

On the Performance of DNS Resolvers in the IPv6 and ECS Era

Rami Al-Dalky and Michael Rabinovich

Case Western Reserve University

KEY QUESTIONS

- DNS resolvers latency?
- DNS resolver ability to support CDN user mapping?
- Effect of IPv6 on the above?

PRIOR KNOWLEDGE (PRE-ECS)

- Public DNS resolvers are more distant from end-user and produce worse CDN user mapping than ISP resolvers
- Has ECS and/or IPv6 changed this?

INFRASTRUCTURES CONSIDERED

- Two ECS-supporting resolvers (Google Public DNS and OpenDNS)
- Two non-ECS resolvers (Cloudflare and Quad9)
- Five CDNs used by top 100 dual-stack CDN-accelerated websites

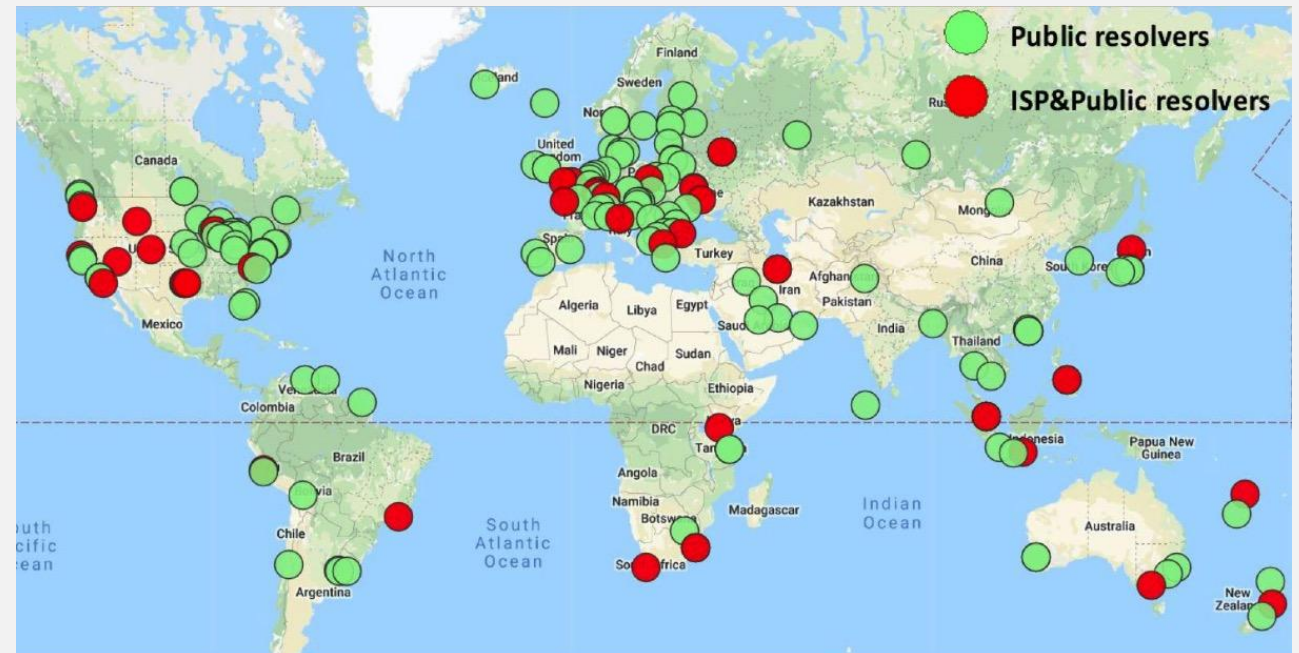
METHODOLOGY

RIPE Atlas vantage points

- Offer both IPv4 and v6 protocols
- Distributed both geographically and across ASes
- 188 RIPE Atlas probes
 - (36 with ISP resolver)
 - 188 Ases
 - 74 countries across 6 continents/regions

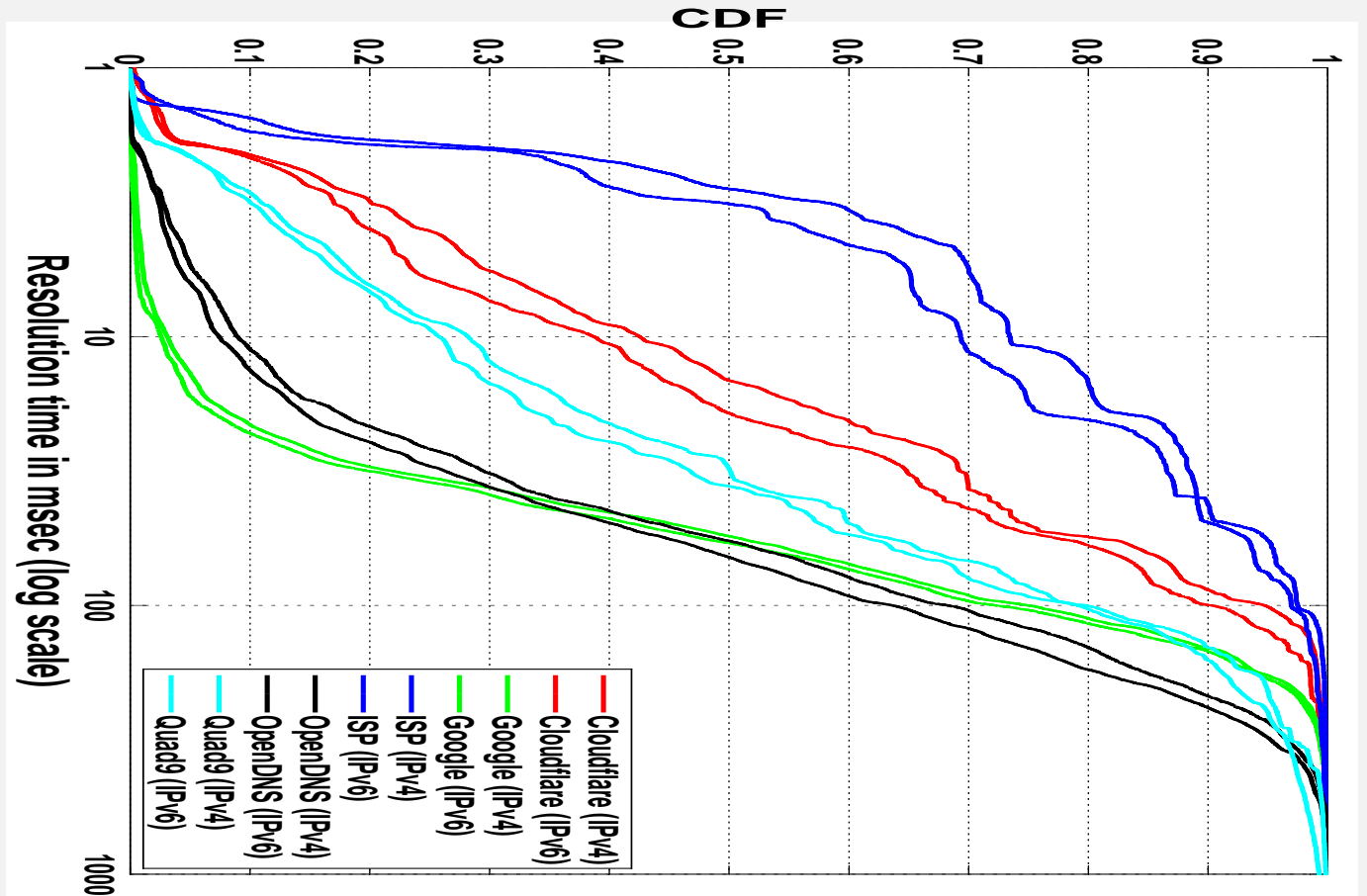
100 dual-stack CDN-accelerated websites

- Akamai (65 sites), Cloudfront(17), Google(9), Fastly(8), and Incapsula (1)



DNS LATENCY

A-type query latencies

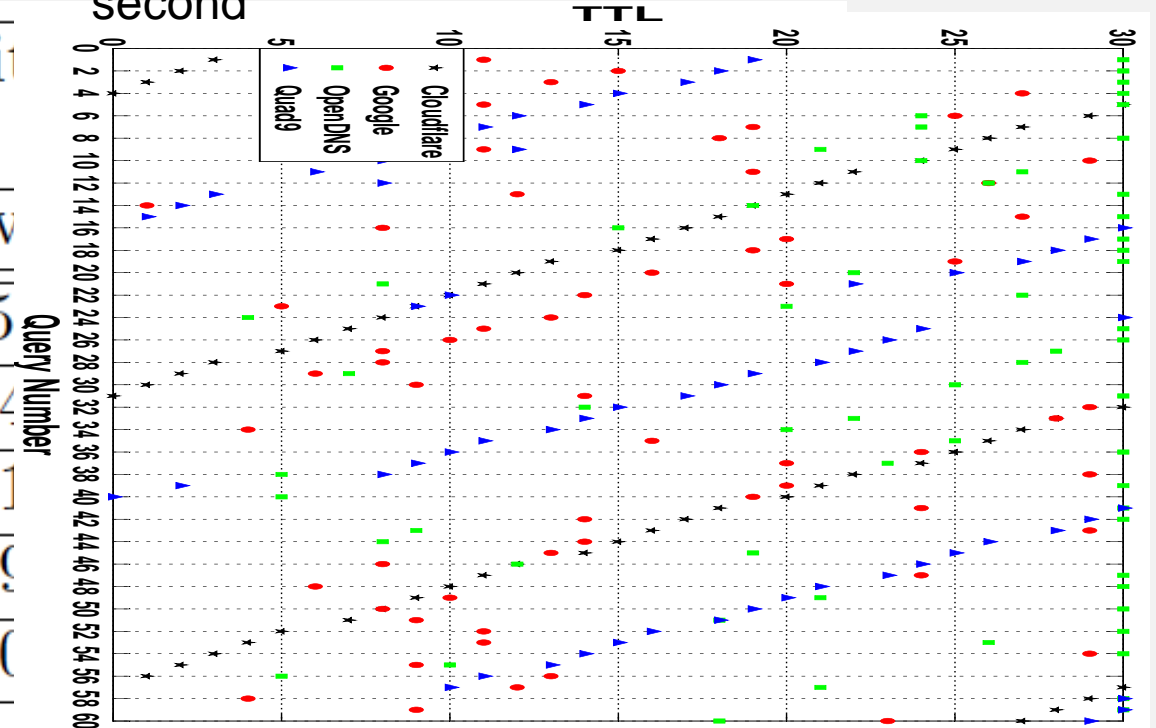


- Prewarm resolver cache
- Use median latency of three subsequent resolutions

REASONS FOR LATENCY DIFFS

Resolver	Miss rate (%)		Hit
	IPv4	IPv6	IPv4
ISP	6.26	7.20	2.5
Cloudflare	1.76	2.26	14.4
Quad9	16.67	17.22	34.1
Google	72.47	75.85	30.9
OpenDNS	83.11	72.94	24.0

TTL of repeated queries to Fastly sent every second



- Different footprints
- **Different miss rate!**
 - Detected from response TTL
 - High miss rates due to server rotation + limited cache sharing

USER MAPPING QUALITY (BASED ON TCP RTT)

Region	CDN	Vantage points	ISP-provided		Cloudflare		Quad9		Google		OpenDNS	
			IPv4	IPv6	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6
Global	Akamai	All			18.93	23.22	29.01	34.09	15.08	20.83	14.32	20.23
		w/ISP resolver	18.23	18.71	23.02	24.47	27.22	28.49	18.58	18.94	17.93	18.71
	Others	All			22.59	30.66	36.12	44.27	24.19	71.66	24.07	67.27
		w/ISP resolver	27.08	34.85	25.09	35.30	34.16	34.93	28.01	76.66	24.81	96.02

- In IPv4, Google and OpenDNS caught up with ISP resolvers on CDN user mapping RTTs
 - Cloudflare and Quad9 are not far behind
- Typically, there is IPv6 penalty in user mapping RTTs

CONCLUSIONS

- DNS latency varies drastically among resolvers
 - Mostly due to differences in intra-platform serve rotation + cache sharing
- Public resolvers largely caught up with ISP resolvers on CDN user mapping quality
- There is no IPv6 penalty in DNS latency but there is IPv6 penalty in user mapping RTTs
 - Can be substantial but within Happy Eyeball thresholds so not masked

Region	CDN	Vantage points	ISP-provided		Cloudflare		Quad9		Google		OpenDNS	
			IPv4	IPv6	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6
Global	Akamai	All			18.93	23.22	29.01	34.09	15.08	20.83	14.32	20.23
		w/ISP resolver	18.23	18.71	23.02	24.47	27.22	28.49	18.58	18.94	17.93	18.71
	Others	All			22.59	30.66	36.12	44.27	24.19	71.66	24.07	67.27
		w/ISP resolver	27.08	34.85	25.09	35.30	34.16	34.93	28.01	76.66	24.81	96.02
North America	Akamai	All			14.99	15.93	18.00	17.95	12.49	18.36	12.76	18.34
		w/ISP resolver	19.02	18.50	22.47	28.67	22.51	29.58	19.22	18.99	19.47	19.00
	Others	All			16.61	20.93	18.29	24.71	17.33	37.61	16.35	34.28
		w/ISP resolver	26.89	34.66	21.57	29.00	22.79	31.95	24.77	35.52	21.23	35.82
Europe	Akamai	All			16.70	18.70	25.08	31.57	14.08	18.08	13.48	17.87
		w/ISP resolver	14.06	13.86	19.04	21.59	22.92	21.57	14.87	17.03	14.44	13.88
	Others	All			21.15	25.53	40.27	42.14	21.89	45.58	21.56	40.57
		w/ISP resolver	22.47	25.23	18.66	23.69	27.06	26.96	21.88	97.69	21.54	92.94
L.America	Akamai	All			34.22	48.00	151.39	158.21	27.56	41.57	22.11	41.61
		w/ISP resolver	15.87	105.32	81.95	113.68	186.36	239.69	22.51	106.51	17.71	106.58
	Others	All			70.07	63.91	148.60	140.64	89.63	94.39	91.81	88.01
		w/ISP resolver	278.39	147.82	94.28	119.29	208.93	351.39	256.96	144.72	256.71	110.85
Asia	Akamai	All			31.03	54.47	65.41	66.35	23.09	38.79	20.77	39.60
		w/ISP resolver	38.81	40.67	34.65	54.55	45.55	45.75	41.43	37.23	38.67	36.82
	Others	All			35.27	59.19	67.49	84.35	43.36	108.26	45.43	108.75
		w/ISP resolver	45.95	78.40	35.27	42.90	79.39	60.14	43.36	78.08	43.13	108.75
Africa	Akamai	All			52.20	49.12	51.81	49.36	52.25	49.15	49.63	49.14
		w/ISP resolver	52.34	18.83	116.24	16.61	52.23	52.19	52.54	18.78	52.26	18.81
	Others	All			121.64	118.77	108.20	132.50	77.98	165.49	82.17	158.66
		w/ISP resolver	83.47	76.35	129.81	133.44	116.38	142.72	126.05	173.98	129.41	158.66
Oceania	Akamai	All			15.92	15.27	20.35	14.64	14.78	14.10	14.09	14.10
		w/ISP resolver	12.98	38.54	41.30	13.24	38.61	38.55	13.84	13.51	13.34	13.45
	Others	All			34.06	57.36	39.25	57.54	43.17	154.87	46.45	100.63
		w/ISP resolver	38.19	58.08	34.06	87.01	73.68	63.71	40.76	203.53	46.45	166.01