

A rack of test tubes containing various colored liquids and substances. The tubes are arranged in two rows. The top row contains five tubes: the first is empty, the second has a green liquid with a copper wire, the third has a white solid, the fourth has a yellow liquid, and the fifth has a white solid. The bottom row contains five tubes: the first has a red liquid, the second has a white solid, the third has a white solid, the fourth has a yellow liquid, and the fifth has a white solid. The background is a blurred laboratory setting.

Network Analytics

Geoff Huston, George Michaelson
APNiC



Before you begin the speed test:
Scan for issues and speed up your Mac

[START NOW](#)

131.203.40.48
FX Networks Ltd
☆☆☆☆☆ [Rate Your ISP](#)

3.595.299.230

SPEED WAVE

Compete with others and gather
broadband statistics.

[Learn more →](#)

PINGTEST.NET

Bandwidth only tells part of the
story - test quality as well!

[See how →](#)

MY RESULTS

Examine your past results and
see how they compare.

[View now →](#)

Welcome to Speedtest.net

Our [Promise Index™](#) compares results to an ISPs "promised speed". Do you get what you pay for? Be sure, and join over 250 million people who visit to test or troubleshoot their Internet

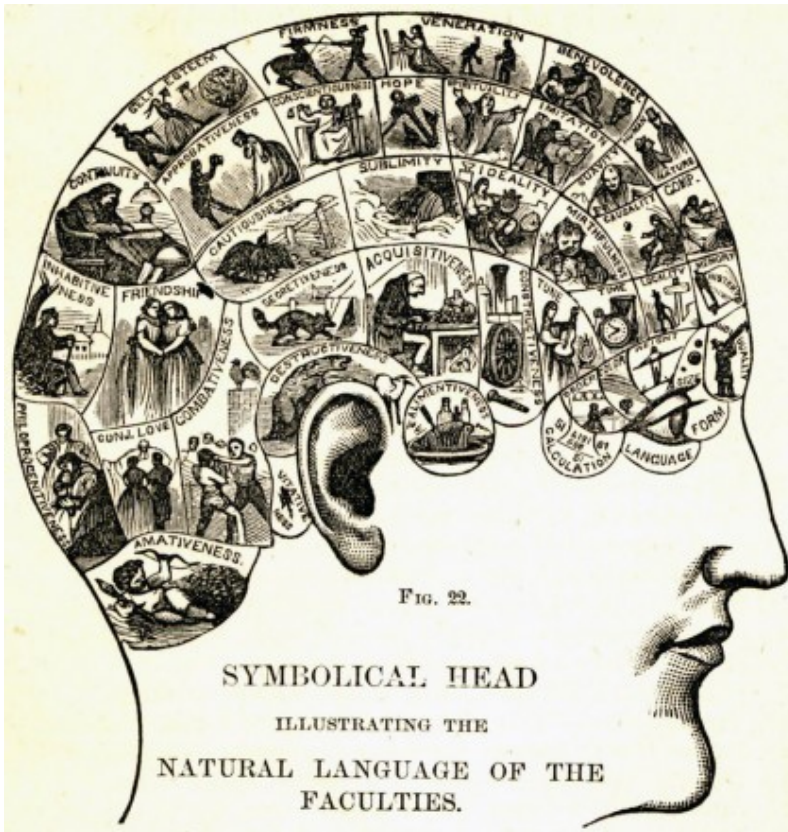


Mobile

Get Speedtest.net for your

How to measure "the Internet"

What do we mean when we say
"we're measuring the internet?"



User experience

- Responsiveness
- Sustained Throughput
- Application performance quality
- Consistency
- Availability

Network Behaviour

- Routing Stability
- Path characteristics

Element Behaviour

- Subnet characteristics
- Switch element behaviour
- Switch resource consumption

Network availability

- Element availability
- Transmission path availability
- Transmission element BER
- Network path availability

Path characteristics

- Latency
- Jitter characteristics
- Loss characteristics

Protocol behaviour

- Transport protocol behaviour
- IPv6 penetration levels
- Failover behaviour
- Connection failures

And so on...

User experience

- Responsiveness
- Sustained Throughput
- Application performance quality
- Consistency
- Availability

Network Behaviour

- Routing Stability
- Path characteristics

Element Behaviour

- Subnet characteristics
- Switch element behaviour
- Switch resource consumption

Network availability

- Element availability
- Transmission path availability
- Transmission element BER
- Network path availability

Path characteristics

- Latency
- Jitter characteristics
- Loss characteristics

Protocol behaviour

- Transport protocol behaviour
- IPv6 penetration levels
- Failover behaviour
- Connection failures

And so on...

What are you trying to measure?

Network Measurement Approaches

PING and related probe techniques

- Send an ICMP echo request to a target device and measure the time to respond
- Often used to interpret some indication of delay, loss and jitter
- BUT has little relationship to application performance, as the probe measurement is heavily impacted by the behaviour of the probe and the echo point
 - i.e. beyond being a remote device availability beacon, its of little practical use

Network Measurement Approaches

SNMP

- Per-element probe to poll various aspects of an element's current status
- Of little practical value in determining end-to-end network performance, as there is a distinct gap between end-to-end path performance and periodic polling of network element state

Network Measurement Approaches

Active Test Traffic

- Perform a particular network transaction in a periodic fashion and correlate application performance across invocations
- Often measures the performance limitations of the test gear and the target rather than the network
- Tests only a small number of network transit paths
- Provides only a weak correlation between measurement results and actual end-user experiences of application performance

What, Where and Why?

- Using a combination of active and passive measurement techniques there is a massive set of possible aspects of network behaviour that can be measured
- Few network measurements have any real bearing on the performance characteristics of applications that include some form of network interaction
 - i.e. there's a difference between measuring any old thing and measuring something relevant and useful

If you are going to measure something...

- Know why you are measuring it
- Understand the limitations of the measurement technique
- Understand the limitations of any interpretation of the measurement
- Understand who is the consumer of the measurement

IP Performance

The end-to-end architectural principle of IP:

- The network should not duplicate or mimic functionality that can or should be provided through end-to-end transport-level signalling
- Wired IP networks can be seen as lossy queue-controlled passive switching devices connected through fixed delay channels
- Wireless IP networks are worse!

IP parameters:

- Delay
 - Delay stability
 - Jitter
 - Loss rate
 - Loss burstiness
- In general the smaller the numbers the better, but ...

TCP Performance

- TCP performance is the interaction of concurrent end-to-end transport sessions performing a role of mutually enforced resource sharing
 - The network is not a mediator or controller of an application's resource requirements
- Its a lot like fluid dynamics:
 - Each network transport flow behaves in a fair greedy fashion, consuming as much of the network's resources as other concurrent network transport applications will permit

Maybe asking how to measure "network performance" is the wrong question

- How well your car operates is an interaction between the functions and characteristics of the car and the characteristics of the road – trip performance is not just the quality or otherwise of the road
- How well an application operates across a network is also an interaction between the application and the local host and the interaction by its remote counterparts and their hosts as well as the interaction between the application's transport drivers and other concurrent applications that occur within the network

How to measure the end user



Anatomy of a web page fetch (1990s)

Welcome back, ANONYMOUS. Today it is Sunday 15 April 2012!

```

      .g8''''''bgd
     .dP'      M
    dn'      '
   MM
  MM.      `7MMF`
  `Nb      MM
    ``bmmndPY

      ,pW''Wq-   ,pW''Wq-   .P''Ybmmn
     6W'      `Wb 6W'      `WB :MI  I8
    SM      MB SM      MS WmmnP''
  `YA.      ,A9 YA.      ,A9 SM
    `Ybnd9'   `Ybnd9'   YMMMMhb
                                .JNML.
                                6'      dP
                                Ybmmnd'

NET SEARCH ENGINE

```

```

TODAY'S NEWS |
              | MIDWEST TORNADOES: 5 DEAD IN OKLA. - CBS... [1]
              | AFGHANISTAN ATTACKERS TAKE OVER HOTEL, PO... [2]
              | ISRAEL MOVES TO BLOCK PRO-PALESTINIAN "FL... [3]
              | SYRIA ARMY SHELLS REBEL AREAS AHEAD OF UN... [4]

```

'Google (S)earch' or 'I'm Feeling (L)ucky'? Choose (S/L)

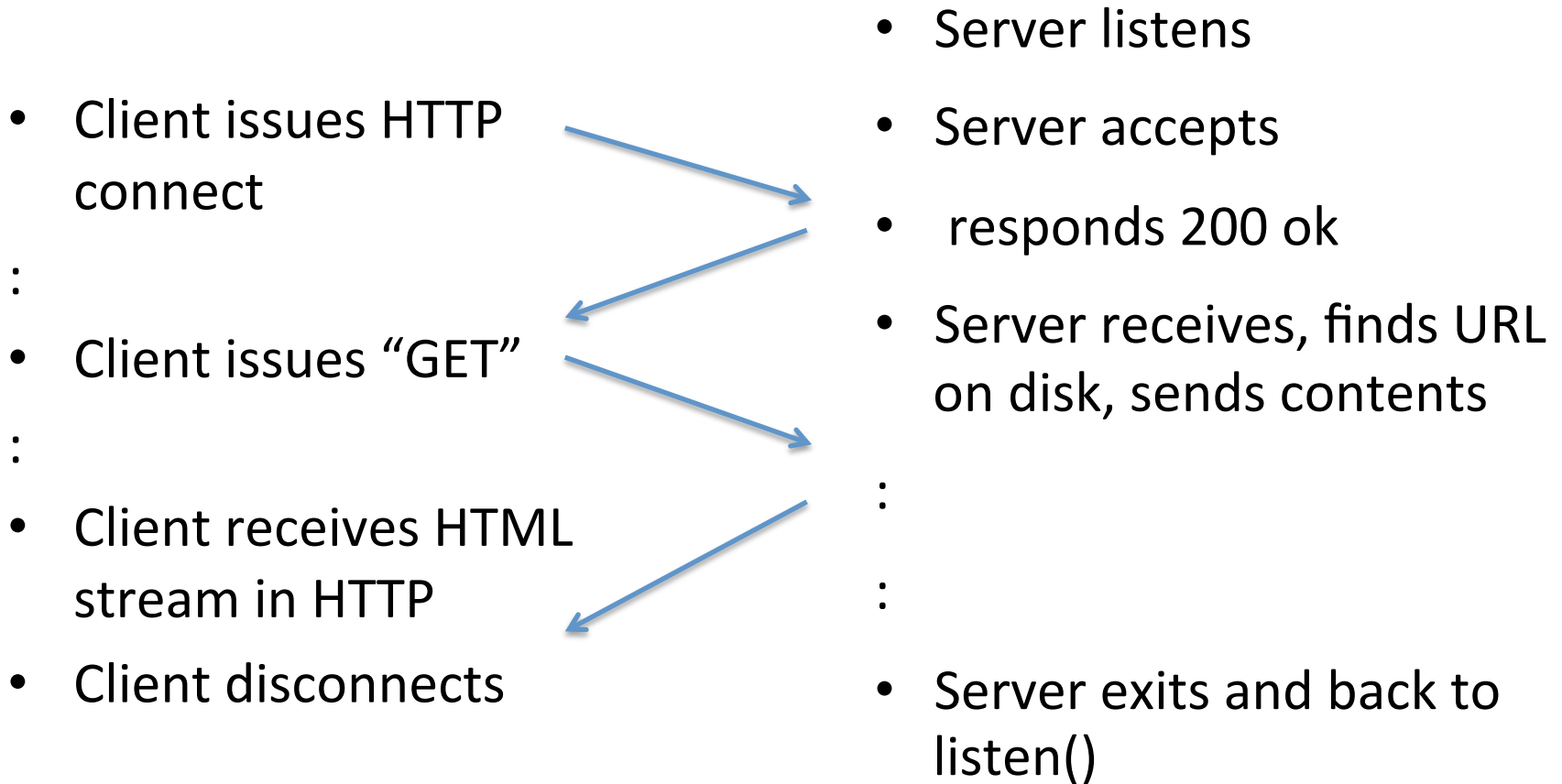
GOOGLE BBS TUNNEL

Serial

Connected

Login time 12:29:38

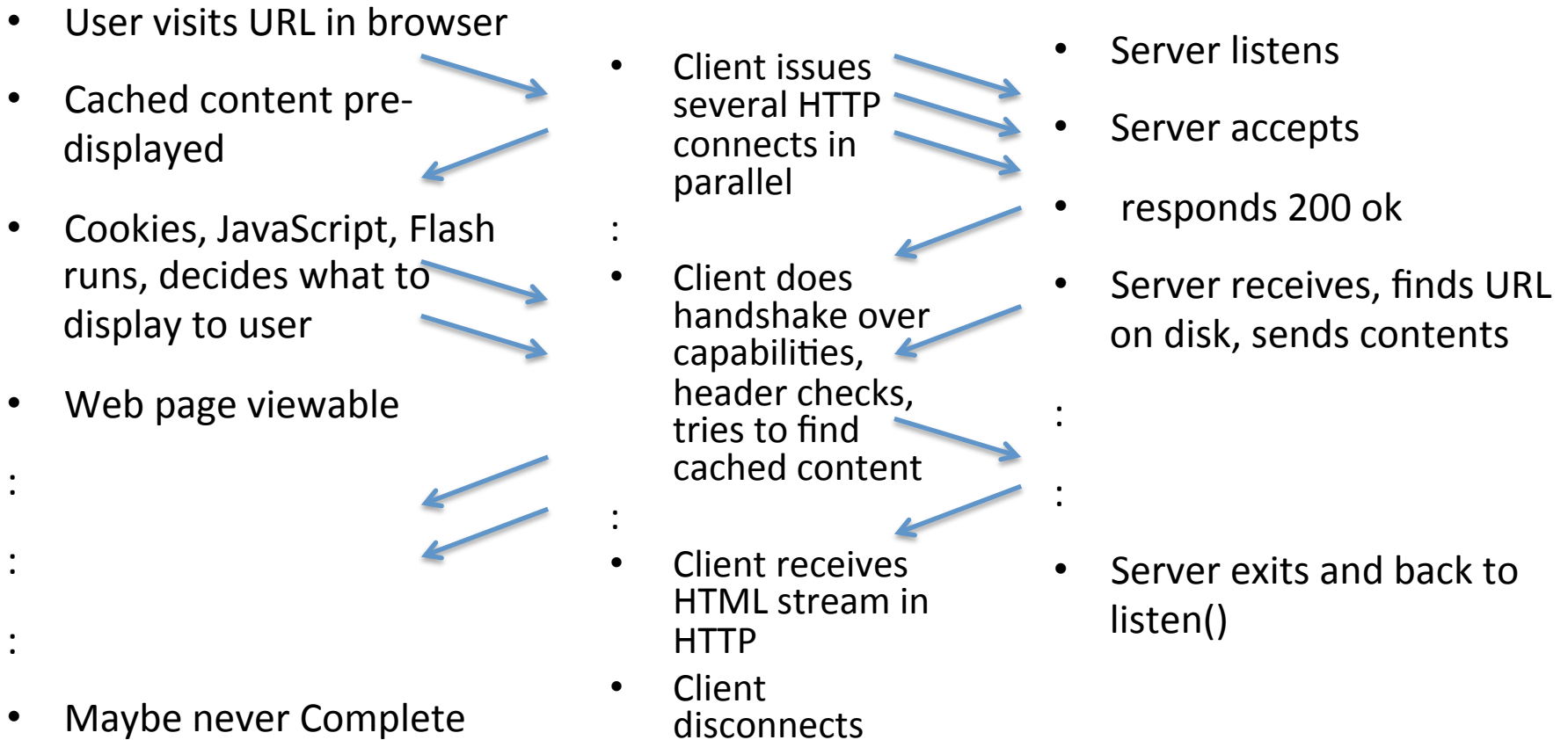
Anatomy of a web page fetch (1990s)



Anatomy of a web page fetch (2010s)



Anatomy of a web page fetch (2010s)



HTTP/HTML ain't what it used to be

- A huge amount of parallelism/asynchrony has been introduced.
- Intermediate processing takes place on the stream of data, deciding what to display and what not to display
 - Adblock, flashblock, cache-optimizations
 - Document Object Model (DOM) includes material not displayed, material not added to DOM by scripts &c
- JavaScript provides rich language including timers, async fetches, string/number processing

Observations



- Most networks are a collection of elephants and rats
 - And the elephants are uncontrollable
 - And the rats breed like crazy
- If all the traffic is TCP then a well tuned client and server should drive a network to the point of packet loss
 - The resultant overall packet loss rate is a function of the average RTT and the average size of network transactions
- If all the traffic is real time streaming then congestion events can become catastrophic



Approaches to Measurement...

Measure the network

- And claim that perfection is in the eye of the network management system
- And everything else is a user problem!

This approach has its weaknesses

Or you can measure the end user...

Approaches to Measurement...

From the inside looking out

- Set up a measurement station
 - Ping, traceroute and fetch routines
 - Measure the absolute outcomes and the variance
- Its not really a user metric
 - It's not that bad
 - But its not that useful either



Approaches to Measurement...

From the outside looking in:

- Set up a measurement station
 - Enrol end users to send traffic to it
 - Measure the absolute outcomes and the variance
- Or instrument your web server
- Its not a bad metric
 - But its a small sample set that is often nerd heavy
 - And nerds are “special”



Approaches to Measurement...

From the outside looking in

– RIPE Atlas

- Many thousands of end points installed in end user networks
- Ping and traceroute to a small set of destinations
- And report back
- Analysing the data to produce relevant outcomes is a challenge



Approaches to Measurement...

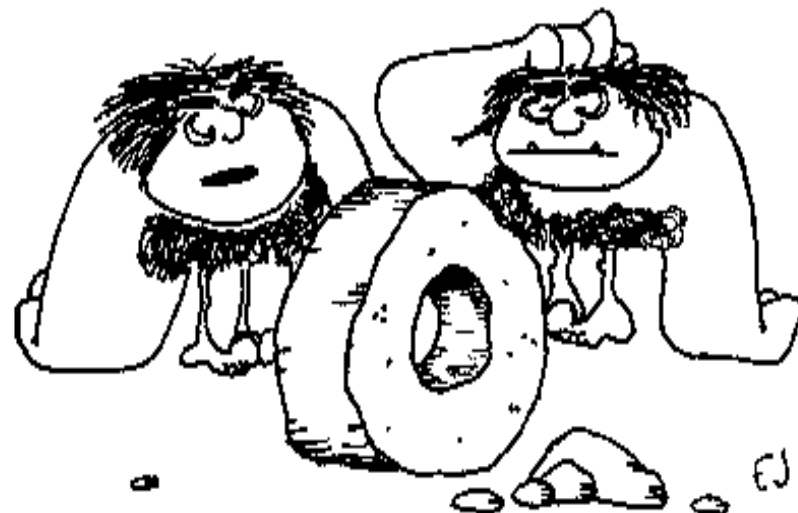
From the outside looking in

- The “Sam Knows” approach
 - “be the user”
 - Use a known common platform (Open WRT DSL modem)
 - Use a common set of tests (short and large data transfer)
 - Take over the user’s connection and perform the tests at regular intervals
 - Report results
- Originally developed to test DSL claims in the UK
- Used by the FCC and ISPs in the US
- Underway in Singapore and in Europe

The screenshot displays the Sam Knows website. At the top left is the Sam Knows logo. Below it is a navigation menu with links: About SamKnows, Volunteer Sign-up, Buy a Whitebox, How it Works, Reporting Suite, Regulator Approved, Code of Conduct, Technical Papers, UK Broadband Availability, News, and Contact Us. The main heading is "Global Leaders in Broadband Measurement" with a sub-heading "Sign up with us today to accurately measure your broadband performance." A prominent "Sign up here to measure..." button is on the left, and a "JOIN UP NOW" button is on the right. Below these are five flags representing different regions: American Broadband (USA), European Broadband (EU), Singaporean Broadband (Singapore), Brazilian Broadband (Brazil), and UK Broadband (UK). At the bottom, there is a "Broadband Report Card" showing performance metrics: 10.1, 3.9 Min, and 4.5. The word "Analyse" is written in large, semi-transparent letters across the bottom of the screenshot.

Observations

- IP performance measurement is not a well understood activity with mature tools and a coherent understanding of how to interpret various metrics that may be pulled out from hosts and networks
- The complex interaction of applications, host systems, protocols, network switches and transmission systems is at best only weakly understood
 - But there's a lot of slideware out there claiming to provide The Answer!



How DOES IT WORK AGAIN?

Approaches to Measurement

A case study: APNIC's approach

- we wanted to measure IPv6 deployment as seen by end users
- We wanted to say something about ALL users
- So we were looking at a way to sample end users in a random but statistically significant fashion
- We stumbled across the advertising networks...

...buy the users



Placement

At low CPM, the advertising network needs to present unique, new eyeballs to harvest impressions and take your money.

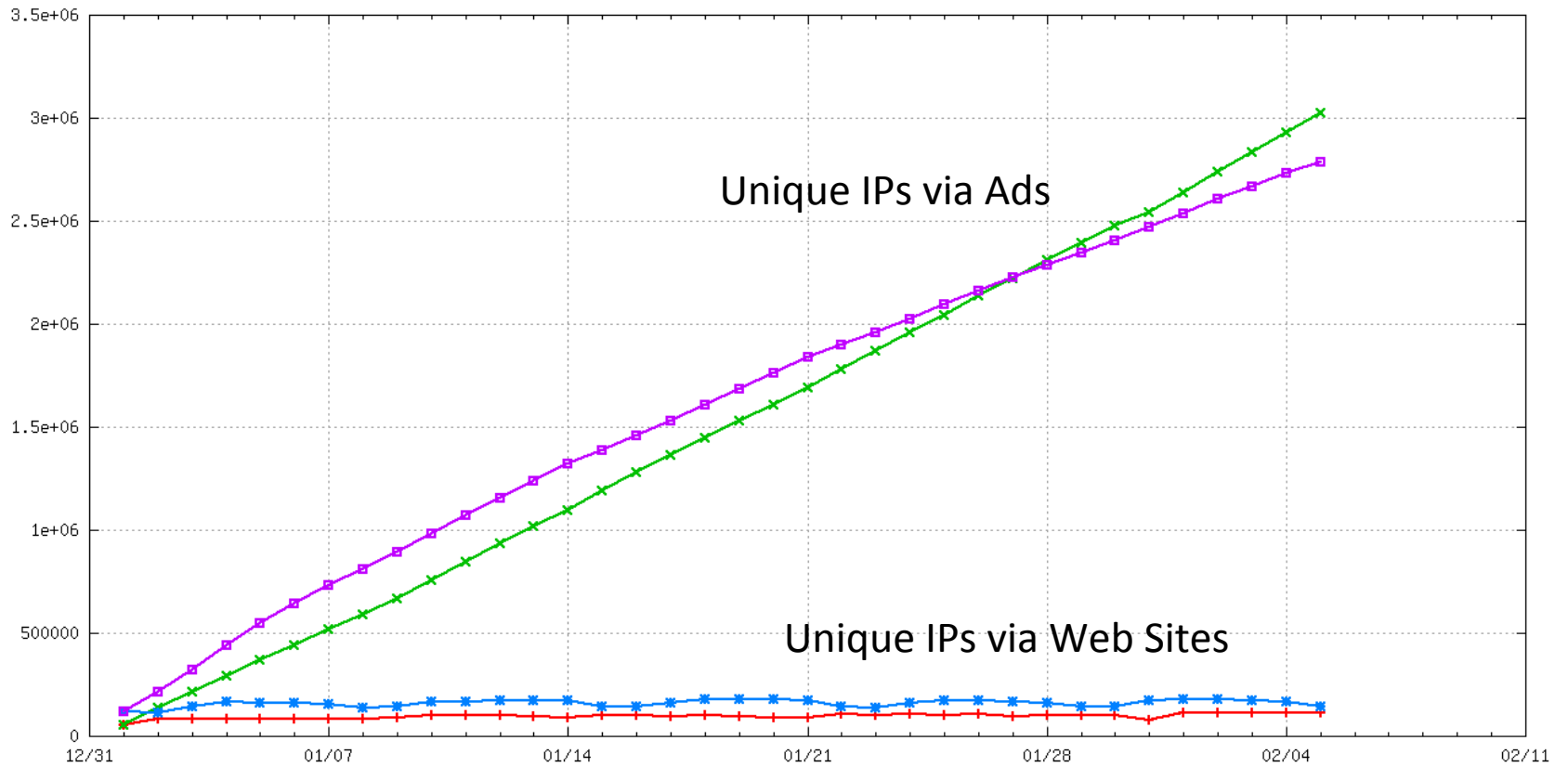
- Therefore, a ‘good’ advertising network provides fresh crop of unique clients per day

Unique IPS?

- Collect list of unique IP addresses seen
 - Per day
 - Since inception
- Plot to see behaviours of system
 - Do we see 'same eyeballs' all the time?

Lots of Unique IP'S

google uniques/day + google cumulative uniques * javascript uniques/day * javascript cumulative unique -



Dealing with the data

- Unified web, dns, tcp dumps
- Measure:
 - IPv6 update rates
 - RTT measurements
 - Connection Drop rate
 - Approx 800,000 experiments/day
- Post-process to add
 - Economy of registration (RIR delegated stats)
 - Covering prefix and origin-AS (bgp logs for that day)
- Combine into weekly, monthly datasets (<10Mb)

What are we finding?



What are we finding?

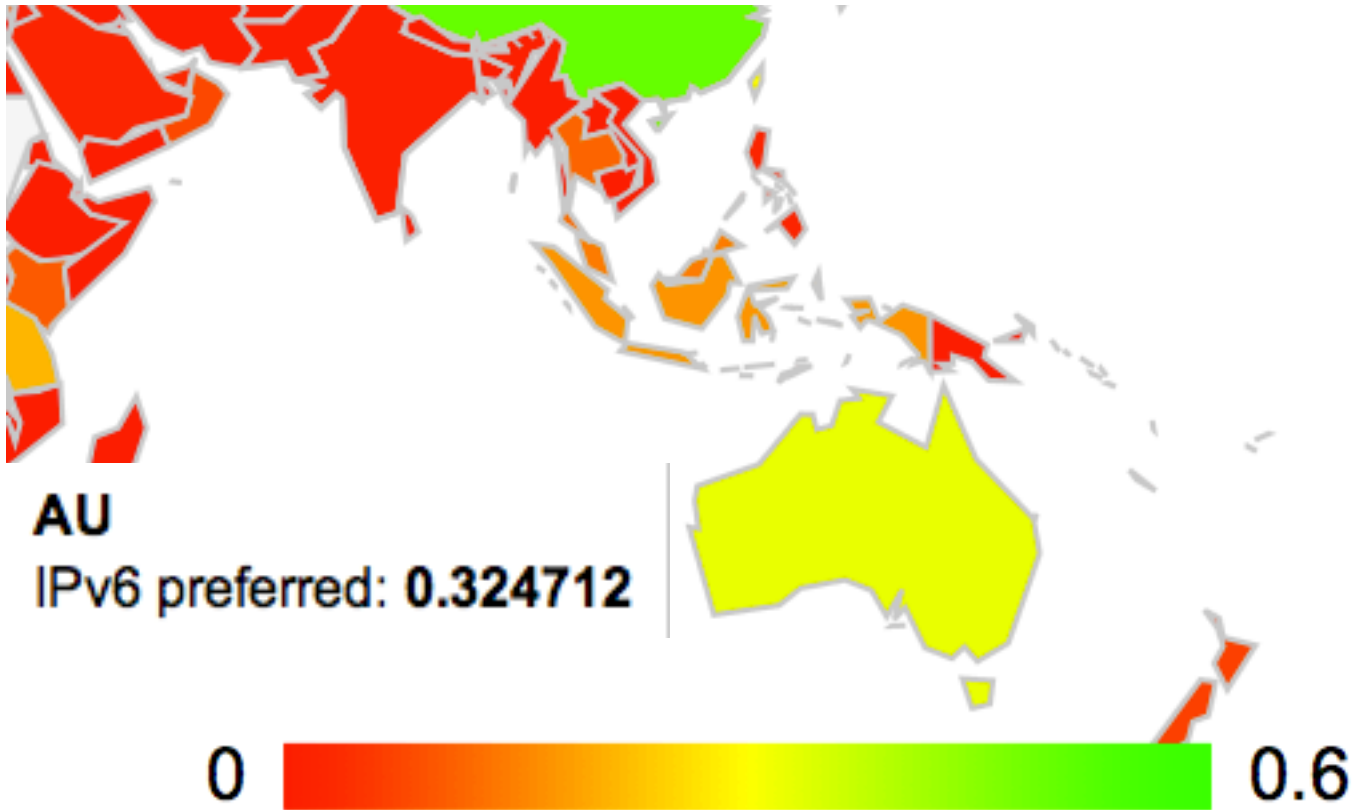
- http://labs.apnic.net/ipv6_measurement
 - Breakdowns by ASN, Economy, Region, Organisation
 - JSON and CSV datasets for every graph produced, on a stable URL
 - Coming soon: single fetch of the dataset for bigtable map/reduce
- 125+ economies provide >200 samples/interval consistently in weeklies, 150+ at monthlies.
 - Law of diminishing returns as more data collected
 - 200 is somewhat arbitrary, but provides for 0.005 level measure if we get one-in-200 hit.
 - Beyond this, data is insufficient to measure lowside IPv6 preference

Google visualization API



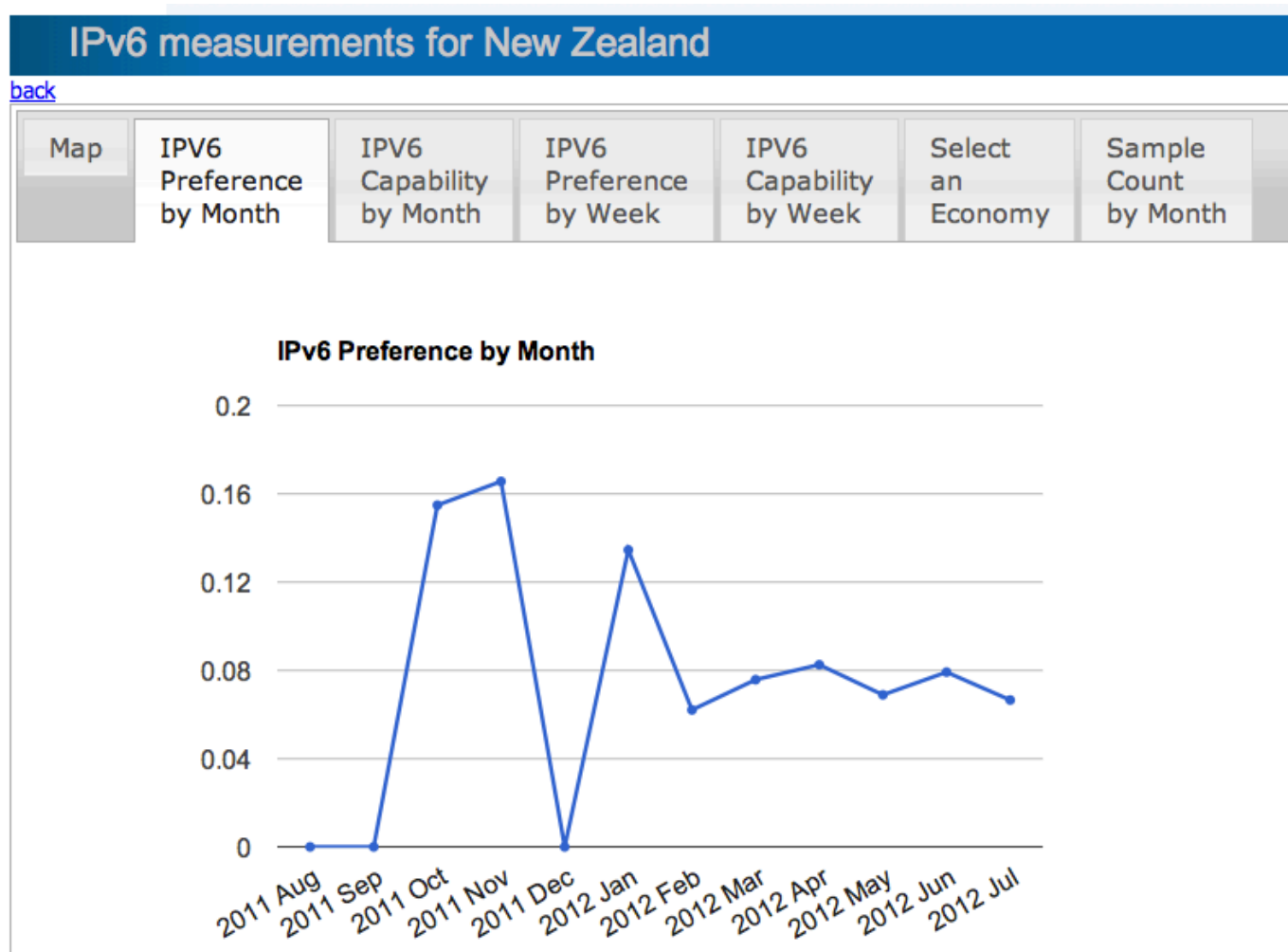
GLE

Google visualization API



NZ
IPv6 preferred: **0.0665299**

Google visualization API



IPv6 measurement

- Penetration rate of IPv6 into the global AS economy is slow
- No signs of ‘game changer’ flip to IPv6 at the end-user yet
- Widely distributed hop-over for IPv6 being seen.
 - due to the CPE gap ?
 - Even IPv6 enabled ISPs have customers tunnelling over the air-gap
- Much more information about IPv6, global internet behaviour is in the data
 - “watch this space” –long-term investment in measurement, ongoing.
 - Better datasets, BigTable map/reduce
 - Collaborations with “the usual suspects” to extend the experiment

Conclusions

Understand **WHY** you want to conduct a measurement exercise

Understand the **LIMITATIONS** of any measurement program

Understand the **CONTEXT** of the measurement

You can either take your data and bend the analysis to suit today's question

Or try and understand what data sets and measurement methodology might directly address your question

Thank You



Discussion?