An IPv6 Addressing Plan

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What is an Address?

Address: Within a given frame of reference, an address is an identifier that uniquely defines an entity, and the path to that entity.

Why is an Addressing Plan Needed?

Planning is needed to deal with complexity

IPv4

IPv4 has 2^{32} addresses, i.e. $4.3 * 10^{9}$ addresses

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Why is an Addressing Plan Needed?

Planning is needed to deal with complexity

IPv6

IPv6 has 2^{128} addresses, i.e. $3.4 * 10^{38}$ addresses

That's to say IPv6 is $7.9 * 10^{28}$ bigger than IPv4 address space

Sites are allocated a /48 from the JANET allocation so that represents $1.2 * 10^{24}$ addresses per site to be managed.

Planning is needed to deal with complexity

Why is an Addressing Plan Needed?

Addressing impacts of the management of the network

An address provide unique identity AND path information.

Path information is used by Routers to compute reachability metrics so that routing decisions can be made.

Routing Policies are also widely used to manage flows.

Aggregated routing is crucial as the more complex the addressing environment the tougher it is for routers and those who manage them.

Governance of an Addressing Plan

The IPv6 Addressing Plan is owned by the organisation.

It's configuration and management will likely be delegated.

The IPv6 Addressing Plan should form a part of the organisation's "Assigned Numbers" registry, and be published.

For example within STFC, the governance function is owned by the Technical Design Authority with management delegated to the Network and Communications Group.

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Goals for an Addressing Plan

Think IPv6! Use IPv4 as a data point and not a model

The plan is scalable and passes the test of time

Security policy is easier to implement and the extent and scope of access within the network is controlled

The routing is structured to streamline the process

Addresses are easier to trace

The Addressing Plan can be visualised

“Get it right first time” ho! hum!

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The IPv6 Address Space

STFC RAL is allocated:

2001:630:58::/48 of which the first allocated 16 bits are used for on-site subnet addressing, i.e. 2001:630:58:0000::/64 though 2001:630:58:FFFF::/64 is available. This equates to 65,536 subnets each of $1.9 * 10^{19}$ hosts.

The subnet space provides the basic structure of the Addressing Plan. Getting this design right is crucial.

Dealing with the Subnet Structure

There isn't a right answer – it depends on what you need.

So, for example, the basic idea is built around 4-bit (nibble) boundaries to limit complexity and to aid aggregated routing.

2001:630:58:	U	U	U	U	L	L	L	L	B	B	B	B	B	B	B	B	::/64

Where:

U: Usage **L**: Location **B**: unallocated Bits

A trade off:

Usage first is good for security / ACLs

Location first good for routing optimisation

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Approaches for Subnet Structure

Allocating the bits within the subnet (and by the nibble)

Monotonic:
Starting from the rightmost bit:
0000; 1000; 2000; 3000; ... nice and simple

Sparse:
Starting from the leftmost bit:
0000; 8000; 4000; c000; ... and leaving space for growth

Best-fit
Allocate smallest available to meet the demand but with IPv6 this really isn't an issue

Random
Deprecated! It's a visual plan!

An Example Subnet Structure

Usage	Location
Core Network	Internal, External, Point-to-Point, ...
Science-1	PP, Space, SCD, ...
Science-2	JASMIN, ISIS, CLF, DLS, ...
Corporate	IT services, Staff wireless, BMS, ...
Visitors	eduroam, Guest
Commercial	Tenants, Commercial wireless, ...
Real-Time	Telephony, Videoconferencing, ...
Cloud Services	...
IOT	...
...	...

An Example Subnet Structure

Science: L bits unallocated: B bits unallocated

2001:630:58:	0	0	0	1	L	L	L	L	B	B	B	B	B	B	B	B	::/64

i.e. 2001:630:58:**1**::/52

Visitors: L bits unallocated: B bits unallocated

2001:630:58:	0	0	1	0	L	L	L	L	B	B	B	B	B	B	B	B	::/64

i.e. 2001:630:58:**2**::/52

Real-Time: L bits unallocated: B bits unallocated

2001:630:58:	0	0	1	1	L	L	L	L	B	B	B	B	B	B	B	B	::/64

i.e. 2001:630:58:**3**::/52

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An Example Subnet Structure

Science Prefix: 2001:630:58:1::/52

Science: JASMIN: B bits unallocated

2001:630:58:	0	0	0	1	1	0	0	0	B	B	B	B	B	B	B	B	::/64

i.e. 2001:630:58:18::/56

Science: Space: B bits unallocated

2001:630:58:	0	0	0	1	0	1	0	0	B	B	B	B	B	B	B	B	::/64

i.e. 2001:630:58:14::/56

Science: PPD: B bits unallocated

2001:630:58:	0	0	0	1	1	1	0	0	B	B	B	B	B	B	B	B	::/64

i.e. 2001:630:58:1C::/56

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And those unallocated bits...?

Delegate allocation and here assigned maximising usage:

Science: JASMIN: Unmanaged Cloud

2001:630:58:	0	0	0	1	1	0	0	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	::/64

i.e. 2001:630:58:18**01**::/64

Science: JASMIN: Managed Cloud

2001:630:58:	0	0	0	1	1	0	0	0	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	::/64

i.e. 2001:630:58:18**02**::/64

Or alternatively....

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And those unallocated bits...?

Delegate allocation but assigned “thinking IPv4”:

Science: JASMIN: Unmanaged Cloud

2001:630:58:	0	0	0	1	1	0	0	0	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	::/64

i.e. 2001:630:58:18**81**::/64, i.e. IPv4 network 129

Science: JASMIN: Managed Cloud

2001:630:58:	0	0	0	1	1	0	0	0	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	::/64

i.e. 2001:630:58:18**82**::/64, i.e. IPv4 network 130

But IPv4 is a data point and not a model

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Managing the /64 Hosts

Three common methods available:

Stateless Address Auto Configuration (SLAAC)

- Router sends the Prefix
- Host uses the MAC for uniqueness (MAC in EUI-64)
- Multiple routers means multiple addresses
- Privacy extensions are problematic – deprecate!

Dynamic Host Configuration Protocol (DHCPv6)

- Use with SLAAC or as a substitute for SLAAC

Static IPv6 addresses

- Recommend for routers, switches, servers

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Managing the /64 Hosts

For vital equipment it's possible to use some or all of the IPv4 address within the IPv6 /64 host allocation:

Science: JASMIN: Managed Cloud

Either 2001:630:58:1802::/64
Or 2001:630:58:1882::/64, following the IPv4 subnet

Consider the IPv4 host 130.246.130.230 which maps to:

2001:630:58:1802::230/128, or

2001:630:58:1882::230/128

But ...

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Managing the /64 Hosts

Consider adding internal structure to the /64 host to identify Gateways, Well-known services, etc. to make these visual too...

Take: 2001:630:58:1802::/64 and add some reserved bits:

i.e. 2001:630:58:1802::RRRR/64

Then allocate meaning into the reserved bits, for example something to say IPv4 is lurking here, and there's a DNS server involved. So if the IPv4 host is 130.246.130.230 then:

2001:630:58:1802::230:C002/128

now provides structured, visual information

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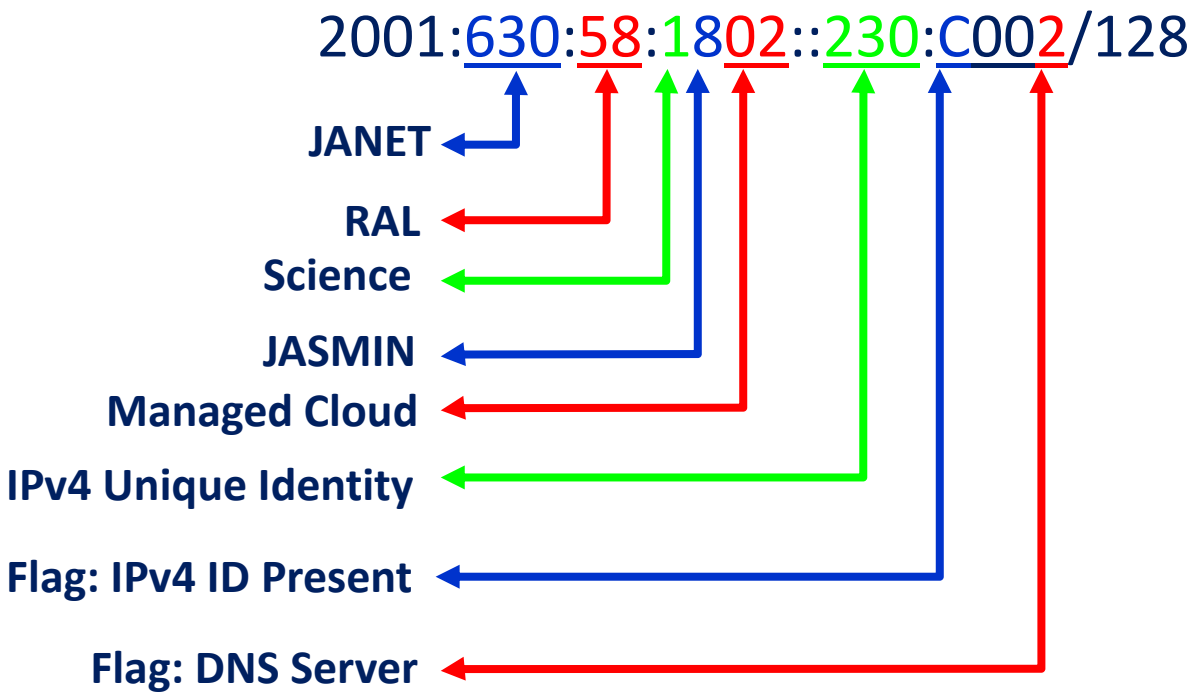
An IPv6 Address Plan

The Addressing Plan provides consistency of structure, is visually accessible and is readily extensible:



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References

RFC4291	IPv6 Address Architecture
RFC6177	IPv6 Address Assignment to End Sites
ISOC	IPv6 Address Planning: Guidelines for IPv6 address allocation
SURFnet	Preparing an IPv6 Addressing Plan
GÉANT	Recommendations for IPv6 addressing plan for the HE sector
APNIC-34	IPv6 Address Planning (Philip Smith)