

# Data Communication BLM3051



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## Lecture Information Form - Weekly Subjects

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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

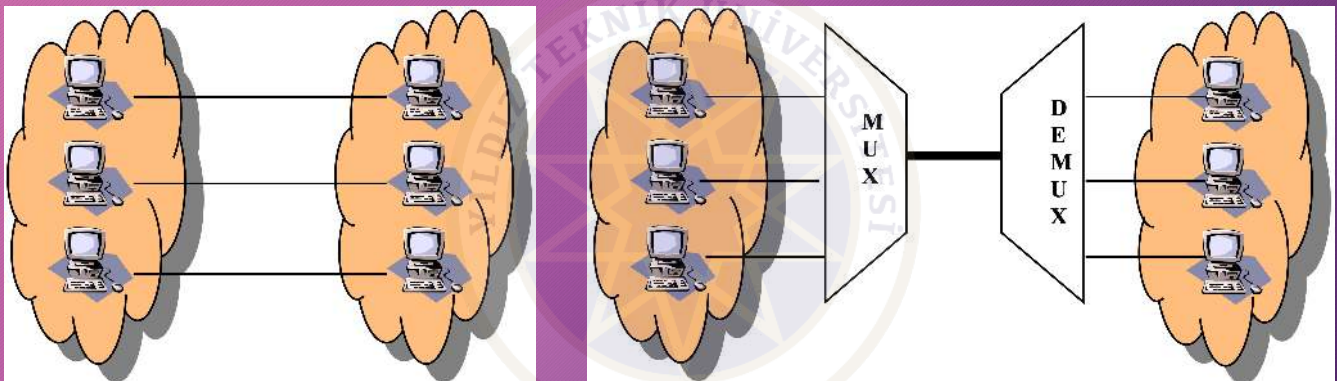
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# Multiplexing

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## Multiplexing Technics

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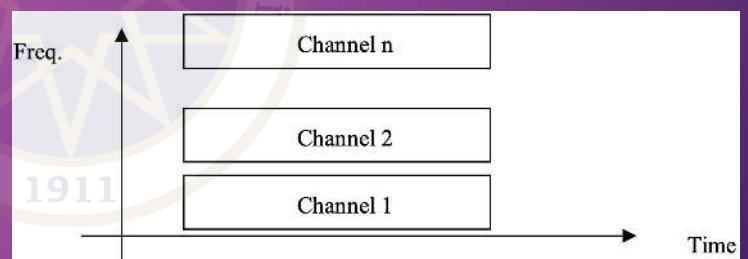
- *FDM (Frequency Division Multiplexing)*
- *WDM (Wavelength Division Multiplexing)*
- *TDM (Time Division Multiplexing)*

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# FDM (Frequency Division Multiplexing)

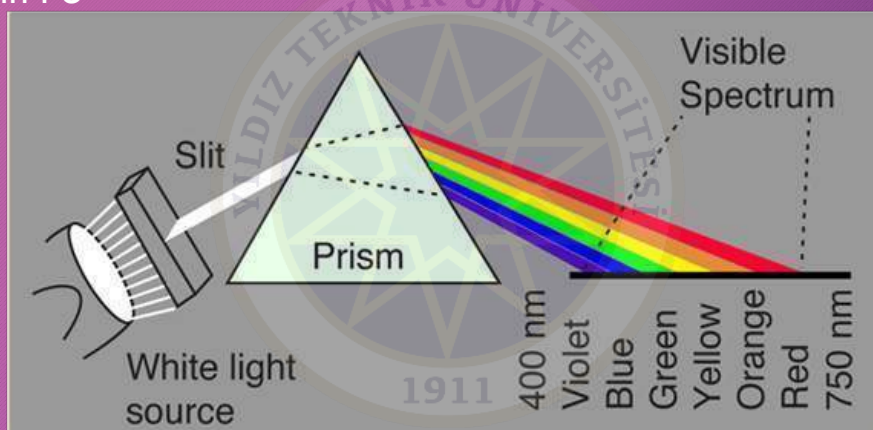
- $\sum(p2p\ BW) < total\ BW$
- Each signal has a different carriage signal
  - The signal to be sent is the sum of the carrier signals
  - Voice: 300-3300Hz BW
  - Guarded Band
- Television and radio broadcasts



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# WDM (Wavelength Division Multiplexing)

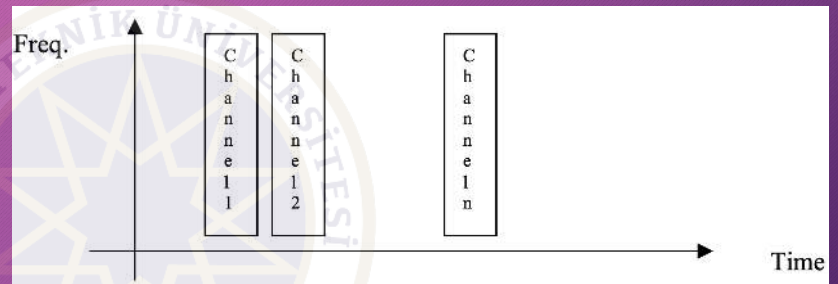
- Like FDM in FO



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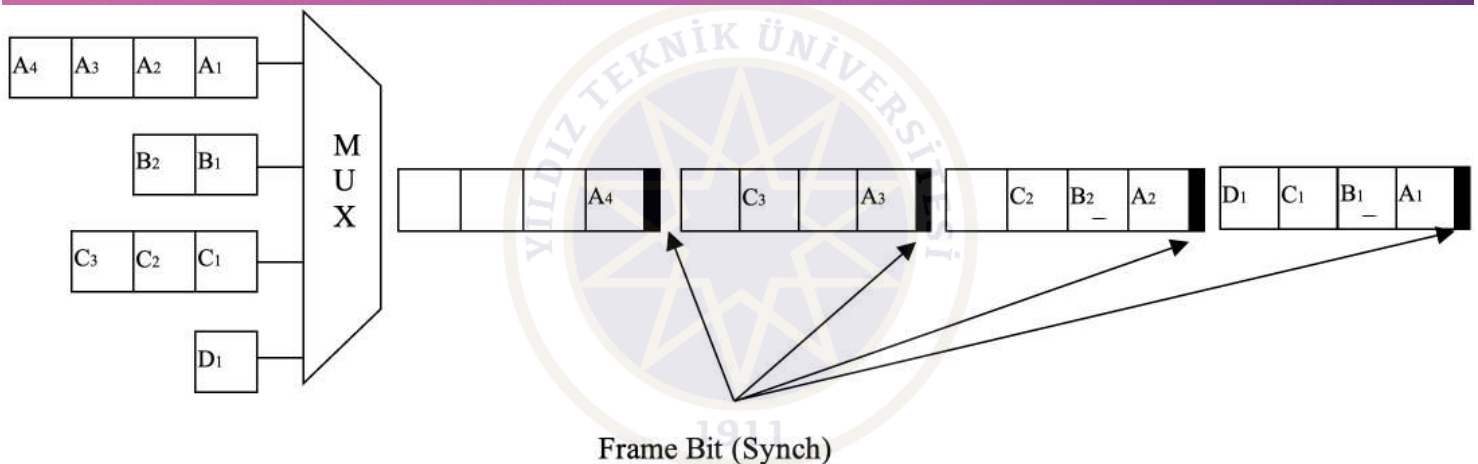
# TDM (Time Division Multiplexing)

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



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# Synchronous TDM



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## Synchronous TDM - Con't

- Example

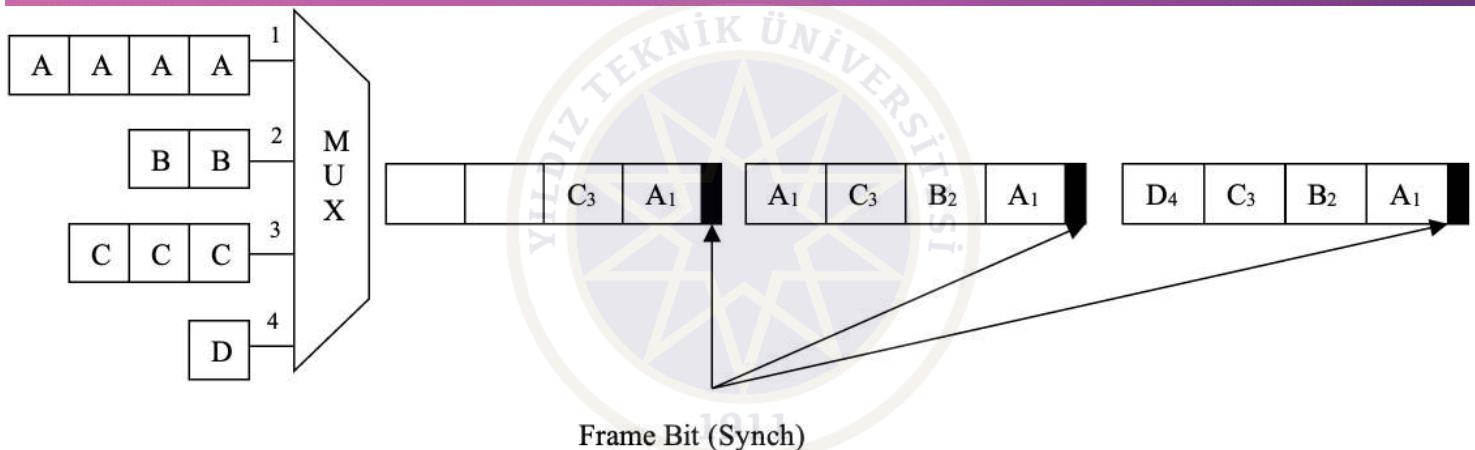
- In Sync. TDM where 4 units are connected, each unit produces 250 characters / sec output.
- 1 bit is used for each frame to ensure synchronization.
- Each frame contains a character from each unit.
- Accordingly, calculate the obtained data communication speed as bps.

- Answer:

- 250 frame + 250 bit (for sync.)
- $250 \text{ frame} \times (4 \text{ unit} \times 8 \text{ bits/unit}) / \text{frame} + 250 \text{ bit} = 8250 \text{ bps}$

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## 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

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## Error Types

- Single bit error
- Multi bit error
- Error bursts

Data Sent

1	0	0	0	0	1	1	1
---	---	---	---	---	---	---	---

1	0	0	0	0	1	1	1
---	---	---	---	---	---	---	---

1	0	0	0	0	1	1	1
---	---	---	---	---	---	---	---

Data Received

1	0	1	0	0	1	1	1
---	---	---	---	---	---	---	---

1	0	1	0	0	0	1	1
---	---	---	---	---	---	---	---

1	0	0	1	1	0	0	1
---	---	---	---	---	---	---	---

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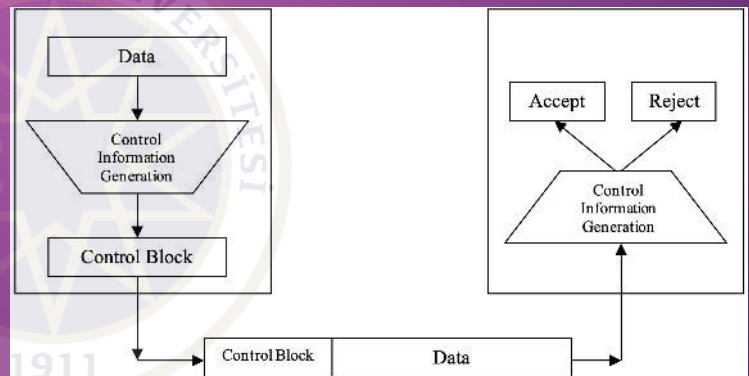


# Error Detection

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



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## VRC (Vertical Redundancy 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	0	1	0	0	1	1	0

Data Received 1

VRC	Data						
1	0	1	0	0	1	1	0

Data Received 2

VRC	Data						
1	0	1	1	0	1	1	0

Data Received 3

VRC	Data						
1	0	1	1	0	1	0	0

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# LRC (Longitudinal Redundancy Code)

- LRC is 2D-VRC

	Byte 1	Byte 2	Byte 3	Byte 4	LRC
	1	0	1	1	1
	0	0	1	1	0
	0	1	0	1	0
	1	1	0	1	1
	1	0	1	0	0
	0	1	1	0	0
	1	0	0	0	1
VRC	0	1	0	0	1

10011010	00110101	11001100	11110000	10010011
10011010	011011	11001100	10110010	10010011

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# CRC (Cyclic Redundancy Check)

- 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 Redundancy Check) - Con't

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



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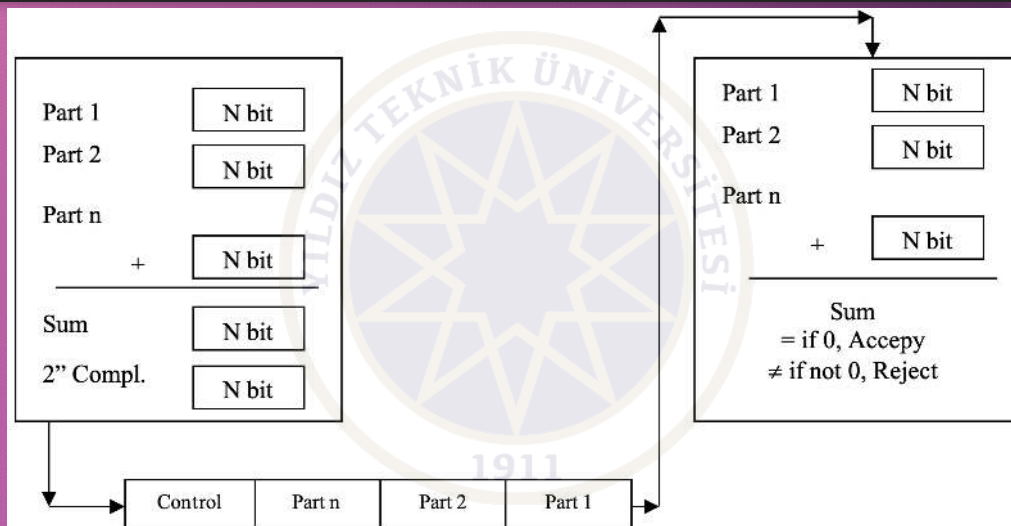
## Checksum

- 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.

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## Checksum - Con't



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## Error Correction

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

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# Hamming Code

- If we sent  $m$  bit data, the error occurs in  $1, 2, \dots, m$  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)

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

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# Hamming Code - Con't

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

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

- $R_1 = B_3 \oplus B_5 \oplus B_7 \oplus B_9 \oplus B_{11} = 1 \oplus 0 \oplus 1 \oplus 0 \oplus 1 = 1$
- $R_2 = B_3 \oplus B_6 \oplus B_7 \oplus B_{10} \oplus B_{11} = 1 \oplus 1 \oplus 1 \oplus 0 \oplus 1 = 0$
- $R_3 = B_4 \oplus B_5 \oplus B_6 \oplus B_7 = 0 \oplus 1 \oplus 1 \oplus 1 = 1$
- $R_4 = B_8 \oplus B_9 \oplus B_{10} \oplus B_{11} = 0 \oplus 0 \oplus 1 \oplus 1 = 0$

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

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	$R_4$	$R_3$	$R_2$	$R_1$	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



Thank you for your listening.

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