8.5 Error detection

Parity

When bit values are sent across wires, especially between chips, electrical interference can erroneously change a 0 to 1 or

Even parity is a method of detecting that a single bit error in a group of sent data bits, by sending a bit whose value makes of 1's even. Ex: A sender (like a memory) wants to send 0111, which has three 1's. The sender appends a 1 to make four 1's 10111. A receiver (like a processor) ensures the number of 1's is even, then discards the parity bit.

PARTICIPATION ACTIVITY 8.5.1: Even parity detects a single bit error.

Start 2x speed

Sender			Receiver		
Even parity bit	Data		Received bits	Data	
1	1110	1 1110	1 1110	1110	
0	0110	0 0110	0 0110	0110	
0	0000	0 0000	0 0000	0000	
0	0110	0 1110	0 1110	Error	*Not even*
0	0110	1 0110	0 0110	Error	*Not even*
0	0110	1 1110	1 1110	1110	*Two errors not detected*

Parity can detect 1, 3, 5, ..., errors. Parity cannot detect 2, 4, 6, ..., errors. Ex: For even parity, 0110 would be sent as 00110. T be 01111 or 00000; the receiver notes an even number of 1's (two) so believes the data is correct. Likewise, four errors mig 01001, each having an even number of 1's.

Parity is popular due to only requiring one extra bit, and to being easy to implement in hardware (computable using a single gate).

Odd parity sets a parity bit with 0 or 1 to make total bits odd, rather than even. Both sender and receiver must agree on whe or even parity.

Example 8.5.1: ASCII codes and parity.

ASCII code is often said to use 8 bits, but in fact the leftmost bit is always 0. Ex: 'A' is 01000001. ASCII code actually uses just 7 bits; the 8th bit can be set as a parity bit. Below are a few ASCII encodings showing an even parity bit as the leftmost bit.

Parity bit	Bit code	Dec	Char
1	100 0000	64	@
0	100 0001	65	A
0	100 0010	66	B
1	100 0011	67	C
0	100 0100	68	D
1	100 0101	69	E
1	100 0110	70	F
0	100 0111	71	G

PARTICIPATION ACTIVITY 8.5.2: Parity bit.

Assume the parity bit is placed in the leftmost digit.

1) To send 1011, the even parity bit should be ___.
   - 0
   - 1

2) To send 1111, the even parity bit should be ___.
   - 0
   - 1

3) To send 1111001, the even parity bit should be ___.
   - 0
   - 1

4) Received bits are 10000111. Even parity is used. What is the received data?
   - 0000111
   - Error

5) Received bits are 11100000. Even parity is used. What is the received data?
   - 1100000
   - Error

6) Received bits are 11000110. Even parity is used. What ASCII character was received?

- F
- Error

7) To send 1011 using odd parity, the parity bit should be ___.
   - 0
   - 1

8) The sender and receiver must know how many bits are in a group of bits that includes a parity bit.
   - True
   - False

9) If a parity error is detected, the receiver knows which bit contains the error.
   - True
   - False

10) Parity detects any number of errors.
    - True
    - False

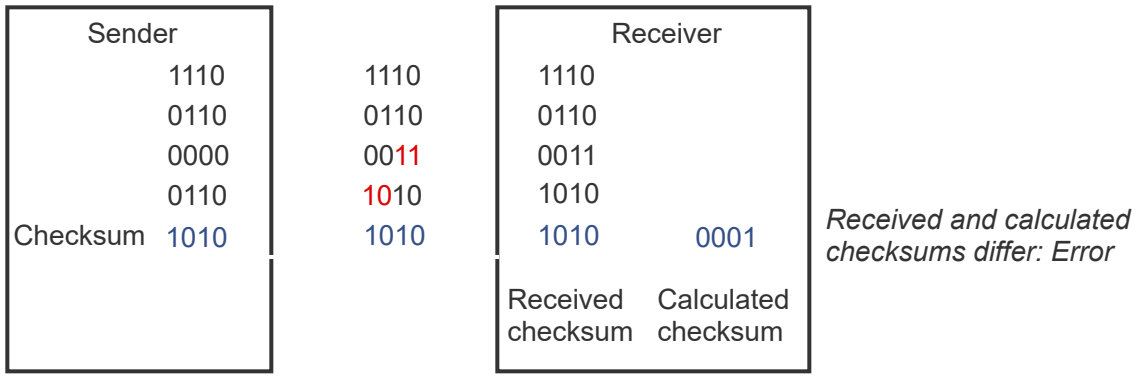
11) A sender can use a(n) _____ gate to compute an even parity bit.
    - XOR
    - XNOR

Checksum

A ***checksum*** is an error detection approach wherein data to be sent is divided into chunks whose sum is sent along; if the r sum doesn't match the sent sum, one or more errors occurred. A checksum is more costly to compute than parity, but can errors.

PARTICIPATION ACTIVITY 8.5.3: A checksum approach can detect multiple errors.

Start 2x speed



PARTICIPATION ACTIVITY 8.5.4: Checksum.

1) 8 bits 00010011 are to be sent. The checksum computed on 4-bit chunks is ____ .

   - 0111
   - 0100

2) 12 bits are received in 4-bit chunks: 0000, 1111, and 0001 (checksum). Did

an error occur?

- Yes
- No

3) Does checksum detect all errors?

- Yes
- No

4) Checksum is easier to calculate than parity.

- True
- False

An even more sophisticated form of checksum (not discussed here), known as a cyclic redundancy check (CRC), is even le errors, at the expense of more calculation. The term "checksum" is used for nearly any way of combining data for error che sum is involved.

Exploring further:

- Checksum (Wikipedia)
- CRC (Wikipedia)

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