Dyn's Real User Monitoring (RUM)

- Measures Internet performance from a "real user" perspective, i.e., from a browser

- Javascript "beacon" measures performance to multiple HTTP origins and reports timing back to Dyn

- Results inform Dyn's Managed DNS and Internet Intelligence products

- Every beacon instance has a unique ID that forms part of a DNS QNAME

1. Retrieve Javascript beacon code, unique ID and monitoring instructions

4. Match client IP from HTTP and recursive IP from DNS via unique ID

Client — HTTP → Dyn

DNS — Recursive Server — DNS

2. Query for <unique-ID>. dyninsight.com

3. QNAME guaranteed not to be cached, relayed to Dyn-operated authoritative servers
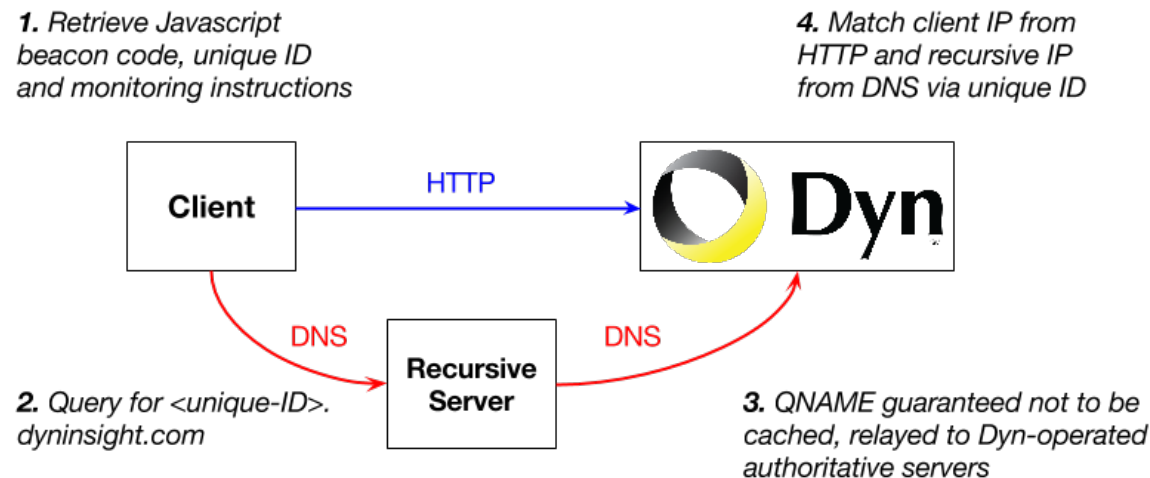
Definitions

- **Beacon**

  - A Javascript program running in a browser that measures times to fetch assets over HTTP/HTTPS

  - Each beacon that runs has a single-use unique ID

- **Client**

  - The host running the web browser that the beacon runs in

  - This host connects to Dyn via HTTP

- **Recursive server**

  - The host that sends the non-recursive query with the QNAME containing unique beacon ID to one of the authoritative servers for *dyninsights.com*

  - Not necessarily the same IP configured as the recursive server on the client where the beacon runs

    - Servers can originate queries with a different address than they receive queries on

    - There could be forwarding, i.e., other hosts between the client and the host whose source IP address queries Dyn

The Data Set

- Each successful beacon run results in <client IP,recursive IP> tuple

- Just over three months of beacons (May through July, 2015)

- Beacon was initiated from web pages of about a dozen design partners and early customers

  - Mix of different kinds of web sites (social, e-commerce) but slight North American bias

- The numbers:

  - **228,638,094** beacons ran over IPv4

  - **48,303,138** unique client IPv4 addresses

  - **319,389** unique recursive server IPv4 addresses

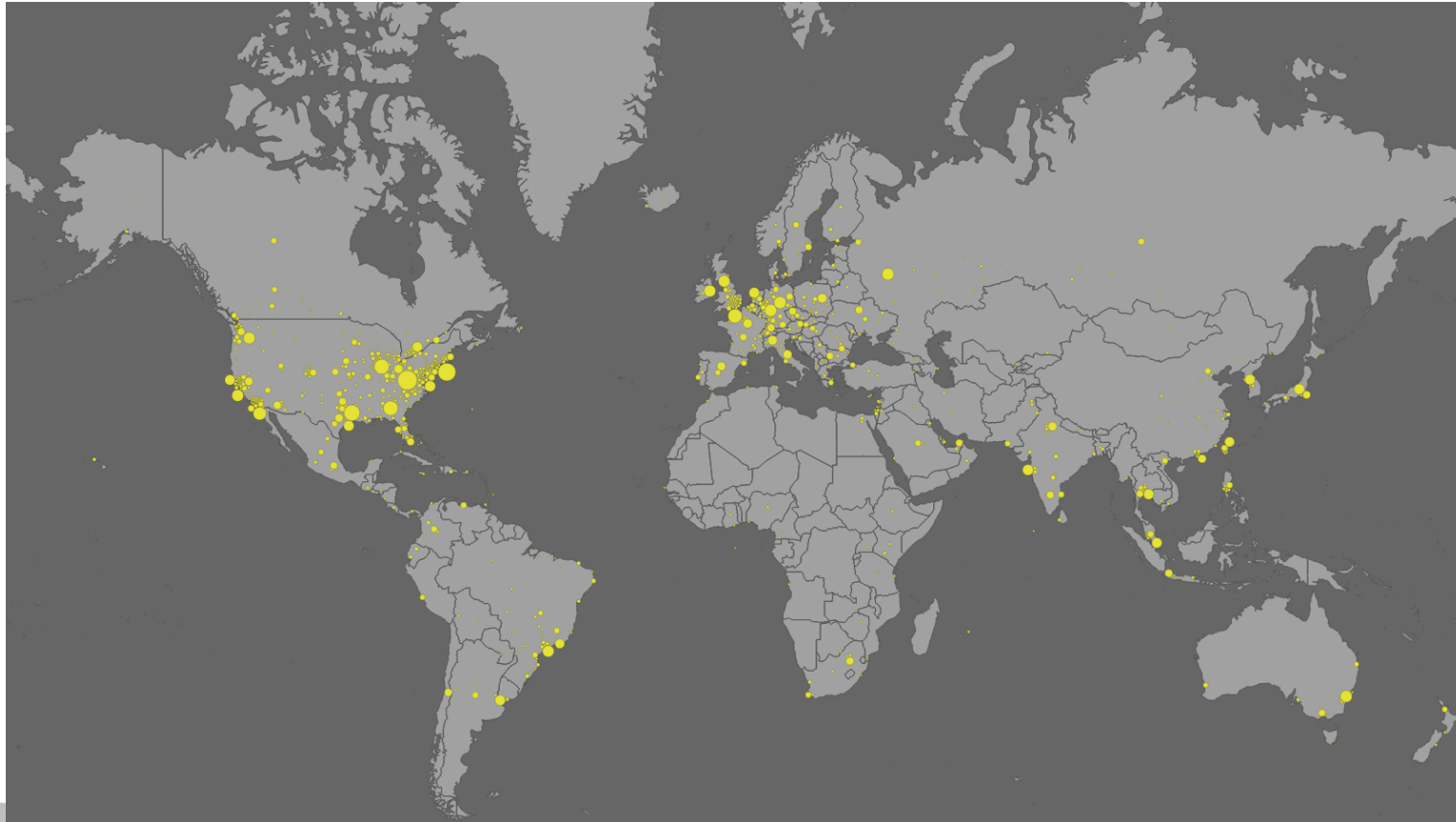 - Average of **151** clients per server

Geomapping IP Addresses

- Upfront acknowledgements:

  1. IP addresses were geomapped during the creation of this presentation

  2. Geomapping IP addresses is an inexact science

  3. All geo IP databases have shortcomings (see #2)

- However, Dyn's gep IP data is not your father's geo IP data

  - Custom schema with multiple levels of credibility/certain

  - Seeded from various registries and commercial geo IP providers

  - Augmented and corrected with proprietary techniques

Where are the Recursive Name Servers?

Clients Per Recursive (CDF)

Cumulative percentage (y-axis) vs. Number of clients per recursive server (N=319,389) (x-axis)

Legend:
- Cumulative percentage of clients per recursive
- ◆ 35% of servers have one client
- ■ 75% of servers have 17 clients or fewer
- ● 90% of servers have 117 clients or fewer
- ▲ Top 1% of servers have more than 11,537 clients
- ✳ Top server has 220,120 clients

Clients Per Recursive

Plot legend:
- ◆ 112,984 servers have one client
- ✳ Top server has 220,120 clients

Y-axis: Number of recursive servers (1 to 1×10^6)
X-axis: Number of clients per recursive server (N=319,389)

Clients Per Recursive (By Geography)

Top Recursives by Client Count

|							
1	220120	74.125.19.146	Google Inc.	NA	US	NC	Lenoir
…			*(same)*	*(same)*			*(same)*
6	209938	74.125.190.210	Google Inc.	AS	SG		Singapore
…			*(same)*	*(same)*			*(same)*
11	202367	74.125.181.85	Google Inc.	EU	BE		Saint-Ghislain
…			*(same)*	*(same)*			*(same)*
19	189163	76.96.13.150	Comcast Cable Communications, Inc.	NA	US	PA	Pittsburgh
20	173515	76.96.13.152	Comcast Cable Communications, Inc.	NA	US	PA	Pittsburgh
21	168221	74.125.47.20	Google Inc.	EU	BE		Saint-Ghislain
…			*(same)*	*(same)*			*(same)*
26	157082	65.24.26.35	Time Warner Cable Internet LLC	NA	US	OH	Columbus
…			*(same)*	*(same)*			*(same)*
36	152053	217.237.150.44	Deutsche Telekom AG	EU	DE		Frankfurt am Main
37	149140	217.237.149.149	Deutsche Telekom AG	EU	DE		Hannover
38	146962	68.87.75.197	Comcast Cable Communications, Inc.	NA	US	PA	Pittsburgh
39	146867	68.87.75.203	Comcast Cable Communications, Inc.	NA	US	PA	Pittsburgh
40	146423	76.96.98.22	Comcast Cable Communications, Inc.	NA	US	UT	Salt Lake City
41	142500	76.96.42.216	Comcast Cable Communications, Inc.	NA	US	TX	Houston
42	142073	68.87.77.141	Comcast Cable Communications, Inc.	NA	US	MI	Westland
43	141780	190.157.8.46	Telmex Colombia S.A.	SA	CO		Bogota
44	141636	76.96.98.24	Comcast Cable Communications, Inc.	NA	US	UT	Salt Lake City
45	141382	76.96.42.221	Comcast Cable Communications, Inc.	NA	US	TX	Houston
46	141205	68.87.77.133	Comcast Cable Communications, Inc.	NA	US	MI	Westland
47	138928	76.96.98.5	Comcast Cable Communications, Inc.	NA	US	UT	Salt Lake City
48	138528	76.96.98.4	Comcast Cable Communications, Inc.	NA	US	UT	Salt Lake City
49	132705	69.252.66.223	Comcast Cable Communications, Inc.	NA	US	IL	Chicago
50	132285	69.252.66.222	Comcast Cable Communications, Inc.	NA	US	IL	Chicago

ASNs Per Recursive
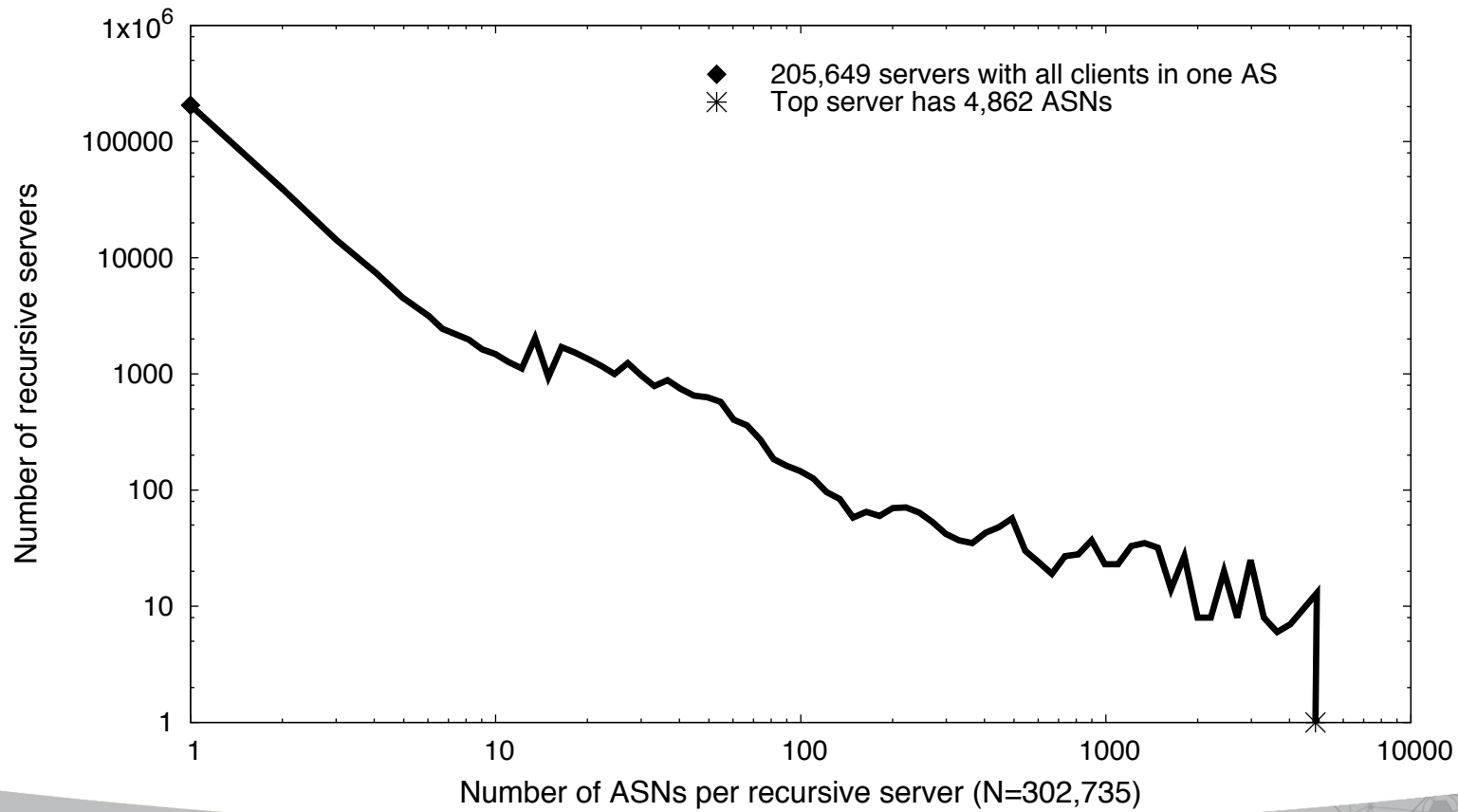
ASNs Per Recursive (By Geography)
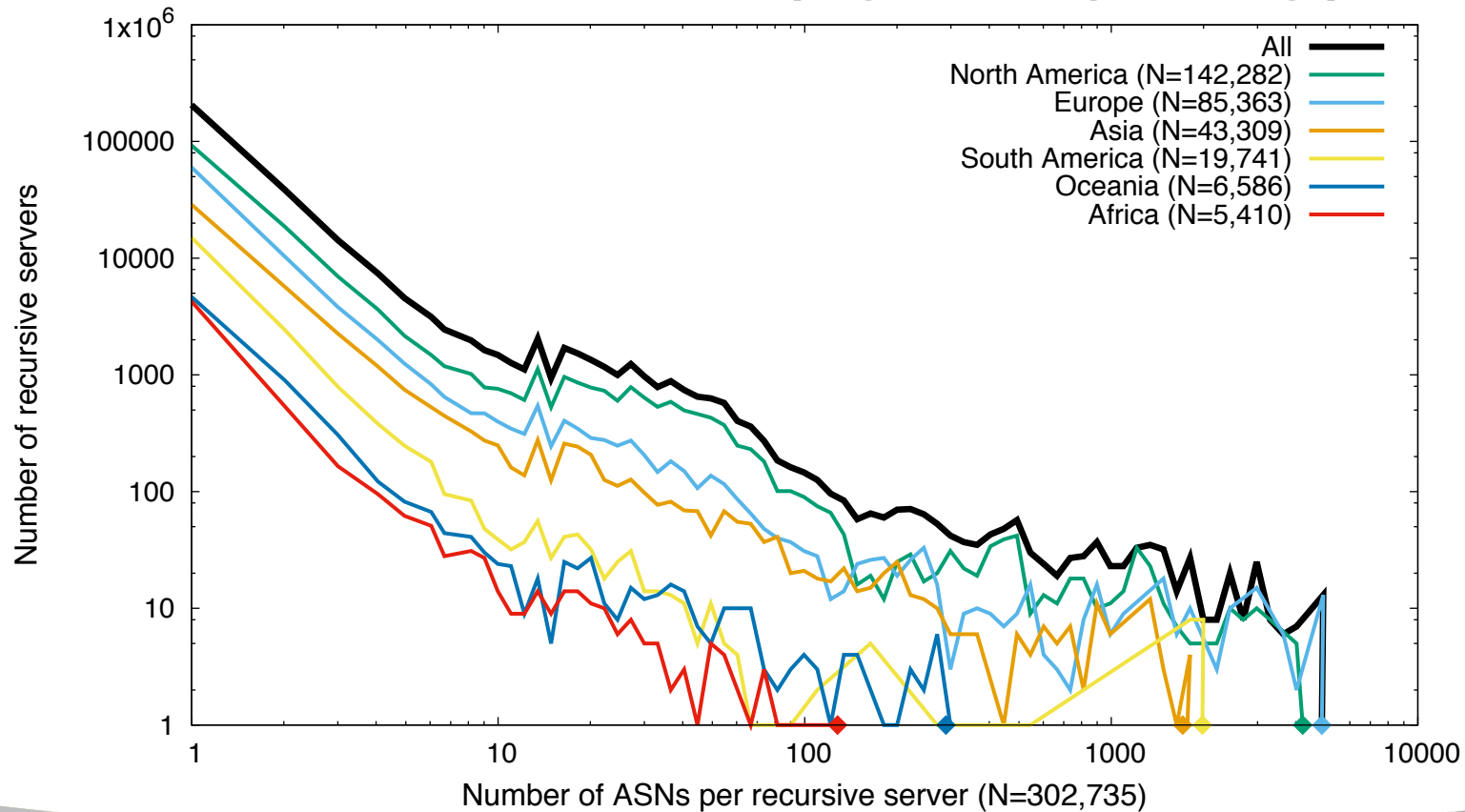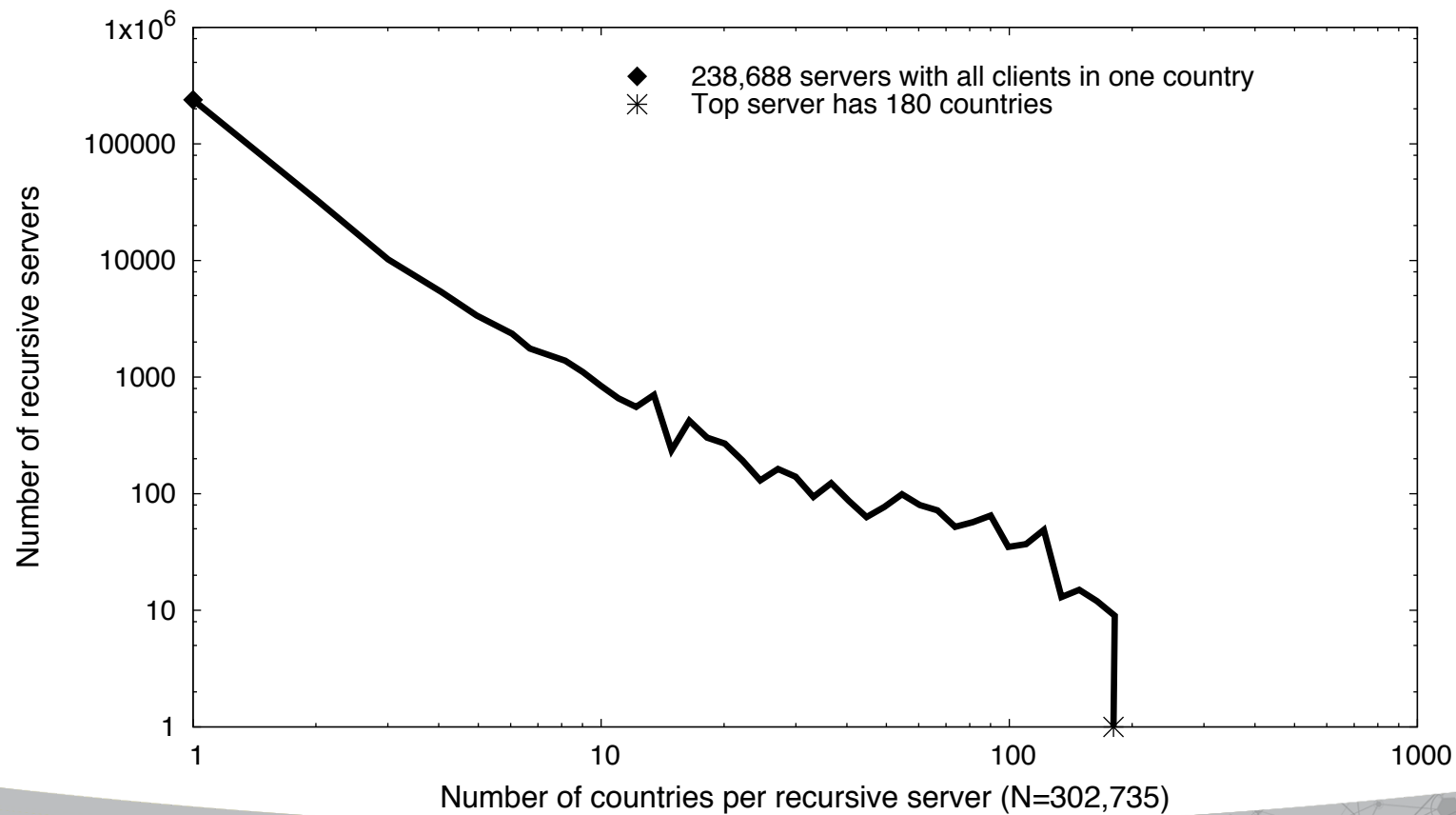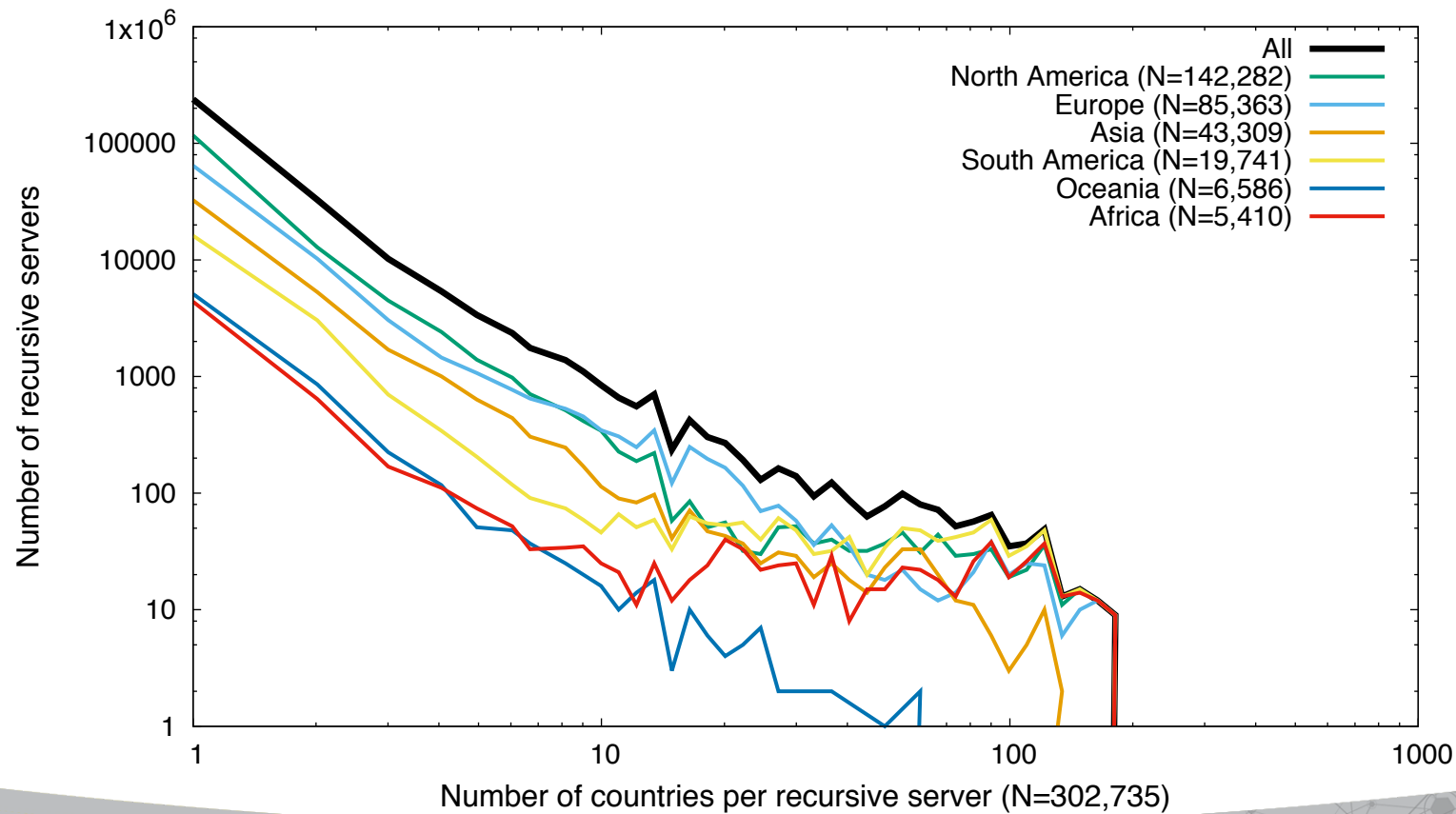
ASNs Per Recursive
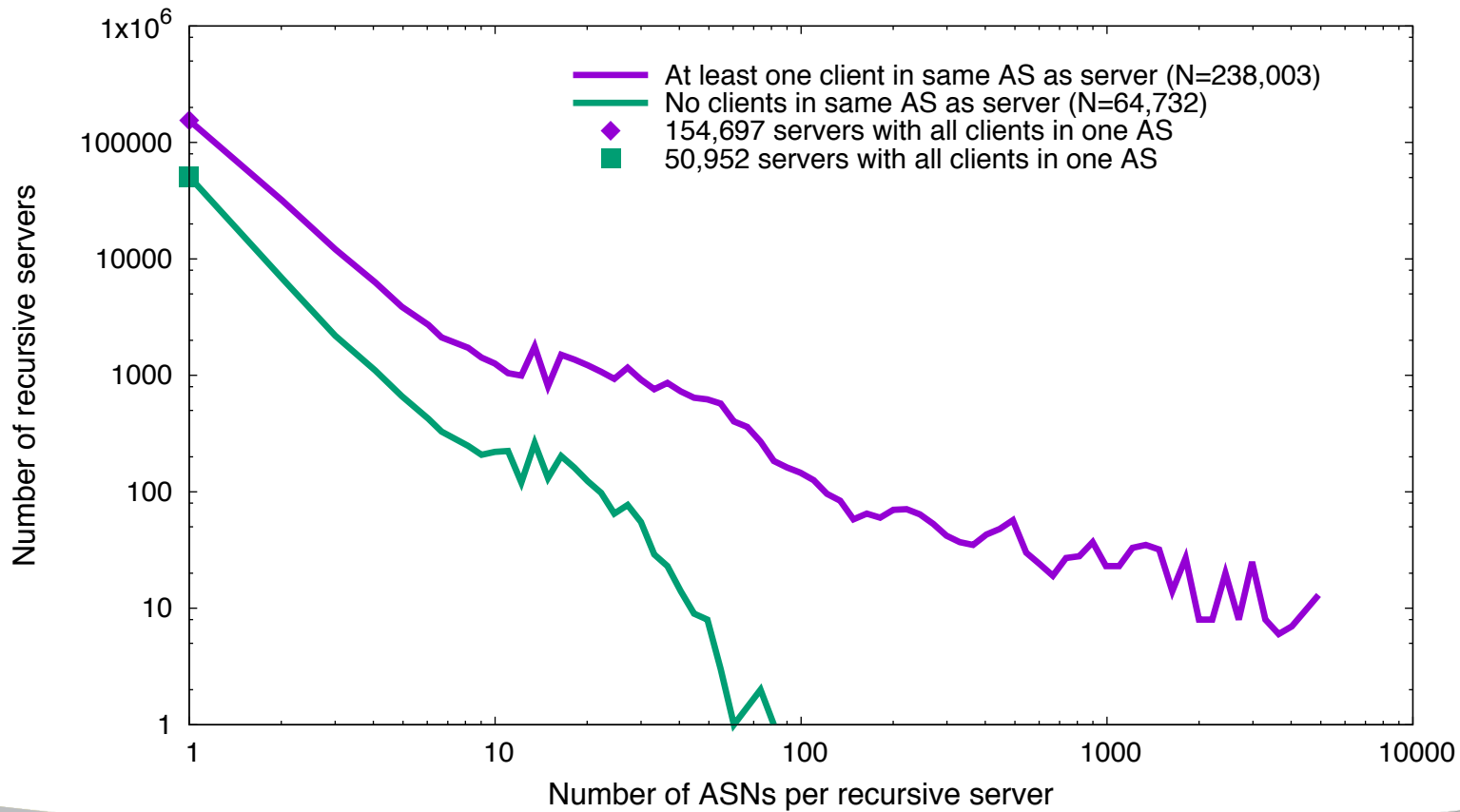
Top Recursives by ASN Count

1	4862	74.125.181.85	Google Inc.	EU	BE		Saint-Ghislain
…	4707		*(same)*	*(same)*			*(same)*
14	4211	74.125.19.144	Google Inc.	NA	US	NC	Lenoir
…	4206		*(same)*	*(same)*			*(same)*
19	3860	74.125.73.21	Google Inc.	EU	BE		Saint-Ghislain
…	3838		*(same)*	*(same)*			*(same)*
27	3277	74.125.19.211	Google Inc.	NA	US	NC	Lenoir
…	3231		*(same)*	*(same)*			*(same)*
35	3110	74.125.74.84	Google Inc.	EU	FI		Hamina
36	3085	74.125.183.145	Google Inc.	NA	US	IA	Council Bluffs
37	3084	74.125.74.82	Google Inc.	EU	FI		Hamina
38	3083	74.125.183.147	Google Inc.	NA	US	IA	Council Bluffs
…	3073		*(same)*	*(same)*			*(same)*
44	3062	74.125.74.80	Google Inc.	EU	FI		Hamina
45	3061	74.125.183.146	Google Inc.	NA	US	IA	Council Bluffs
…	3053		*(same)*	*(same)*			*(same)*
48	3031	74.125.74.83	Google Inc.	EU	FI		Hamina
…	3013		*(same)*	*(same)*			*(same)*
50	2988	173.194.92.18	Google Inc.	EU	BE		Saint-Ghislain

Countries Per Recursive

◆ 238,688 servers with all clients in one country
✳ Top server has 180 countries

Y-axis: Number of recursive servers

X-axis: Number of countries per recursive server (N=302,735)

Countries Per Recursive (By Geography)

Top Recursives by Country Count

1	180	74.125.181.87	Google Inc.	EU	BE		Saint-Ghislain
…	178		(same)	(same)			(same)
25	152	74.125.19.145	Google Inc.	NA	US	NC	Lenoir
…	151		(same)	(same)			(same)
29	146	173.194.92.19	Google Inc.	EU	BE		Saint-Ghislain
30	146	74.125.19.144	Google Inc.	NA	US	NC	Lenoir
31	144	173.194.92.17	Google Inc.	EU	BE		Saint-Ghislain
32	143	5.45.62.26	AVAST Software s.r.o.	EU	NL		Amsterdam
…	142		(same)	(same)			(same)
37	136	95.169.183.219	Cyberghost S.R.L. IP Network	EU	DE		
38	132	74.125.19.209	Google Inc.	NA	US	NC	Lenoir
39	132	74.125.47.146	Google Inc.	EU	BE		Saint-Ghislain
40	132	8.0.116.0	Level 3 Communications, Inc.	EU	DE		Frankfurt am Main
41	131	74.125.187.209	Google Inc.	NA	US	OR	The Dalles
42	130	185.26.182.141	Opera Software ASA	EU	NL		Amsterdam
43	130	74.125.187.84	Google Inc.	NA	US	OR	The Dalles
44	130	74.125.19.211	Google Inc.	NA	US	NC	Lenoir
45	129	74.125.176.151	Google Inc.	NA	US	NC	Lenoir
46	129	74.125.47.145	Google Inc.	EU	BE		Saint-Ghislain
47	128	159.253.145.148	Hosting Services Inc. (dba Midphase)	EU	NL		Amsterdam
48	128	74.125.176.149	Google Inc.	NA	US	NC	Lenoir
49	128	74.125.19.215	Google Inc.	NA	US	NC	Lenoir
50	127	77.234.43.22	AVAST Software s.r.o.	EU	GB		London

Cities Per Recursive

183,471 servers with all clients in one city
Top server has 5,458 cities

Y-axis: Number of recursive servers
X-axis: Number of cities per recursive server (N=302,735)
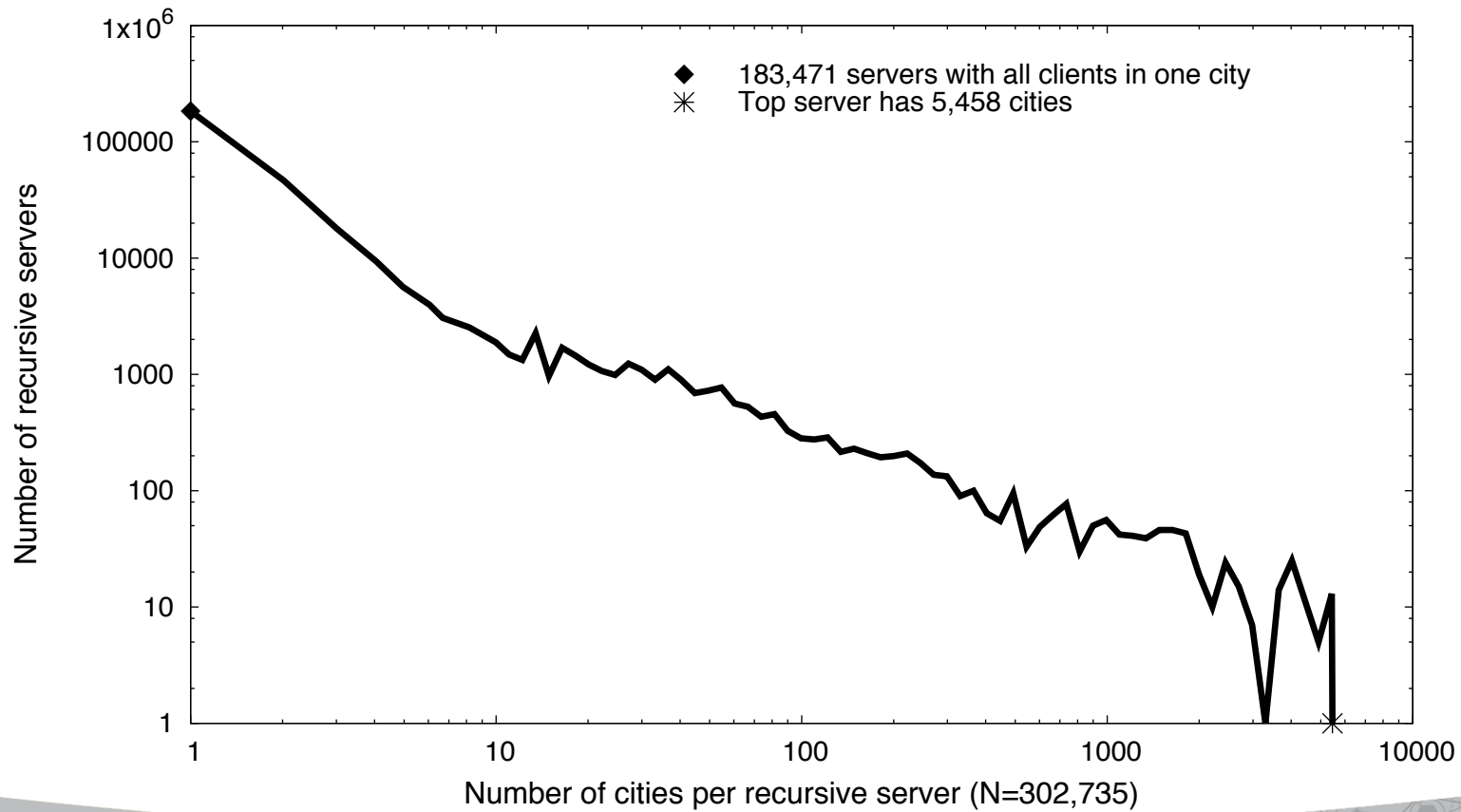
Cities Per Recursive (By Geography)
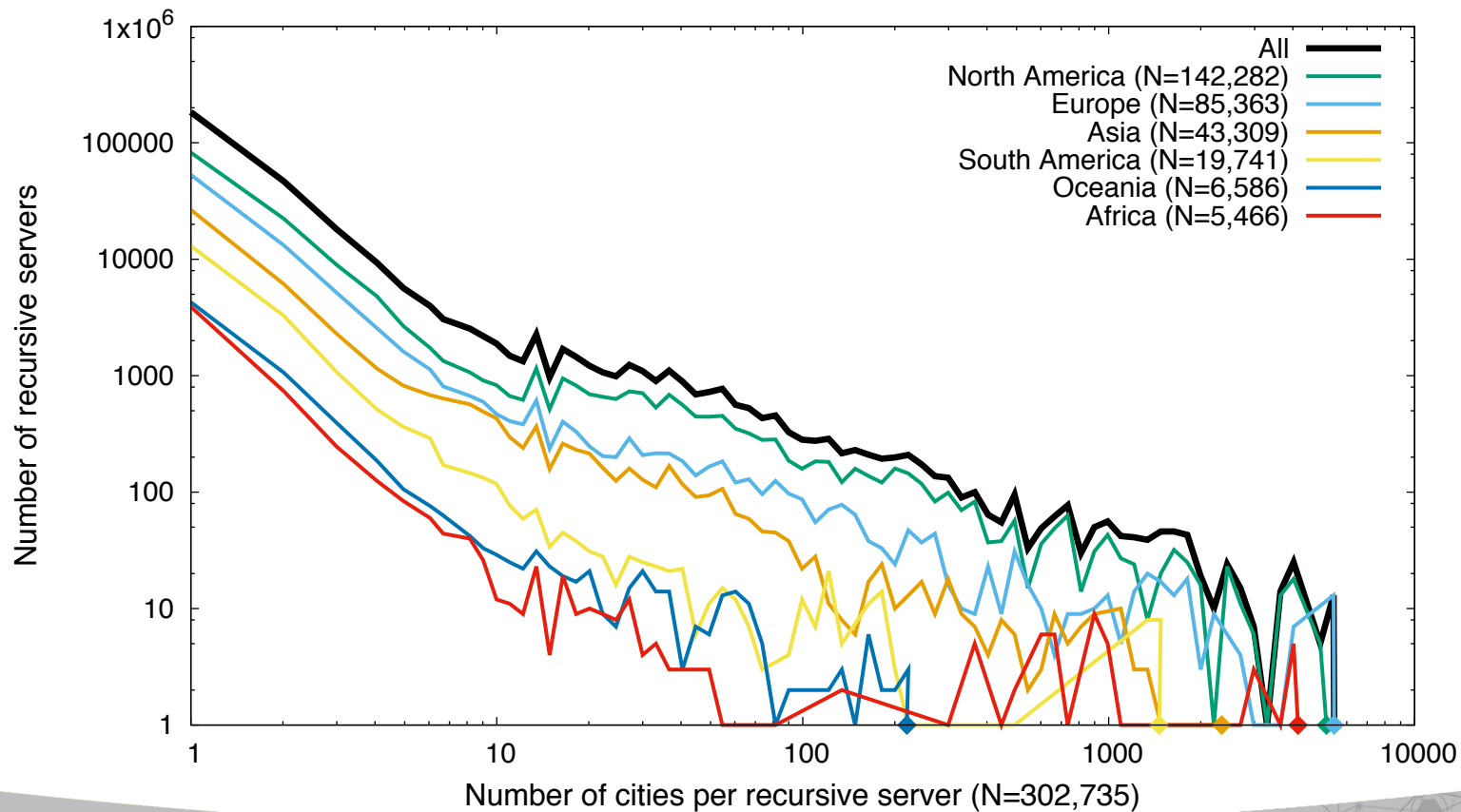
Top Recursives by City Count

1	5458	74.125.181.84	Google Inc.	EU	BE		Saint-Ghislain
…	5414		*(same)*	*(same)*			*(same)*
14	5151	74.125.19.147	Google Inc.	NA	US	NC	Lenoir
…	5136		*(same)*	*(same)*			*(same)*
27	3990	74.125.183.150	Google Inc.	NA	US	IA	Council Bluffs
…	3988		*(same)*	*(same)*			*(same)*
37	3884	74.125.73.23	Google Inc.	EU	BE		Saint-Ghislain
…	3874		*(same)*	*(same)*			*(same)*
45	3718	74.125.176.150	Google Inc.	NA	US	NC	Lenoir
…	3663		*(same)*	*(same)*			*(same)*
50	3656	74.125.176.147	Google Inc.	NA	US	NC	Lenoir

Servers Per Organization (By Name)

Legend (on chart):
◆ Largest organization (by server count) operates 9,915 servers
✳ 59,476 organizations operate just one server

Y-axis: Number of Recursive Servers (1 to 10000)
X-axis: Organizations (Based on Unique Names from GeoIP Database) (N=88,872)
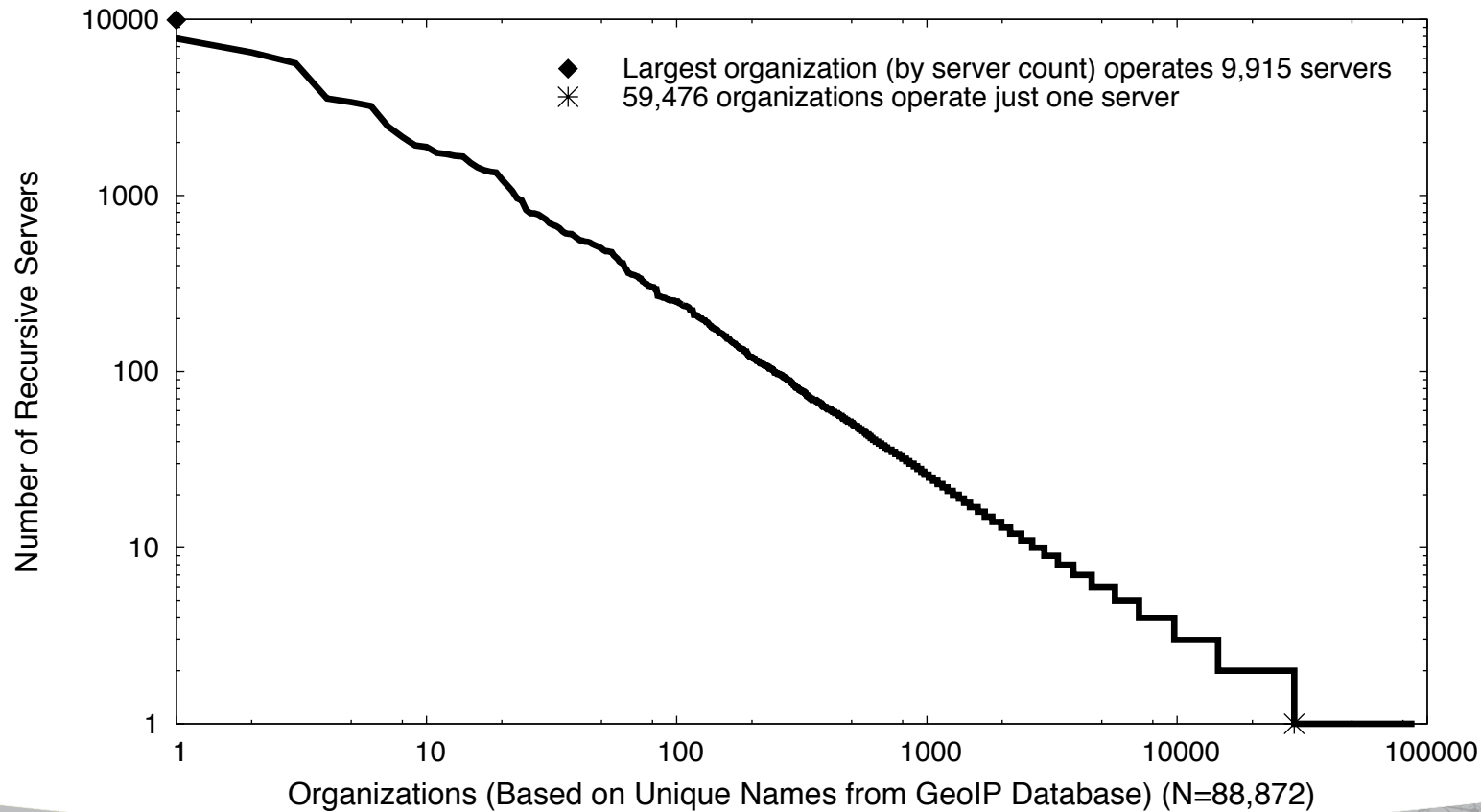
Top Organizations by Client Count

Organization Name	Clients		Recursive Servers	
Comcast Cable Communications, Inc.	12,338,830	11.6895%	1,021	0.3208%
Google Inc.	10,976,083	10.3985%	3,215	1.0101%
Time Warner Cable Internet LLC	6,452,331	6.1128%	5,563	1.7478%
AT&T Internet Services	4,223,415	4.0012%	935	0.2938%
AT&T Worldnet Services	3,946,983	3.7393%	254	0.0798%
Verizon Online LLC	3,424,839	3.2446%	2,469	0.7757%
Cox Communications Inc.	2,052,448	1.9444%	1,578	0.4958%
Charter Communications	2,050,054	1.9422%	1,708	0.5366%
Qwest Communications Company, LLC	1,601,942	1.5176%	819	0.2573%
Deutsche Telekom AG	1,434,162	1.3587%	3,312	1.0406%
OpenDNS, LLC	1,257,782	1.1916%	96	0.0302%
Level 3 Communications, Inc.	1,085,135	1.0280%	9,911	3.1138%
Bell Canada	1,074,147	1.0176%	149	0.0468%
Sky UK Limited	888,139	0.8414%	49	0.0154%
Telefonica de Espana SAU	850,806	0.8060%	516	0.1621%
Proxad / Free SAS	771,587	0.7310%	146	0.0459%
Frontier Communications of America, Inc.	757,173	0.7173%	916	0.2878%
Telecom Italia SPA	753,462	0.7138%	72	0.0226%
TalkTalk Communications Limited	703,388	0.6664%	60	0.0189%
Infra misc.	665,317	0.6303%	35	0.0110%

Top Organizations by Server Count

Organization Name	Clients		Recursive Servers	
Level 3 Communications, Inc.	1,085,135	1.0280%	9,911	3.1138%
Amazon Technologies Inc.	70,910	0.0672%	7,779	2.4440%
Amazon.com, Inc.	65,590	0.0621%	6,481	2.0362%
Time Warner Cable Internet LLC	6,452,331	6.1128%	5,563	1.7478%
Comcast Cable Communications Holdings,	6,826	0.0065%	3,459	1.0867%
Deutsche Telekom AG	1,434,162	1.3587%	3,312	1.0406%
Google Inc.	10,976,083	10.3985%	3,215	1.0101%
Verizon Online LLC	3,424,839	3.2446%	2,469	0.7757%
tw telecom holdings, inc.	83,042	0.0787%	2,144	0.6736%
(HiNet) Chunghwa Telecom Co., Ltd.	171,079	0.1621%	1,926	0.6051%
Comcast Business Communications, LLC	2,676	0.0025%	1,769	0.5558%
Cogent	31,969	0.0303%	1,713	0.5382%
Charter Communications	2,050,054	1.9422%	1,708	0.5366%
Wayport, Inc.	17,213	0.0163%	1,648	0.5178%
Cox Communications Inc.	2,052,448	1.9444%	1,578	0.4958%
PACNET	433,208	0.4104%	1,530	0.4807%
Service Provider Corporation	102,296	0.0969%	1,439	0.4521%
NET Servi√ßos de Comunica√ß√£o S.A.	398,666	0.3777%	1,392	0.4373%
Global Village Telecom	296,898	0.2813%	1,365	0.4289%
Cox Communications	2,488	0.0024%	1,229	0.3861%

In Conclusion

- There is a wide distribution of recursive servers based on number of clients: a few servers with a large number clients and a surprising number of servers with very few clients (or one client).

- There are recursive servers with very diverse client populations, whether measured by their clients' ASNs, countries or cities.

- There are no significant differences based on geography, at least at the continental level.

- There is a significant recursive server population with all of their clients in different ASNs.

- The list of organizations with the most recursive servers is significantly different than the list of organizations with the most clients of their recursive servers.

QUESTIONS?