Is IPv6 Finally Gaining Ground?

George Lawton

When the Internet Engineering Task Force approved Internet protocol version 6 several years ago, proponents acclaimed it as a major development.

Since then, IPv6 (see the sidebar "IPv6 Primer") has received support only in some areas. In Asia, for example, the profusion of smart cellular phones and PDAs has caused the demand for IP addresses to outstrip the limited supply provided by IPv4, the previous Internet protocol version.

Meanwhile, equipment and OS vendors have just begun supporting IPv6, as have manufacturers of devices using wireless and embedded technologies.

However, there is relatively little support for IPv6, particularly in North America, from the Internet service providers (ISPs) and network administrators who would use the protocol and thus are key to its success.

Industry observers say the lack of support is partly due to the cost and effort required to migrate to IPv6, as well as the protocol's shortcomings and a perceived lack of need for the standard's advantages.

Some engineers contend that because IPv6 represents such a major change in Internet technology, widespread adoption will take years. IBM Distinguished Engineer Brian Carpenter, who has studied IPv6, said, "I have always looked at this as a 15-year process starting in 1995."

LOW ADOPTION LEVEL

IPv6's current adoption status is a study in contrast between initial vendor support and a lack of deployment by ISPs and network administrators.

Early vendor support

To support IPv6 in their products, vendors generally add software. However, some equipment, such as high-speed routers with hardware acceleration, also needs hardware upgrades.

To work optimally, IPv6 requires support throughout a network, in various types of hardware and software, including routers, switches, firewalls, applications, and operating systems.

In 1997, IBM became the first Unix equipment and software supplier to offer an OS with a TCP/IP stack that supports IPv6 applications, in this case for the RS/6000 server. IBM recently provided IPv6 support for OS/390 servers and plans to add it for Linux, OS/400, and other systems.

Cisco Systems has released IOS (internetworking operating system) routers that support IPv6. This could be important to IPv6's future because, said company spokesperson Mia Bradway, Cisco routers carry 80 percent of the Internet's backbone traffic.

Microsoft has released a developer's IPv6 technology preview for Windows 2001 SP1 (Service Pack 1) and included IPv6 in the beta version of Internet Explorer bundled with Windows XP.

These Microsoft IPv6-enabled development stacks are also potentially important to the protocol's future. They would help vendors create additional IPv6 applications, such as those for Internet telephony, for the millions of users who run Microsoft products.

Meanwhile, Sun Microsystems has built IPv6 support into its Solaris 8 OS and the early-access version of Java Development Kit 1.4, scheduled for release later this year.

Several Japanese companies have announced plans to support IPv6 in future products, such as Fujitsu's GeoStream R940 router, Hitachi's GR2000 backbone router, Matsushita's IPv6 security gateway and router, and NEC's IP8800/700-series switch. In addition, Sony is working with Cisco to develop a dual IPv4/IPv6 stack for the Internet-enabled PlayStation.

Lack of user support

Although vendors are releasing products that support IPv6, the protocol will not gain widespread acceptance until ISPs and enterprises activate and use the protocol's capabilities in equipment and software.

Enterprises are not likely to activate IPv6 capabilities unless their business partners do so, which creates a vicious circle that could delay deployment, according to IBM's Carpenter.

Meanwhile, ISPs could be a key factor in the protocol's future because of their significant network presence and the many routers and switches they operate.

Some ISPs, particularly those targeting the Asia-Pacific region, have launched major IPv6 initiatives.

For example, Zama Networks has built an entire IPv6 network from scratch to serve the Pacific Rim.

In addition, NTT Communications' OCN (Open Computer Network) has launched an IPv6 native gateway service; an IPv6 tunneling service; and the world's first commercial global IPv6 backbone across Europe, Asia, and the US.

The gateway service provides direct connectivity to the IPv6 backbone via leased lines or Ethernet, said Shin'ichi Ezaka, manager of NTT's Global IPv6 Business Development and Strategy Division.

IPv6 Primer

The Internet Engineering Task Force began work in 1994 on IPv6, a proposed standard designed to address various problems with the previous Internet protocol, IPv4, introduced in 1978. (The IETF skipped an IPv5 standard because network operators had already adopted many of the protocol's potential provisions before it could be adopted.)

Proponents have been experimenting with IPv6 since shortly after its approval. An international network of research and commercial sites launched an experimental IPv6 test bed, the 6Bone, in 1996.

Nonetheless, equipment and OS vendors have only recently begun adding support for the protocol. And ISPs and network administrators are only slowly implementing IPv6 in their systems.

Advantages

IPv6 offers several advantages over IPv4.

More IP addresses

IPv4's 32-bit addressing scheme can support a theoretical maximum of 4.29 billion IP addresses. However, operational inefficiencies, such as the need for enough addresses to permit flexible subnet configuration within the Internet, limit the useful IP addresses to about 200 million.

Industry experts say this won't be nearly enough addresses for the many cellular phones, handheld devices, and embedded systems that will connect to the Internet in the next few years.

To cope with existing shortages, some organizations are using network-address-translation technology. NAT lets companies create large numbers of private, unregistered Internet addresses for internal use. These private addresses connect to the Internet via a limited number of public, registered addresses. IPv6 proponents say NAT creates network-security vulnerabilities and other problems.

IPv6 offers a 128-bit addressing scheme that permits about $2^{1,033}$ useful IP addresses.

Extensibility

Internet authority Steve Deering, a technical leader at Cisco Systems who is chair of the IETF's IP Next Generation Working Group, said IPv4 supports extensibility. However, he added, IPv4 limits to only 40 bytes the amount of data that can be used to describe the additional functionality provided by the extensions. IPv6 allows considerably longer option descriptions so that extensions can better add functionality such as improved security and routing control.

Autoconfiguration

The large number of IPv6 addresses will let each device on the Internet have its own address. This would eliminate the need for manual device configuration or DHCP (dynamic host configuration protocol) servers, which manage and assign addresses within IPv4 networks.

The tunneling service lets users encapsulate IPv6 packets within IPv4 packets for transmission through IPv4 networks, he explained.

Most North American-oriented ISPs are pursuing a more cautious deployment. For example, Steve Dougherty, director of systems vendor management at EarthLink, a major US ISP, said that his company is researching IPv6-related equipment and interoperability issues but is holding off on deployment. "IPv6 is the solution," Dougherty said, "but the question is when and how."

North America doesn't need IPv6's additional addresses as badly as Asia because it received more IPv4 addresses than other regions to begin with and hasn't adopted wireless technology as extensively as Asia.

However, the need for IPv6 is particularly acute in places like China, a large country with access to fewer IPv4 addresses than individual US schools such as MIT or Stanford University, according to Lawrence Orans, an analyst with market research firm Gartner Inc.

The European Union has mandated adoption of IPv6. However, said independent Internet-technology consultant Noel Chiappa, this doesn't necessarily mean adoption will occur quickly.

FACTORS HOLDING BACK ADOPTION

Despite IPv6's advances, numerous factors are holding back its adoption.

For example, Bill Moffitt, Sun's Solaris product line manager, said that many equipment vendors aren't heavily supporting IPv6 because they are US-based and focus on the North American market, where IPv6 demand is relatively low.

Cost and effort

Some industry observers, such as Gartner's Orans, say businesses and ISPs will be slow to migrate to IPv6 because this would require them to spend considerable money and time upgrading their PCs, servers, and routers.

Orans said that companies would have to ensure compatibility between their IPv6 and IPv4 networks by installing network address translation (NAT) boxes between them. Chiappa explained that keeping the existing IPv4 infrastructure and deploying a few NAT boxes at the edge to deal with IPv6 transmissions are less expensive than converting to IPv6 and deploying many NAT boxes to handle IPv4 communications.

Because IPv6 is a new technology without an extensive track record and because North America doesn't face a severe IP address shortage, Orans said, US and Canadian network managers might not implement IPv6 during the next five years. "Why would a network manager want to risk his job going to IPv6 unless there was a need?"

In contrast, some IPv6 proponents say companies could choose to migrate to the protocol because they would incur little incremental cost and effort.

For example, Tim Martin, Zama's vice president of professional services, said companies could include IPv6 upgrades as part of their normal equipment replacement strategy. "People will not put a lot of money specifically into IPv6," he explained. "It will just be part of the normal network upkeep."

In fact, Martin said, IPv6's elimination of the need for DHCP (dynamic host configuration protocol) servers, which manage and automatically assign addresses within an IPv4 network, would lower network-administration costs.

IPv6 shortcomings

"IPv6 is the fundamentally wrong design for what next-generation networking should be," said consultant Chiappa. "They essentially took IPv4 and made the address [space] a little longer."

The problem, he said, is that IPv6 does not overcome some of IPv4's important limitations. For example, the new protocol doesn't address the trouble that routing tables—which help servers find the addresses of other servers on the Internet—have in handling the explosion of online traffic.

However, IPv6 proponents like Steve Deering, a technical leader at Cisco Systems who is chair of the IETF's IP Next Generation Working Group, say solving the IPv4 address-shortage problem was the first priority and the Internet community can focus on other issues later.

Who needs IPv6?

Industry observers such as Zama's Martin say there is a need for IPv6 now because users in various parts of the world are already running out of Internet addresses.

On the other hand, Tom Nolle, an analyst with CIMI Corp., a networking consultancy, said the biggest obstacle to widespread IPv6 adoption, particularly in North America, is that there isn't a need for it yet. He said many users acknowledge the long-term need for the additional Internet addresses that IPv6 will provide, but they don't want to spend the time and money necessary to migrate until they have to.

Gartner's Orans said there won't be an IP address shortage in North America for at least five more years. In addition, he explained, deploying DHCP to handle device configuration and NAT boxes to generate more private Internet addresses for organizations has mitigated some of IPv4's problems and lessened the immediate need for the new protocol.

However, some observers say NAT boxes create vulnerable network entry points and cause confusion for applications that assume that if they're talking to

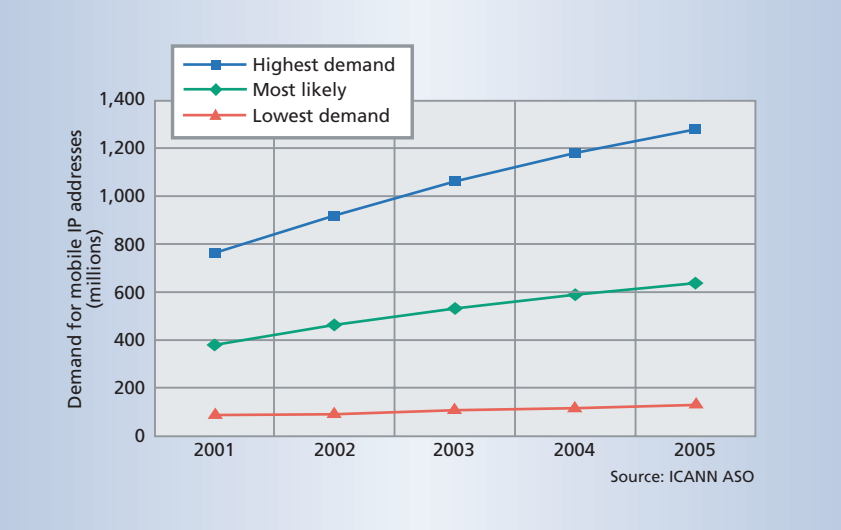

Figure 1. Information presented at the recent general assembly of the Address Council that is part of the Internet Corporation for Assigned Names and Numbers' Address Supporting Organization shows three scenarios for the growing demand for mobile IP addresses. Each scenario indicates that demand will increase steadily during the next few years, perhaps reaching 1 billion in 2003 and 1.27 billion in 2005.

the same Internet address on different occasions, they're talking to the same device. This is not necessarily true with NAT boxes, which can assign the same Internet address to multiple devices on different occasions.

FUTURE

The jury is still out on IPv6's future. Because the technology is so new, the protocol could take various directions.

Wireless: IPv6's killer app?

IPv6 may be most widely deployed in mobile phones, PDAs, and other wireless terminals in the near future, according to Svend Nielsen, cellular-phone vendor Ericsson's director of IP technology. He said that 500 million mobile users could be connected to the Internet by late 2003 and a billion by late 2005. By this time, he noted, all IPv4 addresses may be used up, thereby necessitating IPv6 adoption.

As Figure 1 shows, other estimates

indicate the demand for mobile IP addresses could reach 1.27 billion by late 2005.

Meanwhile, Europe's Third-Generation Partnership Project (http://www.3gpp.org), which is working on next-generation wireless-network technology, has specified IPv6 as the standard addressing scheme for mobile IP multimedia. This focus on wireless technology has changed the marketing strategy of many IPv6 proponents, who previously concentrated on convincing wireline ISPs to adopt the protocol.

Nielsen said Ericsson will begin releasing IPv6-enabled phones as part of a pilot project later this year, will undertake full-scale release next year, and plans to deploy IPv6 in all of its routers and middleware in the near future.

When wireless terminals represent the majority of Internet-connected devices, said Cisco's Deering, many ISPs and users of PCs, laptops, and other older technologies will migrate to IPv6 to maintain interoperability with the terminals.

Gartner's Orans was skeptical about widespread North American deployment of IPv6 in the near future but said it eventually will occur. He explained that activities such as home networking will use up IPv4 addresses, thereby increasing demand for IPv6.

First, though, said CIMI's Nolle, the Internet community must figure out how to adopt IPv6 incrementally because users will want to migrate to the new protocol gradually.

According to IBM's Carpenter, several techniques could permit gradual IPv6 adoption and interoperation with IPv4. For example, he explained, routers, operating systems, and middleware could have dual IPv6 and IPv4 stacks. When IPv6 is more widely adopted, Carpenter said, network address translation could bridge the two types of networks, as Figure 2 shows. Eventually, application-specific translation gateways could improve communications between IPv6- and IPv4-based programs.

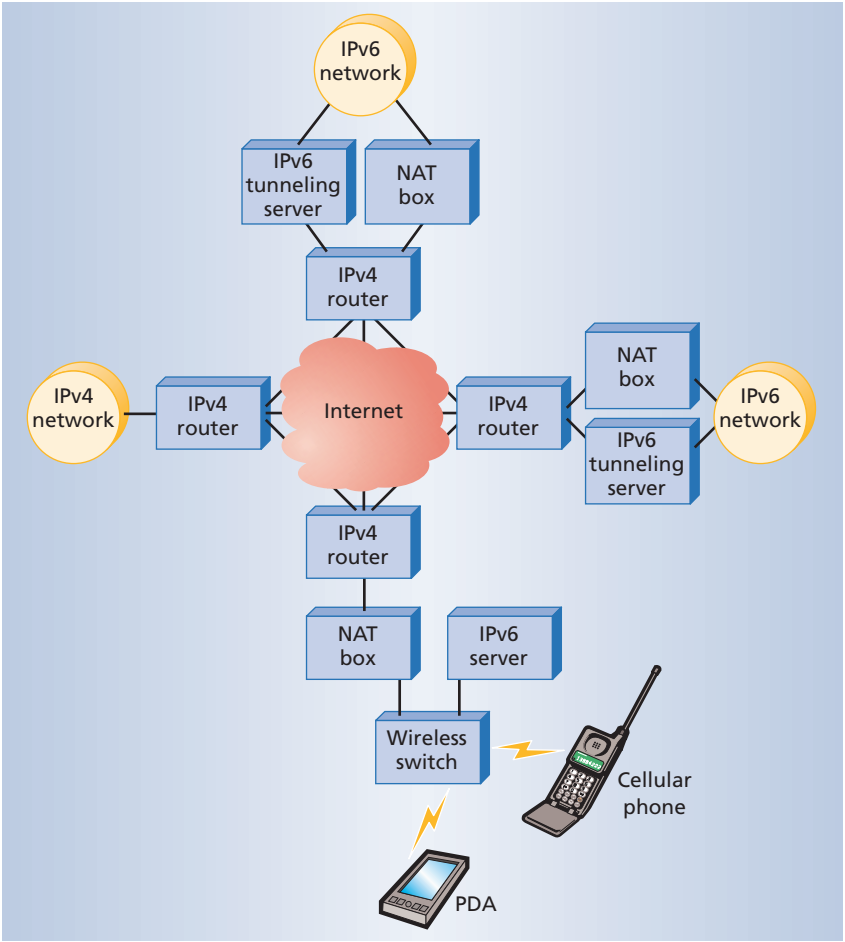

Figure 2. As users gradually transition to IPv6, they will need ways to interact with existing IPv4 networks. NAT (network address translation) boxes could translate from one protocol to the other. In addition, tunneling servers could permit the encapsulation of IPv6 packets within IPv4 packets for transmission across IPv4 networks. Mobile users could also connect directly to an IPv6 server.

Sun's Moffitt said IPv6 will grow the way the Internet did, with pockets of users connecting. However, he said, the protocol will grow faster because the Internet infrastructure is already in place.

Chiappa, on the other hand, said IPv6 will flourish only for certain applications, such as wireless telephony, or in certain markets, such as China. Otherwise, he contends, there will be no rush to adoption. "When I see vendors with limited budgets put more money into it," he explained, "I will be a little more impressed. IPv6 has been six or seven years under development, which is forever in the technology world. I am just wondering how long it will be before everyone wakes up to the fact that it isn't going anywhere."

Moffitt disagreed. "I don't think [IPv6] has experienced slow growth, considering the scope of the changes it entails."

According to IBM's Carpenter, IPv6 is proceeding on schedule. "People have to look at this as a strategic issue," he said, "not as something that is going to be profitable in six months. It is something we have to do to make the network grow worldwide for the next 100 years." ✸

George Lawton is a freelance technology writer based in Brisbane, California. Contact him at glawton@glawton.com.