INFO-COMMUNICATIONS DEVELOPMENT AUTHORITY OF SINGAPORE

INFORMATION PAPER:

INTERNET PROTOCOL VERSION 6 TRANSITION PLANS FOR SINGAPORE

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OVERVIEW OF INTERNET PROTOCOL VERSION 6

1.1 Today's public Internet functions on the common network layer standard of Internet Protocol version 4 ("IPv4") but there is on-going discussion internationally about the transition to the next standard, i.e., Internet Protocol version 6 ("IPv6").

1.2 The transition to IPv6 is driven by several factors, namely IPv4's limitations, future needs of Next Generation Networks and Services and the technical capabilities of IPv6.

IPv4 Exhaustion

1.3 There has been much discussion since the early 1990s that IPv4 addresses would run out. While predictions differ, there is consensus that IPv4 address exhaustion will happen[1]. IP addressing needs are also added to by the flourishing number of new applications, "always on" broadband connectivity and plain accelerated increase in the number of Internet users. To increase addressing space for networked devices, the Internet Engineering Task Force[2] in 1994 adopted IPv6. IPv6 uses 128 bit addresses that allow for 3.4×10^{38} unique addresses compared to 4.3 billion unique addresses offered by IPv4. In July 2004, the Internet Corporation for Assigned Names and Numbers ("ICANN") announced that IPv6 addresses have been added to the Domain Names System root zone, which paved the way for IPv6 deployment.

Needs of Next Generation Networks and Services

1.4 Trends in rich and interactive multi-media applications such as telemedicine and high-definition video-conferencing have been identified as drivers for Next Generation Networks. These applications and

[1] There are varying predictions for IPv4 exhaustion. For reference, Geoff Huston of the Asia Pacific Network Information Centre has predicted an exhaustion date at the Internet Assigned Numbers Authority ("IANA") level to be August 2012. His current prediction of IPv4 exhaustion date at the global level is approximately 20 years later in January 2027. (Source: http://www.potaroo.net/tools/ipv4/ dated 1 May 06.)

[2] An open, all-volunteer, standards organisation that develops and promotes Internet standards.

services require a network that allows users to communicate and run applications across the Internet, on a peer-to-peer basis. This would mean that each device has to be equipped with unique IP addressing and has to operate on a flat-based network architecture. Features of IPv6 such as those listed in the section below will be able to provide simplified network processes to greatly facilitate the exchange of customised information interactively. The adoption of IPv6 will also facilitate fixed-mobile convergence.

Technical Capabilities of IPv6

1.5 IPv6 features several technical capabilities useful for Next Generation Networks and Services, and fixed-mobile convergence. They include the following:

a. *Larger address space*. To circumvent address exhaustion considerations, IPv4 uses Network Address Translation ("NAT") to build network hierarchy and allow multiple devices to connect to the public Internet through a single IP address. This means the devices do not directly connect to the Internet, but hide behind the enabling router. However, this could eventually block or inhibit the growth of peer-to-peer applications like Voice over IP, since there is no true end-to-end connectivity and the connection could be disrupted. This is not necessary for IPv6 given the larger address space. Larger address space also has other advantages, such as deterring scanning of certain IP blocks for vulnerabilities, providing greater ease of configuration and greater flexibility for the use of static IP addresses.

b. *Multicast*. Multicast refers to the delivery of data (which can be video or audio data) to a group of destinations simultaneously, using the most efficient way to deliver over the network only once and only create copies when the destinations split. In IPv6, multicast is part of the base protocol suite, unlike IPv4 where multicast is optional, rarely deployed and creates overheads.

c. *Auto-configuration of Hosts and Mobile IP*. IPv6 hosts can be configured automatically when connected to a routed IPv6 network because the routers can provide a router advertisement

packet that contains network-layer configuration parameters, thus making it easily deployable even on mobile networks.

d. *Mobile IP.* Mobile IP is a standard communication protocol designed to allow mobile device users to move from one network to another while maintaining their permanent IP addresses[3]. However Mobile IP requires a device to have 2 IP addresses when it is roaming, thus IPv6's advantage of a larger address space, makes it more suited for Mobile IP.

e. *Network-layer Security*. IPsec – the protocol for IP network-layer encryption and authentication – is an integral part of the base protocol suite in IPv6. It is a more flexible protocol designed for securing packet data flows and encryption key exchanges.

SINGAPORE'S SITUATION

2.1 Singapore will be affected by the IPv4 exhaustion in the next one to two decades. Our Internet Service Providers ("ISPs"), who obtain IP addresses from the Asia Pacific Network Information Centre ("APNIC"), will have to compete with heavy demand from countries like China and India for IP addresses. While IDA understands that ISPs are monitoring IPv6 technologies and market development, they may wait for more specific market demand before transiting their networks to IPv6.

2.2 Nevertheless, the case for IPv6 is not based on the singular consideration of an IPv4 address shortage, but hinges on the larger package of technology renewal with its suite of benefits as expressed in the preceding paragraphs. Reliance on market forces alone to drive IPv6 adoption may not be sufficient especially with the deployment of Next Generation Networks.

2.3 Therefore, it is appropriate and timely for IDA to develop a clear policy position and strategy to catalyst the deployment of IPv6 for Singapore.

[3] Mobile IP is usually found in wireless WAN environments where users need to carry their mobile devices across multiple LANs with different IP addresses. It may also be used in 3G networks to provide transparency when Internet users migrate between cellular towers.

International Initiatives

2.4 Countries internationally face a similar situation; organisations would prefer to receive more concrete and immediate evidence of the benefits of IPv6 migration before making the move, while application developers are waiting for the trend of IPv6 adoption to be firmed before committing resources to develop major applications. Recognising the longer-term benefits of IPv6 deployment, many countries have thus taken positions on IPv6 transition through Government-led initiatives to catalyse the movement of IPv6 migration. Once the IPv6 migration becomes a trend, both organisations and application developers are more inclined to commit the necessary resources to join the migration. For example, the US announced in June 2005 that all its federal agencies must deploy IPv6 by June 2008, and the White House has issued a policy memorandum dictating full federal IPv6 compliance[4]. In 2001, the EU announced a joint strategy called e-Europe to promote IPv6 adoption. Funds were made available to several research projects dedicated to developing protocol knowledge, deployment experience and new applications.

2.5 The Telecom Regulatory Authority of India published their recommendations in January 2006 on IPv6, entailing Government facilitation through setting up of technology test beds, mandating IPv6 compatibility for Government's procurement, and the creation of a national Internet Registry within the framework of APNIC. Other jurisdictions in the Asia-Pacific region like China, Taiwan, Japan and South Korea have similarly created Government-led initiatives for test beds to sort out IPv6 inter-operability issues and create awareness for IPv6 in the form of forums and promotional councils.

PROPOSED IPv6 INITIATIVES FOR SINGAPORE

3.1 A mandatory IPv6 transition would be difficult to implement especially for a highly connected nation like Singapore. Indeed, no country has mandated an immediate IPv6 transition with a cut-off for IPv4. Instead of regulatory intervention, the preferred option internationally has been for the Government to take the lead in encouraging IPv6 transition.

[4] The US Office of Management and Budget opined that IPv6 transition would further increase industry activities in the US and allow US companies to be the first to develop new applications that utilise IPv6.

Initiatives are generally tailored according to two consistent themes: (a) Government catalyses IPv6 transition through its procurement process; and (b) Government provides initiatives for industry to formulate its own transition plans through education or research initiatives. This approach will help to assure the different stakeholders of the benefits of IPv6 by show-casing how IPv6 transition could be implemented.

3.2 Thus, IDA will put in place a strategy to promote nation-wide IPv6 transition via the inclusion of IPv6 elements in the Next Generation National Infocomm Infrastructure ("Next Gen NII"), the Government Procurement policy and industry capability building.

Next Gen NII

3.3 As our Government moves ahead to develop infrastructure ahead of demand, it is important to ensure that Next Gen NII is capable of supporting emerging Next Generation Services. With the planning of a nation-wide ultra-high speed broadband access network and a pervasive wireless broadband network by 2010, it is important for the networks to have inter-operability to enable seamless end-user experience. Security needs become more important with the usage of the networks for e-commerce and the transfer of sensitive information, and such risks are increased when connectivity is 'always-on'. The enhanced features of IPv6 in security and routing capability are important factors for the fixed-mobile convergence.

Government Procurement

3.4 Given that the Government is a major buyer and user of infocomm equipment, a full Government transition to IPv6 would be a key catalyst for the private sector to follow suit. It would also instill confidence of an IPv6 transition among the industry. However, an immediate and full replacement of all public sector network equipment with IPv6 capable equipment at this juncture is wasteful and costly. It would be more feasible to ensure a progressive replacement of public sector equipment with IPv6-capable equipment when the current set of equipment is due for replacement upon reaching their useful lifespan, but set a deadline for full IPv6 capability.

3.5 In determining the deadline for full IPv6 capability, IDA recognises that in less than a decade, the supply of IPv4 addresses could be tight. However, in appreciation of the shifting nature of such address exhaustion prediction, the deadline should be set earlier to avoid running the risk that Singapore faces IPv4 address shortages even before the country's systems are fully upgraded. In this regard, IDA has adopted a deadline of end 2010 for full public sector IPv6 transition.

Formation of National IPv6 Task Force

3.6 Even with the above IDA-led initiatives, the nation-wide IPv6 transition may not be sufficiently accelerated to fully capitalise on the benefits provided by IPv6. To catalyse the transition, IDA will also form an IPv6 Task Force, compromising of IPv6 experts from IDA and partnering local research institutes, telecommunications companies, ISPs, and equipment manufacturers where the need arises. Besides recommending a technical transition plan for the migration from IPv4 to IPv6, there will be several other activities that the Task Force will carry out. These activities which seek to develop the industry's capabilities in IPv6 technologies and facilitate better understanding of its suite of benefits, will include the following:

a. *Guidelines for Government IPv6 transition*. IPv6 transition for the Government will entail many implementation issues. The Task Force will develop a set of technical guidelines for IPv6 transition, and subsequently share the guidelines with relevant parties if appropriate.

b. *IPv6 Test bed.* Setting up an IPv6 test bed has the advantage of engaging the industry, especially the service providers, to try out small scale systems in a controlled environment. Any inter-operability issues could be studied and resolved with the equipment vendors without committing the network owners, e.g., ISPs, to potentially costly mistakes. The test bed could also potentially serve as a neutral platform for potential users like video content providers to test their services in an IPv6 environment.

c. *Seminars.* To deepen industry's knowledge and expertise in deploying IPv6, IDA will bring together different industry players,

including equipment vendors, system software developers, ISPs, managers of facility management / data centres, research institutes and other relevant stakeholders to share technical know-how and adoption experiences

SUMMARY OF THE INITIATIVES

4.1 In summary, IDA recognises the benefits offered by IPv6 which will be useful for next generation networks and services, and fixed-mobile convergence. With the appreciation that the Government needs to catalyse IPv6 transition in order to drive such adoption by Singapore entities, IDA will include IPv6 elements in the Next Gen NII, the Government Procurement policy and industry capability building through seminar sessions. IDA has adopted a deadline of end 2010 for a public sector wide adoption of IPv6, while a Task Force will be formed to develop the industry's capabilities in IPv6 technologies and facilitate better understanding of its suite of benefits. The exact details of the activities conducted by the Task Force will be released upon the formation of the Task Force.