

Error Detection and Correction in Computer Systems

When data is stored in memory or transmitted between devices, it can get corrupted due to noise, hardware faults, or transmission errors. To ensure data integrity, computer systems use Error Detection Codes and Error Correction Codes.

A. Error Detection Codes

These are used to check whether an error has occurred during data transmission/storage.

Common Techniques:

1. Parity Bit

A single bit is added to the data.

Even Parity → The total number of 1's (including parity) should be even.

Odd Parity → The total number of 1's should be odd.

Example: Data `1010` with even parity → `10101`.

2. Checksums

Data is divided into blocks.

A sum is calculated and sent along with the data.

Receiver recalculates the sum and compares it with the sent checksum.

3. Cyclic Redundancy Check (CRC)

Uses polynomial division to generate a CRC code.

Very powerful in detecting burst errors in communication.

Limitation: Detection codes only detect errors, they cannot fix them.

B. Error Correction Codes (ECC)

These not only detect but also correct errors automatically.

- 1. Hamming Code**

- 2. Reed–Solomon Code**

Used in CDs, DVDs, QR codes, and data transmission.

Corrects burst errors effectively.

- 3. Convolutional Codes & Turbo Codes**

Used in modern communication systems like Wi-Fi, 4G/5G, satellite communication.