IPv6 Deployment in European National Research and Education Networks (NRENs)

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IPv6 rationale

• IP is fundamental converging platform for the future
• IPv6 has clear advantages for scalability
  – 128-bit address space, improved mobility, plug and play networking, end-to-end communication (NAT avoidance)
• Academic networks are and can be used for
  – Commercial university operation
  – Research projects
  – Wireless campuses
  – Remote learning
  – Collaborative working
  – Distributed computing (the Grid and E-Science)
• IPv6 can enhance all these areas
IPv6 Applications

- Taking IPv6 into research
  - NRENs can deploy ahead of commercial viability
- By deploying IPv6 we hope to promote
  - Peer-to-Peer (p2p) applications
  - Transparent end-to-end connectivity (no NAT, middleboxes)
  - New Grid and distributed computing functionality
  - New mobile features
  - Device to device communication
  - New classes of devices, e.g. remote sensor networks
- There is no killer IPv6 application (yet…)
  - But the Web came many years after IPv4 was deployed
Wireless campus deployment

• Growing numbers of students own laptops
• PDA devices have Wireless LAN adaptors
• Opportunity to deliver WLAN in campuses
  – Easy access to information
  – New channels to deliver material
  – Combine with location awareness
  – Sensors and embedded systems with wireless IP
  – Opportunistic networking and service discovery/use
• Mobile IPv6 enables campus-wide roaming
  – Much improved support over Mobile IPv4
  – Including MIPv6 route optimisation
  – Deeper IP WLAN subnets to reduce multicast flooding
Access into student homes

- Many student homes now have ADSL
  - And many of those homes have Wireless LAN
- Many student halls have Ethernet
- Can consider broadband applications
  - Conferencing between tutor and student
  - Make use of always-on, higher bandwidth connectivity
  - p2p file sharing can be improved with IPv6
- IPv4 home networking invariably uses NAT
  - Makes it hard to run applications into the home
  - IPv6 enables remote access for many applications
GÉANT and 6NET

• All the European NRENs are interconnected by GÉANT, offering a production IPv4 network service
  – Up to 10Gbit/s links, using Juniper routers
  – An IPv6 service is expected on GÉANT in 2003
  – Many NREN plans are in sync with those of GÉANT
  – NREN networks use a variety of hardware and technologies

• GÉANT includes over 25 NRENs
  – Technical IPv6 discussion in TERENA TF-NGN WG

• 15 of the NRENs are members of the 6NET project
  – Has deployed a native IPv6-only network
  – Funded in part by the European Commission
NREN transition

- Wish to offer IPv6 services nationally
  - Harmonised with IPv6 in the GÉANT core network
- They need IPv6 address allocations
  - Most NRENs have a production /32 prefix from RIPE NCC
- Need to transport IPv6 – options include:
  - Dual-stack networking
  - IPv6 in IPv4 tunnels
  - Parallel IPv6 network
  - IPv6 over MPLS (where MPLS already exists)
  - IPv6 with ATM (ATM now rare in NREN networks)
IPv6 address space

- In Europe, IPv6 address space is allocated by the RIPE NCC
  - Most NRENs have a production IPv6 network address allocation (SubTLA)
  - The prefix is a /32, e.g. JANET (UK) is 2001:0630::/32
  - Each university site would receive a /48 prefix
  - Thus an NREN can address $2^{16}$ universities
  - A site /48 prefix allows $2^{16}$ site subnets to be allocated, with up to $2^{64}$ (!) hosts per subnet

- Address allocation policies will be important
  - A /48 per university seems a lot now, but in 5-10 years?
Allocations of SubTLAs

- RIPE: July 2001 - 100, October 2002 - 120
- ARIN: July 2001 - 20, October 2002 - 60
- APNIC: July 2001 - 40, October 2002 - 80
Dual-stack strategy

• NRENs need an IPv6 transition strategy
  – Need to be able to carry IPv6 on their infrastructure, and offer IPv6 services to end sites (universities)
  – Help break the4 “chicken and egg” cycle
  – Needs to be integrated with the university strategies

• Can run IPv4 and IPv6 on the same router equipment, and run both protocols over the same links, natively
  – Requires vendor implementation to have fast (hardware-based) IPv6 forwarding, and to support the required IPv6 routing protocols (BGP4+)
Dual-stack NRENs

• Some NRENs have already migrated to dual-stack on their production networks:
  – SURFnet (Cisco) – the Netherlands
  – FUnet (Juniper) - Finland
  – Renater (Cisco) - France

• Many NRENs are planning a dual-stack transition:
  – They already have an IPv6 pilot of some kind
  – DFN, UKERNA, RedIRIS, CESNET, POZNAN, UNINETT, SWITCH, …
  – Many plan to introduce native IPv6 in 2003
  – Need confidence that IPv6 performance is as good as IPv4, and that IPv6 will not adversely affect the IPv4 service
IPv6 Land Speed Record

- Promoted by Internet2 community
  - [http://www.internet2.edu/lsr/](http://www.internet2.edu/lsr/)
- Enables demonstration of IPv6 performance
- Record recently set on network comprising GÉANT backbone and US link
  - Ran on IPv4 production Juniper M20, M40, M160 routers
  - Static IPv6 routes used
  - Primary NREN sites RedIRIS and ARNES
  - Result was as good as IPv4 record at the time
- Furthered case for dual-stack on GÉANT in 2003
  - Bolstered by experiences of Abilene Juniper network
The LSR record confirmed…

- IPv6 single stream record confirmed at I2 Fall Meeting in L.A. in October 2002
- Next record?
The 6net project

- Deployed a pan-European IPv6 research network
  - Backbone in place since May 2002 at STM-1 rates
- Project runs until December 2004
  - 1,100 man months between 35 partner organisations
- Many study areas beyond the basic network rollout:
  - Transition tools, MIPv6, DNS, QoS, address allocation policies, IPv6 multicast, IPsec, VPNs, multihoming, application porting, VoIP, Globus/GRID toolkit, multimedia tools, network management and monitoring,…
- Desire to interconnect to international networks to further research goals through collaboration
6NET staging

• Held in Brussels early in 2002, as part of Cisco Professional Services deployment
6NET results

- 6NET has 100 deliverables due during 2002-2004
  - 97 of those are public
  - http://www.6net.org/publications/
- Existing reports include
  - MIPv6 implementations evaluation
  - Network routing models (IS-IS, IPv6-only)
  - DHCPv6 implementations evaluation (due soon)
  - IPv6 transition technologies and cookbooks
  - IPv6 application porting
  - Network management tools (e.g. RIPE NCC TTM server)
  - IPv6 deployment “missing pieces”
Missing pieces for deployment

• NRENs identifying issues from experience
  – Basic services generally working well
  – But many IPv6 required features are still lacking
• OS and router implementations improving
  – Many vendors now have good IPv6 support out of the box
• General areas to consider for IPv6 include:
  – Network robustness and performance
  – Network management
  – Application and IPv6-specific features
  – Security considerations
Network robustness

• IPv6 routing stability
  – The 6bone has led to an uncontrolled mesh of tunnels and transit (a tunnel arms race) and unpredictable behaviour
  – Problems affect the “production” IPv6 space
  – Need to promote policies to allow reliable day-to-day use of the IPv6 network

• Preference for IPv4 or IPv6 addresses
  – IPv6 preference is bad if IPv6 routing is poor

• IPv6 multihoming
  – IETF multi6 WG is stalled
  – Need to control size of DFZ routing table
  – Classic “multi-PA address” method has issues
Network management

- Includes many aspects of management...
- IPv6 and DNS
  - IPv6 transport for network lookups
  - DNS discovery in stateless autoconfiguration
  - IPv6 DNS root servers
  - Registering domain with IPv6 name servers
  - The ip6.int to ip6.arpa transition
- IPv6 and SNMP
  - MIBs being redesigned to be dual-stack
  - Currently little use of IPv6 transport for SNMP
Network management (2)

• IPv6 prefix delegation
  – Required for ISP customer access networks
  – Also useful in an academic environment
  – Proposed solution via DHCPv6 option

• Wireless LANs
  – WLAN access points managed over IPv4 only
  – Access points must be in dual-stack wired network
  – Even if only IPv6 used on the air interface

• IPv6 NTP
  – Now implemented in NTP project
Service discovery

• Wide range of methods:
  – IPv4 or IPv6 anycast
  – Link or site local IPv6 Multicast
  – Well-known site-local addresses
  – Service Location Protocol
  – Well-known DNS name
  – Piggybacking the Router Advertisements
  – DHCPv6 options

• Different protocols use different methods
  – So an IPv6 network may need to support many of them
Application issues

• Use of IPv6 site local addresses (fec0::/10)
  – A very contentious issue in IETF ipv6 WG
  – General problem of address ambiguity and leakage

• IPv6 code porting
  – Best practice required for IPv6-enabling

• Many missing applications (e.g. database methods)

• Use of the IPv6 Flow Label
  – Current definition is “open” in nature

• Use of RFC3041 privacy extensions
  – Problems for authentication by IP, and for DDoS recognition
Security issues

• Implementation and use of IPv6 IPSec
  – Support “mandated” in full IPv6 implementation
  – IETF send WG for secure Neighbor Discovery
• IPv6 Firewalls
  – Handling end to end encrypted traffic
  – Handling extension header chains, unknown options
• Security of transition methods
  – Have two protocols to handle, not one
  – Specific transition issues, e.g. open 6to4 relays
The m6bone

- IPv6 Multicast protocols are being developed and implemented
  - PIM-SM: FreeBSD/KAME, 6WIND, Cisco beta
  - Clients: Linux, FreeBSD/KAME, Windows 2000/XP
- Problem in deployment is similar to IPv4
  - Need IPv6 Multicast support in routers
  - Otherwise need to tunnel IPv6 Multicast in regular (unicast) IPv6 or IPv4 links
- First international testbed is the m6bone
  - Centred on a router operated by Renater in Paris
  - http://www.m6bone.net
M6bone, December 2002
IPv6 Multicast issues

• Experience in tools and protocols very valuable
  – Includes IPv6 Multicast beacon

• Lack of inter-domain method for PIM-SM
  – No MSDP for IPv6
  – Proposal to embed RP location in multicast address
  – Probable wider use of PIM-SSM (with no RP)

• Layer 2 snooping
  – MLD, MLDv2
  – May be important in wireless domains
  – Not clear snooping is the right thing to do
NREN next steps…

- Continue dual-stack deployment programme
  - NRENs are making national networks IPv6-enabled
  - Many more deployments planned in 2003, including GÉANT
  - Improved routing efficiency and reliability
- The key is to bring the universities online
  - Transition strategies and cookbooks for NRENs
  - But users want applications, not IP versions
  - No mandate for universities to deploy
  - Early interest, like IPv4, will be in the CS departments
- Show case studies to promote the technology
- Build and encourage national communities