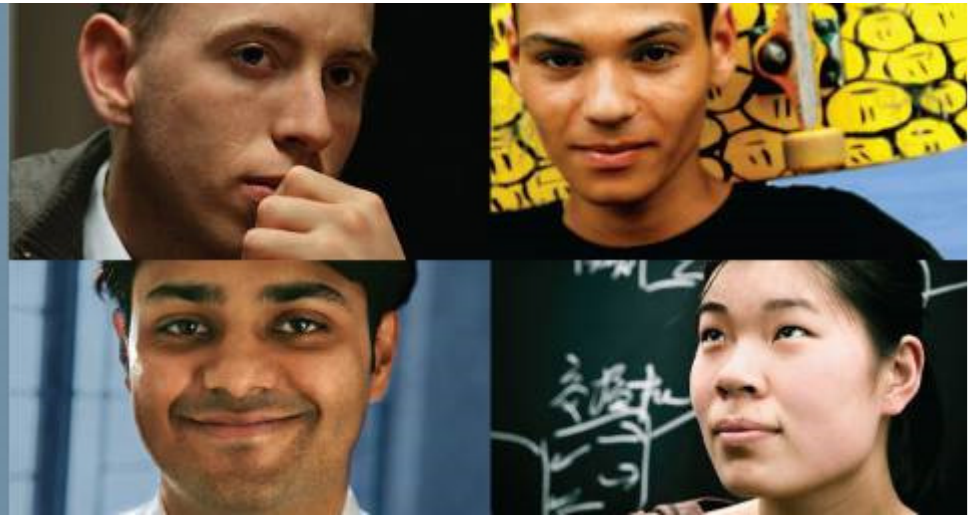
Chapter 4: Frame Relay



Connecting Networks

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Chapter 4

4.0 Introduction

4.1 Introduction to Frame Relay

4.2 Configuring Frame Relay

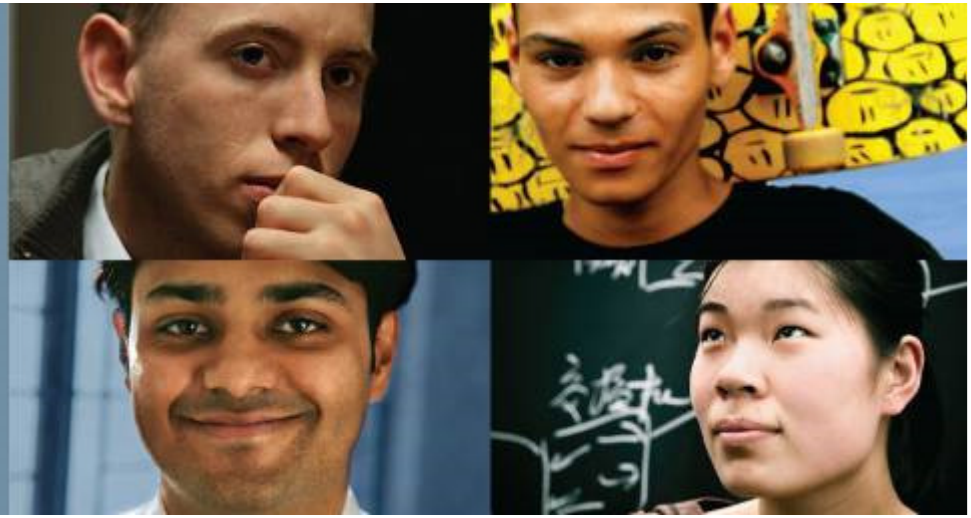
4.3 Troubleshooting Connectivity

4.4 Summary

Chapter 4: Objectives

- Describe the fundamental concepts of Frame Relay technology, including operation, implementation requirements, maps, and Local Management Interface (LMI) operation.
- Configure a basic Frame Relay permanent virtual circuit (PVC), including configuring and troubleshooting Frame Relay on a router serial interface and configuring a static Frame Relay map.
- Describe advanced concepts of Frame Relay technology, including subinterfaces, bandwidth, and flow control.
- Configure an advanced Frame Relay PVC, including solving reachability issues, configuring subinterfaces, and verifying and troubleshooting a Frame Relay configuration.

4.1 Introduction to Frame Relay



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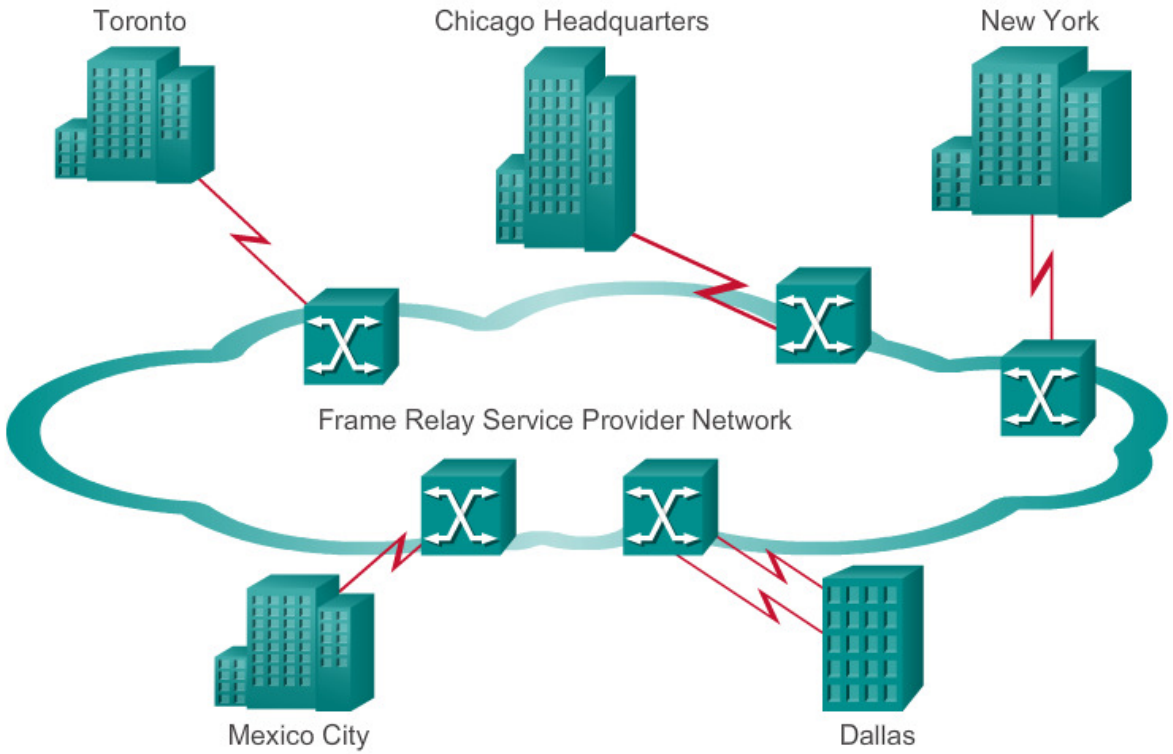
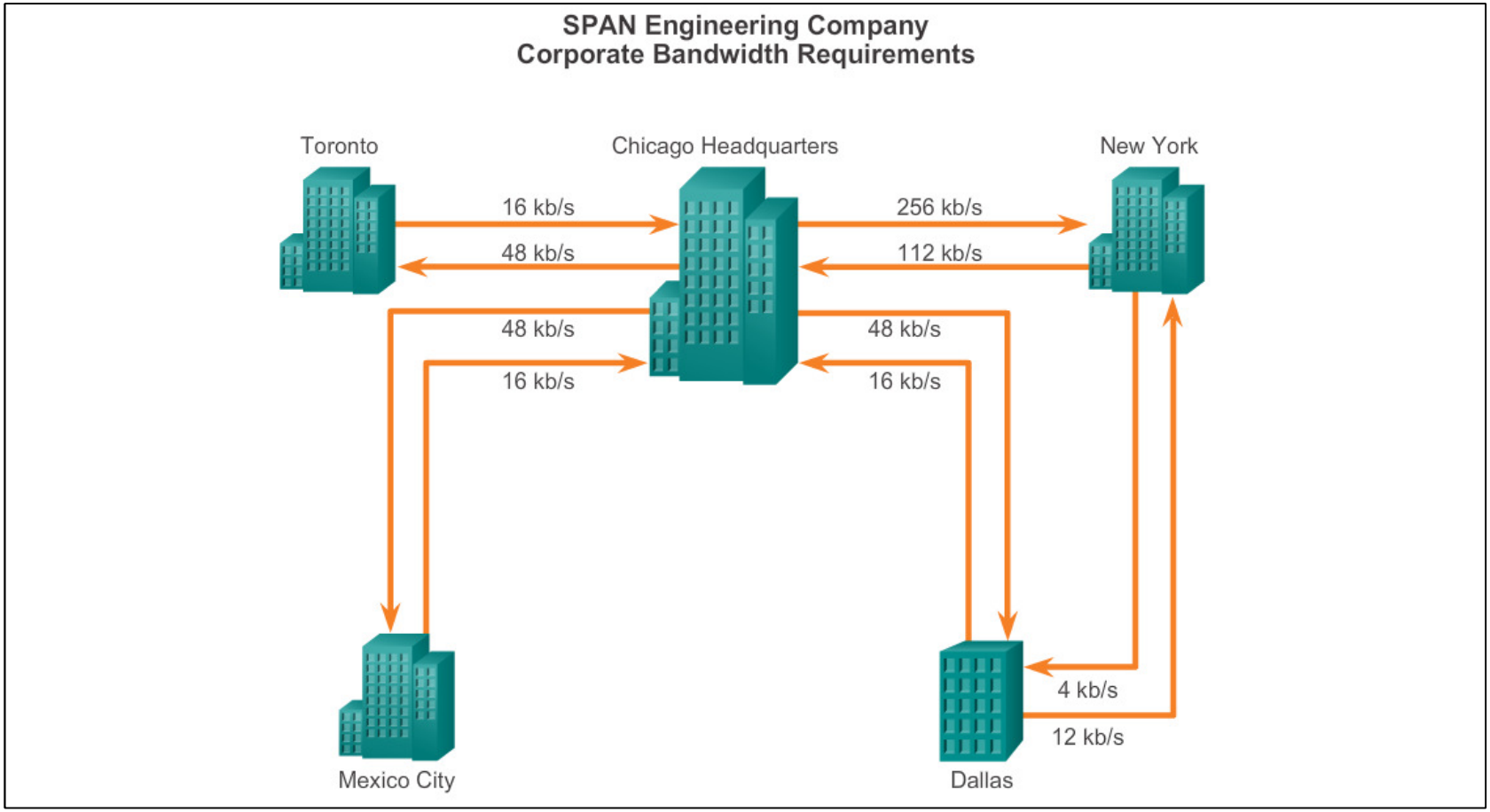
Benefits of Frame Relay

Introducing Frame Relay

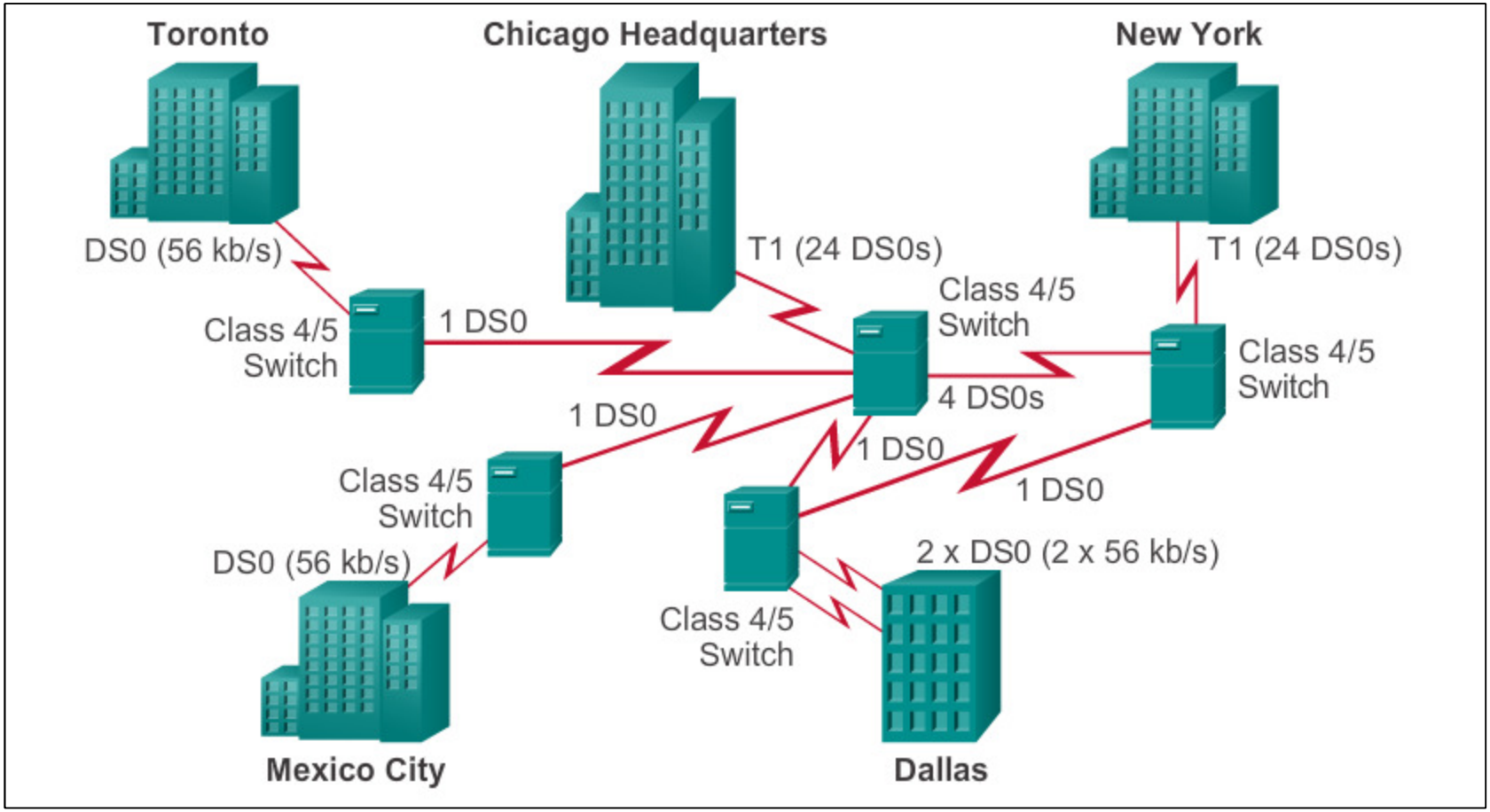


Frame Relay allows communications between all sites using a single access circuit to the provider.

Benefits of Frame Relay WAN Technology



Dedicated Line Requirements



Frame Relay Cost Effectiveness and Flexibility

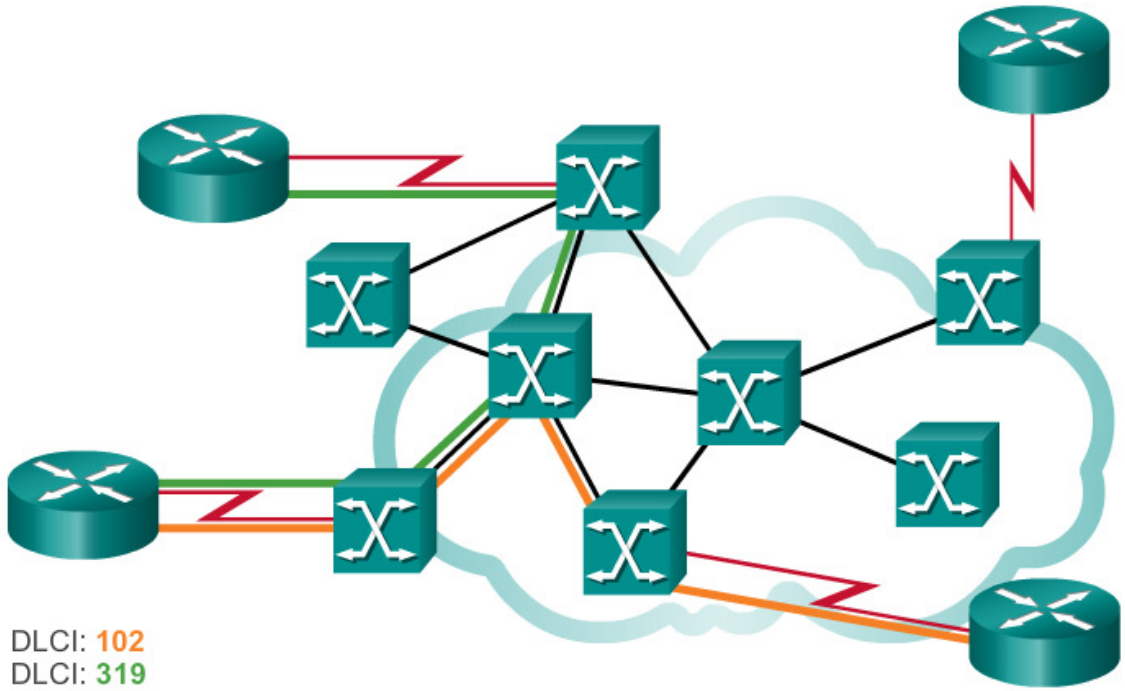
- With dedicated lines, customers pay for an end-to-end connection, which includes the local loop and the network link. With Frame Relay, customers only pay for the local loop, and for the bandwidth, they purchase from the network provider.
- Frame Relay shares bandwidth across a larger base of customers. Typically, a network provider can service 40 or more 56 kb/s customers over one T1 circuit. Using dedicated lines would require more CSU/DSUs (one for each line) and more complicated routing and switching.

Virtual Circuits

- **Switched virtual circuits (SVC**) – Established dynamically by sending signaling messages to the network.
- **Permanent virtual circuits (PVCs)** – Preconfigured by the carrier, and after they are set up, only operate in DATA TRANSFER and IDLE modes.
- VCs are identified by DLCIs. Frame Relay DLCIs have local significance, which means that the values are not unique in the Frame Relay WAN. A DLCI identifies a VC to the equipment at an endpoint.
- A DLCI has no significance beyond the single link.

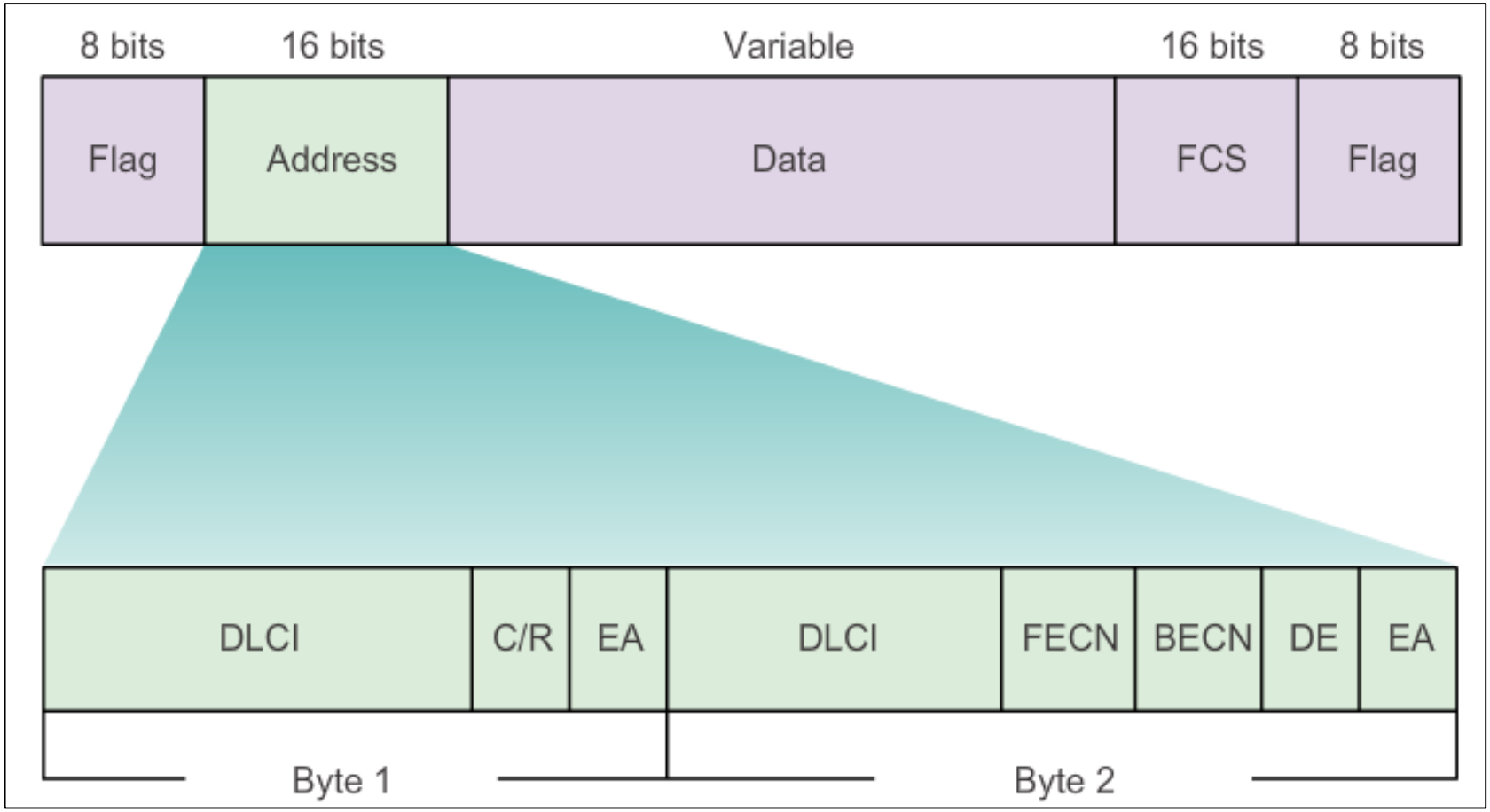
Frame Relay Operation

Multiple Virtual Circuits

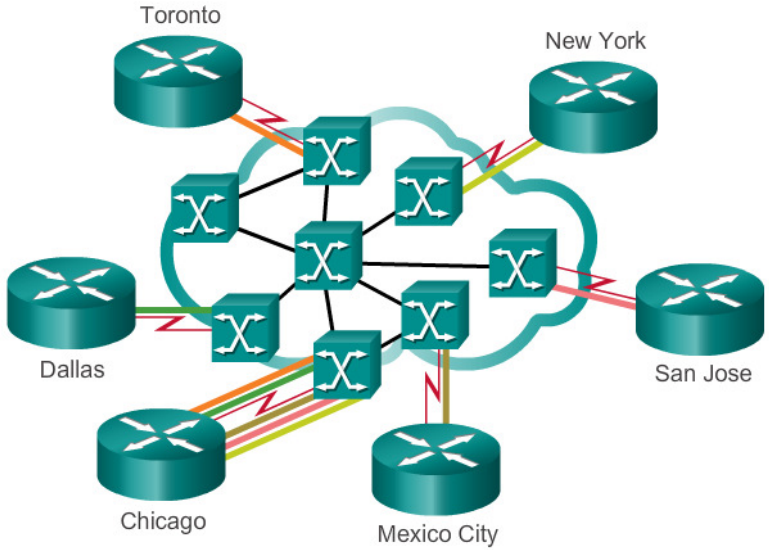


Multiple VCs on the same access link are distinguishable by the DLCI.

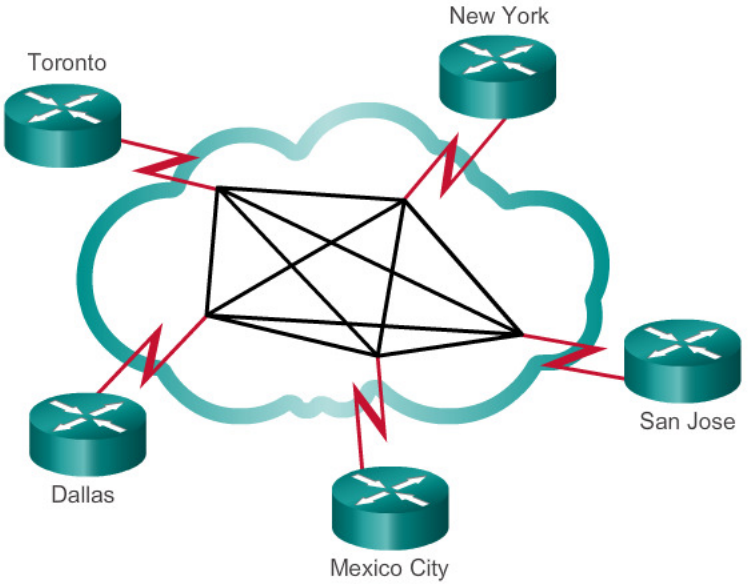
Frame Relay Encapsulation



Frame Relay Topologies



Frame Relay Star - hub with one physical link carrying 5 VCs



h Topology - Each DTE has one physical link carrying 4 VCs

Frame Relay Address Mapping

```
R1(config)# interface serial 0/0/1
R1(config-if)# ip address 10.1.1.1 255.255.255.0
R1(config-if)# encapsulation frame-relay
R1(config-if)# no frame-relay inverse-arp
R1(config-if)# frame-relay map ip 10.1.1.2 102 broadcast
cisco
R1(config-if)# no shutdown
R1(config-if)#
*Mar 31 18:57:38.994: %LINK-3-UPDOWN: Interface Serial0/0/1,
changed state to up
R1(config-if)#
```

```
R1# show frame-relay map
Serial0/0/1 (up): ip 10.1.1.2 dlci 102(0x66,0x1860), static,
              broadcast,
              CISCO, status defined, active
R1#
```

Frame Relay Operation

Local Management Interface (LMI)

```
R1# show frame-relay lmi

LMI Statistics for interface Serial0/0/1 (Frame Relay DTE)
LMI TYPE = CISCO
  Invalid Unnumbered info 0Invalid Prot Disc 0
  Invalid dummy Call Ref 0Invalid Msg Type 0
  Invalid Status Message 0Invalid Lock Shift 0
  Invalid Information ID 0Invalid Report IE Len 0
  Invalid Report Request 0Invalid Keep IE Len 0
  Num Status Enq. Sent 368Num Status msgs Rcvd 369
  Num Update Status Rcvd 0Num Status Timeouts 0
  Last Full Status Req 00:00:29Last Full Status Rcvd 00:00:29
R1#
```

LMI Extensions

- VC status messages
- Multicasting
- Global addressing
- Simple flow control

VC Identifiers	VC Types
0	LMI (ANSI, ITU)
1..15	Reserved for future use
992..1007	CLLM
1008..1022	Reserved for future use (ANSI, ITU)
1019..1020	Multicasting (Cisco)
1023	LMI (Cisco)

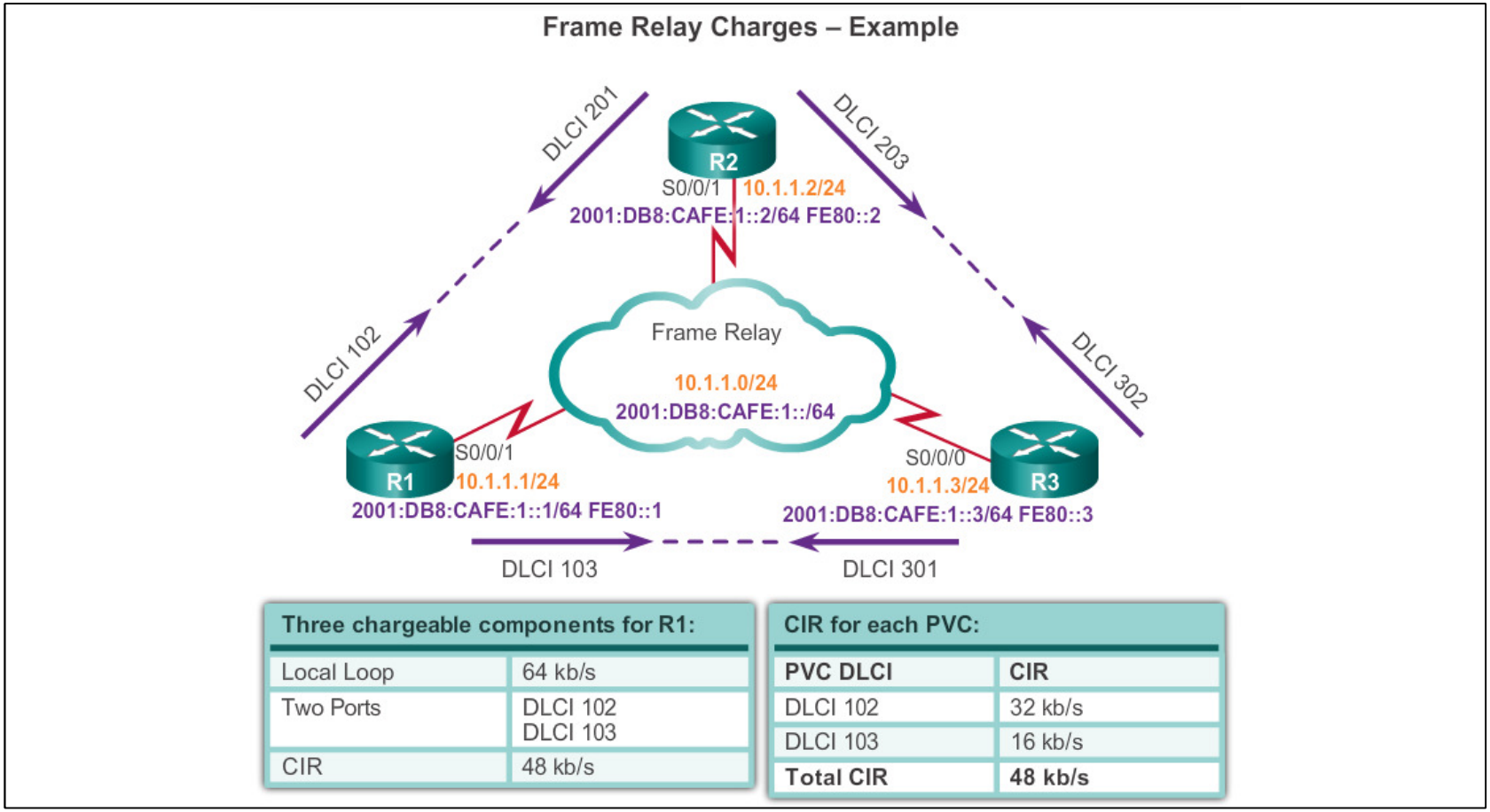
Using LMI and Inverse ARP to Map Addresses

1. The Inverse ARP request includes the source hardware, source Layer 3 protocol address, and the known target hardware address.
2. The Inverse ARP request fills the target Layer 3 protocol address field with all zeroes. It encapsulates the packet for the specific network and sends it directly to the destination device using the VC.
3. Upon receiving an Inverse ARP request, the destination device uses the source device's address to create its own DLCI-to-Layer 3 map.
4. It then sends an Inverse ARP response that includes its Layer 3 address information.
5. When the source device receives the Inverse ARP response, it completes the DLCI-to-Layer 3 map using the provided information.

Access Rate and Committed Information Rate

Term	Access
Access Rate	The capacity of the local loop.
Committed Information Rate (CIR)	The capacity through the local loop guaranteed by the provider.

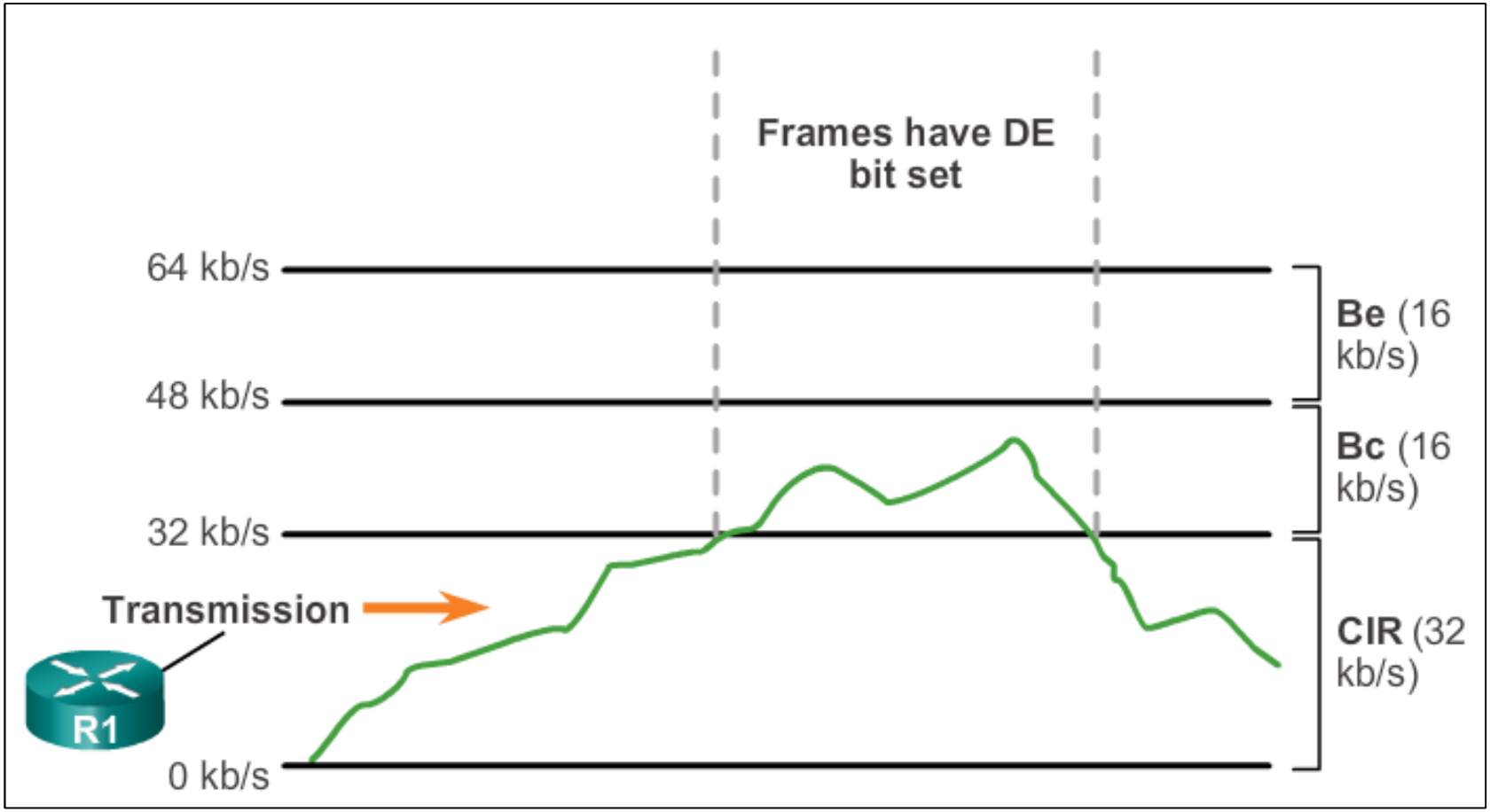
Frame Relay Example



Three chargeable components for R1:	
Local Loop	64 kb/s
Two Ports	DLCI 102 DLCI 103
CIR	48 kb/s

CIR for each PVC:	
PVC DLCI	**CIR**
DLCI 102	32 kb/s
DLCI 103	16 kb/s
Total CIR	**48 kb/s**

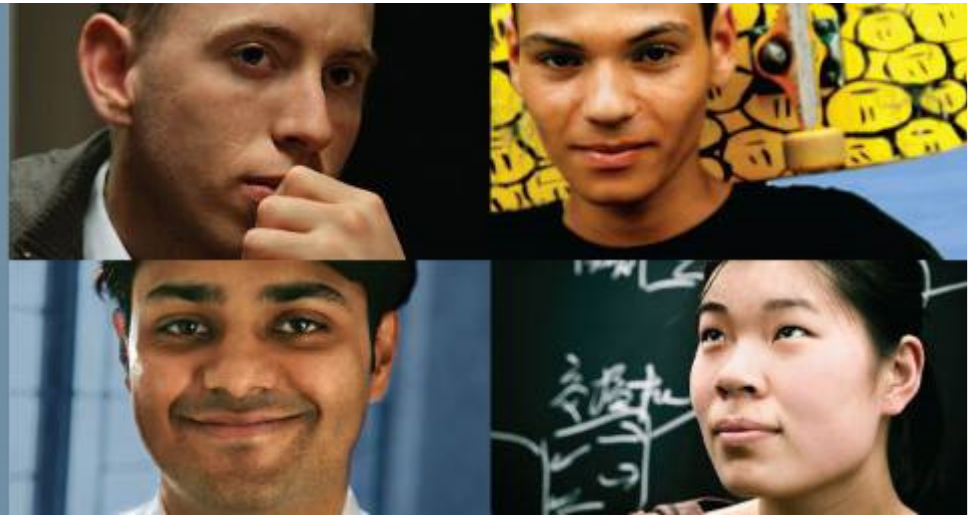
Bursting



Frame Relay Flow Control

- When the DCE sets the BECN bit to 1, it notifies devices in the direction of the source (upstream) that there is congestion on the network.
- When the DCE sets the FECN bit to 1, it notifies devices in the direction of the destination (downstream) that there is congestion on the network.
- DTE devices can set the value of the DE bit to 1 to indicate that the frame has lower importance than other frames. When the network becomes congested, DCE devices discard the frames with the DE bit set to 1 before discarding those that do not.

4.2 Configuring Frame Relay



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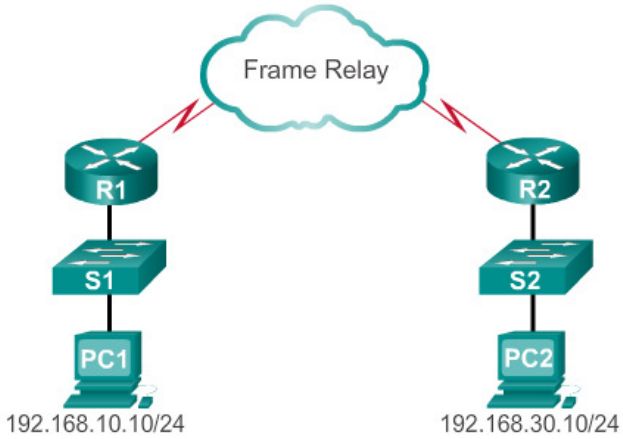
Configure Basic Frame Relay

Basic Frame Relay Configuration Steps

Frame Relay Configuration Tasks



Required Tasks	Optional Tasks
Enable Frame Relay encapsulation on an interface.	Configure the LMI.
Configure dynamic or static address mapping.	Configure Frame Relay SVCs.
	Configure Frame Relay traffic shaping.
	Customize Frame Relay for your network.
	Monitor and maintain Frame Relay connections.

Configuring a Static Frame Relay Map

```
frame-relay map protocol protocol-address dlci [broadcast]
```

Command Parameters	Description
protocol	Defines the supported protocol, bridging, or logical link control: ip (IPv4), ipv6, appletalk, decnet, dlsw, ipx, llc2, rsrb, vines and xns.
protocol-address	Defines the network layer address of the destination router interface.
dlci	Defines the local DLCI used to connect to the remote protocol addres.
broadcast	(Optional) Allows broadcasts and multicasts over the virtual circuit. This permits the use of dynamic routing protocols over the VC.

Configure Basic Frame Relay

Verifying a Static Frame Relay Map

```
R1# show frame-relay map
Serial0/0/1 (up): ipv6 2001:DB8:CAFE:1::2 dlci 102(0x66,0x1860),
                  static, CISCO, status defined, active
Serial0/0/1 (up): ipv6 FE80::2 dlci 102(0x66,0x1860), static,
                  broadcast, CISCO, status defined, active
Serial0/0/1 (up): ip 10.1.1.2 dlci 102(0x66,0x1860), static,
                  broadcast, CISCO, status defined, active
R1#
```

```
R2# show frame-relay map
Serial0/0/1 (up): ipv6 2001:DB8:CAFE:1::1 dlci 201(0xC9,0x3090),
                  static, CISCO, status defined, active
Serial0/0/1 (up): ipv6 FE80::1 dlci 201(0xC9,0x3090), static,
                  broadcast, CISCO, status defined, active
Serial0/0/1 (up): ip 10.1.1.1 dlci 201(0xC9,0x3090), static,
                  broadcast, CISCO, status defined, active
R2#
```

Reachability Issues

Frame Relay networks provide NBMA connectivity, using a hub-and-spoke topology, between remote sites. In an NBMA Frame Relay topology, when a single multipoint interface must be used to interconnect multiple sites, routing update reachability issues may result.

Reachability Issues:

- Split horizon
- Broadcast/multicast replication
- Neighbor Discovery: DR and BDR

Solving Reachability Issues

- **Disable split horizon** – One method for solving the reachability issues that are produced by split horizon may be to turn off split horizon; however, disabling split horizon increases the chances of routing loops in your network.
- **Full-meshed topology** – Another method is to use a full-meshed topology; however, this topology increases costs.
- **Subinterfaces** – In a hub-and-spoke Frame Relay topology, the hub router can be configured with logically assigned interfaces called subinterfaces.

Configuring Point-to-Point Subinterfaces

Configuring Point-to-Point Subinterfaces

```
router(config-if)# interface serial number.subinterface-number
[multipoint | point-to-point]
```

Assigning a DLCI

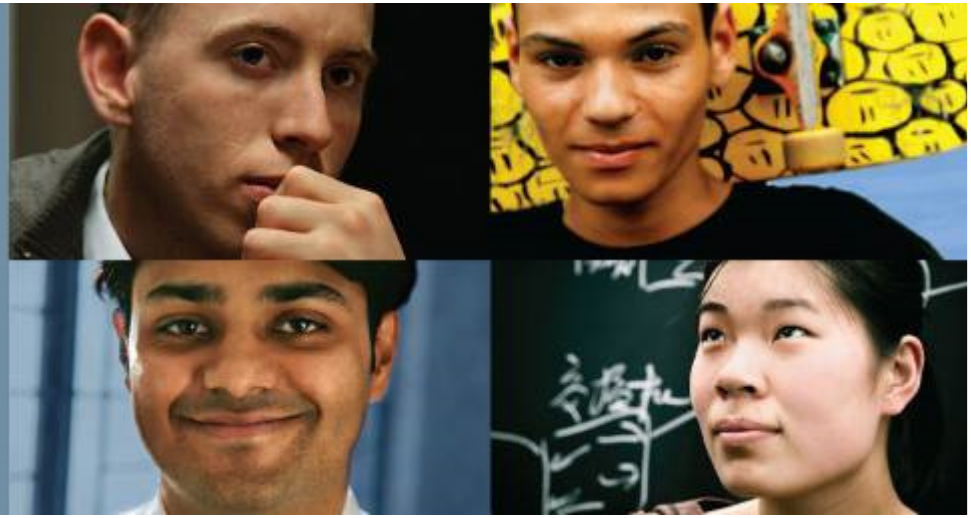
```
router(config-subif)# frame-relay interface-dlci dlci-number
```

Configure Subinterfaces

Example: Configuring Point-to-Point Subinterfaces

```
R1(config)# interface serial 0/0/1
R1(config-if)# encapsulation frame-relay
R1(config-if)# no shutdown
R1(config-if)# exit
R1(config)# interface serial 0/0/1.102 point-to-point
R1(config-subif)# ip address 10.1.1.1 255.255.255.252
R1(config-subif)# bandwidth 64
R1(config-subif)# frame-relay interface-dlci 102
R1(config-fr-dlci)# exit
R1(config-subif)# exit
R1(config)# interface serial 0/0/1.103 point-to-point
R1(config-subif)# ip address 10.1.1.5 255.255.255.252
R1(config-subif)# bandwidth 64
R1(config-subif)# frame-relay interface-dlci 103
R1(config-fr-dlci)#
```

4.3 Troubleshooting Connectivity



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Troubleshoot Frame Relay

Verifying Frame Relay Operation: Frame Relay Interface

```
R1# show interfaces serial 0/0/1
Serial0/0/1 is up, line protocol is up
  Hardware is GT96K Serial
  MTU 1500 bytes, BW 1544 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, loopback not set
  Keepalive set (10 sec)
  CRC checking enabled
  LMI enq sent  443, LMI stat recvd 444, 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 1723/0,
  interface broadcasts 1582
  Last input 00:00:01, output 00:00:01, output hang never
<output omitted>
```

Troubleshoot Frame Relay

Verifying Frame Relay Operation: LMI Operations

```
R1# show frame-relay lmi

LMI Statistics for interface          (Frame Relay DTE) LMI TYPE = CISCO
Serial0/0/1

  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 578                Num Status msgs Rcvd 579
  Num Update Status Rcvd 0                Num Status Timeouts 0
  Last Full Status Req 00:00:28           Last Full Status Rcvd 00:00:28
R1#
```

Troubleshoot Frame Relay

Verifying Frame Relay Operation: PVC Status

```
R1# show frame-relay pvc 102

PVC Statistics for interface Serial0/0/1 (Frame Relay DTE)

DLCI = 102, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE,
INTERFACE = Serial0/0/1.102

  input pkts 1230          output pkts 1243         in bytes 103826
  out bytes 105929         dropped pkts 0           in pkts dropped 0
  out pkts dropped 0                 out bytes dropped 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 1228      out bcast bytes 104952
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
  pvc create time 01:38:29, last time pvc status changed 01:26:19
R1#
```

Troubleshoot Frame Relay

Verifying Frame Relay Operation: Inverse ARP

```
R1# clear frame-relay inarp
R1# show frame-relay map
Serial0/0/1.102 (up): point-to-point dlci, dlci 102(0x66,0x1860),
broadcast status defined, active
Serial0/0/1.103 (up): point-to-point dlci, dlci 103(0x67,0x1870),
broadcast status defined, active
R1#
```

```
R2# clear frame-relay inarp
R2# show frame-relay map
Serial0/0/1.201 (up): point-to-point dlci, dlci 201(0xC9,0x3090),
broadcast status defined, active
Serial0/0/1.203 (up): point-to-point dlci, dlci 203(0xCB,0x30B0),
broadcast status defined, active
R2#
```

```
R3# show frame-relay map
Serial0/0/0 (up): ip 10.1.1.9 dlci 302(0x12E,0x48E0), dynamic,
              broadcast, CISCO, status defined, active
R3#
```

Troubleshooting Frame Relay Operation

```
R1# debug frame lmi
Frame Relay LMI debugging is on
Displaying all Frame Relay LMI data
R1#
*Apr  1 14:57:43.559: Serial0/0/1(in): Status, myseq 22, pak size 29
*Apr  1 14:57:43.559: RT IE 1, length 1, type 0
*Apr  1 14:57:43.559: KA IE 3, length 2, yourseq 22, myseq 22
*Apr  1 14:57:43.559: PVC IE 0x7 , length 0x6 , dlci 102, status 0x2 , bw 0
*Apr  1 14:57:43.559: PVC IE 0x7 , length 0x6 , dlci 103, status 0x2 , bw 0
R1#
*Apr  1 14:57:53.555: Serial0/0/1(out): StEnq, myseq 23, yourseen 22, DTE up
*Apr  1 14:57:53.555: datagramstart = 0xED802AF4, datagramsize = 13
*Apr  1 14:57:53.555: FR encap = 0xFCF10309
*Apr  1 14:57:53.555: 00 75 01 01 01 03 02 17 16
*Apr  1 14:57:53.555:
*Apr  1 14:57:53.559: Serial0/0/1(in): Status, myseq 23, pak size 13
*Apr  1 14:57:53.559: RT IE 1, length 1, type 1
*Apr  1 14:57:53.559: KA IE 3, length 2, yourseq 23, myseq 23
R1# un all
All possible debugging has been turned off
```

Chapter 4: Summary

This chapter described:

- The fundamental concepts of Frame Relay technology, including operation, implementation requirements, maps, and Local Management Interface (LMI) operation.
- How to configure a basic Frame Relay permanent virtual circuit (PVC), including configuring and troubleshooting Frame Relay on a router serial interface and configuring a static Frame Relay map.
- Advanced concepts of Frame Relay technology including subinterfaces, bandwidth and flow control.
- Advanced Frame Relay PVCs, including solving reachability issues, configuring subinterfaces, and verifying and troubleshooting a Frame Relay configuration.