Consolidation Amongst Top Level Domains

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IDS 2022
15 November 2022
Agenda

- Why?
- Some Background
- Visualizing Flows
- Explaining the Visuals
- Examining by Category
- Looking at Interesting Features
- Looking at Changes Over Time
- Take Aways
Premise

- The early Internet boasted decentralization

- Economics has taken over, commodity functions are centralizing

- There is concern that centralization is a threat to the Internet

- Is centralization seen in Internet registries, domains & numbers?
Why Examine This Topic?

- As part of a study of RPKI adoption insight into decision points is desired
  - Observing shared operations guides the analysis of measurements
  - The goal is to understand the pattern of adoption
- While this study is based on a routing study, there are broader uses
  - Understanding the degree of fate-sharing
    - DDoS impacts (beyond the primary target)
    - Failures by one service rolling to others
  - Analysis of deployment patterns
  - Observing changes over time
    - Mergers and Acquisitions change how services are provided
Some Definitions Related to This Talk

- For the purposes of this talk, a top-level domain is either a ccTLD, a gTLD or the first label in the reverse map (327.in-addr.arpa. or Z.ip6.arpa.)
  - (Yes, those reverse map zones don’t exist)

- DNS House is a new term for a DNS-managing platform

- AS House or AS Bloc is a new term for a set of AS numbers operated in a common manner
Structure of a Registry

- **Registry Policy Implementation**
  - Who can register? (How much IPv4?)
  - Account status?

- **The Registry (Database)**
  - Zone files, cryptokeys, DNSSEC may be separate

- **The DNS (DNSSEC)**
  - Lines in configuration files

- **(DNS) Server Hosting**
  - Address space (may be provided by registry or service)

- **Equipment Racks**
  - Location, power, cooling, physical security

- **Connectivity**
  - Interconnections (IXP, transit, anycast)

- **Routing**

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Text file, CSV(Excel), SQL-based; local or cloud
Determination of Houses

- DNS House
  - Based on DNS Start of Authority (SOA) resource records and the published contents of the IANA root zone data base
  - TLD “front offices” are connected to a DNS House (or platform)

- AS House
  - Based on name server network address routing information
  - Zones are connected from DNS Houses to AS Houses (or AS blocs)

- A zone can be run by only one DNS House but may be published on servers in many AS houses
The Visualizations

- The visualizations are data-driven but are more like abstract art than a chart or graph
  - Beware of drawing specific conclusions as some data is the result of manual updates to databases
  - Names that appear in the charts are either from public databases or heuristically simplified, they do not necessarily reflect commercially-used (corporate) names
  - Keep in mind that sometimes plot drawing libraries may introduce accidental effects (especially when it comes to coloring elements)
  - These charts do not track merger & acquisitions (M&A), they reflect systems in transition. I.e., a corporate purchase may be announced one day, with many months of technical transitions to follow
All gTLDs, ccTLDs and reverse map, 1 November 2022

- Left: Zones “stacked”, ordered by their DNS house
- Middle: DNS houses, sorted by number of zones managed
- Right: AS blocs, sorted by number of zones
All gTLDs, ccTLDs and reverse map, 1 November 2022

Zones

DNS Houses

AS Houses

For 1 November 2022
Comparison to a Conventional Chart of AS House size (1 Nov 2022)

Excel-generated chart, “not useful”: the X-axis is incomplete
## In Numbers, by DNS (1 November 2022)

<table>
<thead>
<tr>
<th>Total Zones</th>
<th>gTLDs</th>
<th>ccTLDs</th>
<th>Reverse Map</th>
<th>DNS House</th>
</tr>
</thead>
<tbody>
<tr>
<td>427</td>
<td>413</td>
<td>14</td>
<td>0</td>
<td>hostmaster.donuts.email./noc.afilias-nst.info.</td>
</tr>
<tr>
<td>226</td>
<td>223</td>
<td>3</td>
<td>0</td>
<td>admin.tldns.godaddy./dnsmaster.knipp.de.</td>
</tr>
<tr>
<td>125</td>
<td>123</td>
<td>2</td>
<td>0</td>
<td>info.verisign-grs.com./nstld.verisign-grs.com.</td>
</tr>
<tr>
<td>113</td>
<td>107</td>
<td>6</td>
<td>0</td>
<td>hostmaster.centralnic.net./support.nic.coop.</td>
</tr>
<tr>
<td>104</td>
<td>0</td>
<td>0</td>
<td>104</td>
<td>dns-ops.arin.net.</td>
</tr>
<tr>
<td>67</td>
<td>66</td>
<td>1</td>
<td>0</td>
<td>hostmaster.nic.uk./hostmaster.nominet.org.uk.</td>
</tr>
<tr>
<td>65</td>
<td>0</td>
<td>0</td>
<td>65</td>
<td>dns.ripe.net.</td>
</tr>
<tr>
<td>62</td>
<td>0</td>
<td>0</td>
<td>62</td>
<td>read-txt-record-of-zone-first-dns-admin.apnic.net.</td>
</tr>
<tr>
<td>47</td>
<td>47</td>
<td>0</td>
<td>0</td>
<td>noc.gmoregistry.net.</td>
</tr>
<tr>
<td>46</td>
<td>46</td>
<td>0</td>
<td>0</td>
<td>cloud-dns-hostmaster.google.com.</td>
</tr>
<tr>
<td>21</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>td_dns_gtld.knet.cn.</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>dnsmaster.corenic.org.</td>
</tr>
<tr>
<td>19</td>
<td>13/18</td>
<td>6/1</td>
<td>0</td>
<td>“tie”: “AFNIC” and “uniregistry”</td>
</tr>
</tbody>
</table>

Long tail: Out of 256 total houses: 237 have fewer than 10; of those 177 houses have 1; 38 houses have 2
In Numbers, by AS (1 November 2022)

<table>
<thead>
<tr>
<th>Total Zones</th>
<th>gTLD Zones</th>
<th>ccTLD Zones</th>
<th>Reverse Map</th>
<th>AS House/Bloc</th>
</tr>
</thead>
<tbody>
<tr>
<td>451</td>
<td>419</td>
<td>16</td>
<td>16</td>
<td>US-AFILIAS1</td>
</tr>
<tr>
<td>429</td>
<td>415</td>
<td>14</td>
<td>0</td>
<td>IE-AFILIAS</td>
</tr>
<tr>
<td>376</td>
<td>342</td>
<td>34</td>
<td>0</td>
<td>US-ULTRADNS</td>
</tr>
<tr>
<td>350</td>
<td>22</td>
<td>136</td>
<td>192</td>
<td>US-WOODYNET</td>
</tr>
<tr>
<td>291</td>
<td>1</td>
<td>34</td>
<td>256</td>
<td>NL-RIPE</td>
</tr>
<tr>
<td>256</td>
<td>0</td>
<td>0</td>
<td>256</td>
<td>US-ARIN</td>
</tr>
<tr>
<td>227</td>
<td>121</td>
<td>2</td>
<td>104</td>
<td>US-VERISIGN</td>
</tr>
<tr>
<td>168</td>
<td>0</td>
<td>16</td>
<td>152</td>
<td>AP-APNIC</td>
</tr>
<tr>
<td>152</td>
<td>0</td>
<td>0</td>
<td>152</td>
<td>UY-LACNIC</td>
</tr>
<tr>
<td>136</td>
<td>20</td>
<td>60</td>
<td>56</td>
<td>SE-NETNOD</td>
</tr>
<tr>
<td>121</td>
<td>109</td>
<td>12</td>
<td>0</td>
<td>GB-CENTRALNIC</td>
</tr>
<tr>
<td>71</td>
<td>66</td>
<td>5</td>
<td>0</td>
<td>GB-NOMINET</td>
</tr>
</tbody>
</table>

Note: All zones served by IE-AFILIAS are also served by US-AFILIAS.

Long tail: Out of 284 total houses: 261 have fewer than 10; of those 139 houses have 1; 70 houses have 2
Understanding the Visualization

- The next few slides will show simpler environments
  - The familiar “com/net/org”
  - ”.SE” (Swedish ccTLD) set up

- These examples may provide a good orientation
<table>
<thead>
<tr>
<th>Zones</th>
<th>DNS Houses</th>
<th>AS Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORG.</td>
<td>“donuts/afilias”</td>
<td>“AFILIAS”</td>
</tr>
<tr>
<td>COM.</td>
<td>“verisign-grs”</td>
<td>“AFILIAS”</td>
</tr>
<tr>
<td>NET.</td>
<td></td>
<td>“VERISIGN”</td>
</tr>
</tbody>
</table>

- COM & NET, run “in-house” by Verisign
- ORG, administered by PIR is operated on a Donuts/Afilias platform
- Names are taken from on-line databases
- One AS House does not mean one network nor only one AS number
dotSE

- .SE, the Swedish ccTLD
- Uses 6 AS blocs, their own, other ccTLDs, and more

Zones

DNS Houses

AS Houses

For 1 November 2022
Difference between gTLD, ccTLD, reverse map

- The next few visualizations use a familiar divide
  - gTLD registries
  - ccTLD registries
  - reverse map zones (RIRs)
gTLD

- The long tail isn’t all that long
- Group of large DNS Houses as well as AS Houses
- Evidence of “economy of scale”
ccTLD

- Very different structure
- Almost all long-tail
- Names are short or have “--” visible in them
- Largest DNS House is due to IDN ccTLDs for India
- Largest AS Houses are those not affiliated with registries

Zones | DNS Houses | AS Houses

Only ccTLDs | | For 1 November 2022
Reverse map

- RIRs plus a few operators of (mostly) legacy IPv4 class A space
- RIRs (and ICANN) before the (short) tail
- A lot of sharing of AS bloc infrastructure
Highlighting RIRs and a few AS Blocs

- When looking at the overall picture a few features standout
  - Flows related to the RIRs
  - The “shortness” of names in the long tail
  - The prevalence of three AS blocs serving the long tail
All gTLDs, ccTLDs and reverse map, 1 November 2022

• You’ve seen this before...

Zones

DNS Houses

AS Houses

For 1 November 2022
All gTLDs, ccTLDs and reverse map, with color, 1 November 2022

...but now with color to separate the structures
- Red, tan, orange, silver for the 4 visible RIRs
- Green, blue for AS blocs that serve much of the long tail
Comparing 1 Nov 2022 and 4 May 2021

- Over time – what does this look like?
  - Comparing 1 Nov 2022 with 1 Nov 2021 – no change
  - But going back to May 2021 shows shifts in the industry
    - 4 May 2021 is the oldest date in the current data set
All gTLDs, ccTLDs and reverse map, 1 November 2022

Zones

DNS Houses

AS Houses

- You’ve seen this before...
- ...before...

For 1 November 2022
For those who follow the industry, names have changed, order shuffled a bit.
“If We Still Have Time” Slides

- A few more individual cases
  - ICANN
  - RIPE
  - The other RIRs
  - India and its IDN ccTLDs
Zones managed by ICANN – “Class E” address space and .int

Zones

DNS Houses

AS Houses

Zones administered by noc.dns.icann.org.

For 1 November 2022
in-addr.arpa and ip6.arpa

Zones

DNS Houses

AS Houses

Zones administered by nstid.iana.org.

For 1 November 2022
RIPE managed zones

Zones administered by dns.ripe.net. For 1 November 2022
RIPE served zones

Zones

DNS Houses

AS Houses

Only zones on NL-RIPE ASblock

For 1 November 2022
AFRINIC managed zones

Zones administered by dns-admin.afrinic.net.  

For 1 November 2022
APNIC managed zones

Zones administered by read-txt-record-of-zone-first-

For 1 November 2022
APNIC managed “special” zone

Zones

DNS Houses

dns-admin.apnic.net.

AS Houses

NL-RIPE
AU-APNIC
UY-LACNIC
US-ARIN

Zones administered by dns-admin.apnic.net. For 1 November 2022
ARIN managed zones

Zones administered by dns-ops.arin.net.  
For 1 November 2022
LACNIC managed zones

Zones: 181.in-addr.arpa, 2.1.1.0.0.2.ip6.arpa, 191.in-addr.arpa, 0.8.2.ip6.arpa, 3.1.1.0.0.2.ip6.arpa, 200.in-addr.arpa, 187.in-addr.arpa, 201.in-addr.arpa, 189.in-addr.arpa, 190.in-addr.arpa, 177.in-addr.arpa, 179.in-addr.arpa, 180.in-addr.arpa

DNS Houses: hostmaster.lacnic.net

AS Houses: BR-Núcleo de Inf. e Coord. do

Zones administered by hostmaster.lacnic.net.  For 1 November 2022
India and it’s IDN ccTLD registries

Zones

DNS Houses

dns.registry.in.

AS Houses

US-ULTRADNS

Zones administered by dns.registry.in.

For 1 November 2022
Takeaways

- gTLDs have a few large DNS managers
  - Perhaps the commercial nature of proposals
  - The technical risk in the implementation is mitigated by shared expertise

- ccTLDs exhibit independence managing DNS but rely on a few global hosting providers
  - Perhaps due to the jurisdictional nature
  - The independence empowers innovation in registry services

- revmap community is mostly the RIRs, coordinating amongst themselves
  - Small cluster, where registry policy is far more significant than operating the DNS
Final Thoughts

- I’ve worked for registries over the past two decades, including all kinds represented here
  - None of what is shown in these visualizations surprises me, which is reassuring. As visualizing the data matches my expectations, I have faith in it. Still, it may not be “perfect”

- This isn’t machine learning or “AI”, it’s a helpful tool to assist in further studies
  - After the first “final slides” I used this to determine what operators have done DNSSEC algorithm rollovers, that is identifying zones managed in the same manner. Found some bugs, fixed, this has been the second “final slides”
Engage with ICANN

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