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Why Install IPv6 Instead Of IPv4?

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Introduction

To understand why IPv6 should be installed instead of IPv4, it helps to understand a bit of the history of IPv4. The TCP/IP protocol suite was developed by the Department of Defense Advanced Research Projects Agency (hence the name DARPA or ARPA).

In 1963 ARPA sponsored researchers to communicate using computers. At that time, Bob Taylor, of ARPA had three terminals in his office; each one connected to a different remote computer. The three other computers were located at:

- System Development Corp. (SDC) in Santa Monica, CA
- Project Genie at the University of California—Berkeley
- Multics at MIT

Bob Taylor observed that communicating with each remote computer on a different terminal was not efficient. He realized that there needed to be an intermediary device to make communications more efficient and scalable. By mid-1968, small computers known as Interface Message Processors (IMPs—now called routers) were developed.

Initially, ARPAnet had four IMPs located at UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah. The first link was formed between the IMP at UCLA and the IMP at SRI on November 21st, 1969. By March 1970, ARPAnet reached the East coast and by September of 1973 the number of IMPs had increased from four to 40. By 1981, the number of hosts had grown from the original four to 213.

The original framers of ARPAnet did not foresee the growth of what is now known as the Internet. No one could foresee that the IPv4 address structure would fall short of the addresses needed; nor could anyone foresee all the devices that would need IP addressing. TheIPv4 addresses are being exhausted.

Larger Address Space

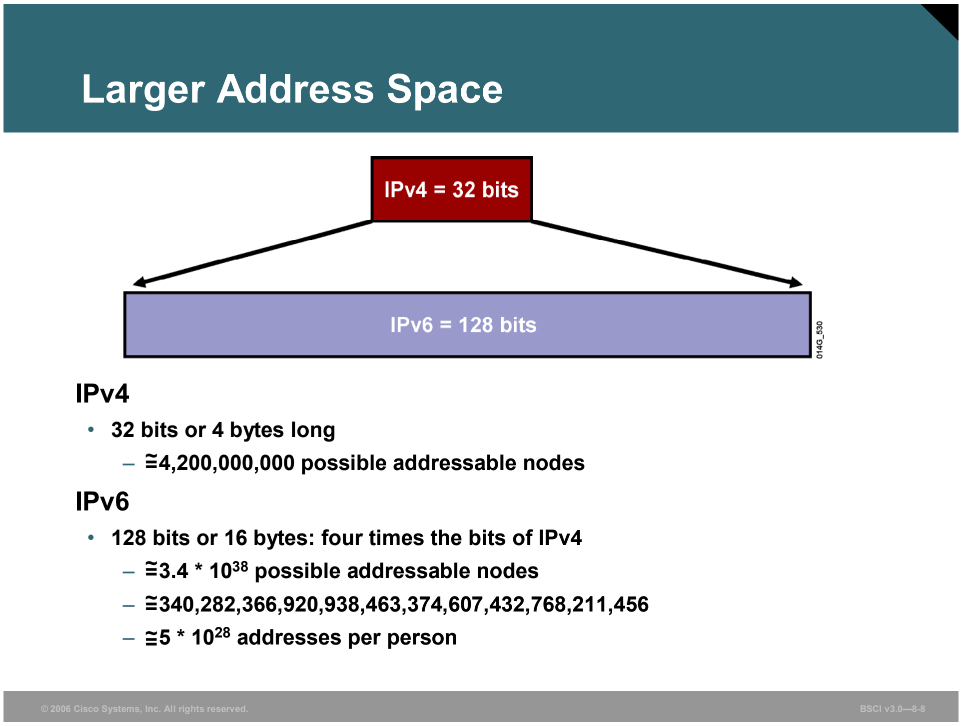
Why Do We Need a Larger Address Space?

- Internet population:
  - Approximately 1,463,632,361 users in 2nd quarter 2008
  - Emerging population/geopolitical and Address space
- Mobile users:
  - PDA, Pen-Tablet, Notepad, etc
- Mobile phones:
  - Already 2.7 billion mobile phones delivered as of January 2007
- Transportation:
  - 1 billion automobiles forecast for 2008
  - Internet access in Planes
- Consumer devices:
  - Sony mandated that all its products be IPv6-enabled by 2005
  - Billions of Home and Industrial Appliances

 BSCI v3.0—8-5

The address space is being depleted in the US, but the problem is worse in places like China, Japan, and Africa. These parts of the world got involved with the Internet later than others; less address space was available, so they were allocated fewer addresses. For example: China has only two Class A addresses for the entire continent and some countries in Africa have only a /24 address space.

With IPv6, the address space is changing from a 32-bit address structure to a 128-bit address. This new address structure allows more than 1000 addresses for every person on the planet. Originally, places such as China and Japan were adopting IPv6 more aggressively. The Department of Defense (DoD) mandate that entities doing business with the DoD must be IPv6-compliant has caused companies within the US to more aggressively pursue IPv6 compliance as well.



IPv6 addresses use 16-bit hexadecimal number fields separated by colons (:) to represent the 128-bit addressing format. An example of an IPv6 address is

2031:0000:130F:0000:0000:09C0:876A:130B

The leading zeros in a field are optional. To shorten an IPv6 address, a double colon may be used (::) to compress successive hexadecimal fields of zeros at the beginning, middle, or end of an IPv6 address. This can be done only one time. The address above could be abbreviated as follows.

2031:0:130F::9C0:876A:130B.

IPv6 Address Representation

Format

- x:x:x:x:x:x:x:x **where** x **is a 16-bit hexadecimal field**
  - **Case-insensitive for hex A, B, C, D, E, and F**
- **Leading zeros in a field are optional:**
  - **2031:0:130F:0:0:9C0:876A:130B**
- **Successive fields of 0 can be represented as :: but only once per address**

Examples:

- **2031:0000:130F:0000:0000:09C0:876A:130B**
- **2031:0:130f::9c0:876a:130b**
- **2031::130f::9c0:876a:130b—incorrect**
- **FF01:0:0:0:0:0:0:1→FF01::1**
- **0:0:0:0:0:0:0:1→::1**
- **0:0:0:0:0:0:0:0→::**

The IPv6 header has 40 octets and is simpler and more efficient than the IPv4 header. It uses an optional extension header that may be daisy-chained to facilitate many operations, including authentication, fragmentation, and specification of destination options.

Some of the benefits of IPv6 addressing include larger address space, globally unique IP address, header format efficiency, improved privacy and security, flow labeling capability, and increased mobility and multicast capabilities.

IPv6 Address Types

With IPv6, devices will have more than one IP address. All interfaces are required to have one link-local address, and a single interface may also have multiple IPv6 addresses of any type—unicast, anycast, or multicast.

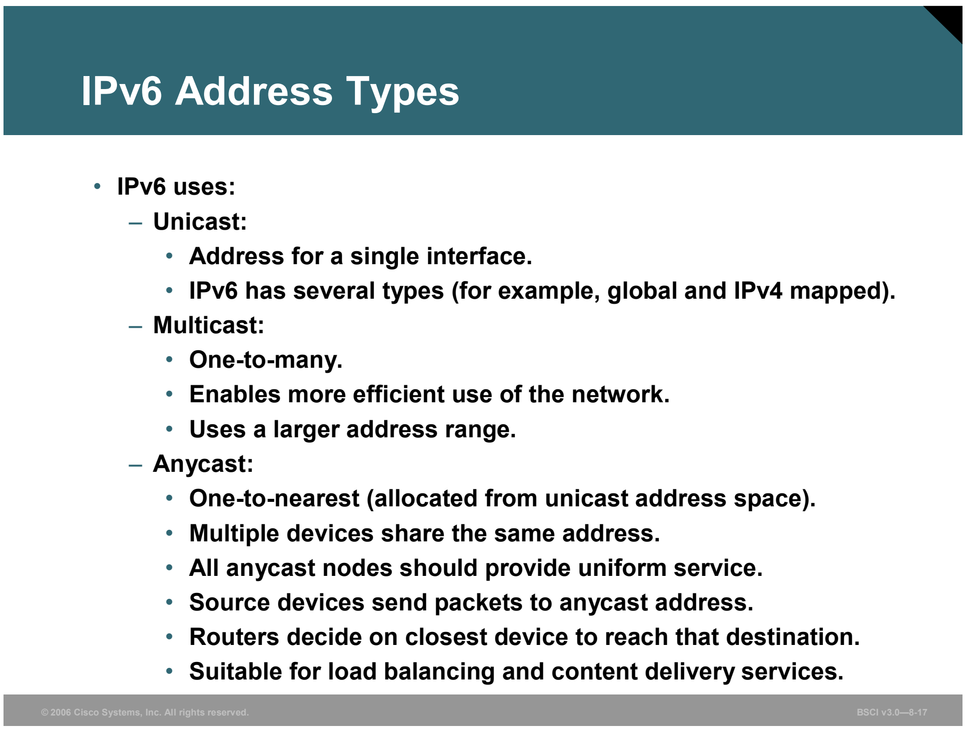
Link-local addresses are designed to be used for addressing on a single link for purposes such as automatic address configuration, neighbor discovery, or for address assignment when no routers are present. Routers must not forward any packets with link-local source or destination addresses to other links (more on this later).

An IPv6 unicast address is the same as an IPv4 unicast address. A single source sends data to a single destination address.

An IPv6 anycast address (per RFC 3513) is an address that is assigned to more than one interface (typically belonging to different nodes), with the property that a packet sent to an anycast address is routed to the "nearest” interface having that address, according to the routing protocols’ measure of distance. An anycast address must not be used as a source address; rather, it may only be used as a destination address.

An IPv6 multicast address is a one-to-many relationship. As with IPv4, there are well-known reserved multicast addresses that must never be assigned to any multicast group, and an IPv6 interface may belong to any number of multicast groups. A packet that is sent to a multicast address is delivered to all of the interfaces that the address identifies. IPv6 multicast addresses are defined by the prefix FF00::/8.

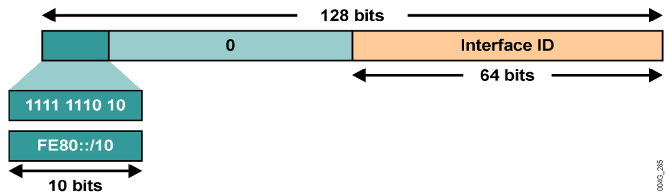
There is no concept of broadcast addresses in IPv6; multicast addresses are used instead.



IPv6 Address Assignment Strategies

Link-local addresses were mentioned previously. RFC 2461 describes link-local addresses as a unicast address having link-only scope that can be used to reach neighbors. All interfaces on routers must have a link-local address. Also, interfaces on hosts must have a link-local address. Router interfaces and hosts autoconfigure their link-local addresses. Cisco uses the EUI-64 (Extended Unique Identifier) format to for stateless autoconfiguration with a router. This format uses the 48-bit mac address and expands it to 64 bits by inserting FFFE into the middle 16 bits. This is shown in the diagram below as the interface ID.

Link-Local Address



- **Link-local addresses have a scope limited to the link and are dynamically created on all IPv6 interfaces by using a specific link-local prefix FE80::/10 and a 64-bit interface identifier.**
- **Link-local addresses are used for automatic address configuration, neighbor discovery, and router discovery. Link-local addresses are also used by many routing protocols.**
- **Link-local addresses can serve as a way to connect devices on the same local network without needing global addresses.**
- **When communicating with a link-local address, you must specify the outgoing interface because every interface is connected to FE80::/10.**

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A router on the local link can enable autoconfiguration by sending a router advertisement that includes network information, such as a 64-bit prefix of the local-link network and the default route. This can also be done in response to a router solicitation message from a host. Either way, a host can autoconfigure itself by appending its IPv6 interface identifier (64-bit format) to the local link prefix (64 bits). This process results in a full 128-bit address that is usable and guaranteed to be globally unique.

Autoconfiguration enables "plug-and-play," which allows devices to connect to the network without any configuration and without as many servers (like DHCP). This key feature enables deployment of new devices on the Internet, such as cell phones, wireless devices, home appliances, and home networks.

Summary

IPv6 satisfies the increasingly complex requirements of hierarchical addressing that IPv4 does not provide. One key benefit is that IPv6 can re-create end-to-end communications without the need for NAT—a requirement for a new generation of shared-experience and real-time applications.

Transitions to IPv6 from IPv4 deployments can use various techniques, including an auto-configuration function.

IPv4 is in no danger of disappearing overnight. Rather, it will coexist with and then gradually be replaced by IPv6. But this change has already begun, particularly in Europe, Japan, and Asia Pacific.

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About the Author

Carol Kavalla's background includes teaching at Rockland Community College in New York, managing networks and being a consultant for the NYS small business development center.

For the last eight and a half years Carol has taught for Global Knowledge and is certified to teach nine Cisco courses: ICND1; ICND2; CCDA; BSCI; BCMSN; TCN; ICMI; BGP; and ARCH.

She also has a consulting firm in Charleston, SC, where she works with small companies (100-200 nodes) installing, configuring routers and switches, and troubleshooting network problems.