The closure lecture

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Agenda

- Block Coding
- Scrambling
- Digital Modulation Techniques
  - ASK
  - FSK
  - BPSK
  - QPSK
- Bandwidth Utilization
  - Multiplexing
  - Multiple Access techniques
  - Spreading

Block Coding

- Block coding is normally referred to as *m*B/*n*B coding;
- it replaces each *m*-bit group with an *n*-bit group.
- Mainly used for error detection and correction

Error detection example (1B/2B)

Data	Block code
0	00
1	11

Received code	status	Data
00	ok	0
01	nok	?
10	nok	?
11	ok	1

- Error correction Example (1B3B)

Data	Block code
0	000
1	111

Received code	Distance (000)	Distance (111)	Data
000	0	3	0
001	1	2	0
010	1	2	0
011	2	1	1
100	1	2	0
101	2	1	1
110	2	1	1
111	3	0	1

- Error detection 2B4B

Data	Code
00	0000
01	0011
10	1100
11	1111

Received code	Distance from 0000	Distance from 0011	Distance from 1100	Distance from 1111	Decision
0000	0	2	2	4	00
0001	1	1	3	3	error
0010	1	1	3	3	error
0011	2	0	4	2	01
0100	1	3	1	3	error
0101	2	2	2	2	error
0110	2	2	2	2	error
0111	3	1	3	1	error
1000	3	3	1	1	error
1001	2	2	2	2	error
1010	2	2	2	2	error
1011	3	1	3	1	error
1100	2	4	0	2	10
1101	3	3	1	1	error
1110	3	3	1	1	error
1111	4	2	2	0	11

- Error correction 2B6B

Data	Code
00	000000
01	001111
10	111100
11	111111

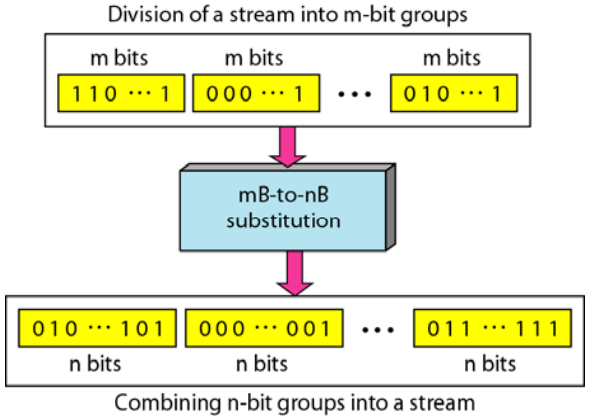
	000000	000111	111000	111111	Decision
000000	0	3	3	6	00
000001	1	2	4	5	00
000010	1	2	4	5	00
000011	1	2	5	4	01
000100	1	2	4	5	00
000101	2	1	5	4	01
000110	2	1	5	4	01
000111	3	0	6	3	01
001000	1	4	2	5	00
001001	2	3	3	4	00
001010	2	3	3	4	00
001011	3	2	4	3	01
001100	2	3	3	4	00
001101	3	2	4	3	01
001110	3	2	4	3	01
001111	4	1	5	2	01

	000000	000111	111000	111111	Decision
010000	1	4	2	5	00
010001	2	3	3	4	00
010010					
010011					
010100					
010101					
010110					
010111	4	1	5	2	01
011000					
011001					
011010					
011011	4	3	3	1	11
011100					
011101					
011110					
011111	5	2	4	1	11

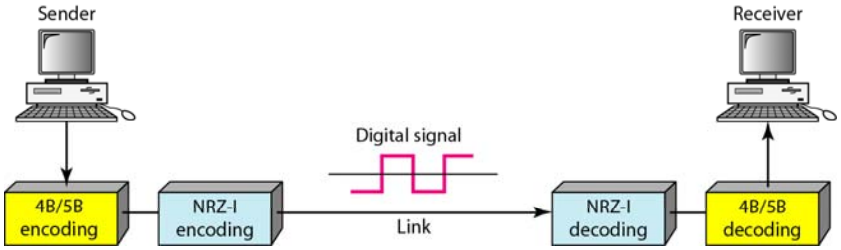
	000000	000111	111000	111111	Decision
100000	1	4	2	5	00
100001					
100010					
100011					
100100	2	3	3	4	00
100101					
100110					
100111					
101000					
101001	3	4	2	3	10
101010					
101011					
101100					
101101					
101110					
101111	5	2	4	1	11

	000000	000111	111000	111111	Decision
110000	2	5	1	4	10
110001					
110010					
110011	4	3	3	2	11
110100					
110101					
110110					
110111					
111000	3	6	0	3	10
111001					
111010					
111011					
111100	4	5	1	2	10
111101					
111110					
111111	6	3	3	0	11

Block coding concept



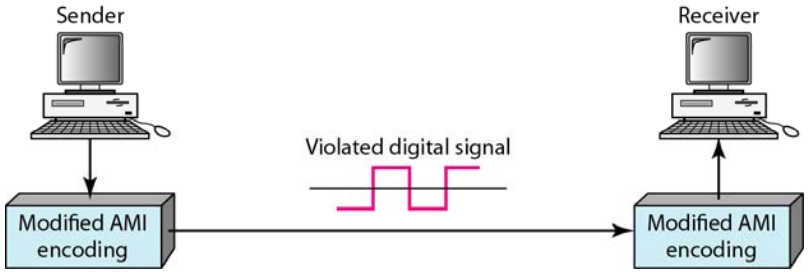
Using block coding 4B/5B with NRZ-I line coding scheme



Scrambling

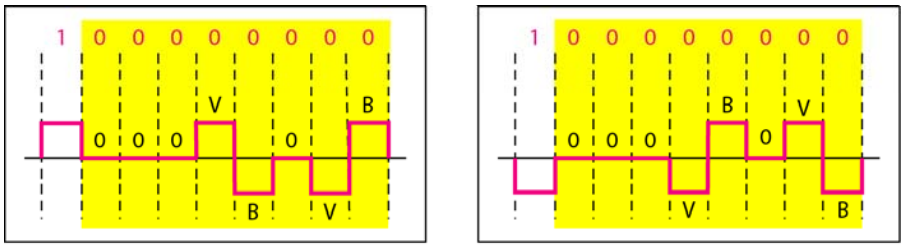
- Scrambling is a technique used to create a sequence of bits that has the required c/c's for transmission - self clocking, no low frequencies, no wide bandwidth.
- It is implemented at the same time as encoding, the bit stream is created on the fly.
- It replaces 'unfriendly' runs of bits with a violation code that is easy to recognize and removes the unfriendly c/c.

AMI used with scrambling



- For example: B8ZS substitutes eight consecutive zeros with 000VB0VB.
- The V stands for violation, it violates the line encoding rule
- B stands for bipolar, it implements the bipolar line encoding rule

Two cases of B8ZS scrambling technique

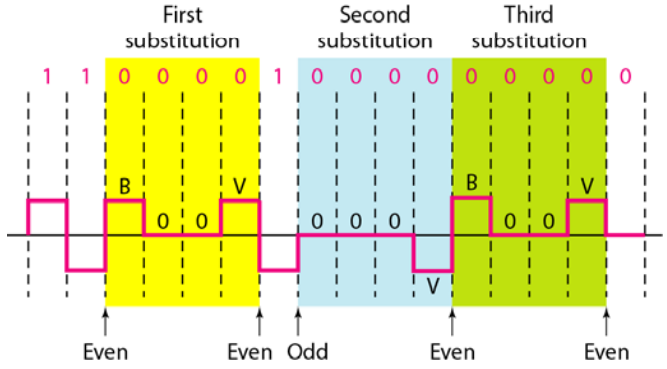


a. Previous level is positive.

b. Previous level is negative.

- HDB3 substitutes four consecutive zeros with 000V or B00V depending on the number of nonzero pulses after the last substitution.
- If # of non zero pulses is even the substitution is B00V to make total # of non zero pulse even.
- If # of non zero pulses is odd the substitution is 000V to make total # of non zero pulses even.

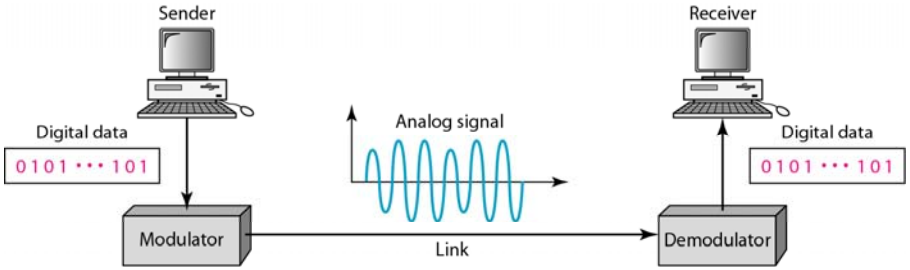
Different situations in HDB3 scrambling technique



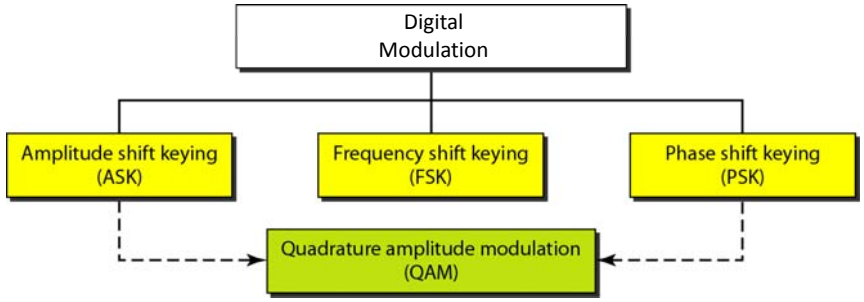
Digital Modulation

- Digital data needs to be carried on an analog signal.
- A carrier signal (frequency f_c) performs the function of transporting the digital data in an analog waveform.
- The analog carrier signal is manipulated to uniquely identify the digital data being carried.

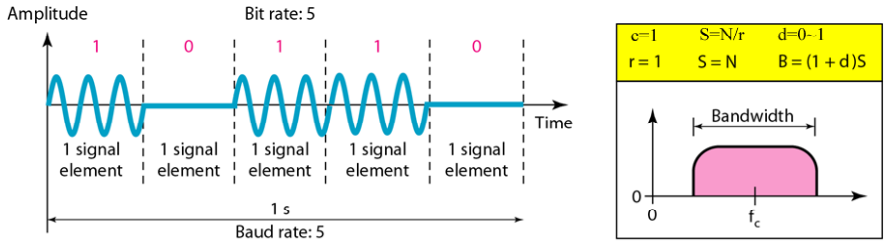
Digital Modulation



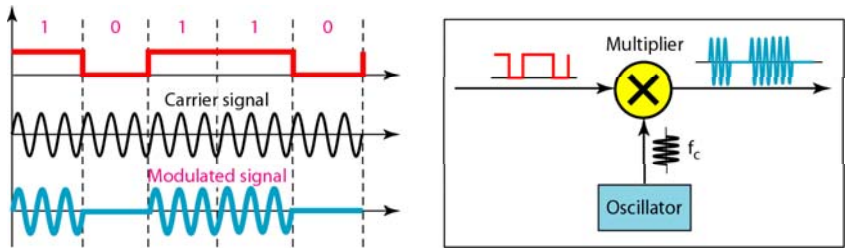
Types of Digital Modulation



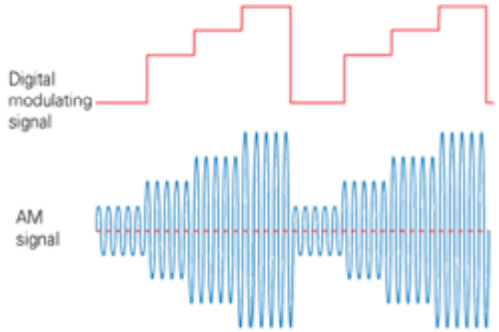
>> Binary amplitude shift keying



Implementation of binary ASK

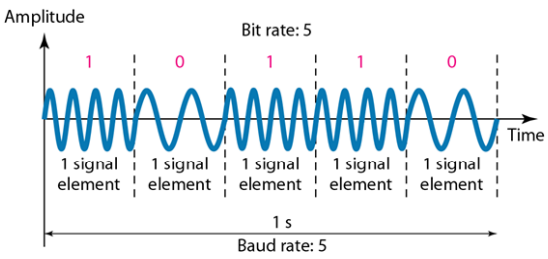


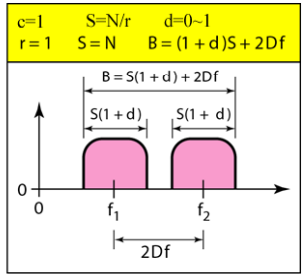
Multi level ASK (MSK)



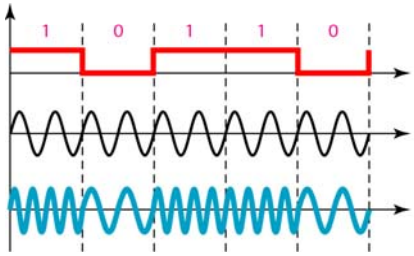
>> Frequency Shift Keying

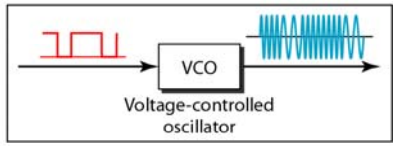
- The digital data stream changes the frequency of the carrier signal, f_c.
- For example, a "1" could be represented by $f_1=f_c+\Delta f$, and a "0" could be represented by $f_2=f_c-\Delta f$.





Implementation of binary FSK





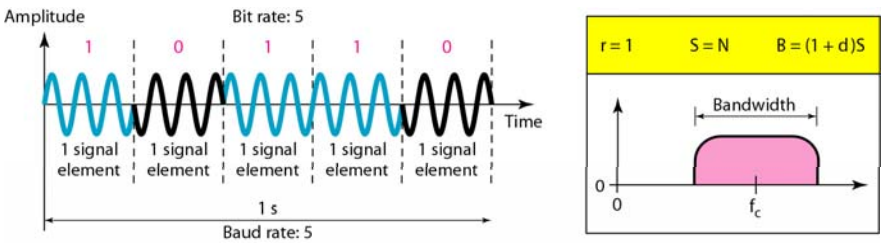
Coherent and Non Coherent

- In a non-coherent FSK scheme, when we change from one frequency to the other, we do not adhere to the current phase of the signal.
- In coherent FSK, the switch from one frequency signal to the other only occurs at the same phase in the signal.

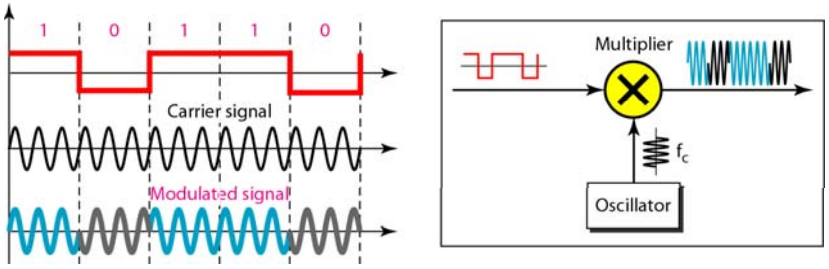
Multiple FSK

>> phase shift keying

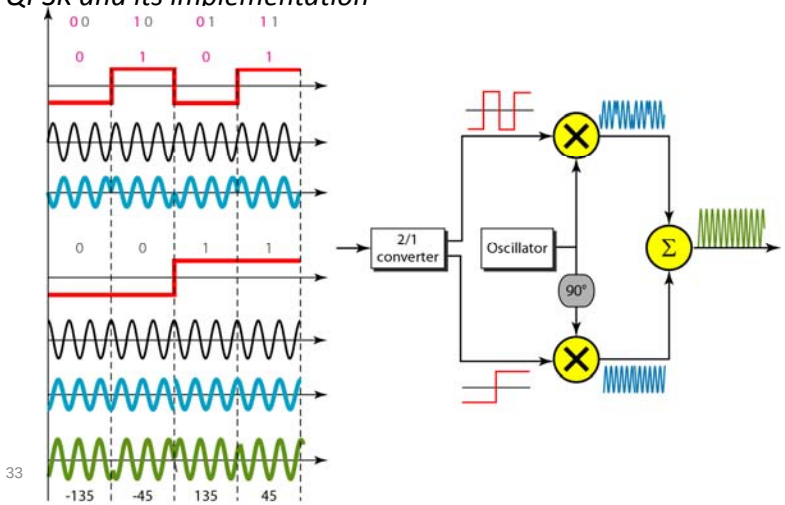
Binary phase shift keying



Implementation of BASK



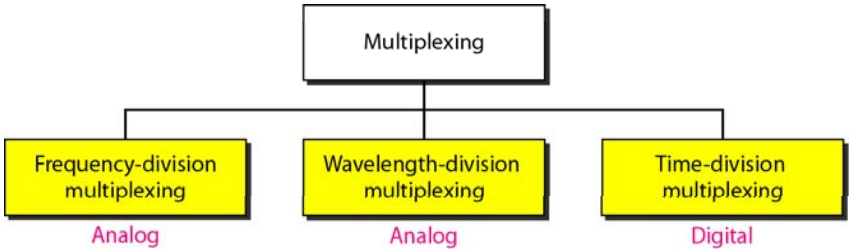
QPSK and its implementation



Bandwidth Utilization

- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared.
- Multiplexing is the set of techniques that allows the (simultaneous) transmission of multiple signals across a single data link.
- As data and telecommunications use increases, so does traffic.

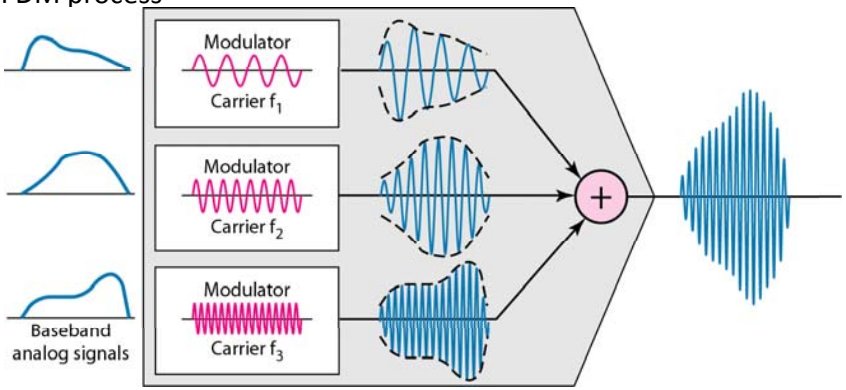
Categories of multiplexing



>> Frequency-Division Multiplexing

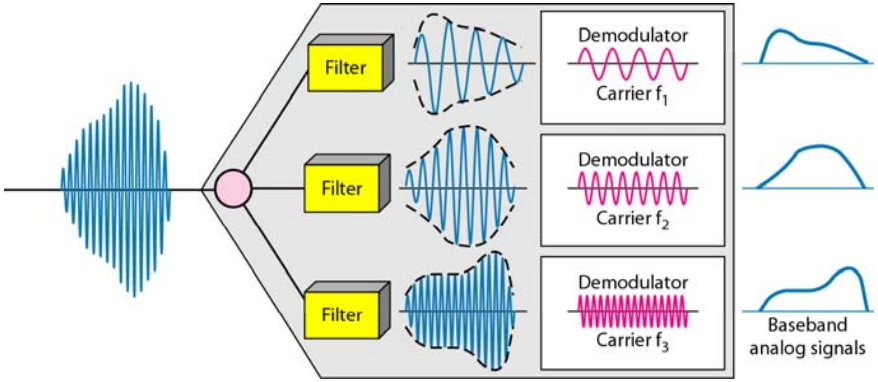
Frequency-division multiplexing (FDM)

FDM process

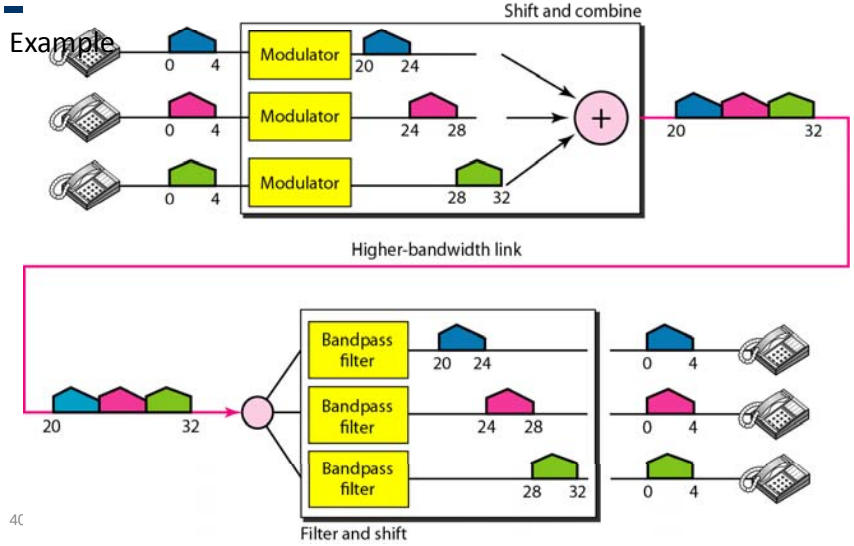


FM

FDM demultiplexing example

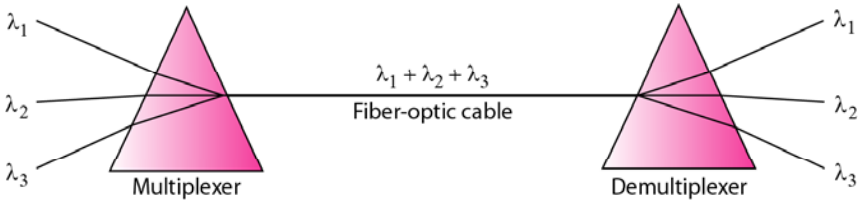


Example



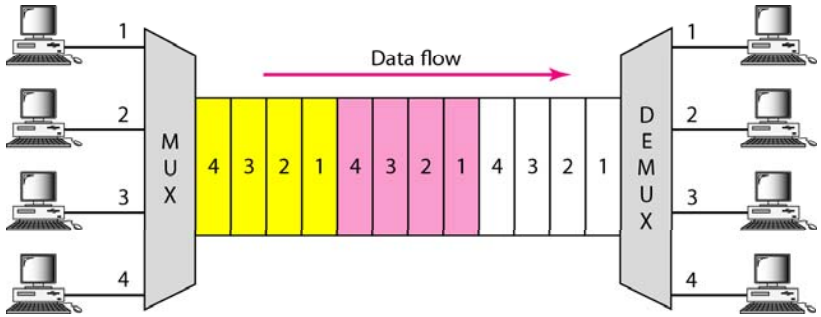
>> Wavelength-division multiplexing (WDM)

- WDM is an analog multiplexing technique to combine optical signals.



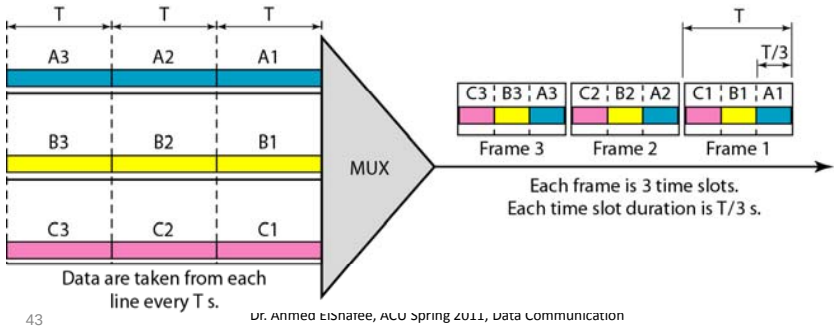
>> Time Division Multiplexing (*TDM)*

TDM is a digital multiplexing technique for combining several low-rate digital channels into one high-rate one.



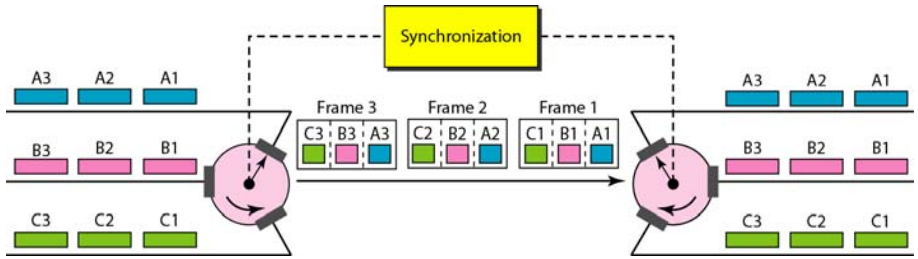
Synchronous time-division multiplexing

In synchronous TDM, the data rate of the link is *n* times faster, and the unit duration is *n* times shorter.

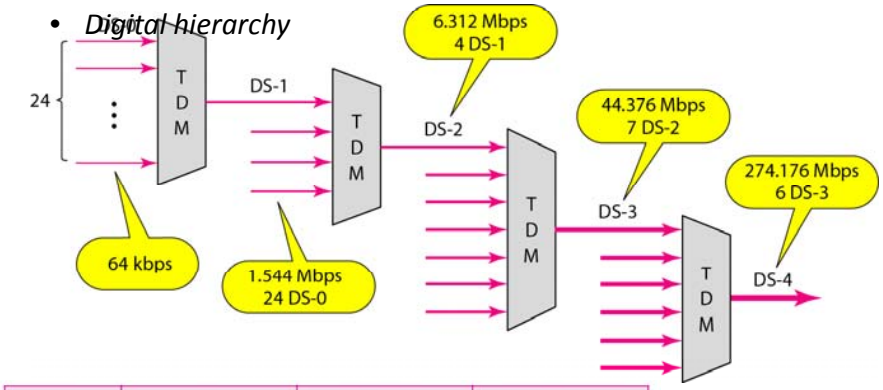


Interleaving

- The process of taking a group of bits from each input line for multiplexing is called interleaving.
- We interleave bits (n - 1) from each input onto one output.



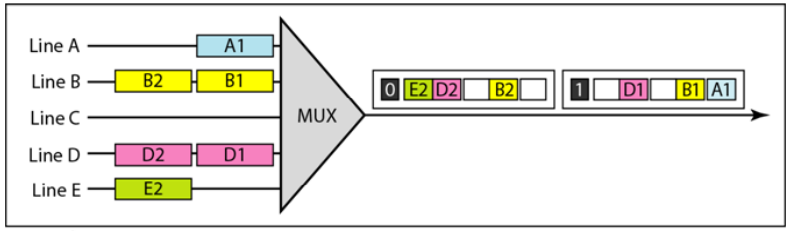
- *Digital hierarchy*



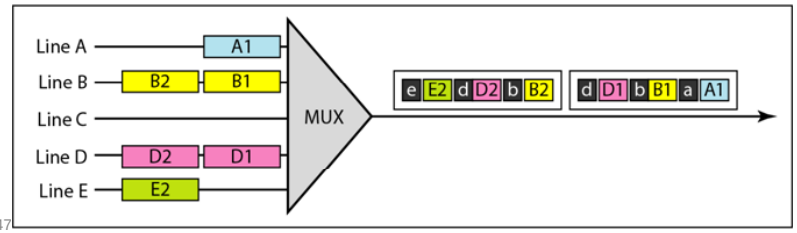
Service	Line	Rate (Mbps)	Voice Channels
DS-1	T-1	1.544	24
DS-2	T-2	6.312	96
DS-3	T-3	44.736	672
DS-4	T-4	274.176	4032

Line	Rate (Mbps)	Voice Channels
E-1	2.048	30
E-2	8.448	120
E-3	34.368	480
E-4	139.264	1920

>> Multiple Access techniques



Synchronous TDM



TDMA

Thanks,…