Computer Networks

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1.1 Definition of a Computer Network

Definition

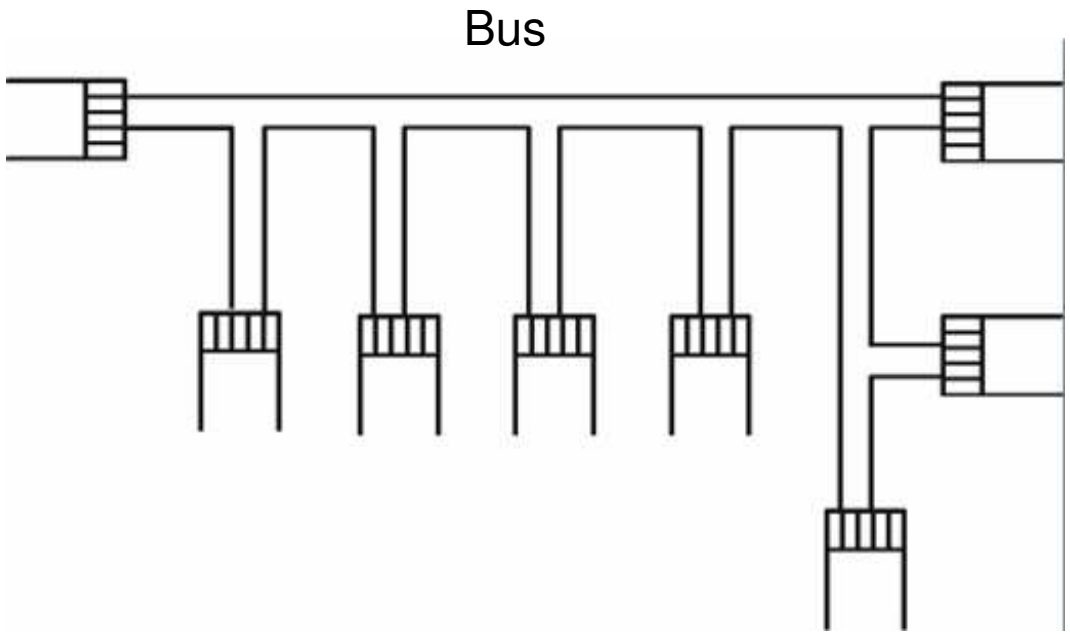
A computer network connects independent computers for the purpose of data exchange.

As opposed to:

- Bus, channel
- Interconnection network for parallel computers (multiprocessor systems)
- Terminal network

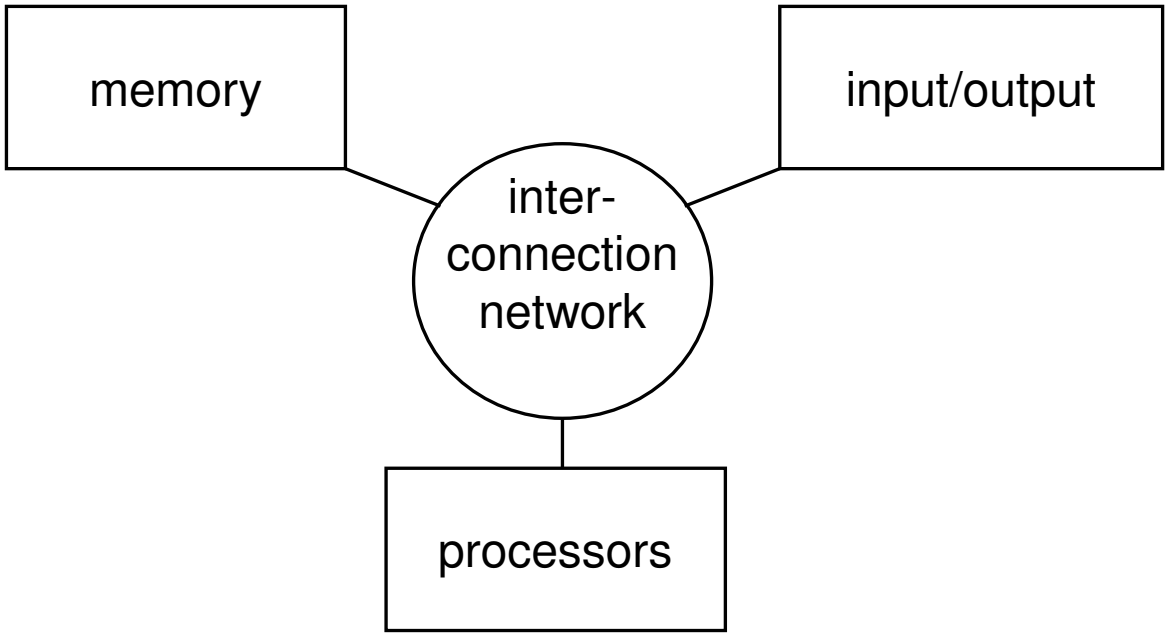
Bus

A **bus** connects the components of a computer within the box.



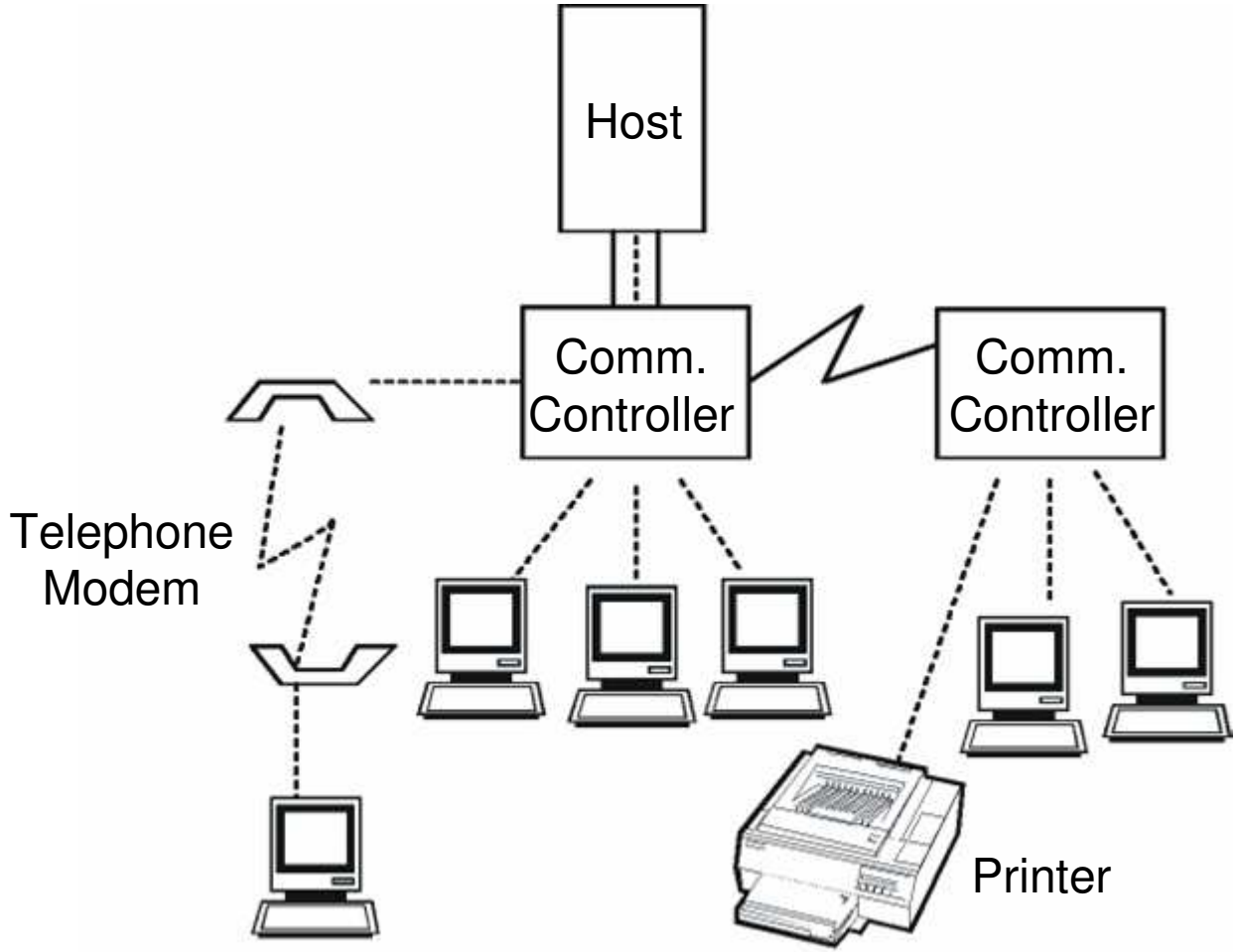
Interconnection Network

Interconnection network in a multiprocessor



n processors

Terminal Network



1.2 Standard Organizations

- International Organization for Standardization (ISO)
- International Telecommunications Union (ITU)
- CEN/ CENELEC/ ETSI (European)
- National Institute of Standards and Technology (NIST)
- and many more

International Standards Organization (ISO)

Standardization on an international level

- Members: National Standards Organization (DIN, ANSI, AFNOR,...)
  - ISO TC 97: Information Processing Systems
  - DIN: Normungsausschuss Informationsverarbeitung (NI)
  - TC 97/SC 6: Data Communications
  - TC 97/SC 18: Text and Office Communications
  - TC 97/SC 21: Open Systems Interconnection
- Steps towards a standard:
  1. Working Draft (WD)
  2. Draft Proposal (DP)
  3. Draft International Standard (DIS)
  4. International Standard (IS)

International Telecommunications Union (ITU)

Formerly: Comité Consultatif International de Télégraphie et Téléphonique (CCITT)

- ITU-R (ITU Radiocommunication Standardization Sector)
- ITU-T (ITU Telecommunication Standardization Sector)

- International union of telecom organizations
- Plenary assembly every 4 years (..., 1980, 1984, 1988, 1992, 1996 ...)
- Standard documents are called „recommendations“
- ITU is a UN organisation

CEN / CENELEC / ETSI

- European Standards Organizations
- Europe-wide harmonization of national standards
- Often prepare input for ISO and ITU-T

Internet Standards

- IAB (Internet Activity Board)
  - IETF (Internet Engineering Task Force)
  - IRTF (Internet Research Task Force)
- RFC (Request for Comment) fulfills the role of an internet standard. Surprisingly the definition of RFCs is an informal process!
- Working groups, each with a leader
  - anyone can become a working group member
  - communication mainly by e-mail, occasional IETF meetings
  - typical duration: 9-18 months
  - result: Internet Draft
- Steps towards a standard: Internet Draft at least two independent implementations; interoperability tests; stability for 4 months Internet Standard (RFC)

Industry Consortia

- Association of predominantly industrial partners
- Goal: rapid realiziation of compatible products. Therefore: quick development of a common de-facto standard
- Submission of the results to international standardization organizations
- Exaples:
  - NFS (Network File System)
  - ATM (ATM-Forum)
  - WWW consortium

1.3 Protocol Architecture

We structure the complex communication system into ***layers:***

- The lowest layer (layer 1) provides the physical connection.
- Each higher layer adds more functionality, hiding details from the next higher layer.
- „Horizontal“ interfaces between layers are a local matter (there is no need for standardization). They are called „service interfaces“.
- The rules of communication between two entities at the same layer are called „communication protocol“.

1.4 The ISO/OSI Reference Model

- OSI = OPEN SYSTEMS INTERCONNECTION
- In short: ISO/OSI Reference Model
- ISO International Standard 7498
- Introduces the layered architecture and basic terminology
- Proposes seven layers and their functionality

Seven Layers and their Functionality

Terminal A

Terminal B

Application layer	Application-specific protocols	7
Presentation layer	Data representation formats	6
Session layer	Dialog control	5
Transport layer	End-to-end data transport	4
Network layer	Routing	3
Data Link layer	Next-neighbor error and flow control	2
Pysical layer	Physical data transfer	1

Physical link

Seven Layers of the ISO-Reference Model (1)

- The **physical layer** provides the transmission of a digital data stream over a transmission line.
- The **data link layer** provides error and flow control for the physical bit stream. In LANs it also implements medium access control.
- The **network layer** provides routing algorithms to compute end-to-end paths through the network. It also implements packet queueing and forwarding in the “routers”.
- The **transport layer** provides reliable end-to-end data connections from a process at the source node to a process at the destination node.
- The **session layer** coordinates the cooperation (dialog) between applications.

Seven Layers of the ISO-Reference Model (2)

- The **presentation layer** provides a common transfer syntax for all systems, and conversion rules from the local to the common data representation.
- The **application layer** implements the application-specific protocols.

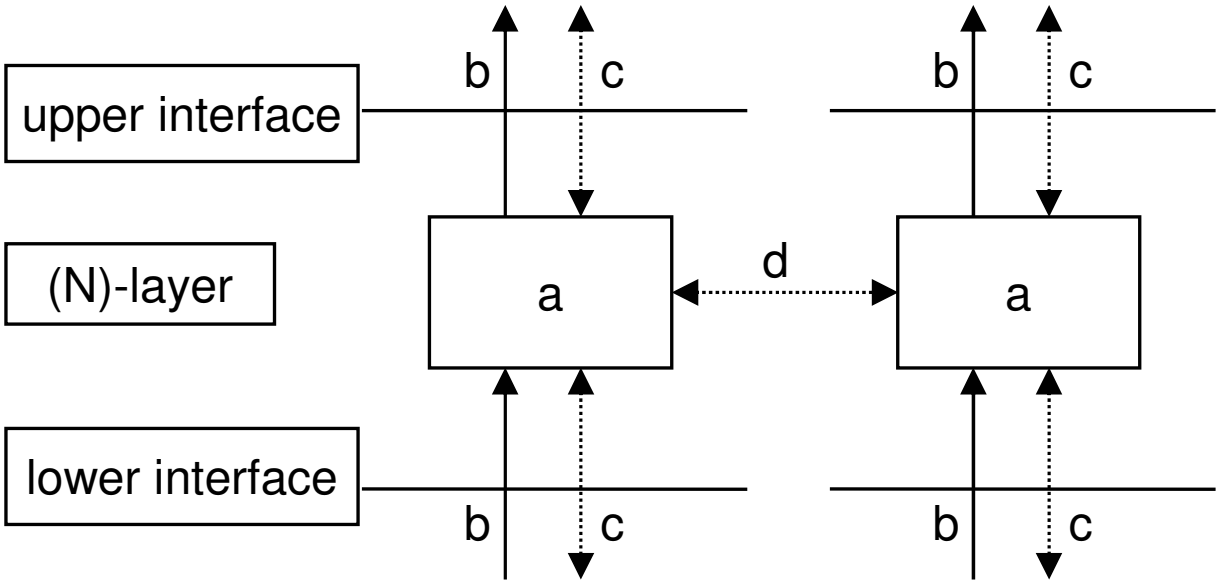
Terminology of the ISO Reference Model (1)

- **Open System**
  - Computer system (hardware, software, periphery, ...) that intends to communicate and implements the OSI standards
- **(N)-Layer**
  - Is formed by all entities of a (N)-hierarchy level in all open systems
- **(N)-Entity**
  - Implementation of a (N)-layer in a system
  - There can be different types of (N)-entities that implement (N)-layer protocols in a different way, e.g., from different manufacturers
- **Peer Entities**
  - Entities of the same layer at different locations.

Terminology of the ISO Reference Model (2)

- The main task of every layer is to offer ***services*** to the layer above. These services are made up of
  - services implemented within this layer, and
  - the cumulative result of services of all the layers below.
- Layers are connected to the next higher and lower layers by ***service primitives***.
- Direct (local) communication takes place with layers (N+1) and (N-1).
- Indirect communication with peer entities takes place according to the rules of the communication ***protocol***.

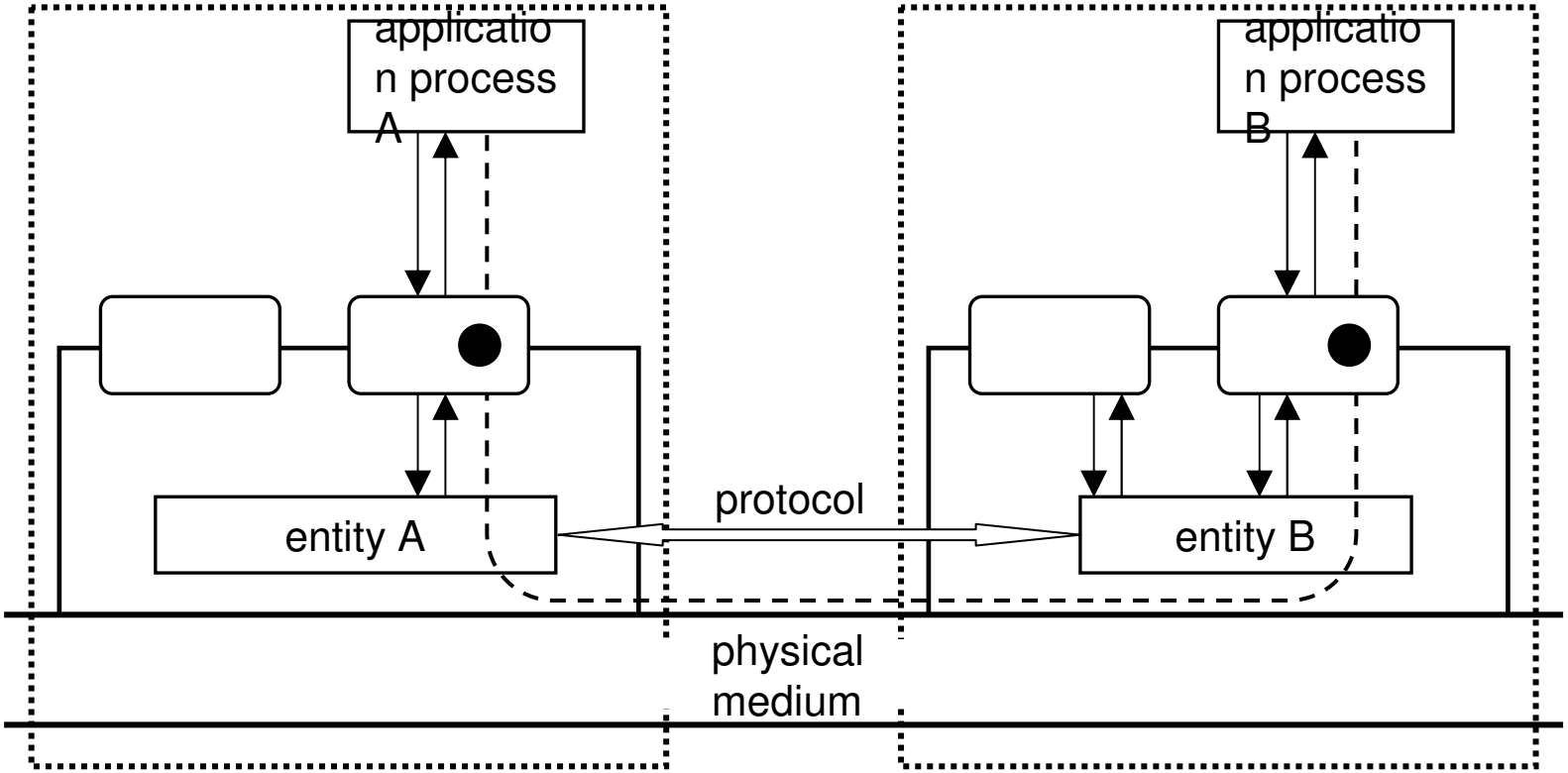
Terminology of the ISO Reference Model (3)



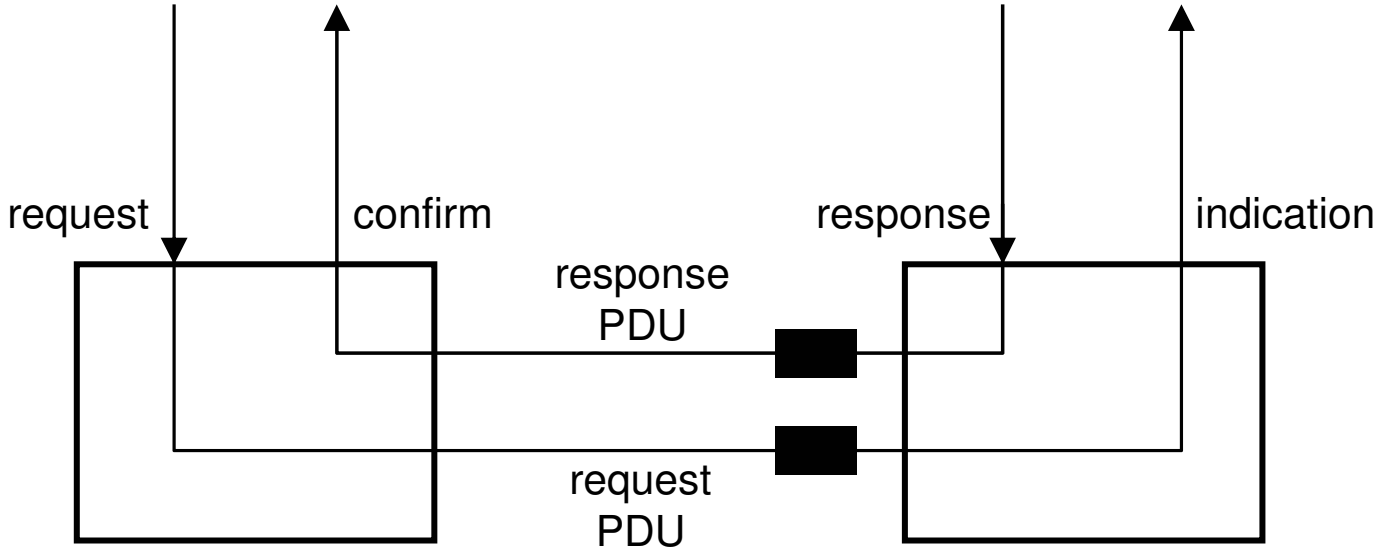
a = Peer Entities
b = Layer Service
c = Service Primitives
d = Protocol

Protocol

A **protocol** is the set of rules for data exchange between two entities of the same layer.



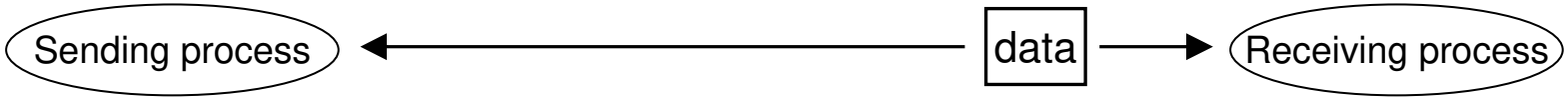
Service Events and Protocol Data Units



Types of Service Primitives

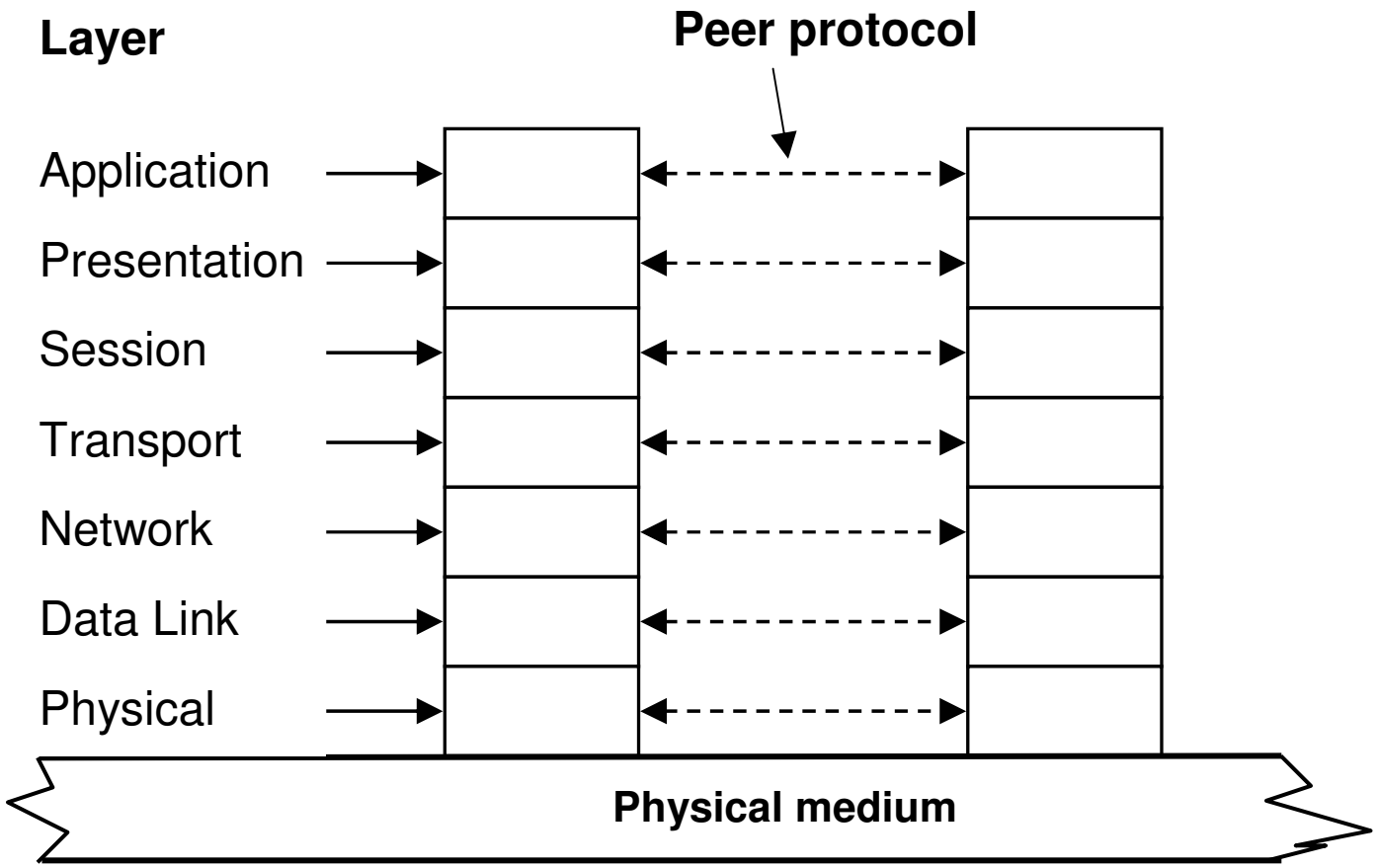
- Request
  - request of a service by the user
- Indication
  - indicates to the user that a service has been requested by the remote user or that an event has occured in the layer
- Response
  - acknowledgement of a preceeded indication by the user
- Confirmation
  - acknowledgement of a preceeded request to the local requestor

Headers and Trailers in the Layered Model

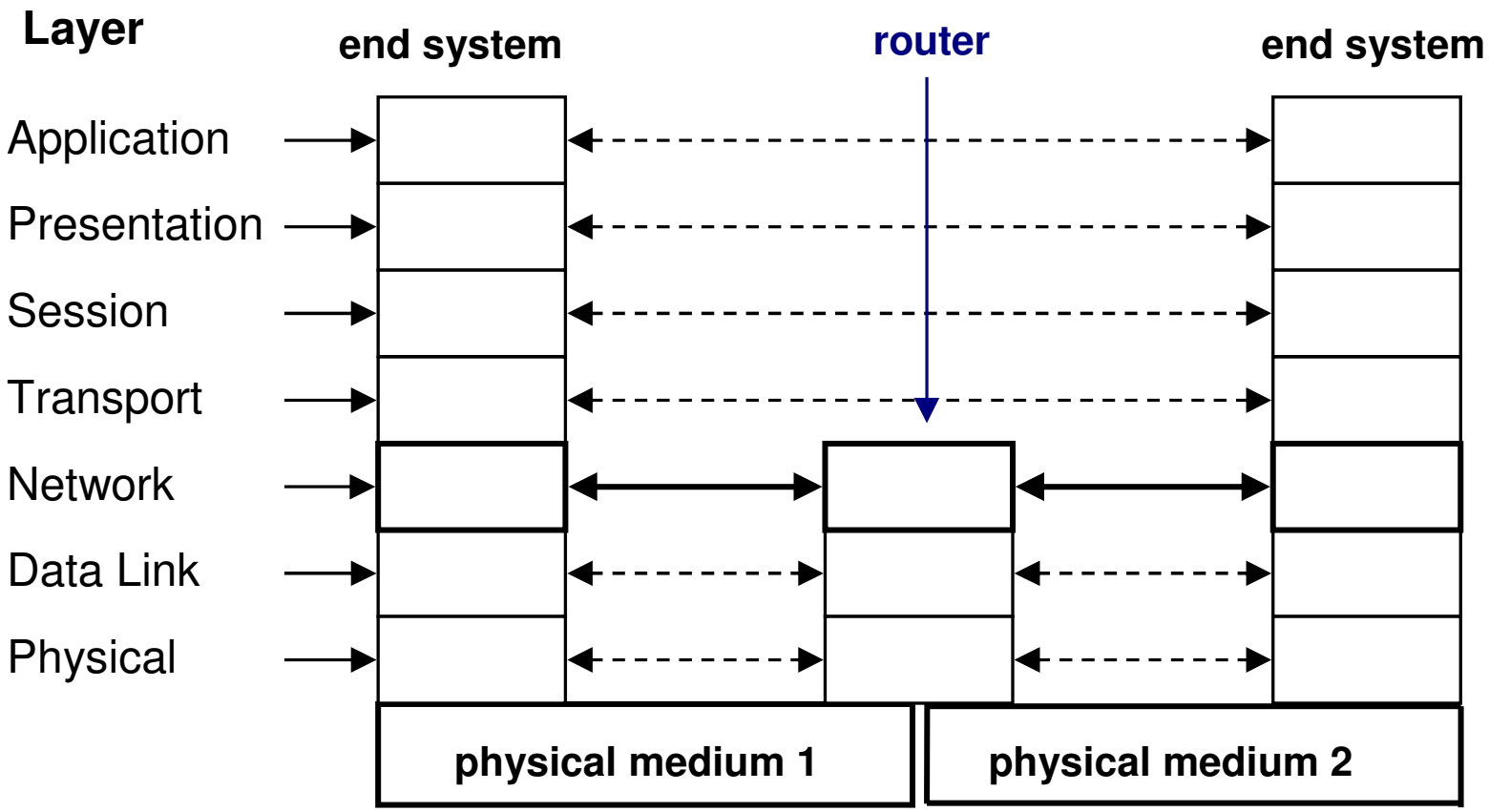


Application layer	Application protocol — AH | data	Application layer
Presentation layer	Presentation protocol — PH | data	Presentation layer
Session layer	Session protocol — SH | data	Session layer
Transport layer	Transport protocol — TH | data	Transport layer
Network layer	Network protocol — NH | data	Network layer
Data Link layer	DH | data | DT	Data Link layer
Physical layer	bits	Physical layer

Reference Model and Peer Protocols



Router


Layer
end system
router
end system
Application
Presentation
Session
Transport
Network
Data Link
Physical
physical medium 1
physical medium 2

Layer Models of Different Network Arcitectures

Layer	ISO	Internet	SNA
7	Application	smtp ftp telnet http …	End user
6	Presentation		NAU services
5	Session		Data flow control
4	Transport	TCP, UDP	Transmission control
3	Network		Path control
		IP	
2	Data Link	Data link control	Data link control
1	Physical	Physical	Physical