# IPv6 Deployment

Glen Eustace

Infrastructure Support Section, Information Technology Services, Massey University

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## *Introduction*

The paper discusses the current state of today's Internet Protocol (IPv4), and the impending exhaustion of its address pool. It will then describe the current state of IPv6 deployment at Massey University, outline our strategy for wider scale deployment, and discuss some open areas of investigation.

## *The Need for IPv6* [i]

IPv4, the current version of the Internet Protocol, faces an impending exhaustion of addresses. Current projections are that IANA, the Internet Assigned Numbers Authority, will have handed out its remaining IPv4 address blocks to regional Internet registries by mid 2011. And by mid 2012 or so, it's expected that the regional registries (e.g. APNIC in Asia/Pacific) will have given out all those addresses to their customers (typically ISPs and large enterprises). After this time, no one will be able to obtain new IPv4 addresses, at least not in the normal manner. Yet Internet usage continues to grow at an aggressive rate. Currently connected organizations as well as new organizations and people connecting to the Internet will continue to place large demands on future address resources.

It is worth noting that the projected depletion date is based on the current rate of allocation of the remaining addresses. Some technology analysts think it is quite possible that an accelerated rate of depletion may start to happen as time passes.

IPv6, the next generation of the Internet Protocol, has been available for many years. It provides a greatly expanded address space which is expected to last into the foreseeable future. Yet, its uptake has been poor, and IPv6 still remains largely undeployed in most parts of the Internet and its connected organizations.

The original expectation was that most computers and networks would already be dual-stack by this time. Dual-stack means that they would have both IPv4 and IPv6 capability and connectivity. And there would be a fairly simple and gradual transition to IPv6 over the course of time.

It now seems likely that an orderly dual-stack transition will not occur in time. And a number of undesirable scenarios may develop. There could be a mad rush or panic by organizations to claim the remaining address space. There might develop a black market of IPv4 addresses, with companies buying and selling blocks of addresses to the highest bidder (although regional registries are already formulating policies allowing sanctioned IPv4 address transfers between agreeable parties). Service providers and enterprises may decide to deploy more and more layers of NAT (Network Address Translators), with their increasingly damaging impacts on a variety of applications. It is inevitable that many new organizations and services will come online using IPv6 only. And thus, there will likely be a balkanization of the Internet, i.e. the emergence of islands of IPv4-only systems, and IPv6-only systems, which will not be able to communicate with each other. Even organizations that think they have an adequate amount of existing IPv4 address space will face problems, because they may no longer be able to use the new class of emerging IPv6-only services.

We feel that IPv6 deployment is necessary for the continued growth of the Internet. And to preserve important architectural properties of the Internet that have made it successful in enabling new generations of applications and services (universal connectivity, end-to-end addressability etc). Furthermore, the scale of networking IPv6 enables is ideally geared to the Internet's future, where one might imagine Internet access is needed by all our home appliances, our ever growing set of consumer electronic gadgetry, or millions or even billions of wireless sensor devices. The IPv4 Internet cannot possibly accommodate the needs of this world.

## *Current State of IPv6 Deployment at Massey*

Massey started investigating IPv6 in 2007. As a founding member of REANNZ (the Research and Education Advanced Network of New Zealand) we make significant use of the network it operates called KAREN. KAREN has had IPv6 fully deployed throughout its network infrastructure since it was built in 2007. The upgrade of Massey's commodity Internet service and continued development of our border topology has resulted in native IPv6 peering at the Auckland and Wellington IPv6 Internet Exchanges and with Verizon Business using their experimental IPv6 service via a 6to4 tunnel.

IPv6 deployment in the Massey network began with enabling IPv6 on our border routers and campus core routers. A small number of end-user subnets (specifically in the ITS Building) were IPv6 enabled in native mode. All other end-user subnets were IPv6 enabled by setting up ISATAP on the server farm routers. This initial implementation enabled us to deploy a few IPv6 enabled application services and test them from client computers in ITS and from the outside of our network.

Some of the notable central application services that have been enabled for IPv6 include: DNS (Domain Name Service), Electronic Mail (external) and NTP (Network Time). Massey's main website is accessible via IPv6 using the URL http://ipv6.massey.ac.nz. Telnet and SSH remote login to some of the servers and some network equipment also supports IPv6 for systems administration and networking staff.

## *Next Steps in IPv6 Deployment*

In terms of network infrastructure, the main task ahead is to extend native IPv6 from the core of the campus networks to the various campus building subnets. Until recently, this has not been possible as the releases of Cisco's IOS on our distribution layer infrastructure did not support IPv6 dynamic routing using EIGRP or DHCPv6 relay functionality. Massey are currently in the process of updating the IOS versions on the distribution infrastructure to releases which now support our requirements.

As these plans proceed, Massey will continue to enable or enhance IPv6 capability in its various network applications, like Web, E-mail, Authentication (AD, RADIUS, etc), Directory (AD), etc.

For centralized management of client addresses, Massey will implement its IPv6 configuration policy and deploy a DHCPv6 service.

## *Open Issues and Areas of Investigation*

## DHCPv6

Assigning IPv6 leases from pools does not require a unique Client Identifier and as such presents no additional challenges. Unfortunately, assigning a static lease necessitates being able to uniquely identify the client in order to identify the appropriate lease. DHCPv4 uses either a supplied ClientID or the MAC address of the client if a ClientID is not specified. The protocol designers for DHCPv6 have elected to use an opaque value as the ClientID. Determining this identifier for a specific client is proving a significant challenge and as yet we have no solution.

## Tunneling

A variety of tunneling mechanisms exist by which computers can use IPv6 without a working IPv6 network infrastructure. Two of the popular mechanisms are 6to4 and Teredo. IT staff should be aware that users both on and off campus may already be using IPv6 via these mechanisms, and in doing so, perhaps evading filtering and monitoring infrastructure that may be oblivious to IPv6 (like many current varieties of firewalls, passive flow monitors, etc). This tunneled traffic is also possibly being relayed through a tunnel exit point in a distant part of the Internet (e.g. a Microsoft server in the case of Teredo), where that traffic could potentially be analyzed. Massey's deployment of ISATAP and having the majority of platforms in our AD Domain to a large extent prevents Microsoft client's from attempting to use other IPv6 tunneling technologies. Deploying native IPv6 infrastructure throughout the campus would eliminate the need for tunneling and would also prevent Microsoft's client from attempting any form of tunneling.

External clients using tunneling to reach Massey resources are beyond our control. However, the deployment of 6to4 and Teredo relay routers at our borders should optimise tunnel transit paths and provide the best achievable performance.

## IPv6 Peering with the Commercial Internet

Very few commercial ISPs have deployed IPv6 to date. Massey has connections to the IPv6 Internet today via KAREN, the New Zealand IPv6 Internet Exchanges and an experimental service from Verizon Business. Massey will continue to pursue a native IPv6 service from Verizon Business in order to increase the resiliency of its IPv6 connectivity.

## State of IPv6 Application Support [1]

Most modern operating systems today offer a fairly complete IPv6 network stack. This includes Microsoft Windows (from XP onwards), Apple's Mac OS X, Linux, various flavors of BSD, Sun Solaris, etc. Application support is slightly more complicated. While many applications do support it, many others don't. There are also varying levels of maturity of software implementations. Fortunately, we are in the early stage of IPv6 adoption, so implementations of IPv6 are only expected to get better and more complete over time. Mac OS X does not yet support DHCPv6 for address configuration, as an example. Any application that stores data about IP addresses, particularly in a database (e.g. for connection logging, access control lists, billing etc) will likely also need to be updated to support the storage of IPv6 addresses, which are four times as long as IPv4 addresses, and have a different textual presentation format.

## IPv6 Support in Middleboxes [1]

Middleboxes are network devices like firewalls, NATs, VPN concentrators, server load balancers, etc that examine, block, modify, IP packets in flight. They have many and varying effects on the network, but will certainly need enhancements to support IPv6 packets. Many older versions of such devices do not support IPv6. And depending on how they are architected, they may allow all IPv6 traffic through unconditionally, block all IPv6 traffic unconditionally, or cause some effect intermediate between these two extremes. IT staff and users deploying these devices will need to take into account what IPv6 support is present in them.

Massey's Check Point firewalls support IPv6 in terms of connectivity and allow the implementation of IPv6 security policies. IPv6 is not supported in high-availability mode or the advanced routing service.

Massey's Bluecoat Web cache appliances do not support IPv6 in the currently deployed operating system. Evaluation of a new Bluecoat OS beta has not been particularly successful as the product engineers appear to have made design decisions that are inappropriate in our infrastructure.

## 6-4 Translators[1]

In large parts of the Internet, the dual-stack transition model has failed to materialize. In light of this fact, it is inevitable that IPv6-IPv4 translators will emerge. The IETF deprecated a previous standard called NAT-PT in this area for reasons of operational problems, but is now in the midst of standardizing replacement protocols, despite their various intrinsic limitations. Massey's strategy should remain focused on native IPv6 deployment as much as possible. It is likely that we will still need to support a class of older IPv4-only devices (e.g. specialized hardware appliances, critical applications and/or systems that have no recourse to code upgrades). So, NAT64 translators may also have a place in Massey's network for such specialized uses.

## 3rd-Party Service Providers

Massey currently do not make use of any outsourced services from commercial service providers. Should the opportunity arise where such services might be adopted, it will be important to ensure that IPv6 support in such services is at an appropriate level.

## Implications for Security, Monitoring, Billing, etc

The IPv6 implications for security were already mentioned in the Middleboxes section of this paper. Any security device or application that relies on network layer address information needs to be enhanced to understand IPv6.

## *Conclusion*

The projected depletion of the IPv4 address pool is only 3 years away. Fairly soon, new Internet services will likely come online, accessible only via IPv6. New populations of users with IPv6 only connectivity will also emerge, who are potentially customers or consumers of Massey's Internet services. It is in Massey's best interests to adopt IPv6 as soon as possible. And to deploy IPv6 throughout its network infrastructure and develop IPv6 capability in all its applications and network services.

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i **IPv6 Deployment Strategy** at Penn by Shumon Huque, Jorj Bauer, Mark Wehrle and Jeff Edwards – Networking & Telecommunications, University of Pennsylvania, Mach 2009