



# IBM System z Technical University



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## IPv6 in z/VSE – Basics & Interfaces

zDG04

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April 15, 2009

CEO/Executive Name  
Organization Name  
Postal Address Block

**SUBJECT:** Notice of Internet Protocol version 4 (IPv4) Address Depletion

Dear [Addressee],

*This letter concerns the fact that Internet Protocol version 4 (IPv4) addresses are running out and calls your attention to what we are doing about it. You are receiving this letter as your organization currently utilizes IPv4 number resources. [1]*

IP addresses are the numbers behind domain names and are essential to the Internet. In May 2007, the American Registry for Internet Numbers (ARIN) advised the Internet community on IP address depletion in what is called Internet Protocol version 4 (IPv4) [2]. **At the current rate of consumption, IPv4 will be depleted within the next two years [3].** After that, organizations that need additional IP addresses will need to adopt IPv6, a newer version of the Internet Protocol that provides a much larger pool of address space.

Please note the following two important items:

1. **You should begin planning for IPv6 adoption if you are not doing so already.** One of the most important steps is to make your organization's publicly accessible resources (e.g. external web servers and e-mail servers) available via IPv6 as soon as possible. This will maintain your Internet connectivity during this transition. For more information on IPv6, please refer to ARIN's online IPv6 Information Center [4].
2. ARIN is taking additional steps to ensure the legitimacy of all IPv4 address space requests. Beginning on or after 18 May 2009, ARIN will require applications for IPv4 address space to include an attestation of accuracy from an organizational officer. This ensures that organizations submitting legitimate requests based on documented need will have ongoing access to IPv4 address space to the maximum extent possible.

Please feel free to contact ARIN if you have any questions regarding this notice. Send e-mail to [hostmaster@arin.net](mailto:hostmaster@arin.net) or call the registration services helpdesk at 703-227-0660.

Sincerely,

John Curran  
Chairman, Board of Trustees  
American Registry for Internet Numbers

## IPv4 Basics

### § IPv4 addresses are 32-Bit (4 Bytes) in length

- Theoretically up to 4.294.967.296 unique addresses
- IPv4 addresses are usually written in dot-decimal notation, which consists of the four octets of the address expressed in decimal and separated by periods:
  - Example: 207.142.131.235
  - Each block is 8 bits (1 byte). That is, the value range for each block is 0 to 255.

### § In order to facilitate routing a data packet across multiple networks, the address is divided into two parts:

- **Network prefix:** A contiguous group of high-order bits that are common among all hosts within a network.
- **Host identifier:** The remaining low-order bits of the address that are not designated in the network prefix. This part specifies a particular device in the local network.
- All endpoints which have the same network prefix are in the same IP network.
  - This implied that the endpoints can communicate directly with each others (e.g. through a switch, a hub or a crosslink cable), without the need to use a router.
- To communicate between different networks, a router is required.

### § In IPv4, subnet masks consist of 32 bits, usually a sequence of ones (1) followed by a block of 0s. The last block of zeros (0) designate that part as being the host identifier.

- Example: 255.255.255.0

	Dot-decimal notation	Binary form
IP address	192.168.5.130	11000000.10101000.00000101.10000010
Subnet Mask	255.255.255.0	11111111.11111111.11111111.00000000
Network Portion	192.168.5.0	11000000.10101000.00000101.00000000
Host Portion	0.0.0.130	00000000.00000000.00000000.10000010



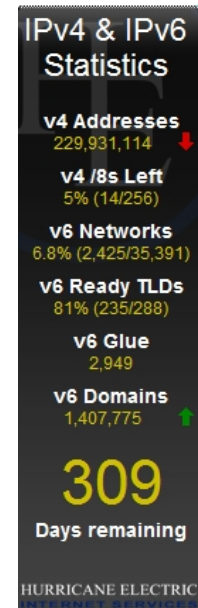
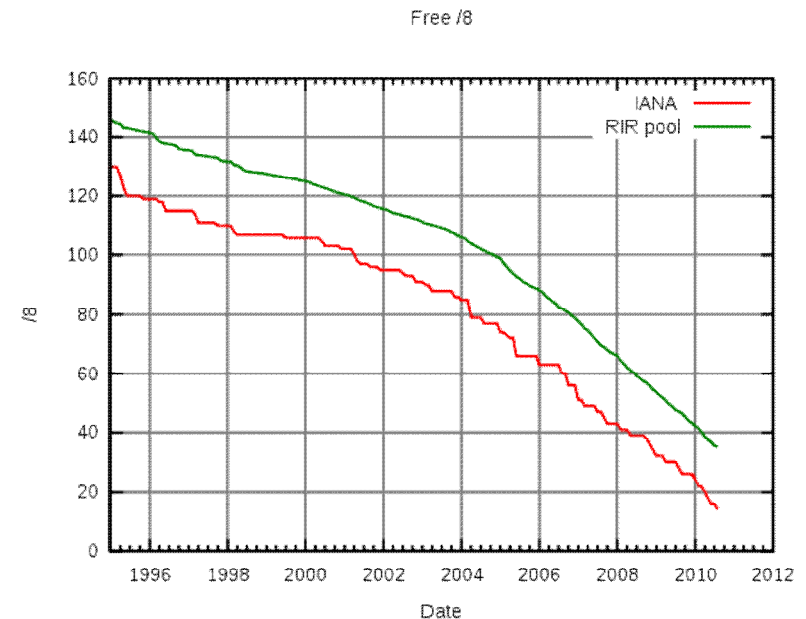


## What's the problem with IPv4?

- § The **depletion of the IPv4 allocation pool** has been a concern since the 1980s when the Internet started to experience dramatic growth
  - IPv4 only provided for approximately 4 billion addresses, a limit that is estimated to be reached before **2012**
- § At the moment, there are still about **230 Million** unused IP addresses available.

### Reasons for the IPv4 address depletion:

- § Unforeseen (?) **growth of the Internet** and its usage
  - Example: Asian countries
- § Every **mobile device** (Phone, PDA, ...) has an IP address today
- § **Always-on** connections: Today most devices stay on all the time. Thus assigned IP addresses stay assigned and can not be shared in an address pool
- § Almost every second house has at least one IP address (DSL, etc.)
- § Inefficient address allocation: For example, large companies or universities were assigned class A address blocks with over 16 million IPv4 addresses each.
  - Universities and governmental organizations in the US hold about 74 % of the worldwide assigned IPv4 addresses.
  - Example: Genuity is a IP network provider in the US. They have reserved 3 class A networks. That is about 48 million addresses. However, China has only about 20 million addresses, which is not even half of what Genuity uses.



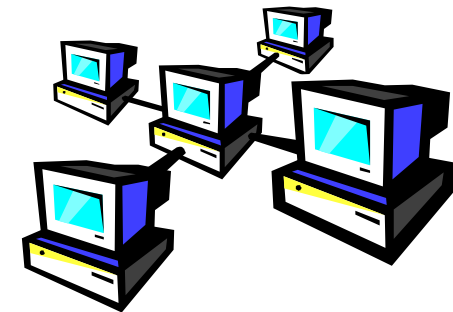
## Other disadvantages of IPv4

### § Network Address Translation (NAT)

- Allows to remap multiple internal IP addresses to one external IP address
  - Every DSL router does that
- But:
  - Quite complicated and processing time consuming
  - Only a limited number of connections possible at a time (limited due to the size of the NAT table)
  - Only connections from internal networks to external networks (outbound) are possible. For inbound connections a service like DynDNS is required.

### § IPv4 contains many **redundant and inefficient** features:

- Variable Length IP Header Options
  - Very processing time consuming for routers
- IP Header Checksum
  - TCP Header also contains a checksum
- Fragmentation of IP packets
  - Very processing time consuming and inefficient
- Classification of IP packets
  - Still exists, but is not used anymore



## The solution: IPv6

### § Wait a second, what about IPv5 ?

- Yes, it did exist as a test protocol only
- Not used anymore

### § Design goals of IPv6

- Avoid errors made when designing IPv4
- Much larger address range (16 bytes instead of only 4 bytes)
- Increase scalability
  - ‘Jumbograms’ (up to 4 GB-1 per packet)
- More efficient processing
  - Fixed Length IPv6 Header
  - No fragmentation
  - No Checksums
  - IPv6 header fields are aligned at 64 bit boundaries
- Easily extendable
- Simpler routing
- ‘True’ multicasting
- Auto configuration
  - Neighbor Discovery
  - Router solicitation
- Support for mobile devices



## IPv6 Basics

### § IPv6 Addresses

- 128 Bits in length (16 bytes)
  - 4 times larger than a IPv4 address
- Up to  $2^{128}$  (about  $3.4 \times 10^{38}$ ) unique addresses
  - That's approximately  $5 \times 10^{28}$  (roughly  $2^{95}$ ) addresses for each of the roughly 6.8 billion ( $6.8 \times 10^9$ ) people alive in 2010.
  - In another perspective, this is the same number of IP addresses per person as the number of atoms in a metric ton of carbon!
- IPv6 address are usually written as eight groups of four hexadecimal digits (each group representing 16 bits, or two bytes), where each group is separated by a colon (:).
  - Example: `2001:0db8:85a3:08d3:1319:8a2e:0370:7344`
- Leading zeroes in a group may be omitted (but at least one digit per group must be left):
  - `2001:0db8:0000:08d3:0000:8a2e:0070:7344` is the same as `2001:db8:0:8d3:0:8a2e:70:7344`
- A string of consecutive all-zero groups may be replaced by two colons. In order to avoid ambiguity, this simplification may only be applied once:
  - `2001:db8:0:0:0:0:1428:57ab` is the same as `2001:db8::1428:57ab`





## IPv6 Basics - addressing

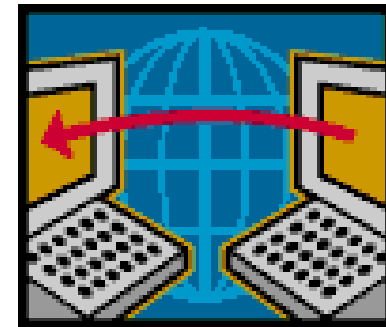
§ IPv6 Addresses gets assigned to interfaces (network adapters)

§ One interface (network adapter) can have multiple IPv6 addresses

- Assigned address
- Link local address

§ Every IPv6 address has a "scope":

- Link local
- Site local
- Global



§ IPv6 addresses are typically composed of two logical parts:

- Routing prefix
  - The length of the prefix is specified with the address separated by a slash: /64
- Interface identifier
  - Usually automatically determined from the MAC address of the interface
- Internet service providers (ISPs) usually get assigned the first 32 bits (or less) as their network from a regional internet registry (RIR)

## IPv6 Basics – address types

### § IPv6 address types:

- `::1/128` Is the **loopback** IPv6 address
- `::/128` Is an **unspecified** IPv6 address
- `FF00::/8` Is a **multicast** IPv6 address
- `FE80::/10` Is a **link local** IPv6 address
- `FEC0::/10` Is a **site local** IPv6 address
- `FC00::/7` Is a **unique local** IPv6 address (private address)
- All others are **global unicast** IPv6 addresses

### § Interfaces (network adapters) have at least 2 IPv6 addresses:

- Assigned (global) IPv6 address
  - `806::1:2`
- Link local IPv6 address
  - FE80 + Mac Address (020000000008)
  - `FE80:0:0:0:0200:0000:0100:0008`
  - `FE80::200:0:100:8`

### § Further address types:

- Site local IPv6 address (not used anymore)
- Multicast IPv6 address



## IPv6 Basics – auto configuration

### Goal: Plug 'n' Play network

§ An IPv6 endpoint needs at least 3 pieces of information to be able to communicate:

- IPv6 address
- IPv6 network
- IPv6 gateway

§ Right after the start, an endpoint only knows its link local address

- E.g. determined from the MAC address of the interface
- With that, it can only communicate within its local network segment

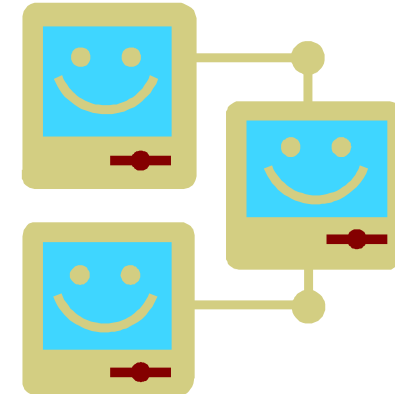
§ The interface then uses [Neighbor Discovery Protocols](#) to search for routes in its local network segment

- It sends requests to the multicast address FF02::2, which all routes are reachable at (Router Solicitation)
- Available routes then reply with information about the network

§ Router also send [Router Advertisements](#) in regular intervals to all hosts in the network(s) segment they are responsible for

§ [ICMPv6](#) provides essential functions in an IPv6 network

- Address Resolution Protocol (ARP) is replaced by Neighbor Discovery Protocol (NDP)



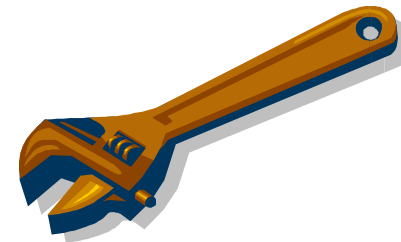
## Migration from IPv4 to IPv6

- § Contrary to popular belief, **IPv6 is not backward compatible** !
- § But: IPv4 and IPv6 networks can be used concurrently over the same cable and with the same endpoint

### Transition methods:

#### § Dual IP Stacks

- That's the easiest possibility
- The IP stack supports both protocols concurrently
  - Examples: Linux since Kernel 2.6, Windows since XP SP1
- Existing IPv4 applications can continue to run unchanged
  - Applications can be IPv6-enabled over time, one after the other



#### § Tunneling

- IPv6 packets are sent as payload of other protocols (usually IPv4) to a tunneling broker, which is located in an IPv6 network. The broker extracts the IPv6 packet from the payload and sends it as IPv6 packet through IPv6 routing to the final destination.
  - Example: **6in4** using Tunneling-Broker

## Migration from IPv4 to IPv6

Which infrastructure parts needs to be migrated?



### § Layer 1 devices (e.g. hubs)

- Those are completely transparent for IPv6

### § Layer 2 devices (switches)

- Devices which have been purchased within the last 10 years most likely support IPv6 already

### § Layer 3 devices (routers)

- Usually not required for local LANs
- Today most router manufacturer provide IPv6 capable routers
- Routers that use Multiprotocol Label Switching (MPLS) are protocol independent

### § Endpoints (PCs, Server, etc.)

- Most modern operating systems support IPv6

### § Applications

- May have to be adapted (IPv6-enabled) to be able to work with IPv6 addresses



## Why should a z/VSE customer care about IPv6?

Independent on your concrete benefits

à You will have to care about IPv6,  
sooner or later!



Why?

- Your internet service provider (ISP) migrates to IPv6
- Your customers or partners are only reachable via IPv6 (e.g. China)
- Governmental organizations may only allow manufacturers of IPv6 capable products and applications to participate in advertised biddings
  - Example: The US Department of Defense (DoD) only allows products that are on the “Unified Capabilities Approved Products List” (UC APL) for its advertised biddings.
    - “This list is used by procurement offices in the DoD and the U.S. Federal agencies for ongoing purchases and acquisitions of IT equipment”

**Already fulfilled with**

z/VSE V4.3 internet ready software IPv6 solution that will enable z/VSE to participate in an IPv6 network.

All statements regarding IBM's plans, directions, and intent are subject to change or withdrawal without notice.



## IPv6 Products for z/VSE

### IPv6/VSE Version 1 Release 1

IPv6/VSE is a registered trademark of Barnard Software, Inc.

Extract from  
Announcement Letter 210-066



- § The IPv6/VSE V1 product is designed to provide an IPv6 solution for z/VSE to:
- Allow z/VSE users to participate in an IPv6 network
  - Bring the benefits of IPv6 functionality to z/VSE users
  - Help z/VSE users to meet the requirements of the commercial community and governmental agencies and thus fulfills the statement of direction in Software Announcement 209-319, dated October 20, 2009
- § IPv6/VSE V1 is designed to provide an IPv6 TCP/IP stack, IPv6 application programming interfaces (APIs), and IPv6-enabled applications.
- § IPv6/VSE V1 supports the IPv6 protocol only, while TCP/IP for VSE/ESA V1.5 supports the IPv4 protocol only.
- § Both TCP/IP stacks can be run concurrently within one z/VSE system. Existing IPv4 applications continue to run unchanged, thus protecting and leveraging existing customer investments while new IPv6-enabled applications can be gradually introduced using the IPv6 stack.
- § In addition, IPv6/VSE's dual stack support allows IPv6-enabled applications to transparently communicate with partners via either the IPv6 or IPv4 network.

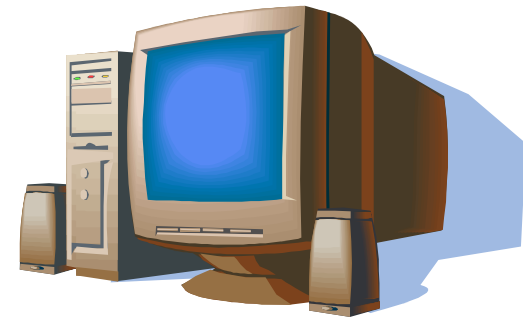
**Available since: May 28, 2010**



## IPv6 enabled applications

The following applications and tools are part of the IPv6/VSE product:

- § FTP Server (POWER queues, VSAM catalogs, SAM file, z/VSE libraries, ...)
- § Batch FTP Client
- § TN3270E server (TN3270/TN3270E Terminal & TN3270E Printer Sessions)
- § Network Time Protocol Server (NTP server)
- § Network Time Protocol Client (NTP client)
- § System Logger Client
- § Batch Email Client
- § Batch LPR
- § Batch Remote Execution client (REXEC)
- § Batch PING
- § GZIP data compression
- § REXX automation



Home grown applications may need to get adapted (IPv6 enabled)

## IPv6 programming interfaces (APIs)

Existing APIs were extended:

### § EZASOCKET and EZASMI API (APAR DY47077 for z/VSE 4.2)

– New functions:

- GETADDRINFO
- FREEADDRINFO
- GETNAMEINFO
- NTOP
- PTON

– New Address-Family: AF\_INET6

### § LE/C Socket API

– Not yet IPv6 capable

### § CSI's Assembler SOCKET Macro

– BSI: transparent IPv6 extension using the existing SOCKET Macros



## Summary

z/VSE is IPv6 ready

§ **The TCP/IP stack is IPv6 ready**

–IPv6/VSE Product

§ **Many standard applications are IPv6 ready**

–FTP, Telnet, e-Mail, ....

–Part of the IPv6/VSE Products

§ **Programming interfaces (APIs) are IPv6 ready**

–EZASMI and EZASOCKET

§ **But: Is your network environment already IPv6 ready ?**





## Questions ?

