# Hamming code(4 bit data)

## Parity bit:

Its value is determined w.r.t the #1s.

1. Even Parity:

   If the #1s is odd, set parity to 1.

2. Odd Parity:

   If the #1s is even, set parity to 1.

## Parity bit:

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1. Even Parity:

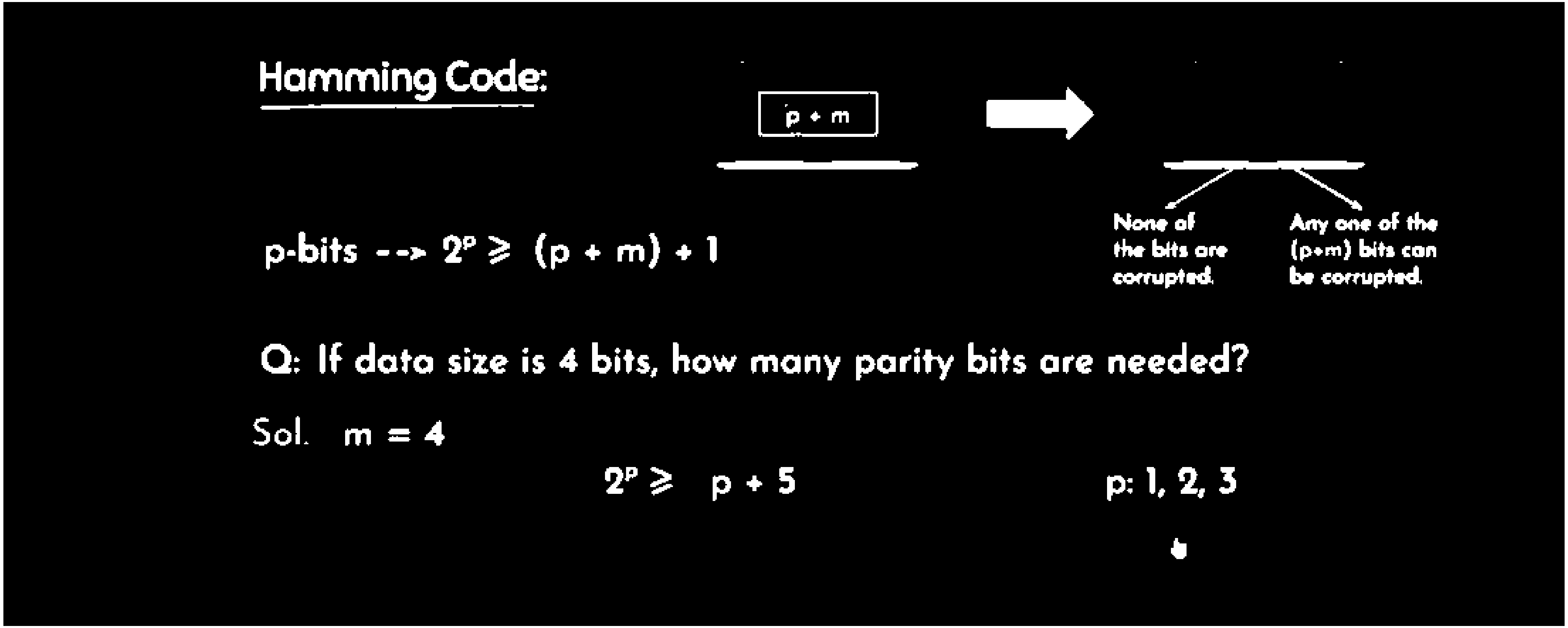
   If the #1s is odd, set parity to 1.

2. Odd Parity:

   If the #1s is even, set parity to 1.

| | | | $P_e$ |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 |

# Problems using Hamming Distance and Parity



## Hamming Code:

$m_1\ m_2\ m_3\ m_4$

$m = 0\ 1\ 1\ 0$

$p = p_1 p_2 p_3$

$\boxed{p + m}$

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

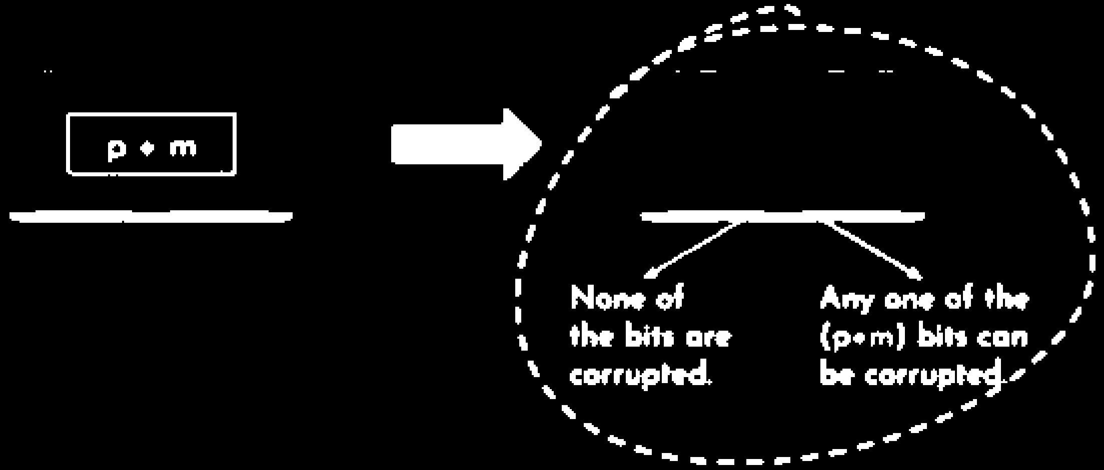
None of the bits are corrupted.

Any one of the (p+m) bits can be corrupted.

# Hamming Code:

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

| $c_1$ | $c_2$ | $c_3$ | |
|---|---|---|---|
| 0 | 0 | 0 | ✓ |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 2 |
| 0 | 1 | 1 | 3 |
| 1 | 0 | 0 | 4 |
| 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 6 |
| 1 | 1 | 1 | 7 |



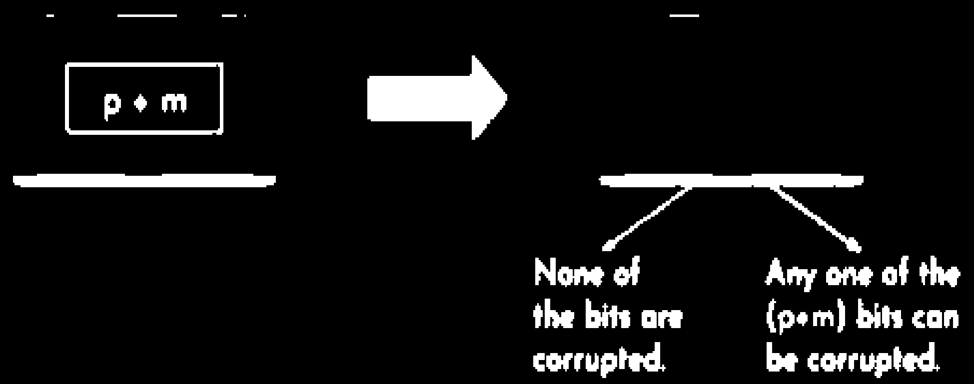

$p_1 \longrightarrow c_3$ (1, 3, 5, 7)

$p_2 \longrightarrow c_2$ (2, 3, 6, 7)

$p_3 \longrightarrow c_1$ (4, 5, 6, 7)

## Hamming Code:

$$\begin{array}{ccccc} & m_1 & m_2 & m_3 & m_4 \\ m = & 0 & 1 & 1 & 0 \end{array}$$



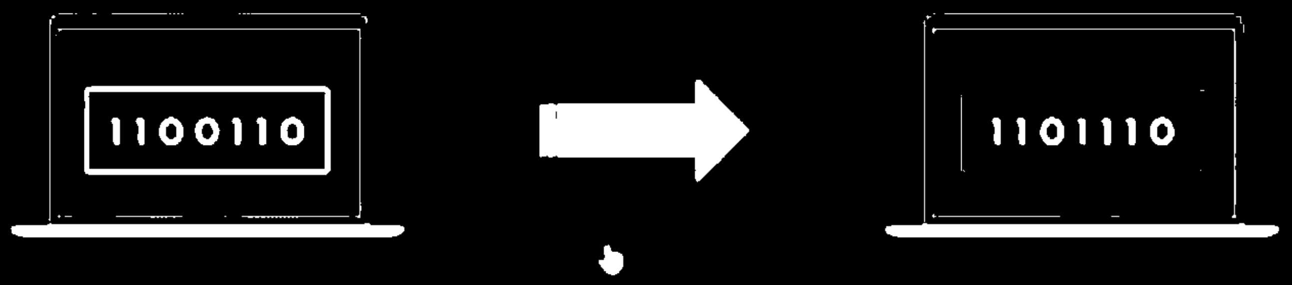

$p_1$ (1, 3, 5, 7)

$p_2$ (2, 3, 6, 7)

$p_3$ (4, 5, 6, 7)

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 1 | 0 | 0 | 1 | 1 | 0 |

## Hamming Code:



## Hamming Code:

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 1 | 0 | 0 | 1 | 1 | 0 |

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 |

## Hamming Code:

| $c_1$ | $c_2$ | $c_3$ | | |
|---|---|---|---|---|
| 0 | 0 | 0 | ----→ | ✓ |
| 0 | 0 | 1 | ----→ | 1 |
| 0 | 1 | 0 | ----→ | 2 |
| 0 | 1 | 1 | ----→ | 3 |
| 1 | 0 | 0 | ----→ | 4 |
| 1 | 0 | 1 | ----→ | 5 |
| 1 | 1 | 0 | ----→ | 6 |
| 1 | 1 | 1 | ----→ | 7 |

$c_1 \longrightarrow 1$

$c_2 \longrightarrow 0$

$c_3 \longrightarrow 0$

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 |

$c_1$ (4, 5, 6, 7)

$c_2$ (2, 3, 6, 7)

$c_3$ (1, 3, 5, 7)

## Hamming Code:

| $c_1$ | $c_2$ | $c_3$ | |
|---|---|---|---|
| 0 | 0 | 0 | $\dashrightarrow$ ✓ |
| 0 | 0 | 1 | $\dashrightarrow$ 1 |
| 0 | 1 | 0 | $\dashrightarrow$ 2 |
| 0 | 1 | 1 | $\dashrightarrow$ 3 |
| $\boxed{1}$ | $\boxed{0}$ | $\boxed{0}$ | $\boxed{\dashrightarrow 4}$ |
| 1 | 0 | 1 | $\dashrightarrow$ 5 |
| 1 | 1 | 0 | $\dashrightarrow$ 6 |
| 1 | 1 | 1 | $\dashrightarrow$ 7 |

$c_1 \longrightarrow 1$

$c_2 \longrightarrow 0$

$c_3 \longrightarrow 0$

| $p_1$ | $p_2$ | $m_1$ | $p_3$ | $m_2$ | $m_3$ | $m_4$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 |

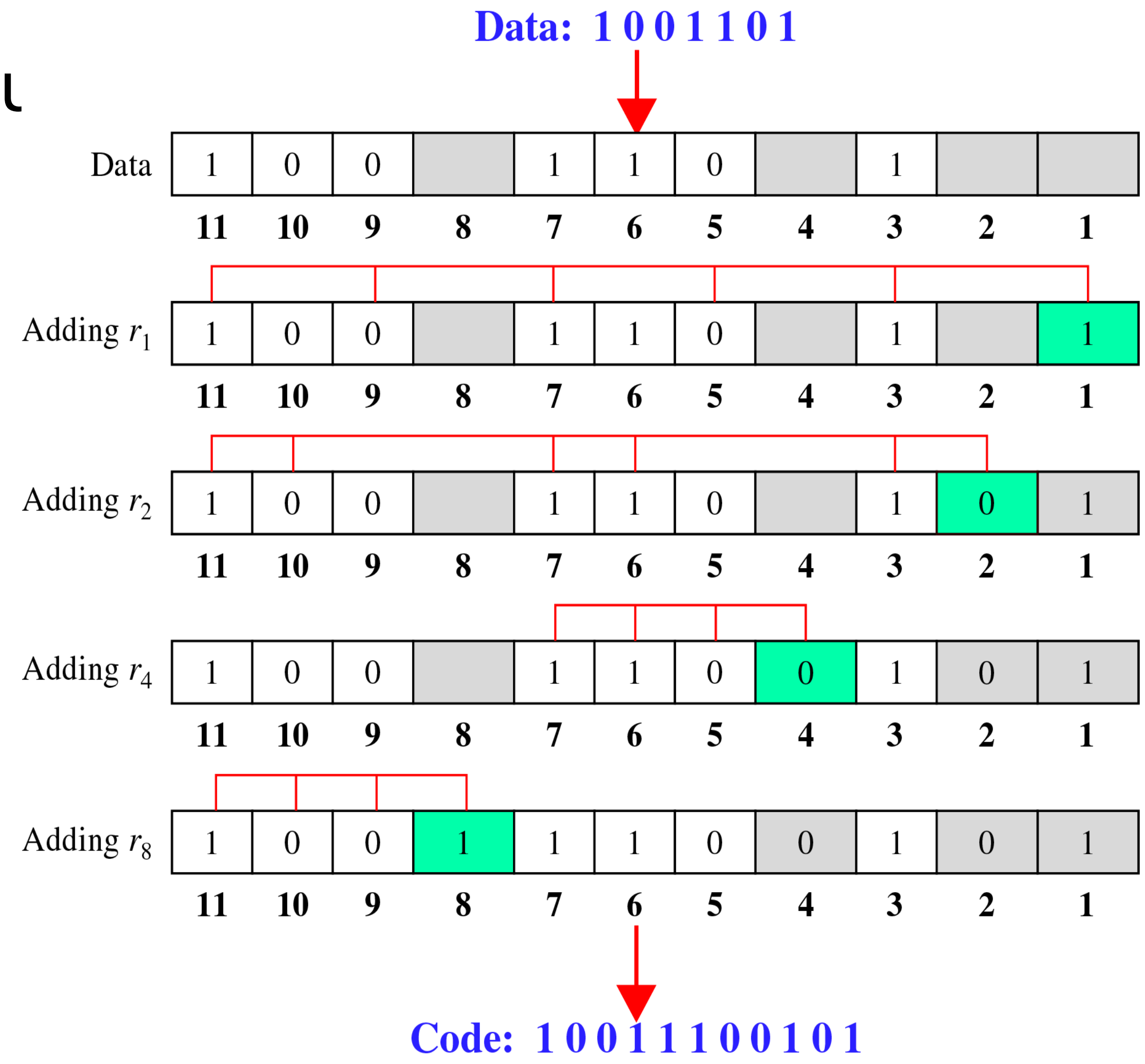
**A four bit message, 1101 is transmitted through a network with even parity. Now, according to Hamming code policy, examine the following:**

a) The code-word of the transmitter side.

b) If the receiver has received an error code where 5th bit is flipped then how the error is detected and corrected in the receiver side.

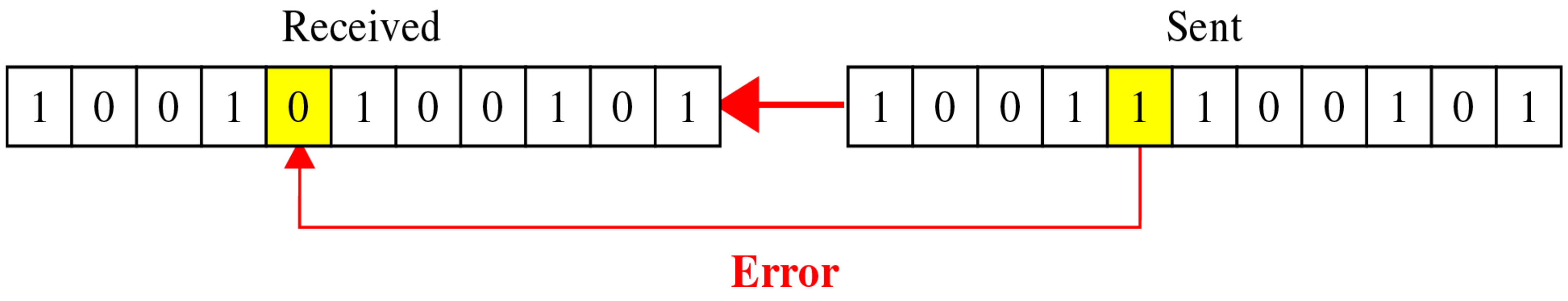
# Error Correction(cont'd)

- Calculating the r valu



# Error Correction(cont'd)

- Error Detection and Correction



# Error Correction(cont'

- Error detection using Hamming Cod