What’s the question?

How many users do <x>?

- How many users can retrieve a URL using IPv6?
- How many users perform DNSSEC validation when they resolve a domain name?
- How many users follow DNAME chains in the DNS etc
“Measurable” Questions

• How much traffic uses IPv6?
• How many connections use IPv6?
• How many routes are IPv6 routes?
• How many service providers offer IPv6?
• How many domain names have AAAA RRs?
• How many domains are DNSSEC signed?
• How many DNS queries are made over IPv6?
...

Users vs Infrastructure

• None of these specific measurement questions really embrace the larger questions about the end user behaviour
• They are all aimed at measuring an aspect of behaviour within particular parameters of the network infrastructure, but they don’t encompass how the end user assembles a coherent view of the network
For example… IPv6

• To make an IPv6 connection everything else (routing, forwarding, DNS, transport) has to work with IPv6

• So can we measure how many connected devices on today’s Internet are capable of making IPv6 connections?
How to measure a million end users for their IPv6 capability
How to measure a million end users for their IPv6 capability

• Be Google (or any other massively popular web service provider)
How to measure a million end users for their IPv6 capability

• Be Google (or any other massively popular web service provider)
  – And insert measurement code on the web page that is executed as part of the page load
How to measure a million end users for their IPv6 capability

• Be Google (or any other massively popular web service provider)

or
How to measure a million end users for their IPv6 capability

• Be Google (or any other massively popular web service provider)

or

• Get your code to run on a million users’ machines through another delivery channel
Ads are ubiquitous
Ads are ubiquitous
Ads are ubiquitous
Ads are implemented in Adobe Flash

- Advertising channels use Flash to make ads interactive
  - This is not just an ‘animated gif’
Flash makes ads interactive

- [Apply Now] hover-over is interactive, and responds when selected.
Flash and the network

• Flash includes primitives in ‘actionscript’ to fetch ‘network assets’
  – Typically used to load alternate images, sequences
  – Not a generalized network stack, subject to constraints:
    • Port 80
    • crossdomain.xml on hosting site must match source name (wildcard syntax)

• Flash has asynchronous ‘threads’ model for event driven, sprite animation
APNIC’s measurement technique

• Craft flash/actionscript which fetches network assets to measure.
• Assets are reduced to a notional ‘1x1’ image which is not added to the DOM and is not displayed
• Assets can be named (DNS resolution via local gethostbyname() styled API within the browser’s Flash engine) or use literals (bypass DNS resolution)
• Encode data transfer in the name of fetched assets
  – Use the DNS as the information conduit:
    • Result is returned by DNS name with wildcard
  – Use HTTP as the information conduit
    • Result is returned via parameters attached to an HTTP GET command
Advertising placement logic

• Fresh Eyeballs == Unique IPs
  – We have good evidence the advertising channel is able to sustain a constant supply of unique IP addresses

• Pay by click, or pay by impression
  – If you select a preference for impressions, then the channel tries hard to present your ad to as many unique IPs as possible

• Time/Location/Context tuned
  – Can select for time of day, physical location or keyword contexts (for search-related ads)
  – But if you don’t select, then placement is generalized

• Aim to fill budget
  – If you request $100 of placement a day, then inside 24h algorithm tries hard to even placement but in the end, will ‘soak’ place your ad to achieve enough views, to bill you $100
Advertising placement logic

- **Budget:** $100 per day, at $1.00 ‘CPM’ max
  - Clicks per millepressions: aim to pay no more than $1 per click but pay up to $1 for a thousand impressions

- **Even distribution of ads throughout the day**

- **No constraint on location, time**

- **Outcome:** 350,000 placements per day, on a mostly even placement model with end of day ‘soak’ to achieve budget goal
Ad Placement Training – Day 1
Ad Placement Training – Day 3
Ad Placement Training – Days 5, 6 & 7
Measurement Control Channel

• Use Flash code that is executed on ad impression that retrieves the actual measurement script
  – Ad carries code to send the client to retrieve an ad-controller URL
    http://drongo.rand.apnic.net/measureipv6id.cgi?advertID=9999
  – Client retrieves set of “tests” from the ad-controller as a sequence of URLs to fetch and a “result” URL to use to pass the results to the ad-server

• This allows us to vary the measurement experiment without necessarily altering the ad campaign itself – the ad, and its approval to run, remain unchanged so that measurements can be activated and deactivated in real time.
Experiment Server config

- There are currently three servers, identically configured (US, Europe, Australia)
- Server runs Bind, Apache and tcpdump
- Experiment directs the client to the “closest” server (to reduce rtt-related timeouts) based on simple /8 map of client address to region
Measuring IPv6 via Ads

Client is given 5 URLs to load:

- Dual Stack object
- V4-only object
- V6-only object
- V6 literal address (no DNS needed)
- Result reporting URL (10 second timer)

All DNS is dual stack
Measuring DNSSEC via Ads

Client is given 4 URLs to load:

• DNSSEC-validly signed DNS name
• DNSSEC-invalidly signed DNS name
• Unsigned DNS name (control)
• Result reporting URL (10 second timer)

All DNS is IPv4
Discovering Routing Filters via Ads

Client is given 3 URLs to load:

• DNS name that resolves into the test prefix
• DNS name the resolves to a control prefix
• Result reporting URL (10 second timer)
Caching

• Caching (generally) defeats the intent of the measurement
  – Although some measurements are intended to measure the effects of caching
• We use unique DNS labels and unique URL GET parameters
  – Ensures that all DNS resolution requests and HTTP fetch requests end up at the experiment’s servers
• We use a common “tag” across all URLs in a single experiment
  – Allows us to join the individual fetches to create the per-user view of capability
Collected Data

• Per Server, Per Day:
  – http-access log
    (successfully completed fetches)
  – dns.log
    (incoming DNS queries)
  – Packet capture
    All packets
Collected Data

Web Logs:

h.labs.apnic.net 2002:524d:xxxx::524d:xxxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?
t10000.u7910203317.s1367214905.i888.v1794.v6lit
h.labs.apnic.net 2002:524d:xxxx::524d:xxxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?
t10000.u7910203317.s1367214905.i888.v1794.r6.td
h.labs.apnic.net 82.77.xxx.xxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?
t10000.u7910203317.s1367214905.i888.v1794.rd.td
h.labs.apnic.net 82.77.xxx.xxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?
t10000.u7910203317.s1367214905.i888.v1794.r4.td
h.labs.apnic.net 82.77.xxx.xxx [29/Apr/2013:05:55:05 +0000] "GET /1x1.png?
t10000.u7910203317.s1367214905.i888.v1794&rzrdtd-348.zr4td-376.zr6td-316.zv6lit-228

(In this case the client is using 6to4 to access IPv6, and prefers to use IPv4 in a dual stack context)
Collected Data

DNS Logs:
27-Feb-2014 00:00:07.849 queries: client 12.121.116.213#54311 query:
f.t10000.u3934702783.s1393459207.i1022.v6022.47c34.z.dotnxdomain.net IN A -EDC (199.102.79.186)
27-Feb-2014 00:00:07.850 queries: client 12.121.116.213#30544 query:
e.t10000.u3934702783.s1393459207.i1022.v6022.47c33.z.dashnxdomain.net IN A -EDC (199.102.79.186)
27-Feb-2014 00:00:07.851 queries: client 12.121.116.213#55619 query:
d.t10000.u3934702783.s1393459207.i1022.v6022.47c33.z.dotnxdomain.net IN A -EDC (199.102.79.186)
What does this allow?

• In providing an end user with a set of URLs to retrieve we can examine:
  – Protocol behaviour
    e.g.: V4 vs V6, protocol performance, connection failure rate
  – DNS behaviours
    e.g.: DNSSEC use, DNS resolution performance...
The generic approach

- Seed a user with a set of tasks that cause identifiable traffic at an instrumented server
- The user does not contribute measurements
- The server performs the data collection
Collision detection?

There was a thought that this approach could be used to perform collision detection:

Test:

http://<unique_id>-a.TestName.CandidateTLD/1x1.png?<uniqueid>-a
http://<unique_id>-a.TestName.ExistingTLD/1x1.png?<uniqueid>-b
http://results.TestName.ExistingTLD/1x1.png?<uniqueid>?za=<a_result>&zb=<b_result>

Result Analysis:

If the server sees a query for B and NOT A, then we can infer that there is possibly a collision for the use of CandidateTLD between local and globally scoped contexts.
Really?

• But is this collision or the opposite?
• This shows the extent of local zone instances occluding a global zone
• But I thought we were looking for the possibility of global zone delegation altering the behaviour of client applications using / assuming a local zone resolution
• Which looks like the opposite
Furthermore ...

• Is it the use of a local name or the content of local name search lists that is critical here?
• And what name forms trigger the local name resolution function to invoke the local search list to apply to the given name?
• Are we measuring the extent of name collision itself or the extent of deployment of various forms of name resolution with search lists?
What about...

Test:
http://<unique_id>-single-label-name/1x1.png?<uniqueid>-a
http://second-label.<unique_id>-single-label-name/1x1.png?<uniqueid>-b
http://<unique_id>-single-label-name.Existing.domain.name/1x1.png?<uniqueid>-c
http://results.TestName.Existing.domain.name/1x1.png?<uniqueid>?
zg=<a_result>&zb=<b_result>&zc=<c_result>

Question:
If we launched a high volume of ads, then what would we see at a root server?
A few observations

• Measuring what happens at the user level by measuring some artifact or behaviour in the infrastructure and inferring some form of user behaviour is going to be a guess of some form.

• If you really want to measure user behaviour then its useful to trigger the user to behave in the way you want to study or measure.

• The technique of embedding code behind ads is one way of achieving this objective, for certain kinds of behaviours relating to the DNS and to URL fetching.
Questions?

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