The University of Sydney

AUSTRALIA

School of Electrical and Information Engineering

Advanced Communication Networks

Chapter 4

ISDN Physical Layer

Based on chapter 7 of Stallings ISDN-4e book

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4.1 Basic User-Network Interface

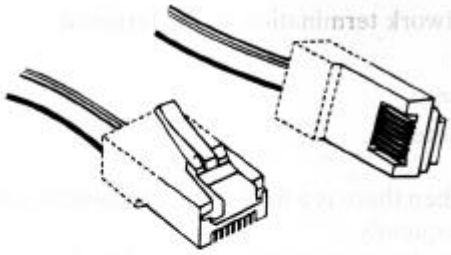
- **Physical layer functions (at reference point S or T)**
  - encoding of digital data for transmission across the interface
  - full-duplex transmission of B channel data
  - full-duplex of transmission of D channel data
  - multiplexing of channels to form basic or primary access
  - activation and deactivation of physical circuit
  - power feeding from network termination to the terminal
  - terminal identification
  - faulty terminal isolation
  - D channel contention access (for multipoint configuration in basic)
- **Layer 1 specification is defined in I.430**
- **Key aspects of basic interface (supports a 2B+D at 192 kbps)**
  - Line coding
  - Physical connector
  - Framing and multiplexing
  - Contention resolution for multidrop configurations

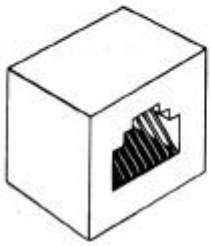
Line Coding

- full-duplex digital data transmission (one line for each direction)
- no echo cancellation or time-compression multiplexing needed
- use of pseudoternary coding scheme
  - “1”: absence of voltage
  - “0”: a positive or negative pulse of 750 mV ± 10%
  - data rate is 192 kbps

Basic Access Physical Connector

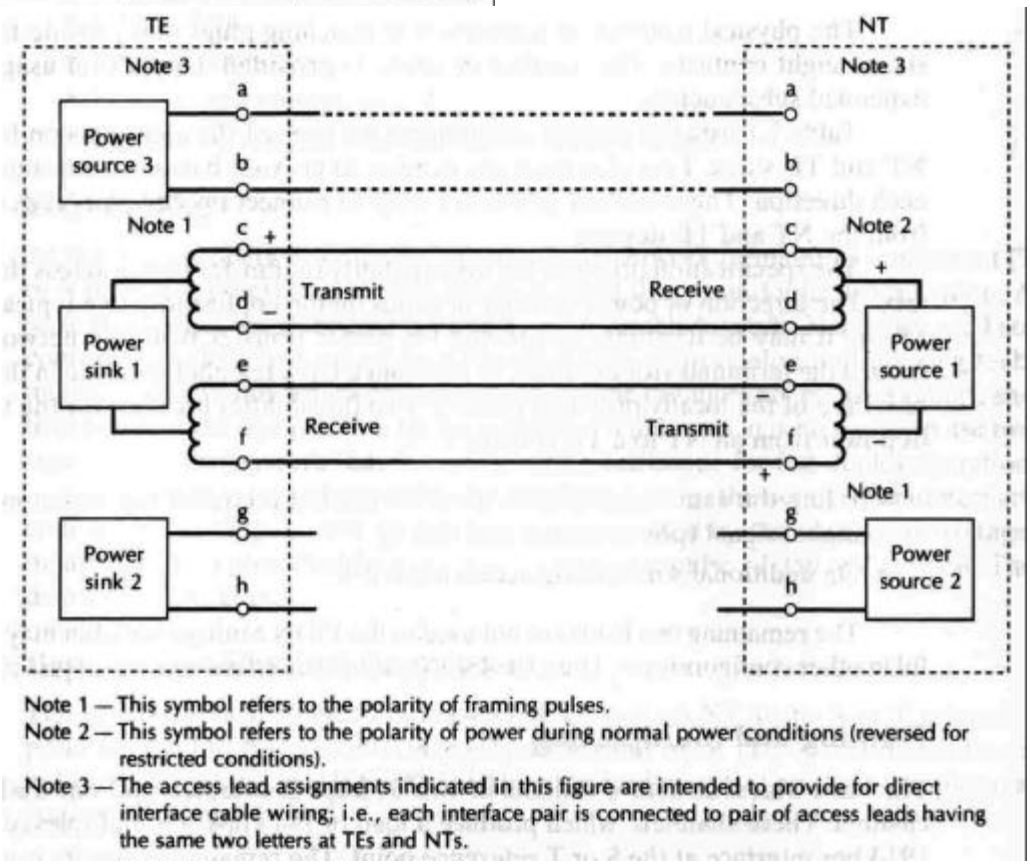
- Physical connection between a TE and an NT: ISO 8887
- eight-pin ISDN physical connector
- for twisted-pair connections
- power transfer from the network





using only six leads out of eight

Contact	TE	NT
a	Power Source 3	Power Sink 3
b	Power Source 3	Power Sink 3
c	Transmit	Receive
f	Receive	Transmit
e	Receive	Transmit
d	Transmit	Receive
g	Power Sink 2	Power Source 2
h	Power Sink 2	Power Source 2

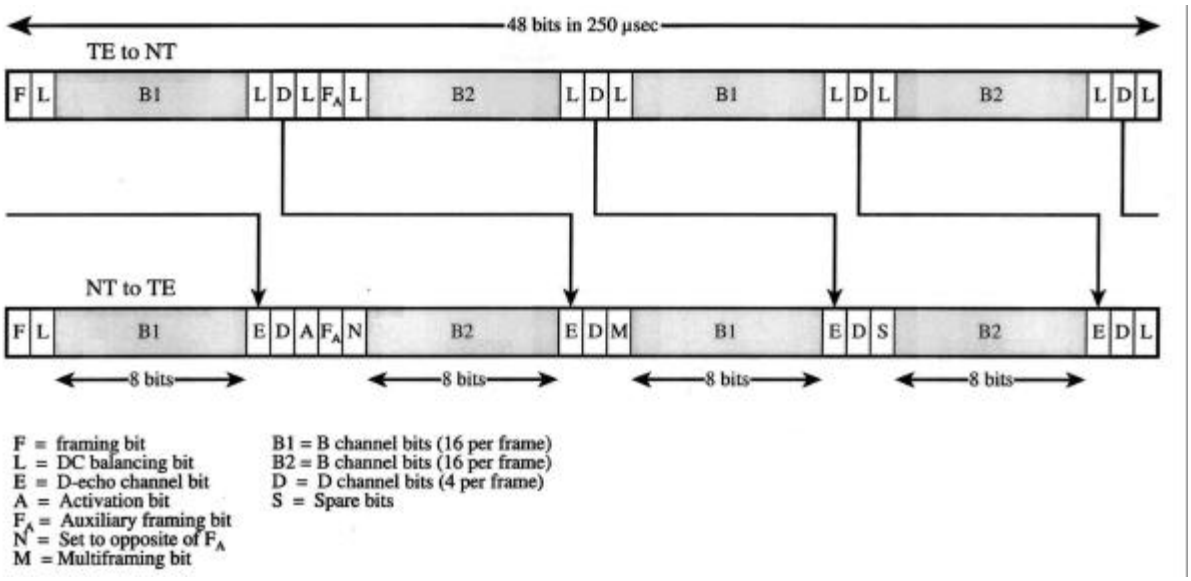


Note 1 — This symbol refers to the polarity of framing pulses.
Note 2 — This symbol refers to the polarity of power during normal power conditions (reversed for restricted conditions).
Note 3 — The access lead assignments indicated in this figure are intended to provide for direct interface cable wiring; i.e., each interface pair is connected to pair of access leads having the same two letters at TEs and NTs.

Reference configuration for signal transmission and power feeding

Framing and Multiplexing

- basic structure: two 64-kbps B ch. and one 16-kbps D channel
  - multiplexing of 144 kbps over 192-kbps interface at S or T ref. pnt.
  - remaining capacity used for framing and synchronization purposes
  - 48-bit frames at a rate of one frame every 250 μs
  - frame from TE to NT is later than the frame in opposite site by 2 bt.
  - F-L pattern synchronizes the receiver (F positive, L negative)
  - F_A bit is used in a mutiframe structure
  - A bit is used to activate or deactivate a TE
  - N and M bits may be used for multiframing
  - S bit is reserved for future standardization
- pseudoternary code violation for alignment of Rx and Tx
  - The first F bit: always +0, last zero bit of the frame is positive
  - The first zero bit after the first L bit: both negative zeros
- Q channel: an additional channel for traffic in TE-NT direction
  - multiframe structure by setting M (NT-to-TE) to "1" on 20th frame
  - F_A in every 5th frame is a Q bit (4 Q bits in each 20 frames MF)

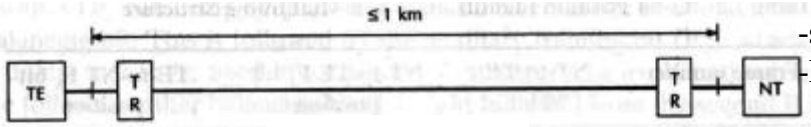


Frame structure at reference points S and T for ISDN basic rate access

Contention Resolution for Multidrop Configurations

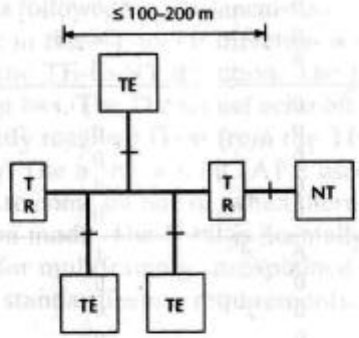
- More than one TE device in a passive bus configuration

point-to-point, short passive bus, extended passive bus, NT1 star



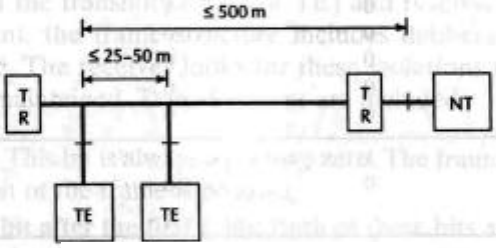
(a) Point-to-point

-simplest configuration
-length of the medium (S/N)

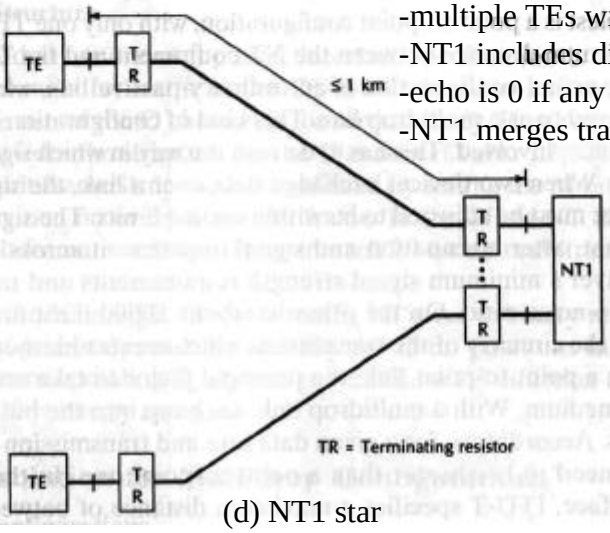


(b) Short passive bus

-each tap creates losses/distortions
-shorter than a point-to-point line
-for basic access between 100-200 m
-length limited also by round trip delay



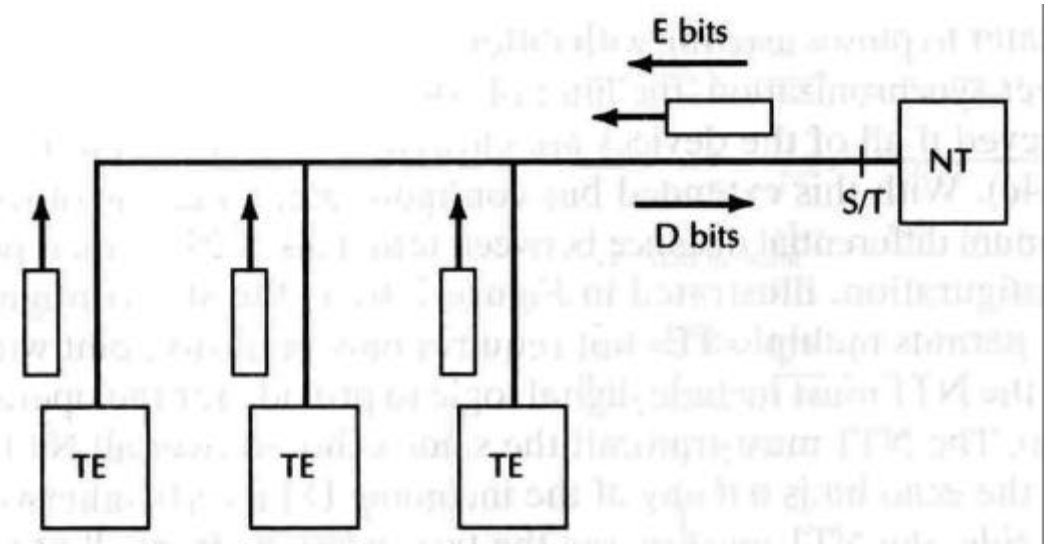
(c) Extended passive bus



(d) NT1 star

-multiple TEs with point-to-point wiring
-NT1 includes digital logic for D channel echo
-echo is 0 if any of incoming D bits is 0
-NT1 merges transmissions from all TEs

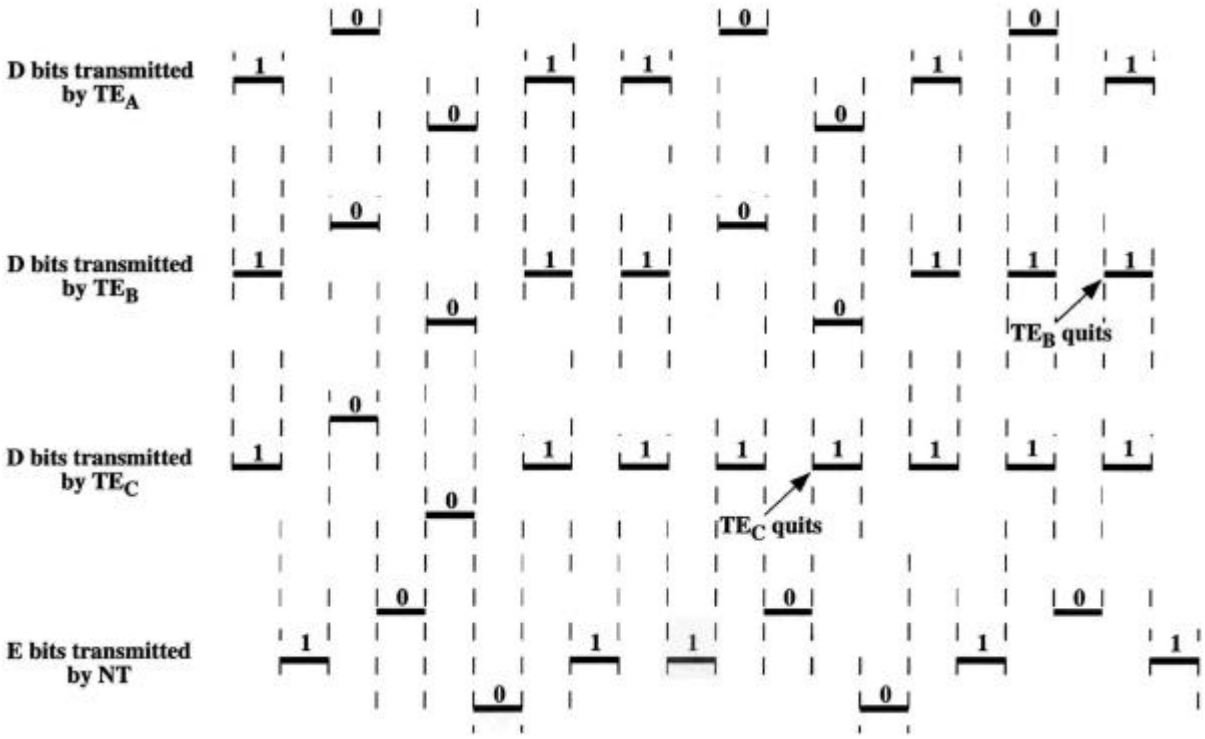
- Three types of traffic considered in contention resolution
  - **B channel traffic**-each channel is dedicated to one TE, no additional functionality is thus needed
  - **Incoming D channel traffic**-available for all devices, thus contention exists. Used LAPD addressing scheme to solve
  - **Outgoing D channel traffic**-only one device to transmit at a time
- Contention resolution algorithm on D channel
  - In the absence of LAPD frames, subscriber transmits a series of "1" on the D channel (pseudoternary encoding → no line signal)
  - NT reflects back the binary value as D ch echo bit (E bit)
  - When a terminal is ready to transmit an LAPD frame, it listens to the incoming D ch echo bits. If it detects a string of 1-bits of length equal to threshold X_i, it may transmit, otherwise wait.
- Priority mechanism based on the threshold value X_i
  - signaling information is given priority over packet information
  - a station begins at normal priority, then reduced to lower priority
    - Signaling information
      - Normal Priority X_1= 8, Lower Priority X_1=9
    - Nonsignaling information
      - Normal Priority X_2=10, Lower Priority X_2=11



Contention resolution

Example of contention resolution

- Three TEs are attempting to use the D channel.
- Each TE maintains two priority values, X_1 and X_2, corresponding to signaling and nonsignaling information to be transmitted on the D channel. Each of these values is initialized to a normal priority level. When a TE has D channel information of class *i* to transmit, it waits until it sees a string of 1 bits on the E channel equal to X_i and then transmits. This causes the corresponding priority value to be placed at lower priority.
- To recover to normal priority, a TE listens for consecutive E bits equal to 1. When the TE observes a string of 1 bits on the E channel equal to the value of the lower level of priority, it changes the priority for that class back to the value for the normal level of priority.



4.2 Primary Rate User-Network Interface

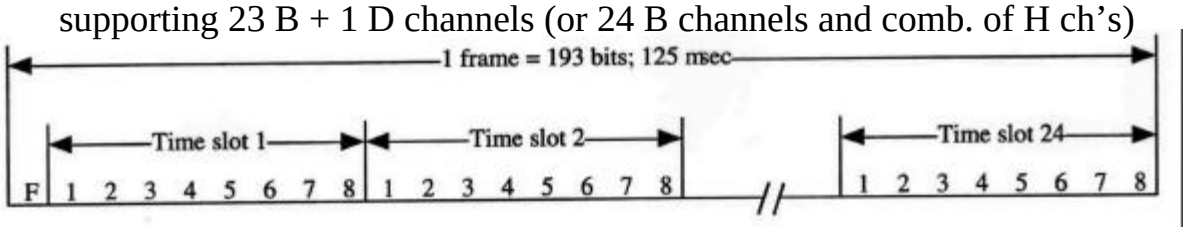
- Like basic interface to multiplex multiple channels on a single medium
- Only point-to-point configuration is allowed
- Typical interface: at T reference point with a digital PBX
- Two data rates defined: 1.544 Mbps and 2.048 Mbps

Interface at 1.544 Mbps

- based on N. America DS-1 transmission structure used on T1
- bit stream of repetitive 193-bit frame (24X8-bit time slots + a framing bit)
- frames repeated at a rate of one every 125μs (8000 frames/sec)

Thus each channel supports 64-kbps data rate

- supporting 23 B + 1 D channels (or 24 B channels and comb. of H ch's)



Multiframe frame number	Multiframe bit number	F bits Assignments FAS	O&M	CRC
1	1	—	m	—
2	194	—	—	e_1
3	387	—	m	—
4	580	0	—	—
5	773	—	m	—
6	966	—	—	e_2
7	1159	—	m	—
8	1352	0	—	—
9	1545	—	m	—
10	1738	—	—	e_3
11	1931	—	m	—
12	2124	1	—	—
13	2317	—	m	—
14	2510	—	—	e_4
15	2703	—	m	—
16	2896	0	—	—
17	3089	—	m	—
18	3282	—	—	e_5
19	3475	—	m	—
20	3668	1	—	—
21	3861	—	m	—
22	4054	—	—	e_6
23	4247	—	m	—
24	4440	1	—	—

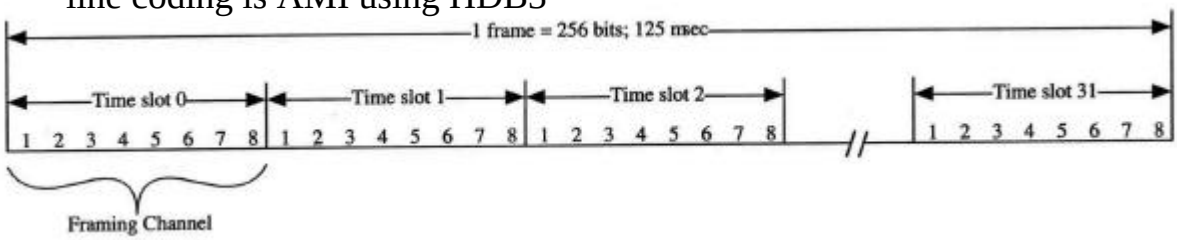
Assignment of 24 framing bits across the 24-frame multiframe

-Synchronization by FAS: 001011
-6-bit CRC composed by e_i bits
-line coding: AMI using B8ZS

FAS: frame-alignment signal
O&M: operations and maintenance
CRC: cyclic redundancy check

Interface at 2.048 Mbps (defined in ITU-T G.704 recommendation)

- 256-bit frames (32X8), 8000 f/s, each channel supports 64 kbps
- supporting 30 B + 1 D channels (or 31 B + combination of H channels)
- line coding is AMI using HDB3



Allocation of bits in time slot 0 (framing and synchronization purposes)

Bit Number / Alternate Frames	1	2	3	4	5	6	7	8
Frame containing the frame-alignment signal	S_1	0	0	1	1	0	1	1
	Note 1	Frame-alignment signal						
Frame not containing the frame-alignment signal	S_1	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
	Note 1	Note 2	Note 3	Note 4				

Note 1: S_1 = bits reserved for international use. One specific use is for CRC.
Note 2: This bit is fixed at 1 to assist in avoiding simulation of the frame-alignment signal.
Note 3: A = remote alarm indication (set to 1 in an alarm condition).
Note 4: S_{a4} to S_{a8} = additional spare bits.

	Sub-multiframe (SMF)	Frame Number	Bits 1 to 8 in the Frame							
			1	2	3	4	5	6	7	8
Multiframe	I	0	C_1	0	0	1	1	0	1	1
		1	0	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
		2	C_2	0	0	1	1	0	1	1
		3	0	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
		4	C_3	0	0	1	1	0	1	1
		5	1	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
		6	C_4	0	0	1	1	0	1	1
		7	0	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
	II	8	C_1	0	0	1	1	0	1	1
		9	1	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
		10	C_2	0	0	1	1	0	1	1
		11	1	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
		12	C_3	0	0	1	1	0	1	1
		13	E	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}
		14	C_4	0	0	1	1	0	1	1
		15	E	1	A	S_{a4}	S_{a5}	S_{a6}	S_{a7}	S_{a8}

E=error indicator bits
S_{a4} to S_{a8}=spare bits
C_1 to C_4=CRC-4 bits
A=remote alarm indication

Multiframe structure for 2.048-Mbps interface

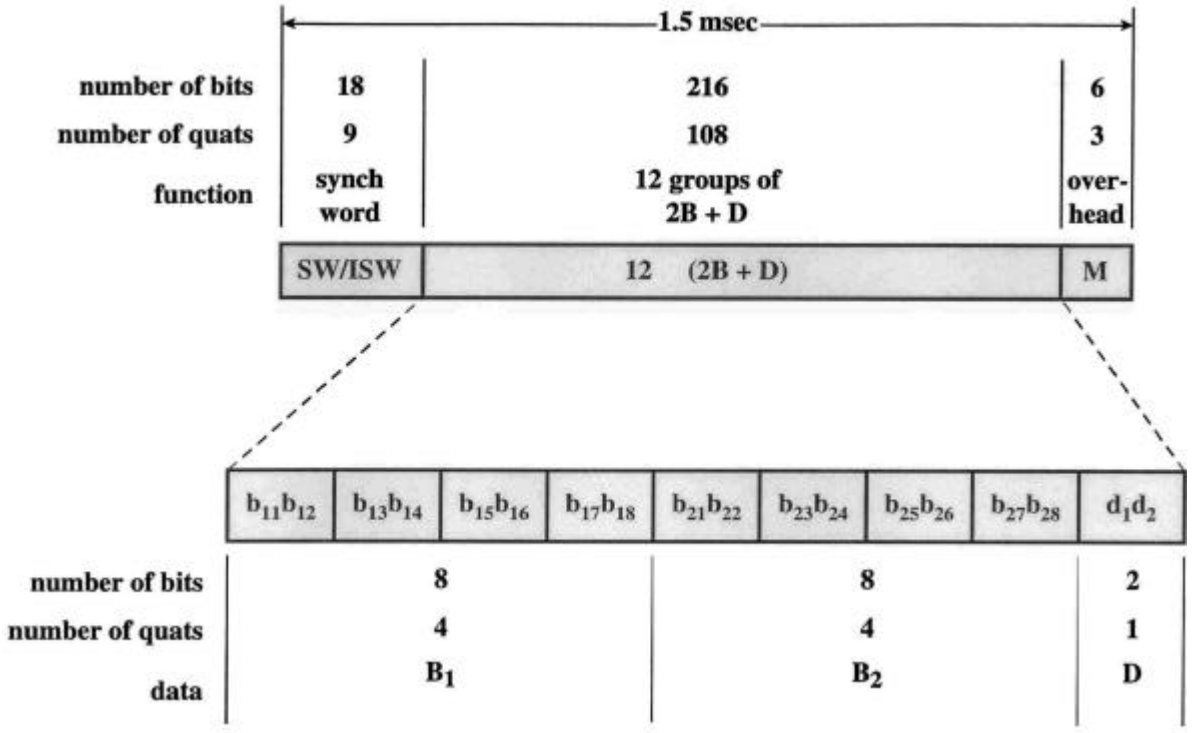
4.3 U Interface

- ANSI T1.601 standard for U interface supporting basic rate ISDN access
- two 64-kbps B and one 16-kbps D channels multiplexed an 160 interface
- frames of 240 bits, at 160 kbps, repeated one frame every 1.5 ms
  - ***Synchronization word:*** for receiver synchronization (18 bits)
  - ***User data:***12 groups of 18 bits carry B and D channel data
  - ***M channel:*** a 4-kbps channel for maintenance and other purposes
- line coding is 2B1Q (two binary, one quaternary) coding
  - more efficiency in use of bandwidth each signal element representing two bits
  - using 4 different voltage levels

1sr bit	2nd bit	quat symbol	voltage
1	0	+3	2.5
1	1	+1	0.833
0	1	-1	-0.833
0	0	-3	-2.5

Multiframe Structure

- organizing into superframes of eight frames each
- within superframe are 48 M bits (e.g., to form 12-bit CRC)



2B1Q superframe technique and overhead bit assignment

		Framing	2B+D	Overhead Bits (M_1 – M_6)					
	Quad positions	1–9	10–117	188s	118m	119s	119m	120s	120m
	Bit positions	1–18	19–234	235	236	237	238	239	240
Superframe #	Basic frame #	Synch word	2B+D	M_1	M_2	M_3	M_4	M_5	M_6
A	1	ISW	2B+D	eoc_{a1}	eoc_{a2}	eoc_{a3}	act	1	1
A	2	SW	2B+D	eoc_{dm}	eoc_{11}	eoc_{12}	dea	1	fbe
A	3	SW	2B+D	eoc_{13}	eoc_{14}	eoc_{15}	1	crc_1	crc_2
A	4	SW	2B+D	eoc_{16}	eoc_{17}	eoc_{18}	1	crc_3	crc_4
A	5	SW	2B+D	eoc_{a1}	eoc_{a2}	eoc_{a3}	1	crc_5	crc_6
A	6	SW	2B+D	eoc_{dm}	eoc_{11}	eoc_{12}	1	crc_7	crc_8
A	7	SW	2B+D	eoc_{13}	eoc_{14}	eoc_{15}	1	crc_9	crc_{10}
A	8	SW	2B+D	eoc_{16}	eoc_{17}	eoc_{18}	1	crc_{11}	crc_{12}
B, C, ...									

act: activation bit, crc:cyclic redundancy check covers 2B+D & M_4
dea: deactivation bit, eoc: embedded operations channel

Basic rate interface comparison of physical layer standards

	CCITT I.430	ANSI T1.601
Reference point	S or T	U
Devices	TE1/TA to NT	NT1 to LE
Distance	1 km	5.5 km
Physical configuration	Point-to-point or point-to-multipoint	Point-to-point
Bit Rate	192 kbps	160 kbps
User data rate	144 kbps	144 kbps
Line code	Pseudoternary	2B1Q
Signaling rate	192 kbaud	80 kbaud
Maximum voltage	± 750 mV	± 2.5 V
Timing source	NT	LE
Number of wire pairs	2	1
Full-duplex method	One wire pair for each direction	Echo cancellation
Interleaving scheme*	$B1_8D_1B2_8D_1$ (twice per frame)	$B1_8B2_8D_2$ (12 times per frame)
Number of bits per frame	48	240
Number of bits user data	36	216
Number of bits overhead	12	24
Number of frames/s	4,000	666.666...

*Subscript indicates the number of contiguous bits that are sent on B1, B2, and D channels.