IPv6 Design & Subnetting

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IPv6 Address Assignment Considerations

- RFC 5375 IPv6 Unicast Address Assignment Considerations.
- IPv6 Address Allocation and Assignment Policy from RIPE or your regional registry.
- Let’s start with prefix lengths. RFC 5375 is very explicit (section 3):
  - Using a subnet prefix length other than a /64 will break many features of IPv6, including Neighbor Discovery (ND), Secure Neighbor Discovery (SEND) [RFC3971], privacy extensions [RFC4941], parts of Mobile IPv6 [RFC4866], Protocol Independent Multicast - Sparse Mode (PIM-SM) with Embedded-RP [RFC3956], and Site Multihoming by IPv6 Intermediation (SHIM6) [SHIM6], among others.
IPv6 Address Assignment Considerations

- **A Subnet (VLAN):** highly recommended to use a /64 prefix on every subnet –VLAN-.
- **Point-to-point links** (as between PE & CE): officially must also be /64 prefix.
  - The use of longer prefixes on point-to-point inter-router links is debatable (some people recommend /126 or /127, others /112). Properly-implemented network devices have no problem with shorter subnets; after all, IPv6 is classless. However, to ensure you won’t get a hiccup from a just-good-enough-too-cheap-to-pass box someone will eventually connect to your network, be conservative and use /64 everywhere.

Expanded Address Space

- **Usual sizes for end-users are:**
  - /48: 65536 subnets, for business and residential customers
  - /56: 256 subnets, for residential customers.
  - /64: 1 subnet, for 1 device (i.e. laptop).
- **Other sizes are possible.**
4 Bit Boundaries

Multiple Addresses per Interface

- **Unicast**
  - Link-Local fe80::5a55:caff:fe6:bdbf/64
  - Global Unicast 2001::5a55:caff:fe6:bdbf/64

- **Multicast**
  - All Nodes ff02::1 (scope: link)
  - Solicited Node ff02::1:fff:bdbf
  - Routers
    - All Routers ff02::2 (scope: link)
IPv6 Addresses in URLs

- The IPv6 address written in brackets
- http://[2001:db8:4f3a::206:ae14]:8080
- Difficult for users
- DNS has to work

Fragmentation

- Routers don’t fragment packets with IPv6
  - More efficient handling of packets in the core
  - Fragmentation is done by host
- If a packet is too big for the next hop:
  - “Packet-too-big” error message
  - This is an ICMPv6 message
  - Filtering ICMPv6 causes problems
Path MTU Discovery

- A sender who gets this “message-too-big”
- ICMPv6 error tries again with a smaller packet
  - A hint of size is in the error message
  - This is called Path MTU Discovery

Why Create an Addressing Plan?

- Benefits of an IPv6 Addressing Plan:
  - Mental health during implementation(!)
  - Easier implementation of security policies
  - Efficient addressing plans are scalable
  - More efficient route aggregation
Customers

- Customers should get a large block of addresses
  - /48 - Business
  - /48 or 56 - Residential
- For more than a /48, send a request form
- Every assignment must be registered

Example Situation

- Customer has 6 functions:
  - Servers
  - Office PCs
  - Network Engineers PCs
  - Guests
  - VPN (remote workers)
  - Infrastructure (point-to-point and loopbacks)
Example Situation

- Customer has 3 locations:
  - Main building floor 1
  - Main building floor 2
  - Secondary office

Example Assignment from LIR

- The customer gets 2001:0db8:1a2b::/48
- Work on 4 bit boundary
  - 6 functions, leaves room for 10 new functions
  - 3 locations, leaves room for 13 new locations
  - We still have 8 bits!
  - Room for 256 networks per function per location
Example Plan 1

- Putting this in the address:
- 2001:0db8:1a2b:FLXX::/64
  - F = function (0=infrastructure, 1=servers, 2=office, 3=engineers, e=vpn, f=guest)
  - L = location (0=main building, 1=main building 2, 2=secondary office
  - XX = Number for network of type +location

Example Plan Usage

- 2001:0db8:1a2b:1000::/64
  - Servers in Main building, floor 1, network 0
- 2001:0db8:1a2b:1200::/64
  - Servers in Secondary office, network 0
- 2001:0db8:1a2b:f009::/64
  - Guest in Main Building, floor 1, network 9
Example Plan Usage

- **2001:0db8:1a2b:0000::1/128**
  - loopback address (location doesn’t apply!)
- **2001:0db8:1a2b:0102::/64**
  - point-to-point link (0 for infrastructure)
- **2001:0db8:1a2b:e1ab::/64**
  - VPN in main office, floor 1, user 171

Alternatives

- The previous example is just an idea
  - Adapt as necessary
- **2001:0db8:1a2b:FFLX::/64**
  - 256 functions
  - 16 locations
  - 16 networks per function per location
End User Summary

Tips:
- Work on 4-bit boundary
- Group subnets by function
- Group subnets by location
- Make a scalable addressing plan

ISP Addressing Plan

What should an ISP Addressing Plan contain?
- Address space for internal use
- loopback interfaces
- point-to-point connections
- servers, routers and other infrastructure at PoPs
- Use a /48 per POP
- Address space for customers
Loopback Interfaces

- One /128 per device
  - One /64 contains enough space for
  - 18,446,744,073,709,551,616 devices
- Take an easy to remember block for loopbacks
  - 2001:0db8:1a2b:0000:0000:0000:0000:0000

Point-to-Point Interfaces

- One /64 per point-to-point connection
  - Reserve 1 /64 for the link, but configure a /127
- (RFC 6164)
ISP Guidelines

- In common cases:
  - One /48 per PoP
  - Calculate growth
  - Make it scalable

- Things to consider
  - Administrative ease!
  - Use assignments on 4 bit boundary

IPv6 Address Assignment Considerations

- Why not giving less than /64 subnet to customer and using NAT if he needs more?
- I asked someone more familiar (but no hands-on-experience) about this, and got the answer that I should use a link-local or unique-local addresses for all computers within the company, the same way we use RFC1918 addresses today, and then just NAT them to the /120 network I got assigned from the ISP.
NATing IPv6

- Link-local addresses are a better solution for unnumbered interfaces and other communication needs before you get a real IPv6 address (for example, DHCPv6 request packets are sent from a link-local address);
- Unique local addresses (ULA) can be used for intra-network connectivity (for example, for those hosts and servers that never communicate with the Internet). Your host could have an ULA and a global IPv6 address (or even more than one global address) and use one or the other as needed.
- In most cases, your hosts should have a globally unique IPv6 address.
- Regardless of whether you decide to use ULA or not, remember that there is no NAT in IPv6 (although some people are seriously longing for NAT66). Let me repeat that: **there is no NAT in IPv6**.

End Users IPv6 Address Allocation

- A minimum allocation an ISP has to give to a residential end-user is a /64.
- If a residential end-user needs multiple subnets, he should get a /56 Minimum.
- End-site allocation is /48.
- Minimum provider-independent allocation assigned by RIPE or ARIN is /48.
- To get a larger allocation; you just have to provide the paperwork documenting your needs.
- **Summary**: If you are an enterprise customer and your ISP is giving you anything less than a /48, it’s time to consider changing the ISP.
RIPE Allocation Policy

- **5.4. Assignment**
  LIRs must make IPv6 assignments in accordance with the following provisions.

- **5.4.1. Assignment address space size**
  End Users are assigned an End Site assignment from their LIR or ISP. The size of the assignment is a local decision for the LIR or ISP to make, using a minimum value of a /64 (only one subnet is anticipated for the End Site).

- **5.4.2. Assignments shorter than a /48 to a single End Site**
  When a single End Site requires an assignment shorter than a /48, it must request the assignment with documentation or materials that justify the request. Requests for multiple or additional prefixes exceeding a /48 assignment for a single End Site will be processed and reviewed (i.e., evaluation of justification) at the RIR/NIR level.

- **Note:** There is no experience at the present time with the assignment of multiple network prefixes to the same End Site. Having the RIR review all such assignments is intended to be a temporary measure until some experience has been gained and some common policies can be developed. In addition, additional work at defining policies in this space will likely be carried out in the near future.
RIPE and Reverse Lookup for IPv6

5.6. Reverse lookup

When an RIR/NIR delegates IPv6 address space to an organisation, it also delegates the responsibility to manage the reverse lookup zone that corresponds to the allocated IPv6 address space. Each organisation should properly manage its reverse lookup zone. When making an address assignment, the organisation must delegate to an assignee organisation, upon request, the responsibility to manage the reverse lookup zone that corresponds to the assigned address.

RIPE Subsequent allocation

5.2.3. Subsequent allocation size

1. When an organisation has achieved an acceptable utilisation for its allocated address space, it is immediately eligible to obtain an additional allocation that results in a doubling of the address space allocated to it. Where possible, the allocation will be made from an adjacent address block, meaning that its existing allocation is extended by one bit to the left.

2. If an organisation needs more address space, it must provide documentation justifying its requirements for a two-year period. The allocation made will be based on this requirement.
Myths

Here are the myths:

1. There are \(3.4 \times 10^{38}\) or \(3.4\) undecillion IPv6 addresses.
2. Service Providers will not have enough IPv6 addresses to allocate /48 IPv6 prefixes to small businesses and home users.

And my results:

1. There are only \(4.2 \times 10^{37}\) 42 undecillion IPv6 addresses currently defined and usable.
2. With a bit of creative programming, it would only take 69000 years to scan all the IPv6 addresses on a 48 bit IPv6 subnet if you were scanning at a million addresses per second.
3. Service Providers have to stop worrying about running out of addresses and plan for /48 allocations to end user.
4. Small businesses and home users can be allocated /56 prefixes.

ISPs who currently have IPv6 enabled for residential customers

Canada:

- **Videotron**: Videotron has a [beta-program](http://example.com) for residential customers who want to test IPv6 (no official technical support, it is possible they don’t have enabled it in your area so check first before investing in new hardware). Although at date of writing, a large part of their networks are IPv6, you must go through a 6rd tunnel because they still need to upgrade some of their equipments and your router must support the 6rd protocol. You should be in business and see all of the hosts on your network with an IPv6 stack enabled being assigned a public IPv6 address starting with 2607:f048.

- **TekSavvy**: TekSavvy has a [IPv6 beta-program](http://example.com) for residential customers who use their DSL service. Just ask them to enable IPv6 to your subscription and it should be available within the next 24 hours. Their IPv6 connectivity is native so you don’t need to setup a tunnel.
ISPs who currently have IPv6 enabled for residential customers

- **Canada**
  - Shaw
  - Cogeco cable
  - Telus

- **Bell**: Bell appears to have an official IPv6 support especially for its business subscribers via a toolkit and various web pages on the subject.

- **France**
  - Free
  - Nerim
  - the French Data Network (FDN)

- **United States**:
  - Comcast (limited pilot in some areas only)

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Home routers compatible with IPv6

- Most of the home and small routers (cable and DSL) manufactured since 2010 and up are supporting IPv6.

- But you have to test the product, as most of them have minor issues, such as:
  - IPv6 firewall support.
  - Tunneling to brokers, to support non native full ipv6 network path to the internet.
  - What tunneling protocols does it support.
  - The automatic addressing process and features (DHCP & SLAAC).
  - IPv6 VPN

- Test the products then chose the best to your customers, and don’t forget to test how much easy to support this product.
Home routers

- Survey from RIPE IPv6 Act Now:
- Tp-Link devices:
  - [http://www.tp-link.us/article/?faqid=482](http://www.tp-link.us/article/?faqid=482)

Network-Level Design Considerations

- IPv6 provides network administrators with a significantly larger address space, enabling them to be very creative in how they can define logical and practical addressing plans. The subnetting of assigned prefixes can be done based on various logical schemes that involve factors such as:
  1. Using existing systems
     A. Translate the existing subnet numbers into IPv6 subnet IDs.
     B. Translate the VLAN IDs into IPv6 subnet IDs.
Network-Level Design Considerations

2. Redesign:
   A. allocate according to your need

3. Aggregation:
   A. Geographical Boundaries - by assigning a common prefix to all subnets within a geographical area.
   B. Organizational Boundaries - by assigning a common prefix to an entire organization or group within a corporate infrastructure.

**Example:**

- ISP AS 2000
- ISP prefix 2001:db8::/32
- We will have 65536 subnet of 2001:db8:XXX::/48
- We will use half of them for big customers (enterprises), and provide them with /48 prefixes
- Enterprises range: From 2001:db8:0::/48 To 2001:db8:7FF::/48, that is 32768 Subnets
- The other half would be divided to two parts, one for small customers, the other for ADSL subscribers.
Subnetting Example:

- Small customers: will provide them with /56 prefixes.
  - The range: From 2001:db8:8000:0:/56 to 2001:db8:BFF0:0:/56 this is \(4,194,304\) Subnets

- ADSL users, and links between sites (P2P connections), and other home users will have the rest of the range as /64 prefixes.
  - The range: From 2001:db8:C000:0:/64 to 2001:db8:FFFF:FFFF::/64 this is \(1,073,741,824\) Subnets

Note: IPv6 is classless, use your old IPv4 subneting skills.

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Subnetting Example:

- The home customer will have /64 prefix for one subnet.
- The small customer will have /56 prefix this is enough for 256 subnets of /64 prefix.
- Enterprise will have /48 prefix which is enough for 65536 VLANs of /64 prefix each. (the maximum VLANs number you can create on 6500 switch is 4000 so you can have 16 sites each of 4000 VLANs in the enterprise).
- The ISP with this design can serve more than \(1,077,968,896\) customer of deferent types, and every one will be happy.
- So Mr. Palestinian ISP you only have to get one /32 range from RIPE.