HURRICANE ELECTRIC
INTERNET SERVICES

IPv4->IPv46->IPv6 Changing the Internet one address at a time.

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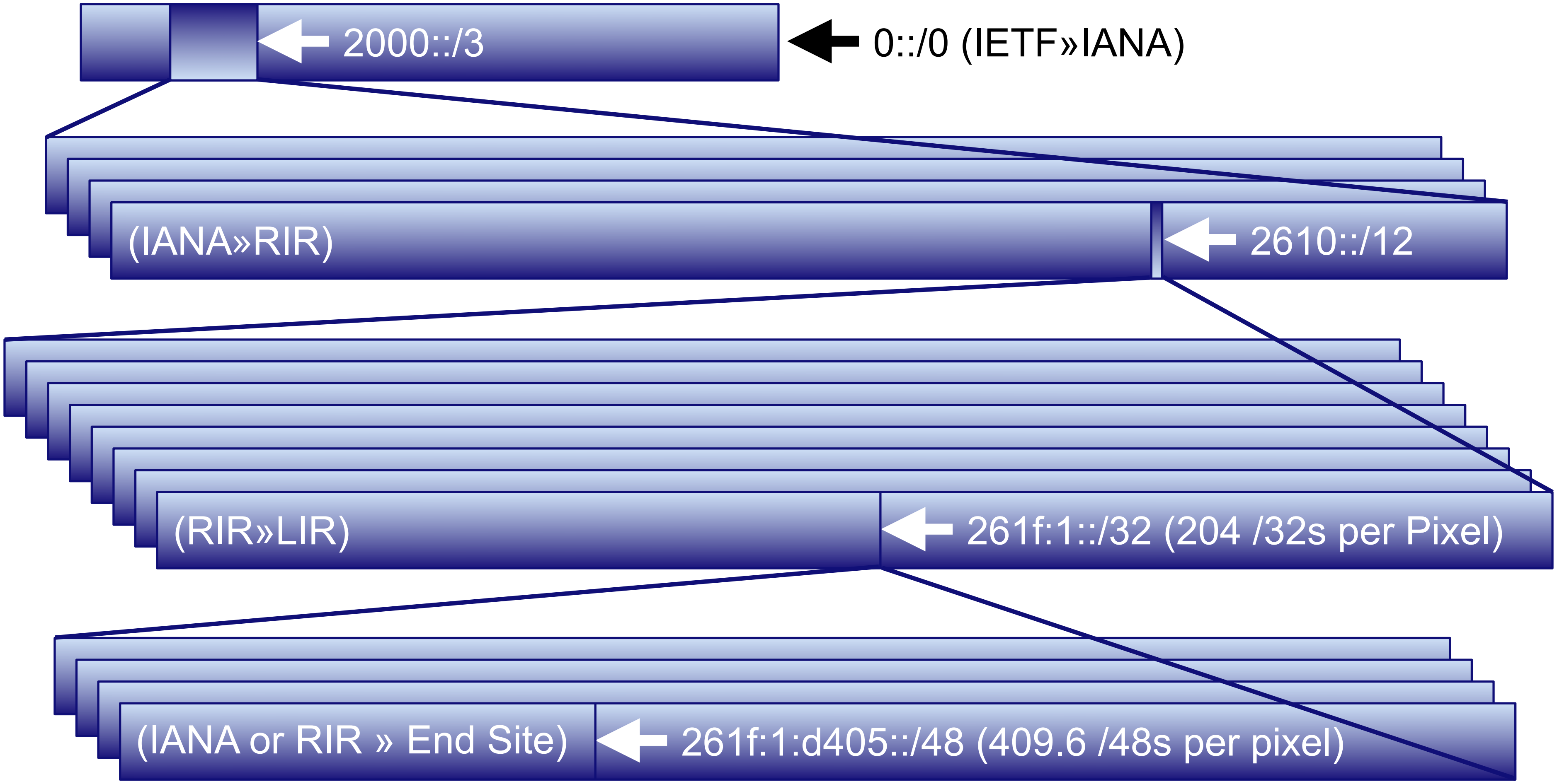
IPv6 -- The basics

Anatomy of a Global Unicast address

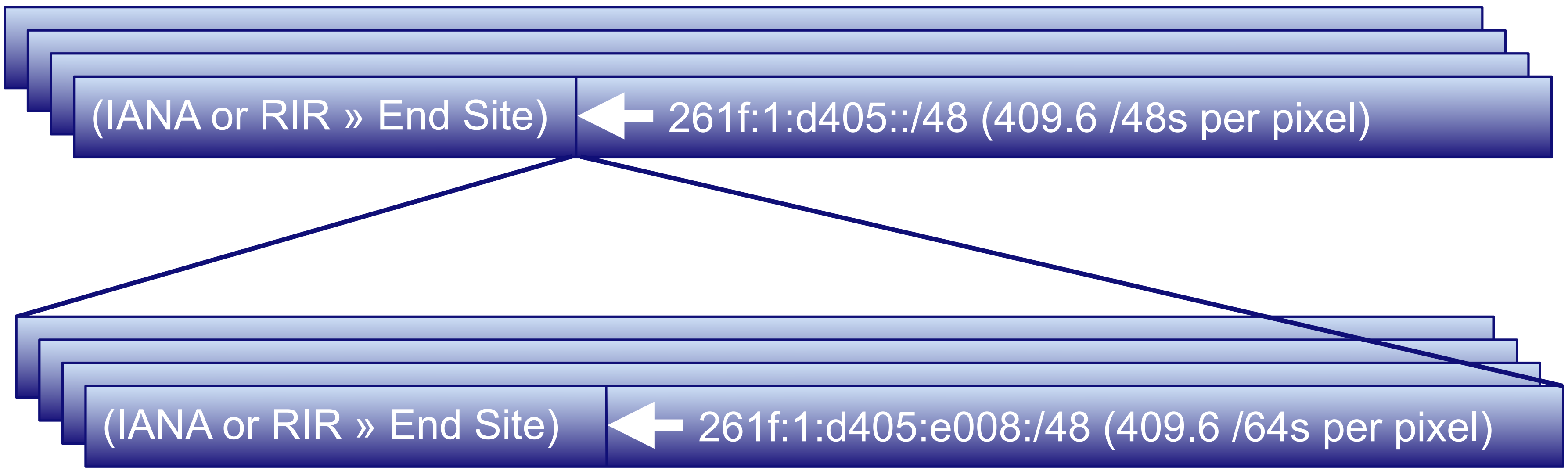
3 bits	9 bits	20 bits	16 bits	16 bits	64 bits
001	IANA to RIR	RIR to ISP	ISP to End Site	Net	Interface ID
001	IANA to RIR	RIR to End Site		Net	Interface ID
3 bits	9 bits	36 bits		16 bits	64 bits

- 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



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

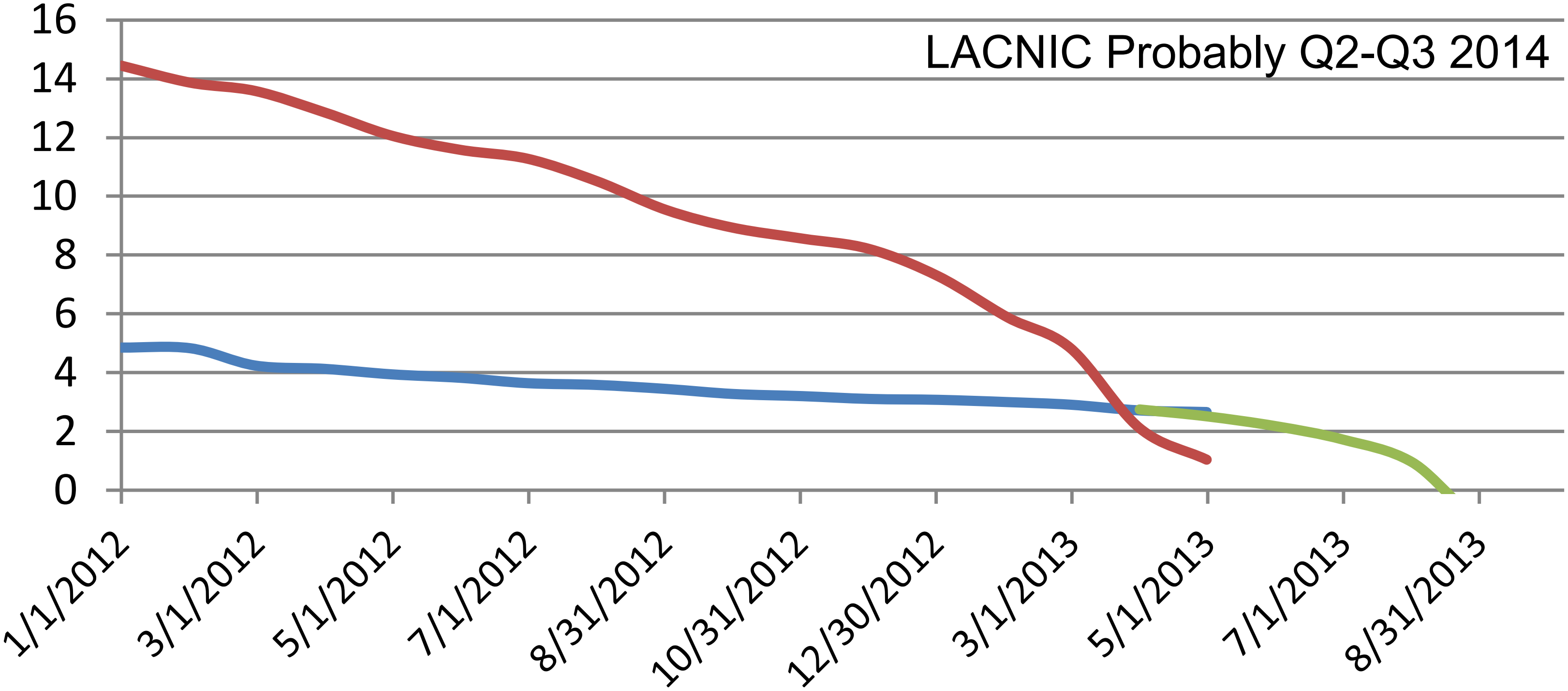
How Urgent is This?

http://tndh.net/~tony/ietf/ARIN-runout-projection.pdf

Arin projected

(heavy weight more recent events)

overlayed with APnic final months



Don’t Mistake Extension for Transition

- IPv6 “Transition” technologies
  - CGN/LSN/NAT444
  - NAT-PT
  - NAT64/DNS64
  - 6rd
  - DS-Lite
  - 464XLAT
  - Dual Stack

Extension-only technologies

- CGN/LSN/NAT444
  - More IPv4 NAT
  - Even more dysfunctional than traditional NAT
  - Does nothing to help you move to IPv6
  - May divert resources away from IPv6 transition
  - Costly
    - Equipment Costs
    - Deployment Costs
    - Maintenance/Logging/Administration costs
  - May have legal implications/encumbrances

Extension-only technologies

- NAT-PT
  - Deprecated NAT Protocol Translation
  - Mostly replaced by NAT64/DNS64
  - Difficult to deploy
  - Breaks many applications
  - Fragile
  - Costly
  - More a workaround for isolating IPv4-only networks and IPv6 networks with translation boundary than a transition technology.

Quasi-Translation Technologies

- NAT64/DNS64
  - Two flavors (Client and Server)
  - Client Flavor (IPv6 client, IPv4 server)
    - Recursive DNS server intercepts A record and synthesizes AAAA record pointing to a unique address on translator box.
    - Translator box translates IPv6 packets to IPv4 and basically acts as stateful NAT.
  - Server Flavor (IPv4 server, IPv6 clients)
    - NAT box located proximal to IPv4-only server.
    - Translates incoming IPv6 connections to IPv4 sessions.

Quasi-Translation Technologies

- 6rd (IPv6 “Rapid” Deployment)
  - Essentially a 6to4 Tunnel mechanism, but more deterministic and under local (service provider) control.
  - Usually requires new CPE
  - Suitable if your aggregation equipment can’t speak IPv6.
  - Ideally, hammer your vendors to get native IPv6 support, but this can get you by temporarily.
  - ARIN Policy supports special 6rd allocations.

Quasi-Translation Technologies

- DS-Lite
  - Native IPv6
  - Native IPv4 in LAN, tunneled over IPv6 on WAN
  - Single NAT layer managed by Service Provider (CGN, but NAT44 instead of NAT444).

Quasi-Translation Technologies

- 464XLAT
  - Primarily for Mobile Operators
  - Double NAT (4->6 and later 6->4)
  - Moves IPv4 over IPv6 network
  - More information at: https://sites.google.com/site/tmoipv6/464xlat

Coexistence and Forward Progress

- Dual Stack
  - IPv4 and IPv6 running simultaneously
  - Dual stack hosts can talk to anything
  - IPv4 side can continue with traditional NAT and/or CGN/LSN/NAT444 as needed
  - To the extent IPv6 can be used, reduces/eliminates dependency on NAT444/CGN/LSN
  - Provides greatest flexibility
  - Ideal originally planned transition strategy
  - Hybrid of Dual-Stack and others probably necessary.

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.

IPv6 -- Address Planning Methodology

- Don't start with a predetermined size 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, 65536...)

IPv6 Address Planning Analysis (ISP version)

- 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 (ISPs)

- 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 Analysis (End-User Version)

- What's an end-site?
  - A single building, structure, or tenant in a multi-structure building.
- How much do I need for my end-site?
  - This is actually pretty simple in most cases.
  - Up to ~48,000 subnets needed, just give each end-site a /48.
  - If you have an end-site that needs more than 48,000 unique subnets, then assign the necessary number of /48s.

IPv6 Address Planning Analysis (End-user)

- Take the total number of /48s you need for all of your end-sites and round-up to a nibble boundary (if your local RIR policy permits. Currently ARIN is the only RIR that explicitly permits this).
- Once you receive your /48s it is worth considering distributing them to end sites using sparse allocation to the extent practicable.
- Though the RIR will provide a single aggregable prefix, each end site can be an independent /48 and should be administered accordingly. However, when possible, routing should be aggregated.

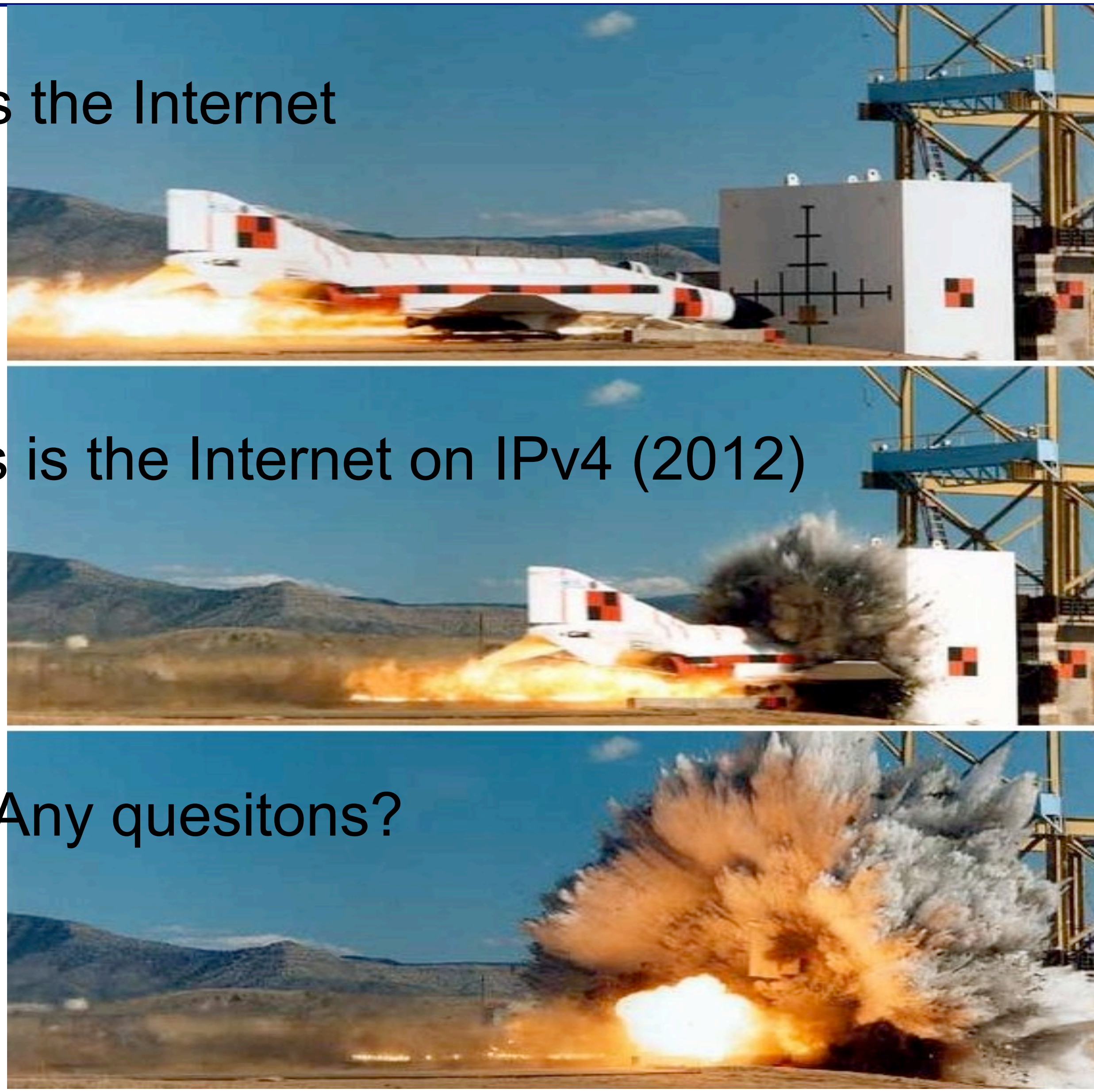
IPv6 Address Planning
Apply for your addresses

- 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.

This is the Internet

This is the Internet on IPv4 (2012)

Any quesitons?



IP Address Planning
Carving it up

- These examples are for ISPs.
- 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).

IPv6 Address Planning
Carving it up

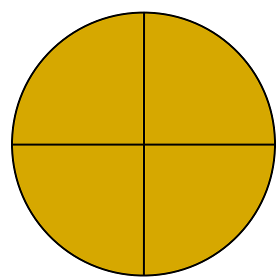
- Now let's give address segments to our POPs.
- First, let's reserve the first /48 for our infrastructure. Let's use 2000:db80 - 2000:db8f as our example /28.
- Since each POP gets a /36, that means we have 2 hex digits that designate a particular POP.
- Unfortunately, in our example, that will be the 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...



First, we cut it in half.
Then we cut it in half again
Then Again
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
  - Our available space is now 2001:db80:0001:: to 2001:db8f:ffff:ffff:ffff:ffff:ffff:ffff. Cutting that in half we get 2001:db88:0000::/36 as our first POP address.
  - That leaves the largest chunk at 2001:db88:1000:: to 2001:db8f:ffff:ffff:ffff:ffff:ffff:ffff. Cutting that in half, we get 2001:db8c:0000::/36 as our next POP

IPv6 Address Planning Allocation by Bisection

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

Infrsastructure	2001:db80:0000:/48	POP1	2001:db88:0000::/36
POP12	2001:db80:8000::/36	POP13	2001:db88:8000::/36
POP8	2001:db81:0000::/36	POP9	2001:db89:0000::/36
POP4	2001:db82:0000::/36	POP5	2001:db8a:0000::/36
POP14	2001:db83:0000::/36	POP15	2001:db8b:0000::/36
POP2	2001:db84:0000::/36	POP3	2001:db8c:0000::/36
POP16	2001:db84:8000::/36	POP17	2001:db8c:8000::/36
POP10	2001:db85:0000::/36	POP11	2001:db8d:0000::/36
POP6	2001:db86:0000::/36	POP7	2001:db8e:0000::/36
POP18	2001:db87:0000::/36	POP19	2001:db8f:0000::/36

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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