Lecture 4

How to rate networks

- Speed
  - Bitrate
  - Goodput
- Last long
- Reliable
- Cost

Token ring vs CSMA

Token Ring	**CSMA**
You can calculate the longest delay (deterministic)	If one machine is disconnected there wont be any problems
Better speed	Cheaper
Token needs to be passed constantly, only one at all times.	Longest delay cannot be reliably calculated
If a machine detaches that currently owns the token, the whole network is blocked	

Transmission Error Detection

- Simple parity bits can be added to code words to detect bit b_nb_{n-1}...b_1b_0errors, however, aren't very strong in detecting errors which affect multiple bits
- Computation of error check codes must be efficient

Cyclic Redundancy Check (CRC)

A bit sequence (bit block) $b_n b_{n-1} \dots b_1 b_0$ is represented as a polynomial $B(x) = b_n x^n + b_{n-1} x^{n-1} + \dots + b_1 x + b_0$. A generator polynomial $G(x) = g_r x^r + \dots + g_1 x + g_0$ with $g_r = 1$ and $g_0 = 1$ is agreed upon between the sender and the receiver. The sender transmits $U(x) = x^r \cdot B(x) + t(x)$ with $t(x) = (x^r \cdot B(x)) \mod G(x)$. Then the receiver tests whether the polynomial corresponding to the received bit sequence can be divided by $G(x)$ without a remainder.

- Efficient hardware implementation possible using XOR gates and shift registers
- Only errors divisible by $G(x)$ will go undetected

Choosing Generator Polynomials

- $G(x)$ detects all single-bit errors if $G(x)$ has more than one non-zero term

- $G(x)$ detects all double-bit errors, as long as $G(x)$ has a factor with three terms
- $G(x)$ detects any odd number of errors, as long as $G(x)$ contains the factor $(x+1)$
- $G(x)$ detects any burst errors for which the length of the burst is less than or equal to r
- $G(x)$ detects a fraction of error bursts of length $r+1$; the fraction equals to $1-2^{-r}$
- $G(x)$ detects a fraction of error bursts of length greater than $r+1$; the fraction equals to $1-2^{-r}$

Internet Checksum

Properties

- Summation is commutative
- Computation independent of the byte order
- Computation can be parallelized on processors with word sizes larger than 16-bit
- Individual data fields can be modified without having to recompute the whole checksum
- Can be integrated in a copy loop
- Often implemented in assembler or special hardware

Further Error Situations

- Despite bit errors, the following transmission errors can occur:
    - Loss of complete data frames
    - Duplication of complete data frames
    - Receipt of data frames that are never sent
    - Reordering of data frames during transmission
- The sender must adapt its speed to the speed of the receiver (end-to-end flow control)
- The sender must react to congestion situations in a network (congestion control)