames – flow and error control in the frame layer

U-Frames- used to set up and disconnect the links between a DTE and a DCE.

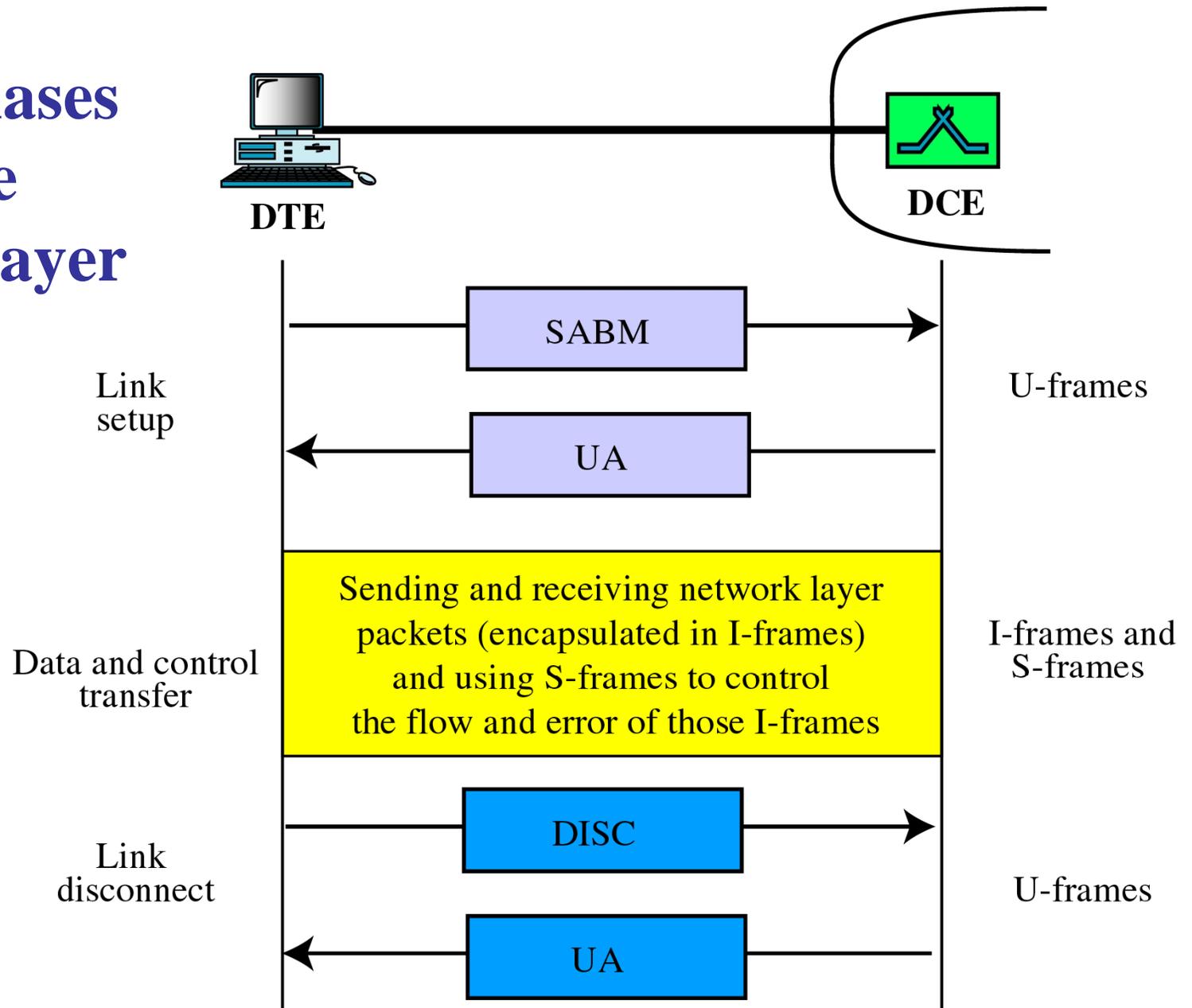
In the frame layer, communication between a **DTE - DCE** involves three phases:

1: Link Setup ; 2: Packet Transfer ; 3:
Link Disconnect

Frame Layer and Packet Layer Domains



Three Phases of the Frame Layer

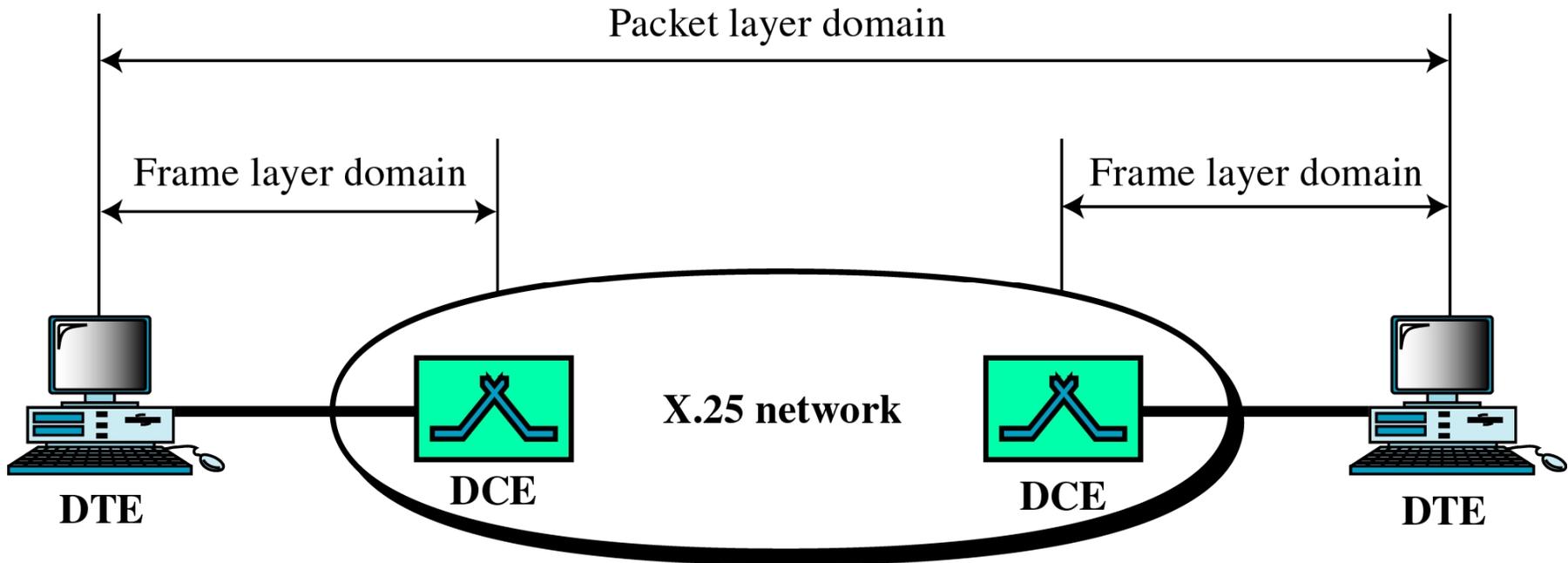


X.25 Packet layer (PLP)

iii. Packet Layer Protocol (PLP)

- it is the network layer in X.25
- this layer is responsible for establishing the connection, transferring the data, and terminating the connection between **2 DTEs**.
- it also responsible for creating the virtual circuits and negotiating network services between two DTEs.
- Virtual circuits in X.25 are created at the network layer (not the data link layers as in some other wide area networks such as Frame Relay and ATM)

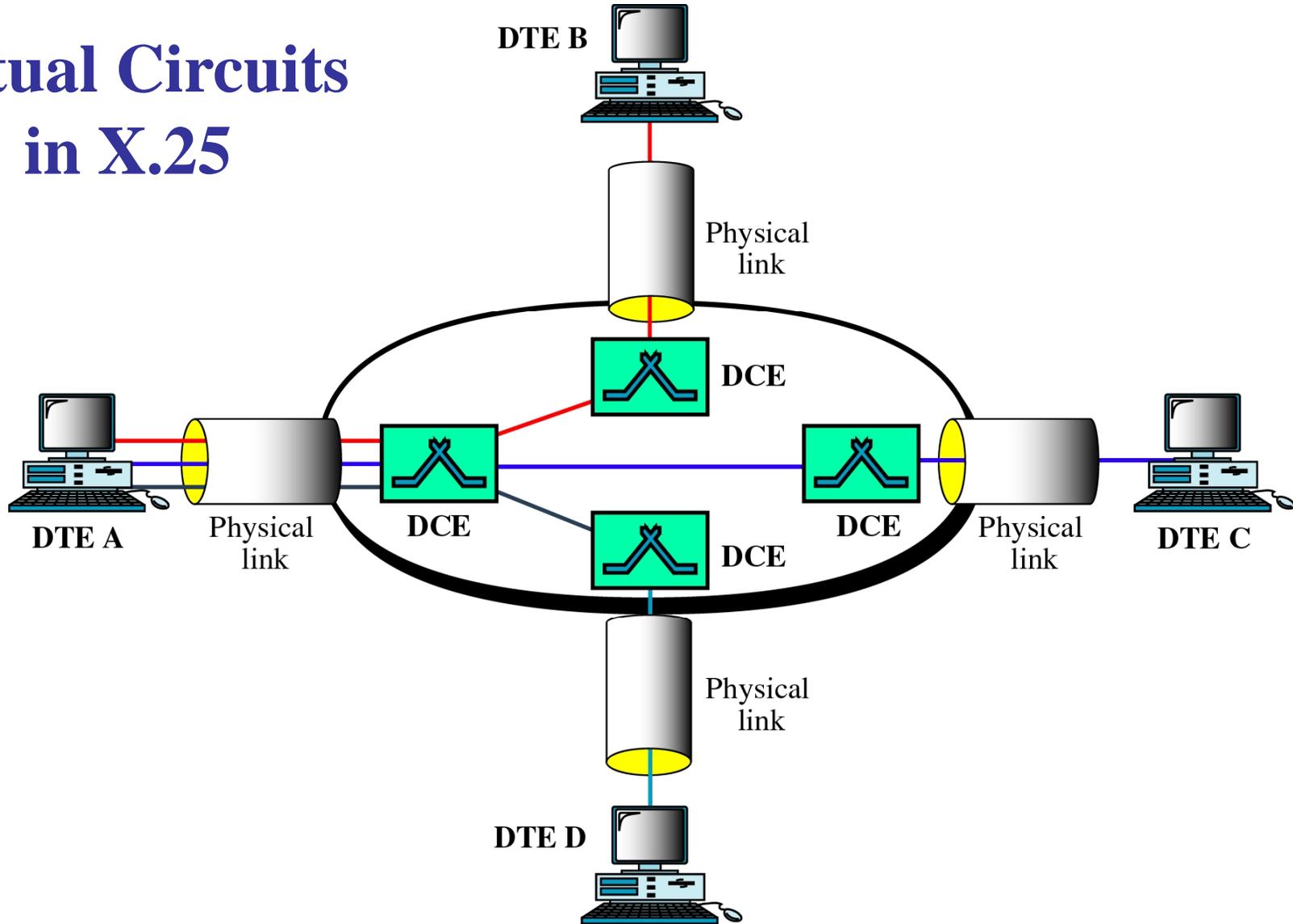
Frame Layer and Packet Layer Domains



Implementation of X.25

- X.25 protocol is a packet-switched virtual circuit network.
- Virtual Circuit in X.25 created at the network layer. unlike Frame Relay and ATM which both VC created at Data Link Layer.
- Fig 17.7 shows an X.25 network in which 3 virtual circuits have been created between DTE A and 3 other DTEs.

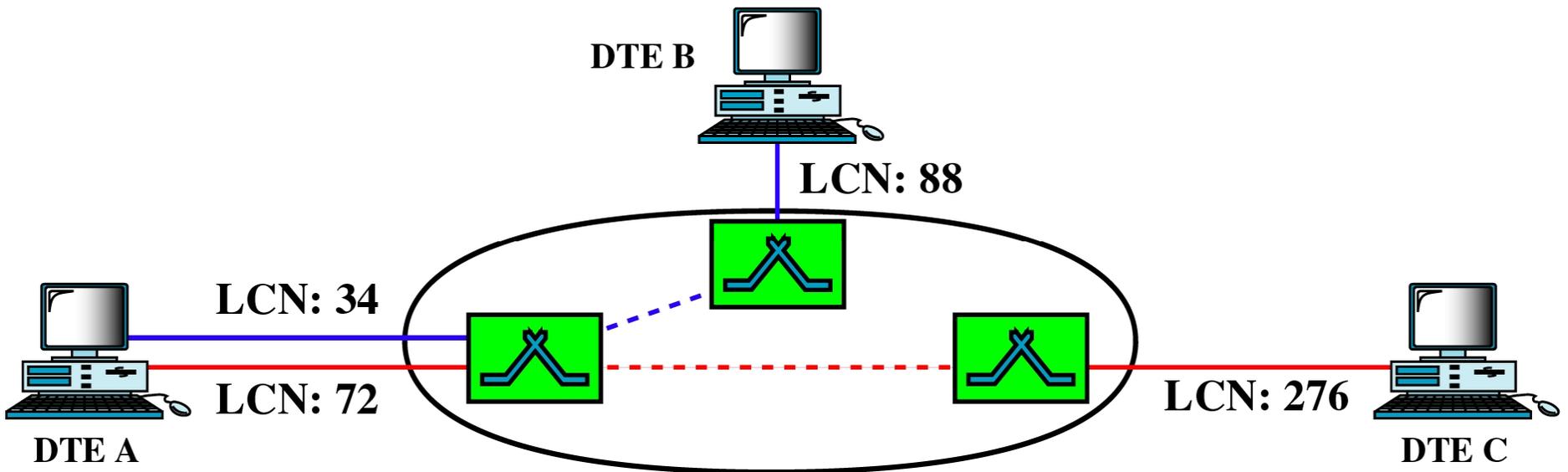
Virtual Circuits in X.25



Virtual Circuit in X.25

- Each virtual circuit in X.25 should be identified for use by the packets.
- The VC in X.25 is called logical channel number (LCN). See fig 17.8

LCNs in X.25



PVC and SVC in X.25

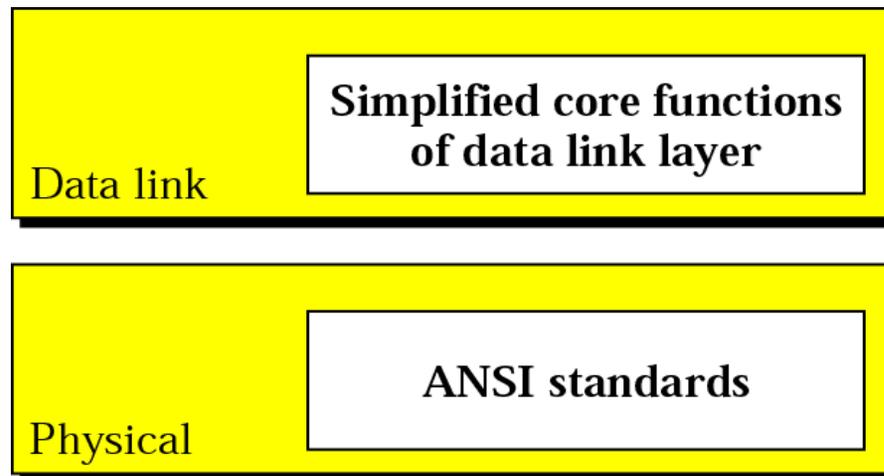
- PVC = permanent Virtual Circuit
- SVC = Switched virtual circuit
- **X.25 applied both PVC and SVC.**
- PVCs are established by the X.25 network providers. (similar to the leased line in telephone networks.)
- SVCs are established at each session. Involve 5 events (like 3-phase). Setup, transfer & connection released.

5 events in SVC

- A Link is setup between DTE and DCE also between REMOTE DTE and DCE
- A virtual circuit is established between the local DTE and the remote DTE.
- Data are transferred between the two DTEs.
- The virtual circuit is released
- The link is disconnected

Frame Relay

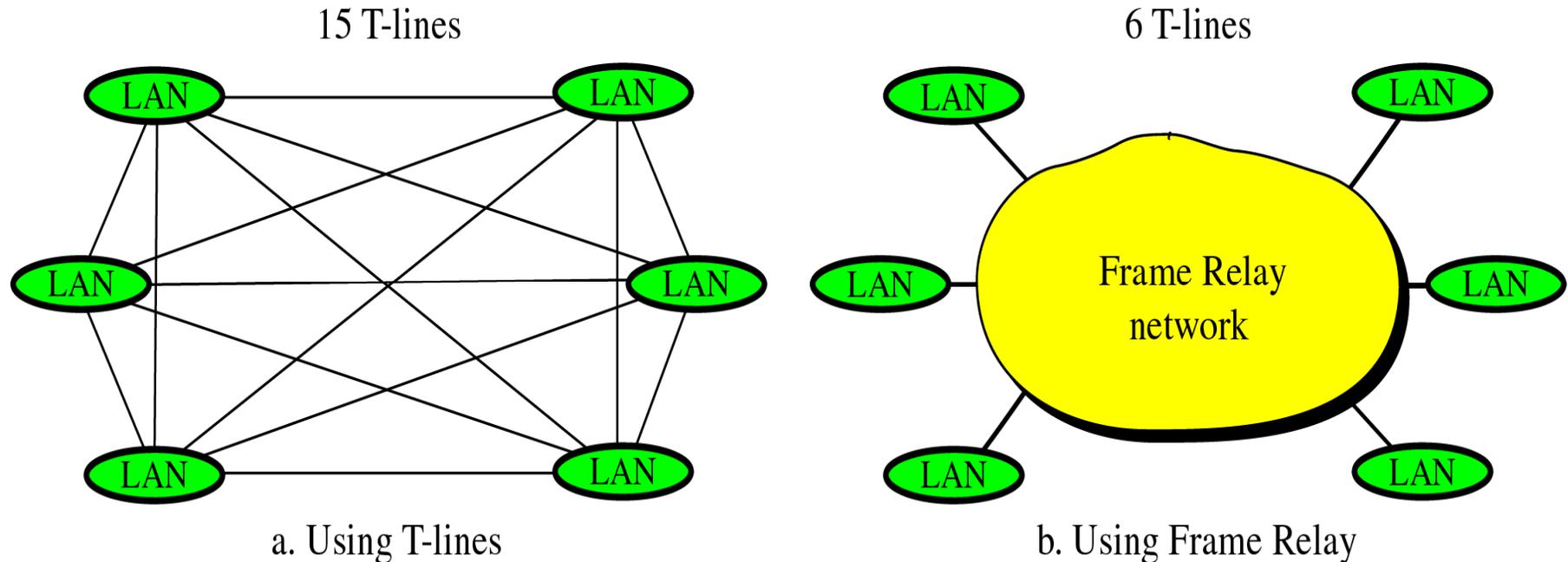
- Packet-switching with virtual-circuit technology
- Improvement of previous technology X.25
- Operate only at the PHY and Data link layer.



Frame Relay: Why it is needed?

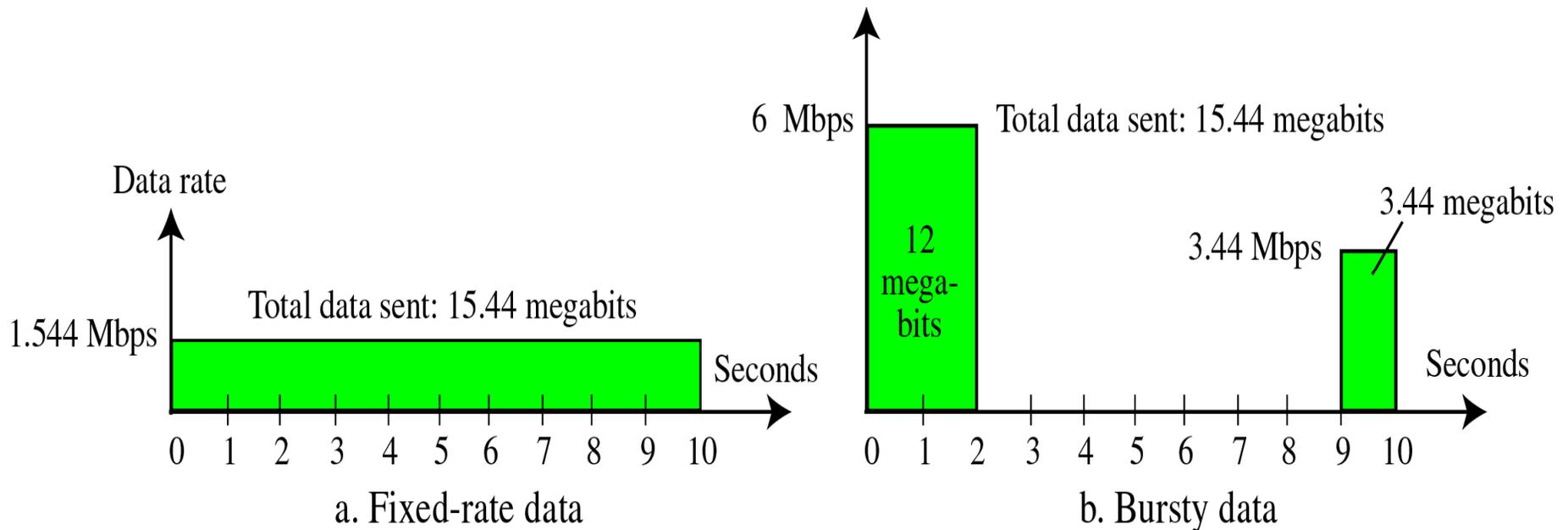
- Higher Data Rate at Lower Cost
- Allow Bursty Data
- Less Overhead Due to Improved Transmission Media (compared to prev. tech X.25)

Higher Data Rate at Lower Cost



- **Fig. Frame Relay versus Pure Mesh T-Line Network**
- **To connect all the highspeed LANs, it is better used frame-relay network rather than T-Line Network which cost a lot of money and impractical**

Frame Relay allows Bursty Data



Fixed-Rate versus Bursty Data

Less Overhead Due to Improved Transmission Media

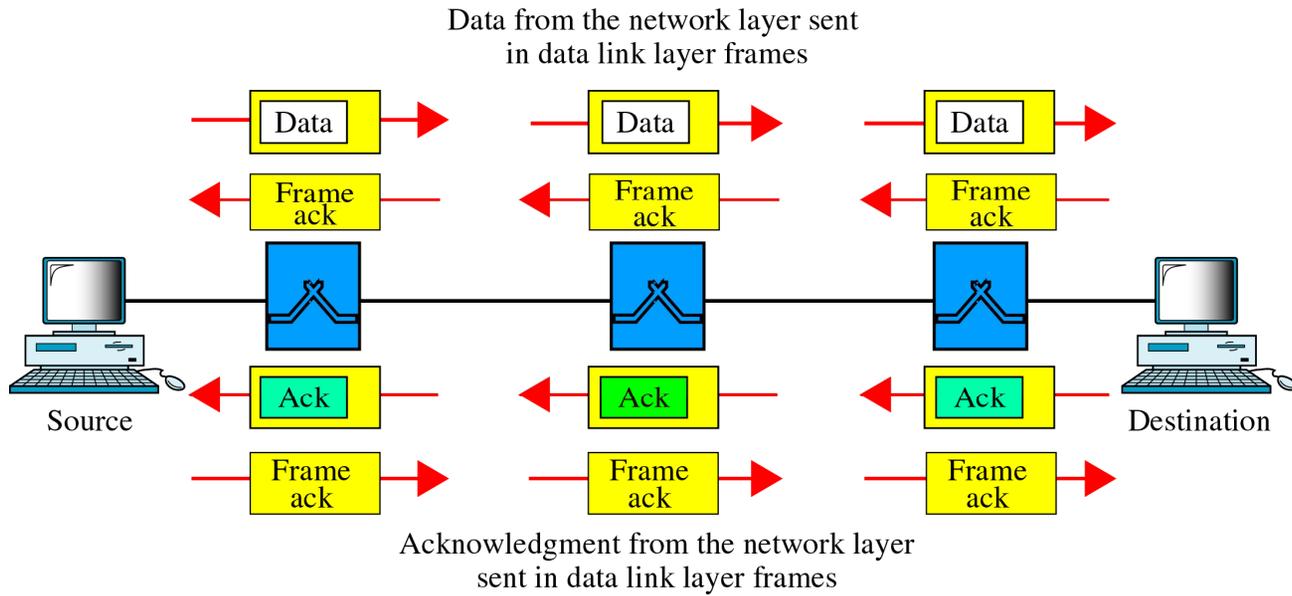
- Due to improvement of transmission media and greater use of fiber optic cable, frame relay does not provide error checking or require ACK in data link layer (like X.25 ~ previous tech did).
- Instead , all error checking is left to the protocols at the network and transport layer which use the services of Frame Relay

Less Overhead Due to Improved Transmission Media

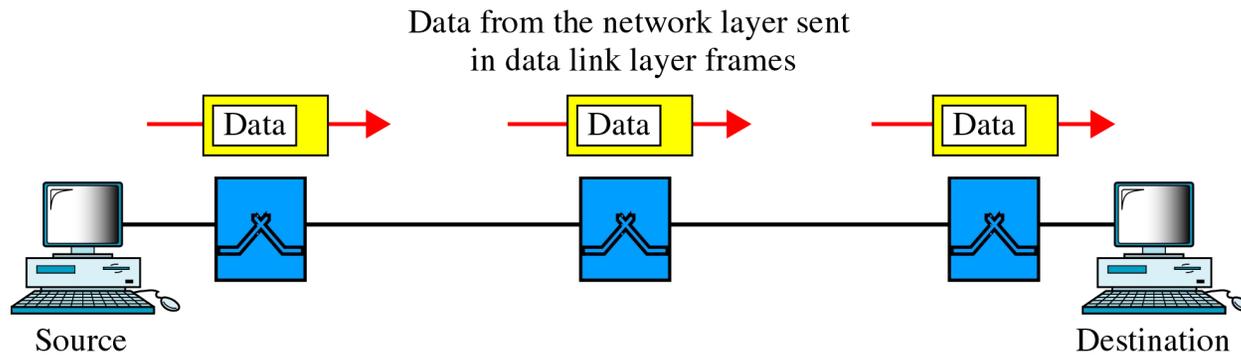
- The design of [X.25](#) aimed to provide error-free delivery over links with high error-rates. Frame relay takes advantage of the new links with lower error-rates, enabling it to eliminate many of the procedures used by X.25. The elimination of functions and fields, combined with digital links, enables frame relay to operate at speeds 20 times greater than X.25.
- X.25 specifies processing at layers 1, 2 and 3 of the [OSI model](#), while frame relay operates at layers 1 and 2 only. This means that frame relay has significantly less processing to do at each node, which improves throughput by an order of magnitude.

CONT...

- X.25 prepares and sends packets, while frame relay prepares and sends frames. X.25 packets contain several fields used for error and [flow control](#), none of which frame relay needs. The frames in frame relay contain an expanded [link layer](#) address field that enables frame relay nodes to direct frames to their destinations with minimal processing .
- X.25 has a fixed bandwidth available. It uses or wastes portions of its bandwidth as the load dictates. Frame relay can dynamically allocate bandwidth during call setup negotiation at both the physical and logical channel level.



a. X.25 traffic

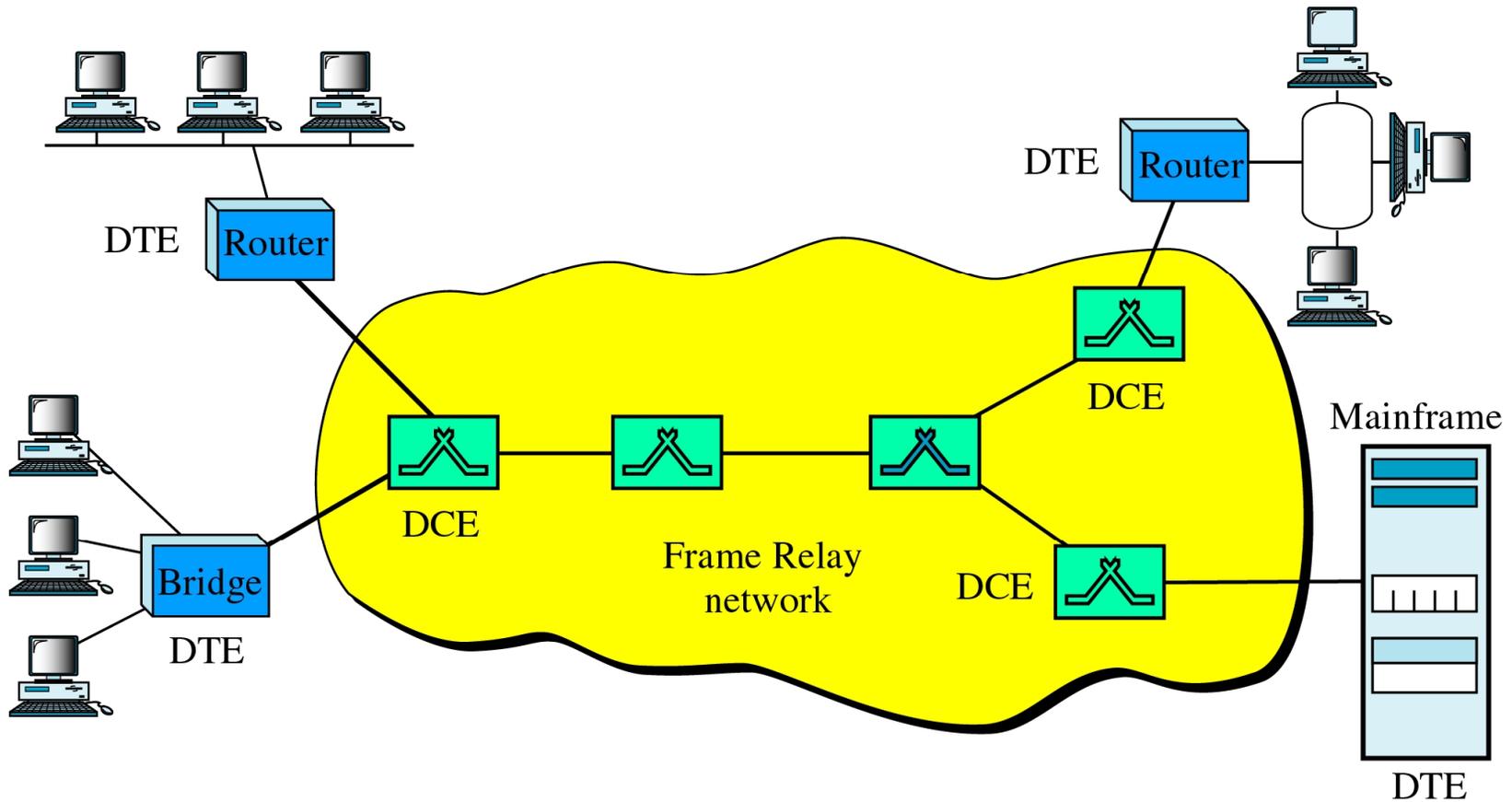


b. Frame Relay traffic

Frame Relay Operation

- Frame relay provides permanent virtual and switched virtual circuit connections (PVC and SVC)
- The devices that connects users to the network are DTEs.
- The switches that route the frames thru the network are DCEs (see fig 18.5)

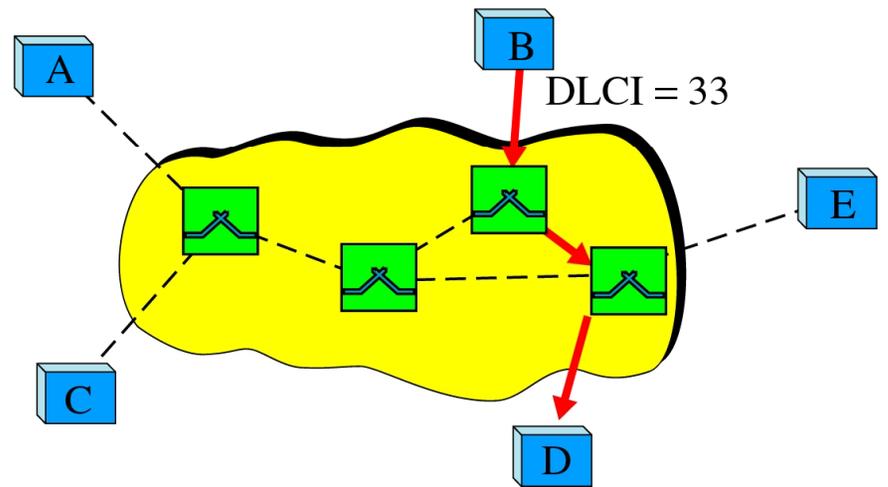
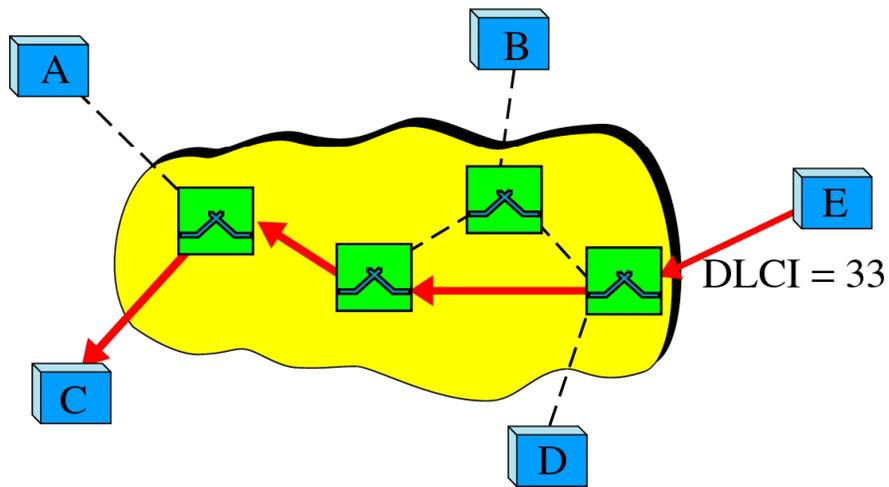
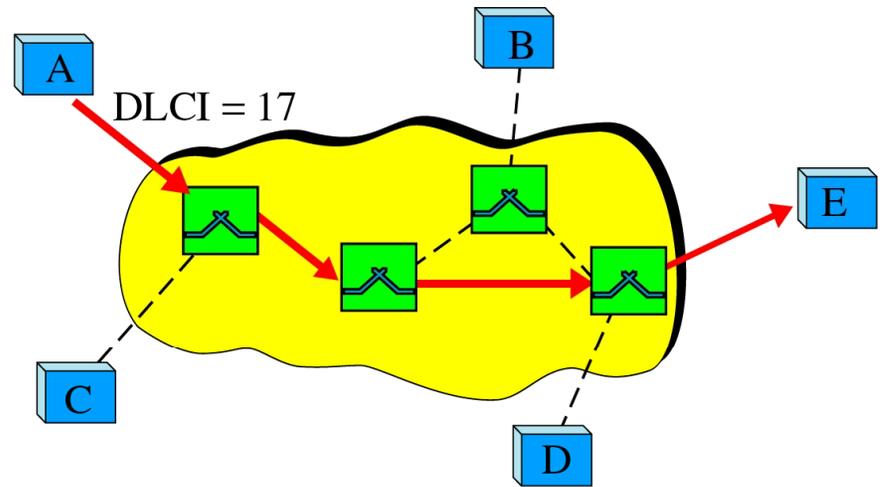
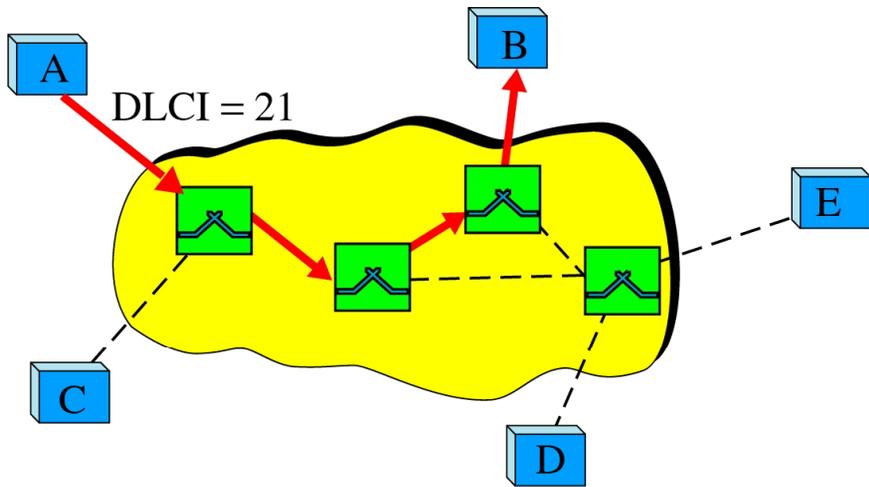
Frame Relay Network



Virtual Circuit in FR

- FR is a virtual circuit network. It therefore does not use PHY addresses to define the DTEs connected to the network.
- It uses VCI called Data Link Connection Identifier (DLCI).
- DLCI is assigned to the DTEs when Virtual Circuit is established for connection

DLCIs

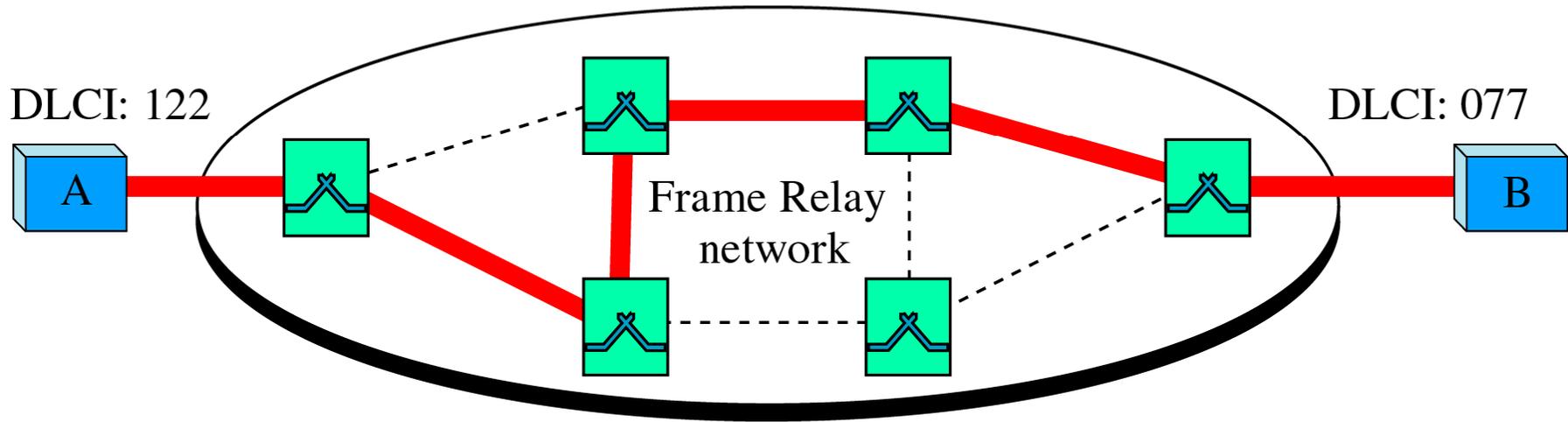


FR Operation: SVC and PVC

- It uses a virtual circuit identifier that is known as **data link connection identifier (DLCI)**.
- Two types of connection:
 1. Permanent virtual connection (PVC)
 - The connection is already exist for 2 DTE in the network
 - 2 DLCI is given for each end of the connection
 2. Switched virtual connection (SVC)
 - Everytime when one DTE needs to connect to other DTE, VC will be established. It needs a protocol that has network layer function and network layer addressing like IP.
 - Generally, local DTE will send a SETUP message to the remote DTE which will response by sending message CONNECT.
 - VC will be establish for sending the data
 - Message RELEASE is sent to terminate the connection.

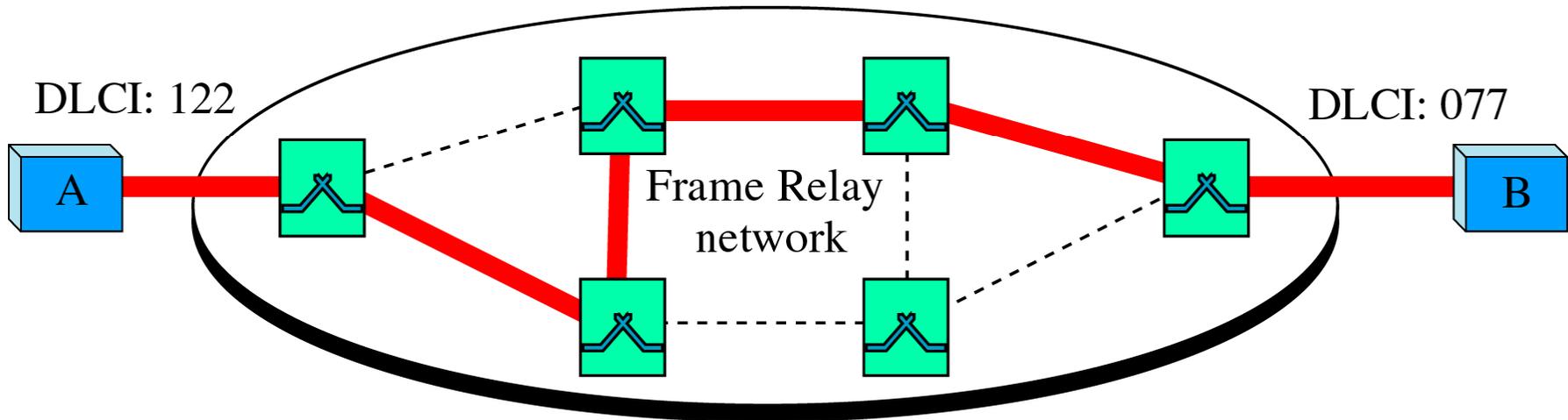
PVC DLCIs

The DLCIs are permanent and assigned by the Frame Relay network provider.

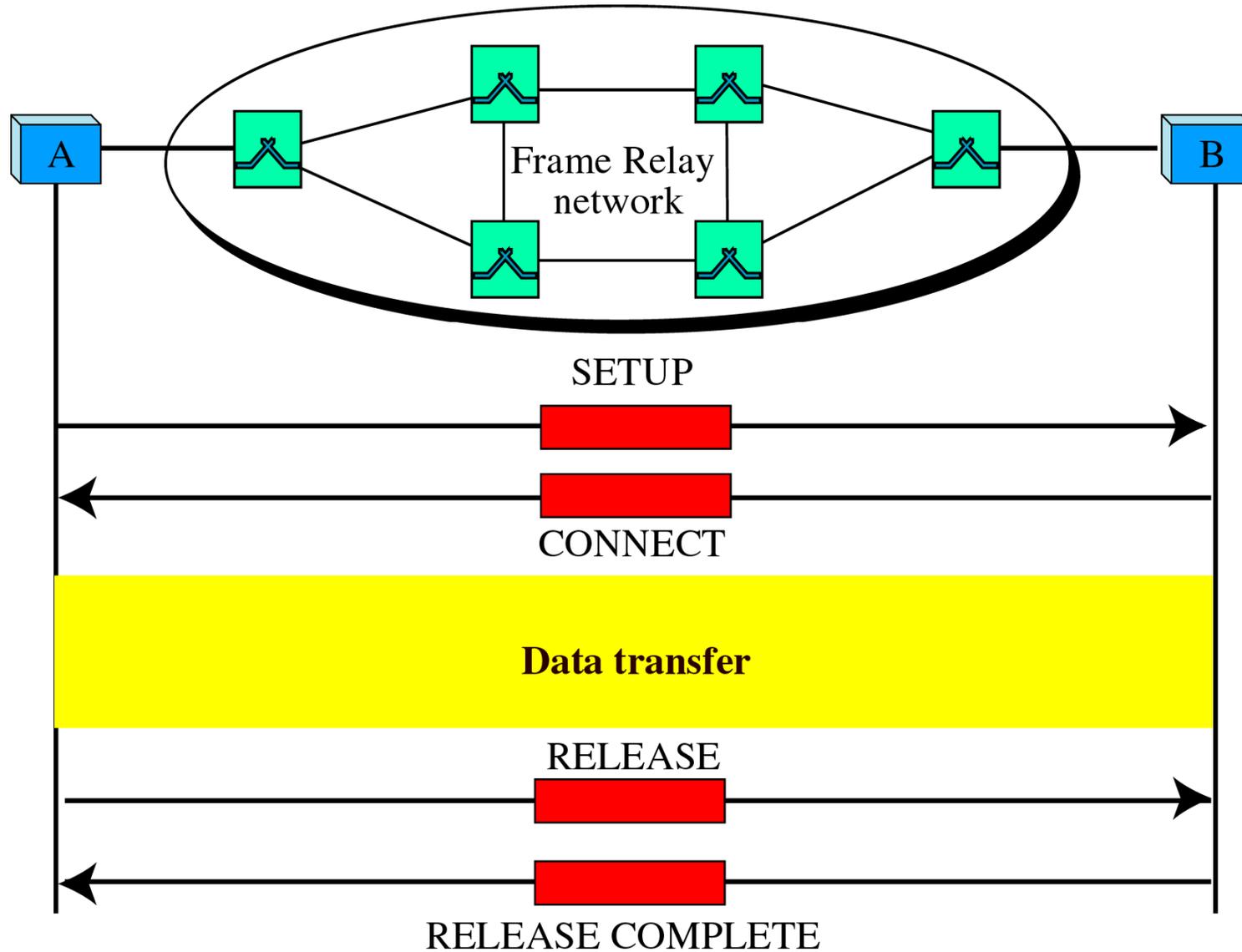


SVC DLCIs

The DLCIs are temporary and assigned by Frame Relay during the connection phase.

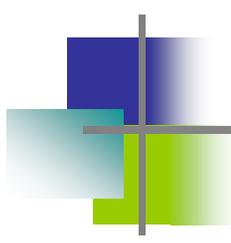


SVC Setup and Release

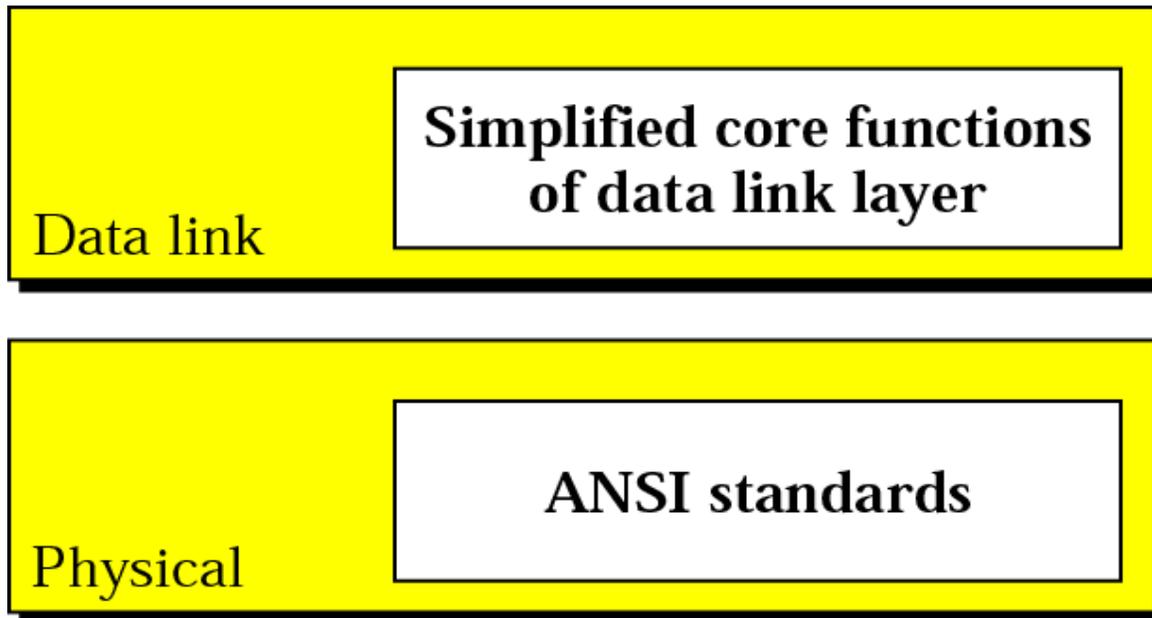


Frame Relay Layers

- Only 2 layers: Physical layer and data link layer
 - 1. Physical layer**
 - No specific protocol, it is left to the implementer to use whatever is available
 - Supports any of the protocols recognized by ANSI
 - 2. Data link layer**
 - Employs a simplified version of HDLC called core LAPF with no extensive error and flow control fields.

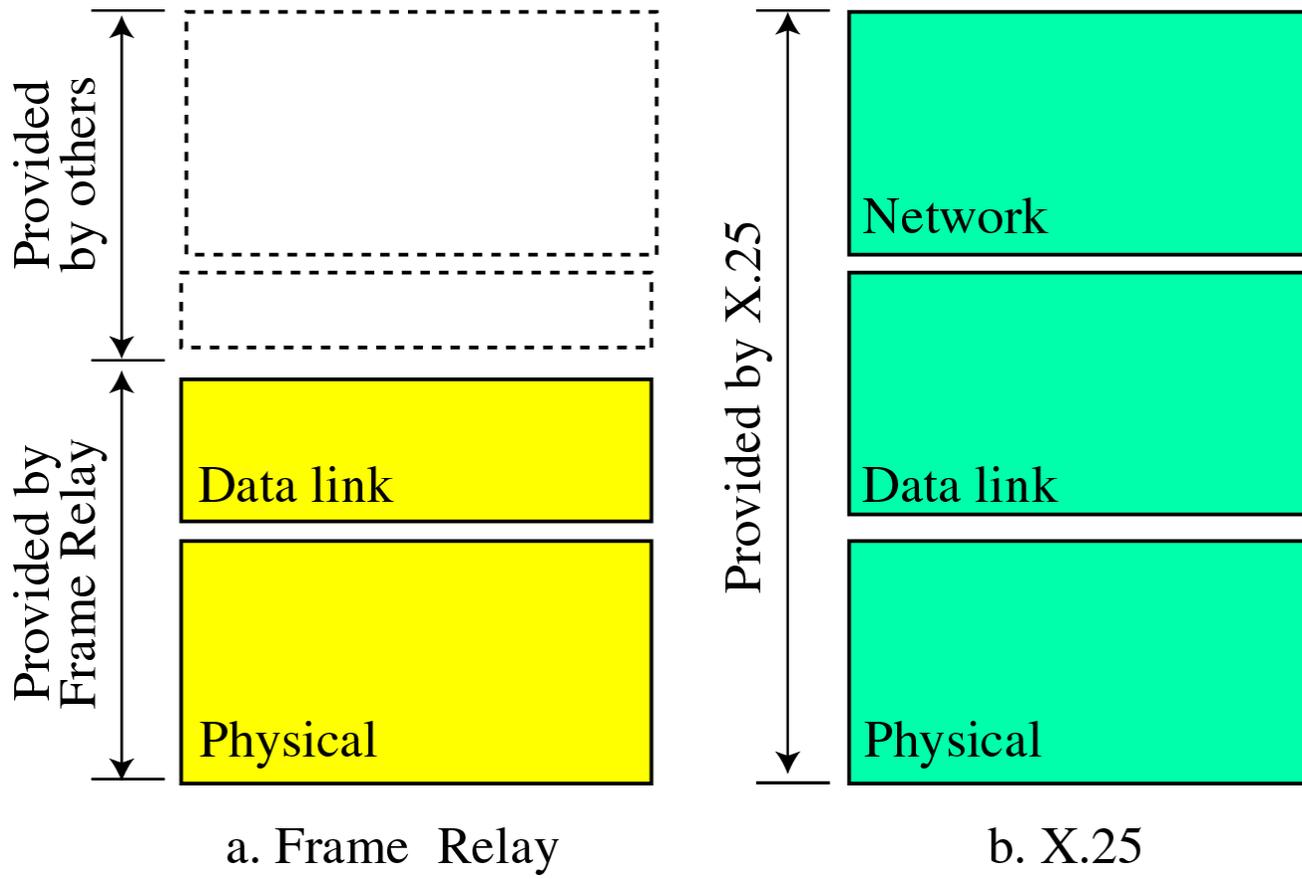


Frame Relay layers



Frame Relay operates only at the physical and data link layers.

Comparing Layers in Frame Relay and X.25

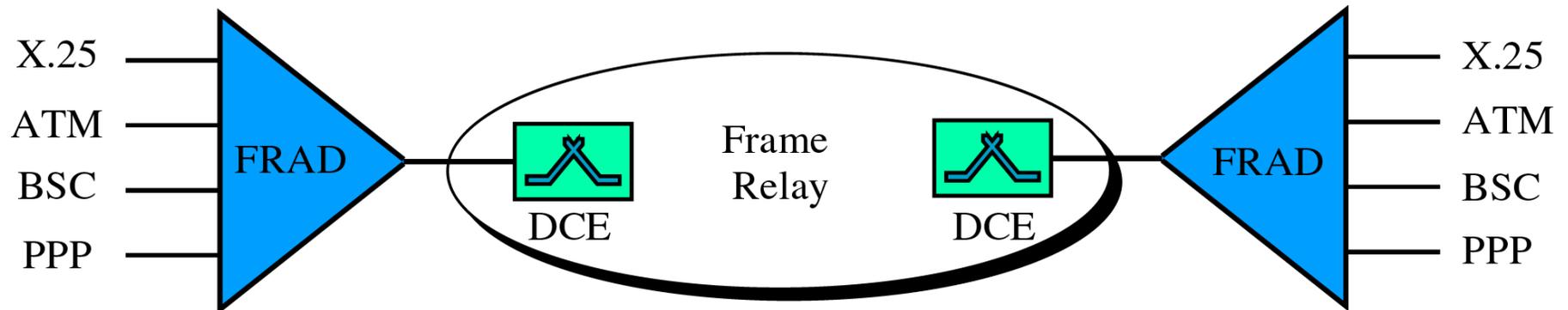


FRAD

To handle frames arriving from other protocols, Frame Relay uses a device called a FRAD.

A FRAD assembles and disassembles frames coming from other protocols to allow them to be carried by Frame Relay frames.

A FRAD can be implemented as a separate device or as part of a switch.



Frame Relay frame

C/R: Command/response

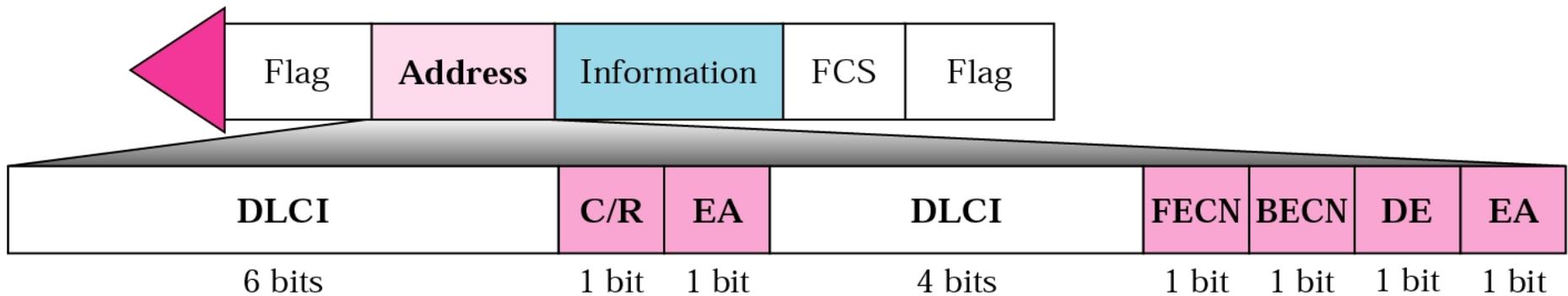
EA: Extended address

FECN: Forward explicit congestion notification

BECN: Backward explicit congestion notification

DE: Discard eligibility

DLCI: Data link connection identifier



Congestion Control

- There are a few strategy developed to deal with the congestion in frame relay that is to control queue length in frame manager:
 1. discard strategy
 - When congestion getting worse until a maximum level is reach, the network will discard the frame.
 2. congestion avoidance
 - Using checkpoint in which when congestion occur in one checkpoint, then, congestion will be try to avoid for the next checkpoint.
 3. congestion recovery
 - Recover the network from congestion.

Adv of Frame Relay tech.

- Higher speed than X.25 (44.376 Mbps)
- Application that used TCP/IP protocol such as email/http/chat can easily use Frame relay as it backbone bcoz FR operates at only 2 layer (DL and PHY).
- Allow bursty data
- Allow frame size of 9000 bytes, which can accommodate all LAN frames
- Less expensive compared to other WANs tech.

Disadv. Of Frame Relay

- Max. transfer rate is at 44.376. Not enough speed compared to nowadays demand
- allows variable-length frames which may cause varying delays for different users.
- Because of the varying delays, which are not under user control, Frame relay is not suitable for sending delay sensitive data such as real time voice or video. E.g. FR not suitable for teleconferencing.