Studying DNS Resolver Concentration

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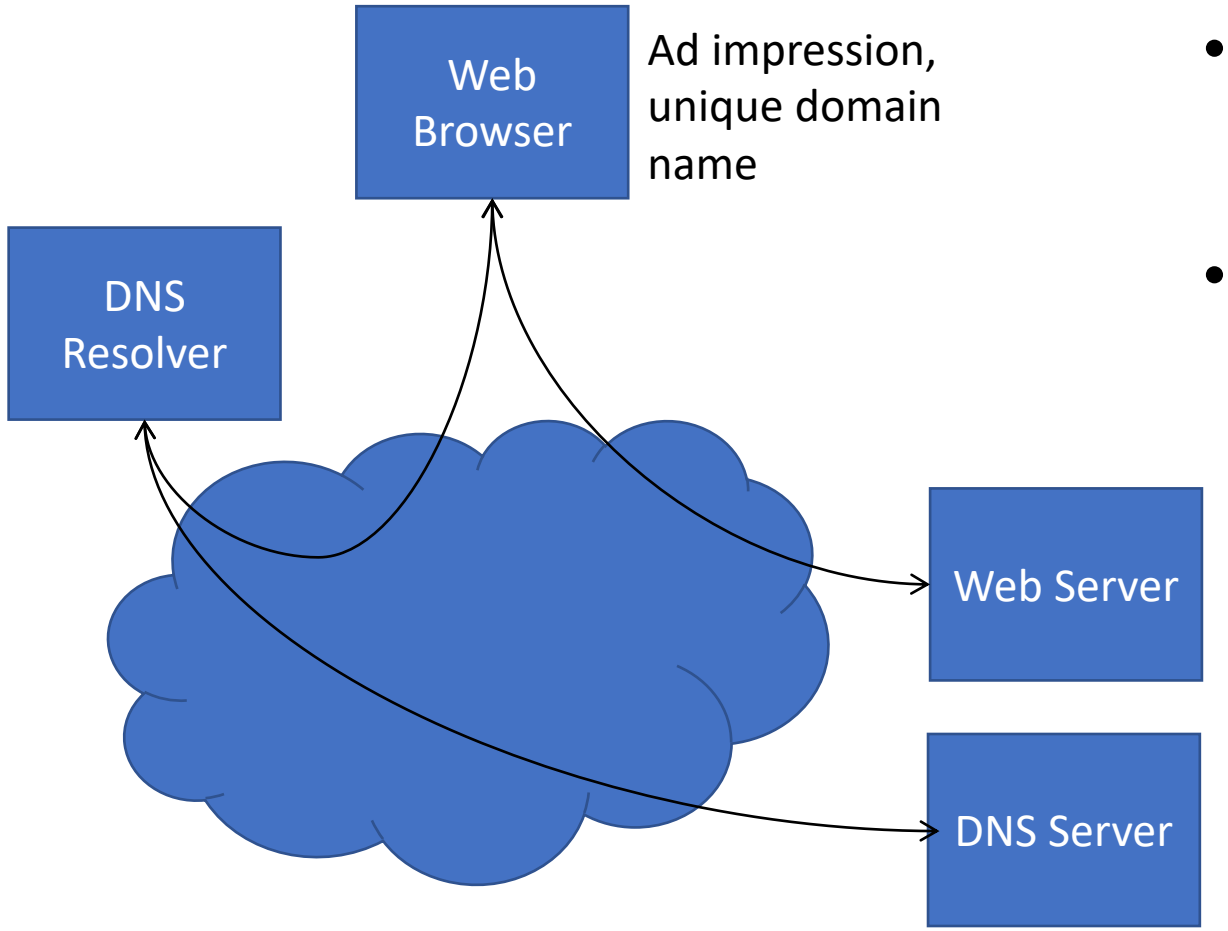
IDS

Measuring the Concentration of DNS Resolvers

- Public DNS resolvers offer an alternative to ISP DNS services
  - Concern: concentration of DNS traffic to a few services
- Our challenge:
  - Measure the share of DNS queries going through Public DNS Resolvers
  - Observe market share of these resolvers
  - Understand drivers for adoption of public DNS resolvers

Measuring Market Share Using APNIC Study



- Ad impression creates request to load “single pixel” in unique subdomain of experimenter domain
- Web server and DNS server are controlled by experimenter

IP Address in HTTP =>
- User AS,
- User country

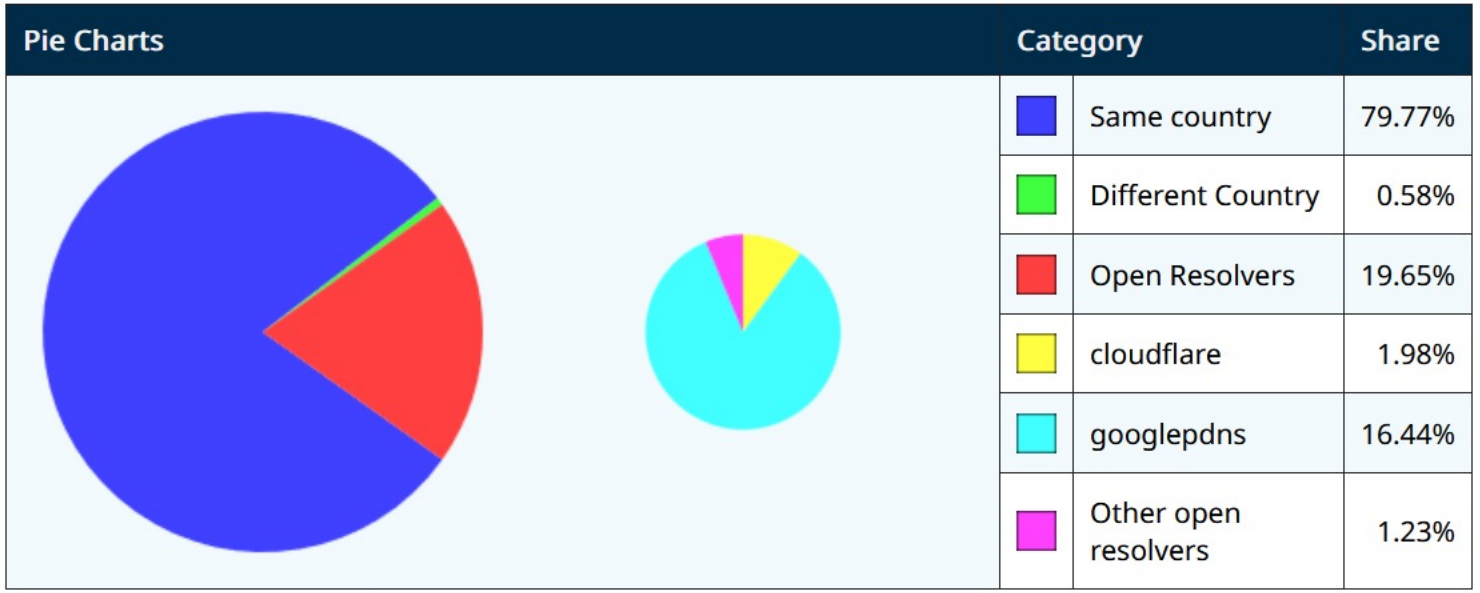
IP Address in Query =>
- Resolver AS,
- Resolver country

Measurements and Limitations

- Sampling of browser traffic
  - Random sampling world wide
  - Millions of queries
  - Lots of statistics: source IP, DNS resolver IP
- Dependency on Google Ads
  - Less data for some countries, e.g., Russia, China
  - No data for “non browser” traffic, e.g., IOT
  - Sampling of countries depends on Google Ads algorithms
- If user behind Proxy, see proxy IP, proxy-chosen DNS resolver
  - Similar issues with VPN

New ITHI Metrics M10,
Concentration of DNS Resolver Services

Global measurements show us global numbers, as here “world wide” shares for July 2022



Pie Charts	Category	Share
	Same country	79.77%
	Different Country	0.58%
	Open Resolvers	19.65%
	cloudflare	1.98%
	googlepdns	16.44%
	Other open resolvers	1.23%

Market Share of Public Resolvers, Word Wide

	All Public DNS	Google DNS	Cloudflare	Open DNS	Level3	Green Team DNS	DNS PAI	Others
1/31/2022	19.4%	16.3%	1.7%	0.6%	0.3%	0.1%	0.1%	0.2%
3/31/2022	20.2%	17.0%	1.9%	0.7%	0.3%	0.1%	0.1%	0.3%
5/31/2022	20.7%	17.1%	2.1%	0.5%	0.3%	0.1%	0.0%	0.5%
7/31/2022	19.6%	16.4%	2.0%	0.5%	0.2%	0.1%	0.1%	0.2%
9/30/2022	19.4%	16.2%	2.1%	0.5%	0.3%	0.1%	0.1%	0.2%

- No obvious trend, market shares appear stable
- Hard to separate variations from measurement noise.

What Drives Adoption of Public DNS Resolvers?

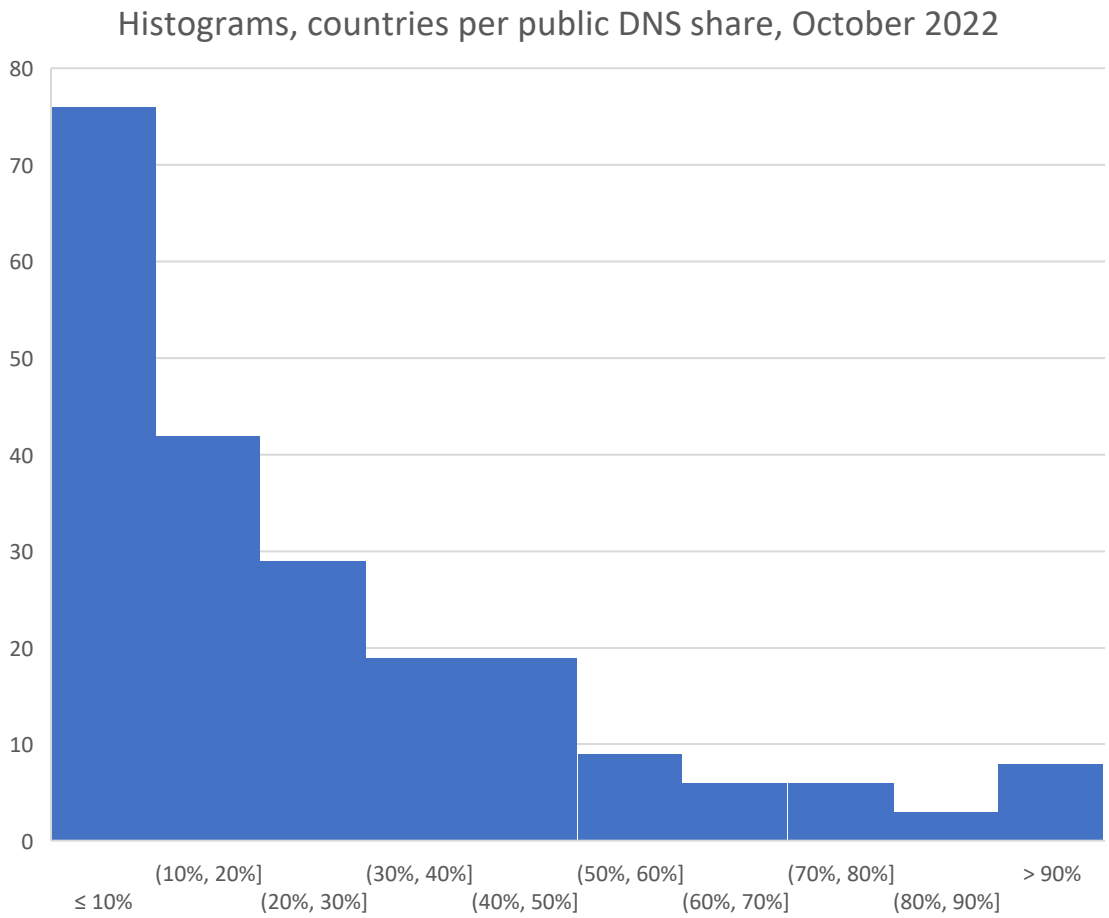
- Hypotheses
  - User Choice of browser configuration
  - ISP Choice
  - Others?
- Let’s check against the data

Hypothesis : User Choice

- Hypothesis:
  - Users configure their browser to use a Public DNS Resolver
- Supporting evidence:
  - Functionality is available in several browsers
- But:
  - Few users ever change the default software configuration
  - Sample of large consumer ISP shows low PDNS rate

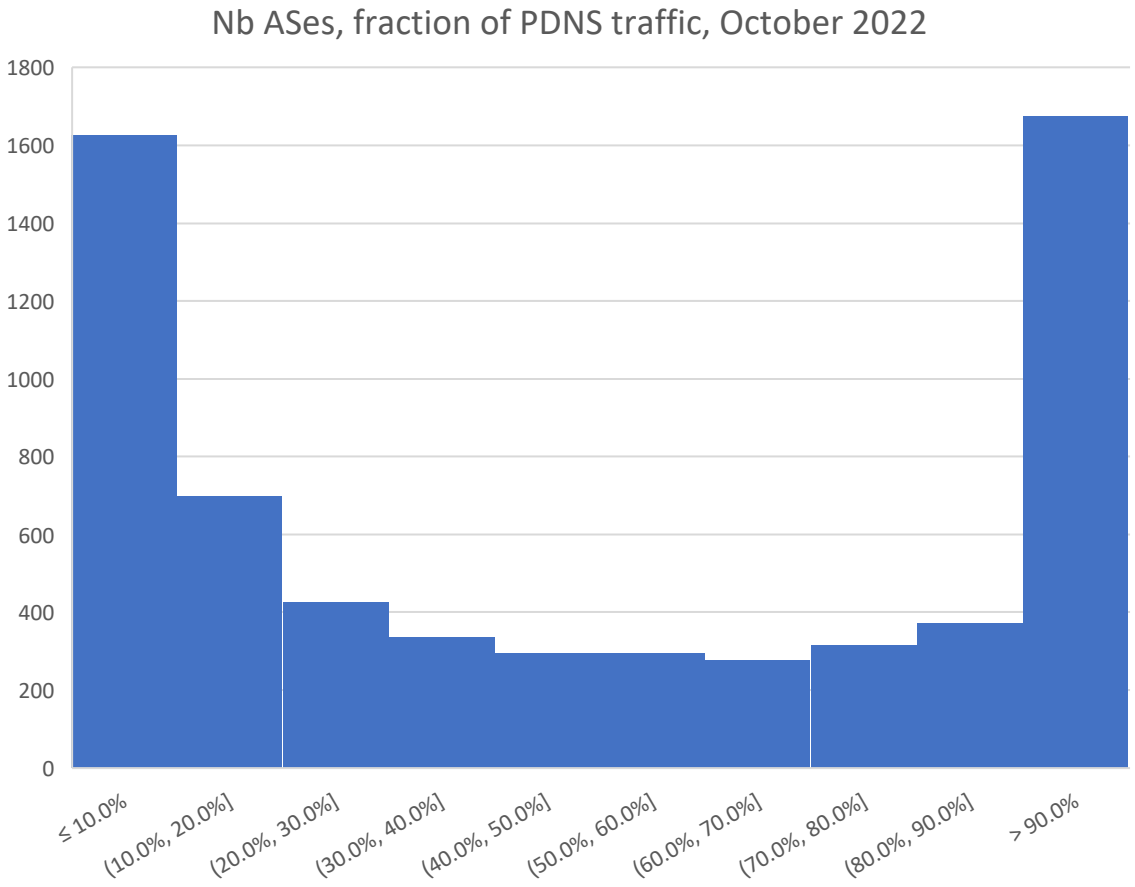
CC	AS Name	Ratio
IN	Reliance JIO Infocom	7.5%
IN	Bharti Airtel Ltd.	1.3%
ID	Telekomunicasi Cellular	8.5%
US	Comcast	5.6%
GB	Sky UK Ltd	1.7%
GB	Bristish Telecom	3.0%
SE	Telia Company AB	4.2%
GB	Virgin Media Ltd	3.3%
TR	Turk Telekomunikasyon	8.2%
US	AT&T Inc.	5.6%
VN	Viettel Group.	9.2%
FR	Orange S.A.	3.3%
DE	Deutsche Telekom AG	2.9%

Share of Public DNS per Country Varies Widely



- For 76 countries, < 10%
- But some countries show >90% share:
  - Chad, Sierra Leone, Central African Republic, Maldives, Zambia, Djibouti, Northern Mariana Islands, Somalia
- Cannot be explained by “user choice” alone

Hypothesis: ISP Choice



- Some Internet Service Providers treat DNS as cost center
- Outsource to Public DNS Resolvers for cost reduction
- Certainly explains some of the data that we see
- … but not all.

<10%, >90% and In Between?

	AS <10% PDNS	AS In between	AS >90% PDNS
%NB ISP	26%	48%	26%
%Total Queries	67%	28%	5%
%PDNS Queries	19%	51%	29%

- Why so much “in between” ?
  - Not explained by previous hypotheses
- Hypothesis: fractional deployment
  - Outsource some regions, not others
- Hypothesis: customer categories
  - Business customers outsourcing their traffic
- Something else?

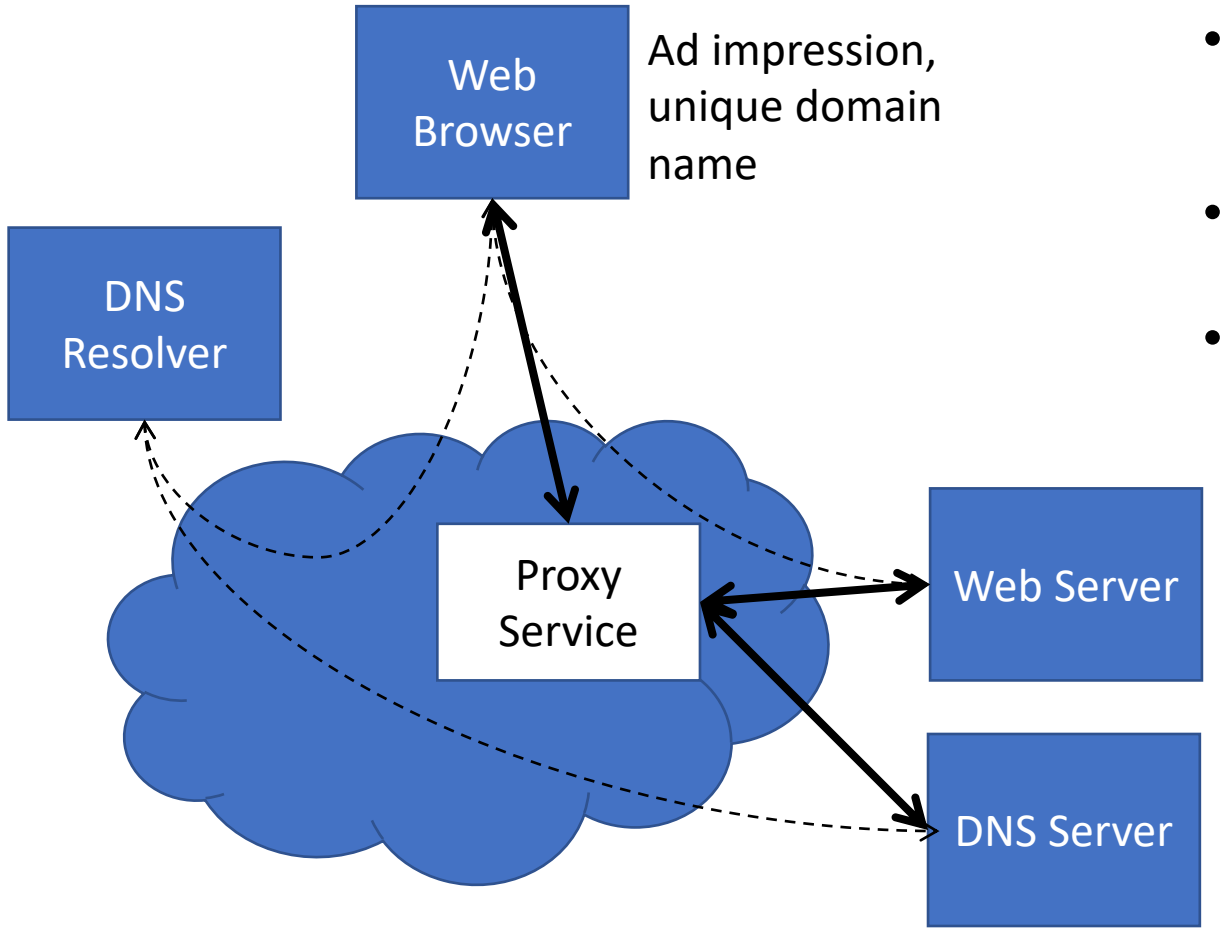
Summary:
Two Known Sources of Public DNS traffic

- Users tweaking browser or DNS configurations
  - Few % of users in large ASes
    - Few users change their default configuration
- ISPs treating DNS as cost center, offloading to PDNS
  - Very common in Africa, South Asia
  - Frequent for small ISP

Further Study:
Unknown Sources of Public DNS traffic

- ISPs offloading a fraction of DNS traffic
  - May appear if doing statistics by Address Prefixes
- Enterprise and other organizations choosing DNS provider
  - May appear if isolating statistics for Enterprise Networks
- Users subscribing to VPN or proxy services
  - Will require new methodology
- Some other unknown…

Hypothesis: VPN and Proxies



- New services:
  - Apple's Private Relay, Cloudflare's "WARP", Google syndication, Mozilla VPN
- Cause traffic to appear "from cloud servers"
- Outside measurement hypotheses

IP Address in HTTP =>
- ~~User AS,~~ Proxy AS!
- ~~User country~~ Proxy Country

IP Address in Query =>
- ~~Resolver AS,~~ Chosen by Proxy!
- ~~Resolver country~~ Chosen by Proxy!