The University of Sydney

AUSTRALIA

School of Electrical and Information Engineering

Advanced Communication Networks

Chapter 5

ISDN Data Link Layer

Based on chapter 8 of Stallings ISDN-4e book

Abbas Jamalipour

5.1 Link Access Protocol–*D* Channel

- All traffic over D channel uses LAPD defined in Q.921.
- LAPD service will support
  - multiple terminals at the user-network installation
  - multiple layer 3 entities (e.g., X.25 level 3, Q.931)
- Two types of service to LAPD users by LAPD standard
  - unacknowledged information-transfer service
  - acknowledged information-transfer service

unacknowledged information-transfer service

- does not guarantee delivery of data nor inform of failure
- no flow control, no error control mechanism
- supports both point-to-point and broadcast
- fast data transfer, e.g. management procedures (alarm messages)

acknowledged information-transfer service

- more common, similar to service of LAPB and HDLC
- three phases of connection establishment between two users
  - connection establishment
  - data transfer
  - connection termination
- guarantee of frame delivery in the order of transmission

Two types of LAPD operation corresponding to two types of service

- **unacknowledged operation:** layer 3 information is transferred in unnumbered frames, error detection, no error or flow control
- **acknowledged operation:** layer 3 information is transferred in frames with sequence numbers and acknowledged, with error and flow control, also referred to as *multiple-frame operation*

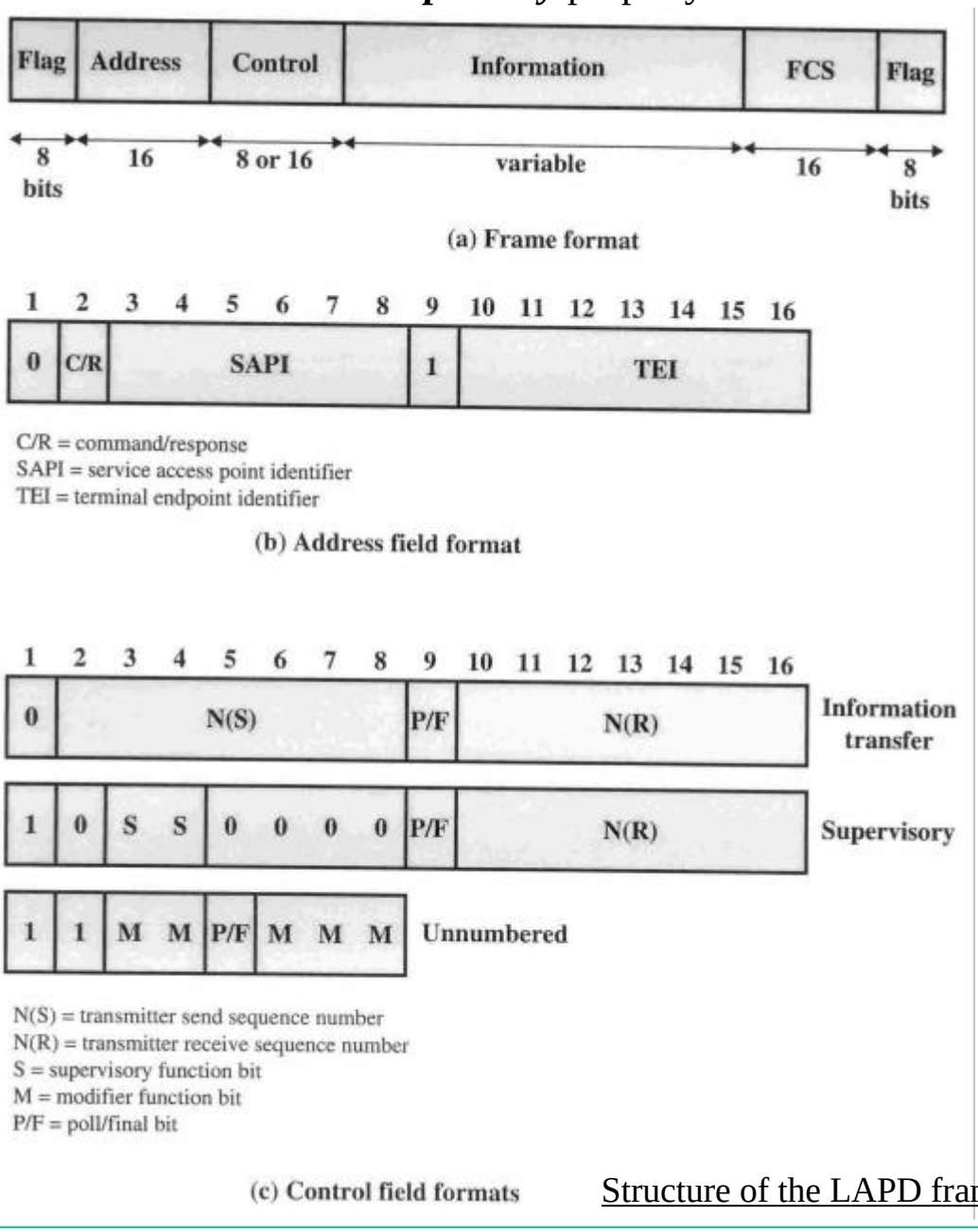
two types of operation may coexist on a single D channel

Frame Structure

Flag Fields

- a unique pattern of 01111110 to delimit the frame at both ends
- using bit stuffing to allows the presence of arbitrary patterns

data transparency property



Structure of the LAPD frames

Address Field

- a two-part address for dealing with two levels of multiplexing
  - multiple user devices sharing the same physical interface
  - multiple types of traffic within each user device (PS data and cont.)

☛ Terminal endpoint identifier (**TEI**)
  - given to each user device manually or automatically

☛ Service access point identifier (**SAPI**)
  - corresponds to a layer 3 protocol entity within a user device

- SAPI values are unique within a TEI
- SAPI and TEI together identify a logical connection → **DLCI**
- at any time, LAPD may maintain multiple logical connection, each with a unique DLCI → one log. connec. per a layer 3 entity
- Command/response (C/R) bit shows the type of LAPD message

SAPI and TEI assignments

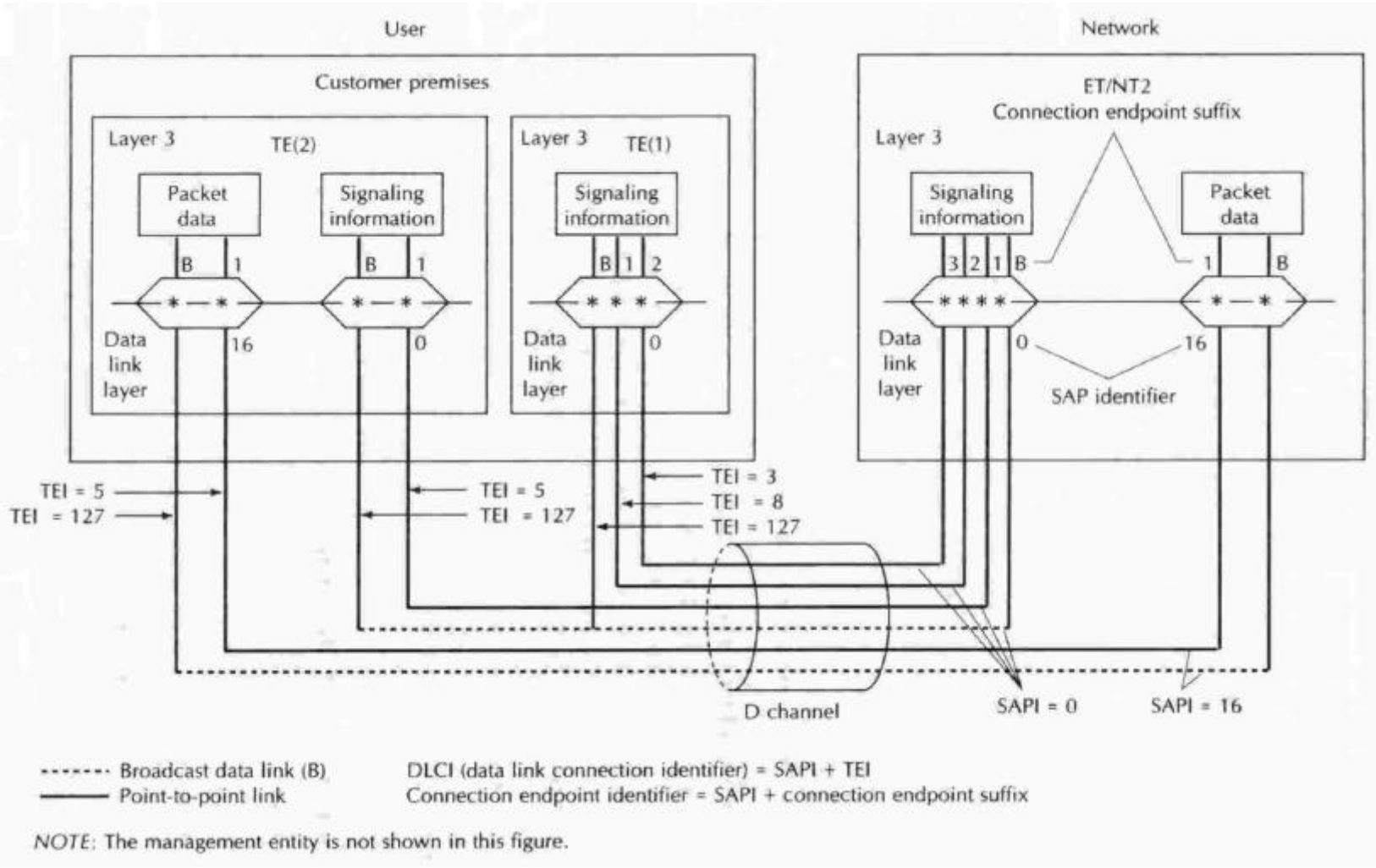
(a) TEI Assignments

TE1 Value	User Type
0–63	Nonautomatic TEI assignment user equipment
64–126	Automatic TEI assignment user equipment
127	Used during automatic TEI assignment

(b) SAPI Assignments

SAPI Value	Related Protocol or Management Entity
0	Call control procedures
16	Packet communication conforming to X.25 level 3
32–61	Frame relay communication
63	Layer 2 management procedures
All others	Reserved for future standardization

Example: six independent logical connections over a single D channel interface terminating in two TEs on the user side of the interface



NOTE: The management entity is not shown in this figure.

Control Field

- three types of frames and three different control field
  - Information-transfer frames (I-frames)
    - carrying data to be transmitted for user
    - piggybacked of flow- and error-control data using go-back-N ARQ
  - Supervisory frames (S-frames)
    - providing ARQ mechanism
  - Unnumbered frames (U-frames)
    - providing supplemental link-control functions
    - supporting unacknowledged operation
- poll/final (P/F) bit
  - P=1: solicit a response frame from the peer LAPD entity
  - F=1 in response frame indicating the response frame transmission

Information Field

- presents only in I-frames and some unnumbered frames
- max length of information field specified in Q.921=260 bytes

Frame-Check Sequence Field

- an error-detecting code for all field except flags using CRC

Three phases in acknowledged operation

- *Connection Establishment*
  - requested by either network or subscriber by sending a SABME (Set Asynchronous Balanced Mode Extended) frame (used in HDLC)
  - SABME contains TEI and SAPI of the layer 3 of requested entity
  - replied by a UA or DM frame to confirm or reject the request
- *Data Transfer*
  - sending I-frames with N(S) and N(R) fields in modulo 128
  - flow- and error-control, sliding window FC and go-back-N ARQ EC
- *Disconnect*
  - by sending a DISC frame which replied by a UA frame

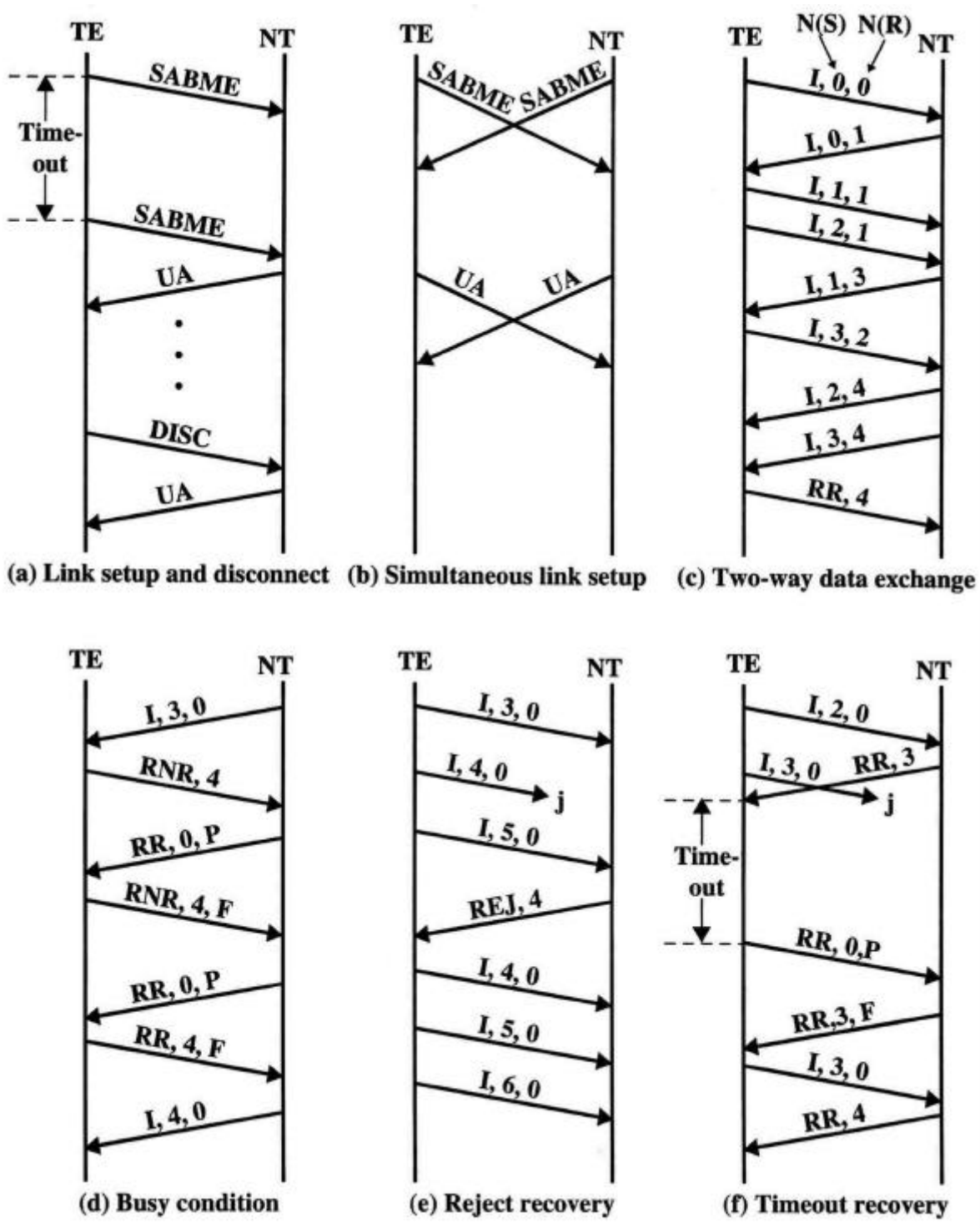
Frame-Reject Frame (FRMR)

- indicating an improper frame reception because of
  - receipt of an undefined or not implemented control field
  - receipt of an S-frame or U-frame with incorrect length
  - receipt of an invalid N(R)
  - receipt of an I-frame with a too long information field
- The FRMR effect is to abort the connection.

LAPD commands and responses

Name	Command/ Response	Description
Information (I)	C/R	Exchange user data
Supervisory (S)		
Receive ready (RR)	C/R	Positive acknowledgment; ready to receive I-frame
Receive not ready (RNR)	C/R	Positive acknowledgment; not ready to receive
Reject (REJ)	C/R	Negative acknowledgment; go back N
Unnumbered (U)		
Set asynchronous balanced mode extended (SABME)	C	Request logical connection
Disconnected mode (DM)	R	Unable to establish or maintain logical connection
Unnumbered information (UI)	C/R	Used to unacknowledged information transfer service
Disconnect (DISC)	C	Terminate logical link connection
Unnumbered acknowledgment (UA)	R	Acknowledge SABME or DISC
Frame reject (FRMR)	R	Report receipt of unacceptable frame
Exchange identification (XID)	C/R	Exchange identification information

Example of LAPD acknowledged operation



5.2 Terminal Adaption

- During transition period, existing ISDN-incompatible data communication devices can use a terminal adapter (TA).
- TA function id to map a non-ISDN terminal to an ISDN interface.
- Functions that performed in this mapping are:
  - Rate adaption: mapping low data stream into 64 kbps
  - Signaling conversion: mapping signaling protocol into Q.931
  - X.25 conversion: converting functions of non-ISDN X.25 devices to operate on the B and/or D channels
  - Physical interface conversion: mapping non-ISDN interface onto ISDN's twp twisted pairs at the S or T interface
  - Digitization: analog-to-digital conversion for analog devices

Summary of TA procedures

ISDN Service	TA Procedures	R Interface(s)	ISDN Channel(s)
Circuit switched	I.465/V.120 (U.S.) I.463/V.110 (Europe, Japan) I.461/X.30	V.24, V.35 V.24, V.35 X.21	B, H B B
Packet switched	I.462/X.31 circuit mode I.462/X.31 packet mode	X.25 X.25	B B, D, H

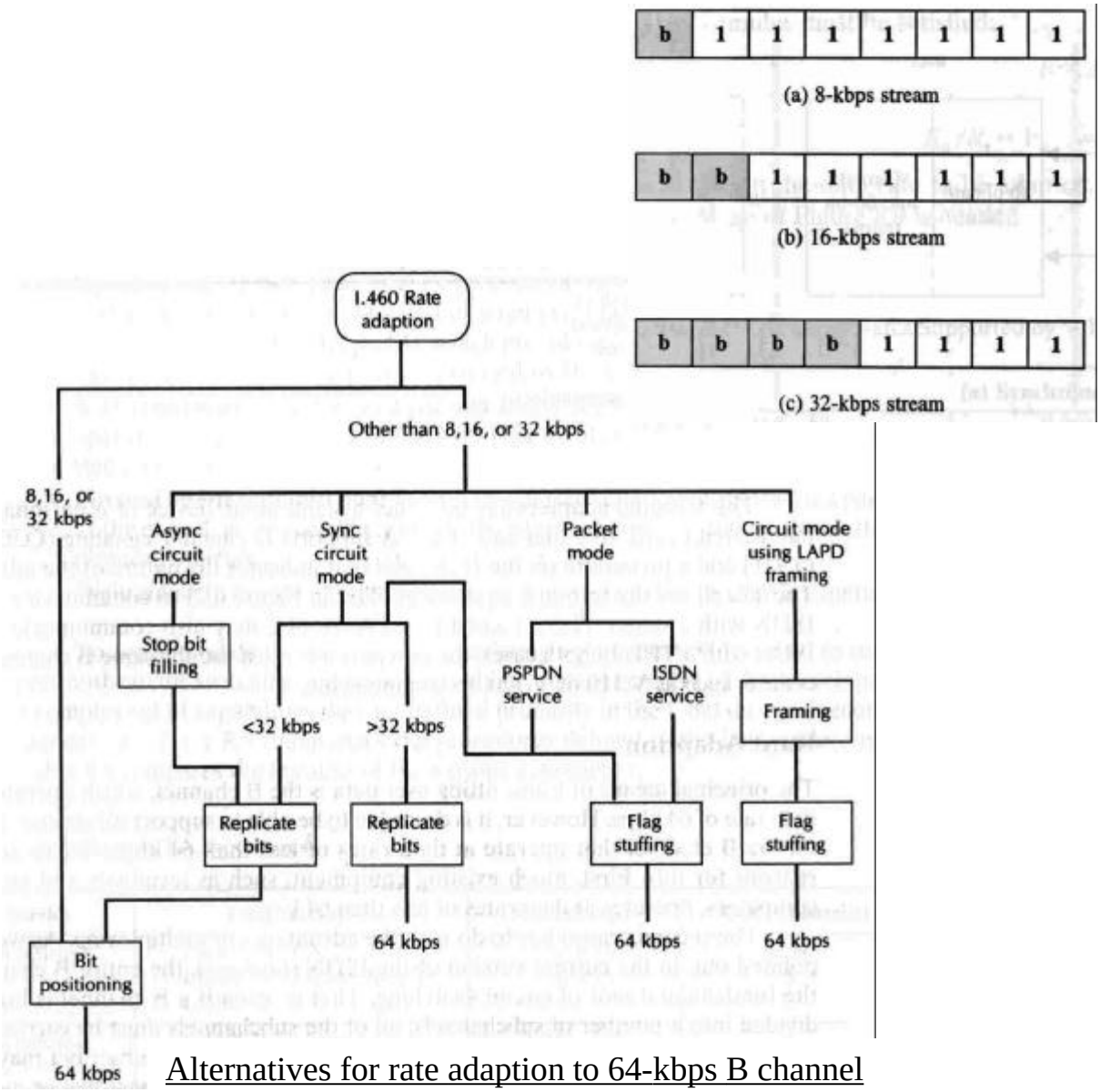
Comparison of TA standards

	I.463/V.110 & I.461/X.30	I.465/V.120	I.462/X.31
ISDN bearer service	Circuit	Circuit	Circuit/packet
Rate adaption	1–3 stages	Flag stuffing	Flag stuffing
Multiple destinations	No	No	Yes
HDLC-based	No	Yes	Yes
B channel multiplexing	No	Yes—LLI	Yes—VCN
D channel operation	No	No	Yes, with packet bearer service
Error detection	None	CRC—V.41	CRC—V.41
Error correction	None	Retransmission	Retransmission
Flow control	Limited (X bit)	Yes—sliding window	Yes—sliding window
Type of DTE at R	Async/sync (bit transparent)	Async/HDLC/bit transparent	X.25 sync

CRC = cyclic redundancy check
DTE = data terminal equipment
VCN = virtual circuit number
LLI = logical link ID
PAD = packet assembler/disassembler
TA = terminal adapter

Rate Adaption

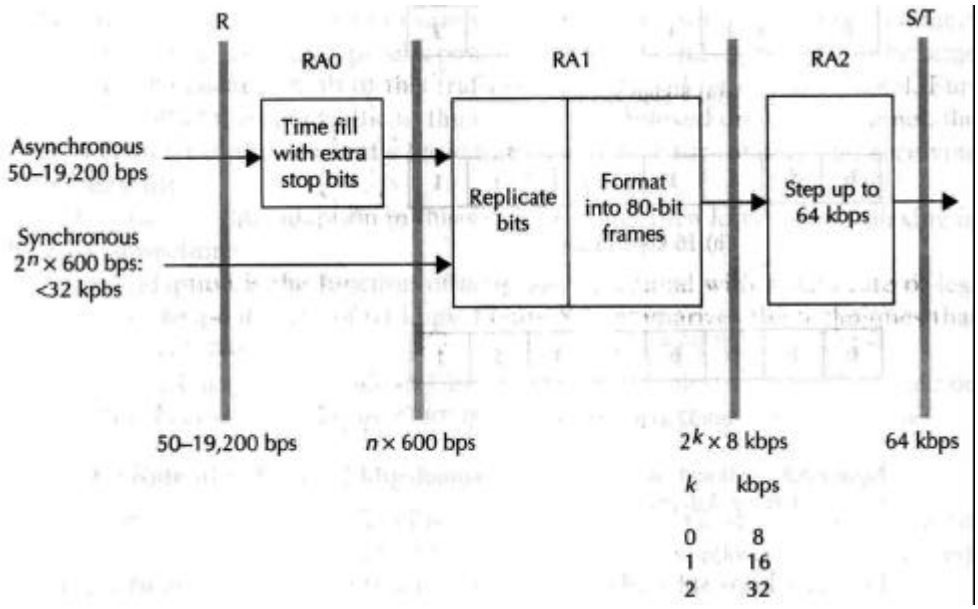
- It is desirable to have devices at data rates < 64 on B channel
  - much existing equipment operates at data rates less than 64 kbps
  - having advantages of multiplexing
    - ISDN is circuit-switched: all subchannels are on a single circuit
    - one B channel for fax and PC (multiplexed) and one B channel for phone
- Rate adaption: to adapt a terminal with < 64 to a data rate of 64
  - For rates of 8, 16, or 32 kbps, simple bit positioning technique is used.



Alternatives for rate adaption to 64-kbps B channel

Rate adaption for rates other than 8, 16, or 32 kbps

- Synchronous circuit-mode devices
  - For rates < 32 kbps, a two-stage adaption function is used.
  - The user data rate is first converted to an intermediate rate of 8, 16, or 32 kbps, then in second stage (RA2) bit positioning method used.
  - In circuit-switching rate adaption, the two subscriber operate at the same data rate (which is identified during call setup).



Rate adption I.463/V.110

Adaption of 2400-bps user rate to 8-kcs intermediate rate

Octet	Bits							
1	0	0	0	0	0	0	0	0
2	1	D1	D1	D2	D2	D3	D3	S
3	1	D4	D4	D5	D5	D6	D6	X
4	1	D7	D7	D8	D8	D9	D9	S
5	1	D10	D10	D11	D11	D12	D12	S
6	1	1	1	0	E4	E5	E6	E7
7	1	D13	D13	D14	D14	D15	D15	S
8	1	D16	D16	D17	D17	D18	D18	X
9	1	D19	D19	D20	D20	D21	D21	S
10	1	D22	D22	D23	D23	D24	D24	S

D = data bits
S = status bits
E = user data rate indication
X = reserved for future use

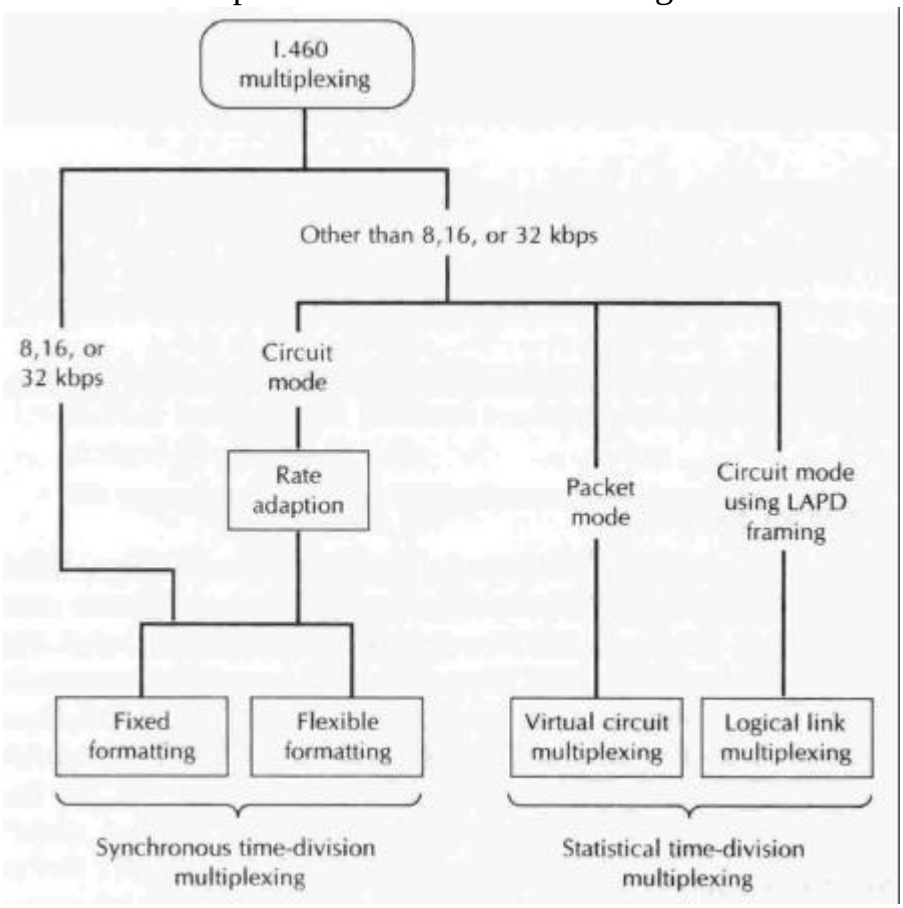
- Asynchronous circuit-mode devices
  - For handling asynchronous devices, a three stage method is used.
  - In first stage (RA0) asynchronous stream converts to sync data rate.
  - The technique is to add additional stop bits between characters to step up data rate to the nearest intermediate rate acceptable by RA1.
- Packet-mode support
  - support of packet-mode equipment over ISDN operated < 64 kbps
  - LAPB frames accepted from subscriber and buffered in TA.
  - Each frame is then transmitted onto the B channel at 64 kbps with gaps being filled with flag (01111110): *interframe flag stuffing*
  - Two-stage rate adaption is also possible but it is less flexible.
- Circuit-mode support using LAPD framing
  - An alternative method of supporting synchronous circuit-mode equipment is to encapsulate the incoming synchronous bit stream into LAPD frames and then adapted to 64 kbps by flag stuffing.
  - The advantage of this method compared to the previously discussed method is that the data are transmitted now using a data link control protocol which provides for the benefits of flow and error control that are inherent in a link-control protocol.

Multiplexing

- combining traffic from multiple <64 terminals onto a 64 B ch.
- For data rate of 8, 16, or 32 kbps, bits from different streams, up to a total of 64 kbps, are interleaved within each octet.
  - fixed-format multiplexing
    - bit positions are fixed according to the data rate of incoming stream
    - the 64-kbps capacity may not be utilized effectively
  - flexible-format multiplexing
    - first, subrate stream using fixed-format procedure is attempted.
    - If it fails, subrate stream is added by inserting each successive bit of the new stream into the earliest available bit position in the B channel octet.
    - always allows sbrate streams to be multiplexed up to the 64 limit
  - Both methods are examples of synchronous TDM

Multiplexing for rates other than 8, 16, or 32 kbps

- Circuit-mode devices
  - A two-stage approach is used:
    - First, each stream is rate adapted to 8, 16, or 32 kbps.
    - Second, the resulting streams are multiplexed.
- Packet-mode support
  - multiplexing function is provided by layer 3 VC mechanism of X.25
  - once a connection is made via a B or D ch. to a packet-switching node, multipe VCs cab be set up across that connection.
- Circuit-mode support using LAPD framing
  - using the 13-bit logical link identifier (LLI) field of LAPD frame
  - with LLI, user can simultaneously establish multiple logical links over a single B channel circuit.
  - LLI enables recipient to sort out the incoming traffic and to route it.

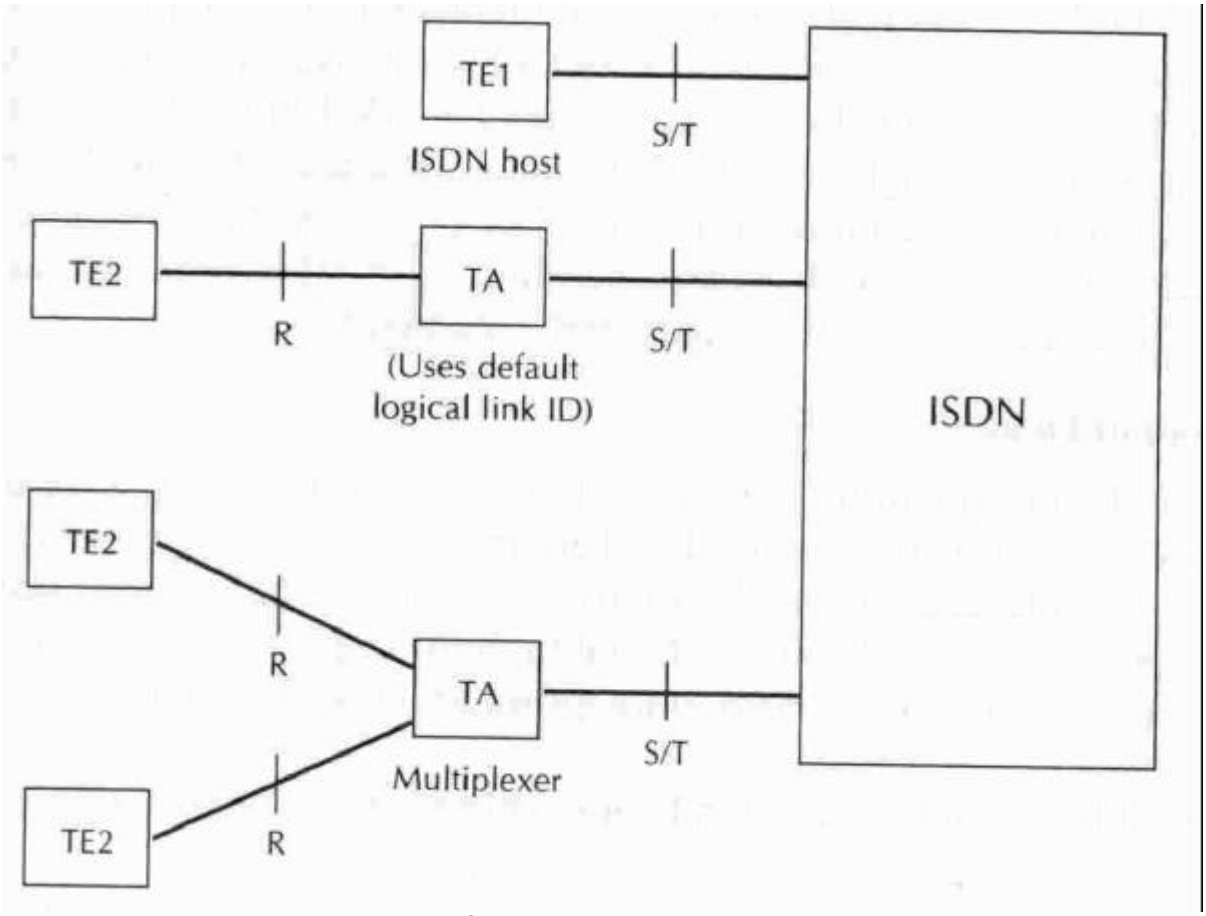


5.3 Bearer Channel Data Link Control

- I.465/V.120 provides a technique for supporting non-ISDN terminals over a B channel using a data link protocol that is a modified form of LAPD.
  - Asynchronous protocol sensitive
  - HDLC synchronous protocol sensitive
  - Bit transparent

different types of data stream carried by I.465/V.120

- I.465/V.120 provides a flexible and useful data link protocol for B ch.
- V.120 standard may be used in circuit-switching or frame relay
  - Over either circuit-mode or frame-mode connections ¬ ***operation***
  - Using either demand or semipermanent establishment of communications
  - Over any of the following types of access channel:
    - for circuit-mode connections: D, Ho, H10, or H11
    - for frame-mode connections: B, H0, H10, or H11, or D



Types of I.465/V.120 TE connections