Computer Networks

Session 03

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General Schedule

All exercises will follow this general schedule

- Identify potential understanding problems
  → Ask your questions
  → Recap of the lecture
- Address the understanding problems
  → Answer your questions
  → Repeat certain topics
- Walk through the exercises/solutions → Some hints and guidance
  → Work time or presentation of results

Reference Models

You have seen . . .

- how a Computer Network can be broken down into layers
- what a reference model is and which relevant ones exist
- which layers exist in the hybrid reference model and what tasks they have

Topologies

You have seen ...

- what a topology is
- what the difference between the physical and the logical topology is
- the advantages and drawbacks of the different topologies
- which topologies are used in current networks

Fundamentals of Data Signals

You have seen . . .

- how an analog signal can be transformed into a digital signal (and vice versa) using quantization and sampling
- how often a channel needs to be sampled to reconstruct the original analog signal
- how a square wave signal can be constructed by a fundamental frequency and its harmonics
- the difference between bandwidth, data rate, and symbol rate
- what data date can be achieved on a noiseless and a noisy channel with finite bandwidth

Data Encoding

You have seen . . .

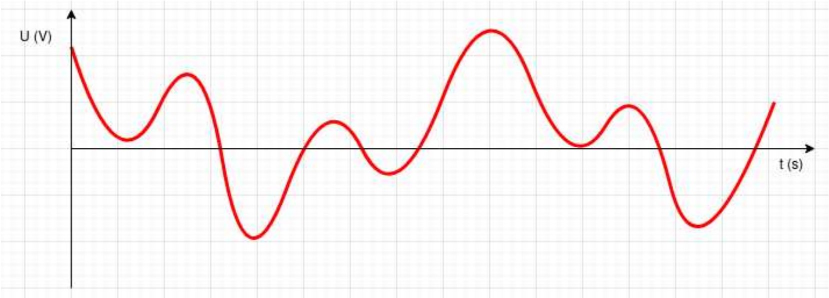
- what a baseband transmission is
- which requirements exist for a good encoding (robustness, efficiency, and clock recovery)
- several line codes and how they relate to these requirements
- what the problems of baseline wander and clock recovery are and how to tackle them

Any other questions left?

Exercise 1: Layers of Reference Models

- Protocol example for the session layer
  - Point-to-Point Tunneling Protocol (PPTP) was used for Virtual Private Networks (VPNs)
  - Encapsulate layer 2 frames into a TCP control channel
  - Layer 3 protocols like IP can be transported over PPTP
  - Password Authentication Protocol (PAP) can be used for password-based authentication
- Protocol example for the presentation layer
  - External Data Representation (XDR) is a data serialization format
  - It allows for de- and encoding between different representations of data types
  - Supported data types comprise: `boolean`, `int`, `float`, `enumerations` ...
  - An example can be found here:
    `https://github.com/brendanhay/xdr/blob/master/example.xdr`

Exercise 2: Quantization and Sampling



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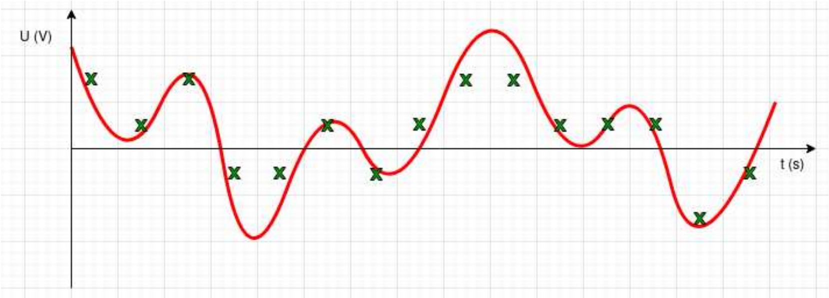

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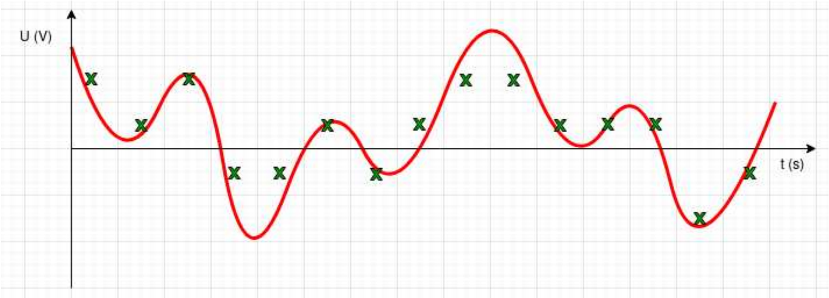


- Until the 1980s the whole telephone system was voice only

⇒ the lowest frequency was 300 Hz, the highest frequency was 3.4 kHz

Exercise 3 and 4: Bit, Symbol and Data Rate

Remember the differences between bit rate and symbol rate:

Bit rate

- The number of bits that can be transmitted per unit of time
- Typically expressed as bit/s, or bps in conjunction with a SI prefix
- The physical layer defines the gross bitrate
- It is also used in digital multimedia to represent the number of bits used to encode audio or videos

Baud rate

- Number of symbol or waveform changes per unit of time
- Typically expressed as baud (Bd)
- The symbol duration time or unit interval is T_s
  $T_s = \frac{1}{f_s}$
  where f_s is the symbol rate

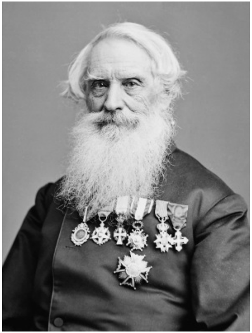
The bit rate depends on the bandwidth of the communication channel and the number of bits per symbol

Encoding Data

Image source: Wikipedia (CC0)

- Efficient data encoding is important not only since the rise of computer networks
- An example for an efficient encoding is the Morse Code, invented by Samuel Morse from 1838

A	· —	M	— —	Y	— · — —
B	— · · ·	N	— ·	Z	— — · ·
C	— · — ·	O	— — —	1	· — — — —
D	— · ·	P	· — — ·	2	· · — — —
E	·	Q	— — · —	3	· · · — —
F	· · — ·	R	· — ·	4	· · · · —
G	— — ·	S	· · ·	5	· · · · ·
H	· · · ·	T	—	6	— · · · ·
I	· ·	U	· · —	7	— — · · ·
J	· — — —	V	· · · —	8	— — — · ·
K	— · —	W	· — —	9	— — — — ·
L	· — · ·	X	— · · —	0	— — — — —



Samuel Morse (1791 – 1872)