# IPv6 Capabilities

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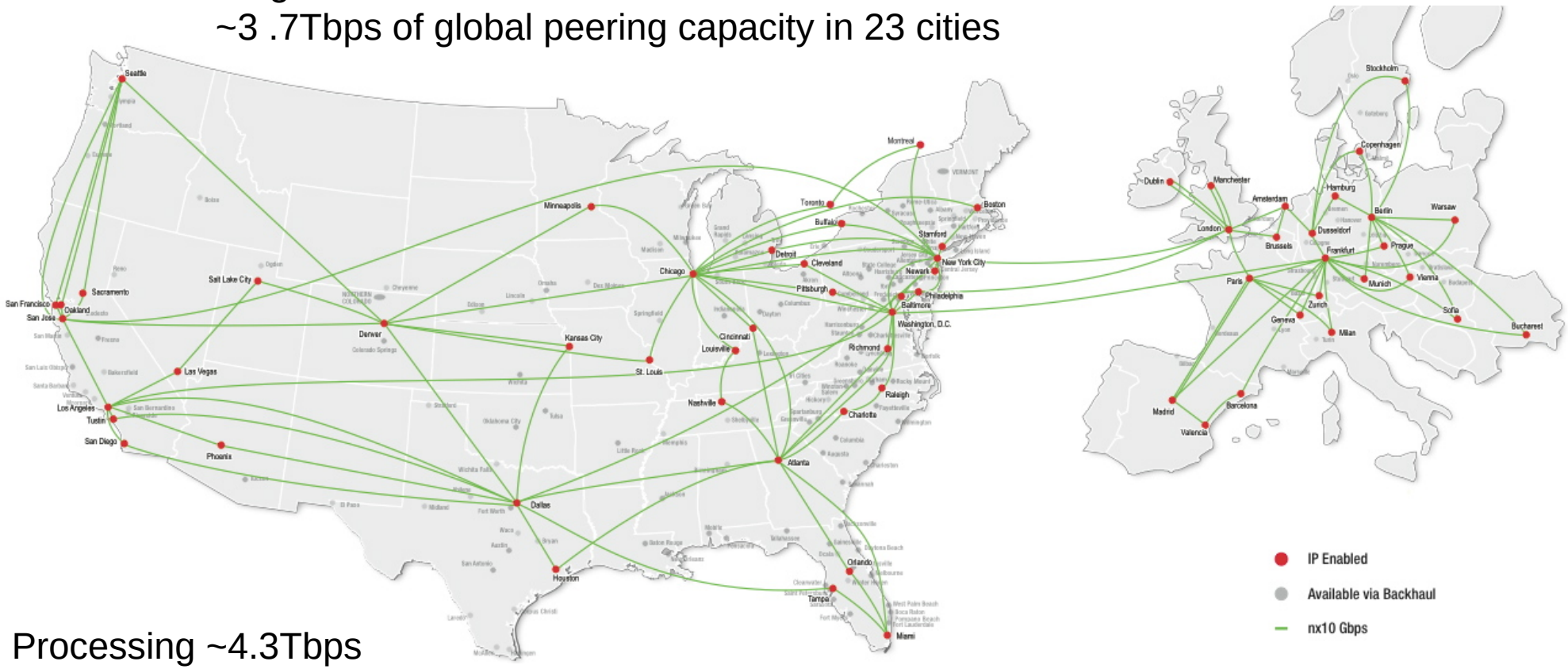
# Agenda

- Level 3 IPv6 history
- IPv6 Design Goals and Implementation
- World IPv6 Day
- Issues and Observations
- IPv4 to IPv6 Interoperability
- Takeaways

# Level 3 Tier 1 IP Network

Single AS 3356
~3 .7Tbps of global peering capacity in 23 cities




Processing ~4.3Tbps
inbound traffic globally

460 Gb transatlantic protected
capacity; 930 Gb total

# IPv6 History at Level 3

- May 2005 — Started offering tunneled IPv6 service
  - EU-based 6PE solution
  - Limited number of selected customers and peers using tunnels or @LINX using low-speed ports
- 2005 – 2008 — The solution expanded
  - Tunnel boxes deployed in North America for better geographic coverage
  - Routing options reached parity with IPv4 (i.e. community-based TE)
  - Larger number of customers and peers; AMSIX peerings also established
  - All connections standardized to manually configured tunnels; No longer 6PE
- 2009 — Started offering dual-stack services in EU
  - Some customers started to genuinely “demand” dual-stack
  - Still connected back to the original tunnel-based service
- Today — Network is fully dual-stack enabled
  - GA July 1, 2010, and the routing ecosystem is evolving

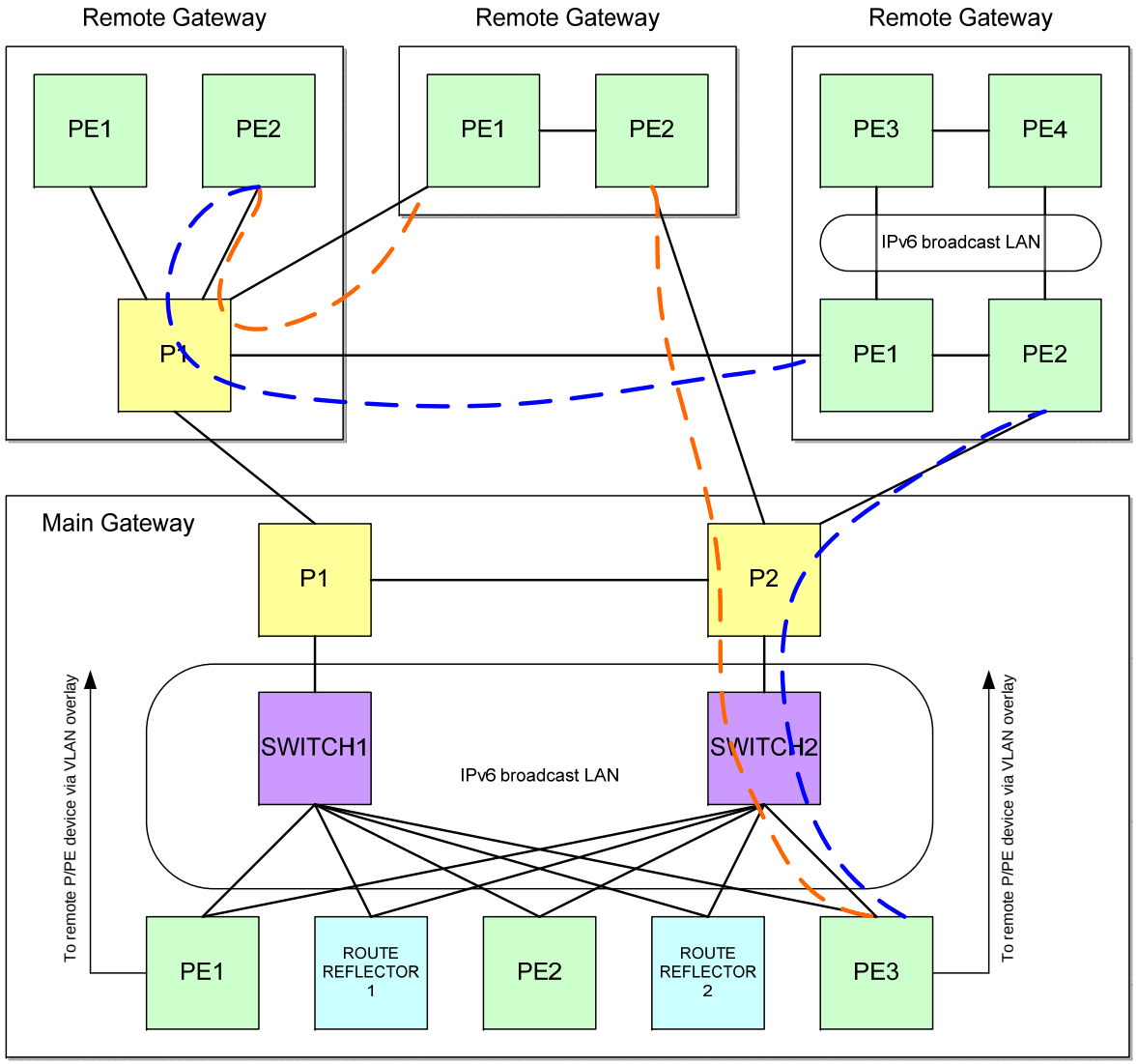
# Goals and Decisions

***"Thou shalt not break the IPv4 network"***

- Tunnel solution difficult to scale due to hardware limitations; 2009 demand for full IPv6 solution reached tipping point
- Issue: keeping core network costs down
- IPv6 over VLAN for economic and technical efficiencies
  - Enables "full speed" dual-stack IPv6 everywhere
- Separate IGP for IPv6 for safety and stability
  - OSPFv3 chosen over existing IS-IS
- Moved route reflection off tunnel devices, onto standard route reflectors
- IPv6 enabled natively on all existing LANs, alongside IPv4
- Design as similar to IPv4 as possible for operations

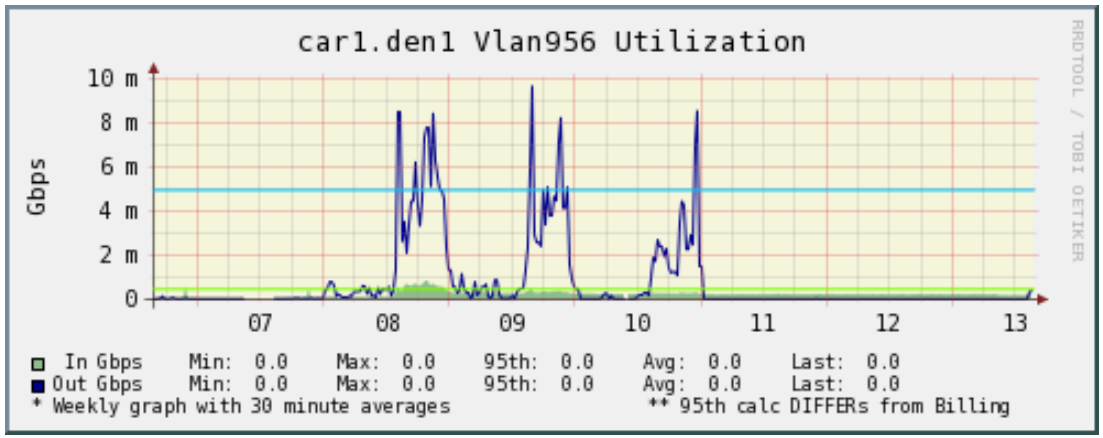
# IPv6 Design

- PE pairs function as ‘core’ devices
  - LANs run IPv6 and OSPFv3
  - Ptp VLANs for intercity connectivity
  - No segregation of IPv4 and IPv6 traffic on LAN broadcast domain
- Existing route reflectors stood up for IPv6 reflection
- Allows mapping IPv6 forwarding-path for intercity transit to follow same path as IPv4, if built correctly
- Future design will go back to IPv6 over an MPLS core



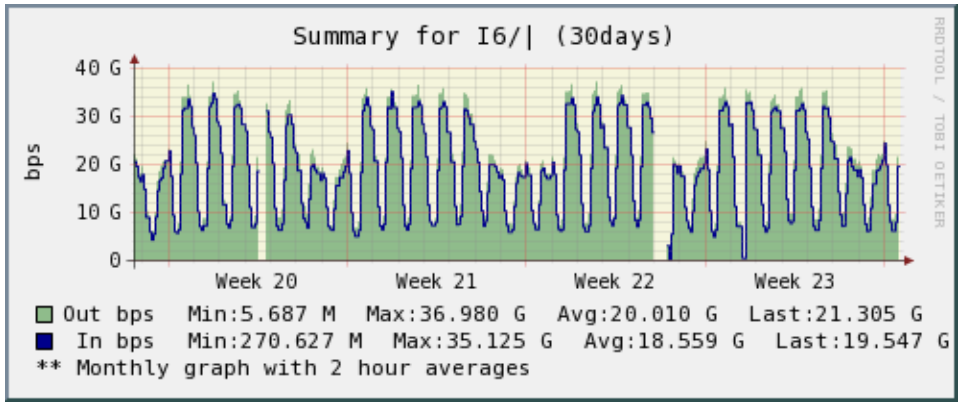
# World IPv6 Day

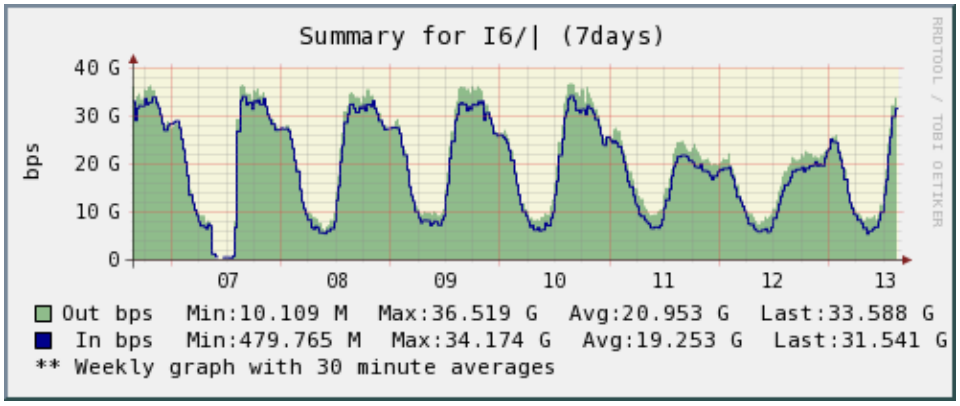
- IPv6 version of level3.com, for the last year, at ipv6.level3.com
- For World IPv6 Day, converted ipv6.level3.com to level3.com
- No work was done on the network – it was already ready
- AAAA records for level3.com were published about an hour before 0:00 GMT on June 8; lowered the TTL to 5 minutes
- DNS propagation worked well; site published quickly to Internet
- Numerous people on Internet set up to poll participating web servers



# World IPv6 Day — On The Backbone

- Impacts of World IPv6 Day not very noticeable on our backbone
- Level 3 carries close to 8 Tbps of traffic, at peak, daily
- Only 48 Gbps of that traffic was IPv6 — 0.6% of overall traffic
- No significant traffic issues seen
- Saw some sub-optimal routing to peers reported for the first time
- Issues due to inconsistent specific route advertisements from peers; all corrected within a few minutes of reporting with peers



# World IPv6 Day — Issues

- One IPv6 web server not configured correctly for level3.com
- 404 connection errors to most who tried to connect early in the day
- Publicity generated large number of social media hits
- Worked with Marketing team to contact those people — very time intensive
- Internal router had trouble with IPv6 Neighbor Discovery
- Several employees' mobile digital devices could only reach web page by doing a traceroute
- Issue resolved with router reboot; plan to upgrade software
- No impact to external customers

# Supporting IPv6

- Several ways to support IPv6 on your network
  - Transition – Tunnels, which customers use to connect in some way, over existing IPv4 network, if you like that sort of thing…
  - Dual-stack – Enables IPv6 on existing network, at least at the edge
- Is your existing kit capable of supporting IPv6?
  - Still a LOT of very old kit out there; some doesn't support IPv6 at all
  - Some supports IPv6, but…
    - ...only in software
    - ...only with specific software versions
    - ...TCAM issues prohibit use
    - ...load-balancing isn't good
- Understand what customers need before you make this decision

# IPv6 Addressing

- Level 3's view:  most large entities will have to obtain provider-independent IPv6 address space (PI space)
  - Most ISPs (Level 3 included) will route a /48 as the smallest allowable block
  - The ARIN /56s that are available will not be useable under these ISP policies
- PI space allows an enterprise to multi-home with multiple ISPs
- Avoids renumbering issues with changing or adding another carrier

# IPv6 to IPv4 Interoperability

- What we've seen
  - IANA ran out of IPv4 addresses
  - Test run two months later — only ~90% of websites got v6 going, most backed out 24 hours later
  - New entrants must use IPv6 and interoperate with a mostly IPv4 world; others with large IPv4 requirements may also be forced down this road

- What we're considering
  - NAT64 solution to allow IPv6-enabled customers to connect to the legacy, IPv4 Internet
  - NAT64 operates like a stateful firewall: IPv4 address that client wants to reach imbedded inside IPv6 address
  - The NAT64 device strips IPv4 information, creates a valid IPv4 packet
  - Number of IPv6 addresses is large; server must be stateful and maintain table of IPv4 addresses / ports to IPv6 address "inside" network

# Platform Issues

- Most modern network hardware supports IPv6 in some way
- Check that your kit includes (full) IPv6 support
  - But do you have to update all configurations? ADDRESS-FAMILIES!!!
- TCAM issues
  - On many platforms, TCAM used for fast route table lookups
  - TCAM “carved up,” can’t be shared in many different ways (ACLs, QoS, MAC, IPv4 and IPv6), allocated in “profiles”
  - Allocating reasonable amount of TCAM space to IPv6 can limit space for IPv4
    - You may run out sooner than you think!
    - How much would this cost you?
  - Look at profiles — what’s reasonable for you for now?
    - Different answers for core and yedge

# Differentiating IPv4/IPv6 Traffic

- Common problem: differentiating data sets and graphs for IPv4 and IPv6 traffic
  - Most existing systems SNMP poll IF-MIB, which counts octets in and out; doesn't care what protocol traffic is
  - Can cause support and planning issues
- No easy solution, but two common approaches
  - On 'J' vendor, have an inet6 traffic filter inbound and outbound to count IPv6 traffic in and out of interfaces
    - Collect data by SNMP or CLI
    - Probably takes special stuff to make it work in your regular package
  - On most vendors, you could have different VLANs on a physical interface for IPv4 and IPv6 traffic
    - Allows measurement per VLAN and therefore does differentiation
    - Not real dual-stack and introduces other problems; often isn't acceptable for customers
- You could use NetFlow — requires v9 and good support

# Other Important Factors to Consider

- Supporting IPv6 on your network is NOT the biggest issue you'll encounter
- Training staff
  - Technical and non-technical staff must be trained on IPv6 to sell and support it
  - Who will do IPv6 training? In-house expert? Outsourced IPv6 training?
  - How will you keep skills up to date?
- Supporting back-office systems
  - Large numbers of new and old systems
  - Non-trivial task requiring time and expense
  - Will billing system be happy with IPv6?
- Supporting network management platform(s)
  - Does your existing NMS support IPv6? Load balancers, firewalls, IDS, etc.?

# Takeaways (1)

- Good news: most modern router and server kits do support IPv6 properly… BUT code still has bugs; it hasn't been stressed and people haven't cared much when it's failed.
- Many monitoring systems do not support IPv6 as well as IPv4.
- Security is likely to be messy.  How many firewalls, AV, load balancers, VPNs support IPv6 properly?
- Skill base for IPv6 is still VERY low.

# Takeaways (2)

- If you don't already, you really need to have a plan in place for IPv6.
  - Many networks are now complete, how will you complete your plans?

- Don't assume activating IPv6 is the only task. You may be pulling along other organizations!
  - Think about training.
    - Even to the point of (re)training everyone in hex!
    - Differentiate your training.
  - Think about back-office systems.
  - Think about monitoring and supporting IPv6.

# Thank You

- **Questions?**

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