IPv6

CERN, 6th June 2012 - IPv6 day
edoardo.martelli@cern.ch
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


Site prefix-subnet-host
Number of addresses

**IPv4**

32 bits means $2^{32} \sim= 4$ billions

**IPv6**

128 bits means $2^{128} \sim= \text{infinite}$

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:

\[2001:0\text{db8:a100:0001:0020:0300:0000:4000}\]

can also be written:

\[2001:\text{db8:a100:1:20:300:0:4000}\]

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

\[2001:0\text{db8:a137:0000:0000:abcd:0000:1234}\]

can also be written:

\[2001:0\text{db8:a137::abcd:0:1234}\]
## 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**

- Version
- IHL
- Type-of-Service
- Total Length
- Identification
- Flags
- Fragment Offset
- Time to Live
- Protocol
- Header checksum
- Source address
- Options

**IPv6 header**

- Version
- Traffic Class
- Flow Label
- Payload Length
- Next Header
- Hop Limit
- Source address
- Destination address

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.
MTU

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
0000 0010

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:

Dual Stack:
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:feb0: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 0xffffff0000 broadcast 128.141.255.255
media: autoselect
status: active

mac$ **netstat -rn**
Routing tables
Internet6:
Destination Gateway Flags Netif
**default** fe80::218:71ff:febb:6e00%en1 UGc en1
::1 ::1 UH lo0
2001:1458:202:167::/64 link#6 UC en1
2001:1458:202:167::1 a:0:30:b0:20:c1 UHLW en1
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
          On-link
          On-link
  12    281 fe80::/64               On-link
  12    281 fe80::b87d:a686:7f8f:cb3b/128


Check IPv6: http://ipv6-test.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

<table>
<thead>
<tr>
<th>Default</th>
<th>Off</th>
</tr>
</thead>
</table>

Last Updated

02/17/2012

Homepage

http://entropy.me.uk/sixornot/

Rating

4.33 out of 5 stars 10 reviews

Show addressbar icon

Sets whether the SixOrNot icon is shown in the address bar or not

Greyscale mode
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 '^['].
More information:
http://cern.ch/ipv6