

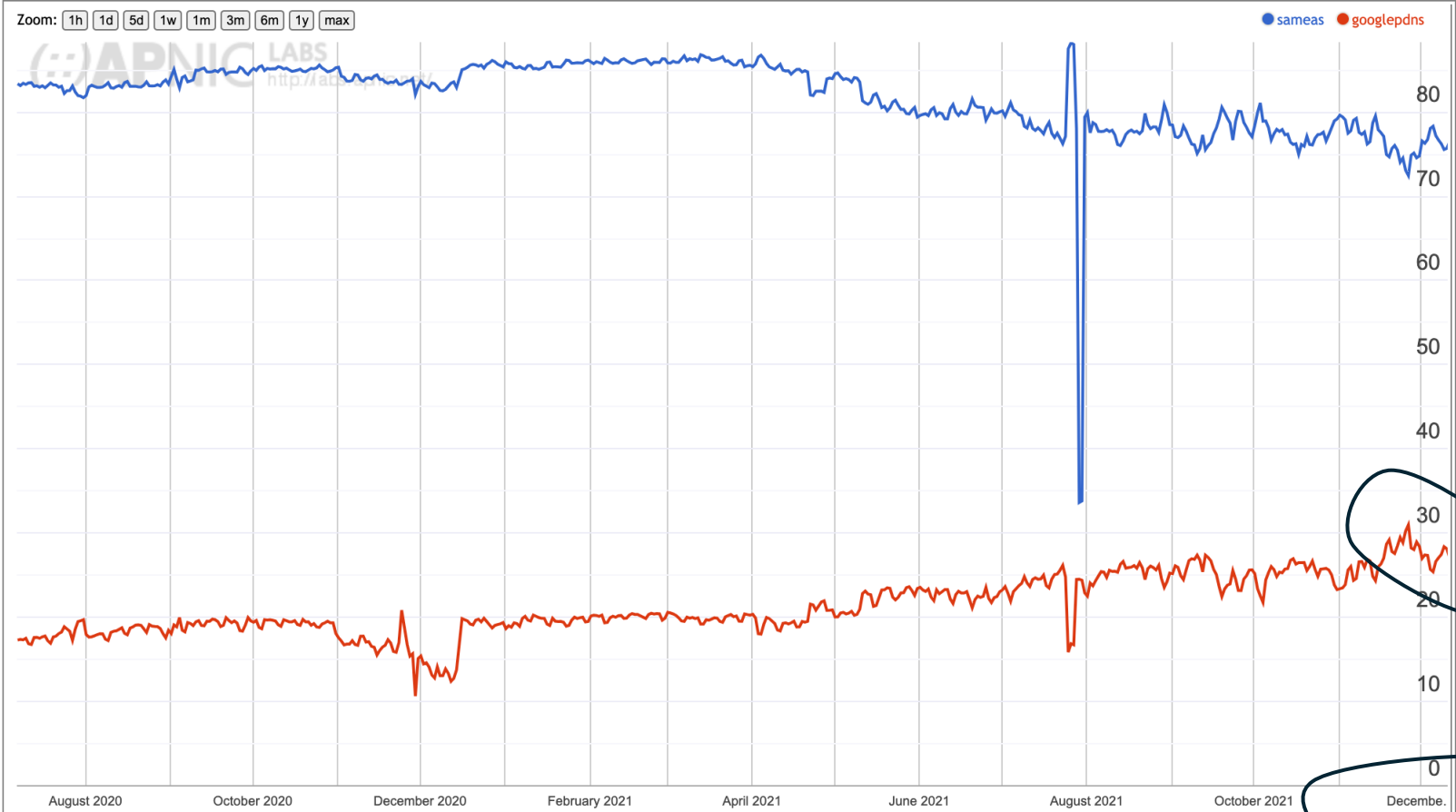
DNS Centrality

Geoff Huston
APNIC Labs

The DNS...

- Is a massive distributed system with no central locus of control
- Both resolvers and servers are diverse and highly distributed
- So why should we worry about centrality and concentration in the DNS?

Resolver Concentration in EU

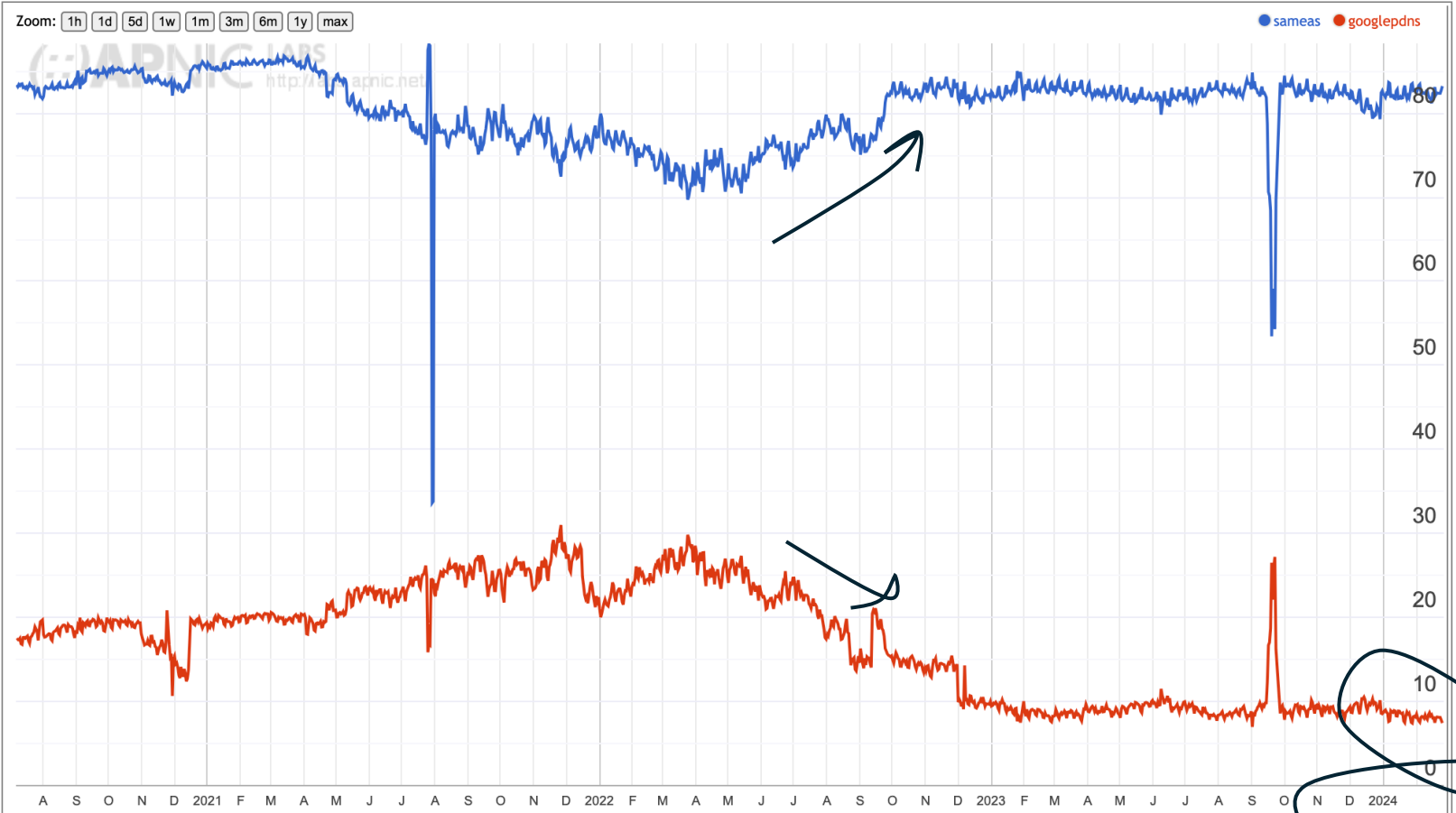


ISP Resolver

Google 8.8.8.8 share

December 2021

EU pressure on ISPs!



iSP Resolver

Google 8.8.8.8 share

Feb 2024

Concentration Measurements

- Let's look at the “market” of DNS open resolvers using the “all resolvers” measurements
 - Single Entity Dominance:
 - Google has 68.7% of the open DNS resolver market
 - Four-Firm Concentration:
 - Google, Cloudflare, 114DNS and OpenDNS have 91.6% market share
 - HHI Index:
 - 49%
- So the open resolver market sector is **highly centralized**.
- But this open resolver activity represents only one third of the total resolution market, and the HHI Index of the open resolvers as a subset of the total resolution market is far lower, at 5%

Authoritative Servers

- Data about the recursive-to-authoritative query set is hard to find
 - Recursive resolvers sit in a privileged position in the DNS as they are exposed to both the identity of the stub resolver (the ‘user’) and the DNS names that they are querying
 - So there are many caveats that apply to access to such data – and rightly so
- At APNIC we have limited access to the data relating to the use of the 1.1.1.1 recursive resolver
 - We don’t know who is querying, but we can see query names and query protocol
 - The market share of Cloudflare’s open resolver service is around 3% of users which is a non-trivial resolver in the open resolver set (ranked #2 in terms of market share)

Centrality in Authoritative Servers?

- One way to measure this is to look at the **query-count weighted ranking** of the DNS authoritative server providers
- If an authoritative name server hosts a very popular domain name then it's likely that the query count will be high
- If a service operator hosts a large number of domains on its authoritative server infrastructure, then it's likely that the query count will be high
- So lets characterise the authoritative service hosting market by their query-based 'market share'

Measurement Technique

- Obtain a data set of 24 hours of query name data from the 1.1.1.1 resolver system
- Group the query names
- Resolve the names to find the “lowest” authoritative name server for the query name using a local resolution environment
- Take the first name server name
- Discard the query names
- Resolve the name server names to IP address, and discard the name server names
- Map the IP addresses to AS numbers, and discard the IP addresses
- Group the query counts into AS numbers and rank by query share

Data Set

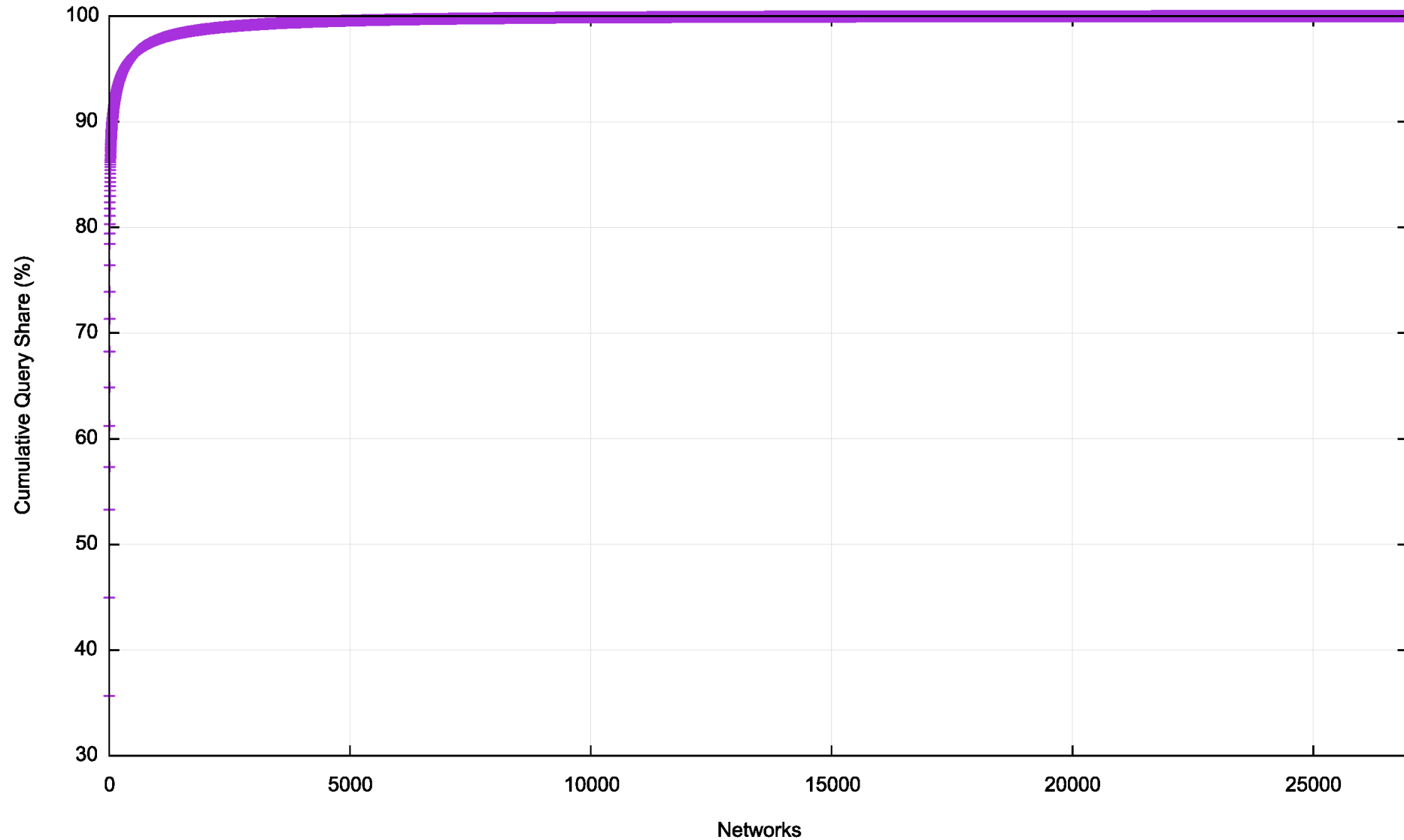
Rank	AS Number	Query Share	Cumulative Share	Name
56	31034	0.06%	89.64%	Aruba, IT
57	20446	0.06%	89.70%	Stackpath CDN, US
58	199524	0.06%	89.76%	Gcore, LU
59	60068	0.05%	89.82%	CDN77, GB

Here's an extract of the resultant data set

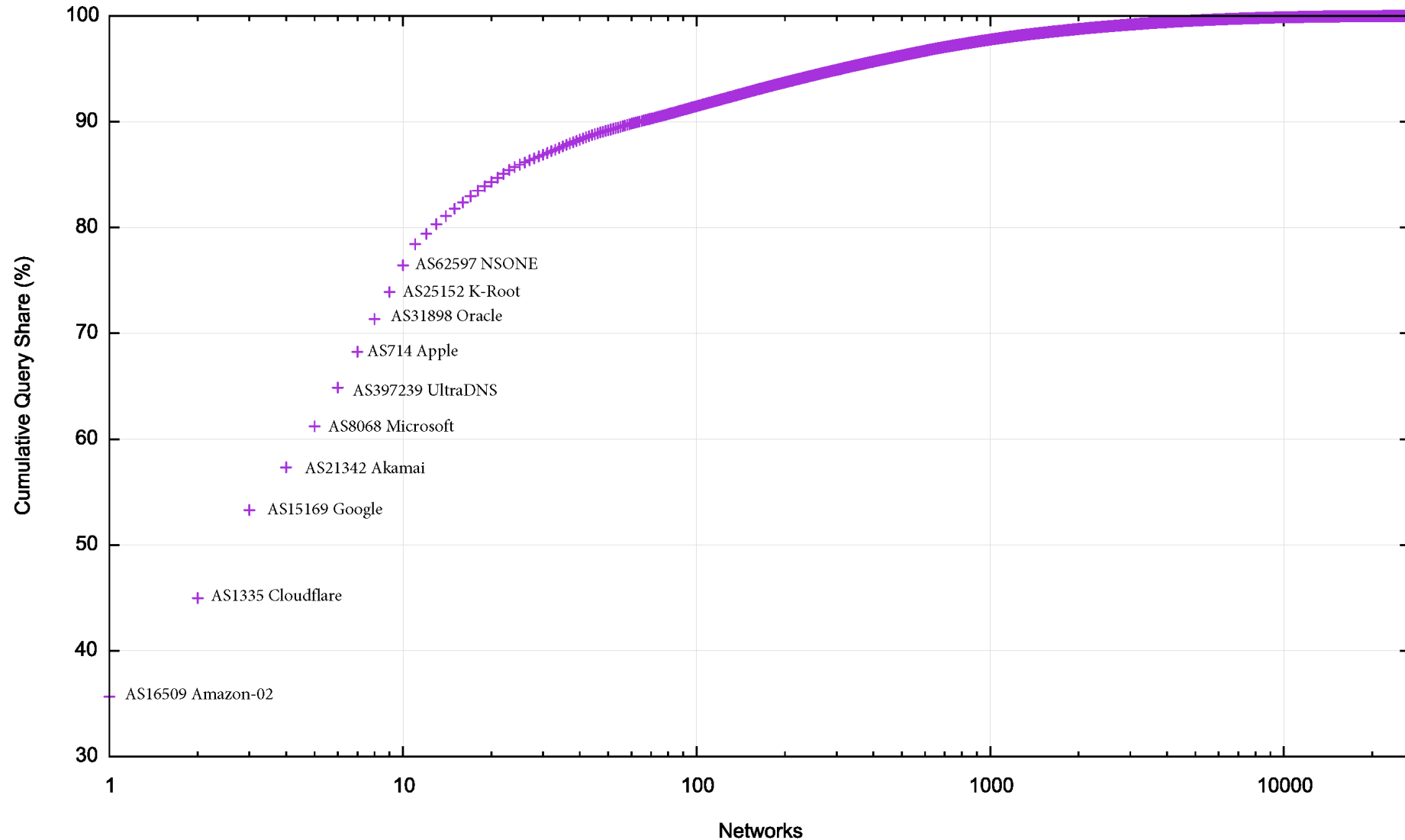
The 24 hour data capture identified 26,971 unique AS numbers (out of a total of 75,000 unique AS numbers in the routing table)

While approximately one third of networks host at least one queried authoritative name server the top 50 ASNs have 89.2% of the query share.

Cumulative Distribution



Cumulative Distribution



Top 10 Auth Server Networks

Rank	AS Number	Query Share	Cumulative Share	Name
1	AS16509	35.7%	35.7%	Amazon-02, US
2	AS13335	9.3%	45.0%	Cloudflare, US
3	AS15169	8.3%	53.3%	Google, US
4	AS21342	4.0%	57.3%	Akamai – ASN2, US
5	AS8068	3.9%	61.2%	Microsoft, US
6	AS397239	3.7%	64.9%	UltraDNS, US
7	AS714	3.4%	68.3%	Apple, US
8	AS31898	3.1%	71.4%	Oracle, US
9	AS*	2.5%	73.9%	Root Server System
10	AS62597	2.5%	76.4%	NSONE, US

Concentration Measurements

- Lets look at the “market” of DNS authoritative server providers using query-weighted ranking
 - Single Entity Dominance:
 - Amazon has 35.7% of the Authoritative Server market
 - Four-Firm Concentration:
 - Amazon, Cloudflare, Google, and Akamai have 57.3% market share
 - HHI Index:
 - 15%
- This appears to be a “**moderately concentrated**” market

Geopolitical Centrality?

- There are 10 network entities who host the authoritative name servers that have a query share of three quarters of the recursive-to-authoritative DNS query volume
- All 10 networks are attributed to US entities
- **Is this market for authoritative DNS services concentrated?**

Thanks!