



IPv6 at Monash University

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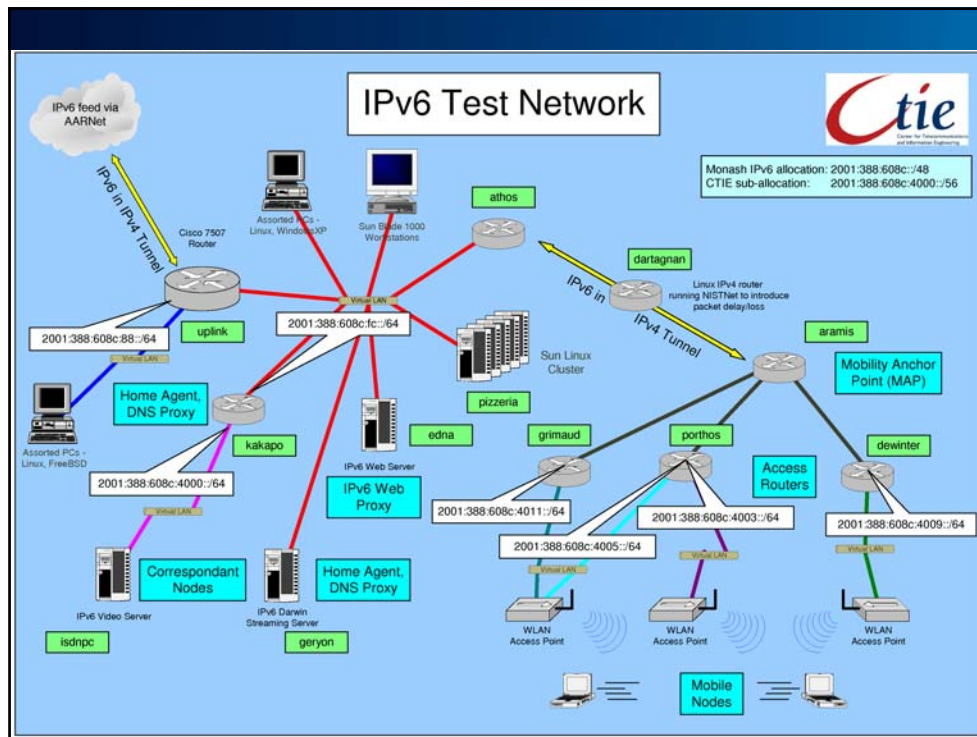
Summary

- **IPv6 research at CTIE, AT CRC**
- **Production IPv6 dual-stack network**
- **Problems**
- **Future Plans**

The Centre for Telecommunications and Information Engineering, and Advanced Technologies CRC

Did leading-edge research into

- Mobile IPv6
- Protocols for Detecting Network Attachment
- Fast handovers and fast address configuration for Mobile IPv6
- Streaming Video over IPv6



Advanced Technologies CRC

Involved

- 14 staff from Monash and RMIT
- 50+ students

And resulted in

- 30+ Internet Drafts
- RFC 4135 and RFC 4429
- Optimistic DAD now in Linux kernel
- 125k lines of IPv6Suite simulation code
- 7 PhDs

Production Monash IPv6 dual-stack Network

- Why Now?
- Addressing Plan
- Configuring Routers and ACLs
- DNS and DHCP Services
- Servers
- Clients

Why Now?

- **Monash is like a battleship, it will take a long time to change direction**
- **Need to break the chick-and-egg problem by providing the IPv6 infrastructure**
- **Need to raise IPv6's profile, and show that it does actually work**
- **Need to find out what we don't know**
- **Dual-stacking the infrastructure is a 50-device problem, v. dual-stacking edge devices which is a 30,000-device problem**
- **Cost of failure, or having to do things over, is low now, compared to having to do things in a rush later**
- **Be seen to be a leader**

IPv4 address plan

- **Originally used 130.194/16 for everything**
- **When that became full, added**
 - 172.16/16 (private nets)
 - 172.17/16 (wireless)
 - 172.18/16 (students)
 - 172.19/16 (staff)
 - 172.20/16 (management)
 - ...
 - with Internet access via Proxies
- **Renumbered half the network**

IPv6 Address Plan

- **No easy way to map IPv4 addresses \Leftrightarrow IPv6 addresses**
- **IPv4 address plan a bit disorganised anyway**
- **So, new logical IPv6 address plan**

Use (2 bits)	Org Unit (4 .. 12 bits)	Location (8 .. 0 bits)
Server	ITS	North
Research	Admin	East
Staff	Arts	West
Student

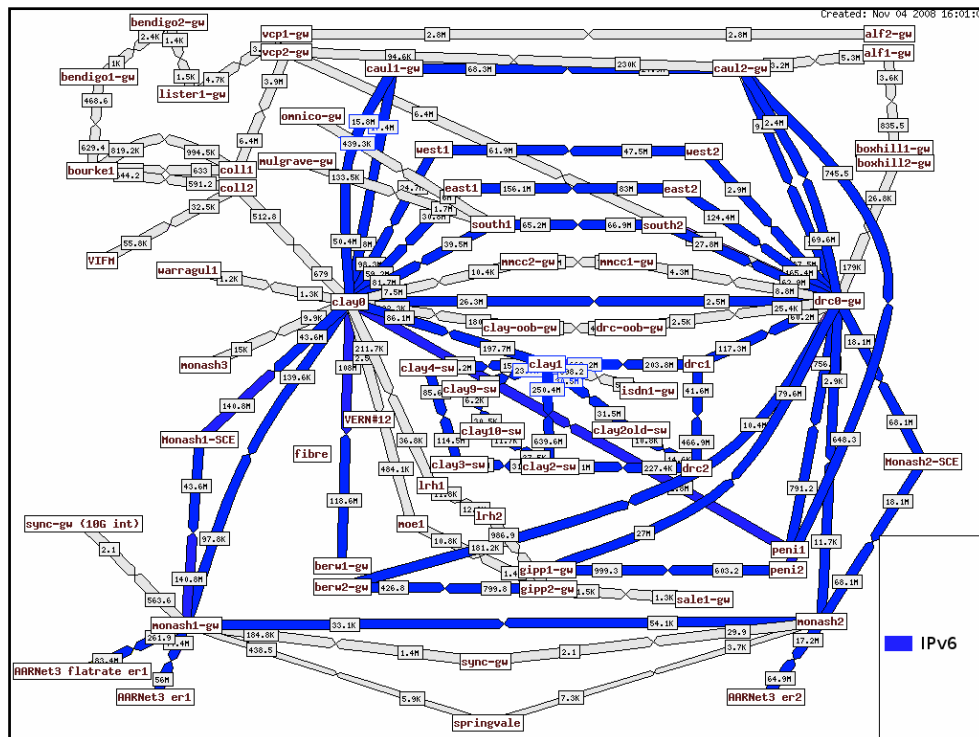
- **/64 for p-p router backbone links**
- **/64 for router loopbacks, DNS anycasts**

IPv4 Address Plan 2

- **In 2008, replaced Web and SOCKS proxies with Cisco Service Control Engine (SCE)**
- **All hosts that want Internet access needed to move to Public IPv4 addresses**
- **Obtained extra IPv4 addresses, and renumbered half the network again**
- **IPv4 network plan is now less messy – so less justification for a different IPv6 network plan**

Cisco Routers

- **Catalyst 6500 routers**
 - IPv6 availability varies with releases/feature sets
 - From 12.2(33)SX1, released 13th Nov 2008, IPv6 is in IP SERVICES, previously ADVANCED IP SERVICES
- **Catalyst 3750 routers**
 - IPv6 features with ADVANCED IP SERVICES license, about \$4k list price
 - IPv6 ~halves TCAM available for IPv4 functions
 - Has severely restricted IPv6 for small campuses that use 3750's as their routers



Router Configuration

- **We enter all subnet information into a subnet database: subnet name, address ranges, vlan name/number, router names, access rights, ...**
- **The database is the used to generate router configurations**
- **Extended the database to manage IPv6 addresses and generate IPv6 router configs**

ACL Management

- **Old scheme creates IPv4 ACLs using a Perl script and a flat-file list of exceptions**
- **ACL heuristics in script evolved over time**
- **Now need to generate IPv6 ACLs as well**
- **New ACL creation scheme uses templates and macro expansion for both IPv4 and IPv6 ACLs**
- **More-transparent scheme, but lower level**

IPv6 out ACL Template Example

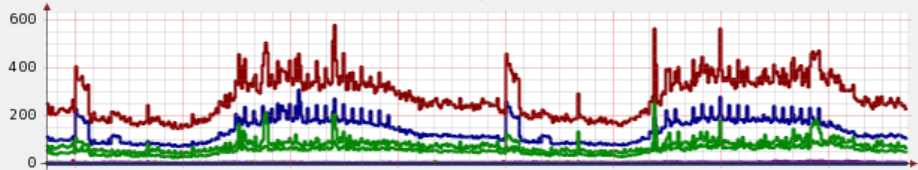
```

permit tcp any any established
%special-top-out6
permit ipv6 %fromgroup6 any ! normal out traffic
deny udp any any range 135 139 log ! block window virus
deny udp any any eq 445 log ! block window virus
permit udp %net-monash-au6 any ! NACP
permit udp any any gt 1024 ! NACP2
permit icmp any any ! NACP
permit ipv6 any ff00::/8 ! multicast out
%special-bottom-out6
deny ipv6 any any log-input
  
```

DNS

- **Addhost, our network host registration scheme, was extended to cater for**
 - Fixed IPv6 addresses; and also
 - “auto” IPv6 addresses generated from
IPv4 address => IPv4 subnet => IPv6 subnet table,
and Ethernet address => EUI-64 host address
- **No need for normal users to enter long hex addresses**
- **Forward and reverse DNS**
 - But not fe80::/64 reverse yet
- **DNS servers have IPv6 Anycast addresses, tied to tun0 device, advertised using Quagga**

ns1a.its.monash.edu DNS queries: Last 48 Hours



■ A queries/sec	Current: 106.15	Min: 71.41	Average: 138.54	Max: 306.85
■ PTR queries/sec	Current: 48.78	Min: 24.87	Average: 55.50	Max: 132.33
■ ANY queries/sec	Current: 40.24m	Min: 17.05m	Average: 161.86m	Max: 874.54m
■ MX queries/sec	Current: 4.82	Min: 3.45	Average: 5.73	Max: 12.82
■ NS queries/sec	Current: 2.83	Min: 990.01m	Average: 2.83	Max: 9.60
■ CNAME queries/sec	Current: 3.31m	Min: 0.00	Average: 9.96m	Max: 76.19m
■ SOA queries/sec	Current: 50.14m	Min: 20.07m	Average: 351.61m	Max: 2.97
■ SRV queries/sec	Current: 80.11m	Min: 40.29m	Average: 169.58m	Max: 1.48
■ AAAA queries/sec	Current: 65.75	Min: 41.59	Average: 76.26	Max: 275.51
■ TOTAL queries/sec	Current: 228.50	Min: 146.50	Average: 279.56	Max: 577.55

Tue Nov 11 22:23:05 2008

IPv6 DNS Usage

- About 25% of DNS queries are for AAAA records
- Unfortunately, most of these are for non-existent domains, or hosts without AAAA records
- For example: 4 AAAA queries before A query
 - 15:00:04.106 query: directory.monash.edu.au IN AAAA +
 - 15:00:04.109 query: directory.monash.edu.au.its.monash.edu.au IN AAAA +
 - 15:00:04.110 query: directory.monash.edu.au.monash.edu IN AAAA +
 - 15:00:04.111 query: directory.monash.edu.au.monash.edu.au IN AAAA +
 - 15:00:04.111 query: directory.monash.edu.au IN A +
- Also occasional storms of requests for "ISATAP"
 - 600 queries per second, per PC !!

Rackspace Search Results - Konqueror

The screenshot shows the Rackspace website's search interface. At the top left is the Rackspace Hosting logo. To the right, there are flags for various countries and contact information: "US Sales: 1.800.961.2888" and "US Support: 1.800.961.4454". A search bar contains the text "ipv6" and a "SEARCH" button. Below the search bar is a navigation menu with links for "Hosting Solutions", "Why Rackspace", "Partner Programs", "Information Center", and "Careers". A large red banner features the text "SEARCH RESULTS FOR RACKSPACE.COM" and "HOSTING SOLUTIONS FROM THE WORLD'S LEADER IN HOSTING". Below the banner, a message states: "Your search for **ipv6** produced **0** result(s).". At the bottom, there are logos for various partners including Microsoft, redhat, DELL, CISCO, hp, AMD, vmware, and pci. A footer contains links for "Home", "Hosting Solutions", "Contact Us", "Copyright Notices", "Privacy Statement", "Site Map", "Partners", and "Rackspace Europe", along with the copyright notice "©2008 Rackspace Hosting, Inc.".

Offsite DNS Hosting FAIL

DomainName.edu.au - Services - Konqueror <2>

The screenshot shows the DomainName.edu.au registrar interface. At the top, there is a search bar with "SEARCH FOR DOMAIN WWW." and a dropdown menu set to "edu.au", followed by a "SUBMIT SEARCH" button. Below this are four main navigation buttons: "REGISTER DOMAIN", "MANAGE DOMAIN", "WHOIS", and "POLICY". To the right is a vertical menu with links for "HOME", "NEWS", "FAQ", "ABOUT", and "CONTACT". The main content area is titled "Registering fredfred3.edu.au" and offers two options: "Proceed without delegating domain name (name servers may be added later)" (selected) or "Delegate Domain Name:". Under the delegation option, there is a table for "NAME SERVERS" with columns for "IP address" and "Name".

NAME SERVERS	IP address	Name	NAME SERVERS	IP address
Primary NS	2001:388:608c:8		Secondary NS1	
Secondary NS2			Secondary NS3	

At the bottom, there are logos for "aictec", "education.au creative capable connected", and ".auDA THE AUSTRALIAN DOMAIN NAME ADMINISTRATOR". A footer note states "education.au limited is an auDA authorised registrar".

Parent DNS Zone FAIL

DHCP and network auto-discovery

- **Since we are planning to run a dual-stack network, there isn't a pressing need for IPv6 DHCP**
- **Hosts get (IPv4) DNS server addresses from IPv4 DHCP, or statically configured**
- **Network router auto-discovery has worked very well so far – have only rebooted routers once in last 1.5 years**
- **Haven't done IPv6 HSRP**
- **Beware of rogue IPv6 routers**

Servers

- **Many servers auto-configure IPv6 by default**
- **May need to tweak**
 - /etc/hosts
 - /etc/hosts.allow
 - ifcfg-eth0
 - > Preference to use auto-discovery IPv6 address rather than fixed IPv6 address for outgoing connections

Web Servers

- **A customised Apache 1.3 is used on our main Web serving farm**
 - Too hard to add IPv6 support
- **Apache 2.0 does support IPv6**
 - Need to check .htaccess files
 - > Permissions based on IPv4 addresses aren't relevant any more

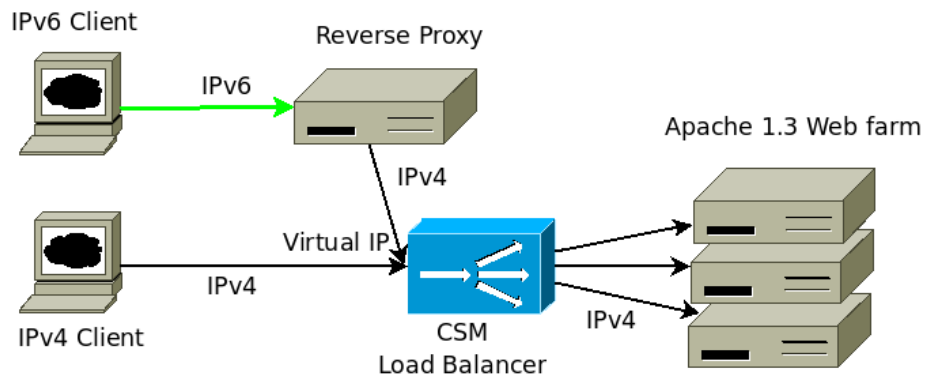
Web Reverse Proxy

- **Use Apache in Reverse-proxy mode as IPv6 -> IPv4 gateway**

```

Listen [2001:388:608c:88b::123]:80
<VirtualHost *:80>
    ProxyPreserveHost On
    ProxyPass / http://130.194.11.123:80/
    ProxyPassReverse /
        http://130.194.11.123:80/
</VirtualHost>
  
```

Diagram of IPv6 -> IPv4 Web proxy



Clients

- **Currently, end-user IPV6 subnets are limited to**
 - Electrical Engineering
 - eResearch
 - ITS
- **Biggest problem was one Vista laptop with ICS that wanted to be a IPv6 router**
- **Technical users are enjoying e.g. direct IPv6 connections between desktop at work, and PCs on home network**

Problem: Monitoring IPv6 Network

- **Statseeker V3**
 - Can monitor interface usage and up/down status
 - Can't ping IPv6 addresses
- **flow-tools**
 - Handles Cisco NetFlow V5 – IPv4 only
 - Need NetFlow V9 for IPv6
- **Fluke NetFlow Tracker 3.0.7**
 - Can accept NetFlow V9
 - Can show 6to4 IPv6 traffic
- **Snort 2.8**
 - IPv6 support is incomplete
 - Needs addresses like 2001:0:0:0:0:0:0/16
- **No IPv6 usage statistics collection !!!**

Problem: IPv6 Capability of Middle-boxes

- **CSM - Content Switch Module**
 - Load-balances and routes IPv4 only
 - Could add extra IPv6-only router interface to provide IPv6 service to real server Vlan
- **FWSM - Firewall Services Module**
 - L2 mode - Pass IPv6 without inspection
 - L3 mode - IPv6 inspected, but no Multicast
- **SSL Services Module**
 - IPv4 only
- **WISM - Wireless Services Module**
 - IP protocol independent !!!
- **SCE 2000 - Service Control Engine**
 - Pass IPv6 without inspection
- **VPN 3000 Concentrators**
 - VPN over IPv4 only, IPv4 inside (could do v6-in-v4 in VPN)

Lessons Learnt

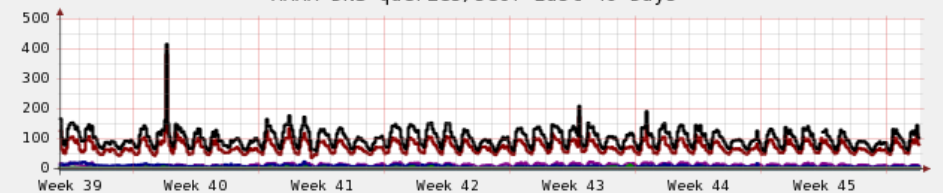
- **IPv4 not broken yet. Users see little need to migrate to IPv6, or dual-stack**
- **IPv4 address exhaustion like Y2K, or Global Warming, or Urban Sprawl, or ...**
 - But no definite deadline date
 - IPv4 will continue to work after exhaustion
 - “Will effect others, not us”
- **Enabling IPv6 (over a relaxed timescale) has created opportunities for improving many IPv4 practices**
 - Address plan
 - ACLs
 - Router configuration management
 - Network monitoring

To Do

- **IPv6 for off-site DNS secondaries**
 - University of Newcastle
 - Rackspace.com
- **AAAA records in .edu.au parent zone**
- **IPv6 E-mail services**
- **IPv6 for South Africa and Malaysia campuses**
- **IPv6 usage statistics**
- **More**
 - IPv6 servers
 - IPv6 user subnets
 - IPv6 education

Questions?

AAAA DNS queries/sec: Last 48 Days

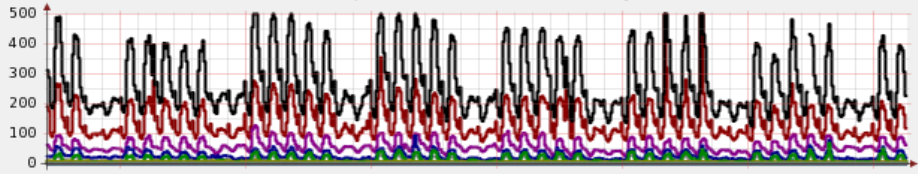


Protocol	Current	Min	Average	Max
ns0b	182.44m	135.13m	290.89m	1.10
ns0c	0.00	0.00	27.27m	570.27m
ns1a	80.59	36.68	73.21	381.67
ns2a	9.52	2.68	11.42	22.92
ns3a	376.68m	102.24m	1.08	4.96
ns4a	211.53m	7.92m	273.60m	860.21m
ns5a	2.49	1.06	3.49	11.28
ns6a	6.83	3.06	8.74	23.37
ns7a	735.89m	158.20m	1.64	12.57
ns8a	279.46m	103.65m	291.03m	807.04m
nsaa	43.05m	1.11m	42.94m	100.12m
ns3	1.42	867.55m	1.63	2.92
ns0a-old	0.00	0.00	698.54u	44.44m
ns7a-old	12.92m	7.50m	17.29m	41.12m
total	102.69	58.51	102.10	415.63

Tue Nov 11 21:38:48 2008

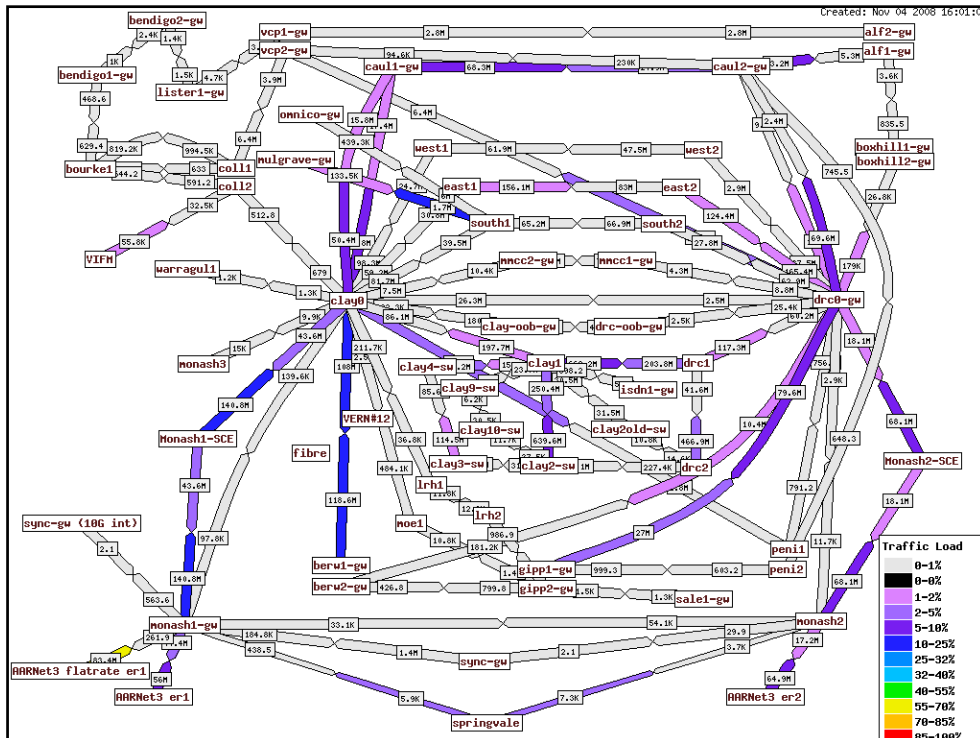


A DNS queries/sec: Last 48 Days



Server Group	Current	Min	Average	Max
ns0b	358.12m	198.07m	432.57m	1.09
ns0c	9.16m	7.22m	53.40m	695.56m
ns1a	118.85	74.23	143.84	746.84
ns2a	61.86	16.25	59.25	127.89
ns3a	1.81	711.87m	3.56	14.51
ns4a	687.04m	103.21m	1.28	12.06
ns5a	8.99	3.92	12.90	28.93
ns6a	19.42	10.55	26.75	93.43
ns7a	7.79	2.79	13.83	68.50
ns8a	1.33	599.17m	1.65	5.08
nsaa	27.21m	6.94m	25.07m	107.08m
ns3	5.79	3.84	6.86	11.37
ns0a-old	0.00	0.00	6.92m	358.61m
ns7a-old	24.17m	11.53m	25.86m	55.41m
total	226.94	125.72	270.25	973.79

Tue Nov 11 21:40:27 2008



AT CRC

Major Lessons

- **IPv6 is a useful tool for 3G+ networks**
- **When funding stops, research setups and expertise is lost**

Future Work

- **Research in IPv6 and Wireless networking**
- **Emphasis is on network simulation rather than physical networking**