IT 4505
Section 1.3

Data Transmission Concepts

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1.3.4 Error control methods

Error types

- **single bit errors :**

  This errors are caused by

  extreme values of thermal noise that overwhelm the signal briefly and occasionally.

  Presents on optical fiber.

- **Burst errors:**

  This model follows from the physical processes that generate them (such as a deep fade on a wireless channel) transient electrical interference on a wired channel, causing a series of bits to corrupt.

  Eg: loss of bits.

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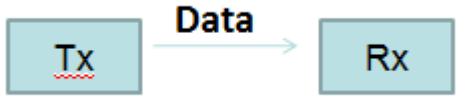
Error Control

There are two basic strategies for dealing with errors. Both add redundant information to the data that is sent.

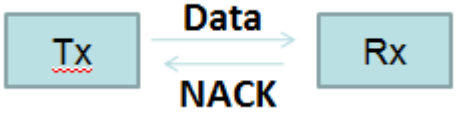
- Forward Error Control

  Send extra redundant bits with the data. The redundant bits are used by the receivers to recover the original data in case of an error.



- Feedback Error Control

  The frame contains only enough information for the receiver to detect errors. In case of an error the receiver requests the sender to resend the frame.



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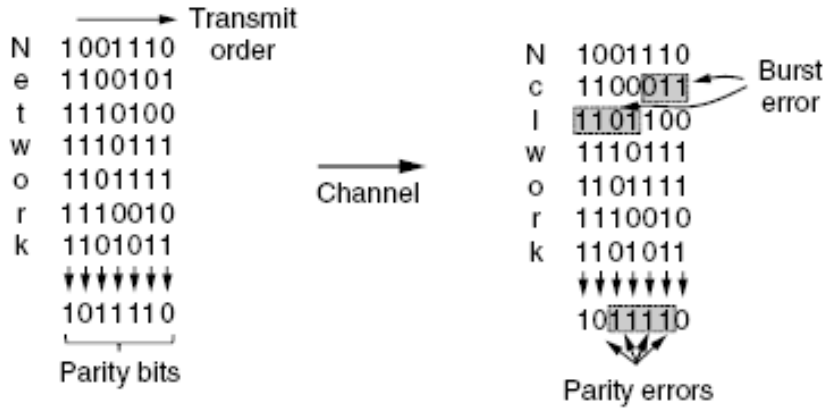
1.3.5 Error detection

Some popular error-detecting codes exist. They are all linear(based on liner operations) and systematic block codes(constant length code words).

- Parity check
- Cyclic Redundancy Check (CRC)



Interleaving of parity bits to detect a burst error.

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Parity Check

- Transmitter adds an additional bit to each character code before transmission
    - This extra bit is called the parity bit
    - Even parity
        - Parity bit makes the total number of 1's in the [character+parity] even
    - Odd parity
        - Total number of 1's are odd
- The receiver checks whether the parity is correct
    - If not it indicates an error ; detects only 1-bit errors.

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Cyclic Redundancy Check

- A **cyclic redundancy check** (**CRC**) is an error detecting code used in digital networks and storage devices. Also known as a **polynomial code.**

- Polynomial codes are based upon treating bit strings as representations of polynomials with coefficients of 0 and 1 only.

- Blocks of data entering these systems get a short *check value* attached.

- They are simple to implement.

- Easy to analyze mathematically.

- Particularly good at detecting common errors caused in transmission channels.

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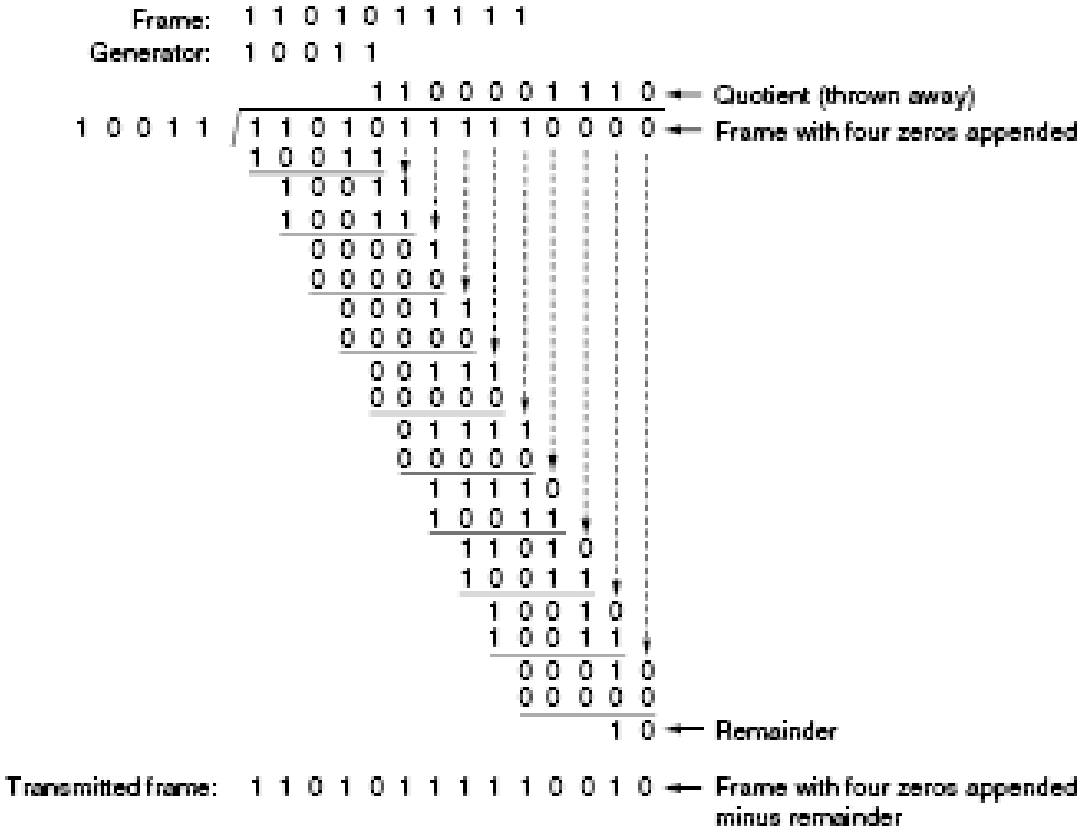
Cyclic Redundancy Check cont.

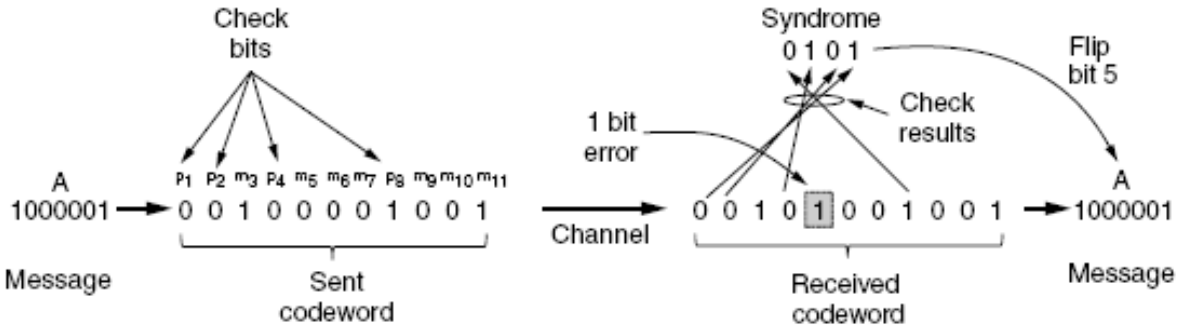


Example calculation of the CRC.

1.3.6 Error Correction

Here are four different error-correcting codes:

1. Hamming codes.
2. Binary convolution codes.
3. Reed-Solomon codes.
4. Low-Density Parity Check codes.



Example of an (11, 7) Hamming code correcting a single-bit error.

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Hamming Codes

- 1-bit error correcting code
- Bits of the code word are numbered consecutively
  - Bit 1 is the leftmost bit
- The bits that are of power of two (1, 2, 4 etc.) are check bits (r bits)
- Other bits (3, 5, 6 etc.) are data bits (m bits)

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Hamming Codes

- A check bit forces the parity of some collection of bits including itself
  - To find the check bits that the data bit at position k contributes to write the k as a sum of power of 2
    - Example 11 = 1 + 2+ 8
    - bit 11 is checked by the check bits 1, 2 and 8

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Hamming Codes

- On arrival of a code word the receiver initializes a counter to 0
- Then check the each check bit, k, to see whether it has the correct parity
  - if not add k to the counter
- At the end if the counter is zero the word is accepted as correct
  - else the counter contains the number of the incorrect bit

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End of Chapter