

IPv6: Features, Current Deployment Scenario, Issues and Migration Status In India

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Abstract—IPv6 was developed to replace and improve the existing Internet Protocol (IP), the IPv4 in many ways. Among the improved areas are addressing space, routing efficiency, header format, auto-configuration, Quality-of-Service (QoS), security and mobility. Although IPv6 promises enhancements to IPv4 standards, its deployment is rather slow in India. This paper examines the IPv6 prominent features in details, discusses on the IPv6 deployment around the world and studies some of the transition mechanisms available today. We will also discuss on some of the contributing factors towards the slow IPv6 deployment phenomenon in India which include lacking of awareness among the public, unclear differentiating benefits to network operators, uncertain risk to the network operators and lacking of IPv6 applications. Finally, we will provide some possible potential solutions to improve the rate of deployment and experimentation of IPv6 in India.

Keywords- IPv6 Deployment, Migration Strategy, Dual stack, Translation.

I. INTRODUCTION

IPv6 was first invented by Internet Engineering Task Force (IETF) in the mid 1990s due to the urgent need to supplement the rapidly diminishing IPv4 addressing space. It was thought that IPv4 would be totally exhausted therefore a successor was designed. With the majority of networks still utilizing IPv4, there are currently no serious motivational factors to move over to a new method of working when the current provision is still adequate for the majority of users. The debate has been ongoing for years in terms of whether IPv6 should be deployed [1], [2], hence very few migration plans have been made in the industry [3].

As we all are aware, there has been a massive deployment of internet-enabled resources worldwide during the last decade. In addition to the Internet and the World Wide Web all other Communication networks are also slowly migrating from circuit switched technology to IP based technologies and India is no exception. Newer and newer types of consumer devices and applications are coming up which will be IP-enabled. The current technology is IPv4 based having a 32-bit addressing space of only 4 billion devices. Despite the use of network address translation (NAT) as a strategy for reducing the use of public IPv4 addresses, several experts forecast depletion in the next few years. There is a wide recognition that this addressing space is insufficient for the future networks. Therefore IPv6

technology was developed which has a 128 bit address space and it will cater to the addressing requirements of future networks.

India is expected to face a severe shortage of IPv4 addressing space in the near future if timely action is not taken to migrate from IPv4 to IPv6. It is expected that rapid growth of broadband and wireless technologies in telecom sector will push the demand for IP addresses in India. The table below shows the availability of IPv4 addresses for India as compared to other countries in the world –

TABLE I. AVAILABILITY OF IPV4 ADDRESSES FOR INDIA AND OTHER COUNTRIES

Country	Addresses (million)	Per Capita
United States	1474.319	5.297
China	194.425	0.152
Japan	153.327	1.210
European Union	114.103	-
Germany	85.300	1.038
Canada	76.197	2.446
South Korea	72.239	1.542
United Kingdom	70.795	1.187
France	68.385	1.155
Australia	37.378	1.979
Italy	32.344	0.561
Brazil	29.755	0.175
Russian Federation	24.919	0.170
Taiwan	24.681	1.109
Spain	22.065	0.559
Mexico	21.503	0.217
Netherlands	21.249	1.339
Sweden	18.998	2.144
India	18.312	0.018

The Government of India has placed a high priority for making the country IPv6 ready to meet the rising demand for IP addresses in future. This paper will address some of the key issues as given below.

- What is the need of IPv6 in India?

- What is the current state of deployment of IPv6 compliant networks? What are their migration plans and issues involved?
- What is the current state of IPv6 compliant equipment manufacturing and applications developed in the India?
- What kind of policies by the government can help in the migration strategy?

II. IPV6 DEPLOYMENT AROUND THE WORLD

One of the first questions asked by almost anyone considering IPv6 anywhere in the world is, "What is the rest of the world doing?" An examination of IPv6 activities [4] in various regions is instructive of the motivations for deploying IPv6 and the progress that has been made in moving toward an IPv6 Internet.

Globally major efforts are going on in Japan, Korea, Taiwan, China, Europe, USA, etc. to deploy the IPv6 across their networks and services. European commission is perusing the R & D activities in the IPv6 area, as well, focusing on projects, networks, trials and applications developed and demonstrated under the Information Society Technologies (IST) Program. The table below shows the deployment of IPv6 in five continents [5]. (BY APRIL 2009)

TABLE II. IPV6 DEPLOYMENT IN FIVE CONTINENTS

Continents	Deployment Ratio	Leading Countries
Europe	8.8%	Vatican- 100%
		Monaco- 33%
		Isle of Man -25 %
		Czech Republic – 19%
America	7.6 %	Cuba -60 %
		Fiji -50%
		Uruguay – 35%
		Costa Rica -18%
		Virgin Island -18%
Asia	3.6%	Bhutan -20%
		Qatar- 17%
		Japan- 15%
		Vietnam -15%
		Taiwan- 15%
		China – 15%
Africa	3.4%	Tunisia -33%
		Senegal – 33%
		Mali – 33%
		Madagascar – 20%
		Ivory Coast- 17 %
Australia	6.3%	New Zealand – 18%
		Australia – 7%

III. ADVANTAGES OF IPV6 OVER IPV4

The following list provides a summary of the most Important advantages between IPv4 and IPv6 [6], showing some of the ways that the IPv6 team met the design goals for the new protocol:

1) Larger Address Space:

IPv6 addresses are 128 bits long instead of 32 bits. This expands the address space from around 4 billion addresses to, well, an astronomic number (Over 300 trillion trillion trillion addresses).

2) Hierarchical Address Space:

One reason why the IPv6 address size was expanded so much was to allow it to be hierarchically divided to provide a large number of each of many classes of addresses.

3) Hierarchical Assignment of Unicast Addresses:

A special global unicast address format was created to allow addresses to be easily allocated across the entire Internet. It allows for multiple levels of network and sub-network hierarchies both at the ISP and organizational level. It also permits generating IP addresses based on underlying hardware interface device IDs such as Ethernet MAC addresses.

4) Better Support for Non-Unicast Addressing:

Support for multicasting is improved, and support is added for a new type of addressing: *anycast* addressing. This new kind of addressing basically says "deliver this message to the easiest-to-reach member of this group", and potentially enables new types of messaging functionality.

5) Auto-configuration and Renumbering:

A provision is included to allow easier auto configuration of hosts and renumbering of the IP addresses in networks and sub-networks as needed. A technique also exists for renumbering router addresses.

6) New Datagram Format:

The IP datagram format has been redefined and given new capabilities. The main header of each IP datagram has been streamlined, and support added for easily extending the header for datagrams requiring more control information.

7) Support for Quality of Service:

IPv6 datagrams include QoS features, allowing better support for multimedia and other applications requiring quality of service.

8) Security Support:

Security support is designed into IPv6 using the authentication and encryption extension headers and other features.

9) Updated Fragmentation & Reassembly Procedure:

The way that fragmentation and reassembly of datagrams works has been changed in IPv6, to improve efficiency of routing and better reflect the realities of today's networks.

10) *Modernized Routing Support:*

The IPv6 protocol is designed to support modern routing systems, and to allow expansion as the Internet grows.

11) *Transition Capabilities:*

Since it was recognized from the start that going from IPv4 to IPv6 is a big move, support for the IPv4/IPv6 transition has been provided in numerous areas. This includes a plan for interoperating IPv4 and IPv6 networks, mapping between IPv4 and IPv6 addresses and more.

IV. IPV6: PROS AND CONS

Here we just differentiate the Pros and Cons with following two questions.

A. *What drive the migration?*

- IPv4 address depletion
- Lack of IPv4's scalability
- Mobile IPv6
- End-to-end network model
- Applications such as VoIP and video that require good end-to-end networks
- IPv6 capabilities are present on most networks
- New protocols ease network administration

B. *What hold back the migration?*

- Interoperability with software and hardware
- Equipment upgrades worthwhile?
- Massive leftover of legacy office equipments
- People resilient to change
- Experience with the new protocol is limited
- Difficulty of time scheduling
- Business return on investment is uncertain

V. TRANSITION TOOL FROM IPV4 TO IPV6

For the transition to IPv6 to be successful, there must be compatibility with large installed base of IPv4 hosts and routers. The following paragraphs introduce techniques that IPv6 hosts and routers can use to interoperate with IPv4 hosts and employ the existing IPv4 routing infrastructure.

A. *Tunneling:*

To communicate by using IPv6, sender/receiver PCs and communications equipment such as relaying routers have to be all IPv6-ready. If non-IPv6-ready products are on the way, the IPv6 packet is encapsulated into an IPv4 capsule to pass non-IPv6-ready equipment as an IPv4 packet.

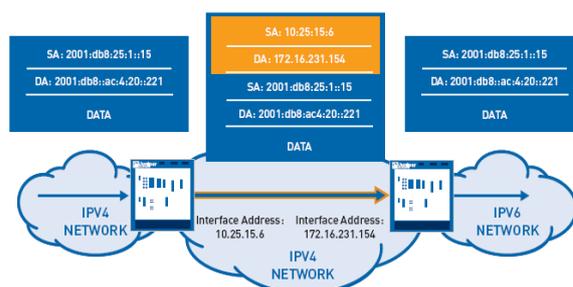


Figure 1. An IPv6-in-IPv4 Tunnel adds IPv6 packet in IPv4 [8]

In this technique IPv6 packets are just tunneled through an IPv4 network.

B. *Dual Stack:*

By adapting PCs and network equipment to be both IPv4 and IPv6-ready, IPv6 is used if the other end is IPv6-ready, and IPv4 is used if the other end is IPv4-ready.

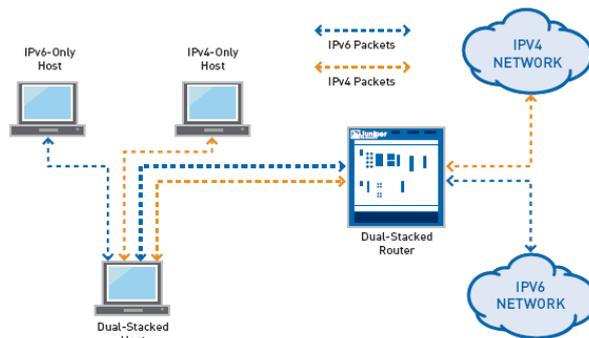


Figure 2. A dual-stacked device can send and receive both IPv4 and IPv6 packets [8]

It is like a bilingual person who can speak two languages of IPv4 and IPv6. Hosts and routers run both an IPv4 and IPv6 protocol stack.

C. *Translation:*

A translator device converting IPv4 to IPv6 and vice versa is installed, and communications between IPv4 and IPv6 nodes are enabled via this translator, so that it serves as an "interpreter" between IPv4 and IPv6. It just translates IPv4 packets to IPv6 packets and vice versa.

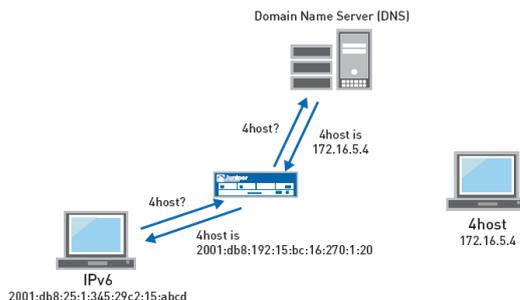


Figure 3. A DNS application Level Gateway (ALG) in a NAT-PT translates an IPv4 DNS response to an IPv6 DNS response.[8]

VI. IPV6 DEVELOPMENT ISSUES IN INDIA

Through the two- three year's experience of promoting IPv6 in India and having met many people from the public, research institutes as well as industries, we have discovered some factors [8] that are contributing towards the slow rate of deployment in India. And they are:

- *Uncertain risk to the network operators:*

Many network operators perceive that migration towards IPv6 is very complex process and require many resources in terms of manpower, time and money. In addition, with their hectic day-to-day business operation, they couldn't afford to meddle in this experiment process and rather wait until everything is finalized.

- *Unclear differentiating benefits of IPv6 to the network operators:*

Besides providing more addresses to clients, many local network operators or Internet Service providers (ISP) still couldn't comprehend the business value proposition of IPv6 just yet. This is because most of them are into Internet access and service business only, as opposed to their counterparts around the world that are in to more diversified telecommunication service such as mobile service.

- *Lack of IPv6 applications or no "killer applications" yet:*

Lacking of IPv6 application occurs due to the limited participation from the Internet community in porting IPv4 application to IPv6, with majority are only from Japan and European countries. So far, no killer applications have been introduced in IPv6 due to wide variety of application that are already available today.

- *Lack of technical knowledge:*

Lacking of practical experiences, as opposed to theory is one of the weaknesses found in many local researchers. This result in slow growth of Ipv6 network and thus hinders the development of IPv6 research in these institutes.

- *Lack of public awareness:*

Since the Internet Protocol is transparent to the end users, many of them are no aware of the changes made on this protocol. Hence, the importance of Ipv6 remains unknown and this creates lack of demand for IPv6 network.

VII. POTENTIAL SOLUTIONS

Some of the potential solutions to improve IPv6 deployment rate and IPv6 research in India are as follows:

- *Keeping up-to-date on IPv6 activities around the world:*

The network operators should participate in world IPv6 conventions such as theIPv6Forum to gain more understanding on IPv6 market. Moreover, by keeping up-to

date with IPv6 community, they will gain knowledge on latest deployment strategy.

- *Produce more IPv6 developers among locals:*

Local universities should open up more courses on IPv6 technology and encourage application developments through competitions, grants and loans.

- *Develop technical competency among researchers:*

Researchers should undergo attachment with industries or pursue postgraduate programs to improve their technical skills.

- *Create more awareness program:*

Local media should publish more IPv6 related materials. Local universities should conduct lecture series on IPv6 technology. IT-related exhibitions should also include a section on IPv6 in their future road show.

- *Require government intervention:*

Policy makers should support and encourage IPv6 growth in India by proposing tax exemption on companies that undertake IPv6 research.

VIII. CURRENT SCENARIO OF IPV6 IN INDIA

Let us look in to the current scenario of IPv6 in detail.

- *Why IPv6 is necessary?*

Tomorrow, we see that the mobile Internet would be the call of the day. Here, one issue that is very important for us to put forth is to check whether we have included backward compatibility of the IPv6 protocol with IPv4. The business case for IPv6 that all of us agree with is the Internet itself. We want the Internet to continue. And for that, we need addresses. Socially, we can all be very happily telling our end users that the IP address is an addition to your personality, in addition to your name and address, having an IPv6 address is an addition to the personality that you have. And maybe that would make a big business case.

- *From the point of technology:*

If we look at the technological aspect, the request to most of us would be to have a mechanism and standardization for co-existence of both protocols to avoid unacceptable service interruptions and any plausible damage to critical distributed applications. Many of which were not well designed to benefit from the new functionalities enabled by IPv6. What is not globally acceptable, as we understand, is a large-scale deployment of the new IP architecture, to provide any disruptive services or applications or innovations. But what is generally acceptable to us is a gradual interoperability and co-existence between IPv4 and IPv6.

- *From the point of service providers:*

If I take the case of the service providers or the network handlers, what they would prefer, they would prefer to preserve the heavy investments that they have made to run and deploy the IPv4 networks. Service/network providers' plea would be to grant them more time to move to IPv6.

- *Where India stands in service providers?*

India is the second largest number of service providers, and yet we have attained only 1/8 usage of IP addresses until now. That implies that the demand for IP – for services and Internet and Internet penetration is yet to happen in this country, and the cultural diversity and the need for localized content is something, which will be very, very essential to push the case for demand for more IP addresses. The government of India has taken many initiatives, and one more core program is the national e-governance program where we are trying to reach out citizen services for people to realize the benefits that they can gain from the Internet.

- *By what time India will have IPv6?*

It was realized well in time and we had IPv6 addresses available to us before the IPv4 address space got exhausted. The IPv6 is here to complement and supplement the existing IPv4 address space that is still there with us. But one common perception that most of the service providers of the developing countries have is that the new protocol is very similar to the existing one. All major Service providers (having at least 10,000 internet customers or STM-1 bandwidth) will target to handle IPv6 traffic and offer IPv6 services by December-2011.

IX. PROPOSED INDIAN ROAD MAP FOR IPv6

- Facilitate the efforts of stakeholders regarding the adoption and the deployment of IPv6, for instance through awareness-raising campaigns.
- Undertaking detailed study for transition from IPv4 to IPv6 environments based on the experience gained through the networks within the country.
- Involve Internet Service Providers to get connected to IPv6 based network and initiate the services within one year.
- To facilitate, among other things by enabling IPv6, an integrated part of research & educational networks.
- Making all major ISPs and major universities / research laboratories in India IPv6 aware: Implement a show case for awareness creation among all stakeholders: users, ISPs, industries, research institutes policy makers and politicians.
- R&D test bed for identifying the issues that need to be addressed for a smooth transition.
- Undertake research and development activities for products, processes and systems for IPv6 environment. Success of such products, processes and system depends on the spread of commercialization, therefore, industry to be involved into it.
- To participate actively in the establishment of a nation wide, vendor independent, training and education program on IPv6.
- Making at least 2 large ISPs (both in public and private sectors) ERNET and BSNL, VSNL, Satyam etc. to provide select commercial IPv6 services.

- All major Service providers (having at least 10,000 internet customers or STM-1 bandwidth) will target to handle IPv6 traffic and offer IPv6 services by December-2011
- All Central and State Government Ministries and Departments, including its PSUs, shall switch over to IPv6 services by March-2012. The transition from IPv4 to IPv6 will affect many organizations and no organization can bring this change alone.

X. CONCLUSION

The migration over to IPv6 is a necessity in the long term, but IPv6 is not just about IP address space - there are some other advantages including long-term cost savings and better performance. As we all know China highlighted its progress with IPv6 at the 2008 Olympics. Lighting control systems and security cameras throughout the Olympic venues operated over IPv6, and IPv6-enabled sensors in taxis helped ease traffic congestion. Close behind China in population size is India. And while the Indian economy is not yet expanding as fast as China's, and has begun its expansion more recently, it is growing. And while IPv6 deployment is not yet being as aggressively pushed as it is in China, the motivations for IPv6 in India are the same as China's and will soon be on the rise. Implementing IPv6 can be challenging under any circumstances. But with the right planning and the right choices of methodology and implementation tools, the costs and risks associated with an implementation project can be controlled.

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