IPv6

CERN, 6th June 2012 - IPv6 day

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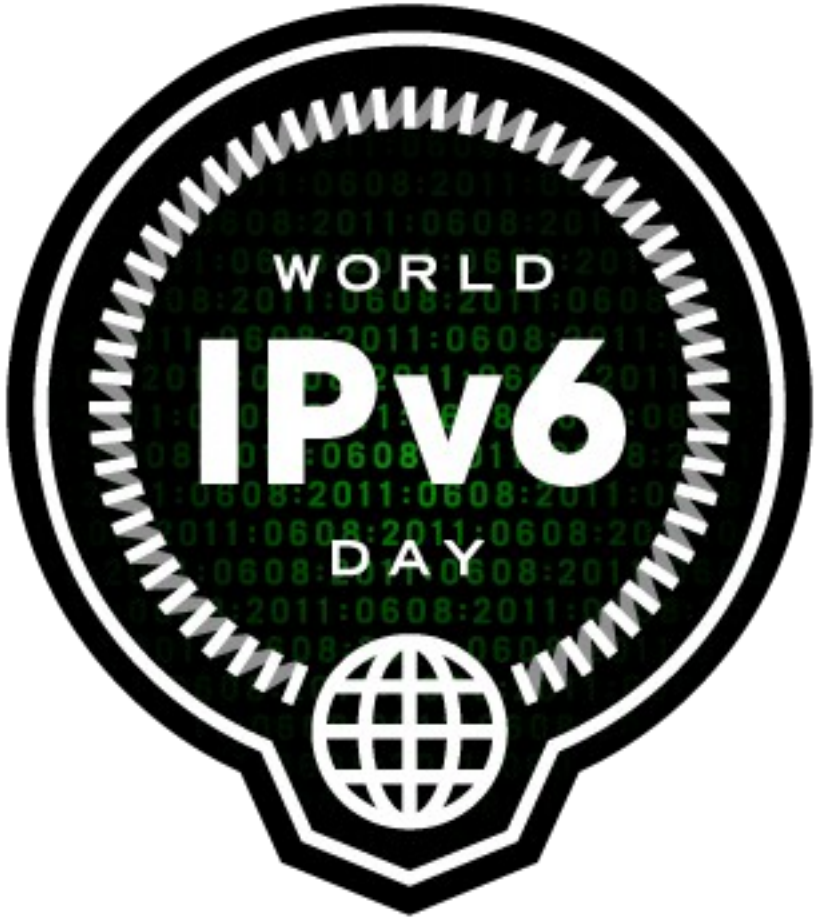
IPv6 day: 6th of June 2012



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

Number of addresses

IPv4

32 bits means 2^{32} ~= 4 billions

IPv6

128 bits means 2^{128} ~= 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

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

[http://tools.ietf.org/html/rfc4291]

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)

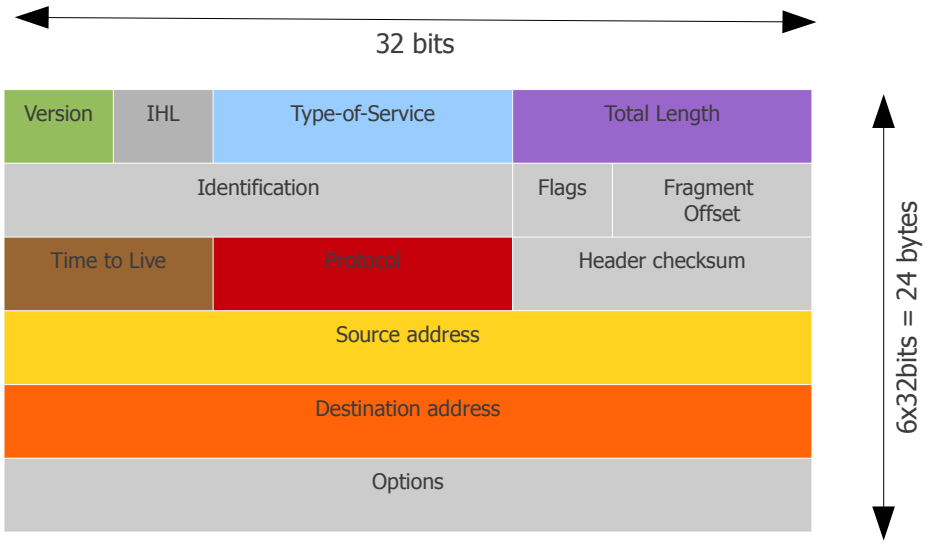
FF05::1:3 (site-local)

[http://tools.ietf.org/html/rfc2375]

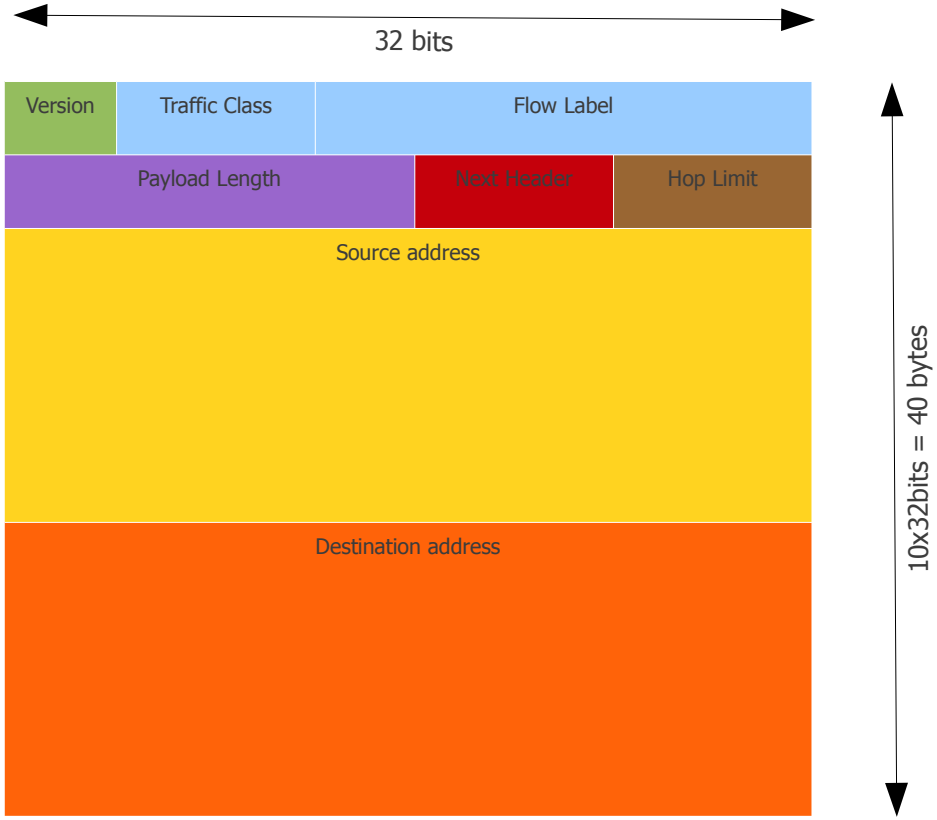
Packets

IP headers

IPv4 header



IPv6 header



[http://tools.ietf.org/html/rfc2460]

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.
[http://en.wikipedia.org/wiki/IPv6_packet#Fragmentation]

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

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

[http://tools.ietf.org/html/rfc4861]

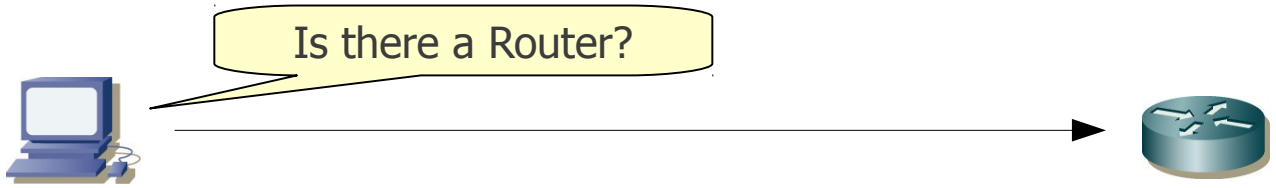
Host Auto-configuration

IPv4: **DHCP**

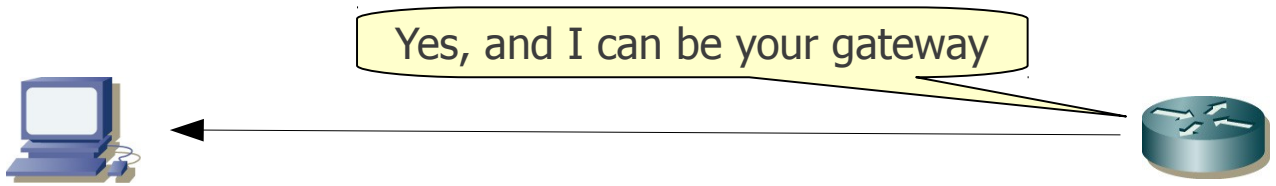
IPv6: **SLAAC** StateLess Address AutoConfiguration
DHCPv6

SLAAC

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).



[http://tools.ietf.org/html/rfc2462]

EUI-64

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

[http://tools.ietf.org/html/rfc3513]

Routing

RIP(v2) IPv4 only

RIPng IPv6 only

OSPF(v2) IPv4 only

OSPFv3 IPv6 only

ISIS IPv4 and IPv6

Multiprotocol BGP IPv4 and IPv6

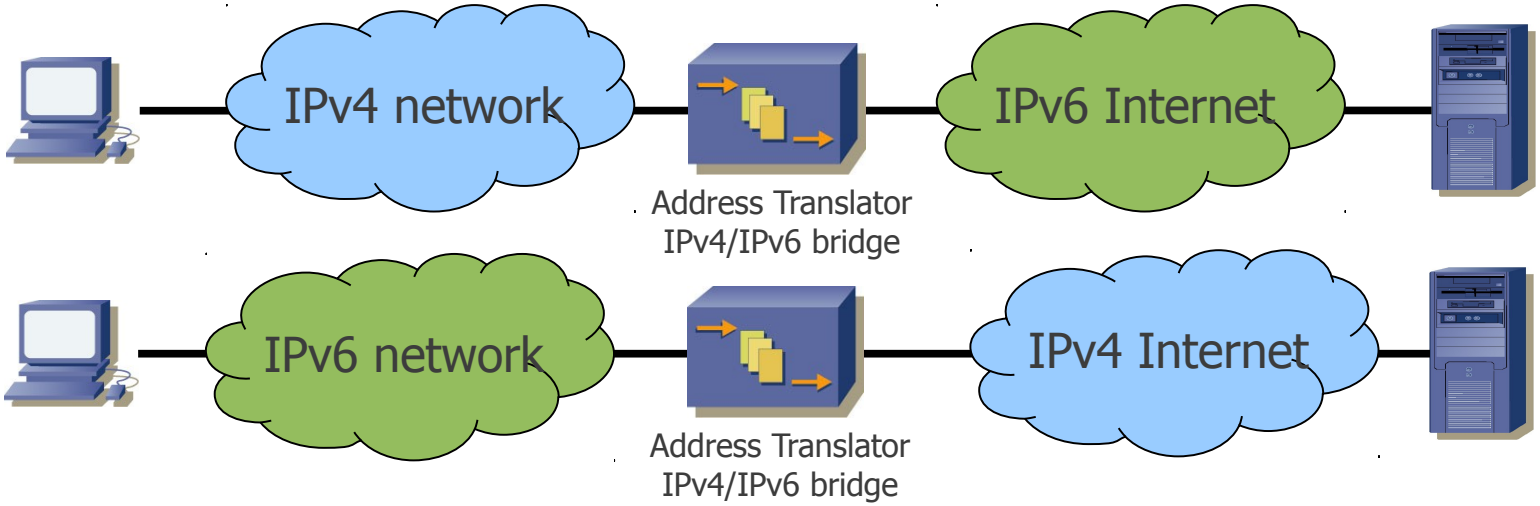
Deployment

Change your mindset

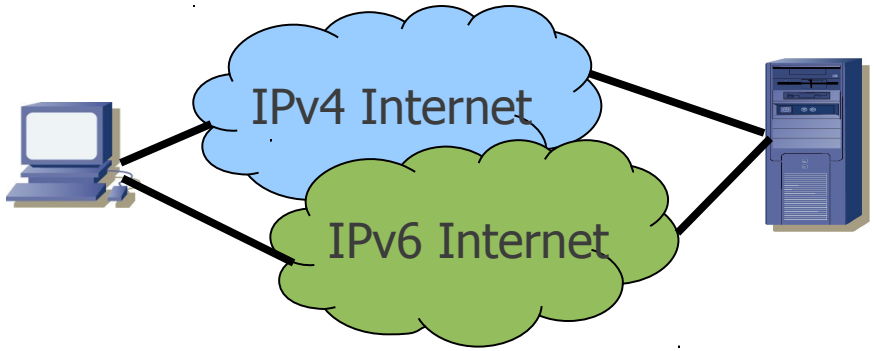
- No fear to waste
- Multiple addresses per interface, even in the same IPv6 subnet
- No NAT (not even designed)

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

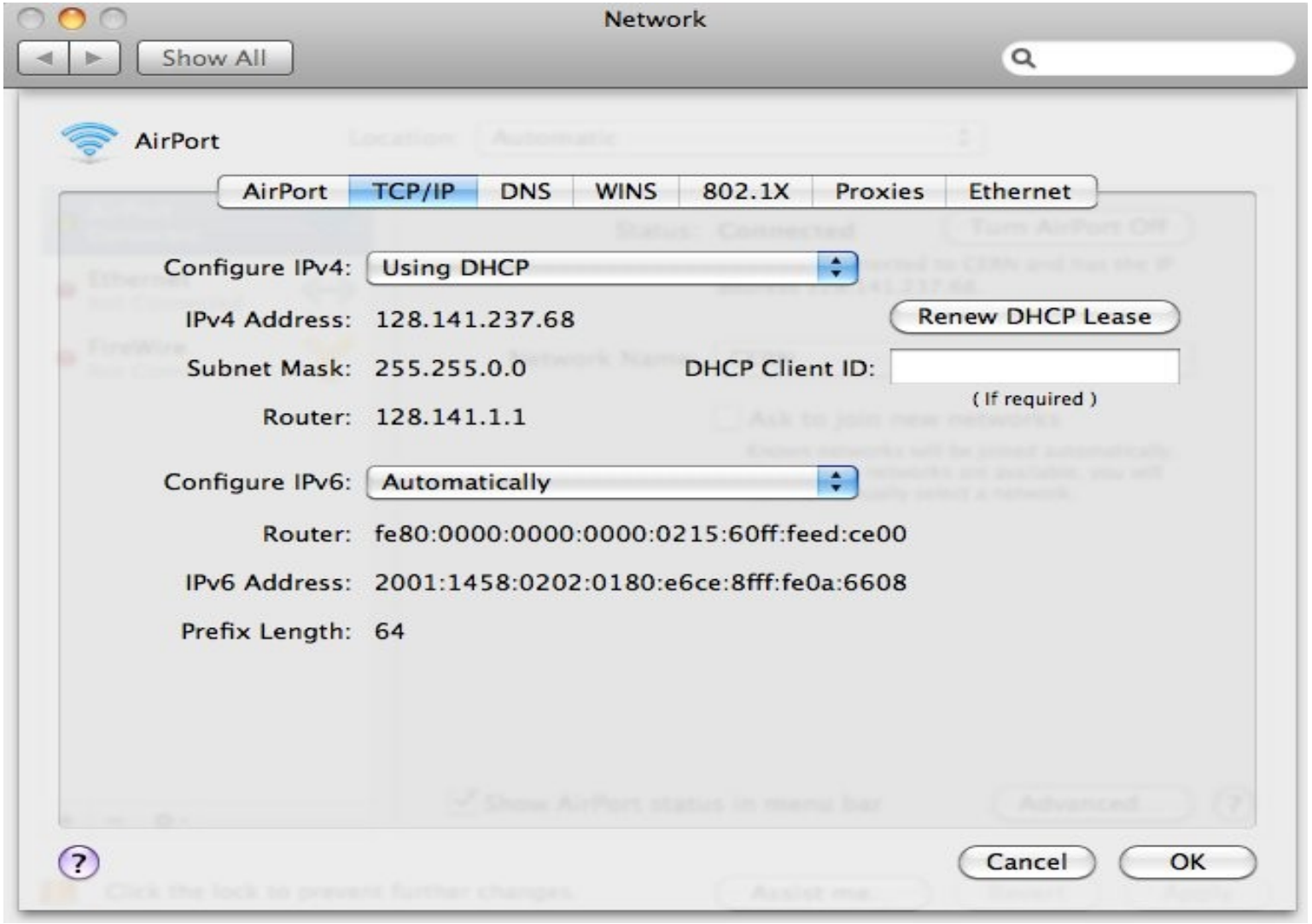
Start IPv6: Linux

- **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

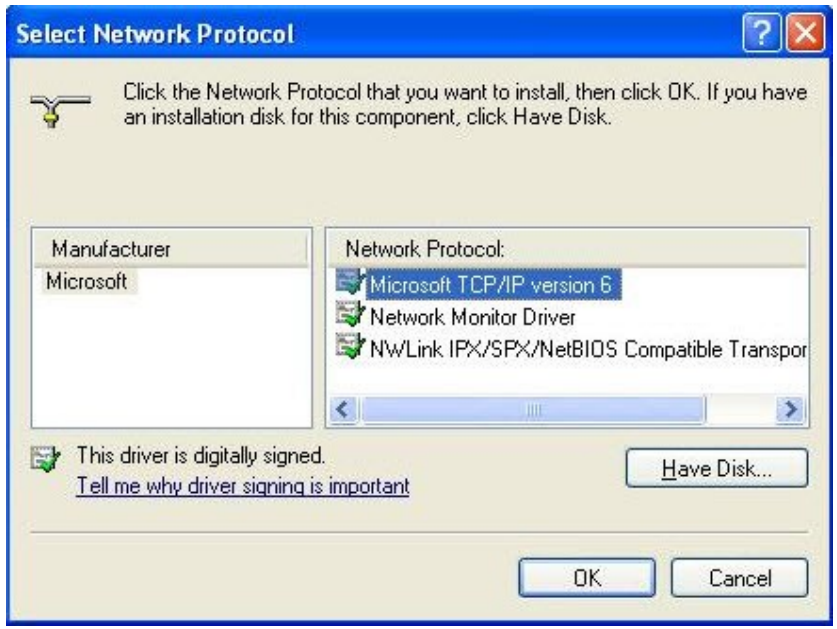
Enable IPv6 in System Preference, Network:



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: 2001:1458:202:180:ceaf:78ff:feb0:d5f4/64 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
      inet6 2001:1458:202:167:e6ce:8fff:fe0a:6608 prefixlen 64 autoconf
      inet 128.141.236.202 netmask 0xffff0000 broadcast 128.141.255.255
      media: autoselect
      status: active
```

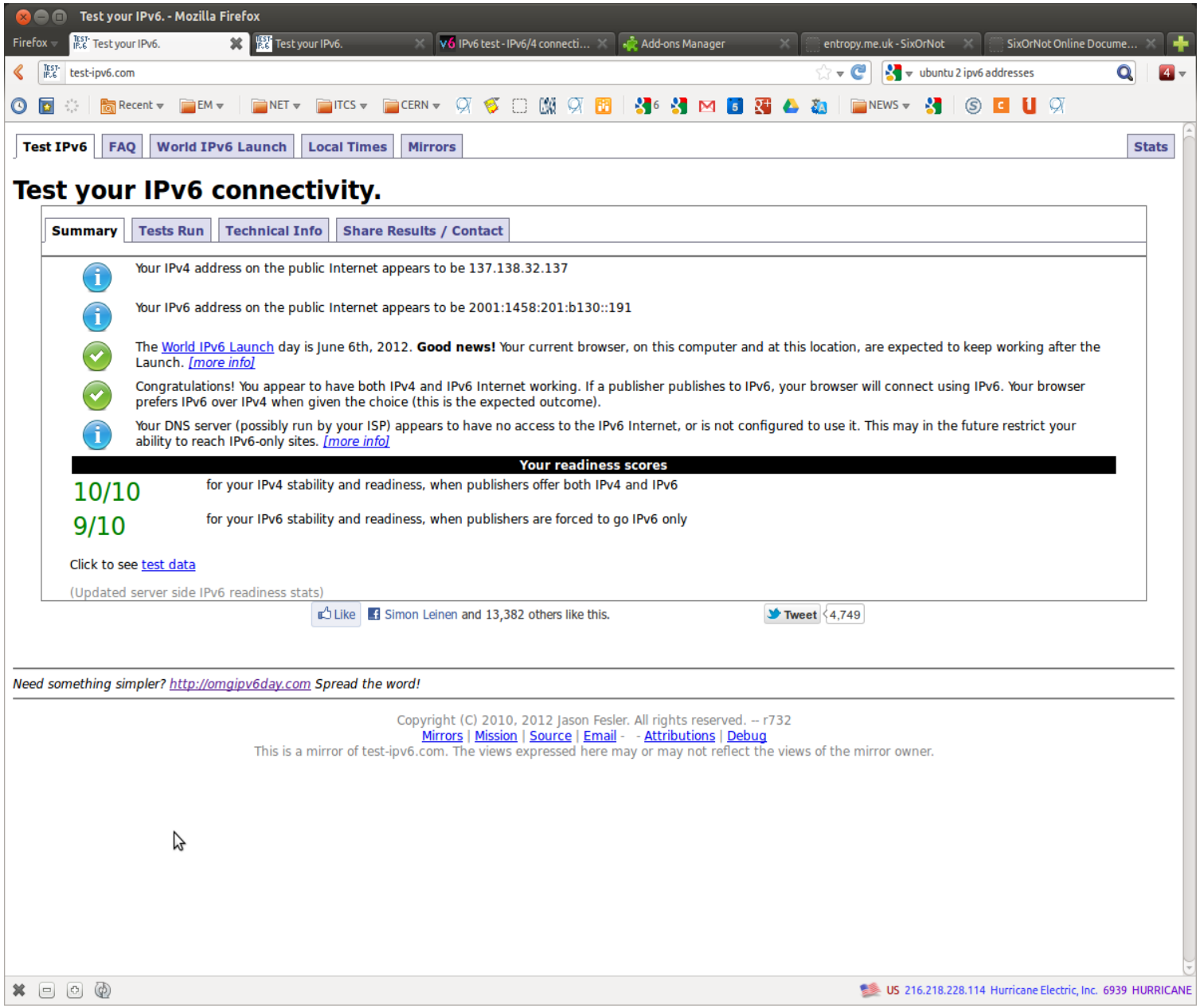
```
mac$ netstat -rn
Routing tables
Internet6:
Destination                 Gateway                           Flags     Netif
default                     fe80::218:71ff:febb:6e00%en1      UGc       en1
::1                         ::1                               UH        lo0
2001:1458:202:167::/64      link#6                            UC        en1
2001:1458:202:167::1        a:0:30:b0:20:c1                   UHLW      en1
```

Check IPv6: Windows 7

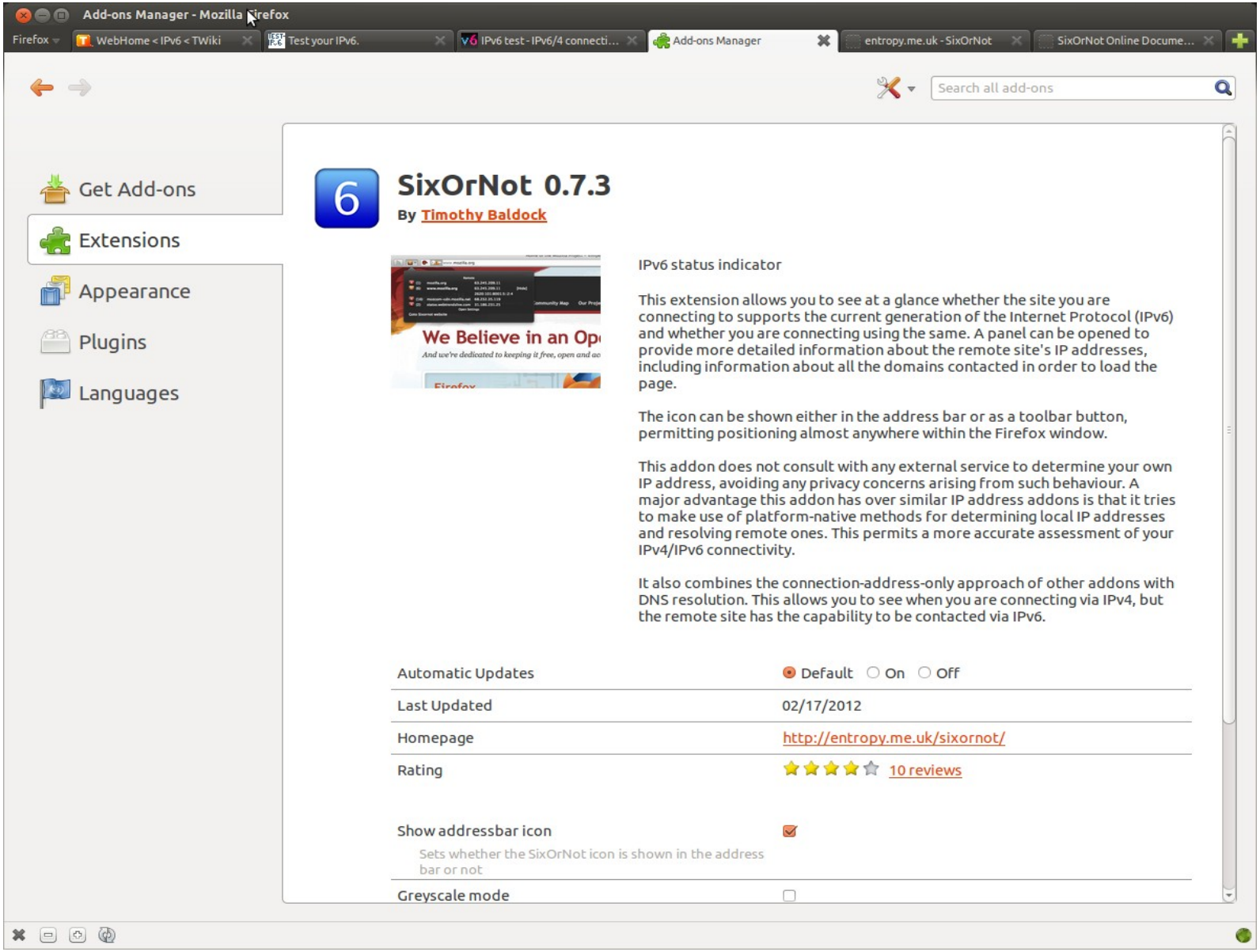
```
C:\>ipconfig
Wireless LAN adapter Wireless Network Connection:
   IPv6 Address. . . . . . . . . . . : 2001:1458:202:180:b87d:a686:7f8f:cb3b
   Temporary IPv6 Address. . . . . . : 2001:1458:202:180:dc2d:e953:1553:2b2c
   Link-local IPv6 Address . . . . . : fe80::b87d:a686:7f8f:cb3b%12
   IPv4 Address. . . . . . . . . . . : 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 2001:1458:202:180:b87d:a686:7f8f:cb3b/128
                                   On-link
12    281 2001:1458:202:180:dc2d:e953:1553:2b2c/128
                                   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



Server issue

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