

Data Link Layer: Error Detection

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General Approach

- Add redundant information to a frame
- At Sender:
 - Add **k** bits of redundant data to a **m** bit message
 - $k \ll m$; $k = 32$; $m = 12,000$ for Ethernet
 - k derived from original message through some algorithm
- At Receiver:
 - Reapply same algorithm as sender to detect errors; take corrective action if necessary

Parity Bit

- Even Parity: 1100, send 11000
- Detects odd number of errors

Two Dimensional Parity

1101001	0
1011110	1
1001000	0
1111001	1
0000110	0

Parity Bits

Data

- Used by BISYNC protocol for ASCII characters
- “N + 8” bits of redundancy for “N” ASCII characters (character is 7 bits)
- Catches all 1, 2, 3 bit errors and most 4 bit errors

Internet Checksum

- Used at the network layer (IP header)
- Algorithm:
 - View data to be transmitted as a sequence of 16-bit integers.
 - Add the integers using 16 bit one's complement arithmetic.
 - Take the one's complement of the result – this result is the checksum
 - Receiver performs same calculation on received data and compares result with received checksum

Example

- Sender: IPV4 header in hexadecimal
 - 4500 0073 0000 4000 4011 c0a8 0001 c0a8 00c7 (16-bit words)
 - Sum up the words (can use 32 bits): 0002 479c
 - Add carry to the 16-bit sum: 479e
 - Take the complement: b861 → checksum
- Receiver:
 - Sum up the words including checksum (use 32 bits): 2fffd
 - Add carry to the 16 bit sum: ffff (= 0 in 1's complement) → no error was detected

Internet Checksum

- Not very strong in detecting errors
 - Pair of single-bit errors, one which increments a word, other decrements a word by same amount
- Why is it used still?
 - Very easy to implement in software
 - Majority of errors picked by CRC at link-level (implemented in hardware)

Cyclic Redundancy Check (CRC)

- Used by many link-level protocols: HDLC, DDCMP, Ethernet, Token-Ring
- Uses powerful math based on finite fields

Summary

- Important to detect errors in frames
- Many techniques exist (simple to complex)
 - Parity, Checksum, CRC
- Error Detection often used in conjunction with error control (reliable data transfer protocols)