

IPv6: Enterprise Addressing Plans

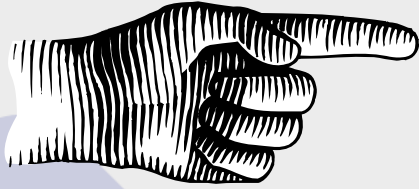
Prepared for the IPv6 Business Information Exchange

**Dr. Peter J. Welcher,
Chesapeake NetCraftsmen**

About the Speaker

- **Dr. Pete Welcher**
 - Cisco CCIE #1773, CCSI #94014, CCIP
 - Specialties: Large Network Design, Multicast, QoS, MPLS, Wireless, Large-Scale Routing & Switching, High Availability, Management of Networks
 - Customers include large enterprises, federal agencies, hospitals, universities, cell phone provider
 - Taught many of the Cisco router/switch courses
 - Reviewer for many Cisco Press books, book proposals
 - Designed and reviewed revisions to the Cisco DESGN and ARCH courses
 - Presented lab session on MPLS VPN Configuration at Networkers 2005-2007; presenting on BGP at Cisco Live 2008-2009
- Over 150 articles plus blogs at <http://www.netcraftsmen.net>

Agenda



- **Quick Review of IPv6 Addressing**
- **Quick Review of Some IPv4 Addressing Techniques**
- **Choosing Prefix(es)**
- **Addressing Plan**
 - IPv4 Mapping to IPv6
 - New Plan
- **Summary, Q&A, References**

IPv6 Addressing Review

- **Defined in RFC 4291**
- **128 bit addresses, written as 8 blocks of hexadecimal digits separated by colons (:)**
- **Leading zeros in any of the 8 blocks omitted**
- **Any one block of consecutive zeros can be replaced by double colon (::)**



IPv6 Addressing Review – 2

Type of IPv6 address	Prefix
Global unicast addresses	2000::/3
Site-local unicast addresses (deprecated)	FEC0::/10
Unique local unicast addresses (replaces site-local)	FC00::/8 (managed), FD00::/8 (random)
Link-local unicast addresses	FE80::/10
IPv4-mapped IPv6 address (96 0's then the hex form of the IPv4 address)	::pqrs:tuvw, also written as ::M.N.P.Q
IPv4 compatible IPv6 address (somewhat deprecated) (80 0's then FFFF then the IPv4 address)	0:0:0:0:0:FFFF:IPv4 address, also written as ::FFFF:M.N.P.Q
ISATAP tunnel	FE80:0000:0000:0000:0000:5EFE:IPv4 address
Unspecified address	0:0:0:0:0:0:0:0 or 0::0 or ::/128
Loopback	0:0:0:0:0:0:0:1 or ::1

IPv6 Addressing Review

- **Format of an IPv6 address (in hexadecimal)**

pppp:pppp:eeee:ssss:hhhh:hhhh:hhhh:hhhh

provider /32

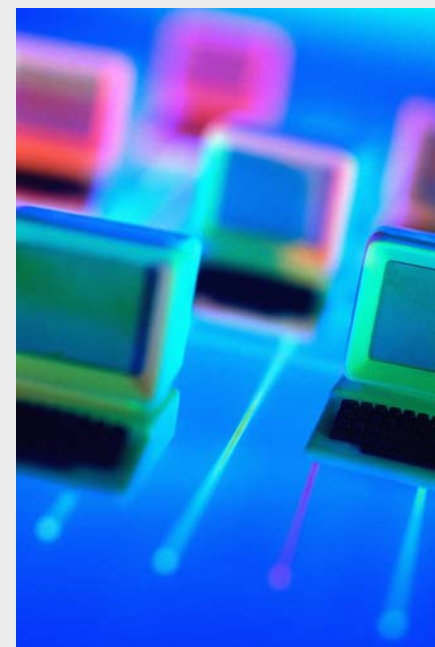
enterprise
/48 (more
or less)

subnet bits

host bits
(interface ID)

Quirks of IPv6 Addressing

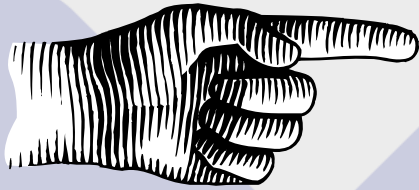
- **Get used to huge subnets**
 - 64 bits of host
 - EUI-64 mildly wasteful (perception of “plenty” leads to wastage?!)
 - Known vs. random end station addresses
 - Known vs. random router addresses



IPv6 Addressing -- Original concepts:

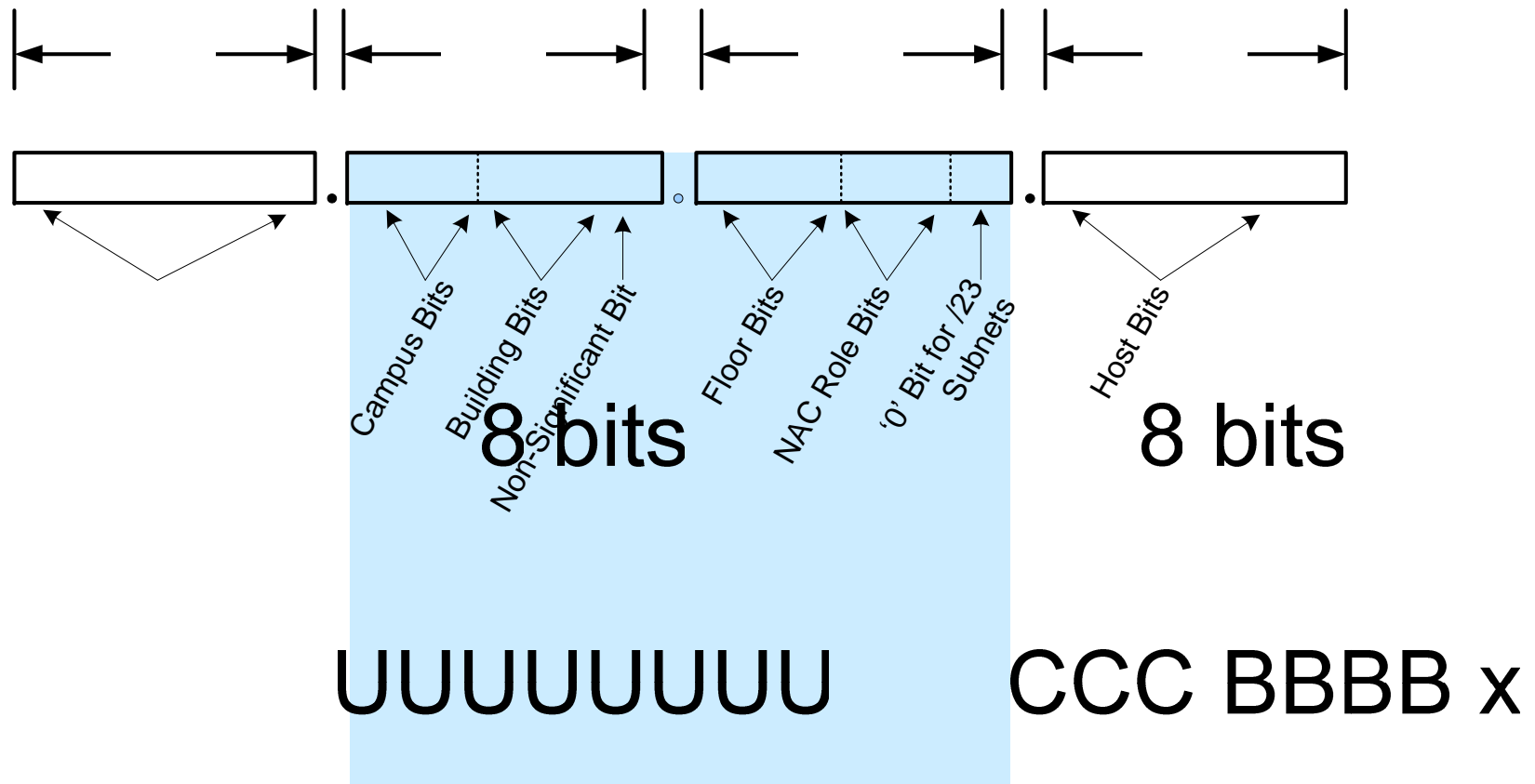
- **IPv6 globally summarizable routing**
 - Minimize global routing table growth
 - Stay within performance regime of current / likely router hardware (compared to driving costs way up)
- **/32 assigned to provider**
- **/48 or smaller block assigned by provider (***)**
 - That provides 16 bits for subnetting

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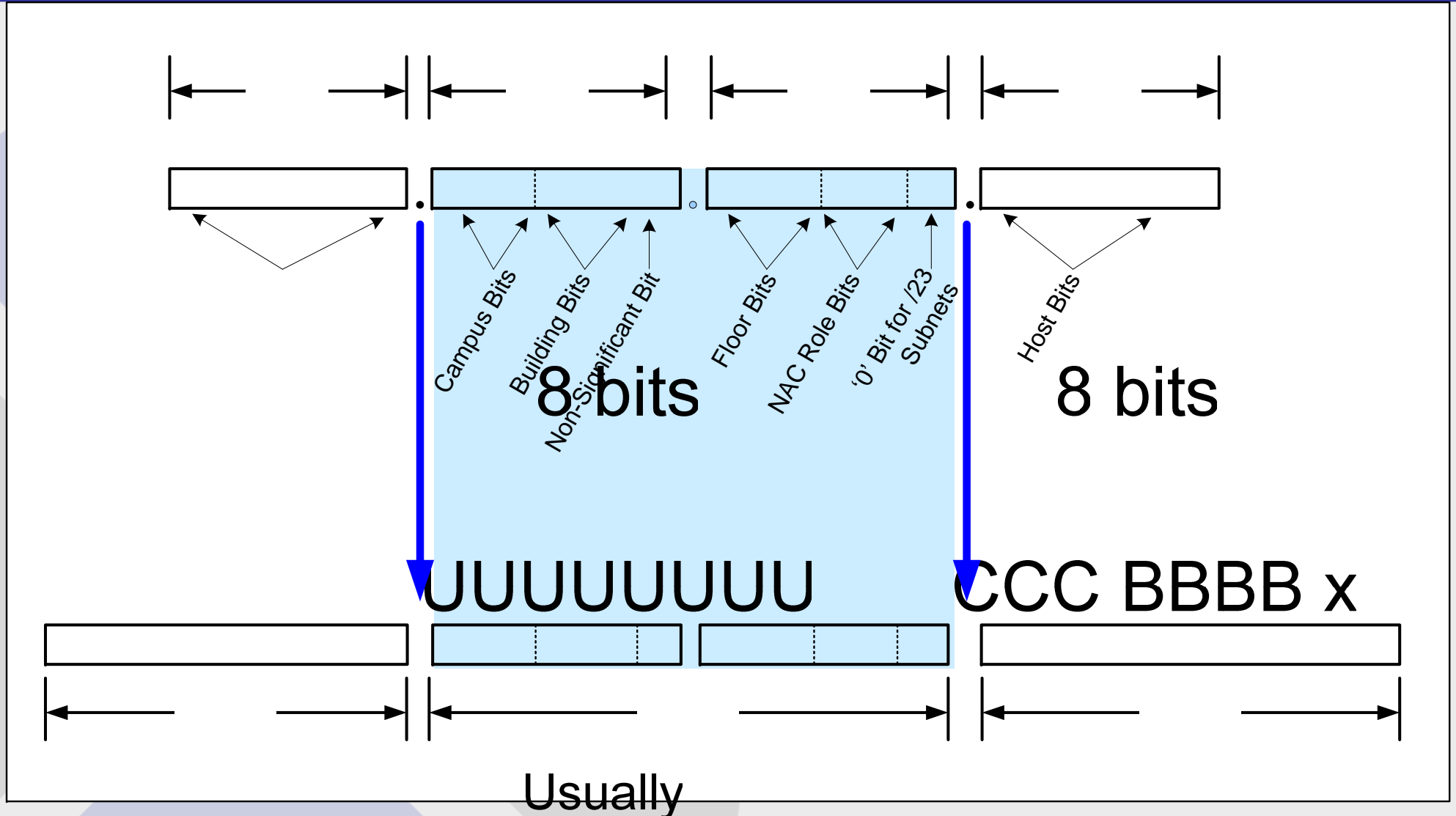
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Advanced IPv4 Addressing: Bit Assignments



Usually
10

Advanced IPv4 Addressing: Bit Assignments



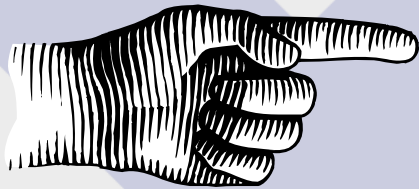
You can do the same sort of thing with IPv6 subnet bits

Advanced IPv4 Addressing Approach

- **Summarizable NAC-ready addressing**
 - Old technique from OSPF area assignment: assign subnets in a coherent way using bit assignments
 - Site / bldg bits, floor bits, closet bits, NAC / service bits ...
 - Yes, not enough bits for many NAC roles
 - But that's arguably a good thing!
 - Cisco TrustSec may obviate the need for NAC roles in addresses, a little simpler – but not be vendor-neutral
 - Advanced version: two or three variants, tuned to fit small / medium / large site (lead prefix bits identify the site and implicitly the bit assignments)
- **Maximizes geographic summarization**
- **Other alternatives: service- or role-based (voice, guest, etc.)**
 - Larger routing tables (geographically summarizes per-service)

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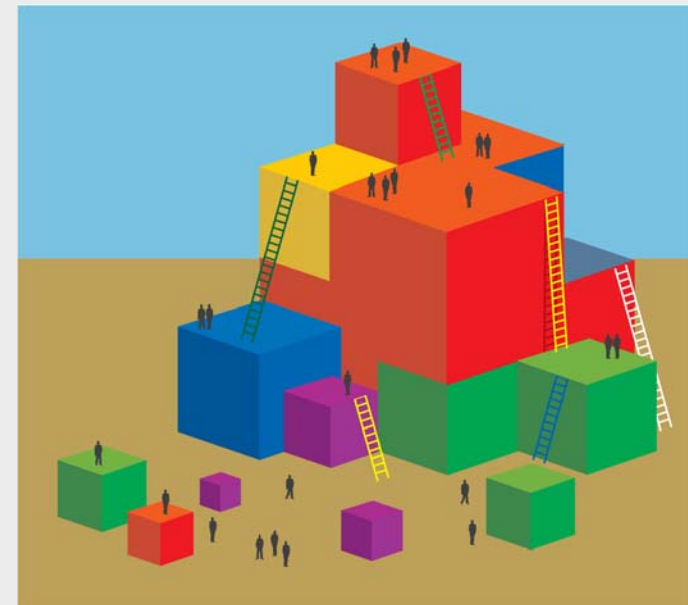


Summarizable Global Prefixes; Multi-Homing

- The IPv6 protocol has had several interesting real-world oversights as far as I'm concerned (one or two mentioned later)...
 - They did well overall, complex situation, small gaps
- One was assuming multi-homing via a single provider
 - (Almost nobody in the U.S. wants to do that)
- The issue with multiple providers is that when one fails, the path through the other uses different addresses
 - Losing session state
- shim6 was proposed as a small tweak to deal with that
 - Initial effort had security, source routing, and other issues
 - Protocol refined and now specified
 - Now under testing
- Current ARIN policy is to allocate blocks of addresses for multi-homing under the same policies as for IPv4
 - Some fear “the routing swamp”
 - Chance to get non-provider address block before policy changes

Prefix Choices

- **Choice:**
 - **Get one or several provider-supplied blocks**
 - **If several, form multi-homing strategy based on them**
 - **Where's IPv6 NAT when you need it?**
 - **Heresy!**
 - **NAT does create problems for app developers, makes firewalls more complex**
 - **Get an allocation from ARIN**
 - **Is a /48 enough?**
 - **How much to ask for?**
 - **Ask for bigger block to provide more subnets (see below)?**

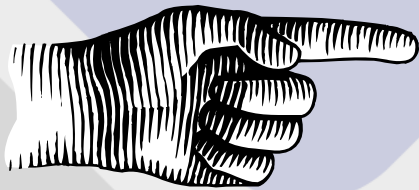


Is a /48 enough?

- **If you get a /48, you have $64-48 = 16$ bits of subnetting to work with**
 - Is 65,000 subnets enough?
 - Comparable to 10.a.b.0 with /24 subnets
 - If large, may not be enough for site / building / floor / NAC bit usage
 - Such schemes are inherently wasteful of address space, BUT conserve human time
- **It may be a short-term-only issue**
 - Other new security schemes?
- **Your alternative: ask ARIN for more?**

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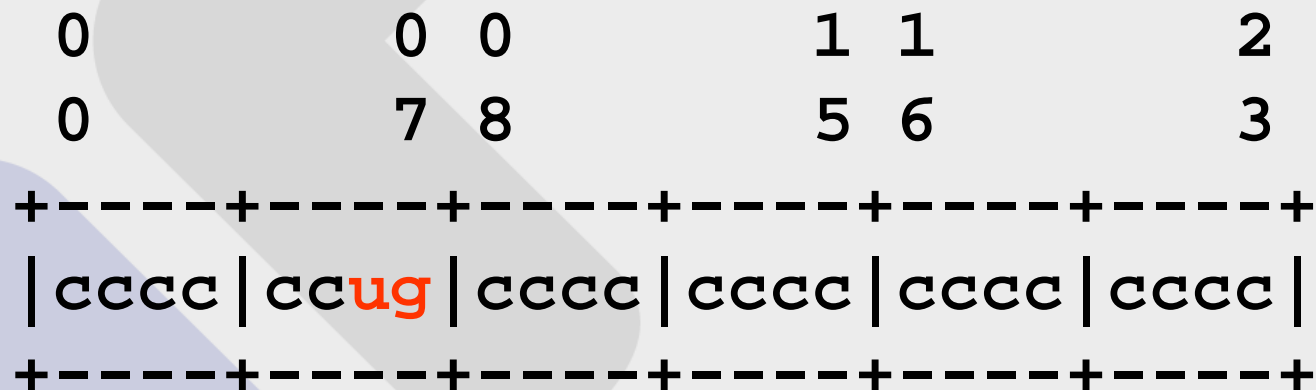
Addressing Plans



- **Choices:**
 - Use IPv4 mapped directly to IPv6
 - Use tunneling in some form
 - Use NAT-PT (scalability???)
 - Dual-stack and “real” addresses seem better to me
 - Use an ad hoc IPv4 mapping to IPv6
 - Is your current addressing summarizable?
 - Come up with a new addressing plan
 - Preferably with better summarizability and / or NAC-readiness
 - Won't help with NAC much unless you retrofit IPv4 ... in which case might ad hoc map v4 to 6?
 - Summarization really helps
 - Rapid routing convergence
 - Human manageability of the network

IPv6 Subnets

- **Some (including RFC's) say only do /64's**
 - Later thinking seems mixed
 - I hate disagreeing with Jeff Doyle...
 - /64 is rather desirable for end station subnets
 - And /128 for loopbacks
- **Do you mind /126's? (I like them for infrastructure links)**
 - The interface ID u/g bit fine point:



How IPv4 “Ad Hoc” Mapping Works

- **10.x.y.0 /24: Take x.y and convert to hex**
- **Organization prefix as /48, tack on hex version of xy (16 bits = 4 hex digits). Result is a /64**
- **Map /30 to /126 as hex in last byte**
 - Watch the u/g bits... if map last byte, no problem, lots of lead 0’s
- **Embedded XLS below, just uses string functions (could do hex math if necessary)**

Sample Prefix	2610:0040:1000				/38				Treated as a /48 (just using part)
10.162.20.0	10	162	20	0 0A	A2	14	00		2610:0040:1000:A214::/55
Last octet carryover for a /30:									
10.162.0.5	10	162	0	5 0A	A2	00	05		2610:0040:1000:A200::05/126

Forming a new IPv6 Addressing Plan

- Take your prefix and divide up the bits as in our IPv4 approach
- Routing summarizability matters
 - (not overwhelmingly)
- Have to choose whether to do all /64's, or take /126's out of the plentiful space from

your-prefix: **16 more bits:xx00:** and-48-more-bits

There are only $2^{46} \approx 7 \times 10^{13}$ or
70,000,000,000,000 /126 blocks this way

Dealing with /64 Subnets

- **EUI-64 calls for 2^{64}**
 - Ridiculously large number of host addresses
 - You have to decide what to do with them
 - I like automatically assigned EUI-64 “extended MAC” auto-addressing
 - Even though EUI-64 “wastes” 16 bits, for no useful purpose, as far as I can see
- **IEEE exhibited human tendency to get lax with resources perceived as plentiful (e.g. bandwidth?)**
 - IEEE tendency to tweak things? (Think Ethernet headers, VRRP vs. HSRP, etc.)

Host Anonymity in IPv6

- **There are schemes for host anonymity**
 - Random 64 bits used
 - Changes over time
 - Creates problems if security, RIAA, etc. trigger finding out which device did something in the past (forensics)
 - Would require at least historical Neighbor MAC table snapshots, timestamps, lookup technique
 - If everyone wears a mask and hoodie, theft is easy?
- **Scanning for hosts could be hard with a /64**
 - Virii have to work hard to find 64 bit addresses that are randomly distributed
 - That may confound common security approaches
- **Servers can't be anonymous: DNS, fixed addresses**
- **Routers can be more anonymous, but that can make management harder**
 - Your choice

DHCP

- **Not needed for address per se (“stateless”)**
- **Can be useful for providing other info, e.g. DNS server IP’s, preferred default gateway choice**

IPv6 Router Addressing

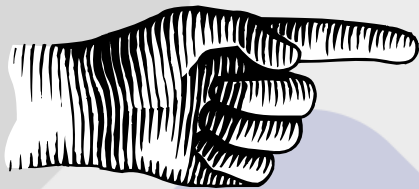
- **We've covered /126 and /128**
- **Router interfaces don't need to be addressed out of global space**
- **Link-local addressing suffices for routing**
 - **Can be a bit painful to learn to troubleshoot**
 - **Can break network management tools that ping interfaces directly (link-local addresses can't be routed, not necessarily unique either)**
 - **Provides external security: not globally reachable**
 - **Could do link-locals ending in 1 or 2...**
 - **Perhaps assign global /128's to loopbacks, so can SSH from remotely**
 - **I think it better to never underestimate the flaws and limitations of network management software (the programmers usually lack real networking experience)**

FHRP's: HSRP, VRRP, GLBP

- **A bit late to Cisco IOS**
 - I.e. check your code level, don't assume...
- **Can use Router Discovery priority**
- **Implementation allows control of active router by means of**
 - Interface tracking
 - Enhanced Object Tracking
- **Not needed if use VSS on Cisco 6500 (one virtual router, two chassis)**
- **Still needed with Cisco Nexus 7000 series**

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Summary

- **IPv6 addressing is similar to but a little different from IPv4 (as all of IPv6 is)**
 - We can use good ideas from IPv4 with IPv6
- **Need to think about obtaining a prefix**
 - Go to ARIN?
 - Obtain from one or more providers
- **Need to form a policy re how you will address loopbacks, infrastructure links**
- **Need to think about host, server, router addressing**
 - DHCP
 - First Hop Routing Protocol

Any Questions?



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Reference URLs

- **Basic IPv6 addressing**
 - <http://tools.ietf.org/html/rfc4291>
- **Unicast address assignment considerations**
 - <http://tools.ietf.org/html/rfc5375>
- **Enterprise network analysis (transition)**
 - <http://tools.ietf.org/html/rfc4852>
- **Use of /127 Prefix Length Between Routers Considered Harmful**
 - <http://tools.ietf.org/html/rfc3627>
- **Somewhat useful link, provider-addressing (mostly)**
 - http://www.getipv6.info/index.php/IPv6_Addressing_Plans
- **IPv6 block allocation tool**
 - <http://www.ipv6book.ca/allocation.html>
- **Shim6 links:**
 - <http://tools.ietf.org/wg/shim6/charters>
 - <http://www.shim6.org/>
 - <http://www.rfc-editor.org/rfc/rfc5533.txt> (and others)

My IPv6 Web Content

- <http://www.netcraftsmen.net/resources/archived-articles/280-introduction-to-ipv6-part-1.html>
- <http://www.netcraftsmen.net/resources/archived-articles/281-introduction-to-ipv6-part-2.html>
- <http://www.netcraftsmen.net/resources/archived-articles/279-introduction-to-ipv6-part-3.html>
- <http://www.netcraftsmen.net/resources/archived-articles/387-securing-ipv6-networks.html>
- <http://www.netcraftsmen.net/resources/archived-articles/657-preparing-for-ipv6.html>

About Chesapeake Netcraftsmen



- **For a copy of the presentation, email me at pjw@netcraftsmen.net**
- **About Chesapeake Netcraftsmen:**
 - **Cisco Premier Partner (have the certifications for Gold status)**
 - **Cisco Customer Satisfaction Excellence rating** ★
 - **We wrote the original version of the Express Foundations courses required for VAR Premier Partner status (and took and passed the tests)**
 - **We rewrote the DESGN / ARCH (CCDA / CCDP courses)**
 - **Cisco Advanced Specializations:**
 - **Advanced Route & Switch (10+ CCIEs on staff)**
 - **Advanced Unified Communications (and IP Telephony)**
 - **Advanced Wireless**
 - **Advanced Security (4 double R&S/Sec CCIE's now)**
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 - **We do Network / Security / Data Center / Wireless / Unified Communications design, assessment, deployment**
 - **Expertise and experience in many other areas as well**

