IPv6

– An Internet Evolution –

Introduction

A Peek Inside

If one could imagine that it were possible to peer into the collective mind of the powerful visionaries behind the Internet, what do you think you would see? You would discover a rich depository of technological constructs, prototypes, and advancements, highlighted with such developments as Internet backbone fortification, ISP-provided closed-loop services, NAPs (Network Access Points) shifting to peer-to-peer interconnections, enhanced mobility, upgraded security options, and gigabit routers. Here, you would be privy to all of the elements needed to conceive, shape, and architect a technological evolution.

If you were to probe still further, immersing yourself deeper into the technological mind, you may encounter a focal point, a centralized design for all these elements, one that is not so surprisingly devoted to the needs of those key players driving the developments (i.e., the entertainment, banking, publishing, telecommunications, and media industries). Once at this level, you will see that it is these same markets that are pushing the Internet's capabilities to the breaking point - demanding more, insisting on greater, expecting the ultimate.

Yet, delving deeper inside this potent tool, you will find, superimposed over all of these expectations and demands, not a construct or prototype, but an actual advancement, a revision to the current Internet Protocol - IPv6. Internet Protocol version 6 is the exoteric layer that enables all these advancements to happen. In fact, the advances inherent in IPv6 stretch over and fill in many of the gaps left in the existing Internet Protocol, IPv4.

The Angst of Change

IPv4, though still up and running, has become outdated. The key players in Internet development mandate an evolution, insisting we find a way to accommodate their demands, expectations, and postulations. The key players are clamoring for an answer, a transition.

The transition from IPv4 to IPv6 will mark a period of pubescence for the Internet community – a time where a feeling of angst will float judgementally over the adoption of IPv6 standards and implementation. Additionally, there is a symptomatic insurgence coming from those in the community that cling to the utopian view that the Internet is an unfettered and free medium engineered for the exchange of ideas and the development of commercial enterprises.

This transitional period will also be a time when Internet engineers will decide whether to deploy weak fixes and/or add-ons to IPv4 or upgrade to the integrated and more powerful IPv6. Admittedly, the transition to IPv6 will not be effortless, but, by carefully coordinating IPv4 upgrades with IPv6 deployments, networks can mature and evolve gracefully without experiencing costly growing pains, making tomorrow's 'next generation' networks more efficient to deploy, maintain and operate.

A Commitment to Technology

United States' technology manufacturers have dominated the information technology world, both in product penetration and revenue. IPv6 offers non-U.S. vendors the prospect of supplanting U.S. counterparts for the first time in years. In doing so they not only have an opportunity to recapture market share (and increase revenue), but may be able to actually pole vault into the "Who's Who" IT.

Because businesses around the globe continue to leverage the Internet as a business critical system, both for information management and commercial advancement, plans to utilize the Internet as a new medium offers endless possibilities. However, they most likely will not succeed without an infrastructure upgrade. Before transferring age-old business processes onto this IP-based, worldwide enterprise marketplace, it must become more robust, more flexible, and more secure.

Unlike IPv4, IPv6 attends to critical areas such as IP address depletion, efficient packet handling, authentication and security, and ease of networking. IPv6 is about inventing a global technology platform for the decades to come that will enable access ubiquity, recovery of the end-to-end design, true IP mobility, and ease-of-use for new end-user experiences.

Fad or Strategy?

For the past several years, debates have arose as to whether IPv6 was a passing fad or a strategic maturation. Scores of magazine articles, technology analysts, and industry pundits have compared and contrasted, analyzed, estimated, and calculated the benefits of IPv6, often without fully understanding its true capabilities. Consequently, opinions have ranged from "interesting, but not needed today" to "horse and buggy, Betamax, and IPv6." So, with a struggling global economy, continuing distress in the telecom arena, and fluctuating consumer confidence, a palpable question might be "Who cares about IPv6?"

In the subsequent sections, both the technological imperatives and the business drivers are discussed. In addition to the preceding reasons for adoption, it is important to recognize two fundamental facts regarding IPv6 and its impact on the networks and Internet tools of the future. The first (and most important) fact is that IPv6 is inevitable. While some have labeled v6 a "fad" technology, international giants like HP, Cisco, NEC, Nokia, NTT, Ericsson, Sony, British Telecom, Matsushita, Microsoft, and a host of other companies around the globe have collectively spent hundreds of millions testing and integrating the IPv6 protocol into their respective products and services. With such an impressive list in the technology sector, combined with significant work from the IETF and the awareness raising efforts of the IPv6 Forum, it is clear that IPv6 is a substantial and viable technology.

The second significant point is that while IPv6 may be a network protocol, its impact on the consumer and enterprise sectors will be quietly significant. As already highlighted, the Internet is impacting almost every sector of the economy. Its high rate of adoption, coupled with the fact that IPv4 is reaching its technological limits, has created an environment not all that dissimilar to Y2K. The critical difference is that the transition to IPv6 will not happen at a stroke of midnight.

This analogy is not intended to scare and no one is suggesting that any organization should move to IPv6 immediately! However, if a bank had failed to update its system, and on January 1, 2000 every customer's bank balance vanished, we could assume that on January 2, 2000 that bank would lose most of its client base. The same business immunization logic can also be applied to IPv6. As integration occurs, the benefits IPv6 provides will become more apparent to the end user. Companies that fail to recognize IPv6's impact and do not integrate/migrate may find themselves with an eroding customer base. So, it is in the best interest of both the enterprise and consumer alike to care about IPv6.

Technological Imperatives for Adoption

Beyond the IP Address

Much has been said about the need for a "killer app" to drive the worldwide adoption of IPv6. Mobile IP, online gaming, voice over IP, and other applications, have been cited as candidates for that role. Others argue that no "killer app" is needed. Rather, we just need enough IP addresses for the applications we already have. Often, home and small office networkers must pay extra for additional IPv4 addresses, forcing them to use Network Address Translation (NAT) if they share a single address among multiple Internet-connected devices. Even assuming that these small network operators are savvy enough to set up a NAT device, they face limitations on what they can do on the Internet through NAT. (See the NAT: Just Say No section for a discussion of some of those limitations.)

IPv6 would not exist were it not for the recognized depletion of available IPv4 addresses. However, beyond the increased IP address space, the development of IPv6 has presented an opportunity to apply lessons learned with the limitations of IPv4 to create a protocol with new and improved features. A simplified header architecture and protocol operation translates into reduced operational expenses. Built-in security features mean easier, and therefore more ubiquitous, security practices that are sorely lacking in many current networks.

But perhaps the most significant improvement offered by IPv6 is its address autoconfiguration features. The Internet is rapidly evolving from a collection of stationary devices to a fluid network of mobile devices. IPv6 allows mobile devices quick acquisition and transition of addresses as they move among foreign networks, with no need for a foreign agent.

Address autoconfiguration also means more robust plug-and-play network connectivity. Any consumer who wants to have any combination of computers, printers, digital camera, digital radio with 8000 channels, IP phones, Internet-enabled toaster, and a robotic dog all connect to a home network (without the aid of a 250-page manual), needs the autoconfiguration capabilities that IPv6 provides. Autoconfiguration is another reason why manufacturers have already started integrating IPv6 into product lines.

NAT: Just Say No

The enormous success of the Internet came as a surprise to most all of its early developers, and that certainly holds true for the developers of IPv4. No one expected that the 32-bit IPv4 address space would be insufficient to accommodate the future needs of what was then a small research network. But by the mid-1990s the steadily increasing demand for IP addresses threatened the remaining supply. Many predicted that the available IPv4 addresses would last for only a few years more.

The long-term solution to the IP address depletion problem was to create a new version of IP with an expanded address space. Originally called IPng for IP next generation, this proposed version eventually became IPv6. However, short-term workarounds were required to slow the rate of IPv4 address depletion until the work on IPv6 could be completed. One short-term solution was Network Address Translation (NAT). Also known as IP masquerading or Port Address Translation (PAT), NAT resides between the Internet and a group of hosts on a server, firewall, or router. Through a clever manipulation of port numbers, NAT allows a large number of hosts to share a single unique IPv4 address.

Fueled by the lack of public IP addresses, 70% of Fortune 1000 companies have been forced to deploy NATs.[1] NATs are also found in hundreds of thousands of small business and home networks where several hosts must share a single IP address. It has been so successful in slowing the depletion of IPv4 addresses that many have questioned the need for IPv6 in the near future. However, such conclusions ignore the fact that a strategy based on avoiding a crisis can never provide the long-term benefits that solving the underlying problems that precipitated the crisis offers.

However, NAT was never intended as a long-term solution, and it presents a number of problems in modern networks. Most significantly, NAT destroys a key benefit of the Internet as a network of 'always-on, equally-connected, easily-reachable' peers. Peer-to-peer capability provides a powerful tool, empowering users to become active contributors to the Internet, rather than just consumers. Peer-to-peer systems assume that a user can find and connect to another user, but if a user is hidden behind a NAT device this assumption is not valid. As a result, present peer-to-peer systems utilize an extra level of complexity made necessary only to circumvent NAT obstacles.

NAT also presents challenges for many applications that incorporate the host's IP address in the application-layer data. This issue is particularly problematic for security protocols such as IPSec. If the Internet is to become a community of peers, strong security is essential. Additionally, NAT is a roadblock for applications requiring Quality of Service (QoS) such as Voice over IP (VoIP) and real-time video. NAT is recognized as one of the single largest roadblocks to the widescale adoption of VoIP with its promised cost

[1] Center for Next Generation Internet (www.ngi.org)

savings and enhanced communication services. However, NAT was helpful in delaying a global IP address crisis, but in return has extracted a proportional ‘pound of flesh’ by delaying uncounted peer-to-peer network innovations and their associated cost savings.

The adoption of IPv6, with its abundance of addresses, eliminates any need for NAT and, by extension, eliminates the roadblocks to Internet progress that NAT represents.

Mobile Networking and Terminals

Wireless networks are not just the Internet with radio access (yet), but rather complex infrastructures and terminals supporting the mobility of its users, as well as their access to applications from both fixed Internet and other wireless networks. Such civilian wireless networks, which started in Scandinavia with Nordic Mobile Telephony (NMT) out of social necessity, have enjoyed explosive growth worldwide, with over one billion users today. More than 420 million new mobile terminals are sold each year,[2] easily surpassing PC or game console sales. Subsequently, as mobile users are now demanding access to Internet services, which carriers have provided to a limited extent with so-called second-generation mobile systems.

However, these limited deployments quickly proved that IPv4 alone would not be able to cope with continued demand. From a network infrastructure perspective, there is an increasing need for better flow control, mobility support, and enhanced security. The terminals (handsets) required simpler autoconfiguration, improved management, and a larger IP address space.

Fortunately, by itself, any mobile network constitutes a “closed world” with well-specified interfaces to other networks (telephone or Internet). Consequently, technology ‘leapfrogging’ was made less dependent on legacy systems. About the same time, the third generation (3G) mobile network standards were being architected, tested, and standardized. ETSI (www.etsi.org) and later, the global 3GPP (www.3gpp.org) standardization organization, saw significant improvements with early migration to IPv6. In a landmark decision in 1999, it was determined by 3GPP that, from Release 3 deployment, all third generation mobile networks would use IPv6 as the default IP protocol[3]. The users and regulators, especially in the developing countries, cast a sigh of relief as this would alleviate address space issues, enhance security, and foster localized service creation and software development. This decision would also revitalize growth potential.

At this time, a shift to IPv6 was triggered among terminal vendors, many of which already had dual stacks (IPv4/IPv6) engineered and implemented into devices--even in 2.5G networks such as GPRS and CDMA 2000. This capability in the terminals, coupled with support in network hardware and operating systems, generated a number of research and trial projects across Asia, the EU (www.cordis.lu), and even within the defense communities in Europe and the U.S. These various trials have identified significant improvements in mobile networking, including cost reductions. More importantly,

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[2] http://story.news.yahoo.com/news?tmpl=story&u=/pcworld/20021126/tc_pcworld/107363

[3] http://www.3gpp.org/ftp/Specs/archive/21_series/21.101/

operators can leverage some of IPv6's intrinsic advantages to create new service revenue models, while co-existing with the IPv4 Internet.

Although the economy has delayed the widespread network deployment of 3G, application developers are already using the software tools motivated initially by 3G to develop novel capabilities, not only in wireless networks, but also in billing applications, network management software, and unified communications services.

Peer-to-Peer Networking

The original concept and implementation of the Internet was a network of 'always-on, easily-reachable' peers forming collective information and processing resources. That is, the Internet was peer-to-peer (P2P) and the hosts *were* the Internet. Things have changed drastically since those early days. Now, the Internet is perceived as a "services in the middle" model, in which centralized, closely controlled servers provide services to mostly passive hosts connected around the edge.

Yet, within the past few years, evolved versions of P2P systems have made a dramatic comeback (i.e., Napster). In its short life, Napster became enormously popular. The popularity had nothing to do with P2P technology itself, but with the service Napster offered: a distributed, easily accessible database of MP3 music files. Although legal challenges stemming from concern over copyright violations eventually resulted in Napster's demise, its huge participant base drew widespread attention to the potential of P2P systems and resulted in a number of distributed file systems such as Freenet, Gnutella, Morpheus, Kazaa, and others. With the global music industry reeling from the impact of such systems, the economic and social implications of P2P technologies are just now beginning to be understood.

At the same time that Napster was demonstrating the power of P2P for file sharing, systems like SETI@home, Popular Power, and Folding@home were demonstrating the power of distributed computing. Embodying Sun Microsystems' well-known slogan, "The Network is the Computer," these systems divide demanding data processing challenges such as large-scale signal analysis and protein-folding simulation into pieces, distributing the task among hundreds or thousands of individual PCs. Otherwise unused processing time on each PC is utilized to perform the required calculations, with the results returned to a central server.

Interestingly, few of the modern P2P systems are purely peer-to-peer in the traditional sense. Many, such as Napster, have client/server elements and some, like SETI@home, are entirely server-based. What, then, is meant by P2P? It is a system in which users are active contributors—both consumers and producers, both clients and servers.

In the next few years, online gaming will move strongly in the direction of P2P. As an industry, its potential is already widely recognized. Microsoft, for example, recently announced that it is investing $2 billion in its new XBox Live online system. South Korean gaming developer NCSoft predicts that online gaming revenue in the United

States will grow from the present $210 million to $1.8 billion by 2005,[4] an increase of more than 100% per year. In Japan, the industry accounted for ¥35 billion in 2001 and is expected to grow to ¥271 billion ($2.2 billion) by 2006.[5] The entertainment market research firm DFC Intelligence[6] predicts 114 million online gamers worldwide by 2006.

Presently, most online games are server based. If the predictions regarding the increase in online gamers are accurate, servers will become an increasingly bottlenecked, both in performance and in bandwidth. For games in which quick reactions mean the difference between winning and losing, real-time performance must be kept to <100ms. Server delays quickly translate into customer frustration and abandonment. P2P gaming eliminates the server bottleneck, thus improving response times.

Existing P2P systems must possess an added layer of complexity to circumvent the problems presented by the ubiquity of NAT and dynamic IP address assignment. As the proliferation of P2P systems increases, it becomes increasingly important for hosts to have consistent, global IP addresses. Rather than continue with a diverse array of application-specific host identification systems, the adoption of IPv6 does away with the need for NAT and greatly simplifies the development, operation, and economic return of P2P systems. *Thus, it can be reasoned that IPv6 will be a significant factor in future online gaming scenarios.*

Business Drivers for IPv6 Adoption

Global Initiatives and Advocacy

Asia

Japan took political leadership in the design of a roadmap for IPv6 in the fall of 2000 in a policy speech by Prime Minister Yoshiro Mori to the 150th Session of the Diet. The Japanese government mandated the incorporation of IPv6 and set a deadline of 2005 to upgrade existing systems in every business and public sector. Japan sees IPv6 as one of the ways of helping them leverage the Internet to rejuvenate the Japanese economy. The IPv6 Promotion Council (`www.v6pc.jp`), led by Prof. Jun Murai, was created to address, in a comprehensive way, all issues related to the deployment and rollout of IPv6.

The Japanese initiative was crucial to the Asian regions with Korea following suit on February 22, 2001, by announcing plans to adopt IPv6. China and Japan have declared jointly in the 7th Japan-China regular bilateral consultation toward further promotion of Japan-China cooperation that IPv6 is an important matter in the area of info-communications fields. The Taiwanese government launched an aggressive promotion and research plan for IPv6 in April 2002 (http://www.ipv6.org.tw/English/index.html). Similar government initiatives promoting IPv6 are under discussion, mainly in China and Malaysia.

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[4] Source: NCSoft press release, 29 June 2002, www.ncsoft.co.kr
[5] Source: Nomura Research Institute, www.nri.co.jp
[6] www.dfcint.com

While not every government in Asia is mandating IPv6, many countries have widespread commercial and public support. India, well known for its legions of programmers, has seen a tremendous amount of popular support, culminating in the creation of an IPv6 Forum, India. The Indian IPv6 Forum has followed with numerous actions, primarily targeted toward the software industry, which in turn has catalyzed many neighboring Asian countries.

Europe

The European Commission initiated an IPv6 Task Force in April 2001 to design an "IPv6 Roadmap 2005" and delivered its recommendations in January 2002, which were endorsed by the EC[7] (see www.ipv6tf.org). A phase II IPv6 Deployment Task Force was enacted Sep 12, 2002 with a dual mandate of initiating country/regional IPv6 Task Forces across the European states and seeking global cooperation around the world. The EC IPv6 Task Force and the Japanese IPv6 Promotion council (www.v6pc.jp), led by Prof Jun Murai, forged a strategic alliance to foster IPv6 deployment worldwide.

North America

A North American IPv6 Task Force (www.nav6tf.org) was initiated in 2001. The mission of the NAv6TF is to engage the North American markets to adopt IPv6. The first significant government interest in this effort comes from the U.S. government defense community, where trial IPv6 Networks have begun and IPv6 is part of emerging production programs. This program is currently working with government agencies, ISPs, and applications vendors to develop an aggressive campaign to deploy IPv6 in North America.

Richard Clarke, Special Advisor to the President for Cyberspace Security, Critical Infrastructure Assurance Office (CIAO), in a keynote address at the Next Generation Networks conference in Boston, shared nine specific security goals that he requested network equipment vendors and service providers to resolve. Included in that address was a request to quickly adopt protocols that enhance security, particularly IPv6. Additionally, Clarke indicated that the adoption process should occur rapidly because there may be more security threats in a dual-stacked environment. For more information, see: (http://www.convergedigest.com).

Models for ROI on IPv6 Adoption

Although there have been many compelling reasons for adoption of IPv6 from a technical perspective, the fundamental business drivers have been missing…until now. While the primary reason for the next generation protocol was increased address space, it alone is insufficient to drive an economically sound transition strategy. With the addition of concepts like inherent security, autoconfiguration, improved multicasting, and a more efficient packet structure, the opportunities to create products and services that will generate new revenue streams are greatly enhanced.

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[7] http://www.europa-web.de/europa/03euinf/39INFTEC/ecresult.htm

Return on Investment, or ROI, is a fairly straightforward concept. Any product or service should generate more income than it consumes to develop, manufacture, and support. While the specific ROI for any given product or service will vary based upon number of factors, including duration to develop, market share and the cost of money (the cost to borrow or opportunity cost to skip an alternative investment), certain generalities can be made regarding the ROI for IPv6.

Technology ROI can be assessed across six phases: research and innovation; engineering; migration and replacement (when two generations of technology coexist); incremental development (with the exploitation of capabilities of the new version over a predecessor technology); competitive deployment (when a competing technology emerges); and phase-down. Investment and revenue can be achieved in all phases, although to varying degrees. IPv6 ROI is rather unique in several aspects when measured against these six phases.[8]

Fundamentally, IPv6 is an upgrade of an existing Internet protocol. Much like the next version of an operating system, IPv6 is very similar to its predecessor. And, as with an operating system upgrade, users must only learn the new features, relying upon the fact that many of the reasons they chose the operating system in the first place are still present. IPv6 offers users a host of new, or restored, features that will enhance the Internet for decades to come. This fact will make the migration and replacement phase much less painful, and costly, than if IPv6 were an entirely new and dissimilar protocol.

This same principle is applicable to the engineering phase as well. In many cases the porting of existing applications to recognize and support IPv6 will be relatively simple. Because the base application is present, only small modifications need to be made to extend the applications life. This also has the added benefit of extending the product lifecycle of many existing applications.

Other than the new revenue stream opportunities, IPv6 should also bring cost reduction to larger networks. With the improvement in routing, inherent security, and the autoconfiguration capability, tomorrow's next generation networks will cost less to deploy, maintain and operate. Add services that will either reduce expense elsewhere, i.e. communications (VoIP, IP videoconferencing, etc) or improve productivity (true mobile access to files, information, inventory, etc), and the cumulative ROI effect is positive for both adopters and developers.

Finally, it is important to note that, assuming an adoption rate of Internet usage similar to the last ten years, the cost of maintaining and adding to the existing Internet infrastructure (IPv4 based) will continue to rise. Many opponents of IPv6 adoption claim that most everything the market desires (from a technical perspective) can be accomplished using today's technology. However, the incremental benefits provided to the end user are far outweighed by the exponential costs of supplying those benefits. Superimposing the

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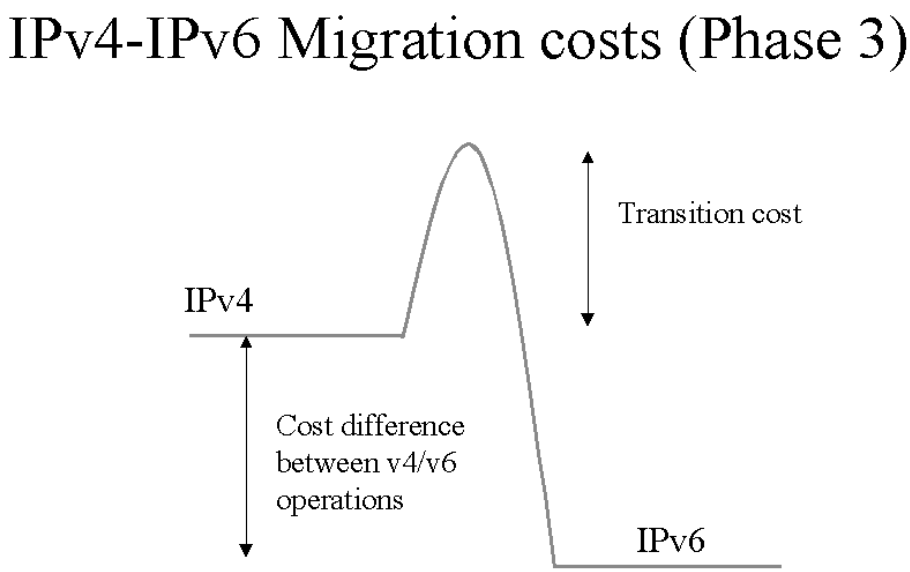
[8] L.F.Pau et al, IPv6 Return on investment (R.O.I) analysis framework at a generic level, and first conclusions, IPv6 Forum report, August 2002

continued support of an IPv4 based Internet against the widespread adoption of IPv6, demonstrates the following:



Even though there is a substantial increase in the theoretical spending for IT (with the adoption of IPv6) which can be directly attributed to the transition costs (new equipment, application upgrades, training), the longer term support costs are significantly lower than before. Basic financial accounting tells us that if the time-adjusted value of the difference between the top line (IPv4 costs) and the bottom line (IPv6 costs) is greater than the transition cost, migration should occur. Marry this information with the tremendous number of new revenue stream potentials, and a very compelling ROI case is made for the adoption of IPv6.

For a more technical approach to understanding the ROI for IPv6 adoption, please see the paper “IPv6 Return on Iinvestment (R.O.I.) Analysis Framework at a Generic Level and First Conclusions” by L.F. Pau on the IPv6 Forum website.

The Early Bird Special

In evaluating the IPv6 marketplace, terms like “early adopter” are often found in magazine articles and analyst reports. For the purpose of this paper, it is important to distinguish between early adopters and First-to-Market or First Mover advantage. In technology, early adopters can often be distinguished by the fact they receive funding to develop or research a particular technology. The aim is not necessarily to develop product, but rather to assess the impact or viability of a technology to improve the overall functionality or efficiency of its own systems, a client's systems, or the systems of its financiers.

By contrast, First-to-Market Advantage (or First Movers Advantage, aka FMA) is characterized by companies researching and developing products based upon a technology, which will create a market position superior to its competition. The key difference between the two is that one favors a broader scope with more altruistic intent while the other is strictly about increasing shareholder wealth.

For the past five or more years, IPv6 has had its share of early adopters. Organizations like WIDE in Japan, SPAWAR in the US, and IPv6 Cluster in Europe have all done valuable research and development that has positively impacted the development of IPv6. Because of the efforts of these early adopters, in conjunction with the various working groups from the IETF, IPv6 has become a mature and viable network protocol ready for deployment. As a result, there is a tremendous global FMA environment. So what are the First Mover advantages in the IPv6 arena? Segmenting the market into broad, functional areas, opportunities can be found in the hardware, software, and service solutions fields.

Hardware is one of the first areas to experience a high degree of IPv6 enablement. Bordering on being early adopters (using the definition provided here), networking hardware manufactures around the globe such as Cisco, Ericsson, Hitachi, Juniper, NEC, and Nokia have integrated IPv6 capabilities into existing platforms. However, due to a globally stagnant economy and an excess capacity of bandwidth and networking equipment, no clear FMA has yet been established. Hardware manufacturers continue to develop IPv6-enabled equipment platforms and the first mover advantage will come from which feature sets of the IPv6 protocol are best leveraged. Additionally, very little hardware has been released commercially outside of simple routing platforms. There is still a need for switches, load balancers, cache boxes, and other hardware, which present additional FMA prospects.

From a software perspective, the prospects for application developers are staggering. With the restoration of the peer-to-peer model, the ability to address and identify each device individually, along with the autoconfiguration and mobility features, offer astounding FMA opportunities in the gaming, location-based services, telematics, and e-commerce fields. Of course, development of applications like these, coupled with support from the hardware vendors and operating system providers, enable service solution exploitations to materialize in other markets.

For the ISP, particularly in North America, adoption of IPv6 has generally not been a hot topic. The potentially high cost of transition for the ISP, accompanied by a serious lack of business drivers, has not precipitated a great deal of interest for the telecoms. Nonetheless, companies like Sony, Nintendo, and Microsoft are now developing, or have developed, devices to utilize game platforms online and are looking to create exclusive gaming networks. Sony announced almost 18 months ago its intention to put IP addresses on every device, which means IPv6.[9] Certainly this represents a chance for an aggressive and forward thinking ISP to develop the IPv6 network to carry all that gaming (and eventually other types of digital content such as movies, television programming, and music).

In the world of Internet technology, it can be challenging to have a distinct technological advantage over the competition because the underlying protocols are developed in open communities such as the IETF and 3GPP. Regardless, many corporations are proving that good engineering, coupled with well thought out marketing strategies create excellent first-to-market scenarios. IPv6, although continuously maturing, is now at a stage where smart companies can capture the FMA. As already discussed, functions of the IPv6 protocol such as mobility, autoconfiguration, and multicasting present enormous product market opportunities waiting to be exploited by those companies with sufficient vision to take the lead.

IPv6 Mythology

For many years IPv6 adoption has suffered from a number of inimical myths. Like most myths, they start from some truth, but are then misconstrued by those who share an "ideology." In this case, the ideology is that IPv6 is somehow causing more problems than it fixes. This section works to dispel many of the myths surrounding IPv6.

We'll Never Put a Man on the Moon

The reason we successfully put a man on the moon was that we accepted the challenge. We put our best people on the job and we had a deadline. Clearly the current Internet has good people on the job and there is a deadline (if something is not done, the cost of IP addresses will rise drastically as they become more and more scarce). Many have accepted the challenge. However, there are factions that continue to criticize IPv6 as an unnecessary or too difficult transition. What is needed is leadership, not dissection, rhetoric, and myths.

There have been spates of recent articles that promoted a set of myths that are similar to "we can't ever send a man to the moon." These generally take the following form of "IPv6 can't succeed because:"

- All devices need to be upgraded to IPv6
- The core of the network is too difficult and expensive to upgrade to IPv6
- It would be too hard to change all applications to IPv6

First, let us look at "all devices need to be upgraded to IPv6." There are many applications on the Internet today that run over IP that are not IP. For example, Generic Routing Encapsulation (GRE) tunnels non-IP traffic such as SNA, IPX, and AppleTalk through IP networks. Using GRE and other existing, proven tunneling protocols, IPv6 applications can run over the IPv4 core. Tunneling may not be as efficient as natively

[9] http://bizns.nikkeibp.co.jp/cgi-bin/asia/frame-asia.pl?NSH_KIJIID=129248&NSH_CHTML=asiabiztech.html

supporting IPv6, but NAT creates its own set of inefficiencies. A great deal of effort has been expended to address this very issue, which is why there are a number of circumspect transition mechanisms.

How about the myth, "the core of the network is too difficult and expensive to upgrade to IPv6?" A case can be made that it is on the access points of the network that IPv6 makes the most sense. The core of the network is not the problem. The problem is that the access points of the network need more IP addresses than are available with IPv4 addressing. Tunneling allows IPv6 to be added at the edges of networks in the first phase of the transition, without converting the IPv4 core.

Another set of recent web articles deals with the difficulty in transitioning all IPv4 applications to IPv6. However, there is no compelling reason to do this today. Clients that need IPv6 should support and communicate with IPv6 applications. Clients that need to support both IPv4 and IPv6 applications will use a dual-stack approach or translation. It is doubtful that one technology will replace all others and over time, the market will decide which technology wins. It is not unreasonable that eventually all applications will leverage IPv6 only. But, it is a myth to assume that all IPv4 applications and infrastructure need to be converted to IPv6 at one time.

We Just Don't Have the Energy

For those who live in California, the blackouts and energy crises of 2001 was a memorable experience. This is what happens when an entire state, its government, and industry ignore a problem. Regardless of the root cause of the crisis, it was a real crisis that caused a range of serious problems. Because this predicament needed to be fixed in near real-time, the cost to fix it was massive. Californians are still paying this cost and will be for years to come.

What is the lesson for the Internet? Let us face it, we need energy more than we do the Internet. When the Internet has its crisis, there is not going to be a mad rush with massive dollars to fix the problem. The fact is that growth will be stunted and work-around technologies will continue to obstruct true innovation. The reason why Internet leaders like Vint Cerf have said this transition is important is they know that without it, the growth of the Internet will be limited. On the positive side, with an IPv6-enabled Internet, a myriad of potentially revolutionary new applications and innovations will be possible.

Conclusions

IPv6 is no longer years away from deployment. With ten years of solid development, support from almost every major Internet technology vendor on the globe, and cooperation from both governments and Internet governing bodies, IPv6 is no longer an adolescent technology wading through pubescent angst. It has become a robust and mature protocol that will bring revitalization and innovation back to a stagnant and tired Internet.

It is clear that today's protocol can no longer support the world's continued voracity for Internet-enabled applications and services. As the world seeks improved communications, enhanced data security, and superior entertainment experiences, the current Internet protocol begins to show its age and inability to adapt. IPv6 offers end-users and enterprises a chance to evolve beyond their current relationship, and enhance cash flow as well.

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