

IPv6: Status Around the World

1. Introduction

From July 1999, we have the right to say that IPv6 isn't a theory, it's a FACT.

The reason is because on that date the major industry players joined together in a non profit organization, "*IPv6 Forum*", with a common mission: educate the market on the advantages of IPv6 protocol, and promote its use, to enforce its worldwide deployment.

The list of corporations involved in this project is a powerful mix, including manufacturers, Research & Development institutions, Education organizations, Telecom Operators, Consulting Companies, amongst others.

That means, of course, generating a lot of efforts, from persons to entire companies, to press the Standards Organizations for speeding up the process, to terminate the creation of a stable and complete protocol definition.

Let's us introduce the IPv6 Forum and the actual situation of the protocol around the world.

2. IPv6 Forum Constitution: The Press Release

This was the official Press Release content:

The New Internet Forum has been established: The IPv6 FORUM

Luxembourg, July 7th, 1999. A worldwide consortium of leading Internet solutions vendors, Internet service providers (ISP's) and research and education networks joined to form the IPv6 FORUM. This FORUM will have a clear mission to promote IPv6 (Internet Protocol version 6) in order to create a higher quality and more secure next generation Internet: The NEW INTERNET. The FORUM plans to dramatically improve the market and user awareness of IPv6 providing world-wide, equitable access to knowledge and technology. The FORUM will work closely with the Internet Engineering Task Force (IETF) which is responsible for the IPv6 technical specifications and to which many FORUM members contribute.

"IPv6 is here and now, so take the Internet where no other network has gone before!" comments Dr. Vint Cerf, Chairman of the Internet Societal Task Force and known as one of the fathers of the Internet.

"We've known for some years that IP version 4 was heading towards its limits, and the IETF has been working on IPv6 since 1994. Now, the basic standards are agreed and implemented, and it is time to move forward," adds Dr. Brian E. Carpenter, Chair of the IETF's Internet Architecture Board, and a Program Director in IBM's Internet Division.

"We have been very active in building a strong IPv6 infrastructure in Japan as we see immediate benefits to our economy, knowledge and education potential to our people" confirms Dr. Jun Murai, General Chairman of the WIDE IPv6 Project and Professor of KEIO University.

"Nokia believes that IPv6 is a fundamental enabler of Nokia's vision of the Mobile Information Society. Today, the number of cellular handsets already far exceeds the number of fixed Internet terminals; IPv6 is the only viable architecture that can accommodate the coming wave of Internet capable cellular devices. Nokia is eager to



contribute to the IPv6 Forum's efforts to accelerate the acceptance and deployment of IPv6 throughout the Internet." states Pekka Ala-Pietilä, President, Nokia.

"Ericsson has a clear business and technology vision about how IPv6 enables the performance and service offerings mandated by both mobile infrastructure (GPRS, UMTS), broadband networks, consumer electronics and terminals, and the interoperability/management thereof, extending therefore full support to the IPv6 Forum", emphasizes Jan Uddenfeldt, Senior VP and Technical director of L.M.Ericsson.

"The IPv6 FORUM's noble objectives will be to promote this new technology on a worldwide basis sharing knowledge, experience and interoperability and creating common grounds for the New Internet of the next millennium", states Latif Ladid, President of the IPv6 FORUM & VP at Telebit Communications.

IPv6 Forum Founding Members

Initial members of the IPv6 Forum include 42 of the top companies and institutes active in the new Internet technology, a truly international forum from day one:

Europe & Middle East (18): BT, Case Technology, Consulintel, Deutsche Telekom, CSELT, DFN, Ericsson, Eurocontrol, Gigabell, IABG, Intracom, Netmedia, Nokia, Teldat, Telebit Communications, CSELT, Telia Networks Services, Thomson-CSF Detexis.

North America(18): 3Com, Advanced Systems Consulting, AT&T, Cisco, Compaq, ESNet, Hewlett-Packard, IBM, MCI WorldCom, Mentat, Microsoft, Motorola, Qwest, SGI, Sprint, Sun, The Business Internet, Viagenie-Canarie.

Asia Pacific(6): Centre for Wireless Communications (Singapore), Hitachi, NTT, NTT Software Corporation, Trumpet Software, WIDE Japan.

For more details about the IPv6 Technology or membership in the IPv6 Forum, please visit the IPv6 FORUM Web Page: <http://www.ipv6forum.com>

We can discover, in this press release, the high level of endorsement, since the outset, for this goal, from local, international and multinational companies to key speakers in the Internet (including D. Vinton Cerf, the honorary Chairman), worldwide.

Just as a "measure" of the importance for the market of the IPv6 protocol, we can mention an anecdote, about the number of members in the constitution of the Forum. We have reached 42 founding members in a few weeks of work, while some years ago, the ISDN Forum took more than 2 years to reach the same number of players! It goes without saying, as a comparative, the importance that ISDN technology has played over the last years in the worldwide telecom market.

3. IPv6 Forum Members

The actual status of the IPv6 Forum Members, dated on December 1, 1999, is of 69 companies/organizations:

- 1 - Case Technology - UAE
- 2 - Thomson-CSF Detexis - France
- 3 - Ericsson Telebit - Denmark
- 4 - Eurocontrol - France
- 5 - Gigabell - Germany
- 6 - Hitachi - Japan
- 7 - Hewlett-Packard - US
- 8 - DFN - Germany
- 9 - Canarie-Viagenie - Canada
- 10- NTT - Japan
- 11- WIDE - Japan

- 12- BT - UK
- 13- CSELT - Italy
- 14- Mentat - US
- 15- SUN - US
- 16- Netmedia - Finland
- 17- Trumpet Software - Australia
- 18- Intracom - Greece
- 19- Cisco - US
- 20- COMPAQ - US
- 21- SPRINT - US
- 22- NOKIA - US
- 23- AT&T - US
- 24- Teldat - Spain
- 25- Deutsche Telekom - Germany
- 26- Qwest - US
- 27- IABG - Germany
- 28- ESnet-6REN - US
- 29- MCI WorldCom - US
- 30- Ericsson - Sweden
- 31- Microsoft - US
- 32- 3Com - US
- 33- Advanced Systems Consulting, Inc. - US
- 34- Consulintel - Spain
- 35- The Business Internet - US
- 36- NTT Software Corporation - Japan
- 37- Motorola - US
- 38- Telia Networks Services - Sweden
- 39- Centre for Wireless Communications - Singapore
- 40- Siemens - Germany
- 41- IBM - US
- 42- BellSouth - US
- 43- Teleglobe - US
- 44- Silicon Graphics, Inc (SGI) - US
- 45- Etisalat - UAE
- 46- SwitchCore AB - Sweden
- 47- UCAID - Internet2 - US
- 48- University College of London (UCL) - UK
- 49- University of Southampton - United Kingdom
- 50- University of Lancaster - United Kingdom
- 51- Royal Philips - The Netherlands
- 52- Royal KPN (Royal Dutch Telecom) - The Netherlands
- 53- The Open Group - UK
- 54- CIAC - France
- 55- UNINETT - Norway
- 56- NEC - Japan
- 57- ETRI - Korea
- 58- INTAP - Japan
- 59- Alpha Group - US
- 60- Korea Telecom - Korea
- 61- CNRS - France
- 62- YDC (Yokogawa Digital Computer Corporation) - Japan
- 63 - Alcatel - France
- 64 - GITEP - France
- 65 - ISI - US - UK
- 66 - Nortel Networks - US
- 67 - ISOC
- 68 - Stardust.com - US
- 69 - Telefónica - Spain



Some additional companies in process of joining, waiting for internal approval procedures:

1. France Telecom - France
2. Apple - US
3. Lucent - US
- 4- SPAWAR - US

This listing, compiled in order of when these companies joined the Forum, is kept up to date in the IPv6 Forum Web site: <http://www.ipv6forum.com/navbar/members/foundingmembers.htm> (founding members) and <http://www.ipv6forum.com/navbar/members/generalmembers.htm> (general members).

4. IPv6 Forum Goal:

According to the words of Latif Ladid, Chair of the IPv6 Forum, we define this as a world-wide consortium of leading Internet vendors, Research and Education Networks, with a clear mission to promote IPv6 by dramatically improving the market and user awareness of IPv6, creating a quality and secure Next Generation Internet and allowing world-wide equitable access to knowledge and technology, embracing a moral responsibility to the world.

To this end, the IPv6 Forum will:

- Establish an open, international FORUM of IPv6 expertise
- Share IPv6 knowledge and experience among members
- Promote new IPv6-based applications and global solutions
- Promote interoperable implementations of Ipv6 standards
- Co-operate to achieve end-to-end quality of service
- Resolve issues that create barriers to IPv6 deployment

The IPv6 Forum will not develop protocol standards, because the Internet Engineering Task Force has sole authority to do that.

5. IPv6 Forum Structure

The IPv6 Forum has been organized in two main "structures" both depending on the *IPv6 Forum Board*:

- *IPv6 Deployment Technical Directorate.*

This directorate have full autonomy in its decisions from the promotion group, guaranteeing an objective and vendor-independent definition of IPv6 technical deployment solutions, and is available to the Forum members to assist with technical, deployment, and implementation issues and opportunities.

The directorate consist of about 20 members "active contributors", aiming for a wide range of expertise covering areas such as security, routing, mobility, QoS, PC environments, open source software, network managers, application developers, testing and verification, IP telephony, etc.
- *IPV6 Forum Promotion Group.*

The Promotion Group consists of the following *Work Groups* (always open to additions):

 - ◆ Projects: Real Life Business Cases, IPv6 Success Stories, National & International Projects, Funded Projects, ... The goal is demonstrate the on going evolution towards the New Internet with collaborative projects working on the IPv6 technology, facilitate interchange of information between projects and the creation of new projects.
 - ◆ Education, Awareness and Public Relations. The target is create and promote by any means, quality messages, documents, presentations,

and tools, to educate-evangelize about IPv6 and to ensure a clear and powerful image of the benefits of IPv6.

- ◆ Global IPv6 Summits: IPv6 International and Regional Summits/Conferences, Partner Conferences, ... Who's objective is to create worldwide and local events to promote diverse IPv6 aspects.
- ◆ Fellows Program: Alternative way, non-cost, for individuals to participate in the promotion of the IPv6 protocol. Destined to people interested in writing articles, doing speech's, presentations, or any other promotional/educational activity, mainly locally based.

6. IPv6 Forum Summits and Events

The first "official" IPv6 Forum meeting was held in Oslo, in July 1999, together with the IETF meeting. This was more a "constitution" meeting than a public one.

After that, the 1st Global IPv6 Summit was organized in Paris, during October 1999. It was a big event with great success.

The next event will be in Berlin during December 1999.

Upcoming planned events are being prepared in Birmingham (May 2000), Tokyo, US (March 2000), and Madrid (November 2000).

IPv6 Forum is open to any cooperation to prepare this type of events, regardless they are locally or globally focused.

7. IPv6 Forum Cooperation with other institutions

Under pinning it's promotional goal, the IPv6 Forum will keep open the doors to relationships with other institutions or industry Forums.

In fact, we've already established very close cooperation with the UMTS Forum, GSM Forum, ISOC, and the ETSI, amongst others.

As a direct result of this collaboration, IPv6 Forum will be participating in other events: UMTS Forum Workshop (Singapore, November 1999), Next Generation Billing Systems (Cannes, December 1999), ComNet 2000 (Washington, January 2000), Mobile.ISP (Paris, March 2000).

8. IPv6 Protocol Definition Situation

According to the experts, in general, the IPv6 protocol is well defined, and the core specs are pretty solid.

But still some key points need some extra work:

- Multi-homing problem. Basically the same that we have in IPv4, and we are surviving ! Several proposals in the way, including using mobile IP mechanism, host mechanisms, router-only mechanism, ... Anyway, any of these proposals should hold IPv6 deployment.
- Is fixed length addressing the right approach? Some people still don't agree. But it's clear that fixed length address of 128 bits is a "hard" boundary. Actually, we are working within this boundary with the IPv6 aggregatable format. It's widely adopted, so no longer a question to redefine.
- According to the IETF DHC Working Group wants to verify that the models that are being used with DHCPv6 (architecture is different and must incorporate RFC 2462 Stateless Address Configuration) are valid and will work based on

the knowledge gained from DHCPv4 implementors. The IPng Working Group want to extend what could not be done in DHCPv4 but not loose learned knowledge from DHCPv4. This work is being done right now, and we should have a solid draft by May 2000, ready for implementation and for Proposed Standards.

- Use of scopes for unicast IPv6 addresses as far as nailing down how they are used and deployed. Scopes are already well understood in IPv6 for unicast global addresses, link-local addresses, and multicast. Actually is under discussion the use of site-local addresses and how they are used within the architecture, and they affect to implementations.
- Still need to deploy and test IPv6 Multicast protocols, as unfortunately, has not been tested enough. There is work ongoing for PIMv6 (Protocol Independent Multicast IPv6) at present, but we don't have to await the multicast routing to begin IPv6 deployment. It would be good if we saw more OSPFv6 implementations as that has not been well tested at this time.
- Another recent request has been for work on IS-IS for IPv6. IS-IS is an OSI protocol that can adapt to any other protocol by encapsulating it. Like IPv4, IPv6, IPX, DecNet, ...

9. IPv6 Standardization Issues

Most of the work was defined as done after the 45th meeting of the IETF in Oslo.

The IESG indicated that we just need some more "in the field" experience.

10. Is IPv6 enough for end to end QoS?

If we figure out how to best use the Traffic Class and Flow label, it is at least a start and the IPv6 header provides an inherent infrastructure type right within the IP header.

But like IPv4, the issue is how do applications use QoS when this is turned on application by application.

What does this mean? Easy: IPv6 alone is not sufficient for that.

Being just a network layer protocol, IPv6 will only be able to provide a network to network QoS when combined with appropriate mechanisms in network routers under a particular approach of providing quality service: Integrated or Differential services.

As we said, fortunately, IPv6 couples well with both these technologies and offers some improvements over IPv4, such as availability of the Flow label field along with the Traffic Class to carry micro-flow identification for Int-serv or ID of Diff-serv behavior aggregate.

There are proposals for use these fields to place MPLS labels if MPLS is used as QoS enabling technology.

As a resume, we can say that over IPv4, the advantage of IPv6 is that we have no legacy problems, and the easier classification of packets with flow ID's.

11. IPv6 Competitors

Some people can say that some form of adjustable length addressing can be pretty well implemented and no one would need to delegate anything down. All addresses would be scoped to the length at which they are used. It's a sort of CLNS in nature.



Yes, it could be a better solution, however, options processing is still a big win with IPv6 over any other solution.

The fact is that there is no any real proposal for other protocols (they were rejected during the IPng selection process). So the real competitor can be NAT and its son, RSIP.

NAT is nearly "transparent" by in fact exchange address space against management complexity (this will kill it in the long term).

NAT isolates intranets from internet working around the scarcity of address. Schemes are devisable, where unlimited number of NAT boxes are used to provide global connectivity. However this approach is violating the overall concept of Internet: transparency at the network level.

NAT also increases the complexity of configuration and creates a single point of failure for connection of networks.

NAT breaks the end-to-end model too (then it breaks end-to-end security for instance) and puts some state at the wrong place (ie. in the network, this is bad for scalability).

RSIP is not transparent, it needs an upgrade for every application at the end nodes (like IPv6) and extends only by a few bit the real address length (ie. It can't be enough). So the only real advantage of RSIP is its NAT relationship !

NAT is an aid to solve IPv4 problems, but somebody compared these with fantasy islands if we think they can solve the core IPv4 problems that IPv6 fixes. NAT is the main Band-Aid and we aren't fighting it anymore but will coexist with it until IPv6 makes it unnecessary.

12. IPv6 target users, actual and future.

Obviously, the best targets for IPv6 deployment are places where you can't get IPv4 addresses today, for instance emerging and growing countries (because major US ISP's are trying to reserve the remaining IPv4 address space for themselves).

There is no killer application for IPv6, it solves only the address space problem, but this problem has not other real solution and it can kill any new application with large address space requirements, like IP mobile telephony. If anybody has any doubts about this fact itself being a killer one? We know, in fact, that cellular phones have already grown over the numbers of Internet connections!

Any application actually running over IPv4 will run BETTER on IPv6, having a lot of extra resources, and offering better ways for QoS and CoS. What about VoIP?

I've my own experience in VoFR and VoIP in really large installations ... I'm convinced about IP success over FR in the future, but also, I'm convinced about VoFR while we can't offer real world wide "VoIPv6", I mean over public IP networks, over Internet.

Users? IPv6 Forum is defining this situation. End users will go first!, because IPv6 will grow from the Intranets to the Internet. As many Intranets use it and tunnel between them and more vendors ship products, and the IPv6 Forum does its own job, ISP's and Telcos will be able to feel comfortable moving to IPv6.

But no one will move without products being shipped. It's like the chicken and egg. It's the main IPv6 Forum mission!

13. IPv6 Success Stories, trials, test beds



You can't believe it: Hundreds of them! With real users, real corporations, education and research institutions, and more coming.

Just go to the 6Bone web site ... lot's of links, really worldwide.

If not enough: 6Ren, 6Inet, 6Tap, FREEnet, WIDE, US Navy, Eurocontrol.

Probably no one technology has got in so short term a large success like IPv6.

Just go to the web ...

Somebody isn't clear about this? Of course, since IPv6 Forum started, and this is another of our big targets, we will promote these initiatives, and open new projects, new collaborations; we need and will involve as many people as possible.

D. Vinton Cerf just confirmed that MCI WorldCom runs "native mode IPv6" in the vBNS network, for example.

14. IPv6 Deployment Situation

We defined IPv6 as the "Next Millenium Internet", and this is just around the corner!

Year 2000 is many things, and it's the year for vendors really to start shipping their prototypes. Some of them already have products, real products, working very well in fact, not just betas.

But of course, most of the people using IPv6 is trough tunnelled systems/servers everywhere.

Actually, at the time of this being written, 22 corporations/institutions applied for subTLA allocation. And just starting; not bad!

Some of these have already announced native IPv6 regular services offerings. They took the chance to bed on the future: they will be winners!

Some other major ISP's will wait for customers willing to pay for IPv6 service before investing. It's their own business chance.

Look at this site for and automatic and updated list of production subTLA allocations: <http://www.dfn.de/service/ipv6/ipv6aggis.html>

15. IPv6 Barriers

Not too many, day to day will solve them:

- The multi-homing problem
- The fans of adjustable-length addressing
- IPv4 itself, in some way, with the "patches" like NAT.
- Lack of real support from dominant router and software vendors (ie. no IPv6 running on current or near future router firmware releases or Windows OS).
- Complexity of transition/migration.
- End users NEED business "enforced" reasons to move to IPv6.

16. Current IPv6 Status over the World

We can identify five distinct regions in terms of their IPv6 related development status:

- a) Asia Pacific: In this area, the impact of the IPv4 shortage have become more obvious, and APNIC, the Regional Internet Registry for this region (<http://www.apnic.net>) is expected to run out of IPv4 addresses in some months. Correspondingly, the pressure to find related solutions is very high, and a number of activities have been started, particularly in Japan: WIDE (<http://www.v6.wide.ad.jp>), KAME (<http://www.kame.net>) and TAHI (<http://www.tahi.org>).
- b) Europe: The mobility industry is a strong supporter of the transition to IPv6. Correspondingly, the European Telecommunications Standards Institute (ETSI) and the IPv6 Forum have established a cooperation agreement to join their forces; this move of ETSI was quoted to be prompted by “the strong desire of wireless operators”. In addition to its cooperation agreement with ETSI, the IPv6 Forum has also partnered the UMTS Forum and GSM Association, and is in discussion with the 3GPP group.
- c) North America: Many activities related to IPv6, both in terms of standardization and deployment/testing have their origin in this region. Quite a lot of these activities can be found when looking to the “6bone”, the international IPv6 test bed (<http://6bone.net>). Other IPv6 related activities with strong North American participation are 6REN (<http://www.6ren.net>) – coordination initiative for IPv6 research and education networks, 6TAP (<http://6tap.net>) – initiative to provide a central IPv6 router in Chicago facilitating peering between multiple IPv6 networks, and Freenet/Viagenie (<http://www.freenet6.net> and <http://www.viagenie.qc.ca>) – automatic tunneling initiative. Nevertheless, commercial IPv6 deployment in this region has started slow; currently only 2 commercial IPv6 address ranges (out of 20 worldwide) have been allocated in North America. This reflects the appearance that operational deployment of IPv6 “may be not in this area first” (as quoted in the IPng minutes IETF-46), since the problems of IPv4 address shortage have not emerged to be urgent in this region yet.
- d) Russia: strong relations between the official IPv6 Forum, their National one, and FREEnet (Russia-wide academic and research network). Aiming to create a Russian community of IPv6 users and service/solution providers.
- e) Rest of the World: we will see, in short, several examples of new actions in Mexico, Korea, India, Australia and Singapore. Not so strange as they are high tech countries (India) or between two big development areas (Australia, squeezed between Japan and US). In Singapore the reason is the high degree of wireless communications, by several means.

According to D. Vinton G. Cerf, there is speculation that this could become much more mainstream as large numbers of end devices, such as cell phones and cable set top boxes require IP addressing and the developers choose to use IPv6 rather than IPv4 to achieve unique addressing of each device. Such step would also invoke the use of Network Address Translators, in many cases, to allow for transport of the IPv6 packets across IPv4 backbones.

17. When and Where IPv6?

As we said at the beginning of this document, IPv6 is a fact.

First implementations were available in 1995 (the first trace of an IPv6 connection is dated at the end of March 1995).

Most of the software and OS vendors have IPv6 stacks in their standard products, and some others as “early access kits”, free of charge, w/o any official “support”. But a lot of users and large development communities self-support these packages.



No software vendor is without its own offering. That's the indisputable reality.

In the previous chapters we already discussed about samples in countries like Japan, Europe, US, India and Australia.

We need to look again, very seriously, for Year 2000! Isn't a myth.

18. When I should migrate to IPv6?

Most of us already started in some way, probably through tunnels.

We need to push building test beds and using IPv6 over the Internet with other IPv6 users.

Commercial companies, most of the time, should better wait a bit until standardization issues become clear, evaluate cost, etc.

But non-profit networks, like research, education, must migrate gradually now, gaining experience and sharing it with others. After all, the R&D networks always are first to start working with anything, as it was with the Internet.

Conclusion: as soon as possible, depending on your case. Maybe when you can forecast you're not going to get any more IPv4 address space it will be too late!

19. IPv6 Resources

To finish with this introduction, there follows a compilation of useful URL's where the reader can continue learning about IPv6:

- IPv6 Forum: <http://www.ipv6forum.com>
- IPv6 Information Page: <http://www.ipv6.org/>
- IPv6 Over Everything: <http://www.data.com/issue/991021/ipv6.html>
- Why IPv6?: <http://www.opengroup.org/orc/xnet/yv6/>
- IPng: <http://playground.sun.com/pub/ipng/html/>
- IETF IPng Working Group: <http://playground.sun.com/pub/ipng/html/meetings.html>
- The 6Bone Network: <http://www.6bone.net/>
- Internet2: <http://www.internet2.org/>
- IAB: <http://128.9.160.55/>

This relation is a very limited list of available resources in the Web. It's something like a "point to start".

On most of these sites you will find "hyperlinks" to a lot of extra information. If that's not enough, just point your window to any web search tool and ask for "IPv6". Probably you will not get enough time to read all you can find!

Mailing list related to IPv6:

- users@ipv6.org
- education@ipv6forum.com



- deployment@ipv6.org
- projects@ipv6forum.com
- tech@ipv6forum.com
- ipng@sunroof.eng.sun.com

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