Just Enough IPv6 to Make You Dangerous

IPV6 Training

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Joe St Sauver, Ph.D. (joe@oregon.uoregon.edu)
MAAWG Senior Technical Advisor

http://www.uoregon.edu/~joe/ipv6-training/

Disclaimer: All opinions expressed in this talk are solely those of the author and do not necessarily represent the opinions of any other entity.

Section 1. Introduction

Today's Goals

- After polling today's attendees by email, it appears that most attendees are just getting started with IPv6.

- We also know that most MAAWG attendees are NOT programmers, NOT system administrators, NOT DNS admins, and NOT network engineers. This implies a need for different coverage and different technical level than many IPv6 trainings.

- Our goals today are thus fairly simple:
  -- Develop awareness of IPv6's existence and importance
  -- Help participants try native IPv6 on their own systems
  -- Understand remaining IPv6 issues, particularly relating to email
  -- Take away an IPv6 "agenda" for your own ISP or company

- … all while avoiding too much jargon or technical minutiae. ("I can drive a car without being able to rebuild its transmission.")

- Optionally, we can also talk about some of the security implications associated with IPv6, in more technical detail

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Today's Native IPv6 Connectivity

- Today we're very fortunate to have native IPv6 connectivity for your use. Native connectivity means that local users get "real IPv6 connectivity" that should feel on par for them with IPv4 connectivity. This is the sort of connectivity we'd like to see offered at *every* site.

- For today's IPv6 experience we'd like to offer many thanks to:
  -- UPC Broadband for our wide-area IPv6 connectivity,
  -- Verilan Event Services, particularly Morgan Sackett, for handling the onsite plumbing
  -- Anthony Purcell of cv.net, for providing a local test IPv6 server
  -- Comcast, particularly Michael O'Rierdan and John Jason Brzozowski, for their active interest in IPv6 -- including both its presence here today and the ongoing work of the MAAWG IPv6 subcommittee!
  -- Everyone who has worked so hard to make IPv6 a reality!

Understanding IPv6: Some Foundation Work

- Because we have users with vastly different backgrounds, let's step back and make sure we approach this with the same foundation material in hand.

Domain Names and IP Addresses

- While most people use domain names (such as www.maawg.org) to refer to Internet resources, in reality, in the background, the domain name system (DNS) is hard at work resolving those easy-to-remember symbolic names into the numeric IP addresses our computers need to actually make the Internet work.

- For example, www.maawg.com resolves to 66.179.20.209:
  ```
  % dig +short www.maawg.com
  66.179.20.209
  ```

- Numeric IP addresses can also be mapped back to symbolic domain names; for example, 66.179.20.209 points right back to www.maawg.com…
  ```
  % dig +short -x 66.179.20.209
  www.maawg.com
  ```

What's That "dig" Thing You're Showing Us??

- dig is a command line unix tool that can help you to "dig in" and see what's happening with the domain name system.

- dig ships as a standard part of most unix systems, including Macs.

- You don't need to use dig to use IPv6, although it is a helpful tool to have in your toolkit, and we'll use it throughout this talk to illustrate various IPv6-related points.

- Under Windows, you can use **nslookup** instead:
  ```
  C:\> nslookup
  set q=a                              (or q=aaaa for ipv6)
  www.maawg.org
  exit
  ```

Why Do We Need Domain Names AND IP Addresses?

- After all, the telephone system just uses numbers, right? And we can send postal mail without needing GPS coordinates for the destination… so why do we need IP addresses and domain names?

- If we use domain names, multiple domain names can "live" on a single IP address, thereby conserving IP addresses.

- If we use domain names, a single domain name can be spread across multiple IPs, thereby allowing us to balance the traffic for a particularly popular site across multiple physical computers.

- If we use domain names, we get the "benefits of indirection:" that is, we can modify the IP address that a domain name points at, and everyone will automatically end up going to the new address

- Ultimately, however, network connections get made to IP addresses, not to domain names. For a computer to be on the Internet, it MUST have an IP address.

There Aren't As Many IP Addresses As You Might Think

- Each IP address is a 32 bit number. That's written as 4 integers separated by dots, each of those integers ranging from 0 to 255.

- Mathematically, we can determine that a 32 bit IP address can have 2^32 addresses, or 4,294,967,296 unique values.

- That may sound like a lot of potential addresses, however just for context, remember that we had over 6,706,993,152 people on the planet as of July 2008.

- Thus, even if we could perfectly utilize every conceivable IPv4 address (and we can't), we still don't have enough addresses for each person on the plant to have even just one apiece, and many of us already use multiple addresses.

- Some of the theoretical 2^32 addresses are reserved, and the available address space isn't able to be utilized with perfect efficiency.

Factoid: IP Addresses Are Assigned in Chunks

- When an Internet Service Provider requests IP address space, they're given a contiguous range of addresses called a "prefix."

- For example, MAAWG's IP address, 66.179.20.209, is part of a range of 65,534 IP addresses administered by Inflow Inc., ranging from 66.179.0.0 to 66.179.255.255

- Inevitably, some fraction of each assigned prefix will go unused, particularly since prefixes are usually assigned in chunks that are powers of 2, e.g., 128 addresses, 256 addresses, 512 addresses, etc.

- These and other factors tend to reduce the number of remaining available addresses.

Factoid: Addresses Are Assigned Hierarchically

- IANA (the Internet Assigned Names and Numbers authority) controls the entire Internet's address space.

- IANA allocates blocks of address space to regional authorities (called "RIRs") such as ARIN (in North America), RIPE (in Europe), APNIC (in the Asian Pacific region), LACNIC (in South and Latin America) and AFRINIC (in Africa).

- Carriers and large ISPs apply to ARIN (or one of the other regional authorities, as appropriate) to receive a block of IP addresses for customer use.

- Customers, in turn, normally get IP addresses from their carrier or ISP.

That All Works Pretty Smoothly

- Although that process may sound complex, it actually works surprisingly smoothly, and hundreds and hundreds of millions of IP addresses are in use.

- In fact, the problem we face is that we're the "victim of our own success."

We're Close to Running Out of IP Addresses

- In fact, we're **shockingly close to running out of IPv4 addresses,** the sort of IP addresses you currently use and rely on every day.

- While estimates may vary from forecast to forecast, and may drift one way or the other over time, **within less than three years there will likely be no more IPv4 addresses left to allocate.**

- For example, http://www.potaroo.net/tools/ipv4/index.html estimates that IANA will allocate its last block of IP addresses on 22 June 2011, and that the regional registries will allocate their last pool of addresses on 17 March 2012.

- **As of 7 June 2009, there's only 2 years and 15 days left until 22 June 2011, and 2 years, 9 months and 10 days under 17 March 2012.**

- *THAT'S REALLY NOT VERY MUCH TIME!*

Two Thoughts For You, Given That Timeline

- Thought #1: If you have an immediate legitimate need for more IP addresses to support a project that you're working on, **I wouldn't wait until the last second** to request the additional IPv4 address space you may need. If you do wait, there may simply be none left at that point you finally get around to asking.

- Thought #2: **You might want to be thinking and planning a bit about how you'll use IPv6**, since IPv6 addresses will be the only kind which will be available once we run out of IPv4 addresses, unless a secondary market for IPv4 addresses emerges, or some alternative scheme is worked out.

- "But, but, but… what about NAT?"

NAT

- Network address translation, or NAT, allows one public IP to be mapped to a variety of internal addresses (often addresses in private RFC1918 space)

- This allows, for example, one public address from an ISP to be shared by multiple systems. For example, a family might have one public address that's seemingly magically shared by the parent's PC and by the children's PC, all handled by a Linksys broadband wireless access point/hardware firewall/"router."

- NAT is also used in larger settings, such as at some small colleges or some businesses.

- While NAT may appear to be magic, in reality it can simply be incompatible with some applications (such as video conferencing), and its use results in a loss of Internet end-to-end transparency.

- NAT is not an adequate replacement for deploying IPv6.

So What About IPv6 Addresses?

- Today's IP addresses ("IPv4 addresses") are 32 bits long, while IPv6 addresses are far longer -- 128 bits long.

- Since 128 divided by 32 is 4, you might think that we're just talking about just four times as many addresses as we currently have.

- We're not. **Each** additional bit of address we add **doubles** the number of addresses available for our use. Thus, if we go to 128 bit addreses, we theoretically have

  $2^{128}=340,282,366,920,938,463,463,374,607,431,768,211,456$

  addresses available (vs. "only" 4,294,967,296 IPv4 addresses)

How Are IPv6 Addresses Written?

- While IPv4 addresses are written as four numbers (each from 0 to 255) separated by dots, IPv6 addresses are written as eight groups of four hexadecimal digits (0123456789ABCDEF), with each group of four digits separated by colons.

- www.maawg.org doesn't currently have an IPv6 address, so we can't use it for this example, but phloem.uoregon.edu has one:

  ```
  % dig +short phloem.uoregon.edu aaaa
  2001:468:d01:20::80df:2023
  ```

- Note that leading zeros within each colon separated chunk can be omitted (e.g., 468 in the above address is really 0468), and a double colon represents multiple zeroes. Without those "shortcuts," we'd have to write: `2001:0468:0d01:0020:0000:0000:80df:2023`

What About Inverse IPv6 Records?

- If an inverse address record has been defined, you can go from a numeric IPv6 address back to a symbolic name:

```
% dig +short -x 2001:468:d01:20::80df:2023
phloem.uoregon.edu.
```

- Just as in the IPv4 world, however, many times inverse address records may not be defined.

- Still, in spite of the longer length and different address format, things appear roughly parallel between IPv4 and IPv6.

Well, That All Sounds Easy Enough!

- Given the way IPv6 parallels IPv4, it sounds like it should be easy enough to just begin using IPv6 addresses alongside IPv4 ones -- wouldn't it? You might think so, but there are "a few" details that need to be sorted out before that's more or less true.

- For example, programs that use the network, like your web browser, or your email client, need to learn how to work with IPv6 addresses. Many popular network programs, including the Firefox web browser and the Thunderbird email client, have been extended by their programmers to understand how to work with IPv6.

- Unfortunately, not all network application programs are equally IPv6-ready, and there's no magic converter that can automatically convert an IPv4-only program to work with both IPv4 and IPv6 -- each application needs to be converted manually one at a time.[19]

And Then There's the Operating System

- Even if we have "IPv6ified" application software, we also need an "IPv6ified" operating system on which to run them.

- Some operating systems, such as recent versions of Linux and Mac OS X, and Windows Vista, are (more or less) ready to do IPv6 out of the box.

- Other operating systems (including things like older versions of Windows XP), may need additional attention to become IPv6-ready.

- Oh yes: we also need wide area IPv6 connectivity.

- What might an IPv6 "connection" look like?

IPv6 Addresses On An Interface

```
% ifconfig -a

lo0: flags=8049<UP,LOOPBACK,RUNNING,MULTICAST> mtu 16384
    inet6 ::1 prefixlen 128
    inet6 fe80::1 prefixlen 64 scopeid 0x1
    inet 127.0.0.1 netmask 0xff000000
    [snip]
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
    inet 128.223.214.xx netmask 0xffffffe00 broadcast 128.223.215.255
    inet6 fe80::203:93ff:fecf:b6xx prefixlen 64 scopeid 0x4
    inet6 2001:468:d01:d6:203:93ff:fecf:b6xx prefixlen 64 autoconf
    [snip]
```

Note: the last two hex digits of each address have been replaced with *xx* because this data came from a live IPv6-connected workstation

- What are all those addresses? The lo0 addresses are loopback addresses referring to the machine itself. The en0 addresses include both a link local address (the fe80 address) and a "real" IPv6 address, the one that begins with 2001:468.

Why Do Machines Sometimes Have Multiple IPv6 Addresses?

- While IPv6 was designed to insure we don't run out of IP addresses, it also had another goal, and that was to contain growth in the routing table. As a result, paradoxically, a single machine may have multiple IPv6 addresses, one for each upstream provider, as well as some special purpose addresses. This poses a number of potentially very interesting questions, including things as basic as "How would a workstation decide which of those IPv6 addresses to use when originating IPv6 traffic?"

- Increasingly, however, most providers will obtain their own provider independent IPv6 address allocation, advertising that prefix across all IPv6 upstream providers.

Where Do Machines Get AN IPv6 Address?

- Like many things in IPv6, this depends.

- Most machines will get IPv6 addresses from the router they connect to via something known as "stateless autoconfiguration" -- that is, the router magically hands them the address.

- Some systems, such as servers, may be assigned static IPv6 addresses.

- Other machines (but notably NOT Macs running OS X), can also get IPv6 addresses via DHCPv6.

What Do Automatically Assigned IPv6 Addresses Look Like?

- Automatically assigned addresses may take two forms:
  -- addresses whose low order bits are consistently derived from the machine's physical ethernet address (it's MAC address), or
  -- privacy-enabled IPv6 addresses, designed to make it difficult or impossible for someone to persistently track your network behavior via an invariant IPv6 address

- Vista uses privacy addresses by default.

- To enable use of privacy addresses on the Mac, as root you'd do:
  ```
  # sysctl -w net.inet6.ip6.use_tempaddr=1
  ```

- In reality, either format will work fine for most users.

AAAA Records

- What about servers, and other devices which need a persistent and well know domain name, even under IPv6?

- Domain names in IPv4 space are defined in the Domain Name System (DNS) using A records; comparably, domain names in IPv6 space are defined in the DNS using AAAA records.

Types of Wide Area IPv6 Connectivity

- The best sort of IPv6 connectivity, and the sort that we're using here at MAAWG today, is native IPv6 connectivity.

- When native IPv6 isn't available, a number of "transition mode" connection alternatives may end up being used instead, including:

  -- manually configured tunnels
  -- 6to4 translation service
  -- Teredo tunneling service
  -- and there are other mechanisms.

  These mechanisms usually are less desirable than native connectivity because traffic may follow indirect paths (e.g., East Coast of the US to the West Coast via Europe!)

One Last Point

- IPv6 should not be viewed as an immediate replacement for IPv4.

- IPv6 and IPv4 will coexist for many years, and only gradually will IPv6 go from being "second fiddle" to "first violin" in the IP orchestra.

- This approach, known as a "dual stack" approach, provides maximum flexibility and is the easiest way of dealing with resources that may only be available on IPv4 or only available on IPv6.

- There are alternative approaches that try to make living solely in IPv6 space palatable, but currently those approaches are too experimental to recommend (IMHO).

- But enough talking, let's try IPv6!

Section 2. An IPv6 Experiment

Because We <u>Do</u> Have Live Connectivity…

- We're going to do things a bit differently than we otherwise might.

- We want everyone here today to actually try using IPv6

- This experience is really something of an "experiment," a good proxy for what you might find if you turned up IPv6 in your own company or for your own customers

- Some things will probably work immediately and painlessly while other things may take a little more work. In some cases, we may find that some things don't work at all. That is, after all, the nature of an experiment.

- What we don't have today are some of the complexities that may be present in a real world environment:
  -- we have no customers with truly ancient PCs
  -- and we have no "middle boxes" (broadband "routers"/hardware firewalls)

Let's Start By Doing An Experiment

- Connect to the MAAWG wireless network using the VeriLAN ssid if you haven't already done so (if you elect to use the WPA-enabled ssid, see the username and password on the back of your name badge). Do NOT connect to the IPv6 only ssids!
- Open your web browser of choice
- **Without tweaking anything,** try visiting http://ipv6.google.com/
- How many of you see Google with a "dancing" logo? Hands up, please…
- My prediction is that this will work for **some** of you and you will see a dancing Google "logo", and will **not** work for the rest of you (there should be no shame or embarassment if it doesn't)
- Let's see if there are any patterns we can identify in that data.

Experiment Results

- How many saw the "dancing" Google logo?

  YES:
  NO:

- If you did see "dancing" what operating system are you using?

  VISTA:
  MAC OS/X:
  LINUX:
  OTHER:

- If you did see "dancing" Google logo, what browser did you use?
  INTERNET EXPLORER:
  FIREFOX:
  SAFARI:
  OPERA:
  CAMINO:
  OTHER:

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Discussion of the "Experiment"

- Why did some see the dancing Google icon, and some did not? Potential issue(s) may be:

  -- Your operating system simply doesn't know about IPv6 (yet)

  -- Your operating system knows about IPv6, but it's not configured to ask for an IPv6 address by default

  -- Your machine may be fine, but you may have hard-coded name servers which may not know about IPv6 (e.g., the name servers you're using may not support AAAA records)

  -- Everything else is find, but your web browser isn't asking for IPv6 address records, and so connects via IPv4 by default

  -- or you may be running into something else.

  We'll do our best to fix any of these issues you run into.

But First, Let's Also Do One Other Test

- If you were successful in connecting to ipv6.googlr.com, now try
  connecting to: http://whatismyv6.com/
  Which address is preferred when an IPv4 **and** IPv6 capable host
  connects to a server that supports **both** IPv4 **and** IPv6 addresses,
  as the whatismyv6.com server does?
  Is IPv6 preferred?
  Or is IPv4 preferred?

- If you find yourself routinely curious about whether you're
  connecting to a site via IPv4 or IPv6, you can install the ShowIP
  Firefox addon available from
  https://addons.mozilla.org/en-US/firefox/addon/590
  It will then report the IP address that it is using for each web site
  you visit, green for IPv6 and red for IPv4

Which *Should* Have Priority, If Both IPv6 and IPv4 Are Available?

- **A Philosophical Point To Ponder:**

  The issue of whether IPv4 connectivity or IPv6 connectivity "should" have precedence when both are available is an interesting "philosophical" question which we'll just note in passing here.

- Those of us who might *philosophically* want to promote IPv6 use/adoption might naturally put IPv6 connectivity over IPv4 connectivity (given a choice between both).

- But would **pragmatic** protocol-disinterested **real users** do the same thing? Or do they just want to connect with as little pain as possible (probably implying IPv4, not IPv6!)

Section 3. Let's Work on Getting ALL Participants Connected Via IPv6

System and Browser Tweaking Time

- **If you did NOT get a dancing Google logo**, let's try tweaking your system and web browser to make that happen.

- **Windows XP SP 2 users** should have two sheets from me, one for tweaking their OS, and one for tweaking their web browser.

- **Mac OS users** should also have two sheets, from me, one for tweaking their OS, and one for tweaking their web browser.

- Let's have you go through those handouts now.

- If we run out of handouts, or you're looking at this after the fact, copies of the handouts are available at: http://www.uoregon.edu/~joe/ipv6/

The Special Case of IPv6 Unexpectedly Not Working Under Windows Vista

- Vista users should have IPv6 work "out of the box," although Firefox users will need to tweak their browser to enable IPv6 DNS

- **But what if you're a Vista users and IPv6 doesn't work even when you use the latest version of IE (or some web browser other than Firefox?)** You **may** be on a managed laptop where the system administrator has "intentionally broken" IPv6 (see http://support.microsoft.com/kb/929852). We can fix that, but in some cases it can involve editing the registry (yuck), while in other cases you may "just" need to re-enable use of IPv6 (Start ==> right click on Network, select Properties, click on Manage Network Connections. Right click on the wireless connection. Select Properties. Tick the IPv6 box.)

- Note: if you "unbreak" IPv6 on your corporate laptop, visit with your system admin after you return home to confess your sins.[37] :-)

So Let's Pause And Make Sure Everyone's Connecting to IPv6 Okay At This Point

- If you're already set, while we get the other folks caught up, go on to the next page.

Record Your IPv6 Accomplishment

- Let the world know that you were here via IPv6:

  http://maawgv6.monkor.us/

Trying Some IPv6-Enabled Sites

- If you look on the back page of the web browser one page handout you received, you'll see a listing of some current IPv6-enabled web sites. This listing obviously isn't every IPv6-enabled web site out there, but it does give you a sense of some of the sites that are available.

- You should be able to visit any of those sites via IPv6 just by entering the site's fully qualified domain name, but if you want to be sure that you're accessing them via IPv6, you can also use their numeric IP address. For example, to force your visit to the IETF web site to explicitly be by IPv6, you'd enter:

  http://[2001:1890:1112:1::20]

  Note the required square brackets around the IP address.   40

What About YOUR Web Site?

- **Is your company or ISP's web site IPv6 accessible?** If not, why not? The most popular web servers, e.g., Apache and Microsoft IIS, both support IPv6 these days! So what's the "holdup," eh?

- Often, your site may not have IPv6 connectivity (but it should!)

- Another potential roadblock to explore is whether hardware load balancers are IPv4 only. Hardware load balancers commonly sit in front of multiple physical computers, making a pile of systems act as if it were one computer. Some popular hardware load balancers license IPv6 functionality separately from IPv4.

- Other times the issue may be the use of outsourced content delivery networks (CDNs) which may not be IPv6-enabled.

- Lastly, at least sometimes, no one may every have asked, "Hey, why isn't our web site IPv6 accessible?" Perhaps that's a question that YOU should ask once you're back from MAAWG?

4. IPv6 And Email

Email Is The "Forgotten" Application of IPv6

- While many people are very excited about the thought of using IPv6 for web servers, for some reason there seems to be less excitement about using IPv6 for email.

- Let's consider a few examples of this:
  -- Many mainstream mail software products support IPv6, but relatively few mail administrators apparently enable IPv6 support
  -- IPv6 DNS Blocklist suport is missing
  -- IPv6-accessible public web email services are nearly nil

- But some sites ARE deploying IPv6-accessible mail servers right now. For example…

Sample Institutional IPv6 Enabled MX

- `% dig ucla.edu mx +short`
  `5 smtp.ucla.edu.`

- `% dig smtp.ucla.edu a +short`
  `169.232.46.240`
  `169.232.46.241`
  `169.232.46.242`
  `169.232.46.244`
  `etc.`

- `% dig smtp.ucla.edu aaaa +short`
  `2607:f010:3fe:302:1013:72ff:fe5b:60c3`
  `2607:f010:3fe:102:101c:23ff:febe:116e`
  `2607:f010:3fe:102:101c:23ff:febf:cfa7`
  `2607:f010:3fe:102:101c:23ff:fed0:918c`
  `etc.`

IPv6 Support In Mainstream Email Software Products

- Virtually all modern mail transfer agents support IPv6:
  -- Exchange 2007 SP1 (only under Windows Server 2008, and only with both IPv4 and IPv6 enabled); see http://technet.microsoft.com/en-us/library/bb629624.aspx
  -- Exim (http://www.exim.org/exim-html-current/doc/html/spec_html/ch04.html at section 4.8)
  -- Postfix (http://www.postfix.org/IPV6_README.html)
  -- Qmail (via Qsmtp, see http://opensource.sf-tec.de/Qsmtp/)
  -- Sendmail (see the Sendmail Installation and Operation Guide)

- What about Procmail as a local mail delivery agent? Umm… see http://www.procmail.org/todo.html

IPv6 Support for imapd

- Yep, imapd support under IPv6 is available as well… For example:

  -- Courier: http://www.courier-mta.org/imap/features.html

  -- Dovecot: http://www.dovecot.org/

  -- UW: www.washington.edu/imap/documentation/IPv6.txt.html

  -- etc.

Modern MUAs Also Support IPv6

- Apple Mail.App

- Opera Mail client

- Outlook 2007 (see http://support.microsoft.com/kb/924469) and Windows Mail

- Thunderbird:
  Just as you need to enable IPv6 DNS in Firefox, you also need to enable it in Thunderbird. To do so, go to Thunderbird preferences, General, Config Editor Button. Filter on ipv6. Make sure network.dns.disableIPv6 is false (double click it if it is true)

- Other MUAs?

An Example of How the Email World Is Lagging in IPv6 Space: DNS Blocklists

- DNS blocklists, such as those offered by Spamhaus, are a key anti-abuse tool in today's IPv4-dominated Internet, directly blocking spam while also encouraging ISPs to employ sound anti-abuse practices.

- Virtually all sites that use DNS-based blocklists rely on rbldnsd (see http://www.corpit.ru/mjt/rbldnsd/rbldnsd.8.html).

- rbldnsd does NOT support IPv6 records at this time

- Spamhaus (and all other block list operators I'm aware) also do not maintain any IPv6 blocklists.

- How, then, is the mail community to block abusive traffic sources coming from IPv6 space?

- If we cannot support IPv6 entries in blocklists, I believe we have a fundamental deficiency we still need to address.

Redeeming Features of IPv6 Email

- Just as in the "good old days" of IPv4, most of the people who are doing IPv6 email today are pretty responsible folks so thankfully there hasn't been much IPv6-delivered abuse.

- At some point, however, we will begin to see unwanted traffic coming in over IPv6, and at that point it would sure be great if we were ready to block it, eh?

- Some anti-abuse email technologies are ready today, e.g., SPF does support IPv6 (see http://www.openspf.org/SPF_Record_Syntax)

Public IPv6-Accessible Web Email

- As another example of IPv6 email lagging relative to where it should be, consider web-based email, one of the most popular and widely used applications on the Internet today.

- To the best of my knowledge, there is currently only ONE (1) public web email provider which has even an experimental web email service accessible via IPv6, and that's http://ipv6.rollernet.us/

- Technically, if you're able to manipulate your local hosts file, you can also access Google's Gmail via IPv6, see http://jeremy.visser.name/2008/11/25/ how-to-access-gmail-and-google-reader-over-ipv6/ (URL wrapped due to length), but that's hardly the sort of thing that a typical user should be expected to be able to do.

- **If you're aware of any additional IPv6-accessible public web email service providers, I'd love to know about them.**

Section 5. What Your Site Should Be Doing

You Company Should Be Getting Ready For IPv6

- If you're not currently deploying IPv6 locally, or at least experimenting with IPv6 in a lab setting, the time has come for you to begin to do so.

- Deploying IPv6 support will be a team effort, so make sure your conversation includes:
  -- your network engineers
  -- your domain name server administrators
  -- your system administrators
  -- your support staff
  -- your security and abuse handling people
  -- your vendors

- Deployment can be incremental. You can take baby steps, you don't need to boil the ocean on day one.

- The following list of suggested steps is not all inclusive nor detailed, but is meant to give you a sense of steps you might take.

Identify a Source of Wide Area IPv6 Transit

- You need wide area IPv6 connectivity, or "IPv6 transit." Your current IPv4 transit providers may or may not provide IPv6 transit.

- You can find lists of IPv6 transit providers at:

  http://www.sixxs.net/faq/connectivity/?faq=ipv6transit

  If you're an IPv6 transit provider, and not currently listed there, I'd encourage you to contact sixxs.net to request to be added.

- Large providers may also be interested in IPv6 peering opportunities. For a nice example of what's possible, see http://www.nanog.org/meetings/nanog43/presentations/ Levy_IPv6_%20Peering_N43.pdf (URL split due to length) 53

Decide On An IPv6 Address Plan

- You can use IPv6's vastly expanded address space to try new and innovative architectures, but you can also just map your IPv4 address space to your IPv6 address space as UO does.

  For example:

  ```
  % dig phloem.uoregon.edu +short
  128.223.32.35
  % dig phloem.uoregon.edu aaaa +short
  2001:468:d01:20::80df:2023
  ```

  ```
  128 ==> 80
  223 ==> df
   32 ==> 20
   35 ==> 23
  ```

Request Address Space

- Beyond talking about IPv6 and beginning to plan for IPv6, you should request IPv6 address space. This is a very straightforward process, see:

  https://www.arin.net/resources/request/ipv6_initial_alloc.html

  European sites should see:

  http://www.ripe.net/docs/ipv6policy.html

- If you're a small end-site, you can simply ask your IPv6 transit provider for IPv6 address space.

Make Your Name Servers IPv6 Aware

- You'll need to think about making your name servers IPv6 aware. By this I mean your recursive resolvers and your authoritative name servers should both "know about" AAAA records.

- BIND from ISC, the most common name server, is fully able to support IPv6

- Note that your *access* to your name servers need not change -- you can continue to access them over IPv4 -- you just need to make sure that they understand AAAA records.

- If you have off site secondary name servers, make sure that those secondary name servers are also IPv6 aware

Review Your Security Infrastructure

- "Middleboxes" such as firewalls, intrusion detection systems, packet shapers and other "bumps" in the wire may interfere with IPv6 deployment unless those systems are fully IPv6 aware.

- Corporate IP architectures which use Network Address Translation (NAT) are particularly likely to experience "issues" when deploying IPv6, particularly if NAT is seen as providing "protection" for systems behind that device.

IPv6-ify Your Website

- Your webmaster or web administrator may be initially reluctant to IPv6-ify your production website, however you can experiment by creating an IPv6-only web site address.

- For instance, if your production web site is www.example.com you might consider creating a parallel IPv6-enabled trial web site at www.ipv6.example.com By doing so, if something were to go awry, your primary IPv4 accessible web site would not be impacted.

- Be alert for load balancer issues, too.

Enabling IPv6 For Your Local Network

- This is the step that requires the greatest preparation, however after the other bits are done, you will be well prepared to undertake this final step.

- Enabling IPv6 will typically require changing the configuration of the routers you're using for your LAN. The theory and practice behind that are really book length topics in and of themselves, and beyond the scope of this talk. See, for example:

  "Configuring IPv6 for Cisco IOS" by Sam Brown, et. al.

6. Further Information

IPv6 Books

- If you go to Amazon's book section and search for IPv6, you get 156 hits. That's a bit better than in the old days. :-)

- When considering which of those books might work for you, recognize that some are written for specific audiences (like programmers), and those sort of books may not meet your particular needs (unless you're a coder and you're trying to come up to speed for IPv6).

- Also recognize that IPv6 is rapidly evolving, so beware of any books that haven't been recently updated.