Censored Planet

TSPU: Russia's Decentralized Censorship System

Diwen Xue, Benjamin Mixon-Baca[+], ValdikSS*, Anna Ablove, Beau Kujath[+], Jedidiah R. Crandall[+], Roya Ensafi

University of Michigan, [+]ASU/Breakpointing Bad, *Independent

NEWS

The day the news died Here are all Russia's independent media outlets banned, blocked, or shuttered in just the past few days

12:49 am, March 5, 2022 · Source: Meduza

Russia blocks access to Facebook and Twitter

Russian Internet Takes a Hit as Cogent Cuts Off Its Backbone Network

A major internet service provider's disconnection is a new step toward the "splinternet" that adds fragmentation to the global communication network.

WIRED BACKCHANNEL BUSINESS CULTURE GEAR IDEAS SCIENCE SECURITY SIGN IN SUBSC

Russia's Internet Censorship Machine Is Going After Tor

The attempt to block the site, which helps users mask their online activity, is the latest in the country's efforts to control the internet.

Over 600 Companies Have Withdrawn from Russia—But Some Remain

April 14, 2022

Russia is blocking more and more VPNs

By Anthony Spadafora published 23 days ago

BBC, CNN and other global news outlets suspend reporting in Russia

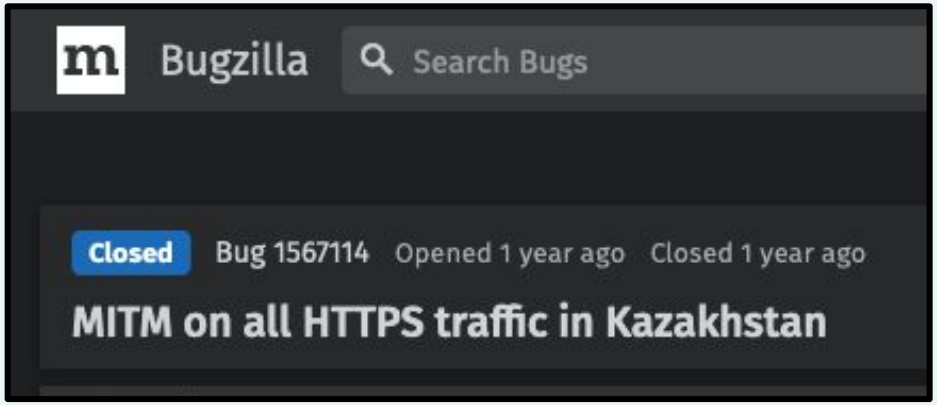
BBC's director-general says new Russian legislation 'appears to criminalise the process of independent journalism'

TikTok created an alternate universe just for Russia

The Chinese-owned social media giant weathered Putin's information crackdown by muzzling its users there and cutting them off from the outside world, while allowing state propaganda

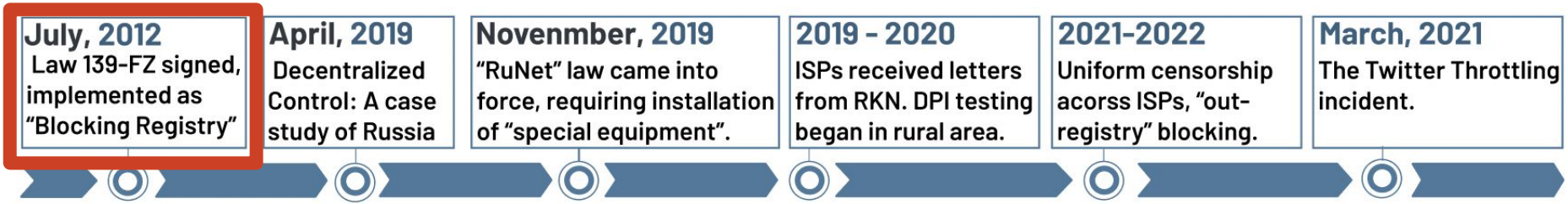
Internet Censorship

How Great is the Great Firewall?
Measuring China's DNS Censorship



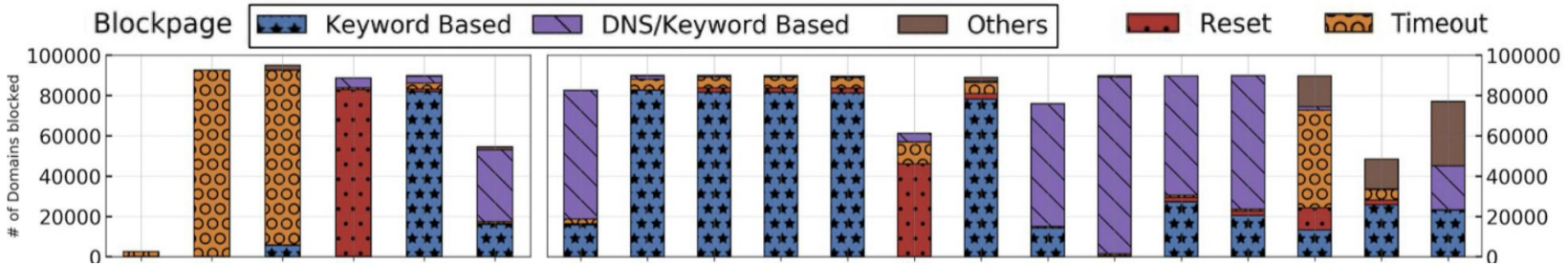
Censorship in Russia: 139-FZ

- 139-FZ “Blocklist Law” was signed in 2012.
- **Roskomnadzor,** federal agency on media and communication, maintains “the **Registry of Blocking Sites**”.
  - IP, subnets, domain names.
  - ISPs are required to block websites from the list.



Censorship in Russia: “Decentralized Control”

- Blocking Registry grows to 132K domains and 324K IP addresses (2019).
- Significant differences in both **types** and **amount** of blocking between ISPs.



July, 2012
Law 139-FZ signed, implemented as “Blocking Registry”

April, 2019
Decentralized Control: A case study of Russia

Novenmber, 2019
“RuNet” law came into force, requiring installation of “special equipment”.

2019 - 2020
ISPs received letters from RKN. DPI testing began in rural area.

2021-2022
Uniform censorship acorss ISPs, “out-registry” blocking.

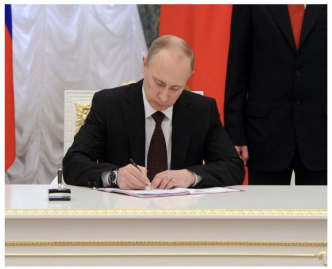
March, 2021
The Twitter Throttling incident.

[1] Decentralized Control: A Case Study of Russia NDSS'20

Censorship in Russia: RuNet

The President signed the law on sustainable Runet

Newsroom - 02.05.2019



Vladimir Putin signed on Wednesday the federal law "On Amendments to the Federal Law "On Communications" and the federal law "On Information, Information Technologies and Information Protection," Kremlin.ru reports .

This is the so-called law on the sustainability of the Runet, according to which a national Internet traffic routing system will be created in the country in order to ensure the reliable operation

- Appoints Roskomnadzor to guard the "stability, security, and integrity" of Russia's Internet.
- Provides legal grounds for the government to **require ISPs to install "special equipment".**

July, 2012
Law 139-FZ signed, implemented as "Blocking Registry"

April, 2019
Decentralized Control: A case study of Russia

Novenmber, 2019
"RuNet" law came into force, requiring installation of "special equipment".

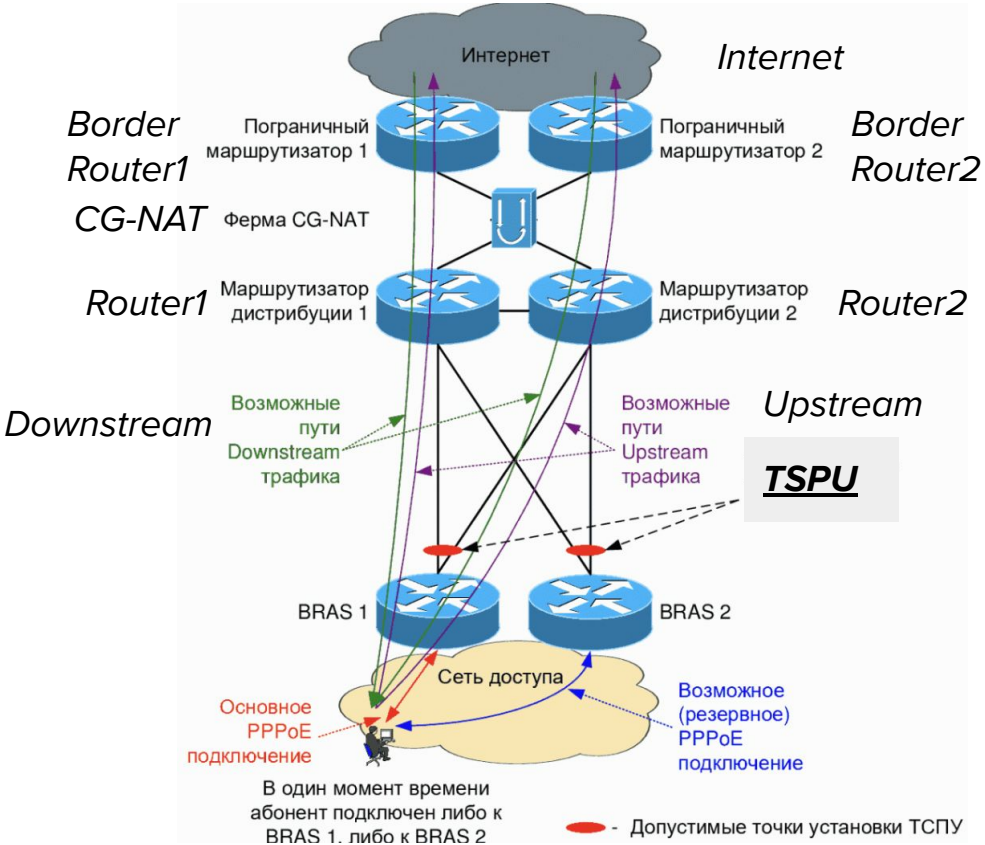
2019 - 2020
ISPs received letters from RKN. DPI testing began in rural area.

2021-2022
Uniform censorship acorss ISPs, "out-registry" blocking.

March, 2021
The Twitter Throttling incident.

Leaked Installation Guide on TSPU

https://habr.com/ru/post/459894/



July, 2012 Law 139-FZ signed, implemented as "Blocking Registry"

April, 2019 Decentralized Control: A case study of Russia

Novenmber, 2019 "RuNet" law came into force, requiring installation of "special equipment".

2019 - 2020 ISPs received letters from RKN. DPI testing began in rural area.

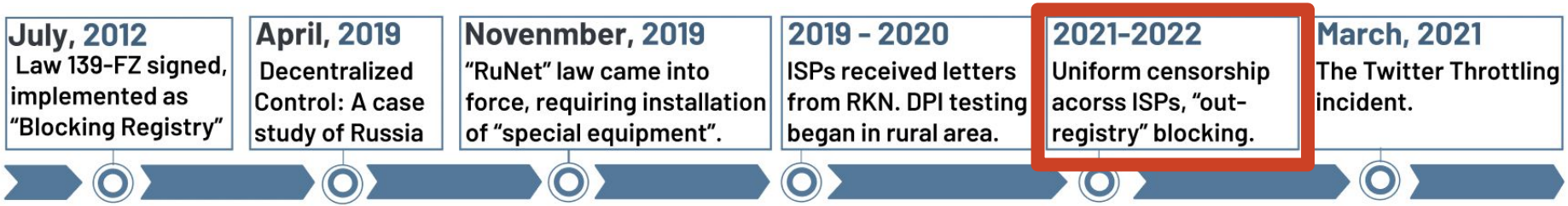
2021-2022 Uniform censorship acorss ISPs, "out-registry" blocking.

March, 2021 The Twitter Throttling incident.

Censorship in Russia: RuNet

- Users report on blocked resources that were *not* present in the blocking registry (**out-registry blocking**).

- Plus, measurement studies suggest **temporal and geographic uniformity.**



Censorship in Russia: Twitter Throttling

A new system was put into use!

- **Identical throttling behaviors** were observed from vantage points across ISPs.
- Parliament member acknowledged that new DPI devices had been installed in major ISPs, which were used for throttling.

July, 2012 Law 139-FZ signed, implemented as "Blocking Registry"

April, 2019 Decentralized Control: A case study of Russia

Novenmber, 2019 "RuNet" law came into force, requiring installation of "special equipment".

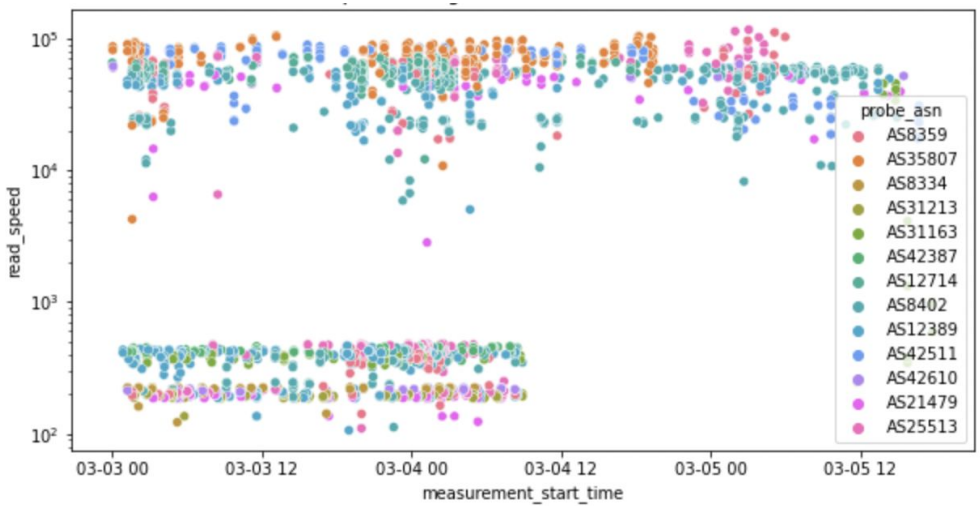
2019 - 2020 ISPs received letters from RKN. DPI testing began in rural area.

2021-2022 Uniform censorship acorss ISPs, "out-registry" blocking.

March, 2021 The Twitter Throttling incident.

[1] Throttling Twitter: An Emerging Censorship Technique in Russia. IMC '21

Censorship in Russia: Twitter Throttling



July, 2012
Law 139-FZ signed, implemented as "Blocking Registry"

April, 2019
Decentralized Control: A case study of Russia

Novenmber, 2019
"RuNet" law came into force, requiring installation of "special equipment".

2019 - 2020
ISPs received letters from RKN. DPI testing began in rural area.

2021-2022
Uniform censorship acorss ISPs, "out-registry" blocking.

March, 2021
The Twitter Throttling incident.

https://ooni.org/post/2022-russia-blocks-amid-ru-ua-conflict/

These events…

➔ marked a **departure from Russia's previous censorship model**.

➔ suggest the deployment of an emerging system that **enforces censorship uniformly across Russia** in real-time, without relying on ISP's technical capabilities or blocking registry.

➔ But very little is known about its **design**, **capability**, or **the extent of its deployment**.

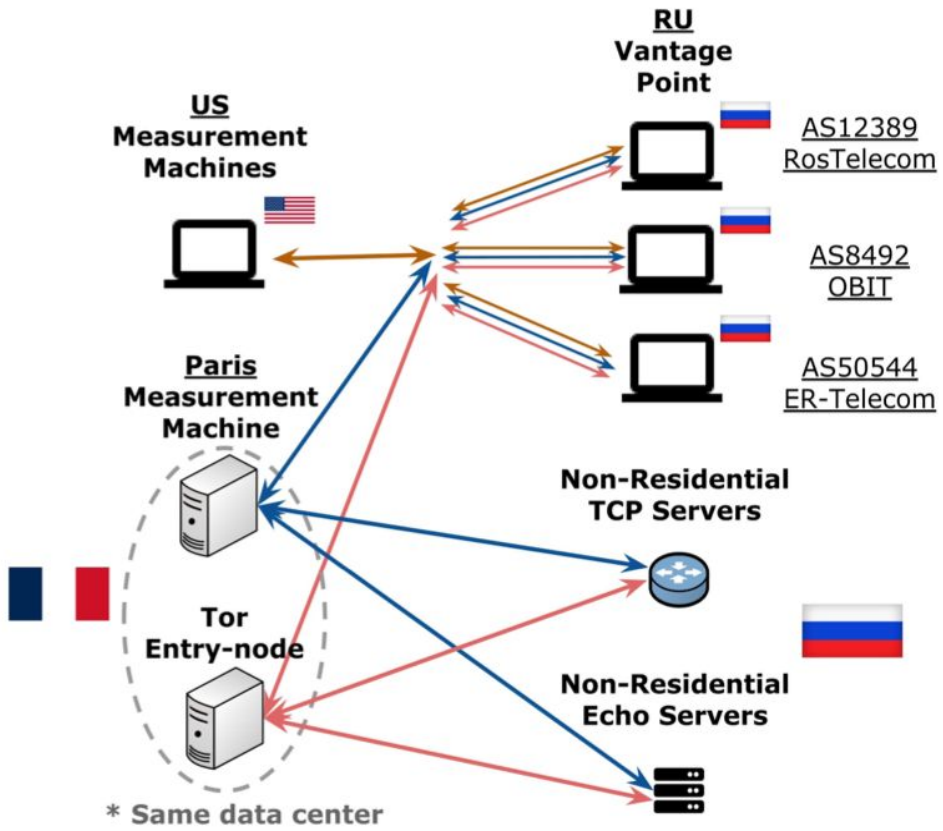
➔ A better understanding of the TSPU is needed, as the model can be adopted by other countries with similar networks.

TSPU

технические средства противодействия угрозам

(Technical Measures to Combat Threats)

Centrally controlled by RKN, Decentrally deployed in ISP networks.



Measurement Setup & Challenges

A. Acquiring Vantage Points.

B. Distinguishing TSPU and ISP Censorship.

C. Adopting remote measurements due to the asymmetricity of TSPU censorship.

Understanding TSPU

1. ***How:*** Discover how TSPU tracks and blocks a connection.

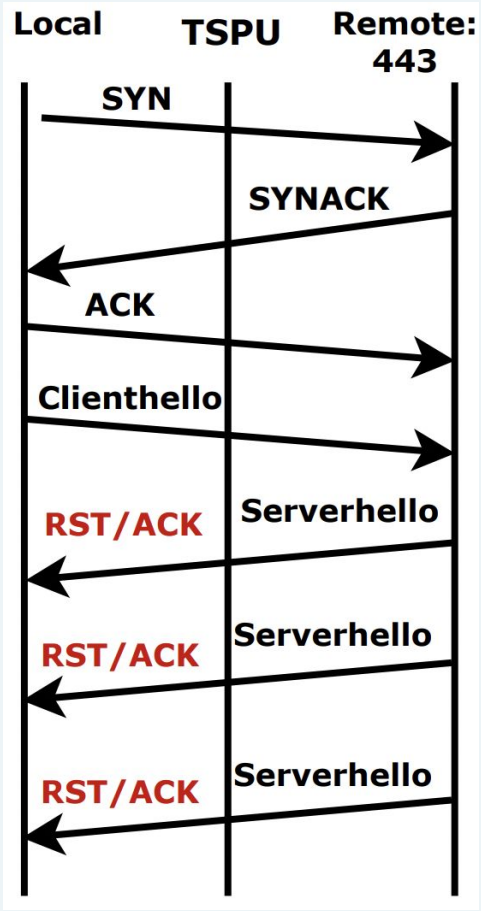
2. ***What:*** Identify what resources are targeted by TSPU.

3. ***Where:*** Detect and Position TSPU devices w.r.t Russian users.

Identify TSPU Blocking: QUIC, IP, SNI-based

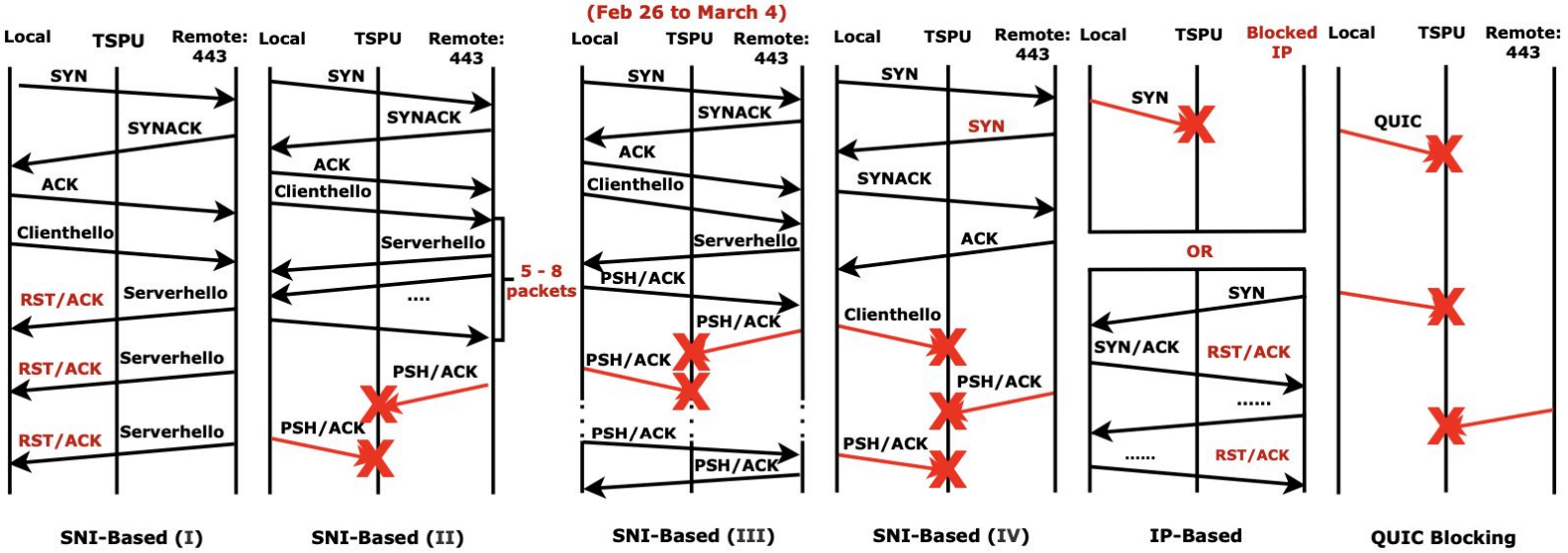
- Uniformity in blocking behaviors across ISPs.
- Consistency in blocking targets across ISPs.
- Co-location of different TSPU blocking mechanisms.

Example: SNI-based Blocking



TSPU Blocking: In-path

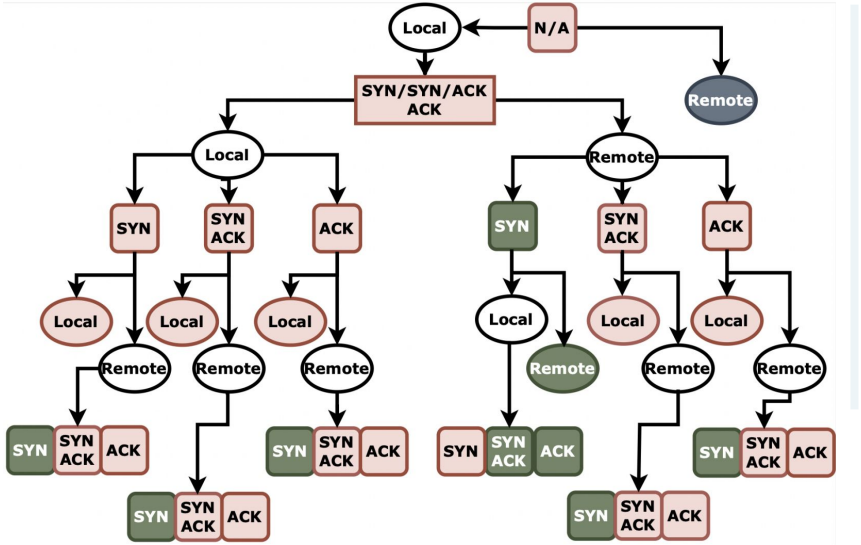
- **In-path** devices as TSPU modifies or drops packets to block connections.



➔ Each blocking mechanism requires either dropping or modifying packets, suggesting **in-path** positions.

➔ Being **in-path**, TSPU has more means to interfere with users' traffic, compared to on-path systems (e.g., GFW)

TSPU Blocking: Stateful



- Censorship Triggers.
- Degree of Statefulness
- State Timeouts
- Triggering Reliability

→ Refer to the paper

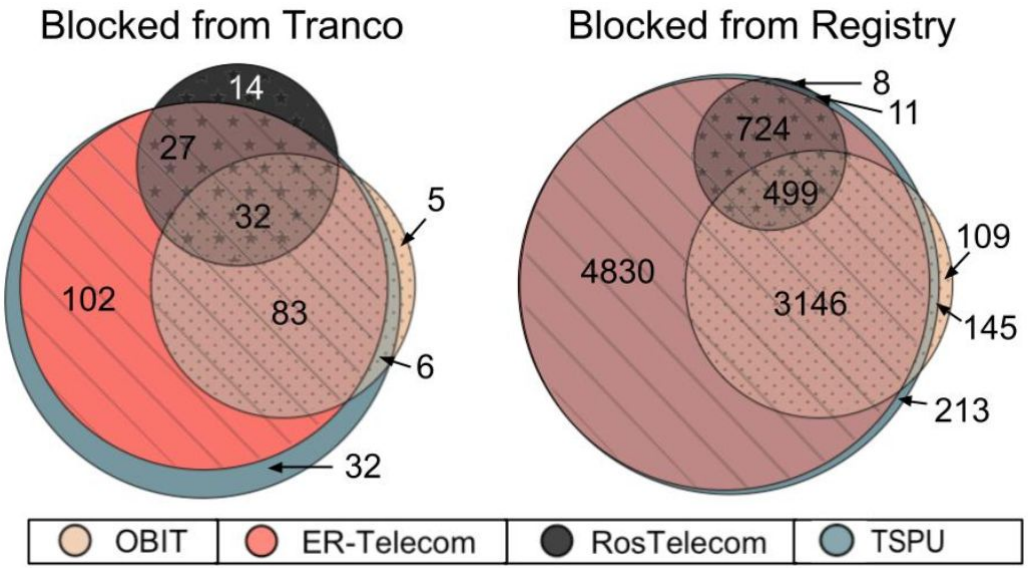
Understanding TSPU

1. ***How:*** Discover how TSPU tracks and blocks a connection.

2. ***What:*** Identify what resources are targeted by TSPU.

3. ***Where:*** Detect and Position TSPU devices w.r.t Russian users.

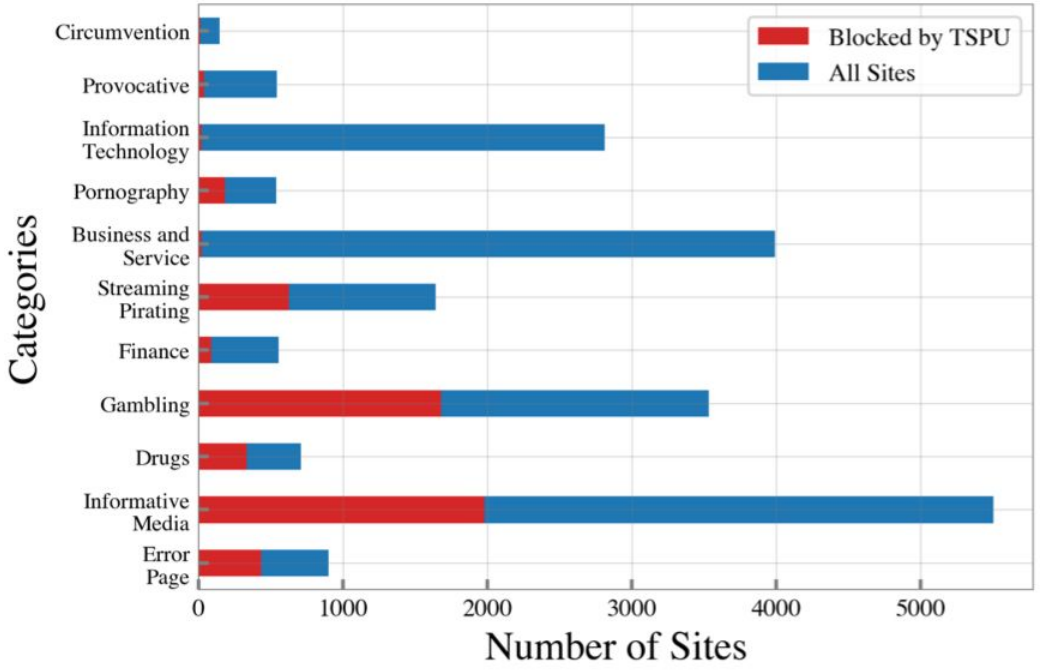
What **Does TSPU Block?**



Domain lists for testing

- **Tranco List:**
  - 10,000 Top domains.
  - Augmented with *Citizen Lab Global Blocklist*
- **Registry List:**
  - 10,000 domains from *Blocking Registry*.
  - Sampled from domains added after Jan 1, 2022

What **Does TSPU Block?**



Classifying Blocked Domains (n=9866)

- **Topic modeling by clustering received HTMLs from control.**
- **“Informative media” are heavily targeted.**
  - Blogs, news, social media

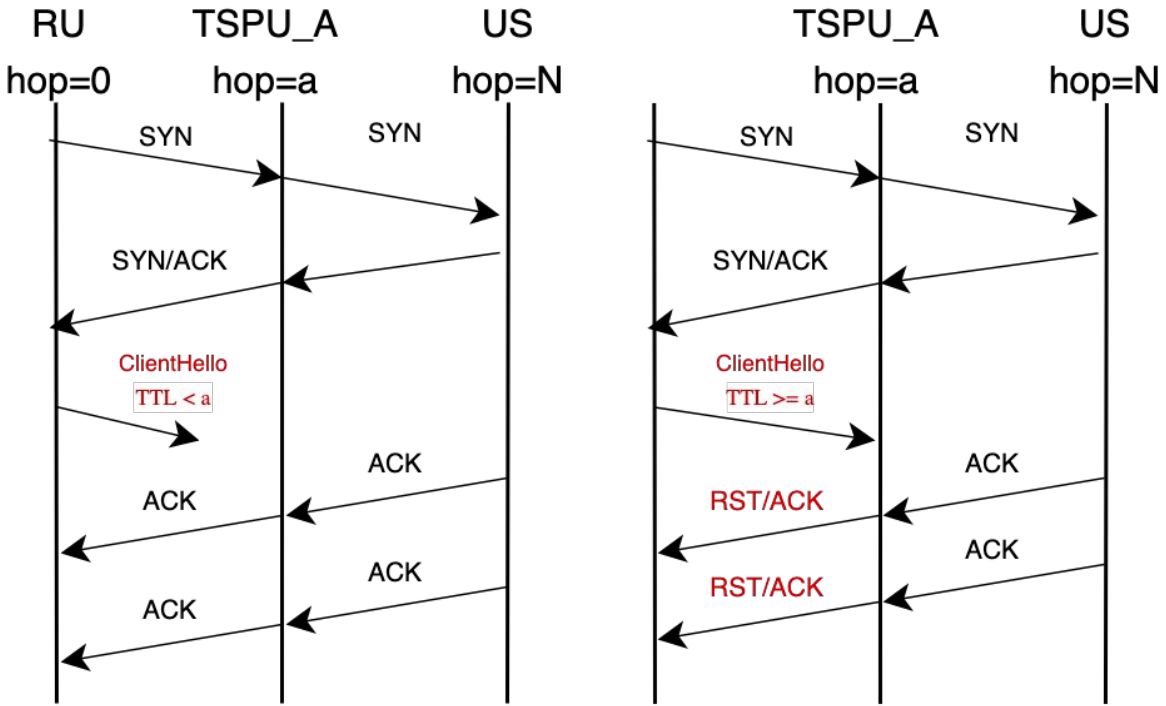
Understanding TSPU

1. ***How:*** Discover how TSPU tracks and blocks a connection.

2. ***What:*** Identify what resources are targeted by TSPU.

3. ***Where:*** Detect and Position TSPU devices w.r.t Russian users.

Local TTL Measurement



TSPUs are close to end-users.

Detect & Locate TSPU

Local Measurement

TTL-based measurements from in-country vantage points.

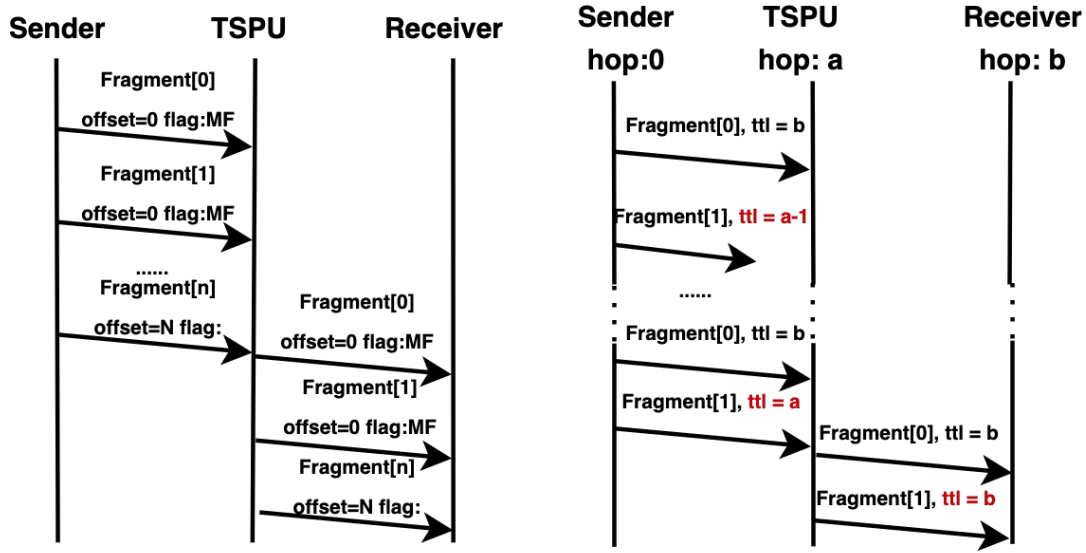
- Limited scale

Remote Measurement

Problem: TSPU censorship is not symmetric (RU→US only)

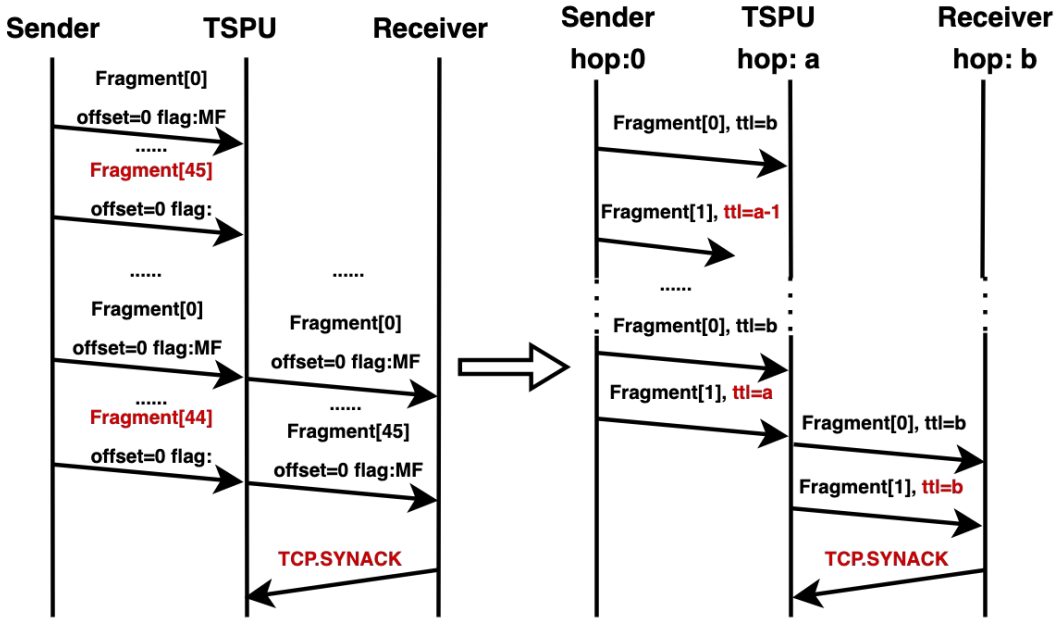
- **ECHO + Asymmetric Routing**
  - (refer to the paper)
- **IP Fragmentation Characteristics**

TSPU: IP Fragmentation Behaviors



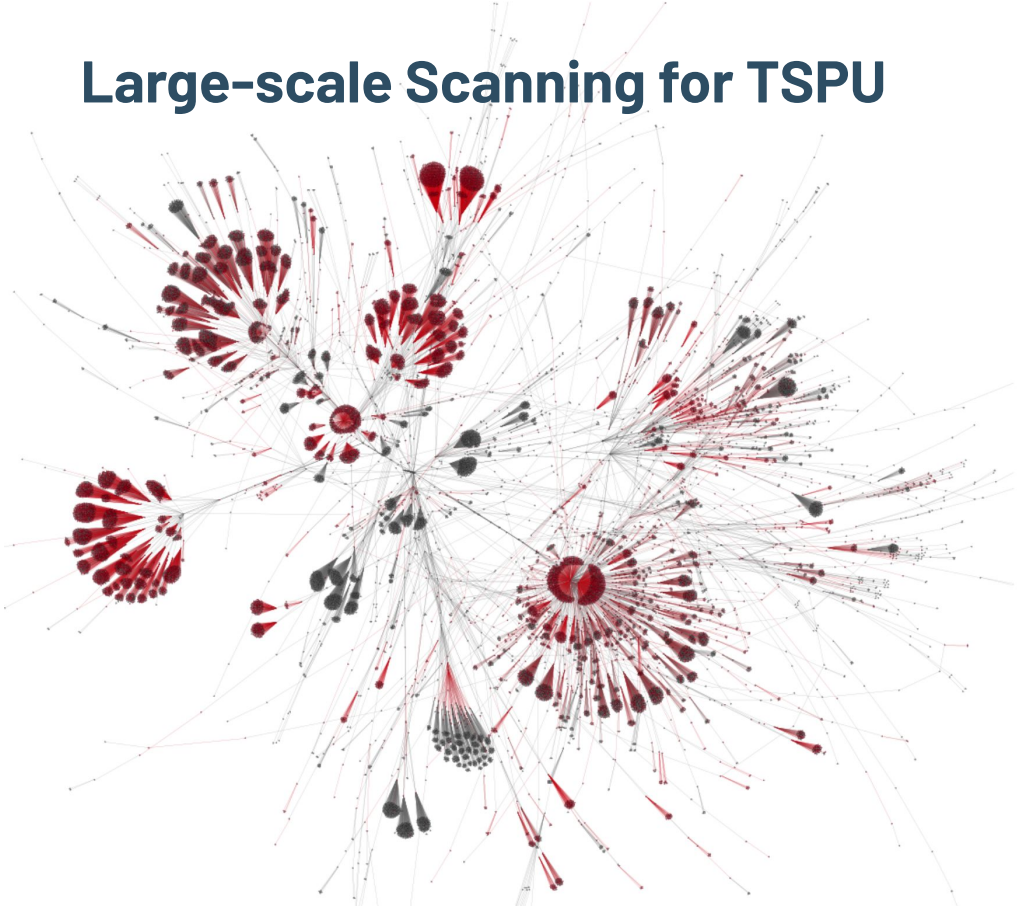
- How TSPU handles fragmentation
  - Buffers fragments
  - Forward Individually
  - Overwrite TTL (Time-To-Live)
  - Drop Duplicates (non-RFC)
  - Maximum 45 fragments.

TSPU: IP Fragmentation Behaviors



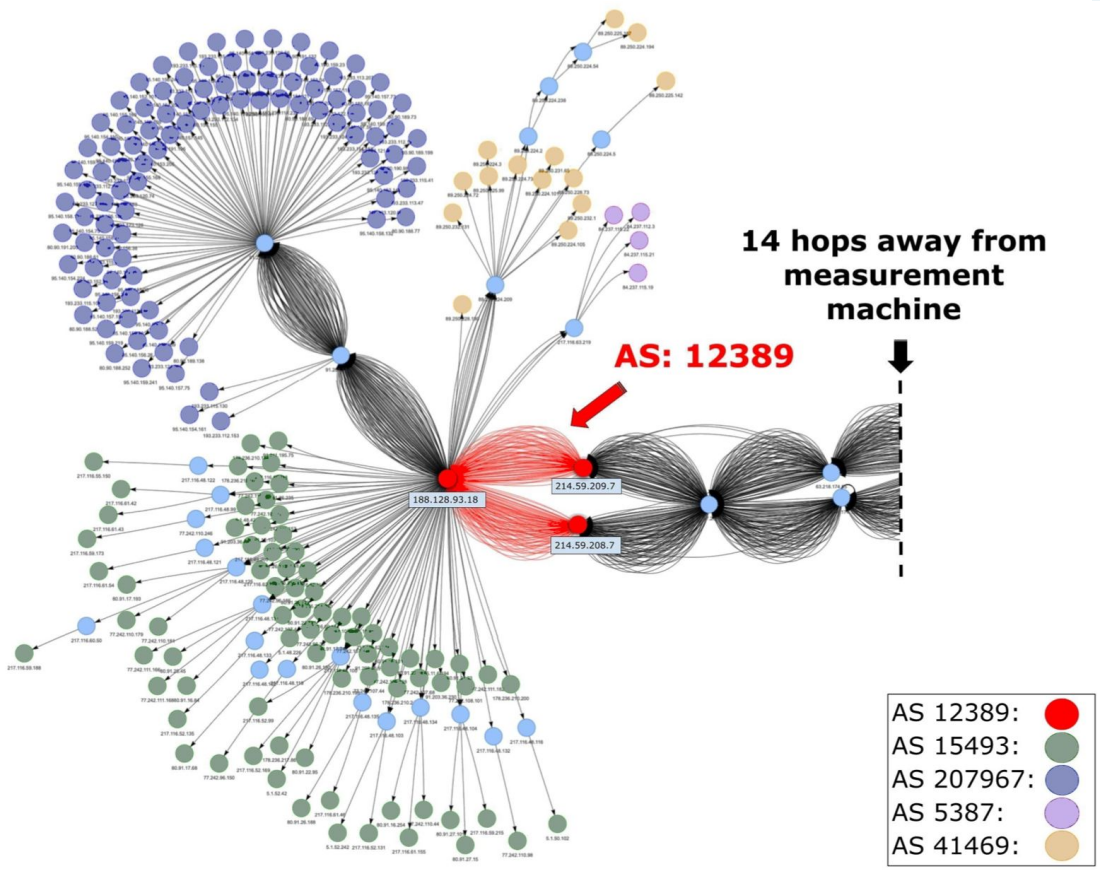
- How TSPU handles fragmentation
  - Buffers fragments
  - Forward Individually
  - Overwrite TTL (Time-To-Live)
  - Drop Duplicates (non-RFC)
  - Maximum 45 fragments.

Large-scale Scanning for TSPU



- ➔ 1.013M/4.005M (25.31%) traceroutes suggest TSPU.
  - ◆ 6,871 unique TSPU devices
- ➔ TSPUs are within two hops away in over 70% cases.
- ➔ Location and the substantial number of deployments suggest a different approach from the GFW.

Large-scale Scanning for TSPU



- **TSPUs installed in upstream ISPs.**
  - The TSPU law explicitly allows downstream ISPs to rely on upstream providers for compliance.

Takeaway

- Our study found pervasive deployment of TSPU devices in Russia.
- TSPU empowers RU government to **unilaterally** control the Internet.

Takeaway

- Our study found pervasive deployment of TSPU devices in Russia.
- TSPU empowers RU government to **unilaterally** control the Internet.
- In-path and close to edges, TSPU can launch attacks **beyond censorship**. (e.g., MITM, targeted surveillance)

Takeaway

- Our study found pervasive deployment of TSPU devices in Russia.
- TSPU empowers RU government to **unilaterally** control the Internet.
- In-path and close to edges, TSPU can launch attacks **beyond censorship**. (e.g., MITM, targeted surveillance)
- **Decentralized deployment, centralized control**.
    - May become a blueprint for other countries with similar network topology.

Censored Planet

TSPU: Russia's Decentralized Censorship System

Diwen Xue, Benjamin Mixon-Baca[+], ValdikSS*, Anna Ablove, Beau Kujath[+], Jedidiah R. Crandall[+], Roya Ensafi

University of Michigan, [+]ASU/Breakpointing Bad, *Independent

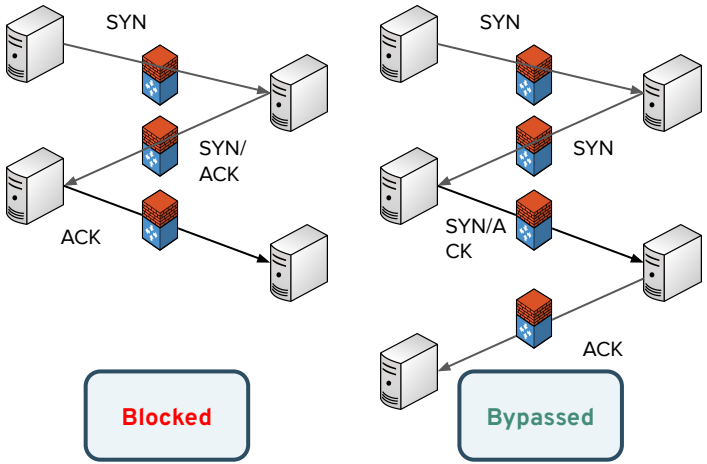
Circumvention

Client-side Strategies

- IP fragmentation/TCP segmentation.
- TLS padding, prepending another TLS record.
- Encrypted proxies, VPNs.
  - Face blocking themselves

Server-side Strategies

- Window-size Reduction
- **Split Handshake**

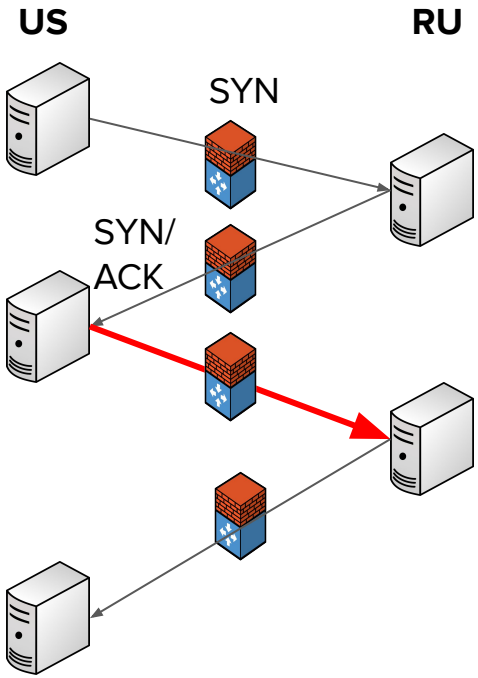


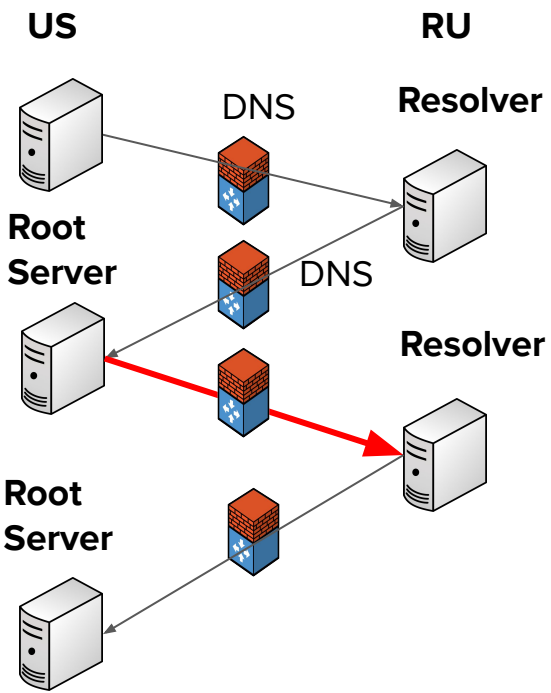
Backup

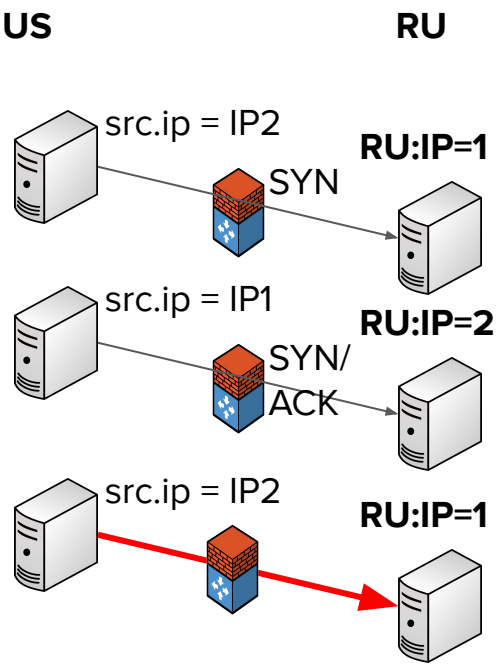
Backup

Backup

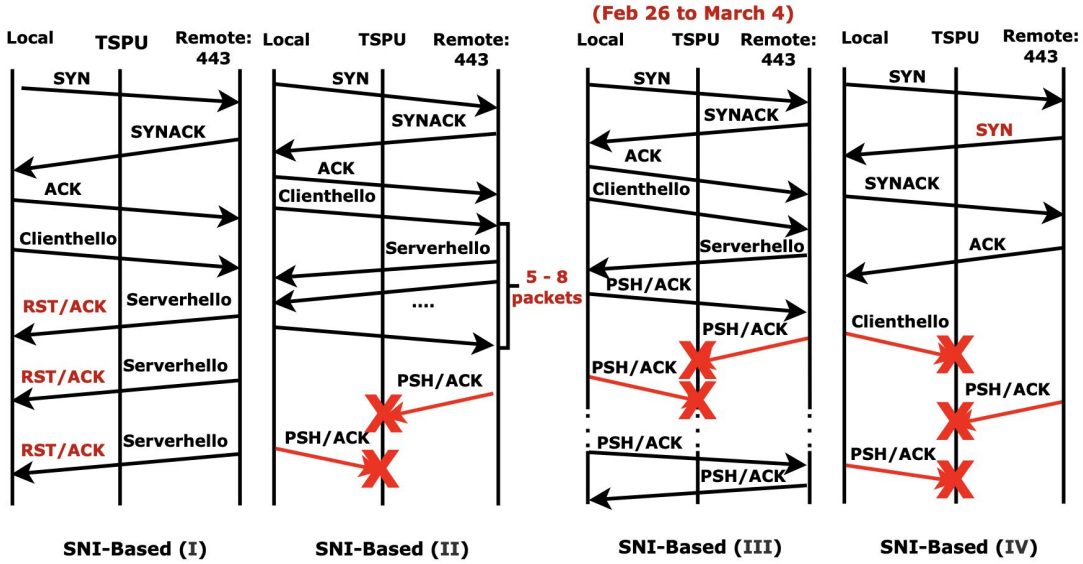
Asymmetricity of TSPU censorship





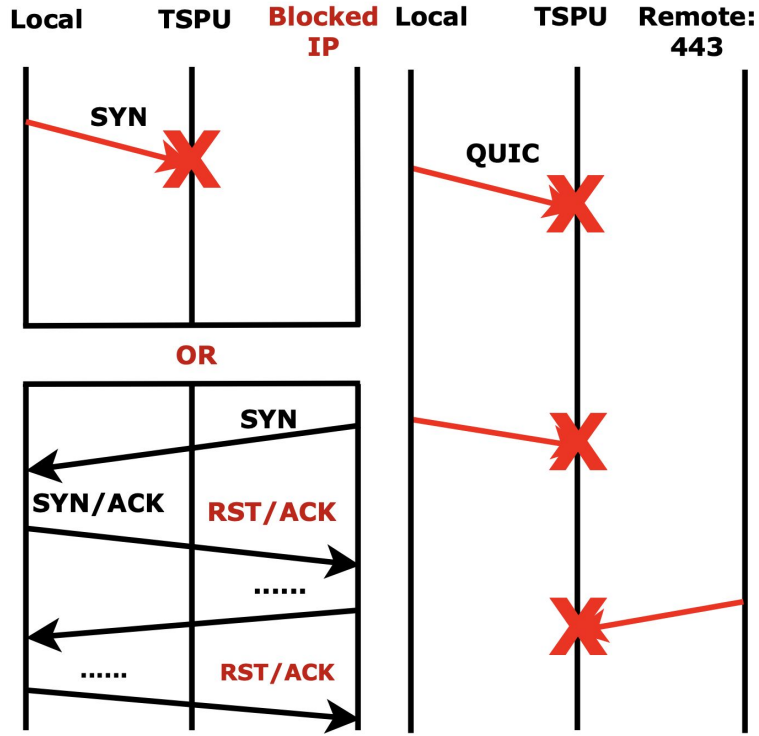


Triggers and Behaviors (SNI)



- SNI (Server Name Indication)
  - Transferred in plaintext in at the beginning of a TLS session
- Depending on the domain name, different blocking behaviors were observed.

Triggers and Behaviors (IP, QUIC)

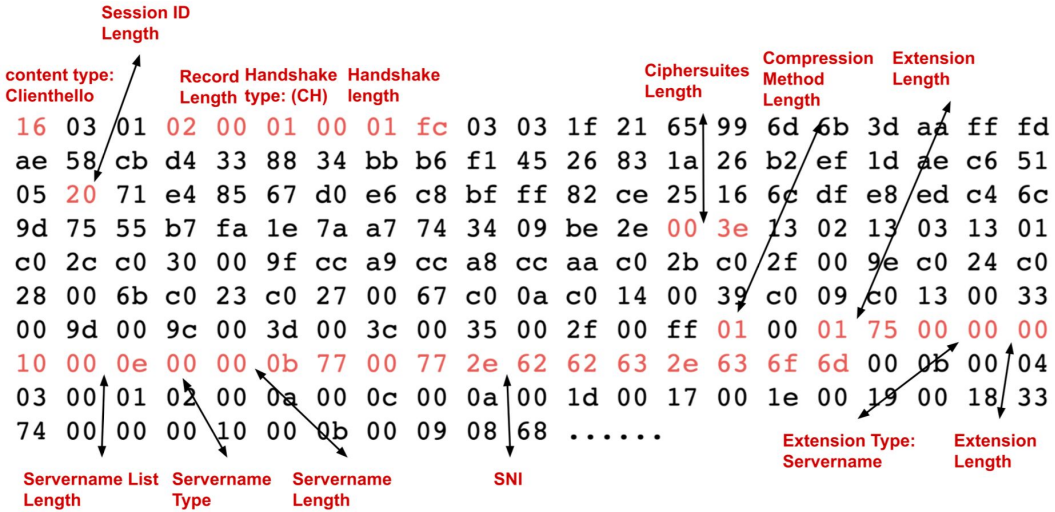


- IP-based blocking
  - Connections blocked regardless of payloads or TCP port.
- QUIC Blocking
  - Protocol fingerprint based on plaintext “Version” field.
- **Require dropping or modifying packet (In-path Capability)**

Version: (1)

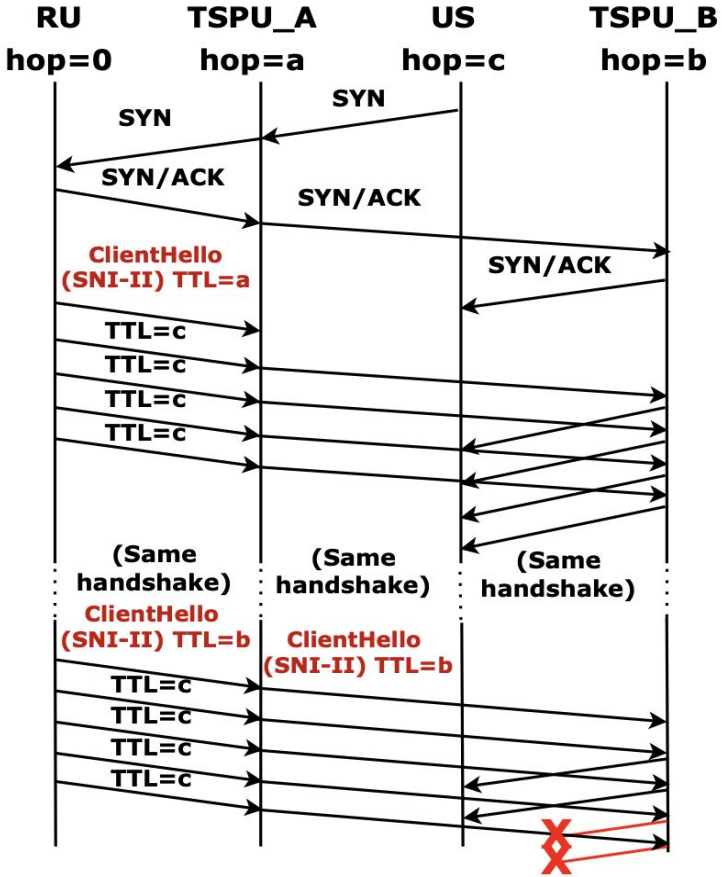
ff 00 00 00 01 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
ff ff ff ff ff ff ff ff ff ff ff ff ..... Lengthe > 1000 bytes

Clienthello Fingerprint



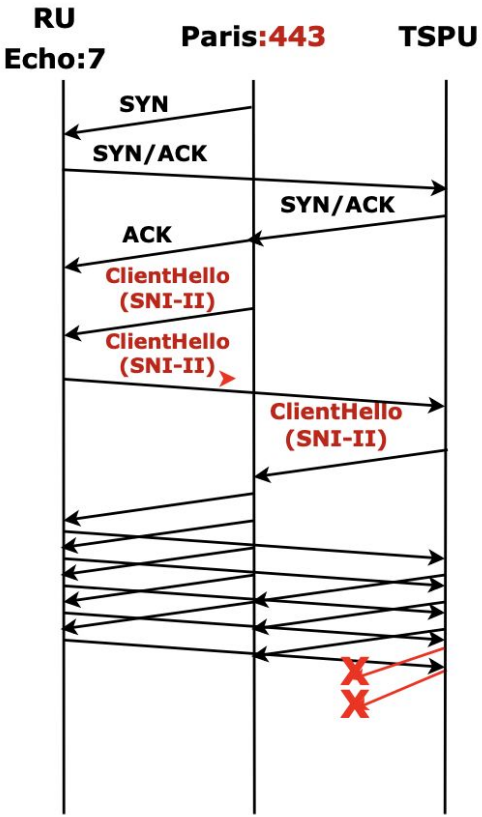
- ClientHello Fuzzing
  - To understand which parts of the packet are inspected.

Asymmetric TSPUs



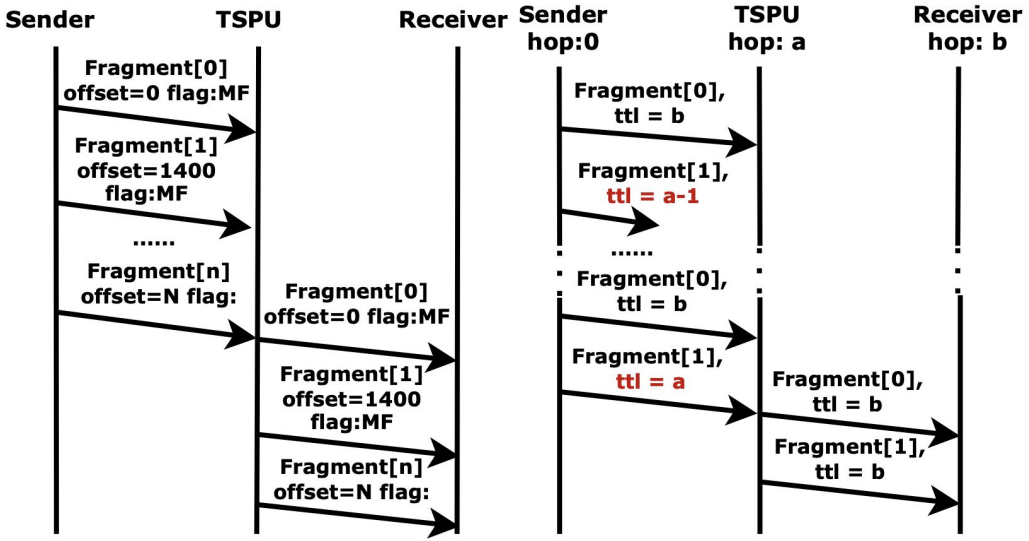
- TSPU Law allows ISPs to route upstream and downstream through different TSPUs.
- Discover upstream-only TSPUs
  - By exploiting the fact that only local connections are censored.
- Located three TSPUs with asymmetric visibility.

Remote Measurement: Echo



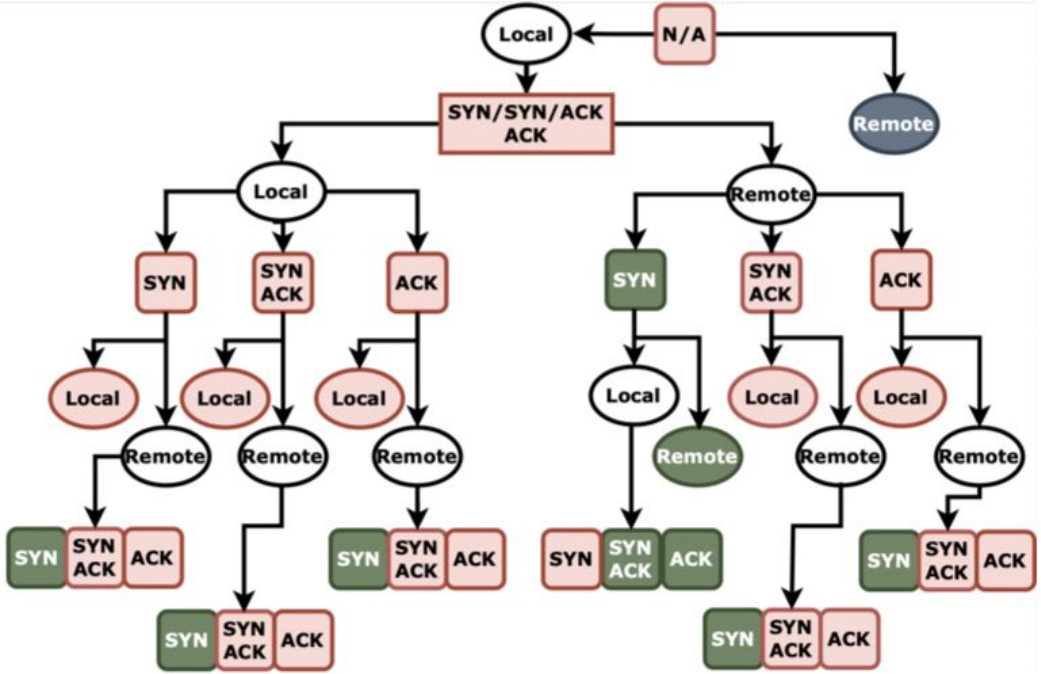
- Echo servers would echo back anything sent to them.
  - Ensures that triggers would be sent once from RU to remote.
- Client needs to set port to 443.
  - The roles of “client” and “server” are reversed.

TSPU State Management - IP Fragmentation



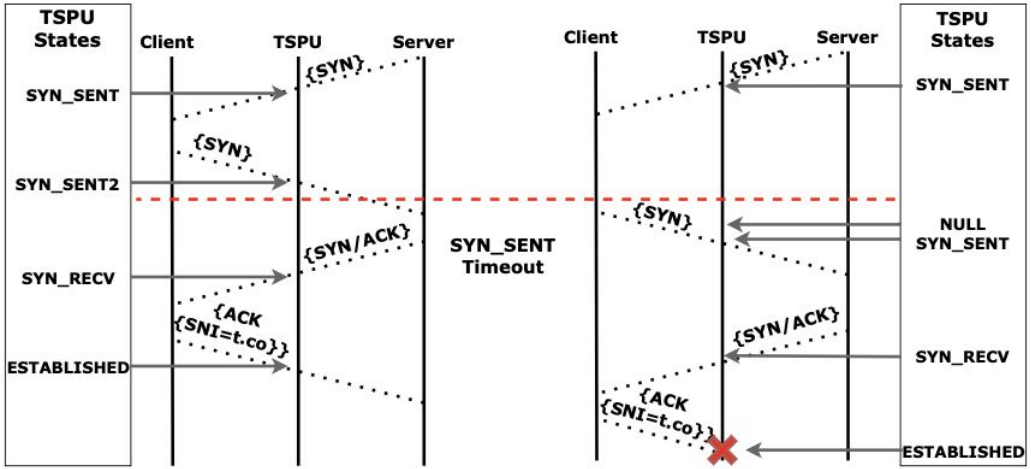
- How TSPU handles fragmentation
  - Buffers fragments
  - Forward Individually
  - Overwrite TTL (Time-To-Live)
  - Maximum 45 fragments.

TSPU State Management - TCP Flags



- Sequences of TCP flags
  - Create states at TSPU
  - Remote-originated sequences bypass inspection & blocking.
- Remote SYNs confuses TSPU
  - Simultaneous Open / Split Handshake
  - SNI-IV still blocks the connection.

TSPU State Management - States Timeouts



Sequence	Timeout	State
Remote.SYN; SLEEP; Local.SYN; Remote.SA; Local.Trigger	60	SYN_SENT
Local.SYN; Remote.SYN; Local.A; SLEEP; Local.Trigger	105	SYN_RCVD
Local.SYN; Remote.SA; SLEEP; Remote.ACK; Local.Trigger	480	ESTABLISHED
Local.Trigger(SNI- I); SLEEP	75	SNI- I
Local.Trigger(SNI- II); SLEEP	420	SNI- II
Local.Trigger(SNI- IV); SLEEP	40	SNI- IV
Local.Trigger(QUIC); SLEEP	420	QUIC

- Connection entries are removed after timeouts.
- TSPU timeout values do not conform to any major OSes.
  - Short timeout for SYN-SENT allows opportunity for circumvention

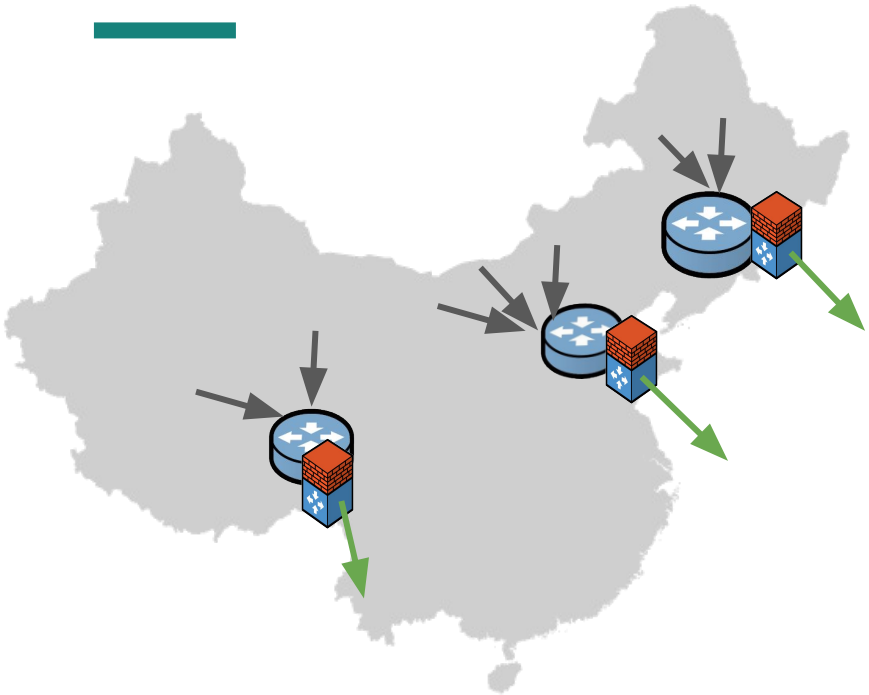
Censorship in Russia: Pre-TSPU

- "***Decentralized Control***", termed by previous work*.
- Facilitated by the commoditization of filtering technologies
- ISPs i***ndependently*** implement censorship in their networks.
  - "Registry of Banned Sites", maintained by Roskomnadzor.
  - Specific blocking techniques were not prescribed.

➔ Model also adopted by other countries, e.g., UK.

[1] Decentralized Control: A Case Study of Russia NDSS'20

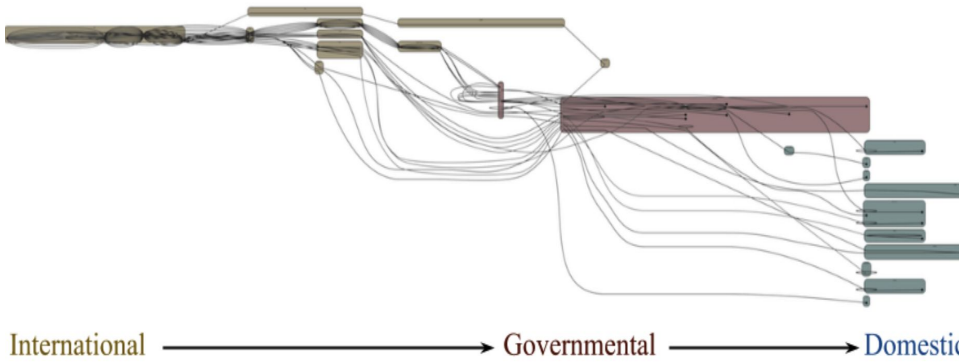
Internet Censorship



only for illustration

Conventionally,
Censorship = Centralized.

- Filters placed at choke points in the nation's Internet topology.



[1] An Analysis of China's Great Cannon [USENIX, 2015]
[2] Internet censorship in china: Where does the filtering occur? [PAM, 2011]
[3] Dimming the Internet: Detecting Throttling as a Mechanism of Censorship in Iran

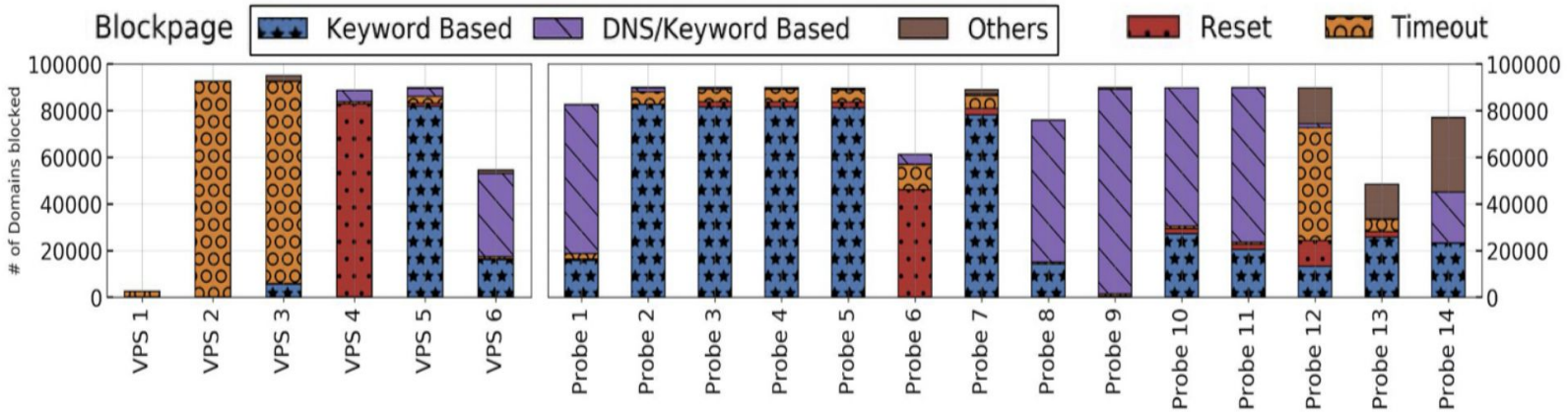
Censorship in Russia, pre-TSPU

- Thousands of privately-owned, distributed ISPs makes leveraging a centralized architecture challenging.

only for illustration

Censorship in Russia, pre-TSPU

- Significant differences in both **types** and **amount** of blocking between ISPs.

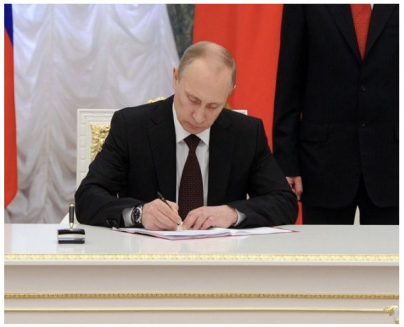


[1] Decentralized Control: A Case Study of Russia NDSS'20

Changes in Russia's Censorship Model

The President signed the law on sustainable Runet

Newsroom - 02.05.2019

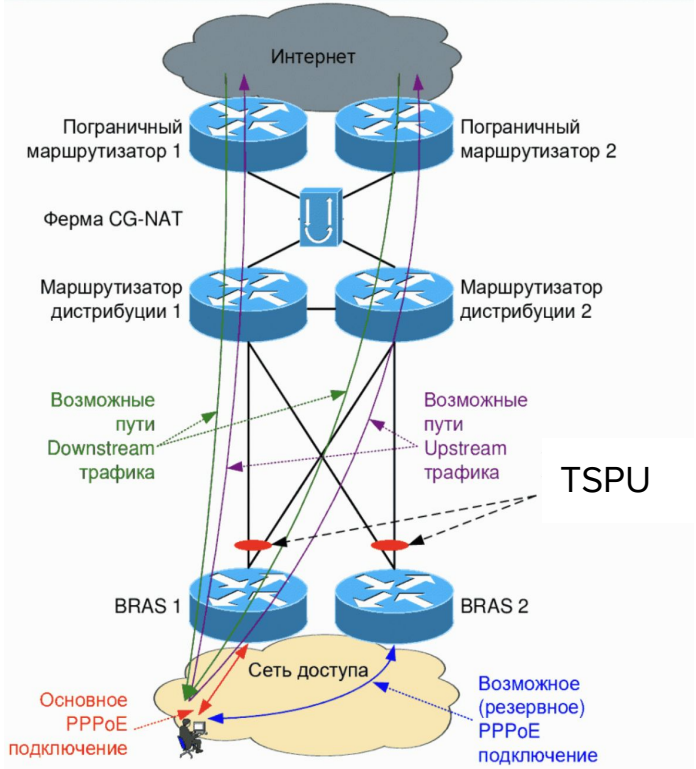


Vladimir Putin signed on Wednesday the federal law "On Amendments to the Federal Law "On Communications" and the federal law "On Information, Information Technologies and Information Protection," Kremlin.ru reports .

This is the so-called law on the sustainability of the Runet, according to which a national Internet traffic routing system will be created in the country in order to ensure the reliable operation

- "On Sustainable RuNet" law signed on May 1, 2019.
- Appoints Roskomnadzor to guard the "stability, security, and integrity" of Russia's Internet.
- Provides legal grounds for the government to **require ISPs to install "special equipment".**

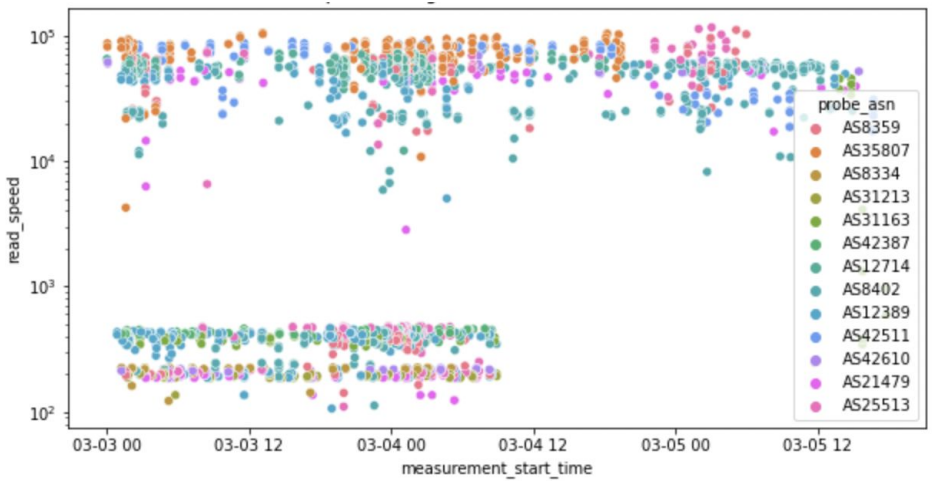
Changes in Russia's Censorship Model



- ISPs receive letters from Roskomnadzor, demanding information and installation of black-box DPIs, a.k.a TSPU.
- ISPs are concerned these devices may increase risks of failure and deprive citizens of their right to information.

https://habr.com/ru/post/459894/

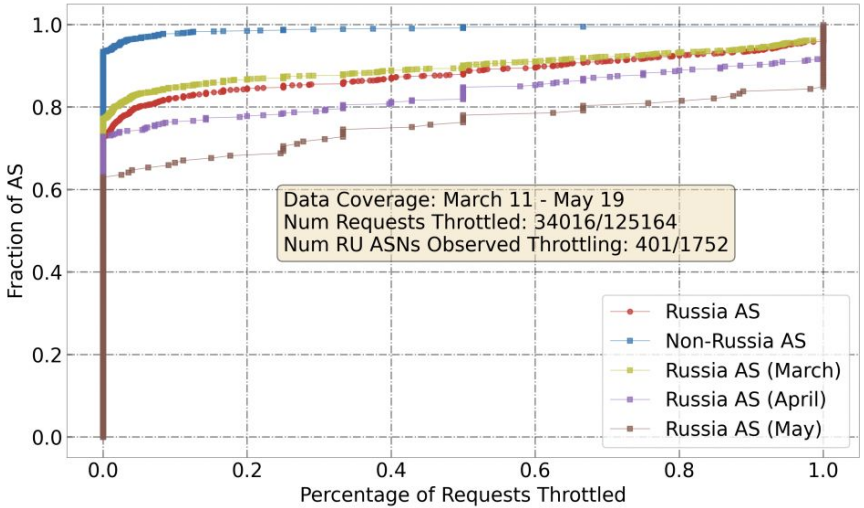
Changes in Russia's Censorship Model



https://ooni.org/post/2022-russia-blocks-amid-ru-ua-conflict/

- Users report on blocked resources that were not present in the blocking registry (out-registry blocking).
- Plus, measurement studies suggest **temporal and geographic uniformity.**

Throttling Twitter (2021)



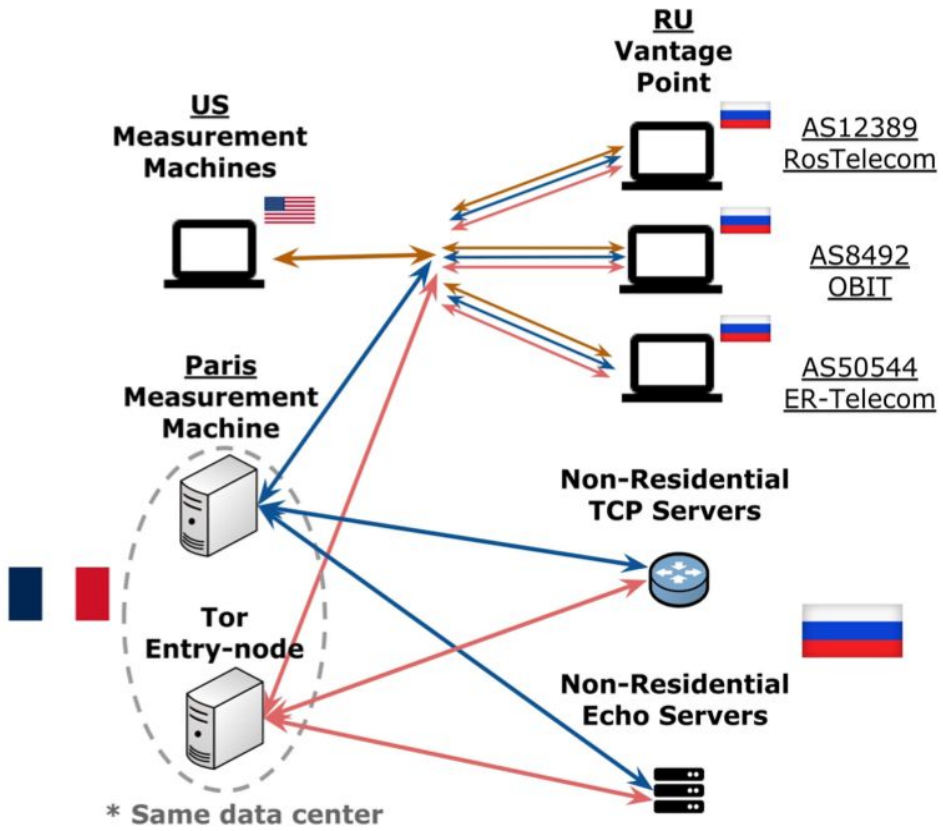
[1] Throttling Twitter: An Emerging Censorship Technique in Russia. IMC '21

- **Identical throttling behaviors** were observed from vantage points across ISPs.
- Throttling was **widespread, implemented in at least 401 ASes**, even though the domains were not in the blocking registry.

A new system was put into use!

Measuring TSPU is Challenging

1. Acquiring vantage points
2. Distinguishing ISP and TSPU censorship
3. Adopting remote measurement due to asymmetricity of TSPU censorship



Measurement Setup

- **Run in-country measurement to characterize:**
  - SNI-based Censorship
  - IP-based blocking
  - QUIC blocking
- **Remote measurements to scan the deployment of TSPUs.**

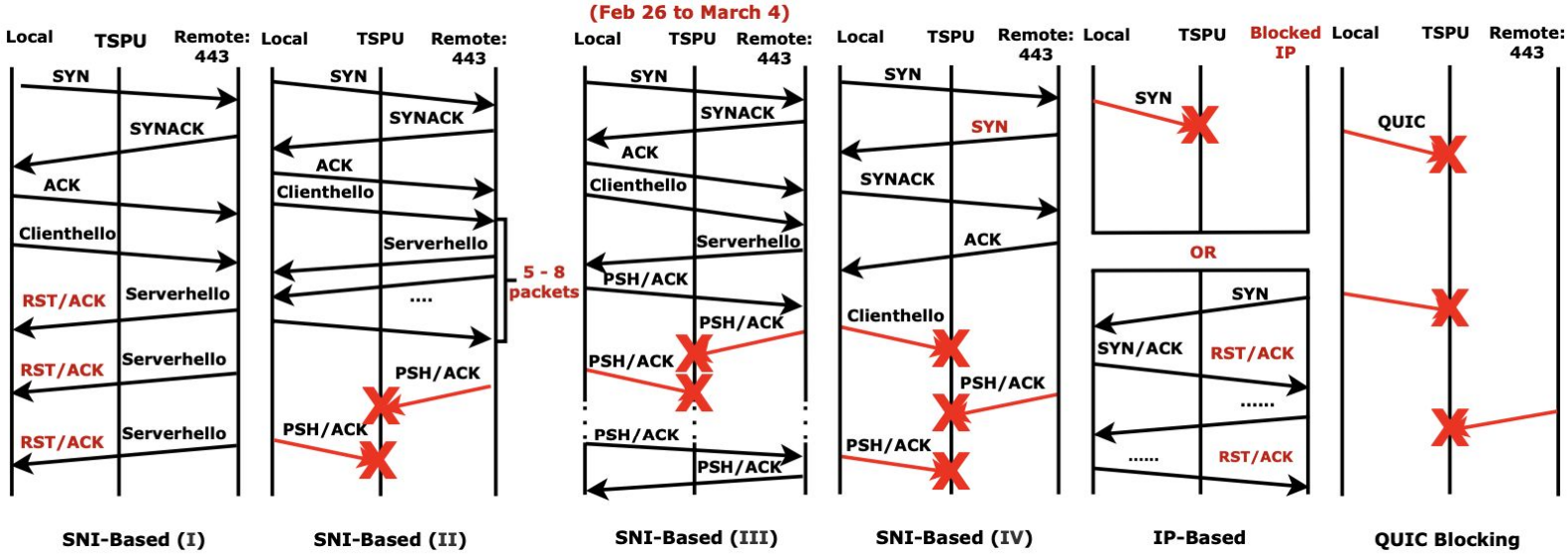
TSPU

технические средства противодействия угрозам
(Technical Measures to Combat Threats)

Centrally controlled by RKN, Decentrally deployed in networks.

- ***How*** TSPU blocks a connection?
- ***What*** resources it blocks?
- ***Where*** it is installed w.r.t. Russian users?

TSPU Blocking: In-path and Stateful



Connection tracking, degree of statefulness, reliability
→ Refer to Paper