

W3

(3)

# Computer Networks I

## Error Detection

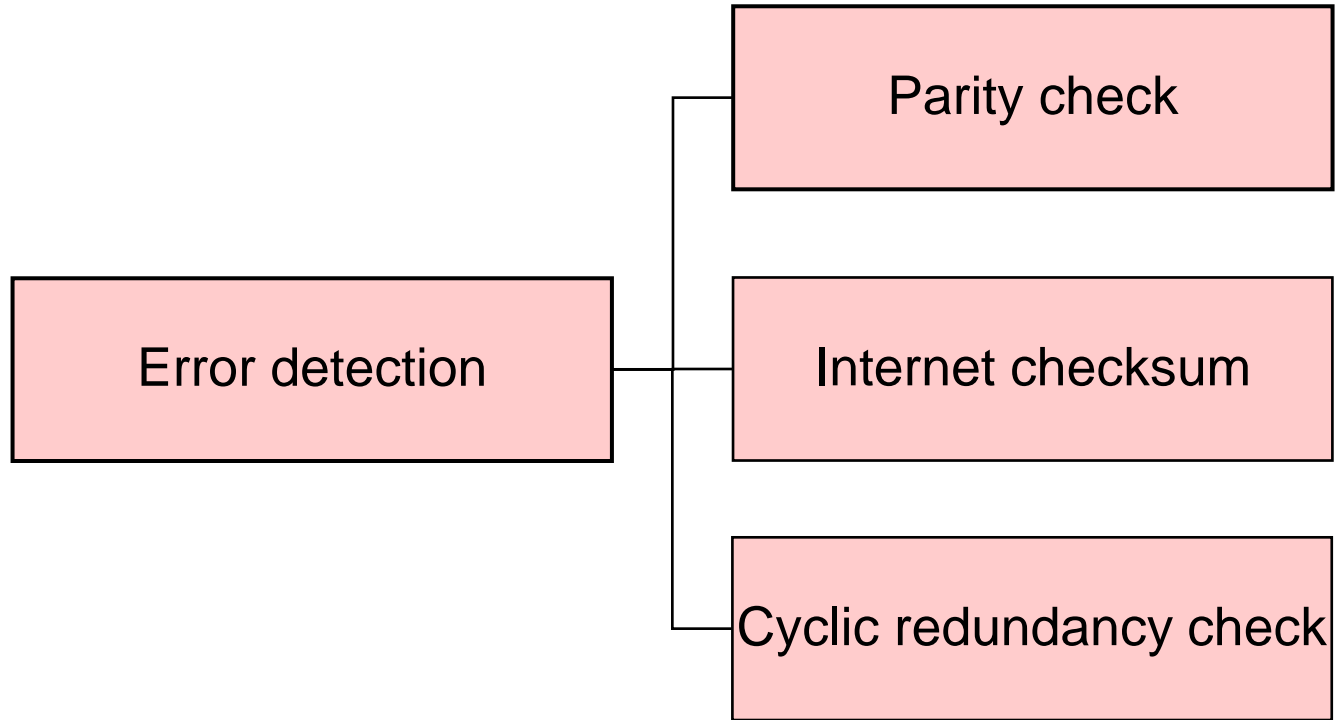
(Cyclic Redundancy Check)

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# Error Detection



# Cyclic Redundancy Check

- ❑ One of the most powerful error-detecting codes
  - ❑ Two equivalent ways of presenting CRC:
    - ❑ Modulo 2 arithmetic
    - ❑ Polynomials
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# Cyclic Redundancy Check

- One of the most powerful error-detecting codes
- **Modulo 2** arithmetic:
  - Uses binary addition with no carries
  - Based on exclusive-OR (XOR) operation

$$\begin{array}{r} 1111 \\ + 1010 \\ \hline \end{array}$$

$$\begin{array}{r} 1111 \\ - 0101 \\ \hline \end{array}$$

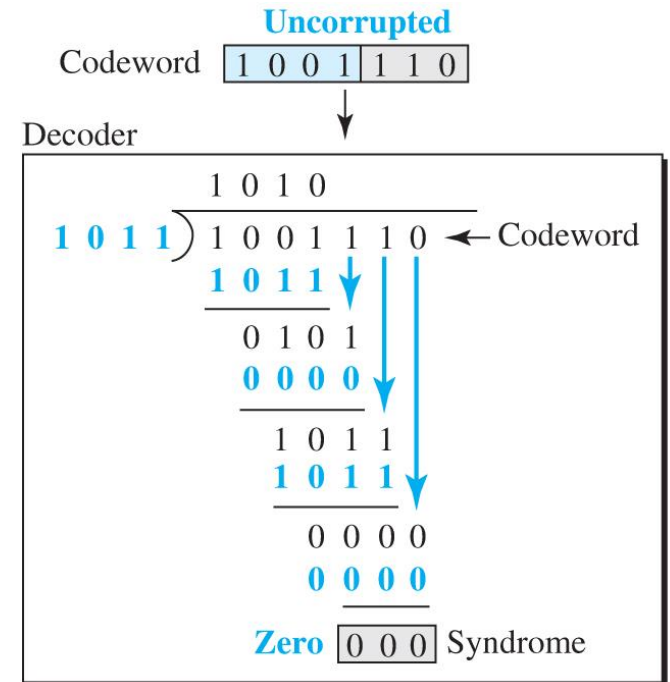
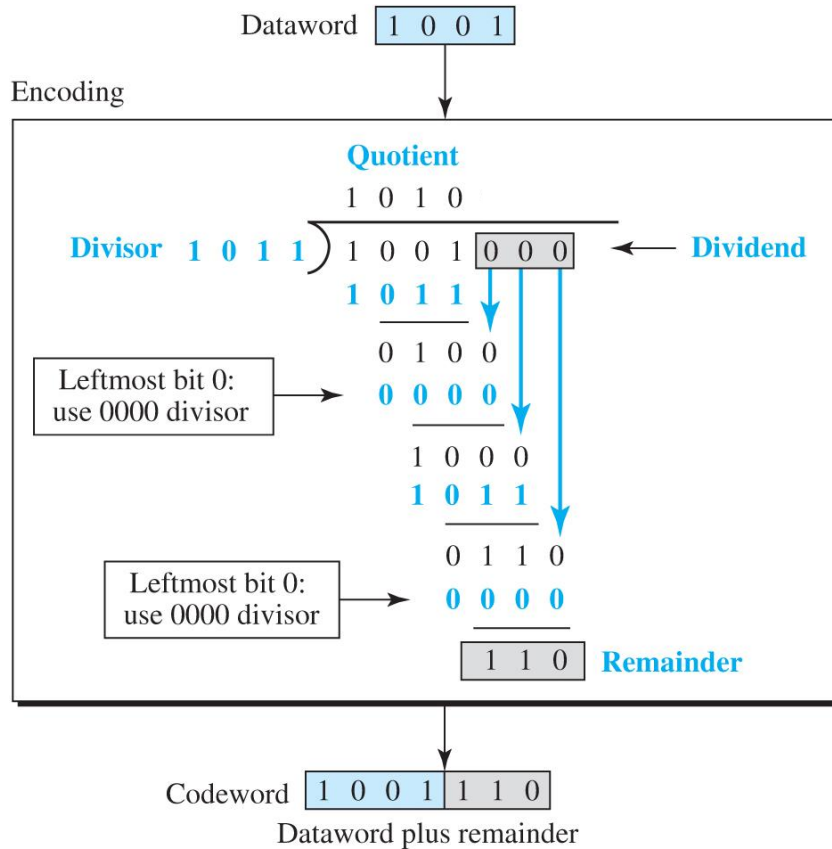
$$\begin{array}{r} 11001 \\ \times 11 \\ \hline \end{array}$$

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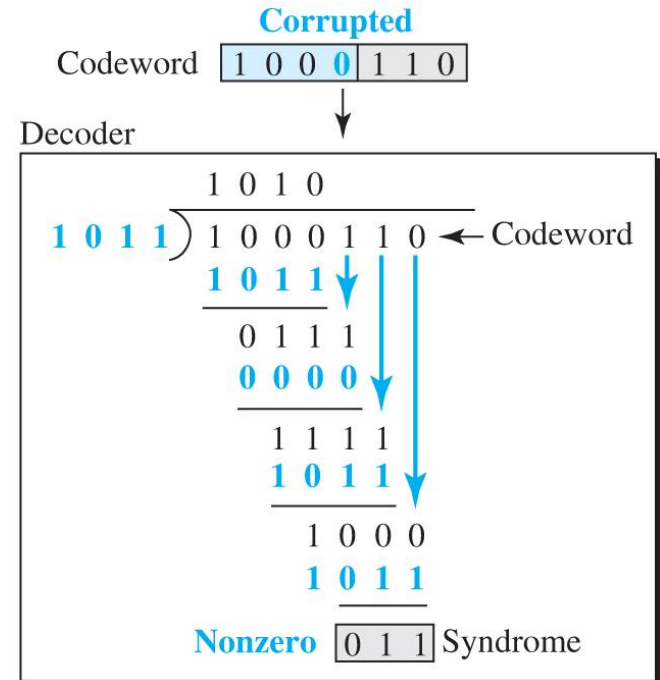
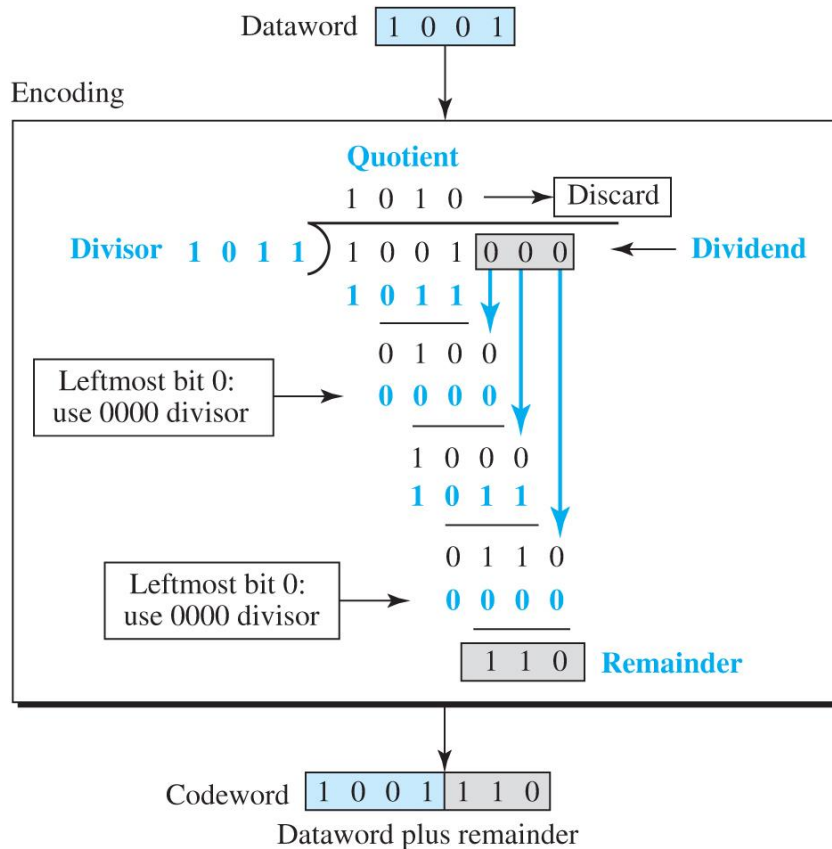
# Cyclic Redundancy Check

- Given a block of bits, the transmitter generates a **frame check sequence (FCS)**, such that
    - The resulting frame is exactly divisible by some predetermined number
  - Receiver divides the incoming frame by that number
    - If there is no remainder, assume there is no error
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# Cyclic Redundancy Check



# Cyclic Redundancy Check



# Cyclic Redundancy Check

- One of the most powerful error-detecting codes
  - Polynomials:
    - Represent bit-strings as polynomials
    - 110001 can be represented as  $x^5 + x^4 + 1$
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# Cyclic Redundancy Check

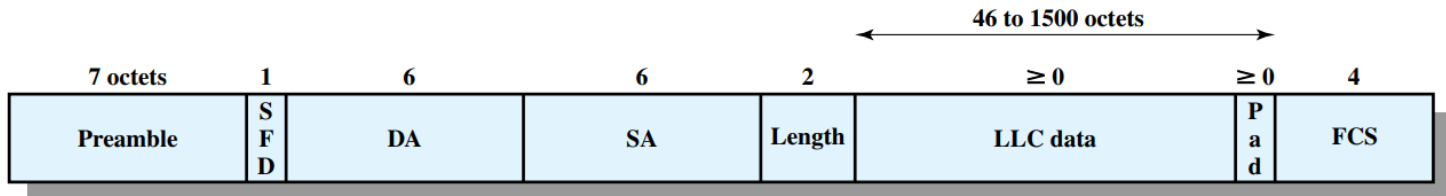
$$D(X) = X^9 + X^7 + X^3 + X^2 + 1$$

$$P(X) = X^5 + X^4 + X^2 + 1$$

$$\begin{array}{r}
 \begin{array}{l} P(X) \rightarrow X^5 + X^4 + X^2 + 1 \end{array} \left/ \begin{array}{l} X^9 + X^8 + X^6 + X^4 + X^2 + X \\ X^{14} \quad X^{12} \quad X^8 + X^7 + \quad X^5 \end{array} \right. \begin{array}{l} \leftarrow Q(X) \\ \leftarrow X^5 D(X) \end{array} \\
 \hline
 \begin{array}{r} X^{14} + X^{13} + \quad X^{11} + \quad X^9 \\ X^{13} + X^{12} + X^{11} + \quad X^9 + X^8 \\ X^{13} + X^{12} + \quad X^{10} + \quad X^8 \\ X^{11} + X^{10} + X^9 + \quad X^7 \\ X^{11} + X^{10} + \quad X^8 + \quad X^6 \\ X^9 + X^8 + X^7 + X^6 + X^5 \\ X^9 + X^8 + \quad X^6 + \quad X^4 \\ X^7 + \quad X^5 + X^4 \\ X^7 + X^6 + \quad X^4 + \quad X^2 \\ X^6 + X^5 + \quad X^2 \\ X^6 + X^5 + \quad X^3 + \quad X \\ X^3 + X^2 + X \end{array} \leftarrow R(X)
 \end{array}$$

# Cyclic Redundancy Check

Name	Binary	Application
CRC-8	100000111	ATM header
CRC-10	11000110101	ATM AAL
CRC-16	10001000000100001	HDLC
CRC-32	100000100110000010001110110110111	LANs



SFD = Start of frame delimiter  
DA = Destination address  
SA = Source address  
FCS = Frame check sequence

# Summary

- ❑ Cyclic redundancy check
    - ❑ Modulo 2 arithmetic
    - ❑ Polynomials
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