Communication Networks II
Introduction and Overview

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Scope

<table>
<tr><td></td><td colspan="8">KN III (Mobile Networking), Distributed Multimedia Systems (MM I and MM II), Telecooperation II,III. ...; Embedded Systems</td></tr>
<tr><td rowspan="2">L5</td><td rowspan="2">Application Layer
(Anwendung)</td><td rowspan="2">Terminal access</td><td rowspan="2">File access</td><td rowspan="2">E-mail</td><td rowspan="2">Web</td><td rowspan="2">Peer-to-Peer</td><td rowspan="2">Inst.-Msg.</td><td>IP-Tel.</td></tr>
<tr><td>SIP & H.323</td></tr>
<tr><td>L4</td><td>Transport Layer
(Transport)</td><td colspan="3">Internet:
UDP, TCP, SCTP</td><td rowspan="3">Netw. Transitions</td><td rowspan="3">Security</td><td rowspan="3">Addressing</td><td>Transport QoS - RTP</td></tr>
<tr><td>L3</td><td>Network Layer
(Vermittlung)</td><td colspan="3">Internet:
IP</td><td>Network QoS</td></tr>
<tr><td>L2</td><td>Data Link Layer
(Sicherung)</td><td colspan="3">LAN, MAN
High-Speed LAN</td><td></td></tr>
<tr><td>L1</td><td>Physical Layer
(Bitübertragung)</td><td colspan="7">Queueing Theory & Network Calculus</td></tr>
<tr><td colspan="9">Introduction</td></tr>
</table>

Legend: **KN I** **KN II**

Overview

1. Communication Networks and Computer Networks: Objectives
2. ISO Reference Model for Open Systems

3. Layer Concepts
4. 5-Layer-Model Used Here

1. Communication Networks and Computer Networks: Objectives

Shared usage of resources
- (resource sharing: programs, data, devices)
- share data
- share load
- share operation

High reliability

Cost reduction
- e.g. shared usage of a data server (a.o. with X-terminal)

Extensibility

High-performance communication media
- person to person (e.g. E-mail, interactively)
- person to machine (e.g. data bases, WWW, video server)
- machine to machine (e.g. often Peer-to-Peer)

2. ISO Reference Model for Open Systems

Problem: engineering communication means

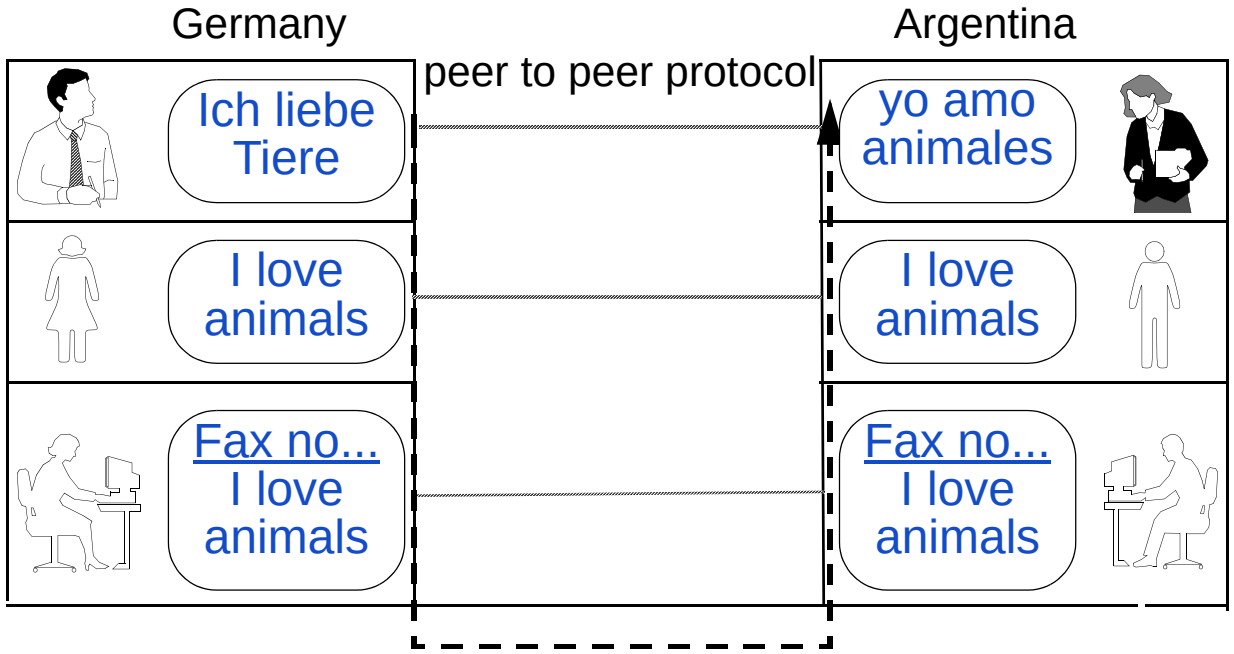
- **multitude of partially very complex tasks**
- **interaction of differing systems and components**

Simplification:

- **to introduce abstraction levels of varying functionalities**
- **general module, preferable: layer, level**

Example (here using OSI-OSI reference model, later 5 layers

- **biologists with translator and FAX-office**

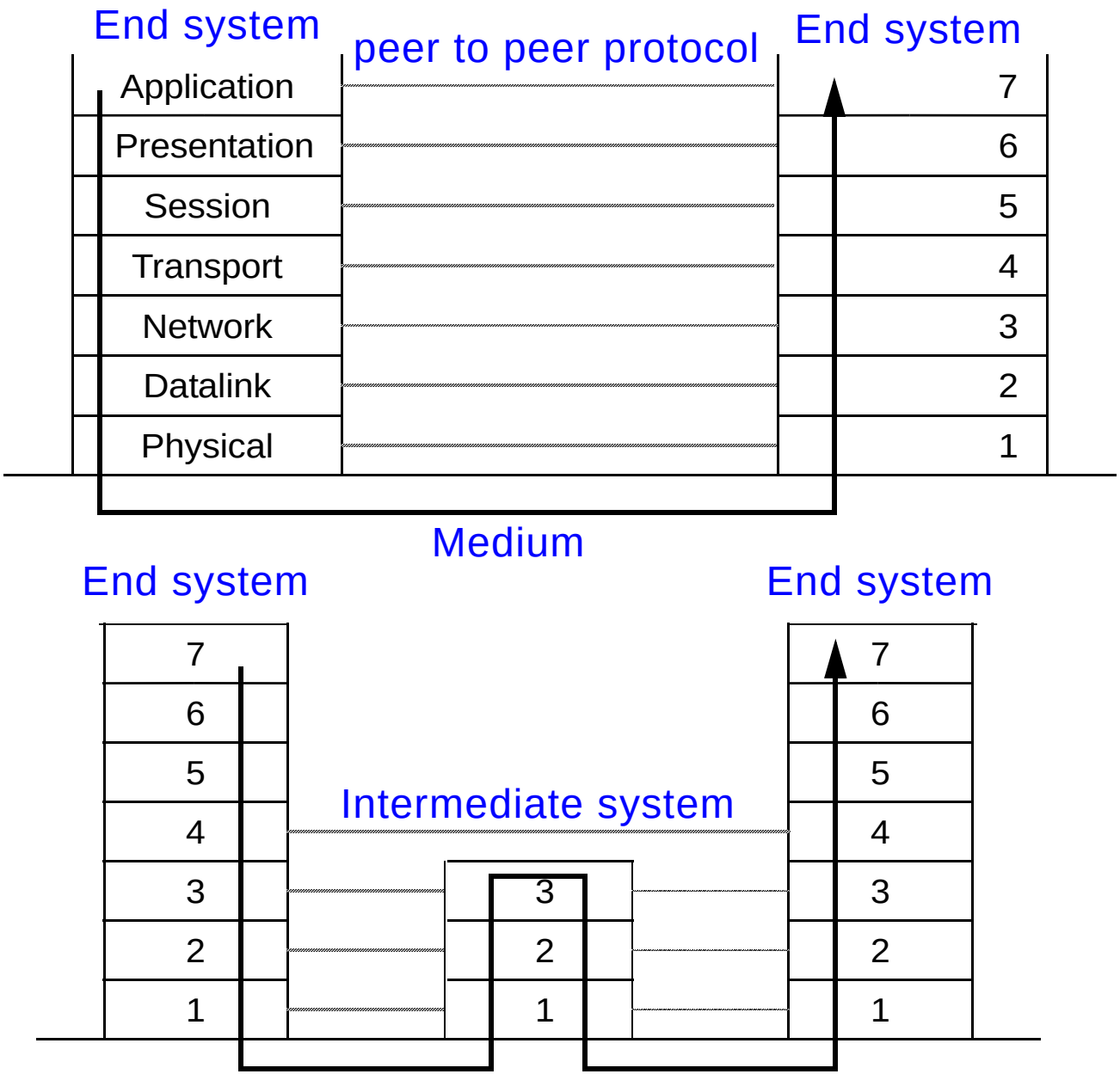


OSI (Open Systems Interconnection) Reference Model

- **model for layered communication systems**
- **defines fundamental concepts and terminology**
- **defines 7 layers and their functionalitites**

7	Application Layer
6	Presentation Layer
5	Session Layer
4	Transport Layer
3	Network Layer
2	Data Link Layer
1	Physical Layer

OSI Architecture



OSI Layers: Functions

Layer	Function

1
Physical
	sending bit 1 is also received as bit 1
	(and not as bit 0):
	• **mechanics: connector type, cable/medium,..**
	• **electronics: voltage, bit length,..**
	• **procedural:**
	  • unidirectional or simultaneously bidirectional
	  • initiating and terminating connections

2 ***Data Link***	reliable data transfer between neighbouring stations with frames • **introducing data frames and acknowledgement frames** • **error recognition and correction within the frame: manipulation, loss, duplication** • **fast sender, slow receiver: flow control** • **distribution network requires access control: Medium Access Control (MAC)**

Layer	Function

3
Network
	connection endsystem with endsystem (subnets) with packets
	• **routing, i.e. among others**
	  • fixed, defined during connect, dynamic
	  • congestion control (too many packets on one path)
	  • quality of service dependent
	• **varying subnets, Internetworking, i.e. among others**
	  • addressing and packet size
	• **comment distribution network: routing often simplified or non-existent, i.e. this layer often does not exist here**
	• **example: IP**

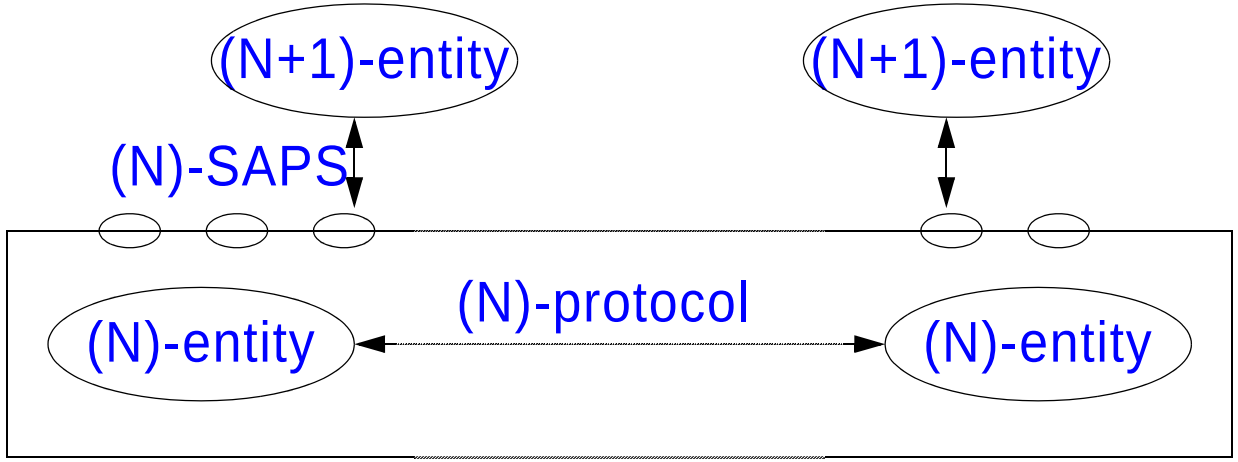
4
Transport
	connection end/source (application/process) to end/drain (application/process)
	• **optimize required quality of service and costs**
	  • 1 L4 connection corresponds to 1 L3 connection
	  • increase througput: 1 L4 connection uses several L3 connections (splitting)
	  • minimize costs: several L4 connections multiplexed onto 1 L3 connection
	• **process addressing, connection management**
	• **fast sender, slow receiver: flow control**

Layer	Function
5 ***Session***	support "session" over a longer period • **synchronization (during interrupted connection)** • **token management (coordinate simultaneous processing of different applications)**

6
Presenta-tion
	data presentation independent from the end system
	• **negotiating the data structure, conversion into a global data structure**
	• **examples:**
	  • data types: date, integer, currency,
	  • ASCII, unicode,..

7
Application
	application related services
	• **example:**
	  • electronic mail, directory service
	  • file transfer, WWW, ..

3. Layer Concepts



N-Layer

- **abstraction layer with defined tasks**

N-Entity

- **active elements in a layer**
- **process or intelligent I/O module**
- **peer entities: corresponding entities on different systems**

N-Service Access Point, N-SAP

- **service identification**

N-Protocol:

- **amount of rules for transfering data between N-entities**

Layer Concepts: Service and Protocol (2)

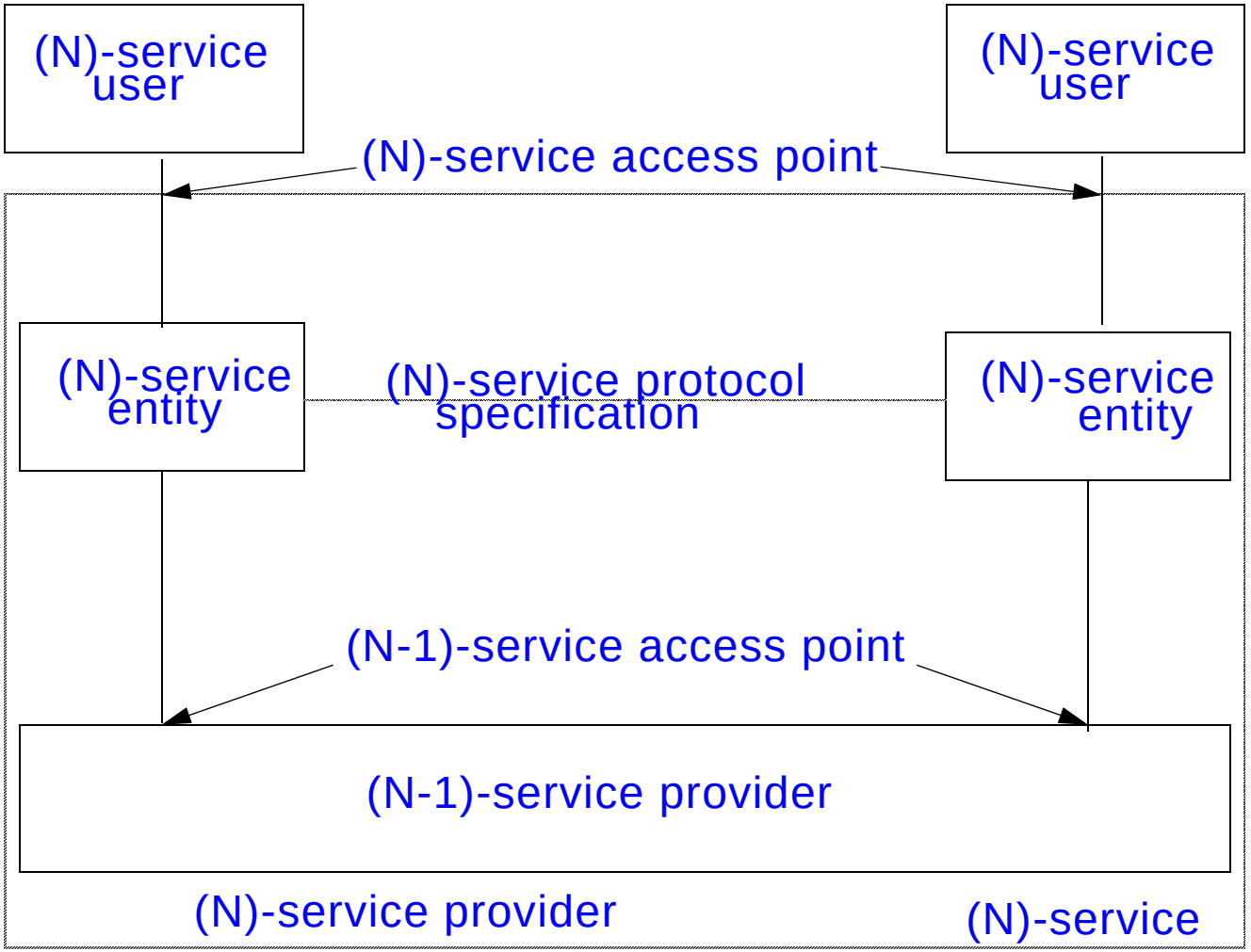
Service

- **amount of primitives/operations/functions which one layer offers to the next superior one**
- **characterized by the "interface"**
- **does not reveal anything about the implementation**
- **analogy: programming, service corresponds to**
  - abstract data type
  - object

Protocol

- **rules for the syntax (format) and the semantics (contents) of the data transfer (frames, packet, message) occuring between the peer entities**
- **analogy: programming, protocol corresponds to**
  - realizing the data type (procedures,etc.)
  - the "interior" of the object

Layer Concepts: Service and Protocol (3)

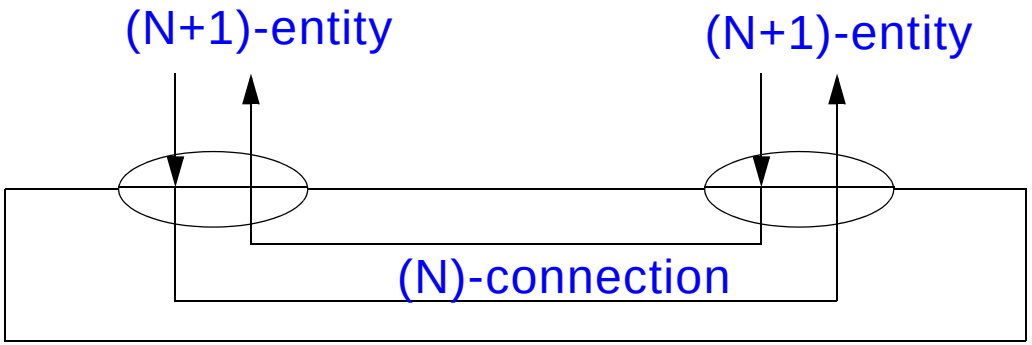


Service Provider

Service User

3.1 Connection Oriented Service

Connection oriented:



3 phases:

1. **connect**
2. **data transfer**
3. **disconnect**

Analog: telephone service

- **applications (preferentially):**
  1. **regularly recurring data units**
  2. **longer period**
  3. **quality of service guarantees (time, bandwidth)**

3.2 Connectionless Service

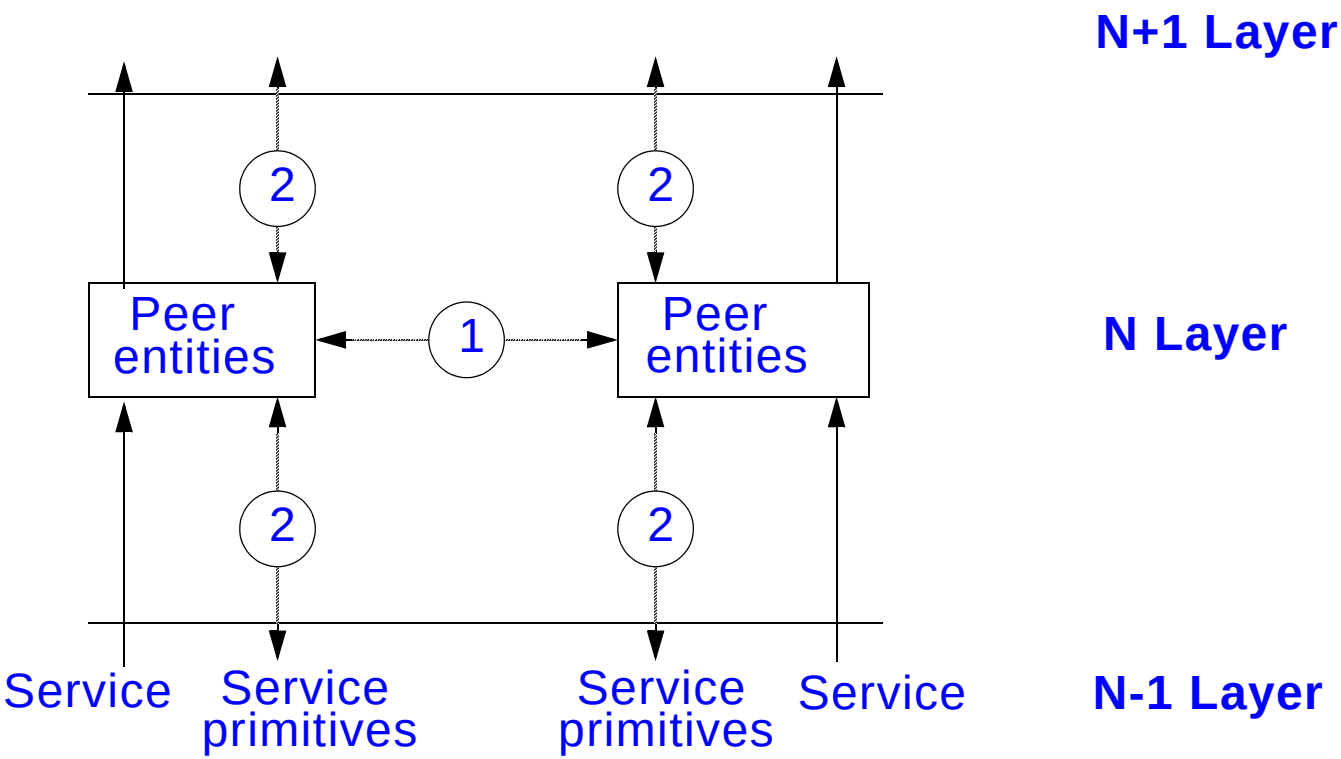
Connectionless (Datagram Service)

- **transfer of isolated unit data**

Analog: letter delivery

- **applications (preferentially):**
  - one-time data transfer
  - short duration

3.3 Communication between Layers



1 = Logical Peer-Peer communication

2 = Physical Adjacent Layer Communication

Between peers: PROTOCOL

Between layers: SERVICE PRIMITIVES

Service Primitives

Service primitives

- **define a service in an abstract manner**
- **are usually parametrized**

Types:

- ***service.* REQUEST**
- ***service.* INDICATION**
- ***service.* RESPONSE**
- ***service.* CONFIRMATION**

Example:

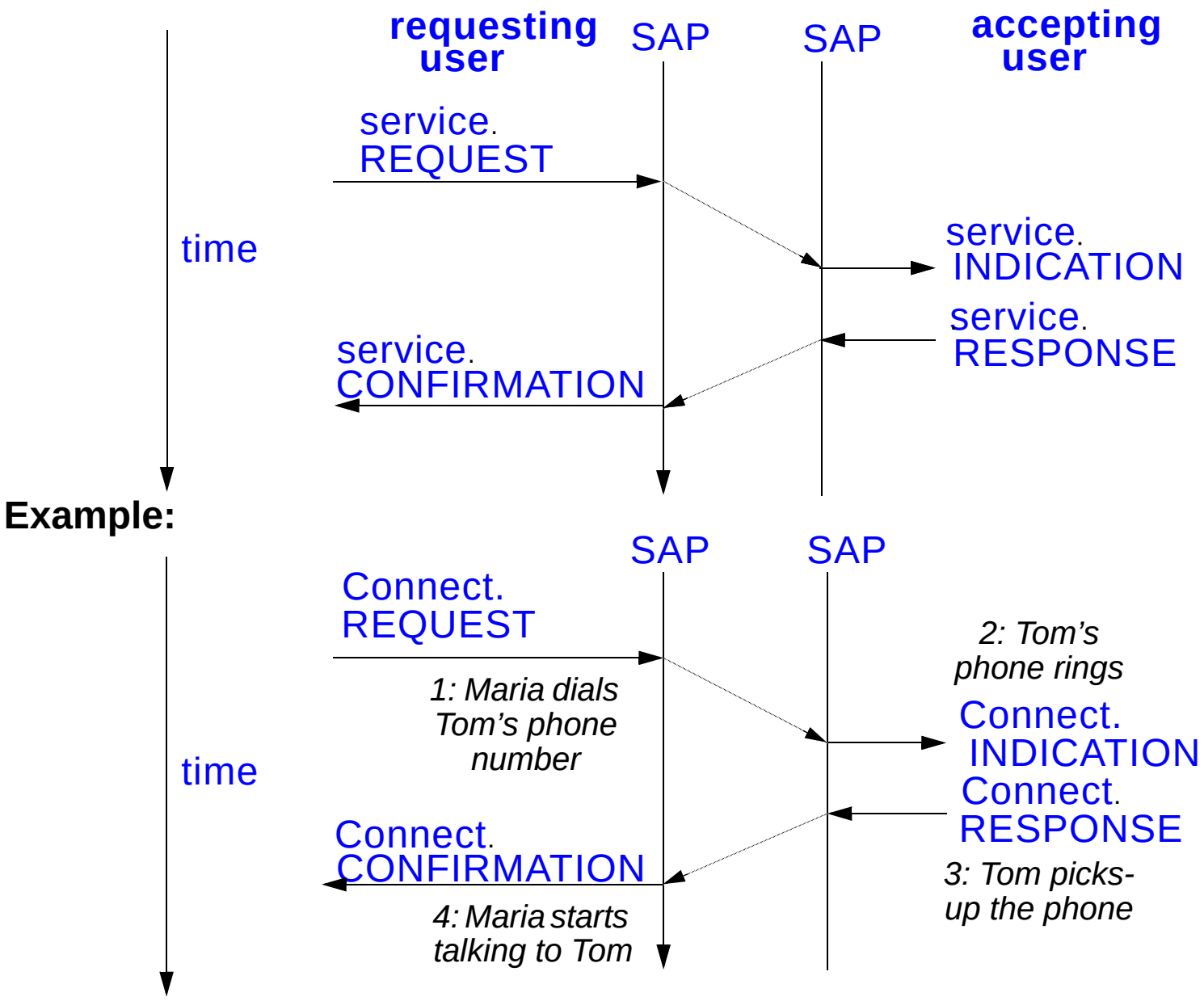
Connect. REQUEST

Connect. INDICATION

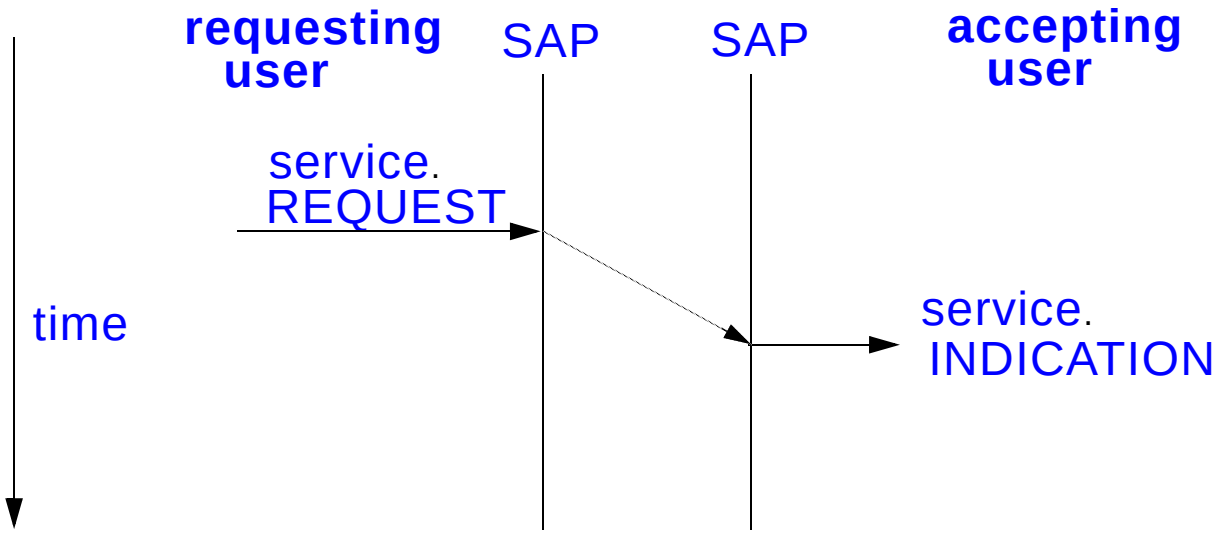
Connect. RESPONSE

Connect. CONFIRMATION

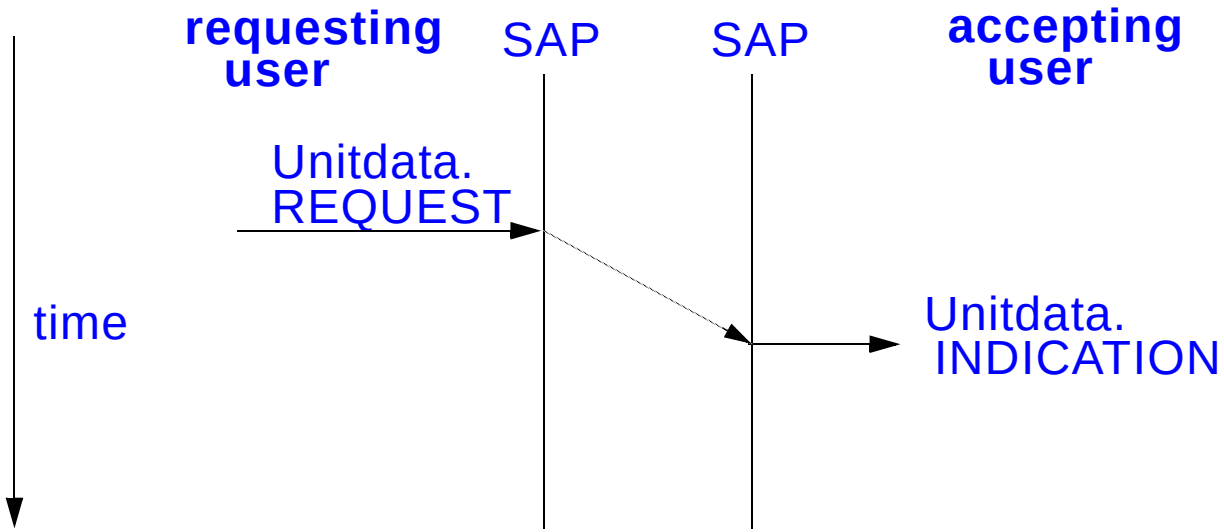
3.4 Confirmed Service



3.5 Unconfirmed Service



Example:



4. 5-Layer-Model Used Here

ISO-OSI

- **standardized too late**
- **implementations usually worse than those of Internet protocols**
- **in general, however, mainly good concepts**

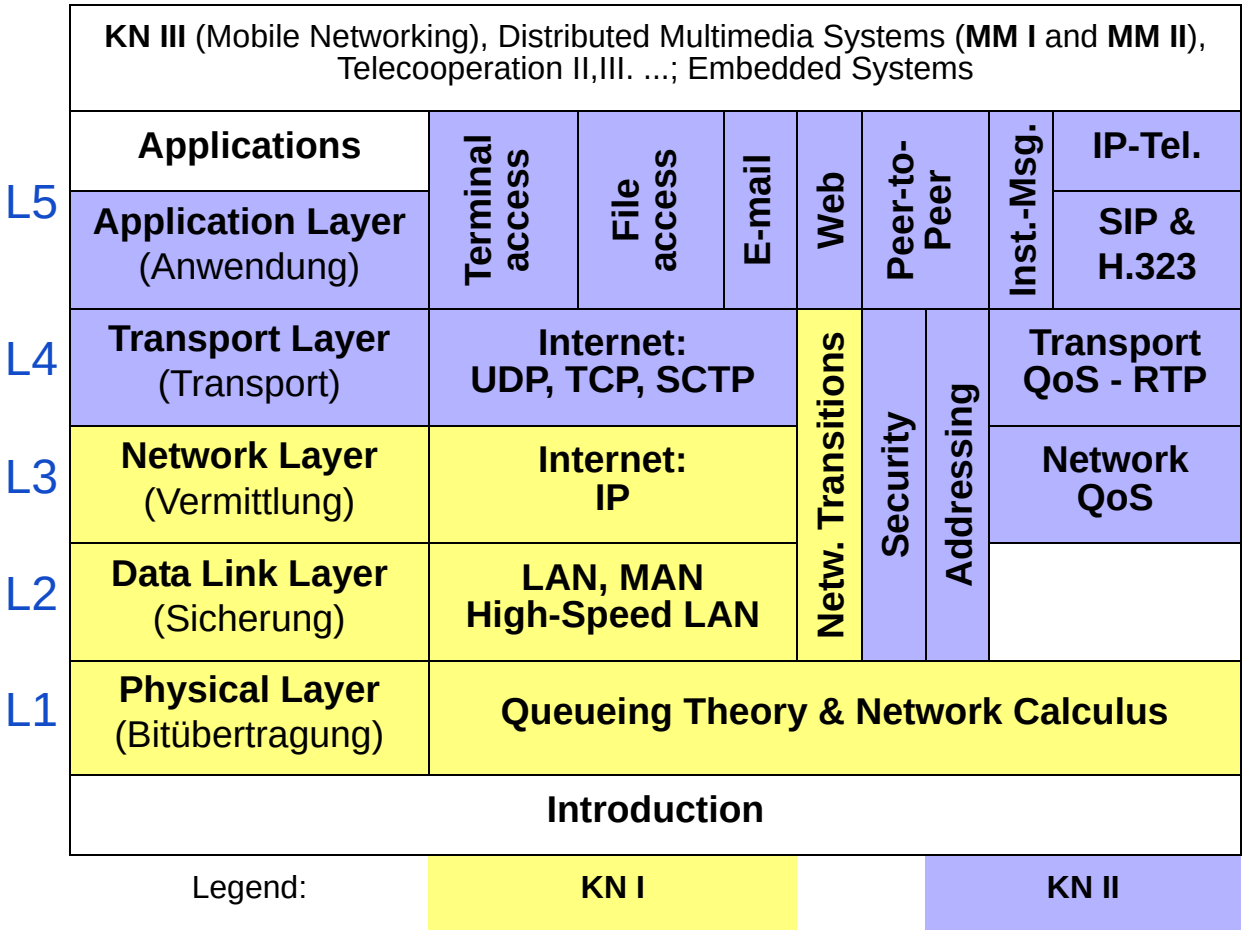
TCP/IP (Internet)

- **TCP/IP already prevalent, SMTP also, now e.g. WWW**
- **integrated into UNIX**

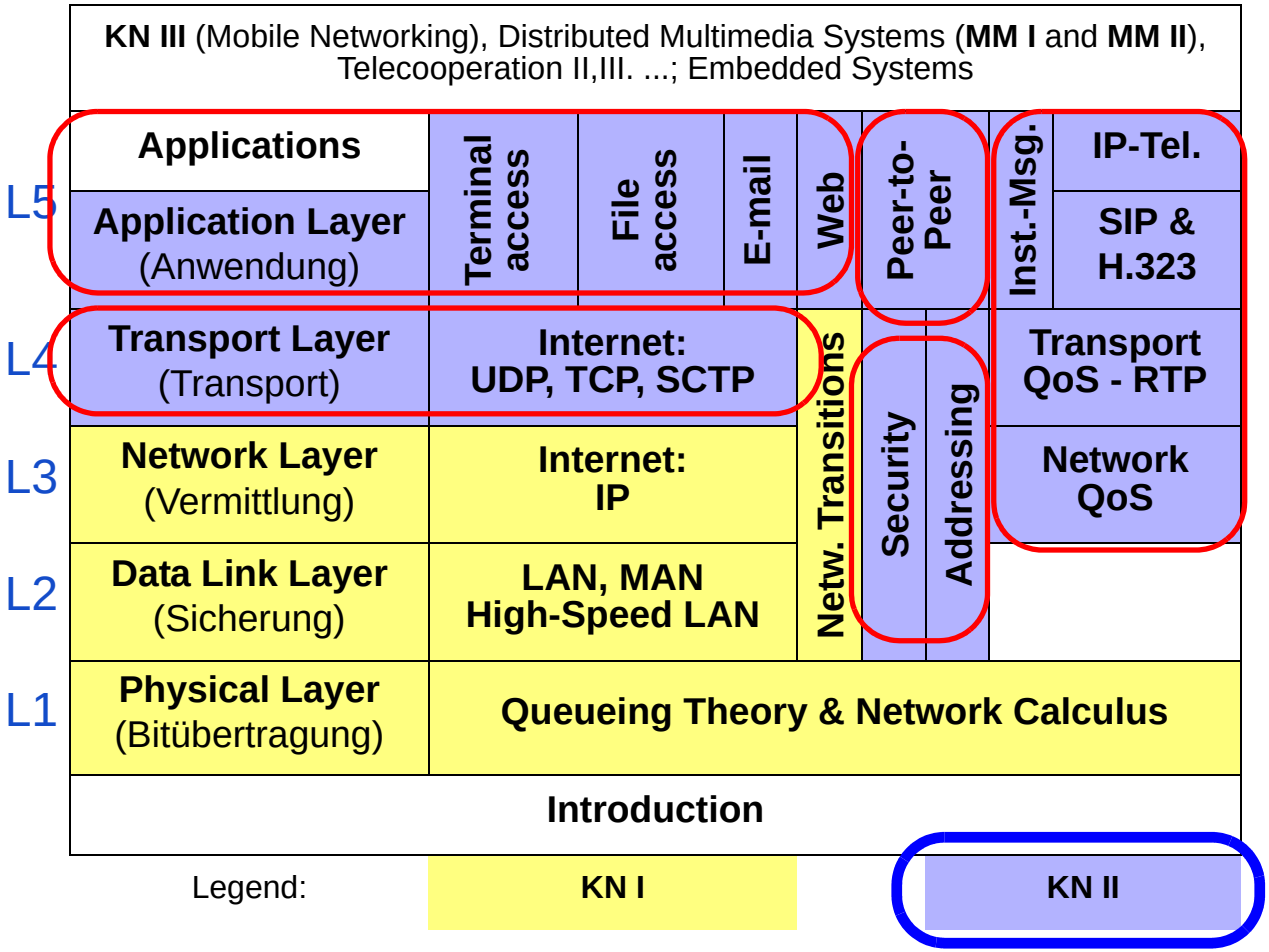
To be considered herein:

Layer		Function
5	***Application***	application related services incl. ISO-OSI L5 and L6 (as far as necessary)
4	***Transport***	connection end/source (application/process) to end/drain (application/process)
3	***Network***	connection end-system to end-system
2	***Data Link***	reliable data transfer between neighbouring stations
1	***Physical***	sending bit 1 is also received as bit 1

5-Layer-Model: Some Details



5-Layer-Model: Some Details (2)



Layers: Conception vs. Implementation

Concept

- **each layer has its own process or a multitude of processes (entities, because of multiplexing/splitting)**
- **buffers between layers (incl. buffer management)**

Experiences with communication systems

- **changing the context of processes takes a lot of time**
- **most of the processing time is used up for copying (despite e.g. DMA)**
  - adapter -> main memory
  - within the main memory (layer to layer)
  - main memory -> adapter
- **difficult to review for correctness**
  - parallelism, many potential states

Implementation

- **pooling several layers to one process**
- **using dedicated buffer management**
  - copying is logical copying (pointer operations)
- **specification methods with conformance testing**