

Error Detection and Correction Techniques

BLM3051
Data
Communication
Week 5

- 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

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- Single bit error
- Multi bit error
- Error bursts

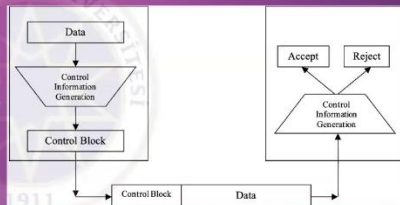
Data Sent	Data Received
1 0 0 0 0 1 1 1	1 0 1 0 0 1 1 1
1 0 0 0 0 1 1 1	1 0 1 0 0 0 1 1
1 0 0 0 0 1 1 1	1 0 0 1 1 0 0 1

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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	1	
Data Received 1	VRC	Data
1 0 1 0 0 1 1 0	1	
Data Received 2	VRC	Data
1 0 1 1 0 1 1 0	1	
Data Received 3	VRC	Data
1 0 1 1 0 1 0 0	1	

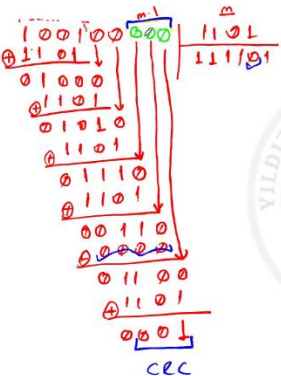
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- | | Byte 1 | Byte 2 | Byte 3 | Byte 4 | LRC |
|-----|--------|--------|--------|--------|-----|
| | 1 | 0 | 1 | | 1 |
| | 0 | 0 | 1 | 1 | 0 |
| | 0 | 1 | 0 | 1 | 0 |
| | 1 | 1 | 0 | 1 | 1 |
| | 1 | 0 | 1 | 0 | 0 |
| | 0 | 1 | 1 | 0 | 0 |
| | 1 | 0 | 0 | 0 | 1 |
| VRC | 0 | 1 | 0 | 0 | 1 |
- ←
- | | | | | |
|----------|----------|----------|----------|----------|
| 10011010 | 00110101 | 11001100 | 11110000 | 10010011 |
|----------|----------|----------|----------|----------|
- ←
- | | | | | |
|----------|----------|----------|----------|----------|
| 10011010 | 0/1101/1 | 11001100 | 101100/0 | 10010011 |
|----------|----------|----------|----------|----------|
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-

$$\overbrace{1101} \quad -$$


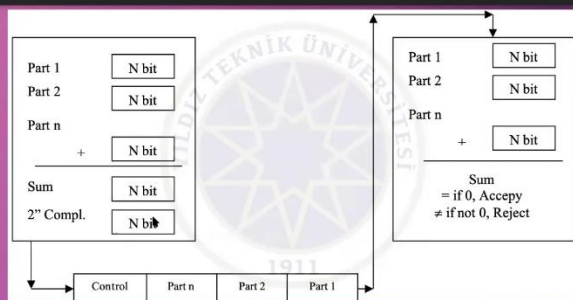
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Checksum - Con't

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Hamming Code

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- 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

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- So, control block length must be $\log_2(m+r+1) \leq r$
- (1, 2, 4, 8, 16, bits)

	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

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Hamming Code - Con't

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

	R ₄	R ₃	R ₂	R ₁	Info
0	0	0	0	0	Error-free
1	0	0	0	1	1. bit error
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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

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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		

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

	R ₄	R ₃	R ₂	R ₁	Info
0	0	0	0	0	Error-free
1	0	0	0	1	1. bit error
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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

Hamming Code

- If we sent m bit data, the error occurs in 1,2,...,m bit