WHITE PAPER

THE COMING INTERNET EVOLUTION: IPv6 AND ITS IMPLICATIONS FOR THE SERVICE PROVIDER MARKETPLACE

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INTRODUCTION

A new Internet Protocol (IP) is presenting opportunities to North America's service providers, and those who embrace this upgraded technology stand to improve and expand services, attract new customers, increase revenues, and outpace competitors.

Known as IP version 6 or IPv6, this new protocol promises a host of advantages that may in the future far surpass those of IPv4—the dominant IP today. IPv6 integrates all IPv4 improvements from the past 20 years, improvements that focus on network security, expansion of quality of service (QoS) options, embedded IP-friendly mobility, autoconfiguration, ready-to-use support, and peer-to-peer capability—the kinds of advantages that service providers can capitalize on to differentiate themselves and expand their businesses.

The Internet will be transformed after IPv6 fully replaces its less versatile parent years from now. Nevertheless, IPv4 is no danger of disappearing overnight. Rather, it will co-exist with and then gradually be replaced by IPv6. But this transformation has already begun, particularly in Europe, Japan, and Asia Pacific.

These areas are exhausting their allotted IPv4 addresses, which makes IPv6 all the more attractive. In addition to its vast technical and business potential, IPv6 offers a virtually unlimited supply of IP addresses. Whereas the existing IPv4 provides some two billion useable addresses with its 32-bit address space, IPv6, because of its generous 128-bit address space, will generate a virtually unlimited stock of addresses—enough to allocate more than 1000 to everyone on the planet.

Consequently, some countries, such as Japan, are aggressively adopting IPv6 today. Others, such as those in the European Union, are moving toward IPv6, and China is considering building pure IPv6 networks from the ground up. Even in North America where Internet addresses are abundant, as of October 1, 2003, the U.S. Department of Defense mandated that all new equipment purchased be IPv6-capable. In fact, the Department intends to switch entirely to IPv6 equipment by 2008. As these examples illustrate, IPv6 enjoys strong momentum.

CISCO IPV6 LEADERSHIP

From its pioneering work developing IPv6 standards to incorporating IPv6 capability into its networking products and software, Cisco Systems® is the industry leader in developing and implementing IPv6.

Cisco® engineers coauthored several of the core IPv6 specifications, and the company is a founding member of the IPv6 Forum, a worldwide consortium of leading Internet vendors. Cisco has served as co-chair with the IETF IPv6 and NG Trans working groups for several years. In addition, starting in 1996, Cisco experimented with IPv6 on 6Bone, an early test-bed for the IPv6 protocol. Cisco is also a founding partner of 6Net, a large 16-country European project to evaluate IPv6.

IPv6 is supported by Cisco IOS® Software in more than 20 platforms, integrating advanced IPv6 features such as coexistent technologies (tunneling, IPv6 provider edge router [6PE], Network Address Translation-Protocol Translation [NAT-PT], etc.), security (authentication, authorization, and accounting [AAA], IP Security [IPSec], Cisco IOS Firewall), QoS, and multicast. The Cisco IPv6 hardware portfolio ranges from its router series, including the new industry-leading Cisco CRS-1 Carrier Routing System, to LAN switches and firewalls. Next steps are being taken to integrate home networking equipment and IP telephony. Today, Cisco customers running a recent Cisco IOS Software release have the capability to configure IPv6 on their networks.

IPV6 SERVICE PROVIDER ADVANTAGES

IPv6 offers more than a solution to an overseas IP address-supply problem: It offers numerous important business advantages over IPv4 that service providers can capitalize on to produce new services and new revenues.

Increased Security Opens Doors to E-Commerce

Many people are reluctant to buy over the Internet because of security concerns. With IPv6, these people will have far greater incentive to conduct business online. Optional with IPv4, IPSec is mandatory with IPv6. IPv6's security extension headers make it simpler to encrypt and authenticate data and provide VPNs. This next-generation protocol will better control security end to end and protect data integrity.

Improving the Internet's security will remove a big hurdle to e-commerce as well as better safeguard important business and financial data—considerations vital to companies today.

Built-In Mobility Caters to On-the-Move Customers

Just as drive-through restaurants continue to consume market share in the fast-food business, so do mobile IP applications continue to gain market share in the communications world. Stretched by competing demands, people are striving to do more in less time, and that means staying connected at home, in the office, or on the road—whether on business or vacation.

Fortunately, with the advent of IPv6, these people will be able to use their mobile phones, personal digital assistants (PDAs), and laptops to access information and services on the Internet no matter where they go. In short, location will cease to be a constraint to connecting to the Internet, and service providers can capitalize by introducing services that take advantage of this newfound freedom.

Today, IPv4 mobility can be accomplished via third-party client software in addition to a mobility-enabled infrastructure, but this approach adds cost, deployment complexity, and virtually no security compared with mobile IPv6.

How does IPv6 offer greater mobility? Connecting while on the go requires a mobile IP address, something that IPv4 is ill-suited to provide. Implemented before IP mobility was even considered, IPv4 assumes that a node's IP address uniquely identifies the node's point of attachment to the Internet. In the IPv4 environment, each device is assigned a fixed IP address that belongs to a network. If a device changes to a different network, the packets sent to it will be routed to its former network and then be discarded for lack of a destination. Consequently, a mobile IPv4 device has difficulty changing its point of attachment without losing its ability to communicate. In such a case, the system requires a new IP address, which adds a layer of infrastructure and administration, one that IPv6 fortunately avoids.

With IPv6, regardless of where they connect to the network, mobile devices are always identified by their home addresses. When a mobile device changes links, however, it must inform a router (called the "Home Agent") to redirect packets to its address on the foreign link, called a "care-of address." Traffic directed to the node's home address is then delivered to the care-of address.

Always-On Capability Permits Push-to-Talk Applications

Applications that are always able to accept a connection from a host on the Internet are know as "always on," and IPv6 is ideally suited to such applications. The availability of trillions of IP addresses will allow billions of data phones, handheld PDAs, home appliances, and other devices to connect continuously to the Internet.

One such promising always-on application is known as "push to talk." Users simply press a button on their cell phones, and they are almost instantaneously connected to another party or a talk group. The system operates much as two-way radio does: Conversations are one-way in that while one person speaks, the other or others listen. When someone else presses the push-to-talk key, that person's voice can be heard by others on the call.

Push to talk promises to enhance cellular services and open doors to new voice-based business opportunities. Service providers stand to attract new customers and profitably increase their average revenue per user.

Quality of Service Allows Videoconferencing and Voice over IP

All data is not created equally. Some, such as e-mail, can take its time arriving at its destination (within reason). Others, such as videoconferencing or voice over IP (VoIP), require real-time delivery because straggling data packets can ruin a videoconference or turn a voice call into a cryptic mess.

Service providers that need to prioritize VoIP packets or guarantee bandwidth availability or process e-commerce transactions before Web-browsing requests will appreciate IPv6's QoS capabilities. IPv6 includes a 20-bit traffic-flow identification field that allows service providers to classify packets according to destination and service (and thereby prioritize traffic), allocate bandwidth to different applications and users, and enforce security. IPv6 also has the capability to speed end-to-end transmissions by processing packets faster at each node along a route.

These capabilities add up to one thing for service providers: increased network control. And better controlling their networks means better controlling their businesses.

Autoconfiguration Broadens Internet's Appeal

IPv6 also offers address autoconfiguration, which allows cell phones, wireless equipment, home appliances, and other devices to plug into the Internet and immediately obtain new, globally unique IPv6 addresses. For one thing, this capability will allow mobile devices to easily move among foreign networks, quickly acquiring new addresses without the need of a foreign agent. And for another, consumers will be able to easily connect their computers, printers, IP phones, digital cameras, and other devices to the Internet. Only the most technically savvy would not hesitate to do this without the benefit of autoconfiguration.

IPv6 offers two types of autoconfiguration: stateful and stateless. Stateful autoconfiguration is the IPv6 equivalent of Dynamic Host Configuration Protocol (DHCP)—the technique that IPv4 uses to assign IP addresses. Stateful autoconfiguration requires that the DHCP server and the client both maintain state information to prevent address conflicts, manage leases, and renew addresses.

With stateless autoconfiguration, a host automatically "leases" an address, which spares the server from having to send out an address space. Stateless autoconfiguration allows a host to propose a likely unique address (based on the network prefix and its Ethernet MAC address) and propose this address's use on the network. Consequently, no server has to approve the address's use or pass the address out, so stateless autoconfiguration is simpler than its stateful alternative. Most IPv6 systems, including servers, use stateless autoconfiguration as their defaults.

Peer-to-Peer Support Lays Groundwork for Interactive Applications

Service providers stand to earn substantial revenues from consumers who adopt peer-to-peer applications such as interactive chat or online gaming—applications that rely heavily on IPv6.

Today most online gaming applications are server-based. But as the popularity of online gaming grows, these servers will slow down and interfere with games that depend on split-second reactions. Peer-to-peer systems avoid that problem, although today's IPv4-based peer-to-peer systems require extra complexity to get around restrictions implemented to manage NAT (see sidebar). IPv6 eliminates these restrictions and simplifies developing and operating true peer-to-peer systems. This capability will be a boon for online gaming and other peer-to-peer applications such as distributed data sharing and file sharing that allow users to provide Internet content rather than just consume it, as is typical today. With the advent of IPv6, people will be much better equipped to interact with others and to share information, knowledge, and content.

IPv6 Makes NAT Irrelevant

IPv6 makes Network Address Translation (NAT) and its associated restrictions unnecessary. Introduced to temporarily curb the depletion of IPv4 addresses, NAT sits between the Internet and a series of hosts on servers, firewalls, or routers, allowing numerous hosts to share one unique IPv4 address.

NAT has eased the address shortage, but it requires extra processing to translate addresses, which needlessly burdens network devices and applications. As well, NAT stands in the way of peer-to-peer applications and network security. It has also impeded VoIP service adoption because connecting to a NAT network, especially one running many services, is difficult, if not impossible using IPv4. By overcoming these sorts of NAT-related restrictions, IPv6 will allow service providers to use existing broadband infrastructures to generate new revenues.

IPv6 Ideal for Instant Messaging

An immensely popular Internet application, instant messaging relies on unique, globally routable addresses at each end node of a peer-to-peer link. Because IPv6 allows any two nodes or points on the Internet to communicate unhindered with each other, this next-generation protocol is ideal for instant-messaging applications.

As these foregoing benefits suggest, IPv6 will offer service providers an opportunity to create innovative services and deliver them with unprecedented control.

THE WORLD'S INCREASING DEMAND FOR IP ADDRESSES

If demand for Internet addresses rises as quickly as some expect, the world will eventually run out of these now-indispensable resources. Indeed, in 2002, the United Nations reported that the IPv4 32-bit address space is inadequate to support one-third of a global population of 6.3 billion people.

Computers, cell phones, and other IP-enabled devices will all require unique Internet addresses to communicate directly with one another. Consequently, numerous organizations and governments, particularly in Japan, Asia Pacific, and Europe, are now implementing IPv6, and several operate well-advanced programs to promote the technology and its adoption.

The following section explores some of the factors that are accelerating this rising demand.

Growth in Number of Mobile Devices

The proliferation of mobile devices around the world is contributing substantially to the seemingly insatiable demand for IP addresses.

Based on data from Pyramid Research and *The Economist*, Table 1 projects the growth in mobile subscribers in various regions by 2007. Note that even though only 38 out of 100 people in China are forecast to use mobile phones by 2007, the sheer volume of China's population will produce more than half a billion mobile subscribers.

Table 1. Mobile Subscribers Forecast by Region in 2007 ('000)

Area	Mobile Subscribers by 2007	Percentage per 100 Population
United States	220,351	73.2
Hong Kong	7268	95.3
Japan	104,944	82.3
China	502,147	37.6

Third-generation (3G) telephony and multimedia networks of wireless devices embed an IP stack to enable Internet applications and services to become mobile. As the next generations of devices will tend to support several data-link technologies, such as WLAN and cellular, they can benefit from mobile IPv6 to allow roaming between them.

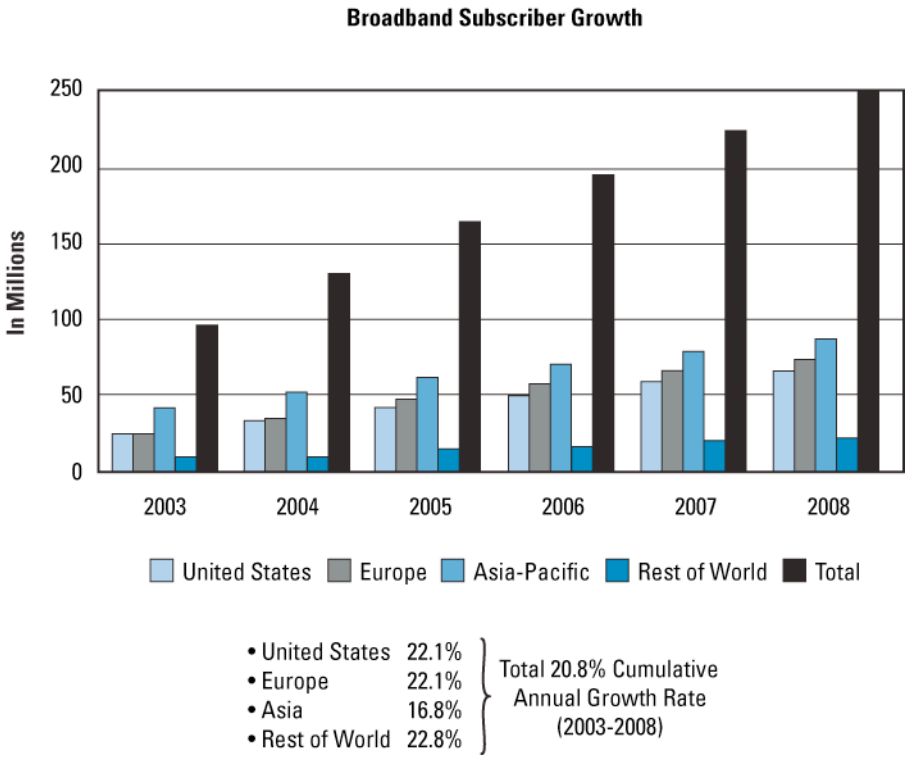
Wireless and Wireline Convergence

Moreover, service providers will soon roll out converged phones that easily switch between landline and wireless voice and data. For example, teaming with wireless carrier Vodafone UK, British Telecom (BT) announced in May 2004 that it intends to introduce converged phones by the end of the year. These converged phones will access BT's landline system when at the office or at home and, when mobile, easily switch to Vodafone's wireless system.

Growth in Broadband Access

Research firm IDC estimates that 97.3 million households and businesses worldwide subscribed to broadband Internet access services at the end of 2003. IDC projects this total to rise to 251.3 million by the end of 2008. This increase represents an average 20.8 percent compound annual growth rate (CAGR) throughout the world. Figure 1 illustrates the projected growth of broadband subscribers from 2003 to 2008.

Figure 1. Broadband Subscribers by Region 2003–2008



Voice over IP

No longer a technology in waiting, VoIP enjoyed a breakout year in 2003. Technology-forecasting company InfoTech reported that 21 percent of U.S. enterprises have implemented VoIP at more than five locations. Synergy Research Group, a communications-market analyst company, predicts that shipments of IP private branch exchanges (PBXs) will surpass those of traditional PBXs by 2006. Not surprisingly, Federal Communications Commission chairman Michael Powell said in that the "world will change now inevitably" as VoIP offers cost-effective communications over the Internet.

Convergence of Network Services

The convergence of voice, video, and data services is also accelerating the demand for broadband capacity and IP addresses.

For instance, European service providers and U.S. incumbent local exchange carriers (ILECs) are now moving into video services and increasing the demand for broadband capacity. An example: In June 2004, SBC Communications announced that it intends to spend US$6 billion over five years to deploy a high-speed Internet network that will provide digital TV service to millions of customers.

And just as telephone companies are penetrating traditional cable markets, so too are cable companies penetrating traditional telephony markets with services such as VoIP, blurring the lines that once clearly separated these new competitors.

Vast Array of New Embedded Device Possibilities

"In 2005, all Sony products will be IPv6-enabled."
Mario Tokoro
Corporate Executive Vice President
Co-CTO and President of Network & Software Technology Centre
Sony Corporation

In the future, many home appliances—furnaces, air conditioners, alarm systems, microwaves, refrigerators, stereos, computers, televisions, radios—will be connected together over the Internet, as will be vehicles, mobile phones, PDAs, and other devices yet to be invented. In fact, the average U.S. home contains some 250 devices that could be connected to the Internet. Each device will require a unique Internet address to communicate with other devices on the network. With its bountiful IP-address pool, IPv6 will permit this unfettered connectivity.

LEADING MARKETS

Which markets are leading the push for IPv6? The following section concentrates on two major contributors: geographical markets and vertical markets.

Geographical Markets

Support for IPv6 is strongest outside North America. The majority of IPv4 addresses have been allocated to North American organizations, so the rest of the world is looking to IPv6 to boost supply.

Japan

Japan is an IPv6 leader, aided by its government's "e-Japan" policy, which aims to create a ubiquitous network that will allow any device—from a powerful server to a dog collar that contains a minute tracking chip—to connect to the Internet. Japan is offering tax incentives to encourage carriers and manufacturers to adopt IPv6, and the government is offering low-interest loans (or no-interest loans in some cases) to stimulate IPv6 investment.

By embracing IPv6 as soon as possible, Japan expects to capitalize on the widespread connectivity, stricter privacy, and improved network security that the technology offers. The Japanese government sees IPv6 as a business-development tool, one that can help spark the country's stagnant economy.

Example of a Service Provider Initiative in Japan
In late 2003, Asia Netcom and NEC launched a multicast solutions package for Japanese corporations and government agencies, and this solution includes end-to-end IPv6 support.

Asia Pacific

Korea

Other countries are following Japan's IPv6 lead. For instance, Korea announced a plan in June 2004 to offer its citizens and businesses uninterrupted access to the Internet, fixed-line services, and mobile networks any time, in any location. Named "u-Korea" (short for ubiquitous Korea) this project will encompass a host of leading-edge technologies and applications including digital TV, sophisticated robots, imbedded software, and IPv6.

Example of a Service Provider Initiative in Korea
The National Computerization Agency in Korea is planning to launch a joint public-private IPv6 network pilot in 2004. Known as "Koreav6," this network will test the technological feasibility and marketability of peer-to-peer solutions, home networking, and other services.

China

Prompted by the eventual need for billions of IPv6 addresses, China is also actively promoting IPv6 development. The country launched a new nationwide IPv6 backbone network project, a joint initiative of eight government ministries. Under the project, China will promote, research, and develop IPv6 technologies, products, applications, businesses, and services. In fact, the country will devote some US$170 million over two years to the project, and cooperate with the European Union and Japan to fulfill the project's objectives.

Example of a Service Provider Initiative in China

China Telecom is planning to invest more than US$12.08 billion in the next 10 years to test the transition to IPv6 and to develop services. And France Telecom SA announced in June 2004 that it will invest tens of millions of euro in a research and development center with China Telecom. The companies will do research into IPv6, among other areas.

Europe

6NET

6NET is a three-year European project to demonstrate that IPv6 can fuel the Internet's continued growth. Coordinated by Cisco and involving some 34 partners, the project has built a native IPv6-based network that connects 16 countries. The goal of the project is to gain experience deploying IPv6 and migrating from IPv4-based networks. Participants are extensively testing a variety of new IPv6 services and applications as well as interoperability with existing applications.

European Union IPv6 Task Force

Launched in 2001, the European Union IPv6 Task Force was established to ensure that Europe develops a clear roadmap to IPv6, primarily to enhance, or at minimum maintain, its competitiveness in wireless technology.

Example of a Service Provider Initiative in Europe

In 2003, NTT Europe Ltd. announced that it would launch a commercial IPv6 service in Europe. The company is setting up IPv6 points of presence (POPs) in London, Amsterdam, Paris, Frankfurt, and Madrid to provide IPv6 native connections as well as IPv6-over-IPv4 tunneling connections. NTT Europe had been offering IPv6 trials since 2000.

North America

Although Europe, Japan, and Asia Pacific are leading the IPv6 revolution, North America is by no means sitting idle.

For example, in March 2004, tests were completed on the second phase of Moonv6, the world's largest multivendor IPv6 network. Participants included the North American IPv6 Task Force, the University of New Hampshire, the Joint Interoperability Testing Command, and various other U.S. Department of Defense (DoD) agencies as well as dozens of private-sector technology and communications companies including Cisco.

Stretching from New Hampshire to California, the tests demonstrated IPv6's ability to work with high-speed links, firewalls, routing, common applications, and QoS for real-time business applications such as multimedia.

Mobile operators are expected to lead North America's adoption of IPv6; in fact, wireline and wireless convergence will also accelerate U.S. adoption as will large enterprise accounts such as government.

Example of a Service Provider Initiative in North America

In June 2004, Verio, a subsidy of NTT Communications, announced that it was expanding the capability of the large-scale IPv6 commercial offering that the company launched in late 2003. The enhancements include a managed router service that supports end-user hardware devices. As part of the service, Verio will help ensure that IPv6-enabled devices meet network objectives for fault management, configuration, performance, and security.

END-USER MARKETS

Higher Education and National Research Networks

National research networks have been working on IPv6 since 1995. For instance, SURFnet is the national computer network for higher education and research in the Netherlands. SURFnet connects universities, colleges, research centres, academic hospitals, and scientific libraries not only to one another but also to other networks in Europe and around the world. This network runs both IPv4 and IPv6 at present.

In France, the Renater network connects some 600 sites involved with research, technology, education, and culture. The Renater-3 network operates both IPv4 and IPv6 and is a leader in delivering IPv6 multicast services.

Government

Governments are also strong candidates for adopting IPv6. For example, in the United States, the DoD now requires that all Global Information Grid requests for proposals be IPv4- and IPv6-capable. And every DoD RFC specifies IPv6 today. The U.S. Commerce Department is also requesting public comments on the costs and benefits of switching to IPv6 from IPv4.

Service providers are responding. For example, ATS and Verio announced in early 2004 that they would immediately start offering IPv6 gateway services to federal, state, and local government customers.

CONCLUSION

IPv6 may be new, but this technology is expected to grow and eventually usurp its older and more restricted IPv4 cousin. This evolution will take place over time, and both technologies will likely coexist for years.

Nevertheless, IPv6 will offer North American service providers an opportunity to tailor offerings to customers, launch innovative services, and generate new revenues. By capitalizing on IPv6's improved security, QoS options, mobility, autoconfiguration, and peer-to-peer capability, service providers can create a powerful suite of next-generation Internet services and stimulate new revenues.

In addition to offering North American service providers and their customers better security, mobility, and peer-to-peer support, IPv6 will address the escalating need for Internet addresses—a requirement largely now restricted to Europe, Japan, and Asia Pacific. The growing worldwide demand for IP addresses is due to the increase in mobile devices; the growth of broadband access; the convergence of voice, data, and video; the proliferation of potential IP-enabled devices; and the burgeoning popularity of VoIP.

Not surprisingly, IPv6 market interest is strongest today in Europe, Japan, and Asia Pacific, but demand can also be found in national research networks and governments, many of whom have programs to test and promote IPv6. In North America, IPv6 is recognized as a technology requirement as organizations, including the U.S. DoD, specify support of the protocol in current RFCs.

For service providers that face the challenge of deploying transit and end-user services over IPv6, Cisco Systems has the most complete product offering and most operational experience to easily integrate communications networks. Building on its long-standing commitment to IPv6 standards and innovation, Cisco provides a trusted IPv6 solution backed by years of development, covering the largest worldwide IPv6-enabled installed base.

Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

European Headquarters
Cisco Systems International BV
Haarlerbergpark
Haarlerbergweg 13-19
1101 CH Amsterdam
The Netherlands
www-europe.cisco.com
Tel: 31 0 20 357 1000
Fax: 31 0 20 357 1100

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-7660
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems, Inc.
168 Robinson Road
#28-01 Capital Tower
Singapore 068912
www.cisco.com
Tel: +65 6317 7777
Fax: +65 6317 7799

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