The Internet
Model - Architecture - Services

- Protocols & Communication
- OSI and DoD Model
- Architecture of the Internet
- Services of the Internet
- History & Organisation of the Internet

Hochschule für Angewandte Wissenschaften Hamburg
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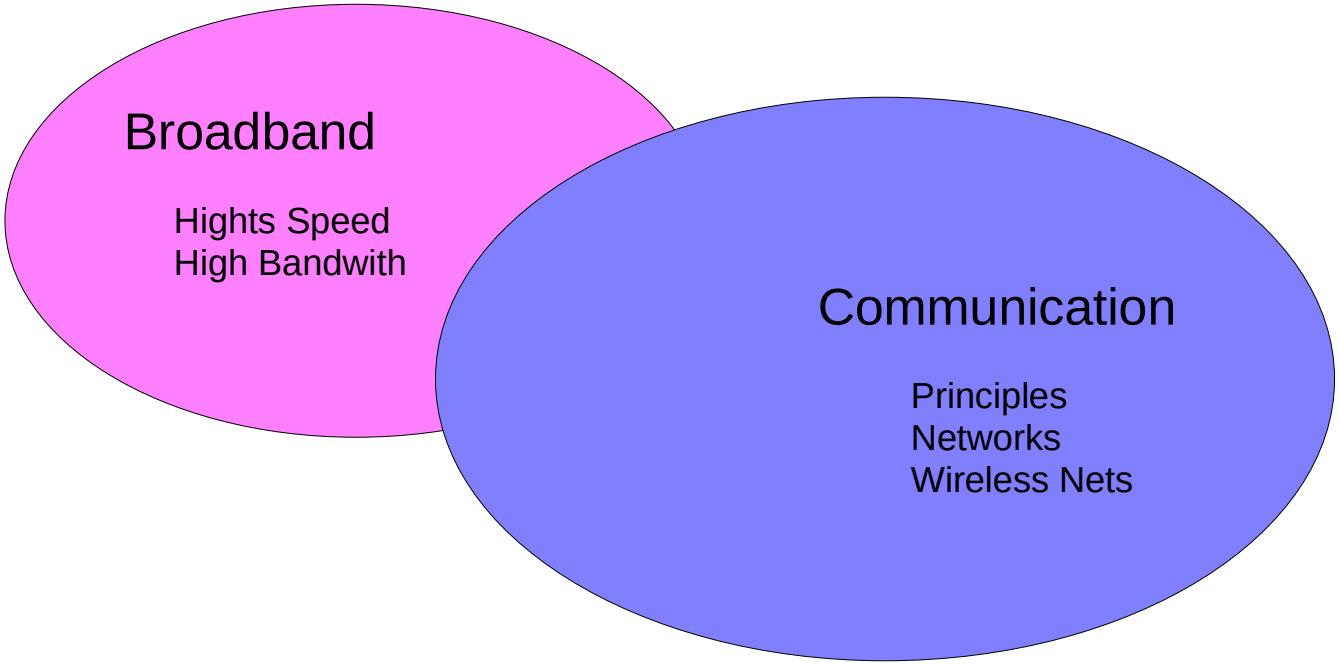
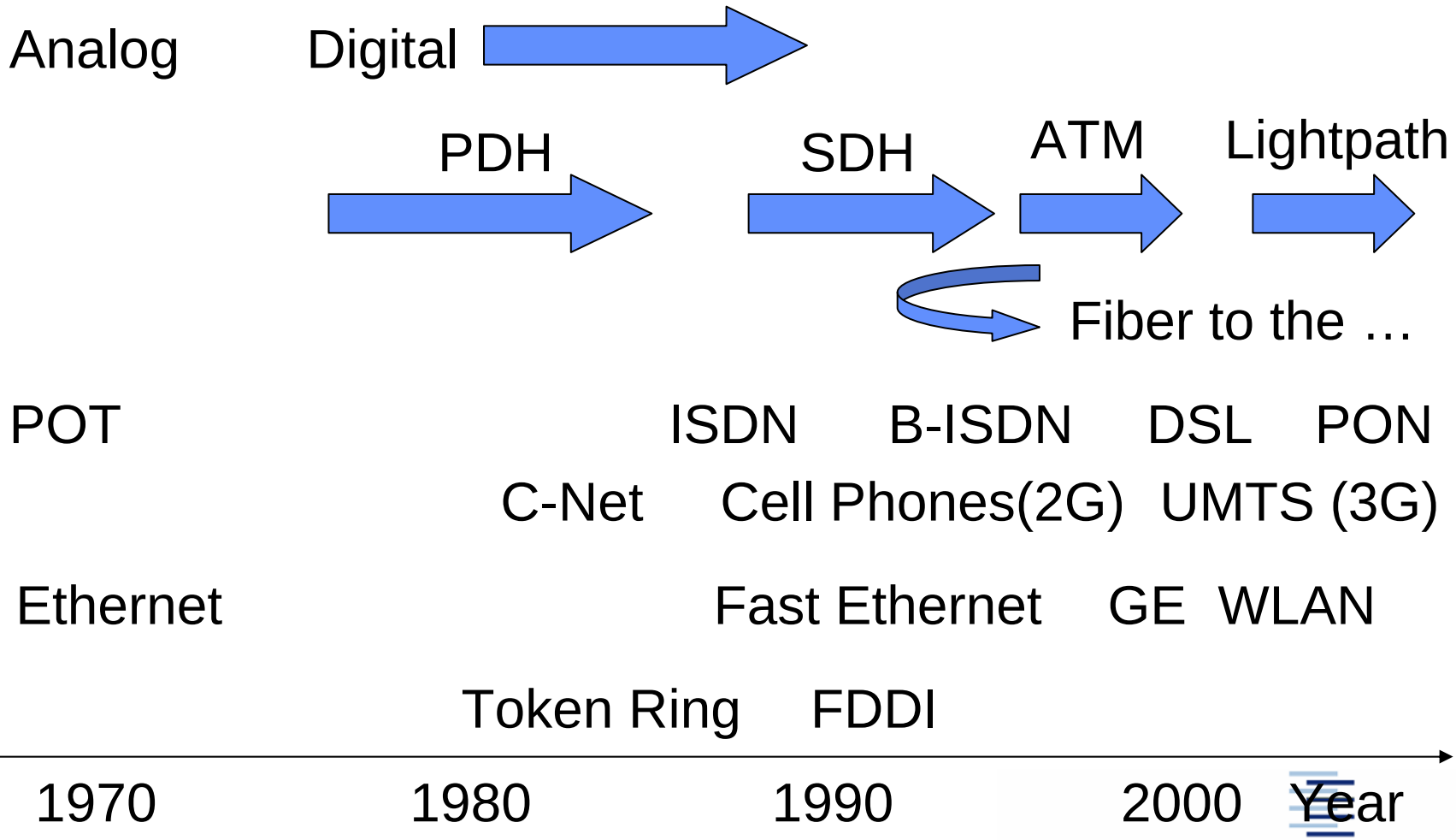
Communication



Historical Perspective



Moores and Gilders Law

- Moore's Law:

  Performance of chips doubles every 18 Month

- Gilder's Law: in communication

  Transmission capacity triples every year

Increasing Demand for Bandwidth

.... the driving force ...

- ..... generell Transmission of pictures, sound, video, ... high speed data
  - Video Conferencing
  - CAD
  - Multimedia
  - Industrial, Scientific, Medical Applications
  - Home Technique and Entertainment
- Future Virtual Reality

Satisfied by New Technologies

Advances in cable, optical fibre, wireless technology

- Higher Efficiency of Optical Fibres (WDM)
- Access by DSL and tv-cables
- 3rd generation Mobile Telephone Communication

However ....

At the time being, particular in case of long haul capacities, companies facing a hard competition, overcapacities due to the more efficient usage of optical fibers

Protocols

Computers need common languages to communicate with each other: so called protocols

- Protocols manage the data exchange between partners
- Different requirements / contexts result in many protocols
- Protocols in the Internet model are organised in hierarchical layers
- Protocols provide services for the user / the layer above

Protocol Tasks

Functions of high-level communication protocols:

- Addressing
- Encapsulation
- Segmenting of data packets
- Error detection and correction
- Flow control
- Connection control

Reliability

Reliable Communication

- No data loss
- Verification of packet arrival per receipt (handshake)
- Overhead may slow down the data transfer rate (wait for receipt)

Unreliable Communication

- Data losses possible
- No verification that the packets arrived, no receipt
- Acknowledgement might take place in higher protocol levels

Connection Control

Protocols can transmit data with different objectives

Therefore protocols are either:

- Connection-oriented

  - Statefull, (reliable)
    - Three phases between partners:
      connection establishment – data transfer - connection clearing

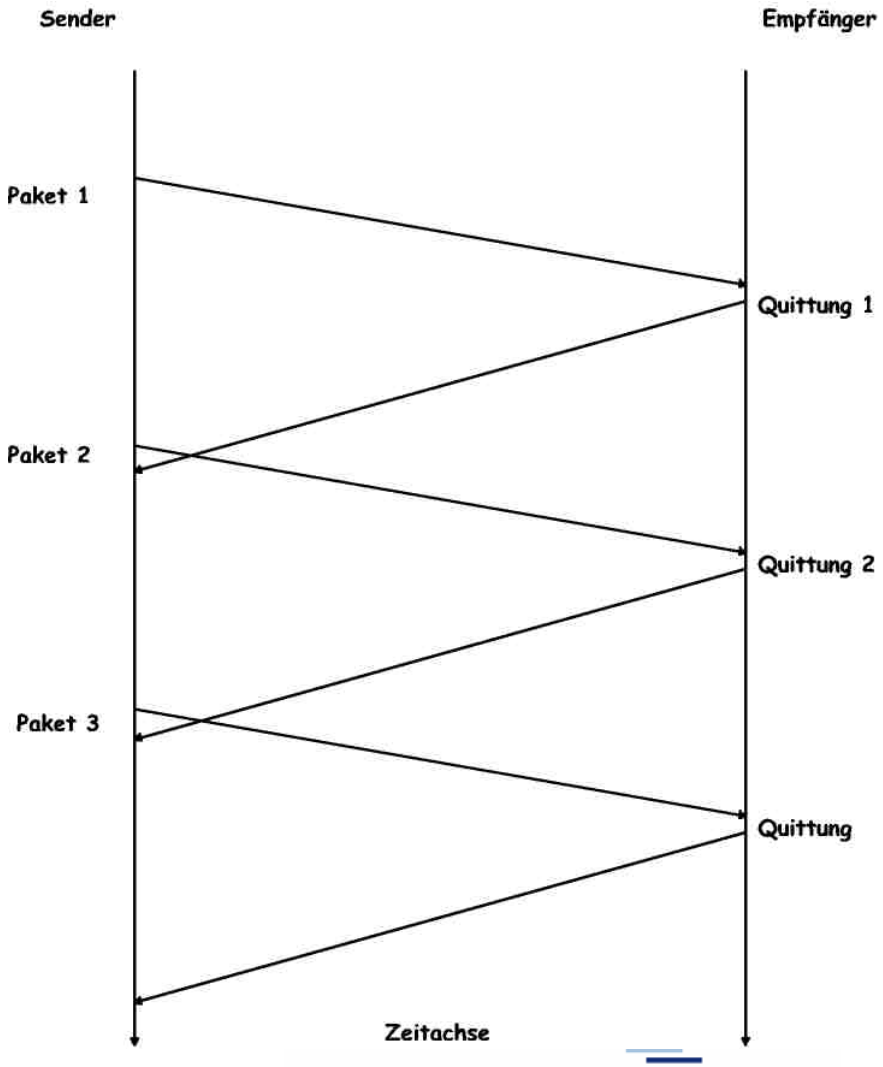
or

- Connectionless

  - Unacknowledged, stateless
  - Transfer between independent partners

Connection Oriented

- Receiver sends receipts:
- Acknowledgement of receipt
  - reliability -
- Announcement of receive buffers
  - flow control -
- State signalling
  - connection control -



Modes of Communication

Synchronous

- Joint action of sender and receiver
- Requires (waiting of) communication readiness of all partners
- Example: telephony, terminal session, videoconferencing

Asynchronous

- Sender and receiver operate independent of each other
- Requires buffer mechanisms
- Example: SMS, email, Instant Messaging

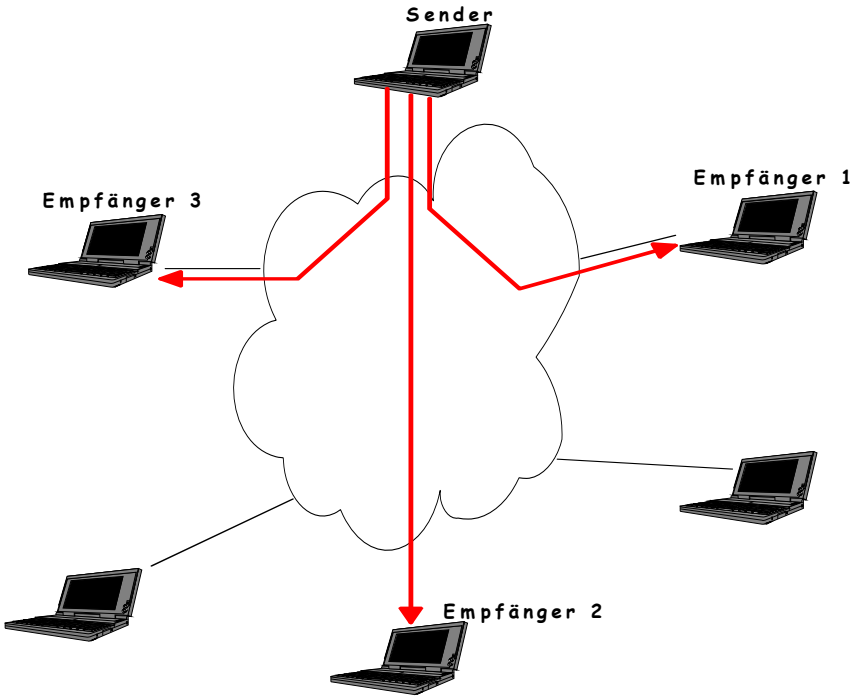
Types of Communication

- Point-to-Point — one station to one station (telephone)
- Multicast — one to several (selected) stations (group conference)
- Broadcast — one to all stations (broadcast radio)
- Anycast — one to “nearest” station

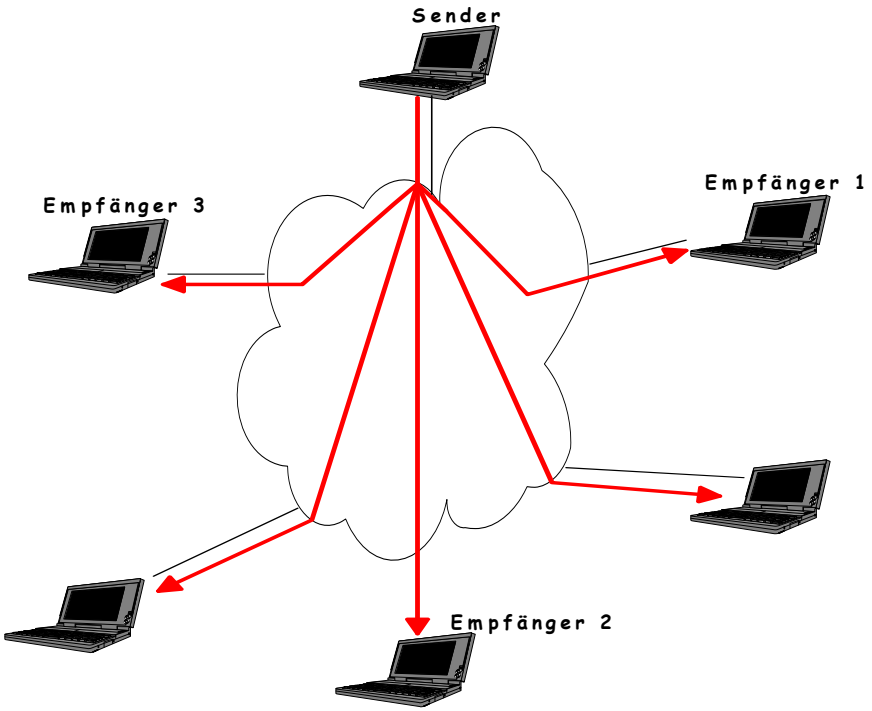
Rule of thumb (with exceptions): Broadcast is bound to locality, point-to-(multi-)point suitable for long distances

Types of Communication

Unicast

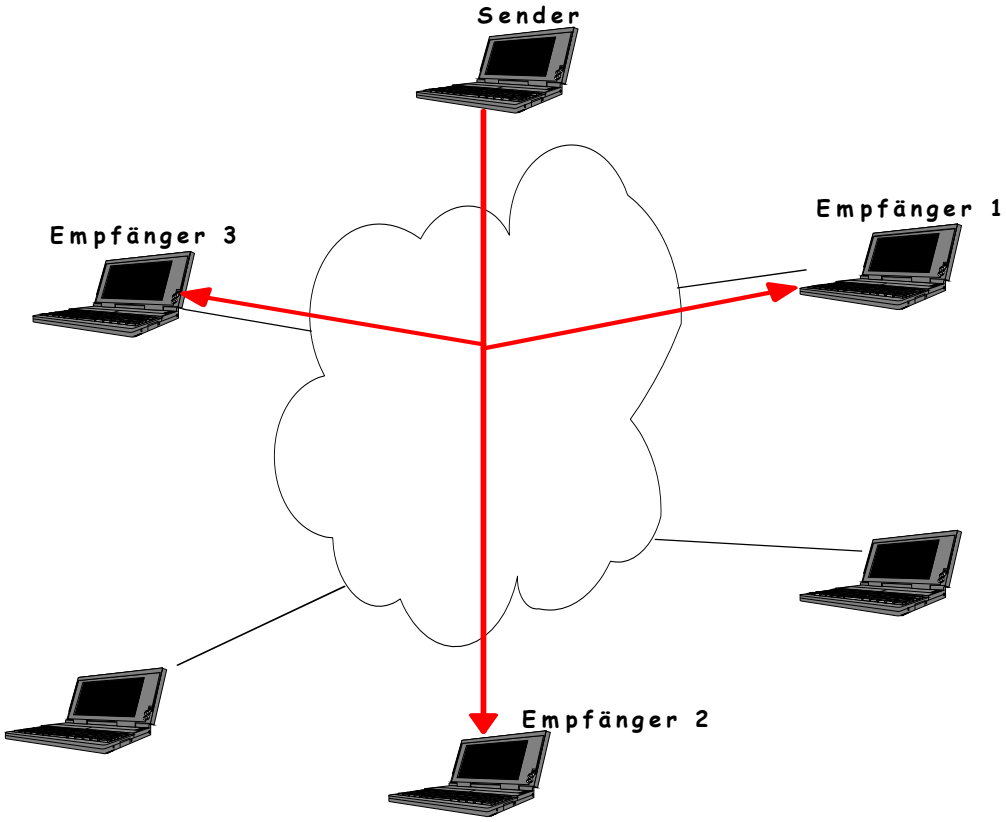


Broadcast



Specific Group Communication

Multicast



Services

Well-defined functions of general use

- Separated functional package at a Server site
- Components: service function, -primitives, -procedures
- Utilisation by Clients

Service quality

- Appropriateness / accessibility
- Technical quality: response time, accuracy, ...
- Cost
- Reliability
- Security / trust

Distributed Service Models

Client-Server Model

- Distributed roles: Server provides a service, Client requests a service
- Communication mode: 1 Server : n Clients (one to many)
- Examples: WWW, ftp, Mail (almost all Internet services)

Peer-to-Peer Model

- Equal roles: Client/server communication between equal partners
- Communication kind: m : n (many to many)
- Example: Filesharing, VCoIP

Quality of Distributed Services

The aggregation of performance metrics

- Availability
- Throughput
- Packet Loss
- Delay
- Delay Variation

The Communication Problem

- Heterogeneous network infrastructure
- Heterogeneous computer architecture
- Heterogeneous application structure
- Distributed applications

The Net should equally enable communication between all users!

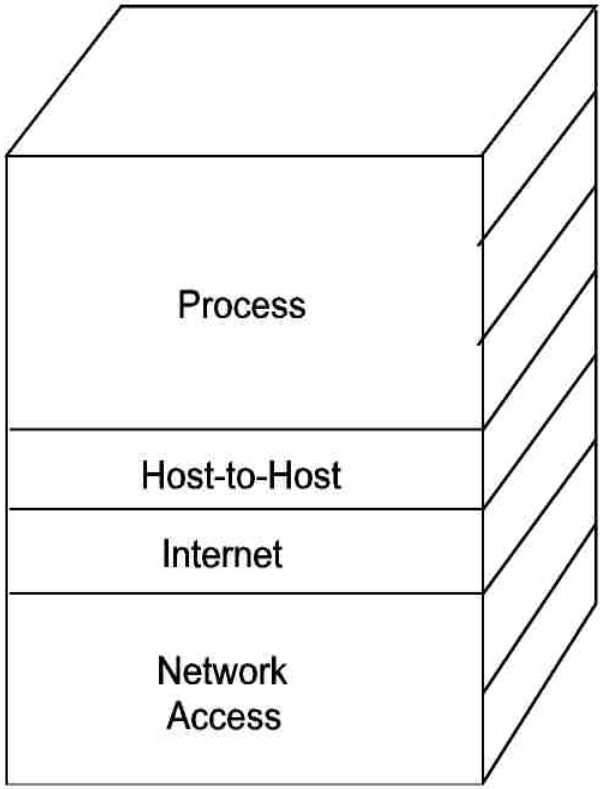
Solution

For communication in heterogeneous, open systems it is essential to have a conceptional separation of functionalities:

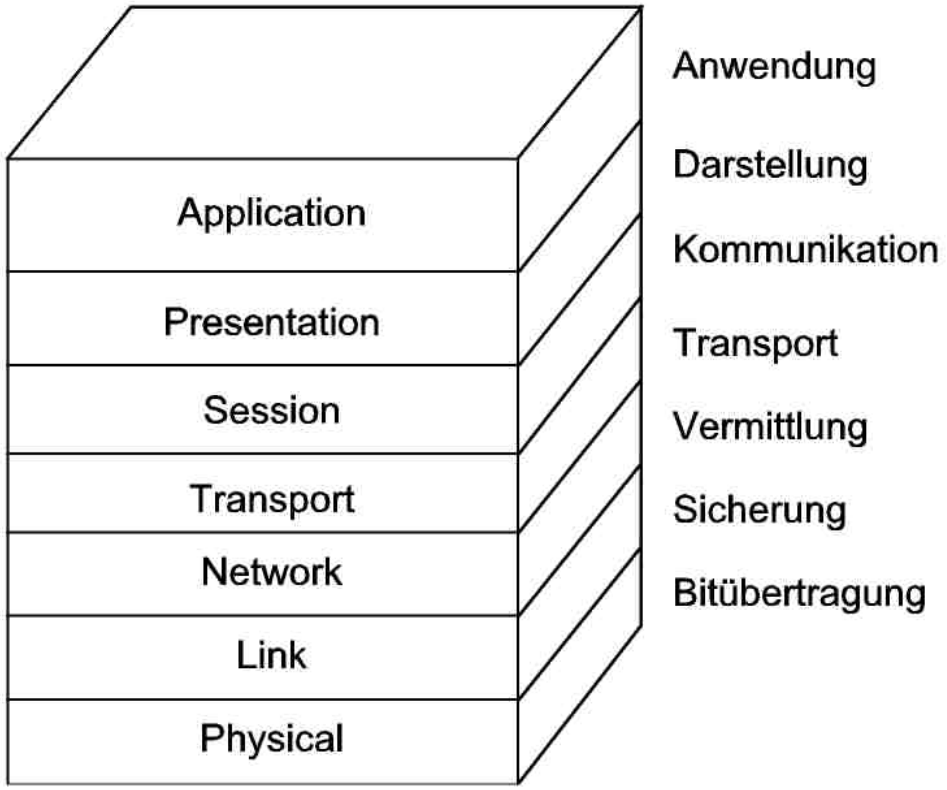
- Structure the entire problem in parts (layers)
- Every layer solves a part of the entire problem
- Every layer precisely interacts with its direct neighbour
- Compatible implementations are required (well defined interfaces)

Reference Models

DoD
Internet Reference Model



ISO/OSI
7 Layer Reference Model



OSI Model

- 1977:
  - the International Organization for Standardization (ISO), assigned a subcommittee for the development of a communication architecture between open systems.
- Tasks of the Model:
  - Reference to describe protocols and functions
  - Standardization basis for OSI-Protocols
  - No implementation specification

Standard conformance and interoperability is problematic

DoD Internet Model

- DoD (Department of Defence) – communication architecture

- Parts of the model:
  - Process: implemented by application programs
  - Host-to-Host: offers the runtime environment for communicating
  - Internet: enables communication between hosts
  - Network Access: provide access to network media (10/100/1000 Base T, FDDI, etc.)

Internet Layer

- Part of the operating system
- Enables communication from computer to computer
- IP (Internet Protocol) delivers an unreliable, stateless transfer service
- Further Internet layer protocols:
  - ICMP (control protocol)
  - IGMP (group management protocol)
  - ARP/RARP (address resolution)
  - EGP/Hello/OSPF (path discovery / routing)

Host-to-Host Layer

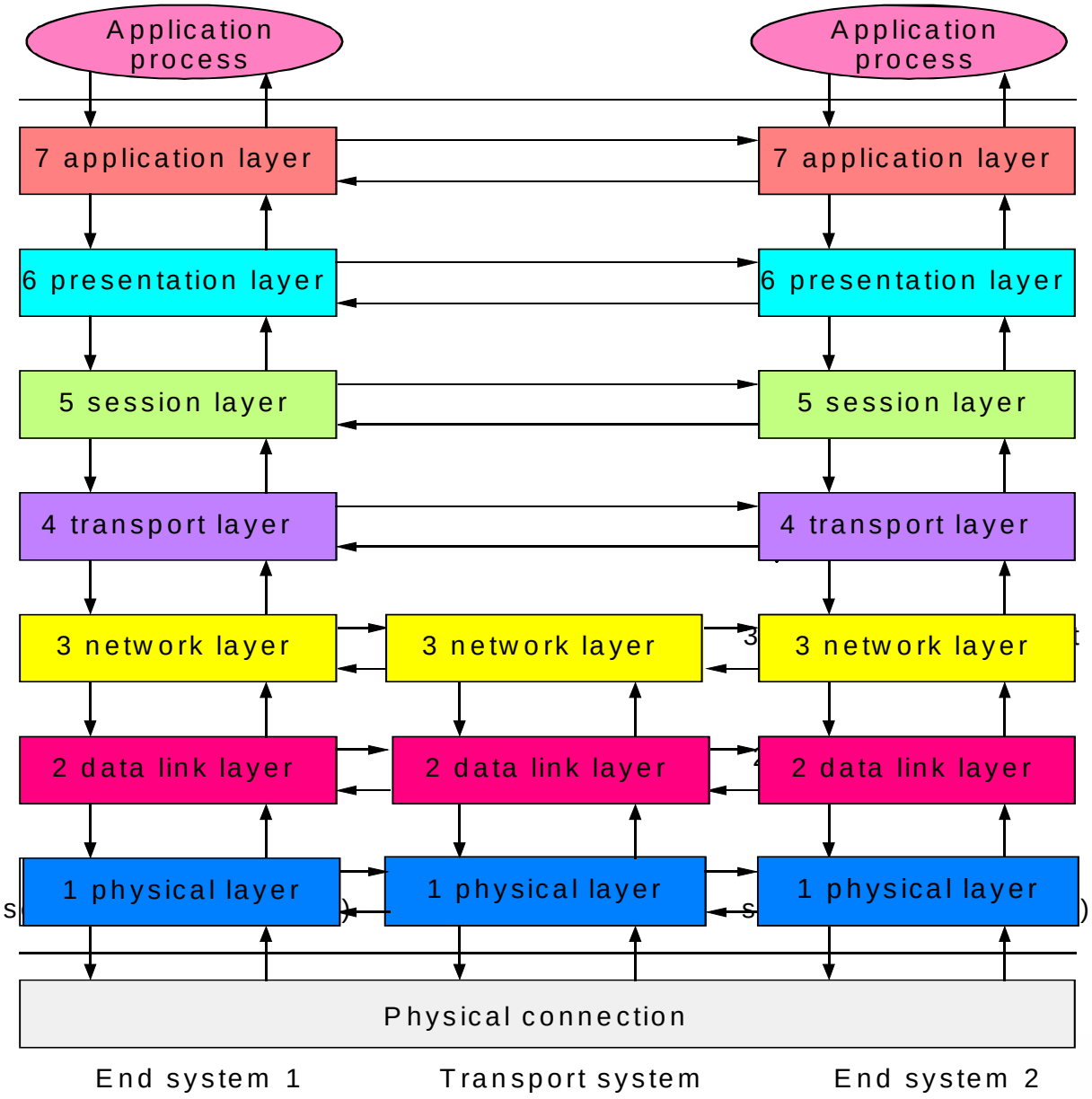
- Part of the operating system
- Enables the communication of programs
- Delivers with UDP (User Datagram Protocol) an unreliable, stateless transfer service
- Delivers with TCP (Transmission Control Protocol) a reliable, statefull transfer service

Process Layer

- Implemented by communicating application programs
- Using many application specific protocols
- Examples:
  - FTP, Telnet, SMTP (classical)
  - DNS, RIP, SNMP (administrative)
  - HTTP, IRC (Internet)
  - SQL*net, SIP (specific)

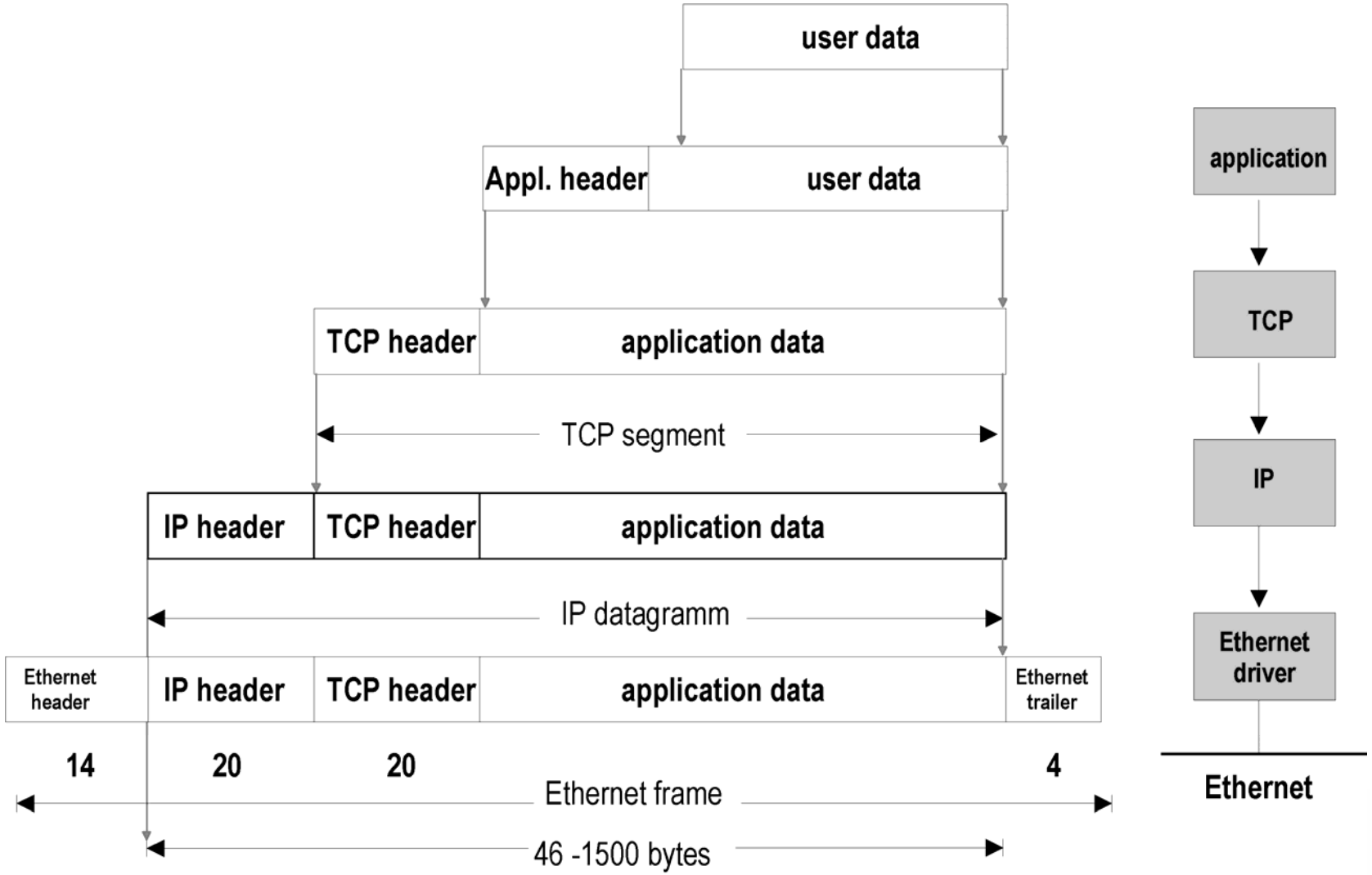
Further Components of the Internet Model

- Networks connecting hosts
- Routers connecting networks
- Applications/Processes communicate with each other
- Gateways connecting application layers
- Ports provide access to network software
- Services/Middleware distribute network information bases

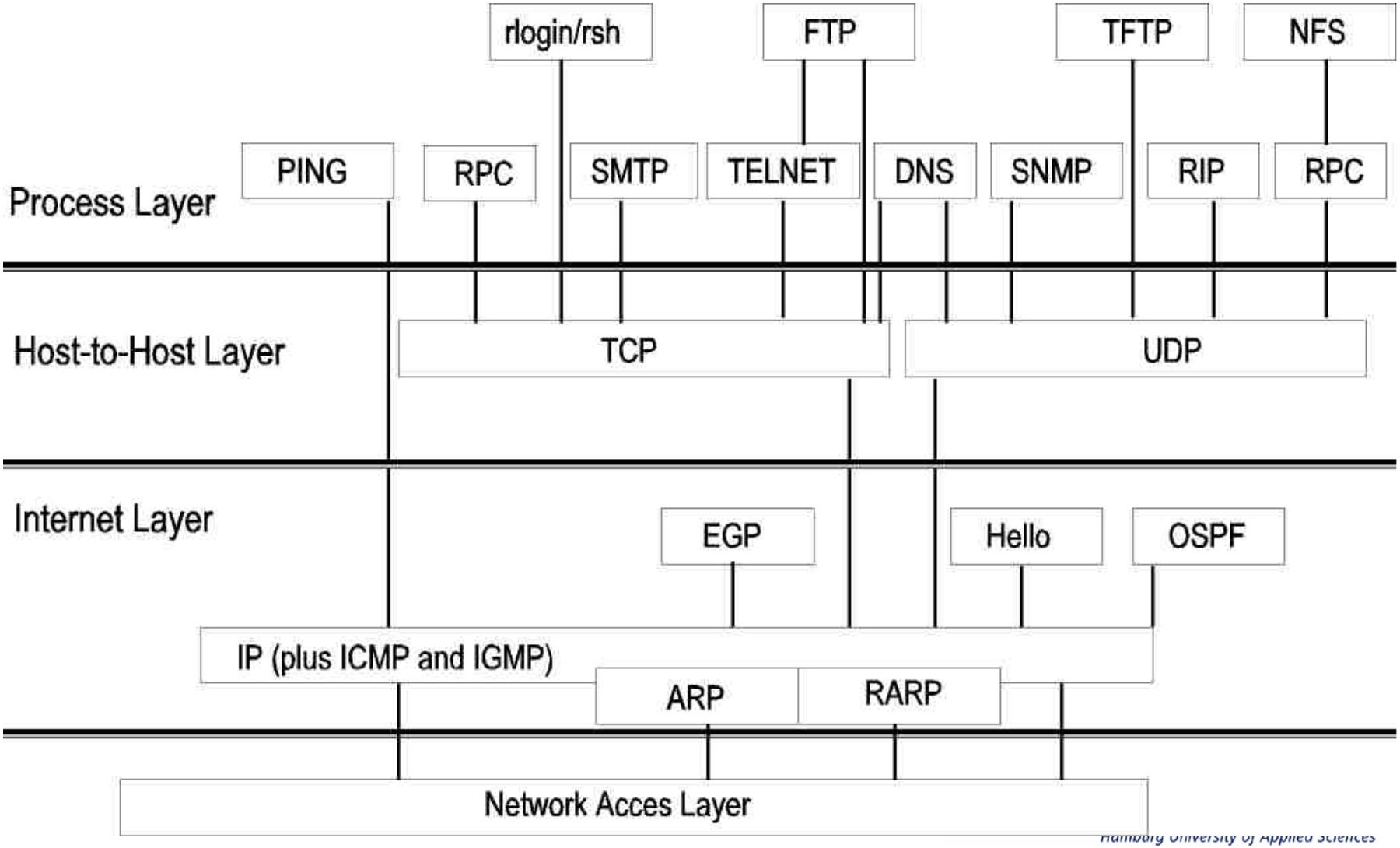


ISO-OSI Reference Model

Packet Encapsulation



Internet Protocols



The Domain Name System

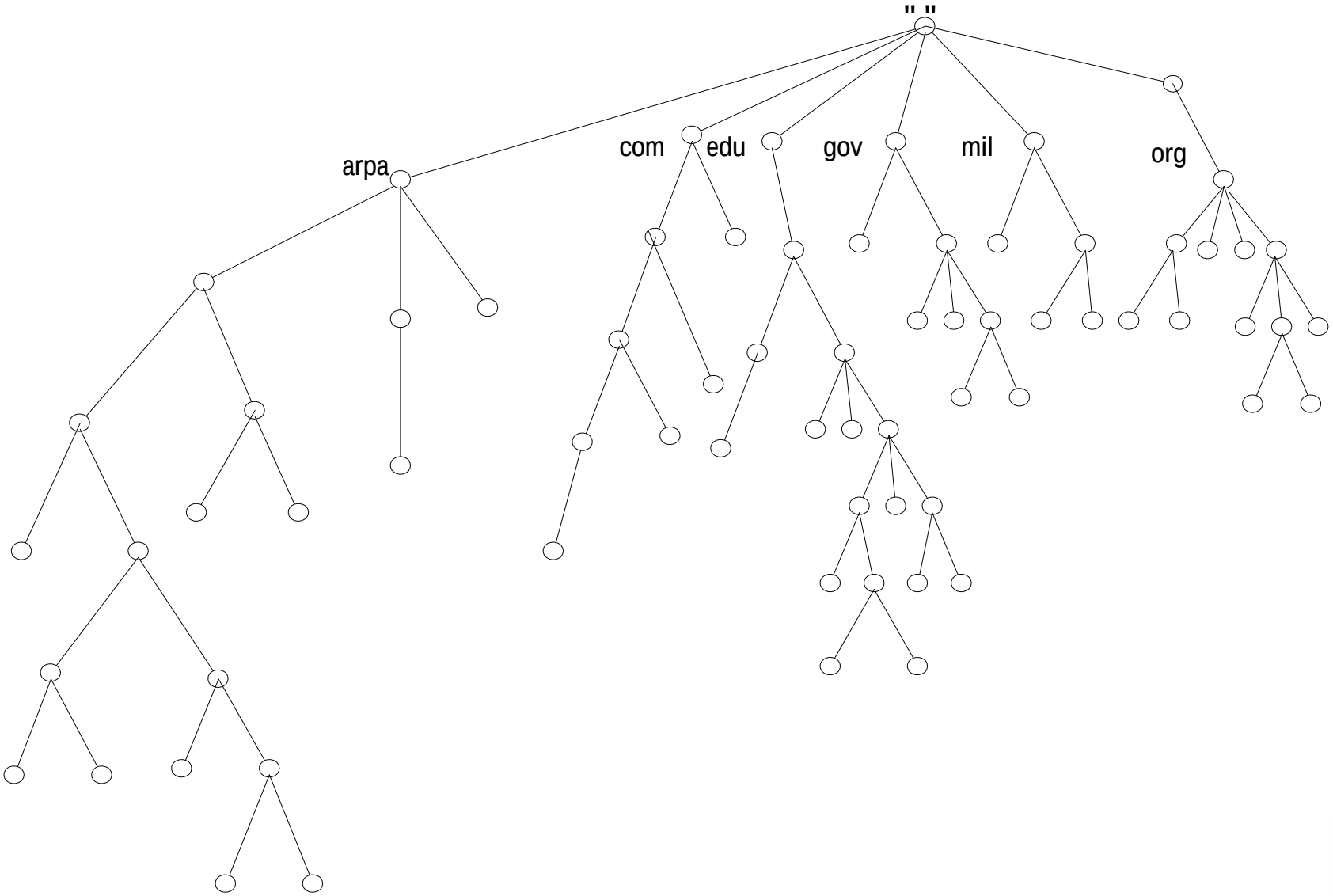
Devices and networks within the Internet carry names to

- create a user friendly computer addressing scheme
- decouple binding to technical (IP) addresses

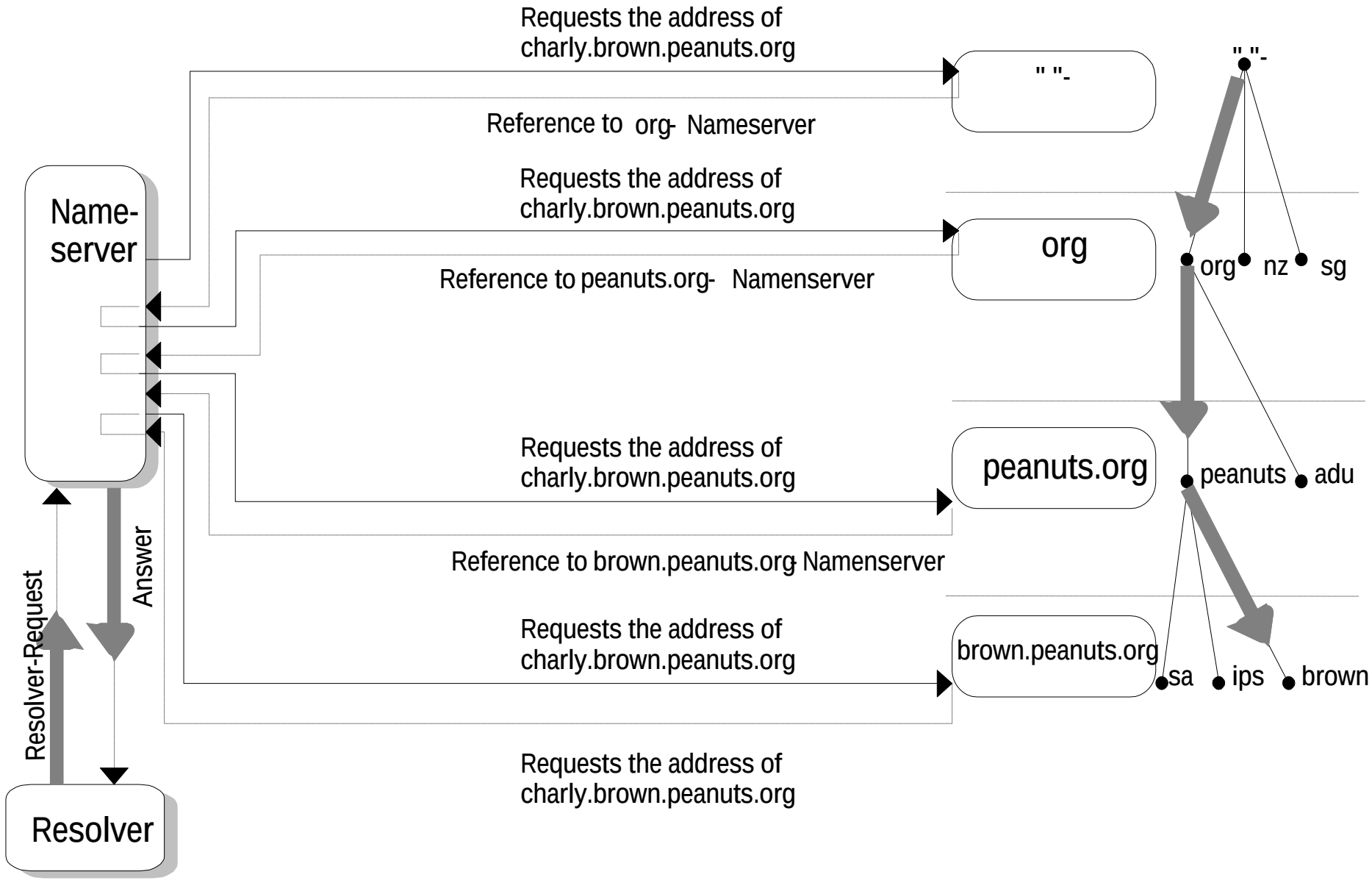
Example: www.whitehouse.gov

- Name administration within Domain Name Service (DNS)
- Hierarchical, distributed namespace
- Distributed name allocation at inter-domain DNS-Server
- Top-Level Domains at root (➦ NIC)
- Local caching of frequently requested data
- Resolution of unknown names by contacting servers (in ascending name hierarchy)

DNS Directory Tree



DNS Resolution Process

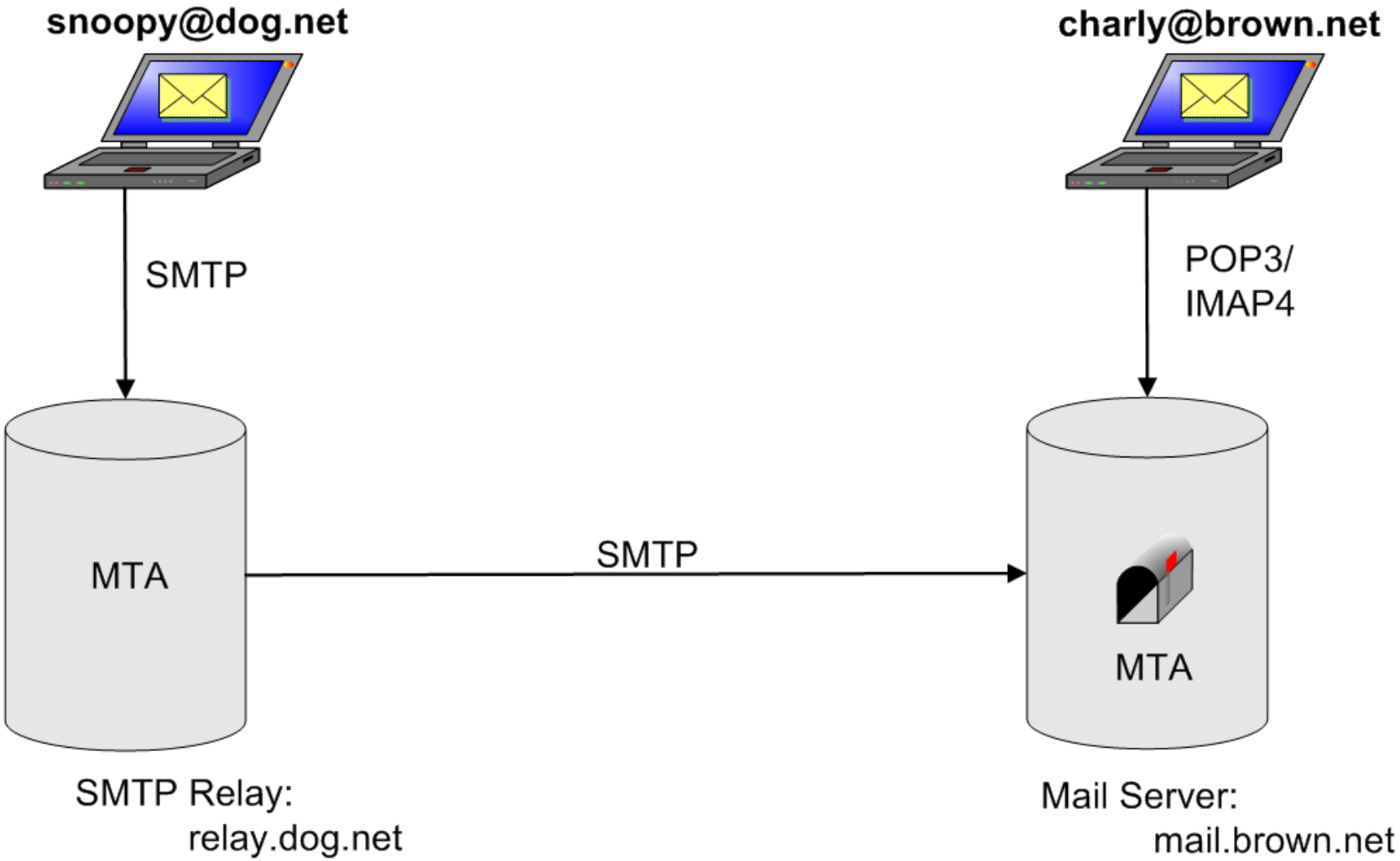


Electronic Mail

Today email is the most popular Internet service. Other mail services (X400, bitnet, ...) vanished from the market.

- RFC 821 defines the Simple Mail Transfer Protocol (SMTP)
  - Tiny command set
  - Exchange of (ASCII-) text messages according to the store-and-forward principle
  - Binary data (images, sound, etc.) are converted to ASCII Standard: Multipurpose Internet Mail Extensions (MIME)
- An email consists of an Envelope decorated with transmission data (env-to) and ‚stamps' of the relay servers.
- Header with sender, recipients (to/cc), subject are part of the actual message.

Internet Mail Architecture



SMTP

- 220 mail.rz.fhtw-berlin.de ESMTP sendmail 8.8.8 ready at Sat, 14 Nov
- **helo neptun.f4.fhtw-berlin.de**
- 250 mail.rz.fhtw-berlin.de Hello neptun.f4.fhtw-berlin.de, pleased to ...
- **MAIL From:<otto@neptun.f4>**
- 250 <otto@neptun.f4> ... sender ok
- **RCPT to:helga**
- 250 helga... Recipient ok
- **DATA**
- 354 Enter mail, end with "." on a line by itse
- ...
- 250 ok
- **QUIT**
- 221 mail.rz.fhtw-berlin.de closing connection

SMTP

```
HELO - Greeting Clients To
       Server
DATA - Message Text
Quit - Dialog End
MAIL - Sender Specification
RCPT - Receiver Specification
VRFY - User Verification
EXPN - Expanding Of The
       Distribution List
SEND - Sends The Message To
       The User Terminal
TURN - Change Between Sender
       And Receiver
RSET - Transaction Break
HELP - Help
NOOP - No Action
```

World Wide Web

The World Wide Web has been developed as a universal information service, to access any resources from any Internet host. The main features are:

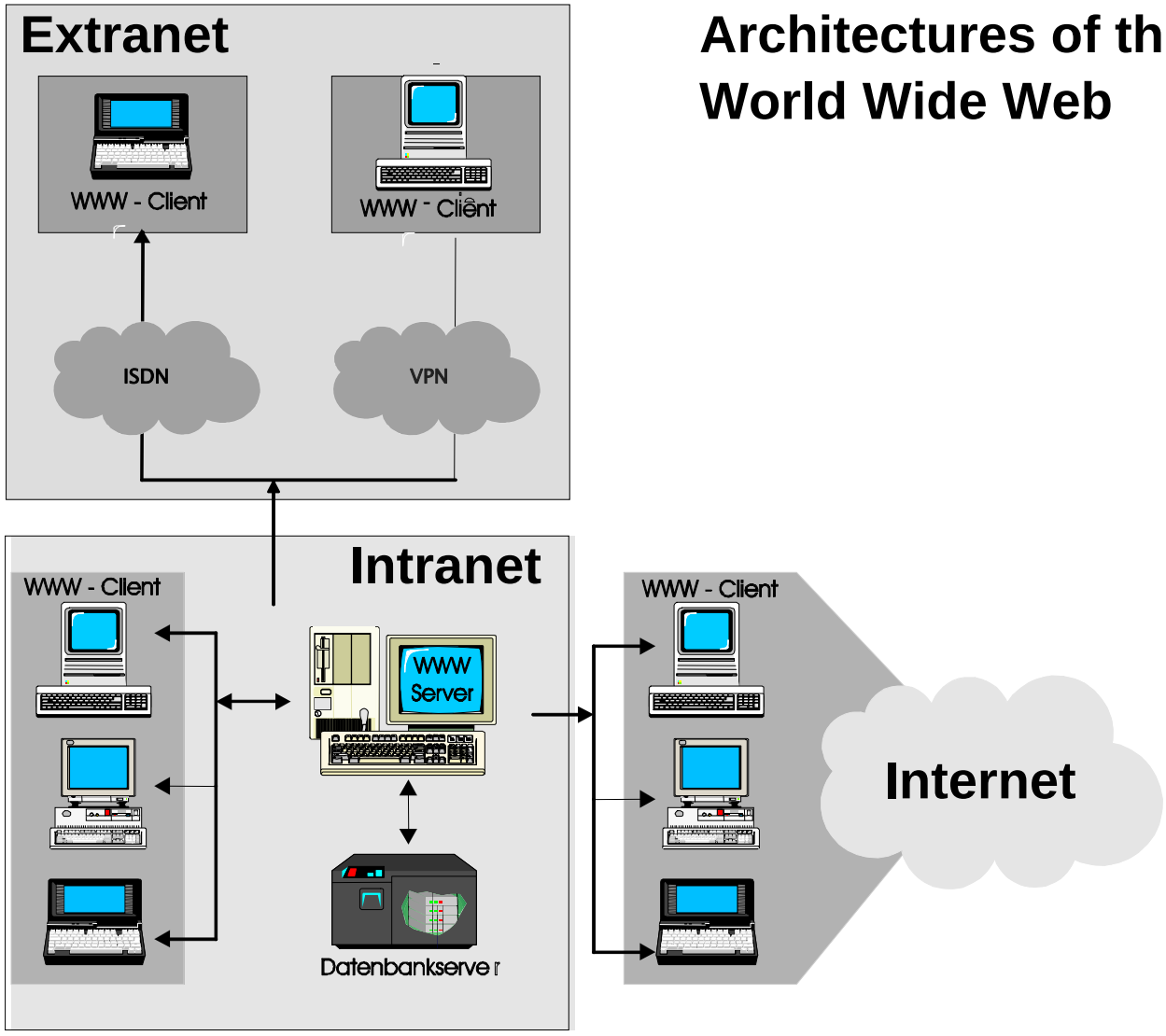
- URI - Uniform Resource Identifyer (RFC 2396):
  <scheme>://<authority><path>?<query>
- http - Hypertext Transfer Protocol (RFC 2616):
  - GET – document query of the WWW-client from server:

Client: GET /index.html HTTP/1.0
Connection: Keep-Alive
User-Agent: Mozilla/5.0
Host: www.whitehouse.gov
Accept: image/gif, image/jpeg, ...

Server: HTTP/1.0 200 Document follows
Date: Tue, 26 Feb 2002 8:17:58 MET
Server: Apache/2.0.1
Last-modified: Mon, 17 Jun 1999 21:53:08 MET
Content-type: text/html
Content-length: 2482
(body of document to come here)

  - HEAD, POST

Architectures of the World Wide Web



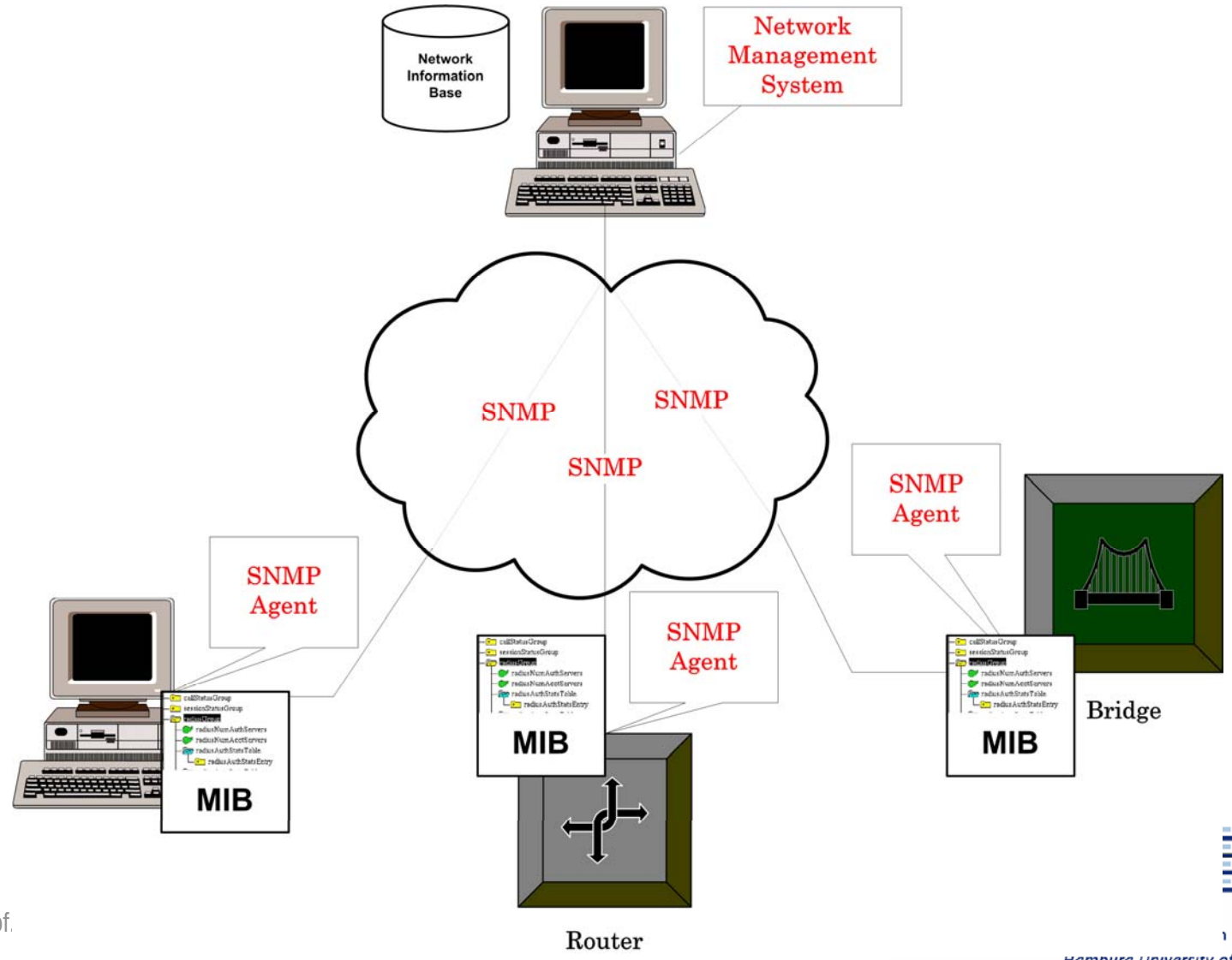
The Standard SNMP

For managing heterogeneous networks a standard was defined:

Simple Network Management Protocol

- 1988 as a temporary solution designed (RFC 1157)
- Simple concept, compactly implementable
- Abstract, expandable data description
- Low device and network load
- Provides the basis for a full management
- Needs a powerful management system

Architecture of an SNMP-System



Brief History of the Internet

- 1968 Call of the Advanced Research Project Agency (ARPA) for a interconnecting network (UCLA, UCSB, SRI, UoU)
- 1974 Draft of the basics of TCP/IP-Protocol family (V. Cerf and R. Kahn)
- 1977-79 Development of basic protocols
- 1980 The ‚Internet' on TCP/IP-Basis ‚arises' by connecting CSnet and ARPAnet through Cerf and Kahn.
  TCP/IP is released and integrated into Berkeley UNIX.
- 1981/84 ISO/OSI Reference Model
- 1992 IPng Initiative of the IETF
- 1995 End of the national domination in the Internet
- 1999 Start of IPv6 deployment

Organisation of the Internet

- The Internet Society (ISOC) represents the Internet in public since 1992
- The Internet Assigned Number Authority (IANA) assigns protocol parameter (formerly also IP-Addresses)
- The Internet Corporation for Assigned Names and Numbers (ICANN) administrates names and address services
- The coordination and (technical) development is lead by the Internet Architecture Board (IAB) with:
  - IRTF for long term research
  - IETF for technical development
- Distribution of standards on basis of technical reports
  ➦Requests for Comments

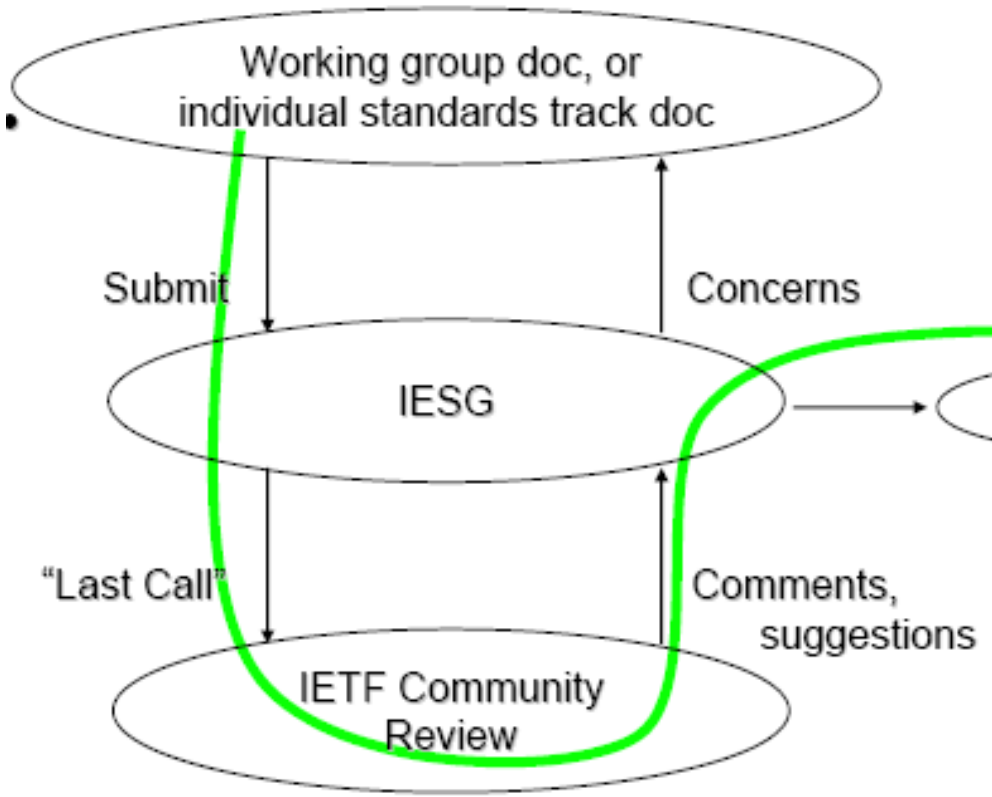
Standardization: The IETF

- does not exist (in a legal sense), no members, no voting
  - Groups make decisions by "**rough consensus & running code**"
    - *"We reject kings, presidents and voting. We believe in rough consensus and running code", David Clark, 1992*
  - Consensus must be found on mailing lists rather than at physical meetings
- 118ish working groups (where the stuff happens)
- 8 areas (for organizational convenience) with ADs
  - GEN, APS, RAI, TSV, RTG, INT, OPS, SEC
- IESG: management (ADs + IETF Chair)
- produces standards and other

RFCs

- To develop an Internet standard every Internet user is enabled to write and publish a technical report called ‘Internet draft’. After publication and discussion an IDs eventually becomes a
  Request for Comment (RFC)
- RFCs pass the status proposed, implementation, draft, full
- More information under www.rfc-editor.org
- Example: 2400
  J.Postel, J. Reynolds, „INTERNET OFFICIAL PROTOCOL STANDARDS“ 09/24/1998 (Obsoletes RFC2300) ...

IETF Standardization Process



- Draft-00 → RFC: avg. 23 months
  - If successful
- RFC Editor Queue: avg. 9 weeks
  - Up to 2 years

Standardisation Authorities

CCITT Comité Consultatif International de Télégraphique et Téléphonique

ISO International Organisation for Standardization

ITU International Telecommunication Union

ANSI American National Standards Institute

CEN Comité Européen de Normalisation

DIN Deutsches Institut für Normung

IEEE Institute of Electrical and Electronics Engineers

ETSI European Telecommunications Standards Institute

ECMA European Computer Manufactures Association

Discussion and Examples

Please discuss the following questions for different types of data on the next slide:

Which type of QoS parameters are relevant and why?

Which type of connection is relevant (point to point – point to multi-point, connectionless or connection oriented, reliable or non reliable) ?

Is real time capability necessary?

Discussion and Examples

Types of data:

- Video on demand (streaming video)
- Download of data from a server station to client stations
- Videoconferencing File transfer (ftp)
- Transfer of Medical pictures
- Application sharing
- Internet Browsing
- Email
- Voice – Radio over the Internet
- Financial transactions

Discussion and Examples

Discuss and compare connection orientation and reliability

- Role of the Header
- Way of Addressing
- Types of Addresses
- Routing

Bibliography

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