Measuring IPv6

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Some IPv6 Questions

- How many clients are capable of IPv6 access?
- What forms of IPv6 access are they using?
- Is their experience over Dual Stack better or worse than IPv4?

An Approach to IPv6 Measurement

Insert an IPv6 “test” into a web page

- Whenever the client visits the web page the client will execute the “test”
- The test consists of a number of 1x1 gif element fetches
  - Dual Stack
  - IPv4 only
  - IPv6 only
  - Plus others....

APNIC's IPv6 capability measurement system

http://labs.apnic.net

Built on google ‘analytics’ method

- Javascript, highly portable
- Asynchronous, runs in the background

Data integrated into Google Analytics reports

- Graphs of ‘events’ to monitor IPv4, IPv6 and dual-stack

Configurable by website manager

- Sample or every connection, extra tests etc

But...

Measuring the IPv6 capabilities from a small number of web sites is not necessarily representative of the entire Internet (unless you are Google!)

So can we expand the measurement system to look at a broader sample of everyone?

The Power of Advertising!

We extended this technique into Flash, and created an anonymous banner ad

The IPv6 capability test is built into the Flash code

Banner Ad Fun

No clicks needed

(indeed we would prefer that clients did NOT click the ad, as it costs us more for a click!)

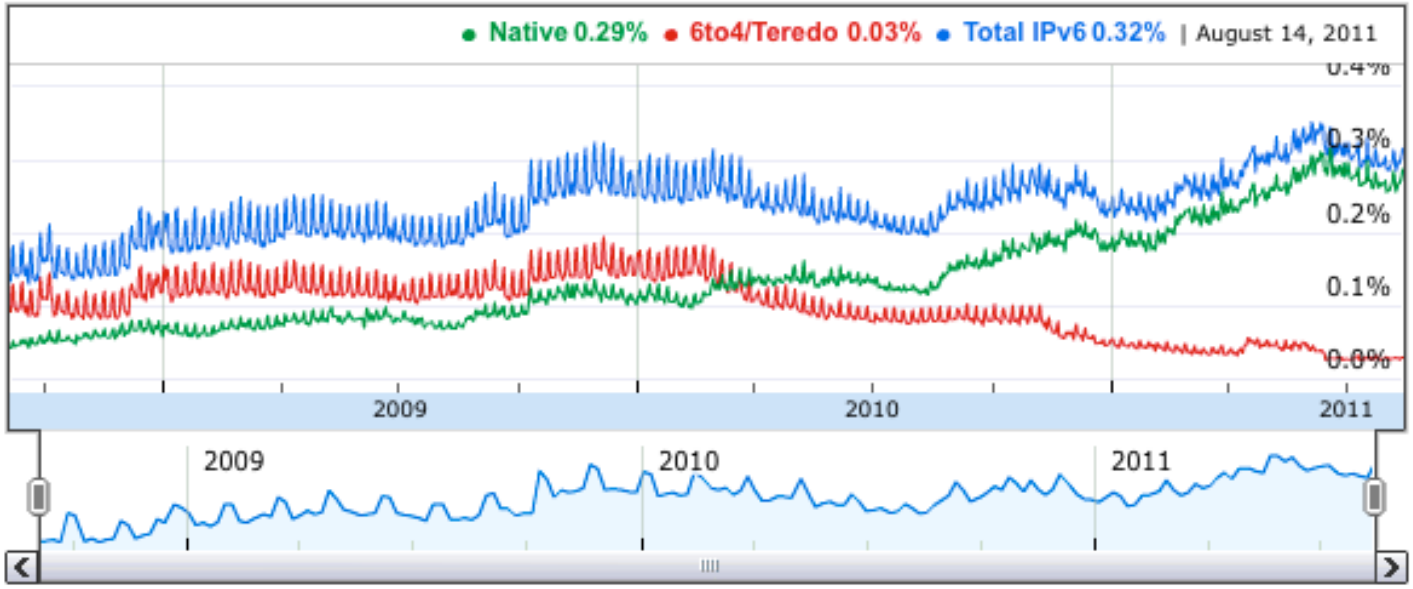
Impressions are really cheap

$25 per day buys around 25,000 impressions

Every impression carries the complete IPv6 test set

And we get impressions from all over the Internet

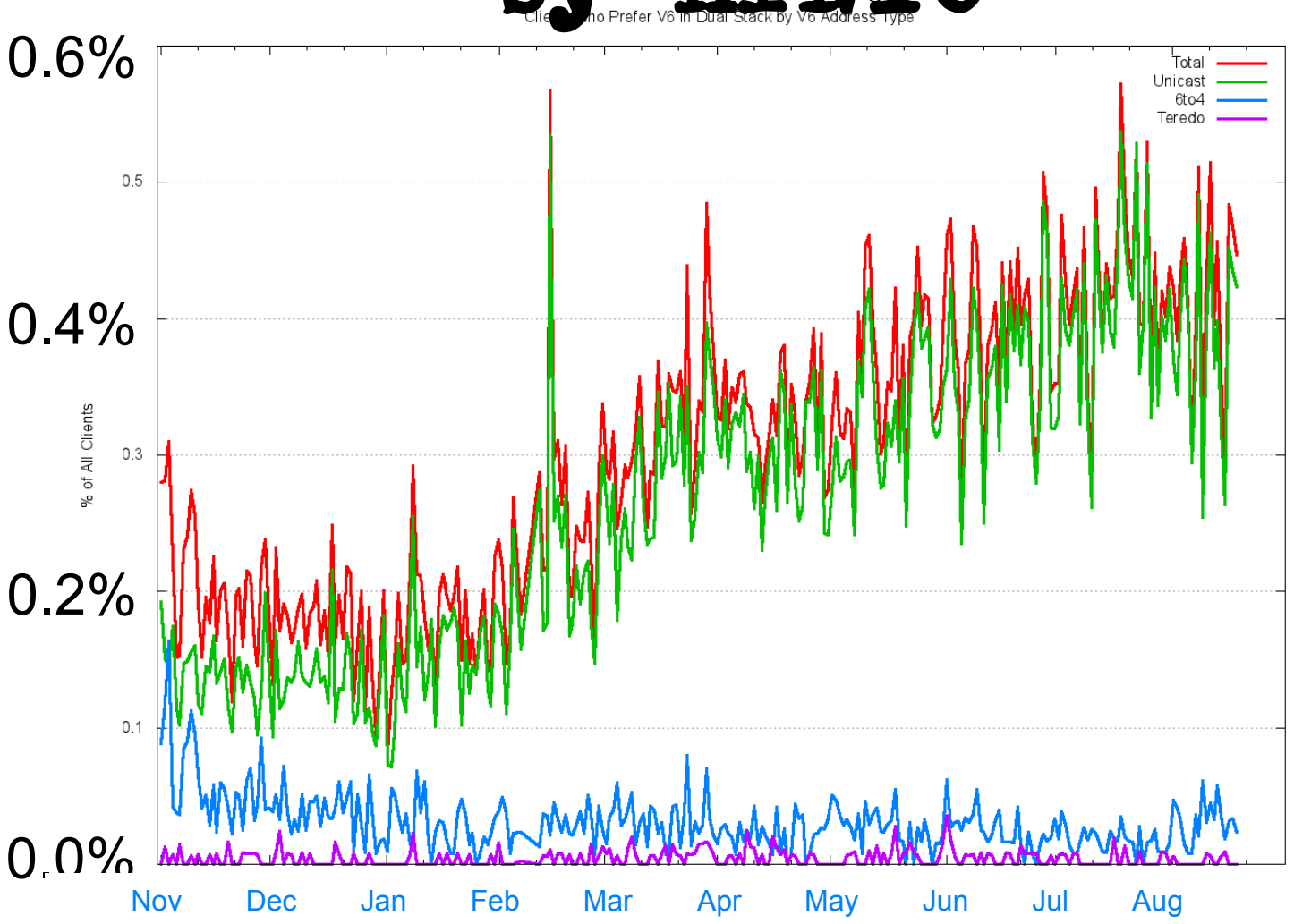
IPv6 capability, as seen by Google



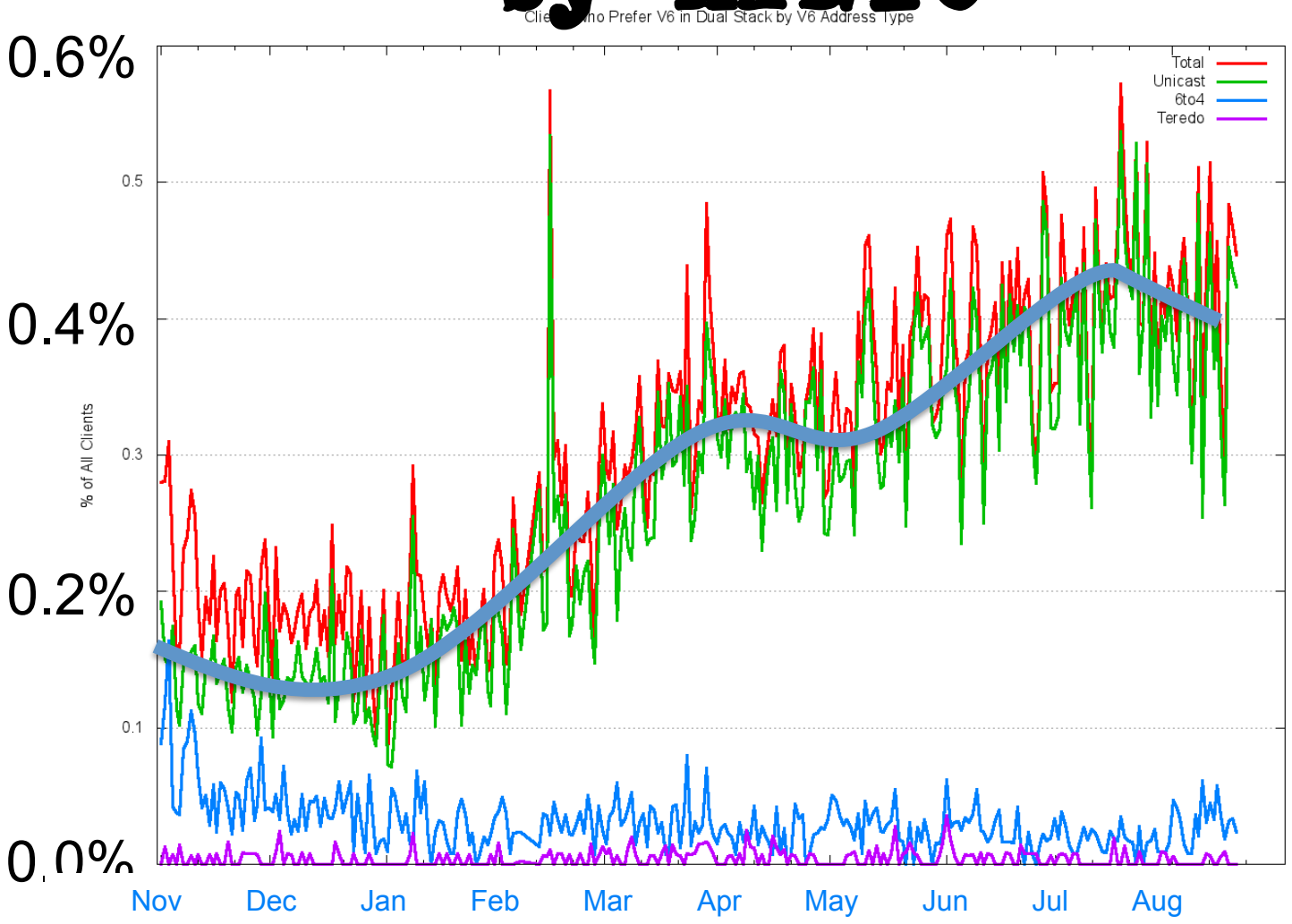
©2011 Google

http://www.google.com/intl/en/ipv6/statistics/

IPv6 capability, as seen by APNIC



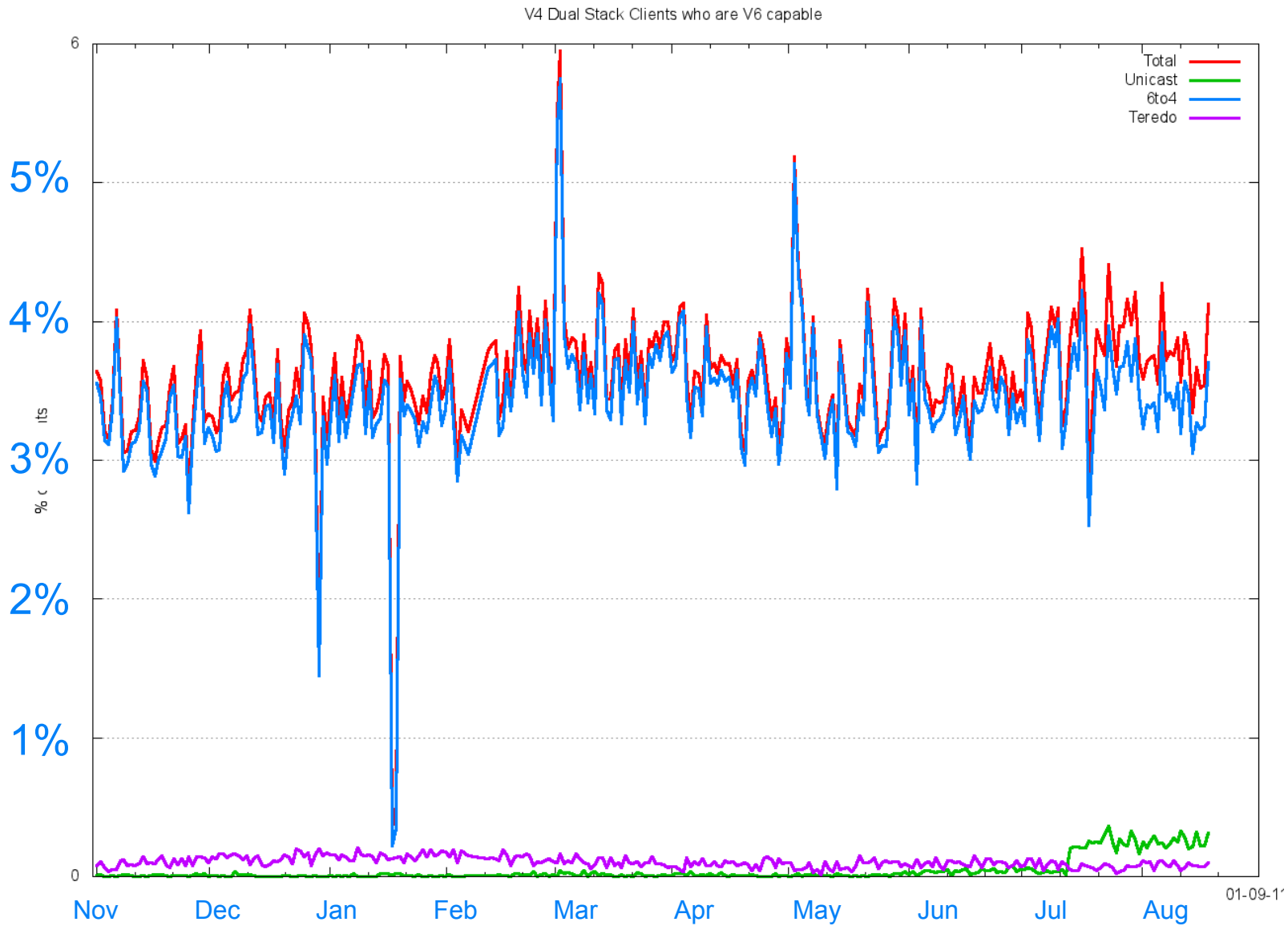
IPv6 capability, as seen by APNIC



Is This All There Is?

- **0.3% – 0.4%** of clients is a very low number
  - And most of the IPv6 access we see here uses unicast IPv6
  - Where are all the 6to4 and Teredo auto-tunnels?
  - What is going on in the past few weeks with the drop in IPv6 access?
- Lets look harder by testing with an IPv6-only image

IPv6 Capable Clients



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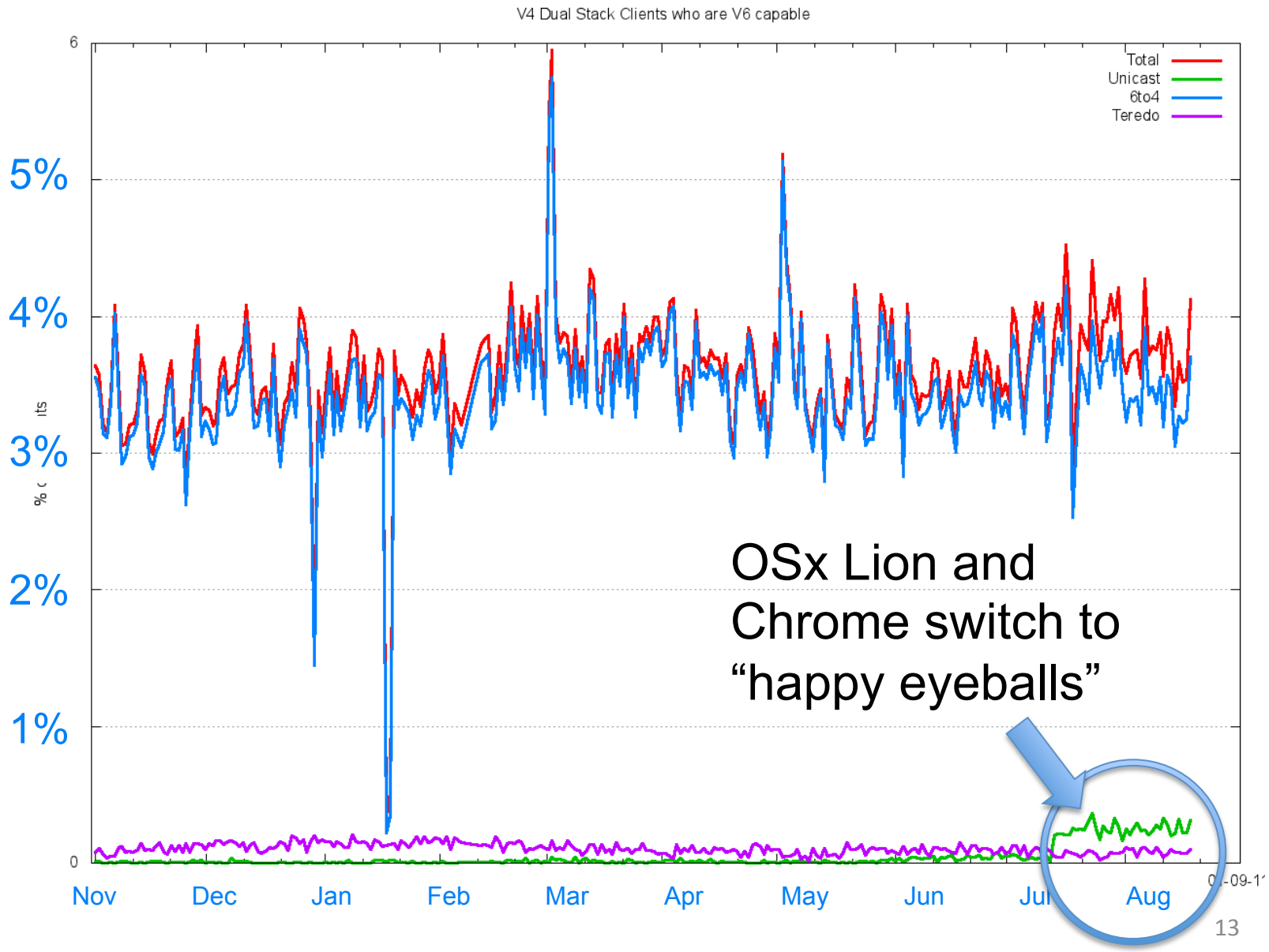
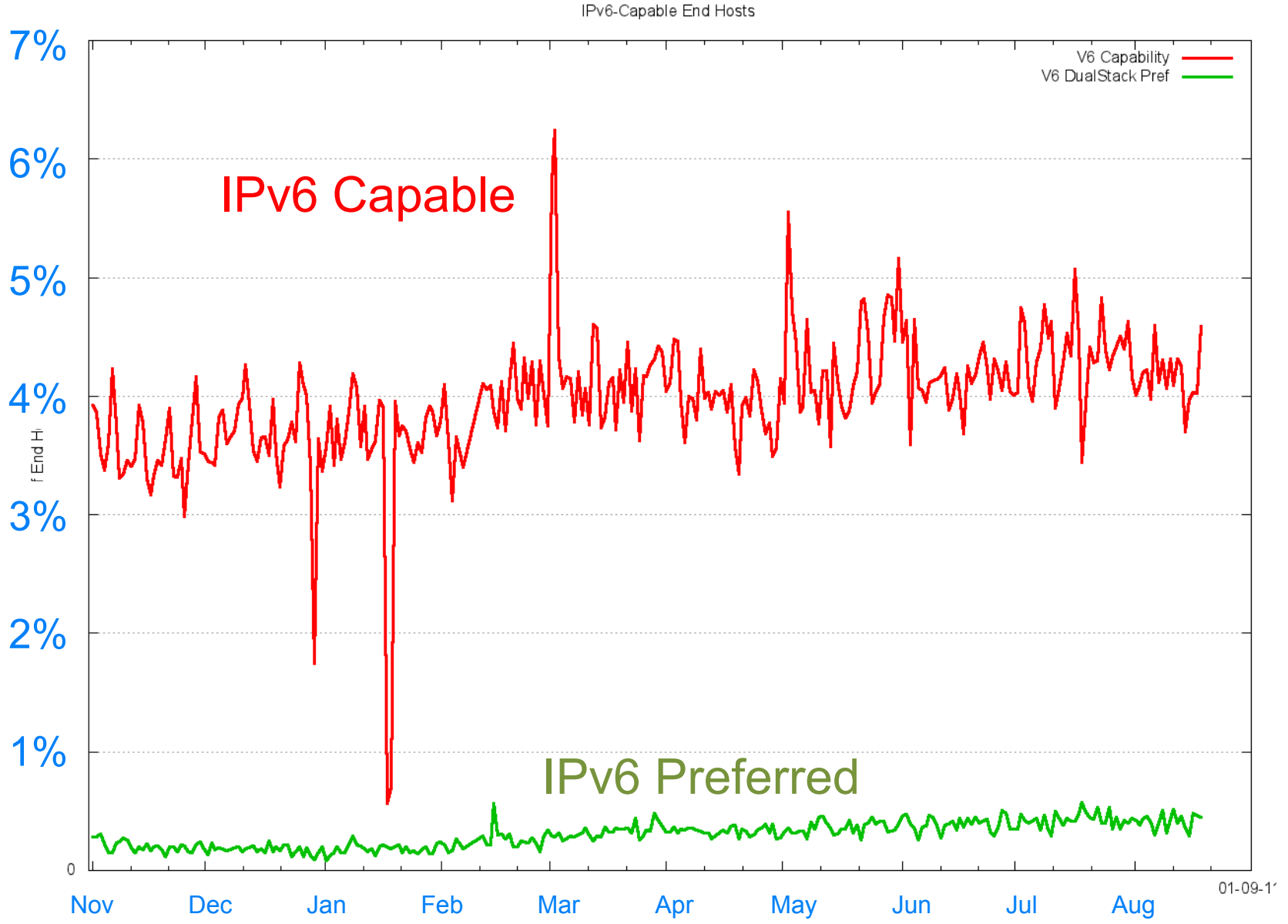


IPv6: "could" vs "will"

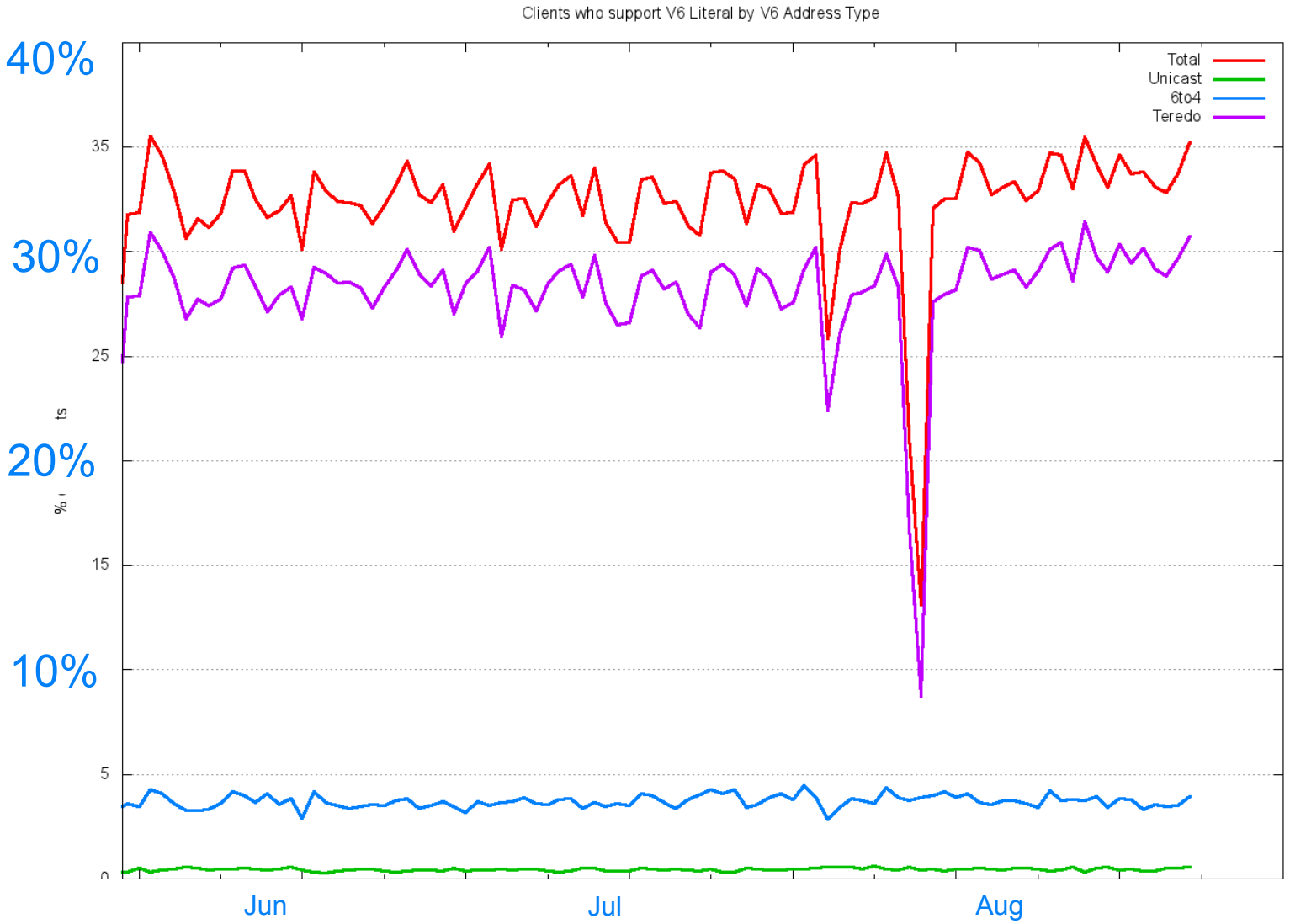


Is This All There Is?

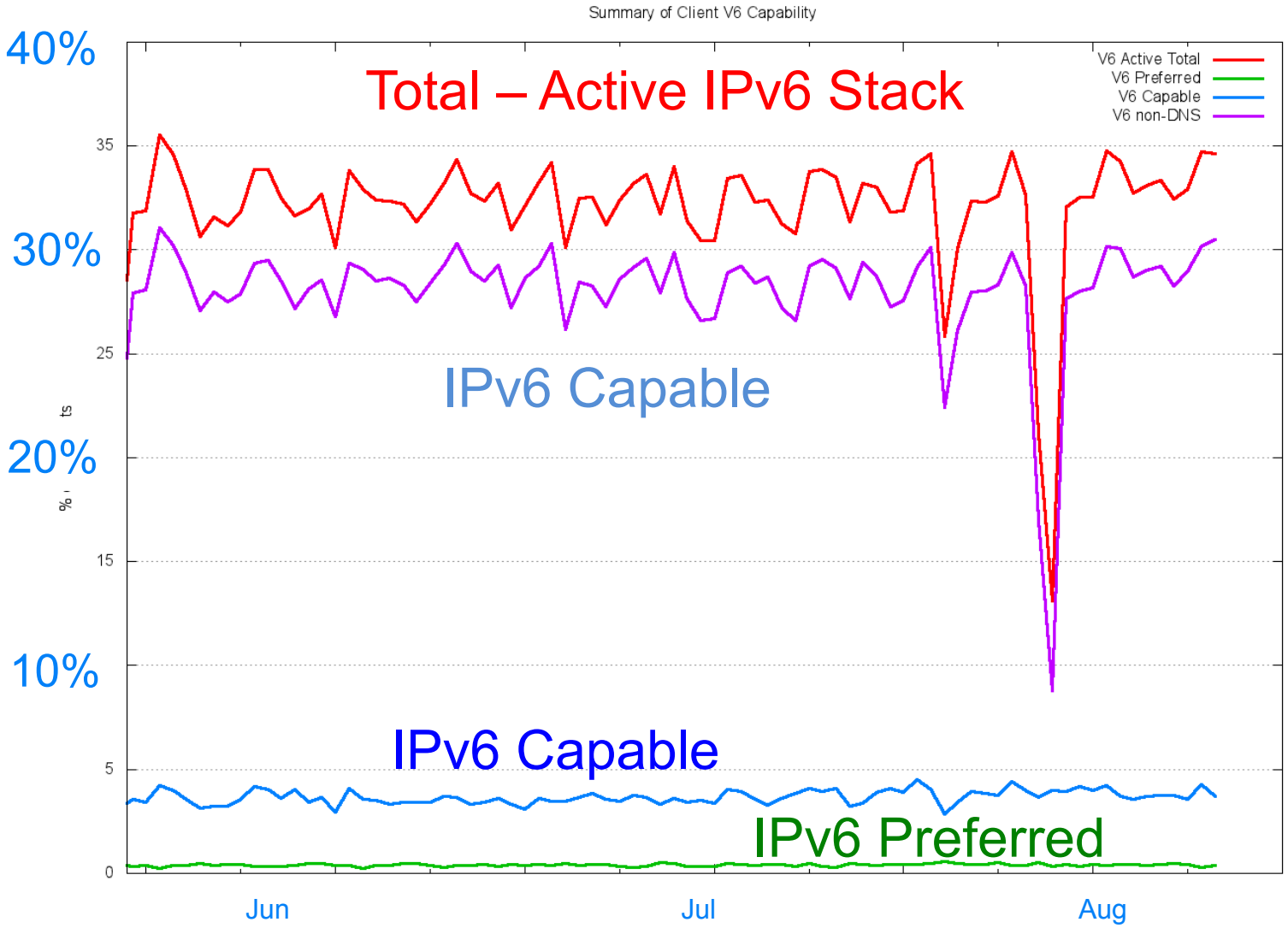
- **3% - 4%** of clients is still a very low number
  - Most of the access in IPv6-only is via 6to4 auto-tunnelling
  - Where is Teredo?
- Lets look harder by testing with an image that does not require a DNS lookup:

  http://[2401:2000:6660::f003]/1x1.png

IPv6 "Coerceable" Clients

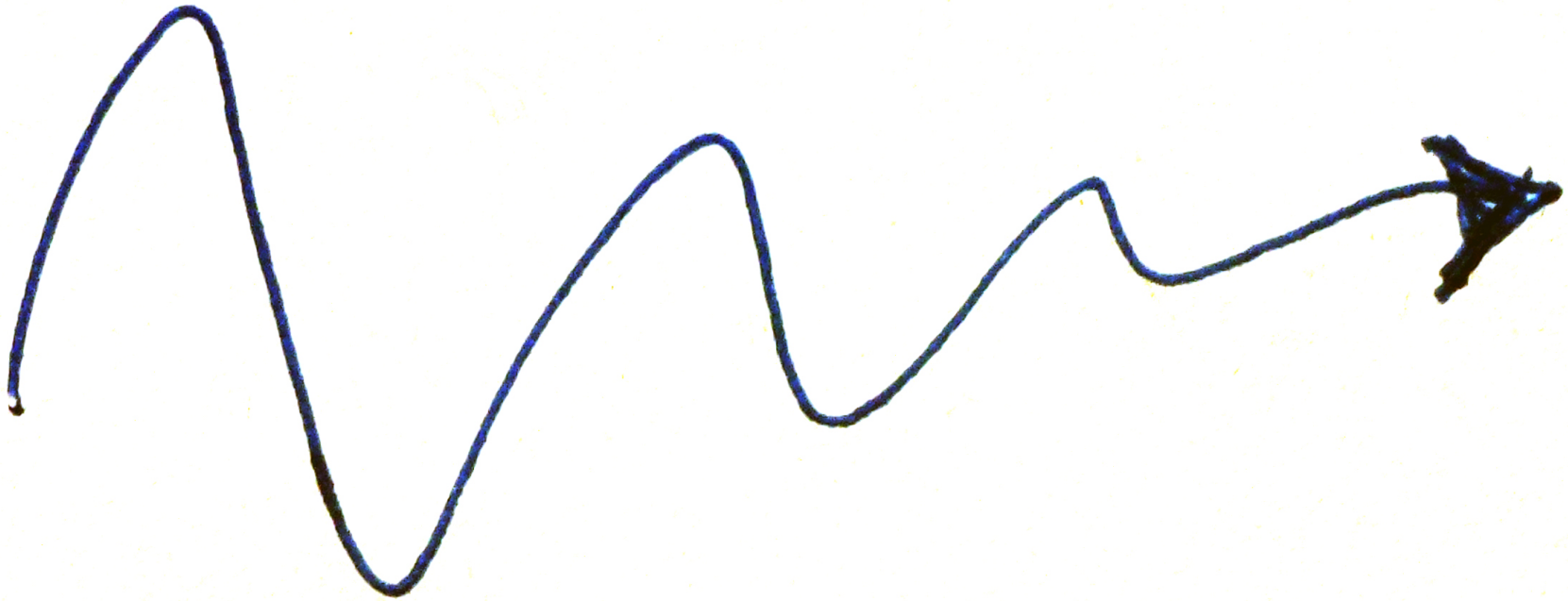


IPv6 Client Capabilities



How Much IPv6 is Out There?

- Around **0.4%** of the Internet's clients can and will use IPv6 in a Dual Stack scenario
  - These clients are generally using a "native" IPv6 service
- Around **4%** of the Internet's clients can use IPv6 in an IPv6-only scenario
  - The additional clients are generally using 6to4 auto-tunnelling
- Around **28%** of the Internet's clients are equipped with IPv6 capability that can be exposed
  - The additional clients are using Teredo auto-tunnelling



Some Measurements

39% of the IPv4 transit networks appear to be dual stack capable

48% of the Internet's end devices have an installed IPv6 stack that can be tickled into life

0.3% of the Internet's end devices have native IPv6 delivered to them

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- **48%** of the Internet's end devices have an installed IPv6 stack that can be tickled into life
- **0.3%** of the Internet's end devices have native IPv6 delivered to them

Where's the problem here?

The last mile access service business is not doing IPv6 because:

A) they are stupid
B) they are lazy
C) they are uninformed
D) they are broke
E) they operate in an economic and business regime that makes provisioning IPv6 an unattractive investment option for them

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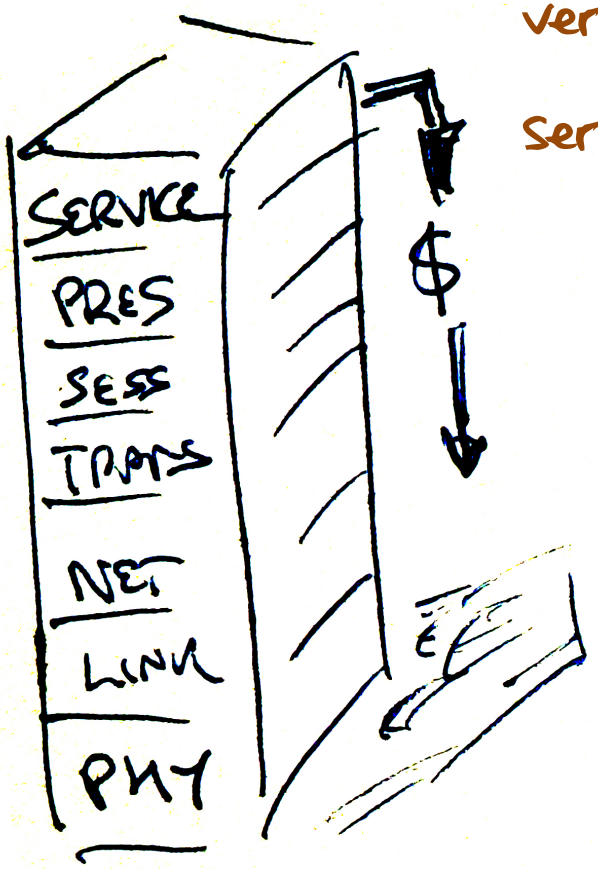
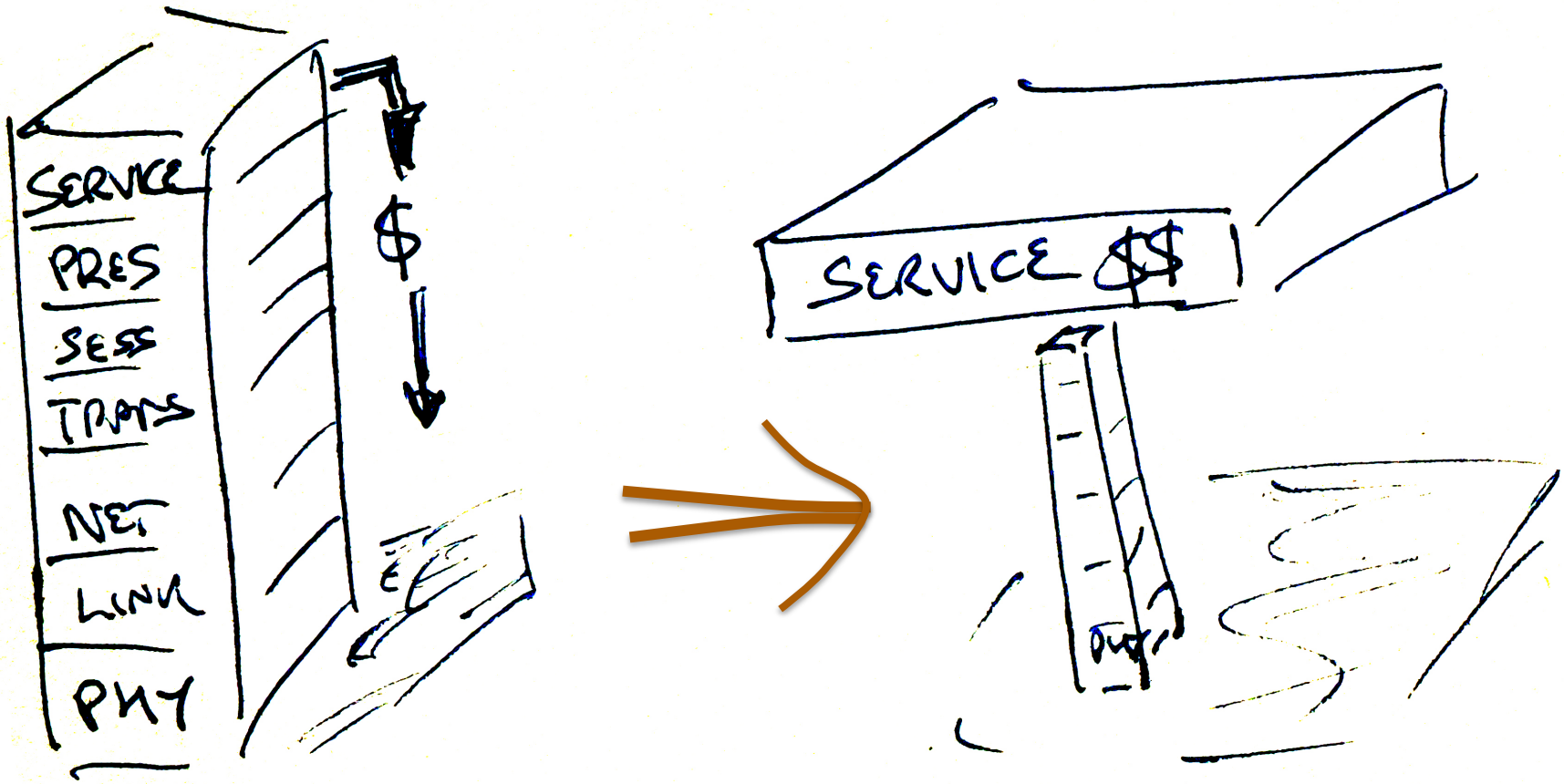
Why is IPv6 such an unattractive business proposition for Carriage Providers?

Back to networking basics....

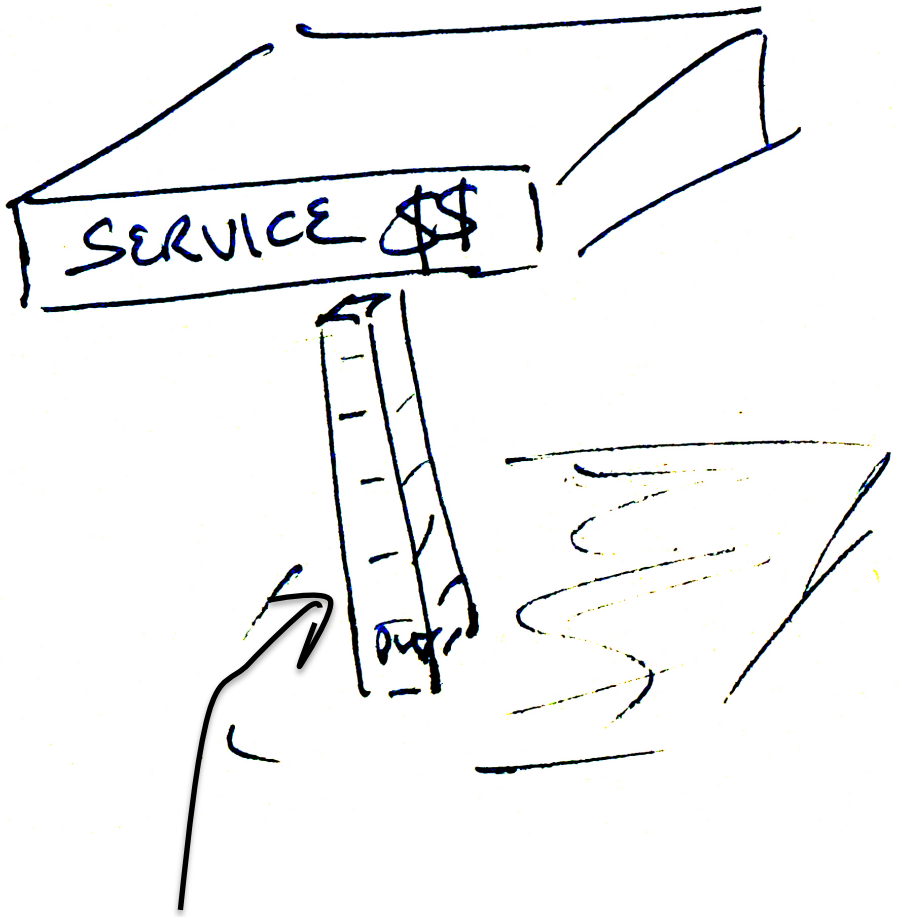
Telco nostalgia...

The historical vertically integrated service architecture





Devolution of the integrated service architecture through an open IP service architecture and deregulation

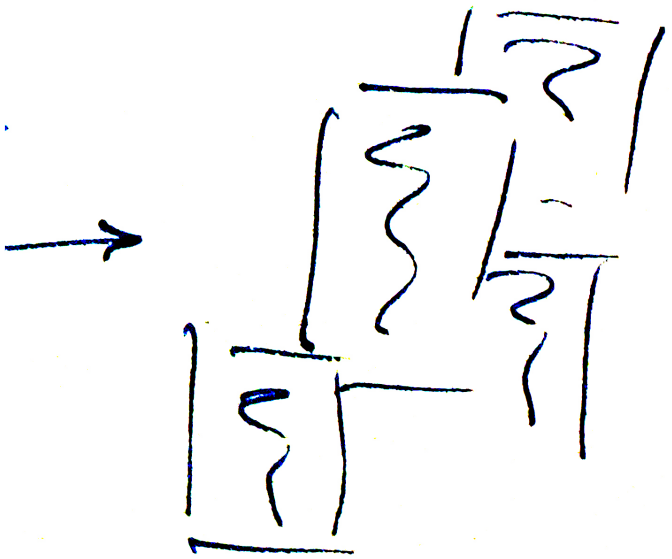


Devolution of the integrated service architecture

Where's the money to invest in new network services?

Users

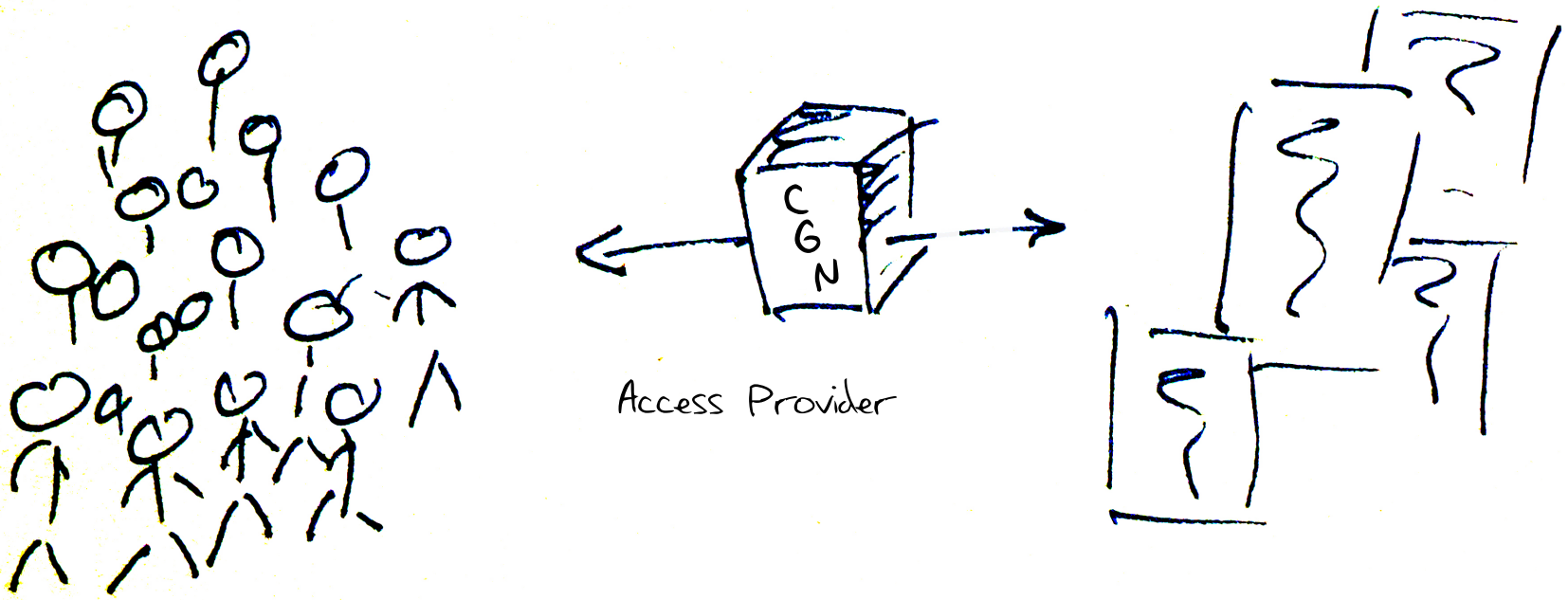
Services



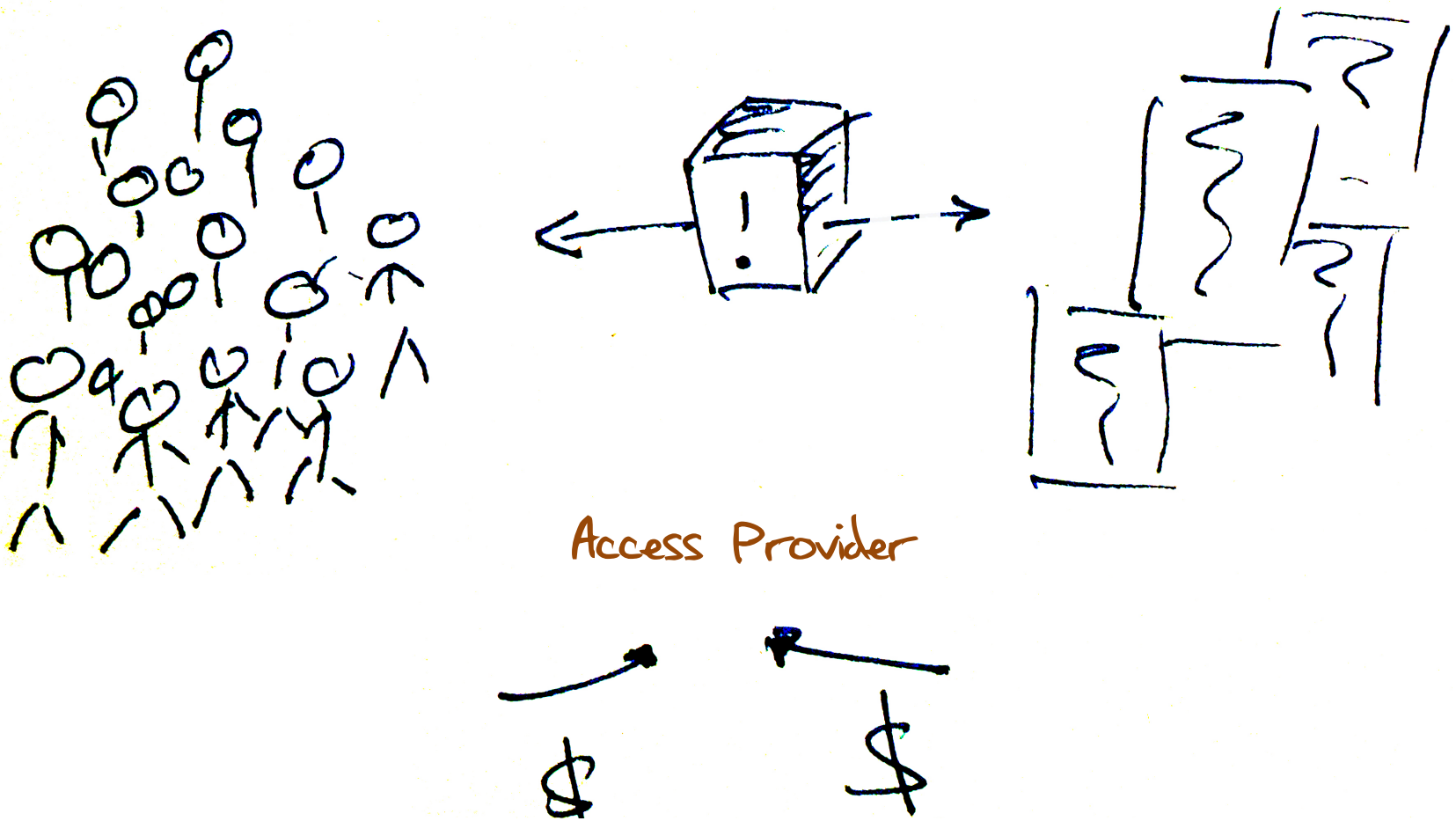
Access Provider

Users

Services



CGNs and ALGs and similar IPv4 rationing middleware devices provide control points in the IPv4 network that allow monetary extraction from both consumers and content providers



A digression...

How "real" is this risk?

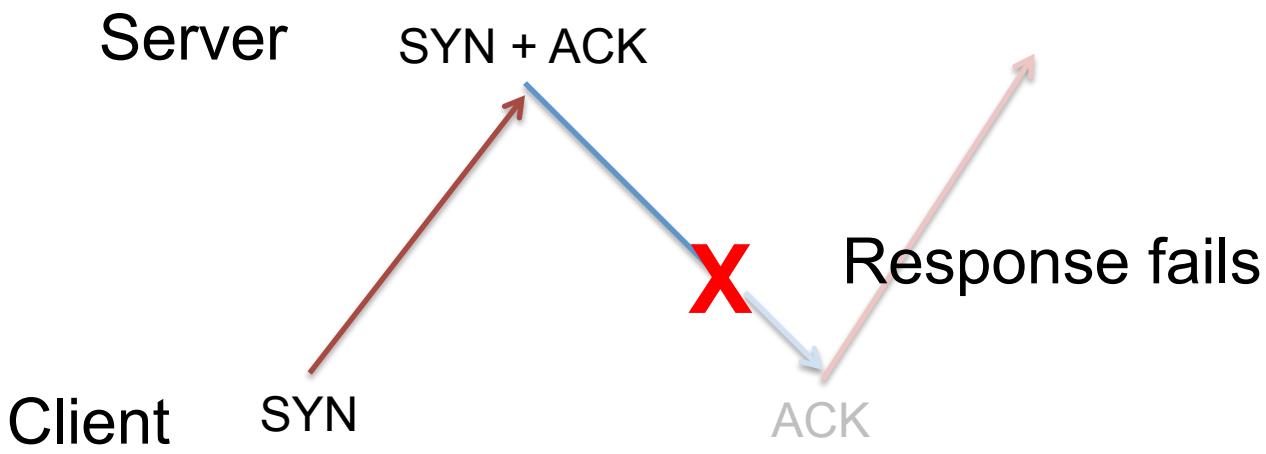
Is this industry seriously prepared to contemplate an IPV4 forever strategy?

Yes – it's a possibility!

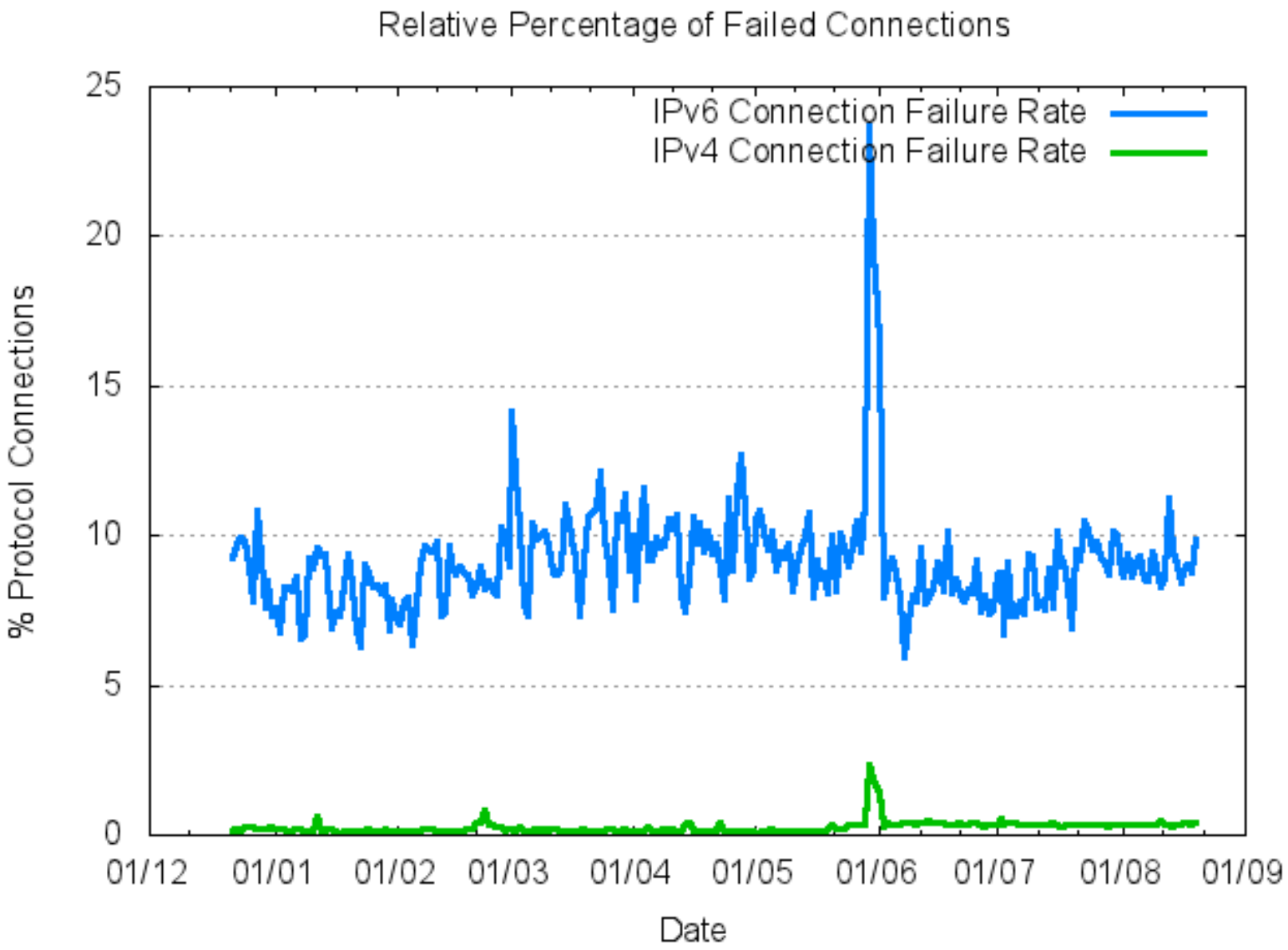
Failure Observations

Connection Failure

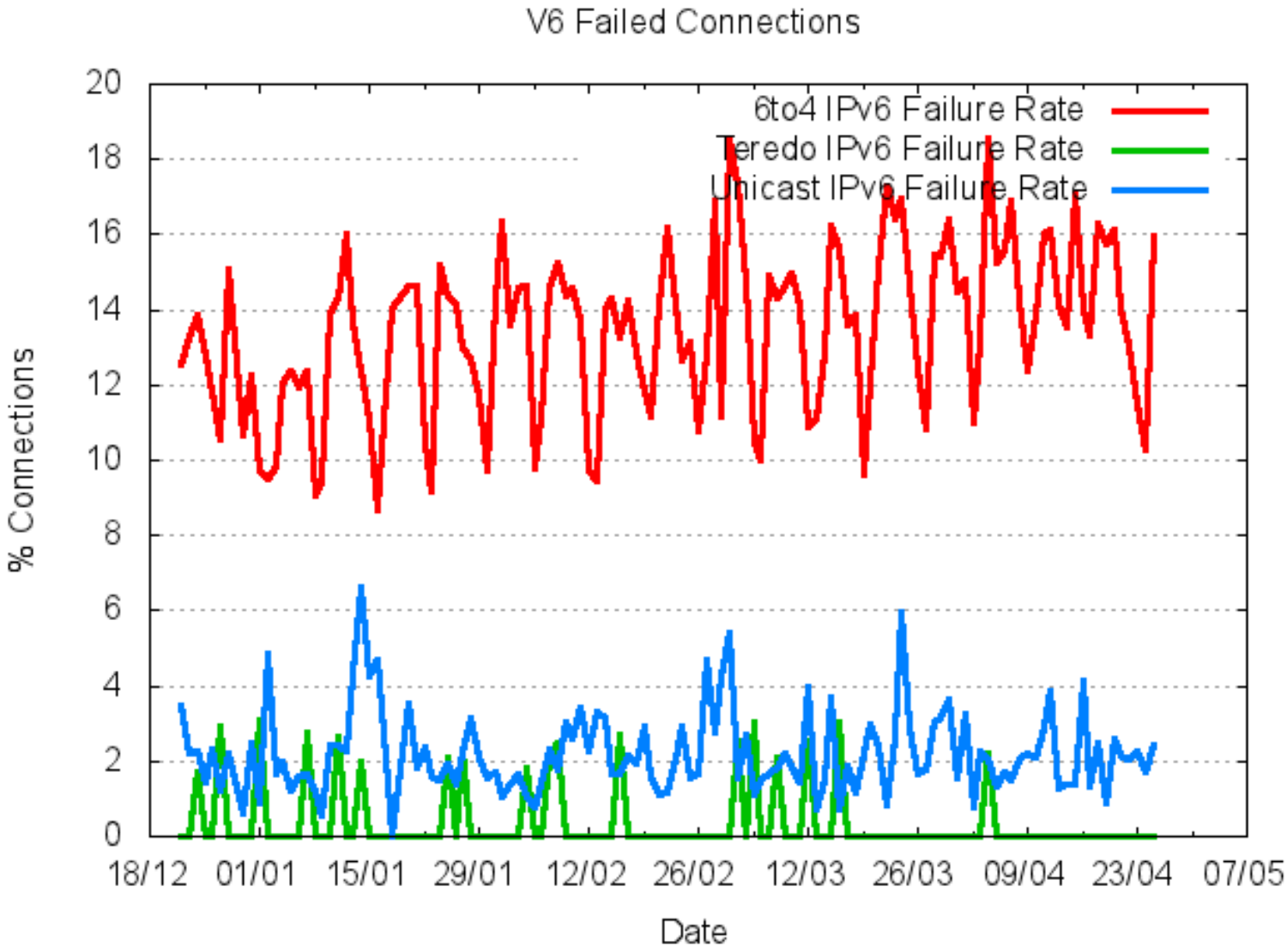
To attempt to look at some instances of connection failure, lets looking for connections that fail after the initial TCP SYN



Connection Failure



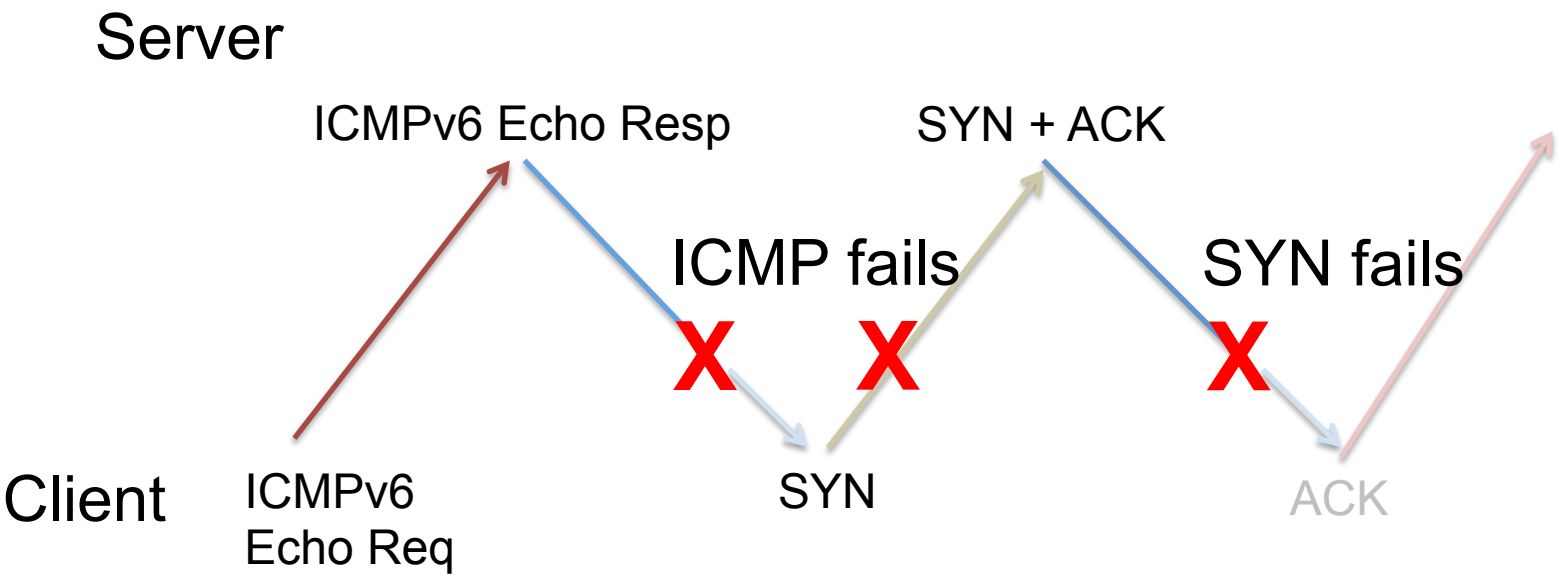
IPv6 Connection Failure



Is Teredo really THAT good?

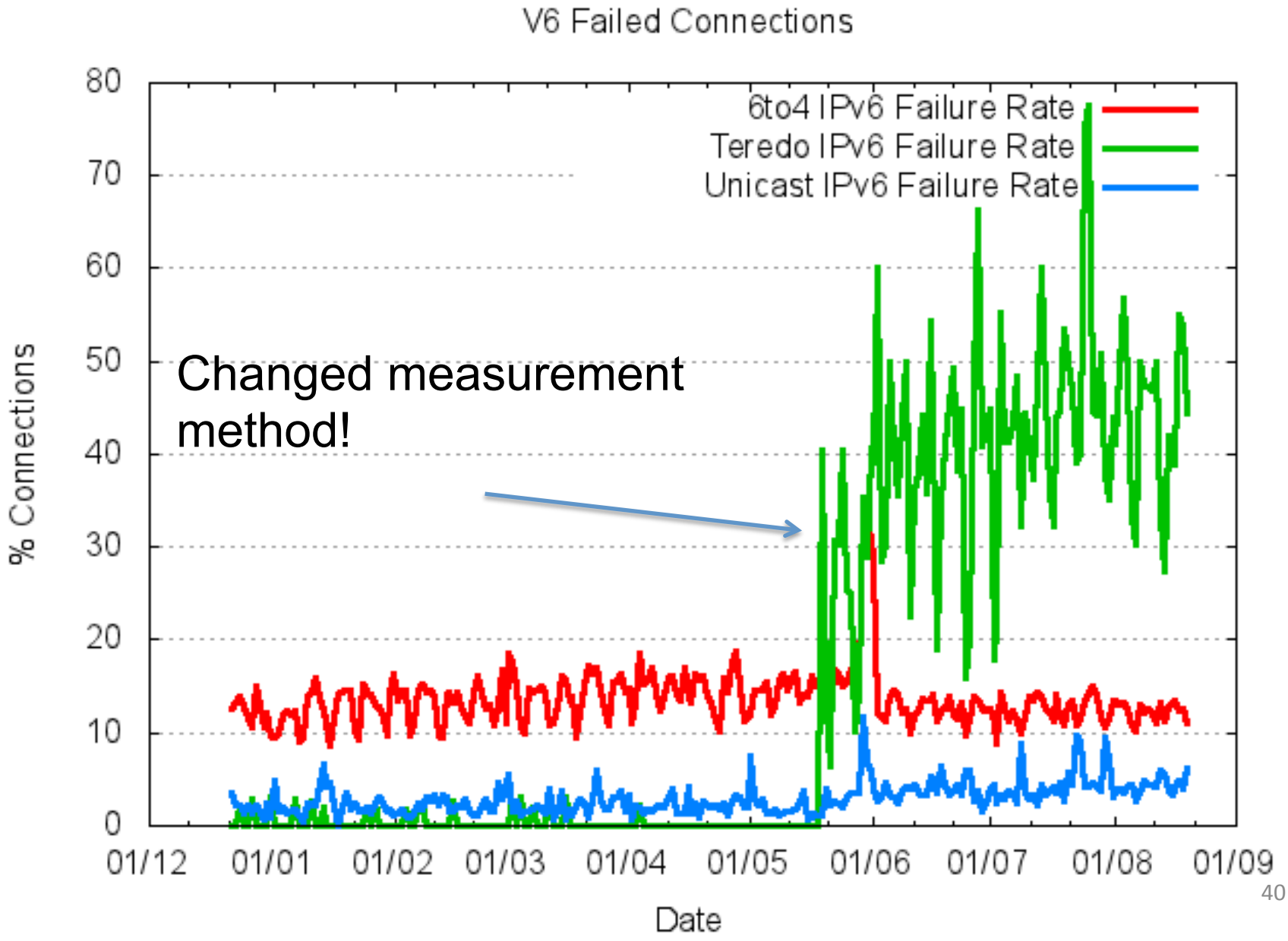
Teredo Connection Failure

Teredo uses an initial ICMPv6 exchange to assist in the Teredo Server / Relay state setup



Note that this approach does not detect failure of the initial ICMPv6 echo request , so the results are a lower bound of total connection failure rates

IPv6 Connection Failure



IPv6 Connection Failure

- Some **2%-5%** of **IPv6 unicast** connections fail!
  - This rate is better than IPv6 auto-tunnels, but is still 20x the rate of IPv4 connection failure
- Some **12% - 15%** of **6to4** connections fail!
  - This is a very high failure rate!
  - The failure is most likely a protocol 41 filter close to the client that prevents incoming 6to4 packets reaching the client
- Some **45%** of **Teredo** connections fail!
  - This is an amazingly high failure rate!
  - And its not local firewall rules!
  - Teredo's NAT traversal is failing 45% of the time

Teredo's NAT traversal algorithm is failing 45% of the time

What have we learned about applications and their ability to perform NAT traversal for multi-party NAT bindings?

This is seriously broken!

NATs are incredibly difficult and unreliable for applications to cope with!

What about CGNs?

CGNs are just big remote NATs

What can we say about applications and CGN traversal for multi-party NAT bindings?

Thank You!