Considerations for IPv6 Address Planning

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Enterprise & IPv6 Workshop

UK IPv6 Council

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Agenda

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- Gathering Requirements for IPv6 Assignment
- Obtaining IPv6 Prefix
- Creating IPv6 Addressing Plan
- Closing Remarks – IPAM; ULA or not; IPv6 host Address Assignment

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Gathering Requirements for IPv6 Assignment

Requirement Gathering – 1.

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- Number of **locations** and the level of hierarchy
  - Within a region, country, continent, global presence?
  - NOT important: # hosts within a subnet (**/64 = 2^{64}**)
  - Will you need allocations from multiple RIRs?
- Number of different **network segments**
  - What is the maximum within a level of hierarchy?
  - Corporate, development, remote-access VPN, guest Wifi, Network services & Management
  - Different types of IoT, extranet services for partners and suppliers
  - Per Business unit?
- Services **centralized** (one DC) or **distributed** (in branches/multiple DCs/Cloud)
  - DC Components that require IP (not an exhaustive list) – not a problem for IPv6:

Requirement Gathering – 2.

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- Your network segments might/will/already extend to DCs/Cloud
  - Maybe mirror them within the DC/Cloud addressing construct
- Security
  - Easily manageable ACL
  - Exposing information about the network (e.g. VLAN number)
- Rate of change and growth
  - Mergers & acquisitions

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Obtaining IPv6 Prefix

Types of Unicast Addresses - RFC 4291

- (Node) Loopback Address
- **Link-Local Address (LLA) – fe80::/10**
- **Unique Local Address (ULA) – fc00::/7**
- **Global Unicast Address (GUA) – 2001::/3**

- **NOTE:** An interface will have multiple IPv6 addresses

Where To Get an IPv6 Prefix?

- IPv6 Prefix (GUA) assigned from:
  - an **Local Internet Registry (LIR)** – typically your ISP (PA prefix)
  - directly from an **Regional Internet Registry (RIR)** – RIPE in Europe
    - Typical for ISPs and large enterprises which span multiple countries, have dual-homing requirements (have AS number)
    - RIPE IPv6 Address Allocation and Assignment Policy
- The minimum Provider Independent (PI) assignment is /48
  - Contractual Requirements for Provider Independent Resource Holder in RIPE NCC region
- An organisation can request a larger prefix with appropriate documentation of their address usage/need
  - /32 is typical, allocated from a reserved /29 in case of additional need to ensure continuity
- Company operating in multiple region can obtain prefixes from different RIRs
- Out-of-region announcements
  - No RIR policy which would prevent this, check with upstream ISP

What does your Allocation look like?

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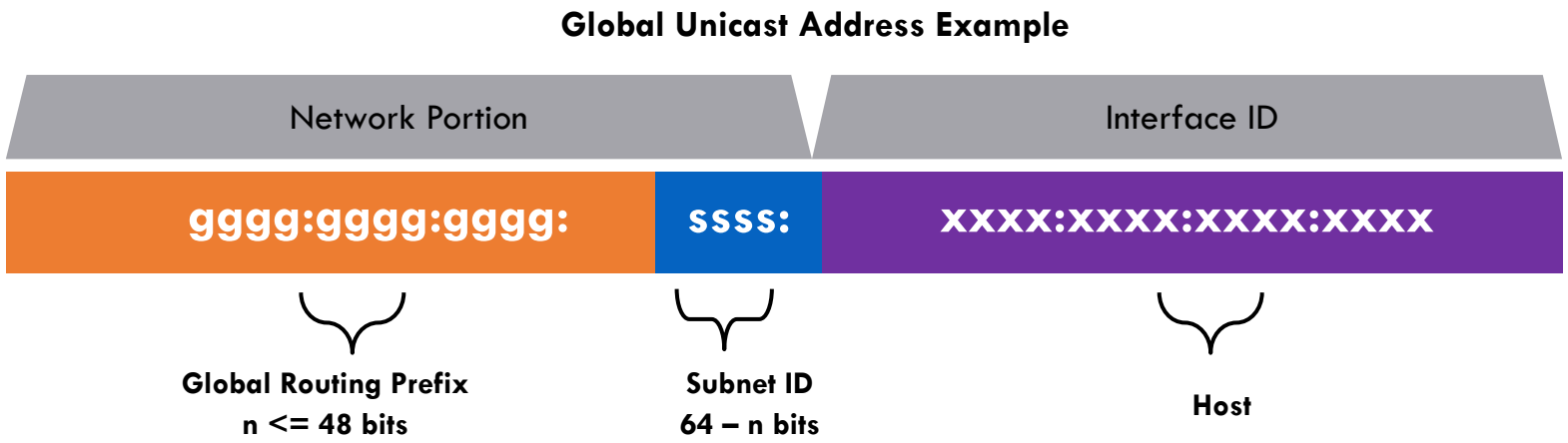
- Allocated prefix has fixed length, work with the bits between the assigned prefix and the /64 (Interface ID)



- Let go of "conservation" mindset! The **IPv6 addressing space is HUGE….**

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Creating IPv6 Address Plan

Considerations – 1.

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- The hierarchy and a well thought-through process will help
  - With operations & troubleshooting
  - Deployment is easy to automate
- Cookie-cutter approach is desirable, think in terms of the number of subnets
  - Number of hosts in is NOT important – /64 for end-point segments
  - Maintain the same structure across regions
  - Base on the highest common denominator, there's plenty of addresses
- Think about your **aggregation** and security enforcement points
  - /48 accepted to announce on the Internet
  - Filtering on specific "nibble"
  - Exposing information about the network (e.g. VLAN number)?

Considerations – 2.

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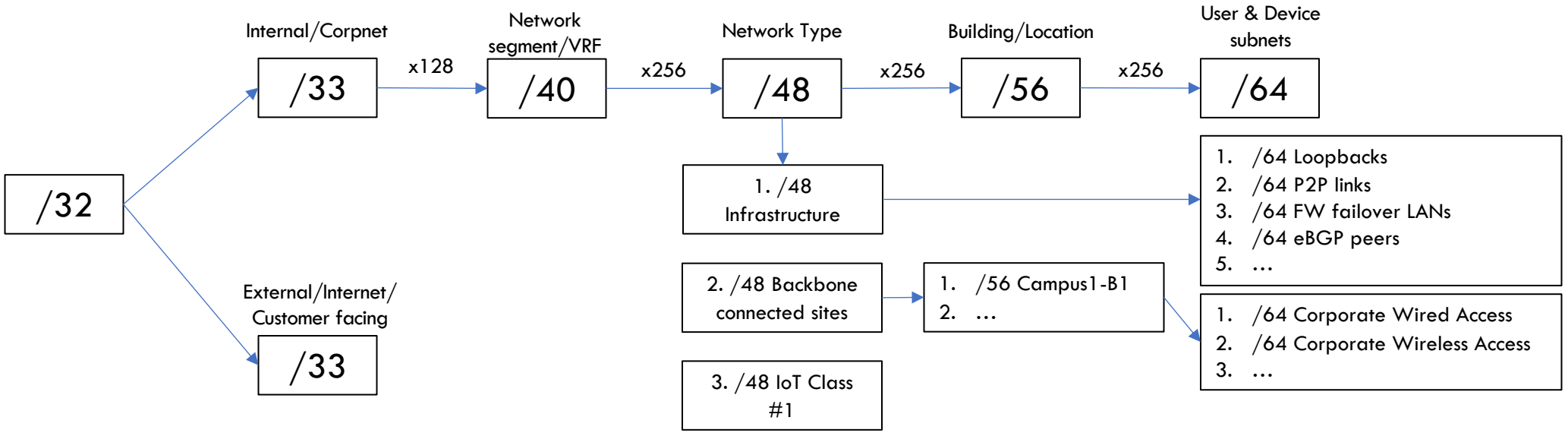
- L2 domain = VLAN = /64
  - Keep L2 domains relatively small
  - NDP is chatty, and dual-stack with ARP can be **pain** for your network devices
- Encoding information within the IPv6 address possible
  - Locations, PINs, services, business units etc.
  - For accounting & administrative reasons, troubleshooting
  - Practices vary - Keep it simple!
- Re-addressing can be automated
  - Monitoring is essential

”Nibble” Boundary

- 2001:0db8:1234:5678::/64
  - Nibble = 4 bits = 1 HEX character
- Keep the addressing plan tidy
- If you are coming to an existing IPv6 address plan (e.g. after a pilot), it’s worth cleaning up and enforce the nibble boundary

Example of /32 Hierarchy



- Comments on a DC/Cloud
  - /48 per DC / Cloud deployment is typical
  - /64 is the least common denominator, Top-of-Rack switches are the L3 boundary

Infrastructure Addressing

Point-to-point Links & Loopbacks

- Current recommendation, RFC 6164, for **Point-to-point links** /127
  - It mitigates ND exhaustion attacks
  - ! In older IPv6 implementations you might see /126 and it's OK !
- Allocate /64 from a block (e.g. /56) but configure:
  - /**127** or /**112** for multi-access network segments
- Allocate /64 for **Loopbacks** and configure /128
- NOTE: Remember to check how many Longest Prefix Matches (LPM) [/128] your network devices can carry
  - Does not always equal the total number of supported IPv6 prefixes

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Closing remarks

IPAM

ULA or not ULA

IPv6 Host Address assignment methods

IP Address Management (IPAM)

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- **Please, use IPAM**
- Let go of Excel spreadsheets ☺

- IPAM can manage IPv6 networks and their AAAA, PTR and host resource records
- Enables you to reserve a specific IPv6 prior to a device deployment
- Possible integration with your network orchestration

ULA or not ULA

- ULA has the lowest priority, below IPv4, so is NOT USED
  - Avoid deploying for end-point addressing in a Dual-stack environment
  - IETF draft – Unintended Operational Issues with ULA
- It SHOULD work in **IPv6-only** closed system not requiring Internet access
  - Example: CPEs – management address, P2P links, IoT
    - Can your management systems manage over IPv6-only?
- A voluntary registry of SixXS (stopped in June 2017) now re-vived by Ungleich - https://ula.ungleich.ch/ ☺

Host IPv6 address assignment methods

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- Stateful DHCPv6
  - A host gets IPv6 address fully assigned with DNS and other information too
  - Not supported on Android devices
- Stateless Address Autoconfiguration (aka SLAAC)
  - A host receives a Router Advertisement (RA) message (ICMPv6) from a default GW (subnet router)
  - RA provides IPv6 prefix and the hosts follows its implementation of SLAAC
    - EUI-64 or other method (check RFC7721)
  - The host needs to obtain DNS information
    - Stateless DHCPv6 or Recursive DNS Server (RDNSS – RFC8106) message
- Manual/Automated (= static)
  - Useful for server deployments which need stable IPv6 addresses
    - Remember: best practice for static IPv6 address assignment is automation – avoids human errors ☺

Resources

- IPv6 Address Planning – Tom Coffeen, O'Reilly, 2014
- Create an Addressing Plan – RIPE NCC, 2015
- BRKRST-2667 How to write an IPv6 Addressing Plan – Veronika McKillop & Wim Verrydt, CiscoLive, 2016

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 & deploy IPv6.

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Appendix

Link-Local Address - RFC 4291

- Range: **fe80::/10**
  - No subnet significance
- Used for communication with hosts on the same link
  - Examples: Stateless Address Autoconfiguration (SLAAC), Neighbor Discovery, Duplicate Address Detection
- For link operation purposes
  - Leveraged by routing protocols and gateways
- Never routed to other links
  - No meaning outside the link

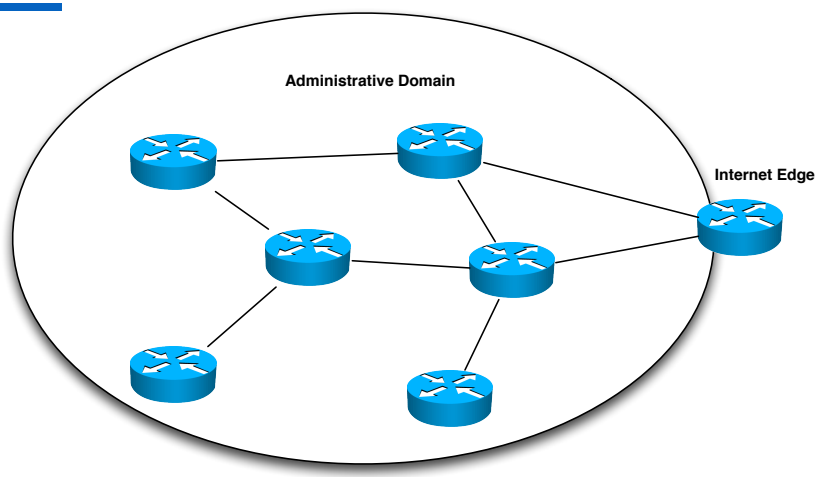
- Typically, first 64 bits are fixed, only Interface Identifier is modified
- **Example:** fe80::0224:d7ff:fe2c:7831

Global Unicast Address - RFC 3587

- Globally unique and routable
  - Defined for use across the IPv6 Internet
- Primary goal is to provide plenty of globally accessible addresses
- Reserved and identified by **high-level 3 bits** set to "**001**"
  - Range: **2000::/3**
- Global IPv6 Prefix received from an LIR or RIR
- Presence in Global Routing Table
  - Aggregation is critical
  - Hierarchical assignment enforced through IANA allocation policy

- **Example:** 2001:420:0:1::1

Unique Local Address - RFC 4193



- Range: **fc00::/7**
  - Currently used fd00::/8
- Globally unique address for local communications
- **40-bit global ID** generated using a pseudo-random algorithm
- Not designed to be aggregated
- Not expected to be routed on the Internet but routable within an **administrative domain**
- Scope needs to be managed
  - ACLs and Prefix lists
  - Your upstream ISP will filter it anyway
- **Example**: fd68:df3d:80ee::/48 (LACNIC)

fc00:gggg:gggg:	ssss:	xxxx:xxxx:xxxx:xxxx

Unique-Local (ULA) – fc00::/7

Host Addresses on IPv6-only Network

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```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . : [redacted]
   Description . . . . . . . . . . . : Marvell AVASTAR Wireless-AC Network Controller
   Physical Address. . . . . . . . . : BC-83-85-04-99-0C
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   IPv6 Address. . . . . . . . . . . : 2a01:[redacted]:711e:55df:3bd1:bc41(Preferred)
   Temporary IPv6 Address. . . . . . : 2a01:[redacted]:cdee:aec2:65d4:c268(Preferred)
   Link-local IPv6 Address . . . . . : fe80::711e:55df:3bd1:bc41%3(Preferred)
   Autoconfiguration IPv4 Address. . : 169.254.188.65(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.0.0
   Default Gateway . . . . . . . . . : fe80::200:5eff:fe00:240%3
   DHCPv6 IAID . . . . . . . . . . . : 79463301
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-20-96-89-62-BC-83-85-04-99-0C
   DNS Servers . . . . . . . . . . . : 2a01:[redacted]fe::6464
                                       2a01:[redacted]fe::6464
```