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An Integrator's Perspective on IPv6

Proliferation of Internet-linked Devices Calls for an Internet Protocol Capable of Limitless, Secure IP Addresses. IPv6 is Prepared to Deliver.

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An IP (Internet Protocol) address is a unique set of numbers that identifies an electronic device of any kind that is connected to the Internet. Every Internet-linked device has a unique "IP address," including the device you are using to read this document, whether it is a laptop, a pager, or a cell phone. As Internet linkages to electronic devices have proliferated – in everything from building sensors and traffic monitors to mobile and medical devices – there has been a corresponding rise in demand for IP addresses. Unfortunately, the Internet Protocol used today to issue IP addresses cannot continue to accommodate the volume of demand, to say nothing of demands for increased security, flexible architecture, and the ability to multicast. The number of available IP addresses is limited, and they may be exhausted by as soon as May 2011, according to estimates from Cisco. Thus, a new Internet Protocol has been introduced, and eventually, every device on the globe will be required to convert to the new Internet Protocol in order to maintain Internet connectivity. The new version of the Internet Protocol is called Internet Protocol version 6, or, more commonly, "IPv6" (also called IPng for IP Next Generation or simply "v6"). IPv6 will inevitably replace Internet Protocol version 4 (IPv4), the dominant IP used today.

Briefly, here is how IPv6 came to be. In 1991, the Internet Engineering Task Force (IETF) recognized that the Internet would outgrow IPv4. In early 1999, IETF created the IPv6 Forum to address the pending shortage of IP addresses and other limitations of IPv4. Four years later, a new protocol was made ready for general availability. In mid-2004, the Internet Corporation for Assigned Names and Numbers (ICANN) announced that the root DNS servers for the Internet had been modified to support both IPv6 and IPv4 (known as the "dual stack" methodology). During this time, the Department of Defense's CIO, John Stenbit, established the goal of IPv6 transitioning by summer 2008. The Office of Management and Budget later issued a mandate to support the transition. The General Services Administration also awarded more than $150 billion in recent contracts, but the total costs may swell far beyond that (to as much as $500 billion) when the United States Government transitions its entire IT infrastructure to IPv6. There is good reason for the expenditure of these funds and efforts to support the rollout of IPv6.

WHAT'S WRONG WITH IPV4?

There is unanimous agreement that IPv4 is inadequate for the surging demand for Internet connectivity across every aspect of the global economy. IPv4 addresses consist of four numeric sequences separated by periods. These addresses are a common sight for today's Internet users. An example of a 32-bit IP address issued under IPv4: 201.65.2.57. Each numeric sequence contains an 8-bit value, with numbers that can range up to 255. This is also called 32-bit addressing, because each of the four sequences contains eight bits. Given the mathematical possibilities represented by this type of sequence, 4 billion IP addresses are possible. However, because of the proliferation of IP addresses through the bi-level architecture that assigns IP numbers (to a network and the hosts on that network), the 32-bit addressing schema of IPv4 holds the distinct possibility that those 4 billion addresses will soon be exhausted.

The new IPv6 employs a 128-bit IP addressing schema, and IPv6 addresses consist of eight sections – each containing a 16-bit value. The number of IP addresses possible with this 128-bit schema is equal to approximately 3.5×10^{38} (the exact number is 340,282,366,920,938,463,463,374,607,431,768,211,456). This is a number that will not be exhausted in any foreseeable future. In a slight formatting change, the IPv6 addresses will be written as numeric sequences (eight sections, each containing a 16-bit value), but they are separated by colons – not periods. An example of a 128-bit IP address issued under IPv6: 1080:0:0:0:8:800:200C:417A.

WHY SWITCH TO IPV6?

Even after all of the arguments for an IPv6 transition are spelled out, the fact of the matter is that IPv4 is being phased out. Any forward-looking organization must convert to IPv6 if it intends to maintain a secure, optimized connection to the Internet. IPv6 not only allows for practically limitless IP addresses, but it offers remarkably more capability in these areas:

Addressing and Routing

- IPv6's extremely large capacity for addresses lends connectivity to many more electronic devices – mobile phones, laptops, in-vehicle computers, televisions, cameras, building sensors, medical devices, etc.

Security

- The security for IPv6 comes in the form of IPsec, which allows authentication, encryption, and compression. IPv6 also possesses capabilities for packet integrity that IPv4 does not offer. Indeed, IPv6 mandates that security be provided through information encryption and source authentication.

Address Auto-Configuration

- IPv6 auto-configures new equipment to communicate with the network once it is detected, which means devices are ready to use on demand. Auto-configuration enables plug-and-play.

Administrative Workload

- IPv6 improves communication and eliminates the need for network address translation (NAT) through its automated configuration capabilities.

Support for Mobile Devices

- IPv6 hosts are not restricted by location. The mobility comes in the form of Mobile IP, which allows devices to roam among different networks without losing their established IP addresses.

Sophisticated Peer-to-Peer Communication Tools that can Improve Interagency Collaboration

- IPv6 allows multicast technologies to optimize media-streaming applications, allowing timely video feeds and quality-rich information to be easily distributed to millions of locations.

IPV6 COMPATIBILITY

With the debut of IPv6, just 15% of the address space has been allocated with 85% allocated for future use. A major concern during the development of IPv6 was its compatibility with IPv4. Changing Internet protocols means changing dozens of other conventions, ranging from how IP addresses are stored in applications and DNS (domain name system) to how datagrams are sent and routed over Ethernet, PPP, Token Ring, FDDI, and every other medium. However, there are standards, protocols and procedures for the coexistence of IPv4 and IPv6, such as tunneling IPv6 within IPv4, running IPv4 and IPv6 on the same system ("dual stack") for an extended period of time, and mixing and matching the two protocols in a variety of environments. Even though IPv6 is compatible with IPv4, the full transition from the current IP addressing schema to IPv6 will require years, but the transition is inevitable. As an indication of the need to carefully transition to IPv6, note that today's IPv4-only client computers cannot communicate directly with IPv6-only clients. They will require service-specific intermediate servers or protocol-translation servers.

IPV6 AND TRAINING

Before reviewing the steps in an IPv6 transition plan, note that the integration of IPv6 must be preceded by training. It is impossible to develop an IPv6 transition plan without thoroughly understanding IPv6, and understanding is best achieved through training by authorized professionals. Since the initial integration of IPv6 within core infrastructure will provide the building blocks for all other integrations and transitions throughout the entire network, the value of proper IPv6 implementation by trained personnel should not be underestimated.

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The training phase of an IPv6 integration plan should provide a detailed overview that relevant staff members can master to understand the basics of IPv6 and how it interacts with IPv4 in both dual-stack and tunnel environments. Training should occur well in advance of all other integration phases and, at a minimum, it should address the design, implementation, configuration, and maintenance of IPv6 networks.

STEPS TO TRANSITION TO IPV6

Integrating IPv6 involves changes across a number of sectors of a network and IT enterprise. A poorly planned transition process can lead to unnecessary and costly disruption. However, there are clear roadmaps for transitioning from IPv4 to IPv6, and the key steps are outlined below. Before the actual IPv6 integration begins, acquire a block of IPv6 addresses. As you prepare to assign and deploy the addresses, it is advisable that you budget for, create, and actively use an IPv6 lab or "test bench" that closely emulates all network elements (routers, switches, hosts, O/S) to determine the full implication of the integration.

Step 1: Plan, Inventory and Upgrade. Create an IPv6 Network Transition Plan that outlines pre-conversion, conversion, and post-conversion network plans. This plan should start with a network inventory and a map of the network's topology, routing, applications, and business drivers. The network inventory may determine that there are IPv6-capable elements already within the existing IPv4 infrastructure, such as routers, switches, IP service appliances, clients and hosts. A network assessment can also help provide cost estimates if certain portions of the network require full upgrades to support IPv6. Determine upgrade paths to router code and firewall code. Appraise the disposition, quality, and compliance of all switches, client operating systems, server code, management stations and monitors, and any IP telephony system.

Step 2: Evaluate Existing ISP. Engage the Internet service provider (ISP) in communications and determine their current IPv6 capability and road-map. In some cases, switching ISPs may be required.

Step 3: Obtain IPv6 Address and Test. Contact the ISP or one of the LIR/RIR (Local or Regional Internet Registries) such as ARIN to receive an IPv6 address space. Create a lab environment with a separate connection to the ISP, then begin assessment and testing of network capabilities, applications, monitoring/management, security, and wired, wireless, and remote clients.

Step 4: Integrate and Transition. Begin a phased deployment of servers (DNS, DHCPv6, Teredo, NAT-PT), implement and test the IPv6 model (dual-stacks, tunneling, and/or hybrid), test mail and applications, perform a baseline security audit, and involve relevant vendors whenever possible.

IPV6 IS HERE TO STAY

The complete transition of the world's networks (and all Internet-linked hardware and software) to IPv6 is inevitable, and it is only a matter of time before IPv4 is obsolete. Prudent organizations that wish to minimize the disruption of this change in protocols will commence the integration process, because the costs for the transition as measured in time, human impact, and equipment requirements are unpredictable. Given that the IPv6 integration must be completed, it would be prudent to begin the transition process, starting with training, planning, and creation of a testing environment. As an indication of the risks one runs to remain with IPv4, note that the United States Government has mandated that its IT infrastructure be transitioned to IPv6 by summer 2008. With that transition already underway, other major contractors, suppliers, and forward-looking companies will follow suit in short order, further accelerating the demand for IPv6 compliant networks, whether they are dual-stack or IPv6-only systems. Budgeting, planning, and executing a well-paced, careful integration process will benefit your organization and secure its future. Moreover, this takes giant steps toward ensuring that your relationships to your customers are secure and enduring.

For more information on IPv6, visit www.wwt.com.

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