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IPv6 at Imperial

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ICT Networks

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Introduction

- ~17,000 students
- ~8,000 staff
- ~50,000 unique hosts on wired network
- >33,000 concurrent clients on wireless at peak time
- 2x100G to Janet
- Many VRFs (MPLS L3VPNs)
- Firewalls between VRFs

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Journey so far

- 2003 – Started experimenting: 6in4 tunnel, separate infrastructure
- 2006 – Routers enabled, separate firewall, test subnets and servers
- 2010 – Upstream native IPv6, dual-stack firewalls
- 2010/11 – Most production and BYOD enabled
- 2010/11 – Some services including mail & DNS
- 2011 – World IPv6 Day: College websites enabled
- 2013 – Wireless enabled
- 2015 – AAAAs added to most load-balanced VIPs (IPv4 backends)
- 2020 – IPv6 only HPC

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Current position

- ~44% of our Internet traffic is IPv6
- ~58% for BYOD
- ~90% for HEP (LHCONE)
- Dual stack almost everywhere
- Usual suspects IPv6 enabled: DNS, WWW, SMTP, NTP
- AAAAs on most load-balanced services
- SLAAC and RDNSS rather than DHCPv6
- IPv6 mandated in tenders
- IPv6 support added to majority of network management

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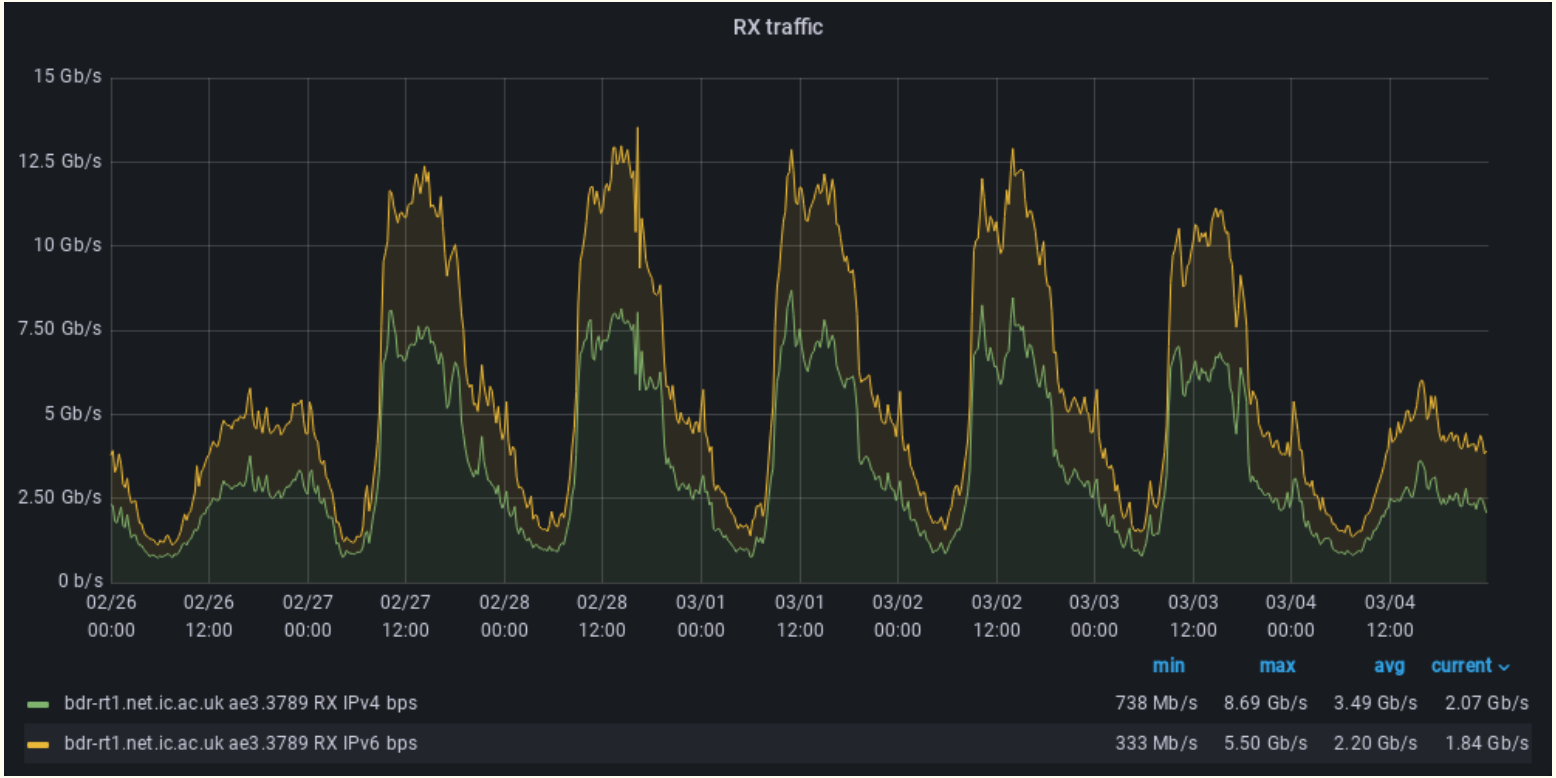

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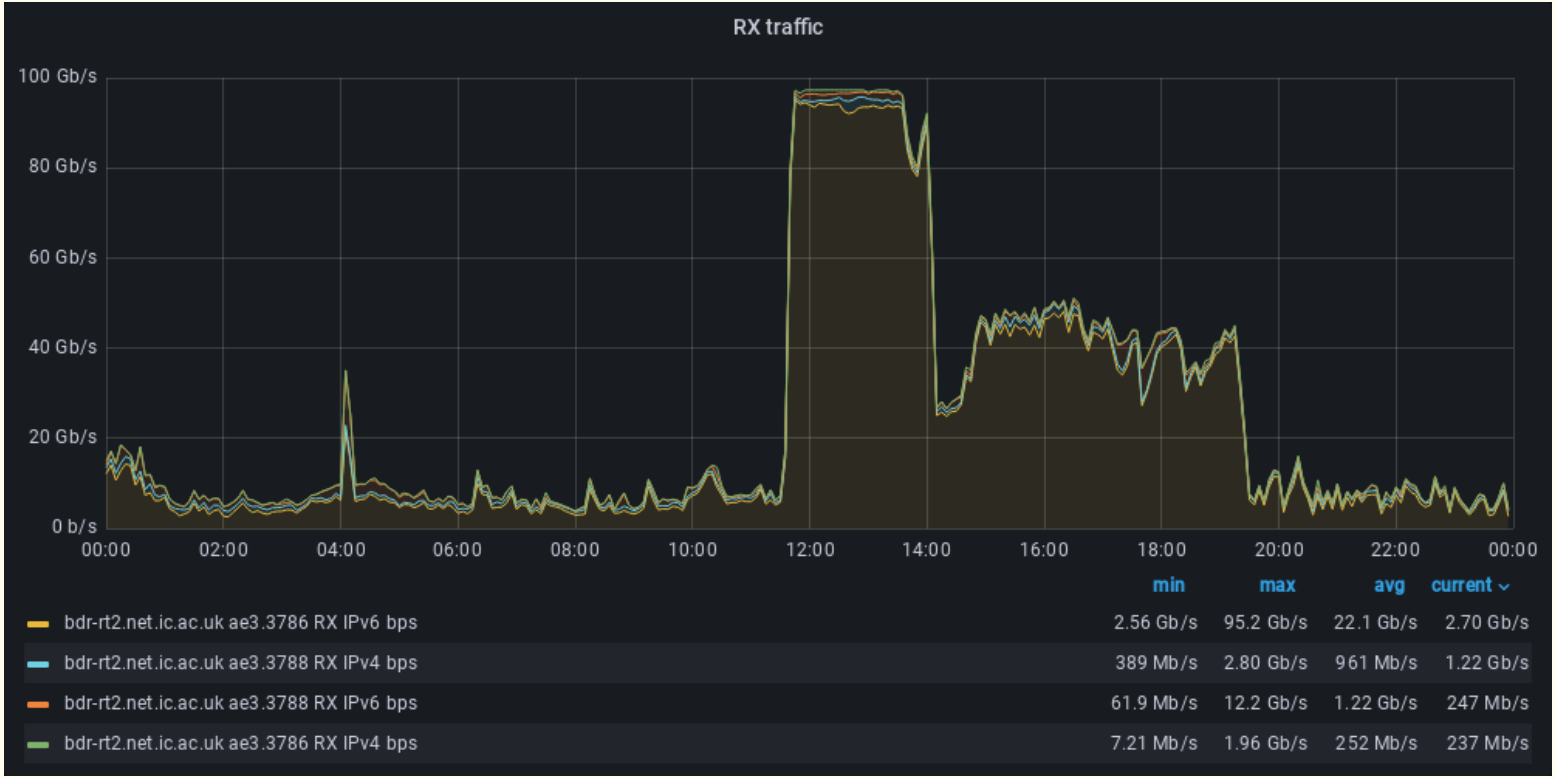

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HPC refresh

- Multi-year programme to replace HPC estate
- An opportunity to go IPv6 only!
- 2x spine switches and leaf per rack
- 100G to each server (30 per rack)
- EBGP, ASN per switch
- /64 IPv6 per leaf/rack
- Flat /64 1G management network
- NAT64/DNS64 to reach IPv4 resources outside HPC network
- clatd (464XLAT) to mop up IPv4 literals and IPv6 incapable applications

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Experience

- Yet to encounter any problems we couldn’t work around
- Less NAT has reduced need for multi-homing
- NAT64/DNS64 alone was not enough
- Heavily managed Linux estate made CLAT possible
- DHCPv6 implementations in switches and PXE not great

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Legacy campus architecture

- IPv6
- SLAAC, RDNSS
- Public IPv4
- DHCPv4, with mostly static assignments
- No NAT
- A records in DNS for static IPv4 addresses
- Many IPv4 firewall policies

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New campus architecture

- IPv6
- NAT64/DNS64
- SLAAC, RDNSS
- RFC 1918 IPv4
- NAT44
- DHCPv4, with mostly dynamic assignments
- AAAA records in DNS for stable IPv6 addresses
- ZTNA to provide access to internal resources
- Deny DHCPv4 requests for hosts capable of IPv6 only

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Experience so far

- Generally working very well
- Avoids twice as many VLANs/subnets
- ZTNA solution currently has limited IPv6 support :-(
- NAT sucks!
- Xboxes don’t like DNS64
- macOS CLAT hindered by lack of PREF64 on routers
- Windows CLAT… don’t even get me started
- Future wired 802.1x may hinder selective DHCPv4
- University environment poses unique challenges

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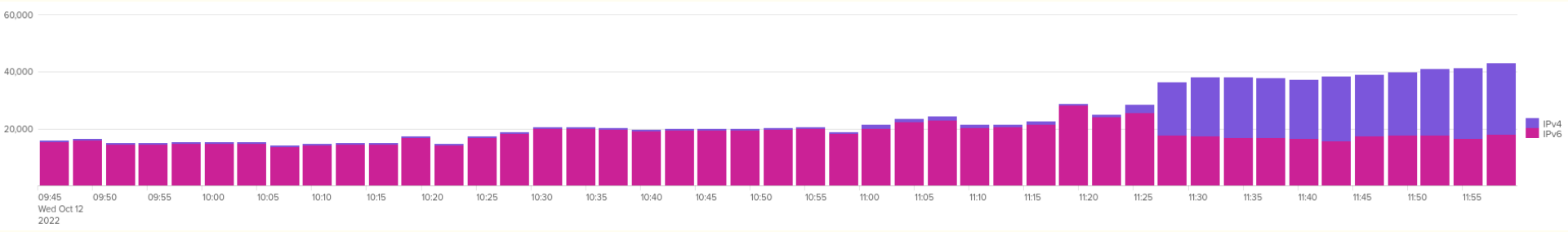
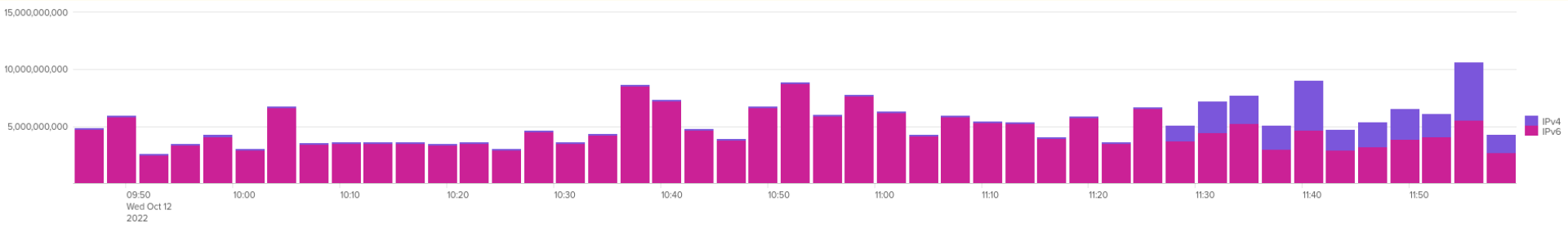
What if IPv4 was to “break”?





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What next

- Complete transition to new campus architecture
- Consolidate public IPv4 space
- Full IPv6 support within ZTNA
- IPv6 enable services not behind ZTNA
- Internal services can be IPv6 only
- Stateless DHCPv6
- IPv6 in Azure
- Wean hosts off IPv4
- Migrate management of switches and access points to IPv6

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Any questions?