z/OS Communications Server

February, 2011

Do you still think IPv6 is something you don't need to deal with?

Alfred B. Christensen
alfredch@us.ibm.com
Gus Kassimis
kassimis@us.ibm.com

Enterprise Network Solutions, Raleigh NC

Do you still think IPv6 is something you don't need to deal with?

Date and time:	Wednesday February 23, 2011 - 11:00 - 12:00
Speakers:	Alfred B Christensen, IBM Gus Kassimis, IBM
Abstract:	Of course you have you heard of IPv4 addresses running out, but are you aware that this will happen within about one year? Do you know what IPv6 really is and how IPv6 can help you continue to grow your presence on the Internet? This session will provide an introduction to IPv6 in general and specifically to IPv6 on z/OS, providing an overview of the IPv6 protocol and its major components. It will also answer key questions such as why IPv6 is important, what are the benefits of IPv6 when compared to IPv4, when will IPv6 become prevalent, and what are some of the transition issues which must be addressed when enabling IPv6 support.

Trademarks, notices, and disclaimers

The following terms are trademarks or registered trademarks of International Business Machines Corporation in the United States or other countries or both:

- Advanced Peer-to-Peer Networking®
- AIX®
- alphaWorks®
- AnyNet®
- AS/400®
- BladeCenter®
- Candle®
- CICS®
- DataPower®
- DB2 Connect
- DB2®
- DRDA®
- e-business on demand®
- e-business (logo)
- e business(logo)®
- ESCON®
- FICON®
- GDDM®
- GDPS®
- Geographically Dispersed Parallel Sysplex
- HiperSockets
- HPR Channel Connectivity
- HyperSwap
- i5/OS (logo)
- i5/OS®
- IBM eServer
- IBM (logo)®
- IBM®
- IBM zEnterprise™ System
- IMS
- InfiniBand ®
- IP PrintWay
- IPDS
- iSeries
- LANDP®
- Language Environment®
- MQSeries®
- MVS
- NetView®
- OMEGAMON®
- Open Power
- OpenPower
- Operating System/2®
- Operating System/400®
- OS/2®
- OS/390®
- OS/400®
- Parallel Sysplex®
- POWER®
- POWER7®
- PowerVM
- PR/SM
- pSeries®
- RACF®
- Rational Suite®
- Rational®
- Redbooks
- Redbooks (logo)
- Sysplex Timer®
- System i5
- System p5
- System x®
- System z®
- System z9®
- System z10
- Tivoli (logo)®
- Tivoli®
- VTAM®
- WebSphere®
- xSeries®
- z9®
- z10 BC
- z10 EC
- zEnterprise
- zSeries®
- z/Architecture
- z/OS®
- z/VM®
- z/VSE

* All other products may be trademarks or registered trademarks of their respective companies.

The following terms are trademarks or registered trademarks of International Business Machines Corporation in the United States or other countries or both:

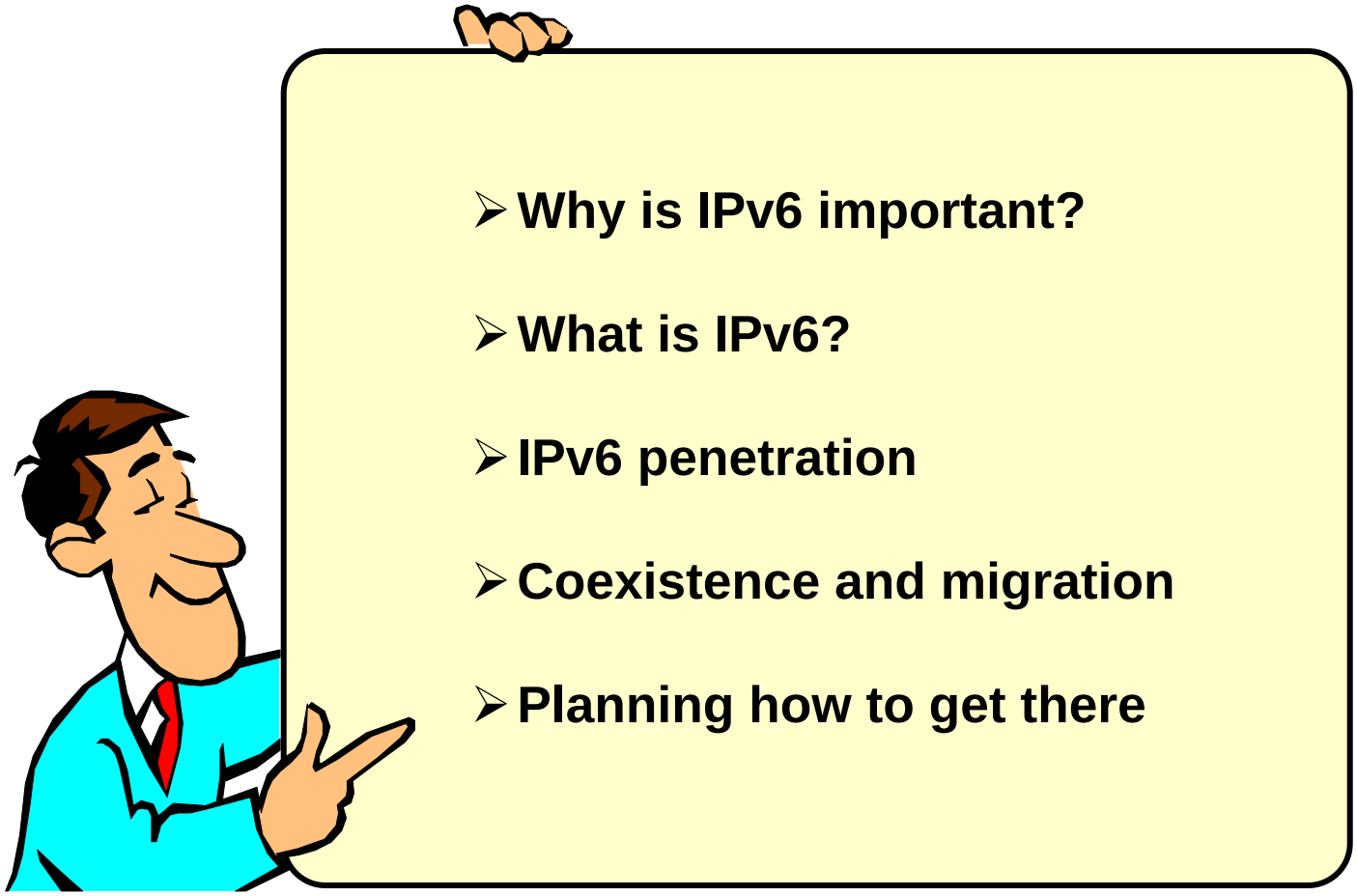
- Adobe, the Adobe logo, PostScript, and the PostScript logo are either registered trademarks or trademarks of Adobe Systems Incorporated in the United States, and/or other countries.
- Cell Broadband Engine is a trademark of Sony Computer Entertainment, Inc. in the United States, other countries, or both and is used under license there from.
- Java and all Java-based trademarks are trademarks of Sun Microsystems, Inc. in the United States, other countries, or both.
- Microsoft, Windows, Windows NT, and the Windows logo are trademarks of Microsoft Corporation in the United States, other countries, or both.
- InfiniBand is a trademark and service mark of the InfiniBand Trade Association.
- Intel, Intel logo, Intel Inside, Intel Inside logo, Intel Centrino, Intel Centrino logo, Celeron, Intel Xeon, Intel SpeedStep, Itanium, and Pentium are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.
- UNIX is a registered trademark of The Open Group in the United States and other countries.
- Linux is a registered trademark of Linus Torvalds in the United States, other countries, or both.
- ITIL is a registered trademark, and a registered community trademark of the Office of Government Commerce, and is registered in the U.S. Patent and Trademark Office.
- IT Infrastructure Library is a registered trademark of the Central Computer and Telecommunications Agency, which is now part of the Office of Government Commerce.

Notes:

- Performance is in Internal Throughput Rate (ITR) ratio based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve throughput improvements equivalent to the performance ratios stated here.
- IBM hardware products are manufactured from new parts, or new and serviceable used parts. Regardless, our warranty terms apply.
- All customer examples cited or described in this presentation are presented as illustrations of the manner in which some customers have used IBM products and the results they may have achieved. Actual environmental costs and performance characteristics will vary depending on individual customer configurations and conditions.
- This publication was produced in the United States. IBM may not offer the products, services or features discussed in this document in other countries, and the information may be subject to change without notice. Consult your local IBM business contact for information on the product or services available in your area.
- All statements regarding IBM's future direction and intent are subject to change or withdrawal without notice, and represent goals and objectives only.
- Information about non-IBM products is obtained from the manufacturers of those products or their published announcements. IBM has not tested those products and cannot confirm the performance, compatibility, or any other claims related to non-IBM products. Questions on the capabilities of non-IBM products should be addressed to the suppliers of those products.
- Prices subject to change without notice. Contact your IBM representative or Business Partner for the most current pricing in your geography.

Refer to www.ibm.com/legal/us for further legal information.

Agenda



- **Why is IPv6 important?**
- **What is IPv6?**
- **IPv6 penetration**
- **Coexistence and migration**
- **Planning how to get there**

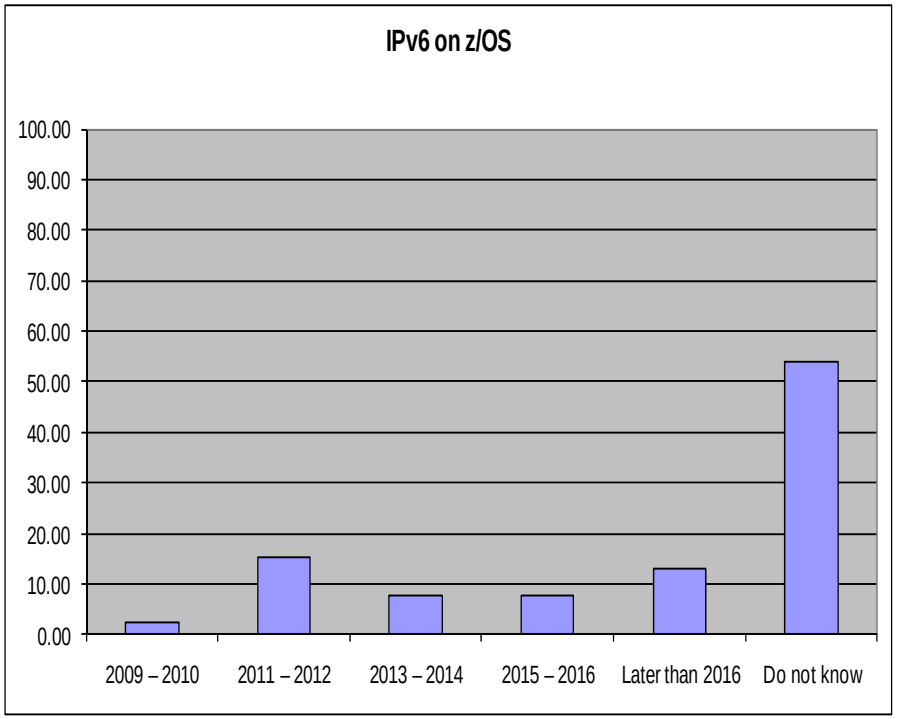
Disclaimer: All statements regarding IBM future direction or intent, including current product plans, are subject to change or withdrawal without notice and represent goals and objectives only. All information is provided for informational purposes only, on an "as is" basis, without warranty of any kind.

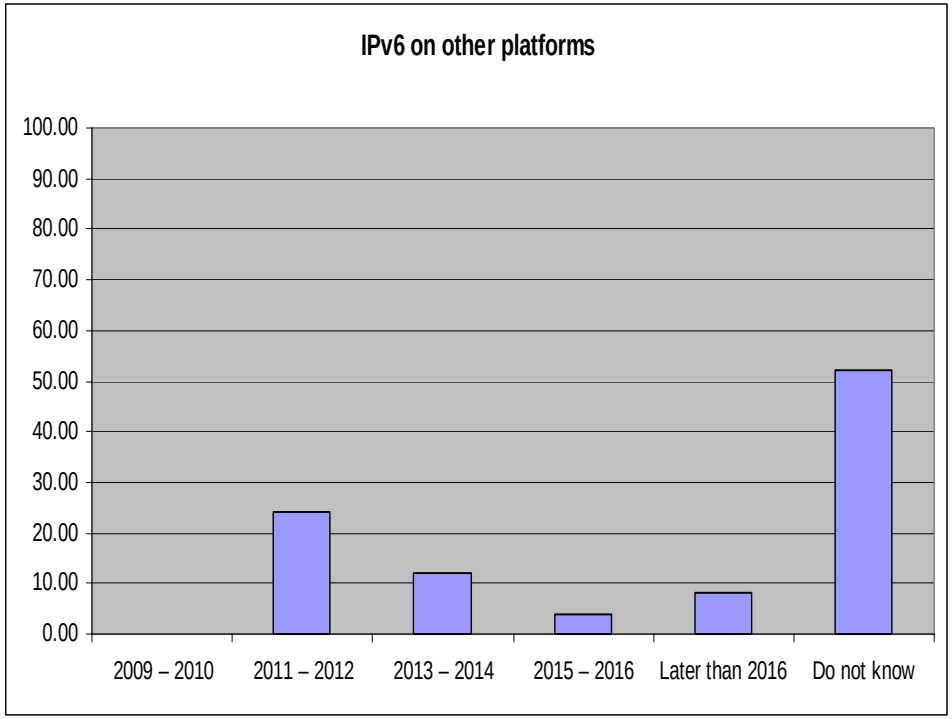
Do you still think IPv6 is something you don't need to deal with?

Why is IPv6 important?

When do our z/OS customers believe they will need IPv6?

- The majority of z/OS customers do not know
  - Expectations are that it will be needed slightly earlier on other platforms than z/OS
- It is time to start thinking, learning, and preparing ***now*** !

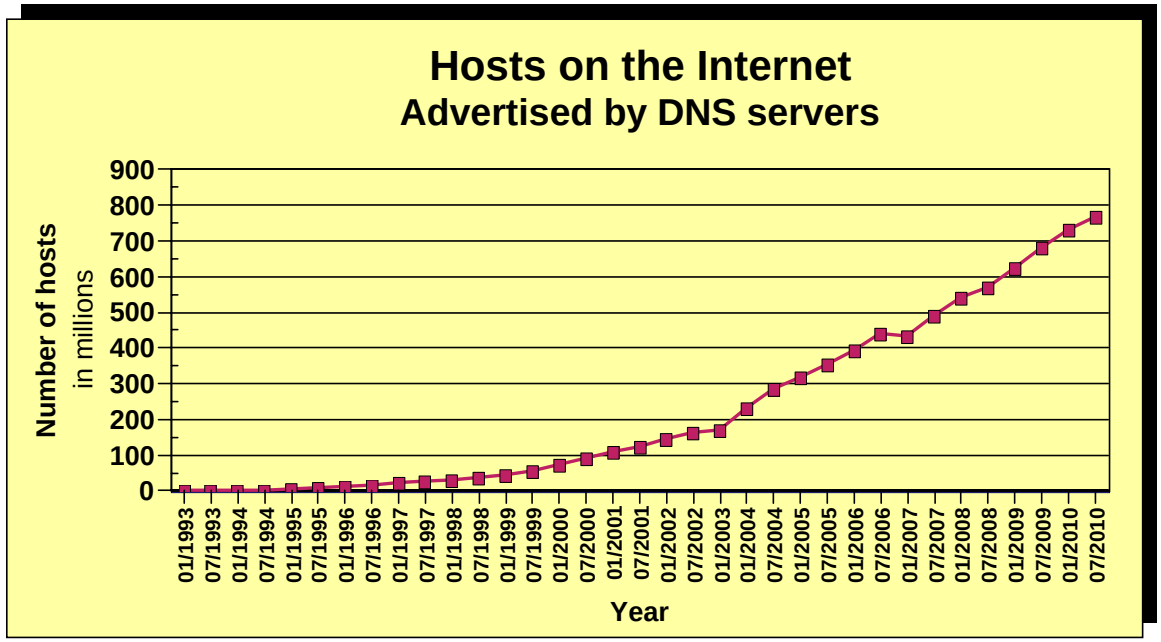




Source: Survey conducted by ENS early 2009 among a selected set of customers (39 responses to this question)

IPv4 address usage since early 1993 – *Chart from Summer 2010*

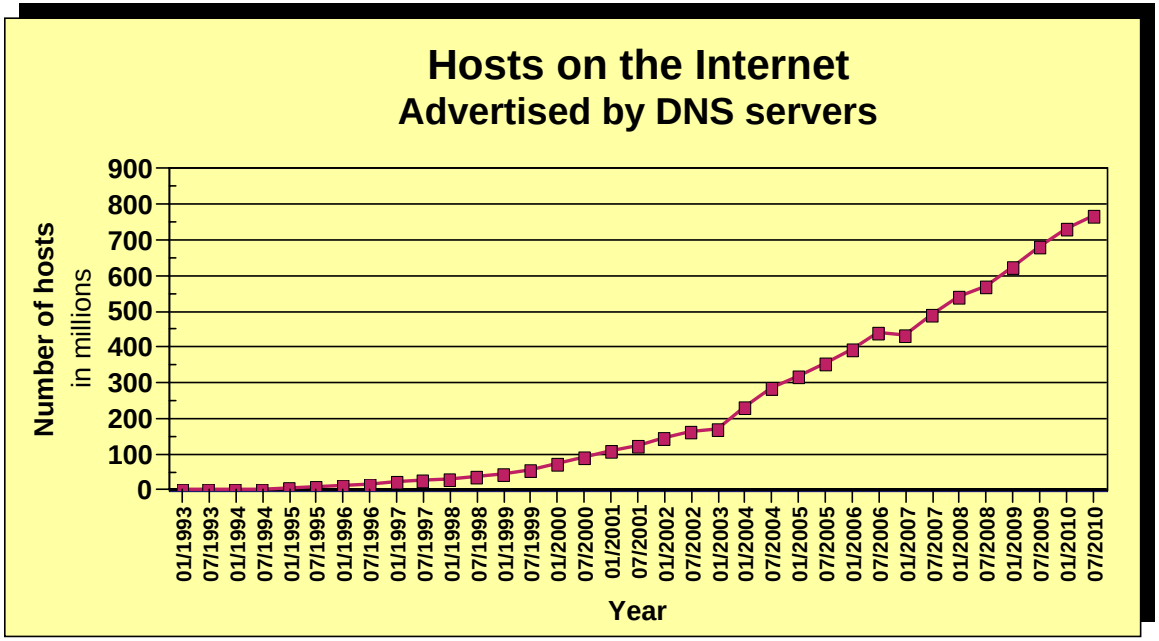
- Projected Internet Assigned Numbers Authority (IANA) Unallocated Address Pool Exhaustion
  - **May 2011**
- Projected Regional Internet Registries (RIR) Unallocated Address Pool Exhaustion
  - **Jan 2012**
- z/OS Communications Server continues to focus on IPv6 standards currency
  - US DoD/NIST
  - IPv6 Forum



- **What is the upper practical limit (the ultimate pain threshold) for number of assigned IPv4 addresses? Some predictions said 250,000,000 (250 million), others go up to 1,000,000,000 (one billion or one milliard).**
- **Source: https://www.isc.org/solutions/survey**
- **Source: http://www.potaroo.net/tools/ipv4/index.html**
- **Source: http://penrose.uk6x.com/**

IPv4 address usage since early 1993 – *Chart update for February 2011*

- ~~Projected~~ Internet Assigned Numbers Authority (IANA) Unallocated Address Pool Exhaustion
  - **February 3, 2011**
- Projected Regional Internet Registries (RIR) Unallocated Address Pool Exhaustion
  - ~~**Jan 2012**~~ **Aug 2011**
- z/OS Communications Server continues to focus on IPv6 standards currency
  - US DoD/NIST
  - IPv6 Forum

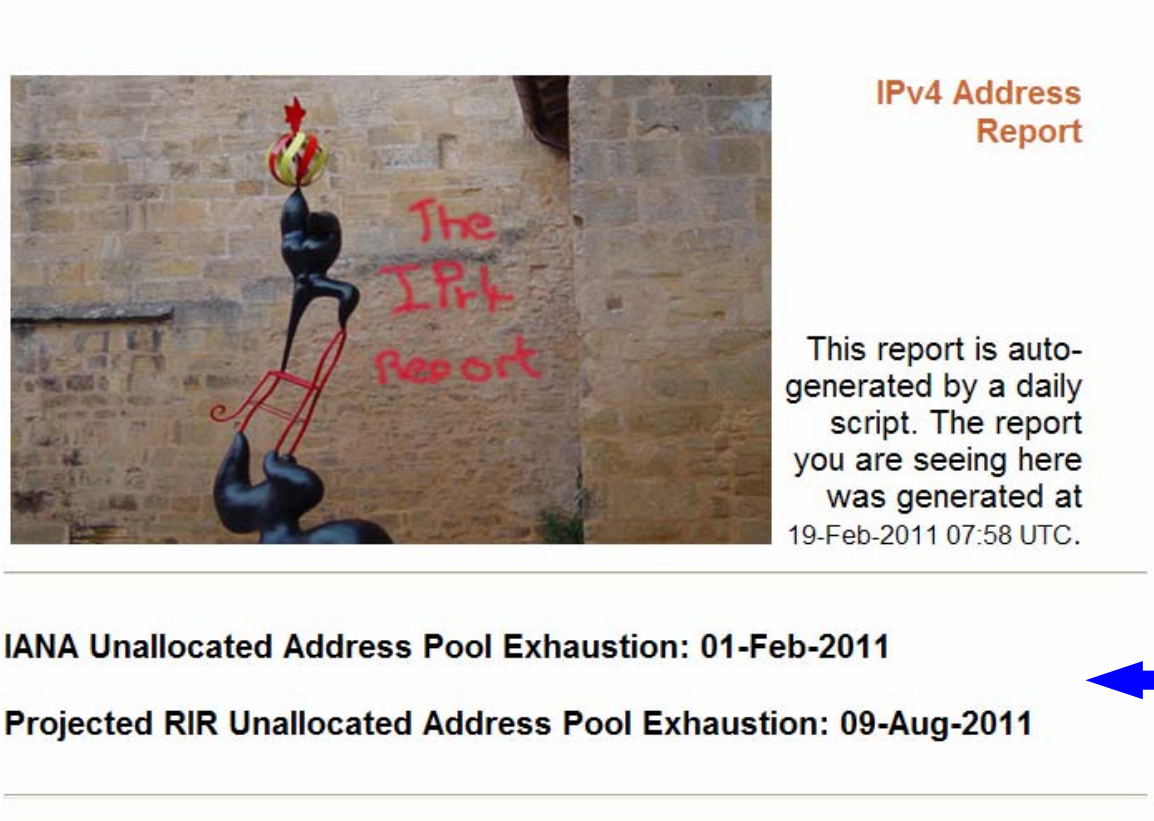


- **What is the upper practical limit (the ultimate pain threshold) for number of assigned IPv4 addresses? Some predictions said 250,000,000 (250 million), others go up to 1,000,000,000 (one billion or one milliard).**
- **Source: https://www.isc.org/solutions/survey**
- **Source: http://www.potaroo.net/tools/ipv4/index.html**
- **Source: http://penrose.uk6x.com/**

If you want to stay in business after 2011/2012, you'd better start paying attention!
Do not worry too much; the sky isn't falling – IPv4 and IPv6 will coexist for many years to come.
Your applications need to be able to use both. If you write directly to the TCP/IP sockets layer, you need to start changing those applications.

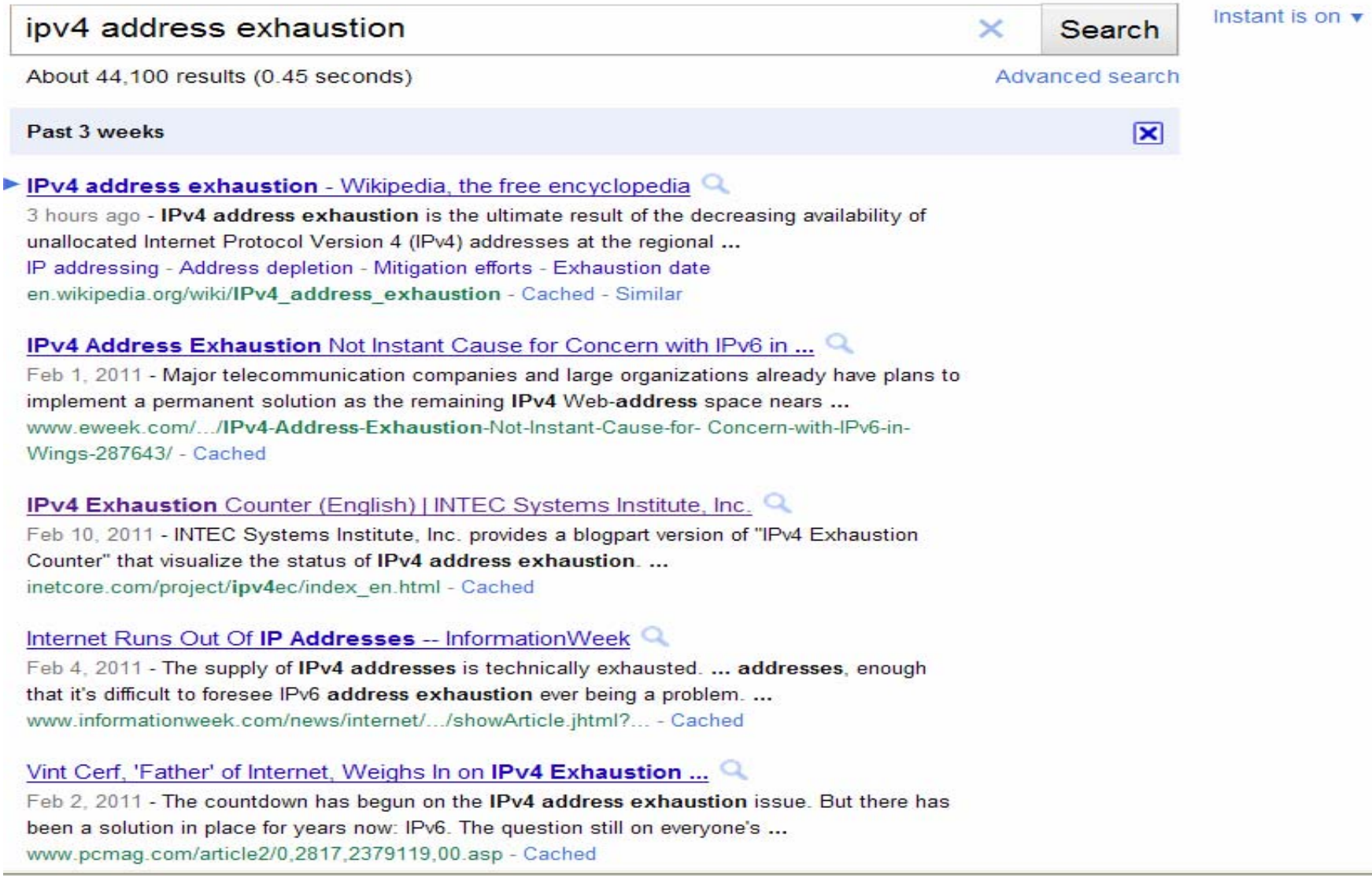
When is Doomsday going to be here?

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



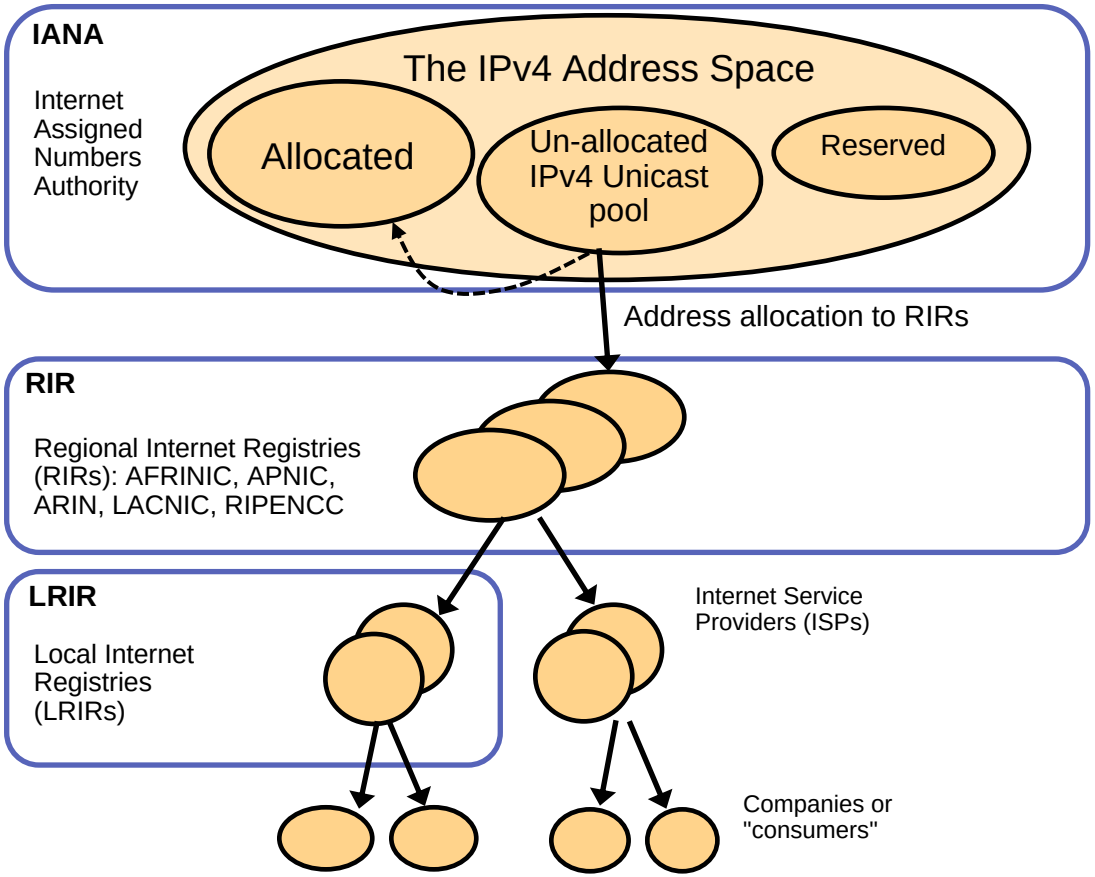
This is no longer a future long term concern!!!!

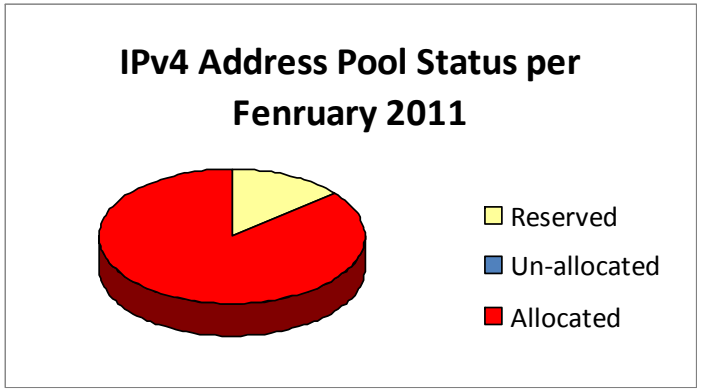
IPv4 Address exhaustion awareness is becoming a hot topic



Network World – early May 2010

How the IPv4 address space is managed

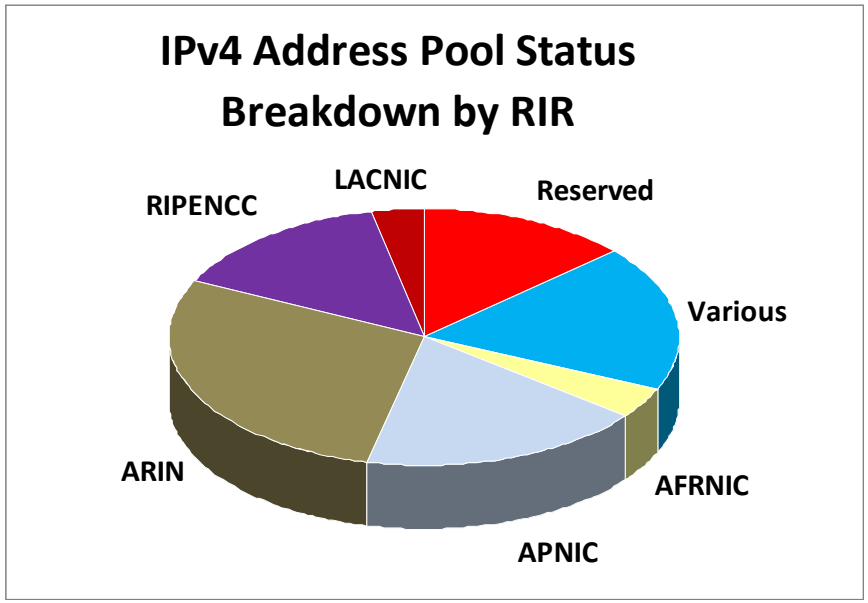


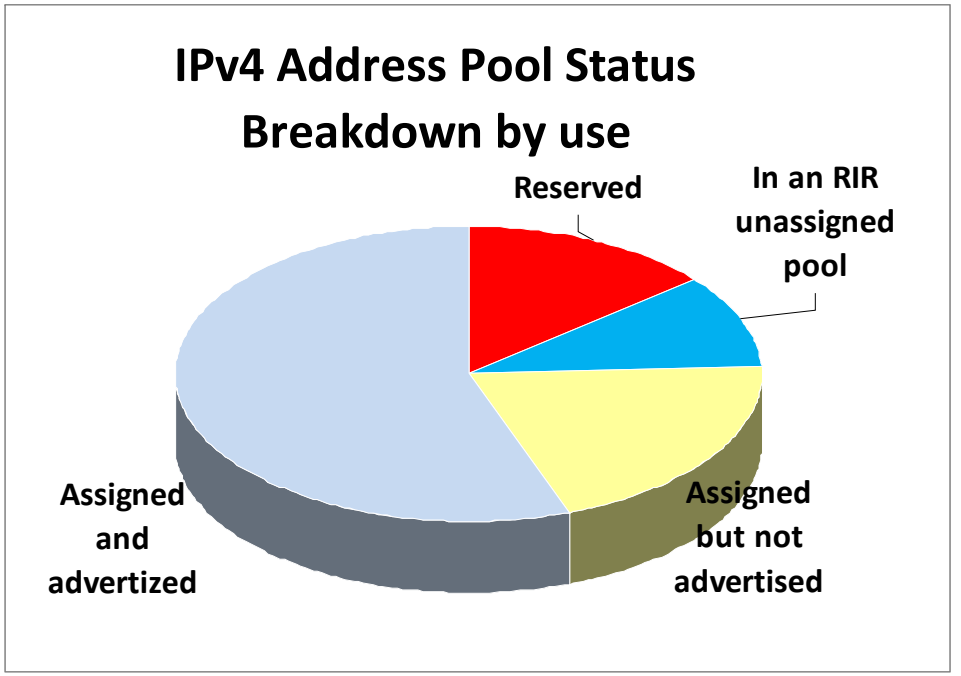


The IANA pool of un-allocated addresses was exhausted in February 2011

Source: "IPv4 Address Report" - http://www.potaroo.net/tools/ipv4/

IPv4 address space data as of February 2011

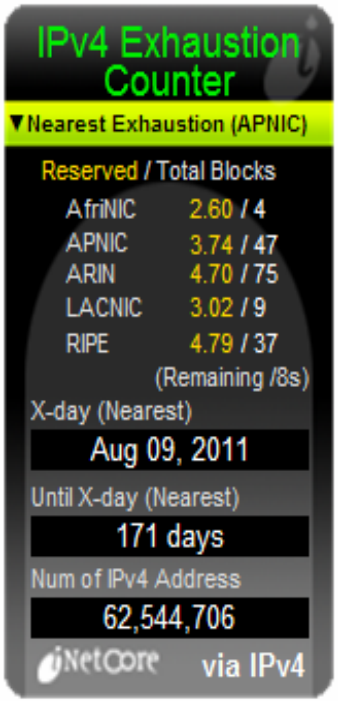




Reserved:	Reserved by the IETF
Un-allocated:	Available to be allocated to the RIRs ***(None available)***
Various:	Space allocated to various registries (before regional registries were introduced)
AFRINIC:	Africa, portions of the Indian Ocean
APNIC:	Portions of Asia, portions of Oceania (includes Australia, China, India)
ARIN:	Canada, United States, islands in the Caribbean Sea and North Atlantic Ocean
RIPENCC:	Europe, the Middle East, Central Asia
LACNIC:	Latin America, portions of the Caribbean

Tracking RIR allocations

Projected RIR Unallocated Address Pool Exhaustion: 09-Aug-2011

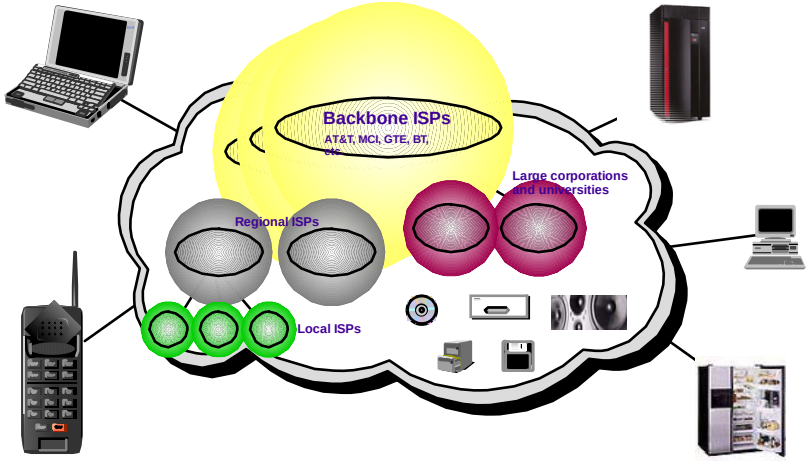


http://www.potaroo.net/tools/ipv4/index.html

Why IPv6? - It's really simple: IPv4 addresses are running short!

- **Forget about fancy IPv6 features as a reason for moving to IPv6**
  - (Some of them are actually good!)
- **IPv6 deployment is inevitable**
  - Literally running out of IPv4 addresses
    - IPv4 address pool projected to be exhausted soon
    - To minimize disruption, IPv6 needs to be in place and in actual use before exhaustion occurs
  - No other credible alternative to IPv6
    - Only alternative is IPv4 with significant increase in NAT
      - Increased use of private addresses and resulting address collisions
      - Complete loss of globally unique addressing
      - Even NAT requires pools of public IPv4 addresses
- **All major vendors have maturing IPv6 product lines**
  - All IBM operating systems support IPv6, with middleware and application support starting to ship as well
  - Router vendors (such as Cisco) have supported IPv6 for several years
  - Both Windows VISTA and Windows 7 were IPv6-enabled “out of the box”

The Internet - a worldwide digital utility.



Connectivity for ***anyone*** from ***anywhere*** (car, plane, home, office) to ***anything***!

IPv6 promises true end-to-end connectivity for peer-based collaborative solutions.

Current trends driving IPv6

- **Growing mobility of users**
  - Internet access from anywhere (car, airplane, home, office)
  - Multiple addresses per person
  - Pervasive Computing

- **Continued rapid growth of the Internet**
  - China plans to roll out ~1 billion Internet nodes, starting with a 320 million student educational network
    - Network operations for 2008 Summer Olympics done solely on IPv6 network
  - Asia/Pacific, and to a lesser extent Europe, missed out on the early IPv4 address allocations

- **Government support**
  - Wide-scale IPv6 promotion underway in China, Japan, Korea and Taiwan
  - European Commission (EC) encourages IPv6 research, education, and adoption in member countries
  - US Department of Defense - All platforms offered to DoD must meet very specific IPv6 capabilities
  - Other US government institutions through the National Institute of Standards and Technologies - NIST has also published detailed IPv6 compliance requirements

- **More and more "push" applications being deployed in the wireless market space.**
  - Clients subscribe to services that get pushed out by servers – requires public addresses for clients

- **Convergence of voice, video and data on IP**
  - Need for reliable and scalable architecture
  - “Always-on Connections"

Do you still think IPv6 is something you don't need to deal with?

What is IPv6?

So - what is IPv6?

- **IPv6 is an evolution of the current version of IP, which is known as IPv4**
  - Work on new IETF standard started in early 90's
  - Not backward compatible, but migration techniques defined
- **Today's IPv4 has 32 bit addresses**
  - Theoretical limit is around 4 billion addresses
  - Due to IPv4 address assignment structure and policies, the practical limit is less than 1 billion useable global addresses

IPv4 Address:
9.67.122.66

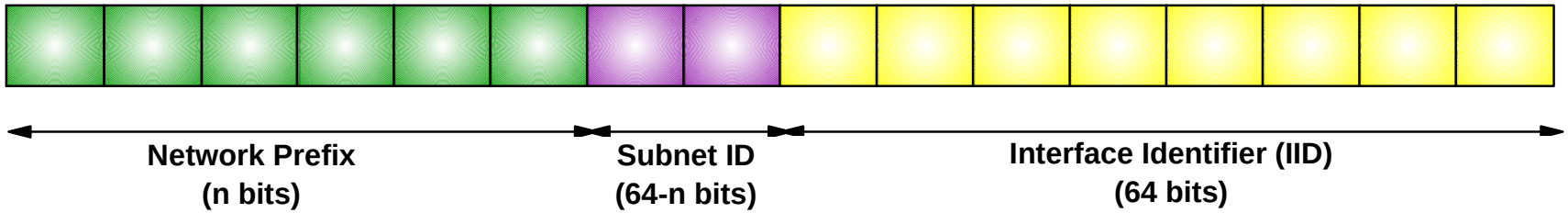
- **IPv6 provides almost unlimited number of addresses**
  - IPv6 addresses are 128 bits
  - No practical limit on global addressability
  - Enough address space to meet all imaginable needs for a while
  - More addresses *cannot* be retrofitted into IPv4

IPv6 Address:
2001:0DB8:4545:2::09FF:FEF7:62DC

- **Other improvements important, but to some extent secondary:**
  - Facilities for automatic configuration
  - Improved support for site renumbering
  - End to end IP security
  - Mobility with route optimization (important for wireless)
  - Miscellaneous improvements aimed at improving router performance

Important IPv6 technical features

- **IPv6 header and extensions header**
  - Streamlined IPv6 header
    - Fixed length to speed up forwarding processing in routers
  - Optional extension headers for fragmentation, security, etc.
- **Routers are no longer allowed (able) to fragment forwarded data-grams**
  - Path MTU is always used
- **Expanded size of IP address space**
  - Address space increased to 128 bits
    - Provides 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses
      - 3.4028 * 10**38
    - Enough for many(!) addresses per person on the planet
  - A 64-bit subnet prefix identifies the link
  - Followed by a 64-bit Interface Identifier (IID)
- **IID may be derived from IEEE identifier (MAC address)**
  - Only leftmost 64 bits available for routing and "network addressing"
  - The rightmost 64-bits identify the host on the target link



IPv6 address textual representation

- Addresses are represented as 8 segments of 4 hex digits (16 bits), separated by colons
  - **2001:0DB8:0:0:240:2BFF:FE3D:71AD**
- Two colons in a row can be used to denote one or more sets of zeroes, usually used between the prefix and the interface ID
  - **2001:0DB8::240:2BFF:FE3D:71AD**
- The prefix length can be indicated after a slash at the end
  - **2001:0DB8::240:2BFF:FE3D:71AD/64**
- A prefix alone is represented as if the interface ID bits are all zero
  - **2001:0DB8::/64**
- Obviously, this syntax may be a bit difficult for humans…..
  - Use of DNS/hostnames is no longer an optional convenience

Common IPv6 addresses and prefixes

- **::/128**
  - INADDR6_ANY (the unspecified address)
  - All zero address
- **::1/128**
  - IPv6 loopback address
- **FF00::/8**
  - Multicast addresses
- **FE80::/10**
  - Link-local addresses
  - fe80::14:5e00:6674:e0f0
- **FC00::/7**
  - Unique local addresses
- **::FFFF/96**
  - IPv4-Mapped IPv6 Address
- **2000::/3**
  - Current globally unique IPv6 address space
    - May change later
  - In a sense, anything different from the ones above are to be considered globally unique addresses

8 bits	4 bits	4 bits	112 bits
11111111	Flags	scope	Group ID

10 bits	54 bits	64 bits
1111111010	0	Interface ID

7 bits	121 bits
1111110	Local address

80 bits	16 bits	32 bits
0	FFFF	IPv4 address

3 bits	45 bits	16 bits	64 bits
Network prefix		Subnet	Interface ID
001	Network id		

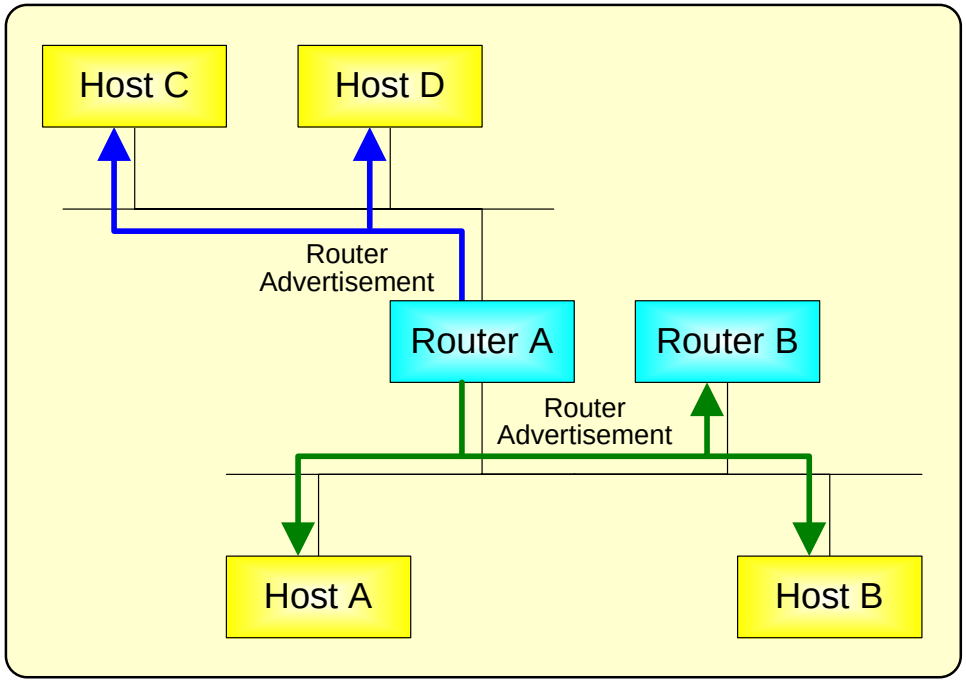
Stateless Address Auto-configuration and Neighbor Discovery

- Address Configuration without separate DHCP server
  - Router is the server, advertising key address configuration information
- Address formed by combining routing prefix with Interface ID
- Link-local address configured when an interface is enabled
  - Allows immediate communication with devices on the local link
  - Primarily used for bootstrapping and mgmt.
  - Well-known prefix combined with locally-generated 64-bit IID
- Other addresses configured via Routing Advertisements (RA)
  - RA advertises 64-bit prefixes (e.g., on-link, form an address)
  - Public (e.g., server) addresses formed from Interface ID
- Duplicate Address Detection (DAD)
  - Ensures uniqueness of configured IP address

Router Discovery
- Router Solicitations and Router Advertisements used to find and keep track of neighboring routers
- Includes additional information for IP stack configuration

Address resolution
- Neighbor Solicitations and Neighbor Advertisements perform address resolution (i.e., ARP functions)

Neighbor Un-reachability Detection (NUD)
- Keep track of reachability of neighbors
- If path to router fails, switch to another router before TCP timeouts



Do you still think IPv6 is something you don't need to deal with?

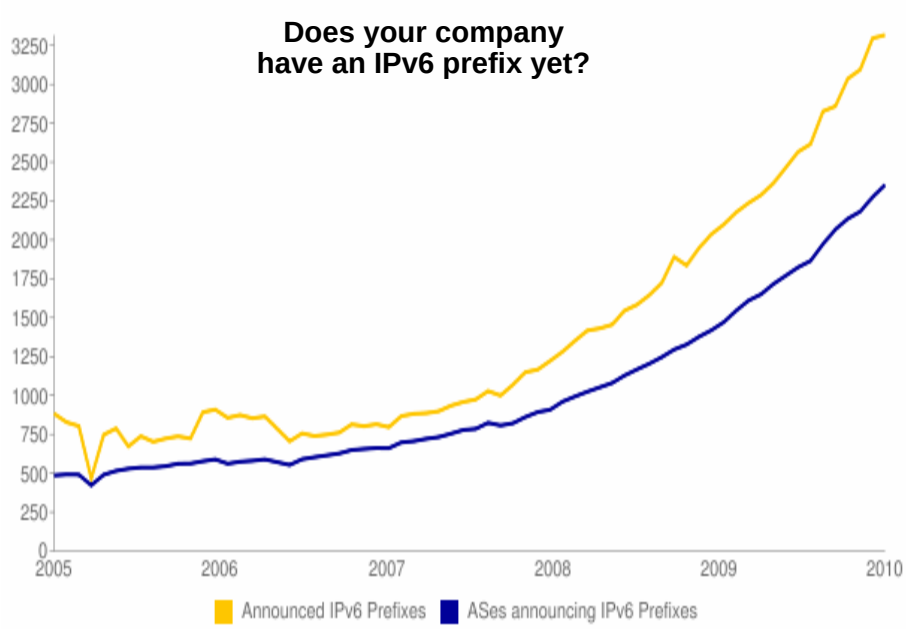
IPv6 penetration

Who is currently taking the lead on IPv6 deployment?

- **US Department of Defense (DoD)**
  - IPv6 compliance requirements detailed
  - All platforms offered to DoD must meet very specific IPv6 capabilities
- **Other US government institutions through the National Institute of Standards and Technologies (NIST)**
  - NIST has also published detailed IPv6 compliance requirements
  - Generally platforms offered to any US government institution must meet these very specific IPv6 requirements
- **Worldwide, other organizations are closely looking at the IPv6 compliance tests done according to the IPv6 forum – the IPv6-Ready Phase 1 and Phase 2 logo certification (Tahi test suite)**
  - z/OS V1R5 is IPv6-Ready Logo Phase 1 certified
  - z/OS V1R8 and z/OS V1R11 are IPv6-Ready Logo Phase 2 certified
  - z/OS V1R10 is IPv6 certified according to the US DoD IPv6 requirements
- **Russia has begun developing similar IPv6 compliance requirements**
- **The European Union is trying to jump-start IPv6 deployment within the European Union**
  - ADVANCING THE INTERNET - Action Plan for the deployment of Internet Protocol version 6 (IPv6) in Europe (issued in 2008)
- **Japan and China have had operational IPv6 networks for a few years**
- **The mobile telephone (device) industry is moving beyond GSM into IMS (IP multimedia Subsystem)**
  - Agreed to by the industry that it has to be based on IPv6
- **The internal management network in zEnterprise is IPv6 due to the facilities IPv6 offers in terms of auto configuration**
  - Cloud infrastructure solutions in general are assumed to move to IPv6 for the same reasons
- **Improved peer-to-peer communication with end-to-end security**

IANA IPv6 Prefix allocations

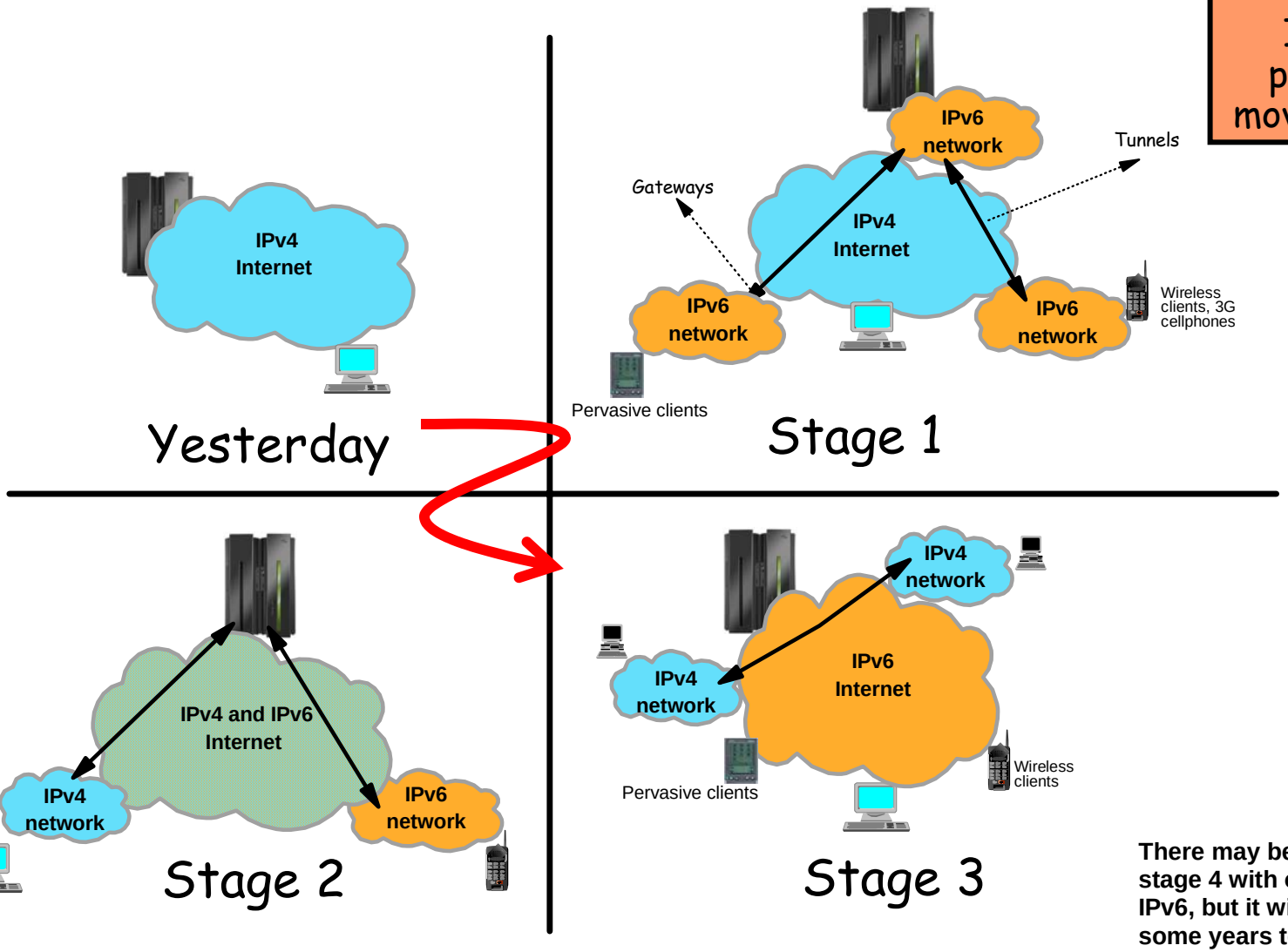
- IANA assigns IPv6 prefixes to the Regional Internet Registries for both IPv4 and IPv6
- The table to the right lists the current IPv6 prefix allocation to the RIRs
  - You will typically be assigned a 48-bit prefix out of these
  - Note: they all currently start with binary 001
- The graph below shows how many autonomous Systems (AS) currently announce IPv6 prefixes



Prefix	Designation	Date	Status
2001:0000::/23	IANA	7/1/1999	ALLOCATED
2001:0200::/23	APNIC	7/1/1999	ALLOCATED
2001:0400::/23	ARIN	7/1/1999	ALLOCATED
2001:0600::/23	RIPE NCC	7/1/1999	ALLOCATED
2001:0800::/23	RIPE NCC	5/2/2002	ALLOCATED
2001:0A00::/23	RIPE NCC	11/2/2002	ALLOCATED
2001:0C00::/23	APNIC	5/2/2002	ALLOCATED
2001:0E00::/23	APNIC	1/1/2003	ALLOCATED
2001:1200::/23	LACNIC	11/1/2002	ALLOCATED
2001:1400::/23	RIPE NCC	2/1/2003	ALLOCATED
2001:1600::/23	RIPE NCC	7/1/2003	ALLOCATED
2001:1800::/23	ARIN	4/1/2003	ALLOCATED
2001:1A00::/23	RIPE NCC	1/1/2004	ALLOCATED
2001:1C00::/22	RIPE NCC	5/4/2001	ALLOCATED
2001:2000::/20	RIPE NCC	5/4/2001	ALLOCATED
2001:3000::/21	RIPE NCC	5/4/2001	ALLOCATED
2001:3800::/22	RIPE NCC	5/4/2001	ALLOCATED
2001:3C00::/22	IANA		RESERVED
2001:4000::/23	RIPE NCC	6/11/2004	ALLOCATED
2001:4200::/23	AfriNIC	6/1/2004	ALLOCATED
2001:4400::/23	APNIC	6/11/2004	ALLOCATED
2001:4600::/23	RIPE NCC	8/17/2004	ALLOCATED
2001:4800::/23	ARIN	8/24/2004	ALLOCATED
2001:4A00::/23	RIPE NCC	10/15/2004	ALLOCATED
2001:4C00::/23	RIPE NCC	12/17/2004	ALLOCATED
2001:5000::/20	RIPE NCC	9/10/2004	ALLOCATED
2001:8000::/19	APNIC	11/30/2004	ALLOCATED
2001:A000::/20	APNIC	11/30/2004	ALLOCATED
2001:B000::/20	APNIC	3/8/2006	ALLOCATED
2002:0000::/16	6to4	2/1/2001	ALLOCATED
2003:0000::/18	RIPE NCC	1/12/2005	ALLOCATED
2400:0000::/12	APNIC	10/3/2006	ALLOCATED
2600:0000::/12	ARIN	10/3/2006	ALLOCATED
2610:0000::/23	ARIN	11/17/2005	ALLOCATED
2620:0000::/23	ARIN	9/12/2006	ALLOCATED
2800:0000::/12	LACNIC	10/3/2006	ALLOCATED
2A00:0000::/12	RIPE NCC	10/3/2006	ALLOCATED
2C00:0000::/12	AfriNIC	10/3/2006	ALLOCATED

IPv4 to IPv6 Internet evolution

So where are we?
In stage 1, preparing to move to stage 2.



There may be a stage 4 with only IPv6, but it will take some years to get there.

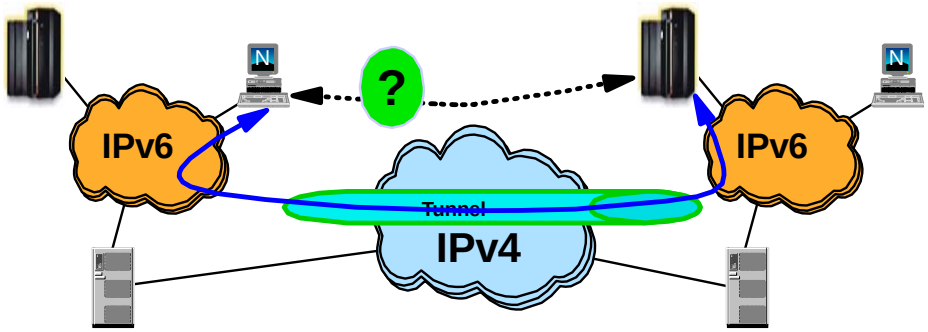
Do you still think IPv6 is something you don't need to deal with?

Coexistence and migration

General transition considerations

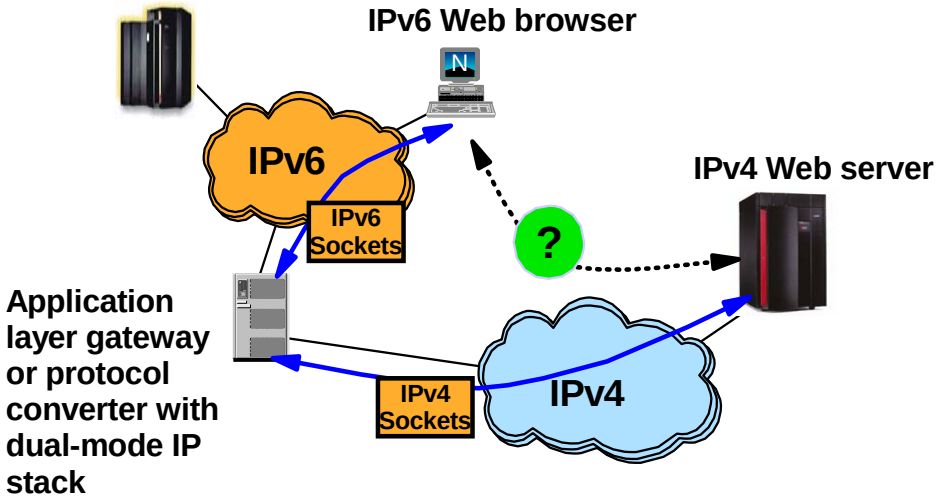
1 ***How do we share the physical network so that both IPv4 and IPv6 can be transported over one and the same physical network?***

- Standard LAN technologies for multiplexing multiple network protocols over the same media
- Dual-mode stack (supports both IPv4 and IPv6 in one TCP/IP stack)
- Tunneling of IPv6 over IPv4



2 ***How do applications that have not yet been enhanced to support IPv6 communicate with applications that only support IPv6?***

- Dual-stack
- Application Layer Gateways (ALG)
- Various other IPv6 transition technologies, such as ISATAP, 6to4 prefixes, SIIT, etc.
  - Look them up yourself!



Isn't IPv6 enablement just a network engineering exercise?

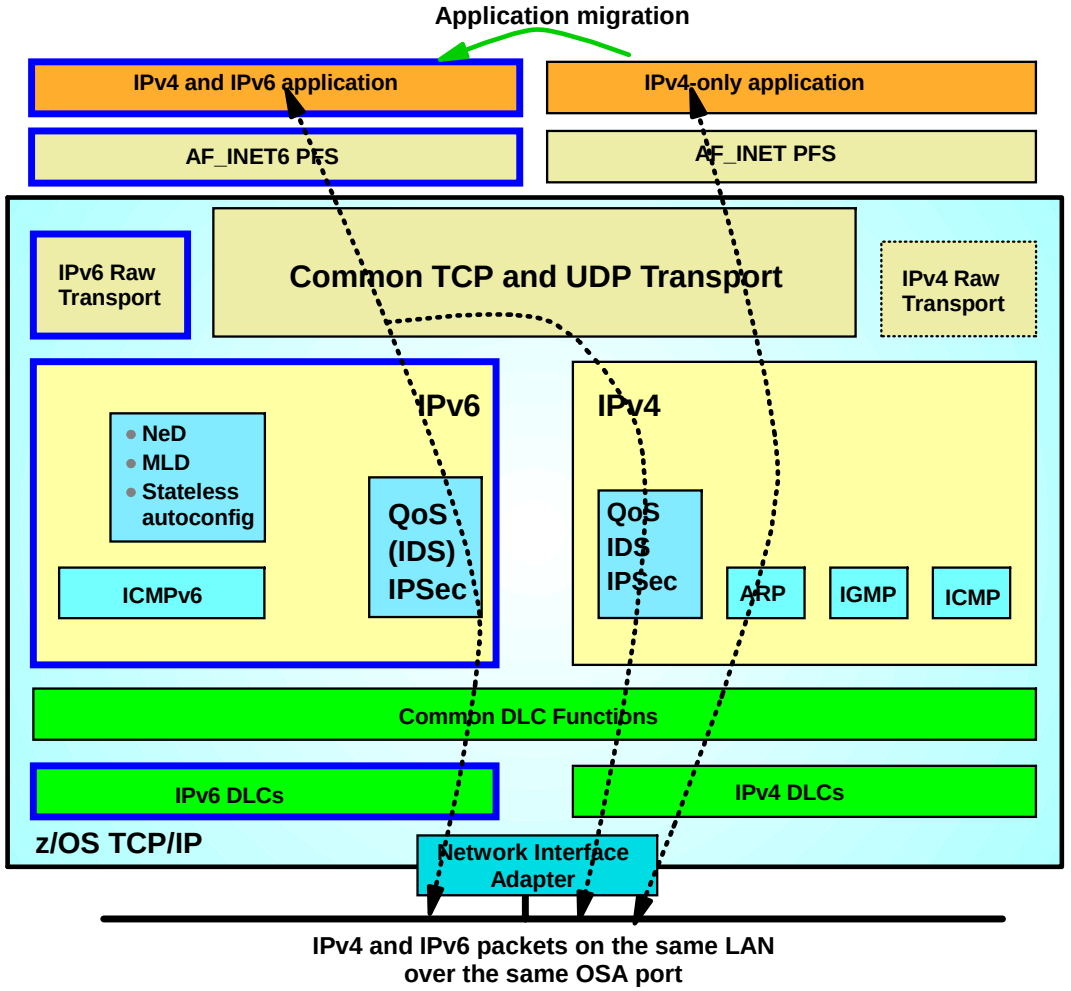
- Wish so !!

- A few facts:
  - The network infrastructure will have to be updated to support IPv6 network infrastructure functions, such as neighbor discovery (an auto-addressing technology), IPv6 routing tables (OSPFv3), ICMPv6, Name servers with IPv4 and IPv6 addresses, DHCP servers for IPv6, etc.
    - Layer-3 routers
    - Firewalls
    - Intrusion Detection devices
    - Application layer gateways (ALGs)
    - Etc.
  - The physical media you use today can carry both IPv4 and IPv6 – so no new cabling (!)
  - A TCP/IP stack must be updated to support IPv6 – alongside with IPv4 (known as dual-mode TCP/IP stack)
  - IPv6 requires a new sockets interface, known as AF_INET6 (Addressing Family IPv6)
    - IPv4 sockets programs today use AF_INET, which is IPv4 only. An AF_INET sockets program can communicate with an IPv4 sockets partner only
    - Sockets programs that are updated to support AF_INET6 can communicate with both IPv4 and IPv6 sockets partners

- Sockets programs must be updated to talk IPv6 !!

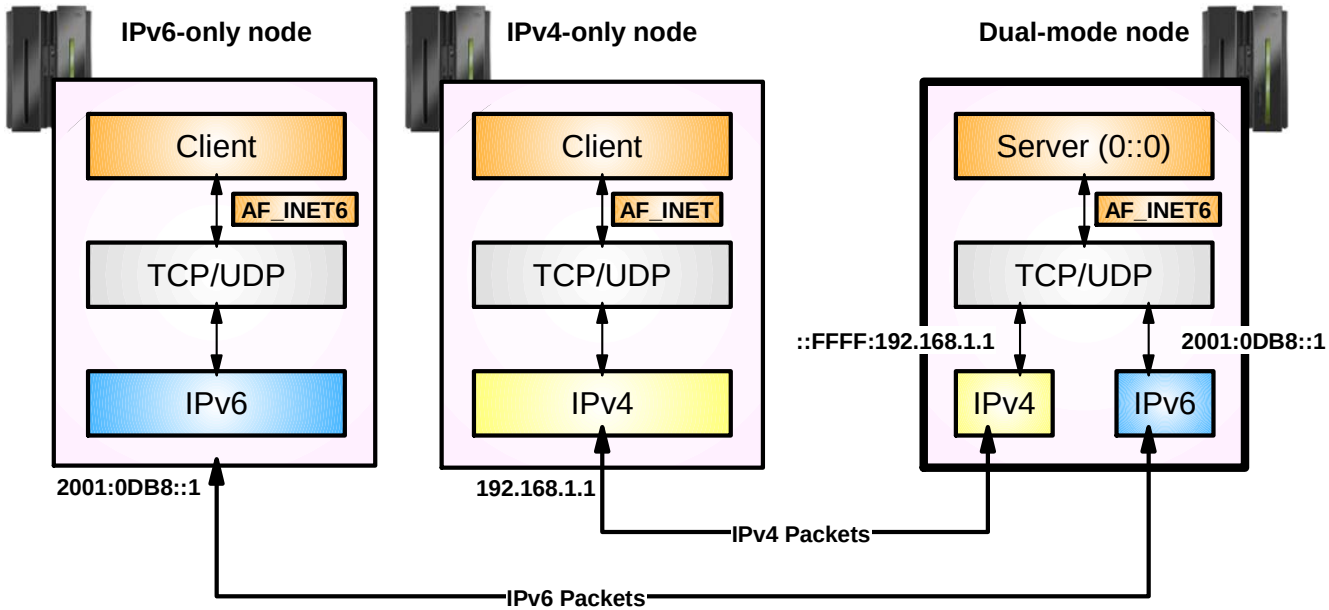
z/OS TCP/IP is a dual-mode TCP/IP stack

- A dual-mode (or dual-stack) TCP/IP implementation supports both IPv4 and IPv6 interfaces – and both old AF_INET and new AF_INET6 applications.
- The dual-mode TCP/IP implementation is a key technology for IPv4 and IPv6 coexistence in an internet.
- For AF_INET6 applications, the common TCP or UDP transport layer determines per communication partner if the partner is an IPv4 or an IPv6 partner - and chooses IPv4 or IPv6 networking layer component based on that.



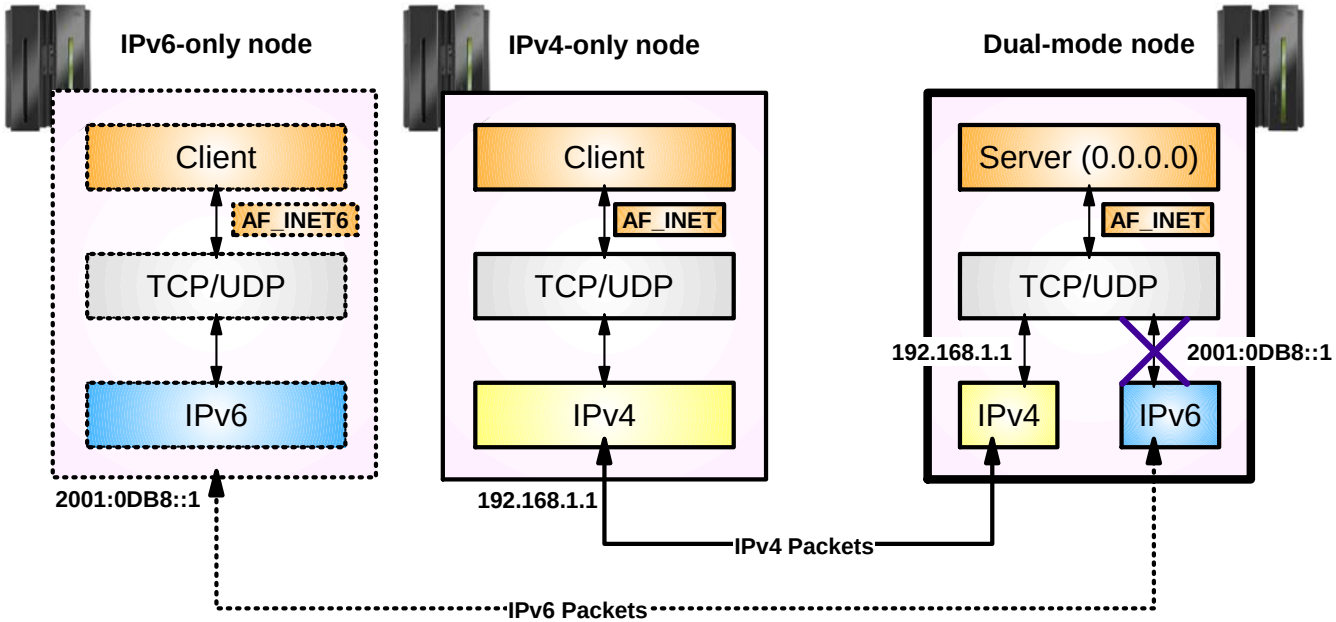
- Raw applications make the determination themselves when they choose IPv4 or IPv6 raw transport.

IPv6-enabled application on a dual mode stack



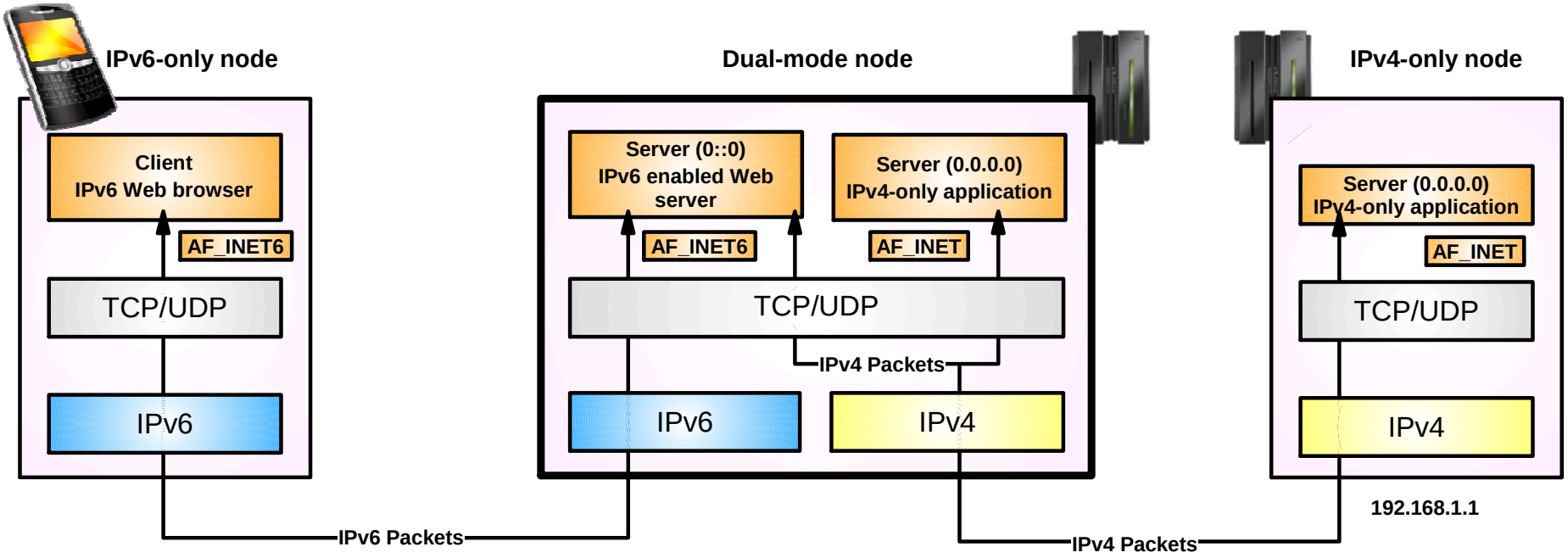
- An IPv6-enabled application can communicate with both IPv4 and IPv6 peers
  - A single socket can be used to send or receive traffic from either IPv4 or IPv6 partners
  - IPv4 packets to the IPv4 partner and IPv6 packets to the IPv6 partner
  - No changes need to be made to the partner application
- An IPv6-enabled application uses AF_INET6 sockets for both IPv4 and IPv6 partners
  - An IPv4 address is mapped to IPv6 addresses by the Transport Layer in the TCP/IP stack
  - Uses a special address format which identifies the IPv6 address as an IPv4-mapped IPv6 address
  - For example, 9.67.115.69 would be represented as ::FFFF:9.67.115.69

IPv4-only application on a dual-mode stack



- An IPv4 application running on a dual-mode stack can communicate with an IPv4 partner.
  - The source and destination addresses will be native IPv4 addresses
  - The packet which is sent will be an IPv4 packet
- If partner is IPv6 running on an IPv6 only stack, then communication fails
  - If partner was on dual-mode stack, then it would fit in previous page discussion
  - The partner only has a native IPv6 address, not an IPv4-mapped IPv6 address
  - The native IPv6 address for the partner cannot be converted into a form the AF_INET application will understand

Accessing IPv4-only applications through an IPv6 application layer gateway (ALG)



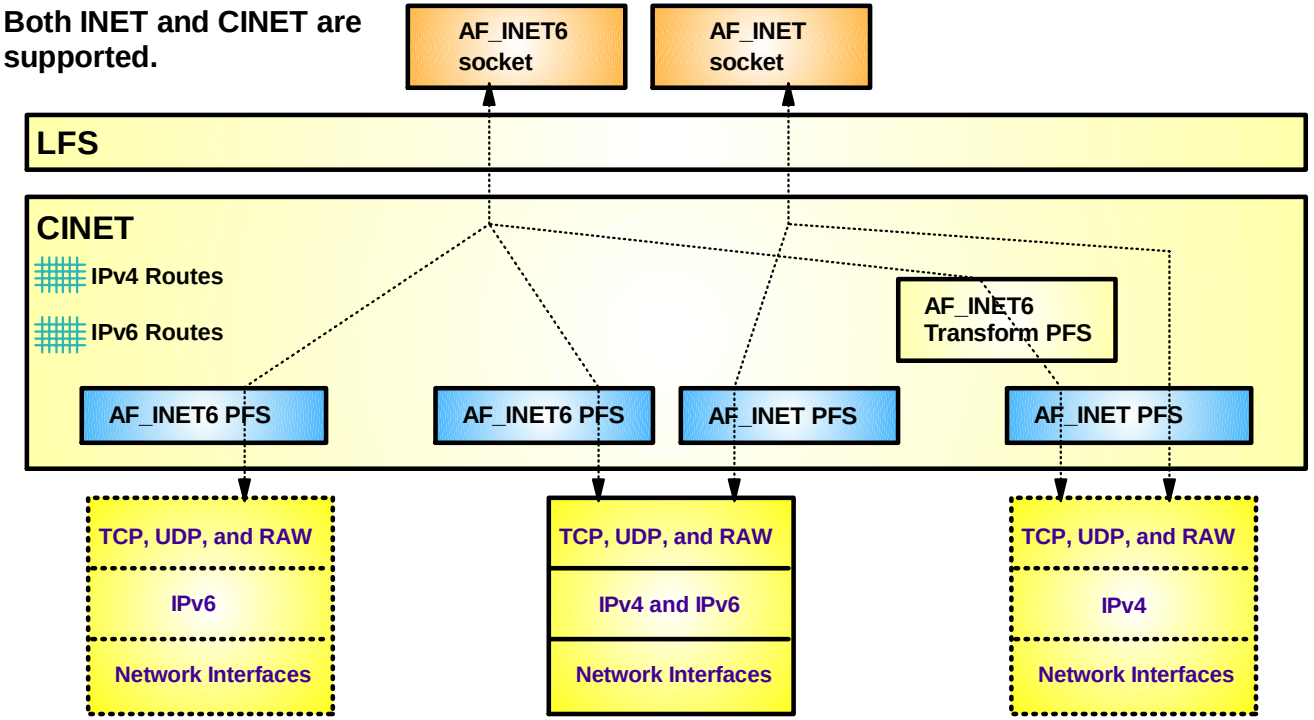
- An IPv6-only client can access IPv4-only servers via an IPv6 “proxy”
  - The IPv6 proxy communicates with the IPv6-only client using IPv6, and accesses the IPv4-only server using IPv4
  - The IPv4-only server may be on the same node as the IPv6 proxy, or may reside on a different node
  - The use of a backend IPv4-only server is, in most cases, completely transparent to the IPv6 client

Enabling IPv6 support on z/OS

IPv6 is enabled at an LPAR level via an option in BPXPRMxx to enable AF_INET6 support.

Both INET and CINET are supported.

When IPv6 is enabled, a z/OS TCP/IP stack will always have an IPv6 Loopback interface. You can define real IPv6 interfaces in addition to the loopback interface.



IPv6-only TCP/IP Stack

This will not be the case on z/OS for the foreseeable future! An AF_INET6 stack is required to also support AF_INET!

Dual Mode TCP/IP Stack

A z/OS TCP/IP stack will always come up as dual-mode if AF_INET6 is enabled in BPXPRMxx

IPv4-only TCP/IP Stack

(such as an OEM TCP/IP stack)

- Existing AF_INET sockets programs will continue to work as they always did - no difference in behavior or support.
- AF_INET6 enabled sockets programs will be able to communicate with IPv4 partners (just as before they were changed to support IPv6), but in addition to that they will also be able to communicate with IPv6 partners.

Netstat output format LONG or SHORT

- When IPv6 is enabled, most netstat reports will look different because of the potential for long IPv6 addresses.
  - Without IPv6 enabled, Netstat uses what is known as a SHORT report format
    - It is possible to have both local and remote IPv4 address in one 80-character line
    - You can override the SHORT format by coding IPCONFIG FORMAT LONG
  - With IPv6 enabled, Netstat uses a LONG report format
    - Each IPv6 address may potentially be up to 45 characters long, which makes it impossible to have both local and remote IPv6 addresses in a single 80-character line
- Make sure you update any netstat screen-scraping REXX programs you might have developed in the past!

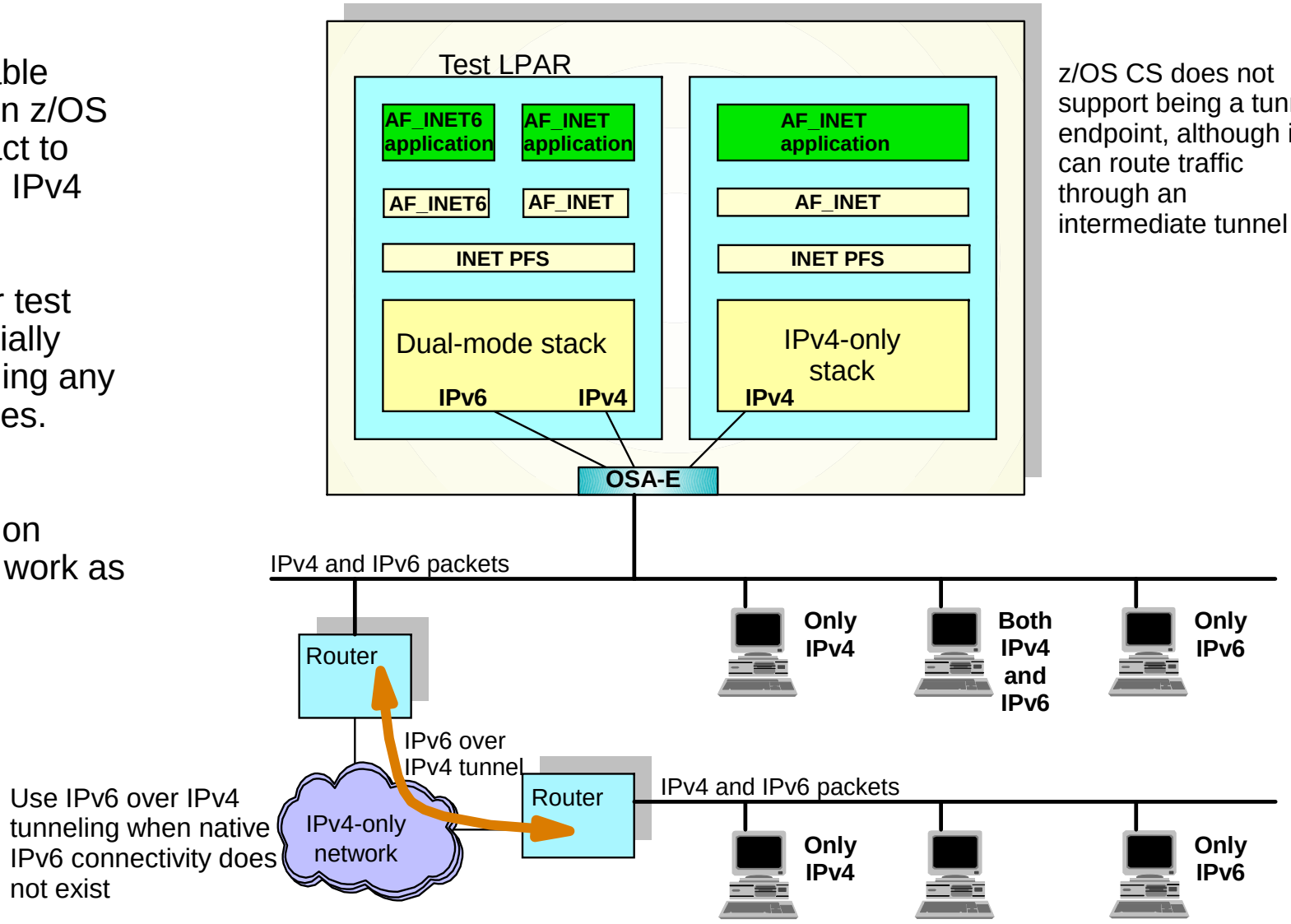
```
MVS TCP/IP NETSTAT CS V1R11       TCPIP Name: TCPCS          12:50:02
User Id  Conn     State
-------  ----     -----
MYINETD1 00000025 Listen
  Local Socket:   9.42.104.161..23
  Foreign Socket: 0.0.0.0..0
TN3270A  00000045 Listen
  Local Socket:   ::..23
  Foreign Socket: ::..0
TN3270A  00001B5E Establsh
  Local Socket:   ::ffff:9.42.105.45..23
  Foreign Socket: ::ffff:9.50.52.109..58646
  Application Data:  EZBTNSRV TCPABC81 TSO10001 ET B
```

Accessing z/OS over IPv6 from a remote site

Remember:
You can enable IPv6 today on z/OS without impact to your existing IPv4 users.

Do it on your test system – initially without defining any IPv6 interfaces.

All IPv4 communication continues to work as before.



z/OS CS does not support being a tunnel endpoint, although it can route traffic through an intermediate tunnel

z/OS and IPv6 - certifications

- z/OS V1R5 is IPv6 Ready Phase 1 certified by the IPv6 Forum
- z/OS V1R8 and z/OS V1R11 are IPv6 Ready Phase 2 certified by the IPv6 Forum
- z/OS V1R10 is IPv6 certified according to the US DoD IPv6 requirements!
  - See the "Special Interoperability Test Certification of the IBM z/OS Version 1.10 Operating System for IBM Mainframe Computer Systems for Internet Protocol Version 6 Capability"
  - From US government, Defense Information Systems Agency, Joint Interoperability Test Command
    - (http://jitc.fhu.disa.mil/adv_ip/register/certs/ibmzosv110_dec08.pdf)

"The IBM z/OS Version 1.10 operating system for IBM mainframe computer systems has met the Internet Protocol (IP) Version 6 (IPv6) Capable interoperability requirements of an Advanced Server as described in the Department of Defense (DoD) Information Technology Standards Registry, "DoD IPv6 Standard Profiles for IPv6 Capable Products Version 2.0," 1 August 2007, reference (c). The IBM z/OS Version 1.10 operating system for IBM mainframe computer systems has successfully completed the related IPv6 Interoperability portions of the "DoD IPv6 Generic Test Plan (GTP) Version 3," August 2007, reference (d), and is certified for listing on the Unified Capabilities (UC) Approved Products List (APL) as IPv6 Capable."

Do you still think IPv6 is something you don't need to deal with?

Planning how to get there

Steps for moving to an IPv6 Environment

- **Network access**
  - A LAN can carry both IPv4 and IPv6 packets over the same media
  - An OSA-EXPRESS port can be used for both IPv4 and IPv6
  - Update TCP/IP Profile to include the INTERFACE statement(s) for any IPv6 interfaces
  - For LPAR-LPAR communication for IPv6, several options exist:
    - using QDIO to a shared LAN (or a Shared OSA)
    - MPCPTP6 interfaces (via XCF if on the same sysplex or ESCON CTC links)
    - IPv6 HiperSocket connections (if on the same CEC)

- **IPv6 address selection**
  - Obtain an address block from your ISP, use one of your IPv4 addresses to create a 6to4 prefix, or create local IPv6 unicast addresses using the FC00::/7 prefix
    - For test purposes, local IPv6 unicast addresses is sufficient, but avoid using them in production
    - Remember: IPv6 sitelocal addresses have been deprecated and should not be used (even though some implementations still support them)
  - IPv6 addresses can be assigned to the IPv6 Interfaces and static VIPAs
  - Addresses can be manually configured on the INTERFACE statement in the TCP/IP Profile or auto-configured using Neighbor Discovery Stateless Auto-configuration
    - VIPA addresses must be manually configured

Steps for moving to an IPv6 Environment

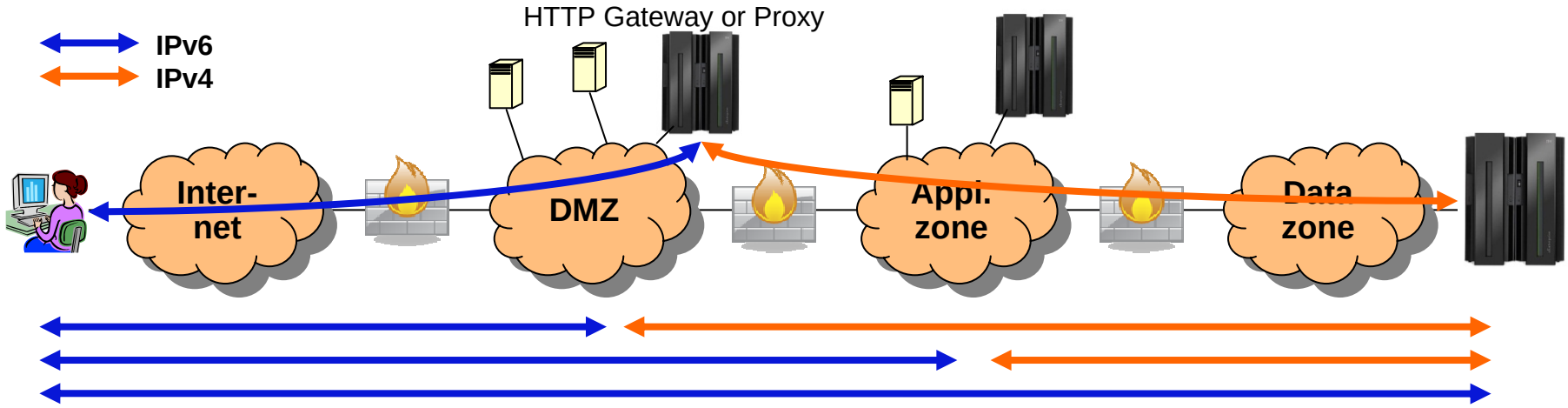
- **DNS setup**
  - A DNS BIND 9 Name Server can be used for both IPv4 and IPv6 resources
  - Continue to use the existing host name for IPv4 connectivity to avoid possible disruption in network connectivity and IPv4-only applications on an IPv6-enabled stack
  - Create a new host name to be used for IPv6 and IPv4 connectivity
  - Optionally, a third host name which may be used only for IPv6 can be configured
  - If using stateless auto-configuration to define IPv6 addresses, static VIPA addresses should be stored in DNS since the auto-configured addresses will change over time

- **INET or Common INET**
  - Both are supported for IPv6, but INET is much simpler
  - Running IPv4-only and dual-mode stacks under CINET is not recommended - run dual-mode stacks in a separate LPAR from IPv4-only stacks
    - All z/OS TCP/IP stacks in an LPAR are either IPv4-only or dual-mode - (Based on your BPXPRMxx definitions)
    - Only case where this could become an issue is if you start CA's TCPAccess TCP/IP stack side-by-side with a z/OS TCP/IP stack in an LPAR that have been enabled for IPv6 in the BPXPRMxx parmlib member
  - AF_INET6 NETWORK statement must be coded in BPXPRMxx before starting IPv6-enabled stacks

Steps for moving to an IPv6 Environment

- **Selection and placement of IPv6 to IPv4 translators or application gateway**
  - z/OS does not implement any functions that will allow IPv6-only nodes to communicate with z/OS-resident AF_INET applications, so an outboard protocol converter or application-layer gateway component may be needed
  - This component will only be needed if the test configuration includes IPv6-only platforms
  - Various technologies are being made available by various vendors

- **Connectivity to non-local IPv6 locations**
  - Tunneling may be needed between a router connected to the LAN that z/OS is connected to, and a router at another location where IPv6 test equipment is located



What can you do today? Start learning, planning, and testing!

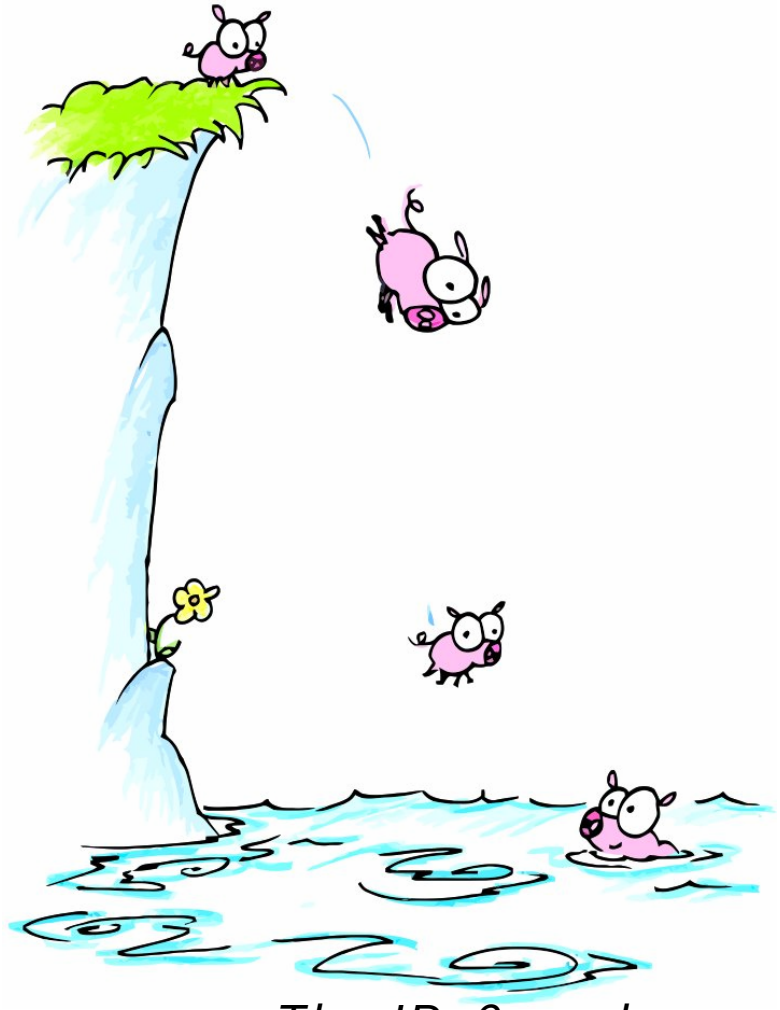
- Develop a multi-step plan
  - Eventual goal is fully IPv6-enabled dual-stack operating environment
- Choose a target date for being IPv6-enabled
  - Work backwards in developing a timeline on when key steps need to be completed
- Develop detailed plan for each sub-step
  - To resolve critical dependencies in the necessary timeframe
- Not too early to begin planning today
  - Need for IPv6 may occur quickly and with little advanced warning
  - Rapid realization that IPv6 is needed
  - Take several years to actually get IPv6 deployed
  - Need to have IPv6 already in use (and tested) before it becomes a requirement that it be used operationally
- Develop an internal addressing plan for distributing/managing IPv6 addresses
  - Determine how IPv6 addresses will be obtained
  - Either from your ISP, or from a Regional Internet Registry (RIR)
  - Consider whether Unique Local Addresses are appropriate
- Understand your ISPs IPv6 plans
- Perform a detailed inventory of all systems
  - Determine what is involved in IPv6-enabling them
  - All network hardware and software
  - All client and server hardware, software and applications
- Develop plans to ensure all components are IPv6-enabled according to a workable timeline
  - Work with vendors to understand their plans for adding IPv6 support for all critical components
- Determine how end users will use IPv6 services
  - Likely involve tunneling initially
  - But need IPv6-capable routers on the edge links where clients connect
  - Need to provide remote IPv6 access
- Develop plans for IPv6 training, education and consulting

Things to consider ..

z/OS is ready for IPv6 – are you?

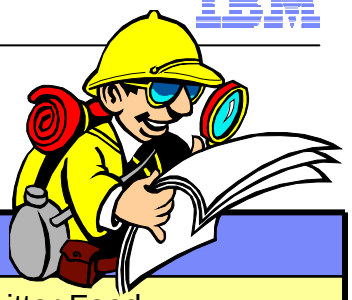
Phase-1

Phase-2



The IPv6 pool

For more information



URL	Content
http://www.twitter.com/IBM_Commserver	IBM Communications Server Twitter Feed
http://www.facebook.com/IBMCommserver	IBM Communications Server Facebook Fan Page
http://www.ibm.com/systems/z/	IBM System z in general
http://www.ibm.com/systems/z/hardware/networking/	IBM Mainframe System z networking
http://www.ibm.com/software/network/commserver/	IBM Software Communications Server products
http://www.ibm.com/software/network/commserver/zos/	IBM z/OS Communications Server
http://www.ibm.com/software/network/commserver/z_lin/	IBM Communications Server for Linux on System z
http://www.ibm.com/software/network/ccl/	IBM Communication Controller for Linux on System z
http://www.ibm.com/software/network/commserver/library/	IBM Communications Server library
http://www.redbooks.ibm.com	ITSO Redbooks
http://www.ibm.com/software/network/commserver/zos/support/	IBM z/OS Communications Server technical Support – including TechNotes from service
http://www.ibm.com/support/techdocs/atsmastr.nsf/Web/TechDocs	Technical support documentation from Washington Systems Center (techdocs, flashes, presentations, white papers, etc.)
http://www.rfc-editor.org/rfcsearch.html	Request For Comments (RFC)
http://www.ibm.com/systems/z/os/zos/bkserv/	IBM z/OS Internet library – PDF files of all z/OS manuals including Communications Server

For pleasant reading ….