

# Computer Networks

## Exercise 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 rate 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
- how an encoding of **group of bits** in combination of another encoding can be used to address all requirements → e.g., **4B/5B**

# Modulation

You have seen ...

- how data can be **modulated** onto a **carrier frequency** in **broadband**
- what **amplitude**, **frequency**, and **phase modulation** are
- which advantages and drawbacks these methods have

Any other questions left?

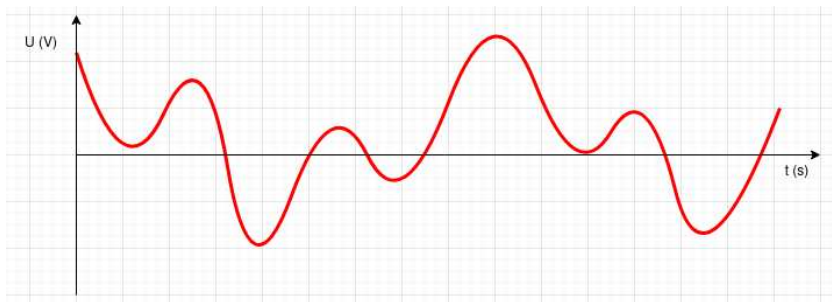




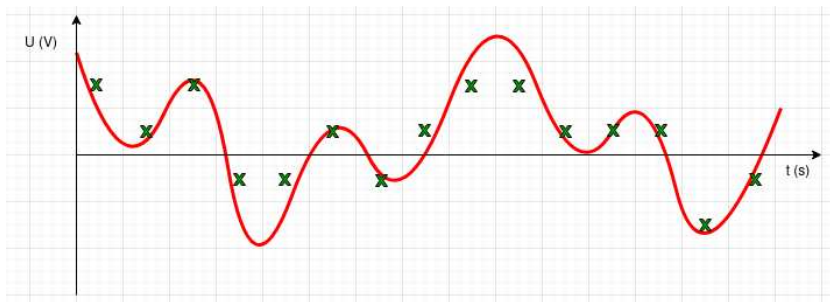
# Exercise 1: Layers of Reference Models

- 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>

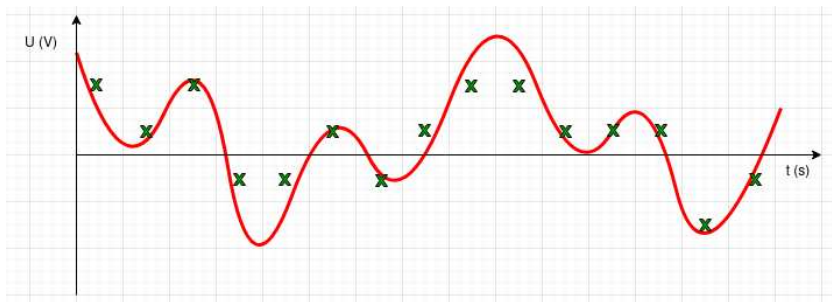
## Exercise 2: Quantization and Sampling



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- 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

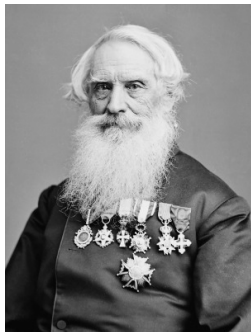
The **bit rate** depends on the **bandwidth** of the communication channel and the **number of bits per symbol**

# 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)