Peer-to-Peer Networks

The Internet
6th Week

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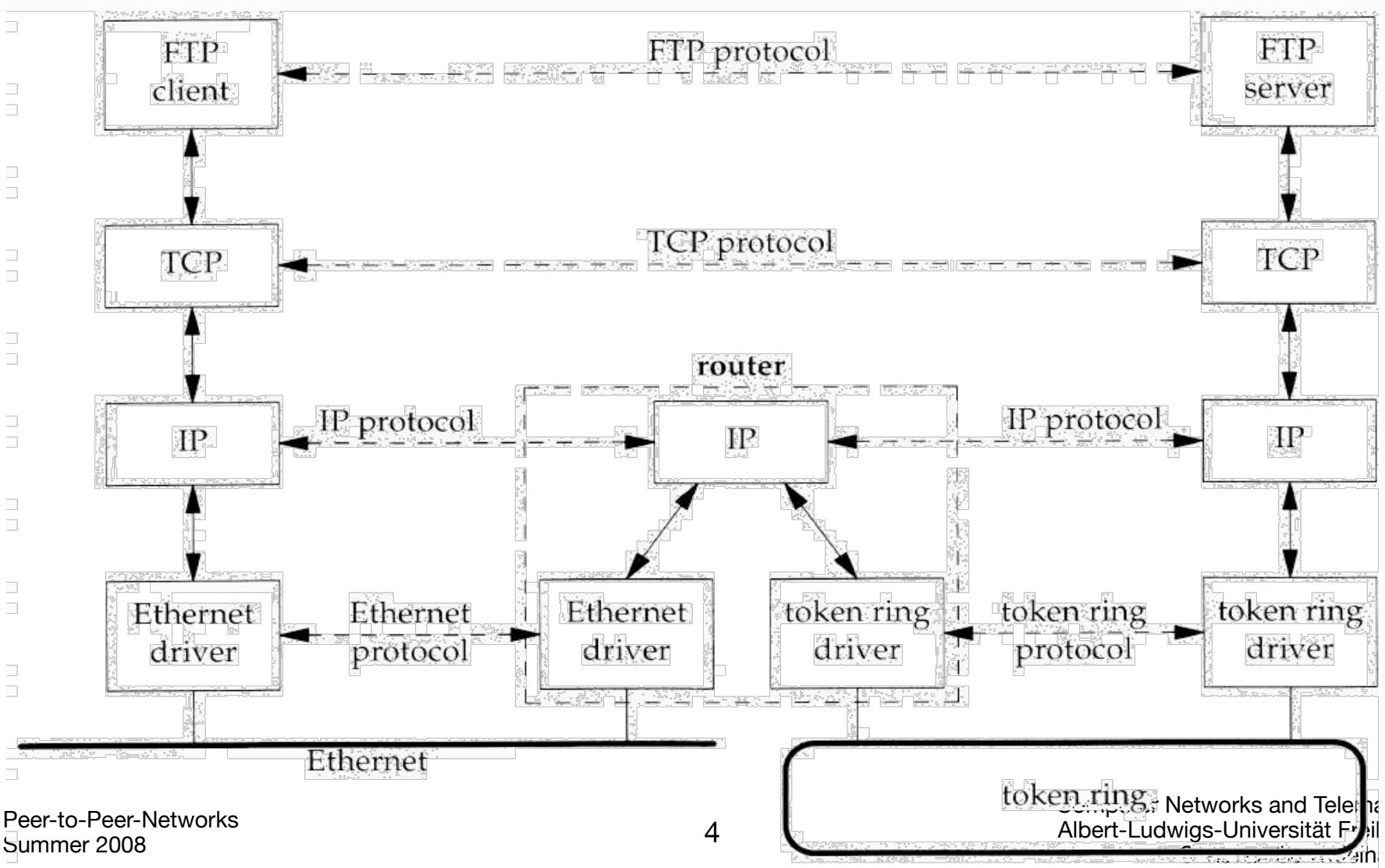
Peer-to-Peer Networks

Internet

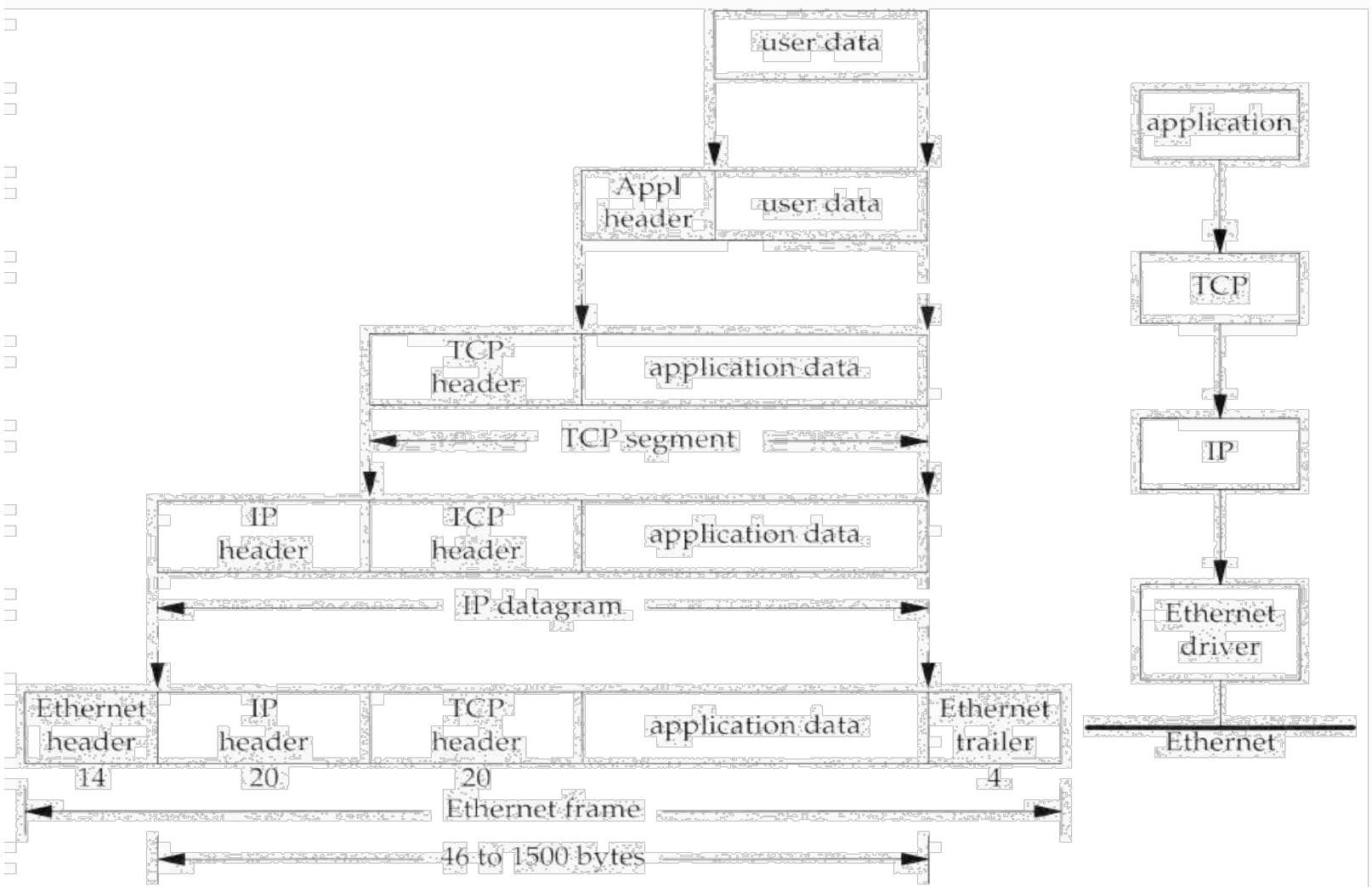
Die Internet-Schichten
TCP/IP-Layer

Application	Peer-to-Peer Networks, HTTP (Web), SMTP (E-Mail), ...
Transport	TCP (Transmission Control Protocol) UDP (User Datagram Protocol)
Network	IP **(Internet Protocol)** + ICMP **(Internet Control Message Protocol)** + IGMP **(Internet Group Management Protoccol)**
Link	LAN **(e.g. Ethernet, Token Ring etc.)**

Internet Layers At Work



Internet Headers

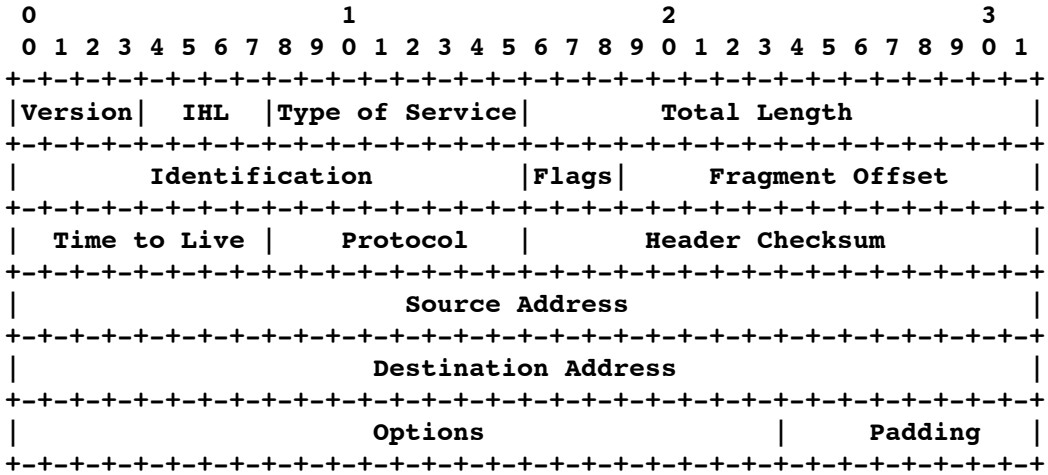


Network Layer

- **IP (Internet Protocol) & Helping Protocols**
  - ICMP (Internet Control Management Protocol)
    - error handling
  - IGMP (Internet Group Management Protocol)
    - for multicasting
  - IP is an unreliable connectionless datagram exchange service
- **Datagram consists of application data and header**

IP-Header (RFC 791)

- **Version: 4 = IPv4**
- **Total Length: header length**
  - in 32 bit words (>5)
- **Checksum**
- **Source and destination IP-address**
- **Protocol**
  - identifies protocol
  - e.g. TCP, UDP, ICMP, IGMP
- **Time to Live**
  - maximum hops



IP Addresses and Domain Name System

- **IP Addresses**
  - Each interface of a host has a unique IP address
    - worldwide
    - local
  - 32 bits separated in Net-ID and Host-ID
  - Net-ID assigned by Internet Network Information Center
  - Host-ID assigned by local network administration
- **Domain Name System (DNS)**
  - enables names as substitutes for IP Addresses
    - e.g. http://www.ifvl.de/ for80.67.17.75
  - distributed robust database

IPv4- Addresses

- **Until 1993 (not in use)**
  - 5 classes (A,B,..,E) with fixed prefix
  - then sub-net of fixed length (depending on class) and host-ID
- **Since 1993**
  - Classless Inter-Domain-Routing (CIDR)
  - Network address and host-ID have variable length
  - e.g.
    - network mask
      - 11111111.11111111.11111111.00000000
    - divides IP addresses
      - 10000100. 11100110. 10010110. 11110011
    - into network
      - 10000100. 11100110. 10010110
    - and host 11110011

Routing Table and Packet Forwarding

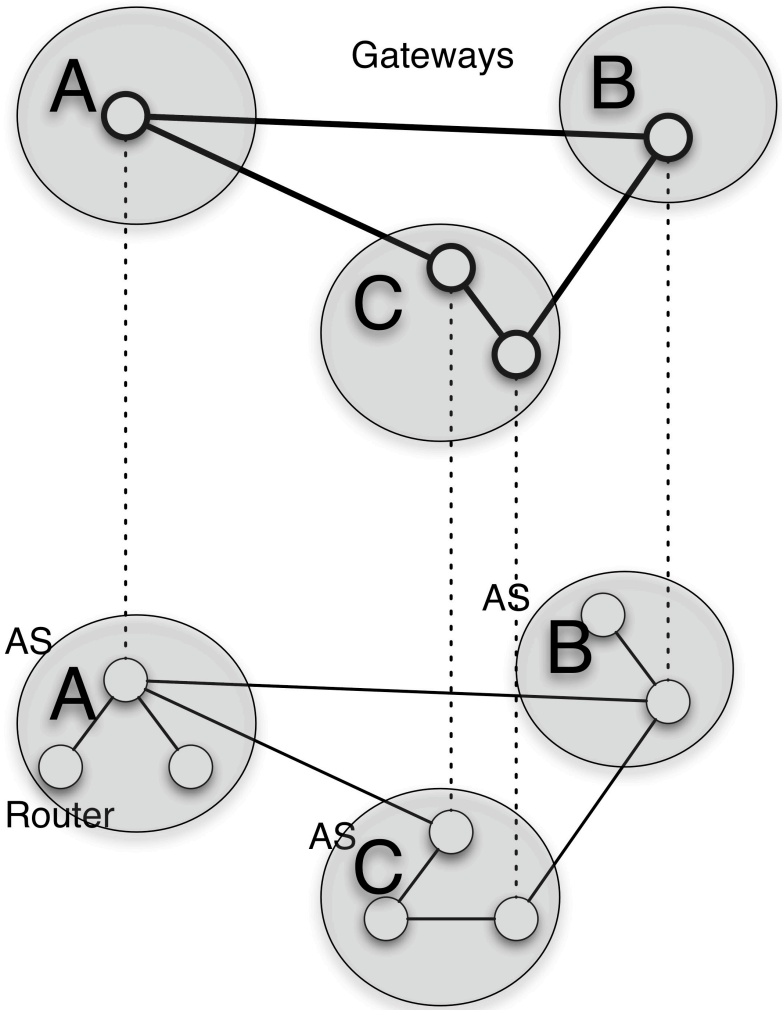
- **IP Routing Table**
  - stores for a destination the address of the next hop (gateway)
  - destination can be a host or a whole sub-net
  - for all unspecified destinations it stores a default gateway
- **Packet Forwarding**
  - (aka. packet routing)
  - IP packet (datagram) contains start and destination IP address

Packet Forwarding

- **IP packet (datagram) consists of**
  - TTL (Time-to-Live)
  - start IP address
  - destination IP address
- **Packet Forwarding Algorithm at Router**
  - Decrement TTL
  - If TTL ≠ 0 then forward packet according routing table
  - If TTL = 0 or if problems occur during packet forwarding
    - delete packet
    - if packet is not an ICMP-packet
      - send ICMP packet with
        - start = router‘s IP address
        - destination = original start IP address

AS, Intra-AS and Inter-AS

- **Autonomous Systems (AS)**
  - two layer model for routing in the Internet
  - example for AS
    - uni-freiburg.de
- **Intra-AS-Routing**
  - find routes inside an AS
  - e.g. RIP, OSPF, IGRP, ...
- **Inter-AS-Routing**
  - decentral routing
  - ASs choose optimization criteria
  - BGP (Border Gateway Protocol)



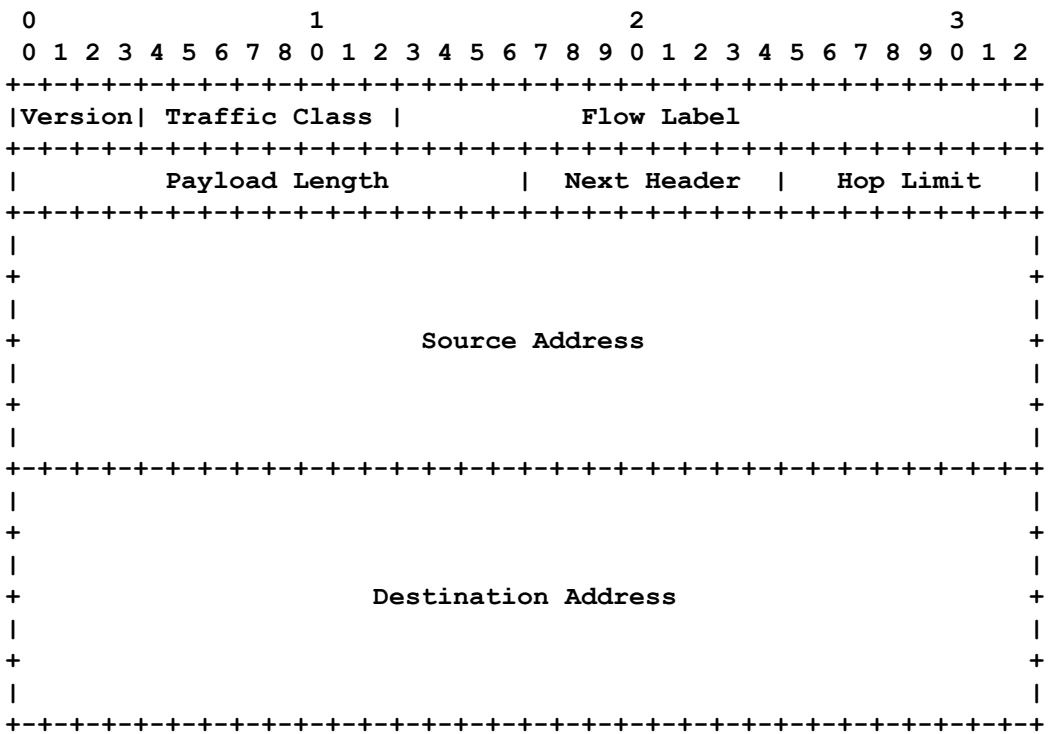
IPv6

Why IPv6

- **IP address are rare**
  - 32 bit address space allow 4 billion possible IPv4-addresses (32 Bit)
  - combination of Net-ID and Host-ID leads to overhead
- **Auto-Configuration**
  - DHCP, Mobile IP, renumbering
- **New Services**
  - Security (IPSec)
  - Quality of Service (QoS)
  - Multicast
- **Simplifications for routers**
  - no IP check sums
  - no partitioning of IP datagrams

IPv6-Header (RFC 2460)

- **Version: 6 = IPv6**
- **Traffic Class**
  - for QoS
- **Flow Label**
  - for QoS or real-time applications
- **Payload Length**
  - size of the rest of the datagram
- **Next Header (IPv4: protocol)**
  - e.g. ICMP, IGMP, TCP, EGP, UDP, ...
- **Hop Limit (Time to Live)**
  - maximum hops
- **Source Address**
- **Destination Address**
  - 128 bit IPv6 addresses

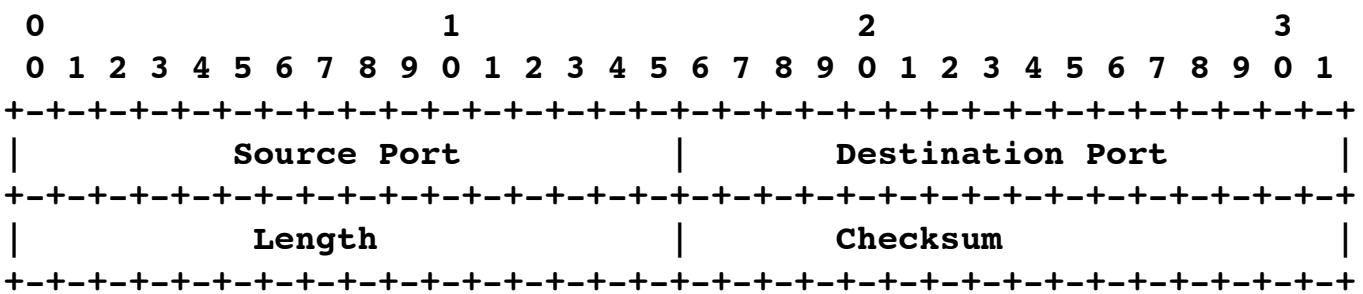


Transport Layer

- **TCP (transmission control protocol)**
  - generates reliable bidirected byte flow between two hosts
  - Partitions data flow into segments (packets)
  - sends acknowledgments
- **UDP (user datagram protocol)**
  - simple unreliable service for transport of single datagrams
  - application layer determines datagram size
- **Transmission by network layer**
- **No routes: end to end protocol**

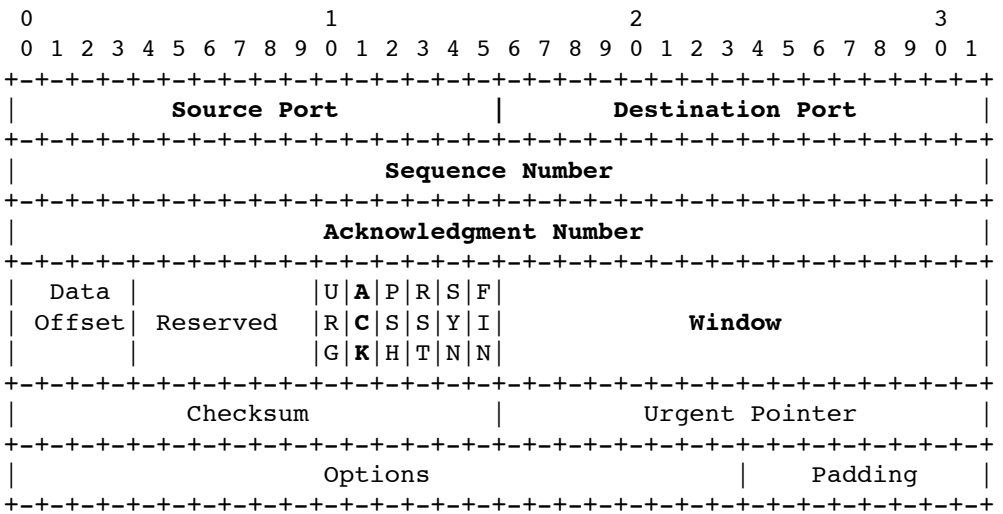
UDP Header

- **Port Addresses**
  - Source Port
  - Destination Port
- **Length of data**
- **Checksum for header**



TCP-Header

- **Sequence Number**
  - number of the first byte in the segment
- **Acknowledgement Number**
  - activated by ACK flag
  - number of the next awaited data byte
    - = last sequence number + last segment size
- **Port Addresses**
  - Source Port
  - Destination Port
  - resolve service type



TCP Open Connection

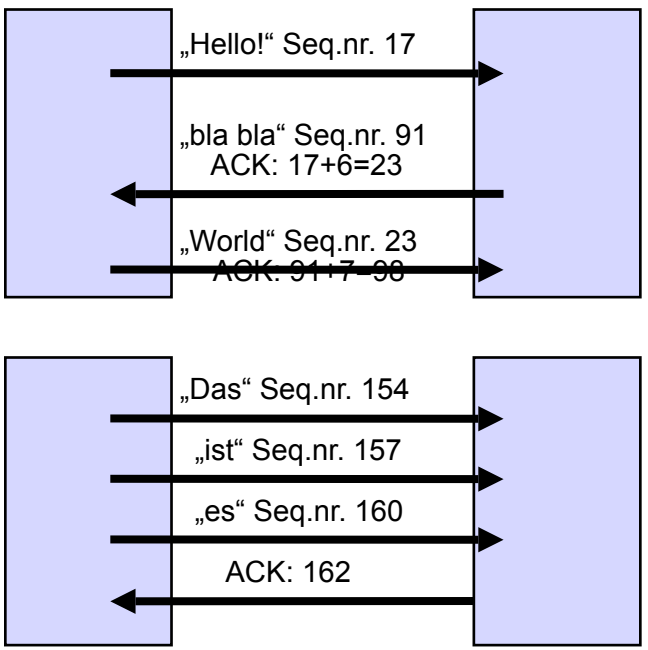
- **Client-Server**
  - client sends SYN (synchronize) segment
    - combined with MSS maximum segment size
  - server answers with
    - SYN segment with
    - piggy packed ACK segment
  - client sends ACK
- **Connection is established**

TCP Closing Connection

- **Half Close**
  - sender announces end with a FIN segment and waits for acknowledgment
  - opposite direction is still open for sending
- **Two half close close the TCP connection**

Acknowledgments

- **Piggyback**
  - ACKs ride on the data segment of the opposite direction
- **ACKs can acknowledge many segments**



Host to Network Layer

- **Interface to local network**
  - e.g. Ethnernet or WLAN
- **Transform IP address to MAC (medium access layer) address**
  - ARP (Address Resolution Protocol)
  - RARP (Reverse Address Resolution Protocol)
- **Possibly further partitioning of datagrams into smaller packets**

Summary Internet as Underlay

- **IP Network Layer**
  - NAT, PAT, DHCP and Firewalls are obstacles to direct peer to peer connections
    - hosts cannot be addressed directly
  - IPv6
    - solves the IP address problem
    - back porting of DHCP and IPsec prevents the growth of IPv6
  - IPsec enables secure direct connections
- **Transport Layer**
  - UDP is unreliable, but fast and simple
  - TCP is reliable with some overhead
  - own network protocols can be implemented using UDP
    - yet fairness and efficiency of TCP connections are at stake
  - Good peer to peer network designs take the structure of the Internet into account

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End of 6th Week

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