October 2007

Impact of IPv6 on Vertical Markets

Study commissioned by the EUROPEAN COMMISSION

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Produced by inno group and Zaltana

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Content

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Executive summary

inno group - Zaltana

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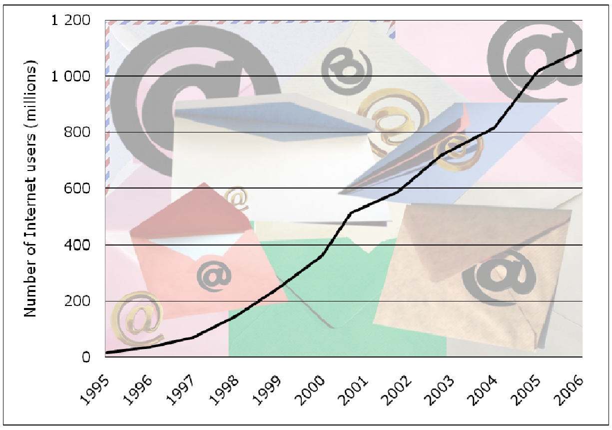
[English]

Problem definition

The Internet is using a dedicated protocol, known as Internet Protocol (IP), to enable devices (computers, mobile phones, PDA…) to exchange data. Being worldwide used, the Internet Protocol can only provide 4.3 billion public addresses. Since January 2007, 2.4 billion addresses have already been allocated, leaving only 1.3 billion available with an accelerating consumption rate. Current expert estimations forecast an exhaustion of the unallocated pool of IPv4 addresses to happen by 2010-2011.

Until now, a technical workaround named NAT (Network Address Translation) has been used to delay the exhaustion. This solution demonstrated its capabilities at the cost of an increased complexity and reduced performance in some cases. The well-known solution to avoid the address shortage problem is to integrate into the existing infrastructure the next version of the Internet Protocol, called IPv6. One of the main advantages of this technology is its wide address space: 3.4×10^{38} available addresses. Nevertheless, despite its proven capability, this protocol has been little used up to now.



EVOLUTION OF INTERNET USERS.

Drivers of this IP addresses shortage are straightforward. First, the Internet usage has not stopped growing since its creation. The number of Internet users worldwide reached the 1.2 billion in 2007. At the same time new services (such as triple-play boxes providing Internet access, telephony and television) and usages have been deployed. Secondly, IPv6, for which deployment might be inducted by the need of increased address space, is not yet adopted.

Multiple factors are delaying the integration of IPv6. NAT is one of them. As many companies and countries are already running out of IP public addresses, NAT allows them to use only one IP address for all their corporate computers and devices. NAT is a viable solution in the short term but from a network operator point of view, costs are externalised and incurred finally by the end user. Also, a study points out a lack of understanding on multiple topics such as address allocation: as an example, it is largely thought that Europe, as compared to some Asian countries for instance, holds enough IPv4 addresses for the near future. This is not true as an address pool is managed on a global scale within a close relationship between IANA and the RIRs. In the same topic, education on IP addresses shortage and IPv6 is very poor.

SWOT Analysis

An analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) to integrate IPv6 has been performed on 15 sectors. For each sector, specificities as well as adoption scenarios have been evaluated. A macroscopic view of the SWOT analysis shows that the large address space provided by

IPv6 coupled with the “all over IP” world are the main motivators, cross-sectors, for the integration of IPv6. On the other hand, a strong counter argument is the fact that IPv4 works well in all situations and has been used in production systems for years.

Interviews done during the study demonstrate that first IPv6 deployment should come during 2010-2012 and should probably be led by the media industry (e.g. phone, media, IP television), providing services requiring a huge number of IP addresses. It was also shown that sectors developed their own protocols they may use in case a sufficient IPv6 connectivity would not be available at the time they will deploy their applications.

Evolution of the problem

Multiples scenarios can be envisaged before and after the IPv4 public addresses exhaustion point.

Considering IPv4 public addresses as a “Resource”, some organisations may go into a state of panic in order to secure as many IPv4 addresses as possible, creating a demand surge. Others, due to increasing difficulties to obtain IPv4 addresses may opt for alternative solutions (increased use of NAT, alternative protocols…). To further extend the lifetime of the IPv4 Internet several options have been envisioned such as trading of the address space, adapting the addresses allocation rules or maintaining the IPv4 Internet by further optimising the use of NAT.

But the only viable solution to ensure business continuity is based on the integration of IPv6. It has been tested for more than ten years: the first IPv6 RFC has been submitted in 1995, a huge amount of research, development and standardization have been done so far and no competitive alternative exists in the short-term.

Today there is a very low take up in IPv6 deployment despite the increasing number of network operators preparing for it as more and more equipment are integrating both IPv4 and IPv6 functionalities. Actually no full deployment of IPv6 is foreseen before 2020 and some analysts are encouraging large businesses not to take IPv6, while recommending these businesses to ensure that new investments are being made with IPv6 compatible equipments and softwares.

IPv6 itself does not bring a high degree of innovativeness but rather enlarges the potential capabilities of existing IP networks. Applications that may derive from a mass IPv6 adoption could lead to some radical innovations in a number of sectors. Once again IPv6 is not the only solution for this and IPv4 could handle much of it but the address space limitation would push the vertical sectors into using IP alternative technologies. This would slow down the networks interoperability and the media convergence, identified as a key factor for growth and employment.

Potential spill-over benefits or coordination failures related to IPv6 integration that would encourage action of Public Bodies have been identified:

Technology spill-over: Innovation in ICT has been identified as crucial for Europe’s competitiveness as well as its and social and economic growth. Such effectiveness in innovation strongly relies on the trans-sectors, systems interoperability that the networks will allow. IPv6 has been identified as a key technology for such a convergence within many sectors willing to move to IP.

Market spill-over: Europe today represents approximately 20% of the world's ICT supply. Falling behind other countries regarding IT infrastructures would reduce the European ICT industry technological knowledge therefore decreasing their competitiveness in the worldwide competition. Alternatively, having the European industry well prepared to face IPv6 related product requests and possibly technical difficulties thanks to an adapted infrastructure would give Europe a clear advantage in the worldwide market.

Coordination failures: IPv6 is today facing a kind of chicken and egg situation, where network operators face a lack of demand and unclear business models, while application sectors complain about missing supporting infrastructure. Another cooperation failure that may have an effect on the development policy of Europe is the ability for a European organisation to cooperate with its international counterparts which may have moved to IPv6.

Objectives of an EC action

A rapid analysis of the current EU and national government policy context regarding ICT shows that ICTs are expected to play a major part in driving forward the growth of the EU economy, especially in terms of GDP and employment. The new Lisbon Governance cycle has highlighted ICT to be one of the drivers for growth and jobs creation. A quarter of the European Union's GDP growth is a direct result of ICT. It is therefore essential to secure state of the art European IT infrastructures supporting the EC development priorities.

The above mentioned policies imply that all efforts should be deployed to ensure that growth of the European industry will not be hindered by diminished access to IT infrastructures, compared to the rest of the world. This is likely to happen if Europe remains focused on the IPv4 protocol, as IPv4 resources become scarcer. Three specific objectives are identified:

Ensure business continuity of European organisations. If badly prepared, the integration of IPv6 together with the foreseen exhaustion of IPv4 addresses will present a risk, hinder European growth and therefore reduce the competitiveness of its industry.

Exploit European expertise allowing European industry to benefit from the new business opportunities created by the IPv6 integration.

Ensure European citizens and organisations will benefit from state of the art innovations in a fair and competitive environment, IPv6 being a path to a stabilised and secured Internet while opening the door to a range of new applications.

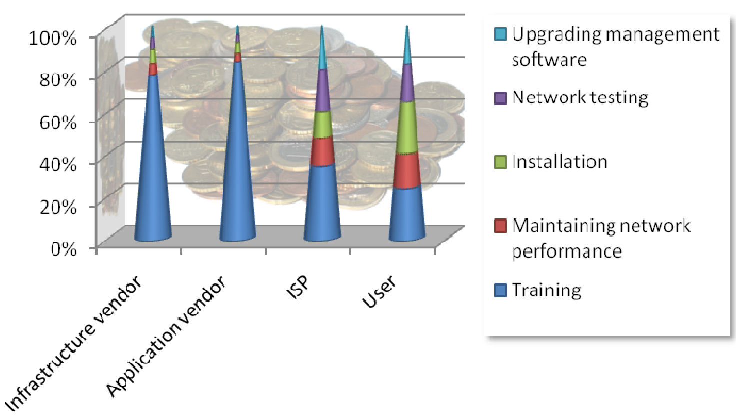
IPv6 is a protocol invisible (as is IPv4) to the large majority of users, whether they are individuals or organisations, they only tend to look at applications. These users are not aware and do not have to be aware of the underlying technology and the specific IPv6 situation but they have to ensure the continuity of their operations. For many organisations, they will go on using their internal IPv4 network. As they renew their IT infrastructure they will become more and more IPv6 compliant and the day they do need IPv6, they will have to be able to switch to IPv6 for a limited cost. Other organisations may choose to switch rapidly to IPv6 and this has already been observed for some large multi-national industries wanting to benefit from IPv6 advantages, even if initially pushed by governmental requests. From this statement, the previous above-mentioned specific objectives have been turned into operational ones:

- **Ensure common availability of IPv6 connectivity in Europe**
- **Ensure all European IT managers are made aware of the IPv6 situation**
- **Ensure that IPv6 integration remains safe**
- **Ensure existence of a sufficient pool of trained people**

Policy options and main impacts

To achieve the operational objectives detailed above, three main options may be envisioned from a European Union point of view, ranging from a 'do nothing more than today', to a regulatory initiative with an intermediate solution aimed at coordinating IPv6 integration.

First option is let the things on their own way. In this option, the market would be left alone and the issues related to IPv4 address pool exhaustion may not be widely known. Furthermore the lack of mobilisation of European Public Bodies would send a signal of 'non-urgency' regarding the IPv6 integration, which could delay the mass adoption of IPv6 in Europe. A more pro-active solution (option two) is the launch of targeted actions aimed at supporting and encouraging the integration of IPv6 in Europe. A Communication from the Commission to the Council and the European Parliament would be a useful instrument to sustain these actions. Such an option, while not being associated with any obligation, would allow a broader range of actions to be encouraged at various levels. The last and stronger option (third) is the definition of a date for when Europe should have to "switch" to IPv6. The regulation should ensure that at a given date, a competitive and standard offer of IPv6 connectivity should be made available in all EU countries.



EXPECTED COST BREAKDOWN OVER TYPE OF BUSINESS

Direct costs of the IPv6 integration will firstly concern backbone operators and ISP, as the infrastructure has to be compliant in order to handle IPv6. Moreover, one can note that core networks are already mostly compatible thanks to the depreciation renewal cycle. Staff training as well as software upgrades will also imply direct costs. The maintenance of networks supporting both IPv4 and IPv6 will impose extra costs and the longer the transition lasts, the greater the associated cumulated costs will be. These costs cannot be avoided but can be diminished by shortening the transition period as much as possible.

There is no solution for IPv6 integration that will be a no-cost operation. Nevertheless, for most of the European users (industry, research, industrial…) there is not an urgent need to move their whole infrastructure to IPv6, while a IPv4/IPv6 gateway would allow connection of an IPv4 "island" to an IPv6 Internet.

The i2010 Communication underlines that over the second half of the 1990s, ICT investments and technical progresses in the production of ICT goods and services, accounted for about 40% of EU labour productivity growth. Breaking the ICT business continuity by insufficient pooling of the IP address elementary resource would lead to a global slow down of the European labour productivity. Such a situation would be avoided in case of integration of IPv6 in due time.

Moreover, the first moving region will gain a capacity to build a worldwide leadership in the ineluctable move to IPv6, thus reinforcing its international competitiveness. This consideration mostly applies to IT companies but due to the pervasive aspect of the Internet, may impact the whole European economy.

Apart from economical impacts, social impacts might be brought about by the adoption of IPv6 since addresses, becoming a non-restricted resource, are required to support the further deployment of the Internet and to reduce the digital divide. IPv4 address exhaustion can restrict equal access to the Internet and hence to goods and services. European citizens might benefit from IPv6 at large (even while being unaware of the technology they use), since new e-government applications and entertainment services could be deployed. One could also mention disaster prevention and management solutions, based on IPv6, and the educational system which could benefit from new functionalities of IPv6.

Comparing the options

Options for an IPv6 adoption have been analysed in detail in terms of economical, social and environmental impacts. This analysis shows that the “Do nothing option” is the only one that gives negative results. Going into more detail on the comparison of option 2 and 3 shows that accelerating the adoption within option 3 would lead to a cost increase due to infrastructure updates out of the normal depreciation/renewal circle. Moreover, due to its larger scope, option 2 is expected to bring out more impacts than option 3.

The option of supporting the transition through the deployment of soft measures will push for integration by leveraging on the existing R&D and the competitiveness of European firms. This option will bring marginal additional costs for businesses while opening new windows of opportunities. On a global scale, being proactive, Europe will stay among IT leaders and this option is the one to be recommended.

Conclusion

The shortage of available public addresses is an ineluctable issue of the 4th version of the Internet Protocol. While for years, expert views on the date at which shortage will occur have shown large discrepancies, there is now a consensus to predict an exhaustion to happen by 2011-2012.

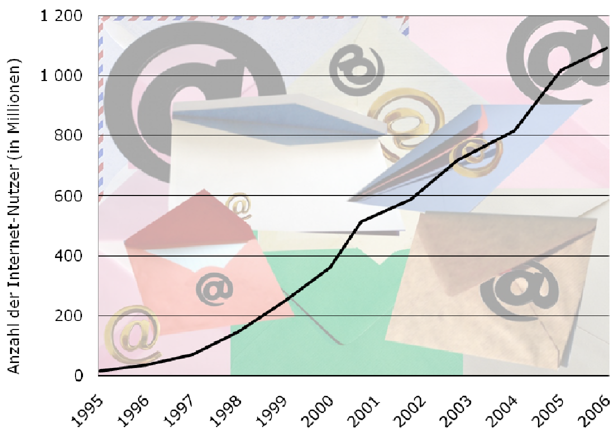
Among the options analysed, the one aimed at supporting the IPv6 adoption in Europe through a set of “soft” measures is the one which is likely to bring the greater benefits for Europe at economic, social and environmental levels. These actions should address: common IPv6 connectivity availability, awareness of IT managers, network security during the integration, availability of a sufficient pool of trained people and proper exploitation of European expertise.

Immediate consideration of IPv6 integration has to be undertaken as this is the only way to minimize the costs associated with this activity and to facilitate the smooth transition of this integration tackling the issue of the address shortfall.

[Deutsch]

Problemstellung

Der Austausch von Daten über verschiedene Geräte, wie z.B. Computer, Handys oder PDAs, erfolgt im Internet mit Hilfe eines dedizierten Protokolls, dem Internet Protocol (IP). Aufgrund seiner weltweiten Nutzung stehen über das Internet Protocol nur etwa 4,3 Milliarden IP-Adressen zur Verfügung. Im Januar 2007 waren bereits 2,4 Milliarden Adressen vergeben, was einen Restbestand von 1,3 Milliarden verfügbarer Adressen bei zunehmend schnellerer Adressvergabe bedeutet. Laut Expertenaussagen wird der momentane Vorrat an nicht vergebenen IPv4-Adressen bis zum Jahre 2010-2011 ausgeschöpft sein.



ENTWICKLUNG DER ANZAHL DER INTERNET-NUTZER

Bisher konnte diese Ausschöpfung mittels eines technischen Workarounds namens NAT (Network Address Translation) verzögert werden. In einigen Fällen brachte dieser Lösungsweg neben Vorteilen jedoch auch Nachteile, wie z.B. eine erhöhte Komplexität und reduzierte Leistungsfähigkeit. Ein weit verbreiteter Lösungsansatz für das Problem der drohenden Adressenknappheit ist die Integration der nächsten Version des Internet Protocol, IPv6, in die existierende Infrastruktur. Einer der größten Vorteile dieser Technologie ist der umfangreiche Adressenbestand: 3.4×10^{38} verfügbare Adressen. Doch trotz dieses erwiesenen Leistungspotenzials wurde dieses Protokoll bisher nur sehr selten eingesetzt.

Die Gründe für die Knappheit von IP-Adressen sind recht simpel. Zum einen ist das Internet seit seiner Entstehung stetig weiter gewachsen und die Anzahl der weltweiten Internet User lag im Jahre 2007 bei 1,2 Milliarden Menschen. Gleichzeitig kamen neue Dienstleistungen (z.B. Triple-Play Boxes, die Internetzugang, Telephonie und TV bieten) und Anwendungen auf. Darüber hinaus ist eine Anpassung von IPv6, welches eine Lösung für den großen Bedarf an IP-Adressen sein könnte, noch nicht vorgenommen worden.

Die Integration von IPv6 wird derzeit von mehreren Faktoren behindert. Einer davon ist NAT. Da zahlreiche Unternehmen und Länder bereits über zu wenige IP-Adressen verfügen, greifen sie auf NAT zurück, welches die Nutzung nur einer IP-Adresse für alle Computer und Geräte des Unternehmens ermöglicht. Daher ist NAT kurzfristig gesehen eine durchaus praktikable Lösung, aus der Sicht eines Netzbetreibers werden die Kosten jedoch nur ausgelagert und fallen schließlich für den Endnutzer an. Darüber hinaus zeigt eine Studie zu diesem Thema, dass es im Bereich Vergabe von IP-Adressen eine Reihe von Missverständnissen gibt. So ist z.B. die Überzeugung verbreitet, dass in Europa z.B. im Vergleich zu einigen asiatischen Ländern für die nahe Zukunft genügend IP-Adressen zur Verfügung stehen. Dies trifft jedoch eindeutig nicht zu, da es einen Adressen-Pool gibt, der im Rahmen einer engen Verbindung zwischen IANA und RIRs weltweit verwaltet wird. Genauso gibt es Defizite in der Informationsbereitstellung zu den Themen Mangel an IP-Adressen und IPv6.

SWOT-Analyse

In 15 verschiedenen Branchen wurde eine Analyse der Strengths, Weaknesses, Opportunities und Threats (SWOT) durchgeführt, die im Zusammenhang mit der Integration von IPv6 auftreten können. Hierbei wurden für jede Branche sowohl Spezifikationen als auch Adaptionsszenarien evaluiert. Eine nähere Betrachtung dieser SWOT-Analyse zeigt, dass die große Anzahl an IP-Adressen, die über IPv6 möglich ist, verbunden mit der starken Internetorientierung über alle Branchen hinweg die Hauptgründe sind, die für die Integration von IPv6 sprechen. Ein Gegenargument hierzu wäre jedoch, dass IPv4 in jeder Situation gut funktioniert und seit Jahren in Produktionssystemen verwendet wird.

Interviews, die im Rahmen dieser Studie geführt wurden, zeigen, dass in den Jahren 2010-2012 mit der Integration von IPv6 begonnen werden sollte, und zwar unter Federführung der Medienindustrie, die Dienstleistungen mit einem hohen Bedarf an IP-Adressen anbieten (z.B. Telefone, Medien, IP-TV). Zudem wurde ersichtlich, dass die jeweiligen Branchen ihre eigenen Protokolle entwickelt haben, die sie für den Fall einer nicht ausreichend vorhandenen Verbindung zu IPv6 anwenden würden.

Problementwicklung

Es gibt zahlreiche Szenarien, die vor bzw. nach der totalen Ausschöpfung des Bestands an IPv4-Adressen denkbar sind.

Aufgrund der Einstufung von IP-Adressen als „Ressource" könnten manche Organisationen bei dem Versuch, sich so viele IPv4-Adressen wie möglich zu sichern, in Panik verfallen und so eine explosionsartige Zunahme der Nachfrage auslösen. Andere wiederum könnten sich wegen der Schwierigkeiten IPv4-Adressen zu bekommen, für Alternativen, wie z.B. eine stärkere Nutzung von NAT oder anderen Protokollen, entscheiden. Weiterhin werden für die Verlängerung der Nutzungsdauer von IPv4 Maßnahmen, wie z.B. der Handel mit Adressen, die Überarbeitung der Regeln für die Vergabe von IP-Adressen sowie die Optimierung der Nutzung von NAT, vorgeschlagen.

Die einzige praktikable Lösung zur Sicherstellung einer reibungslosen Business Continuity stellt jedoch die Integration von IPv6 dar. Diese neue Version wurde inzwischen über zehn Jahre lang getestet. Seit der Veröffentlichung des ersten IPv6 RFC im Jahre 1995 wurde in den Bereichen Forschung, Entwicklung und Standardisierung sehr viel getan, und kurzfristig gesehen keine wettbewerbsfähige Alternative zu IPv6 gefunden.

Trotz der zunehmenden Anzahl von Netzwerkbetreibern, die sich auf IPv6 vorbereiten, geht es mit der Einführung dieser neuen Protokollversion nur langsam voran, da viele Geräte eine Integration sowohl von IPv4 als auch von IPv6-Funktionalitäten ermöglichen. Mit einer vollständigen Integration von IPv6 wird daher nicht vor dem Jahre 2020 gerechnet. Einige Analysten raten großen Unternehmen von der Umstellung auf IPv6 ab, empfehlen diesen aber gleichzeitig in IPv6-kompatible Geräte und Software zu investieren.

IPv6 selbst stellt keine große Innovation dar, sondern erweitert eher die Möglichkeiten und das Leistungspotenzial existierender IP-Netzwerke. Anwendungen, die aus einer flächendeckenden Einführung von IPv6 resultieren, könnten jedoch bahnbrechende Innovationen in einer Reihe von Branchen mit sich bringen. Wie bereits erwähnt, ist IPv6 sicherlich nicht der einzige Lösungsansatz und IPv4 könnte hier auch ähnliches leisten, allerdings wären die vertikalen Branchen aufgrund der

Adressknappheit dann gezwungen, auf alternative Technologien auszuweichen. Dies würde allerdings wiederum die Kompatibilität von Netzwerken und Medien beeinträchtigen, die ja als Schlüsselfaktoren für Wachstum und Beschäftigung gelten.

Die folgenden Spill-Over-Effekte, die in Verbindung mit einer Integration von IPv6, möglich sind, könnten öffentliche Behörden zur Ergreifung entsprechender Maßnahmen bewegen:

Technologie-Spill-Over: Innovation in der Informations- und Kommunikationstechnologie (ICT) wurde als einer der wichtigsten Faktoren für die Wettbewerbsfähigkeit und das soziale und wirtschaftliche Wachstum in Europa identifiziert. Diese Effektivität ist eng mit einer branchenübergreifenden Kompatibilität von Systemen und Netzwerken verknüpft. IPv6 wurde als eine Schlüsseltechnologie für eine solche Annäherung vieler Branchen mit IP-Orientierung identifiziert.

Makt-Spill-Over: Europa stellt heute etwa 20% der weltweiten IT-Infrastruktur. In diesem Bereich hinter andere Länder zurückzufallen, würde zu einem Rückgang des technologischen Know-hows der europäischen IT-Industrie und somit zu einer Reduzierung der Wettbewerbsfähigkeit Europas im weltweiten Vergleich führen. Eine entsprechende Vorbereitung der europäischen IT-Industrie auf Produktanfragen und mögliche technische Schwierigkeiten in Zusammenhang mit IPv6 durch eine rechzeitige Anpassung der Infrastruktur würde Europa einen klaren Vorteil gegenüber dem Weltmarkt verschaffen.

Koordinationsprobleme: Hinsichtlich IPv6 besteht heutzutage ein grundlegendes Koordinationsproblem, da Netzwerkbetreiber einerseits über mangelnde Nachfrage und unklare Geschäftsmodelle klagen, während die Anwender andererseits eine fehlende Unterstützung durch eine entsprechende Infrastruktur monieren. Ein weiteres Problem könnte sich außerdem dadurch ergeben, dass europäische Organisationen nicht in der Lage sind, mit internationalen Partnern zu kooperieren, die bereits IPv6 integriert haben.

Maßnahmen und Ziele der Europäischen Kommission

Eine Kurzanalyse der derzeitigen Maßnahmenkataloge im Bereich ICT auf europäischer und nationaler Ebene zeigt, dass diesem Bereich für das europäische Wirtschaftswachstum eine große Bedeutung zugemessen wird, insbesondere hinsichtlich Bruttoinlandsprodukt und Beschäftigung. Der neue Lissabonner „Governance Cycle" hat ICT als einen Motor für Wachstum und die Schaffung von Arbeitsplätzen hervorgehoben. Da ein Viertel des Bruttoinlandsprodukts der Europäischen Union direkt aus ICT resultiert, ist es unabdingbar, eine hochmoderne europäische IT-Infrastruktur sicherzustellen, die dem Stand der Technik entspricht und die Prioritäten der Europäischen Kommission unterstützt.

Die oben genannten Maßnahmenkataloge implizieren, dass die Sicherstellung des Wachstums der europäischen Industrie höchste Priorität ist und diese nicht durch einen im weltweiten Vergleich schlechteren Zugang zu IT-Infrastruktur behindert werden soll. Dies kann jedoch durchaus passieren, sollte Europa sich weiterhin ausschließlich auf das IPv4-Protokoll fixieren. In diesem Zusammenhang wurden drei Ziele formuliert:

Sicherstellung der Business Continuity von europäischen Organisationen: Bei schlechter Vorbereitung kann die Integration von IPv6 in Kombination mit der Ausschöpfung des Bestands an IPv4-Adressen ein Risiko für das europäische Wachstum darstellen und somit die Wettbewerbsfähigkeit der europäischen Industrie beeinträchtigen.

Die Verwertung europäischen Know-hows, die es der europäischen Industrie ermöglicht von neuen Geschäftsmöglichkeiten zu profitieren, die sich durch die Integration von IPv6 ergeben.

Die Garantie, dass europäische Bürger und Organisationen von hochmodernen Innovationen in einer fairen und wettbewerbsfähigen Umgebung profitieren. IPv6 stellt einen Weg zu einem stabilen und sicheren Internet dar und ermöglicht gleichzeitig eine Reihe neuer Anwendungen.

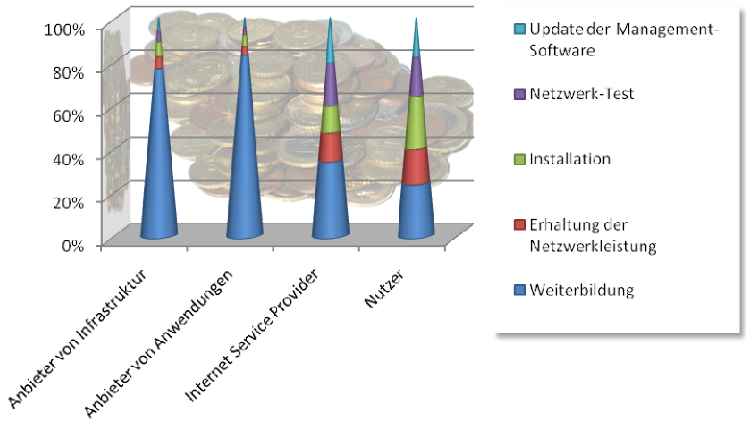
IPv6 ist ein Protokoll, das (genauso wie IPv4) für einen Großteil der Nutzer unsichtbar bleibt. Dies gilt sowohl für Einzelpersonen als auch für Organisationen, da diese sich eher auf Anwendungen konzentrieren. Diese Nutzer sind sich der zugrundeliegenden Technologie und der besonderen IPv6-Situation nicht bewusst und müssen dies auch nicht sein. Allerdings sind sie daran interessiert, die reibungslose Fortsetzung ihrer Arbeitsabläufe sicherzustellen. Viele Organisationen werden zunächst weiterhin ihr internes IPv4-Netuwerk nutzen. Im Zuge der regelmäßigen Aktualisierung ihrer IT-Infrastruktur werden sie jedoch immer kompatibler zu IPv6 werden, sodass am Tage der Umstellung auf IPv6 diese mit nur sehr geringen Kosten verbunden sein wird. Andere Einrichtungen hingegen werden sich vielleicht zu einer raschen Umstellung auf IPv6 entschließen. Dies wurde bereits in großen multinationalen Industrieunternehmen beobachtet, die von den Vorteilen, die IPv6 mit sich bringt, profitieren möchten, auch wenn die ursprüngliche Motivation durch öffentliche Anfragen begründet war. Auf Grundlage dieser Beobachtungen wurden die oben genannten sehr spezifischen Ziele in operative Handlungsempfehlungen umformuliert:

- **Sicherstellung einer allgemeinen IPv6-Verbindung in ganz Europa**
- **Schaffung eines Bewusstseins der europäischen IT-Manager für die IPv6-Situation**
- **Gewährleistung einer sicheren IPv6-Integration**
- **Sicherstellung eines Pools an entsprechend ausgebildeten Fachkräften**

Handlungsoptionen und Auswirkungen

Zur Erreichung der vorgenannten operativen Ziele bieten sich aus Sicht der Europäischen Union drei Handlungsoptionen an, die von "nicht viel mehr als momentan tun" bis hin zu einer behördlich angeordneten Initiative für eine Zwischenlösung reicht, die eine Koordinierung der IPv6-Integration zum Ziel hat.

Im Rahmen der ersten Option würde man den Dingen einfach ihren Lauf lassen, d.h. der Markt würde nicht weiter thematisiert werden und die Knappheit der IPv4-Adressen weitgehend unbekannt bleiben. Darüber hinaus würde die Nicht-Mobilisierung der europäischen Organe ein Signal „geringer Dringlichkeit" hinsichtlich der IPv6-Integration sein, was die flächendeckende Einführung von IPv6 weiter verzögern könnte. Eine pro-aktivere Lösung (Option 2) könnte mit der Durchführung gezielter Aktivitäten geschaffen werden, die auf die Unterstützung und Integration von IPv6 in Europa abzielen. Eine entsprechende offizielle Aufforderung der Europäischen Kommission an den Europäischen Rat und das Europäische Parlament wäre ein nützliches Instrument für die nachhaltige Verankerung dieser Aktivitäten. Obwohl eine solche Option nicht unbedingt mit einer Verpflichtung einhergeht, würde sie doch eine Reihe von Aktivitäten auf verschiedenen Ebenen ermöglichen. Die letzte und stärkste Option (3) beinhaltet die Festlegung eines Datums, an dem Europa auf IPv6 „umschalten" soll. Diese Regelung könnte sicherstellen, dass ab einem bestimmten Zeitpunkt in allen EU-Ländern eine wettbewerbsfähige und standardisierte IPv6-Verbindung verfügbar ist.



ERWARTETE KOSTENAUFSTELLUNG IN VERSCHIEDENEN BRANCHEN

Direkte Kosten für die IPv6-Integration werden zunächst auf die Backbone-Betreiber und Internet Service Provider zukommen, da die Infrastruktur mit IPv6 kompatibel sein muss. Zudem sind die Haupt-Netzwerke aufgrund des Erneuerungskreislaufs heutzutage schon zum größten Teil kompatibel. Die Weiterbildung von Personal und Software-Updates werden hier weitere direkte Kosten verursachen. Darüber hinaus bedeutet die Unterhaltung von Netzwerken, die sowohl IPv4 als auch IPv6 unterstützen, extra Kosten und je langwieriger sich dieser Übergang gestaltet, desto höher werden die hiermit verbundenen Gesamtkosten sein. Diese können zwar nicht komplett vermieden werden, doch durch eine entsprechende Verkürzung der Übergangszeit lässt sich eine gewisse Reduzierung der Kosten erreichen.

Eine kostenlose Lösung für die Integration von IPv6 wird es mit Sicherheit nicht geben. Die meisten europäischen Nutzer (Industrie, Forschung etc.) sehen eine Umstellung auf IPv6 jedoch nicht als besonders kritisch an, obwohl eine IPv4/IPv6-Schnittstelle eine Verbindung der IPv4-„Insel" mit dem IPv6-Internet ermöglichen würde.

Die i2010 Initiative unterstreicht, dass in der zweiten Hälfte der 90er Jahre ICT-Investionen und technischer Fortschritt etwa 40% des Wachstums im Bereich der Arbeitsproduktivität in der Produktion von ICT-Gütern und Dienstleistungen ausgemacht haben. Die Unterbrechung der Business Continuity in ICT aufgrund eines Mangels an verfügbaren IP-Adressen als elementare Ressource würde die europäische Arbeitsproduktivität im globalen Vergleich deutlich abbremsen. Dieses Szenario könnte durch eine rechtzeitige Integration von IPv6 vermieden werden.

Weiterhin haben die ersten Regionen, die diese Integration angehen, die Möglichkeit, sich als weltweite Vorreiter in der unvermeidlichen Einführung von IPv6 zu etablieren und somit ihre internationale Wettbewerbsfähigkeit zu stärken. Diese Überlegung trifft wohl am ehesten auf IT-Unternehmen zu, könnte sich jedoch aufgrund der Allgegenwärtigkeit des Internets auf die gesamte europäische Wirtschaft auswirken.

Neben wirtschaftlichen Auswirkungen könnte die Einführung von IPv6 auch soziale Auswirkungen mit sich bringen, da IP-Adressen zu einer unbegrenzten Ressource werden können, die für die weitere Ausbreitung des Internets erforderlich sein und zur Verringerung der digitalen Kluft beitragen wird. Die Ausschöpfung der IPv4-Adressen hingegen kann für manche den Zugang zum Internet und damit zu bestimmten Produkten und Dienstleistungen erschweren. Die europäischen Bürger werden wohl auf lange Sicht von IPv6 profitieren (auch wenn sie sich der Technologie, die sie verwenden, nicht bewusst sind), da neue E-Government-Anwendungen und Entertainment-Dienstleistungen entwickelt werden könnten. Ferner könnten Lösungen für Katastrophenvorhersage und –management sowie Ausbildungssysteme von den neuen Funktionalitäten von IPv6 profitieren.

Vergleich der Optionen

Die verschiedenen Optionen für eine Integration von IPv6 wurden detailliert analysiert im Hinblick auf wirtschaftliche, soziale und umweltpolitische Auswirkungen. Diese Analyse zeigt, dass die „Nichts tun"-Option als einzige negative Ergebnisse bringt. Bei einem näheren Vergleich der Optionen 2 und 3 wird ersichtlich, dass die Beschleunigung der Integration, wie in Option 3 vorgesehen, zu einem Anstieg der Kosten führen würde aufgrund von zusätzlichen Infrastruktur-Updates. Aufgrund ihrer größeren Reichweite werden von Option 2 bessere Ergebnisse erwartet als von Option 3.

Die Option der Unterstützung des Übergangs von IPv4 zu IPv6 durch die Einführung von Soft Measures wird die Integration durch die Hebelung existierender F&E und Wettbewerbsfähigkeit europäischer Unternehmen vorantreiben. Diese Option wird marginale zusätzliche Kosten für Unternehmen bedeuten, aber andererseits neue Möglichkeiten eröffnen. Weltweit gesehen wird Europa durch den pro-aktiven Ansatz dieser Option im Bereich IT an der Spitze bleiben – daher wird diese Option empfohlen.

Schlussfolgerung

Die Knappheit der verfügbaren IP-Adressen ist für die 4. Version des Internet Protocol eine unvermeidliche Entwicklung. Trotz widersprüchlicher Expertenaussagen hinsichtlich des genauen Zeitpunkts, zu dem diese Ausschöpfung der Adressen erreicht sein wird, gibt es inzwischen Übereinstimmung darüber, dass dies in den Jahren 2001-2012 der Fall sein wird.

Von den untersuchten Handlungsoptionen ist diejenige, welche die Einführung von Soft Measures vorsieht, am vielversprechendsten hinsichtlich positiver wirtschaftlicher, sozialer und umweltpolitischer Auswirkungen. Die damit verbundenen Aktivitäten sollten auf die folgenden Ziele ausgerichtet sein: allgemeine Verfügbarkeit von IPv6-Verbindung, Bewusstseinsstärkung von IT-Managern, Netzwerksicherheit durch Integration, Verfügbarkeit eines Pools entsprechend ausgebildeter Fachkräfte sowie angemessene Verwertung von europäischem Know-how.

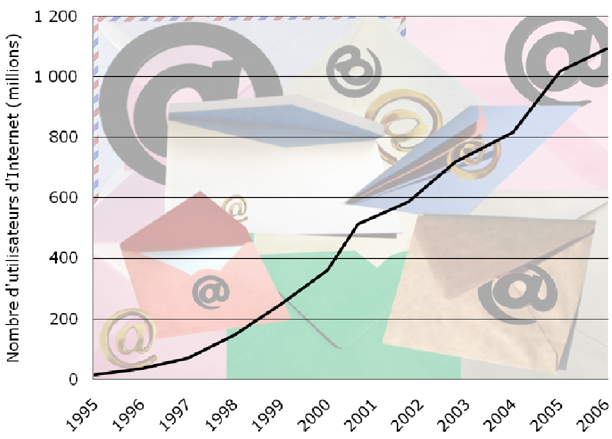
Eine Auseinandersetzung mit dem Thema der IPv6-Integration ist also dringend erforderlich, um eine Minimierung der hiermit verbundenen Kosten zu erreichen und einen reibungslosen Übergang zu IPv6 zur Lösung des Problems der Adressenknappheit zu gewährleisten.

[Français]

Définition du problème

Internet utilise un protocole de communication connu sous le nom d'IP (Internet Protocol). Ce dernier permet à tout terminal (ordinateur, téléphone mobile, capteur sans fil) connecté au réseau d'échanger des données. Utilisé mondialement, ce protocole peut seulement fournir 4,3 milliards d'adresses publiques. Depuis Janvier 2007, 2,4 milliards d'adresses ont déjà été allouées. En conséquence, il ne reste que 1,3 milliard d'adresses disponibles et la consommation de ces adresses ne fait que s'accélérer. Les estimations actuelles des experts prédisent uniformément une pénurie d'adresses IPv4 pour 2010-2011.

Jusqu'à présent, une solution technique appelée NAT[1] a été utilisée afin de repousser la date de



EVOLUTION DU NOMBRE D'UTILISATEURS D'INTERNET.

cette pénurie. Cette solution a démontré ses possibilités à un coût élevé, entraînant la complexité des réseaux, voire la réduction des performances. La solution à ce problème, connue depuis plus d'une décennie, est d'intégrer dans les infrastructures existantes la prochaine version du protocole IP : IPv6. Un de ses principaux avantages réside dans son large espace d'adressage : $3{,}4 \times 10^{38}$ adresses disponibles. Néanmoins, malgré ses avantages reconnus, ce protocole n'a été que peut utilisé jusqu'à présent.

Les causes de cette pénurie d'adresses IPv4 sont flagrants. D'abord, l'utilisation de l'Internet n'a fait que progresser depuis sa création. Le nombre de personnes connectées à Internet a atteint 1,2 milliard en 2007. En même temps, de nouveaux services (dans les services dits *triple-play*, regroupant l'accès Internet, la téléphonie et la télévision dans la même offre) ont été largement déployés. Ensuite, IPv6, dont le déploiement aurait dû être déclenché par la demande croissante d'adresses IP, n'est pas encore largement adopté.

Plusieurs facteurs retardent l'intégration d'IPv6. Le NAT est l'un deux. Alors que de nombreuses sociétés et gouvernements manquent déjà d'adresses IP publiques, le NAT leur permet d'utiliser des adresses dites privées dans leurs réseaux internes. Le NAT est une solution viable dans le court terme mais du point de vue d'un opérateur de réseaux, les coûts sont externalisés et finalement répercutés sur le client final. De plus, l'étude montre qu'il existe un manque de compréhension sur différents sujets tels que les mécanismes d'allocation d'adresses : par exemple, il est souvent acquis que l'Europe, en comparaison de certains pays, détient assez d'adresses IPv4 pour le futur proche. Cela n'est pas exact car la gestion des allocations adresses est effectuée a une échelle mondiale,

[1] Network Address Translation

impliquant une forte relation entre IANA[2] et les RIRs[3]. De même, la prise de conscience sur la pénurie d'adresse est très faible.

Analyse SWOT

Une analyse SWOT[4] (Forces, Faiblesses, Opportunités et Craintes) a été effectuée sur 14 secteurs. Pour chaque secteur, ses spécificités ainsi que des scénarii d'adoption d'IPv6 ont été évalués. Une vue macroscopique de l'analyse montre que le large espace d'adressage fourni par IPv6 couplé au « monde tout IP » sont les principaux arguments, indépendamment du secteur, pour l'intégration d'IPv6. D'un autre côté, un solide contre argument est le fait qu'IPv4 fonctionne bien dans toutes les situations et est utilisé dans des systèmes en production depuis plusieurs décennies.

Les entretiens effectués pendant l'étude montre que le déploiement d'IPv6 devrait avoir lieu entre 2010 et 2012 et devrait être piloté par l'industrie des médias (téléphonie, télévision IP, …) qui fourni des services demandant un nombre très important d'adresses IP. Ces entretiens montrent également que certaines industries ont développée leurs propres protocoles de communications dans le cas où la connectivité IPv6 ne serait pas suffisamment disponible au moment où leurs applications seraient déployées.

Évolution du problème

Plusieurs scenarii peuvent être envisagés avant et après la date d'épuisement des adresses IPv4.

En assimilant les adresses IPv4 à une ressource, certaines organisations pourraient entrer dans un état de panique afin de se prémunir de la pénurie en approvisionnant autant d'adresses IP que possible ; créant ainsi une augmentation des demandes. D'autres, dû aux difficultés croissantes à obtenir des adresses, pourraient opter pour une solution différente (utilisation intensive de NAT, protocoles alternatifs, …). Pour étendre la durée de vie de l'Internet IPv4, plusieurs options ont été prédites, telles le commerce d'adresses IP, la modification des règles d'attribution des adresses ou encore le maintien de l'IPv4 grâce à des optimisations des NAT.

Mais la seule solution viable pour assurer la continuité des activités (commerciales, de recherche, …) liées à Internet est basée sur l'intégration d'IPv6. IPv6 a été testé pendant plus de 10 ans : la première RFC IPv6 a été soumise en 1995. De plus, de nombreux travaux de recherche, développement et standardisation ont été menés depuis et aucune solution alternative efficace existe pour le court terme.

Aujourd'hui, l'intégration d'IPv6 est faible malgré un nombre croissant d'opérateurs de réseaux s'y préparant et le nombre croissant d'équipements proposant les fonctionnalités IPv6 en standard. Actuellement, aucun déploiement d'IPv6 est prévu avant 2020 et certains analystes encouragent les grands groupes à ne pas adopter IPv6 ; recommandant tout de même que les investissements soient faits sur des équipements (matériels et logiciels) compatibles avec ce protocole.

IPv6 ne propose pas un haut niveau d'innovation mais élargi plutôt le potentiel des réseaux IP actuels. Les applications qui peuvent émerger suite à un déploiement massif d'IPv6 peuvent des certaines innovations radicales dans bon nombre de secteurs. Une fois encore, IPv6 n'est pas la seule

[2] Internet Assigned Numbers Authority
[3] Regional Internet Registry
[4] Strengths, Weaknesses, Opportunities and Threats

solution pour cela et IPv4 pourrait correspondre aux besoins mais la limitation de l'espace d'adressage forcerait les secteurs verticaux à utiliser une alternative à IP. Cela ralentirait l'interopérabilité des réseaux et la convergence des médias, identifiés comme facteurs clés pour la croissance et l'emploi.

Des bénéfices ou des échecs de coordination liés à l'intégration d'IPv6 qui favoriserait l'action des organismes publics ont été identifiés:

- **Retombées technologiques** : l'innovation dans le secteur des NTIC a été identifié comme étant crucial pour la compétitivité de l'Europe ainsi que pour sa vitalité sociale et sa croissance économique. Cette efficacité dans l'innovation est fortement tributaire de l'interopérabilité des systèmes trans-secteurs que les réseaux permettent. IPv6 a été identifié comme une technologie clé pour une telle convergence dans de nombreux secteurs désireux d'aller vers IP.

- **Retombées de marchés** : l'Europe représente aujourd'hui environ 20% de la production mondiale d'approvisionnement NTIC. Être derrière les pays concurrents en ce qui concerne les infrastructures informatiques réduirait le savoir technologique que l'industrie européenne a acquis dans ce domaine et par conséquent diminuerait sa compétitivité dans la course mondiale. À l'opposé, si l'industrie européenne est bien préparée à faire face à des produits et demandes liées à IPv6, et éventuellement à des difficultés techniques grâce à une infrastructure adaptée, un avantage évident sera donné à l'Europe dans le marché mondial.

- **Absence de coordination** : IPv6 est aujourd'hui confronté au problème de la poule et de l'œuf où les opérateurs de réseaux font face à une demande insuffisante et à un manque de business model, tandis que les fournisseurs d'applications et de services se plaignent d'un manque d'infrastructure. Un autre échec de coordination susceptible d'avoir une incidence sur la politique de développement de l'Europe serait l'impossibilité pour une organisation européenne de coopérer avec ses homologues internationaux qui peuvent avoir déjà adopté IPv6.

Objectifs d'une action de la Commission Européenne

Une rapide analyse de l'actuelle politique de l'Union Européenne et des gouvernements nationaux concernant les NTIC montre que celle-ci joue un rôle majeur en faisant progresser la croissance de l'économie de l'Union Européenne, en particulier en termes de PIB et d'emplois. Le nouveau cycle de gouvernance de Lisbonne a mis en évidence les NTIC comme l'un des moteurs de croissance et de création d'emplois. Un quart de la croissance du PIB de l'Union Européenne est le résultat direct des NTIC. Il est donc essentiel d'assurer l'état de l'art des infrastructures européennes en supportant les priorités de développement de la Commission Européenne.

Les politiques mentionnées ci-dessus impliquent que tous les efforts doivent être déployés pour faire en sorte que la croissance de l'industrie européenne ne soit pas entravée par une diminution de l'accès aux infrastructures, par rapport au reste du monde. Cela est susceptible de se produire si l'Europe reste axée sur le protocole IPv4, alors que les ressources IPv4 deviennent rares. Trois objectifs spécifiques ont été identifiés:

- **Assurer la continuité de l'activité des organisations européennes**. Si mal préparée, l'intégration d'IPv6 couplée à la prévision d'épuisement des adresses IPv4 présentera un danger, entravera la croissance européenne et donc de réduira la compétitivité de ses industries.

- **Exploiter l'expertise européenne** permettant à l'industrie européenne de bénéficier des nouvelles opportunités commerciales créées par l'intégration d'IPv6.

- **Assurer que les citoyens européens et les organisations bénéficient de l'état de l'art des innovations dans un environnement concurrentiel et équitable**, IPv6 étant un outil pour stabiliser et sécuriser Internet tout en ouvrant la porte à toute une gamme de nouvelles applications.

IPv6 est un protocole invisible (comme c'est le cas pour IPv4) à la grande majorité des utilisateurs. Qu'il s'agisse d'individus ou d'organisations, ils ont seulement besoins d'accéder à des applications. Ces utilisateurs ne savent pas et n'ont pas à être conscient de la technologie sous-jacente et de la situation particulière d'IPv6, mais ils doivent assurer de la continuité de leurs opérations. Pour de nombreuses organisations, ils continueront à utiliser leurs réseaux internes IPv4. Au fur et à mesure du cycle de renouvellement de leur infrastructure informatique, de plus en plus de matériels IPv6 seront intégrés et le jour où IPv6 sera disponible, son adoption se fera à moindre coût. D'autres organisations peuvent choisir de passer rapidement à l'IPv6, et cela a déjà été observé pour certaines industries qui souhaitent bénéficier des avantages d'IPv6, même si elles ont été initialement poussées par des demandes gouvernementales. De ce postulat, les objectifs spécifiques se déclinent en objectifs opérationnels :

- S'assurer de la disponibilité de la connectivité IPv6 Europe

- S'assurer que tous les responsables informatiques européens sont conscients de la situation actuelle de l'IPv6

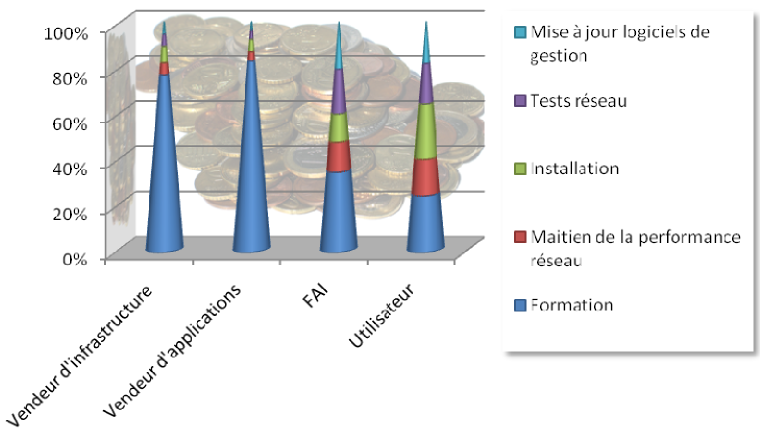
- Veiller à ce que l'intégration d'IPv6 n'implique pas de problème de sécurité

- Veiller à l'existence d'un bassin suffisant de personnes formées

Options politiques et principaux impacts

Pour atteindre les objectifs opérationnels détaillés ci-dessus, trois grandes options de l'Union Européenne peuvent être envisagées, allant d'un scénario où la Commission Européenne ne s'implique pas à une initiative réglementaire, avec une solution intermédiaire visant à coordonner l'intégration d'IPv6.

La première option consiste à laisser les choses évoluer par leurs propres moyens. Dans cette option, le marché serait laissé à lui-même et les questions liées à l'épuisement d'adresses IPv4 pourraient ne pas être largement connues. En outre, l'absence de mobilisation des services publics européens enverrait un signal de non-urgence en matière d'intégration d'IPv6, ce qui pourrait retarder l'adoption en masse d'IPv6 en Europe. Une solution plus proactive (option deux) est le lancement d'actions ciblées visant à appuyer et à encourager l'intégration d'IPv6 en Europe. Une communication de la Commission au Conseil et au Parlement Européen serait un instrument utile pour soutenir ces actions. Une telle option, sans être liée à aucune obligation, permettrait un plus large éventail d'actions. La dernière et la plus forte option (la troisième) est la définition d'une date à laquelle l'Europe devrait passer à IPv6. La réglementation devrait veiller à ce que, à une date donnée, une offre compétitive et standard soit disponible dans tous les pays de l'UE.



Répartition des coûts d'intégration d'IPv6 suivant les degments.

Les coûts directs de l'IPv6 concerneront tout d'abord l'intégration du protocole chez les opérateurs backbone et les fournisseurs d'accès Internet, étant donné que l'infrastructure doit être compatible afin de supporter l'IPv6. En outre, on peut noter que les principaux réseaux sont déjà compatibles grâce principalement au cycle de renouvellement des équipements. La formation du personnel ainsi que des mises à jour de logiciels impliquera aussi des coûts directs. Le maintien de réseaux supportant IPv4 et IPv6 va imposer des frais supplémentaires et plus l'étape de transition se prolongera, plus les coûts seront cumulées. Ces coûts ne peuvent être évités, mais ils peuvent être diminués par le raccourcissement de la période de transition.

Il n'y a pas de solution pour l'intégration d'IPv6 sans coût. Néanmoins, pour la plupart des utilisateurs européens (industrie, recherche), il n'y a pas de besoin urgent pour l'intégration dans leur infrastructure ; une passerelle IPv4/IPv6 permettant le raccord d'un « îlot » IPv4 à l'Internet IPv6.

Le Communication i2010 souligne que dans la deuxième moitié des années 1990, les investissements dans les NTIC et les progrès techniques ont compté pour environ 40% de la croissance de la productivité. Briser la continuité des activités NTIC à cause d'une insuffisance de la de ressource élémentaire que constituent les adresses IP conduirait à un ralentissement mondial de la productivité. Une telle situation serait évitée dans le cas d'intégration d'IPv6 dans les délais.

Par ailleurs, la première région en mouvement dans l'inéluctable passage à l'IPv6 va acquérir une capacité à bâtir un leadership mondial, ce qui renforcera sa compétitivité internationale. Cette considération s'applique également à la plupart des entreprises liées aux NTIC, mais en raison de l'omniprésence des aspects de l'Internet, peuvent avoir une incidence sur l'ensemble de l'économie européenne.

Mis à part les impacts économiques, des retombées sociales seront induites par l'adoption d'IPv6 puisque les adresses IP, devenant une ressource non limitée, sont nécessaires pour poursuivre le déploiement de l'Internet et en conséquence réduire la fracture numérique. La pénurie d'adresse IPv4 peut restreindre l'égalité d'accès à l'Internet et donc aux biens et services. Les citoyens européens pourront bénéficier de l'IPv6 dans son ensemble (même sans être au courant de la technologie qu'ils utilisent), car de nouvelles applications, telle que l'administration électronique (e-*gouvernement*) pourraient être déployées. On pourrait également mentionner les solutions de prévention et gestion des catastrophes, basées sur IPv6, ainsi que le système éducatif, qui peuvent profiter de nouvelles fonctionnalités d'IPv6.

Comparaison des options

Les 3 options pour l'adoption d'IPv6 ont été analysées en détail, en termes économiques, sociaux et environnementaux. Cette analyse montre que le choix « Ne rien faire » (option n°1) est le seul qui donne des résultats négatifs. En examinant plus en détail la comparaison des l'options 2 et 3, on s'aperçoit que l'accélération de l'adoption au sein de l'option 3 conduirait à une augmentation des coûts dûs à des mises à jour de l'infrastructure hors de la période normale d'amortissement et du cycle de renouvellement. En outre, en raison de sa plus grande portée, l'option 2 aura des impacts positifs plus larges et nombreux que l'option 3.

L'option de soutenir la transition au travers le déploiement de mesures accentuera l'intégration d'IPv6 en misant sur les activités de recherches et développement existantes et sur la compétitivité des entreprises européennes. Cette option rendra marginaux les coûts supplémentaires pour les entreprises tout en ouvrant de nouvelles fenêtres d'opportunités. À l'échelle mondiale, étant proactive, l'Europe restera parmi les leaders mondiaux dans les domaines des NTIC. Cette option est la seule à être recommandée.

Conclusion

La pénurie d'adresses publiques disponibles est un problème inexorable de la 4ème version du protocole IP. Alors que pendant des années, les points de vue sur la date à laquelle aura lieu la pénurie ont montré de grandes divergences, il existe désormais un consensus pour prédire qu'un épuisement se produira en 2011-2012.

Parmi les options analysées, celle visant à soutenir l'adoption d'IPv6 en Europe grâce à un ensemble de mesures douces est celle qui est susceptible d'apporter de plus grands avantages pour l'Europe aux niveaux économique, social et environnemental. Ces mesures devront porter sur la disponibilité de la connectivité IPv6, la sensibilisation des responsables des NTIC, la sécurité des réseaux au cours de l'intégration, la disponibilité d'un nombre suffisant de personnes formées et la bonne exploitation de l'expertise européenne.

La considération immédiate de l'intégration d'IPv6 doit être entreprise : elle constitue la seule façon de minimiser les coûts associés à cette activité et facilitera la transition sans heurt, en s'attaquant aux problèmes de la pénurie d'adresse.

Impact of IPv6 on vertical markets

inno group - Zaltana

2007

Contents

1 Procedural issues and consultation of interested parties

There has been wide consultation with stakeholders in order to promote IPv6 use and detect deployment problems, the impact of Ipv6 in sectors and opportunities for innovation in terms of IPv6.

In February 2006 a public consultation was held on the "Hurdles and Triggers for the Deployment of IPv6 Technology". The result was the publication of a series of conclusions regarding IPv6 integration. Triggers are – said to include; mobility, end-to-end transparency and convergence of ICT technologies and services. As for hurdles, lack of market demand, lack of available IPv6 services and lack of available applications all need to be overcome. It was also stated that there are a number of policy initiatives that would be worthwhile adopting, these include: financial support for IPv6-enabled structures, stimulation of IPv6 procurement and stimulation of sectoral initiatives and applications.

On 29th March 2006 a meeting with the Defence market Stakeholders was held in Brussels. At this meeting it was decided that despite the vast amount of non-IPv6 equipment, IP plays a key role in today's society. It was said that IPv6 is an important factor in achieving differentiation in cyberspace (extending land, air and sea). Therefore, even taking into account its potential problems, it would be more advantageous to adopt IPv6 rather than IPv4.

A meeting was also held with the Media and Telecom Stakeholders, in Brussels on 5th April 2006 which highlighted the need for applications to demonstrate the added value of IPv6 and therefore provide service providers and broadcasters with appropriate evidence and incentives to adopt the technology. Multicasting and Quality of Service were also discussed and are said to be two fundamental issues in the media industry. It is imperative, for this reason, to differentiate IPv6 functionalities from those of IPv4 and other technologies. Finally, the participants spoke of reducing OPEX and CAPEX in operating IPv6.

An International Conference on "Convergence: new opportunities to accelerate the IPv6 momentum" took place in Vienna between 1-2 June 2006. Many key points were raised during this event, firstly it was expressed that IPv6 has clear technical advantages over IPv4 which should be translated into commercial advantages using business models specific to sectors. Furthermore, it was said that training and education to increase awareness and usage capabilities has to take place.

On 14th November 2006 a global summit on IPv6 was held in Cannes, France. Among the numerous presentations given, Ulf Dahlsten, Director of the emerging technologies and infrastructure (Directorate general for "Information Society"), presented a roadmap for "IPv6 deployment in Europe". This summit confirmed the conclusions of the other recent stakeholder consultations.

To deepen the vision regarding the potential impact of IPv6 on some vertical sectors, a systematic analysis, relying on desk research, interviews and web survey took place at the beginning of 2007. The detailed results are given in the annex.

2 Problem definition

2.1 Extent of the problem

2.1.1 Overview

The Internet, as a communication mechanism, is using a dedicated Internet protocol, known as IP, to enable devices (computers, mobile phones, PDA…) to exchange data.

As Internet usage and the number of users are continually increasing, IP addresses, identifying connected devices, are being increasingly demanded. Furthermore, that usage is being accelerated by new services requiring multiple IP addresses and entire industries are discovering the advantage of being connected to the Internet. Being widely (and almost uniquely) used in its former version (the fourth), the Internet Protocol can only provide 4.3 billion public[1] addresses. Out of this address pool, 3.7 billion addresses can be allocated worldwide. Since January 2007, 2.4 billion addresses have already been allocated, leaving only 1.3 billion available with an accelerating consumption rate. Current expert estimations forecast an exhaustion of the unallocated pool of IPv4 addresses to happen by 2010-2011 [1].

In order to understand the address shortage, Europe can be used as example: Europe has 810 million citizens (493 million for EU27) out of the total global population of approximately 6.5 billion persons (2007 estimations). It is simply not possible, without involving add-on to the IP protocol, to supply everyone with Internet access: there are more people on the earth than available Internet addresses. And as will be explained later new services may require multiple global addresses per person. This is a very simple example which clearly illustrates the fact that we need an Internet system capable of growth and the technology currently in place does not permit this growth. By having a limited number of IP addresses available we are halting Internet growth and innovations which come with it.

Until now, a technical workaround named NAT (Network Address Translation) has been used to delay the exhaustion of IPv4 addresses. This solution demonstrated its capabilities at the cost of an increased complexity in applications development and reduced performance in some cases where a direct device to device communication is requested. The well-known solution to avoid the address shortage problem is to integrate into the existing infrastructure IPv6, the next version of the Internet Protocol. One of the main advantages of this technology is its wide address space: 3.4×10^{38} available addresses[2], while IPv4 only provides 4.3×10^{9} addresses.

This protocol, despite its proven capability (even in large scale deployments such as NRENs[3]), has been little used up to now. The main reasons given for this includes a lack of compatible applications and the cost to train IT professions to get them deploying. This being said, solutions to integrate IPv6 within IPv4 (tunnelling, gateways…) and vice-versa exist and can be deployed at a reasonable cost. Nevertheless, IPv6 is already in used in backbones (and more in some countries, like Asia which could be a threat to Europe's leadership), and many EC-financed projects have a strong focus on

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[1] This addresses are named “public” (or “global”) since they are valid everywhere on the Internet, compared to “private” addresses used in situation where not enough IP addresses are available. This is made possible thanks to NAT, introduced later in the document.

[2] e.g. 340 282 366 920 938 463 463 374 607 431 768 211 456 addresses

[3] National Research and Education Networks

IPv6, therefore indicating that there is a developed know-how in Europe and perceived need for IPv6 in the future, but has not yet reached wide operational deployment because of a lack of communication towards businesses for which IPv6 could grant business opportunities.

2.1.2 Problem drivers

2.1.2.1 Need for increased address space:

The IP addresses shortage is driven by various facts related to the Internet evolution: the usage growth, the arrival of new services for end-users and the entry of entire industries in the IP world.

Since its creation, Internet usage has not stopped growing (worldwide as well as at European level). New uses as well as new, existing and emerging access technologies (ADSL, Wi-Fi, mobile phones, Wi-Max…) and the decrease of access costs (DSL connection for example) have participated in this growth. In Q2 2007, 294 million ADSL subscribers were counted worldwide [2]. Figure 1 shows the evolution of Internet users.

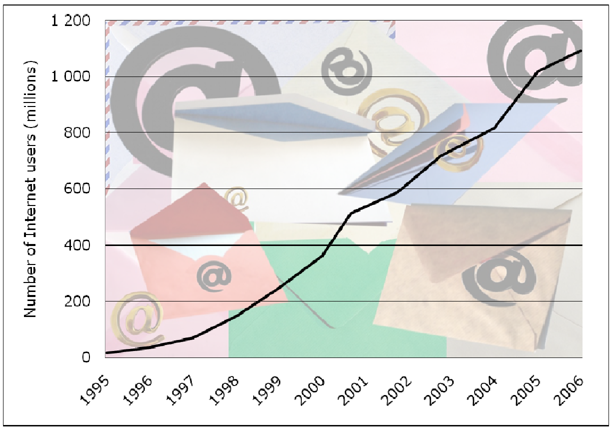

FIGURE 1: EVOLUTION OF INTERNET USERS.

The number of Internet users reached 1.2 billion in 2007 with an average penetration rate of 18.9% of the population.

As previously stated, 3.7 billion public IPv4 addresses can be allocated. This number will not change; this limit is a technical constraint (the 3.7 billion addresses were estimated as sufficient for a very long period of time in the early days of the Internet) because IP was not designed for public and commercial uses of the Internet as we know it nowadays. Moreover, IPv6 takes this dimension of the problem into account by targeting new usages. It is worth noting that whereas in 2004, Geoff Huston from APNIC[4] was forecasting in 2003 an IPv4 address exhaustion, at IANA and RIR levels, in ~2021-2022 [6], he revised the date to 2012-2013 in 2005 [7] and to 2010-2011 in May 2007 [1][5].

[4] APNIC is the Regional Internet Registry (RIR) for Asia-Pacific. A RIR is responsible for IP addresses allocations for its region. It acts upon the supervision of IANA, the Internet Assigned Numbers Authority.
[5] These abrupt changes come from model adaptation required to take into account the accelerating consumption of address space.

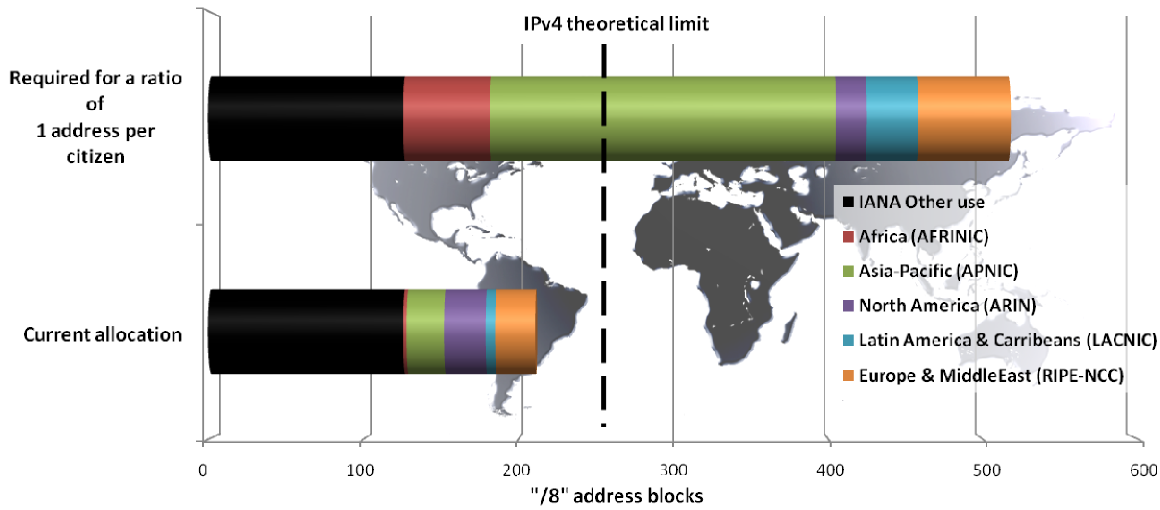

FIGURE 2: NUMBER OF PUBLIC IPV4 ADDRESSES WITHIN RIR POOLS COMPARED TO THEIR CORRESPONDING POPULATION.

Also, Internet addresses were not allocated fairly in the early days of the Internet and large blocks of IPv4 were allocated to a few organisations, mostly based in North-America. This could have led to some interpretation error when calculating the ratio of allocated IPv4 public address per citizen[6] (Figure 2). Nevertheless, taking a reasonable target ratio of 1 address per citizen, the 3.7 billion of available IPv4 addresses will not cover the needs of the current population of 6.5 billion.

It has often been said that some countries are already running out of IPv4 public addresses. This should be moderated by the continuously evolving allocation process made by the IANA together with the RIRs [3]. The problem of address exhaustion then becomes global and cannot be reduced to a limited number of countries (see §2.1.2.3).

The Internet growth is also due to the arrival of new services. Among those services, triple-play boxes (Internet gateway providing multiple services: high-bandwidth Internet access, television and telephone) can be quoted as well as home automation, online governmental applications, peer-to-peer applications… All those new services require IP addresses not only for services providers but also for customers.

The demand for IP addresses is also coming from industries looking to the Internet for new business opportunities. In the automotive industry for example: If this industry is making demands for onboard communicating systems to equip each new car, we would consume at a minimum, 30 million additional addresses per year (ten years to renew the nearly 300 million European cars [38]). This calculation is made by considering that each car will consume one IP address but several projects are proposing to grant each car with more IP addresses to cover the various functionalities to be deployed with the next generations of car (security, entertainment, navigation…)

In addition to this, we are entering the IP convergence: everything is moving to IP (Voice over IP, Video on Demand) therefore creating new IP needs.

[6] This calculation is made simply by comparing the number of IPv4 addresses managed by RIR with the population of the corresponding geographical area.

2.1.2.2 NAT: a workaround

As many companies and countries are already running out of IP public addresses, a solution exists allowing them to use only one IP address for all their corporate computers and devices: this mechanism is called NAT (Network Address Translation [4]).

NAT can be compared to the regular telephone system. As many organizations don't have enough public phone numbers for every telephone in their organization they use private phone extensions so employees are able to be connected through the reception. NAT runs in the same way: in IP, some specific address space has been reserved for private use, as compared to public use, therefore making the distinction between public addresses, which can only exist in one location on the entire Internet, and private addresses, which can be used anywhere in any intranet network (e.g. to allow internal communications) [5]. By using NAT, a single public Internet IP address can be shared by multiple hosts in a home network, an intranet or a very large network.

NAT is a viable solution in the short term. This mechanism is already largely deployed and running applications are already NAT capable. Moreover, from a network operator point of view, costs are externalised and incurred finally by the end user.

However, in the long term, NAT limits the possible usages of the Internet:

- By having a computer in between two Internet devices which want to exchange data, the NAT breaks the Internet model, where two peers should be able to communicate directly (peer-to-peer communications without the need of a server acting as a gateway in between).
- By breaking the peer-to-peer model, NAT raises technical issues to be solved, which increase application development costs (CAPEX) as well as operational costs (OPEX) for applications to be managed. A well-known ISV[7] is reporting that NAT increases its software development costs by 10% which, as stated earlier, are incurred by the final user.
- Currently there are several types of NAT, and several layers of NAT: this further complicates Internet communications.
- There is a perceived idea that NAT provides security: this is not true and it is the role of the firewall to secure the network. Furthermore, IPv6 addresses could be for private use only like IPv4 private addresses do.

2.1.2.3 Allocation mechanism

The IP addresses mechanism works as follows: IP addresses are distributed by IANA[8] (under the control of ICANN[9]) to Regional Internet Registries (RIR)[10] who in turn provides an allocation mechanism to Local Internet Registries (for example ISP or businesses).

In the early days of the Internet, before its globalisation, some companies, such as Apple Computers or General Electrics received more addresses than they will ever need to use (16 millions+ for example for Apple Computers) leading to a pool of allocated but unused addresses around the world.

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7 Independent Software Vendor

8 Internet Assigned Numbers Authority

9 Internet Corporation for Assigned Names and Numbers

10 Five RIR exist: APNIC for Asia and the Pacific region, ARIN for North America, LACNIC for Latin America and the Caribbean region and AfriNIC for Africa.

Most people are unaware of the IP address shortage. This is due to the fact that it is largely thought that Europe, as compared to some Asian countries for instance, holds enough IPv4 addresses for the near future. This is not true as an address pool is managed on a global basis within a close relationship between IANA and the RIR:

“The allocation of address space to RIRs from the IANA, and to ISPs from the RIRs (sometimes via National Internet Registries, or NIRs, in the APNIC region) is a continual process, and all allocations are made according to need based upon a consistent set of criteria. There is no preallocation of addresses to any economy or region in the world, meaning that a 'shortage' in any one country or economy simply cannot happen, except (and in theory only) as a result of specific national circumstances” [3].

The IPv4 public address exhaustion therefore becomes a global issue, not restricted to a subset of nations. This may be a sign that it should even be discussed at the level of the United Nations.

2.1.2.4 Lack of understanding

Misunderstanding of the situation leads to a delay in IPv6 adoption. This is driven by various facts:

- Stakeholders have not received the correct messages regarding the evolution of their network. Most of the time, when talking about IPv6, discussion papers talks about migration or transition, terms which can be understood as “let’s replace our existing system by a new one”. This is not the correct way of understanding IPv6: IPv6 should be integrated into an existing system.
- It would be desirable to teach IPv6 in European Universities or Engineering schools but currently this is not the case. Most of the time it is just mentioned as the next version of the Internet Protocol which will arrive sometime in the future.
- Everybody is waiting for the IPv6 killer application to go to IPv6. This will not happen since it might be an “Internet killer application”, not dedicated to any version of IP. Moreover, IPv4 has reached its limits and is deterring innovation. Of course, by bringing its new functionalities, IPv6 will enable innovative initiatives but this cannot be predicted. IPv6 should be seen simply as IPv4 with a wider address space which integrates IPv4 add-ons features as native ones. Also, in the past decade, IPv6 as been presented as a revolution leading to a misunderstanding: IPv6 is the natural evolution of IPv4.
- The business models associated with the move to IP of new services (such as mobile telephones) lack a clearly identified model, with proven benefits compared to the existing ones.
- People are nervous of new technologies following the “never touch a working system” golden rule, but IPv6 has been proved to be a well-tested technology.
- There are limitations: lack of use and experience, lack of monitoring tools (this being less and less true as tools developer and providers are going to IPv6).
- Integrating IPv6 into an existing system requires new staff training whereas the IPv4+NAT solution is already in place.

2.2 Affected sectors

A SWOT analysis was devised for over fourteen sectors to identify the Strengths, Weaknesses, Opportunities and Threats regarding the integration of IPv6. These sectors have been chosen, from early results of the consultation process, based on the potential impact they may suffer or benefit from if a wider IPv6 adoption were to happen.

• Central Government	• Collective Transportation
• Education	• Health
• Defence	• Buildings
• Media/Entertainment: Gaming	• Public Safety
• Media/Entertainment: Television	• Finance
• Tourism	• Logistics
• Automotive Transportation	• Service operators

TABLE 1: LIST OF 14 SECTORS ANALYSED THROUGH A SWOT ANALYSIS.

As detailed in the full SWOT analysis report, there are some differences from one sector to another regarding their possible reasons to integrate IPv6. Nevertheless, several common trends were identified in these sectors.

Main motivators to integrate IPv6

The main advantage of version 6 over version 4 is the benefit of having an increased number of addresses. The large majority of actors share this belief. For example, the adoption of IPv6 in automation and control industry would require a lot of IP public addresses that IPv4 cannot deliver.

All of the sectors interviewed have considered IPv6 adoption but due to the lack of a real large scale deployment emergence, they have also developed alternative solutions most of the time proprietary ones. The fact that IPv6 is an open standard could make the development of solutions in the long run less expensive than proprietary ones.

The enhanced mobility feature of IPv6 is mentioned as a benefit to many industries (automotive, transportation, public safety). Even if version 4 supports that kind of mobility, version 6 makes it easier to deploy and use. Nevertheless, some experts underline the fact that the IPv6 mobility features are not perfect and that IPv6 will have to evolve or even get replaced (next generation Internet).

Main counter arguments

The main accepted counter argument to the adoption of IPv6 is the fact everything works with IPv4 (even if it does not scale naturally to billions of users and connected devices) and technical solutions are being proposed for its evolution. Business solutions are being developed using the existing standard, IPv4. Convincing industries to move to a new version of a standard which would involve staff training and technical support without having a strong and clear competitive advantage compared to version 4 is barely possible. Solutions are still implemented using proprietary standards or IPv4. Despite the complexity induced by the use of NAT, Voice over IP (VoIP) uses IPv4 and the related industries still does research on it.

IPv6 competes with other standards in some sectors but has to face the lack of a real demand. Markets have to be created. Upfront investments need to be made and ROI is difficult to see in the short-term view. For instance, IP payment cards are technically feasible but the banking sector has not asked for such solutions yet.

Finally, even if “all IP” transition can be observed, IPv6 cannot satisfy all the technical requirements. In the Air Traffic Management or for critical time response applications (car to car communication), going through all the OSI layers is not as efficient as other specially designed solutions.

Main opportunities

In fast moving sectors such as media and entertainment, IPv6 can benefit from the development of network transformation and equipment upgrades due to the increasing demand for bandwidth-heavy applications. In others such as defence, the deployed solutions have a longer life cycle than in other industries. Solutions to be launched in 2007-2008 will have to last 15 to 25 years. As it is estimated that IPv6 will be more widely deployed at that time, solutions have to be IPv6 compliant.

Globalisation at all levels can also advance the use of IPv6. Some relatively new countries to the IP world are starting with IPv6. The case of French universities having to integrate IPv6 in order to continue cooperating with its African counterpart has been mentioned during the interviews. It is also part of homogenisation process in Europe. Europe is thinking about adopting single standards in public safety for example.

Main challenges:

“All IP” transition scares some companies. Companies that were developing in-house proprietary protocols and that were making money on it can be worry about the integration of IP. Indeed, IP code developers are numerous and new business models can attract IP specialized players.

The main issue across all sectors remains the security level that is brought by NAT. With IPv4 and NAT, a huge part of the network is hidden from the public Internet which is often mentioned as being a necessary security level. Removing NAT is a concern for the privacy of these sub-networks whereas this mechanism should normally be implemented within firewalls using standard IP capabilities[11].

Introducing IP products raises questions in highly secured sectors such as banking whereas IPv6 has been selected in other secured sector such as defence.

2.2.1 Adoption Scenario

According to a study by the National Institute of Standards and Technology (NIST) and the RTI International on IPv6 migration [23], only 30% of the Internet service provider networks will support IPv6 by 2010, and 30% of user networks by 2012,

The InfoPro reports [24] that only 5% of US organizations interviewed have IPv6 in use today. The research also reveals that an additional 18% have expressed some interest in adopting IPv6 for their infrastructure in the next 12 to 18 months (2006).

The majority of stakeholders in the 15 sectors are in a position that can be qualified as a “wait & see situation”. Industries are aware of IPv6 but do not expect a significant move in their sector before 2010-2012, underlining the fact that networks are not sufficiently ready to support their

[11] As mentioned early in this report, there is a misunderstanding on the role of NAT in the ICT world. It is commonly admitted that NAT brings a layer of security which is not correct.

applications. Most of the sectors, while recognising the advantages of IPv6 are also preparing alternative solutions in case IPv6 takes too long to be deployed, at a risk of limited interoperability between applications.

The result of interviews showed there is a window of opportunity around 2010-2012 for many sectors to move to IPv6. If a sufficient and reliable offer is available, they would make the adoption. However, they would continue to look for alternative solutions. It is worth noting that this window also corresponds to the date at which exhaustion of the IPv4 address pool is expected. Moreover, one could argue that the shortage could happen early than actual forecast due to new emerging and innovative services requiring multiple IP addresses per user.

2.3 How would the problem evolve if the current EU approach were to continue?

The usage of IPv6 is extremely low today and workarounds to extend the lifetime of IPv4 exist and have proven their workability. Nevertheless, it has been shown that in the near future, the IPv4 public address space will be exhausted which will become a worldwide problem.

Considering IPv4 public addresses as a “Resource”, an analysis of the phenomena to be anticipated before and after the exhaustion point can be drafted. The JPNIC [8] made an analysis of the anticipated phenomena before exhaustion:

- **Demand surge**: while approaching the exhaustion point, organisations may go into a state of panic in order to secure as many IPv4 addresses as possible in order to safeguard their infrastructures. Such phenomena would nevertheless be limited by addresses attribution policies in place.
- **Avoidance of consumption of IPv4 address space**: increasing difficulties to obtain IPv4 addresses would lead to a reduced demand, organizations moving to alternative solutions (increased use of NAT, IPv6…)
- **Efforts to delay the exhaustion point**: among current allocated IPv4 addresses, many are unused. The allocation criteria may be tightened to slow down the consumption rate.

Several options exist to extend the lifetime of the IPv4 Internet.

- **Trading of IPv4 address space**: one could imagine the possibility of setting-up a trading market aimed at allocating IPv4 addresses. Such a market would give incentives for organizations having unused IPv4 addresses to give them up for re-use. On the other hand, such a solution may distort the IT market and could increase the digital divide. Finally, one could observe the development of a black market, as it was already described in 1995 in the MIT VooDoo journal [9].
- **Maintenance of IPv4 Internet**: mechanisms such as NAT are already largely deployed and could even be further optimised to delay the exhaustion point by some years. However, the associated increased network complexity would increase maintenance costs.
- **Integration of IPv6 Internet**: This could be done either in deploying native IPv6 networks or through a step by step integration of IPv6, making use of IPv6 over IPv4 tunnelling solution for example.

- This above options being mentioned, it is worth noting that the longer we wait, the more new services will be put in places using IPv4, further complicating the migration to IPv6. Therefore, new services must be designed to work with IPv6.

It appears that the only medium-term solution available today to the IPv4 public address space depletion is the integration of IPv6. Alternative technologies have been proposed but none have been yet developed enough today or have even got a wide enough acceptance to appear as a credible solution. The current estimated exhaustion point made by an APNIC member, based on current consumption rates, is around 2010. The process is an accelerating phase and taking into account a five years depreciation time of equipment, the right time to ensure invested equipments are IPv6 compatible would be 2007 at the latest. Network address translation (NAT) has temporarily solved the issue of limited address availability and even being pushed to its known limits could delay the exhaustion by some 10-15 years. However, this use of NAT limits applications such as end-to-end public VoIP, global IP-based cellular service, large sensor networks and IP addressability of appliances ranging from automobiles to PDAs, home appliances, medical sensors etc. [10].

2.4 Is it in the Union's remit to act upon this problem?

Today there is a very low take up in IPv6 deployment despite the increasing number of network operators preparing for it as more and more new equipments are integrated both IPv4 and IPv6 functionalities. The lack of supervision software and training of technical teams is the main factor highlighted in slowing down the adoption. At time of writing no full deployment of IPv6 is foreseen before 2020 and some analysts are encouraging large businesses not to take up IPv6. However, they are encouraging these businesses to ensure that new investments are being made with IPv6 compatible equipments and software [11]. To moderate this viewpoint, one must mention the recent policy proposal submitted to APNIC and ARIN aimed at coordinating all RIR to define a date to terminate allocation of IPv4 addresses [12] and RIR have started to encourage migration to IPv6 numbering resources where possible [13, 39-42].

IPv6 itself does not bring a high degree of innovativeness but rather enlarges the potential capabilities of existing IP networks. Applications that may derive from a mass IPv6 adoption could lead to some radical innovations in a number of sectors. Once again IPv6 is not the only solution for this and IPv4 could handle much of it but the address space limitation would push the vertical sectors into using IP alternative technologies. This would slow down the networks interoperability and the media convergence, identified as a key factor for growth and employment [14].

Some phenomena that are likely to happen if Europe were to be a late IPv6 adopter or adopter of a bridled IPv6 (such as limited multicast capabilities or pursuing dynamic address allocation to end-users) have also been identified.

Technology spill-over: when it comes to identifying the benefits a new technology can bring to a population, only tests carried out in the real world can identify possible benefits. New possibilities offered by IPv6 native features could largely contribute to move the Internet into a new degree of expression meanwhile allowing other sector applications to be developed more easily and deployed with enhanced device to device capabilities. Innovation in ICT has been identified as crucial for Europe's competitiveness as well as its social and economic growth. Such effectiveness in innovation strongly relies on the trans-sectors, systems interoperability that the networks will allow. IPv6 has been identified as a key technology for such a convergence within many sectors willing to move to

IP. Nevertheless, a slow IPv6 adoption rate will force these sectors to move to alternative, sector-specific, technologies which would reduce the potential productivity gains, thus impacting on European competitiveness.

Market spill-over: Europe today represents approximately 20% of the world's ICT supply. Falling behind other countries regarding IT infrastructures would reduce the European ICT industry technological knowledge therefore decreasing their competitiveness in the worldwide competition. Alternatively, having the European industry well prepared to face IPv6 related product requests and possibly technical difficulties thanks to an adapted infrastructure would give Europe a clear advantage in the worldwide market. Such a phenomenon has come to light in Korea, where following the Mankiw law the government invested heavily in IT infrastructure which resulted in a high growth of FDI[12] in the service sector.

Coordination failures: IPv6 is today facing a kind of chicken and egg problem, where network operators face a lack of demand and unclear business models, while software editors complain about missing supporting infrastructure. The public authorities could help to find a common solution. A good example of this is that of the automotive industry where car manufacturers, road infrastructures managers and associated ISPs together with service provider could cooperate to focus on an largely standardized protocol such as IPv6 rather than trying to develop proprietary protocols or at least protocols with reduced interoperability toward other services.

Another cooperation failure that may have an effect on the development policy of Europe is the ability for an European organisation to cooperate with its international counterparts which may have moved to IPv6. An example is that of a French university which had to move to IPv6 to cooperate more successfully with an African university which is connected to IPv6.

In conclusion, there is still little real momentum towards using IPv6 and workarounds exist that may extend the lifetime of IPv4. However, many potential spill-over can be identified that would encourage action of Public Bodies.

As this is a worldwide problem, it has to be tackled at all levels. Moreover, the addresses allocation being done at a regional (in the sense of continent) level with a worldwide coordination, these transnational aspects have to be tackled at the Union level. Competitiveness of Europe is at stake and is a major signal to send to the EC governments, listing what could happen in case of late adoption.

[12] Foreign Direct Investment

3 Objectives

3.1 General objectives

A rapid analysis of the current EU and national government policy context regarding ICT shows that ICTs are expected to play a major part in driving forward the growth of the EU economy, especially in terms of GDP and employment. The new Lisbon Governance cycle for example has highlighted ICT to be one of the drivers for growth and jobs creation (11). A quarter of the European Union's GDP growth is a direct result of ICT.

Supporting the Lisbon Agenda, there is the i2010 agenda. This initiative calls for a "Single European Information Space" which would offer affordable and secure high-bandwidth communications, rich and diverse content and digital services. Applications which can be greatly enhanced through the use of IPv6 technology. i2010 also looks to creating an inclusive European Information Society through sustainable growth and development with the focus being on better participation and the inclusion of society as a whole [14] which will result in greater use and demand for Internet services.

The planned i2010 Mid Term Review will focus on future networks and Internet as one of three central themes. Previous EU Communications on IPv6 [15] have made the case for the adoption of IPv6 Europe. IPv6 is expected to be a cornerstone in the i2010 strategy to ensure the integration of the networks of the future, and therefore will be a key element of the Mid Term Review.

As the general awareness regarding such issues as sustainable development and management increases, various policy initiatives have been adopted by the EC, many of which promote the enhanced use of ICT. Transport, sustainable energy and health are among those sectors for which initiatives exist. For example the "Sustainable Energy Europe Campaign 2005-2008" which aims to apply ICT-based solutions to Energy efficiency challenges. Or even the "Competitiveness and Innovation framework Programme 2007-2013" which covers the "ICT Policy Support Programme".

According to the European Councils conclusions of December 2006, the Spring Council 2008 will review the challenges of the next generation of Internet and networks within the framework of the Lisbon Strategy.

Finally, the EC has created a development policy specifically for the African, Caribbean and Pacific (ACP) group of countries. Facing the problem of new users accessing the Internet and the problem of address allocation, the ACP group of countries has already taken a position on IPv6 infrastructures. The implementation of the development program will then strongly benefit from interoperable IPv6 based networks.

It is therefore essential to secure state of the art European IT infrastructures supporting the EC development priorities.

3.2 Specific objectives

The above mentioned policies imply that all efforts should be deployed to ensure that growth of the European industry will not be hindered by diminished access to IT infrastructures, compared to the rest of the world. This is likely to happen if Europe remains focused on the IPv4 protocol, as IPv4 resources become scarcer. Moreover, as international organisations are moving towards IPv6, pursuing cooperation with such organisations will require Europeans to be IPv6 compliant. The first objective of the intended action is then to **ensure business continuity of European organisations**. If badly prepared, the integration of IPv6 together with the foreseen exhaustion of IPv4 addresses will present a risk, hinder European growth and therefore reduce the competitiveness of its industry.

The integration of IPv6 at a worldwide level will not be straightforward. It will require careful integration planning, hardware and software updates, appropriate training of IT staff, test and validation campaigns. Moreover, enlarged address space and restoration of the end-to-end transparency is expected to bring a new generation of usages. All of this will renew an international market relying on existing IPv6 expertise. European organisations have been involved in the development of the IPv6 protocols since the beginning[13] and have never stopped developing skills and competencies. As an example, more than €90 million [16] has been invested in supporting IPv6 related research projects by the European Commission. The second objective of the intended action is then to **exploit European expertise** allowing European industry to benefit from the new business opportunities created by the IPv6 integration. This expertise should now be commercialised and exploited or there is a risk it will be diluted or move abroad.

While an Internet network keeping with the IPv4 version may generate market distortions due to the lack of public addresses resources, the IPv6 version eliminates this risk while restoring the possibility to set-up transparent end-to-end connections. Native integration of security protocols (IPsec) will simplify the establishment of end-to-end secured connections, contributing to the protection of data. Finally, The IPv6 protocol is expected to simplify networks administration tasks and reduce applications development costs due to the removal of NAT compliance necessity[14]. IPv6 being a path to a stabilised and secured Internet while opening the door to a range of new applications, the third specific objectives of the intended action is: **Ensure European citizens and organisations will benefit from state of the art innovations in a fair and competitive environment**.

3.3 Operational objectives

The IPv6 deployment is often mentioned as being a chicken and egg problem as ISPs do not offer IPv6 connectivity, users and organisation can not use the technology and because there is no request for IPv6 connectivity, ISPs are not offering such services. But this is only partially true.

IPv6 is a protocol invisible (as is IPv4) to the large majority of users, whether they are individuals or organisations, they only tend to look at applications. These users are not aware and do not have to be aware of the underlying technology and the specific IPv6 situation but they have to ensure the continuity of their operations. For many organisations, they will go on using their internal IPv4 network[15]. As they renew their IT infrastructure they will become more and more IPv6 compliant and the day they do need IPv6, they will have to be able to switch to IPv6 for a limited cost. Other organisations may choose to switch rapidly to IPv6 and this has already observed for some large multi-national industries wanting to benefit from IPv6 advantages, even if initially pushed by

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1) [13] In 1996, several implementers and users met and agreed to start an international testbed called the 6bone. By June 1996, two groups raced to provide the first IPv6 connectivity: the University of Lisbon (Portugal), the Naval Research Laboratory (U.S.), and Cisco Systems (U.S.); a Danish universities consortium (UNI-C), a French universities consortium (G6), and a Japanese universities consortium (WIDE)(20).

[14] NAT is often perceived as being a security layer as it hides private addresses of an organisation. This functionality can be restored within IPv6 by proper configuration of the firewall.

[15] It would be non sense to upgrade all equipments connected to the network while deploying in a v4/v6 would be enough.

governmental requests [17]. From this statement, the previous above mentioned general objectives can be turned into operational one:

1) **Ensure common availability of IPv6 connectivity in Europe**: this means that a competitive and standard offer of IPv6 based services should be available to European citizens and organisations before the foreseen IPv4 exhaustion at RIR levels. Based on the current foreseen exhaustion date[16], this means that by 2011
    a. *All infrastructure operators should support native IPv6 transport*
    b. *The service offer of the European Internet Service Providers should include IPv6 connectivity as a standard service.*
2) **Ensure all European IT managers are made aware of the IPv6 situation:** despite all the efforts made in the past years, the IPv6 situation is still not fully known by the IT community. Most of the IT managers focus on day to day issues, deployment and the update of network and applications and have not yet fully considered the issues relating to IPv6 integration. On the other hand, events organised on IPv6 in Europe are finding it increasingly difficult to attract people. A renewed effort to raise awareness about the IPv6 situations should be launched with the support of the highest governmental and European representatives.
3) **Ensure that IPv6 integration remains safe:** As with any technology update, IPv6 will not be protected from potential security problems, in particular during the transition phase and, as has happened with IPv4, associated standards are likely to evolve and to be complemented. Also, potential security problems may happen due to lack of know-how of IT departments not used to IPv6 and trying to think security the same way as IPv4 without using the protocols correctly. So, lack of know how may bring a security threat. The European organisations and agency in charge of standardisation[17] or network security[18] should have the means to closely follow these potential issues. Information published by these organisations should be made available to the public and potentially relayed at national levels.
4) **Ensure existence of a sufficient pool of trained people:** IPv6 specificities and IPv4/IPv6 transition mechanisms should not be mastered by a limited number of experts but should be widely known by the people having to deal with IP related products and services:
    a. *IPv6 together with integration mechanisms should be taught at all European IT educational institutes as is IPv4.*
    b. *The presence of a sufficient pool of IPv6 postgraduate programs should be monitored and their development encouraged if necessary.*

5) **Encourage proper exploitation of European expertise**: the availability of IPv6 connectivity may bring a new range of applications and associated services. A strong European expertise has been developed in the field of IPv6 and services have been identified to play a very important role in developed economies, accounting for two thirds of employment and value creation to be a key vector of European competitiveness [18]. The IT services market alone is forecast to exceed $730 billion in 2007 [19] and taking the example of US federal security

[16] Since its model update on may, 8th, the following estimation is accepted by the whole IPv6 community : http://www.potaroo.net/tools/ipv4/index.html

[17] Such as the European Telecommunications Standards Institute (ETSI) which is already largely involved in IPv6 standardisation and testing.

[18] Such as the European Network and Information Security Agency (ENISA) which is already considering the IPv6 aspects [20].

spending which will reach $7.4 billion by 2012, IPv6 is a driver of spending [21]. Being dominated by US based companies, the deal flow associated with IPv6 related innovation [22] should be increased in Europe to allow :

a. *Detection of innovation exploitation opportunities within universities and research institutes*
b. *Awareness raising of funding institutions towards IPv6 potential markets.*

6) **Ensure that IPv6 is used in governmental and EC facilites:** make sure that administration networks are using IPv6, ensure that all purchase done at state or EC level are supporting IPv6 and make IPv6 mandatory for all EC-funded project which may use Internet.

4 Policy options

4.1 Options scenarios

To achieve the operational objectives detailed above, three main options may be envisioned from a European Union point of view, ranging from a 'do nothing more than today', to a regulatory initiative with an intermediate solution aimed at coordinating IPv6 integration.

These three options are detailed here and their respective impacts evaluated in the following sections.

4.2 Analysis of the different scenarios

4.2.1 'Do nothing' scenario

Since it's 2002 Communication, the European Commission has invested about 90million euros in R&D IPv6 projects [16]. These projects have mainly focused on technical aspects, including applications of IPv6 but some of them have also addressed awareness raising aspects and networking between stakeholders. The impact of this investment has not been measured but it has probably helped put Europe ahead in the current IPv6 addresses allocation.

Even if there are still research topics related to IPv6 to be undertaken, most of the work has been done and is now moving towards commercial exploitation. From a European point of view, Research and Technological Development (RTD) focus is now moving towards future challenges such as the Next Generation Internet (post-IPv6) and the budget allocated to IPv6 research is likely to decrease. The same would apply for awareness raising activities.

In this option,' do nothing' scenario the market would be left alone and the issues related to IPv4 address pool exhaustion, may be not be widely known. Furthermore the lack of mobilisation of European Public Bodies would send a signal of 'non-urgency' regarding the IPv6 integration, which could delay the mass adoption of IPv6 in Europe

4.2.2 Support IPv6 integration

A more pro-active solution is the launch of targeted actions aimed at supporting and encouraging the integration of IPv6 in Europe. A Communication from the Commission to the Council and the European Parliament would be a useful instrument to sustain these actions.

Such an option, while not being associated with any obligation, would allow a broader range of actions to be encouraged at various levels. Referring to the operational objectives (§3.3), some directions are detailed here:

- Ensure common availability of IPv6 connectivity in Europe
    - Make sure ISPs are made aware of the IPv6 situation
    - Monitor progress
    - Support RIPE-NCC in applying IPv6 oriented policies.
    - Encourage good communication campaigns around RIPE-NCC actions, as has been done by APNIC and ARIN
    - Encourage use of IPv6 in public procurement making use of financial instruments such as structural funds.

- Ensure all European IT managers are made aware of the IPv6 situation
    - Large communications campaign associated with a Communication
    - Implement a ‘road-show’ in ISP and large industries IT services
- Ensure IPv6 integration is made secure
    - Support ENISA for monitoring of security issues related to IPv6, in particular during the integration phase. Ensure the presence of a European alert network.
    - Support ETSI for maintenance of existing standards and integration of emerging ones
- Ensure existence of a sufficient pool of trained people
    - Available documentation is abundant but often outdated or incomplete. Create a reliable, complete, and objective resource directory
    - Encourage universities and other educational organisations to incorporate IPv6 in the programs.
    - Set-up training campaigns focused on ‘training the trainers’, making use of the expertise developed in GÉANT and the most advanced NREN[19].
- Encourage proper exploitation of European expertise
    - Launch an opportunity detection program with universities and research institutes to increase the European deal-flow associated with IPv6 opportunities
    - Launch a communication campaign within the financing community

4.2.3 Set a transition/switch over date

The last and stronger option is the definition of a date for when Europe should have to “switch over” to IPv6. This indeed does not mean anything and has to be refined. To go back to the first objective, the regulation should ensure that at a given date, a competitive and standard offer of IPv6 should be made available in all EU countries.

While some operators are already proposing such services, others are not ready. A survey we made over 50 Internet Service Providers showed than 28% of them were providing IPv6 as a standard feature, 30% as an experimental service and 30% were not proposing any IPv6 based service. Among these last 30%, 20% were planning an IPv6 deployment within 2 or 3 years while 10% have not planned any IPv6 deployment. Figures are roughly the same at worldwide and EU25 scale (annex III).

Several regulation options can be considered:

- ✓ Oblige all ISPs to provide IPv6 connectivity at a given date
- ✓ Oblige all EU countries to ensure that at a given date, all European citizens and organisation may choose among a minimum of a given number of different offers for IPv6 connectivity.

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But whatever is the considered regulation option, it will bring associated administrative costs such as:

- ✓ **Compliance costs**: ISP not already supplying IPv6 connectivity would have to invest to renew part of their infrastructure sooner than they would have normally done in the depreciation cycle.
- ✓ **Administrative costs:** ISP would need to provide information to a regulatory authority regarding their actions and service offer
- ✓ **Control costs**: Any regulation option should include a definition of a minimum Service Level and means to verify conformance of the ISP offers to this minimum Service Level should be deployed.

Even if actions are taken to minimise these costs [25], there will never be zero costs which would reduce the efficiency of the actions from a global economic point of view.

5 Analysis of impacts

The potential impacts have been identified following a logical methodology where possible impacts, divided into sublevels of economic, environmental and social impacts have been analysed. Using the results of the consultation, each potential impact has been qualified and is discussed below.

5.1 Economic impact

The i2010 initiative recognises ICT as a driver for productivity. The benefits from ICT stem directly from investment in ICT, a fast growing and innovative ICT sector, and indirectly from improvements in business processes through a wider use of these technologies across the economy. The IP protocol is used in the lower layers of the Internet and as such, impacts most of the applications making use of the Internet. The integration of IPv6 is then likely to largely impact the ICT sectors which in turn will impact on the EU economy as a whole.

5.1.1 Direct costs of IPv6 adoption

As with any integration of a new technology, there will be costs to pay for the transition. These costs will be at first incurred by" backbone" operators and Internet Service Providers, as the infrastructure (hardware and software) has to be IPv6 compliant and the staff trained to handle IPv6 specificities. Nevertheless, most of the equipment and software now integrate IPv6 in their latest releases and the ISP networks are becoming IPv6 compliant within the normal renewal circle. Options 2 allows infrastructure upgrade to be pursued within this normal renewal circle while option 3, asking for a fixed transition date may oblige ISP to replace not yet fully depreciated material, which would increase the transition costs. In the case of Option 1, the market may understand the IPv4 address exhaustion issue and may be willing to start integrating IPv6 from now on. However, the limited IPv6 deployment observed today shows that up to now this has not been the case, Option 1 could lead to higher costs with than Option 3 being potentially the most costly the longer the decision is deferred. . The same considerations would apply to staff training as well as a smaller difference between the options, most of the staff having to gain the required IPv6 expertise.

The maintenance of a dual-stack v4/v6 network will impose extra costs and the longer the transition lasts, the greater the associated cumulated costs will be. These costs cannot be avoided but can be diminished by shortening the transition period as much as possible. While options 2 and 3 are expected to shorten the transition period by encouraging a global move, Option 1 would be risk extending the transition phase, increasing the associated maintenance costs. Moreover, the transition period is said to be more sensitive to potential security holes than a pure IPv4 or IPv6 network which impacts directly on the competitiveness o the industry.[20].

There is no solution for IPv6 integration that will be a no-cost operation (Figure 3). Nevertheless, for most of the European users (industry, research, industrial …) there is not an urgent need to move their whole infrastructure to IPv6, while a v4/v6 gateway would allow connecting ion to an IPv6 network while still pursuing the internal activities over IPv4. It would not make sense to upgrade all IP connected equipment, such as printers, to be IPv6 compliant. But to minimize the need of incremental investment, when they do need to migrate, organisations should ensure that any IT purchasing made from now is IPv6 compliant or is supported by a strong IPv6 roadmap [11].

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[20] As an example, the worldwide cost of malware attacks has been estimated at €9.5 billion [30]

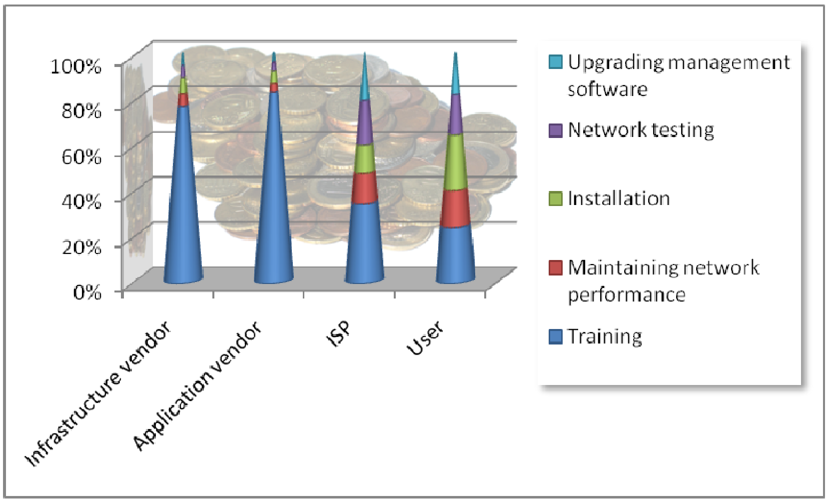

FIGURE 3: EXPECTED COST BREAKDOWN OVER TYPE OF BUSINESS [31, 32, 33]

5.1.2 Economic benefits of IPv6 adoption

The direct benefit of an IPv6 is to guarantee the **business-continuity** of European Organisations. The i2010 Communication underlines that during the second half of the 1990s, ICT investments and technical progress in the production of ICT goods and services, accounted for about 40% of EU labour productivity growth. A breakdown in the ICT business continuity by insufficient pooling of the IP address elementary resources would lead to a global slowing down of European labour productivity [35].

In the short term, if European IPv6 adoption were to be delayed, companies specialized in IPv6 products/services could miss out on market opportunities in Europe and worldwide and existing and potential clients may be willing to move towards regions that are more IPv6 friendly. In the long-run, with the exhaustion of IPv4 addresses and the move to IPv6 of other worldwide regions, Europe could further suffer more from this delay as it would have to re-import the expertise. This applies mainly to IT companies but other sectors that have already developed new applications and services based on IPv6 could also be affected.

Furthermore, being a **first-mover** may create barriers to new entrants or at least influence the decisions of other organisations [32]. The first moving region will then have the capacity to build a worldwide leadership in the inevitable move towards IPv6, thus reinforcing it's competitiveness internationally. This consideration mostly applies to IT companies but due to the pervasive aspect of the Internet, may impact on the whole of the European economy.

The second point concerns the competition in the internal market. Options 2 and 3 clearly support the prevention of rising Internet access prices as a result of an IPv4 address shortage. Choosing option 1 will not change this outcome and will keep the European market in its current state while the other options open up possibilities for new services and processes in European businesses.

The i2010 initiative recognizes that Europe has to make efforts in financing the EU ICT R&D, compared to some countries such as the US for whom, ICT account for 30% of R&D. Moreover, services have been identified to account for two thirds of employment and value creation [18] and IT services represent a market forecast to exceed $730 billion in 2007 [19].

Option 2 and 3 will encourage research in IPv6 and in the new services that can be developed as a result. They will promote academic and industrial research and in the long term they will facilitate the introduction and dissemination of new technologies and products. Choosing either option 2 or 3 will maintain this investment and increase the industrial part as the real move to market of IPv6 is observed. This R&D activity would not focus on the IPv6 protocol itself but rather on integration opportunities within other sectors (transportation, entertainment …)

If nothing is done as outlined in option 1, research in this field will probably slow down and therefore stop the innovation cycle of IPv6 in Europe. IPv6 R&D will be outsourced to countries that are a step ahead (Asia) and Europe will only benefit later from the new products based on this protocol. Competing protocols are already under research or developed in many sectors (Fastnet for automobile, Zigbee in home control industry…). IPv6 can be seen as a product in a competitive market. If IPv6 is not adopted, innovation will be supported by other standards, at a risk of reducing the system's interoperability and limiting the convergence of technologies, infrastructures and applications which would turn into an under-stimulation of new converging services innovations.

Internet is not just a European issue, it affects the world in a global way and Europe has to pay attention to other actor's policies. Indeed, the consequences on relationships, trade exchanges and foreign policies have also to be taken into account. It has been repeated that Asia (Korea, Japan, and China) is pro active concerning IPv6. China has widely recognised its need for a large address space, far beyond IPv4 capabilities, and Korea is engaged in an aggressive move for the deployment of a ubiquitous network. At this time, IPv6 networks are islands in oceans of IPv4 but with the massive adoption of IPv6 in Asia, the situation could be reversed and if nothing is done, Europe could be an island of IPv4 in oceans of IPV6 communications. This is not a problem as long as applications are dual stack. If Asia develops specific applications for IPV6 networks, the delay accumulated by European countries will restrict them at different levels: trade, foreign policy…

This is also true for the strong relationships that Europe has got with African and South American countries. Universities in these countries are deploying networks with IPv6 as they do not have enough IPv4 address space and therefore are anticipating the transition towards IPv6. Joint research can be more difficult to implement at the network level if Europe remains at the IPv4 stage.

Finally, an incentive for ISP to integrate the IPv6 technology may be the adoption in some countries of laws obliging them to record, for one year, all information concerning the Internet user to be identified. Recording such information in a network making intensive use of NAT will largely increase ISP operational costs whereas the use of public addresses will greatly simplify the operation. This concern has been raised during the interviews by mobile operators.

In conclusion, the IPv6 integration cannot be avoided and the costs associated with such a transition will not be avoided either. Nevertheless depending on the chosen option, the global cost may differ:

- Option 1 will not have repercussions in the short term but could lead to negative ones in the mid-term and long term. Indeed, competitiveness, operations and global policies will suffer from a forced adoption as a result of the exhaustion of IPv4 addresses. Moreover, a late move will force new investments to be made hurriedly, leading to not yet depreciated material being renewed. Finally, this scenario is the one in which the v4/v6 transition phase is will last the longest, thus increasing the maintenance cost of a dual-stack architecture and raising the potential security risks associated with such a dual-stack system.

- Option 2 by promoting a smooth integration will keep Europe at the same pace as other parts of the world in terms of innovation and competitiveness. Transition costs will be made within the normal depreciation circle and the launch of a larger range of activities will limit security risks.
- Option 3 will bring higher costs in the short term due to the material replacement but Europe would benefit in economic terms in the long run from such a decision.

No credible evaluation of IPv6 integration costs has yet been made. Nevertheless there are two factors which help when considering the options:

- The acceleration of IPv6 integration within a timeframe shorter than the depreciation cycle (5 years) of IT goods will lead to an increase of 285% of the Present Value of Integration costs [31]
- Independent Software Vendors relate that dealing with the NAT technology increases the software development cost from 10% to 30%.

So whatever is the real cost of IPv6, the Net Present Value (NPV) of its integration will favour Option 2.

The Present value to integrate IPv6 has been evaluated as €25 billion [31], which represents 0.14% of the European Gross Domestic Product (GDP).

5.2 Social impacts

The adoption of IPv6 impacts the common availability of Internet public addresses. Such addresses are required to support the further deployment of the Internet and to reduce the digital divide [36]. IPv4 address exhaustion can restrict equal access to the Internet and hence to goods and services. This phenomenon can lead to an increase in price for Internet access thus increasing the digital divide and limiting opportunities. In options 2 and 3, it would be assumed that the consumer will have a better awareness concerning the ISP and the IP address. However, integrating IPv6 will not in itself improve access to broadband connection but the deployment of new networks should be seen as an opportunity to become IPv6 compliant.

Others have also been identified:

- Concerning the rights related to job quality, options 2 and 3 facilitate the use of technological innovations in the workplace by promoting end-to-end communication and by enhancing innovation.
- New citizen-centric services could be added in the case of integration (option 2 and 3). E-government is at stake in Europe in order to limit public money sending and to give a better quality of service to every European citizen. European projects are done in this way (i-2010) and Asian examples such as the Korean policy for ubiquitous network for an e-government or Japanese trials for remote services are promising.
- The development of solutions using IPv6 multicast or end-to-end communication feature can encourage freedom of speech and the content creation in Europe. Option 3 and in a more reasonable way option 2, will allow Europeans to create, for example, their own TV channels from home. Digital Right Management will be questioned too.

- Concerning disaster prevention and management, development of solutions based on the web2.0 and IPv6 could improve crime control (there are examples of cities in Japan that are monitored by security systems using IPv6). Regarding the security of the overall network, IPSec[21] is a feature that is natively embedded in IPv6. Returning to the end-to-end communication paradigm without NAT could create a more efficient network security control. Military services are considering using IPv6 which is an indication of the confidence in this protocol.

- Finally, the educational system can benefit in the long-term, from new services developed with IPv6 (for example student-to-student communication). Once again, this is not a direct result of IPv6 integration. Options 2 and 3 will allow universities and schools to use IPv6 in their development while option 1 will limit the development of educational networks.

5.3 Environmental impact

Any of these options will have a limited effect on the environment. Nevertheless, there will be some potential contributions to energy savings and environment protection which are worth mentioning. Choosing to use IPv6 over IPv4 can reduce the consumption of electrical power in a cell phone as the removal of NAT will limit the use of “keep-alive” signalling for always-on applications [26].

IPv6 derivatives such as the 6LoWPAN[22] include an energy saving consideration [27] and allow the use of the IP technology at energetic costs comparable with other Wireless Sensor Networking Technologies.

New applications whose deployment would be facilitated by the use of the IPv6 protocol, compared to other alternatives, have demonstrated they could contribute positively to the environment.

- ***Energy management in buildings***: sensor networks developed in IPv6 technology that allows better management of energy in public or private buildings (control of the lightening, control of the heating, control of the elevators). For examples in Japan, the Tokyo Metropolitan Art Museum and the Tokyo Art Space have shown a reduction of energy consumption of around 5% [28].
- ***Road traffic management***: infrastructure to car communication systems is quite promising for road traffic management and hence the reduction of traffic jams and fuel consumption. Traffic delays account for 1.3 billion litres of wasted fuel annually across the USA [29].
- ***Risk detection and prevention***: IPv6 can be used for global monitoring and disaster management (seismic activity,, volcanic eruptions, landslides and avalanches, floods and storms, forest fires…) disaster prevention, environmental problems (air and sea pollution …) including the management of on site rescue people (firemen, doctors, …). European projects such as u-2010 are looking at the use of IPv6 for some of the developed applications.

[21] IP Security

[22] IPv6 over IEEE802.15.4 (a.k.a. 6LoWPAN) is a communication network for limited power and relaxed throughput requirements. It comprises devices that conform to the IEEE 802.15.4-2003 standard and are characterized by short range, low bit rate, low power and low cost. These devices work together to connect the physical environment to real-world applications, e.g., wireless sensors. 6LoWPAN uses IPv6 as the networking technology.

In conclusion, IPV6 itself is not expected to largely contribute to the renewed sustainable development strategy. Nevertheless, it would facilitate the deployment of applications in this area. Option 1 will leave the decisions to local or regional project managers whereas the two other options will force or encourage them to think about an integration of such technologies in their day-to-day activities.

6 Comparing the options

Three options have been analysed in detail from a list of 119 possible impacts divided into sub-levels of economic, social and environmental indicators The results of the survey to assess the impact of Ipv6 adoption have been evaluated qualitatively on a five point scale, , ranging from really negative to really positive impact.

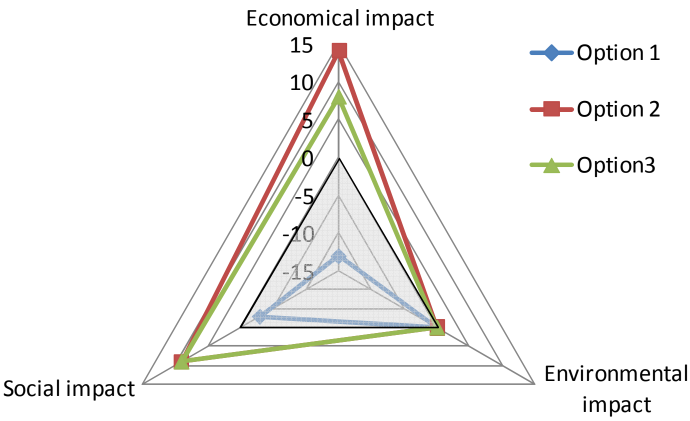

FIGURE 4: QUALITATIVE ANALYSIS OF POLICY OPTIONS IMPACTS.

The results give a qualitative overview of the number of foreseen impacts depending on the chosen option.

This simple analysis shows that the 'Do nothing more than today' scenario is the only one that gives a negative result.

Options 1 and 2 are comparable on both social and economical aspects, the difference between the two options for economic impact being too small to be considered within this type of analysis.

Comparing options 2 and 3 in detail shows that accelerating the adoption using option 3 would lead to increased costs resulting from infrastructure updates undertaken outside of the normal depreciation/renewal circle. Furthermore,, due to its larger scope, option 2 is expected to have more positive impacts than option 3.

The option of supporting the transition through the deployment of "soft" measures that push for integration by leveraging existing R&D and supporting the competitiveness of European firms. This option will generate marginal additional costs for businesses while opening new windows of opportunities. On a global scale, being proactive, Europe will stay among IT leaders and this option is the one recommended.

7 Conclusion

The shortage of available public addresses is an inevitable result of the 4th version of the Internet Protocol. For years, experts have widely disagreed on the date at which the address shortfall will occur, but now there is a broad consensus that predicts exhaustion by 2011-2012. These estimates are based on forecasts of current consumption figures.

A large majority of the fifteen sectors analysed have indicated that they are actively considering IPv6 as a natural protocol to support their future applications. But a general concern about IPv6 connectivity availability is also forcing them to consider alternative technologies. For most of the sectors interviewed, these new services would target millions of new users and operational launches are expected to start by 2010-2012. This is likely to increase the pressure on the IP public addresses consumption and a insufficient availability of such addresses would limit the take-up of interoperable ICT-enabled solutions.

Considerable efforts have been made in the past year, Europe still has the opportunity to be a leader in this field but recent announcements by US federal agencies and Chinese government are increasing the pressure.

Among the options analysed, the one aimed at supporting the IPv6 adoption in Europe through a set of “soft” measures is the one which is likely to bring the greatest benefits for Europe at economic, social and environmental levels. These actions should address: common IPv6 connectivity availability, awareness of IT managers, network security during the integration, availability of a sufficient pool of trained people and proper exploitation of European expertise.

Immediate consideration of Ipv6 integration has to be undertaken as this is the only way to minimize the costs associated with this activity and to facilitate the smooth transition of this integration tackling the key issue of the address shortfall.

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