Modeling and Detecting Internet Censorship Events

Elisa Tsai, Ram Sundara Raman, Atul Prakash, Roya Ensafi

University of Michigan

Internet censorship is pervasive

Turkey tightens internet censorship ahead of elections

New controls on VPNs underline Erdoğan's moves to curb freedom of information

The internet curbs, which curtail access to independent sources of news and information, come ahead of local elections in March © Kerem Uzel/Bloomberg

Adam Samson in Ankara JANUARY 14 2024 74

Financial Times, Jan 2024

Russia's Online Censorship Has Soared 30-Fold During Ukraine War

A report from Citizen Lab laid out how much online censorship has increased on one of Russia's biggest social media sites.

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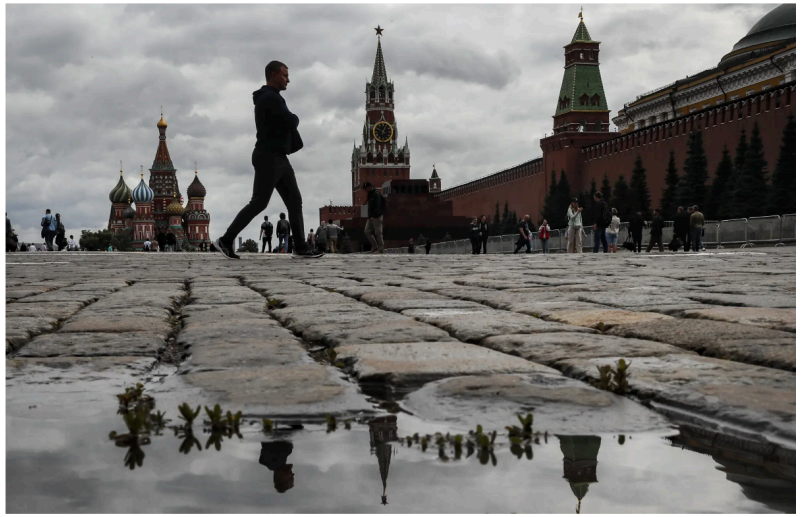

The New York Time, Jul 2023

Internet censorship is pervasive

Numerous peer-reviewed publications on Internet censorship:

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Numerous peer-reviewed publications on Internet censorship studies:

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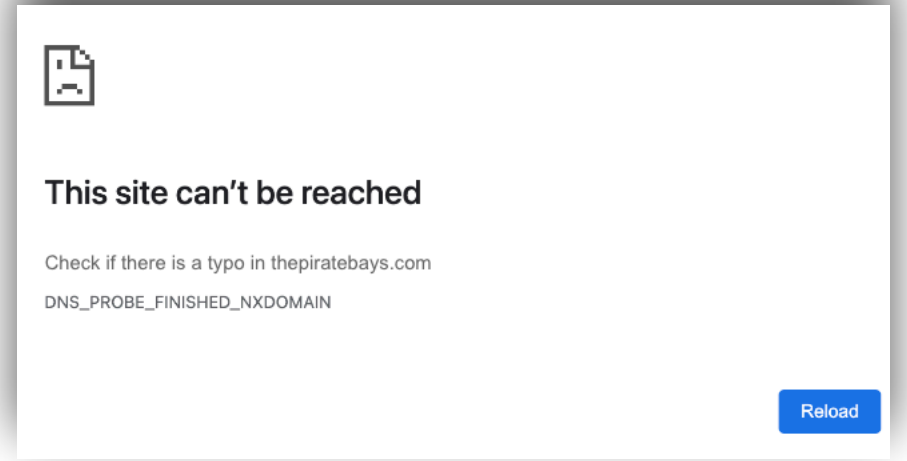
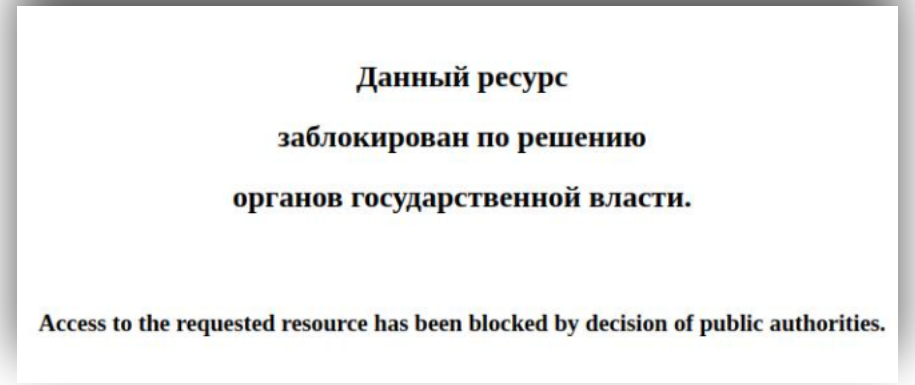
Internet censorship

1. Domain blocking





Internet censorship

1. Domain blocking
2. **Content takedowns**
    1. Domain admins
    2. Social media platforms

    …

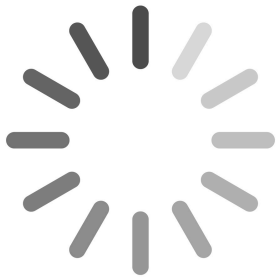
The Atlantic, Mar 2019

Internet censorship

1. Domain blocking
2. Content takedowns
3. **Circumvention tools blocking**

Internet censorship

1. Domain blocking
2. Content takedowns
3. Circumvention tools blocking
4. **Throttling**



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REPORT

Throttling of Twitter in Russia

AUTHORS: Diwen Xue, Reethika Ramesh, ValdikSS, Leonid Evdokimov, Andrey Viktorov, Arham Jain, Eric Wustrow, Simone Basso, Roya Ensafi (ensafi@umich.edu)

AFFILIATIONS: Censored Planet at the University of Michigan

DATE: April 6, 2021

Elon Musk's X is throttling traffic to websites he dislikes

The site formerly known as Twitter added a five-second delay when a user clicked on a shortened link to the New York Times, Facebook and other sites Musk commonly attacks, a Washington Post analysis found

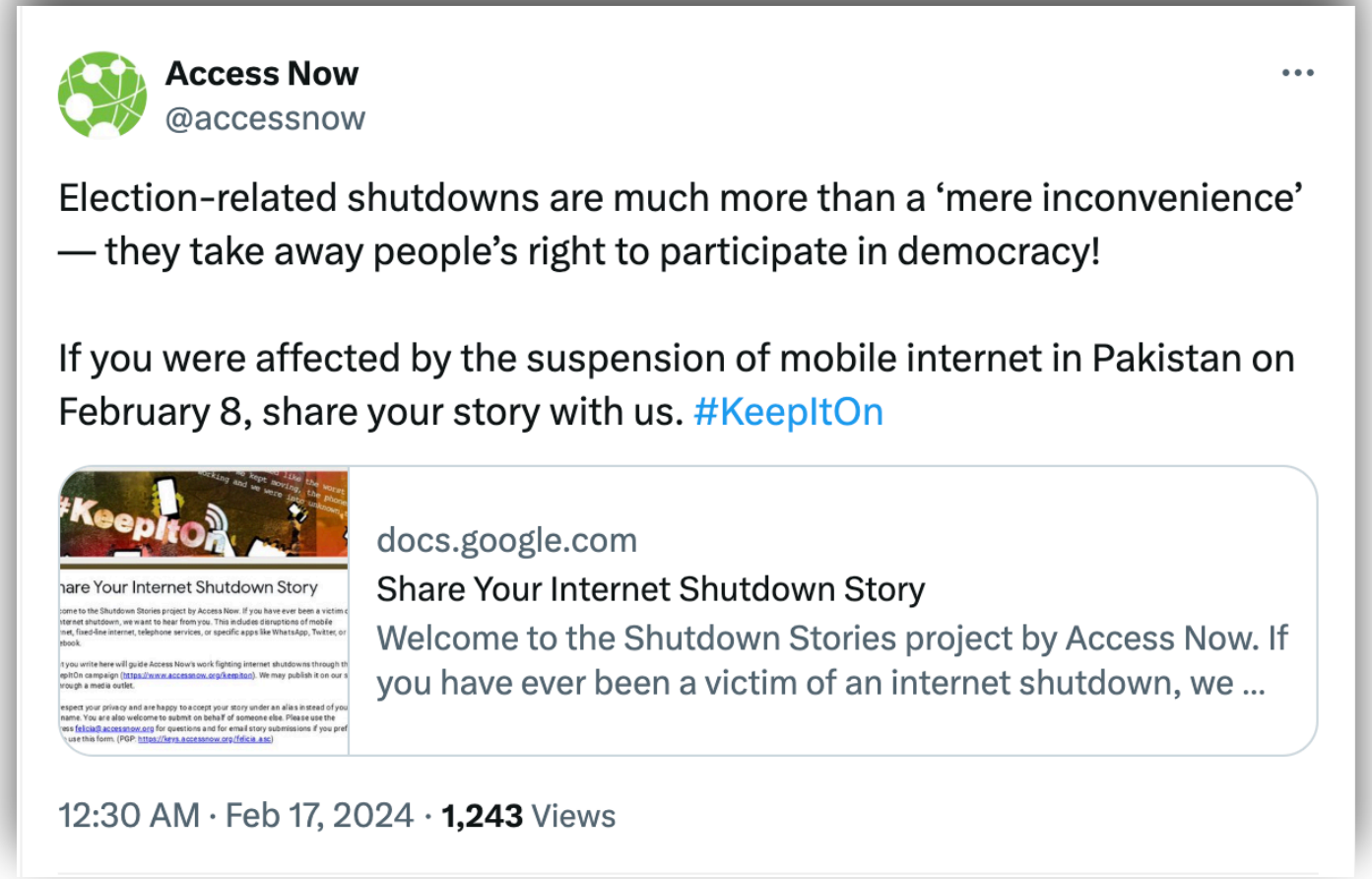
By Jeremy B. Merrill and Drew Harwell

Updated August 16, 2023 at 11:53 a.m. EDT | Published August 15, 2023 at 1:27 p.m. EDT

The New York Time, Aug 2023

Internet censorship

1. Domain blocking
2. Content takedowns
3. Circumvention tools blocking
4. Throttling
5. **Internet shutdowns**

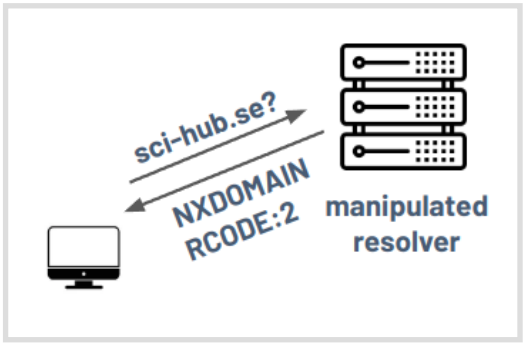


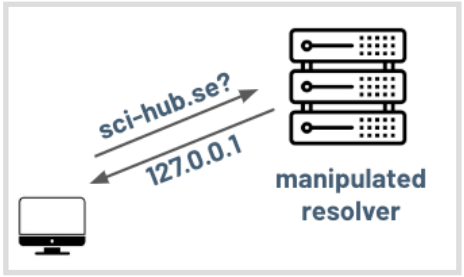
Internet censorship

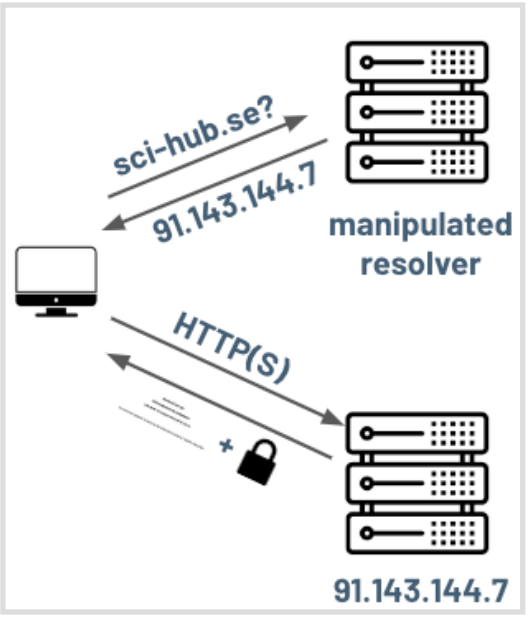
1. **Domain blocking**
2. Content takedowns
3. Circumvention tools blocking
4. Throttling
5. Internet shutdowns

Internet censorship

1. Domain blocking
    1. **DNS manipulation**

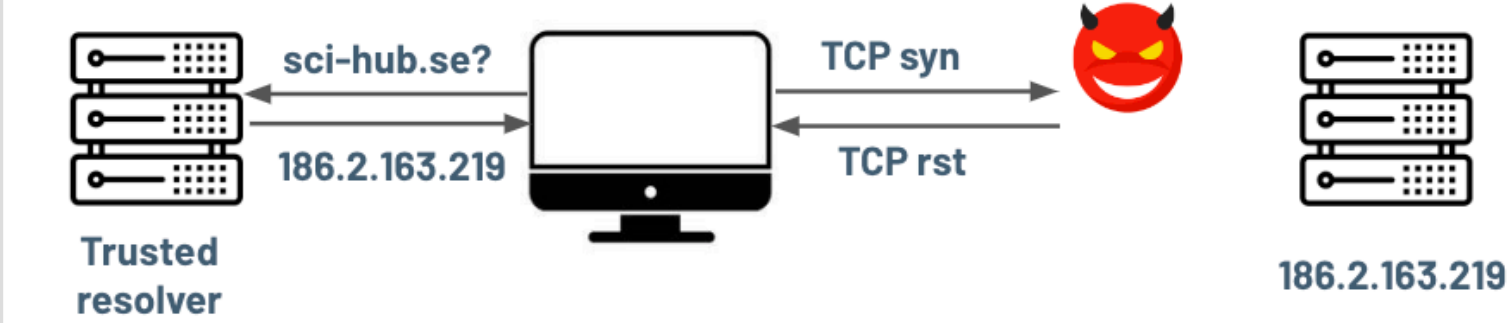






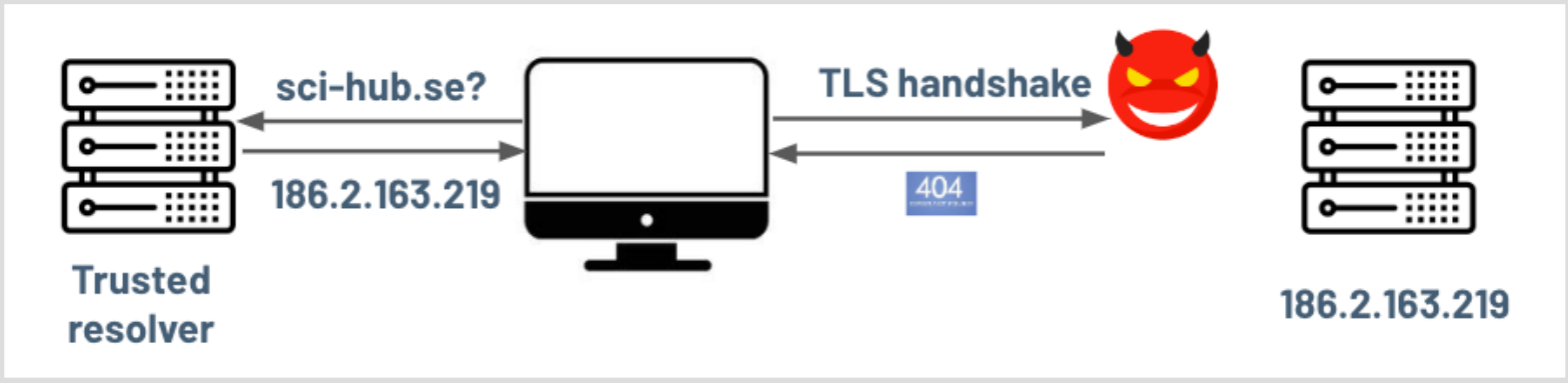
Internet censorship

1. Domain blocking
    1. DNS manipulation
    2. **IP Blocking**



Internet censorship

1. Domain blocking
    1. DNS manipulation
    2. IP Blocking
    3. **HTTP(S) blocking**



Global Internet censorship observatories

Censored Planet

Remote Measurement

OONI

In Situ Measurement

Global Internet censorship observatories

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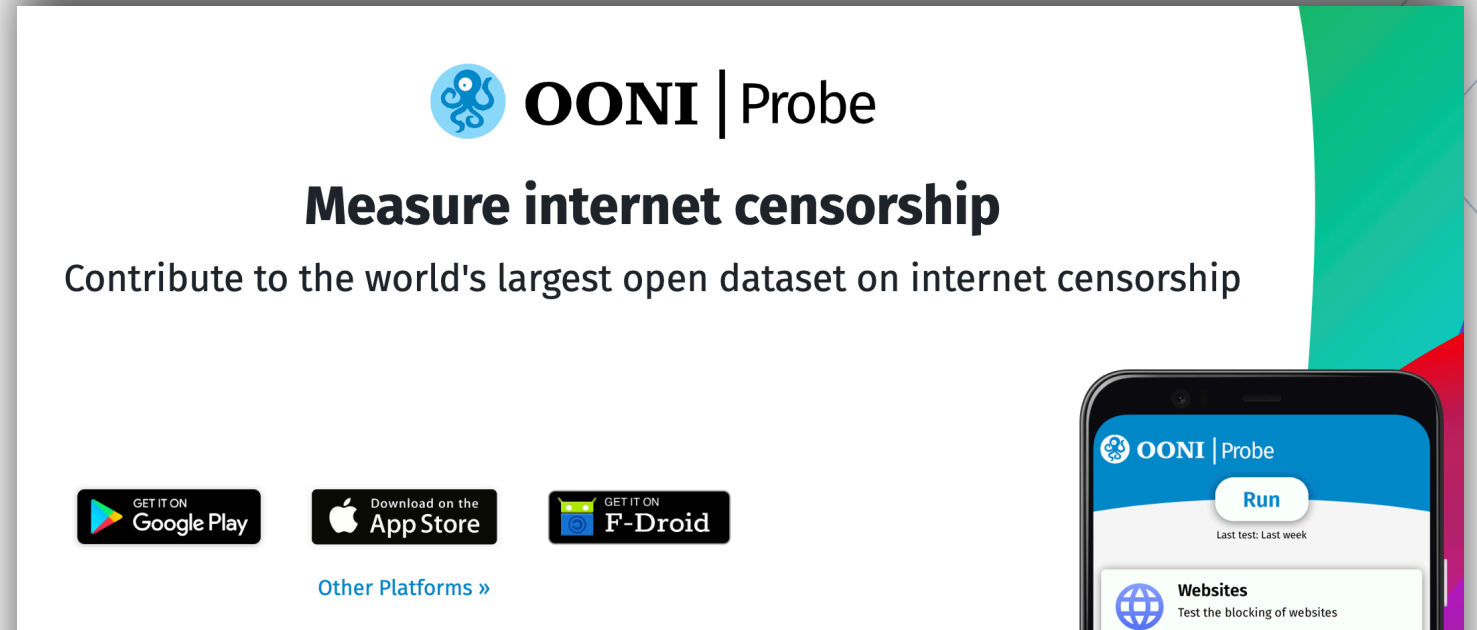
In Situ Measurement



NDSS SYMPOSIUM/2024

Presented by Internet Society

Global Internet censorship observatories

Censored Planet

Remote Measurement

78 B Measurements
Accumulated (Apr 2023)

241 Countries and Regions

OONI

In Situ Measurement

1.38 B Measurements
Accumulated (Apr 2023)

223 Countries and Regions

Global Internet censorship observatories

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Massive data has been collected for inspection!

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Internet censorship event detection

Classical Internet censorship event detection pipeline

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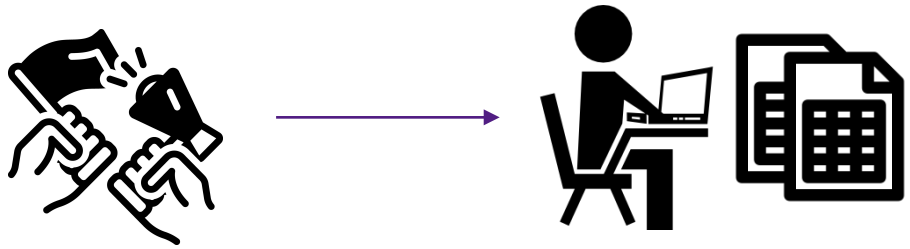
Journalists or on-the-ground activists reach out

Internet censorship event detection

Classical Internet censorship event detection pipeline



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Researchers investigate data from recent measurements in the country of interest

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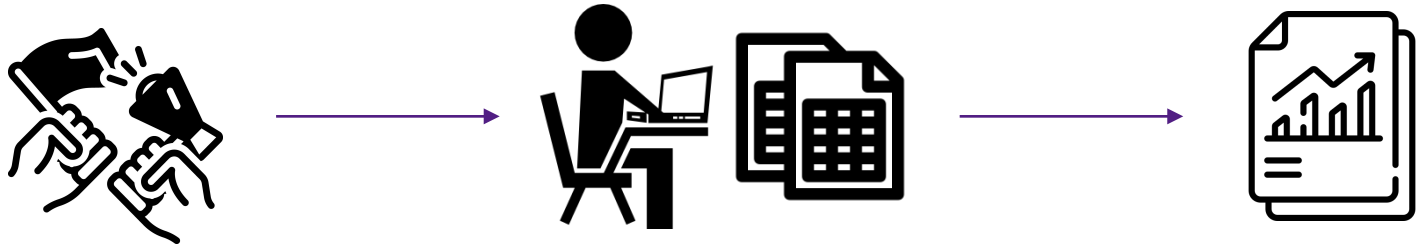

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Generate reports

Internet censorship event detection

OONI About Tests Data Get Involved Reports Blog Donate

Research reports

Grindr blocked in Jordan: Shrinking LGBTQ spaces
20 Sep 2023

Senegal: Social media blocks and network outages amid political unrest
1 Aug 2023

China is blocking OONI
28 Jul 2023

Brazil: OONI data on the blocking of Telegram
28 Apr 2023

Throttling of news media amid Kazakhstan's 2022 presidential election
28 Apr 2023

OONI measurements show ongoing internet censorship in Azerbaijan
28 Feb 2023

How Internet censorship changed in Russia during the 1st year of military conflict in Ukraine
Translations: ru
24 Feb 2023

Ethiopia: Ongoing blocking of social media
15 Feb 2023

GUIDE

KeepItOn: Fighting internet shutdowns around the world

In 2021, Access Now's Shutdown Tracker Optimization Project (STOP), in collaboration with the #KeepItOn coalition, recorded at least 182 internet shutdowns in 34 countries worldwide, including the longest internet shutdowns on record.

LEARN MORE

RESOURCES

FREEDOM OF EXPRESSION
#KeepItOn: 2022 elections and internet shutdowns watch
Elections and internet shutdowns are a disaster for democracy. See which…

DIGITAL SECURITY
Internet shutdowns in 2021: the return of digital authoritarianism
In 2021, Access Now and the #KeepItOn coalition documented 18…

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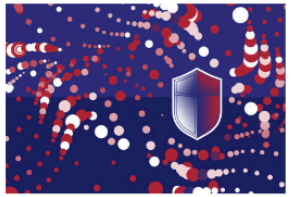
Taxonomy of a shutdown: 8 ways governments restrict access to the internet, and how to #KeepItOn
Our new guide explains the technology behind network…

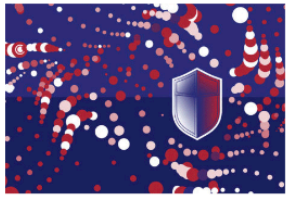
INTERNET SHUTDOWNS
Internet shutdowns and elections handbook
Internet shutdowns and elections handbook A guide for election…

INTERNET SHUTDOWNS
KeepItOn: frequently asked questions
#KeepItOn: A global movement to end

FREEDOM OF EXPRESSION
Have questions about internet shutdowns? Kill Switch has answers



OTHER PODCASTS
BBC podcast on shutdowns Human rights talks podcast on shutdowns



Digital safety tips if you are disconnected — a framework for individuals to get prepared

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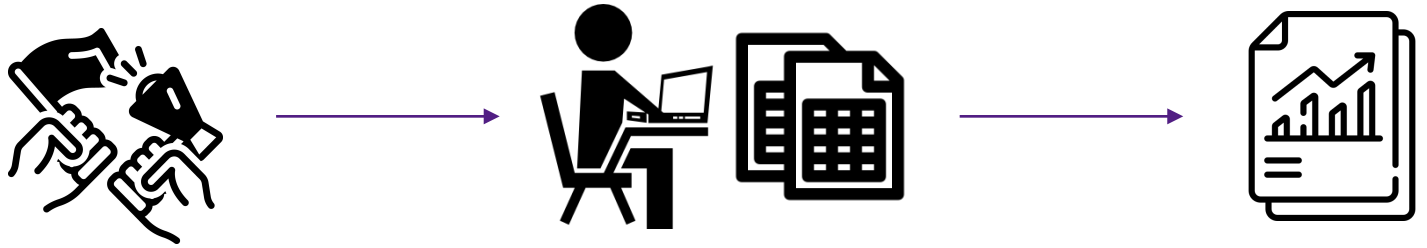

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Generate reports

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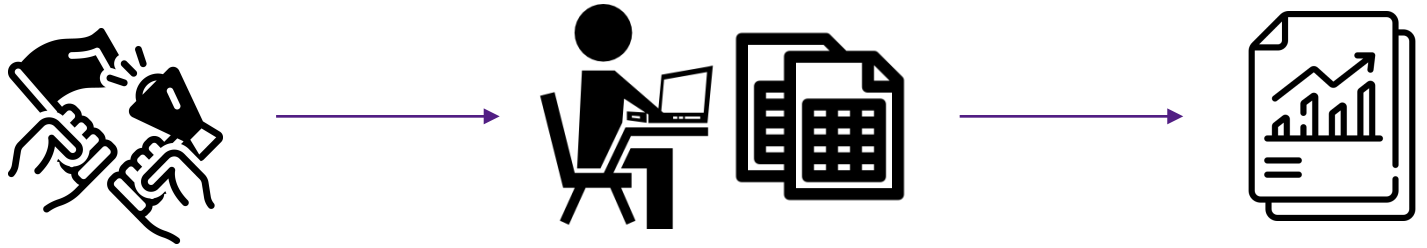

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🙅‍♀️ Not scalable on a global scale

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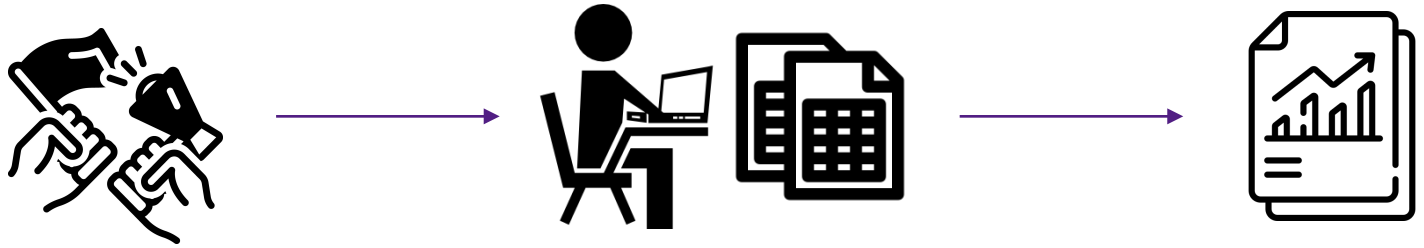

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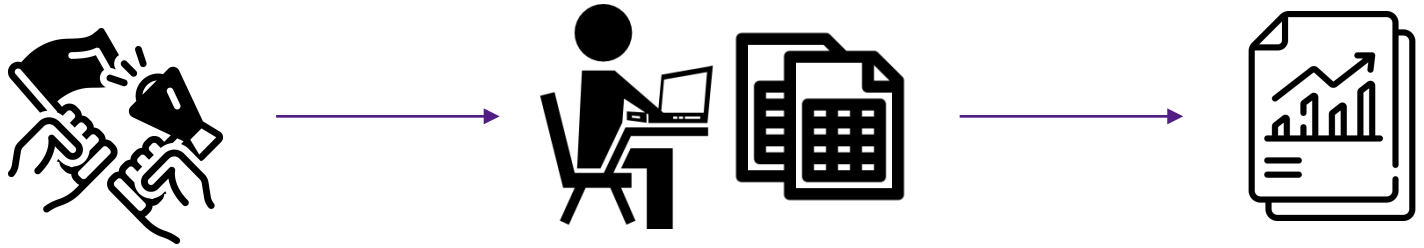

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- 🙅 Not scalable on a global scale
- 🚮 Data is wasted if no one reaches out
- ❗ Automated method is needed

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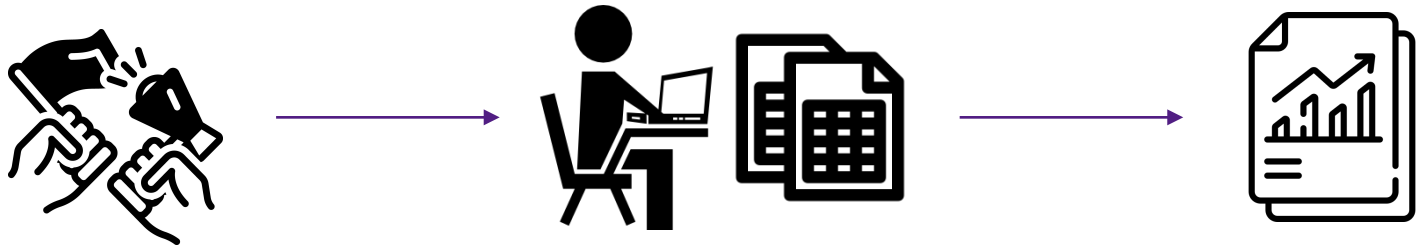

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Other proposed methods

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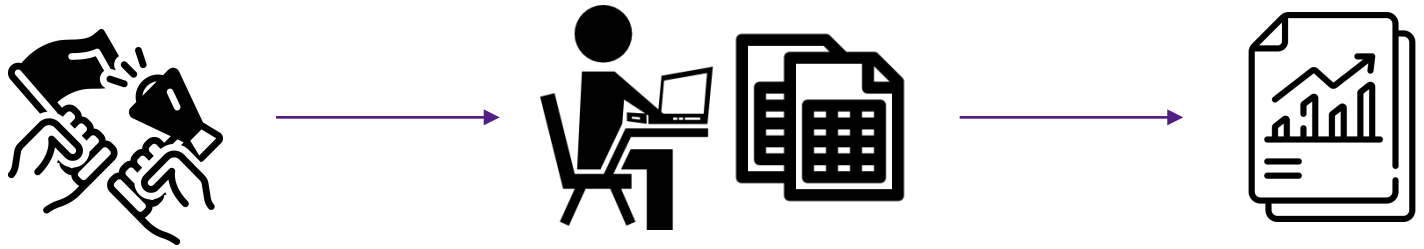

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Other proposed methods

- **Time-series anomaly detection** techniques: bitmap-based detection. Sundara Raman et al.
- **Supervised Learning** on DNS measurement. Brown et al.

Internet censorship event detection challenges

1. Lack of ground truth.

- **Censorship observatories** stopped labelling “normal/ blocked” and now report various network anomalies.

Internet censorship event detection challenges

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⚠ Binary classification based on a fixed set of heuristics is error-prone.

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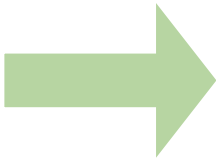

Unsupervised Learning

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Unsupervised Learning

2. Measurement volatility.

- Domain test list (Tranco and the Citizen Lab Test List)
- Vantage point list

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Unsupervised Learning

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- Vantage point list

3. Large volume of data (78 billion data points from Censored Planet from 2019-2022**).**

Internet censorship event detection goal

1. Efficiency

Internet censorship event detection goal

1. **Efficiency**
2. **Explainability**

- Where (geolocation of censorship)?
- When (timespan of censorship)?
- How (blocking method)?
- What (blocklist)?

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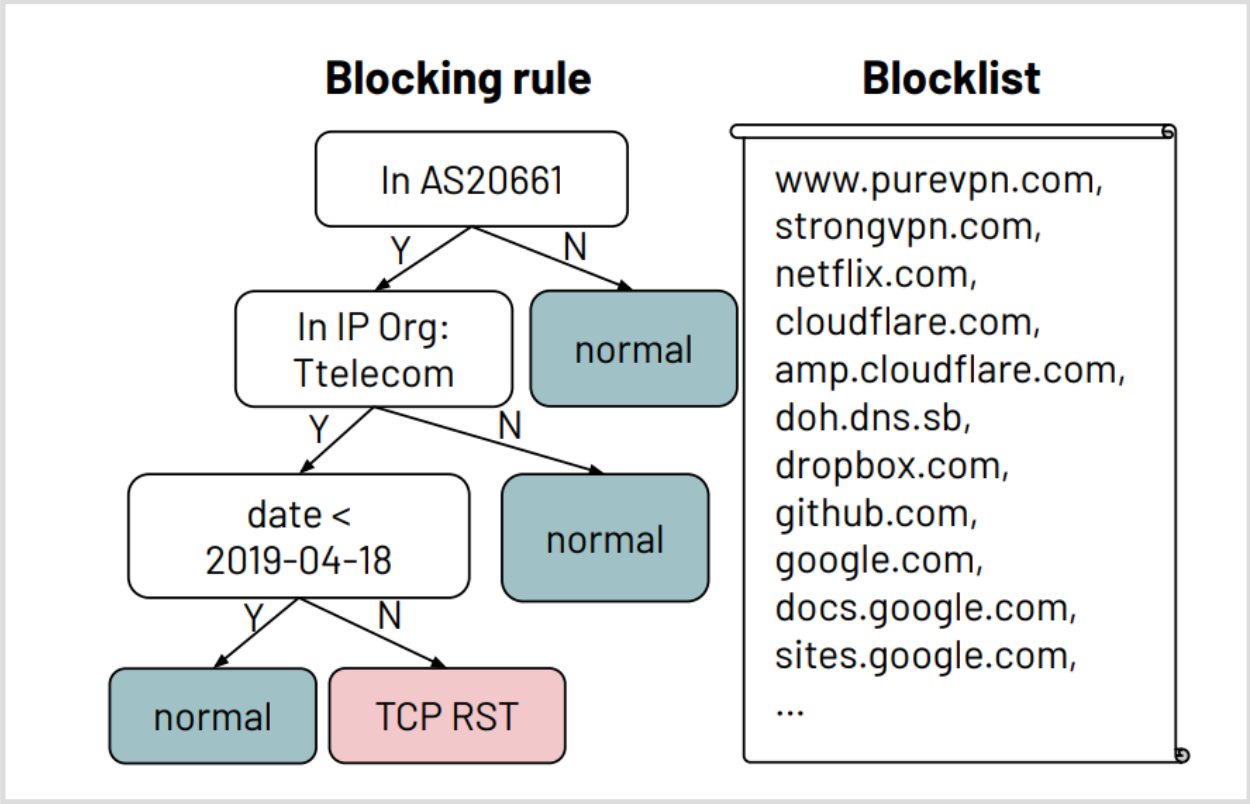

Where: Turkmenistan, AS20661, IP organization Ttelecom

When: After 2019 April

How: TCP reset

Blocklist: domains in the blocklist

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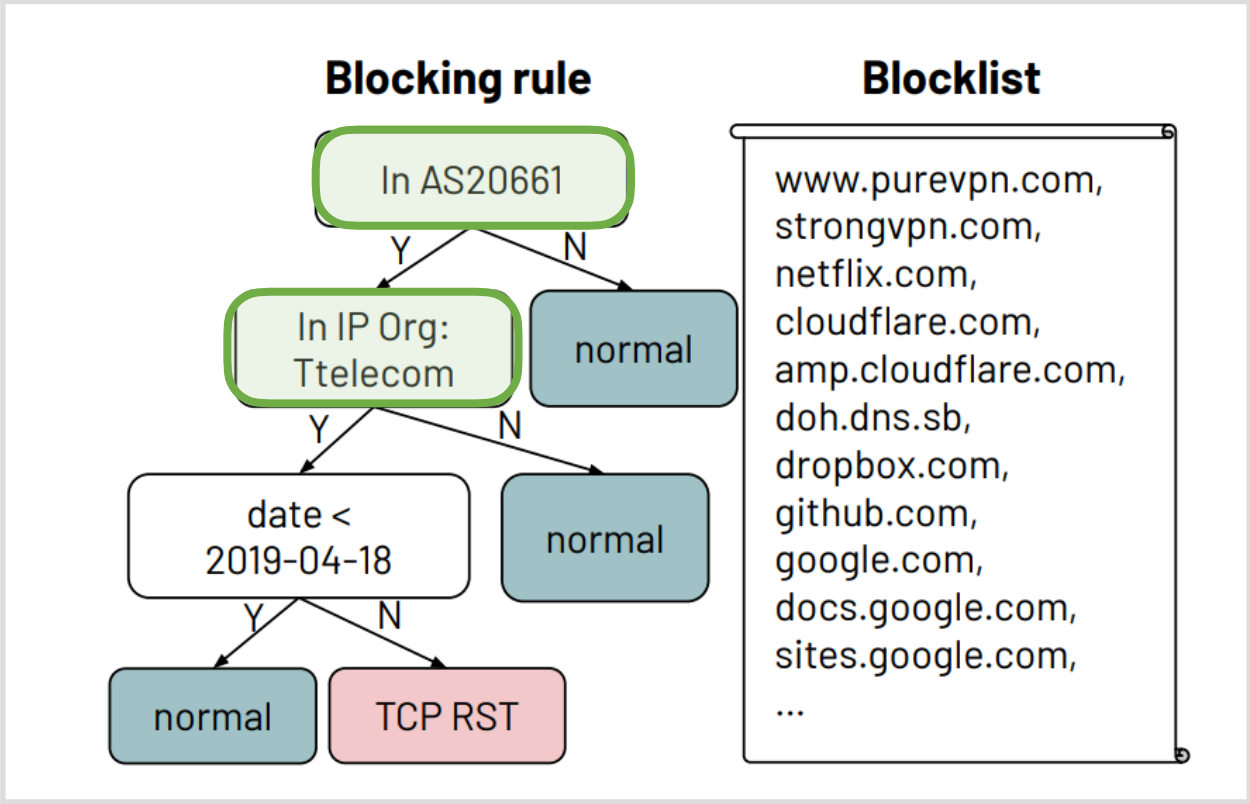

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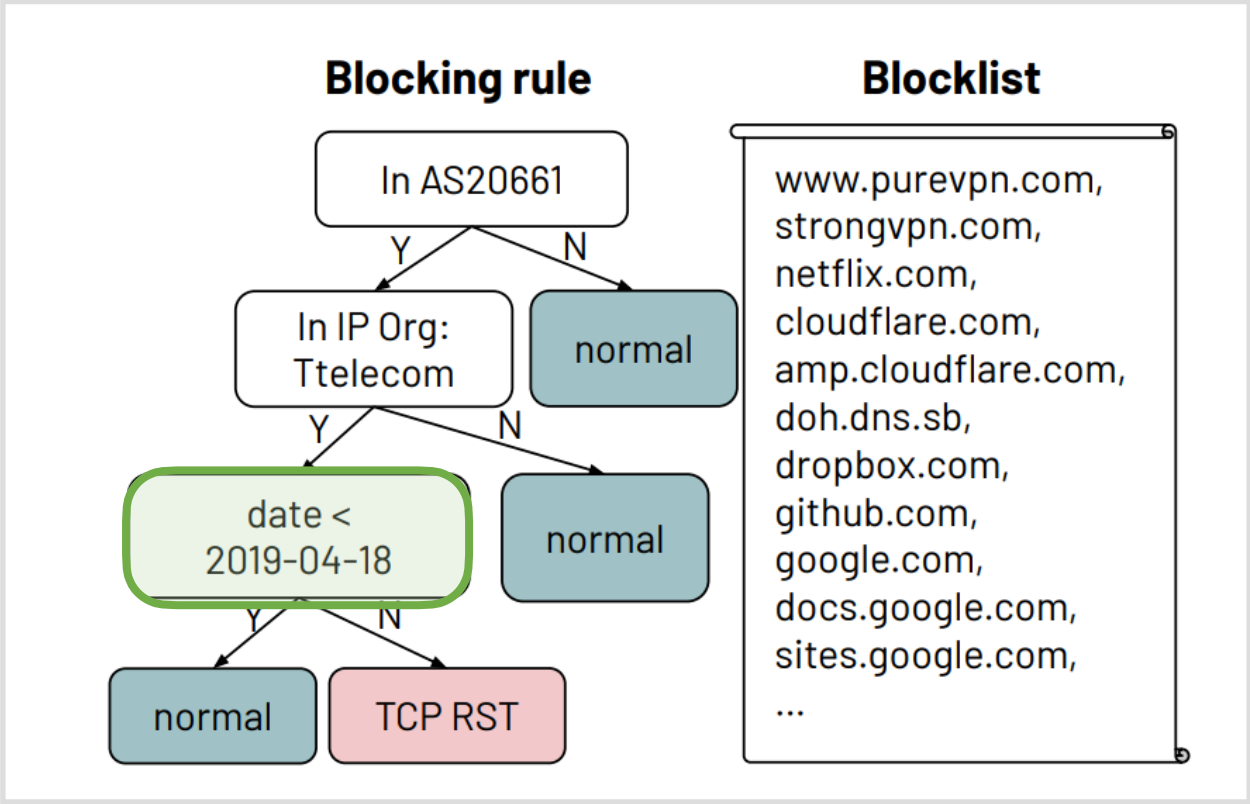

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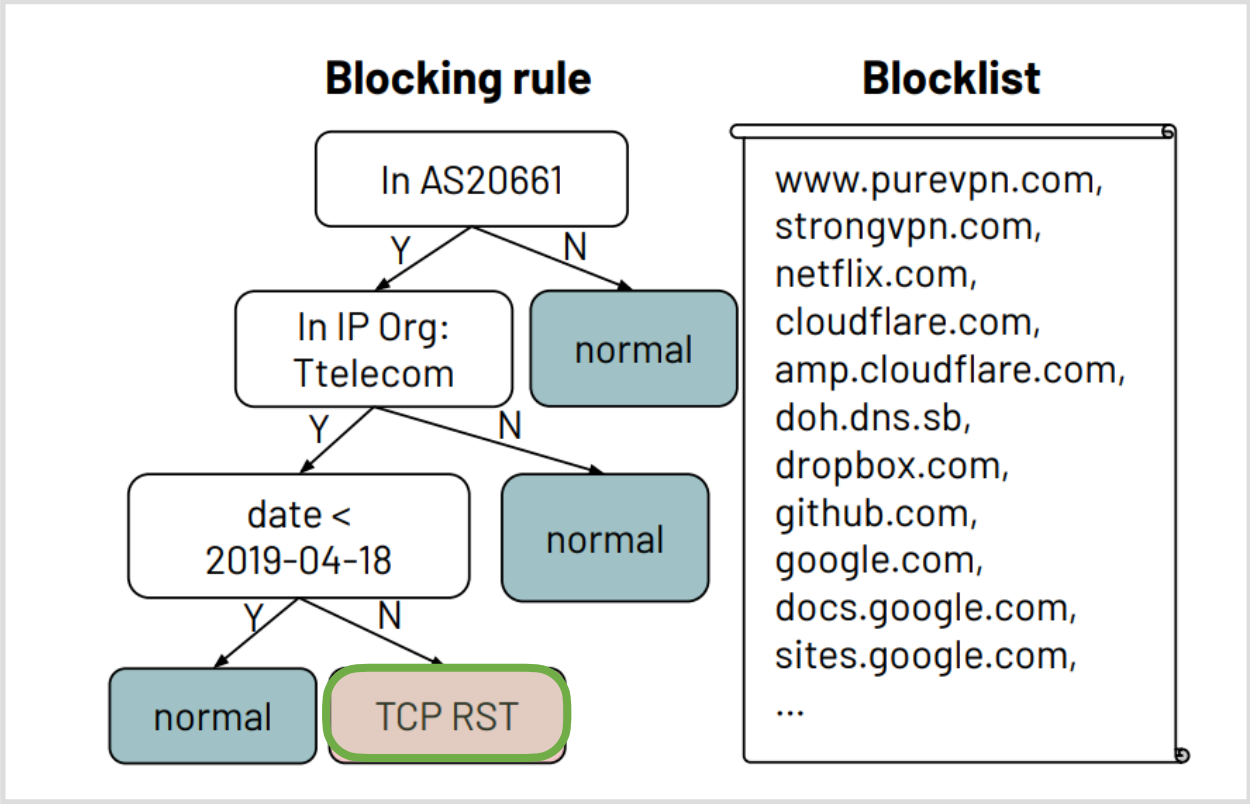

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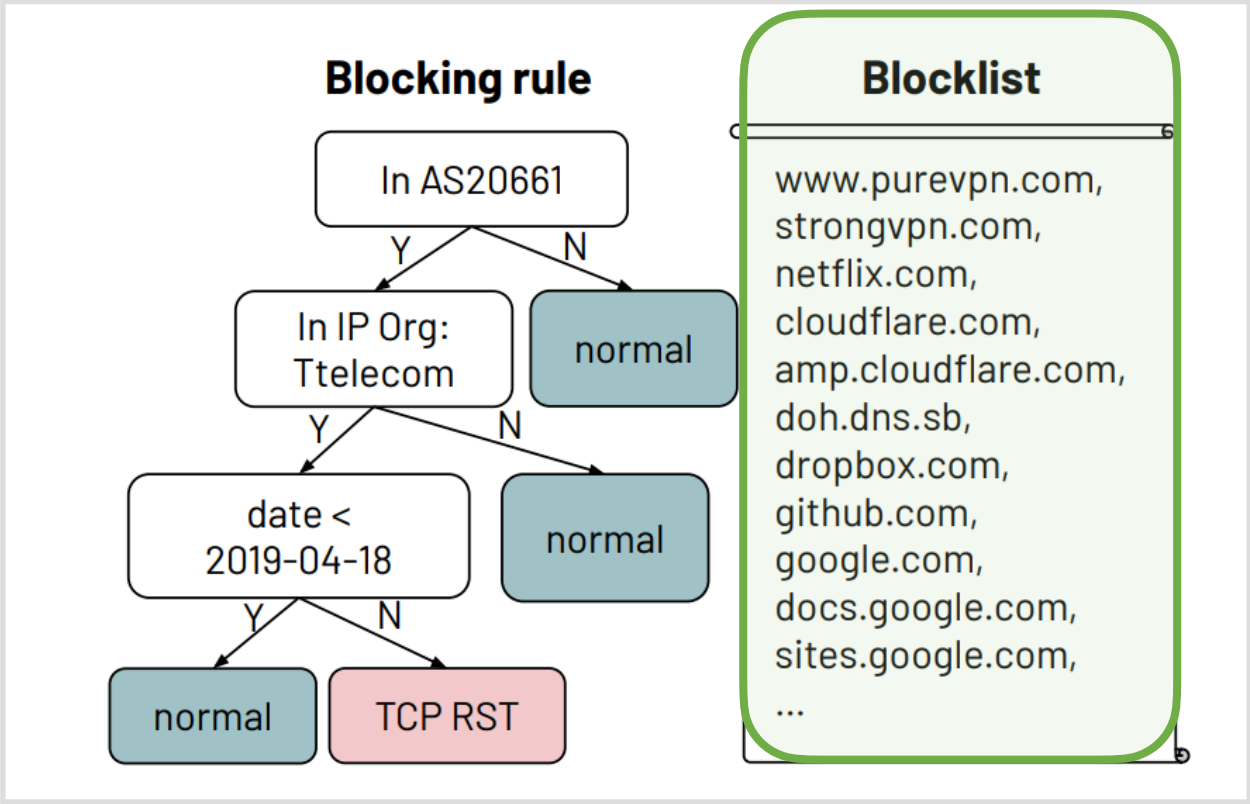

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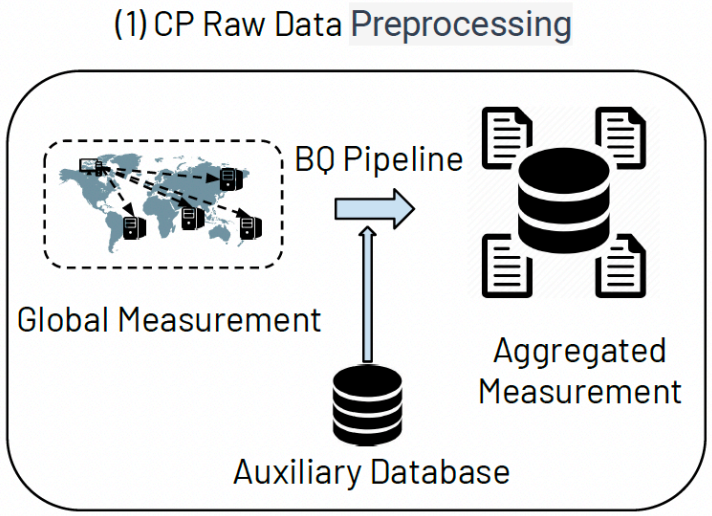
CenDTect: an unsupervised learning censorship event detection system



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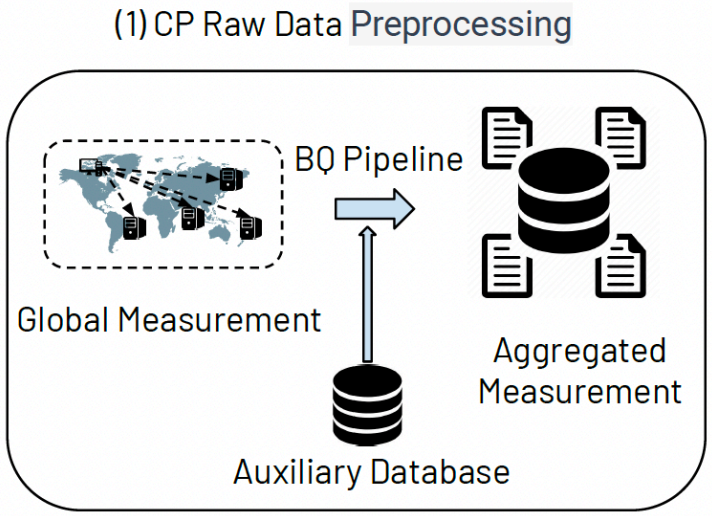

Assumptions

IP Organization is the unit of censorship

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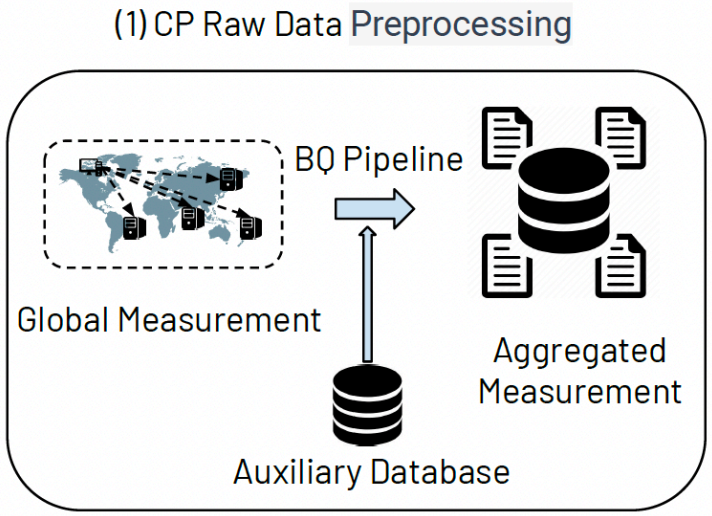

Assumptions

IP Organization is the unit of censorship

- IP Organizations: the organization listed in the WHOIS record for an IP
- Network admins of ISPs, university networks, company networks are able to implement and update blocking policies

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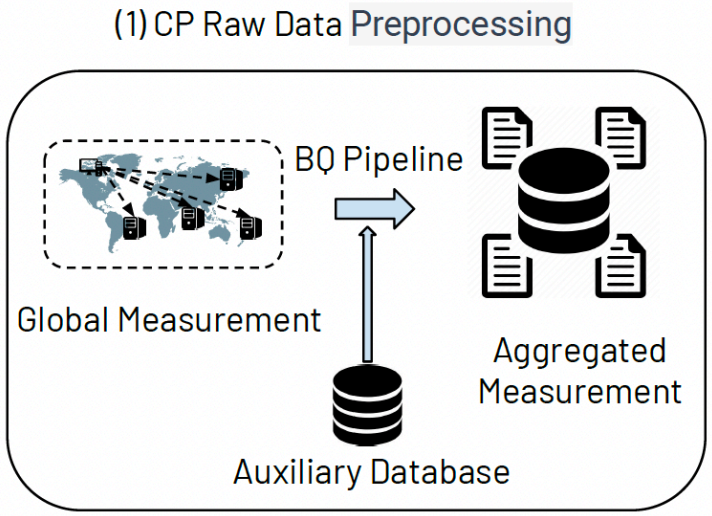

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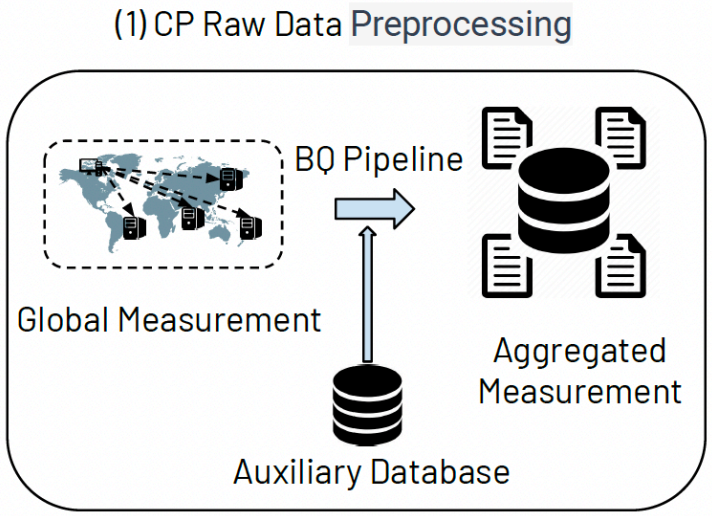

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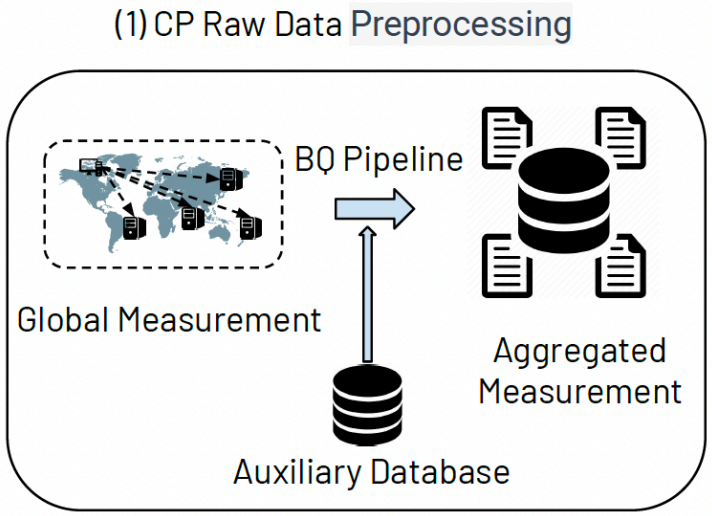


Assumptions

IP Organization is the unit of censorship

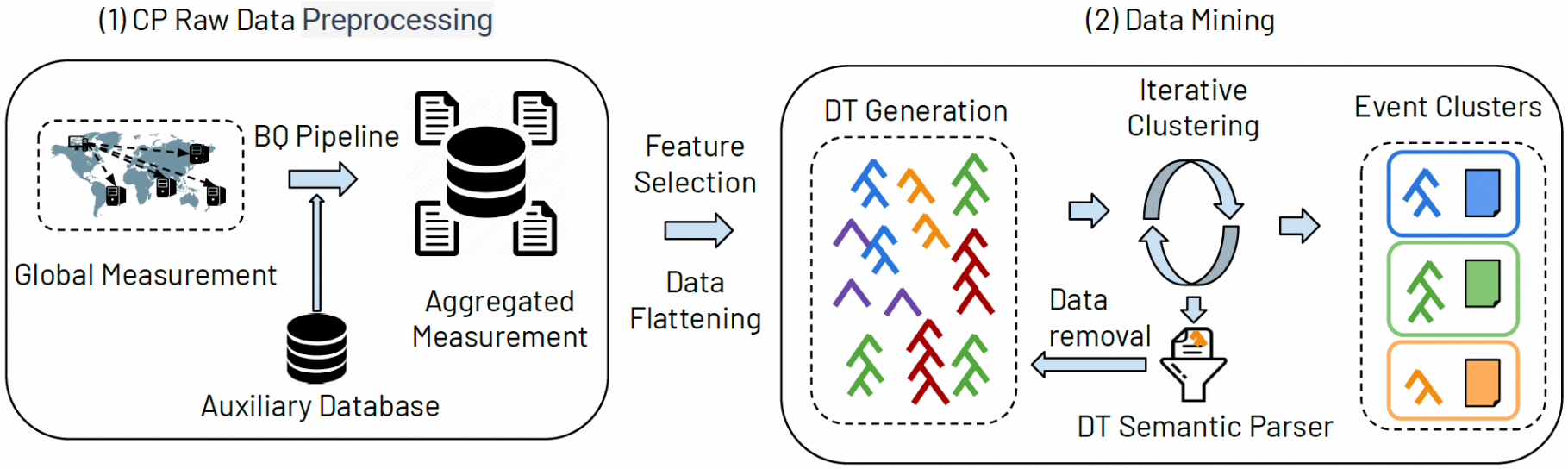
→ annotate measurement with IP org information in preprocessing

Censorship events involves simultaneous blocking of multiple domains

→ use decision tree to describe blocking behaviors on a set of vantage points

→ cluster domains with the similar blocking behaviors

CenDTect: an unsupervised learning censorship event detection system



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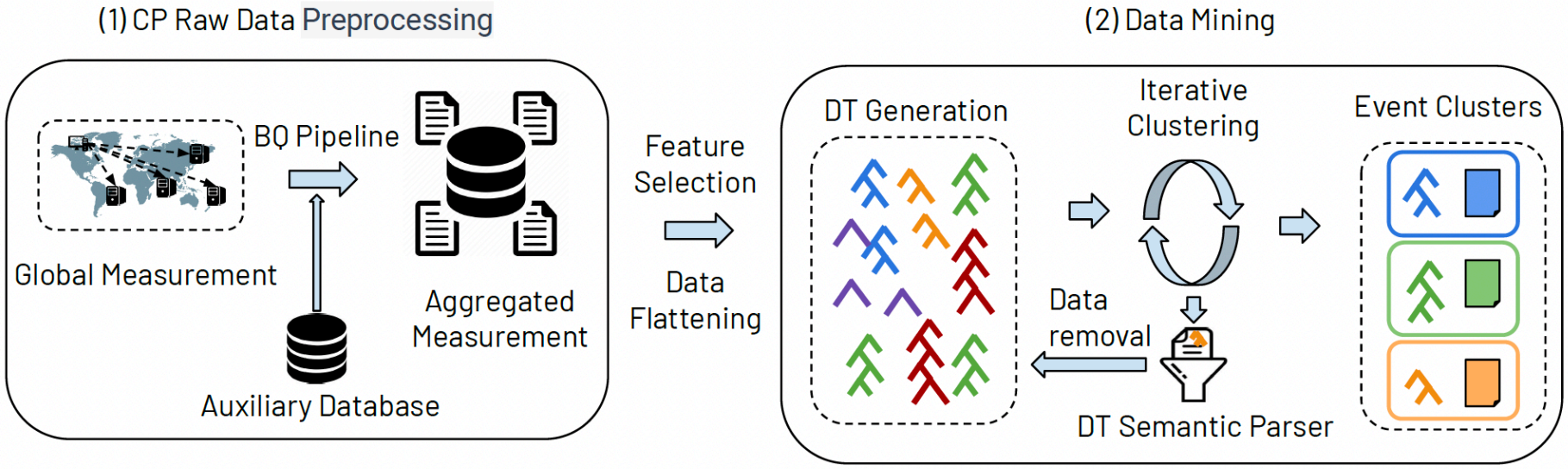

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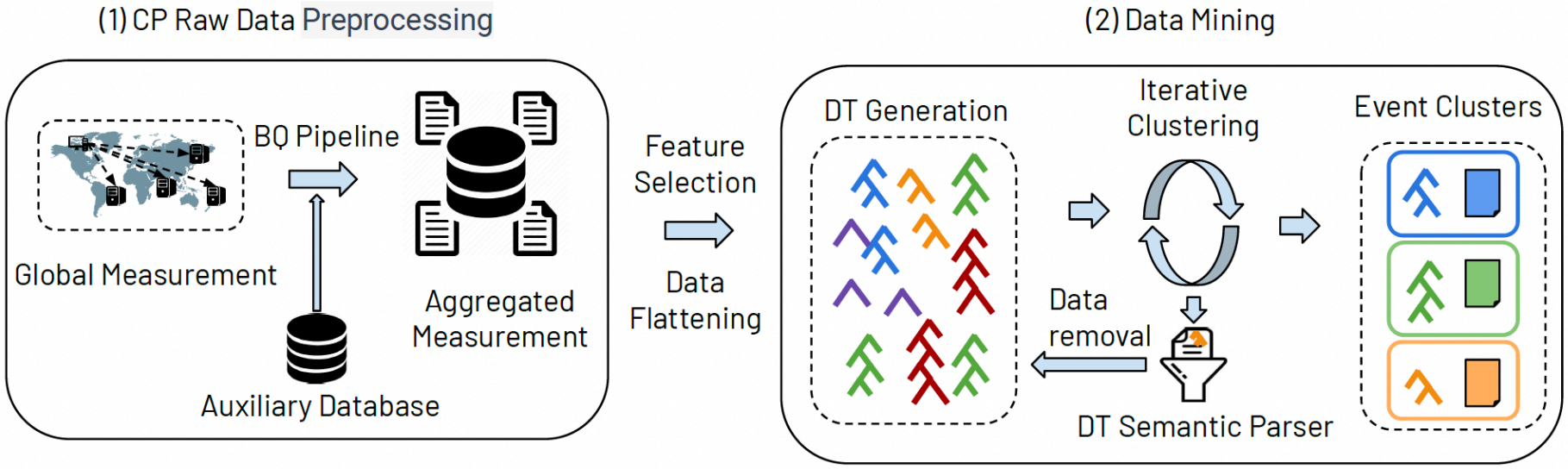

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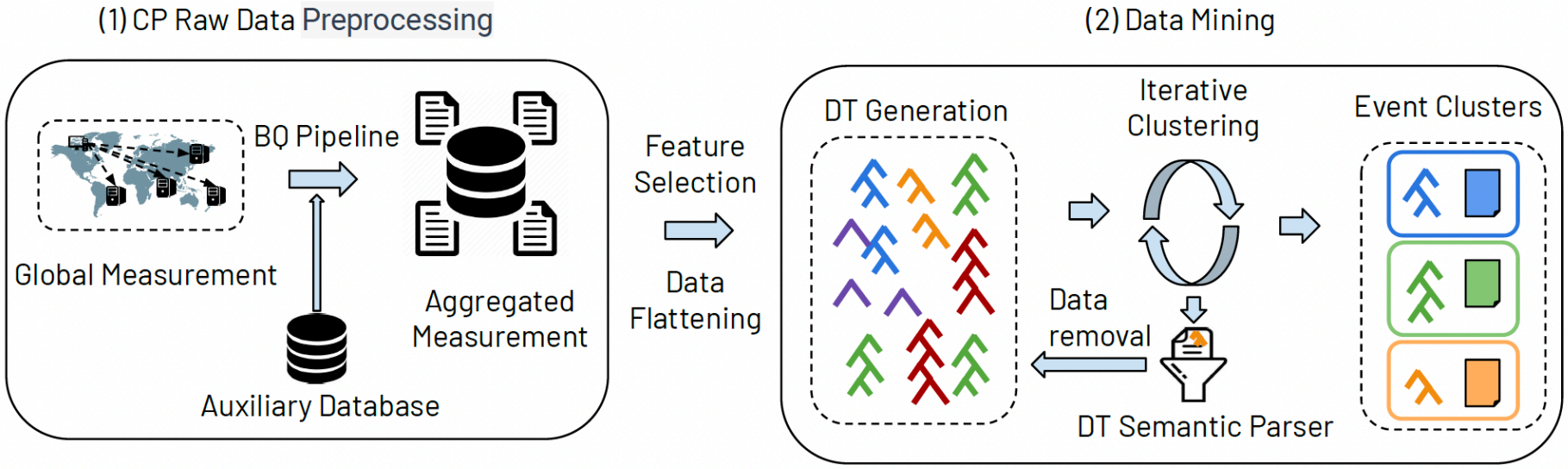

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Iterative clustering with adapted prediction:

True Label	p_1	p_1	p_1	0	0
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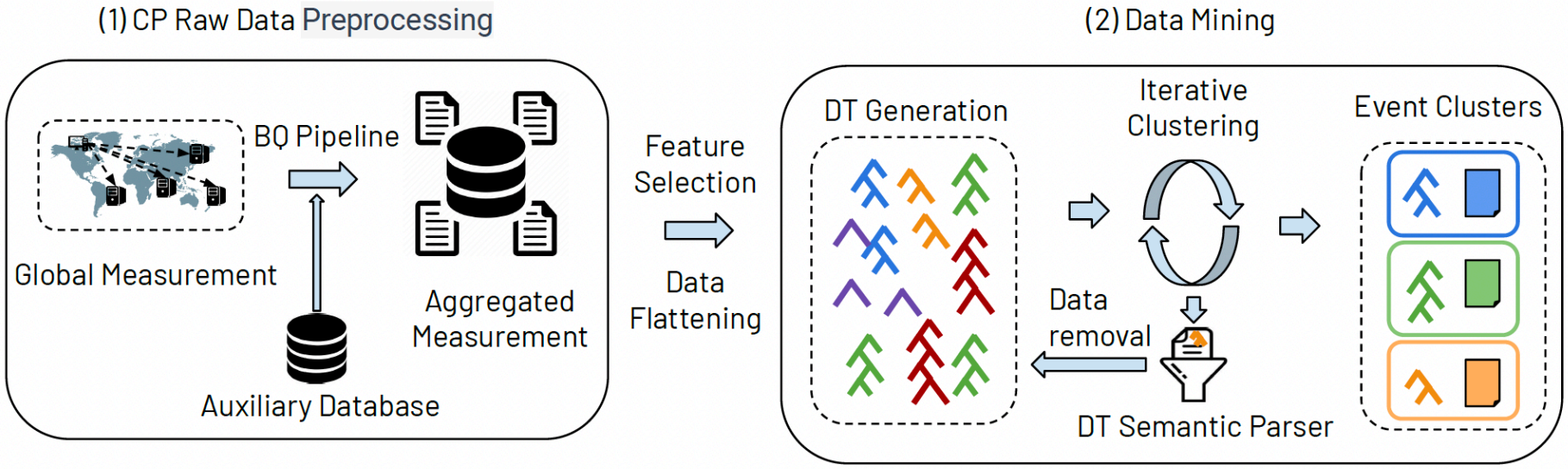

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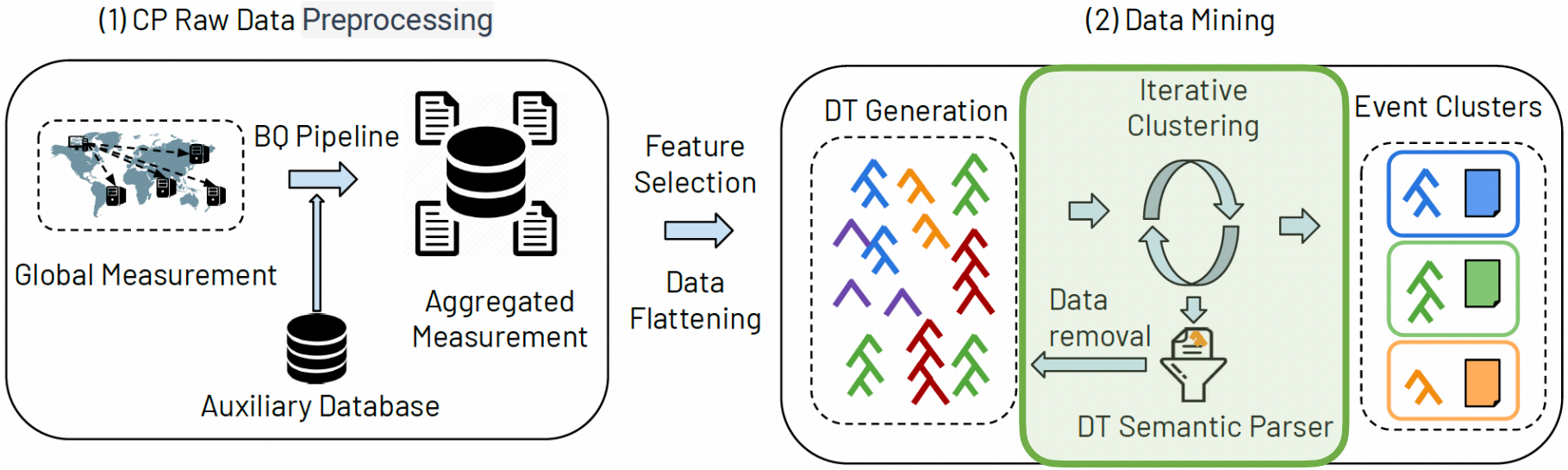

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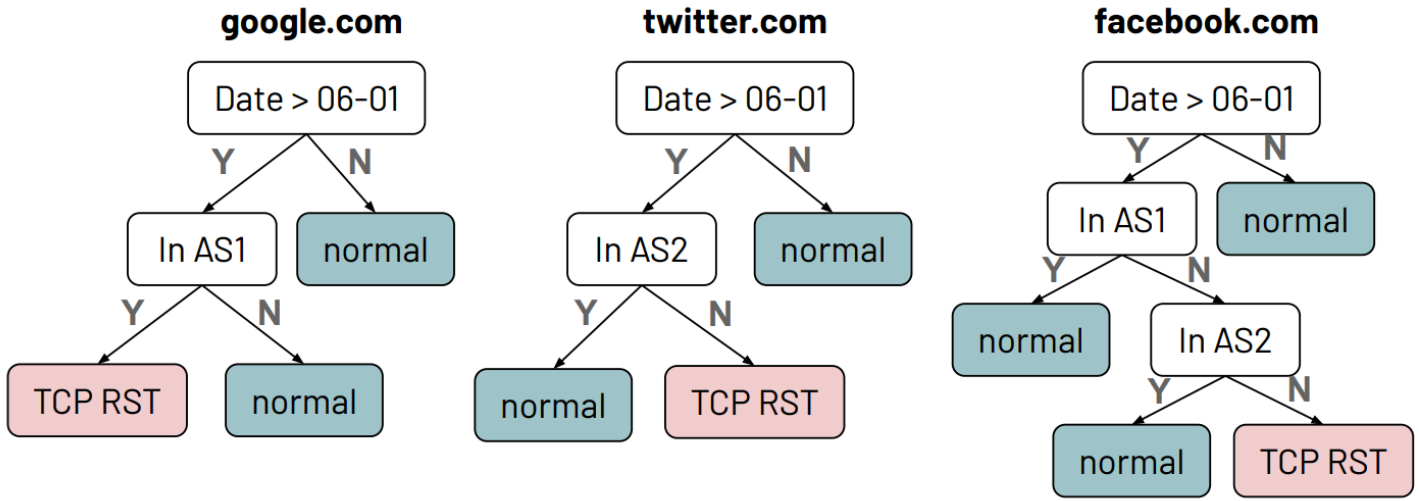

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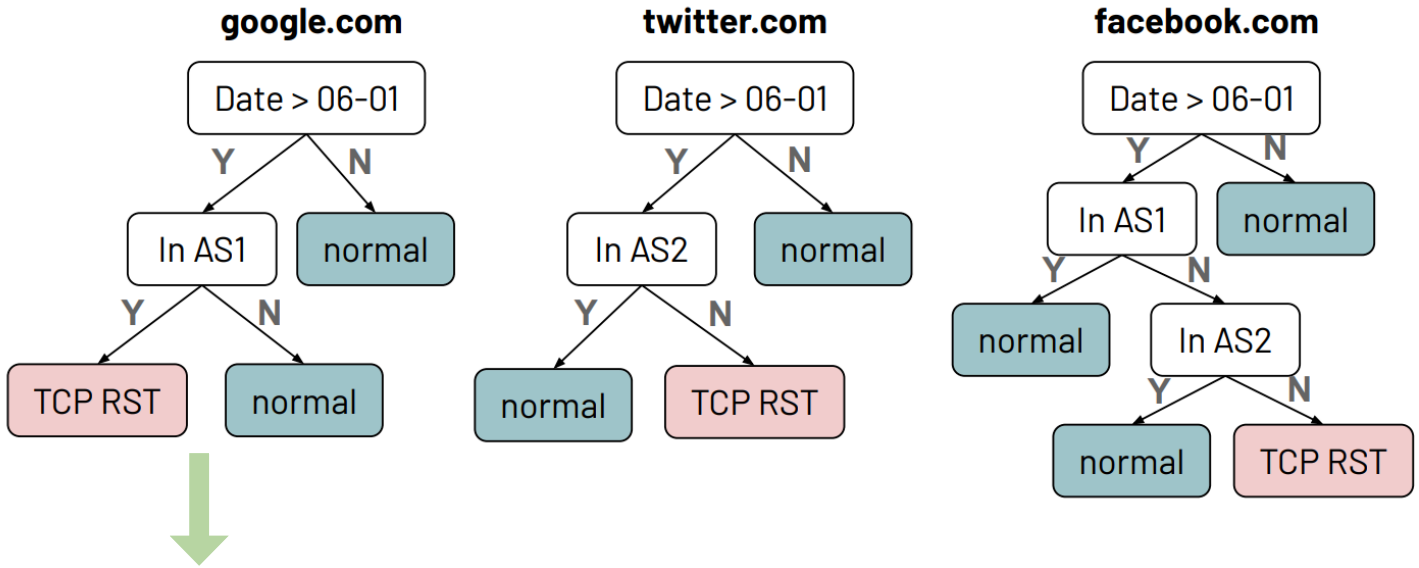

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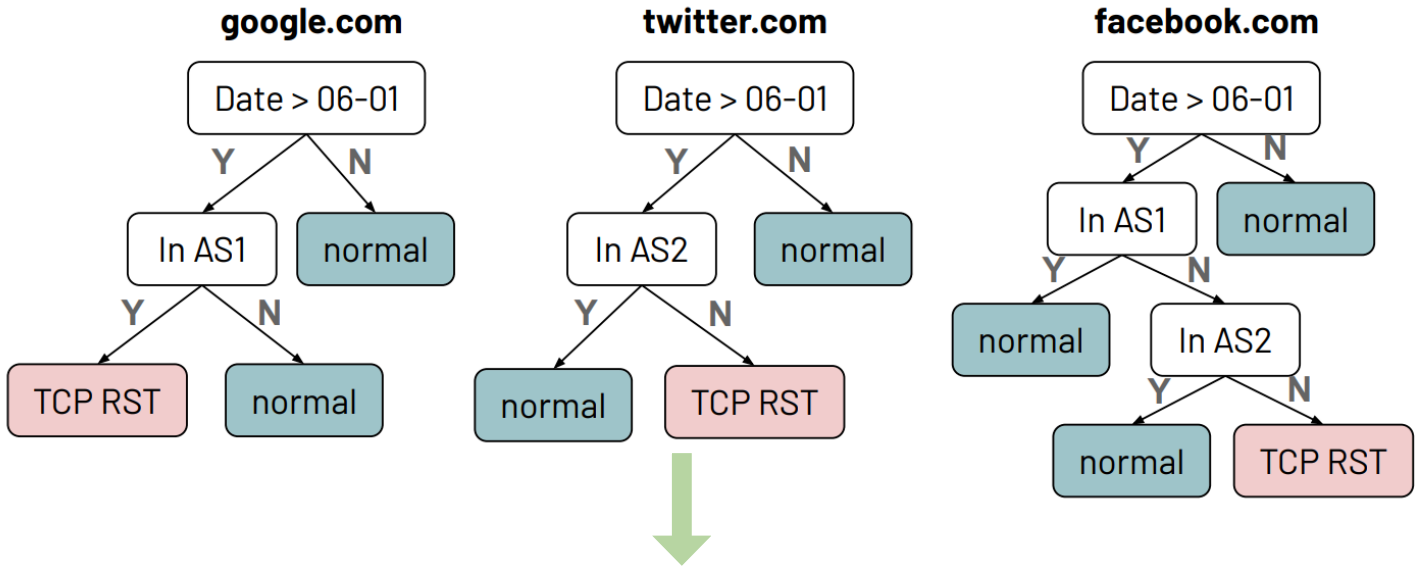

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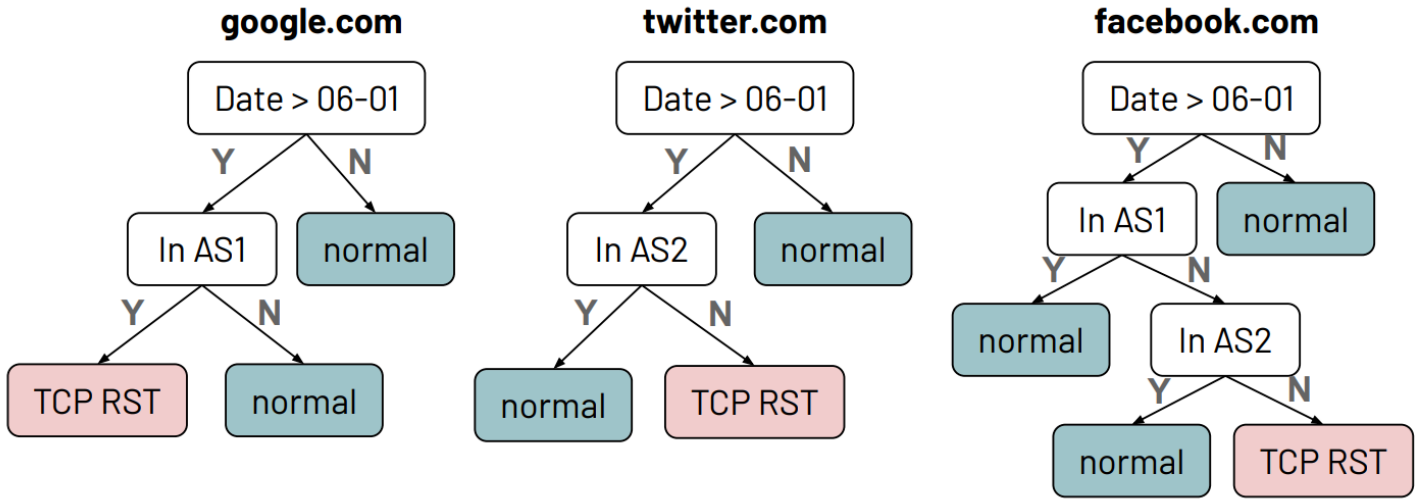

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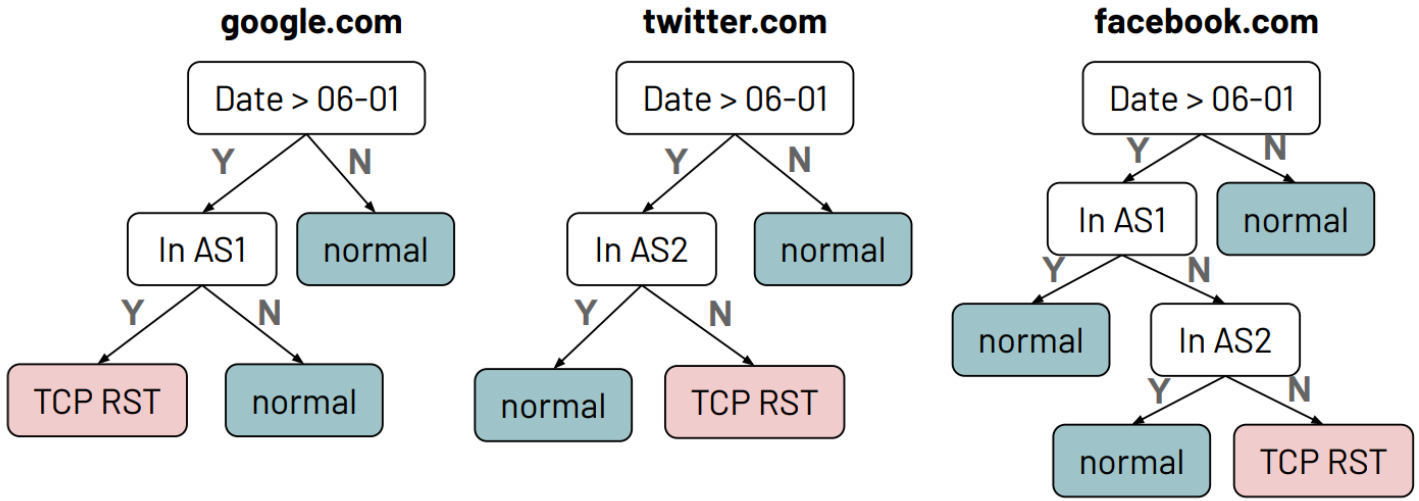

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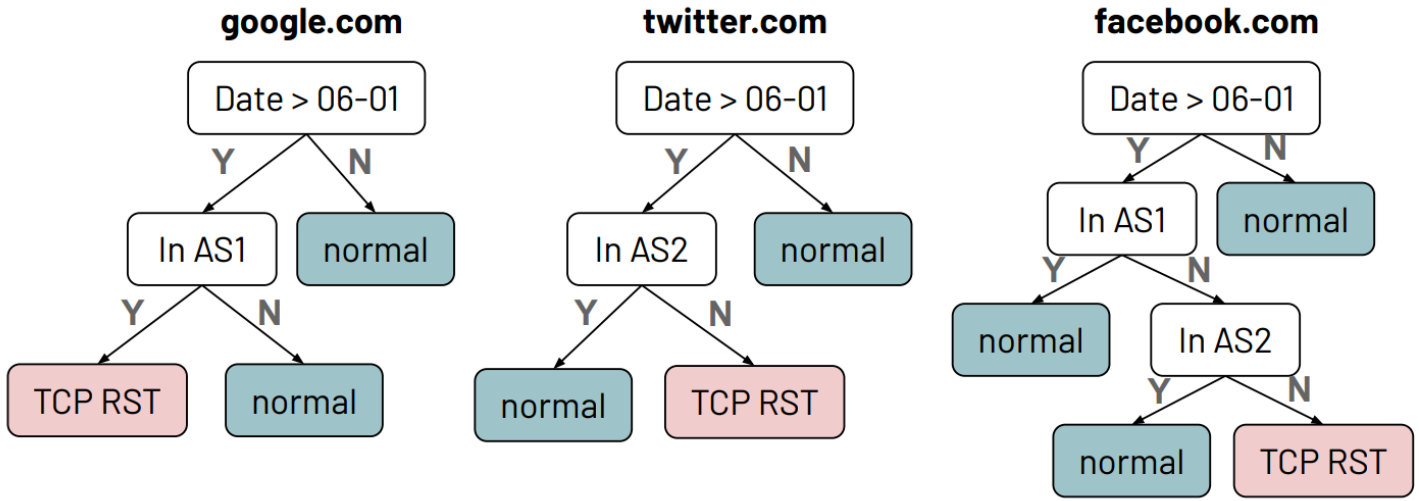

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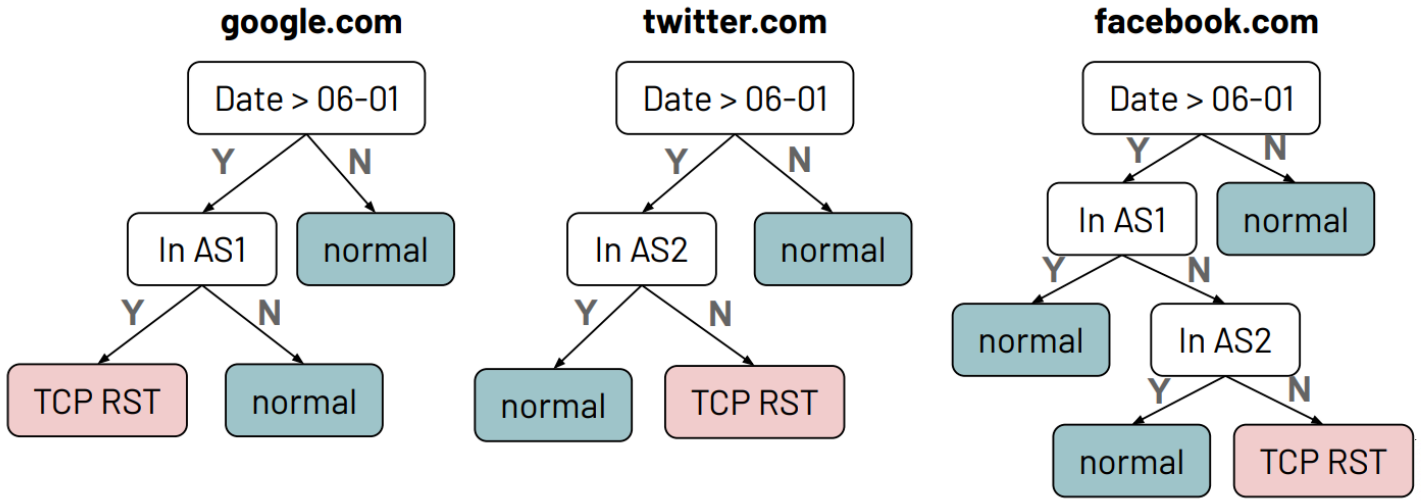

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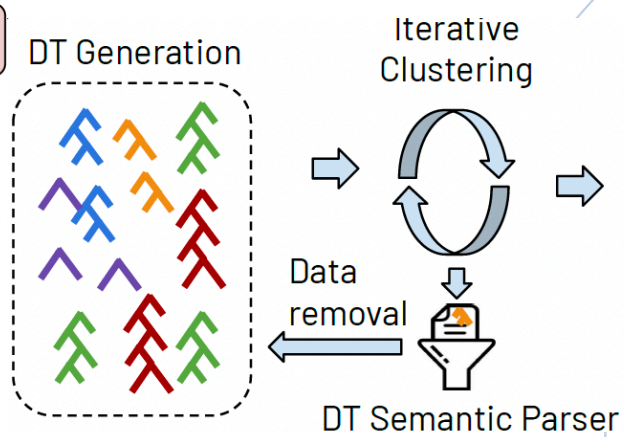

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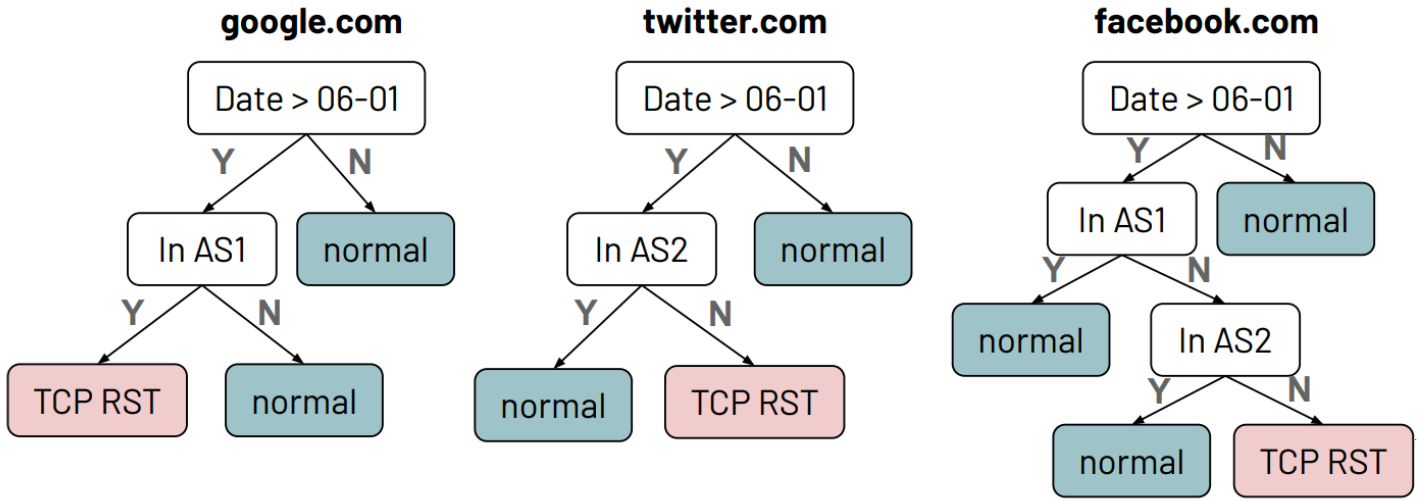

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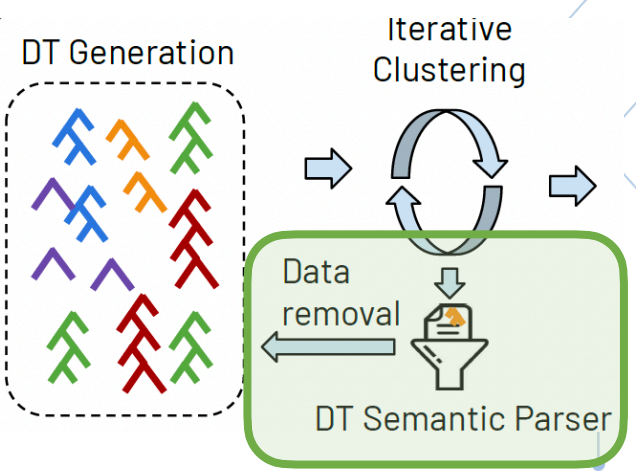

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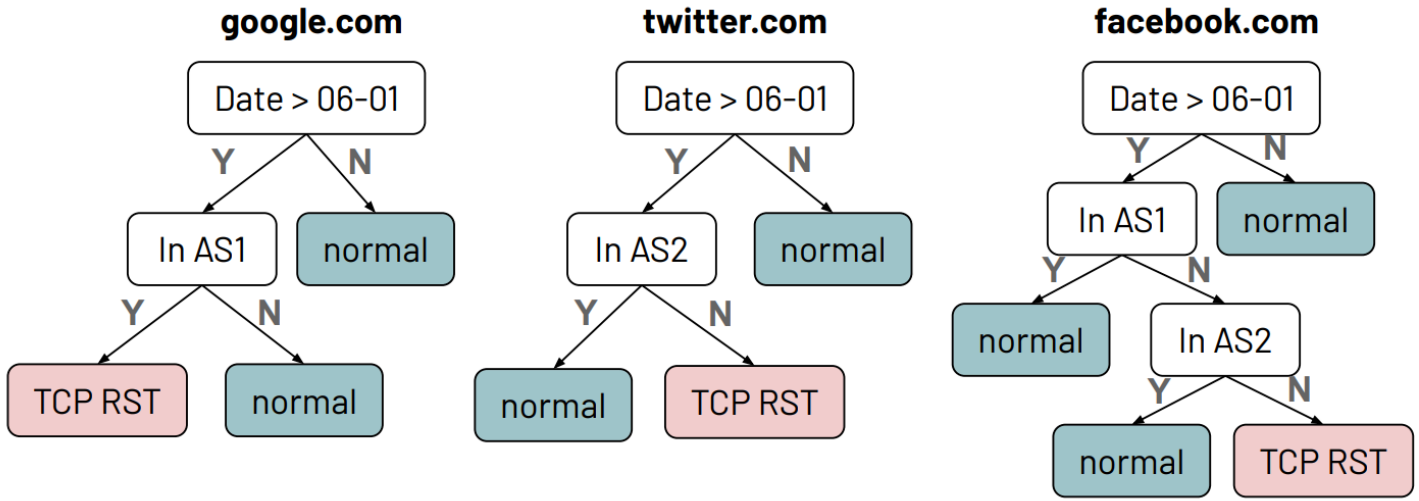

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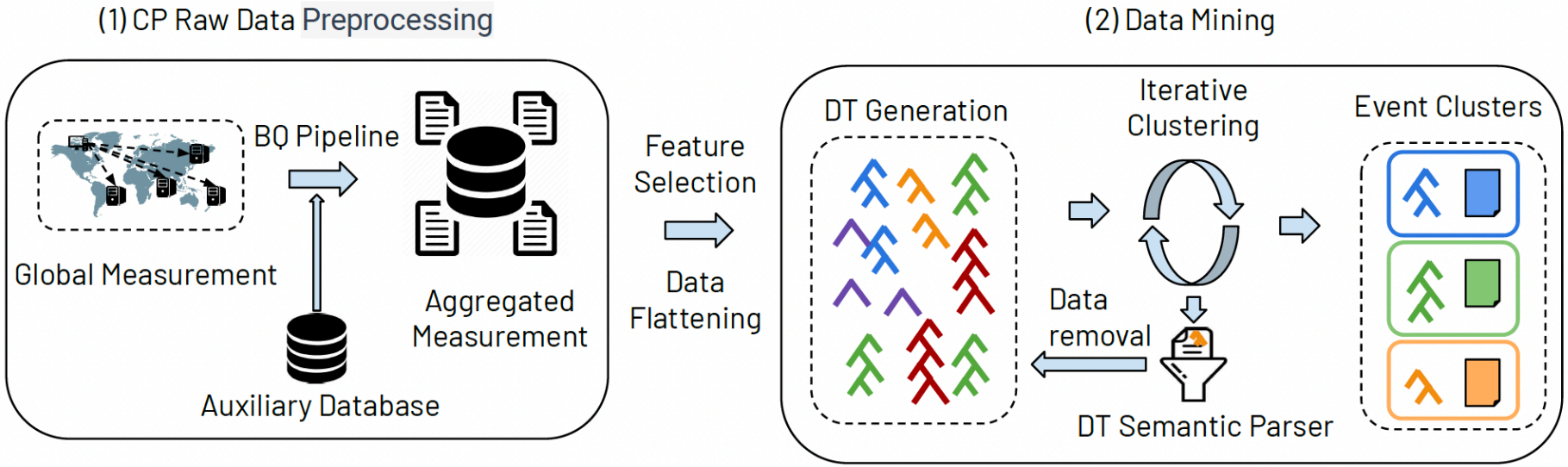

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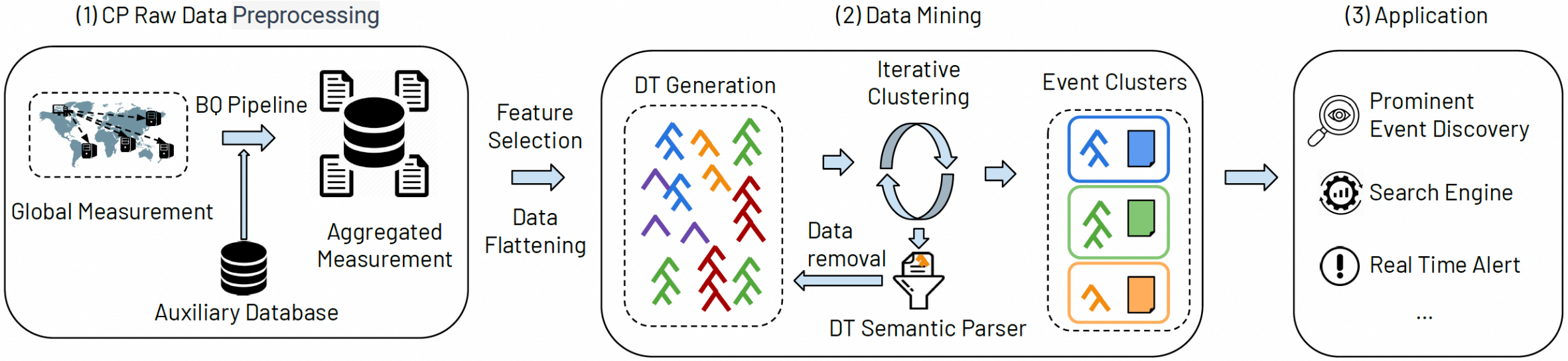

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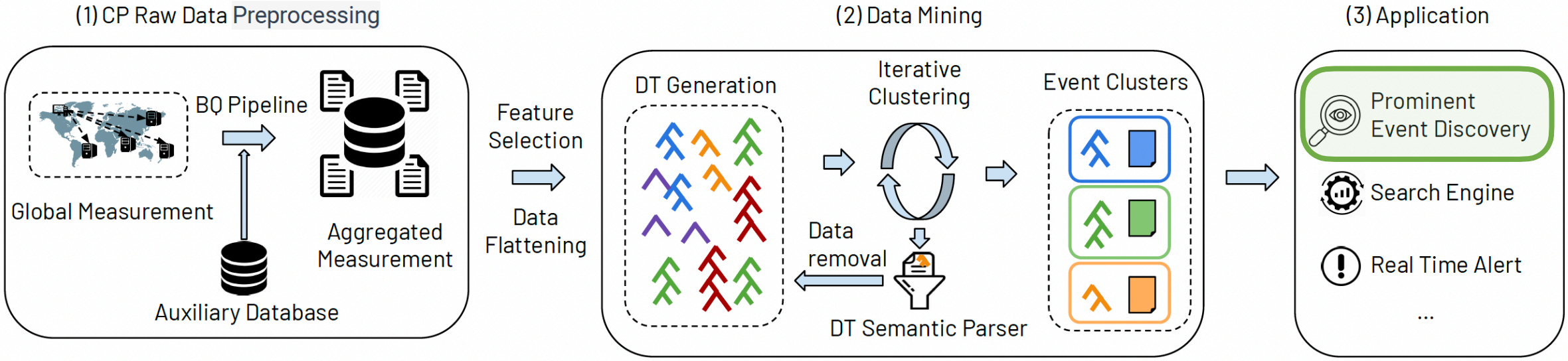

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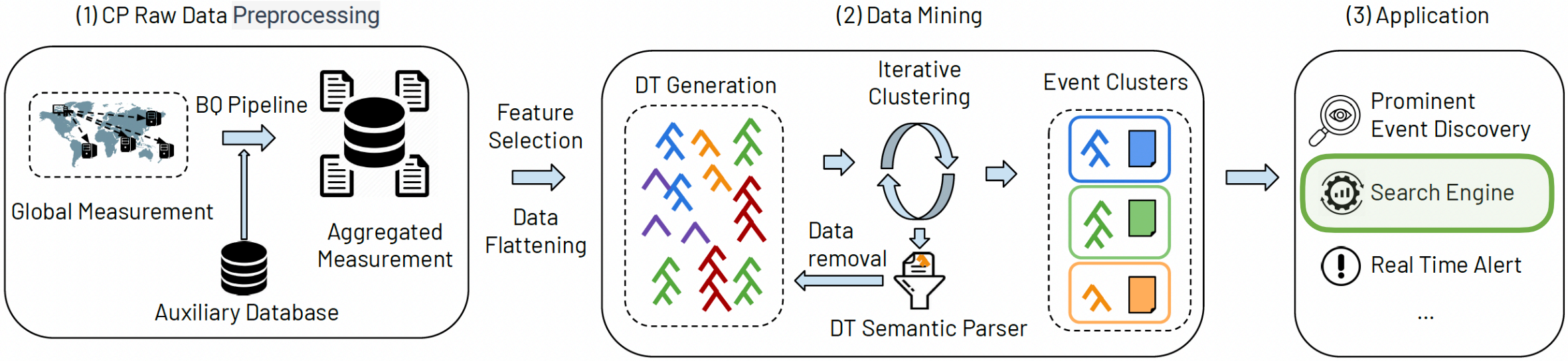

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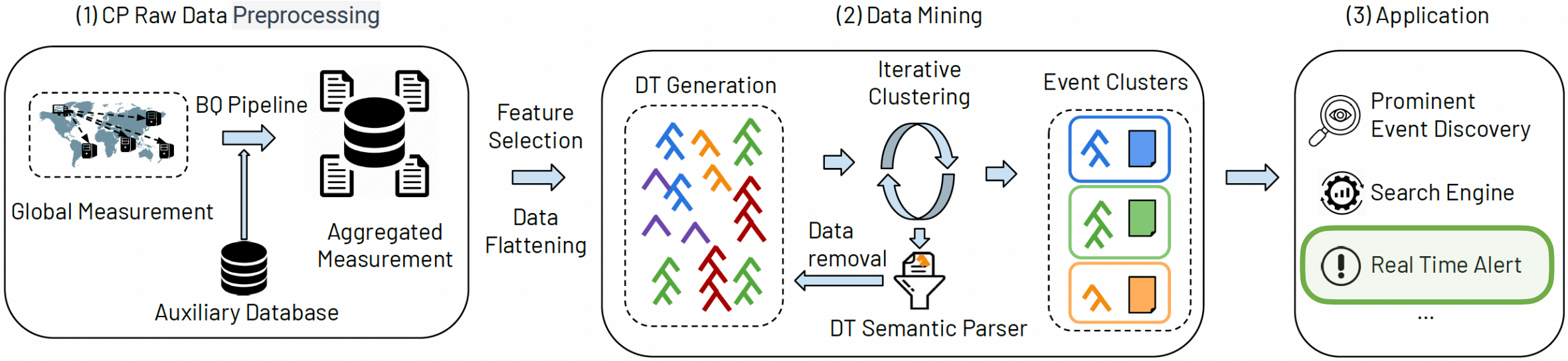

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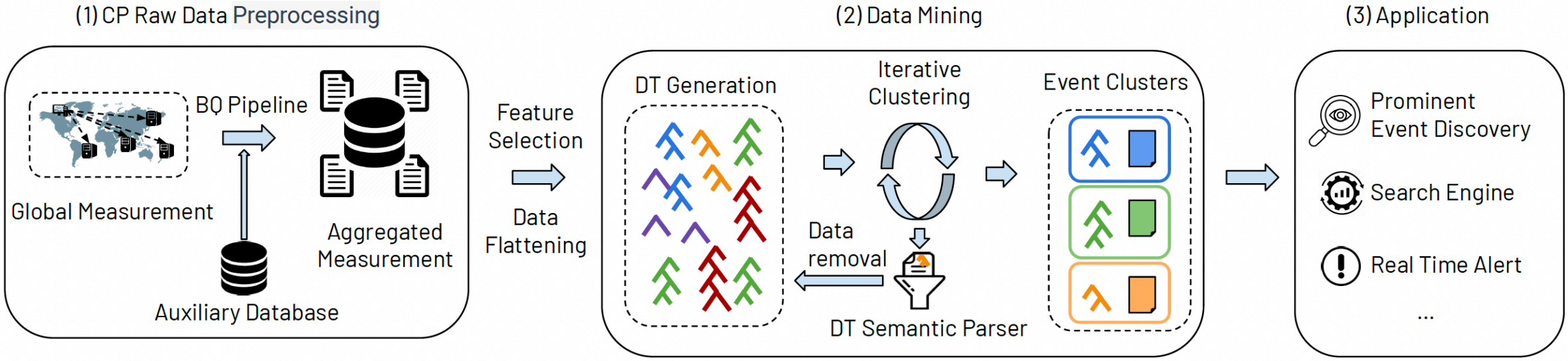

Prominent event discovery pipeline

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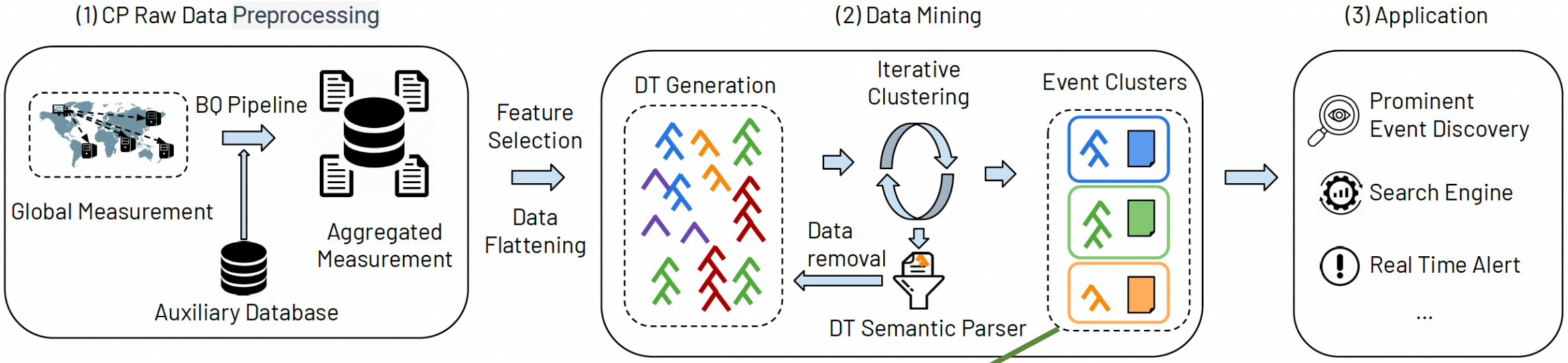

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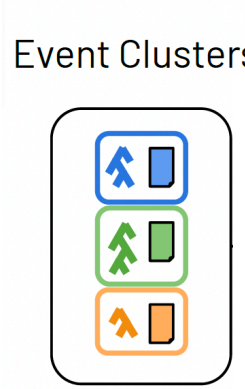

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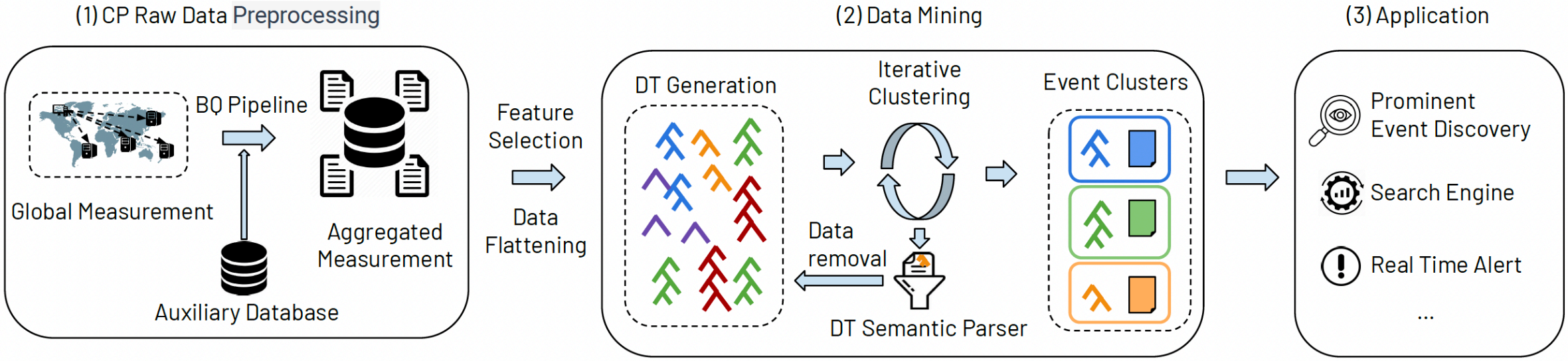

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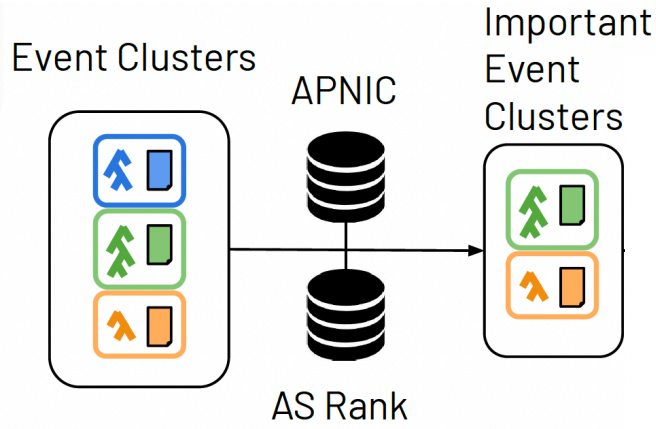

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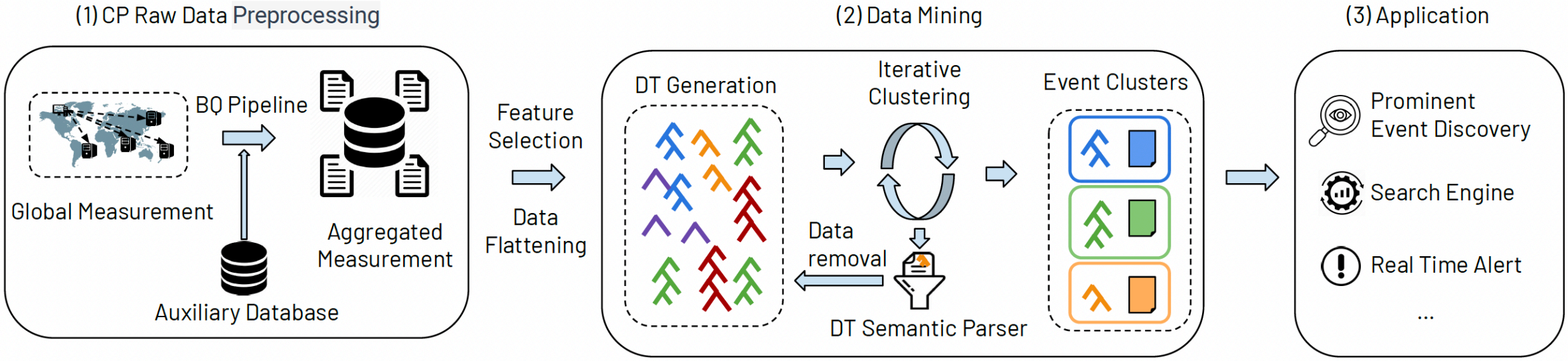

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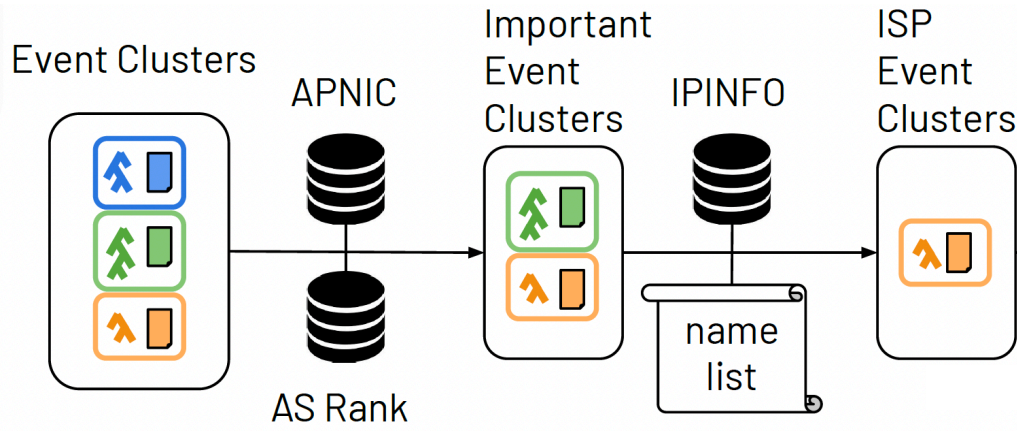

ISP blocking: detected within IPs owned by Internet Service Providers.

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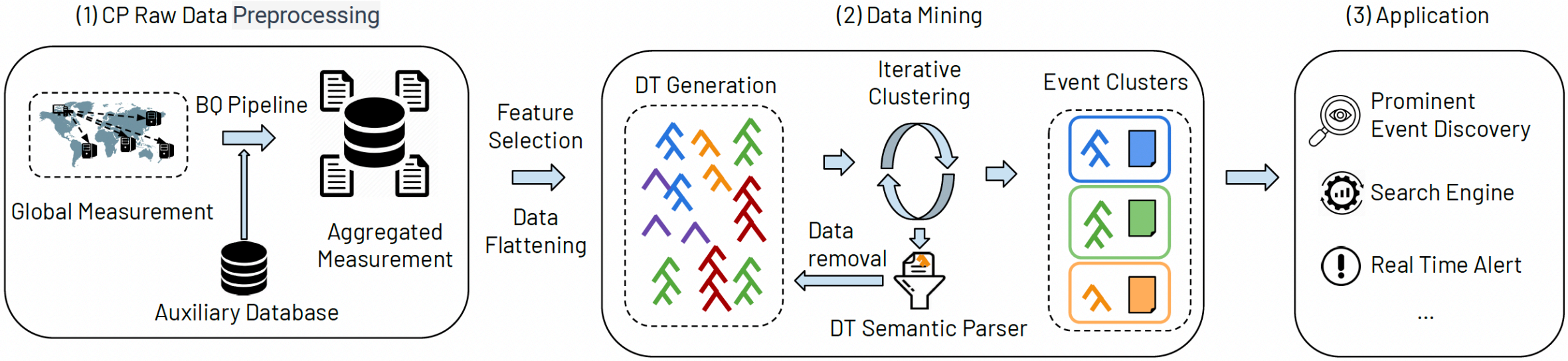

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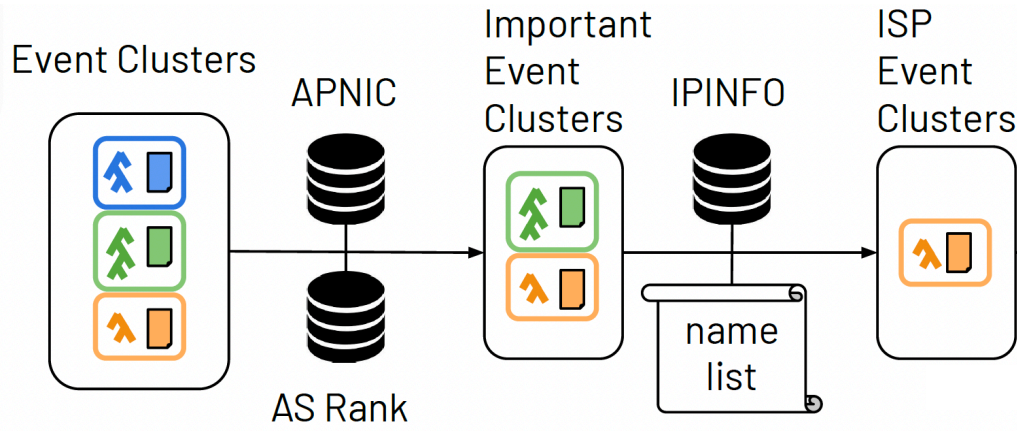

Organizational blocking: detected within corporations or educational institutions.

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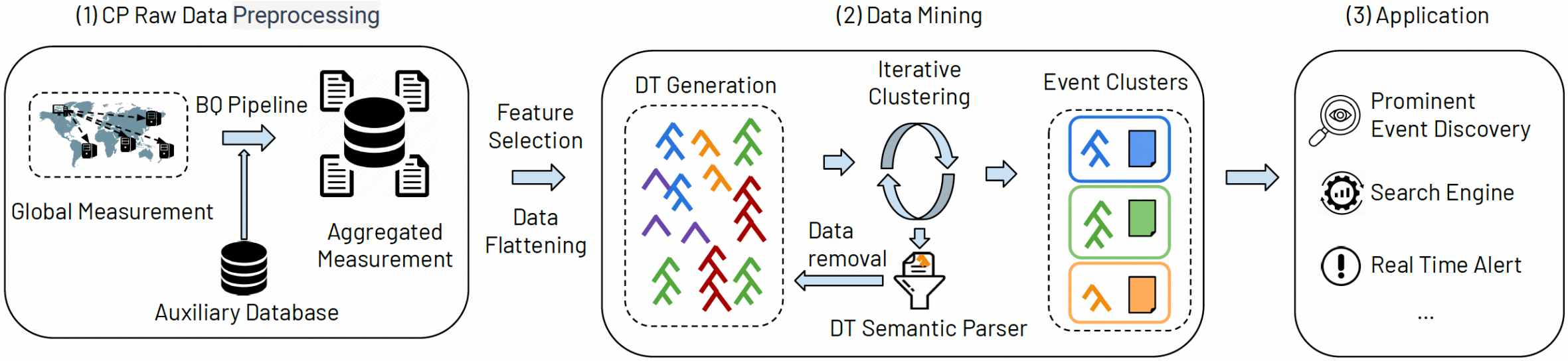

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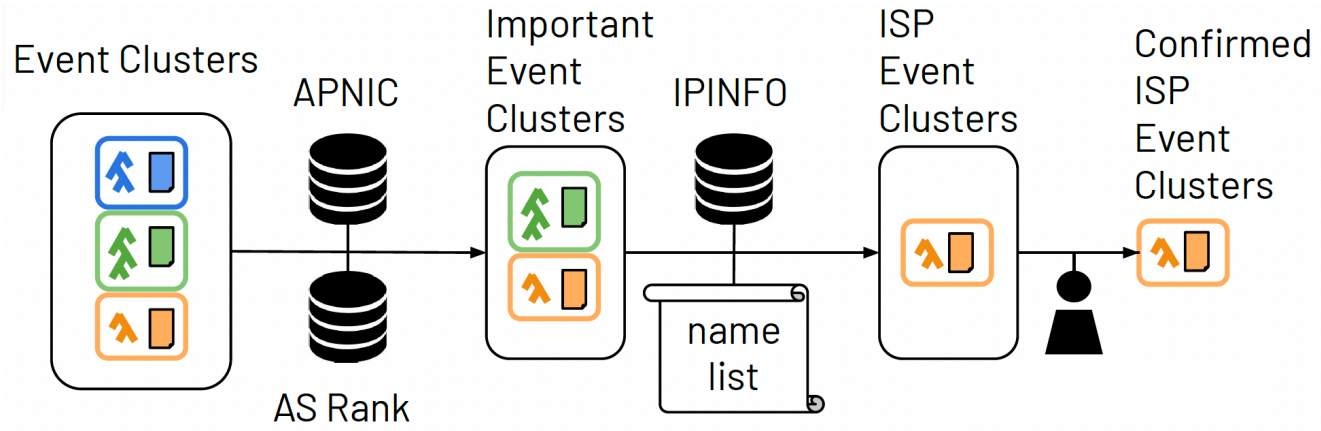

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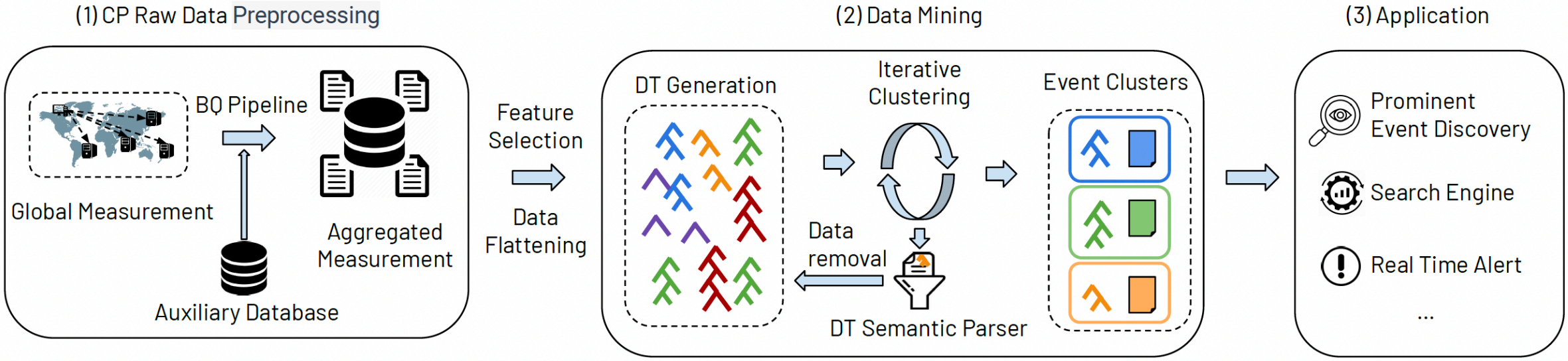

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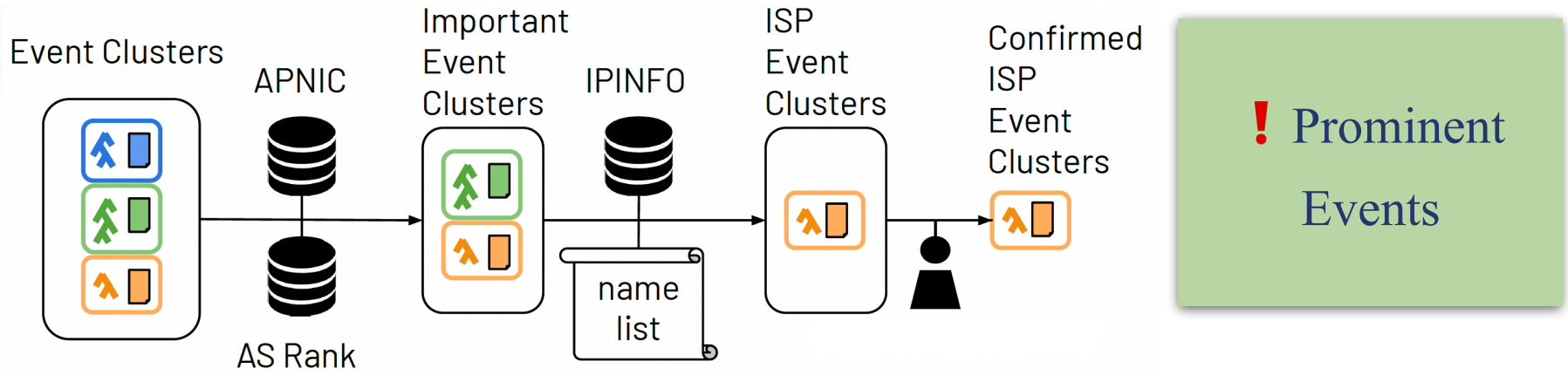

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- 1,166 DNS clusters in 77 countries in 4-month (Aug 2022 to Dec 2022).

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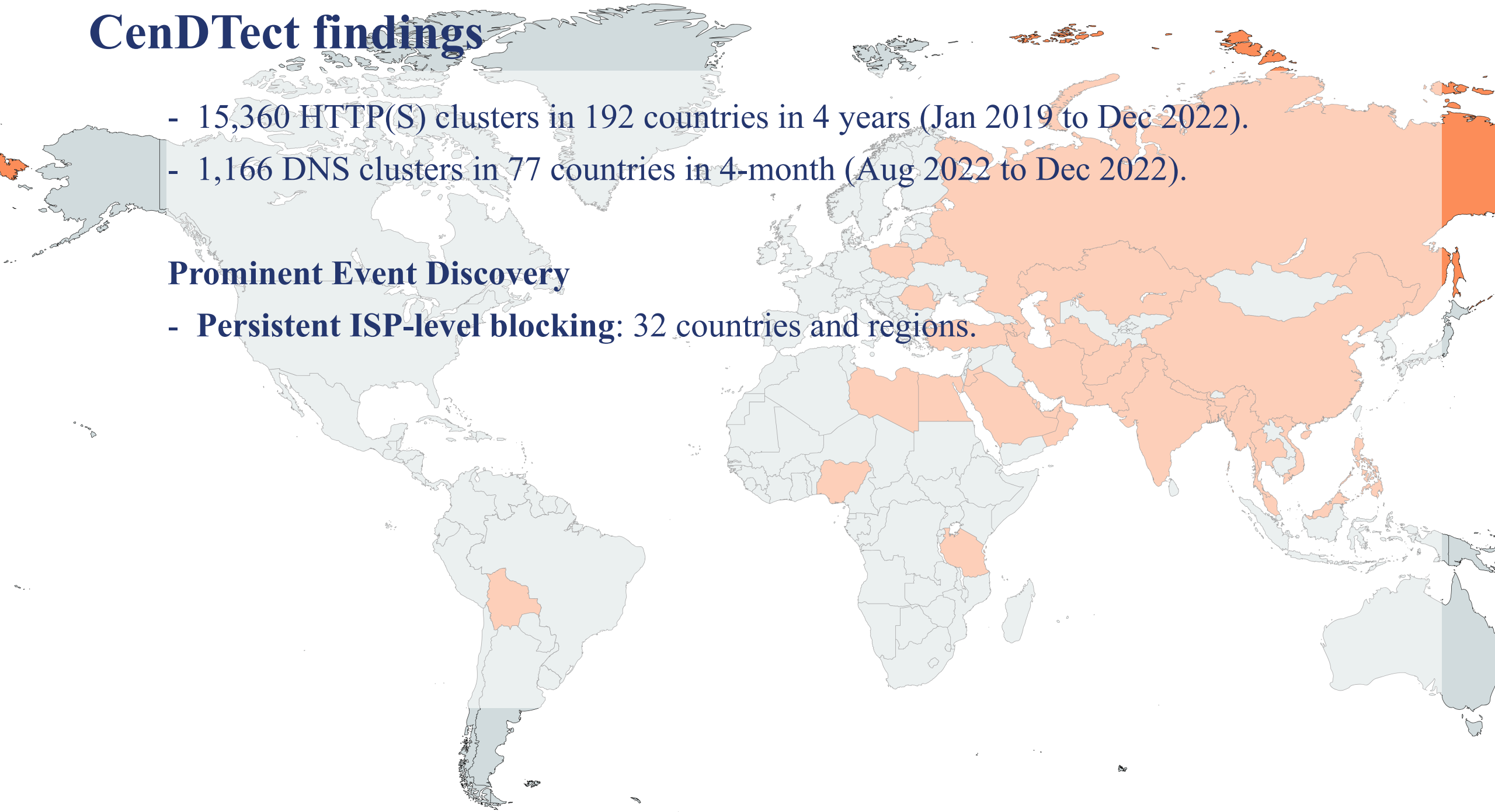

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  - Verified with research papers, independent studies, OONI data and news reports.
  - Confirmed well-documented countries.
  - Discovered 16 unreported countries.

  - 📖 Please refer to our paper for more details

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- **Temporal blocking**: 11 events from measurements in 2022.

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Venezuela	AS8048	8	ANON, NEWS, MEDIA	Feb	
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Sri Lanka	AS18001	7	SOCIAL, NEWS	Apr-May	Protect [30]
Estonia	AS3327 AS3249	5	NEWS, HUMANR, FILE	May	Russia War [29]
Zimbabwe	AS37204★	17	NEWS, GOV, HUMANR	May-June	
Uganda	AS20294	5	NEWS, HUMANR, FILE	July	
Burkina Faso	AS37721	7	NEWS, SOCIAL, ANON	Aug	
Zambia	AS36959★ AS37146	20	COMM,SOCIAL,ANON	Aug	Election [87]
Armenia	AS43733★ AS12297★	38	NEWS, COMM, ANON	Sep	Conflict [6]
Iran	AS42337★ *AS25184**	22	SOCIAL, ANON, BLOG	Sep-Oct	Protest [7]

Temporal blocking detected in HTTP(S) 2022 data.

Temporal blocking events

- Happened during periods of **election, political unrest, protest, and war.**

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Iran, September 2022:

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- Several DNS over HTTPS canary domains were blocked
  - doh.opendns.com
  - doh-fi.blahdns.com
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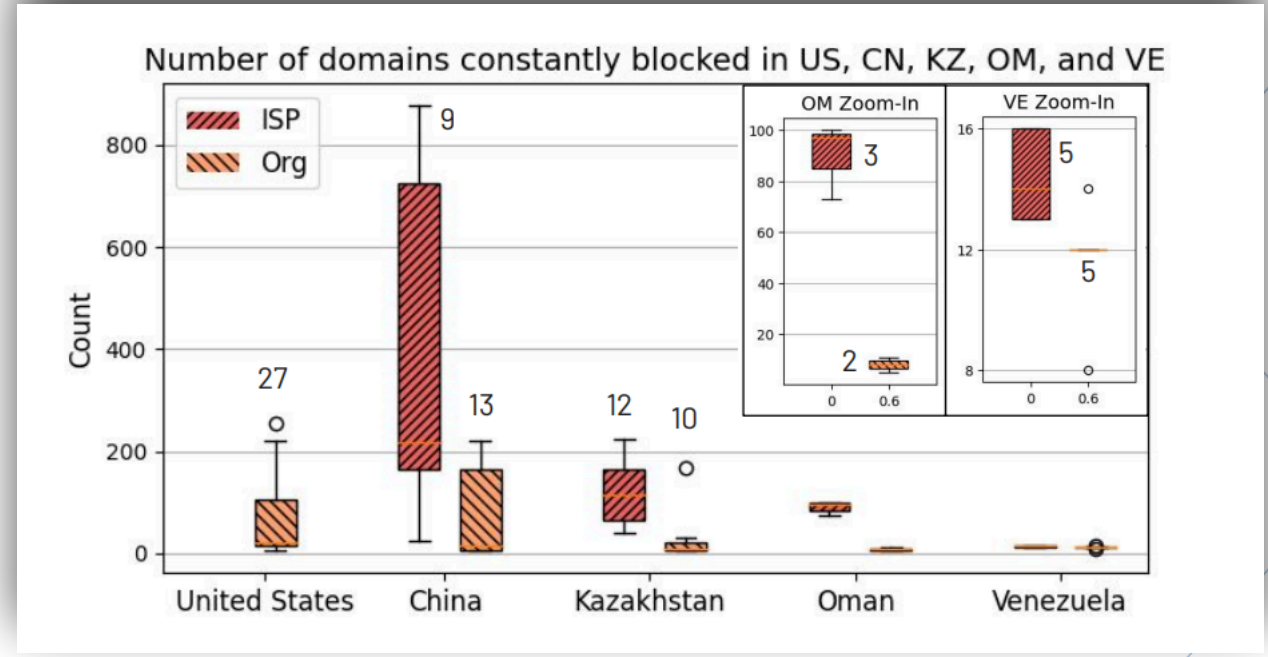
Venezuela	AS8048	8	ANON, NEWS, MEDIA	Feb	
Russia	AS28891 AS3216★ *AS60459**	77	NEWS, SOCIAL	Mar	War [6]
Sri Lanka	AS18001	7	SOCIAL, NEWS	Apr-May	Protect [30]
Estonia	AS3327 AS3249	5	NEWS, HUMANR, FILE	May	Russia War [29]
Zimbabwe	AS37204★	17	NEWS, GOV, HUMANR	May-June	
Uganda	AS20294	5	NEWS, HUMANR, FILE	July	
Burkina Faso	AS37721	7	NEWS, SOCIAL, ANON	Aug	
Zambia	AS36959★ AS37146	20	COMM,SOCIAL,ANON	Aug	Election [87]
Armenia	AS43733★ AS12297★	38	NEWS, COMM, ANON	Sep	Conflict [6]
Iran	AS42337★ *AS25184**	22	SOCIAL, ANON, BLOG	Sep-Oct	Protest [7]

Temporal blocking detected in HTTP(S) 2022 data.

Heterogeneous blocking within countries

- ⚠️ Many prior works report censorship based on the blocking ratio of the entire country/ASes.



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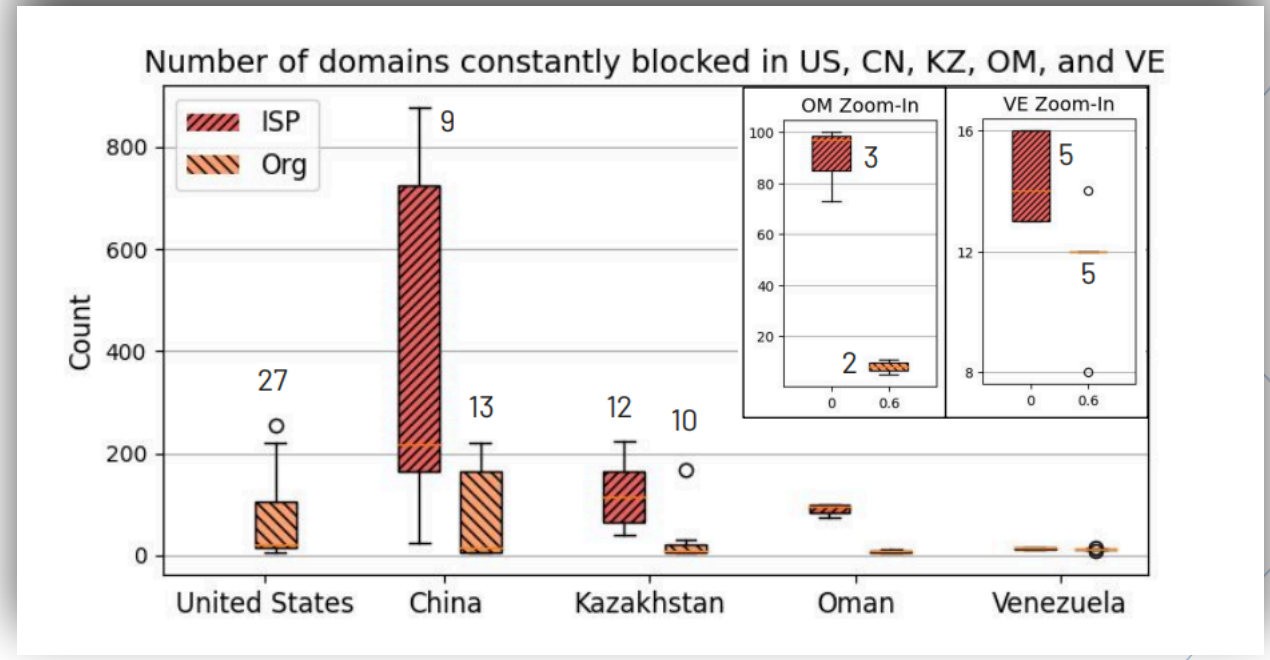

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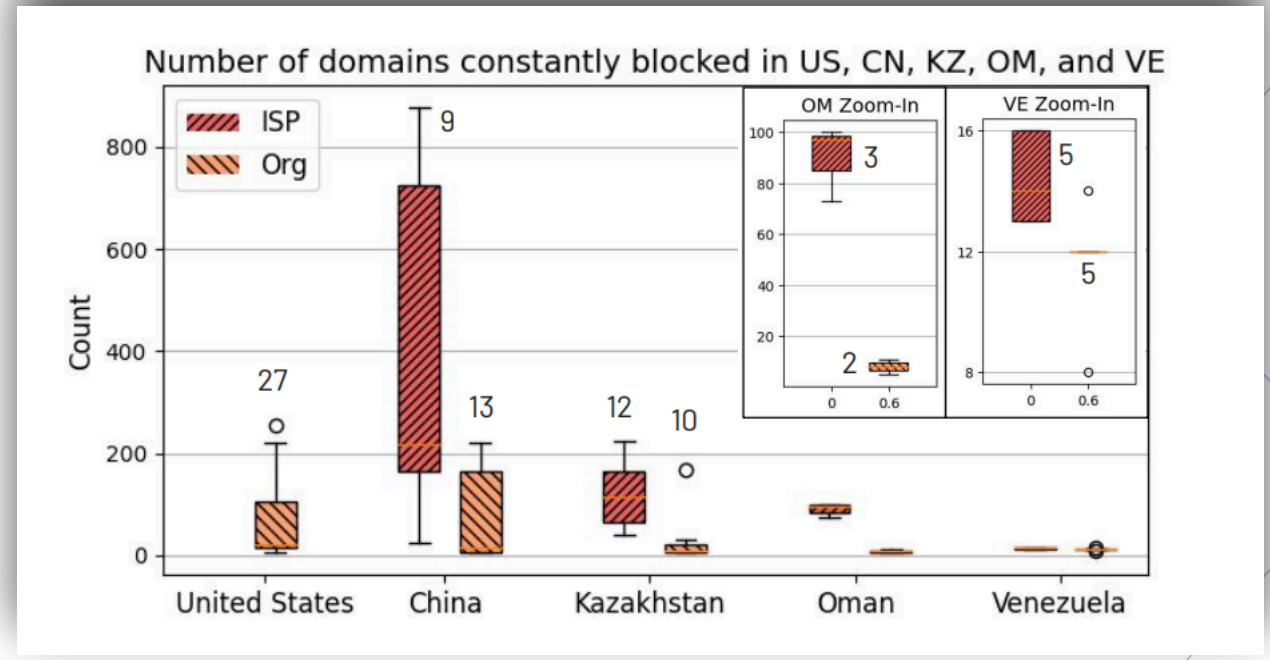
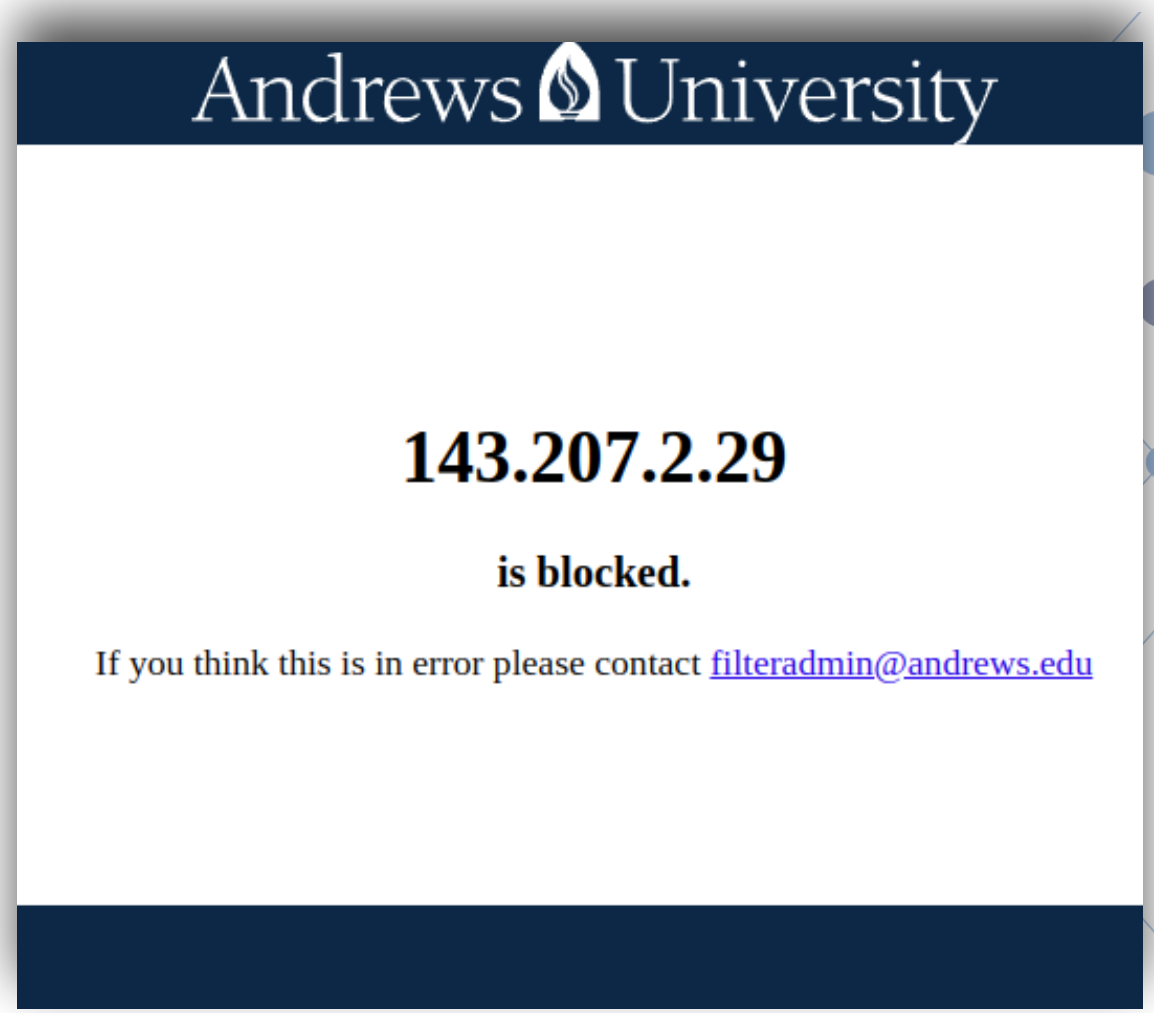


💡 Tips

- Recognize the diversity in blocking behavior within countries and Autonomous Systems (ASes) and avoid generalizations.

Organizational blocking in free countries

- **ISP blocking** and **organizational blocking** affect different population segments and have different impacts on global Internet censorship.



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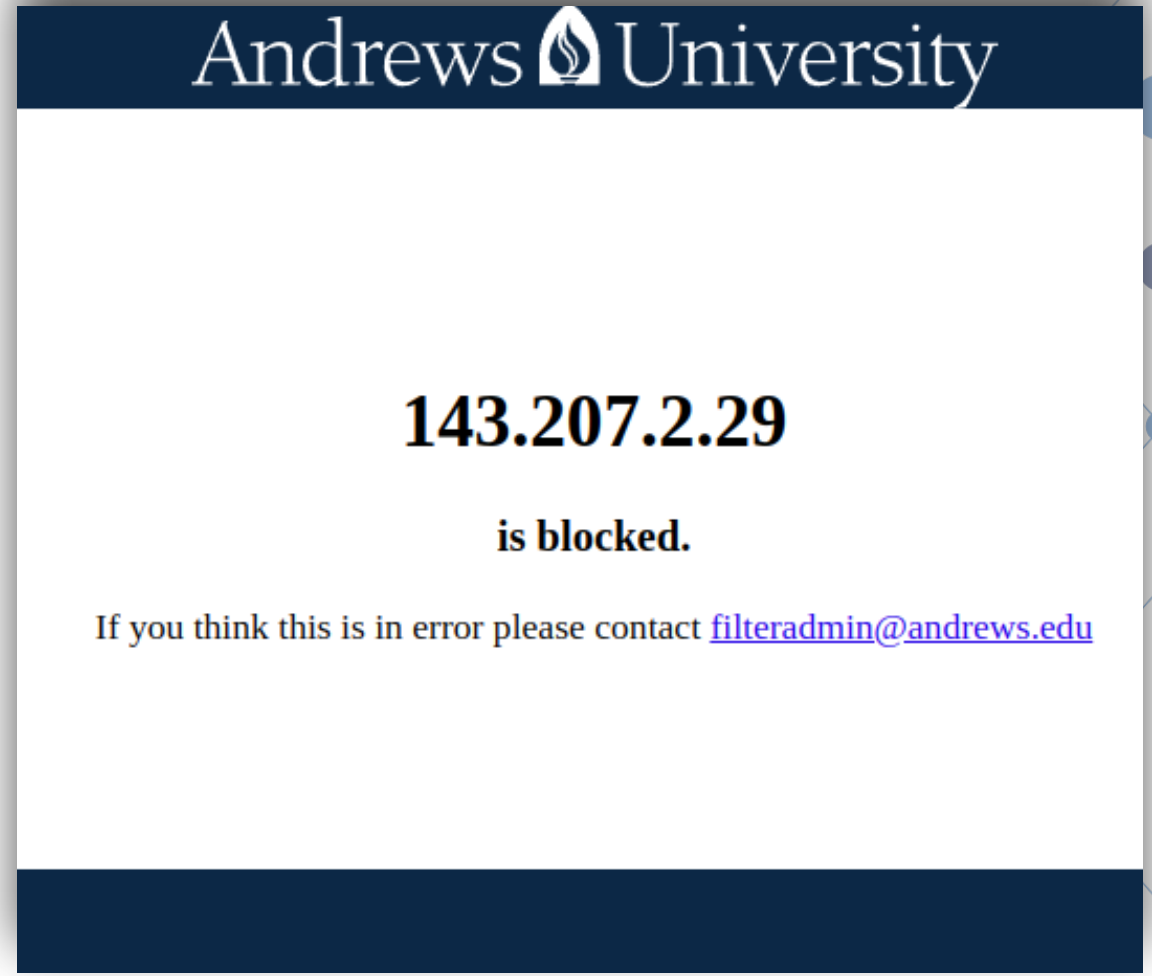
- Discovered 14 free countries with organizational blocking, such as the United States, Australia, Canada, and Japan.
  - In the United States alone, we identify 59 clusters for organizational blocking



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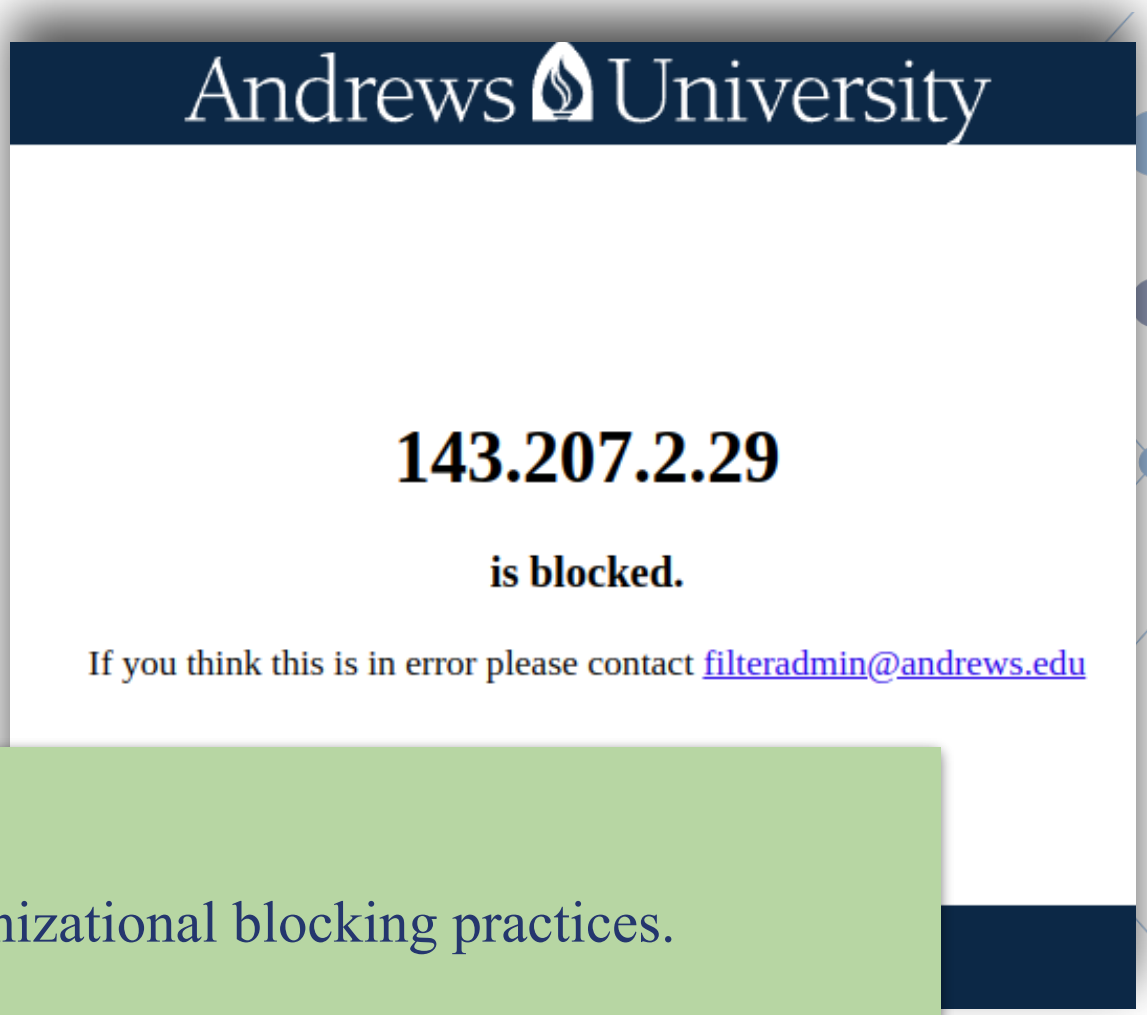

💡 Tips

- Differentiate between ISP and organizational blocking practices.

Contributions

CenDTect: an automated system for detecting Internet censorship events.

- 🌳 Decision trees
- 🔄 Iterative clustering

We report more than 100 ASes in 32 countries with persistent ISP blocking.

We identify 11 temporary blocking events in clusters discovered in 2022

Observed during periods of election, political unrest, protest, and war.

Our findings provide insights on

- 💡 The heterogeneity of blocking practices within countries.
- 💡 The importance of distinguish ISP blocking and organizational blocking

Thank you!