

## **Chapter Objectives**

**At the end of this chapter you will be able to:**

- **Describe standardisation in the data communications area**
- **Describe the following technologies: X.25, Frame Relay, ISDN, PPP, Modem, XDSL and ATM**
- **Analyse the protocols of the X.25, Frame Relay and ISDN technologies**

## Leased Line and Dial-Up

- Leased Line

- With a leased line connection, a data user has a permanent dedicated transmission path which can be end to end across the network, locally, nationally or internationally.

- Dial-up

- This method is used for modem to modem data communication over the Public Switched Telephone Network (PSTN). Both the source and destination must have compatible modems

# Circuit Switching and Packet Switching

## □ Circuit Switching

- In a circuit switched network, a dedicated communications path is established between two terminals through the nodes of the network and for information transfer

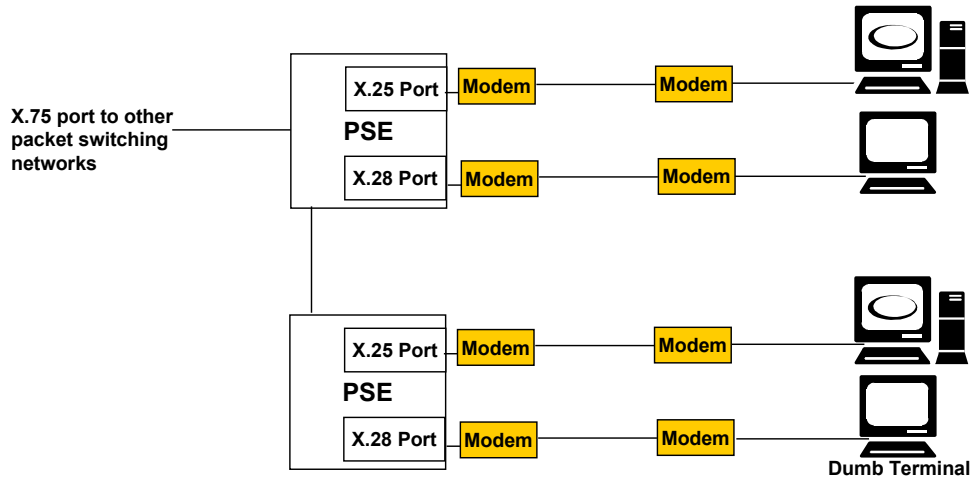
## □ Packet Switching

- In this case it is not necessary to dedicate transmission capacity along a path through the network. Rather, data is sent out in a sequence of small chunks, called packets. Each packet is passed through the network from node to node along some path leading from the source to the destination

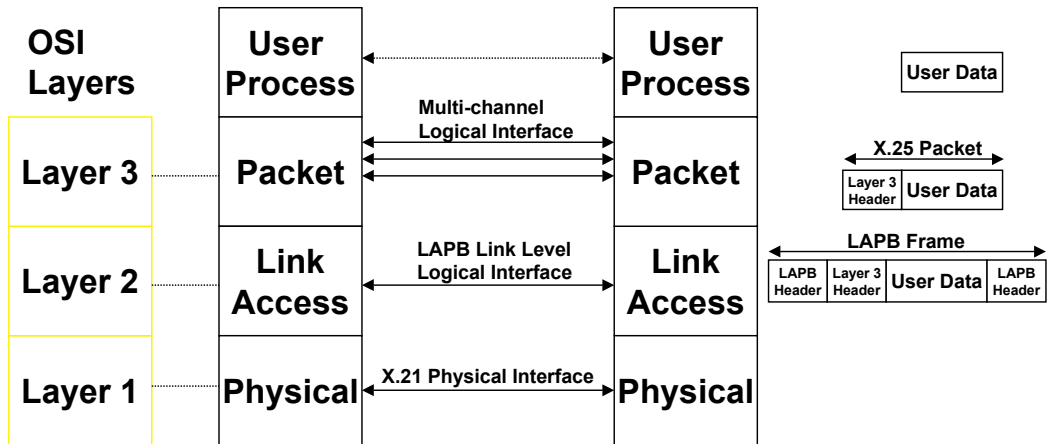
## HDLC Variations

HDLC Subset	Uses
NRM	Multipoint networks that typically use SDLC
LAP	Early X.25 implementations
LAPB	Current X.25 implementations
LAPD	ISDN D channel and frame relay
LAPM	Error-correcting modems (specified as part of V.42)

# X.25 Network



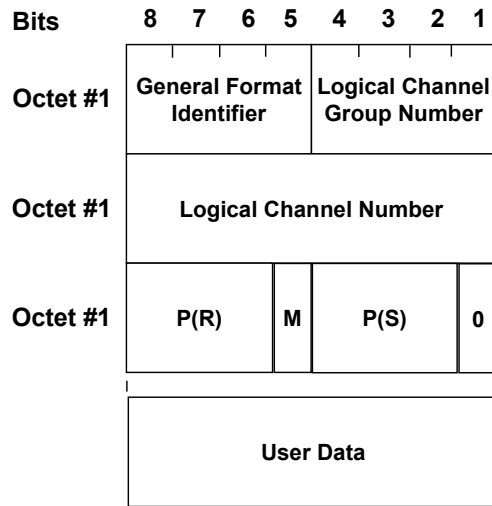
# X.25 Interface



## LAPB Commands and Responses

Command Name	Content of Control Octet			
	Bit Number			
	876	5	432	1
I (Information)	N(R)	P	N(S)	0
RR (Receiver Ready)	N(R)	P	000	1
RNR (Receiver Not Ready)	N(R)	P	010	1
REJ (Reject)	N(R)	P	100	1
SABM (Set Asynchronous Balanced Mode)	001	P	111	1
DISC (Disconnect)	010	P	001	1
Response Name				
RR (Receiver Ready)	N(R)	F	000	1
RNR (Receiver Not Ready)	N(R)	F	010	1
REJ (Reject)	N(R)	F	100	1
UA (Unanswered Acknowledgement)	011	F	001	1
DM (Disconnect Mode)	000	F	111	1
FRMR (Frame Rejected)	100	F	011	1
<p>N(S) is a three bit counter for packets sent from one end of the link                      N(R) indicates the next value of N(S) expected to be returned from the other end of the link</p>				

## X.25 Packet Header

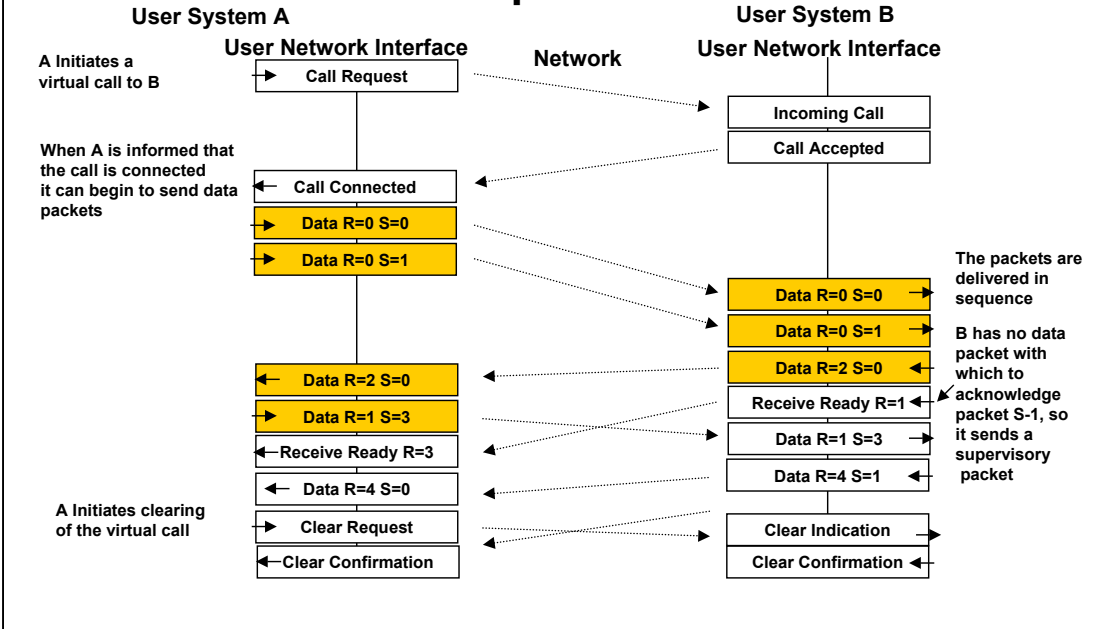




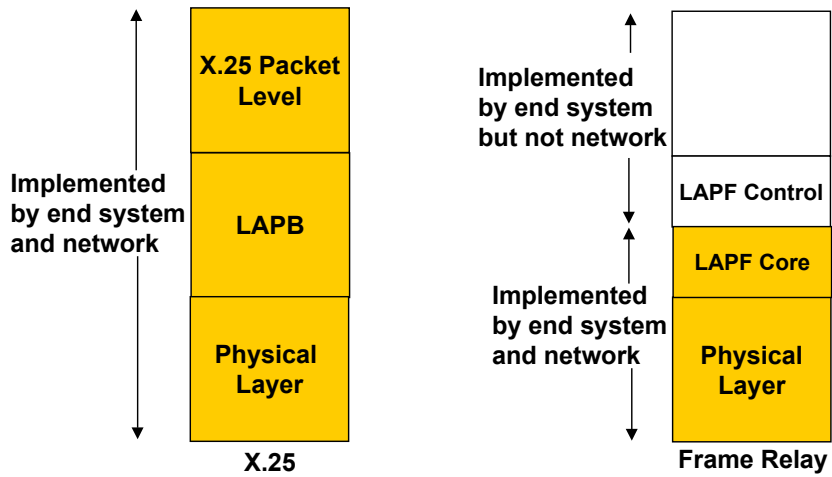
## X.121 Addressing

Data Network Identification Code (DNIC)		Network Terminal Number (NTN) (Max. 10 Digits)	
Data Country Code	Network Digit	Private Network Identification Code (PNIC)	Private Network Terminal Number (PNTN)
3 Digits	1 Digit	4 Digits 3 Digits 2 Digits	Max. 6 Digits Max. 7 Digits Max. 8 Digits
Example: 505 505 505	Example: 7 7 7	Examples: 2500 564 88	Examples: 321654 3217654 32197654

# X.25 Operation



## Frame Relay and X.25 Protocol Stacks



# LAPF Formats

<b>Flag</b>	<b>Address</b>	<b>Information</b>	<b>FCS</b>	<b>Flag</b>
1	2-4	Variable	2	1

< Frame Format >

Upper DLCI				C/R	EA 0		
Lower DLCI		FECN	BECN	DE	EA 1		
8	7	6	5	4	3	2	1

Address Field (2 Octets – default)

Upper DLCI				C/R	EA 0
DLCI		FECN	BECN	DE	EA 0
Lower DLCI or DL-Core Control				D/C	EA 1

Address Field (3 Octets)

EA Address field extension bit

C/R Command/response bit

FECN Forward explicit congestion notification

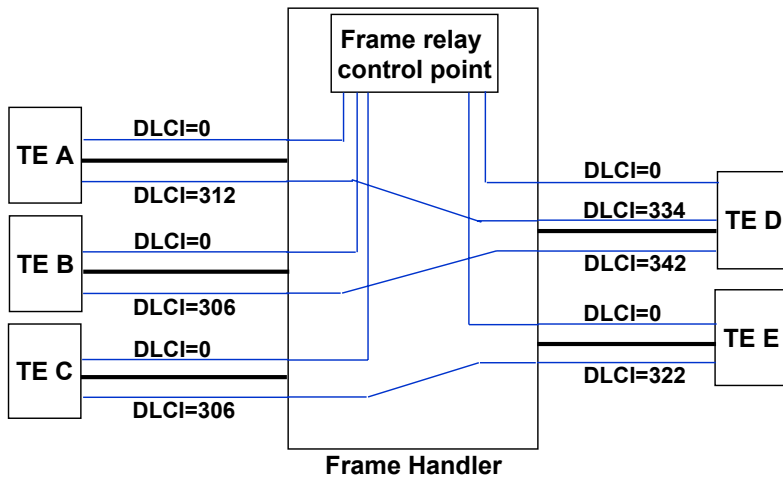
BECN Backward explicit congestion notification

DLCI Data link congestion identifier

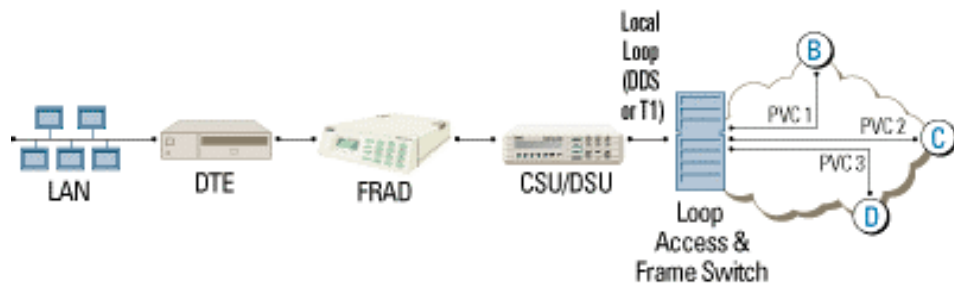
D/C DLCI or Core control indicator

DE Data link congestion identifier

# Frame Handler Operation



## Frame Relay Network Access



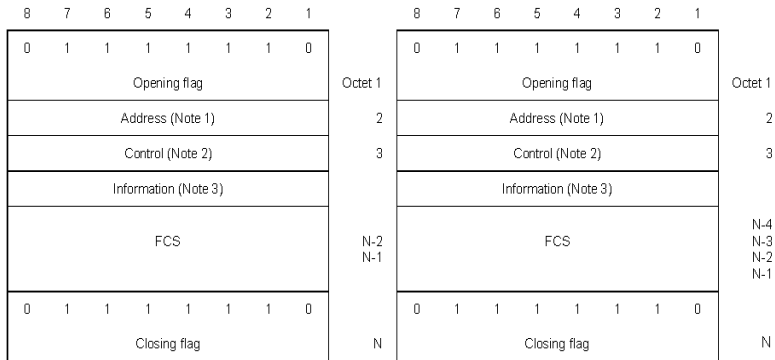
Rec.	Speed (bit/s)	Transmission Mode	PSTN	LL 2W	LL 4W	Back-up via PSTN	Mod. Method
V.21	300	Asynchronous (A)	FD	FD			FSK
V.23	1200/600	A and S	HD	HD	FD	*	FSK
V.22	1200/600	A and S	FD	FD		*	DPSK
V.22bis V.22f.bk	2400/1200	A and S	FD	FD		*	QAM
V.26bis	2400/1200	Synchronous (S)	HD	HD	FD	*	DPSK
V.26ter	2400/1200	A and S	FD	FD		*	DPSK
V.27ter V.26bisf.bk	4800/2400	S	HD	HD	FD	*	DPSK
V.29	9600/7200/4800	A and S			FD		QAM
V.32	9600/4800	A and S	FD	FD		*	QAM/TCM
V.33	14400/12000	S			FD		QAM/TCM
V.34	28800	S	FD				TCM
V.34bis	28800/31200/33600	S	FD				TCM
Baseband	2400/1800/1200 7200/4800/3600 19200/14400/9600	A and S		HD	FD		
V.90	56000 to the end user 33600 from the end user	S	Asymetric				PCM

## Basic AT Commands

Command	Function
<b>A</b>	<b>Manually answer incoming call</b>
<b>AT</b>	<b>Appears at the beginning of every command line</b>
<b>B_</b>	<b>ITU-T Mode (B0)</b>
	<b>Bell Mode (B1)</b>
<b>D_</b>	<b>Pulse Dialling (DP)</b>
	<b>Touch-tone Dialling (DT)</b>
<b>H_</b>	<b>Force modem on-hook, that is hang up (H0)</b>
	<b>Force modem off-hook, that is make busy (H1)</b>
<b>M_</b>	<b>Internal speaker off (M0)</b>
	<b>Internal speaker on until carrier detected (M1)</b>



## LAPM Frame Format



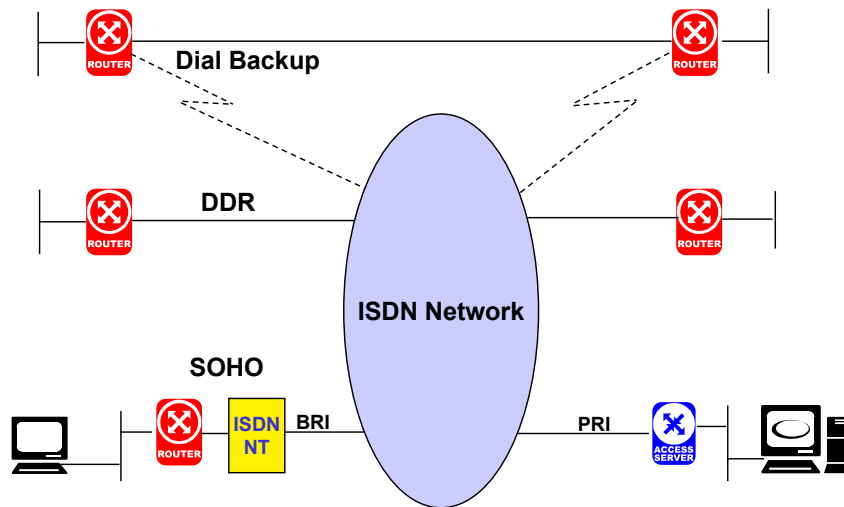
**a) 16-bit FCS**

**b) 32-bit FCS**

**NOTES**

1. The maximum size of this field is limited to two octets.
2. The control field is two octets for frame types with sequence numbers and one octet for frame types without sequence numbers.
3. Not all frame types have an information field.

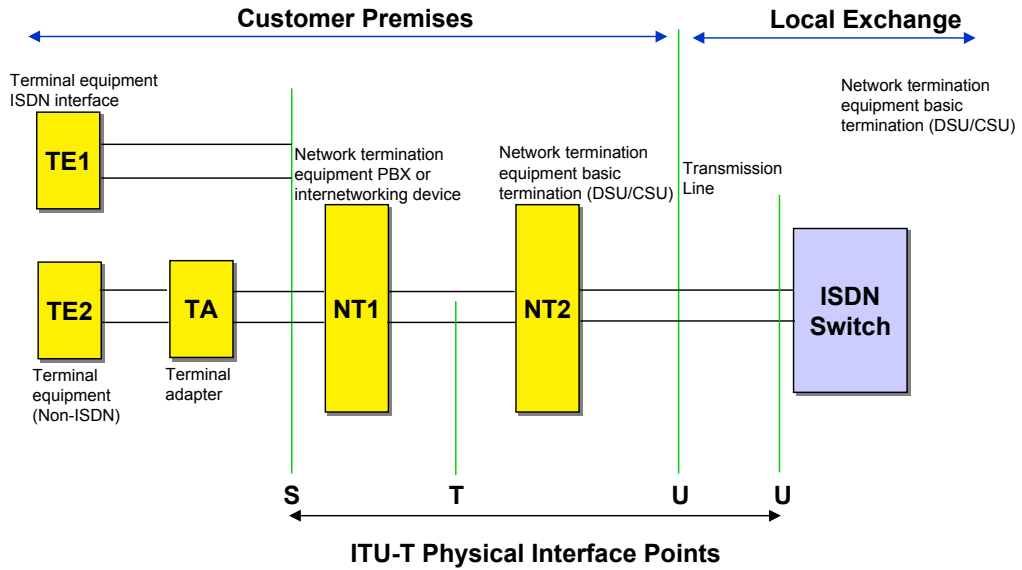
# Applications of ISDN in Internetworking



## **ISDN Access**

- Basic Rate Interface (BRI)**
- Primary Rate Interface (PRI)**

# ISDN Functional Devices and Physical Interfaces



# LAPD Frame Format

			Length in Octets
<b>FLAG</b>			1
<b>Service Access Point Identifier (SAPI)</b>	<b>C/R</b>	<b>O</b>	1
<b>Terminal Endpoint Identifier (TEI)</b>			1
<b>Control</b>			1-2
<b>Information</b>			0-128 or 0-260
<b>Frame Check Sequence</b>			2
<b>FLAG</b>			1

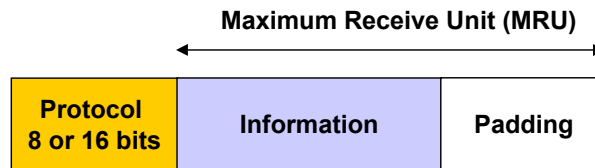
## Messages for Circuit-mode Connection Control

<i>Call Establishment Messages</i>	<i>Call Information Phase Messages</i>	<i>Call Clearing Messages</i>	<i>Miscellaneous Messages</i>
Alerting	Resume	Disconnect	Information
Call Proceeding	Resume Acknowledge	Release	Notify
Connect	Resume Reject	Release Complete	Status
Connect Acknowledge	Suspend		Status Enquiry
Progress	Suspend Acknowledge		
Setup	Suspend Reject		
Setup Acknowledge			

## **Main Components of PPP**

- Encapsulation Scheme**
- Link Control Protocol**
- Network Control Protocols**

# PPP Encapsulation





## **LCP Management Functions**

- Determine encapsulation format options**
- Negotiate optimal packet size**
- Terminate the link**
- Authenticate the identity of the peer on the link (optional)**
- Negotiate PPP Multilink Data Compression (optional)**
- Link quality monitoring (optional)**

## **Network Control Protocol (NCP)**

NCPs are a series of independently-defined protocols that encapsulate network layer protocols such as TCP/IP, DECnet, AppleTalk, IPX, XNS, and OSI.

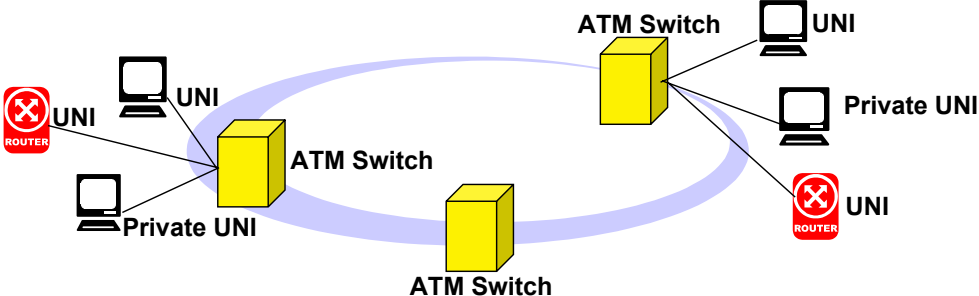
## PPP Link Phases

- In the process of configuring, maintaining and terminating the point-to-point link, the PPP link goes through several distinct phases:
  - Link dead (Physical layer not ready)
  - Link establishment
  - Authentication
  - Network-layer protocol
  - Link termination

## PPP Peer to Peer Connection

- Setting up a PPP connection between two peers involves four phases:
  - LCP negotiation
  - LCP steady state
  - NCP negotiation
  - Network layer protocol data flow

# ATM Network



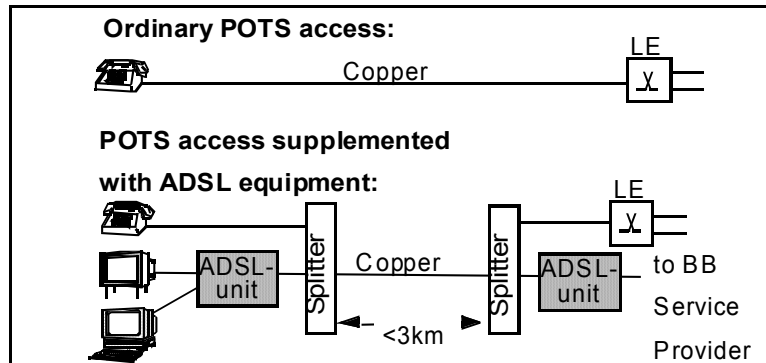
## ATM Connections

- ATM supports two types of connections:
  - Point-to-point, which connects two ATM end systems and can be unidirectional (one-way communication) or bidirectional (two-way communication).
  - Point-to-multipoint connects a single-source end system (known as the root node) to multiple destination end systems (known as leaves). Such connections are unidirectional only. Root nodes can transmit to leaves, but leaves cannot transmit to the root or each other on the same connection. Cell replication is done within the ATM network by the ATM switches where the connection splits into two or more branches.

## **XDSL**

- **Asymmetric Digital Subscriber Line (ADSL)**
- **Rate adaptive Digital Subscriber Line (RADSL)**
- **High-bit-rate Digital Subscriber Line (HDSL)**
- **Symmetrical Digital Subscriber Line (SDSL)**
- **Very-high-digital-rate Digital Subscriber Line (VDSL)**

# Copper Access



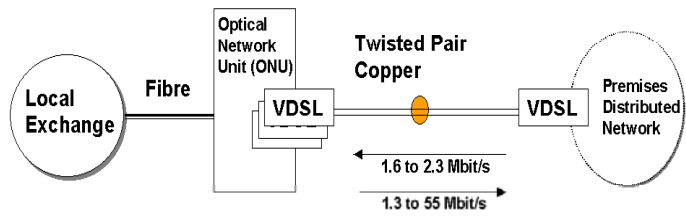


## DMT Subchannels



# VDSL Connection

## VDSL Connection



# HDSL

