Computer Networks

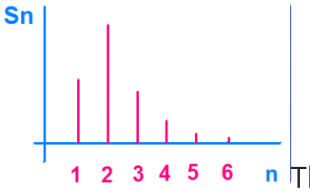
Obsah

Data Transfers

We can classify transfers using several criteria:

- **According to the Direction of the Communication**
  - Simplex – signal can flow in only one direction;
  - Half duplex – communication is possible in both directions, but only one direction at a time;
  - Full duplex – allows communication in both directions simultaneously.
- **According to the Multiple of Units in Communication**
  - Parallel – multiple bits transmitted in parallel;
  - Serial – data are transmitted bit-by-bit, mostly used in computer networks;
    - Asynchronous Serial Communication – data are transmitted character by character, both sides maintain their own clocks; before transmission of every single character, the phase of a receiver clock is synchronized; the parity bit at the end of each character helps to detect transmission errors;
    - Synchronous Serial Communication – data are transmitted in frames containing header, payload and frame checksum delimited by flags in a transmitted bit stream. If there are no data to transmit, the transmitter transmits just the empty frames.
- **According to the means of Transmission**
  - Baseband – utilizes the full bandwidth of the medium; the signal can include frequencies that are very near zero
  - Broadband – uses a specific part of the utilizable bandwidth of the medium, multiple communications may share the medium at the same time

Data Transmission Processes



The transmitted data are represented by changes of a suitable physical quantity, i.e. a **signal** $s(t)$. The signal travels along the **medium** (either guided or wireless). **Transmitter encodes** the signal with **modulation** to transfer via medium to use **demodulation** and **decoding** on the **receiver** side. Via travelling through the medium, we care about several **media** characteristics - attenuation (decreasing the

amplitude of signal), crosstalk, velocity of the signal propagation or return loss. Media characteristics are often frequency-dependent.

Harmonic Decomposition of Signal

Sine-wave signal contains just the single frequency, any other periodic signal may be treated as a sum of the sine-wave signals of various frequencies (decomposing signal into the **harmonic components**). Using Fourier series we use discrete decomposition with first n components and create the **frequency spectrum of the signal** and asses the media characteristics with the signal.

Broadband Transmission

The signal have to be shifted to a frequency band suitable for transmission over a particular medium using the **modulation**. Using sine-wave equation $s(t) = A \cdot \sin(\omega t + \phi)$ we define amplitude, frequency and phase modulation.

- **Phase-Shift Keying** (PSK) – if we have 2^n possible phase changes, we may encode n bits using one signal change. The number of possible signal change options is limited by capability of the receiver to differentiate between them;
- **Quadrature Amplitude Modulation** (QAM, QAM64) – combines together the amplitude and PSK modulation.

Modulation Rate is a number of changes of a signal during a time interval, measured in *bauds* $[Bd]$. **Transfer rate** is a number of bits transferred during a time interval, measured in *bits per seconds* $[bps]$. The transfer rate can be higher than the modulation rate, as we may represent multiple bits by a single signal change.

Baseband Transmission

The encoded bit stream is transmitted in the original frequency band. We need an another mechanism of the phase synchronization between transmitter and receiver using **data encoding** – we need to ensure enough changes of the signal.

- **Non Return to Zero Encoding (NRZ)** – 0s and 1s are encoded directly by a low and high signal levels during the whole bit interval.
- **Line code** – http://en.wikipedia.org/wiki/Line_code
- **Manchester** – 1 is expressed by a low-to-high transition at the middle of the period, a 0 by a high-to-low transition; used in 10Mbps Ethernet
- **Differential Manchester** – 0 is expressed as a signal change at the beginning of a period, 1 is an unchanged value
- **Return Zero (RZ)** – three signal levels, the first half of the bit interval encodes the bit value (+1 represents 1, -1 represents 0), the signal always goes to 0 in the second half of the bit interval.
- **Non Return to Zero Inverted (NRZI)** – two signal levels, change of the signal encodes binary 1
- **Alternate Mark Inversion (AMI)** – 3 signal levels, binary 0 represented as 0, binary 1 alternates +1 and -1, violation of polarity marks a significant event in the data stream.

- **HDB3** – modification of AMI, inserts 1 after 3 consecutive 0s, the inserted 1 is identified by violation of polarity alternation rule, used on PCM E1-E3 links
- **Code Mark Inversion (CMI)** – transfers AMI/HDB3 over optical lines, the one of the original 3 signal levels is encoded as a combination of two bits