# DigiPoints Volume 1

# Leader Guide

# Module 11 – Access Protocols

## Summary

This module describes the differences between access and backbone protocols, how virtual connections are established through packet switched networks, and how 1s and 0s are coded into two examples of protocol data units for access.

## Outcomes

Students who complete this lesson will be able to compare and explain how the X.25 and the Frame Relay protocols transport information across a network. The student will also be able to discuss the relative advantages and disadvantages of each. Finally, the student will know the basic difference between a backbone, network access, and LAN network.

## Objectives

Upon successful completion of the module, the student should be able to:

- Identify the three general categories of protocols.
- Describe the X.25 protocol's layers and their functionality.
- Identify the four types of network connections that X.25 uses.
- Describe the differences between Logical Channels and Virtual Circuits.
- Name and describe the different types of Virtual Circuits.
- Describe the three types of packets used by the X.25 protocol.
- Describe how X.25 handles lost packets.
- Describe how Frame Relay differs from X.25.
- Explain the use of the Control Plane and User Plane in Frame Relay.
- Describe Frame Relay's frame structure.
- Explain the two ways that Frame Relay handles congestion.

## Prerequisites

Students should have read Chapter 11 of *DigiPoints, Volume 1*.

## Length

90 minutes

## Materials/Preparation for Instructor

- One workbook per student
- Visual Aids
- Instructor should read Chapter 11 of *DigiPoints, Volume 1*.

## Supplies/Equipment

- Dry Erase Board/Markers, chalkboard or flipchart
- Masking Tape
- Pointing Tool
- Tent Cards

## Audience

The intended audience will be mid- to senior-level technicians or other associates who are seeking an understanding of digital basics.

# Module Outline

This is an introductory level module that will provide a review of the following topics:

Objectives ..... 1
Network Interface Definition ..... 2
X.25 Access Protocols ..... 3
Frame Relay ..... 7
Summary ..... 12
Appendix ..... 13

## Objectives

**EXPLAIN**

**REFER TO WB 11.1**

Tell students that when they have completed this module, they will be able to accomplish these objectives.

- Identify the three general categories of protocols.
- Describe the X.25 protocol's layers and their functionality.
- Identify the four types of network connections that X.25 uses.
- Describe the differences between Logical Channels and Virtual Circuits.
- Name and describe the different types of Virtual Circuits.
- Describe the three types of packets used by the X.25 protocol.
- Describe how X.25 handles lost packets.
- Describe how Frame Relay differs from X.25.
- Explain the use of the Control Plane and User Plane in Frame Relay.
- Describe Frame Relay's frame structure.
- Explain the two ways that Frame Relay handles congestion.

## Network Interface Definition

**ASK & DISCUSS**

***Introduction***

- What are the two classes of networks discussed?
- What is the purpose of a network?
- What type of access methods has been discussed?
- What is an access point?

  *Answer:*

  - ◊ *Access point is the user's network interface*
  - ◊ *Access point has OSI Layers 1 -3*
  - ◊ *OSI Layers 4 - 7 reside at the application*

***Use as intro and as a way to evaluate skill base of students***

**DISPLAY VA 11.1**
**DISCUSS WB 11.2**

**USE BOARD**

***Network Access Trends***

- There are numerous access protocols
- Three basic protocol categories are:
  - ◊ Backbone – Fastest, most expensive
  - ◊ Network Access
  - ◊ LAN

Ask students to sketch an oval across all bandwidths, and label it IP.

- Unlike LANs, access networks and backbones move several PDUs at once.
- Note that switched LANs are really interconnected small LANs. The segments within the switched LAN still only move one PDU at a time.
- Network Access Protocols to be discussed are:
  - ◊ X.25
  - ◊ Frame Relay

***Discuss how & why technology migrates from backbone to LANs.***

***As an example of how fast protocols evolve, note that only a couple of years ago, IP was not used enough to show on the visual aid. Now, IP is a leading standard for access, backbone and LAN applications.***

***Describe a switched LAN as discussed in this module as a way to move more PDUs within a LAN.***

## X.25 Access Protocols

- International market applications

**DISPLAY VA 11.2**
**DISCUSS WB 11.3**

### *How X.25 Works*

- Three-layer protocol
  - ◊ Physical
  - ◊ Link
  - ◊ Packet – where most work is done

***Write on board***
***Physical***
***Link***
***Packet***

### *Physical Level*

- Electrical path
- Specifies hardware
  - ◊ X.21 or X.21 bis
  - ◊ EIA 232
  - ◊ V.24 & V.28

***Using markers for overhead foil, fill in the specifics***

### *Link Level*

- Transfers data across the physical link.
- The standard is LAP-B (Link Access Protocol - Balanced).
- Links can be single or multiple.
- MLP – provides frame sequence numbers for sequence reconstruction at destination.
- DTE & DCE have specific definitions for X.25.

**DISPLAY VA 11.3**
**DISCUSS WB 11.4**

### *Packet Level*

- The packet is a specific type of PDU.
- The packet header provides OSI Layer 3 controls and information on the type of connection.
- Four types of connections are available.
  - ◊ Permanent Virtual Circuit
  - ◊ Virtual Call
  - ◊ Fast Select Call
  - ◊ Fast Select Call with Immediate Clear
- Variety of packet sizes are possible.

***Point out the need to track data at the Link Level and the Packet Level***

**DISPLAY VA 11.4**
**DISCUSS WB 11.5**

***Logical Channels & Virtual Circuits***

- Logical Channels – End user sessions
  - ◊ Multiple users (sessions) can be on one channel.
  - ◊ LCNs are assigned to track packets.
- Virtual Circuits define the end-to-end network path.
  - ◊ Dynamic allocation of resources
  - ◊ Changes from session to session
  - ◊ Multiplexing function
  - ◊ Each packet has a 12-bit virtual circuit number

***Point out how the multiplexing that occurs in virtual circuits is different from time division multiplexing.***

***Permanent Virtual Circuit (PVC)***

- Similar to leased line
- Prearranged path
- Same for every session
- Faster
- Always available

**DISPLAY VA 11.5**
**DISCUSS WB 11.6**

***Virtual Call (Switched Virtual Circuit – SVC)***

- Setup and disconnect are required.
- Once setup completed, only LCNs are needed to define connection.
- On completion, "Clear" or disconnect packets are exchanged.

***Fast Select Call***

- Used for VERY short sessions.
- Overhead is reduced.
- User information is sent with call request packets.

***Using VA 11.5, explain how the number of packets are reduced when separate call request packets are not required.***

***Fast Select Call with Immediate Clear***

- VERY short sessions, (e.g., POS, EFT).
- User information is sent with call request packet.
- Clear request is sent upon receipt of incoming packet.
- User information is contained in each.

**DISPLAY VA 11.6**
**DISCUSS WB 11.7**

### *Packet Contents*

- There are three types of X.25 packets.
  - Call Request
  - Data
  - Call Termination
- Call Request
  - GFI – Packet Sequencing
  - LCN – 12-bit number
  - Packet type
  - Calling & called address lengths
  - Actual addresses
  - Facility Field – service parameters
  - Call user data fields – password
- Data
  - GFI and LCN – to identify packet
  - Octet 3 – Indicates type packet, sequence, if more follow, and sequence number for next packet
  - USER DATA
  - 1 – 4096 octets
  - Default is 128 octets
  - May contain information from upper protocol layers
- Call Termination
  - GFI & LCN identifier
  - Packet type
  - Clear Clause
  - Diagnostic code

***Discuss each of these packets and what can be found in the octets highlighted. Note the use of the facility field to carry Quality of Service information, and point out the importance of QoS to emerging applications like IP telephony.***

**DISCUSS WB 11.8**

***Use board to discuss***

### *Handling Lost Packets*

- Call clear can complete before data packets reach their destination.
- Higher level protocols (>3) begin correction procedure.
- Reset packet reinitializes a virtual circuit and begins the recovery process.
- Restart packet reinitializes the entire packet layer – used when network has failed.

### *X.25 Summary*

- Operates in Layers 1-3 of the OSI Model.
- Upper layers, 4-7, reside with other protocols.
- Four types of connections are used.
- Typical speed is 9.6 kbps or lower.

## Frame Relay

**DISPLAY VA 11.7**
**DISCUSS WB 11.9**
**AND WB 11.10**

- Reduces delays in data transmission.
- Uses Layer 1 and 2 only within the network.
- End points handle Layer 3 and above.
- Less need for error checking because improved media transports data with less errors.
- Less overhead for error checking allows higher speed operation (e.g., 56 kbps to 45 Mbps).
- LAPD protocol evolved from designs that provided X.25 over an ISDN D Channel.

**DISPLAY 11.8**
**DISCUSS WB 11.11**

### *Control Plane & User Plane*

- LAPD defined C & U planes.
- Q.922 enhanced LAPD.
- C Plane has signaling functions common to all ISDN services.
- U Plane functionality:
  - ◊ Delimiting, alignment, transparency
  - ◊ Address field
  - ◊ Frame Integrity – length and format
  - ◊ Error detection
  - ◊ Congestion Control
- Frame relay is connection oriented.
- Preserves frame order.
- Prevents frame duplication.
- Minimizes frame loss.

### *Frame Relay Virtual Circuits*

- The X.25 Layer 3 routing functionality is in Layer 2 for Frame Relay.
- Data Link Connection Identifier (DLCI) handles the routing function.
  - ◊ Creates virtual connection
  - ◊ Default address size is 2 octets
  - ◊ Expanded address of 3 – 4 octets
  - ◊ Some bits in the octets are used for functions other than addressing
  - ◊ Connections can be PVC or VC
  - ◊ 992 end points or connections

**DISPLAY VA 11.9**
**DISCUSS**
**WB 11.12**

### *Congestion Control*

- Occurs when offered traffic exceeds network capacity.
- At A congestion is introducing delay.
- At B the congestion is high enough to degrade throughput? network shuts down.
- Two types of congestion control.
  - ◊ Explicit Signaling
  - ◊ Implicit Signaling
- Redefining three LAPD bits makes control possible.

**DISPLAY VA 11.10**

**DISCUSS WB 11.13 AND WB 11.14**

***Explicit Signaling***

- Users are requested to take action.
- BECN – Backward Explicit Congestion Notification.
  - ◊ Message is sent to receive end.
  - ◊ Advises user to reduce the rate data is sent back to sending end.
  - ◊ Reduction continues until normal conditions return.
- FECN – Forward Explicit Congestion Notification.
  - ◊ More complex.
  - ◊ Data going in SAME direction as the FECN frame is slowed.
  - ◊ FECN is dependent on higher level protocols communicating to sending end.
  - ◊ Originating end slows down data transfer rate.

***Use the board to make the point of which end will slow transmission rates.***

***Refer to VA 11.10. Point out FECN & BECN***

**DISCUSS WB 11.15**

***Implicit Signaling***

- Network switches discard packets to avoid congestion.
- Senders are advised by upper layer protocols.
- DE bits set by sender to aid in process.
- CIR (Committed Information Rate) is a guaranteed data rate.
- Frame handler can set DE bit to discard bits when CIR is exceeded.

***Point out DE bit location on VA 11.10.***

### *Frame Structure*

- Flag – beginning and end of frame.
- Address Field
  - ◊ DLCI here
  - ◊ Default length is 2 octets – maximum of 4 octets
  - ◊ Vendor defined Command/Response (C/R) bit
- Frame Relay Information Field
  - ◊ Higher layer user information
  - ◊ Up to 8189 octets
  - ◊ Data need not be segmented in separate frames in network
- Frame Check Sequence
  - ◊ Two octets – 16 bits
  - ◊ Cyclic Redundancy Check (CRC) performed here to verify transmission integrity

### *Special Conditions*

- Transparency
  - ◊ Zero bit insertion to avoid confusion with frame flags
- Frame Abort
  - ◊ Seven or more 1 bits – data link ignores the frame
- Invalid Frames
  - ◊ Insufficient flags
  - ◊ Fewer than 5 octets between flags
  - ◊ Partial octets in frame
  - ◊ CRC error
  - ◊ Address field only 1 octet long
  - ◊ DLCI not supported

### *Frame Relay Summary*

- More efficient than X.25
- Faster
- Assumes reliable transmission medium
- Operates at Layer 2 of OSI Model
- Less delay on network

## Summary

**DISPLAY VA 11.11**
**DISCUSS WB 11.16**

***Review these items***

- Network protocols can be backbone, network access, or LAN protocols.
- Review X.25 protocol key points.
  - ◊ OSI Layers 1 – 3
  - ◊ Four types of connections
  - ◊ 9.6 kbps access speeds
  - ◊ Error correction at switches
  - ◊ Logical Channels & Virtual Circuits
  - ◊ Call Request, Data, and Call Termination Packets
  - ◊ Restart vs. Reset
- Review Frame Relay key points.
  - ◊ OSI Layers 1 – 2
  - ◊ Faster
  - ◊ No error checking
  - ◊ 56 kbps to 45 Mbps
  - ◊ Control Plane & User Plane
  - ◊ Virtual Circuits
  - ◊ Frame Structure: Flag, Address, Information Check Sequence, Flag
  - ◊ Congestion Control: Explicit and Implicit
  - ◊ DLCI, FECN, BECN, DE, CIR

**REFER TO WB 11.17 AND WB 11.18**

Have students answer the study questions at the end of Module 11. Review the answers.

***Answers in Appendix***

## Appendix

***Answers to the questions at end of student workbooks.***

1. What is a Switched Virtual Circuit? How does it differ from a Permanent Virtual Circuit?

   *A switched virtual circuit is a logical connection through a network, with a path that is different for every session or call. A permanent virtual circuit is also a logical connection through a network, but the path through the network is the same for each session or call. The term virtual is used because the entire connection is set up in software, and any given part of the data path is only connected when data units are on that segment of the path.*

2. Describe in detail the way a Switched Virtual Circuit (Virtual Call) is set up under X.25.

   *A virtual call works like a telephone connection, in that it requires a setup and a disconnect procedure, in addition to the transfer of user information. This setup and disconnect is accomplished by specially formatted call packets. The transmitting user initially sends a call request packet, which is acknowledged or denied, by the receiving station. The call request packet contains the Logical Channel Number that was chosen by the originating user's data terminal equipment (DTE). Similarly, on the other side of the interconnecting network, an incoming call packet indicates a call coming into the receiving user's data terminal equipment on the Logical Channel Number that was assigned by the receiver's DTE. The receiving end DTE sends a call accepted (or call denied) packet in response, and on the transmitting side of the network, the transmitting DTE sees a call connected packet. Although the initial call request and incoming call packets need address information, after they have been exchanged, the Logical Channel Numbers contain all the information needed to perform the routing for subsequent packets.*

   *Once the call path has been established, data packets can be exchanged. After the data exchange is complete, a set of call clear packets disconnects the path.*

©SCTE

3. What are the differences in the way calls are routed through a network in Frame Relay and X.25?

*In Frame Relay, any use of Layer 3 and above is limited to the end points of the network. Furthermore, flow control and error control are also limited to the end points of the network, known as the user interface. With less time spent going up and down the protocol stack at every switch in the backbone and avoiding some error and flow control, the throughput of the network is increased. Delays in data transmission through a network went from 200 milliseconds for X.25 to about 20 milliseconds for frame relay.*

4. How are calls multiplexed in Frame Relay?

*Calls are multiplexed using the address field in the U plane of layer 2. Frame relay connections are set up using the DLCI fields in the address part of the frame. Multiple logical frame relay connections can be multiplexed over a single physical channel, if each logical connection has a different DLCI field.*

5. How do access and backbone protocols differ?

*Access protocols operate as part of the network interface to the end user, and therefore regulate data closer to the end user than backbone protocols. They are typically slower than backbone protocols because of the need for more error correction. Also, backbone protocols regulate the data of more users than access protocols. This allows costs of new development to be spread over a greater base of users, facilitating earlier introduction of new technologies.*

6. Describe the four types of possible connections in an X.25 network.

*The four types of connection in a X.25 network are Permanent Virtual Circuit, Virtual Call or Switched Virtual Circuit, Fast Select Call, and Fast Select Call with Immediate Clear. Permanent Virtual Circuit connections establish the same path through a network on each session or call. The path is specified when the network is set up and can only be changed by the network administrator. Virtual Calls establish a path through the network that may differ with each data session. This is done with a series of protocol data units for call setup, sending data, and call clear. (See the answer to 2 above.) Fast Select Call works like a virtual call, except that the call setup PDU carries user data. Fast Select Call with Immediate Clear also uses a setup PDU with user data, but immediately sends a clear request packet, which contains more user data, back to the sender.*

7. How does the DLCI in Frame Relay differ from an X.25 virtual circuit number? In what ways is it the same?

   *The DLCI is part of an addressing scheme that operates at Layer 2 of the OSI model, while the X.25 virtual circuit number operates at Layer 3. Both the DLCI and the X.25 virtual circuit number are used to route data from a source to a destination. Both have only local significance (not end to end). Both are a means of implementing multiplexing of data connections over one physical link.*

8. What is the purpose of the Committed Information Rate in Frame Relay?

   *The Committed Information Rate, or CIR, is the maximum data rate that is guaranteed to be sent across the Frame Relay network. Although data rates above the CIR may be sent (and quite often are), there is no guarantee that data at these rates will go through. This is one method of controlling network congestion.*