Communication Systems
Introduction and Overview

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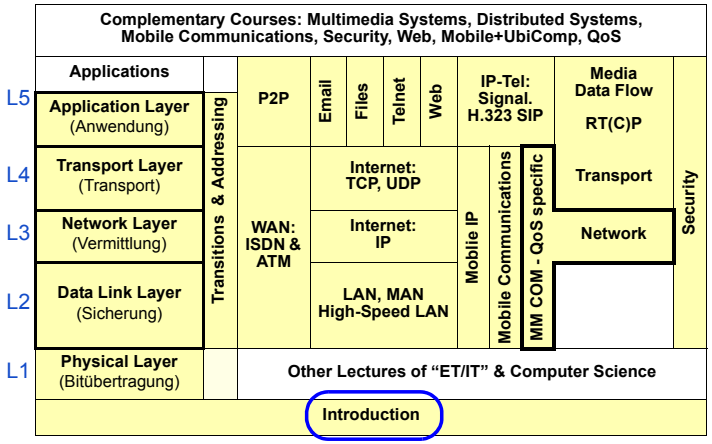
Scope



Overview

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⇒ ..... 8. Structuring

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1. History

18th century	Mechanics Industrial Revolution 1791: Semaphoric Telegraph (Chappe)
19th century	Steam Engine Electricity 1837: Telegraph with coded signals (Morse) 1861: Telephone (Reis) 1877: First (manually switched) phone exchange USA 1881: Also installed in Berlin with 8 participants
20th century	Electronics Radio, TV, telephone, automobiles, airplanes, data processing, analog to digital, networks
21st century	Information, knowledge mobility ubiquitous (hidden) computers AND communication

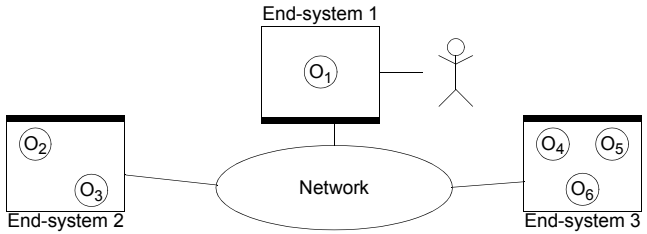
History (2)

1950	Main memory 64 K Single user operation Periphery: punched tape
1960	Main memory 64 K (magnetic cores) Batch operating systems Periphery: magnetic drum, magn. (hard-) disk, magn. tape, punch card 1969: COMPUTER NETWORK ARPANET WITH 4 NODES (USA)
1970	Main memory 256 K (semiconductor/magnetic cores) Time-sharing operating system Virtual memory (paging) Terminals for system programmers
1980	Main memory 1 MB (semiconductor) Time-sharing Interactive program development at the terminal Online transaction processing at the terminal Terminal networks over dedicated lines 1982: PC 1986: first ISDN private branch exchanges 1989: precursor broadband network VBN

History (3)

1990	High performance workstations and PCs with main memory from 8 to 100 MB, Department systems Supercomputers, large processing centers COMPUTER NETWORKS (LAN, WAN, MAN) NETWORK ARCHITECTURES (INTERNET, OSI, MANUFACTURERS) DISTRIBUTED SYSTEMS 1991: Mobile radio network D
1998	PC adapted to approximate workstation Broadband - wide-area networks: 2,4 GBit ATM HIGH-SPEED LANS Among others: Gigabit-ethernet, IP-telephony Markets and industries merge: communication systems + computers + media + entertainment electronics
2005	Mobility, a large amount of hidden communicating systems Photonic switching? Mini-Internet-Device?

2. Computer Network / Communication Network



Computer Network

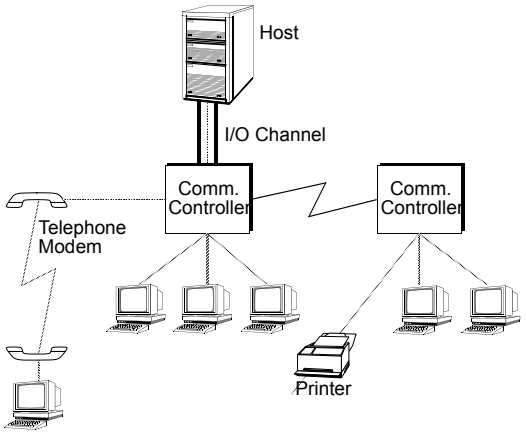
- **several autonomous computers/end-systems interconnected with the aim to exchange information**
- **herein "connected" means:**
  - data can be exchanged
  - no distribution transparency

Demarcation

- **master/slave configurations**
- **multiprocessor systems**
- **distributed systems**

2.1 Master/Slave Configuration

Terminal Networks

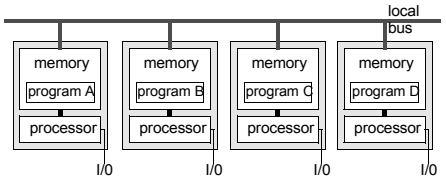


i.e., Master/slave (and not autonomous) means

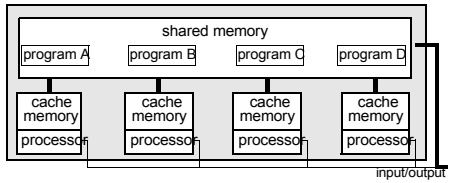
- **one system controls, starts, stops, ... others**
- **example: printers, control units, terminals**

2.2 Multiprocessor Systems

loosely-coupled distributed system

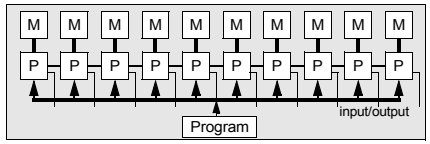


tightly-coupled multiprocessor system



array processor

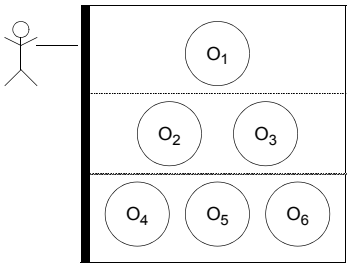
M: Memory
P: Processor



2.3 Distributed System

Examples

- **operating systems**
- **data base systems**
- **office applications**
- **real-time systems**



Distributed system

- **is executed by several independent CPUs/systems**
- **objective:**
  - among others: optimized load distribution
    operating system usually allocates physical units
- **user perspective:**
  - centralized system
    (i.e., for example no explicit "login")
- **the existence of single objects/units/systems is not visible**

⇒ **distribution transparency**

3. 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 (a.o., E-mail, interactively)**
- **person to data pool (a.o., data bases, WWW, video server)**

4. Implications on Society

Open communication
- **Who, when, with whom, about what**
- **different forms of communication (and of formal speech)**
- **increased communication among many people across the globe**
- **consequences:**
  - information flood
  - cultures melt
  - monitoring of communication between "entities" can become possible

Speed
- **fast distribution of information**
- **meaning: democracy, efficiency, ...**

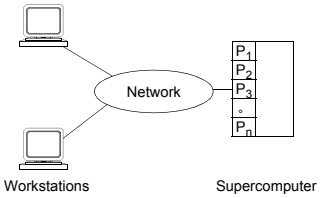
Legal problems
- **copyright**
- **validity of electronic contracts (signature)**

Contents
- **besides technology also politics, religion and sex**
- **multitude of media, possibly even live**
- **responsibility? (network carriers: hardly possible)**

⇒ **security in networks, etc.**

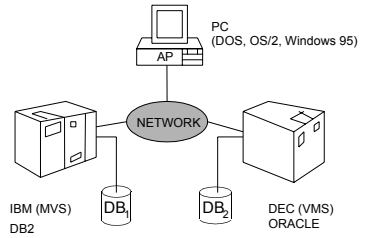
5. Applications

Access to remote programs

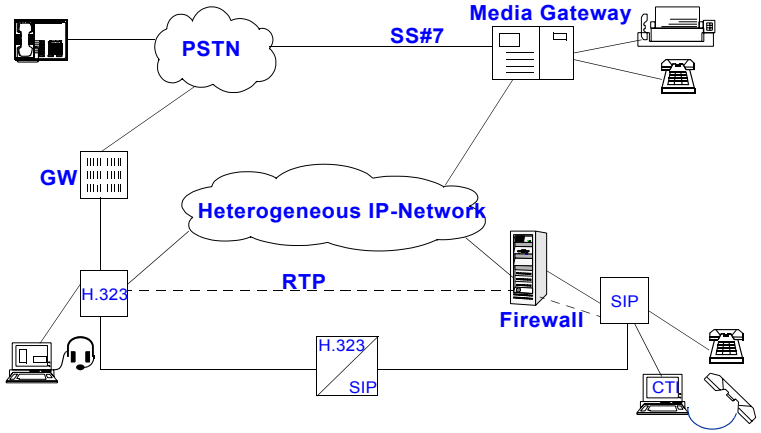


Access to remote data

e.g.,
- **reservation systems**
- **home banking**
- **electronic newspaper**
- **library**
- **poss. "Kiosk" as client**



Applications: Network as a Communication Medium (2)



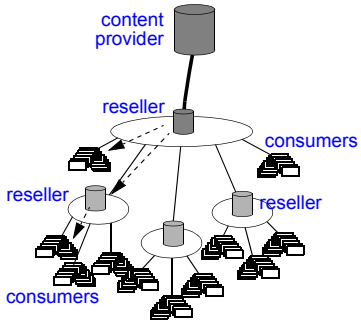
e.g.,
- **electronic mail (several media)**
- **bulletin boards (several media)**

and (as outlined above) Internet telephony

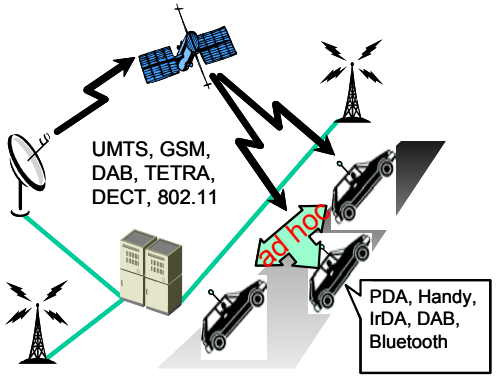
Applications: Classic Multimedia Applications (3)

e.g.,
- **WWW**

but also
- **video-on-demand (based on digital television)**
- **tele-action, tele-vision, tele-conferencing, tele...**
- **distributed games !**



Applications: Communication for Road Scenarios (4)



Communication system support for (road) traffic participants

e.g.,

- **traffic flow information (congestion)**
- **marketing (special offer for fuel at next station)**

Applications: Ubiquitous Computing and Communication (5)

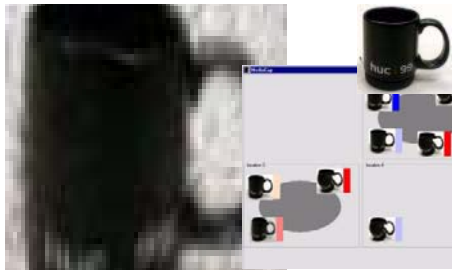
often means hidden communication

example furniture

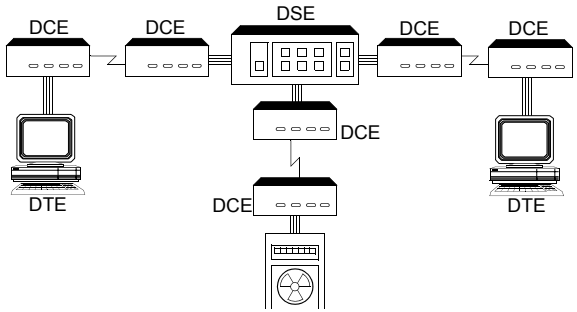
example coffee cup

`http://www.teco.edu/`

- **sensors, processing and communication capabilities**
- **collect information and use it within the respective context**



6. Basic Components



Data Terminal Equipment (DTE)::

- **OSI: end-system (ES)**
- **example: terminal, computer, telephone**

Data Circuit terminating Equipment (DCE)

Data transfer equipment

- **example: modem, multiplexer, repeater**

Data Switching Exchange (DSE)::

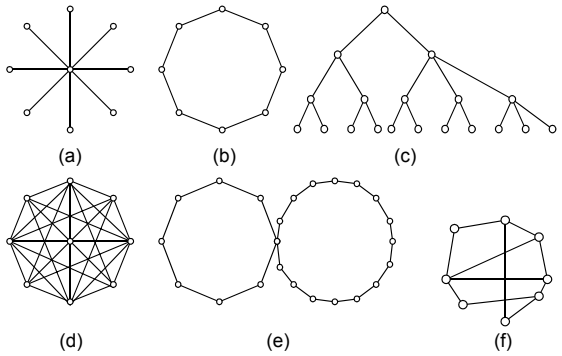
- **OSI: Intermediate System (IS)**

6.1 Network Structures

Point-to-point channels

- **net = multitude of cable and radio connections often also called a network**
- **whereby a cable always connects two nodes**
- **more prevalent in wide area domains (e.g., telephone)**

Topologies:

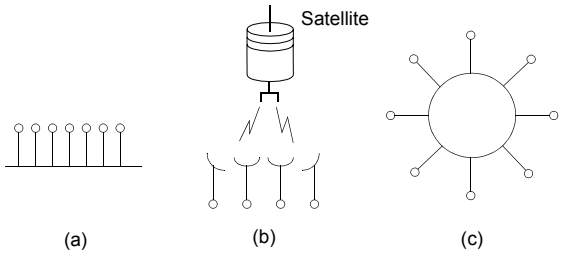


Network Structures (2)

Broadcasting channels
- systems share one communication channel
- one sends, all others listen

Used for
- wide area: radio, TV, computer communication
- local area: local networks

Topologies:



6.2 Network Types

Distance betw. Processors	CPUs jointly located on/in ..	Example
<= 0,1 m	Boards	usually tightly coupled multi-processor system
1 m	Systems	usually loosely coupled multi-processor system
10 m	Rooms	LAN
100 m	Buildings	
1 km	Campuses	
10 km	Cities	MAN
100 km	Countries (national)	WAN
1.000 km	Continents (intern.)	
>= 10.000 km	Planets	

Reviewing computer networks/communication networks
- Local Area Network (LAN) examples: IEEE 802.3 = Ethernet, IEEE 802.11
- Metropolitan Area Network (MAN): (being replaced by LAN + WAN), e.g., FDDI
- Wide Area Network (WAN): examples: ATM, optical networks
- also others: body, personal, desk, storage, ... area networks

Network Types: Mobile Communication

Expansion
- with the areas: LAN, MAN and WAN

Examples for "Wireless"
- GSM, UMTS, .
- wireless telephony: DECT, ..
- LANs: Bluetooth, WaveLAN, ..

wireless communication ≠ mobile communication

		Wired or Radio Connection	
		Wired	Wireless
Connection to network either static or dynamic	Mobile	mobile IP e.g., laptop in the hotel	mobile telephony e.g., laptop in the car PDA at customer's site
	Fixed	POTS existing LANs e.g., workstation in the office	wireless LAN cordless telephone e.g., wireless "last mile"

7. Examples

UUCP (UNIX TO UNIX COPY) - NETWORK

NETWORK: UNIX systems connected by switched lines

Principle (sub-network)
- systems equipped with modems
- central system equipped with automatic dialing options
  - dials up one system after another, login
  - uploads the files to be sent
  - downloads these same files to the receiving systems

At the time it was a very large network:
- ≈ 10.000 end-systems
- ≈ 1 million users

International network:
- multitude of national networks
- one gateway per national network

Services
- E-mail
- news
- file transfer

Examples: ARPANET (2)

- **initiated and financed by ARPA (Advanced Research Projects Agency of the U.S. Department of Defense (DoD))**

Objective:
- originally: network to survive a nuclear war
- later: connecting scientific and military institutions

1969:
- experimental network with 4 nodes, followed by rapid growth, BBN first contractor

Development of the INTERNETs
- standardized protocols for the communication between networks:: TCP/IP (1983)
- linking military sub-networks (MILNET, MINET)
- linking satellite networks (SATNET, WIDEBAND)
- linking universities' LANs

- **TCP/IP technology as a part of UNIX spreads fast → ARPANET growing rapidly (1987:: 15% per month)**

1987: 20.000 computers, more than 100.000 users

1990: ARPANET has been replaced, MILNET still exists

Services: E-mail, file transfer, remote login, WWW. . .

Examples: CSNET (3)

History:
- **Initiated in 1980**
- **financed by the NSF (National Science Foundation), because ARPANET usage may imply a contract with DoD**

Objective:
- **to provide a network which is accessible for all CS departments of U.S. universities**

Consists of 4 components:
- ARPANET
- public X.25 networks (Telenet, Uninet)
- PHONENET (switched lines to the CSNET-RELAY)
- CYPRESS (low budget variant of the ARPANET)

- **components are linked by one node: CSNET-RELAY**

Services:
- **E-mail, file transfer, remote login**
- **ARPANET protocols (TCP/IP)**

Examples: NSFNET (4)

1988: NSF Supercomputer centers and NSF Mid-level network

- **financed by the NSF (National Science Foundation)**

Objective: backbone network to connect supercomputer centers
- **history and bandwidths:**
  - 1984: 56 kbps, later 1,5 Mbps,
  - 1990: 45 Mbps (as ANSNET, ANS= Advanced Networks and Services)
  - 1991: NREN (National Research and Education Network) founded with the following objectives:
    - to succeed NSFNET in research
    - Gigabit per second
  - NSF enters into contracts with 4 common carriers to form the NAP (Network Access Point) as a backbone for existing speeds
  - 1995: sold to America Online

Services: E-mail, file transfer, remote login
- **ARPANET protocols (TCP/IP)**

Examples: "Internet 2" (5)

1996: project started among 34 universities
- **strongly supported by the industry**
  - $500Mio: Cisco Systems, 3Com, MCI ...
- **infrastructure for science and teaching**
- **GigaPOPs with capacities**
  - OC-12 (622 Mbps), OC-48 (2.5 Gbps), ..

Features
- integration of QUALITY OF SERVICES CONCEPTS
- designed as a "proof of concept"
- innovative applications: what to do with the bandwidth?

Examples: Next Generation Internet (NGI) (6)

Started in 1996 because of a government initiative

Next Generation Internet Initiative

Objectives (Clinton, 1996-10-10, Oak Ridge, Tenn.)

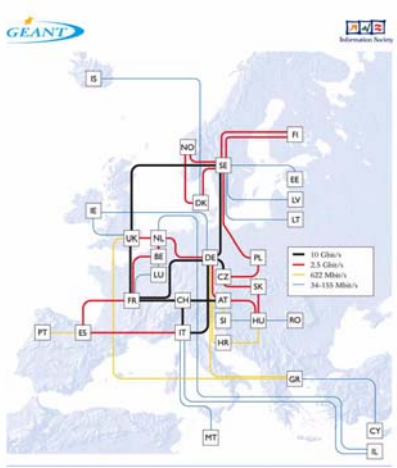
- " 100 to 1000 times faster than the present Internet, sufficiently secure, usable for every American, ..."

Used in

- medicine,
- national security,
- "DISTANCE EDUCATION"

Examples: GÉANT (7)

pan-European Gigabit Research Network
URL: http://www.dante.net/geant/



Examples: DFN (8)

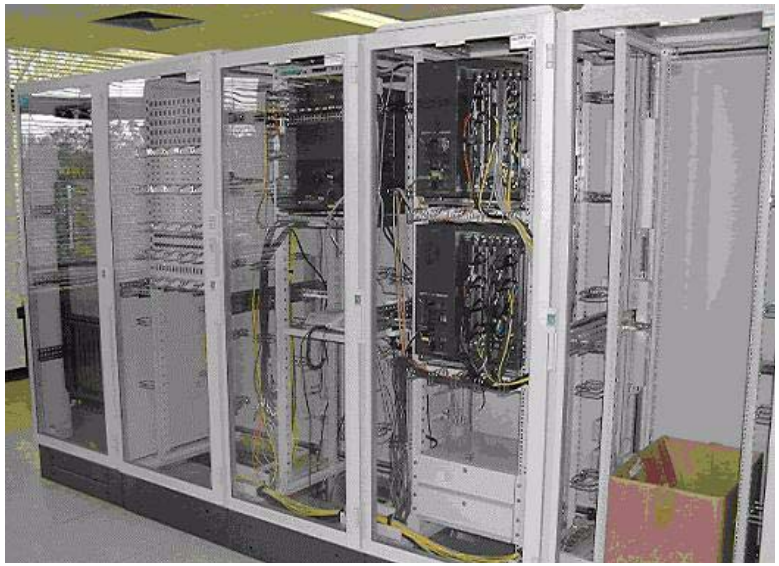
Deutsches Forschungsnetz (German research network):

- WiN network
  URL: http://www.dfn.de/win/bwin/bwinkarte.html

now replaced by GWIN (Gigabit-WIN)

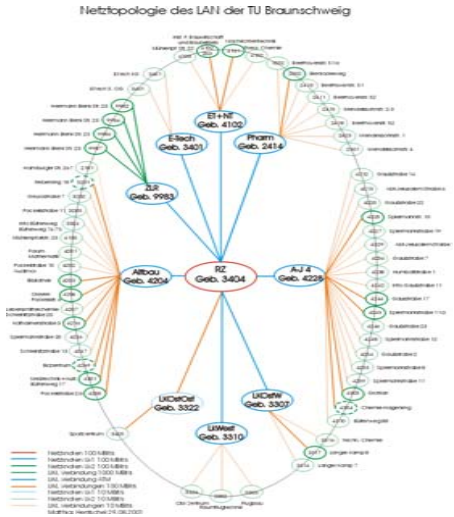
- BWIN: ATM-based
- GWIN: IP-over-SDH

Examples: Gigabit Node of the DFN (9)



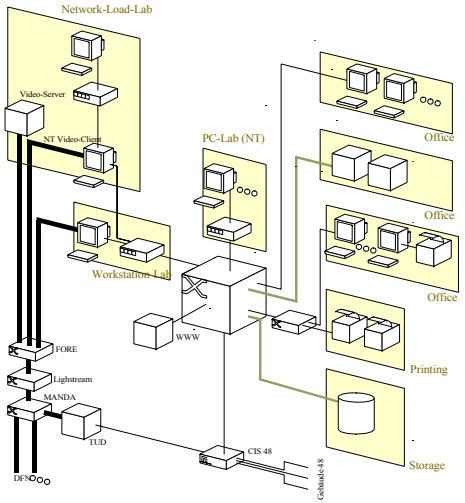
Examples: TU Braunschweig (10)

http://www.tu-bs.de/rz/tubsnet/struktur/

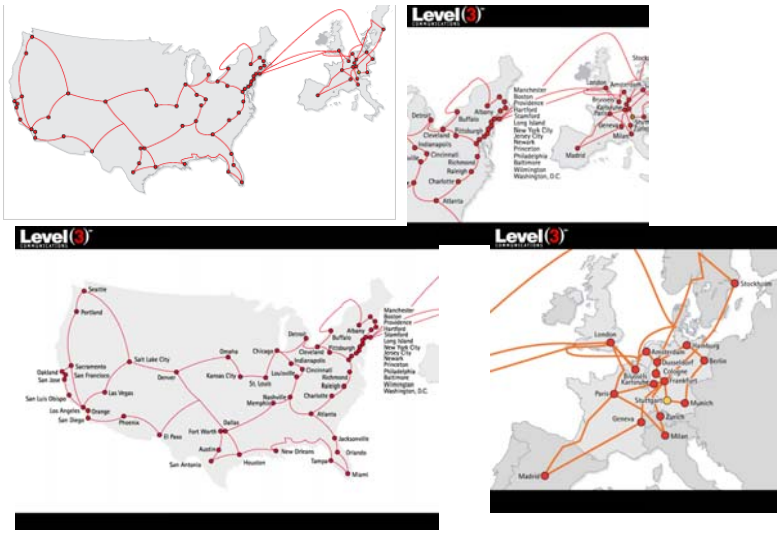


Examples: Building Internal Network (11)

e.g., some university institute



Examples: Commercial Internet Service Provider (12)



8. Structuring

Problem: engineering communication means

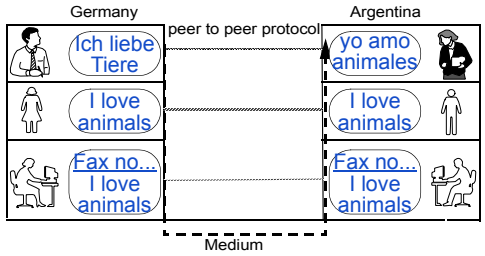
- **multitude of partially very complex tasks**
- **interaction among differing systems and components**

Simplification:

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

Example:

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



Structuring within communication often using layered model:

- **in this section using ISO-OSI reference model**
- **later using 5 layer model**

8.1 ISO Reference Model for Open Systems

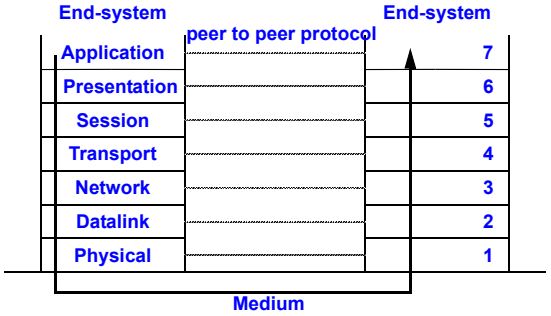
OSI (Open Systems Interconnection) Reference Model

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

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

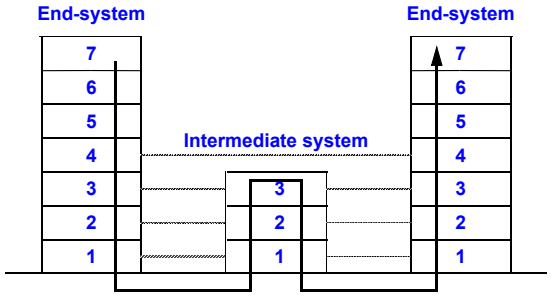
OSI Architecture

Actual data flow between two neighboring systems:



OSI Architecture

Real data flow with intermediate system:



8.2 ISO-OSI Layers: Functions

Layer	Function
1 ***Physical***	**sending of 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 adjacent 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***	**transfer from end-system to end-system** internetworking: links (sub-) nets (to achieve end-to-end) connection-oriented or connection-less routing congestion control (too many packets on one path) quality of service support
4 ***Transport***	**transfer from end/source (application/process) to end/ destination (application/process)** addressing transport service users (processes) connection management (if connection-oriented, may also be connection-less) data transfer between users in end-systems transparent with respect to underlying technologies and networks optimize required quality of service and costs flow control, error control / reliability

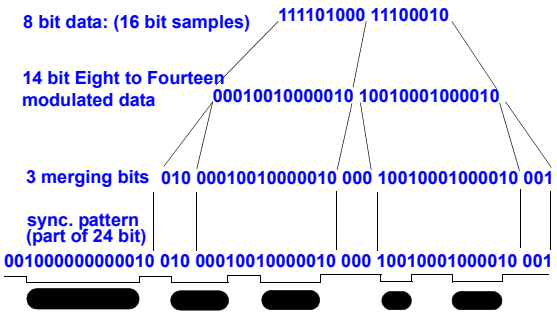
Layer	Function
5 ***Session***	**support a "session" over a longer period** synchronization (during interrupted connection) token management (coordinate simultaneous processing of different applications)
6 ***Presentation***	**data presentation independent from the end-system** negotiating the data structure, conversion into a global data structure examples: data types: date, integer, currency, ASCII, unicode,..
7 ***Application***	**application related services** examples: electronic mail, directory service file transfer, WWW, ..

Comment:
- **layer does not necessarily correspond to unit of implementation**
  - not necessarily 1:1 mapping of layer and process/thread
  - otherwise loss of efficiency

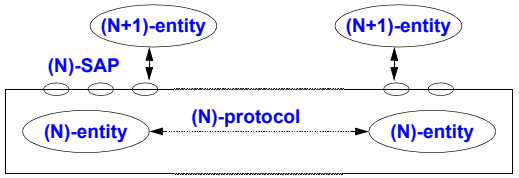
8.3 Layers

only in communication?
- **abstraction is a standard approach**
- **layers exist in various areas**
  - e.g.,
    - compression: MPEG
    - CD technology

Example: CD Digital Audio
- **here also levels**
- **here also data units**



Layer Concepts



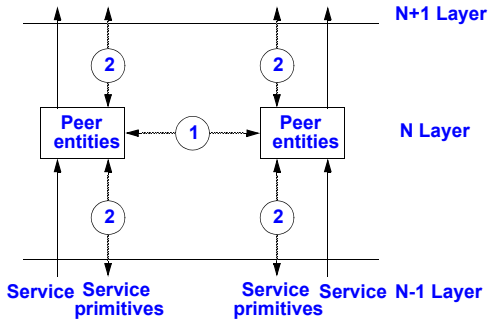
N-Layer
- **abstraction level with defined tasks**

N-Entity
- **active elements within 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:
- **a set of rules for transfering data between N-entities**

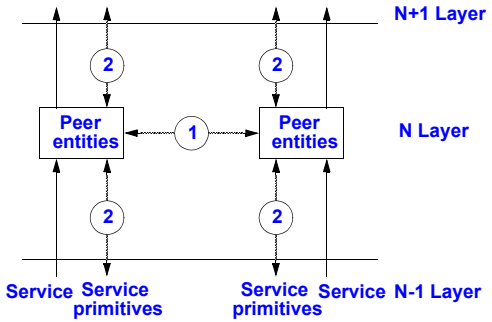
Communication between Layers: Service



Service

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

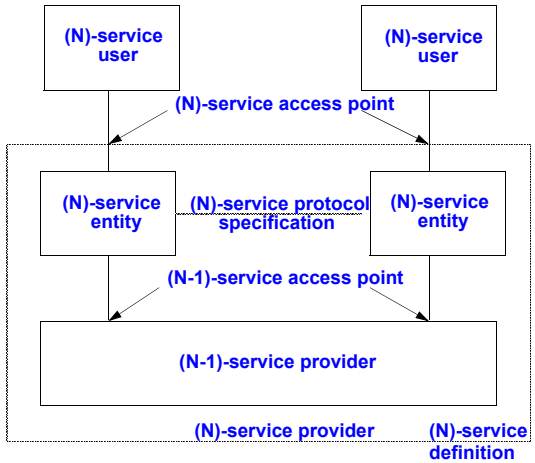
Communication between Layers: Protocol



Protocol

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

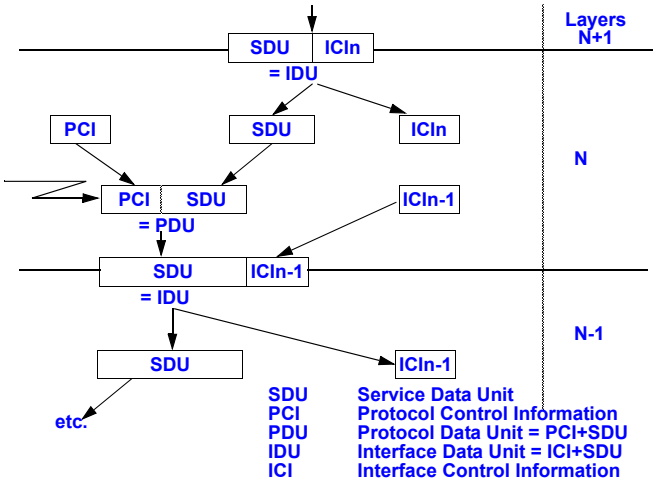
Layer Concepts: Service Provider and Service User



Service Provider

Service User

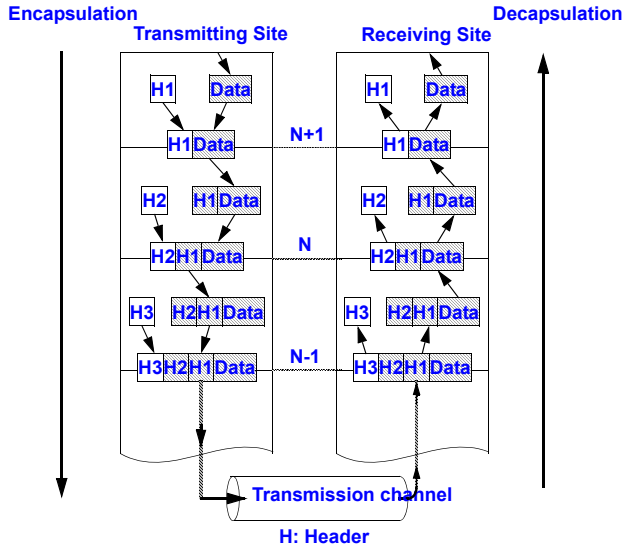
Interface Data Unit (IDU)



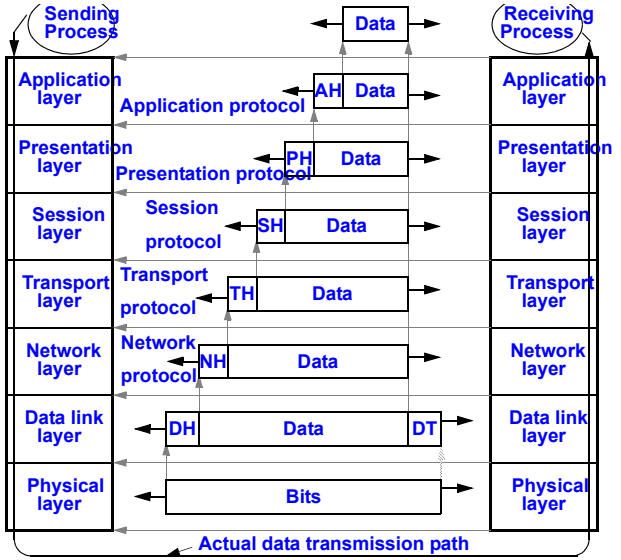
PDU → IDU

- 1 : 1
- 1 : n (splitting)

Nested Protocol Data Units (PDUs)



Nested Protocol Data Units (PDUs) (2)



Nested Protocol Data Units (PDUs) (3)

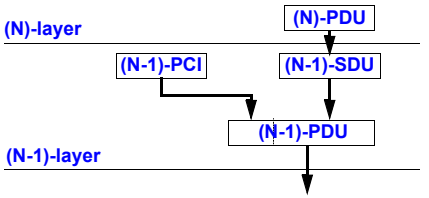
L2	L3	L4	L5	L6	L7	User	L2
PCI	PCI	PCI	PCI	PCI	PCI	Data	FCS

- with the following abbreviations:

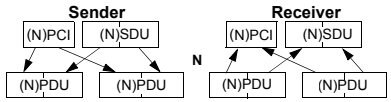
SDU	Service Data Unit
PCI	Protocol Control Information
PDU	Protocol Data Unit = PCI+SDU
IDU	Interface Data Unit = ICI+SDU
ICI	Interface Control Information
FCS	Frame Check Sequence (e.g., CRC)

Service Data Units and Protocol Data Units

Basis:



With segmentation / reassembling

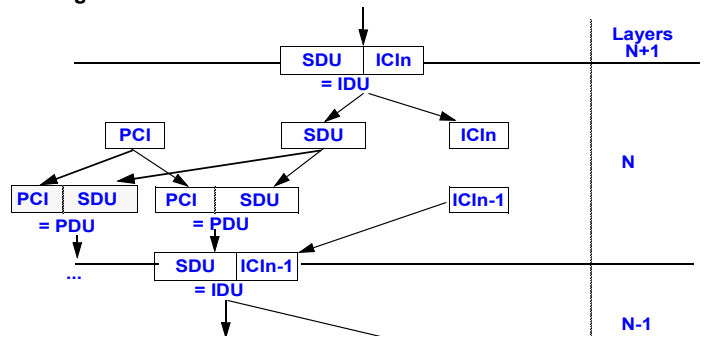


- with the following abbreviations:

SDU	Service Data Unit
PCI	Protocol Control Information
PDU	Protocol Data Unit = PCI+SDU
IDU	Interface Data Unit = ICI+SDU
ICI	Interface Control Information
FCS	Frame Check Sequence (e.g., CRC)

Service Data Units and Protocol Data Units (2)

i.e., divide larger SDUs into several PDUs



- with the following abbreviations:

SDU	Service Data Unit
PCI	Protocol Control Information
PDU	Protocol Data Unit = PCI+SDU
IDU	Interface Data Unit = ICI+SDU
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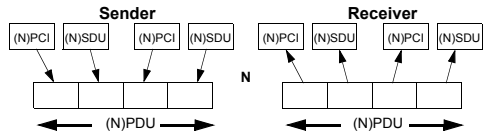
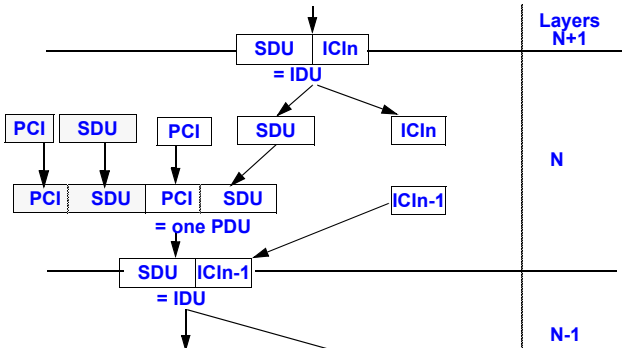
FCS	Frame Check Sequence (e.g., CRC)

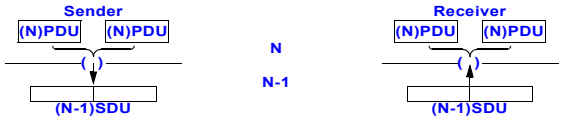
Service Data Units and Protocol Data Units Blocking / Deblocking (2)



i.e., to pool several SDUs in one PDU

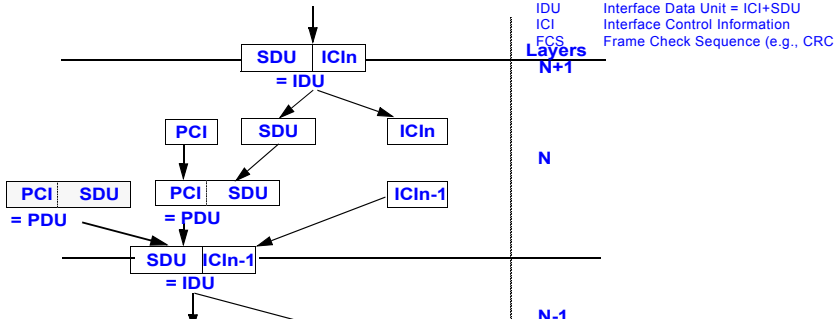


Service Data Units and Protocol Data Units Concatenation / Separation (3)



i.e., to hand over several PDUs together to an underlying layer

SDU	Service Data Unit
PCI	Protocol Control Information
PDU	Protocol Data Unit = PCI+SDU
IDU	Interface Data Unit = ICI+SDU
ICI	Interface Control Information
FCS	Frame Check Sequence (e.g., CRC

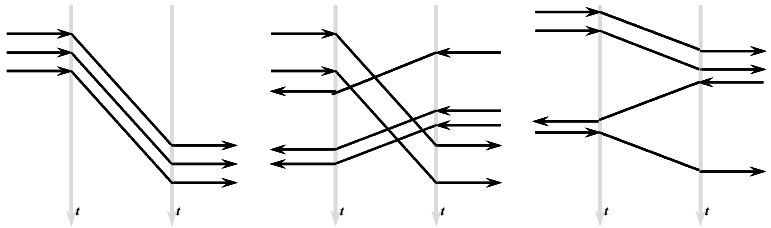


8.4 Parallelism in Communication

Simplex Communication
- data is always transfered in one direction

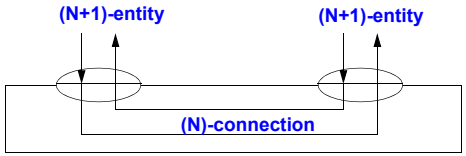
Fully-Duplex-Communication
- data can flow simultaneously in both directions

Semi-Duplex-Communication
- data is transfered in both directions
- but never simultaneously



8.5 Connection-Oriented Service

Connection oriented:



- **3 phases:**
  1. **connect**
  2. **data transfer**
  3. **disconnect**

analogy: telephone service

- **applications (preferably):**
  - regularly recurring data units
  - longer duration
  - quality of service guarantees (time, bandwidth)

8.6 Connectionless Service

Connectionless (Datagram Service)

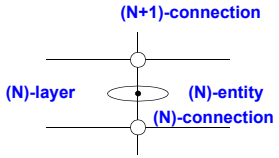
- **transfer of isolated unit data**

Analogy: letter delivery

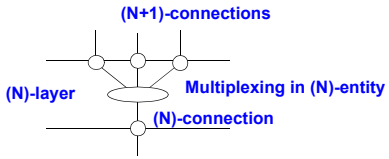
- **applications (preferably):**
  - one-time data transfer
  - short duration

8.7 Multiplexing and Splitting (of connections)

1-to-1:

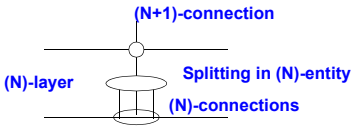


Multiplexing / Demultiplexing:



Splitting / Recombining

- (often also called "upward" multiplexing):



8.8 Service Primitives

Service primitives

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

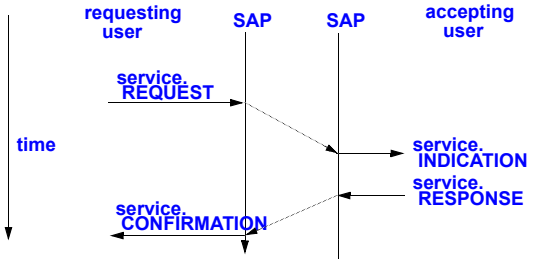
Types:

1. **service. REQUEST**
   2.service. INDICATION
   3.service. RESPONSE
   4.service. CONFIRMATION

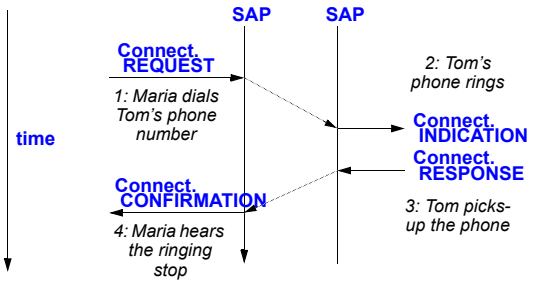
Example:

Connect. REQUEST
Connect. INDICATION
Connect. RESPONSE
Connect. CONFIRMATION

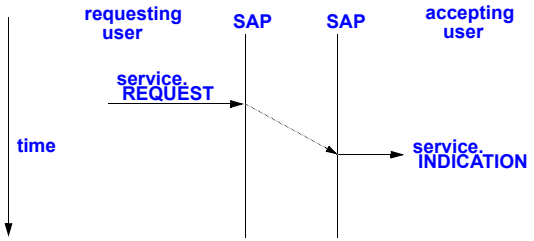
Confirmed Service



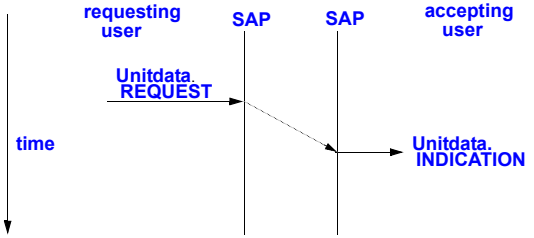
Example:



Unconfirmed Service



Example:



Service Primitives: Practical View

Above service primitives are basically abstract

More concrete service primitives

- **to establish a simple connection-oriented service**

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

8.9 Layers: Conception vs. Implementation

Concept

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

Experiences with communication systems

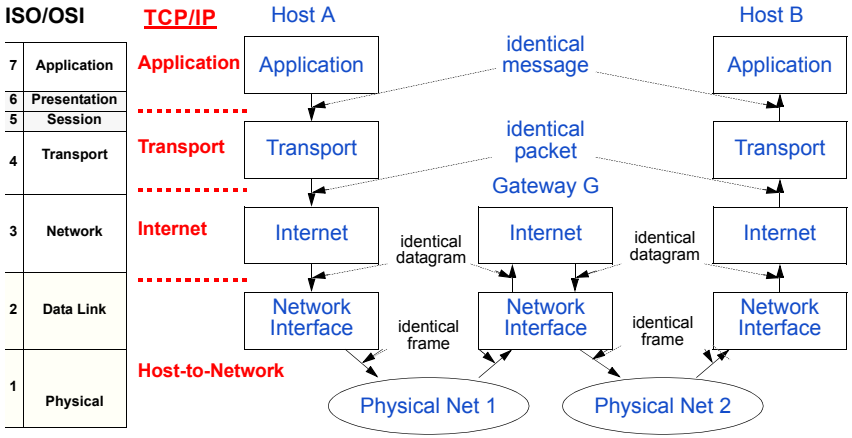
- **changing the context of processes takes a lot of time**
- **most of the processing time is used up for copying (despite, e.g., DMA)**
  - adapter -> main memory
  - within the main memory (layer to layer)
  - main memory -> adapter
- **difficult to check correctness**
  - parallelism, many potential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

Implementation

- **pooling several layers to one process**
- **using dedicated buffer management**
  - copying is logical copying (pointer operations)

9. Other Reference Models and Comparison

9.1 TCP/IP



- **ISO-OSI presentation and session do not exist**
- **data link and physical layer combined**

TCP/IP Reference Model: Some Critique

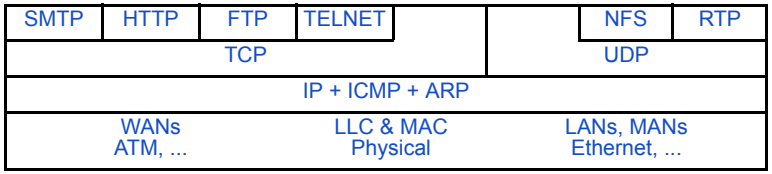
Service, interface, and protocol not distinguished

Not a general model

Minor protocols deeply entrenched, hard to replace

Data link and physical layer combined to form Network Interface or Host-to-Net
- **Hardly any statements in the model about this**
- **No mention of physical and data link layers**
- **not really a 'layer'**

TCP/IP: Well-Known Internet Protocols



ARP	=	**Address Resolution Protocol**
FTP	=	**File Transfer Protocol**
HTTP	=	**Hypertext Transfer ProtocolIP=Internet Protocol**
ICMP	=	**Internet Control Message Protocol**
LLC	=	**Logical Link Control**
MAC	=	**Media Access Control**
NFS	=	**Network File System**
SMTP	=	**Simple Mail Transfer Protocol**
TELNET	=	**Remote Login Protocol**
TCP	=	**Transmission Control Protocol**
UDP	=	**User Datagram Protocol**
RTP	=	**Real-Time Transport Protocol**

9.2 Reference Model Comparison

ISO-OSI:
- **standardized too late**
- **implementations usually worse than those of Internet protocols**
- **some issues are not sufficiently clear**
  - resp. committee compromises ...
- **in general, however, good concepts**

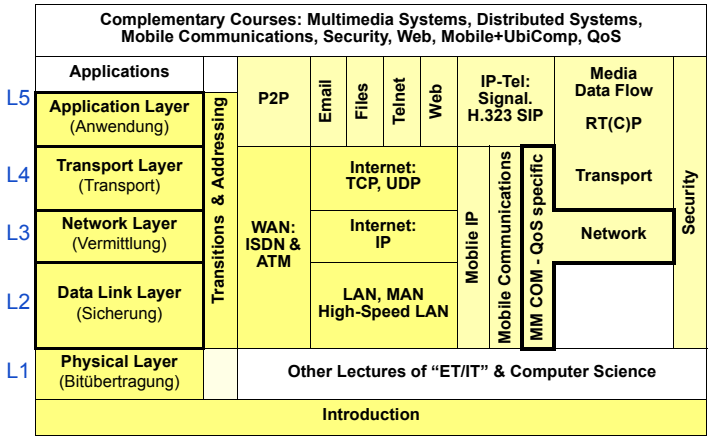
TCP/IP (Internet):
- **TCP/IP already prevalent**
  - and also application protocols, e.g., SMTP, now WWW, etc.
- **integrated into UNIX**
  - BSD

9.3 Hybrid 5-Layer Model Used Herein

Model considered here:

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/ destination (application/process)
3	***Network***	connection end-system to end-system
2	***Data Link***	reliable data transfer between adjacent stations
1	***Physical***	sending bit 1 is also received as bit 1

i.e., Structure used within the course



10. Standardization

Term "standardization"

Standardization is the methodical simplification of material and immaterial objects for the benefit of the general public, executed jointly by the interested circles

- **communication means compatibility, i.e., exchange is important**
- **in general: not legally binding**

Types

- **de facto**
  - manufacturer or user driven
  - VHS, Ethernet, Internet, ...
- **de jure**
  - telephone, ...
- **usually a combination of both**

⇒ **Panels for Standardization**

Panels for Standardization: ISO

ISO: International Organization for Standardization

- **national organizations for standardization send delegates**
  - DIN: the national German institute for standardization
  - ANSI (American National Standards Institute)
  - AFNOR (France), BSI (GB), ...
- **organized**
  - in more than 200 Technical Committees (TC)
  - TC has subcommittees (SC)
  - SC has working groups (WG)
- **steps for standardization**
  1. **Working Draft (WD)**
  2. **Draft Proposal (DP)**
  3. **Draft International Standard (DIS)**
  4. **International Standard (IS)**
- **up to now more than 5000 standards, among others: OSI**

Panels for Standardization: ITU (2)

ITU: International Telecommunication Union

- **since 1947 part of the UN (United Nations)**
- **among others subdivision such as**
  - ITU-R: radio communication
  - ITU-T: telecommunication (important here)

- **until 1993, ITU-R was know as CCITT:**
  Comite Consultatif International de Telegraphie et Telephonique
  - international union of post and telecom
  - plenary meeting every 4 years
  - passing of "recommendations"
    example SDL, CHILL, ...

- **example: V.24 by ITU-T (also known as EIA RS-232)**

Panels for Standardization: Internet Society (3)

Internet (Internet Society)

- **in the mid-80s a multiple of networks was designated as the "Internet"**
- **Jan. 1992: (actual) foundation of the Internet Society**
  objective: to distribute the Internet (protocols & services)

Tasks in the INTERNET

- **connect different networks over gateways**
- **define protocols that will work on all subnets**
- **define a standardized addressing pattern for a very large network**
- **define a global routing architecture**

Panels for Standardization: Internet Society (4)

Areas / structure of the Internet Society:

- **IAB: INTERNET ARCHITECTURE BOARD**
  - founded in 1983 to involve researchers in the ARPANET
  - today it is the most supreme Internet board
- **IAB oversees/nominates**
  - **IETF (INTERNET ENGINEERING TASKFORCE)**
    - divided into approx. 70 working groups
      (e.g., RSVP)
    - actual board
  - IRTF (Internet Research Taskforce)

RFCs (REQUESTS FOR COMMENTS)

- **recommendations**
- **today (March 2002) numbering more than 3200**
- **work in progress: Internet Drafts**

Panels for Standardization: Internet Society (5)

But:

- **from S. Bradner: The Internet Standards Process -- Revision 3, RFC 2026, October 1996**

```
*************************************************************
*                                                           *
*   It is important to remember that not all RFCs           *
*   are standards track documents, and that not all         *
*   standards track documents reach the level of            *
*   Internet Standard. In the same way, not all RFCs        *
*   which describe current practices have been given        *
*   the review and approval to become BCPs. See             *
*   RFC-1796 [6] for further information.                   *
*                                                           *
*************************************************************
```

Internet Standards Track

- **Standards Track Maturity Levels**
  - Proposed Standard
  - Draft Standard
  - Internet Standard
- **Non-Standards Track Maturity Levels**
  - Experimental
  - Informational
  - Historic

Panels for Standardization: Others (6)

ECMA: European Computer Manufacturers Association
- **manufacturers' lobby**

IEEE: Institute of Electrical and Electronics Engineers
- **IEEE actually worldwide the biggest professional organization**
- **among others resp. for standards, e.g., LANs IEEE 802 later also ISO 8802**

Industry Fora:
- **ATM Forum**
- **Bluetooth**
- **3GPP**
- **...**