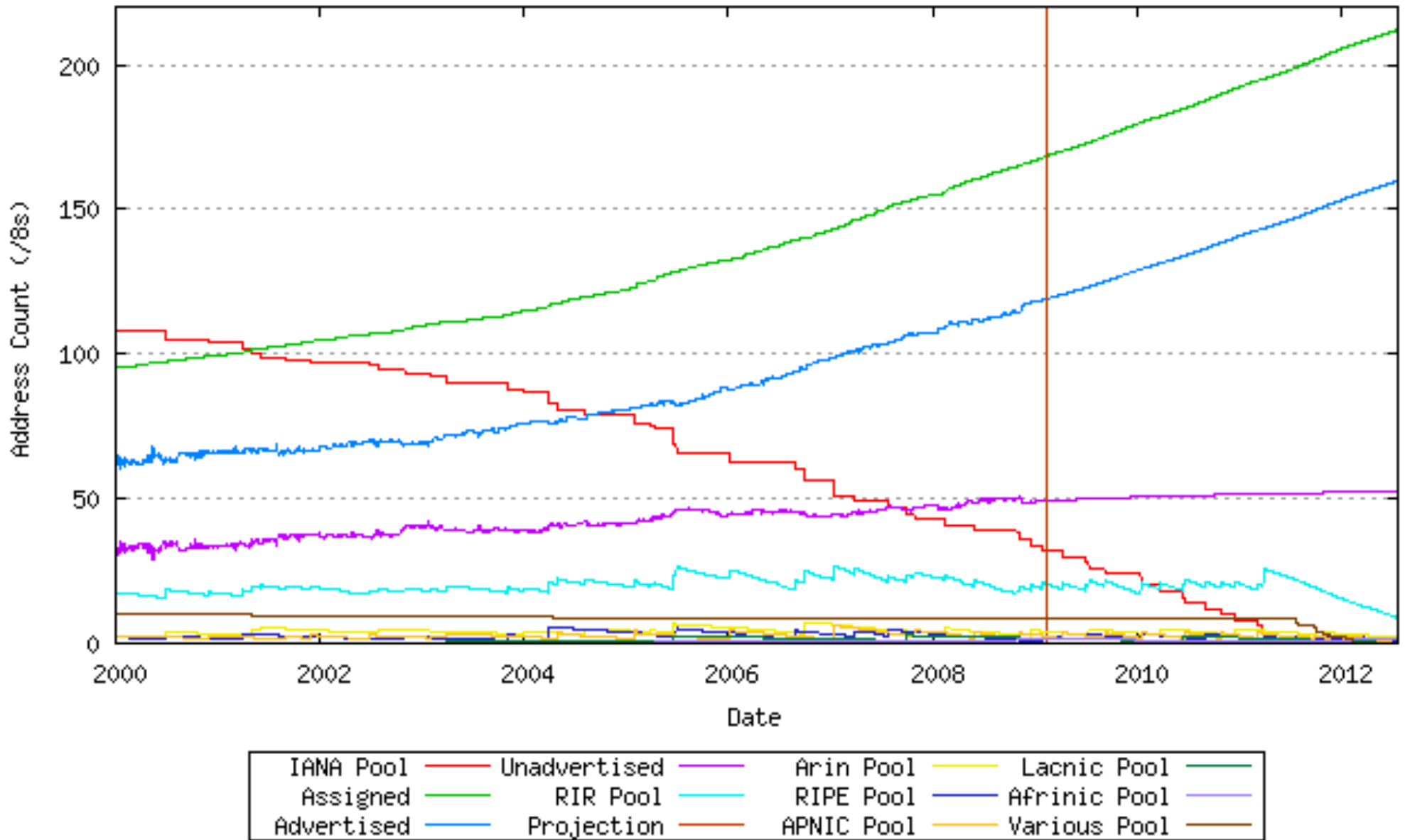




IPv6 at Google

Lorenzo Colitti
lorenzo@google.com

Why IPv6?



IPv4 address space predictions (G. Huston)

Why IPv6? Cost

- Buying addresses will be expensive
- Carrier-grade NAT may be expensive
 - Lots of session state memory
 - Session logging for legal reasons
 - Bandwidth
- 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

Why IPv6? Opportunity

- We see a growing number of IPv6-only deployments
 - Comcast set-top boxes
 - free.fr set-top boxes
 - NTT's Hikari IPTV over IPv6
- 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 search for the killer application

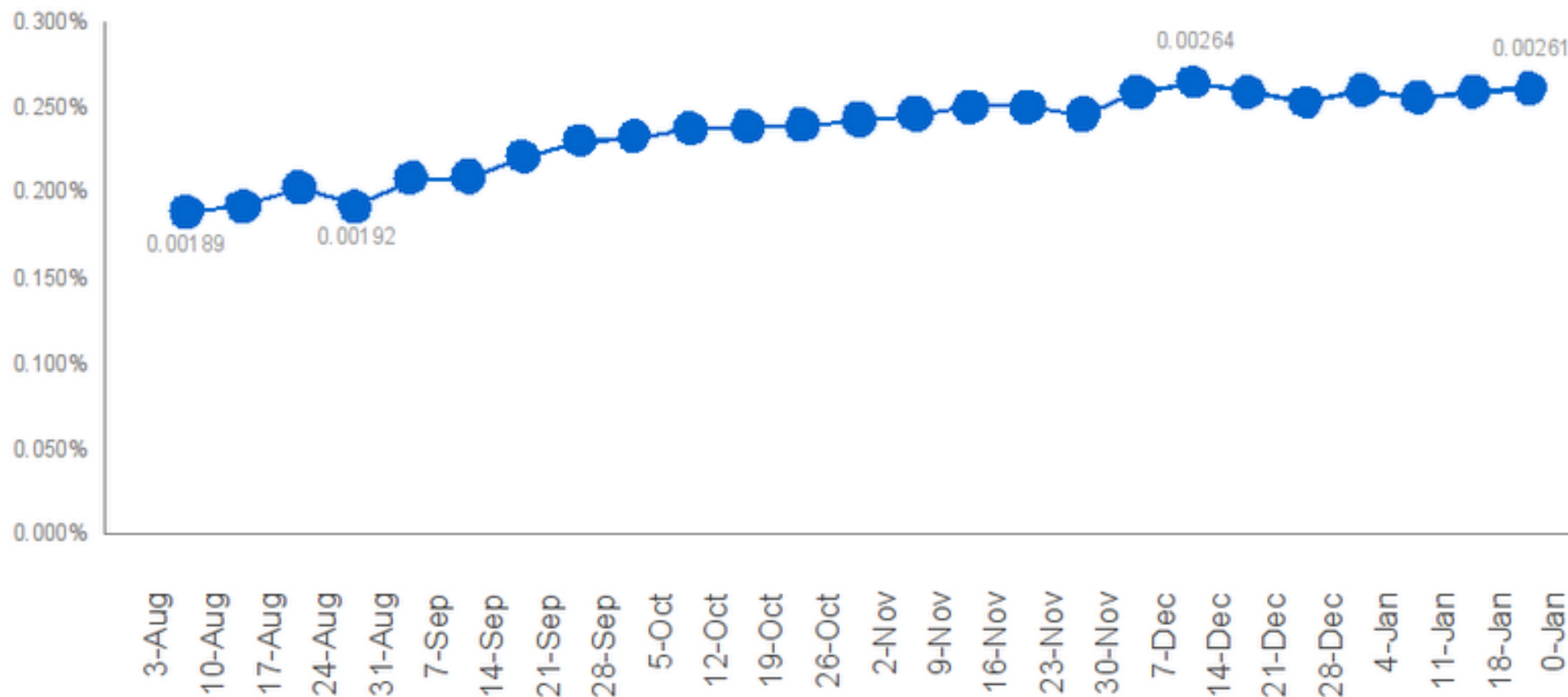
- Many are waiting for a "killer application" for IPv6
- This is a misconception
 - It's not "what can IPv6 can do better than IPv4?"
 - It's "can the Internet as we know it continue to operate using IPv4?"
- The killer application of IPv6 is the survival of the open Internet as we know it

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's the problem?

IPv6 adoption



- Climbing, but still low
- We need faster growth than this

Barriers to IPv6 deployment

- Nash equilibrium for IPv6 adoption is to do nothing
 - Why deploy IPv6 if you can't connect to anyone?
- Chicken and egg problem
 - ISPs say there is no content
 - Content providers say there are no users
- All the same, the writing is on the wall
- How do we break the cycle?

Engineering a chicken

- If content providers offer content over IPv6, that can provide an incentive for users
 - Even better if the content is somehow "better" than that available over IPv4
- Unfortunately, there's another problem:
 - Low adoption causes low traffic
 - Low traffic leads to bad connectivity
 - Bad connectivity hampers adoption

IPv6 connectivity problems

- Transition mechanisms can slow connections down
- Badly designed equipment can slow down or break IPv6 connectivity
 - Home Internet gateways
 - Broken DNS servers
- IPv6 networks less well-supported due to low adoption and low demand
- Not protocol problems, but deployment problems!
 - IPv6 not inherently any less reliable than IPv4

Enable IPv6 for www.google.com?

- Our data shows that 1 in 1000 users would not be able to reach Google if we enabled IPv6
- So we can't enable IPv6 for www.google.com today
 - For Google, 1 in 1000 users is a large number
 - If you have a problem, you might want to reach Google to see how to fix it
 - High latency due to tunneling slows down users with non-native IPv6 connections

So, what have we done?

What we have done so far

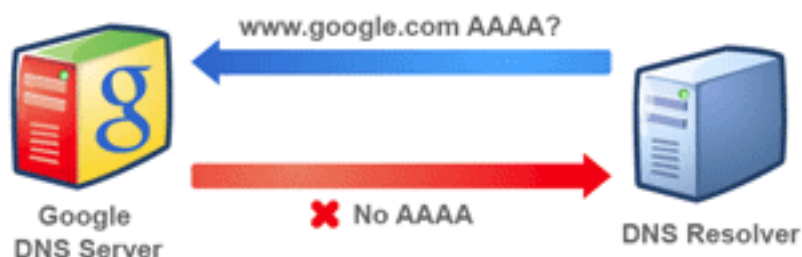
- IPv6 network rollout
- IPv6-only websites
 - ipv6.google.com (Mar 2008)
 - ipv6.google.cn, ipv6.google.co.jp
- IPv6 evangelism
 - Google IPv6 conference (Jan 2008)
 - Conference talks, panels, blackout sessions, ...
 - Vendor outreach
- Google over IPv6 (Jan 2009)

Google over IPv6

- Enables IPv6 access to Google for selected networks
- IPv6 access to most Google web properties
 - www, mail, calendar, docs, ...
- Requirements:
 - Good IPv6 connectivity to Google
 - Production-quality IPv6 network
 - Commitment to fix problems that stop users from reaching Google

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/>

Initial results

- Enthusiastic response:
 - Almost 30 organizations participating
 - Many universities and research institutions
 - One large French access provider
 - > 200k unique IPv6 addresses per day
- Feedback so far has been positive
 - Some networks see better IPv6 routing than IPv4
 - Networks now have enough IPv6 traffic that problems get reported and fixed
 - One network was able to bypass IPv4 congestion by using IPv6

How did we do it?

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
January 2008	Google IPv6 conference, Google available over IPv6 to attendees
March 2008	ipv6.google.com (IETF 72)
July 2008	ipv6.google.cn
October 2008	ipv6.google.co.jp
October 2008 - November 2008	First Google over IPv6 networks enabled. Google over IPv6 at RIPE / IETF / ...
January 2009	Google over IPv6 publicly available

And all this with a small core team

What worked for us

- Tap enthusiasm
 - IPv6 at Google started as a 20% project
 - Incredible influx of contributors
- Make it easy for contributors to get initial results
 - A pilot network is not expensive
 - Once 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 no use to anyone

Where do we go from here?

How do we increase adoption?

- Content providers: selectively provide content
- ISPs: roll out IPv6 to users
- Enterprises / agencies: ask for real, native IPv6
 - Being excluded from an RFP because of bad IPv6 support is a powerful driver - yes, this happens
- Governments: incentivate IPv6 to home users
 - Agency adoption? Incentives? Universal service?
 - Remember: if lots of users don't have IPv6, then content providers will not see an incentive



Questions?

Lorenzo Colitti
lorenzo@google.com