Client-Side IPv6 Measurement

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How to measure millions of end devices for their IPv6 capability?
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OR

Have your measurement code run on millions of end devices
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...
Thank you for helping us measure the Internet.
Thank you for helping us measure the Internet.
The Ad Measurement Technique

End user

Ad Server

Authoritative Name Server

Web Server
The Ad Measurement Technique

1. Ad Impression

- End user
- Ad Server
- Authoritative Name Server
- Web Server
The Ad Measurement Technique

2. DNS resolution

Ad Server

Authoritative Name Server

DNS Resolvers

Web Server

End user
The Ad Measurement Technique

1. End user
2. Ad Server
3. Web Fetch
4. Authoritative Name Server
5. Web Server
The Ad Measurement Technique

1. End user
2. Ad Server
3. Authoritative Name Server
4. Web Server
5. 4. Result Web Fetch
What can be scripted

• Not much:
  – `http.FetchImg()`
    i.e. attempt to retrieve a URL

• But that’s enough!
  – It’s EXACTLY what users do!
  – A URL consists of a DNS question and an HTML question
  – What if we point both the DNS and the HTML to servers we run?
  – As long as each Ad execution uses unique names we can push the user query back to our servers
Think of a URL name as a microcoded instruction set directed to programmable DNS and HTTP servers ...
Ad 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
Ad Presentation Volumes

Daily Total Ad Impressions for Google Campaign Group - Month: 09-May to 13-Jun

- Impressions
- Completed
- Incomplete
- Abandoned
Ad Presentations: Countries

Ad Impressions by Country (Top 20) by day

Countries: India, Turkey, United States of America, Indonesia, Russian Federation, Brazil, China, Argentina, Mexico, Vietnam, Bangladesh, Algeria, Ukraine, Pakistan, Italy, Japan, Republic of Korea, France, Taiwan, Colombia.
• The ad presentation is NOT uniform across the Internet’s user population
  – The ad machinery ‘over-presents’ in some countries:
Bias Compensation

• The ad presentation is NOT uniform across the Internet’s user population
  – The ad machinery ‘under-presents’ in some countries:
Bias Compensation

- Use ITU data on Internet users per country as the reference set, and weight the ad results to compensate for ad placement bias.

<table>
<thead>
<tr>
<th>CC</th>
<th>Country</th>
<th>IPv6 Capable</th>
<th>IPv6 Preferred</th>
<th>Samples</th>
<th>Weight</th>
<th>Weighted Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN</td>
<td>India, Southern Asia, Asia</td>
<td>63.64%</td>
<td>62.68%</td>
<td>1,030,515</td>
<td>0.97</td>
<td>1,003,783</td>
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<td>BE</td>
<td>Belgium, Western Europe, Europe</td>
<td>58.89%</td>
<td>58.59%</td>
<td>13,139</td>
<td>1.64</td>
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<td>55.06%</td>
<td>782,992</td>
<td>0.78</td>
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<td>46.80%</td>
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<td>15,228</td>
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<td>TW</td>
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<td>43.06%</td>
<td>95,145</td>
<td>0.42</td>
<td>39,994</td>
</tr>
</tbody>
</table>
Dealing with the data

• Unified web logs, dns query logs, packet capture
• Map individual DNS and HTML transactions using a common experiment identifier
• For example:
  – DNSSEC validation implies:
    • DNS queries include EDNS(0) DNSSEC OK flag set
    • See DNS queries for DNSSEC signature records (DNSKEY / DS)
    • User fetches URL corresponding to a validly signed DNS name
    • User does not fetch URL corresponding to a in validly signed DNS name
What are we measuring?

- IPv6 Adoption
- IPv6 Dual Stack Preference
- IPv6 Performance
- IPv6 Fragmentation Extension header fragility
What are we seeing?
IPv6 Adoption and Preference
IPv6 Preference

IPv6 Per-Country Deployment for AS9500: VODAFONE-TRANSIT-AS Vodafone NZ Ltd., New Zealand (NZ)
IPv6 Performance

V6/V4 RTT Comparison by country (ms)
IPv6 Reliability
But...

It’s not a general purpose compute platform, so it can’t do many things

– Ping, traceroute, etc
– Send data to any destination
– Pull data from any destination
– Use different protocols

This is a “many-to-one” styled setup where the server instrumentation provides insight on the inferred behaviour of the edges
Measurement Ethics

• There is no user consent
• And cookies (even “don’t measurement me!” cookies) are progressively being frowned upon
• Don’t generate large data volumes
• Don’t publish PII
• Don’t use ‘compromising’ URL names
In Summary...

• Measuring what happens at the user level by measuring some artifact or behaviour in the infrastructure and inferring some form of user behaviour is always 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 simple test code behind ads is one way of achieving this objective
  – for certain kinds of behaviours relating to the DNS and to URL fetching