Tracking Transport-Layer Evolution with *PATHspider*

Brian Trammell, Mirja Kühlewind, and **Piet De Vaere,** ETH Zürich, Switzerland
Iain Learmonth and Gorry Fairhurst, University of Aberdeen, Scotland

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mami
measurement and architecture for a middleboxed internet

measurement | architecture | experimentation

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The problem, a solution

Middleboxes interfere with connections

→ Transport protocols must **react**

& Reaction must be **data-driven**

Data can be provided by **active internet measurement**

We build a toolchain for:

Controlled experiments

Diverse protocol features

Diverse targets

That observes **conditions** associated with **paths**

Overview

PATHspider architecture

Scaling up cloud-based measurements

Long term evolution & reducing noise floor

Measurement methodology for

DSCP

ECN

TFO

Increasing deployment

+ Results and insights

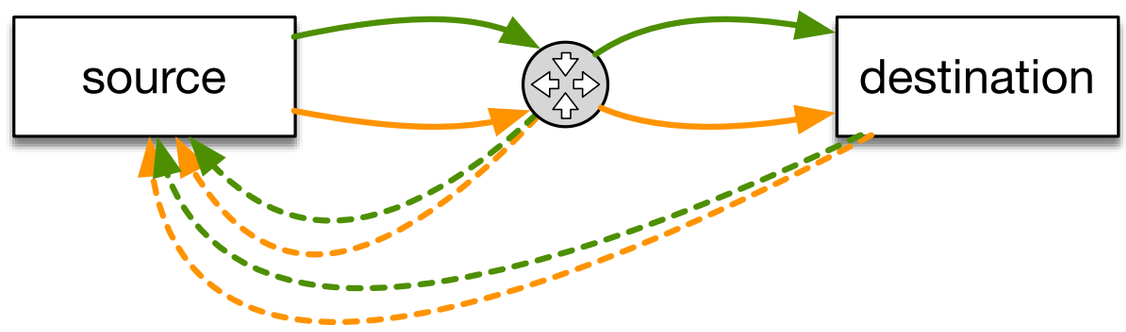
A/B testing of path transparency

Controlled measurement setup

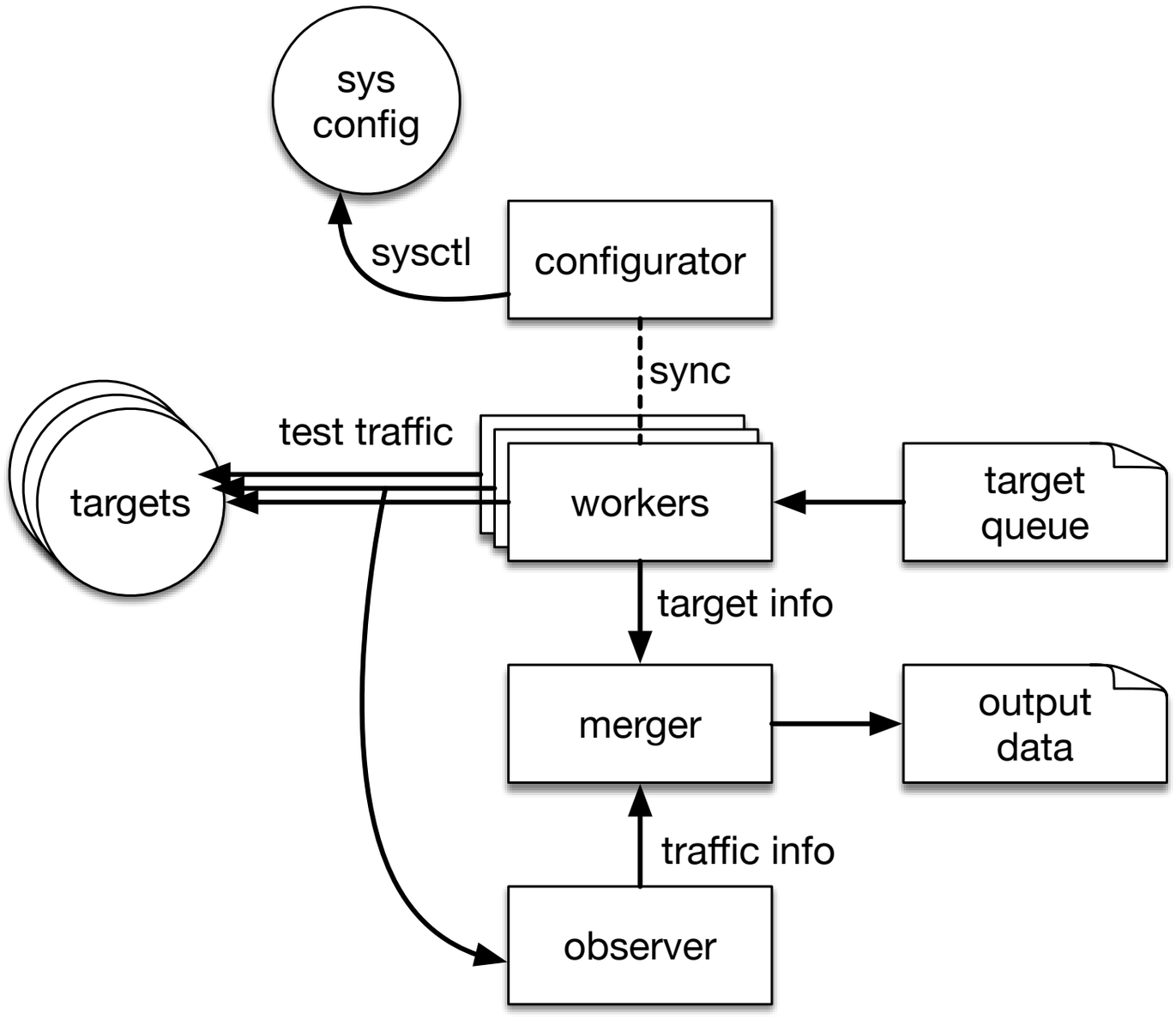
Baseline: vanilla TCP, {no|default} option

Experimental: protocol feature under test

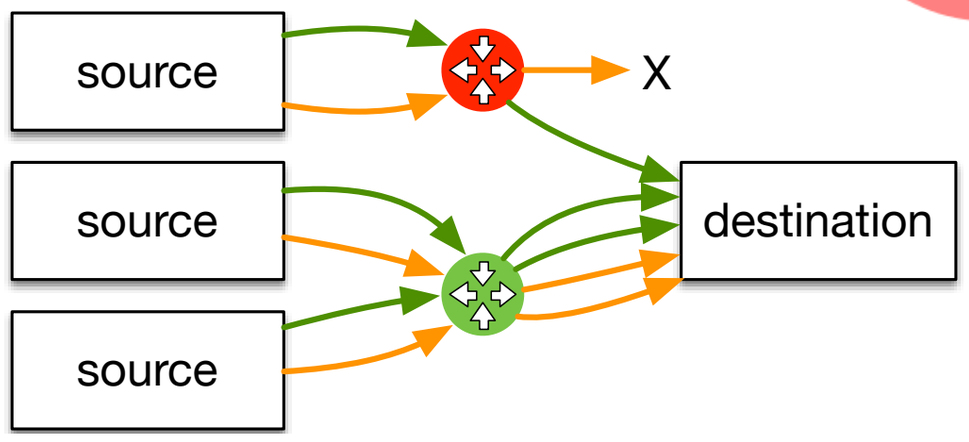
Find feature-dependent issues



Design of *PATHspider*



Site versus path dependency



Impairments exist

- Close to target
- Close to internet core ← More troubling!

Distinguish by

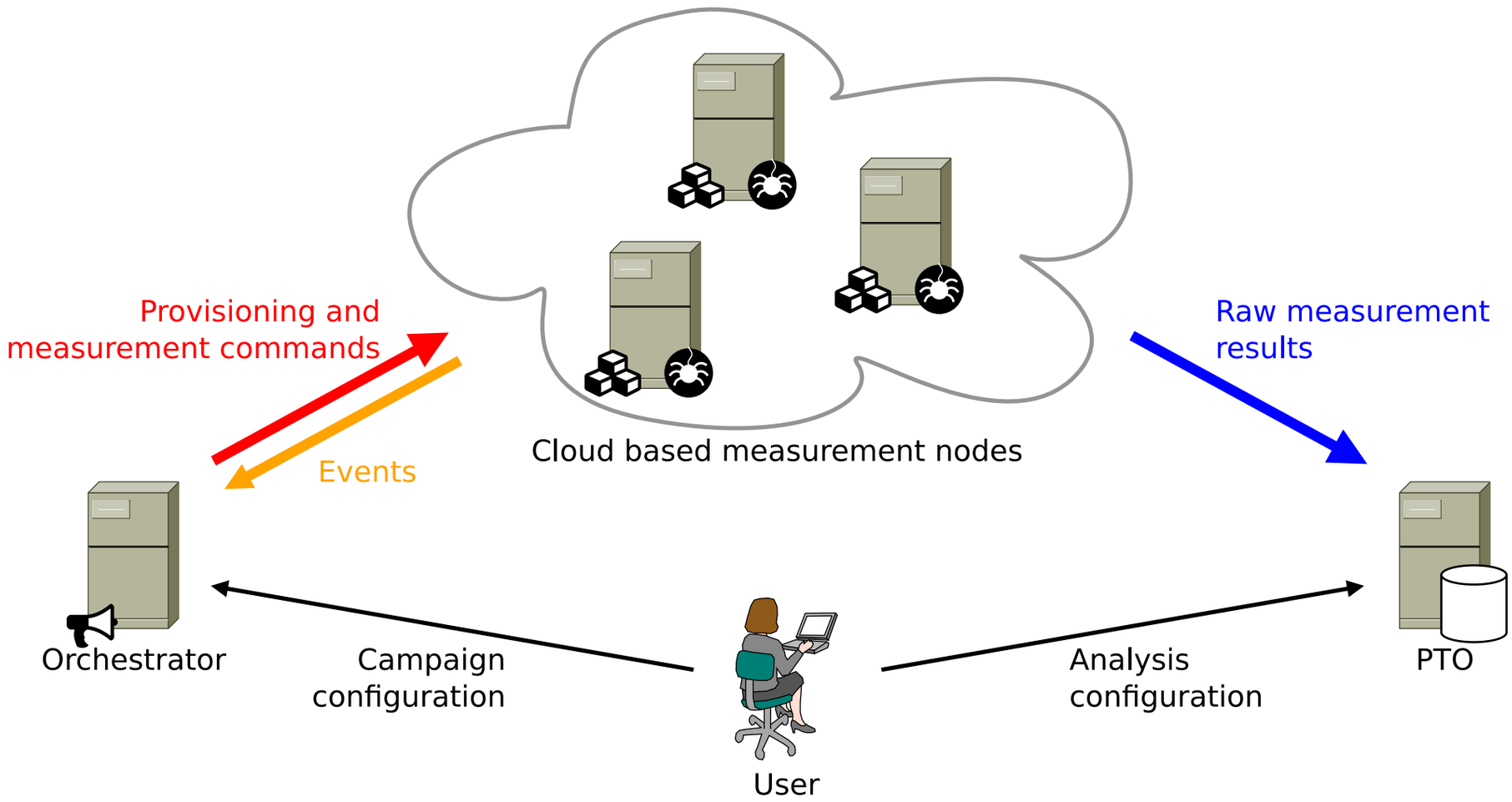
- Measuring from diverse vantage points
- Repeat measurements to detect transients

Scaling up

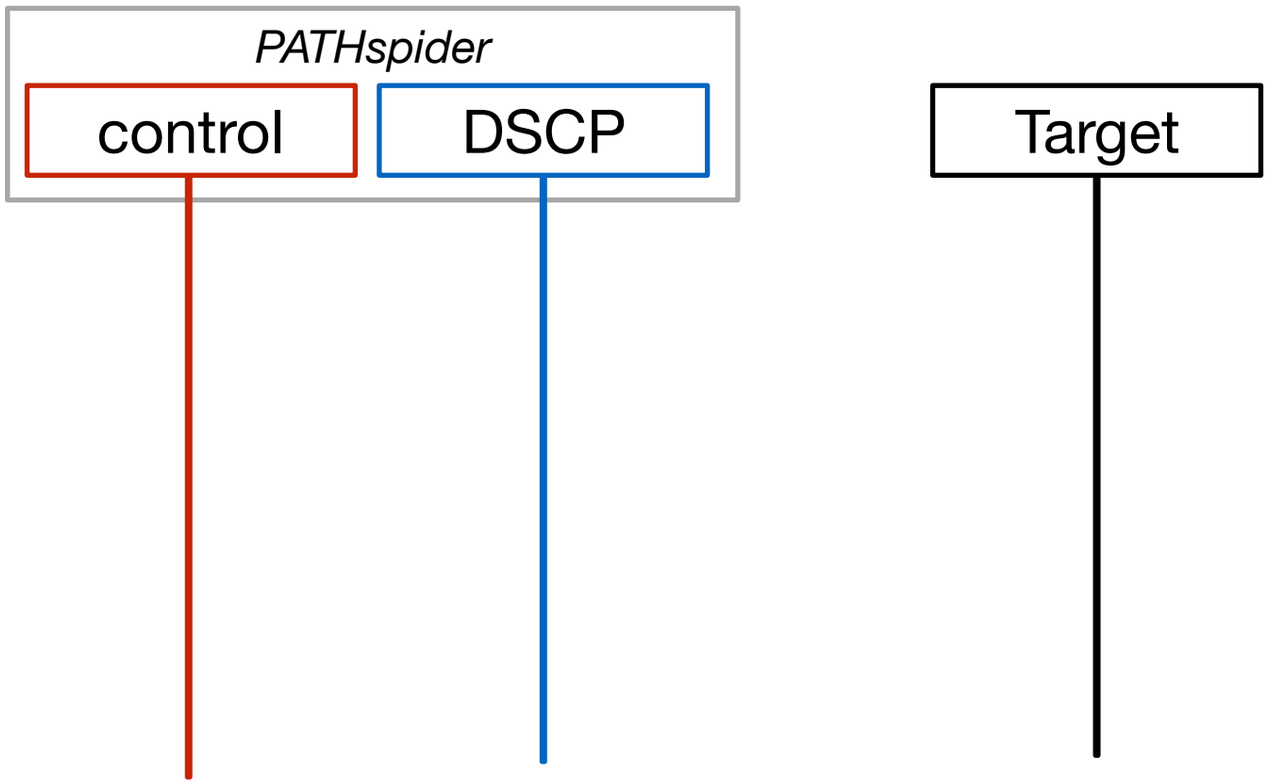
Cloud based measurements

Orchestrated using SaltStack

Results analysed on *Path Transparency Observatory*



Methodology
Differentiated Services (DSCP)



Send SYNs with default (0), and non-default DSCP

Interpret connection failure on non-default as dropped SYN.

Observe DSCP codepoint on SYN+ACK.

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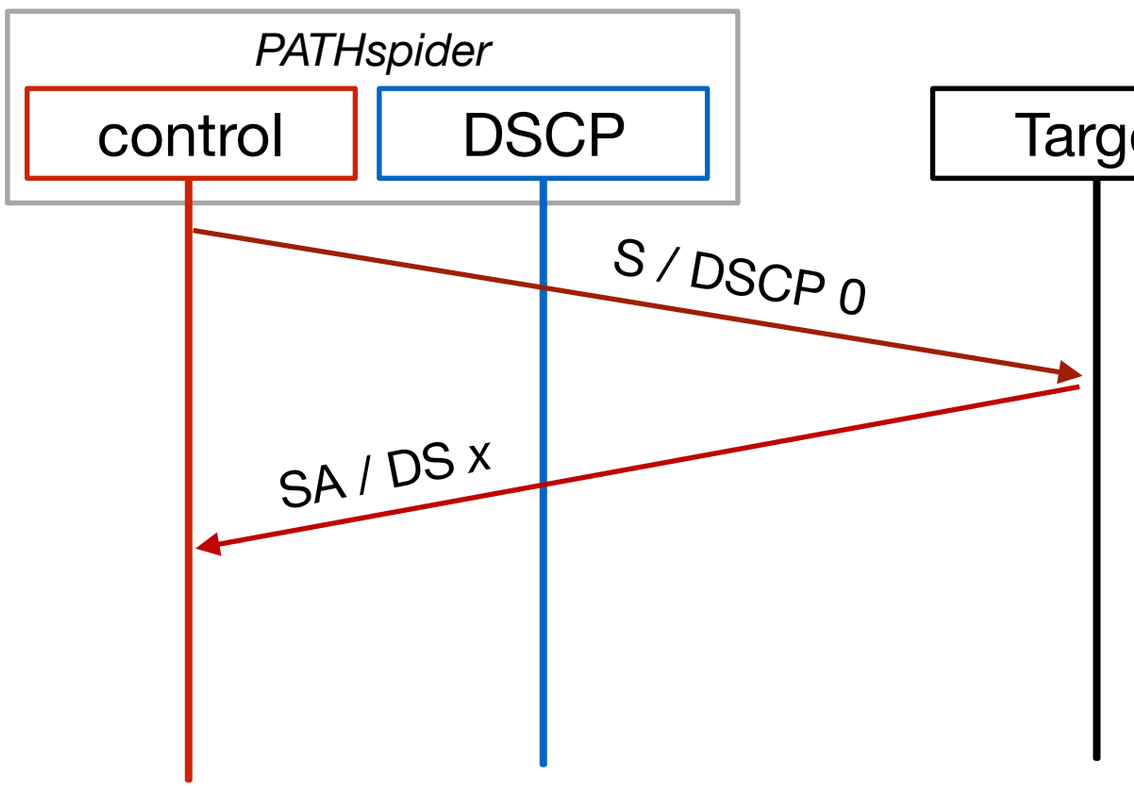

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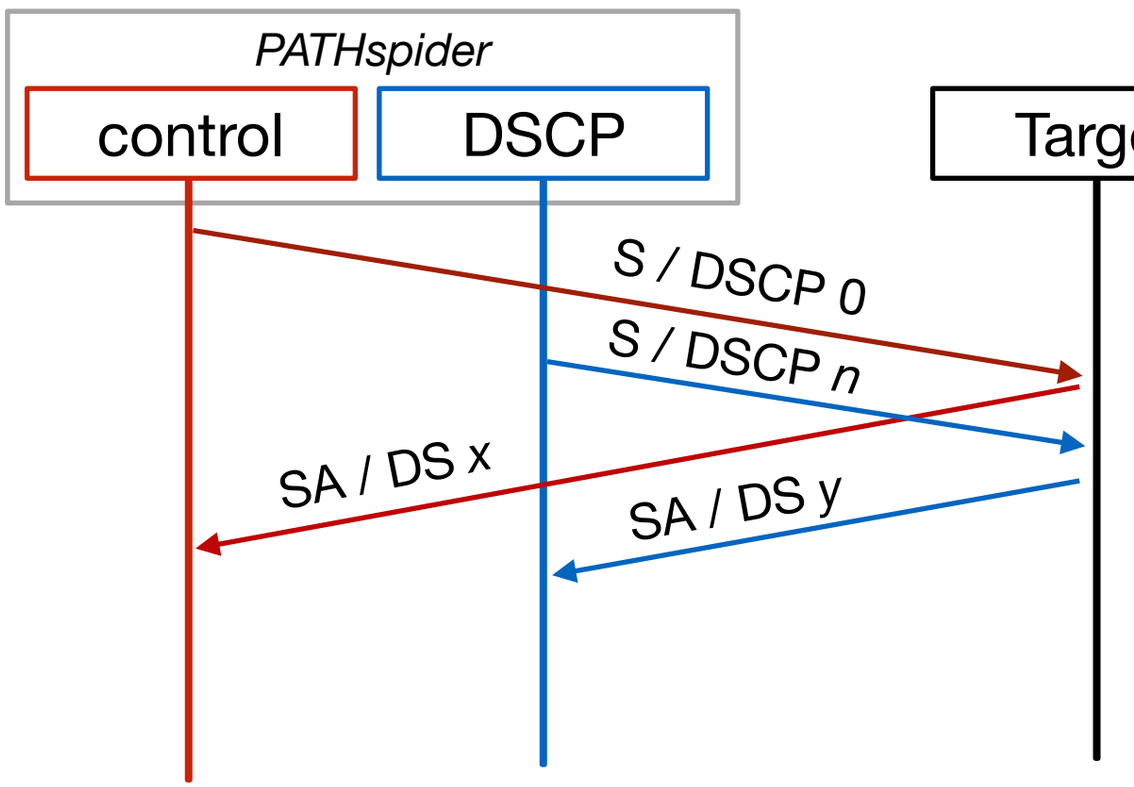

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Results: DSCP blocking

Measurements from Digital Ocean DCs

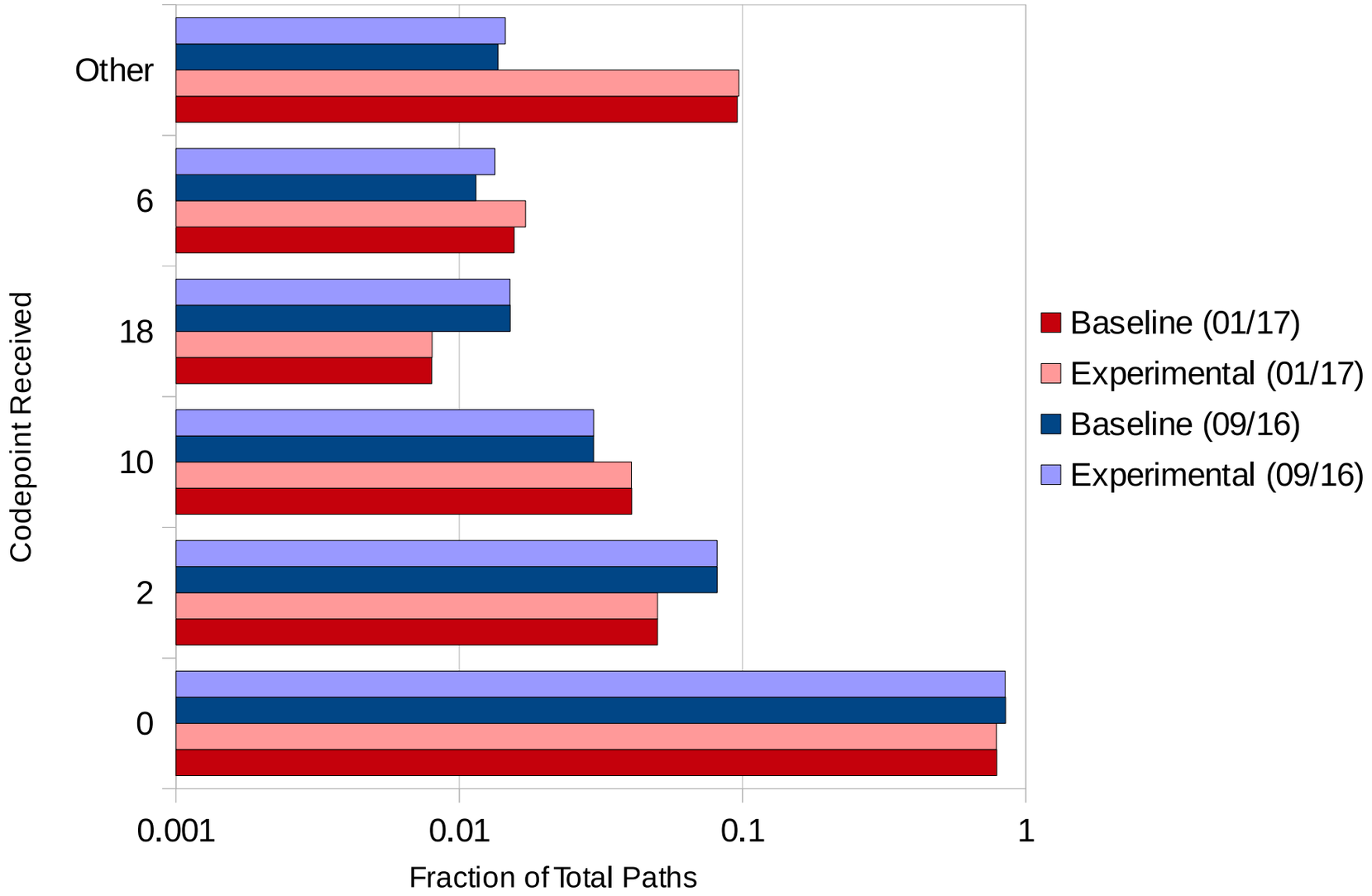
Negligible blocking of codepoint 46 (EF)

Most blocking seems path-dependent.

January 2017				
IPv4 n =620 611		IPv6 n =52 766		
hosts	pct	hosts	pct	
63 177	10.18%	28 985	54.93%	Completely failed to connect
557 434	**89.82%**	**23 781**	**45.06%**	Successfully connted with DSCP 0 (default); of which:
1 770	0.32%	124	0.52%	Failed to connect when DSCP 46 (EF) used;
1 334	0.24%	121	0.50%	but succeeded from at least one vantage point
556 998	**99.92%**	**23 778**	**99.98%**	Successfully connected with 46 (EF)

Results: DSCP return codepoint

DSCP on **return not dependent** on DSCP **on request**.



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TCP Fast Open (TFO)

Check connectivity without TFO, abort on fail.

API issue → long timeout

TFO experiment:

Connect once with TFO:

`tfo.cookie.received`

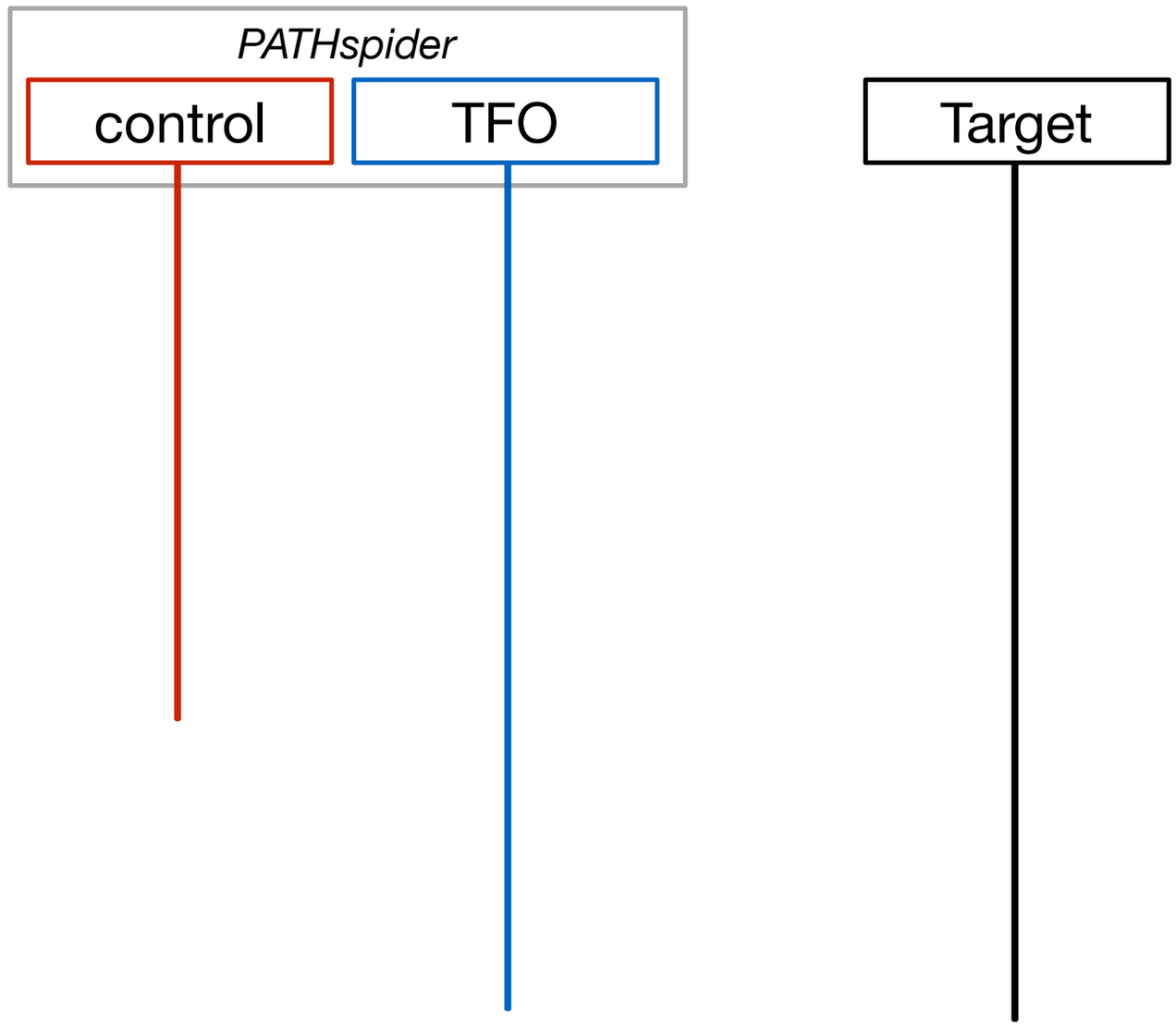
`tfo.cookie.not_received`

Connect again with TFO:

`tfo.syndata.acked`

`tfo.syndata.not_acked`

`tfo.syndata.failed`



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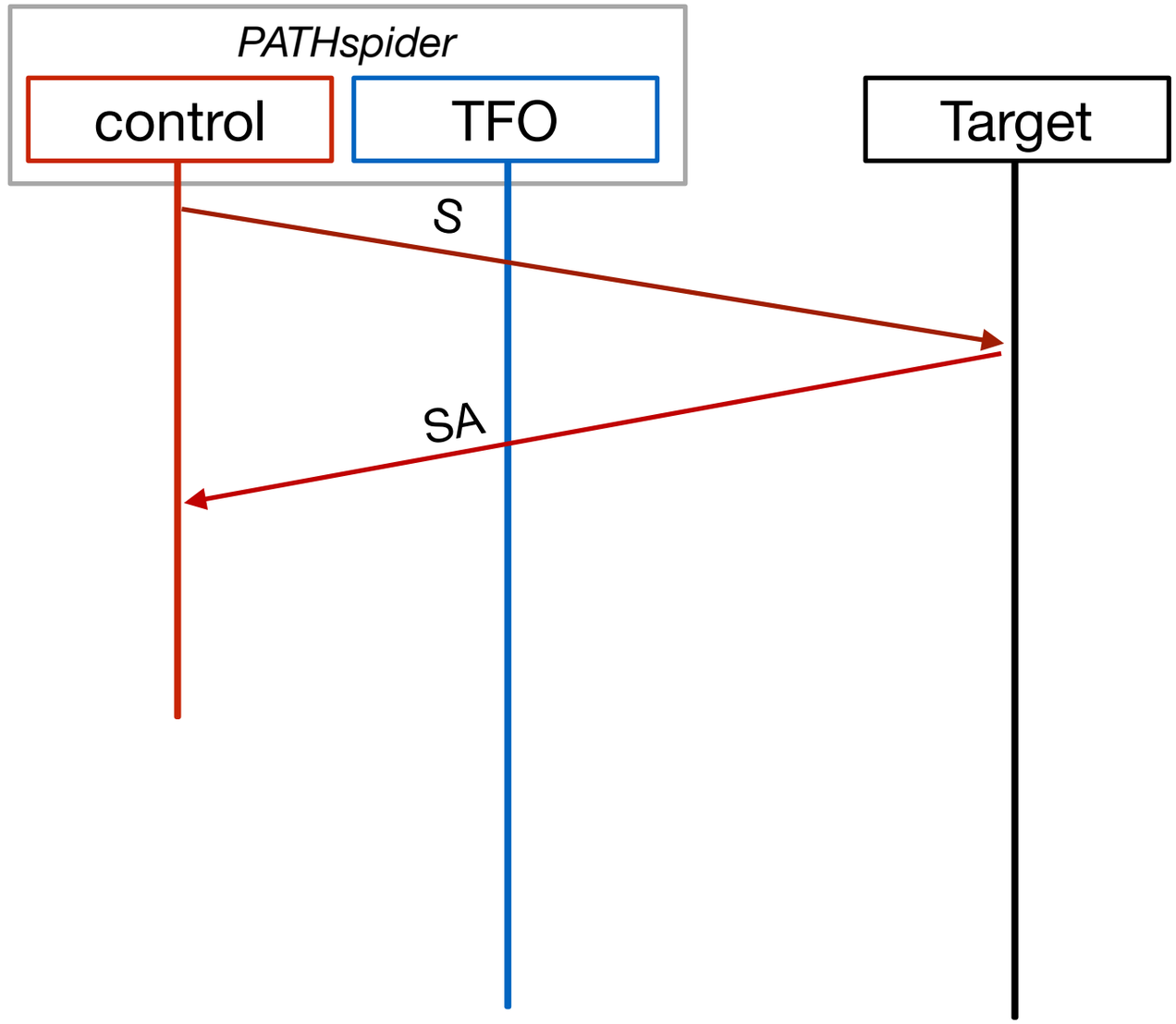

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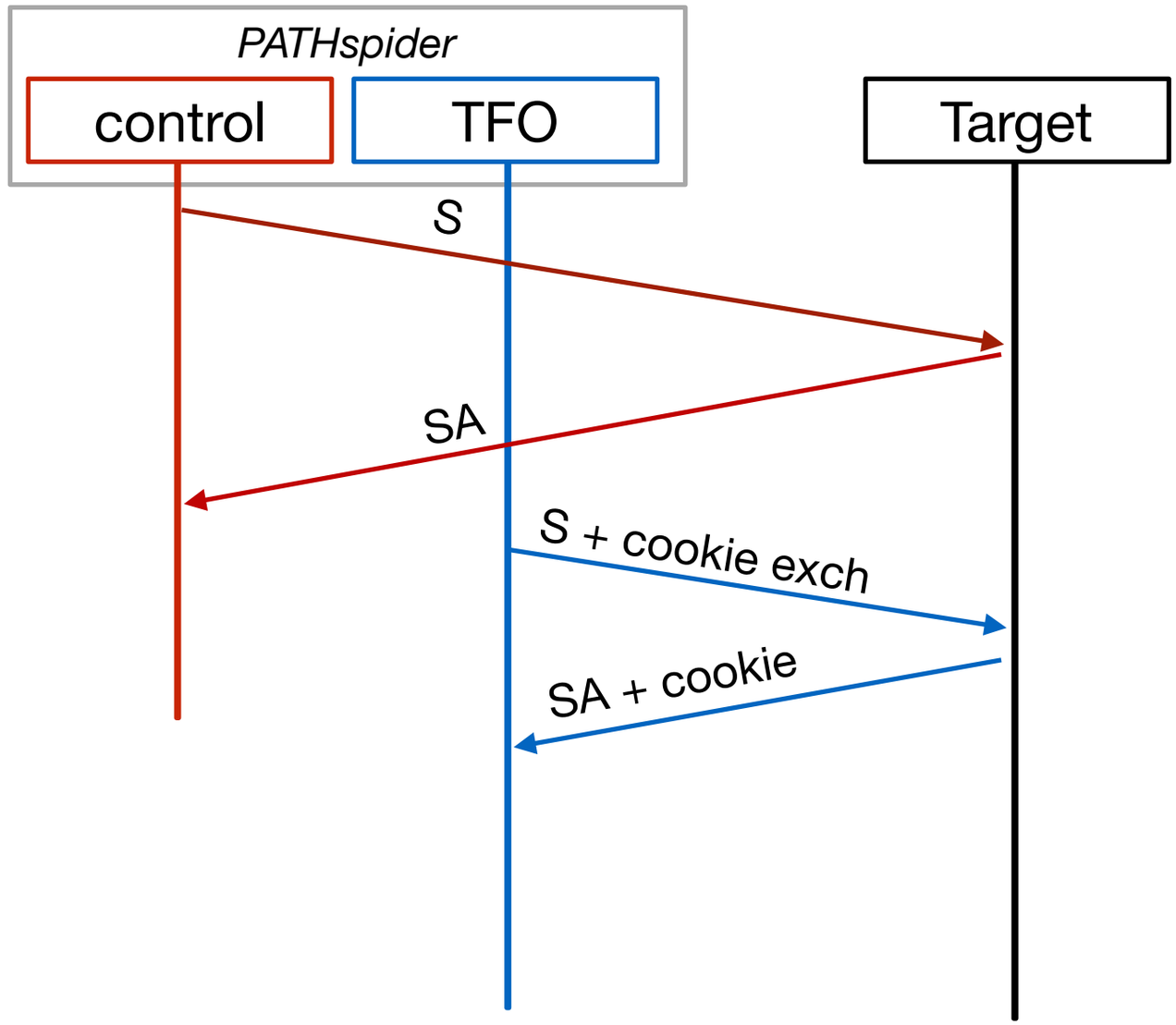

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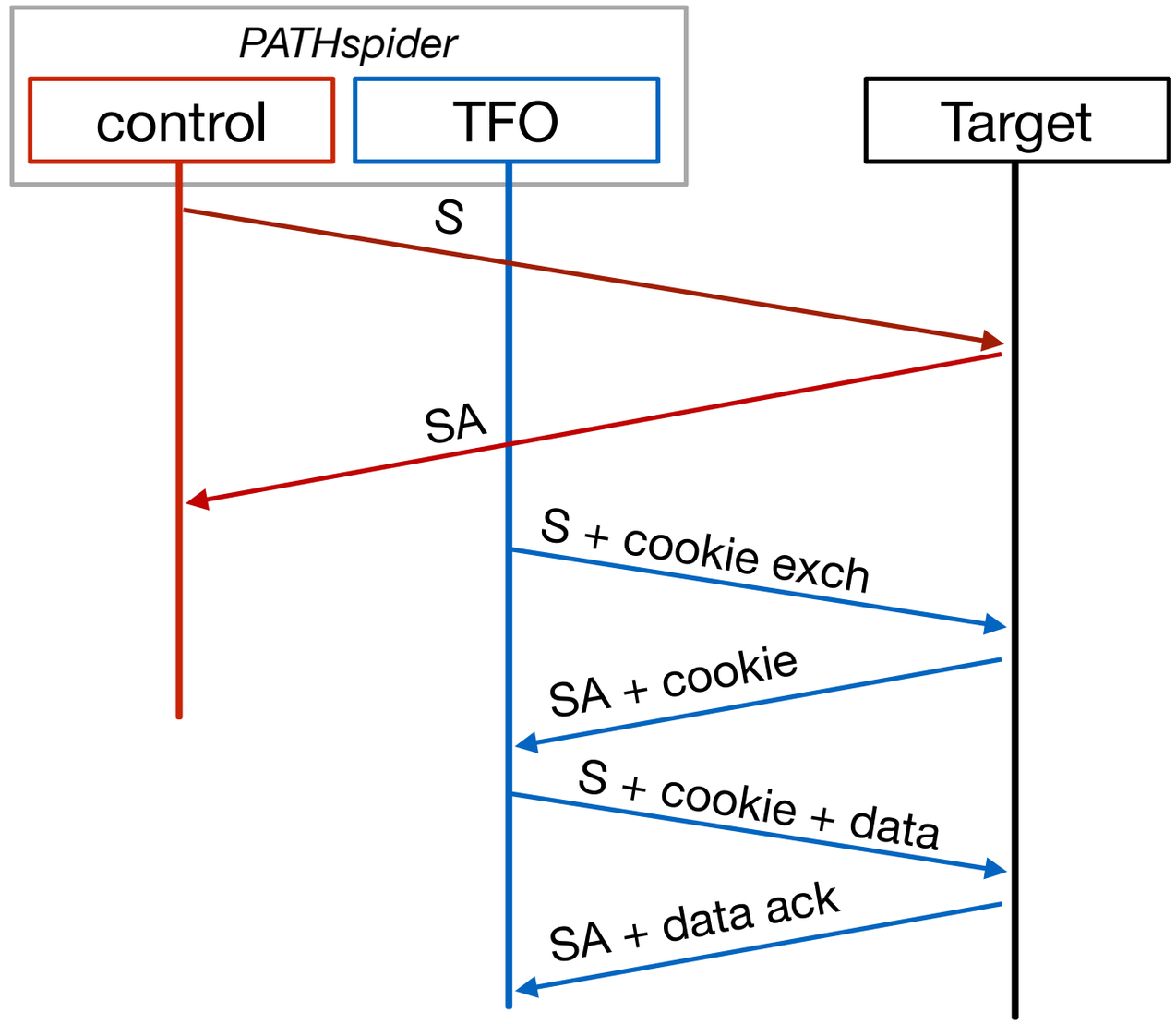


Results: TFO

Web, Jan '17 n =939 680 hosts	pct	DNS, Jan '17 n =53 267 hosts	pct	description
29 839	3.18%	4 906	9.21%	Completely failed to connect
177	0.019%	26	0.049%	Failed to connect w/TFO option
908 464	96.7%	48 276	90.6%	Did not negotiate TFO
866	**0.092%**	**56**	**0.105%**	Negotiated TFO (exchanged a cookie); of which:
830	95.8%	54	96.4%	ACKed data on SYN †
0	0%	2	3.57%	Failed connection with data on SYN
33	3.81%	0	0%	Returned a cookie on ACKed data
12	1.39%	2	3.57%	Responded with a 6-byte cookie
31	3.58%	0	0%	Responded with an experimental option †
690	79.7%	53	94.6%	are in AS15169 (Google)

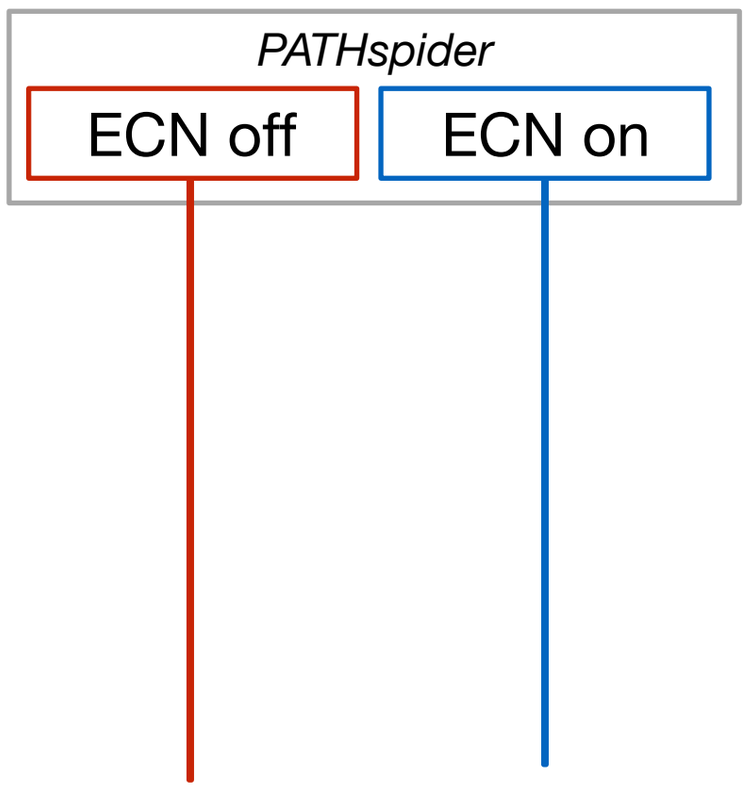
Correct TFO limited mostly to Google.

One anomaly linked to a single firm: unique implementation?

No path dependency seen (but N is small…)

Previous findings (Paasch): TFO impairment is in access networks

Methodology
Explicit Congestion Notification (ECN)



Connect **with and without ECN**

Measure

`ecn.connectivity.`*`status`*

`works`: off + on OK

`broken`: off OK, on fails

`transient`: on OK, off fails

`offline`: no connection

`ecn.`*`codepoint`*`.seen`

generate traffic

negotiation $\overset{?}{\rightarrow}$ ECT marking

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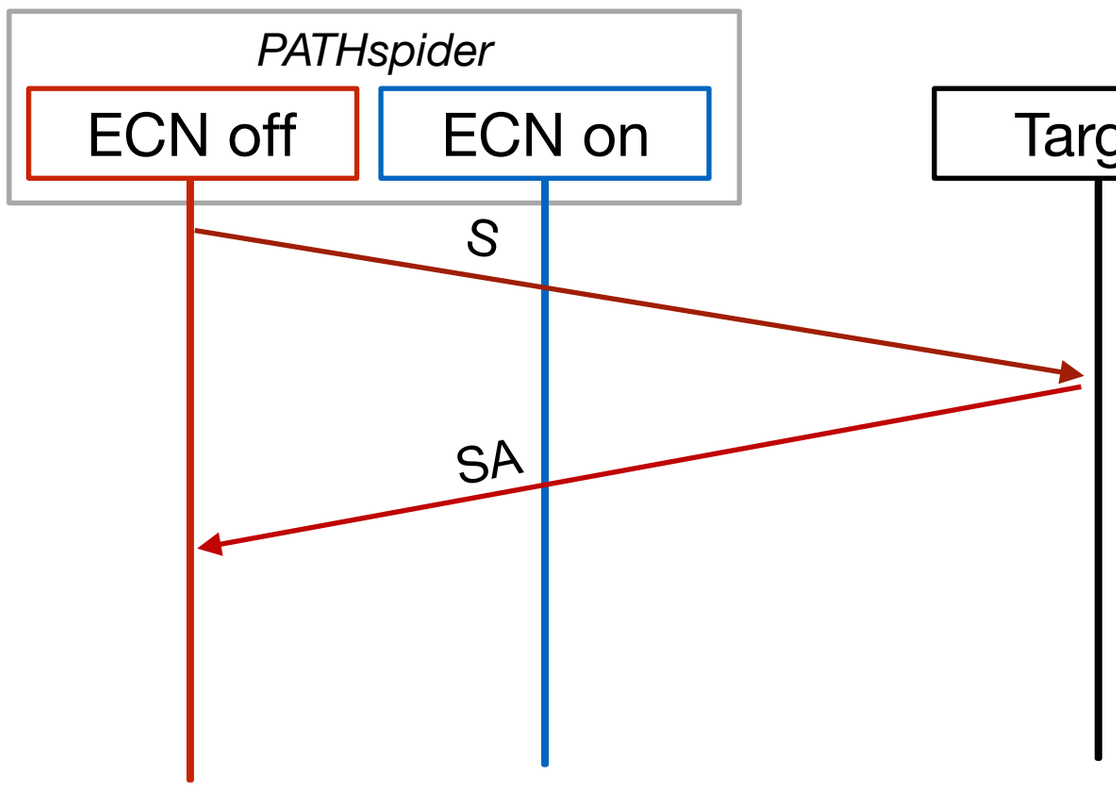

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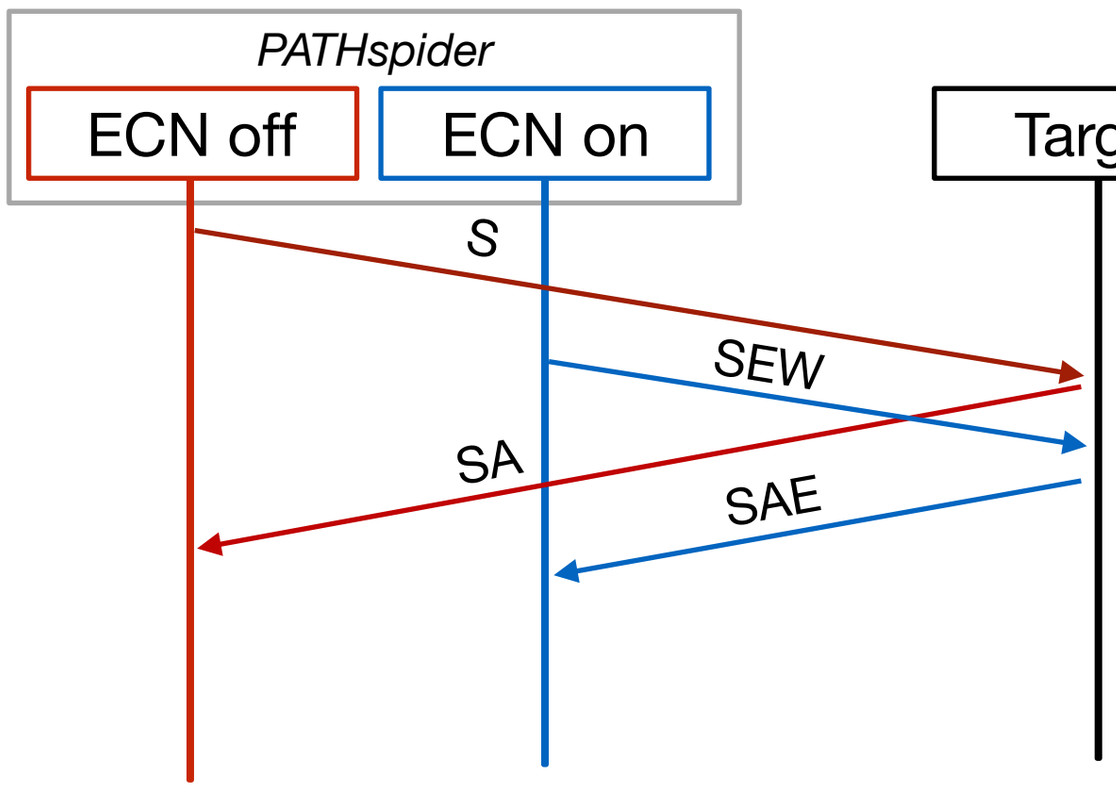

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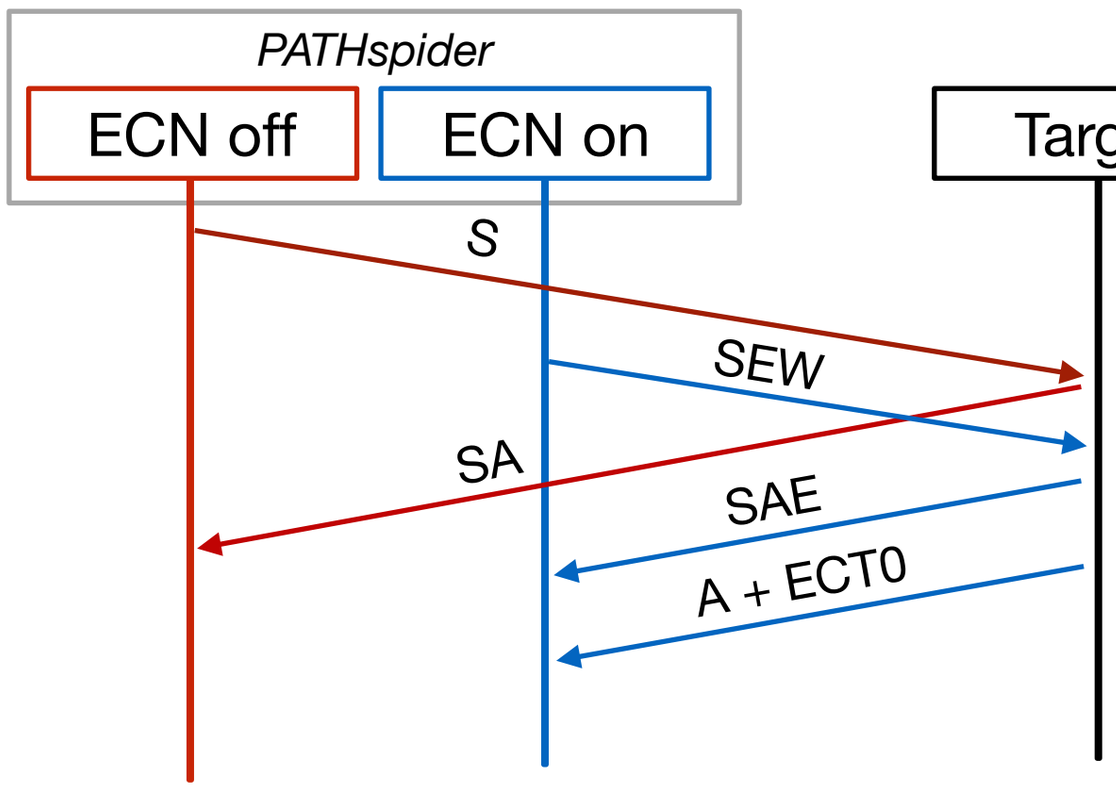

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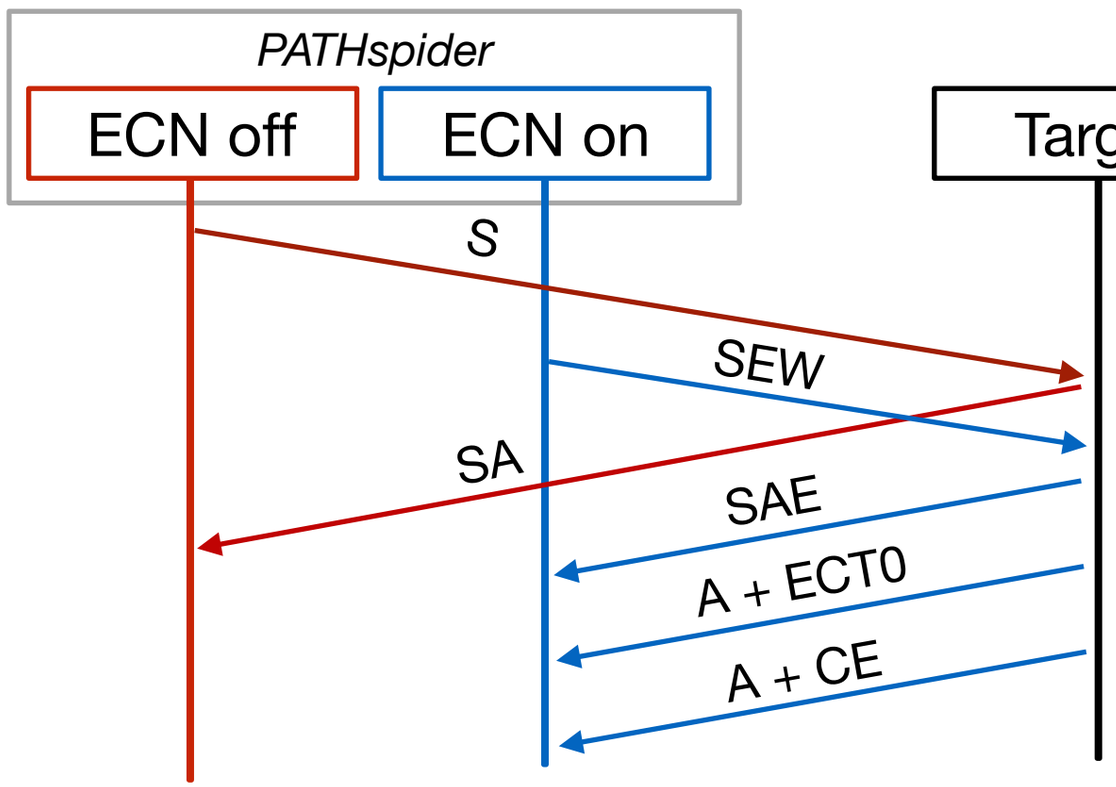

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generate traffic

negotiation $\xrightarrow{?}$ ECT marking

Results: ECN

Server-side ECN deployment continues to increase

And hosters are figuring out how to make v6 work…

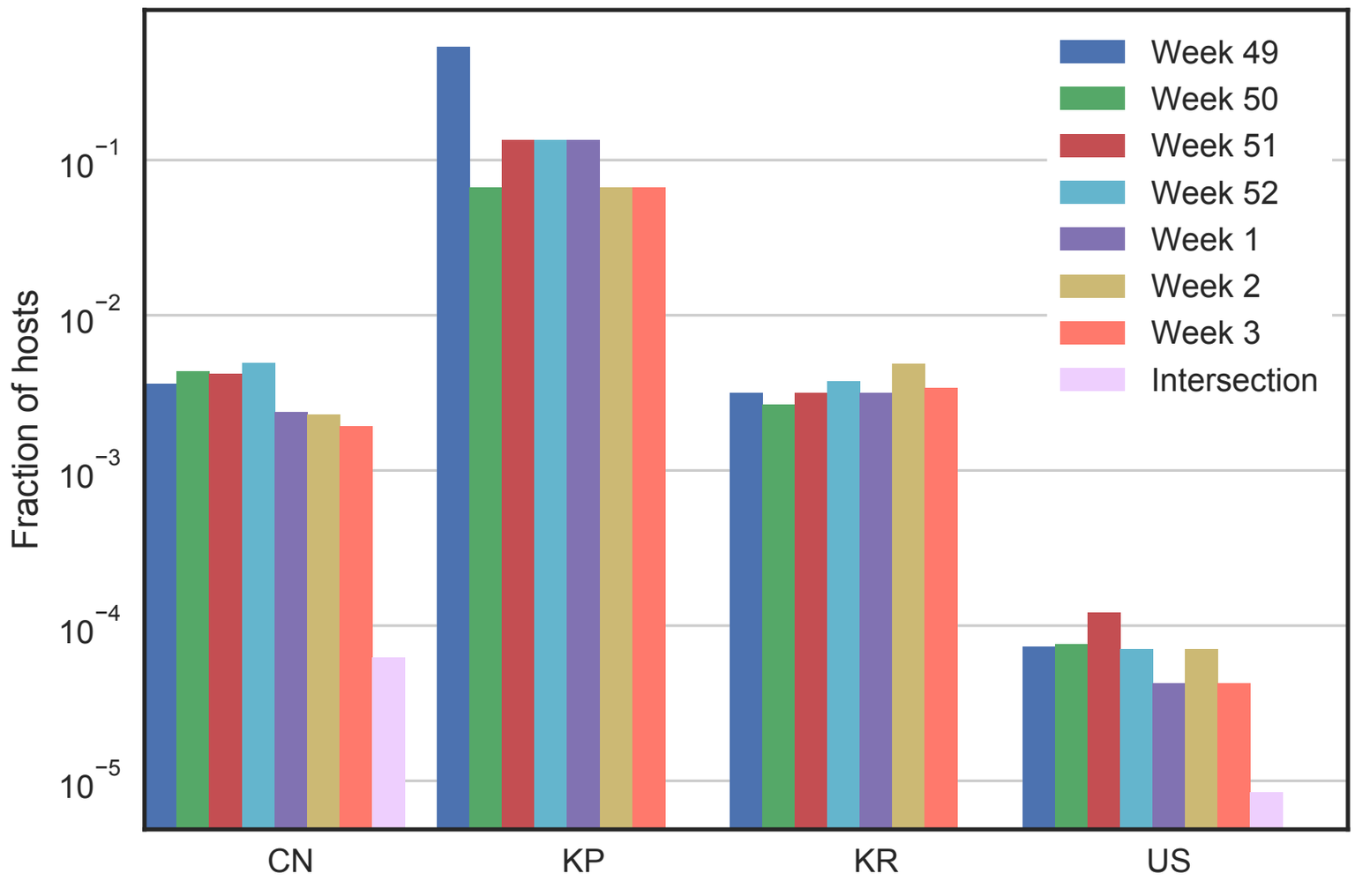
Continued: no change in errors in ECN once negotiated

June 2016				January 2017				
IPv4 n =617 873		IPv6 n =24 472		IPv4 n =675 289		IPv6 n =90 531		Description
hosts	pct	hosts	pct	hosts	pct	hosts	pct	
9221	1.49%	2637	10.78%	12583	1.863%	3621	4.000%	Completely failed to connect
432544	68.78%	20262	76.77%	498866	73.874%	82722	95.232%	Capable of negotiating ECN, of which:
11718	1.86%	2167	8.21%	15000	3.007%	6622	8.005%	Never mark ECT
-	-	-	-	30	0.006%	16	0.019%	Mark ECT1
1112	0.18%	964	3.65%	1851	0.274%	23	0.025%	Failed to connect w/ECN

On censorship and ECN interference

Heterogeneous TCP-layer censorship → more ECN path dependency

Automated measurements reduce path dependency noise floor



Conclusions

ECN brokenness good indicator for path impairments at L3/ L4

- Comprises additional codepoints both in IP and TCP
- Correlates with purposeful interference (censorship)

TCP Fast Open remains effectively a niche extension.

- Impairments are mainly access network linked

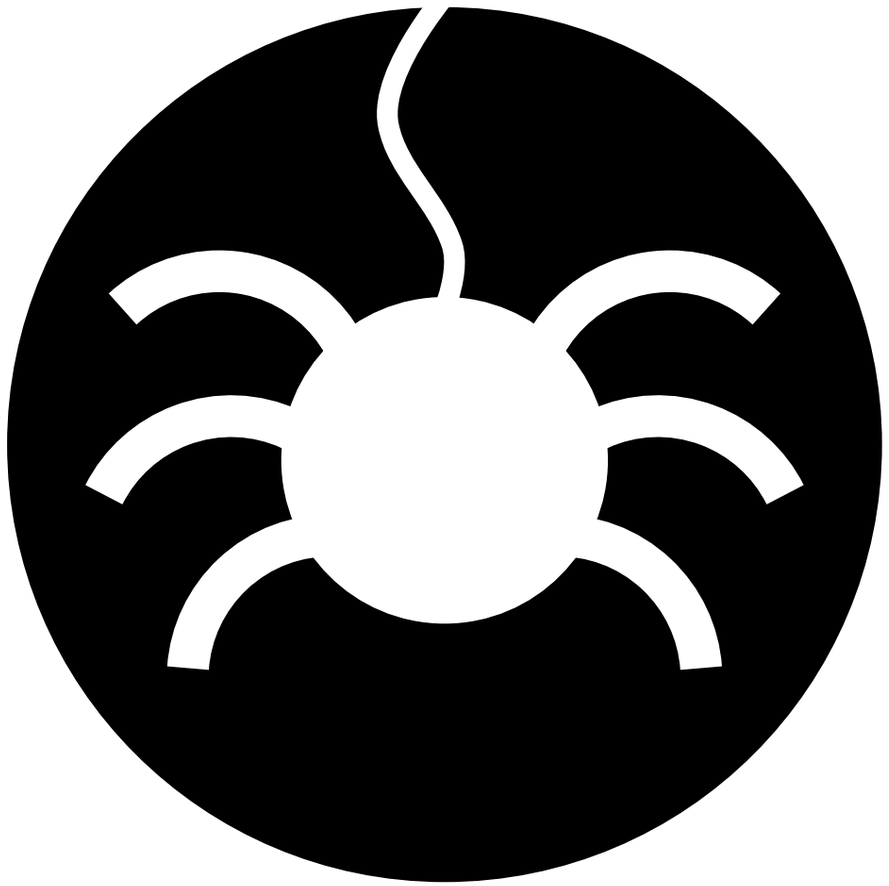
DSCP may be widely bleached

- But using DSCP doesn’t lead to connectivity risk.

Learn More

https://github.com/mami-project/pathspider

https://pathspider.net



```
# apt install pathspider
```

(2.0.0 release pending fixes to curl)