Rechnernetze – Computer Networks

Problem Set 6: Foundation ISO/OSI Reference Model

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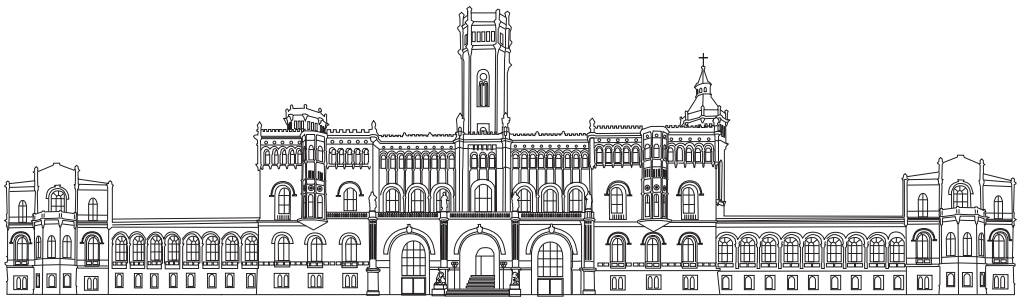

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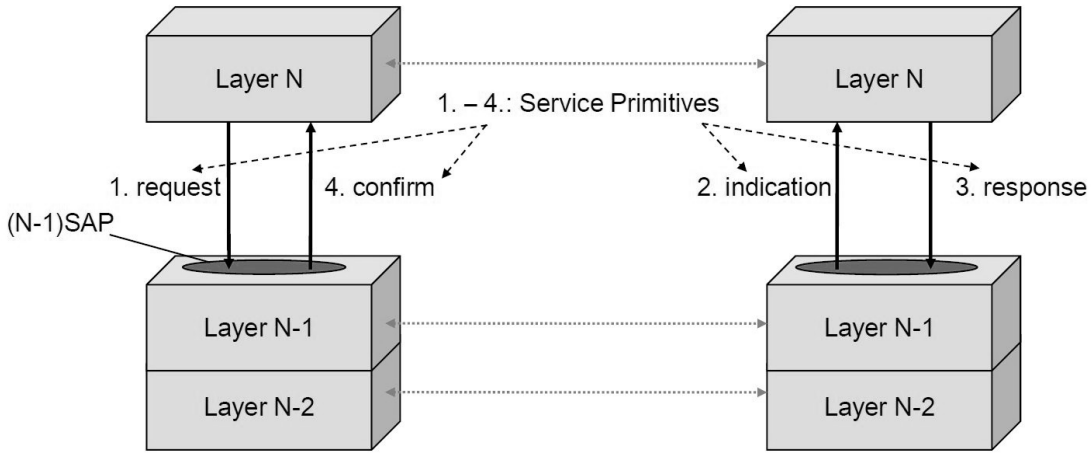
- 1.1 What do the following terms, used in the OSI reference model, stand for?
  - **layers:** decomposition into layers
  - **service:** the service defines the functions that are provided by a layer for the next higher layer
  - **interface:** the interface defines how a service is accessed
  - **protocol:** the protocol defines how the layer implements the service

- 1.2 What are the most significant advantages of the separation of service, interface, and protocol?
  - the protocol is hidden from the next higher layer at the interface; the service does not specify how the protocol implements the service
    Advantage: protocols are modifiable and exchangeable
    - service: transmission of characters
    - protocol: morse code or any other code
  - the implementation of a system including its interface is hidden from other peer systems by the protocol
    Advantage: communication between heterogeneous systems
    - interface on system A: ASCII characters
    - interface on system B: Unicode characters

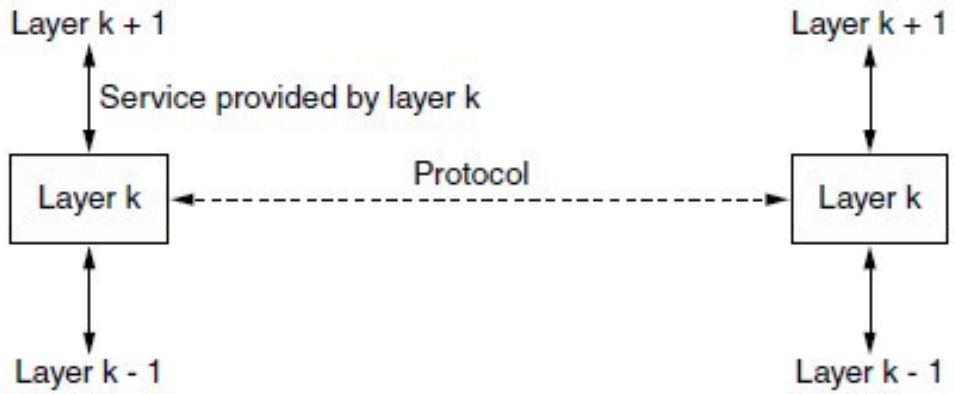
- 1.3 What are the drawbacks of the OSI Model?
  - OSI model is in fact too complex to be effectively and properly implemented.
  - The session and presentation layers are hardly used.
  - The data link and network layers are often split into several sub-layers, since they are pretty complex.

- 1.4 What does the horizontal aspect mean in OSI reference model?
  - Protocols present the horizontal component of communication.
  - Protocols are defined between corresponding (equal) layers.
  - They describe the syntactic (format) and semantic (meaning) rules and message formats that are used for communication.

- 1.5 What does the vertical aspect mean in OSI reference model?
  - Services present the vertical component of communication.
  - Functionality that a layer offers to the next higher layer
  - The higher layer can access the lower layer's services via an interface (Service Access Point, SAP).
  - Completely separated from protocols: The protocol may be changed, but the service remains the same.
  - Concealment of the internal processes within a layer.



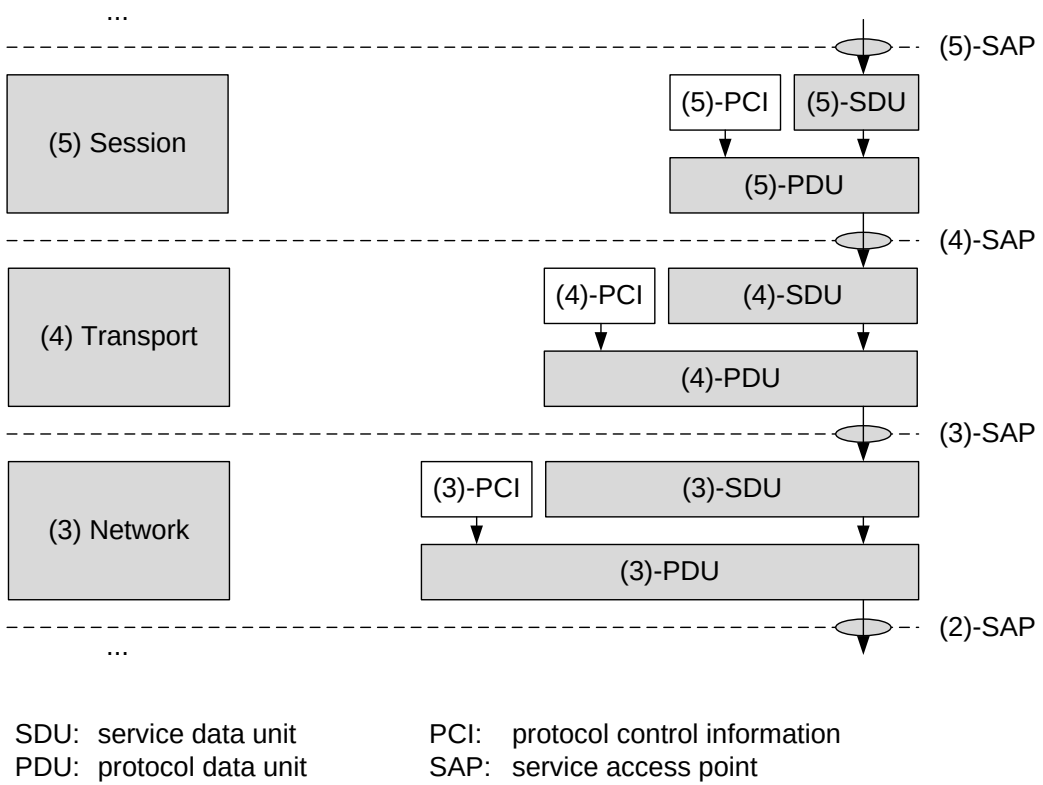
- 1.6 Explain with the help of diagram the relationship between a service and a protocol.



  - A service is a set of primitives (operations) that a layer provides to the layer above it.
  - A protocol, in contrast, is a set of rules governing the format and meaning of the packets, or messages that are exchanged by the peer entities within a layer.

- 2.1 What do the abbreviations SDU, PDU and PCI stand for?
  - SDU - Service Data Unit
  - PCI - Protocol Control Information
  - PDU - Protocol Data Unit

- 2.2 Explain nesting of data units.



- Each layer attaches its control information (the PCI) to the data of the adjacent upper layer (the SDU)
- The SDU and the PCI form the PDU of layer N
- For layer N-1 the PDU of layer N in turn becomes the SDU

- 2.3 A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, an h-byte header is added. What fraction of the network bandwidth is filled with headers?

  With n layers and h bytes added per layer, the total number of header bytes per message is $h \cdot n$, so the space wasted on headers is $h \cdot n$.
  The total message size is $M + h \cdot n$, so the fraction of bandwidth wasted on headers is $\frac{h \cdot n}{M + h \cdot n}$.

- 2.3 ... In an additional step, reformulate the equation in a way that it can be applied to the case of non-equal header sizes?

$$\frac{h \cdot n}{M + h \cdot n}$$

In the case of non-equal header size, the term $h \cdot n$ is replaced by $\sum_{i=1}^{n} h_i$ where $h_1, h_2, \ldots h_n$ represent the header size of the layers 1 to n. So the fraction of bandwidth wasted on headers is $\frac{\sum_{i=1}^{n} h_i}{M + \sum_{i=1}^{n} h_i}$.

- 2.4 Given a sequence of 750 Bytes seen on the wire. Assume that the following protocols have been used: IP (20 Bytes header), Ethernet (14 Bytes header), UDP (8 Bytes header) and no overhead is generated in the physical layer. Any frame check sequence can be ignored. Complete the following table. Finally, what fraction of bandwidth is wasted on headers?

l	$layer$	$size\ of...\ (bytes)$		
		$(l)-PCI$	$(l)-SDU$	$(l)-PDU$
4	Transport	8	708	716
3	Network	20	716	736
2	Data Link	14	736	750
1	Physical	0	750	750

Fraction of headers: $\frac{\sum_{i=1}^{n} h_i}{M+\sum_{i=1}^{n} h_i} = \frac{8+20+14}{750} = 5.6\%$

- 3.1 Consider below task descriptions each standing for a layer of the OSI model. Bring these in order (use numbers 1-7), start with the one closest to the transmision media.

  - 5. synchronization, e.g. after lost connection
  - 1. coding, modulation, and physical transmission
  - 3. addressing and routing
  - 7. application related services, e.g. email transfer
  - 6. machine independent representation, e.g. UTF
  - 2. per-hop data transfer, medium access control
  - 4. end-to-end connection between hosts

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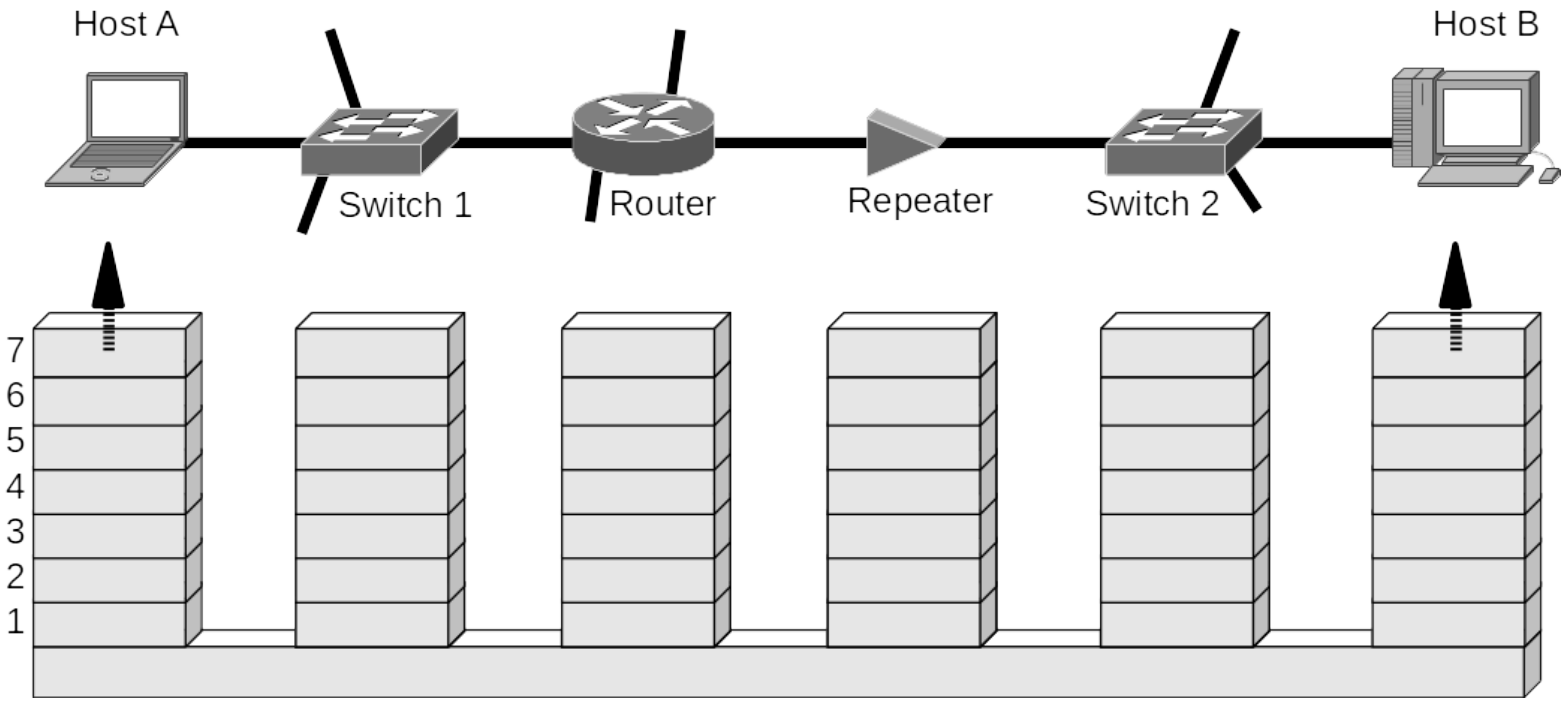
- 3.2 Consider the 7 items above and the terms below. Chose the best-describing term for each one of the 7 items.
  data link, application, physical, session, transport, presentation, network
  - 1. coding, modulation, and physical transmission - **physical**
  - 2. per-hop data transfer, medium access control - **data link**
  - 3. addressing and routing - **network**
  - 4. end-to-end connection between hosts - **transport**
  - 5. synchronization, e.g. after lost connection - **session**
  - 6. machine independent representation,e.g.,UTF- **presentation**
  - 7. application related services, e.g. email transfer - **application**

- 3.2 ... Compare your solution with the OSI reference model.
  - 7. application related services, e.g. email transfer- **application**
  - 6. machine independent representation,e.g.,UTF- **presentation**
  - 5. synchronization, e.g. after lost connection - **session**
  - 4. end-to-end connection between hosts - **transport**
  - 3. addressing and routing - **network**
  - 2. per-hop data transfer, medium access control - **data link**
  - 1. coding, modulation, and physical transmission - **physical**

- 3.3 What layer are these protocols associated with?
  - HTTP - Hypertext Transfer Protocol: **7**
  - IP - Internet Protocol (used for addressing and routing in the Internet): **3**
  - SMTP - Simple Mail Transfer Protocol: **7**
  - UDP - User Datagram Protocol (connectionless end-to-end data transfer): **4**
  - Ethernet: **2**

- 4.1 The hosts A and B are physically interconnected over below network consisting of a router, switches, and a repeater. Sketch the physical communication path between hosts A and B for layer 7 messages and remove the unused layers.



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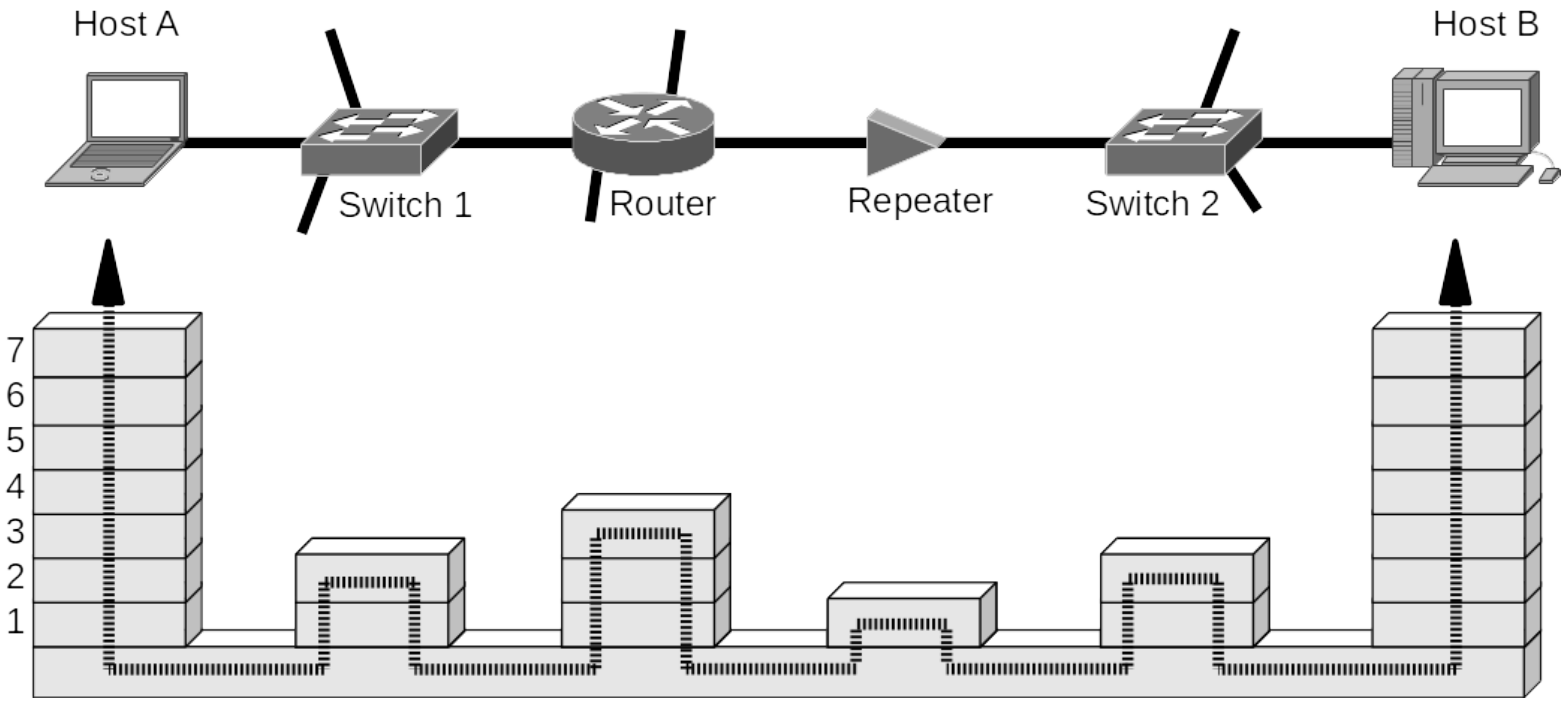

- 4.2 Which of the intermediate systems components such as routers, switches, repeaters, gateways can provide end-to-end flow control?

  End-to-end flow control is typically implemented in layer 4 transport protocols. Hence, only gateways at layer 4 can provide end-to-end flow control.

- 4.3 Which of the intermediate systems components such as routers, switches, repeaters, gateways can use automatic repeat request (ARQ) for retransmission of erroneous or lost data frames?

  This functionality is potentially part of layer 2 (link) and layer 4 (end-to-end). Note, that its implementation is optional and, for example, not available in standard Ethernet. If implemented in layer 2 then it is implicitely available to routers and gateways implementing the upper layers.