



Informatik der Systeme – Chapter 2: Internet Basics

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▶ Just a few examples ...

▶ Access Technologies

- DSL: Digital Subscriber Line
- Kabel
- GSM: Global System for Mobile Communications
- UMTS: Universal Mobile Telecommunications System
- LTE: Long-Term Evolution
- 5G

▶ Local Area Networks

- Ethernet
- WiFi (no acronym, German: WLAN)
- Token Ring

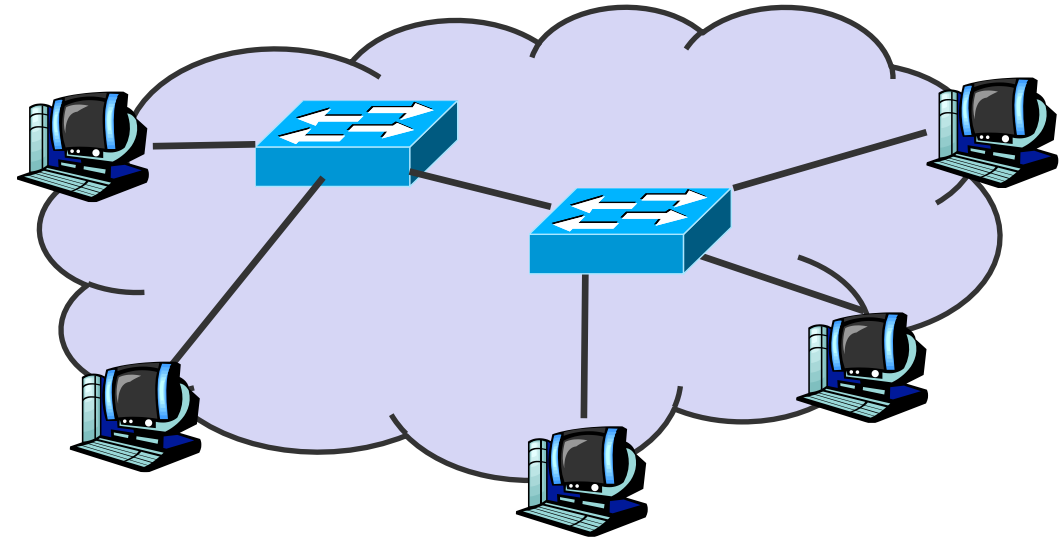
▶ Wide Area Networks

- OTN: Optical Transport Network
- ATM: Asynchronous Transfer Mode
- MPLS: Multiprotocol Label Switching



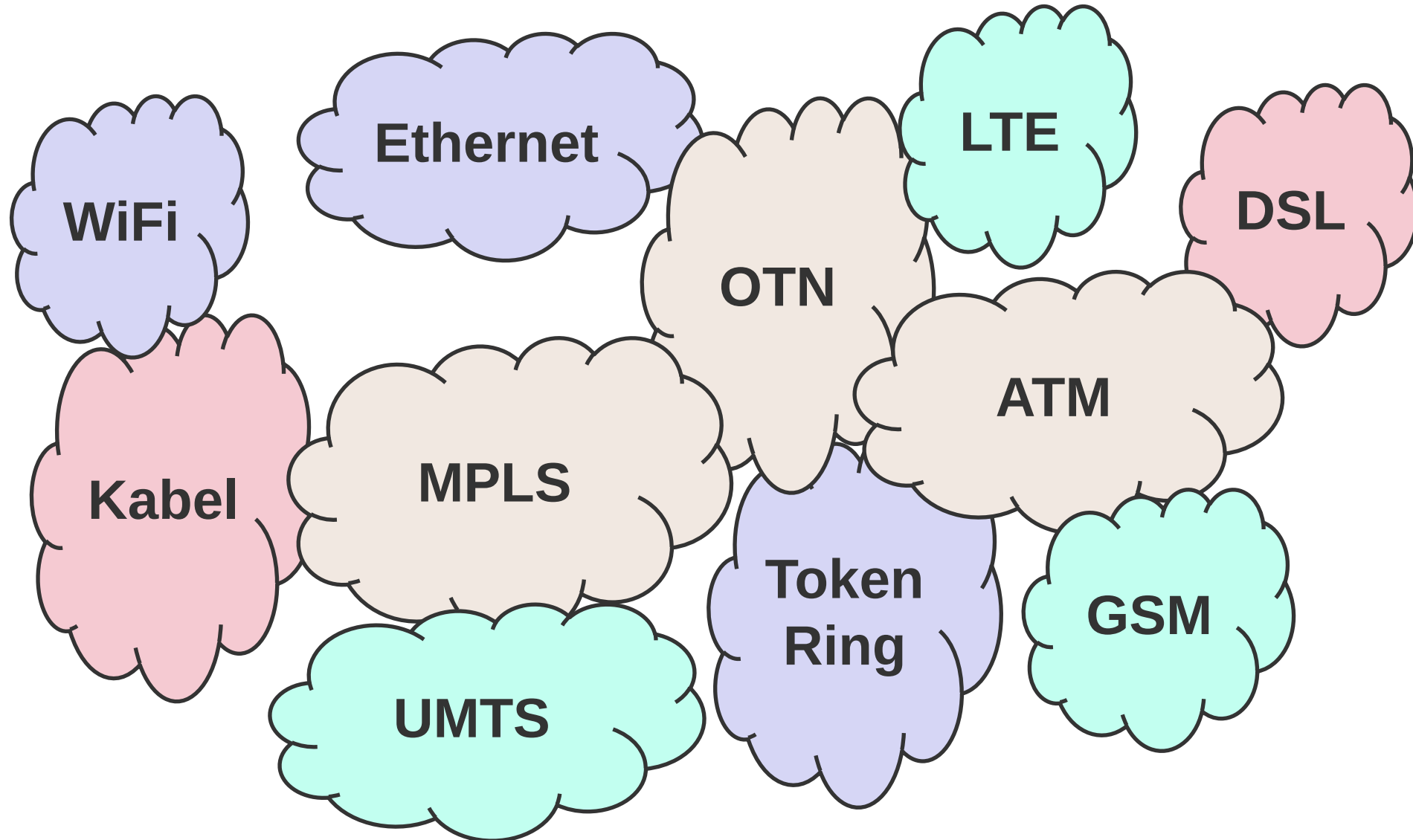
► Switch

- Connects other switches and end systems via cables
 - Ports (hardware)
 - Interfaces (software)
- Forwards frames
 - Source and destination address
 - 6 bytes MAC addresses





How to build an inter-network?





► Problem

- Comm. technologies have technology-specific pkt formats and addresses
 - Frequently used: MAC addresses, 6 bytes long
- No world-wide forwarding mechanism across networks

► Solution: Internet Protocol (IP)

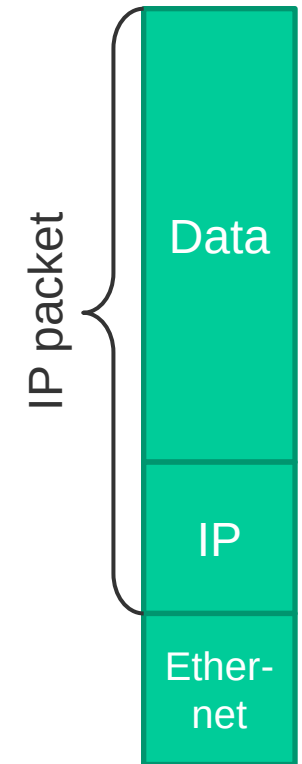
- End systems add an IP header to user data (IP packet) before transmitting it over technology-specific network
- IP header contains
 - Version number (IPv4/6), source and destination IP addresses (4 or 16 bytes long), protocol number to interpret data correctly, other information

► IP routers

- Intermediate nodes at network boundaries
- Have multiple interfaces (links) with possibly different technologies
- Receive IP packets
- Forward IP pkts based on IP destination addresses and forwarding table

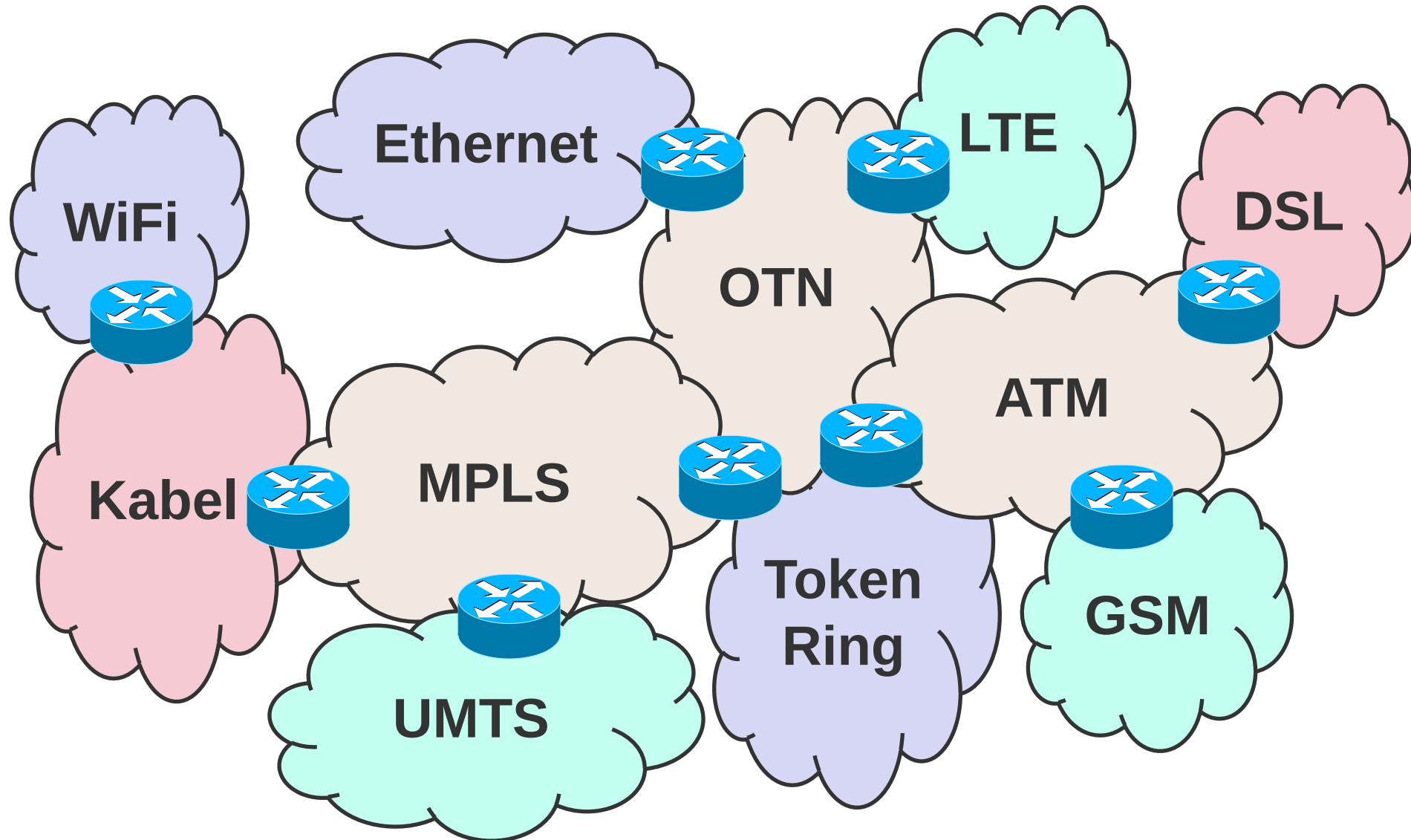
► IP addresses

- Have topological significance based on prefixes (EKUT: 134.2/16)
- Allocation to networks reflected in IP forwarding tables



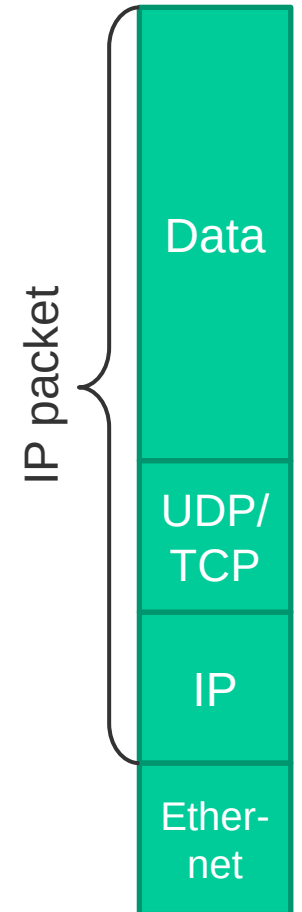


IP Routers Connecting Different Technologies



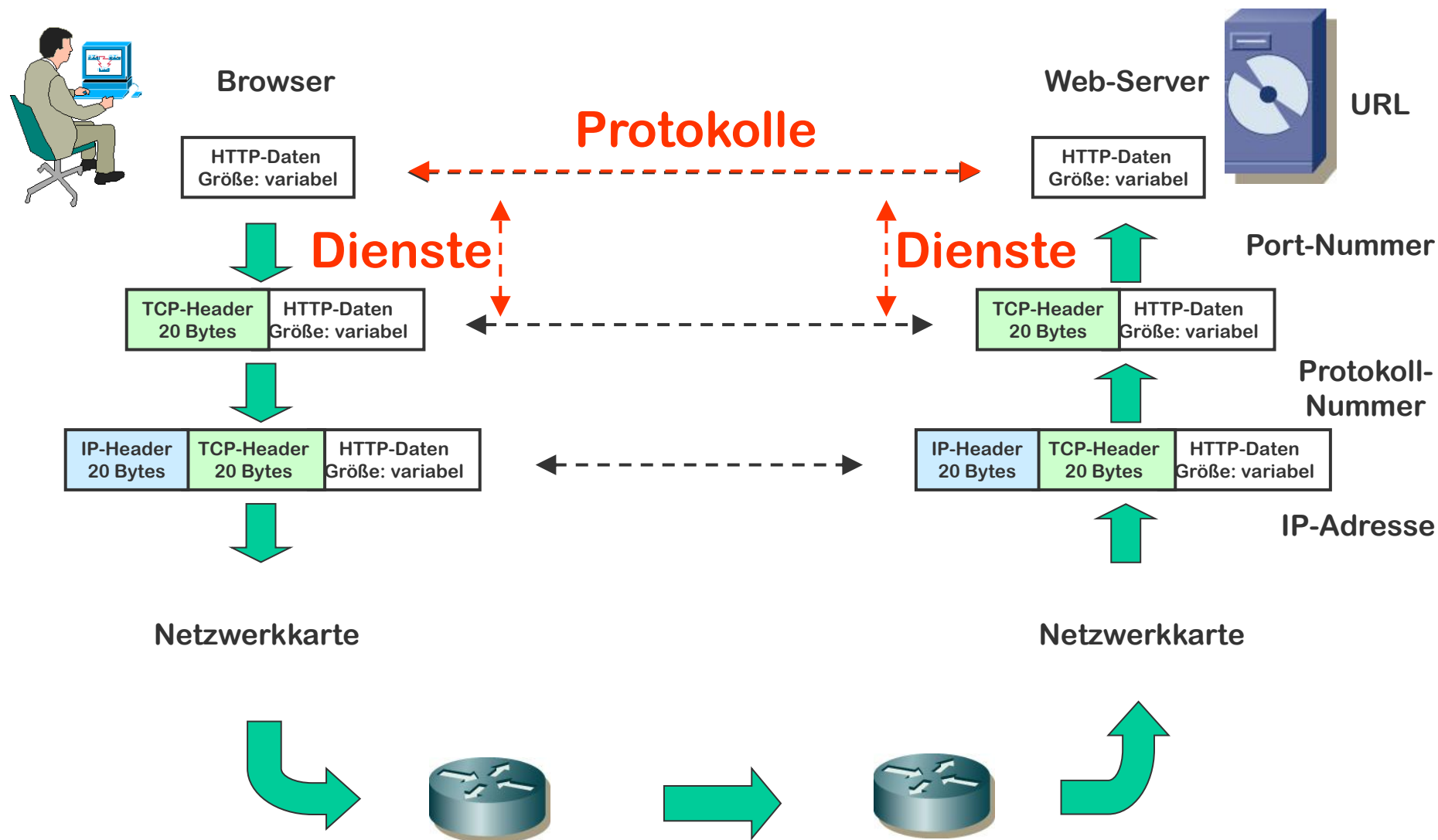


- ▶ Problem: how does a host know for which application a packet is received?
- ▶ Solution: a transport header (UDP or TCP) is wrapped around the data containing
 - A **port number** associated with an application to which host forwards the data (source and destination port number)
 - A checksum to find potential errors in data
- ▶ User datagram protocol (UDP): very simple
- ▶ Transmission control protocol (TCP)
 - Cuts stream into segments and reassembles them
 - Reliable transmission (seq. numbers, retransmission)
 - Flow control: avoid receiver is overloaded
 - Congestion control: avoid network is overloaded
- ▶ Problem: how does a host know whether UDP or TCP is used?
- ▶ Solution: IP header contains a **protocol number** indicating upper layer protocol



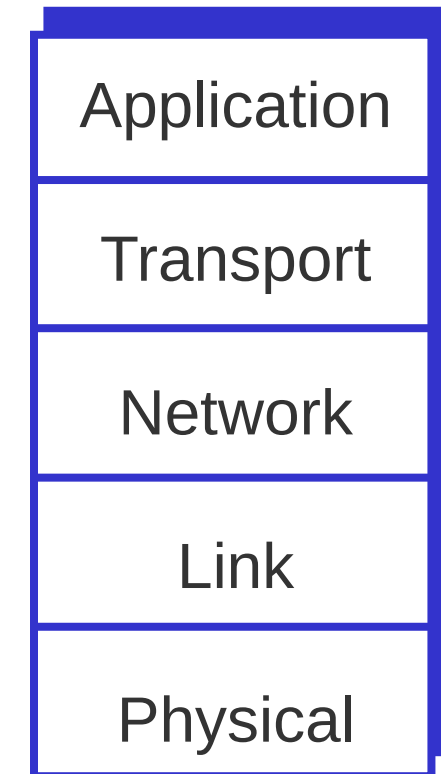


- ▶ Exchange control messages and data
- ▶ Define rules (protocols) for communication between different processes on remote nodes
 - Format of control messages and data
 - State machines for behavior of end systems
 - Finite number of states
 - Actions: $f(\text{state}, \text{input}) = (\text{next state}, \text{output})$
- ▶ Examples
 - SMTP: Simple Mail Transfer Protocol
 - FTP: File Transfer Protocol
 - HTTP: Hypertext Transfer Protocol
 - Telnet, POP3, IMAP, ...
- ▶ Open standards enable communication between products of different vendors (browsers, VoIP applications, ...)



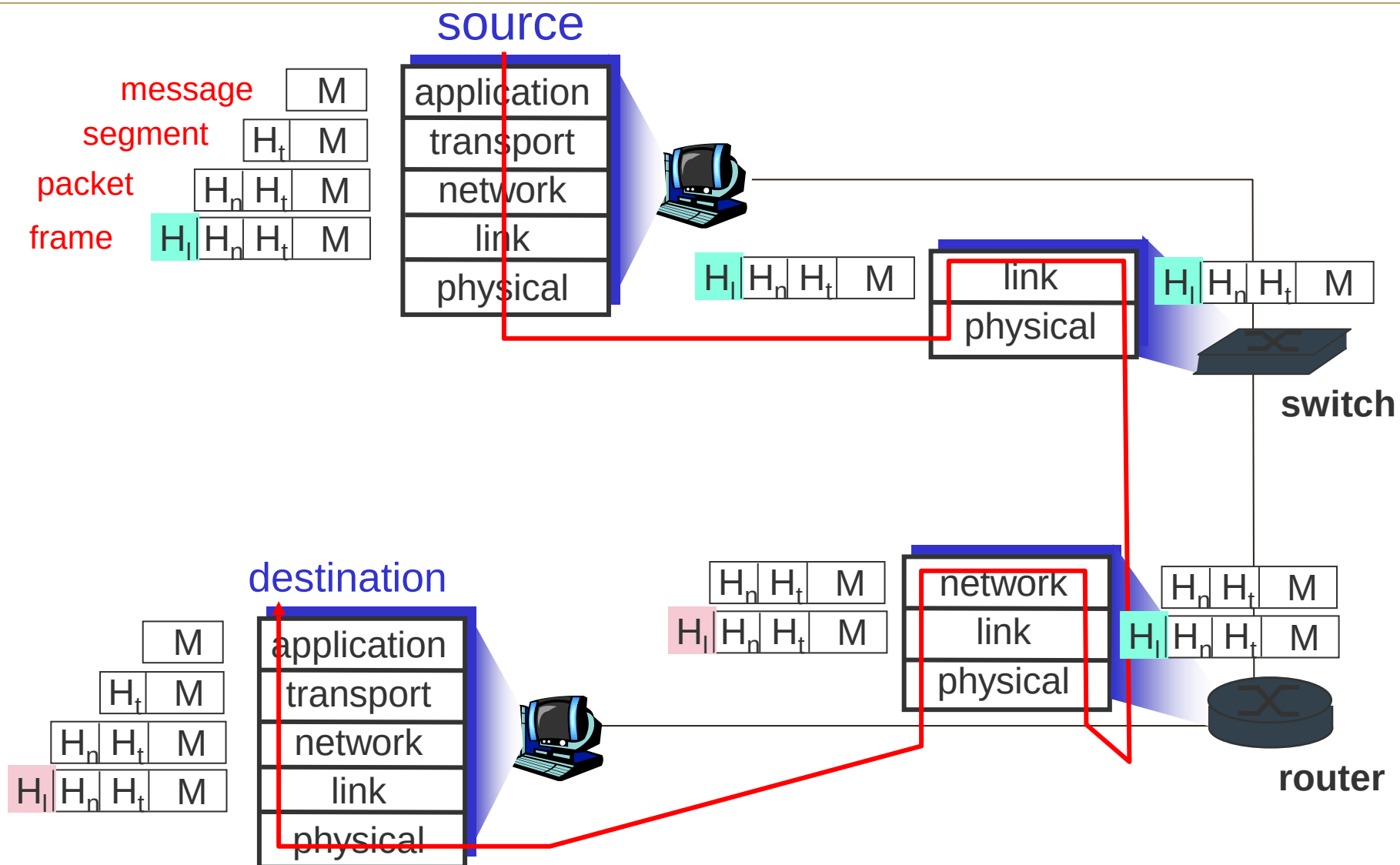


- ▶ Application: supporting network applications
 - FTP, SMTP, HTTP
- ▶ Transport: host-host data transfer
 - UDP
 - TCP: congestion control, flow control
- ▶ Network: forwarding of packets from source to destination
 - IP
 - Routers relay packets between networks of different technology
- ▶ Link: data transfer between neighboring network elements
 - PPP, Ethernet, WiFi, ...
 - Switches relay frames between nodes of the same technology
- ▶ Physical: bits “on the wire”
 - Defines connectors, link speeds, etc.
 - Repeaters refresh bits, hubs multiply bits to several wires





Encapsulation and Forwarding



- ISO: International Standardization Organization
- OSI: Open System Interconnection

7 Layers

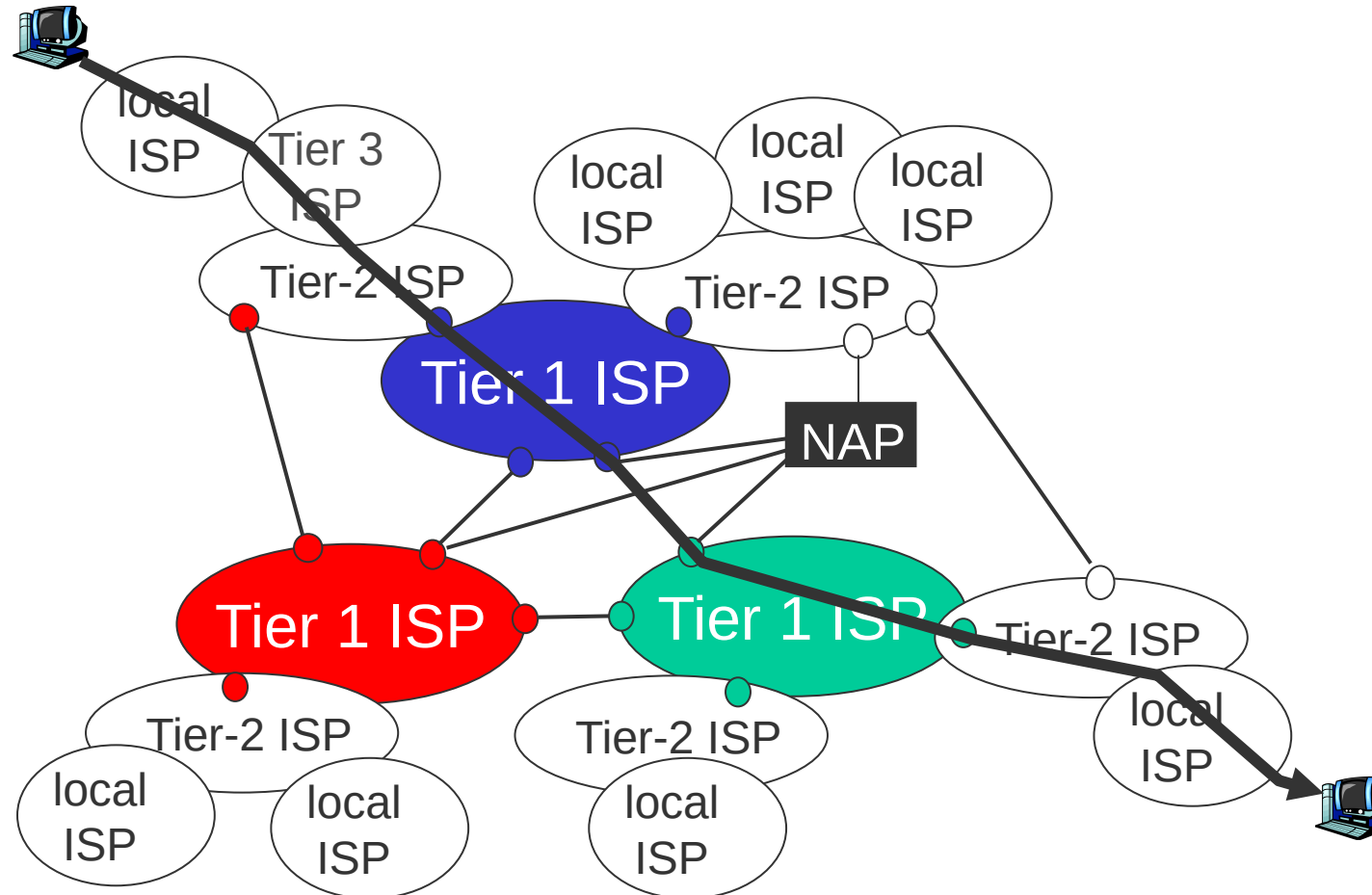
7 Schichten

Away!	7. Application	Anwendungs-orientiert	Anwendung
	6. Presentation		Darstellung
	5. Session		Kommunikationssteuerung
Throw	4. Transport	Transport-orientiert	Transport
Not	3. Network		Vermittlung
Do	2. Data Link		Sicherung
Please,	1. Physical		Bitübertragung



- ▶ Almost hierarchical structure with multiple shortcuts

- ▶ ISP: Internet service provider
 - Tier-1: highest level in hierarchy





► Forwarding

- Moving packets from input to output ports based on a forwarding table

► Routing

- Distributed algorithms filling routing / forwarding tables

► Autonomous System (AS), aka (autonomous routing) domain

- Networks under the control of a specific organisation

► The IP addresses of all devices within an AS

- Are taken from a few IP address blocks (numbers with same prefix)

► Internet

- The network of interconnected ASs

► Intradomain routing

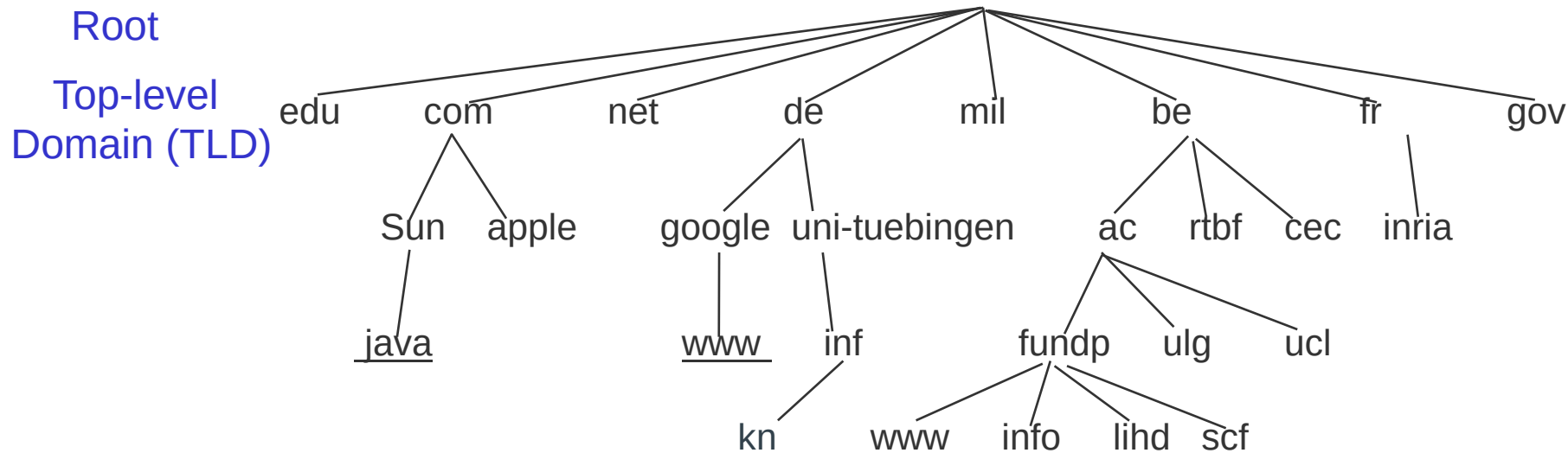
- Helps to forward packets within an AS
- Paths within AS mostly determined by shortest path principle

► Interdomain routing

- Helps to forward packets between ASes
- Paths between ASes determined by business relationships



Domain Name System (DNS)



► Problem

- Hard to remember IP addresses

► Solution: DNS

- Create hierarchical name space of DNS names
- DNS servers map DNS names to IP addresses
- Humans mostly use DNS names instead of IP addresses

► No correlation between IP addresses and DNS names

► Example

- Browse www.uni-tuebingen.de
- Browser resolves DNS name to IP address by request to DNS server (caching possible)
- Browser retrieves web page using IP address