CONSULTATION PAPER

ON

"TRANSITION FROM IPv4 TO IPv6 IN PAKISTAN"

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TABLE OF CONTENTS

LIST OF FIGURES:

EXECUTIVE SUMMARY:

Internet Protocol (IP) has become the standard communication tool, ever since its introduction in 1970's. This resulted in major technological developments of the internetworking devices. The existing Internet protocol (Ipv4) supports only about 4 billion IP addresses, inherently limiting the large number of devices that can be assigned unique IP address. This resulted in development of new Internet protocol, the IP version 6 (Ipv6). IPv6 is the "next generation" protocol designed by the Internet Engineering Task Force (IETF) to replace the current version Internet Protocol, IP Version 4 ("IPv4"). This new protocol has sufficient IP's and thus can be used to develop many applications, inherently leveraging mobile Internet connectivity.

Most of today's internet uses IPv4, which is now nearly twenty years old. IPv4 has been remarkably resilient in spite of its age, but it is now encountering problems. Most importantly, there is a growing shortage of IPv4 addresses, which are needed by all new machines added to the Internet. IPv6 fixes a number of problems in IPv4, such as the limited number of available IPv4 addresses. It also adds many improvements to IPv4 in areas such as routing and network auto configuration. IPv6 is expected to gradually replace IPv4, with the two coexisting for a number of years during a transition period. IPv6 is designed to solve many problems of the current version of IP (known as IPv4) such as address depletion, security, auto configuration, and extensibility. Its use will also expand the capabilities of the Internet to enable a variety of valuable and exciting scenarios, including peer-to-peer and mobile applications.

The way worldwide development is moving beyond infrastructure these days, IPv6 will be everywhere soon. IPv6 is available today in Gaming Devices, Mobile Phones, Digital Cameras, Cars, Refrigerators, TVs, Internet Phones and many more devices. IPv6 is specified as IP of choice for 3GPP networks. A report by Gartner Group in 2002 estimated, that by the year 2006 approximately 50 % of the ISPs will offer commercial IPv6 services. So in the

beginning, IPv6 packets will travel over the IPv4 Internet tunneled within IPv4 packets. At some point the number of IPv6 links in the Internet will exceed the number of IPv4 links. The amount of IPv4 traffic will invariably increased by tunneling IPv4 traffic within IPv6. Keeping in view the growing need for IP with all the technological advancements, the majority of countries around the world have already initiated their efforts for transition phase from IPv4 to IPv6.

Many Asian countries have already started efforts for transition from IPv4 to IPv6. The main reason for this is due to the small percentage of IPv4 addresses allocated to these countries and also due to the rocketing growth of technological advancements the already assigned 20% of the global IPv4 addresses to the Asian countries is getting exhausted and hence there is a sense of urgency for transition from IPv4 to IPv6.

Pakistan is in the process of making considerable efforts to face future challenges in the information and communication technologies (especially networking and Internet technologies). To gear up the process, Pakistan Telecom Authority (PTA) organized an Industrial Forum on 31st July 2007, which was a consortium of Academia, Stakeholders , Private Sector and Government functionaries .It was decided that PTA shall formulate a consultation paper on ***"Transition from IPv4 to IPv6"*** to support the local industry to meet the upcoming challenges. The basic aim of PTA in writing the consultation paper on "***Transition from IPv4 to Ipv6"*** is to nurture new IP based technologies & applications and also to abreast the country with the new technological advancements by guiding the local industry to develop new IPv6 based applications & services, and to increase the internet penetration in the country. There are many considerations before incorporating new technologies into industry. These considerations ensure smooth, methodical, and mindful transition mechanism with full awareness of the perceived benefits, challenges, and expected outputs.

1. OVERVIEW OF IPV4 AND IPV6:

Internet emerged as a fundamental technology for commercial and social activity ever since the creation of World Wide Web in early 90's. The Internet has grown rapidly to a scale, initially not estimated by the original Internet designers

The current version of IP i.e. IPv4 was developed in 1970's which provides the basis for Internet interoperability. However, this current version has some deficiencies that gave rise to the development of the new IP protocol in early 1990's. The Next Generation IP is better from its predecessor IPv4 in many aspects like number of users, security and functionality.

IPv4 uses 32bit addressing. It means that it can address up to 2^32 (4,294,967,296) unique addresses (RFC 791). Although the number addresses seems to be far enough, but due to technological advancements it is too small for tomorrow's Internet. Out of these 4 million addresses, some are reserved for special purpose such as private addresses (1 million) and some for multicast addresses (1 million). This reduced the available IP's pool. To overcome this shortage, special techniques such as NAT (Network Address Translation) were adopted. NAT to some extent delayed the exhaustion of IPv4 address space, but on the other hand, it also complicated the communication by maintaining large routing tables. The IPv4 addresses are represented with dot decimal notation. The addresses are divided into two parts, the network ID and the host ID. The network ID is of 8 bits, therefore it can addresses up to 256 hosts. To overcome this limit, five different classes namely A, B, C, D & E were created and were named as classful addressing. Classless Inter Domain Routing (CIDR) replaced the classful addressing, which allowed the re-division of class A, B & C networks. Class A, B & C are reserved for use by private networks.

On the contrary, IPv6 is designed to overcome the deficiencies of IPv4 by expanding the available IP's pool and by incorporating features such as IPSec, quality of service (QOS), efficient routing and mobile communications. These new features can be used to develop new E-Commerce businesses, increase broadband penetration and to enhance the mobile communication.

The transition from IPv4 to IPv6 will take place in three stages i.e. substitution, diffusion and complete transformation. In substitution IPv6 will substitute the IPv4. In this phase organizations implementing IPv6 in their infrastructure will operate in a dual stack environment on experimental basis. In diffusion, new applications will be developed using IPv6 that will be more innovative and economical. In diffusion, IPv4 will be obsolete and new hardware will run entirely on IPv6. The complete transition from IPv4 to IPv6 is expected to take many years.

2. IPV6 FEATURES AND BENFITS:

It was several years' effort of Internet engineering task force (IETF) proposals and working groups that IPv6 has evolved. IPv6 incorporated some features of IPv4 and also provided some new services and capabilities. The following are the features of the IPv6 protocol:

- Large address space
- Simplified Header format
- Network layer security (IPSec).
- Quality Of Service (QOS)
- Extensibility
- Stateless and Stateful addresses configuration
- Efficient and hierarchical addressing and routing infrastructure
- Inherent mobility support.

The following Details these features:

2.1 Large address space:

IPv6 uses 128 bit addresses, it means that it can addresses up to 2^128 (3.4 * 10^{38}) unique addresses (RFC 4291). The addresses are divided into two logical parts, a 64-bit network addresses and a 64-bit host addresses. Irrespective of IPv4 dot decimal notation, IPv6 is represented with eight groups of four hexadecimal notations. IPv6 does not use classes rather it supports three different types namely unicast, multicast & anycast.

2.2 Header Format:

IPv4 header is more complicated which results in maintaining large routing tables by the routers, thus increasing the cost of routing. Comparatively to that, the IPv6 header is more robust and simple. The IPv6 header is more efficiently processed with lower processing costs.

2.3 Network Layer Security (IPSec):

IPv4 is an internetworking protocol that does not incorporate any significant security features. IPv6 includes packet encryption i.e. ***ESP (Encapsulated***

Security Payload) and addresses authentication ***AH (Authentication Header)***. This makes it more secure than its predecessor does.

2.4 Quality of Service (QoS):

IPv4 ***QoS*** relies on IPv4 ***ToS (Type of Service).*** The identification of the payload uses the TCP or UDP port. In addition, payload identification using the TCP or UDP port is not possible when the IPv4 packet is encrypted. IPv4 based system has no way to differentiate between data payloads that are time sensitive (audio, video streaming etc.) and those that are not (normal file transfer). QoS problems in IPv4 includes fragmentation, control overhead, inefficient routing. Hence they have got high latency.

IPv6 header includes new fields Traffic Class and Flow label. These fields differentiate between the time sensitive applications and those that are not time sensitive by giving them priority hence we have low latency. IPv6 supports QoS when the packet payload is encrypted through IPSec.

2.5 Extensibility:

IPv6 is more extensible for new features with the addition of extension headers after the IPv6 header. On the other hand, IPv4 can only support 40 bytes of options, while size of IPv6 is only constrained to the size of the IPv6 packet.

2.6 Stateless and Stateful address configuration:

IPv6 supports both stateful address configuration (such as address configuration in the presence of a DHCP server), and stateless address configuration (address configuration in the absence of a DHCP server, to simplify host configuration). With stateless address configuration, hosts on a link automatically configure themselves with IPv6 addresses for the link (called link-local addresses) and with addresses derived from prefixes advertised by local routers. Even in the absence of a router, hosts on the same link can automatically configure themselves with link-local addresses and communicate without manual configuration.

2.7 Efficient and Hierarchical Address Configuration:

IPv6 global addresses are designed to create an efficient and hierarchical routing infrastructure that is based on the common occurrence of multiple levels of Internet service providers.

2.8 Inherent Mobility Support:

Mobile IP is a standard communication protocol that allows mobile device users to move from one network to another while maintaining their permanent IP addresses. Mobile IPv6 shares some of its properties with IPv4, however it also incorporates some new features that make it more efficient than its predecessor. Mobile IPv6 does not requires to deploy special routers as "foreign agents" as in IPv4. Mobile IPv6 operates in any location without any special support required from the local router. Mobile IPv6 performs route optimization securely even without pre-arranged security associations. The IPv6 Neighbor Un-reachability Detection assures symmetric reachability between the mobile node and its default node in the current location. IPv4 uses directed broadcast approach that returns separate replies from each agent, while the dynamic home agent address discovery mechanism in IPv6 returns a single reply to the mobile node.

3. TRANSITION MECHANISMS FOR IPV6:

This section will outline some of the major challenges faced in transition to IPv6. To provide a smooth transition from IPv4 to IPv6, following mechanisms will be used. The RFC2893 gives the complete specification of the transition mechanism from IPv4 to IPv6. Following stages are included in transition:

- Dual IP layer.
- Tunneling of IPv4 over IPv6.
- Translators.

3.1. Dual IP Layer:

The dual IP layer allows IPv6 nodes to be compatible with IPv4 nodes by providing complete IPv4 implementation. This is the mechanism used by "IPv6/IPv4 nodes" (IPv6 nodes that communicate with both IPv4 and IPv6). These nodes have the ability to send both the IPv4 and the IPv6 packets i.e. they send IPv4 nodes IPv4 packets, similarly to IPv6 nodes send IPv6 packets.

3.2. Tunneling of IPv6 over IPv4:

These are amongst the most basic techniques that can be deployed in order to allow operation of two or more protocols on the network. This technique involves the encapsulation of IPv6 packets with in IPv4 header. A tunnel is a link between two IPv4 end points that must be configured by specifying the IPv6 destinations for which the packets are to be encapsulated, and the remote IPv4 end point to which they must be sent.

Following tools are used for tunneling:

3.2.1. 6 to 4(RFC 3056)

It is a method of constructing the IPv6 address directly from the IPv4 address. This mechanism enables sites to communicate over the IPv4 Internet with out using explicit tunnels while still communicating with IPv6 relay routers. 6 to 4 treats IPv4 Internet as a unicast point-to-point link layer and specify an encapsulation mechanism for transmitting IPv6 packets using the prefix. This

mechanism is implemented entirely in border routers and is thus becoming a standard feature of router software.

Below is the diagram given for 6 to 4:

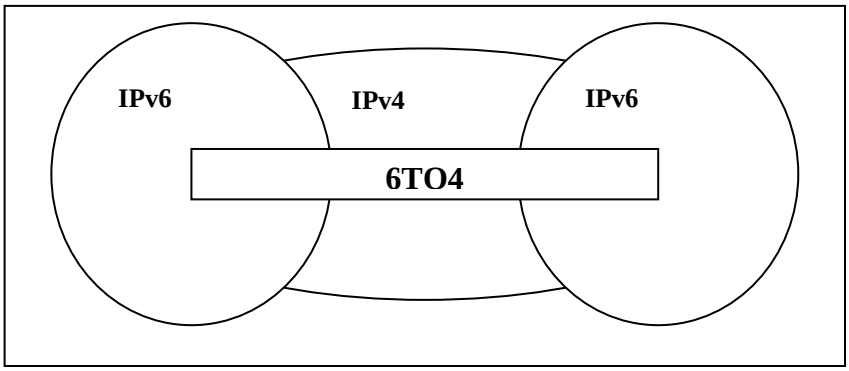

Fig 1: 6 to 4 tunneling

3.2.2. 6 over 4 (RFC 2529):

This mechanism facilitates IPv6 connectivity with in a site that lacks any IPv6 infrastructure. It describes the frame format for IPv6 packets as well as method of forming IPv6 link local addresses over IPv4 multicast domains. It allows IPv6 hosts to become functional if at least one IPv6 router is located in the same domain.

This technique is helpful for sites that still have no IPv6 networks but wish to deploy it or test it. 6 over 4 have received very limited support from the major vendors; only Microsoft and Nokia have implementations of 6 over 4.

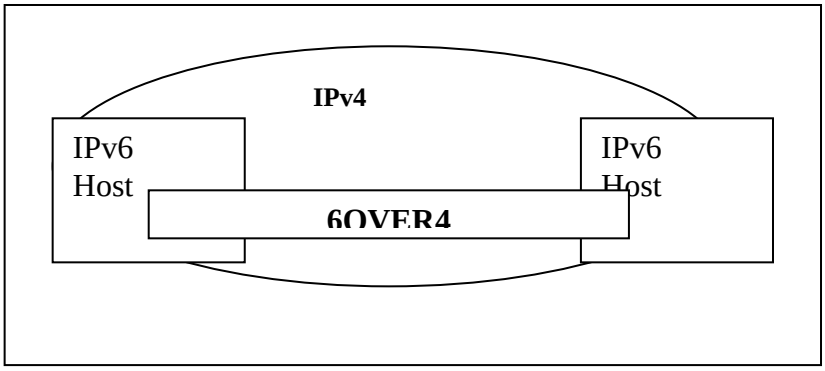

Fig 2: 6 over 4 tunneling

3.2.3. IPv6 Tunnel Broker (RFC 3053):

This technique uses dedicated servers that can automatically configure tunnels on behalf of users. This reduces the management load on network administrators. A good example would be the 6Bone that uses the configured tunnels extensively. It is particularly suitable for connections between small users and an IPv6 Service Provider.

The tunnel broker have received a reasonable amount of support from the industry as this tool does not belong to the sites or the networks, generally sites and ISP's will deploy tunnel broker as a service to others.

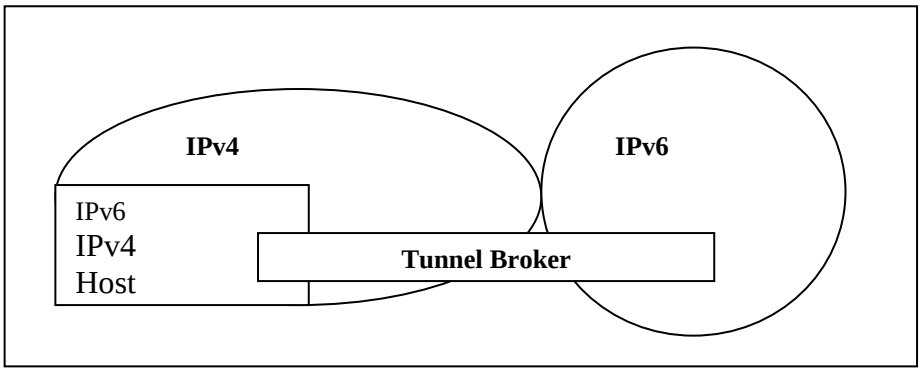

Fig 3: IPv6 Tunnel Broker

3.3. Translators:

Since IPv4 and IPv6 packets are not directly compatible, therefore a technique known as translators are used that translate the IPv4 packets into IPv6 and vice versa. But translators tend to slow the network. Translation between IPv4 and IPv6 can take place at three levels i.e. IP level, transport level and the application level.

- ***IP level translation*** involves converting from one header to another and is the simplest & fast method of translation.
- In ***transport translation*** the translator works as a relay, working on TCP/UDP flows.
- ***Application level translation*** acts in the form of an Application level Gateway (ALG) and is the most complex form of translation.

Different tools are used for translation. These are listed as follows:

a. ***SIIT-PT*** (Stateless IP/ICMP Translation- Protocol Translation).
b. ***NAT-PT*** (Network Address Translation – Protocol Translation).
c. ***BIS – PT*** (Bump in the stack – Protocol Translation).
d. ***TRT-PT*** (Transport Relay Translator – Protocol Translation).
e. SOCKS64 (Socks based IP6/IPv4 Gateway Mechanism).

4 GLOBAL SCENARIO:

Knowing the importance of IPv6, many countries have already started work on the transition. Some of the countries are listed below:

4.1. Japan:

Japan is one of the proactive nations in deployment of IPv6 enabled services in the country. The govt. took the initiative by launching national "***e-Japan***" policy in 2001 and has spent about 8billion Japanese's yen for research and development. According to this policy the govt. laid down the foundation of "IT Strategic Headquarters" under the leadership of Japanese prime minister and has set a deadline of 2005 for up gradation of existing IPv4 networks to IPv6. This policy also includes the incorporation of IT basic law. The ISP industry adopted the IPv6 specification in 2002 and this policy was later extended to other related industries in 2003 to enhance the infrastructure of IPv6 development. In order to speed up the transition, govt. exempted tax on the purchase of IPv6-capable routers from corporate and property taxes. By the initiation of the Ministry of Posts, Telecommunications, Public Management and Home Affairs, the IPv6 promotion council of Japan has more than 300 industry related members. In 2006 the govt. has started another program around the concept of ubiquity called "***u-Japan***" (Ubiquitous Japan). Under this program govt. aims at providing ubiquitous connection to its citizens and to connect everything and everyone by 2010.

4.2. South Korea:

Just like Japan the South Korean government also holds a strong desire for transition to IPv6. In March 2000 Korean ministry of information and communication (MIC) formed the "IPv6 Forum Korea". The activities of this forum include conducting fundamental research, promoting application products, and planning policy recommendation. In 2003, govt. invested about 46.8 billion Korean Dollars on the development of IPv6. In 2004, the number of IPv6 products grew rapidly due to strong govt. support on hardware development.

4.3. China:

China is also a prime promoter of IPv6 in its country. In December 2003, the National Development Reform Commission (***NDRC***) started a project "***China Next Generation Internet (CNGI)***" and allocated a fund of 1.4billion Yuan for the development of IPv6 networks. China also proposed to establish ***CERNET2***, which is the biggest inter-network operation in the world and connects 25 universities in 20 cities and will work purely on IPv6. The urge of Chinese Govt. in the deployment of IPv6 infrastructure is due to the shortage of IPv4 addresses. China has 4.4 times more population than United States but the IPv4 address allocation is 1/38 times that of United States. In April 2007, China hosted Global IPv6 Summit which shows the desire of the Chinese Govt. as well that of industry to establish proper IPv6 infrastructure in the country.

4.4. India:

India is also keen in the development and deployment of IPv6. IPv6 is part of India's Ministry of Communication & IT (MCIT) ten point agenda. In this regard ***TRAI*** (Telecom Regulatory Authority of India) has already written a consultation paper in August 2005. Ministry of communication & IT formed the IPv6 implementation Group (IPIG) to help put together an IPv6 roadmap for India. This group meets at least twice a year to discuss items relevant for the development of IPv6. In 2005, India hosted fifth Global IPv6 Summit.

4.5. Europe:

European countries have also contributed much in the development of IPv6. In 2001, the European Commission (EC) took the initiative by forming "IPv6 Task Force" and had approximately invested 185 million Euros for the development of IPv6, with another 300 million added in 2003. In 2002, European Union (EU) launched "***eEurope 2005***" action plan which aimed at increasing broad band networks and development of new protocols (IPv6). To foster the deployment in Europe, the EC funded two major internet projects ***6NET & Euro6IX***.

The "***eEurope***" program finished in 2005 and was replaced by "***i2010***". The main vision of this program is to develop IPv6 based applications in the

transportation sector, telecommunications and emergency & crisis management. This program also entitles to standardize the IPv6 application based businesses.

4.6. USA:

The primary leader in the development of IPv6 in USA is the U.S Department Of Defense. It declared not to purchase IPv4 based networks and is expected to replace the whole infrastructure to IPv6 by 2008. The largest testbed in U.S is ***Moonv6 project*** which is the collaborative effort of U.S Department Of Defense, the North American IPv6 Task Force ***(NAV6TF)***, University Of New Hampshire Interoperability Lab (UNH-IOL) and the Joint Interoperability Testing Command (JITC).

However critics argue that USA is not urgent for the deployment of IPv6 due to the fact that US owns almost 70 % of IPv4 addresses.

5 PAKISTANI SCENARIO:

Telecommunication sector in Pakistan is presently highly competitive. This sector is rapidly migrating from circuit switching to packet switching. Few of long distance and international service providers have deployed Next Generation Network and operating in IP environment in the core network.

Pakistan is also fostering its efforts to deploy and develop new IP based services and applications. Some of the efforts made in this regard are listed as under:

5.1. Government Policies:

Government of Pakistan understands any new concept specially if it is related to new age communication and Internet. Government shall facilitate the cause and efforts for any new technological emergence in Pakistan.

IT Policy (Aug, 2000):

"Government shall be the facilitator and enabler to encourage the private sector to drive the development in IT and Telecommunications".

According to the Broadband policy 2004, the government envisaged on increase of internet penetration in the country and to develop new Broadband internet based services and applications. The Broadband policy has also insisted on developing & deploying various Broadband interactive services.

However, In order to achieve governments IT & Broadband policies/objectives & targets, Pakistan's Broadband network needs to be globally competitive, secure & affordable. Moreover with the rapid emergence of new technologies in the field of communications, Government's rapidly adopting, bringing and developing new technologies to bridge digital divide. The present IPv4 may not help in fulfilling these objectives. In this regard Pakistan is also cultivating its efforts to deploy and develop new IP based services and applications.

5.2 Private Sector Efforts:

Leading ISP's of the country (CYBERNET, SUPERNET & DANCOM) decided to get their v6 prefix from APNIC. These ISP's started initial IPv6 development with in their own domain since March, 2000. In Sep, 2006 national IPv6 task force (http://www.IPv6tf.org.pk) was established to further increase the pace of v6 activities in Pakistan. The main objectives of this task force are to accelerate the deployment of IPv6 in Pakistan. In June 2007, this task force hosted "***IPv6 Technical Summit"*** to understand the technological needs for the successful integration of IPv6. This task force has already started a project ***6Core***, providing the test bed for IPV6 in the country.

5.3 Academia Role:

Academia can play a vital role in transitioning from IPv4 to IPv6. Industry-academia partnership can foster the pace of transitioning. IPv6 taskforce Pakistan shall collaborate with the leading universities of the country to do research on technical hurdles during transition while Government can support by allocating ***National ICT R&D fund*** and ***HEC research fund*** to academia where Test beds could be established for research purposes and could be prevailed developing IPv6 native support products. Industry can help by transferring knowledge to academia that is pre-requisite for research. Efforts can then be fostered to connect these test beds to the national test bed (***project 6Core***) and ultimately also with international test bed networks such as ***live IPv6 network***. The local industry can benefit from these sorts of collaborations by achieving their targets at low costs, also they can enroll those students who have worked in development and can have trained HR/Engineers.

5.4 Needs and Benefits of Creating National IPv6 Backbone:

So far, not a single organization has come forward to establish a national IPv6 Backbone. It is essential to have national backbone that should integrate the research activities taking place on various scattered places carried out by various stakeholders. This national backbone can then be tested to develop various applications and should also be connected to international test bed networks such as ***live IPv6 network***.

This backbone can be created by involving different stakeholders like ***ISPAK*** (internet service providers association Pakistan), ***NDC*** (National Development Corporation) & also leading universities of the country.

5.5 Regulator's (PTA) Role:

Pakistan Telecom Authority is committed through its vision statement *"**to creating a fair regulatory regime to promote investment, encourage competition, protect consumer interest and ensure high quality information and communication technology services"***. It provides initiatives to industry to formulate its own transition plans and also create awareness by organizing industrial forums and seminars.

It clearly understands the recent technological advancements in the field of IP enabled services and applications. The present internet protocol version 4 (IPv4) is getting exhausted and may not be able to meet the future challenges as well as to promote & support development of new technologies. PTA is catalyzing its efforts to promote transition of IPv6 by proactive initiatives.

Pakistan Telecom Authority established an *"Online Expert Group Forum"* in April 2007 (http://www.pta.gov.pk/egf/default.asp). Main aim of this forum was to provide a platform to congregate opinions and recommendations on technical, financial, legal and policy related issues arising from emerging technologies.

ICT Cell in PTA organized an industrial forum on 31st August 2007 to discuss issues related to transition from IPv4 to IPv6. All major stakeholders from industry, ministry & academia participated in this forum and shared their expertise and provide recommendations for the sustainable growth of an information based society, particularly IPv6 was one of the agenda point discussed during the forum. Realizing the importance of IPV6, Pakistan Telecom Authority has formulated a focal group and made IPV6 Taskforce (Pakistan) an integral part of it. It was also decided that PTA will float a consultation paper on issues pertaining to ***transition from IPv4 to IPv6*** and also facilitate the academia to establish IPv6 test nodes.

Therefore, a consultation paper has been formulated to get feed back on issues mentioned below:

Issues for consultations:

1. ***What kind of IP based services does your Company offer? If there are no such services do u have any future plans to start IP- based services?***
2. ***Which type of vendor equipment do you use for offering IP-based services i-e Switches, Router etc? Please specify the name of the vendor as well.***
3. ***Does your core IP-based network is compatible with IPV6; If no please specify if you have any future plans on upgrading it to Ipv6 compatible?***
4. ***Does the regulator has any role to play in the transition from IPv4 to IPv6 or the stakeholders can handle themselves? If yes, what regulatory steps and initiatives are required? (General practices for transition phase in other countries must be considered)***
5. ***State whether there is any subsidiary given by the Government in the form of taxes on the import of IPv6 capable equipments and services?***
6. ***If no, what are the taxes that the stakeholder is paying? In addition are there any tax impositions on IPV6 capable equipment, in comparison with other countries?***
7. ***Is any need to establish National Internet Registry of Pakistan (NIRP)?***
8. ***Do the stake holders have got enough expertise to establish IPv6 test nodes or will they acquire some foreign expertise?***
9. ***Is there any sort of research collaboration with the top academia of the country or not?***
10. ***If yes, then state research activities that are undergoing in collaboration with academia? Also state whether academia has got enough technically strong human resource required for transitioning from IPv4 to IPv6?***
11. ***If no, state what role academia can play in developing & deploying IPv6 based infrastructure?***

Issues for consultation:

12. ***State whether the IPv6 migration will help improving QoS issues for the end user?***

13. ***What is the present static/permanent IP allocation procedure in Pakistan? Will the transition affect/change the present IP allocation in Pakistan? Also state whether there is any problem in getting static/permanent IP addresses from APNIC?***

14. ***Is there any need to create national IPv6 Backbone?***

15. ***What transition mechanism is best suited for transition from IPv4 to IPv6? How the DNS infrastructure will be upgraded?***

16. ***If yes, then state briefly whether there will still be a need of firewall hardware, security intrusion hardware, and other security servers presently used in IPv4 infrastructure?***

17. ***State how the transition will help in establishing, improving & enhancing Broad Band services in the country?***

18. ***Do you see any difference in training engineers for IPv4 & IPv6***?

ANNEX A: Cost Model of Nodes

Proposed IPv6 Research Lab Solutions for Universities

Scenario # 1 : Cisco 3845 IPv6 Gateway Router with Inbox - Xeon Server Machines.

Equipments	Quantity	Make-Model	Memory	Operating System	Hard Disk	Modules 1	Modules 2	Cost (PKR)
Router	1	Cisco - 3845	256 DRAM / 64 FLASH	IPv6 Compatible IOS	N/A	ADSL WIC	G703 (E1)	560,117
Switch	1	Cisco - 2960	64 DRAM/ 32 FLASH	IOS	N/A	N/A	N/A	96,000
Servers Machines	4	Inbox- Xeon (Dual CPU Board)	2 GB RAM	Linux and Windows	200 GB	Dual Ethernet	Modem	640,000
Total cost of Scenario								**1,296,117**

Scenario # 2 : Juniper J4300 IPv6 Gateway Router with Inbox - Xeon Server Machines.

Equipments	Quantity	Make-Model	Memory	Operating System	Hard Disk	Modules 1	Modules 2	Cost (PKR)
Router	1	Juniper - J4350	256 DRAM / 64 FLASH	JunOS - 8.2	N/A	ADSL WIC	G703 (E1)	309,043
Switch	1	Cisco - 2960	64 DRAM/ 32 FLASH	IOS	N/A	N/A	N/A	96,000
Servers Machines	4	Inbox- Xeon (Dual CPU Board)	2 GB RAM	Linux and Windows	200 GB	Dual Ethernet	Modem	640,000
Total cost of Scenario								**1,045,043**

Scenario # 3 : Cisco 2811 IPv6 Gateway Router with Desktop Machines.

Equipments	Quantity	Make-Model	Memory	Operating System	Hard Disk	Modules 1	Modules 2	Cost (PKR)
Router	1	Cisco - 2811	256 DRAM / 64 FLASH	IPv6 Compatible IOS	N/A	ADSL WIC	G703 (E1)	185,619
Switch	1	Cisco - 2960	64 DRAM/ 32 FLASH	IOS	N/A	N/A	N/A	96,000
Servers Machines	4	Inbox - Desktop Machine	2 GB RAM	Linux and Windows	200 GB	Dual Ethernet	Modem	140,000
Total cost of Scenario								**421,619**

Scenario # 4 : Juniper J2300 IPv6 Gateway Router with Desktop Machines.

Equipments	Quantity	Make-Model	Memory	Operating System	Hard Disk	Modules 1	Modules 2	Cost (PKR)
Router	1	Juniper - J2350	256 DRAM / 64 FLASH	JunOS - 8.2	N/A	ADSL WIC	G703 (E1)	183,000
Switch	1	Cisco - 2960	64 DRAM/ 32 FLASH	IOS	N/A	N/A	N/A	96,000
Servers Machines	4	Inbox - Desktop Machine	2 GB RAM	Linux and Windows	200 GB	Dual Ethernet	Modem	140,000
Total cost of Scenario								**419,000**

Annex B

GLSOSSARY

ICT: (Information and Communication Technologies) - An international term to represent services and technologies that are driven by computer and telecommunication networks.

IP :(INTERNET PROTOCOL) - Procedures that allow transmission of communication packets between various PoPs.

IPv4: Internet Protocol Version 4.

Ipv6: Internet Protocol Version 6.

ISP: (Internet Service Provider) - Company that owns Internet based infrastructure (Routers, Servers) and provides Internet access to users.

WiMAX: (worldwide interoperability of microwave access)- standards based technology enabling the delivery of last mile wireless broadband access over long distances.

NAT: (Network Address Translation)- NAT is the translation of IP address used with in one network to a different IP address known in different network.

CIDR: (Classless Inter-Domain Routing)- an expansion of IP addressing system that allows for a more efficient and appropriate allocation of addresses.

IETF- (internet Engineering Task Force)-a non-membership, voluntary standards organization to identifying problems and opportunities in IP data networks and proposing technical solutions to the Internet community.

RFC: **(Request for comments)-** a document that describes specifications for recommended technology. These are used by Internet Engineering Task Force (IETF).

Network Address: the network address of an IP address or a group of characters that uniquely identify the location of a node on the network.

Host Address: Physical address of a computer in a network. On the internet host address is the IP address of the machine.

Unicast: communication between a single sender and receiver on a network.

Multicast: communication between a single sender and multiple receivers on a network.

Anycast: a technique for updating routing tables in Ipv6. anycast sends a message to the nearest router with in a group. That router in turn sends to its nearest router.

6Bone: an international Ipv6 back bone set up by IETF for testing.

APLG: (Application Level Gateway)-A firewall system in which service is provided by processes that maintain complete TCP connection state and sequencing.

NAV6TF: North American Ipv6 task force.

UNH-IOL: University of New Hampshire interoperability lab.

6Core: National Ipv6 backbone of Pakistan.

National ICT R&D fund: A national fund allocated by the Ministry of IT (MoIT) to universities and other organizations for carrying out research & development.

ISPAK: Internet service providers association Pakistan.

NDC: National Development Corporation.

ASIC: (Application level integrated circuit) - A microchip that has been designed from scratch for a specific application.

DNS: **(Domain Name System)**- A system for converting host names and domain names into IP addresses on the internet or on local networks that use TCP/IP protocol.