Data Communication BLM3051

Furkan ÇAKMAK

Lecture Information Form - Weekly Subjects

BLM3051 Data Communication

Week 5

Week	Date	Subjects
1	04.10.2021	Introduction to Data Communication Standards Used on Data Communication, Architectural models
2	11.10.2021	OSI Reference Model , Layers and Their Functions
3	18.10.2021	Signaling and Signal Encoding
4	25.10.2021	Parallel and Serial Transmission, Communication Media and Their Technical Specs., Multiplexing (TDM, FDM)
5	01.11.2021	Error Detection and Error Correction Techniques
6	08.11.2021	Data Link Control Techniques, Flow Control
7	15.11.2021	Asynchronous and Synchronous Data Link Protocols (BSC, HDLC)
8	22.11.2021	Ara Sınav
9	29.11.2021	Synchronous and Asynchronous Data Link Protocols
10	06.12.2021	LAN Technologies Continued, IEEE 802.4, 802.5, 802.11
11	13.12.2021	Connectionless and Connection Oriented Services, Switching
12	20.12.2021	Wide Area Networking Technologies (X.25, ISDN, FR, ATM, xDSL.)
13	27.12.2021	Communications Equipment's, TCP/IP Model, Security Issues
14	03.01.2022	Research Presentation 1

Multiplexing

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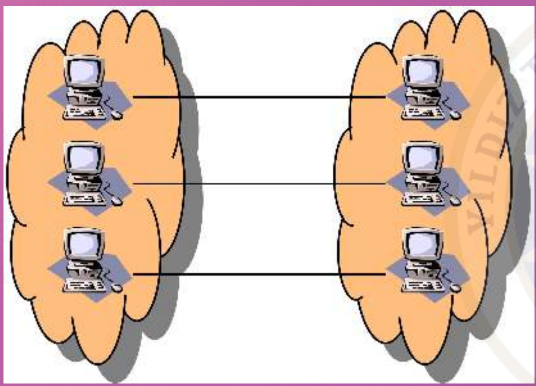

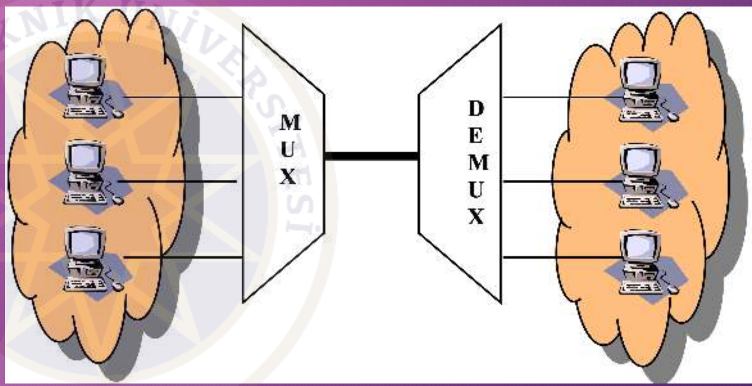

Multiplexing Technics

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- *FDM (Frequency Division Multiplexing)*
- *WDM (Wavelength Division Multiplexing)*
- *TDM (Time Division Multiplexing)*

FDM (Frequency Division Multiplexing)

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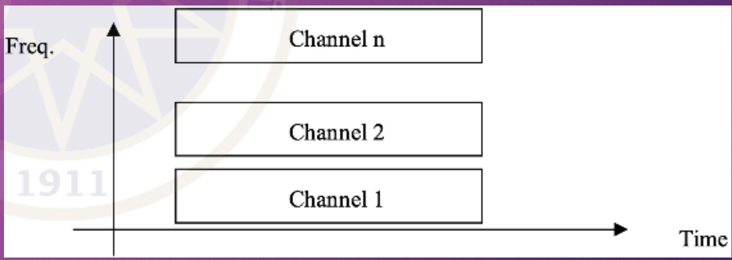
- $\sum(p2p\ BW) < total\ BW$
- Each signal has a different carriage signal
  - The signal to be sent is the sum of the carrier signals
  - Voice: 300-3300Hz BW
  - Guarded Band
- Television and radio broadcasts



WDM (Wavelength Division Multiplexing)

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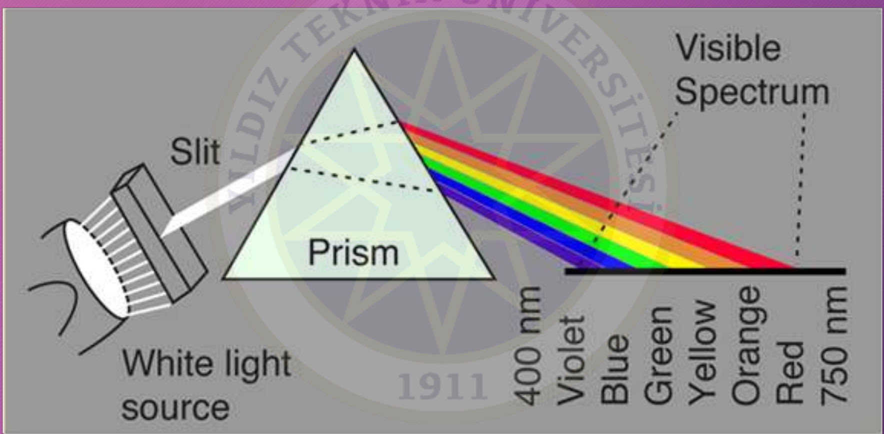
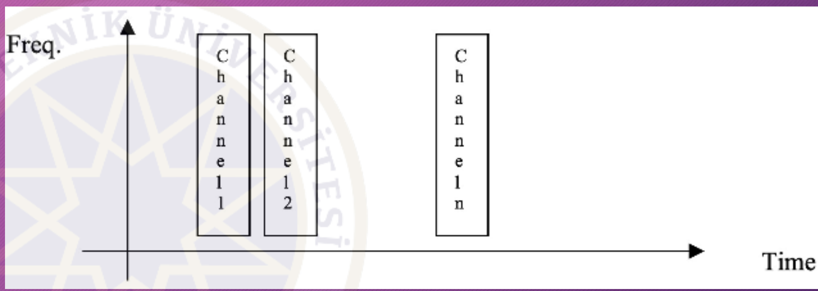
- Like FDM in FO

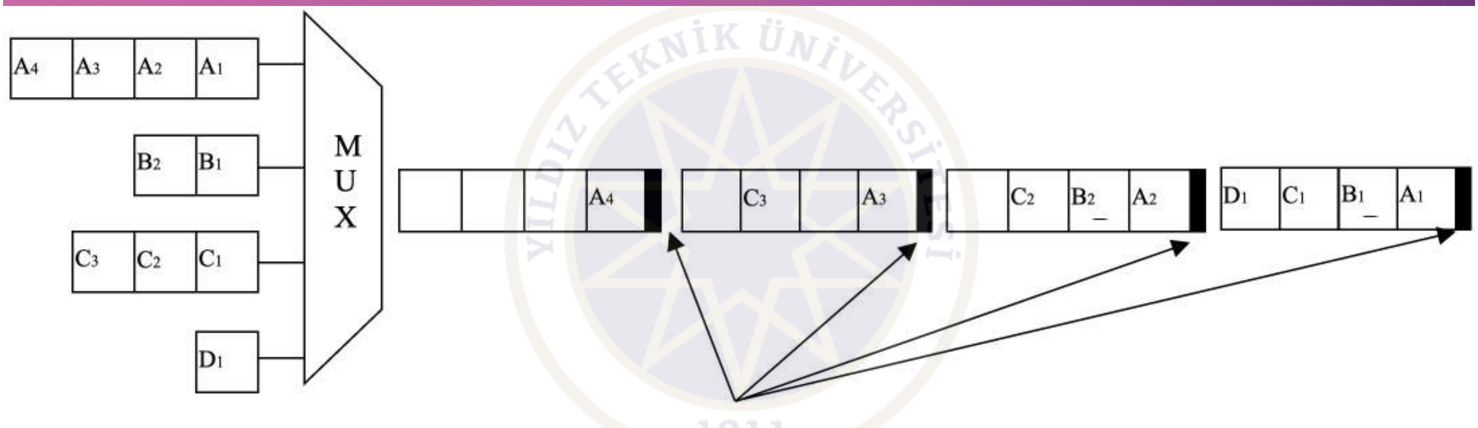


TDM (Time Division Multiplexing)

- $\max(p2p\ BW) < BW$
- 2 Types
  - Synchronous TDM
    - Data
    - Digitized Voice
  - Asynchronous TDM



Synchronous TDM



Synchronous TDM – Con’t

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- Example
  - In Sync. TDM where 4 units are connected, each unit produces 250 characters / sec output.
  - 1 bit is used for each frame to ensure synchronization.
  - Each frame contains a character from each unit.
  - Accordingly, calculate the obtained data communication speed as bps.

- Answer:
  - 250 frame + 250 bit (for sync.)
  - 250 frame x (4 unit x 8 bits/unit) / frame + 250 bit = 8250 bps

Asynchronous TDM

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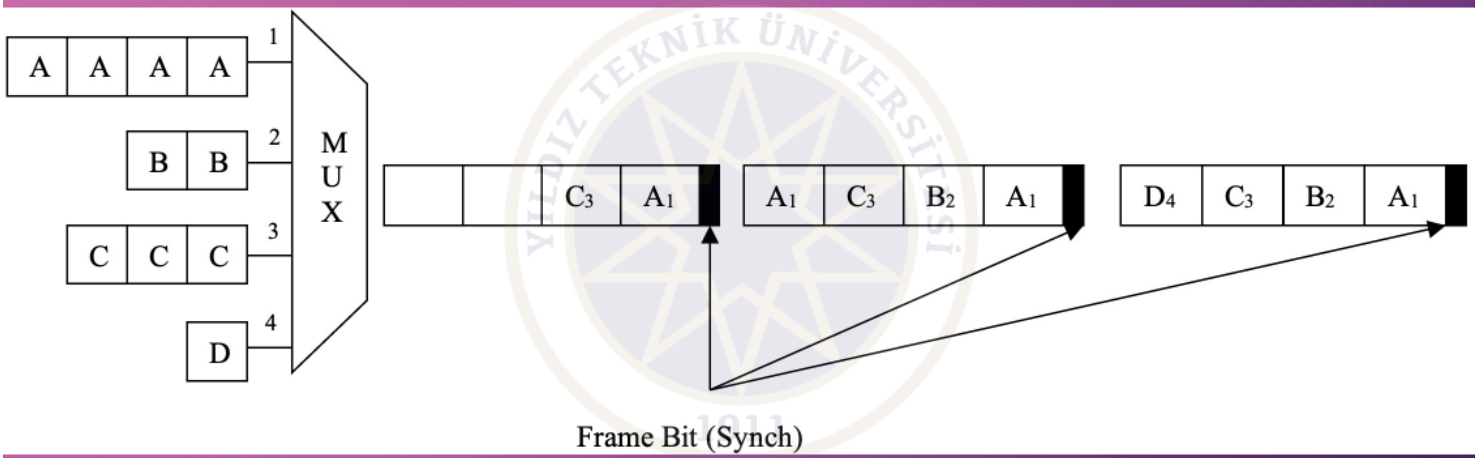

Error Detection and Correction Techniques

- Data Link Layer (in OSI model)
- Error reasons
  - Attenuation
  - Delay Distortion
    - Video + Voice
    - Problem in time sensitive conditions
  - Noise in the communication environment
    - Thermal noise
      - Random electron motion
    - Intermodulation noise
    - CrossTalk
    - Impulse Noise

Error Types

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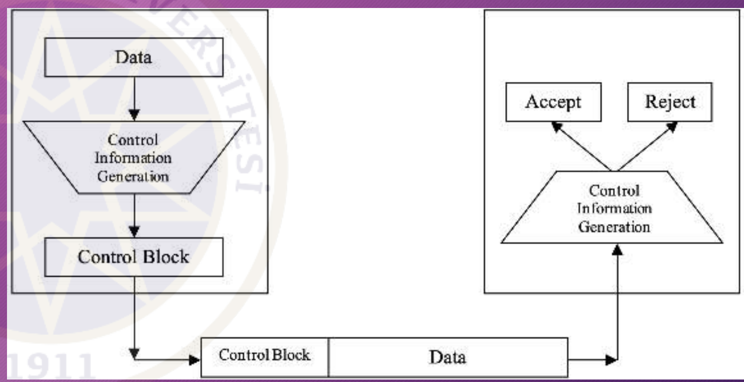
	Data Sent	Data Received
Single bit error	1 Ø Ø Ø Ø 1 1 1	1 Ø 1 Ø Ø 1 1 1
Multi bit error	1 Ø Ø Ø Ø 1 1 1	1 Ø 1 Ø Ø Ø 1 1
Error bursts	1 Ø Ø Ø Ø 1 1 1	1 Ø Ø 1 1 Ø Ø 1

Error Detection

- Both sides have original data?
- Sending data twice?
- Control block?
  - 4 different types
    - VRC (Vertical Redundency Code)
    - LRC (Longitudial Redundency Code)
    - CRC (Cyclic Redundency Check)
    - Checksum



VRC (Vertical Redundency Code)

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- Parity check
- Simple error coding technique
- The number of errors should be **odd**.
- XOR operation

Data Sent

VRC	Data						
1	Ø	1	Ø	Ø	1	1	Ø

Data Received 1

VRC	Data						
1	Ø	1	Ø	Ø	1	1	Ø

Data Received 2

VRC	Data						
1	Ø	1	1	Ø	1	1	Ø

Data Received 3

1	Ø	1	1	Ø	1	Ø	Ø

LRC (Longitudial Redundency Code)

- LRC is 2D-VRC

	Byte 1	Byte 2	Byte 3	Byte 4	LRC
	1	Ø	1	1	1
	Ø	Ø	1	1	Ø
	Ø	1	Ø	1	Ø
	1	1	Ø	1	1
	1	Ø	1	Ø	Ø
	Ø	1	1	Ø	Ø
	1	Ø	Ø	Ø	1
VRC	Ø	1	Ø	Ø	1

1ØØ11Ø1Ø	ØØ11Ø1Ø1	11ØØ11ØØ	1111ØØØØ	1ØØ1ØØ11

1ØØ11Ø1Ø	Ø*1*11Ø1*1*1	11ØØ11ØØ	1*Ø*11ØØ*1*Ø	1ØØ1ØØ11

CRC (Cyclic Redundency Check)

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- The data to be sent is divided into a predetermined prime polynomial.
- The remainder value is added to the data to be sent as an error control code.
- The remainder zero in receiver side means that error-free transmission.
- Common polynomials used for CRC: 13-bits, 17-bits, 33-bits
  - The number of undetectable errors is almost zero
- Commonly used polynomials in CRC technique:
  - CRC-12 $x^{12}+x^{11}+x^{3}+x+1$
  - CRC-16 $x^{16}+x^{15}+x^{2}+1$
  - CRC-ITU $x^{16}+x^{12}+x^{5}+1$
  - CRC-32 $x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^{8}+x^{7}+x^{5}+x^{4}+x^{2}+x+1$

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CRC (Cyclic Redundency Check) - Con’t

Example: Data Sent: 100100, polynom: $x^3 + x^2 + 1$, CRC = ?

Checksum

- The sender divides the data into N-bits parts (usually 16 bits are used).
- The parts are collected using the first complementary arithmetic.
  - In this way, a total value of only N bits is obtained.
- Calculate two's complement using summed value
  - The calculated value is added to the end of the information to be sent.
- The checksum detects all of the odd errors and most of the even numbers.
  - However, if one or more bits in a part are 0 when they are 1, but there is a 0 when 1 in another part, the error will not be understood because there will be no difference in this column sum.

Checksum - Con’t

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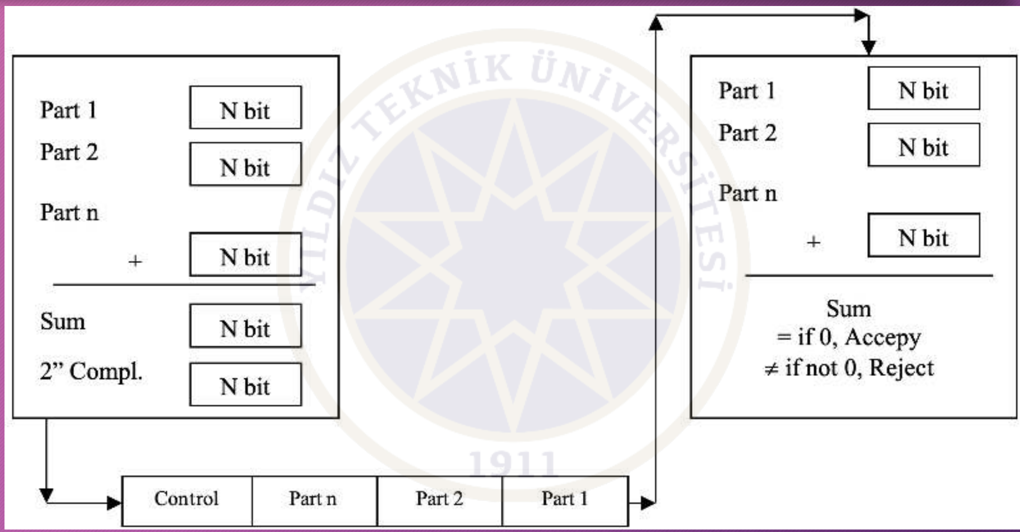

Error Correction

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- 2 methods
  - Send data again
  - If one bit error
    - Hamming Code / Distance

Hamming Code

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- If we sent m bit data, the error occurs in 1,2,…,m bit
- Adding error-free state, the data length will be m+1
- Control block length must be $log_2(m+1) \leq r$
- $m+r$ bit must be sent error-free
- So, control block length must be $log_2(m+r+1) \leq r$
- (1, 2, 4, 8, 16. bits)

B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
D_7	D_6	D_5	R_4	D_4	D_3	D_2	R_3	D_1	R_2	R_1

Hamming Code - Con't

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- $R_1=B_1 \oplus B_3 \oplus B_5 \oplus B_7 \oplus B_9 \oplus B_{11}$
- $R_2=B_2 \oplus B_3 \oplus B_6 \oplus B_7 \oplus B_{10} \oplus B_{11}$
- $R_3=B_4 \oplus B_5 \oplus B_6 \oplus B_7$
- $R_4=B_8 \oplus B_9 \oplus B_{10} \oplus B_{11}$

B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
1	0	0		1	1	0		1		

- $R_1=B_3 \oplus B_5 \oplus B_7 \oplus B_9 \oplus B_{11}$ = $1 \oplus 0 \oplus 1 \oplus 0 \oplus 1$ = 1
- $R_2=B_3 \oplus B_6 \oplus B_7 \oplus B_{10} \oplus B_{11}$ = $1 \oplus 1 \oplus 1 \oplus 0 \oplus 1$ = 0

	R_4	R_3	R_2	R_1	Info
0	0	0	0	0	Error-free
1	0	0	0	1	1. bit error
2	0	0	1	0	2. bit error
3	0	0	1	1	3. bit error
4	0	1	0	0	4. bit error
5	0	1	0	1	5. bit error
6	0	1	1	0	6. bit error
7	0	1	1	1	7. bit error
8	1	0	0	0	8. bit error
9	1	0	0	1	9. bit error
10	1	0	1	0	10. bit error
11	1	0	1	1	11. bit error

B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
D_7	D_6	D_5	R_4	D_4	D_3	D_2	R_3	D_1	R_2	R_1

Thank you for your listening.