Error Handling

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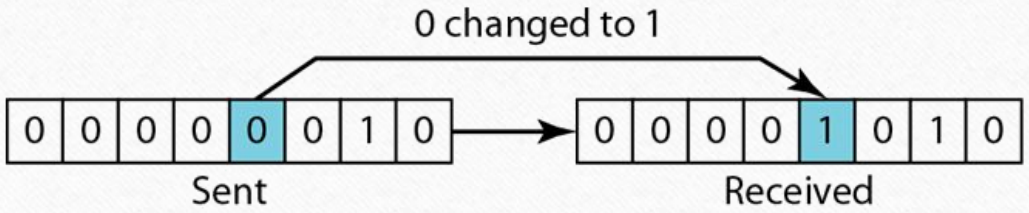
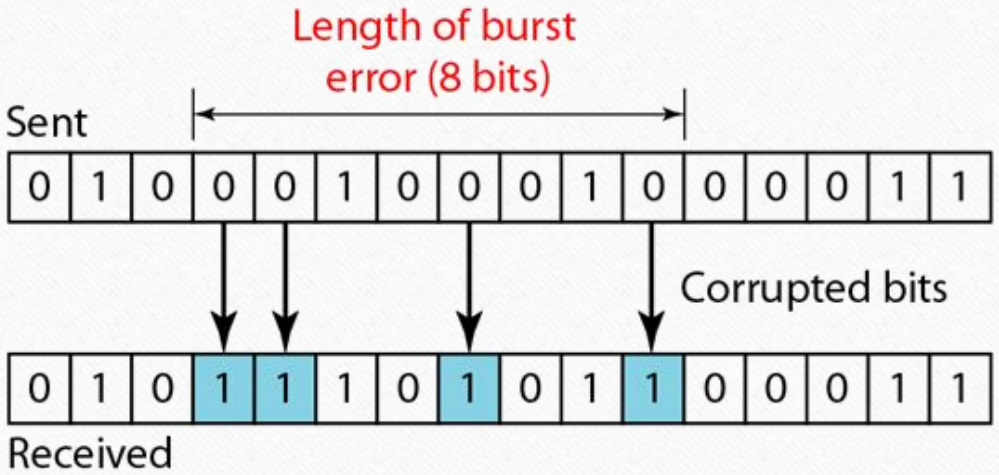
Error



Single-Bit Error: The term single-bit error means that only 1 bit of a given data unit (such as a byte, character, or packet) is changed from 1 to 0 or from 0 to 1.



Burst Error: The term burst error means that 2 or more bits in the data unit have changed from 1 to 0 or from 0 to 1.

Error Detection

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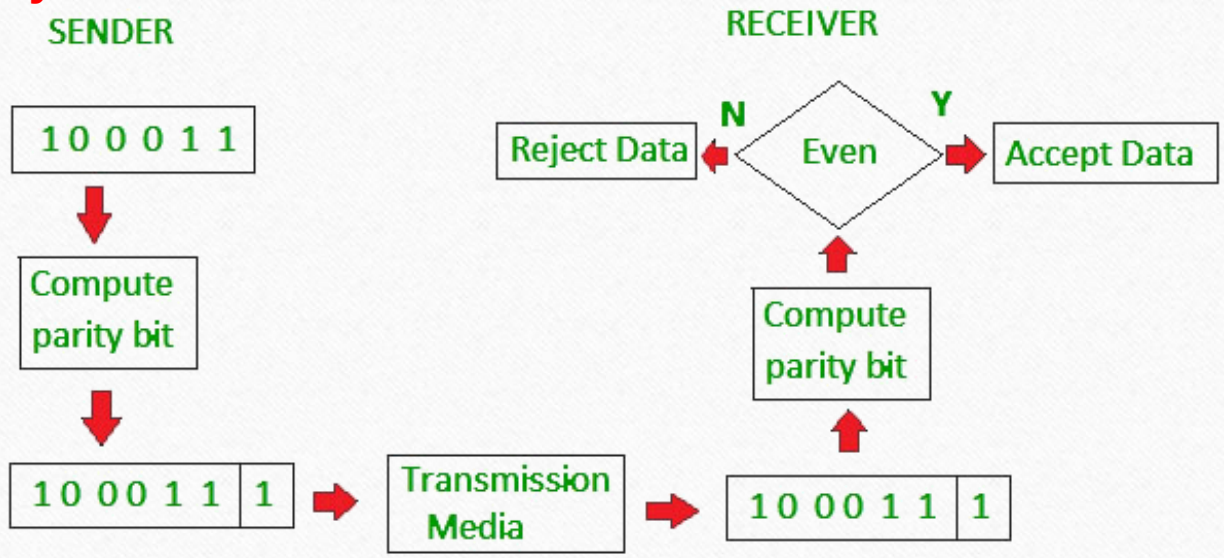
1. Parity Check
2. Checksum
3. Cyclic Redundancy Check (CRC).

Parity Check

The parity check is done by adding an extra bit, called parity bit to the data to make a number of 1s either even in case of even parity or odd in case of odd parity.



2D Parity Check

Original Data

10011001	11100010	00100100	10000100

Parity check bits are calculated for each row and column.

	Row parities
10011001	0
11100010	0
00100100	0
10000100	0
11011011	0

Column parities

100110010	111000100	001001000	100001000	110110110

Data to be sent

Checksum

Original Data

10011001	11100010	00100100	10000100
1	2	3	4

k=4, m=8

Sender

```
1      10011001
2      11100010
       ---------
      (1)01111011
           1
       ---------
       01111100
3      00100100
       ---------
       10100000
4      10000100
       ---------
      (1)00100100
           1
       ---------
Sum:   00100101
       ---------
CheckSum: 11011010
```

Reciever

```
1      10011001
2      11100010
       ---------
      (1)01111011
           1
       ---------
       01111100
3      00100100
       ---------
       10100000
4      10000100
       ---------
      (1)00100100
           1
       ---------
       00100101
       11011010
       ---------
Sum:   11111111
Complement: 00000000
```

Conclusion: Accept Data

CRC

original message
1 0 1 0 0 0 0

@ means X-OR

Generator polynomial
x^3+1
$1.x^3+0.x^2+0.x^1+1.x^0$
CRC generator
1 0 0 1 4-bit

If CRC generator is of n bit then append (n-1) zeros in the end of original message

Sender

```
1001 | 1010000000
     @1001
      0011000000
      @1001
       01010000
       @1001
        0011000
        @1001
         01010
         @1001
          0011
```

Message to be transmitted

```
1010000000
      +011
1010000011
```

```
1001 | 1010000011
     @1001
      0011000011
      @1001
       01010011   <- Receiver
       @1001
        0011011
        @1001
         01001
         @1001
          0000
```

Zero means data is accepted

Error Detection and Correction

Error correction techniques find out the exact number of bits that have been corrupted and as well as their locations.

Hamming Code

Hamming code is a set of error-correction codes that can be used to detect and correct the errors that can occur when the data is moved or stored from the sender to the receiver. It is technique developed by R.W. Hamming for error correction

$$2^r \geq m + r + 1$$

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

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Hamming Example

Position	R8	R4	R2	R1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1

Determining the position of redundant bits –

These redundancy bits are placed at the positions which correspond to the power of 2.

As in the above example:

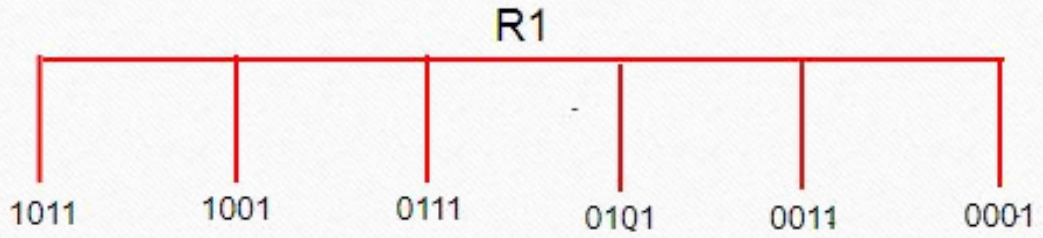
1. The number of data bits = 7
2. The number of redundant bits = 4
3. The total number of bits = 11
4. The redundant bits are placed at positions corresponding to power of 2- 1, 2, 4, and 8

Hamming Example

Suppose the data to be transmitted is 1011001, the bits will be placed as follows:

11	10	9	8	7	6	5	4	3	2	1
1	0	1	R8	1	0	0	R4	1	R2	R1

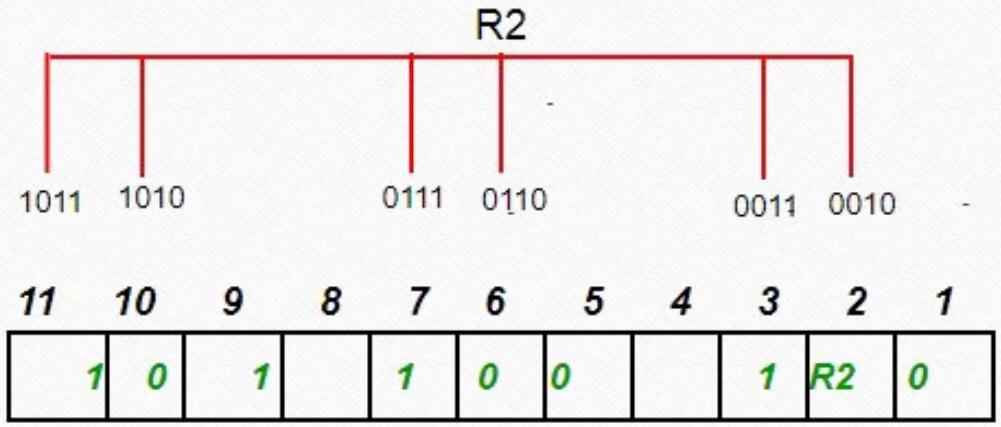
R1: bits 1, 3, 5, 7, 9, 11



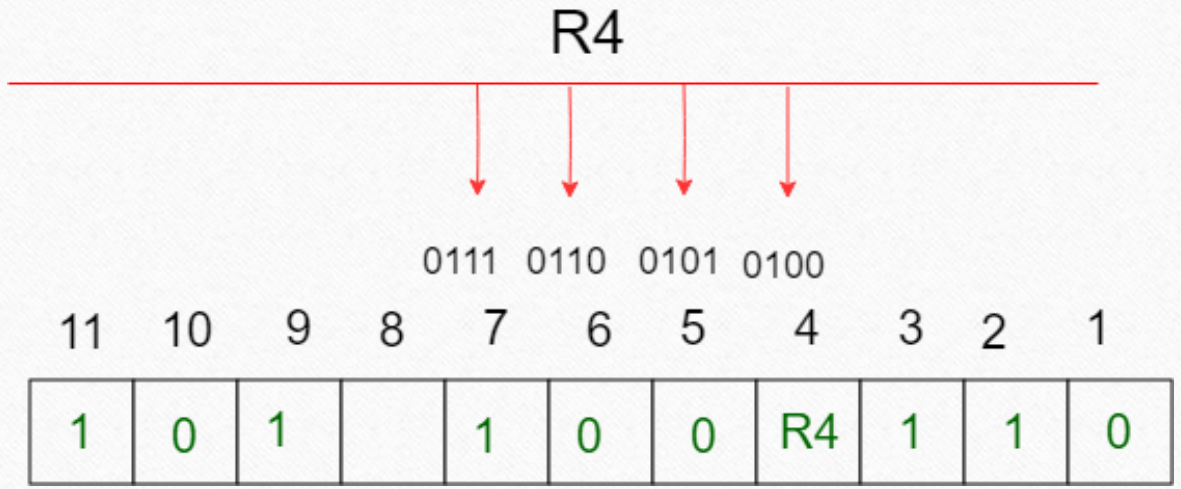
11	10	9	8	7	6	5	4	3	2	1
1	0	1		1	0	0		1		R1

Hamming Example

R2: bits 2,3,6,7,10,11

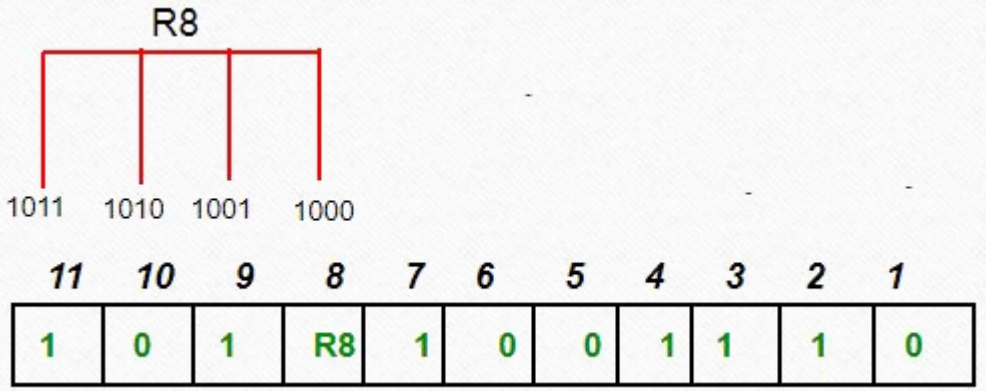


R4: bits 4, 5, 6, 7

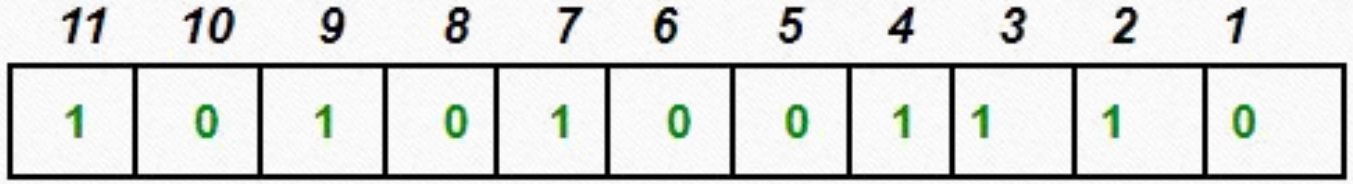


Hamming Example

R8: bit 8,9,10,11

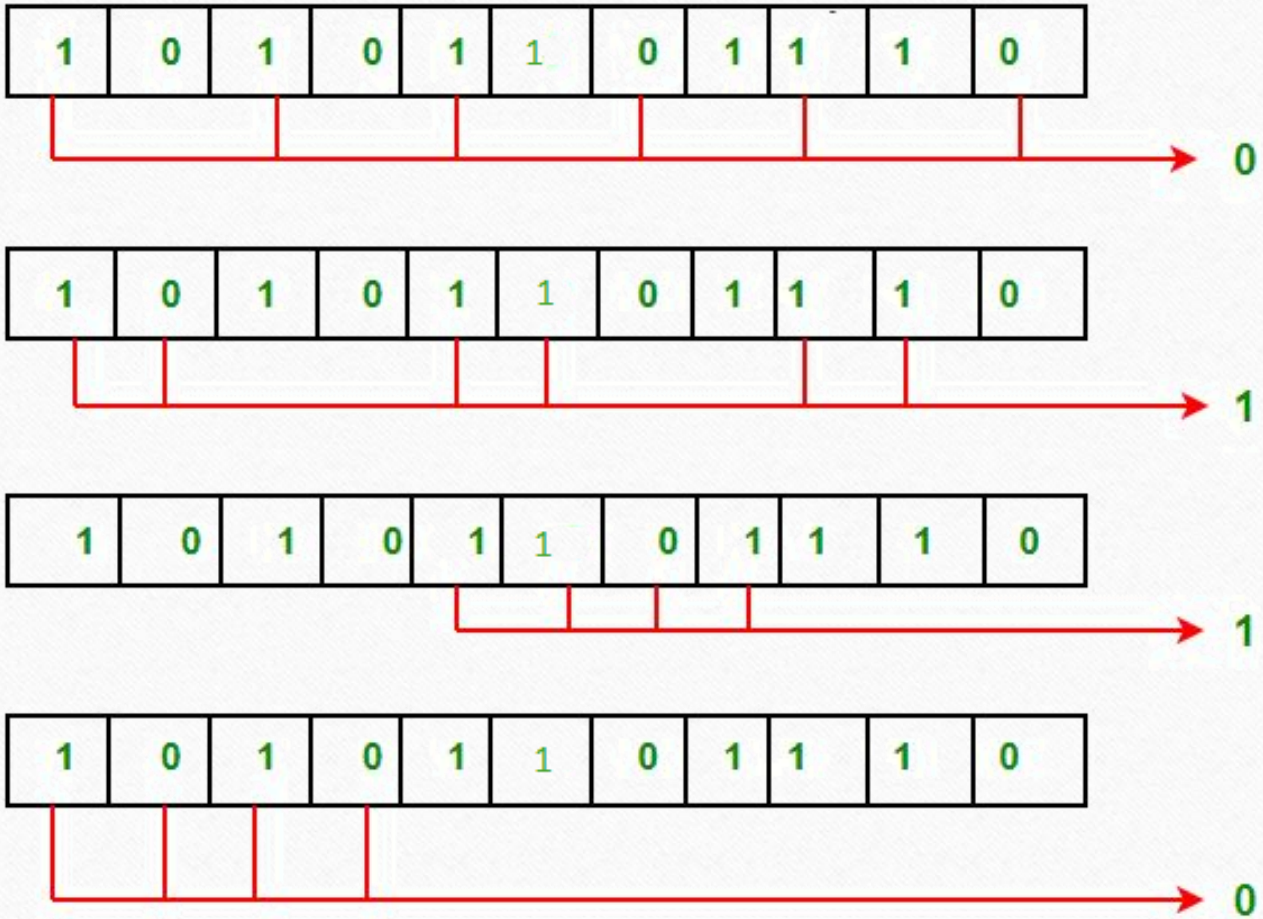


Thus, the data transferred is:



Hamming Example

Error detection and correction –



Thank You

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