X.25

- 1976
- Interface between host and packet switched network
- Almost universal on packet switched networks and packet switching in ISDN
- Defines three layers
  - Physical
  - Link
  - Packet

X.25 - Physical

PAD

- Interface between attached station and link to node
- Data terminal equipment DTE (user equipment)
- Data circuit terminating equipment DCE (node)
- Uses physical layer specification X.21
- Reliable transfer across physical link
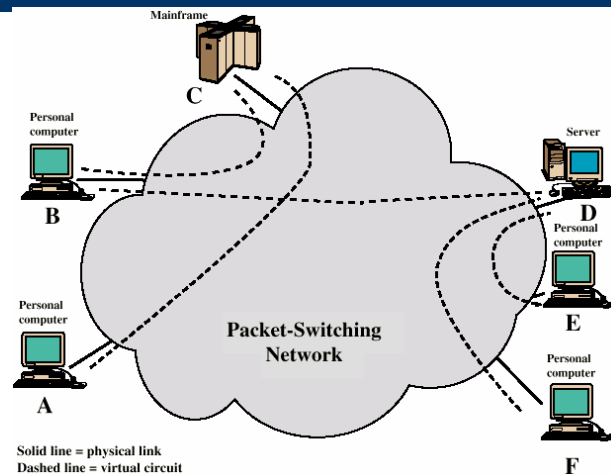- Sequence of frames

X.25 - Link

- Link Access Protocol Balanced (LAPB)
  - Subset of HDLC
  - see chapter 7

X.25 - Packet

- External virtual circuits
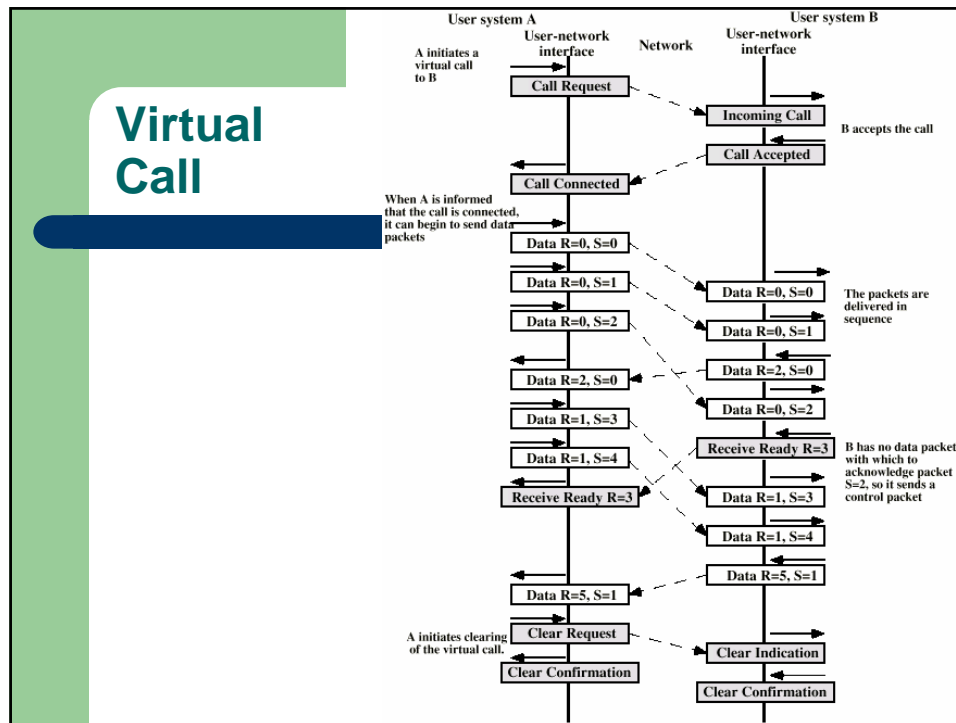- Logical connections (virtual circuits) between subscribers
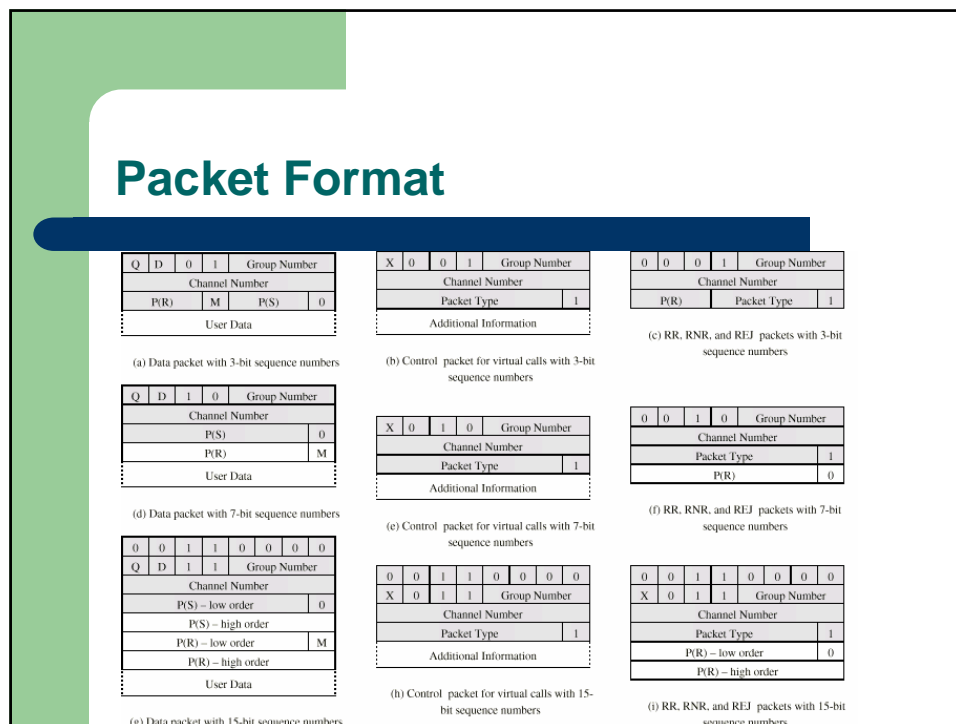
X.25 Use of Virtual Circuits

Virtual Circuit Service

- Virtual Call
  - Dynamically established
- Permanent virtual circuit
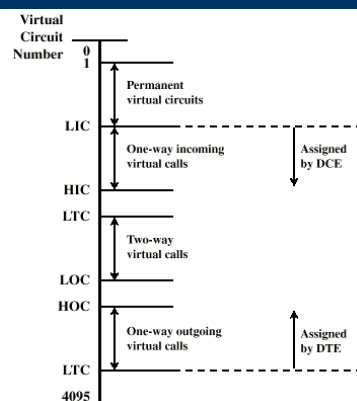 - Fixed network assigned virtual circuit

Virtual Call

User system A User-network interface Network User system B User-network interface

A initiates a virtual call to B

Call Request
Incoming Call → B accepts the call
Call Accepted
Call Connected

When A is informed that the call is connected, it can begin to send data packets

Data R=0, S=0
Data R=0, S=1
Data R=0, S=0 → The packets are delivered in sequence
Data R=0, S=2
Data R=0, S=1
Data R=2, S=0
Data R=2, S=0
Data R=1, S=3
Data R=0, S=2
Data R=1, S=4
Receive Ready R=3 → B has no data packet with which to acknowledge packet S=2, so it sends a control packet
Receive Ready R=3
Data R=1, S=3
Data R=1, S=4
Data R=5, S=1
Data R=5, S=1

A initiates clearing of the virtual call.
Clear Request
Clear Indication
Clear Confirmation
Clear Confirmation

Packet Format

Q	D	0	1	Group Number
Channel Number				
P(R)	M	P(S)		0
User Data				

(a) Data packet with 3-bit sequence numbers

X	0	0	1	Group Number
Channel Number				
Packet Type				1
Additional Information				

(b) Control packet for virtual calls with 3-bit sequence numbers

0	0	0	1	Group Number
Channel Number				
P(R)		Packet Type		1

(c) RR, RNR, and REJ packets with 3-bit sequence numbers

Q	D	1	0	Group Number
Channel Number				
P(S)				0
P(R)				M
User Data				

(d) Data packet with 7-bit sequence numbers

X	0	1	0	Group Number
Channel Number				
Packet Type				1
Additional Information				

(e) Control packet for virtual calls with 7-bit sequence numbers

0	0	1	0	Group Number
Channel Number				
Packet Type				1
P(R)				0

(f) RR, RNR, and REJ packets with 7-bit sequence numbers

0	0	1	1	0	0	0	0
Q	D	1	1	Group Number			
Channel Number							
P(S) – low order							0
P(S) – high order							
P(R) – low order							M
P(R) – high order							
User Data							

(g) Data packet with 15-bit sequence numbers

0	0	1	1	0	0	0	0
X	0	1	1	Group Number			
Channel Number							
Packet Type							1
Additional Information							

(h) Control packet for virtual calls with 15-bit sequence numbers

0	0	1	1	0	0	0	0
X	0	1	1	Group Number			
Channel Number							
Packet Type							1
P(R) – low order							0
P(R) – high order							

(i) RR, RNR, and REJ packets with 15-bit sequence numbers

Multiplexing

- DTE can establish 4095 simultaneous virtual circuits with other DTEs over a single DTC-DCE link
- Packets contain 12 bit virtual circuit number

Virtual Circuit Numbering

Virtual Circuit Number

0
1

Permanent virtual circuits

LIC

One-way incoming virtual calls — Assigned by DCE

HIC
LTC

Two-way virtual calls

LOC
HOC

One-way outgoing virtual calls — Assigned by DTE

LTC

4095

LIC = Lowest incoming channel   HTC = Highest two-way channel   Virtual circuit number =
HIC = Highest incoming channel   LOC = Lowest outgoing channel   logical group number and
LTC = Lowest two-way channel   HOC = Highest outgoing channel   logical channel number

Packet Sequences

- Complete packet sequences
- Allows longer blocks of data across network with smaller packet size without loss of block integrity
- A packets
  - M bit 1, D bit 0
- B packets
  - The rest
- Zero or more A followed by B

Reset and Restart

- Reset
  - Reinitialize virtual circuit
  - Sequence numbers set to zero
  - Packets in transit lost
  - Up to higher level protocol to recover lost packets
  - Triggered by loss of packet, sequence number error, congestion, loss of network internal virtual circuit
- Restart
  - Equivalent to a clear request on all virtual circuits
  - E.g. temporary loss of network access