Towards Viable Information Infrastructures for Trustworthy Networking

Random, General Thoughts
Illustrated with Frustrations from Robust Interdomain Routing

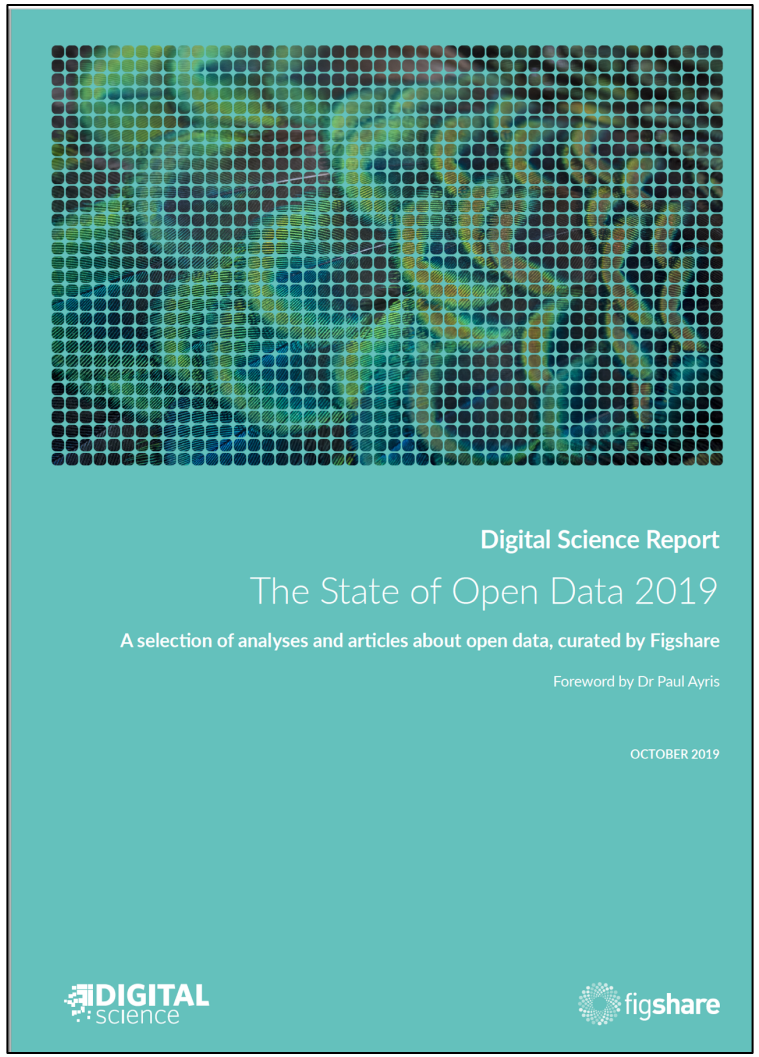
Doug Montgomery (dougm@nist.gov)

https://www.nist.gov/programs-projects/robust-inter-domain-routing

Open Knowledge Network ?

- **OKN-KISMET**
  - Outline research agenda.
  - The goal is to start thinking about …something with "transformative impact".
- **What are others thinking?**

- The State of Open Data 2019
  - https://digitalscience.figshare.com/articles/The_State_of_Open_Data_Report_2019/9980783
- FAIR - Findable, Accessible, Interoperable, Reusable
  - https://www.go-fair.org/fair-principles/
- Internet of FAIR Data & Services
  - https://www.go-fair.org/resources/internet-fair-data-services/
- Creating Value From Open Data
  - https://www.europeandataportal.eu/sites/default/files/edp_creating_value_through_open_data_0.pdf
- Open Government Data Act
  - https://www.data.gov/open-gov/

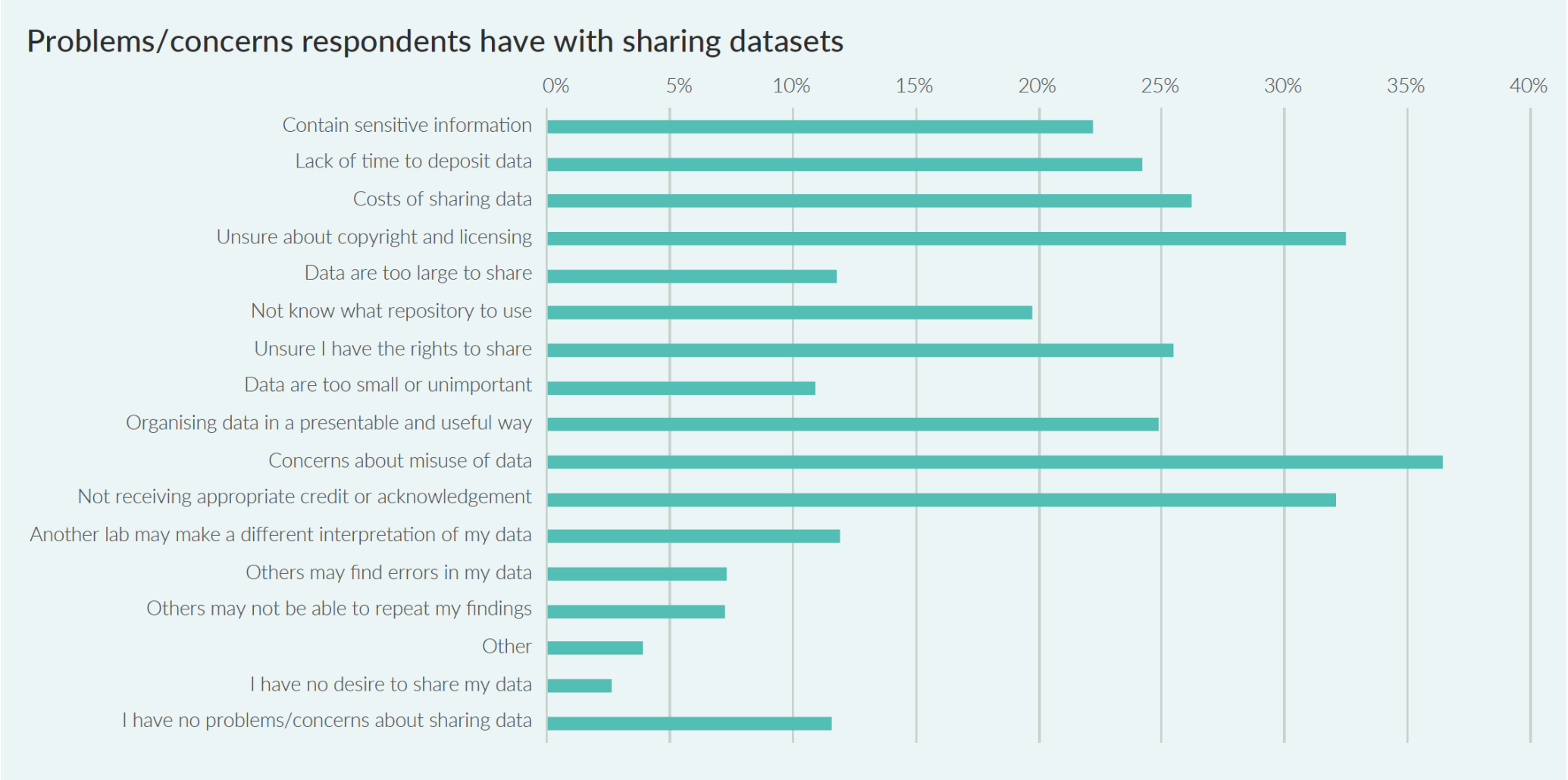


GO FAIR - Findable, Accessible, Interoperable, Reusable

https://www.go-fair.org/fair-principles/

- **Findable**
  The first step in (re)using data is to find them. Metadata and data should be easy to find for both humans and computers. Machine-readable metadata are essential for automatic discovery of datasets and services.
  - (Meta)data are assigned a globally unique and persistent identifier
  - Data are described with rich metadata
  - Metadata clearly and explicitly include the identifier of the data they describe
  - (Meta)data are registered or indexed in a searchable resource
- **Accessible**
  Once the user finds the required data, she/he needs to know how can they be accessed, possibly including authentication and authorization.
  - (Meta)data are retrievable by their identifier using a standardised communications protocol
  - The protocol is open, free, and universally implementable
  - The protocol allows for an authentication and authorisation procedure, where necessary
  - Metadata are accessible, even when the data are no longer available
- **Interoperable**
  The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing.
  - (Meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
  - (Meta)data use vocabularies that follow FAIR principles
  - (Meta)data include qualified references to other (meta)data
- **Reusable**
  The ultimate goal is to optimize the reuse of data. To achieve this, metadata and data should be well-described so that they can be replicated and/or combined in different settings.
  - Meta(data) are richly described with a plurality of accurate and relevant attributes
  - (Meta)data are released with a clear and accessible data usage license
  - (Meta)data are associated with detailed provenance
  - (Meta)data meet domain-relevant community standards

Barriers to Open Knowledge Networks?

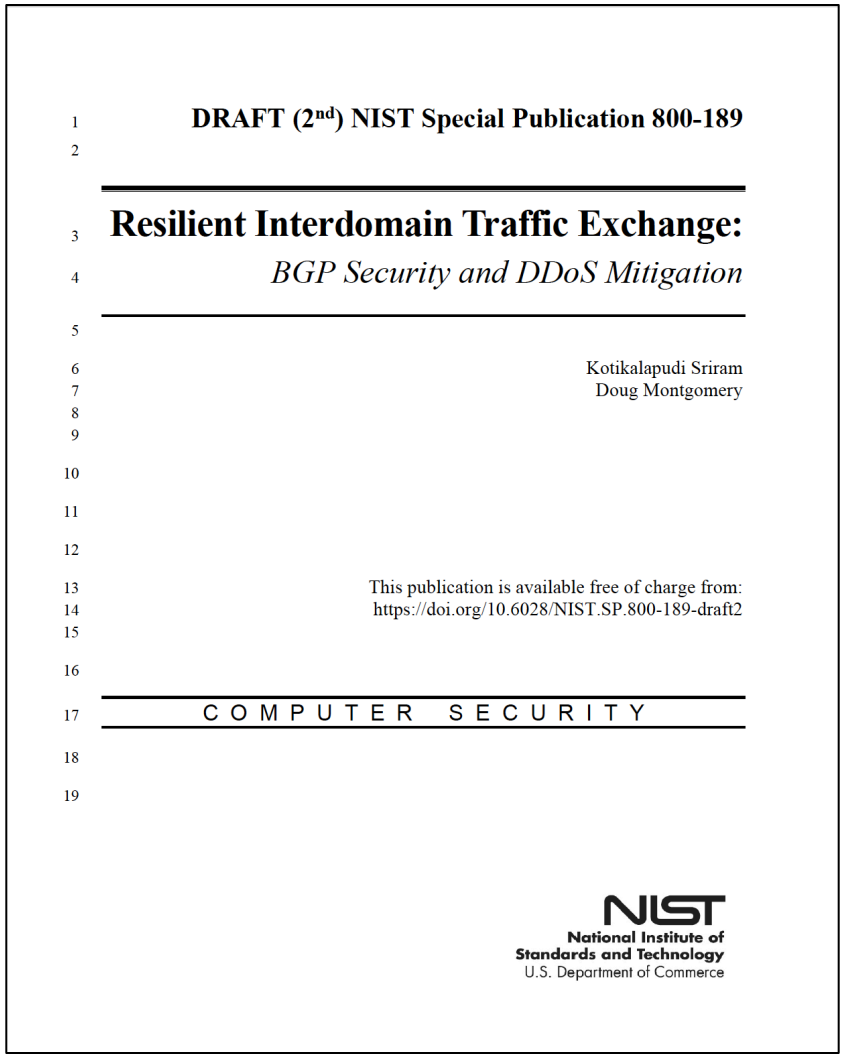


https://digitalscience.figshare.com/articles/The_State_of_Open_Data_Report_2019/9980783

BGP “Robustness Data” and OKNs?

Data Sets to address BGP Robustness Issues

- **BGP Robustness Issues**
  - Unauthorized originations (hijacks)
  - BGP AS-Path manipulations to misdirect traffic, undermine origin validation.
  - Detecting and mitigating “route leaks”.
    - https://tools.ietf.org/html/rfc7908
  - Enabling Source Address Validation (SAV) in the data plane.
    - Anti-spoofing techniques.
- **What data sets are necessary?**
  - To design, test, and implement viable solutions?



DRAFT (2nd) NIST Special Publication 800-189

Resilient Interdomain Traffic Exchange:
BGP Security and DDoS Mitigation

Kotikalapudi Sriram
Doug Montgomery

This publication is available free of charge from:
https://doi.org/10.6028/NIST.SP.800-189-draft2

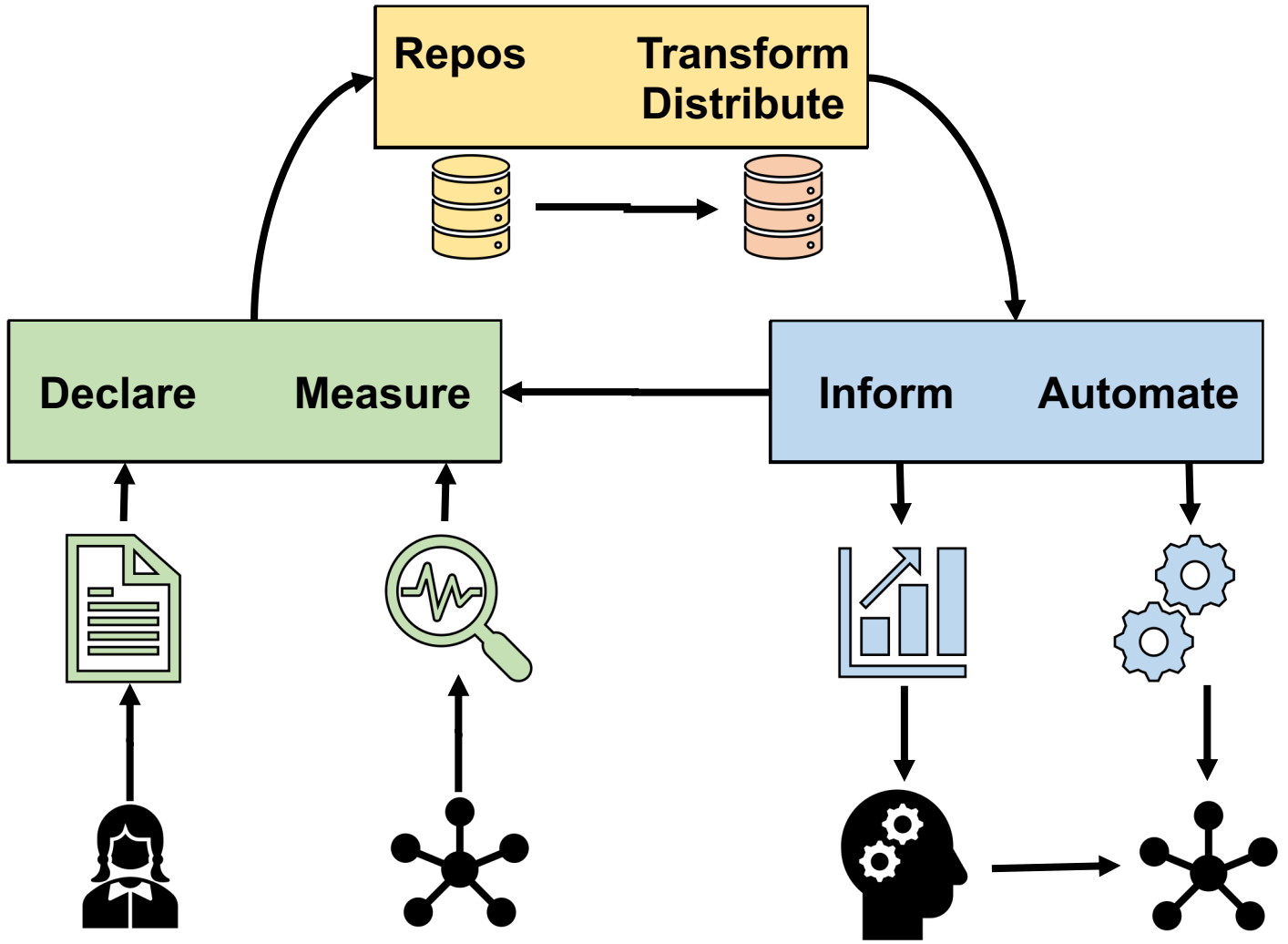
COMPUTER SECURITY

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

https://csrc.nist.gov/publications/detail/sp/800-189/draft

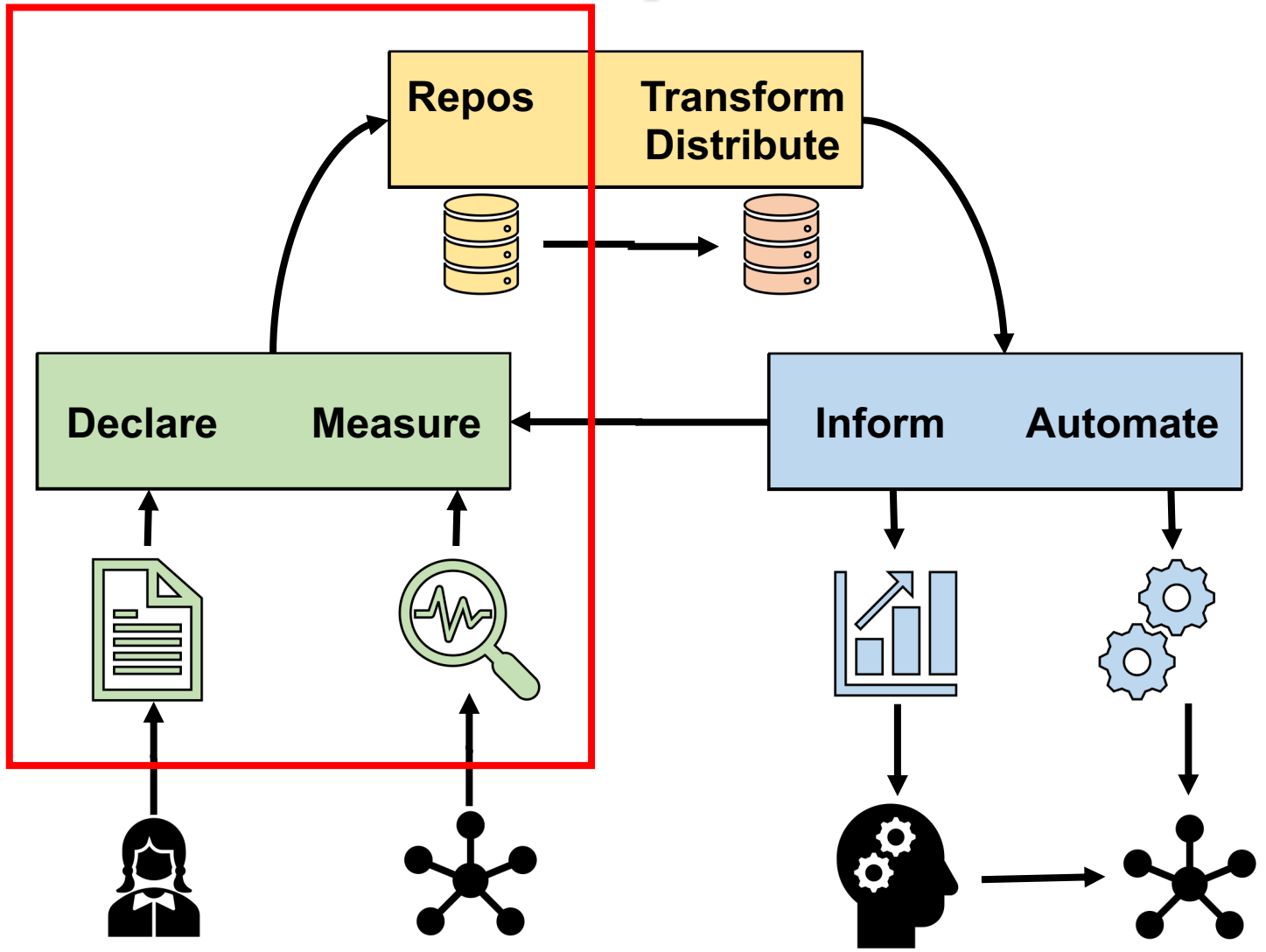
Info Infrastructure for Trustworthy BGP

- **Producers**
  - Declarative
    - Whois, RPKI, IRR
  - Measured
    - Routeviews, RIS
- **Data**
  - Repositories
    - RPKI, Routeviews
  - Intermediaries
- **Consumers**
  - Informative
    - Publications, Anomaly Detectors
  - Automation
    - BGP Route Filters, SAV



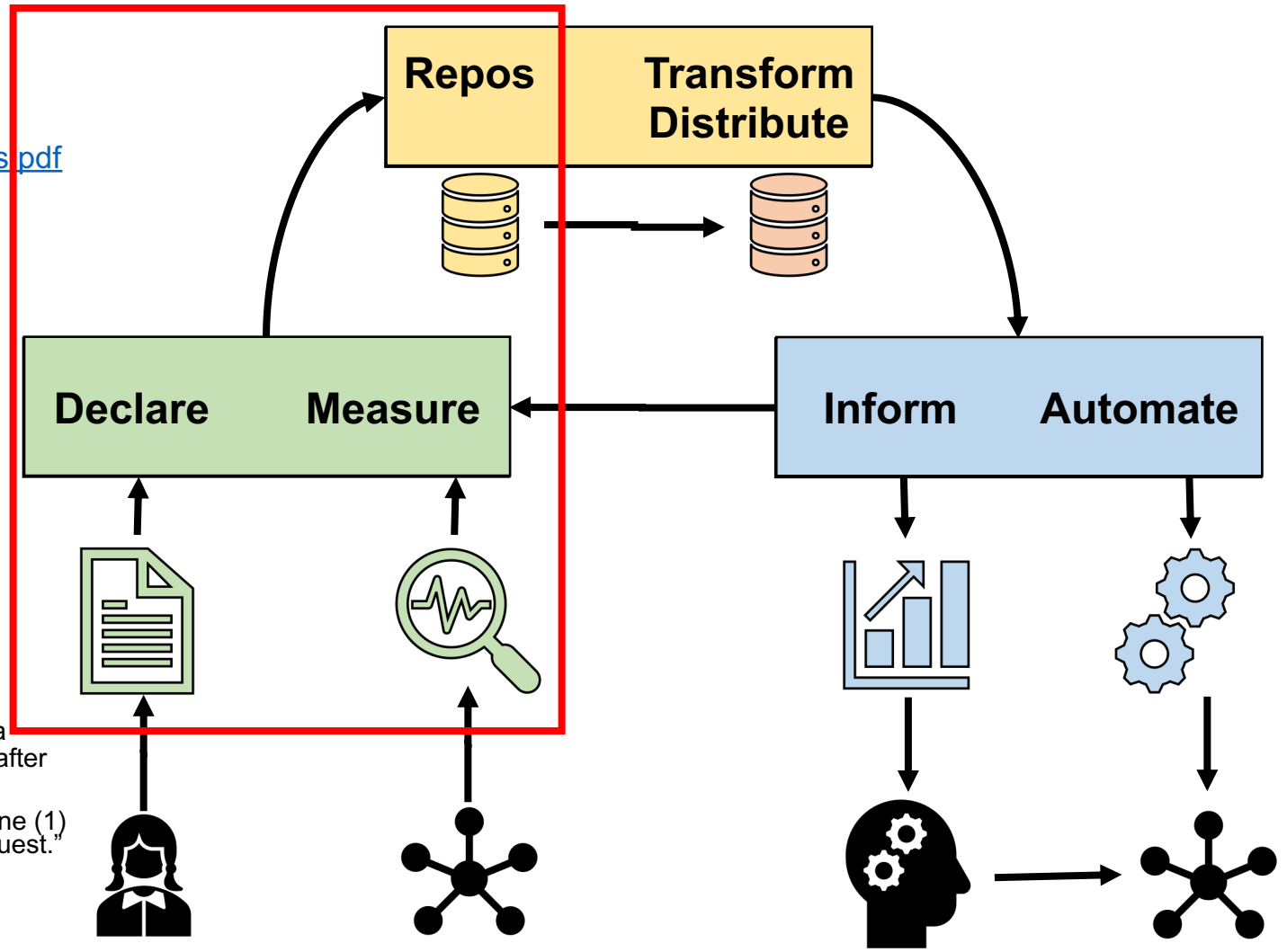
Information Infrastructure Properties

- **Producers**
  - Access control & Authentication
    - Who / what provides input
    - How do you verify above?
  - Information Quality
    - Correctness
    - Completeness
    - Uncertainty
  - Responsiveness / Liveness
    - Input stimulus to repository
    - Purging stale data



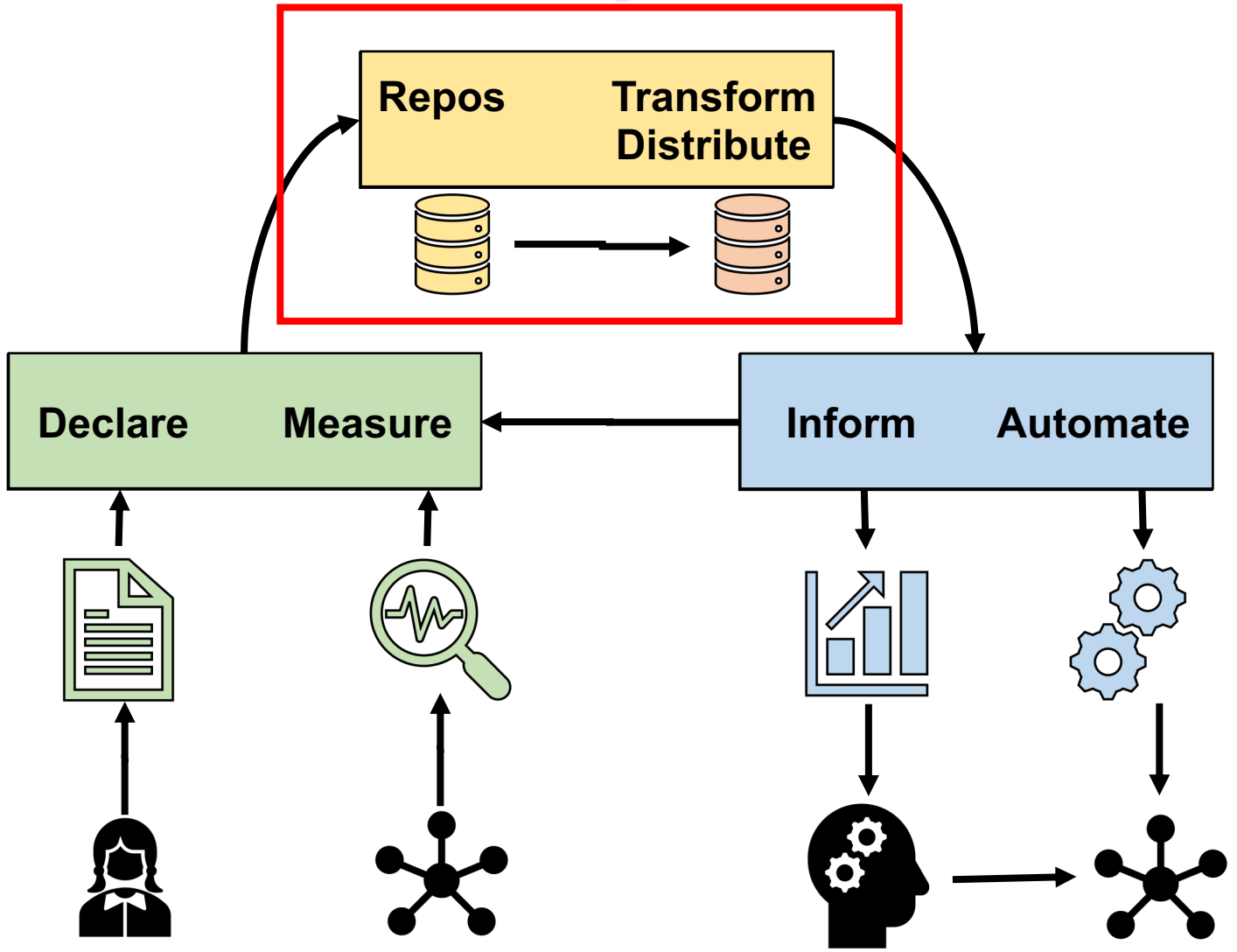
Information Infrastructure Properties

- **BGP Producers**
  - CPS – Certificate Practice Statement
    - https://www.arin.net/resources/manage/rpki/cps.pdf
  - RPKI
    - Strong Access control & Authentication Model
    - ARIN – constrained by implications of RSA.
  - Information Quality
    - Mechanisms to help users avoid input errors.
    - Informal efforts to scrub RPKI data with measurement data.
  - Measurement data is ground truth?
    - How do we know that BGP data sent to collector is not malicious?
  - Responsiveness / Liveness
    - CPS – a vague SLA?
      - Designed for resource assignment & transfer.
      - "ARIN expects to issue a certificate attesting to a resource allocation within one (1) business day after approval of the allocation."
      - "ARIN will process a revocation request within one (1) business day of receipt and validation of the request."
    - Need data on measured performance of RPKI production system.



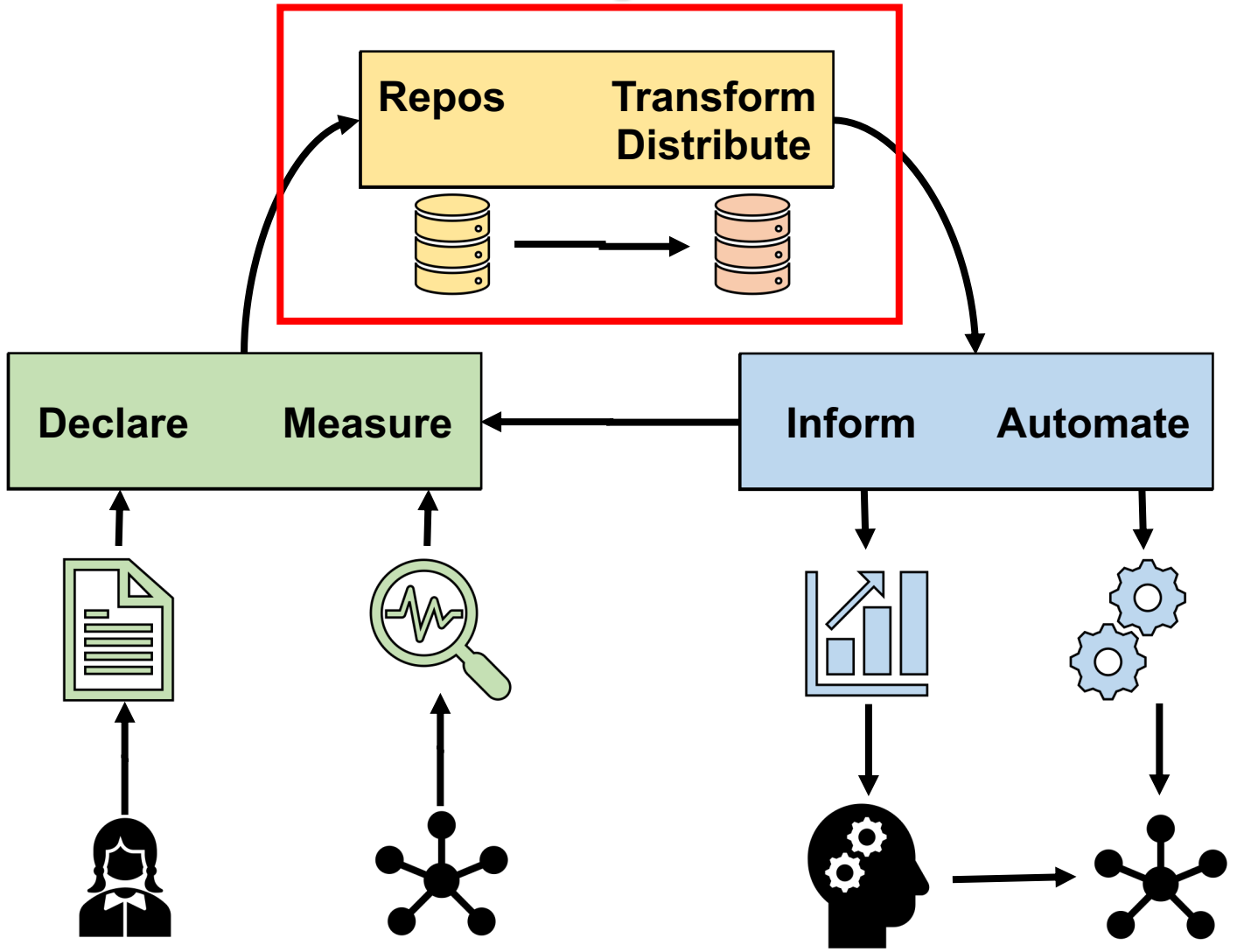
Information Infrastructure Properties

- **Data Repositories**
  - Access control & Authentication
    - Who / what can access data?
    - How do you verify above?
    - Privacy issues?
  - Information Quality
    - Meta data for completeness, correctness, uncertainty?
  - Repository Quality
    - Integrity / Availability
  - Transformation / Distribution
    - To promote interoperability
    - To foster adoption / use
    - To scale dissemination



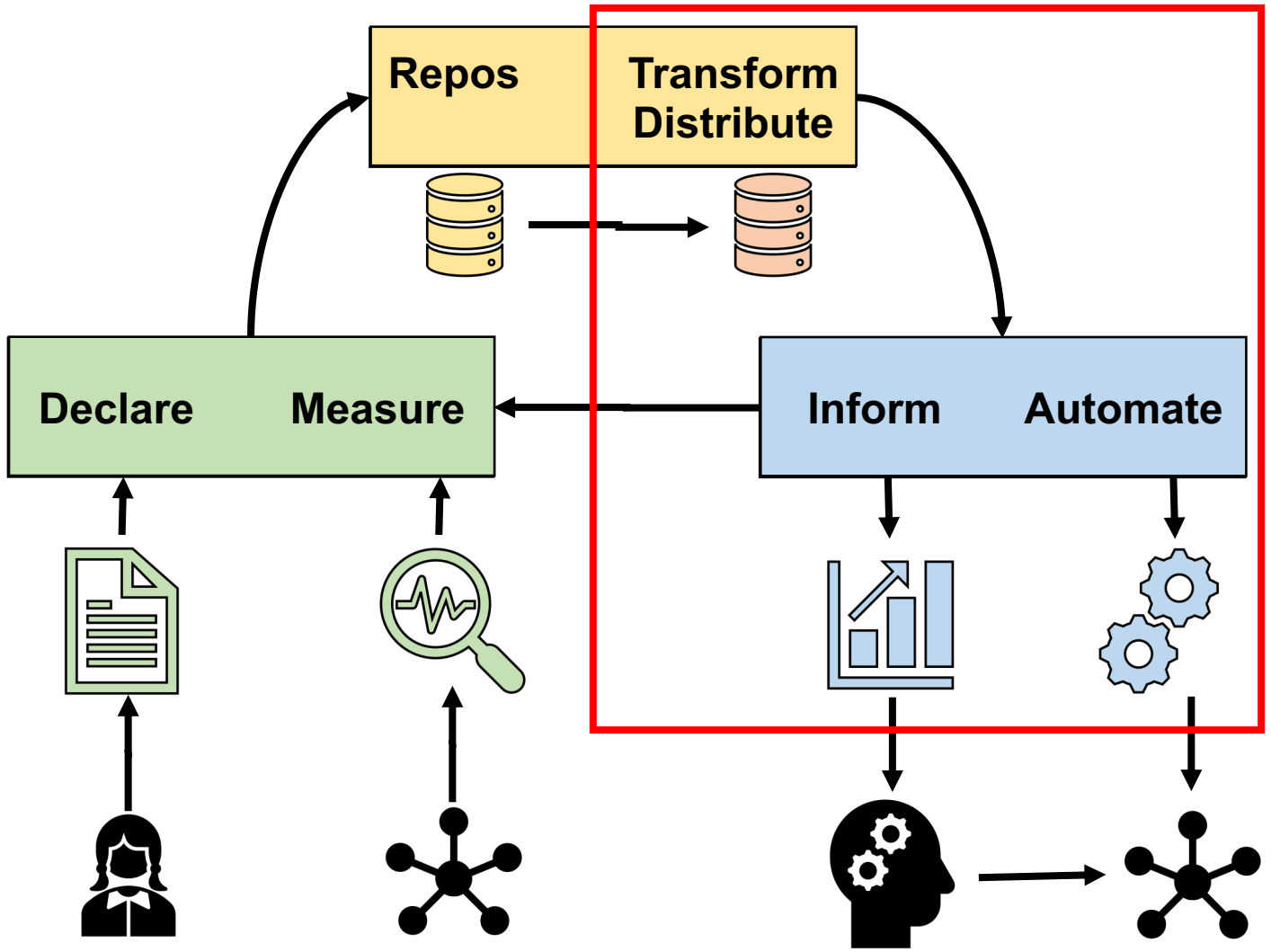
Information Infrastructure Properties

- **BGP Data Repositories**
  - RPKI
    - ARIN - Must accept Relying Party Agreement (RPA) to access data.
    - https://www.arin.net/resources/manage/rpki/rpa.pdf
  - Repository Quality
    - RPKI provides repository integrity / authentication.
    - Repository availability needs to be measured.
  - Transformation / Distribution
    - RPKI to RPSL for local use.
      - https://blog.apnic.net/2018/08/01/treating-rpki-roas-as-irr-route6-objects/
    - RPKI to JSON to CDN to scale distribution, ensure consistency.
      - https://blog.cloudflare.com/cloudflares-rpki-toolkit/
    - RPKI + BMP + Kafka for OV in data centers
      - https://sites.google.com/site/amitsciscozone/home/networking-datascience/bgp-prefix-origin-validation-without-rpki-in-datacenter-networks



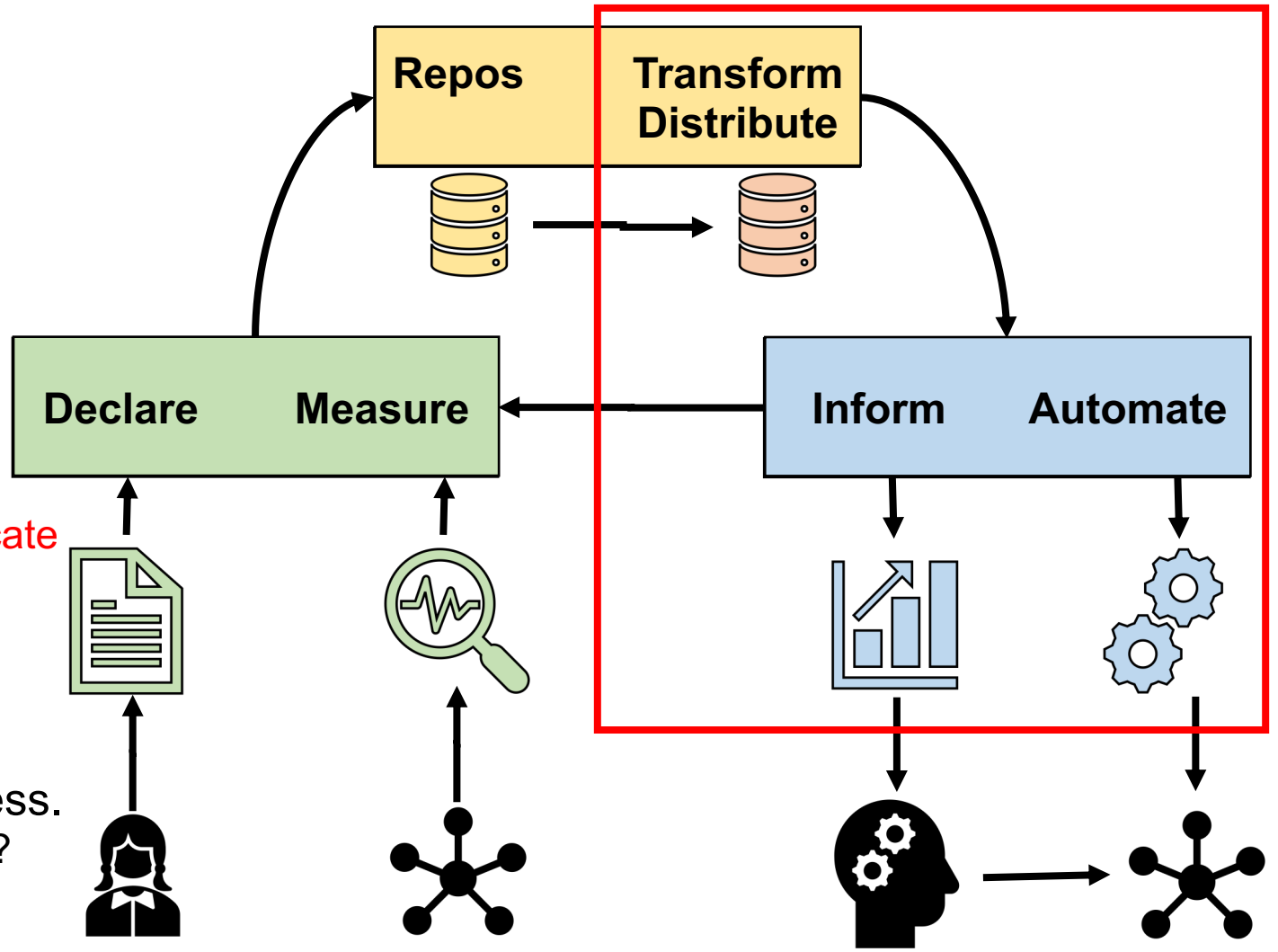
Information Infrastructure Properties

- **Data Consumers**
  - Access control & Authentication
    - Who / what can access data?
    - How do you verify above?
  - Information Quality
    - Meta data for completeness, correctness, uncertainty?
    - Meta data for information provenance?
  - Responsiveness / Liveness
    - Repository change to automated change to control/data plane or alert?



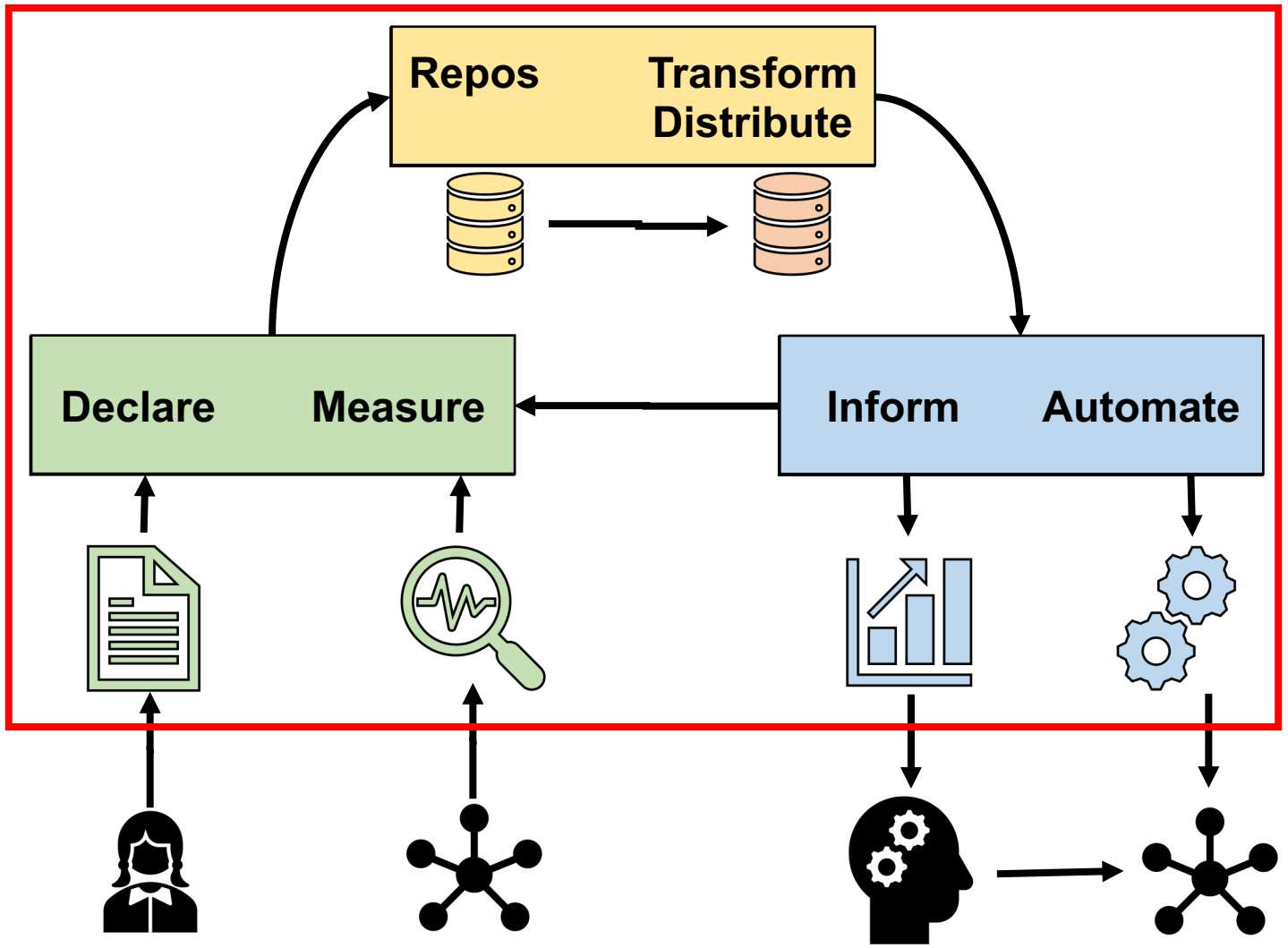
Information Infrastructure Properties

- **Data Consumers**
  - Access control & Authentication
    - ARIN – RPA to access TAL, otherwise open and unauthenticated access.
  - Information Quality
    - Meta data for completeness, correctness, uncertainty?
    - Meta data for information provenance?
      - RPKI ROAs/CERTs do not indicate who created them?
  - Responsiveness / Liveness
    - Repository change to automated change to control/data plane or alert?
    - End to end system responsiveness.
      - E.g., Reactive DDoS mitigation?



Information Infrastructure Properties

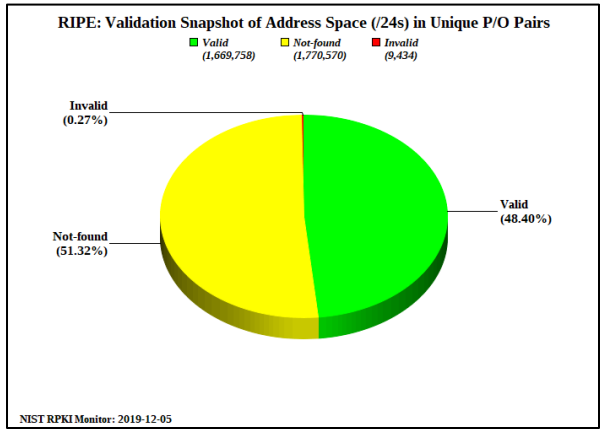
- **Other Operational Issues**
  - Incremental Deployment and Phased Adoption
    - Can producers control which consumers use the data?
    - Can producers influence how consumers use data?
      - Soft launch – flag and report?
  - Monitoring Information Use.
    - Can producers monitor consumers' behavior?
    - Who is using the information and how?
      - Standardized behavior / use?
  - Systemic Risk Issues
    - Risk of compromise / failure of each component?
    - Ability to diagnose problems?
    - Behavior at scale?

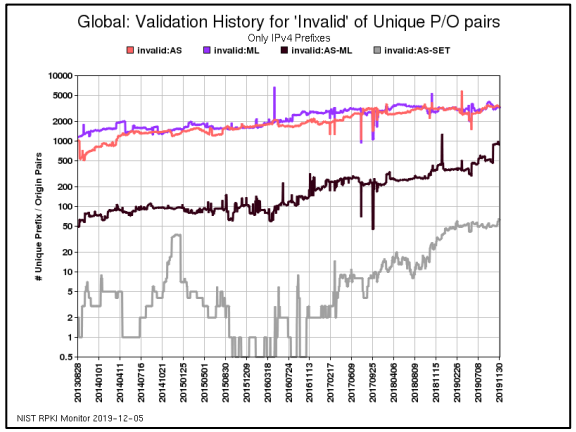


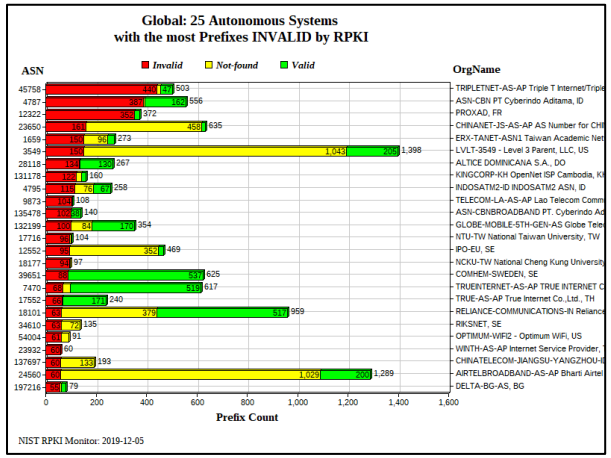
RPKI Monitoring Tools

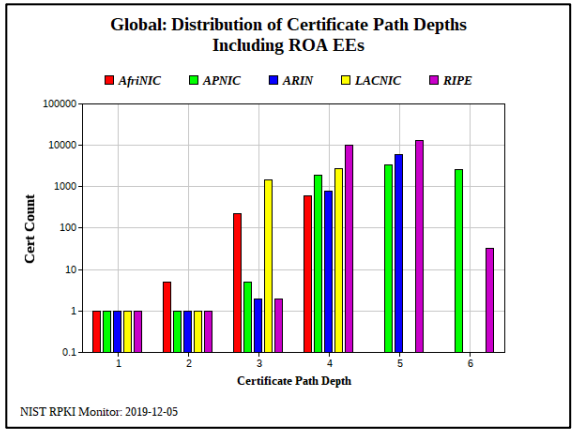
NIST RPKI Monitor(s)

- https://rpki-monitor.antd.nist.gov/
  - Running since ~2013
- **Status of RPKI adoption**
  - Relative to BGP – Origin Validation
    - Analysis of RPKI relative to BGP Data.
    - Analysis of apparent issues.
    - Tracking adoption trends – good and bad.
    - Global / per region statistics.
  - Analysis of RPKI Data – size / shape
    - Understand RPKI usage per region
      - Mainly how the RIR hosted RPKI data sets compare



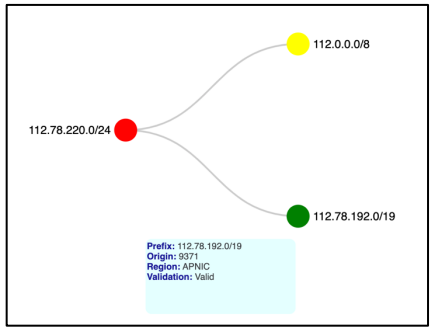






New RPKI Monitor

- https://coming.soon :^)
- **New focus / capabilities**
  - Focus on identifying significant changes
    - Being able to correlate change in OV to change in RPKI.
    - Being able to understand potential routing impact of such changes.
    - Email / twitter feeds to alert users when there is something of interest



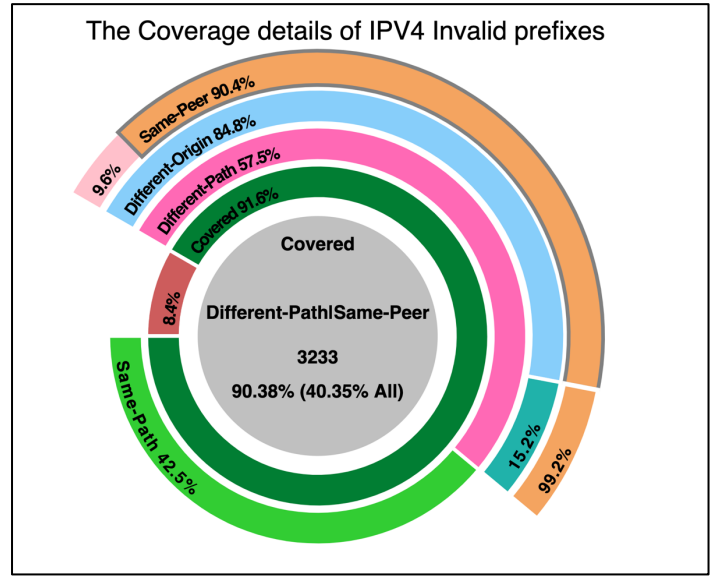
Latest RPKI-Validation changes (From 2019-12-09:12 To 2019-12-09:18)

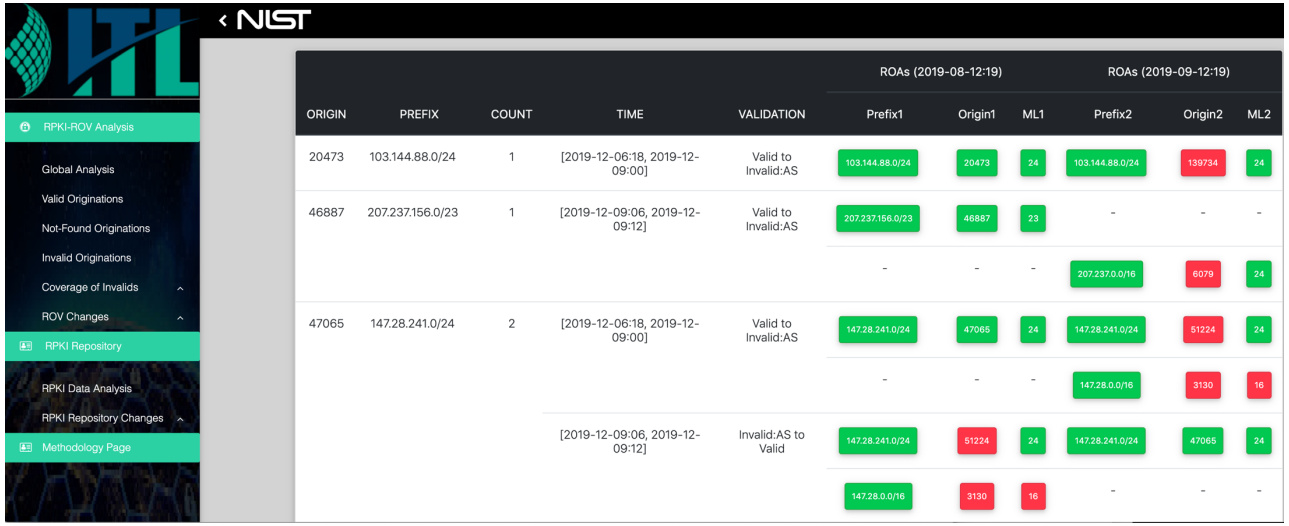
IPV4 RPKI Origin Validation Changes

Number of changes :	47	100%
Not-Found to Valid :	43	91.49%
Not-Found to Invalid :	2	4.26%
Valid to Invalid :	1	2.13%
Invalid to Valid :	1	2.13%

IPV6 RPKI Origin Validation Changes

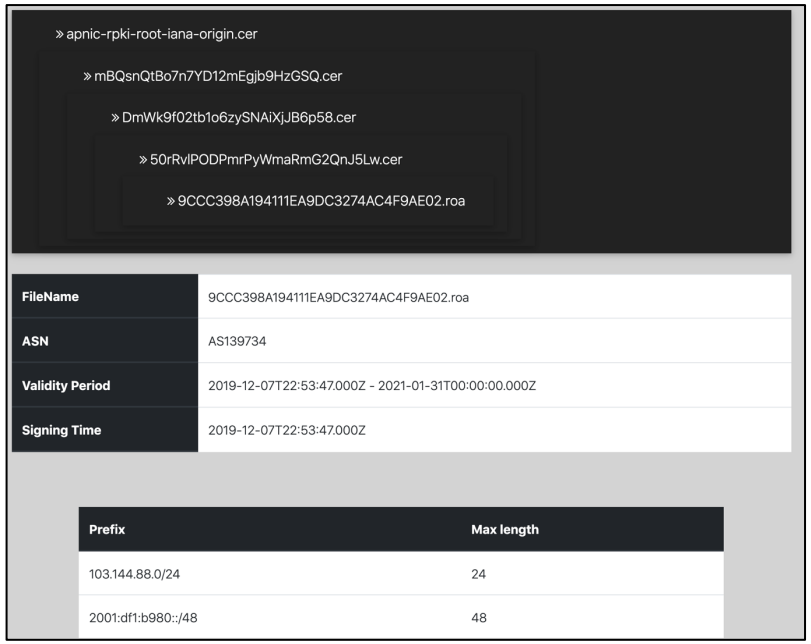
Number of changes :	8	100%
Not-Found to Valid :	5	62.50%
Invalid to Valid :	3	37.50%

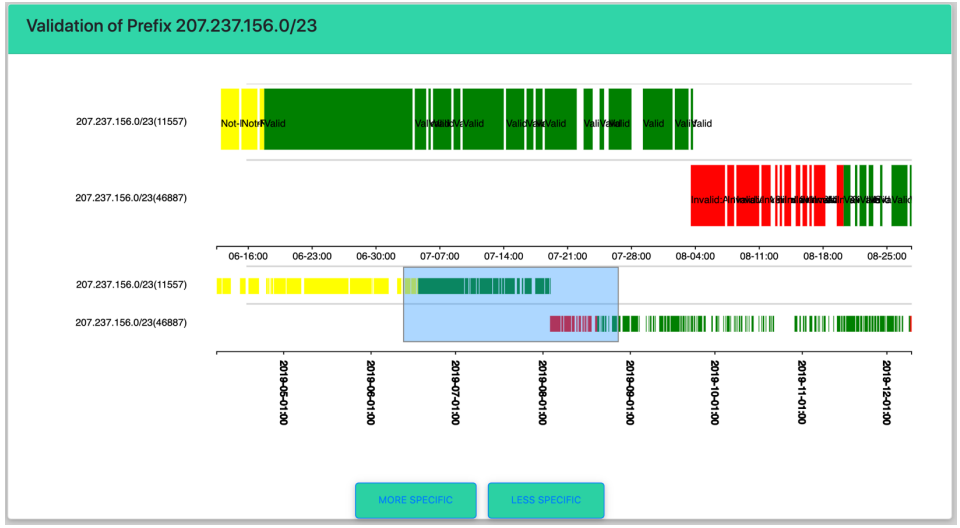


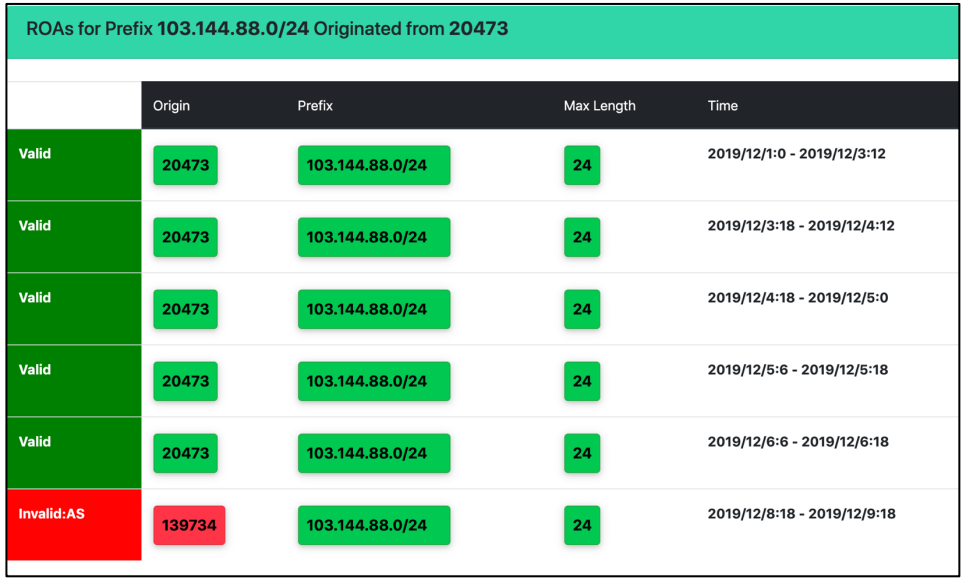


New RPKI Monitor

- **Explore validation history**
  - Examine validation history of a prefix.
  - Correlate OV changes to RPKI data.
  - Drill down into RPKI certs at chosen point in time.







Questions and Discussion

- **For more information:**
  - Robust Interdomain Routing Project
    - https://www.nist.gov/programs-projects/robust-inter-domain-routing
  - Advanced Network Technologies Division.
    - https://www.nist.gov/itl/antd
  - Information Technology Laboratory
    - https://www.nist.gov/itl