



Informatik der Systeme – Chapter 2: Internet Basics

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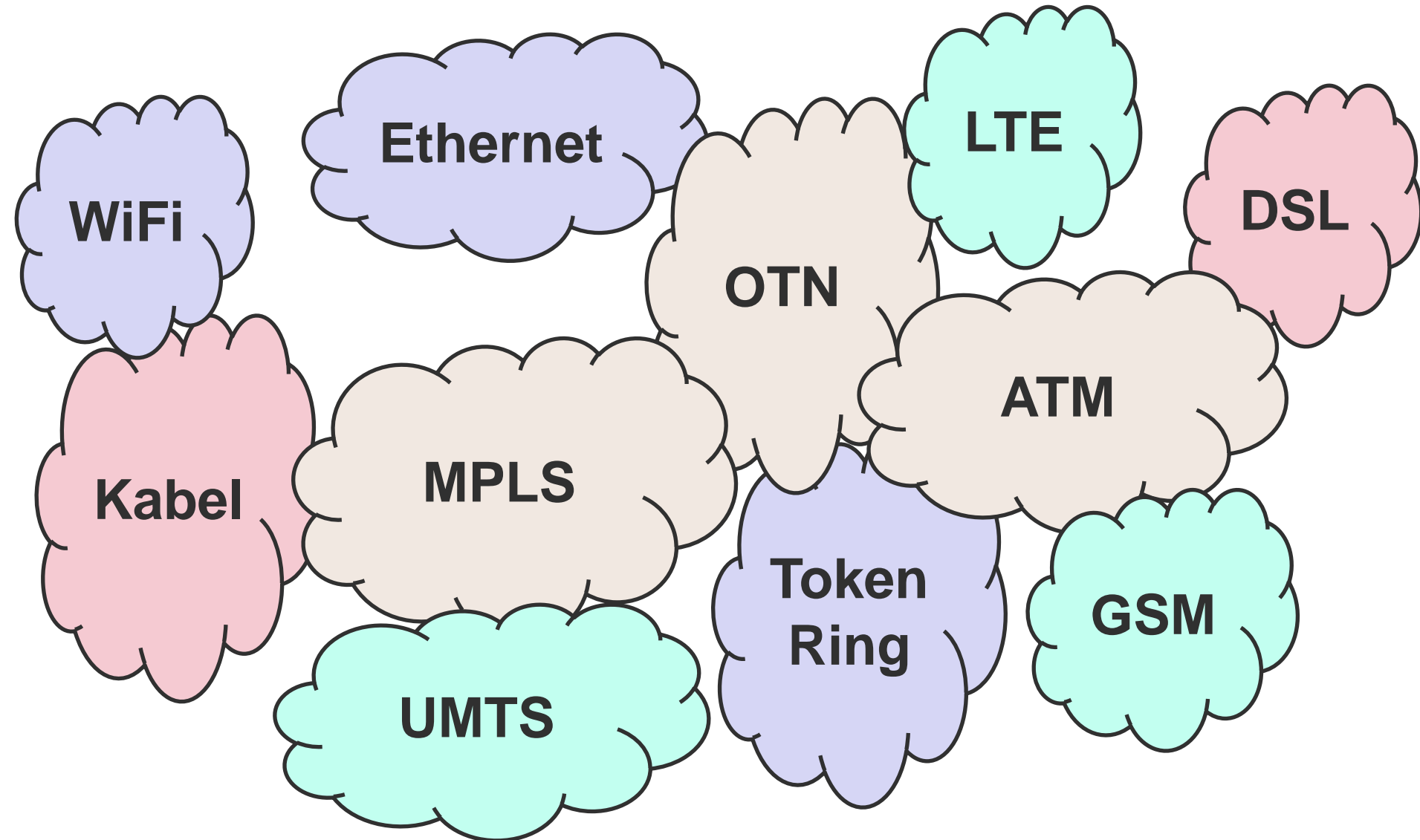
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- ▶ Just a few examples ...
- ▶ Access Technologies
 - GSM: Global System for Mobile Communications
 - UMTS: Universal Mobile Telecommunications System
 - LTE: Long-Term Evolution
 - DSL: Digital Subscriber Line
 - Kabel
- ▶ Local Area Networks
 - Ethernet
 - WiFi (no acronym, German: WLAN)
 - Token Ring
- ▶ Wide Area Networks
 - OTN: Optical Transport Network
 - ATM: Asynchronous Transport Mode
 - MPLS: Multiprotocol Label Switching



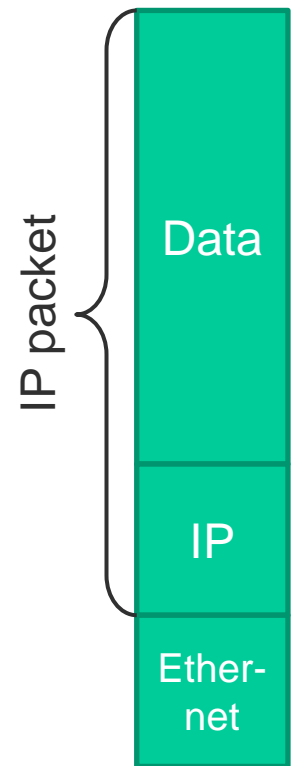
How to build an inter-network?





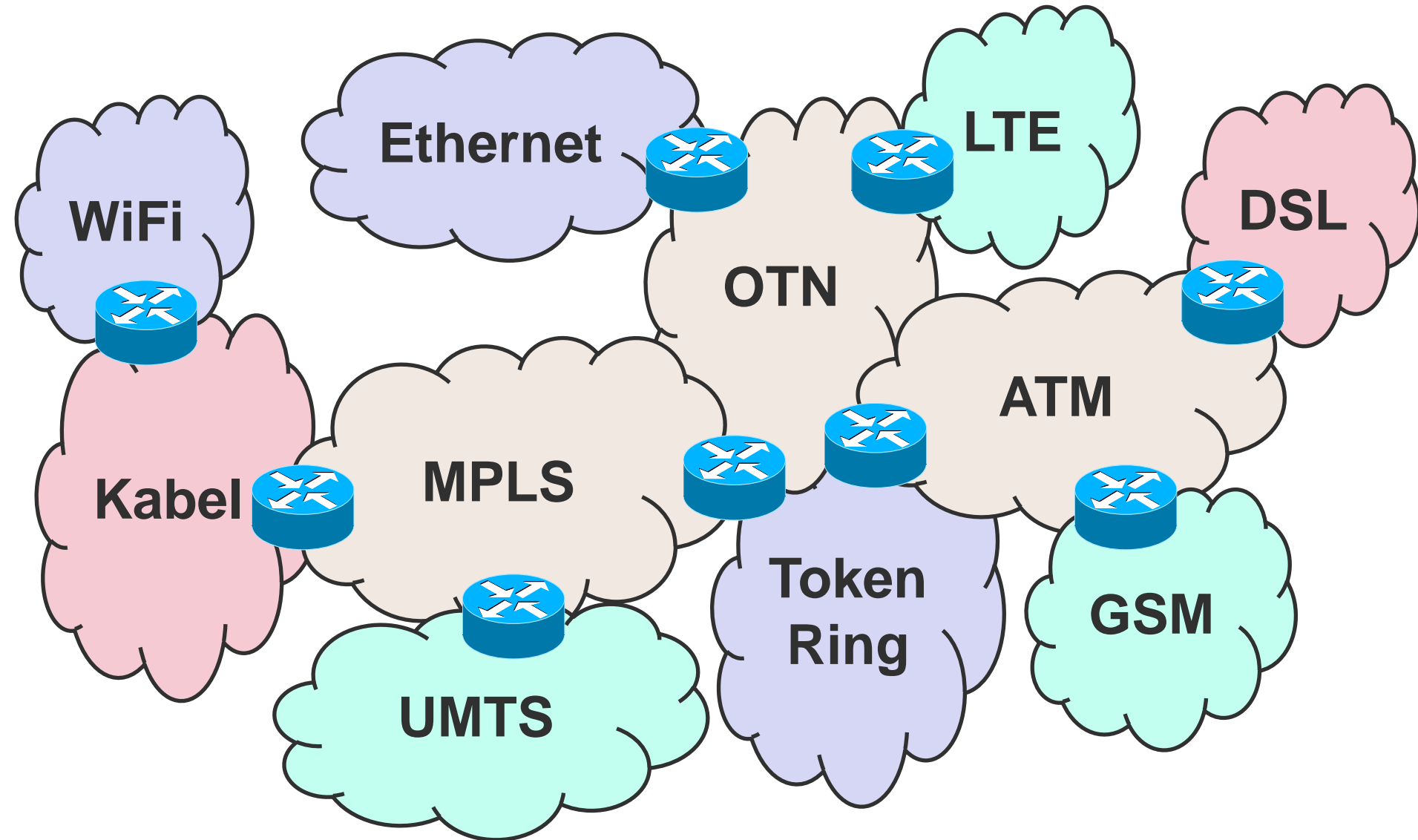
The Internet Protocol (IP)

- ▶ Problem: how can packets be carried over different networks?
 - Packets have technology-specific formats and addresses
 - Frequently used: MAC addresses, 6 bytes long
 - Networks do not know how to forward packets to outside dests
- ▶ Solution: Internet Protocol (IP)
 - End systems add an IP header to message (IP packet) before forming technology-specific packets
 - IP header contains
 - Source and destination IP addresses (4 bytes long), protocol number to interpret data correctly, version number (IPv4/6), other information
- ▶ IP hosts
 - Send and receive IP packets over technology-specific networks
- ▶ IP routers
 - Intermediate nodes that forward IP packets and translate between different network technologies if needed
- ▶ IP addresses are routable
 - Have topological significance
 - IP routers take forwarding decisions based on dest address and forwarding table, choose appropriate next IP hop towards destination



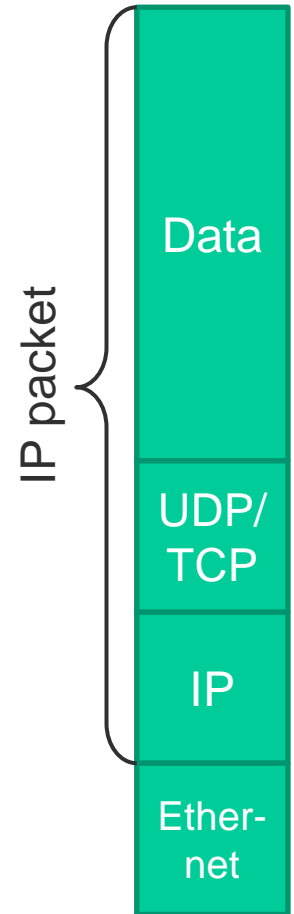


IP Routers Connecting Different Technologies





- ▶ 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

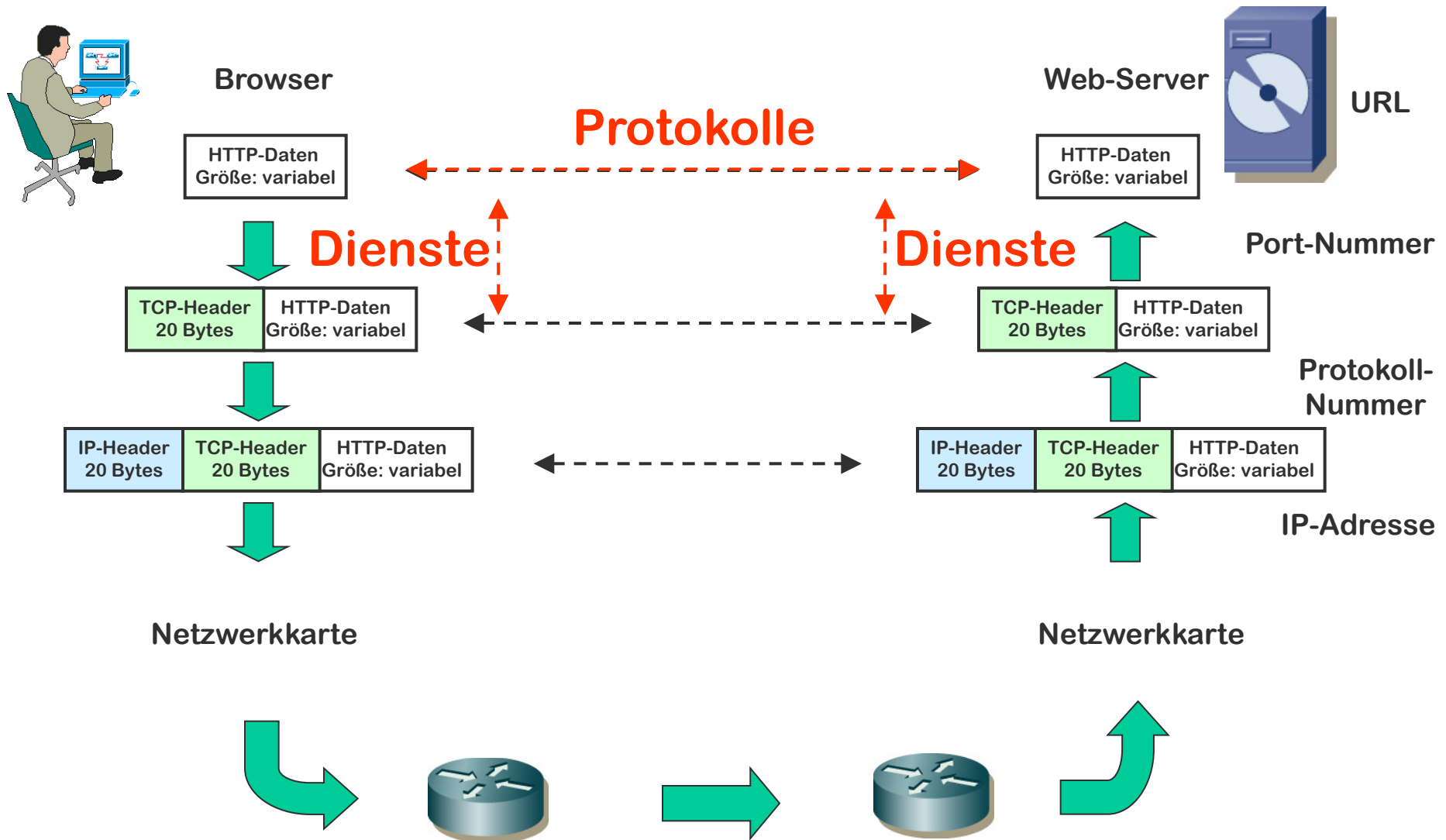




- ▶ Exchange control messages and data
- ▶ Define rules (protocols) for communication between different processes on remote nodes
 - Format of control messages and data
 - State machines for behavior of end systems
 - Finite number of states
 - Actions: $f(\text{state}, \text{input}) = (\text{next state},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



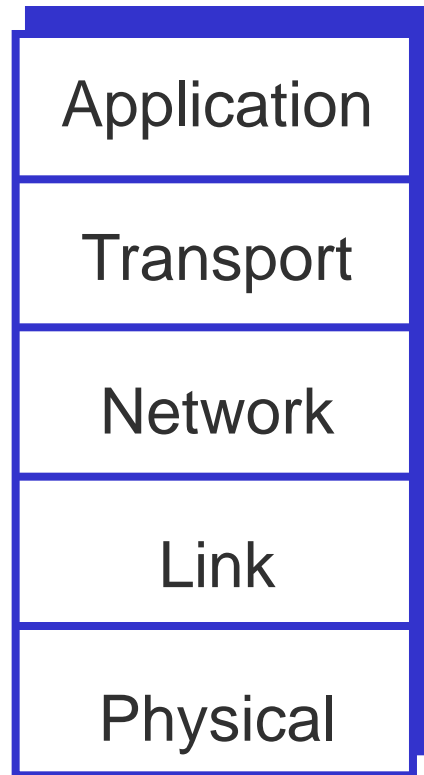
Einführendes Beispiel





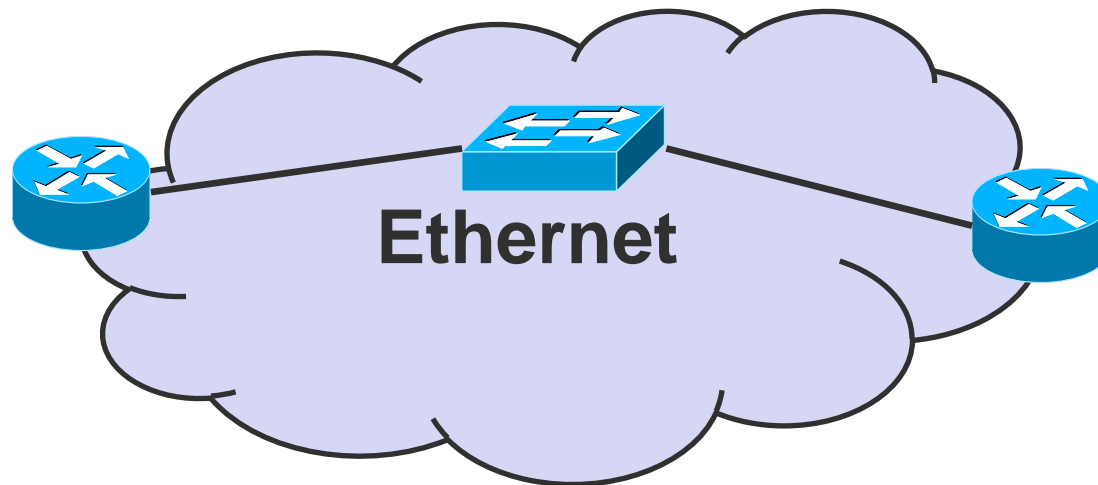
5-Layer Protocol Stack for the Internet

- ▶ 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, ATM, ...
 - 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



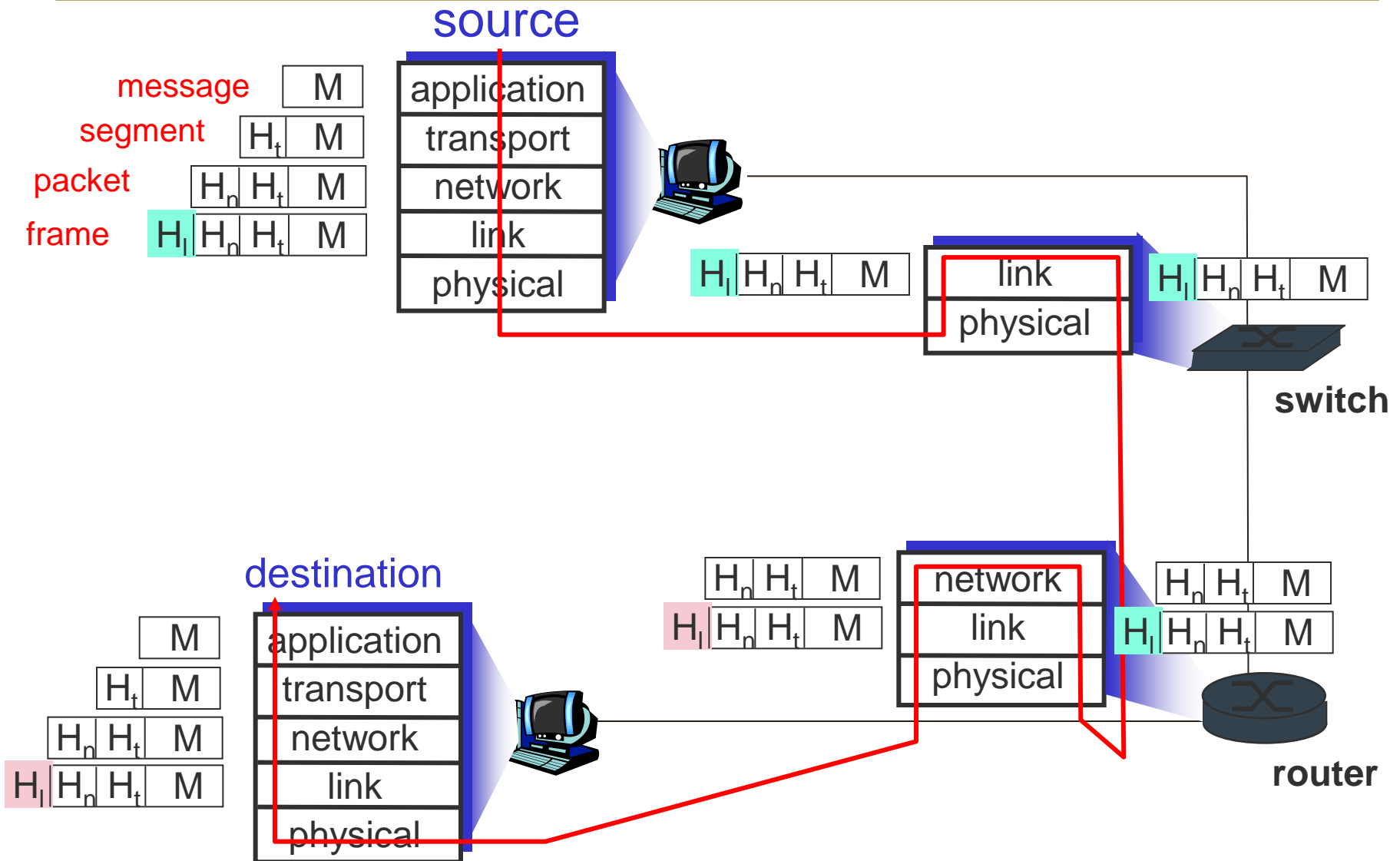


- ▶ Connects other devices to relay packet among them
- ▶ Do not interpret or modify IP header
- ▶ Do not exchange link layer header
- ▶ Do not represent IP-hops but support IP links





Encapsulation and Forwarding





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

7 Layers

7 Schichten

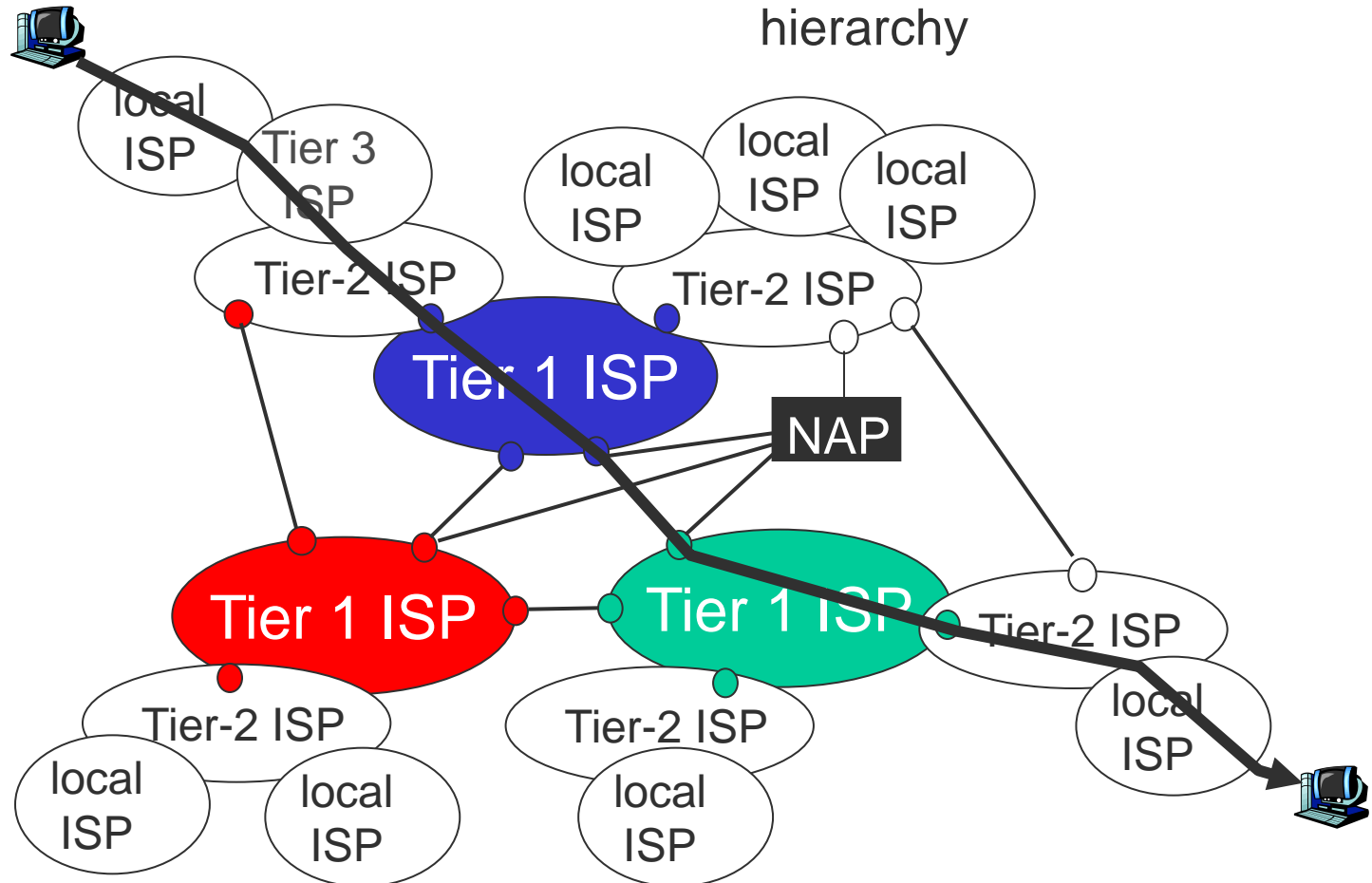
Away!	7. Application	Anwendungs-orientiert	Anwendung
	6. Presentation		Darstellung
	5. Session		Kommunikationssteuerung
Throw	4. Transport	Transport-orientiert	Transport
Not	3. Network		Vermittlung
Do	2. Data Link		Sicherung
Please,	1. Physical		Bitübertragung



Structure of the Internet

- ▶ Almost hierarchical structure with multiple shortcuts

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

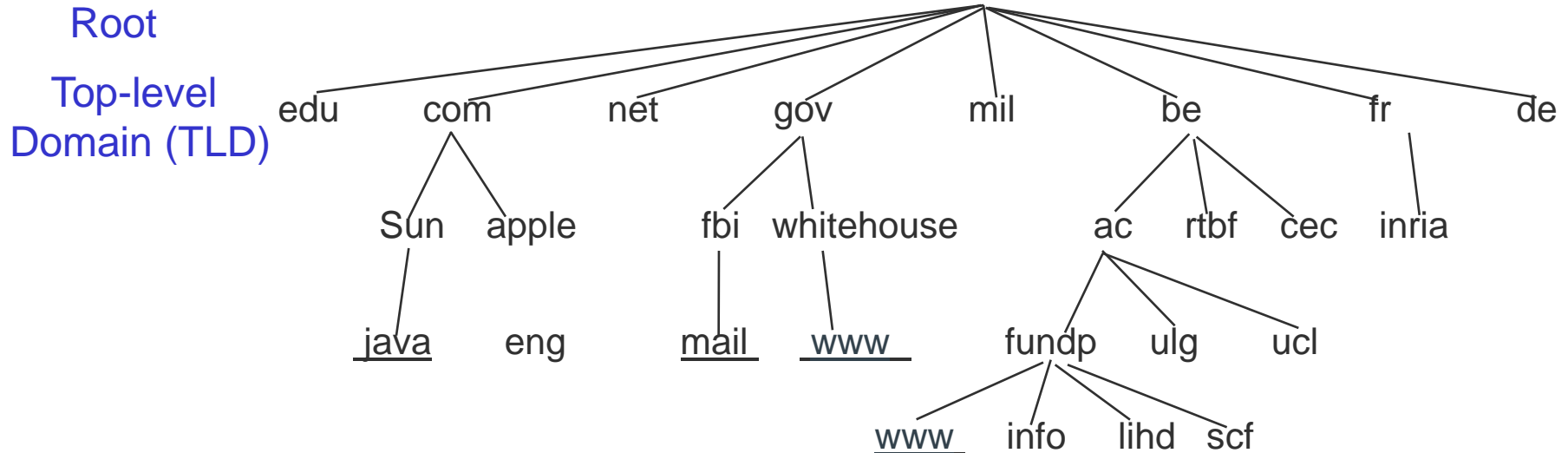




- ▶ Forwarding
 - Moving packets from input to output ports based on a forwarding table
- ▶ Routing
 - Distributed algorithms filling routing / forwarding tables
- ▶ Autonomous System (AS), aka (autonomous routing) domain
 - Networks under the control of a specific organisation
- ▶ The IP addresses of 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 often 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