Network Analytics

Geoff Huston, George Michaelson
APNIC
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...
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- Sustained Throughput
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What are you trying to measure?
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?

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)
Anatomy of a web page fetch (1990s)

- Client issues HTTP connect
- Client issues “GET”
- Client receives HTML stream in HTTP
- Client disconnects
- Server listens
- Server accepts
- Responds 200 ok
- Server receives, finds URL on disk, sends contents
- Server exits and back to listen()
Anatomy of a web page
fetch (2010s)
Anatomy of a web page fetch (2010s)

- User visits URL in browser
- Cached content pre-displayed
- Cookies, JavaScript, Flash runs, decides what to display to user
- Web page viewable
- Maybe never Complete

- Client issues several HTTP connects in parallel
- Client does handshake over capabilities, header checks, tries to find cached content
- Client receives HTML stream in HTTP
- Client disconnects

- Server listens
- Server accepts
- Server exits and back to listen()
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

- It's not really a user metric
  - It’s not that bad
  - But it's not that useful either
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
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!
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

Unique IPs via Ads

Unique IPs via Web Sites
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](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
Google visualization API

AU
IPv6 preferred: 0.324712

NZ
IPv6 preferred: 0.0665299
Google visualization API

IPv6 measurements for New Zealand

<table>
<thead>
<tr>
<th>Map</th>
<th>IPV6 Preference by Month</th>
<th>IPV6 Capability by Month</th>
<th>IPV6 Preference by Week</th>
<th>IPV6 Capability by Week</th>
<th>Select an Economy</th>
<th>Sample Count by Month</th>
</tr>
</thead>
</table>

IPv6 Preference by Month

![IPv6 Preference by Month graph](image)

- 2011 Aug
- 2011 Sep
- 2011 Oct
- 2011 Nov
- 2011 Dec
- 2012 Jan
- 2012 Feb
- 2012 Mar
- 2012 Apr
- 2012 May
- 2012 Jun
- 2012 Jul
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?