

Consolidation Amongst Top Level Domains



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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

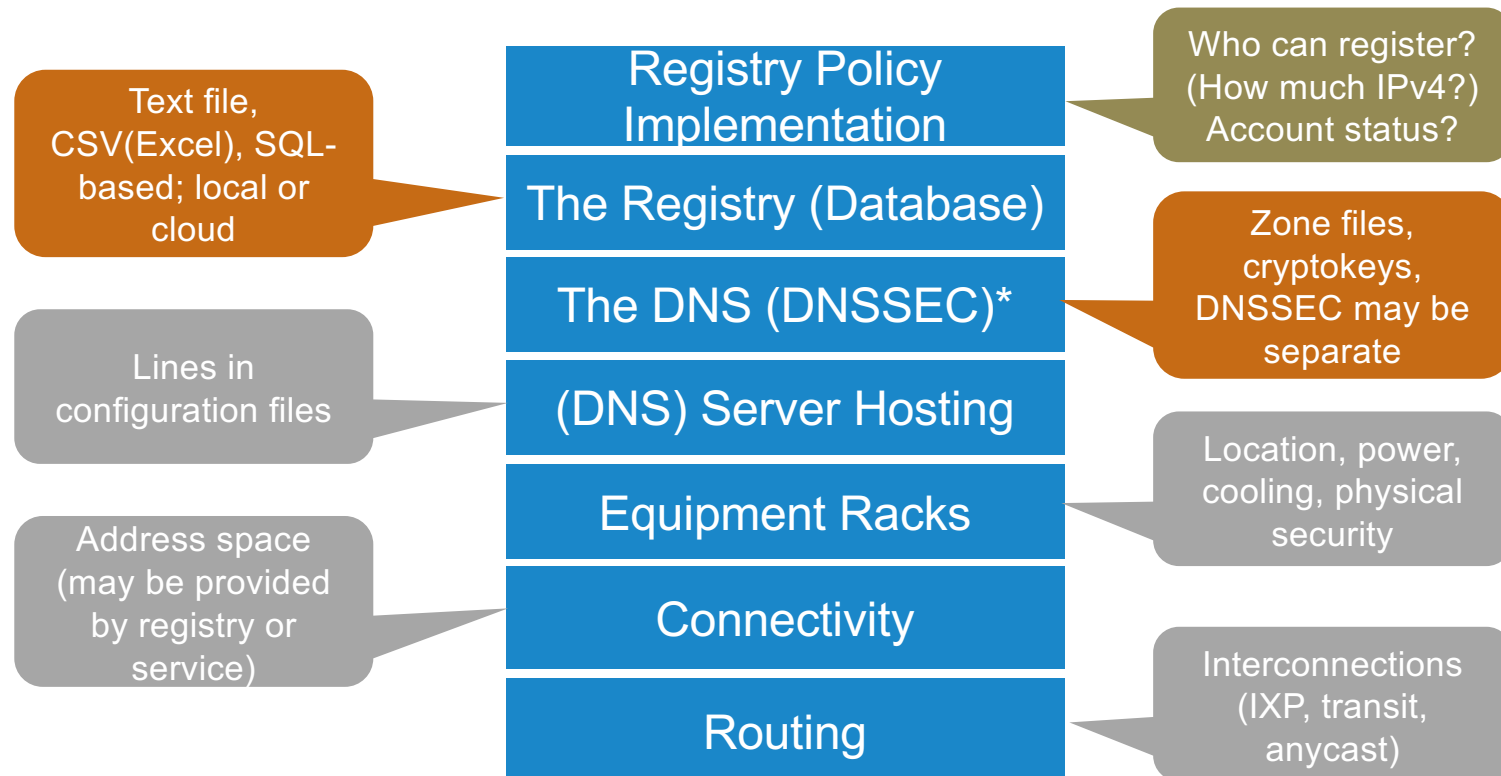
Some Definitions Related to This Talk

- ⦿ 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



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)

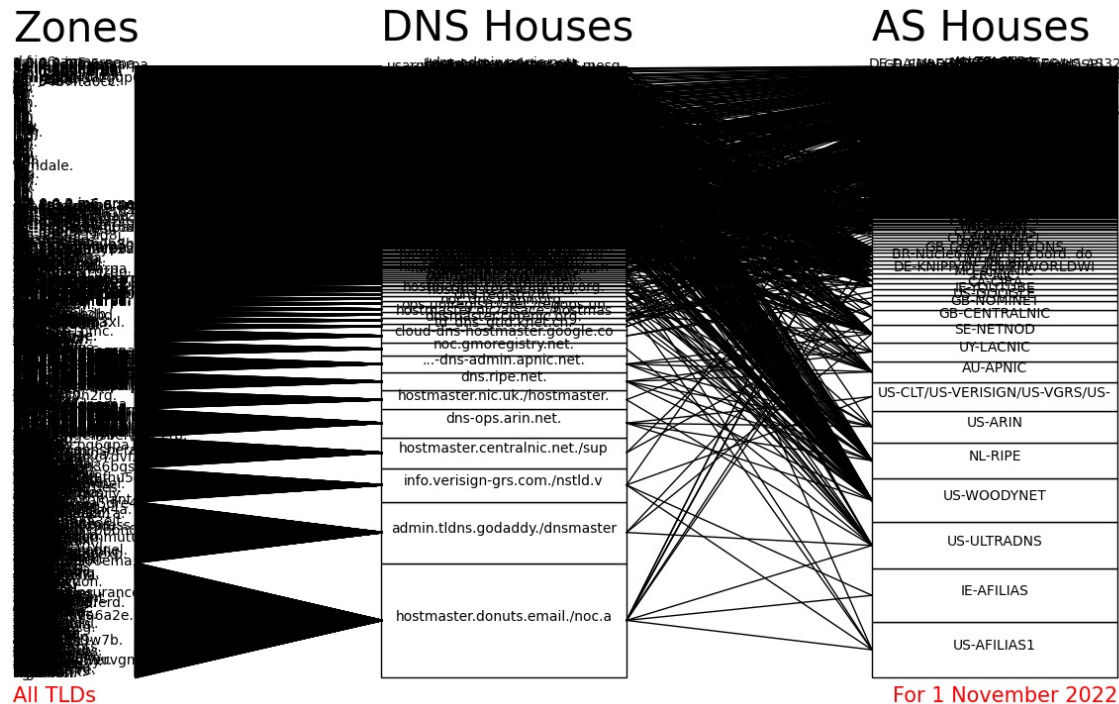
- ⊙ AS House
 - Based on name server network address routing information
 - Zones are connected from DNS Houses to AS Houses (or AS blocs)

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

The Visualizations

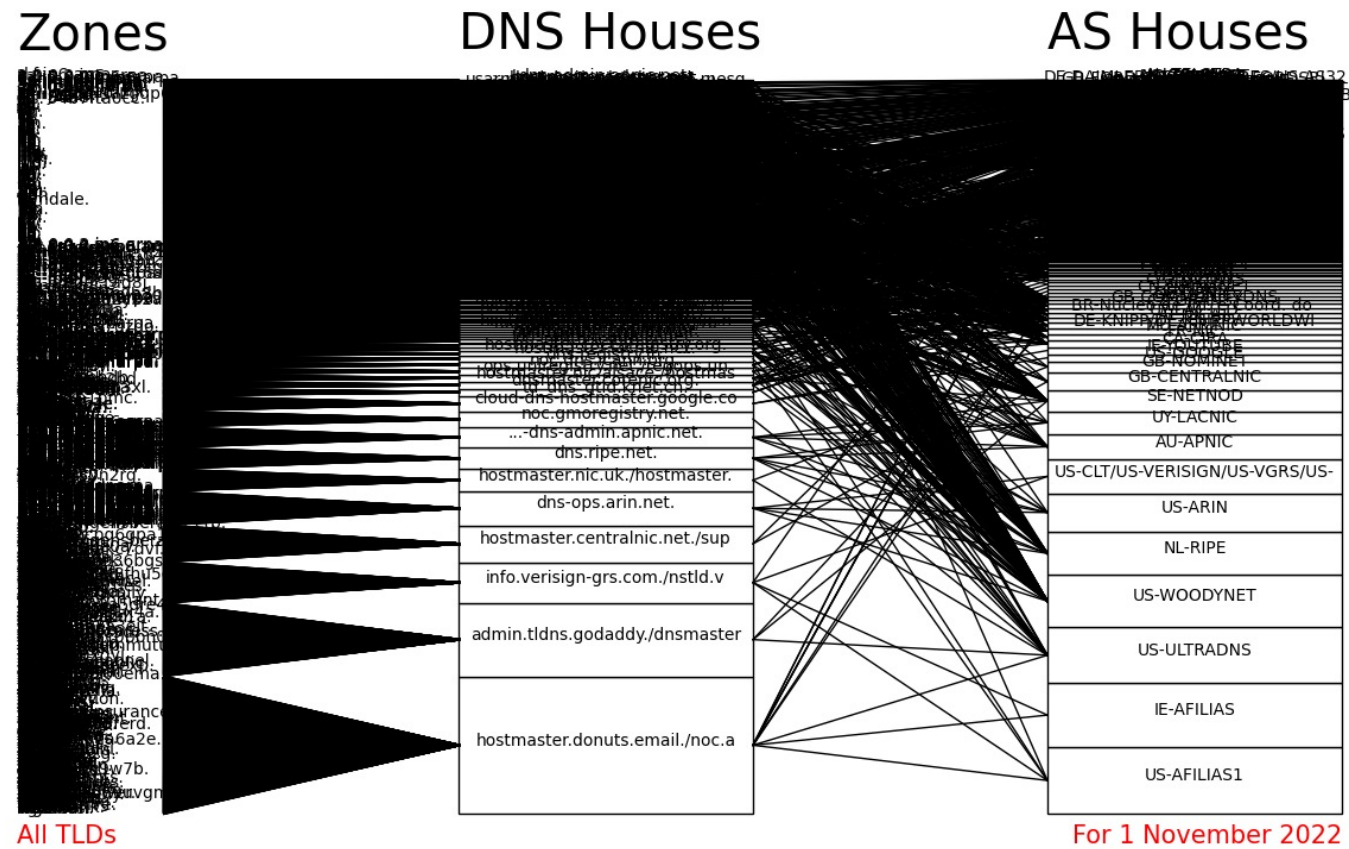
- ⊙ The visualizations are data-driven but are more like abstract art than a chart or graph
 - Beware of drawing specific conclusions as some data is the result of manual updates to databases
 - Names that appear in the charts are either from public data bases or heuristically simplified, they do not 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



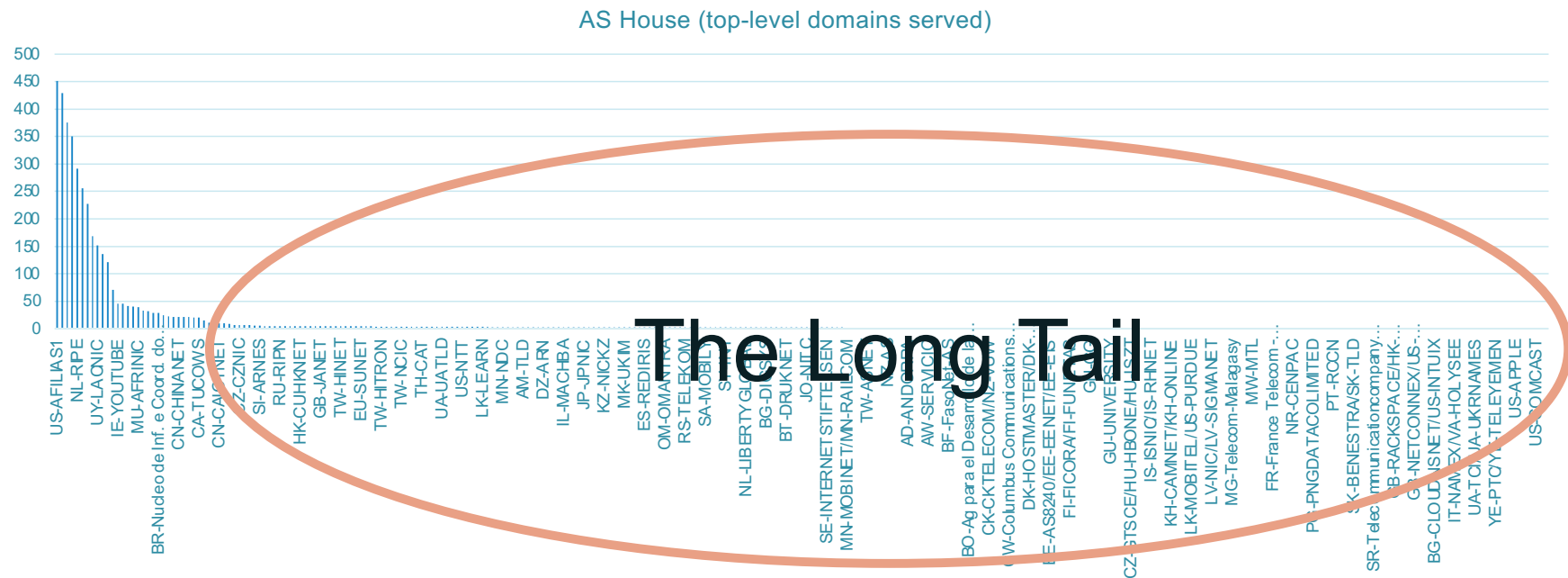
- Left: Zones “stacked”, ordered by their DNS house
- Middle: DNS houses, sorted by number of zones managed
- Right: AS blocs, sorted by number of zones

All gTLDs, ccTLDs and reverse map, 1 November 2022



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)

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

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)

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

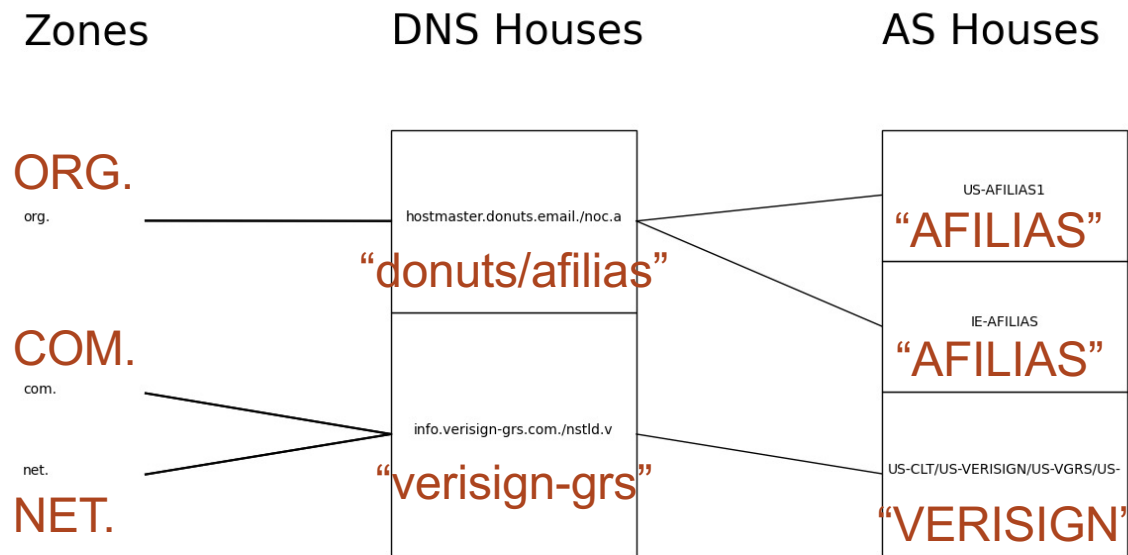
Note: All zones served by IE-AFILIAS are also served by US-AFILIAS.

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

COM/NET/ORG

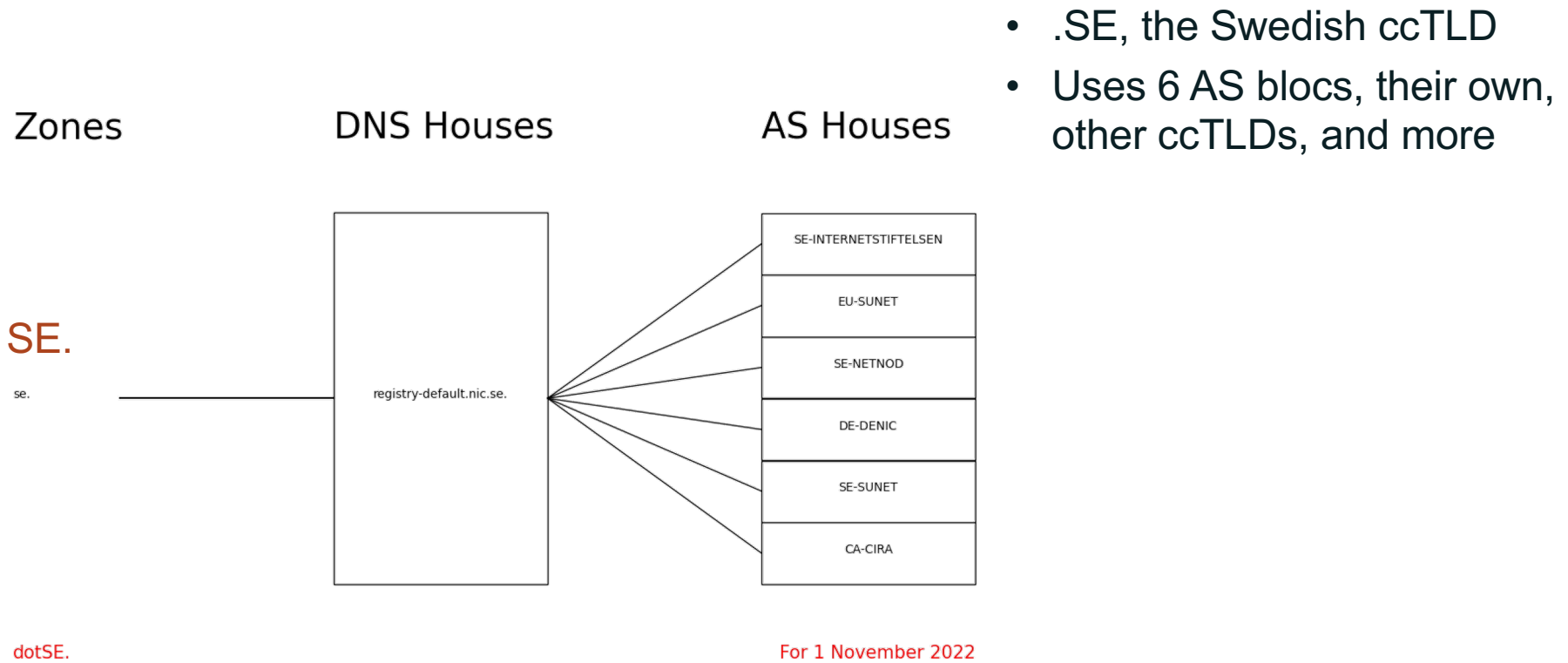


COM/NET/ORG

For 1 November 2022

- 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

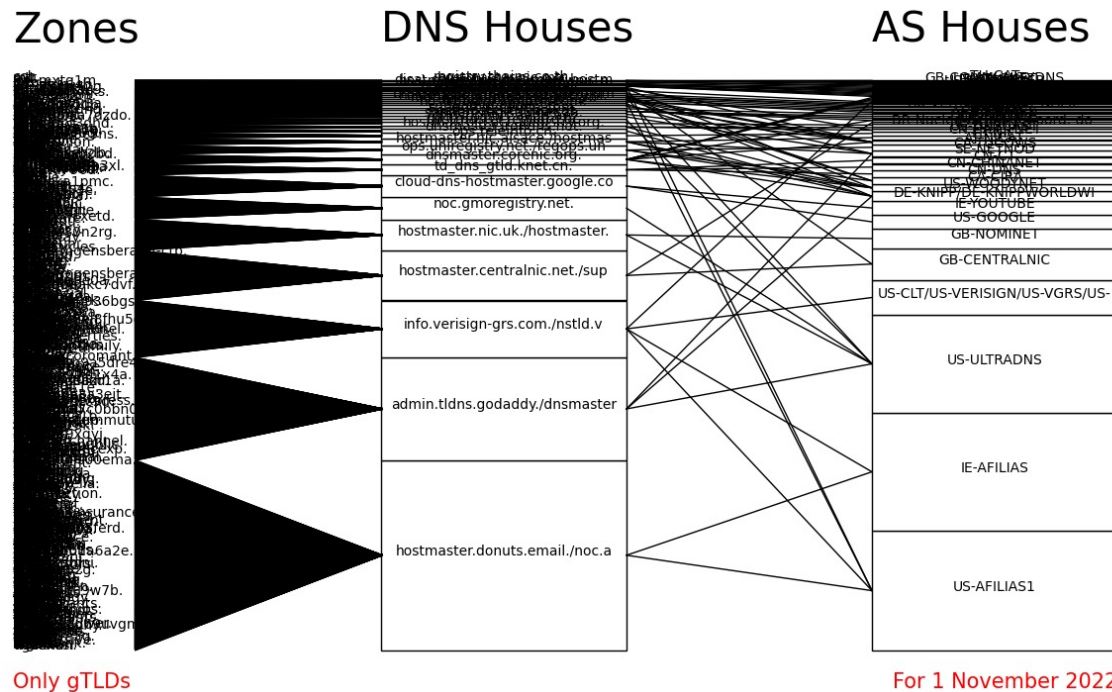
dotSE



Difference between gTLD, ccTLD, reverse map

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

gTLD

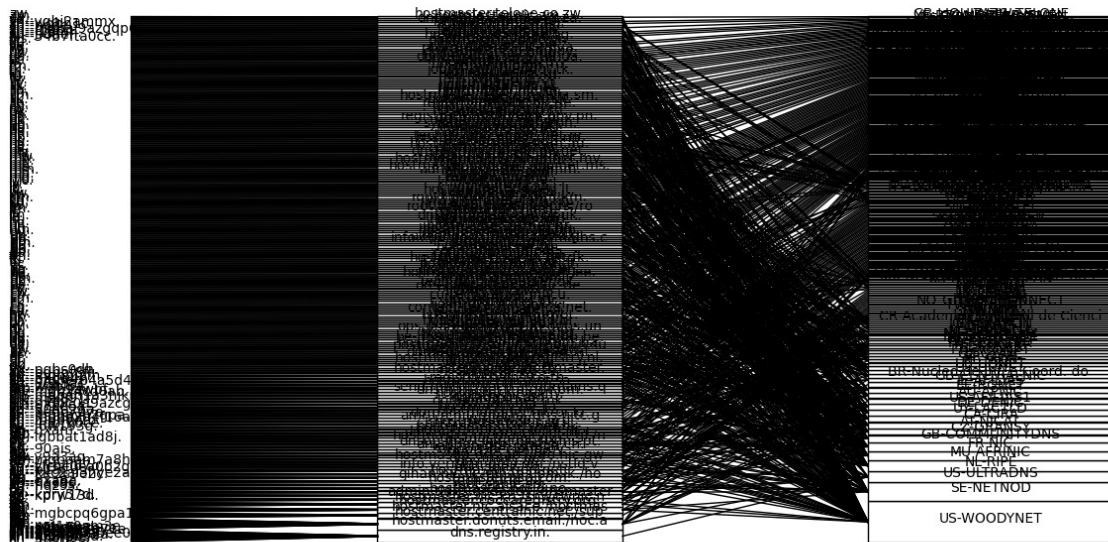


- The long tail isn't all that long
- Group of large DNS Houses as well as AS Houses
- Evidence of “economy of scale”

Zones

DNS Houses

AS Houses

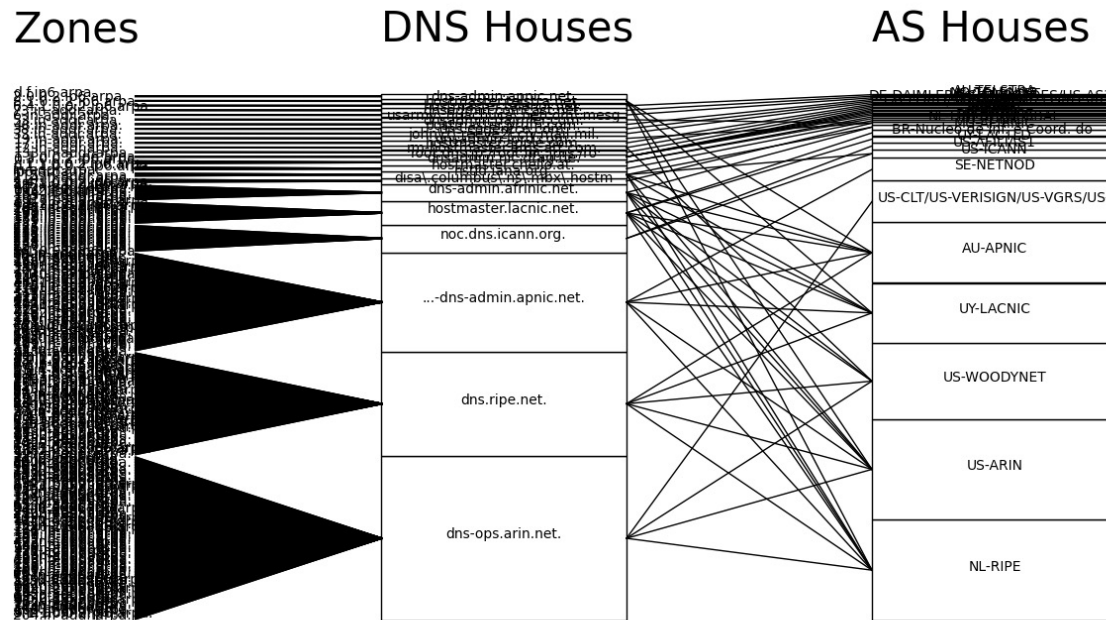


Only ccTLDs

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- 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

Reverse map



Only Reverse Map tops

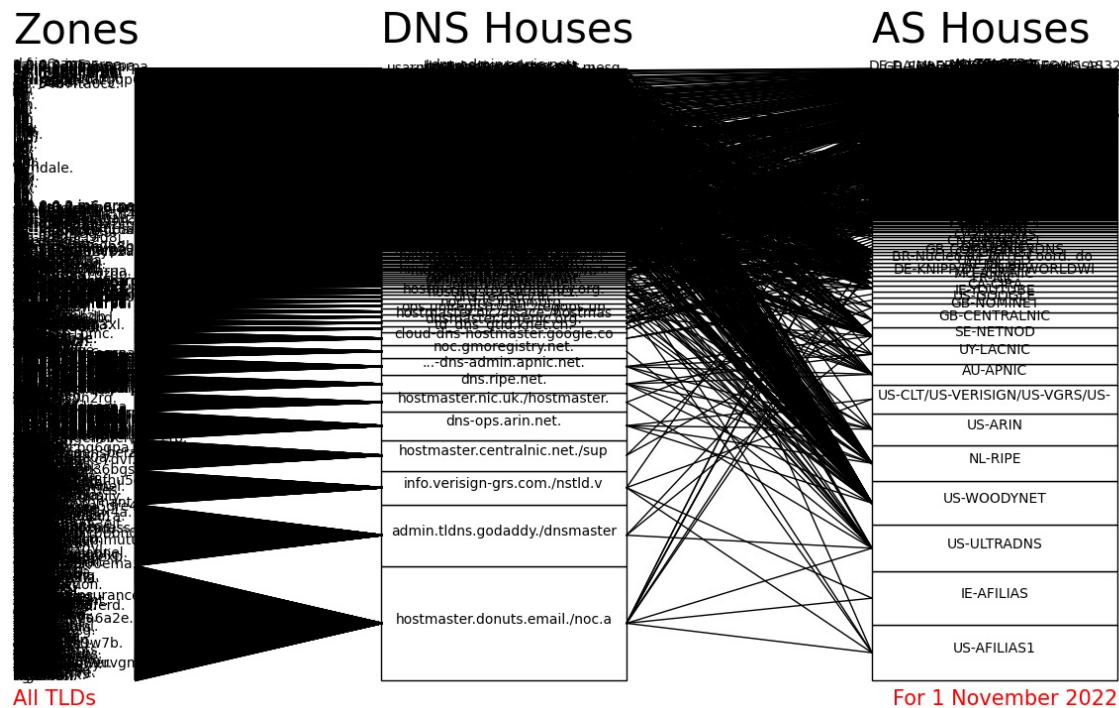
For 1 November 2022

- 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

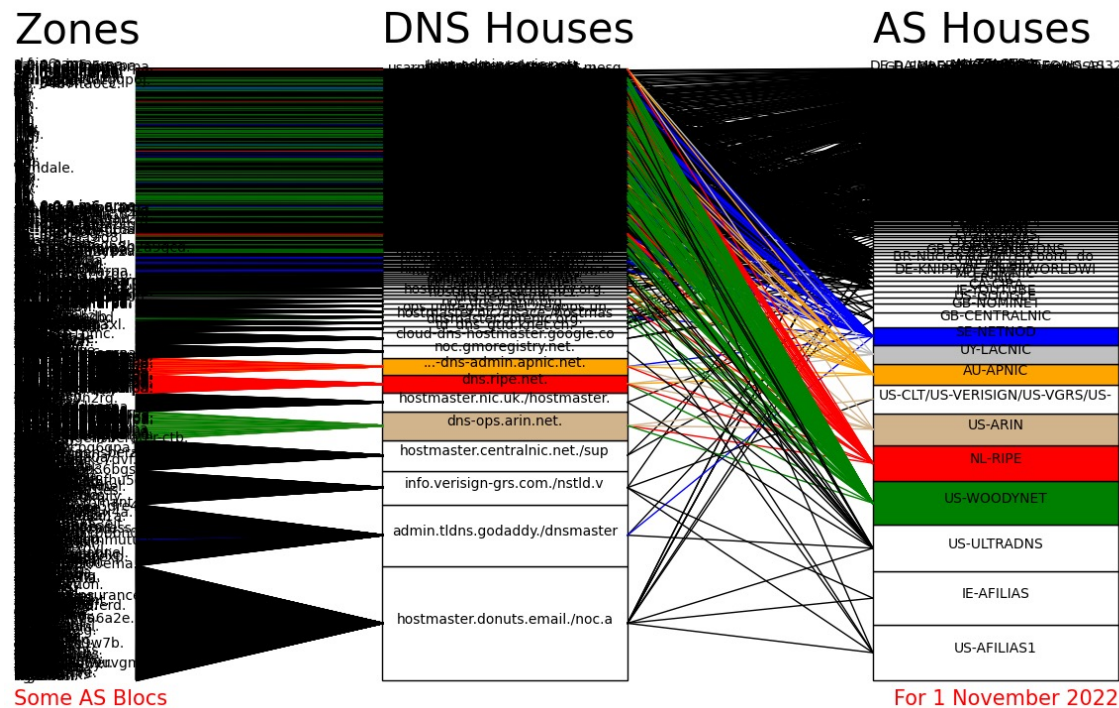
- ◉ When looking at the overall picture a few features stand out
 - Flows related to the RIRs
 - The “shortness” of names in the long tail
 - The prevalence of three AS blocs serving the long tail

All gTLDs, ccTLDs and reverse map, 1 November 2022



- You've seen this before...

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

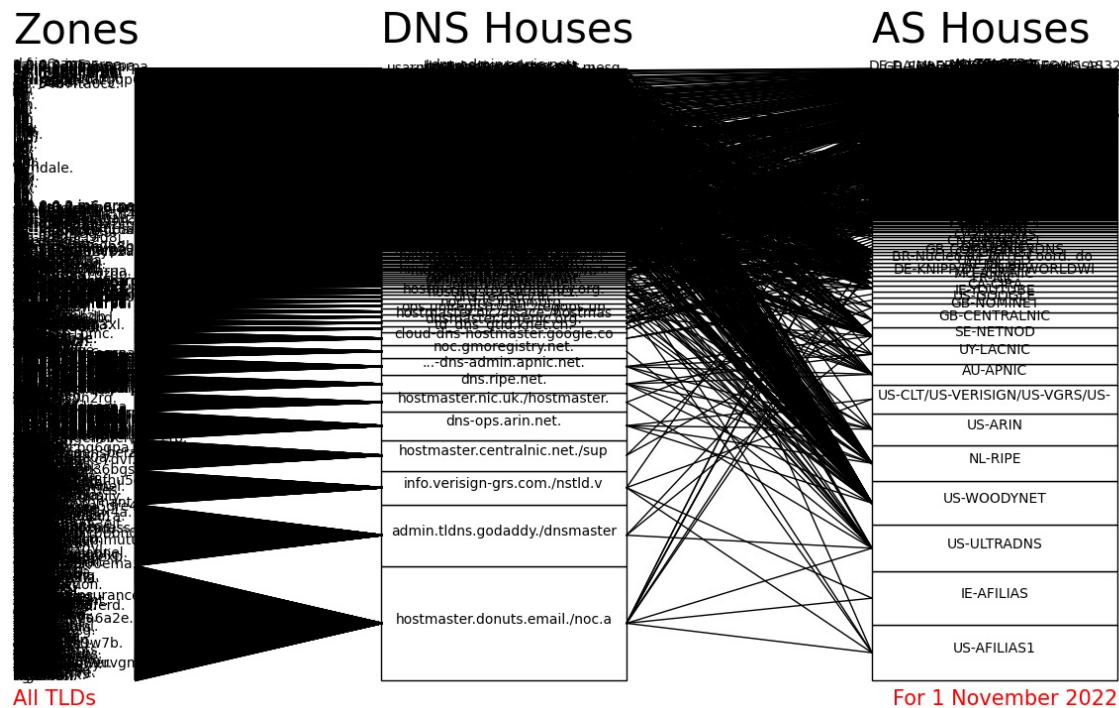


- ...but now with color to separate the structures
- Red, tan, orange, silver for the 4 visible RIRs
- Green, blue for AS blocs that serve much of the long tail

Comparing 1 Nov 2022 and 4 May 2021

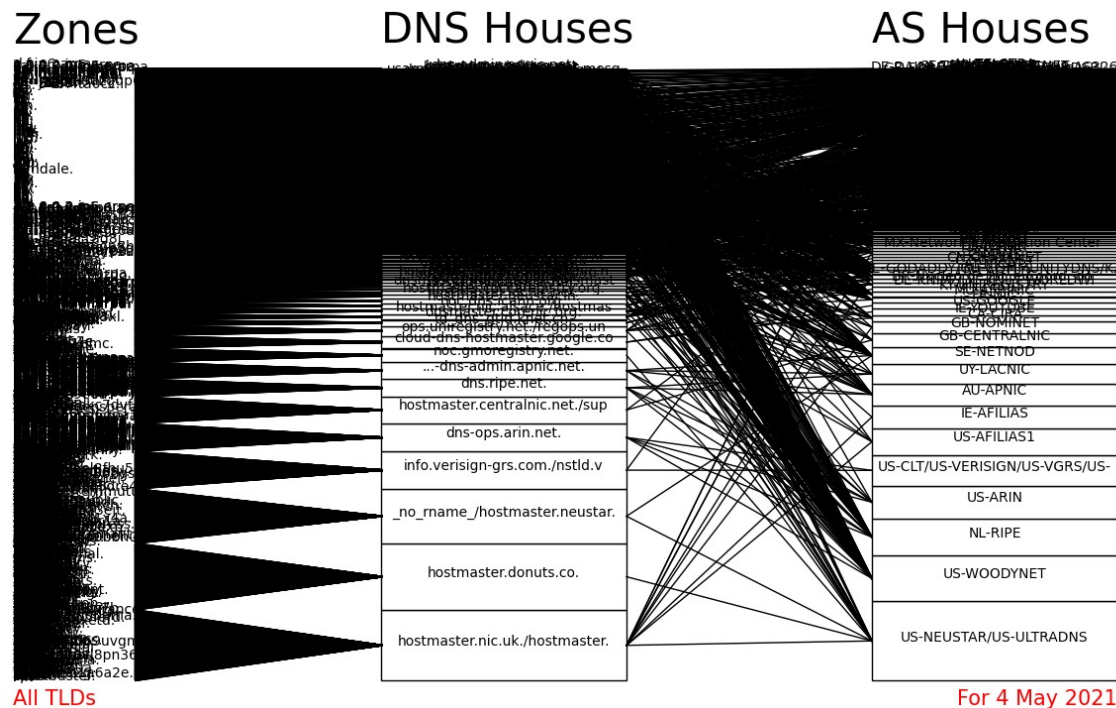
- ⊙ Over time – what does this look like?
 - Comparing 1 Nov 2022 with 1 Nov 2021 – no change
 - But going back to May 2021 shows shifts in the industry
 - 4 May 2021 is the oldest date in the current data set

All gTLDs, ccTLDs and reverse map, 1 November 2022



- You've seen this before...
- ...before...

All gTLDs, ccTLDs and reverse map, 4 May 2021

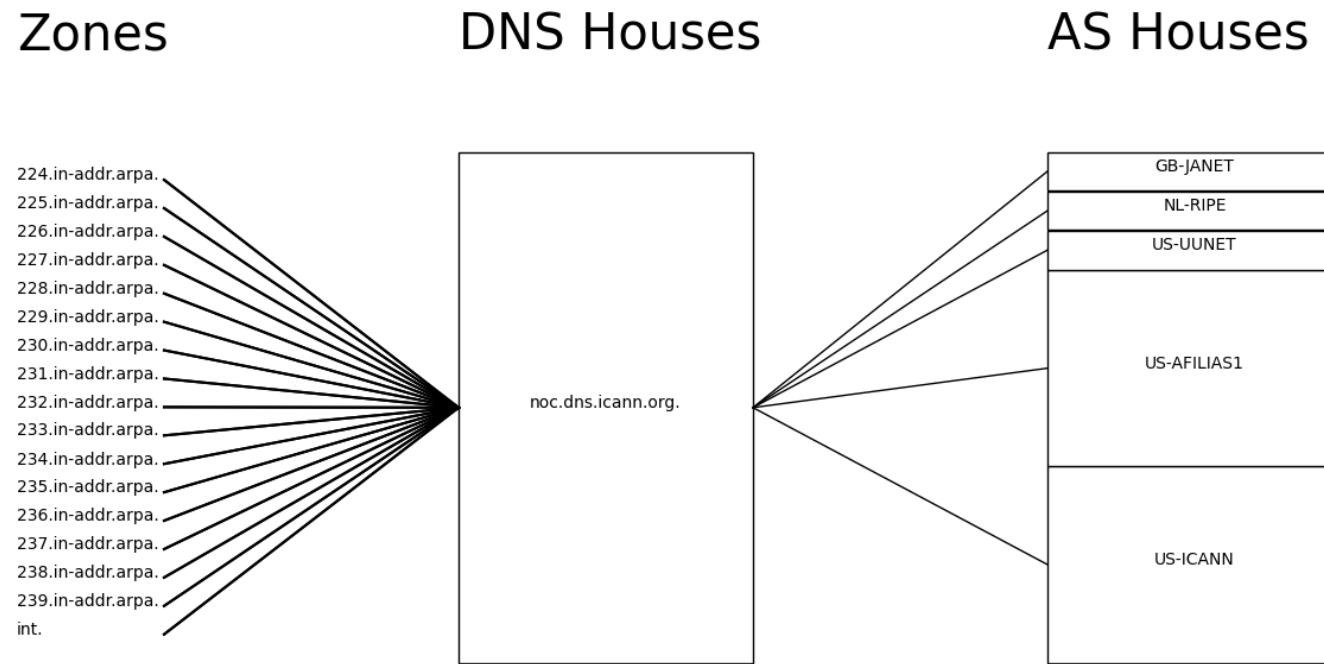


- For those who follow the industry, names have changed, order shuffled a bit

“If We Still Have Time” Slides

- ⊙ A few more individual cases
 - ICANN
 - RIPE
 - The other RIRs
 - India and it's IDN ccTLDs

Zones managed by ICANN – “Class E” address space and .int



Zones administered by `noc.dns.icann.org.`

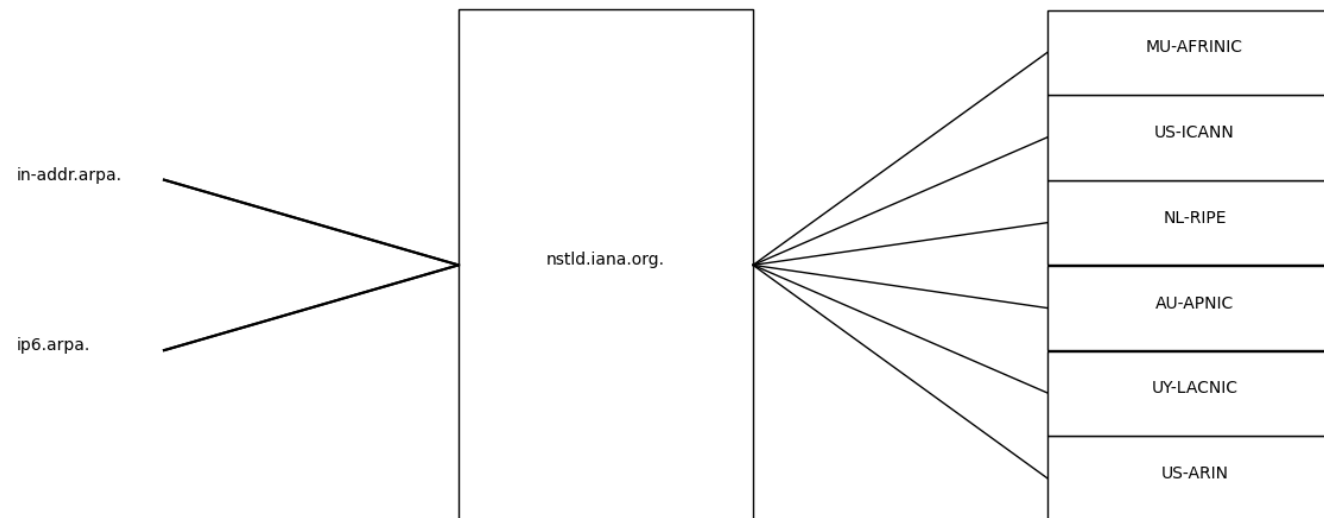
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in-addr.arpa and ip6.arpa

Zones

DNS Houses

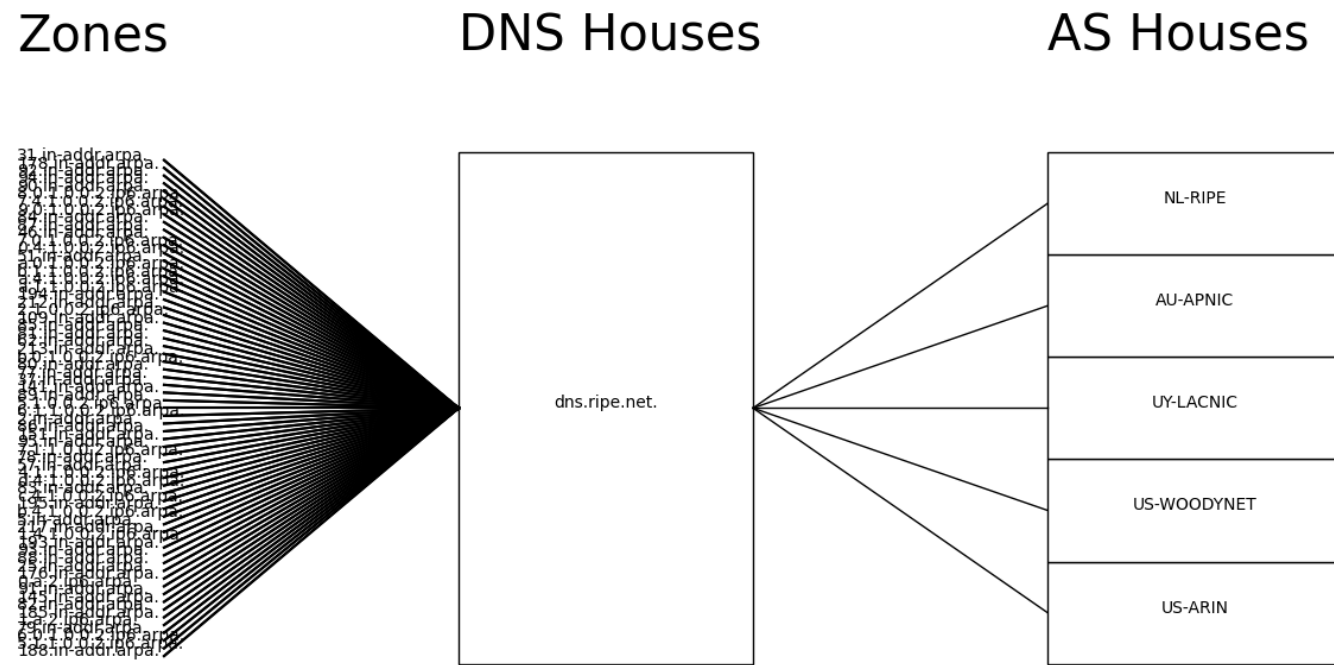
AS Houses



Zones administered by nstld.iana.org.

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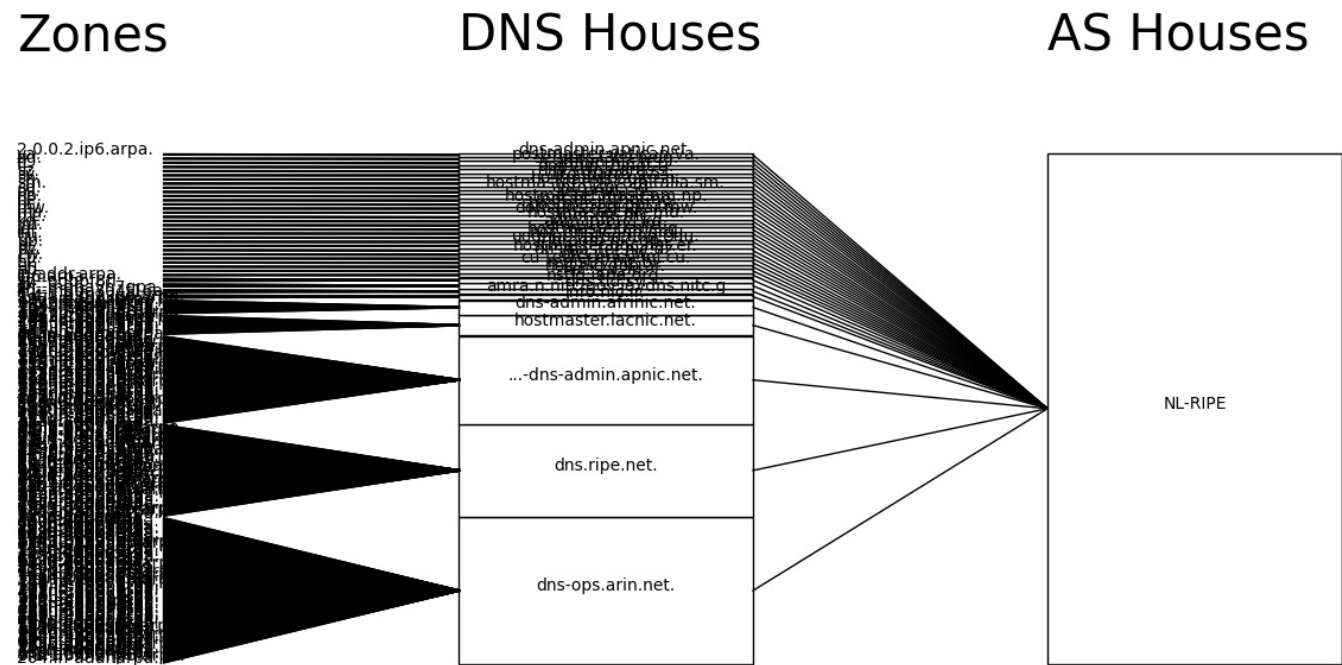
RIPE managed zones



Zones administered by `dns.ripe.net.`

For 1 November 2022

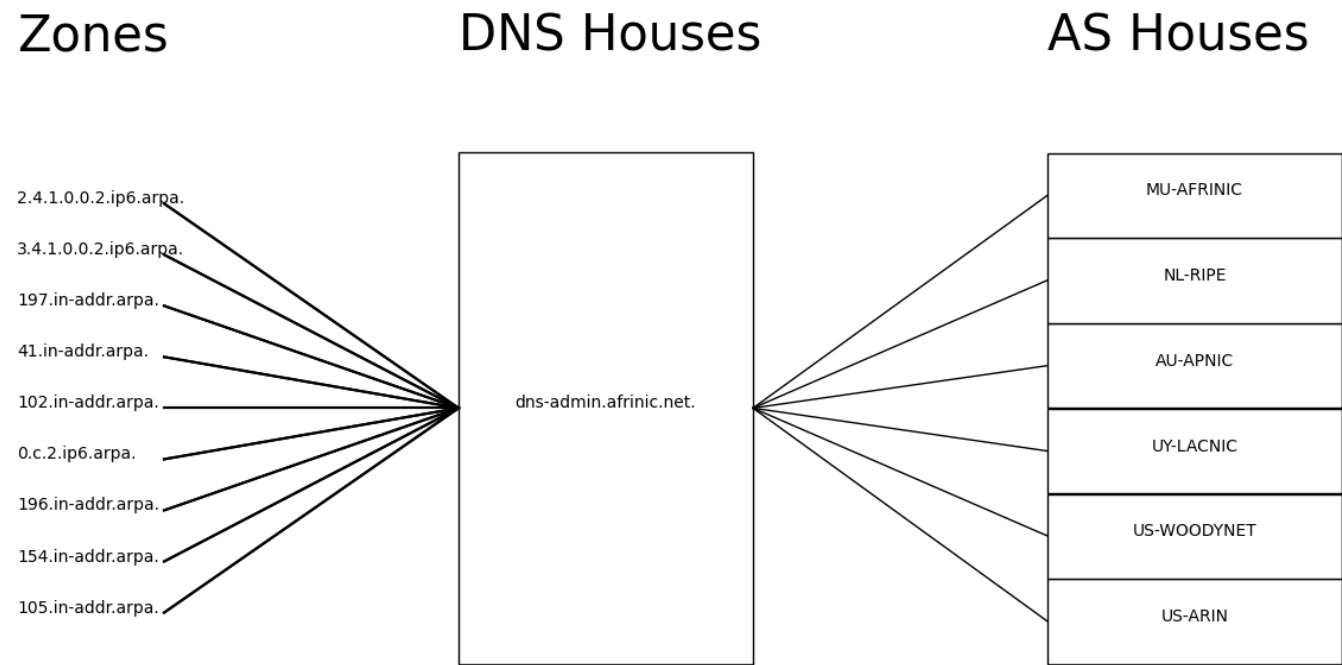
RIPE served zones



Only zones on NL-RIPE ASbloc

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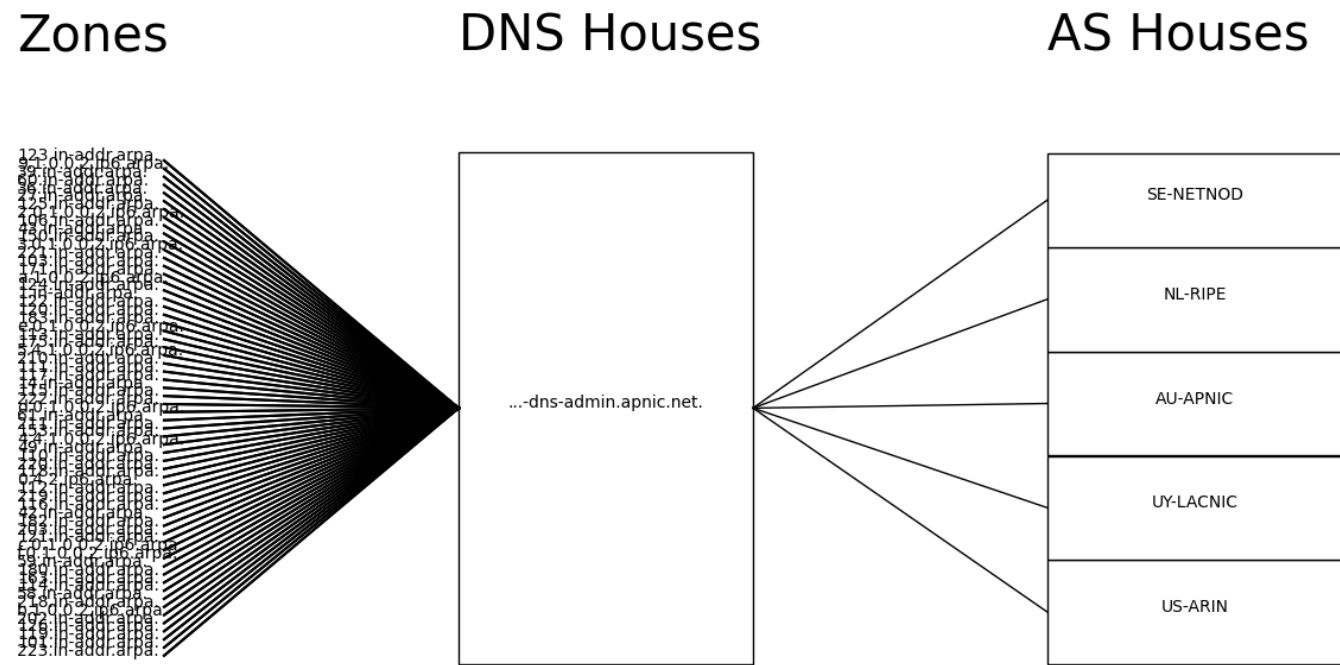
AFRINIC managed zones



Zones administered by `dns-admin.afrinic.net.`

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APNIC managed zones



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

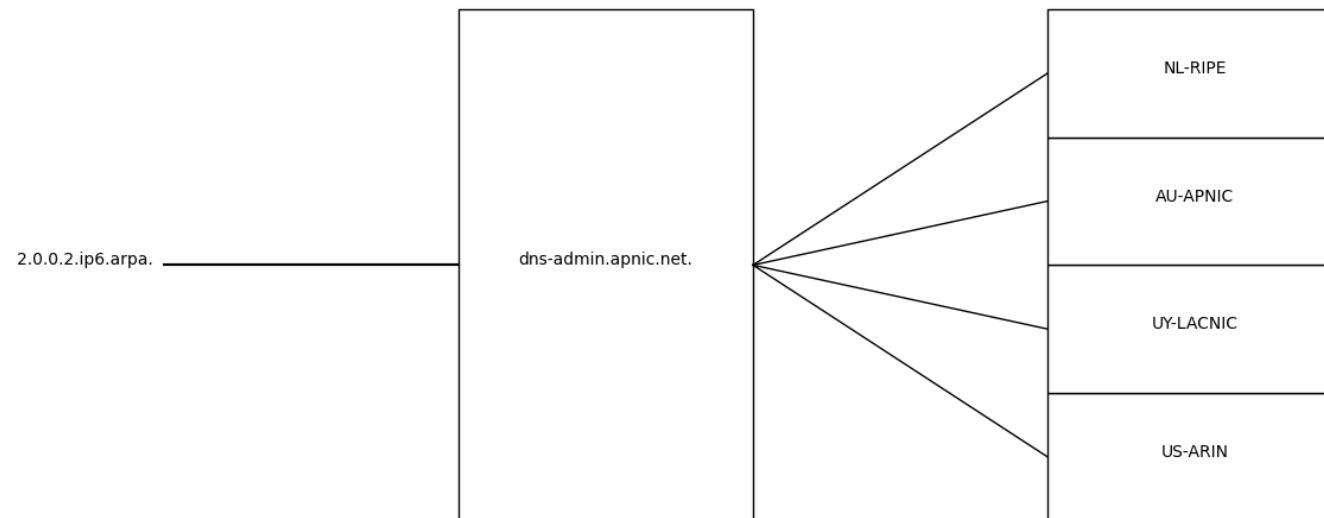
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APNIC managed “special” zone

Zones

DNS Houses

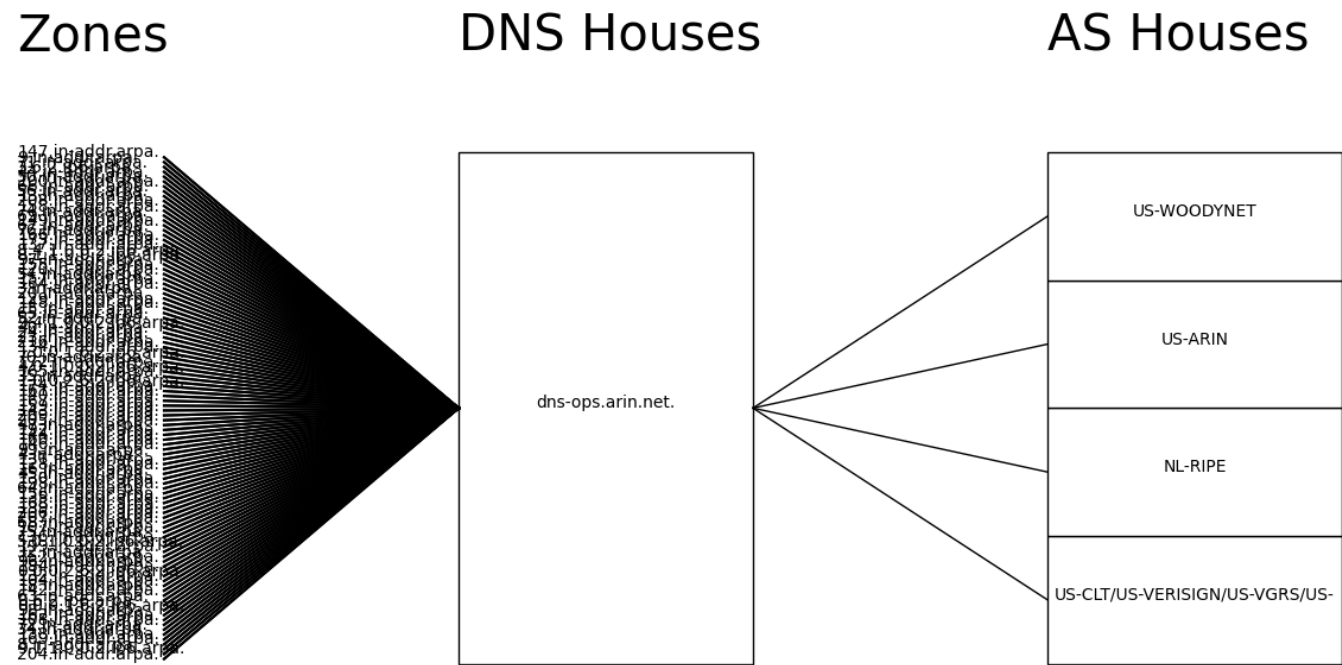
AS Houses



Zones administered by dns-admin.apnic.net.

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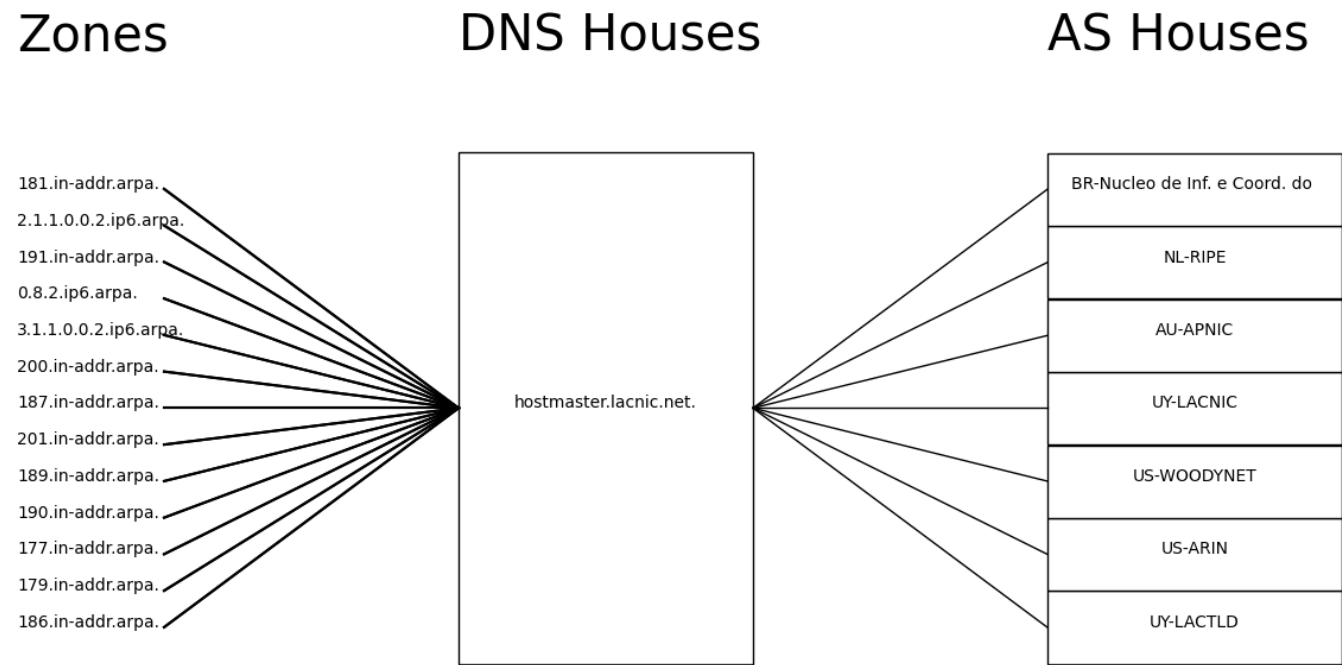
ARIN managed zones



Zones administered by dns-ops.arin.net.

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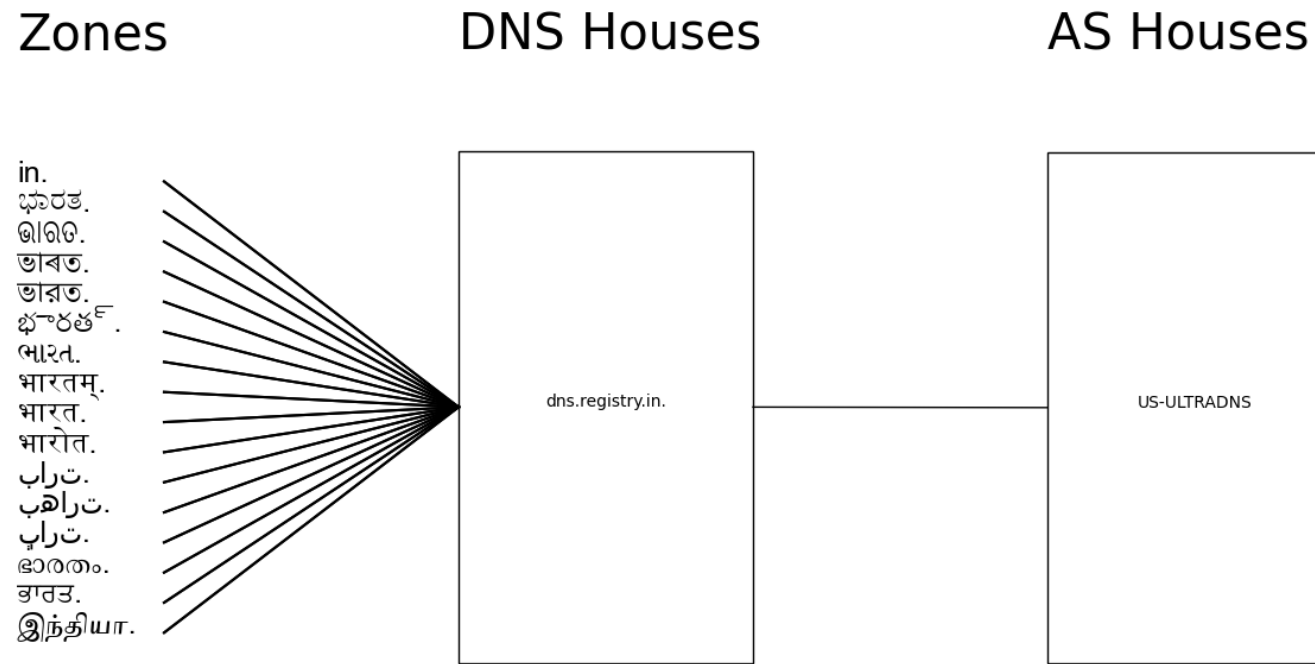
LACNIC managed zones



Zones administered by hostmaster.lacnic.net.

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India and its IDN ccTLD registries



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”

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