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Section 10
Establishing Frame Relay Connections

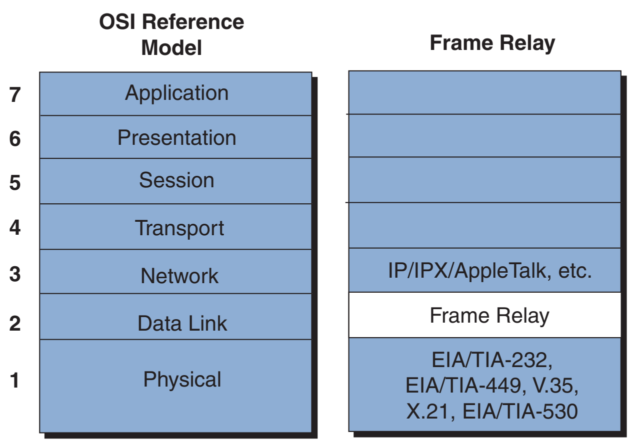
Frame Relay is a connection-oriented Layer 2 protocol that allows several data connections (virtual circuits) to be multiplexed onto a single physical link. Frame Relay relies on upper-layer protocols for error correction. Frame Relay specifies only the connection between a router and a service provider's local access switching equipment.

A connection identifier maps packets to outbound ports on the service provider's switch. When the switch receives a frame, a lookup table maps the frame to the correct outbound port. The entire path to the destination is determined before the frame is sent.

Frame Relay Stack

As Figure 10-1 shows, the bulk of Frame Relay functions exist at the lower two layers of the OSI reference model. Frame Relay is supported on the same physical serial connections that support point-to-point connections. Cisco routers support the EIA/TIA-232, EIA/TIA-449, V.35, X.21, and EIA/TIA-530 serial connections. Upper-layer information (such as IP data) is encapsulated by Frame Relay and is transmitted over the link.

FIGURE 10-1
Frame Relay Functions at Layer 1 and 2 of the OSI Reference Model



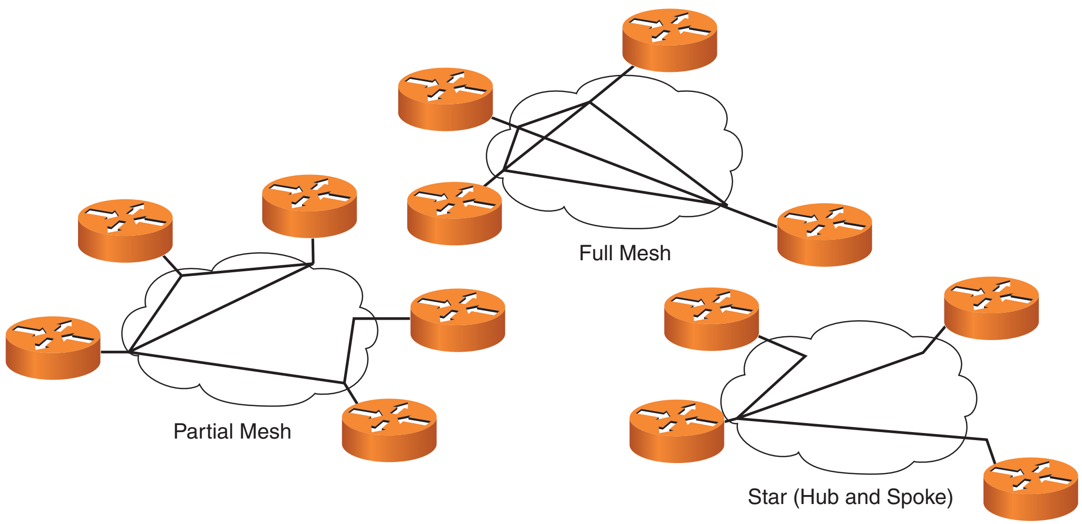
Frame Relay Terminology

- **VC (virtual circuit):** A logical circuit between two network devices. A VC can be a permanent virtual circuit (PVC) or a switched virtual circuit (SVC). PVCs save bandwidth (no circuit establishment or teardown) but can be expensive. SVCs are established on demand and are torn down when transmission is complete. VC status can be active, inactive, or deleted. Today, most Frame Relay circuits are PVCs.
- **DLCI (data-link connection identifier):** Identifies the logical connection between two directly connected sets of devices. The DLCI is locally significant.
- **CIR (committed information rate):** The minimum guaranteed data transfer rate agreed to by the Frame Relay switch.
- **Inverse ARP (Inverse Address Resolution Protocol):** Routers use Inverse ARP to discover the network address of a device associated with a VC.
- **LMI (Local Management Interface):** A signaling standard that manages the connection between the router and the Frame Relay switch. LMIs track and manage keepalive mechanisms, multicast messages, and status. LMI is configurable (in Cisco IOS Software Release 11.2 and later), but routers can autosense LMI types by sending a status request to the Frame Relay switch. The router configures itself to match the LMI type response. The three types of LMIs supported by Cisco Frame Relay switches are Cisco (developed by Cisco, StrataCom, Northern Telecom, and DEC), ANSI Annex D (ANSI standard T1.617), and q933a (ITU-T Q.933 Annex A).
- **FECN (forward explicit congestion notification):** A message sent to a destination device when a Frame Relay switch senses congestion in the network.
- **BECN (backward explicit congestion notification):** A message sent to a source router when a Frame Relay switch recognizes congestion in the network. A BECN message requests a reduced data transmission rate.

Frame Relay Topologies

Frame Relay networks can be designed using star, full-mesh, and partial-mesh topologies. Figure 10-2 shows the three topologies in Frame Relay.

FIGURE 10-2
Frame Relay Topologies



A star topology, also known as a hub-and-spoke configuration, is the common network topology. Remote sites are connected to a central site, which usually provides services. Star topologies require the fewest PVCs, making them relatively inexpensive. The hub router provides a multipoint connection using a single interface to interconnect multiple PVCs.

In a full-mesh topology, all routers have virtual circuits to all other destinations. Although it is expensive, this method provides redundancy, because all sites are connected to all other sites. Full-mesh networks become very expensive as the number of nodes increases. The number of links required in a full-mesh topology that has n nodes is $[n * (n - 1)]/2$.

In a partial-mesh topology, not all sites have direct access to all other sites. Connections usually depend on the traffic patterns within the network.

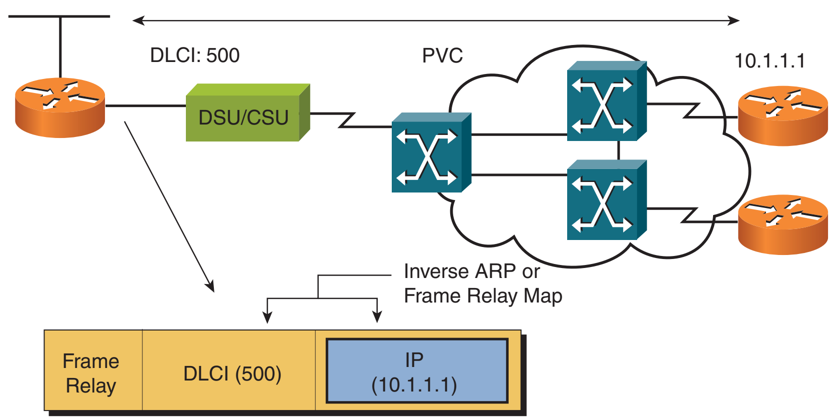
By default, a Frame Relay network provides nonbroadcast multiaccess (NBMA) connectivity between remote sites. An NBMA environment is treated like other broadcast media environments, such as Ethernet, where all the routers are on the same subnet.

However, to reduce costs, NBMA clouds are usually built in a hub-and-spoke topology. With this topology, the physical network does not provide the multiaccess capabilities that Ethernet does, so each router might not have a separate PVC to reach the other remote routers on the same subnet. When running Frame Relay with multiple PVCs over a single interface, you can encounter split horizon when running a routing protocol.

Frame Relay Address Mapping

Because Frame Relay is an NBMA, it needs to have a way to map Layer 2 information with Layer 3. In typical multiaccess networks, broadcasts perform this functionality. Because Frame Relay is nonbroadcast, another mechanism is needed. To correctly route packets, each DLCI must be mapped to a next-hop address. These addresses can be manually configured or dynamically mapped using Inverse ARP. After the address is mapped, it is stored in the router's Frame Relay map table. Figure 10-3 shows how Inverse ARP maps a DLCI to an IP address.

FIGURE 10-3
Inverse ARP Maps DLCIs to IP Addresses



LMI Signaling Process

1. The router connects to a Frame Relay switch through a channel service unit/data service unit (CSU/DSU).
2. The router sends a VC status inquiry to the Frame Relay switch.
3. The switch responds with a status message that includes DLCI information for the usable PVCs.
4. The router advertises itself by sending an Inverse ARP to each active DLCI.
5. The routers create map entries with the local DLCI and network layer address of the remote routers. Static maps must be configured if Inverse ARP is not supported.
6. Inverse ARP messages are sent every 60 seconds.
7. LMI information is exchanged every 10 seconds.

How Service Providers Map Frame Relay DLCIs

DLCIs are numbers that identify the logical connection between the router and the Frame Relay switch. The DLCI is the Frame Relay Layer 2 address, and it is locally significant. DLCIs are usually assigned by the Frame Relay service provider. A Frame Relay router learns about a remote router's DLCI by either Inverse ARP (which is automatically enabled on Cisco routers) or by static mappings.

Configuring Frame Relay

The three commands used to configure basic Frame Relay on a router select the Frame Relay encapsulation type, establish the LMI connection, and enable Inverse ARP. The commands used are as follows:

```
encapsulation frame-relay [cisco | ietf]
frame-relay lmi-type {ansi | cisco | q933i}
frame-relay inverse-arp [protocol] [dlci]
```