# Semantic Metadata Annotation for Network Anomaly Detection
draft-netana-nmop-network-anomaly-semantics-01

# Experiment: Network Anomaly Postmortem Lifecycle
draft-netana-nmop-network-anomaly-lifecycle-01

Helps to annotate operational data, refine outlier detection, supports supervised and semi-supervised machine learning development, enables data exchange among network operators, vendors and academia, and make anomalies for humans apprehensible

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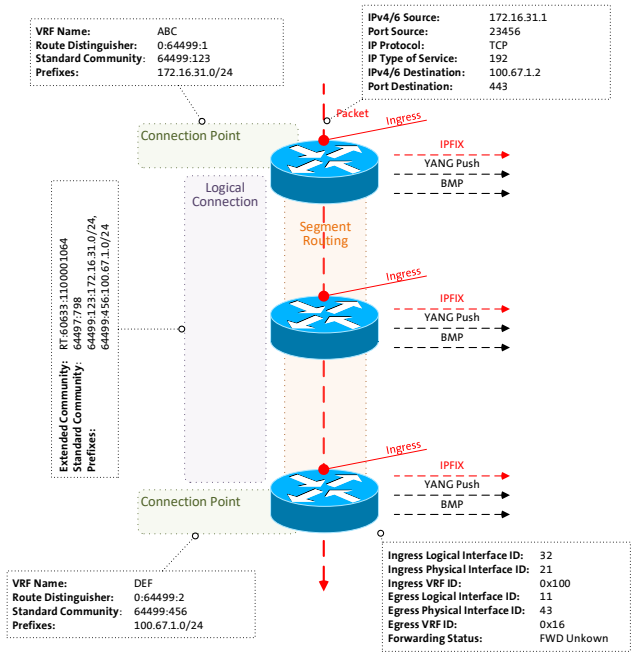
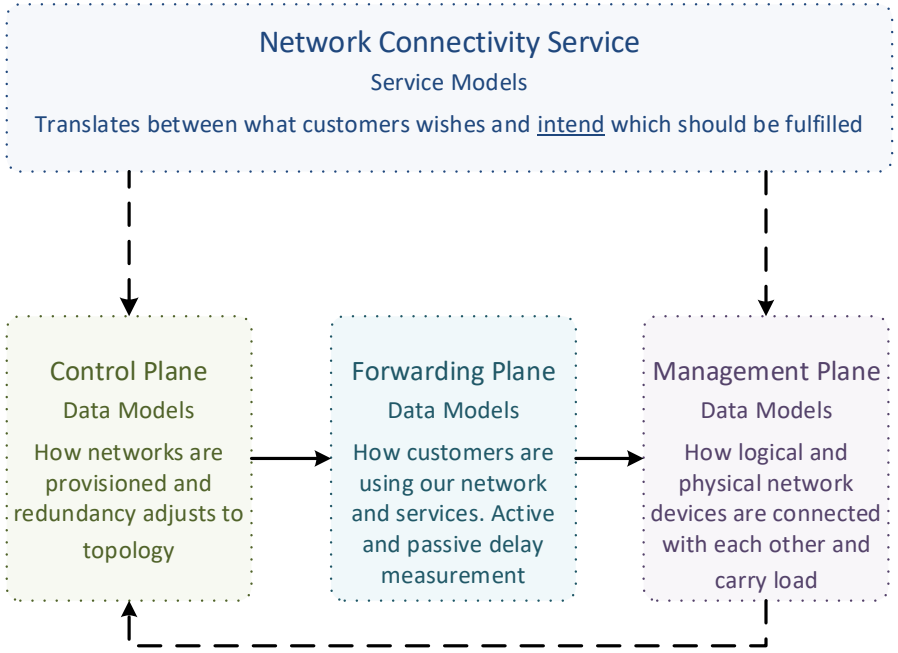
# What to monitor

## Which operational metrics are collected

« Network operators connect customers in routing tables called VPN's »

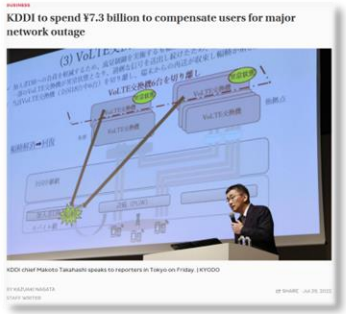


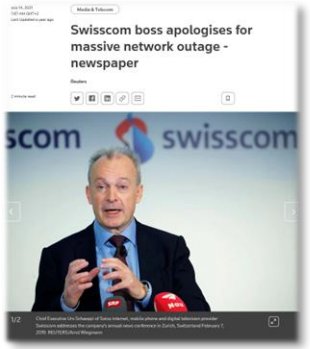

« Network Telemetry (RFC 9232) describes how to collect data from all 3 network planes efficiently »



# Why to automate monitoring

## Recognize network incidents faster than humans can

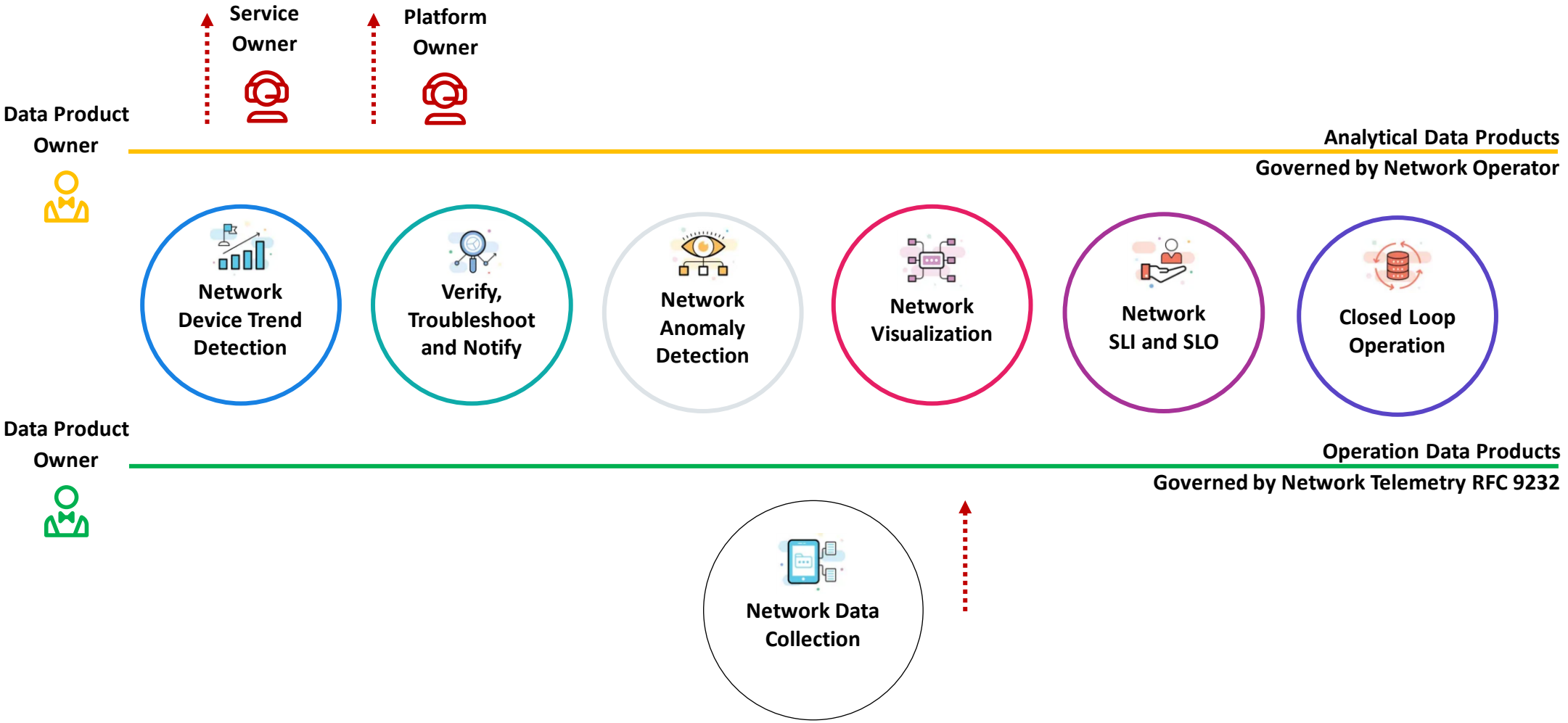




« Customers are always connected, when VPN's changing, regardless due to operational or configurational reasons, network operators are late to react due to missing visibility and automation »

# How to organize and collaborate with data

## The Data Mesh Architecture enables Network Analytics use



# What does Network Anomaly Detection mean

## Monitor changes

## Network Anomaly Detection

**For VPNs**, Network Anomaly Detection **constantly monitors and detects any network or device topology changes**, along with their associated forwarding consequences for customers as outliers. Notifications are sent to the Network Operation Center before the customer is aware of service disruptions. **It offers operational metrics for in-depth analysis,** allowing to understand on which platform the problem originates and facilitates problem resolution.

**Answers**

What changed and when, on which connectivity service, and how does it impact the customers?

**Focuses**

Provides meaningful connectivity service impact information before customer is aware of and support in root-cause analysis.

**Data Mesh**

Consumes operational real-time Forwarding Plane, Control Plane and Management Plane metrics and produces analytical alerts.

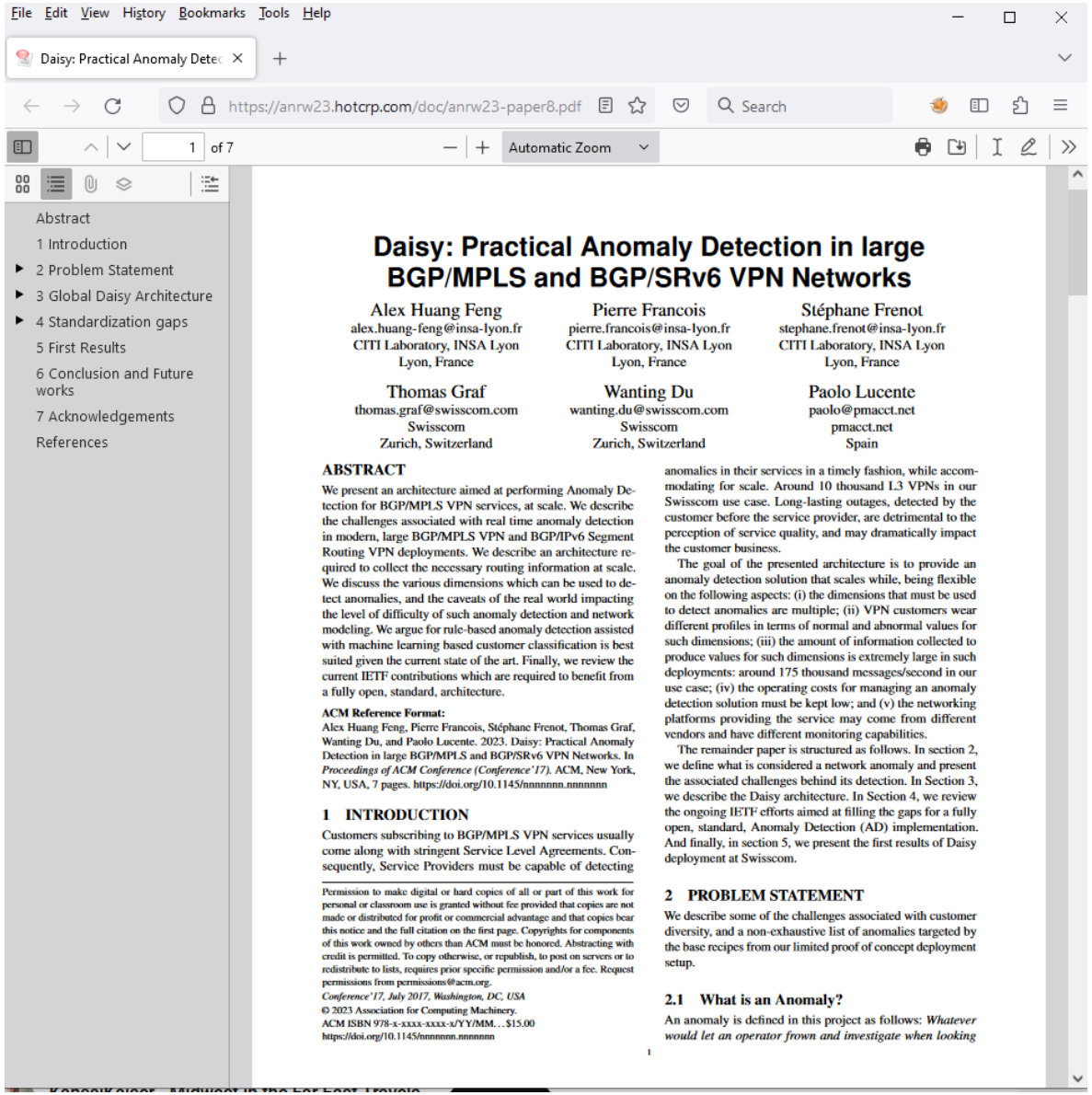
**Direction**

From connectivity service to network platform.

# Presented in ANRW 2023

## At IETF 117 San Francisco

« A more detailing paper will be submitted soon to IEEE Transactions on Network and Service Management»



# What our motivation is

## Automate learn and improve

From network incidents postmortems we network operators **learn and improve** so does network anomaly detection and supervised and semi-supervised machine learning.

The more network incidents are observed, the more we can improve. With more incidents the **postmortem process needs be automated, let's get organized** first by defining human and machine-readable metadata semantics and annotate operational and analytical data.

Let's get further organized by exchanging standardized labeled network incident data among network operators, vendors and academia to **collaborate on academic research**.

« The community working on Network Anomaly Detection is probably the only group wishing for more network incidents »

# What is a symptom and how to categorize them

## From action to reason to cause

**Action:** Which action the network node performed for a packet in the forwarding plane, a path or adjacency in the control plane or state or statistical changes in the management plane.

**Reason:** For each reason one or more actions describing why this action was used. From drop unreachable, administered, and corrupt in forwarding plane, to reachability withdraw and adjacency teared down in control plane, to Interface down, errors or discard in management plane.

**Cause:** For each reason one or more causes describes why the action was chosen. From missing next-hop and link-layer information in forwarding plane, to reachability withdrawn due to peer down or path no longer redistributed.

« Symptoms are categorized in which plane they have been observed, their action, reason and cause »

# Questions to the audience

## Do you care?

**Network Operators:** Do you agree that today's actions; traffic is dropped, path is withdrawn and interface down, are always exposed through Network Telemetry. But reasons and causes, dropped due to unreachable next-hop, withdrawn due to peer down, interface down due to missing signal, are rarely exposed to telemetry  would be most interesting?

**Network Vendors:** Is the assumption correct that a when network service process, routing process and withdrawing a path occur, most of the time the vendor knows why it acts that way, and could potential make this reason and cause information available?

**Academia:** Would it help if network operators would provide well defined labeled operational and analytical data to enable and validate their research?

**Everybody:** Should these symptoms be clearly described and standardized for a common terminology so that operators, researchers and anomaly detection systems alike understand their meaning and learn and act accordingly?

# Outliers in Anomaly Detection

## From global to contextual to collective

**Global outliers:** An outlier is considered "global" if its behavior is outside the entirety of the considered data set.

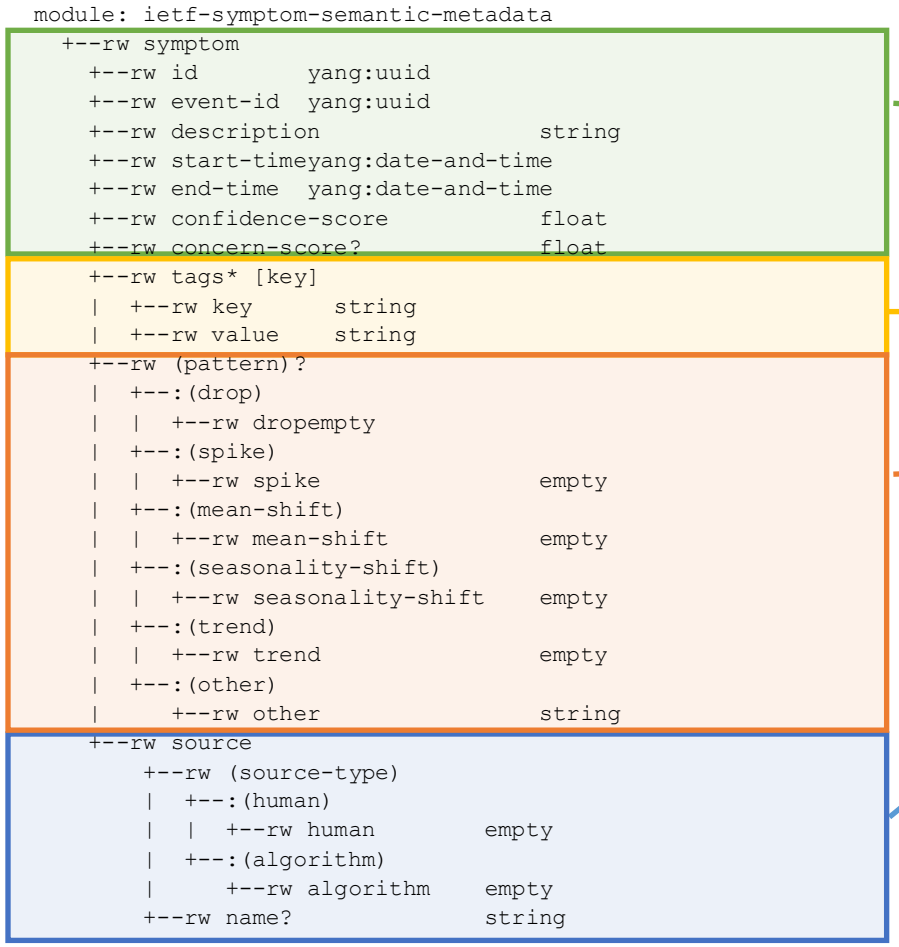
**Contextual outliers:** An outlier is considered "contextual" if its behavior is within a normal (expected) range, but it would not be expected based on some context. Context can be defined as a function of multiple parameters, such as time, location, etc.

**Collective outliers:** An outlier is considered "collective" if the behavior of each single data point that are part of the anomaly are within expected ranges (so they are not anomalous, it's either a contextual or a global sense), but the group taking all the data points together, is.

« Collective outliers are important because networks are connected. Through different planes interconnected symptoms from various angles can be observed »

# Annotate Operational Data

## YANG Module

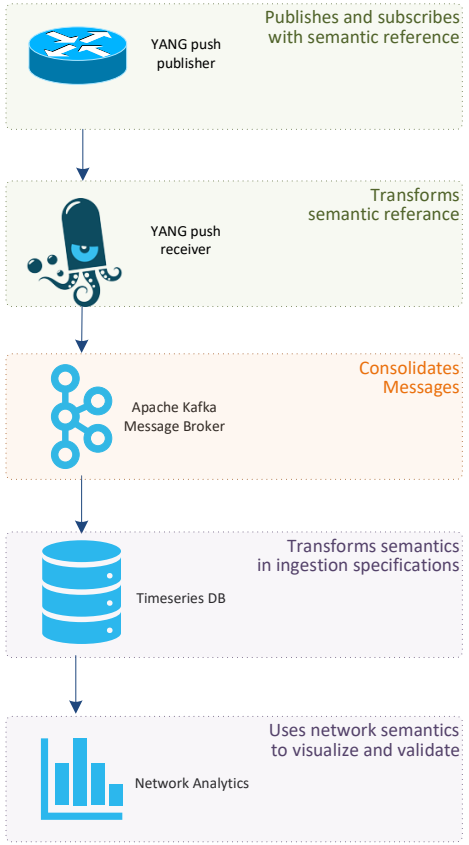



- **Symptoms** describe what changed in the network for what reason and cause with which concern score from when to when.
- **Tags** describes in which network plane, which action, reason and cause was observed.
- **Pattern** describes the measurement pattern over time of the time series data.
- **Source** describes which system **observed** the outlier. A human or a network anomaly detection system.

# Semantic Metadata Annotation for Network Anomaly Detection

## Next steps

- **This work relates to the Network Anomaly Detection topic in the NMOP charter.**
- It bridges network and data engineering, operator, vendors and academia, domains by having the **semantics and ontology of network symptoms for operational and analytical data defined**.
- This work will unveil what is missing in Network Telemetry data and provide input to other documents such as draft-davis-nmop-incident-terminology to enable a more detailed and holistic view for networks.
- **Do you realize the benefit of having standardized semantic metadata annotation for Network Anomaly Detection and how it helps network operators, vendor and academia to collaborate?**
- **-> What are your thoughts and comments?**
- **-> We request NMOP working group adoption.**

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# Network Anomaly Postmortem Lifecycle

draft-netana-nmop-network-anomaly-lifecycle

**4. Lifecycle of a Network Anomaly**

The lifecycle of a network anomaly can be articulated in three phases, structured as a loop: Detection, Validation, Refinement.

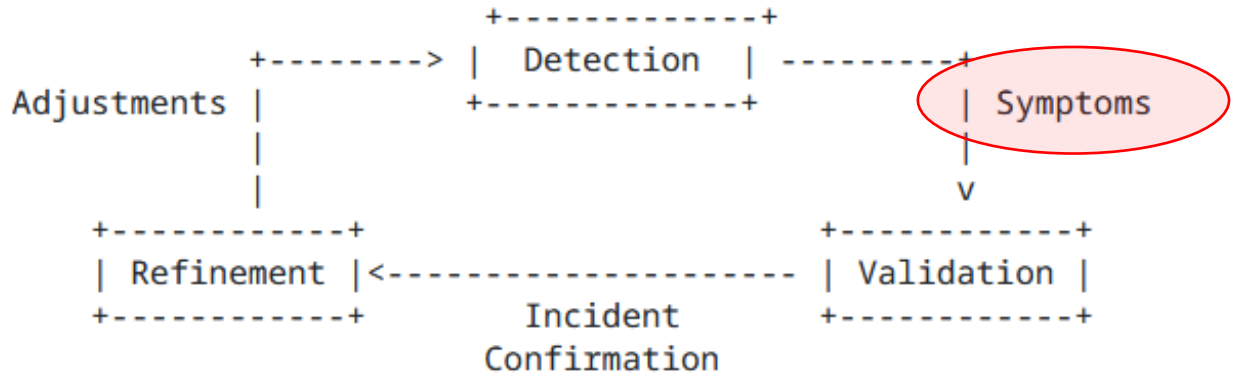



Figure 1: Anomaly Detection Refinement Lifecycle

Each of these phases can either be performed by a network expert or an algorithm or complementing each other.

**Detection:** The Network Anomaly Detection stage is about the continuous monitoring of the network through Network Telemetry [RFC9232] and the identification of symptoms.

**Validation:** Decides if the detected symptoms are signaling a real incident or if they are to be treated as false positives.

**Refinement:** Network operator performs detailed postmortem analysis of the network incident, collected Network Telemetry data and detected anomaly with the objective to identify useful adjustments in the Network Telemetry data collection and Anomaly Detection system.

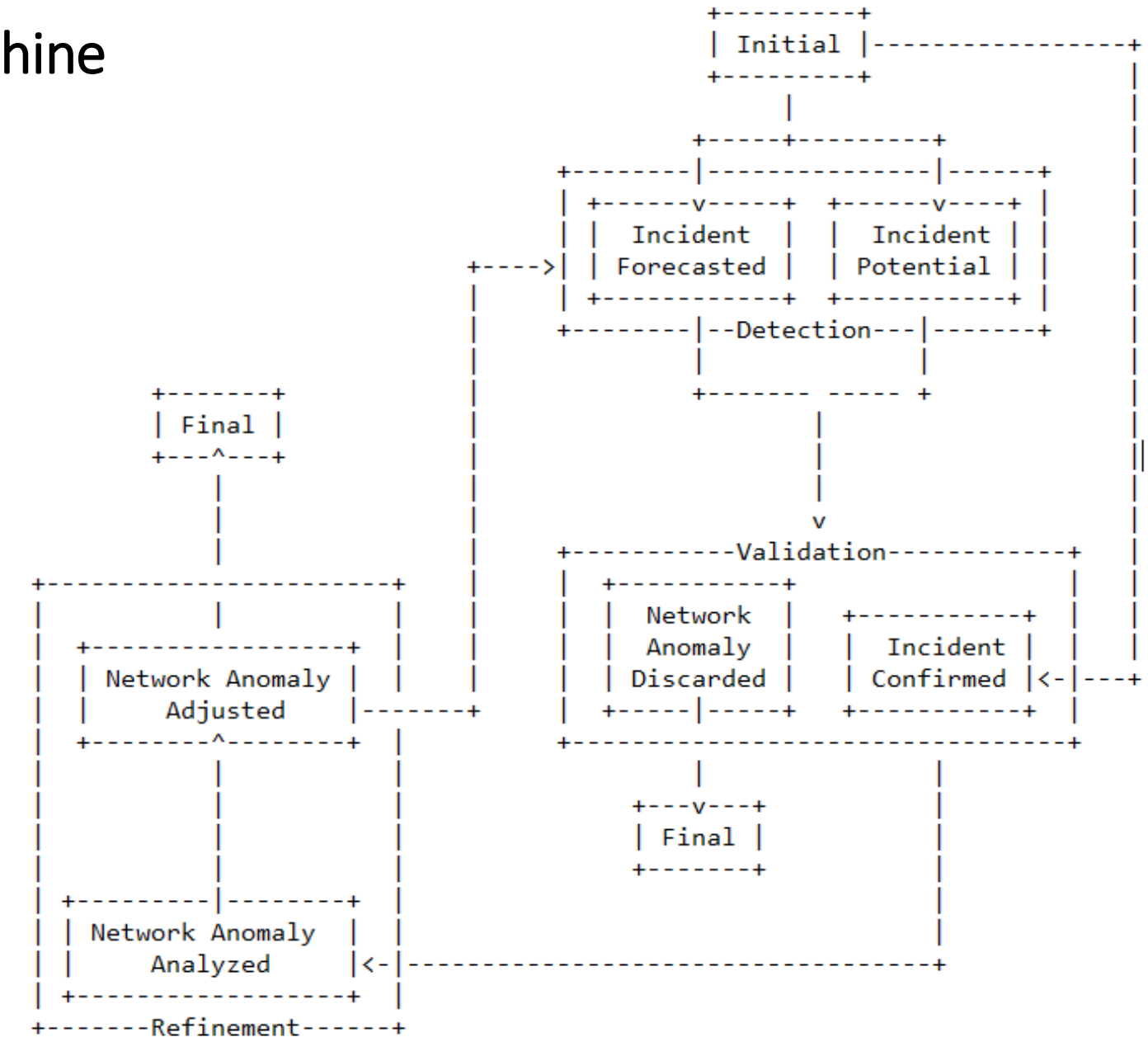
# Network Anomaly State Machine

## Incident Relationships

**Incident Forecasted:** A potential network incident is predicted in the future by the Network Anomaly Detection system.

**Incident Potential:** A potential network incident has been detected by the Network Anomaly Detection system.

**Incident Confirmed:** A potential network incident has been confirmed in the postmortem validation.



# Network Anomaly Metadata

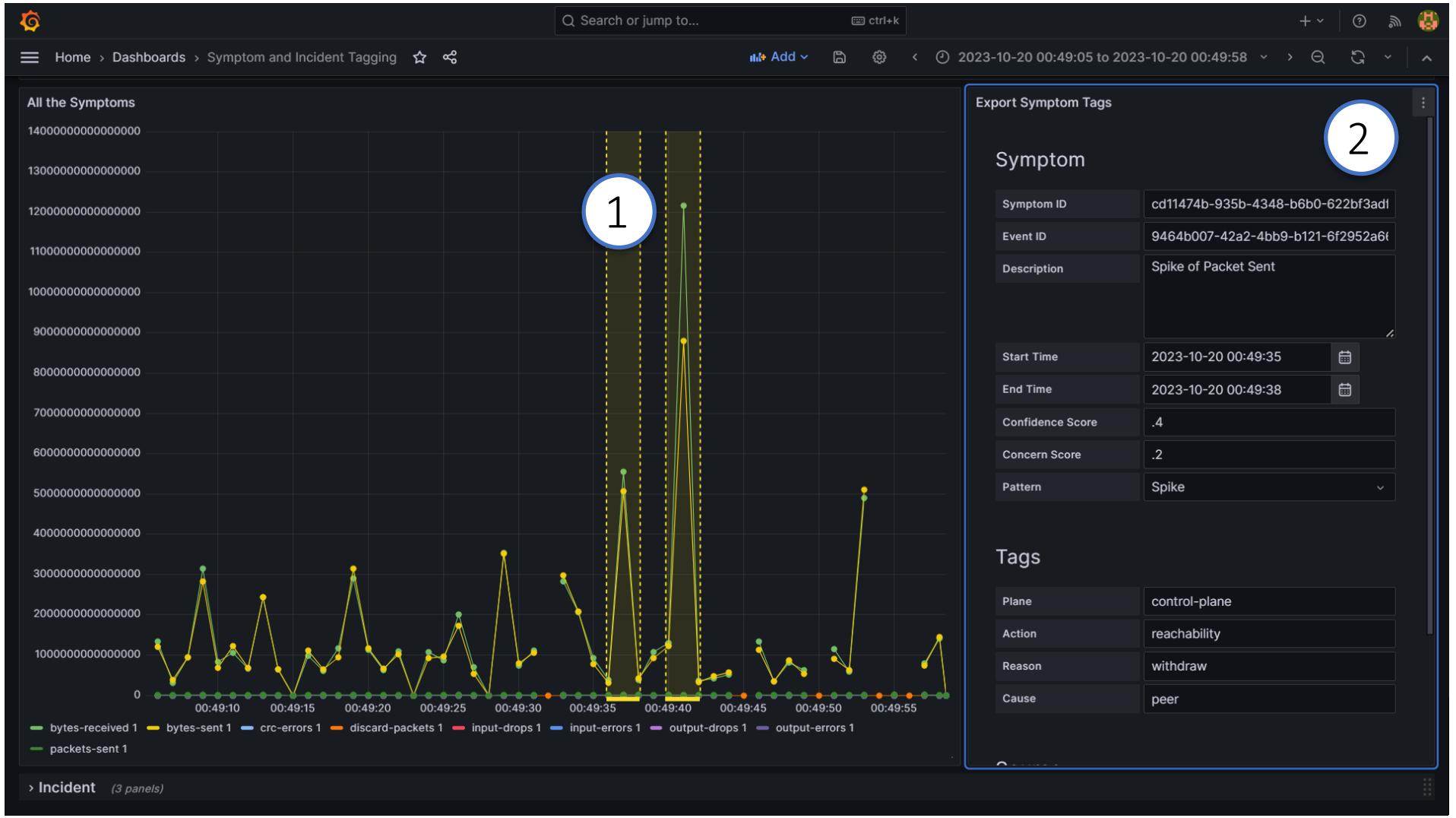
## YANG Module

```
module: ietf-network-anomaly-metadata
  +--rw network-anomalies
     +--rw network-anomaly* [id author-name version state]
        +--rw id              yang:uuid
        +--rw description?    string
        +--rw author-name     string
        +--rw author
        |  +--rw author-type?    identityref
        |  +--rw algo-version?   uint8
        +--rw version         uint8
        +--rw state           identityref
        +--rw symptoms* [symptom_id]
           +--rw symptom_id    yang:uuid
```

- **ID and Description** uniquely identifies the detected anomaly.
- **Author Name, Type, Version and Algo-Version** describes wherever the anomaly was detected by a human or algorithm and uniquely identifies the system and version who/which detected.
- **State** describes the state of the anomaly.
- **Symptoms** describes the identified symptoms defined in ietf-symptom-semantic-metadata.

# IETF 118 Hackathon – Antagonist

## Labelling a Symptom in Grafana



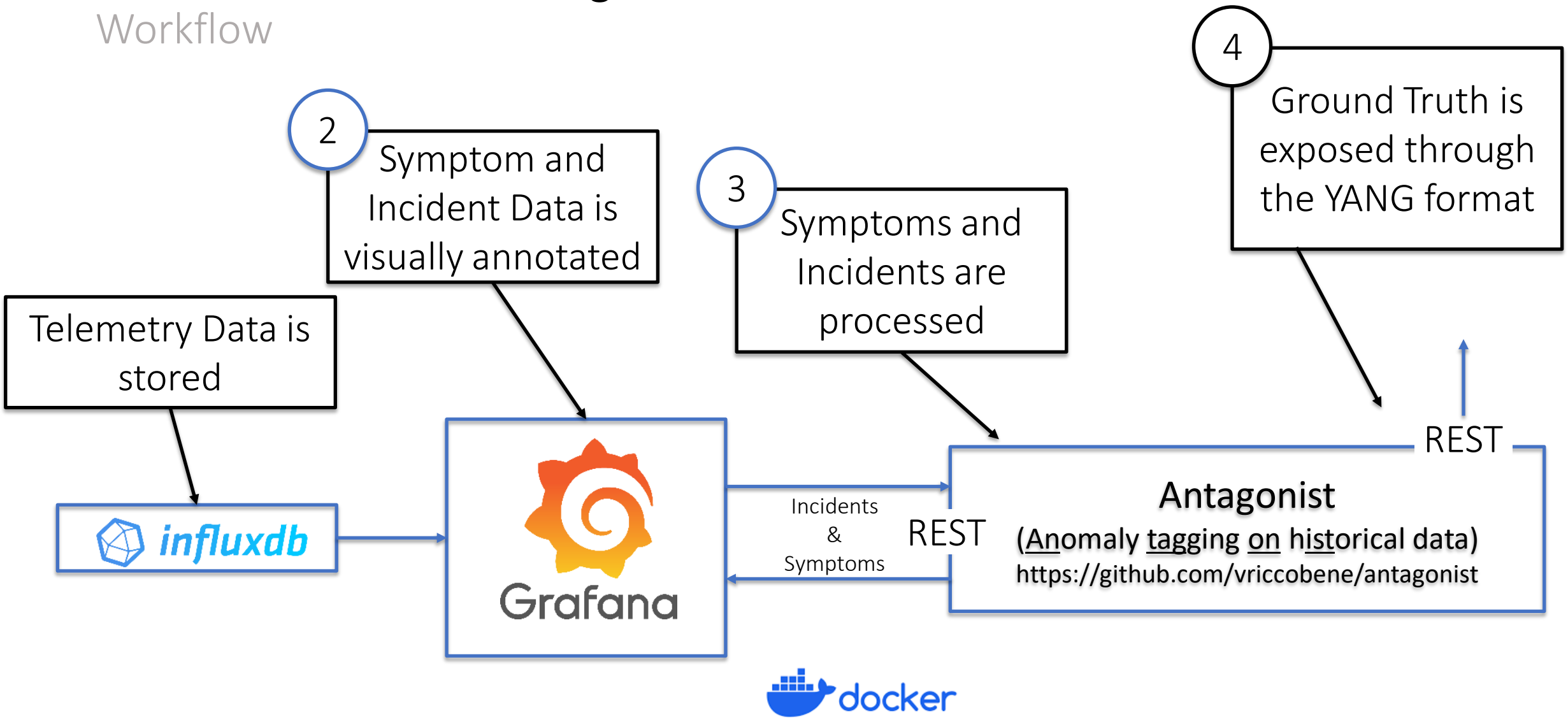

(1) Vertical dotted lines are the tagged symptoms.

(2) Once the symptom is selected, the user can add all the details.

Once the symptom is defined it gets submitted to Antagonist.

# IETF 118 Hackathon - Antagonist

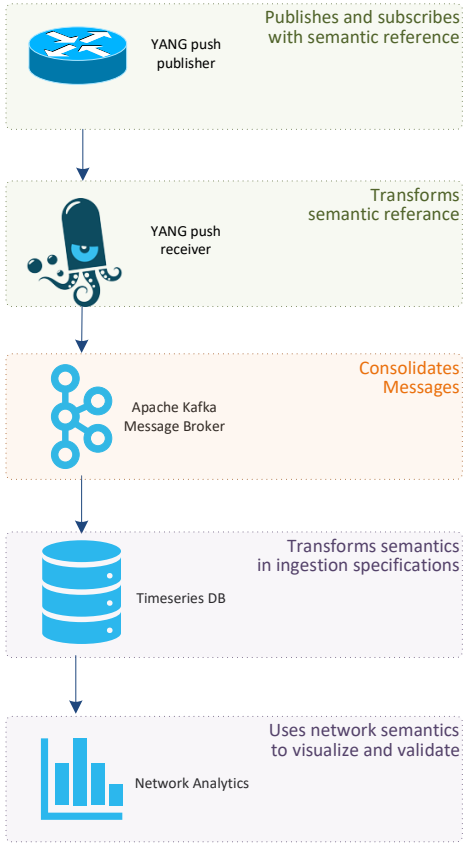
## Workflow



# Experiment: Network Anomaly Postmortem Lifecycle

## Next steps

- **This work relates to the Network Anomaly Detection topic in the NMOP charter.**
- It defines the Network Anomaly lifecycle by including the Network Incident Postmortem process.
- This work will provide input to draft-davis-nmop-incident-terminology and complement other documents such as RFC 8632 and draft-feng-opsawg-incident-management where semantics for alerts and incidents are defined.
- **Do you realize the benefit of having a defined workflow and semantics to automate the Network Anomaly Postmortem Lifecycle?**
- **-> What are your thoughts and comments?**

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