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INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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H4.SMR. 405/8

SECOND WORKSHOP ON TELEMATICS

6 - 24 November 1989

Data Transmission Protocols

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CONTENTS

DEFINITION OF INFORMATION

- LET E BE SOME EVENT WHICH OCCURS WITH PROBABILITY P(E). IF WE ARE TOLD THAT EVENT E HAS OCCURRED, WE SAY WE HAVE RECEIVED

$$I(E) = \log \frac{1}{P(E)}$$

UNITS OF INFORMATION.

- IF WE USE A LOGARITHM TO THE BASE 2, THE UNIT OF INFORMATION IS CALLED THE BIT.

ONE BIT IS THE AMOUNT OF INFORMATION WE OBTAIN WHEN ONE OF TWO POSSIBLE EQUALLY LIKELY ALTERNATIVES IS SPECIFIED.

- MODEL OF A DISCRETE INFORMATION SOURCE.

$$S = \{s_1, s_2, \ldots, s_q\}.$$

SUCCESSIVE SYMBOLS ARE SELECTED ACCORDING TO SOME FIXED PROBABILITY LAW.

ZERO-MEMORY SOURCE: SYMBOLS EMITTED FROM THE SOURCE ARE STATISTICALLY INDEPENDENT.

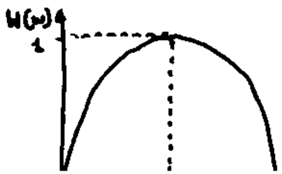
- ENTROPY: THE AVERAGE AMOUNT OF INFORMATION PER SOURCE SYMBOL

$$H(S) \triangleq \sum_{S} P(s_i) \log_2 \frac{1}{P(s_i)} \quad [\text{bits}]$$

- ZERO-MEMORY BINARY SOURCE $S = \{\emptyset, 1\}$

$P(\emptyset) = \omega$, $P(1) = 1 - \omega$

$$H(S) = \omega \log_2 \frac{1}{\omega} + (1-\omega) \log_2 \left(\frac{1}{1-\omega}\right)$$



CODES

- A CODE IS A MAPPING OF ALL POSSIBLE SEQUENCES OF SYMBOLS OF A SOURCE ALPHABET $S = \{s_1, s_2, \ldots, s_q\}$ INTO SEQUENCES OF SYMBOLS OF SOME OTHER ALPHABET THE CODE ALPHABET $X = \{x_1, x_2, \ldots, x_q\}$.

- WE SHALL CONSIDER :

BLOCK CODES: EACH OF THE SYMBOLS OF THE SOURCE ALPHABET IS MAPPED INTO A FIXED SEQUENCE OF SYMBOLS OF THE CODE ALPHABET (CODE WORD)

UNIQUELY DECODABLE: ANY SEQUENCE OF CODE WORDS WHICH MAPS A SEQUENCE OF SOURCE SYMBOLS IS DISTINCT.

INSTANTANEOUS: IT IS POSSIBLE TO DECODE EACH WORD IN A SEQUENCE WITHOUT REFERENCE TO SUCCEEDING CODE SYMBOLS.

TABLE 10/T.50

Basic 7-bit code table

b_4	b_3	b_2	b_1		0	1	2	3	4	5	6	7
				b_7	0	0	0	0	1	1	1	1
				b_6	0	0	1	1	0	0	1	1
				b_5	0	1	0	1	0	1	0	1
0	0	0	0	0	NUL	DLE	SP	0	③	P	③	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	# / £ ②	3	C	S	c	s
0	1	0	0	4	EOT	DC4	¤ / $ ②	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF ①	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT ①	ESC	+	;	K	③	k	③
1	1	0	0	12	FF ①	IS4	,	<	L	③	l	③
1	1	0	1	13	CR ①	IS3	-	=	M	③	m	③
1	1	1	0	14	SO	IS2	.	>	N	③	n	③
1	1	1	1	15	SI	IS1	/	?	O	_	o	DEL

CCITT-12401

① See § 4.1.2.2.

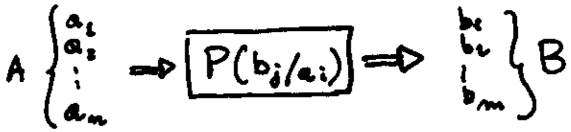
② See § 4.3.2.

③ See §§ 4.3.3 and 6.2.3.

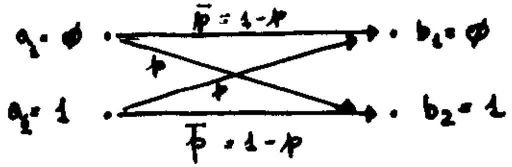
CHANNELS

- AN INFORMATION CHANNEL IS DESCRIBED BY:

  AN INPUT ALPHABET $A = \{a_i\}$
  AN OUTPUT ALPHABET $B = \{b_j\}$
  A SET OF CONDITIONAL PROBABILITIES $P(b_j/a_i)$



- BINARY SYMMETRIC CHANNEL (BSC)



p = PROBABILITY OF ERROR

$$\begin{bmatrix} \bar{p} & p \\ p & \bar{p} \end{bmatrix}$$

- MUTUAL INFORMATION OF THE CHANNEL

$$I(A;B) = H(A) - H(A/B)$$

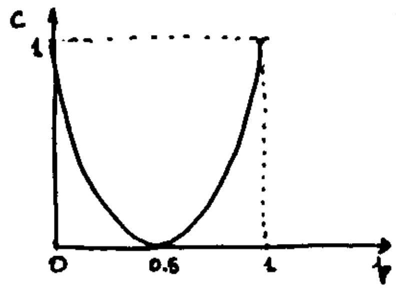
$H(A/B)$ ↓ EQUIVOCATION OF A WITH RESPECT TO B

- CAPACITY OF THE CHANNEL

$$C = \max_{P(a_i)} I(A;B)$$

- FOR A BSC CHANNEL WITH ERROR PROBABILITY p

$$C = 1 - H(p)$$



CHANNELS WITH NOISE

- HAMMING DISTANCE : THE NUMBER OF PLACES IN WHICH TWO BINARY SEQUENCES DIFFER

```
1 0 1 1 1 1
1 1 1 1 0 0
  *     * *
```

HAMMING DISTANCE $D_H = 3$

- A CODE WITH HAMMING DISTANCE D_H CAN DETECT UP TO $D_H - 1$ ERRORS IN A RECEIVED WORD AND CAN CORRECT t ERRORS PROVIDED THAT $D_H \geq 2t+1$

- SHANNON'S THEOREM GIVES AN UPPER LIMIT FOR THE ERROR-FREE MESSAGE RATE

  IF WE SEND M MESSAGES WITH BLOCK LENGTH n, THE MESSAGE RATE IS MEASURED AS $\log_2 M/n$.

  SHANNON'S THEOREM: THE PROBABILITY OF ERROR CAN BE MADE ARBITRARILY SMALL AS LONG AS M IS LESS THEN 2^{nC}.

$$\frac{\log_2 M}{n} \Rightarrow \frac{\log_2 2^{nC}}{n} = C$$

COMMUNICATION SERVICES

CAN BE CLASSIFIED ACCORDING TO:

MARKET : RESIDENTIAL
BUSINESS

INFORMATION TYPE : VOICE
SOUND
VIDEO
DATA

TRAFFIC BEHAVIOUR : TRAFFIC INTENSITY
TERMINAL ACTIVITY
MESSAGE LENGTH DISTRIBUTION

PERFORMANCE REQUIREMENTS : DELIVERY DELAY
ERRORS

CHANNEL CAPACITY

Low Activity (< 0.5)	● **Bursty Data** Remote Interactive Remote File Management Remote Entry: On Line Videotex Telemetry
High Activity (> 0.8)	● **Bulk Data** Remote Entry: Off Line CPU-CPU: File Transfer Remote Batch Teletex Facsimile

Table II.1.1 Classification of Data in Accordance with Terminal Activity.

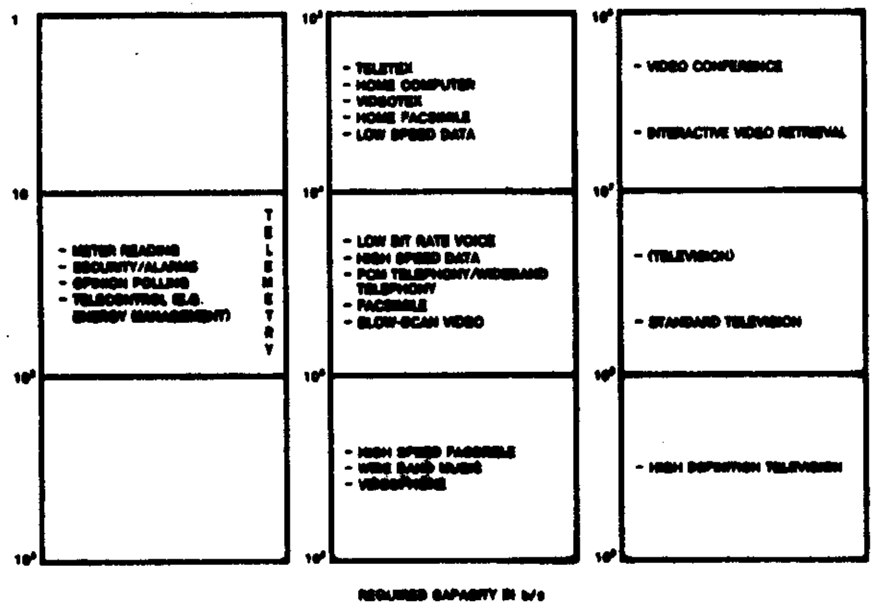


Table II.1.2 Required Capacity for Emerging Digital Communication Services.

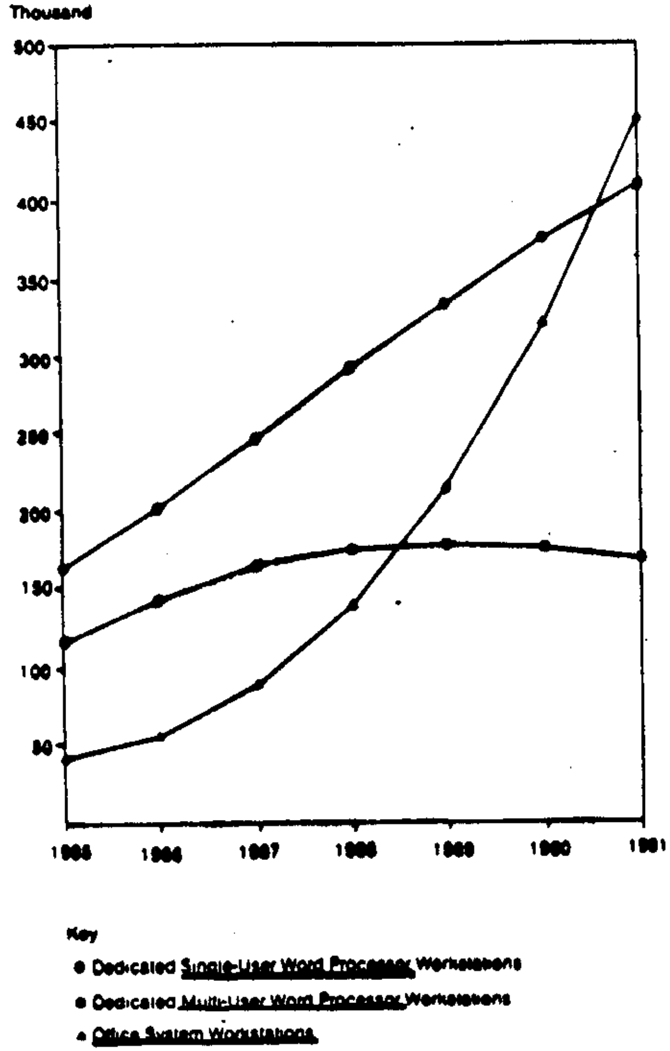


Figure S1.1: Installed Base of Dedicated Single and Multi-User Word Processor and Office System Workstations in Western Europe, 1985–1991

FONTE : TELEMATICA '85

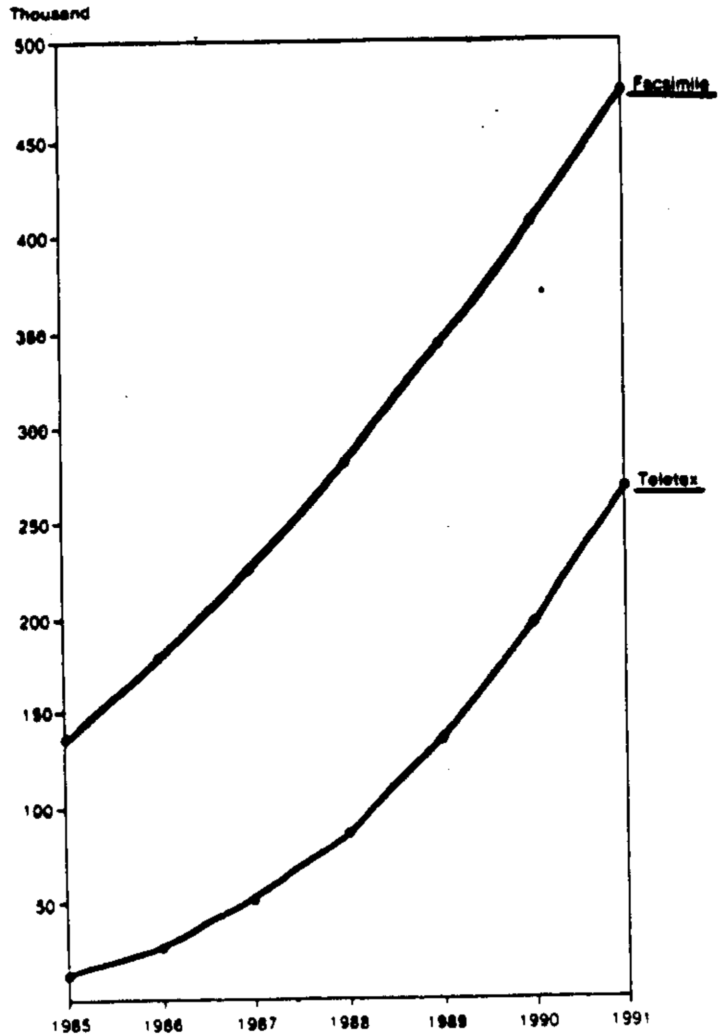
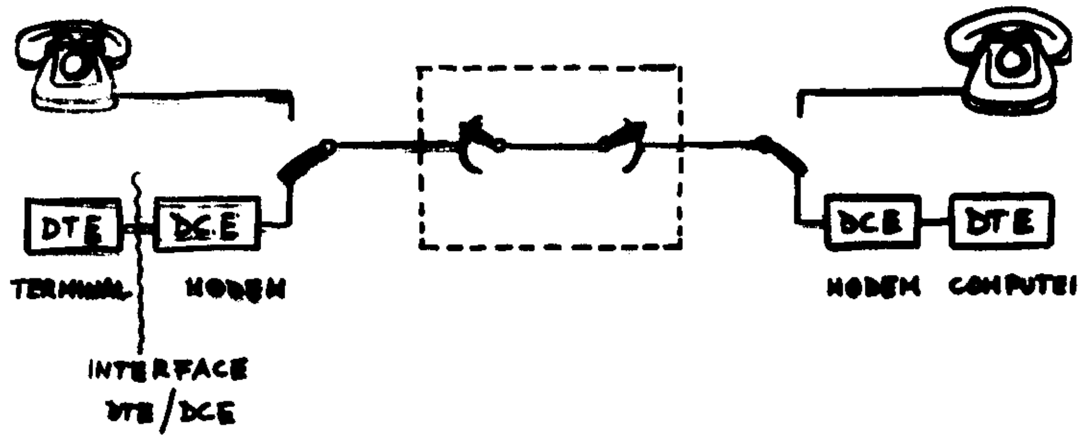


Figure S1.2: Installed Base of Teletex Connections and Facsimile Terminals in Western Europe, 1985–1989

FONTE : TELEMATICA '85 41

DATA COMMUNICATION OVER THE GENERAL SWITCHED TELEPHONE NETWORK



DTE = DATA TERMINAL EQUIPMENT
DCE = DATA CIRCUIT TERMINATING EQUIPMENT

- LIMITED BANDWITH (≃ 3 KHz)
- LIMITED SIGNALLING SPEED (UP TO 2400 BIT/S ONLY HALF DUPLEX)
- HIGH VALUES OF BIT ERROR RATE (B.E.R. ≃ 10^{-3}
- HIGH CALL SET-UP TIME (> 1 s)
- LOW CONNECTION RELIABILITY
- NO AUXILIARY FACILITIES

DATA COMMUNICATION OVER THE GENERAL SWITCHED TELEPHONE NETWORK

The General Switched Telephone Network (GSTN), for its wide-spread diffusion and for economical reasons, has been used as the first support for data communication.

However the telephone channel is an alien environment for digital data. In fact the telephone channel cannot handle very low frequencies or the DC component of a signal because of the transformers used in the transmission bridge. The presence of carrier systems introduces distortion (of phase principally) at both extremes of the band, leaving the central frequencies as the most suitable location for data signals. Moreover in some cases a special multilevel coding can be required in order to reduce the band of the data signal within the telephone channel limits (300 Hz ÷ 3400 Hz).

For all these reasons a special equipment (MODEM) is needed to transfer digital signals into a form compatible with the network and to interpret the received signal.

However there are many disadvantages in using the telephone channel for data:

- attenuation and phase distortion of voice channel
- impulsive noise (contact closures and transients in power cables)
- short interruptions (maintenance work and automatic changeover of equipment in carrier systems)
- variability of connection characteristics (adaptative equalisation is required)
- limited usable bandwith and, consequently, limited classes of speed (up to 2400 bit/s in half-duplex operation)
- too high call set-up time.

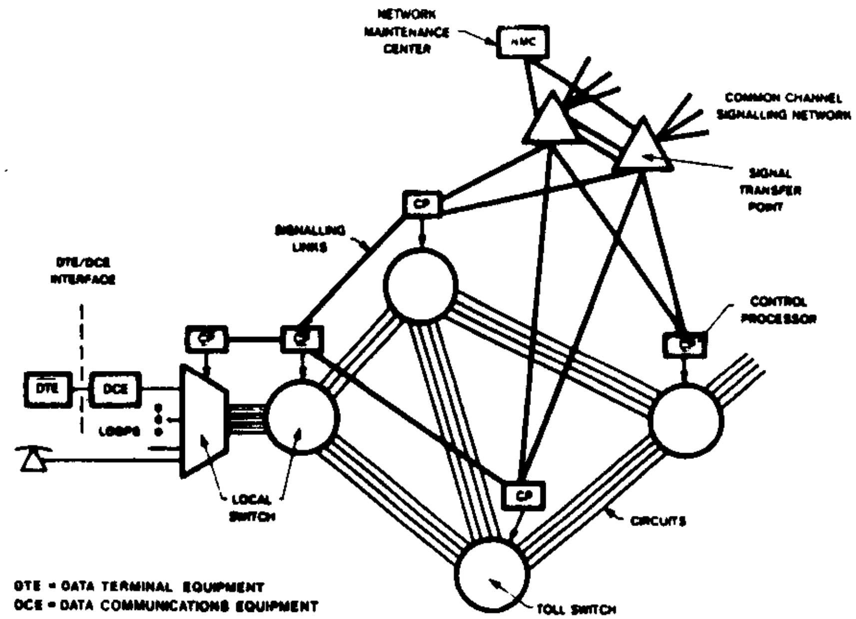


Fig.II.1.3 Synchronous Circuit-Switched Network (for Voice and Data Applications) using Common Channel Signalling.

CIRCUIT SWITCHED NETWORKS

(1) - ASYNCHRONOUS NETWORKS

- BASED ON THE PRINCIPLE OF TELEX SYSTEMS
- INFORMATION IS ASSOCIATED TO STATE TRANSITIONS THAT ARE OBTAINED BY SAMPLING INPUT DATA SIGNAL FROM THE DTE.
  THE SAME STATE TRANSITIONS ARE REGENERATED ON THE OUTPUT LINE
- TELEGRAPHIC DISTORSION
- EXAMPLE : EDS (ELECTRONIC DATA SWITCH) DEVELOPED BY SIEMENS A.G.

(2) - SYNCHRONOUS NETWORKS

- INFORMATION IS ASSOCIATED TO THE SINGLE BITS ORIGINATED BY THE SENDER DTE
- TIME-DIVISION MULTIPLEXING IS USED TO CARRY MANY CIRCUITS ON ONE PHYSICAL CHANNEL TO THE DSE
- USER RATES UP TO 48 kbit/s
- BIT TIMING AND (OPTIONAL) BYTE TIMING PROVIDED BY THE NETWORK TO THE DTE
- ENVELOPES 6+2 OR 8+2
- POSSIBILITY OF PHYSICAL INTEGRATION WITH TELEPHONY

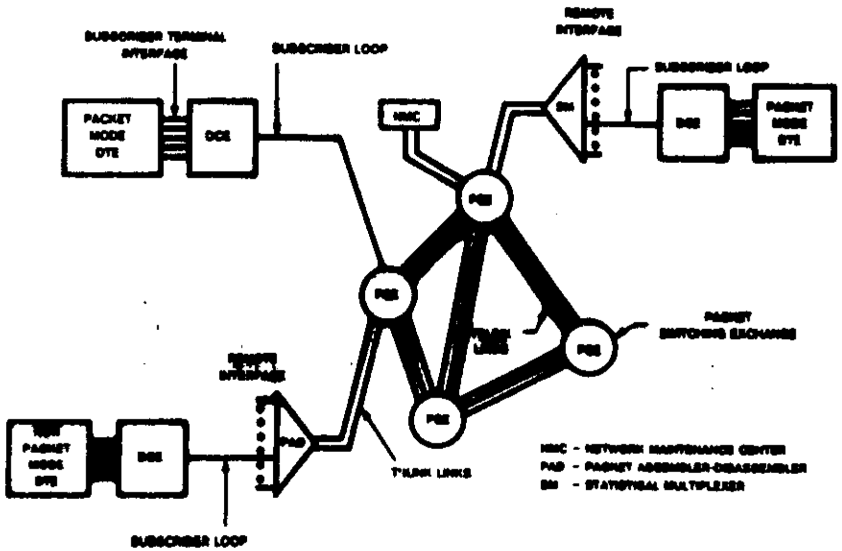


Fig.II.1.4 Packet-Switched Data Network.

BASIC CHARACTERISTICS OF PACKET SWITCHED NETWORKS

- SEGMENTING OF MESSAGES IN PACKETS WITH SUCH A MAXIMUM LENGTH AS DELAY IS MINIMUM (~ 1000 bits)
- POSSIBILITY OF DYNAMIC ROUTING
- BIDIRECTIONAL COMMUNICATIONS
- REASSEMBLING OF MESSAGES
- POWERFUL MECHANISMS FOR ERROR RECOVERY

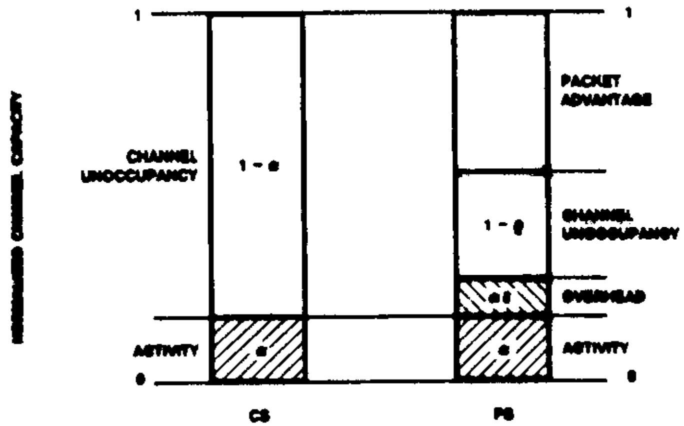
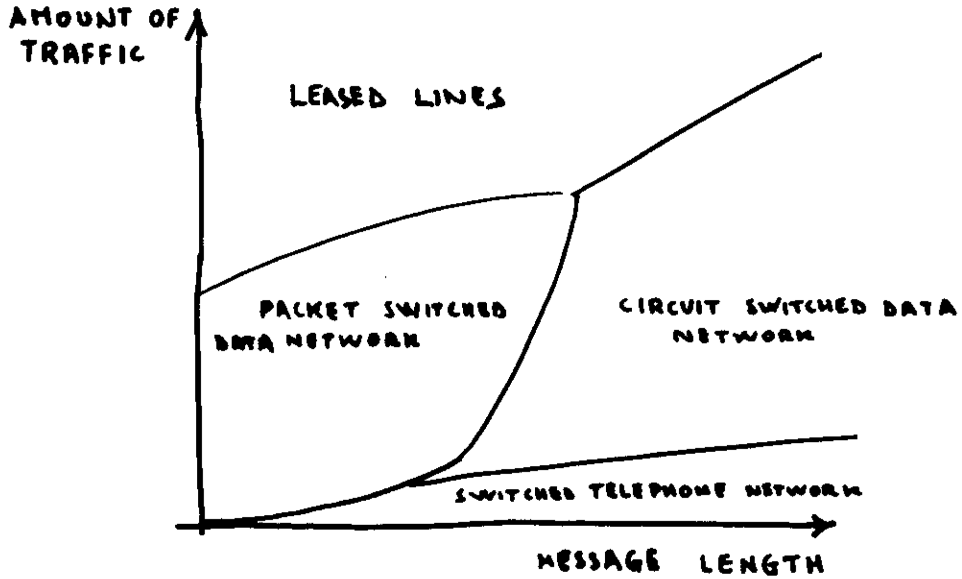


Fig.II.2.3 CS versus PS: Trade-off on Channel Utilization.

PERFORMANCE COMPARISON

	GSTN	CSDN	PSDN
SET-UP TIME	~10 s	< 1 s	< 1 s
TRANSFER DELAY	< 1 ms	< 1 ms	< 300 ms
RELIABILITY	LOW	MEDIUM	HIGH
SPEED AND CODE CONVERSION	NO	NO	YES
PROTOCOL CONVERSION	NO	NO	YES
BIT ERROR RATE	10^{-3}	10^{-7}	10^{-10}
LOGICAL MULTIPLEXING	NO	NO	YES
USER IDENTIFICATION	NO	YES	YES
TARIFF SYSTEM	DURATION + DISTANCE	DURATION + DISTANCE	VOLUME
TRANSMISSION RATE	≤ 2400 bit/s	≤ 64 kbit/s	≤ 64 kbit/s

AREA OF APPLICATION OF DATA COMMUNICATION TECHNIQUES



Message switching is not considered, being viewed as a particular case of packet switching

AREA OF APPLICATION OF DATA COMMUNICATION TECHNIQUES

Circuit switching and packet switching may have different areas of application. Packet switching, which carries bursty traffic efficiently but imposes transmission delays, is generally, considered suitable for the relatively short message transmission which takes place in such interactive applications as time sharing service and on-line file access.

Digital circuit switching, which requires call set-up and release time, is generally considerd to be advantageous for the transmission of longer messages that occur in such applications as remote job entry (RJE) service and file transfer (FT).

For a considerable amount of traffic, as it is shown in the graphic, leasing of lines gets convenient with any length of messages.

The use of GTSN is limited to applications requiring low transmission speed and poor quality of service.

Quantitative evaluation, however, depends upon the exact quality of service to be provided as well as on the tariffs to be applied.

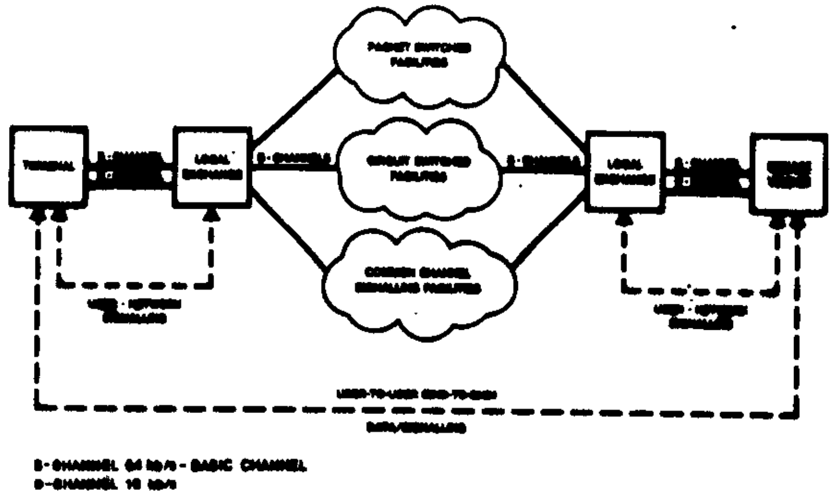
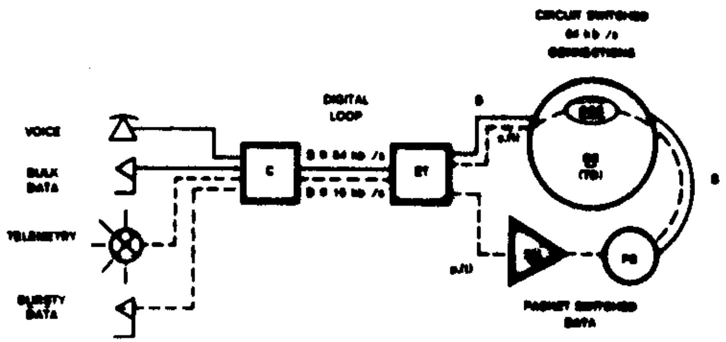


Fig.II.1.6 Early ISDN Architecture for Voice and Data Capability.



C - TERMINAL CONTROLLER
ET - EXCHANGE TERMINATION
SM - STATISTICAL MULTIPLEXER

PS - PACKET SWITCHING FACILITY
CS/TD - CIRCUIT SWITCHING/TIME DIVISION FACILITY
CCS - COMMON CHANNEL SIGNALLING

Fig.II.2.11 Full Digital Approach: Merging of Digital Voice and Data Networks.

- **D-Channel Services (16 kb/s)**
  - Enhanced Telephony
  - Low Speed Data (PS)
  - Videotex
  - Teletex
  - Telemetry
    - EMERGENCY SERVICES
    - ENERGY MANAGEMENT
- **B-Channel Services (64 kb/s)**
  - Voice
  - High Speed Data (CS & PS)
  - High Quality Voice
  - Voice & Data End-to-End
  - Assembly of Subrate Channels
  - Facsimile
  - Slow-Scan Video

CS - CIRCUIT SWITCHING
PS - PACKET SWITCHING

Table II.1.3 ISDN Services for B- and D-Channels.

CCITT — Consultative Committee for International Telegraphy and Telephony

ISO — International Standard Organization

OSI REFERENCE MODEL

OSI : Open System Interconnection

A MODEL FOR DEVELOPING COMPATIBLE PROTOCOLS FOR COMMUNICATION AMONG HETEROGENEOUS SYSTEMS (TERMINALS, COMPUTERS, NETWORKS, PROCESSES, ---)

IT USES A STRUCTURED APPROACH TO PROTOCOL SPECIFICATION BASED ON A SEVEN LAYER ARCHITECTURE

KEY ASPECTS:

* DEFINITION OF HOMOGENEOUS FUNCTIONS AND PROCEDURES WITHIN EACH LAYER, WHICH ALLOW ENTITIES OPERATING IN THE SAME LAYER TO COMMUNICATE CORRECTLY
* CREATION OF BOUNDARIES BETWEEN LAYERS, SO THAT EACH LAYER HAS DIRECT INTERACTION WITH ONLY THE TWO ADJACENT LAYERS.

OSI PROTOCOLS AND SERVICES

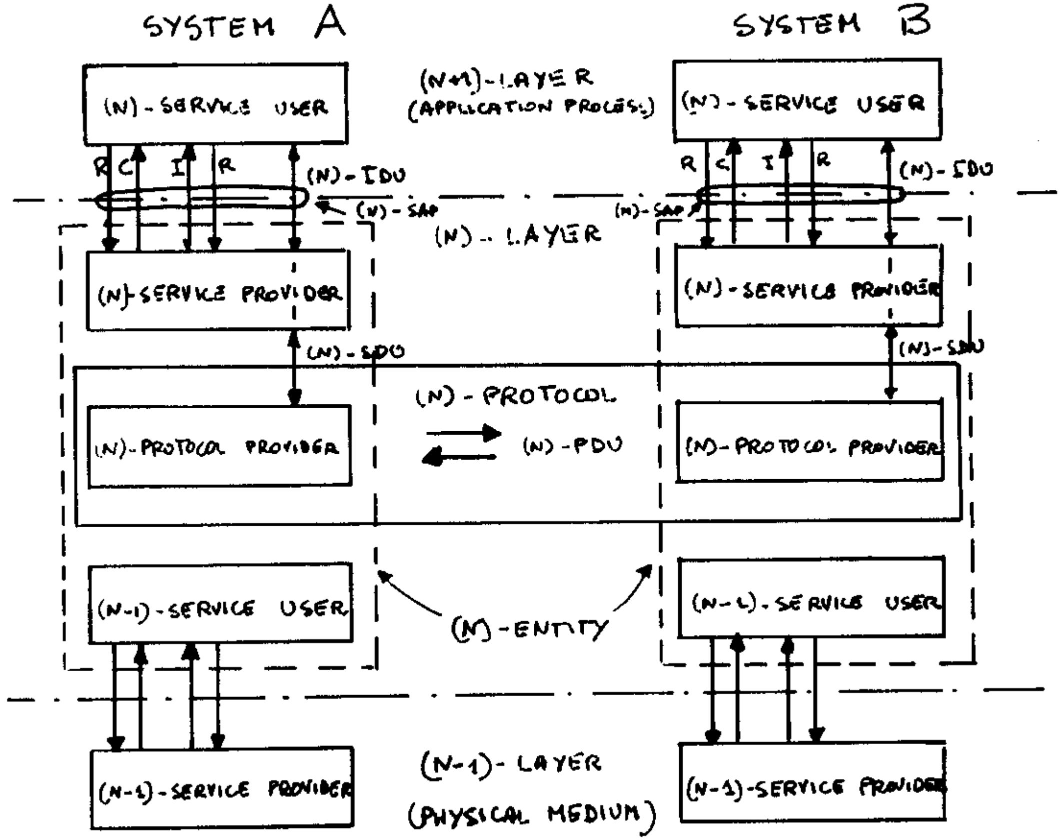
CCITT : RECOMMENDATIONS

ISO : INTERNATIONAL STANDARD

		CCITT	ISO
REFERENCE MODEL		X.200	7498
LAYER			
7 APPLICATION			
	ASSOCIATION CONTROL SERV	X.217	8649
	PROT	X.227	8650
	RELIABLE TRANSFER SERV	X.218	9066-1
	PROT	X.228	9066-2
	REMOTE OPERATION SERV	X.219	9072-1
	PROT	X.229	9072-2
	MESSAGE HANDLING SYSTEMS	X.400 SERIES F.400	10021 SERIES
	DIRECTORY	X.500 SERIES F.500	9594 SERIES
	FILE TRANSFER ACCESS and MANAGEMENT (FTAM)		DIS 8571 SERIES
	JOB TRANSFER and MANIPULATION (JTM)		DP 8831-8832
	-----		
6 PRESENTATION			
	SERVICE	X.216	8822
	PROTOCOL	X.226	8823
	ABSTRACT SYNTAX NOTATION ONE (ASN.1)	X.208 - X.209	8824
5 SESSION			
	SERVICE	X.215	8326
	PROTOCOL	X.225	8327
4 TRANSPORT			
	SERVICE	X.214	8072
	PROTOCOL	X.224	8073

LAYER			CCITT	ISO
3	NETWORK			
	SERVICE		X.213	8348
	PROTOCOL	PSDN	X.25 - X.75	8208
		CSDN	X.21	
	LOCAL AREA NETWORK			DIS 8880 -8881
2	LINK			
	PSDN		X.25 - X.75	DIS 7776
	CSDN		X.21	
	LOCAL AREA NETWORK			DIS 8802
1	PHYSICAL			
	PSDN		X.25 - X.75 V - SERIES	
	CSDN		X.21 X.21 bis	
	LOCAL AREA NETWORK			DIS 8802

(N)-LAYER PROTOCOL AND SERVICE



SERVICE PRIMITIVES :

R	REQUEST
C	CONFIRM
I	INDICATION
R	RESPONSE

SAP : SERVICE ACCESS POINT

IDU : INTERFACE DATA UNIT

SDU : SERVICE DATA UNIT

PDU : PROTOCOL DATA UNIT

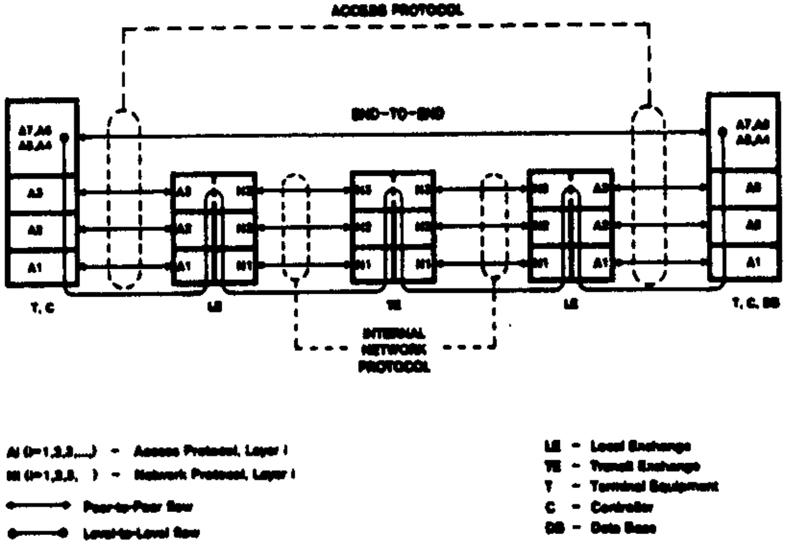


Fig.II.1.9 Distinction between Access and Internal Network Protocols.

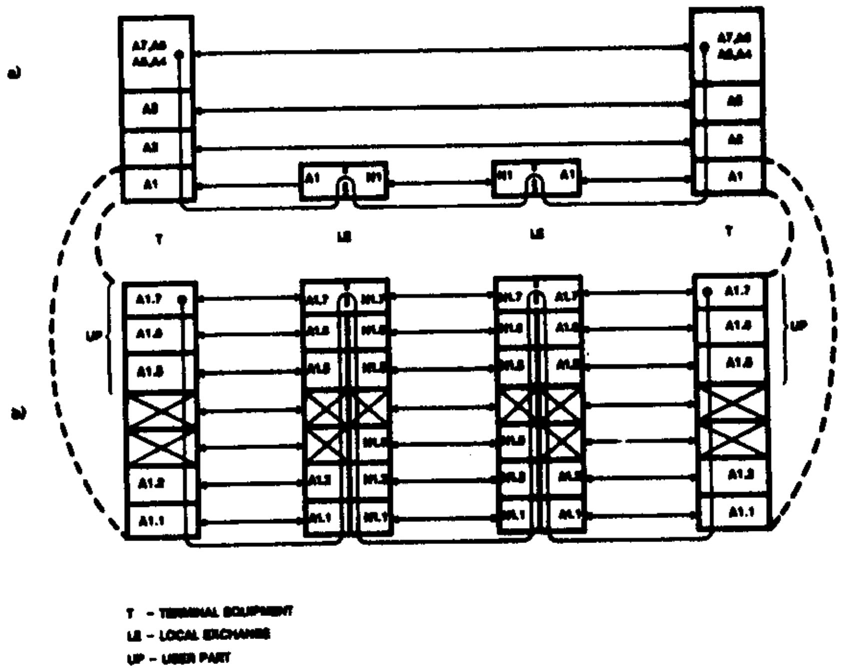


Fig.II.3.2 CS Signalling and User Data Protocol Handling:

(a) User Data;

(b) Signalling.

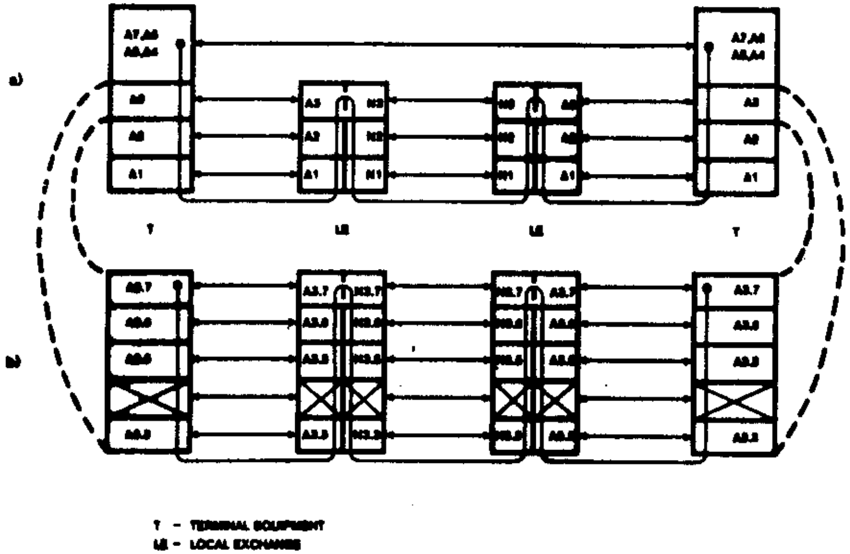


Fig.II.3.4 PS Signalling and User Data Protocol Handling:

(a) User Data;

(b) Signalling.

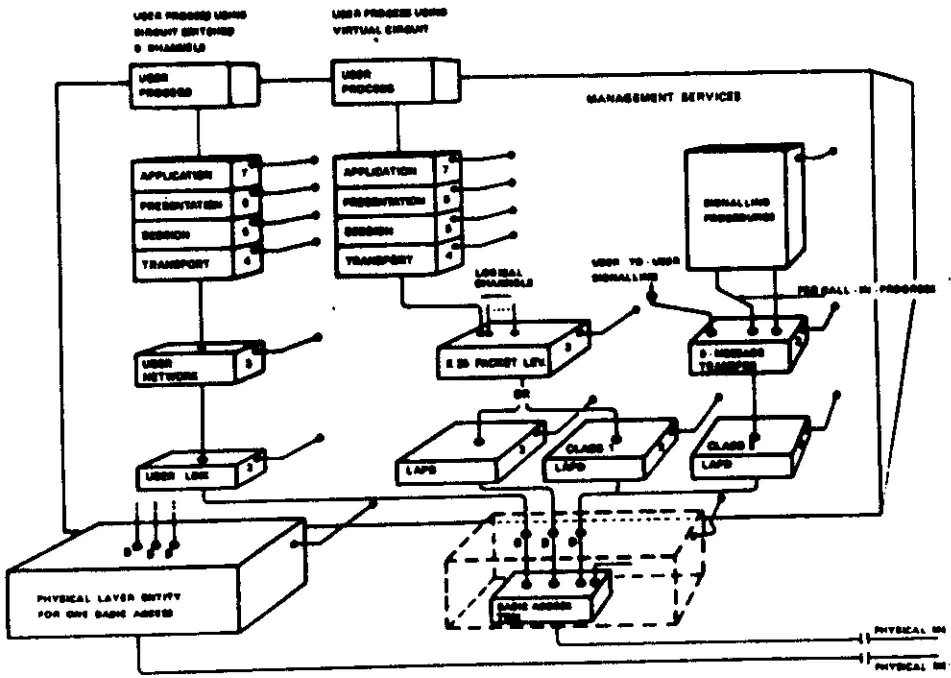


Fig.II.3.40 Example of an ISDN Terminal Equipment.

PHYSICAL LAYER
LAYER 1

* CONCERNS MECHANICAL, ELECTRICAL, FUNCTIONAL AND PROCEDURAL CHARACTERISTICS REQUIRED TO ESTABLISH, MAINTAIN AND RELEASE THE PHYSICAL CONNECTION (DATA CIRCUIT).

* OFFERS A SET OF SERVICES TO LAYER 2:
  - TRANSPARENT BIT TRANSMISSION
  - PHYSICAL FAULT DETECTION
  - PERFORMANCE MONITORING.

TRANSMISSION CHARACTERISTICS

PHYSICAL TRANSMISSION OVER ANALOG LINES CAN BE ACHIEVED:

* IN HALF-DUPLEX OR FULL-DUPLEX MODE OF OPERATION
* WITH ASYNCHRONOUS (START-STOP) TRANSMISSION (E.G. TELEX NETWORKS, EDS (W. GERMANY)) OR SYNCHRONOUS TRANSMISSION (THE SAME CLOCK MUST BE AVAILABLE AT BOTH ENDS OF THE TRANSMISSION PATH)
* AT DIFFERENT TRANSMISSION RATES

  200 300 600 1200 2400 4800 9600 48000 bit/s

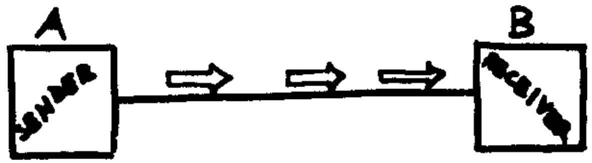
  SIGNALLING SPEED (SYMBOL RATE) [baud] CAN BE LESS WHEN TRANSMITTED SYMBOLS (SIGNAL LEVELS) MAP MORE BINARY DIGITS
* OVER SWITCHED LINES OR LEASED LINES

  ADVANTAGES OF LEASED LINES:
  - REDUCED CHANCE OF MISCONNECTION
  - NO DELAY DUE TO DIALLING AND CONNECTION
  - PARAMETERS OF THE CIRCUIT REMAIN CONSTANT IN TIME
  - REDUCED PULSE NOISE (ASSOCIATED WITH SWITCHING)

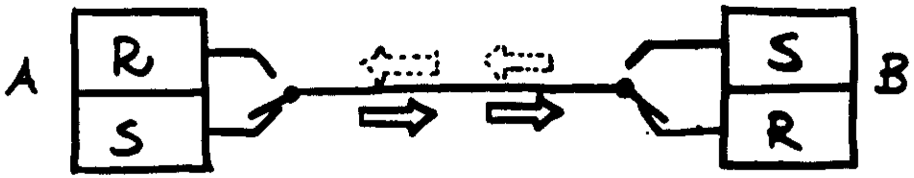
  ALL TELEPHONE CIRCUITS ARE SUBJECT TO:
  * IMPULSIVE NOISE WHICH PRODUCES BURSTS OF ERRORS
  * PHASE DISTORTION WHICH IS CORRECTED BY EQUALISERS
* WITH BASEBAND SYSTEMS (ONLY LEASED LINES) FOR SHORT DISTANCE OR VOICE BAND SYSTEM (300 - 3400 Hz)

DUPLEX AND SIMPLEX OPERATION OF CIRCUITS

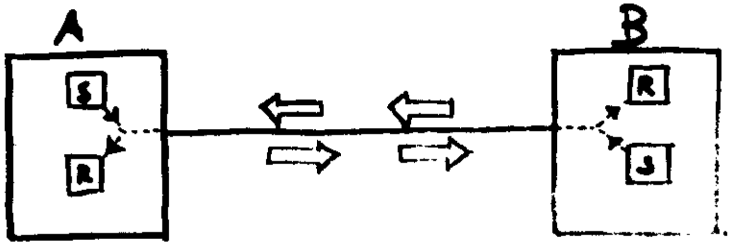
SIMPLEX (ONE WAY ONLY)



HALF-DUPLEX (ONE WAY ALTERNATE)



FULL-DUPLEX (BOTH WAY SIMULTANEOUS)

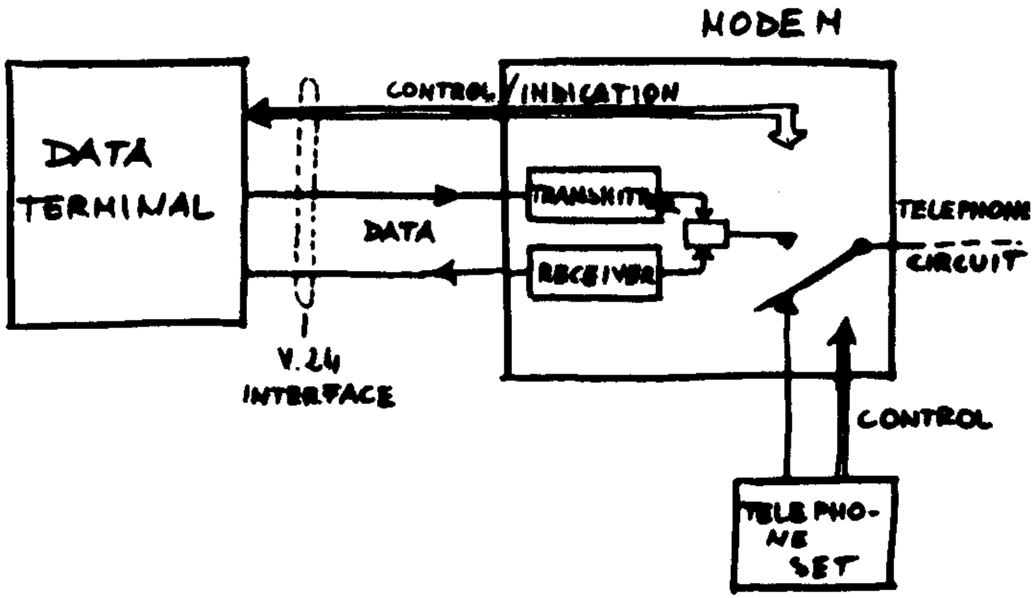


S = SENDER

R = RECEIVER

⇒ = DATA

MODEM INTERFACE



MODEM CHARACTERISTICS

TRANSMISSION RATE [bit/s]	LINES	OPERATION	CCITT RECOMMENDATION
UP TO 300	SWITCHED/ LEASED	FULL-DUPLEX	V.21
1200	SWITCHED/ LEASED	FULL-DUPLEX	V.22
1200 (600)	SWITCHED	HALF-DUPLEX	V.23
2400	SWITCHED	FULL-DUPLEX	V.22 bis
2400	LEASED	FULL-DUPLEX	V.26
2400 (1200)	SWITCHED	HALF-DUPLEX	V.26 bis
4800	LEASED	FULL-DUPLEX	V.27 bis
4800 (2400)	SWITCHED	HALF-DUPLEX	V.27 ter

EXAMPLE:

"V.21" MODEM FOR DUPLEX OPERATION UP TO 300 bit/s

MODULATION METHOD: FREQUENCY SHIFT KEYING (FSK)

THE TWO DIRECTIONS OF TRANSMISSION USE DIFFERENT PAIRS OF FREQUENCIES

CHANNEL No.	"Ø" STATE	"1" STATE
1	1,180 Hz	980 Hz
2	1,850 Hz	1,650 Hz

THAT IS: CHANNEL 1 CARRIER FREQUENCY 1,080 Hz
CHANNEL 2 CARRIER FREQUENCY 1,750 Hz
FREQUENCY SHIFT ± 100 Hz.

DATA COMMUNICATION ON LEASED CIRCUITS

As already seen, data can be transmitted, via modems, over connections made by dialling.

Alternatively, a circuit can be leased from the network authority and equipped with modems specifically for data transmission. This is called a leased circuit.

Such a leased circuit will, in general, go through trunks of various kinds, but it surely offers better properties than most switched connections.

Therefore, by using circuits leased from the carrier, a lot of data communication users set up their proprietary networks, in order to overcome the disadvantages offered by switched connections over the telephone network. This has been possible considering that the early service requirements of the users were only provided with connections within a same organization (bank, research center, point of sale, travelling agency, etc.).

However the private network solution, based on leased circuits, could not resolve the problem of interconnection among a large number of different users. With the wide-spread diffusion of data users and the rapid growth of data traffic the need of an international public switched data service has been getting more and more pressing and since 70's many countries started to set up their public data networks.

III DEFINITIONS OF INTERCHANGE CIRCUITS

III.1 *100 series – General application*

Interchange circuit number	Interchange circuit name	Ground	Data		Control		Timing	
			From DCE	To DCE	From DCE	To DCE	From DCE	To DCE
1	2	3	4	5	6	7	8	9
102	Signal ground or common return	X						
102a	DTE common return	X						
102b	DCE common return	X						
103	Transmitted data			X				
104	Received data		X					
105	Request to send					X		
106	Ready for sending				X			
107	Data set ready				X			
108/1	Connect data set to line					X		
108/2	Data terminal ready					X		
109	Data channel received line signal detector				X			
110	Data signal quality detector				X			
111	Data signalling rate selector (DTE)					X		
112	Data signalling rate selector (DCE)				X			
113	Transmitter signal element timing (DTE)							X
114	Transmitter signal element timing (DCE)						X	
115	Receiver signal element timing (DCE)						X	
116	Select standby					X		
117	Standby indicator				X			
118	Transmitted backward channel data			X				
119	Received backward channel data		X					
120	Transmit backward channel line signal					X		
121	Backward channel ready				X			
122	Backward channel received line signal detector				X			
123	Backward channel signal quality detector				X			
124	Select frequency groups					X		
125	Calling indicator				X			
126	Select transmit frequency					X		
127	Select receive frequency					X		
128	Receiver signal element timing (DTE)							X
129	Request to receive					X		
130	Transmit backward tone					X		
131	Received character timing						X	
132	Return to non-data mode					X		
133	Ready for receiving					X		
134	Received data present				X			
142	Test indicator				X			
191	Transmitted voice answer					X		
192	Received voice answer				X			

– 100-series interchange circuits by category

Interchange circuit number	Interchange circuit name	From DCE	To DCE
201	Signal ground or common return	X	X
202	Call request		X
203	Data line occupied	X	
204	Distant station connected	X	
205	Abandon call	X	
206	Digit signal (2^0)		X
207	Digit signal (2^1)		X
208	Digit signal (2^2)		X
209	Digit signal (2^3)		X
210	Present next digit	X	
211	Digit present		X
213	Power indication	X	

– 200-series interchange circuits specifically for automatic calling

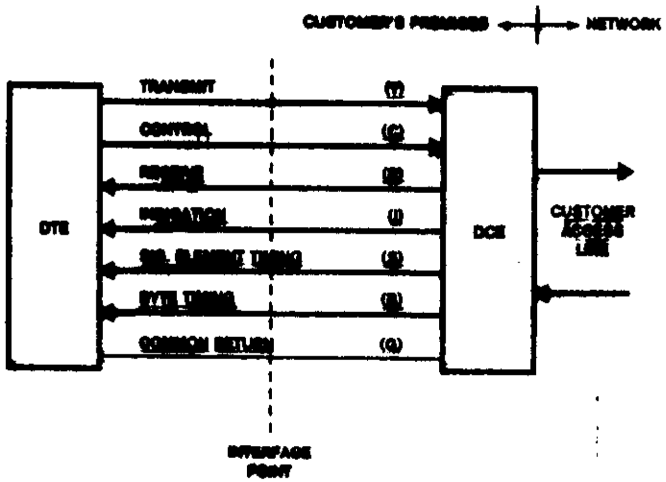


Fig.II.3.6 DTE/DCE Interface according to Recommendation X.21.

DATA LINK LAYER
LAYER 2

- * DATA-LINK-CONNECTION ESTABLISHMENT AND RELEASE
- * DATA UNIT (FRAME) DELIMITING AND SYNCHRONIZATION
- * SEQUENCE CONTROL
- * ERROR DETECTION
- * FLOW CONTROL
- * ERROR RECOVERY

DATA LINK PROTOCOLS

BSC : BINARY SYNCHRONOUS COMMUNICATION

HDLC : HIGH LEVEL DATA LINK CONTROL

UNBALANCED NRM : NORMAL RESPONSE MODE

ARM : ASYNCHRONOUS RESPONSE MODE

BALANCED ABM : ASYNCHRONOUS BALANCED MODE

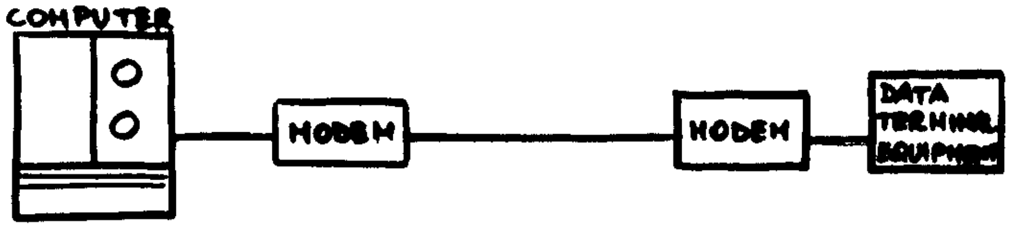
SDLC : SYNCHRONOUS DATA LINK CONTROL

DDCMP : DIGITAL DATA COMMUNICATIONS MESSAGE PROTOCO

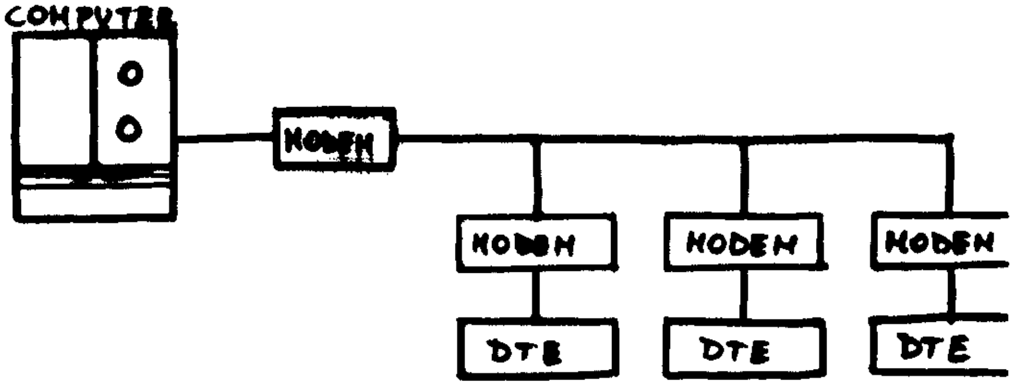
DATA LINK PROTOCOLS CHARACTERISTICS

	BSC	HDLC	SDLC	DDCMP
	HALF DUPLEX	FULL DUPLEX	FULL DUPLEX	FULL DUPLEX
	BYTE ORIENTED	BIT ORIENTED	BIT ORIENTED	BYTE OR.
	POINT-TO-POINT (BELL, BSC)	POINT-TO-POINT	POINT-TO-POINT	POINT-TO-POINT
	MULTIPOINT		MULTI POINT	MULTIPOINT
RAME DELIMITING	STX → ETX	FLAG	FLAG	COUNTER
RANSPARENCY	BYTE STUFFING (DLE)	BIT STUFFING	BIT STUFFING	COUNTER
YNCHRONIZATION	SYN SYN	FLAG	FLAG	SYN SYN
EQUENCE CONTROL	ACK∅ ACK1	N(S)	N(S)	N(S)
RROR DETECTION	BLOCK CHECK CHARACTER (BCC)	FRAME CHECKING SEQUENCE (FCS)	FCS	CYCLIC REDUNDANCY CHECK (CRC)
FLOW CONTROL	ACK∅ ACK1 (WINDOW=1)	WINDOW (MAX 7)	WINDOW (MAX 7)	WINDOW
RROR RECOVERY	RETRANSMISSION (NACK)	RETRANSMISSION	RETRANSMIS.	RETRANS.

DATA COMMUNICATIONS ON LEASED LINES



POINT - TO - POINT CONNECTION



MULTIPOINT CONNECTION

- SIGNALLING SPEED > 2400 BIT/S FULL DUPLEX
- BER < 10^{-5}
- LOWER CALL SET-UP TIME
- POSSIBILITY OF LINE SHARING WITH MULTIPOINT CONNECTIONS

ERROR DETECTION

* VERTICAL REDUNDANCY CHECK

A PARITY (ODD OR EVEN) BIT IS ADDED AT THE END OF THE CODE WORD (USUALLY A BYTE)

IT DETECTS ONLY ODD ERRORS

* LONGITUDINAL REDUNDANCY CHECK

ONE MORE CHARACTER IS ADDED AT THE END OF A MESSAGE BLOCK (BCC). ITS BITS ARE THE EX-OR (MODULO 2 SUM) OF THE BITS IN THE CORRESPONDING POSITION IN THE BLOCK CHARACTERS

VRC + LRC DETECT DOUBLE ERRORS
CORRECT SINGLE ERRORS

* CYCLIC REDUNDANCY CHECK

A CODE VECTOR CAN BE REPRESENTED BY A POLYNOMIAL. THE ELEMENTS OF AN m-ELEMENT CODE ARE THE COEFFICIENTS OF A POLYNOMIA OF ORDER $m-1$

$$P(x) \doteq a_{m-1}x^{m-1} + a_{m-2}x^{m-2} + \dots \quad a_1 x + a_0$$

$$A = [a_{m-1}, a_{m-2}, \dots, a_1, a_0]$$

IF WE DEVIDE $P(x)$ BY THE GENERATOR POLYNOMIAL

$$G(x) = x^{16} + x^{12} + x^5 + 1$$

$$P(x) = Q(x)\,G(x) + R(x)$$

AND WE TRANSMIT $P(x) - R(x) = I(x)$

THE FINAL REMAINDER WILL BE ZERO FOR AN ERROR FREE TRANSMISSION AFTER DIVIDING $I(x)$ BY $G(x)$

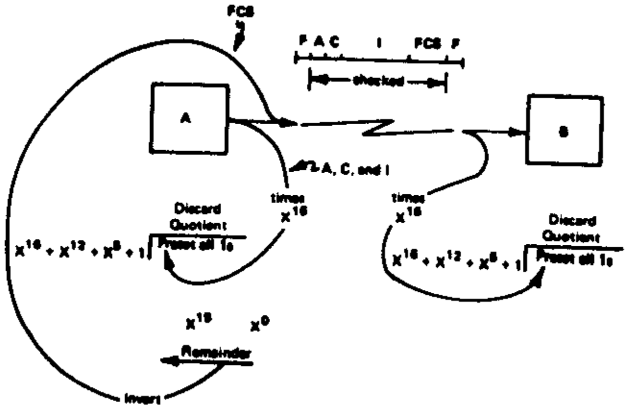
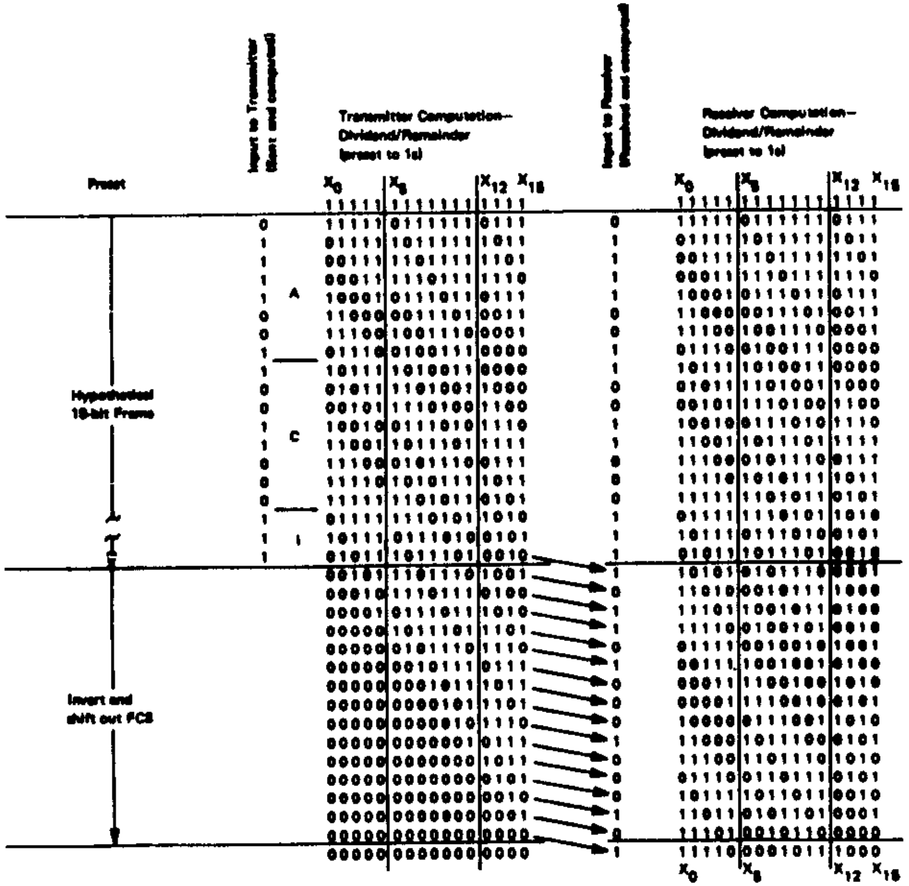


Figure 18. CRC Operation with SDLC



Note: Generator polynomial (divisor) = $X^{16} + X^{12} + X^{5} + 1$, exemplified in shift register form:

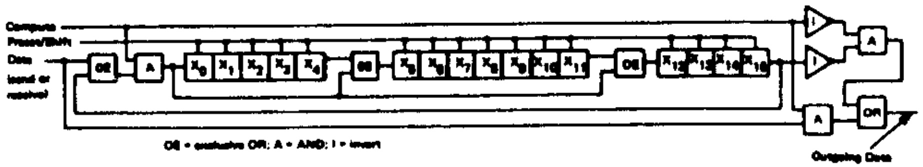
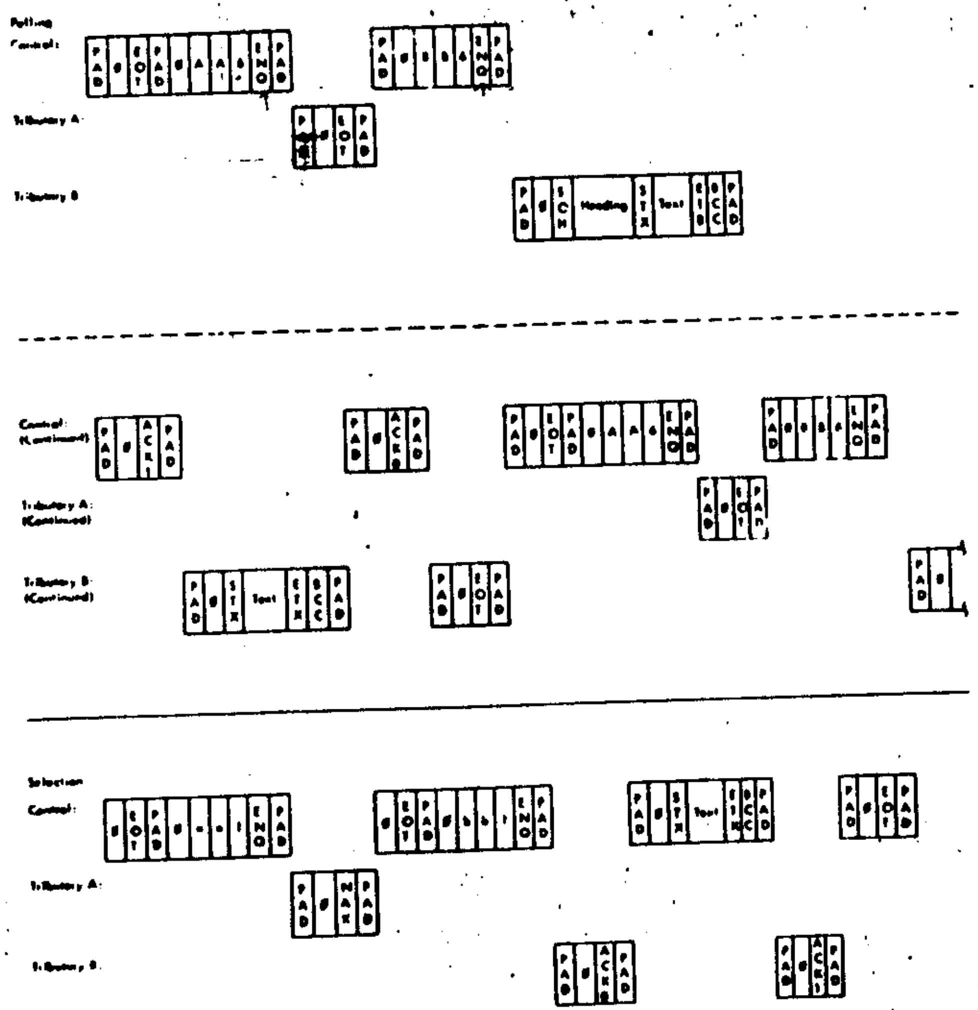


Figure B-1. A Case of CRC as Done for SDLC



Note: ∅ represents SYN character.

Figure 16. Typical Data Link Message Traffic (Centralized Multipoint Operation)

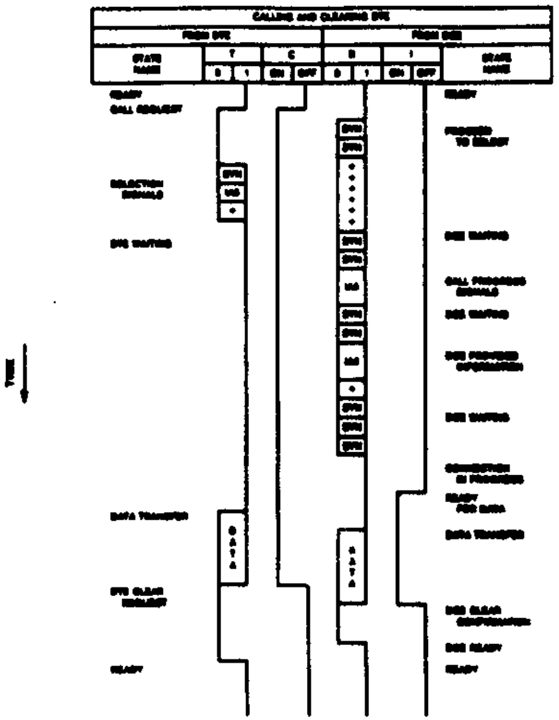


Fig.II.3.7 Recommendation X.21: Example of Sequence of Events for the Successful Call Set-up and Clear-down at Calling and Clearing DTE/DCE Interface.

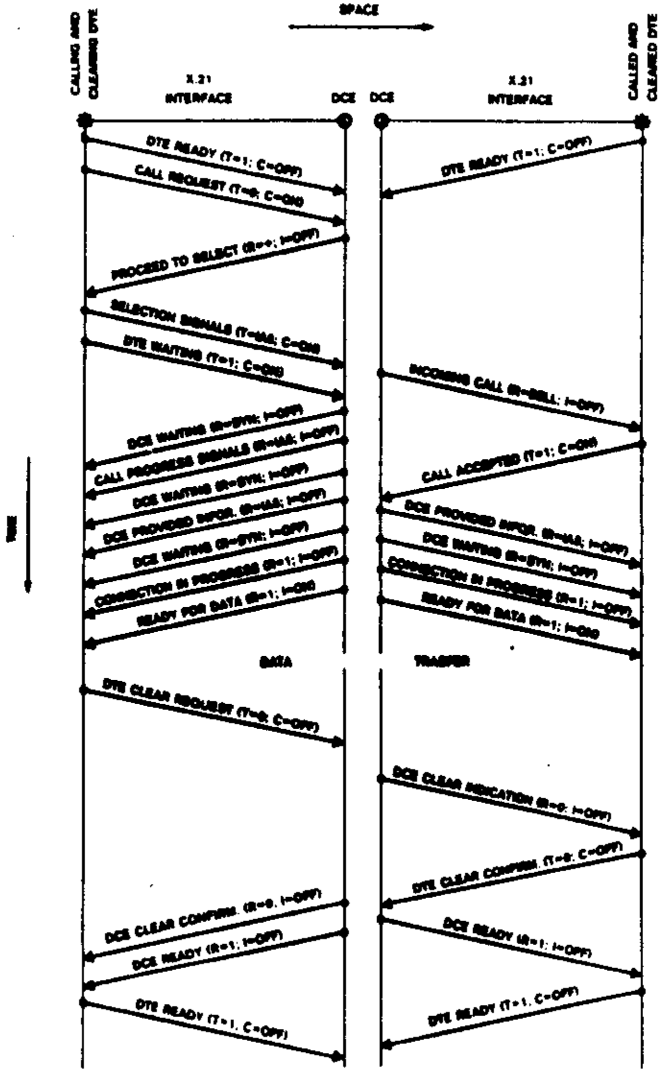


Fig.II.3.8 Recommendation X.21: Signalling for a Typical Connection.

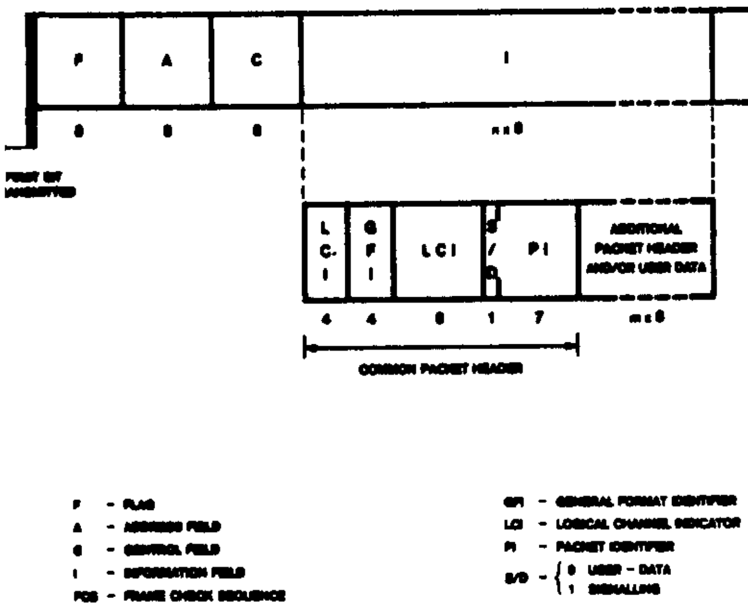


Fig.II.3.18 Recommendation X.25:

a) Level 2 Frame Format;

b) Level 3 Packet Format.

CONTROL FIELD FOR	CONTROL FIELD BITS 1	2	3	4	5	6	7	8
INFORMATION TRANSFER (I FRAME)	0	N (S)			P/F	N (R)		
SUPERVISORY (S FRAME)	1	0	S	S	P/F	N (R)		
UNNUMBERED (U FRAME)	1	1	M	M	P/F	M	M	M

N(S) - TRANSMITTER SEND SEQUENCE NUMBER
N(R) - TRANSMITTER RECEIVE SEQUENCE NUMBER
S - SUPERVISORY FUNCTION BIT
M - MODIFIER FUNCTION BIT
P/F - POLL BIT WHEN ISSUED AS A COMMAND, FINAL BIT WHEN ISSUED AS A RESPONSE

Table II.3.2 Recommendation X.25: Control Field Format.

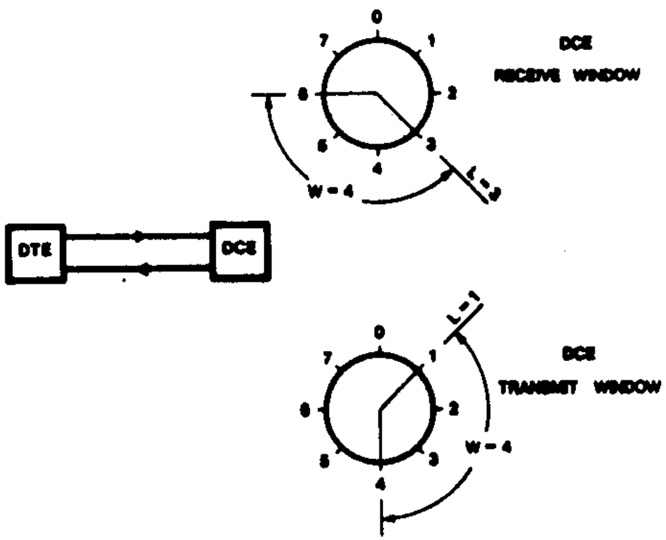


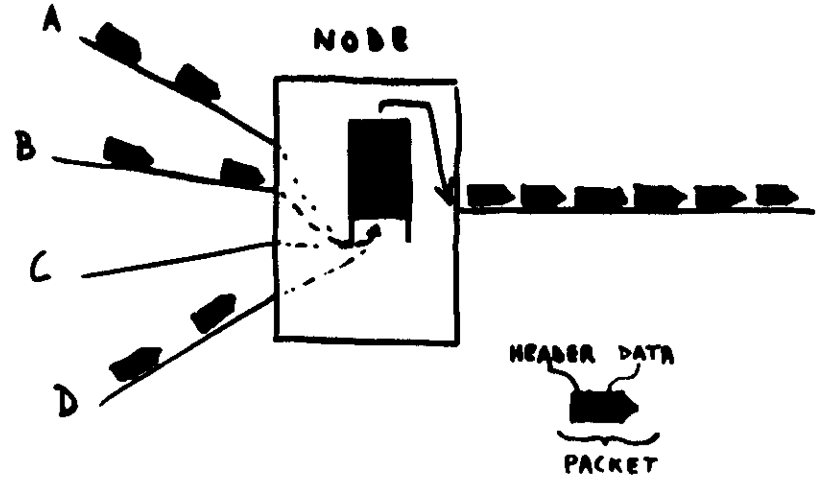
Fig.II.3.26 Flow Control: Example of DCE Receive- and Transmit-Window.

NETWORK LAYER
LAYER 3

* ROUTING AND RELAYING
* NETWORK CONNECTIONS
* NETWORK CONNECTIONS MULTIPLEXING
* SEGMENTING AND BLOCKING
* ERROR DETECTION
* ERROR RECOVERY
* SEQUENCING
* FLOW CONTROL
* EXPEDITED DATA TRANSFER
* RESET

- PACKET SWITCHING ALLOWS TRANSMISSION CHANNELS TO BE BETTER UTILIZED, ESPECIALLY IN LONG DISTANCE CONNECTIONS, AS IT PROVIDES INTELLIGENT MULTIPLEXING OF VARIOUS TRAFFIC FLOWS, WHICH CHARACTESTICS ARE "IMPULSIVE".
- DATA FLOW IS ASSEMBLED IN BLOCKS AND A HEADER FOR ADDRESSING IS ATTACHED. THESE BLOCKS ARE CALLED PACKETS
- THE PACKETS ARE STORED AND PROCESSED IN THE NODES. THEN THEY ARE ROUTED ON THE BACKBONE NETWORK.

THIS IS A TYPICAL QUEUING SYSTEM

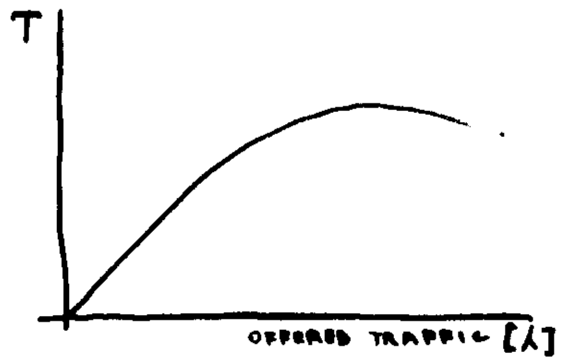


THROUGHPUT = TRAFFIC IN PACKETS/s THAT A NETWORK NODE CAN MANAGE KEEPING DELAY FOR A PACKET LOWER THAN A PREFIXED VALUE (GENERALLY CORRESPONDING TO AN UTILIZATION FACTOR OF ρ (RO) < 0,7)

$$T = \frac{\rho}{\tau_p}$$

τ_p MEAN SERVICE TIME FOR ONE PACKET

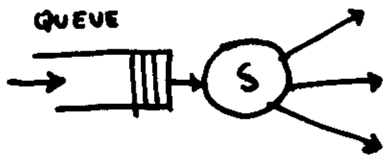
ρ UTILIZATION FACTOR



THROUGHPUT VERSUS OFFERED TRAFFIC IN A NETWORK SUBJECT TO CONGESTION

DELAY (OR TIME IN THE SYSTEM) =

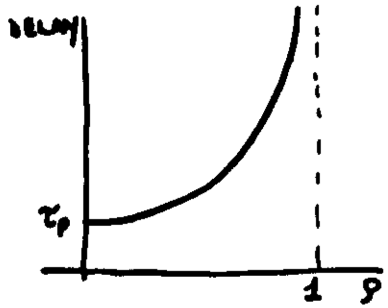
= WAITING TIME + SERVICE TIME



S = SERVER

SIMPLE MODEL OF A PACKET SWITCHING NODE

$$\text{DELAY} = \frac{\tau_p}{1-\rho}$$



ASSUMPTIONS :

1) NODE REGARDED AS SINGLE QUEUE

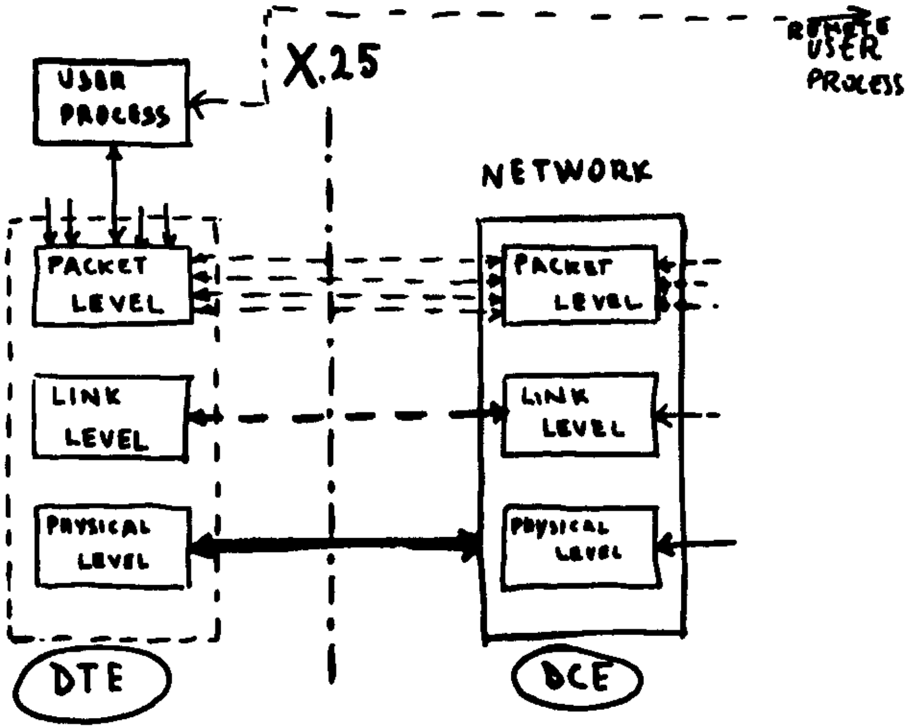
2) ARRIVALS OF PACKETS WITH POISSON DISTRIBUTION RATE

3) SERVICE TIME : EXPONENTIAL DISTRIBUTION

TYPES OF ROUTING (IN P.S.N)

- FIXED
- ADAPTIVE PER CALL
  - CENTRALIZED
  - DISTRIBUTED
- ADAPTIVE PER PACKET
  - CENTRALIZED
  - DISTRIBUTED

X.25 INTERFACE LOGICAL STRUCTURE



PHYSICAL LEVEL _ MECHANICAL, ELECTRICAL, FUNCTIONAL AND PROCEDURAL CHARACTERISTICS TO ACTIVATE, MAINTAIN AND DEACTIVATE THE PHYSICAL LINK BETWEEN DTE AND DCE

LINK LEVEL _ LINK ACCESS PROCEDURE FOR DATA INTERCHANGE ACROSS THE LINK BETWEEN DTE AND DCE

PACKET LEVEL _ PACKET FORMAT AND CONTROL PROCEDURES TO ACTIVATE, MAINTAIN AND DEACTIVATE THE VIRTUAL CIRCUITS (MULTIPLEXED ON THE PHYSICAL LINK) BETWEEN THE LOCAL DTE AND A MULTITUDE OF REMOTE DTEs.

A **VIRTUAL CALL** IS A TEMPORARY OR SWITCHED-VIRTUAL CIRCUIT THAT HAS TO BE SET UP BY AN EXCHANGE OF PACKETS BEFORE INFORMATION TRANSFER CAN TAKE PLACE.

A **PERMANENT VIRTUAL CIRCUIT** IS A PERMANENT ASSOCIATION BETWEEN TWO DTEs WHICH IS ANALOGOUS TO A LEASED TELEPHONE LINE AS IT DOES NOT HAVE TO BE SET UP BEFORE INFORMATION TRANSFER OR CLEARED AFTERWARDS. IT PERMANENTLY OCCUPIES ONE LOGICAL CHANNEL AT EACH DTE.

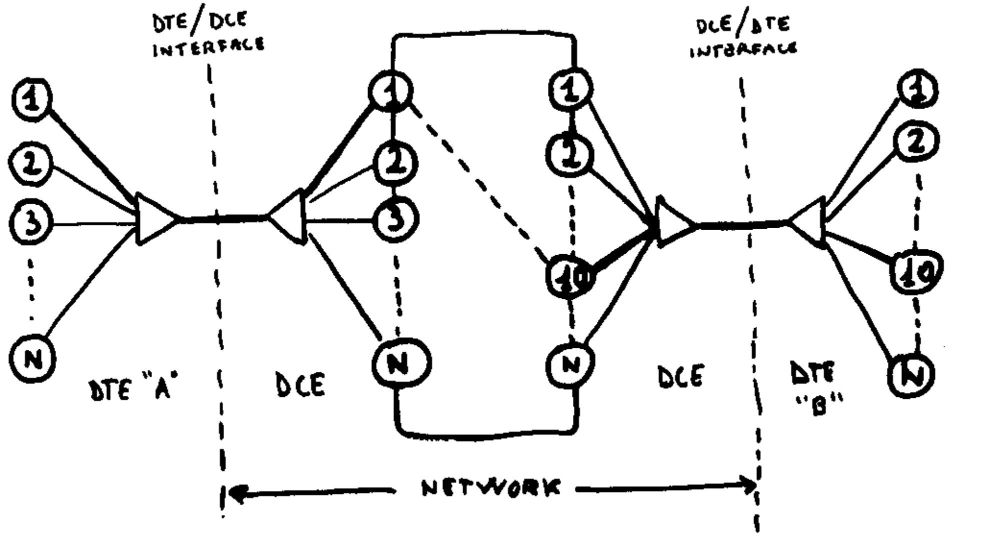
_ A CHANNEL THAT HAS NOT BEEN ASSIGNED TO A V.C. OR P.V.C. IS CALLED A :
READY CHANNEL

VIRTUAL CALL SERVICE

The concept of virtual call service is somewhat along the line of circuit switching. In the case of circuit switching, a physical link is established before data transfer, whereas in the case of virtual call, a logic link is set up prior to data transfer. Packets carrying data are transferred over the logical link thus established.

In setting up a logical link, some packets carrying no data, which are named the call supervision packets, are sent back and forth. At the end of the data transfer, the call supervision packets are again interchanged in order to release the logical link. During the data transfer phase, virtual call service performs packet sequence control as well as packet flow control. Sequence control is done by numbering the data packets being transferred over each logical link so that the packets can be identified. Flow control is to control the rate of packet flow between the terminals and the network. By doing this, the number of packets existing in the network can be restricted so that network congestion and terminal overloading are avoided.

A special kind of virtual call service is possible in which the logical links between specific terminals are permanently set up so that call set-up and release procedures are eliminated. This concept is similar to the leased line service and is called th Permanent Virtual Call (PVC).



A VIRTUAL CIRCUIT ASSOCIATES LOGICAL CHANNEL 1 IN DTE "A" WITH LOGICAL CHANNEL 10 IN DTE "B".

- THE PACKET LEVEL ALLOWS A MAXIMUM OF 16 GROUPS OF 256 LOGICAL CHANNELS (TOTAL 4096 LOGICAL CHANNELS) BETWEEN A DCE AND A DTE.
- BOTH DTE AND DCE USE THE SAME NUMBER TO IDENTIFY A PARTICULAR LOGICAL CHANNEL.
- THE LOGICAL CHANNELS ARE USED TO PROVIDE BIDIRECTIONAL ASSOCIATIONS BETWEEN TWO END DTEs.
- THESE ASSOCIATIONS ARE KNOWN AS VIRTUAL CIRCUITS (VCs) AND MAY HAVE DIFFERENT CHANNEL NUMBERS AT BOTH DTEs.

VIRTUAL CIRCUIT	LOGICAL CHANNEL
_ AN END-TO-END ASSOCIATION BETWEEN TWO DTE;	_ A LOCAL ENTITY BETWEEN DTE AND DCE
_ MAY MAKE USE OF DIFFERENT LOGICAL CHANNELS AT EACH DTE	_ ONLY 1 VC CAN BE ASSIGNED TO A LOGICAL CHANNEL
_ A VC EXISTS ONLY AFTER BEING SET UP, AND A PVC ALWAYS EXISTS	_ ALWAYS EXISTS AND MAY BE EITHER ASSIGNED TO A VC OR READY (FREE)

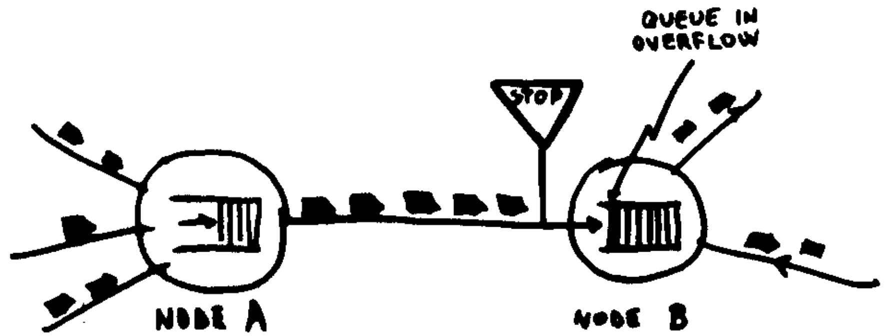
DIFFERENCES BETWEEN VIRTUAL CIRCUIT AND LOGICAL CHANNEL

_ HEADERS OF THE PACKETS CONTAIN NOT ONLY INFORMATION FOR ADDRESSING, BUT ALSO FOR ERROR CONTROL, ERROR RECOVERY, PACKETS SEQUENCING AND FLOW CONTROL.

_ FLOW CONTROL ALLOWS THE NETWORK TO REDUCE FOR A TIME ITS CAPACITY OF PACKETS HANDLING (THROUGHPUT) WHITHOUT DATA LOSS.

_ FLOW CONTROL IS OBTAINED BY SENDING OF SPECIAL CONTROL PACKETS : { RECEIVE READY / RECEIVE NOT READY

AND BY USING A PARTICULAR CONTROL MECHANISM FOR ACKNOWLEDGING, THAT IS CALLED WINDOW MECHANISM.



ALL THESE CHARACTERISTICS MAKE THE PACKET SWITCHING NETWORK A :

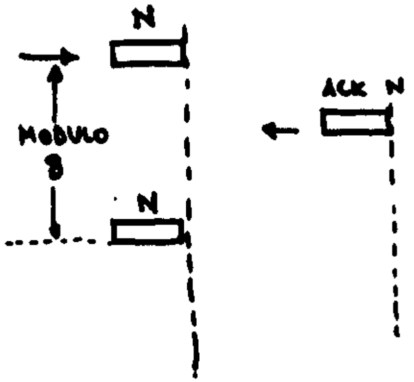
V<u>ALUE</u> A<u>DDED</u> N<u>ETWORK</u>

HOW MAINTAIN PACKETS SEQUENCE ?

EACH PACKET TRANSMITTED OR RECEIVED ON A GIVEN V.C. IS SEQUENTIALLY NUMBERED

MODULO 8 (0, 1, 2, ... 7, 0, 1, ...)

THE FIRST DATA PACKET TO BE TRANSMITTED IN A GIVEN DIRECTION AFTER VIRTUAL CIRCUIT SET UP IS NUMBERED 0



THE MAXIMUM NUMBER OF SEQUENTIALLY NUMBERED DATA PACKETS THAT A DTE OR DCE IS AUTHORISED TO TRANSMIT AND HAVE OUTSTANDING (NOT ACNOWLEDGED) AT ANY GIVEN TIME MAY NEVER EXCEED THE MODULO.

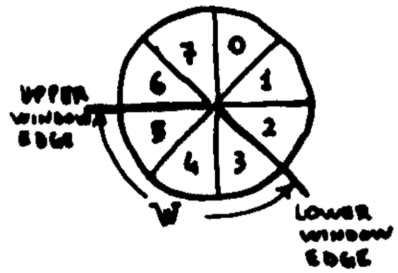
THIS MAXIMUM NUMBER IS CALLED : TRANSMIT WINDOW

FLOW CONTROL IN X.25

W WINDOW MECHANISM

THE WINDOW IS THE MAXIMUM NUMBER W OF PACKETS THAT A DTE OR DCE MAY SEQUENTIALLY TRANSMIT BEFORE RECEIVING ACKNOWLEDGMENT.

W = 3



- WINDOW SIZE = 3
- LAST ACK RECEIVED = 3
- FIRST DATA PACKET NOT AUTHORISED FOR TRANSMISSION HAS NUMBER 6
- RECEIPT BY THE OTHER END OF PACKET OUTSIDE THE WINDOW WILL CAUSE A RESET

THE WINDOW SIZE IS A PARAMETER AGREED FOR A CONTRACTUAL PERIOD BETWEEN THE USER AND THE NETWORK

BESIDES WINDOW MECHANISM, FLOW CONTROL IN X.25, CAN BE HANDLED BY TWO SIGNALLING PACKETS :

RR (N) RECEIVE READY

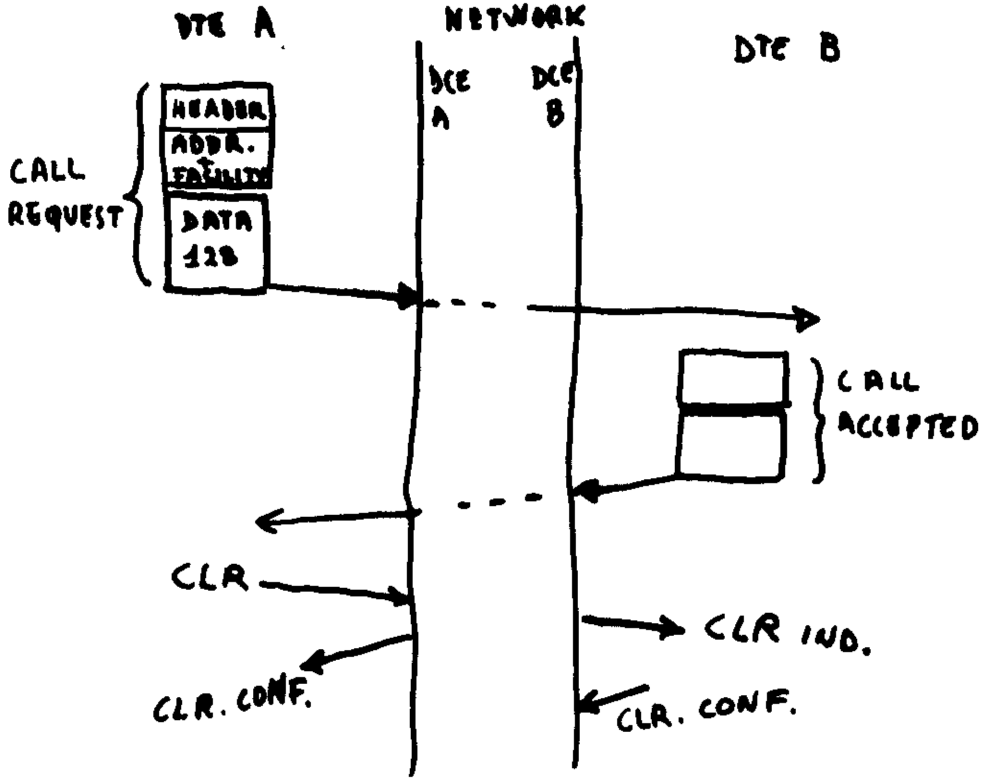
IT IS USED TO ADVANCE LOWER WINDOW EDGE UP TO NUMBER N

RNR (N) RECEIVE NOT READY

IT IS USED TO STOP THE FLOW OF RECEIVED PACKETS - THE LAST PACKET, CORRECTLY RECEIVED, HAS NUMBER (N-1)

TRANSACTION ORIENTED APPLICATION

FAST SELECT 2+2 PACKETS



2+1 PACKETS

DTE B CAN ANSWER A CLEAR INDICATION PACKET WITH DATA (128 BYTES), INSTEAD OF A CALL ACCEPTED PACKET

RESET

THE RESET PROCEDURE REINITIALIZES A PARTICULAR VIRTUAL CIRCUIT IN BOTH DIRECTIONS AND REMOVES, IN EACH DIRECTION, ANY DATA PACKET THAT MAY BE WITHIN THE VIRTUAL CIRCUIT

REINITIALIZATION : P(S) and P(R) = 0

EXAMPLES OF RESET CAUSES

- PACKETS TOO LONG
- PACKETS OUT OF SEQUENCE
- ACK NOT CORRECT
- HIGHER LEVEL ERROR

THE RESET CAN PRODUCE LOSS OF DATA.

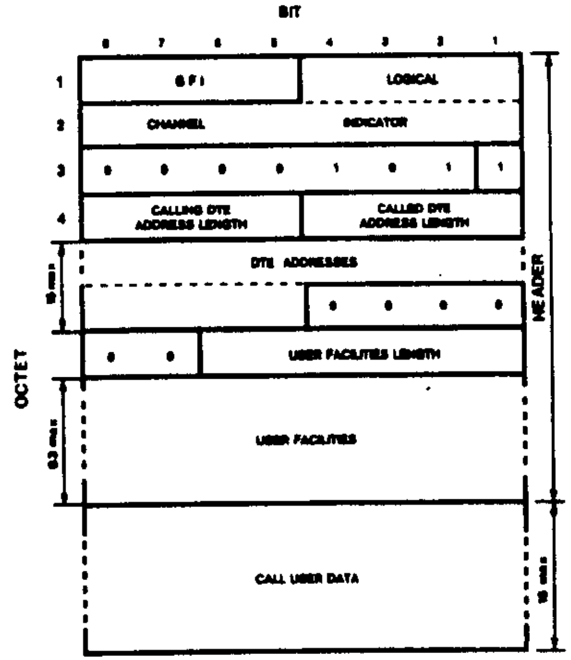
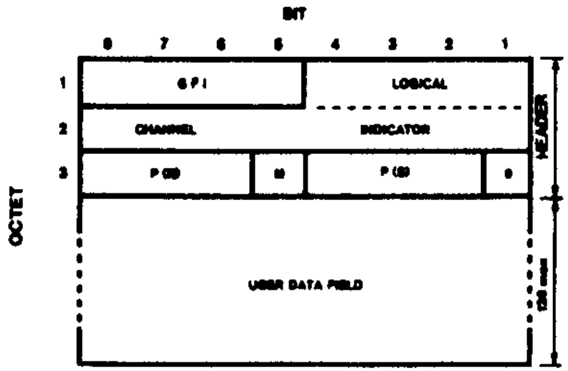
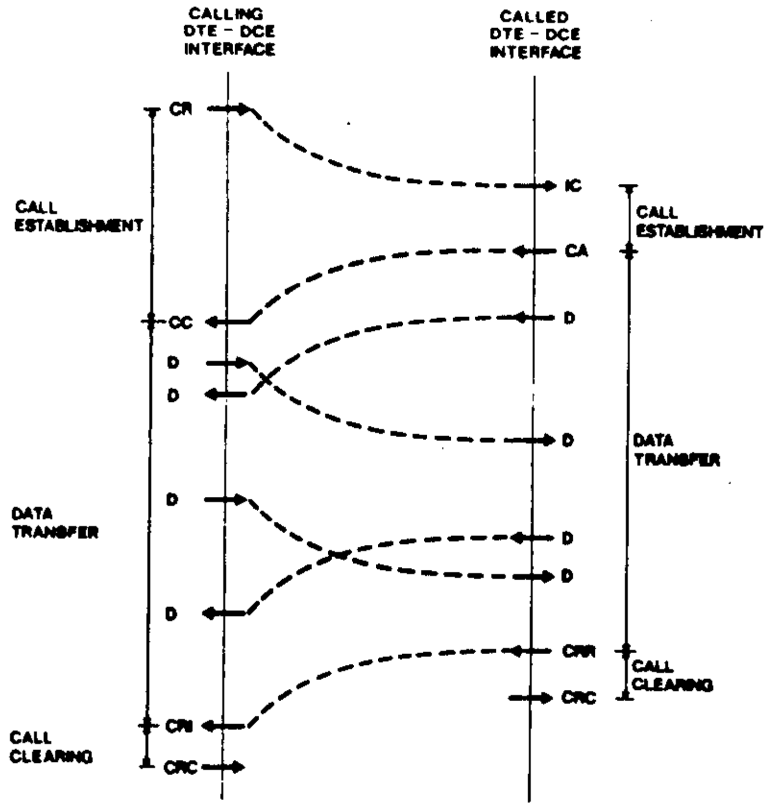


Fig.II.3.20 Recommendation X.25: Format of the CALL REQUEST Packet.



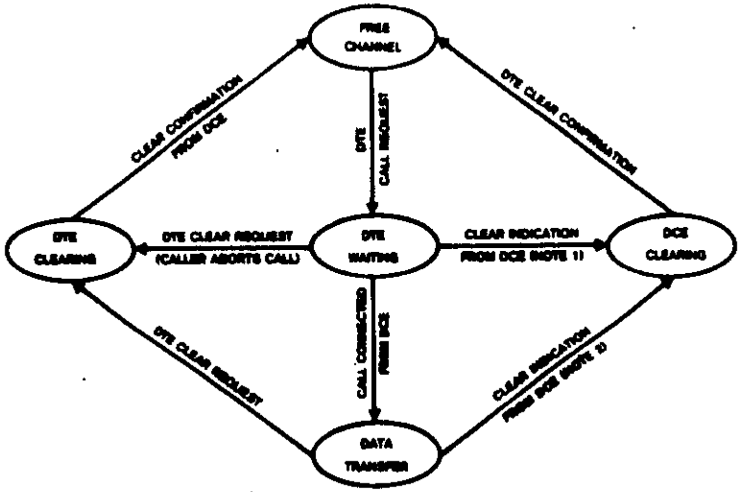
M - MORE DATA BIT
P(S) - PACKET SEND SEQUENCE NUMBER
P(R) - PACKET RECEIVE SEQUENCE NUMBER

Fig.II.3.21 Recommendation X.25: Format of the DATA Packet.



CR - CALL REQUEST
IC - INCOMING CALL
CA - CALL ACCEPTED
CC - CALL CONNECTED
CRR - CLEAR REQUEST
CRI - CLEAR INDICATION
CRC - CLEAR CONFIRMATION

Fig.II.3.22 Recommendation X.25: Evolution of a Virtual Call.

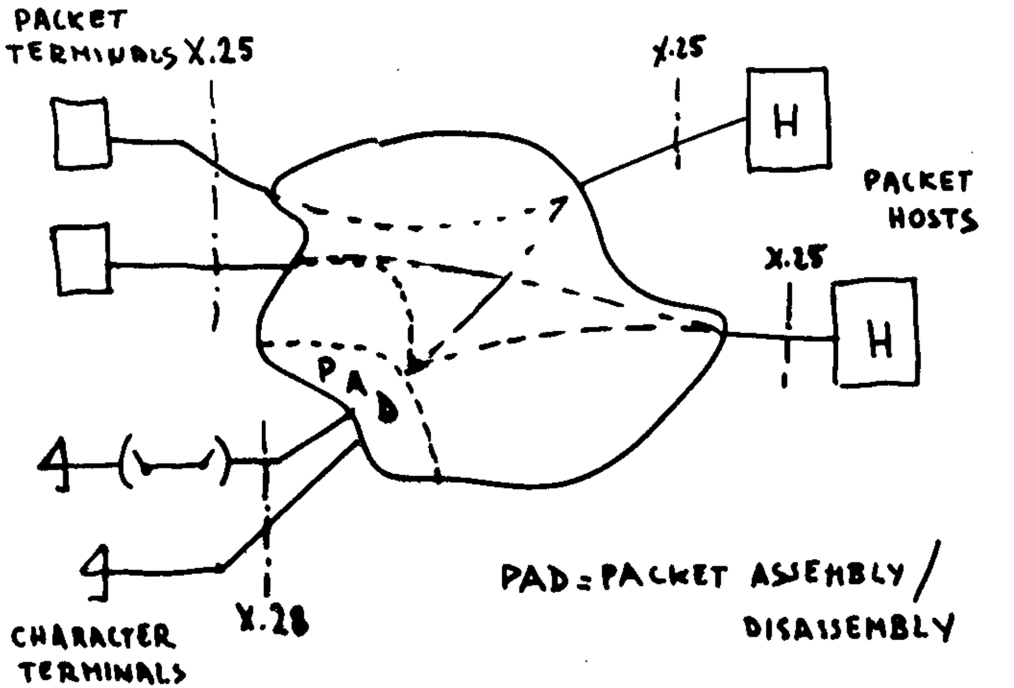


NOTE 1 : EITHER CALLED DTE REFUSED CALL OR CALL ATTEMPT HAS FAILED

NOTE 2 : EITHER CALLED DTE CLEARED DOWN CALL OR CALL CLEARED DUE TO NETWORK FAILURE

Fig.II.3.23 Recommendation X.25: Call Establishment and Clearing at the Calling DTE/DCE Interface.

INTERFACING A PACKET SWITCHED NETWORK



X.25 = PROTOCOL AT THE INTERFACE DTE/DCE FOR PACKET-MODE DTEs

X.28 = PROTOCOL AT THE INTERFACE DTE/DCE FOR CHARACTER-MODE DTEs

} CCITT STANDARDS

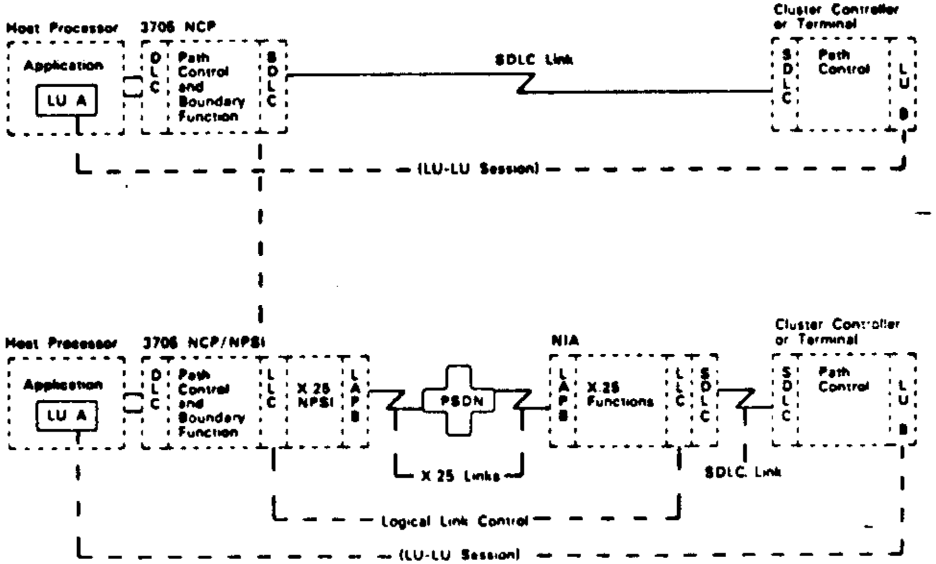


Figure 1-6. SNA-to-SNA Configuration Comparing SDLC Links to Packet Switching

TRANSPORT LAYER
LAYER 4

THE TRANSPORT SERVICE PROVIDES TRANSPARENT TRANSFER OF DATA BETWEEN SESSION ENTITIES AND RELIEVES THEM FROM ANY CONCERN WITH THE WAY IN WHICH RELIABLE AND COST EFFECTIVE TRANSFER OF DATA IS ACHIEVED.
ALL PROTOCOLS DEFINED IN THE TRANSPORT LAYER HAVE END-TO-END SIGNIFICANCE.
THE TRANSPORT LAYER IS RELIEVED OF ANY CONCERN WITH ROUTING AND RELAYING

* MAPPING TRANSPORT ADDRESS ONTO NETWORK ADDRESS
* MULTIPLEXING END-TO-END TR. CONNECTIONS ONTO NET. CONN.
* END-TO-END SEQUENCE CONTROL
* END-TO-END ERROR DETECTION
* END-TO-END ERROR RECOVERY
* END-TO-END SEGMENTING, BLOCKING AND CONCATENATION
* END-TO-END FLOW CONTROL

TRANSPORT PROTOCOL

THE FUNCTIONS OF THE TRANSPORT LAYER HAVE BEEN ORGANIZED INTO CLASSES AND OPTIONS

CLASS : A SET OF FUNCTIONS

OPTIONS : FUNCTIONS WITHIN A CLASS WHICH MAY OR MAY NOT BE USED

CLASS Ø SIMPLE CLASS
CLASS 1 BASIC ERROR RECOVERY CLASS
CLASS 2 MULTIPLEXING CLASS
CLASS 3 ERROR RECOVERY AND MULTIPLEXING CLASS
CLASS 4 ERROR DETECTION AND RECOVERY CLASS

THE USE OF CLASSES AND OPTIONS IS NEGOTIATED DURING CONNECTION ESTABLISHMENT

THE CHOICE WILL DEPEND ON THE TS-USERS' REQUIREMENTS AND THE QUALITY OF THE AVAILABLE NETWORK SERVICES.

NETWORK SERVICES CAN BE CLASSIFIED IN TERMS OF QUALITY:

TYPE A : NETWORK CONNECTION WITH ACCEPTABLE RESIDUAL ERROR RATE AND ACCEPTABLE RATE OF SIGNALLED ERRORS

TYPE B : NETWORK CONNECTION WITH ACCEPTABLE RESIDUAL ERROR RATE BUT UNACCEPTABLE RATE OF SIGNALLED ERRORS

TYPE C : NETWORK CONNECTION WITH UNACCEPTABLE RESIDUAL ERROR RATE

TRANSPORT PROTOCOL CLASSES

CLASS Ø

THE SIMPLEST TYPE OF TRANSPORT CONNECTION

FULLY COMPATIBLE WITH RECOMMENDATION T.70 (TELETEX)

TO BE USED WITH TYPE A NETWORK CONNECTIONS

CLASS 1

ITS MAIN PURPOSE IS TO RECOVER FROM NETWORK DISCONNECTION OR RESET

TO BE USED WITH TYPE B NETWORK CONNECTIONS

CLASS 2

PROVIDES A WAY TO MULTIPLEX SEVERAL TRANSPORT CONNECTIONS ONTO A SINGLE NETWORK CONNECTION

USE OF END-TO-END FLOW CONTROL IS ALLOWED

TO BE USED WITH TYPE A NETWORK CONNECTIONS

CLASS 3

PROVIDES THE CHARACTERISTICS OF CLASS 2 PLUS THE ABILITY TO RECOVER FROM NETWORK DISCONNECTION OR RESET

TO BE USED WITH TYPE B NETWORK CONNECTIONS

CLASS 4

PROVIDES THE CHARACTERISTICS OF CLASS 3 PLUS THE CAPABILITY TO DETECT AND RECOVER FROM ERRORS.

IT ALSO PROVIDES FOR INCREASED THROUGHPUT CAPABILITY

TO BE USED WITH TIPE C NETWORK CONNECTIONS

SESSION LAYER
LAYER 5

THE SESSION LAYER PROVIDES THE MEANS FOR ORGANIZED AND SYNCHRONIZED EXCHANGE OF DATA BETWEEN COOPERATING SS-USERS.

IT PROVIDES ITS USERS WITH MEANS TO:

* ESTABLISH A CONNECTION
  EXCHANGE DATA IN A SYNCHRONIZED MANNER
  RELEASE THE CONNECTION IN AN ORDERLY MANNER
* NEGOTIATE FOR THE USE OF TOKENS TO:
  EXCHANGE DATA
  SYNCHRONIZE
  RELEASE THE CONNECTION
* ARRANGE FOR DATA EXCHANGE TO BE
  TWO WAY ALTERNATE (TWA)
  TWO WAY SIMULTANEOUS (TWS)
* ESTABLISH SYNCHRONIZATION POINTS WITHIN THE DIALOGUE
* INTERRUPT A DIALOGUE AND RESUME IT LATER

A TOKEN IS AN ATTRIBUTE OF A SESSION CONNECTION WHICH IS DYNAMICALLY ASSIGNED TO ONE SS-USER AT A TIME.
LOGICAL PIECES OF WORK BETWEEN SS-USERS ARE DISTINGUISHED IN ACTIVITIES, EACH ACTIVITY CONSISTS OF ONE OR MORE DIALOGUE UNITS, WHICH ARE SEPARATED BY MAJOR SYNCHRONIZATION POINTS.
MINOR SYNCHRONIZATION POINTS ARE POSSIBLE WITHIN A DIALOGUE UNIT.
DURING SESSION CONNECTION ESTABLISHMENT THE USE OF A GROUP OF RELATED SERVICES (OR ELEMENTS OF PROCEDURE) CALLED FUNCTIONAL UNIT CAN BE NEGOTIATED.

TABLE 1/X.215

Functional Units Using Tokens

Functional unit	Token
Negotiated release	release token
Half-duplex	data token
Minor synchronize	synchronize-minor token
Major synchronize	major/activity token
Activity management	major/activity token

TABLE 2/X.215

Services Associated With Each Functional Unit

Functional unit	Service(s)	Reference
Kernel (non-negotiable)	Session connection Normal data transfer Orderly release U-Abort P-Abort	12.1 13.1 14.1 14.2 14.3
Negotiated release	Orderly release Give tokens Please tokens	14.1 13.5 13.6
Half-duplex	Give tokens Please tokens	13.5 13.6
Duplex	No additional service	
Expedited data	Expedited data transfer	13.2
Typed data	Typed data transfer	13.3
Capability data exchange	Capability data exchange	13.4
Minor synchronize	Minor synchronization point Give tokens Please tokens	13.8 13.5 13.6
Major synchronize	Major synchronization point Give tokens Please tokens	13.9 13.5 13.6
Resynchronize	Resynchronize	13.10
Exceptions	Provider exception reporting User exception reporting	13.11 13.12
Activity management	Activity start Activity resume Activity interrupt Activity discard Activity end Give tokens Please tokens Give control	13.13 13.14 13.15 13.16 13.17 13.5 13.6 13.7

PRESENTATION LAYER
LAYER 6

THE PRESENTATION LAYER IS CONCERNED ONLY WITH THE SYNTAX OF INFORMATION (EX: THE REPRESENTATION) AND NOT WITH ITS SEMANTIC (EX: ITS MEANING TO THE APPLICATION LAYER), WHICH IS KNOWN ONLY BY THE APPLICATION-ENTITIES.

IT PROVIDES FOR A COMMON REPRESENTATION TO BE USED BETWEEN APPLICATION-ENTITIES.

IN ORDER TO PROVIDE SYNTAX INDEPENDENCE, THE APPLICATION-ENTITIES CAN USE ANY SYNTAX AND THE PRESENTATION LAYER PROVIDES THE TRANSFORMATION BETWEEN THESE SYNTAXES AND THE COMMON SYNTAX NEEDED FOR COMMUNICATION BETWEEN APPLICATION-ENTITIES.

TRANSFER SYNTAX

A TRANSFER SYNTAX IS A SET OF RULES FOR THE REPRESENTATION OF USER INFORMATION SUBMITTED TO THE PRESENTATION SERVICE.

CORRESPONDING TO A PRESENTATION CONTEXT THERE IS USUALLY ONE TRANSFER SYNTAX.

PRESENTATION CONTEXT

FOR A SERVICE USER, A PRESENTATION CONTEXT INCLUDES THE CATEGORIES OF INFORMATION WHICH HE CAN TRANSFER OR WHICH HE MAY RECEIVE OVER A PRESENTATION CONNECTION.

FOR THE SERVICE PROVIDER, A PRESENTATION CONTEXT INCLUDES THE CATEGORIES OF INFORMATION WHICH HE MAY TRANSFER OVER A PRESENTATION CONNECTION TOGETHER WITH THE TRANSFER SYNTAX TO BE USED TO REPRESENT INFORMATION.

PRESENTATION SERVICE

THE PRESENTATION SERVICE INCLUDES THE FOLLOWING FACILITIES:

- CONNECTION ESTABLISHMENT
- CONNECTION TERMINATION
- CONTEXT MANAGEMENT
- INFORMATION TRANSFER
- DIALOGUE CONTROL

PURPOSE OF PRESENTATION LAYER

The Presentation Layer provides for the representation of the information that application-entities communicate and for their definition and selection.

It covers two complementary aspects of this representation of information:

a) the representation of data to be transferred between application-entities;

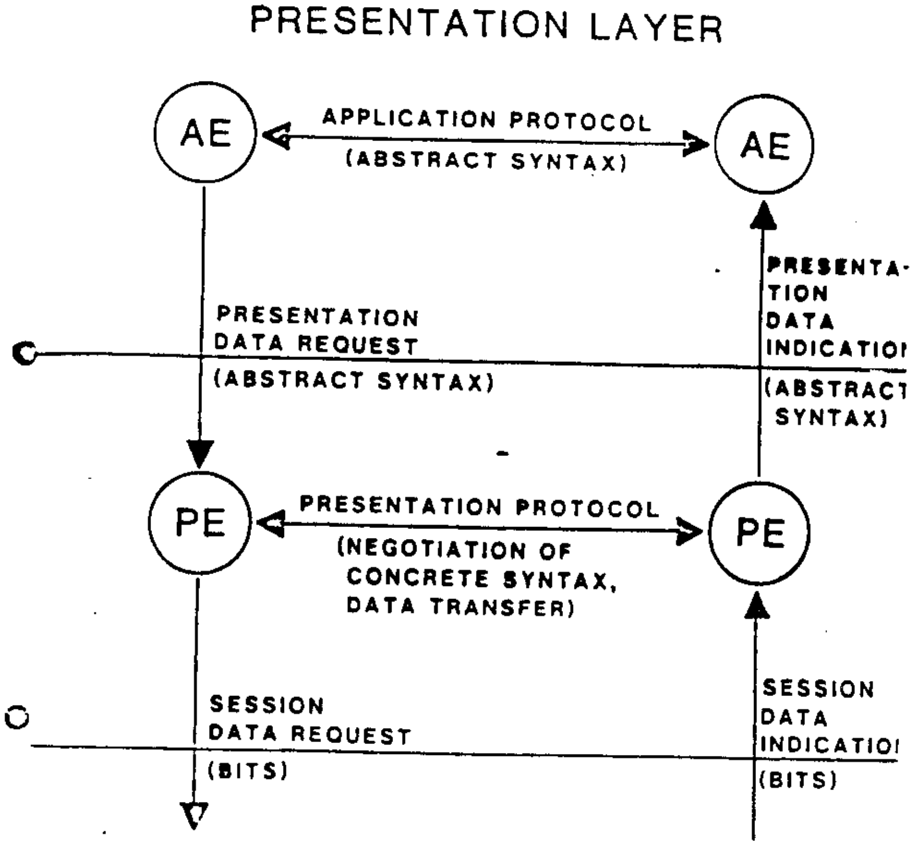
b) the representation of the references to the data structures to which application-entities refer in their communication, along with the representation of the set of actions which may be performed on these data structures.

SCOPE OF PRESENTATION LAYER

The Presentation Layer is concerned only with the syntax of information (i.e. the representation) and not with its semantics (i.e. its meaning to the Application Layer), which is known only by the application-entities.

It provides for a common representation to be used between application-entities.

In order to provide syntax independence, the application-entities can use any syntax and the Presentation Layer provides the transformation between these syntaxes and the common syntax needed for communication between application-entities.



COMMON SYNTAX AND LOCAL SYNTAXES

For each category of information within a context, there are three syntaxes:

- the syntax used by the originating application-entity
- the syntax used by the receiving application-entity
- the syntax used between the presentation-entities (transfer syntax)

The Presentation Layer contains the functions necessary to transform between the transfer syntax and each of the other two syntaxes.

The transfer syntax to be used within a context is negotiated between the peer presentation-entities.

ABSTRACT SYNTAX

Def.: (from DP 8822)

ABSTRACT SYNTAX: those aspects of the rules used in the formal specification of data which are independent of the encoding technique to represent the data.

In other words

an abstract syntax is concerned with the set of A-PDU type definitions associated with an application protocol, that is describes the structure of the application data and the semantics associated with that data.

APPLICATION CONTEXT is a specific abstract syntax definition.

An abstract syntax can be defined, for example, in terms of a set of data-type definitions or in terms of a BNF grammar.

ABSTRACT SYNTAX NOTATION is a set of rules for defining an abstract syntax.

TRANSFER SYNTAX

Def.: (From IS 7498)

TRANSFER SYNTAX: those aspects of the rules used in the formal specification of data which embody a specific representation of that data used in the transfer of data between open systems.

In other words

a transfer syntax is concerned with the way in which data are actually represented in terms of bit patterns while in transit.

ENCODING RULES are the rules which provide a convenient mechanism for generating a transfer syntax from an abstract syntax.

Being an abstract syntax given and expressed by an abstract syntax notation, the identification of encoding rules to be associated with it effectively specifies the transfer syntax.

For the purpose of transferring data between open systems it is necessary to identify:

- the abstract syntax being used
- a transfer syntax which is capable to represent data values that may be generated using the above abstract syntax

In general,

there need not be a unique abstract/transfer syntax combination,

it may be possible:

- to support a specific abstract syntax with one or more different transfer syntaxes
- to use one transfer syntax to support more than one abstract syntax

PRESENTATION CONTEXT

Def. (from DP 8822):

PRESENTATION CONTEXT: An association of an abstract syntax with a compatible transfer syntax. The transfer syntax shall be compatible in the sense that it can be used to express all the information transfer requirements of the abstract syntax.

DEFINED CONTEXT SET: A defined context set is a set of presentation contexts that has been ~~identified~~ defined by agreement between all three parties to a communication: i.e. the presentation service provider and two service users.

DEFAULT CONTEXT. The default context is the context which applies to all user data if and only if the defined context set is empty.

CONTEXT DEFINITION MECHANISM

Presentation layer provides facilities for the definition of presentation contexts both at connection establishment and subsequently.

In defining a presentation context, it is necessary that both service users and the service provider have knowledge of the abstract syntax to be supported by the context. Moreover, the service provider requires knowledge of transfer syntaxes (or equivalently, encoding rules) that may be associated with that abstract syntax.

The negotiation mechanism enables the initiator to supply a list of supported transfer syntaxes, any one of which may be selected by the responder.
The list of offered transfer syntaxes is in a preference order, to assist the responder in making a suitable selection in cases where more than offered syntax is supported.

PRESENTATION CONTEXT IDENTIFIER:

An abstract representation of the technique used by a presentation service user to identify a specific presentation context at the conceptual service interface

ABSTRACT SYNTAX NAME:

An abstract representation of the technique used by a presentation service user to identify a specific abstract syntax at the conceptual service interface.

It is outside of the scope of the presentation service and protocol standards to constrain or specify the abstract and transfer syntaxes supported by a particular open system.

ASN 1

ABSTRACT SYNTAX NOTATION ONE

IT IS THE PRESENTATION TRANSFER SYNTAX

IT DESCRIBES

STANDARD NOTATION	THE SET OF CONVENTIONS EMPLOYED TO DENOTE A TYPE OR A VALUE OF A DATA ELEMENT
ENCODING RULES	FOR TRANSMISSION OF A TYPE AS A SEQUENCE OF OCTETS

A DATA ELEMENT IS A STANDARD REPRESENTATION FOR A VALUE OF EACH TYPE. IT HAS THREE COMPONENTS

- IDENTIFIER
- LENGTH
- CONTENTS

THE IDENTIFIER DISTINGUISHES ONE TYPE FROM ANOTHER

TYPES CAN BE

UNIVERSAL	APPLICATION INDEPENDENT TYPES
APPLICATION-WIDE	PECULIAR TO A PARTICULAR APPLICATION
CONTEXT-SPECIFIC	PECULIAR TO A CONTEXT
PRIVATE-USE	RESERVED FOR PRIVATE USE

DATA ELEMENTS (AND TYPES) CAN BE ATOMIC OR CONSTRUCTED ACCORDING TO THEIR FORM THEY ARE DISTINGUISHED AS:

PRIMITIVE TYPES	CONSTRUCTOR TYPES	CONSTRUCTED TYPES
BOOLEAN	SEQUENCE	IA5 STRING
INTEGER	SET	NUMERIC STRING
BIT STRING	TAGGED	PRINTABLE STRING
OCTET STRING	CHOICE	T.61 STRING
NULL	ANY	VIDEOTEX STRING
		GENERALIZED TIME
		UTC TIME

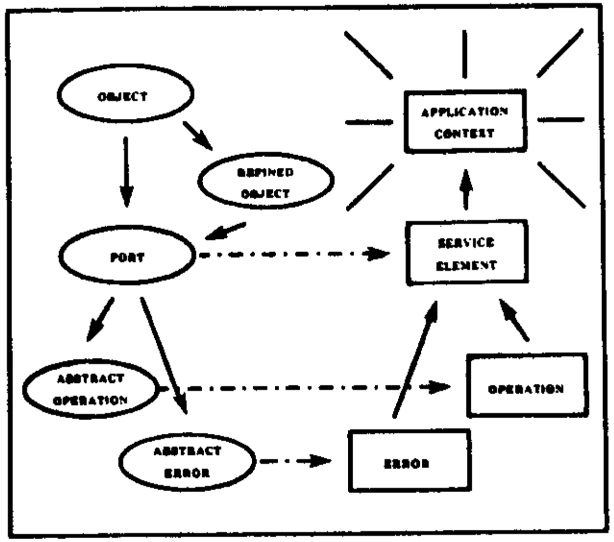


Figure 4. The steps from Abstract Service to finished Application Context

APPLICATION LAYER

LAYER 7

THE APPLICATION LAYER HAS TO SUPPORT MANY DIFFERENT TYPES OF USE, AND THEREFORE IT HAS TO PROVIDE DIFFERENT SERVICES AND TO SERVE AS A "WINDOW" BETWEEN COMMUNICATING USERS.

THE "USER" IS REPRESENTED BY THE APPLICATION ENTITY TO ITS PEER: ALL USER SPECIFICABLE PARAMETRS OF EACH COMMUNICATION INSTANCE ARE MADE KNOWN TO OSI VIA THE APPLICATION LAYER.

THE APPLICATION LAYER PROVIDES ALL THE SERVICES DIRECTLY COMPREHENSIBLE AND APPROPRIATE TO THE OSI USERS, TO THEIR MANAGEMENT AND TO THE SYSTEM MANAGEMENT.

THE SERVICES INCLUDE:

- IDENTIFICATION AND AUTHENTICATION OF INTENDED PARTNERS;
- DETERMINATION OF ADEQUACY OF REQUIRED RESOURCES;
- SYNCHRONIZATION AND DIALOG DISCIPLINE;
- IDENTIFICATION OF CONSTAINTS ON DATA SYNTAX;
- INFORMATION TRANSFER;
- AGREEMENT ON RESPONSIBILITY FOR ERROR RECOVERY, FOR DATA VALIDITY COMMITTMENT, FOR ACCEPTABLE QUALITY OF SERVICE.

APPLICATION LAYER

THE APPLICATION LAYER PROVIDES SERVICES TO THE USERS OF THE OSI ENVIRONMENTS, NOT TO A NEXT HIGHER LAYER: ITS PURPOSE IS TO SERVE AS THE "WINDOW" BETWEEN COMMUNICATING USERS OF THE OSI ENVIRONMENT.

THE "USER" IS REPRESENTED BY THE APPLICATION ENTITY TO ITS PEER; ALL USER SPECIFICABLE PARAMETERS OF EACH COMMUNICATION INSTANCE ARE MADE KNOWN TO OSI VIA THE APPLICATION LAYER.

APPLICATION LAYER INTERFACE

AN APPLICATION ENTITY IS COMPOSED BY:

- CASE (COMMON APPLICATION SERVICE ELEMENTS)
- SASE (SPECIFIC APPLICATION SERVICE ELEMENTS)
- USER ELEMENT

THE CASE ELEMENTS ARE COMMON TO ALL THE APPLICATION ENTITIES.

THE SASE ELEMENTS ARE SPECIFIC FOR PARTICULAR APPLICATIONS AND COULD BE NOT STANDARDIZED.

CASE SERVICES ARE SUBDIVIDED IN:

- SERVICES FOR CONTEXT AND ASSOCIATION CONTROL
- SERVICES FOR INFORMATI N TRANSFER AND DIA GUE CONTROL

MESSAGE HANDLING SYSTEM

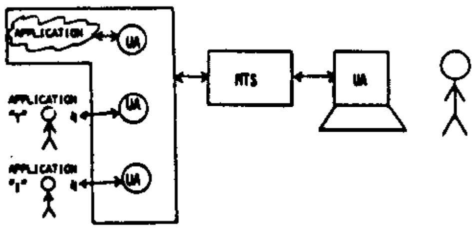
THE MH ENTITIES AND PROTOCOLS ARE LOCATED IN THE APPLICATION LAYER. THAT IS SUBDIVIDED INTO TWO SUBLAYERS:

- THE USER AGENT: IT CONTAINS THE UA FUNCTIONALITY
- THE MESSAGE TRANSFER: IT CONTAINS THE MTS FUNCTIONALITY

TWO BASIC INTERACTIONS BETWEEN MTA AND UAs:

- THE SUBMISSION OF A MESSAGE FROM AN ORIGINAL UA TO AN MTA
- THE DELIVERY OF A MESSAGE FROM AN MTA TO A RECIPIENT UA

MHS: USER AGENT



USER AGENT (UA): SET OF COMPUTER APPLICATION PROCESSES (EX: EDITOR, WP, FILE SYSTEM) THAT, AS A MINIMUM, CONTAIN THE FUNCTIONS NECESSARY TO INTERACT WITH THE MTS.

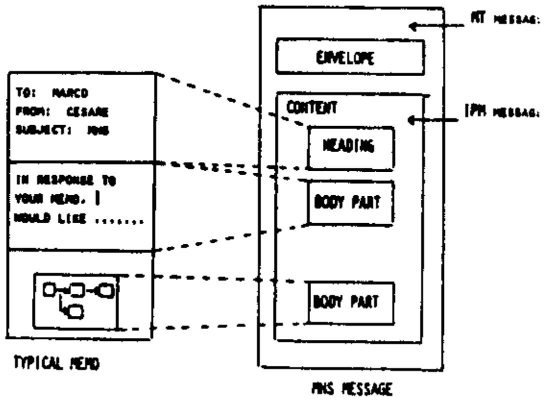
THERE IS ONE UA FOR EVERY MHS USER.

THE MHS PROVIDES TWO SERVICES:

MT - MESSAGE TRANSFER SERVICE, THAT ENABLES UAs TO ACCESS AND TO BE ACCESSED BY THE MTS IN ORDER TO EXCHANGE MESSAGES.

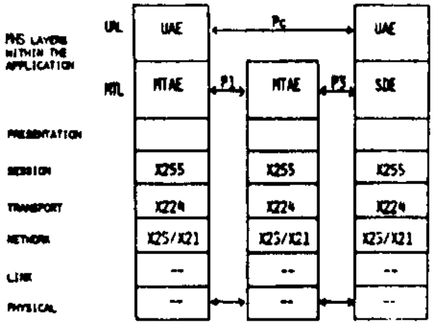
IPM - INTERPERSONAL MESSAGING SERVICE, THAT IS BUILT UPON THE MT SERVICE AND ENABLES A USER TO SEND AN IP-MESSAGE TO ONE OR MORE RECIPIENTS AND TO HAVE IT RECEIVED BY THOSE RECIPIENTS.

MT AND IPM MESSAGES STRUCTURE



IN GENERAL A BODY MAY CONSIST OF A NUMBER OF DIFFERENT ENCODED INFORMATION TYPES SUCH AS VOICE, TEXT, FACSIMILE AND GRAPHICS.

[illegible] OF THE MHS



For IPM System, Pc = P2

THE PROTOCOLS:

- P 1 : MESSAGE TRANSFER PROTOCOL (X.411)
- P c : RANGE OF PROTOCOLS DEFINING THE SYNTAX AND SEMANTICS OF THE MSG CONTENT.
  EACH INSTANCE OF A Pc IS ASSOCIATED WITH A CLASS OF COOPERATING UA.
  P2 IS A SPECIFIC Pc CALLED INTERPERSONAL MESSAGING PROTOCOL (X.420).
- P 3 : SUBMISSION AND DELIVERY PROTOCOL (X.411)
- P T : INTERACTIVE TERMINAL TO SYSTEM PROTOCOLS FAMILY OF INTERACTIVE PROTOCOLS (e.g. x29) THAT IS A NATIONAL MATTER AND IS NOT DEFINED BY X.400.

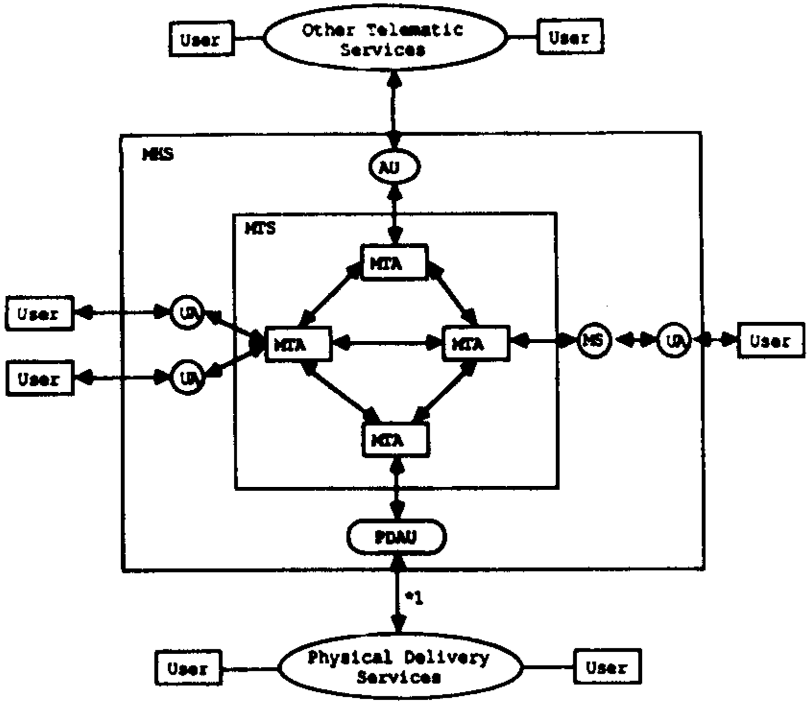
MESSAGE TRANSFER SERVICE ELEMENTS

BASIC	Access Management Content Type Indication Converted Indication Delivery Time Stamp Indication Message Identification Non Delivery Notification Original Encoded Information Types Indication Registered Encoded Information Types Submission Time Stamp Indication
SUBMISSION AND DELIVERY	Alternate Recipient Allowed Deferred Delivery Deferred Delivery Cancellation Delivery Notification Disclosure of other Recipients Grade of Delivery Selection Multidestination Delivery Prevention of Non-Delivery Notification Return of Contents
CONVERSION	Conversion Prohibition Explicit Conversion Implicit Conversion
QUERRY	Probe
STATUS AND INFORMATION	Alternate Recipient Assignment Hold for Delivery

INTERPERSONAL MESSAGING SERVICE ELEMENTS

BASIC	All the Basic MT Service Elements IP-message Identification Typed Body
SUBMISSION AND DELIVERY	All the Submission and Delivery MT Service Elements
COOPERATING IPM UA ACTION	Blind Copy Recipient Indication Non-receipt Notification Receipt Notification Auto-forwarded Indication
COOPERATING IPM UA INFORMATION CONVEYING	Originator Indication Authorizing User Indication Primary and Copy Recipients Indication Expiry Date Indication Cross Referencing Indication Importance Indication Obsoleting Indication Sensitivity Indication Subject Indication Replying IP-message Indication Reply Requests Indication Forwarded IP-message Indication Body Part Encryption Indication Multi-part Body
QUERRY	MT Service Element (probe)
STATUS AND INFORMATION	MT Service Elements

[X.400|100;



* 1): Message input from PDS to MHS is [for further study|not currently possible]. Flow from PD Services to the PDAU shown is for notifications.

Figure 1[/X.400|]
MHS Functional Model

MHS Functional Model

An originator prepares messages with the assistance of his User Agent. A User Agent (UA) is an application process that interacts with the Message Transfer System (MTS) or a Message Store (MS), to submit messages on behalf of a single user. The MTS delivers the messages submitted to it, to one or more recipient UAs, Access Units (AUs), or MSs, and can return notifications to the originator. Functions performed solely by the UA and not standardized as part of the message handling Elements of Service are called local functions. A UA can accept delivery of messages directly from the MTS, or it can use the capabilities of a MS to receive delivered messages for subsequent retrieval by the UA.

The MTS comprises a number of Message Transfer Agents (MTAs). Operating together, in a store and forward manner, the MTAs transfer messages and deliver them to the intended recipients.

Access by indirect users of MHS is accomplished by AUs. Delivery to indirect users of MHS is accomplished by AUs, such as in the case of physical delivery, by the Physical Delivery Access Unit (PDAU).

The Message Store (MS) is an optional general purpose capability of MHS that acts as an intermediary between the UA and the MTA. The MS is depicted in the MHS Functional Model shown in Figure 1[/X.400[]. The MS is a functional entity whose primary purpose is to store and permit retrieval of delivered messages. The MS also allows for submission from, and alerting to the UA.

The collection of UAs, MSs, AUs and MTAs is called the Message Handling System (MHS).

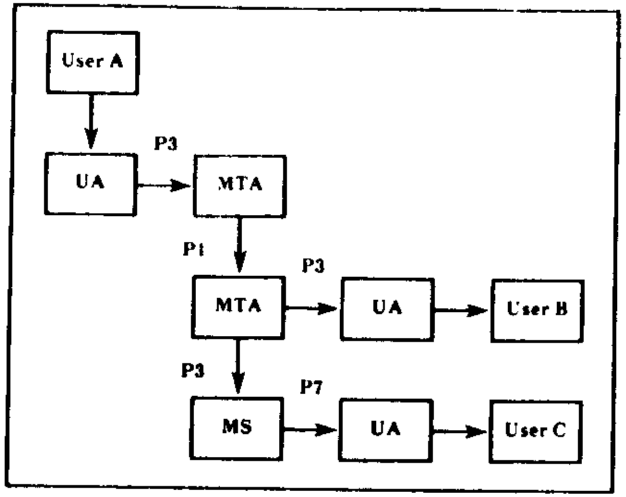
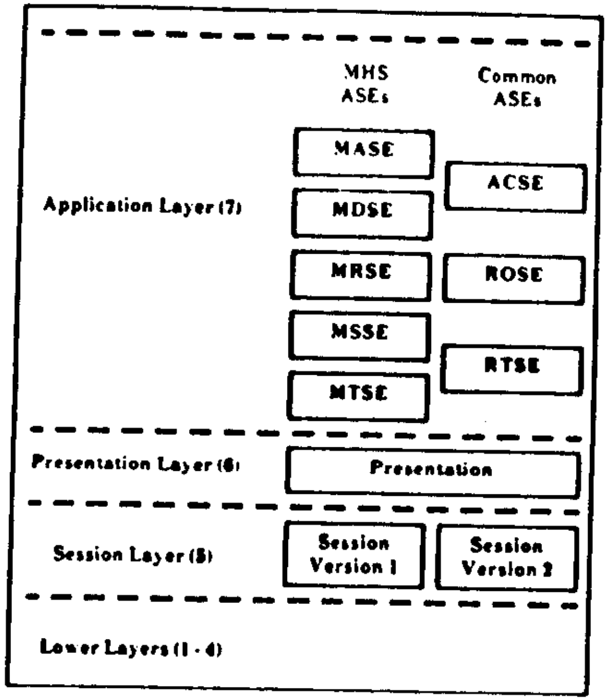


Figure 12 Example of how the 1988 MHS protocols can be used

OSI "building blocks" for MHS '88



8.1 Functional Model

The functional model of the Directory is shown in Figure 4.

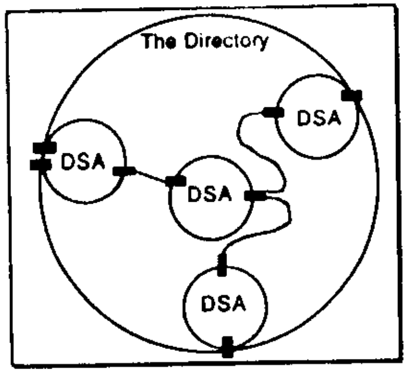


Figure 4. Functional Model of the Directory

A *Directory System Agent (DSA)* is an OSI application process which is part of the Directory and whose role is to provide access to the DIB to DUAs and/or other DSAs. A DSA may use information stored in its local database or interact with other DSAs to carry out requests. Alternatively, the DSA may direct a requestor to another DSA which can help carry out the request. Local databases are entirely implementation dependent.

8.2 Organizational Model

8.2.1 A set of one or more DSAs and zero or more DUAs managed by a single organization may form a Directory Management Domain (DMD). The organization concerned may or may not elect to make use of this series of Recommendations to govern the communications among the functional components within the DMD.

8.2.2 Subsequent Recommendations specify certain aspects of the behavior of DSAs. For this purpose, a group of DSAs within one DMD may, at the option of the organization which manages the DMD, behave as a single DSA.

8.2.3 A DMD may be an Administration DMD (ADDMD), or a Private DMD (PRDMD), depending on whether or not it is being operated by a public telecommunications organization.

Note: It should be recognized that the provision of support for private directory systems by CCITT members falls within the framework of national regulations. Thus, the technical possibilities described may or may not be offered by an Administration* which provides directory services. The internal operation and configuration of private DMDs is not within the scope of envisaged CCITT Recommendations.

8.3 Operation of the Model

8.3.1 The DUA interacts with the Directory by communicating with one or more DSAs. A DUA need not be bound to any particular DSA. It may interact directly with various DSAs to make requests. For some administrative reasons, it may not always be possible to interact directly with the DSA which needs to carry out the request, e.g. to return some directory information. It is also possible that the DUA can access the Directory through a single DSA. For this purpose, DSAs will need to interact with each other.

8.3.2 The DSA is concerned with carrying out the requests of DUAs and with obtaining the information where it does not have the necessary information. It may take the responsibility to obtain the information by interacting with other DSAs on behalf of the DUA.

8.3.3 A number of cases of request handling have been identified, as illustrated in Figures 5-7, and described below.

8.3.3.1 In Figure 5a, DSA C receives a referral from DSA A and is responsible for either conveying the request to the DSA B (named in the referral from DSA A) or conveying the referral back to the originating DUA.

In Figure 5b, the DUA receives the referral from DSA C, and is responsible for reissuing the request directly to DSA A (named in the referral from DSA C).

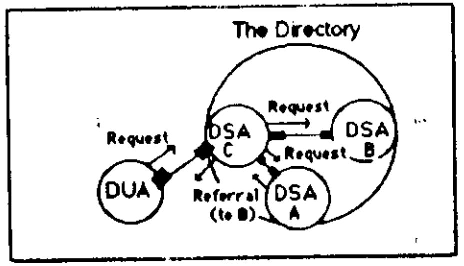


Figure 5a. Referrals

Note - If DSA C returns the referral to the DUA, the "request (to B)" will not occur. Similarly, if DSA C conveys the request to DSA B, it will not return a referral to the DUA.

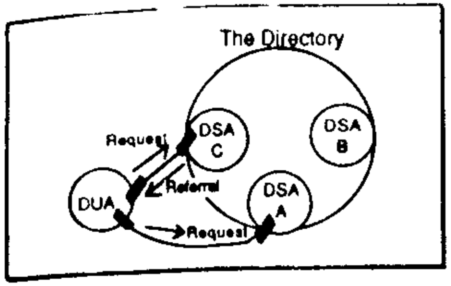


Figure 5b. Referrals

8.3.3.2 Figure 6 shows DSA chaining, whereby the request can be passed through several DSAs before the response is returned.

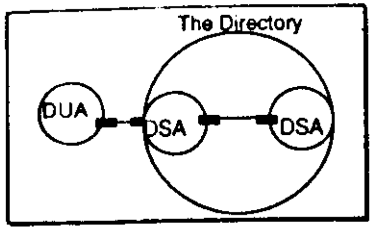


Figure 6. Chaining

8.3.3.3 Figure 7 shows multicasting, where the DSA associated with the DUA carries out the request by forwarding it to two or more other DSAs, the request to each DSA being identical.

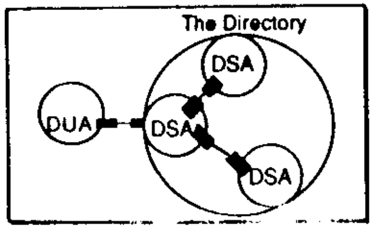


Figure 7. Multicasting

8.3.4 All of the approaches have their merits. For example, the approach in Figure 5 may be used where it is desirable to offload the burden from the local DSA. In other circumstances, a hybrid approach that combines a more elaborate set of functional interactions may be needed to satisfy the initiator's request, as illustrated in Figure 8.

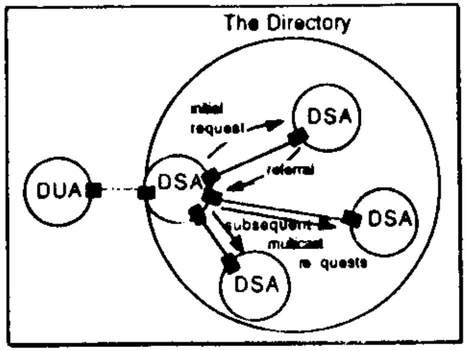


Figure 8 - Mixed Modes Hybrid Approach

9 Directory Protocols

Note - the OSI application layer protocols defined to allow DUAs and DSAs in different open system to cooperate are specified in Recommendation X.519

9.1 There are two Directory protocols:

- the Directory Access Protocol (DAP), which defines the exchange of requests and outcomes between a DUA and a DSA;
- the Directory System Protocol (DSP), which defines the exchange of requests and outcomes between two DSAs.

9.2 Each protocol is defined by an application context, each containing a set of protocol elements. For example, the DAP contains protocol elements associated with interrogating and modifying the Directory.

9.3 Each application context is made up of application service elements. These application service elements are defined to use the Remote Operations Service (ROS) of X.219 to structure and support their interactions. Thus the DAP and DSP are defined as sets of remote operations and errors using the ROS notation.

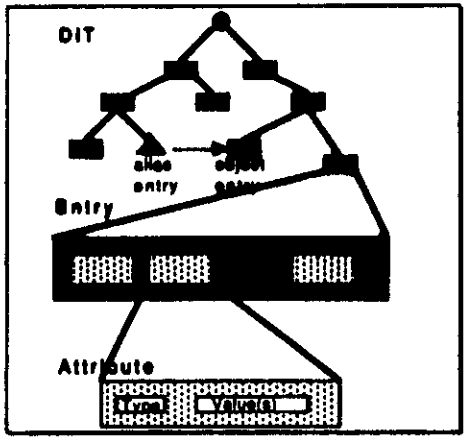


Figure 2. Structure of the DIT and of Entries

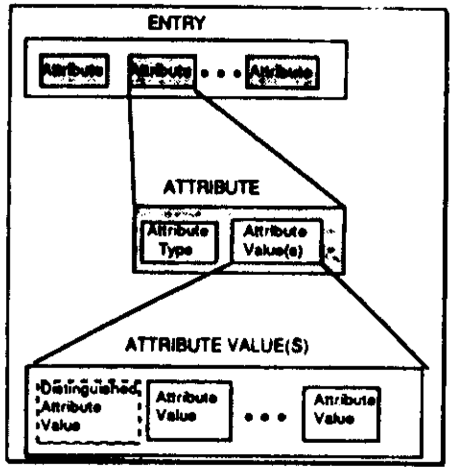


Figure 3. Structure of an Entry

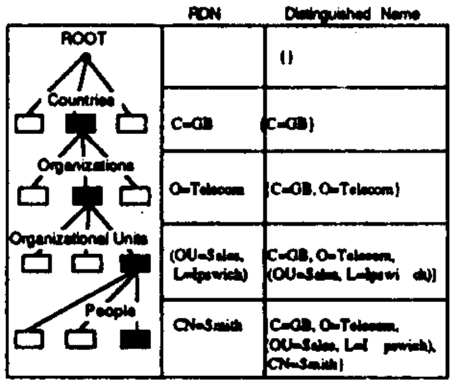


Figure 4. Determination of Distinguished Names

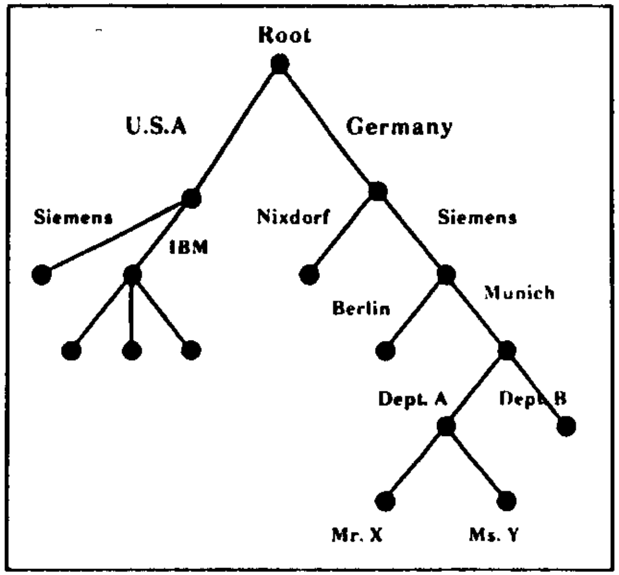


Figure 23 Simple example of the Directory Information Tree

FTAM

FILE SERVICES PROVIDE:

- FILE ACCESS, TO ALLOW INSPECTION, MODIFICATION OR REPLACEMENT OF ALL OR PART OF THE CONTENTS OF VIRTUAL FILE
- FILE MANAGEMENT, TO ALLOW THE INSPECTION OR THE MANIPULATION OF THE PROPERTIES ASSOCIATED WITH THE VIRTUAL FILE AS A WHOLE
- FILE TRANSFER, TO ALLOW THE MOVING OF THE CONTENTS AND THE ASSOCIATED PROPERTIES OF VIRTUAL FILE FROM ONE "OPEN" SYSTEM TO ANOTHER.

FILE SERVICES PROVIDE AN INDEPENDENCE OF:

- THE SPECIFIC HOST
- THE FILE LOCATION
- THE DATA MODEL

VIRTUAL FILE

THE "VIRTUAL FILE" IS A COMMONLY AGREED DESCRIPTION OF A FILE SO AS TO ALLOW DATA MODEL INDEPENDENCE.

VIRTUAL FILE ATTRIBUTES

THE DESCRIPTION OF A VIRTUAL FILE IS MADE BY MEANS OF DEFINING A SET OF DISTINCT PROPERTIES CALLED ATTRIBUTES.

THE VALUES OF THE ATTRIBUTES DEFINE, IDENTIFY AND DESCRIBE THE VIRTUAL FILE COMPLETELY, ALLOWING CORRECT MAPPING BETWEEN REAL AND VIRTUAL FILES.

THE ATTRIBUTES OF A VIRTUAL FILE CAN BE CLASSIFIED INTO 3 CATEGORIES:

CONTAINER ATTRIBUTES: FOR ADDRESSING AND PROTECTION. THEY INCLUDE:

FILE NAME
FILE PASSWORDS
ACCESS-CONTROL-LIST

HISTORY ATTRIBUTES: AUTOMATICALLY MAINTAINED BY THE FILESTORE TO REFLECT THE ACCUMULATED FILE ACTIVITY.

CONTENTS ATTRIBUTES: FOR DESCRIPTION OF THE STRUCTURE OF THE FILE CONTENTS. THEY ARE THE MOST NUMEROUS AND ARE SUBDIVIDED FOR BETTER MODULARITY INTO SUBCATEGORIES AS FOLLOW:

GLOBAL ATTRIBUTES:	FILE-STRUCTURE FILE-DATA-TYPE FILE-CURRENT-SIZE FILE-MAXIMUM-SIZE
RECORD ATTRIBUTES:	RECORD-SEQUENCE DIRECT-ACCESS RECORD-SIZE-TYPE RECORD-SIZE
KEY ATTRIBUTES:	KEY-POSITION KEY-LENGTH KEY-FIELD-RANK
FIELD ATTRIBUTES:	FIELD-RANK FIELD-DATA-TYPE FIELD-SIZE FIELD-COMPLEMENT

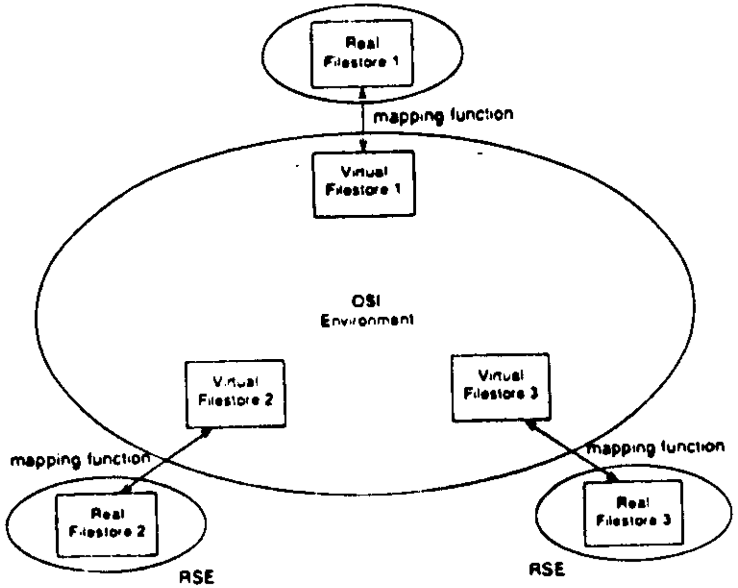


Figure 6 — Mapping between real systems and open systems

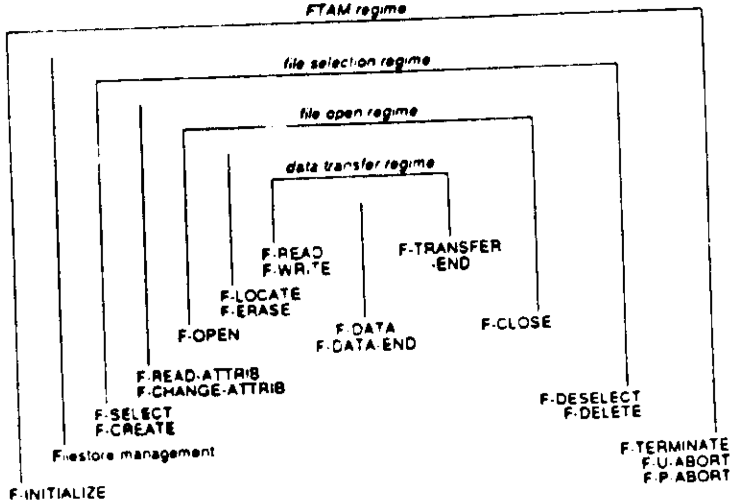
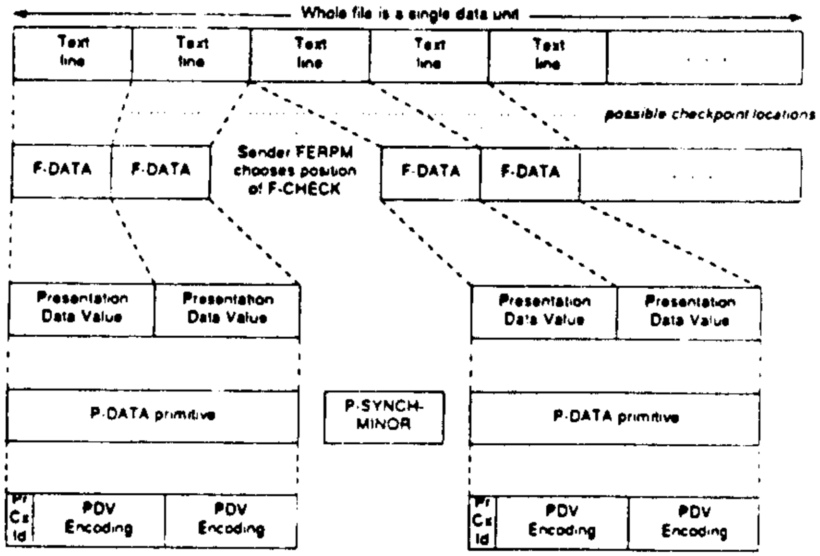
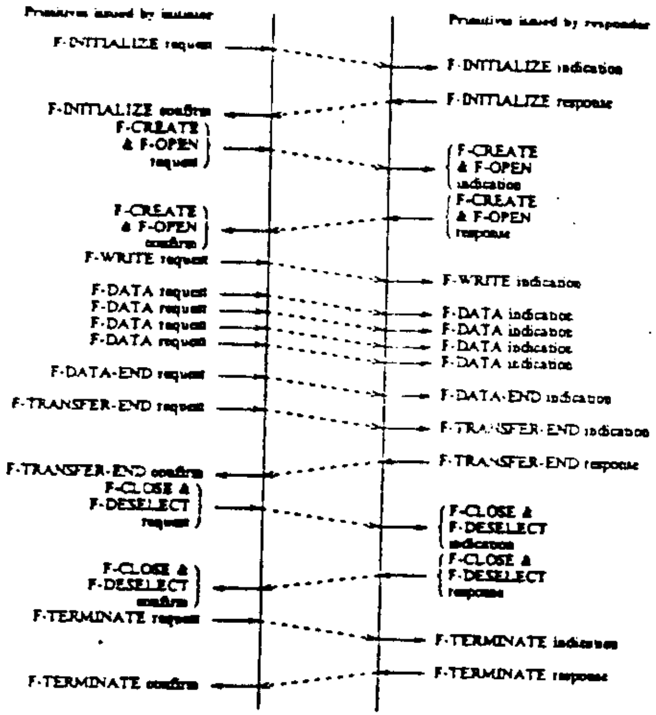


Figure 10 — File service regimes and related primitives



FERPM File Error Recovery Protocol Machine
PDV Presentation Data Value
Pr Cx Id Presentation Context Identifier

Figure 9 — Transmission of an unstructured text file



A.2 Transmission of a complete file to a remote system

Suppose a user on one system wishes to transfer a file to a colleague on a different system, via a public data network. The steps which are taken are as follows (see figure 0):

a) the initiating user requests an application association. It provides the information necessary to address the remote system and to identify itself. The implementation chooses the necessary quality of service and presentation contexts on the basis of its system control information, and selects the transfer class with the write and limited management functional units. The selection of the recovery and restart functional units will be based on cost benefit choices.

b) the responding system performs any necessary authorization of the calling system's location, the identity of the initiating user and the proposed account, and accepts the association.

c) the initiating system sends the specifications of the file to be created on the remote system and of the data transfer to be performed. These are specified separately in ISO 8571 to allow more complex usage, but in this simple case they are always concatenated and sent as a single operation.

d) the responding system accepts this specification.

e) the initiating system sends, as a continuous stream of transmissions, the specification of the write action to be performed, the file's contents, an end of data marker and a request that the end of the transfer be confirmed.

f) the responding system confirms receipt of the file's contents.

g) the initiating system releases the linkage with the newly created file; again, this is a concatenation of separately specified components.

h) the responding system confirms the release.

i) the initiating system requests the release of the association with the remote system.

j) the responding system confirms the release.

k) the initiating system dissolves the supporting connections, and records any necessary accounting and logging information.

THE TELETEX SERVICE (F. 200)

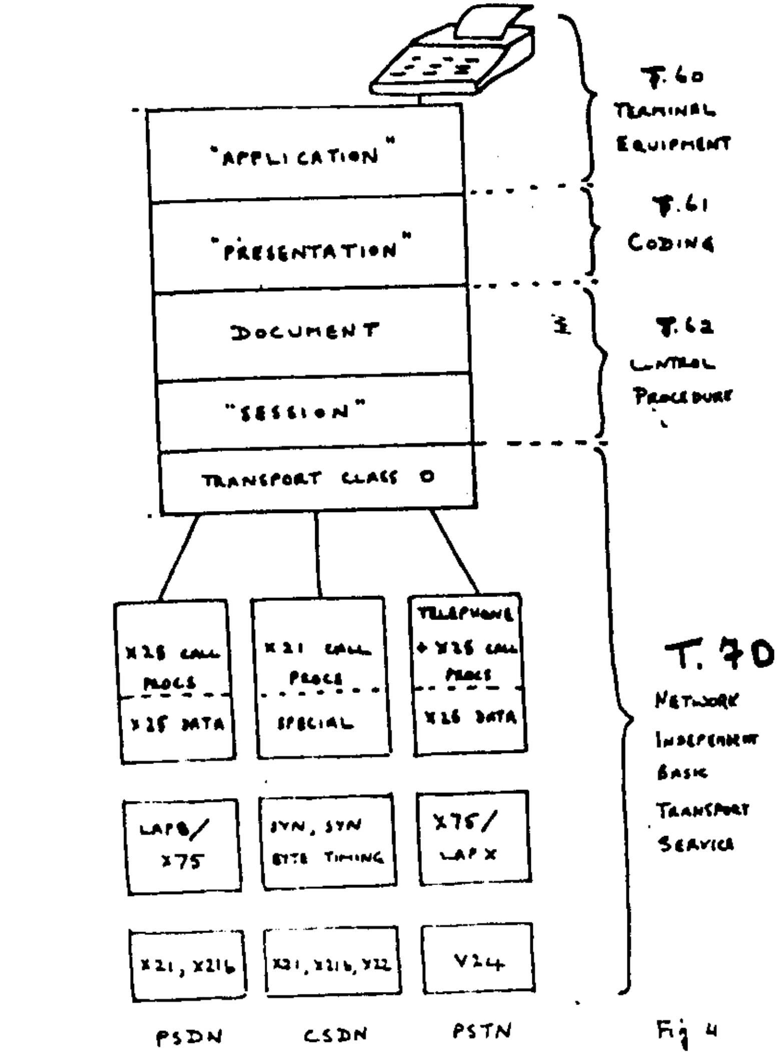
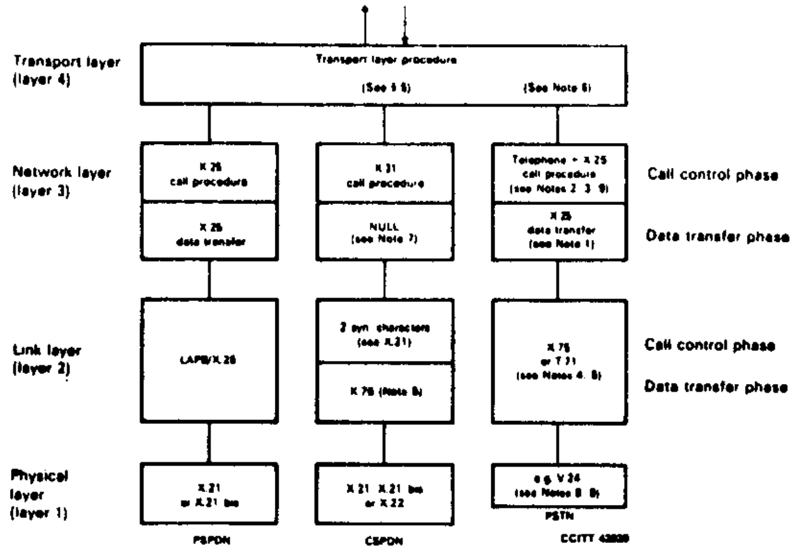


Fig 4



Note 1 — The X.25 network layer procedure is introduced to ease interworking with PSPDNs.

Note 2 — The establishing of the network connection is performed by two-stage selection: the first using normal telephone procedures and the second using X.25 call control procedures.

Note 3 — For terminals connected to PSTN accessing PSPDN, the procedures in Note 2 apply. See also Rec. X.32

Note 4 — T.71 defines a half-duplex link access procedure, based on Recommendation X.75 for single link operation (see § 3.2.2).

Note 5 — The link layer procedures are in accordance with Recommendation X.75 for single link operation (however, see §§ 3.2.2 and 3.3.2) and in this respect Recommendation X.75 (1980 version) is to be regarded as the reference specification of this protocol.

Note 6 — In all cases of interworking including interworking between terminals connected to the same type of network or to different types of networks (i.e. CSPDN, PSPDN, PSTN), this transport layer procedure is executed peer-to-peer between the communicating terminals.

Note 7 — For terminals connected to CSPDNs, no function is needed in the network layer in the data transfer phase as indicated in this figure. However, in order to facilitate interworking with PSPDNs a minimum network layer is introduced (see § 3.3.3).

Note 8 — The modem may also be integrated within the terminal and in such cases Recommendation V.24 need not apply (see § 3.2.1).

Note 9 — For automatic calling and/or answering, Recommendation V.25 may be applicable.

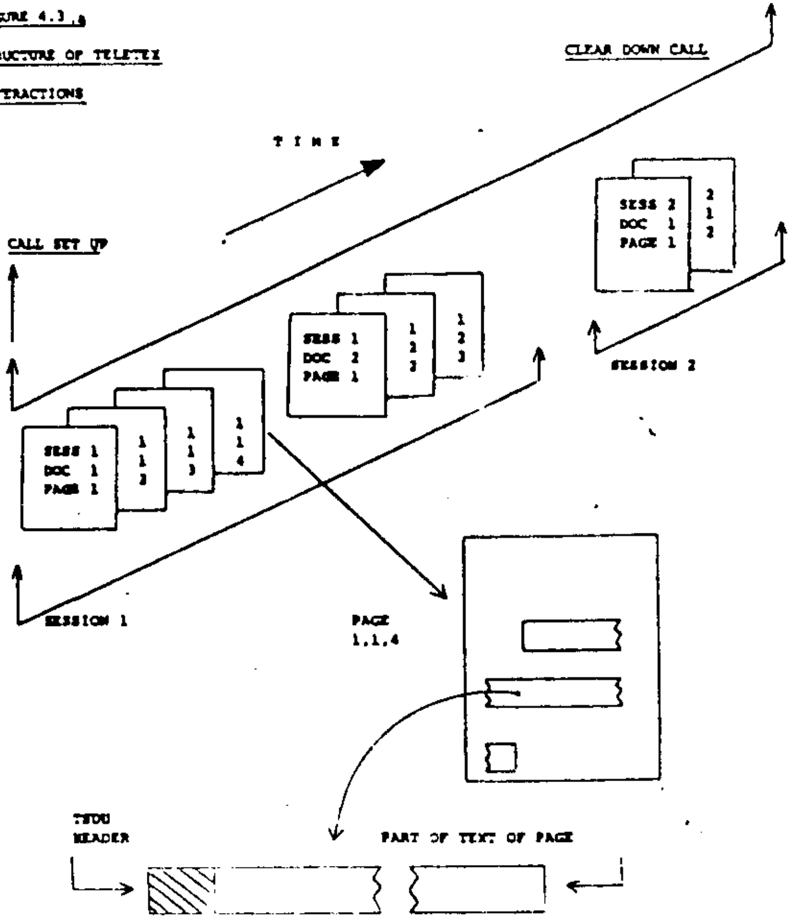
FIGURE 1/T.70

Transport service general structure

FIGURE 4.3.a

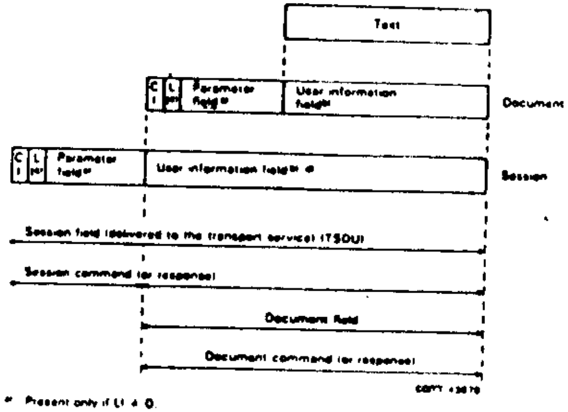
STRUCTURE OF TELETEX

INTERACTIONS



TRANSPORT SERVICE DATA UNITS

i.e. about 120 characters or around 2 lines of text
ARE THE BASIC UNITS USED FOR TRANSFER OF INFORMATION



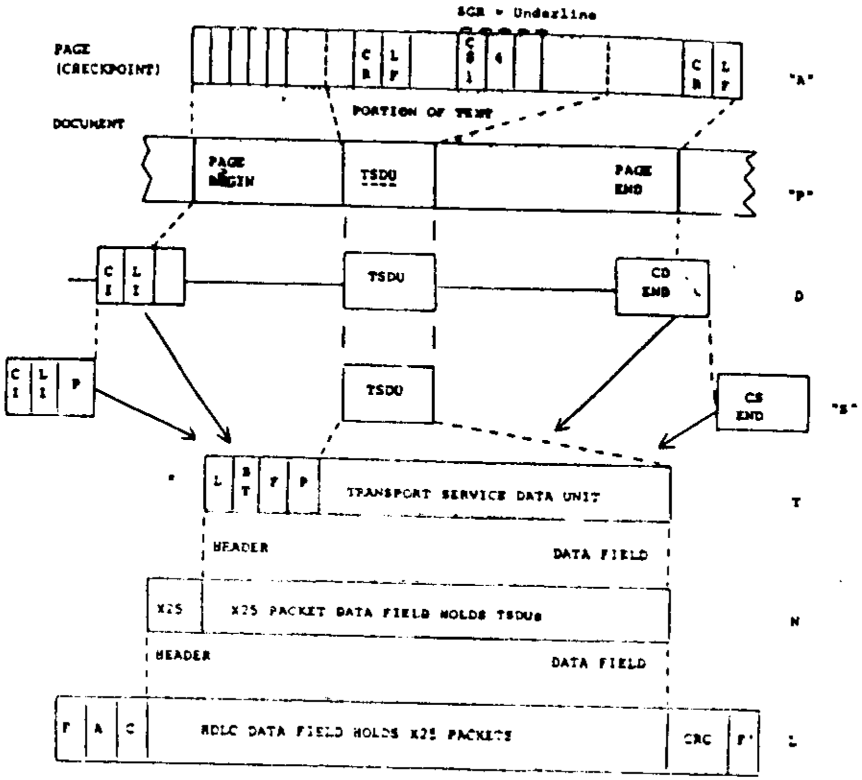
- Present only if LI ≠ 0.
- Present only after user information commands (or responses).
- See § 5.2.4
- See § 1.2.1

FIGURE 4/S.62

Illustration of the relationship between session and document commands

FIGURE 4.3.b

RELATIONSHIP BETWEEN FORMATS AT VARIOUS LEVELS OF PROTOCOL.



* NB The TSDU Carries SESSION AND DOCUMENT COMMANDS during control phases and the text of pages during data transfer.

From telex to Teletex

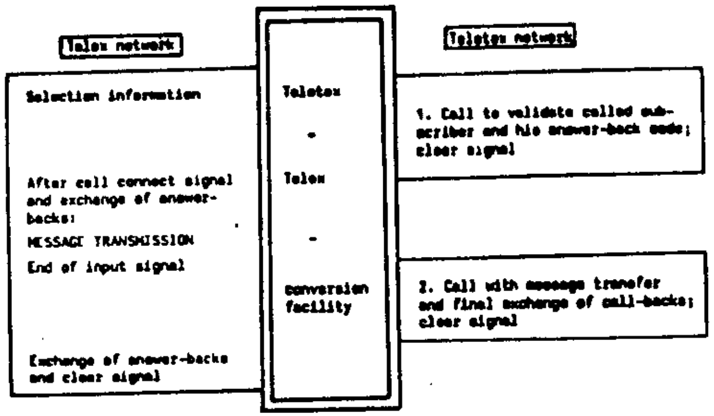


Figure 15. Interworking with telex (telex – Teletex).

From Teletex to telex

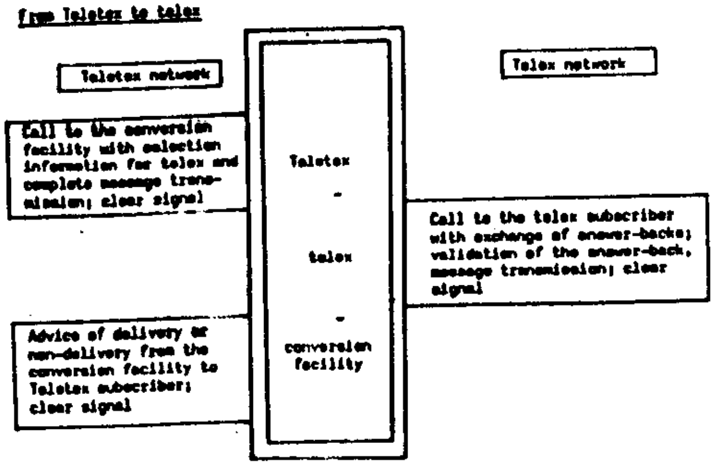


Figure 16. Interworking with telex (Teletex – telex).

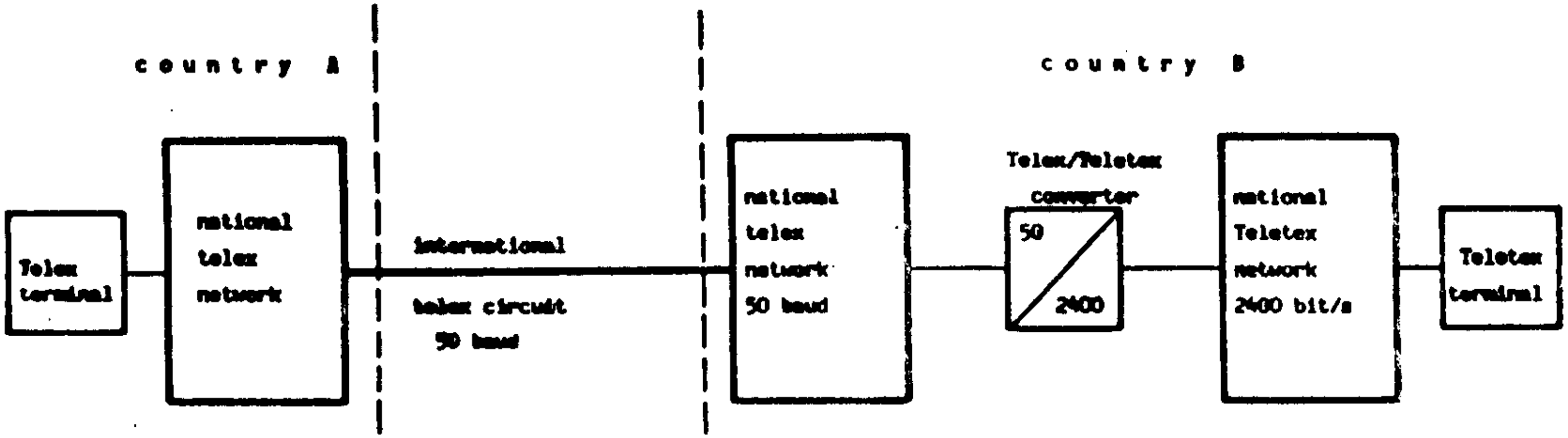


Figure 14. Basic configuration for interworking with telex.