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Subject:	Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Advancing the Internet Action Plan for the deployment of Internet Protocol version 6 (IPv6) in Europe

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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMITTEE OF THE REGIONS

ADVANCING THE INTERNET
Action Plan for the deployment of Internet Protocol version 6 (IPv6) in Europe

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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMITTEE OF THE REGIONS

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Action Plan for the deployment of Internet Protocol version 6 (IPv6) in Europe

1. OBJECTIVE

It is the objective of this Action Plan to support the widespread introduction of the next version of the Internet Protocol (IPv6) because

- Timely implementation of IPv6 is required as the pool of IP addresses provided by the current protocol version 4 is being depleted

- IPv6 with its huge address space provides a platform for innovation in IP based services and applications

2. RATIONALE FOR ACTION

2.1. Preparing for the growth in Internet usage and for future innovation

One common element of the Internet architecture is the "Internet Protocol" (IP) which in essence gives any device or good connecting to the Internet a number, an address, so that it can communicate with other devices and/or goods. This address should generally be unique, to ensure global connectivity. The current version, IPv4, already provides for more than 4 billion such addresses.[1] Even this, however, will not be enough to keep pace with the continuing growth of the Internet. Being aware of this long-term problem the Internet community developed an upgraded protocol, IPv6, which has been gradually deployed since the late 90s.[2]

In a previous Communication on IPv6[3] the European Commission made the case for the early adoption of this protocol in Europe. This Communication has been successful in establishing IPv6 Task Forces[4], enabling IPv6 on research networks, supporting standards, and setting-up training actions. Following the Communication more than 30 European R&D projects related to IPv6 were financed. Europe has now a large pool of experts with experience in IPv6 deployment. Yet despite the progress made, adoption of the new protocol has remained slow while the issue of future IP address scarcity is becoming more urgent.

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[1] IPv4 is specified in RFC 791, 1981. RFC stands for "Request for Comments" See the "Internet Engineering Task Force" (IETF); http://www.ietf.org

[2] RFC 2460, 1998. http://www.ietf.org/html.charters/OLD/ipv6-charter.html and http://www.ietf.org/html.charters/6man-charter.html

[3] COM(2002) 96 "Next Generation Internet – priorities for action in migrating to the new Internet protocol IPv6". ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/ipv6-communication_en.pdf

[4] such as http://www.ipv6tf.org

2.2. Maintaining Europe's competitiveness

It is now time to reinforce the actions taken. Otherwise there is a risk that many actors will not be prepared in time to keep pace with an accelerating deployment of IPv6. Taking no action could also lead to a further delay of IPv6 adoption with disadvantages for all users and a weaker competitive position of Europe's industry.

This Communication analyses the present-day situation and sets out a number of actions to achieve widespread IPv6 implementation in Europe by 2010.

2.3. Contributing to the Lisbon Strategy

This Action Plan is part of the Lisbon Strategy as implemented in the i2010 initiative[5]. It will contribute to the assessment of the performance of the EU in the Internet economy and its readiness to face future challenges foreseen for the Spring Council in 2009.

3. THE CURRENT SITUATION

3.1. Increasing scarcity of IPv4 addresses: a difficulty for users, an obstacle to innovation

Initially all Internet addresses are effectively held by the "Internet Assigned Numbers Authority" (IANA)[6] and then large blocks of addresses are allocated to the five Regional Internet Registries (RIRs)[7] which in turn allocate them in smaller blocks to those who need them, including Internet Service Providers (ISPs). The allocation, from IANA to RIR to ISP, is carried out on the basis of demonstrated need: there is no pre-allocation.

The address space of IPv4 has been used up to a considerable extent. At the end of January 2008 about 16% was left in the IANA pool, i.e. approximately 700 million IPv4 addresses. There are widely quoted and regularly updated estimates which forecast the exhaustion of the unallocated IANA pool somewhere between 2010 and 2011.[8] New end-users will still be able to get addresses from their ISP for some time after these dates but with increasing difficulty.

Even when IPv4 addresses can no longer be allocated by IANA or the RIRs the Internet will not stop working: the addresses already assigned can and most probably will be used for a significant time to come. Yet the growth and also the capacity for innovation in IP-based networks would be hindered without an appropriate solution. How to deal with this transition is currently the subject of discussion in the Internet

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[5] COM(2005) 229 final "i2010 – A European Information Society for growth and employment"
[6] IANA is a function currently fulfilled by ICANN: Internet Corporation for Assigned Names and Numbers; http://www.icann.org/general/iana-contract-17mar03.htm
[7] AfriNIC (for Africa), APNIC (for the Asia/Pacific region), ARIN (North America and the Caribbean), LACNIC (Latin America) and RIPE NCC (Europe, the Middle East and parts of central Asia).
[8] http://www.potaroo.net/tools/ipv4/index.html
http://www.tndh.net/~tony/ietf/ipv4-pool-combined-view.pdf
For an earlier estimate which contains a description of the analytical background:
http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_8-3/ipv4.html

community in general, and within and amongst the RIR communities in particular. All RIRs have recently issued public statements and have urged the adoption of IPv6.

3.2.   IPv4 is only a short term solution leading to more complexity

Concerns about the future scarcity of IP addresses are not a recent phenomenon. In the early days of the Internet, before the establishment of the RIRs and before the take-off of the World-Wide Web, addresses were assigned rather generously. There was a danger of running out of addresses very quickly. Therefore changes in allocation policy and in technology were introduced which allowed allocation to be more aligned to actual need.

One key IPv4 technology has been "Network Address Translation" (NAT)[9]. NATs connect a private (home or corporate) network which uses private addresses to the public Internet where public IP addresses are required. Private addresses come from a particular part of the address space reserved for that purpose. The NAT device acts as a form of gateway between the private network and the public Internet by translating the private addresses into public addresses. This method therefore reduces consumption of IPv4 addresses. However the usage of NATs has two main drawbacks, namely:

- It hinders direct device-to-device communication: intermediate systems are required to allow devices or goods with private addresses to communicate across the public Internet.

- It adds a layer of complexity in that there are effectively two distinct classes of computers: those with a public address and those with a private address. This often increases costs for the design and maintenance of networks as well as for the development of applications.

Some other measures could extend the availability of IPv4 addresses. A market to trade IPv4 addresses might emerge which would offer incentives to organisations to sell addresses they are not using. However IP addresses are not strictly property. They need to be globally acceptable to be globally routable which a seller cannot always guarantee. In addition they could become a highly priced resource. So far RIRs have been sceptical about the emergence of such a secondary market.

Another option consists of trying to actively reclaim those already-allocated address blocks that are under-utilised. However, there is no apparent mechanism for enforcing the return of such addresses. The possible cost of it has to be balanced against the additional lifetime this would bring to the IANA pool. [10]

Though such measures may provide some interim respite, sooner or later the demand for IP addresses will be too large to be satisfied by the global IPv4 space. Efforts to stay with IPv4 too long risk increasing unnecessary complexity and fragmentation of the global Internet. A timely introduction of IPv6 is thus the better strategy.

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[9]   RFC 2663, 1994
[10]   The release of a block of the size currently allocated by IANA to an RIR would only delay the end-date by about three weeks.

3.3. IPv6: the best way forward

IPv6 provides a straightforward and long term solution to the address space problem. The number of addresses defined by the IPv6 protocol is huge[11]. IPv6 allows every citizen, every network operator (including those moving to all IP-"Next Generation Networks"), and every organisation in the world to have as many IP addresses as they need to connect every conceivable device or good directly to the global Internet.

IPv6 was also designed to facilitate features which were felt to be missing in IPv4. Those features included quality of service, auto-configuration, security, and mobility. In the meantime, however, most of those features have been engineered in and around the original v4 protocol. It is the large address space that makes IPv6 attractive for future applications as this will simplify their design compared to IPv4.

The benefits of IPv6 are, therefore, most obviously apparent whenever a large number of devices or goods need to be easily networked, and made potentially visible and directly reachable over the Internet. A study funded by the Commission demonstrated this potential for a number of market sectors[12] such as home networks, building management, mobile communication, defence and security sector, and car industry.

Prompt and efficient adoption of IPv6 offers Europe potential for innovation and leadership in advancing the Internet. Other regions, in particular the Asian region, have already taken a strong interest in IPv6. For instance the Japanese consumer electronics industry increasingly develops IP enabled products and exclusively for IPv6. The European industry should therefore be ready to meet future demand for IPv6-based services, applications, and devices and so secure a competitive advantage in world markets.

To conclude, the key advantage of IPv6 over IPv4 is the huge, more easily managed address space. This solves the future problem of address availability now and for a long time to come. It provides a basis for innovation - developing and deploying services and applications which may be too complicated or too costly in an IPv4 environment. It also empowers users, allowing them to have their own network connected to the Internet.

3.4. What needs to be done?

IPv6 is not directly interoperable with IPv4. IPv6 and IPv4 devices can only communicate with each other using application specific gateways. They do not provide a general future-proof solution for transparent interoperability.

However IPv6 can be enabled in parallel with IPv4 on the same device and on the same physical network. There will be a transition phase (expected to last for 10, 20 or even more years) when IPv4 and IPv6 will co-exist on the same machines (technically often referred to as "dual stack") and be transmitted over the same network links. In addition other standards and technologies (technically referred to as

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[11] The number is 3.4 times 10^{38}.
[12] "Impact of IPv6 on Vertical Markets", October 2007.
http://ec.europa.eu/information_society/policy/ipv6/docs/short-report_en.pdf

"tunnelling") allow IPv6 packets to be transmitted using IPv4 addressing and routing mechanisms and ultimately vice versa.[13] This provides the technical basis for the step-by-step introduction of IPv6.

Because of the universal character of the Internet Protocol, deployment of IPv6 requires the attention of many actors worldwide. The relevant stakeholders in this process are:

- **Internet organisations** (such as ICANN, RIRs, and IETF), which need to manage common IPv6 resources and services (allocate IPv6 addresses, operate domain name system (DNS) servers, etc), and continue to develop needed standards and specifications.
  As of May 2008 the regional distribution of allocated IPv6 addresses is concentrated on Europe (RIPE 49%) with Asia and North America growing fast (APNIC: 24%, ARIN: 20%).[14] Less than half of those addresses are currently being announced on the public Internet (i.e. visible in the default-free routing table).
  In the DNS the root and top-level name servers are increasingly becoming IPv6 enabled. For instance, the gradual introduction of IPv6 connectivity to .eu name servers will begin in 2008.

- **ISPs,** which need over time to offer IPv6 connectivity and IPv6 based services to customers.
  There is evidence that less than half of the ISPs offer some kind of IPv6 interconnectivity. Only a few ISPs have a standard offer for IPv6 customer access service (mainly for business users) and provide IPv6 addresses.[15] The percentage of "Autonomous Systems" (typically ISPs and large end-users) that operate IPv6 is estimated at 2.5%.[16]
  Accordingly, IPv6 traffic seems to be relatively low. Typically the IPv6/v4 ratio is less than 0.1% at Internet Exchange Points (of which about one in five supports IPv6).[17] However, this omits direct ISP to ISP traffic and IPv6 which is "tunnelled" and so appears at first glance to be still IPv4. Recent measurements suggest that this kind of traffic IPv6 which is "tunnelled" is growing.

- **Infrastructure vendors** (such as network equipment, operating systems, network application software), which need to integrate IPv6 capability into their products. Many equipment and software vendors have upgraded their products to include IPv6.[18] However there are still issues with certain functions and performance, and

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[13] See RFCs 2893, 3056, 4214, 4380
[14] http://www.ripe.net/rs/ipv6/stats/index.html
[15] http://www.sixxs.net/faq/connectivity/?faq=ipv6transit
      http://www.sixxs.net/faq/connectivity/?faq=native
[16] http://bgp.he.net/ipv6-progress-report.cgi
[17] Traffic analysis at Amsterdam Internet Exchange reveals for the first 10 months 2007 average daily IP traffic of 177 Gbs; of which IPv6 traffic is 47 Mbs, i.e. 0.03%. http://www.ripe.net/ripe/meetings/ripe-55/presentations/steenman-ipv6.pdf
[18] http://www.ipv6-to-standard.org/
      There is also a programme of the IPv6 Forum which defines an optional IPv6 Ready Logo.
      http://www.ipv6ready.org/pdf/IPv6_Ready_Logo_White_Paper_Final.pdf
      http://www.ipv6ready.org/logo_db/approved_list_p2.php
      http://www.ipv6ready.org/logo_db/approved_list.php

vendor support equivalent to IPv4

The installed equipment base of consumers, such as small routers and home modems to access the Internet, still by and large do not yet support IPv6.

- **Content and service providers** (such as websites, instant messaging, e-mail, file-sharing, voice over IP), which need to be reachable by enabling IPv6 on their servers.

  Worldwide there are only very few IPv6 websites. Almost none of the global top sites offer an IPv6 version. The de-facto non-existence of IPv6 reachable content and services on the Internet is a major obstacle in the take-up of the new protocol.

- **Business and consumer application vendors** (such as business software, smart cards, peer-to-peer software, transport systems, sensor networks), which need to ensure that their solutions are IPv6 compatible and increasingly need to develop products and offer services that take advantage of IPv6 features. Today there are few if any current applications that are exclusively built on IPv6. One expectation has been that proliferation of IP as the dominant network protocol would drive IPv6 into new areas such as logistics and traffic management, mobile communication, and environment monitoring which has not taken place to any significant degree yet.

- **End-users** (consumers, companies, academia, and public administrations), which need to purchase IPv6 capable products and services and to enable IPv6 on their own networks or home Internet access.

  Many home end-users, without being aware of it, operate IPv6 capable equipment and yet as a result of missing applications without necessarily making use of it. Companies and public administrations are cautious to make changes to a functioning network without a clear need. Therefore there is not much user deployment in private networks visible.

  Among the early adopters have been universities and research institutions. All EU national research and education networks also operate on IPv6. The European Géant network[19] is IPv6 enabled, whereby approximately 1% of its traffic is native IPv6.

How much and which efforts are required to adopt IPv6 differ amongst actors and depend on each individual case. Therefore it is practically impossible to reliably estimate the aggregated costs to introduce IPv6 globally.[20] Experience and learning from projects have shown that costs can be kept under control when deployment is gradual and planned ahead. It is recommended introducing IPv6 step-by-step, possibly in connection with hardware and software upgrades, organisational changes, and training measures (at first glance unrelated to IPv6). This requires a general awareness within the organisation in order not to miss those synergies. The costs will be significantly higher when IPv6 is introduced as a separate project and under time constraints.

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[19] Géant is the pan-European communication network connecting 30 million research and education users across Europe and beyond. http://www.geant.net/

[20] One study has made an attempt and estimated the transition costs for the US economy over a period of 25 years at about 25 billion (2003 constant) US Dollar but it raises a number of methodological questions: http://www.nist.gov/director/prog-ofc/report05-2.pdf

Introduction of IPv6 will take place alongside the existing IPv4 networks. Standards and technology allow for a steady incremental adoption of IPv6 by the various stakeholders which will help to keep costs under control. Users can use IPv6 applications and generate IPv6 traffic without waiting for their ISP to offer IPv6 connectivity. ISPs can increase their IPv6 capability and offer this in line with perceived demand.

3.5. The need for policy driving at European level

Today, for most stakeholders the advantages of adopting IPv6 are not immediately visible. The benefits are long-term and also depend on other stakeholder's decisions on when and how to implement IPv6.

The more users work with IPv6 the more attractive it becomes for others to do the same. As the number of users increases more products and services will be offered at lower prices and better quality. The collective knowledge about IPv6 operation and management will also increase. The result will be an eco-system of suppliers and service providers re-enforcing each other, boosting confidence, and accelerating deployment. However similar market forces apply to IPv4 where this eco-system has been in place for many years resulting in a large legacy of appliances and applications.

A collective movement to implement IPv6 is difficult to trigger as stakeholders cannot easily take into account others' decisions. There is no single authority to steer IPv6 introduction or to establish a co-ordinated master plan. Thus roll-out of IPv6 is largely a decentralised and market driven process on a global scale. In this situation many stakeholders have taken a "wait and see" position on IPv6 or opted for a "safe and known" IPv4 solution. The cumulative result has been the described delay in the widespread adoption of IPv6. This is a situation where appropriate policy measures could give a market stimulus by encouraging people and organisations to consider moving ahead positively. Those measures will be more effective when taken collectively at European level.

4. ACTIONS: IPV6 TO BECOME WIDELY IMPLEMENTED IN EUROPE BY 2010

Europe should set itself the objective to widely implement IPv6 by 2010. Concretely speaking at least 25% of users should be able to connect to the IPv6 Internet and to access their most important content and service providers without noticing a major difference compared to IPv4.

4.1. Actions to stimulate IPv6 accessibility to content, services, and applications

- The Commission will work with Member States to enable IPv6 on public sector websites and eGovernment services. To this end common deployment objectives should be agreed. The use of available instruments such as the i2010 eGovernment Action Plan and the IDABC Programme[21] will be envisaged. For its

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[21] Interoperable Delivery of European eGovernment Services to public Administrations Programme. http://ec.europa.eu/idabc/en/document/5101/3

part the Commission will make the "Europa" and "CORDIS" websites IPv6 accessible by 2010.

- The Commission calls upon content and service providers to make their offer IPv6 accessible by 2010, amongst them the top 100 European web sites. It intends to facilitate this co-operation through ''Thematic Networks'' involving vendors, ISPs, and content and service providers, as part of the Competitiveness and Innovation Programme (CIP).

- The Commission calls upon industrial stakeholders that are now embracing IP technology in their core business to consider IPv6 as their primary platform for developing applications or appliances (such as sensors, cameras etc). In this context the Commission envisages supporting the testing and validation of IPv6 related applications in trials, funded as part of the CIP beginning in 2009.

- The Commission has provided financial aid through standardisation support actions to improve interoperability of networks. In this context, the Commission is willing to support standardisation actions on protocols running over IPv6 networks (e.g. SIP – Session Initiation Protocol). Furthermore, the Commission calls on the European Standardisation Organisations to develop best practices manuals on the deployment of internet IPv6-enabled services.

- The Commission will encourage research projects funded by Framework Programme 7and facing a choice of computer network protocol, to utilise IPv6 whenever possible.

4.2. Actions to generate demand for IPv6 connectivity and products through public procurement

In a public consultation[22] the use of public procurement was identified as an efficient way to speed up the transition to IPv6. For example in 2005, the US Government directed all federal government agencies to migrate their core backbone networks to IPv6 by mid 2008[23].

- The Commission encourages Member States to prepare for IPv6 within their own networks and when renewing their external network services contracts ensure that these also include provisions for IPv6 connectivity, and that all equipment procured is IPv6 capable. The Commission will bring together IT managers from Member States to exchange experience and to monitor progress.

- The Commission will equally specify IPv6 capabilities as a core requirement for the continuous renewal cycle of its own network equipment and services. It will carry out timely and appropriate internal trials and projects to prepare for IPv6.

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[22] Public Consultation held in February 2006 ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/ipv6-public-consultation-report_en.pdf

[23] OMB Memorandum 05-22, "Transition Planning for Internet Protocol Version 6 (IPv6)," http://www.whitehouse.gov/omb/memoranda/fy2005/m05-22.pdf, 2 August 2005

4.3. Actions to ensure timely preparation for IPv6 deployment

The transition to IPv6 will take some time and will require operating a dual IPv4/IPv6 network, bringing up specific issues to be resolved. All actors will need to prepare themselves for developing and deploying IPv6 compliant solutions; the sooner the better. Organisations should not wait for their ISPs to provide native IPv6 connectivity but should begin to enable the protocol on their own network.

- The Commission will undertake targeted awareness campaigns to various user groups. Such actions are best conducted in public-private partnerships and in co-operation with Member States.

- The Commission intends to support "specific support actions" (within Framework Programme 7) to disseminate practical deployment knowledge.

- The Commission encourages ISPs to provide full IPv6 connectivity to their customers by 2010 and where applicable to upgrade the equipment they supply to consumers.

- The Commission invites Member States to support the inclusion of IPv6 technology knowledge in relevant retraining curricula and in computer and network engineering courses of universities etc. The Commission will launch an accompanying study and intends to organize a conference in 2009.

4.4. Actions to tackle security and privacy issues

Security issues in IPv6 are not better or worse than in IPv4, they are just different. In a dual IPv4/v6 environment security issues could become complex to deal with in terms of implementation and configuration.[24]

The Court of Justice has recognised that an IP address may be considered as personal data falling within the scope of the Data Protection directives[25]. Some concerns have been expressed about IPv6 and privacy, in particular by the Article 29 Data Protection Working Party.[26] One particular concern has been taken up in a standard. However the situation needs to be monitored when it comes to configuration and actual implementation.

- The Commission will disseminate best practices and will work with vendors to provide full IPv6 functionality. Where necessary the Commission will call upon the expertise of the European Network and Information Security Agency, ENISA, to support these efforts.

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[24] http://www.ipv6forum.com/dl/white/NAv6TF_Security_Report.pdf

[25] Case C-275/06, Promusicae vs. Telefonica, judgment of 29 January 2008, paragraph 45. Directives 95/46/EC and 2002/58/EC.

[26] Opinion 2/2002 on the use of unique identifiers in telecommunication terminal equipments: the example of IPV6. http://ec.europa.eu/justice_home/fsj/privacy/docs/wpdocs/2002/wp58_en.pdf. The problem was that for ease of configuration parts of an IPv6 address came from the interface identifier (the Ethernet MAC address). The solution was to allow machines to generate part of the address at random, see RFC 4941.

- The Commission will monitor the privacy and security implications of widespread IPv6 deployment, in particular through consultation with stakeholders such as data protection authorities or law enforcement.

5. **EXECUTION OF THE ACTION PLAN**

This Action Plan is scheduled to be executed over the next 3 years. The Commission will monitor the adoption of IPv6; in particular it will carry out an implementation test to measure the degree of IPv6 availability and functionality for users in Europe.

The Commission will continue to follow the activities of the Internet organisations, such as the ongoing debate about IPv4 distribution policies within the registries communities, and where necessary make contributions.

The Commission will regularly report progress to the i2010 High Level Group. It will also make available progress reports on its Website and by other appropriate means.

In 2010 the Commission will conduct a review to decide if any follow-up actions are required.