Chapter 10

Error Detection and Correction

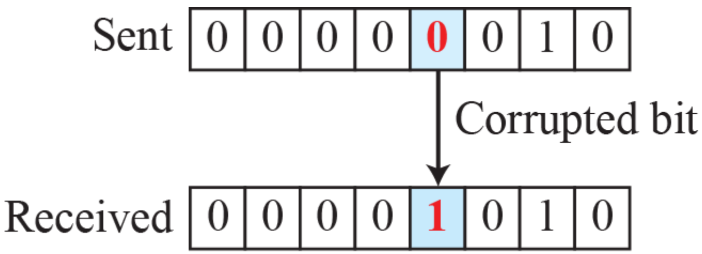
Types of Errors

Whenever bits flow from one point to another, they are subject to unpredictable changes because of interference.

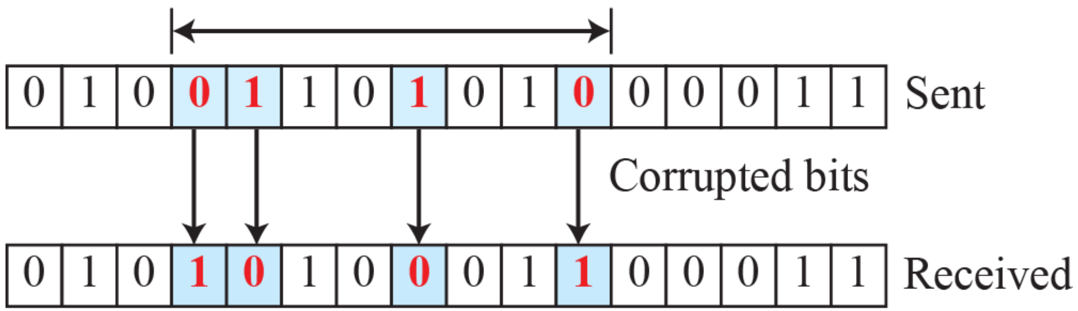
- **Single-bit error: only 1 bit data is changed from 1 to 0 or from 0 to 1.**

- **Burst error: 2 or more bits have changed from 1 to 0 or from 0 to 1.**

Single-bit and burst error



a. Single-bit error



b. Burst error

Redundancy

- The central concept in detecting or correcting errors is redundancy.

- To be able to detect or correct errors, we need to send some extra bits with our data.

- These redundant bits are added by the sender and removed by the receiver.

Coding

- Redundancy is achieved through various coding schemes.

- The sender adds redundant bits through a process that creates a relationship between the redundant bits and the actual data bits.

- The receiver checks the relationships between the two sets of bits to detect errors.

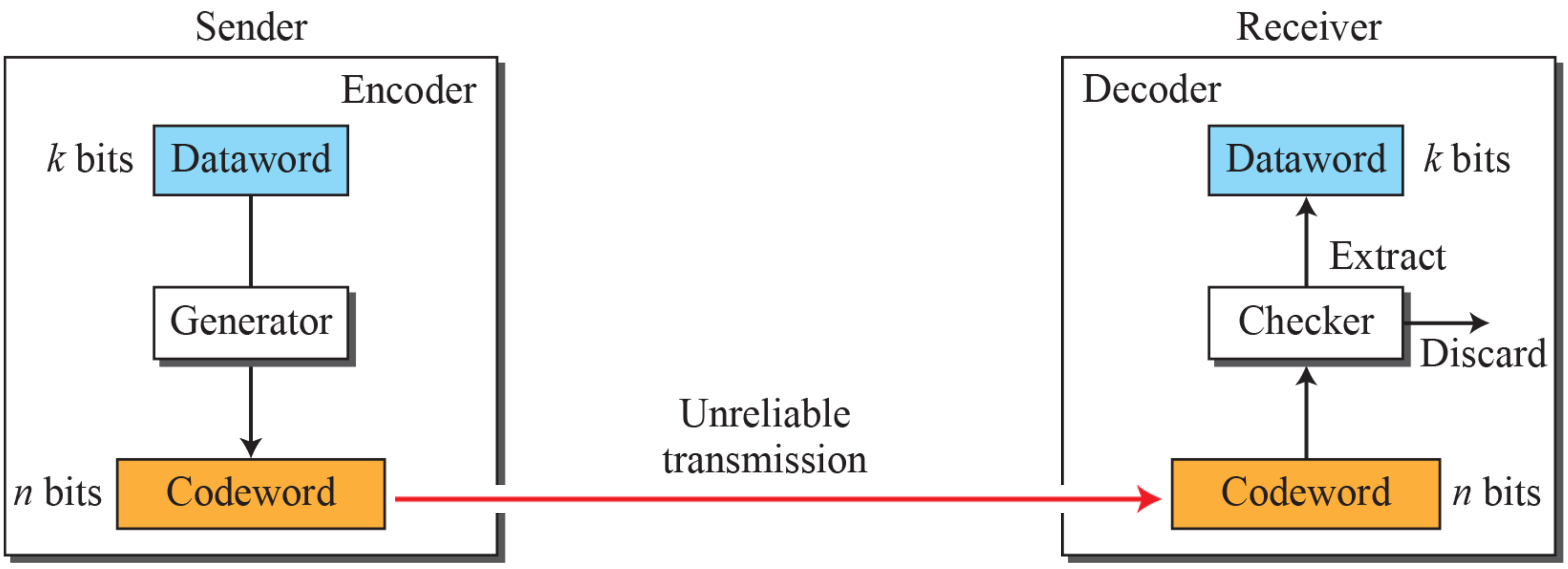
Block Coding

- We divide our message into blocks, each of k bits, called **datawords**.

- We add r redundant bits to each block to make the length $n = k + r$.

- The resulting n-bit blocks are called **codewords**.

Process of error detection in block coding

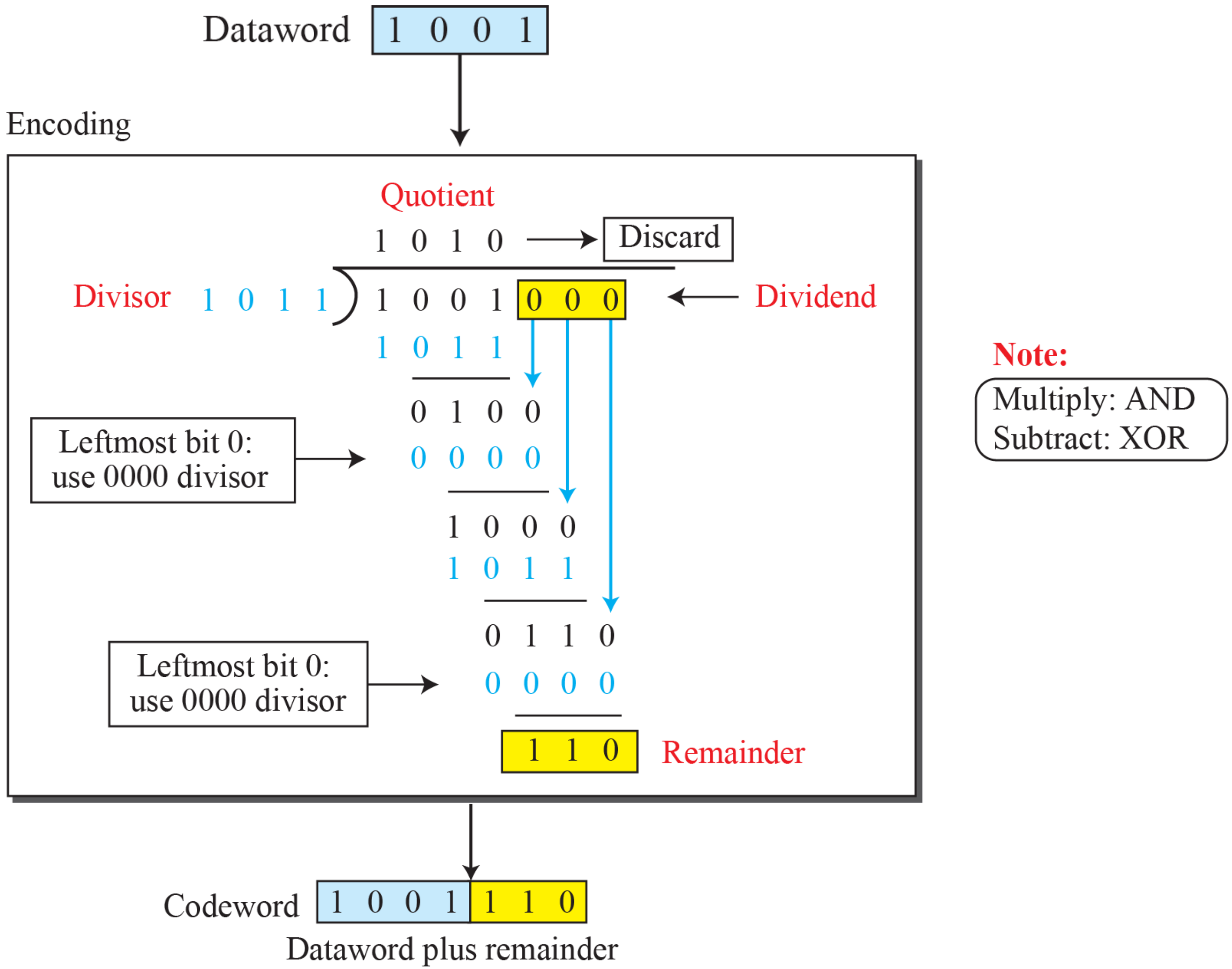


Parity-check code

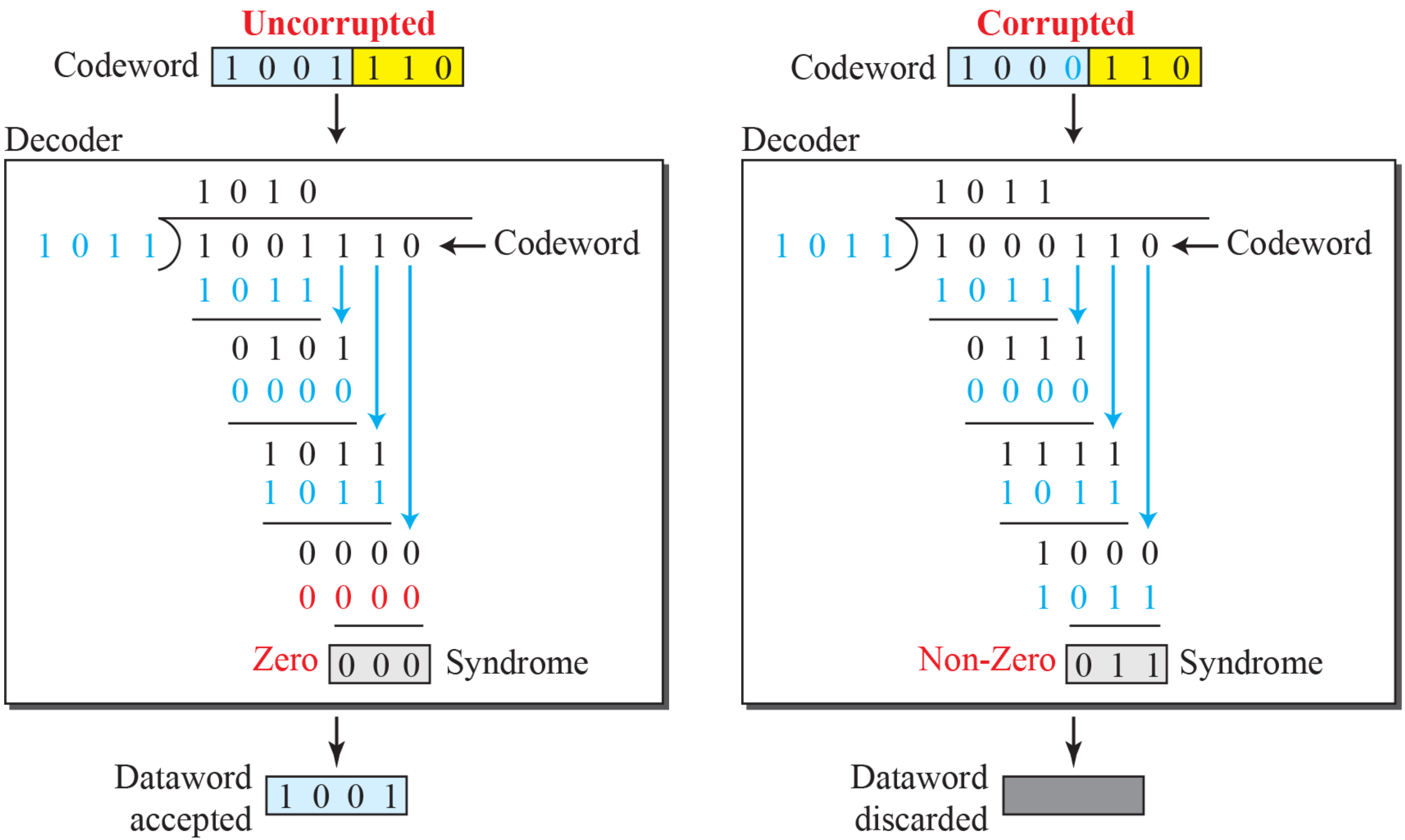
Cyclic Redundancy Check

is used in networks such as LANs and WANs.

Figure 10.6: Division in CRC encoder



Division in the CRC decoder for two cases



Polynomials

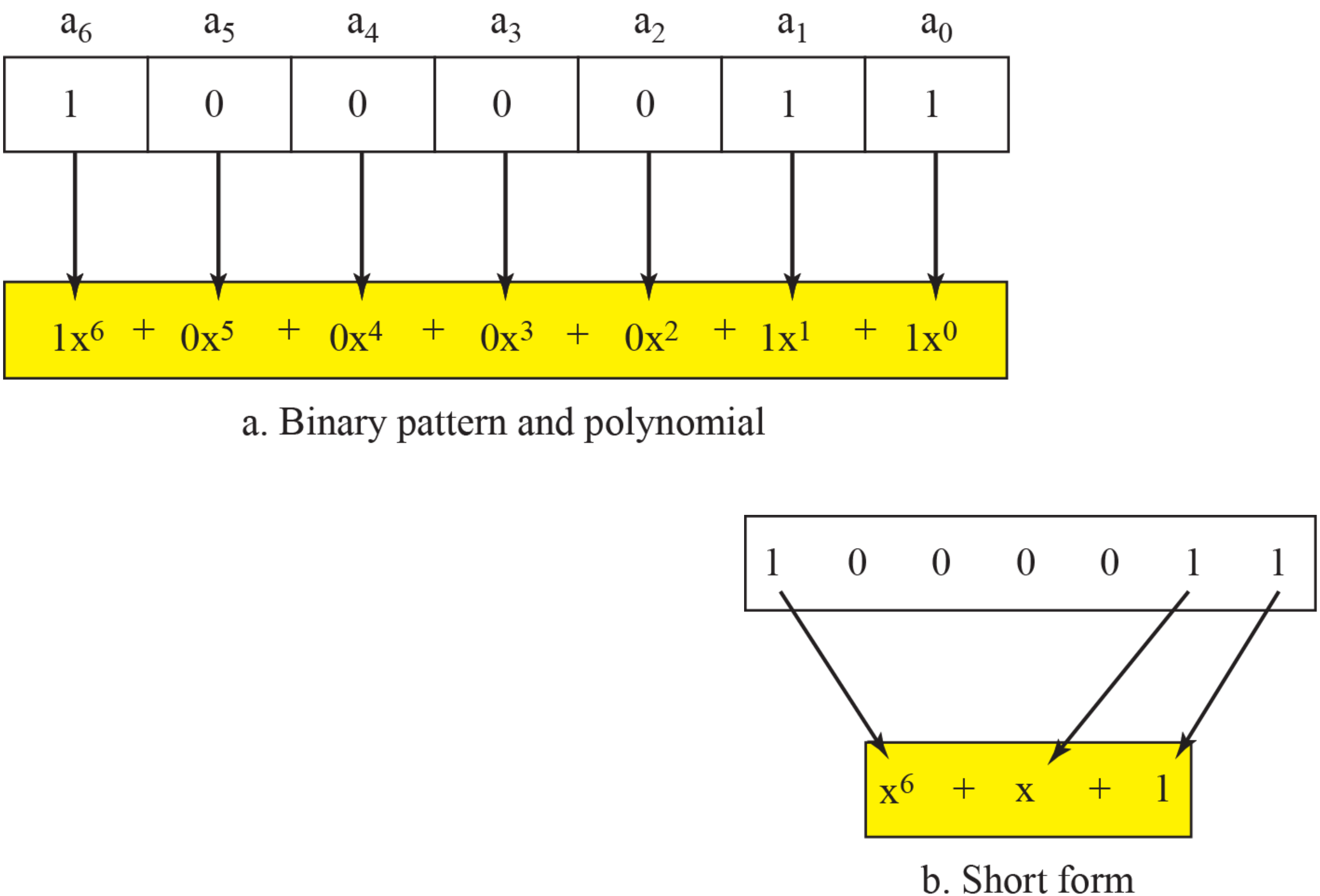
- A better way to understand cyclic codes

- A pattern of 0s and 1s can be represented as a polynomial with coefficients of 0 and 1.

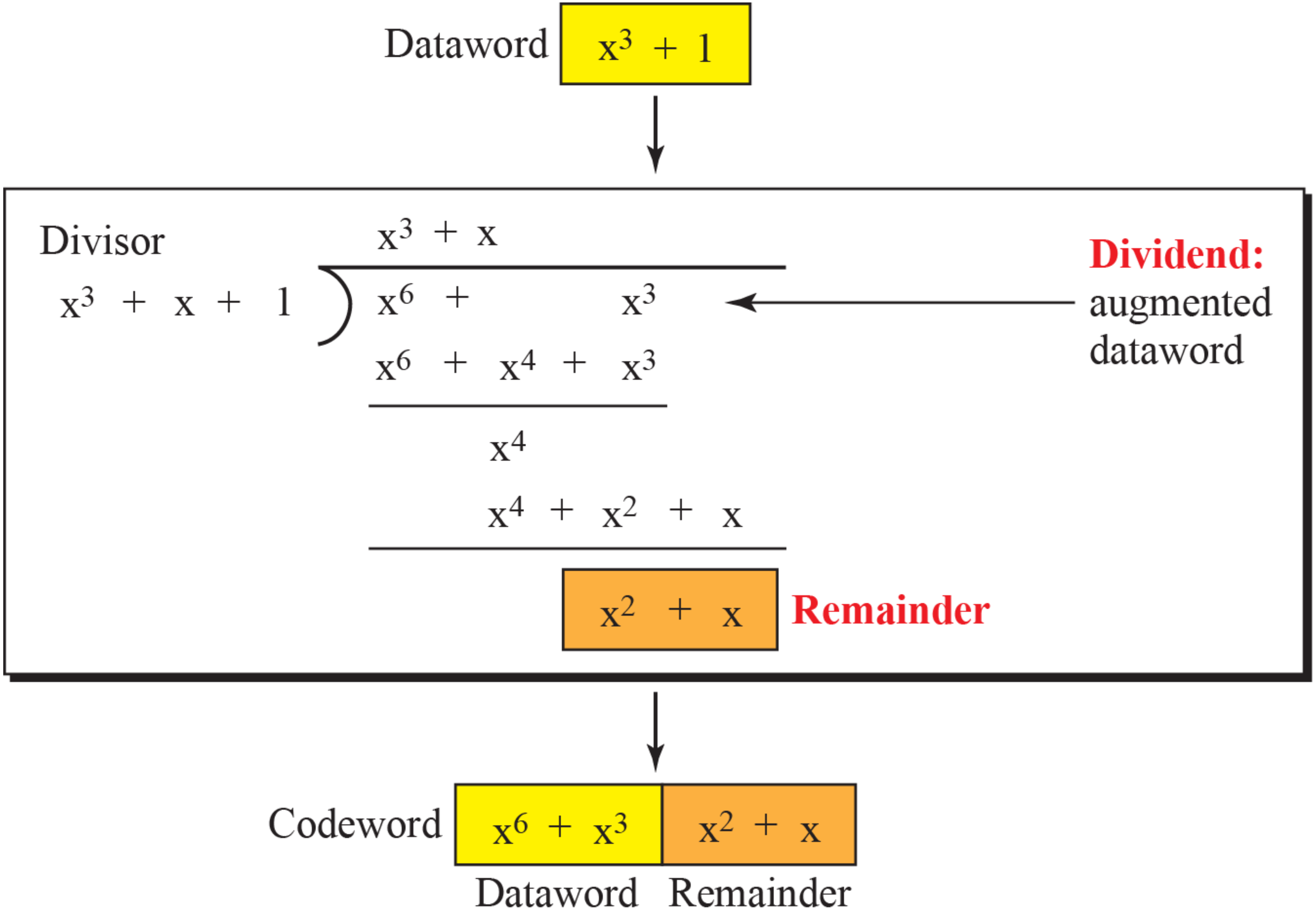
- The power of each term shows the position of the bit

- the coefficient shows the value of the bit.

Figure 10.8: A polynomial to represent a binary word



CRC division using polynomials



Standard polynomials

Name	*Polynomial*	*Used in*
CRC-8	$x^8 + x^2 + x + 1$ 100000111	ATM header
CRC-10	$x^{10} + x^9 + x^5 + x^4 + x^2 + 1$ 11000110101	ATM AAL
CRC-16	$x^{16} + x^{12} + x^5 + 1$ 10001000000100001	HDLC
CRC-32	$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$ 100000100110000010001110110110111	LANs

Checksum

- Checksum is an error-detecting technique that can be applied to a message of any length.

- In the Internet, the checksum technique is mostly used at the network and transport layer rather than the data-link layer.