

整體數位服務網路簡介

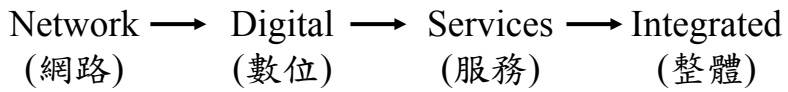
陳伯寧教授

國立交通大學電信工程學系

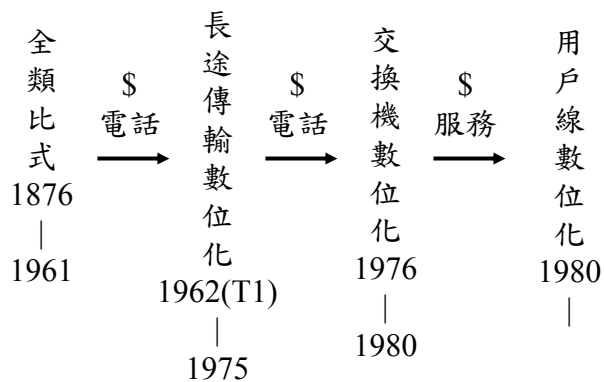
定義—

- ISDN是從電話網路演進而來的一種端對端數位式連接網路，能提供廣泛的資訊服務—包括語音及非語音，而使用者則透過幾種有限的用戶網路介面即可存取服務。
- 它採用數位式的傳輸方式，更方便的提供語音、數據、影像、視訊等服務。

定義—

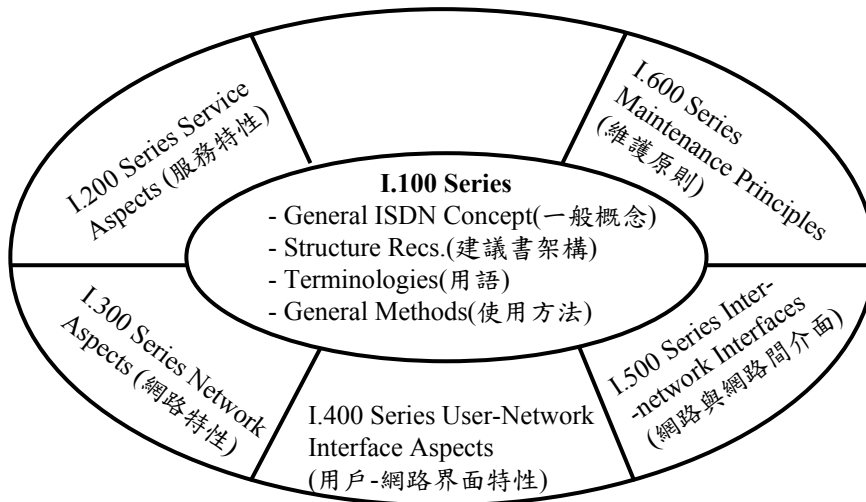


電信網路演進



ITU-T(CCITT) I-Series Recommendations (ISDN)

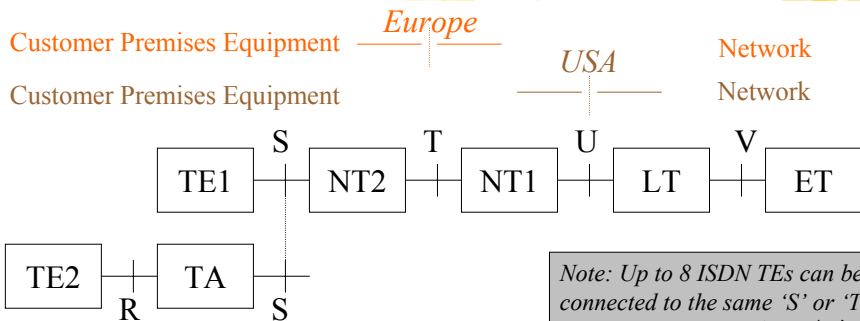
(前國際電信電話諮詢委員會I系列建議書標準)



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ISDN接線和資料通道

Functional Groupings and Reference Points (功能群組與參考點)

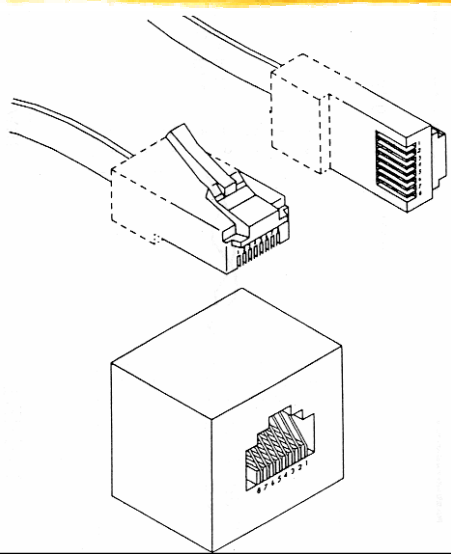


Note: Up to 8 ISDN TEs can be connected to the same 'S' or 'T' reference point. ('S' or 'T' 參考點最多可接八個ISDN TEs)

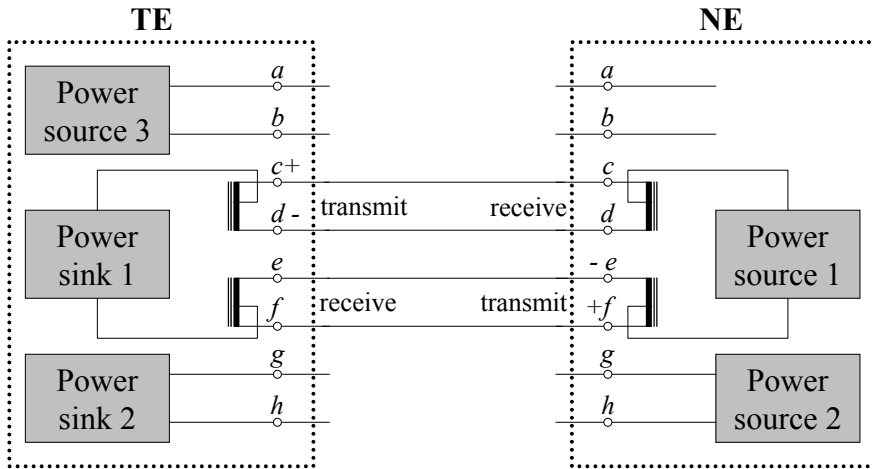
□ Functional Groupings

- R, S, T and U : Reference points
- TE : Terminal Equipment
- TA : Terminal Adapter
- NT : Network Termination
- LT : Line termination
- ET : Exchange termination

介面之接頭與插座

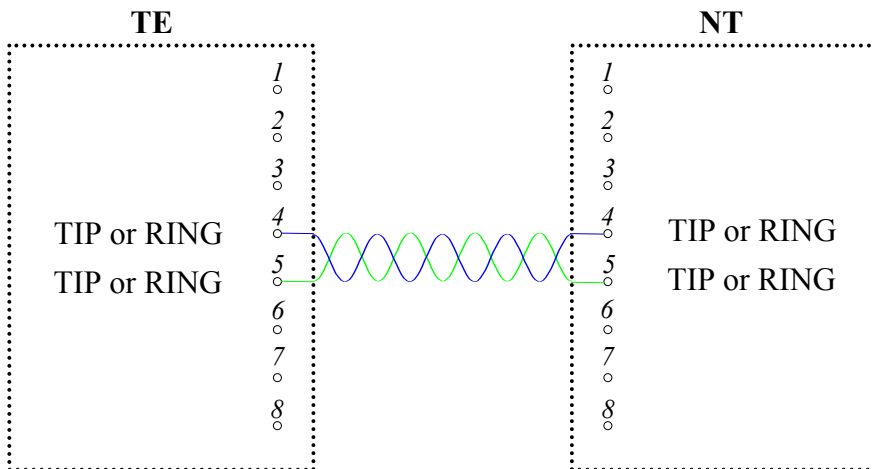


Pin Assignment of S/T Interface



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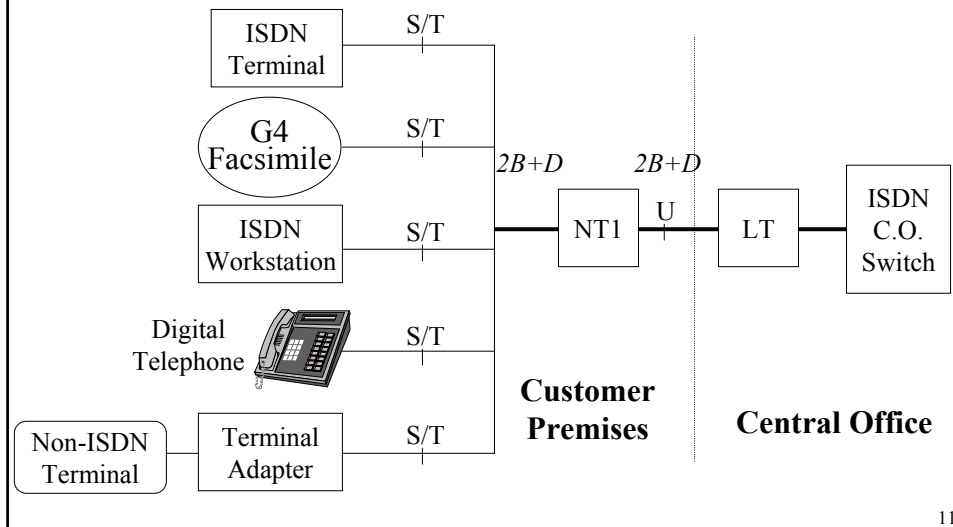
Pin Assignment of U Interface



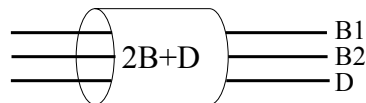
Pins 1, 2, 3, 6, 7 and 8 are not connected.

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ISDN Basic Access Subscriber Interface



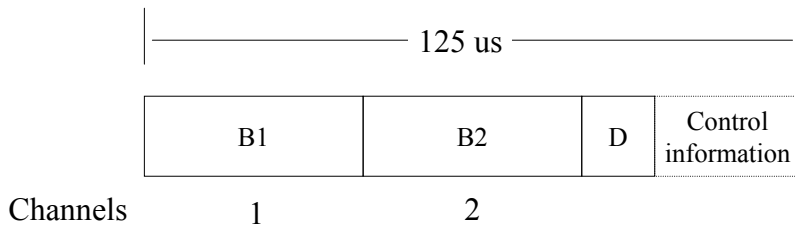
Access Type - Basic Access



□ Access Rate:

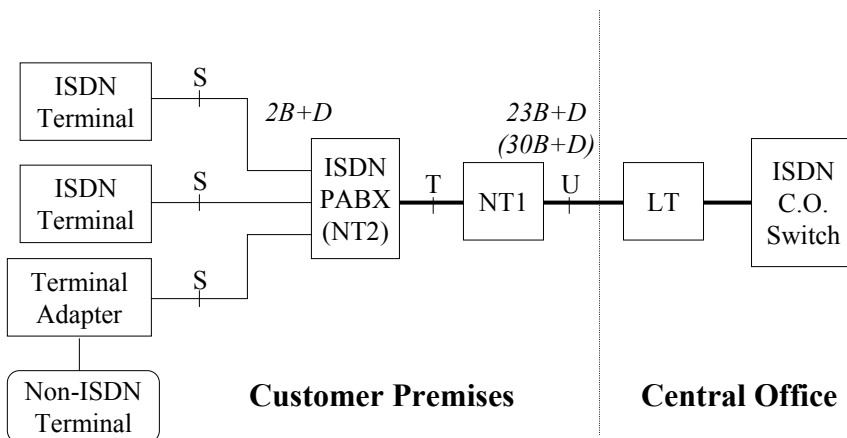
- ◆ $2B+D = 192$ Kbps worldwide
- ◆ B1 and B2 : 64 Kbps
- ◆ D : 16 Kbps
- ◆ Overhead : 48 Kbps

Basic Rate Interface Frame Format



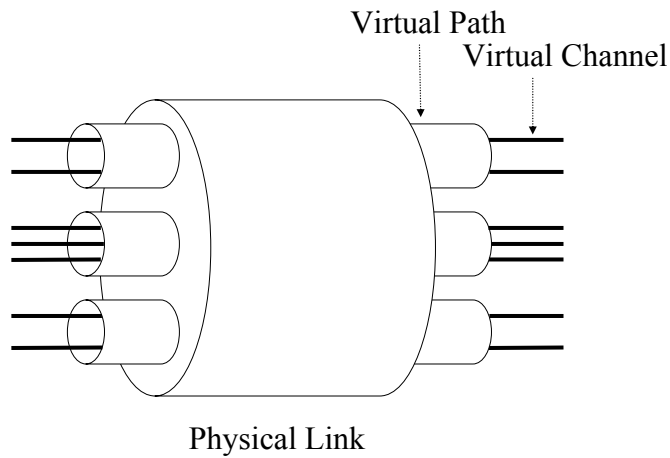
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ISDN Primary Access Subscriber Interface



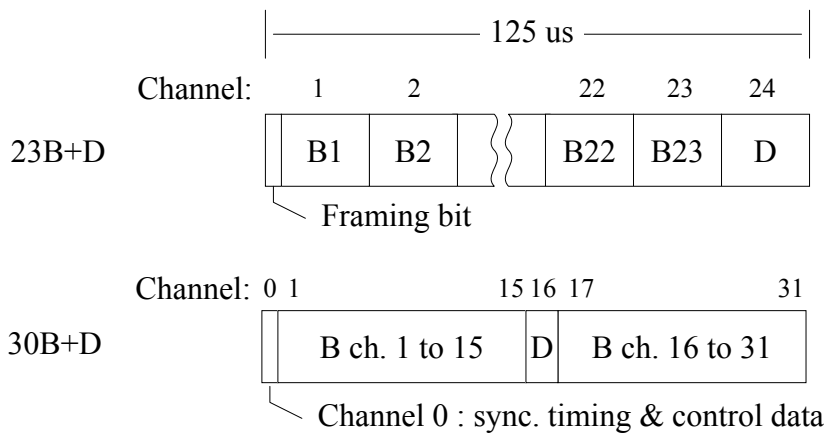
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Access Type - Primary Access



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Primary Rate Interface Frame Format



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ISDN Channel Types

- ❑ D channel: for packet data and signaling
 - ◆ 16 Kb/s in Basic Rate ISDN
 - ◆ 64 Kb/s in Primary Rate ISDN
- ❑ B Channel: 64 Kb/s circuit switched channel for voice and data

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ISDN Channel Types

- ❑ Some user applications require more bandwidth than a B channel can provide, such as video teleconferencing.

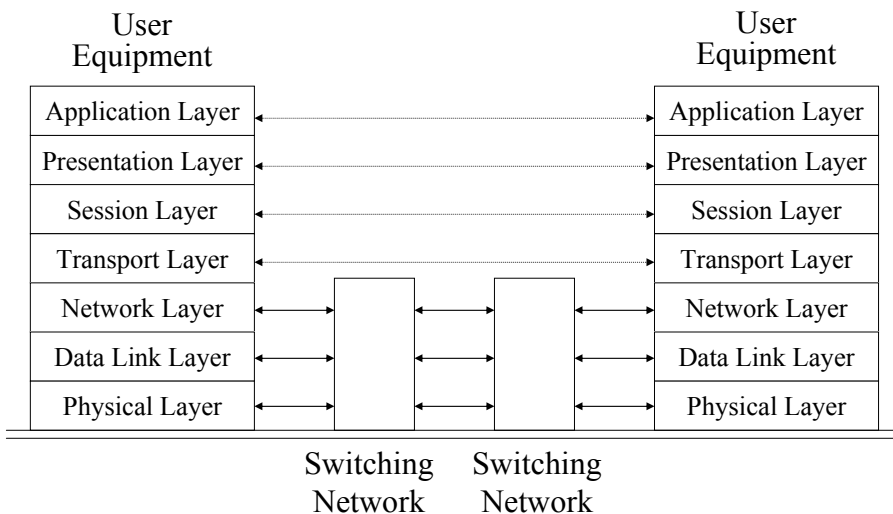
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ISDN Channel Types

- ❑ Standard configurations of bandwidth, known as H channels, provide such higher bit rate.
 - ◆ H0 Channel: 384 Kb/s, a logical grouping of six (circuit switched) B channels.
 - ◆ H11 Channel: 1536 Kb/s, made up of all available H0 (circuit switched) channels on a single-user interface employing a T1 line (23B+D)
 - ◆ H12 Channel: 1920 Kb/s (30B+D) , European Version of H11

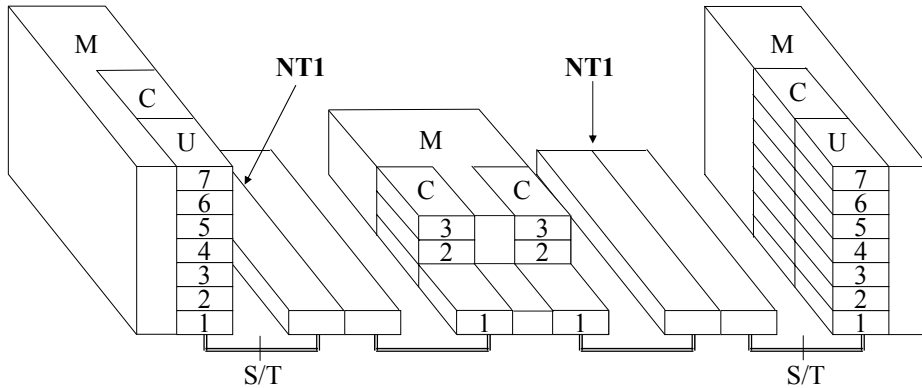
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Open Systems Interconnection (OSI) Model of the International Standards Organization (ISO)



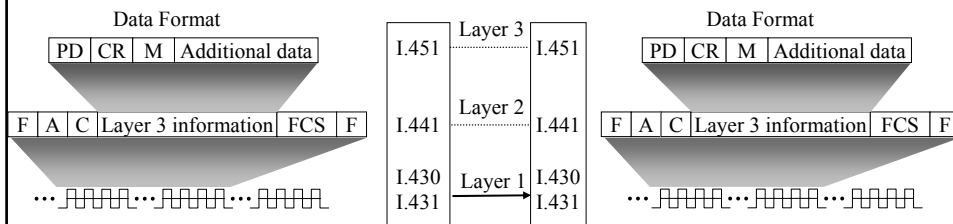
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ISDN Layer Model (CCITT Rec. I.320)



<i>M</i>	<i>Management Functions</i>	<i>S/T</i>	<i>S or T reference point</i>
<i>C</i>	<i>Control Functions (Signaling)</i>	<i>NT1</i>	<i>Network Termination 1</i>
<i>U</i>	<i>User Functions</i>		

ISDN Protocol



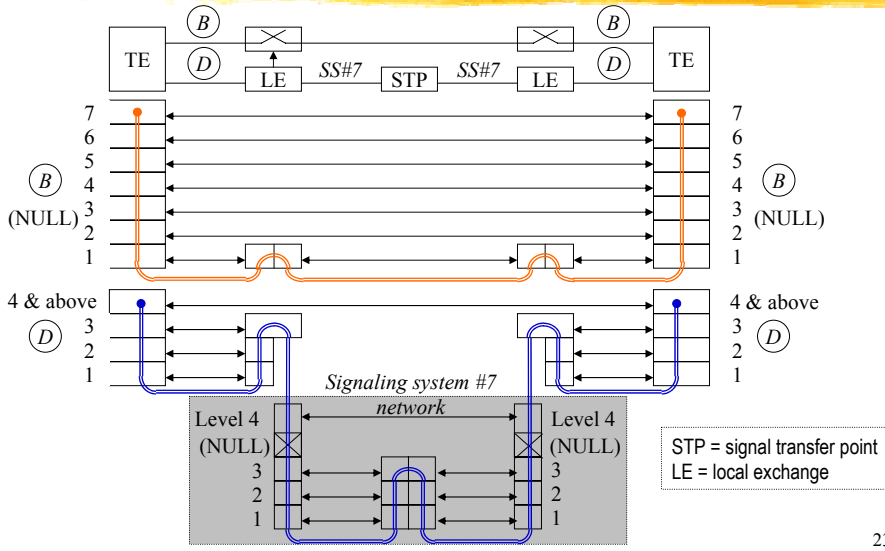
Layer 3: *PD* : Protocol Discriminator
CR : Call Reference
M : Message type

Layer 2 (Link Access Procedure on the D-channel, LAPD) :
F : 8-bit Flag byte
A : 16-bit Address word
C : 8- or 16-bit Control word
FCS : 8-bit Frame Check Sequence

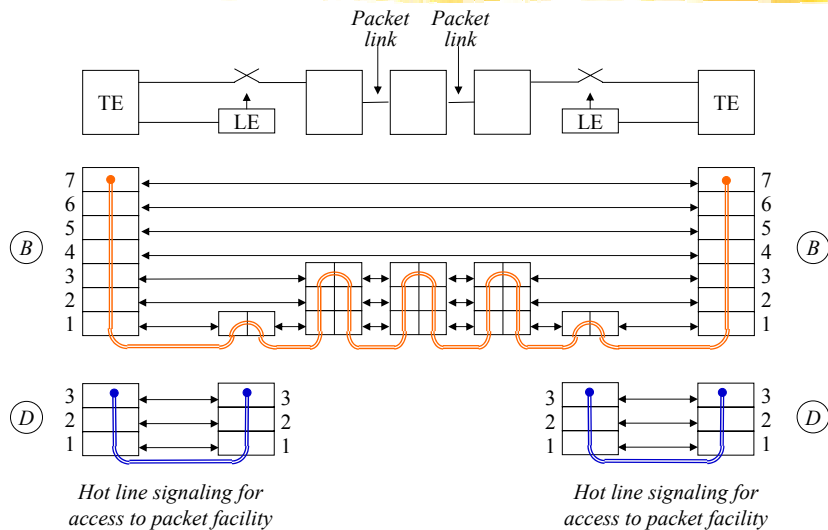
Layer 1: *B-channel* : 64 kbps channel for data or voice
D-channel : 16 kbps channel for signaling
 (Layer 2 messages are transmitted through *D-channel*)

I.451 : CCITT standard
 for ISDN layer 3 protocol
I.441 : CCITT standard
 for ISDN layer 2 protocol (LAP-D
 or D-channel link access protocol)
I.431 : CCITT standard
 for ISDN layer 1, basic rate protocol
I.430 : CCITT standard
 for ISDN layer 1, primary rate protocol

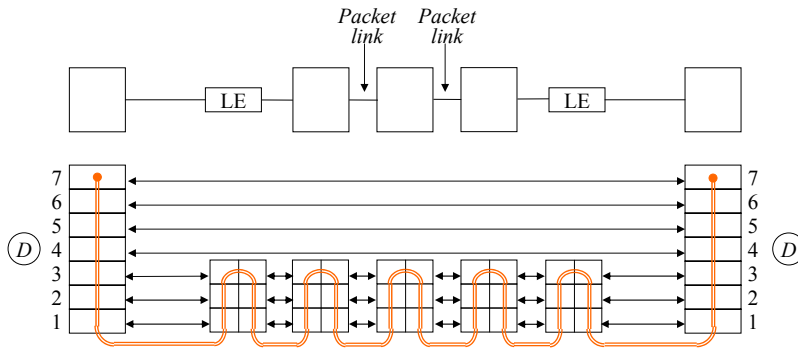
經由B頻道的線路交換模式



經由B頻道的分封交換服務






經由D頻道的分封交換服務



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ISDN用戶網路介面

-  Physical Layer
-  Link Layer
-  Network Layer

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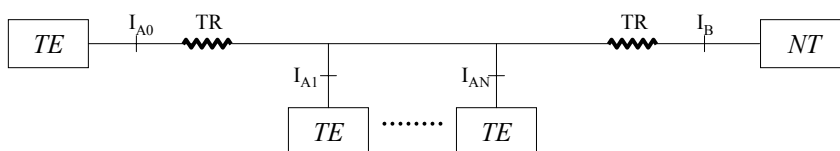
S/T界面

- 需要四線(兩對)作信號傳輸
- 位元速率(Bit Rate) : 192 Kbps
- 數據速率(Data Rate) : 144 Kbps (2B+D)
- 提供「單點對單點」與「單點對多點」的連線
- 最多可有八部終端設備

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佈線(Wiring)

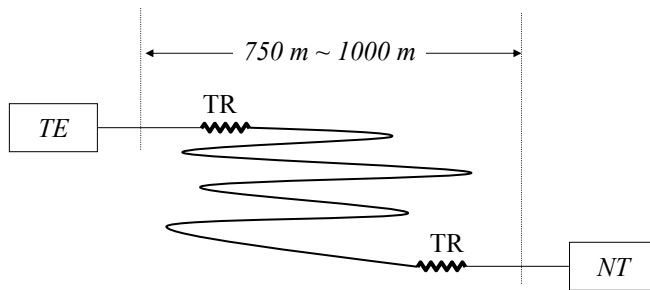
- ◆ 佈線的極性
 - 單點對單點：在一對線中，其兩線之極性可以是相反的
 - 單點對多點：從終端設備到網路終端方向佈線的極性，在終端設備間必需維持一致
- ◆ 終端設備TE的連接線 I_{Aj} , $0 \leq j \leq N$, 不長於10公尺
- ◆ 網路終端NT的連接線 I_B 不長於3公尺
- ◆ 終端電阻 $TR=100$ Ohm



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點對點佈線

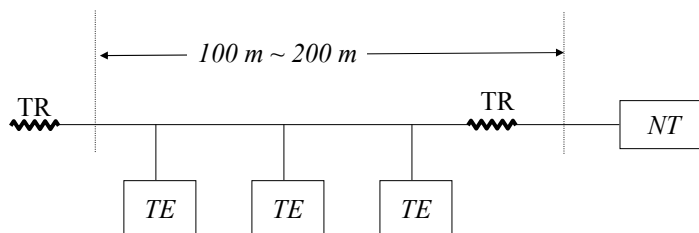
- 長度之限制: 傳96KHz的訊號衰減量達6 dB時之距離



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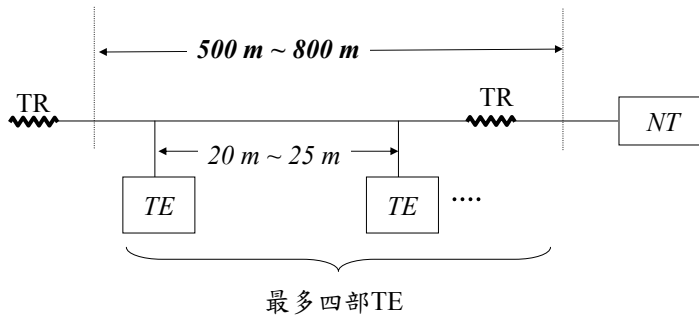
點對多點佈線—Short Passive Bus

- 長度之限制來自 Roundtrip Delay 需在10 us ~ 14 us，不是由訊號衰減量所限制



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點對多點佈線—Extended Passive Bus



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碼框結構(Frame Structure)

- 每碼框48位元—250us/frame
- 從TE到NT或NT到TE方向，位元速率都為192 Kbps

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Contention for D channel

□ Contention resolution scheme for D channel

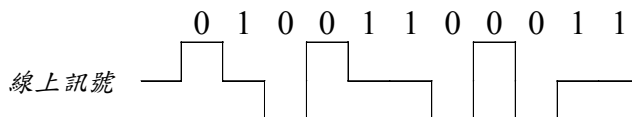
- ◆ A TE with nothing to transmit sends out a series of binary “1”s.
- ◆ A TE wishing to transmit monitors E bits. If it hears enough E bits with a value “1”s, it assumes no transmission on the line and transmits.
- ◆ If a TE detects E bits with different values than it is transmitting, it assumes another TE is transmitting and breaks off contention for the D channel.

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傳輸碼(Line Code)

□ 二進制假三階碼(Pseudo-ternary line code)

- ◆ 1 = 線上無訊號
- ◆ 0 = 線上訊號為正或負的脈波



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傳輸碼(Line Code)

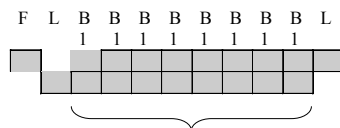
□“框構位元”(Framing Bit)與“平衡位元”(DC Balancing Bit)之下一個“0”，不需極性交替(即極性必需相同)。接著之“0”必需極性交替。

- ◆如果自前一個“平衡位元”以後之“0”的數目為奇數，則現在之“平衡位元”為“0”；
- ◆如果自前一個“平衡位元”以後之“0”的數目為偶數，則現在之“平衡位元”為“1”。
- ◆(簡言之。“0”的總數需為偶數)

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傳輸碼(Line Code)

Example. TE to NT



Case 1) 1 + 奇數個“0”

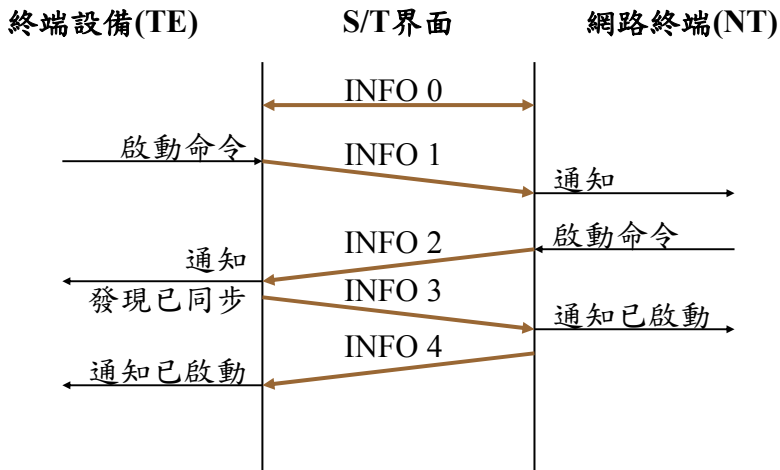


Case 2) 0 + 偶數個“0”



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啟動之程序



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定義INFO信號(S/T界面之信號種類)

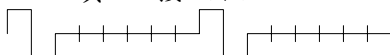
□ 信號從TE送往NT

◆ INFO 0 = 沒有信號

■ =全部為“1”

◆ INFO 1 =

■ 連續的信號，正“0”
負“0”接六個“1”



◆ INFO 3 =

■ 碼框同步，B及D通道可載送資料

□ 信號從NT送往TE

◆ INFO 0 = 沒有信號

■ =全部為“1”

◆ INFO 2 =

■ 所有的B、D、回送位元E與A都填“0”，N與L依規則處理

◆ INFO 4 =

■ 所有的B、D、回送位元E與A都填“1”，N與L依規則處理

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ISDN用戶網路介面

- Physical Layer
- Link Layer
- Network Layer

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D通道存取程序之製作需求

8	7	6	5	4	3	2	1
0	1	1	1	1	1	1	0
SAPI						C/R	EA 0
TEI							EA 1
控制欄, 1~2 位元組							
資訊欄, 最多 260 位元組							
碼框偵錯碼(CRC16)							
0	1	1	1	1	1	1	0

開頭旗標(Opening flag)

SAPI: 服務存取點識別

TEI: 終端設備識別(最多8台)

EA: 位址延伸如果EA=0

C/R: 命令或回應

$CRC16 = I \div (X^{16} + X^{12} + X^5 + 1)$ 之餘數

結尾旗標(Closing flag)

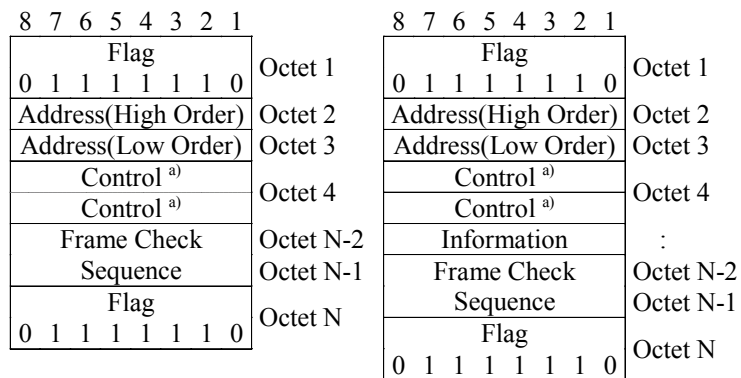
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LAPD Functions

- ❑ Provision of one or more data link connections on a D-channel
- ❑ Frame delimiting, alignment and transparency
- ❑ Sequence control
- ❑ Error detection
- ❑ Error recovery
- ❑ Link by link flow control

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Frame Structure



a) Unacknowledged Operation - One Octet

Multiple Frame Operation - Two Octets for Frames with sequence numbers

- One Octet for Frames without sequence numbers

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Address Field

8	7	6	5	4	3	2	1		
SAPI						C/R	EA	Octet 2	
TEI							EA	Octet 3	

EA = Address field extension bit
 C/R = Command/response field bit
 SAPI = Service Access Point identifier
 TEI = Terminal endpoint identifier

SAPI Value	Related Layer 3 or Management Entity
0	Call Control Procedures
1	Reserved for Packet Mode Comm's. Using Q.931 Call Control Procedure
16	Packet Communication Conforming to X.25 Level 3 Procedures
63	Layer 2 Management Procedures
All others	Reserved for future standardization

TEI Value	User Type
0 – 63	* Non-automatic TEI Assignment User Equipment
64 – 126	** Automatic TEI Assignment User Equipment
127	Group TEI for Broadcasting

* Non-automatic TEI values are selected by the User.
 ** Automatic TEI values are selected by the Network.

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Control Field Format

Control field bit(mdoulo 128)	8	7	6	5	4	3	2	1	
I format	N(S)							0	Octet 4
	N(R)							P	Octet 5
S format	X	X	X	X	S	S	0	1	Octet 4
	N(R)							P/F	Octet 5
U format	M	M	M	^{P/F}	M	M	1	1	Octet 4

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

X : Reserved and Set to "0"

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Control Field Format

❑ I frame (information transfer frame)

- ◆ carry user information

❑ S frame (supervisory frame)

- ◆ provide flow control and error control data, which control the transmission of I frames on the link

❑ U frame (unnumbered frame)

- ◆ establish, maintain and terminate the logical links.

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Frame Types

Application	Format	Commands	Responses	8	7	6	5	4	3	2	1	Oct.		
Unacknowledged And Multiple Frame Acknowledged Information Transfer	Information Transfer	I(Information)		N(S)							0	4	Exchange	
				N(R)							P	5	User data	
	Supervisory	RR(Receive Ready)	RR(Receive Ready)	0	0	0	0	0	0	0	0	1	4	Positive Ack
				N(R)							P/F	5		
		RNR(Receive Not Ready)	RNR(Receive Not Ready)	0	0	0	0	0	1	0	0	1	4	Positive Ack
				N(R)							P/F	5	Ack	
	REJ(Reject)	REJ(Reject)	0	0	0	0	1	0	0	0	1	4	Negative ack	
				N(R)							P/F	5	Go back N	
	Unnumbered	SABME(Set Asynchronous Balanced Mode Extended)		0	1	1	P	1	1	1	1	1	4	Request Logic Channel
			DM (Disconnect Mode)	0	0	0	F	1	1	1	1	1	4	Unable to est. Or Maintain Logic channel
		UI (Unnumbered Information)		0	0	0	P	0	0	1	1	1	4	
		DISC (Disconnect)		0	1	0	P	0	0	1	1	1	4	Terminate Logic Channel
			UA (Unnumbered Acknowledgement)	0	1	1	F	0	0	1	1	1	4	Ack for SABME or DISC
		FRMR (Frame Reject)	1	0	0	F	0	1	1	1	1	4	Reports receipt of unacceptable frame	
	Connection Management		XID(Exchange Identification)	XID (Exchange Identification)	1	0	1	P/F	1	1	1	1	4	Exchange Identity Information

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The Management Entity

8	7	6	5	4	3	2	1		
0	1	1	1	1	1	1	1	0	Flag
1	1	1	1	1	1	1	C/R	0	Address(SAPI=63)
1	1	1	1	1	1	1	1	1	Address(TEI=127)
0	0	0	P	0	0	1	1	1	Control(UI)
Management Entity Identifier (cf. next slide)									Information
Reference Number (cf. next slide)									
Message Type (cf. next slide)									
Action Indicator								E	
Frame Check Sequence									
0	1	1	1	1	1	1	1	0	Flag

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TEI Management Entity

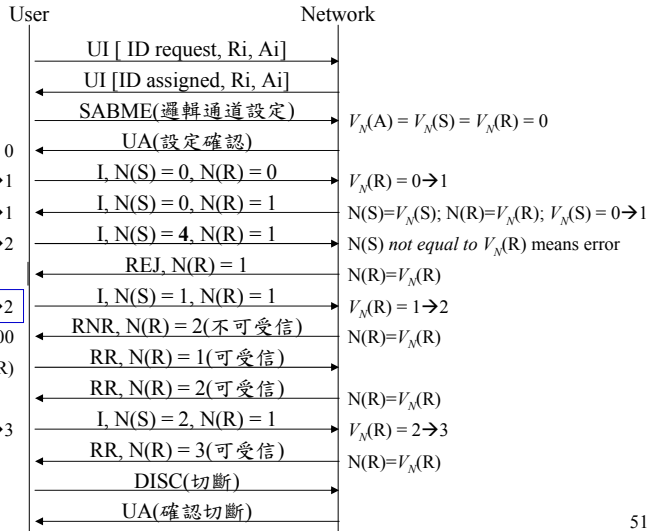
Message Name	Management Entity Identifier	Reference Number Ri	Message Type	Action Indicator Ai
Identity Request (User to Network)	0000 1111	0 – 65535	0000 0001	Ai = 127, Any TEI Value Acceptable
Identity Assigned (Network to User)	0000 1111	0 – 65535	0000 0010	Ai = 64 – 126, Assigned TEI Value
Identity Denied (Network to User)	0000 1111	0 – 65535	0000 0011	Ai = 127, No TEI Value Available
Identity Check Request (Network to User)	0000 1111	Not Used (Coded 0)	0000 0100	Ai = 127, Check ALL TEI Values
Identity Check Response (User to Network)	0000 1111	0 – 65535	0000 0101	Ai = 0 – 126, TEI Value To Be Checked
Identity Remove (Network to User)	0000 1111	Not Used (Coded 0)	0000 0110	Ai = 0 – 126, TEI Value in Use
Identity Verity (User to Network)	0000 1111	Not Used (Coded 0)	0000 0111	Ai = 127, Request For Removal of All TEI Values
				Ai = 0 – 126, TEI Value To Be Removed
				Ai = 0 – 126, TEI Value To Be Checked

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Example

$V(A)$: # of acked frames
 $V(S)$: # of transmitted frames
 $V(R)$: # of received frames

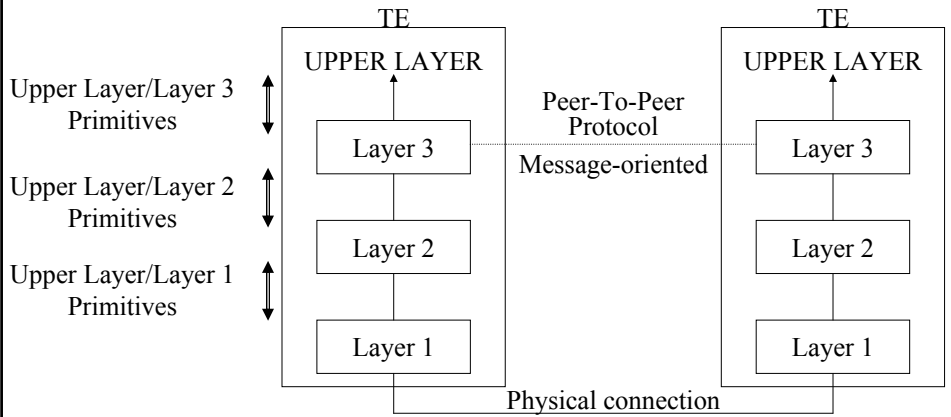
$V_U(A) = V_U(S) = V_U(R) = 0$
 $N(S) = V_U(S); N(R) = V_U(R); V_U(S) = 0 \rightarrow 1$
 $V_U(R) = 0 \rightarrow 1$
 $N(S) = V_U(S); N(R) = V_U(R); V_U(S) = 1 \rightarrow 2$
error in processing
 $N(S) = V_U(S); N(R) = V_U(R); V_U(S) = 1 \rightarrow 2$
 Start T200
 $N(R) = V_U(R)$
 $N(S) = V_U(S); N(R) = V_U(R); V_U(S) = 2 \rightarrow 3$



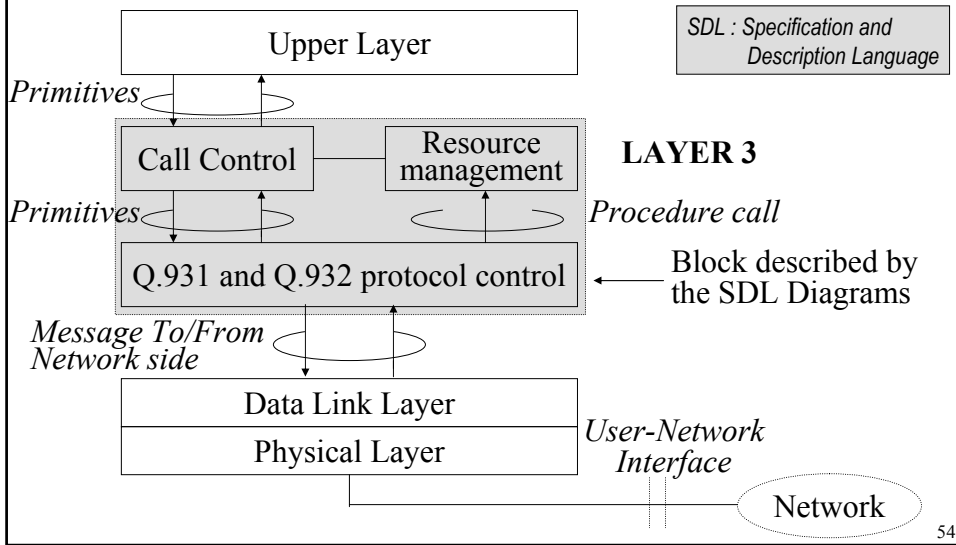
ISDN用戶網路介面

- Physical Layer
- Link Layer
- Network Layer

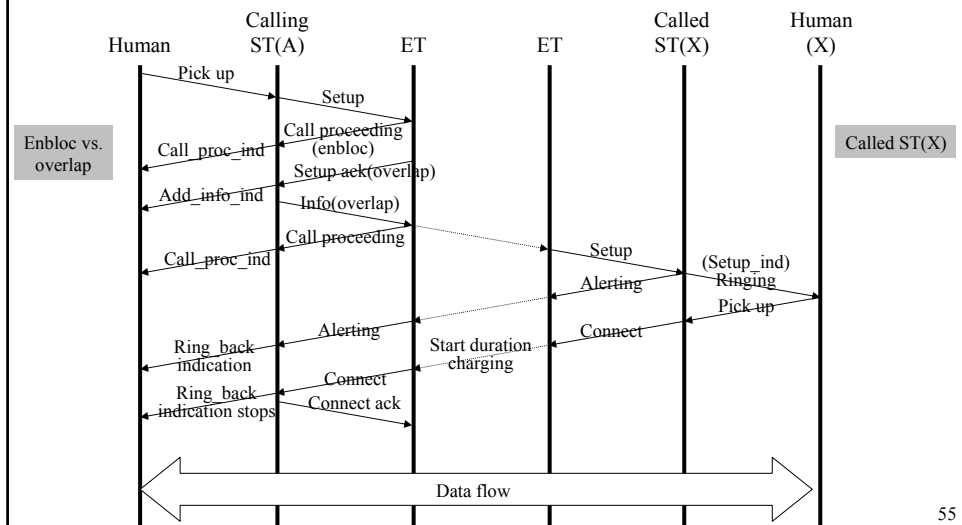
Reference Model (參考模式)



Module Diagram (模組方塊圖)



呼叫之建立



Functions of Q.931

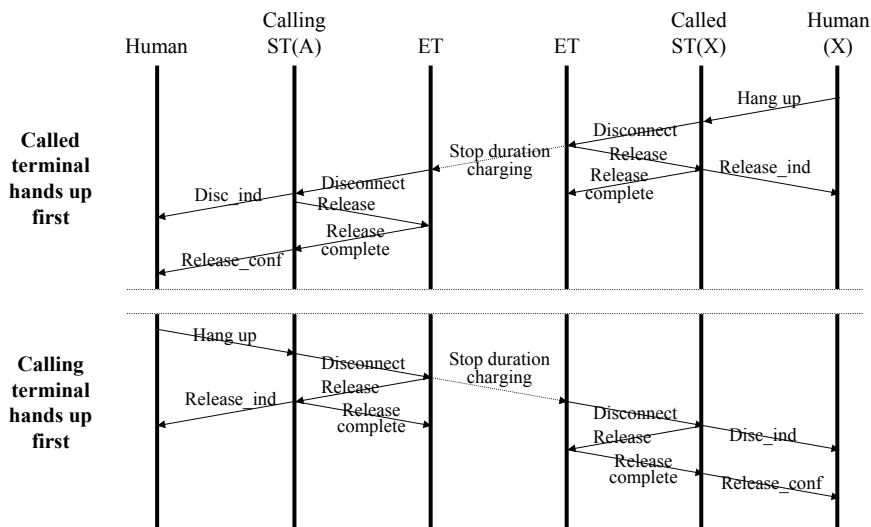
□ Establish, maintain, and clear network connections at the ISDN user-network interface by exchanging messages over D-channel

- ◆ 1. Processing of primitives from LAPD or Call Control
- ◆ 2. Generation and interpretation of Q.931 messages for peer-level communication
- ◆ 3. Management of timers and logical entities (call references)

Functions of Q.931

- ◆4. Administration of access resources including B-channel and packet-layer logical channels;
- ◆5. Consistency checking (compatibility, address such as caller address and callee address)

呼叫之清除

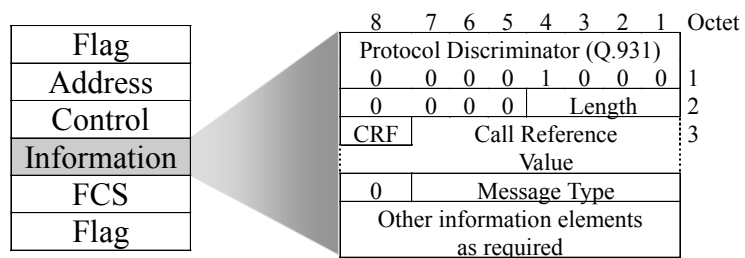


Basic Calls vs. Supplementary Services

- ❑ Basic Call Control means that the call is simply established, maintained, and disconnected. A single connection is setup between the calling and called parties. (Q.931)
- ❑ Supplementary Services refer to features that provide additional capabilities so that users have greater control over how the network handles their transmission paths. E.g., Call Forwarding, Call Waiting, Call Transfer, and Call Hold. (Q.932)

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Q.931 Message Format



LAPD frame format

Q.931 message format

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Call Reference

- ❑ The Call Reference is used to identify the call at local user-network interface; there is no end-to-end significance.

8	7	6	5	4	3	2	1	Octet
0	0	0	0	Length				1
CRF				Call Reference Value				2
								etc.

CRF = Call Reference Flag

0 : Message sent from the side originating the call

1 : Message sent to the side originating the call

Length = Number of octets for CRV

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Call Reference

- ❑ At a minimum, all networks and users must be able to support a one-octet CRV for a BRI and a two-octet CRV for a PRI.
- ❑ The dummy call reference is a single zero-filled octet. Its use is specified in Rec. Q.932.

8	7	6	5	4	3	2	1	Octet
0	0	0	0	0	0	0	0	1

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Call Reference

- ❑ The *global* call reference is used to refer to all calls associated with a given data link address. The numerical value of the CRV is zero (a two-octet CRV is shown here.)

8	7	6	5	4	3	2	1	Octet
0	0	0	0	0	0	1	0	1
0/1	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	3

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Message Types

- ❑ Call establishment messages
 - ◆ Alerting, Call Proceeding, Connect, Connect Acknowledge, Progress, Setup, Setup Acknowledge
- ❑ Call information phase messages
 - ◆ Resume, Resume Acknowledge, Resume Reject
 - ◆ Suspend, Suspend Acknowledge, Suspend Reject
 - ◆ Hold, Hold Acknowledge, Hold Reject
 - ◆ Retrieve, Retrieve Acknowledge, Retrieve Reject
 - ◆ User Information

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Message Types

❑ Call clearing messages

- ◆ Disconnect, Release, Release Complete, Restart, Restart Acknowledge

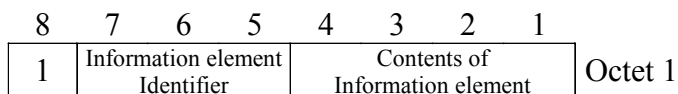
❑ Miscellaneous messages

- ◆ Information, Notify, Status, Status Enquiry, Facility, Segment

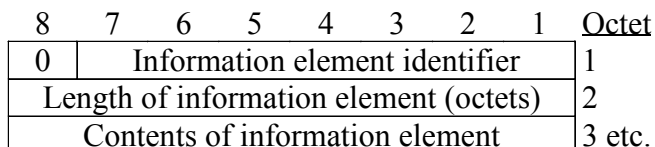
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Formats of Information Element

a) Single octet information element format



b) Variable-length information element format



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Information Elements

▣ Single Octet

Locking Shift, More Data, Sending Complete, Congestion Level

▣ Variable Length

Segmented Message	Keypad Facility	Called Party Number
Bearer Capability	Signal	Called Party Subaddress
Cause	Information Rate	Redirecting Number
Call Identify	End-to-End Transit Delay	Transit Network Selection
Call State	Transit Delay Selection and Indication	Restart Indicator
Channel Identification	Packet Layer Binary Parameters	Low-layer Compatibility
Facility	Packet Layer Window Size	High-layer Compatibility
Progress Indicator	Packet Size	User-User Information
Network-specific Facilities	Connected Number	Escape for Extension
Notification Indicator	Connected Subaddress	
Display	Calling Party Number	
Data/time	Calling Party Subaddress	

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Call States

User State

Network State

U0	Null	N0	Null
U1	Call Initiated	N1	Call Initiated
U2	Overlap Sending	N2	Overlap Sending
U3	Outgoing Call Proceeding	N3	Outgoing Call Proceeding
U4	Call Delivered	N4	Call Delivered
U6	Call Present	N6	Call Present
U7	Call Received	N7	Call Received
U8	Connect Request	N8	Connect Request
U9	Incoming Call Proceeding	N9	Incoming Call Proceeding
U10	Active	N10	Active
U11	Disconnect Request	N11	Disconnect Request
U12	Disconnect Indication	N12	Disconnect Indication
U15	Suspend Request	N15	Suspend Request
U17	Resume Request	N17	Resume Request
U19	Release Request	N19	Release Request
		N22	Call Abort
U25	Overlap Receiving	N25	Overlap Receiving

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Timers in the User Side

Timer Number	Time-out value	State of Call	Cause of start	Normal stop	At the first expiry	At the second expiry
T303	4 s	Call Initiated	SETUP sent	ALERTING, CONNECT SETUP ACK, CALL PROC, or RELEASE COMPLETE received	Retransmit SETUP; restart T303, if REL COMP has been received, clear the call.	Clear internal connection. Send REL COMP. Enter Null state.
T305	30 s	Disconnect Request	Disconnect sent	RELEASE or DISC received	RELEASE sent.	Timer is not restarted
T308	4 s	Release Request	RELEASE sent	RELEASE COMPLETE or RELEASE received	Retransmit RELEASE restart T308	Place B-channel in maintenance condition. Release call reference.
T309	90 s	Any stable state	Data link disconnection calls in stable states are not lost.	Data link reconnected	Clear internal connection release B-channel and call reference	Timer is not restarted.

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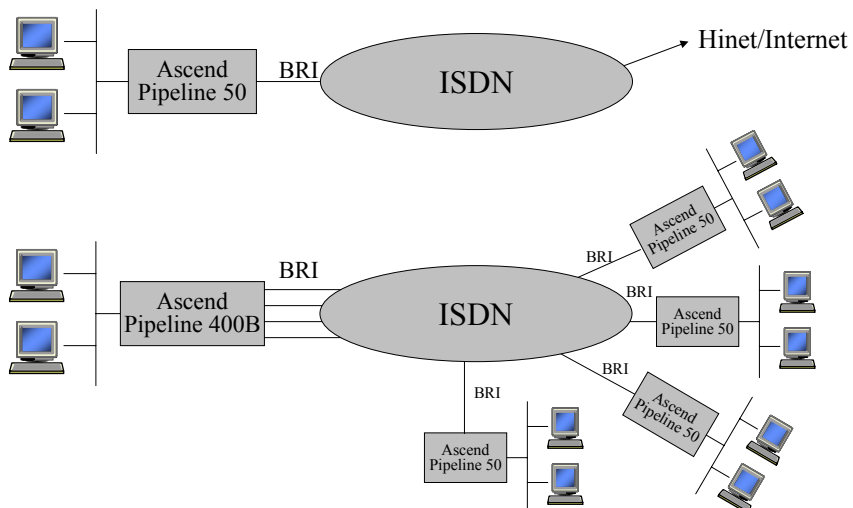
Timers in the User Side

Timer Number	Time-out value	State of Call	Cause of start	Normal stop	At the first expiry	At the second expiry
T313	4 s	Connect Request	CONNECT sent	CONNECT ACKNOWLEDGE received	send DISCONNECT	Timer is not restarted
T318	4 s	Resume Request	RESUME sent	RESUME ACKNOWLEDGE or RESUME REJECT received	Clear internal connect. Release call reference. Enter Null state.	Timer is not Restarted
T319	4 s	Suspend Request	SUSPEND sent	SUSPEND ACKNOWLEDGE or SUSPEND REJECT received	Enter Active state. Notify user application.	Timer is not restarted

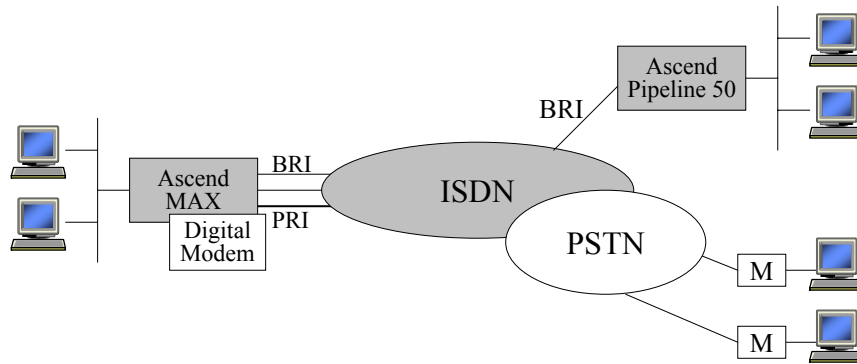
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ISDN應用和Internet Access

Ascend Internet Access & Remote LAN Access

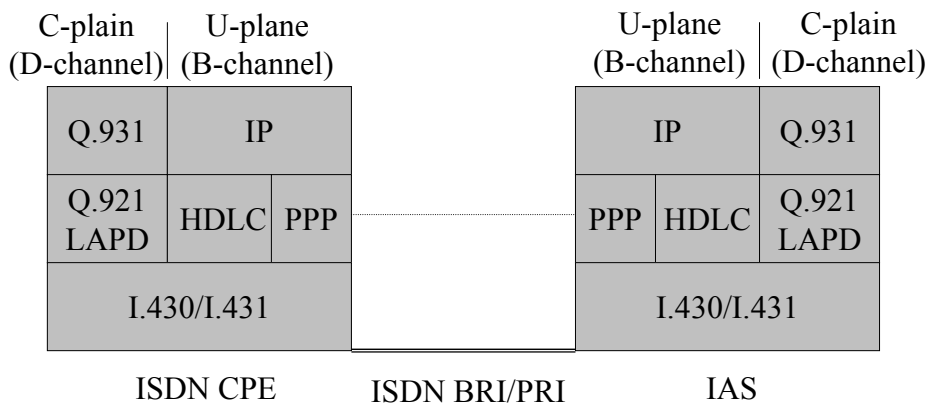


Ascend Internet Access & Remote LAN Access



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ISDN CPE與Internet Access Server 互連架構



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附錄

ISDN 相關系統參數

System Parameters

- 1) $T200 = 1$ second
 - ◆ Max. time between transmission of command frames and reception of their corresponding response or acknowledgement frames
- 2) $N200 = 3$
 - ◆ Max. number of retransmissions
- 3) $N201 = 260$
 - ◆ Max. number of octets in an information field

System Parameters

4) $N202 = 3$

◆ Max. number of TEI assignment requests

5) $K = 1$ for an SAP supporting signaling,
= 3 for SAPs supporting packet information

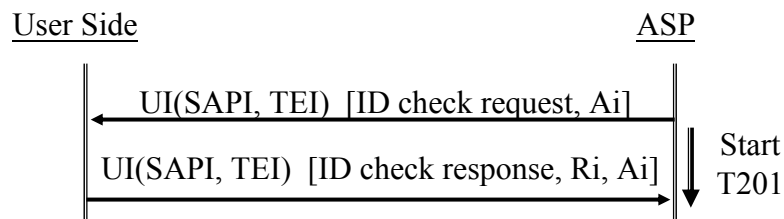
◆ Max. number of outstanding I frames

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System Parameters

6) $T201 = 1$ second

◆ Min. time between retransmission of TEI check



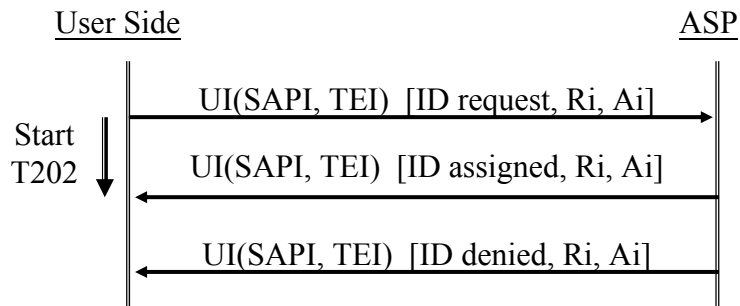
* ASP = Assignment Service Point

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System Parameters

7) $T202 = 2$ seconds

◆ Min. time between transmission of TEI request.



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System Parameters

8) $T203 = 30$ seconds

◆ Max. period of Link inactivity

9) $T204 = 2$ seconds

◆ Min. time between transmission of XID commands

10) $N204 = 3$

◆ Max. number of XID retransmissions

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