IPv6: A Bright Future for China

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A friend in the construction business often tells me that it is easier to build a new house than to modernize an old one. The same can be said about data networks, and in this there is a golden opportunity for the People's Republic of China. Currently, there are only 68 million Chinese Internet users—a mere 5.2 percent of the total population.[1] Over the next decade that percentage will grow enormously, requiring a massive expansion of the Internet infrastructure within China. This new infrastructure can be, if the country so desires, one of the most advanced in the world.

A key component of such Next-Generation networks is IPv6. In China, a major network shift to IPv6 is expected before 2007.[2] It is reasonable to expect that within five years, China will be the world leader not only in the deployment of IPv6, but also in the research and development of new applications that take advantage of this new version of the Internet Protocol.

A Brief History

In its infancy, what we now call the Internet was a research and development network. There was little if any expectation that this internetworking of academic, military, and corporate networks would have the phenomenal commercial success it has since enjoyed. As a result great blocks of IP addresses were taken by universities, companies, and government organizations involved in this internetwork with the assumption that the IPv4 address space was fairly inexhaustible. The vast majority of those early address allocations were made in the United States, where most of the early research and development was taking place.

You know the rest of the story. Many university students exposed to this internetwork understood its potential and went on to build companies to exploit that potential. The World Wide Web became the first of the "killer apps" that popularized the Internet with the general public and caused an explosion of new users. Suddenly, what was once assumed to be a vast supply of available IP addresses was quickly becoming depleted. In the mid-nineties, there were a number of analyses predicting that based on existing allocation trends, the IPv4 address space would be used up in a few short years.

The solution to IP address exhaustion was to develop a new version of IP, with a larger address space. That solution, which was first called IPng (ng for "next generation") and eventually became IPv6, quadrupled the size of the address to 128 bits. This larger address size means an exponentially larger number of available addresses. But it was understood that a short-term solution was needed to slow IP address exhaustion while the long-term IPng was being developed. The short-term solution was to create "private" IP addresses which could be reused in many networks, and a mechanism that allowed many

[1] Source: "Internet Usage and Impact in Twelve Chinese Cities," Chinese Academy of Social Sciences.
[2] Source: "Prospect of Telecom and Internet Markets in China," Beijing Internet Institute

of these non-unique private addresses to share one or a few globally unique IP addresses: Network Address Translation, or NAT.

NAT and dynamic private IP addresses have become so widely accepted that it is a part of most modern networks, from small multi-computer home networks to large enterprises. And the mechanism has been so successful in slowing the depletion of IPv4 addresses that many question the need for IPv6 in the near future. But NAT is increasingly viewed as an inhibitor to innovation in application development. Peer-to-peer applications, for example, are made more difficult if not impossible when the end systems are hidden behind NAT devices. Likewise, VoIP, grid computing, security, quality-of-service, and multicast applications are more difficult when run from behind NAT. Moving NAT back to what it was originally intended to be—a short-term solution to the IP address exhaustion problem—and moving the IP world to IPv6 will re-energize the innovative thinking of the earlier Internet and result in new and unexpected kinds of applications.

Why All the Interest in Asia?

The early push for widespread adoption of IPv6 has been in Asia, with its large consumer electronics industries. These industries, and the governments that back them, understand that to continue selling new network-enabled devices and services there must be a large pool of readily available, globally unique IP addresses. Additionally, Asia is aggressively building new Internet infrastructures. But because large portions of the IPv4 address space were allocated in the United States in the early days of the Internet, acquiring the addresses necessary to support the burgeoning Asian Internet is increasingly difficult. In India, you can find hierarchical NAT architectures five layers deep to compensate for that lack of IP addresses.

A single example clearly explains the Asian interest in IPv6: Some 65% of the total IPv4 address space has been allocated, leaving approximately 1.3 billion globally unique addresses still available. The population of the Peoples' Republic of China is also, it turns out, about 1.3 billion. So by giving a single IPv4 address to each person in China, all of the remaining IPv4 addresses would be used up.

Which is not to say that IPv4 addresses *will* be used up, by China, India, or anyone else. The reality is that the IPv4 address space will never be completely depleted. What possible justification could a network operator give that would allow him to acquire the very last IPv4 address?

Already, stringent guidelines are in place to insure that globally routable IPv4 addresses are not given out frivolously. If you are a service provider or enterprise network operator, you must provide careful justification for the address space you request. If you run a very small business or home network, you likely have to pay your service provider for static IP addresses, if you can get them at all. As the number of available IPv4 addresses continues to shrink, they will become increasingly more difficult and expensive to obtain. It is predicted that at some point those companies and institutions that acquired a surplus of address space in the early days of the Internet will recognize their spare IPv4 addresses as a valuable commodity, and private market for IPv4 addresses will spring up. So, this is the true driver for IPv6: A new, plentiful source of easily obtainable IP addresses.

Asian governments—particularly those of Japan, South Korea, Taiwan, and China—see IPv6 as essential to the security and continued growth of their technology-based economies. Similar interest is growing in Europe for much the same reason. And North America, where the relative wealth of IPv4 addresses has until recently kept enthusiasm for IPv6 low, government interest—particularly from the military—is expected to drive development of new IPv6 applications that will in turn drive commercial deployment.

IPv6 Features

The most understood feature of IPv6 is its 128-bit address size. This larger address means a total address space that is almost incomprehensibly larger than that of IPv4: some 340 trillion trillion trillion addresses, as opposed to 4.3 billion IPv4 addresses. To put the relative sizes of these two address spaces into some perspective, suppose each IPv4 and IPv6 address weighed one gram. If so, the entire IPv4 address space would weigh approximately 1/17th the weight of New York City's Empire State Building.[3] In contrast, the IPv6 address space would be 56.7 billion times the weight of the planet Earth![4]

But plentiful IP addresses are only one of the advantages of IPv6. The protocol also has features for efficient neighbor discovery and for individual devices to automatically configure their own IP addresses. This capability has tremendous importance for plug-and-play networking, less complex and less expensive network operations, and, most significantly, for mobile communications. Devices moving from one network to another can acquire new addresses and transition between addresses without disruption of their communication sessions.

IPv6 is also designed in such a way that future extensions to the protocol can be made simply and cleanly, something that has never been possible with IPv4. This "extensibility" means that new and as-yet unpredicted applications can be adopted much more quickly, leading to a much more hospitable environment for innovative applications development.

Changing the Way We Communicate

The Internet was originally envisioned as a transparent network of peer-to-peer connected devices, in which all users contributed to the overall richness and usefulness of the connected community. Several factors have changed that original concept.

Foremost among those factors is the ubiquity of NAT devices. True peer-to-peer networking is impossible when a large portion of the Internet population is "hidden" behind NAT. As a result, most transactions on the Internet are client/server based. Users are now seen as connected around the "edge" of the Internet, and services flow out to the users, who themselves provide little or no content. In other words, users are now only consumers of services, not providers of services.

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[3] According to www.gibnet.org/heavy.htm, the Empire State Building weighs 365,000 tons or 328.5 billion grams.

[4] According to www.howstuffworks.com/question30.htm, the Earth, based on gravitational measurements, weighs 6.00e+27 grams. My thanks too Brian McGehee for this example.

IPv6, by eliminating the need for NAT to conserve scarce IP addresses, opens the Internet back up to what it was originally intended to be: a worldwide community of active participants and contributors rather than passive consumers.

I am often asked what the "killer application" is for IPv6. But this question puts the cart before the horse. The "killer apps" of the past did not begin as such. Rather, they come upon us quietly. E-mail, mobile phones, the World Wide Web, and personal digital assistants gained acceptance relatively slowly, and become killer apps when we found ourselves wondering how we ever lived without them. So, IPv6 is a precursor to new killer applications. Removal of the NAT barrier creates a fertile creative environment in which new and unexpected applications are more likely to be developed, and are more likely to again change the way we live, learn, communicate, and do business.

Another factor hindering the advancement of new applications is the way we practice network security. The Internet is, without a doubt, a dangerous place. Irresponsible, dishonest, and malicious elements lurk in ever corner. Our present method of protecting ourselves from these undesirables is to hide our networks behind firewall-based security perimeters. But walls are not the answer. Castle walls, ancient city walls, France's Maginot Line, and even China's Great Wall have all been ineffective against determined invaders. The same is true of modern firewalls. They tend to present a nuisance to the users they are meant to protect, and yet present little more than a nuisance to a knowledgeable hacker determined to get past it. And once a firewall is compromised, the entire network behind it is compromised.

IPv6 is itself no more secure than IPv4. But with its integrated security features, it offers us a chance to change the way we practice network security. Rather than hide our networks behind firewalls, we can collapse our security perimeters so that each and every networked device has its own perimeter. With IPv6 every packet can be authenticated before being accepted and every communication session can be encrypted. The result is communication that is at once both more secure and more open.

The Future is Here

IPv6 is not an experimental protocol, or a protocol still in the turmoil of development. The standards are established, and the protocol has been proven in networks around the world. All of the major operating systems—Microsoft Windows, Apple OS X, Unix and its many variants—all support IPv6, as do all of the major router vendors. Essential applications such as DNS have been ported to IPv6. IPv6 is ready.

In the People's Republic of China, the government recognizes IPv6 as a vital component to the advancement of its information industry and is providing the necessary leadership to begin nationwide deployment. Valuable experience has been gained through research networks such as CERnet and the China Advanced IP Experiment Network, through cooperation with international research and development projects such as Japan's WIDE project, and through the advocacy of internationally recognized groups such as the Beijing Internet Institute and the China NGN Forum. All of the major Chinese telecoms and carriers have plans to begin IPv6 projects. China is ready to lead the world to the next generation of the Internet. Are you ready?