Address Planning --
Trials without
Tribulations

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    - All of you
IPv6 -- The basics
Anatomy of a Global Unicast address

<table>
<thead>
<tr>
<th>3 bits</th>
<th>9 bits</th>
<th>20 bits</th>
<th>16 bits</th>
<th>16 bits</th>
<th>64 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>IANA to RIR</td>
<td>RIR to ISP</td>
<td>ISP to End Site</td>
<td>Net</td>
<td>Interface ID</td>
</tr>
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<tr>
<td>3 bits</td>
<td>9 bits</td>
<td>36 bits</td>
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<td>64 bits</td>
<td></td>
</tr>
</tbody>
</table>

- Every end site gets a /48
- Global Unicast currently being allocated from 2000::/3
  - Top: Provider assigned
  - Bottom: Provider Independent
IPv6 -- The basics

How Global Unicast is Allocated

0::/0 (IETF→IANA)

2000::/3

2610::/12

261f:1::/32 (204 /32s per Pixel)

261f:1:d405::/48 (409.6 /48s per pixel)

IANA→RIR

RIR→LIR

IANA or RIR → End Site
IPv6 -- The basics
How Global Unicast is Allocated

- The Numbers:
  - 8 /3s, one of which is in use
  - 512 /12 allocations to RIRs in first /3 (6 used so far)
  - 1,048,576 LIR /32s in each RIR /12
  - 65,536 /48 Assignments in each /32
IPv6 -- Address Planning
Don’t oversimplify too much!

- There are lots of people saying “ISPs get /32s, end sites get /48s.”
- That’s an unfortunate oversimplification.
- ISPs get AT LEAST a /32 and can get whatever larger allocation they can justify.
- End sites should get at least a /48 and should be given whatever larger assignment they can justify.
Plan a Trial vs. Plan a Deployment

- There’s really nothing to be saved by planning your trial address structure separately.
- Take your best stab at planning your real deployment and use that.
  - If you’re right, you don’t have to renumber a bunch of customers to go from trial to production.
  - If you’re wrong, you probably got better data about how you were wrong and why.
IPv6 -- Address Planning Methodology

- Don’t start with a /32 and figure out how to make your needs fit within it.
- Start by analyzing your needs and apply for a prefix that will meet those needs.
- In your analysis, it’s worth while to try and align allocation units to nibble boundaries. A nibble boundary is a single hex digit, or, a number $2^n$ such that $n$ is a multiple of 4. (e.g. 16, 256, 4096, 16384, 65536...)
IPv6 Address Planning Analysis

- Start with the number of end sites served by your largest POP. Figure a /48 for each. Round up to the a nibble boundary. (if it’s 3,000 end sites, round up to 4096, for example... a /36 per POP.

- Next, calculate the number of POPs you will have. Include existing POPs and likely expansion for several years. Round that up to a nibble boundary, too. (140 POPs, round up to 256).
IPv6 Address Planning Analysis

- Now that you have an address size for each POP (4096 = 12 bits in our example) and a number of POPs (256 = 8 bits in our example), you know that you need a total of POP*nPOPs /48s for your network (4096*256=1,048,576 or 12+8=20 bits).

- 48 bits - 20 bits is 28 bits, so, you actually need a /28 to properly number your network.

- You probably could squeeze this into a /32, but, why complicate your life unnecessarily?
IPv6 Address Planning

Apply for your addresses

- Now that you know what size block you need, the next step is to contact your friendly neighborhood RIR (Regional Internet Registry) and apply.

- Most RIRs provide either an email-based template or a web-based template for you to fill out to get addresses.

- If you are a single-homed end-user, you usually should get your addresses from your upstream rather than an RIR.
IPv6 Address Planning

The bad news

- The addressing methodology I described above may not be consistent with RIR policy in all regions (yet)*.
- This means you might have to negotiate to a smaller block.
- All RIRs have an open policy process, so, you can submit a proposal to enable this kind of allocation, but, that may not help you immediately.

* Prop-096 in APNIC this week, Adopted 2011-3 in ARIN, mostly permitted in RIPE, not yet discussed in AfriNIC or LACNIC.
IPv6 Address Planning

The good news

- Having things on nibble boundaries is convenient, but, not necessary.
  - ip6.arpa DNS delegations
  - Human Factors
  - Routing Table management
  - Prefix lists

- The techniques that follow should work either way.
IP Address Planning
Carving it up

- For the most part, you’ve already done this.
- Take the number you came up with for the nPOPs round-up and convert that to a number of bits (256 = 8 bits in our example).
- Now, take what the RIR gave you (/28 in our example) and add that number to the above number (28+8 = 36) and that’s what you need for each POP (a /36 in our example).
This is the Internet

This is the Internet on IPv4 (2012)

Any questions?
IPv6 Address Planning
Carving it up

- Now let’s give address segments to our POPs.
- First, let’s reserve the first /48 for our infrastructure. Let’s use 2000:db80 - 2000:db8f as our example /28.
- Since each POP gets a /36, that means we have 2 hex digits that designate a particular POP.
- Unfortunately, in our example, that will be the last digit of the second group and the first digit of the third group.
IPv6 Addressing
Carving it up

Strategy

- Sequential Allocation
  - Advantage: Simple, easy to follow
  - Advantage: POP Numbers correspond to addresses
  - DisAdvantage: Complicates unexpected growth

- Allocation by Bisection
  - Advantage: Simplifies growth
  - Advantage: Greatest probability of Aggregation
  - Disadvantage: “Math is hard. Let’s go shopping!”
IPv6 Addressing
Allocation by Bisection

- Bisection? What does THAT mean?
- Simple... It means to cut up the pieces by taking the largest remaining piece and cutting in half until you have the number of pieces you need.
- Imagine cutting up a pie into 8 pieces...
IPv6 Addressing
Allocation by Bisection

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First, we cut it in half...
IPv6 Addressing Allocation by Bisection

- Bisection? What does THAT mean?
- Simple... It means to cut up the pieces by taking the largest remaining piece and cutting in half until you have the number of pieces you need.
- Imagine cutting up a pie into 8 pieces...

Then we cut it in half again
IPv6 Addressing Allocation by Bisection

- Bisection? What does THAT mean?
- Simple... It means to cut up the pieces by taking the largest remaining piece and cutting in half until you have the number of pieces you need.
- Imagine cutting up a pie into 8 pieces...

Then Again
IPv6 Addressing Allocation by Bisection

- Bisection? What does THAT mean?
- Simple... It means to cut up the pieces by taking the largest remaining piece and cutting in half until you have the number of pieces you need.
- Imagine cutting up a pie into 8 pieces...

And finally a fourth cut
IPv6 Addressing Allocation by Bisection

- It’s a similar process for IPv6 addresses.
  - Let’s start with our 2001:db80::/28 prefix.
  - We’ve already allocated 2001:db80:0000::/48
IPv6 Address Planning Allocation by Bisection

After repeating this for 19 POP allocations, we have a table that looks like this:

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>2001:db80:0000::/48</th>
<th>POP1</th>
<th>2001:db88:0000::/36</th>
</tr>
</thead>
<tbody>
<tr>
<td>POP8</td>
<td>2001:db81:0000::/36</td>
<td>POP9</td>
<td>2001:db89:0000::/36</td>
</tr>
<tr>
<td>POP4</td>
<td>2001:db82:0000::/36</td>
<td>POP5</td>
<td>2001:db8a:0000::/36</td>
</tr>
<tr>
<td>POP2</td>
<td>2001:db84:0000::/36</td>
<td>POP3</td>
<td>2001:db8c:0000::/36</td>
</tr>
<tr>
<td>POP6</td>
<td>2001:db86:0000::/36</td>
<td>POP7</td>
<td>2001:db8e:0000::/36</td>
</tr>
<tr>
<td>POP18</td>
<td>2001:db87:0000::/36</td>
<td>POP19</td>
<td>2001:db8f:0000::/36</td>
</tr>
</tbody>
</table>
IPv6 Address Planning Allocation by Bisection

- Notice how by doing that, most of the /36s we created have 15 more /36s before they run into allocated space and all have at least 7.

- Notice also that if any POPs get larger than we expect, we can expand them to /35s, /34s, /33s, and most all the way to a /32 without having to renumber.

- By default, at /36, each pop has room for 4096 /48 customers. End sites that need more than a /48 should be extremely rare*.
IPv6 Address Planning Allocation by Bisection

* End Site means a single customer location, not a single customer. Many customers may need more than a /48, but, with 65,536 /64 subnets available, even the largest building should be addressable within a /48.
Q&A

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The end

Thank you

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