JANET(UK) IPv6 Technical Summary for Network Managers

About this Document

This document is aimed at network managers who are responsible for deploying and managing the network infrastructure for their organisation, and want some understanding of the issues involved in enabling IPv6. The appendix at the end outlines the history of IPv6 on JANET(UK) to date.

The JANET(UK) IPv6 Technical Guide provides a more detailed account, including technical information and case studies that will assist with the implementation of IPv6. It is available at: http://www.ja.net/documents/publications/technical-guides/ipv6-tech-guide-for-web.pdf

IPv4 Address Exhaustion

On 3rd February 2011, a critical milestone in the history of the Internet was reached. The Internet Assigned Numbers Authority (IANA), who manage the existing IP version 4 (IPv4) address space, assigned their last remaining address prefixes to the five Regional Internet Registries (RIR).

Each RIR will continue with standard allocation policy until only one /8 address block remains. After that, only a single /22 block (1024 addresses) will be made available to each Local Internet Registry (LIR), which includes JANET(UK). Note that the RIR for the Asia-Pacific region, APNIC, reached its last /8 address block in April 2011. The other RIRs are forecasted to reach this stage within the next 2 to 3 years[1].

This means that the future expansion of the Internet and all dependant services now depends upon the successful deployment of the new version of the Internet Protocol, IP version 6 (IPv6).

What is IPv6?

IPv6 is the new version of the Internet Protocol, the common protocol underpinning all Internet communications. It supersedes the current version, IPv4, in order to accommodate the rapid expansion of the Internet.

With the growing number of users and electronic devices connecting to the Internet, there is a need to ensure that adequate global address space is available as IPv4 will not be able to accommodate this growth. IPv6 was developed by the IETF (Internet Engineering Task Force) during the 1990s and offers 3.4 x 10^{38} addresses; the IETF document RFC2460[2] defines the IPv6 protocol in detail.

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[1] http://www.potaroo.net/tools/ipv4/index.html

[2] Internet Protocol, Version 6 (IPv6) Specification - http://tools.ietf.org/html/rfc2460

The transition from IPv4 to IPv6 will take some years, but in the meantime, the two protocols will coexist as 'dual-stack' deployments. Note that IPv6 does not implement interoperability features with IPv4, and creates essentially a parallel, independent network. Cross-communication between IPv4 and IPv6 hosts require special translation gateways.

The Appendix to this report provides a brief history on IPv6 development within JANET(UK).

Why IPv6?

The US and Western Europe consume a large proportion of the IPv4 address space. In other parts of the world, such as Asia, perceived difficulties in obtaining large blocks of IPv4 address space have led to an advanced deployment of IPv6.

IPv6 now ships as standard in all common host and router platforms. Therefore, there is no reason not to begin IPv6 deployment now, as the growth of IP services in the future is dependent upon its adoption. For example, developments in Mobile IP are only continuing in the Mobile IPv6 area: work on Mobile IPv4 has decreased.

IPv6 also implements additional features that are not present in IPv4. It simplifies aspects of address assignment (via stateless address auto-configuration), network renumbering and router announcements so that the restructuring of a network does not equate to an administrative nightmare.

On 8th June 2011, a "World IPv6 Day" event was held, sponsored by the Internet Society. The event consisted of several large content providers and industry players enabling IPv6 on their main websites to test any IPv6 brokenness. There were over 400 participants including Facebook, Google, Yahoo, Microsoft, AOL, BBC, Cisco and Juniper. The day was hailed as a success by many of the content providers[3][4][5].

Why is IPv4 and NAT not enough?

IPv4's lifetime has been extended since 1994 by the deployment of Classless Inter-Domain Routing (CIDR) and Network Address Translation (NAT).

CIDR is a method of allocating and routing IPv4 address space more efficiently than the original specification allowed for, in particular the allocation of address space in blocks other than three fixed sizes ('Classfull' addressing at /8, /16 and /24 boundaries).

NAT allows many hosts to share a single public IP address, thereby reducing the number of globally unique addresses an organisation needs. Each host on the network is numbered using a private IP address, which is never visible to the rest of the Internet. When a host makes a connection outside the local organisation's network, a NAT device translates the private address to the public address before packets are transmitted and/or received.

Since CIDR and NAT have been valuable in delaying the global depletion of IP addresses, some people have questioned whether the move to IPv6 is necessary. However, CIDR and NAT were never intended as a permanent solution. Using CIDR and NAT to extend the use of IPv4 address space has a number of architectural implications and is the main reason why IPv6 protagonists

[3] http://www.facebook.com/note.php?note_id=10150198443513920
[4] http://googleblog.blogspot.com/2011/06/world-ipv6-day-begins-24-hours-from-now.html
[5] http://blogs.cisco.com/news/world-ipv6-day-a-watershed-moment-towards-a-new-internet-protocol/

often denounce the “evils” of NAT, referencing IETF documents such as RFC 2993[6], and RFC 3027[7] , Protocol Complications with the IP Network Address Translator.

NAT destroys a key benefit of the Internet with respect to peer-to-peer connectivity and hampers the ability of individuals to contribute content and services. Problems also arise with NAT when applications incorporate IP addresses in the application-layer data. This issue is particularly problematic for security protocols such as IPSec. Moreover, NAT is a barrier for applications requiring Quality of Service (QoS) such as Voice-over-IP (VoIP) and real-time video. Indeed, NAT complications are often mooted to be the principal barrier to wide scale VoIP adoption.

While there are workarounds for many of these issues, none are clear-cut, and common support for the workarounds across different vendors’ equipment is rare.

The widespread use of NAT since 1994, has led to many network admins becoming comfortable with its deployment, to the point where they may attribute more functionality to it than it actually provides and tend to overlook the increased level of complexity, architectural problems and impact on applications and services.

For example, a common NAT-related claim is that it improves network security. While NAT does provide some security measure, as it hides internal hosts from inbound connection attempts, it is no substitute for a proper security policy and firewalls used in conjunction with global addressing.

To alleviate some of the fears that any NAT-related benefits would be lost with IPv6, the IETF released RFC 4864[8], which shows how Local Network Protection (LNP) using IPv6 can provide the same or more benefits without the need for address translation.

It is important to realise that the adoption of IPv6 and its abundance of addresses, removes the primary need for NAT and, by extension, eliminates the barriers to true end-to-end communication and content delivery that NAT represents.

Taking into account these factors: decreasing availability of global IPv4 address space, avoiding the issues associated with the extension of IPv4 addresses, and the increase in devices connecting to the global Internet and requiring public IP addresses, the deployment of IPv6 is essential.

Where is IPv6 Deployed?

Most national and international networks have successfully deployed IPv6 alongside their IPv4 infrastructure through dual-stack services where IPv4 and IPv6 coexist on the same routing equipment and network links. This is the infrastructure currently deployed on the JANET(UK) core. Note that the deployment of dual-stack networking services does not affect the IPv4 service.

Enabling dual-stack on a network will allow the basic network capability of both IPv4 and IPv6. Once the basic network transmission capability is in place, the next step is to make services available over IPv6. JANET(UK) currently makes its main web server, **www.ja.net**, available via IPv6 and the core nameservers are reachable using IPv6. Much of this work is straightforward as

[6] RFC 2993 Architectural Implications of NAT - http://tools.ietf.org/html/rfc2993
[7] RFC 3027 Protocol Complications with the IP Network Address Translator - http://tools.ietf.org/html/rfc3027
[8] RFC 4864 Local Network Protection for IPv6 - http://tools.ietf.org/html/rfc4864

most server operating systems now provide IPv6 support as standard, and built-in support for IPv6 is commonplace in most network service software such as web, DNS and e-mail.

An interesting situation is where a service is deployed using IPv6 only, which an IPv4-only host has a requirement to use. The IETF has done much work on transition tools to aid this situation; so far, there have been no reports of any major issues encountered.

Points to Consider for JANET(UK)-Connected Organisations

As with any emerging technology, a number of issues need to be considered prior to the deployment of IPv6 on a production network. These include:

- Understanding the differences between IPv4 and IPv6
- Managing the use of both IPv4 and IPv6 addresses within the same organisation
- Educating and training technical staff, including acquiring technical expertise and knowledge for the staff within the organisation who will be responsible for maintaining the service
- Prepare an IPv6 transition plan for your organisation.

Bear in mind that:

- Production scale rollout needs to be managed appropriately and carried out during maintenance periods
- Equipment (including software) needs to be able to support both IPv4 and IPv6 simultaneously
- IPv6 security policy should be the same as IPv4. Although IPv6 addresses look different when compared to IPv4 addresses, there is little difference between the two where security is concerned. Network security is a function of the security policies that are in place and the way they are applied to a particular network.

JANET(UK) has published a JANET(UK) IPv6 Technical Guide and holds a number of IPv6 training activities. Further details about these activities can be found on the JANET(UK) website at: http://www.ja.net/documents/publications/technical-guides/ipv6-tech-guide-for-web.pdf and http://www.ja.net/services/training/courses/ipv6.html respectively.

Recommendations

- IPv4 will not go away; however, IPv6 is also here to stay. It is for this reason that JANET(UK) began experimenting with IPv6 services at an early stage and deployed dual-stack services on the JANET(UK) core which has been stable since its deployment in 2003. Note that IPv6 is now included in the JANET(UK) Service Level Agreement. It is therefore recommended that JANET(UK)-connected sites who have not already deployed IPv6, prepare an IPv6 rollout plan as soon as possible.
- Prior to any production deployment, JANET(UK)-connected sites are advised to gain some early experience of IPv6 connectivity and deployment in the form of some kind of testbed. The IPv6 Technical Guide highlights some basic steps.
- The ultimate recommendation for JANET(UK)-connected sites is to enable dual-stack services (using both IPv4 and IPv6), as deployed on the JANET(UK) core, and ensure that future purchases of computer systems and networking equipment are IPv6 capable.

Useful Links

- IPv6 – Extinction, Evolution or Revolution? January 2006, Geoff Huston http://www.potaroo.net/ispcol/2006-01/ipv6revolution.html
- JANET(UK) IPv6 website http://www.ja.net/ipv6/
- IPv6 users email list https://www.jiscmail.ac.uk/cgi-bin/webadmin?A0=ipv6-users
- Community IPv6 website: http://www.ipv6.ac.uk/
- 6Deploy website: http://www.6deploy.org/
- RIPE 'Act Now': http://www.ipv6actnow.org/

Appendix: JANET(UK) IPv6 History

In May 1997, JANET(UK) connected to the global 6bone IPv6 experimental network and obtained 6bone test IPv6 address space for use by JANET(UK) sites. The 6bone was an overlay network, tunnelling IPv6 packets over the IPv4 Internet, which operated in an informal co-operative way between interested networks and equipment vendors. Several JANET(UK) sites, or departments within sites, established tunnels to the 6bone via the JANET(UK) router, giving them very early experience of IPv6.

In 1999, JANET(UK) made an application to the RIPE NCC for a /32 prefix for JANET(UK) in order to carry out experimental work in the IPv6 area, and also to allow Regional Networks and JANET(UK)-connected organisations to be allocated globally recognised IPv6 address space so that they can in turn carry out any IPv6 related activities. The allocation to Regional Networks and JANET(UK) sites was a /48 prefix which allows a potential 65,000 subnets.

IPv6 technology trials were carried out as part of the Bermuda Project, led by the University of Southampton, the University of Lancaster and University College London. In 2001, JANET(UK) participated in the three-year European Commission-funded 6NET project, which was led by Cisco®. In parallel, a JANET(UK) IPv6 experimental service was established where JANET(UK)-connected organisations could formally apply for IPv6 address space for their organisation and experiment with IPv6/IPv4 tunnels.

In 2003, JANET(UK) initiated a comprehensive programme to deploy dual-stack, supporting both IPv4 and IPv6 connectivity, on the JANET(UK) core. This was completed successfully within a short timescale. The pan-European network GÉANT and other national research networks have taken a similar approach and currently support dual-stack IPv4/IPv6 on their networks.

After many years of operation, the 6bone was formally shut down on 6 June 2006. By this time, JANET(UK)'s IPv6 interconnectivity and experience had improved tremendously.

IPv6 unicast was introduced into the JANET Service Level Agreement (SLA) 07/08 and entered the contracts that JANET(UK) has with its Regional Network Operators in 08/09.