Data Communication and Computer Network BLM3051



Dr. Öğr. Üyesi Furkan ÇAKMAK

Lecture Information Form - Weekly Subjects

Hafta	Tarih	Konular							
1	20.02.2024	Introduction to Data Communication Standards Used on Data Communication, Architectural models							
2	27.02.2024	OSI Reference Model , Layers and Their Functions, Signaling and Signal Encoding							
3	05.03.2024	Parallel and Serial Transmission, Communication Media and Their Technical Specs., Multiplexing (TDM, FDM)							
4	12.03.2024	Error Detection and Error Correction Techniques, Data Link Control Techniques, Flow Control							
5	19.03.2024	Asynchronous and Synchronous Data Link Protocols (BSC, HDLC)							
6	26.03.2024	LAN Technologies Continued, IEEE 802.4, 802.5, 802.11							
7	02.04.2024	Connectionless and Connection Oriented Services, Switching							
8	09.04.2024	Tatil - Ramazan Bayramı Arifesi							
9	16.04.2024	1. Ara Sınav							
10	23.04.2024	Tatil - 23 Nisan Ulusal Egemenlik ve Çocuk Bayramı							
11	30.04.2024	Static and Dynamic Routing, Congestion in the Network Layer, Its Causes and Solutions							
12	07.05.2024	IP (Internetworking Protocol), ICMP, BOOTP, DHCP							
13	14.05.2024	2. Ara Sınav 1911							
14	21.05.2024	UDP (User Datagram Protocol), TCP (Transmisson Control Protocol)							

DTE-DCE Interfaces

- DCE (Data Circuit-Terminating Equipment)
 - Modem
- DTE (Data Terminal Equipment)
 - Computer
 - Printer
 - Fax
 - etc.



DTE-DCE Interfaces - Con't

- Standards between DTE and DCE
 - EIA
 - EIA-232
 - EIA-442
 - EIA-449
 - ITU-T
 - V.24
 - V.32
 - V.32bis
 - V.34
 - X.2
 - X.24



BLM3051
Data
Communication
and Computer
Network - 4

- Wire
- Light
- Radio Wave
- Guided and Unguided media

Life Cost

Wiring

Local Area Network Technology

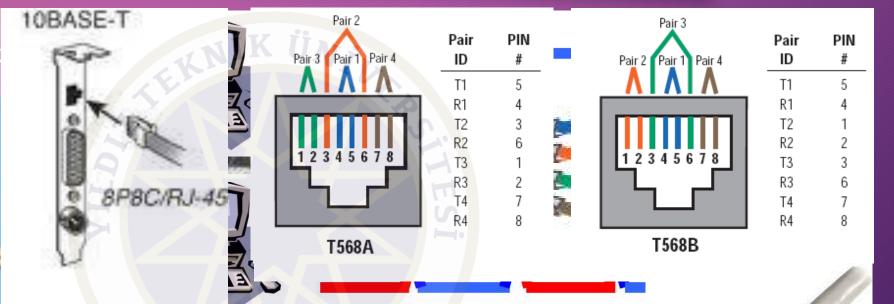
Computer Technology

Yazılım Software

1911

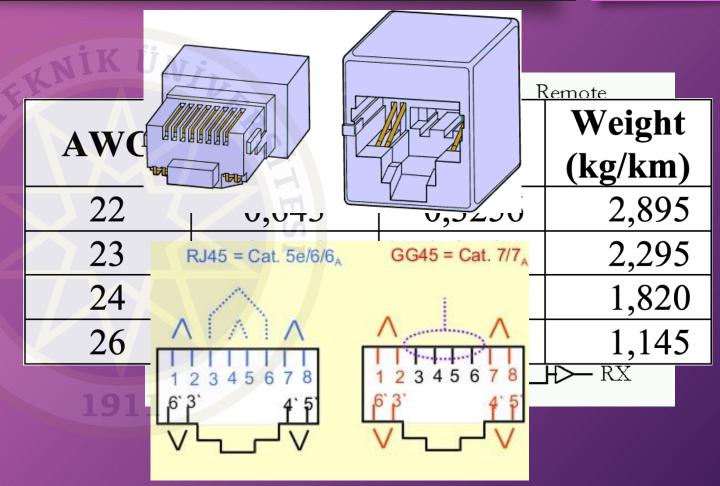
Guided Media

- Coaxial Cable
 - AUI (Attachement
 - Ethernet
 - Thick: 10mm
 - Thin: 5mm
- Twisted pair
 - DGM (Data Grade
 - CATs
 - 2-12 twist/step
 - Different Colors
 - There are 3 differ
 - UTP (Unshielde
 - 100m = 90m + rom
 - ScTP/FTP (Screened Twisted Pair/Foiled Twisted Pair)
 - STP (Shielded Twisted Pair)



Guided Media - Con't

- UTP cables category criterias:
 - Signal Frequency
 - Wire lenght
 - Correct connections
 - Attenuation
 - NEXT (Near-End Crosstalk)
 - PSNEXT (Power Sum NEXT)
 - FEXT (Far-End Crosstalk)
 - ELFEXT (Equal Level FEXT)
 - PSELFEXT (Power Sum ELFEXT)
- CAT 5e
 - gigabit Ethernet
 - 4 pieces of 2
 - Propagation delay
 - Skew
 - Fastest Slowest



BLM3051 Data Communication and Computer Network - 4

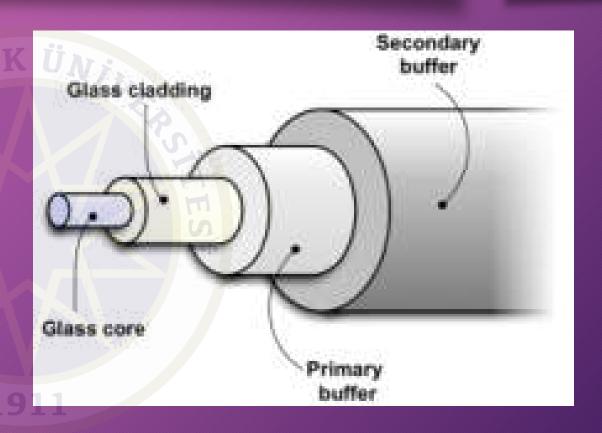
Classification of UTP Cables

Туре	Usage Purpose	Freq. (MHz)	Connector Type ⁷⁴	Usage Area
Cat-1	Voice		6P2C / RJ-11	Voice / Phone
Cat-2	Voice - Data	4	8P8C / RJ-45	Voice / 4Mbps TokenRing / Terminal
Cat-3	Voice - Data	16	8P8C / RJ-45	Voice / 10Base-T / 25Mbps ATM
Cat-4	Data	20	8P8C / RJ-45	10Base-T / TokenRing
Cat-5	Data	100	8P8C / RJ-45	10Base-T / 100Base-T / ATM / CDDI
Cat-5e	Data	> 100	8P8C / RJ-45	100Base-T / 1000Base-T
Cat-6	Data	250	8P8C / RJ-45	1000Base-T / 10GBase-T@55m
Cat-6a ⁷⁵	Data	> 500	8P8C / RJ-45	10GBase-T
Cat-7	Data	600	8P8C / GG- 45 ⁷⁶	10GBase-T
Cat-7a	Data	1000	8P8C / GG-45	40Gbps@50m / 100Gbps@15m
Cat-8	Data	> 1.200	Double Connectivity	> 40 Gbps@30-50m

Dr. Öğr. Üyesi Furkan ÇAKMAK

Guided Media - Fiber Optic Cabels

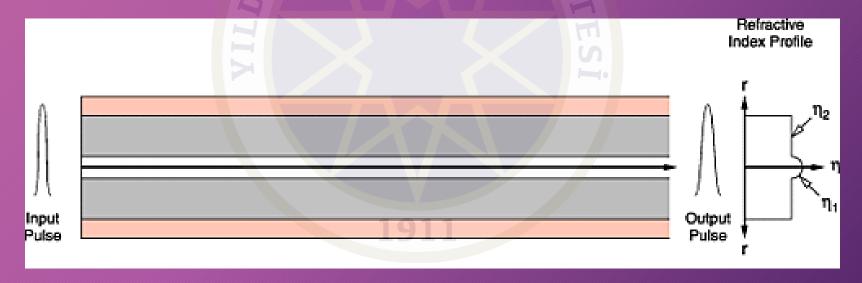
- Coaxial Cables
- Twisted Pair Cables
- Fiber Optic Cables
 - 300.000 km/sec
 - >= 100 Gbps (reached 500 Gpbs)
 - Core
 - Cladding
 - Primary buffer
 - Secondary buffer
 - Armor
 - Plastic Shield
- SMF (Single Mode Fiber)
- MMF (Multi Mode Fiber)



BLM3051 Data Communication and Computer Network - 4

Guided Media - Fiber Optic Cabels - Con't

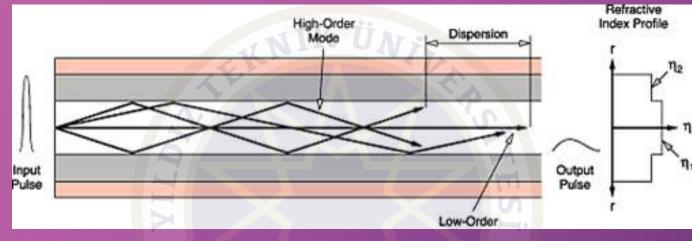
- Single Mode Fiber (SMF)
 - Core: 9 μm
 - Light wavelength: 1.3 1.5 μm
 - 1.3 μ m \approx 9 μ m \rightarrow Transmission is carried out as a single, unbreakable beam



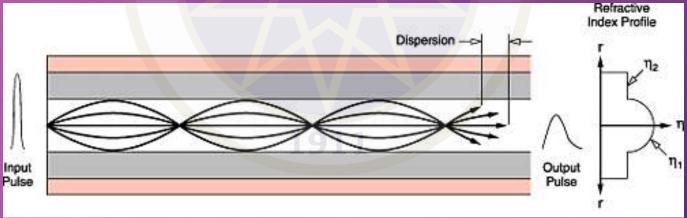
Guided Media - Fiber Optic Cabels - Con't

BLM3051
Data
Communication
and Computer
Network - 4

Step Index



Grade Index

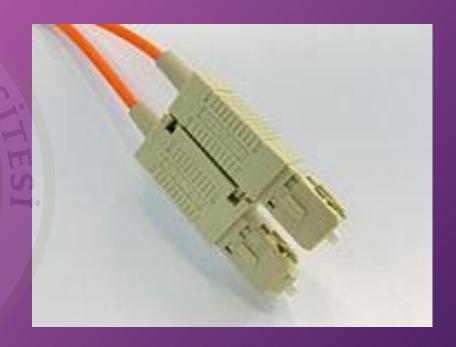


Dr. Öğr. Üyesi Furkan ÇAKMAK

Guided Media - Fiber Optic Cabels - Con't







Guided Media - Fiber Optic Cabels - Con't

- Light sources used in fiber optic media:
 - LED (Light Emitting Diode)
 - Nonfocusable
 - ILD (Injection Laser Diode)
 - Focusable
 - Receiver side: fotodiod (Photosensitive cell)
 - It is a circuit element that can generate electrical signals depending on the strength of the light falling on it.

Advantages of Fiber Optic Cables over Copper Cables

- Broad Bandwidth
- Immunity to Electromagnetic Interference
- Attenuation
- Insulation
- Space Saving
- Security
 - Eavesdrop

Things to Consider When using Fiber Optic Cables

BLM3051 Data Communication and Computer Network - 4

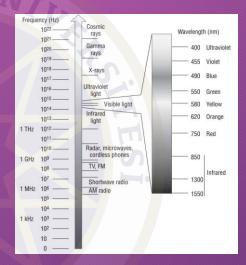
- The core parts of the fibers used at both ends must overlap exactly.
 - Attention should be paid to dirt, oil, dust and scratches.
 - Dirt, dust, etc. should be cleaned with air gun or alcohol.
 - Scratches should be polished and rounded.
- Fiber cables are fragile like glass and must be kept gently bent.
- When not in use, fiber cables should be stored with special headers to protect them from dust and scratches.
- The laser beam at the end of the fiber optic cable is dangerous to the eyes.

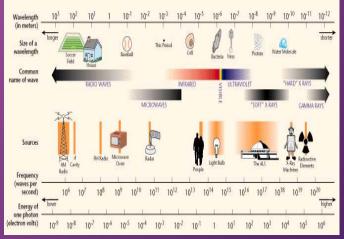
1911

Unguided Media

BLM3051 Data Communication and Computer Network - 4

- Technologies that aim to use the atmosphere:
 - RF (Radio Frequency)
 - Microwave
 - IR (Infra Red)
- Ionosphere
 - Ground propagation < 2 MHz
 - Sky propagation 2-30 MHz
 - Line of sight propagation > 30 MHz





1911

Unguided Media - Radio Frequency

- 3 kHz 1 GHz
- Television ve Radio
- Omnidirectonal
- Antennas do not need to be aligned
- RF can go through the Wall.
- Obtain approval from authorities to use RF.
- Non-approval RF types:
 - Bluetooth, IEEE 802.11, etc.

Unguided Media - Microwaves

- 1-300 GHz
- Satellite Ground Station
- Parabolic and horn antennas
 - Unidirectional
 - LOS Line Of Sight
- Microwaves can not go through the Wall
- It can be harmful to the living creature between the transceiver, depending on the signal strength used.

Unguided Media - Infra Red

- 300GHz-400THz
- Point-to-point
 - Device's remotes
- Infra Red can not go through the Wall
- Tapping-eavesdropping
- Jamming Immune
- 75 kbps in max. 8m distance
 - Top: 4 Mbps

BLM3051 Data Communication and Computer Network - 4

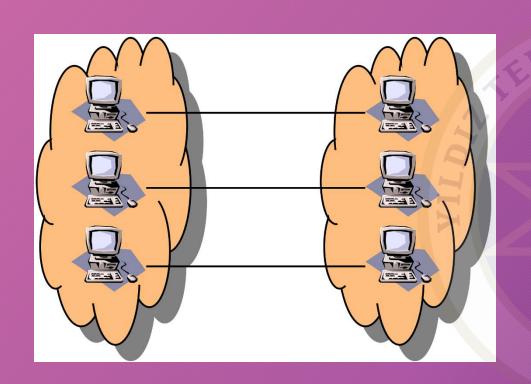
Comparison of Transmission Medium

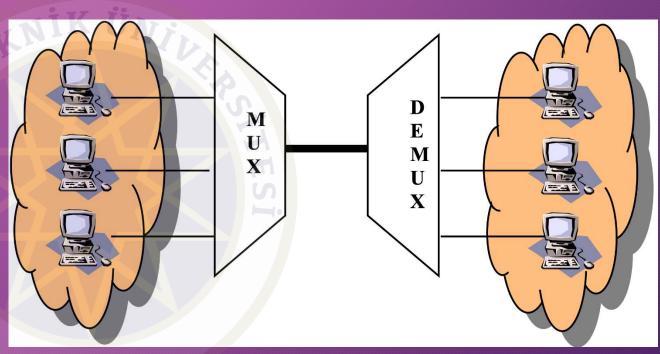
Ortam Özellik	UTP	STP	Coax	FO	RF	IR	Mikro Dalga	Uydu	Hücresel
Fiyat (\$/m)	Düşük	Orta	Orta	Yüksek	Orta	Düşük (Yüksek)	Yüksek	Yüksek	Yüksek
Hız	1 Mbps- 1 Gbps	1 Mbps- 150 Mbps	1 Mbps- 1 Gbps	10 Mbps- 10 Gbps	1 Mbps- 10 Mbps	4 Mbps (Gbps)	1 Mbps- 10 Gbps	1 Mbps- 10 Gbps	9.6 kbps- 19.2 kbps
Sinyal Zayıflaması	Yüksek	Yüksek	Orta	Düşük	Düşük- Orta	Düşük- Orta	Değişken	Değişken	Düşük
EMI	Yüksek	Orta	Orta	Düşük	Yüksek	Yüksek	Yüksek	Yüksek	Orta
Güvenlik	Düşük	Düşük	Düşük	Yüksek	Düşük	Orta- Yüksek	Orta	Orta	Düşük
Düğüm Ekleme	Kolay	Kolay	Kolay	Zor	Kolay	Kolay	Kolay	Kolay	Kolay
Mesafe	Kısa	Kısa	Orta	Uzun	Orta- Uzun	Kısa- Uzun	Uzun	Uzun	Uzun

Dr. Öğr. Üyesi Furkan ÇAKMAK

Multiplexing

BLM3051
Data
Communication
and Computer
Network - 4





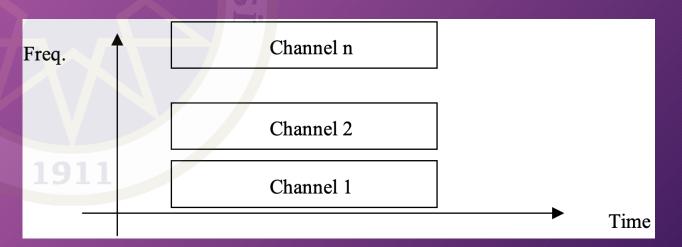
1911

Multiplexing Technics

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

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



WDM (Wavelength Division Multiplexing)

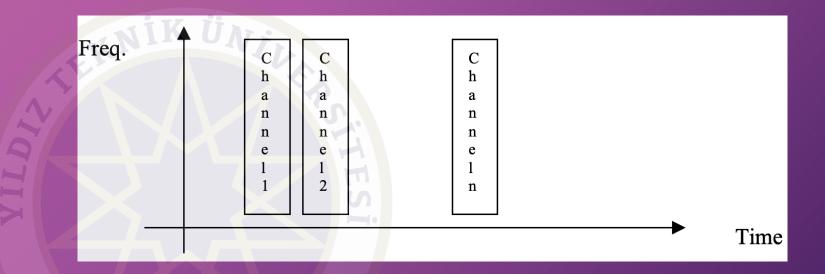
BLM3051 Data Communication and Computer Network - 4

• Like FDM in FO Visible Spectrum Slit Prism 400 nm Violet Blue Green Yellow Orange Red 750 nm White light source

TDM (Time Division Multiplexing)

BLM3051
Data
Communication
and Computer
Network - 4

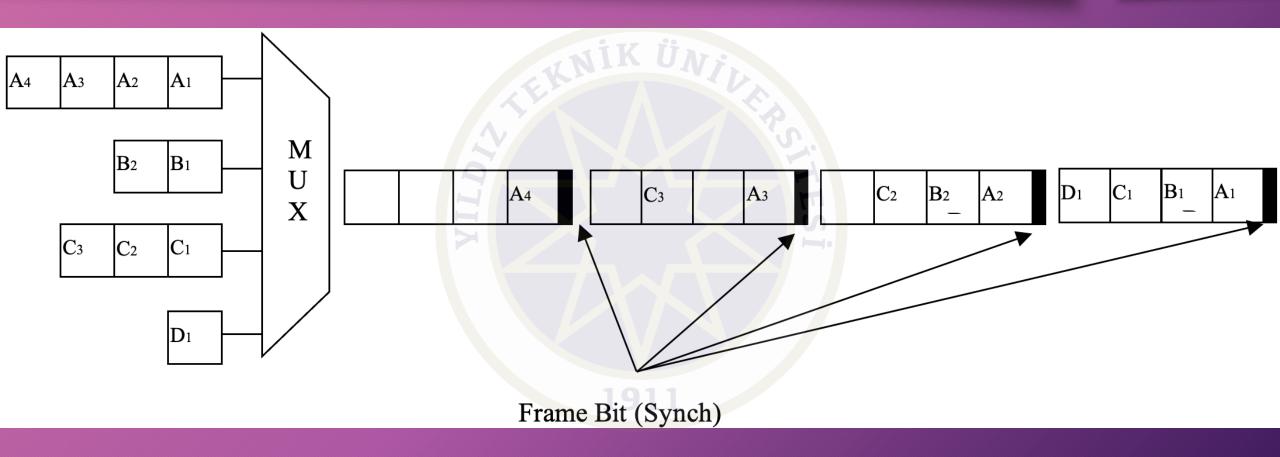
- $\max(p2p BW) < BW$
- 2 Types
 - Synchronous TDM
 - Data
 - Digitized Voice
 - Asynchronous TDM



1911

BLM3051 Data Communication and Computer Network - 4

Synchronous TDM



Synchronous TDM - Con't

BLM3051
Data
Communication
and Computer
Network - 4

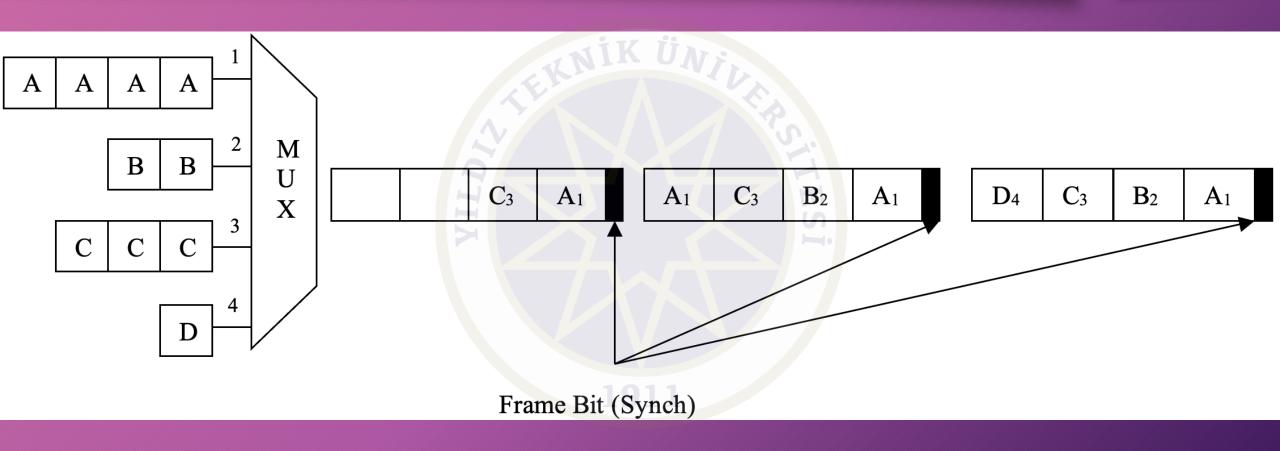
Example

- 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



Error Detection and Correction Techniques

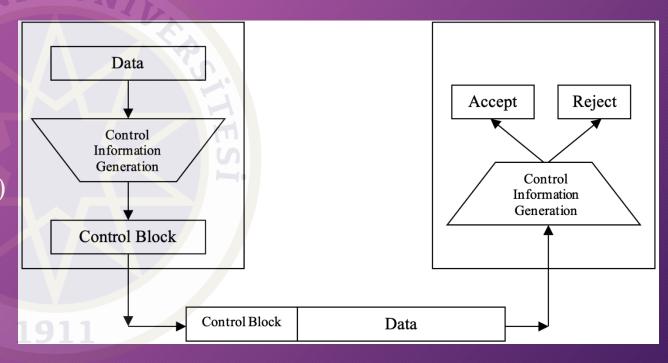
- Data Link Layer (in OSI model)
- Error reasons
 - Attenuation
 - Delay Distortion
 - Video + Voice
 - Problem in time sensitive conditions
 - Noise in the communication environment
 - Thermal noise
 - Random electron motion
 - Intermodulation noise
 - CrossTalk
 - Impulse Noise

Error Types

- Single bit error
- Multi bit error
- Error bursts

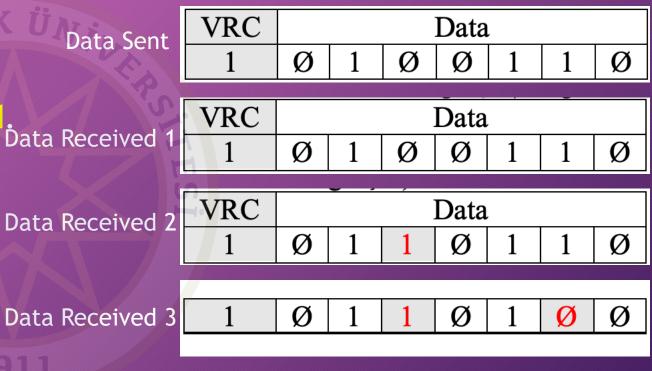


- Both sides have original data?
- Sending data twice?
- Control block?
 - 4 different types
 - VRC (Vertical Redundency Code)
 - LRC (Longitudial Redundency Code)
 - CRC (Cyclic Redundency Check)
 - Checksum



VRC (Vertical Redundency Code)

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

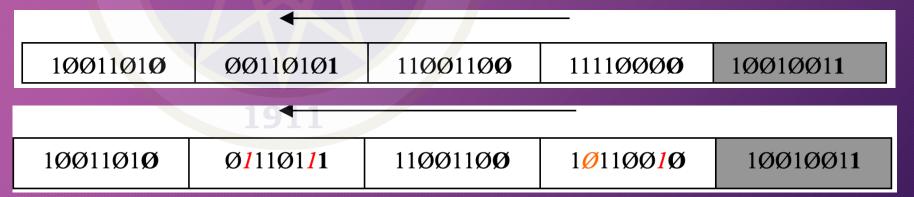


LRC (Longitudial Redundency Code)

BLM3051 Data Communication and Computer Network - 4

• LRC is 2D-VRC

	Byte 1	TIK	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	2	Ø	Ø	1
VRC	Ø		1		Ø	Ø	1



- 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
```

CRC (Cyclic Redundency Check) - Con't

BLM3051 Data Communication and Computer Network - 4

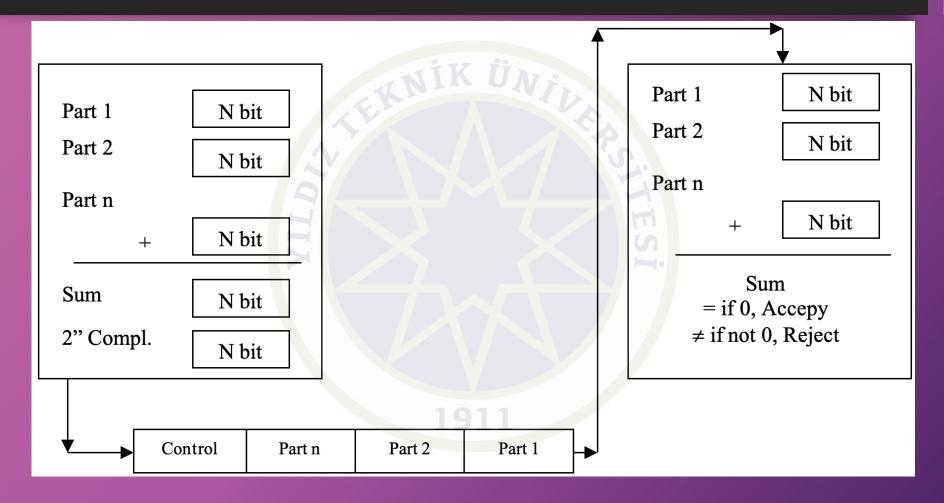
Example: Data Sent: 100100, polynom: $x^3 + x^2 + 1$, CRC = ?



- 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.

1911

Checksum - Con't



Error Correction

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

Hamming Code

- 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 $log_2(m+1) \le r$
- m + r bit must be sent error-free
- So, control block length must be $log_2(m+r+1) \le r$
- (1, 2, 4, 8, 16. bits)

\mathbf{B}_{11}	\mathbf{B}_{10}	\mathbf{B}_9	$\mathbf{B_8}$	\mathbf{B}_7	\mathbf{B}_{6}	\mathbf{B}_{5}	$\mathbf{B_4}$	\mathbf{B}_3	\mathbf{B}_2	\mathbf{B}_1
\mathbf{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

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

B ₁₁	\mathbf{B}_{10}	\mathbf{B}_{9}	$\mathbf{B_8}$	\mathbf{B}_7	$\mathbf{B_6}$	\mathbf{B}_{5}	$\mathbf{B_4}$	\mathbf{B}_3	\mathbf{B}_2	$\mathbf{B_1}$
1	0	0		1	1	0		1		

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

\mathbf{B}_{11}	\mathbf{B}_{10}	\mathbf{B}_{9}	$\mathbf{B_8}$	\mathbf{B}_7	\mathbf{B}_{6}	\mathbf{B}_{5}	$\mathbf{B_4}$	\mathbf{B}_3	$\mathbf{B_2}$	\mathbf{B}_1
D_7	D_6	D_5	R ₄	D_4	D_3	D_2	R_3	D_1	R_2	R_1

	\mathbf{R}_4	\mathbb{R}_3	\mathbf{R}_{2}	\mathbf{R}_{1}	Info
0	0	0	0	0	Error-free
1	0	0	0		1. bit error
2	0	0	1	0	2. bit error
3	0	0	1		3. bit error
4	0		0	0	4. bit error
5	0		0		5. bit error
6	0		1	0	6. bit error
7	0		1		7. bit error
8	1	0	0	0	8. bit error
9	1	0	0		9. bit error
10	1	0	1	0	10. bit error
11	1	0	1		11. bit error

Thank you for your listening.

