

# Computer Networks

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## Obsah

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- Data Transfers
  - Data Transmission Processes
    - Broadband Transmission
    - Baseband Transmission

# Data Transfers

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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**

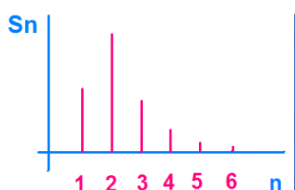
- Parallel – multiple bits transmitted in parallel;
- Serial – data are transmitted bit-by-bit, mostly used in computer networks;
  - Asynchronous Serial Communication – data are transmitted character by character, both sides maintain their own clocks; before transmission of every single character, the 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

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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 assess the media characteristics with the signal.

### Broadband Transmission

The signal has 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 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](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
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