

## Worldwide IPv6 Initiatives

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### Abstract

IP version 6 (IPv6) is the next generation Internet protocol. It solves the demand for the increasing number of IP addresses that are needed as the population in developing countries comes online, sensors and radio-frequency identification (RFID) tags become more widespread and networked, and the billions of mobile phones are used for accessing the Internet. Many initiatives have been launched worldwide to test all the practical issues associated with its deployment, management and coexistence with the current protocol (IPv4). This paper describes some of these major pre-service trials.

### Why IPv6?

There are several valid reasons to upgrade to IPv6. These include auto-configuration, improved security (IPsec), quality of service (Flow Label) and easier packet header processing, through the fixed header length and removal of the checksum. However, the main reason is the vastly expanded address space. This enables end devices to have permanent IP addresses again, which restores the original concept of the Internet, brings advantages for handling mobility and peer-peer communications, and removes the need for address translation devices.

The number of IP addresses available with IPv4 is  $2^{32}$  (approximately 4 billion), but 60% of these are already allocated to organisations in the US with two universities (Stanford and MIT) each having more than China. Therefore, there will not be enough addresses for the developing countries and, furthermore, new devices with Internet capabilities (mobile phone features, smart homes, sensors, RFID tags) will accelerate the need for Internet addresses. The number of addresses available with IPv6 is  $2^{128}$  (approximately 3.4 followed by 38 zeros).

The US Department of Defense has only purchased IPv6 capable equipment since 2005, and will have switched over to IPv6 by 2008. ISPs in Japan and Korea must be certified as "IPv6 Ready" in order to operate.

### IPv6 Trials

This paper describes international IPv6 initiatives led by organisations in North America, Latin America, Asia, Africa and Europe.

### North America-led Initiatives

#### Moonv6

The Moonv6 project [1] is a global effort led by the North American IPv6 Task Force (NAv6TF) involving the University of New Hampshire - InterOperability Laboratory, Internet2, vendors, service providers and regional IPv6 Forum Task Force network pilots worldwide. The Moonv6 project is the largest permanently

deployed multi-vendor IPv6 network in the world. The U.S. Government's Department of Defense Joint Interoperability Testing Command and other government agencies, the Defense Research & Engineering Network and the High Performance Computing Modernization Program also play significant roles in the Moonv6 demonstrations ensuring DoD interoperability and migration objectives are identified and demonstrated.

#### MetroNet6

MetroNet6 [2] is facilitating communication between multiple emergency services. The goal is to enable the police, firemen, hospital 911 personnel, and any other required local authorities to have compatible handheld devices that connect via their own Metropolitan Network (MetroNet6) for exchanging voice, video, graphics, intelligence, medical, and other forms of data. The connectivity is provided by Moonv6

MetroNet6 supports both wireless and wireline technology as the physical medium for communications and the integration of wireless and wireline so either can be used on the MetroNet6. Nodes, such as the command center can be established in an ad-hoc manner, for maximum flexibility.

#### Occaid

Occaid [3] is a non-profit organisation, which provides a dependable and reliable environment for advancing future Internet technologies. Occaid was started in 2000 by a group of students who saw a need for a collaboration network which could effectively promote and embrace leading-edge Internet technologies for the IT industry. With this vision, Occaid has since grown into a nationwide coast-to-coast backbone, interconnecting hundreds of researchers and creating partnerships between academia, the research communities and the carrier industry.

Occaid has built a reputation for moving IPv6 forward throughout the continental United States and beyond.

The Occaid2 project is the latest initiative to deliver the 2nd generation of R&D backbone, with multi-gigabit speed and connecting over 12 metropolitan cities throughout the US and 5 countries in Europe.

### Asia-led Initiatives

#### U-Japan

U-Japan [4] consists of 4 components:

- *Ubiquitous*: Anywhere, anytime, anyone, anything
- *Universal*: User-friendly, accessible for anyone (eg. also for disabled people)
- *User-oriented*: Consumers can contribute too, developing services that are close to people's needs
- *Unique*: Individualised, revitalising society

The main goal of u-Japan is to “*work to realising the Ubiquitous Network Society by 2010*”. For example, by 2010, 100% of the Japanese citizens should have either high-speed, or ultra high-speed Internet connections. Also, by 2010, 80% of the Japanese citizens should feel comfortable with ICT, and appreciate the role of ICT in resolving social problems related to declining birthrates and an aging society, employment opportunities for the elderly, reduction of crime and traffic accidents, etc.

#### **U-Korea**

Electronic communication has played an integral part in developing Korea’s economy over the past four decades. Now with the country becoming one of the most advanced info-tech markets in the world, policymakers and businesses are facing the challenge of keeping growth alive in the matured telecom sector.

U-Korea [5] started in 2003 and is a new national info-tech strategy, dubbed IT839, outlining ambitious goals for eight services, three infrastructure technologies and nine product categories.

The eight new services are portable Internet (WiBro), mobile television (DMB), home networking, vehicle-based information systems (telematics), RFID technology, W-CDMA mobile telephony, digital television broadcasting and voice-over Internet protocol (VoIP) services.

To provide the backbone network for the new services, the government and industry is developing three advanced infrastructures including the broadband convergence network (BeN), a massive Internet protocol providing connections speeds between 50 mbps to 100 mbps, sensor-based computing networks and IPv6.

By enhancing the aforementioned technologies and network infrastructure, the government hopes to foster production in nine industrial sectors comprising mobile handsets, digital televisions and broadcast devices, home network equipment, system-on-chip products, next-generation personal computers, embedded software, digital content and solutions, vehicle-based information equipment and intelligent robot products.

#### **Live E!**

Live E! [6] is a global network of climate measuring stations. It is promoting the use of network based technologies to move beyond climatic forecast for environmental prediction and protection. Educational institutes, public services and businesses are able to use the available information. It is expected that new businesses will therefore be established and additional advancements made in support of creating a better awareness of how weather patterns can be read to forecast environmental threats.

#### **Nautilus6**

Nautilus6 [7] is a mission-oriented project established within the WIDE organisation in 2003 to demonstrate how the long awaited mobile (IPv6) Internet could be actually deployed. The group collaborates with KAME, USAGI, TAHI, InternetCAR, E-Care, and other WIDE teams. The implementations are freely available and released on a regular basis.

Nautilus6 uses IETF standards whenever appropriate or develops and standardises new ones when those are lacking within the IETF community. Nautilus6 is also designing the operational framework of mobile Internet services to accelerate deployment by the commercial ISPs and carriers. It is therefore looking for - and developing - applications to demonstrate the technology. It will also pursue further research into IPv6 mobility.

#### **CNGI**

IPv6 is the technology at the heart of China’s Next Generation Internet (CNGI) [8], and has been chosen because of its addressing space, security and efficiency.

China is betting that by moving to the next-generation Internet before the rest of the world, their researchers, academics and entrepreneurs will be the first ones to develop applications and services that take advantage of the new capabilities. (China isn’t alone in this thinking – as seen earlier, Japan and Korea have also launched national initiatives to move to IPv6). However, China is also working on ways to use IPv6 to enhance its now infamous control over Internet traffic into and out of the country.

#### **Africa-led Initiatives**

##### **AfriNIC IPv6 training**

AfriNIC [9] is a non-governmental and not-for-profit membership based organisation. Its main role is to serve the Africa region as the Regional Internet Registry, like the four other continents which have their own RIRs. AfriNIC’s mission is “*To provide professional and efficient distribution of Internet number resources to the African Internet community, to support Internet technology usage and development across the continent and strengthen self Internet governance in Africa by encouraging a participative policy development.*”

IPv6 has been recognised by AfriNIC as an important technology for Africa and therefore IPv6 workshops are organised in conjunction with each plenary meeting (approximately 3 per year). These workshops offer a practical introduction to the basics of IPv6. The participants learn how to activate IPv6 on PCs, and are given practical instruction on (for example):

- Installing IPv6 on different client and router platforms (XP/W2003, Linux, BSD, Cisco, Juniper, Alcatel, ...)
- Basic stateless/stateful configuration, including privacy setup
- Transition mechanisms (including tunneling)
- Examples of applications

During these workshops, the attendees also learn how to accomplish some basic monitoring and troubleshooting of an IPv6 network.

The workshops are targeted at engineers and network administrators from both ISPs and SOHO/Enterprise networks.

##### **AfNOG**

The Africa Network Operators Group AfNOG [10] is a forum for the exchange of technical information, and aims to promote discussion of implementation issues that require community cooperation through coordination and

cooperation among network service providers to ensure the stability of service to end users.

The goal of AfNOG is to share experience of technical challenges of setting up, building and running IP networks on the African continent. AfNOG holds a technical workshop at each of its annual meetings. IPv6 has been a focus topic of the recent technical workshops, which have consequently been held in conjunction with AfriNIC workshops. The training at these workshops has been oriented towards operators of existing African Internet Service Providers (ISPs) who are participants in the process of developing and enhancing a national Internet with regional and international connectivity.

## European-led Initiatives

### European IPv6 Task Force

The European Commission initiated an IPv6 Task Force [11] driven by major European and worldwide players, to develop a comprehensive action plan by the end of 2001 aiming to ensure the timely availability of IPv6.

The conclusions and recommendations of the Task Force were submitted to the European Council Barcelona meeting (Spring 2002) and in the context of this document, a series of recommendations pertaining to the implementation of IPv6 by all relevant ICT sectors were proposed by the Commission.

As a result, the Heads of State resolution was to prioritise the widespread availability and use of broadband networks throughout the Union by 2005 and the deployment of the New Internet Protocol IPv6.

The current European IPv6 Task Force project (IPv6 Task Force-SC):

- Ensures a working liaison with standards and Internet governance bodies such as ISOC, IETF, ICANN, RIPE NCC, 3GPP, ETSI, IPv6 Forum, Eurescom, ETNO, UMTS Forum and GSM Europe
- Provides a regularly updated review and plan action (“the European IPv6 Roadmap”) on the development and future perspectives of IPv6 in order to coordinate European efforts on IPv6
- Establishes collaboration arrangements and working relationships with similar initiatives being launched in other world regions
- Provides strategic guidance with the assistance of a number of industry and academic players, to quickly propose measures to the appropriate bodies, to involve the European Commission and to verify sustained activities and implementation of proposed measures.

### IPv6 Forum

The IPv6 Forum [12] is a non-profit organisation registered in Luxembourg since July 17, 1999. It represents a world-wide consortium of leading Internet vendors and National Research and Education Networks. It has the 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.

With this goal, the IPv6 Forum is an open, international forum of IPv6 expertise, which:

- Shares IPv6 knowledge and experience among its members
- Promotes new IPv6-based applications and global solutions
- Promotes interoperable implementations of IPv6 standards
- Co-operates to achieve end-to-end quality of service
- Resolves issues that create barriers to IPv6 deployment

### 6bone

The 6bone [13] was established in 1996 by the IETF as an IPv6 Testbed network to enable various IPv6 testing as well as to assist in the transitioning of IPv6 into the Internet. It operated under the IPv6 address allocation 3FFE::/16 from RFC 2471. 6bone was phased out on the 6<sup>th</sup> of June 2006 as per agreements with the IETF IPv6 community.

### M6bone

The m6bone [14] is an experimental IPv6 *Multicast* Network. It allows ISPs, research networks, developers and researchers of various interests to work with IPv6 Multicast. The project formerly started in 2001 with the support of RENATER (the French NREN), G6 and the Aristote association. The m6bone comprises of native multicast links to various universities, research networks, organisations and ISPs. Tunnels are used to connect sites located outside of Europe and/or sites with no native connectivity. The project made possible a lot of improvements, in particular with multicast stacks of various networking equipments, including routers. As the interest in multicast technologies continues to grow, the participation is increasing.

### 6NET

6NET [15] was an EC project (2002-2005) designed to demonstrate that the continued growth of the Internet can be met using new IPv6 technology. The project built a native IPv6-based network connecting 16 countries in order to gain experience of IPv6 deployment and co-existence with IPv4-based networks. This was used to test a variety of new IPv6 services and applications, as well as interoperability with legacy applications.

6NET involved 35 partners from the commercial, research and academic sectors. The IPv6 dissemination, training and support activities continue in the 6DISS project.

### 6DISS

6DISS [16] is an EC project (2005-2007) to provide IPv6 training and knowledge transfer to research networks in developing regions. It also aims to establish contacts with networking personnel and organisations in these regions, in order to encourage cooperation and possible future participation in European R&D activities.

The project is targeting the following 8 regions: Asia-Pacific, the Caribbean, Central Asia, the Mediterranean, South and Central America, South-East Europe, Southern Africa, and Sub-Saharan Africa. IPv6 training workshops are being organised in each of these regions, with follow-up support made available. This opportunity is also taken to evaluate the current state of research networking in each

region. In addition, the project will provide specialist training for instructors and engineers at locations in Europe, develop e-learning material for online distribution, and exchange deployment experiences with research networks in China and India.

6DISS builds upon the IPv6 deployment experiences of the 6NET, Euro6IX and GÉANT projects, as well as the liaisons established with the IPv6 Forum, European IPv6 Task Force and IETF. The aim is to let organisations in developing countries benefit from this experience since they have fewer legacy installations and are therefore able to utilise the IPv6 technology in an efficient manner.

#### **Euro6IX**

Euro6IX [17] was an EC project (2001-2004) to support the rapid introduction of IPv6 in Europe through the provision of Internet Exchanges. A pan-European network was deployed, and research was made on advanced network services, development of applications (that were validated through the involvement of user groups and international trials). The project was very active in the dissemination of results through events and conferences, contributing to standards (IETF and RIPE among others), publishing papers and the project web site.

#### **GÉANT**

GÉANT [18] is the main European multi-gigabit computer network for research and education purposes. GÉANT link speeds range from 155 Mbit/s on the slowest spur links to 10 Gbit/s in the core optical fiber network.

The GÉANT project began in November 2000, and entered full production operation in December 2001. Originally due to finish in October 2004, it was subsequently extended until April 2005. The project to plan, procure, build and operate the next generation of the network was named GÉANT2 and it began in September 2004.

GÉANT interconnects with other regional research networks (such as Abilene, CANARIE, ESnet, SINET) to create a single global research network. It currently has gigabit links to North America and Japan.

The GÉANT network is managed by DANTE (Delivery of Advanced Network Technology to Europe).

#### **U-2010**

U-2010 [19] is an EC project (2006-2008) with 16 partners from 10 European Countries. Its overall objective is to provide the most capable means of communication - and the most effective access to information - to everybody required to act in case of accident, incident, catastrophe or crisis, while using existing or future telecommunication infrastructures.

The U-2010 project addresses the public safety issues by researching new emergency and crisis management solutions investigating on innovative and state-of-the-art communication technologies based on the current and new Internet technologies that could be put to use and realise this vision. Technologies in operations and under evaluation provide an enhancement of availability by

- Interconnecting existing services and networks
- Leveraging redundant communication channels

- Using automatic redirection and/or service transformation in case of failures
- Using new research results in the area of wireless ad-hoc networks.

#### **Occasion**

Occasion [20] is an EC project which provides network management, VoIP and videoconferencing tools for satellite-based IPv6 services. The deployment is targeted at researchers in the so-called "Silk" countries (Caucasus, Central Asia and Afghanistan), in order to enable them to collaborate with their colleagues in the European Union. Another aspect of the project is to identify significant User Groups, active in both the Silk countries and the European Union, who need to use this network for their collaborations. It then fosters the requisite training and joint workshops (co-funded with other bodies) to enable useful collaborations. Finally, it assists the Silk NRENs to move towards an environment in which their networks will be self-sustainable without continued large-scale financial contributions from the EC and NATO.

#### **Latin America-led Initiatives**

##### **CLARA**

The CLARA initiative [21] has two objectives: the development of an infrastructure that integrates the Latin American NRENs and the creation of a non-governmental organisation that represents the interests of this institution.

##### **ALICE**

CLARA is connected to the European Advanced Network GÉANT thanks to the ALICE project [22] (América Latina Interconectada Con Europa - Latin America Interconnected With Europe). For the execution of the ALICE project, the European Commission signed a contract of €12.5 million with DANTE - the organisation in charge of GÉANT - which was the seed for the creation of the Latin American Network and its connection to Europe. That sum represented 80% of the necessary financing for the construction and operation of the CLARA network (RedCLARA) until May 31<sup>st</sup> 2006. The remaining 20% came from the Latin American partners. The participant countries of CLARA are now responsible for the sustainability of the initiative and of its connection with Europe and other regions.

#### **Conclusions**

This paper has summarised in a concise way most of the major IPv6 initiatives worldwide. It is intended to show that preparations for deployment are well advanced, and that the necessary competence and operational tools are available. Indeed IPv6 is more prevalent than is generally recognised, since ISPs are recognising the benefits that it brings. Readers are especially encouraged to visit the 6DISS Website, where interesting IPv6 training material is available, and from where practical workshops can be requested, and questions answered by a helpdesk service.

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