ICPSR

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IPv6 on Linux servers

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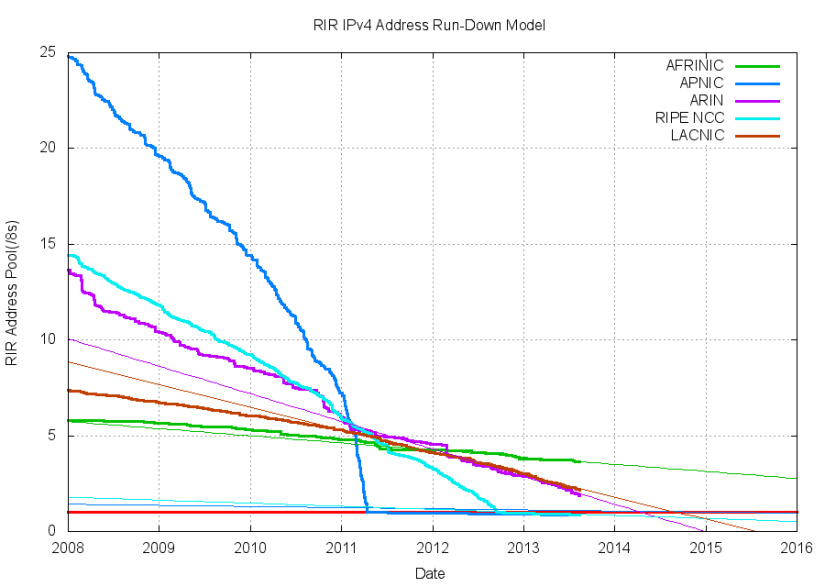
Why IPv6?

- 7 Billion people
- 4 Billion IPv4 addresses (2^{32})
- 340,282,366,920,938,000,000,000,000,000,000,000,000 IPv6 addresses (2^{128})

IPv4 Address Depletion



http://www.potaroo.net/tools/ipv4/index.html

So What?

- NAT is horrendous
- Multi-layer NAT makes regular NAT look good
- “Polluted” address space (1.1.1.1?)
- Even if we at UM do not run out of addresses, much of the rest of the world will, and we need to talk to them.
- Microsoft paid $11.25/address in 2011

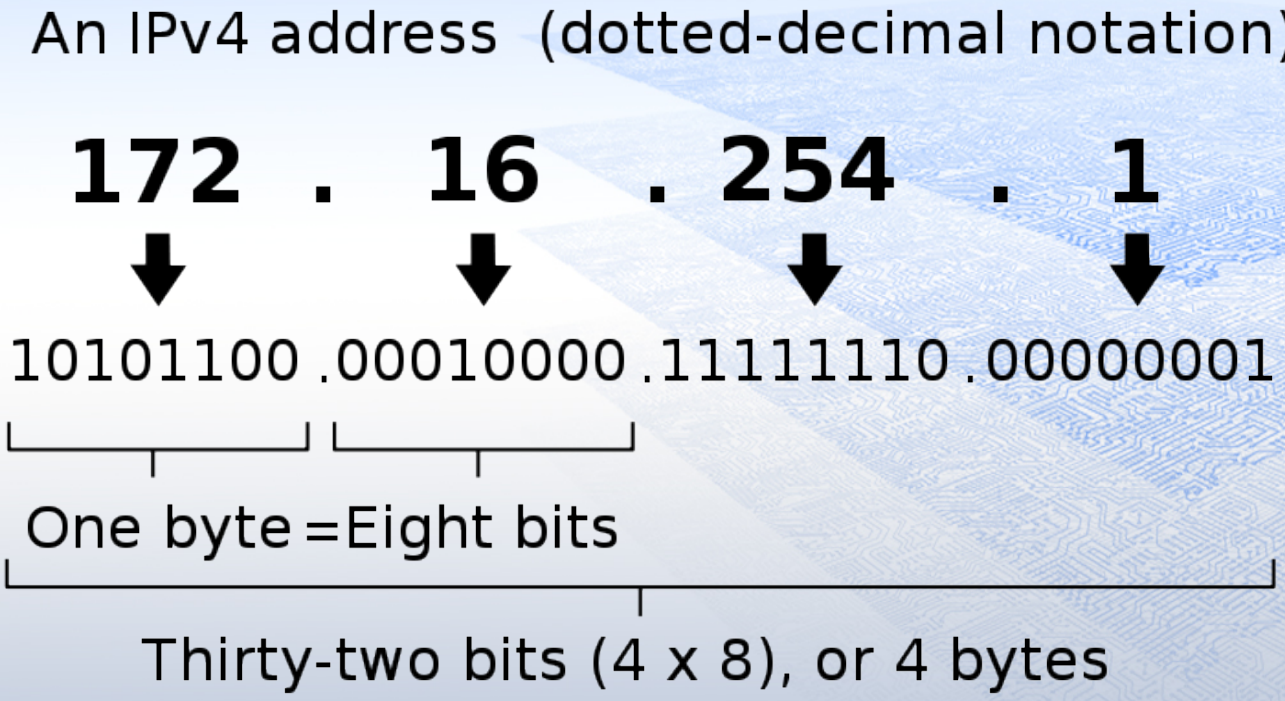
The network is changing

- Our choice is *not* whether we stick with the tried and true, or we migrate to IPv6.

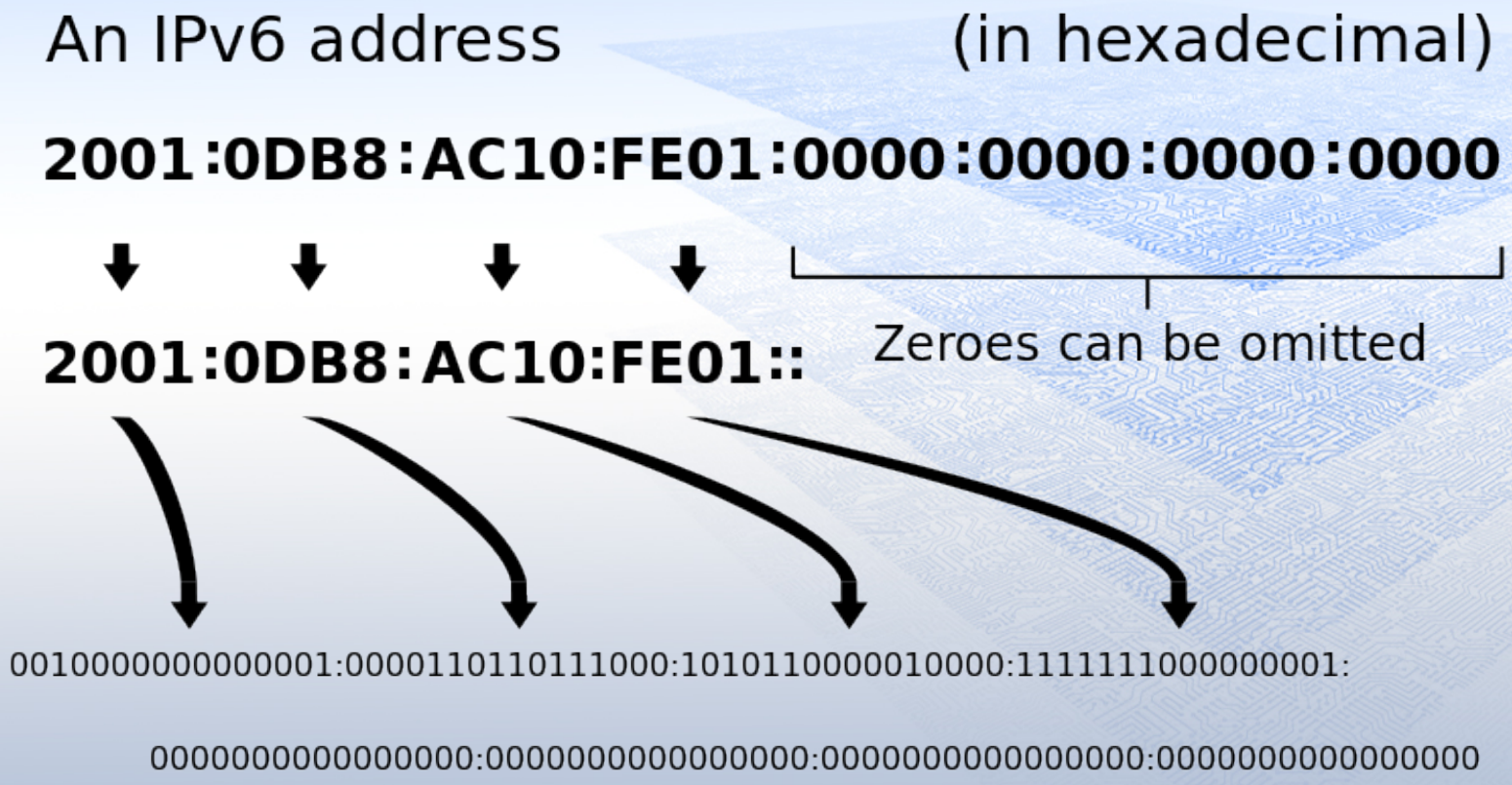
Let's Dive In

```
eth0 Link encap:Ethernet  HWaddr 52:54:00:F1:A7:B9
     inet addr:141.211.255.68  Bcast:141.211.255.71
               Mask:255.255.255.248
     inet6 addr: 2607:f018:704:ffff:5054:ff:fef1:a7b9/64
               Scope:Global
     inet6 addr: fe80::5054:ff:fef1:a7b9/64 Scope:Link
     inet6 addr: 2607:f018:704:ffff::68/64 Scope:Global
     UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
     RX packets:45374 errors:0 dropped:0 overruns:0 frame:0
     TX packets:14725 errors:0 dropped:0 overruns:0 carrier:0
     collisions:0 txqueuelen:1000
     RX bytes:12914756 (12.3 MiB)  TX bytes:1799962 (1.7 MiB)
```

IPv4 address structure – 32 bits



IPv6 Address structure – 128 bits



Real World Example

- 2607:f018:0704:ffff:0000:0000:0000:0068/64
- 2607:f018:704:ffff::68/64

What's the /64?

- This is the subnet mask; it shows the number of address bits used for the local LAN vs. the rest of the Internet.
- Just like in IPv4
- 10.224.146.1/255.255.255.0

  10.224.146.1/24
- 141.211.255.68/255.255.255.248

  141.211.255.68/29

Static Addressing

- Some things don't change much

```
inet6 addr: 2607:f018:704:ffff::68/64 Scope:Global
```

What about the broadcast?

- There isn't one.
- Functions formerly done via broadcast are done via (more targeted) multicasts.
- You don't have to configure broadcast or multicast addresses on interfaces.
- It's an anachronism on IPv4 anyway. I've never used an IPv4 network where it couldn't be computed from the address and netmask.

Link-local address

- Used for various low-level purposes
- Never routed off your subnet
- If everything is working you don't need to worry about this

```
inet6 addr: fe80::5054:ff:fef1:a7b9/64 Scope:Link
```

2 Ways of Automatic Addressing

- DHCPv6
  - Much like the DHCP you are used to, but not supported on all OSes
- Stateless address autoconfiguration (SLAAC)
  - Lighter-weight; runs on routers, arguably lower security
  - Combination of router discovery and node auto-addressing (EUI-64 or privacy)

EUI-64 addressing

- My ethernet address is 52:54:00:F1:A7:B9
- 2607:f018:704:ffff:5054:ff:fef1:a7b9/64
- 2607:f018:704:ffff:5054:00ff:fef1:a7b9/64
- Flip the seventh bit of the first byte: 52->50 (local vs. global)
- 2607:f018:704:ffff:5054:00ff:fef1:a7b9/64

Privacy Addresses

- Use a random 64-bit number
- Rotate periodically
- Privacy win; manageability lose
- On by default in windows client OSes

New messages in ICMPv6

- Router Solicitation/Advertisement (DHCP,RIP)
- ND - Neighbor Solicitation (ARP)
- MLD Multicast listener discovery (was IGMP)

Transition Strategies

- Dual Stack
  - Do both in parallel
  - Presumably what we will use at UM
- Backward Compatibility for IPv6-only networks
  - NAT64/DNS64

Tunneling & transition mechanisms

- There are various tunneling options for IPv4 users to get to the IPv6 internet. Don't, except maybe to experiment.
  - Teredo, 6to4, 6rd, ISATAP
  - Large v6 servers might want to install 6to4 and Teredo gateways
- Happy Eyeballs
  - Apps and OS will prefer IPv6 if it exists.
  - User may have good IPv4 but broken IPv6 connectivity.

You said this talk would be about servers.

IP addressing on Red Hat & derivatives

- /etc/sysconfig/network

```
NETWORKING_IPV6=true
```

- /etc/sysconfig/network-scripts/ifcfg-eth0

```
IPV6INIT=yes
IPV6ADDR=2607:f018:704:ffff::68
# UMNet says to accept router announcements
# this is how to do static
IPV6_DEFAULTGW=2607:f018:704:ffff::2
IPV6PREFIX=64
IPV6_AUTOCONF=no  #EL6 bug?
```

IP addressing on Debian/Ubuntu

```
# The primary network interface
auto eth0
iface eth0 inet static
address 141.211.255.70
broadcast 141.211.255.71
netmask 255.255.248.0
gateway 141.211.255.65
iface eth0 inet6 static
address 2607:f018:704:ffff::70
netmask 64
# UMNet says to accept router announcements
# this is how to do static
gateway 2607:f018:704:ffff::2
```

Checking address, listeners, stats, routing

- `ifconfig`
- `netstat -a [ -A inet6 ]`
- `netstat -r -A inet6`
  - `ip route` command for IPv6?
- `ip neighbor`
  - standalone command like `arp` for ND?

Network toolkit

- Pretty robust; most open source in good shape
- ping6
- traceroute6
- mtr -6
- nmap -6
- socat

Security

Security

- Most things are similar; most of the same problems exist in v6 as v4.
- But tools are not always up to par (e.g., VFW)
- Feature Parity, or Feature Parody?

ip6tables

- Very similar to iptables

Too many addresses

- A /64 has way, way too many addresses to try to scan the whole thing
- IP-address based blacklisting (e.g., for spam) will not necessarily scale
- Wildcard reverse DNS (not)

Private IP addresses?

- There is no “private” IPv6 address space (like 10.0.0.0 or 192.168.0.0)*
- If you have business processes that use this space, think about how to transition
- OTOH IPv4 is not going away anytime soon

* “site-local” is defined, but is deprecated by RFC 3879

Applications

Apache httpd

- If you don't configure up specific IP addresses, it Just Works

```
Listen 80
```

- If you do configure up specific IPs, it's still pretty easy.

```
<VirtualHost 141.211.255.68:443
[2607:f018:704:ffff::68]:443>
```

Apache httpd

- Did you remember to open up port 80 in ip6tables?

BIND

- Again, pretty simple

```
listen-on-v6 port 53 { 2607:f018:704:ffff::68; };
```

BIND

- IPv6 info in the DNS
  - AAAA records instead of A records
  - `ip6.arpa` instead of `in-addr.arpa.net`

```
V6test0 A    141.211.255.68
V6test0 AAAA 2607:F018:704:ffff::68
```

BIND

- Nibble format for reverse lookups (ugh)

% host www.internet2.edu

webprod0.internet2.edu has IPv6 address 2001:48a8:68fe::151

% host 2001:48a8:68fe::151

1.5.1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.e.f.8.6.8.a.8.4.1.0.0.2.ip6.arpa domain name pointer www.internet2.edu.

BIND

2001:48a8:68fe:0000:0000:0000:0000:0151

Read it backwards…

1.5.1.0 . 0.0.0.0 . 0.0.0.0 . 0.0.0.0 . 0.0.0.0 . e.f.8.6 . 8.a.8.4 . 1.0.0.2 .ip6.arpa.

BIND

- Q: How do I pre-fill an end-user subnet with reverse lookups?
- A: You don't.
- How about just a dynamic answer? Code contributions welcome.
- Dynamic DNS (yuck)
- Stop requiring that clients have working reverse lookups.

BIND

- Did you remember to open up port 53 in ip6tables?

Others

- In general, bare IPv6 addresses OR addresses in brackets are accepted by most software.
- If it already uses :portnumber, try brackets.

The whole stack has to work
Case study: Internet2 video streaming

- End-user computer & campus network: check.
- WAN: check.
- Internet2 server LAN, DNS, etc: check.
- Internet2 web server OS & httpd: check.
- Internet2 video streaming server: check.
- Internet2's video player applet? BZZZZ!

Further reading

- Wikipedia articles are quite good
- http://www.hpc.mil/cms2/index.php/ipv6-knowledge-base-deployment/152-v6-training-and-learning

Thanks!

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http://www-personal.umich.edu/~danno/slides/20130816/