Measuring DNS-over-HTTPS Performance Around the World

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IMC `21

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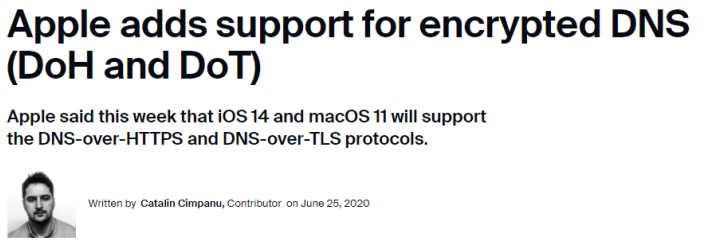
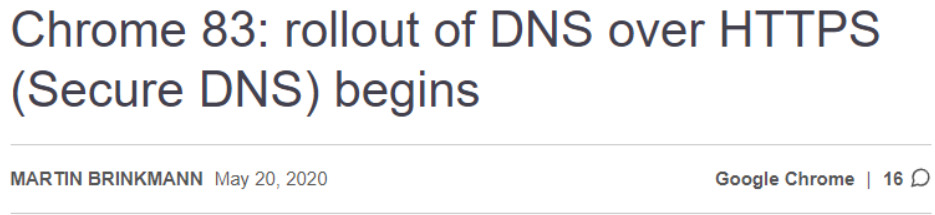
Outline

- Introduction
- Methodology
- Measurement results
- Conclusion

Introduction

- Transition from traditional (unencrypted) DNS to privacy-preserving alternative: Do53 to DoT/DoH
  - Do53: traditional DNS protocol using port 53
  - DoT: DNS-over-TLS
  - DoH: DNS-over-HTTPS

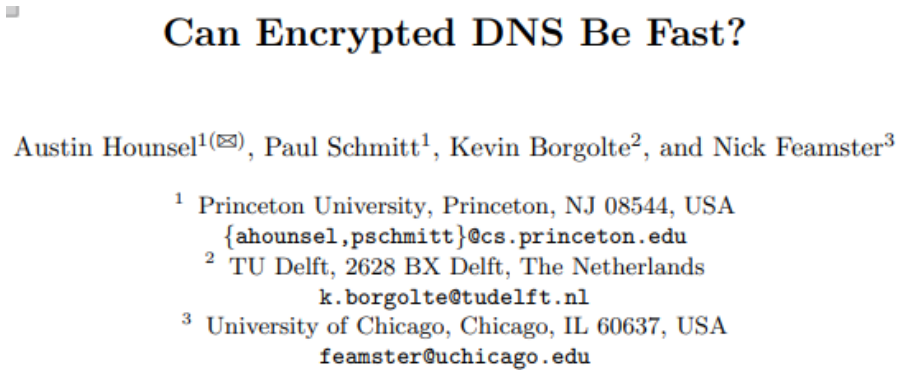




DoT v.s. DoH

	DoT	DoH
Supports	**OS level** support - Hard to update protocol	**App level** support + App update → protocol update
Port	Port **853** (DoT) - DNS query, response are exposed by port number + Easy to block suspicious DoT messages for network operators	Port **443** (HTTPS) + Cannot distinguish DoH with HTTPS messages by port number → better user privacy - Either for network operators

Existing works



Can Encrypted DNS Be Fast?

Austin Hounsel[1(✉)], Paul Schmitt[1], Kevin Borgolte[2], and Nick Feamster[3]

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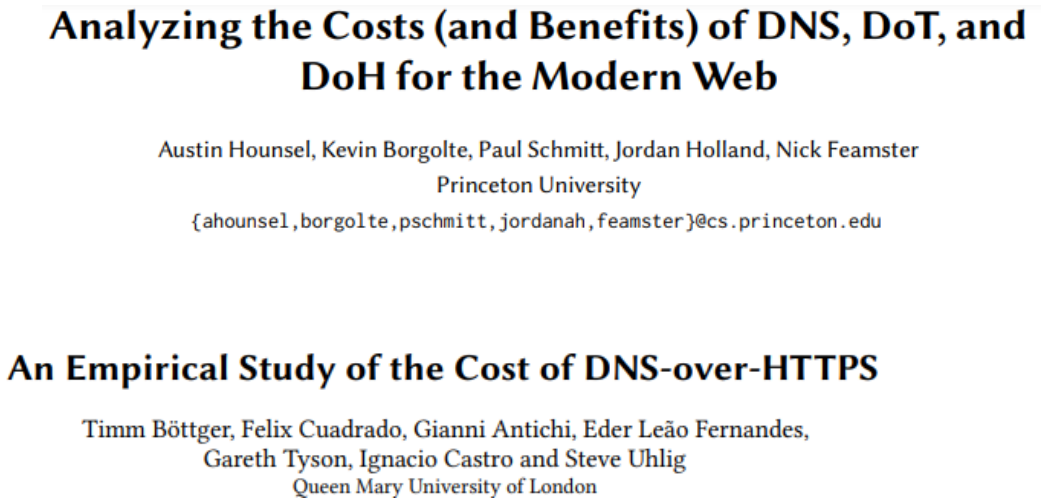


Analyzing the Costs (and Benefits) of DNS, DoT, and DoH for the Modern Web

Austin Hounsel, Kevin Borgolte, Paul Schmitt, Jordan Holland, Nick Feamster
Princeton University
{ahounsel,borgolte,pschmitt,jordanah,feamster}@cs.princeton.edu

An Empirical Study of the Cost of DNS-over-HTTPS

Timm Böttger, Felix Cuadrado, Gianni Antichi, Eder Leão Fernandes,
Gareth Tyson, Ignacio Castro and Steve Uhlig
Queen Mary University of London

- Lacks of global perspective
- Or including other delays (middleboxes, etc.)

Global scale measurements

We wanted to compare DNS-over-UDP (Do53) with DNS-over-HTTPS (DoH) for as many countries as possible

Global scale measurements

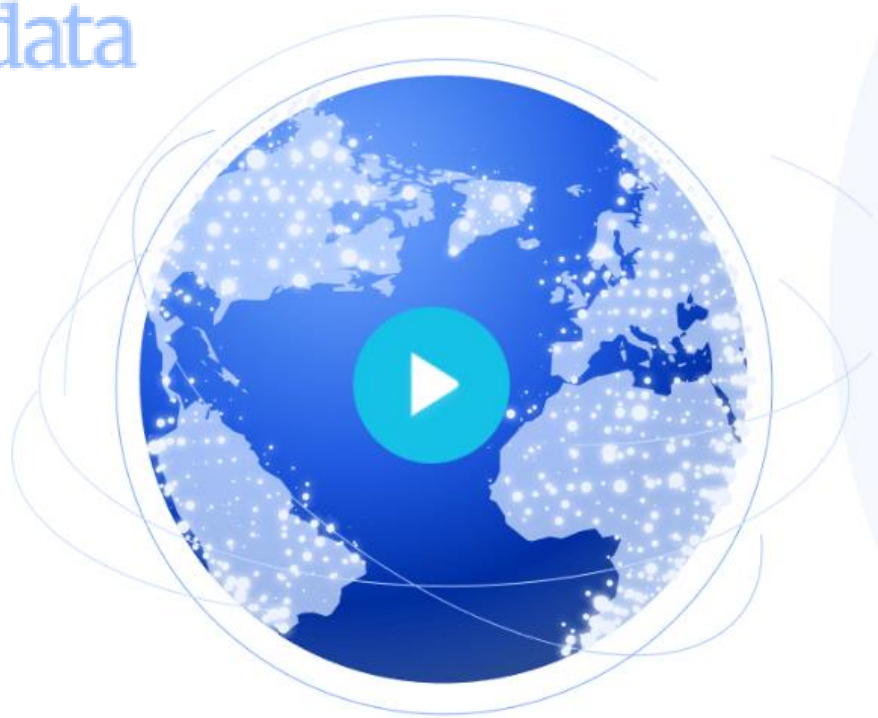
Core questions

- Performance impact of a switch from traditional Do53 or DoH
- Differences across countries and geographical regions
- External factors or variables
- Gap between architecture and performance

Methodology

Obtaining data with “bright data”

bright data



RESIDENTIAL PROXY NETWORK

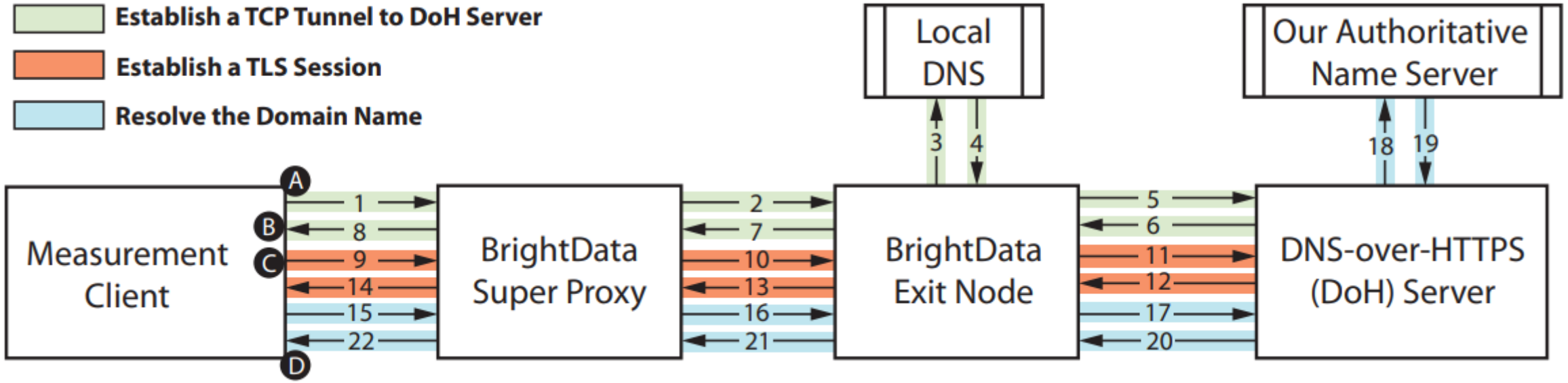
Real Residential Proxies

Avoid restrictions and blocks with the fastest residential proxy network in the industry

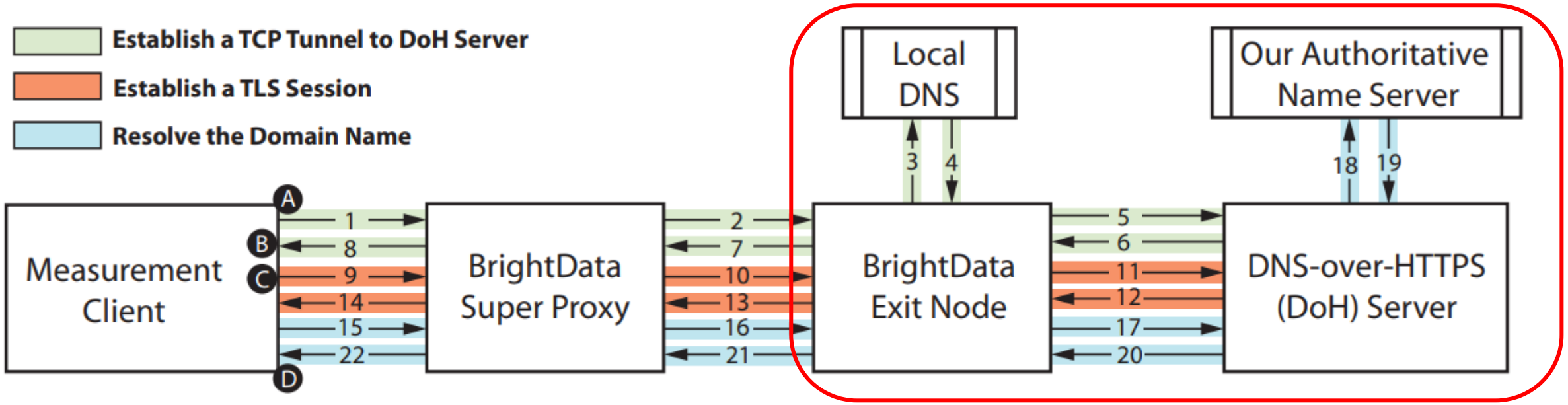
- Target any country, city, carrier & ASN
- 99.99% uptime - extremely stable
- 72+ million ethically-sourced IPs

Globally spread

DoH resolution time data

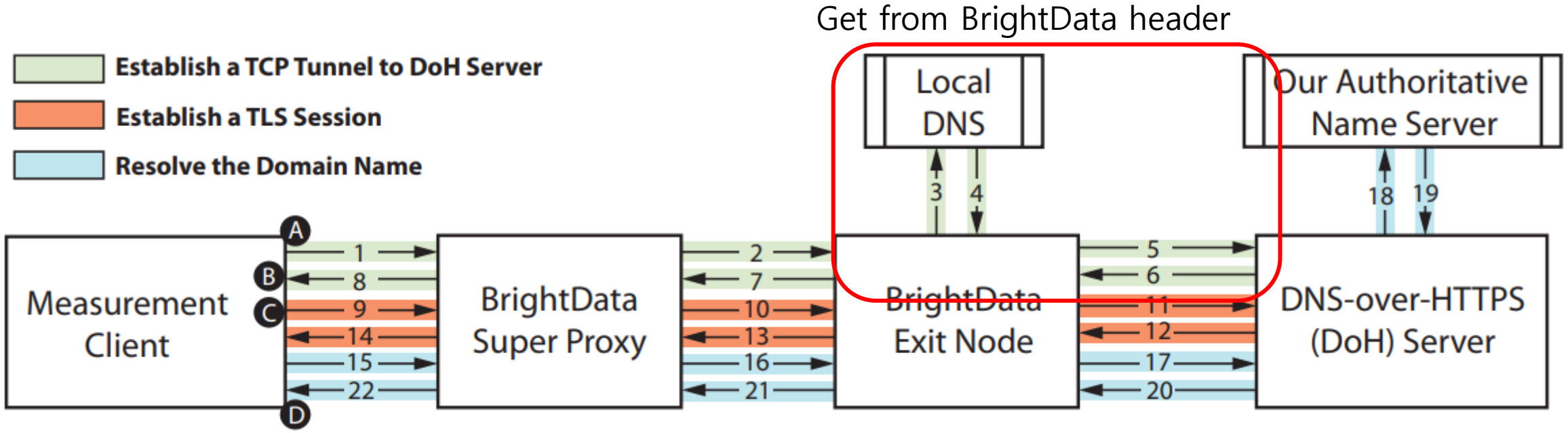


DoH resolution time data

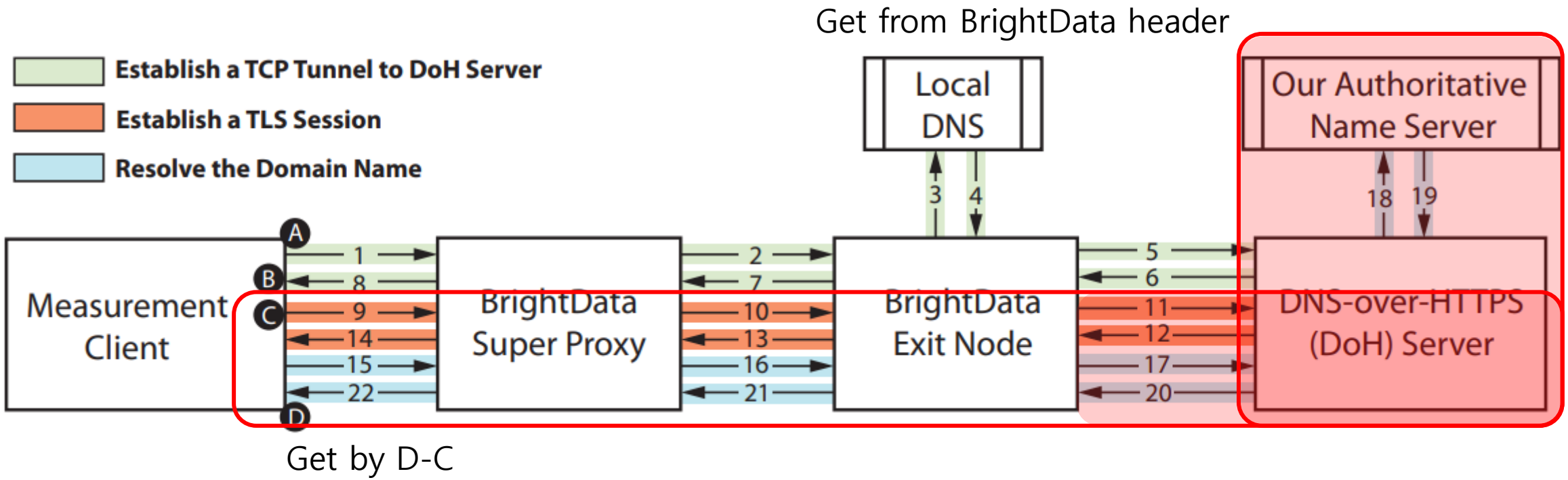


Delays authors wanted

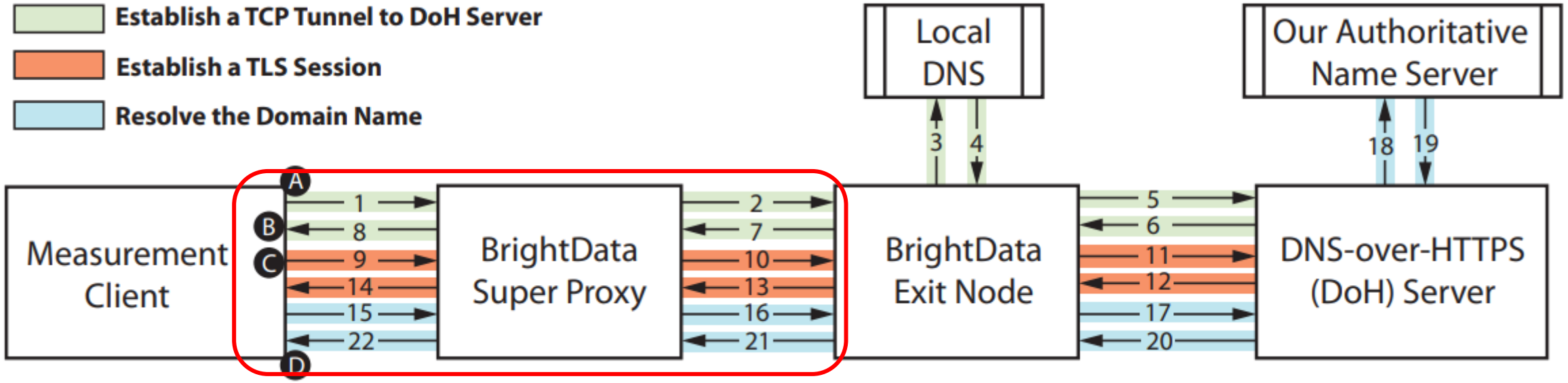
DoH resolution time data



DoH resolution time data



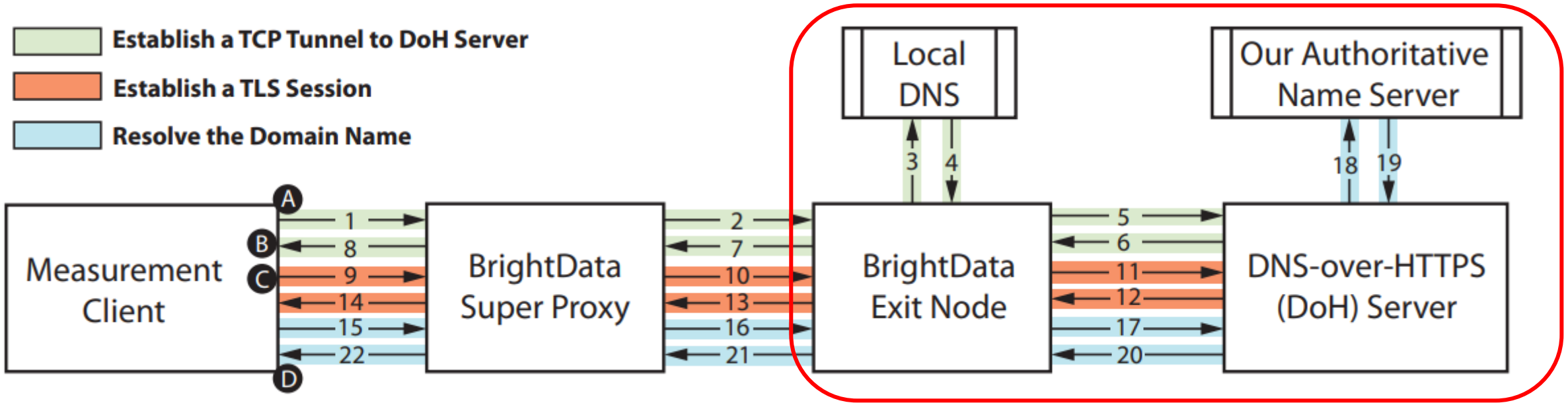
DoH resolution time data



Suppose that RTT between client and exit node is stable

RTT = 1+2+7+8 = B-A-BrightData header = 9+10+13+14 = ……..

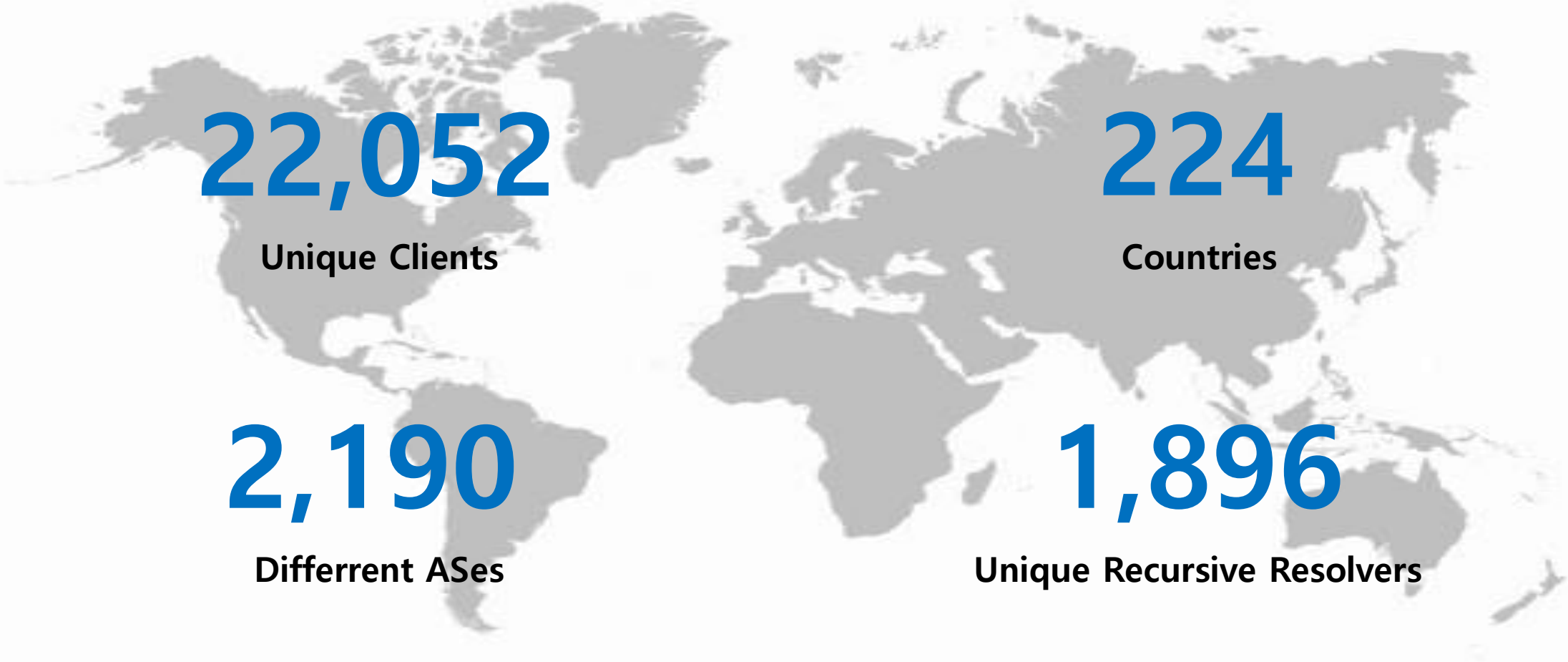
DoH resolution time data



Delays authors wanted
= D-C-2RTT+BrightData header

Results

Data overview



22,052

Unique Clients

224

Countries

2,190

Different ASes

1,896

Unique Recursive Resolvers

Ground-truth validation

Country	Ireland		Brazil		Sweden		Italy		India		USA	
Query Time (ms)	DoH	DoHR	DoH	DoHR	DoH	DoHR	DoH	DoHR	DoH	DoHR	DoH	DoHR
Our Method	116	94	193	182	129	122	246	236	254	251	53	25
Ground-Truth	109	85	190	176	131	126	245	238	260	257	52	23
Difference	7	9	3	6	2	4	1	2	6	6	1	2

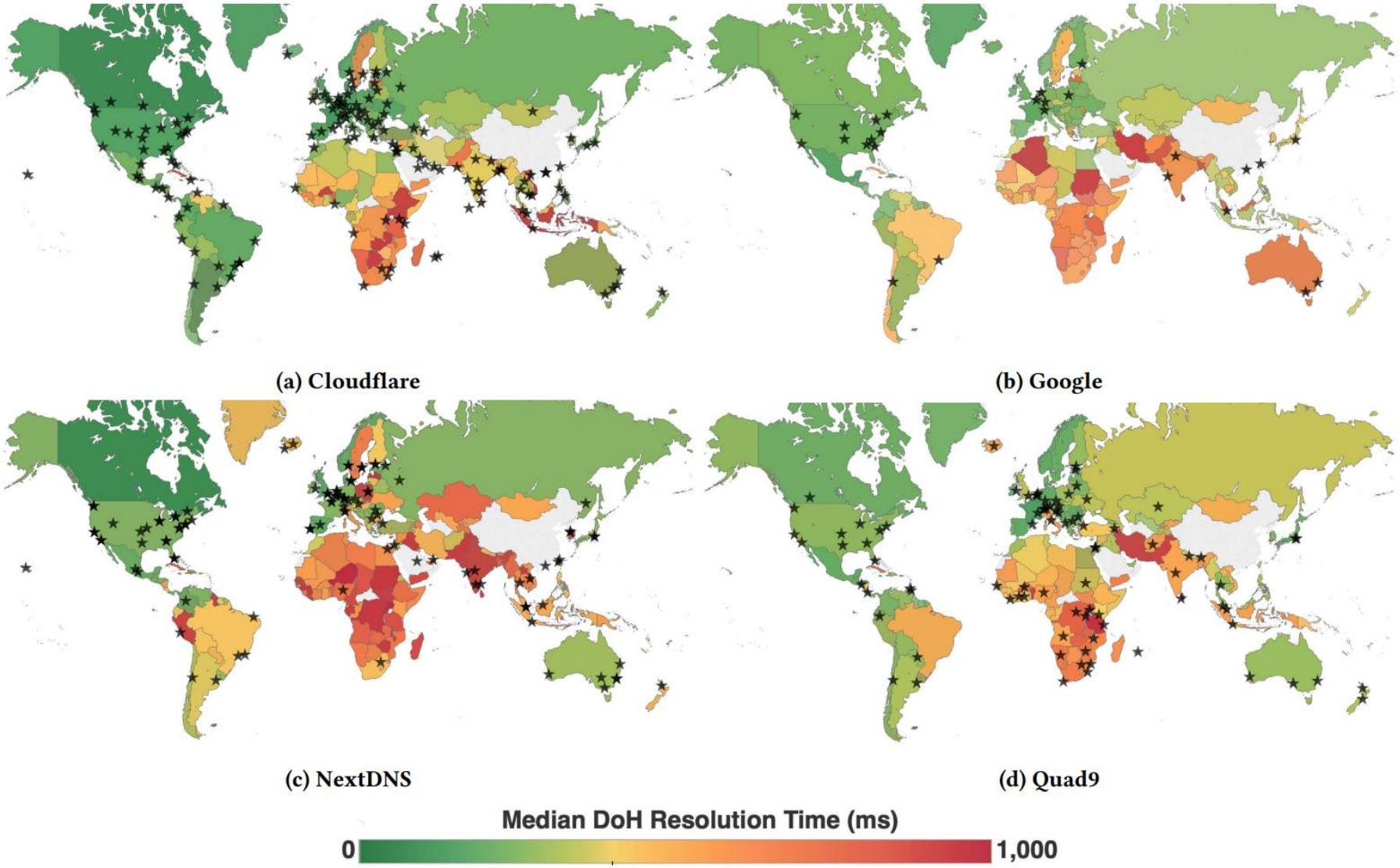
Table 1: Ground-truth Experiments for DoH and DoHR (DoH Connection Reuse)

Country	Ireland	Brazil	Sweden	Italy
Our Method	102	139	131	204
Ground-Truth	102	138	129	203
Difference	0	1	2	1

Table 2: Ground-truth Experiments for Do53

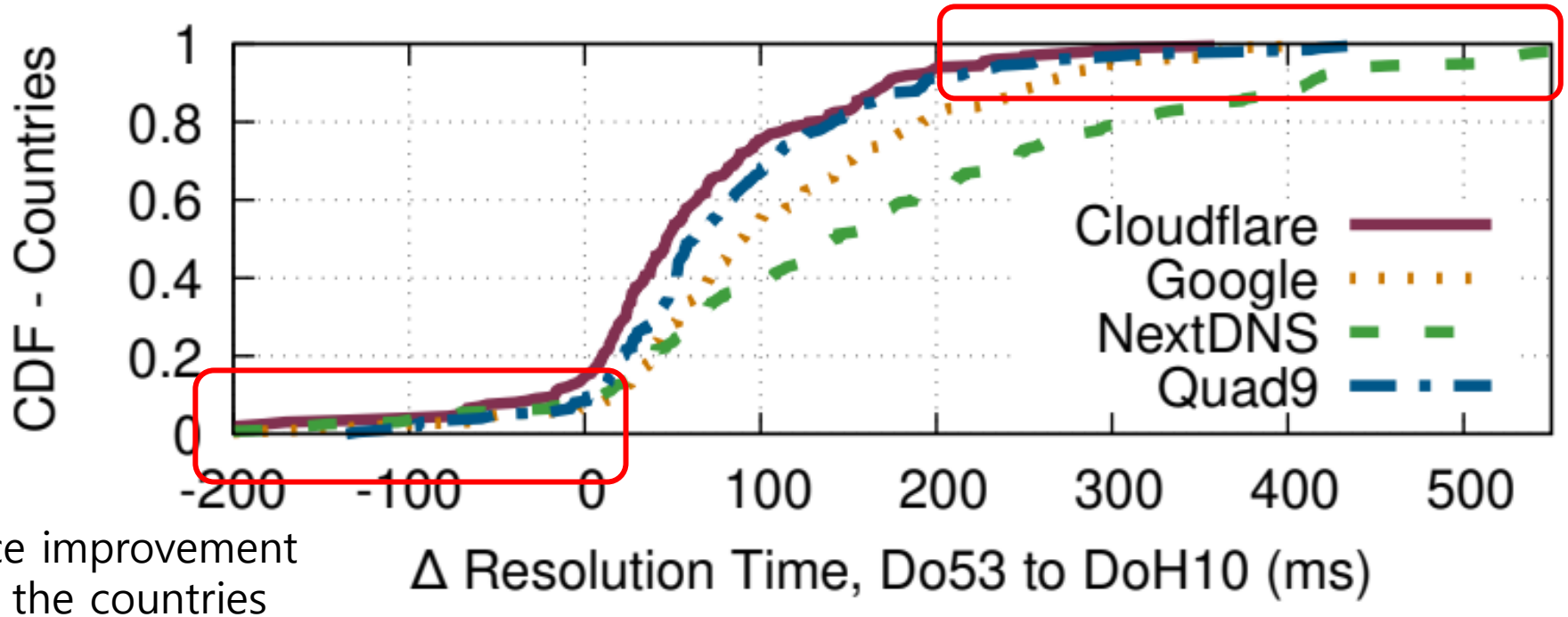
Minor differences between ground-truth and authors' methodology

Global performance



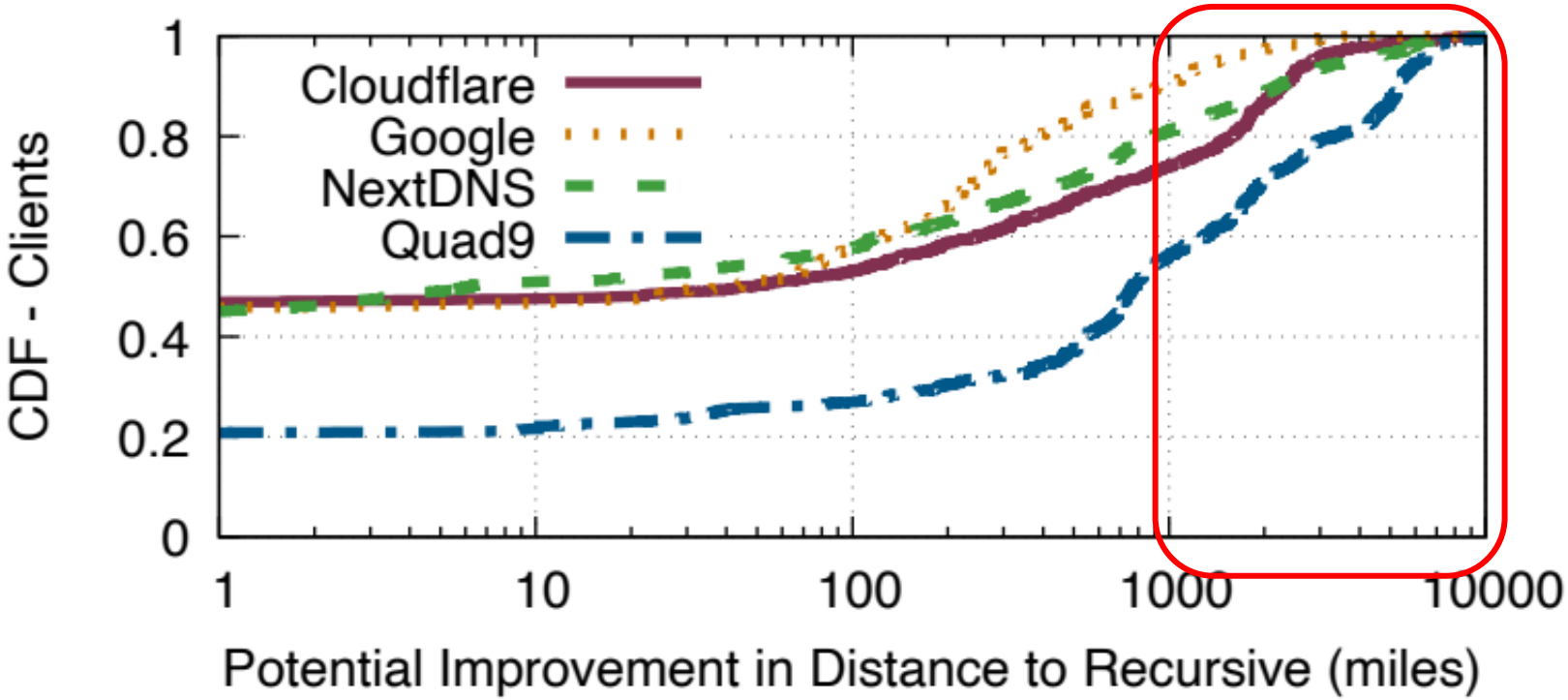
Performance inequality

Might be unacceptable additional delays for 10% of the countries



Performance improvement for 8.8% of the countries

Room for improvement



Potential Improvement: differences between actual PoP and the closest PoP (in the dataset)
→ 10% of Google / 26% of Cloudflare clients can be switched to a PoP at least 1000 miles closer

Conclusion

- Authors conducted global scale measurements with Do53 and DoH
- They shows performance gaps between countries
  - Low Internet infra & economic development will be disproportionately impacted by a unilateral switch to DoH from Do53
- They also shows there is room for improvement