IPv6 Initiatives Within the European National Research and Education Networks (NRENs)

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Abstract

In this paper we present an overview of the IPv6 activities of European National Research and Education Networks, both within the individual national programmes and in joint studies undertaken within the GÉANT Task Force for Next Generation Networks working group. The group has an international testbed activity (GTPv6) under which many IPv6 aspects have been studied, including routing, interoperability, DNS, multicast, registries and addressing, firewalls, transition and IPv6 applications. We present a summary of initiatives, including the m6bone multicast IPv6 network, a successful attempt at the IPv6 Land Speed Record, and the migration of two NRENs - SURFnet and Funet - to dual-stack IPv6 operation.

1. Introduction

GÉANT [4] offers a network backbone that interconnects over 25 European National Research and Education Networks (NRENs). Available bandwidth varies across the backbone, with speeds of up to 10Gbit/s. The backbone is currently IPv4-only, although the Juniper routers have inherent, but unused, IPv6 functionality.

GÉANT is a European Commission IST Project which runs until 2004. Its roadmap has pilot IPv6 services planned by mid-2003, with a production service by mid-2004 at the latest. The results of trials undertaken by individual NRENs, and achievements such as the IPv6 Land Speed Record described below, increase confidence that IPv6 can be successfully deployed alongside IPv4 in a dual-stack environment. Backbone routers would run both protocols, and both protocols would run on the same links between them. Two NRENs have already introduced such a dual stack network, one with Cisco routers, one with Juniper; their experiences are described below.

2. The GÉANT TF-NGN Working Group

The GÉANT Task Force for Next Generation Networks (TF-NGN) [7] meets four times a year, studying a wide variety of topics seen as of immediate or future importance for European NRENs. The participants come from TERENA, DANTE (who manage the GÉANT network), the NRENs, and interested universities. The activities include quality of service (including Premium IP and LBE), network monitoring and measurement, IP multicast, optical networking and IPv6.

The IPv6 experiments are carried out within the GÉANT Test Programme for IPv6 (GTPv6) sub-group of TF-NGN. This group has been active for over four years, and has produced detailed reports of its activities within the GÉANT scope in 2001 [5] and 2002 [6].

The goal of the GTPv6 group is to validate IPv6 services with a view to their introduction in the NRENs and on GÉANT. While routing performance, reliability and interoperation are key requirements, the successful introduction of (dual-stack) IPv6 services requires a wider consideration of issues such as network management, address allocation policies, peering policies, DNS support, multicast and the provision of transition mechanisms.

Many of the GTPv6 participants are also working on 6NET [1], a three-year IST research project which runs to December 2004. 6NET has already deployed a pan-European native IPv6-only network running at STM-1 speeds. However, the GTPv6 activities continue, working on items not yet being covered in 6NET (e.g. Multicast IPv6), acting as a think tank (e.g. on routing policies) and including involvement from organisations and NRENs not involved in 6NET, e.g. RedIRIS, HEAnet, ARNES, CERN and RESTENA.

The NRENs are generally interested in national and international connectivity. Thus some site-specific issues such as Mobile IPv6, IPsec and firewall provision have re-
received less coverage in GTPv6 than they are receiving in the 6NET project.

2.1 Juniper M5 testbed

A Juniper M5 router has been deployed in Paris by RENATER, as part of their IPv6 experiments [6]. The router has allowed early experience of IPv6 features in JUNOS, and interoperability testing where GTPv6 participants connect to the M5 (receiving /64 prefixes for local experiments). BGP exchanges were set up successfully with Cisco and Zebra routers.

2.2 Inter-NREN testbed

In its earlier instantiation, GTPv6 had an international testbed focused on an Ericsson Telebit TBC2000 router, using its own ASN (AS8933) and 6bone pTLA (3ffe:8030::/28) [5]. Since the retirement of the TBC2000, the GTPv6 group is now planning to set up a mini-backbone with the Juniper M5 and a Hitachi GR2000 (based in the UK), using the original ASN and 6bone prefix, and allocating /34 prefixes to connecting NRENs and organisations. This will enable new interoperability and multicast tests.

The original testbed network was heavily ATM-based, allowing native IPv6 connections via ATM PVCs. Most NRENs have now phased out ATM in moving to higher capacity networks, which means dual-stack routers running IPv6 on the same links as IPv4 is the most likely way to enable native connectivity. The new testbed should be live by December 2002.

2.3 PC-based routers

CESNET has performed experiments with the Zebra PC-based routing platform, comparing Zebra to a Cisco 7500 series router. The results were favourable [6], showing that for an early (parallel) IPv6 deployment, or for site deployment, Zebra is a cost-effective and attractive proposition.

3. NREN Projects

In recent months, two specific projects of interest have arisen from the NREN activities.

3.1. The m6bone

The m6bone [10, 6] is a Multicast IPv6 testbed network spanning many European countries and reaching into Africa. The aim of the project is to offer an IPv6 multicast service to interested sites. With no pan-European IPv6 network supporting PIM-SM Multicast natively, the m6bone network is almost entirely tunnelled, either IPv6-in-IpV4 or IPv6-in-IPv6. A single RP lies on the PIM-SM BSD router in Paris.

To date, participants have used (Free)BSD (with the KAME stack), 6WINDGate and Cisco 7200-series routers to connect to the testbed. PIM-SM is used for the multicast routing, and RIPng for the unicast routing. FreeBSD, Linux and Windows 2000 clients have been used to run the vic and rat multicast conferencing applications over the network.

While native multicast is lacking, the testbed has been very useful in diagnosing problems in host and router implementations, and in gaining experience of the tools in an IPv6 environment. Future planned work includes investigation of multiple-RP PIM-SM networks, and use of PIM-SSM (as implementations and MLDv2 become available).

3.2. IPv6 Land Speed Record

The Internet2 Land Speed Record [8] was originally devised to promote IPv4 performance improvements, but has recently been extended to IPv6, for single and multi-stream traffic.

As part of the effort to show the viability of running dual-stack IPv4 and IPv6 on the GÉANT Juniper routers, DANTE, together with RedIRIS and ARNES (Slovenia), made an attempt to set a new Land Speed Record by running IPv6 on the production IPv4 Juniper (M20, M40 and M160) routers, running JUNOS 5.3R2.4 and R3.3. IPv6 was enabled on the routers, and static routes used, with one path within GÉANT via Austria, Switzerland and Italy, and one longer path adding the UK, New York and France.

The attempt used 1.1GHz and 1.3GHz dual Pentium-III PC’s with Intel Pro 1000/XT and 82543 Gigabit Ethernet adaptors, running Linux 2.4.18 and 2.4.20 kernels with RAM disks and the iperf-1.62, wu-ftpd-2.6.2 and ncftp-3.1.3 software. Some TCP parameter tuning was used.

Initially, a single-stream record was accepted on 4th October 2002 at 1.215 Tbit/s; this was then improved with the attempt via New York on 23rd October 2002 at 350Mb/s, which equates to 5,154 Tbit/s. This is actually some 5% faster than the existing IPv4 single stream record, although of course a direct protocol comparison cannot be drawn from this result. However, it showed that IPv6 forwarding on GÉANT was comparable to that obtained with IPv4.

4. Individual NREN Activities

Here we describe individual initiatives by NRENs, the two particularly interesting case studies being in SURFnet and Funet, where IPv6 dual-stack networking has been deployed in the production network.
4.1. SURFnet (Netherlands)

The SURFnet5 network, which was enabled within the national Dutch project GigaPort, was the first broadband research network to provide native support for IPv6.

Prior to building SURFnet5, an OC48 testbed was set up with four Cisco 12416 routers running the IOS dual stack image available at that time. At the start of 2001 two core locations in Amsterdam (each with two GSR+ routers) were deployed. Fifteen concentrator locations (GSR+ routers) each connected by OC192 interfaces to both core locations. Each of the concentrator locations has GE interfaces to connect customers. Linux systems with GE interfaces were used to generate IPv4 and IPv6 traffic to check that IPv6 load on the network would not adversely affect IPv4 performance.

SURFnet also has a number of relatively low speed leased line customers. To connect those customers to the new network a Cisco 7507 router was installed with a GEIP+ interface connected to the GSR+ routers. Unfortunately the 12.2T train (needed for IPv6 for this platform) did not have support for the GEIP+ interface, so the plan for a complete dual-stack network was delayed.

During the latter part of 2001 all customers were migrated to the new SURFnet5 network, which was partly dual-stack at that time. Customers could have a native IPv6 connection or a tunnel to the nearest GSR+. There were no problems experienced apart from failed attempts to move from RIP to IS-IS. It is hoped that IS-IS can be used soon (6NET is running IS-IS on Cisco GSR’s).

Early in 2002 an IPv6 image became available for the Cisco 7507 which supported the GEIP+ interface. After a successful test, this image was deployed on all Cisco 7507 routers in SURFnet5, resulting in an almost completely dual-stack network (the out-of-band network is currently IPv4 only). Customers connected to a Cisco 7507 and an IPv6-in-IPv4 tunnel to the GSR+ were migrated to a native connection or a tunnel on the Cisco 7507.

Some features are still required. The lack of extended ACLs for IPv6 has sometimes prevented IPv6 connectivity to SURFnet service LANs. Measuring the amount of IPv6 traffic flowing through the network can also be difficult, but solutions for these issues will become available.

SURFnet has been able to supply enough IPv6 performance for its customers using a dual-stack strategy. The question is whether this will be true if the amount of IPv6 traffic grows, because a large number of interfaces do not (yet) have support for IPv6 in hardware.

4.2. Funet (Finland)

In 2001, Funet’s core network was upgraded to 2.5 Gbit/s POS links. Six Juniper routers (M20) were added to the previously all-Cisco network.

By the end of 2001 plans for enabling dual-stack on the Juniper routers had been made. Tests early in 2002 led to a cycle of problem fixing and further tests, and in Q2/2002 the minimum working version (JUNOS 5.2R2) was upgraded on the routers, followed by versions 5.3R2 and 5.3R3. JUNOS 5.4R2 is due to be tried next as it should fix all the observed problems.

The IPv4 network uses OSPFv2 and BGP for routing, but OSPFv3 for IPv6 was not ready. There was no desire to change the routing protocol, and for clarity separate IGP’s for IPv4 and IPv6 were wanted: OSPF and IS-IS. In addition, if only IS-IS was used, multiple topologies would have to have been supported as IPv6 routing would have been different (in parts) from IPv4. Thus IS-IS for IPv6 only was the best (and only, discounting RIPng) choice.

Unfortunately, there were problems in JUNOS and IOS with IPv6-only IS-IS. Juniper would always advertise IPv4 addresses used in loopbacks and point-to-point links. Cisco, unless you enabled IS-IS for IPv4 too, would discard all such attempts to form adjacencies: a total interoperability problem. Cisco’s IS-IS implementation has an option ‘no adjacency-check’ to override this; however it would only work using level-2-only IS-IS circuit-type. A first step in interoperability was gained when these were enabled in Cisco.

Further, IS-IS route advertisements from Ciscos to Junipers were accepted in the route database, but not put to Junipers’ routing table: this was caused by the above problem with adjacencies, and fixed in 5.2R2. The issue with Juniper always also advertising IPv4 addresses in IS-IS was fixed with the ‘no-ipv4-routing’ feature in 5.4R1. Also, one could not redistribute static discard routes to IS-IS (to generate a default route) until JUNOS 5.3R3. Also in 2002, the rest of the Cisco routers were replaced by Juniper M10’s and M20’s, in part for their IPv6 capabilities but mainly due to scheduled upgrading and phasing out of ATM.

Funet has almost all the IPv6 features it needs at present; only IPv6 multicast is missing. The dual-stack access line is an approach that should be supported in the long term. The next question is how to offer IPv6 to universities without forcing an upgrade of its edge router to dual-stack IPv4/IPv6 (which may not yet be desirable depending on the hardware).

4.3. Renater (France)

Renater is planning to introduce dual-stack service with its imminent deployment of Renater 3; this could thus be the third European NREN to move to dual-stack operation. Renater is also leader of the m6bone project described above, and Paris is the European end-point of the Trans-Eurasia Information Network (TEIN), which connects Europe directly to Asia (Korea), currently at 20Mbit/s via ATM, but soon to
be raised.

4.4. DFN/JOIN (Germany)

The JOIN project within the DFN is notable for having the largest number of sites connected to any European national pilot (over 100). The JOIN network is described in a 6NET deliverable [2].

4.5. UKERNA (UK)

Since 1999, UKERNA has supported early IPv6 trials, in particular providing management for the Bermuda 2 IPv6 project [3], which utilised native IPv6 links over the JANET ATM Managed Bandwidth Service. However, the new 10Gbit/s POS network no longer supports ATM, and connectivity has dropped back to IPv6-in-IPv4 tunnels for the time being.

In May 2002, UKERNA formally launched a (tunnelled) IPv6 Experimental Service on JANET, to which UK Universities and Colleges can connect. The aim of the experimental service is to allow UKERNA and JANET Connected Organisations to gain early experience in operating IPv6 based networks and services, and to focus the JANET community’s IPv6 efforts. UKERNA are currently investigating the possibility of implementing dual-stack on the production network during 2003.

4.6. RedIRIS (Spain)

RedIRIS has promoted the use of IPv6 in the ESPANIX (Spanish Internet Exchange Point) and has started to exchange IPv6 traffic with Telefónica, BT Spain and Intelídeas. One area of interest has been ongoing DNS testing, where interoperability has been tested between servers with Bind 8, Bind 9, dual stack, IPv6-only and IPv4-only.

4.7. CESNET (Czech Republic)

The CESNET IPv6 network currently consists of eight nodes connected by configured tunnels, which follow closely the physical topology of the underlying IPv4 network.

CESNET is promoting Intel PCs with Linux or NetBSD as a general routing platform for IPv6. Therefore, five of the eight backbone routers are such PCs running the Zebra daemons, the rest being Cisco routers. RIPng is used as the interior gateway protocol, since it is the only one supported by both Zebra and Cisco IOS. In order to increase the performance of PC routers, CESNET is developing a four-port hardware accelerator (PCI board) aimed at throughput up to 10 GBps.

4.8. POZNAN (Poland)

The Poznan Supercomputing and Networking Center (PSNC) has been participating in the m6bone using FreeBSD and Cisco routers. PSNC has developed its own multicast Beacon server application [9] using Java v1.4.1 with IPv6 support. Like the majority of NRENs, PSNC has obtained a SubTLA IPv6 address space from RIPE and offers IPv6 connectivity service to its customers. PSNC has also started establishing native IPv6 connections in Poland within the POL34/155 network.

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6. Conclusions

Interest in IPv6 is steadily growing in the European NRENs, and knowledge and understanding of IPv6 issues is being gained as a result of the 6NET and GÉANT TF-NGN activities. Full details can be found in the cited references, in particular the two GÉANT deliverables. As NRENs take the first steps to dual-stack deployment, GÉANT is also set to begin migration in 2003. Specific activities such as the m6bone and the Land Speed Record illustrate the capacity for NRENs to work together in furthering IPv6 deployment.

References