Discovering IPv6 with Wireshark
June 16, 2010

Rolf Leutert
Network Consultant & Trainer | Leutert NetServices | Switzerland

SHARKFEST ‘10
Stanford University
June 14-17, 2010

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
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 $3.4 \times 10^{38}$ 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  2001:0DB8:0000:0000:0000:0000:1428:57AB

network prefix  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 millimeter$^2$.

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 km$^2$)
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 Headers & Extensions

## IPv4 Header
(20 Bytes without options)

<table>
<thead>
<tr>
<th>Ver.</th>
<th>HL</th>
<th>DiffServ</th>
<th>Payload length</th>
<th>Identification</th>
<th>Flag</th>
<th>Fragment Offset</th>
<th>TTL</th>
<th>Protocol</th>
<th>Header Checksum</th>
<th>32 bits Source Address</th>
<th>32 bits Destination Address</th>
<th>Optional fields</th>
</tr>
</thead>
</table>

- **Fields changed**
- **Fields removed**
- **Fields added**

## IPv6 Header
(40 Bytes without extensions)

<table>
<thead>
<tr>
<th>Ver.</th>
<th>Traff. Class</th>
<th>Flow Label</th>
<th>Payload length</th>
<th>NextHeader</th>
<th>Hop Limit</th>
<th>128 Bits Source Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Optional Extension Headers**
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
<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>IPv6 Source</th>
<th>IPv6 Destination</th>
<th>IPv4 Source</th>
<th>IPv4 Destination</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000000</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td>2001:cafe:0:30:1199</td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.027882</td>
<td>2001:cafe:0:30:1199</td>
<td></td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.001031</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td>2001:cafe:0:30:1199</td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.001832</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td></td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.001464</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1</td>
<td>192.168.20.100</td>
<td>207.46.48.150</td>
<td>192.168.20.100</td>
<td>ICMPv6</td>
</tr>
<tr>
<td>6</td>
<td>0.725076</td>
<td>fe80::4541b:7f68:493c:c443</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1 207.46.48.150</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.007126</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1 207.46.48.150</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.026195</td>
<td>2a02:2e10:3fe1:100:6</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1 207.46.48.150</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.000876</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1</td>
<td>2001:0:2c04:68ad::11:142c:aafe:a1 207.46.48.150</td>
<td>192.168.20.100</td>
<td>TCP</td>
<td></td>
</tr>
</tbody>
</table>

IPv6 Header & Extensions

**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**: 0x0000 [correct]
- **Source**: 192.168.20.100 (192.168.20.100)
- **Destination**: 207.46.48.150 (207.46.48.150)

User Datagram Protocol, Src Port: 50371 (50371), Dst Port: teredo (3544)

IPv6 over UDP tunneling
# IPv6 Header & Extensions

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>IPv6 Source</th>
<th>IPv6 Destination</th>
<th>IPv4 Source</th>
<th>IPv4 Destination</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000000</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td>2001:cafe:0:30:199</td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.027982</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td>2001:cafe:0:30:199</td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.001031</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td>2001:cafe:0:30:199</td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.001852</td>
<td>2001:cafe:0:20:c1c4:83e9:bc72:f0b7</td>
<td>2001:cafe:0:30:199</td>
<td>DNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.001444</td>
<td>2001:0:cf2e:3096:1c11:142c:aafe:a1</td>
<td>2a02:2e0:3fe:100::6</td>
<td>192.168.20.100</td>
<td>207.46.48.110</td>
<td>ICMPv6</td>
</tr>
<tr>
<td>6</td>
<td>0.725076</td>
<td>Fe80::445b:75f8:493c:4c43</td>
<td>2001:0:cf2e:3096:1c11:142c:aafe:a1</td>
<td>192.168.20.100</td>
<td>192.168.20.100</td>
<td>IPv6</td>
</tr>
<tr>
<td>7</td>
<td>0.000712</td>
<td>2001:0:cf2e:3096:1c11:142c:aafe:a1</td>
<td>fe80::445b:75f8:493c:4c43</td>
<td>192.168.20.100</td>
<td>87.251.43.68</td>
<td>IPv6</td>
</tr>
<tr>
<td>8</td>
<td>0.026192</td>
<td>2a02:2e0:3fe:100::6</td>
<td>192.168.20.100</td>
<td>192.168.20.100</td>
<td>ICMPv6</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.000876</td>
<td>2001:0:cf2e:3096:1c11:142c:aafe:a1</td>
<td>2a02:2e0:3fe:100::6</td>
<td>192.168.20.100</td>
<td>192.168.20.100</td>
<td>TCP</td>
</tr>
</tbody>
</table>

---

**Fragment offset:** 0  
**Time to live:** 128  
**Protocol:** UDP (0x11)

**Header checksum:** Ox910 [correct]  
**Source:** 192.168.20.100 (192.168.20.100)  
**Destination:** 207.46.48.130 (207.46.48.130)  

**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 = Flowlabel: 0x00000000  
**Payload length:** 12  
**Next header:** ICMPv6 (0x3a)  
**Hop limit:** 21  
**Destination:** za02:2e0:3fe:100::6 (za02:2e0:3fe:100::6)
IPv6 offers **modular header composition** adding optional information

Basic IPv6 header can be followed by **one or more extension headers**

- Basic header
  - IPv6 Header
    - Next Header: TCP
  - TCP Header and data

- Basic header with one extension
  - IPv6 Header
    - Next Header: Routing
  - Routing Header
    - Next Header: TCP
  - TCP Header and data

- Basic header with two extensions
  - IPv6 Header
    - Next Header: Routing
  - Routing Header
    - Next Header: Fragment
  - Fragment Header
    - Next Header: TCP
  - TCP Header and data
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 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:db8:0:0:0:1428:57ab: 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::100:0:0:0:20: 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

2001:0DB8:0000:0000:0000:0000:1428:57AB
2001:0db8:0000:0000:0000:0000:1428:57ab

leading zeros can be suppressed
consecutive zeros can be compressed with ::

2001:0:0:100:0:0:0:20
2001::100::20
2001:0:0:100::20
2001::100:0:0:0:20

zero compression only once in an address
invalid address
valid address
valid address

fe80::5efe:192.168.20.100

mixed notation, compressed

2001:db8::/64
2001:db8::1428:57ab/128

represents the network 2001:db8:0:0::
represents a single host address
Address types

Four types of addresses are defined in IPv6

• **Unicast** 
  - 2xxx Worldwide unique addresses
  - fdxx 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

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
<td>2xxx</td>
<td>Blocks managed by RIPE NCC (Europe)</td>
</tr>
<tr>
<td></td>
<td>2001:/16</td>
<td>Global unicast addresses (former public)</td>
</tr>
<tr>
<td></td>
<td>2002:/16</td>
<td>6to4 address space</td>
</tr>
<tr>
<td></td>
<td>3ffe:/16</td>
<td>old 6Bone address</td>
</tr>
</tbody>
</table>

## Local

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link-Local</td>
<td>fe80:/64</td>
<td>former IPv4 169.254.0.0/16 APIPA</td>
</tr>
<tr>
<td>Local</td>
<td>fc00:/8</td>
<td>Centrally Assigned Unique Local Address (ULA-central)</td>
</tr>
<tr>
<td></td>
<td>fd00:/8</td>
<td>Unique Local Address (ULA, not routed in the Internet, former IPv4 private)</td>
</tr>
<tr>
<td>Site-Local</td>
<td>fec0:/10</td>
<td>deprecated, do not use anymore</td>
</tr>
</tbody>
</table>
Address types

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

<table>
<thead>
<tr>
<th>Anycast Type</th>
<th>IPv6 Address</th>
<th>IPv4 Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIPE NCC Root Server</td>
<td>2001:7fd::1</td>
<td>193.0.14.129</td>
</tr>
<tr>
<td>VeriSign Root Server</td>
<td>2001:503:c27::2:30</td>
<td>192.58.128.30</td>
</tr>
<tr>
<td>6to4 Relay</td>
<td></td>
<td>192.88.99.1</td>
</tr>
</tbody>
</table>

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
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 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**

```
<table>
<thead>
<tr>
<th>Ethernet MAC address</th>
<th>IPv6 address: EUI-64 format</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:30:64:6b:85:32</td>
<td>fe 80 00 00 00 00 02 30 64 ff fe 6b 85 32</td>
</tr>
</tbody>
</table>
```

```
<table>
<thead>
<tr>
<th>IPv6 address: privacy format</th>
</tr>
</thead>
<tbody>
<tr>
<td>fe 80 00 00 00 00 00 9c 4a e7 8a 20 38 d4 d1</td>
</tr>
</tbody>
</table>
```

Random value
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 01 ff 6b 85 32
```

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

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

24 bits
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

```
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:
  - 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

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’

- 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

#### Link Local Addresses

<table>
<thead>
<tr>
<th>IPv6 Address</th>
<th>Prefix Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>286 fe80::/64</td>
<td></td>
</tr>
<tr>
<td>266 fe80::/64</td>
<td></td>
</tr>
<tr>
<td>281 fe80::/64</td>
<td></td>
</tr>
<tr>
<td>296 fe80::/64</td>
<td></td>
</tr>
<tr>
<td>286 fe80::/64</td>
<td></td>
</tr>
<tr>
<td>266 fe80::/64</td>
<td></td>
</tr>
<tr>
<td>281 fe80::/64</td>
<td></td>
</tr>
</tbody>
</table>

#### Global Addresses

<table>
<thead>
<tr>
<th>IPv6 Address</th>
<th>Prefix Length</th>
<th>Gateway</th>
</tr>
</thead>
<tbody>
<tr>
<td>286 2001::/32</td>
<td></td>
<td>fe80::20b:fdff:feac:c560</td>
</tr>
<tr>
<td>286 2001::/32</td>
<td></td>
<td>fe80::5efe:192.168.20.1</td>
</tr>
<tr>
<td>306 ::1/128</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### IPv6 Routes

<table>
<thead>
<tr>
<th>Interface</th>
<th>Metrik</th>
<th>Netzwerkziel</th>
<th>Gateway</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>If 13</td>
<td>286</td>
<td>2001::/64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If 14</td>
<td>266</td>
<td>2001::/64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If 16</td>
<td>281</td>
<td>2001::/64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If 13</td>
<td>286</td>
<td>192.168.0.205/128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If 14</td>
<td>266</td>
<td>192.168.0.205/128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If 16</td>
<td>281</td>
<td>192.168.0.205/128</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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
TCP/IP Protocols

**TCP/IP Layers**

- Process or Application
- Host-to-Host
- Internet
- Network Interface or Local Network

**OSI Layers**

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

**Internet Protocol Suite**

- **TCP**
  - HTTP
  - SSH
  - SSL
  - FTP
  - POP3
  - SMTP
  - Telnet
  - RUNIX

- **UDP**
  - P2P
  - LDAP
  - DNS
  - NIS
  - NFS
  - RTP
  - RIP
  - SNMP
  - TFTP
  - DHCP
  - NAT-T
  - ISAKMP

- **Many LAN, WLAN and WAN Protocols**

---

**Microsoft Server Message Block Protocol**

**SMB/CIFS**

**Common Internet File System**

**NetBIOS Session Service**

**STP**

**ICMP**

**CDP**

**OSPF**

**ARP**

**Microsoft Windows Browser Protocol**

**SMB/CIFS**

**Common Internet File System**

**NetBIOS Name Service Datagram Serv.**

**Microsoft Server Message Block Protocol**

**Common Internet File System**

**NetBIOS Session Service**

**STP**

**ICMP**

**CDP**

**OSPF**

**ARP**
TCP/IP Protocols

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

Error and Control Messages
- Echo Request/Reply
- Destination unreachable
- Time exceeded
- Redirect
- Parameter Problem
- Packet too big

Multicast Listener Discovery (MLD) Messages
- Multicast Listener Query
- Multicast Listener Report
- Multicast Listener Done

Neighbor Discovery (ND) Messages
- Neighbor Solicitation
- Neighbor Advertisement
- Router Solicitation
- Router Advertisement

ICMPv6
IPv6
LAN, WLAN and WAN Protocols
The initial client startup process includes the following steps:

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
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

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:ff68:8532

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

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**: 00:22:64:68:85:32
- **LLA**: fe80::222:64ff:fe68:8532
- **SNMA**: ff02::1:ff68:8532

**VISTA/7-Client** (random option = on)
- **MAC**: 00:22:64:68:85:32
- **LLA**: fe80::12d:d6a8:dd1c:b3b0
- **SNMA**: ff02::1:ff1c:b3b0

**Router Solicitation Message**
- **Source**: fe80::222:64ff:fe68:8532
- **Destination**: ff02::2
  - **Info**: Link-layer address 00:22:64:6b:85:32

**Neighbor Discovery (ND)**
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


SNMA ff02::1:ffac:c561

Router Advertisement Message

Source: fe80::20b:fdff:feac:c561

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

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

Neighbor Solicitation (ND)
Neighbor Discovery (ND)

**Neighbor Advertisement**

- **VISTA-Client** (random option = off)
  - MAC: 0022:6468:8532
  - LLA: fe80::222:64ff:fe68:8532
  - SNMA: fe80::20b:fdff:feac:c561

- **Router Configuration**
  - MAC: 000b:fdac:c561
  - LLA: fe80::20b:fdff:feac:c561
  - SNMA: ff02::1:ffac:c561
  - Def.GW: fe80::

**Neighbor Advertisement Message**

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

- Info: Target: fe80::20b:fdff:feac:c561
- Info: Link-layer address 00:0b:fd:ac:c561

Subnet 2001:cafe:0:20::

Client

Router
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

• 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
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:

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

O = Other Flag / M = Managed Flag
Host configuration with DHCPv6

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

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

![Wireshark screenshot](image.png)
Host configuration with DHCPv6

Router Solicitation

VISTA-Client (random option = off)

MAC: 00:22:64:68:85:32
LLA: fe80::22:64ff:fe68:8532
SSNMA: ff02::1:ff68:8532

Router Solicitation Message

Source: fe80::222:64ff:fe68:8532
Destination: ff02::2
Info: Link-layer address 00:22:64:6b:85:32
Host configuration with DHCPv6

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

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

Router Advertisement Message:

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

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

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

Option Request: Domain Search List

Option Request: DNS recursive name server

Option Request: Vendor-specific Information

DHCP Relay-forward

- Destination: 2001:cafe:0:20::
- Source: 2001:cafe:0:30::

- Destination: 2001:cafe:0:30::199
Host configuration with DHCPv6

DHCP server reply

Client

Subnet 2001:cafe:0:20::

DHCP Reply

Source: fe80::20b:fdff:feac:c561

Destination: fe80::222:64ff:fe68:8532

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

DHCP Relay

Subnet 2001:cafe:0:30::

2001:cafe:0:30::199

DHCP Server
Host configuration with DHCPv6

DHCP server reply

DHCP Relay-reply
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 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
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
IPv6 Domain Name System (DNS)

- AAAA record query & response over IPv6

**IPv6 DNS over IPv6.pcap - Wireshark**

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
</table>

- AAAA record query & response over IPv4

**IPv6 DNS over IPv4.pcap - Wireshark**

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Source</th>
<th>Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.012933</td>
<td>192.168.10.100</td>
<td>192.168.30.199</td>
<td>DNS</td>
<td>Standard query AAAA <a href="http://www.six.heise.de">www.six.heise.de</a></td>
</tr>
<tr>
<td>4</td>
<td>0.013765</td>
<td>192.168.30.199</td>
<td>192.168.10.100</td>
<td>DNS</td>
<td>Standard query response AAAA 2a02:2e0:3fe:100::6</td>
</tr>
</tbody>
</table>
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
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 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 use locally assigned IPv4 address (public or private) to create the 64-bit interface identifier
### IPv6 Transition Technologies

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>IPv6 Source</th>
<th>IPv6 Destination</th>
<th>IPv4 Source</th>
<th>IPv4 Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00000</td>
<td>f80::5efe:c0a8:1464</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo request</td>
</tr>
<tr>
<td>4</td>
<td>0.00081</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>f80::5efe:c0a8:1464</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo reply</td>
</tr>
<tr>
<td>5</td>
<td>1.00217</td>
<td>f80::5efe:c0a8:1464</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo request</td>
</tr>
<tr>
<td>8</td>
<td>0.00079</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>f80::5efe:c0a8:1464</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo reply</td>
</tr>
<tr>
<td>9</td>
<td>1.01320</td>
<td>f80::5efe:c0a8:1464</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo request</td>
</tr>
<tr>
<td>12</td>
<td>0.00081</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>f80::5efe:c0a8:1464</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo reply</td>
</tr>
<tr>
<td>13</td>
<td>1.01314</td>
<td>f80::5efe:c0a8:1464</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo request</td>
</tr>
<tr>
<td>16</td>
<td>0.00085</td>
<td>f80::5efe:c0a8:1ec7</td>
<td>f80::5efe:c0a8:1464</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>ICMPv6</td>
<td>Echo reply</td>
</tr>
</tbody>
</table>

---

**Frame 1** (118 bytes on wire, 118 bytes captured)


802.1q Virtual LAN, PRI: 0, CFI: 0, ID: 20


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: f80::5efe:c0a8:1464 (f80::5efe:c0a8:1464)
- Destination: f80::5efe:c0a8:1ec7 (f80::5efe:c0a8:1ec7)
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 requests IPv6 global unicast prefix from ISATAP router
- Client sends IPv6 in IPv4 embedded packets to ISATAP router

- ISATAP router unpacks embedded packets and forwards them
IPv6 Transition Technologies

Frame 3 (118 bytes on wire, 118 bytes captured)
Ethernet II, Src: 0010:0461 (00:10:04:61:00:04), Dst: 00:10:04:61:00:04

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 Na valis (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

- Teredo tunnels are set up automatically, no configuration is needed.
IPv6 Transition Technologies

Teredo Tunnel initialization

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>TC-v6</td>
</tr>
<tr>
<td></td>
<td>SRV-v6</td>
</tr>
<tr>
<td></td>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
<td>TS-v4</td>
</tr>
<tr>
<td>DA</td>
<td>SA</td>
</tr>
<tr>
<td>TC-v4</td>
<td>SA</td>
</tr>
<tr>
<td>TS-v4</td>
<td>DA</td>
</tr>
<tr>
<td>Teredo</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
</tr>
<tr>
<td>SA</td>
</tr>
<tr>
<td>TC-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SRV-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Data</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
</tr>
<tr>
<td>SA</td>
</tr>
<tr>
<td>TC-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SRV-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Data</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
</tr>
<tr>
<td>SA</td>
</tr>
<tr>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SRV-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Data</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
</tr>
<tr>
<td>SA</td>
</tr>
<tr>
<td>TC-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SRV-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Data</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA</td>
</tr>
<tr>
<td>SA</td>
</tr>
<tr>
<td>TC-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SRV-v6</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TC-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TR-v4</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Data</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Echo Request

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

Forwarding packet to Teredo Relay

Replying with Bubble packet

Server IPv6 (SRV)

www.six.heise.de

Echo Reply

TCP SYN

IPv6 Transition Technologies

Teredo-CIent (TC)

NAT-Router (NR)

Teredo Server (TS)

IPv4 Internet

Teredo Relay (TR)

Enterprise IPv4 Subnets
IPv6 Transition Technologies

Teredo Tunnel initialization

<table>
<thead>
<tr>
<th>No.</th>
<th>IPv6 Source</th>
<th>IPv6 Destination</th>
<th>IPv4 Source</th>
<th>IPv4 Destination</th>
<th>Protocol</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000000 fe80::ffff:fffe</td>
<td>192.168.30.199</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>DNS</td>
<td>Standard query</td>
</tr>
<tr>
<td>2</td>
<td>0.001233 fe80::ffff:fffe</td>
<td>192.168.30.199</td>
<td>192.168.20.100</td>
<td>192.168.30.199</td>
<td>DNS</td>
<td>Standard query</td>
</tr>
<tr>
<td>5</td>
<td>22.732594 fe80::ffff:fffe</td>
<td>f02::2</td>
<td>192.168.20.100</td>
<td>213.199.162.100</td>
<td>ICMPv6</td>
<td>Router solicitation</td>
</tr>
<tr>
<td>6</td>
<td>22.776317 fe80::ffff:fffe</td>
<td>f227:2a38:5d29</td>
<td>213.199.162.215</td>
<td>192.168.20.100</td>
<td>ICMPv6</td>
<td>Router advertisement</td>
</tr>
<tr>
<td>7</td>
<td>22.778241 fe80::ffff:fffe</td>
<td>2a02:2e0:3fe:100:ff</td>
<td>192.168.20.100</td>
<td>213.199.162.214</td>
<td>ICMPv6</td>
<td>Echo request</td>
</tr>
<tr>
<td>9</td>
<td>22.866134 fe80::b0fc:c458:3114:56bb</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>213.168.20.100</td>
<td>216.66.80.30</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>10</td>
<td>22.881691 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>11</td>
<td>22.881892 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>12</td>
<td>22.899384 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>13</td>
<td>22.899714 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>14</td>
<td>22.899734 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>15</td>
<td>22.931015 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
<tr>
<td>16</td>
<td>22.942904 2a02:2e0:3fe:100::6</td>
<td>2001:0:d5c7:a2d6:1881:3d07:aafe:8d85</td>
<td>216.66.80.30</td>
<td>192.168.20.100</td>
<td>IPv6</td>
<td>No next hop</td>
</tr>
</tbody>
</table>

Frame 7 (94 bytes on wire, 94 bytes captured)
- Ethernet II, Src: QuantaCo_6d:6c:e0 (00:23:8b:6d:6c:e0), Dst: Cisco_ae:c5:60 (00:0b:fd:ac:c5:60)
- Internet 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

192.88.99.1 is the anycast address of the nearest public 6to4 relay
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 ancast-address 192.88.99.1
5. 6to4 relay removes IPv4 header and forwards the pure IPv6 packet
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
# IPv6 Routing Protocols

Routing Information Protocol - next generation (RIPng)

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>IPv6 Source</th>
<th>IPv6 Destination</th>
<th>Protocol</th>
<th>Info</th>
<th>Source MAC</th>
<th>Dest. MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0:00:00:00</td>
<td>fe80::20b:fffe:face:0000</td>
<td>ff02::9</td>
<td>RIPng</td>
<td>version 1 Response</td>
<td>Cisco_ac:c5:60 IPv6cast_00:00:00::00:09</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>28.898385</td>
<td>fe80::20b:fffe:face:0000</td>
<td>ff02::9</td>
<td>RIPng</td>
<td>version 1 Response</td>
<td>Cisco_ac:c5:60 IPv6cast_00:00:00::00:09</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28.898877</td>
<td>fe80::20b:fffe:face:0000</td>
<td>ff02::9</td>
<td>RIPng</td>
<td>version 1 Response</td>
<td>Cisco_ac:c5:60 IPv6cast_00:00:00::00:09</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>25.911809</td>
<td>fe80::20b:fffe:face:0000</td>
<td>ff02::9</td>
<td>RIPng</td>
<td>version 1 Response</td>
<td>Cisco_ac:c5:60 IPv6cast_00:00:00::00:09</td>
<td></td>
</tr>
</tbody>
</table>

- **IP Address**: 2001:cafe:0:20::/64, **Metric**: 1
- **IP Address**: 2001:cafe:0:30::/64, **Metric**: 1
- **IP Address**: 2001:cafe:0:10::/64, **Metric**: 1
IPv6 Routing Protocols

Open Shortest Path First - Version 3 (OSPFv3)

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>IPv6 Source</th>
<th>IPv6 Destination</th>
<th>Protocol</th>
<th>Info</th>
<th>Source MAC</th>
<th>Dest. MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000000</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
<tr>
<td>2</td>
<td>9.998896</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
<tr>
<td>3</td>
<td>9.999924</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
<tr>
<td>4</td>
<td>10.00009</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
<tr>
<td>5</td>
<td>10.00001</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
<tr>
<td>6</td>
<td>9.999724</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
<tr>
<td>7</td>
<td>9.999950</td>
<td>205::20b:ff:feac:c560</td>
<td>ff02::5</td>
<td>OSPF</td>
<td>Hello Packet</td>
<td>CIso_ac:c5:60</td>
<td>IPv6 multicast_00:00:00:00:05</td>
</tr>
</tbody>
</table>

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

- 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

Please fill in evaluation form