CSE3151

COMPUTER NETWORKS

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April 05, 2018

DATA LINK LAYER

Data Link Layer: Types of errors, framing, error detection & correction methods; Flow control, Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, HDLC.

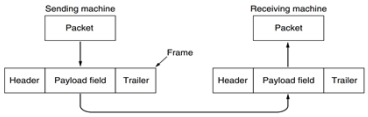


Figure 3-1. Relationship between packets and frames.

FLAG	Header	Payload field	Trailer	FLAG

DATA LINK LAYER

FLAG	Header	Payload field	Trailer	FLAG

- Error
  - error-correcting codes and
  - error-detecting code
- Popular error-correcting codes:
  1. Hamming codes.
  2. Binary convolutional codes.
  3. Reed-Solomon codes.
  4. Low-Density Parity Check codes.

DATA LINK LAYER

- **HAMMING CODE**
  - A frame consists of m data (i.e., message) bits and
  - r redundant (i.e. check) bits.

```
2^r > m + r + 1
where, r = redundant bit, m = data bit
```

Suppose the number of data bits is 7, then the number of redundant bits can be calculated using:
= 2^4 > 7 + 4 + 1
Thus, the number of redundant bits= 4

HAMMING CODE

- **PARITY BITS –**
  - A parity bit is a bit appended to a data of binary bits to ensure that the total number of 1's in the data are even or odd. Parity bits are used for error detection.
  - There are two types of parity bits:
    - Odd parity
    - Even Parity

HAMMING CODE

1 0 1 1 0 0 1

1. The number of data bits = 7
2. The number of redundant bits = 4
3. The total number of bits = 11

11	10	9	8	7	6	5	4	3	2	1

Position of parity bits/ redundant data 2^n

- $2^0 = 1$
- $2^1 = 2$
- $2^2 = 4$
- $2^3 = 8$

11	10	9	8	7	6	5	4	3	2	1

D11	D10	D9	R8	D7	D6	D5	R4	D3	R2	R1
1	0	1	R8	1	0	0	R4	1	R2	R1

11	10	9	8	7	6	5	4	3	2	1
1	0	1	R8	1	0	0	R4	1	R2	R1
D11	D10	D9	R8	D7	D6	D5	R4	D3	R2	R1

01 = 0001
02 = 0010
03 = 0011
04 = 0100
05 = 0101
06 = 0110
07 = 0111
08 = 1000
09 = 1001
10 = 1010
11 = 1011

Hamming Code

1	0	1	R8	1	0	0	R4	1	R2	R1
D11	D10	D9	R8	D7	D6	D5	R4	D3	R2	R1

01 = 0001	01 = 0001	01 = 0001	01 = 0001	01 = 0001
02 = 0010	02 = 0010	02 = 0010	02 = 0010	02 = 0010
03 = 0011	03 = 0011	03 = 0011	03 = 0011	03 = 0011
04 = 0100	04 = 0100	04 = 0100	04 = 0100	04 = 0100
05 = 0101	05 = 0101	05 = 0101	05 = 0101	05 = 0101
06 = 0110	06 = 0110	06 = 0110	06 = 0110	06 = 0110
07 = 0111	07 = 0111	07 = 0111	07 = 0111	07 = 0111
08 = 1000	08 = 1000	08 = 1000	08 = 1000	08 = 1000
09 = 1001	09 = 1001	09 = 1001	09 = 1001	09 = 1001
10 = 1010	10 = 1010	10 = 1010	10 = 1010	10 = 1010
11 = 1011	11 = 1011	11 = 1011	11 = 1011	11 = 1011

Hamming Code

Even Parity: $R1 = 0$

1	0	1	R8	1	0	0	R4	1	R2	R1
1	0	1	R8	1	0	0	R4	1	R2	0
1	0	1	R8	1	0	0	R4	1	R2	0
1	0	1	R8	1	0	0	R4	1	1	0

$R2 = 1$

1	0	1	R8	1	0	0	R4	1	1	0
1	0	1	R8	1	0	0	1	1	1	0
1	0	1	R8	1	0	0	1	1	1	0
1	0	1	0	1	0	0	1	1	1	0

Sender

1	0	1	0	1	0	0	1	1	1	0	
1	0	1	0	1	1	0	1	1	1	0	
1	0	1	0	1	1	0	1	1	1	0	0
1	0	1	0	1	1	0	1	1	1	0	1
1	0	1	0	1	1	0	1	1	1	0	1
1	0	1	0	1	1	0	1	1	1	0	0

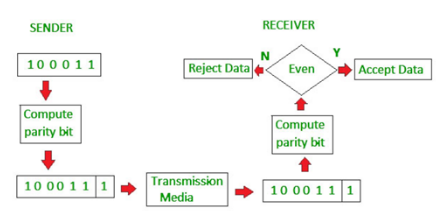
Error Detection

- Error Detection
  1. Parity.
  2. Checksums.
  3. Cyclic Redundancy Checks (CRCs).

1. Simple Parity check
2. Two-dimensional Parity check

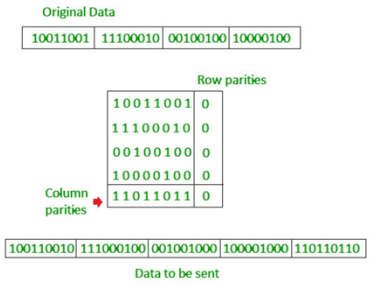
Error Detection

Simple Parity Check



Error Detection

Two Dimensional Parity Check



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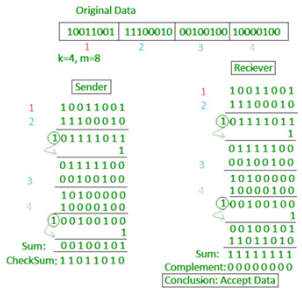
Error Detection

Checksum:



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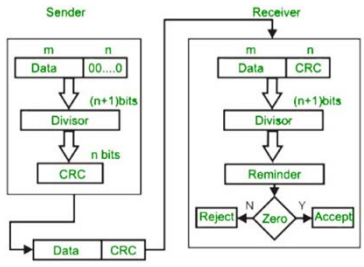
Error Detection

CRC:



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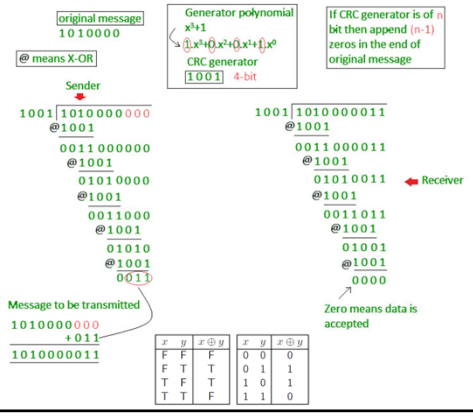

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