

# IPV6 AND NATIONAL STRATEGIES ON INFORMATION AND COMMUNICATION TECHNOLOGIES

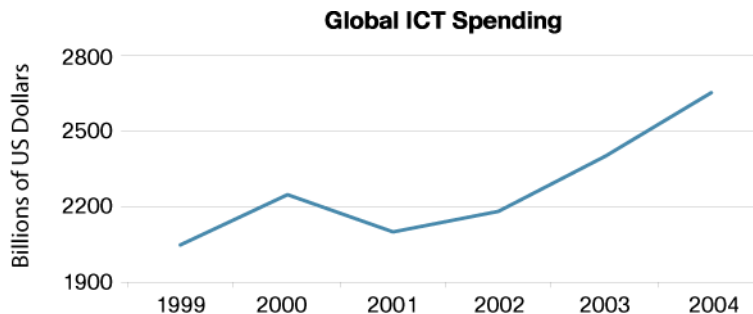
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This paper examines the necessity and economic importance of upgrading the Internet Protocol. IP version 4 imposes significant constraints on the adoption and growth of the Internet. IP version 6 represents an upgrade, an evolution that offers the resources necessary for deeper and wider market penetration of the IP technologies, to support the needs of a global economy, to build new products and new services. These benefits have the potential to stimulate economic revolutions. An Internet upgrade is an opportunity to gain technological edge and develop IT expertise. Countries that trailed US into the information revolution recognize this opportunity to take a leading role in its next expansion phase and have developed national strategies to help better position their respective economies. Despite understanding the constraints imposed by the current version of IP, the private sector is currently inclined to largely ignore IPv6 because of its initial deployment costs and perceived long term returns. The paper analyses the value of a National Strategy in driving IPv6 adoption and in reducing digital divides. It also points out concrete actions that governments can take in order to enable their economies to have a head start in the new Internet.

The past decade established the Information Revolution as something significantly more than just a catch phrase capturing engineering achievements. Information Technologies penetrate every aspect of life from work to education and entertainment due to their ever increasing capabilities and their constantly decreasing prices. Technological advances make IT more accessible, the computational power grew by more than two orders of magnitude in the last three decades of the millennium while the equipment price decreased at an average rate of 8 percent per year. New technologies provide opportunities and minimize entrance barriers by reducing infrastructure costs.

The importance of IT is widely acknowledged at both private business and government levels as reflected in the ICT spending history (Figure 1).

Figure 1. ICT Spending History<sup>[1]</sup>



Early doubts on the return of such investments, the Productivity Paradox of Information Technology<sup>[2]</sup>, did not temper down the ICT spending. The end of the 1990s proved the value of these investments through ICT's impact on the G8 economies<sup>[3]</sup>. In the last decade ICT became responsible for 9 percent of United States' gross national product.

ICT is a multifaceted concept involving things such as: telephony, office equipment, manufacturing equipment control, PCs and networking equipment. All of these elements have their own characteristics, provide their own contribution and have their own impact on economic growth. This

paper is focusing on IP communications, a technology that is poised to become the underlying transport mechanism for all digital communications and services. In particular it discusses the implications of upgrading the IP communications to its next version: IP version 6.

IP and the Internet were born out of the need to share computing resources and evolved to demonstrate the fact that networked devices bring substantially more value than the stand alone ones. Their creation and development is the result of well guided and well managed government<sup>[4]</sup> support of research. Society, economy and research have all benefited from IP communications, the Internet and the World Wide Web yet we are far from taking advantage of their full potential. Further investments are necessary to increase the coverage and the adoption depth of these technologies within individual countries and worldwide. This would increase the return on ICT investments through economies of scale and it would stimulate further innovation through demand for services and through collaborations while providing markets for the products of this innovation.

At a global level, IP technologies and the Internet represent a significant catalyst to the economic globalization process. Advanced data communications infrastructures are enticing to foreign investments as they facilitate growth. They also enable the national workforce to have access to foreign services markets and not just manufacturing markets. In these contexts, IP infrastructures have become strategic resources for businesses and countries alike.

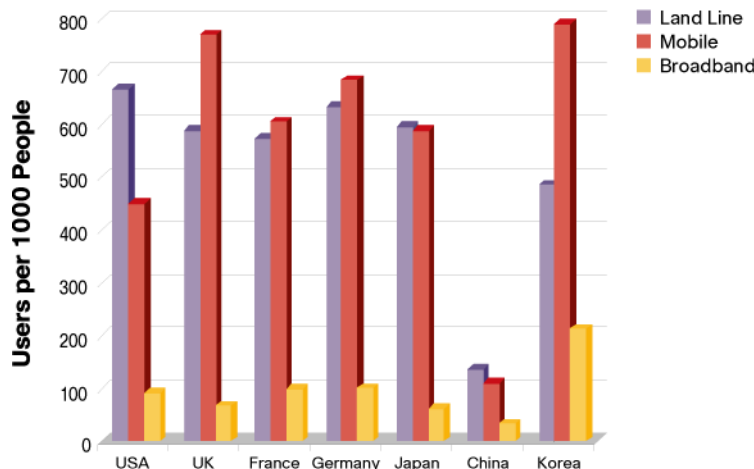
## CONSTRAINTS ON THE GROWTH OF THE INTERNET

There are two major elements that influence the growth of the Internet. One relates to the physical infrastructure and the other to the virtual one, the addresses identifying devices in IP communications.

### Infrastructure

The first challenge in the mass adoption of the Internet is to provide physical access to the network resources. Countries with extensive land-line-telephone service already had an advantage in the information age, an advantage that soon translated into economic benefit. The same infrastructure was leveraged to provide data connectivity and make the Internet easily available to businesses and the larger public. This allowed them to further distance themselves from the digitally poor countries.

**Figure 2.** Number of Land-Line<sup>[5]</sup>, Mobile<sup>[5]</sup> and Broadband<sup>[6]</sup> Users in Select Countries



Access technologies however evolved rapidly to offer faster and better alternatives over different media types (DSL, Cable, Fiber and Wireless). In the same way mobile telephony is eliminating (at a lower cost) the advantage provided by the wide availability of land-line based services, the new access technologies can level the Internet playing field from an infrastructure perspective. Less expensive access options stimulate the build-out of new and more advanced networks that are better positioned to adopt newer services. In fact, the adoption level of these access technologies is changing the landscape of most connected nations worldwide. As early as 2001 the number of Mobile subscribers surpassed or was close to surpassing the number of land-line ones in most countries that have advanced ICT infrastructures with the US a notable exception as shown in Figure 2.

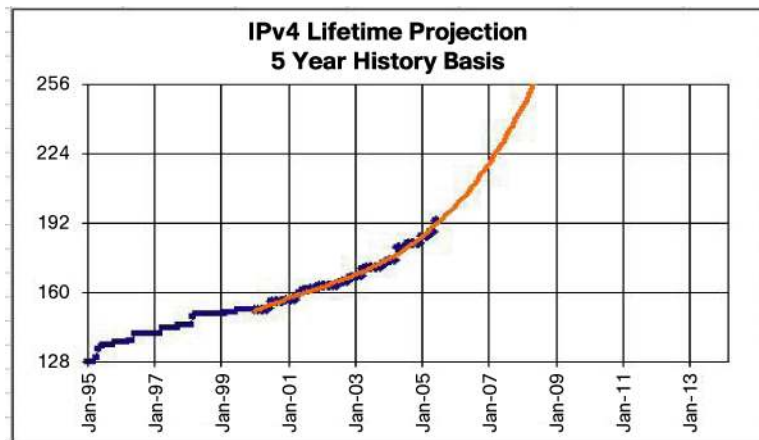
Broadband access availability represents a significant metric for the mass adoption of IP communications and services. Alongside the typical Internet Access service, broadband can deliver multimedia content such as Audio-Video as well as cheaper telephony service based on VoIP. The latest statistics on this metric strengthens Korea's leadership role already apparent in the 2001 data (Figure 2). Today, 78 percent of the Korean households have broadband access.

### IPv4 Addresses

While the infrastructure costs and capabilities are improved through technological advances, addressing is a conceptual constraint built into the IP protocol itself. The IP address to identify hosts on the network is limited to 32 bits in size.

The fast adoption of IP and the advent of Internet accelerated the address consumption. Increased demand of "always on" connectivity through broadband access reduces the ability to reuse IP addresses. Models predict that at the current rate this resource could be exhausted from a practical perspective within a decade. Recent events such as large cable operators running out of private addresses (RFC1918) could lead to even more aggressive predictions than the ones shown in Figure 3.

**Figure 3.** IPv4 Address Space Exhaustion Predictions Based on the Assignment History of the Past Five Years<sup>[7]</sup>.

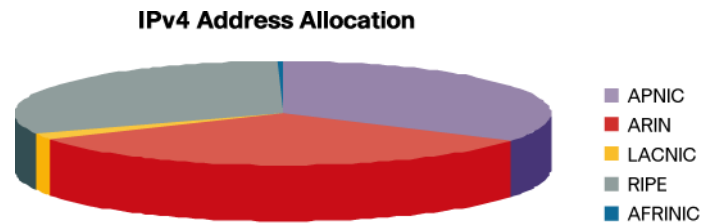


The IP address however is not a commodity so its depletion does not exert overt economic pressures. As a matter of fact, the nominal and maintenance fees for IPv4 addresses continue to decrease as organizations that manage this resource streamline their operations. This makes it difficult to justify investments in an IP upgrade. On the other hand the effects of this shortage are reflected in hidden costs built into the development and support of technical solutions meant to preserve the address space such as Network Address Translation.

In reality, IP addresses are a limiting resource even in absolute terms. In itself the IP address space is not large enough to support the mass adoption of the Internet at a global scale<sup>[8]</sup>, a status reached when at least 20 percent of the population is using it.

This is particularly concerning considering the significant role played by the Internet in the global economy. Through its historical evolution and aggressive investments of early adopters, IP did reach mass adoption in 17.3 percent of the countries (representing 15 percent of the global population) leading to an inequitable distribution of the addressing resources (Figure 4).

**Figure 4.** IPv4 Address Allocation Distribution per region<sup>[9]</sup> (APNIC for Asia Pacific, RIPE for Europe, ARIN for North America, LACNIC for South and Central America, AFRINIC for Africa).



The address space exhaustion was driven mainly by the need for access to the Internet. This process is now accelerated by the increased interest in new applications such as Voice over IP. The continued adoption of IP and the multitude of existent services it supports will be significantly impacted by the address shortages. At the same time, technical workarounds such as NAT, widely used to provide temporary relief, artificially increase the costs and stifle the development and deployment of new types of services and applications.

The appropriate answer to this address demand is an increase in the offer of IP addressing space. IP version 6 (IPv6) is the next generation of IP and it uses a 128 bits address. This new version of the protocol incorporates improvements based on the lessons learned from operating IPv4. After twelve years of development and experimentation, IPv6 and its features are supported in most networking equipment, making it ready for production deployment. Upgrading an infrastructure to IPv6 does involve costs related to equipment upgrades, staff training and new network designs and provisioning. These investments however promise<sup>[10]</sup> significant ROI compared to the alternative of staying with IPv4.

## IP UPGRADE PERCEPTIONS

IP infrastructures are well recognized as strategic business resources. Alongside a significant need for reliability, it is critical to be able to scale them in order to meet expanding business needs and new business models. The growth of the Internet itself opens new markets and new business opportunities. IPv4's limited address space threatens to be an obstacle in the continued growth of the Internet Economies and the benefits such growth provides:

- Leverage the economies of scale. Further expansion of IT infrastructures and networks would amplify the already proven economic benefits of IP communications.
- Increased technology adoption at national level. It creates a large internal market that can support and stimulate national IT innovation.
- Increased global coverage. It provides a worldwide environment for commercializing IT products and services, with easy access to other national markets.

Early investments in Information Technologies and IP communications were rewarded with significant increases in productivity at all levels of national economies. These connected economies became consumers of IP products and services produced primarily by the United States who has been leading innovation in communication technologies. The next generation of IP offers the resources necessary to increase further the adoption of IT technologies as well as the opportunity to develop competitive national IT industries. Recognizing this unique opportunity, several countries established National Strategies for stimulating the adoption of IT technologies and industries.

## Japan

Japan's edge in digital technologies is well recognized with innovation driven by a strong internal consumer market. IP communications can enhance the service capabilities of the various devices produced by the Japanese industry. For these reasons for example, SONY corporation decided to have all its products IP enabled by 2005<sup>[11]</sup>. A scalable IP infrastructure is mandatory to support these devices and whole new services. Their successful deployment in Japan would help improve them and demonstrate externally their competitive edge and value. IPv6 is capable of supporting such an infrastructure. The process of building or upgrading this IPv6 enabled infrastructure represents also an opportunity to develop and strengthen a national network equipment manufacturing industry. Local vendors can find it easier to penetrate this market space currently dominated by US companies.

In September of 2000 Japan was the first country that put forth a National Strategy for the adoption of IPv6 called u-Japan<sup>[12]</sup>. It consisted of support for academic research through the WIDE project, development of new applications and tax incentives for organizations that deploy IPv6. Japan's investment in IPv6 is \$10 to \$13 million a year. To date, Japan is the leading country in knowledge, it holds the most important conferences in the field, and it has the largest commercial deployments<sup>[13]</sup> of IPv6.

## European Union

Member countries of the European Union had significant contributions to the development of the Internet yet EU still lags behind US in terms of IT innovation. At the same time EU countries naturally show significant technology adoption as well as demand for it. For these reasons it was publicly acknowledged that IPv4 is stifling EU's economic growth and a joint strategy to promote IPv6 adoption called e-Europe<sup>[14]</sup> was announced in February 2001. IPv6 is seen as a catalyst for innovation particularly in areas such as 3G mobile services and connectivity to means of transportation such as trains, cars and airplanes.

\$216 million dollars in funds were made available to several research projects (6NET, GEANT, Euro6IX, 6INIT) dedicated to developing deployment experience, protocol knowledge and new applications. They also brought together Universities and industry partners from around the World into various collaborative efforts.

## China

The Chinese economy recently posted 9.5 percent annual growth<sup>[15]</sup>, part of a trend established over several years as the country becomes a worldwide manufacturing center. ICT played a significant role in leveraging the nation's low labor costs more competitively than other developing countries<sup>[16]</sup>. ICT will continue to be strategically important to China's bid to expand its manufacturing role but most importantly to move to the role of innovator<sup>[17]</sup>. The later goal is critical if China is to maintain high economic growth rates. IPv6 offers the resources to pursue the first goal and the innovation opportunities of a new environment. Moreover, the number of Internet users was 52 million in 2002 and showing a fast growth rate providing a significant internal market for IP communications.

In November of 2004 China announced its National Strategy for the promotion and adoption of IPv6. It invested \$170 million that encourage the participation of various organizations (with matching investment) into the national research project called China Next Generation Internet (CNGI). National communications equipment vendors received at a minimum 50 percent of the CNGI orders with the clear intent to stimulate the internal development of IPv6 enabled products and applications.

## Korea

Large ICT investments transformed Korea into one of the most connected economies and societies. In 2003, 71 percent of the population had Mobile Telephone service, 66 percent of the population had Internet Access and 73 percent of the households had Broadband Access<sup>[18]</sup>. This significant level of technology penetration led to productivity increase across the entire economy. The Korean government recognized the benefits of an IP upgrade and in February 2001, the Ministry of Information and Communications established "Next Internet Infrastructure Constructing Plan by Diffusing IPv6".

\$81 million dollars were invested to support several national research projects: KOREN, KREONET2, 6NGIX and TEIN (Trans Eurasia Information Network). In 2004 Korea launched a nationwide trial service called KOREAv6 Project.

## USA

As the developer of IP and the Internet, the United States have naturally acquired significant amounts of addresses. The initial address assignment policies did not take into consideration the incredible interest IP communications will generate so the early adopters received plenty addresses to sustain their growth. This reality is reflected in the lack of interest shown by US businesses towards IPv6. Its importance is recognized, its potential is acknowledged yet adoption steps are tepid. Mainly companies with global coverage, exposed to demands for IPv6 in foreign markets are actively pursuing it. As an example, Microsoft's long term strategy relies on peer-to-peer applications that could be implemented only in an IPv6 Internet with plenty of addresses. The latest release of the Windows operation system code named "Vista" supports both IPv4 and IPv6 while favoring the later. IBM supports IPv6 in its products while networking equipment manufacturers such as Cisco Systems readied their products for operational, large scale IPv6 deployments.

Most US companies however, from software developers, to Service Providers to integrators gave little to no consideration to IPv6 until 2003 when Department of Defense publicly stated its intent to migrate completely to the new version of IP<sup>[19]</sup> by 2011. Its plans to develop a netcentric battle field strategy where IP enabled devices and sensors are widely deployed to acquire, transport and provide information requires far more addressing resources than the ones offered by IPv4. IPv6 with its larger address space and some protocol improvements represents the solution to DoD's needs. DoD now requires IPv6 support in all its IT purchases, a rather vague condition but nevertheless carrying a lot of significance.

This announcement generated a spike in IPv6 interest leading to some planning for IPv6 service offering by and for some providers and manufacturers. This interest however started to wane as DoD is trying to secure the necessary funding for its aggressive and ambitious plans. This trend can be seen in Figure 4 where 2003 led to an increase in ARIN (North America) requests for IPv6 prefixes followed by a decline in 2004. DoD did not seek to solve a problem and to create expertise as ARPA did at the inception of the Internet, it simply presented itself as a potential customer and that did not lead to sustained industry support for a migration.

In March 8, 2004 the Department of Commerce in collaboration with NIST and NTIA completed the review of responses to its "Request for Comment on Deployment of Internet Protocol, Version 6"<sup>[20]</sup>. It was concluded that no government involvement is necessary to support the adoption and the deployment of IPv6. Unlike many of its competitors in the global market, the US chose not to develop a National Strategy on this subject. Nevertheless, DoC made public its plans to migrate to IPv6<sup>[21]</sup>.

Despite having proven recipes for government support of research in communications, US decided not to apply them yet to IPv6. The most significant ongoing IPv6 research projects are Moonv6<sup>[22]</sup> and Internet2<sup>[23]</sup>. Internet2 is still in its infancy in terms of leveraging IPv6 to support the development or evaluation of new applications such as GRID<sup>[24]</sup>. Moonv6 is focusing exclusively on evaluating vendor equipment support of IPv6 features and interoperability. While this work is an important activity in measuring readiness for deployment, it does not address the more important needs for the technology adoption:

- Develop Technical Expertise
- Develop Applications
- Contribute to the further development of the protocol
- Develop Management Processes

These were some of the most important contributions of the ARPA managed project that led to the creation of the Internet. These are the focus areas of the IPv6 research projects led by Japan (WIDE) and EU (6NET). These projects created very useful documents regarding the deployment and management of IPv6 networks and services. They originated many new IPv6 applications and have numerous innovative contributions to the IETF.

The debate on the need of a National Strategy on IPv6 is ongoing in US with inquiries and congressional hearings on the matter. In the context of a rapidly changing world from a technology perspective and a global market environment where governments are actively supporting technologies that can provide innovation edge to their economies, these issues become a matter of national interest.

### IPV6 IN THE WORLD

Recognizing the growth and opportunistic importance of an IP upgrade, many governments defined National Strategies to address and support it politically and financially.

**Figure 5.** Government Investments in IPv6.

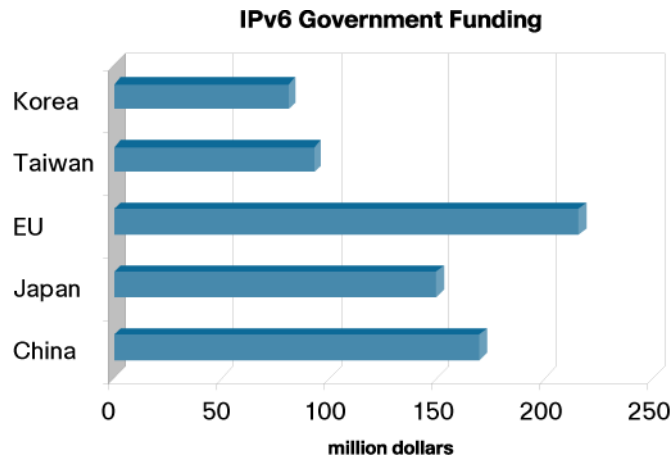
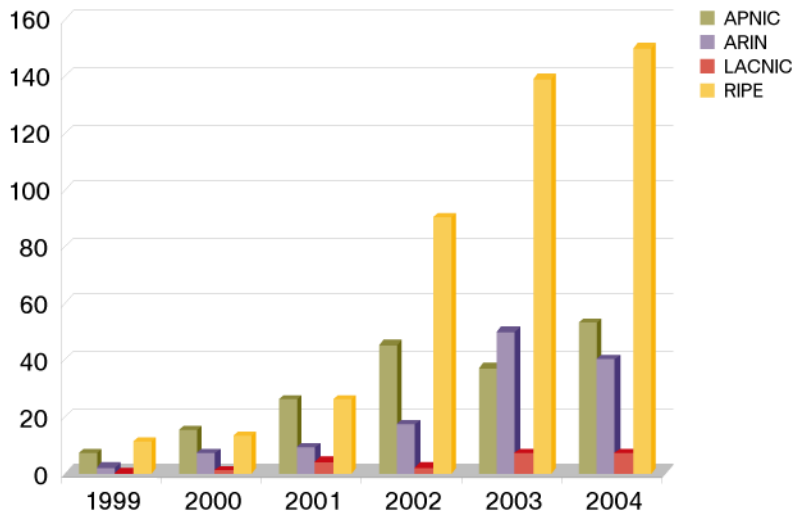


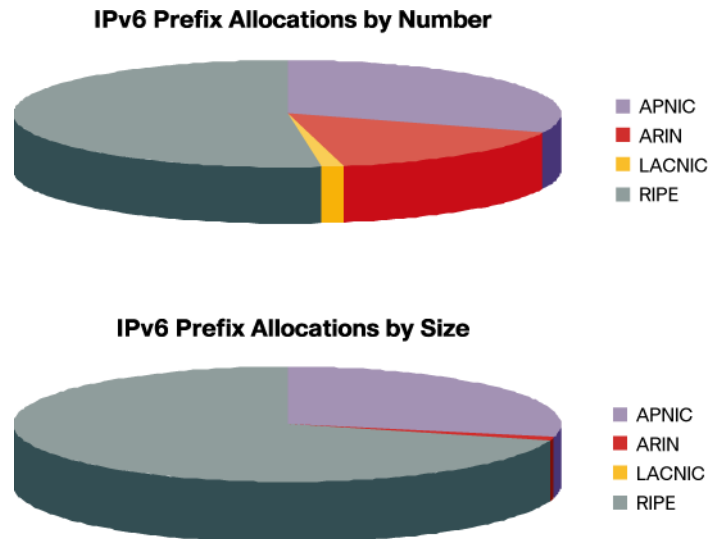
Figure 5 shows some of the investments made by several nations into IPv6 research over the last five years. These investments represent a small percentage of the ICT spending yet they proved very valuable particularly in Asia and Europe where they are already showing returns in terms of expertise and new products. These investments stimulated the interest of the industry in deploying IPv6. A measure of this interest is reflected in the number of allocated IPv6 prefixes (addresses) by the various regional registries (APNIC for Asia Pacific, RIPE for Europe, ARIN for North America, LACNIC for South and Central America) as shown in Figure 4.

**Figure 6.** IPv6 Prefix Allocation History by Registry<sup>[25]</sup>.



While the number of allocated prefixes can reveal the number of organizations interested in evaluating the new protocol, the size of the allocations could indicate an interest in deploying IPv6 into production. Under this assumption, Figure 7 that presents the two statistics would indicate that the European and Asian markets started or are close to starting large scale deployments of IPv6. In fact, Japan already has several major, revenue generating IPv6 networks.

**Figure 7.** IPv6 Prefix Allocation Distribution<sup>[25]</sup>.



Data in Figure 7 could be the result of a “gold rush” to secure addressing space early on but it also underlines without a doubt a clear trend of planned migration to IPv6 by many governments worldwide. Several of the e-projects identify target years, anywhere between 2008 and 2011 for a complete migration of entire countries or at least government infrastructures. The comparison between Figure 4 and Figure 7 reveals a clear redistribution of IP resources across the world.

Today, Japan and EU are probably one to two years ahead of the US in terms of IPv6 knowledge and IPv6 deployment. In the fast paced Internet Economy this gap can prove to be a significant advantage in building new markets and developing new products. From a product and service perspective, IPv6 is not just an upgrade, it offers completely new ways to approach and solve problems. For these reasons their leadership should be followed in order to capitalize early on the upcoming Internet upgrade.

## CONCLUSION

The need and the reasons to pursue an upgrade of the IP protocol and the Internet are as much technical as they are economical. Its importance is recognized by multiple governments that are trying to accelerate the adoption of technology, to increase productivity or to pursue a leading role in IT innovation. National Strategies for IPv6 adoption guide their research and industry communities. The outcome of these projects and investments is already providing them an edge as far as protocol, deployment and operational expertise is concerned.

The inclusion of IPv6 as a significant element of a larger National Strategy on IT is of critical importance. The subject should be aggressively addressed in its own right and alongside infrastructure issues such as adoption of broadband. Governments should not lead through mandates but rather through example and enabling policies. Several types of government support should be considered:

1. Sponsor research in creating and disseminating expertise, producing new applications and contributing to the further enhancement of the protocol.
2. Deployment of IPv6 by government agencies. Such deployments are leading examples as well as customers for businesses such as Internet Service Providers or Integrators.
3. Encourage and support the deployment of IPv6 in schools. They represent an excellent environment for large scale deployments that can trial new applications such as content (audio/video) distribution and interactive classrooms<sup>[26]</sup>.
4. Stimulate and support education and training on the protocol and its benefits. Recent polls suggest that lack of understanding and familiarity with IPv6 is a major obstacle in its adoption.
5. Take an active role in the process of deciding the future governing mechanisms for the IPv6 Internet. With the larger address space available, centralized administration would be less justified. The current distributed administration can support faster Internet growth.
6. Support the deployment of Broadband Access and the adoption of 3/4G IP mobility that would open the door for a whole new set of applications and services in the consumer markets.

IPv6 is an evolutionary step for IP Communications. Despite valuable new features, its main benefit is the significantly larger address space that enables the continued Internet growth and frees service and business models from the addressing constraints. In this sense, this technology upgrade has the potential of revolutionizing the world of IP based services. Most importantly, it offers a second chance to gain technological edge in Information Technologies.

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