X.25

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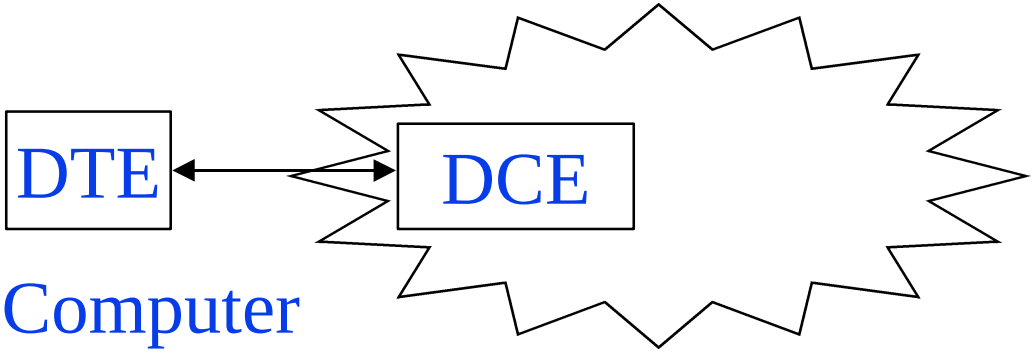
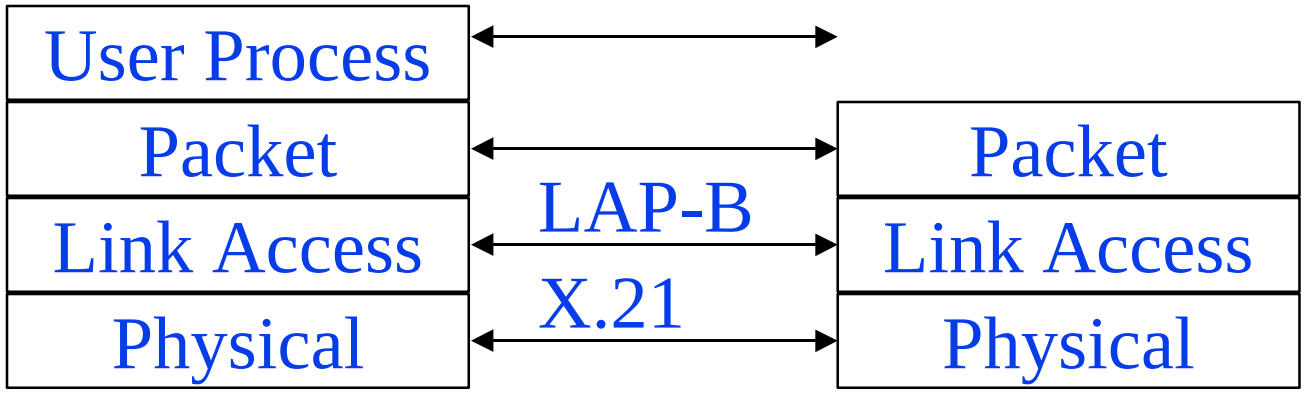
- Protocol layers
- Packet types and format
- Virtual call
- Multiplexing
- Flow, error control, segmentation, and reassembly

X.25

- First packet switching interface.
- Issued in 1976 and revised in 1980, 1984, 1988, and 1992.
- Data Terminal Equipment (DTE) to Data Communication Equipment (DCE) interface ⇒ User to network interface (UNI)
- Used universally for interfacing to packet switched networks



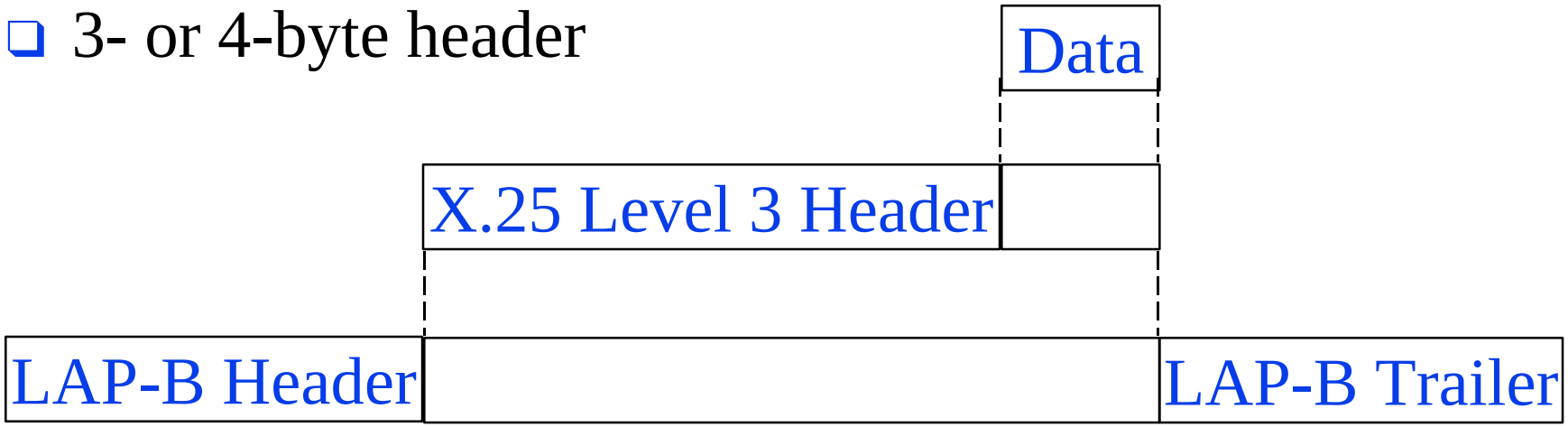
X.25 Protocol Layers



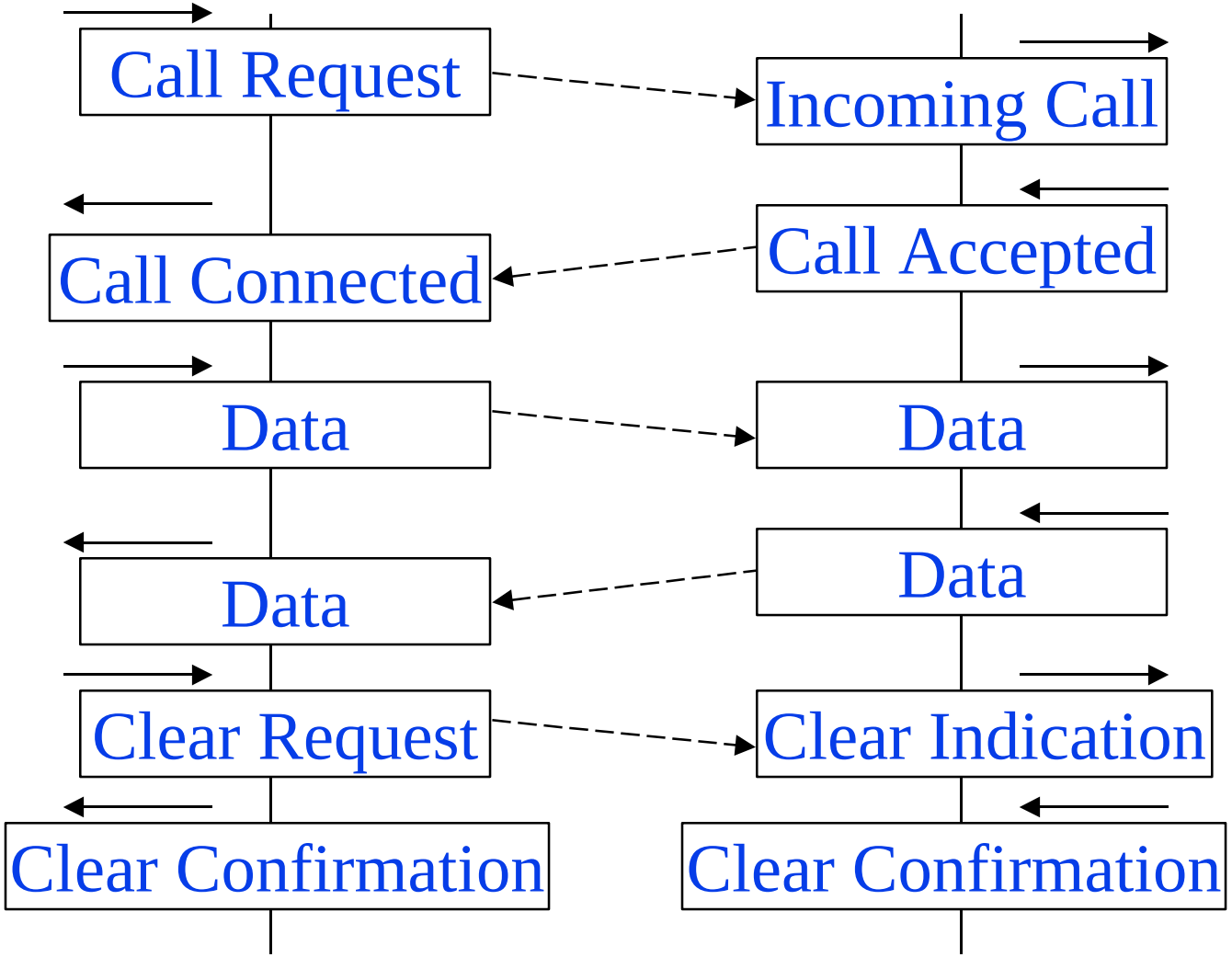
- X.21 often replaced by EIA-232 (RS-232C)
- LAP-B = Link access procedure - Balanced
- Packet layer = Connection-oriented transport over virtual circuits

Virtual circuit service

- Virtual call
  = Switched virtual circuit (SVC)
- Permanent virtual circuit (PVC)
- X.25 Packets
- Data is broken into blocks
- 3- or 4-byte header



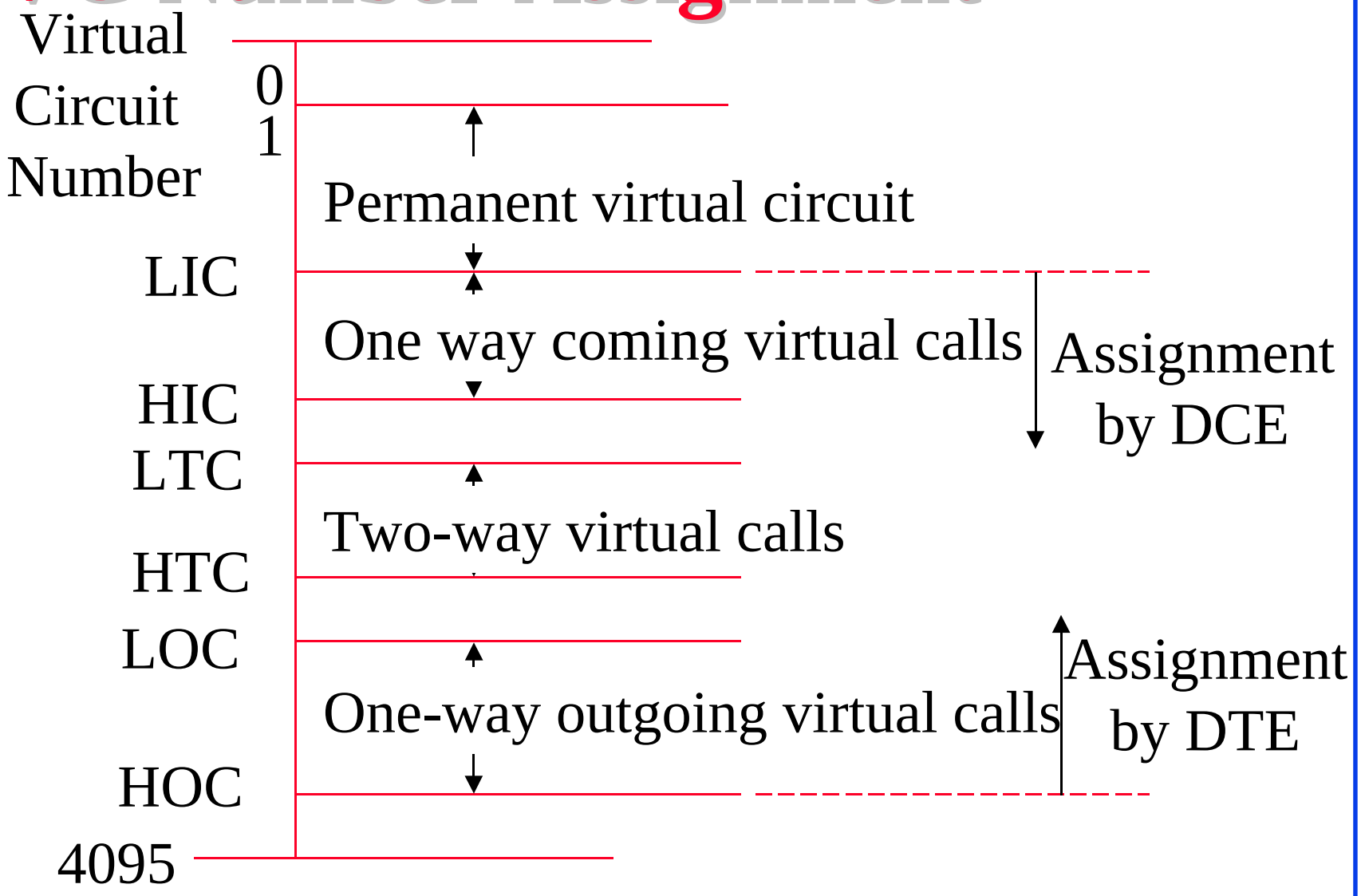
Events


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

Multiplexing

- Allows up to 4095 simultaneous VCs over one physical DTE-DCE link
- All VCs are full-duplex (bi-directional)
- Each packet contains a 12-bit VC number = 4-bit group + 8-bit channel

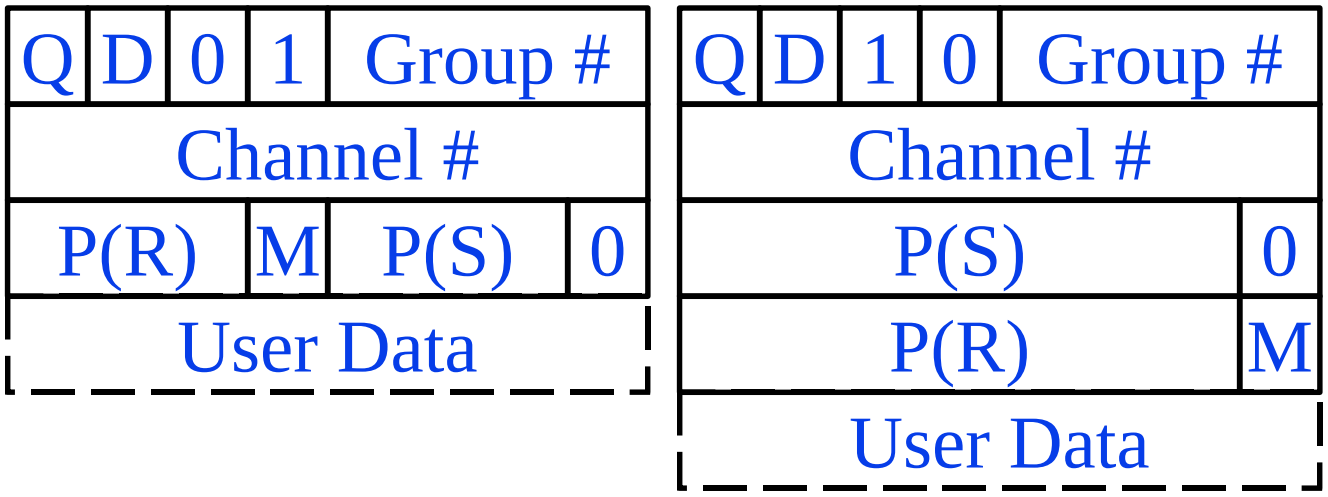
VC Number Assignment



VC Assignment (Cont)

- Lowest incoming channel (LIC)
- Highest incoming channel (HIC)
- Lowest two way channel (LTC)
- Highest two way channel (HTC)
- Lowest outgoing channel (LOC)
- Highest outgoing channel (HOC)
- Virtual Circuit Number
  = Logical Group # and Logical Channel #

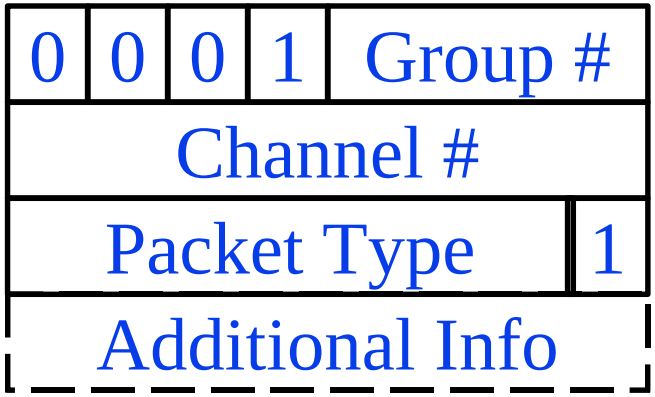
Packet Format



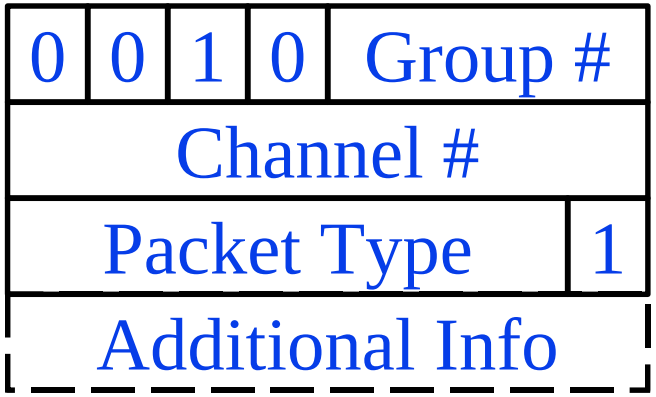
Data w 3-bit Seq # Data w 7-bit Seq #

- Q bit not defined. Allows users to have two classes of packets.
- M and D bits used for segmentation and acknowledgment

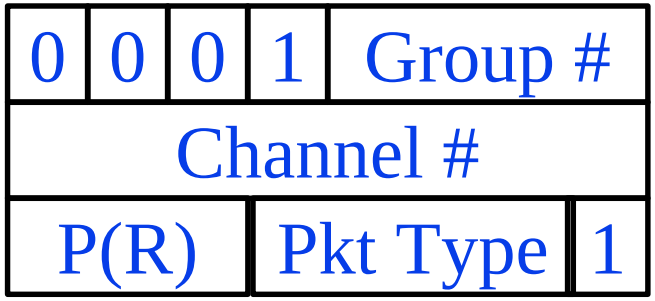
Packet Format (Contd)



Control w 3-bit Seq #



Control w 7-bit Seq #



RR, RNR, and REJ packets with 3-bit seq #

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

Flow and Error Control

- Link Access Protocol - Balanced (LAPB)
- Balanced ⇒ Both stations combined
- 3- or 7-bit sequence numbers
- 3-4th bits of X.25 header =
  01 ⇒ 3-bit sequence number
  10 ⇒ 7-bit sequence number
- Each VC has separate sequence number
- D=0 packets are acked by local DCE
- D=1 packets are acked by remote DTE (end-to-end ack)

Segmentation and Ack

- X.25 allows segmenting large packets into smaller packets inside the network
- A Packet: First and intermediate blocks
- B Packet: Last block
- M = 1 $\Rightarrow$ Additional segments to follow
- D = 1 $\Rightarrow$ end-to-end acknowledgment required from receiving DTE to sending DTE
- M = 1 and D = 0 $\Rightarrow$ A packet
- All others $\Rightarrow$ B packet
- Segments can be further segmented or combined inside the network

X.25 Packet Sequences

EXAMPLE PACKET SEQUENCES

Original seq.			Combined seq.		
Pkt type	M	D	Pkt type	M	D
A	1	0			
A	1	0	A	1	0
A	1	0			
A	1	0	A	1	0
A	1	0			
B	0	1	B	0	1
			Segmented seq		
B	0	0	A	1	0
			B	0	0

Packet Sequences (Contd)

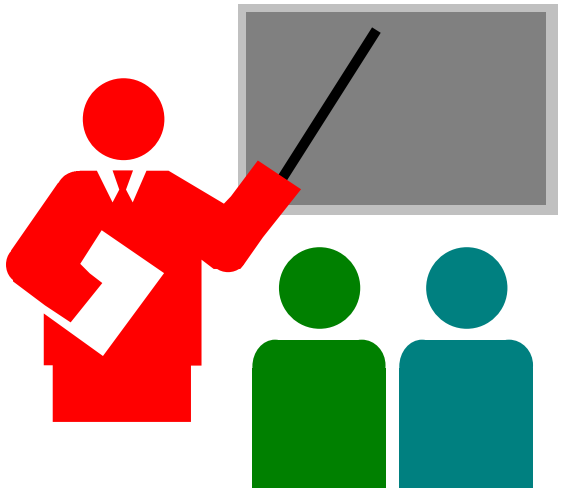
Example Packet Sequences with Intermediate End-to-end Acks

Pkt type	M	D	
A	1	0	
A	1	0	*
A	1	0	
B	1	1	
A	1	0	
A	1	0	*
B	1	1	
A	1	0	
A	1	0	*
A	1	0	
B	0	1	

end of sequence

* Groups of packets that can be combined

Summary



- X.21, LAPB
- PVC and virtual call
- VC numbers
- A and B packets
- M and D bits