IPV6 BASICS: PROTOCOL, ADDRESSING

Piers O’Hanlon

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IPv6 Address Space

$2^{32} = 4,294,967,296$

$2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456$

$2^{96} = 2^{32} \times 2^{96}$

$2^{96} = 79,228,162,514,264,337,593,543,950,336$ times the number of possible IPv4 Addresses (79 trillion trillion)
IPv6 Header

• The IPv6 header is redesigned.
• Minimize header overhead and reduce the header process for the majority of the packets.
• Less essential and optional fields are moved to extension headers.

IPv6 and IPv4 headers are not interoperable!
IPv4 and IPv6 Header Comparison

IPv4 Header

<table>
<thead>
<tr>
<th>Field's Name Kept from IPv4 to IPv6</th>
<th>Fields Not Kept in IPv6</th>
<th>Name and Position Changed in IPv6</th>
<th>New Field in IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>HL</td>
<td>Type of Service</td>
<td>Total Length</td>
</tr>
<tr>
<td>Identification</td>
<td>Flags</td>
<td>Fragment Offset</td>
<td>Time to Live</td>
</tr>
<tr>
<td>Protocol</td>
<td>Header Checksum</td>
<td>Source Address</td>
<td>Destination Address</td>
</tr>
<tr>
<td>Options</td>
<td>Padding</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IPv6 Header

<table>
<thead>
<tr>
<th>Field's Name Kept from IPv4 to IPv6</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>Traffic Class</td>
<td>Flow Label</td>
<td></td>
</tr>
<tr>
<td>Payload Length</td>
<td>Next Header</td>
<td>Hop Limit</td>
<td></td>
</tr>
<tr>
<td>Source Address</td>
<td></td>
<td>Destination Address</td>
<td></td>
</tr>
</tbody>
</table>

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Extension Headers (RFC2460)

- Processed only by node identified in IPv6 Destination Address field => much lower overhead than IPv4 options
  - exception: Hop-by-Hop Options header
- Eliminated IPv4’s 40-octet limit on options
  - In IPv6, limit is total packet size, or Path MTU in some cases
Extension Headers

IPv6 Header Next Header = TCP

IPv6 Header Next Header = Routing

Routing Header Next Header = TCP

Tcp Header + Data

TCP Header + Data

IPv6 Header Next Header = Routing

Routing Header Next Header = Destination

Destination Header Next Header = TCP

Fragment of TCP Header + Data

Extension Headers Are Daisy Chained

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IPv6 extension headers: order is important

- IPv6
- Hop by hop (0)
- Destination
- Routing (43)
- Fragmentation (44)
- Authentication (51)
- Security
- Destination (60)
- Upper Layer

- Processed by every router
- Processed by routers listed in Routing extension
- List of routers to cross
- Processed by the destination after reassembling the packet
- Cipher the content of the remaining information
- Processed only by the destination

RFC 2460
IPv4 options: processed in each router
slow down packets
IPv6 extensions (except Hop-by-Hop) are processed only by the destination.
IPv6 Address Representation (Example)

• Base format (16-byte)


• Compact Format:

2001:660:3003:1::6543:210F

• Litteral representation
  - [2001:660:3003:2:a00:20ff:fe18:964c]
IPv6 Addressing

Prefix Representation

• Representation of prefix is just like CIDR
  [address prefix / prefix length]

• In this representation you attach the
  prefix length
  – IPv4 address: 198.10.0.0/16
  – IPv6 address: 3ef8:ca62:12FE::/48
IPv6 Address Representation

• Loopback address representation
  – 0:0:0:0:0:0:0:1 => ::1
  – Same as 127.0.0.1 in IPv4
  – Identifies self

• Unspecified address representation
  – 0:0:0:0:0:0:0:0 => ::
  – Used as a placeholder when no address available
  – (Initial DHCP request, Duplicate Address Detection DAD)
IPv6 Address Representation

- **IPv4 mapped**
  - 0:0:0:0:0::FFFF:IPv4 = ::FFFF:IPv4
  - 0:0:0:0:0:FFFF:192.168.30.1 = ::FFFF:C0A8:1E01

- **IPv4 compatible**
  - 0:0:0:0:0:0:IPv4 = ::IPv4
  - 0:0:0:0:0:0:192.168.30.1 = ::192.168.30.1 = ::C0A8:1E01
IPv6 Addressing Architecture

- IPv6 Addressing rules are covered by multiples RFC’s
  - Architecture initially defined by RFC 2373
  - Now RFC rfc4291.txt (obsoletes 3513 which obsoletes RFC 2373)

- Address Types are:
  - **Unicast**: One to One (Global, Link local, Site local, Compatible)
  - **Anycast**: One to Nearest (Allocated from Unicast)
  - **Multicast**: One to Many

- A single interface may be assigned multiple IPv6 addresses of any type (unicast, anycast, multicast)
IPv6 - Addressing Model

Addresses are assigned to interfaces:
   Interface 'expected' to have multiple addresses

Addresses have scope:
   - Link Local
   - Site Local
   - Global

Addresses have lifetime:
   - Valid and Preferred lifetime

Site-Local Address Deprecated in RFC 3879 now it is Unique Local Address (ULA) RFC 4193
Aggregatable global unicast addresses are:
- Addresses for generic use of IPv6
- Structured as a hierarchy to keep the aggregation

See RFC 4291
Link-Local

- Link-local addresses:
  - Have a limited scope of the link
  - Are automatically configured with the interface ID
Unique-Local

- Unique-local addresses used for:
  - Local communications
  - Inter-site VPNs
  - Not routable on the Internet
Aggregatable Global Unicast Addresses

- Lowest-order 64-bit field of unicast addresses may be assigned in several different ways:
  - Manually configured
  - Auto-configured from a 64-bit EUI-64, or expanded from a 48-bit MAC address (e.g. Ethernet address)
  - Auto-generated pseudo-random number (to address privacy concerns)
  - Assigned via DHCP
- EUI-64 address is formed by inserting "FFFE" and ORing a bit identifying the uniqueness of the MAC address.
Interface Identifier: Example

MAC address: 00-08-0d-4e-6b-c6

IPv6 link prefix: 2001:648:2320:1::/64


Toshiba Interface!

EUI-64: 0008:0d ff:fe 4e:6bc6

IPv6 Dissemination and Exploitation

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Anycast Addresses (RFC 3513)

- "Anycast addresses allow a packet to be **routed to one of a number** of different nodes all responding to the same address »
- "Anycast addresses are taken from the unicast address spaces (of any scope) and are not syntactically distinguishable from unicast addresses … it may be assigned to an IPv6 router only »
Anycast Addresses
(RFC 3513)

- Anycast address …
  - … can not be a used as a source address of an IPv6 packet
  - … must be assigned only to routers
- Reserved anycast addresses are defined in RFC 2526
Anycast Address

- Anycast:
  - Syntactical the same as a Unicast address
  - Is one-to-nearest type of address
  - Has a current limited use

Prefix

128 bits

(128-n) bits

X

If EUI-64 Format

If Non-EUI-64 Format

Reserved Subnet Anycast address

Subnet Router Anycast address

111111X111111... 111

Prefix

128 bits

00000

Anycast ID

7 bits

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Multicast

- Multicast is used in the context of one-to-many
- A multicast scope is new in IPv6

Flag =
- 0 If Permanent
- 1 If Temporary

Scope =
- 1 = Node
- 2 = Link
- 5 = Site (Deprecated)
- 8 = Organization
- E = Global