Computer Networking and IT Security (CNS)

INHN0012 – WiSe 2025/26

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School of Computation, Information and Technology
Technical University of Munich

Chapter 0: Organizational Matters and Introduction

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Organizational matters and introduction

- Substitute:
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- Office hours:
  by arrangement

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    (Garching)
- Office hours:
  by arrangement

Please use `cns@hndss.cit.tum.de` for all emails

Lecture and exercise mode

Lecture hours

- Wed 14:15 – 17:00 with a short break
  (Lecture Hall C.0.50, Weipertstr. 8-10)

Lecture recording

- The lecture is offered as a face-to-face event without live streaming and without recording
- We recommend to attend the lecture regularly

Central exercise

- No regular central exercise is planned
- Occasionally, instead of lectures, question and answer sessions are held to prepare for exams

Tutorials

- Working on the exercises during the tutorial in small groups
- No compulsory attendance / homework
- Please familiarize yourself with the contents of the respective exercise sheet before participating in the tutorials
- Tutorial hours and information about registration will be announced via Moodle
- Registration via TUMonline

Quizzes

Quizzes („Mini-Midterms“)

- Supervised onsite during the lecture, pen and paper
- 4 quizzes with 15 credits each planned
- 15 min working time
- Closed-book, a non programmable pocket calculator is allowed
- Quizzes will be announced one week prior, but there is no schedule
- The content of quizzes will never cover things that may have been discussed in some of the tutorial groups only, i. e., either content that has been discussed in all tutorial groups so far or new content of today’s lecture
- Quizzes will mostly consist of multiple choice / multiple answer, but some free-text problems are possible

Quizzes are voluntary but make up the bonus system

Endterm / Retake

- Onsite, 90 min, approximately 90 credits
- Closed-book, a non programmable pocket calculator is allowed
- Multiple Choice Multiple Answer possible (up to 20 %)
- No “programming on paper”
- Date and time *tba*

Bonus system

- You can achieve 15 credits per quiz
- These 15 quiz credits are mapped to 5 bonus credits $\Rightarrow$ 20 bonus credits achievable
- Of these 20 bonus credits **max. 15 bonus credits will be credited**
  $\rightarrow$ if you score all 20 bonus credits, only 15 will be credited anyway
- That means you may miss one of the quizzes and are still able to achieve the full bonus
- The bonus is added to the credits of the final exam, provided that it was passed with a grade of at least 4.0 without the bonus
- The bonus is also credited to the retake exam

Scientific misconduct, cheating, and plagiarism

- Exams and quizzes are meant to be done on your own, i. e., no group work, no googling, and no AI
- Cheating in quizzes leads to the exclusion of all involved participants from the bonus system
- Cheating and violations of order in an examination are reported in accordance with the APSO:
  - Entire course failed
  - The exam can be repeated a maximum of once (§24)
  - Cheating may result in expulsion from the course of study (§22)

Lecture notes

- Lecture and exercise material is provided via:

  `https://cns.net.in.tum.de`

- If we provide you with documents that are subject to separate copyright, we will offer those for download in the Moodle course
- For access to Moodle you must be registered for the lecture in TUMonline
- This year's lecture will not be recorded

Note: Up-to-date information on the lecture is available exclusively via Moodle. This concerns in particular information on the status of the lecture or updates on exams. Moodle will notify you of new posts via email unless you have disabled notifications.

Chapter 0: Organizational Matters and Introduction

Chapter 1: Physical layer

1. Signals, information and their meaning
   - What are signals?
   - Entropy and information
2. Classification of signals
   - Time and frequency domains
   - Sampling, reconstruction and quantization
3. Transmission channel
   - Influences of the transmission channel on signals
   - Capacity of a transmission channel (model)
4. Message transmission
   - Source and channel coding
   - Pulse shaping
   - Modulation
5. Transmission media
   - Electromagnetic spectrum
   - Coaxial conductor
   - Twisted pair cables
   - Fiber optic cables

Chapter 2: Data link layer

1. Representation of networks as graphs
   - Network topologies
   - Adjacency and distance matrices
   - Shortest Path Tree and Minimum Spanning Tree
2. Connection characterization, multiple access, and media access control
   - Serialization and propagation delay
   - Message flow diagrams
   - ALOHA and slotted ALOHA
   - CSMA, CSMA/CD und CSMA/CA
   - Token Passing
3. Framing, addressing, and error detection
   - Frame boundary detection and code transparency
   - Addressing and error detection
   - Case study: IEEE 802.3u (FastEthernet)
   - Case study: IEEE 802.11a/b/g/n (Wireless LAN)
   - Security aspects of wireless transmissions
4. Connections on layers 1 and 2
   - Hubs, bridges, and switches
   - Collision and broadcast domains

Chapter 3: Network layer

1. Switching types

- Line switching
- Message switching
- Packet switching

2. Addressing on the Internet

- Internet Protocol version 4 (IPv4)
  - Address resolution (ARP)
  - Internet Control Message Protocol (ICMP)
  - Address classes (for classful routing)
  - Subnetting and prefixes (for classless routing)
  - Encrypted data transfer using IPSec
- Internet Protocol version 6 (IPv6)
  - Stateless Address Autoconfiguration (SLAAC)
  - Internet Control Message Protocol v6 (ICMPv6)
  - Neighbor Discovery Protocol (NDP)

3. Routing

- Static routing
- Longest prefix matching
- Dynamic routing
- Algorithms of Bellman-Ford and Dijkstra
- Routing protocols (distance vector and link state)
- Autonomous systems

Chapter 4: Transport layer

1. Tasks of the transport layer
2. Multiplexing using port numbers
3. Connectionless transmission: UDP
4. Connection oriented transmission: TCP
   - Sliding window protocols (go-back-N and selective repeat)
   - Congestion control
   - Flow control
5. Network Address Translation (NAT)
6. Firewalls

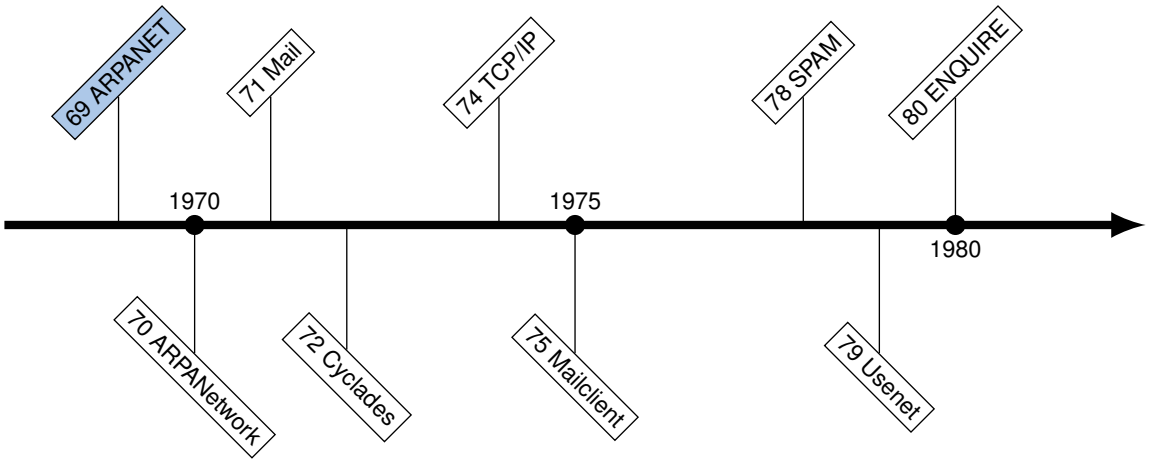
Chapter 5: Layers 5 – 7

1. Advantages and disadvantages of layered models
2. Session layer
   - Services
   - Functional units
   - Synchronisation
   - Quality of service
   - Performance parameter
3. Presentation layer
   - Data compression (Huffman code)
   - JSON
4. Application layer
   - Name resolution (DNS)
   - HTTP
   - SMTP
5. Security
   - TLS, PKI, X.509 certificates
   - HTTPS
   - DoH (DNS over HTTPS)
   - SSH

Chapter 0: Organizational Matters and Introduction

Emergence of the Internet

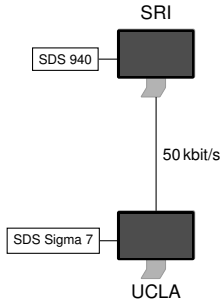
Overview until 1980



Emergence of the Internet

ARPANET with the first four nodes

- University of California, Los Angeles (UCLA) Sept. 1969
- Stanford Research Institute (SRI) Okt. 1969



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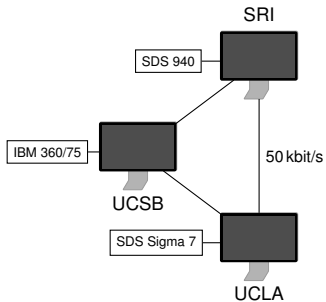

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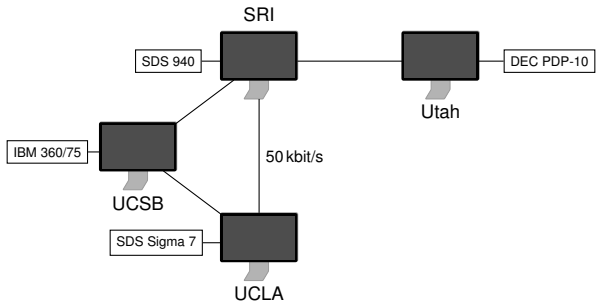
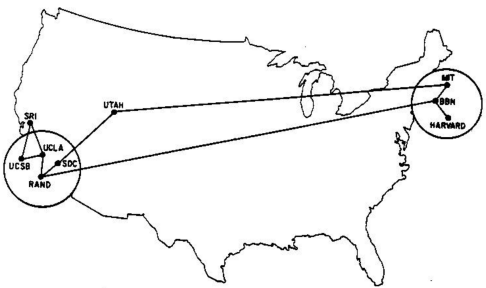


Emergence of the Internet

ARPANET from 1969 to 1972

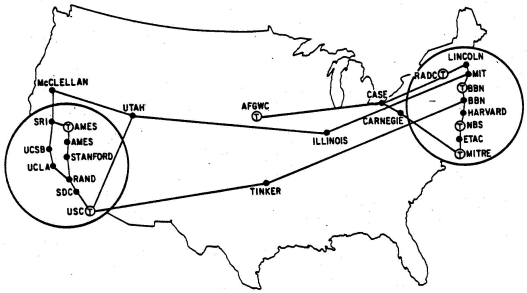
ARPANET 1969, 4 stations



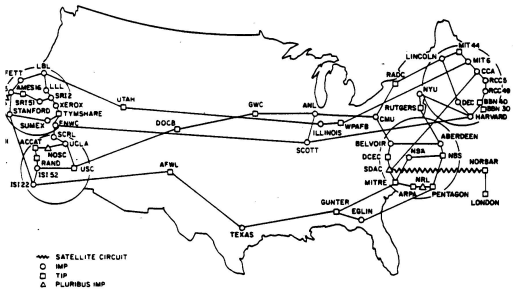
ARPANET 1970, 9 stations

Emergence of the Internet

ARPANET from 1972 to 1977



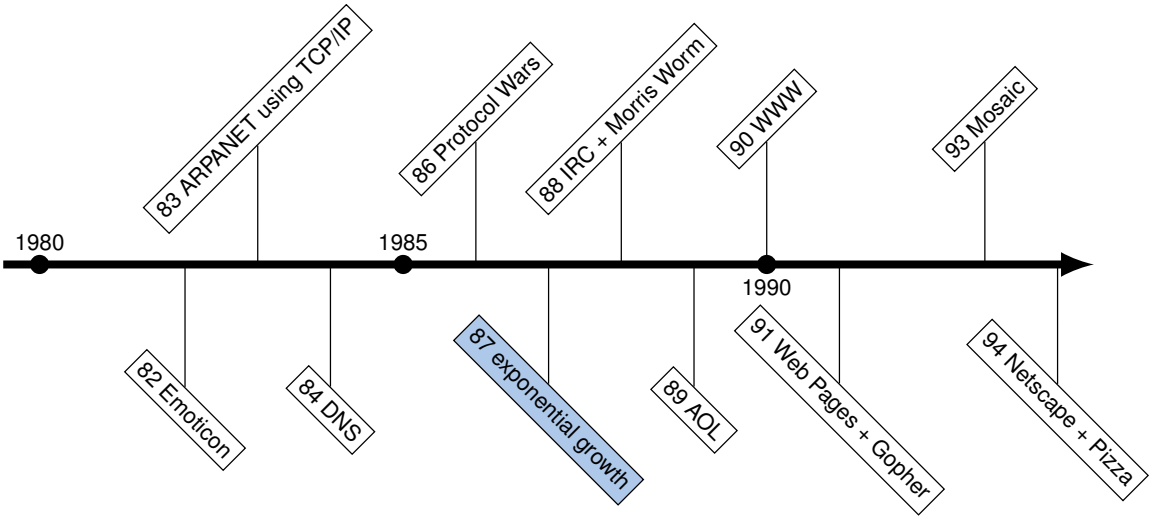
ARPANET 1972, 25 stations



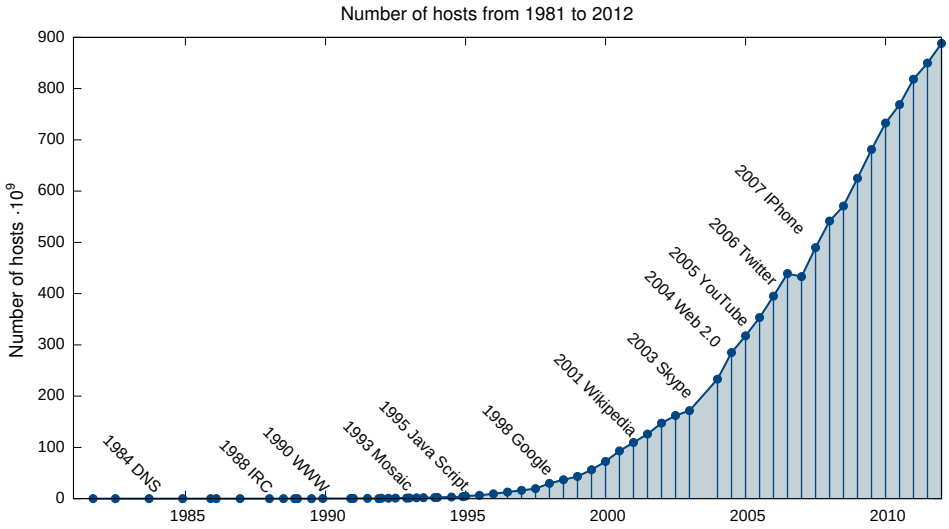
ARPANET 1977, 58 stations

Emergence of the Internet

Overview from 1980 to 1994

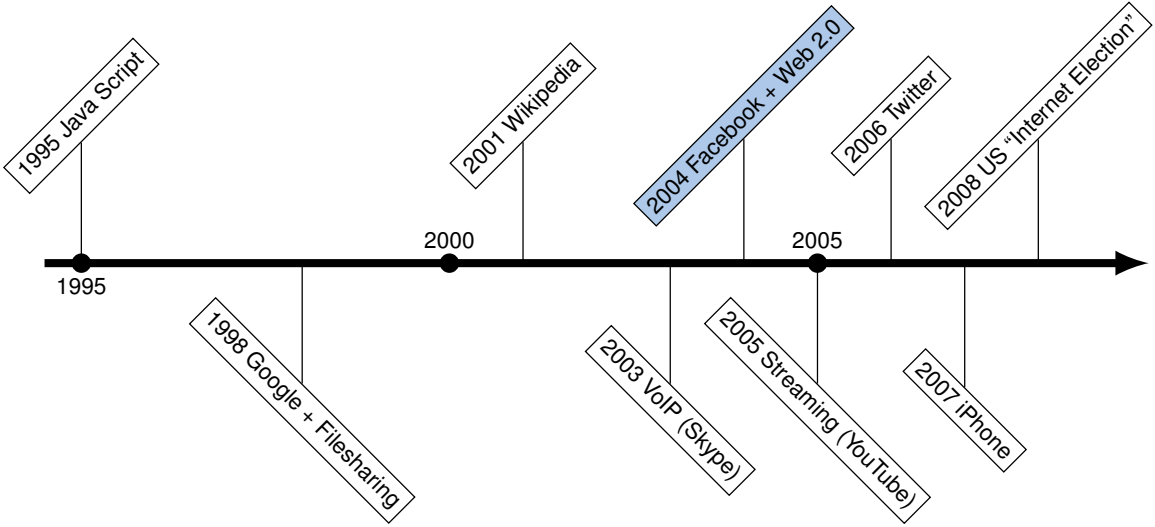


Emergence of the Internet



Emergence of the Internet

Overview since 1994



Emergence of the Internet

Web 2.0 Meme Map, by Tim O'Reilly [2]

Strategic Positioning: The Web as platform

User Positioning: You control your data

Core Competencies of Web 2.0 Companies:

- services, no packaged software
- architecture of participation
- cost-effective scalability
- remixable data source and data transformations
- software above the level of a single device
- harnessing collective intelligence

Emergence of the Internet

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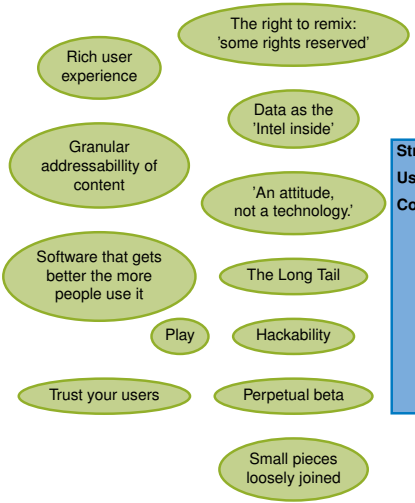

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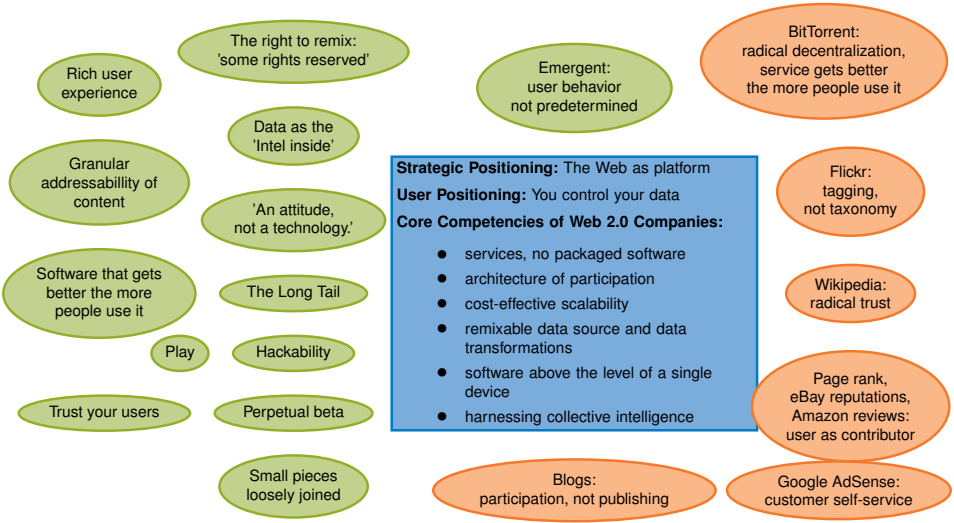
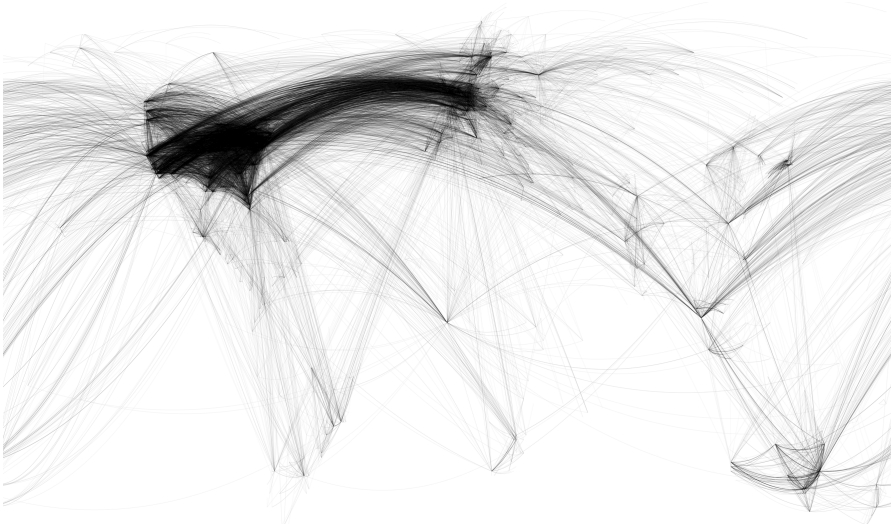


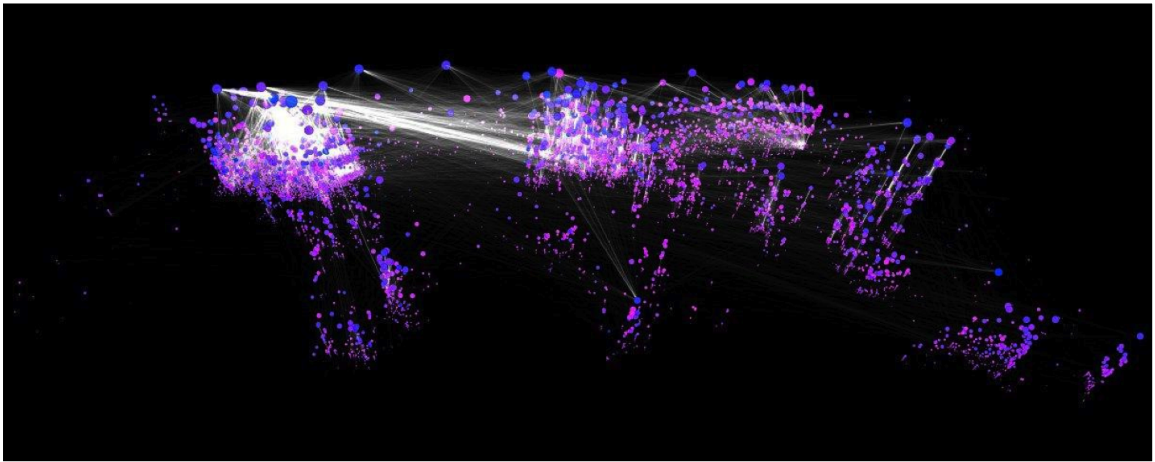
Emergence of the Internet

The Internet today – connections between autonomous systems (2007)



Emergence of the Internet

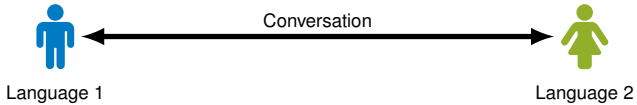
The Internet – long existing autonomous systems highlighted [1]



What are layered models?

A small example

We consider a conversation between two people sharing no common language with the help of two interpreters sharing a common language:



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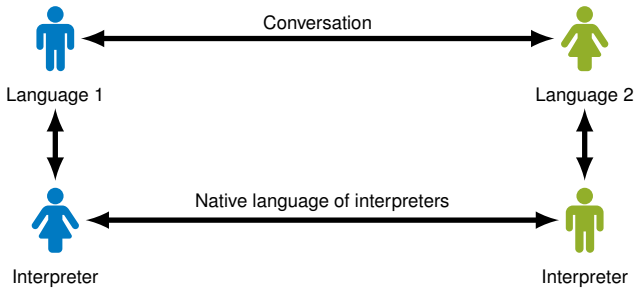

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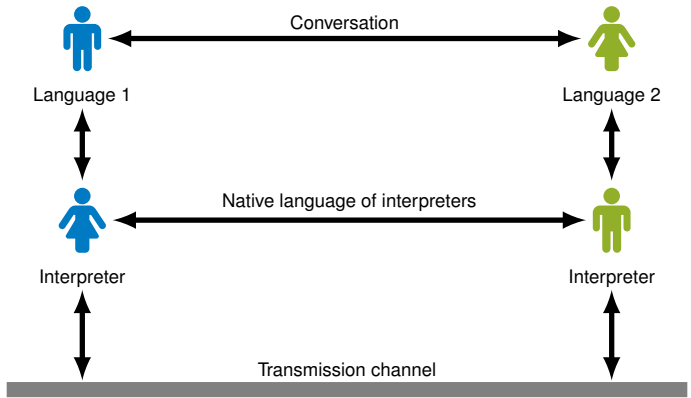

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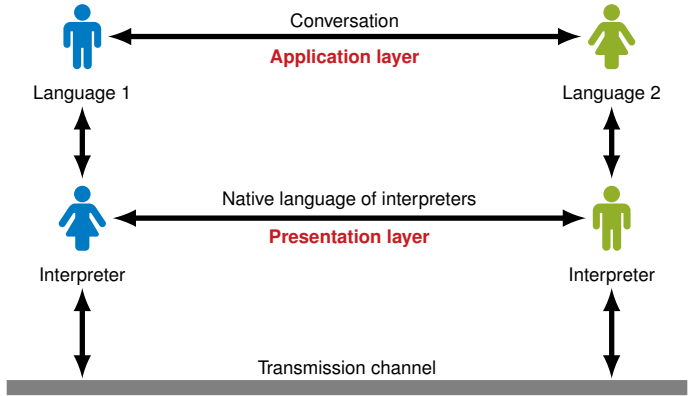

What are layer models good for?

Division of a complex communication process

- Lower layers offer services to higher layers
- Higher layers rely on services of the respective lower layers

Abstraction from the implementation of a layer

- Definition of which services are offered, but not how they are provided
- Exchangeability of individual implementations

Applicable to any communication process

- Communication may be based on the exchange of messages, packets / segments, data streams
- The concrete design depends on the implementation, not the model

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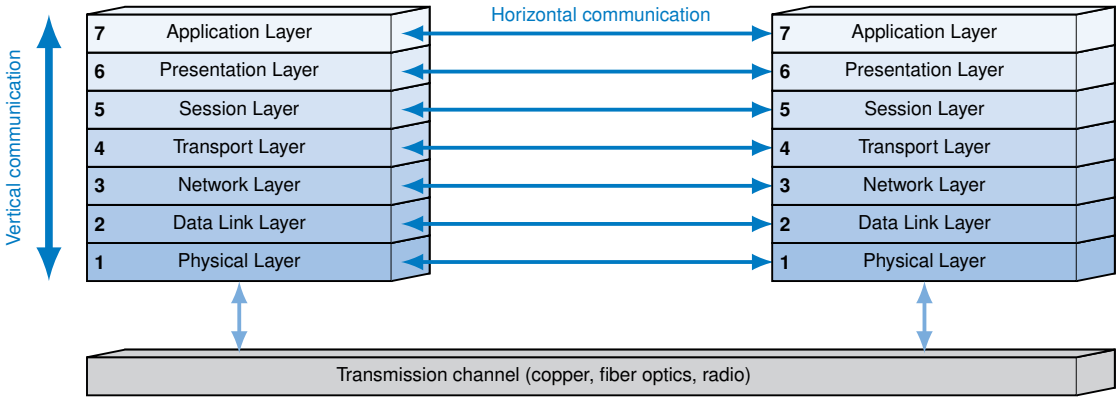
Example: The ISO/OSI model

- Developed between 1979 and 1983 by the International Organization for Standardization (ISO)
- OSI model = Open Systems Interconnection model
- Divides the architecture of the system that provides communication functionality into a total of 7 layers
- Each layer provides certain services, e. g. splitting a message into smaller packets
- No statement about how these services are to be provided

What are layer models good for?

Schematic representation of the OSI model



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Data exchange between layers

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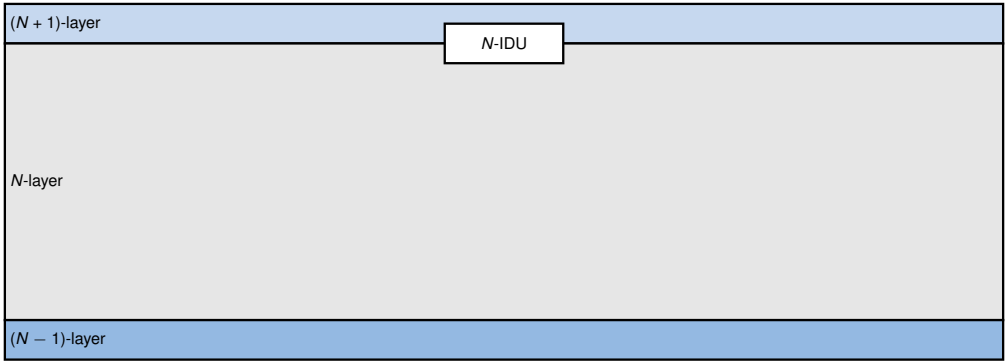
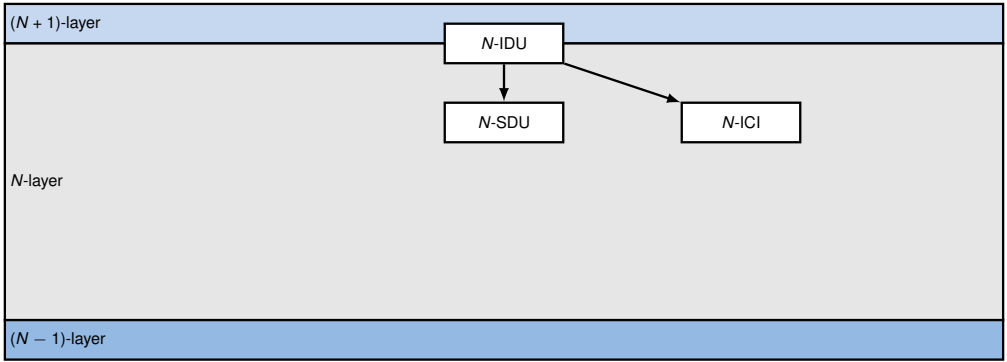


The $(N + 1)$-layer takes services of the N layer:

- The N layer receives an Interface Data Unit (IDU) from the $(N + 1)$-layer.

What are layer models good for?

Data exchange between layers

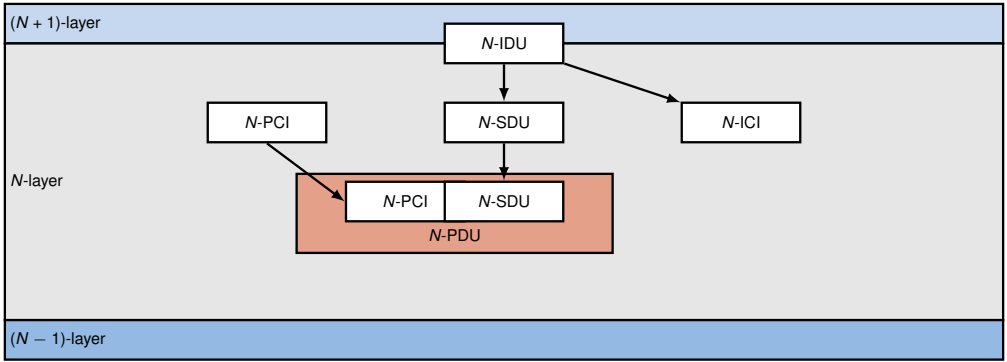


From the perspective of the *N*-layer, the *N*-IDU contains

- a payload (Service Data Unit (SDU)) and
- control information (Interface Control Information (ICI)) that are required to service the SDU, e. g. the length of the SDU or addressing information.

What are layer models good for?

Data exchange between layers

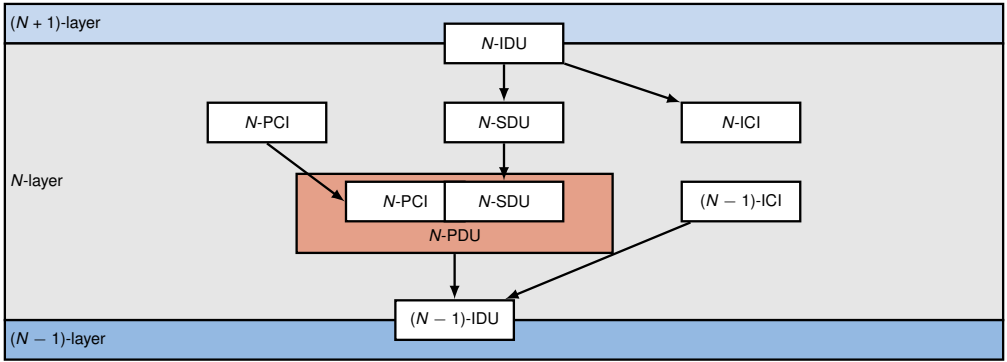


The *N*-layer

- provides the requested services on the *N*-SDU,
- adds so called Protocol Control Information (PCI) for the *N* layer at the remote side, and
- and creates from the PCI and SDU the *N*-PDU Protocol Data Unit (PDU).

What are layer models good for?

Data exchange between layers



The N-layer uses the services of the $(N-1)$-layer.

- It creates an $(N-1)$-ICI, and
- hands it down to the next lower layer together with the N-PDU as $(N-1)$-IDU.

What are layer models good for?

Common is the term Protocol Data Unit (PDU), which denotes on the *N*-layer

- the (may be processed) payload of the $(N + 1)$-layer, i. e., the SDU, and
- the Protocol Control Information (PCI) of the *N*-layer.

The PCI is often prepended to the payload in shape of a header.

PDUs of some layers have common designations, e. g.

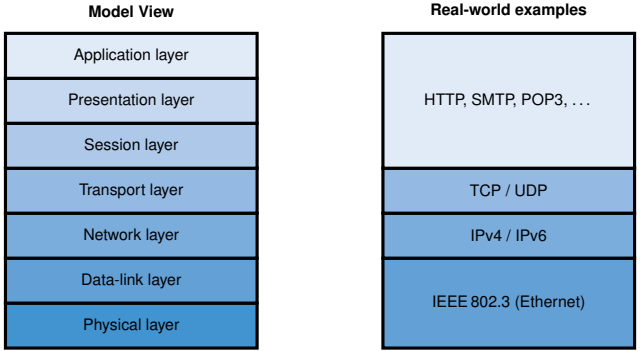
- segments or datagrams on the transport layer (depending on the transport layer protocol in use),
- packets (**not** packages) on the network layer, and
- frames on the data link layer.

These distinctions make it possible to implicitly specify the layer currently under consideration. However, the use of the terms in the literature is not always consistent.

What are layer models good for?

Shortcomings of the ISO/OSI model

- The separation of layers sometimes contradicts other interests, e. g. efficiency.
- Some protocol mechanisms cannot be clearly assigned to a specific layer, or even operate on multiple layers (cross layer).
- The assignment of protocols to individual layers may depend on the concrete use of the protocols.



A brief overview of the ISO/OSI model can be found in [3], among others.

References

[1] C. Harrison.
World City-to-City Connections.
http://www.chrisharrison.net/index.php/Visualizations/InternetMap.

[2] T. O'Reilly.
O'Reilly Network: What Is Web 2.0, Sept. 2005.

[3] E. Stein.
Taschenbuch Rechnernetze und Internet, chapter Das OSI-Modell, pages 22–28.
Fachbuchverlag Leipzig, 2. edition, 2004.