IPv6

CERN, 6th June 2012 - IPv6 day
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IPv6 day: 6th of June 2012

http://www.worldipv6day.org/
IPv6 and IPv4
Addresses
IP addresses

IPv4
32 bits
Written as 4 groups of 8 bits, decimal notation: 

\[137.138.10.16\]
(correspond to: 89.8A.0A.10 Hex)

IPv6
128 bits
Written as 8 groups of 16 bits, hexadecimal notation:

\[2001:0db8:a137:b138:c000:d000:e000:f001\]
Subnets

IPv4
Netmask (0s in the host part):
\[137.138.10.0 \ 255.255.255.0\]
Prefix length (number of bits used for the network address):
\[137.138.10.0/24\]

IPv6
Only prefix length:
\[2001:0db8:a137:b138::/64\]
Host part is omitted
Smallest network: /64 (recommendation)
## Network and Host parts

<table>
<thead>
<tr>
<th>1</th>
<th>16</th>
<th>32</th>
<th>48</th>
<th>64</th>
<th>80</th>
<th>92</th>
<th>108</th>
<th>128</th>
</tr>
</thead>
</table>

- **Site prefix**
- **Subnet**
- **Host**
Number of addresses

**IPv4**

32 bits means $2^{32} \approx 4$ billions

**IPv6**

128 bits means $2^{128} \approx$ infinite

A normal allocation for a site/company (/32) gives:
- $2^{32}$ subnets (the whole IPv4 space)
- $2^{64}$ host addresses per subnet (25000 hosts per square meter on earth, per subnet)
IPv6 notation

IPv6
Leading 0s can be omitted:

2001:0db8:a100:0001:0020:0300:0000:4000

can also be written:

2001:db8:a100:1:20:300:0:4000

Groups of four 0s can be omitted and replaced by :: (only once):

2001:0db8:a137:0000:0000:abcd:0000:1234

can also be written:

2001:0db8:a137::abcd:0:1234
## Special addresses

<table>
<thead>
<tr>
<th></th>
<th>IPv4</th>
<th>IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loopback</td>
<td>127.0.0.1</td>
<td>::1</td>
</tr>
<tr>
<td>Unspecified address</td>
<td></td>
<td>::</td>
</tr>
<tr>
<td>Link Local</td>
<td></td>
<td>FE80::/10</td>
</tr>
<tr>
<td>Unique Local</td>
<td>10.0.0.0/8 (RFC1918)</td>
<td>FC00::/7</td>
</tr>
<tr>
<td>Default route</td>
<td>0.0.0.0/0</td>
<td>::/0</td>
</tr>
<tr>
<td>Multicast</td>
<td>224.0.0.0/4</td>
<td>FF00::/8</td>
</tr>
<tr>
<td>Documentation</td>
<td></td>
<td>2001:DB8::/32</td>
</tr>
</tbody>
</table>

Broadcast vs Multicast

IPv4 uses broadcast to reach all the nodes on a subnet: **255.255.255.255**

Broadcast addresses no longer exist in IPv6, but special multicast addresses for groups of hosts. Some examples:

All Nodes Addresses:
- **FF02::1** (link-local)

All Routers Addresses:
- **FF02::2** (link-local)
- **FF05::2** (site-local)

All DHCPv6 servers:
- **FF02::1:2** (link-local)
- **FF05::1:3** (site-local)

Packets
IP headers

IPv4 header

IPv6 header

Fragmentation

**IPv4**: When a packet is too big for the next link over which it is to travel, it can be fragmented by the sender (host or router).

**IPv6**: Fragmentation can only occur at the source node, and reassembly is only done at the destination node.

IPv6 routers never fragment IPv6 packets. Packets exceeding the size of the maximum transmission unit of the destination link are dropped and this condition is signaled by a Packet too Big ICMPv6 type 2 message to the originating node, similarly to the IPv4 method when the Don't Fragment bit set.

End nodes in IPv6 are expected to perform path MTU discovery to determine the maximum size of packets to send, and the upper-layer protocol is expected to limit the payload size. However, if the upper-layer protocol is unable to do so, the sending host may use the Fragment extension header in order to perform end-to-end fragmentation of IPv6 packets.

IPv4:
Minimum MTU = 576 Bytes
Maximum MTU = 65535 \( (2^{16} - 1) \) Bytes

IPv6:
Minimum MTU = 1280 Bytes
Maximum MTU = 4294967295 \( (2^{32} - 1) \) Bytes
Protocols
Neighbor discovery

IPv4: **ARP**  Address Resolution Protocol

IPv6: **NDP**  Neighbor Discovery Protocol
NDP specifies 5 types of ICMP packets:

- **Router Advertisement (RA):** periodic advertisement of the availability of a router
- **Router Solicitation (RS):** the host needs RA immediately (at boot time)
- **Neighbor Solicitation (NS):** to determine the link-layer address of a neighbor (equivalent to ARP request)
- **Neighbor Advertisement (NA):** answer to a NS packet (equivalent to ARP reply)
- **Redirect:** Used by a router to inform a host of a better route to a given destination

Host Auto-configuration

IPv4: **DHCP**

IPv6: **SLAAC** StateLess Address AutoConfiguration
**DHCPv6**
IPv6 hosts can configure themselves automatically when connected to a routed IPv6 network using ICMPv6 router discovery (RD) messages and EUI-64 for their own unique address.

Routers respond to those requests with a router advertisement (RA) packet that contains network configuration parameters (subnet, default gateway).

EUI-64 is an identifier used to generate a unique host address from the MAC address.

MAC address: 00 12 34 56 78 9A

FFFE inserted: 00 12 34 FF FE 56 78 9A

Bit 7 is inverted: 0000 0000

EUI-64 address: 02 12 34 FF FE 56 78 9A

Routing

**RIP**(v2) IPv4 only

**RIPng** IPv6 only

**OSPF**(v2) IPv4 only

**OSPFv3** IPv6 only

**ISIS** IPv4 and IPv6

**Multiprotocol BGP** IPv4 and IPv6
Deployment
Change your mindset

- No fear to waste
- Multiple addresses per interface, even in the same IPv6 subnet
- No NAT (not even designed)
Transition strategies

**Bridging:**

IPv4 network → Address Translator IPv4/IPv6 bridge → IPv6 Internet

IPv6 network → Address Translator IPv4/IPv6 bridge → IPv4 Internet

**Dual Stack:**

IPv4 Internet → IPv6 Internet
Transition

Bridging

- doesn't scale
- no end-to-end connectivity
- all typical issues of NAT
- may be good for an easy start

Dual-Stack

- The way to go!
Hands-On
Start IPv6: Linux

- **SLC5**: IPv6 may be disable. Edit the file `/etc/modprobe.conf` and remove the lines disabling ipv6 (`#alias ipv6 off, #options ipv6 disable=1`); then reboot

- **Others**: on by default
Start IPv6: MacOS X

Enable IPv6 in System Preference, Network:
Start IPv6: Windows

- **Windows 7**: on by default
- **Windows Vista**: on by default
- **Windows XP**:

  1. Open Network Connections
  2. Right-click any local area connection, and then click Properties.
  3. Click Install.
  4. In the Select Network Component Type dialog box, click Protocol, and then click Add.
  5. In the Select Network Protocol dialog box, click Microsoft TCP/IP version 6, and then click OK.
  6. Click Close to save changes to your network connection.
Check IPv6: Linux

marit> `ifconfig`

wlan0  Link encap:Ethernet  HWaddr cc:af:78:b0:d5:f4
inet addr:128.141.237.134  Bcast:128.141.255.255  Mask:255.255.0.0
inet6 addr: 2001:1458:202:180::ad02:b668:dca8:5d0a/64 Scope:Global
inet6 addr: fe80::ceaf:78ff:fe00:d5f4/64 Scope:Link
UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
RX packets:95074 errors:0 dropped:0 overruns:0 frame:0
TX packets:27280 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:58292242 (58.2 MB)  TX bytes:3596671 (3.5 MB)

marit> `ip -6 route`

2001:1458:201:b130::/64 dev wlan0  proto kernel  metric 256
fe80::/64 dev wlan0  proto kernel  metric 256
default via 2001:1458:202:180::1 dev wlan0  metric 1024
Check IPv6: MacOS X

mac$ `ifconfig`
en1: flags=8863<UP,BROADCAST,SMART,running,SIMPLEX,MULTICAST> mtu 1500
ether e4:ce:8f:0a:66:08
inet6 fe80::e6ce:8fff:fe0a:6608%en1 prefixlen 64 scopeid 0x6
inet 128.141.236.202 netmask 0xffffff000 broadcast 128.141.255.255
media: autoselect
status: active

mac$ `netstat -rn`
Routing tables
Internet6:
<table>
<thead>
<tr>
<th>Destination</th>
<th>Gateway</th>
<th>Flags</th>
<th>Netif</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>fe80::218:71ff:febb:6e00%en1</td>
<td>UGc</td>
<td>en1</td>
</tr>
<tr>
<td>::1</td>
<td>::1</td>
<td>UH</td>
<td>lo0</td>
</tr>
<tr>
<td>2001:1458:202:167::/64</td>
<td>link#6</td>
<td>UC</td>
<td>en1</td>
</tr>
<tr>
<td>2001:1458:202:167::1</td>
<td>a:0:30:b0:20:c1</td>
<td>UHLW</td>
<td>en1</td>
</tr>
</tbody>
</table>
Check IPv6: Windows 7

C:\> ipconfig
Wireless LAN adapter Wireless Network Connection:
  Link-local IPv6 Address . . . . : fe80::b87d:a686:7f8f:cb3b%12
  IPv4 Address . . . . . . . . . . . . . : 128.141.237.112
  Subnet Mask . . . . . . . . . . . . . : 255.255.0.0
  Default Gateway . . . . . . . . : fe80::215:60ff:feed:ce00%12
                                 128.141.1.1

C:\> netstat -rn
===========================================================================
Interface List
12...00 1e 65 71 8b 0a ......Intel(R) WiFi Link 5100 AGNIPv6 Route Table
===========================================================================
Active Routes:
If Metric Network Destination      Gateway
12    281 ::/0                     fe80::215:60ff:feed:ce00
1    306 ::1/128                  On-link
12     33 2001:1458:202:180::/64   On-link
12    281 fe80::/64                On-link
12    281 fe80::b87d:a686:7f8f:cb3b/128
Check IPv6: http://ipv6-test.com
Check IPv6: http://test-ipv6.com
Check IPv6: SixOrNot Firefox Add-on

SixOrNot 0.7.3
By Timothy Baldock

IPv6 status indicator

This extension allows you to see at a glance whether the site you are connecting to supports the current generation of the Internet Protocol (IPv6) and whether you are connecting using the same. A panel can be opened to provide more detailed information about the remote site’s IP addresses, including information about all the domains contacted in order to load the page.

The icon can be shown either in the address bar or as a toolbar button, permitting positioning almost anywhere within the Firefox window.

This addon does not consult with any external service to determine your own IP address, avoiding any privacy concerns arising from such behaviour. A major advantage this addon has over similar IP address addons is that it tries to make use of platform-native methods for determining local IP addresses and resolving remote ones. This permits a more accurate assessment of your IPv4/IPv6 connectivity.

It also combines the connection-address-only approach of other addons with DNS resolution. This allows you to see when you are connecting via IPv4, but the remote site has the capability to be contacted via IPv6.

Automatic Updates: Default, On, Off
Last Updated: 02/17/2012
Homepage: http://entropy.me.uk/sixornot/
Rating: 3 out of 5 stars, 10 reviews
Show addressbar icon: On, Off
Greyscale mode: On, Off
A badly configured server may cause delays in the clients:

host> telnet v6test.ipv6.cern.ch 80
Trying 2001:1458:201:b130::191...
Trying 137.138.32.137...
Connected to v6test.ipv6.cern.ch.
Escape character is '^['].
Questions?
CERN IPv6 Service
Service description

- Dual Stack
- One IPv6 address associated to every IPv4 one
- Same performance as IPv4 (wire speed)
- Common provisioning tools for IPv4 and IPv6
  (cfmgr, csdbweb...)
- Same network services portfolio as IPv4
  (Gates, DNS, DHCP, NTP, Radius...)
- Common security policies for IPv4 and IPv6
CERN IPv6 prefixes

Public prefix 2001:1458::/32
(public addresses like 137.138.0.0/16,
full Internet connectivity)

Local prefix FD01:1458::/32
(private addresses like 10.0.0.0,
no Internet connectivity)
User services

One (or more) IPv6 subnet per physical subnet, together with the IPv4 subnet.

Subnet size: /64 everywhere
Infrastructure management

Addresses assigned by DHCPv6
IPv6 host addresses assigned by DHCPv6 servers, based on the MAC address declared in the Network database (LANDB)

No Auto Configuration
SLAAC disabled and all Router Advertisement messages filtered
Network Services

DNS, DHCPv6, Radius and NTP:
available over IPv6

The existing IPv4 DNS, Radius and NTP servers will also provide the IPv6 services.

DHCPv6 and DHCP(v4): two services running on the same physical server.
Many changes necessary to the Network Database schema (LANDB)

- Much more new information to store
- IPv6 will become the main navigation source
- The new schema is compatible with existing applications and queries
- Many applications to be changed to handle IPv6 information
- Assignment of an IPv6 address to any existing IPv4 one
Security

The same IPv4 security policies will be applied to the IPv6 network service

Every existing IPv4 firewall rule will be extended with IPv6 information
IPv6 ready flag

The DNS name **DEVICE-XYZ.cern.ch** will be resolved only with the IPv4 address until the responsible of the device declares it is “IPv6 Ready”

“IPv6 Ready” means:
- IPv6 connectivity is OK
- All the server's applications are listening on both IPv4 and IPv6 protocols

Consequences:
- IPv6 openings activated in the central firewall
- The DNS query for DEVICE-XYZ.cern.ch will returns both IPv6 and IPv4 addresses
Not "IPv6 ready" means:
- Still testing IPv6 or Client-Only machine

Consequences:
- No IPv6 security openings in the central firewall
- Name DEVICE-XYZ.cern.ch for IPv4 address
- Name DEVICE-XYZ.IPv6.cern.ch for IPv6 address
Testbed

IPv6 Internet

IPv4 Internet

CERN network

IPv6 firewall

IPv4 firewall

IPv4/IPv6 Dual-Stack network
IPv6 only network
IPv4 only network

LCG IPv4/IPv6 router
IPv6/IPv4 Virtual Machines

GPN IPv4/IPv6 router
IPv4/IPv6 Virtual Machines
Risks
The choice of the IP protocol to be used is up to the client application, based on the DNS reply and its own settings.

I want to see http://edh.cern.ch

edh.cern.ch is either:
IPv6 2001:1458:8001::68
IPv4 137.138.7.65

I prefer IPv6; connect to 2001:1458:8001::68 TCP port 80 then

...20 to 180 seconds later...

No IPv6 reply yet? Let's try 137.138.7.65 TCP port 80 then

Dear client, here is the EDH page

Problem: DNS is not application aware!
Multiple services

Servers cannot decide which IP protocol the client will use.
IPv6 can be avoided by the DNS not returning the IPV6 address

I want to see http://edh.cern.ch

For the time being edh.cern.ch is only IPv4 137.138.7.65

Although I'd prefer IPv6, I'll connect to 137.138.144.168 TCP port 80
Broken connectivity

If broken IPv6 connectivity, clients will wait up to 180secs before falling back to IPv4

If degraded IPv6 connectivity, fall back will never occur

Client's perception: there's a server issue
Questions?