X.25

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X.25 Overview
X.25 Protocol Layers
X.25 Physical Layer
X.25 Frame Level: LAPB
X.25 Packet Level
Call Setup/Disconnection
X.25 Overview

- First packet switching interface.
- Data Terminal Equipment (DTE) to Data Communication Equipment (DCE) interface ⇒ User to network interface (UNI)
- Used universally for interfacing to packet switched networks

\[ \text{Your Computer} \rightarrow \text{X.25} \rightarrow \text{DTE} \rightarrow \text{DCE} \rightarrow \text{DCE} \rightarrow \text{DCE} \rightarrow \text{DCE} \rightarrow \text{DCE} \rightarrow \text{X.25} \rightarrow \text{DTE} \rightarrow \text{Your Computer} \]
Virtual Circuits

- Virtual Call
- Two Types of Virtual Circuits:
  - Switched virtual circuit (SVC)
    Similar to phone call
  - Permanent virtual circuit (PVC)
    Similar to leased lines
- Up to 4095 VCs on one X.25 interface
**X.25 Protocol Layers**

- X.21 often replaced by EIA-232 (RS-232C)
- LAP-B = Link access procedure - Balanced
- Packet layer = Connection-oriented transport over virtual circuits
Protocol Layers (Cont)

- X.25 Packets
- Data is broken into blocks
- 3- or 4-byte packet header
- Packets are broken into LAPB frames
X.25 Physical Layer

- Electrical and mechanical specifications of the interface
- X.21 = 15-pin digital recommendation
- X.21bis = X.21 twice = X.21 second
  - Interim analog specification to allow existing equipment to be upgraded.
  - Now more common than X.21 ⇒ X.21 Rev 2
- RS-232-C developed by Electronics Industries Association of America (EIA) is most common
  - Uses 25-pin connector. Commonly used in PCs.
HDLC Family

- Synchronous Data Link Control (SDLC): IBM
- High-Level Data Link Control (HDLC): ISO
- Link Access Procedure-Balanced (LAPB): X.25
- Link Access Procedure for the D channel (LAPD): ISDN
- Link Access Procedure for modems (LAPM): V.42
- Link Access Procedure for half-duplex links (LAPX): Teletex
- Point-to-Point Protocol (PPP): Internet
- Logical Link Control (LLC): IEEE
- Advanced Data Communications Control Procedures (ADCCP): ANSI
- V.120 and Frame relay also use HDLC
HDLC

- Primary station: Issue commands
- Secondary Station: Issue responses
- Combined Station: Both primary and secondary
- Unbalanced Configuration: One or more secondary
- Balanced Configuration: Two combined station
- Normal Response Mode (NRM): Response from secondary
- Asynchronous Balanced Mode (ABM): Combined Station
- Asynchronous Response Mode (ARM): Secondary may respond before command
LAPB

- Uses balanced mode subset of HDLC between DTE and DCE
- Uses 01111110 as frame delimiter
  - Uses bit stuffing to avoid delimiters inside the frames
- Uses HDLC frame format
- Point-to-point: Only two stations - DTE (A), DCE (B)
  - Addresses: A=00000011, B=00000001
  - Address = Destination Addresses in Commands
  - Source Address in Responses,

<table>
<thead>
<tr>
<th>Flag</th>
<th>Address</th>
<th>Control</th>
<th>Info</th>
<th>FCS</th>
<th>Flag</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>8b</td>
<td>8b</td>
<td>8 or 16b</td>
<td>nb</td>
<td>16b</td>
<td>8b</td>
<td></td>
</tr>
</tbody>
</table>

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### Control Field Format

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information</strong></td>
<td>0</td>
<td>N(S)</td>
<td>P/F</td>
<td>N(R)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supervisory</strong></td>
<td>1</td>
<td>0</td>
<td>S</td>
<td>P/F</td>
<td>N(R)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unnumbered</strong></td>
<td>1</td>
<td>1</td>
<td>M</td>
<td>P/F</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **N(S)** = Send Sequence Number
- **N(R)** = Receive Sequence Number = Expected next
- **P/F** = Poll/Final = Command/Response
- **M** = Set Async Balanced Mode (SABM), Disconnect, Unnumbered Ack, …
- **S** = Supervisory function = Receiver Ready (RR), Receiver Not Ready (RNR), Reject (Rej)
HDLC Frames

- **Information Frames: User data**
  - Piggybacked Acks: Next frame expected
  - Poll/Final = Command/Response
- **Supervisory Frames: Flow and error control**
  - Go back N and Selective Reject
  - Final $\Rightarrow$ No more data to send
- **Unnumbered Frames: Control**
  - Mode setting commands and responses
  - Information transfer commands and responses
  - Recovery commands and responses
  - Miscellaneous commands and responses
Examples of HDLC Operation

- **(a) Line setup and disconnect**
- **(b) Two-way data exchange**
- **(c) Busy condition**

Fig 6.12 Stallings
Examples of Operation (Cont)

(d) Reject Recovery

(e) Timeout Recovery

Fig 6.12 Stallings
X.25 Packet Level

- Packet Level = End-to-end
- Packet level procedures:
  - Establishment and clearing of virtual calls
  - Management of PVCs
  - Flow Control
  - Recovery from error conditions
Call Setup/Disconnection

- Call Request
- Incoming Call
- Call Connected
- Call Accepted
- Data
- Data
- Data
- Clear Request
- Clear Indication
- Clear Confirmation
- Clear Confirmation

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## Packet Format

<table>
<thead>
<tr>
<th>4b</th>
<th>4b</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Format Identifier</td>
<td>Logical Channel Group #</td>
</tr>
<tr>
<td>Logical Channel Number</td>
<td>Packet Type Identifier</td>
</tr>
</tbody>
</table>

- **GFI** = Type of packet.
  - Bit 1: Qualifier. Q=1 ⇒ Higher level control
  - Bit 2: 0⇒End-to-end confirm., 1⇒Local conf.
  - Bits 3,4: 01⇒3-bit or 10⇒7-bit sequence #
- **LCGN + LCN** = 12-bit VC # w 4-bit Group
- **PTI** = 20 possible packet types
Packet Format (Cont)

<table>
<thead>
<tr>
<th>Q</th>
<th>D</th>
<th>0</th>
<th>1</th>
<th>Group #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Channel #</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>User Data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q</th>
<th>D</th>
<th>0</th>
<th>1</th>
<th>Group #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Channel #</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P(S)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>User Data</td>
</tr>
</tbody>
</table>

- Q: Data w 3-bit Seq #
- D: Data w 7-bit Seq #

- M = More segments
- P(R) and P(S) refer to packet sequence #
  Different from N(R) and N(S) - frame sequence #
RR, RNR, and REJ packets with 3-bit seq #

RR, RNR, and REJ packets with 7-bit seq #
Summary

- X.21, LAPB
- PVC and virtual call
- VC numbers
- M and D bits
Homework

- Read pages 61-65 of Black’s “Emerging Technologies” book
- Submit answer to the following question: In X.25 why is the VC number used by one station different from the VC number used by the other station? After all, it is the same full-duplex virtual circuit.
- Due Date: April 13, 1999
Additional References