Transmission Errors and Correction

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Source of transmission errors

1. Noise - Unwanted *random* signals or fluctuations
2. Interference - Disruption caused by *external signals*
3. Distortion - *Changes in the shape* or form of the data signal

Single Bit Error

1010110 -> 10**0**0110

Burst Error

A group of bits within a block are changed due to a longer-duration disturbance. Often caused by sustained interferences over a longer period of time.

Bursts start at the first error and end at the last error.

Erasure

A signal received is ambiguous or unclear. Often caused by distortion or strong interference.

Hamming Distance

Given two strings of *n* bits each, the Hamming Distance is defined as the numebr of differences. 10110001011 and 10011010111 have a Hamming Distance of 5.

Error Handling

If we *know* that there is an error in some data that we received...

- Ask sender to send the data again.
- Correct error on our side.

Correction vs. Detection

Detection Identify whether an error has occurred during data.
Generally simpler with less overhead.

Correction Identify and correct the error.
More complex and requires redundancy, but allows for self-correction without retransmission.

Redundancy

One method for error detection is introducing redundancy.

Notationally:

- a *dataword* is the original data
- a *codeword* is the dataword with redundancy added

if a dataword has k bits and r redundant bits are added, the encoding is called an

$$(n, k) \text{ encoding scheme, where } n = k + r$$

Sender	Receiver
Dataword	Dataword
Encoder	Decoder -> Redundant Bits
Codeword	Discard

Parity

Single Parity Checking (SPC) adds a single *parity bit* to data to ensure an even or odd number of 1s.

If a burst error occurs which changes an even number of bits, the receiver will incorrectly classify the data as correct.

No error detection is perfect, some errors may go undetected. The goal becomes:

1. Minimize the possibility that one valid codeword can be transformed into another valid codeword.
2. Minimize the number of redundant bits we must add to the message.

Hamming Distance and Robustness

Data	Code
00	001
01	010
10	100
11	111

All have a hamming distance between each other of 2.

Error Detection Trade Off A larger min distance (d_{min}) between codewords is beneficial for error detection.

If fewere than d_{min} bits are changed, the error can be detected.

The max number of detectable bit errors is:

$$e = d_{min} - 1$$

RAC Parity

Error correction method using 2D parity checks. Data organized into a grid with parity bits added for each row and column.