An Introduction to IPv6

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Outline

- What is IPv6
- What is Driving IPv6 Migration
- The IPv6 Address
- ORNL's Current IPv6 Status
- Operating in an IPv6 world

What is IPv6

What is IPv6

- It is the future of the Internet
- Been around for 20 years – growing pains over?
- Just another IP protocol
  - Only about IP layer
  - Layer-3 (routing) only
  - TCP, UDP, HTTP stay the same
  - Hostnames stay the same
  - Uses same network equipment

IPv4 vs. IPv6

- Differences (not limited to)
  - Not compatible
  - Address Size and format
    - Number of Available Addresses (2^{32} vs. 2^{128})
    - 4.3 billion vs. 340 undecillion
  - No NAT
  - No broadcast traffic in V6
  - ARP vs. Neighbor Discovery
  - V6 address “scope” (more later)
  - Security, performance

What is Driving ORNL's Migration

What's Driving ORNL's Migration?

- To keep pace with new technology
- DOE requires all newly purchased network gear be IPv6 capable
- OMB Memo 9/28/2010
  - Calls for IPv6 enabling public facing:
    - DNS
    - Web servers
    - Mail servers

“Preparing” ORNL

- Created ORNL’s IPv6 Working Group
  - Meeting bi-weekly since 2011
  - Ensure readiness/expertise
  - Coordinate Implementation
    - SME of every affected area wanted
  - Understand
    - Security concerns
    - Performance
    - Changes required
  - Promote Training

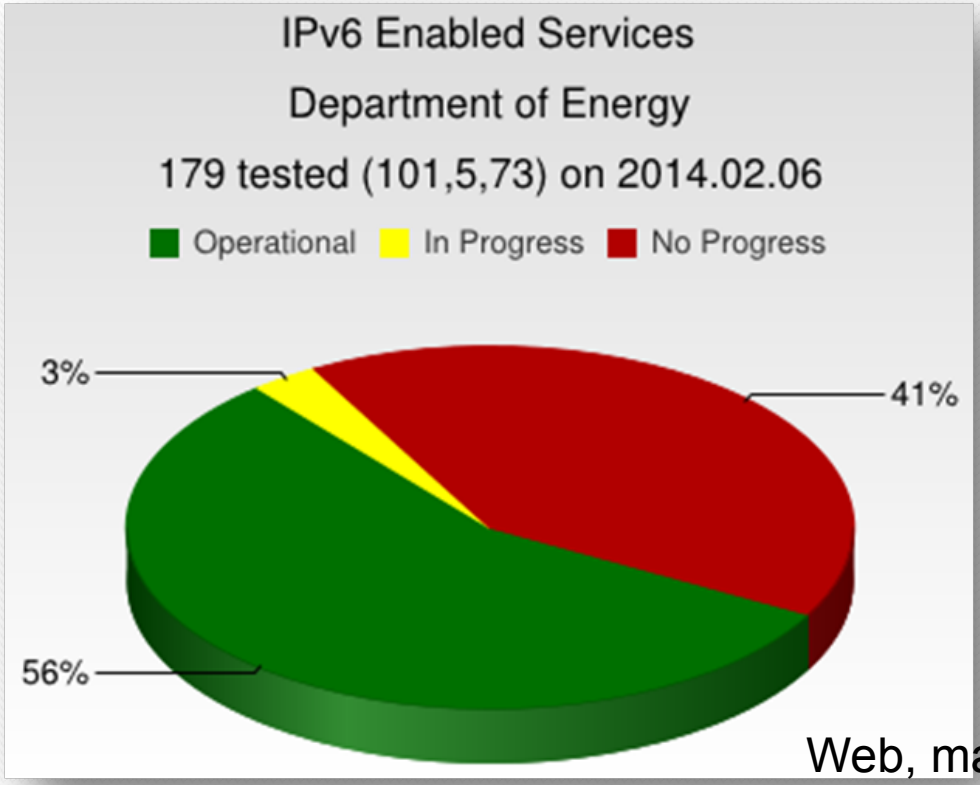
ORNL's IPv6 Presence

- IPv6 is all around us
  - In the world and within ORNL
  - Lots of background v6 traffic from every system
- What ORNL already has
  - IPv6 blocked except to/from specific subnets
  - IPv6 tunnels blocked at border
  - Bandwidth testing systems 2011
  - IPv6 Test networks since 2011
  - DNS servers since 2012
  - CSIIR research project since 2012
  - Externally facing email – Nov 2012
  - Some externally facing web services – Dec 2012

IPv6 Enabled Web at ORNL

- IPv6 enabled
  - casl.gov
  - fueleconomy.gov
  - ntrc.gov
  - ornl.gov
    - www.ornl.gov
    - jobs.ornl.gov
  - sns.gov
- *NOT* IPv6 enabled yet
  - climatechange.gov
  - isotope.gov
  - isotopes.gov
  - nccrc.gov
  - nccs.gov
  - ncrc.gov
  - scidac.gov

DOE Measured IPv6 Presence



Web, mail, DNS

http://usgv6-deploymon.antd.nist.gov/cgi-bin/cfo?agency=energy

Projected Implementation

- Visitor Network -- next few months
- “New” networks deployed will be IPv6 ready (TBD)
- Desktops and internal servers (more than a year)
- Disable IPv4 – after we retire

Current ORNL Issues

- Web Proxy
- MS Load balancing (no support)
- Net Scalars
- CMS (Content Management System)
- IDS/IPS
- Overall integration into existing tools/apps
  - NetReg, SSR, Splunk/logs, Stealthwatch/netflows
- SAP (all or none issue)
- Training

The IPv6 Address

The IPv6 Address Format

- Format better accommodates size
  - IPv6: `2620:0:2b30:1000:2000:3000:4000:5000` (128 bits)
  - IPv4: `128.219.230.233` (32 bits)
- Uses hexidecimal digits (Nibble)
  - `0,1,2,3,4,5,6,7,8,9,a,b,c,d,e,f`

8 groups of 4 hex digits

```
0123:4567:89ab:cdef:0123:4567:89ab:cdef
1    2    3    4    5    6    7    8
```

IPv6 Address Compression

- Leading zeros should be removed
  - e.g. [0021 → 21] and [0000 → 0]
- Use "::“ to simplify groups of zeros
  - Can only appear once in an address
- Lower case is the standard
- Example:

--How would this look compressed?

2620:0000:2b30:0302:0000:0000:0000:0020

--after compression--

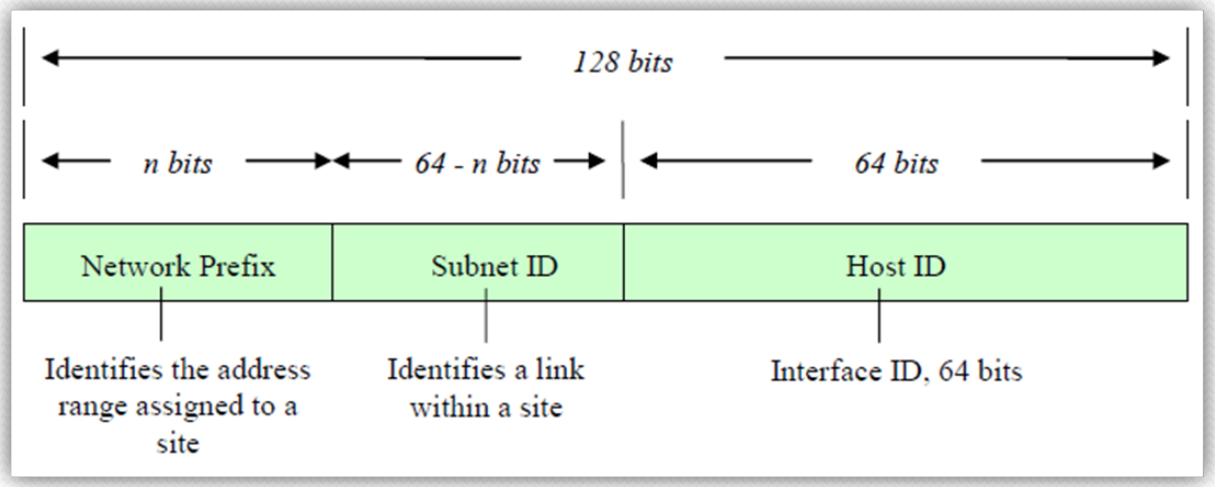
2620:0:2b30:302::20

Examples

- 2001:db8:0:0:8:800:200c:417a
  - 2001:db8::8:800:200c:417a
- fe80:0:0:0:0:0:0:101
  - fe80::101
- 0:0:0:0:0:0:0:1 (localhost)
  - ::1
- 0:0:0:0:0:0:0:0 (unspecified address)
  - ::

The IPv6 Address Structure

- Half of the entire address is the Host ID
- ORNL's Network Prefix is 2620:0:2b30
  - Ex. 2620:0:2b30:302:e0cb:1dd2:9c92:61f6 (address for www.ornl.gov)
  - Subnet in this example is "0302"
  - Host ID is "e0cb:1dd2:9c92:61f6"



The IPv6 Subnet

- CIDR notation only (the slash)
- NETMASK and CLASS go away
  - Replaced by PREFIX
- e.g. 2620:0:2b30::/44 (subnet assigned to ORNL)
  - Prefix for this subnet is “2620:0000:2b30”
  - Prefix Length is 44 (2620:0:2b30 through 2620:0:2b3f)
- Prefix lengths for subnets are typically 64 or less
  - Preferably on a “nibble-boundary”
    - /44, /48, /52, /56, /60, /64

Address Scope

- Global (ORNL's allocation)
  - 2620:0:2b30::/44
    - From 2620:0:2b30:0:0:0:0:0
    - To 2b20:0:2b3f:ffff:ffff:ffff:ffff:ffff
- Local
  - fe80::/10
    - From fe80::0 → febf::ffff:ffff:ffff:ffff

IPv6 and DNS

- New DNS type “AAAA” aka Quad-A
  - Name -> IPv6 address
  - Just like the A-record (Name -> ipv4 address)

```
> nslookup -type=aaaa www.ornl.gov
Server:         160.91.241.30
Address:        160.91.241.30#53

www.ornl.gov    has AAAA address
2620:0:2b30:302:e0cb:1dd2:9c92:61f6
```

Reverse (PTR) Records

- Reverse (PTR) records are still there
  - Extension is different
  - PTR record for www.ornl.gov
    - V4: 32.178.219.128.in-addr.arpa.
    - V6: 0.0.1.0.0.0.0.0.6.5.f.e.0.9.6.a.3.0.2.0.1.3.b.2.0.0.0.0.0.2.6.2.**ip6.arpa**.

```
> nslookup  2620:0:2b30:302:e0cb:1dd2:9c92:61f6
Server:         160.91.241.30
Address:        160.91.241.30#53

6.f.1.6.2.9.c.9.2.d.d.1.b.c.0.e.2.0.3.0.0.3.b.2.0.0.0.0.0.2.6.2.ip6.arpa
name = www.ornl.gov.
```

Operating in an IPv6 world

Operating in an IPv6 world

- You <u>are</u> already using IPv6
  - local network
  - v6 tunnel communication

From your Desktop

```
Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . : ornl.gov
   Description . . . . . . . . . . . : Broadcom NetXtreme 57xx Gigabit Controlle
r
   Physical Address. . . . . . . . . : 00-1A-A0-A6-C6-F3
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   Link-local IPv6 Address . . . . . : fe80::41b5:4fa6:6f6:a46a%11(Preferred)
   IPv4 Address. . . . . . . . . . . : 160.91.216.57(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.252.0
   Lease Obtained. . . . . . . . . . : Thursday, January 23, 2014 10:42:47 AM
   Lease Expires . . . . . . . . . . : Wednesday, February 12, 2014 5:44:14 PM
   Default Gateway . . . . . . . . . : 160.91.[redacted]
   DHCP Server . . . . . . . . . . . : 160.91.[redacted]
   DHCPv6 IAID . . . . . . . . . . . : 251665056
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-16-C2-15-60-00-1A-A0-A6-C6-F3

   DNS Servers . . . . . . . . . . . : 160.91.[redacted]
                                       160.91.[redacted]
   Primary WINS Server . . . . . . . : 160.91.[redacted]
   Secondary WINS Server . . . . . . : 160.91.[redacted]
   NetBIOS over Tcpip. . . . . . . . : Enabled

Tunnel adapter isatap.ornl.gov:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . : ornl.gov
   Description . . . . . . . . . . . : Microsoft ISATAP Adapter
   Physical Address. . . . . . . . . : 00-00-00-00-00-00-00-E0
   DHCP Enabled. . . . . . . . . . . : No
   Autoconfiguration Enabled . . . . : Yes

Tunnel adapter 6TO4 Adapter:

   Connection-specific DNS Suffix  . : ornl.gov
   Description . . . . . . . . . . . : Microsoft 6to4 Adapter
   Physical Address. . . . . . . . . : 00-00-00-00-00-00-00-E0
   DHCP Enabled. . . . . . . . . . . : No
   Autoconfiguration Enabled . . . . : Yes
   IPv6 Address. . . . . . . . . . . : 2002:a05b:d839::a05b:d839(Preferred)
   Default Gateway . . . . . . . . . :
   DNS Servers . . . . . . . . . . . : 160.91.[redacted]
                                       160.91.[redacted]
   NetBIOS over Tcpip. . . . . . . . : Disabled
```

Operating in an IPv6 world

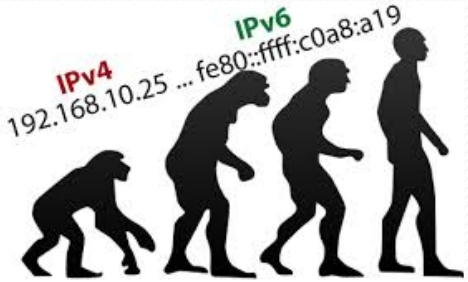
- Make sure new applications and hardware are IPv6 ready
  - RIPE-554 – Requirements for IPv6 in ICT equipment
- Think about v6 when building apps
- You will likely need basic DNS/DHCPv6 knowledge
  - For troubleshooting
  - For making/understanding IT decisions

How will IPv6 Look to you

- Eventually will be using IPv6 at your desk
  - Running dual stack at first
- Some sites will remain IPv4 only for some time
- Dual stack and Happy eyeballs
  - Logic behind preference between IPv6 and IPv4 when dual stacked.
  - E.g. OS and/or Web browser use both and chooses one with fastest response

ORNL's IPv6wg Resources

- Documentation
  - IPv6 Web site
    - https://somrthing.ornl.gov/network/internal/ipv6
    - Announcements, training slides, cheat-sheets, links, …
  - IPv6 Info/FAQ (ORNL's cheat sheet)
- People
  - Networking, Cyber Technicians, Programmers, Project Managers, Network Architects, Group Leaders, Sysadmin
  - Trained over time
    - Conferences, formal classes, OJT, etc…
  - Many willing to offer support, training



Conclusion

- Understanding IPv6 will make your life easier
- Transitioning to IPv6 will not be seamless
  - …if the tools we use cannot accommodate IPv6
  - Have to take time to learn, and modify existing tools
  - Demand from app/service providers that the tools they provide be IPv6 ready
- But not terribly difficult for the average user either

Questions?

1. How many bits in an IPv6 address?
2. What will be your role in the IPv6 migration effort?