1 Grundeinstellungen Router / Switch

Wechsel vom exec-Mode in den privileged Mode
```
Router>enable
Router#
```

Wechsel in den Konfigurationsmodus
```
Router#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#
```

Hostname
```
Router(config)#hostname R1
```

Passworte
```
R1(config)#line console 0
R1(config-line)#password PASSWORD

R1(config)#line vty 0 4
R1(config-line)#password PASSWORD
R1(config-line)#transport input {telnet | ssh | all | none}

R1(config)#enable password PASSWORD        //unverschlüsselte Anzeige
R1(config)#enable secret Hash              //Hashing des Passwortes
```

Passworte für SSH
```
R1(config)#username User1 password Pwxy
R1(config)#line vty 0 4
R1(config-line)#login local
```

Verschlüsselung *aller* Passworte
```
R1(config)#service password-encryption    //(schwache) Verschlüsselung
```

Unterdrückung von DNS-Abfragen
```
R1(config)#no ip domain-lookup
```

Unterdrückung von Unterbrechungen durch Loggingmeldungen
```
R1(config)#line vt 0 4
R1(config-line)#logging synchronous
```

Banner
```
R1(config)#banner motd '
text
'
```

Sicherung der Konfiguration
lokal
```
R1#copy running-config startup-config
```
auf einem TFTP Server
```
R1#copy running-config tftp
...
```
Löschen einer Konfiguration
Router
```
R1#erase startup-config
```
Switch
```
S1#erase startup-config
S1#delete flash:vlan.dat
```

Statusabfragen
Anzeige der Konfiguration
```
R1#show running-config
```

```
R1#show startup-config
```

Angaben zum Gerät und der IOS-Version
```
R1#show version
R1#show flash
```

Übersicht über die vorhandenen IFs
```
R1#show ip interface brief
R1#show ipv6 interface brief
```

Routing Tabelle
```
R1#show ip route
R1#show ipv6 route
```

Switch MAC-Tabelle
```
S1#show mac-address-table
```

ARP Tabelle
```
R1#show ip arp
```

2 IPv4- und IPv6-Konfigurationen auf Routern und Switch

Konfiguration von Router-IFs
```
R1(config)#interface IF-type IF-No
R1(config-if)#description Link to LAN-10
R1(config-if)#ip address IP-addr subnet-mask
R1(config-if)#no shutdown
```

Konfiguration von logischen IFs
```
R1(config)#interface Loopback 0
R1(config-if)#ip address IP-addr subnet-mask
```

Einschalten des IPv6-Stacks
```
R1(config)#ipv6 unicast-routing
```

Konfiguration von IPv6-Addressen
```
R1(config)interface IF-type IF-No
R1(config-if)#ipv6 address IPv6-addr/n
```

Überschreiben der automatisch generierten link-lokalen Adresse
```
R1(config-if)#ipv6 address FE80::1 link-local
```

Adressierung eines Switch
```
S1(config)#interface vlan 1
S1(config-if)#ip address IP-addr subnet-mask
S1(config-if)#no shutdown
```

Default Gateway für Switch
```
S1(config)# ip default-gateway IP-addr
```

IPv6 auf Switch
Aktivierung des IPv6-Stacks
```
S1(config)# sdm prefer dual-ipv4-and-ipv6 default      //anschl.: Neustart nötig
```
Setzen einer IPv6-Adresse
```
S1(config)# interface vlan1
S1(config-if)# ipv6 address IPv6-Addr/n
```

Automatische Adressierung von Endgeräten bei IPv6

- **S**tate**l**ess **A**ddress **A**utok**o**nfiguration (SLAAC) ist Default auf einem Router
- Stateless DHCPv6

```
R1(config-if)#ipv6 nd other-config-flag
```

- Statefull DHCPv6

```
R1(config-if)#ipv6 nd prefix default no-advertise      //nicht unterstützt auf PT
R1(config-if)#ipv6 nd managed-config-flag
```

3 Routing

3.1 Statische Routen für IPv4

```
R(config)#ip route network-addr subnet-mask { ip-addr | interface-type
                  interface-number [ ip-address ]} [ distance ] [ name r_name ]
```

Beispiel:

```
R(config)#ip route 192.168.10.0 255.255.255.0 192.168.1.2          // Next-hop Route
R(config)#ip route 192.168.10.0 255.255.255.0 ser0/0/0             // IF-Route
R(config)#ip route 192.168.10.0 255.255.255.0 ser0/0/0  192.168.1.2
                                                                   // full specified
```

Beispiel einer default Route für IPv4

```
R(config)# ip route 0.0.0.0 0.0.0.0 ser0/0/0
```

Beispiel einer floating Route

```
R(config)# ip route 0.0.0.0 0.0.0.0 ser0/0/0 3                     //Admin. Dist. 3
```

3.2 Statische Routen für IPv6

```
R(config)#ipv6 route ipv6-prefix/prefix-length { ipv6-address | exit-intf }
```

Beispiel:

```
R(config)#ipv6 route 2001:db8:a:b::/64 2001:db8:a:1::1
R(config)#ipv6 route 2001:db8:a:b::/64 ser0/0/0
R(config)#ipv6 route ::/0 ser0/0/0
```

3.3 Dynamisches Routing mit RIP

RIP (IPv4)

```
R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#no auto-summary
R1(config-router)#network A.B.C.D
...
R1(config-router)#passive-interface IF-type IF-No      // Keine Updates in ein Client-Netz
R1(config-router)#default-information originate        // Verbreitung der Default Route
```

Status Abfragen

```
R1#show ip route
R1#show ip protocols
R1#debug ip rip
```

RIPng für IPv6

```
R1(config)#interface IF-type IF-No          //auf jedem IF, wo RIP ausgeführt werden soll
R1(config-if)#ipv6 rip Proc-ID enable
```

Verbreitung der Default-Route

```
R1(config)#interface IF-type IF-No
R1(config-if)#ipv6 rip Proc-ID default-information originate
```

3.4 Dynamisches Routing mit OSPF

OSPFv2 für IPv4

```
R1(config)#router ospf process-id
R1(config-router)#router-id ipv4-addr
R1(config-router)#network network-addr wildcard-mask area No
R1(config-router)#network...
R1(config-router)#passive-interface IF-type IF-No
R1(config-router)#default-information originate
```

Rechengrösse für die Datenrate einer WAN-Leitung setzen

```
R1(config)#interface IF-type IF-No
R1(config-if)#bandwidth NN                                    // [kbit/s]
```

Festlegen der Referenzbandbreite

```
R1(config-router)#auto-cost reference-bandwidth NN            // [Mbps]
```

Loopback-IFs und OSPF

```
R1(config)#interface Loopback n
R1(config-if)#ip ospf network point-to-point
```

Statusabfragen

```
R1#show ip ospf neighbor
R1#show ip protocols
R1#show ip ospf database [router|network|summary|external]
R1#show ip route
```

OSPFv3 für IPv6
Einschalten IPv6 Stack

```
R1(config)#ipv6 unicast-routing
```

Aktivierung von OSPFv3 auf den betroffenen IFs

```
R1(config)#interface IF-type IF-No
R1(config-if)#ipv6 ospf Proc-ID area No
R1(config-if)#exit
R1(config)#ipv6 router ospf Proc-ID
R1(config-rtr)#router-id A.B.C.D
R1(config-rtr)#auto-cost reference-bandwidth NN               //Optional [Mbps]
R1(config-rtr)#default-information originate                  //Optional
R1(config-rtr)#passive-interface IF-type IF-No                //Optional
```

Festlegen der Rechengrösse für OSPFv3 für die Datenrate einzelner IFs

```
R1(config)#interface IF-type IF-No
R1(config-if)#bandwidth NN                                    // [kbit/s]
```

Statusabfragen

```
R1#show ipv6 ospf neighbor
R1#show ipv6 protocols
R1#show ipv6 database [router|network|summary|external]
R1#show ipv6 route
```

Routern Zusammenfassen bei Multiarea OSPF
IPv4

```
R1(config)#router ospf process-id
R1(config-router)#area area-No range address-space subnetmask
```

IPv6

```
R1(config)#ipv6 router ospf process-id
R1(config-rtr)#area area-No range address-space-v6 /n
```

4 Switching

4.1 Switch-Konfiguration

IP-Addresse
```
Switch(conf)#interface vlan n
Switch(conf-if)#ip address A.B.C.D a.b.c.d
Switch(conf-if)#no shutdown
```
Default-gateway:
```
Switch(conf)#ip default-gateway A.B.C.D
```
IPv6 einschalten auf einem Switch:
```
Switch(conf)#sdm prefer dual-ipv4-and-ipv6 default
```
Switch Ports:
```
Switch(conf-if)#duplex {full | half | auto}
Switch(conf-if)#speed {10 | 100 | 1000 | auto}
```
Bekämpfung von MAC-Flooding:
```
Switch(conf-if)#switchport mode access
Switch(conf-if)#switchport port-security
Switch(conf-if)#switchport port-security maximum n
```
Nur einzelne MAC-Adressen zulassen:
```
Switch(conf-if)#switchport port-security mac-address {ab.cd.ef | sticky}
```
Statusabfragen
```
Switch#show interfaces {if-id}
Switch#show ip interface brief
Switch#show mac-address-table
Switch#show version
Switch#show flash
```

SSH-Zugang
Credentials:
```
Switch(conf)#username nameX password XyZ
```
Schlüsselpaar erzeugen:
```
Switch(conf)#ip domain-name domain.local
Switch(conf)#crypto key generate rsa
          ...
```
Zugang:
```
Switch(conf)#ip ssh version 2
Switch(conf)#line vty 0 n
Switch(conf-line)#login local
Switch(conf-line)#transport input ssh
```

Statusabfragen:
```
Switch#show crypto key mypublickey rsa
```

4.2 VLANs

Switch säubern:
```
Switch#erase stratup-config
Switch#delete flash:vlan.dat
Switch#reload
```
VLANs erstellen:
```
Switch(conf)#vlan n
Switch(conf-vlan)#name ABC
```
Zuweisung von Access-Ports zu VLANs:
```
Switch(config)#interface range fa0/n-m
Switch(conf-if)#switchport mode access
Switch(conf-if)#switchport access vlan n
```

Trunk Ports:
```
Switch(conf-if)#switchport trunk encapsulation dot1q //nur auf 35xx, ...
Switch(conf-if)#switchport mode trunk
```

Statusabfragen:
```
Switch#show interface trunk
Switch#show interface switchport
```
Veränderung des native VLAN:
```
Switch(config-if)#switchport trunk native vlan 99
```
Einschränkung der VLANs auf einem Trunk:
```
Switch(config-if)#switchport trunk allowed vlan n,m...
```

4.3 Inter-VLAN Routing

Konfiguration von Sub-IFs auf dem Router:
```
Router(config)#interface g0/0
Router(config-if)#no shutdown
Router(config-if)#interface g0/0.n
Router(config-if)#encapsulation dot1Q n
Router(config-if)#ip address A.B.C.D a.b.c.d
```

5 Spanning Tree Protocol

Festlegen der Root:
```
Switch(config)#spanning-tree vlan n priority 24577 // wie root primary
Switch(config)#spanning-tree vlan n priority 28673 // wie root secondary
```
Änderung der Kosten eines Links:
```
Switch(config-if)#spanning-tree cost mm
```
Änderung der Priority eines Ports:
```
Switch(config-if)#spanning-tree port-priority mm
```

Access-Ports: Portfast
```
Switch(config-if)#spanning-tree portfast
Switch(config-if)#spanning-tree portfast bpduguard enable
```
Global für alle Access-Ports:
```
Switch(config)#spanning-tree portfast default
Switch(config)#spanning-tree bpduguard default
```

Wahl des Spanning-tree Protokolls:
```
Switch(config)#spanning-tree mode ProtocolNAME
```

Statusabfragen
```
Switch#show spanning-tree [detail | interface | summary | vlan | cr]
```

6 Redundanz im Gateway

PAgP:
```
Router(config)#interface IF-ID
Router(config-if)#ip address A.B.C.D e.f.g.h   //phys. Adresse
Router(config-if)#standby group ip A.B.C.d     //virtuelle Adresse
Router(config-if)#standby group priority n     //Prio des Routers für standby
Router(config-if)#standby group track IF-ID    //Verfolgen des IF-Zustandes
Router(config-if)#standby group preempt        //Übernahme des ursprünglichen
                                               //Zustandes nach einem Ausfall
```

Statusabfragen
```
Router#show standby brief
```

GLBP (Gatewas Load Balancing Protocol):
```
Router(config-if)#glbp group ip  A.B.C.d
Router(config-if)#glbp group priority M
Router#show glbp
```

7 VLAN Trunking Protocol (VTP)

VTP einschalten:
```
Switch(config)#vtp domain MyDomain
```
VTP Version wählen:
```
Switch(config)#vtp version n
```
VTP durch PW schützen:
```
Switch(config)#vtp password myPW
```
VTP mode setzen:
```
Switch(config)#vtp mode {client | server}
```
Statusabfragen:
```
Switch#show vtp status
```

8 Link Aggregation

Zusammenfassen zweier Links
```
Switch(config)#interface range fa0/1-3
Switch(config-if)#channel-group 1 mode {desirable | auto | on}
```
Port-Channel in den Trunkmode setzen:
```
Switch(config)#interface port-channel 1
Switch(config-if)#switchport mode trunk
```

Statusabfragen:
```
Switch#show ip interface brief
Switch#show etherchannel
Switch#show etherchannel summary
Switch#show interfaces etherchannel
```

9 L3-Switching

Routing auf dem Switch einschalten
```
Switch(config)#ip routing
```
Switched Virtual IF:
```
Switch(config)#interface vlan N
Switch(config-if)#ip address A.B.C.D a.b.c.d
Switch(config-if)#no shutdown
```
Routed Port:
```
Switch(config)#interface IF-ID
Switch(config-if)#no switchport
Switch(config-if)#ip address A.B.C.D a.b.c.d
```
Ausgabe der Routing Tabelle
```
Switch#show ip route
```

10 Network Management

Konfiguration des Zeit-Masters auf einem Netzgerät
```
Router(config)#ntp server A.B.C.D
```

Syslog
Konfiguration eines Logging-Servers:
```
Router(config)#logging A.B.C.D
Router(config)#logging trap 4 // Logging level 0 – 4 werden geloggt
```

NetFlow
```
Router(config-if)#ip flow ingress
Router(config-if)#ip flow egress
Router(config)#ip flow-export destination A.B.C.D port-No
Router(config)#ip flow-export version n
```

11 Acces Lists

11.1 Nummerierte ACLs

`WCmask`: WildCard mask; anstatt `addr WCmask` kann auch `host addr` oder `any` stehen.
Standard ACL; *n*<100;
```
Router(config)#access-list n {deny|permit|remark} sourceAddr sourceWC [log]
Router(config-if)#ip access-group n {in|out}
```
Bsp.:
```
Router(config)#access-list 1 permit 10.10.10.0 0.0.0.255
```
Kontrolle
```
Router#show access-lists
Router#show running-config | include access-list n
```
Löschen
```
Router#no access-list n
```

Extended ACL; 99 < *n* < 200;
```
Router(config)#access-list n {deny|permit|remark} protocol sourceAddr sourceWC
      [operator {portNumber|name}]
      destinationAddr destinationWC [operator {portNumber|name}] [established]
```
Bsp.:
```
Router(config)#access-list 100 permit tcp 10.10.10.0 0.0.0.255 any eq 80
```

11.2 Named ACLs

Stanard ACL
```
Router(config)#ip access-list standard Name
Router(config-std-nacl)#{deny|permit} sourceAddr sourceWC
Router(config-std-nacl)#{deny|permit} host hostAddr
Router(config-std-nacl)#exit
Router(config)#interface FastEthernet 0/m
Router(config-if)#ip access-group Name {in|out}
```
Bsp.:
```
Router(config)#ip access-list standard ACL-NAT
Router(config-std-nacl)#permit 10.10.10.0 0.0.0.255
```

Extended ACL
```
Router(config)#ip access-list extended Name
Router(config-ext-nacl)#{permit|deny} protocol sourceAdd sourceWC [operator
      {port-No|name}]
      destAddr destWC [operator {port-No|name}] [established]
```

```
Router(config-if)#ip access-group Name {in|out}
```
Bsp.:
```
Router(config)#ip access-list extended ACL-Students
Router(config-ext-nacl)#permit tcp 10.10.10.0 0.0.0.255 any eq 80
```

11.3 IPv6 ACLs

```
Router(config)#ipv6 access-list Name
Router(config-ext-nacl)#{permit|deny} protocol
      {sourcePrefix/lenght|any|host addr} [operator {port-No|name}]
      {destPrefix/lenght|any|host addr} [operator {port-No|name}] [established]
Router(config-if)#ipv6 traffic-filter Name {in|out}
```
Bsp.:
```
Router(config)#ipv6 access-list ACL-STUDENTS
Router(config-ext-nacl)#permit tcp 2001:db8:a:b::/64 any eq 80
```

12 DHCP

Reservierte Adressen ausschliessen
```
Router(config)#ip dhcp excluded-address A.B.C.D a.b.c.d
```
DHCP Pool erstellen
```
Router(config)#ip dhcp pool Name
Router(dhcp-config)#network A.B.C.D a.b.c.d
Router(dhcp-config)#default-router A.B.C.D
Router(dhcp-config)#dns-server A.B.C.D
Router(dhcp-config)#domain-name example.com
```

Weiterleitung von DHCP Anfragen
```
Router(config-if)#ip helper-address A.B.C.D
```

Statusabfragen
```
Router#show ip dhcp binding
Router#show ip dhcp conflict
Router#show ip dhcp pool
Router#show ip dhcp relay
```

Interface Adresse per DHCP konfigurieren lassen:
```
Router(config-if)#ip address dhcp
```

IPv6:
```
R1(config)# ipv6 dhcp pool IPV6POOL-A
```
Weitere Parameter verteilen:
```
R1(config-dhcpv6)# domain-name ccna-statelessDHCPv6.com
R1(config-dhcpv6)# dns-server 2001:db8:acad:a::abcd
```
Zuordnung des Pools zu einem IF
```
R1(config)# interface g0/0
R1(config-if)# ipv6 dhcp server POOL_Name
```
Setzen des Flags zum Abholen weiterer Parameter
```
R1(config-if)# ipv6 nd other-config-flag
```
Setzen des Flags zum Abholen aller Parameter beim DHCPv6:
```
R1(config-if)# ipv6 nd managed-config-flag
R1(config-if)# ipv6 nd prefix default no-advertise
```
Router-IF per DHCP konfigurieren lassen:
```
R1(config-if)#ipv6 enable
R1(config-if)#ipv6 address autoconfig
```
Weiterleitung an DHCPv6 Server:
```
R1(config-if)#ipv6 dhcp relay destination ipv6-addr
```

13 NAT

Statische Network Addres Translation, NAT
```
R1(config)#ip nat inside source static local_ip global_ip
```
Anwenden auf IFs Inside | outside
```
R1(config-if)# ip nat {inside|outside}
```

Port Address Translation, PAT, mit Adress Pool
Definition eines Pools
```
R2(config)#ip nat pool poolname start-addr end-addr netmask a.b.c.d
```
Welche Adressen von innen übersetzen?
```
R2(config)#access-list n permit A.B.C.D a.b.c.d
```
Übersetzung
```
R2(config)#ip nat inside source list n pool poolname overload
```
Auf IFs anwenden wie oben

Port Address Translation auf IF
Welche Adressen von innen übersetzen?
```
R2(config)#access-list n permit A.B.C.D a.b.c.d
```
Übersetzung
```
R2(config)#ip nat inside source list n interface IF-ID overload
```
Auf IFs anwenden wie oben

Statusabfragen
```
R2#clear ip nat translations
R2#clear ip nat statistics
R2#show ip nat translations
R2#show ip nat statistics
```

Port Forwarding: A.B.C.D:ee (öffentlich)-> a.b.c.d:EE (privat)
```
R2(config)# ip nat inside source static tcp a.b.c.d:EE A.B.C.D:ee
```
Auf IFs anwenden wie oben

14 PPP

Setzen des L2-Protokolls PPP auf einem Punkt-zu-Punkt Link:
```
R1(config)# interface s0/0/0
R1(config-if)#encapsulation ppp
```

Authentisierung mit CHAP:
```
R1(config)#username R2 password secretPW
R1(config-if)#ppp authentication chap

R2(config)#username R1 password secretPW
R2(config-if)#ppp authentication chap
```

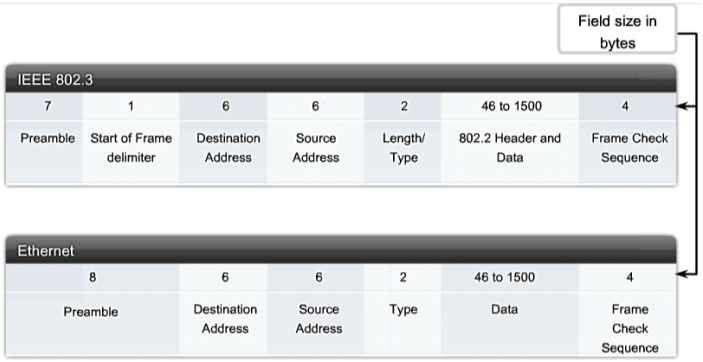
Statusabfragen
```
R1#show interfaces serial 0/0
R1#debug ppp {authentication|negociation|packet}
```

15 Tunnels

Erstellen eines Tunnel-IFs
```
R1(config)#interface Tunnel n
R1(config-if)#ip address A.B.C.D a.b.c.d
R1(config-if)#tunnel source IF-ID
R1(config-if)#tunnel destination addr
R1(config-if)#tunnel mode T-Mode                    //Mode: gre ip;  ipv6ip
```

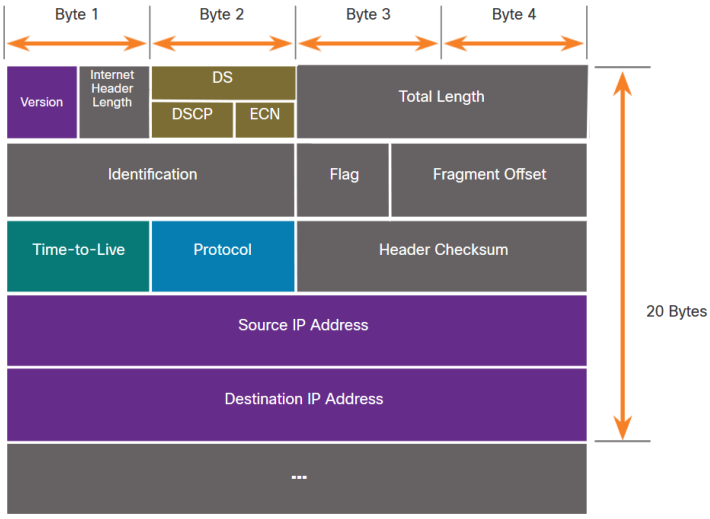
16 Protocol Header

16.1 L2: Ethernet Header



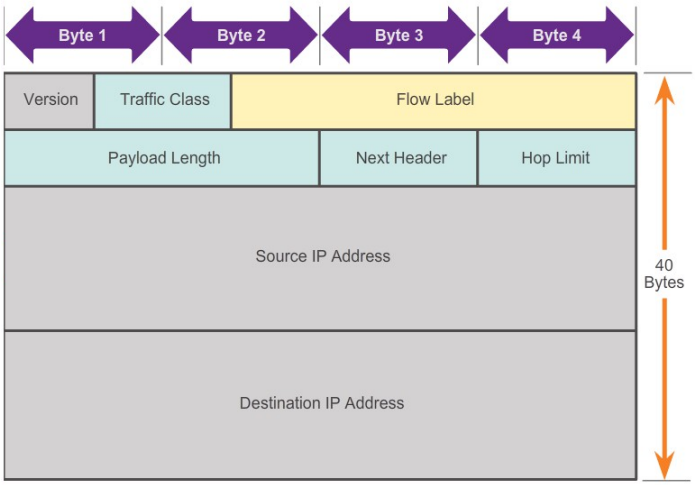

```
Protocol Codes bei Ethernet-2
Type-Feld im Ethernet Header
IP          0x0800
IPv6        0x86dd
ARP         0x0806
MPLS        0x8847
802.1Q      0x8100
EAPoL       0x888e

LLC-Feld im IEEE-Header
STP               0x42
SNAP (CDP, VTP,DTP, PagP)
                  0xAA
```

16.2 L3: IPv4 Header



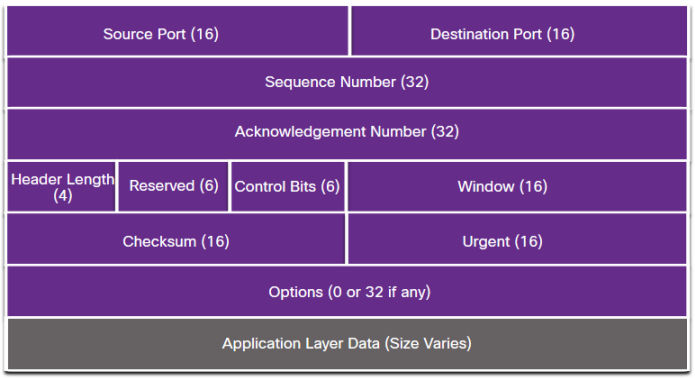

```
   Protocol- / Next-Header-Feld
in IPv4/v6
IPv6    0x29        ICMPv6  0x3a
TCP     0x06        OSPF    0x59
UDP     0x11        ESP     0x32
ICMP    0x01        PIM     0x67
IGMP    0x02
Private Adressbereiche:
10.0.0.0   - 10.255.255.255
172.16.0.0 - 172.31.255.255
192.168.0.0 - 192.168.255.255
Multicast Adressen:
224.0.0.0 -239.255.255.255
1.x.x.x -127.x.x.x:    A-Klass (/8)
128.x.x.x - 191.x.x.x: B-Klass (/16)
192.x.x.x - 223.x.x.x: C-Klass (/24)
```

L3: IPv6 Header

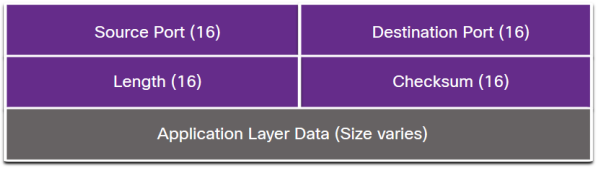


16.3 L4: Transport-Schicht

TCP Header



UDP Header



six control bits (flags) : **URG, ACK, PSH, RST, SYN, FIN**

17 Port-Nummern

Port-Nummer	L4-Protocol	Anwendung	Abkürzung
20	TCP	File Transfer Protocol (data)	FTP
21	TCP	File Transfer Protocol (conftol)	FTP
22	TCP	Secure Shell	SSH
22	TCP	Secute Copy	SCP
23	TCP	Telnet	
25	TCP	Simple Mail Transfer Protocol	SMTP
53	UDP, TCP	Domain Name System	DNS
67	UDP	Dynamic Host Configuration Protocol (server)	DHCP
68	UDP	Dynamic Host Configuration Protocol (client)	DHCP
69	UDP	Trivial File Transfer Protocol	TFTP
80	TCP	Hypertext Transfer Protocol	HTTP
88	TCP	Kerberos	
110	TCP	Post office protocol	POP3
123	UDP	Network Time Protocol	NTP
135	TCP/UDP	MICROSOFT End Point Mapper	DCE/RPC
143	TCP	Internet Message Access Protocol	IMAP
161	UDP	Simple Network Management Protolol	SNMP
389	TCP	Lightweight Directory Access Protocol	LDAP
443	TCP	Hypertext Transfer Protocol Secure	HTTPS
445	TCP	Server Message Block	SMB
514	UDP	Syslog	
500	UDP	Inetrnet Security and Key Management Protocol	ISAKMP
520	UDP	Routing Information Protocol	RIP
1812 / 1646	UDP	RADIUS	