Frame Relay

Outline

- Describe the Introduction
- Describe the history of Frame Relay
- Describe how Frame Relay works
- Describe the primary functionality traits of Frame Relay
- Describe the format of Frame Relay frames

Introduction

- Packet-Switching Networks
  - Switching Technique
  - Routing
  - X.25
- Frame Relay Networks
  - Architecture
  - User Data Transfer
  - Call Control

Introduction

- Frame Relay (FR) is a high-performance WAN protocol that operates at the physical and data link layers of the OSI reference model.
- FR originally was designed for use across Integrated Service Digital Network (ISDN) interfaces.
- Today, it is used over a variety of other network interfaces as well.
- FR is an example of a packet-switched technology.
- Packet-switched networks enable end stations to dynamically share the network medium and the available bandwidth.

What is Frame Relay?

- "A packet-switching protocol for connecting devices on a Wide Area Network (WAN)" quoted from Webopedia.
- FR networks in the U.S. support data transfer rates at T-1 (1.544 Mb/s) and T-3 (45 Mb/s) speeds. In fact, you can think of Frame Relay as a way of utilizing existing T-1 and T-3 lines owned by a service provider. Most telephone companies now provide FR service for customers who want connections at 56 Kb/s to T-1 speeds. (In Europe, FR's speeds vary from 64 Kb/s to 2 Mb/s.
- In the U.S., Frame Relay is quite popular because it is relatively inexpensive. However, it is being replaced in some areas by faster technologies, such as ATM.

Introduction

- FR often is described as a streamlined version of X.25, offering fewer of the robust capabilities, such as windowing and retransmission of last data that are offered in X.25.
- This is because FR typically operates over WAN facilities that offer more reliable connection services and a higher degree of reliability than the facilities available during the late 1970s and early 1980s that served as the common platform for X.25 WANs.
- FR is strictly a Layer 2 protocol suite, whereas X.25 provides services at Layer 3 (the network layer, we will discuss it later) as well.
- This enables FR to offer higher performance and greater transmission efficiency than X.25, and makes FR suitable for current WAN applications, such as LAN interconnection.

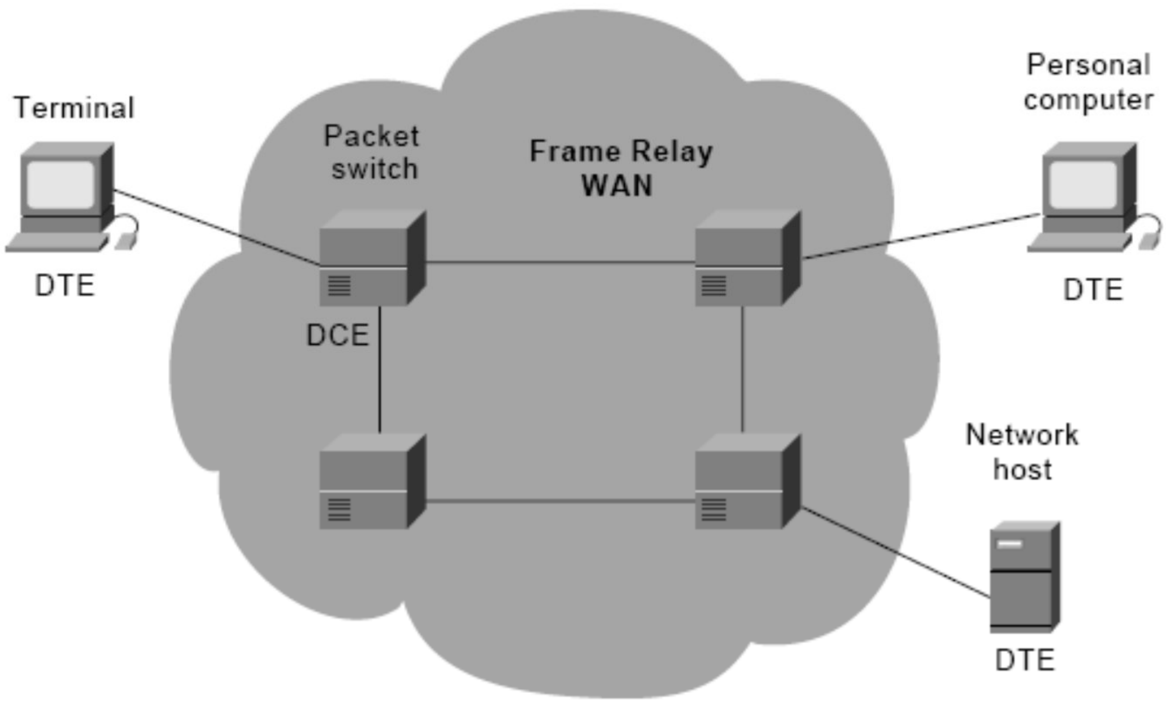
Outline

- Describe the Introduction
- Describe the history of Frame Relay
- Describe how Frame Relay works
- Describe the primary functionality traits of Frame Relay
- Describe the format of Frame Relay frames

Frame Relay Devices

- Devices attached to a Frame Relay WAN fall into the following two general categories:
  - Data terminal equipment (DTE)
    - DTEs generally are considered to be terminating equipment for a specific network and typically are located on the premises of a customer.
    - Example of DTE devices are terminals, personal computers, routers, and bridges.
  - Data circuit-terminating equipment (DCE)
    - DCEs are carrier-owned internetworking devices.
    - The purpose of DCE equipments is to provide clocking and switching services in a network, which are the devices that actually transmit data through the WAN.

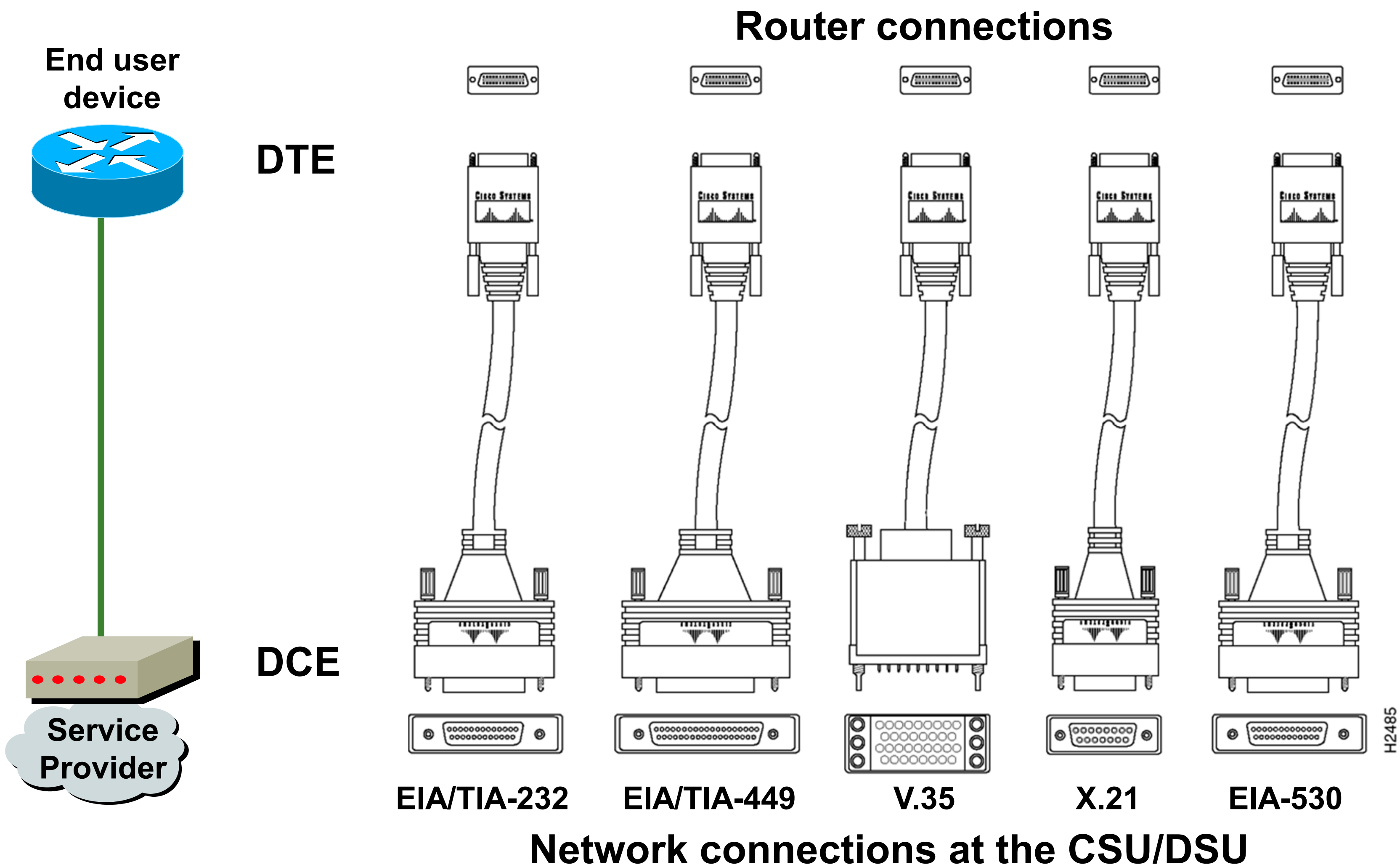
Frame Relay Devices (cont.)



Frame Relay Devices (cont.)

- The connection between a DTE device and a DCE device consists of both a physical layer component (L1) and a link layer component (L2).
- The physical component defines the mechanical, electrical, functional, and procedural specifications for the connection between the devices. One of the commonly used physical layer interface specifications is the recommended standard (RS)-232.

Serial Point-to-Point Connection



Packet-Switching Networks

- Basic technology the same as in the 1970s
- One of the few effective technologies for long distance data communications
- Frame relay and ATM are variants of packet-switching
- Advantages:
  - Flexibility, resource sharing, robust, responsive
- Disadvantages:
  - Time delays in distributed networks, overhead penalties
  - Need for routing and congestion control

Definition of Packet Switching

- Refers to protocols in which messages are divided into packets before they are sent. Each packet is then transmitted individually and can even follow different routes to its destination. Once all the packets forming a message arrive at the destination, they are recompiled into the original message.
- Most modern Wide Area Network (WAN) protocols, including TCP/IP, X.25, and Frame Relay, are based on packet-switching technologies.
- In contrast, normal telephone service is based on a circuit-switching technology, in which a dedicated line is allocated for transmission between two parties.
- Circuit-switching is ideal when data must be transmitted quickly and must arrive in the same order in which it's sent. This is the case with most real-time data, such as live audio and video. Packet switching is more efficient and robust for data that can withstand some delays in transmission, such as e-mail messages and Web pages.

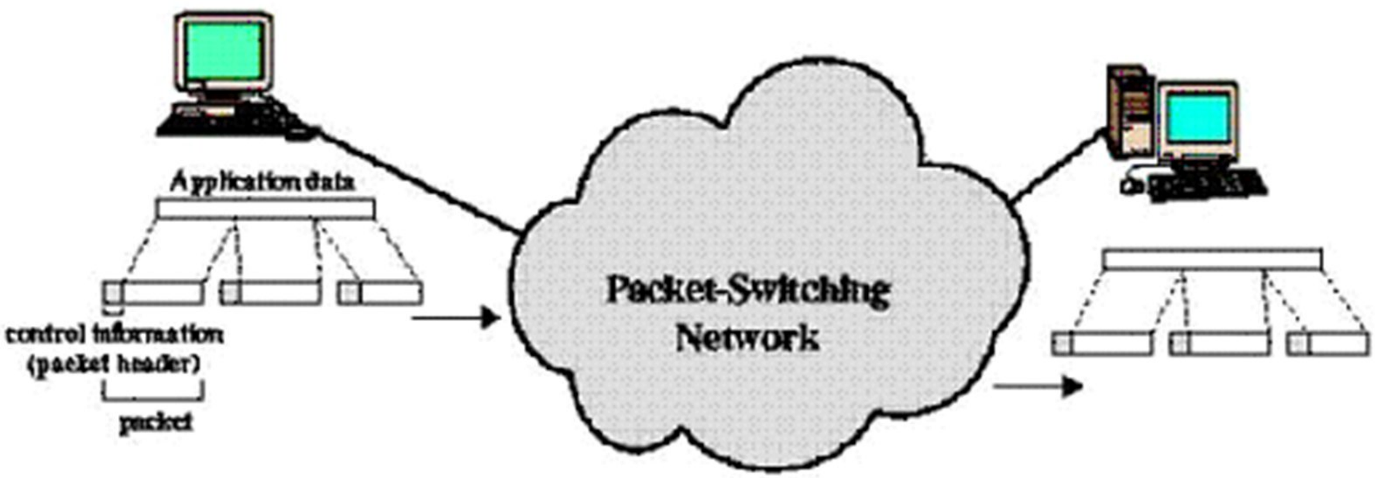
Circuit-Switching

- Long-haul telecom network designed for voice
- Network resources dedicated to one call
- Shortcomings when used for data:
  - Inefficient (high idle time)
  - Constant data rate

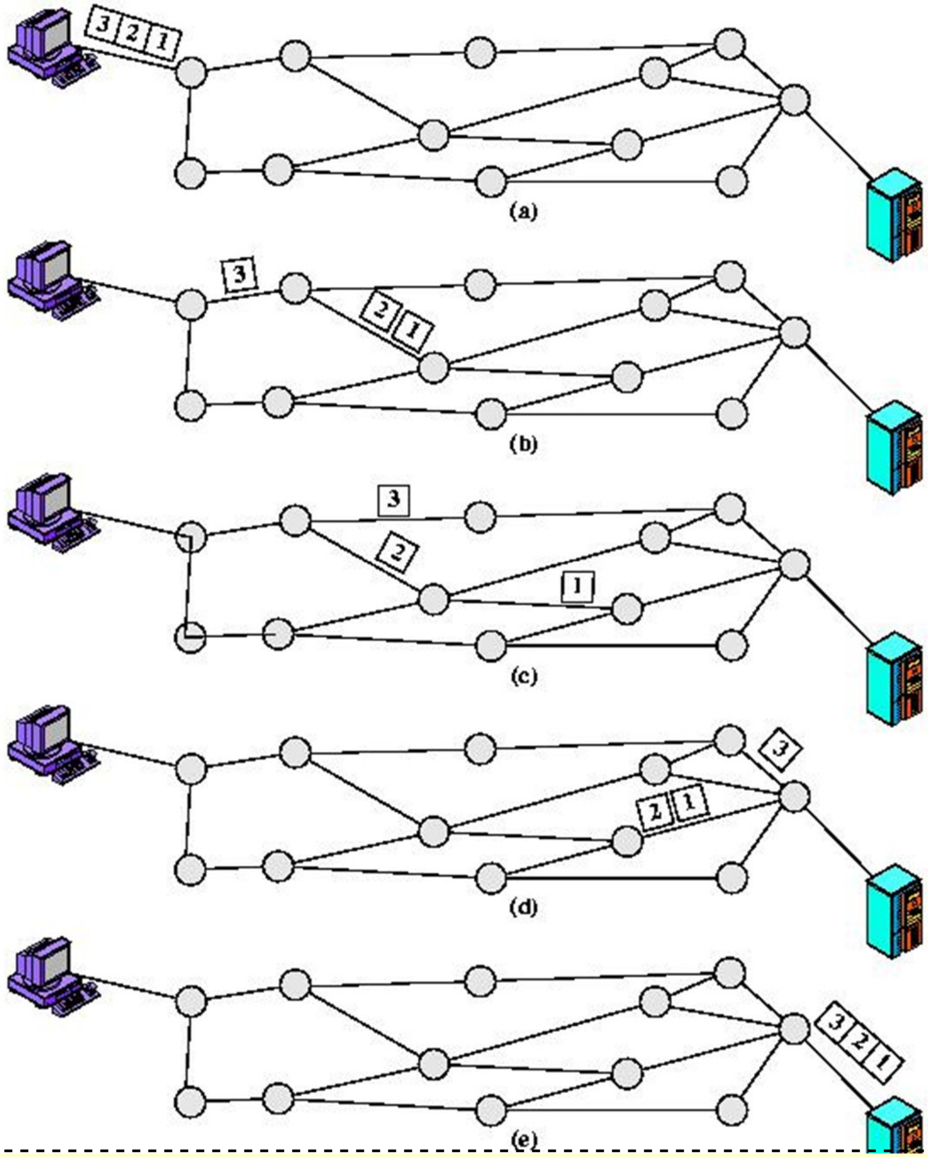
Packet-Switching

- Data transmitted in short blocks, or packets
- Packet length < 1000 octets
- Each packet contains user data plus control info (routing)
- Store and forward

The Use of Packets



Packet Switching: Datagram Approach



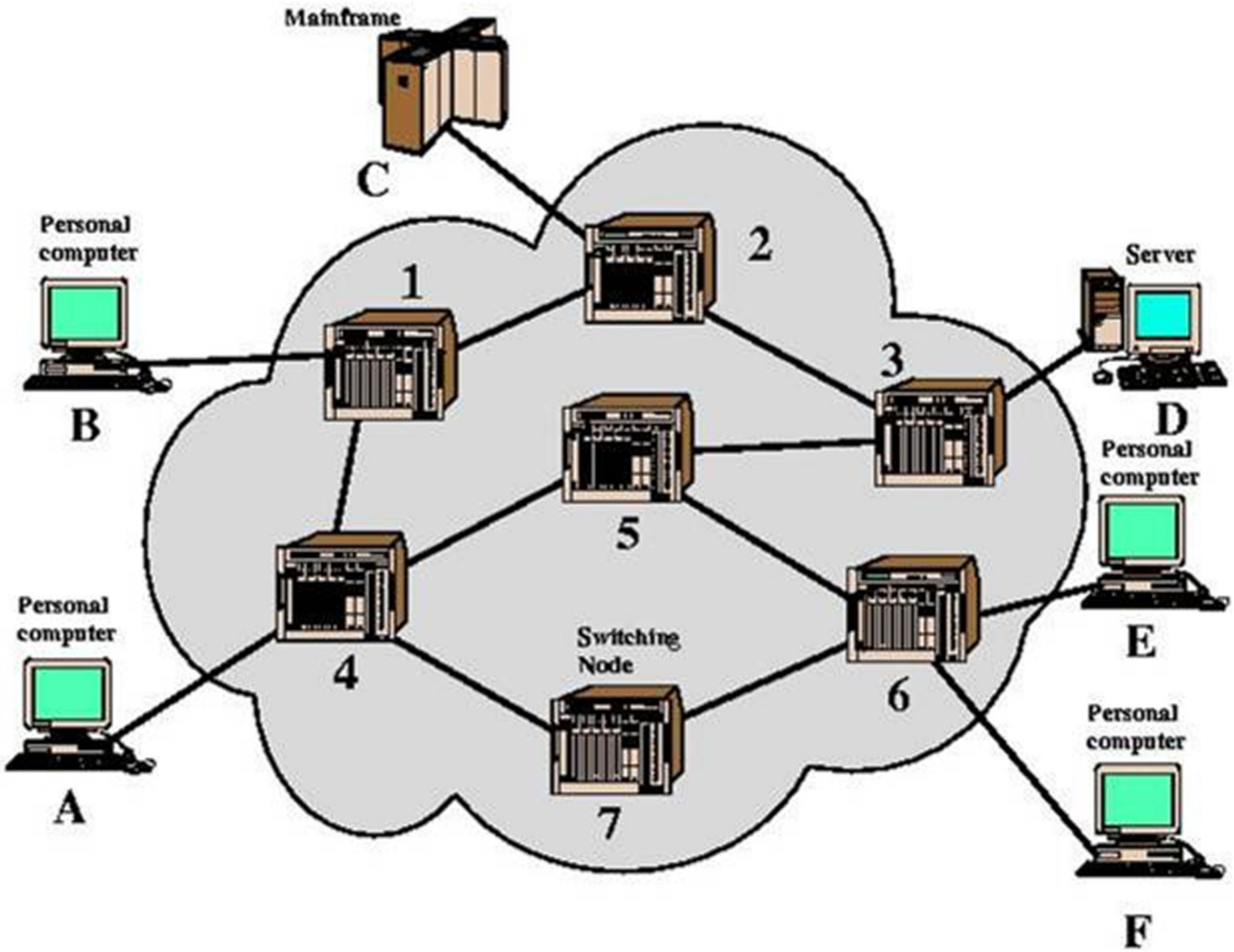
Advantages with compared to Circuit-Switching

- Greater line efficiency (many packets can go over shared link)
- Data rate conversions
- Non-blocking under heavy traffic (but increased delays). When traffic becomes heavy on a circuit-switching network, some calls are blocked.
- Priorities can be used.

Disadvantages relative to Circuit-Switching

- Packets incur additional delay with every node they pass through
- Jitter: variation in packet delay
- Data overhead in every packet for routing information, etc
- Processing overhead for every packet at every node traversed

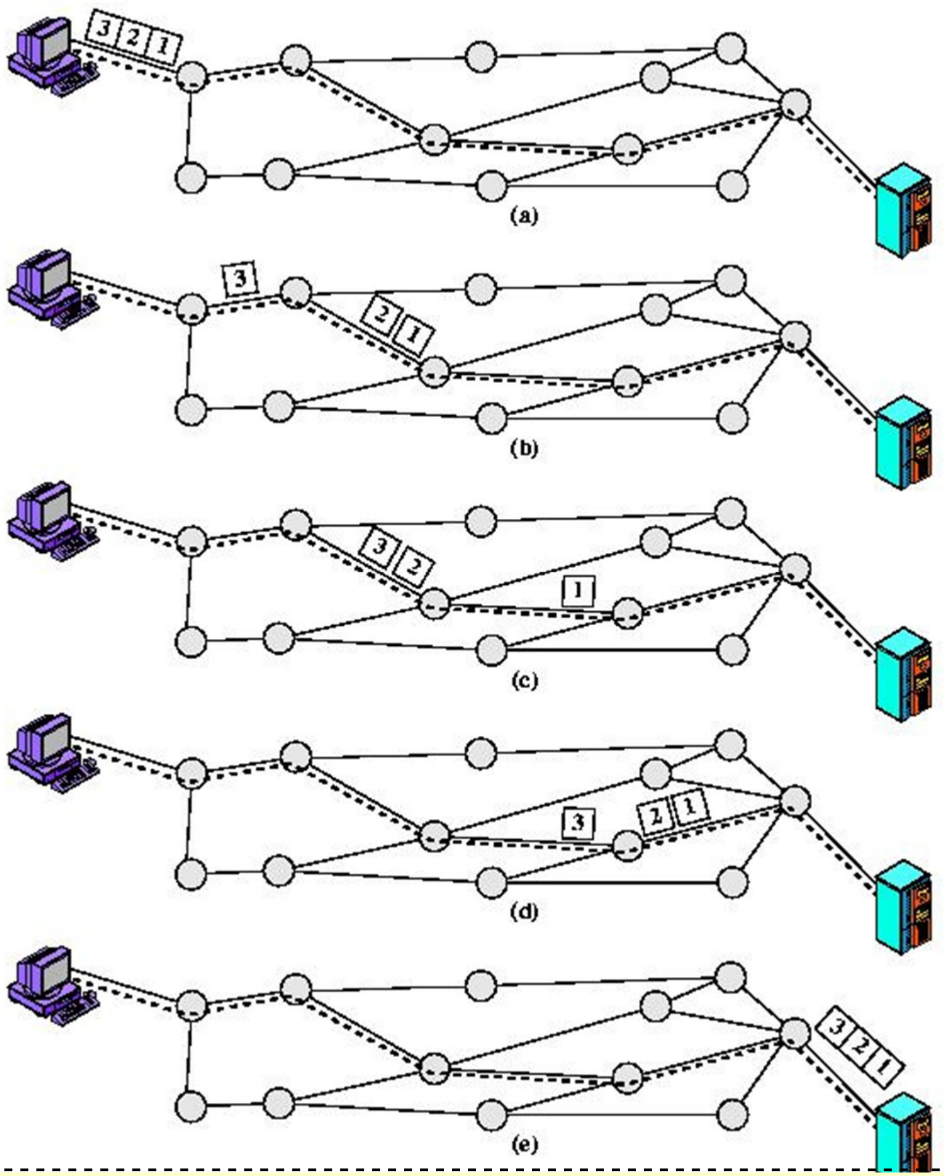
Simple Switching Network



Switching Technique

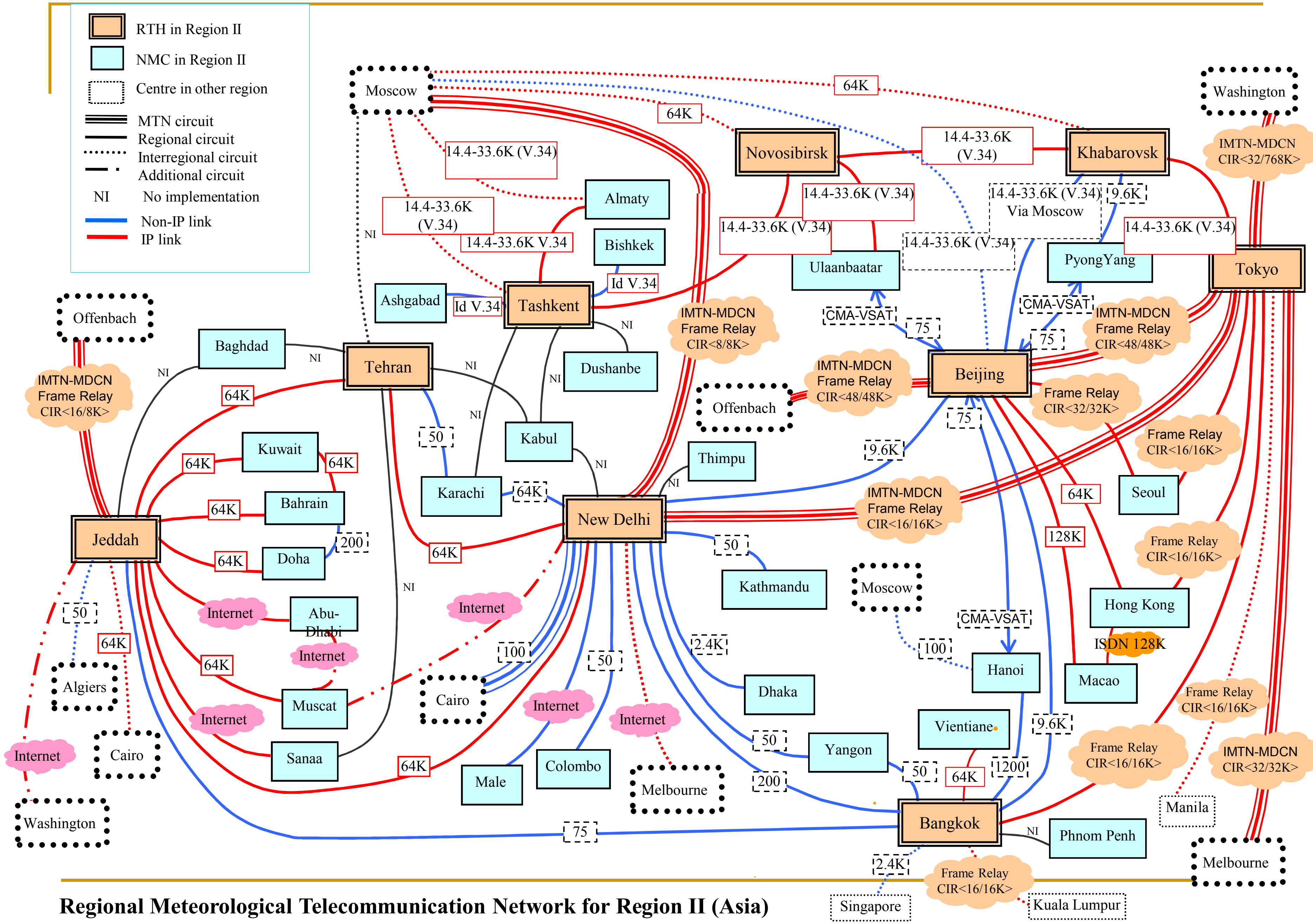
- Large messages broken up into smaller packets
- Datagram
  - Each packet sent independently of the others
  - No call setup
  - More reliable (can route around failed nodes or congestion)
- Virtual circuit
  - Fixed route established before any packets sent
  - No need for routing decision for each packet at each node

Packet Switching: Virtual-Circuit Approach



An Introduction to X.25

- The first commercial packet-switching network interface standard was X.25.
- X.25 is now seldom used in developed countries but is still available in many parts of the world (see next page).
- A popular standard for packet-switching networks. The X.25 standard was approved by the CCITT (now the ITU-T) in 1976. It defines layers 1, 2, and 3 in the OSI Reference Model.
- 3 levels
- Physical level (X.21)
- Link level: LAPB (Link Access Protocol-Balanced), a subset of HDLC (High-level Data Link Control)
- Packet level (provides virtual circuit service)

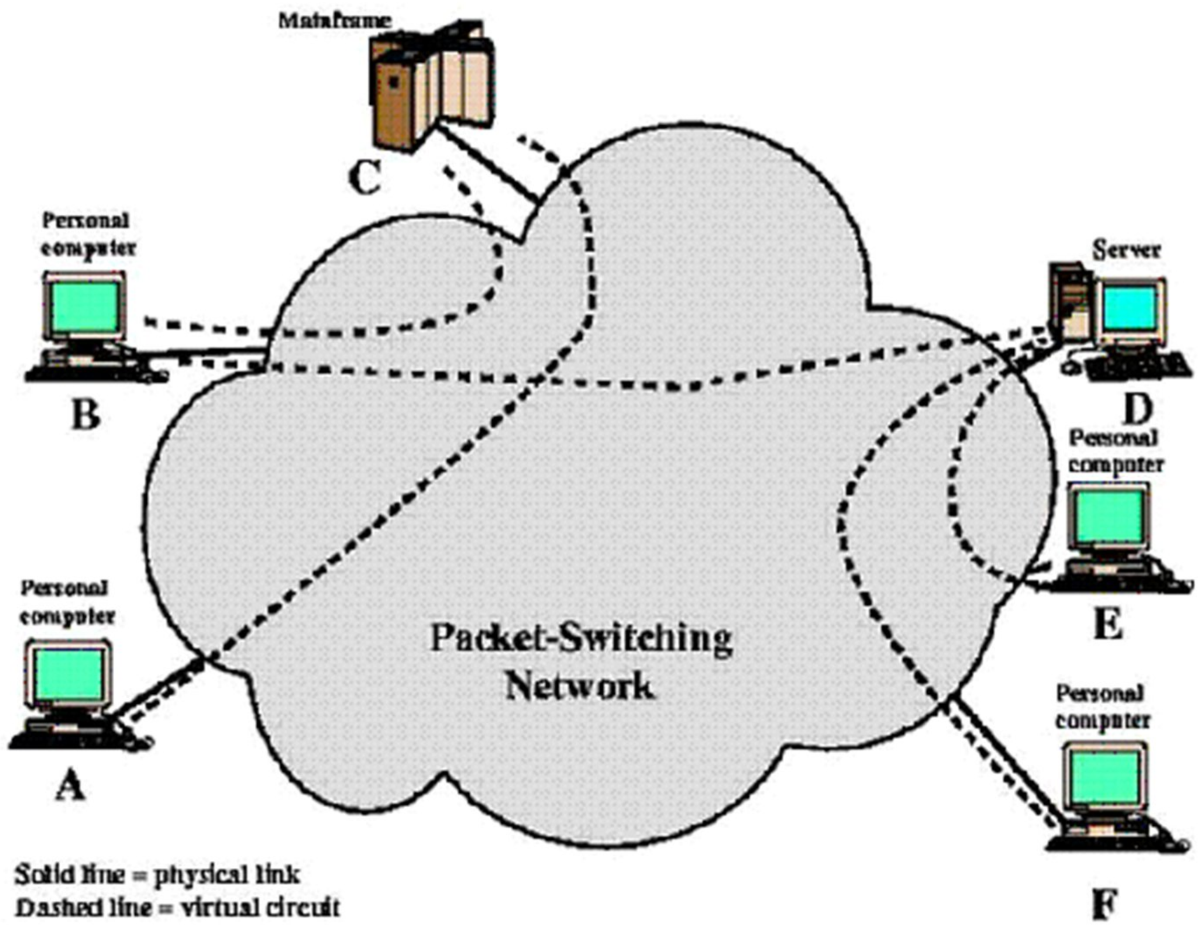


Regional Meteorological Telecommunication Network for Region II (Asia)

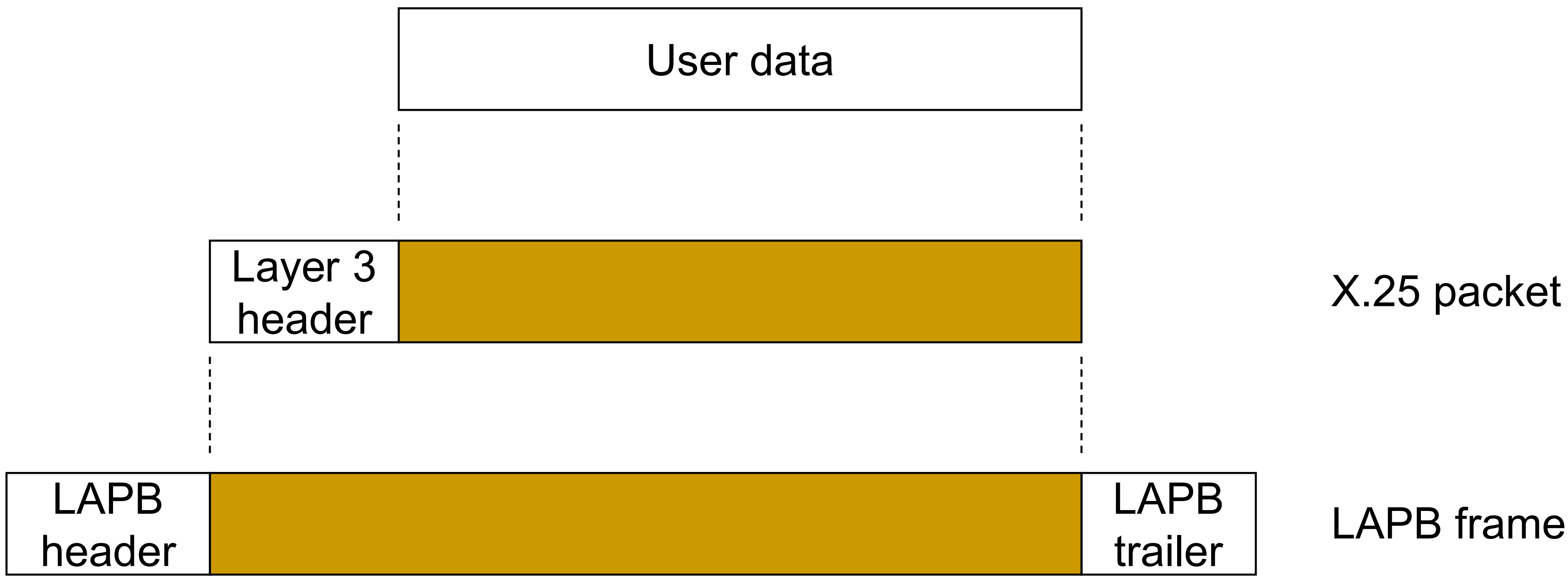
Current status as of December 2004

Frame Relay

The Use of Virtual Circuits



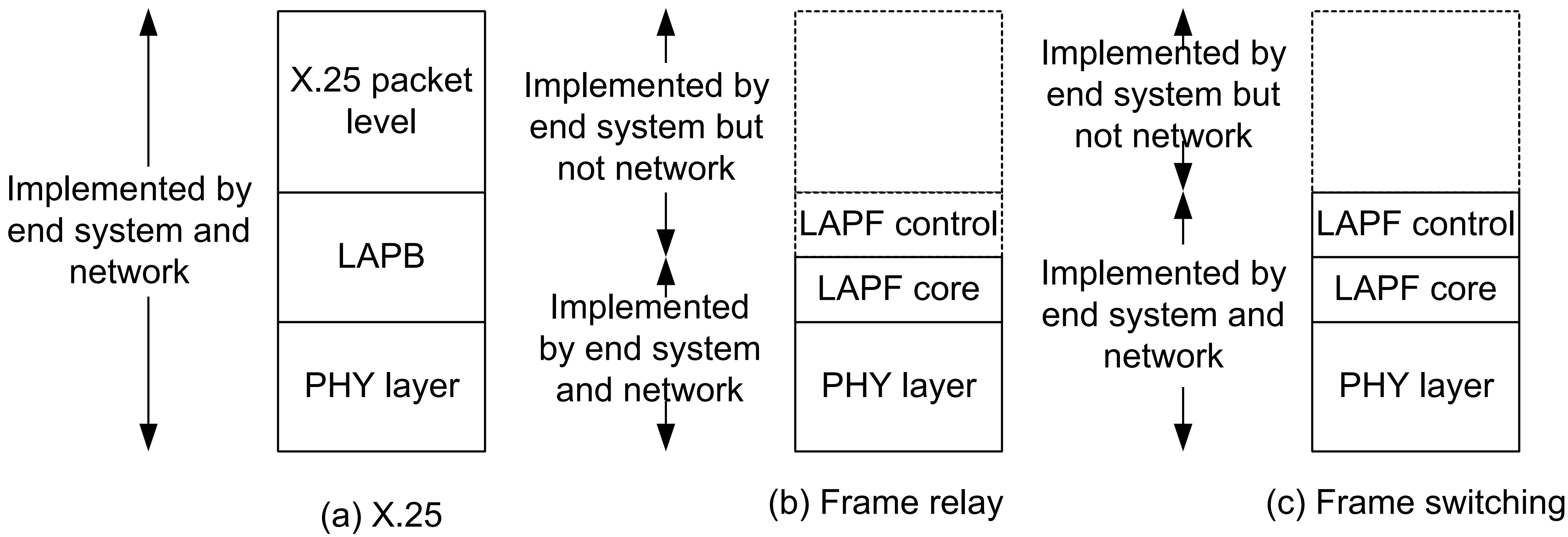
User Data and X.25 Protocol Control Information



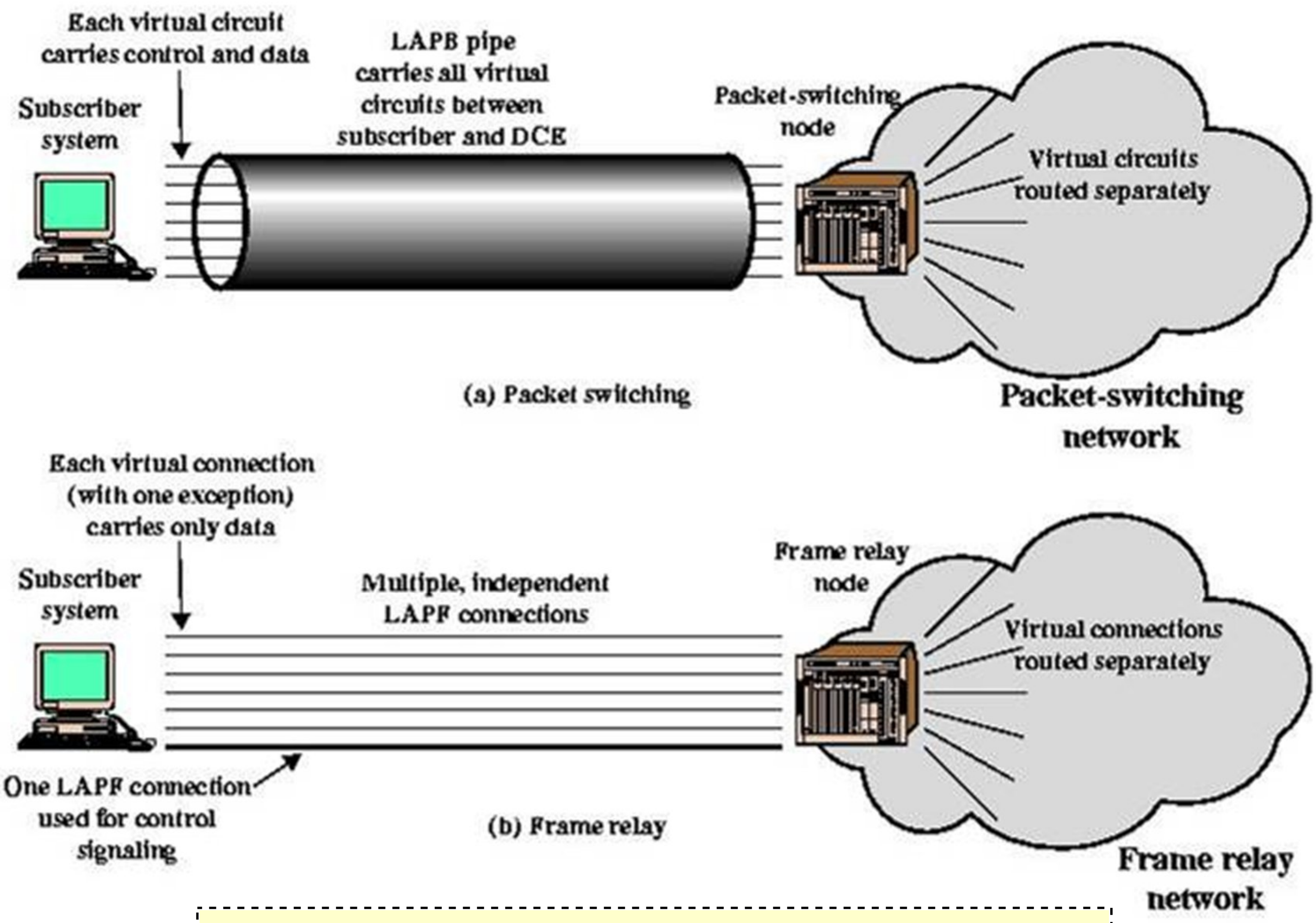
Frame Relay Networks

- Designed to eliminate much of the overhead in X.25
- Call control signaling on separate logical connection from user data
- Multiplexing/switching of logical connections at layer 2 (not layer 3)
- No hop-by-hop flow control and error control
- Throughput an order of magnitude higher than X.25

Comparison of X.25 and Frame Relay Protocol Stacks



Virtual Circuits and Frame Relay Virtual Connections



Frame Relay Architecture

- X.25 has 3 layers: physical, link, network
- Frame Relay has 2 layers: physical and data link (or LAPF, Link Access Procedure for Frame Mode Bearer Services)
- LAPF core: minimal data link control
  - Preservation of order for frames
  - Small probability of frame loss
- LAPF control: additional data link or network layer end-to-end functions

Outline

- Describe the Introduction
- Describe the history of Frame Relay
- Describe how Frame Relay works
- Describe the primary functionality traits of Frame Relay
- Describe the format of Frame Relay frames

Frame Relay Virtual Circuits

- Frame Relay provides connection-oriented data link layer communications. This means that a defined communication exists between each pair of devices and that these connections are associated with a connection identifier (ID).
- This service is implemented by using a FR virtual circuit, which is a logical connection created between two 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).

Frame Relay Virtual Circuits (cont.)

- A number of virtual circuits can be multiplexed into a single physical circuit for transmission across the network.
- This capability often can reduce the equipment and network complexity required to connect multiple DTE devices.
- 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 (SVCs)

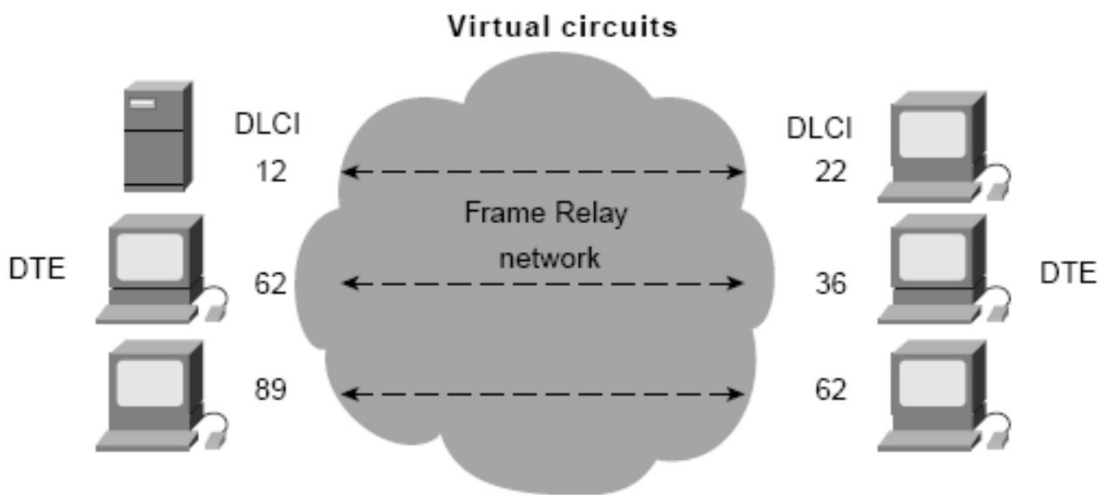
- *Switched virtual circuits (SVCs)* are temporary connections used in situations requiring only sporadic data transfer between DTE devices across the Frame Relay network. A communication session across an SVC consists of the following four operational states:
  - **Call setup**—The virtual circuit between 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.

Permanent Virtual Circuits (PVCs)

- *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. PVCs always operate in one of the following two operational states:
- **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.



Congestion-Control Mechanisms

- Frame Relay reduces network overhead by implementing simple congestion-notification mechanisms rather than explicit, per-virtual-circuit flow control.
- Frame Relay typically is implemented on reliable network media, so data integrity is not sacrificed because flow control can be left to higher-layer protocols. Frame Relay implements two congestion-notification mechanisms:
  - Forward-explicit congestion notification (FECN)
  - Backward-explicit congestion notification (BECN)

Congestion-Control Mechanisms

- 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.
- 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 *Discard Eligibility (DE) bit* is used to indicate that a frame has lower importance than other frames. The DE bit is part of the Address field in the Frame Relay frame header.
- 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 before discarding those that do not. This reduces the likelihood of critical data being dropped by Frame Relay DCE devices during periods of congestion.

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 typically is implemented on reliable network media, so data integrity is not sacrificed because error correction can be left to higher-layer protocols running on top of Frame Relay.

Frame Relay Local Management Interface

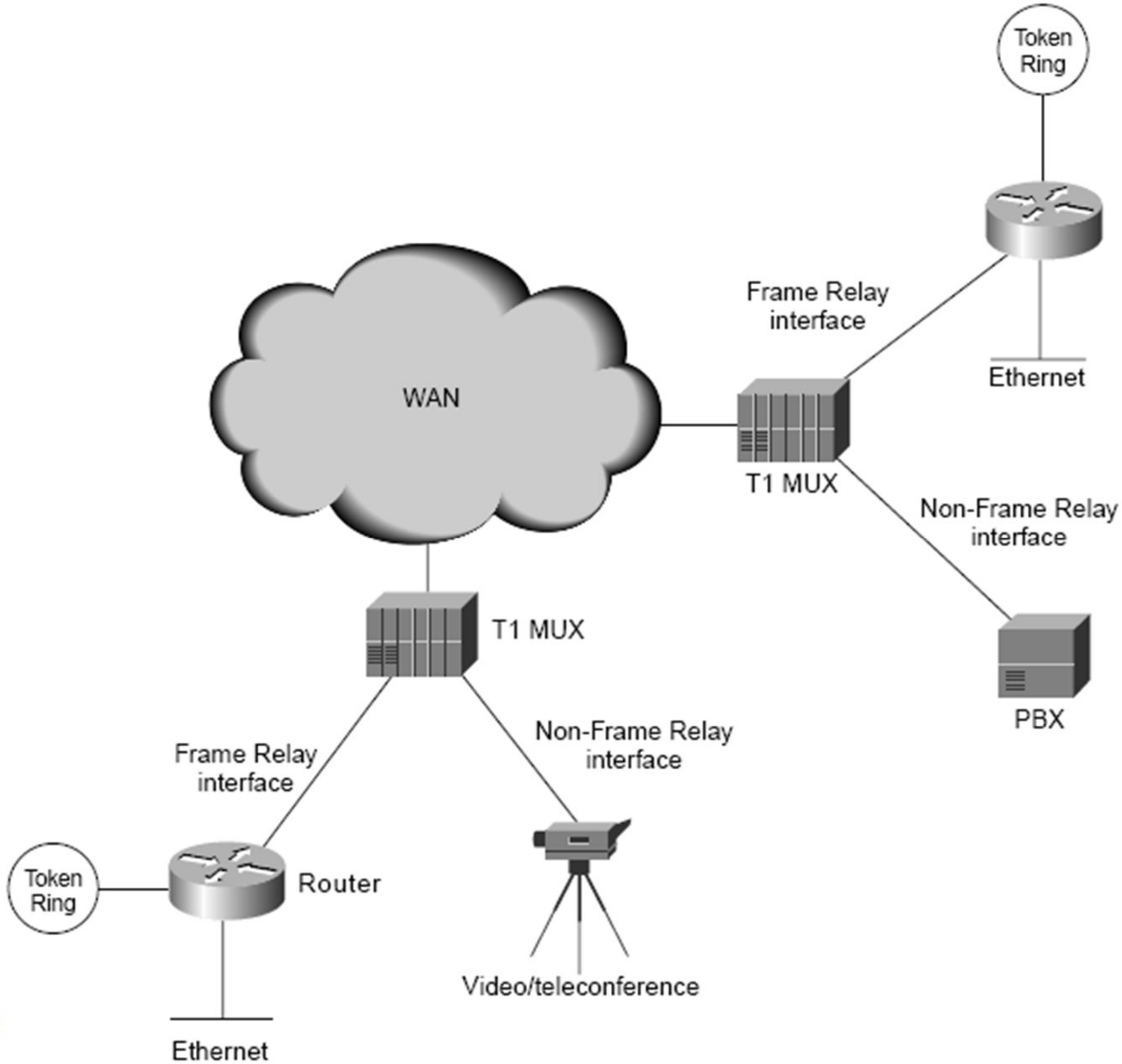
- The *Local Management Interface (LMI)* is a set of enhancements to the basic Frame Relay specification.
- The LMI was developed in 1990 by Cisco Systems, StrataCom, Northern Telecom, and Digital Equipment Corporation.
- It offers a number of features (called extensions) for managing complex internetworks. Key Frame Relay LMI extensions include global addressing, virtual circuit status messages, and multicasting.
- The LMI global addressing extension gives Frame Relay data-link connection identifier (DLCI) values global rather than local significance.
- DLCI values become DTE addresses that are unique in the Frame Relay WAN. The global addressing extension adds functionality and manageability to Frame Relay internetworks.

Frame Relay Local Management Interface (cont.)

- Individual network interfaces and the end nodes attached to them, for example, can be identified by using standard address-resolution and discovery techniques. In addition, the entire Frame Relay network appears to be a typical LAN to routers on its periphery.
- 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).
- The LMI multicasting extension allows multicast groups to be assigned. Multicasting saves bandwidth by allowing routing updates and address-resolution messages to be sent only to specific groups of routers. The extension also transmits reports on the status of multicast groups in update messages.

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

- Frame Relay is implemented in both public carrier-provided networks and in private enterprise networks.
- **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.
  - Generally, the DCE equipment also is owned by the telecommunications provider.
  - DTE equipment either will be customer-owned or perhaps will be owned by the telecommunications provider as a service to the customer.
- **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.

Outline

- Describe the Introduction
- Describe the history of Frame Relay
- Describe how Frame Relay works
- Describe the primary functionality traits of Frame Relay
- Describe the format of Frame Relay frames

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: (in bits)
  - DLCI: ‘0’ for Call Control message
  - Extended Address (EA): Address field extension bit
  - C/R: the C/R bit is not currently defined.
  - Congestion Control:

8	16	Variable	16	8
Flags	Address	Data	FCS	Flags

LAPF Core

- LAPF (Link Access Procedure for Frame Mode Bearer Services)
- Frame delimiting, alignment and transparency
- Frame multiplexing/demultiplexing
- Inspection of frame for length constraints
- Detection of transmission errors
- Congestion control

LAPF-core Formats

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

(a) Address field - 2 octets (default)

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

(b) Address field - 3 octets

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

(c) Address field - 4 octets

EA Address field extention bit
C/R Command/response bit
FECN Forward explicit congestion notification
BECN Backward explicit congestion notification
DLCI Data link connection identifier
D/C DLCI or DL-CORE control indicator
DE Dsicard eligibility

User Data Transfer

- No control field, which is normally used for:
  - Identify frame type (data or control)
  - Sequence numbers
- Implication:
  - Connection setup/teardown carried on separate channel
  - Cannot do flow and error control

Outline

- Describe the Introduction
- Describe the history of Frame Relay
- Describe how Frame Relay works
- Describe the primary functionality traits of Frame Relay
- Describe the format of Frame Relay frames
- Frame Call Control and Example

Frame Relay Call Control

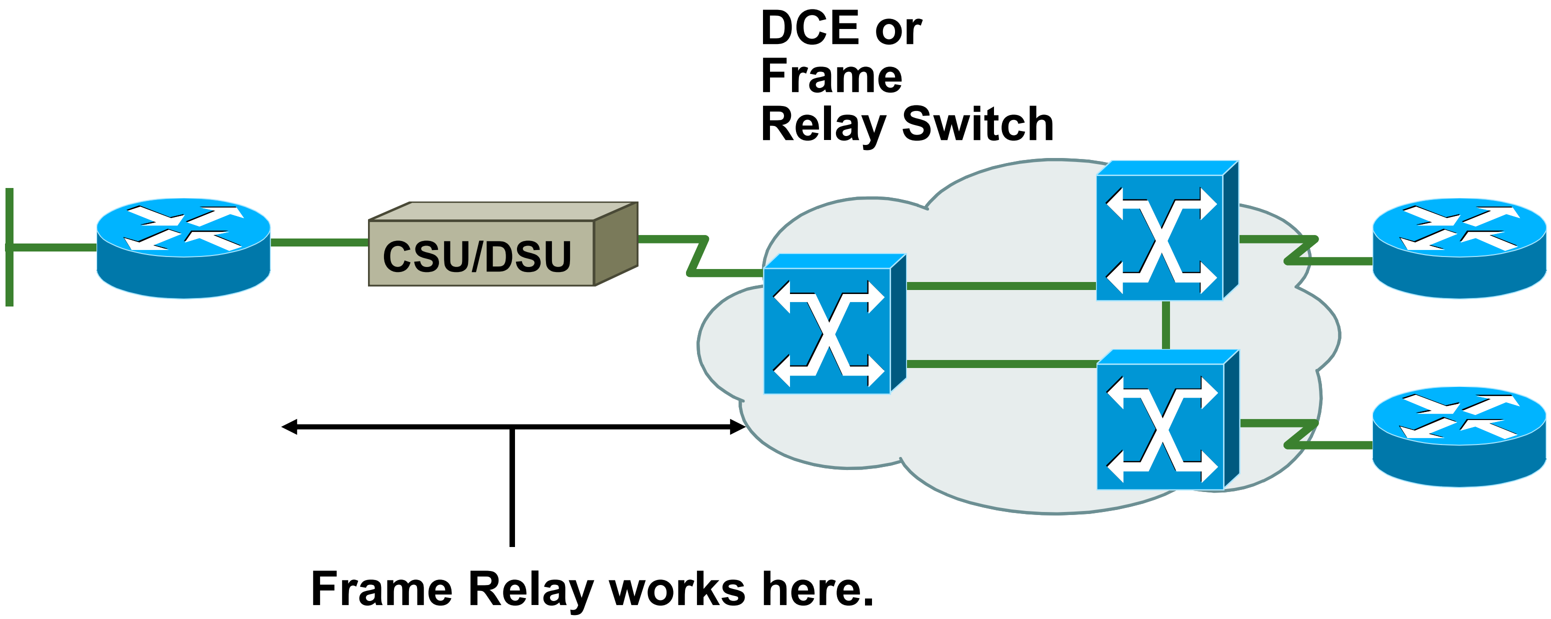
- Frame Relay Call Control
- Data transfer involves:
  - Establish logical connection and DLCI
  - Exchange data frames
  - Release logical connection

Frame Relay Call Control

4 message types needed

- SETUP
- CONNECT
- RELEASE
- RELEASE COMPLETE

Frame Relay Overview

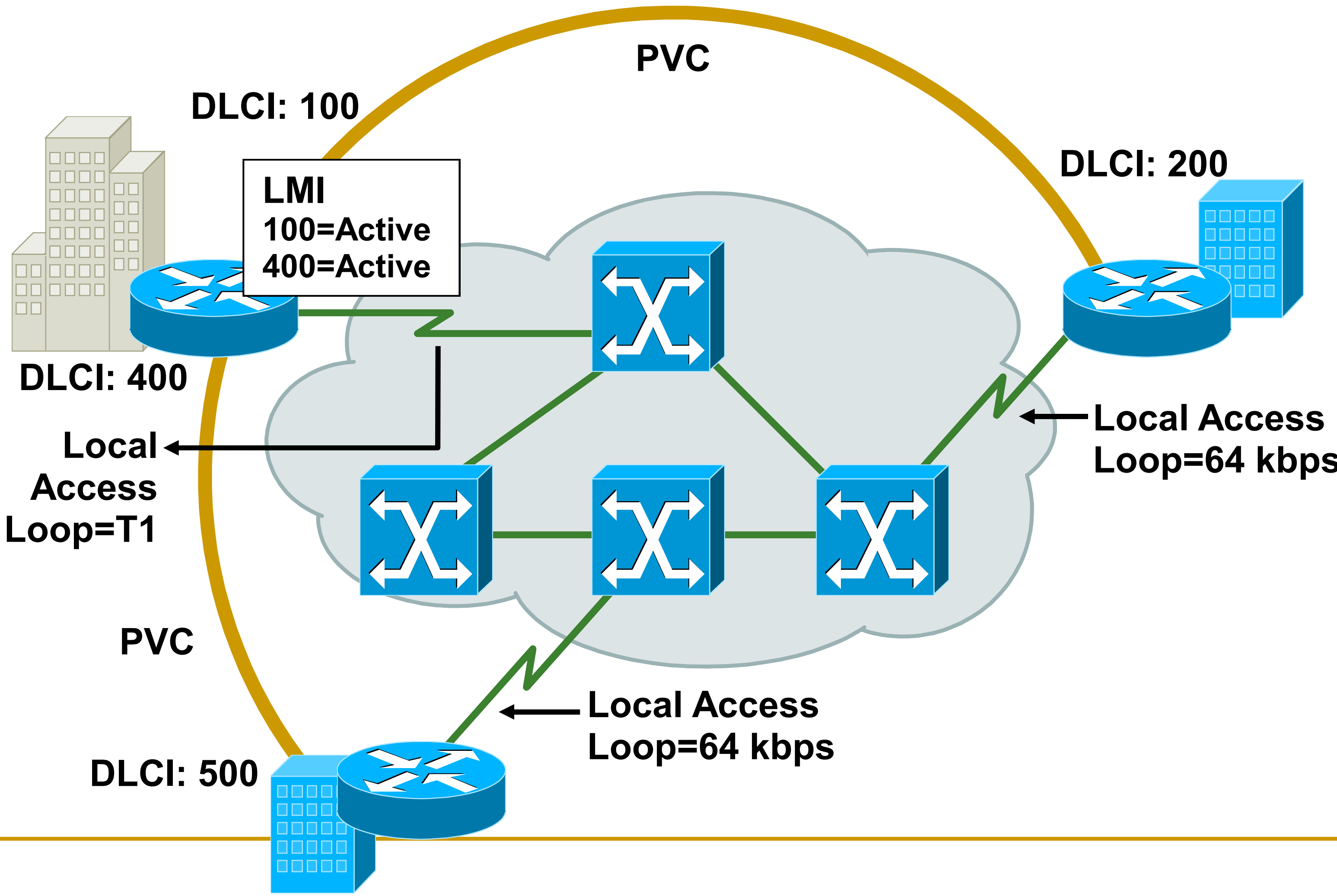


- Virtual circuits make connections
- Connection-oriented service

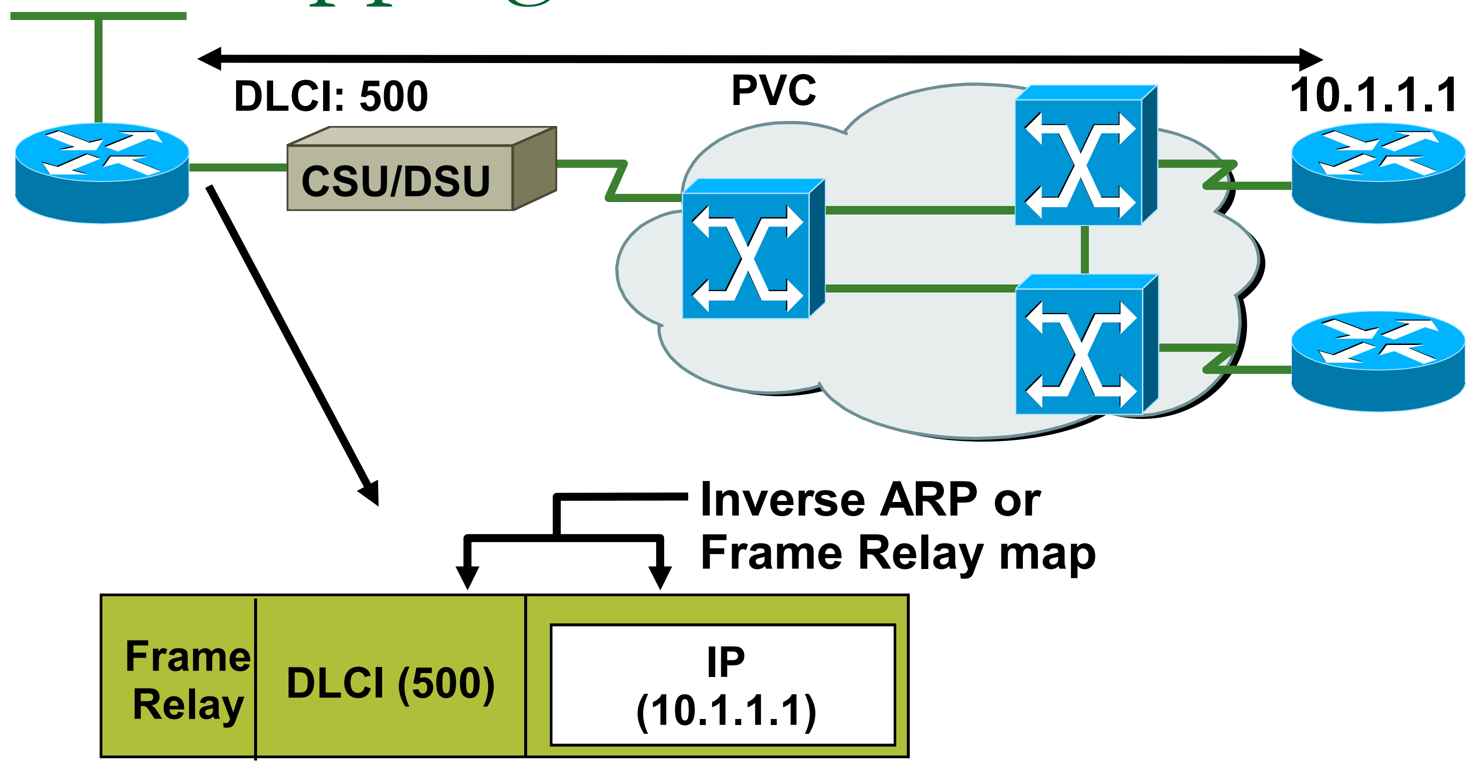
Frame Relay Stack

OSI Reference Model	Frame Relay
Application	
Presentation	
Session	
Transport	
Network	IP/IPX/AppleTalk, etc.
Data Link	Frame Relay
Physical	EIA/TIA-232, EIA/TIA-449, V.35, X.21, EIA/TIA-530

Frame Relay Terminology

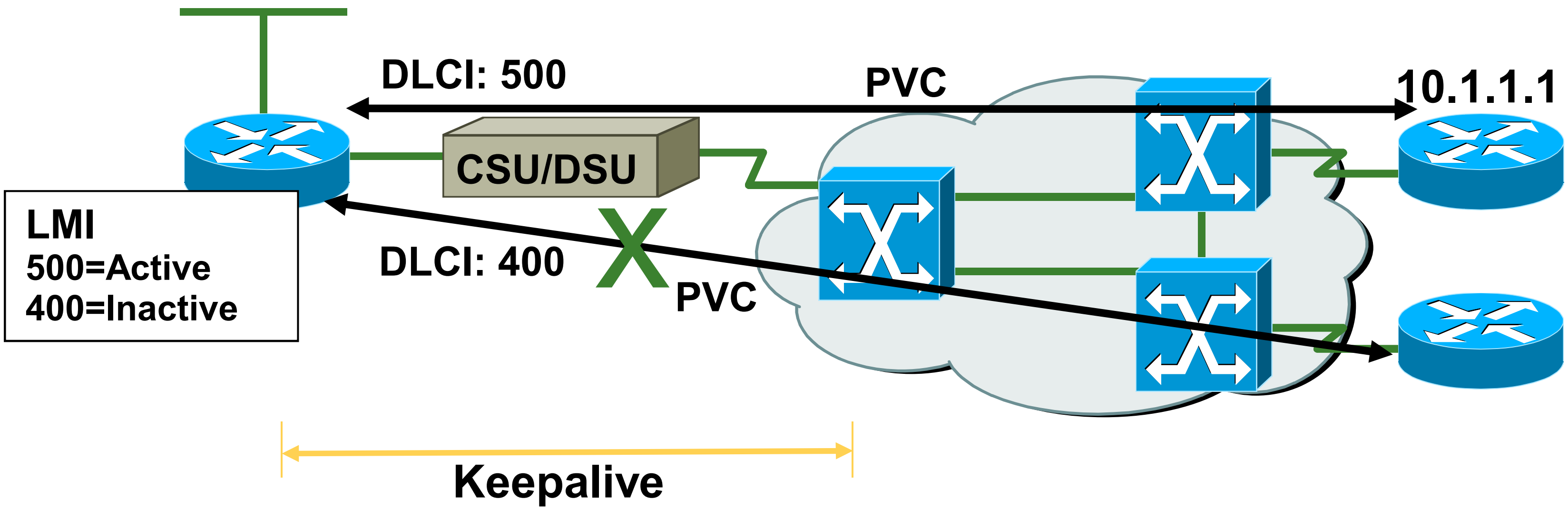


Frame Relay Address Mapping



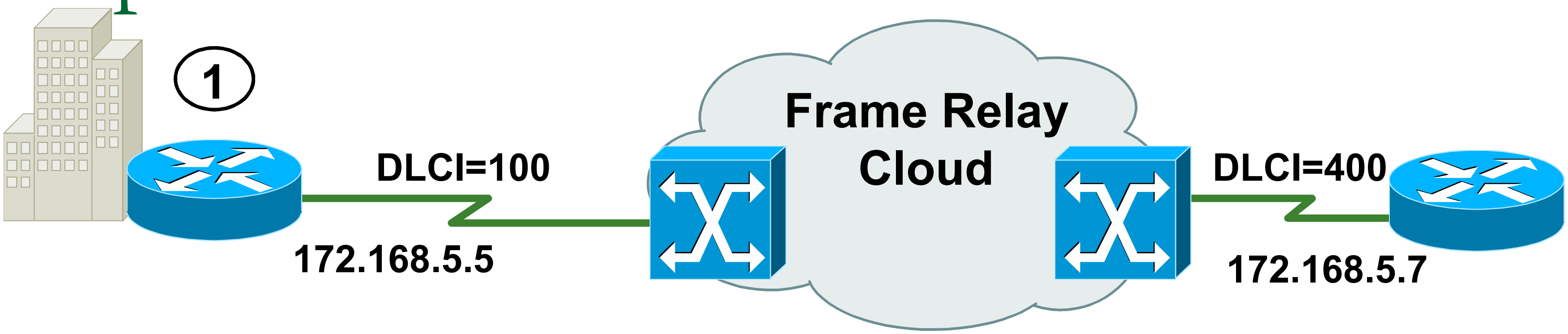
- Get locally significant DLCIs from provider
- Map your network addresses to DLCIs

Frame Relay Signaling

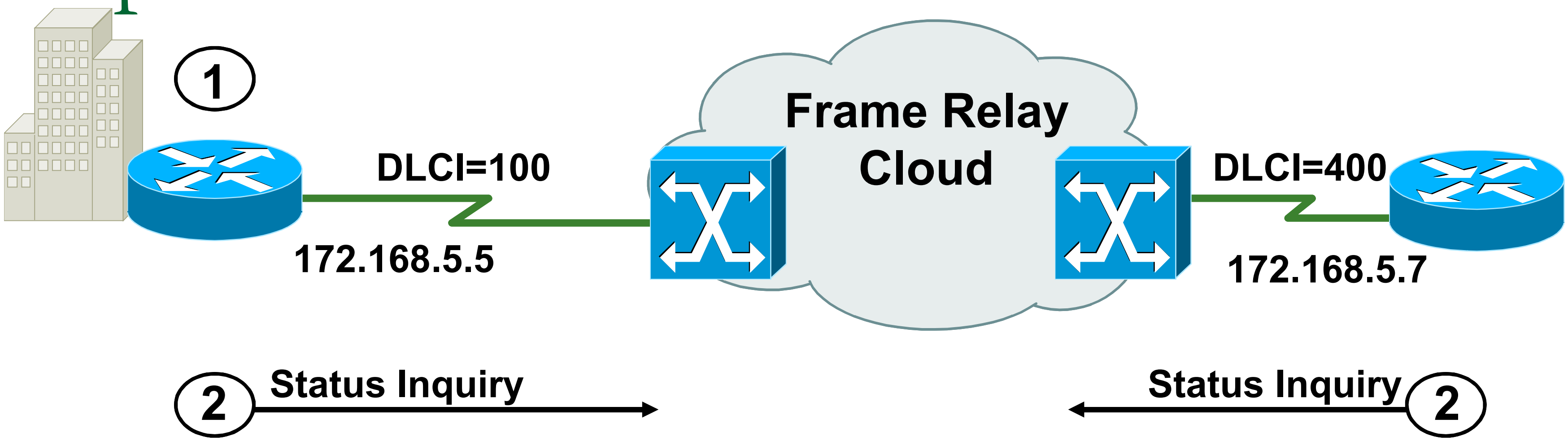


- Cisco supports three LMI standards:
  - Cisco
  - ANSI T1.617
  - ITU-T Q.933

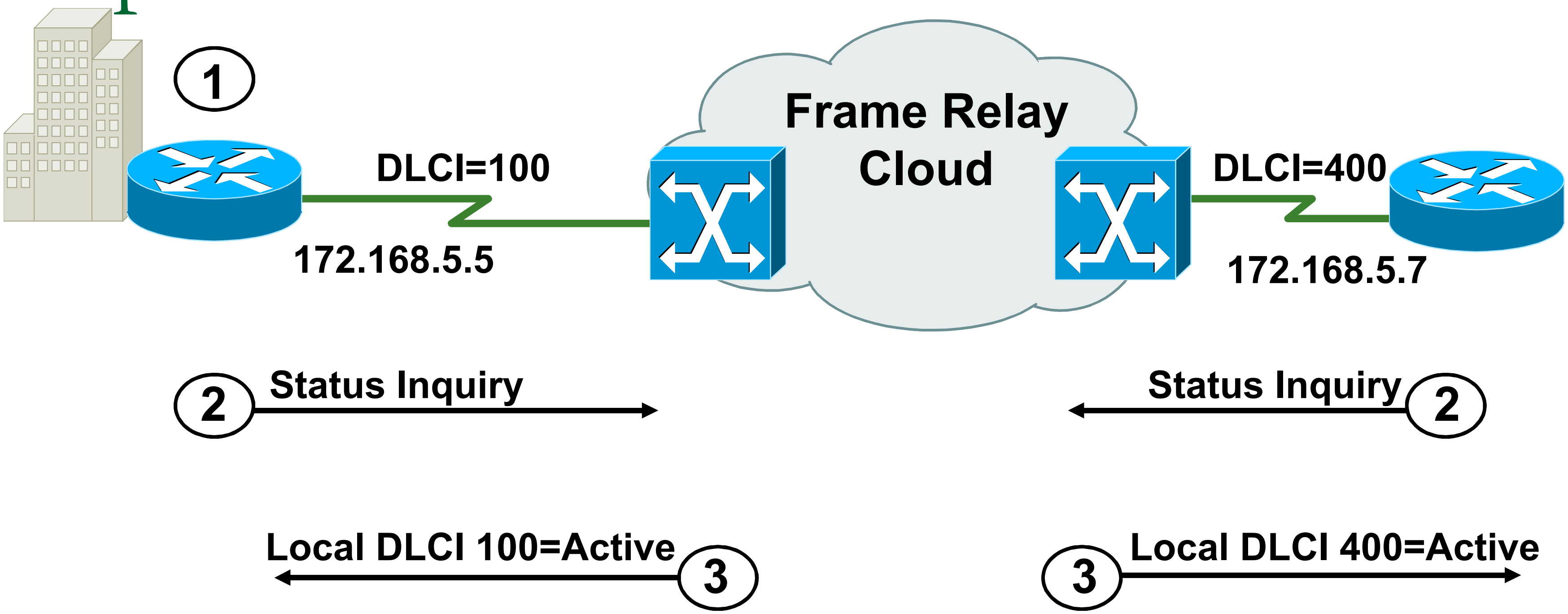
Frame Relay Inverse ARP and LMI Operation



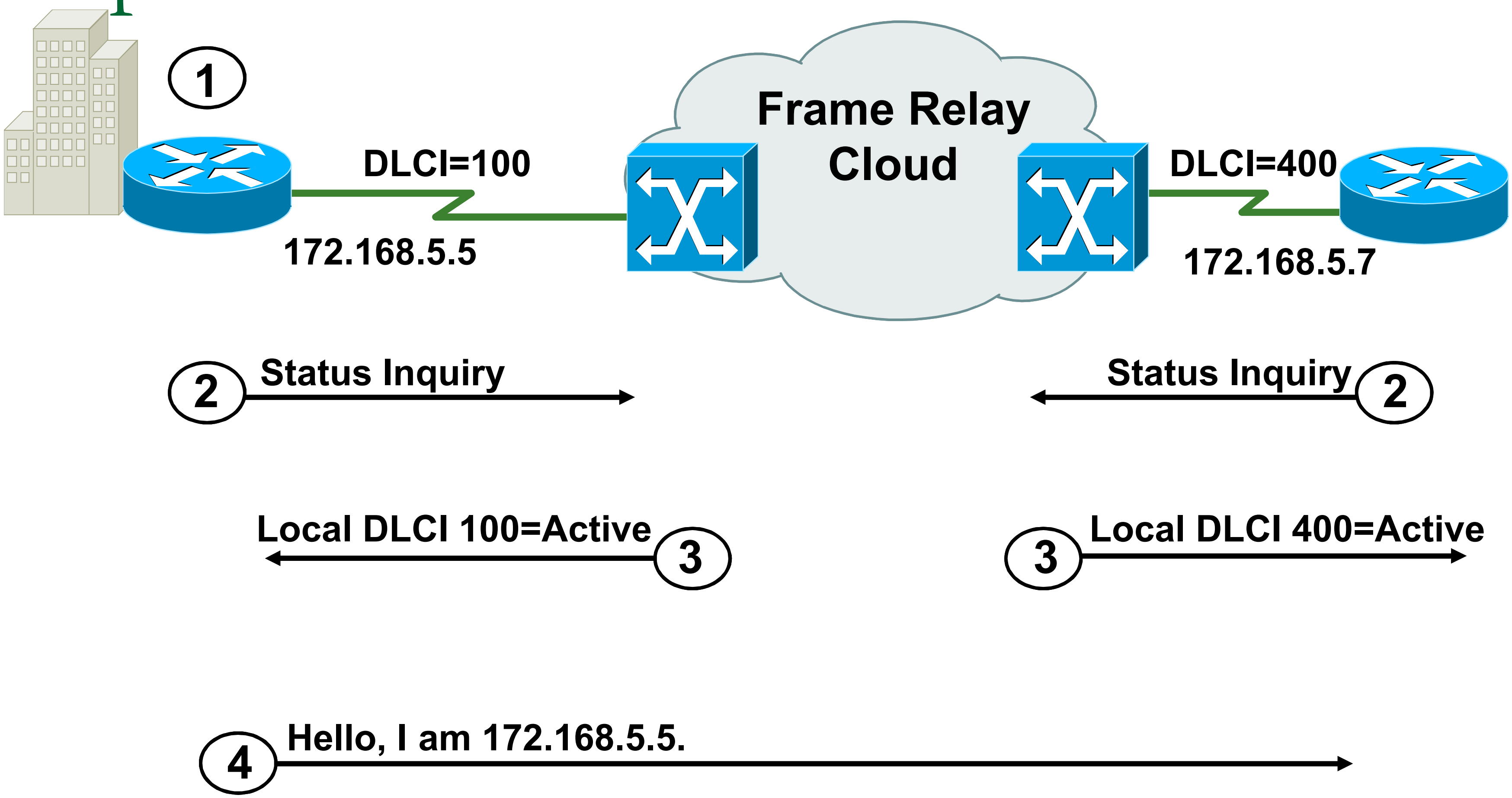
Frame Relay Inverse ARP and LMI Operation



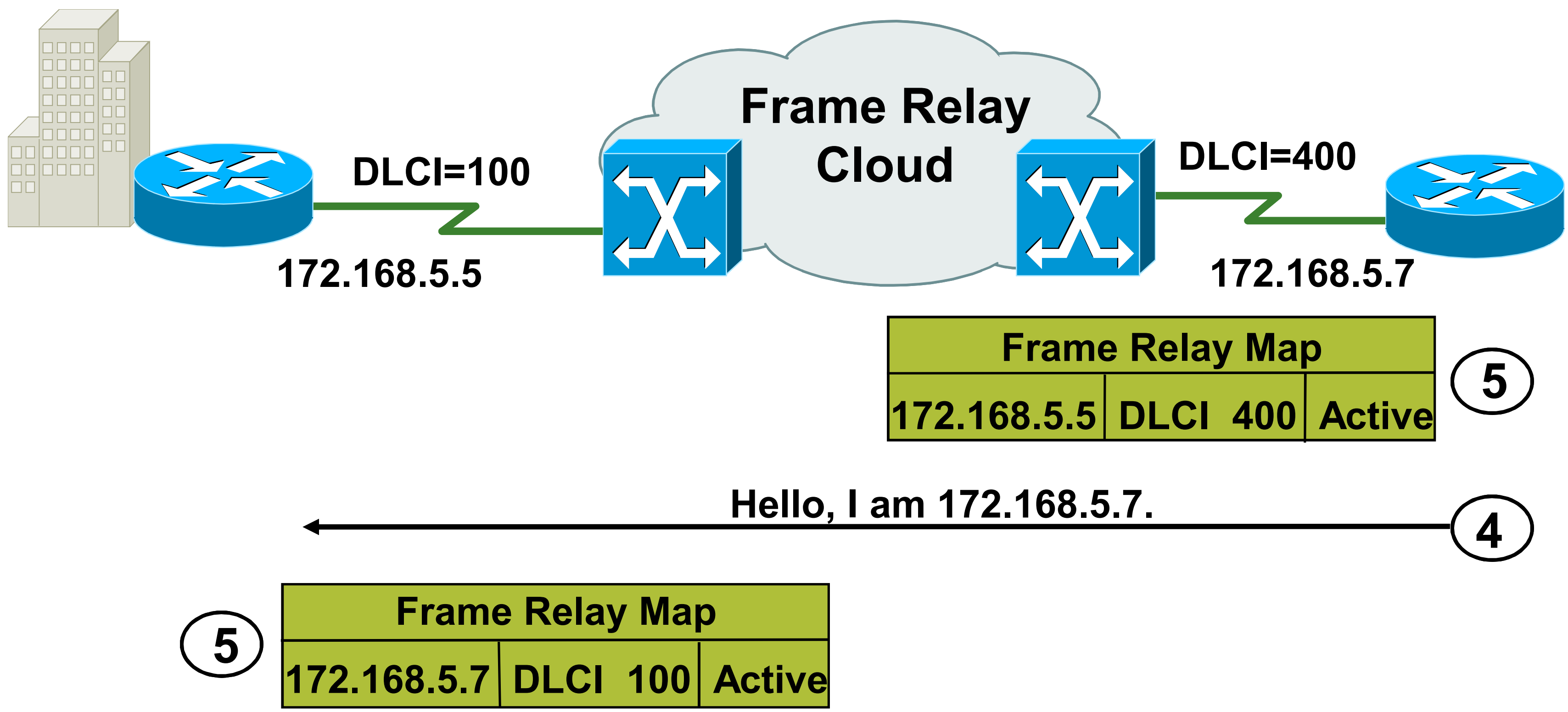
Frame Relay Inverse ARP and LMI Operation



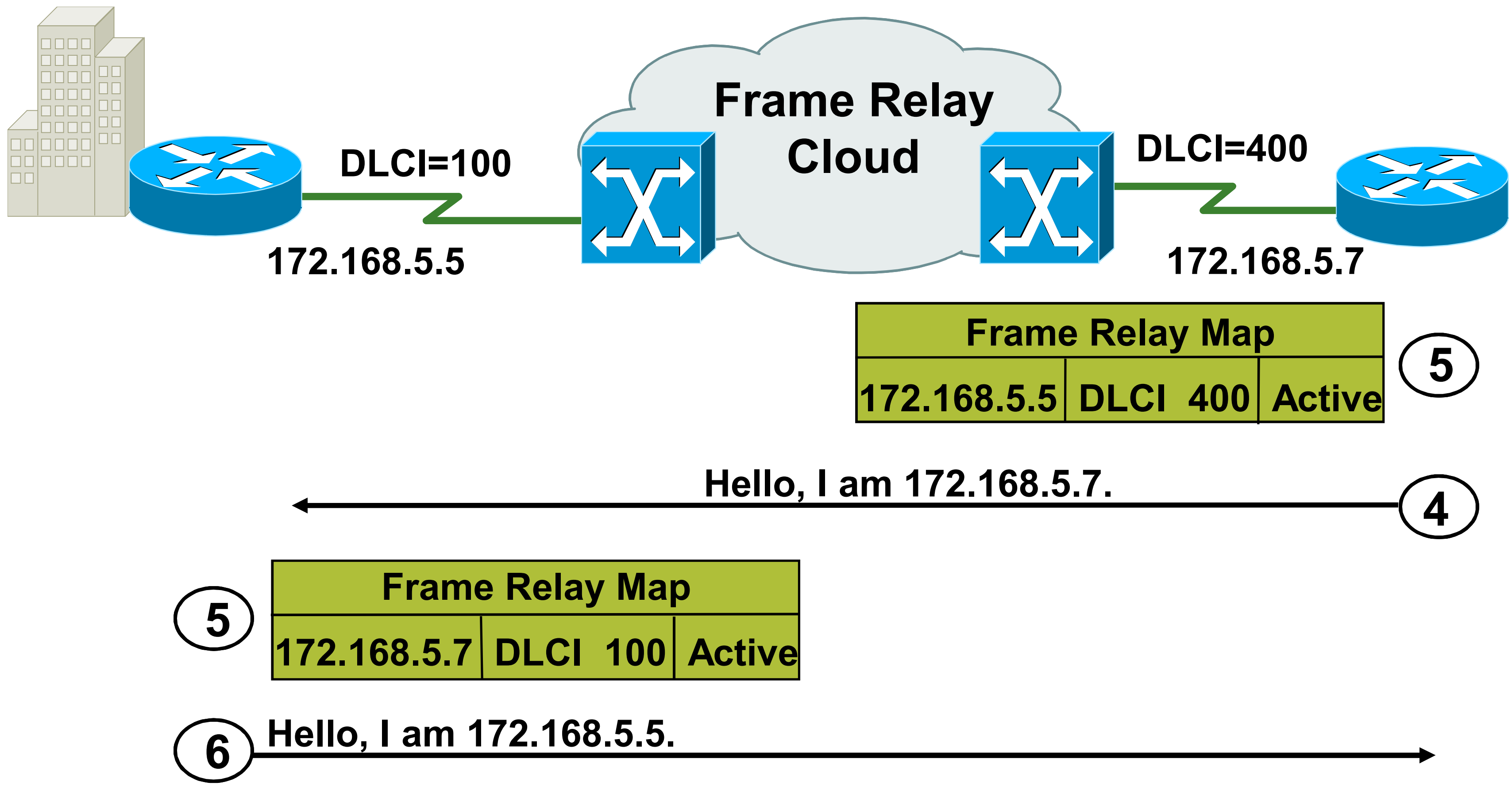
Frame Relay Inverse ARP and LMI Operation



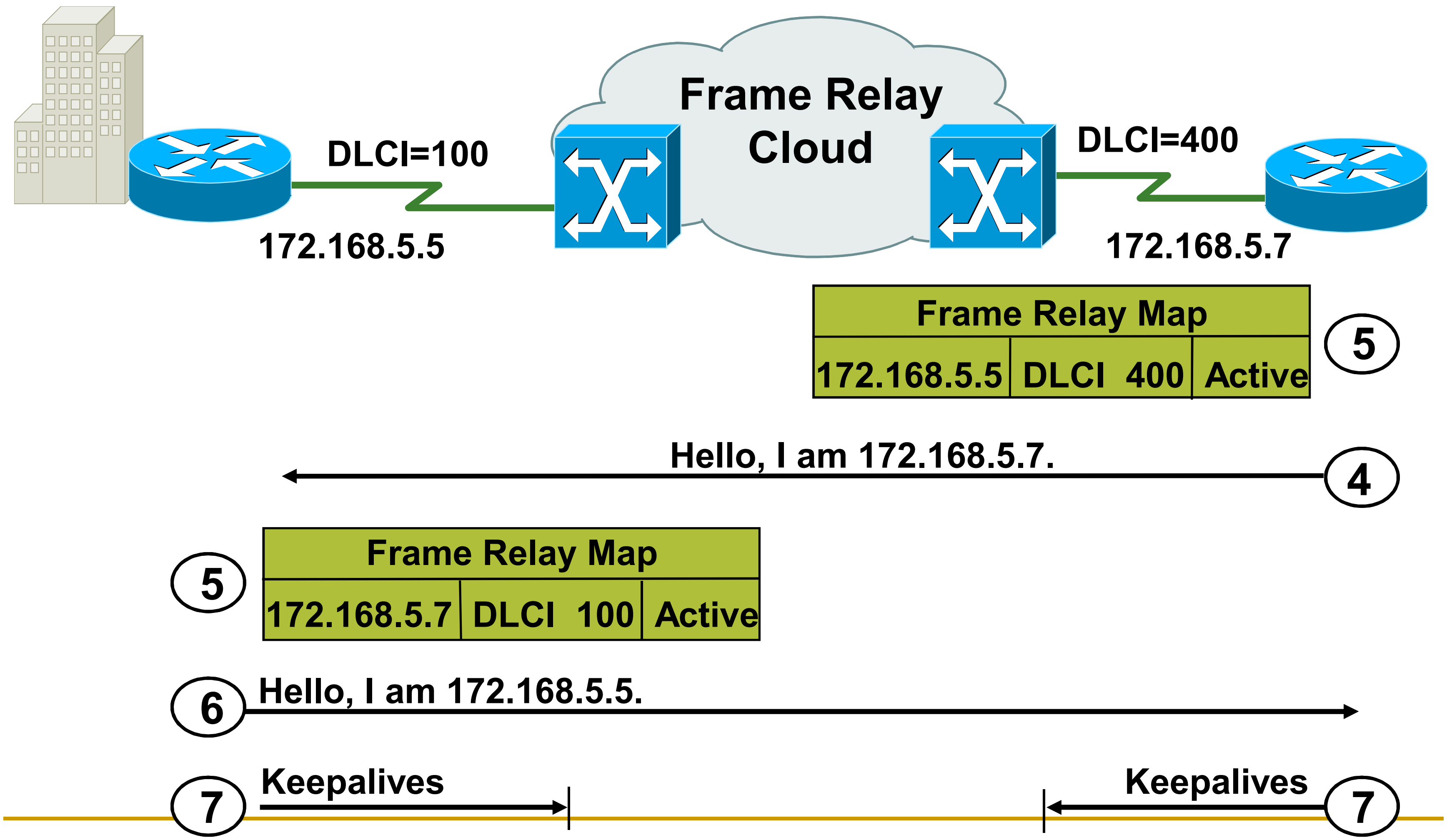
Frame Relay Inverse ARP and LMI Operation (cont.)



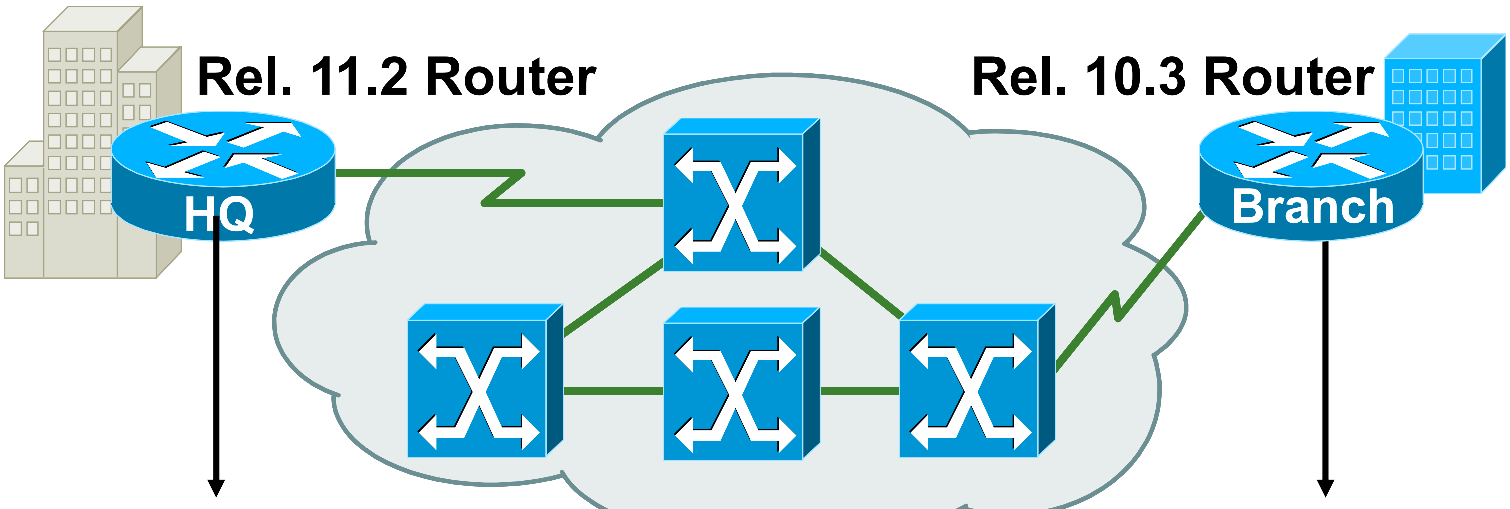
Frame Relay Inverse ARP and LMI Operation (cont.)



Frame Relay Inverse ARP and LMI Operation (cont.)



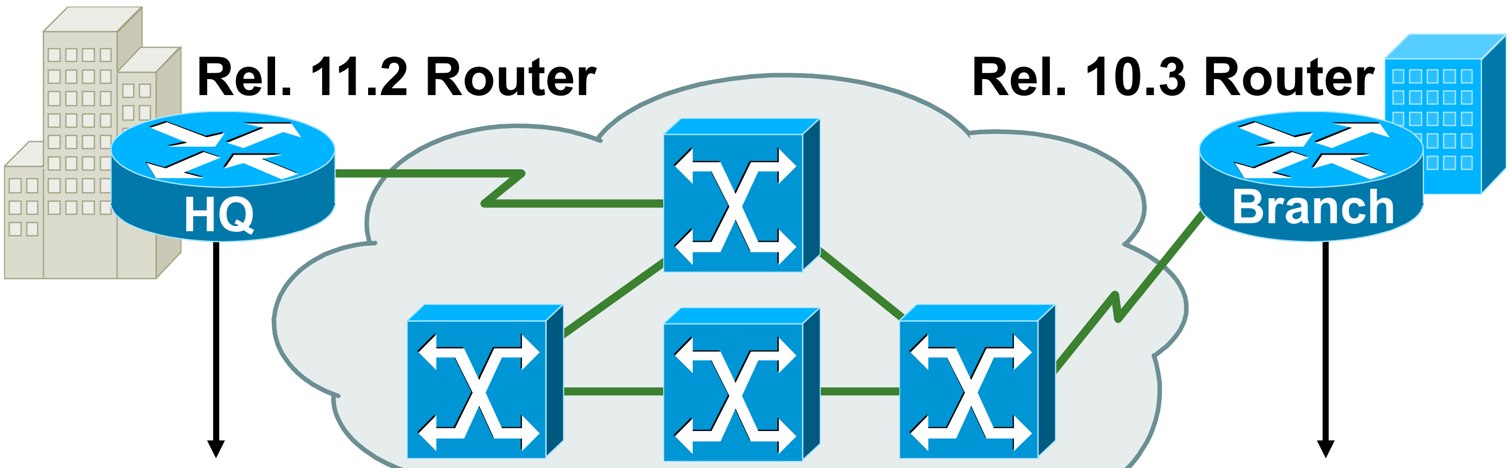
Configuring Basic Frame Relay




```
interface Serial1
 ip address 10.16.0.1 255.255.255.0
 encapsulation frame-relay
 bandwidth 64
```

```
interface Serial1
 ip address 10.16.0.2 255.255.255.0
 encapsulation frame-relay
 bandwidth 64
 frame-relay lmi-type ansi
```

Configuring Basic Frame Relay (cont.)



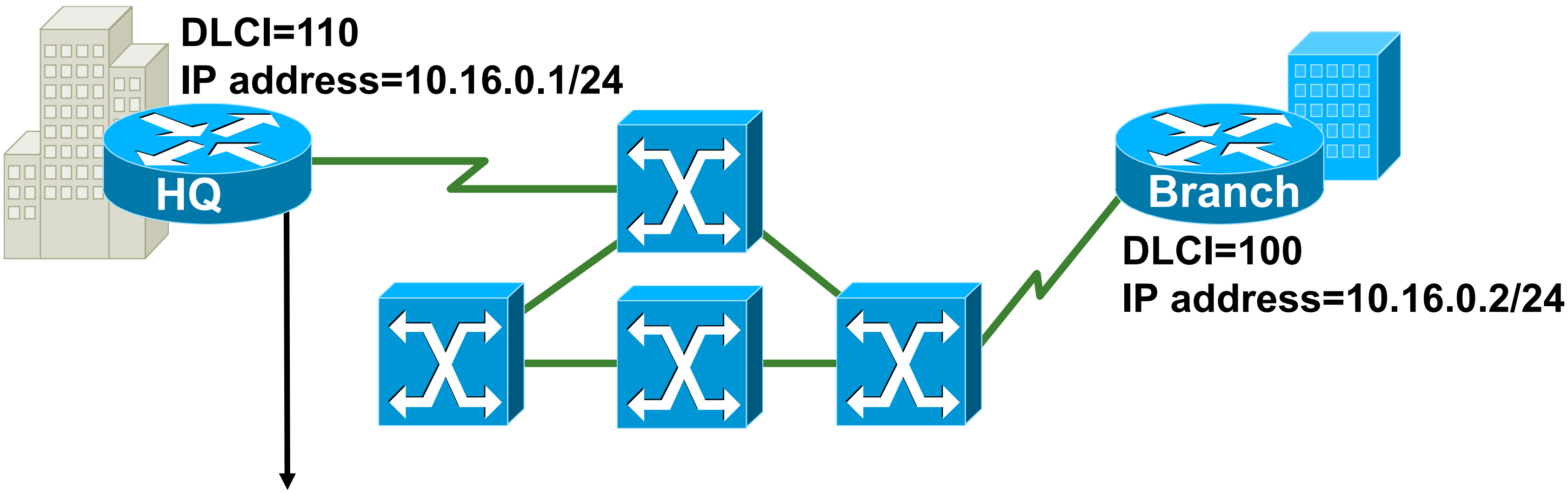

```
interface Serial1
 ip address 10.16.0.1 255.255.255.0
 encapsulation frame-relay
 bandwidth 64
```

```
interface Serial1
 ip address 10.16.0.2 255.255.255.0
 encapsulation frame-relay
 bandwidth 64
 frame-relay lmi-type ansi
```

Inverse ARP

- **Enabled by default**
- **Does not appear in configuration output**

Configuring a Static Frame Relay Map




```
interface Serial1
ip address 10.16.0.1 255.255.255.0
encapsulation frame-relay
bandwidth 64
frame-relay map ip 10.16.0.2 110 broadcast
```

Verifying Frame Relay Operation

```
Router#show interface s0
Serial0 is up, line protocol is up
  Hardware is HD64570
  Internet address is 10.140.1.2/24
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely 255/255, load 1/255
  Encapsulation FRAME-RELAY, loopback not set, keepalive set (10 sec)
  LMI enq sent  19, LMI stat recvd 20, LMI upd recvd 0, DTE LMI up
  LMI enq recvd 0, LMI stat sent  0, LMI upd sent  0
  LMI DLCI 1023  LMI type is CISCO  frame relay DTE
  FR SVC disabled, LAPF state down
  Broadcast queue 0/64, broadcasts sent/dropped 8/0, interface broadcasts 5
  Last input 00:00:02, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  <Output omitted>
```

- Displays line, protocol, DLCI, and LMI information

Verifying Frame Relay Operation (cont.)

```
Router#show frame-relay lmi

LMI Statistics for interface Serial0 (Frame Relay DTE) LMI TYPE = CISCO
 Invalid Unnumbered info 0 Invalid Prot Disc 0
 Invalid dummy Call Ref 0 Invalid Msg Type 0
 Invalid Status Message 0 Invalid Lock Shift 0
 Invalid Information ID 0 Invalid Report IE Len 0
 Invalid Report Request 0 Invalid Keep IE Len 0
 Num Status Enq. Sent 113100 Num Status msgs Rcvd 113100
 Num Update Status Rcvd 0 Num Status Timeouts 0
```

- Displays LMI information

Verifying Frame Relay Operation (cont.)

```
Router#show frame-relay pvc 100

PVC Statistics for interface Serial0 (Frame Relay DTE)

DLCI = 100, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0

  input pkts 28             output pkts 10            in bytes 8398
  out bytes 1198            dropped pkts 0            in FECN pkts 0
  in BECN pkts 0            out FECN pkts 0           out BECN pkts 0
  in DE pkts 0              out DE pkts 0
  out bcast pkts 10          out bcast bytes 1198
  pvc create time 00:03:46, last time pvc status changed 00:03:47
```

- Displays PVC traffic statistics

Verifying Frame Relay Operation (cont.)

```
Router#show frame-relay map
Serial0 (up): ip 10.140.1.1 dlci 100(0x64,0x1840), dynamic,
              broadcast,, status defined, active
```

- Displays the route maps, either static or dynamic

Verifying Frame Relay Operation (cont.)

```
Router#show frame-relay map
Serial0 (up): ip 10.140.1.1 dlci 100(0x64,0x1840), dynamic,
              broadcast,, status defined, active
Router#clear frame-relay-inarp
Router#sh frame map
Router#
```

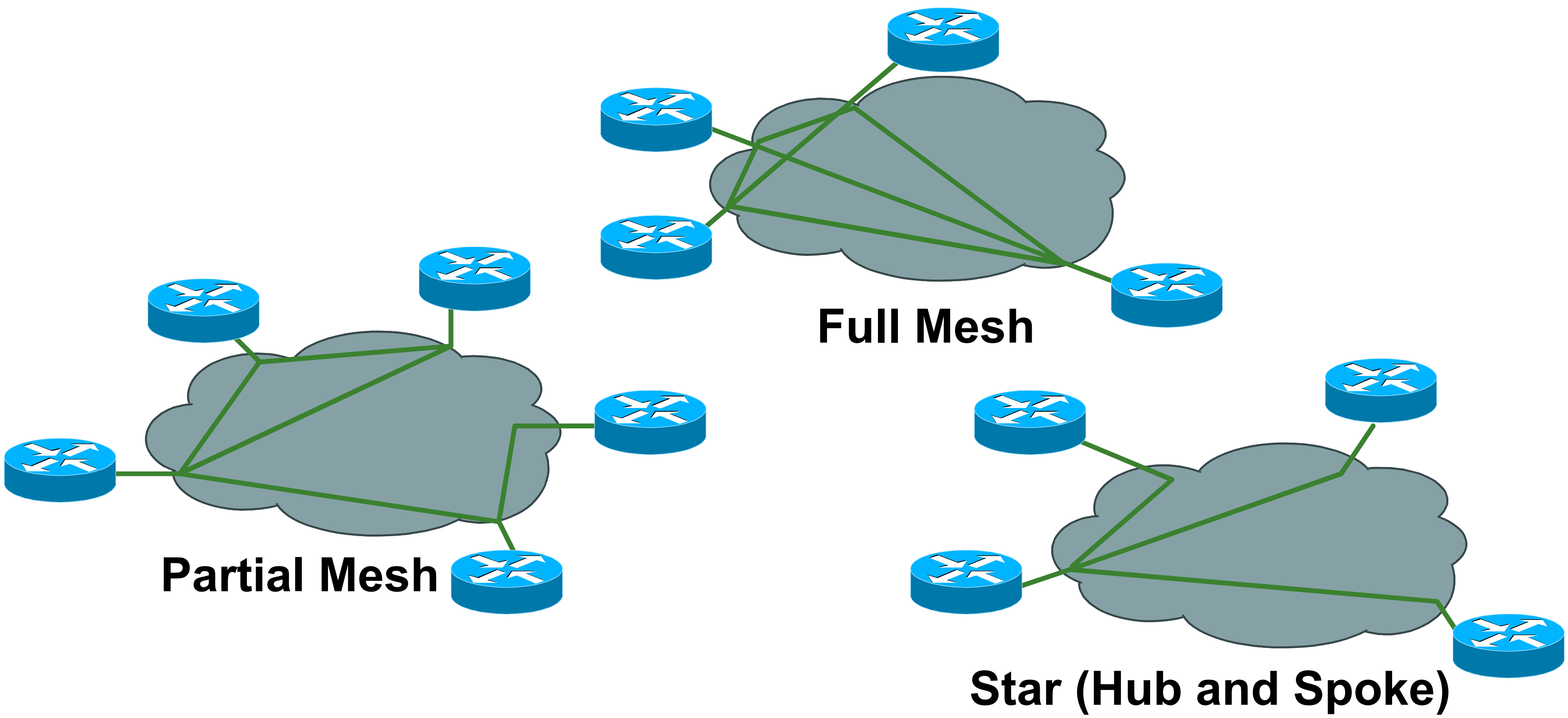
- **Clears dynamically created Frame Relay maps**

Verifying Frame Relay Operation (cont.)

```
Router#debug Frame lmi
Frame Relay LMI debugging is on
Displaying all Frame Relay LMI data
Router#
1w2d: Serial0(out): StEnq, myseq 140, yourseen 139, DTE up
1w2d: datagramstart = 0xE008EC, datagramsize = 13
1w2d: FR encap = 0xFCF10309
1w2d: 00 75 01 01 01 03 02 8C 8B
1w2d:
1w2d: Serial0(in): Status, myseq 140
1w2d: RT IE 1, length 1, type 1
1w2d: KA IE 3, length 2, yourseq 140, myseq 140
1w2d: Serial0(out): StEnq, myseq 141, yourseen 140, DTE up
1w2d: datagramstart = 0xE008EC, datagramsize = 13
1w2d: FR encap = 0xFCF10309
1w2d: 00 75 01 01 01 03 02 8D 8C
1w2d:
1w2d: Serial0(in): Status, myseq 142
1w2d: RT IE 1, length 1, type 0
1w2d: KA IE 3, length 2, yourseq 142, myseq 142
1w2d: PVC IE 0x7 , length 0x6 , dlci 100, status 0x2 , bw 0
```

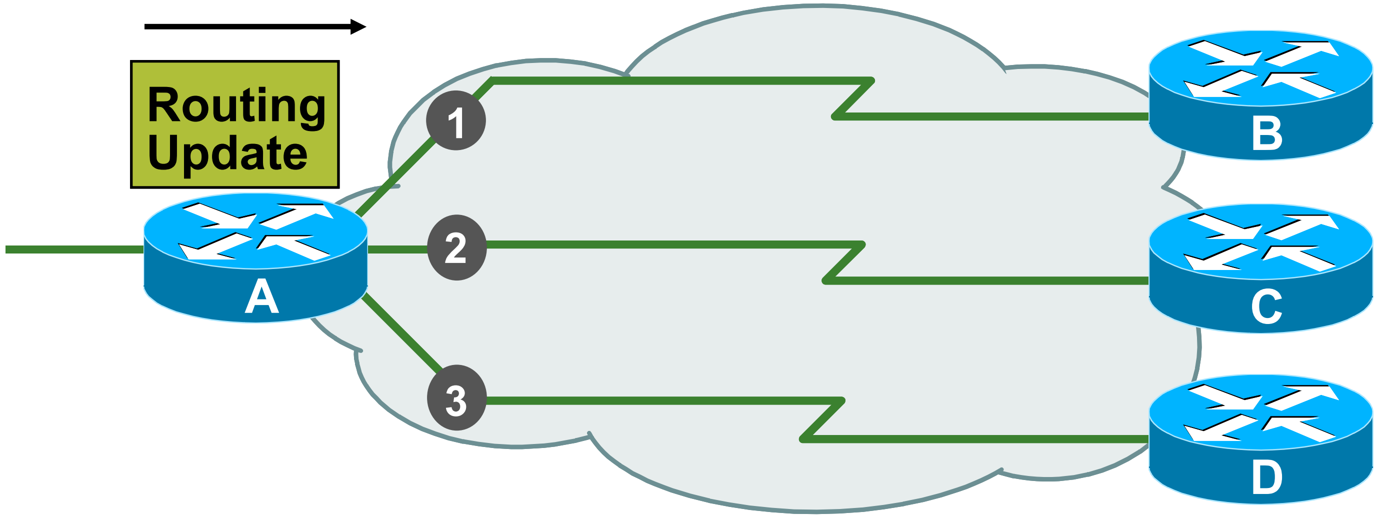
- **Displays LMI debug information**

Selecting a Frame Relay Topology



Frame Relay default: nonbroadcast, multiaccess (NBMA)

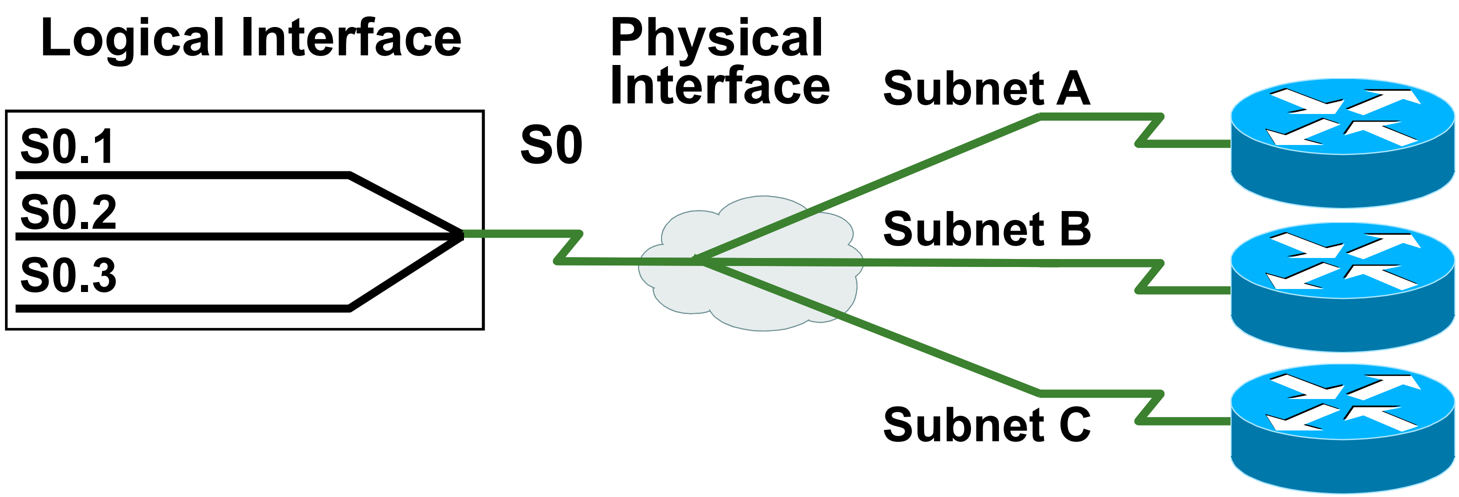
Reachability Issues with Routing Updates



- Problem:

Broadcast traffic must be replicated for each active connection

Resolving Reachability Issues

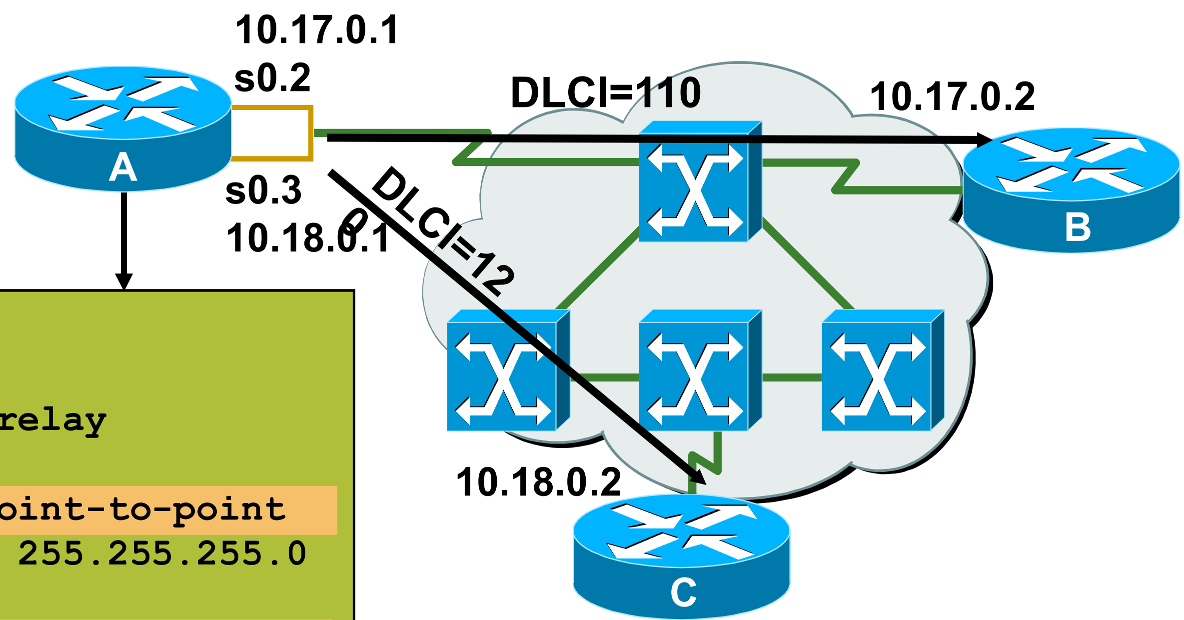


- Solution:
  - Split horizon can cause problems in NBMA environments
  - Subinterfaces can resolve split horizon issues
  - A single physical interface simulates multiple logical interfaces

Configuring Subinterfaces

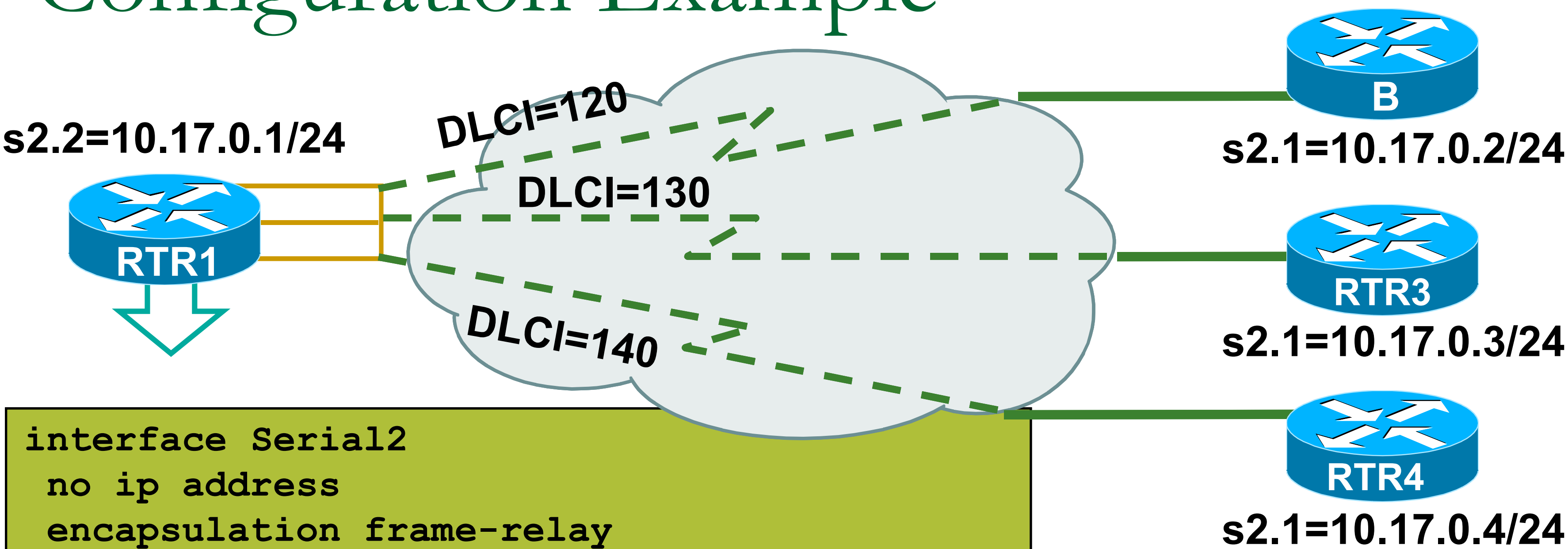
- Point-to-Point
  - Subinterfaces act as leased line
  - Each point-to-point subinterface requires its own subnet
  - Applicable to hub and spoke topologies
- Multipoint
  - Subinterfaces act as NBMA network so they do not resolve the split horizon issue
  - Can save address space because uses single subnet
  - Applicable to partial-mesh and full-mesh topology

Configuring Point-to-Point Subinterfaces



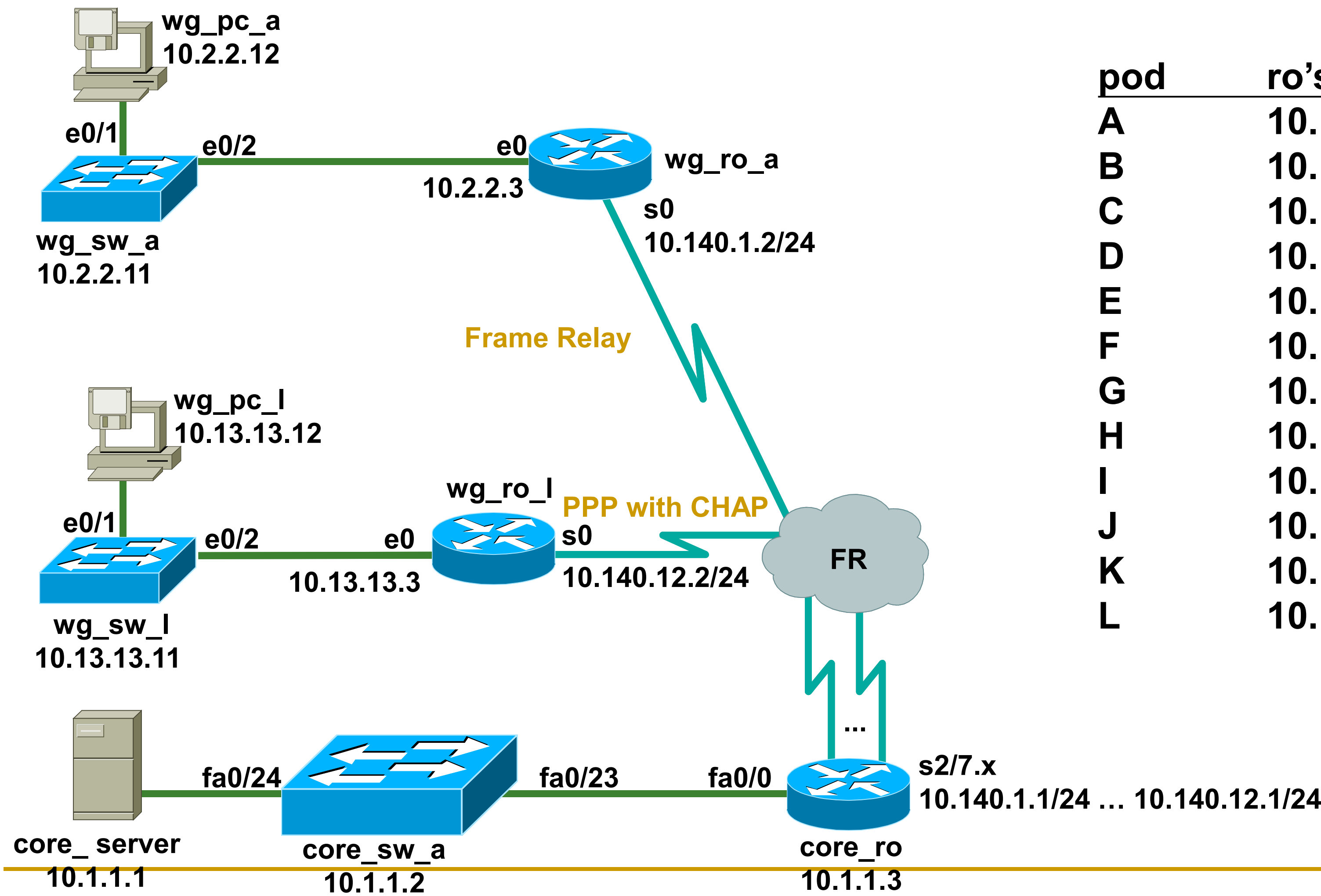

```
interface Serial0
 no ip address
 encapsulation frame-relay
!
interface Serial0.2 point-to-point
 ip address 10.17.0.1 255.255.255.0
 bandwidth 64
 frame-relay interface-dlci 110
!
interface Serial0.3 point-to-point
 ip address 10.18.0.1 255.255.255.0
 bandwidth 64
 frame-relay interface-dlci 120
!
```

Multipoint Subinterfaces Configuration Example




```
interface Serial2
 no ip address
 encapsulation frame-relay
!
interface Serial2.2 multipoint
 ip address 10.17.0.1 255.255.255.0
 bandwidth 64
 frame-relay map ip 10.17.0.2 120
broadcast
 frame-relay map ip 10.17.0.3 130
broadcast
 frame-relay map ip 10.17.0.4 140
broadcast
```

Visual Objective



pod	ro’s s0
A	10.140.1.2
B	10.140.2.2
C	10.140.3.2
D	10.140.4.2
E	10.140.5.2
F	10.140.6.2
G	10.140.7.2
H	10.140.8.2
I	10.140.9.2
J	10.140.10.2
K	10.140.11.2
L	10.140.12.2