Discovering IPv6 with Wireshark

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SHARKFEST **'10**
Stanford University
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Trace files and coloring rules can be copied from circulating memory stick

Session Agenda

- Introduction
- IPv6 Header & Extensions
- Address format, notations & types
- Address Autoconfiguration
- Neighbor discovery, Router discovery
- Host configuration with DHCPv6
- New DNS AAAA record
- Transition technologies, ISATAP, Teredo, 6to4
- IPv6 Routing Protocols

Introduction

IPv4 to IPv6 address space comparison

- There are many changes from IPv4 to IPv6
- The most obvious is the length of the IP address from 32 to 128 bits
- 4 times the number of bits is not 4 times the number of addresses
- It means doubling the address space with each additional bit (96x)
- About $3,4 * 10^{38}$ possible addressable nodes
- More than 10^{27} addresses per person on the planet

IPv4 address, 32 bits 192.168.20.30

IPv6 address, 128 bits

$$\underbrace{\text{2001:0DB8:0000:0000}}_{\text{network prefix}}\text{:}\underbrace{\text{0000:0000:1428:57AB}}_{\text{interface identifier}}$$

Introduction

IPv4 to IPv6 address space comparison

Let's assume, the whole IPv4 address space (2^{32}) with 4.2 Billion addresses is represented by an area of 1 millimeter²

How big would be the corresponding area with IPv6?

The equivalent area would be:

155 Millions of Earth surfaces!!!

(Earth surface area is 510 Million km²)

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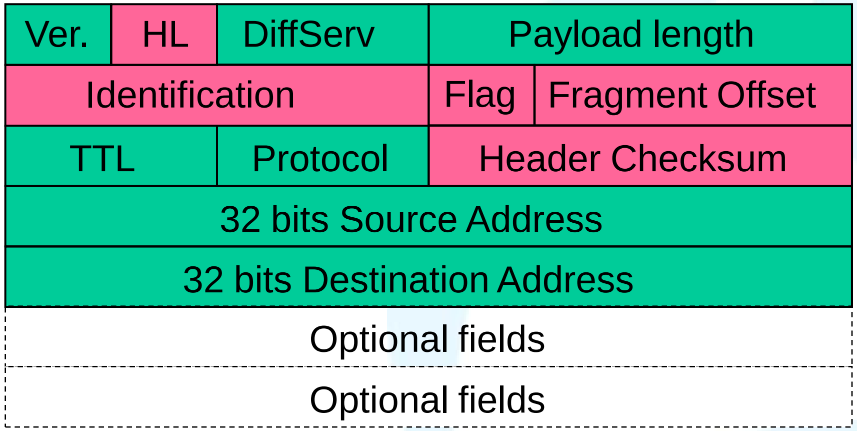
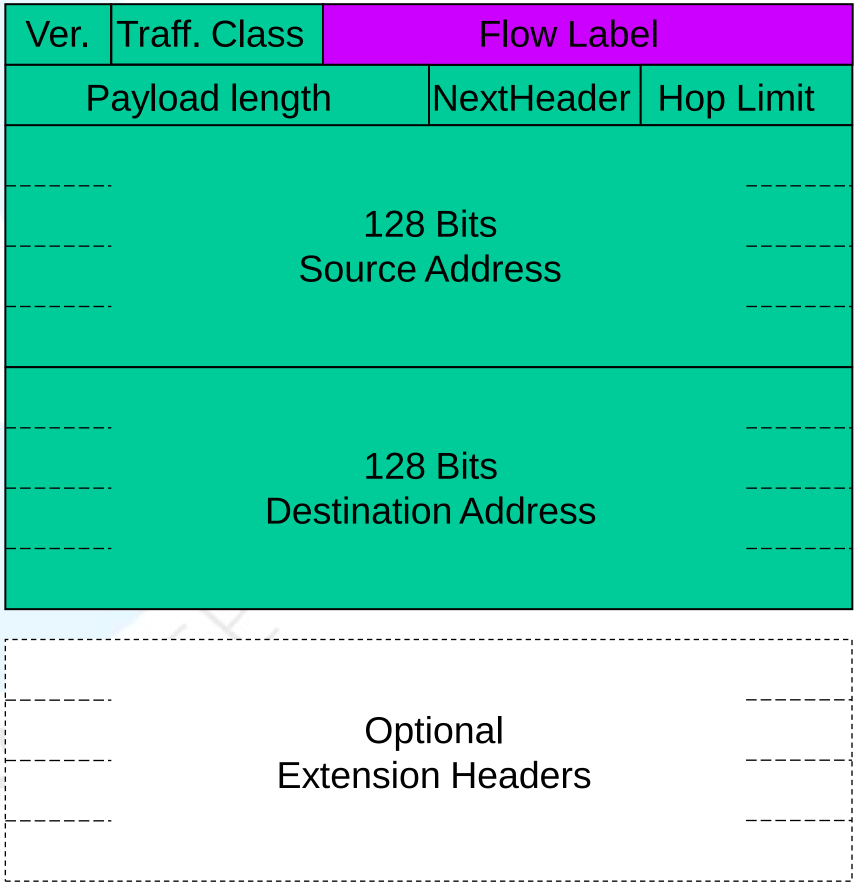
IPv6 Routing Protocols

IPv6 Headers & Extensions

IPv4 Header
(20 Bytes without options)


Ver.
HL
DiffServ
Payload length
Identification
Flag
Fragment Offset
TTL
Protocol
Header Checksum
32 bits Source Address
32 bits Destination Address
Optional fields
Optional fields

IPv6 Header
(40 Bytes without extensions)


Ver.
Traff. Class
Flow Label
Payload length
NextHeader
Hop Limit
128 Bits
Source Address
128 Bits
Destination Address
Optional
Extension Headers

🟩 Fields changed

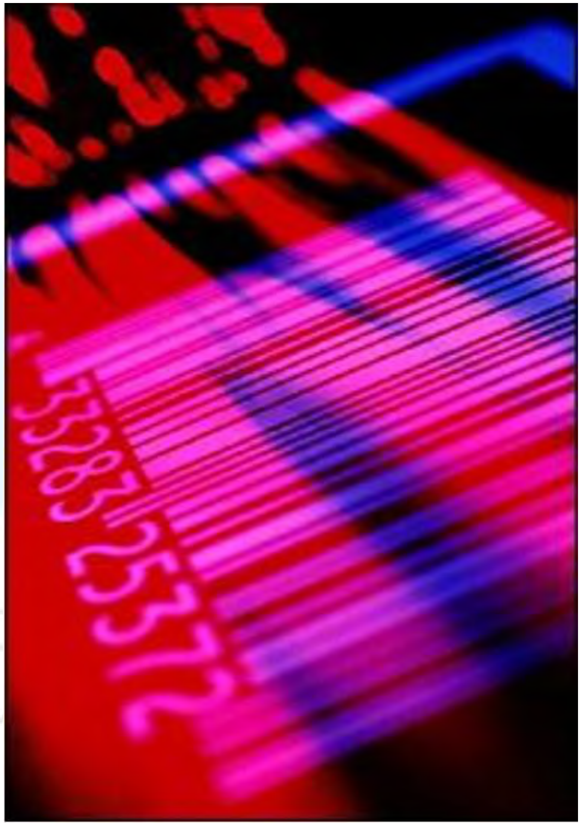
🟥 Fields removed

🟪 Fields added

IPv6 Header & Extensions

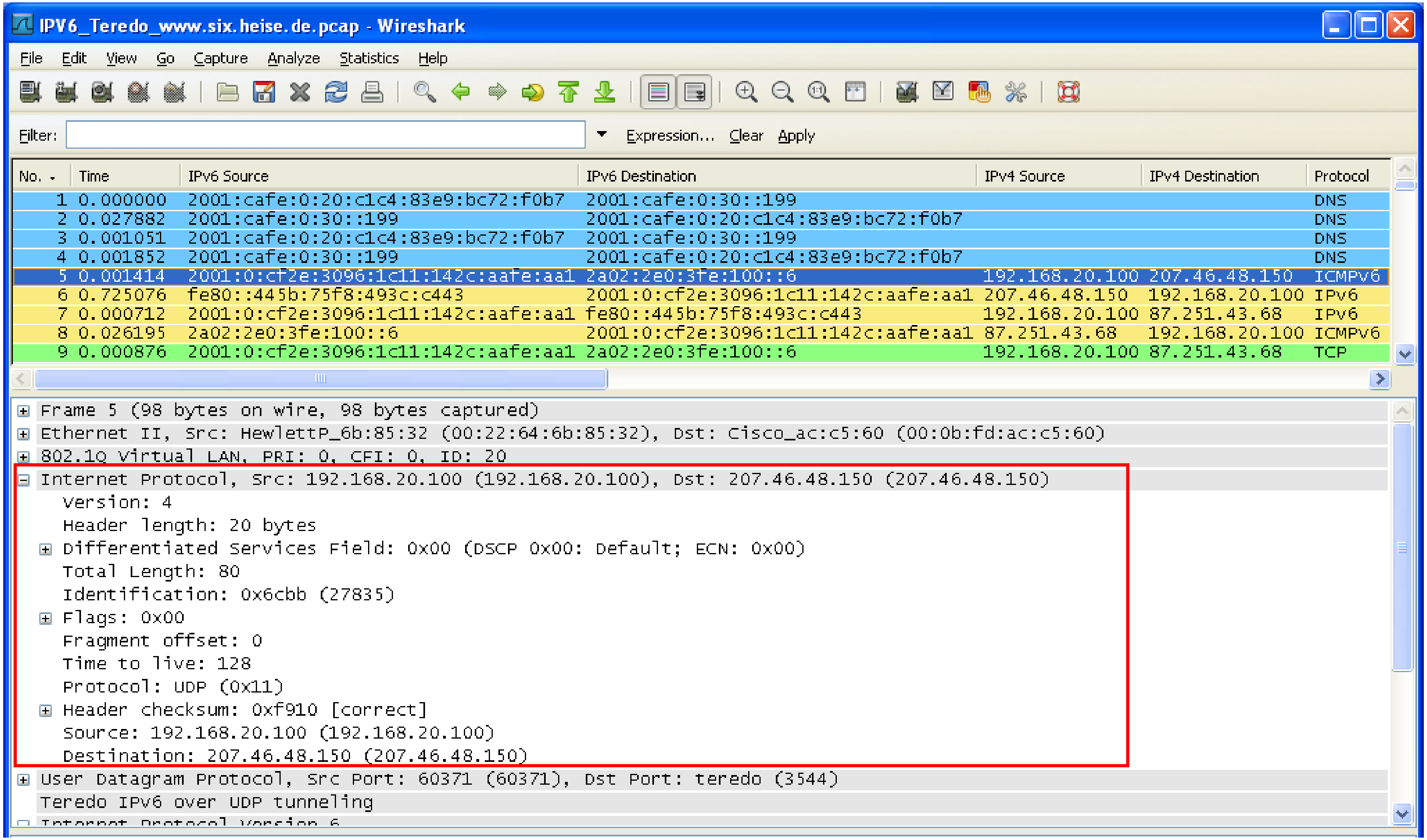
IPv6 Flow Label

- A Flow is a sequence of packets sent from a particular source to a particular destination
- A Flow Label could significantly speed up packet processing on routers
- RFC 3697 defines the use of the 20 bit IPv6 Flow Label initiated by the source nodes
- A Flow path needs to be established on all routers on the path from the source to the destination (e.g. RSVP)
- Not all flow process details are defined at this point of time



SHARKFEST

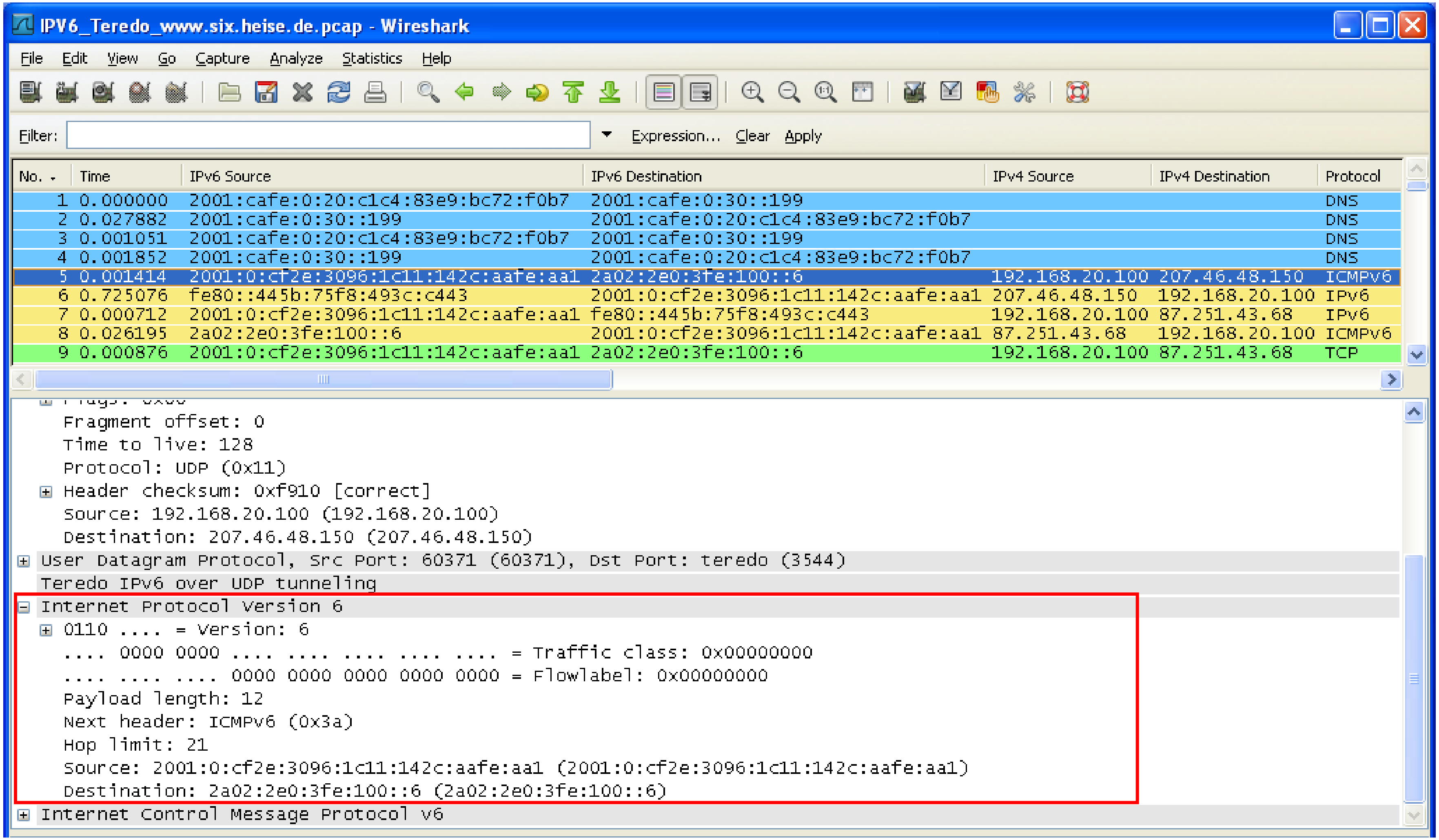
IPv6 Header & Extensions


IPV6_Teredo_www.six.heise.de.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply

No.	Time	IPv6 Source	IPv6 Destination	IPv4 Source	IPv4 Destination	Protocol
1	0.000000	2001:cafe:0:20:c1c4:83e9:bc72:f0b7	2001:cafe:0:30::199			DNS
2	0.027882	2001:cafe:0:30::199	2001:cafe:0:20:c1c4:83e9:bc72:f0b7			DNS
3	0.001051	2001:cafe:0:20:c1c4:83e9:bc72:f0b7	2001:cafe:0:30::199			DNS
4	0.001852	2001:cafe:0:30::199	2001:cafe:0:20:c1c4:83e9:bc72:f0b7			DNS
5	0.001414	2001:0:cf2e:3096:1c11:142c:aafe:aa1	2a02:2e0:3fe:100::6	192.168.20.100	207.46.48.150	ICMPv6
6	0.725076	fe80::445b:75f8:493c:c443	2001:0:cf2e:3096:1c11:142c:aafe:aa1	207.46.48.150	192.168.20.100	IPv6
7	0.000712	2001:0:cf2e:3096:1c11:142c:aafe:aa1	fe80::445b:75f8:493c:c443	192.168.20.100	87.251.43.68	IPv6
8	0.026195	2a02:2e0:3fe:100::6	2001:0:cf2e:3096:1c11:142c:aafe:aa1	87.251.43.68	192.168.20.100	ICMPv6
9	0.000876	2001:0:cf2e:3096:1c11:142c:aafe:aa1	2a02:2e0:3fe:100::6	192.168.20.100	87.251.43.68	TCP

```
⊞ Frame 5 (98 bytes on wire, 98 bytes captured)
⊞ Ethernet II, Src: HewlettP_6b:85:32 (00:22:64:6b:85:32), Dst: Cisco_ac:c5:60 (00:0b:fd:ac:c5:60)
⊞ 802.1Q Virtual LAN, PRI: 0, CFI: 0, ID: 20
⊟ Internet Protocol, Src: 192.168.20.100 (192.168.20.100), Dst: 207.46.48.150 (207.46.48.150)
    Version: 4
    Header length: 20 bytes
  ⊞ Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)
    Total Length: 80
    Identification: 0x6cbb (27835)
  ⊞ Flags: 0x00
    Fragment offset: 0
    Time to live: 128
    Protocol: UDP (0x11)
  ⊞ Header checksum: 0xf910 [correct]
    Source: 192.168.20.100 (192.168.20.100)
    Destination: 207.46.48.150 (207.46.48.150)
⊞ User Datagram Protocol, Src Port: 60371 (60371), Dst Port: teredo (3544)
  Teredo IPv6 over UDP tunneling
⊟ Internet Protocol Version 6
```

IPv6 Header & Extensions


IPV6_Teredo_www.six.heise.de.pcap - Wireshark
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Filter:
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No.	Time	IPv6 Source	IPv6 Destination	IPv4 Source	IPv4 Destination	Protocol
1	0.000000	2001:cafe:0:20:c1c4:83e9:bc72:f0b7	2001:cafe:0:30::199			DNS
2	0.027882	2001:cafe:0:30::199	2001:cafe:0:20:c1c4:83e9:bc72:f0b7			DNS
3	0.001051	2001:cafe:0:20:c1c4:83e9:bc72:f0b7	2001:cafe:0:30::199			DNS
4	0.001852	2001:cafe:0:30::199	2001:cafe:0:20:c1c4:83e9:bc72:f0b7			DNS
5	0.001414	2001:0:cf2e:3096:1c11:142c:aafe:aa1	2a02:2e0:3fe:100::6	192.168.20.100	207.46.48.150	ICMPv6
6	0.725076	fe80::445b:75f8:493c:c443	2001:0:cf2e:3096:1c11:142c:aafe:aa1	207.46.48.150	192.168.20.100	IPv6
7	0.000712	2001:0:cf2e:3096:1c11:142c:aafe:aa1	fe80::445b:75f8:493c:c443	192.168.20.100	87.251.43.68	IPv6
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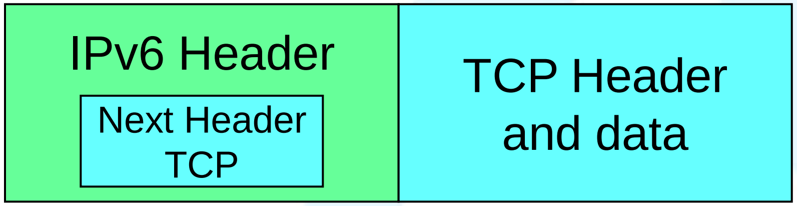
9	0.000876	2001:0:cf2e:3096:1c11:142c:aafe:aa1	2a02:2e0:3fe:100::6	192.168.20.100	87.251.43.68	TCP

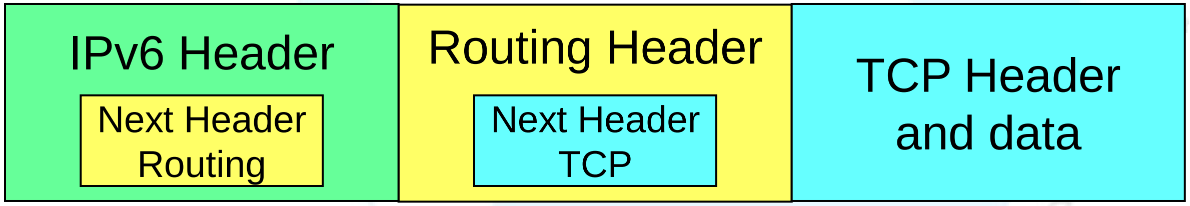
```
    Fragment offset: 0
    Time to live: 128
    Protocol: UDP (0x11)
  ⊞ Header checksum: 0xf910 [correct]
    Source: 192.168.20.100 (192.168.20.100)
    Destination: 207.46.48.150 (207.46.48.150)
⊞ User Datagram Protocol, Src Port: 60371 (60371), Dst Port: teredo (3544)
  Teredo IPv6 over UDP tunneling
⊟ Internet Protocol Version 6
  ⊞ 0110 .... = Version: 6
    .... 0000 0000 .... .... .... .... .... = Traffic class: 0x00000000
    .... .... .... 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000
    Payload length: 12
    Next header: ICMPv6 (0x3a)
    Hop limit: 21
    Source: 2001:0:cf2e:3096:1c11:142c:aafe:aa1 (2001:0:cf2e:3096:1c11:142c:aafe:aa1)
    Destination: 2a02:2e0:3fe:100::6 (2a02:2e0:3fe:100::6)
⊞ Internet Control Message Protocol v6
```

IPv6 Header & Extensions

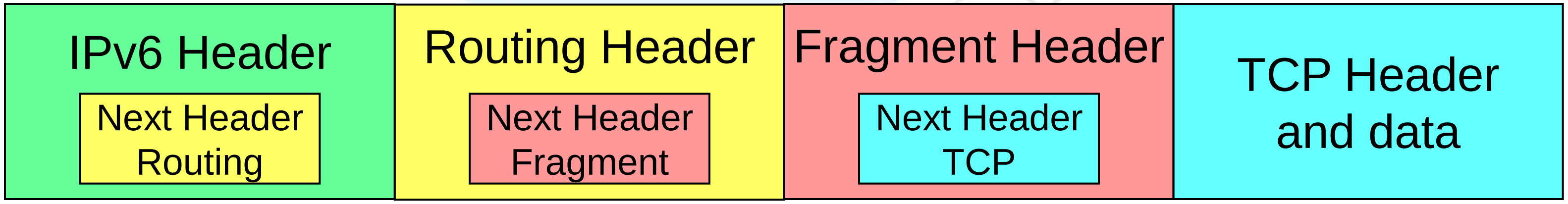
- IPv6 offers modular header composition adding optional information
- Basic IPv6 header can be followed by one ore more extension headers


IPv6 Header
Next Header TCP
TCP Header and data

Basic header


IPv6 Header
Next Header Routing
Routing Header
Next Header TCP
TCP Header and data

Basic header with one extension


IPv6 Header
Next Header Routing
Routing Header
Next Header Fragment
Fragment Header
Next Header TCP
TCP Header and data

Basic header with two extension

Session Agenda

Introduction

IPv6 Header & Extensions

Address format, notations & types

Address Autoconfiguration

Neighbor discovery, Router discovery

Host configuration with DHCPv6

New DNS AAAA record

Transition technologies, ISATAP, Teredo, 6to4

IPv6 Routing Protocols

Address format & notation

IPv6 supports different address notation formats

2001:0DB8:0000:0000:0000:0000:1428:57AB	standard notation
2001:0db8:0000:0000:0000:0000:1428:57ab	notation is case insensitive
2001:db8:0:0:0:0:1428:57ab	leading zeros can be suppressed
2001:db8::1428:57ab	consecutive zeros can be compressed with ::
2001:0:0:100:0:0:0:20	zero compression only once in an address
2001::100::20	invalid address
2001:0:0:100::20	valid address
2001::100:0:0:020	valid address
fe80::5efe:192.168.20.100	mixed notation, compressed
2001:db8::/64	represents the network 2001:db8:0:0::
2001:db8::1428:57ab/128	represents a single host address

Address types

Four types of addresses are defined in IPv6

Unicast	2xxx fdxx	Worldwide unique addresses Locally valid addresses
Multicast	ffxx	play an important role in IPv6, they also replace Broadcasts
Anycast	2xxx	are unicast addresses reserved or assigned to special functions
Special Addresses		reserved for special purposes like DHCP, Loopback etc.
No Broadcast anymore		replaced by multicasts, this is valid for layer 2 and layer 3

Address types

Unicast

• Global	2xxx	Blocks managed by RIPE NCC (Europe)
Range	2001:/16	Global unicast addresses (former public)
Reserved	2002:/16	6to4 address space
Reserved	3ffe:/16	old 6Bone address
• Local		
Link-Local	fe80:/64	former IPv4 169.254.0.0/16 APIPA
Local	fc00:/8	Centrally Assigned Unique Local Address (ULA-central)
	fd00:/8	Unique Local Address (ULA, not routed in the Internet, former IPv4 private)
Site-Local	fec0:/10	deprecated, do not use anymore

Address types

Multicast prefixes and scopes	ff00:: /8
- Interface-local Scope	ff01:: /64
- Link-local Scope	ff02:: /64
- Site-local Scope	ff05:: /64
- Global Scope	ff0e:: /64

Multicast hosts

::1	All nodes
::2	All routers
::3	unassigned
::4	DVMPR router
::5	OSPF IGP
::6	OSPF IGP DR
::7	ST router
::8	ST hosts
::9	All RIP routers
::a	All EIGRP routers
::b	All mobile agents
::c	SSDP
::d	All PIM router
::e	RSVP-encapsulation
::16	LLMNR
::101	NTP server
::1:1	Link name
::1:2	All DHCP relay agents
::1:3	DNS & LLMNR
::1:ffxx:xxxx	Solicited node multicast

Address types

Anycast

- These type of addresses can be used to reach certain functions which are assigned to different servers (i.e. Root Server)

- Anycast addresses are unicast and are routed to the nearest server

RIPE NCC Root Server	2001:7fd::1	193.0.14.129
VeriSign Root Server	2001:503:c27::2:30	192.58.128.30
6to4 Relay		192.88.99.1

Special Addresses

Unspecified	0:0:0:0:0:0:0:0/128 or ::/128 used as source address only
Loopback	::1/128 (former IPv4 127.0.0.1) local host or loopback address
Default Gateway	::/0 used as gateway of last resort

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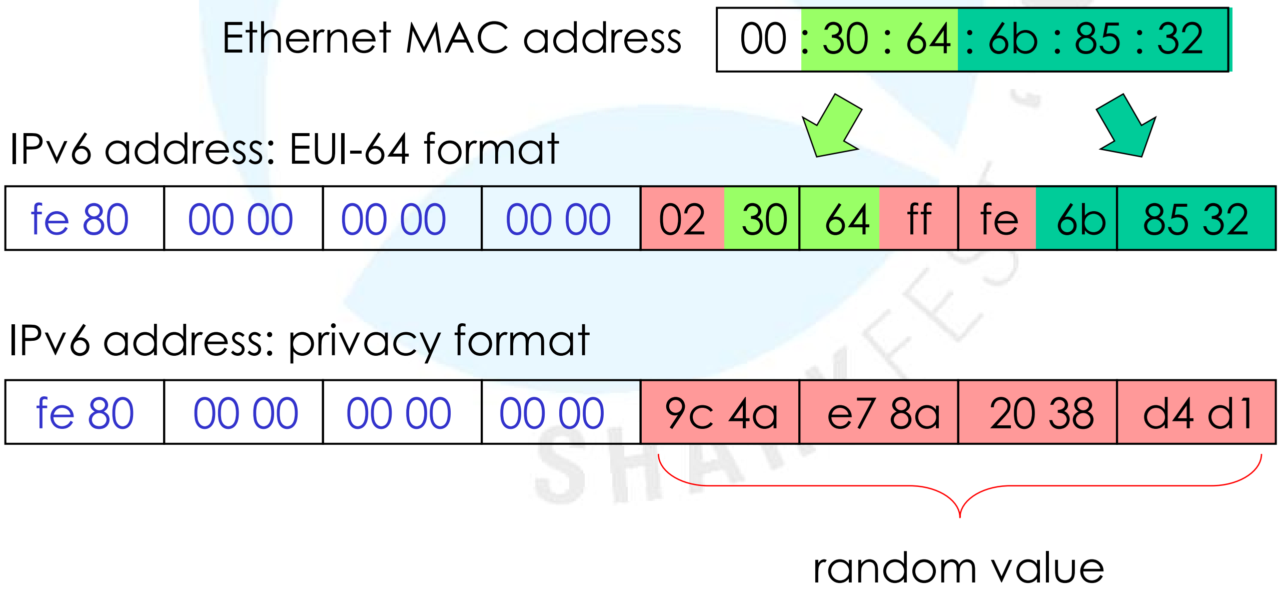
IPv6 Routing Protocols

Address Autoconfiguration

IPv6 Stateless Address Autoconfiguration (SLAAC)

- An IPv6 host will autoconfigure a link-local address for each interface
- Prefix for link-local address is fe80::/64
- Interface ID is either derived from MAC address or a random value



Ethernet MAC address

00 : 30 : 64 : 6b : 85 : 32

IPv6 address: EUI-64 format

fe 80	00 00	00 00	00 00	02	30	64	ff	fe	6b	85 32

IPv6 address: privacy format

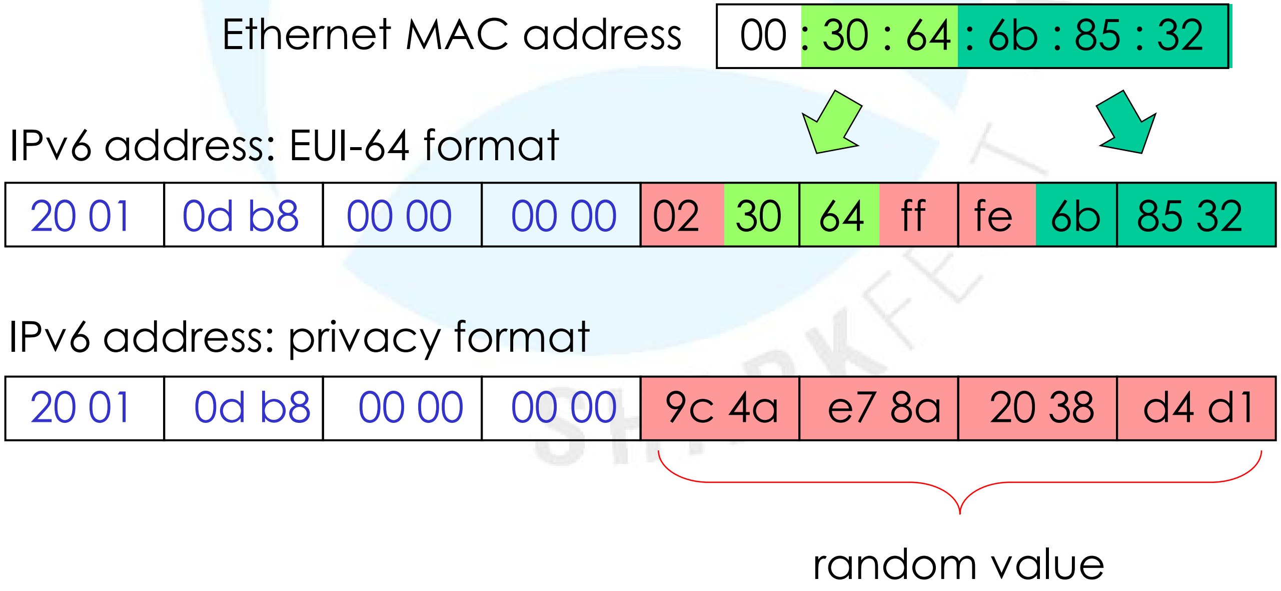
fe 80	00 00	00 00	00 00	9c 4a	e7 8a	20 38	d4 d1

random value

Address Autoconfiguration

IPv6 Stateless Address Autoconfiguration (SLAAC)

- If a router is present, host will also autoconfigure global address
- Prefix will be obtained from router, example 2001:db8::/64
- Interface ID is either derived from MAC address or a random value
- Router indicates in advertisement if stateful configuration may be used



Ethernet MAC address 00 : 30 : 64 : 6b : 85 : 32

IPv6 address: EUI-64 format

20 01	0d b8	00 00	00 00	02	30	64	ff	fe	6b	85 32

IPv6 address: privacy format

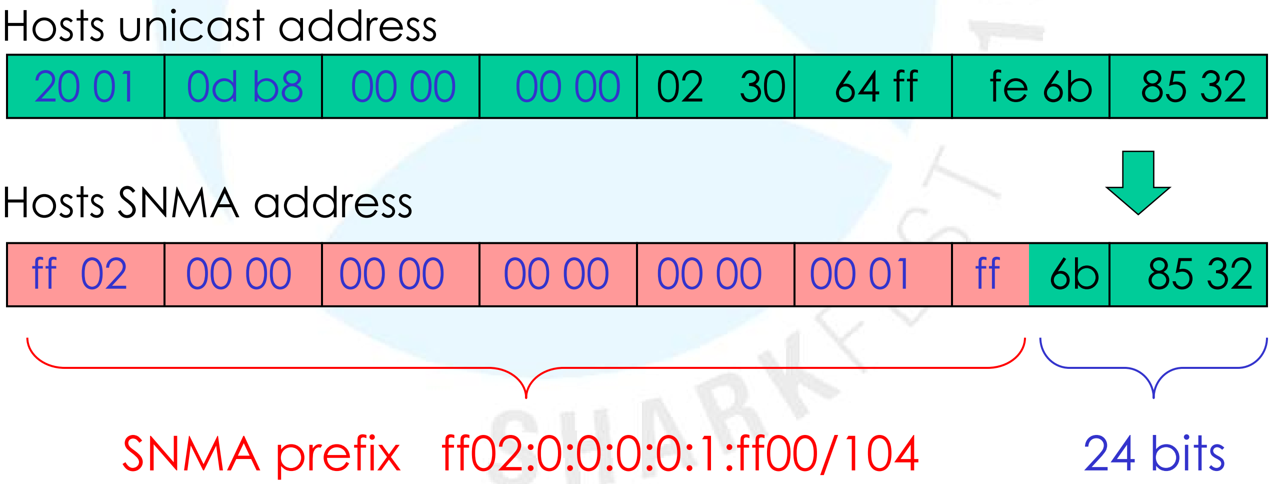
20 01	0d b8	00 00	00 00	9c 4a	e7 8a	20 38	d4 d1

random value

Address Autoconfiguration

Solicited Node Multicast Address (SNMA)

- Probably the most strange part of IPv6 addressing
- An IPv6 host forms a SNMA for each own unicast address in use
- The SNMA address is used for Neighbor Discovery (replacement of ARP)
- The SNMA address is derived from each unicast address in use



Hosts unicast address

20 01	0d b8	00 00	00 00	02 30	64 ff	fe 6b	85 32

Hosts SNMA address

ff 02	00 00	00 00	00 00	00 00	00 01	ff	6b	85 32

SNMA prefix ff02:0:0:0:0:1:ff00/104

24 bits

SNMA derived from unicast address: ff02::1:ff6b:8532

IPv6 Interfaces

- We have to get used, that a host has many IPv6 addresses
- Most hosts support Dual Stack Architecture for IPv4 and IPv6
- IPv6 is self-configuring, but it also allows manual configuration

IPv6 Client

```
C:\windows\system32>ipconfig /all
```

Physical interfaces:

- Ethernet interface
- Wireless LAN interface
- Bluetooth interface

Logical interfaces:

- Loopback pseudo-interface
- ISATAP tunneling interface
- TEREDO tunneling interface
- 6to4 interface

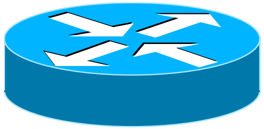
IPv6 Interfaces

- IPv6 hosts and router have the following addresses:

IPv6 Host

- Link-Local address for each interface
- SNMA for each own IPv6 address
- All-nodes multicast address
- Loopback address
- Assigned unicast address (if a router is present)
- Optional Multicast addresses of other groups

IPv6 Router

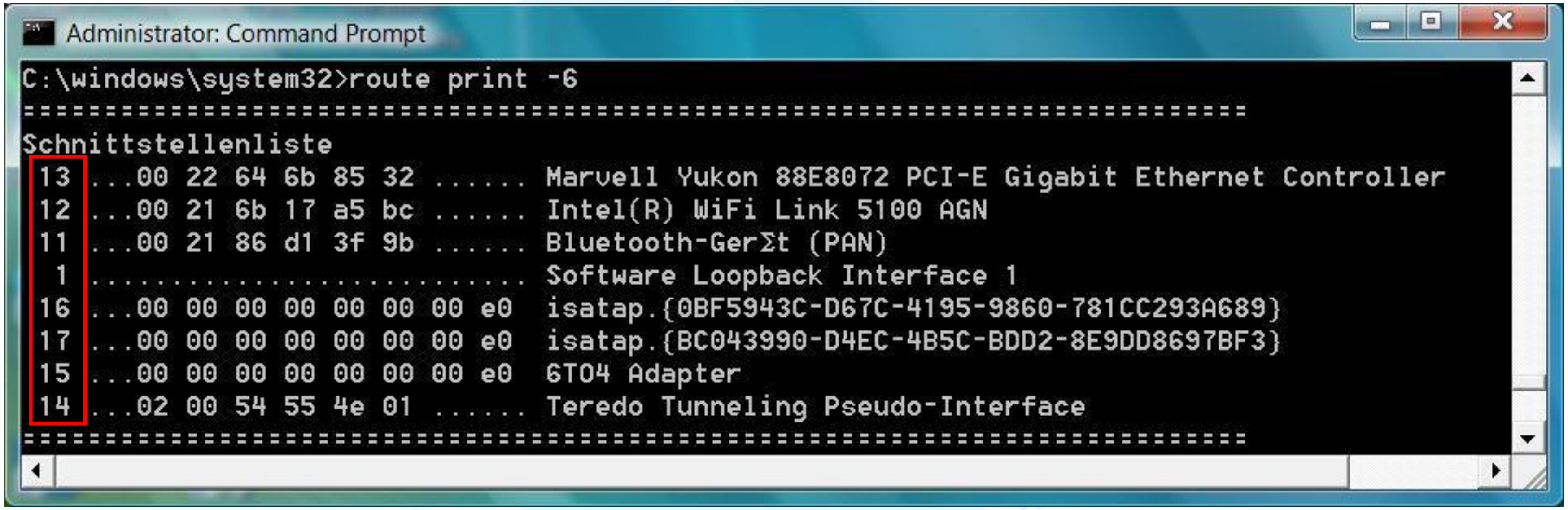


An IPv6 router has in addition:

- Subnet-router anycast address
- All-router multicast address
- Optional other anycast addresses
- Optional Multicast addresses of other groups

IPv6 Interfaces

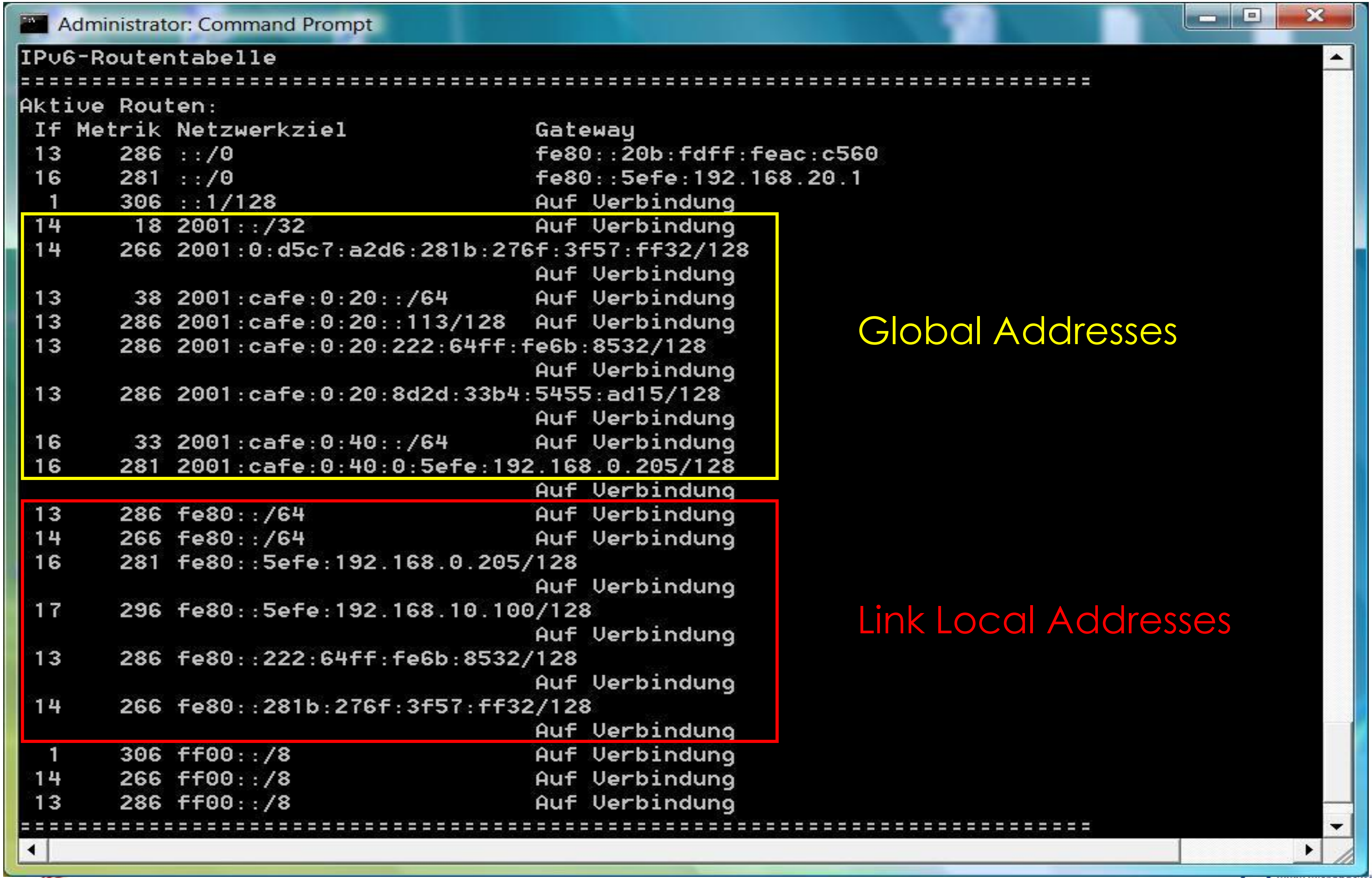
- In Windows Vista/7, each IPv6 interface is numbered with unique 'Zone ID'



```
C:\windows\system32>route print -6
===========================================================================
Schnittstellenliste
 13 ...00 22 64 6b 85 32 ...... Marvell Yukon 88E8072 PCI-E Gigabit Ethernet Controller
 12 ...00 21 6b 17 a5 bc ...... Intel(R) WiFi Link 5100 AGN
 11 ...00 21 86 d1 3f 9b ...... Bluetooth-GerΣt (PAN)
  1 ........................... Software Loopback Interface 1
 16 ...00 00 00 00 00 00 00 e0  isatap.{0BF5943C-D67C-4195-9860-781CC293A689}
 17 ...00 00 00 00 00 00 00 e0  isatap.{BC043990-D4EC-4B5C-BDD2-8E9DD8697BF3}
 15 ...00 00 00 00 00 00 00 e0  6TO4 Adapter
 14 ...02 00 54 55 4e 01 ...... Teredo Tunneling Pseudo-Interface
===========================================================================
```

- A link-local address is automatically configured with the address prefix fe80::/64 for each physical or logical IPv6 interface
- If a router is available, a global address is configured on interface

IPv6 Interfaces



```
IPv6-Routentabelle
===========================================================================
Aktive Routen:
 If Metrik Netzwerkziel             Gateway
 13    286 ::/0                     fe80::20b:fdff:feac:c560
 16    281 ::/0                     fe80::5efe:192.168.20.1
  1    306 ::1/128                  Auf Verbindung
 14     18 2001::/32                Auf Verbindung
 14    266 2001:0:d5c7:a2d6:281b:276f:3f57:ff32/128
                                    Auf Verbindung
 13     38 2001:cafe:0:20::/64      Auf Verbindung
 13    286 2001:cafe:0:20::113/128  Auf Verbindung
 13    286 2001:cafe:0:20:222:64ff:fe6b:8532/128
                                    Auf Verbindung
 13    286 2001:cafe:0:20:8d2d:33b4:5455:ad15/128
                                    Auf Verbindung
 16     33 2001:cafe:0:40::/64      Auf Verbindung
 16    281 2001:cafe:0:40:0:5efe:192.168.0.205/128
                                    Auf Verbindung
 13    286 fe80::/64                Auf Verbindung
 14    266 fe80::/64                Auf Verbindung
 16    281 fe80::5efe:192.168.0.205/128
                                    Auf Verbindung
 17    296 fe80::5efe:192.168.10.100/128
                                    Auf Verbindung
 13    286 fe80::222:64ff:fe6b:8532/128
                                    Auf Verbindung
 14    266 fe80::281b:276f:3f57:ff32/128
                                    Auf Verbindung
  1    306 ff00::/8                 Auf Verbindung
 14    266 ff00::/8                 Auf Verbindung
 13    286 ff00::/8                 Auf Verbindung
===========================================================================
```

Global Addresses

Link Local Addresses

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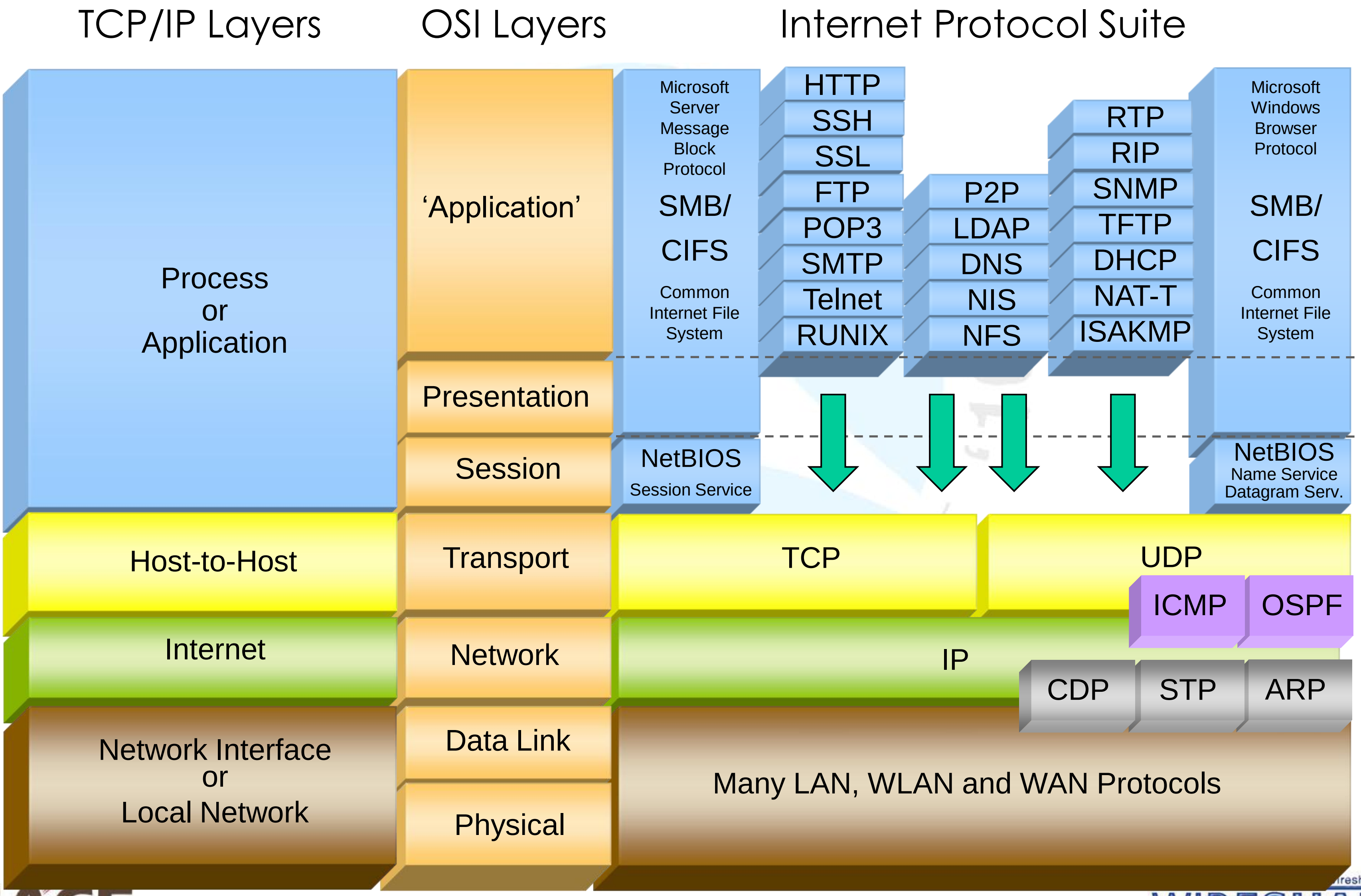
TCP/IP Protocols



TCP/IP Layers

OSI Layers

Internet Protocol Suite

Process
or
Application

'Application'

Microsoft
Server
Message
Block
Protocol

SMB/
CIFS

Common
Internet File
System

HTTP
SSH
SSL
FTP
POP3
SMTP
Telnet
RUNIX

P2P
LDAP
DNS
NIS
NFS

RTP
RIP
SNMP
TFTP
DHCP
NAT-T
ISAKMP

Microsoft
Windows
Browser
Protocol

SMB/
CIFS

Common
Internet File
System

Presentation

Session

NetBIOS
Session Service

NetBIOS
Name Service
Datagram Serv.

Host-to-Host

Transport

TCP

UDP

ICMP

OSPF

Internet

Network

IP

CDP

STP

ARP

Network Interface
or
Local Network

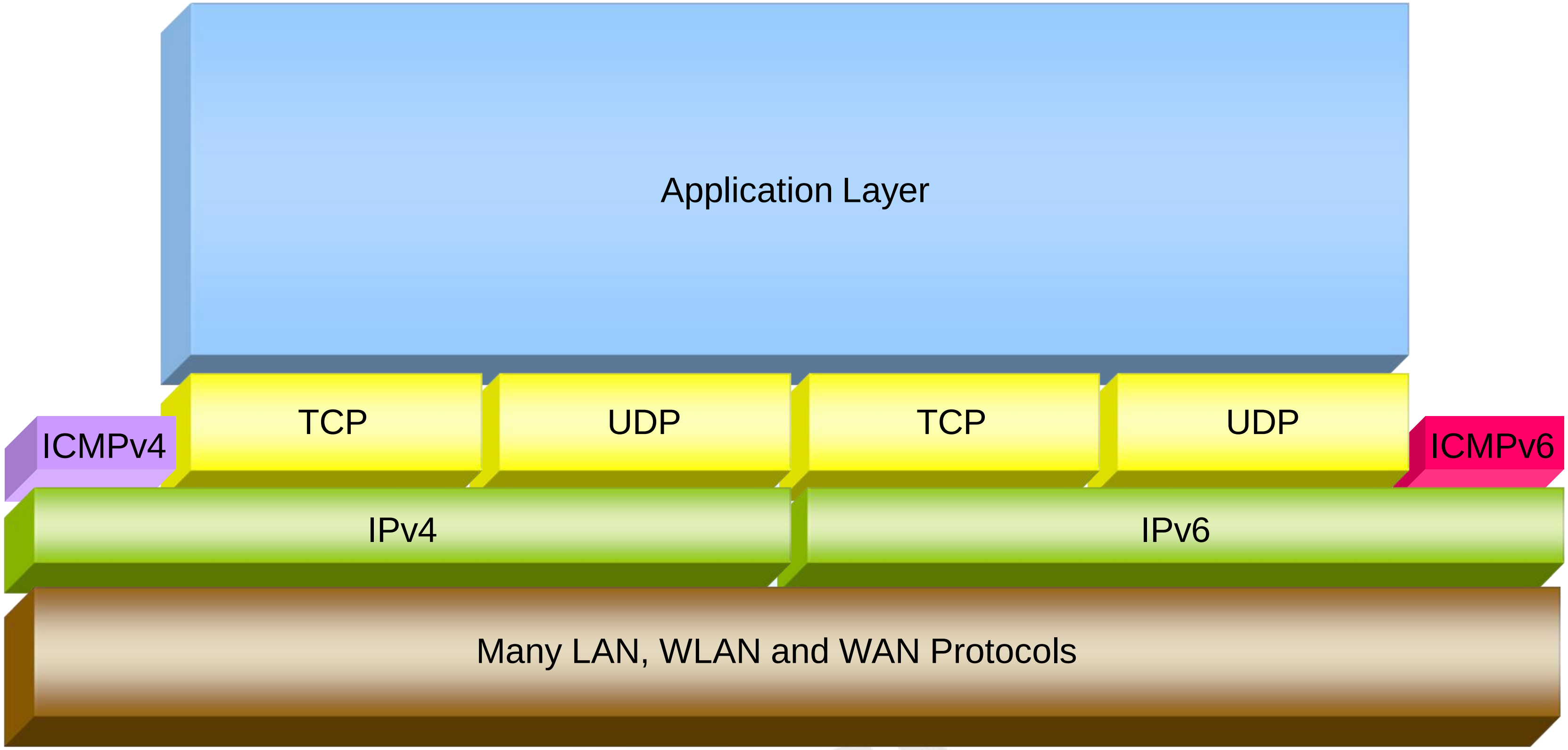
Data Link

Physical

Many LAN, WLAN and WAN Protocols

TCP/IP Protocols

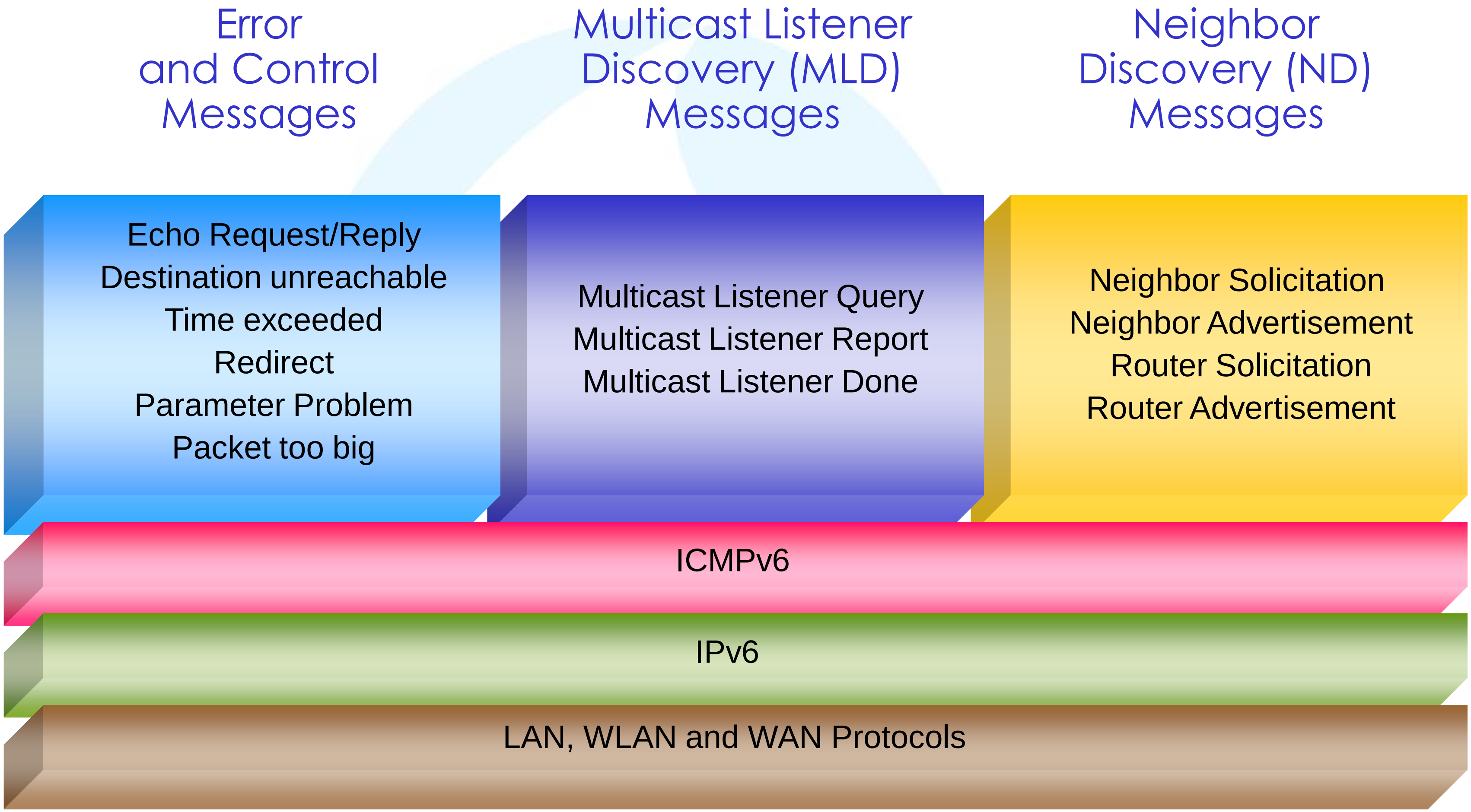
Dual stack implementation


Application Layer
ICMPv4
TCP
UDP
TCP
UDP
ICMPv6
IPv4
IPv6
Many LAN, WLAN and WAN Protocols

- Internet Control Message Protocol v6 (ICMPv6) plays an important role
- Many new ICMPv6 messages have been defined

SHARK

ICMPv6 Messages



Error and Control Messages

Multicast Listener Discovery (MLD) Messages

Neighbor Discovery (ND) Messages

Echo Request/Reply
Destination unreachable
Time exceeded
Redirect
Parameter Problem
Packet too big

Multicast Listener Query
Multicast Listener Report
Multicast Listener Done

Neighbor Solicitation
Neighbor Advertisement
Router Solicitation
Router Advertisement

ICMPv6

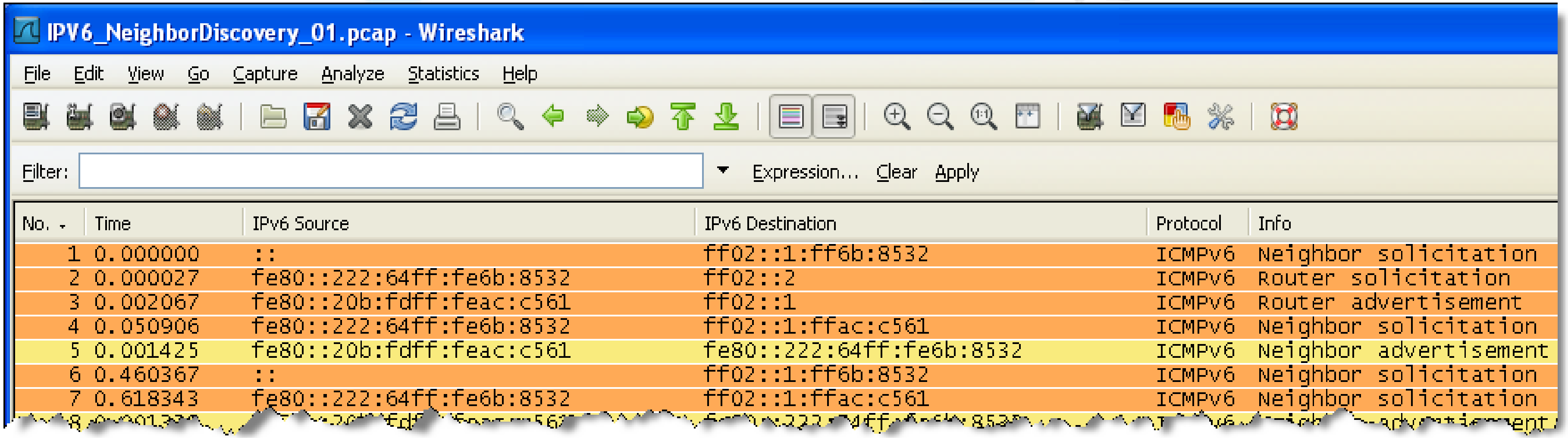
IPv6

LAN, WLAN and WAN Protocols

Neighbor Discovery (ND)

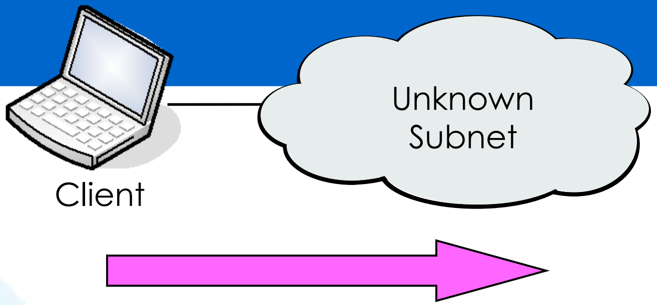
The initial client startup process includes the following steps:

Frame #	
1	Link-Local autoconfiguration and Duplicate Address Detection
2	Router Discovery
3	Prefix acquisition and global address autoconfiguration
4/5	Default router neighbor discovery
6	Duplicate Address Detection with acquired global address


IPV6_NeighborDiscovery_01.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply

No.	Time	IPv6 Source	IPv6 Destination	Protocol	Info
1	0.000000	::	ff02::1:ff6b:8532	ICMPv6	Neighbor solicitation
2	0.000027	fe80::222:64ff:fe6b:8532	ff02::2	ICMPv6	Router solicitation
3	0.002067	fe80::20b:fdff:feac:c561	ff02::1	ICMPv6	Router advertisement
4	0.050906	fe80::222:64ff:fe6b:8532	ff02::1:ffac:c561	ICMPv6	Neighbor solicitation
5	0.001425	fe80::20b:fdff:feac:c561	fe80::222:64ff:fe6b:8532	ICMPv6	Neighbor advertisement
6	0.460367	::	ff02::1:ff6b:8532	ICMPv6	Neighbor solicitation
7	0.618343	fe80::222:64ff:fe6b:8532	ff02::1:ffac:c561	ICMPv6	Neighbor solicitation

Neighbor Discovery (ND)



Duplicate Address Detection (DAD)

VISTA/7-Client
(random option = off)

`Physical Address (MAC)` `0022:6468:8532`
`Link Local Address` `fe80::222:64ff:fe68:8532`

`Solicited Node Multicast` `ff02::1:ff68:8532`

Neighbor Solicitation Message

Source	Destination
::	ff02::1:ff68:8532

Target fe80::222:64ff:fe6b:8532

VISTA/7-Client
(random option = on)

`Physical Address (MAC)` `0022:6468:8532`
`Link Local Address` `fe80::12d:d6a8:dd1c:b3b0`

`Solicited Node Multicast:` `ff02::1:ff1c:b3b0`

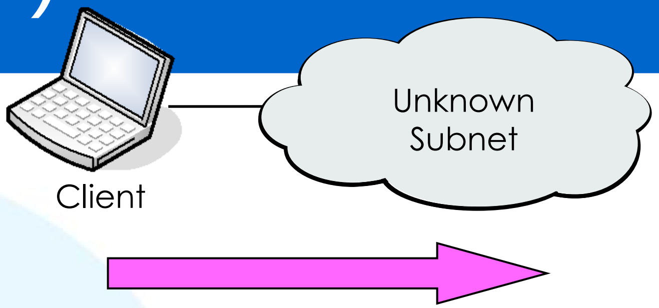
Neighbor Solicitation Message

Source	Destination
::	ff02::1:ff1c:b3b0

Target fe80::12d:d6a8:dd1c:b3b0

Neighbor Discovery (ND)

Router Solicitation



VISTA/7-Client
(random option = off)

MAC	0022:6468:8532
LLA	fe80::222:64ff:fe68:8532
SNMA	ff02::1:ff68:8532

Router Solicitation Message

Source	Destination
fe80::222:64ff:fe68:8532	ff02::2

Info: Link-layer address 00:22:64:6b:85:32

VISTA/7-Client
(random option = on)

MAC	0022:6468:8532
LLA	fe80::12d:d6a8:dd1c:b3b0
SNMA	ff02::1:ff1c:b3b0

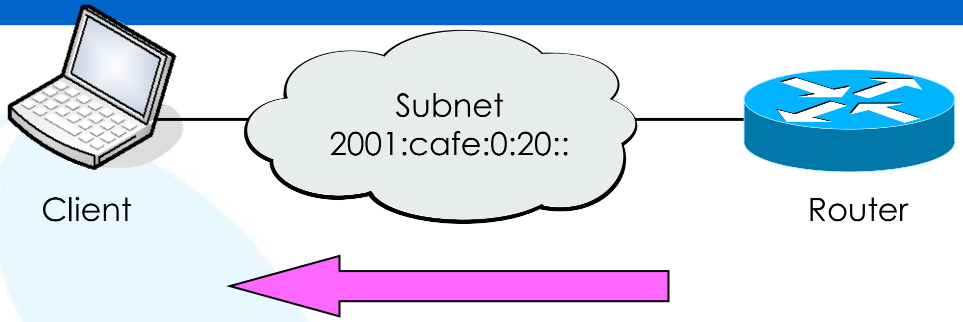
Router Solicitation Message

Source	Destination
fe80::12d:d6a8:dd1c:b3b0	ff02::2

Info: Link-layer address 00:22:64:6b:85:32

Neighbor Discovery (ND)

Router Advertisement



Router Configuration:

```
ipv6 unicast-routing

interface FastEthernet0/1
ipv6 address 2001:CAFE:0:20::/64 eui-64

MAC                          000b:fdac:c561

LLA               fe80::20b:fdff:feac:c561

Global Addresses
       2001:cafe:0:20:20b:fdff:feac:c561

SNMA                    ff02::1:ffac:c561
```

Router Advertisement Message

Source	Destination
fe80::20b:fdff:feac:c561	ff02::1

Info: Link-layer address 00:0b:fd:ac:c5:61

Info: Flags Not managed, Not other

Info: MTU size 1500 bytes

Info: Prefix length 64

Info: Prefix 2001:cafe:0:20::

Neighbor Discovery (ND)

Neighbor Solicitation

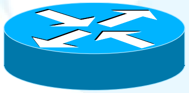
VISTA-Client
(random option = off)

MAC 0022:6468:8532

LLA fe80::222:64ff:fe68:8532

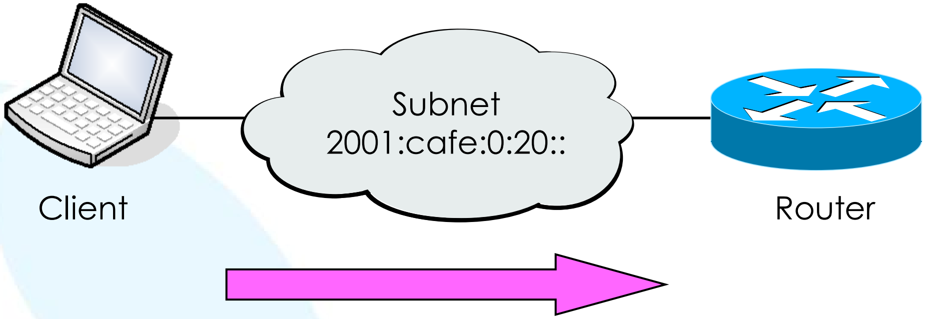
SNMA ff02::1:ff68:8532
Def.GW fe80::20b:fdff:feac:c561

Router Configuration:



MAC 000b:fdac:c561
LLA fe80::20b:fdff:feac:c561

SNMA ff02::1:ffac:c561



Neighbor Solicitation Message

Source	Destination
fe80::222:64ff:fe68:8532	ff02::1:ffac:c561

Info: Link-layer address 00:22:64:6b:85:32

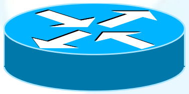
Neighbor Discovery (ND)

Neighbor Advertisement

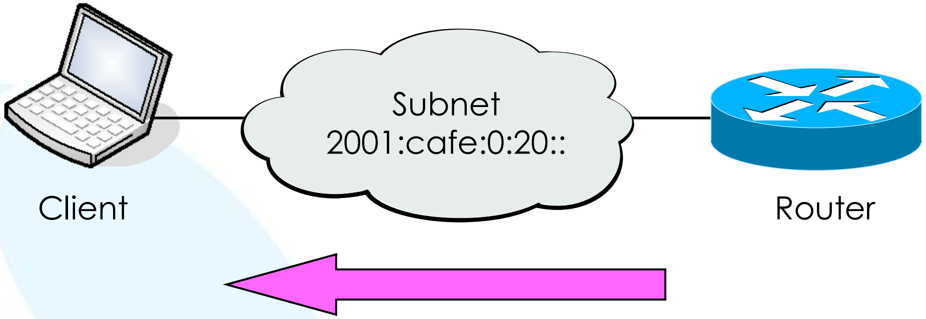
VISTA-Client
(random option = off)

MAC	0022:6468:8532
LLA	fe80::222:64ff:fe68:8532
SNMA	ff02::1:ff68:8532
Def.GW	fe80::20b:fdff:feac:c561

Router Configuration:



MAC	000b:fdac:c561
LLA	fe80::20b:fdff:feac:c561
SNMA	ff02::1:ffac:c561 ff02::1:ff00:1



Neighbor Advertisement Message

Source	Destination
fe80::20b:fdff:feac:c561	fe80::222:64ff:fe68:8532

Info: Target: fe80::20b:fdff:feac:c561

Info: Link-layer address 00:0b:fd:ac:c5:61

Neighbor Discovery (ND)

Duplicate Address Detection (DAD)

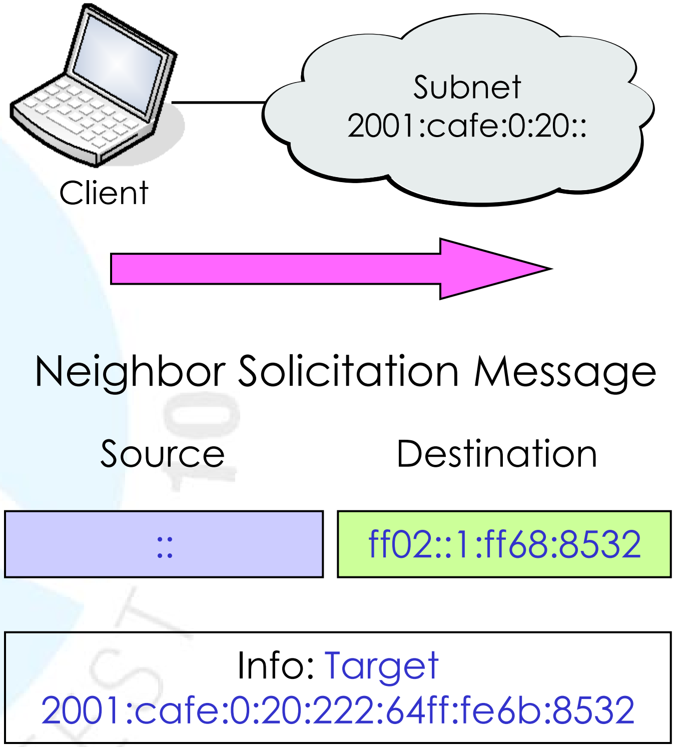
VISTA-Client
(random option = off)

```
Physical Address (MAC)          0022:6468:8532
Link Local Address   fe80::222:64ff:fe68:8532

Global Address
           2001:cafe:0:20:222:64ff:fe6b:8532

Solicited Node Multicast   ff02::1:ff68:8532

Standard Gateway     fe80::20b:fdff:feac:c561
```



Neighbor Solicitation Message

Source	Destination
::	ff02::1:ff68:8532

Info: Target
2001:cafe:0:20:222:64ff:fe6b:8532

- At this state, the client is configured with Link Local Address, Global Unicast Address, and Default Gateway and is ready to communicate.
- Client is still missing parameters like DNS, Domain Suffixes etc.

Session Agenda

Introduction

IPv6 Header & Extensions

Address format, notations & types

Address Autoconfiguration

Neighbor discovery, Router discovery

Host configuration with DHCPv6

New DNS AAAA record

Transition technologies, ISATAP, Teredo, 6to4

IPv6 Routing Protocols

Host configuration with DHCPv6

Despite Address Autoconfiguration, DHCP plays an important role in IPv6 environment. It is required to provide clients with additional parameters like DNS server address and many other options.

DHCPv6 offers different level of control over the workstations:

Client parameters	Stateless Auto Address Config. RFC2462	Stateless DHCP Service for IPv6 RFC3736	Stateful DHCPv6 RFC3315
Subnet Prefix & Mask	From Router Advertisements (O-Flag=0 M-Flag=0)	From Router Advertisements (O-Flag=1 / M-Flag=0)	From Router Advertisements (O-Flag=1 / M-Flag=1)
Interface Identifier	Auto Configuration	Auto Configuration	From DHCPv6 Server
DNS, NTP address etc.	Manual Configuration	From DHCPv6 Server	From DHCPv6 Server

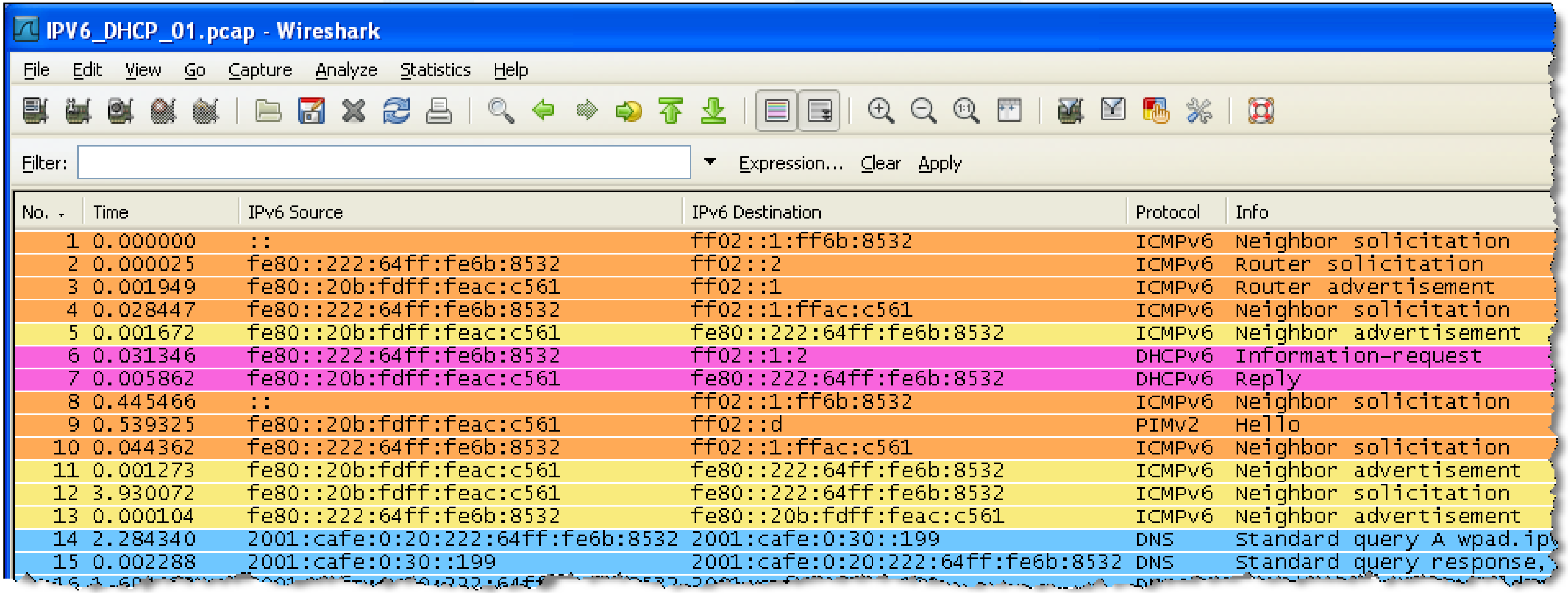
O = Other Flag / M = Managed Flag

Host configuration with DHCPv6

During this phase, the client is supplied with additional parameters:

Frame #

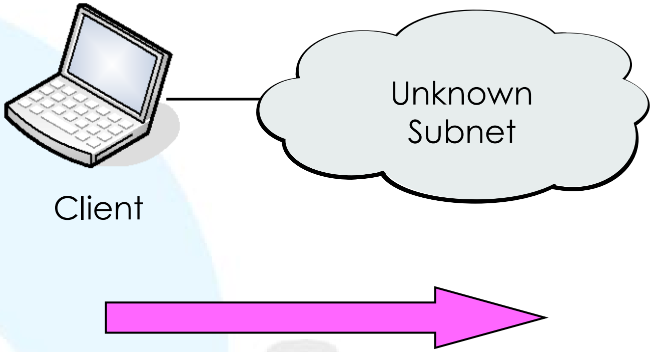
- 2 Router Discovery
- 3 Router Advertisement with ‘Other Flag’ set
- 6 Client contacts DHCP server
- 7 DHCP server delivers additional parameter like DNS, suffixes etc.


IPV6_DHCP_01.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply

No.	Time	IPv6 Source	IPv6 Destination	Protocol	Info
1	0.000000	::	ff02::1:ff6b:8532	ICMPv6	Neighbor solicitation
2	0.000025	fe80::222:64ff:fe6b:8532	ff02::2	ICMPv6	Router solicitation
3	0.001949	fe80::20b:fdff:feac:c561	ff02::1	ICMPv6	Router advertisement
4	0.028447	fe80::222:64ff:fe6b:8532	ff02::1:ffac:c561	ICMPv6	Neighbor solicitation
5	0.001672	fe80::20b:fdff:feac:c561	fe80::222:64ff:fe6b:8532	ICMPv6	Neighbor advertisement
6	0.031346	fe80::222:64ff:fe6b:8532	ff02::1:2	DHCPv6	Information-request
7	0.005862	fe80::20b:fdff:feac:c561	fe80::222:64ff:fe6b:8532	DHCPv6	Reply
8	0.445466	::	ff02::1:ff6b:8532	ICMPv6	Neighbor solicitation
9	0.539325	fe80::20b:fdff:feac:c561	ff02::d	PIMv2	Hello
10	0.044362	fe80::222:64ff:fe6b:8532	ff02::1:ffac:c561	ICMPv6	Neighbor solicitation
11	0.001273	fe80::20b:fdff:feac:c561	fe80::222:64ff:fe6b:8532	ICMPv6	Neighbor advertisement
12	3.930072	fe80::20b:fdff:feac:c561	fe80::222:64ff:fe6b:8532	ICMPv6	Neighbor solicitation
13	0.000104	fe80::222:64ff:fe6b:8532	fe80::20b:fdff:feac:c561	ICMPv6	Neighbor advertisement
14	2.284340	2001:cafe:0:20:222:64ff:fe6b:8532	2001:cafe:0:30::199	DNS	Standard query A wpad.ip
15	0.002288	2001:cafe:0:30::199	2001:cafe:0:20:222:64ff:fe6b:8532	DNS	Standard query response,

Host configuration with DHCPv6

Router Solicitation



VISTA-Client
(random option = off)

MAC 0022:6468:8532

LLA fe80::222:64ff:fe68:8532

SSNMA ff02::1:ff68:8532

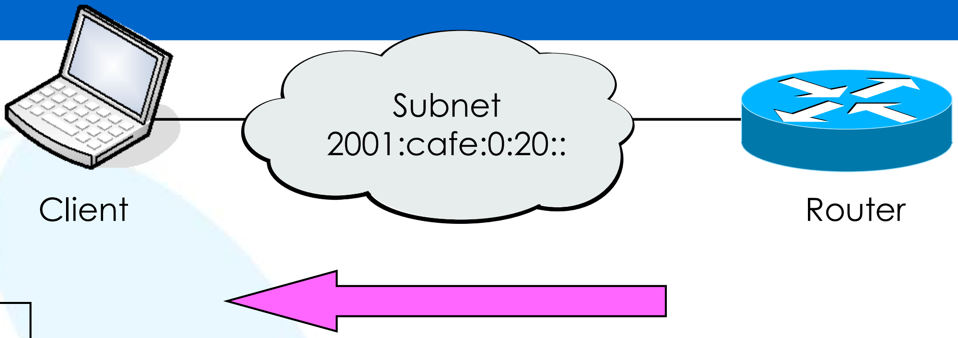
Router Solicitation Message

Source	Destination
fe80::222:64ff:fe68:8532	ff02::2

Info: Link-layer address 00:22:64:6b:85:32

Host configuration with DHCPv6

Router Advertisement



Router Configuration:

```
ipv6 unicast-routing

interface FastEthernet0/1
 ipv6 address 2001:CAFE:0:20::/64 eui-64
 ipv6 nd other-config-flag
 ipv6 dhcp relay destination
                    2001:CAFE:0:30::199

MAC                        000b:fdac:c561

LLA               fe80::20b:fdff:feac:c561

Global Addresses
       2001:cafe:0:20:20b:fdff:feac:c561

SNMA                    ff02::1:ffac:c561
```

Router Advertisement Message

Source	Destination
fe80::20b:fdff:feac:c561	ff02::1

Info: Link-layer address 00:0b:fd:ac:c5:61

Info: Flags Not managed, other

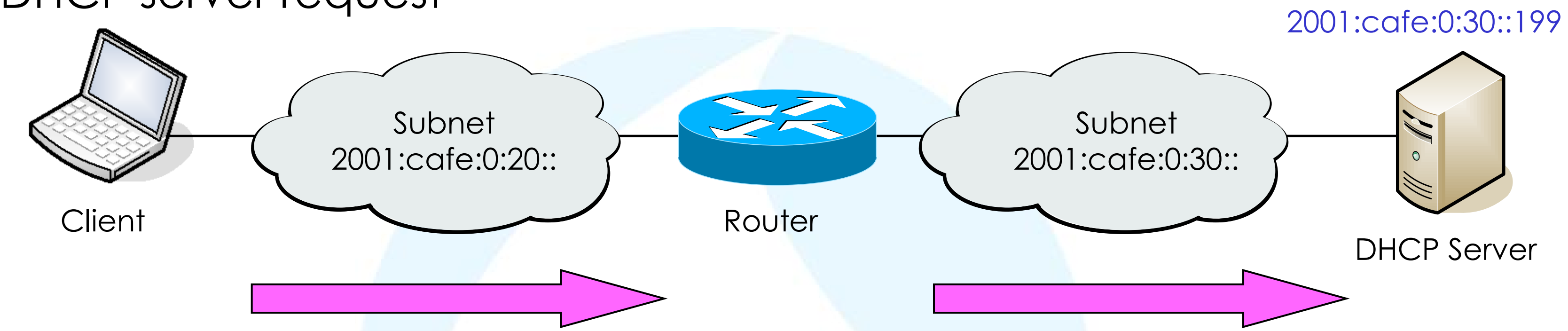
Info: MTU size 1500 bytes

Info: Prefix length 64

Info: Prefix 2001:cafe:0:20::

Host configuration with DHCPv6

DHCP server request



2001:cafe:0:30::199

Subnet
2001:cafe:0:20::

Subnet
2001:cafe:0:30::

Client

Router

DHCP Server

DHCP Information-request

DHCP Relay-forward

Source	Destination
fe80::222:64ff:fe68:8532	ff02::1:2

Info: Link-layer address 00:22:64:6b:85:32

Info: Vendor-class-data

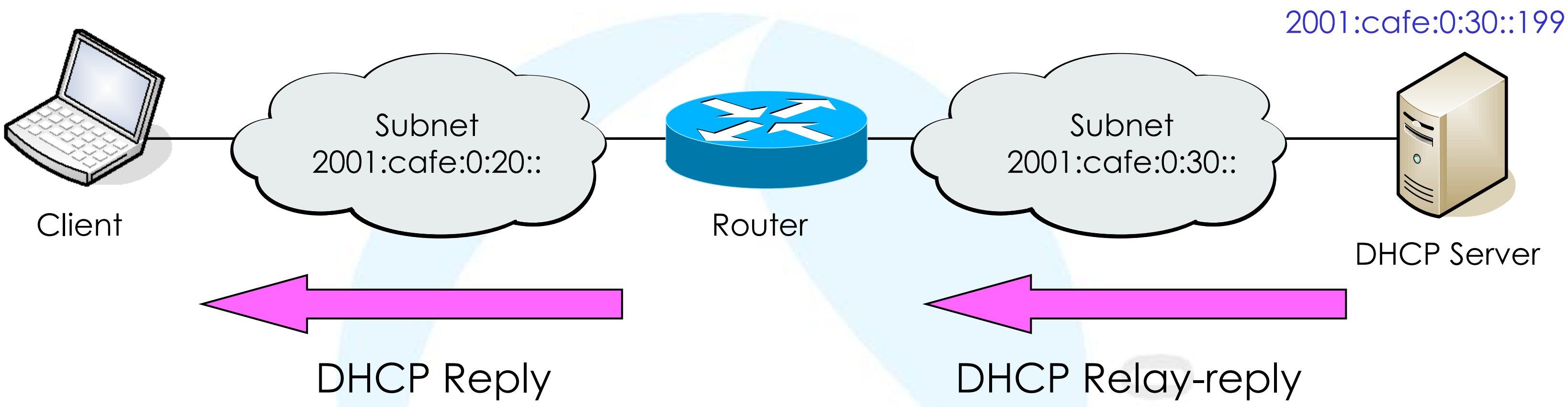
Option Request: Domain Search List

Option Request: DNS recursive name server

Option Request: Vendor-specific Information

Host configuration with DHCPv6

DHCP server reply


2001:cafe:0:30::199
Client
Subnet
2001:cafe:0:20::
Router
Subnet
2001:cafe:0:30::
DHCP Server
DHCP Reply
DHCP Relay-reply

Source	Destination
fe80::20b:fdff:feac:c561	fe80::222:64ff:fe68:8532

Client ID Link-layer address 00:22:64:6b:85:32

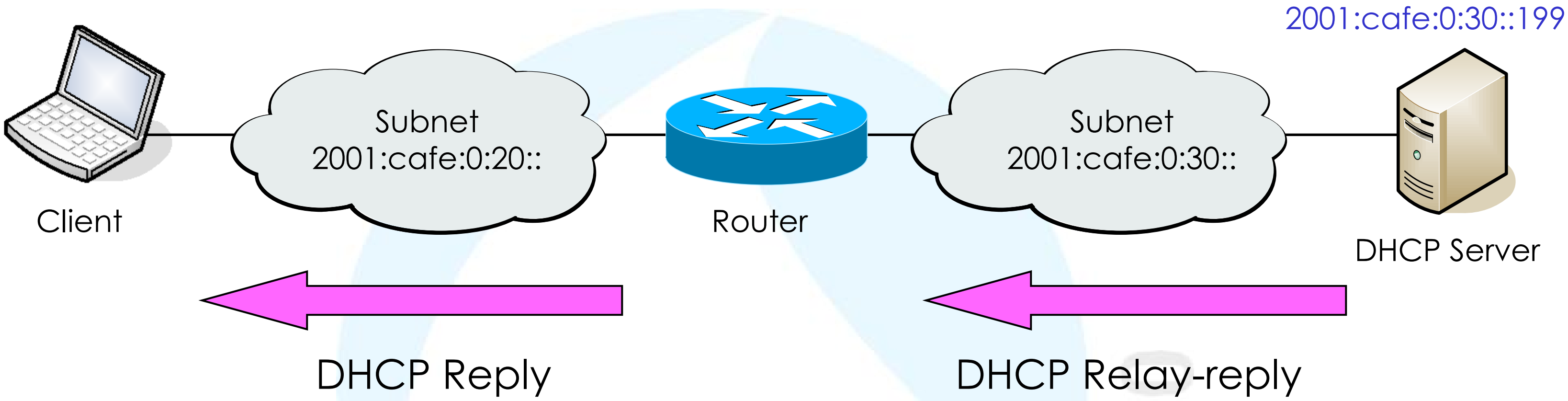
Option Domain Search List
yourdomain.ch ipv6.ch dummy.ch

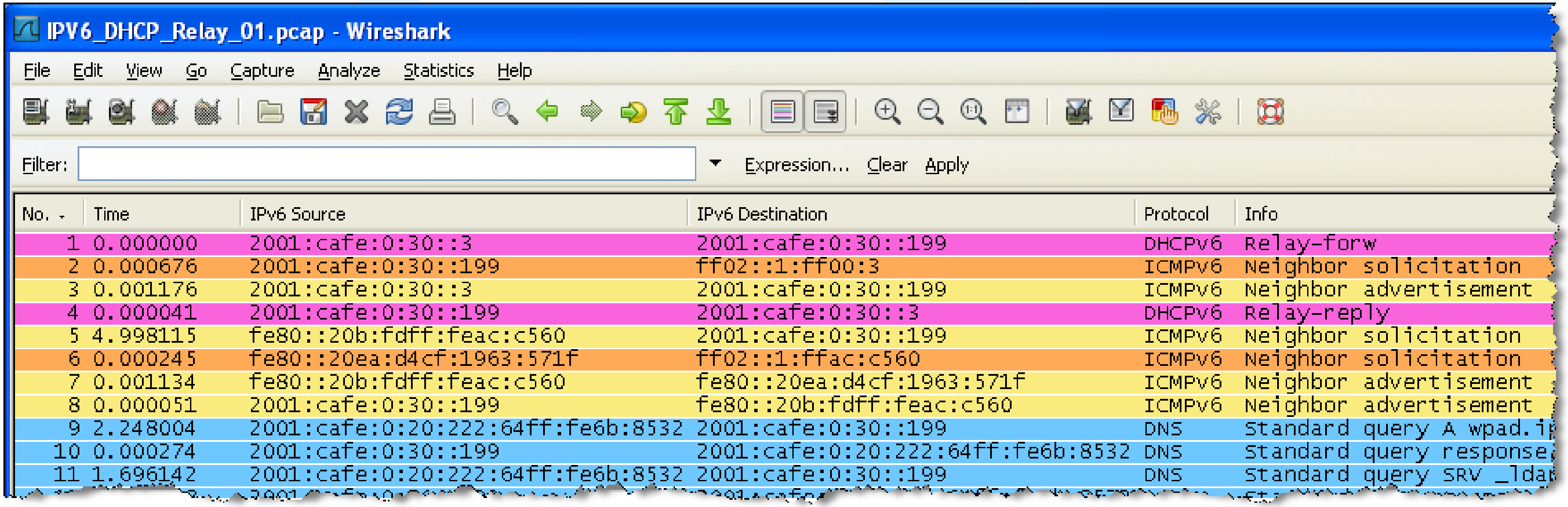
Option DNS server address 2001:cafe:0:30::199

Server ID Link-layer address: 00:0d:60:b0:38:63

Host configuration with DHCPv6

DHCP server reply


2001:cafe:0:30::199
Client
Subnet
2001:cafe:0:20::
Router
Subnet
2001:cafe:0:30::
DHCP Server
DHCP Reply
DHCP Relay-reply


IPV6_DHCP_Relay_01.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply

```
No. .  Time      IPv6 Source                    IPv6 Destination               Protocol Info
    1 0.000000  2001:cafe:0:30::3              2001:cafe:0:30::199            DHCPv6   Relay-forw
    2 0.000676  2001:cafe:0:30::199            ff02::1:ff00:3                 ICMPv6   Neighbor solicitation
    3 0.001176  2001:cafe:0:30::3              2001:cafe:0:30::199            ICMPv6   Neighbor advertisement
    4 0.000041  2001:cafe:0:30::199            2001:cafe:0:30::3              DHCPv6   Relay-reply
    5 4.998115  fe80::20b:fdff:feac:c560       2001:cafe:0:30::199            ICMPv6   Neighbor solicitation
    6 0.000245  fe80::20ea:d4cf:1963:571f      ff02::1:ffac:c560              ICMPv6   Neighbor solicitation
    7 0.001134  fe80::20b:fdff:feac:c560       fe80::20ea:d4cf:1963:571f      ICMPv6   Neighbor advertisement
    8 0.000051  2001:cafe:0:30::199            fe80::20b:fdff:feac:c560       ICMPv6   Neighbor advertisement
    9 2.248004  2001:cafe:0:20:222:64ff:fe6b:8532 2001:cafe:0:30::199         DNS      Standard query A wpad.i
   10 0.000274  2001:cafe:0:30::199            2001:cafe:0:20:222:64ff:fe6b:8532 DNS   Standard query response
   11 1.696142  2001:cafe:0:20:222:64ff:fe6b:8532 2001:cafe:0:30::199         DNS      Standard query SRV _lda
```

Host configuration with DHCPv6

At this state, the client is configured with all required parameters:

```
C:\windows\system32>ipconfig /all

Ethernet-Adapter LAN-Verbindung:

   Verbindungsspezifisches DNS-Suffix: ipv6.ch
   Beschreibung. . . . . . . . . . . : Marvell Yukon 88E8072 PCI-E Gigabit Ethernet
   Physikalische Adresse . . . . . . : 00-22-64-6B-85-32
   DHCP aktiviert. . . . . . . . . . : Ja
   Autokonfiguration aktiviert . . . : Ja
   IPv6-Adresse. . . . . . . . . . . : 2001:cafe:0:20:222:64ff:fe6b:8532(Bevorzugt)
   Verbindungslokale IPv6-Adresse  . : fe80::222:64ff:fe6b:8532%13(Bevorzugt)
   Lease erhalten. . . . . . . . . . : Samstag, 21. Februar 2009 11:46:04
   Lease läuft ab. . . . . . . . . . : Sonntag, 1. März 2009 11:46:03
   Standardgateway . . . . . . . . . : fe80::20b:fdff:feac:c561%13
   DHCPv6-IAID . . . . . . . . . . . : 251667044
   DHCPv6-Client-DUID. . . . . . . . : 00-01-00-01-10-D2-B9-65-00-22-64-6B-85-32
   DNS-Server  . . . . . . . . . . . : 2001:cafe:0:30::199
   Suchliste für verbindungsspezifische DNS-Suffixe:
                                       yourdomain.ch
                                       ipv6.ch
                                       dummy.ch
```

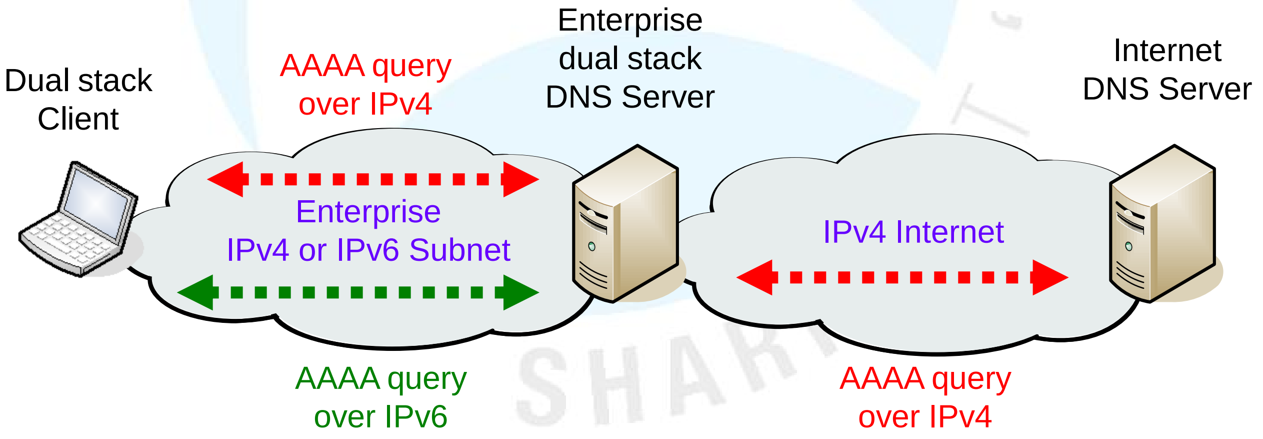
Session Agenda

- Introduction
- IPv6 Header & Extensions
- Address format, notations & types
- Address Autoconfiguration
- Neighbor discovery, Router discovery
- Host configuration with DHCPv6
- New DNS AAAA record
- Transition technologies, ISATAP, Teredo, 6to4
- IPv6 Routing Protocols

IPv6 Domain Name System (DNS)

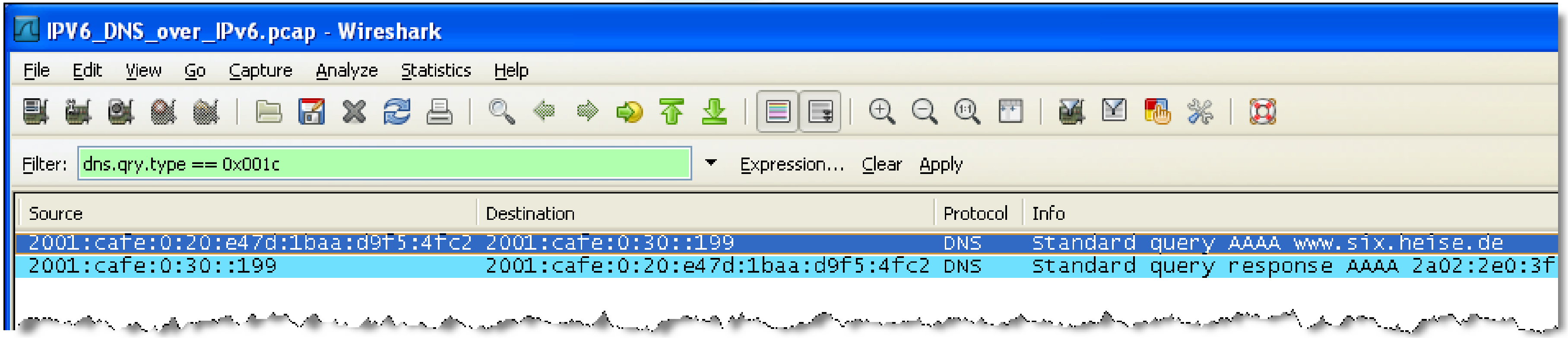
New AAAA resource record

- Due to the unhandy IPv6 address, DNS plays an important role in IPv6
- A new resource record type AAAA (called quad-A) has been defined
- During migration, DNS servers will support dual stack IPv4/IPv6
- IPv6 record queries and response may be transmitted over IPv4 or IPv6


Dual stack
Client
AAAA query
over IPv4
Enterprise
dual stack
DNS Server
Internet
DNS Server
Enterprise
IPv4 or IPv6 Subnet
IPv4 Internet
AAAA query
over IPv6
AAAA query
over IPv4

IPv6 Domain Name System (DNS)

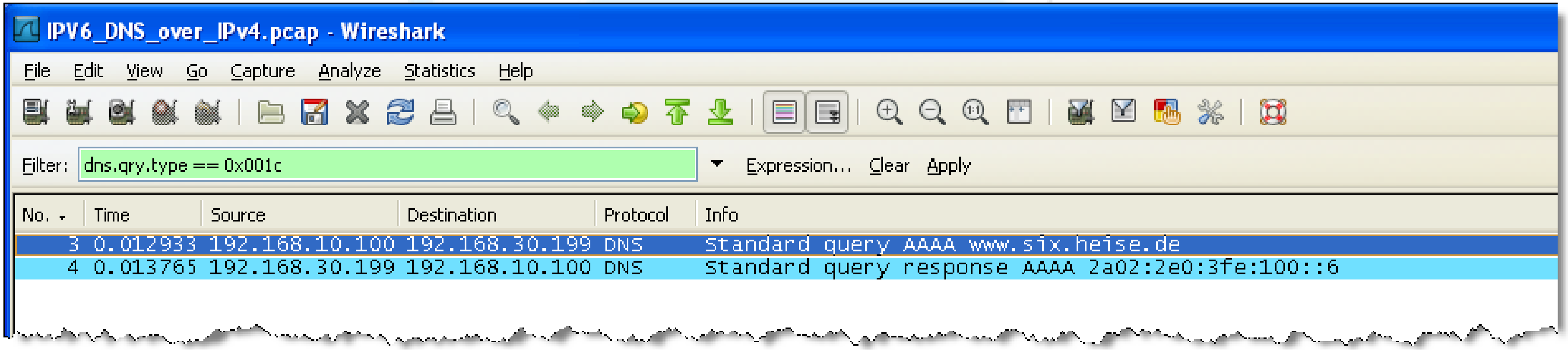
- AAAA record query & response over IPv6


IPV6_DNS_over_IPv6.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Expression... Clear Apply

Filter: dns.qry.type == 0x001c

```
Source                          Destination                     Protocol Info
2001:cafe:0:20:e47d:1baa:d9f5:4fc2 2001:cafe:0:30::199          DNS      Standard query AAAA www.six.heise.de
2001:cafe:0:30::199             2001:cafe:0:20:e47d:1baa:d9f5:4fc2 DNS   Standard query response AAAA 2a02:2e0:3f
```

- AAAA record query & response over IPv4


IPV6_DNS_over_IPv4.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Expression... Clear Apply

Filter: dns.qry.type == 0x001c

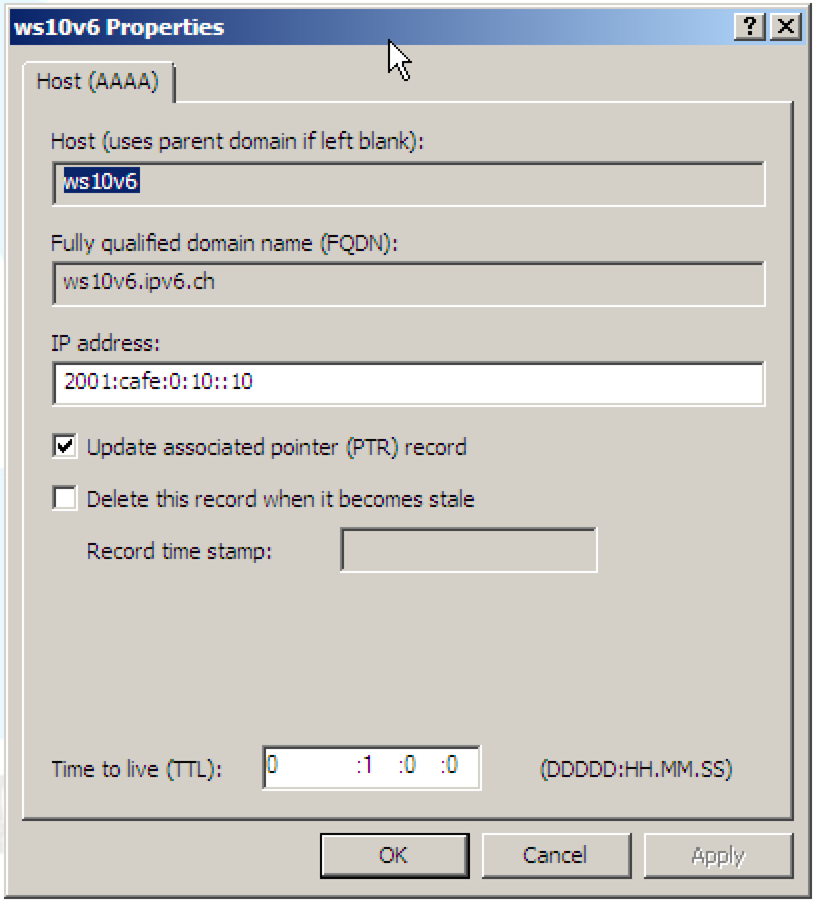
```
No. - Time     Source         Destination    Protocol Info
  3 0.012933 192.168.10.100 192.168.30.199 DNS      Standard query AAAA www.six.heise.de
  4 0.013765 192.168.30.199 192.168.10.100 DNS      Standard query response AAAA 2a02:2e0:3fe:100::6
```

IPv6 Domain Name System (DNS)

New AAAA resource record

- Create AAAA record by entering host name and IPv6 address

- Pointer record will be created automatically if selected →



ws10v6 Properties

Host (uses parent domain if left blank): ws10v6

Fully qualified domain name (FQDN): ws10v6.ipv6.ch

IP address: 2001:cafe:0:10::10

☑ Update associated pointer (PTR) record

☐ Delete this record when it becomes stale

Record time stamp:

Time to live (TTL): 0 :1 :0 :0 (DDDDD:HH.MM.SS)

Session Agenda

- Introduction
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- New DNS AAAA record
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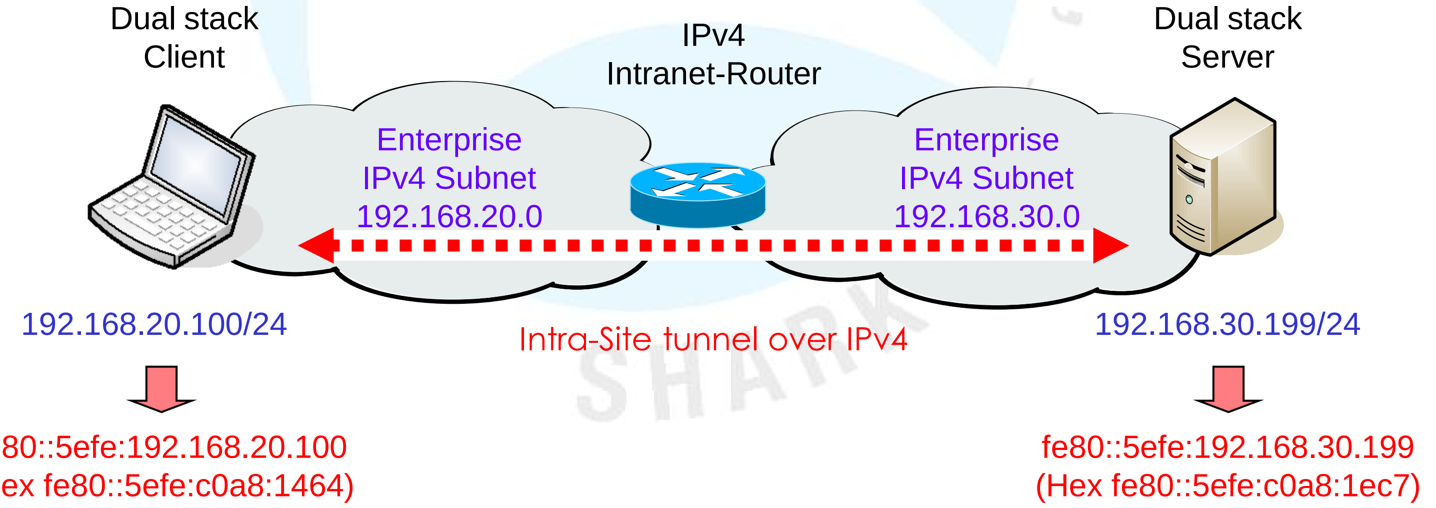
- IPv6 Routing Protocols

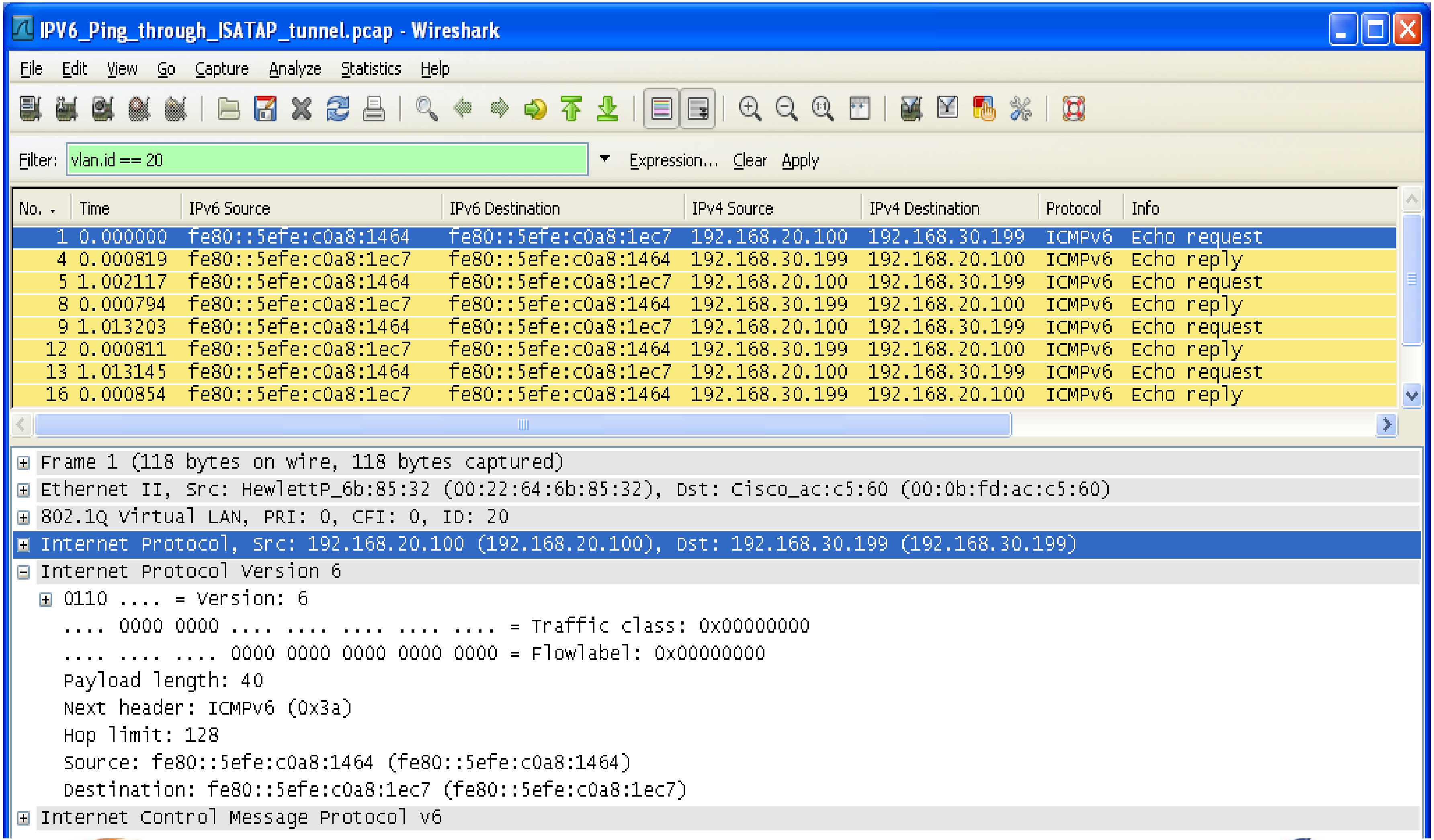
IPv6 Transition Technologies

ISATAP (Intra-Site Automatic Tunnel Addressing Protocol)

- ISATAP enables easy deployment of IPv6 in existing IPv4 infrastructure
- ISATAP hosts do not require any manual configuration
- IPv6 address contains an embedded IPv4 source or destination address
- ISATAP clients uses locally assigned IPv4 address (public or private) to create the 64-bit interface identifier


Dual stack Client
IPv4 Intranet-Router
Dual stack Server
Enterprise IPv4 Subnet 192.168.20.0
Enterprise IPv4 Subnet 192.168.30.0
192.168.20.100/24
Intra-Site tunnel over IPv4
192.168.30.199/24
fe80::5efe:192.168.20.100
(Hex fe80::5efe:c0a8:1464)
fe80::5efe:192.168.30.199
(Hex fe80::5efe:c0a8:1ec7)

IPv6 Transition Technologies



IPV6_Ping_through_ISATAP_tunnel.pcap - Wireshark

Filter: vlan.id == 20

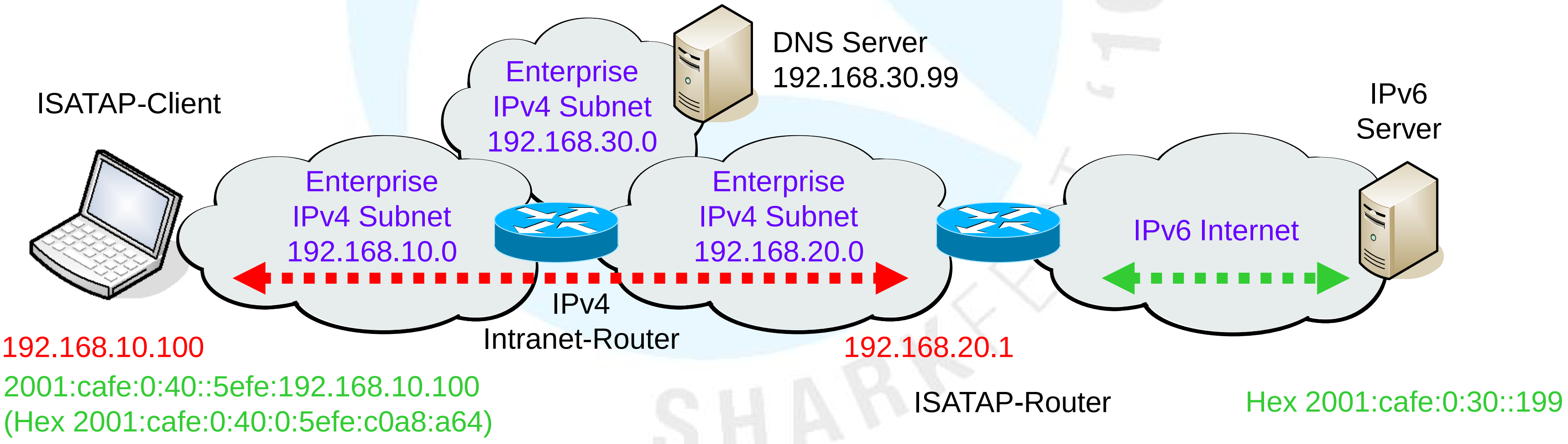
```
No. .  Time      IPv6 Source              IPv6 Destination         IPv4 Source     IPv4 Destination  Protocol  Info
     1 0.000000  fe80::5efe:c0a8:1464     fe80::5efe:c0a8:1ec7     192.168.20.100  192.168.30.199    ICMPv6    Echo request
     4 0.000819  fe80::5efe:c0a8:1ec7     fe80::5efe:c0a8:1464     192.168.30.199  192.168.20.100    ICMPv6    Echo reply
     5 1.002117  fe80::5efe:c0a8:1464     fe80::5efe:c0a8:1ec7     192.168.20.100  192.168.30.199    ICMPv6    Echo request
     8 0.000794  fe80::5efe:c0a8:1ec7     fe80::5efe:c0a8:1464     192.168.30.199  192.168.20.100    ICMPv6    Echo reply
     9 1.013203  fe80::5efe:c0a8:1464     fe80::5efe:c0a8:1ec7     192.168.20.100  192.168.30.199    ICMPv6    Echo request
    12 0.000811  fe80::5efe:c0a8:1ec7     fe80::5efe:c0a8:1464     192.168.30.199  192.168.20.100    ICMPv6    Echo reply
    13 1.013145  fe80::5efe:c0a8:1464     fe80::5efe:c0a8:1ec7     192.168.20.100  192.168.30.199    ICMPv6    Echo request
    16 0.000854  fe80::5efe:c0a8:1ec7     fe80::5efe:c0a8:1464     192.168.30.199  192.168.20.100    ICMPv6    Echo reply
```

```
⊞ Frame 1 (118 bytes on wire, 118 bytes captured)
⊞ Ethernet II, Src: HewlettP_6b:85:32 (00:22:64:6b:85:32), Dst: Cisco_ac:c5:60 (00:0b:fd:ac:c5:60)
⊞ 802.1Q Virtual LAN, PRI: 0, CFI: 0, ID: 20
⊞ Internet Protocol, Src: 192.168.20.100 (192.168.20.100), Dst: 192.168.30.199 (192.168.30.199)
⊟ Internet Protocol Version 6
   ⊞ 0110 .... = Version: 6
     .... 0000 0000 .... .... .... .... .... = Traffic class: 0x00000000
     .... .... .... 0000 0000 0000 0000 0000 = Flowlabel: 0x00000000
     Payload length: 40
     Next header: ICMPv6 (0x3a)
     Hop limit: 128
     Source: fe80::5efe:c0a8:1464 (fe80::5efe:c0a8:1464)
     Destination: fe80::5efe:c0a8:1ec7 (fe80::5efe:c0a8:1ec7)
⊞ Internet Control Message Protocol v6
```

IPv6 Transition Technologies

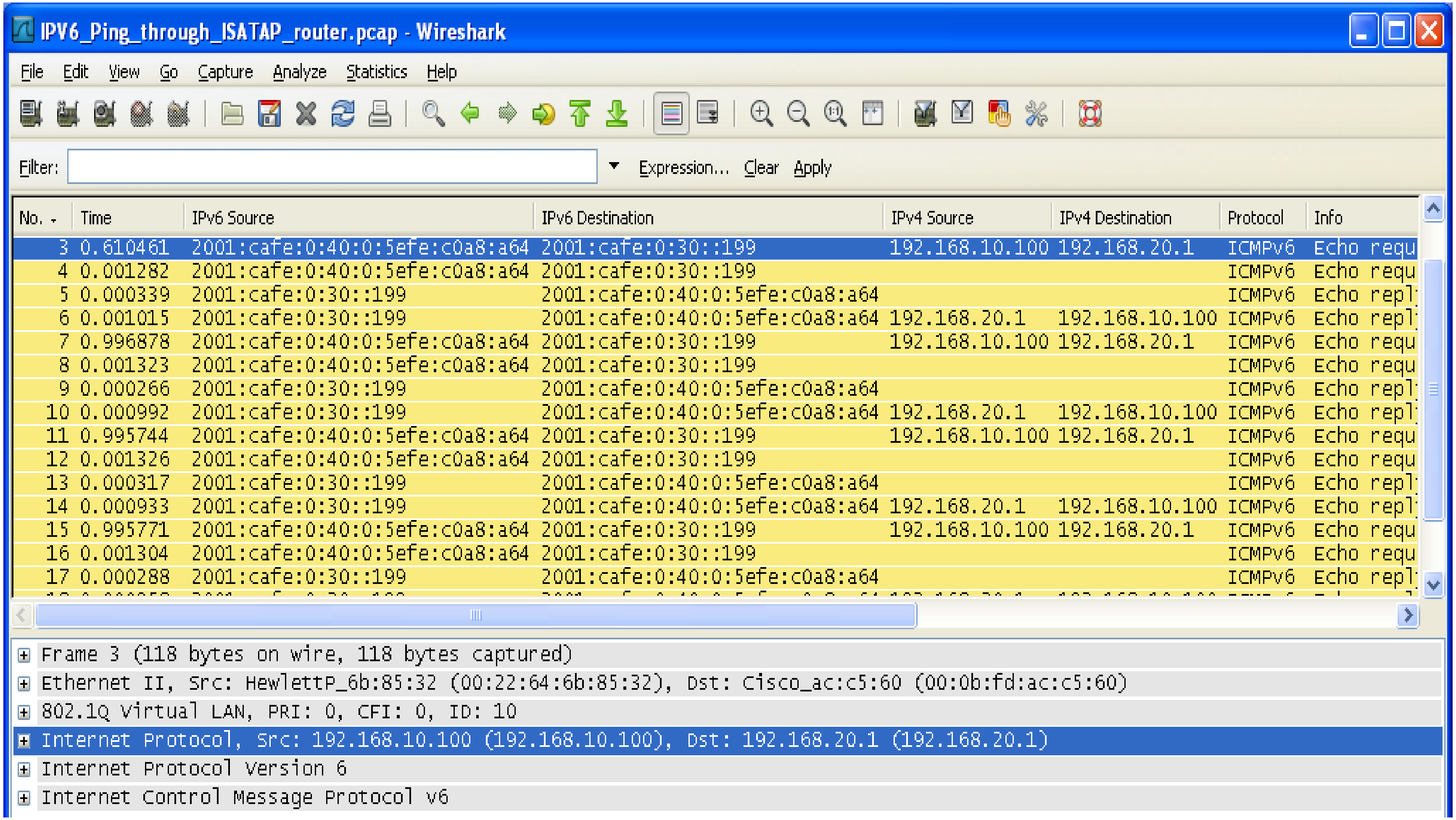
ISATAP (Intra-Site Automatic Tunnel Addressing Protocol)

- ISATAP can also be used to access native IPv6 destinations
- Client resolves ISATAP router IPv4 address through internal DNS
- Client request IPv6 global unicast prefix from ISATAP router
- Client sends IPv6 in IPv4 embedded packets to ISATAP router


ISATAP-Client
Enterprise IPv4 Subnet 192.168.30.0
DNS Server 192.168.30.99
IPv6 Server
Enterprise IPv4 Subnet 192.168.10.0
Enterprise IPv4 Subnet 192.168.20.0
IPv6 Internet
IPv4 Intranet-Router
192.168.10.100
2001:cafe:0:40::5efe:192.168.10.100
(Hex 2001:cafe:0:40:0:5efe:c0a8:a64)
192.168.20.1
ISATAP-Router
Hex 2001:cafe:0:30::199

- ISATAP router unpacks embedded packets and forwards them

IPv6 Transition Technologies


IPV6_Ping_through_ISATAP_router.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply

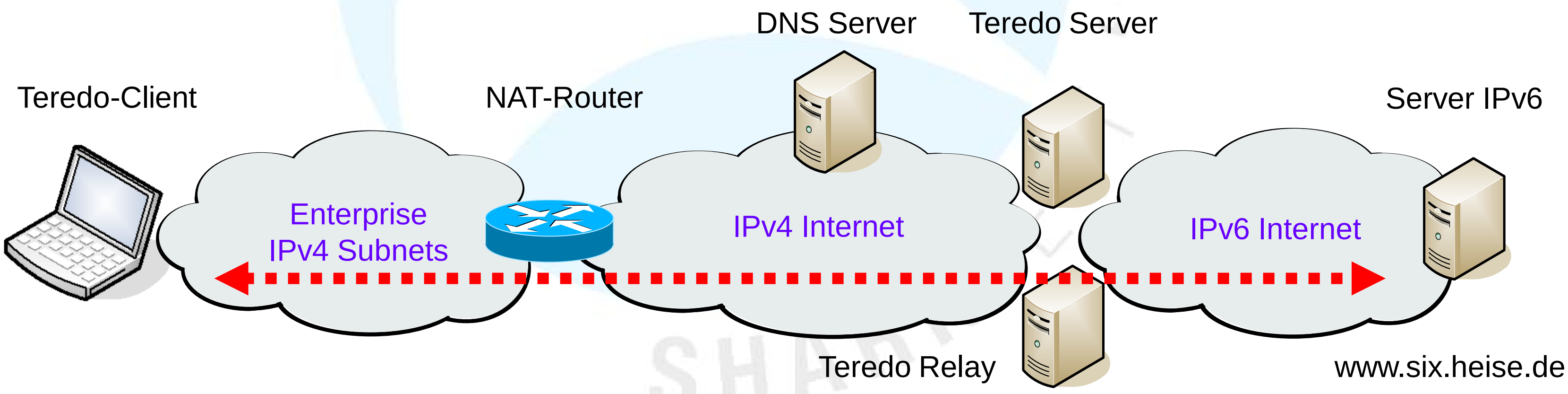
```
No. . Time     IPv6 Source                  IPv6 Destination             IPv4 Source    IPv4 Destination Protocol Info
   3 0.610461 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199            192.168.10.100 192.168.20.1   ICMPv6   Echo requ
   4 0.001282 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199                                          ICMPv6   Echo requ
   5 0.000339 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64                               ICMPv6   Echo repl
   6 0.001015 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64 192.168.20.1   192.168.10.100 ICMPv6   Echo repl
   7 0.996878 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199            192.168.10.100 192.168.20.1   ICMPv6   Echo requ
   8 0.001323 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199                                          ICMPv6   Echo requ
   9 0.000266 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64                               ICMPv6   Echo repl
  10 0.000992 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64 192.168.20.1   192.168.10.100 ICMPv6   Echo repl
  11 0.995744 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199            192.168.10.100 192.168.20.1   ICMPv6   Echo requ
  12 0.001326 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199                                          ICMPv6   Echo requ
  13 0.000317 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64                               ICMPv6   Echo repl
  14 0.000933 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64 192.168.20.1   192.168.10.100 ICMPv6   Echo repl
  15 0.995771 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199            192.168.10.100 192.168.20.1   ICMPv6   Echo requ
  16 0.001304 2001:cafe:0:40:0:5efe:c0a8:a64 2001:cafe:0:30::199                                          ICMPv6   Echo requ
  17 0.000288 2001:cafe:0:30::199            2001:cafe:0:40:0:5efe:c0a8:a64                               ICMPv6   Echo repl
```

```
⊞ Frame 3 (118 bytes on wire, 118 bytes captured)
⊞ Ethernet II, Src: HewlettP_6b:85:32 (00:22:64:6b:85:32), Dst: Cisco_ac:c5:60 (00:0b:fd:ac:c5:60)
⊞ 802.1Q Virtual LAN, PRI: 0, CFI: 0, ID: 10
⊞ Internet Protocol, Src: 192.168.10.100 (192.168.10.100), Dst: 192.168.20.1 (192.168.20.1)
⊞ Internet Protocol Version 6
⊞ Internet Control Message Protocol v6
```

IPv6 Transition Technologies

Teredo Tunnel

- Tunneling method named after Teredo Navalis (Schiffsbohrwurm)
- Teredo encapsulates IPv6 packets within UDP/IPv4 datagram
- Most NAT Routers can forward these packets properly
- Teredo allows a client to communicate with a native IPv6 server
- Teredo Server and Teredo Relay in the Internet care for transitions


DNS Server
Teredo Server
Teredo-Client
NAT-Router
Server IPv6
Enterprise IPv4 Subnets
IPv4 Internet
IPv6 Internet
Teredo Relay

www.six.heise.de

- Teredo tunnels are set up automatically, no configuration is needed.

IPv6 Transition Technologies

Teredo Tunnel initialization (Trace File IPV6_Teredo_www.six.heise.de)

Echo Request

	SA	DA	SA	DA
Data	TC-v6	SRV-v6	TC-v4	TS-v4

(Frame# 7) Step 1 →

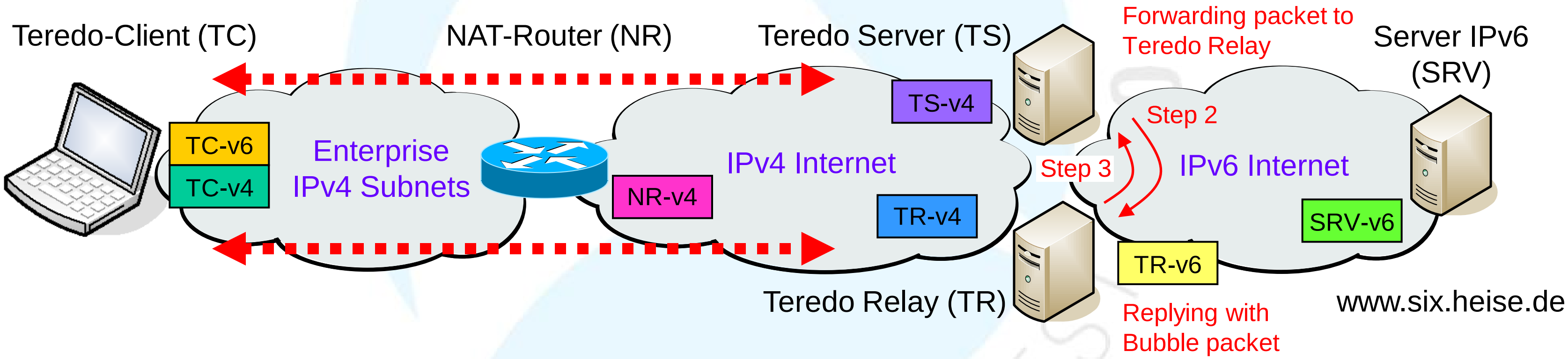
	SA	DA	SA	DA
Data	TC-v6	SRV-v6	NR-v4	TS-v4

Bubble Packet (with IP and UDP Port of Teredo Relay)

DA	SA	DA	SA	Teredo
TC-v4	TS-v4	TC-v6	TR-v6	TR-v4

← (Frame# 8) Step 4

DA	SA	DA	SA	Teredo
NR-v4	TS-v4	TC-v6	TR-v6	TR-v4


Teredo-Client (TC)
NAT-Router (NR)
Teredo Server (TS)
Forwarding packet to Teredo Relay
Server IPv6 (SRV)
TC-v6
TC-v4
Enterprise IPv4 Subnets
TS-v4
IPv4 Internet
NR-v4
TR-v4
Step 2
Step 3
IPv6 Internet
SRV-v6
TR-v6
Teredo Relay (TR)
Replying with Bubble packet
www.six.heise.de

Bubble Packet

SA	DA	SA	DA
TC-v6	TR-v6	TC-v4	TR-v4

(Frame# 9) Step 5 →

SA	DA	SA	DA
TC-v6	TR-v6	NR-v4	TR-v4

Echo Reply

DA	SA	DA	SA	
TC-v4	TR-v4	TC-v6	SRV-v6	Data

← (Frame# 10) Step 6

DA	SA	DA	SA	
NR-v4	TR-v4	TC-v6	SRV-v6	Data

TCP SYN

	SA	DA	SA	DA
Data	TC-v6	SRV-v6	TC-v4	TR-v4

(Frame# 11) Step 7 →

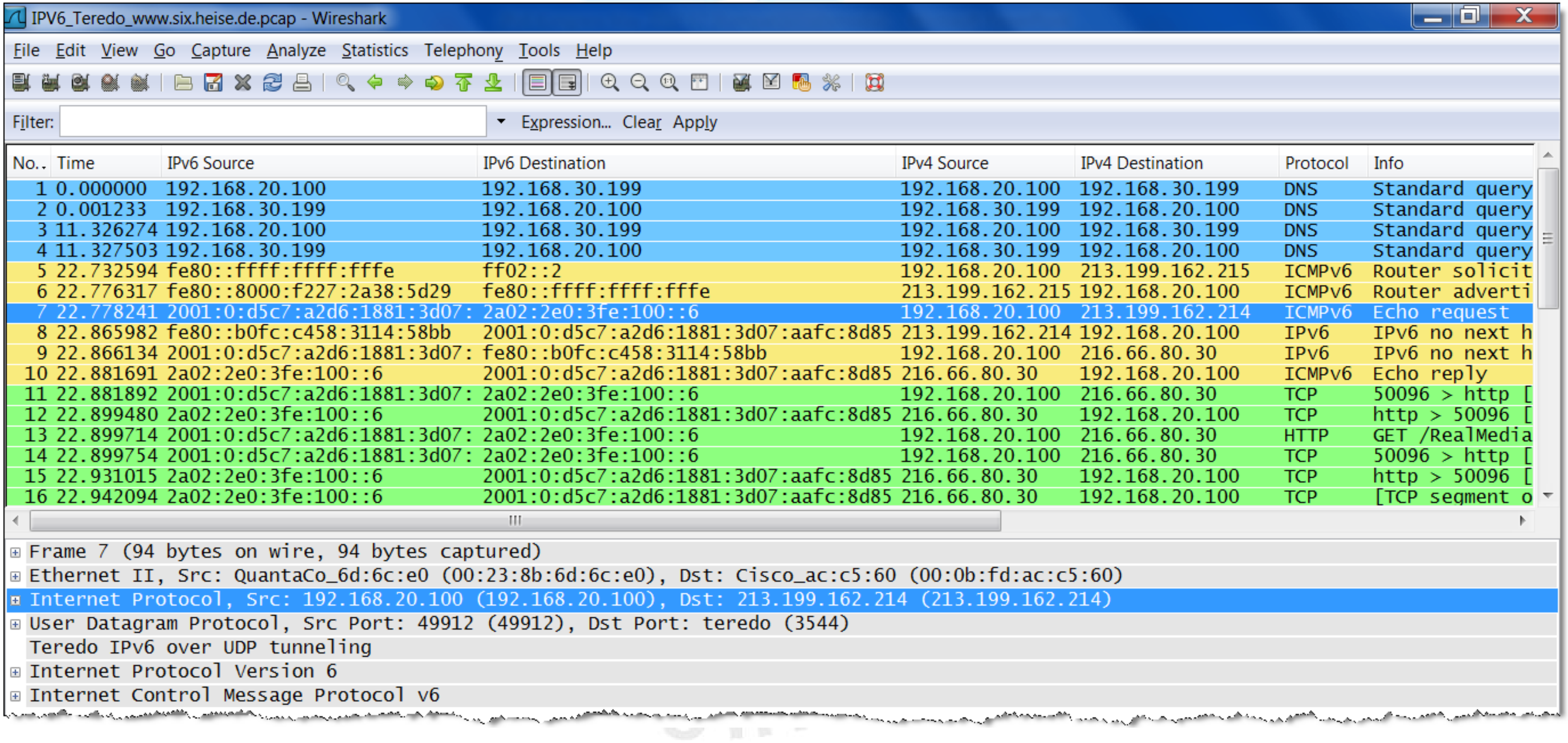
	SA	DA	SA	DA
Data	TC-v6	SRV-v6	NR-v4	TR-v4

	SA	DA
Data	TC-v6	SRV-v6

Step 8 →

IPv6 Transition Technologies

Teredo Tunnel initialization


IPV6_Teredo_www.six.heise.de.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Telephony Tools Help
Filter:
Expression... Clear Apply

```
No.. Time      IPv6 Source              IPv6 Destination                     IPv4 Source     IPv4 Destination Protocol Info
   1 0.000000  192.168.20.100           192.168.30.199                       192.168.20.100  192.168.30.199   DNS      Standard query
   2 0.001233  192.168.30.199           192.168.20.100                       192.168.30.199  192.168.20.100   DNS      Standard query
   3 11.326274 192.168.20.100           192.168.30.199                       192.168.20.100  192.168.30.199   DNS      Standard query
   4 11.327503 192.168.30.199           192.168.20.100                       192.168.30.199  192.168.20.100   DNS      Standard query
   5 22.732594 fe80::ffff:ffff:fffe     ff02::2                              192.168.20.100  213.199.162.215  ICMPv6   Router solicit
   6 22.776317 fe80::8000:f227:2a38:5d29 fe80::ffff:ffff:fffe                213.199.162.215 192.168.20.100   ICMPv6   Router adverti
   7 22.778241 2001:0:d5c7:a2d6:1881:3d07: 2a02:2e0:3fe:100::6               192.168.20.100  213.199.162.214  ICMPv6   Echo request
   8 22.865982 fe80::b0fc:c458:3114:58bb 2001:0:d5c7:a2d6:1881:3d07:aafc:8d85 213.199.162.214 192.168.20.100   IPv6     IPv6 no next h
   9 22.866134 2001:0:d5c7:a2d6:1881:3d07: fe80::b0fc:c458:3114:58bb         192.168.20.100  216.66.80.30     IPv6     IPv6 no next h
  10 22.881691 2a02:2e0:3fe:100::6      2001:0:d5c7:a2d6:1881:3d07:aafc:8d85 216.66.80.30    192.168.20.100   ICMPv6   Echo reply
  11 22.881892 2001:0:d5c7:a2d6:1881:3d07: 2a02:2e0:3fe:100::6               192.168.20.100  216.66.80.30     TCP      50096 > http [
  12 22.899480 2a02:2e0:3fe:100::6      2001:0:d5c7:a2d6:1881:3d07:aafc:8d85 216.66.80.30    192.168.20.100   TCP      http > 50096 [
  13 22.899714 2001:0:d5c7:a2d6:1881:3d07: 2a02:2e0:3fe:100::6               192.168.20.100  216.66.80.30     HTTP     GET /RealMedia
  14 22.899754 2001:0:d5c7:a2d6:1881:3d07: 2a02:2e0:3fe:100::6               192.168.20.100  216.66.80.30     TCP      50096 > http [
  15 22.931015 2a02:2e0:3fe:100::6      2001:0:d5c7:a2d6:1881:3d07:aafc:8d85 216.66.80.30    192.168.20.100   TCP      http > 50096 [
  16 22.942094 2a02:2e0:3fe:100::6      2001:0:d5c7:a2d6:1881:3d07:aafc:8d85 216.66.80.30    192.168.20.100   TCP      [TCP segment o
```

```
⊞ Frame 7 (94 bytes on wire, 94 bytes captured)
⊞ Ethernet II, Src: QuantaCo_6d:6c:e0 (00:23:8b:6d:6c:e0), Dst: Cisco_ac:c5:60 (00:0b:fd:ac:c5:60)
⊞ Internet Protocol, Src: 192.168.20.100 (192.168.20.100), Dst: 213.199.162.214 (213.199.162.214)
⊞ User Datagram Protocol, Src Port: 49912 (49912), Dst Port: teredo (3544)
  Teredo IPv6 over UDP tunneling
⊞ Internet Protocol Version 6
⊞ Internet Control Message Protocol v6
```

IPv6 Transition Technologies

Teredo Tunnel

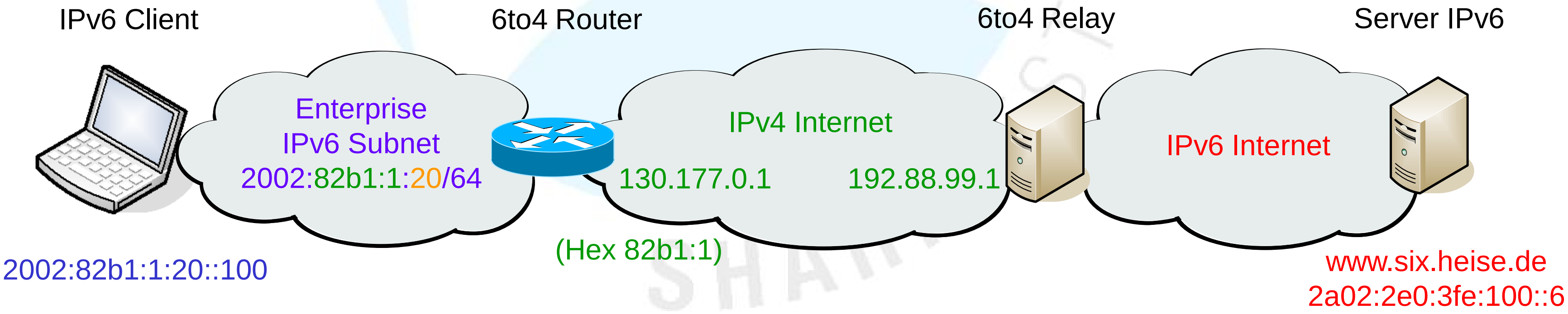
- When starting, a Windows-based computer using Teredo resolves the IPv4 address of the Teredo server teredo.ipv6.microsoft.com
- By the Router solicitation/advertisement dialog through Teredo, the client receives a valid IPv6 prefix
- When activated, the Teredo client contacts Teredo server to obtain information such as the type of NAT that the client is behind
- If the client has only link-local or Teredo IPV6 addresses assigned, then the DNS Client will send only queries for A records
- The client needs at least one valid IPv6 address configured (may be manually) in order to query for AAAA records
- Windows Vista Client computers will always use IPV6 over IPV4
- A default route may have to be configured on Teredo interface:

`netsh interface ipv6 add route ::/0 14` ← Teredo Interface ID

IPv6 Transition Technologies

6to4 Tunnel

- 6to4 provides connectivity between IPv6 sites across the IPv4 Internet
- 6to4 uses the global address prefix 2002:WWXX:YYZZ::/48
- WWXX:YYZZ is the colon-hexadecimal representation of the public IPv4
- 6to4 allows to reach IPv6 Internet destinations over an IPv4 ISP
- Within a site, local IPv6 routers advertise 2002:WWXX:YYZZ:SubnetID::/64
- Client uses announced prefix to build its own address 2002:82b1:1:20::100

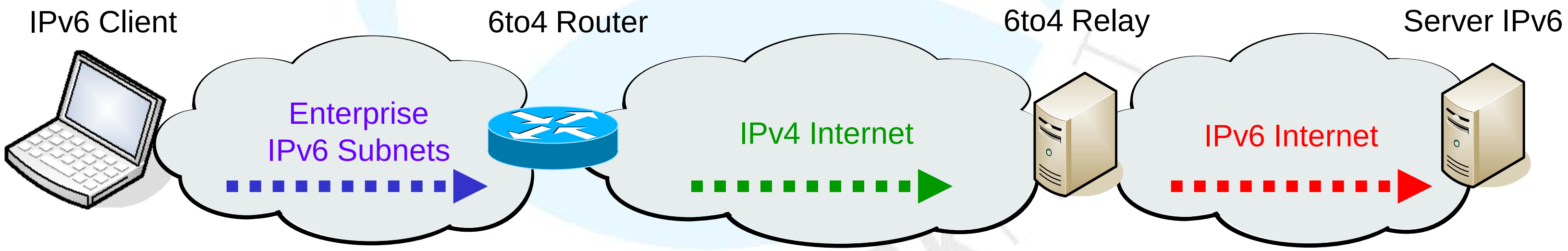

IPv6 Client
6to4 Router
6to4 Relay
Server IPv6
Enterprise
IPv6 Subnet
2002:82b1:1:20/64
IPv4 Internet
130.177.0.1
192.88.99.1
IPv6 Internet
2002:82b1:1:20::100
(Hex 82b1:1)
www.six.heise.de
2a02:2e0:3fe:100::6

- 192.88.99.1 is the anycast address of the nearest public 6to4 relay

IPv6 Transition Technologies

6to4 Tunnel setup

1. IPv6 client builds packet with IPv6 source and IPv6 destination address
2. Client forwards pure IPv6 packet to 6to4 router through IPv6 intranet
3. 6to4 router encapsulates packet in IPv4: source address 130.177. 0.1
4. 6to4 router sends the packet to Relay anycast-address 192.88.99.1
5. 6to4 relay removes IPv4 header and forwards the pure IPv6 packet


IPv6 Client
6to4 Router
6to4 Relay
Server IPv6
Enterprise IPv6 Subnets
IPv4 Internet
IPv6 Internet

130.177.0.1 → 192.88.99.1

www.six.heise.de

2002:82b1:1:20::100 → 2a02:2e0:3fe:100::6

2002:82b1:1:20::100 → 2a02:2e0:3fe:100::6

Session Agenda

Introduction

IPv6 Header & Extensions

Address format, notations & types

Address Autoconfiguration

Neighbor discovery, Router discovery

Host configuration with DHCPv6

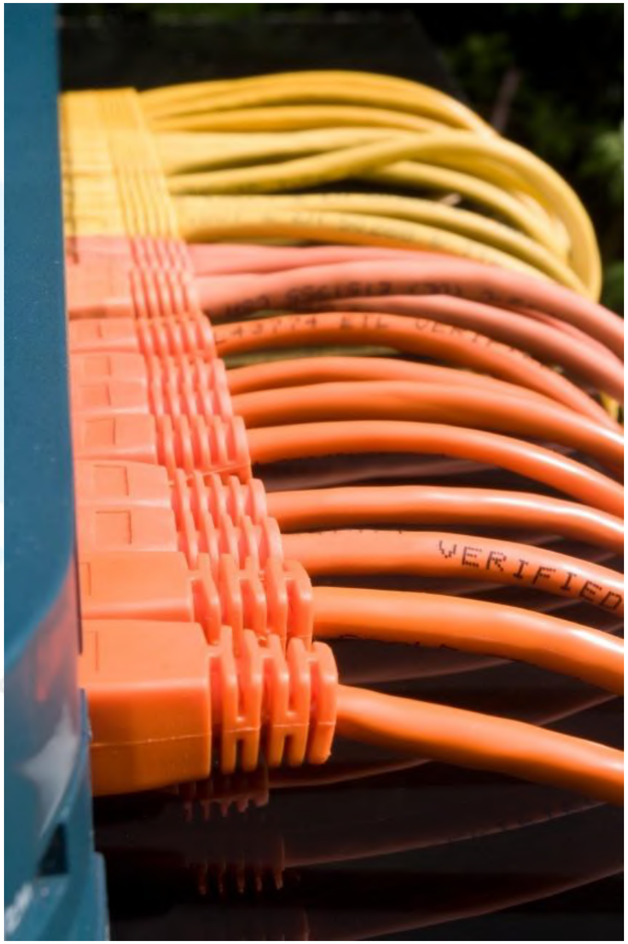
New DNS AAAA record

Transition technologies, ISATAP, Teredo, 6to4

IPv6 Routing Protocols

IPv6 Routing Protocols

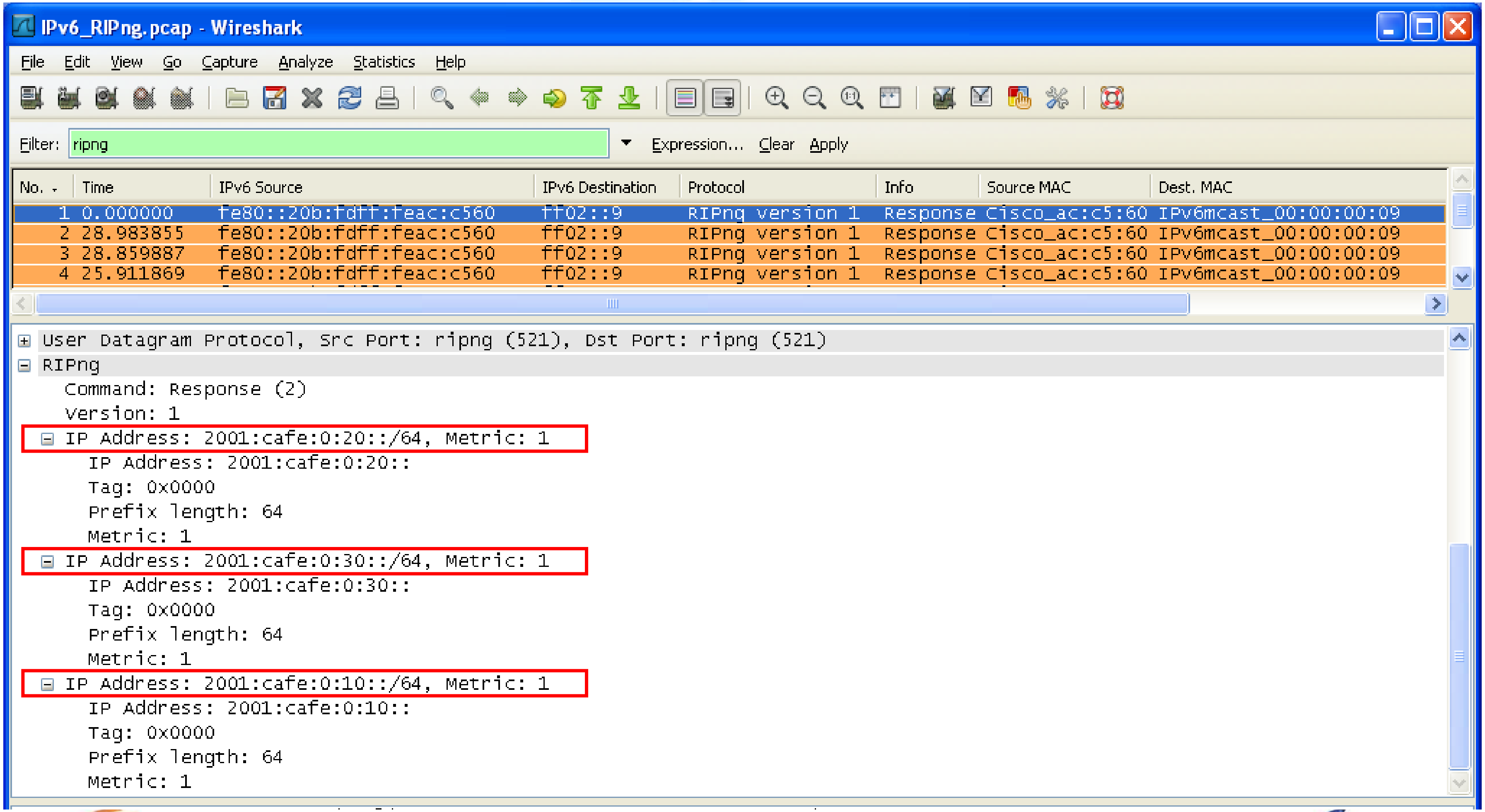
- All major routing protocols have stable IPv6 support
- RIP, OSPF, IS-IS and BGP have been renewed or extended for IPv6
- All routing protocols can coexist with IPv4 routing protocols
- Static route configuration syntax is the same as in IPv4



SHARKFEST

IPv6 Routing Protocols

Routing Information Protocol - next generation (RIPng)

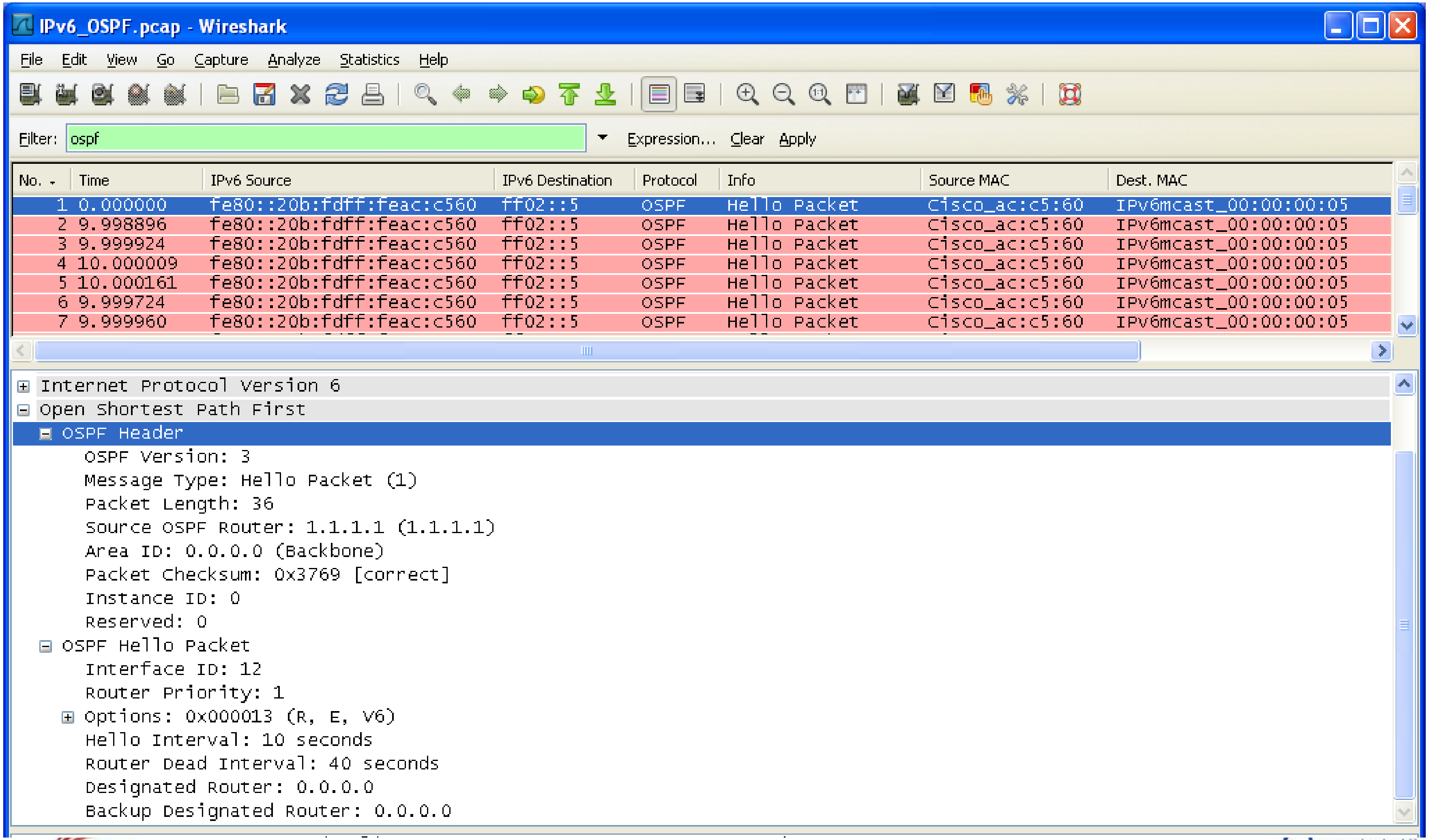

IPv6_RIPng.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter: ripng
Expression... Clear Apply

```
No. -  Time         IPv6 Source                IPv6 Destination  Protocol          Info      Source MAC          Dest. MAC
   1 0.000000     fe80::20b:fdff:feac:c560   ff02::9           RIPng version 1   Response Cisco_ac:c5:60 IPv6mcast_00:00:00:09
   2 28.983855    fe80::20b:fdff:feac:c560   ff02::9           RIPng version 1   Response Cisco_ac:c5:60 IPv6mcast_00:00:00:09
   3 28.859887    fe80::20b:fdff:feac:c560   ff02::9           RIPng version 1   Response Cisco_ac:c5:60 IPv6mcast_00:00:00:09
   4 25.911869    fe80::20b:fdff:feac:c560   ff02::9           RIPng version 1   Response Cisco_ac:c5:60 IPv6mcast_00:00:00:09
```

```
⊞ User Datagram Protocol, Src Port: ripng (521), Dst Port: ripng (521)
⊟ RIPng
    Command: Response (2)
    Version: 1
  ⊟ IP Address: 2001:cafe:0:20::/64, Metric: 1
      IP Address: 2001:cafe:0:20::
      Tag: 0x0000
      Prefix length: 64
      Metric: 1
  ⊟ IP Address: 2001:cafe:0:30::/64, Metric: 1
      IP Address: 2001:cafe:0:30::
      Tag: 0x0000
      Prefix length: 64
      Metric: 1
  ⊟ IP Address: 2001:cafe:0:10::/64, Metric: 1
      IP Address: 2001:cafe:0:10::
      Tag: 0x0000
      Prefix length: 64
      Metric: 1
```

IPv6 Routing Protocols

Open Shortest Path First - Version 3 (OSPFv3)



IPv6_OSPF.pcap - Wireshark
File Edit View Go Capture Analyze Statistics Help
Expression... Clear Apply

Filter: ospf

No.	Time	IPv6 Source	IPv6 Destination	Protocol	Info	Source MAC	Dest. MAC
1	0.000000	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05
2	9.998896	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05
3	9.999924	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05
4	10.000009	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05
5	10.000161	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05
6	9.999724	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05
7	9.999960	fe80::20b:fdff:feac:c560	ff02::5	OSPF	Hello Packet	Cisco_ac:c5:60	IPv6mcast_00:00:00:05

```
⊞ Internet Protocol Version 6
⊟ Open Shortest Path First
  ⊟ OSPF Header
      OSPF Version: 3
      Message Type: Hello Packet (1)
      Packet Length: 36
      Source OSPF Router: 1.1.1.1 (1.1.1.1)
      Area ID: 0.0.0.0 (Backbone)
      Packet Checksum: 0x3769 [correct]
      Instance ID: 0
      Reserved: 0
  ⊟ OSPF Hello Packet
      Interface ID: 12
      Router Priority: 1
    ⊞ Options: 0x000013 (R, E, V6)
      Hello Interval: 10 seconds
      Router Dead Interval: 40 seconds
      Designated Router: 0.0.0.0
      Backup Designated Router: 0.0.0.0
```

Session Summary

How-to get

- Verify IPv6 readiness of your suppliers
- Verify IPv6 readiness of your applications
- IPv6 can perfectly coexist with IPv4
- Network migration can be done smoothly
- Train yourself and your people
- Wireshark is the perfect tool to learn and train

- Interesting IPv6 references:

  www.sixxs.net non-profit, non-cost service for Local Internet Registries (LIR's) and end users

  www.ipv6.org how-to articles, FAQ, technical specifications, mailing list, details of IPv6-enabled applications, and links

Thank you for your attention

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Please fill in evaluation form