IPv6 Technology Overview

Building next-generation networks

What's happening to communications?

It's no secret that major changes are taking place in the communications industry. Users are more demanding when it comes to quality of service and service availability. Use of mobile services continues to grow at a phenomenal rate—a 54 percent increase in worldwide subscriber growth was reported in 1999 alone. Mobile data services are beginning to appear using Wireless Application Protocol (WAP) and General Packet Radio Service (GPRS) devices. Networks are shifting from voice-centric to data-centric and from circuit-switched to packet-switched. Devices are becoming smaller and smaller, with more and more integrated voice, data, and video capabilities. Devices can be configured over the air to support whatever the local networks require—protocols such as GSM, CDMA, W-CDMA, or 802.11b. Devices can support on-demand configuration of services such as MP3 players and point-of-sale devices for commerce transactions. Services that support a world where consumers configure, use, and pay for custom services in real time. A world where the target market is one. A world where "always on" is the norm. Where will you find this new world? On the new Internet at a new address.

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A new address for a superior Internet

An address change is always an important move for individuals, but when it comes to the Internet, an address change will alter the very way that medium is used, unlocking its true potential for the first time. Though largely unknown to the general public at present, the advent of Internet Protocol Version 6 (IPv6) is certain to be a vital ingredient in the evolution of the Internet.

IP—the network-layer protocol—is one of the foundations of the Internet. The currently used version, Internet Protocol Version 4 (IPv4), is an outgrowth of the Internet's earliest days when the medium was merely a data-sharing network for a relatively few research facilities and the military. Back then, few could have foreseen the relatively recent development of the Internet as a public and commercial medium. Despite that, IPv4 has been remarkably successful, as the Internet's growth attests.

However, this growth has also revealed the limitations of IPv4. The most prominent deficiency is a limited number of addresses. The IPv4 32-bit address allows for more than 4 billion addresses, but engineers could foresee the day when that pool would run dry. In the mid-1990s, the Internet Engineering Task Force (IETF) began working on the next-generation protocol that became IPv6.

IPv6 uses a 128-bit address, creating enough addresses for every person and device many times over. But it does far more than that. The so-called "smarter packet" that is IPv6 facilitates the global move toward anywhere, anytime, anyway Internet access—especially wireless mobile access—and provides for increased functionality in such commercially important areas as security and quality of service while opening the door to new services. At the same time, the designers allowed for a smooth transition to IPv6 by making it compatible with the IPv4 world, preserving the capacity to connect systems over a wide variety of networking technologies.

Compaq and IPv6

Compaq strongly believes that the move toward IPv6 will be a boon to telecommunications companies, Internet service providers (ISPs), and others, and is committed to fostering this evolution.

Compaq has been a vital part of the IPv6 story since its beginning. Senior Compaq engineers fostered development of IPv6 within the IETF, contributing to its specifications, and their contributions are ongoing today. Compaq's lead IPv6 design engineer is a member of the IETF IP Next Generation Directorate and also chairs the IPv6 Forum Technical Directorate (www.ipv6forum.com/).

Compaq also provided one of the first implementations of IPv6 with a 1997 Early Adopter Kit, which was successfully used by enterprises such as ES, NET, UUNET, Mitre Corporation, NTT, and Netscape on the developmental 6bone, a worldwide IPv6 testing and pre-production deployment network (www.6bone.net). Altogether, more than 300 IPv6 early adopters used this implementation.

Compaq is proud to have recently unveiled the first commercially available platform with production IPv6 support—the Compaq *Tru64*™ UNIX on *AlphaServer*™ platform. The Compaq *OpenVMS*™ on *AlphaServer* platform with production IPv6 support will be available in early 2001.

Compaq is not alone in its efforts to develop IPv6. Most major vendors in the telecommunications and computing industries, and others in hybrid industries, are working on IPv6 implementations. In addition, the IETF has created the 6bone network, attracting and utilizing the expertise of designers, programmers, and protocol inventors to further IPv6 acceptance. There is no fee for participation on the 6bone network.

The Internet: It can't grow on like this

Why IPv6? A number of trends point to the need. Consider the following:

- Worldwide, the number of Internet users are projected to grow from 240 million this year to 600 million by 2004.[1]
- Every year, 25 to 30 percent more portable computers are sold than the previous year.[2]
- Worldwide wireless subscribers are projected to grow from 450 million this year to nearly 1 billion by 2005.[2]
- The number of mobile handsets will overtake the number of fixed lines within a couple of years.

[1] Mobile Computing Forecast: 2000, Gartner Advisory, Dataquest, August 7, 2000.

[2] Third-Generation Wireless: The Impact on Global Competition, ICM Global Intelligence, November 1999.

Not surprisingly, an exciting range of IP-enabled devices are being introduced in the market, from personal organizers to game consoles. And not too far away is the day when domestic appliances become part of home networks. All these devices necessitate Internet addresses.

Although North America has plenty of Internet addresses, that's not the case in countries with emerging economies. In these and other lands, rather than the building of wireline networks, the primary communications move is toward wireless Internet access. The need for IP addresses in these places is a critical problem today.

Operators have extended the life of IPv4 within networks by using approaches such as network address translators (NATs), which intercept traffic and convert private intra-enterprise addresses into unique Internet addresses. But NAT devices are cumbersome, often foster application failures, and can cause bottlenecks between an enterprise and the Internet. Others utilize CIDR (Classless Inter-Domain Routing), which permits route aggregation but does not guarantee an efficient and scalable hierarchy.

The limitations of IPv4 also aggravate the occasional need in many organizations to renumber network devices—a common occurrence in an age of mergers and acquisitions—wherein new IP addresses must be assigned. And if an enterprise changes ISPs, it may have to renumber all addresses to match the new ISP-assigned prefix.

Because the current hierarchical system lacks uniformity, and because new IPv4 addresses are rationed, Internet addressing and routing is quite complicated, and can be a significant expense as well. And unfortunately, while technologies such as NAT and CIDR can extend the life of IPv4 addresses, there's a significant price to be paid; namely, the numerous advantages of IPv6 cannot be realized.

Advantages of IPv6

Security

IPv6 brings a new standard of service and security to applications, boosting the prospects for e-commerce while simultaneously reinforcing public confidence in such transactions.

Security was an add-on in IPv4, an approach that's clearly unacceptable for today's e-commerce. With IPv4, it's usually impossible for a server to determine whether packets are being received from a legitimate end node. And with IPv4, source-address masquerading (spoofing) can be used to access important business and financial data, or even to gain control of a server. As with the address shortage, there are temporary solutions available, such as firewalls, but these technologies often hamper connectivity.

IPv6 provides for the authentication, security encryption, and data integrity safeguards essential for a successful modern enterprise. The IPv6 standards-based authentication header extension guarantees that a packet is truly from its source address. Another standard header extension provides end-to-end encryption at the network layer. The packet is never touched. IPv6 security headers can be used directly between hosts or in combination with a specialized security gateway for additional security.

There are many types of security currently available in the world of IPv4, but security, by definition, necessitates that both communicators agree on what kind of security is to be used. That commonality is effortlessly achieved via IPv6.

Advantages of IPv6 over IPv4

- *Enough address space to support 3G devices*
- *Efficient mobile IP for the first time*
- *Superior node autoconfiguration; less infrastructure required*
- *Mandatory and effective IP security*
- *Built-in quality of service*
- *Multicasting/anycasting capabilities*

Imagine that you are the director of security for a new mobile operator. You constantly receive registration requests for service from the many new devices that are appearing in the marketplace. Devices that support the software-defined radio concept and can be configured over the air to whatever protocols are required by the network. Devices that require on-demand services, services such as MP3 players or point-of-sale devices for mobile commerce transactions. How do you protect your network? How do you keep from being the weak link in the chain? You don't know it . . . but you need IPv6.

Quality of service

IPv6 allows specific traffic flows to be labeled for special handling, to differentiate between non-urgent communications and highly critical real-time applications such as video conferencing. These capabilities can be constructed with varying success within the IPv4 framework; they're built-in with IPv6.

The IPv6 packet format contains a new 20-bit traffic-flow identification field that lays the foundation for such quality-of-service (QoS) functions as bandwidth reservation in an open, interoperable manner. Additionally, traffic flows can be distinguished for best routing. Those same labels can be used to assure a desired security level or cost.

Though still in the developmental phase because the flow label—data that establishes a packet's priority, essential for QoS within IPv6—is still being defined, the capability to mix and match traffic flows with QoS opens the door to new services and greater customer satisfaction as well.

Compaq's *Tru64* UNIX Version 5.1 operating system provides the Resource Reservation Protocol (RSVP), the first IP specification to use and define the IPv6 flow label. Compaq provides the RSVP protocol for IPv6 for those who manage their network's bandwidth within an intranet. We also provide an RSVP API that takes advantage of the IPv6 basic sockets, allowing access to the IPv6 flow label that can reserve resources across a network.

Imagine that you are director of marketing for a large communications service provider. Your major business is operating a high-bandwidth packet network. You need to support service-level agreements with your customers that guarantee they will have the bandwidth available when they need it. You need to guarantee that their voice-over-IP packets will get higher priority than their e-mail packets. You need to guarantee that their e-commerce transactions will get higher priority than Web browsing. You don't know it . . . but you need IPv6.

Mobile IP

Mobility, of course, is a hallmark of most people's lifestyles and the driving force behind today's new wave of communications devices. Increasingly, people want to connect to the Internet without problems or additional steps when they move from place to place. That necessitates a mobile IP address.

But IP mobility was barely a concept, and hardly a practice, when IPv4 came into existence. There was no need to distinguish between who you were or where you were; they were one and the same in your IP address. IPv4 assumes that there is always the same point of attachment.

So today, connecting to the Internet from different locations is often a frustrating exercise—and a costly one as well. Mobility under IPv4 requires additional infrastructure, because it necessitates informing any agent in the routing process about a new location. There is no information in the IPv4 address that indicates the new point of attachment. The system has to be configured with the new address. Authentication facilities are required and as a further impediment, these are not always deployed in IPv4 nodes.

Mobile IP via IPv6 requires no such infrastructure. It eliminates triangular routing and instead implements a temporary second address. It defines a multi-level global routing infrastructure. The routing is handled by the software; therefore, there's no special infrastructure required in the receiving network for a mobile node.

Consequently, while away from home, every user has this additional temporary "care-of" address. Messages sent to the user's home address are automatically forwarded to the care-of address. With IPv6, location is no longer an issue when connecting to the Internet. And the additional time and infrastructure needed today for mobile connection cease to exist.

Imagine that you are an account executive for a major account. Your competition is fierce. Your ability to close the deal hinges on your ability to send and receive information between yourself, your home office, and your client. You will be out of the office all morning. You are in your car. You have your integrated communications device plugged into your dashboard. You are connected to your home office. You can communicate with your client. You arrive at your next meeting. You need to still be connected and still be able to communicate with your home office and with your client transparently. You don't know it . . . but you need IPv6.

Autoconfiguration

Autoconfiguration is one of the greatest advantages of IPv6—for both consumers and network operators—because it greatly reduces the time and money spent managing and configuring systems.

An IPv6 node initially creates a local IPv6 address for itself using stateless autoconfiguration, where it creates a unique IP address by combining its LAN Medium Access Control (MAC) address with a prefix provided by the network router. There's no need for a manually configured server because no server has to approve or distribute an address. This reduces end-user costs because trained staffers are no longer necessary. Autoconfiguration also allows mobile computers to receive forwarding addresses automatically, wherever they connect to the network.

The IETF is currently developing the IPv6 Dynamic Host Configuration Protocol for customers that want tight control over node address assignment or want to apply additional configuration parameters to nodes. Compaq is helping to define that specification.

Imagine that you are the LAN administrator for your company. You are expected to provide better service with fewer staff and less budget. You are continually looking for ways to reduce your operating expenses and your support staff. But service demands on your network continue to increase. The skills required to manage address assignment, equipment configuration, and network support continue to get more specialized. You need a way to have a node automatically obtain an IP address and automatically configure itself. You don't know it . . . but you need IPv6.

Multicast/anycast

There's a large and growing audience worldwide for streams of audio, video, and animated news and other data. IPv6 advances these capabilities by defining a very large multicast address space limiting the degree to which multicasting routing information is carried throughout an enterprise.

All IPv6 hosts and routers are required to support multicast, with improvements that simplify the use and administration of multicast.

IPv6 also initiates the concept of "anycast" services. A group of nodes can be designated as an anycast group, and a packet addressed to the group's address is delivered to only one of the nodes.

Imagine that you are a regional sales manager. You have the ability to close a deal that your team has been working on for months. You just got some critical information about the competition that your team needs to know immediately. You need to get together with the team to put the final polish on your message before you meet with the client. The problem is that your team is on their way to the meeting. You need to get the competitive information to your team. You don't have time to locate each person and send them a separate message. You need to send one message and have the data reach the entire team. You don't know it . . . but you need IPv6.

IPv6 and next-generation networks: When?

That's the big question. When will the world reap the advantages of the next-generation networks made possible in part by IPv6?

There is no "flag" day, as was the case with the Year 2000 problem. IPv4 and its attendant devices will be around for a long time; they won't be tossed aside immediately. IPv6 was designed with this gradual transition in mind. It can initially be deployed in hosts or routers or in a limited number of adjacent or remote hosts and routers. IETF recognized that many upgraded hosts and routers will need to retain downward compatibility with IPv4 devices for many years.

Consequently, we will live in a dual-IP world for at least another decade. That's the reason why Compaq is using dual stack technology with its *AlphaServer* system, running either the *Tru64* UNIX or *OpenVMS* operating system. Both IPv4 and IPv6 coexist on the same system, so users can communicate regardless of which protocol is used.

The global benefits of IPv6 will only be realized when it becomes the dominant protocol. That will take time. But working in favor of IPv6 are many factors such as the soaring increase in mobile devices and corresponding lack of addresses, the continuing rise of the Internet as a commercial powerhouse, and the tremendous security, quality, manageability, and product/service potential of IPv6 that will yield competitive advantages.

In addition, IPv6 has been adopted as the protocol for next-generation networks by the Third Generation Partnership Project (3GPP), a worldwide standards-setting organization. This endorsement is expected to greatly hasten the adoption of IPv6 by future networks.

Compaq believes IPv6 deployment will occur in stages. The first stage will be deployment of regional IPv6 networks. To launch new subscriber services and gain competitive advantages, service providers will deploy regional IPv6 networks. These regional IPv6 networks will interoperate with national and international IPv4 networks to support global, end-to-end service delivery. Subsequent stages will see the development and deployment of additional products and services that build on the advanced features of the new infrastructure. The final stage will result in the migration of the national and global IPv4 infrastructure to IPv6.

It is a certainty that IPv6 will be a core component as the 3G infrastructure is built around the world. Just as surely, new and innovative services and new consumer devices will be offered that leverage the infrastructure's bandwidth and networking capabilities.

Whatever the pace and whatever the route, Compaq will be in the forefront of creating this exciting new world of communications. Our product portfolio will cover the range of today's and tomorrow's needs, from consumer devices to network infrastructure to back-end billing and customer care.

Compaq will continue to partner with leading-edge solutions providers to realize the capabilities of IPv6. And we will continue to integrate infrastructure solutions with end-user devices, thereby introducing attractive, packaged solutions to the market.

Compaq's IT is far more than information technology—it's *Inspiration Technology*—and it will change communications. Compaq and IPv6: we're ready when you are.

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