ERROR DETECTION AND CORRECTION

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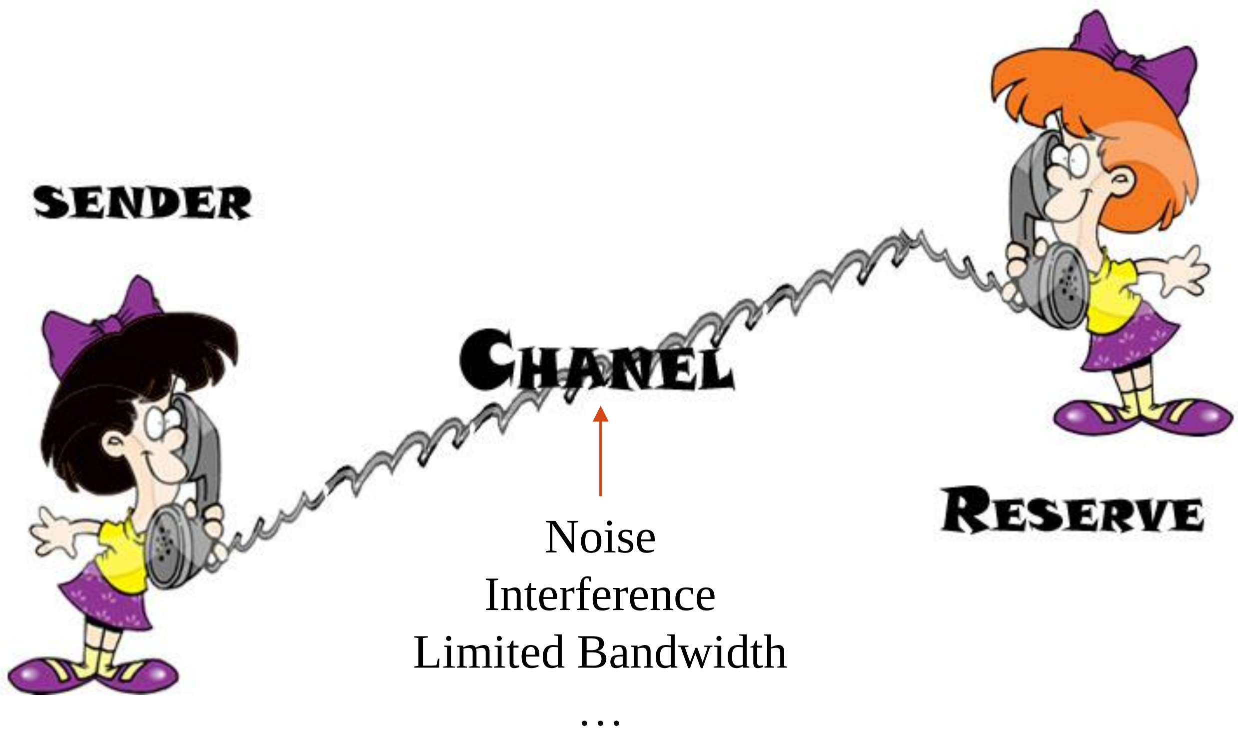
Basic concepts

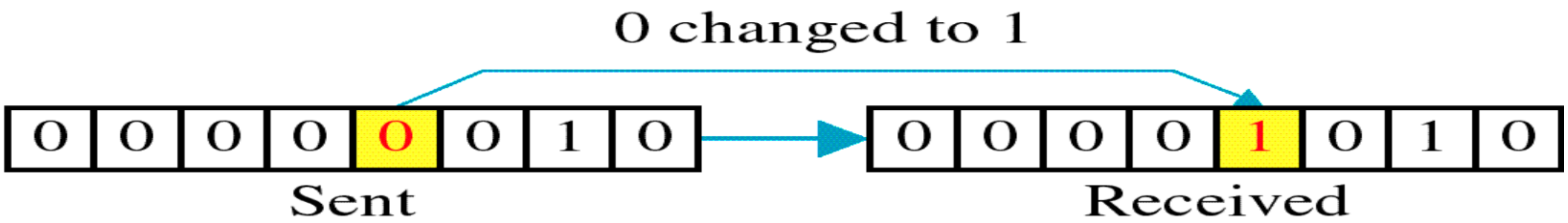
- Networks must be able to transfer data from one device to another with complete accuracy.
- Data can be corrupted during transmission.
- For reliable communication, errors must be detected and corrected.



Types Of Errors

- Single-Bit
- Multiple-Bits
- Burst

Single-bit error

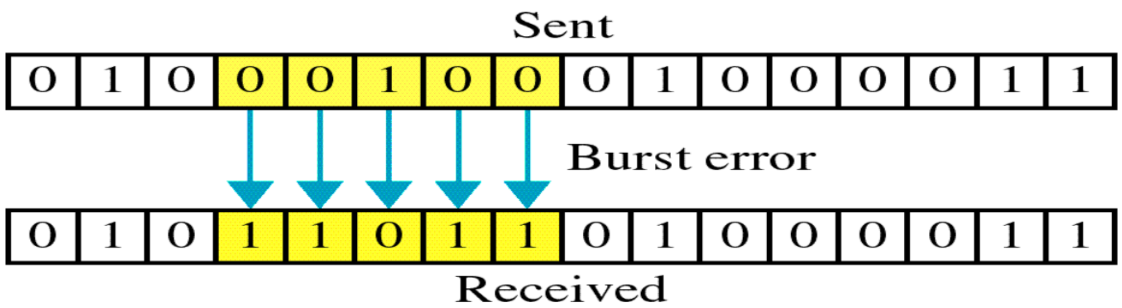


Single bit errors are the **least likely** type of errors in serial data transmission because the noise must have a very short duration which is very rare. However this kind of errors can happen in parallel transmission.

Example:

- If data is sent at 1Mbps then each bit lasts only 1/1,000,000 sec. or 1 μs.
- For a single-bit error to occur, the noise must have a duration of only 1 μs, which is very rare.

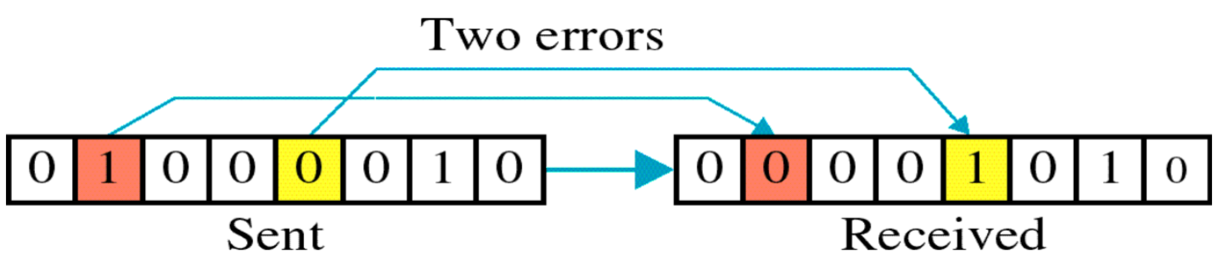
Burst error



The term **burst error** means that two or more bits in the data unit have changed from 1 to 0 or from 0 to 1.

Burst errors does not necessarily **mean that the errors occur in consecutive bits**, the length of the burst is measured from the first corrupted bit to the last corrupted bit. Some bits in between may not have been corrupted.

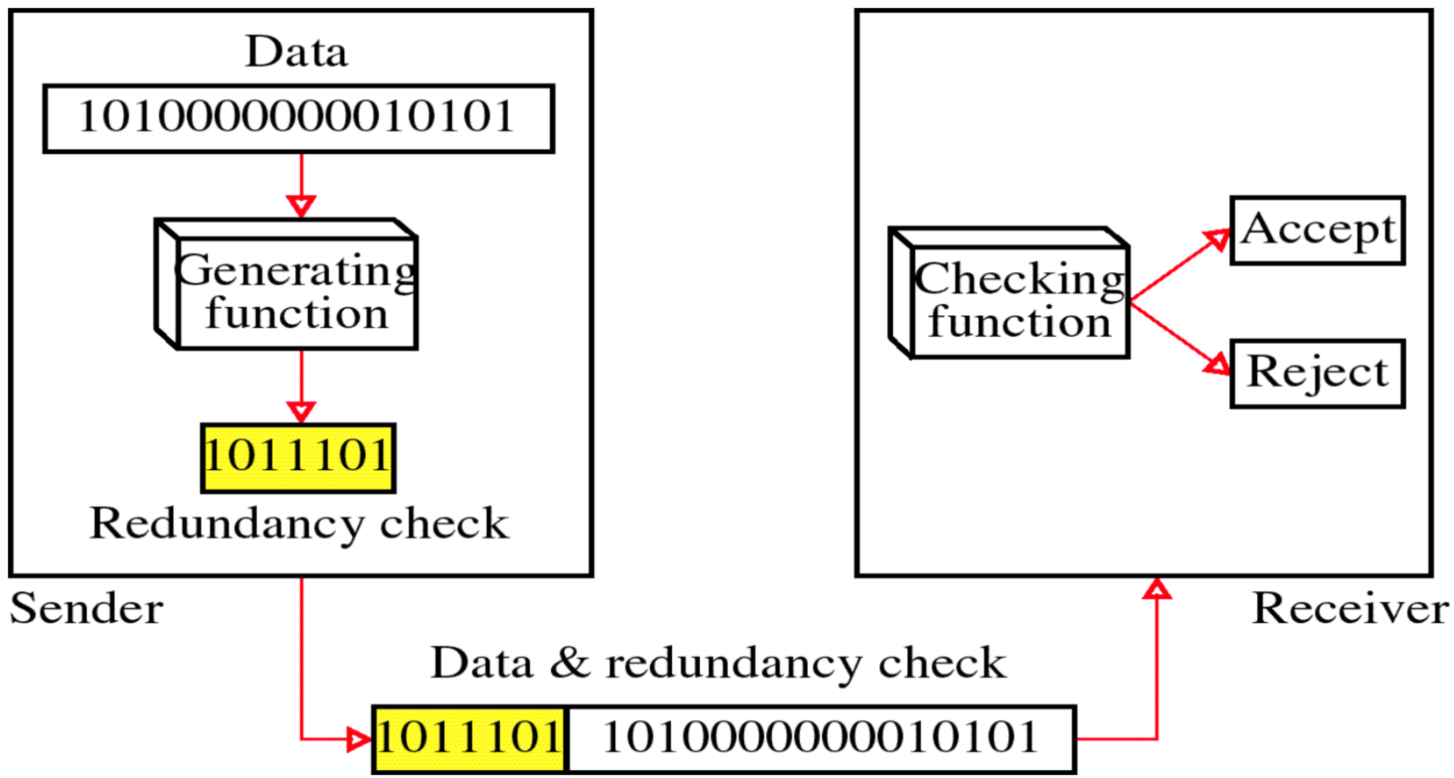
Burst error is most likely to happen in serial transmission since the duration of noise is normally longer than the duration of a bit.



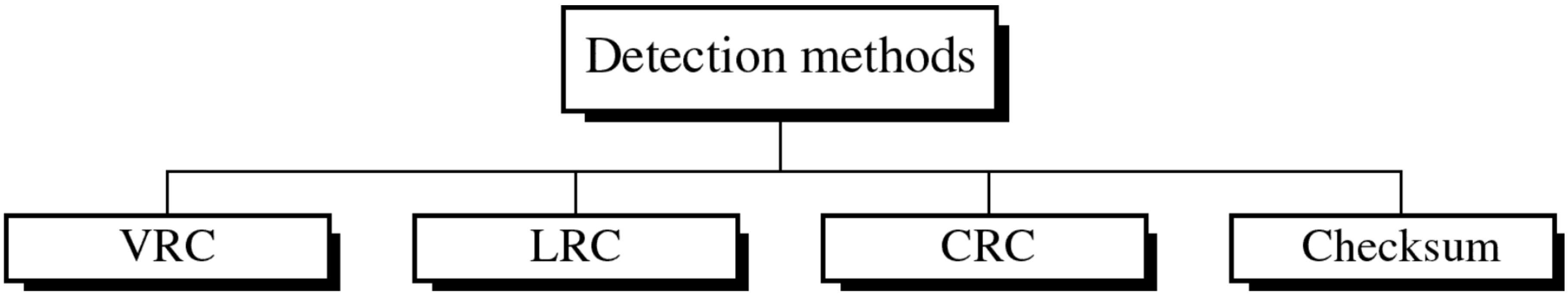
ERROR DETECTION

Error detection means to decide whether the received data is correct or not without having a copy of the original message.

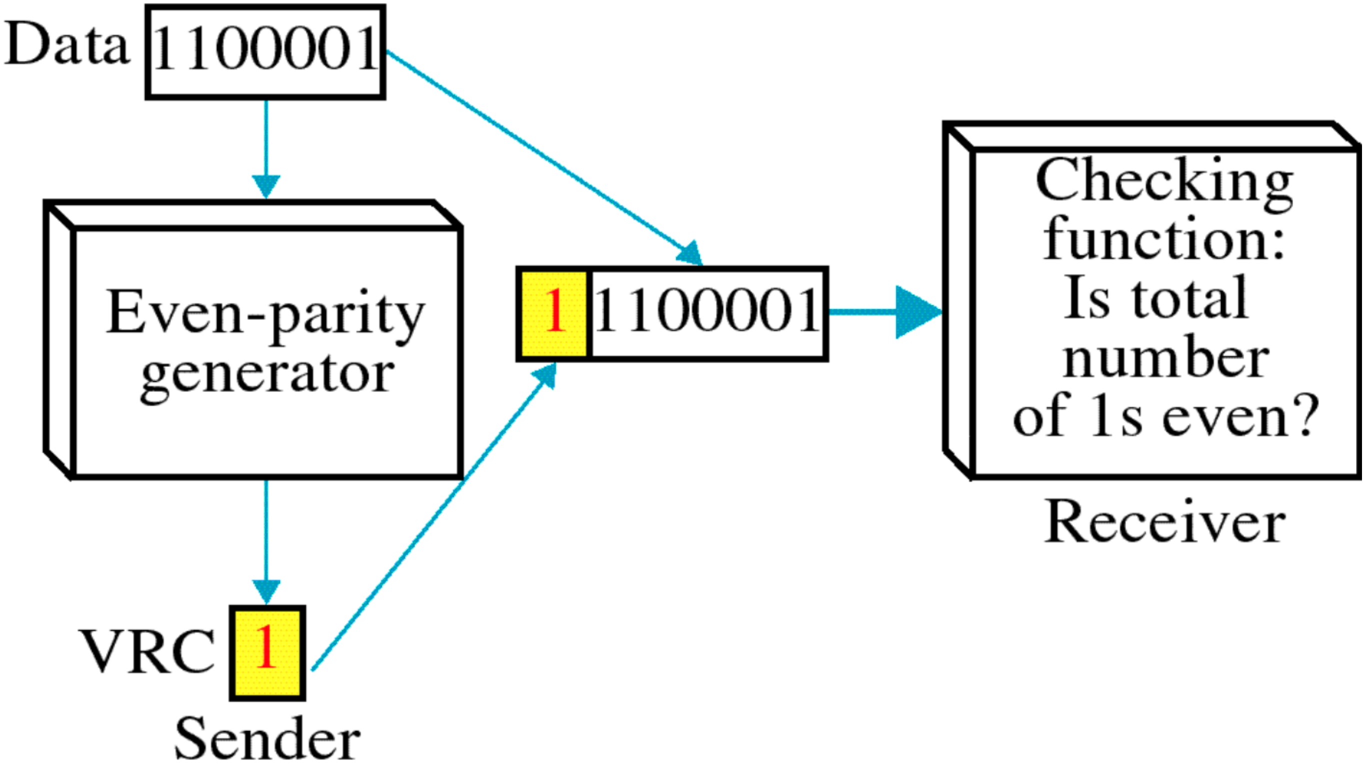
Error detection **uses the concept of redundancy**, **which means** adding extra bits for detecting errors at the destination.



Four types of redundancy checks are used in data communications



Vertical Redundancy Check (VRC)

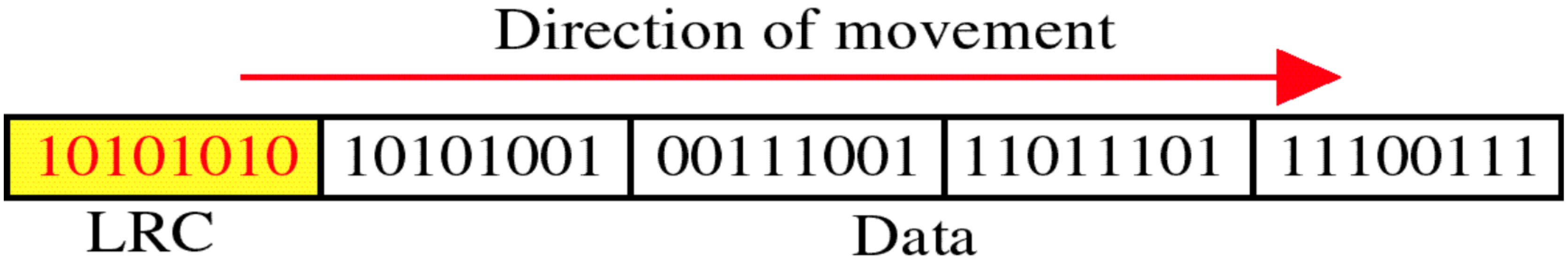


- Performance

➔ It can detect single bit error

➔ It can detect burst errors only if the total number of errors is odd.

Longitudinal Redundancy Check (LRC)

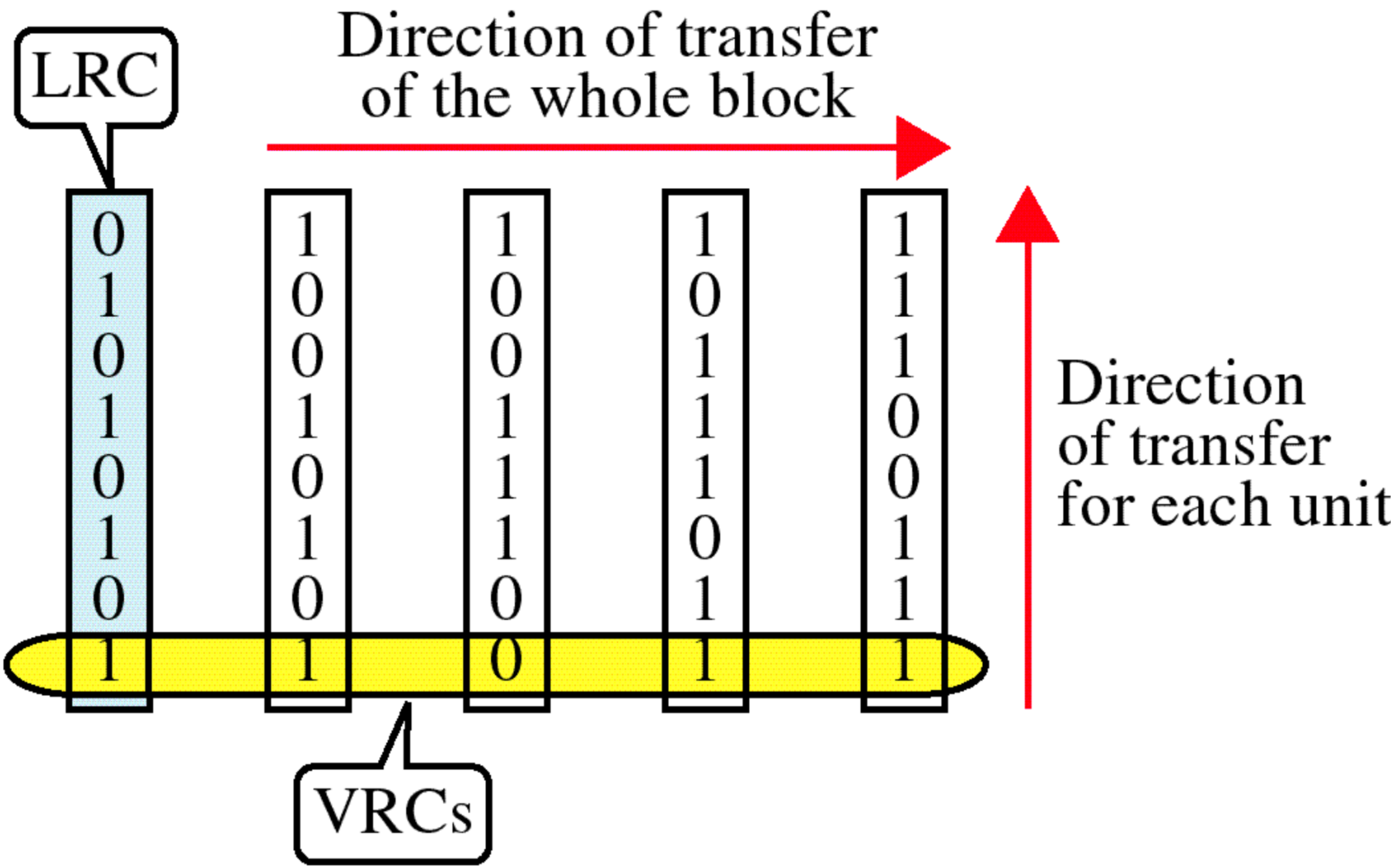


- Performance

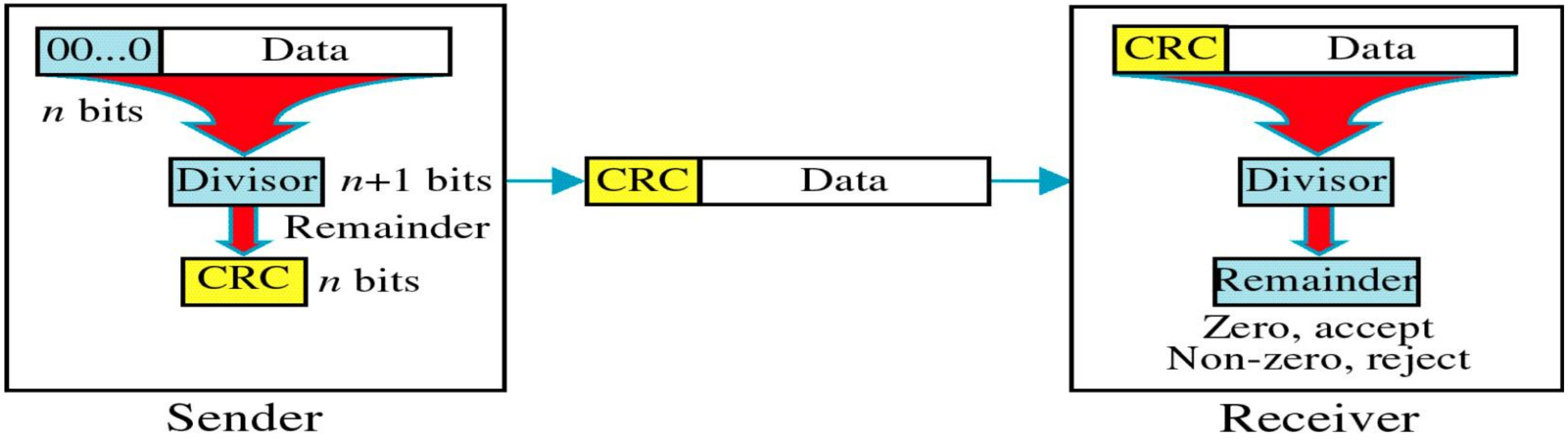
➔ LCR increases the likelihood of detecting burst errors.

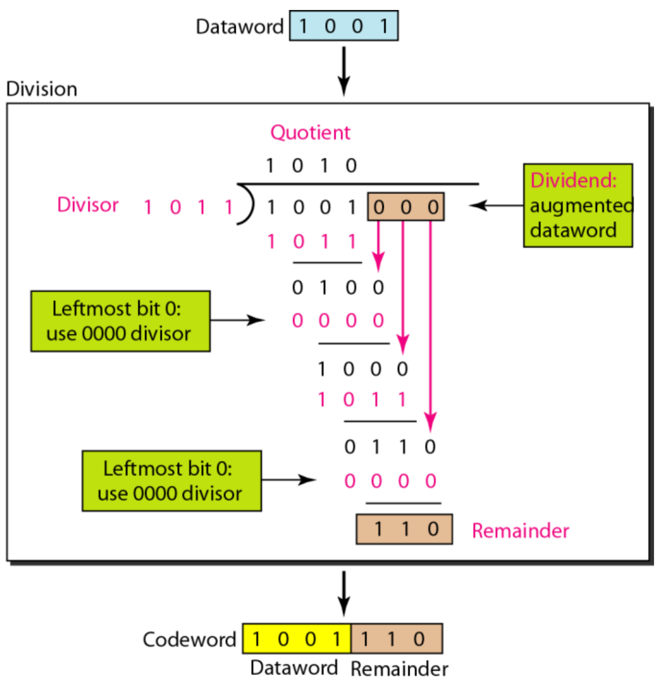
➔ If two bits in one data units are damaged and two bits in exactly the same positions in another data unit are also damaged, the LRC checker will not detect an error.

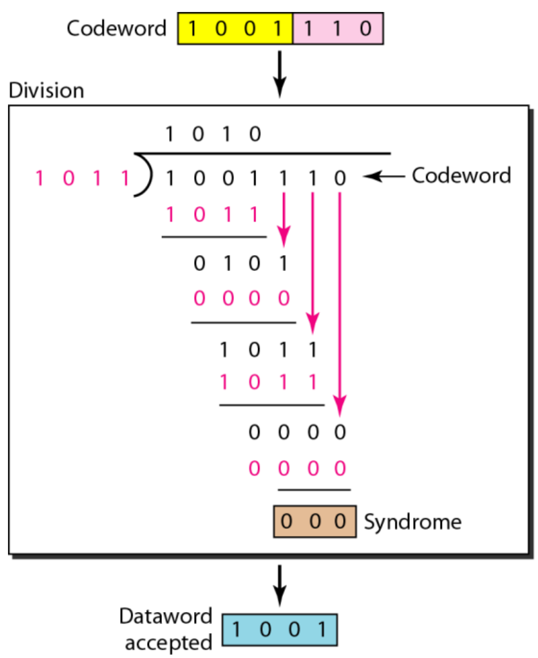
VRC and LRC

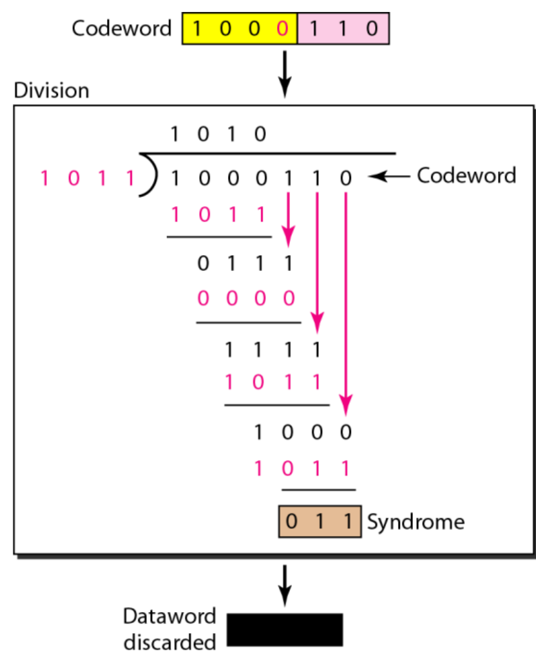

LRC
Direction of transfer
of the whole block
0 1 0 1 0 1 0 1
1 0 0 1 0 1 0 1
1 0 0 1 1 1 0 0
1 0 1 1 1 0 1 1
1 1 1 0 0 1 1 1
Direction
of transfer
for each unit
VRCs

Cyclic Redundancy Check (CRC)







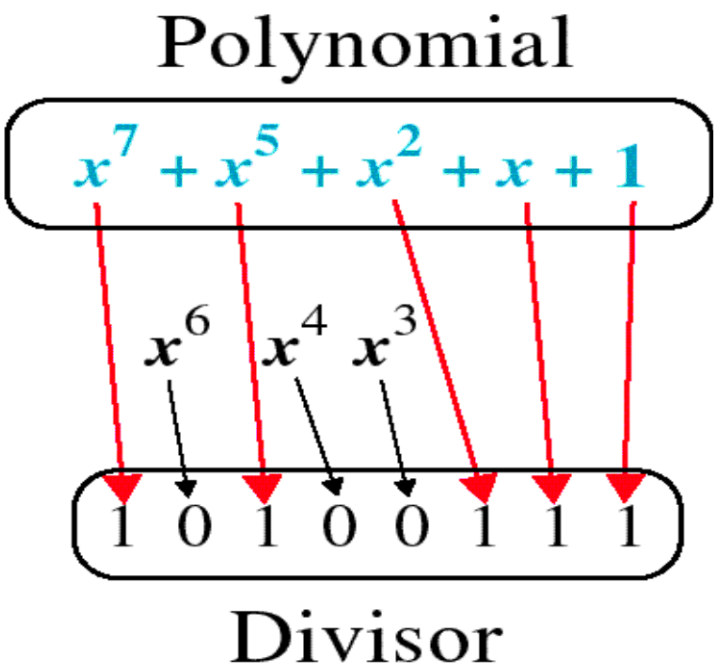


Cyclic Redundancy Check (CRC) Performance

Table 6-4 *Error detection performance of cyclic redundancy checksum*

Type of Error	Error Detection Performance
Single bit errors	100 percent
Double bit errors	100 percent, as long as the generating polynomial has at least three 1s (they all do)
Odd number of bits in error	100 percent, as long as the generating polynomial ends with a Factor of + 1) (they all do)
An error burst of length < r+1	100 percent
An error burst of length = r+1	probability = $1 - (\frac{1}{2})^{(r-1)}$
An error burst of length > r+1	probability = $1 - (\frac{1}{2})^{r}$

Polynomial and Divisor



Standard Polynomials

CRC-12

$x^{12} + x^{11} + x^3 + x + 1$

CRC-16

$x^{16} + x^{15} + x^2 + 1$

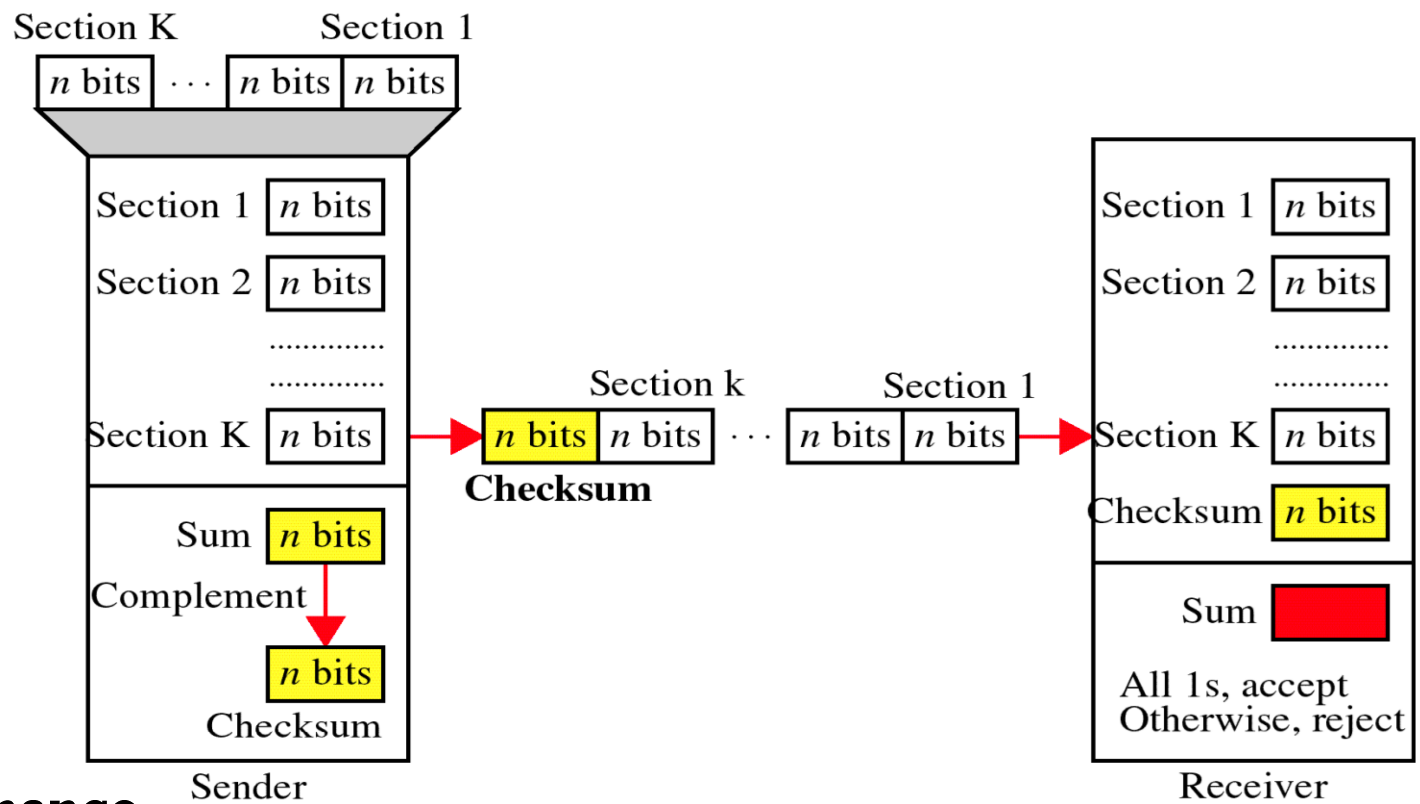
CRC-ITU

$x^{16} + x^{12} + x^5 + 1$

CRC-32

$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$

Checksum



Performrmance

- ➔The checksum detects all errors involving an odd number of bits.
- ➔It detects most errors involving an even number of bits.
- ➔If one or more bits of a segment are damaged and the corresponding bit or bits of opposite value in a second segment are also damaged, the sums of those columns will not change and the receiver will not detect a problem.

ERROR CORRECTION

It can be handled in two ways:

1) receiver can have the sender retransmit the entire data unit.
2) The receiver can use an error-correcting code, which automatically corrects certain errors.

SINGLE-BIT ERROR CORRECTION

To correct an error, the receiver reverses the value of the altered bit. To do so, it must know which bit is in error.

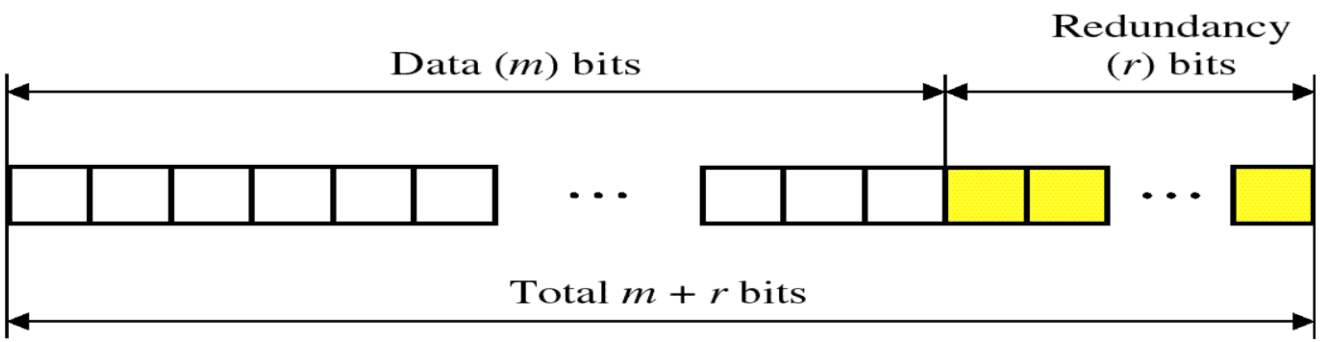
Number of redundancy bits needed

- Let data bits = m
- Redundancy bits = r

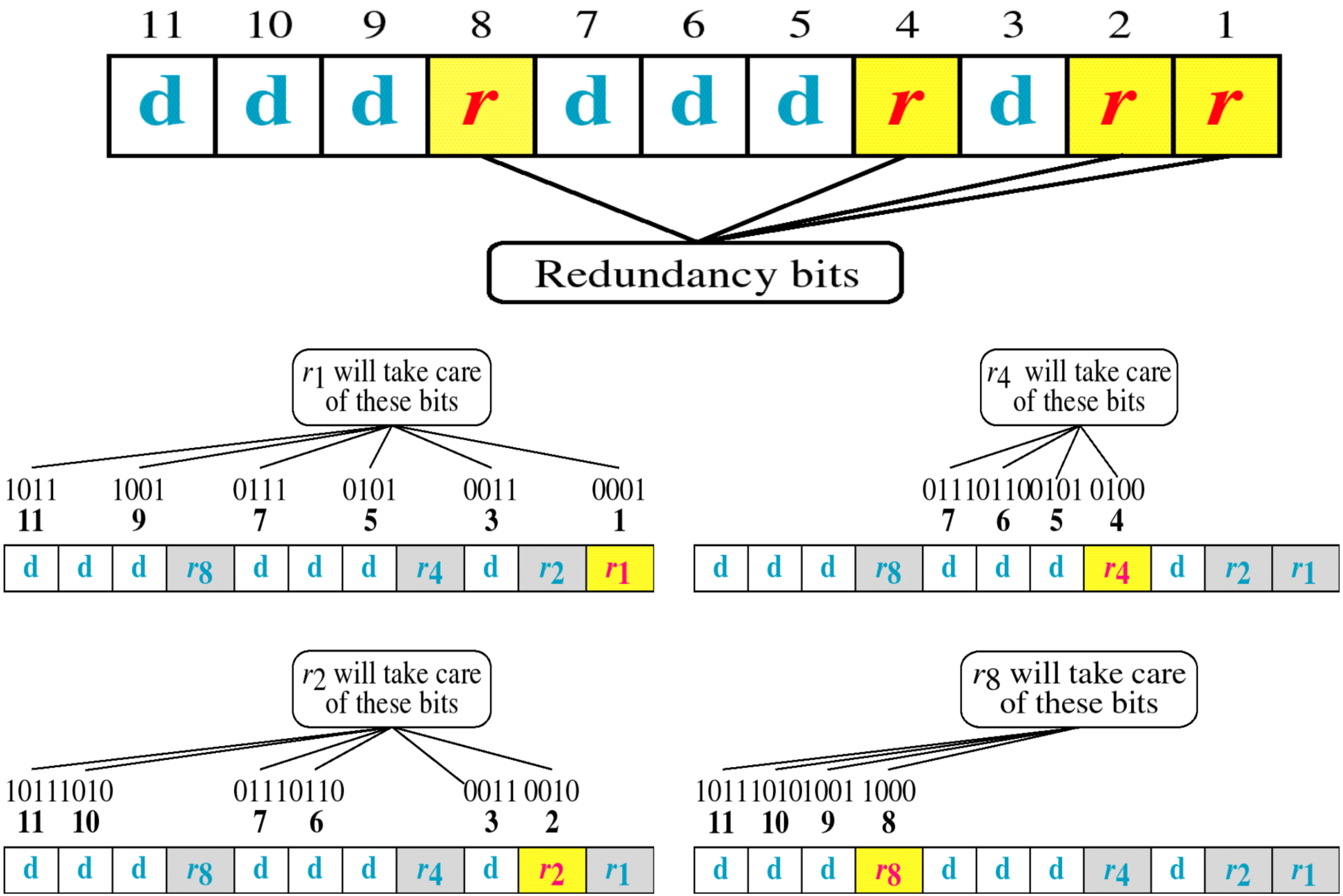
$\therefore$ Total message sent = $m+r$

The value of r must satisfy the following relation:

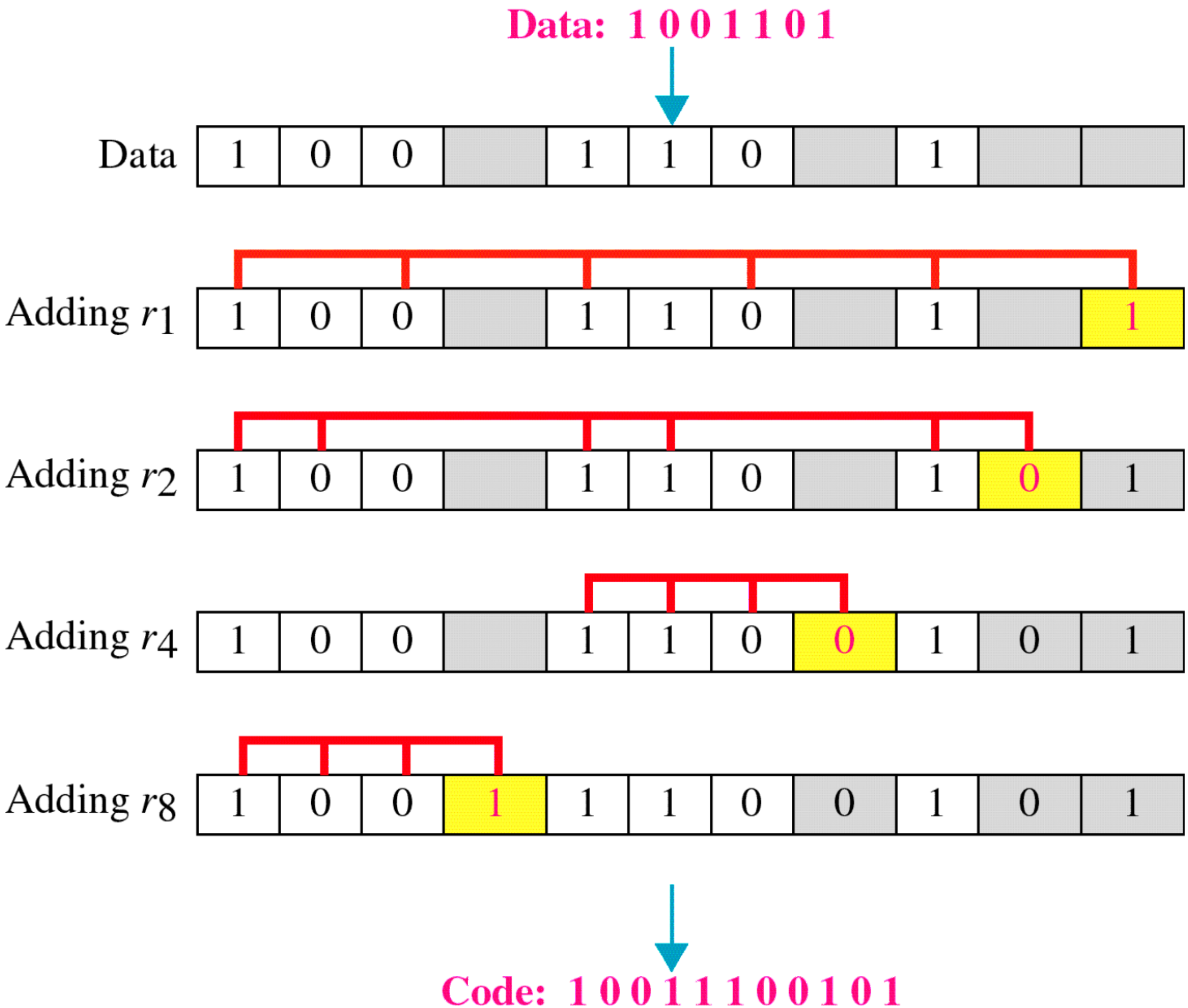
$$2^r \geq m+r+1$$



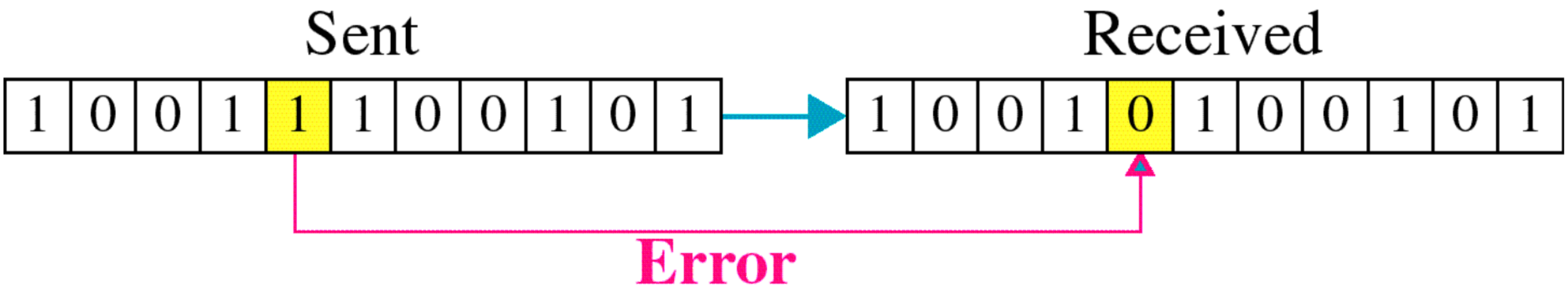
Hamming Code



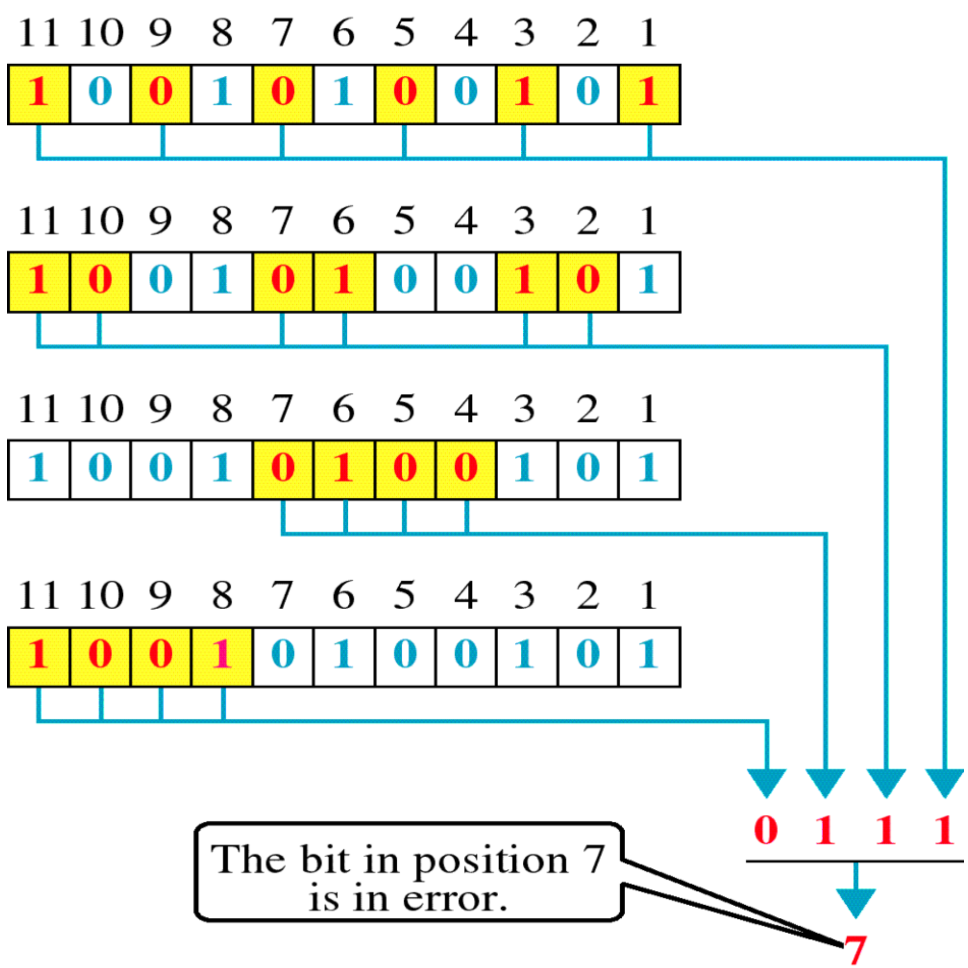
Example of Hamming Code



Single-bit error



Error Detection




Thank You!