



Practical Anomaly Detection in Internet Services: An ISP centric approach

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Introduction

- Monitor networks holistically for an ISP is important to minimize service impact
 - Issues happen to all networks
 - Connectivity service interruptions
 - Cost you money
 - Make you look bad

→ How can we detect anomalies in real world Internet Service Providers?

→ Which data can we use to detect these anomalies? Standards?

→ Can a rule-based approach be effective in detecting such anomalies?

Media & Telecom

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Swisscom boss apologises for massive network outage - newspaper

Reuters



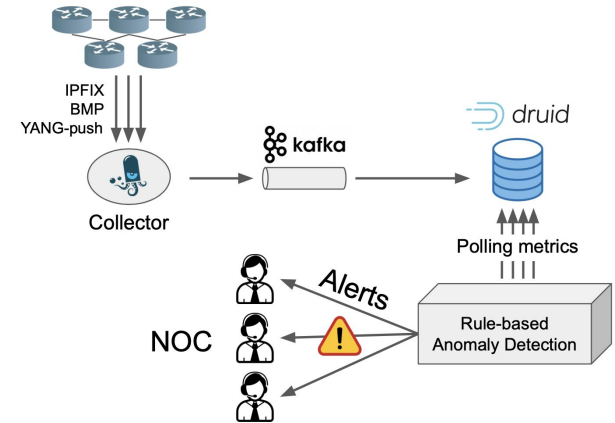
[1/2] Chief Executive Urs Schaeppi of Swisscom, mobile phone and digital television provider Swisscom addresses the company's annual news conference in Zurich, Switzerland February 7, 2019. ... [Read more](#)

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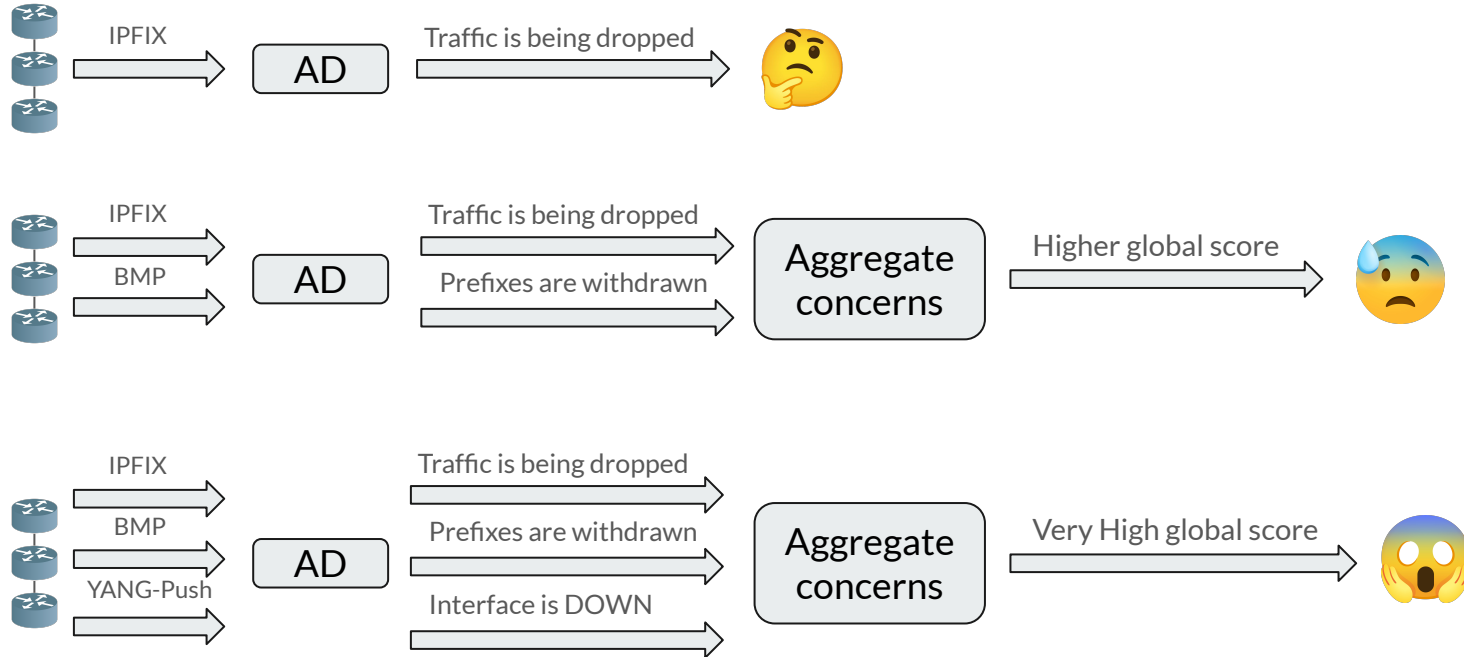
Use case: Anomaly Detection in BGP/MPLS VPN environments

- *Daisy: Practical Anomaly Detection in large BGP/MPLS and BGP/IPv6 VPN Networks* *
- Work presented at **IRTF 117/ANRW'23** San Francisco
- Anomaly Detection based on *Customer profiles*
 - Set of Strategies assigned to each profile
 - Set of Rule-based Checks assigned to each Strategy
 - Execution of these Checks in Real-time in polling mode
 - Comparing traffic to last week
 - Spikes in control-plane (BGP Updates & BGP Withdraws)
 - Interface status gone DOWN
 - ...
- Currently deployed in Swisscom for L3 VPN Customers connectivity services



* Alex Huang Feng, Pierre Francois, Stéphane Frenot, Thomas Graf, Wanting Du, and Paolo Lucente. 2023. *Daisy: Practical Anomaly Detection in large BGP/MPLS and BGP/IPv6 VPN Networks*. In *Proceedings of the Applied Networking Research Workshop (ANRW '23)*. Association for Computing Machinery, New York, NY, USA, 8–14.
<https://doi.org/10.1145/3606464.3606470> (Open access: <https://hal.science/hal-04307611>)

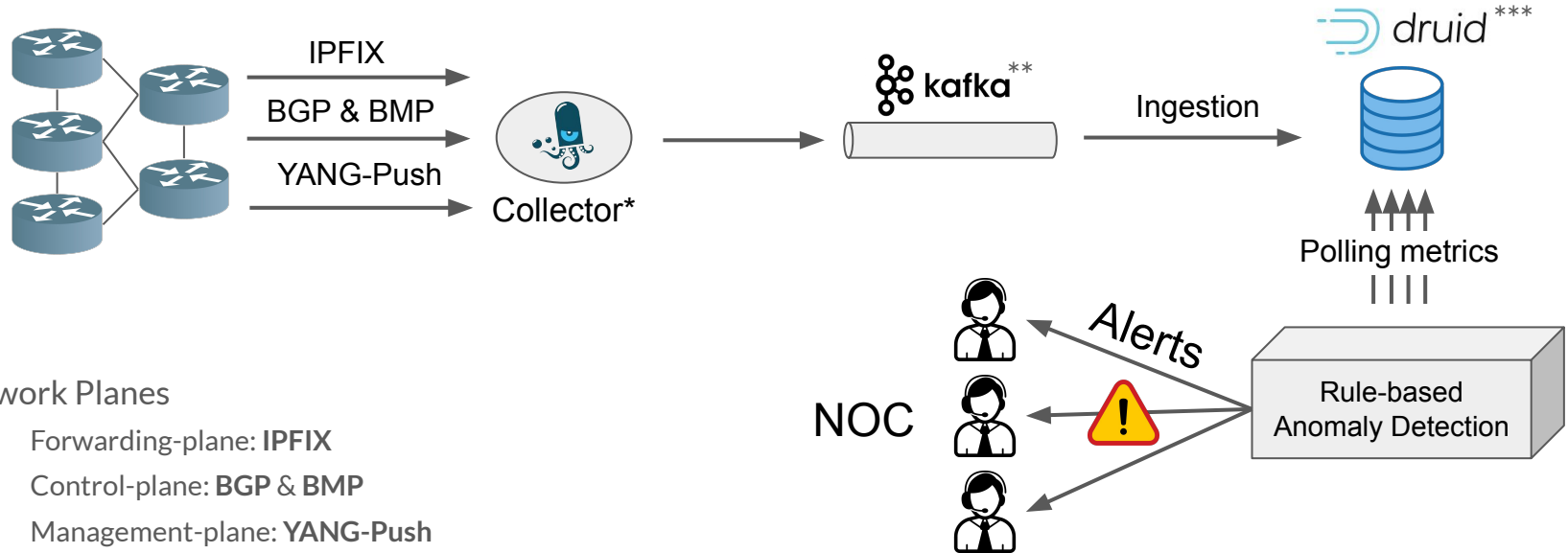
Daisy: Anomaly Detection (AD)



Current work: Anomaly Detection in Internet Connectivity Services

- Plan: use same Framework to detect anomalies in services providing Internet Connectivity
- Customer Profiles: **BGP Communities** vs **AS Number**
- Implement specific Strategies for monitoring ASN traversing an ISP
- **Disruptions Detection**
 - Losing a Top talker
 - Neighbour AS has been disconnected from the Internet
 - Trending analysis: Saturating a neighbour peer link
- **Anomaly Detection**
 - Traffic from a Settlement-free peer has moved to a Transit provider
 - Monitor traffic ratios on Settlement-free peers
 - The traffic from an AS is traversing my whole network instead of rapidly being forwarded to the shortest path
 - Prefix for which RPKI was valid is not anymore
- **Security related anomalies (low priority)**
 - Prefix hijacks
 - DDoS

Architecture - High level view



* *pmacct* collector: <http://www.pmacct.net>

** Apache Kafka: <https://kafka.apache.org>

*** Apache Druid <https://druid.apache.org>

Rule-based checks

- IPFIX
 - Comparing total bytes to one week before
 - Comparing the slope to one week before
 - Spike in flow count
 - Spike drop counters
- BGP / BMP
 - Spike in BGP withdraw messages
 - Spike in BGP update messages
 - Spike in peer down messages
- YANG-Push
 - Interfaces changed status to DOWN

} Based on what operators do when looking at the data

More to come based on post-mortem analysis!

Use case: Losing a top talker (Disruption)

Top talkers = ASN sending the most traffic to you

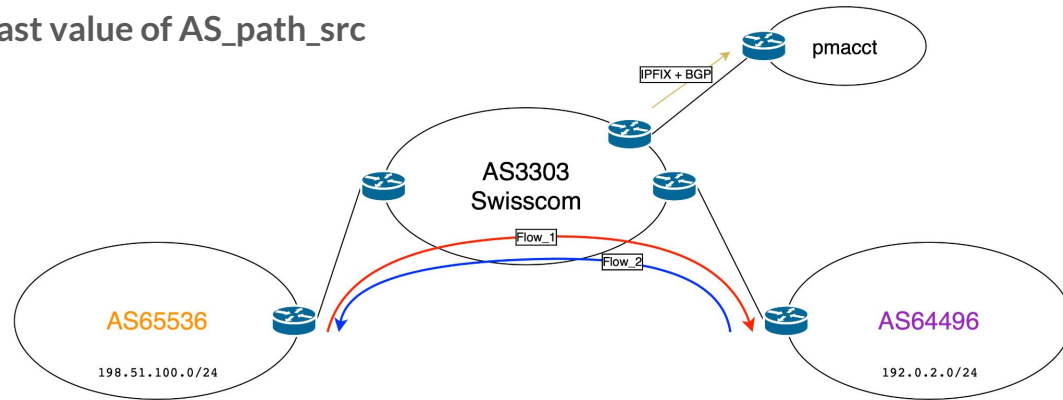
Flow_1:

- src:198.51.100.1; dst:192.0.2.1; Bytes: 10 bytes; AS_path: <AS3303,AS64496>; AS_path_src: <AS3303,AS65536>

Flow_2:

- src:192.0.2.1; dst:198.51.100.1; Bytes: 10 bytes; AS_path: <AS3303,AS65536>; AS_path_src: <AS3303,AS64496>

Top talkers: **Aggregation of flows based on last value of AS_path_src**



Use case: Losing a top talker (Disruption)

Monitor ASN on a ASN basis:

- Compare ingress* traffic to last week
- Compare ingress* slope to last week
- Spike in egress** flow count
- BGP Withdraws spike from the Origin ASN
- BGP Update spike from the Origin ASN

* ingress traffic: Traffic going from the Origin ASN to the local ASN

** egress traffic: Traffic going from the local ASN to the Destination ASN



Use case: Losing a top talker (Disruption)



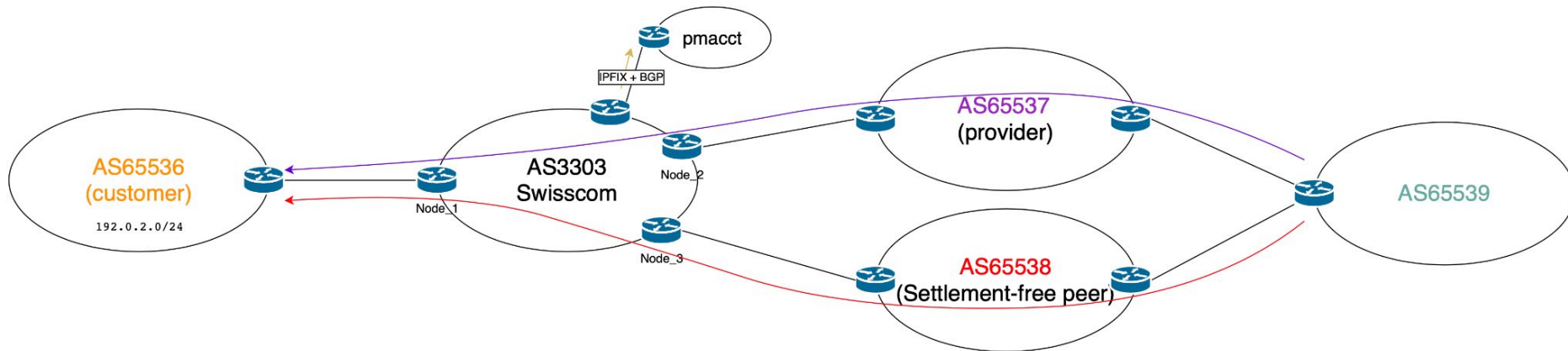
Use case: Settlement-free peer traffic shifted to transit provider (Anomaly)

Flow_1 (aggregated from 2 nodes):

- src:198.51.100.1; dst:192.0.2.1; Bytes: 10 bytes; AS_path: <AS3303,AS65536>; AS_path_src: <AS3303,AS65537,AS65539>; comms: [3303:1000] (customer); comms_src: [3303:XXXX] (Upstream)

Flow_2 (aggregated from 2 nodes):

- src:198.51.100.2; dst:192.0.2.2; Bytes: 10 bytes; AS_path: <AS3303,AS65536>; AS_path_src: <AS3303,AS65537,AS65538>; comms: [3303:1000] (customer); comms_src: [3303:YYYY] (Peer)



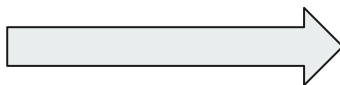
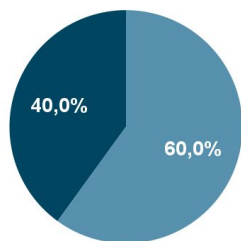
Use case: Settlement-free peer traffic shifted to transit provider (Anomaly)

1. Track for selected ASN:
 - sum of traffic coming from settlement-free peers
 - sum of traffic coming from transit providers
2. Track ratio over time and alert

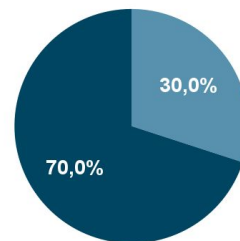
How ?

- Leveraging **BGP communities** identifying where the prefixes **were learned from**

● Settlement-free peer ● Transit provider traffic



● Settlement-free peer ● Transit provider traffic



Project Status

- Current Network Telemetry data:
 - IPFIX (Internet flows)
 - BGP (Internet BGP messages)
 - YANG-Push (Lab only)
- AD Strategies implemented in Python (pulling based mode)
- Checks implemented
 - VPN environments (currently deployed in prod)
 - **Internet Services (WIP)**
- Conducting tests in Swisscom lab
- Analysis of Swisscom Production
- Goal: deployment on a subset of ASNs based on the different use cases

Conclusion

- Network Operators want to be alerted when there are issues in their network but **also want to understand why these alerts were generated**
- We provide a solution based on IETF Standards to collect the data and Open-source solutions
- What's next?
 - Complete use cases on Internet Services
 - Analysis using production use cases
 - Detect missing Standard gaps to support the anomaly detection
 - For some use cases, external views (outside of the ISP) would be needed (RouteViews*)
 - Root cause analysis?

* RouteViews: <https://www.routeviews.org/routeviews/>



Reference Papers

- Alex Huang Feng, Pierre Francois, Kensuke Fukuda, Wanting Du, Thomas Graf, et al.. **Practical Anomaly Detection in Internet Services: An ISP centric** approach. *NOMS 2024-2024 IEEE Network Operations and Management Symposium*, May 2024, Seoul, South Korea. pp.1-4, [10.1109/NOMS59830.2024.10575071](https://doi.org/10.1109/NOMS59830.2024.10575071). [hal-04655324](https://hal.archives-ouvertes.fr/hal-04655324)
- Alex Huang Feng, Pierre Francois, Stéphane Frenot, Thomas Graf, Wanting Du, et al.. **Daisy: Practical Anomaly Detection in large BGP/MPLS and BGP/SRv6 VPN Networks**. *ANRW 2023 : Applied Networking Research Workshop*, Jul 2023, San Francisco, United States. pp.8-14, [10.1145/3606464.3606470](https://doi.org/10.1145/3606464.3606470). [hal-04307611](https://hal.archives-ouvertes.fr/hal-04307611)

Thanks for listening

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