# The role of National Strategies in maintaining Competitive Edge in Information and Communication Technologies

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## ABSTRACT

This paper examines the economical impact of IPv6, Internet Protocol's next generation. Technically, IPv6 represents an upgrade, an evolution that offers the resources necessary for deeper and wider market penetration of the IP technology, to support the needs of a global economy, to build new products and new services. Politically and economically it has the potential of being a quiet revolution. 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 long term returns. Forced by high investor expectations to focus exclusively on the immediate bottom line it trades long term growth opportunities for short term benefits revolving around productivity increases. The paper analyses the importance of a National Strategy in driving IPv6 adoption and in closing a widening knowledge and deployment gap between US and countries such as China, Japan, Korea and the EU.

**Keywords**: Internet Protocol version 6 (IPv6), ICT, Broadband, Department of Defense (DoD), Department of Commerce (DoC) and National Strategy.

## 1. INTRODUCTION

The Information Revolution provided the tools and the environment needed to accelerate the practical implementation of tremendous knowledge accumulated through fundamental research in the 20th century. Information Technologies penetrated every aspect of life from work to education and entertainment due to its ever increasing capabilities and its constantly decreasing prices. The computational power grew (Moore's Law) 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.

*This work reflects the opinions of the authors and not an official position of Cisco Systems.

Recognizing the economical potential of IT, many countries invested heavily in communications infrastructures and information processing equipment. The trend is evident in the recent history of ICT spending (Figure1).

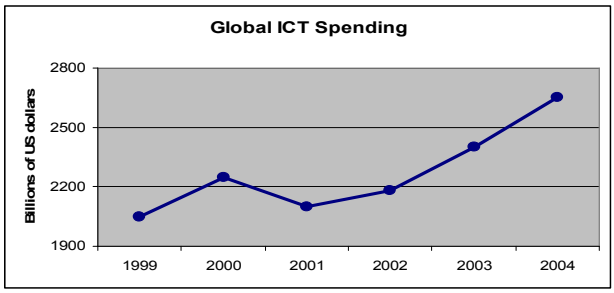


Figure 1. ICT spending history[1].

At first, despite the clear benefits offered by ICT, it was difficult to identify the return generated by this investment in the macroeconomic output statistics. This phenomenon called the Productivity Paradox of Information Technology[2] did not temper down the ICT spending which continued to grow unabated. By the end of the 1990s the massive ICT investments started to show their positive impact on the G7 economies[3] with IT being responsible for 9 percent of United States' gross national product in the last decade.

There are of course multiple aspects to the overall concept of ICT (telephony, office equipment, manufacturing equipment control, PCs and networking equipment), each with its own contribution to and impact on economic growth. This paper is focusing on IP communications, a technology so successful that is poised to become the underlying transport mechanism for all digital communications and services from data to telephony. IP based communications are instrumental in the process of technology adoption and diffusion. IP networks create the environment necessary to provide consumer services, to stimulate the creation of new services and products and to easily tap into the expanding global market.

IP and the Internet were born out of the need to share computing resources and evolved to demonstrate the fact that networked devices bring substantial more value then the stand alone ones. Their creation and development is an example of well guided and well managed government[4] 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. More investments are necessary to increase the coverage and the adoption depth of these technologies within individual countries and worldwide. This would stimulate further innovation through demand for services and through collaborations while providing a market for the products of innovation.

## 2. THE MULTIFACETED CONSTRAINTS OF IPv4 AND THE IPv6 SOLUTION

At first, the mass adoption of the Internet faced the challenge of providing 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. Using this infrastructure to provide data connectivity allowed them to further distance themselves from the digitally poor countries.

The 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. While physical access became a more manageable infrastructure funding problem, IP, Internet's transport protocol faces another challenge: it relies on a limited resource, the 32 bits IP address used to identify hosts on the network.

The fast adoption of IP and the advent of Internet accelerated the address consumption while increased demand of broadband access and "always on" connectivity reduces the ability to reuse addresses. Models predict that at the current rate this resource could be exhausted from a practical perspective within a decade[5]. 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. On the other hand the effects of this shortage are reflected in covert costs built into the development and support of technical solutions meant to preserve the address space such as Network Address Translation.

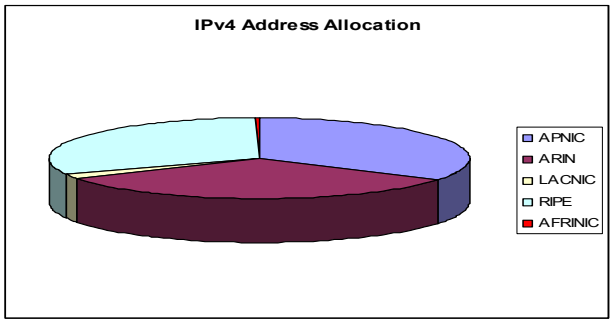


Figure 2. IPv4 Address Allocation Distribution per region[7] (APNIC for Asia Pacific, RIPE for Europe, ARIN for North America, LACNIC for South and Central America, AFRINIC for Africa).

In itself the IP address space is not large enough to support the mass adoption of the Internet at a global scale[6], a status reached when at least 20 percent of the population is using it.

This constraint is particularly concerning considering the significant role played by the Internet in the global economy. The technology did however reach mass adoption in 17.3 percent of the countries (representing 15 percent of the global population) and this emphasizes an inequitable distribution of the resource (Figure 2).

Another reason of concern is the convergence of communication services on the infrastructure offered by IP. Voice over IP is seeing tremendous growth and the mobile service providers are planning to extend the IP transport used in the core of their networks all the way to the mobile subscribers. The new services generated in these environments provide great economic growth potential but they cannot be supported by the current IP address space.

The negative effects of the IPv4 address shortage go beyond limiting adoption and reducing IT's ability to further leverage the economy of scales. 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.

The appropriate answer to this address demand is an increase in the offer of IP addressing space. IPv6 is the next generation of IP and it provides a significantly larger address space than its predecessor. Through this upgrade the IP protocol saw a few other small improvements however, the most relevant aspect is the longer, 128 bits address. After twelve years of development and experimentation, IPv6 and its features are supported in most networking equipment, making it ready for production deployment. Such deployments however imply additional costs involving: migration, upgrades, gaining protocol knowledge and operational experience. The initial investment promises[8] however significant ROI compared to the alternative of staying with IPv4.

## 3. THE ECONOMIC IMPORTANCE OF THE IP UPGRADE

IP communications infrastructures, equipment and applications are a significant part of the ICT investments in all major national economies. Starting with the late 1990s the return on these investments in IPv4 began to show and they proved to be significant. Its limited address space however threatens to be an obstacle in the continued growth of the Internet Economies and the benefits such growth provides:

Further leveraging the economies of scale. One of the possible explanations for the Information Technology Productivity Paradox was the fact that ICT capital stock was a small portion of the national capital stock leading to small relative returns despite the investment[9]. 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 IT innovation.

Increased global coverage. It provides a worldwide environment for commercializing IT products and services, with easy access to other national markets.

Governments who invested heavily in Information Technologies and IP communications saw rewarding increases in productivity throughout their economies. At the same time they saw their economies become consumers of IP products and services produced primarily by the United States who has been leading innovation in communication technologies. IPv6 offers the resources necessary to increase further the adoption of IT technologies and the opportunity to develop a competitive national IT industry. Of the many countries that developed a National Strategy for IPv6, four are particularly important to mention:

**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[10]. 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[11]. 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[12] 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[13] 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 the industry partners from around the World into various collaborative efforts.

**China**
The Chinese economy recently posted 9.5 percent annual growth[14], 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[15]. 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[16]. 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[17]. 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.

## 4. THE STATUS-QUO CAN ENDANGER US INNOVATION LEADERSHIP IN ICT

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

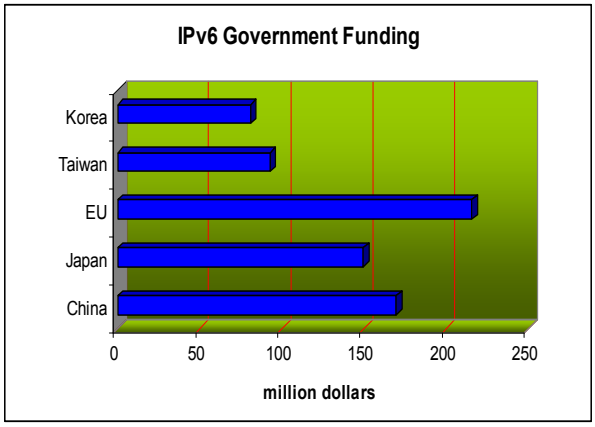


Figure 3. Government Investments in IPv6.

Figure 3 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 ones but they proved very valuable particularly in Asia and Europe where they are already showing returns in terms of expertise

and new products. They have also 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.

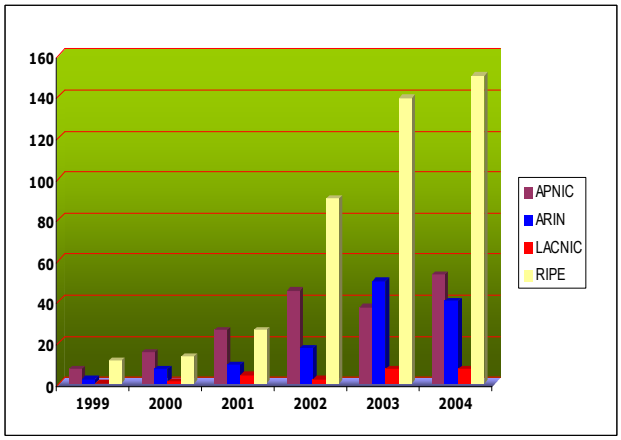


Figure 4. IPv6 Prefix Allocation History by Registry[7].

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 5 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.

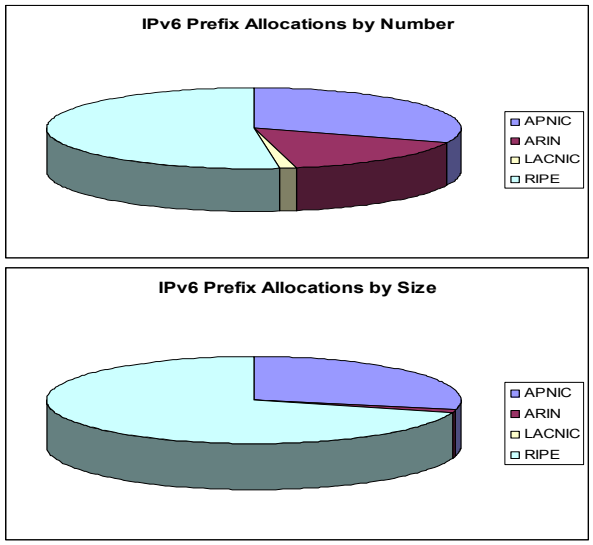


Figure 5. IPv6 Prefix Allocation Distribution[18].

Data in Figure 5 could be the result of a "gold rush" to secure addressing space early on but it 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 2 and Figure 5 reveals a clear shift in the IP prefix distribution across the world.

This shift can become even more significant if entire new infrastructures such as Mobile Access Networks and Broadband Access Networks (Broadband is the access technology targeted to deliver Voice, Data and Video services) leverage the new protocol. Such an event would magnify the negative effects of a slow migration to IPv6 in US due to its slower adoption of new access technologies such as Mobile Telephony and Broadband Access. 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 exception of US as shown in Figure 6.

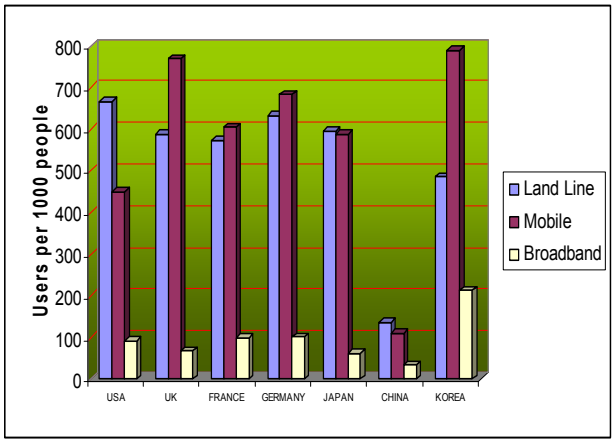


Figure 6. Number of Land-Line[19], Mobile[19] and Broadband[20] users in select countries.

At the accelerated rates of adoption seen by these technologies, this trend is even more accentuated today. This new infrastructure has tremendous market potential that can be enhanced by IPv6 to deliver new, customized applications and services to a very large customer base.

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. US government's stance on topics such as Broadband Access or IPv6 adoption becomes very important.

## 5. IPv6 IN US

ICT has multiple facets and it involves various types of products and services thus IPv6 has a non-uniform impact across the industry:

- **Networking Equipment**. The United States still are the leader through companies such as Cisco Systems and Juniper but new manufacturers in the emerging IPv6 market from Japan and China will create competitive pressure.
- **Mobile Telephony**. As shown earlier, US are lagging in technology dispersion and the adoption of 3/4G IP mobility standards. Asia-Pacific and the EU regions are better positioned to leverage IPv6 for new services.

- **PC Software Applications**. The United States are maintaining leadership through companies such as Microsoft which particularly sees the strategic importance of IPv6 and the value of peer-to-peer applications that it supports. The new release of Windows (Longhorn) will have all applications IPv6 enabled.
- **Linux/BSD Software Applications**. Japan and Europe took the lead through applications developed in the research environments they sponsor.
- **Gaming**. Considering Microsoft's and Sony's commitment to IPv6 this is a market space where a leader has yet to be decided.
- **Digital Devices and Appliances**. Asia is leading in this market space today. The advent of IPv6 has the potential to significantly extend this leadership.

Companies with global coverage took note of the IPv6 requirements in the Asia-Pacific and European markets so they developed IPv6 ready products. Unfortunately most US companies, 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[21] 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 then the ones offered by IPv4. IPv6 with its larger address space and some protocol improvements represents the solution to DoS'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"[22]. 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.

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[23] and Internet2[24]. Internet2 is still in its infancy in terms of leveraging IPv6 to support the development or evaluation of new applications such as GRID[25]. 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.

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, US can be in danger of loosing its competitive edge in IT innovation.

## 6. 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 and political. 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.

Despite the singular event of DoD's declaration of intent to migrate to IPv6, the US Government shows no concerted support for its adoption and development. With the fast paced changes in technology and virtually no private sector support for fundamental IT research, US could be in danger of loosing its leadership position in communications innovation. The economic impact of moving from an exporter to an importer of IT technology could be significant. Despite being just an upgrade, IPv6 has much deeper and overreaching significations.

Pressure has also been mounting to move the Internet under the governance of an organization similar to ITU with United Nations' oversight[17]. IP addressing in particular would be managed by such a body. The arguments used to justify such a move revolve around an equitable distribution of resources. The IPv4 Internet resisted the adoption of such a model to date while the IPv6 Internet, now in its infancy is more susceptible to a change in the governance model. The change could have a significant impact on the evolution of the technology itself under the weight of a more bureaucratic overseeing organization. US Government's lack of involvement in the development and adoption of IPv6 can facilitate dramatic changes in the way Internet, a strategic resource is being managed.

A US National Strategy on IPv6 is of critical importance and it should include the following types of government support:

a. Sponsorship of research with the goals of creating and disseminating expertise, producing new

applications and contributing to the further enhancement of the protocol.

b. Finance the DoD and DoC[26] current plans to migrate to IPv6. Support all the other government agencies migration plans per GAO[27] recommendations. Lead by successful examples.
c. Encourage all branches of the government to adopt applications that are IP version independent. The government represents the single largest IT customer in the US economy.
d. Take an active role in the process of deciding the future governing mechanisms for the IPv6 Internet.
e. 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.
f. Take a lead in securing the next generation of the Internet.

Far from being an exciting new technology, IPv6 can have significant impact on the national and global economies. This infrastructure upgrade will leverage further the economies of scale and will offer new opportunities to lead the IT revolution.

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