INFO-COMMUNICATIONS DEVELOPMENT AUTHORITY OF SINGAPORE

INFORMATION PAPER:

INTERNET PROTOCOL VERSION 6

PHASE 2 TRANSITION PLANS FOR SINGAPORE

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OVERVIEW OF INTERNET PROTOCOL VERSION 6

1.1 The public Internet of today relies upon Internet Protocols ("IP") to route data packets across networks. The Internet Protocol version 4 ("IPv4") is the principal communications protocol that is used today for the Internet. However, the number of IPv4 addresses is limited and the available global free pool of IPv4 addresses is depleting rapidly. As of 3 February 2011, global exhaustion[1] of IPv4 addresses has occurred and regional exhaustion of unallocated IPv4 addresses in the Asia Pacific region has been predicted to occur in September 2011[2].

1.2 To address the impending depletion of IPv4 addresses, the Internet Engineering Task Force ("IETF") developed and published IP version 6 ("IPv6") in 1998. IPv6 uses 128 bit addresses to allow for 3.4×10^{38} unique addresses, as compared to 4.3×10^{9} unique addresses allowed for by IPv4. IPv6 also has several technical advantages over IPv4, such as simplifying aspects of network renumbering and improvements in multicasting and routing speeds.

1.3 IPv6 was designed by IETF to replace IPv4. It is designed to co-exist with IPv4, but is incompatible with IPv4. This means that while both IPv4 and IPv6 traffic can flow over the same physical medium, IPv4-only nodes are not able to communicate directly with IPv6 nodes and vice-versa, which in turn necessitates the use of transition mechanisms. IETF has also defined the transition mechanisms needed. For smooth transition, concerted action from various stakeholders in the ecosystem is required.

1.4 At the point of IPv4 exhaustion, existing nodes that have been allocated IPv4 addresses or are sharing IPv4 addresses (via DHCP[3] or NAT[4]) will experience little or no impact. However, new nodes that are assigned IPv6 addresses will not be able to reach existing IPv4 services and content without transition mechanisms. This will in turn impact the growth of Internet content and

[1] A global exhaustion of IPv4 addresses refers to when the International Assigned Numbers Authority or IANA distributes all its free pool of IPv4 addresses to the Regional Internet Registries (or RIRs).
[2] Regional exhaustion of IPv4 addresses refers to when the RIRs have allocated all of their free pool of IPv4 addresses. The RIR of the Asia Pacific region is the Asia Pacific Network Information Centre (or APNIC).
[3] Dynamic Host Configuration Protocol (DHCP) is an auto-configuration protocol used on IP networks to issue IP addresses.
[4] Network Address Translation (NAT) is the process of modifying network address information, usually used to hide an entire private IP address space behind a single IP address in public address space.

services, the growth of Internet-dependent businesses, and business continuity.

International Initiatives

1.5 Around the world, various countries have put in initiatives to encourage the transition to IPv6 amongst the organisations and application developers in their region. Some of the recent initiatives by other governments are listed below:

a) Hong Kong The Hong Kong government established an IPv6-Enabled Government E-Service system in February 2010[5]; through which all 231 government websites can be accessed through IPv6;

b) Australia: The government has released a set of revised guidelines[6] in 2009, according to which, agencies should have IPv6 capable hardware and software platforms by 2012, and be able to operate dual stack IPv4/Ipv6 environments by 2015;

c) India: The government has announced a plan[7] which mandates federal and state government ministries and departments and public sector companies to switch over to IPv6 services by March 2012. It also requires that all Internet Service Providers ("ISPs") start offering IPv6 services by 2012.

d) US: The US[8] government announced in September 2010 to upgrade their public-facing websites and services by 30 September 2012 to support native IPv6. The directive also required federal agencies to upgrade internal client applications that communicate with public Internet servers to use native IPv6 by 30 September 2014.

e) Japan: IPv6 deployment has had strong Japanese Government support since 2001 through its e-Japan Strategy[9]. Most of its major ISPs such as NTT, KDDI and vendors such as Fujitsu, NEC already offer IPv6 services and products.

[5] Speech by Mr John Wong, Assistant GCIO of the Government of Hong Kong SAR, at IPv6 World.Asia, 23 February 2010

[6] Australian Government Information Management Office: "A Strategy for the Implementation of IPv6 in Australian Government Agencies", July 2009.

[7] http://www.tec.gov.in/National-IPv6-Deployment-Roadmap.pdf

[8] Memorandum for Chief Information Officers of Executive Departments and Agencies, Federal Government of US, "Transition to IPv6", 28 September 2010

[9] http://www.kantei.go.jp/foreign/it/network/0122full_e.html

SINGAPORE'S SITUATION

2.1 On 20 June 2006, IDA published an Information Paper: Internet Protocol Version 6 Transition Plans for Singapore. In the paper, IDA noted the need to catalyse the deployment of IPv6 in Singapore, as reliance on market forces alone to drive IPv6 adoption may not be sufficient, especially with the deployment of the Next Generation National Infocomm Infrastructure ("Next Gen NII") creating a significant step-up demand for IP addresses.

2.2 The proposed IPv6 strategy for Singapore set out in 2006 was to promote nationwide IPv6 transition through a two-prong approach. Firstly, the Government will catalyse IPv6 transition through its procurement process, by ensuring that the Next Gen NII will be IPv6-ready, and to progressive replace public sector equipment with IPv6-capable equipment. Secondly, the Government would provide initiatives for industry to formulate its own transition plans through education and research initiatives. An IPv6 Task Force, comprising IPv6 experts from IDA, local research institutes, telecommunications companies, ISPs, and equipment manufacturers, was set up to design and carry out various initiatives.

2.3 Since then, the depletion rate for IPv4 has been accelerating, possibly due to the rapid growth of the Internet, driven by China and India, and new technologies like the proliferation of smartphones and Web 2.0 applications. Whilst Singapore's strategy has made progress in catalysing IPv6 transition in the country, it is timely for IDA to review the strategy and update Singapore's IPv6 transition plan to address the impending exhaustion of IPv4 addresses.

STOCKTAKE OF INITIATIVES TO MANAGE TRANSITION TO IPv6

Industry Engagement through IPv6 Task Force

3.1 Since 2006, the IPv6 Task Force has been engaging the industry to raise awareness of IPv6, drive IPv6 competency and ensure readiness of stakeholders for a smooth transition to IPv6 as further elaborated below.

3.2 Three IPv6 Executive Briefings were conducted in November 2009, March 2010 and November 2010 to communicate to stakeholders the implications of the impending IPv4 exhaustion. The success of these briefings was validated by surges of IPv6 address allocation during the same months in November 2009 and March 2010.

3.3 To ensure that sufficient IPv6 skills and manpower are available to support Singapore's transition to IPv6, the IPv6 Task Force has also ensured that appropriate IPv6 components are embedded into the network communication course curricula for Institutes of Higher Learning ("IHLs")[10]. IPv6 components

[10] Including the universities, polytechnics and Institutes of Technical Education.

were integrated into the National Infocomm Competency Framework ("NICF"), a continual training framework which leverages on the Critical Infocomm Technology Resource Programme ("CITREP") and Continuing Education Training ("CET") centre at Singapore Polytechnic to reach out to the existing professional workforce.

3.4 To help companies clarify their own IPv6 readiness levels, an IPv6 National Readiness Survey and an IPv6 Technology Pilot trial were undertaken in 2010. Both initiatives had the effect of helping the industry prepare for IPv4/IPv6 coexistence, and allowed industry players to better understand potential operational issues.

3.5 In February 2010, IDA formed the Working Group 5 under the auspices of Telecom Standards Technical Committee to develop an unambiguous mapping of IPv6 standards to requirement specifications, such as usage of terms like "IPv6-Ready" and "IPv6-Enabled". The mapping, collectively known as "Singapore IPv6 Profile", has been consulted upon and was issued on February 2011 on the IDA website.

Government and Industry Readiness for IPv6 Transition

3.6 Anticipating the IPv6 transition, the Singapore government has also included IPv6 support as a requirement in major government-supported industry programmes and government procurement. At the nationwide infrastructural level, IPv6 is now supported in the Next Generation Nationwide Broadband Network ("Next Gen NBN"), the nationwide ultra high speed fibre access infrastructure. IPv6 specifications have also been incorporated into government-supported industry projects like the Singapore Internet Exchange ("SGIX"), Next Generation Innovation Service ("NGSIP") and iSPRINT - Packaged ICT Solutions for SMEs (SaaS Application Solutions).

3.7 For government systems, IPv6 specifications have been incorporated into major procurement projects such as the Standard ICT Operating Environment for government agencies ("SOE"), and the Singapore Government – Technology (ICT) Reference Model ("SG-TRM"). The Singapore Government's network infrastructure, the SGNET SOE Core Network, is also in the midst of upgrading its core and distribution backbone switches, as well as firewall infrastructure, to support the co-existence of IPv4 and IPv6.

3.8 In anticipation of public demand for IPv6 services and to prepare for the IPv6 transition, the Singapore Network Information Centre Pte Ltd ("SGNIC") has upgraded its DNS servers to support IPv6 DNS registration and resolution in December 2008, ensuring that .sg domains will be able to support IPv6 addresses.

3.9 The readiness of Government projects and systems for IPv6 transition provides a catalyst for private sector transition. At the same time, IDA understands that the major ISPs have begun to ready themselves for IPv6 transition, in the form of preparing detailed transition plans, commercial trials and even limited offerings of commercial IPv6 services.

IPv6 TRANSITION: PHASE 2

4.1 A complete transition of the Internet from IPv4 to IPv6 will be a multi-year process. Although IPv6 take-up is increasing, the current take-up rate is still insufficient to reasonably estimate when the Internet will migrate completely to IPv6 with an IPv4 "switch off". Before then, it is generally accepted that there will be a significant period of co-existence of these two addressing systems.

4.2 The various stakeholders in the Internet ecosystem will face differing impact at the point of IPv4 address exhaustion. Existing consumers of IPv4 addresses such as end users, SMEs and enterprises will face little impact to their daily operations. However, the growth plans of business end-users may be impacted if it results in them having to pay a premium for the scarce IPv4 addresses if they could not transit to IPv6 addresses in time, in order to ensure reachability of their content by existing IPv4 users or their access to existing IPv4 content.

4.3 Similarly, the growth plans for on-line service/content providers will be affected. These stakeholders, however, will be concerned with delivering their content/services to their customers that may be on either IPv4 or IPv6 networks. These stakeholders will need transitional mechanisms to be deployed in order to support the delivery of content/services to customers in both IPv4 and IPv6 networks.

4.4 The group of stakeholders that will be most significantly impacted are the ISPs that issue IP addresses and provide access to the Internet. At the point of IPv4 address exhaustion, to maintain business continuity, ISPs need to be able to offer IPv6 services to their customers without breaking the customers' access to existing IPv4 content and services. Significant time and effort is required to ensure that their networks and operations are capable of supporting IPv6. This requires the ISPs to invest early to ensure business continuity. ISPs, therefore, hold the key to an effective transition to the IPv4/IPv6 co-existent environment.

4.5 End user devices with IPv4 capabilities, such as computers or smartphones will continue to be supported by ISPs in the immediate future. However, there may be issues surrounding the end user's ability to access content, e.g., websites addressed by IPv6, unless capabilities are built in within the end user device or the ISPs' networks to access such content.

4.6 From a policy standpoint, IDA is of the view that much of the transition to IPv6 should be led by industry players, especially since there is little clarity on the speed of IPv6 uptake as well as the timing of complete migration or IPv4 "switch-off". However, the Government will continue to put in place measures to ensure seamless adoption of IPv6 in Singapore and co-existence with IPv4. As a start, the Government has taken a 2-pronged approach. The first prong is to ***catalyse IPv6 adoption***, with the aim of ensuring reachability of new IPv6 services by existing IPv4 users and the availability of IPv6 services for new entrants. IDA will continue to conduct and enhance programmes to raise industry awareness of IPv6 and transitional issues, and deepen IPv6 competency within the industry. In addition to regular executive and industry briefings, IDA will be publishing appropriate IPv6 adoption guide(s) and technology guides to assist industry players in navigating the IPv6 transition, and enable co-existence of IPv4 and IPv6. IDA will also continue efforts to create initial IPv6 demand by stepping up IPv6 requirements in government systems and projects. The second prong is to ***manage IPv4 exhaustion***. IDA's industry capability building programmes will include recommendations on the proactive management of the pool of remaining IPv4 addresses to extend their lifespan. This should extend the availability of IPv4 addresses for Singapore businesses beyond the forecasted exhaustion point, and support a smooth IPv6 transition.

4.7 Apart from the programmes described above, IDA envisages that the Internet access services provided to consumers in Singapore should be capable of allowing end users on either address type (IPv4 or IPv6) to access content regardless of its address type, where feasible. This is to prevent a scenario that an end user with an IPv4 address is unable to access content addressable by IPv6, or vice versa, given that both address types are likely to exist on the Internet for a significant period. In this respect, IDA is of the view that industry players should proactively work together to ensure that the abovementioned outcome is achieved. Nonetheless, IDA is prepared to consider and introduce regulatory measures to ensure that consumers' interests are met.

CONCLUSION

5.1 IPv6 transition is an eventuality that industry players will have to accept and manage proactively. IDA has embarked on efforts to prepare for the necessary IPv6 transition for the industry. As full IPv4 exhaustion draws closer, IDA will step up efforts to raise industry awareness, develop IPv6 competency in the industry, create initial IPv6 supply and demand, as well as to assist stakeholders like ISPs to manage the IPv4 exhaustion. IDA will continue to monitor the state of transition, and may introduce regulatory measures where necessary to ensure that businesses and consumers are able to enjoy seamless access to the Internet.