WP1: Measurements

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mami

measurement and architecture for a middleboxed internet

measurement | architecture | experimentation

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Objectives

- Initial and large-scale measurements of Internet path transparency in the Internet
  - Input to middlebox modeling (WP2)
  - Input to path layer architecture (WP3)
- Development of measurement tools
  - PATHspider, copycat, tracebox, revelio, ...
- Access to measurement data and analysis
  - Path Transparency Observatory (PTO)

Objectives: Progress M7-M18

- Initial and large-scale measurements of Internet path transparency in the Internet
  - Completion of Tracebox study as input to WP2
  - Confirmation of viability of UDP encaps for path layer
- Development of measurement tools
  - Building PATHspider into a measurement platform
- Access to measurement data
  - Initial PTO deployment
  - Continue PTO development based on lessons learned

Overview - Who does what?

Partner	MM	Task 1.1 Methodology and Tools	Task 1.2 Initial Measurement	Task 1.3 Large-Scale Measurement	Task 1.4 Data Model and Observatory
ETH	20	✓ pathspider	✓ ECN,TFO	✓ Edit D1.3	✓ Edit D1.2
ULg	12	✓ tracebox + copycat	✓ UDP/TCP, middlebox survey		
UoA	15	✓ pathspider	✓ ECN, DSCP	✓ DSCP	
ZHAW	8				✓
SRL	6	✓ revelio		✓ NAT detection, ECN on MONROE	

Summary

- Transition to large scale measurement

- Further development of core tools (PATHspider)

- Lessons learned from PTO applied to build a better, more sustainable observatory

Measurements Published and Presented

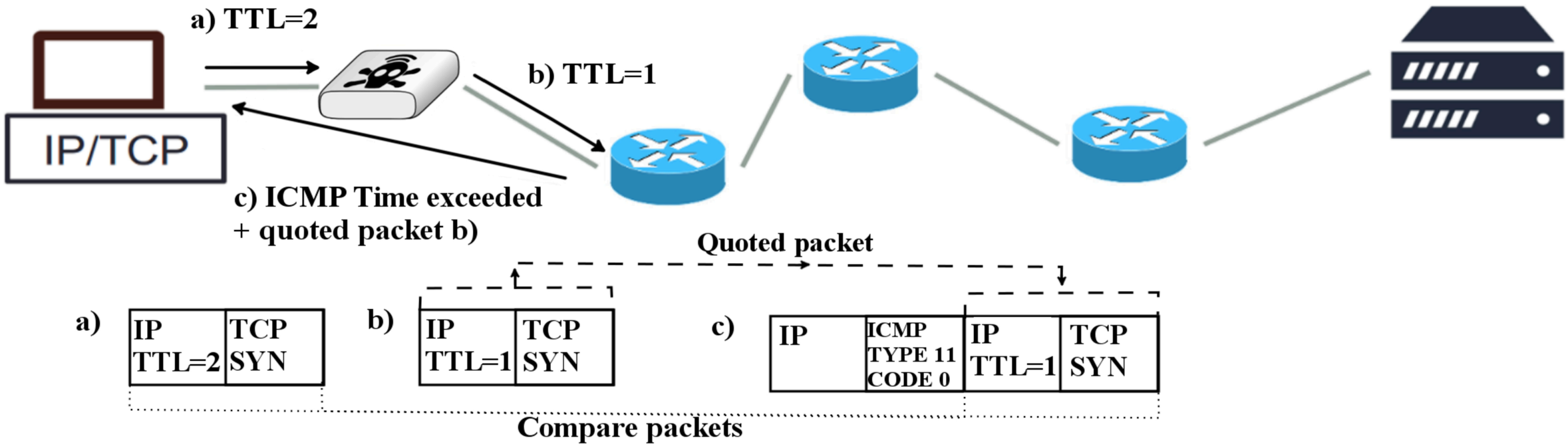
- "Observing Internet Path Transparency" at AIMS 2017, San Diego, 1 Mar 2017
- "Principles for Measurability in Protocol Design“ in ACM SIGCOMM CCR 2017
- "Path Transparency Measurements from the Mobile Edge with PATHspider“ at IEEE/IFIP Workshop on Mobile Network Measurement (MNM’17), Dubin, June 2017
- "copycat: Testing Differential Treatment of New Transport Protocols in the Wild" at ANRW 2017, Prague, 15 Jul 2017
- "Tracking transport-layer evolution with PATHspider" at ANRW 2017, Prague, 15 Jul 2017
- "A First Look at the Prevalence and Persistence of Middleboxes in the Wild" (tracebox) at ITC 29, Genoa, 4-8 Sep 2017 (WP1/WP2)

- A. M. Mandalari, A. Lutu, A. Dhamdhere, M. Bagnulo, kc claffy. Tracking the Big NAT across Europe and the US. arXiv cs.NI 1704.01296. April 2017.
- R. Zullo, A Pescapè, K. Edeline, B. Donnet. "Hic Sunt NATs: Uncovering Address Translation with a Smart Traceroute" MNM’17, June 2017.

WP1 Measurements and Tools

- tracebox
  - Middlebox Survey → WP2
- PATHspider
  - ECN, ECN++
  - DSCP
- Path Transparency Observatory (PTO)
  - version 3

tracebox - Concept



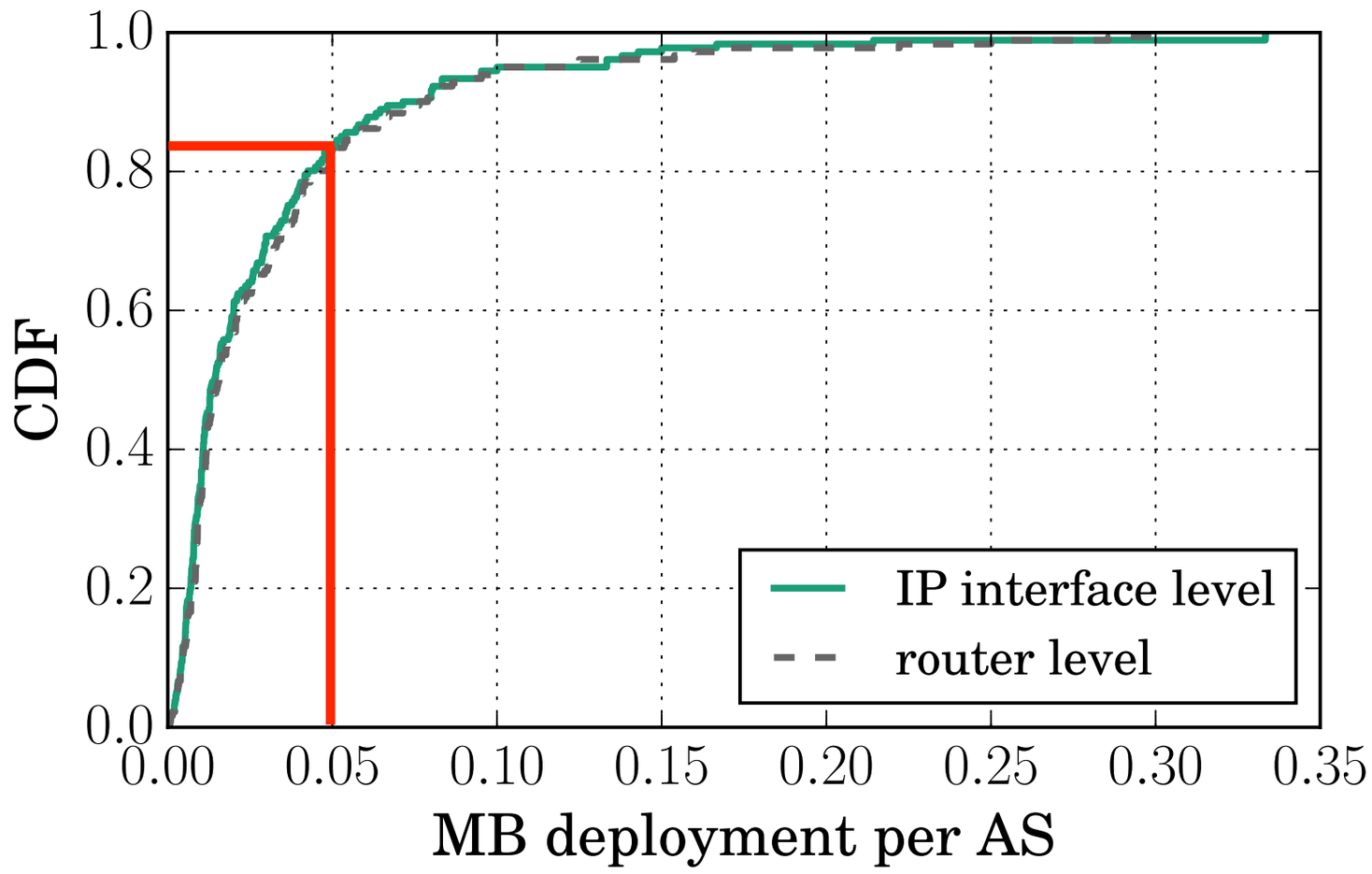
- Detect modifications by comparing packet headers reflected in ICMP Time Exceeded on a hop by hop basis

Dataset

- 14 `tracebox` campaigns
  - one every ~ 5 day
  - over 70 days
- 89 PlanetLab vantage points
  - 594,241 destinations
  - 9 ports tested
  - 0.5×10^9 probes sent
- Results
  - 948,457 responsive intermediate hops overall
    - 59,861 HTTP only
  - 2,978 ASes crossed

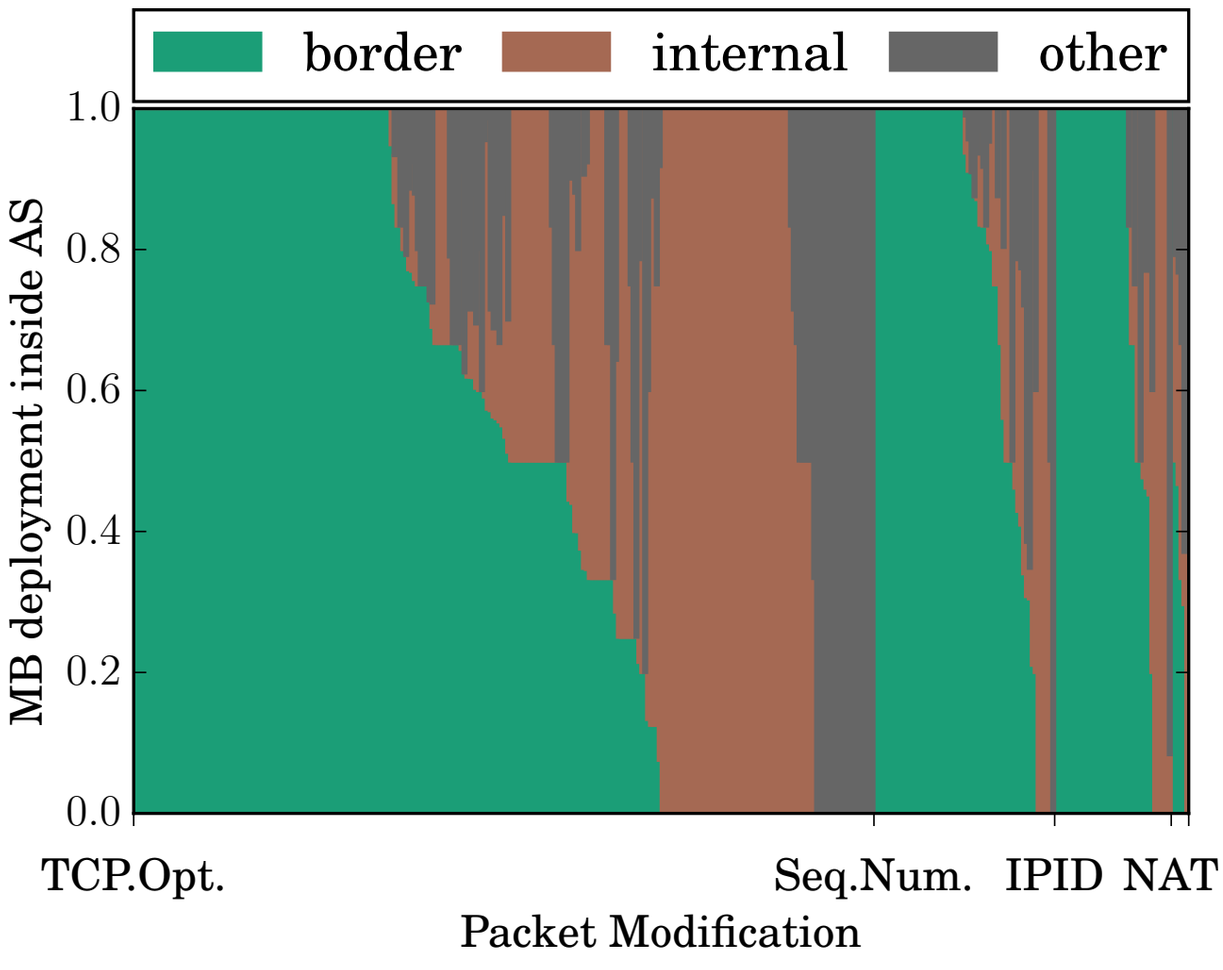
Prevalence - Deployment

- Deployed MB vs. IP interfaces
  - alias resolution: CAIDA ITDK



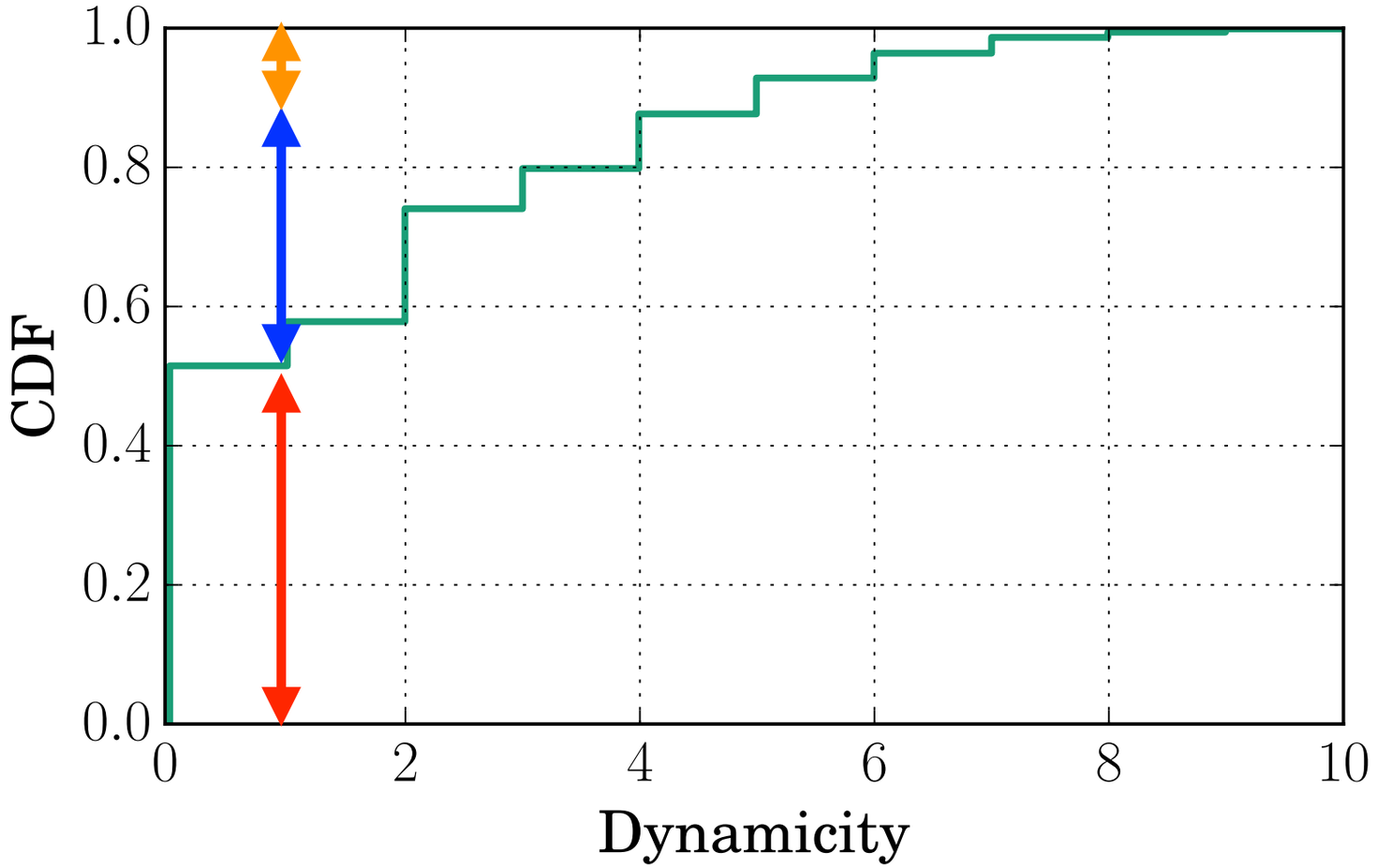
- In general, < 5% hops per AS modify packets

Prevalence - Position



- Border: 4,210 (52.6%)
- Internal: 2,931 (36.6%)
- Other: conflict or unable to derive position (9.1%) or moved (1.7%)
- *Most ASes tend to deploy most of their MBs at their border*
  - 65 ASes (19%) deploy the majority of their MBs in their core network.

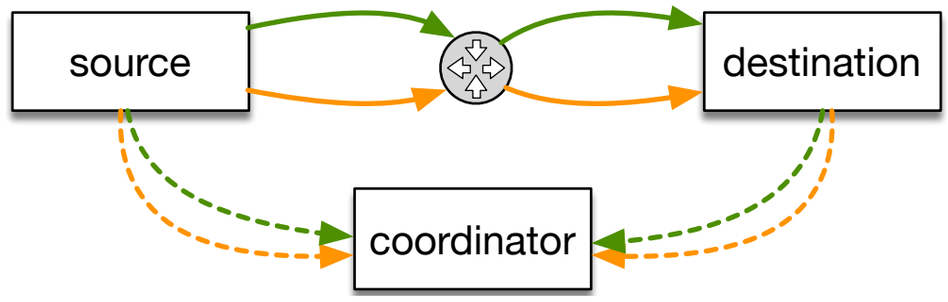
Persistence - Overview

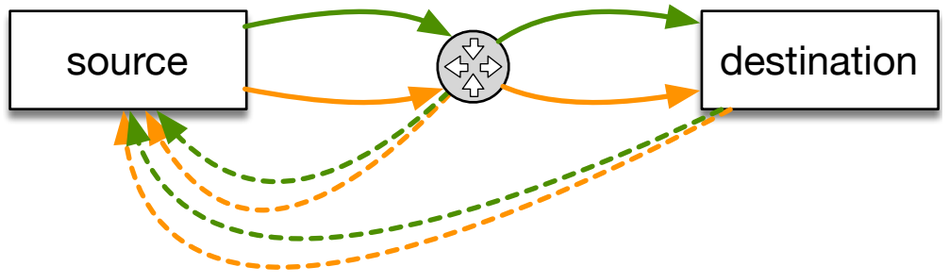


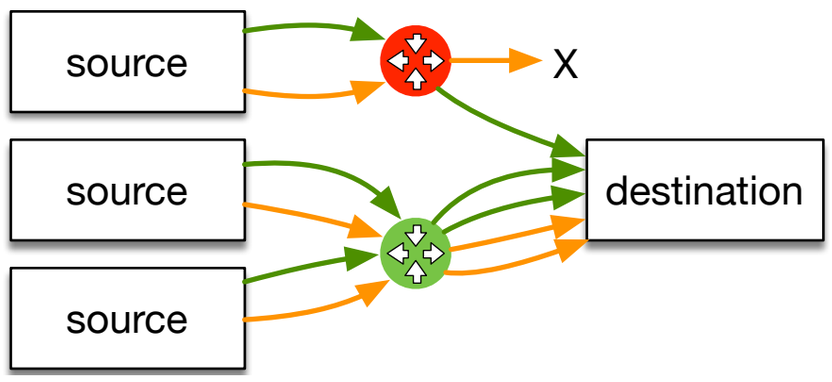
- 51% are stable
- 38% are slightly dynamic ([1:4])
- 11% are highly intermittent ([4:10])

PATHSpider - Review

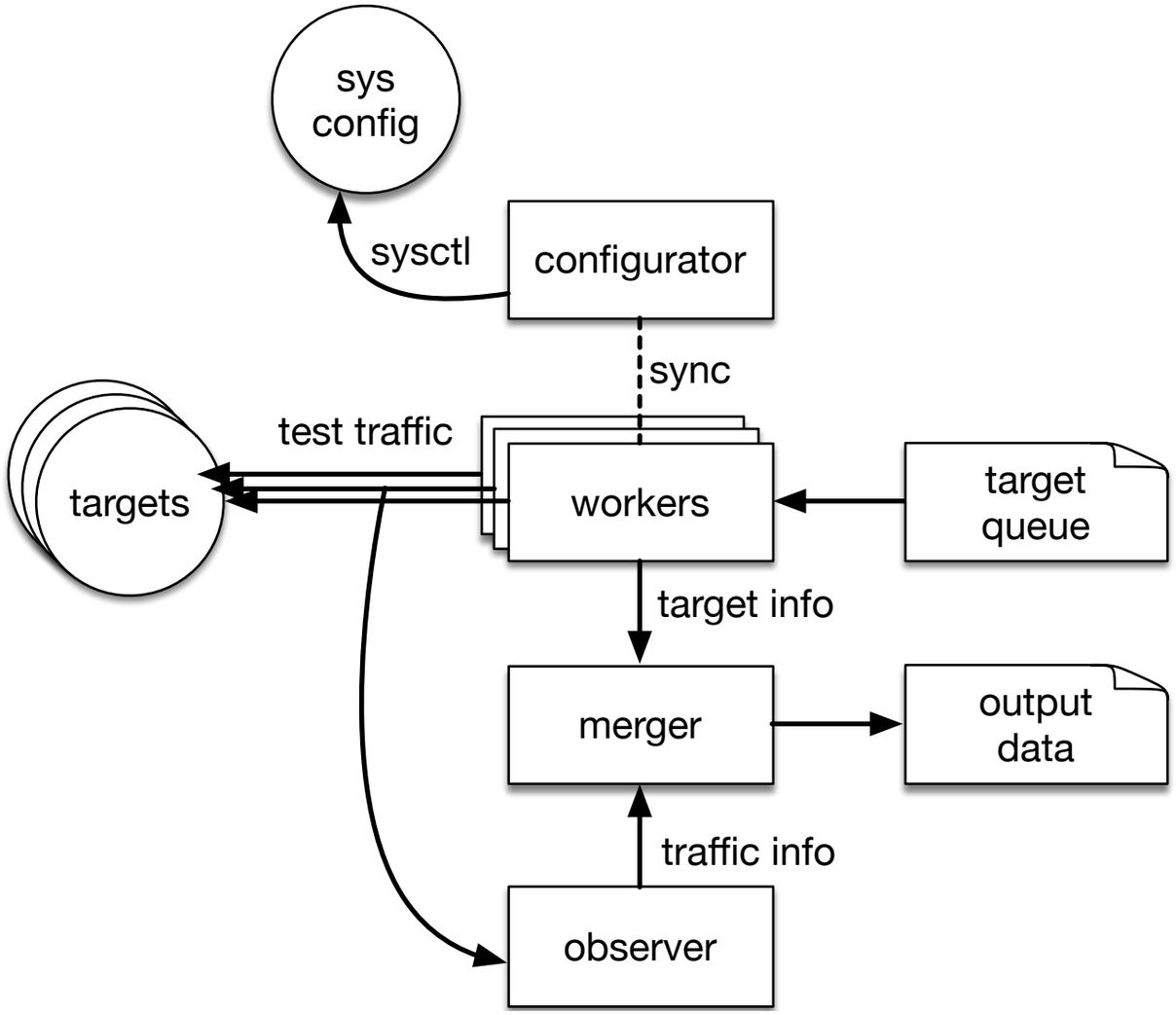
- Active measurement of path transparency
- Basic methodology
  1. throw a bunch of packets at the Internet
  2. see what happens.
- Ideal: two-ended A/B testing
- Scalable: one-ended A/B testing
- Multiple sources isolate on-path from near-target impairment
- PATHspider provides a framework for generalizing and scaling the one-ended approach.
- Details: see https://pathspider.net







PATHSpider - Design Review

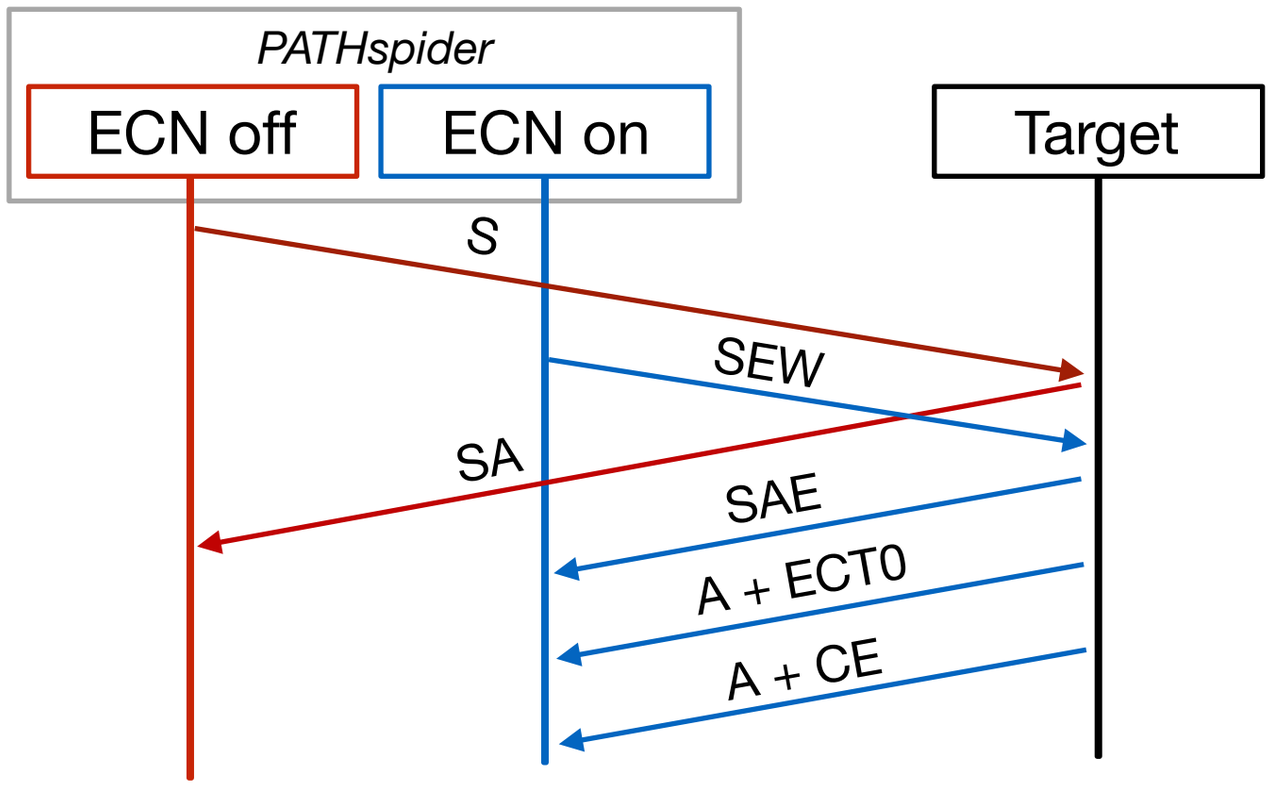


- *Configurator*: puts system into configuration A or B (e.g., `sysctl`)
- *Workers*: generate test traffic
- *Observer*: passively observes test traffic
- *Merger*: combine information about active measurement with passive observations.
- Plugins allow for customizing traffic generation and observation for each kind of test (ECN, DSCP, TFO, etc.)
- Output fed into Path Transparency Observatory

PATHspider - progress

- spiderweb: Automated cloud measurement
  - Cloud node provisioning via Saltstack
  - Automated upload to PTO
- MONROE integration
- Stability and sustainability improvements → 2.0 release
  - plugin and observer generalization
  - use of libcurl for connections
- WIP: tracebox integration

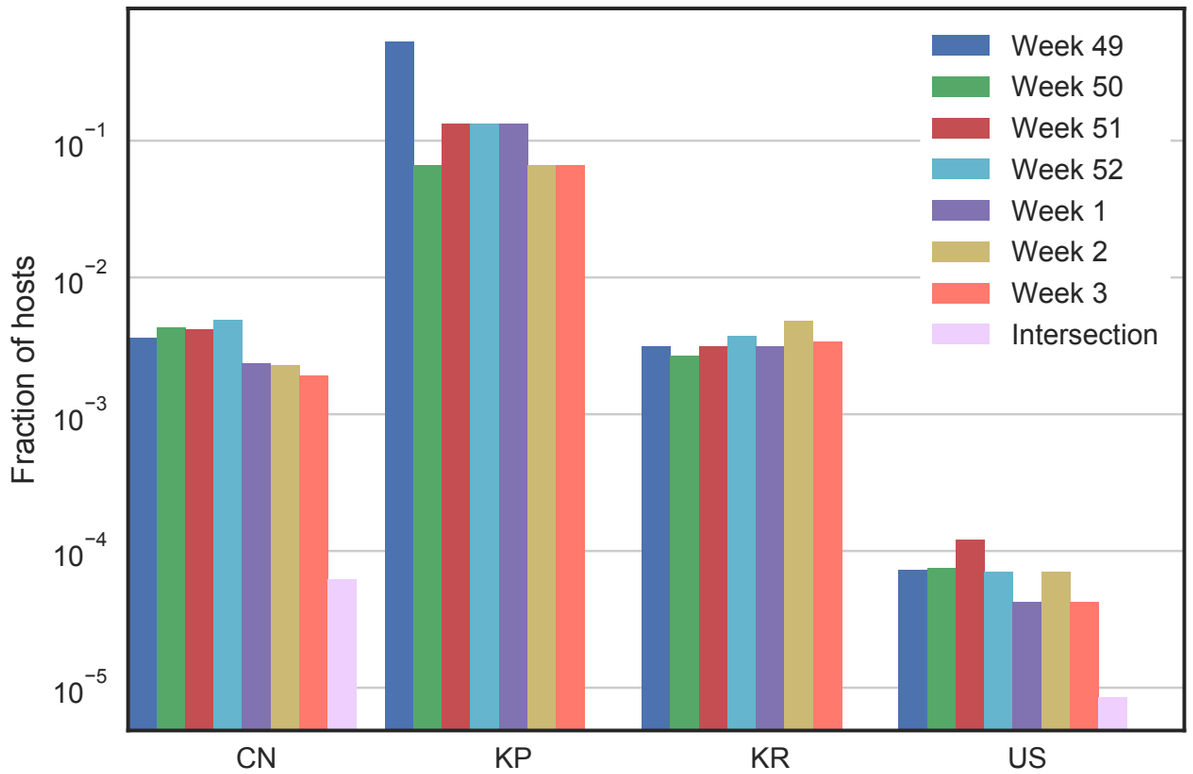
PATHspider Methodology Example: Explicit Congestion Notification (ECN)



- 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
- Measure ecn.*codepoint*.seen
  - Determine whether negotiation leads to ECT marking
  - Load path to attempt to induce CE marking

On Censorship and ECN Interference

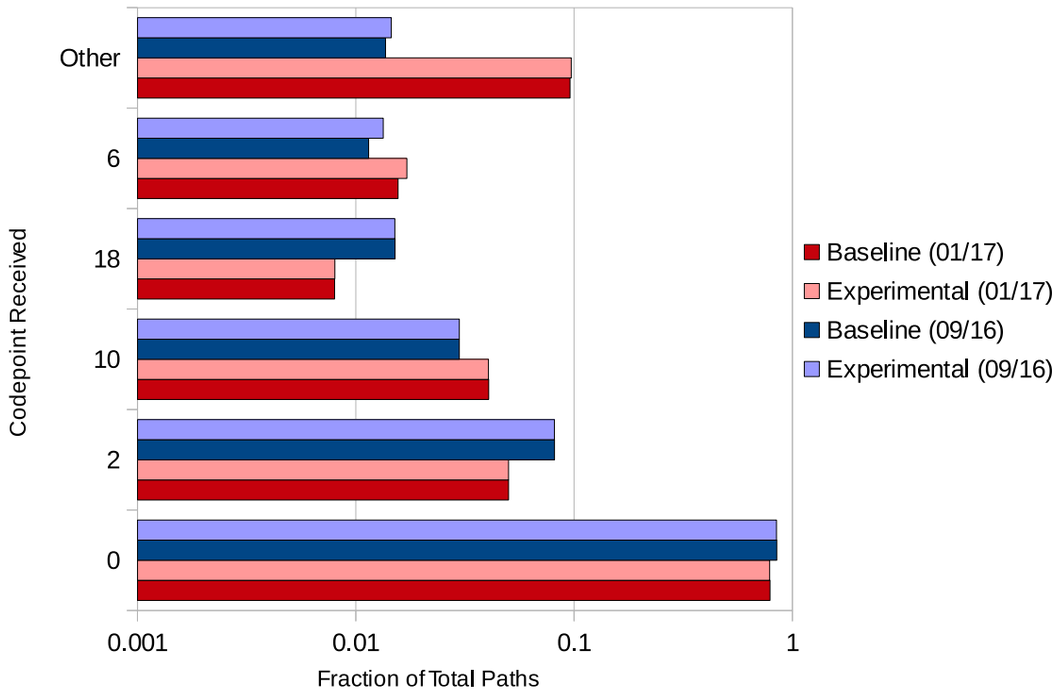
- Automated measurements reduce the noise floor on path-dependent ECN connectivity issues.
- Geolocation of targets with path-dependency: most probable in countries with documented heterogeneous TCP-layer censorship firewalls.



PATHspider Results: DSCP

Table 3: DSCP summary statistics for popular Web servers, September 2016 and January 2017

September 2016				January 2017				
IPv4 n =620 611		IPv6 n =52 766		IPv4 n =620 611		IPv6 n =52 766		Description
hosts	pct	hosts	pct	hosts	pct	hosts	pct	
35 768	5.76%	24 422	46.28%	63 177	10.18%	28 985	54.93%	Completely failed to connect
584 843	**94.24%**	**28 344**	**53.72%**	**557 434**	**89.82%**	**23 781**	**45.06%**	Successfully connted with DSCP 0 (default); of which:
2 321	0.40%	156	0.55%	1 770	0.32%	124	0.52%	Failed to connect when DSCP 46 (EF) used;
2 170	0.37%	154	0.54%	1 334	0.24%	121	0.50%	but succeeded from at least one vantage point
584 692	**99.99%**	**28 342**	**99.99%**	**556 998**	**99.92%**	**23 778**	**99.98%**	Successfully connected with 46 (EF)



- Negligible blocking of a common DSCP codepoint (Expedited Forwarding, 46) from DigitalOcean vantage points.
  - Most blocking seems path-dependent.
- DSCP on return not dependent on DSCP on request.

Measuring ECN++

Feedback mode	Packet	TCP ECN flags (NS:CWR:ECE)		Allowed IP ECN	
		Description	flags	ECN	ECN++
Non-ECN	All	ECN disabled	000	00	00
ECN	SYN	ECN setup SYN	011	00	00
	SYN/ACK	ECN setup SYN/ACK	001	00	XX
	Data	Regular	000	XX	XX
		Echo CE	001	XX	XX
		CWnd Reduced	010	XX	XX
	Control & RTX	Same as data packet		00	XX

- ECN++ [draft-bagnulo-tswg-generalized-ecn]: ECN on control packets
- Test path support for SYN+ECT, pure ACK + ECT, FIN + ECT
- Revisit path support for SYN/ACK + ECT (RFC 5562)
- Multiple tools: tracebox, PATHspider
- Multiple platforms: MONROE (11 mobile) Planetlab (multiple fixed)
- Under submission

Path Transparency Observatory

- Demo at last review, initial at AIMS 2017 presentation
- Lessons learned:
  - Internal data model based on automated analysis made experimentation far too rigid.
  - Reliance on "big data" technologies results in lots of overhead and very little win; frameworks lock you in.
  - RESTful API design works better when fully embraced.
- Outcome: PTO3, in progress

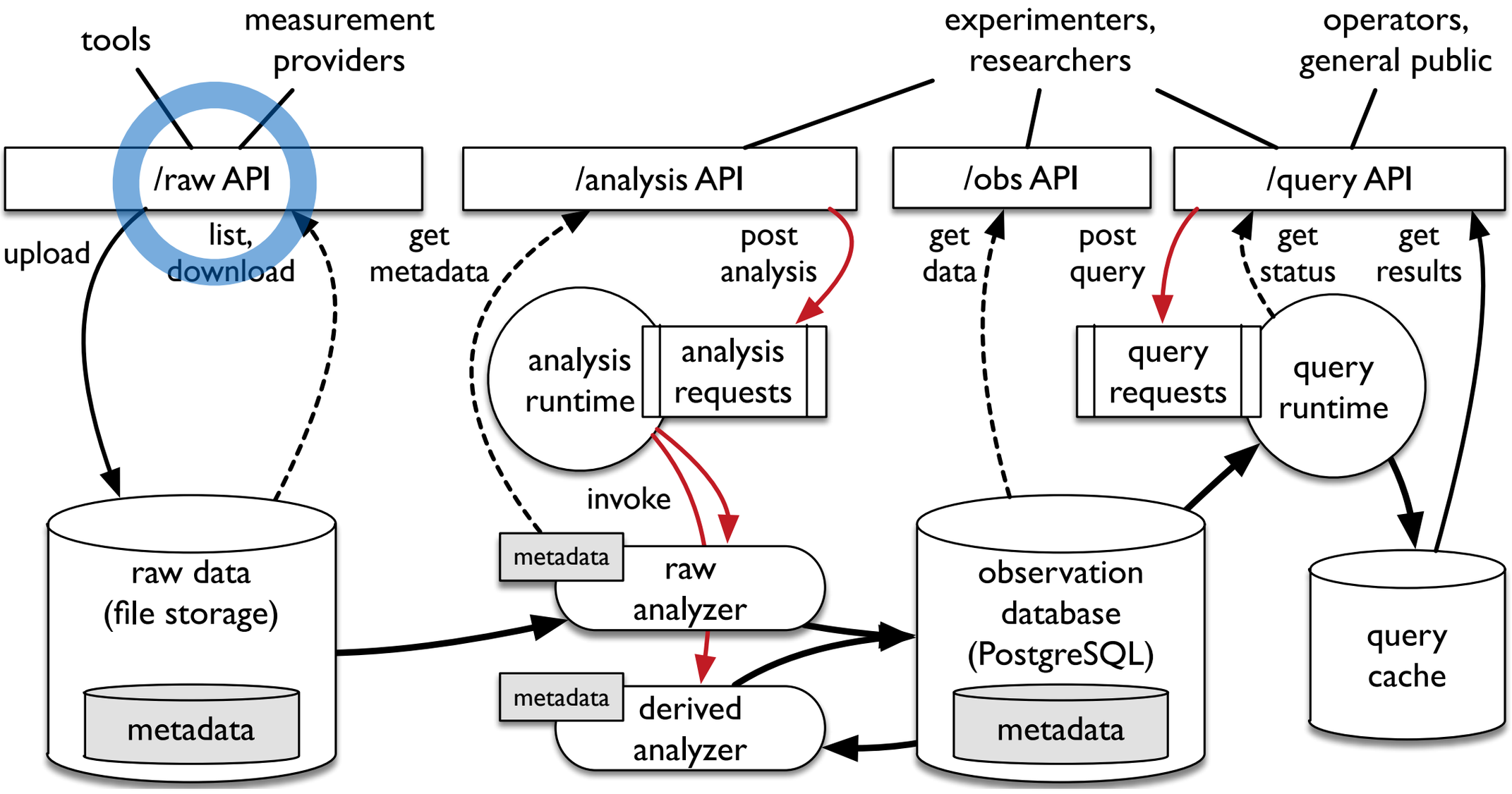
Path Transparency Observatory Data Model

- 1st stage (raw) analysis converts raw data in any format to *base* observation four-tuples:

{t, p, c, v}

  - t: time interval during which observation is valid
  - p: path, a sequence of path elements from observation point or source to target or destination
  - c: condition observed (within a defined space of conditions)
  - v: optional value associated with condition observed
- *n*th stage produces *derived* observations from base observations

Path Transparency Observatory Design (refined)



Path Transparency Observatory API (now more RESTful)

- Raw data organized into campaigns containing files
  - **`/raw/`***`campaign/file`*: extensible metadata
  - **`/raw/`***`campaign/file`***`/data`**: content, immutable
- Analysis performed by analyzers
  - **`/analysis/`***`analyzer`*: extensible metadata
- Observations produced by analysis organized into sets
  - **`/obs/`***`set`*: extensible metadata, provenance via references to raw data and analyzer by URL
  - **`/obs/`***`set`***`/data`**: content, immutable but can be deprecated
- Queries become result sets that can be externally referenced
  - **`/query/`***`id`*: status of running query, result metadata
  - **`/query/`***`id`***`/result`**: content, immutable

Path Transparency Observatory
Advantages of Further Development

- Raw data storage as raw files with metadata in sidecar
  - ease of backup and replication
- Observation storage in relational database
  - Grouping into sets makes provenance tractable
  - Interface via `/obs` API and to analyzers via ndjson
- Analyzer interface: UNIX stdin/stdout and commandline
  - Analysis tools may be written in any language,
    tested without the PTO framework, generalized beyond PTO
- RESTful API makes every stage of analysis referencable
  - Full provenance through link traversal:
    `/query` → `/obs` → `/analysis` + `/obs` → `/analysis` + `/raw`

Outlook

- Transition to tool maintenance (new T1.5, if extended)
  - PTO3, PATHspider 2.0
- Continue large scale measurement campaigns
  - Cloud providers, MONROE