Frame Relay

Raj Jain

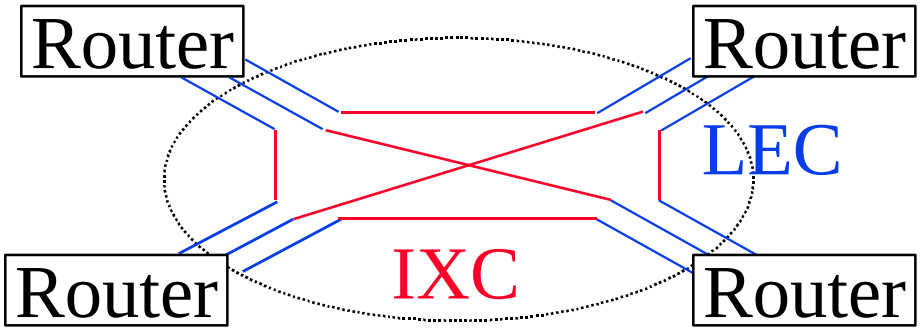
Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/

Overview

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

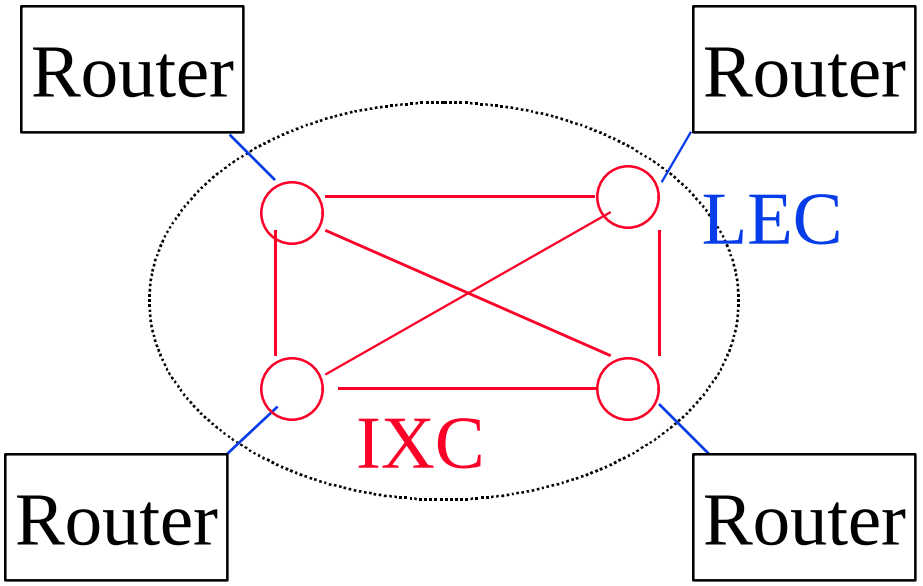
Problems with Leased Lines

- Multiple logical links ⇒ Multiple connections
- Four nodes ⇒ 12 ports,
  12 local exchange carrier (LEC) access lines,
  6 inter-exchange carrier (IXC) connections
- One more node ⇒ 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 ⇒ Virtual Private Networks



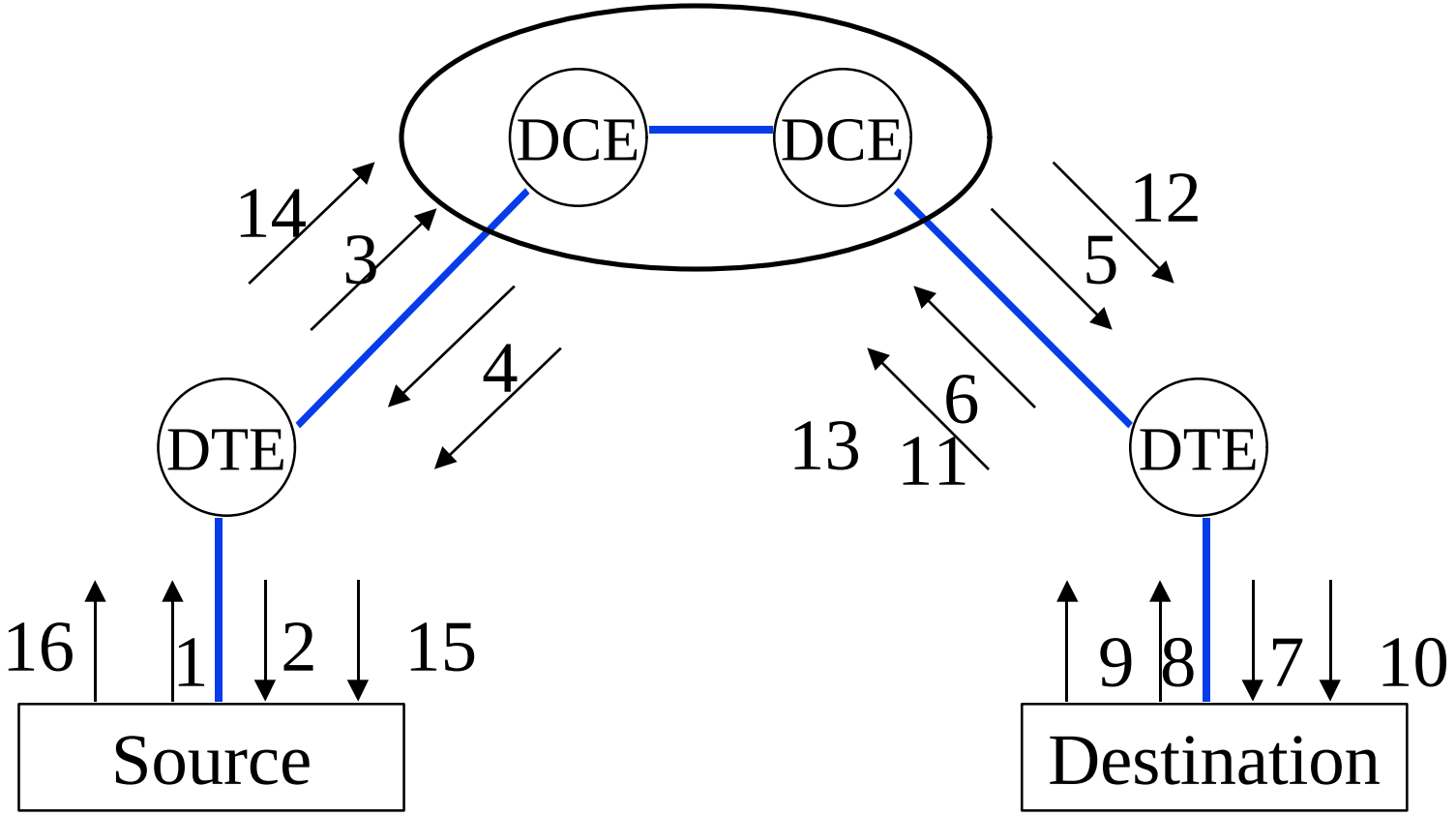
X.25

- 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

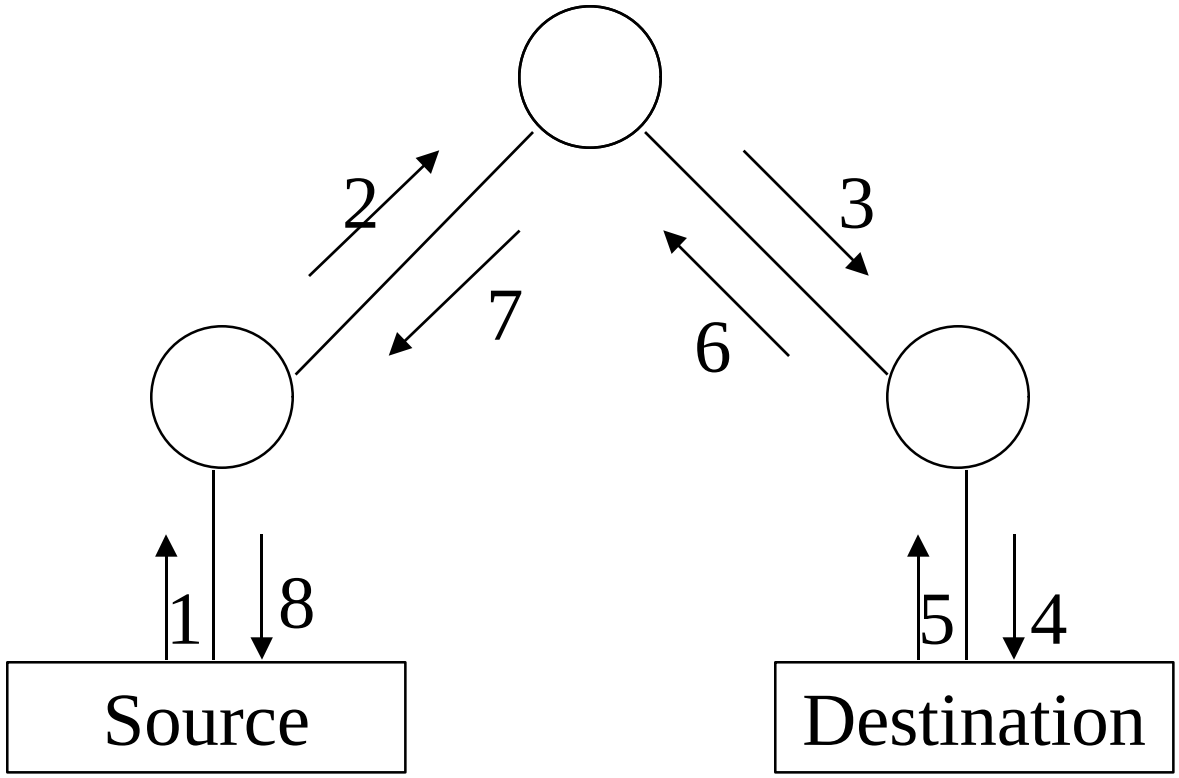
$\Rightarrow$ 12 messages for one packet transfer

Only 6 messages without flow control and error control

X.25 Exchange



Frame Relay Exchange



Frame Relay: Key Features

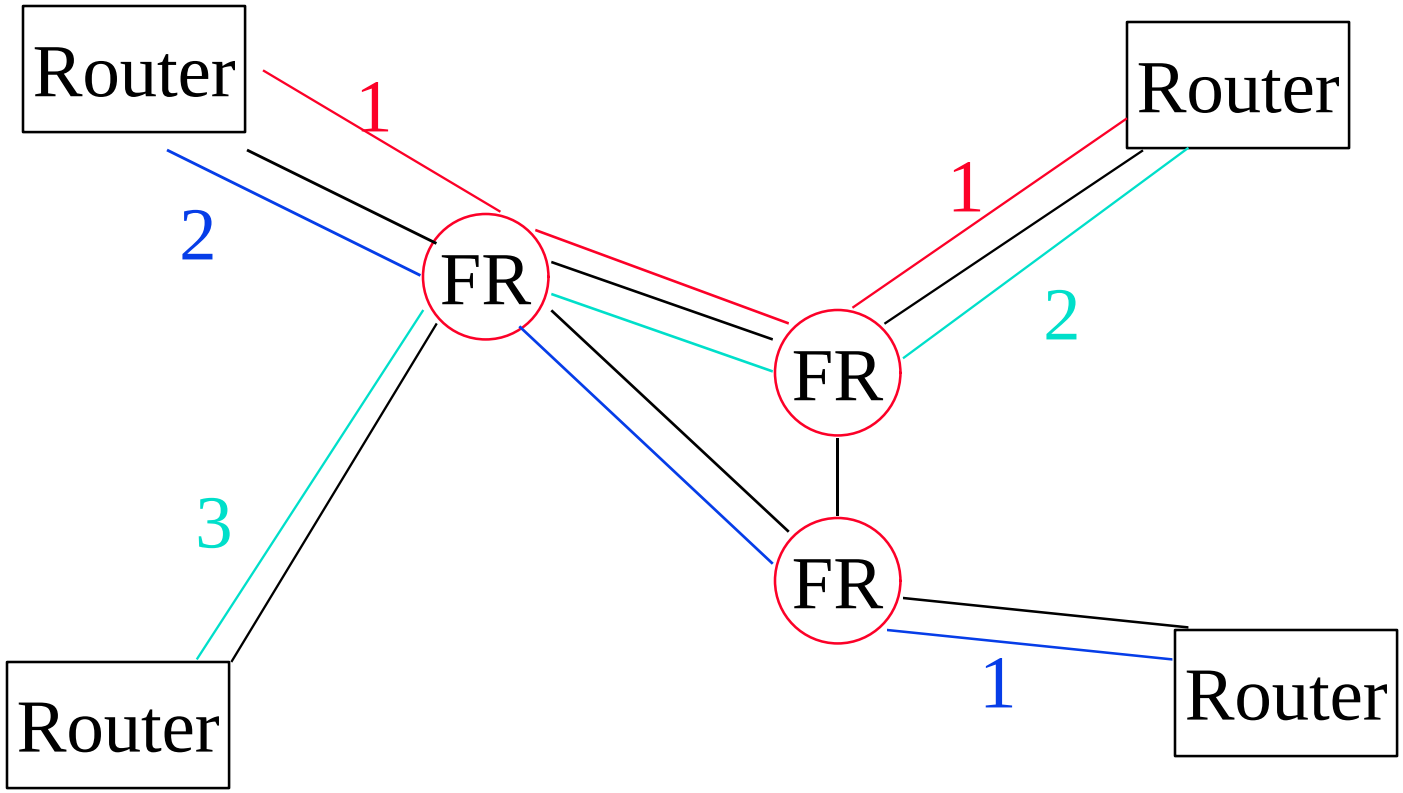
- X.25 simplified
- No flow and error control
- Out-of-band signaling
- Two layers
- Protocol multiplexing in the second layer
- Congestion control added
  ⇒Higher speed possible.
  X.25 suitable to 200 kbps. Frame relay to 2.048 Mbps.

Relay vs Switching

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

Datalink Control Identifiers

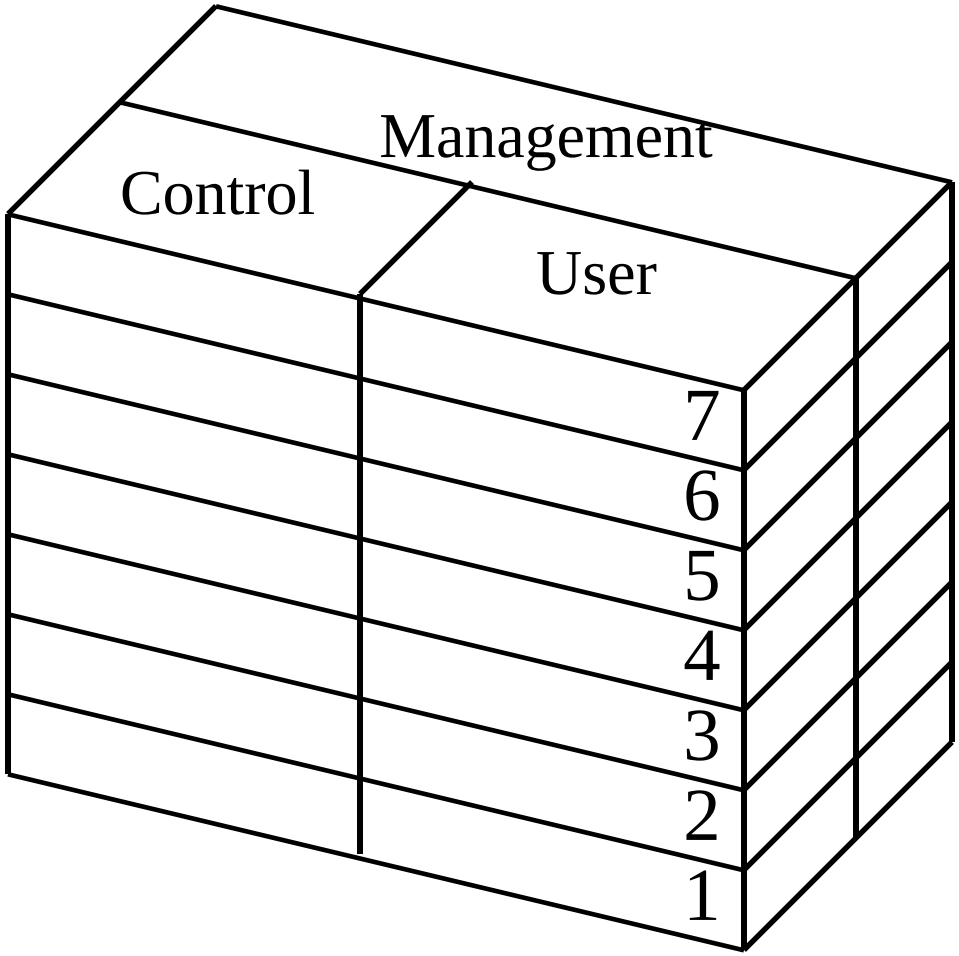
- DLCI: Similar to Logical Channel Numbers in X.25



Data Link Control Identifier

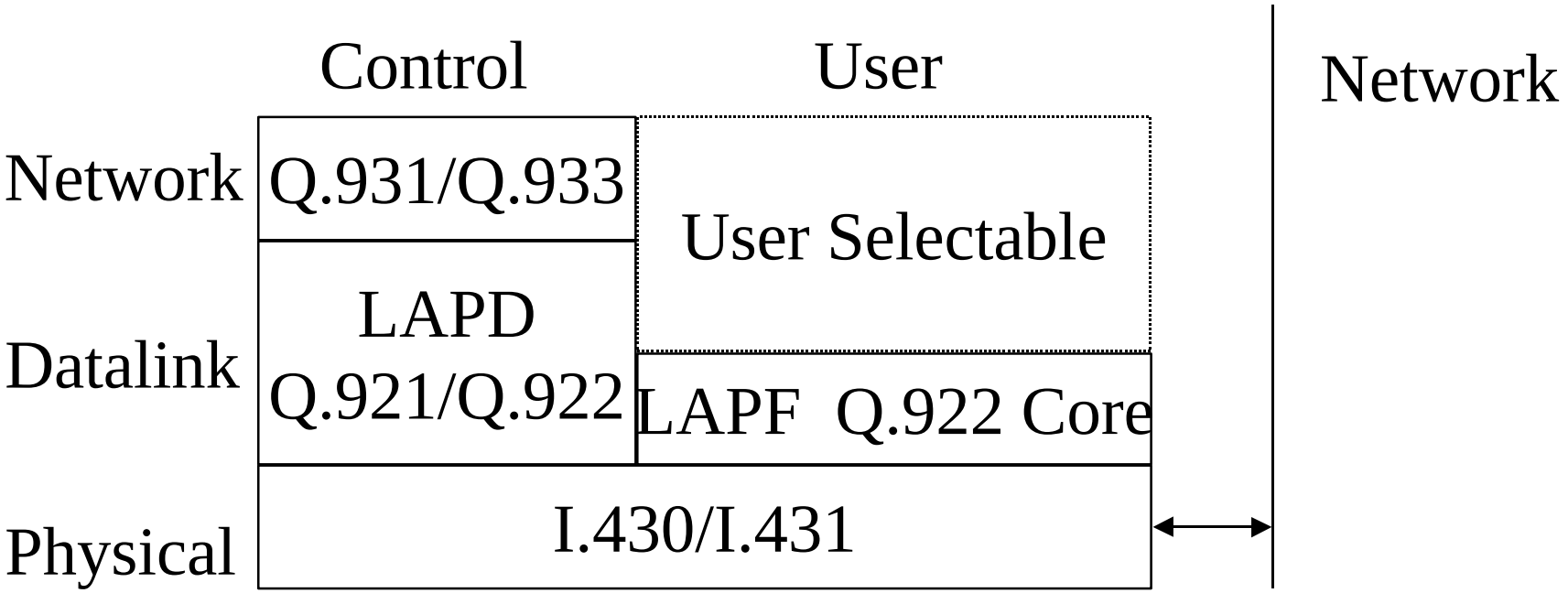
- Only local significance
- Allows multiple logical connections over one circuit
- Some ranges preassigned
- DLCI = 0 is used for signaling

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 $\Rightarrow$ Q.933 + Q.931 Frame relay message

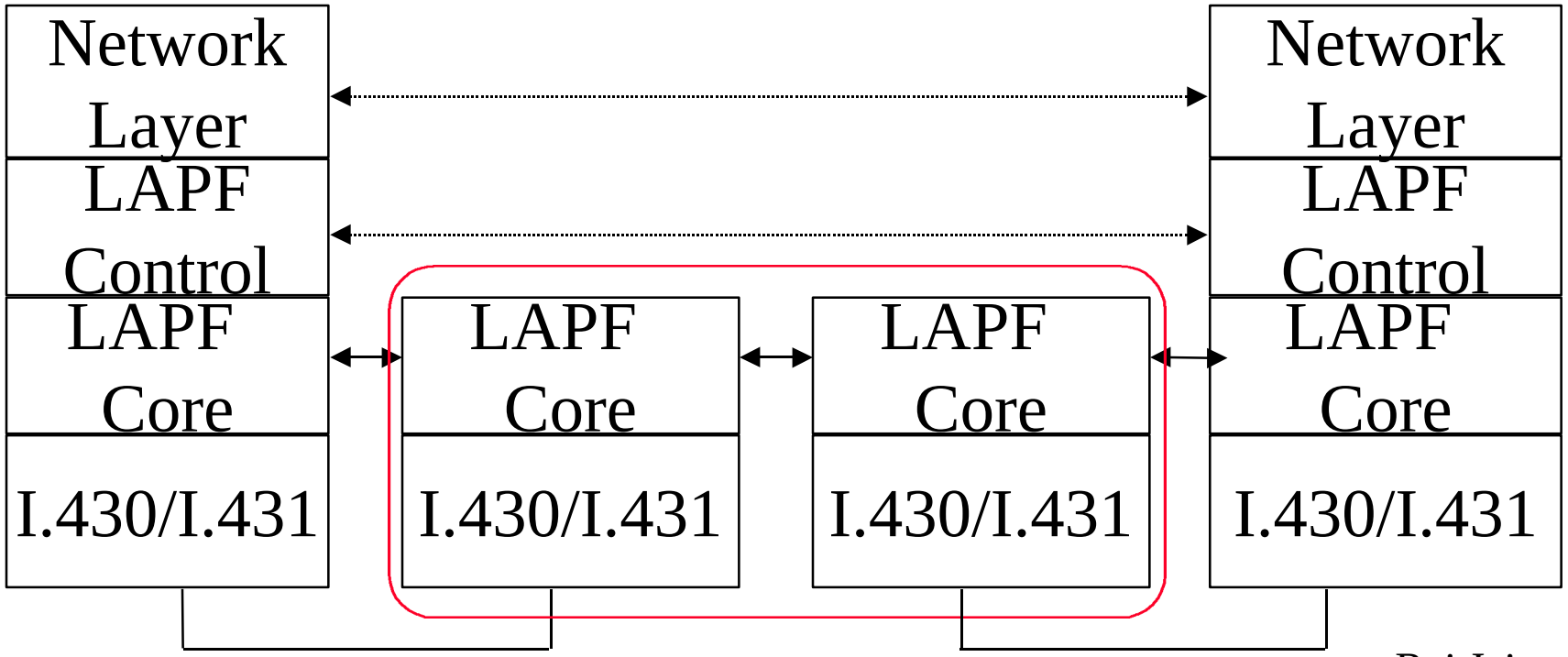
User Plane

- Link Access Procedure for Frame-Mode bearer services (LAPF)
- Q.922 = Enhanced LAPD (Q.921)
  = LAPD + Congestion
- LAPF defined in Q.922
- Core functions defined in Q.922 appendix:
  - Frame delimiting, alignment, and flag transparency
  - Virtual circuit multiplexing and demultiplexing
  - Octet alignment ⇒ 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 ⇒ 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

Flag 01111110	Address	Information	FCS	Flag 01111110
1B	2-4B		2B	2B

LAPF Address Field

- **2 Octet:**

8	7	6	5	4	3	2	1
Upper DLCI						C/R	EA 0
Lower DLCI				FECN	BECN	DE	EA 1

- **3 Octet:**

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

- **4 Octet:**

8	7	6	5	4	3	2	1
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

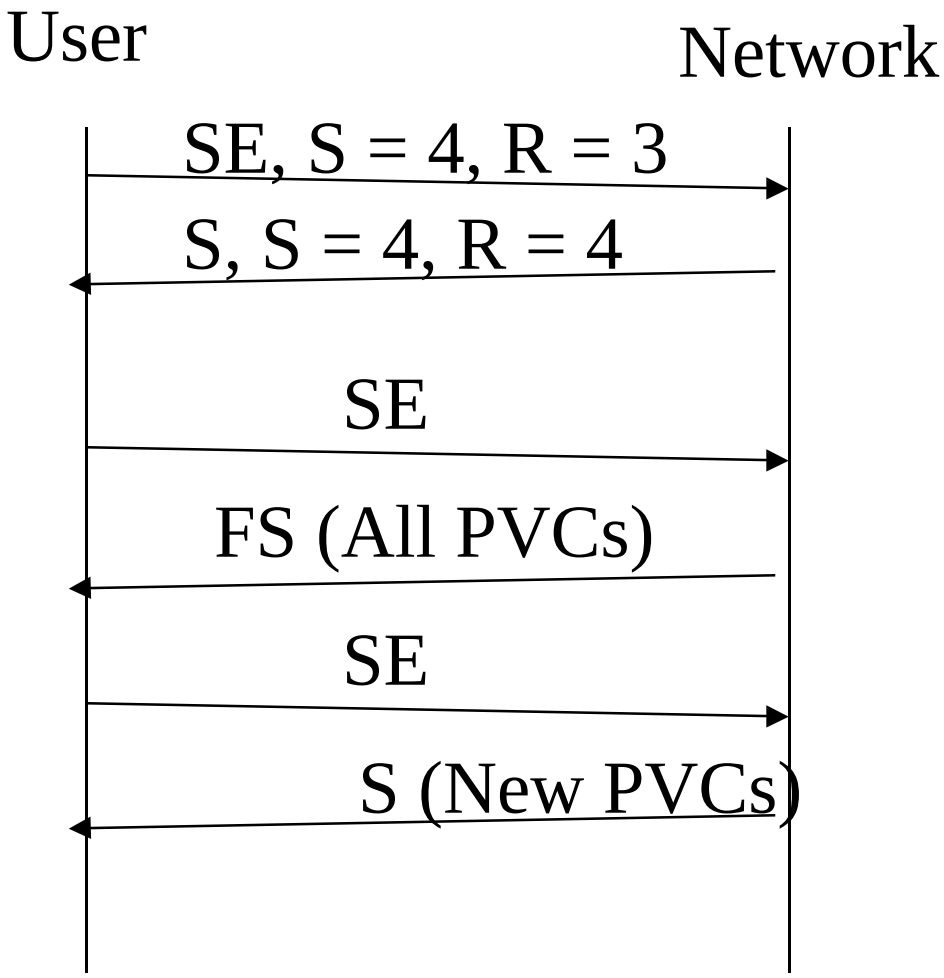
LAPF Address Field

- Address length = 2, 3, or 4 bytes
- Data Link Control Identifier (DLCI) = 10, 16, 17, or 23 bits
- Address Extension (EA) bits: 0 ⇒ 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

Local Management Interface (LMI)

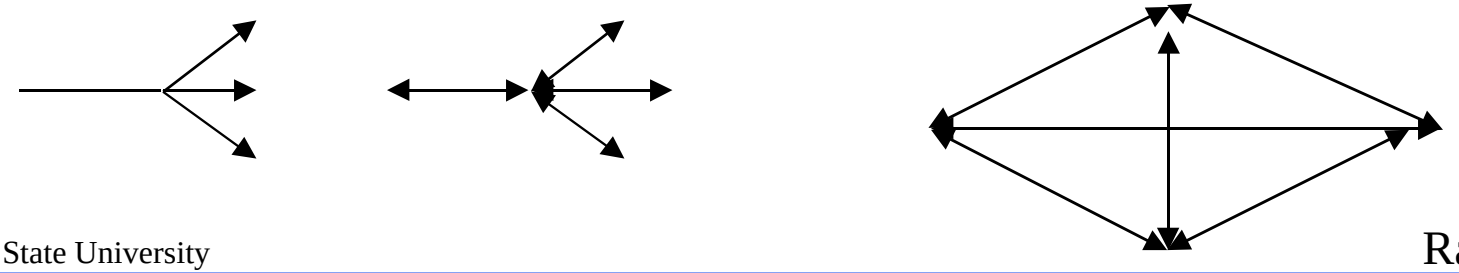
- Extension designed by a group of vendors
- To overcome problems observed in early implementations
- May be standardized by both ANSI and ITU-T
- Status Enquiry (SE) message from user to network
- Status (S) message from network to user
- Uses HDLC UI frames (with sequence numbers)
- Uses protocol ID=00001001,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

LMI Operation



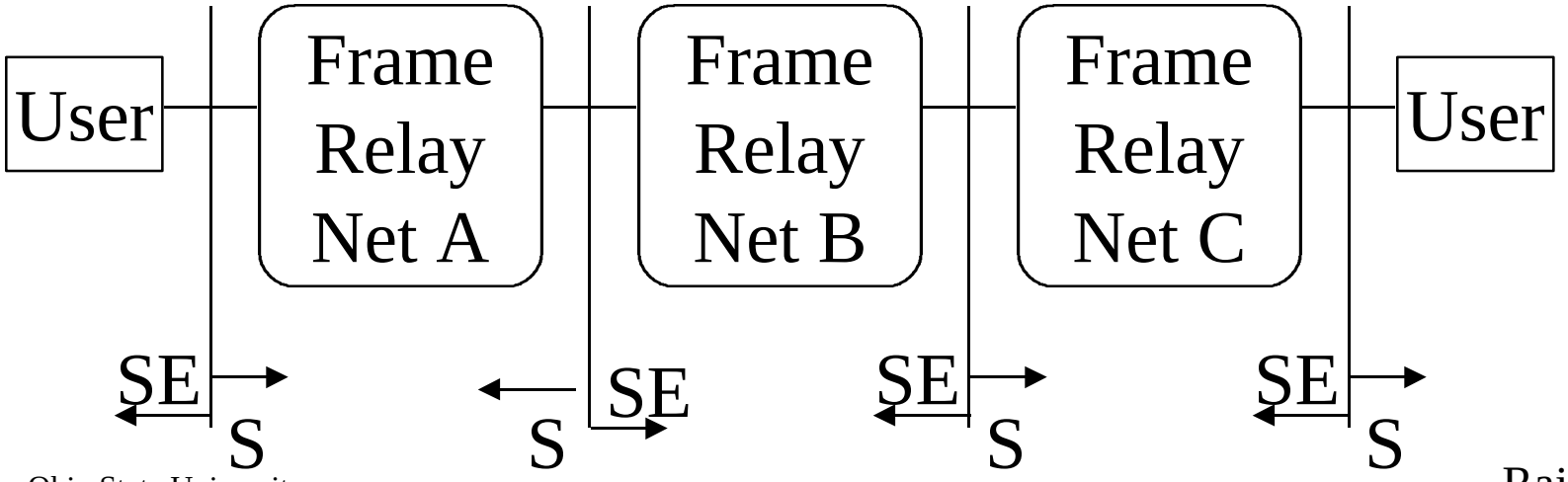
DLCI Extensions

- 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)

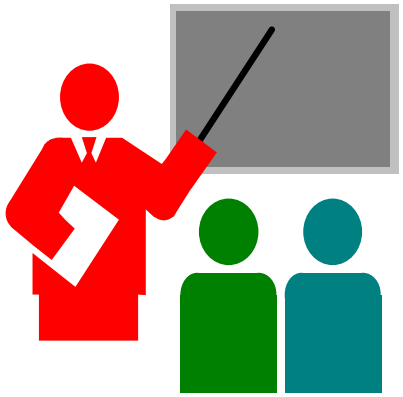
- Developed by frame relay forum: FRF 92.08R1, FRF 92.62
- Working draft of ANSI T1S1.2
- Adding/deleting PVCs between networks
- Diagnosing PVC failures



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 ⇒ 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 Chapter 4 of Black's "Emerging Communications Technologies." Can skip sections on congestion control.

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