IPv6 and Google

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Global IP Business Exchange 2011

Why?

IPv4 addresses are gone

- The last 2 free /8s were issued 2011年 01月 31日（月）
- From IANA's IPv4 address allocation page:

039/8	APNIC	2011-01	whois.apnic.net	ALLOCATED
106/8	APNIC	2011-01	whois.apnic.net	ALLOCATED

- The final 5 free /8s will be distributed 1 to each RIR, per policy
  - estimated RIR runout is 5-6 months from today
- Watch special announcement live, Thursday, 3 February 2011, at 09:30 (UTC -5), on nro.net

Why IPv6? Cost

- Buying IPv4 addresses will be expensive
- Carrier-grade NAT may be expensive
  - Lots of session state memory
  - Session logging for legal reasons
  - Constrains performance
- Being behind a NAT is hard to manage
  - Can't fix problems without NAT operator's help
    - VPN, VOIP, video streaming, gaming, P2P
  - Expensive in operator time, support costs
- Network complexity creates operation / support costs

Why IPv6? Address semantics

- With carrier-grade NAT, users share IP addresses
- Less accurate geolocation
  - Content licensing for streaming, etc.
- Abuse identification / blocking
  - If an IPv4 address is spamming/hacking/...
    - Who is responsible?
    - If we block it, do we take out 100 users?
      - Different from blocking a proxy
- IP-based authentication
  - Of course, nobody would ever do this

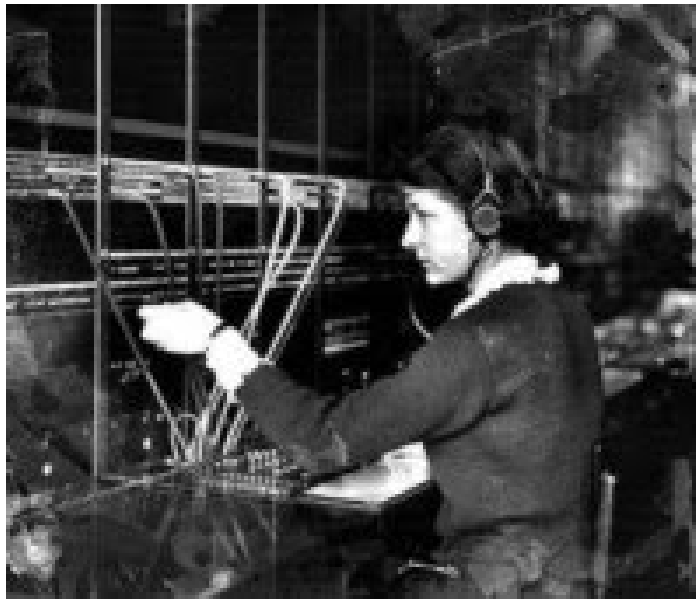
Why IPv6? Opportunity

- We see a growing number of IPv6-only deployments
  - Set-top boxes (free.fr, Comcast, ...)
  - NTT IPTV over IPv6 ("walled garden", though)
  - Mobile networks (LTE, NAT64, ...)
- There is simply not enough address space to assign IPv4 addresses to these devices
  - NAT is too expensive
    - CPU on home gateway
    - CPU on routers
- Want to talk to these devices? Need to use IPv6

Why IPv6? New applications

- The Internet was successful because of end-to-end
- Users *still want* end-to-end!
  - Skype, Bittorrent, ...
    - Neither of these could have been developed in the absence of public IP addresses
- What happens if this goes away?
  - Will the Internet become like TV?
  - Will the Internet become like the phone network?
  - Will any Internet communication require ISP support?

The Internet without IPv6



IP address sharing

TCP port overload

Content inspection/rewriting

Barriers to innovation

The search for the killer application

- Many are waiting for a "killer application" for IPv6
- This is a misconception
  - It's not "what can IPv6 do better than IPv4?"
  - It's "can the Internet as we know it continue to operate using IPv4?"
- The killer application of IPv6 is the survival of the open Internet as we know it

Why IPv6 at Google?

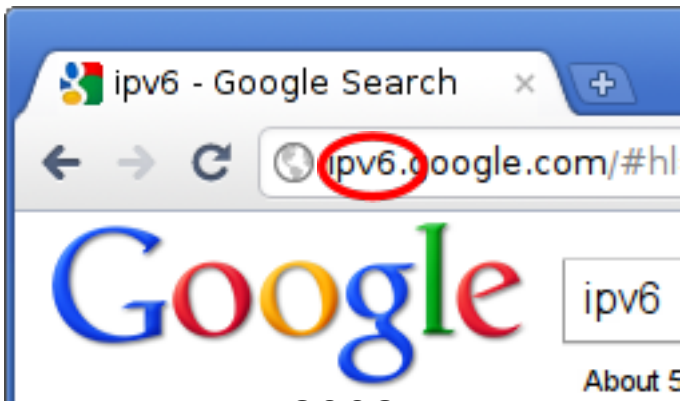
- When the day comes that users only have IPv6, Google needs to be there for them

- Serve current users better over IPv6
  - IPv6 can have lower latency and packet loss
    - We have user reports to prove it
  - AJAX applications break behind excessive NAT
    - Connections exhaust public IP port space
  - Growing number of IPv6-only client deployments
    - Set-top boxes, mobile, ...

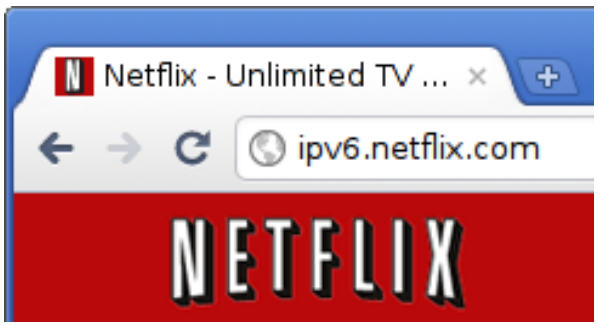
- IPv6 is good for the Internet, and we want to help

So what have we done?

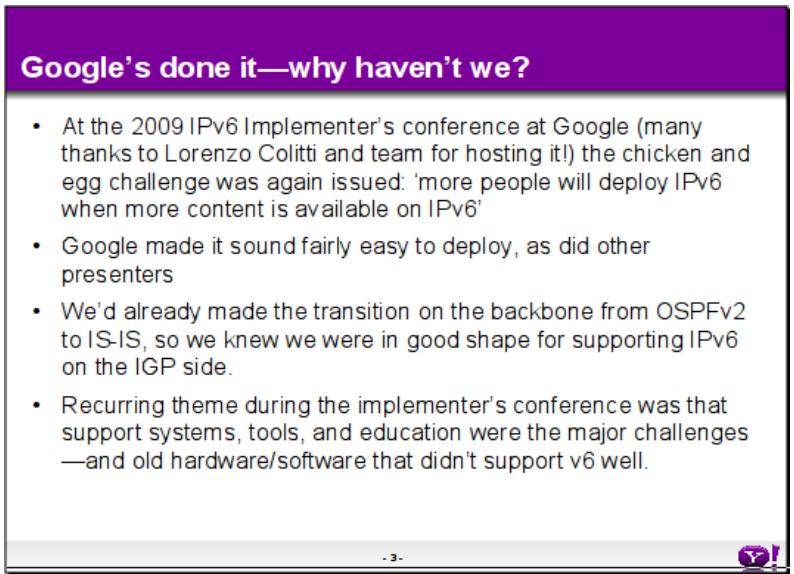
Leading the industry since 2008



2008



2009



2009

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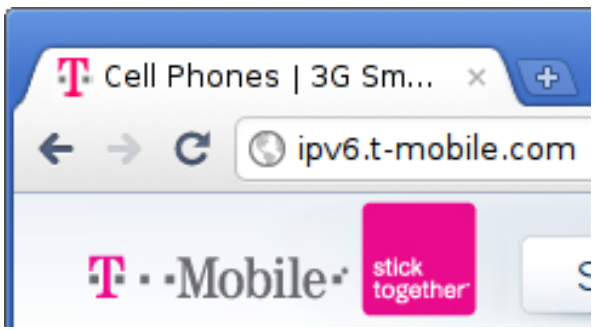


2010

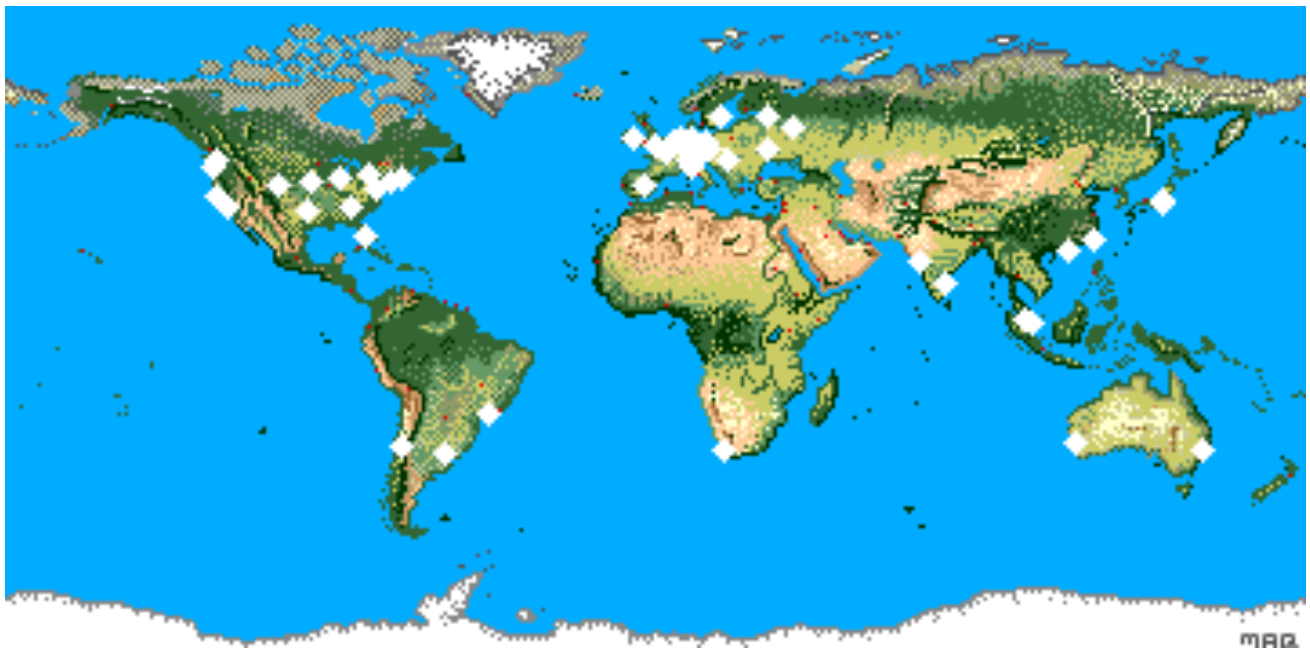
2010

Enable IPv6 for www.google.com?

- We can't enable IPv6 for www.google.com today
  - ~0.05% users won't reach Google any more
    - Broken home gateways, DNS forwarders, ...
    - If the user has a problem, they can't reach Google to search for a fix
    - 1 / 2000 is a lot of users!
  - Many users would have higher latency
    - Long paths, suboptimal routing, tunnels...
    - Bad and incomplete routing is there, but you can't see or fix it if there's nowhere useful to go
    - This has gotten much better now

Providing reliable services over IPv6

- Avoid bad routing by avoiding transit, prefix limits
- Peer with almost everybody
- Bring the network as close to the user as possible
- Serve IPv6 only to production-quality user networks



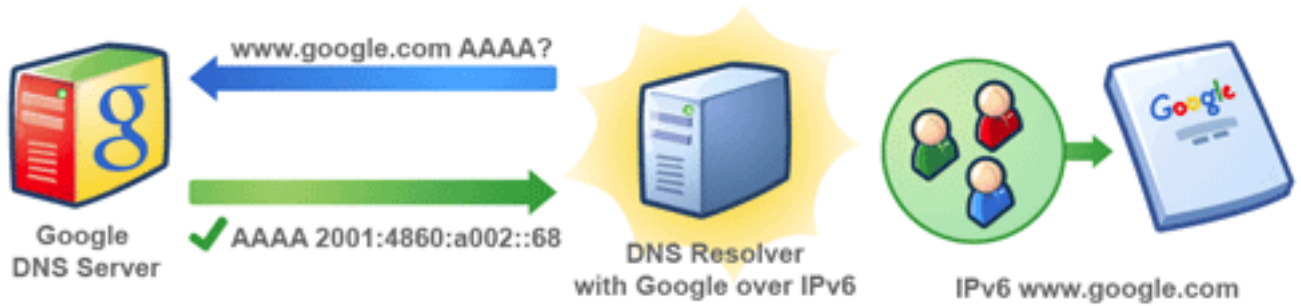
Google over IPv6

- Enables IPv6 access to Google for selected networks
- IPv6 access to most Google web properties
  - www, mail, news, docs, youtube, ...
  - still more to come
  - Which ones do *you* and your users want?
- Requirements:
  - Good IPv6 connectivity to Google
  - Production-quality IPv6 network
  - Commitment to fix problems that break Google for users

How it works

Normally, if a DNS resolver requests an IPv6 address for a Google web site, it will not receive one…

…but a DNS resolver with Google over IPv6 will receive an IPv6 address, and its users will be able to connect to Google web sites using IPv6.



http://www.google.com/ipv6/

Results so far

- Enthusiastic response:
  - Over 80 organizations participating
    - Universities, research institutions, an NREN
    - One large French access provider
  - ~ 75% of the native IPv6 Internet
- Feedback so far has been positive
  - Some networks see better IPv6 routing than IPv4
  - Now enough IPv6 traffic that problems get reported
  - Allows participants to bypass IPv4 congestion
- Want to take part? Let us know!

google.com/ipv6

Lessons learned

High-level strategy

- Start with user-visible services
  - Gives other networks reason to deploy
  - Breaks the chicken and egg cycle
  - Only 0.1% of users have IPv6, so scaling is easy

- Start with prototype infrastructure and work inwards:
  1. External networking
  2. Frontend serving systems
  3. User services
  4. Backend networking, internal applications

- Use shim layers to protect code/infrastructure that doesn't understand IPv6

Methodology

- Tap enthusiasm
  - Started as 20% project, great influx of contributors
- Make it easy for contributors to get initial results
  - A pilot network is not expensive
  - Once the network is up, internal applications follow
- Do it in stages
  - v6 needn't be as capable as v4 on day one
  - But it must be done properly
  - If it's not production-quality, it's of no use to anyone
- Fold it into your normal upgrade cycles

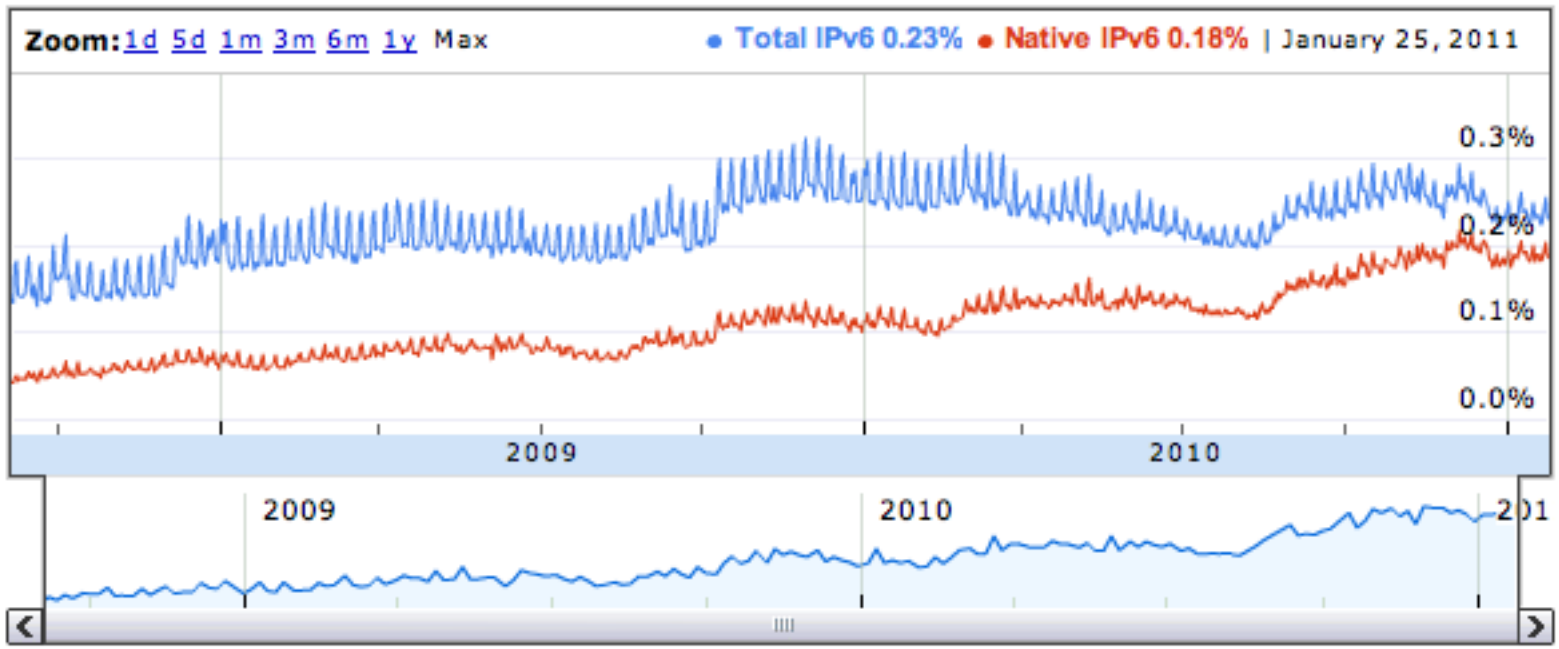
Timeline

April 2005	Obtain and announce address space
...	...
July 2007	Network architecture and software engineering begin (20%)
December 2007	Mark Townsley challenges Google to serve IPv6 by IETF 73
January 2008	First pilot router. Google IPv6 conference, Google over IPv6 for attendees
March 2008	ipv6.google.com (IETF 72)
Q3 2008	ipv6.google.cn, ipv6.google.co.jp
November 2008	First Google over IPv6 networks enabled. Google over IPv6 at RIPE / IETF / ...
January 2009	Google over IPv6 publicly available
March 2009	Google maps available over IPv6, 3x increase in traffic
August 2009	IPv6 enabled in Android (available on Droid and Nexus One)
February 2010	Youtube available over IPv6, 10x increase in traffic

And all this with a small core team

Statistics

Global IPv6 adoption



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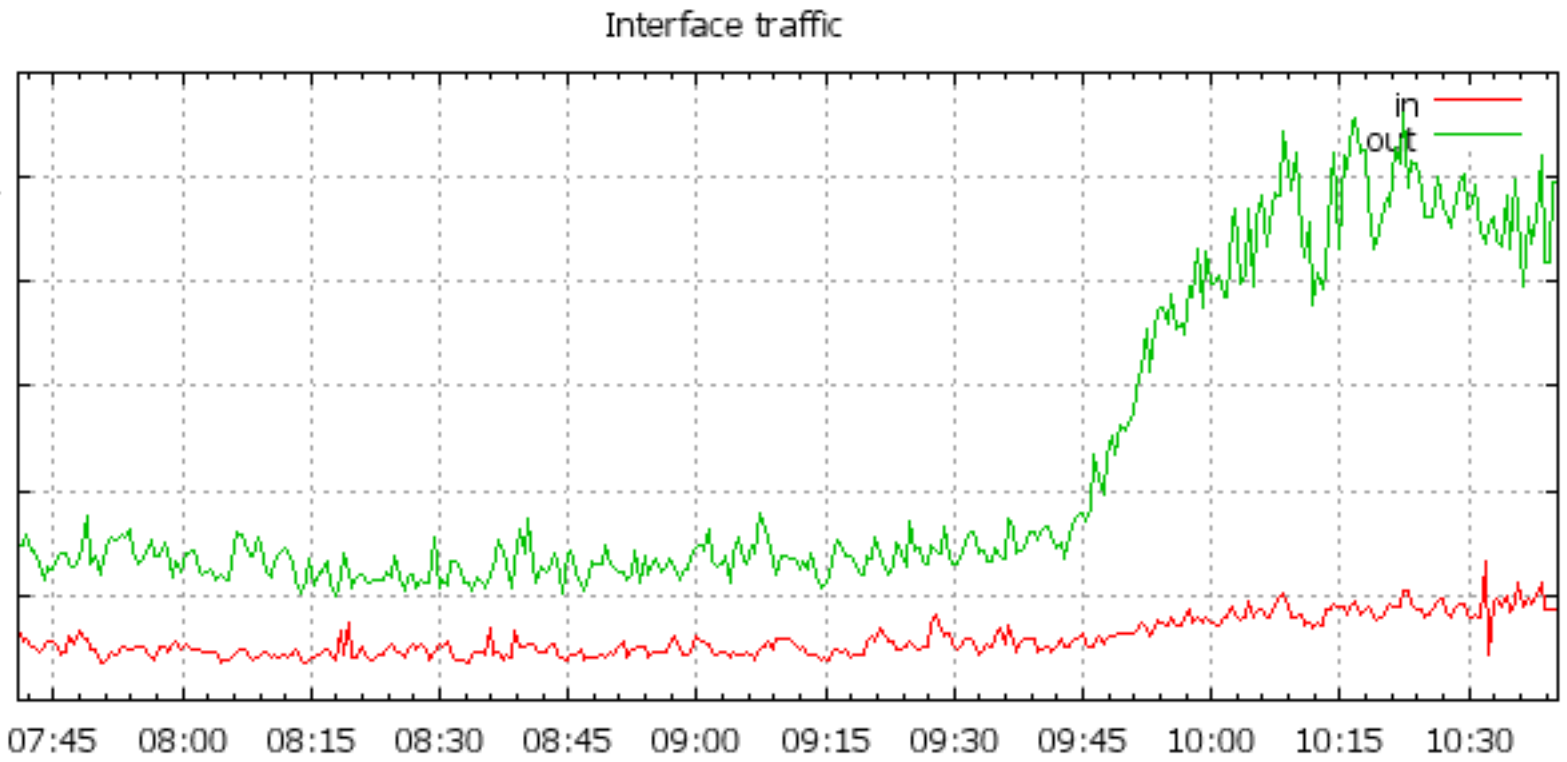
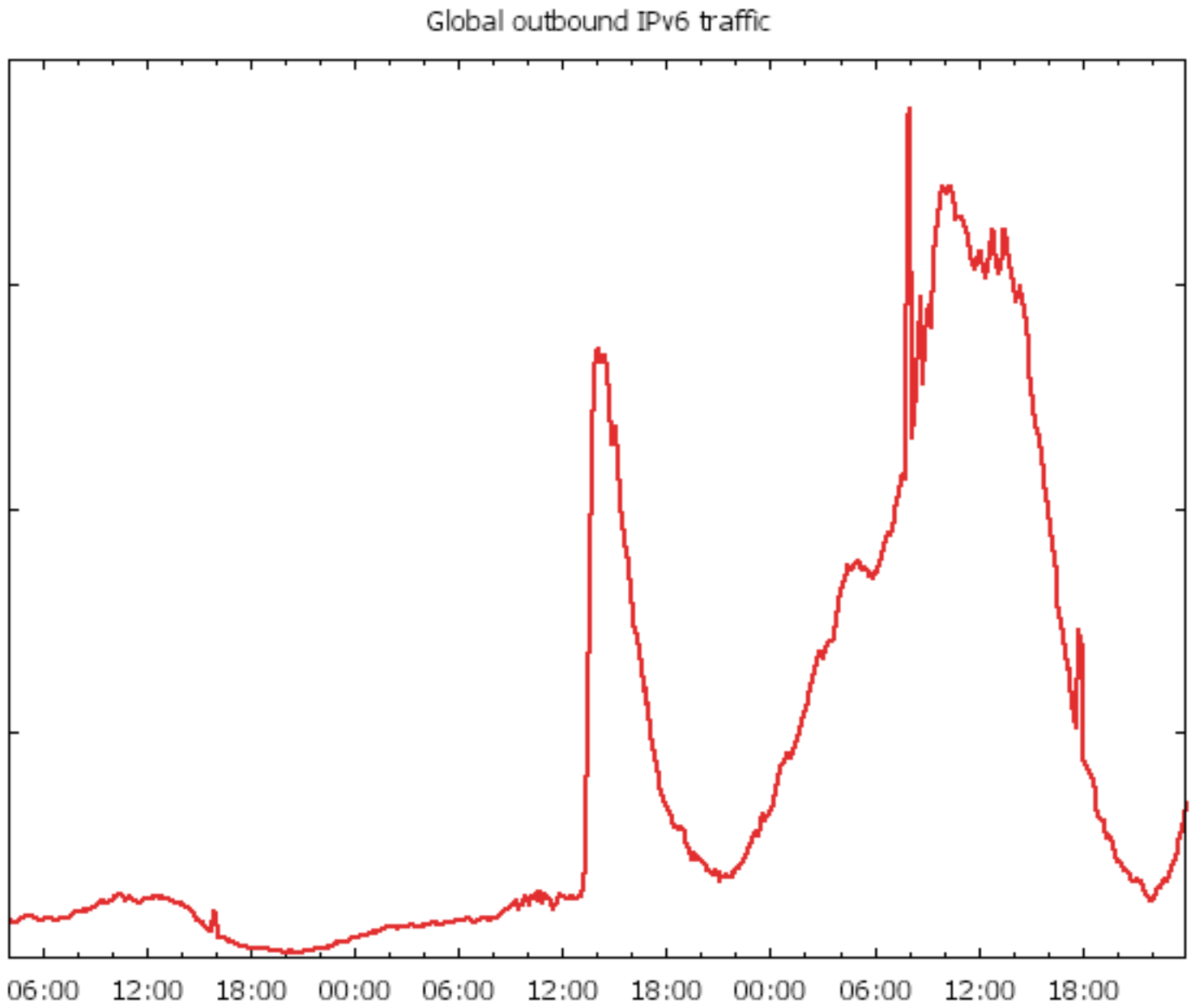
google.com/ipv6/statistics

Traffic can appear overnight



(Maps enabled for Google over IPv6 users on 2009-03-19)

Traffic can appear overnight



Going forward

User IPv6 connectivity is often broken

- Misbehaving home routers, Internet Connection Sharing, or "rogue RAs"
- User misconfiguration
- Firewalls that don't understand and block IPv6
- Path MTU discovery may be blocked
- Unreliable or slow transition mechanisms
- Applications that are not fault-tolerant or do not "fail fast"

It *looks like* Google is broken

- All other dual-stack sites are broken as well
  - ...but user may not notice
- User doesn't realize there is a problem
  - Never calls ISP
  - Suffers in silence, goes to another website, ...
- Our data shows that ~0.05% of users have this problem
  - All the time, every time they connect
- This is the #1 reason content providers cannot enable IPv6

Measuring brokenness

- Ask browser to connect to IPv4 and dual-stack hosts
  - Use Javascript to make multiple requests
  - "Sentinel" after fixed time checks if user disconnected
- Can run on multiple properties
- Use one-time hostnames
  - Uniquely identifies / associates measurements
  - Finds out if browser asked for AAAA, A and when
  - Prevents browsers caching Javascript

World IPv6 Day

- 2011年 6月 8日
- http://isoc.org/worldipv6day
  http://www.attn.jp/worldipv6day (日本語で)
- Coordinated, global awareness
  - Attempt to test at scale
- Content sites include:
  - {facebook,google,yahoo,youtube}.com
  - Akamai and Limelight -hosted sites may choose to
  - ...and many others
  - Join us!

質問?

ありがとう!

google.com/ipv6

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