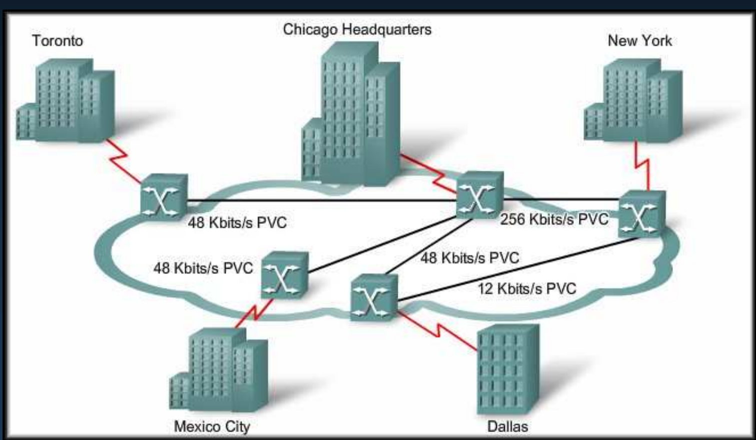
Chapter 3

Frame Relay

Frame Relay

Basic Frame Relay Concepts

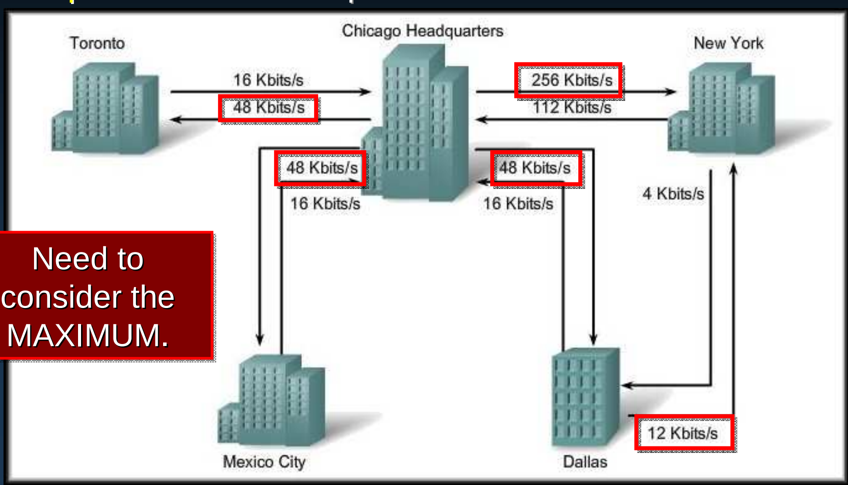


Introducing Frame Relay

- Frame Relay has become the most widely used WAN technology in the world.
- Large enterprises, ISPs, and small businesses use Frame Relay, because of its **price and flexibility**.
- **Price:**
  - As corporations grow, so does their dependence on timely, reliable data transport.
  - Leased line facilities become expensive.
- **Flexibility:**
  - The pace of change and the global nature of businesses demand a flexible, world-wide solution.

An Efficient and Flexible Technology

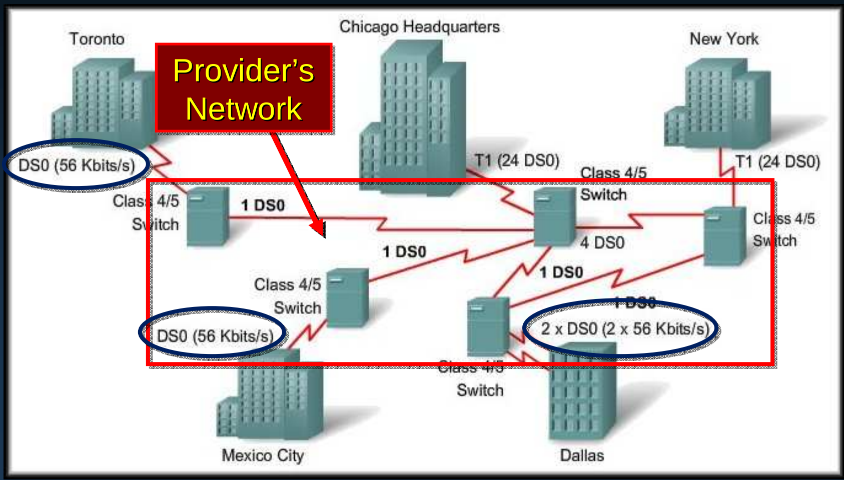
- **Example:** Bandwidth Requirements



Need to consider the MAXIMUM.

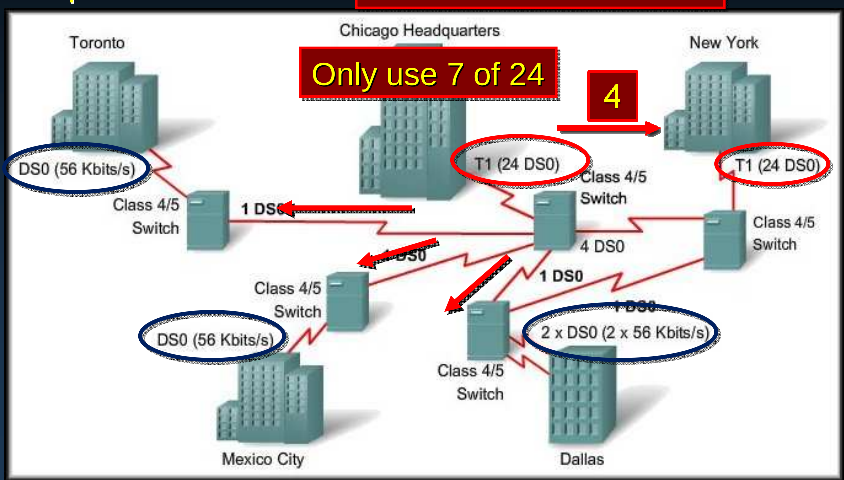
An Efficient and Flexible Technology

- **Example:** Leased Lines



An Efficient and Flexible Technology

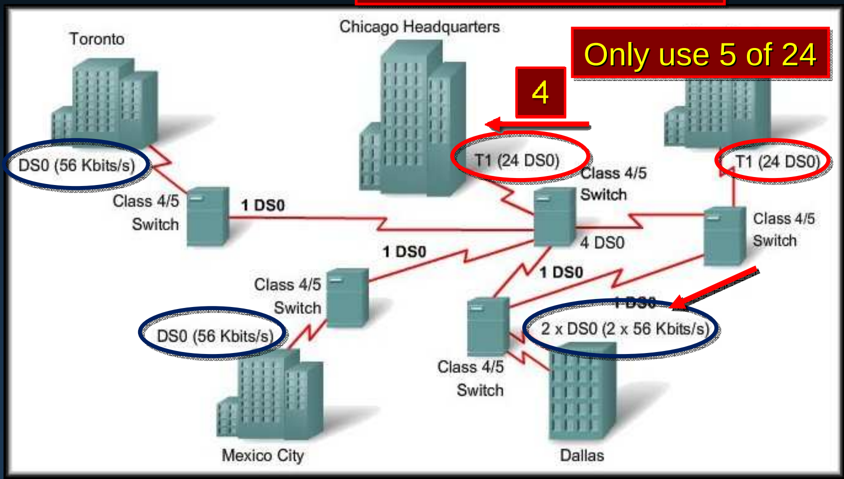
- **Example:** Leased Lines T1 = 24 56K channels



An Efficient and Flexible Technology

- **Example:** Leased Lines

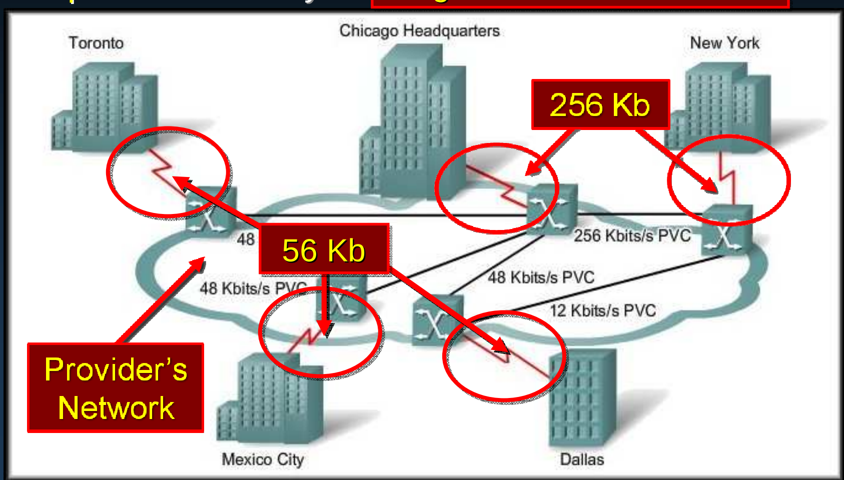
T1 = 24 56K channels



An Efficient and Flexible Technology

- **Example:** Frame Relay

Allows multiple links over a single network connection.



Introducing Frame Relay

- Cost Effectiveness:
  - Customers only pay for the local loop, and for the bandwidth they purchase from the network provider.
    - Distance between nodes is not important.
    - With dedicated lines, customers pay for an end-to-end connection. That includes the local loop and the network link.
  - Shared bandwidth across a larger base of customers. Typically, a network provider can service 40 or more 56 kb/s customers over one T1 circuit.

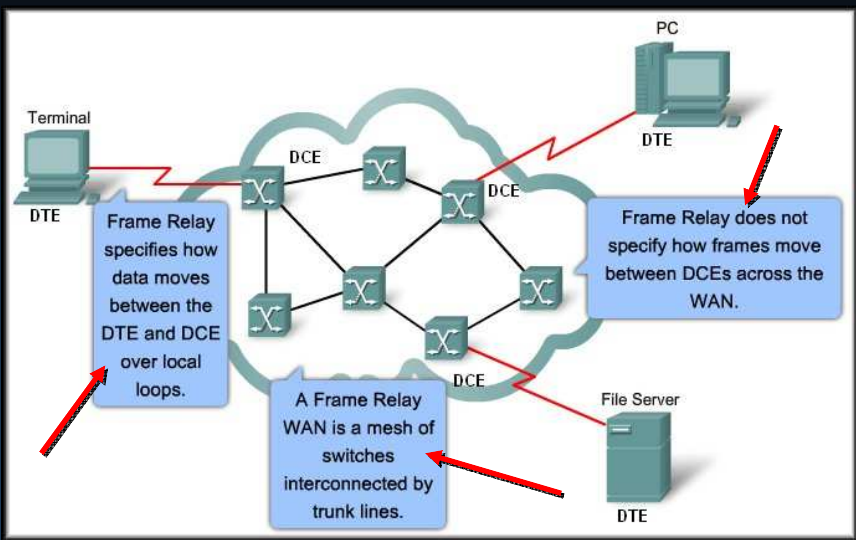
Frame Relay WAN

- When you build a WAN, there are always 3 components,
  - DTE
  - DCE
  - The component that sits in the middle, joining the 2 access points.
- In the late 1970s and into the early 1990s, the WAN technology typically used was the X.25 protocol.
  - Now considered a legacy protocol.
  - X.25 provided a reliable connection over unreliable cabling infrastructures.
  - It included additional error control and flow control.

Frame Relay WAN

- Frame Relay has lower overhead than X.25 because it has fewer capabilities.
  - Modern WAN facilities offer more reliable lines and services.
  - Frame Relay does not provide error correction.
  - A Frame Relay node simply drops packets without notification when it detects errors.
  - Any necessary error correction, such as retransmission of data, is left to the endpoints.
  - Frame Relay handles transmission errors through a standard Cyclic Redundancy Check.

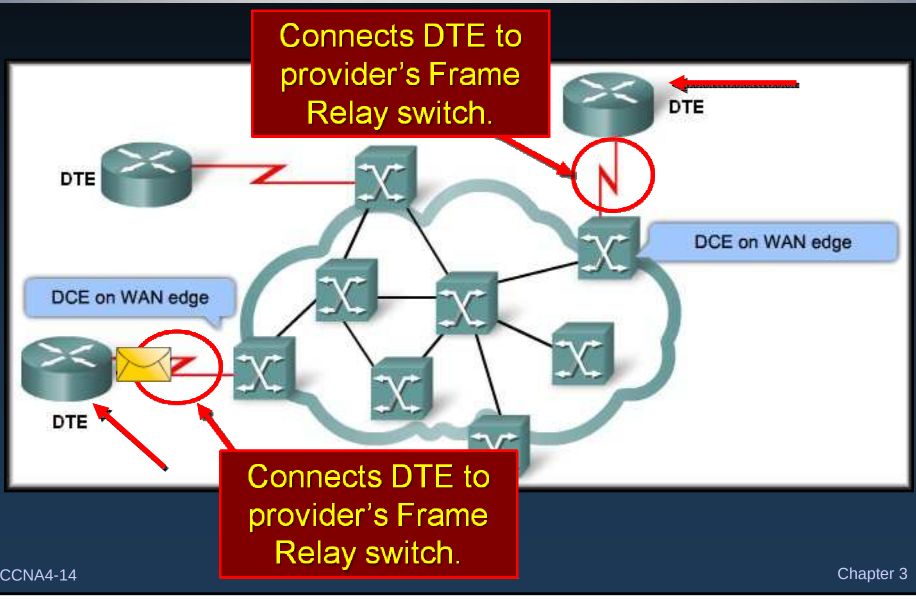
Frame Relay WAN



Frame Relay Operation

- Frame Relay DTE to DCE connection:
  - Two components:
    - Physical Layer:
      - Defines the mechanical, electrical, functional, and procedural specifications for the connection.
    - Data Link Layer:
      - Defines the protocol that establishes the connection between the DTE device (router) and the DCE device (provider's switch).

Frame Relay Operation

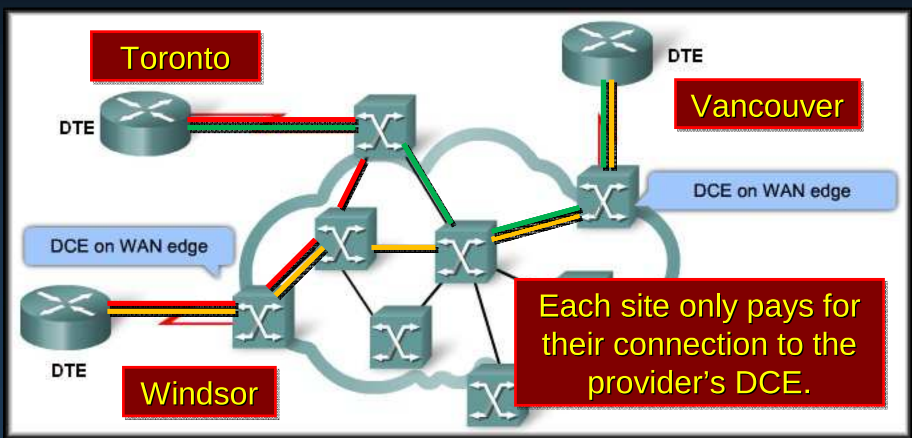


Virtual Circuits

- The connection through a Frame Relay network between two DTEs is called a virtual circuit (VC).
  - The circuits are virtual because there is no direct electrical connection from end to end.
  - The connection is logical.
  - Bandwidth shared among multiple users.
  - *Any single site can communicate with any other single site without using multiple dedicated physical lines.*
- Two types:
  - Switched (SVC): Dynamic call set up and disappears when done.
  - Permanent (PVC): Preconfigured by the provider and always present.

Virtual Circuits

- *Any single site can communicate with any other single site without using multiple dedicated physical lines.*

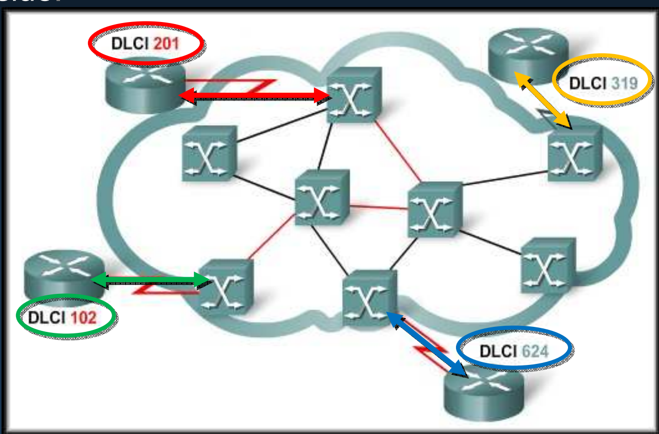


Virtual Circuits

- VCs are identified by DLCIs.
  - (or in English….Virtual Circuits are identified by Data Link Connection Identifiers).
    - Permanent Virtual Circuit = PVC.
    - Switched Virtual Circuit = SVC.
  - DLCI values are assigned by the Frame Relay service provider.
  - Frame Relay DLCIs only have local significance.
    - The DLCI value itself is not unique in the provider's Frame Relay WAN.
    - It simply identifies a VC to the equipment at an endpoint and is only unique on the physical channel where they reside.

Local Significance of DLCIs

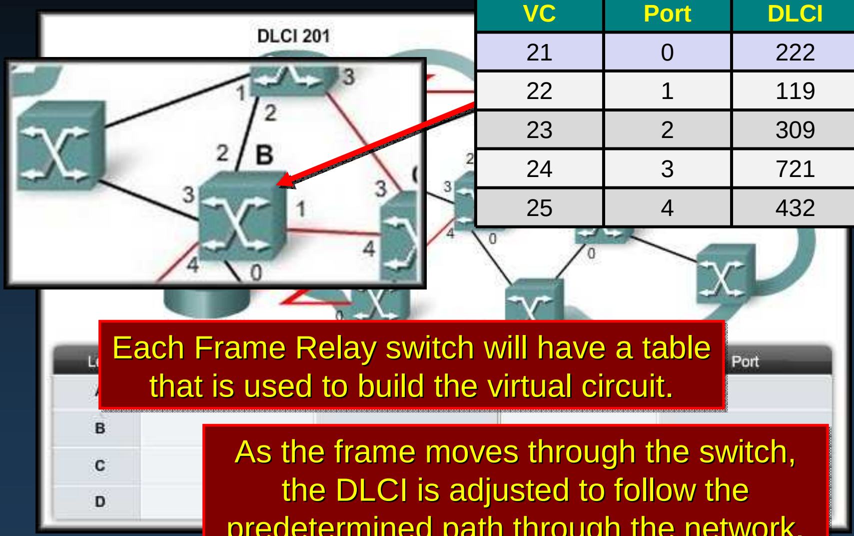
- A DLCI simply identifies a VC to the equipment at an endpoint and is only unique on the physical channel where they reside.



Identifying Virtual Circuits (VC)

- As the frame moves across the network, Frame Relay **labels each VC with a DLCI**.
- The **DLCI is stored in the address field** of every frame to tell the network how the frame should be routed.
  - The Frame Relay service provider assigns DLCI numbers.
    - DLCIs **0 to 15 and 1008 to 1023** are **reserved** for special purposes.
    - Service providers typically assign DLCIs in the range of **16 to 1007**.

Identifying Virtual Circuits (VC)

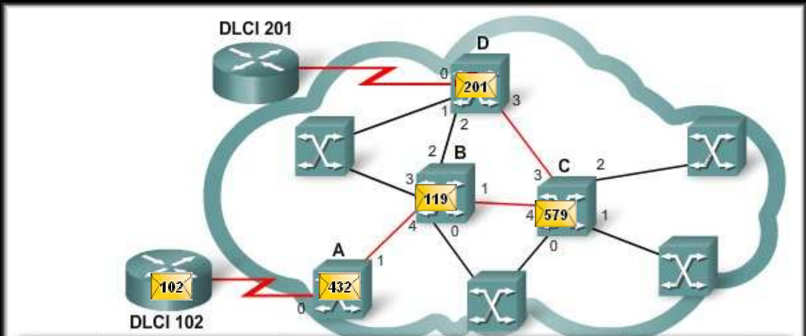


VC	Port	DLCI
21	0	222
22	1	119
23	2	309
24	3	721
25	4	432

Each Frame Relay switch will have a table that is used to build the virtual circuit.

As the frame moves through the switch, the DLCI is adjusted to follow the predetermined path through the network.

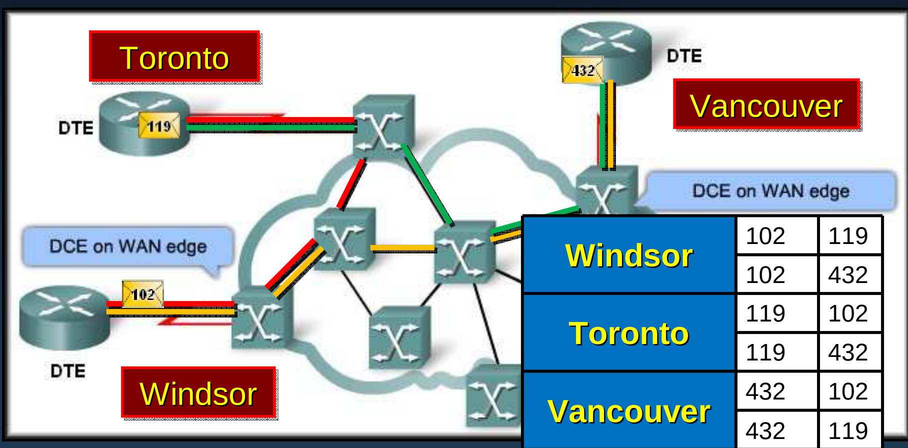
Identifying Virtual Circuits (VC)



Leg	VC	Port	VC	Port
A				
B				
C				
D				

Identifying Virtual Circuits (VC)

- *Any single site can communicate with any other single site without using multiple dedicated physical lines.*



Windsor	102	119
	102	432
Toronto	119	102
	119	432
Vancouver	432	102
	432	119

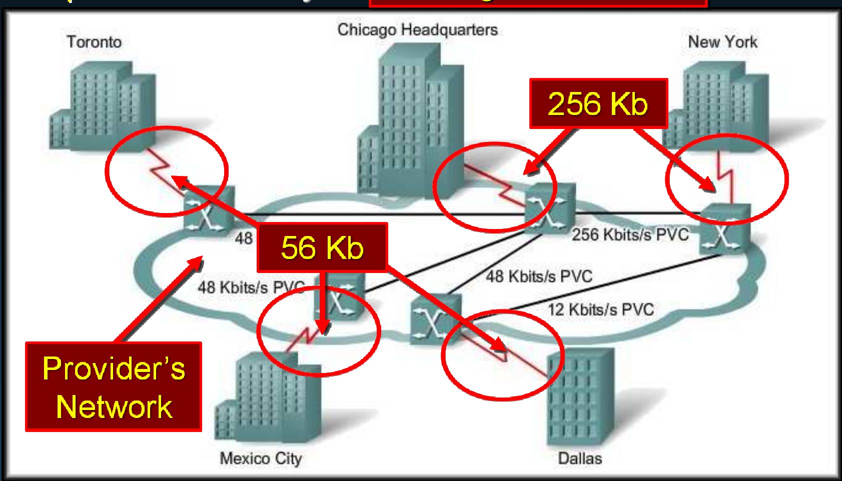
Multiple Virtual Circuits

- Frame Relay is **statistically multiplexed**.
  - It transmits only one frame at a time, but many logical connections can co-exist on a single physical line.
  - Multiple VCs on a single physical line are distinguished because **each VC has its own DLCI**.
  - **Reduces the equipment and network complexity** required to connect multiple devices.
  - **Cost-effective replacement** for a mesh of access lines.
  - More savings arise as the **capacity of the access line is based on the average bandwidth** requirement of the VCs, rather than on the maximum bandwidth requirement.

Multiple Virtual Circuits

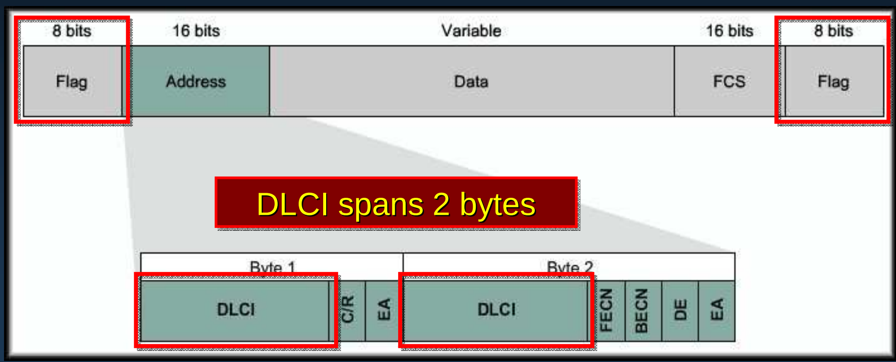
- **Example:** Frame Relay

Capacity based on average bandwidth.



Frame Relay Encapsulation

- Frame Relay takes data packets from a network layer protocol and encapsulates them as the data portion of a Frame Relay frame.

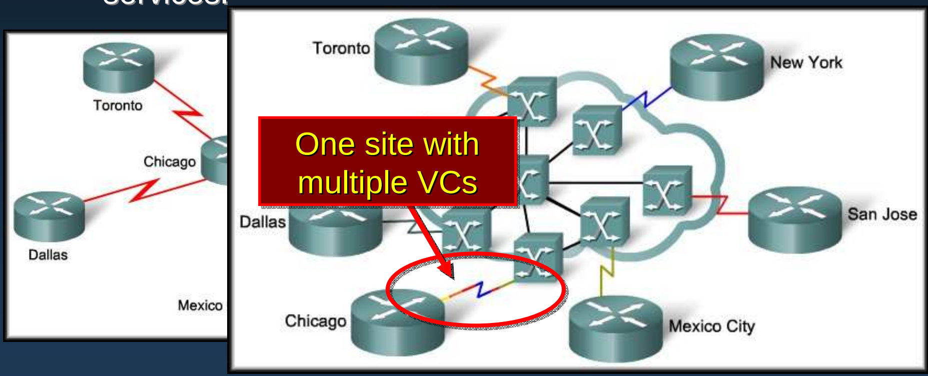


Frame Relay Topologies

- A topology is the map or visual layout of the network.
  - You need to consider the topology from to understand the network and the equipment used to build the network.
  - Every network or network segment can be viewed as being one of three topology types:
    - Star (Hub and Spoke)
    - Full Mesh
    - Partial Mesh

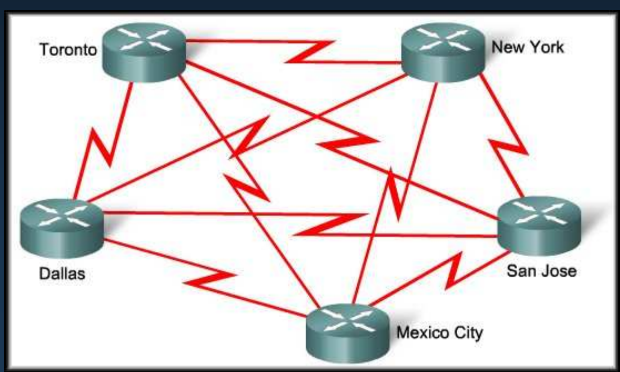
Frame Relay Topologies

- Star (Hub and Spoke):
  - The simplest WAN topology.
  - A central site that acts as a hub and hosts the primary services.



Frame Relay Topologies

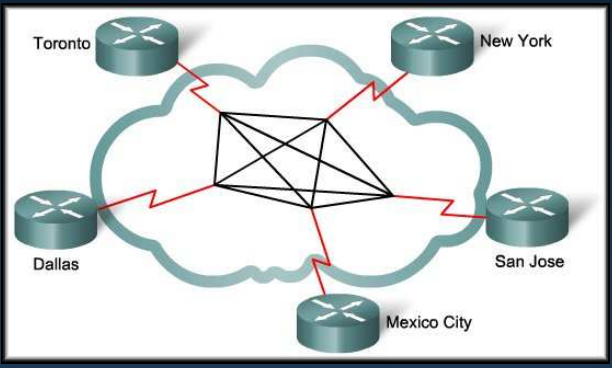
- Full Mesh:
  - A full mesh topology connects every site to every other site. Using leased-line interconnections, additional serial interfaces and lines add costs.



Formula [n(n - 1)]/2	
# Sites	# Circuits
2	1
3	3
4	6
5	10

Frame Relay Topologies

- Full Mesh:
  - Using Frame Relay, a network designer can build multiple connections simply by configuring additional VCs on each existing link.
  - No additional expense for communication lines or hardware.

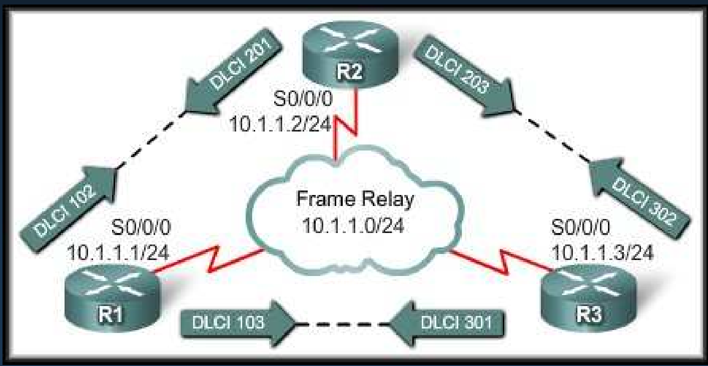


Frame Relay Topologies

- Partial Mesh:
  - For large networks, a full mesh topology is seldom affordable.
  - The issue is not with the cost of the hardware, but because there is a theoretical limit of less than 1,000 VCs per link. In practice, the limit is less than that.
  - For this reason, larger networks are generally configured in a partial mesh topology.
  - With partial mesh, there are more interconnections than required for a star arrangement, but not as many as for a full mesh. The actual pattern is dependant on the data flow requirements.

Frame Relay Address Mapping

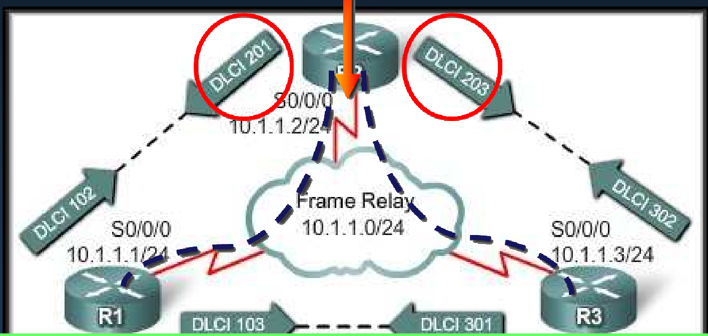
- Before a router is able to transmit data over Frame Relay, it needs to know *which local DLCI maps to the Layer 3 address of the remote destination*.



Frame Relay Address Mapping – WHY?

Remember: The PVC is a permanently defined path through the provider's network.

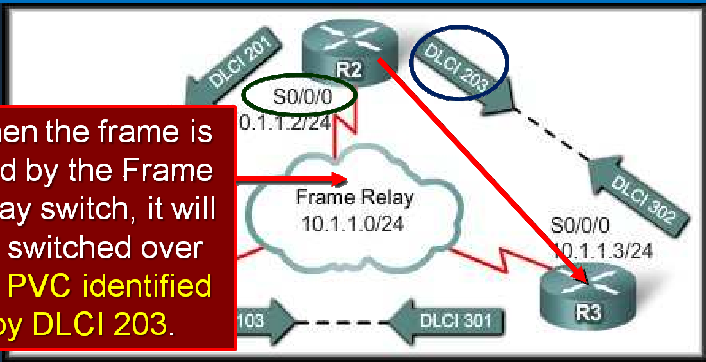
Remember: The DLCI is only locally significant and indentifies the connection to the provider's network.



When R2 has a packet to transmit, it must know which DLCI to put in the header at Layer 2.

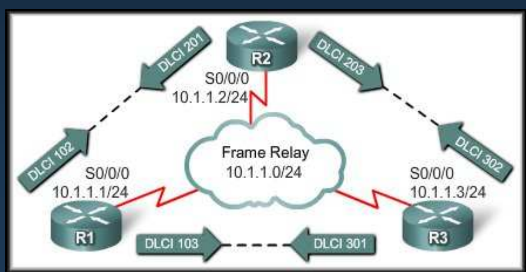
Frame Relay Address Mapping - WHY?

1. R2 has a packet to transmit to 10.1.1.3.
2. The routing table says network 10.1.1.0/24 is out the interface S0/0/0.
3. The address to DLCI mapping says that to send to 10.1.1.3, use DLCI 203 in the Layer 2 header.
4. When the frame is read by the Frame Relay switch, it will be switched over the PVC identified by DLCI 203.



Frame Relay Address Mapping

- Before a router is able to transmit data over Frame Relay, it needs to know *which local DLCI maps to the Layer 3 address of the remote destination*.
  - Two Methods:
    - Dynamic Address Mapping.
    - Static Address Mapping.



Frame Relay Address Mapping

- Dynamic Address Mapping:
  - Uses Inverse ARP (IARP).
    - ARP: *Layer 3* address to obtain *Layer 2* address.
    - IARP: *Layer 2* address to obtain *Layer 3* address.
      - In the case of Frame Relay, IARP uses the Layer 2 DLCI to obtain the Layer 3 address of the router at the other end of the PVC.
  - On Cisco routers, Inverse ARP is enabled by default for only those protocols enabled on the physical interface.

Frame Relay Address Mapping

- Static Address Mapping:
  - Override Dynamic IARP mapping by supplying a manual static mapping for the next hop protocol address to a local DLCI.
  - A static map works associates a specified next hop protocol address to a local Frame Relay DLCI.
    - *You cannot use Inverse ARP and a map statement for the same DLCI and protocol.*
  - *WHEN?*
    - *The router at the other end of the PVC does not support IARP for the protocol you are using.*
    - *Hub and Spoke Frame Relay.*

Local Management Interface (LMI)

- History:
  - When vendors implemented Frame Relay as a separate technology, they decided that there was a need for DTEs to dynamically acquire information about the status of the network.
  - The original design did not include this option.
  - A consortium of Cisco, Digital Equipment Corporation (DEC), Northern Telecom, and StrataCom extended the Frame Relay protocol to provide additional capabilities for complex internetworking environments.
  - These extensions are referred to collectively as the LMI.

Local Management Interface (LMI)

- Basically, the LMI is a keepalive mechanism that provides status information about Frame Relay connections between the router (DTE) and the Frame Relay switch (DCE).
  - Every 10 seconds or so, the end device polls the network.
  - If the network does not respond with the requested information, the user device may consider the connection to be down.
  - When the network responds with a FULL STATUS response, it includes status information about DLCIs that are allocated to that line.
  - The end device can use this information to determine whether the logical connections are able to pass data.

Local Management Interface (LMI)

- The 10-bit DLCI field supports 1,024 VC identifiers:
  - 0 through 1023.
- The LMI extensions reserve some of these identifiers, thereby reducing the number of permitted VCs.
  - LMI messages are exchanged between the DTE and DCE using these reserved DLCIs.

VC Identifiers	VC Types
0	LMI (ANSI, ITU)
1...15	Reserved for future use
992...1007	CLLM
1008...1018	Reserved for future use (ANSI, ITU)
1019...1022	Multicasting (Cisco)
1023	LMI (Cisco)

Local Management Interface (LMI)

- There are several LMI types, each of which is incompatible with the others.
  - Three types of LMIs are supported by Cisco routers:
    - Cisco - Original LMI extension
    - Ansi - Corresponding to the ANSI standard T1.617 Annex D
    - q933a - Corresponding to the ITU standard Q933 Annex A

Local Management Interface (LMI)

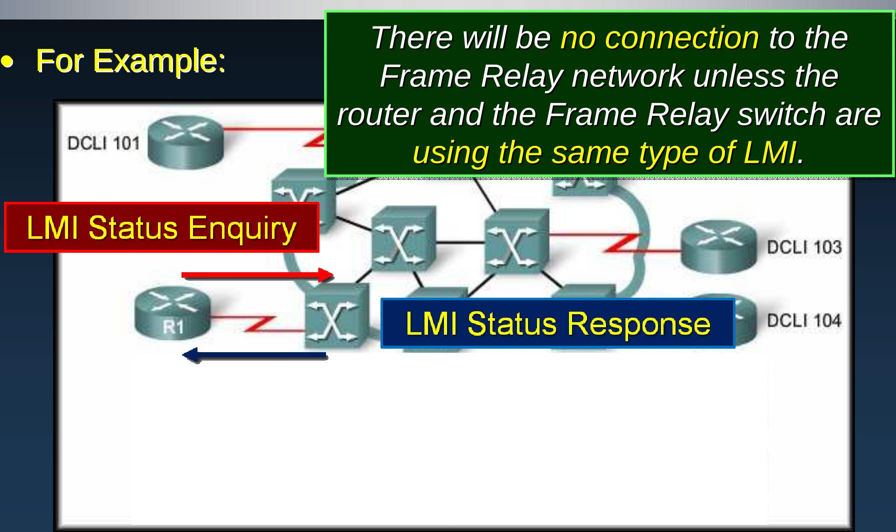
- Starting with Cisco IOS software release 11.2, the **default LMI autosense feature detects the LMI type** supported by the directly connected Frame Relay switch.
  - If it is necessary to set the LMI type, use the **interface** configuration command:

```
frame-relay lmi-type [cisco | ansi | q933a]
```

  - *Configuring the LMI type, disables the autosense feature.*

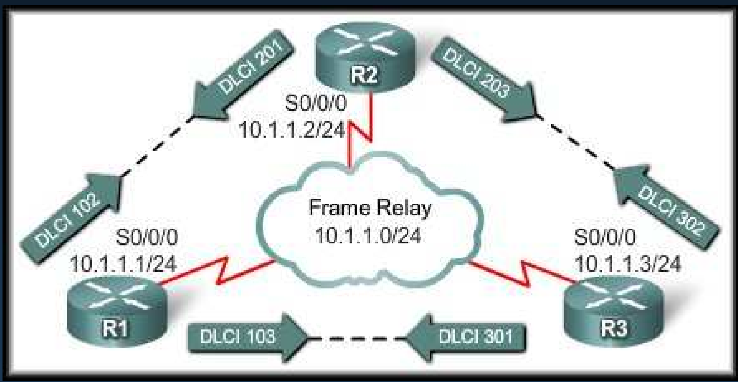
Local Management Interface (LMI)

- For Example:



Frame Relay

Configuring Frame Relay



Configuring Basic Frame Relay

1. Set up the IP address on the Interface.
2. Configure Frame Relay encapsulation.

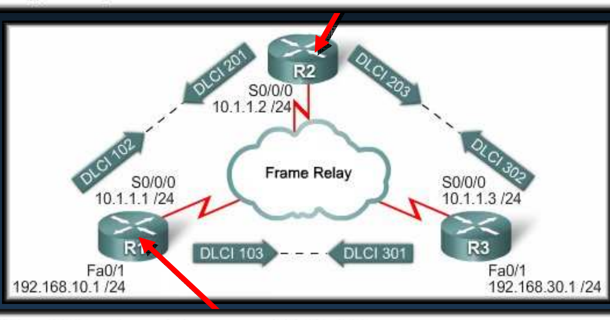
   encapsulation frame-relay ***[cisco | ietf]***

   - The default encapsulation is Cisco HDLC. Use IETF if connecting to another vendor's router.
3. Set the bandwidth.
   - Use the bandwidth command to set the bandwidth for OSPF and EIGRP routing protocols.
4. Set the LMI type (optional). (Auto detects the LMI)

   frame-relay lmi-type ***[cisco | ansi | q833a]***

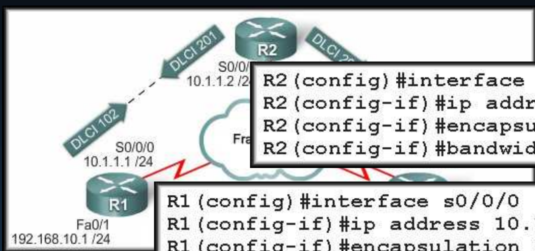
Configuring Basic Frame Relay

```
R2(config)#interface s0/0/0
R2(config-if)#ip address 10.1.1.2 255.255.255.0
R2(config-if)#encapsulation frame-relay
R2(config-if)#bandwidth 64
```




```
R1(config)#interface s0/0/0
R1(config-if)#ip address 10.1.1.1 255.255.255.0
R1(config-if)#encapsulation frame-relay
R1(config-if)#bandwidth 64
```


Configuring Basic Frame Relay




```
R2(config)#interface s0/0/0
R2(config-if)#ip address 10.1.1.2 255.255.255.0
R2(config-if)#encapsulation frame-relay
R2(config-if)#bandwidth 64
```

```
R1(config)#interface s0/0/0
R1(config-if)#ip address 10.1.1.1 255.255.255.0
R1(config-if)#encapsulation frame-relay
R1(config-if)#bandwidth 64
```

- Once the interfaces are enabled with the **no shutdown** command:
  - The Frame Relay switch and the router exchange LMI status messages that announce the DLCIs to the router.
  - IARP maps the remote Layer 3 address to the local DLCI.
  - Routers can exchange data.

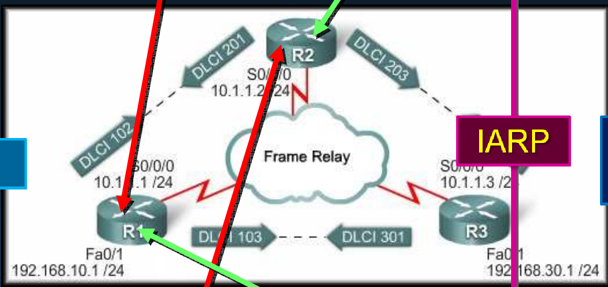
Configuring Basic Frame Relay

```
R2#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.1 dlci 201, dynamic, broadcast,
    CISCO, status defined, active
```

LMI

IARP

OSPF
EIGRP



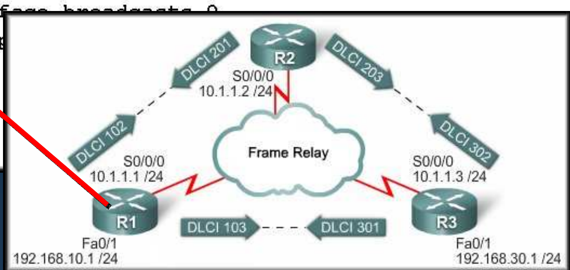

```
R1#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.2 dlci 102, dynamic, broadcast,
    CISCO, status defined, active
```

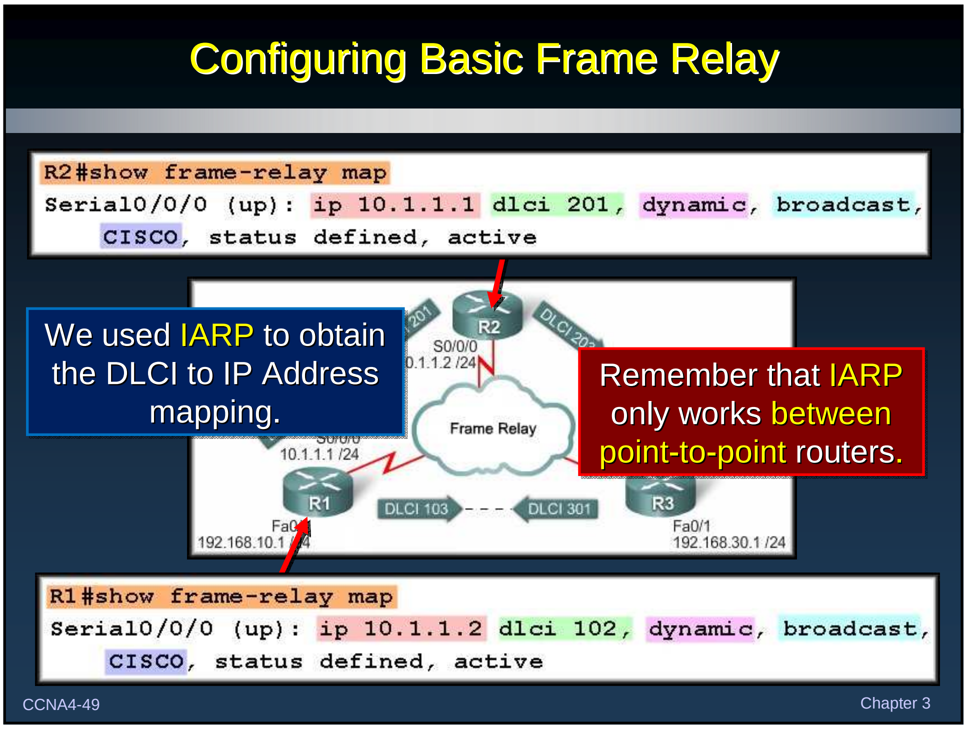

Configuring Basic Frame Relay

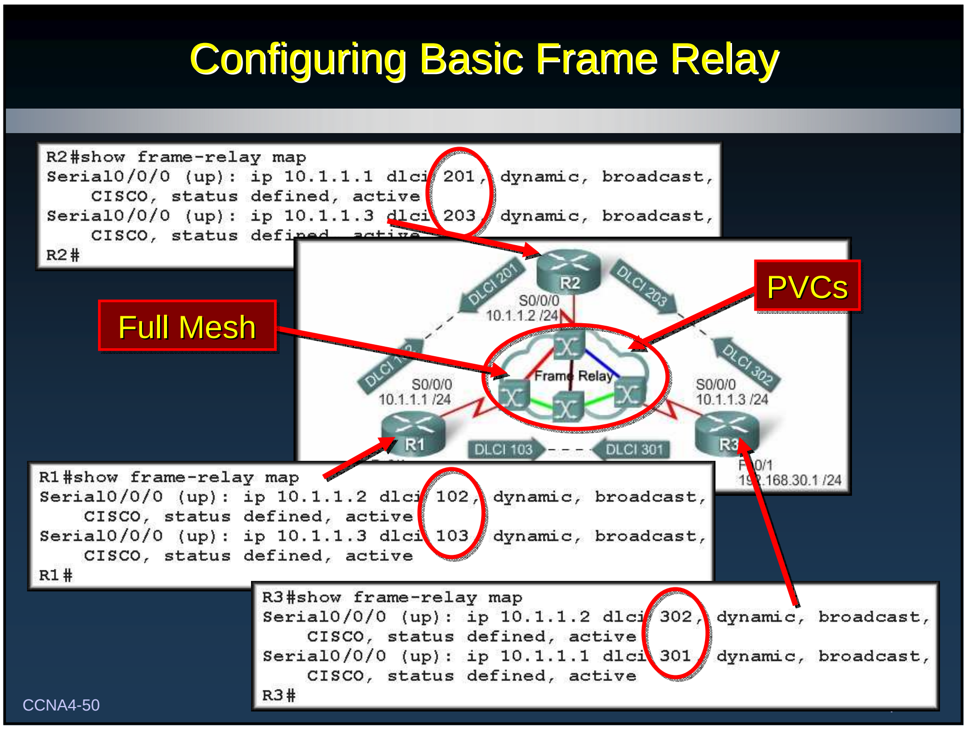
```
R1#show interface s0/0/0
Serial0/0/0 is up, line protocol is up (connected)
  Hardware is HD64570
  Internet address is 10.1.1.1/24
  MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation Frame Relay, loopback not set, keepalive set (10 sec)
  LMI enq sent  116, LMI stat recvd 115, 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
  Broadcast queue 0/64, broadcasts sent/dropped 0/0,
                interface broadcasts 0
  Last input never, outp

<output omitted>

R1#
```




Configuring Basic Frame Relay
R2#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.1 dlci 201, dynamic, broadcast,
CISCO, status defined, active
We used IARP to obtain the DLCI to IP Address mapping.
Remember that IARP only works between point-to-point routers.
R2
S0/0/0
Frame Relay
10.1.1.1 /24
R1
R3
DLCI 103
DLCI 301
Fa0/1
192.168.30.1 /24
R1#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.2 dlci 102, dynamic, broadcast,
CISCO, status defined, active
CCNA4-49
Chapter 3


Configuring Basic Frame Relay
R2#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.1 dlci 201, dynamic, broadcast,
CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.3 dlci 203, dynamic, broadcast,
R2#
Full Mesh
PVCs
R2
DLCI 201
DLCI 203
S0/0/0
10.1.1.2 /24
Frame Relay
S0/0/0
10.1.1.1 /24
S0/0/0
10.1.1.3 /24
DLCI 302
R1
R3
DLCI 103
DLCI 301
R1#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.2 dlci 102, dynamic, broadcast,
CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.3 dlci 103, dynamic, broadcast,
CISCO, status defined, active
R1#
R3#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.2 dlci 302, dynamic, broadcast,
CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.1 dlci 301, dynamic, broadcast,
CISCO, status defined, active
R3#
CCNA4-50

Configuring Static Frame Relay Maps

- To manually map between a next hop protocol address and a DLCI destination address, use the command:

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

- frame-relay map: Command
- protocol: Protocol used on the interface (e.g. IP)
- protocol-address: Protocol remote interface address (e.g. 10.1.1.3)
- dlci: Local DLCI
- [broadcast]: Allow broadcasts

Configuring Static Frame Relay Maps

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

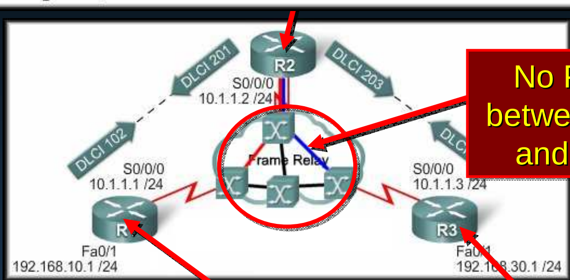
- Frame Relay (and x.25 and ATM) is a non-broadcast multiple access (NBMA) network.
  - It does not support multicast or broadcast traffic.
  - Using the **broadcast** keyword is a simplified way to forward routing updates.
    - Allows broadcasts and multicasts over the PVC.
  - In effect, it turns the broadcast into a unicast do that the other node gets the routing updates.

Configuring Static Frame Relay Maps

- When do we use a static map?
  - Hub-and Spoke Topology.
  - Partial Mesh Topology.
  - If you absolutely need a connection between two sites that are already on your Frame Relay network and there is no PVC.
    - In other words, turning a site between them into a hub.
      - BE CAREFUL!
        - Turning a site into a hub can lead to unexpected results if you do not previously plan the new topology! *(Trust me – I know!)*

Configuring Static Frame Relay Maps

```
R2(config)#interface s0/0/0
R2(config-if)#ip address 10.1.1.2 255.255.255.0
R2(config-if)#encapsulation frame-relay
R2(config-if)#bandwidth 64
```



No PVC between R1 and R3.

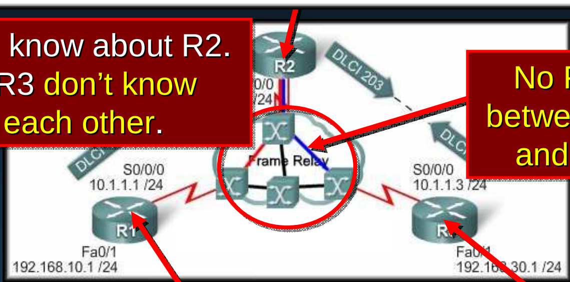
```
R1(config)#interface s0/0/0
R1(config-if)#ip address 10.1.1.1 255.255.255.0
R1(config-if)#encapsulation frame-relay
R1(config-if)#bandwidth 64
```

```
R3(config)#interface s0/0/0
R3(config-if)#ip address 10.1.1.3 255.255.255.0
R3(config-if)#encapsulation frame-relay
R3(config-if)#bandwidth 64
```

Configuring Static Frame Relay Maps

```
R2#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.1 dlci 201  dynamic, broadcast,
    CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.3 dlci 203  dynamic, broadcast,
    CISCO, status defined, active
R2#
```

R1 and R3 know about R2. R1 and R3 don't know about each other.

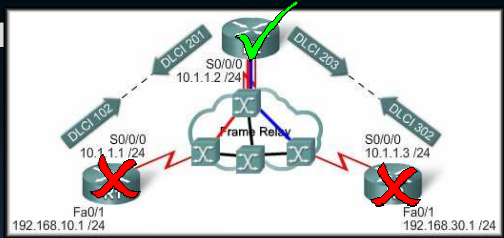


No PVC between R1 and R3.

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

```
R3#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.2 dlci 302, dynamic, broadcast,
    CISCO, status defined, active
R3#
```

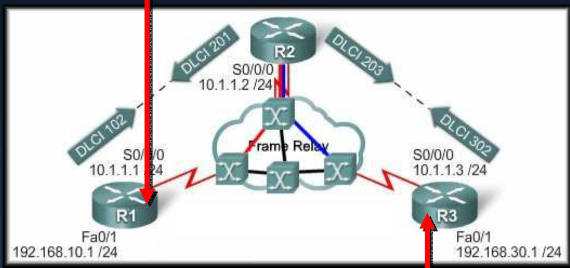

Configuring Static Frame Relay Maps



- How do we fix it?
  - Add another PVC to the network.
    - Additional Expense.
  - Add a static frame relay map to both R1 and R3.
    - R1:
      - We will want to map the R3 IP Address 10.1.1.3 to DLCI 102 on R1. *Anything for that network should go to the hub.*
    - R3:
      - Map 10.1.1.1 to DLCI 302.

Configuring Static Frame Relay Maps

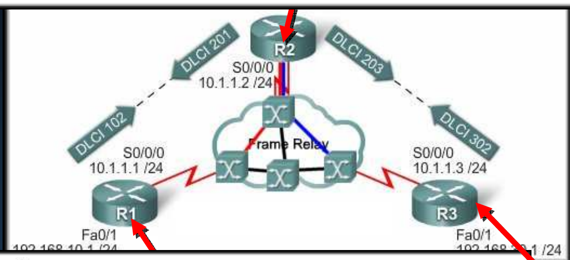
```
R1(config)#interface s0/0/0
R1(config-if)#frame-relay map ip 10.1.1.3 102 broadcast
```




```
R3(config)#interface s0/0/0
R3(config-if)#frame-relay map ip 10.1.1.1 302 broadcast
```


Configuring Static Frame Relay Maps

```
R2#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.1 dlci 201, dynamic, broadcast,
    CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.3 dlci 203, dynamic, broadcast,
    CISCO, status defined, active
R2#
```

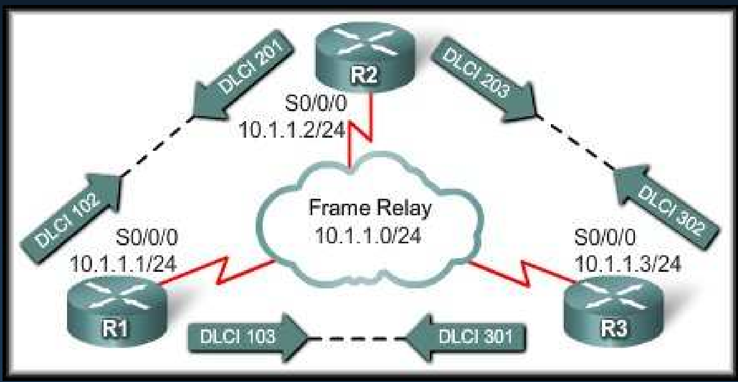



```
R1#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.3 dlci 102, static, broadcast,
    CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.2 dlci 102, dynamic, broadcast,
    CISCO, status defined, active
R1#
```

```
R3#show frame-relay map
Serial0/0/0 (up): ip 10.1.1.1 dlci 302, static, broadcast,
    CISCO, status defined, active
Serial0/0/0 (up): ip 10.1.1.2 dlci 302, dynamic, broadcast,
    CISCO, status defined, active
R3#
```

Frame Relay

Advanced Frame Relay Concepts



Advanced Frame Relay Concepts

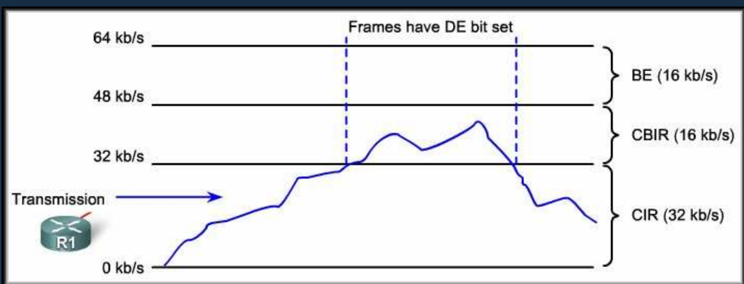
- Paying for Frame Relay:
  - Access or port speed:
    - The cost of the access line from the DTE to the DCE (customer to service provider).
  - Permanent Virtual Circuit (PVC):
    - This cost component is based on the PVCs.
  - Committed Information Rate (CIR):
    - Customers normally choose a CIR lower than the port speed or access rate (U.S.).
    - This allows them to take advantage of bursts.
    - NOTE: There is no CIR in Canada.

Advanced Frame Relay Concepts

- Paying for Frame Relay:
  - Oversubscription:
    - Service providers sometimes sell more capacity than they have on the assumption that not everyone will demand their entitled capacity all of the time.
    - Because of oversubscription, there will be instances when the sum of CIRs from multiple PVCs to a given location is higher than the port or access channel rate.
    - This can cause traffic issues, such as congestion and dropped traffic.
    - *Be aware that this can happen!*

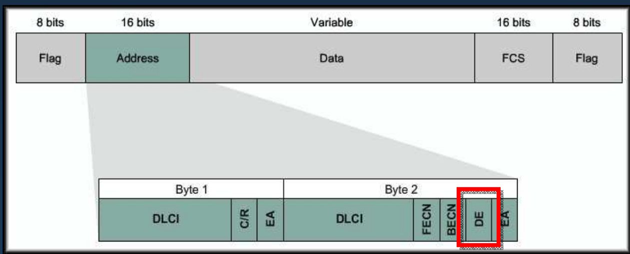
Advanced Frame Relay Concepts

- Bursting:
  - Because the physical circuits of the Frame Relay network are shared between subscribers, there will often be time where there is excess bandwidth available.
  - Frame Relay can allow customers to dynamically access this extra bandwidth and "burst" over their CIR for free.



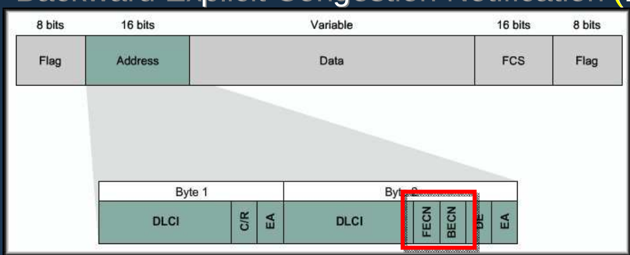
Advanced Frame Relay Concepts

- Frame Relay Discard Eligibility Bit:
  - The frame header also contains a Discard Eligibility (DE) bit, which identifies less important traffic that can be dropped during periods of congestion.
  - DTE devices can set the value of the DE bit to indicate that the frame has lower importance than other frames.
  - *The DE bit is automatically set during a "burst" situation.*



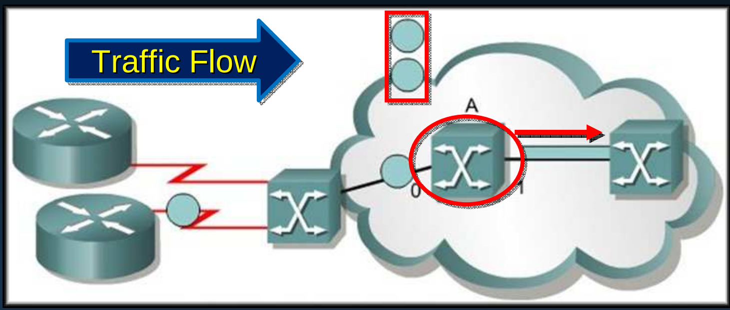
Advanced Frame Relay Concepts

- Frame Relay Flow Control:
  - Frame Relay flow control is a matter of controlling congestion on the frame relay network.
  - There are two bits that are set on the frame header when congestion occurs.
    - Forward Explicit Congestion Notification (FECN)
    - Backward Explicit Congestion Notification (BECN)



Advanced Frame Relay Concepts

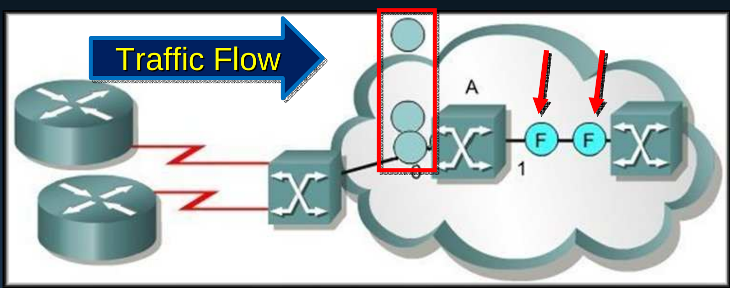
- **Frame Relay Flow Control:**



  - While Frame Relay Switch A is placing a large frame on interface 1, other frames for this interface are queued.

Advanced Frame Relay Concepts

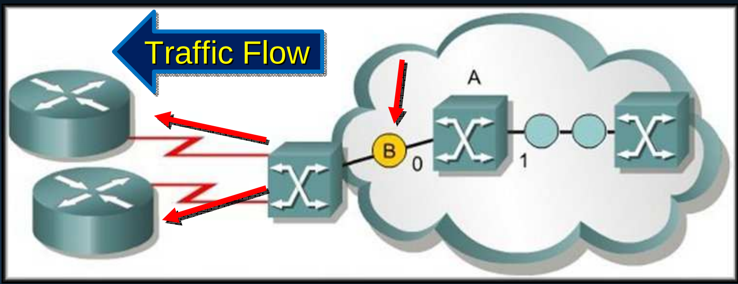
- **Frame Relay Flow Control:**



  - When the queue is sent, down stream devices are warned of the queue by setting the FECN bit in the header of the frame that was received on the congested link.

Advanced Frame Relay Concepts

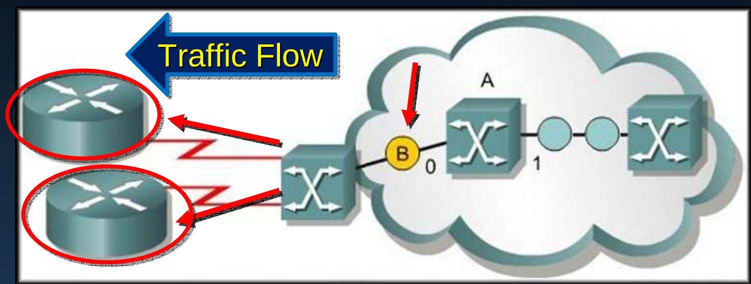
- Frame Relay Flow Control:



  - Upstream devices are warned of the queue by setting the BECN bit in the header of any frames sent on the congested link.
  - Each upstream device receives the BECN frame.

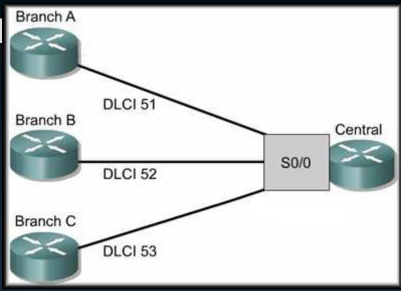
Advanced Frame Relay Concepts

- Frame Relay Flow Control:



  - Even though a device may not have contributed to the congestion, it still receives the BECN frame.
  - Each device that provides input to the switch is instructed to reduce the rate at which it is sending packets.

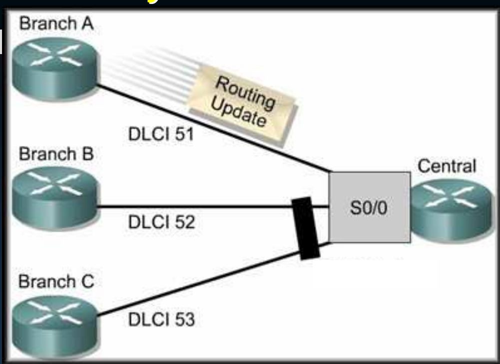
Solving Reachability Issues



- Frame Relay is a Non-Broadcast Multi-Access (NBMA) network.
  - In Ethernet, multiple nodes can access the network and all nodes see all broadcasts or multicasts.
- *However, in a non-broadcast network such as Frame Relay, nodes cannot see broadcasts of other nodes unless they are directly connected by a virtual circuit.*
- This means that Branch A cannot directly see the broadcasts from Branch B, because they are connected using a hub and spoke topology.

Solving Reachability Issues

Split Horizon
prohibits routing updates received on an interface from exiting that same interface.

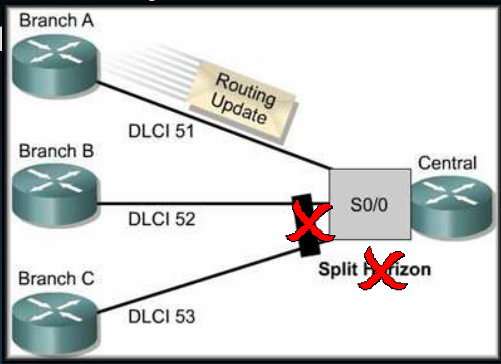


- Example:
  - The *Central* router learns about Network X from *Branch A*.
  - That update is learned via S0/0.
  - The *Central* router must then send its own update to *Branch B* and *Branch C*.

Solving Reachability Issues

- One Solution is to turn off split horizon for IP.

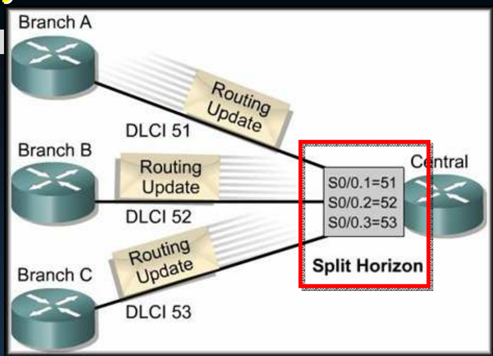
  `no ip split-horizon`



- *Of course, with split horizon disabled, the protection it affords against routing loops is lost.*
- Split horizon is only an issue with distance vector routing protocols like RIP and EIGRP.
- It has no effect on link state routing protocols like OSPF.

Frame Relay Subinterfaces

- A better solution is to use Subinterfaces.
- Subinterfaces are logical subdivisions of a physical interface.
- In split-horizon routing environments, routing updates received on one subinterface can be sent out on another subinterface.
  - With this configuration, each PVC can be configured as a point-to-point connection and treated as a separate physical interface – similar to a single leased line.

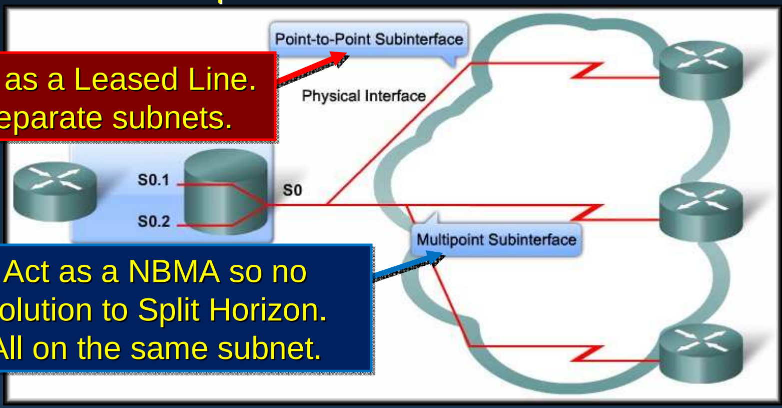


Frame Relay Subinterfaces

- There are **two types** of Frame Relay subinterfaces:
  - **Point-to-Point**
  - **Multipoint**

How to configure – stay tuned!

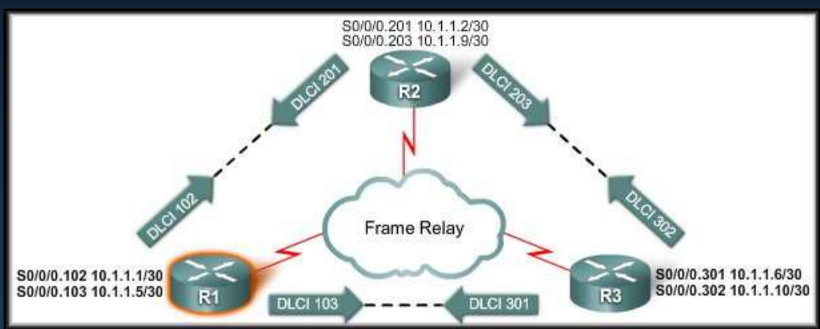
Act as a Leased Line. Separate subnets.



Act as a NBMA so no solution to Split Horizon. All on the same subnet.

Frame Relay

Configuring Advanced Frame Relay



Configuring Frame Relay Subinterfaces

1. Configure encapsulation on the interface.

```
R1(config)#interface serial-number
R1(config-if)#encapsulation frame-relay
```

2. Create the sub-interface with the IP Address and any other parameters that apply.

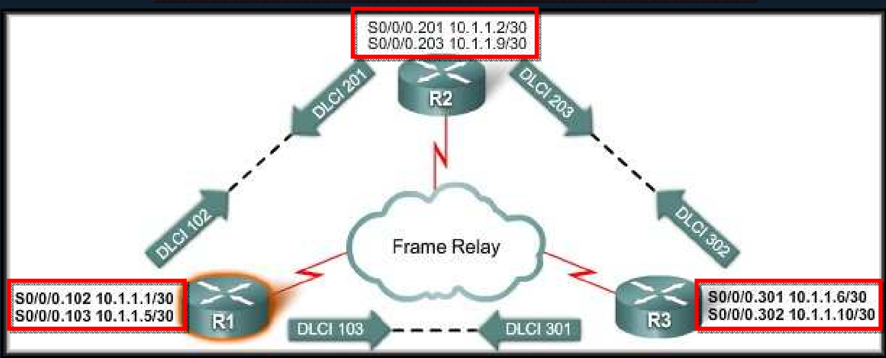
```
R1(config-if)#interface
        serial-number.subinterface-number
              {multipoint | point-to-point}
```

3. Use this command to map the DLCI to the IP Address – not **frame-relay map**.

```
R1(config-subif)# frame-relay interface-dlci
                          dlci-number
```


Configuring Frame Relay Subinterfaces

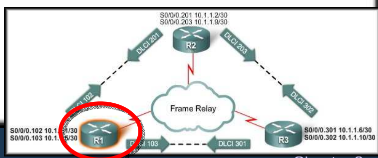
Note that the IP Addressing scheme has changed to provide separate IP subnets for each Frame relay link.



Also note that the DLCI number is used as the sub-interface number.

Configuring Frame Relay Subinterfaces

```
R1(config)#interface s0/0/0
R1(config-if)#encapsulation frame-relay
```



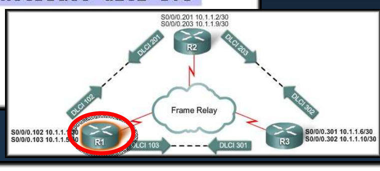
Configuring Frame Relay Subinterfaces

```
R1(config)#interface s0/0/0
R1(config-if)#encapsulation frame-relay

R1(config-if)#interface s0/0/0.102 point-to-point
R1(config-subif)#ip address 10.1.1.1 255.255.255.252
R1(config-subif)#frame-relay interface-dlci 102
R1(config-subif)#bandwidth 64

R1(config-subif)#interface s0/0/0.103 point-to-point
R1(config-subif)#ip address 10.1.1.5 255.255.255.252
R1(config-subif)#frame-relay interface-dlci 103
R1(config-subif)#bandwidth 64

R1(config-subif)#int s0/0/0
R1(config-if)#no shutdown
```




```
R1#show frame-relay map
Serial0/0/0.102 (up): point-to-point dlci, dlci 102, broadcast,
      status defined, active
Serial0/0/0.103 (up): point-to-point dlci, dlci 103, broadcast,
      status defined, active
R1#
```

Configuring Frame Relay Subinterfaces

1. Configure Frame Relay encapsulation on the interface.
2. Create a sub-interface for each DLCI on the connection.
   - Use the DLCI number – helps in troubleshooting
   - Configure the IP address.
   - Map the DLCI.
3. Active the entire interface, not each individual sub-interface.
4. Use the following commands to verify.
   - **show frame-relay-map**
   - **show frame-relay lmi**
   - **show frame-relay pvc [dlci-number]**
   - **debug frame-relay lmi**