Let's Measure

Aftab Siddiqui
Head of Stakeholder Engagement
[APNIC Foundation]

APNIC Foundation

- The APNIC Foundation is dedicated to a global, open, stable and secure Internet that is affordable and accessible to the entire Asia Pacific community

- The Foundation focuses on increasing investment in education and training, community development, research, and related digital development projects and activities

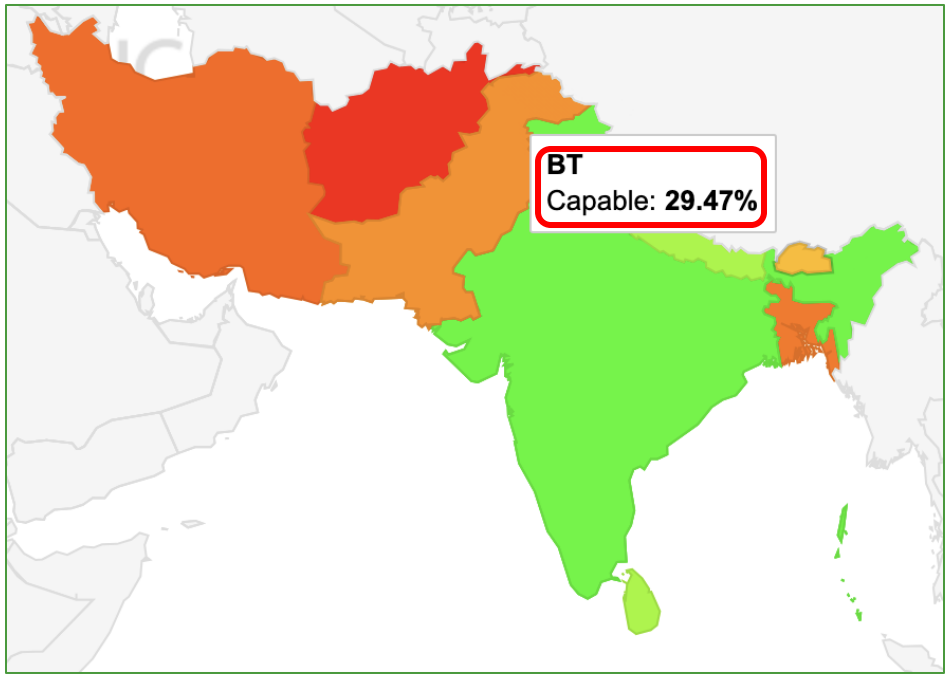
- If you're interested in conducting research and measurement work with us, we are currently seeking research fellows. The application deadline is August 30th

https://apnic.foundation/blog/introducing-the-apnic-foundation-research-fellowship/

IPv6 Adoption

IPv6 adoption varies significantly around the world and across different types of networks. Some regions and countries have significantly higher adoption rates. Major content delivery networks have been at the forefront.

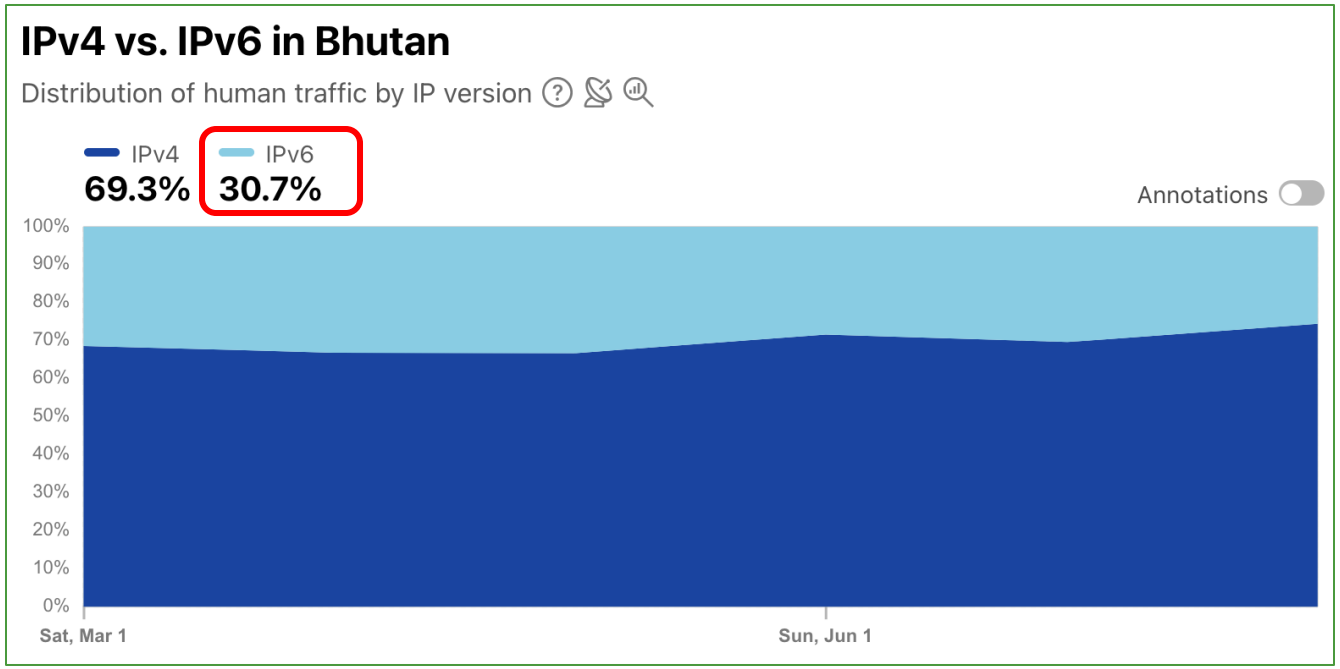
IPv6 Adoption Statistics in Bhutan



APNIC Labs

https://stats.labs.apnic.net/ipv6/BT

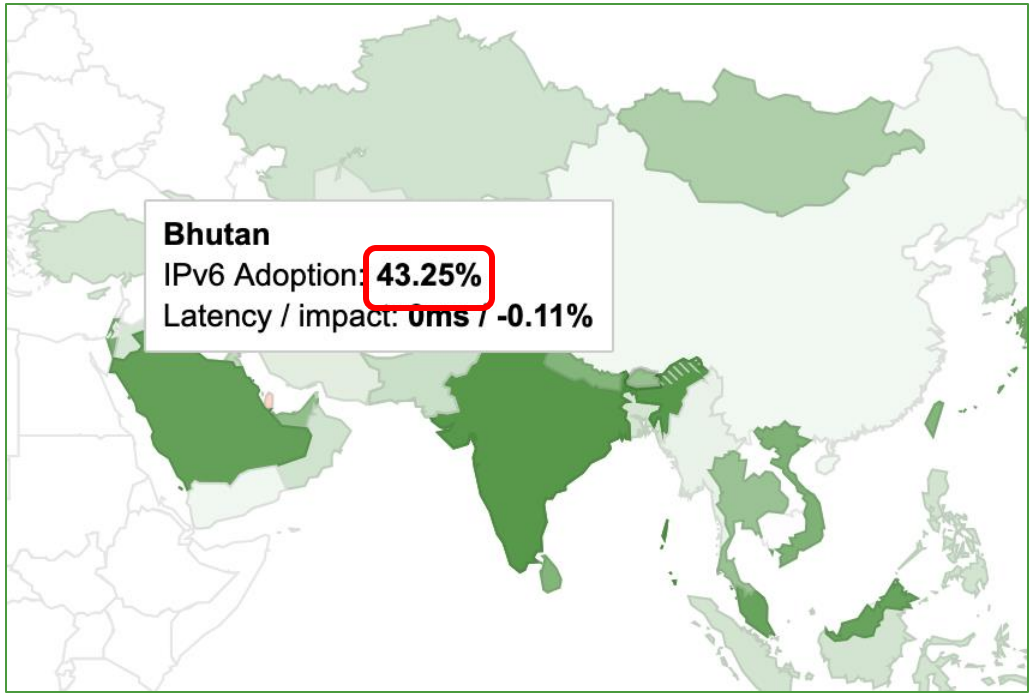
IPv6 Adoption Statistics in Bhutan



https://radar.cloudflare.com/adoption-and-usage/bt?dateRange=24w

Google IPv6

https://www.google.com/intl/en/ipv6/statistics.html#tab=per-country-ipv6-adoption



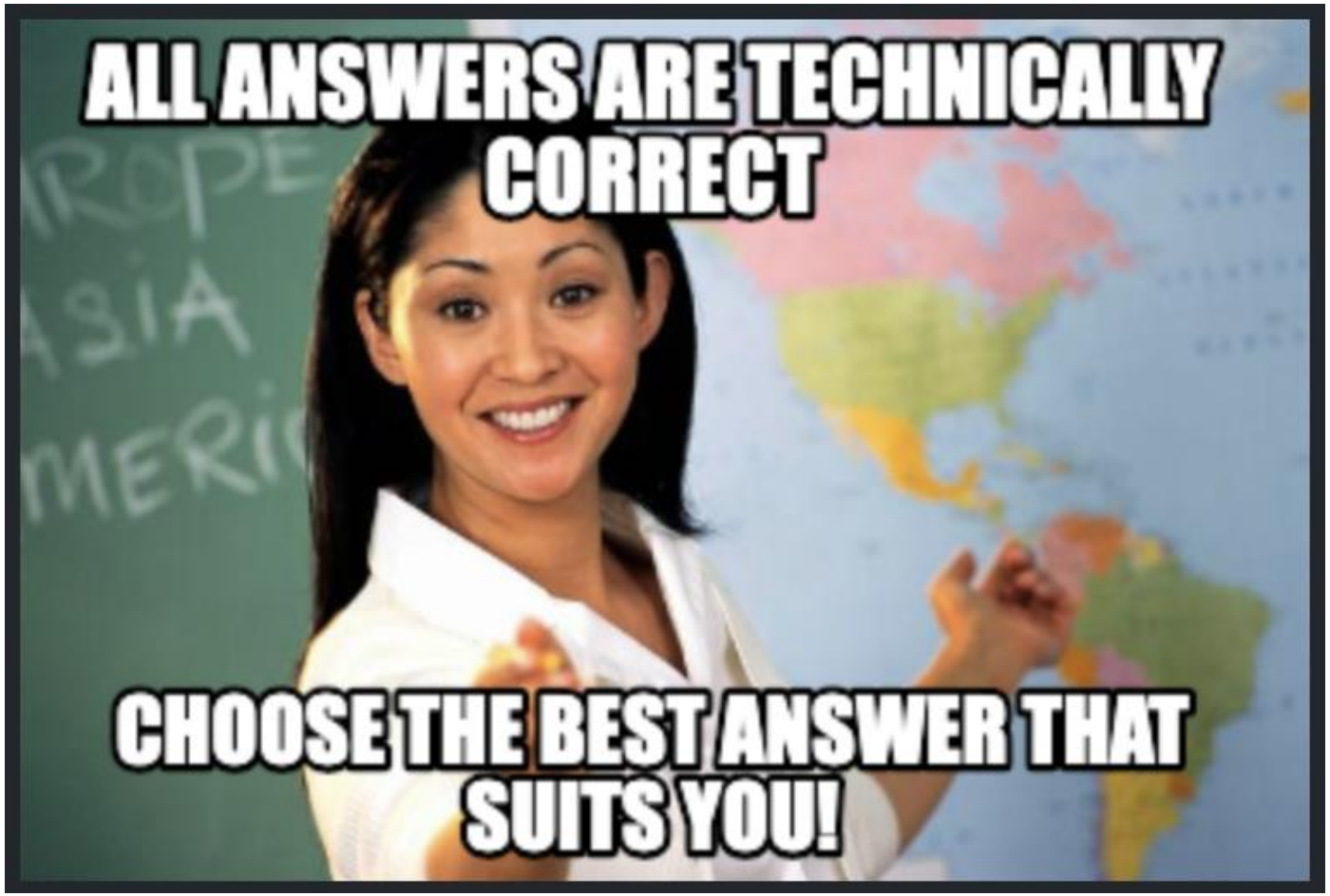
IPv6 Adoption Statistics in Bhutan

APNIC Labs: **29.46%**

Cloudflare: **30.7%**

Google IPv6: **43.25%**

Which number is correct?



Measurement is hard!!!

Bias Type	What it is
Selection Bias	You choose vantage points (e.g. RIPE Atlas probes) or target lists (e.g. Tranco Top 1K websites) that aren't representative.
Sampling Bias	Measurement frequency or timing favours certain networks or times of day.
Confirmation Bias	You design tests to prove a hypothesis (e.g. "IPv6 is faster than IPv4").
Interpretation Bias	When an analyst draws conclusions not directly supported by the dataset.
Presentation Bias	When data is shown without context, caveats or clear interpretation guidance.

IPv6 Adoption Statistics in BT

ASN	AS Name	IPv6 Capable	Pop Coverage (RADAR) K	Net Coverage IHR	Samples	Wt. Avg
AS18024	BTTELECOM-AS-AP Bhutan Telecom Ltd	41.24%	220.00	50.00%	88,824	41.24%
AS137412	TASHICELL-MOBILE-AS Tashicell Domestic AS Thimphu Bhutan	19.86%	145.00	30.60%	58,500	19.86%
AS23955	TASHICELL-DOMESTIC-AS Tashi InfoComm Limited	0.53%	15.00	3.70%	5,865	0.53%
AS134715	GTA-AS-AP Government Technology Agency	35.17%	13.00	4.30%	5,328	35.17%
AS152317	WPDA-AS-AP Wangdue Phodrang Dzongkhag Administration	0.13%	12.00	3.30%	4,761	0.13%
AS136039	NANO-AS-AP NANO, Bhutan	0.42%	11.00	2.30%	4,271	0.42%
AS138558	GDNI-AS-AP Gelephu Digital Network	0.11%	9.00	1.80%	3,620	0.11%
AS138529	DATANET-AS-AP DATANET WIFI	0.17%	5.90	1.30%	2,372	0.17%
AS132894	MUD-AS-AP Sigma Internet Service	0.00%	5.70	1.20%	2,288	0.00%
AS141680	SUPERNET1-AS-AP SuperNet Infocomm	0.09%	2.80	0.60%	1,121	0.09%

https://stats.labs.apnic.net/ipv6/BT

How should we measure?

- Do you want to measure what percentage of population using Internet have IPv6? Around 750K Internet Users in BT

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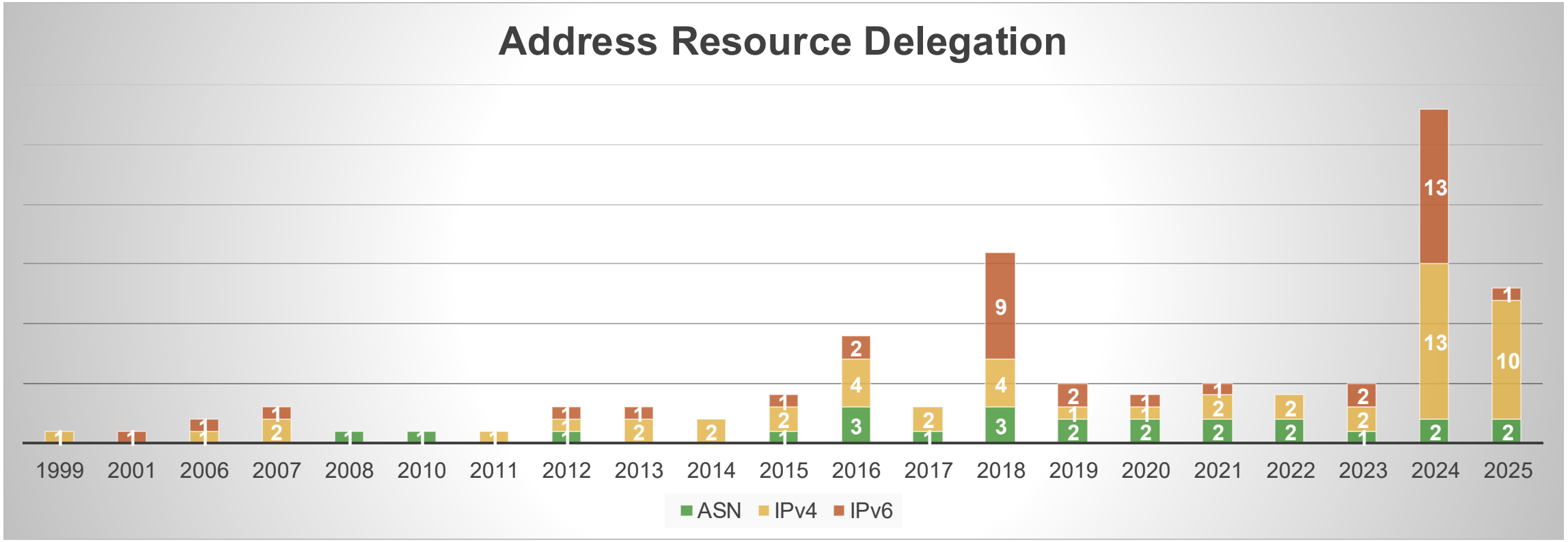
- ***29% IPv6 capable means around 215,000 Internet users have IPv6 access in Bhutan***
- ***But 41.24% of 220k and 19.86% of 145k also adding smaller networks make around 130,000 IPv6 capable***

https://stats.labs.apnic.net/cgi-bin/aspop?c=BT&d=19/08/2025

How should we measure?

- Do you want to measure how many networks in the country providing IPv6 to their end users?



How should we measure?

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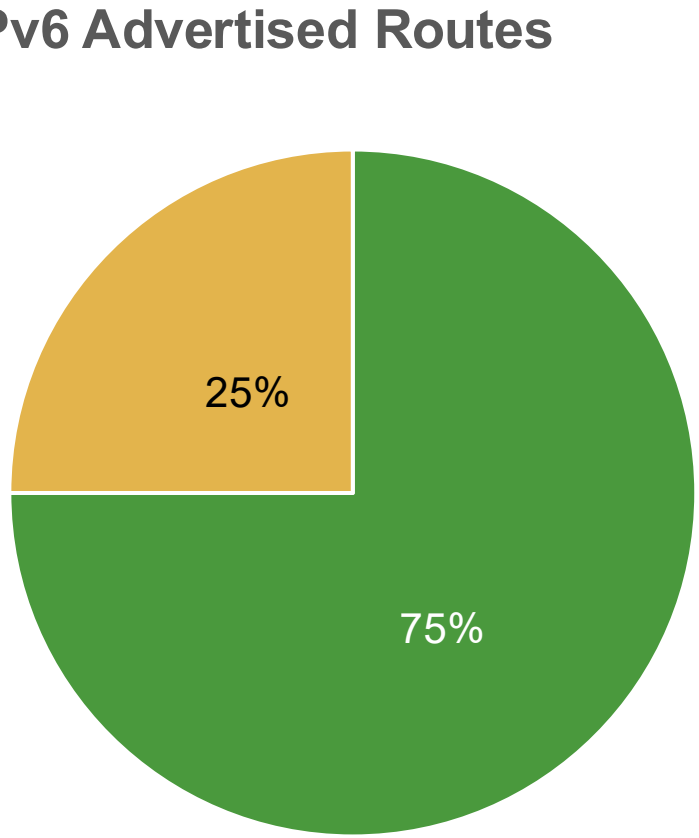
Status	Count
FOUND	18
NOT FOUND	6



Take aways

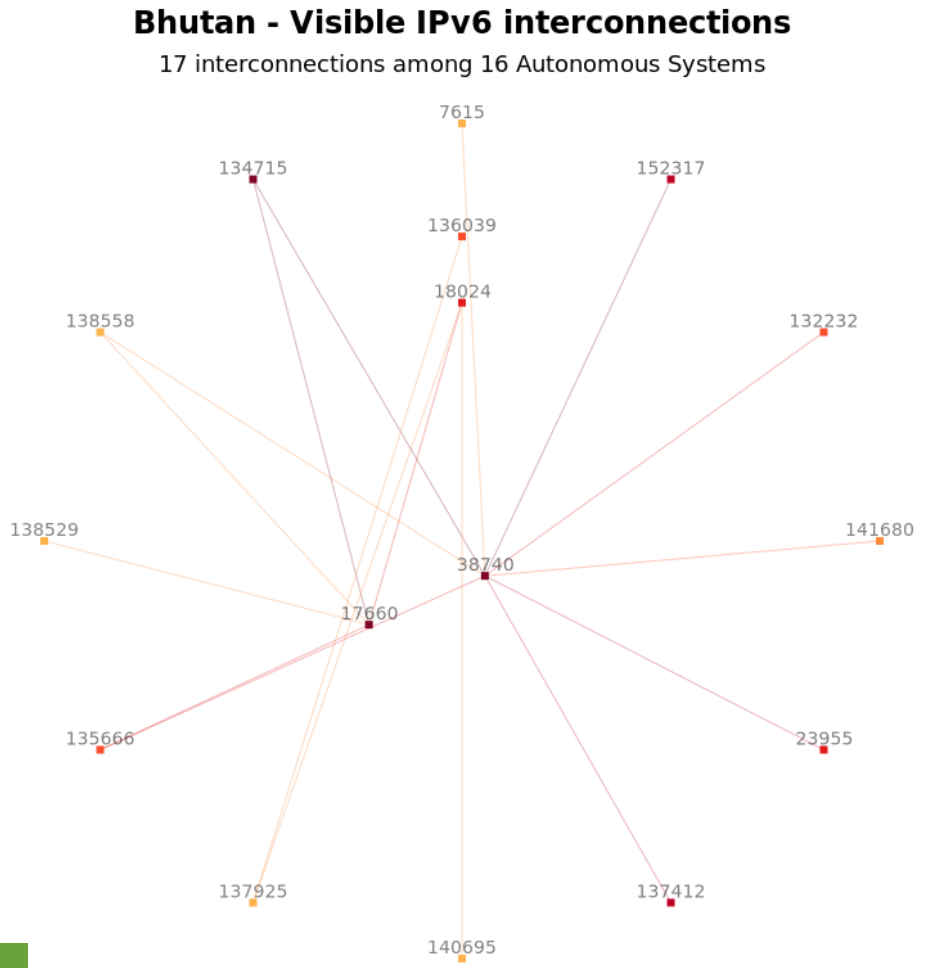
- **Measurements are Indicative, Not Absolutes**
  IPv6 probe-success rates and BGP statistics gives you a snapshot of “what’s out there,” but they can’t capture every nuance. Treat the numbers as directional guides rather than the final answer.
- **Large Operators Drive the Numbers**
  Large consumer ISPs account for the lion’s share of IPv6 announcements and probe-success samples. We should applaud their engineering teams for building robust IPv6 backbones and customer-facing rollouts.
- **Smaller Networks Lag Behind** FOCUS HERE
  Many small carriers, enterprise networks still either don’t advertise IPv6 at all or only do so for the sake of it.

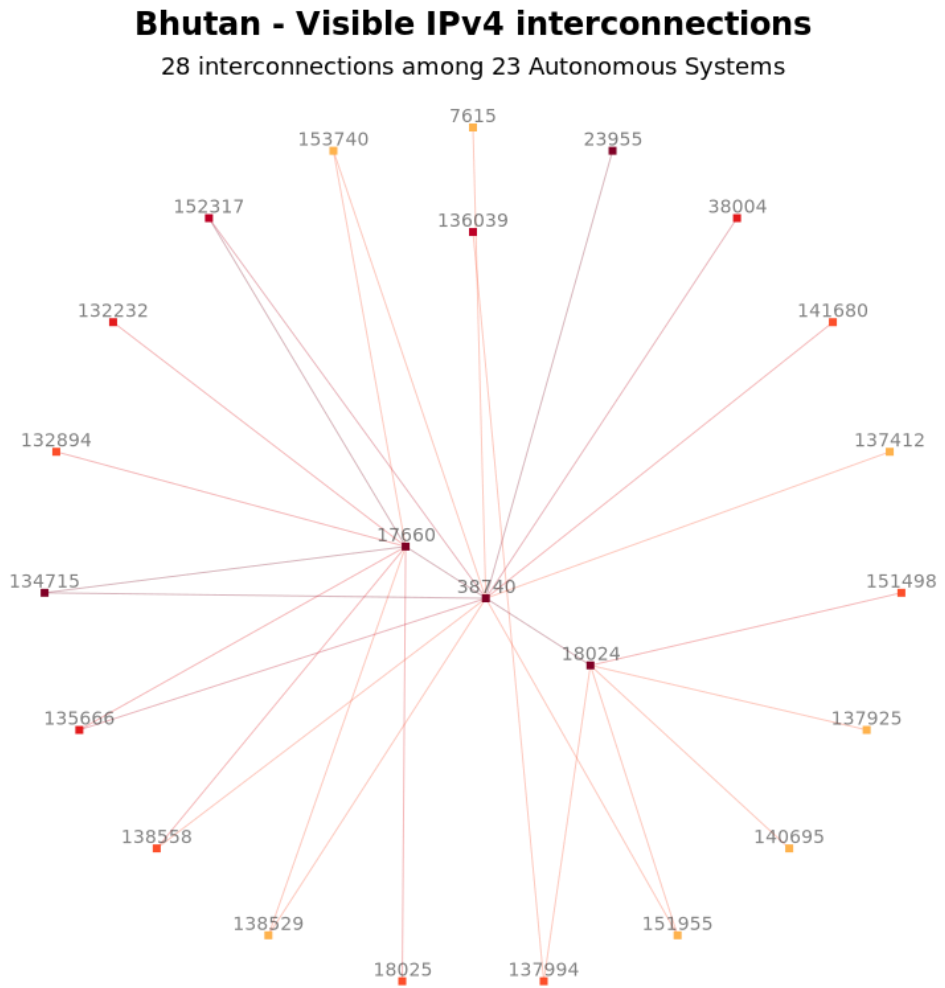
Peering and Interconnect!

Bridging Gap Protocol – Skynews

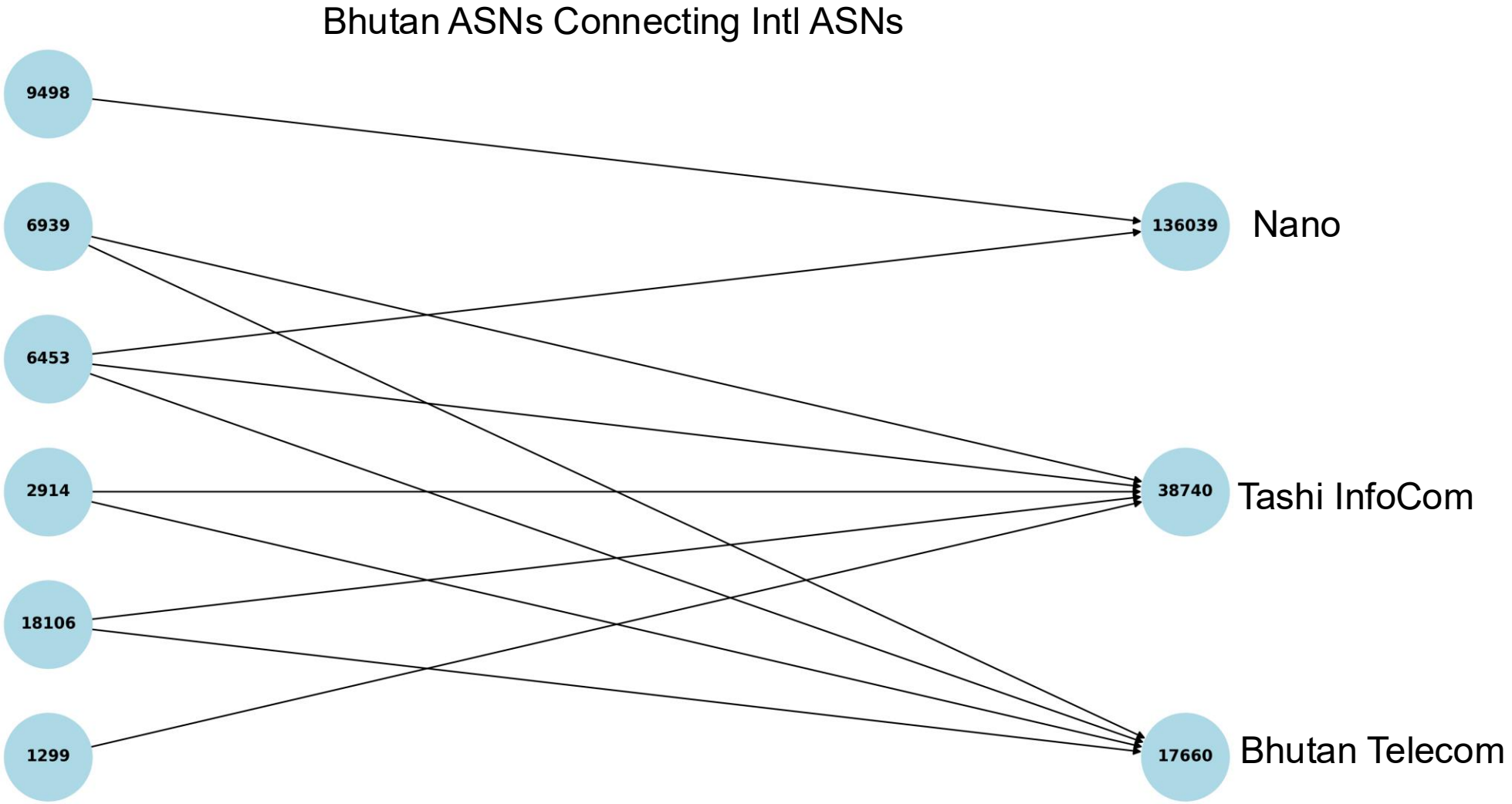
How Networks in Bhutan are connected

BT Networks Interconnection





BT Networks External Connections



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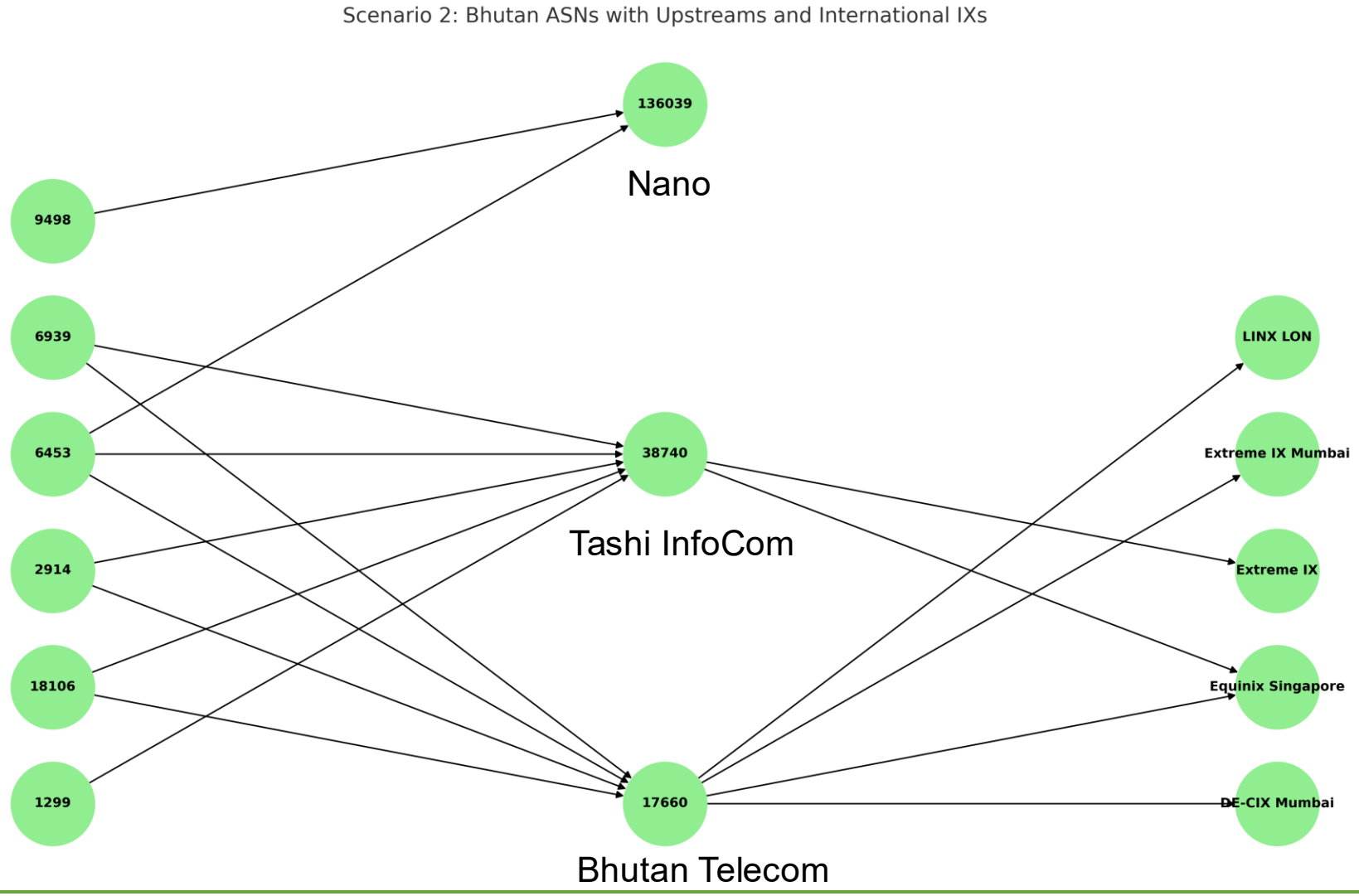
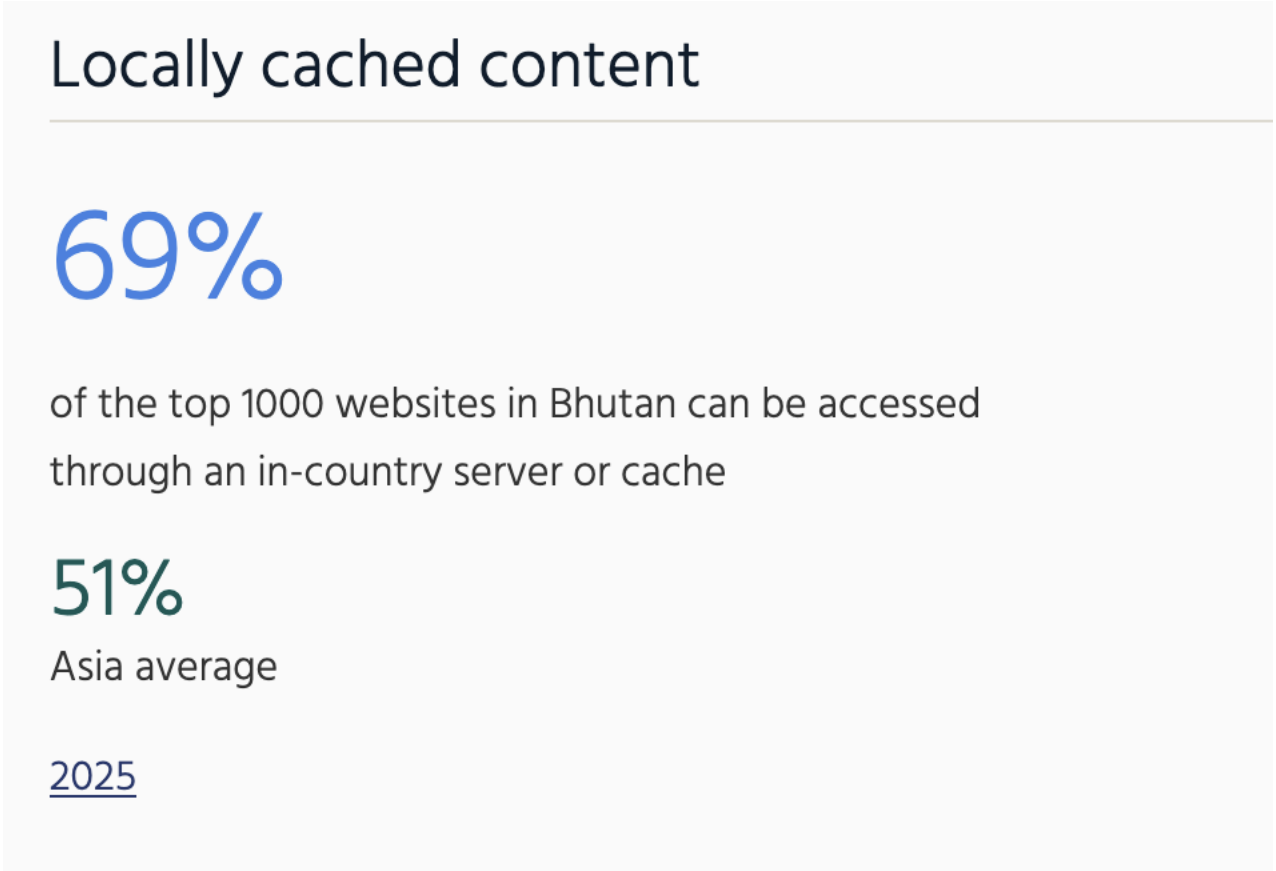


Content Locality

By using Tranco list (Google Chrome User Experience Report (CrUX) and Cloudflare top 100 domains) data to identify content delivery networks (CDNs) serving the most frequently accessed websites within a specific economy. The objective is to assess what proportion of this web content is delivered from domestic servers or local caches."

Content Locality – Pulse ISOC



https://pulse.internetsociety.org/en/reports/bt/

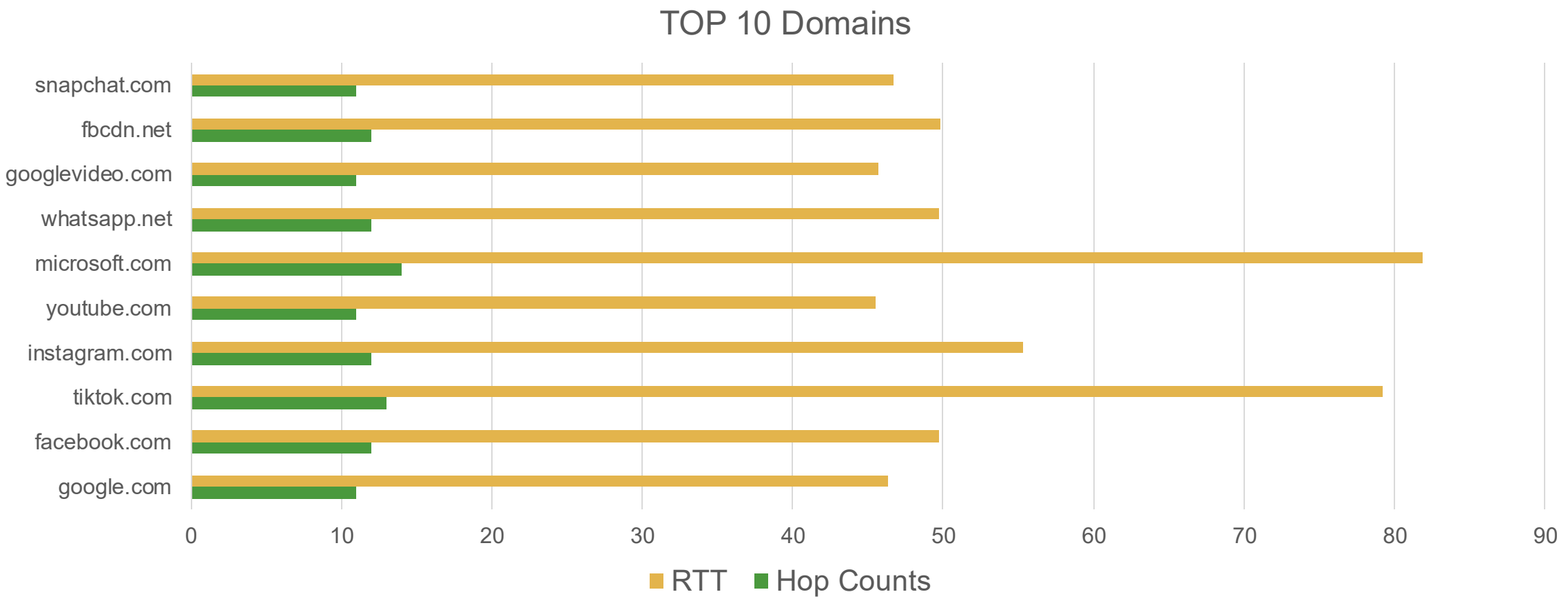
Measurement --> https://github.com/cisagov/findcdn

Content Locality

The top websites in Bhutan are served by a mix of major global content delivery networks and cloud providers, including leading platforms like Google, Microsoft, Amazon, and Cloudflare, alongside regional Asian networks from China and local Bhutanese infrastructure providers. This distribution pattern mirrors what is commonly observed in many countries worldwide.

Word cloud generated from top domain A/AAAA Records

Content Locality



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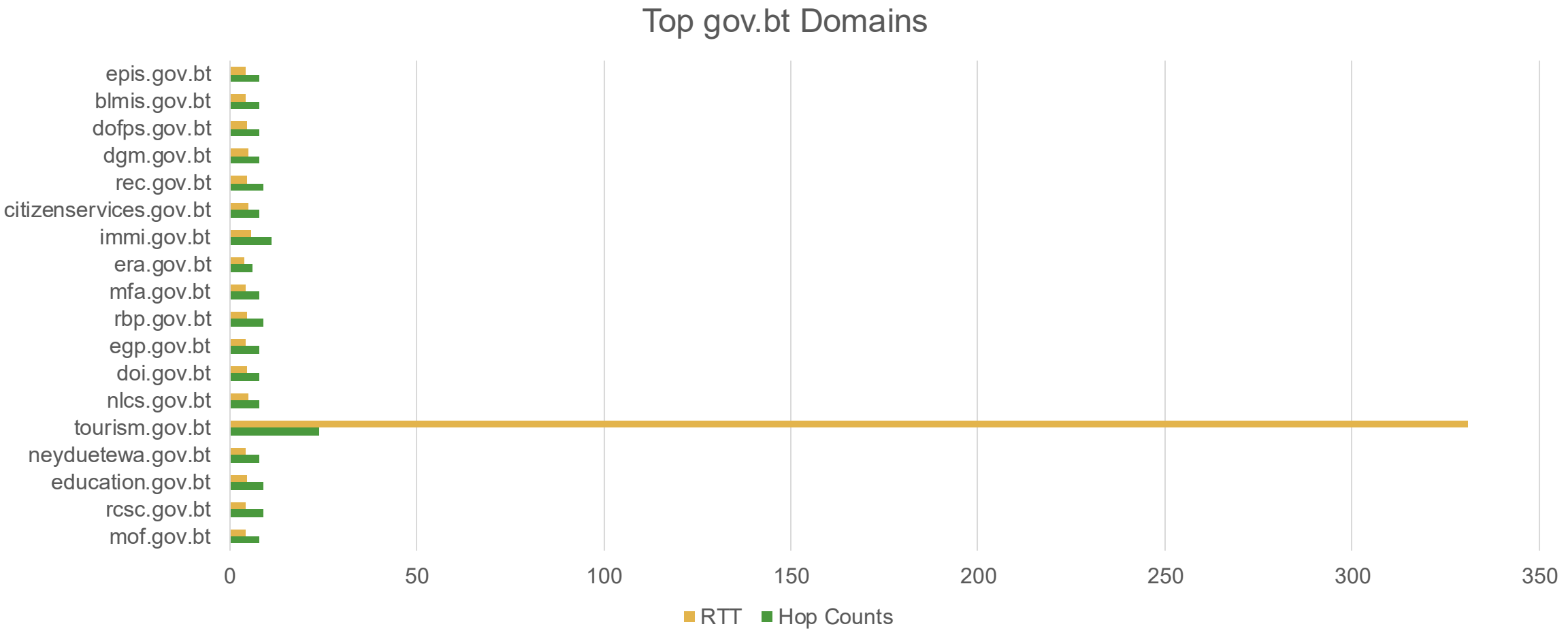
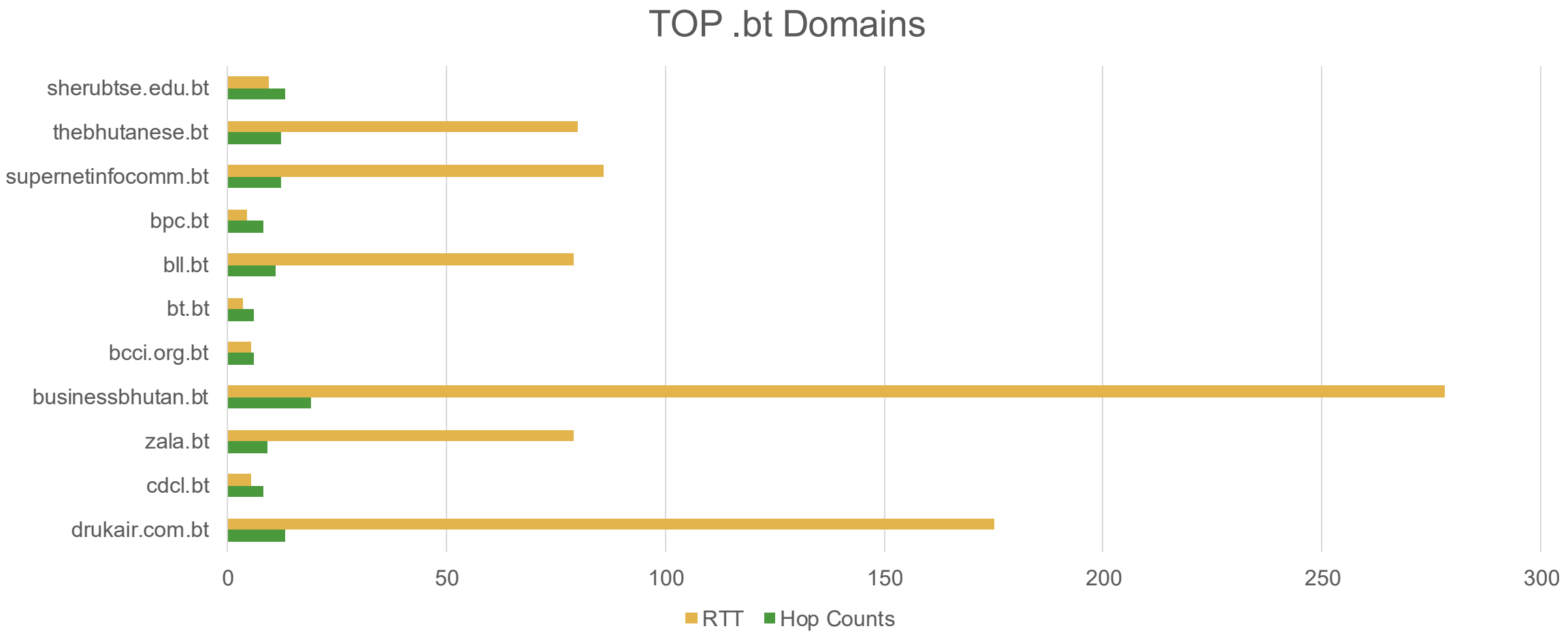


Content Locality



Content Locality

```
supernetbhutan.com. 600 IN A 103.161.249.10

141680  | 103.161.249.10   | SUPERNET1-AS-AP SuperNet Infocomm, BT

Tracing the path to 103.161.249.10 on TCP port 80 (http), 30 hops max
 1  10.10.10.1  3.791 ms  3.115 ms  2.995 ms
 2  ge-0-0-12.hotel-bhutan-home.druknet.bt (202.144.153.205)  4.781 ms  4.101 ms  3.898 ms
 3  163.227.30.1  3.204 ms  4.079 ms  3.263 ms
 4  103.245.240.70  3.537 ms  3.585 ms  3.966 ms
 5  p2p-103.245.242.232.tr1.thimphu.druknet.bt (103.245.242.232)  6.333 ms  6.518 ms  6.578 ms
 6  p2p-103.245.242.228.tr1.pling.druknet.bt (103.245.242.228)  8.200 ms  7.734 ms  7.783 ms
 7  103.245.243.157  79.985 ms  79.953 ms  79.480 ms
 8  38740.sgw.equinix.com (27.111.230.10)  84.785 ms  84.794 ms  84.978 ms
 9  if207-cr1-tpu.as38740.tashicell.com (43.241.139.134)  85.107 ms  85.467 ms  85.007 ms
10  po1-edge1-btix.as38740.tashicell.com (43.241.139.151)  84.942 ms  84.932 ms  84.884 ms
11  supernet-as141680.btix.bt (103.129.62.12)  85.050 ms  84.957 ms  84.897 ms
12  supernetinfocomm.bt (103.161.249.10) [open]  85.292 ms  85.300 ms  85.391 ms
```

Content Locality

```
Traceroute from 157.10.129.97 to 103.161.249.10
Using RIPE, Probe 62286

STARTED QUERY AT 2025/08/22 23:39:11 UTC

Fetching Measurement: 125137581
Traceroute from 10.10.77.20 to 103.161.249.10 (103.161.249.10):
1 * * *
2 * * *
3 * * *
4 supernetbhutan.com (103.161.249.10) 1.68ms 1.317ms 6.622ms
```

Traceroute taken from RIPE Atlas Probe hosted at AS152317 - Wangdue Phodrang Dzongkhag Administration, BT

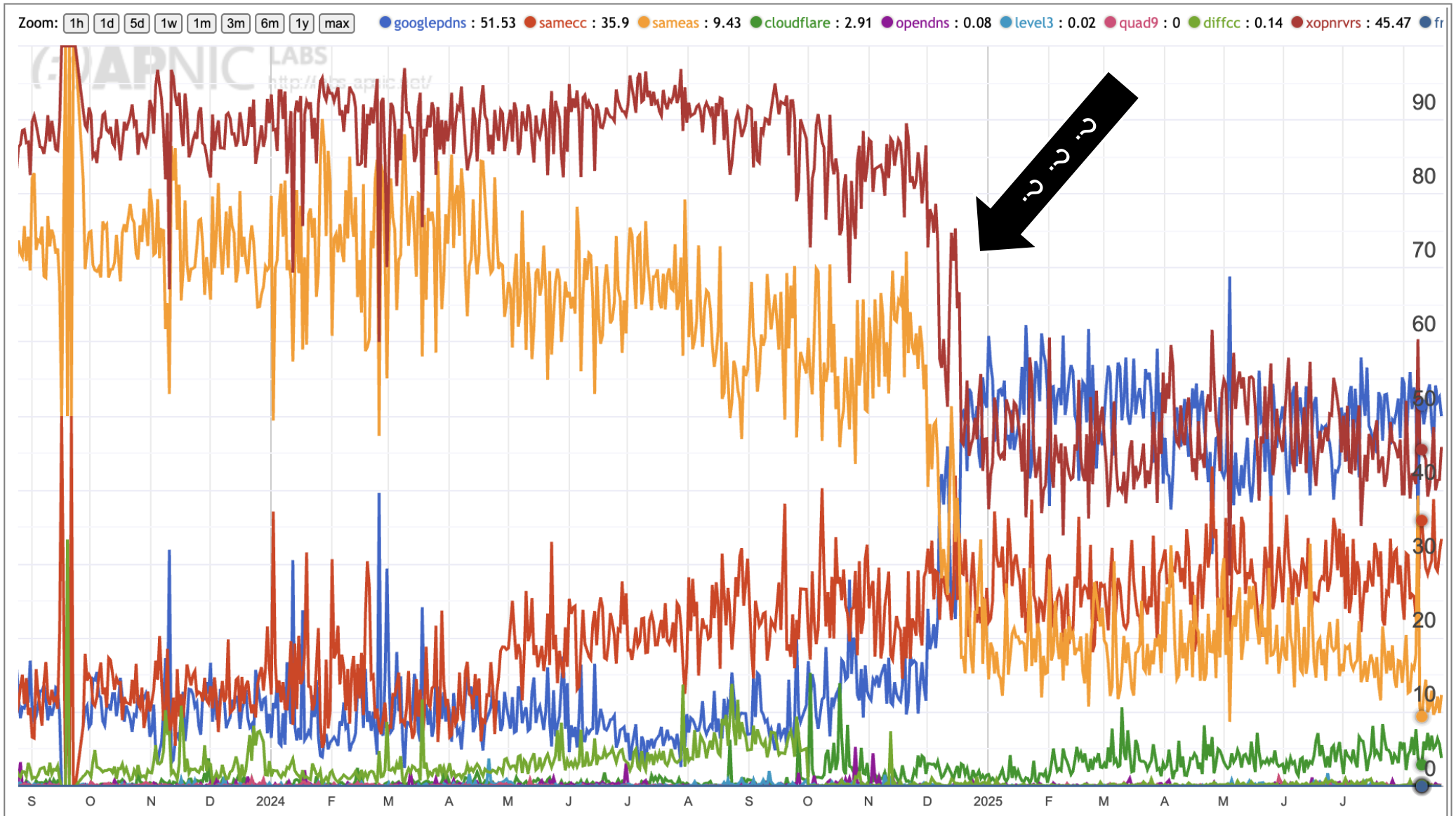
AS18024 (Bhutan Telecom) and AS141680 (SuperNet Infocomm) Please talk to each other

DNS Resolver

DNS resolver choice serves as an indicator of user trust in their internet service provider. When users stick with their ISP's default DNS settings, it typically suggests satisfaction with the service. Conversely, the growing adoption of public DNS resolvers like Google's 8.8.8.8 or Cloudflare's 1.1.1.1 may signal user concerns about their ISP's DNS reliability, privacy practices, or performance.

DNS Resolver

https://stats.labs.apnic.net/rvrs/BT



Summary

These measurements form a holistic view of network resilience, performance optimization, efficiency, and technical autonomy which are critical indicators for assessing a nation's internet infrastructure maturity and identifying areas requiring policy intervention or infrastructure investment.

Accuracy of these measurements is very important because inaccurate data can lead to misallocated resources, flawed network engineering decisions, and incorrect assessments of internet resilience, potentially resulting in suboptimal infrastructure development or overlooked security vulnerabilities.

Thankyou!