HURRICANE ELECTRIC
INTERNET SERVICES

IPv6 -- A light at the end of the tunnel

Owen DeLong
owend@he.net

HURRICANE ELECTRIC
INTERNET SERVICES

IPv6 -- A light at the end of the tunnel

Owen DeLong
owend@he.net

How soon do we need IPv6

How soon do we need IPv6

- Everyone who thinks they need to have IPv6 deployed in 10 years or less raise your hand.

How soon do we need IPv6

- Everyone who thinks they need to have IPv6 deployed in 10 years or less raise your hand.
- Those of you who think it's at least 5 years away take your seats.

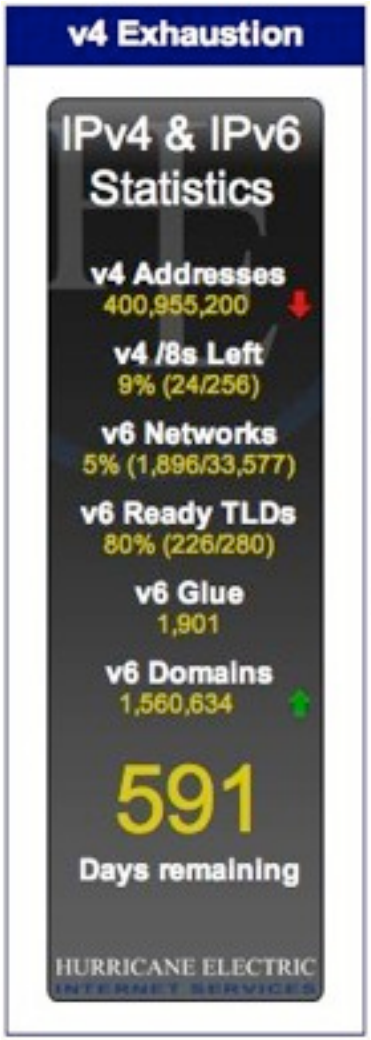
How soon do we need IPv6

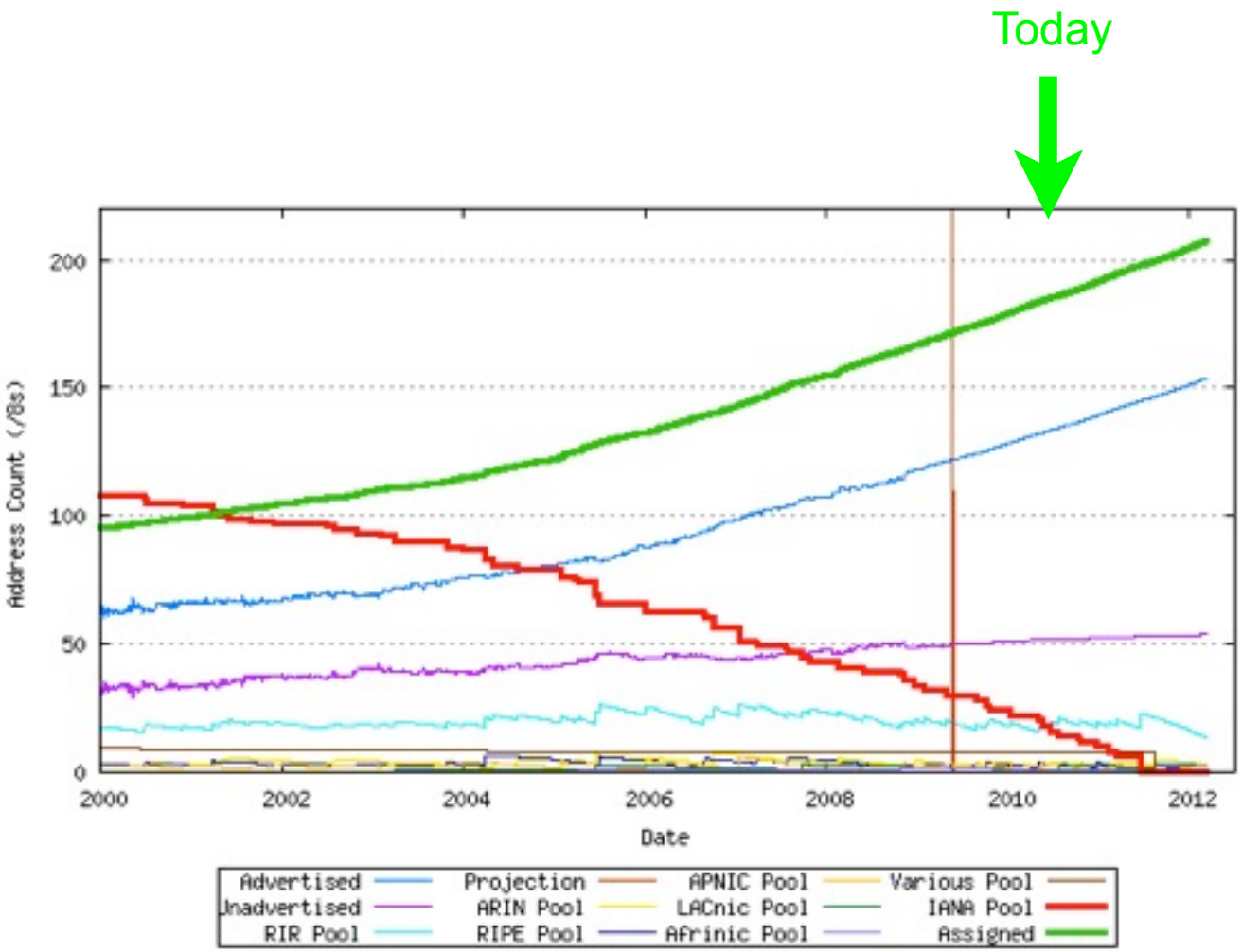
- Everyone who thinks they need to have IPv6 deployed in 10 years or less raise your hand.
- Those of you who think it's at least 5 years away take your seats.
- The real answer is less than 3!

How close are you to the end of the tunnel?

- How many of you have heard of IPv6?
- How many can spell IPv6?
- How many have IPv6 in a lab?
- How many have IPv6 deployed in production at all?
- How many have full IPv6 deployment to your backbone?
- How many offer IPv6 services to your customers?

Why is this important?





Light at the End of the Tunnel

- An apropos metaphor:
  - Could be good (the end of a long dark tube)
  - Could be bad (an oncoming high speed train)
- As applied to IPv6, some of each:
  - Good
    - Much larger address space
    - New Autoconfiguration Features
    - Improved IPSEC support
    - Simplified Header
    - Better Mobility support
  - Bad
    - Requires effort and investment
    - Software updates
    - Hardware upgrades (in some cases)
    - Staff Training
    - Procedure Updates

What is IPv6

- Vastly larger address space
  - 128 bits (IPv4 is 32 bits)
- What does that mean?
- IPv4 4,294,967,296 addresses
- IPv6 340,282,366,920,938,463,463,374,607,431,768,211,456 addresses
- Graphically (if each IP address were a unit of mass):

7 liters of water (IPv4)
Earth 5.9742×10^{24} kg (IPv6)

(1kg = 2.2 Pounds,
15 Pounds of water)

Address Size Comparison (continued)

- Number of networks
  - In IPv4, the generic network chunk is a /24 (254 possible hosts)
  - In IPv6, the generic chunk is a /64 (18,446,744,073,709,551,616 or 18+ quintillion possible hosts)
  - In IPv4, there is room for roughly 14,614,528 /24s.
  - In IPv6, there is room for 18,446,744,073,709,551,616 /64s.

Network Size and Number of networks (graphically)

One IPv4 /24 -- 254 M&Ms

One IPv6 /64 -- Enough M&Ms to fill all 5 of the great lakes.

Full Address Space, One M&M per /24 covers 70% of a football field

Full Address Space, One M&M per /64 fills all 5 great lakes.

Comparison based on Almond M&Ms, not plain. Caution! Do not attempt to eat a /64 worth of any style of M&Ms.

If it ain't broke, why fix it?

- It has been broken for years, we've just gotten used to working around it.
  - Various workarounds for NAT
  - NAT itself is a workaround for not enough addresses
  - Huge routing table (300,000+ routes) due to disaggregation from slow-start and other address conservation tradeoffs
  - Poor implementations of address mobility and IPSEC

That doesn't seem like enough for such a major change

- Going from IPv4 only to IPv6 only would be a major change.
- Going from IPv4 only to IPv4/IPv6 dual stack isn't such a major change (but it's not completely minor, either).
- When we run out of IPv4 addresses, the internet will not stop growing. There will be hosts added which do not have directly workable IPv4 addresses.

Alternatives to IPv6

- The only alternative to IPv6 with any traction at all at this point is what is known as “Carrier Grade NAT”.
- Very few test implementations
- None of the test implementations work with instant messenger services (Yahoo, AIM, Jabber, Skype, IRC ALL break)
- VOIP severely impaired or non-functional in all implementations.
- The internet is more than the web and email. CGN does not support much outside of these services.

Cost Benefit Analysis

- Two sets of alternatives to consider:
  - IPv6 vs. CGN
  - IPv6 now vs. IPv6 later
- IPv6 vs. CGN
  - What is the opportunity cost of incredibly poor user experience (virtually guaranteed by CGN)?
  - CGN is complex to set up, more complex to maintain, and, even harder to troubleshoot. What does that cost?
  - Will it even scale?

Cost Benefit continued

- IPv6
  - Unless hardware is extremely old, likely no required upgrades for IPv6 support.
  - Can be relatively simple to deploy by overlaying existing IPv4 technology.
  - Temporarily requires duplicate maintenance efforts for peering sessions, access control lists, prefix filters, etc.
  - Compared to the likely costs of CGN, IPv6 looks cheap in almost every case.

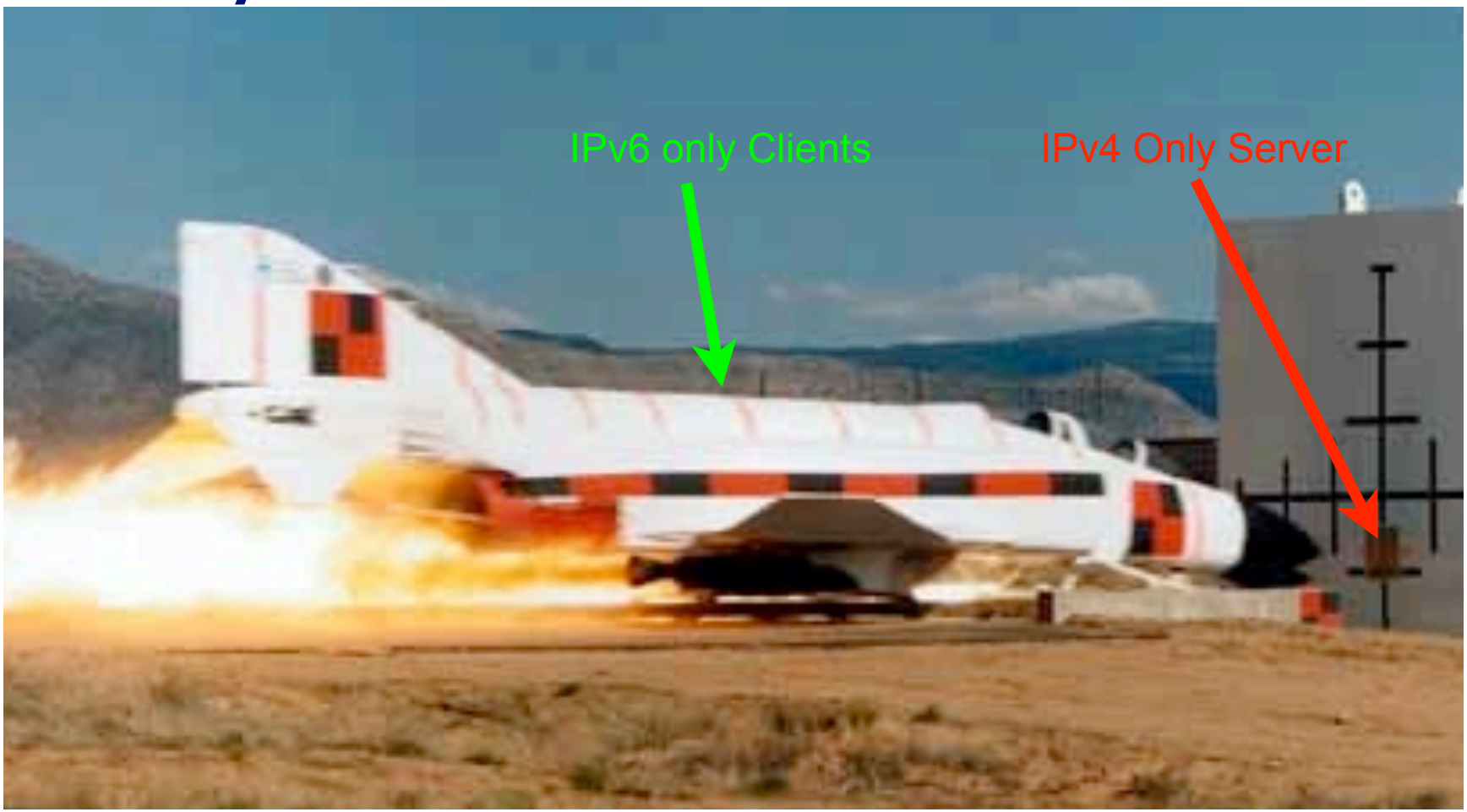
Cost Benefit (Continued)

- IPv6 Now vs. IPv6 later
  - IPv6 offers real savings in the long run
  - Beginning implementation now allows a slow, steady progression to full integration in a controlled manner (planned spending, research, time to seek best pricing).
  - Implementing IPv6 later may require significantly accelerated deployment (emergency spending, increased shipping costs, no time to negotiate)
  - Getting staff exposure to IPv6 while it's not mission critical pays off by reducing training costs and service-affecting outages.

The Ultimate Business Case for IPv6

- There is no “Killer Application”
- There is no “ROI case”
- So, why do it?
- For the same reasons you buy insurance, invested in Y2K compliance and have a disaster recovery plan (you do have one, right?):
  - If you don’t have IPv6 when IPv4 runs out, you will be at an ever increasing disadvantage compared to your competitors that do!

What happens if we aren't ready?



IPv6 From a Carrier Perspective

- I am not a carrier.
- I would love to know more about your perspectives on IPv6.
- So, at this time, let's open the floor to questions, comments, and issues unique to implementing IPv6 in a Carrier environment.
  - Regulatory
  - Financial
  - Legal
  - Management
  - Risk Management
  - Infrastructure
  - Training
  - Etc.

Customer Premise Equipment and the equipment it connects to.

- The most urgent thing from a carrier perspective is to get vendors to make IPv6-ready CO and CPE solutions available.
- The details depend largely on your topology
  - BPON/GPON
  - DSL
  - DOCSIS
  - other?

How to move forward

- Start with a test lab for each phase.
- Deploy IPv6 at one of your peering edges.
- Add IPv6 to the rest of your backbone and your other edges as you connect them.
- Public facing content and interfaces (web, email, etc.)
- In-house “customer” trials
- Consider adding IPv6 capabilities to your enterprise where it makes sense (low hanging fruit)

The test lab

- You don’t need a lot.
- Simulating the full internet is not necessary.
- A small number of routers and end systems is probably sufficient.
- Test configuration elements and become familiar with the configurations and gotchas of whatever vendors apply to your network
- Try out microcosms of various deployment scenarios and break-fix.

Planning Your IPv6 Address Space

- IPv6 is NOT IPv4
- IPv4 -- Driving force in planning was address scarcity with aggregation as a somewhat secondary concern.
- IPv6 -- No scarcity. Get what you need to be able to maximize aggregation without regard for utilization density.
- IPv4 -- Scale was based on hosts.
- IPv6 -- Scale based on networks.

IPv4-think -- Avoid these common mistakes

- Over-conservatism
  - Don't assign various size subnets to stuff. Just accept that a network is a /64, even if it is a point-to-point. There are many advantages to this.
- Disaggregation for density optimization
  - Assign the same size chunk to each site. (Usually a /48 internal, perhaps a /36 or /40 for customers).
  - Some sites may require multiple chunks, that's OK.
  - ROUND UP!!

Rules of Thumb for Address sizing

- Issuing to Customers:
  - Point-to-Point: /64
  - Small site: /56 (residential, maybe small business)
  - Normal site: /48 (issue /48 on request without justification even to small site)
  - Large site or multisite customer: Case-by-case
- Allocating to POPs and Facilities:
  - Point-to-Point: /64
  - POP: /36 or /40 (depending on whether you have a few large (/36) or many small (/40) POPs)

Address Sizing (continued)

- POP Allocations
  - A /40 gives you 256 /48 customer assignments per POP. If you need more than that in more than a handful of POPs, go to /36 per POP.
  - A /36 gives you 4096 /48 customer assignments per POP, but, only 16 POPs fit in a /32 that way.
  - If you need to support more than 16 POPs, but, need /36s in most POPs, ask for a /28 instead of a /32.
  - Start at the bottom (customer assignments) and aggregate upward, rounding up to nibble boundaries at each level.
  - Preserve aggregation by reducing the likelihood for additional prefixes. Try to plan addressing on a 3-year horizon.

Routing Options

- Native IPv6
  - Best choice if available
  - May be uphill battle with upstream providers
  - Worth pushing your upstreams now
- Tunneled Solutions
  - Free tunnels such as http://tunnelbroker.net
  - Good for situations where you can't get native
  - Not ideal in terms of performance
  - Usual preference: 6in4, 6to4, Teredo in that order.

More about Tunnels -- 6in4

- Manual Configuration
- Defined Endpoints
- Essentially like GRE (in fact, can use GRE to tunnel dual-stack over either IPv4 or IPv6)
- Usually minimal “extra topology”
- Easier to troubleshoot (fewer moving pieces which are easier to find than auto-tunneled solutions).

More about Tunnels -- 6to4

- “Server Side” found by anycast
- Automatic, little or no manual configuration required.
- Anycast theoretically minimizes “extra topology”
- As 6to4 servers are deployed topologically closer, automatically migrates tunnel to closer server
- No provision for over/underloaded server balancing.

More about Tunnels -- Teredo

- Mechanism most likely to transit Firewall/NAT
  - Whether you want it to or not!
- Enabled by default on many Windows products
- HUGE security problem for IPv6-unaware enterprises
- Three-party NAT traversal tunneling solution
- Lots of moving parts, works automatically most of the time
- Hard to troubleshoot when it doesn't

What's ready

- Most Routers (Backbone, Core, Enterprise, Workgroup, etc.)
- Most hosts (Linux, BSD, MacOS, Windows*)
- Higher-end Switches (especially most L3 capable switches)
- Many ISPs (such as Hurricane Electric)
- Some Content Providers (NetFlix, Google, YouTube)

*Windows 2000+, but, no IPv6 DNS Resolver before Vista

What's not ready

- CPE
  - Very few consumer-grade residential gateways
  - DHCP-PD mostly unimplemented/untested
- Last-Mile
  - DSLAMs
  - BPON/GPON Concentrators
  - Other consumer aggregator technologies
- Infrastructure Management Systems
  - In-house software
  - Vendor-Provided software

Getting Ready -- Keeping Track

- ARIN IPv6 WIKI: http://www.getipv6.info
- Status Information about most IPv6-ready products and services
- User-updatable -- It's a wiki, contribute what you know!
- Lots of IPv6 Advice and Help available

Getting Connected

- Start by asking your upstream(s) for native IPv6 connectivity
- If they tell you nobody else is asking for it, escalate. Some ISPs are saying that to everyone who asks.
- If they're not ready, push for a commit date. Consider alternatives if necessary.
- Implement via Tunnel at least to get your infrastructure up and tested.

Getting Connected

- If you are at an Exchange Point, leverage that
- Look for peers with open peering policy
- Hurricane Electric offers free IPv6 Transit as well as open peering for IPv4 and IPv6

Vendor Management

- If your vendor(s) aren't IPv6 ready, it's time to push them
- When possible, avoid new purchases of equipment that isn't IPv6 ready
- Make IPv6 a "checklist item" for product qualification
- TEST IPv6 capabilities, don't just trust the vendor "checklist" on the spec. sheet(s)
- Report Bugs as you encounter them

Vendor Management

- Use tools like Wiki to compare notes about vendors and to share information about vendor accomplishments and shortcomings
- Don’t hesitate to make “me too!” phone calls to vendors to raise the visibility of IPv6 as a priority
- Push on sales, marketing, and support
- Minimal operational experience means vendors are still figuring out IPv6 implementation priorities.

Training Resources

- On-line
  - Free training such as at http://tunnelbroker.net
  - Bookshelf products such as http://safari.oreilly.com
  - Executive/Business Case: http://businessv6.he.net
- Books from
  - Juniper
  - Cisco Press
  - O'Reilly

Implementation Considerations

- Staff Training
- Prototyping and Development
- Staff Training
- Backbone Deployment
- Support Department Deployment
- Customer Trials
- Customer Deployment
- Start at an edge and expand, avoid islands where possible

More implementation considerations

- Software Updates
  - Provisioning Systems
  - IP Allocation Systems
  - SWIP/RWHOIS Management Systems
  - Logging/Reporting Systems
  - Monitoring/Alerting Systems
  - Other in-house software
  - Database Schemas
  - Parsers

Q&A

Copy of these and other slides available at:
http://owend.corp.he.net/ipv6/

Contact:

Owen DeLong
IPv6 Evangelist
Hurricane Electric
760 Mission Court
Fremont, CA 94539, USA
http://he.net/

owend at he dot net
+1 (408) 890 7992