Network Measurement Methods for

Locating and Examining Censorship Devices

Applied Networking Research Prize | IETF 118 Prague

Ram Sundara Raman, Mona Wang, Jakub Dalek, Jonathan Mayer, Roya Ensafi

09 November 2023

ars TECHNICA BIZ & IT TECH SCIENCE POLICY CARS GAMING & CULTURE

SNOOPING AT SCALE —

Kazakhstan spies on citizens' HTTPS traffic; browser-makers fight back

npr SIGN IN NPR SHOP

NEWS CULTURE MUSIC PODCASTS & SHOWS SEARCH

TECHNOLOGY

Russia is restricting social media. Here's what we know

The Washington Post
Democracy Dies in Darkness

MIDDLE EAST

Sanctions and censorship are making the Internet in Iran less accessible, analysts say

Large-scale censorship and surveillance events

Enabled by

Client — Advanced network technology — Server

Netsweeper

- Citizen Lab Identified an "**Alternative Lifestyles"** blocklist curated by Netsweeper was used by several countries such as UAE to block LGBTQ content.
- After advocacy based on Citizen Lab's findings, Netsweeper claims they have **removed the option** to block based on this category.

VICE

Canadian Internet Filtering Company Says It's Stopped 'Alternative Lifestyles' Censorship

The UAE was found to be blocking LGBTQ content using a pre-set category in Netsweeper's software. Amid pressure from rights groups, the company says it's disabled that category.

By **Jordan Pearson**

Jan 21 2019, 12:25pm Share Tweet Snap

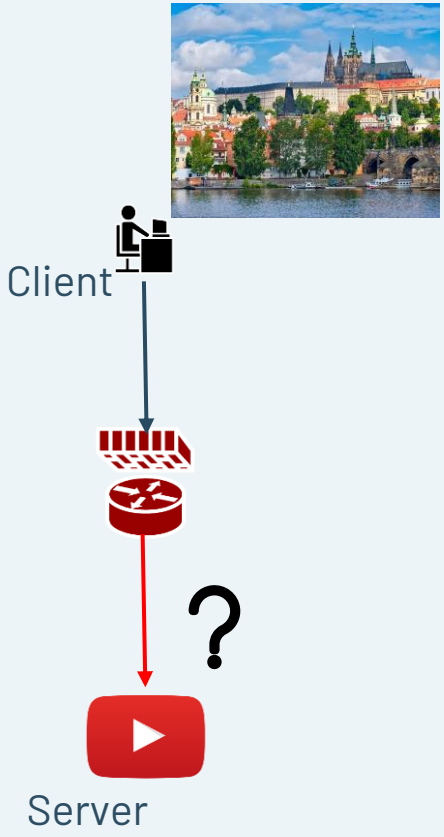
What and When?

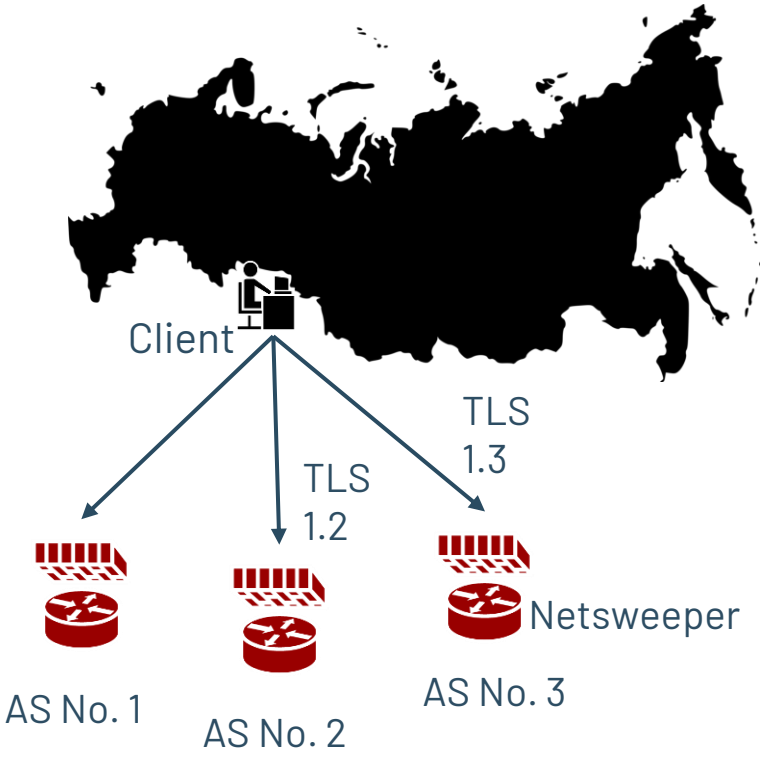
- Censorship Measurement Platforms

Censored Planet

OONI

IODA
INTERNET OUTAGE DETECTION AND ANALYSIS





Who, Where and How?

- Specific censorship systems
  - Great Firewall of China
  - Iran's national firewall
  - Russia's TSPU system

Challenges and Gaps

1. Opaque nature of censorship
2. Lack of transparency
3. Variety of devices and censorship techniques
4. Reliance on specific behaviors
5. Large manual effort does not scale

Need: **General-purpose, robust methods**

To study censorship devices

We built robust, reusable solutions to:

1

Locate censorship devices

Censorship Traceroute

2

Identify device vendors

Banner grabs and Clustering

3

Reverse-engineer censorship triggers

Censorship Fuzzer

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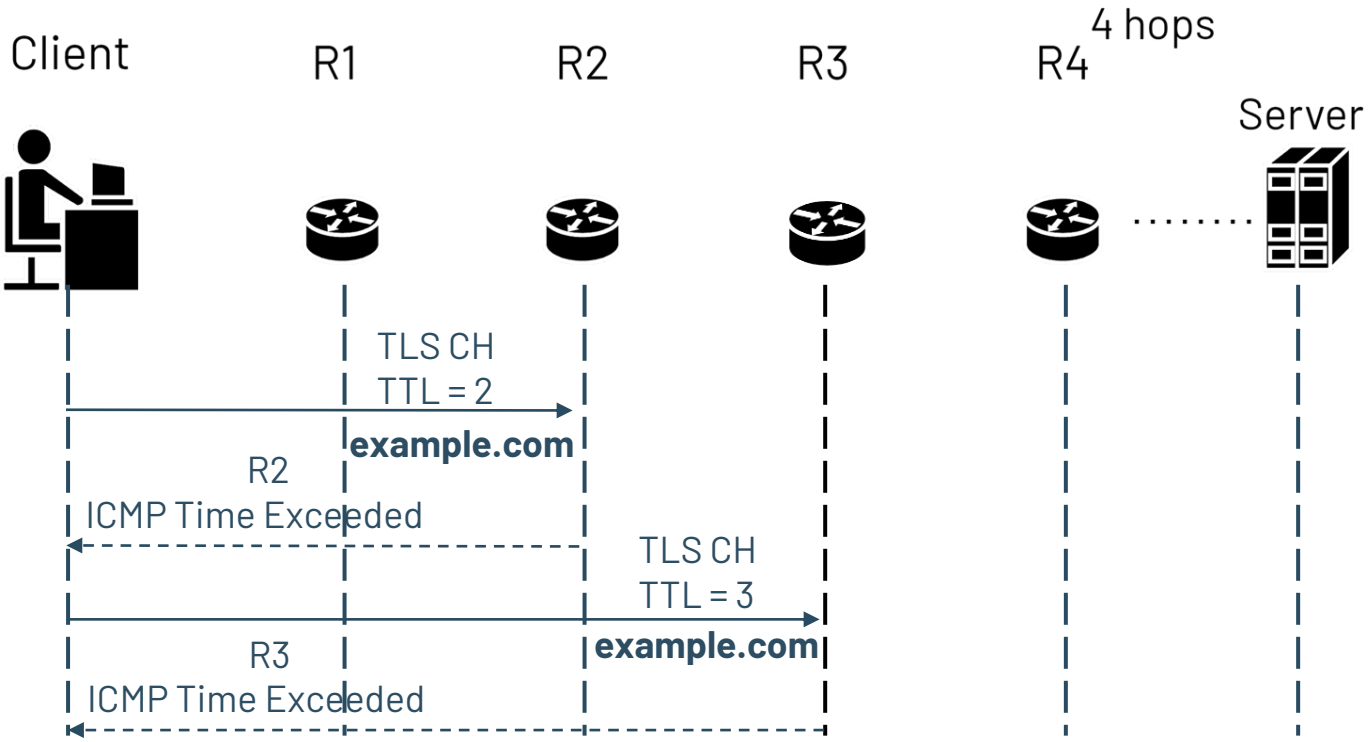
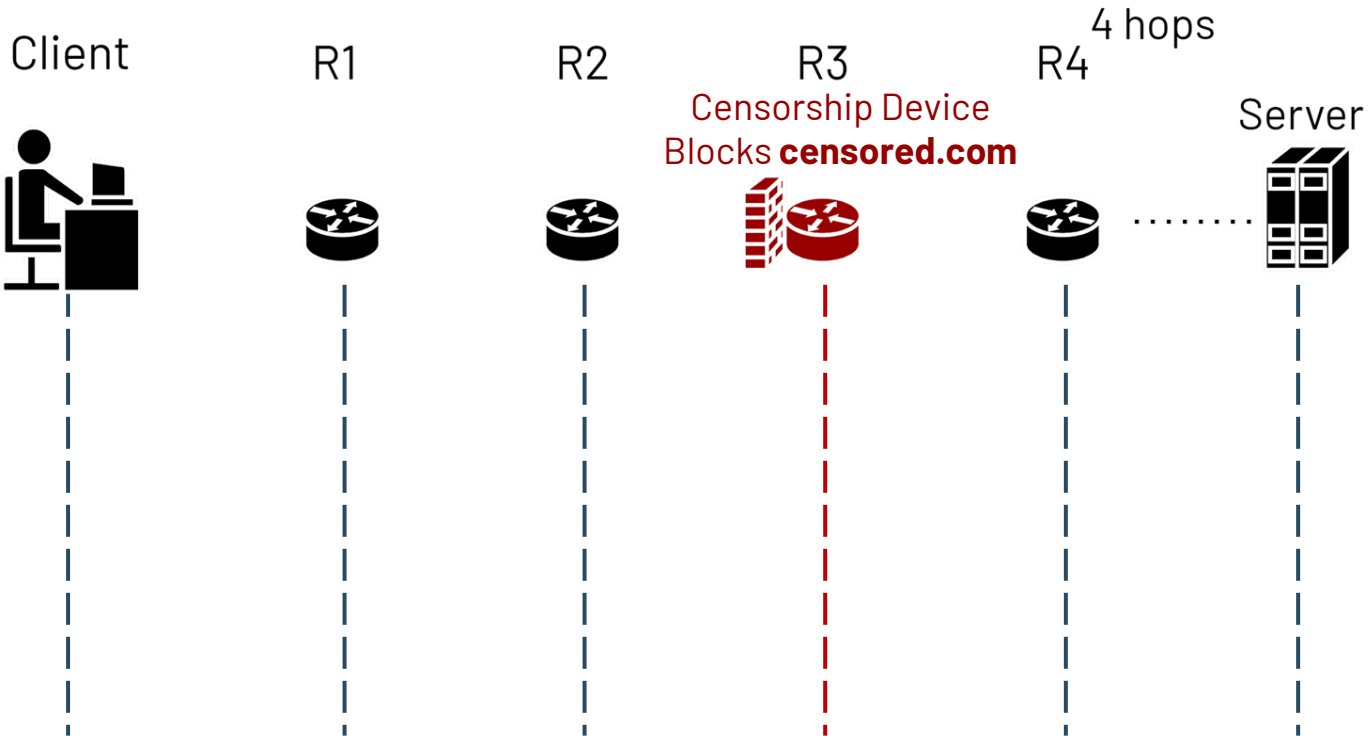
Application Traceroute



Censorship Traceroute



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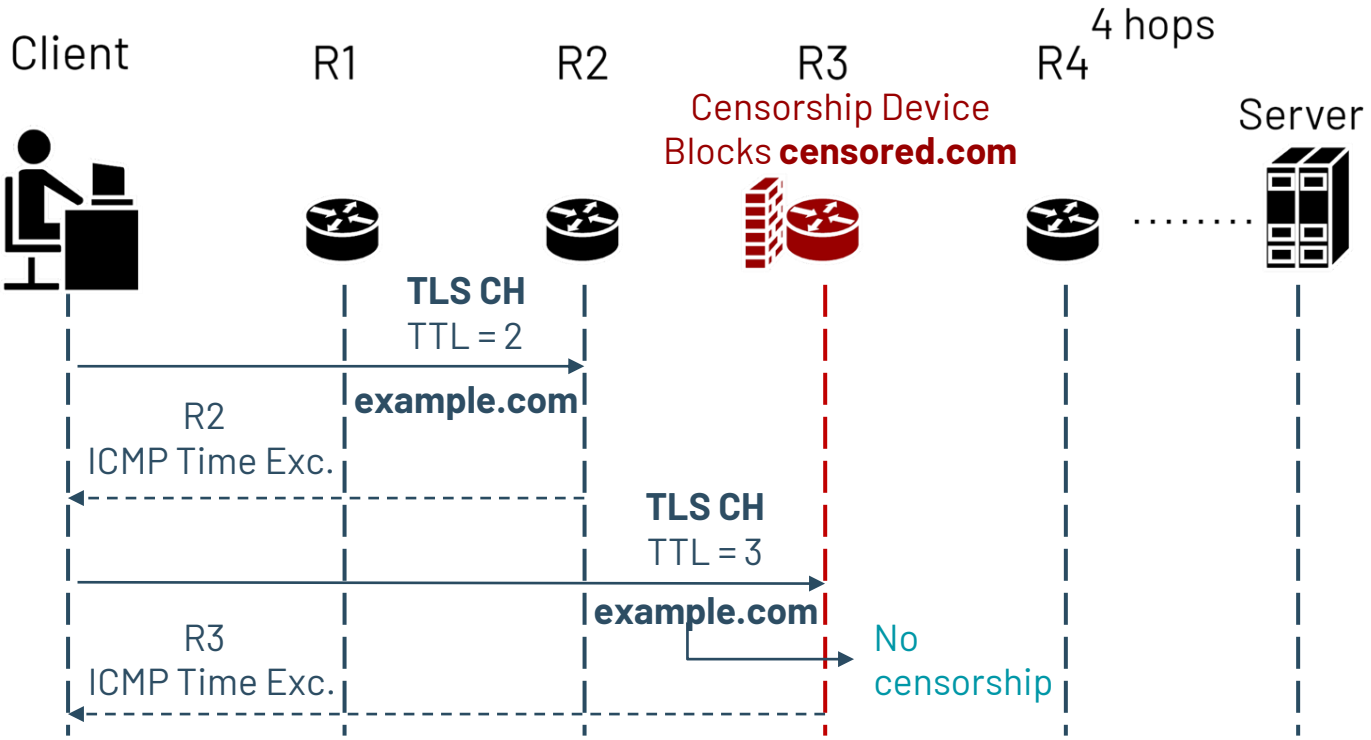

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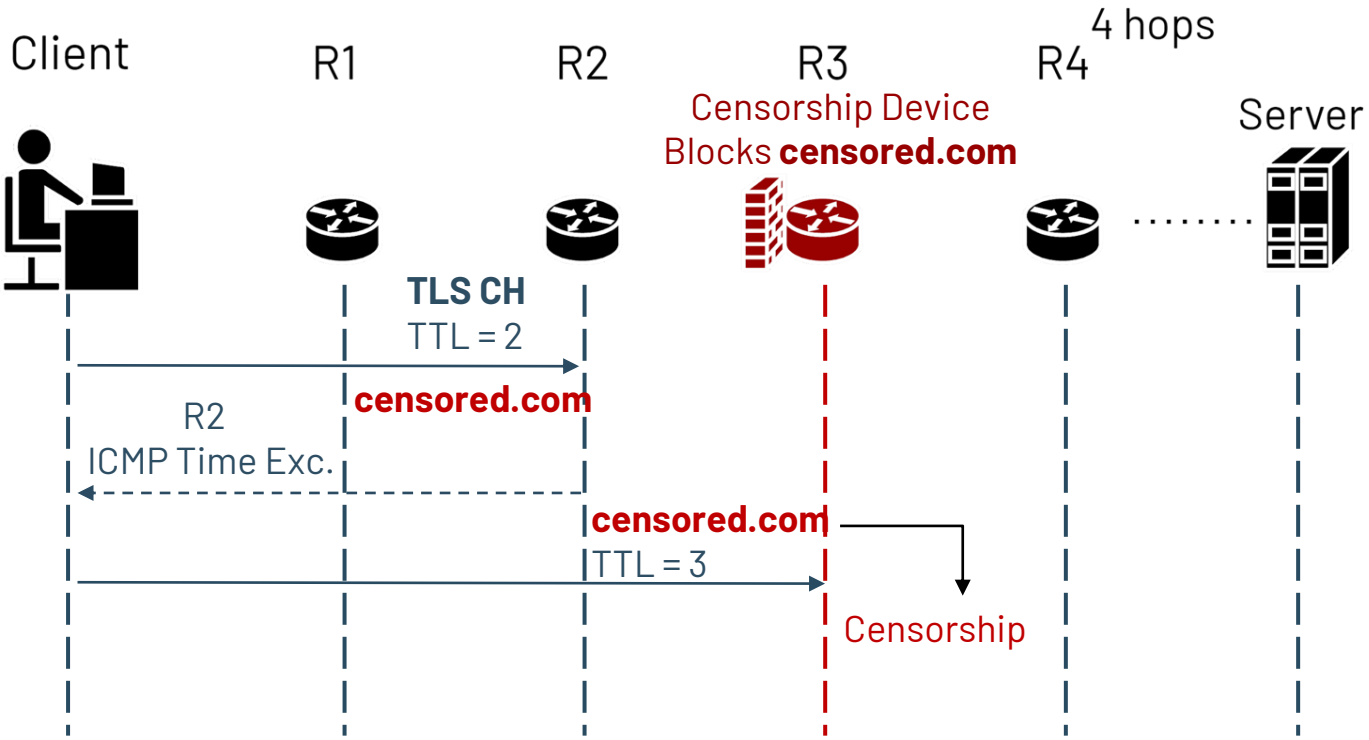
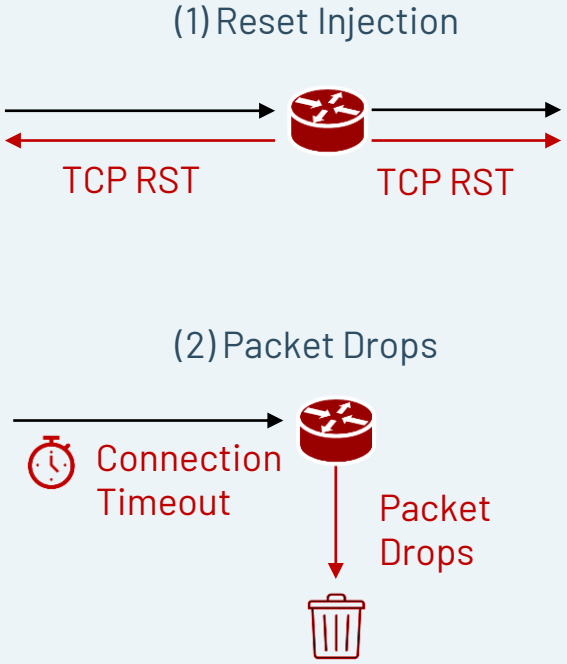


Variety in censorship mechanisms

1. **Censorship methods:**
   RST injection, packet drops
2. **Device deployments:**
   In-path vs On-path
3. **Specialized censor behavior and path variance**

Variety in censorship mechanisms



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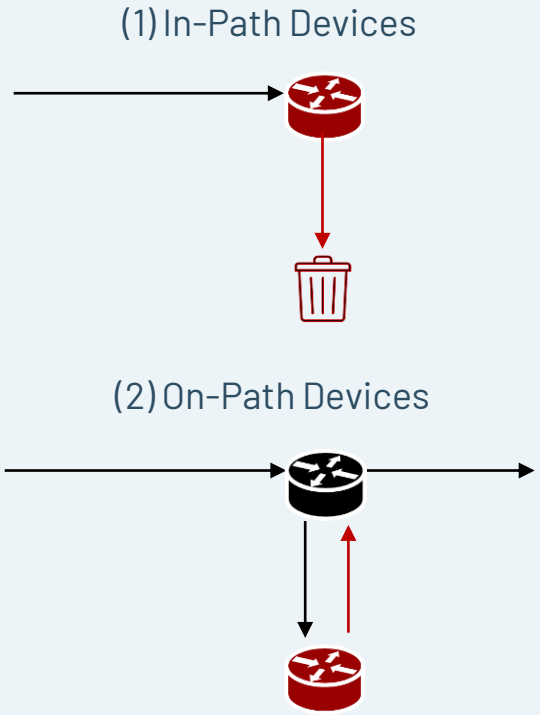
Variety in censorship mechanisms



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3 Specialized censor behavior and path variance

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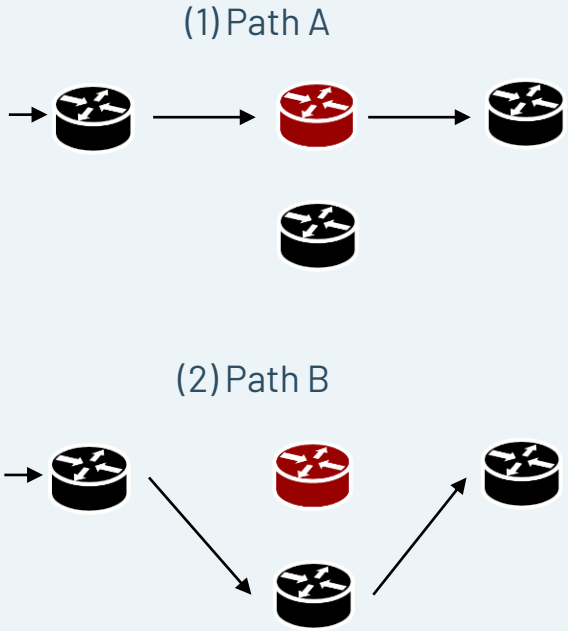

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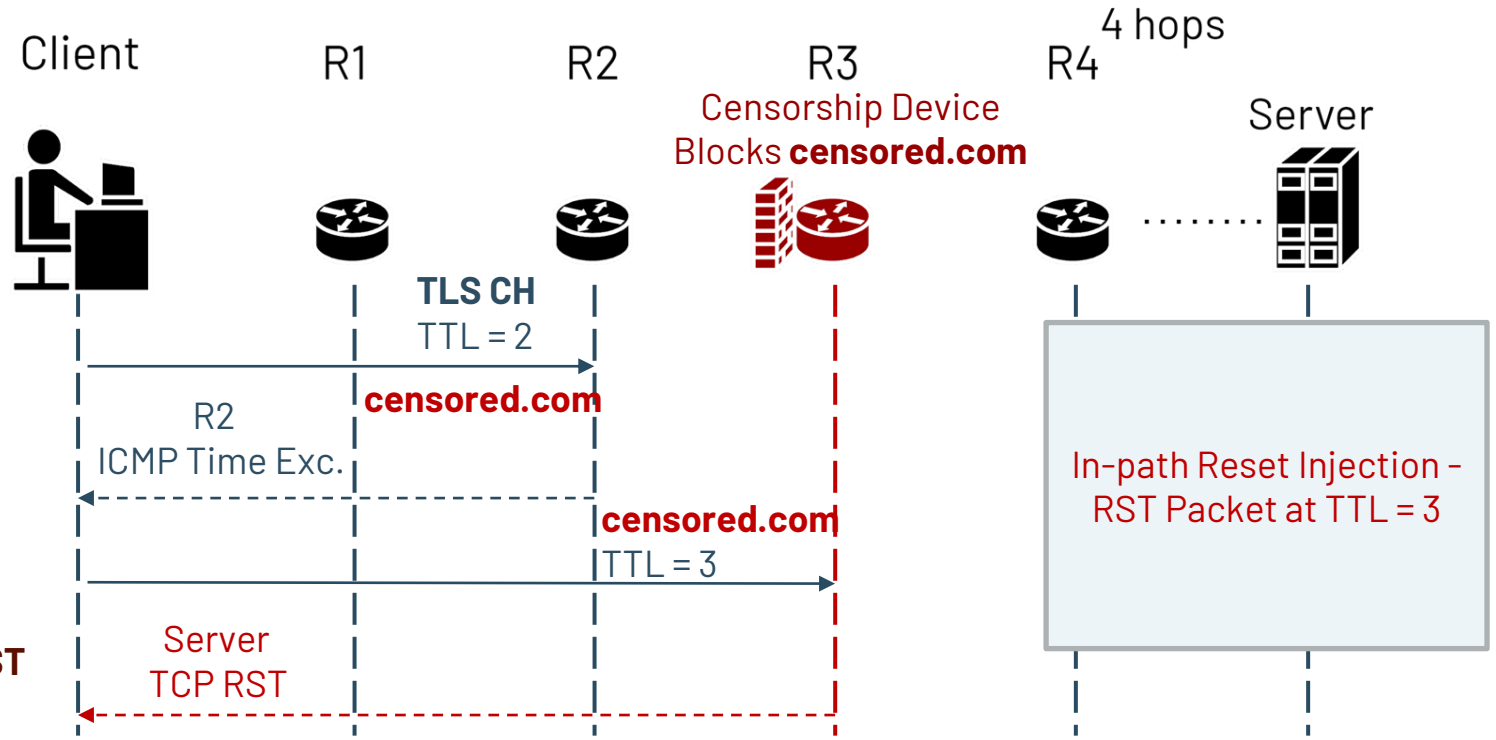

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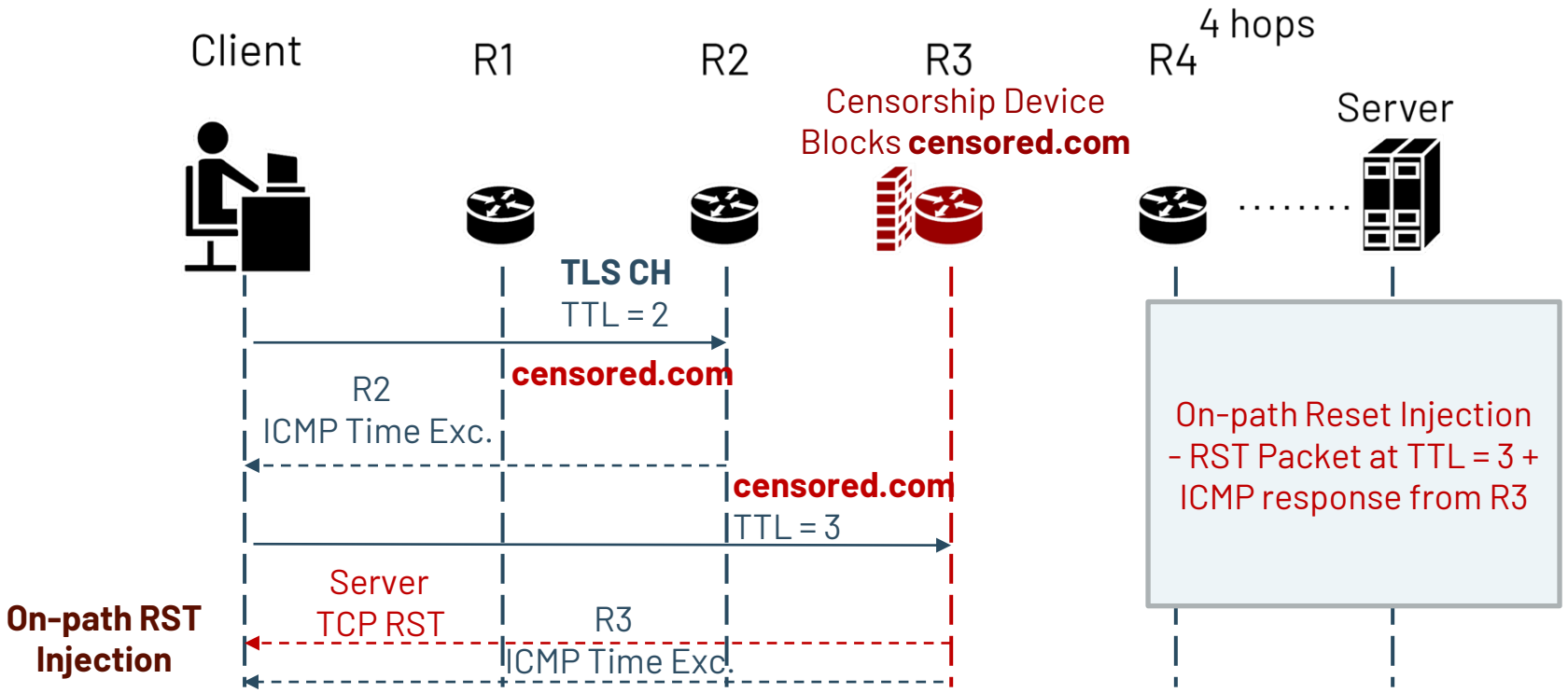

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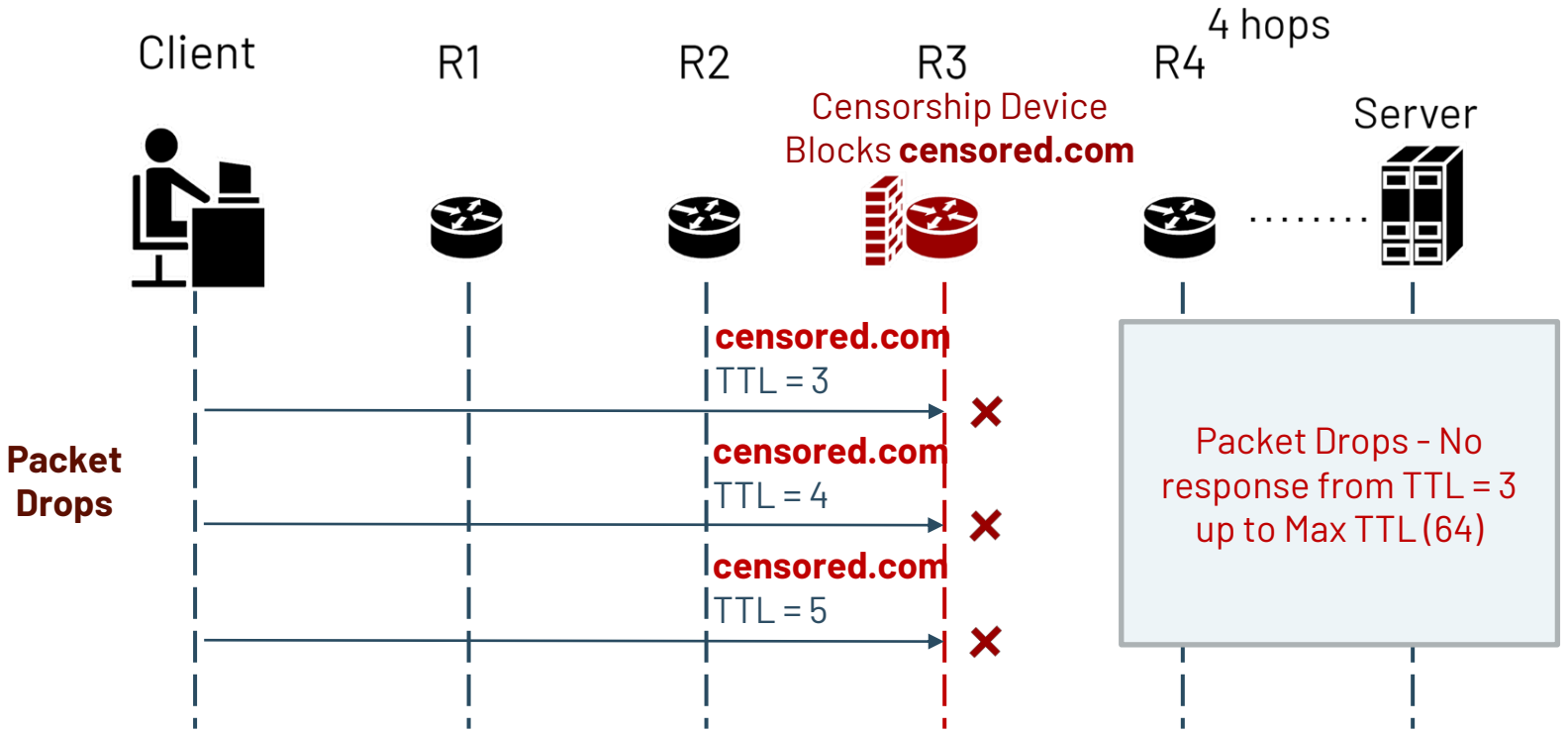

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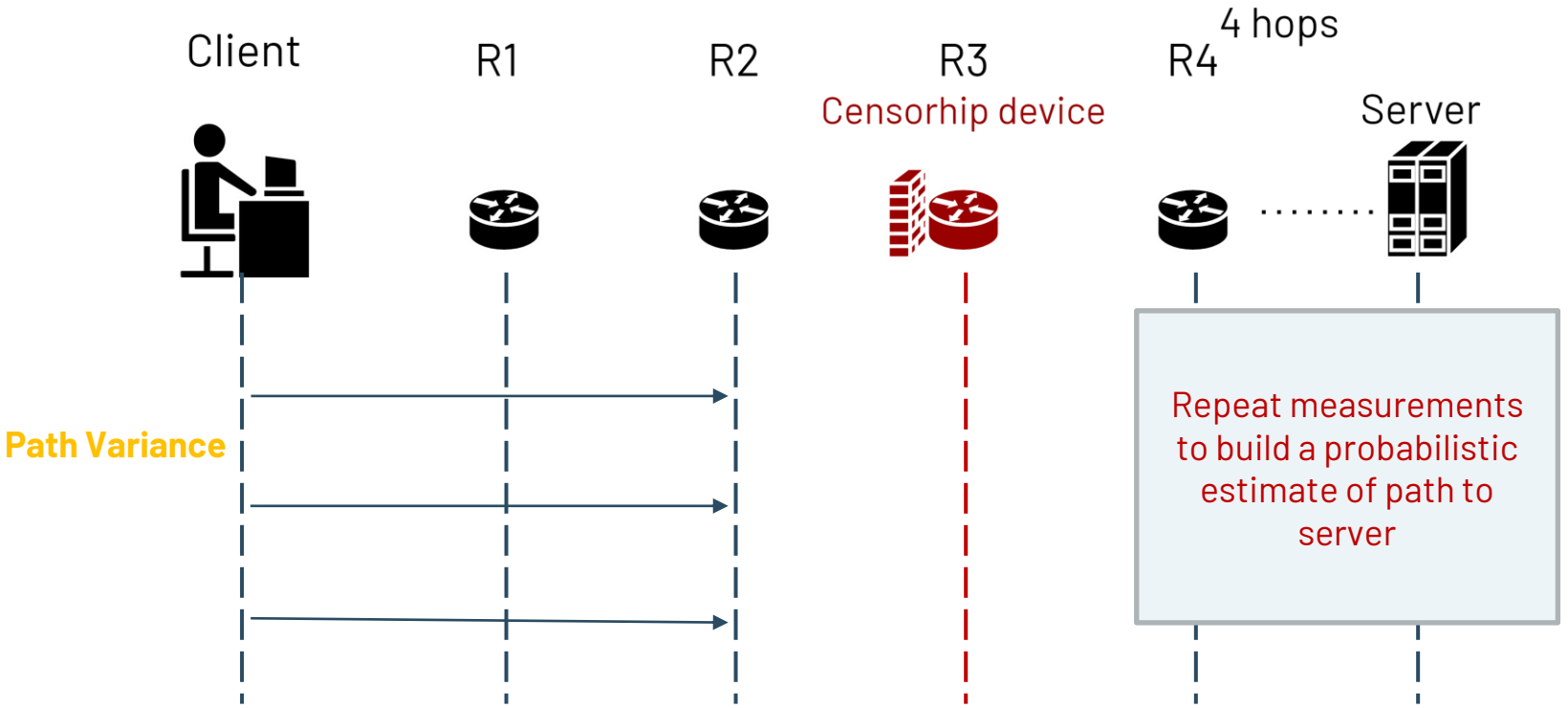

CenTrace

In-country measurements (Country -> Out)

Remote measurements (Out -> Country)

- Conduct in-country and remote measurements in Azerbaijan (AZ), Belarus (BY), Kazakhstan (KZ), Russia (RU)
- HTTP and TLS traceroutes

CenTrace: Finding Blocking Location

	Test CenTrace **censored.com**	Control CenTrace **example.com**
1	213.248.87.253	213.248.87.253
2	62.115.137.58	62.115.137.58
3	213.248.75.239	213.248.75.239
4	TIMEOUT	94.20.50.158
5	TIMEOUT	85.132.89.27
⋮	⋮	⋮
15	TIMEOUT	Server - TLS

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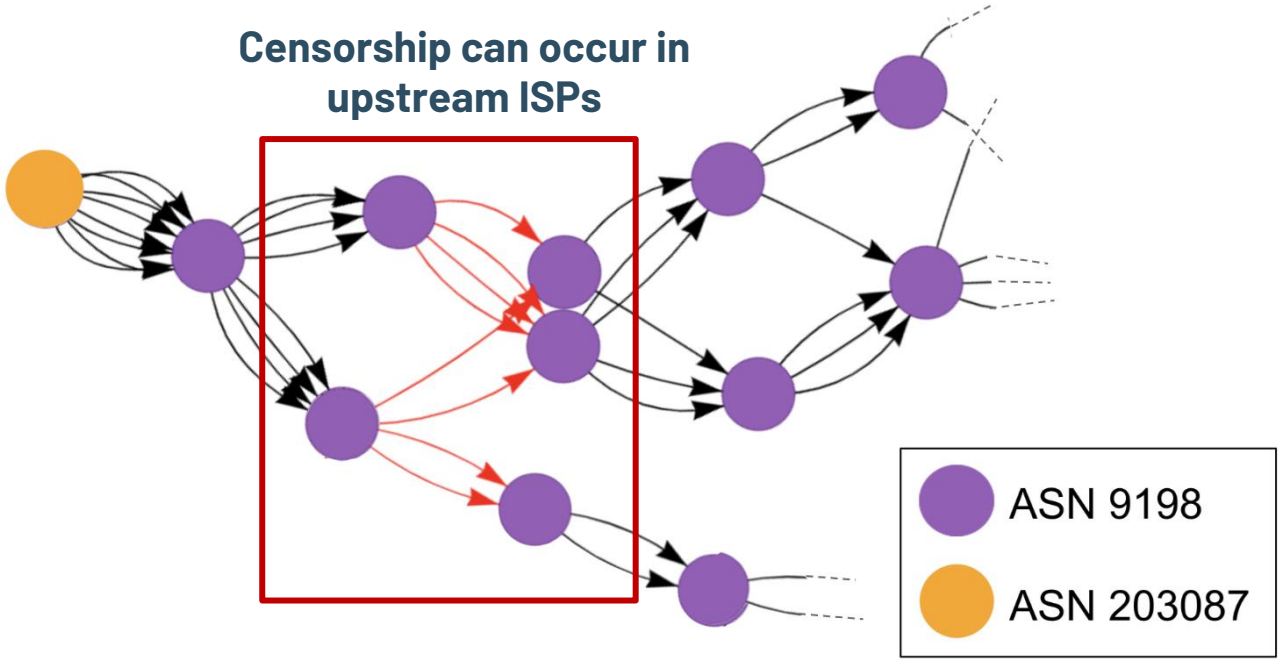
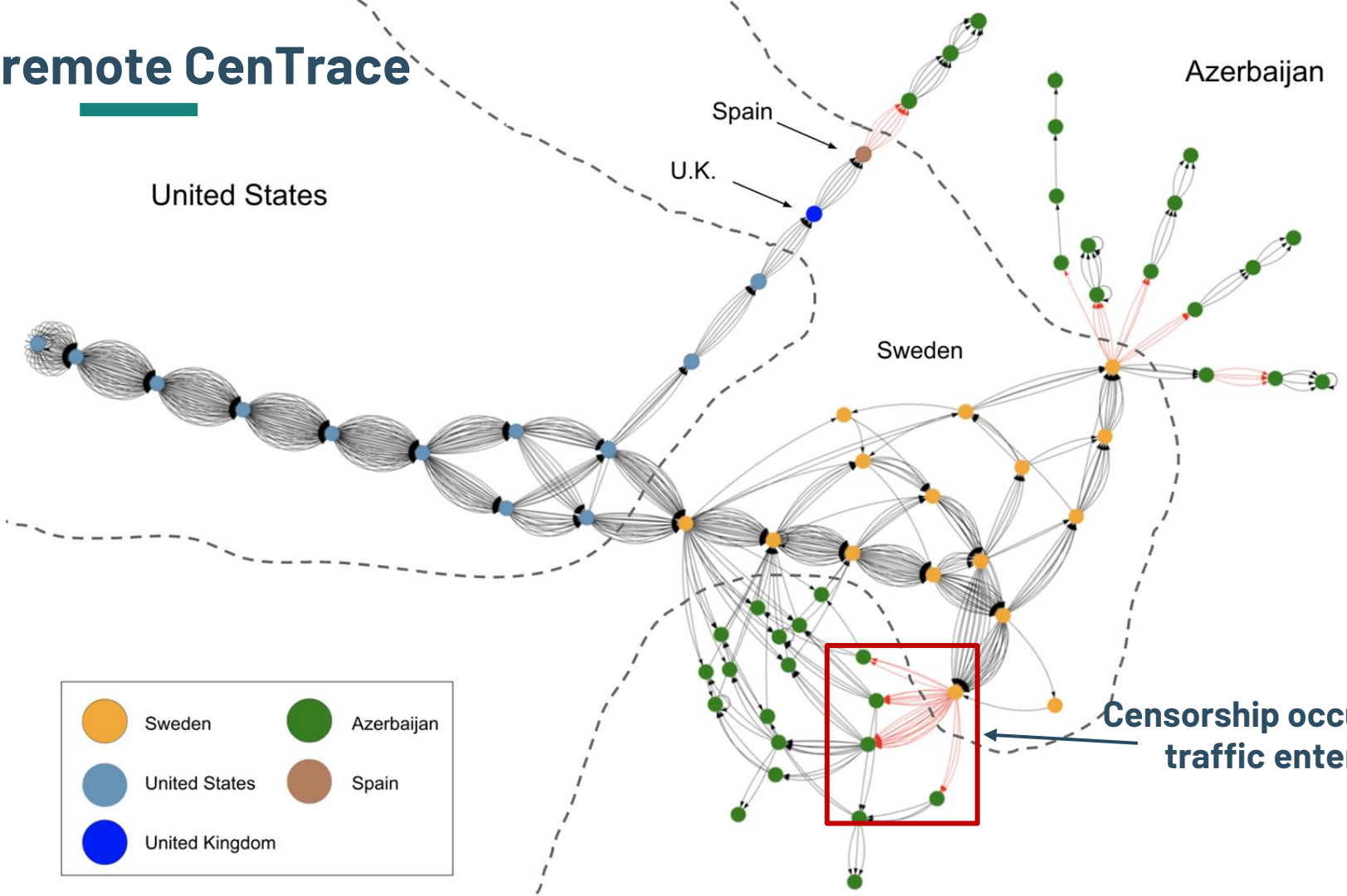


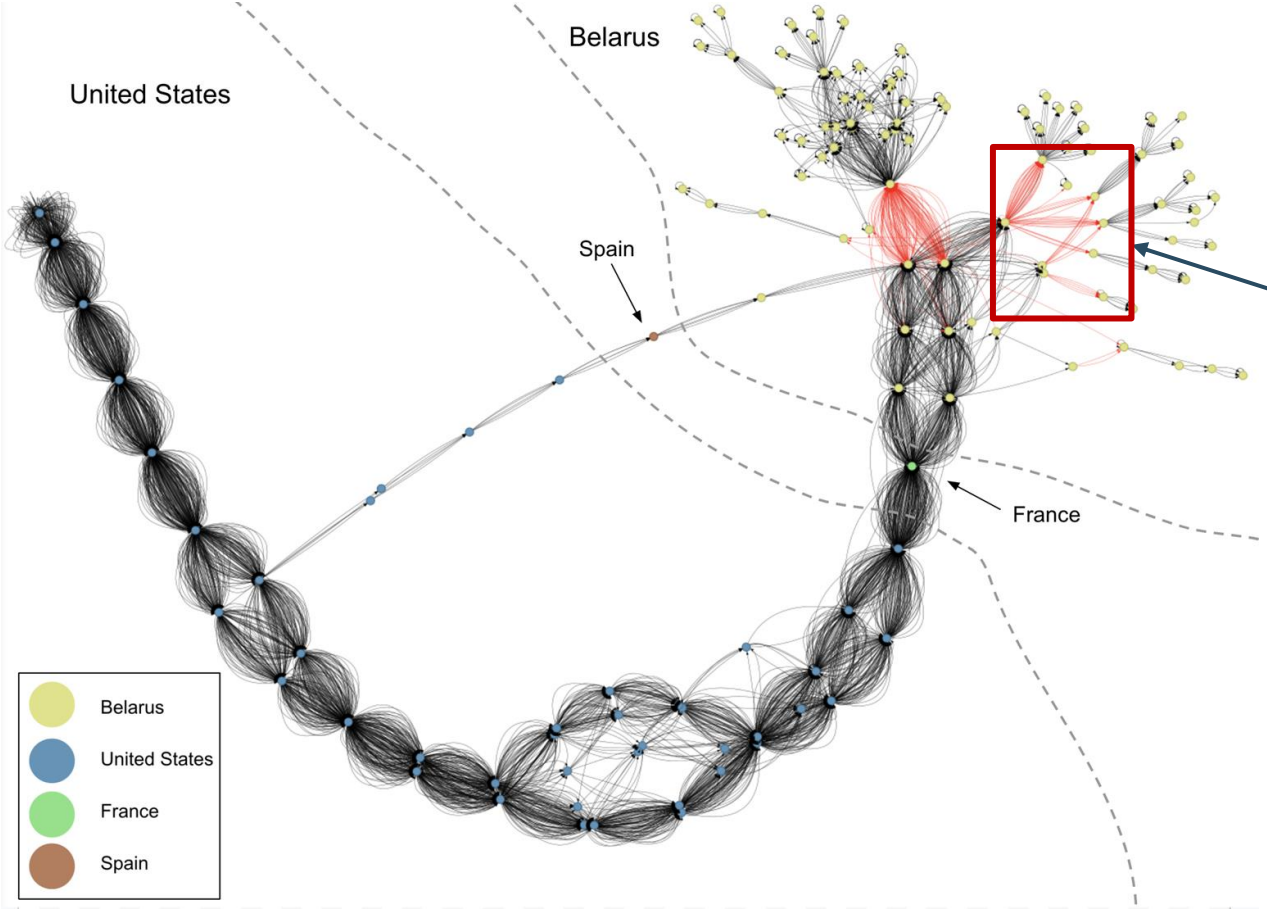
KZ in-country CenTrace

AZ remote CenTrace



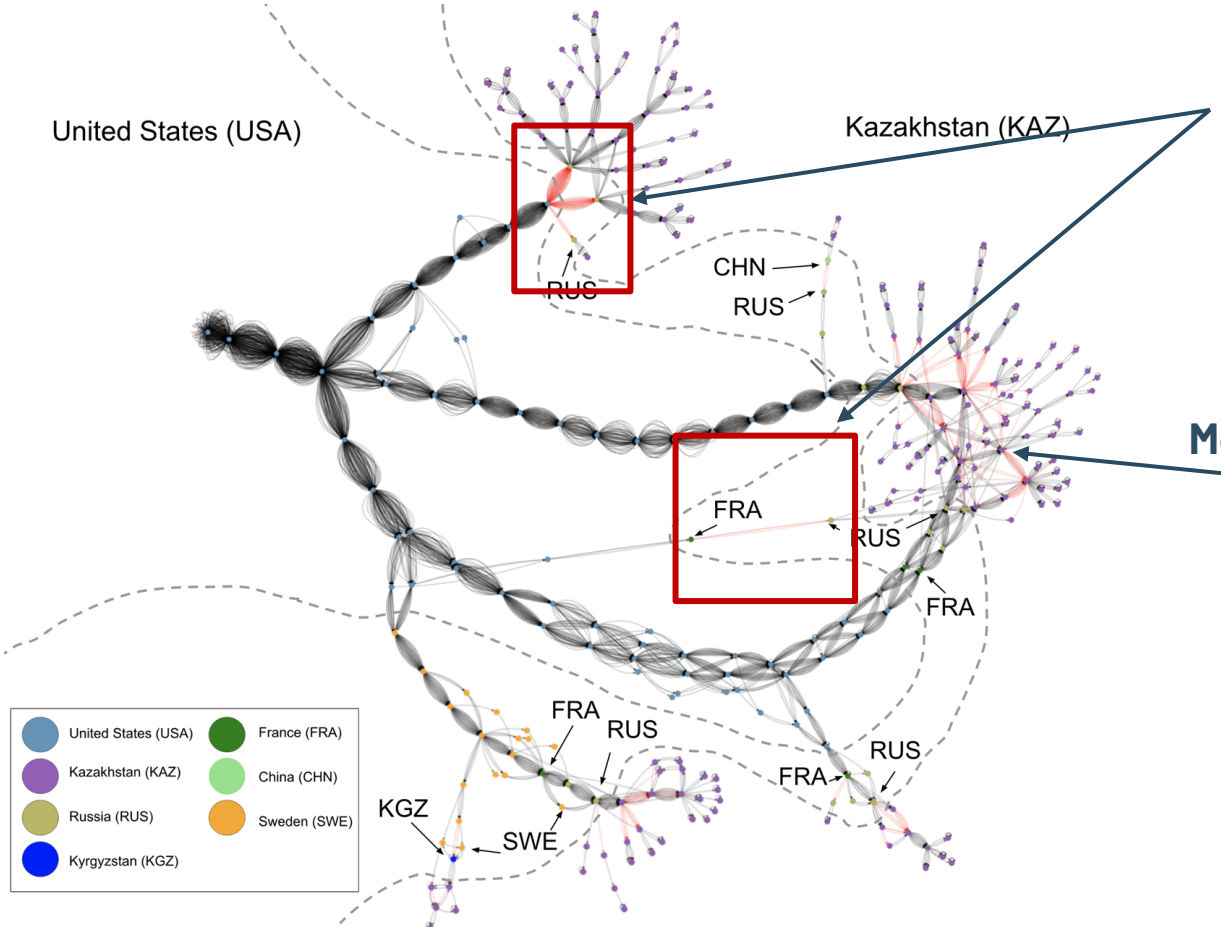
Censorship occurs when traffic enters AZ

BY remote CenTrace



Censorship occurs closer to the user

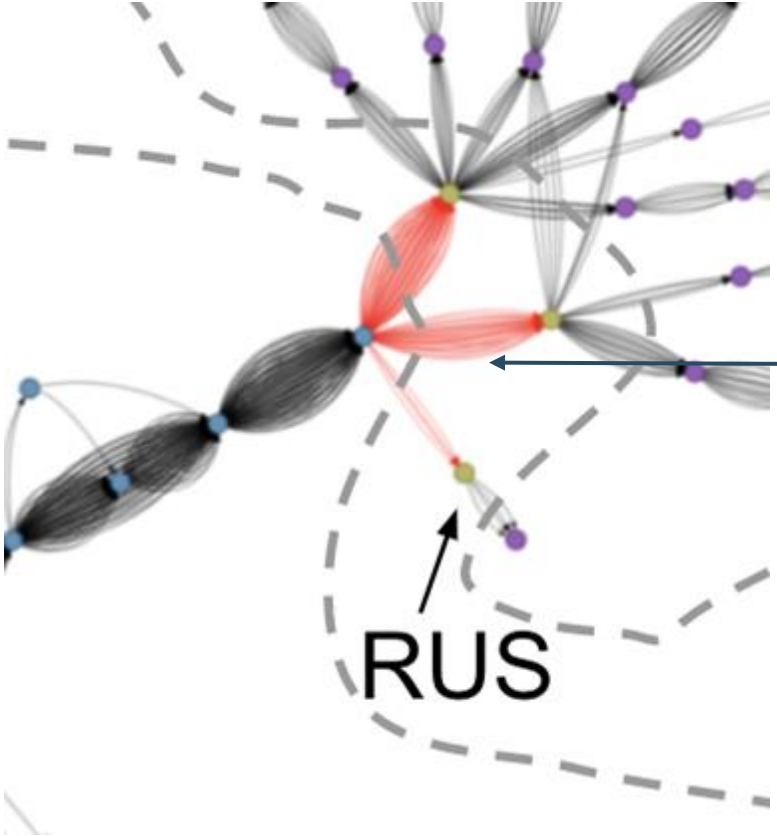
KZ remote CenTrace



What are these cases?

Most censorship occurs inside KZ

KZ remote CenTrace



Censorship occurs in Russian AS, even before entering KZ

CenTrace Observations

- Significant portion of remote measurements are **blocked at the endpoint,** indicate local policies
- Some devices exhibit specialized behavior such as **copying TTL values** from original packet.
- Packet drops in Azerbaijan and Kazakhstan, Resets in Belarus and Russia

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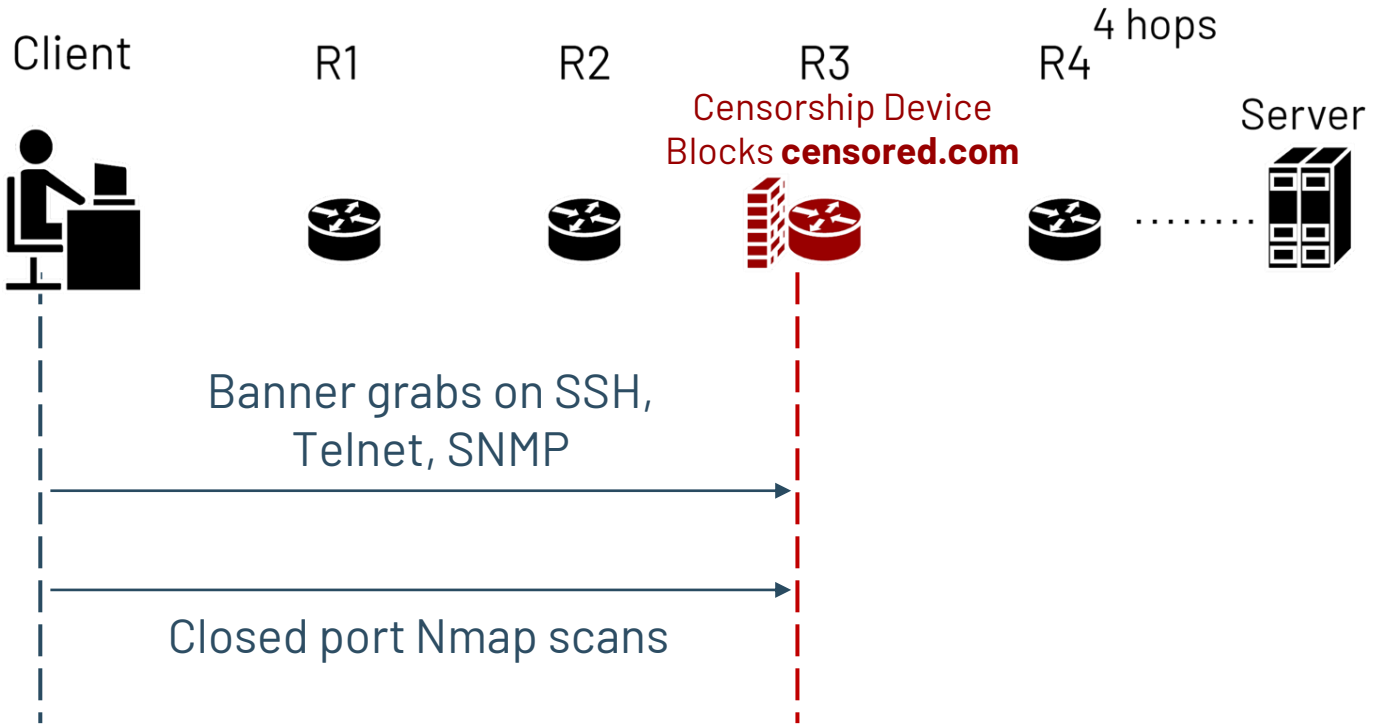
Censorship Device Banners



Censorship Device Banners

- Collect banners on:
  - HTTP
  - TLS
  - SSH
  - Telnet
  - SMTP
  - SNMPv3
- Investigate banners manually and using fingerprint databases (Rapid7 Recog) to identify **commercial** filters
- Investigate blockpages from devices to identify **ISP blocking**
- Most blocking implemented by devices deployed by ISPs in AZ, BY, KZ, RU

Censorship Device Banners

Device	AZ	KZ	RU
Cisco (7)	☒	☒	☒
Fortinet (5)	☒	☒	☒
Kerio Control (2)		☒	
Palo Alto (2)	☒		☒
DDoSGuard			☒
Mikrotik		☒	
Kaspersky			☒

Censorship Device Banners

Device
Cisco (7)
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Do these devices behave the same way?

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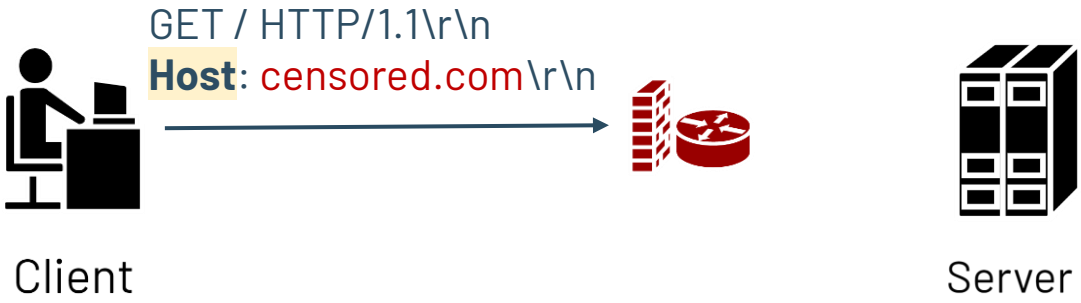
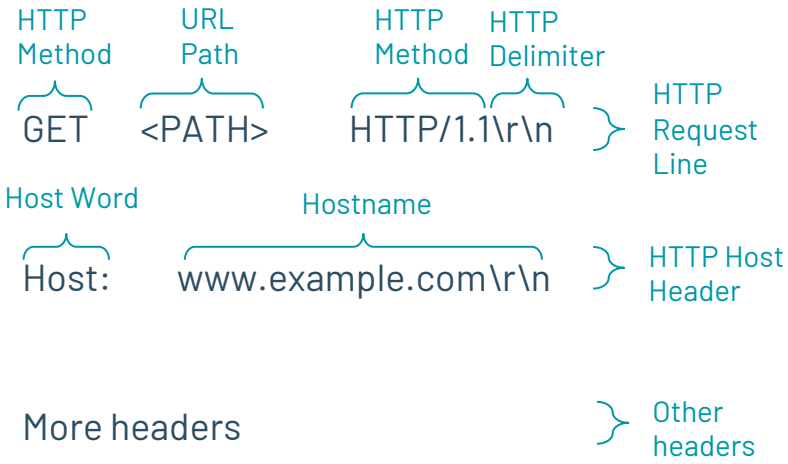
Fuzzing Strategies



Fuzzing Strategies

Fuzzing Strategies: HTTP



~400 fuzzing permutations

Fuzzing Strategies: HTTP

	HTTP Strategy	Examples	Permutations
Alternate	Get Word	POST, PUT	6
	HTTP Word	HTTP/ 1.1, XXXX/1.1	16
	Host Word	HostHeader:	7
	Path	?,z	8
	Hostname	www.example.comwww.example.com	5
	Hostname TLD	www.example.net	10
	Hostname Subdomain	m.example.com	10
	Header	Connection: keep-alive	59
Capitalize or Remove	Get Word	GeT, GE	15
	HTTP Word	HtTP/1.1, HTTP/.1	183
	Host Word	HoST:, ost:	79
	HTTP Delimiter	\r	3
Pad	Hostname Padding	**www.example.com*	9

Fuzzing Strategies: HTTP

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	[illegible]	[illegible]	[illegible]
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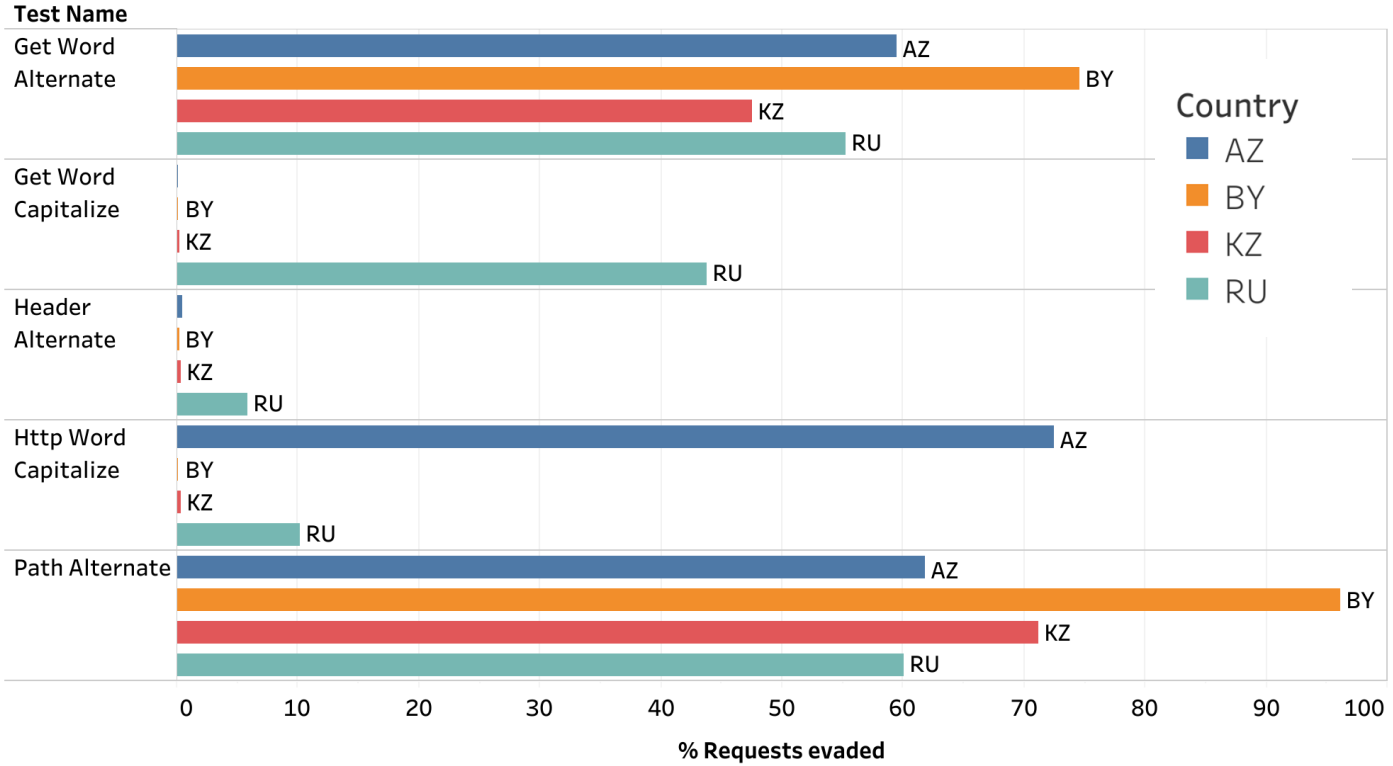
CenFuzz HTTP: Evasion Success Rates



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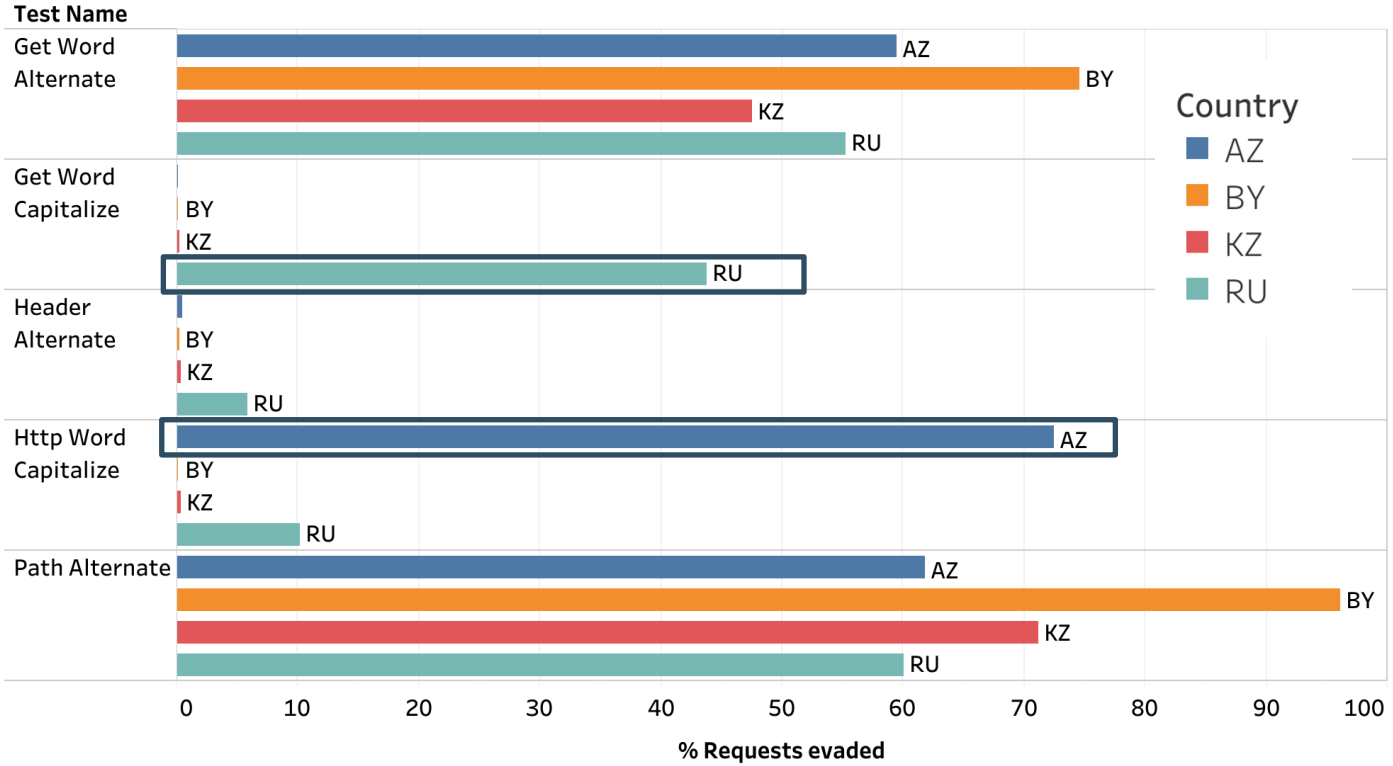
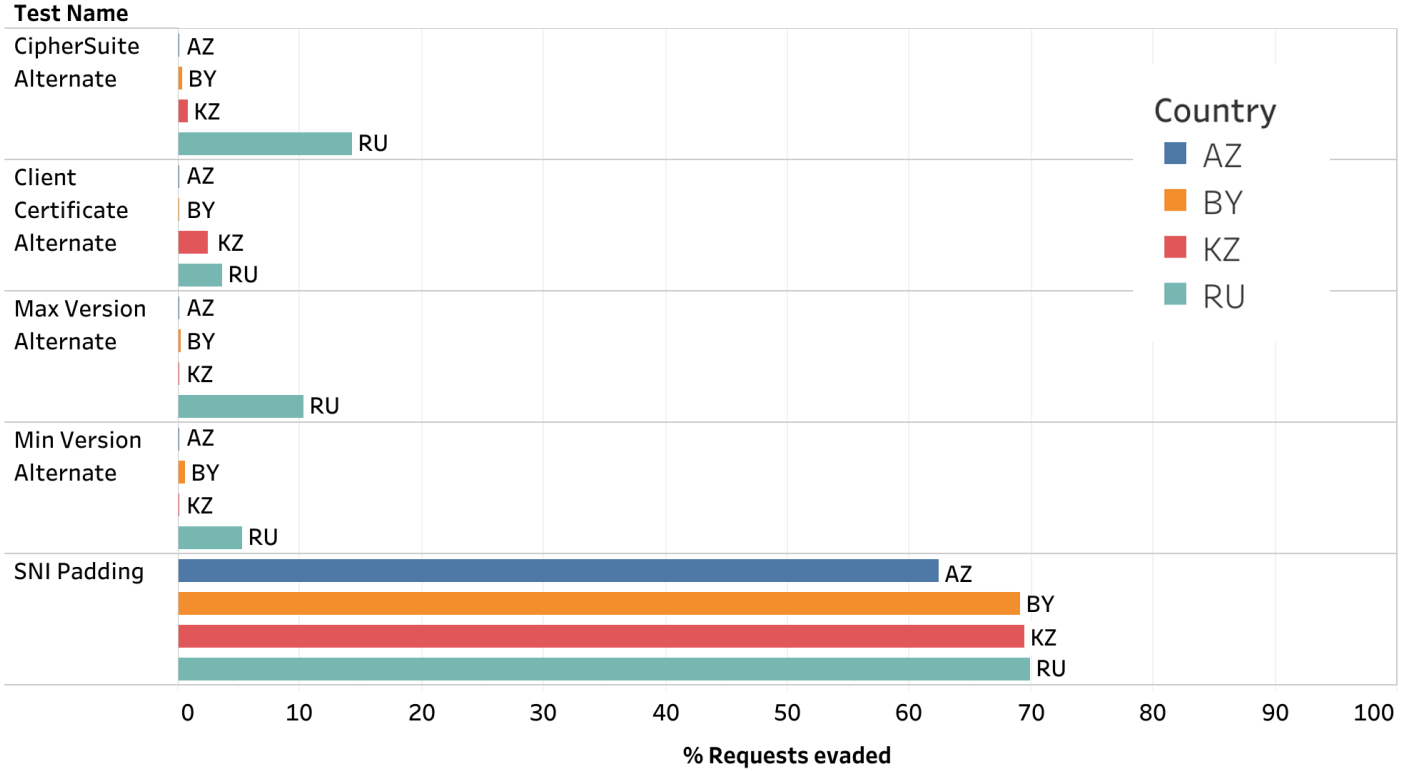


CenFuzz TLS: Evasion Success Rates



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Study similarities between devices

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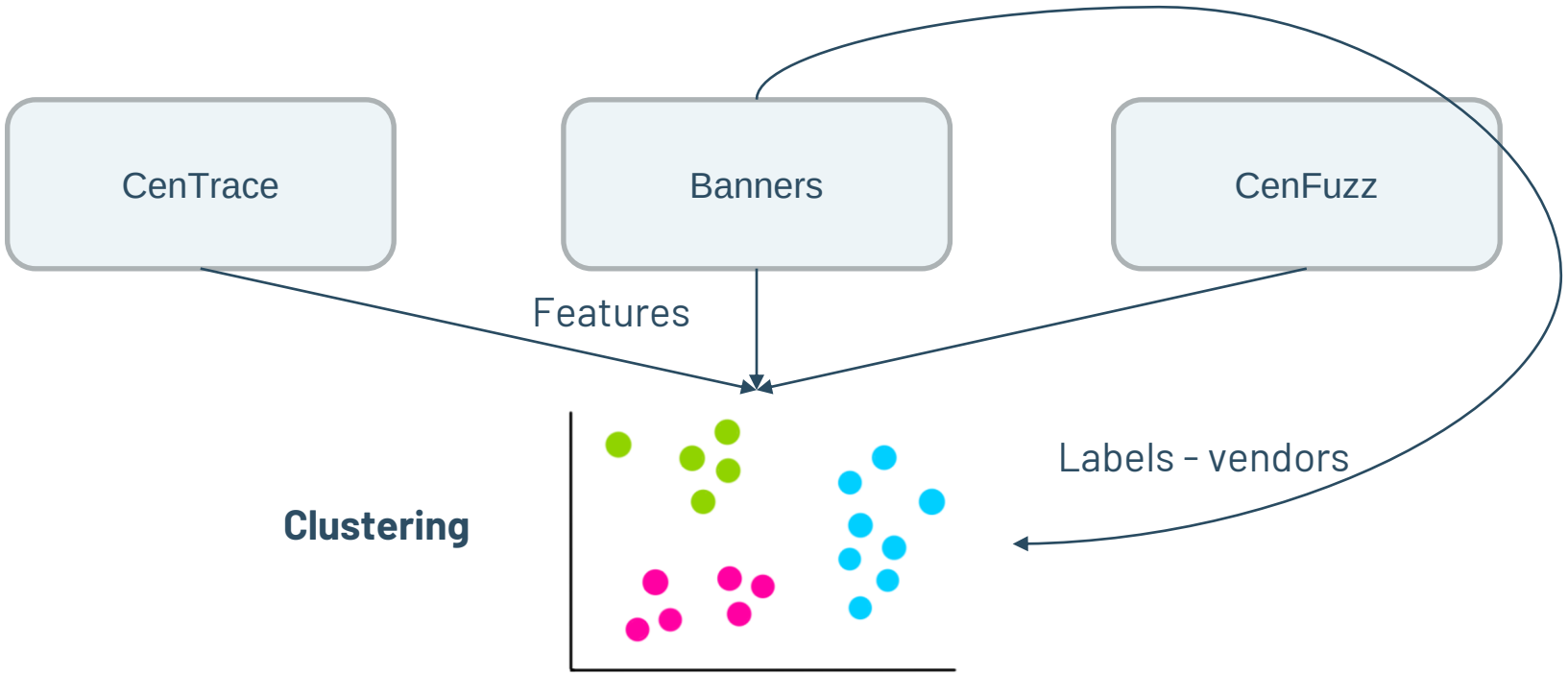
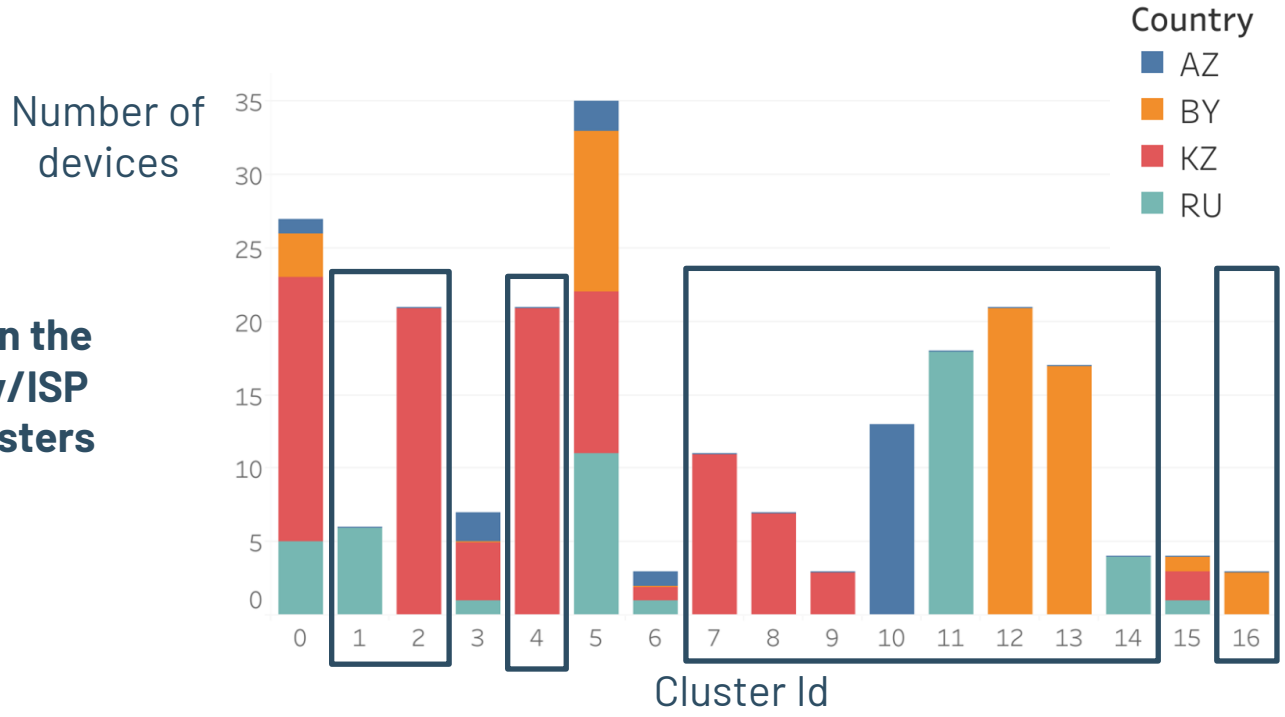
Clustering Devices



Clustering Devices

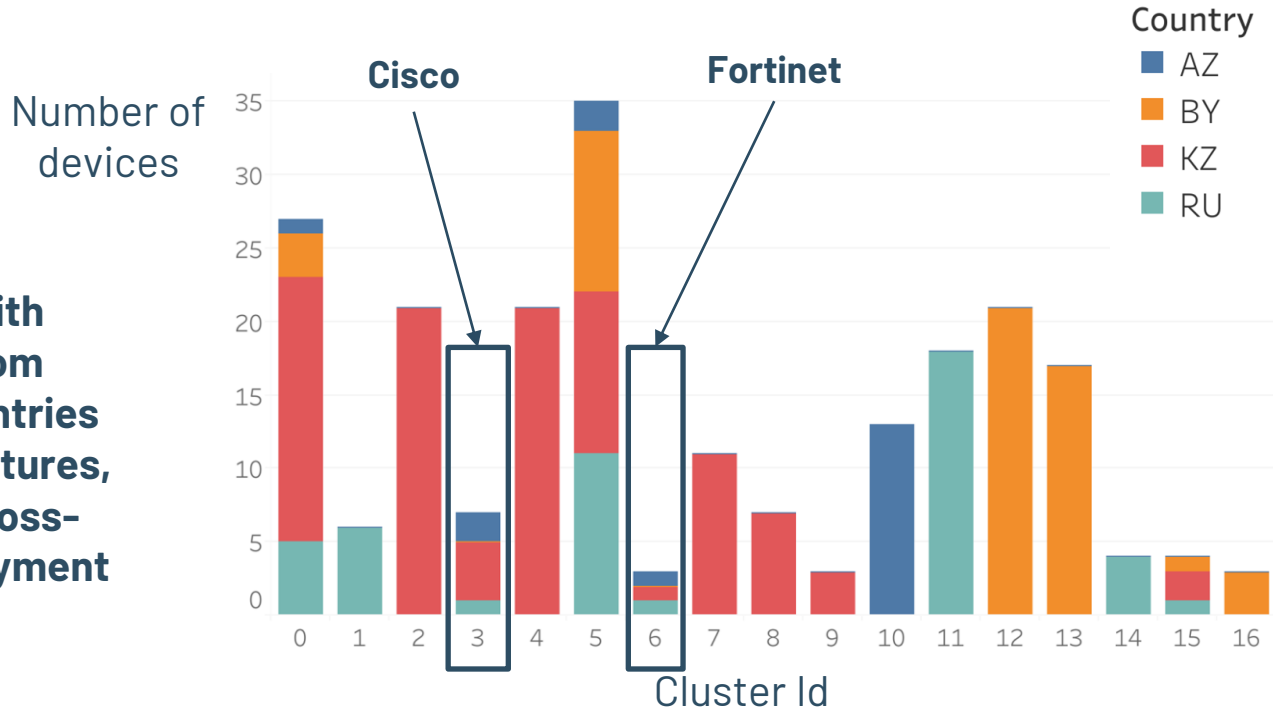
Clustering Devices

Devices within the same country/ISP form tight clusters



Clustering Devices

Clusters with devices from different countries have same features, indicating cross-country deployment



Our code and data are fully open-source

https://github.com/censoredplanet/CenTrace
https://github.com/censoredplanet/CenFuzz
https://github.com/censoredplanet/CenProbe

CoNEXT 2022 paper - https://ramakrishnansr.com/assets/censorship_devices.pdf
Censored Planet report - https://censoredplanet.org/censorship-devices
OTF report - https://www.opentech.fund/news/

Highlighting policy gaps
Assisting censorship research

What's Next?

- Integrate CenTrace, CenFuzz into Censored Planet, OONI
- Improve ground truth
- **Enforce standardized error messages and blocking mechanisms (e.g. in RFC 3234 and RFC 2979)**
- **Encourage publication and auditing of blocklists**
- **Invest in privacy-preserving technologies like Zero Knowledge middleboxes**

Key Takeaways

- Location of censorship is important: **frequently occurs in upstream ISPs or even in other countries**
- Devices can be deployed with different properties: **in-path, on-path, packet drops, copy TTL values**
- **Banners** on popular protocols are useful for identification
- The censorship triggers and other features are **device- or deployment-specific** and can be used to fingerprint them

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Thank you! Questions?

Reach out at ramaks@umich.edu

https://censoredplanet.org/censorship-devices

Need more info?

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