# X.25

CCITT´s Packet Switching Technology

## Agenda

- **Overview, Principles and Standards**
- **X.25 Data Link Layer**
- **X.25 Network Layer**
  - Services and Packet Types
  - Call Setup and Release
  - Data Transfer and Flow Control
  - Reset and Restart
- **X.25 Packet Format**
- **X.25 PAD**







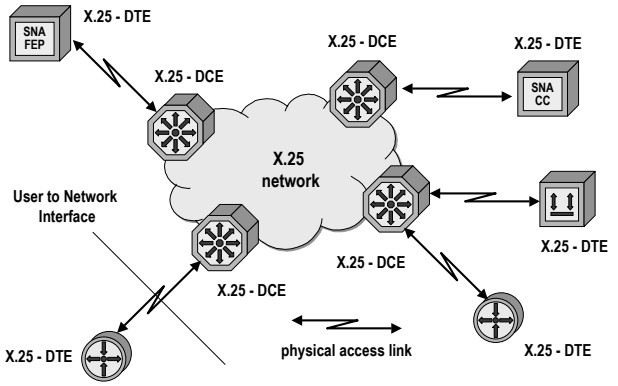


## What is X.25?

- **packet switching technology**
  - based on store-and-forward of packets
  - connection oriented
- **interface definition between user and network equipment**
  - X.25 - DTE (e.g. router) <–> X.25 - DCE (packet switch)
- **wide area network service**
  - based on virtual circuit technique
- **operation within X.25 network cloud**
  - switch to switch communication not standardized
  - vendor specific implementation



## X.25 Topology



## X.25 Virtual Circuits/LCN

- **virtual circuit technique**
  - for statistically multiplexing many logical data conversations over a single physical transmission link
  - end systems (X.25-DTE) use virtual circuits for delivering data to the X.25 network and vice versa
  - virtual circuits appear to end systems as transparent transport pipes (logical point-to-point connections)
- **virtual circuits (VCs) are identified using LCN numbers**
  - logical channel number (LCN)
  - LCN are of local significance only

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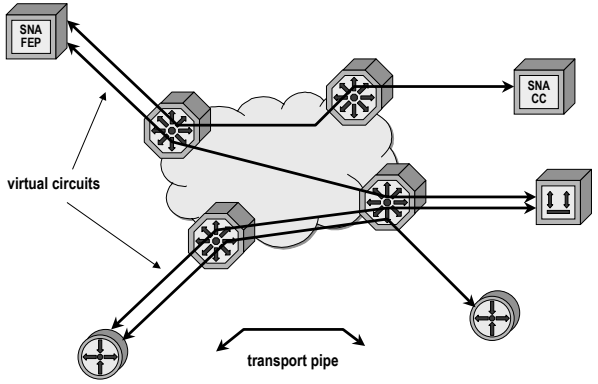
## X.25 Virtual Circuits

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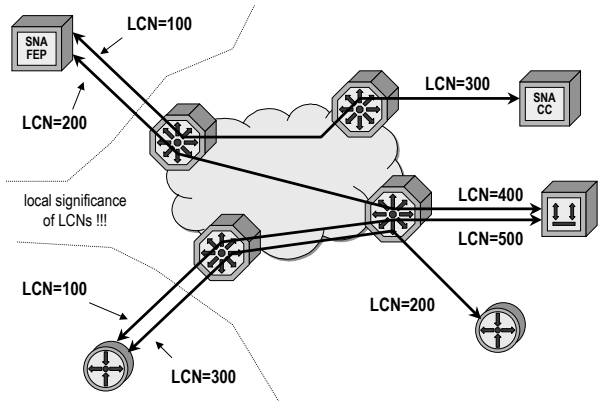
## Logical Channel Number (LCN)

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## Types of Virtual Circuits

- **two kinds of virtual circuits**
  - permanent virtual circuits (PVC) established in advance by service provider
  - switched virtual circuits (SVC) established on demand by user through signaling procedure

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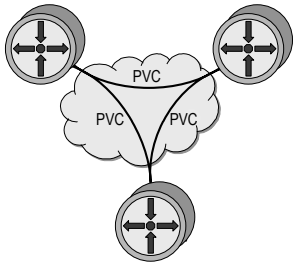
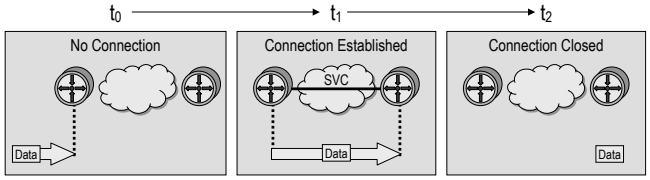
## Permanent Virtual Circuit (PVC)

- **static connection between two end devices**
- **functionally equivalent to dedicated leased lines**
- **but remember**
  - store and forward technology
  - variable delays



## Switched Virtual Circuit (SVC)




- **dynamic connection setup and tear down between two end devices**
- **similar to dial up circuits in that they provide bandwidth on demand**



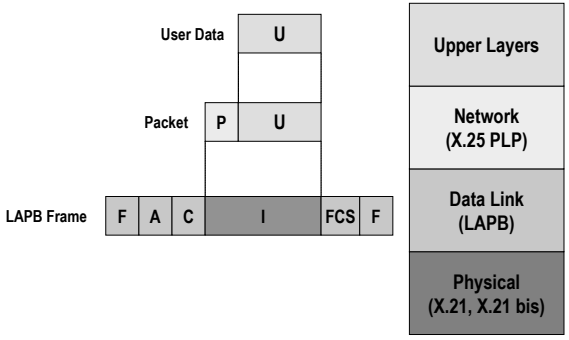


## Roots of X.25

- **originally defined by CCITT**
  - as an interface between user equipment and public switched data network
  - three layers covered
    - X.21 (physical layer)
    - LAPB (data link layer)
    - X.25 (network layer)
  - different versions:
    - four years cycle
    - 1980 (yellow books), 1984 (red books), 1988 (blue book), ...
- **X.25 definitions were expanded by ISO**
  - for provisioning the Connection Mode Network Service (layer 3) in OSI based networks

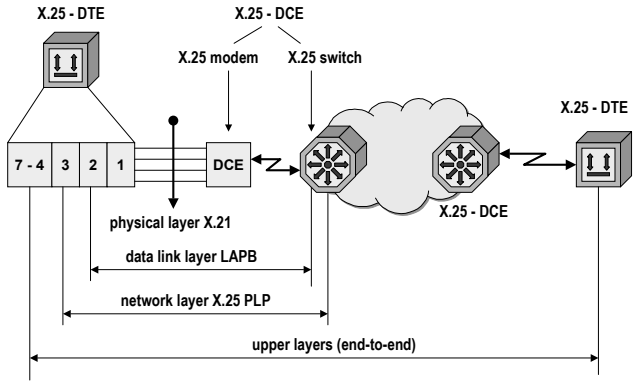
 

## X.25 Layers (CCITT)



## X.25 Interface (CCITT)

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## X.25 and related Standards

- **X.25 specifies layer 1-3 protocol stack between**
  - X.25-DTE and X.25-DCE
  - interface specification
  - only a point-to-point protocol
  - no end-to-end protocol (DTE to DTE)
- **physical layer (1) standards**
  - CCITT X.21, X.21bis (based on V.24)
- **data link layer (2) standards**
  - ISO 7776 LAPB
  - ISO 8802-2 Logical Link Control (LANs)
  - ITU-T Q.921 LAPD (X.25 over ISDN-D Channel)

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## X.25 and related Standards

- **network layer (3) standards**
  - CCITT X.25 L3 (ISO 8208 Packet Level Protocol PLP)
  - CCITT X.121 X.25 Addressing
  - ISO 8348 Network Service Definition
    - Connection Mode Network Service
      OSI use of X.25, Quality of Service QoS
    - Addendum1: NSAP-address
    - Addendum2: Connectionless Mode Network Service
      (-> ISO 8473 CLNP Connectionless Network Layer Protocol)
  - ISO 8880-2 Provisioning and Support of the Connection Mode Network Service
    - ISO 8881 X.25 PLP over LANs
    - ISO 9574 X.25 PLP over ISDN

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## X.25 Facts

- **remember:**
  - X.25 standards defines communication between DTE and DCE only
  - operation (e.g. routing) within network not defined
  - only sequencing must be guaranteed
  - X.25 uses statistical multiplexing
- **X.25 technology was developed for low quality, low speed lines**
  - use error recovery and flow control on layer 2 to control transmission of frames over physical line
  - use flow control and optionally error recovery on layer 3 to control transmission of packets over a virtual circuit

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## Why X.25?

- **it is a widely used interface standard**
  - off-the-shelf hardware and software readily available
  - mature technology (long experience)
- **X.25 network services worldwide available**
- **because of error recovery**
  - X.25 can be used on low quality lines
  - X.25 provides a reliable transport pipe
- **because of flow control**
  - X.25 network can control and even stop traffic from the user (DTE) in order to prevent congestion in the network
- **provides high support of accountability**



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- **X.25 Network Layer**
  - Services and Packet Types
  - Call Setup and Release
  - Data Transfer and Flow Control
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- **X.25 Packet Format**
- **X.25 PAD**





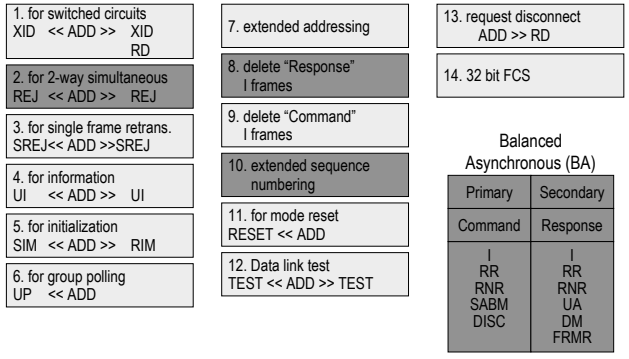


## X.25 Data Link Layer

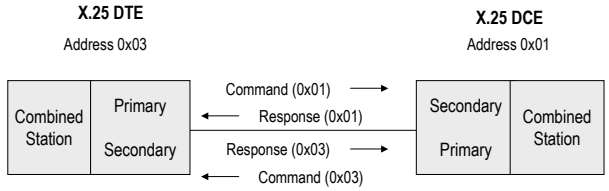
- **Link Access Procedure Balanced (LAPB)**
  - subset of HDLC
    - connection oriented service
    - ABM plus functional extensions (BA 2,8 or 2,8,10)
    - both stations are combined stations
      - can transmit commands and responses at any time
      - commands and responses can be distinguished using address field
    - specific addresses used
      - subscriber DTE must be binary 00000011
      - network node DCE must be binary 00000001
  - X.25 packets are carried within information field of LAPB I-frame
    - LAPB and X.25 use independent sequencing



## LAPB and HDLC



## LAPB Addressing



## LAPB and the Control Field

| Format | Encoding | | | | | | | | Command | Response |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | |
| Information | 0 | - | N(S) | - | | - | N(R) | - | I | I |
| Supervisory | 1 | 0 | 0 | 0 | * | - | N(R) | - | RR | RR |
| | 1 | 0 | 0 | 1 | * | - | N(R) | - | REJ | REJ |
| | 1 | 0 | 1 | 0 | * | - | N(R) | - | RNR | RNR |
| Unnumbered | 1 | 1 | 0 | 0 | P | 0 | 1 | 0 | DISC | |
| | 1 | 1 | 0 | 0 | F | 1 | 1 | 0 | | UA |
| | 1 | 1 | 1 | 0 | F | 0 | 0 | 1 | | FRMR |
| | 1 | 1 | 1 | 1 | F | 0 | 0 | 0 | | DM |
| | 1 | 1 | 1 | 1 | P | 1 | 0 | 0 | SABM | |







## Usage of the P/F bit

- **specific procedures with LAPB**
  - station receiving SABM/SABME, DISC, Supervisory or I frame with P set must set F in the next response
  - P = 1 is used to request a status response only
- **conventions**

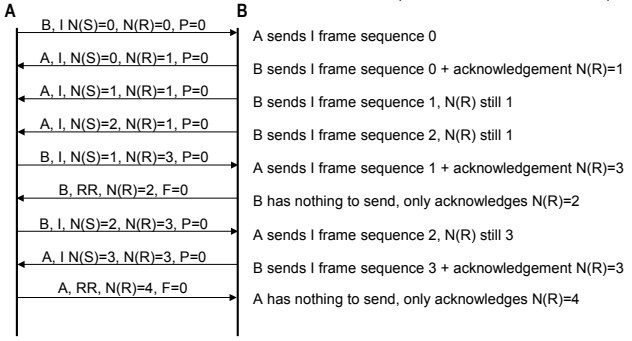
| command sent with P bit set: | response required with F bit set: |
|---|---|
| SABM/SABME, DISC | UA, DM |
| I (information transfer) | RR, REJ, RNR, FRMR |
| I (disconnect mode) | DM |
| supervisory (RR, RNR, REJ) | RR, REJ, RNR, FRMR |

## LAPB Example

- **normal data transfer**

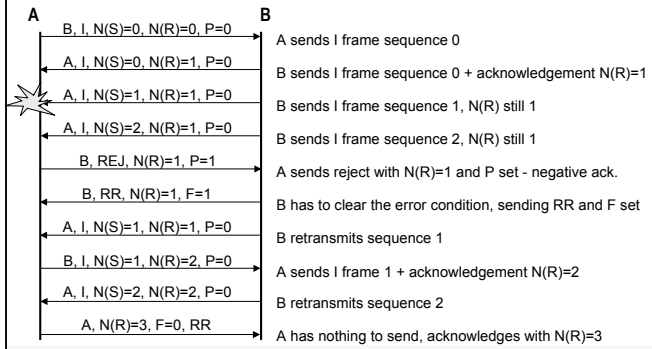
note: all I frames are commands (address of other station is used)



## LAPB Example

- **error recovery with reject**



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- **X.25 PAD**







## X.25 Network Layer

- **X.25 offers virtual circuit services**
- **virtual circuits are identified by logical channel numbers (LCN)**
  - LCN value range: 0 - 4095 (0 reserved for diagnostics)
  - distinguish virtual circuits on one physical link
  - local between DTE and DCE
- **one physical link may contain up to 4095 logical channels**
  - permanent virtual circuit - PVC
    - predefined channel
  - switched virtual circuit
    - established using call setup procedures



## X.25 Network

- **virtual circuit services are responsible for**
  - establishing and clearing of virtual circuits
    - call setup and release
    - necessary for SVC only
  - transfer of data packets
  - transfer of precedence data packets
    - interrupt data
  - flow control
  - reset of virtual circuit(s)
- **necessary protocol procedures are implemented using different types of X.25 packets**

## X.25 Packet Types

| Packet Type | | Service | |
|---|---|---|---|
| **From DCE to DTE** | **From DTE to DCE** | **SVC** | **PVC** |
| Call Setup and Clearing | | | |
| **Incoming Call** | **Call Request** | **X** | |
| **Call Connected** | **Call Accepted** | **X** | |
| **Clear Indication** | **Clear Request** | **X** | |
| **DCE Clear Confirmation** | **DTE Clear Confirmation** | **X** | |
| Data and Interrupt | | | |
| **DCE Data** | **DTE Data** | **X** | **X** |
| **DCE Interrupt** | **DTE Interrupt** | **X** | **X** |
| **DCE Interrupt Confirmation** | **DTE Interrupt Confirmation** | **X** | **X** |
| Flow Control | | | |
| **DCE RR** | **DTE RR** | **X** | **X** |
| **DCE RNR** | **DTE RNR** | **X** | **X** |
| | **DTE REJ** | **X** | **X** |

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## X.25 Packet Types (continued)

| Packet Type | | Service | |
|---|---|---|---|
| **From DCE to DTE** | **From DTE to DCE** | **SVC** | **PVC** |
| Reset | | | |
| **Reset Indication** | **Reset Request** | **X** | **X** |
| **DCE Reset Confirmation** | **DTE Reset Confirmation** | **X** | **X** |
| Restart | | | |
| **Restart Indication** | **Restart Request** | **X** | **X** |
| **DCE Restart Confirmation** | **DTE Restart Confirmation** | **X** | **X** |
| Diagnostic | | | |
| **Diagnostic** | | **X** | **X** |
| Registration | | | |
| **Registration Confirmation** | **Registration Request** | **X** | **X** |

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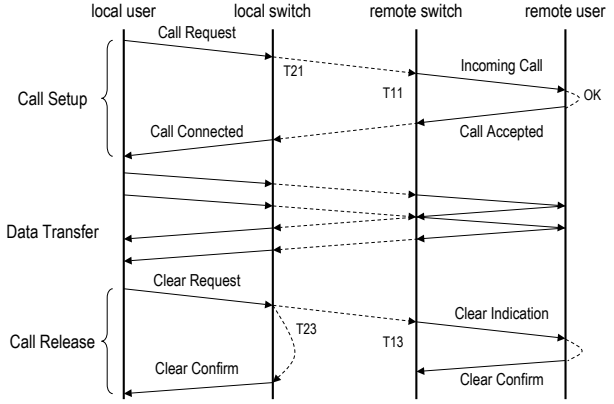
## Call Setup and Call Release

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## Call Setup, LCN handling 1

- **local X.25-DTE**
  - selects a LCN number from the pool of free LCN numbers to identify both the call request and the virtual circuit
  - sends Call Request packet to the local switch
- **Call Request contains**
  - selected LCN number
  - address of calling/called station (remote X.25-DTE)
    - usually X.121 addresses are used
  - facilities for negotiation of network parameters
    - between user and network or user and remote user



## X.25 Facilities

- **some facilities must be provided by all X.25 networks**
  - essential facilities
- **essential facilities are**
  - maximum packet size
  - window size
  - modulo 8/128
  - throughput class
    - 75, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 48000 bit/s
  - transit delay
- **essential facilities have default values**







## X.25 Facilities

- **other facilities may or may not be provided by a X.25 service**
  - optional facilities
- **all facilities, if provided, have default values but can either**
  - be negotiated between user and service provider in advance or by on-line registration
  - or during call setup for individual switched circuits



## X.25 Facilities

- **optional facilities**
  - incoming/outgoing calls barred
    - prevents incoming calls to be presented to DTE
    - prevents outgoing calls to be accepted by DCE
  - closed user groups
    - allows privacy in a public network service
  - reverse charging, reverse charging acceptance
  - hunt groups
    - distributes incoming calls across a designated group of DTE/DCE interfaces
  - call redirection, call redirect notification

## X.25 Facilities

- **optional facilities (cont.)**
  - fast select, fast select acceptance
    - Call Request/ Incoming Call packet carries user data (up to 128 octets) to remote DTE
    - Call Accepted/Call Connected packet carries user data from remote DTE to local DTE
    - immediate clear option
    - used for short transactions
  - transit delay selection and indication
  - online facility registration
    - status of supported facilities can be checked and changed by DTE using Registration Request/Confirmation packets
  - packet retransmission
    - REJ packet support



## Call Setup, LCN handling 2

- **Call Request packet is delivered by network to remote switch**
  - using vendor proprietary transport method
- **remote switch**
  - again selects a LCN number from the pool of free LCN numbers to identify a call request
  - normally LCN number will be different
  - sends Incoming Call packet to remote X.25-DTE
- **remote X.25-DTE**
  - accepts incoming call
  - sends Call Accepted packet to switch





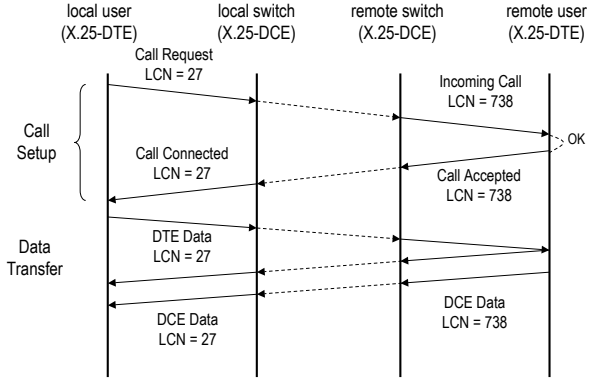


## Call Setup, LCN handling 3

- **Call Accepted packet is delivered by network to local switch**
- **local switch**
  - sends Call Connected packet with local LCN to local X.25-DTE
- **now local and remote X.25-DTE**
  - are ready to use virtual circuit for data transfer
- **local LCN numbers on both sides are used for data packets**
  - mapping is done by X.25 network



## LCN Handling

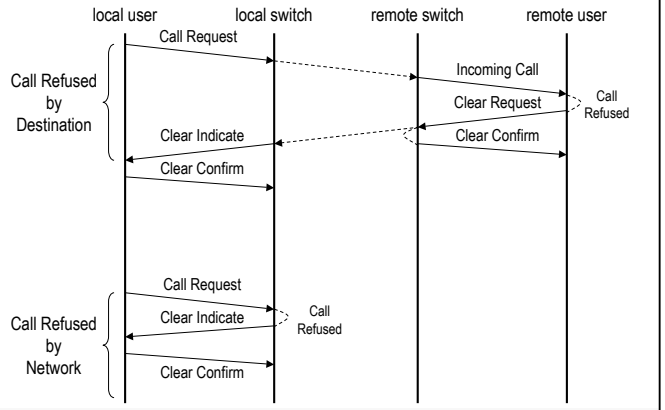


## Call Refusal and Release

- **calls could be denied**
  - by remote X.25-DTE (Clear Request packet is sent)
  - by network itself (Clear Indication packet is sent)
- **Clear Indication packet**
  - contains always reason for clearing
    - e.g. clearing done by remote station or network, non available facilities, network error, access closed, etc.
- **both sides can tear down a virtual circuit**
  - using Clear Request packets
  - other side is informed by Clear Indication packet
- **Call Release finished**
  - when Clear Confirmation packets are received

## Call Refusal

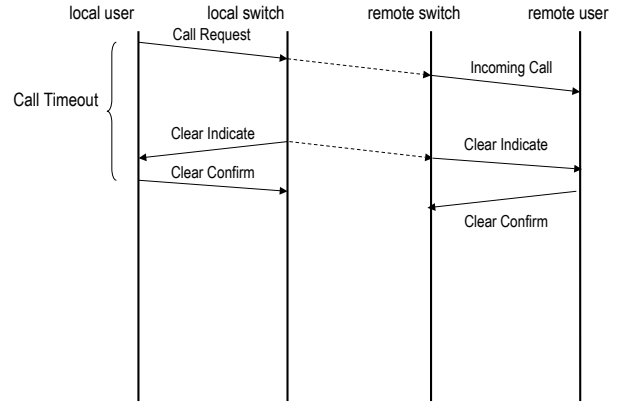






## Call Timeout



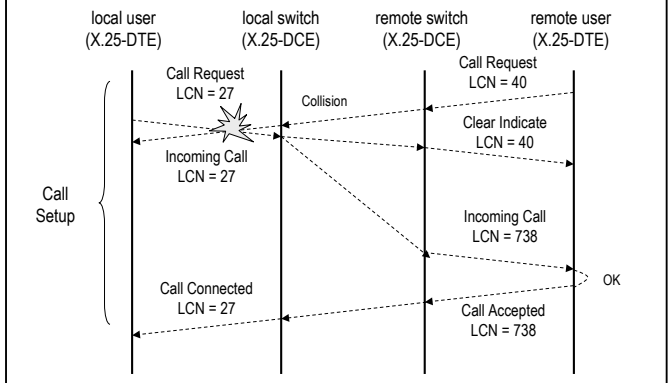

 

## Call Collision

- **Call Request packet contains**
  - LCN number selected by originating X.25-DTE
- **Incoming Call packet contains**
  - LCN number selected by destination X.25-DCE
- **if call setup is interleaved with incoming call**
  - collision of LCN numbers is possible
- **collision solved**
  - call of originating X.25-DTE will be continued
  - incoming call will be refused by Clear Indication on the other side

## Call Collision






## LCN Ranges to avoid Call Collision

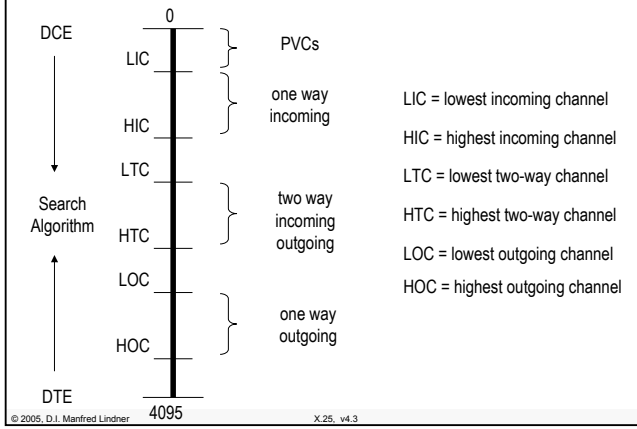
- **in order to minimize collision**
  - incoming calls use low LCN number
  - outgoing calls use high LCN Number
- **LCN values can be divided into four ranges**
  - PVCs
  - one way incoming (LIC – HOC)
  - one way outgoing (LOC – HOC)
  - two way (LTC – HTC)
- **LCN = 0 reserved**
  - diagnostics
  - restart







## LCN Ranges to avoid Call Collision



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## Data Transfer

- **Data Packets**
  - ContinousRQ method with sequencing and piggyback acknowledgement
  - very similar to HDLC
    - P(S) and P(R) instead of N(S) and N(R)
  - range of sequence numbers
    - 0-7 or 0-127 (extended)
  - sequence numbers and windowing are used mainly for flow control reasons and not for error recovery
  - remember:
    - X.25 packets are transmitted in LAPB I-frames
    - a loss of an I-frame and hence loss of X.25 packet will be already covered by error recovery method of LAPB



## Flow Control

- **X.25 flow control**
  - is based on windowing and RR, RNR
    - delay of of acknowledgement (piggybacked or with RR) is used to close the send window at the transmitter side
    - RNR is used to stop the transmitter when send window is open
    - RR, RNR do not cause retransmission of packets
  - is done for individual virtual circuits
    - note: LAPB can handle flow control on physical link only
- **optional error recovery**
  - optional GoBackN with DTE REJ Control Packet
    - usage of REJ can be negotiated during facility exchange
    - makes sense in case end-to-end acknowledgement is used (D-bit = 1; will be covered later)







## Window Size

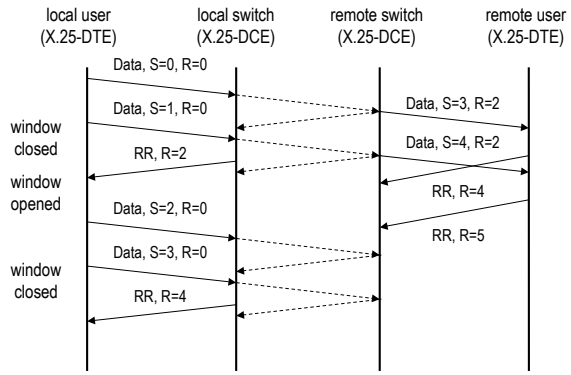
- **window size defines maximum number of unacknowledged packets**
- **window sizes and maximum packet sizes**
  - either are agreed in advance between user and network provider or could be negotiated during call setup for individual SVCs
  - maximum window size depends on modulo used for sequencing
    - modulo 8 - 3 bit sequence number
    - maximum send window size = 7
    - modulo 128 - 7 bit sequence number
    - maximum send window size = 127
  - standard window size of 2



## Data Transfer with D (Delivery) - Bit

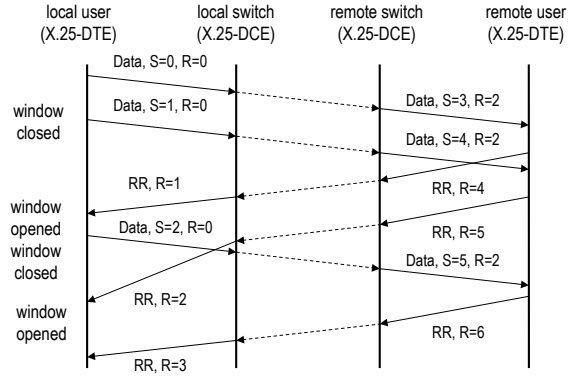
- **Data packet without D-bit indicator**
  - D = 0
  - acknowledgement number P(R) has only local meaning
  - handling of acknowledgement by switch
    - vendor specific
  - flow control and acknowledgement between switches
    - vendor specific
- **Data packet with D-bit indicator**
  - D = 1
  - can force acknowledgement number P(R) to be end-to-end
  - must be negotiated during call setup

## Windowing (w = 2) without D-bit



## Windowing (w = 2) with D-bit

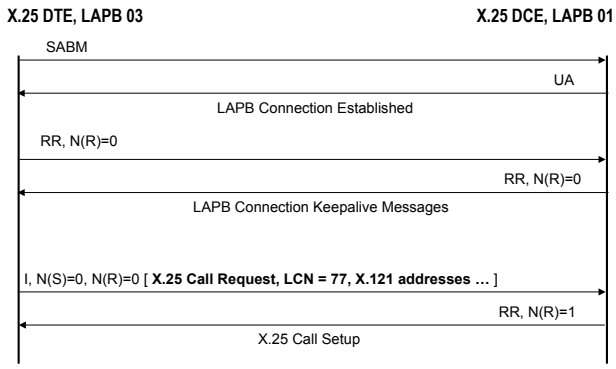




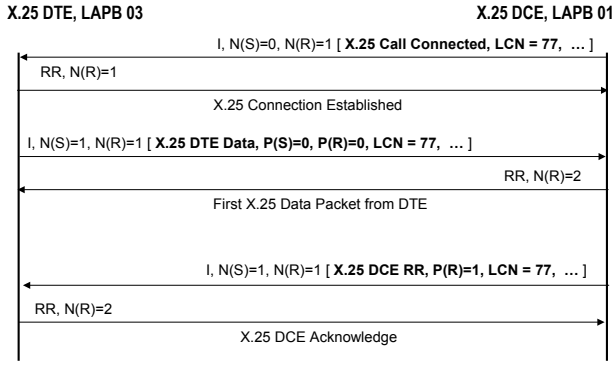


## LAPB - X.25 Example 1 of 2



## LAPB - X.25 Example 2 of 2



## Data Transfer with Q (Qualifier) - Bit

- **Q - bit can be used by higher layers to distinguish two types of data**
  - for example
    - Q = 0 ... user data
    - Q = 1 ... control data
  - usage not defined in X.25
- **some Q - bit usage examples**
  - X.29 control information
    - for PAD equipment
  - QLLC header indication
    - for SNA over X.25



## Data Transfer with M (More) - Bit

- **default maximum data field size in X.25**
  - 128 byte
  - other sizes could be negotiated (64, 256, 512, 1024, 2048, 4096)
  - sizes could be different on local and remote side
- **if remote DTE requests smaller packets then local DTE**
  - remote or local switch can segment packets using M-bit
    - M = 1 first or middle packet (packet completely filled with data)
    - M = 0 single or last packet
- **if remote DTE allows larger packets then local DTE**
  - remote or local switch can combine packets







## Categories of Data Packets

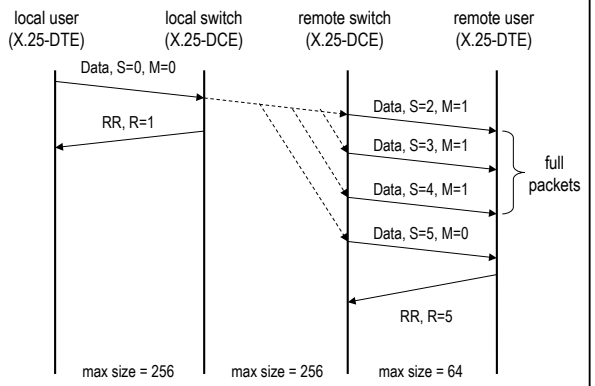
- **combined use of M and D bit allows to define two categories of packets (A and B)**
  - A packets are packets within a sequence of packets
    - M bit is set to 1
    - D bit is set to 0
  - B packets are standalone packets or packets at the end of a sequence
    - M bit is set to 0
    - can have D=1 to request end-to-end acknowledgement
- **a complete packet sequence consists of zero or more A packets followed by an B packet**



## Combining and Segmenting

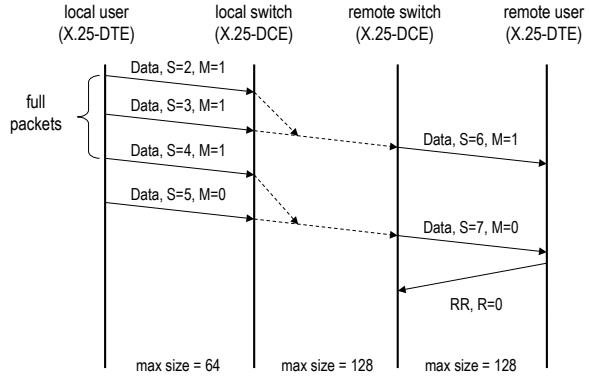
- **the network may combine a sequence of one or more A packets followed by a B packet to make one or more larger packets**
  - complete packet sequence information still remains at the receiver side
- **the network may also segment (fragment) a B packet into a sequence of smaller A and B packets**
  - receiver side is informed about fragmentation by recognizing a complete packet sequence

## Fragmenting with M-bit



## Combining with M-bit







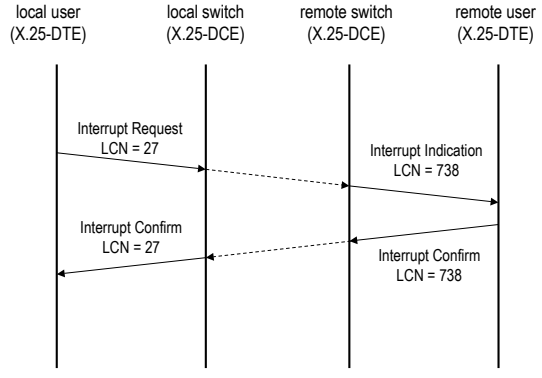


## Precedence Data

- **Interrupt Packets**
  - can be used to send precedence data without taking care of normal sequence
  - IdleRQ method
    - Interrupt packet must be acknowledged by Interrupt Confirmation packet before next Interrupt packet can be sent
    - Stop and Wait
  - only 32 octets of data can be sent using Interrupt packet

## Precedence Data Transfer



## Agenda

- **Overview, Principles and Standards**
- **X.25 Data Link Layer**
- **X.25 Network Layer**
  - Services and Packet Types
  - Call Setup and Release
  - Data Transfer and Flow Control
  - Reset and Restart
- **X.25 Packet Format**
- **X.25 PAD**

## Reset / Restart

- **main error recovery mechanisms associated with packet layer**
- **reset procedure reinitializes a virtual circuit in case of protocol errors**
  - done by DTE (Reset Request) or DCE (Reset Indication)
  - data packets already transmitted are discarded
  - sequence number registers are set to zero
  - but virtual circuit is still available
- **restart procedure clears all virtual circuits**
  - done by DTE (Restart Request) or DCE (Restart Indication)
  - virtual circuits are not available any longer

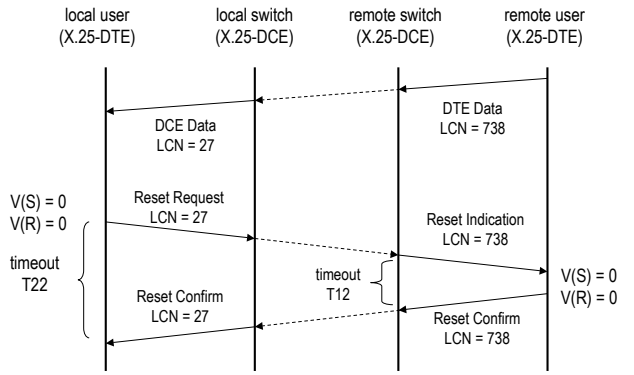
 





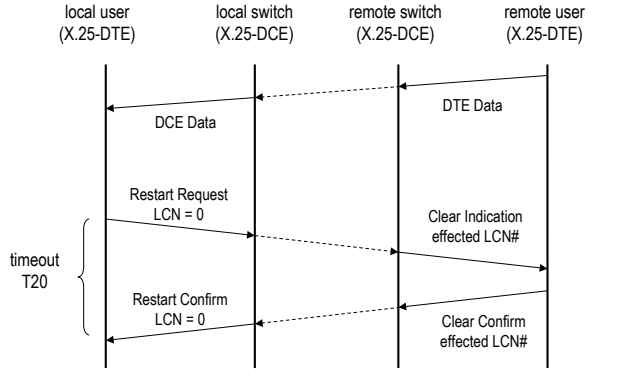


## Reset by DTE



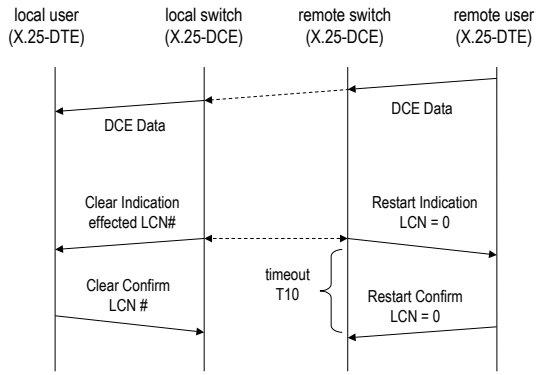

 

## Restart by DTE



## Restart by DCE



## DTE Timeouts

- **DTE timers**
  - T20 … 180 seconds
    - started when DTE issues a Restart Request
  - T21 … 200 seconds
    - started when DTE issues a Call Request
  - T22 … 180 seconds
    - started when DTE issues a Reset Request
  - T23 … 180 seconds
    - started when DTE issues a Clear Request
  - T28 … 300 seconds
    - started when DTE issues a Registration Request







## DCE Timeouts

- **DCE timers**
  - T10 60 seconds
    - started when DCE issues a Restart Indication
  - T11 180 seconds
    - started when DCE issues an Incoming Call
  - T12 60 seconds
    - started when DCE issues a Reset Indication
  - T13 60 seconds
    - started when DCE issues a Clear Indication

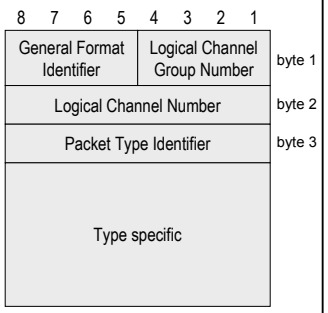
## Agenda

- **Overview, Principles and Standards**
- **X.25 Data Link Layer**
- **X.25 Network Layer**
  - Services and Packet Types
  - Call Setup and Release
  - Data Transfer and Flow Control
  - Reset and Restart
- **X.25 Packet Format**
- **X.25 PAD**

## General Packet Format

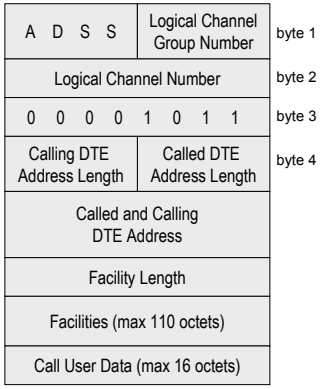
- **every packet contains at least three bytes**
- **third byte is used either**
  - packet type identifier for non data packets
  - sequencing byte for data packets
    - first bit set to 0 to indicate data packet
- **logical channel group number together**
  - with LCN number allows up to 4096 virtual channels




 X.25, v4.3 73

## Packet Format Call Setup

- **Call Request and Incoming Call**
  - packet type (byte 3) = 0x 0B
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)
  - D = 1 D-bit mechanism supported
  - D = 0 D-bit mechanism not supported
  - A = 1 escape from conventional X.25 addresses (1988)




 X.25, v4.3 74





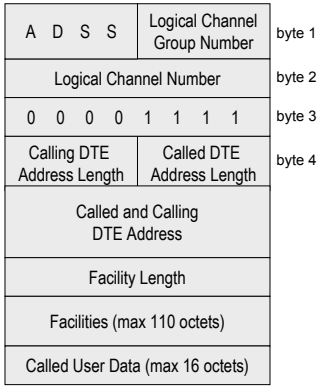
## Call Setup

- **additional fields**
  - DTE address and address length
    - for call establishment packets, usually X.121 addresses are used
  - facilities and facilities length
    - used to negotiate or declare several optional functions of X.25
  - call user data may contain data associated with facility
  - some examples
    - flow control parameter negotiation
    - closed user group
    - reverse charging, reverse charging acceptance
    - network user identification
    - call redirection

 X.25, v4.3 75

## Packet Format Call Setup

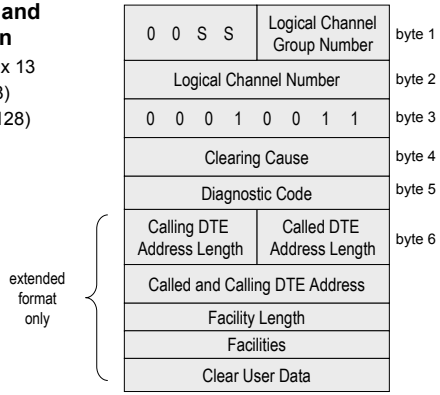
- **Call Accepted and Call Connected**
  - packet type (byte 3) = 0x 0F
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)




 X.25, v4.3 76

## Packet Format Call Release

- **Clear Request and Clear Indication**
  - packet type = 0x 13
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)



## Clearing Cause (Call Release)

- **0x00 normal disconnect request from DTE**
- **0x01 remote DTE busy**
- **0x09 remote DTE failure**
- **0x11 remote DTE protocol failure**
- **0x19 no reverse charging accepted**
- **0x29 no fast select accepted**
- **0x03 invalid facility request**
- **0x0B access denied**
- **0x13 local failure**
- **0x05 network congested**
- **0x0D destination unreachable**
- **0x15 network failure**

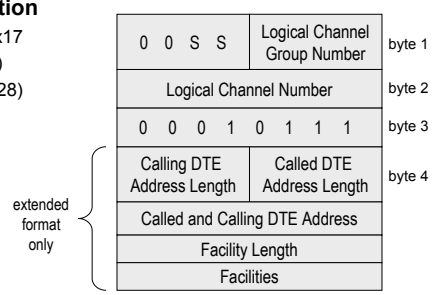
 





## Packet Format Call Release

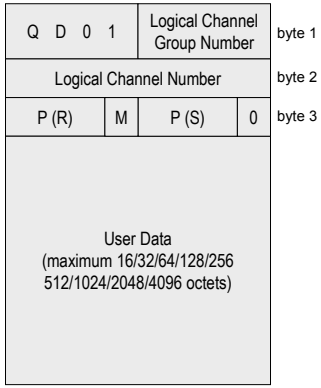
- **Clear Confirmation**
  - packet type = 0x17
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)



## Packet Format Data Transfer

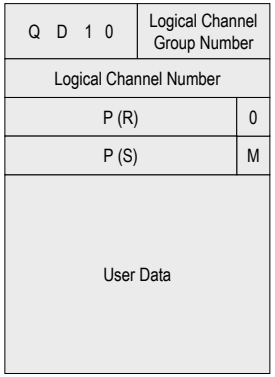
- **Data modulo 8**
  - packet type -> last bit zero
  - D = 1 end-to-end ack. required
  - D = 0 only local ack. required
  - Q = 1 user data
  - Q = 0 control data



## Packet Format Data Transfer

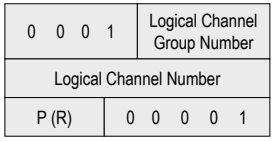
- **Data modulo 128**
  - packet type -> last bit zero
  - D = 1 end-to-end ack. required
  - D = 0 only local ack. required
  - Q = 1 user data
  - Q = 0 control data



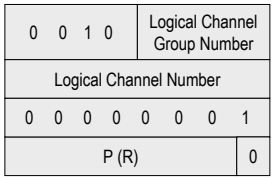

 

## Packet Format RR

- **modulo 8**
  - packet type = XXX 00001 (X ... don´t care)




- **modulo 128**
  - packet type = 0x 01



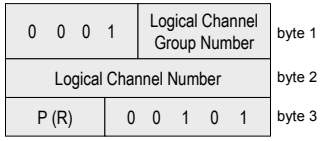

 



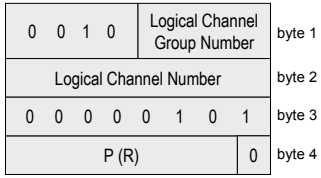


## Packet Format RNR

- **modulo 8**
  - packet type = XXX 0101



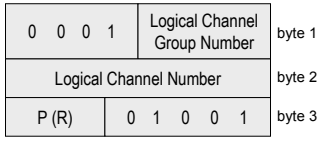

- **modulo 128**
  - packet type = 0x 05



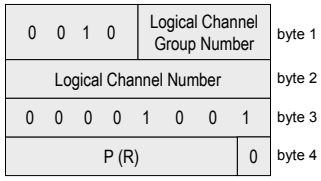

 

## Packet Format REJ

- **modulo 8**
  - packet type = XXX 1001



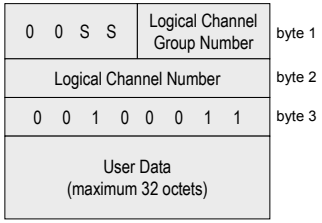

- **modulo 128**
  - packet type = 0x 09



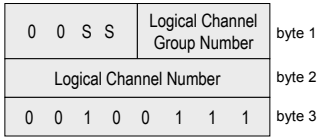

 

## Packet Format Interrupt

- **Interrupt Request and Interrupt Indication**
  - packet type = 0x 23
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)



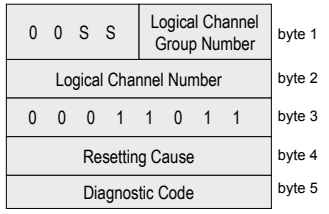

- **Interrupt Confirmation**
  - packet type = 0x 27
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)



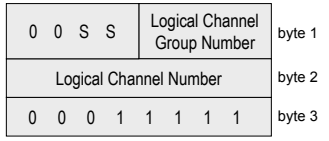



## Packet Format Reset

- **Reset Request and Reset Indication**
  - packet type = 0x 1B
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)




- **Reset Confirmation**
  - packet type = 0x 1F
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)









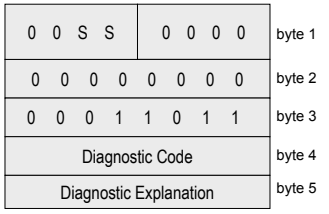

## Clearing Cause (Reset)

- **0x00 reset request from DTE**
- **0x01 remote DTE failure (PVC only)**
- **0x03 remote DTE protocol failure**
- **0x05 local failure**
- **0x07 network congested**
- **0x09 remote DTE available (PVC only)**
- **0x0F network available (PVC only)**
- **0x11 remote DTE incompatible**

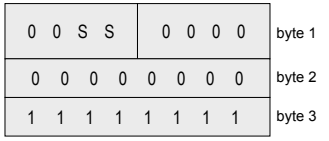


## Packet Format Restart

- **Restart Request and Restart Indication**
  - packet type = 0x 1B
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)




- **Restart Confirmation**
  - packet type = 0x FF
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)



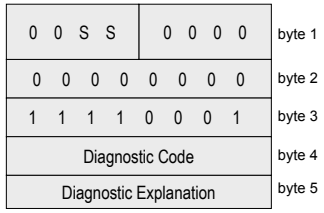
## Clearing Cause (Restart)

- **0x00 restart request from DTE**
- **0x01 local failure**
- **0x03 network congested**
- **0x05 network available**



## Packet Format Diagnostics

- **Diagnostics**
  - packet type = 0x F
  - SS = 01 (mod 8)
  - SS = 10 (mod 128)










## Agenda

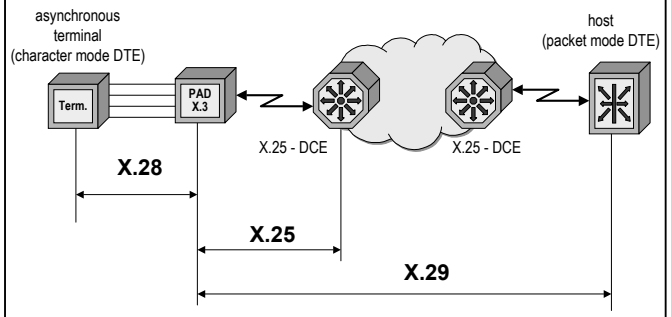
- **Overview, Principles and Standards**
- **X.25 Data Link Layer**
- **X.25 Network Layer**
  - Services and Packet Types
  - Call Setup and Release
  - Data Transfer and Flow Control
  - Reset and Restart
- **X.25 Packet Format**
- **X.25 PAD**



## X.25 PAD

- **provides protocol conversion and packet assembly/disassembly functionality for dumb asynchronous terminals**
- **defined by companion standards X.3, X.28, X.29**

## Packet Assembler / Dissassembler






## X.25 PAD

- **X.3**
  - specifies functionality of PAD
  - provides parameters to service different terminal types
    - escape from data transfer
    - data forwarding signal
    - terminal speed, flow control, linefeed handling, echo
    - forward only full packets
    - forward a packet upon carriage return
    - send service signals to user
    - send interrupt packet upon receipt of a BREAK
    - etc.
  - determines how the PAD communicates with the user DTE







## X.25 PAD

- **X.28**
  - defines the procedures to control the data flow between non-packet DTEs and the PAD
  - non-packet DTE user sends X.28 command to the PAD
  - PAD returns a response value
  - examples
    - setup a call
    - initialize a service
    - exchange data
    - exchange control information
    - configuring PAD parameter
    - read PAD parameter



## X.25 PAD

- **X.29**
  - defines how a PAD and a remote packet station may exchange control information
  - remote station can be a PAD or a remote DTE
  - uses packet header Q bit
    - Q=1, packet contains PAD control information
  - allows for example to change the configuration of a remote PAD

## Summary

- **connection oriented network, using virtual circuits**
- **three layers defined**
  - physical layer
  - data link layer
  - network layer
- **uses HDLC subset at data link layer (LAPB)**
- **supports PVCs and SVCs**
  - call setup sequence required for SVCs
- **supports windowing and flow control**
- **supports several options called facilities**
- **PAD functions for non-packet DTEs defined**