

Frame

Relay

Raj Jain

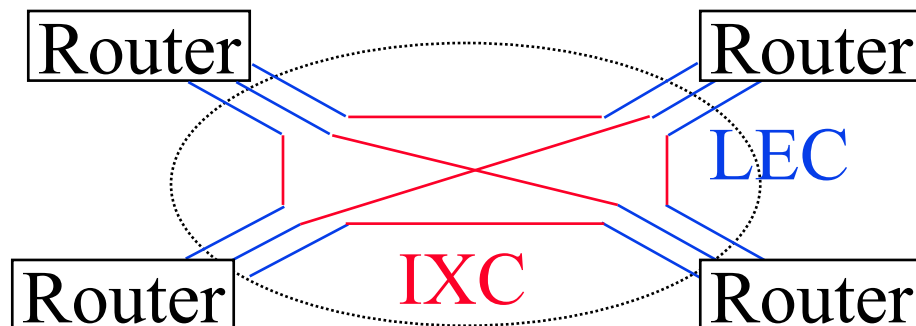
**Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
<http://www.cse.wustl.edu/~jain/>**



- ❑ What is Frame Relay?
- ❑ Why not leased lines or X.25?
- ❑ Frame formats and protocols
- ❑ Signaling

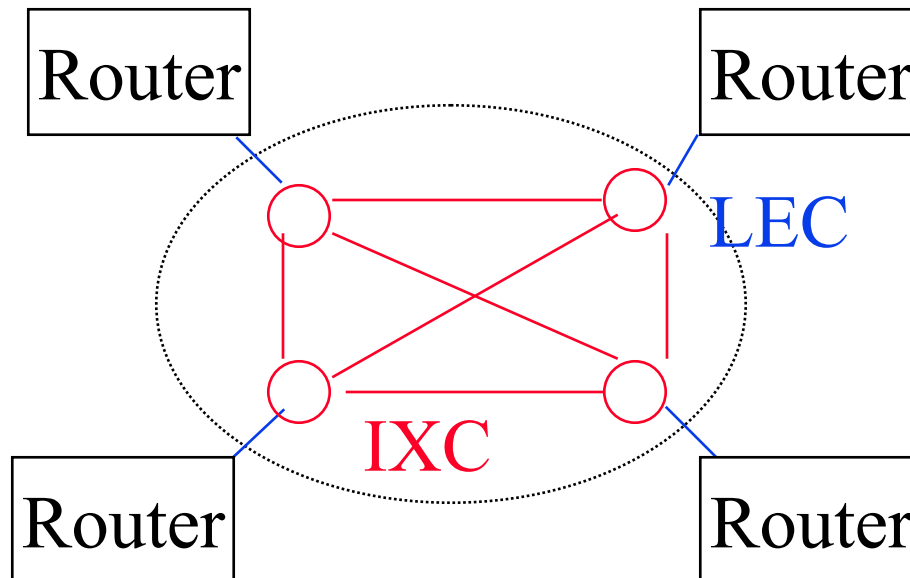
Problems with Leased Lines

- ❑ Multiple logical links \Rightarrow Multiple connections
- ❑ Four nodes \Rightarrow 12 ports,
12 local exchange carrier (LEC) access lines,
6 inter-exchange carrier (IXC) connections
- ❑ One more node \Rightarrow 8 more ports, 8 more LEC lines, 4 more IXC circuits



Solution: X.25/Frame Relay

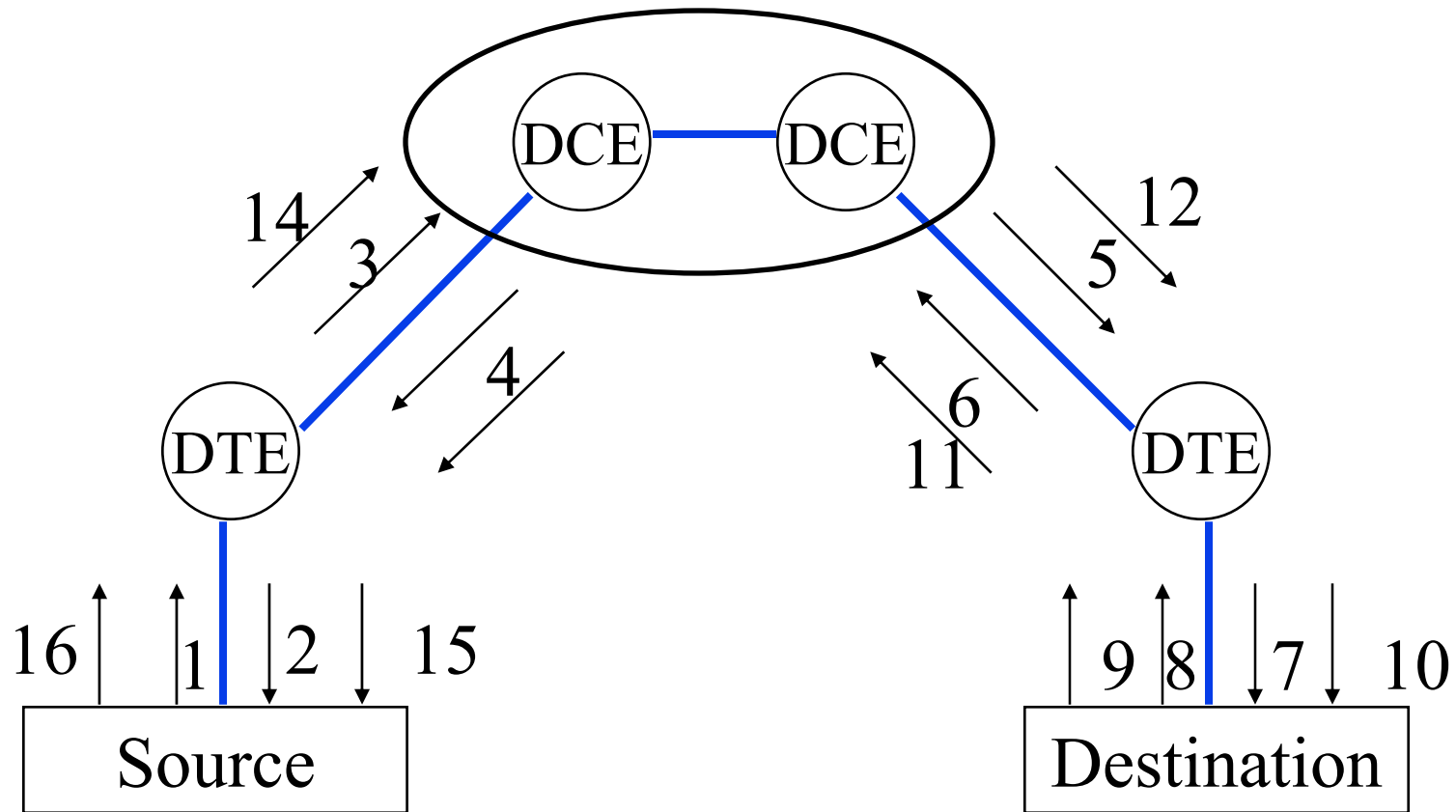
- ❑ Four nodes: 4 ports, 4 LEC access lines, 6 IXC circuits
- ❑ One more node: 1 more port, 1 more access line, 4 more IXC circuits
- ❑ Share leased lines \Rightarrow Virtual Private Networks



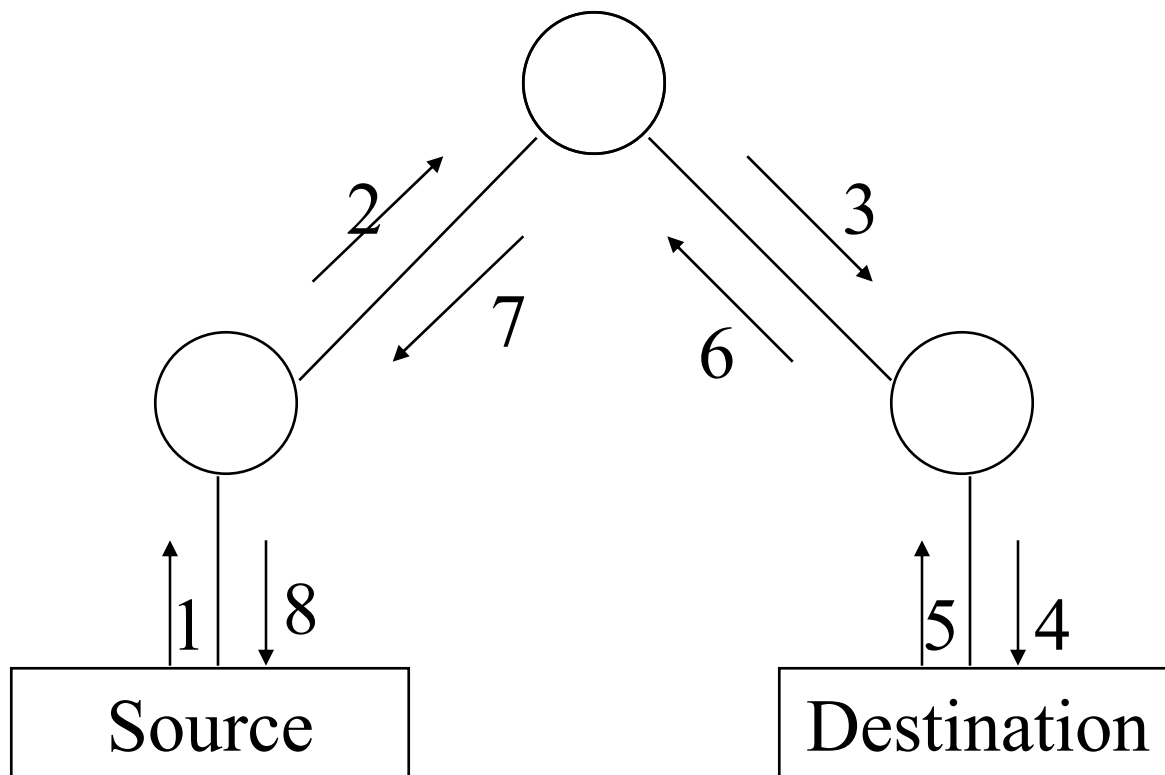
X.25

- ❑ In-band signaling. VC setup and clearing messages in the same channel as data.
 - ❑ Three layer protocol. Third layer for multiplexing.
 - ❑ Flow control
 - ❑ Error control
- ⇒ 16 messages for one packet transfer
- Only 8 messages without flow control and error control

X.25 Exchange



Frame Relay Exchange



Frame Relay: Key Features

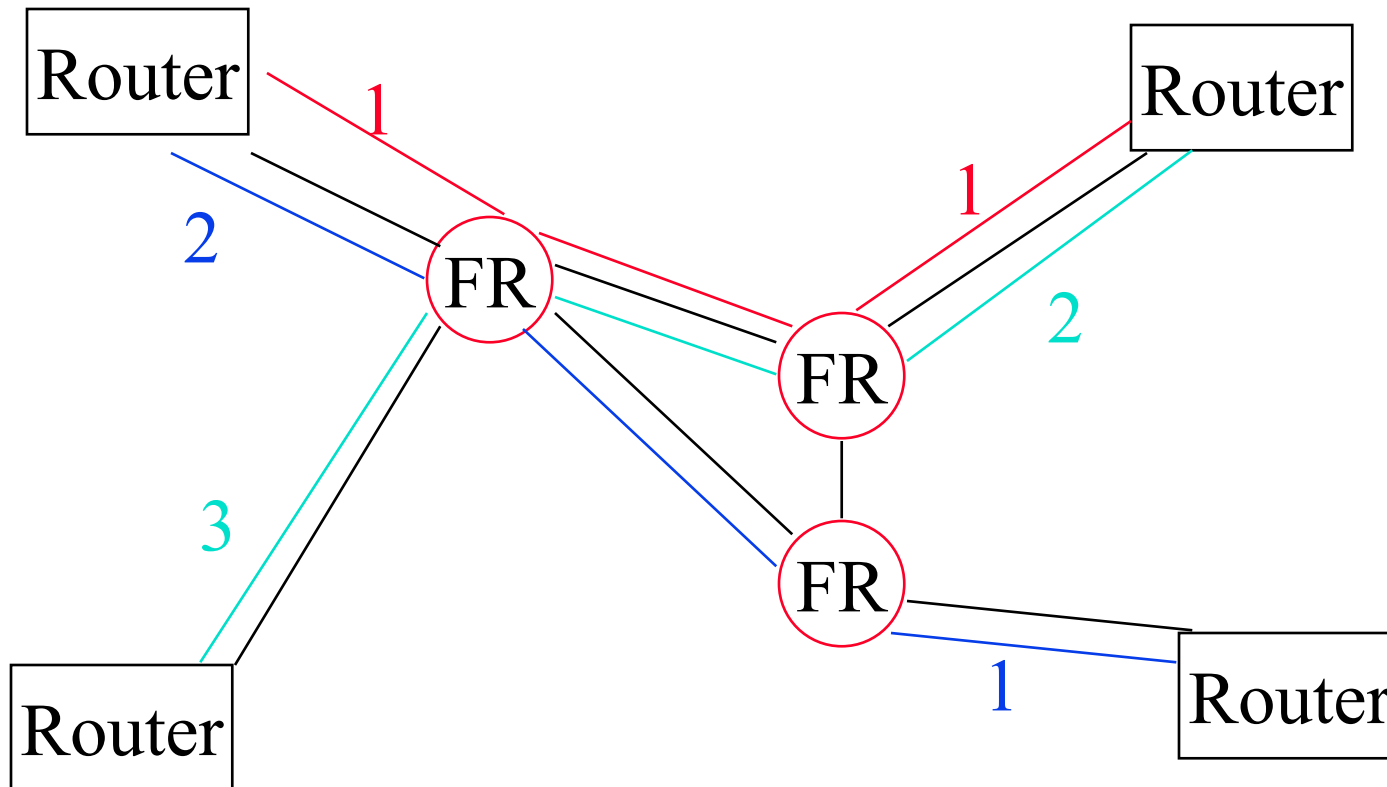
- ❑ X.25 simplified
 - ❑ No flow and error control
 - ❑ Out-of-band signaling
 - ❑ Two layers
 - ❑ Protocol multiplexing in the second layer
 - ❑ Congestion control added
 - ❑ Higher speed possible.
- X.25 suitable to 200 kbps. Frame relay to 2.048 Mbps.

Relay vs Switching

- ❑ Switching = Relaying + Ack + Flow control + Error recovery + loss recovery
- ❑ Switching = X.25
- ❑ Relay = Unreliable multiplexing service

Datalink Control Identifiers

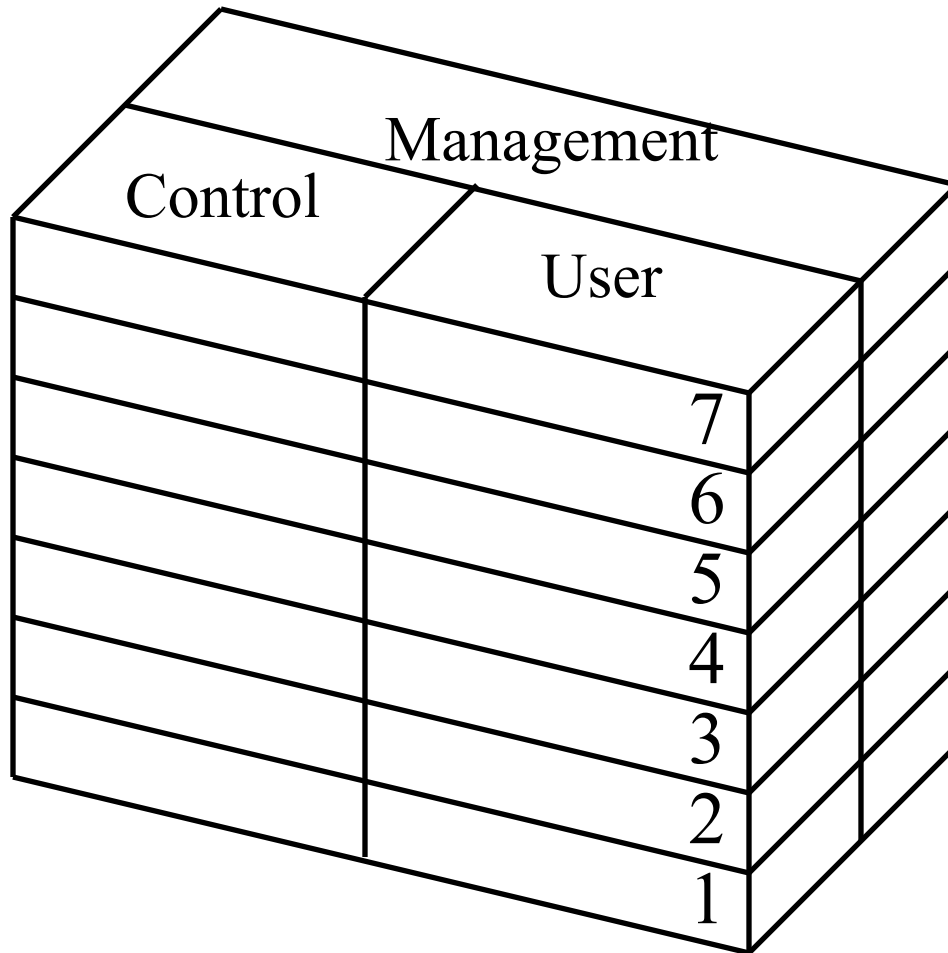
- DLCI: Similar to Logical Channel Numbers in X.25



Data Link Control Identifier

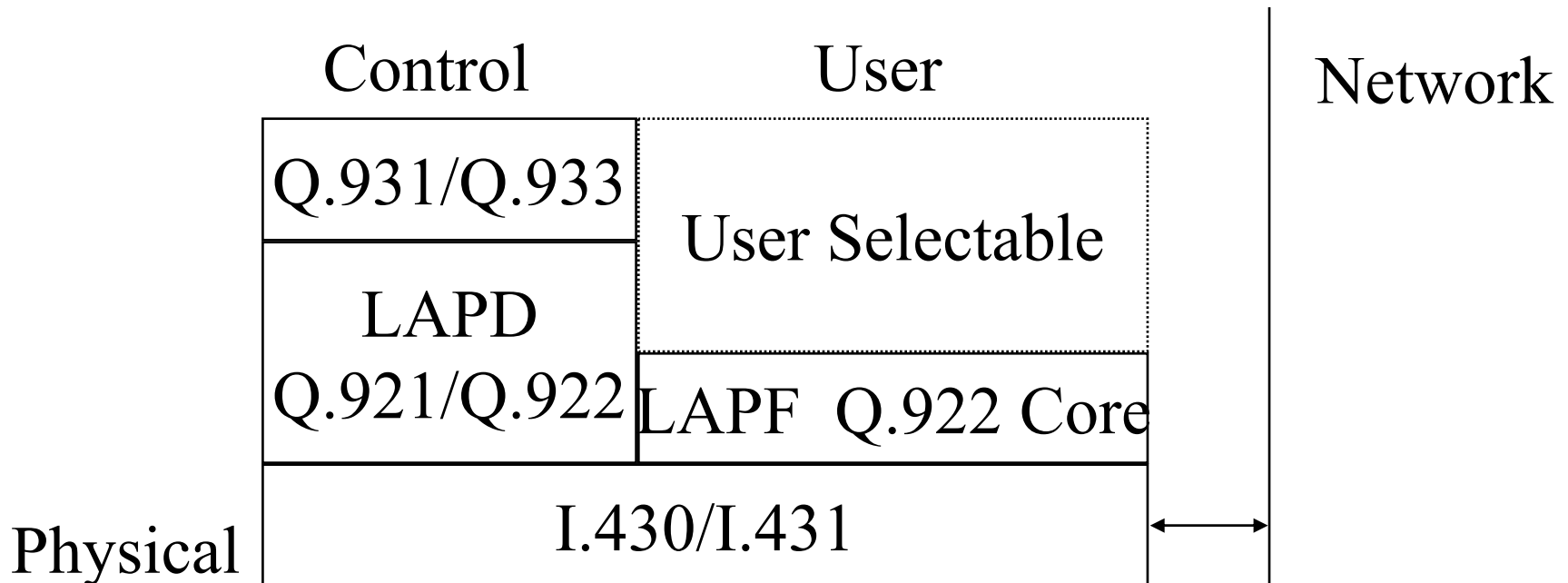
- ❑ Only local significance
- ❑ Allows multiple logical connections over one circuit
- ❑ Some ranges preassigned
- ❑ DLCI = 0 is used for signaling

ISDN Reference Model



Frame Relay UNI Architecture

- ❑ UNI = User-network Interface
- ❑ LAPF = Link Access Protocol - Frame Mode Services
- ❑ LAPD = Link Access Protocol - D Channel



Control Plane

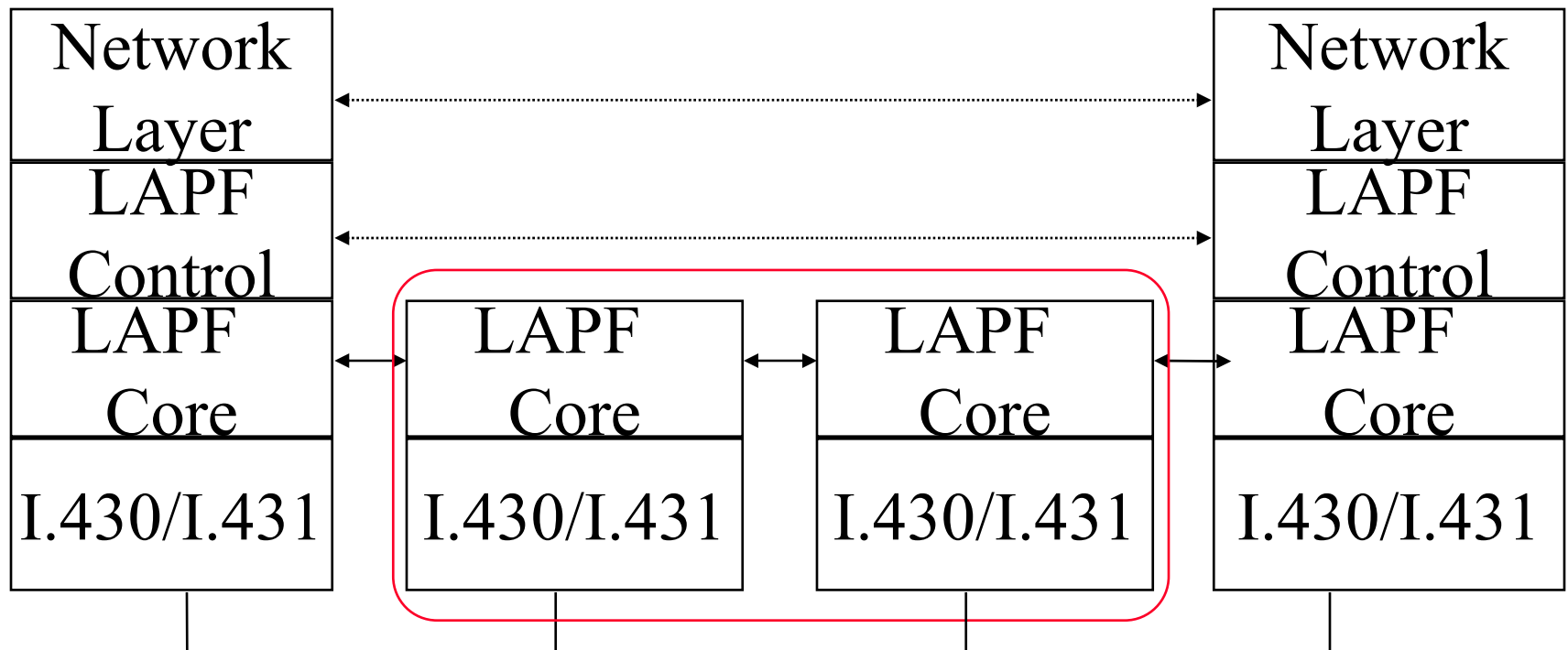
- ❑ Signaling over D channel (D = Delta = Signaling)
- ❑ Data transfer over B, D, or H (B = Bearer)
- ❑ LAPD used for reliable signaling
- ❑ ISDN Signaling Q.933 + Q.931 used for signaling messages
- ❑ Service Access Point Identifier (SAPI) in LAPD = 0
⇒ Q.933 + Q.931 Frame relay message

User Plane

- ❑ Link Access Procedure for Frame-Mode bearer services (LAPF)
- ❑ Q.922 = Enhanced LAPD (Q.921)
= LAPD + Congestion = LAPF
- ❑ LAPF defined in Q.922
- ❑ Core functions defined in Q.922 appendix:
 - Frame delimiting, alignment, and flag transparency
 - Virtual circuit multiplexing and demultiplexing
 - Octet alignment \Rightarrow Integer number of octets before zero-bit insertion
 - Checking min and max frame sizes

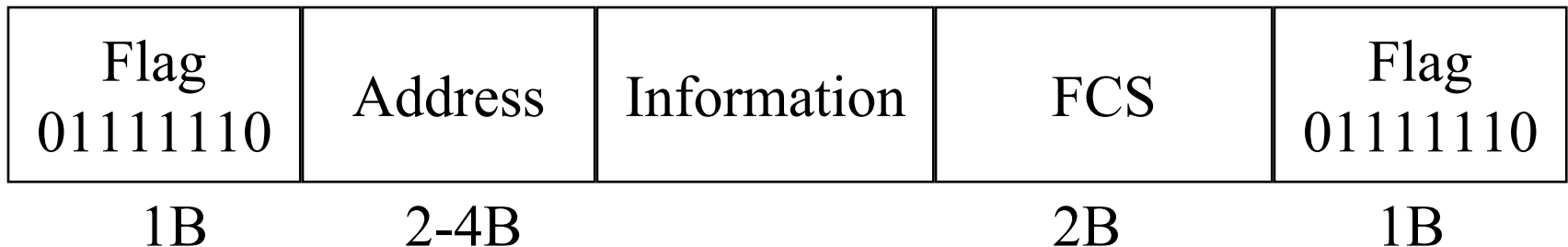
User Plane (Cont)

- Error detection, Sequence and non-duplication
- Congestion control
- LAPF control may be used for end-to-end signaling



LAPF-Core Frame Format

- ❑ LAPF is similar to LAPD: Flag, bit stuffing, FCS
- ❑ No control frames in LAPF-Core \Rightarrow No control field
- ❑ No inband signaling
- ❑ No flow control, no error control, no sequence numbers
- ❑ Logical Link Control (LLC) may be used on the top of LAPF core



LAPF Address Field

	8	7	6	5	4	3	2	1
□ 2 Octet:	Upper DLCI						C/R	EA 0
	Lower DLCI			FECN	BECN	DE	EA 1	
□ 3 Octet:	Upper DLCI						C/R	EA 0
	DLCI			FECN	BECN	DE	EA 0	
	Lower DLCI or DL-Core control						D/C	EA 1
□ 4 Octet:	Upper DLCI						C/R	EA 0
	DLCI			FECN	BECN	DE	EA 0	
	DLCI							EA 0
	Lower DLCI or DL-Core control						D/C	EA 1

LAPF Address Field

- ❑ Address length = 2, 3, or 4 bytes
- ❑ Data Link Control Identifier (DLCI) = 10, 16, 17, or 23 bits
- ❑ Address Extension (EA) bits: 0 \Rightarrow More bytes
- ❑ D/C = Remaining bits for DLCI or for core control protocol (No use for core control has been defined)
- ❑ C/R = Command/response (not used)
- ❑ FECN = Forward Explicit Congestion Indication
- ❑ BECN = Backward Explicit Congestion Indication
- ❑ DE = Discard Eligible

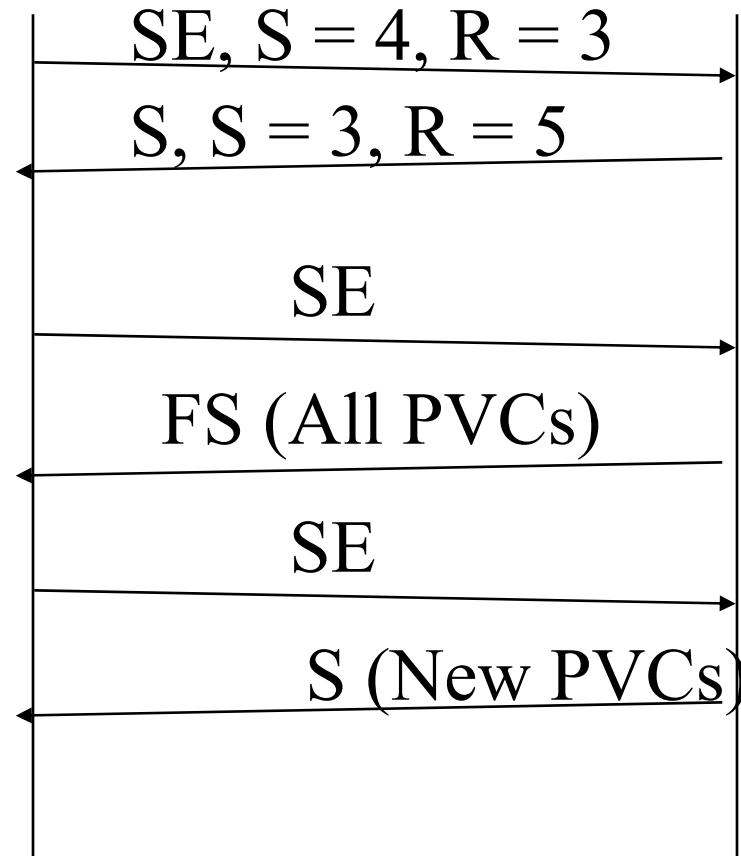
Local Management Interface (LMI)

- ❑ Extension designed by a group of vendors
- ❑ To overcome problems observed in early implementations
- ❑ May be standardized by both ANSI and ITU-T
- ❑ Status Enquiry (SE) message from user to network
- ❑ Status (S) message from network to user
- ❑ Uses HDLC I frames (with sequence numbers)
- ❑ Uses protocol ID=00001001, DLCI=1023

LMI Operation

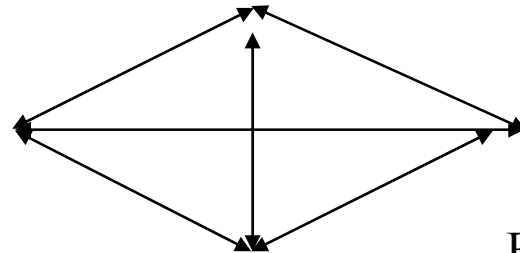
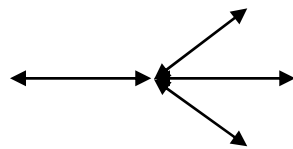
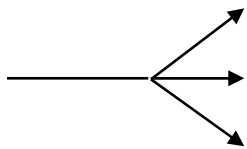
User

Network



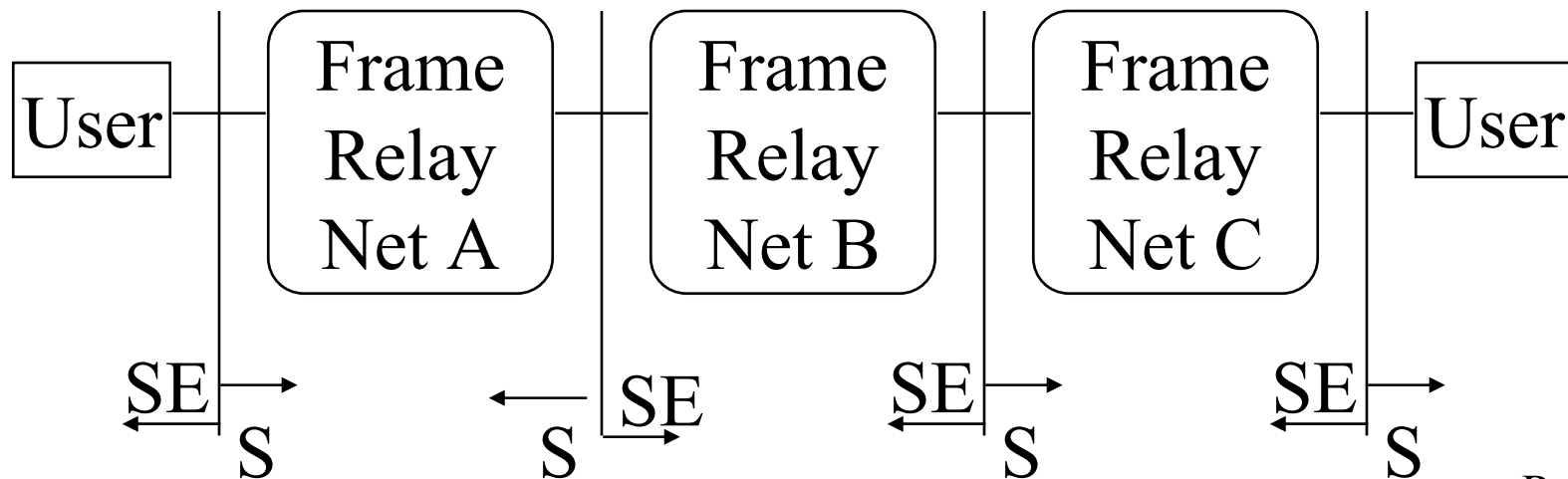
DLCI Extensions

- ❑ Global DLCI
 - ⇒ DLCI points to the same destination at all time and points
(OK for small networks)
- ❑ Multicasting
 - One-way multicasting: 1 to N
 - Two-way multicasting: 1 to N and N to 1
 - N-way Multicasting: N to N



Network-to-Network Interface (NNI)

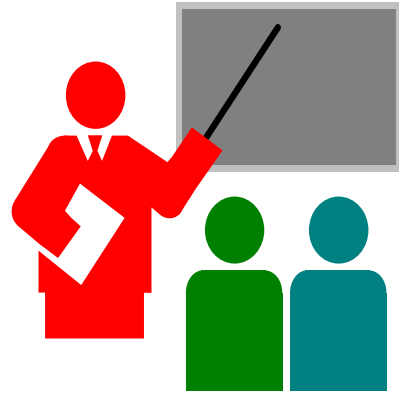
- ❑ Developed by frame relay forum:
FRF 92.08R1, FRF 92.62
- ❑ Working draft of ANSI T1S1.2
- ❑ Adding/deleting PVCs between networks
- ❑ Diagnosing PVC failures



Major NNI Operations

- ❑ Notification of adding a PVC
- ❑ Notification of deleting a PVC
- ❑ Notification of UNI or NNI failures
- ❑ Notification of a PVC segment availability or unavailability
- ❑ Verification of links between frame relay nodes
- ❑ Verification of frame relay nodes

Summary



- ❑ X.25 designed for unintelligent devices over error-prone networks \Rightarrow Slow
- ❑ Frame relay = Simplified X.25
- ❑ Higher data rates than X.25
- ❑ Developed for ISDN but runs in non-ISDN environments
- ❑ Two layer protocol architecture

Homework

- Read Section 7.2 of McDysan's book

Additional References

- ❑ Chapter 11 of Stallings' "ISDN and Broadband ISDN with Frame Relay and ATM"
- ❑ P. Smith, "Frame Relay: Principles and Applications," Addison-Wesley, 1993.
- ❑ U. Black, "Frame Relay Networks," 2nd Ed., McGraw-Hill, 1995
- ❑ C. A. Heckart, "The Guide to Frame Relay Networking," Flatiron Publishing, 1994
- ❑ Frame Relay Forum, <http://www.frforum.com>