Fachhochschule
Dortmund
University of Applied Sciences and Arts

Communications and Computer Networks

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Overview

- Communication fundamentals
- OSI-layer model
- Network devices
- Encapsulation
- Fragmentation

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Learning Objectives

- You know different types of classification of computer networks
- You know the ISO/OSI reference model and can explain it
- You know relevant protocols for the different layers
- You know different network components and the assigned layer.
- You know the problem of fragmentation
- You understand the process of encapsulation

Definition

What is a communication network?

Definition

A computer network is a set of computers sharing resources located on or provided by network nodes.

Computers use common communication protocols over digital interconnections to communicate with each other.

These interconnections are made up of telecommunication network technologies based on physically wired, optical, and wireless radio-frequency methods that may be arranged in a variety of network topologies.

Use of networks and communication

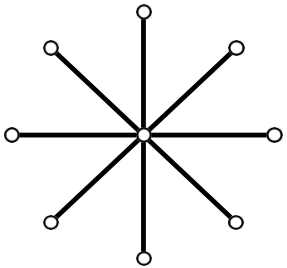
- Access to information
- Person-to-person communication
- Electronic commerce
- Entertainment
- IoT

Classification by extent

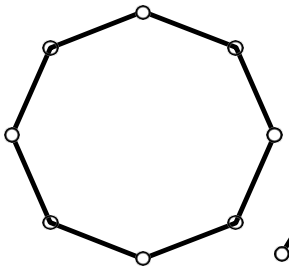
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Classification by topology

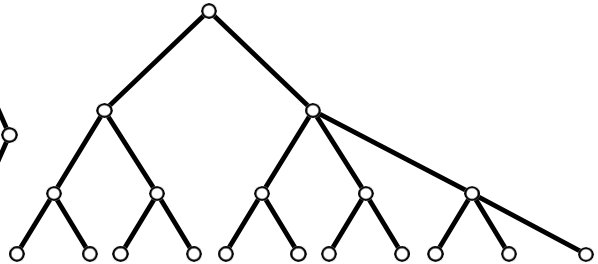
- Differentiation by
  - Cost
  - Performance
  - Robustness
- Further view on topology:
  - Physical
  - Logical



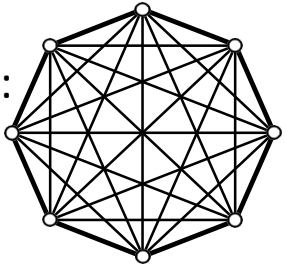
Star



Ring

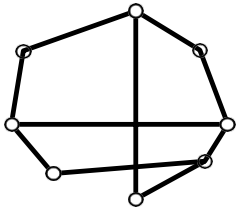


Tree



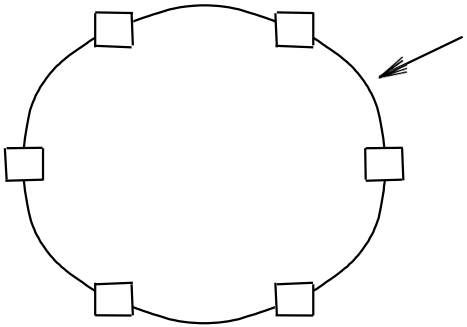
Mesh

Bus

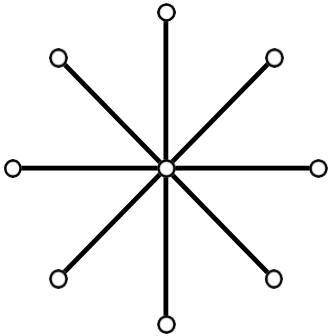


Partially meshed

Classification by transmission technology



- Broadcast networks
  - One transmission channel
  - One sends, all receive
  - Recipient decides whether he needs the package or discards it
  - Address of the recipient in the package
  - Special cases:
    - Broadcast
    - Multicast



- End-to-end networks
  - Connections between individual pairs
  - Often multiple routes possible
  - P2P networks

OSI-reference model

In the ISO standard 7498, the International Organization for Standardization (ISO), a model for the representation of data exchange between computer systems, is described under the name Reference Model for Open System Interconnection (OSI).

The OSI reference model provides a generally accepted framework architecture for the construction of computer networks. The framework architecture described in the OSI reference model was developed in the 70s and standardized in the 80s, with the aim of unifying the discussion on the subject of computer networks.

Important protocols, such as the TCP/IP or the System Network Architecture (SNA) of IBM, already existed at the time of standardization of the OSI reference model by ISO. These protocols, which were developed in practice, therefore did not correspond in all details to the architecture envisaged in the OSI reference model.

Design Criteria

- **Design criteria for developing OSI reference models:**

1. A new layer should also mark a new higher degree of abstraction.
2. Each layer should have exactly one defined function.
3. Existing implementations should be taken into account when selecting functions.
4. The flow of information between the layers should be as low as possible.
5. The number of shifts should be as low as possible, taking into account the other aspects.

- The resulting model consists of seven layers.

Advantages / disadvantages of layers

- Changes / improvements on one layer does not affect implementations of upper or lower layer

  (We will see later, that this is not always correct)
- New protocols can easily be implemented
- Specific tasks can be assigned to a specific layer
  - Reduces redundant implementation

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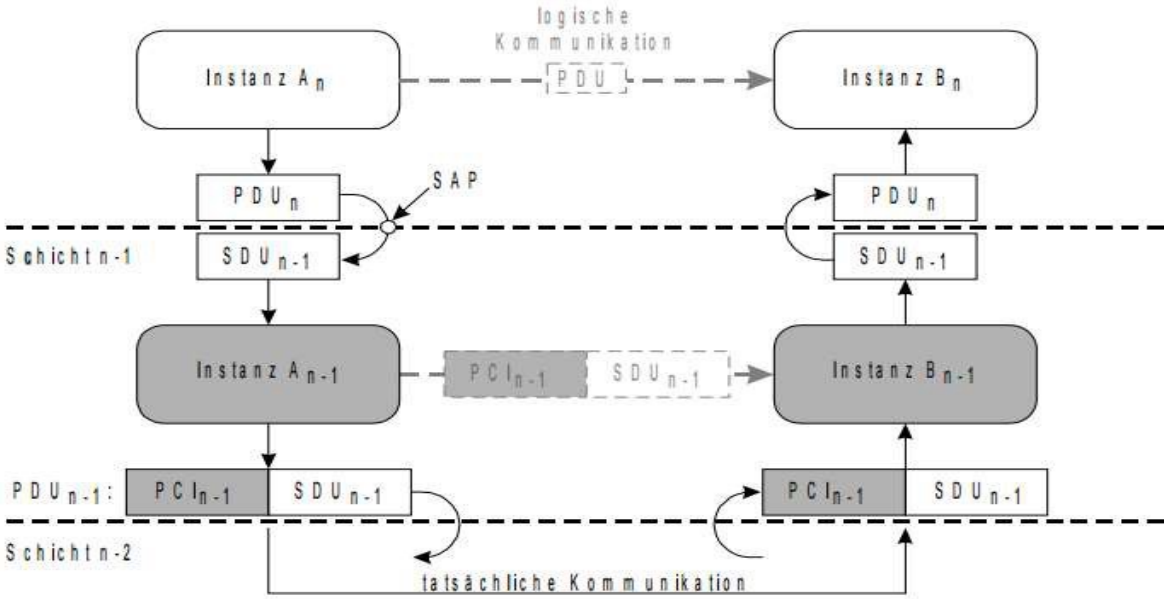
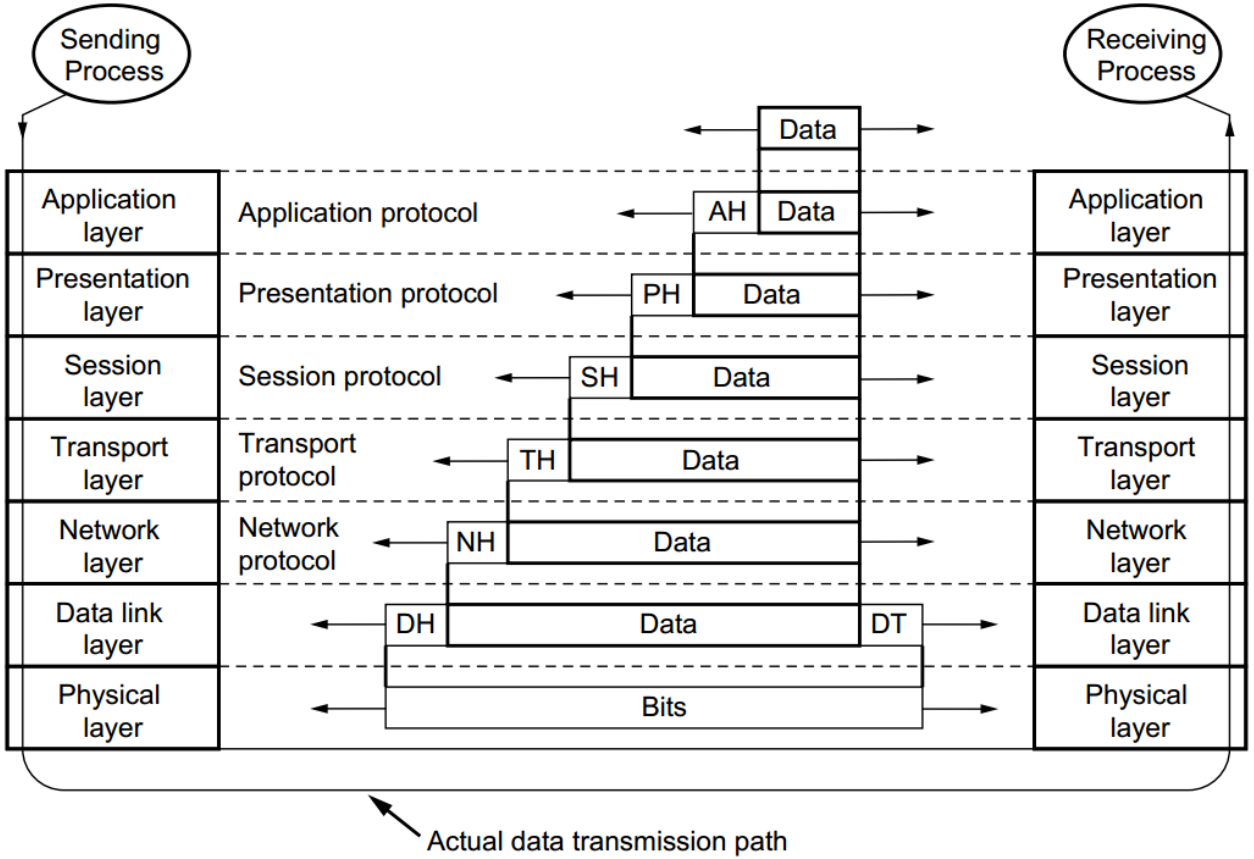
- Specific tasks can be assigned to a specific layer
  - Reduces redundant implementation
- Visionary predictions for evolution error-prone
- Wrong or inappropriate decisions might hamper the implementations

Communication between layers



Protocol Data Unit (PDU)
Protocol Control Information (PCI)
Service Data Unit (SDU)
Service Access Points (SAP)

OSI reference model



Layer 1 – Physical layer

- The physical layer contains the **physical transmission** between end systems. Here, the **electrical and mechanical properties** for the interface between the end device and the transmission medium are defined.
- The **rules according to which the transmission medium is accessed, as well as its physical properties**, are also part of this layer.

Layer 2 – Data link layer

- The task of the data link layer is to **manage the incoming and outgoing data stream**. This is divided into transmission frames or packets, which are transmitted sequentially from the sender to the receiver.
- The **addressing scheme (aka MAC-addresses)** on layer 2 provides a communication inside a restricted network area (**so called broadcast domain**)
- Furthermore, the link layer **has control mechanisms with which it can detect bit errors and „correct“ them by retransmission request (as far as possible).**
- Relevant protocols:
  - Ethernet (IEEE 802.3)
  - Wi-Fi (IEEE 802.11)
  - *MPLS*
  - *PPP*
  - *ATM*

Layer 3 – Network layer

- While the link layer is only responsible for the transmission between two successive transmission systems (broadcast domain), the network layer **carries out the transmission of the packets from the sender to the receiver.**
- Layer 3 provides addressing of endpoints with **IP-addresses**
- The network layer is responsible for the execution of all network functions. This includes, above all, **the choice of route (routing)**. The latter includes the **possibility of deciding between several possible paths based on predetermined criteria (time, quality, costs).** A precise knowledge of the network structure is absolutely necessary for this.
- Relevant protocols:
  - IPv4
  - IPv6
  - ICMP

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Layer 4 – Transport layer

- The transport layer forms **the boundary between the lower, transporting layers, which deal primarily with network tasks, and the application-oriented layers**. The network underlying the transmission no longer plays a role and is transparent for layer 4. **It only knows the address of the source and destination station, the so called ports**

- In addition to the connection build-up and connection dismantling, the transport layer also **carries out flow control and monitoring for transmission errors**.

- Relevant protocols:
  - TCP
  - UDP

Layer 5 – Session layer

- This layer refers to sessions that denote **logical connections between two top-tier user processes**. These sessions are achieved when two processes on different computers want to communicate with each other. For this purpose, the communication control layer determines the address of the corresponding session work unit of the partner computer and then requests a transport connection from the transport layer.
- Relevant protocols:
  - *L2TP*
  - *RPC*
  - *PAP*

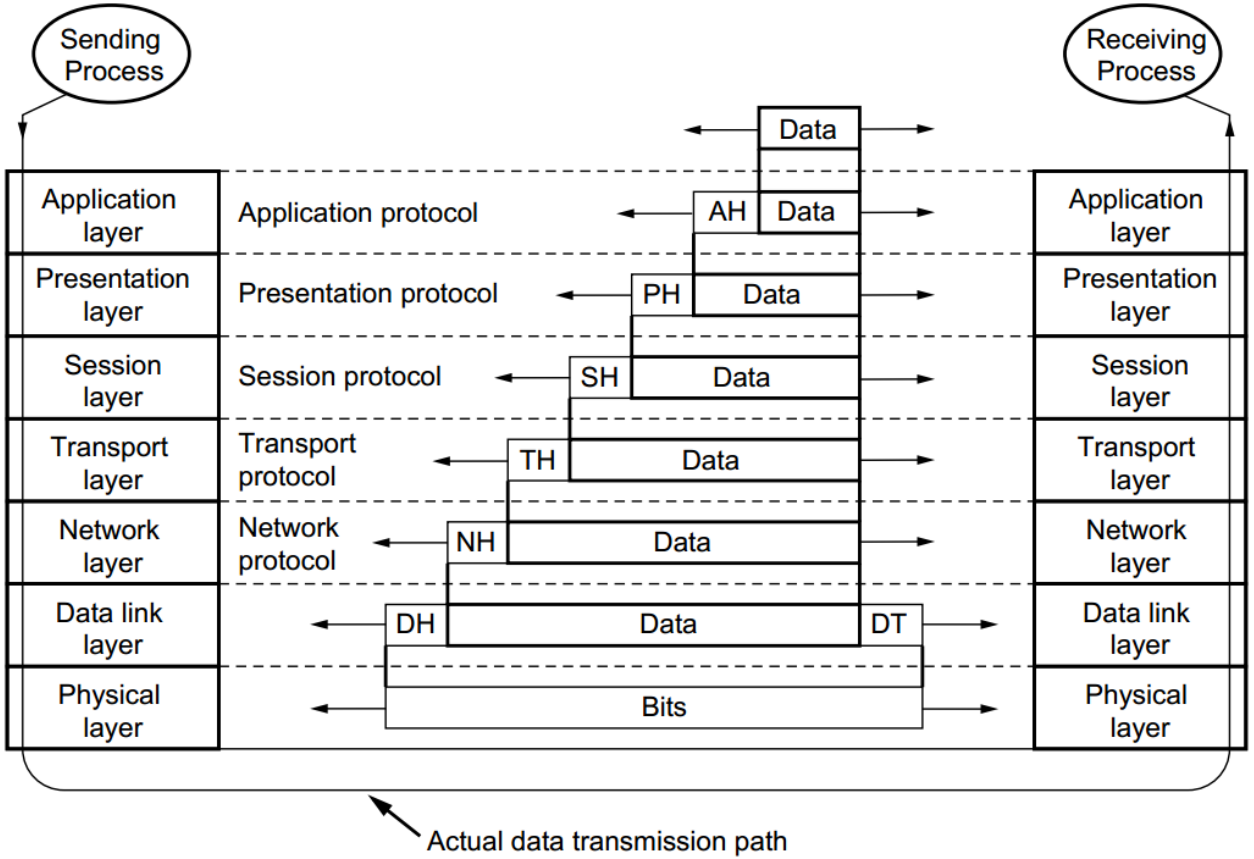
Layer 6 – Presentation layer

- Layer **6 converts the different encoding forms for strings so that both application instances can communicate with each oth**er (e.g. ASCII to EBCDIC). To this end, it provides language tools for the unambiguous naming and presentation of terms and enables an exchange of information by defining a common language, a uniform set of data types and their presentation. Thus, a transformation of the local data representation and the local term set for data into the agreed transfer syntax and the agreed term stock takes place.
- Further tasks are **encryption, compression and serialisation**
- Relevant protocols:
  - *TLS*

Layer 7 – Application layer

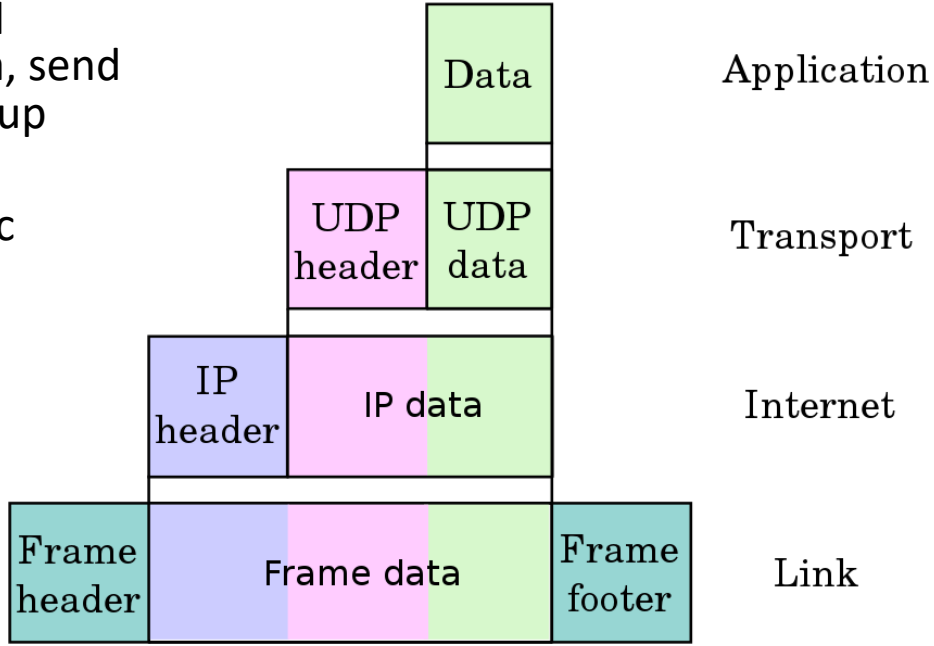
- The last link between application and transmission medium is the application layer.
- **Highest layer** of the OSI-stack
- It is the only layer that has an **interface to the application process.**
- The application process itself is "outside" the scope of the layer model.
- Relevant protocols:
  - DNS
  - DHCP
  - *HTTP*
  - *SMTP*
  - *...*

OSI reference model



Encapsulation

- The data of the application is transmitted from the upper layers down to the media, send to the receiver, and then send the layers up to the application
- The different layers add protocol specific information
  - In front of the data: Protocol header
  - Behind the data: Protocol footer
- Protocol dependency
  - Not all protocols use both
  - The structure of the added information varies



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Network devices

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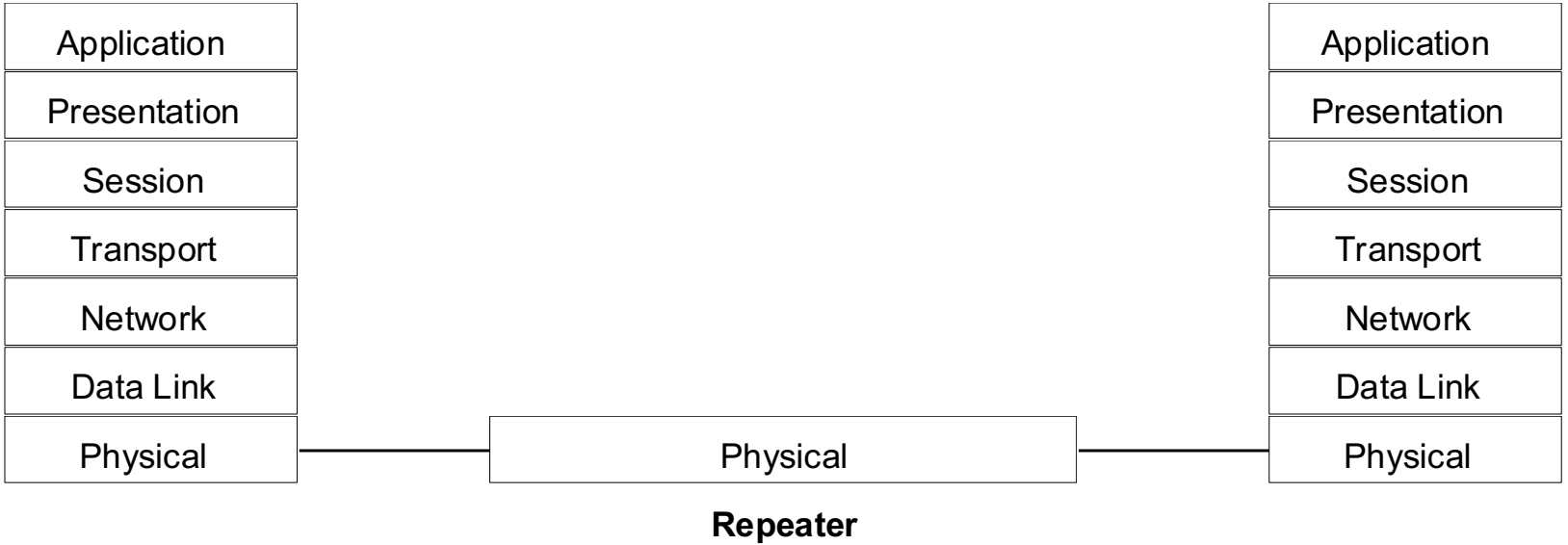
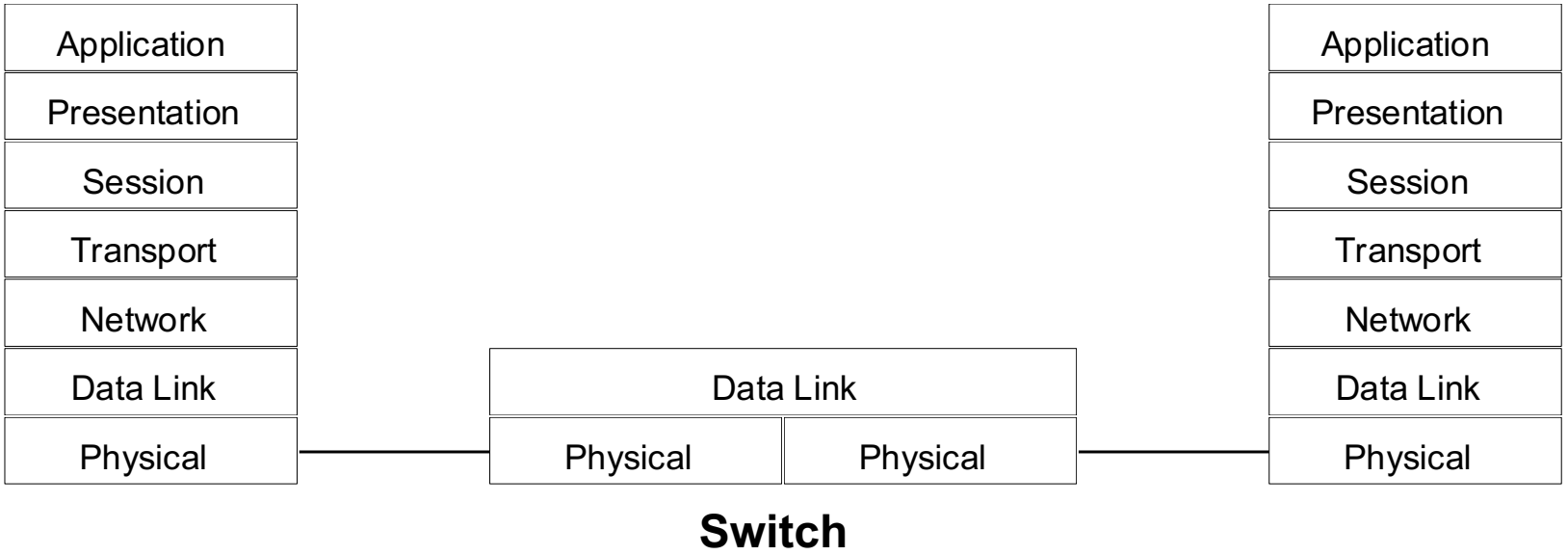
Internetworking Devices

- **Repeaters & HUBs (and NIC)**



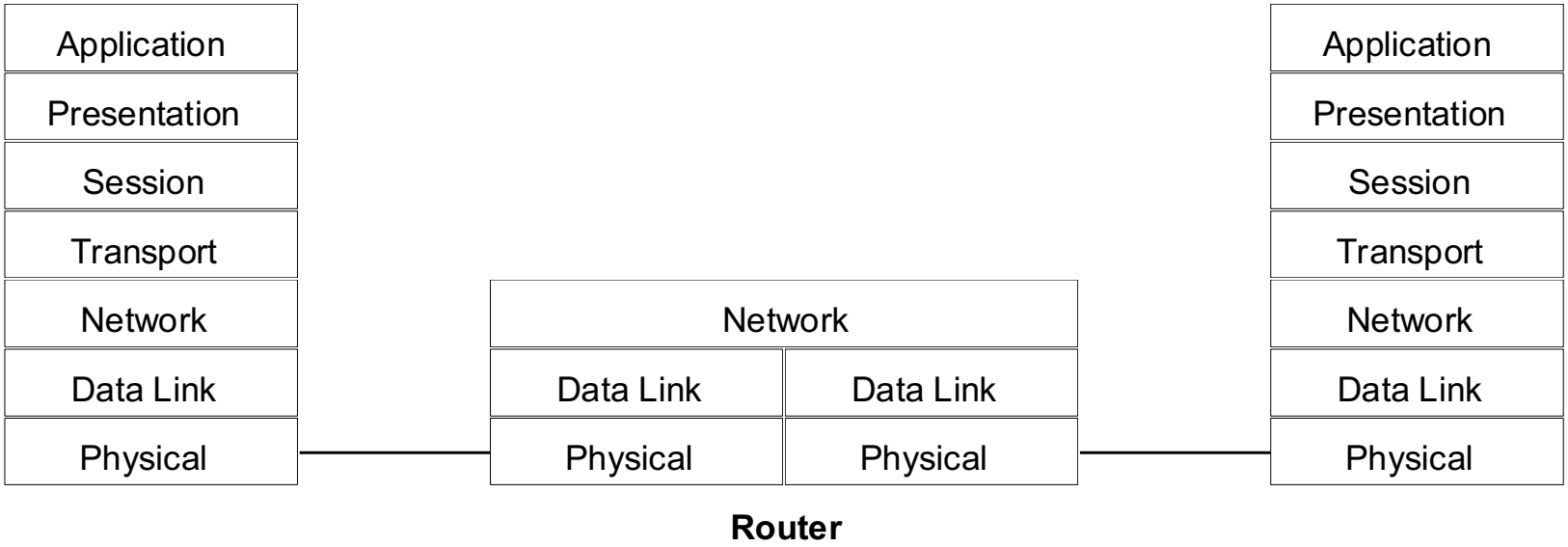
Internetworking Devices

- **Switch (aka Bridge)**



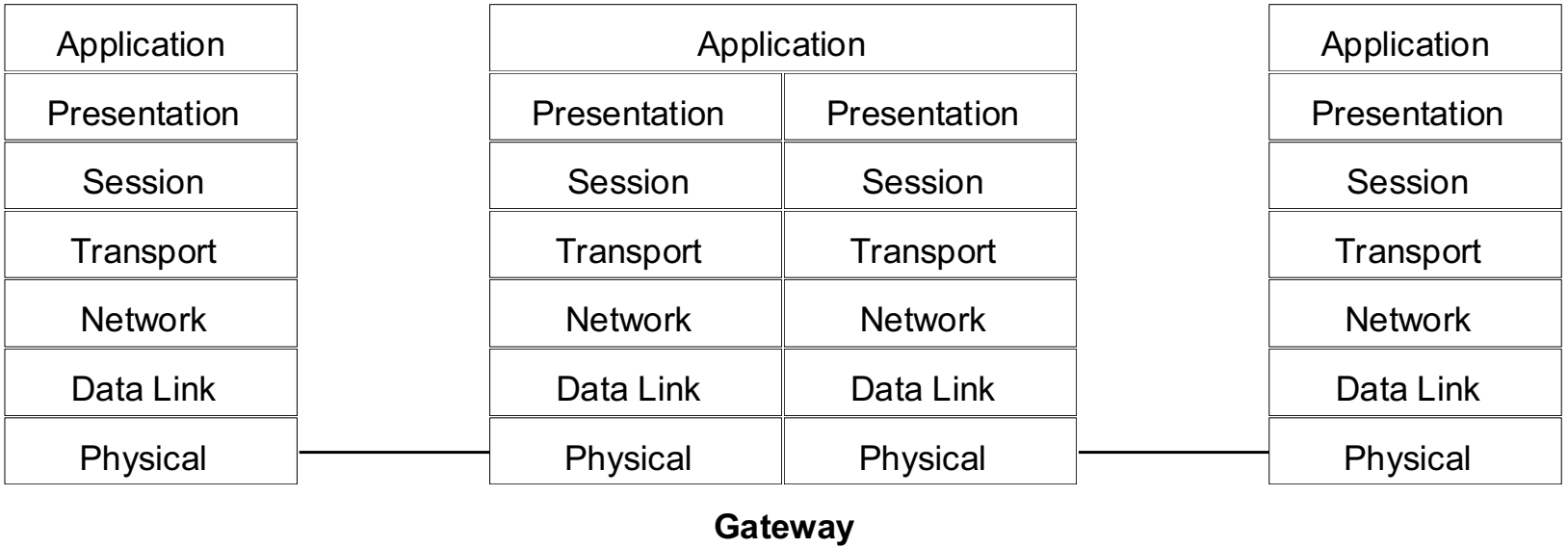
Internetworking Devices

- **Router**



Internetworking Devices

- **Gateways/Proxies**



Fragmentation

- The amount of data an applications sends is mostly unknown
  - The data is „created“ in real-time
  - Short messages like TRUE / FALSE alternate with BLOBS or big files
- The application layer takes this data and gives it to the underlying layer
- But a layer might have a fixed size designated for the data

- The process of fragmentation splits the data in smaller parts
- The fragmenting layer is responsible for the transmission of all parts
  - But the receiving layer is not responsible for the correct reception of **all** parts

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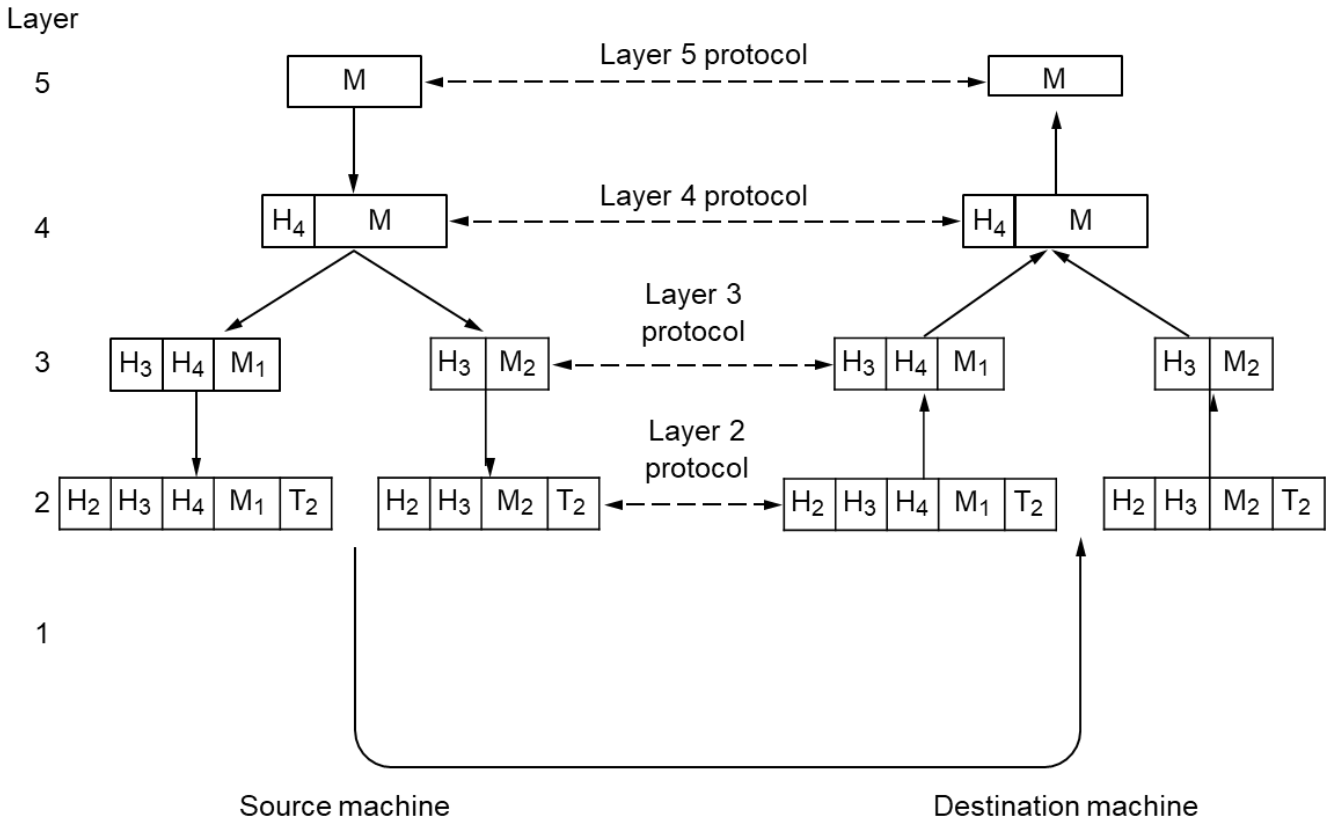
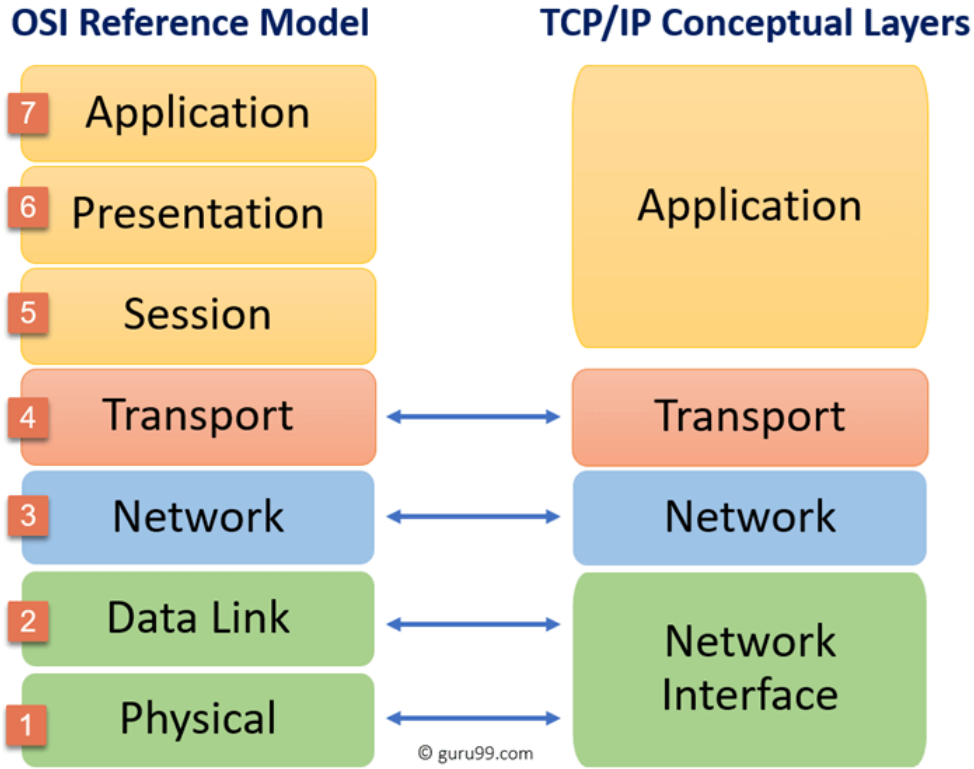
Protocol headers, packet formation, fragmentation



OSI vs. TCP/IP


OSI Reference Model
TCP/IP Conceptual Layers
7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data Link
1 Physical
Application
Transport
Network
Network Interface
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Layer 0? Layer 8?

- The used media is **not** part of the model
- But the used media has an impact to layer 1 (discussion in next sesssion)
- Media is sometimes calles layer 0

- Layer 8 is above the application, so it is:

That's all

Learning Objectives

- You know different types of classification of computer networks
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- You understand the process of encapsulation