Summary Computer Networks

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Contents

1   Motivation

1.1   Communication Metaphors

- Phase 1: Person to person

- Phase 2: Person to machine

- Phase 3: Machine to machine/Network of computers

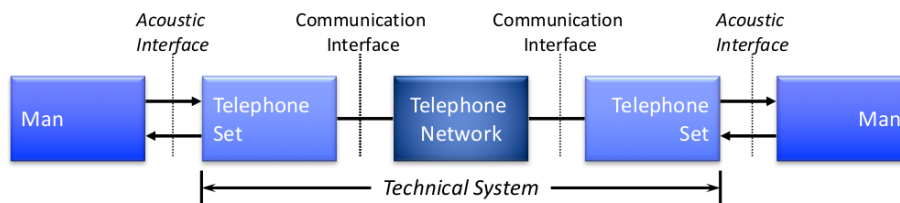- Phase 4: The internet of Things

1.2   History

- 1837: Samuel Morse develops the telegraph

- 1953: First transatlantic Telephone line

- 1876: Alexander Graham Bell patents the telephone (tele=distant, phone=voice)
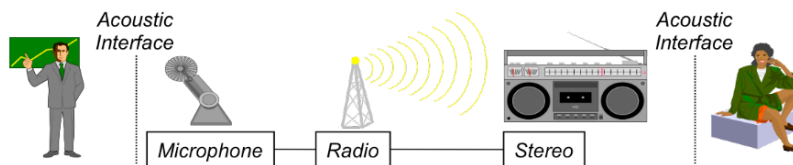
1.3 Telephone Network

Existing networks are going to be integrated
- **Model of telecommunication**

- **Model of broadcasting**

1.4 The Internet

7 The internet consists of

- a set of computers, which

  - use the TCP/IP protocols
  - are somehow (directly or indirectly) connected
  - offer or use particular services

- a set of users, which have access to these services

- a set of other networks, which (somehow) are accessible

Design Principles

- Minimalism and autonomy - The network operates by itself , does not require internal changes when new networks are added

- Best-effort service model

- Soft-state (stateless) - The routers do not need to maintain end-to-end communication information

- Decentralization

2 Introduction

2.1 Data Communication

Data communication is the processing and the transport of digital data over connections between computers (generally over large distances).
Data communication comprises two areas: Computer Networks and Communication Protocols

2.2 What is Digital Data?

- Data: Representation of facts in a formal way, processable by humans and machines, e.g. a language

- Information: is whatever contributes to a reduction in the uncertainty of the state of a system, can only be handled by humans

- Signal: is the physical representation of data by spatial or timely variation of physical characteristics

- Example: Sounds of a language (Data) during speaking are acoustic waves (Signals)

2.3 Data Communication

- Sharing resources saves costs

- Exchange of information

2.4 Networking Principles

Communication Peers

- Unicast: Two communication peers communicate over a Point-to-Point connection.

- Multicast: One sender communicates to several receivers, which are known.

- Broadcast: One sender transmits to all other peers. Typically the other peers are (partially) unknown.

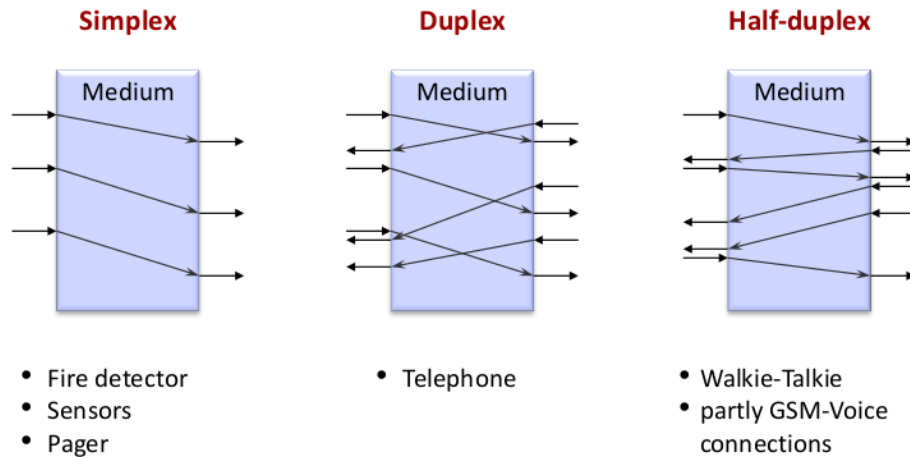- Others: Anycast, Geocast, etc.

Transmission

- Serial Transmission

- Parallel Transmission (Problem: synchronisation of the data)

- Asynchronous Transmission: Transmission in which each block (character) is individually synchronized
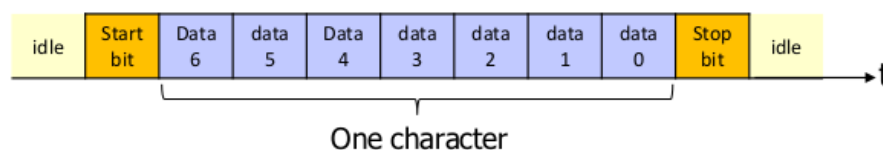
- Synchronous Transmission: Transmission in which the time of occurrence of each signal representing a bit is related to a fixed time frame

Connection Properties

Simplex	Duplex	Half-duplex
Medium	Medium	Medium

- Fire detector
- Sensors
- Pager

- Telephone

- Walkie-Talkie
- partly GSM-Voice connections

Multiplexing: Combining multiple data channels into a single data channel at the source

Quality

- Technical Performance (Delay-Bandwidth-Product = Store capacity of the line)
  - Delay [s]
  - Jitter [s]
  - Throughput [bit/s]
  - Data rate [bit/s] (wird vorgegeben)
- Costs
- Reliability
- Security and Protection
  Safety measures: Encryption, Trustworthy systems

Passive: Eavesdropping

Active: Modifying — Masquerade — Interruption
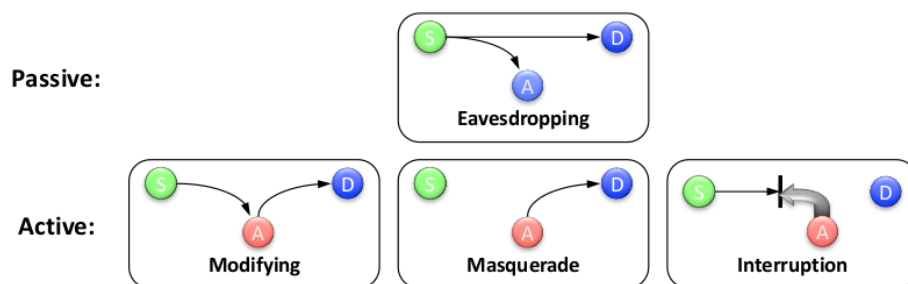
The Client/Server Principle

- Client → Server: Request

- Server → Client: Reply

- Advantages
  - Cost reduction
  - Better usage of resources
  - Modular extensions

4

– Reliability by redundancy

- Server: Program (process) which offers a service over a network.

- Client: Program (process) which uses a service offered by a server.

Peer-to-Peer Principle (ursprüngliche Kommunikation im Internet)

- Equal partners, no fixed client and server roles

- Connections between any pair of computers

- Establishment of a whole network of connections

- Best example: File Sharing, e.g., Napster, Gnutella

2.5 Communication Protocols

A protocol is the set of agreements between (application) processes with the purpose of communication.

To enable understanding in communication, all communication partners have to speak the same language.

- Data formats and their semantics

- Control over media access

- Priorities

- Handling of transmission errors

- Sequence control

- Flow control mechanisms

- Segmentation and composition of long messages

- Multiplexing

- Routing
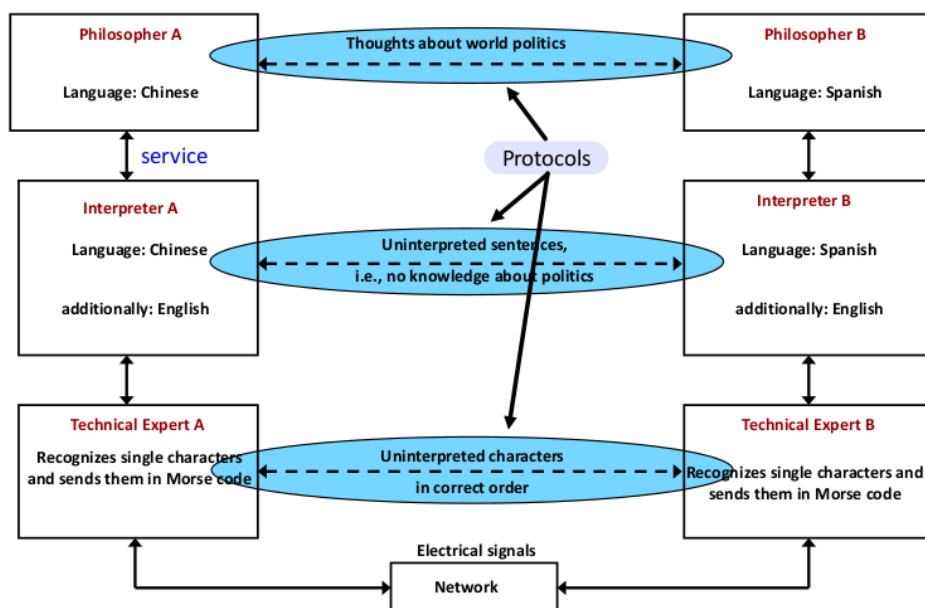
$\rightarrow$ communication between horizontal layers

Peer of a Layer

- use one service (except the bottom)

- offer a service (except the top)

- do not need to know other than the next lower one

- talk according to the rules

Communication architectures are based on

- Service = Communication Service

- Rules = Communication Protocol

A service is offered from a service provider at a service interface to service users.
Types of services are:

- Request

- Indication

- Response

- Confirmation
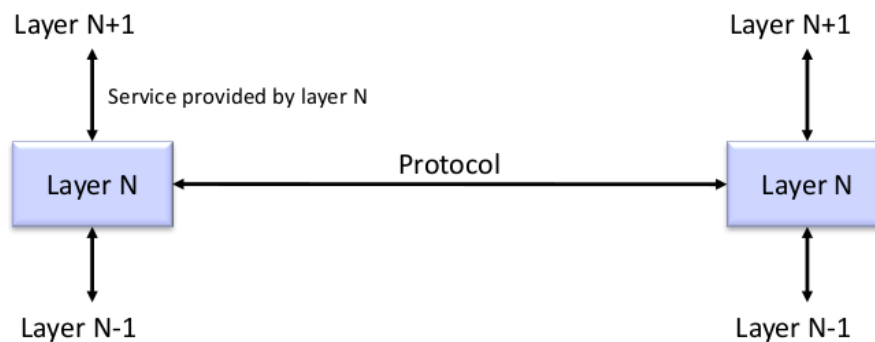
Types of Services

- Unacknowledged Service

  - Modeled after the postal service
  - Initiated by the service user

- Acknowledged Service (Transaction)

- Connection-oriented Service

  - Modeled after the telephone system
  - Before the instances on Layer-(N) can exchange data, a connection on Layer-(N-1) has to be established
  - Negotiation of protocol parameters
    → Communication context

- Connectionless Service

  - Modeled after the postal service

– No establishment of connection on a lower layer required
  → No communication context
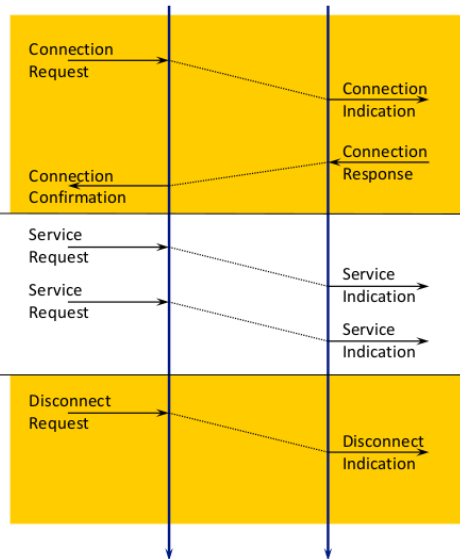
Connection-oriented Service

Three Steps

1. Connection establishment
- Context creation
  - End systems
  - Network

Connection Request
Connection Indication
Connection Response
Connection Confirmation

2. Data exchange (simplex)

Service Request
Service Request
Service Indication
Service Indication

3. Connection termination
- Context release
- Resource release

Disconnect Request
Disconnect Indication

Connectionless Service

- **Connectionless Service is also called Datagram Service**
  - Does not provide relationship between transmissions
  - Does not guarantee the sequence of send data
 - Does not provide reliability
    - No acks!

UnitData.Req
Source address,
Dest address,
Parameter,
Data

UnitData.Ind
Source address,
Dest address,
Parameter,
Data
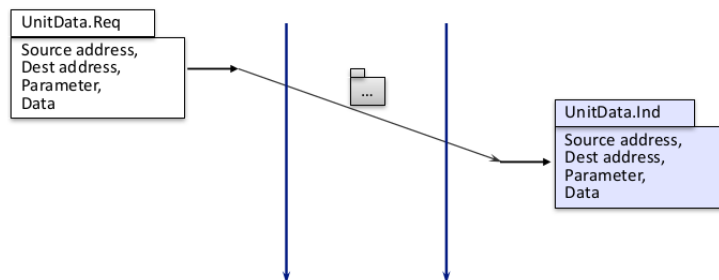
Service primitives

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection
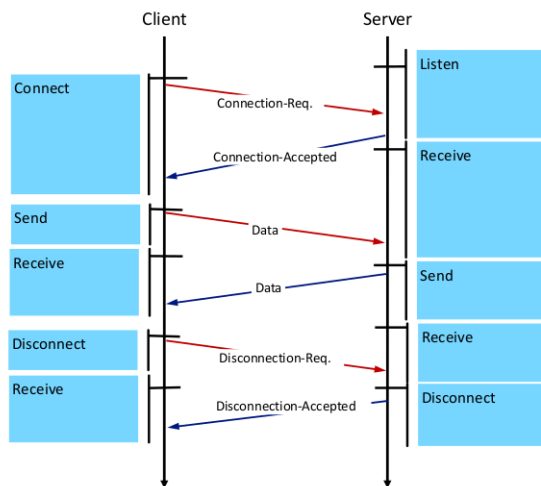
2.6 ISO/OSI Reference Model
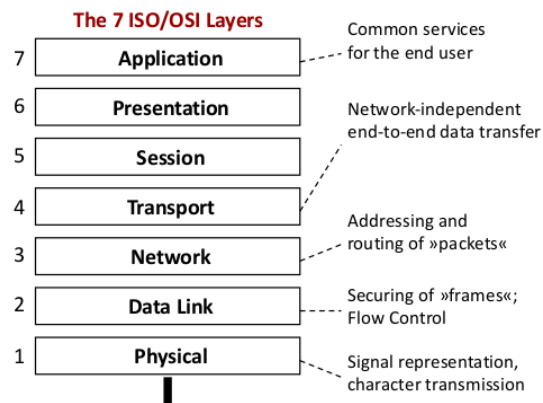
1. Physical Layer

   - Responsible for single bit transmission
   - Details are defined: type of cables, meaning of pins of network connectors, transmission direction on the cable

2. Data Link Layer

   - Ensures an error-free data transmission between two directly connected devices → segmented into frames (transmitted separately)
   - Receiver checks the correctness (checksum)
   - flow control is used to control the re-transmission of corrupt frames and protect the receiver from overload.
   - control of medium access (prevent address conflict)

3. Network Layer

   - Data-transmission over large distances and between heterogeneous sub-networks
   - uniform addressing of hosts
   - routing: select a path through the network.
   - Quality of Service (QoS) issues, i.e., if too many packets are present at the same time in the network, they may form bottlenecks. (congestion, maximum size of the transferred data units (MTU), delay, jitter, transit time, etc.)

4. Transport Layer

- end-to-end communication between two processes
- Ensure that the data are receipt complete and in correct order
- current network state is monitored to adapt to the receiver and to the network capacity