RACI
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Detecting Peering Infrastructure Outages in the Wild

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Peering Infrastructures are critical part of the interconnection ecosystem

Internet Exchange Points (IXPs) provide a shared switching fabric for layer-2 bilateral and multilateral peering.

- Largest IXPs support > 100 K of peerings, > 5 Tbps peak traffic
- Typical SLA 99.99% (~52 min. downtime/year)[1]

Carrier-neutral **co-location facilities** (CFs) provide infrastructure for physical co-location and cross-connect interconnections.

- Largest facilities support > 170 K of interconnections
- Typical SLA 99.999% (~5 min. downtime/year)[2]

[1] https://ams-ix.net/services-pricing/service-level-agreement [2] http://www.telehouse.net/london-colocation/

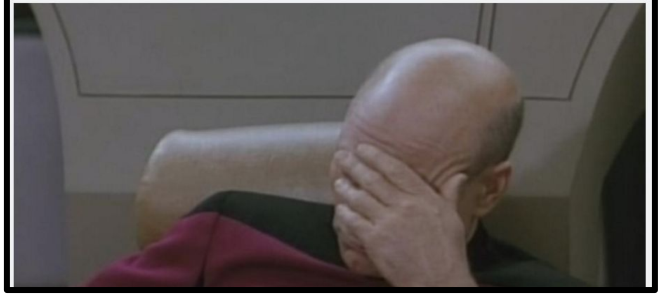
Outages in peering infrastructures can severely disrupt critical services and applications

DOWNTIME WOES —

BT, other ISPs hit by second major Internet outage—power failure blamed

After Telecity power outage, it seems Telehouse has had problems of its own.

KELLY FIVEASH - 21/7/2016, 03:05



BT broadband users hit by second UK-wide outage in two days

Caroline Donnelly
Datacentre Editor
21 Jul 2016 9:50

Power supply issues at Docklands datac… behind loss of internet access for more t… broadband users

Equinix cooling outage leads to flight delays in Australia

13 November 2012 | By Penny Jones

Share | Tweet | Like 0

A "short interruption to utility power supply" at an Equinix data center in Sydney caused up to three hour delays for thousands of passengers flying with three major airlines from Australian airports over the weekend.

DOWNTIME

Equinix Outage Means Downtime for Zoho

BY RICH MILLER ON JANUARY 20, 2012 ADD YOUR COMMENTS

A power outage Friday morning in an **Equinix** data center in California caused problems for a number of customers, most …tably Zoho, which experienced hours of downtime for …eral of its web-based office applications. Equinix …nowledged the incident, but did not provide details on … cause of the outage at its SV4 facility in Silicon Valley.

TECHNOLOGY | TOP STORIES

OUTAGE AT AMSTERDAM INTERNET HUB AFFECTS MUCH OF NETHERLANDS

By Janene Pieters on May 13, 2015 - 13:11

With additional reporting by Zack Newmark.

A technical fault at the internet hub AMS-IX in Amsterdam caused online problems in several places in the Netherlands for about an hour Wednesday afternoon. The internet hub, one of the most used internet exchanges in the world, announced they resolved the problem shortly after 1:30 p.m.

Biting the hand that feeds IT

…CURITY | TRANSFORMATION | DEVOPS | BUSINESS | PERSONAL TECH

Telecity London data centre outage borks VoIP, websites, AWS...

LINX reports sudden sharp traffic drop, Amazon Direct Connect goes TITSUP

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Outage detection crucial to improve **situational awareness**, **risk assessment** and **transparency**.

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LINX reports sudden sharp traffic drop, Amazon Direct Connect goes TITSUP

Current practice: “Is anyone else having issues?”

[outages] Power problems at the Westin in SEA?

Sean Crandall sean at megapath.com
Wed Feb 23 17:58:06 EST 2011

- Previous message: [outages] Phonebooth.com Servi
- Next message: [outages] Power problems at the Wes
- **Messages sorted by:** [date] [thread] [subject] [a

```
Hi everyone...

We appear to be having power problems in the Westin B
Seattle and have heard reports of other colo provider
power issues which implies it is a greater building p

Is anyone else having power issues in the Westin?
```

[outages] So what is broken

Michael Peterman Michael at seeus4it.com
Tue Aug 12 14:21:09 EDT 2014

- Previous message: [outages] Major outages today, not much info at this time
- Next message: [outages] So what is broken
- **Messages sorted by:** [date] [thread] [subject] [author]

```
So is this issue all related to a fiber cut or a DC/Peering point
having issues?

http://www.thewhir.com/web-hosting-news/liquidweb-among-companies-
affected-major-outage-across-us-network-providers



Michael  Peterman
```

[outages] Telehouse North - Major Problems

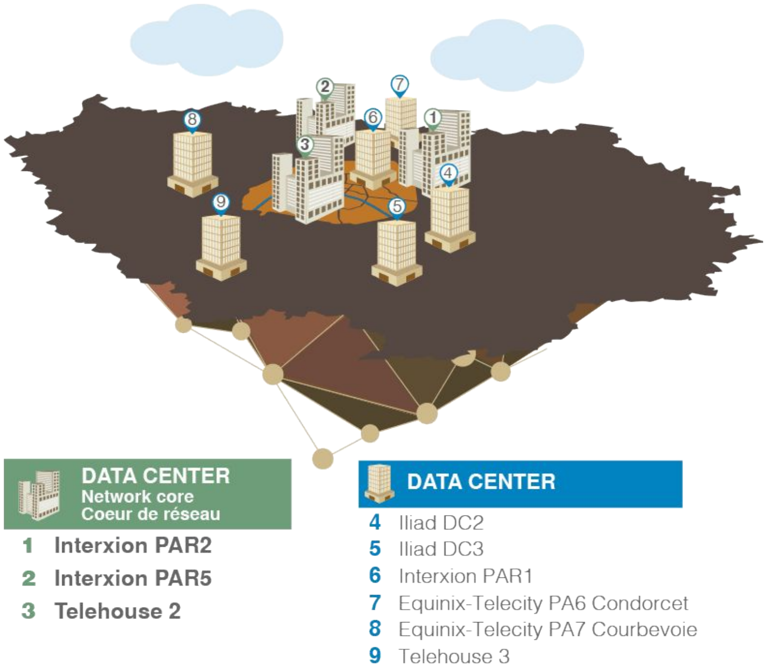
Phil Lavin phil.lavin at cloudcall.com
Thu Jul 21 03:48:18 EDT 2016

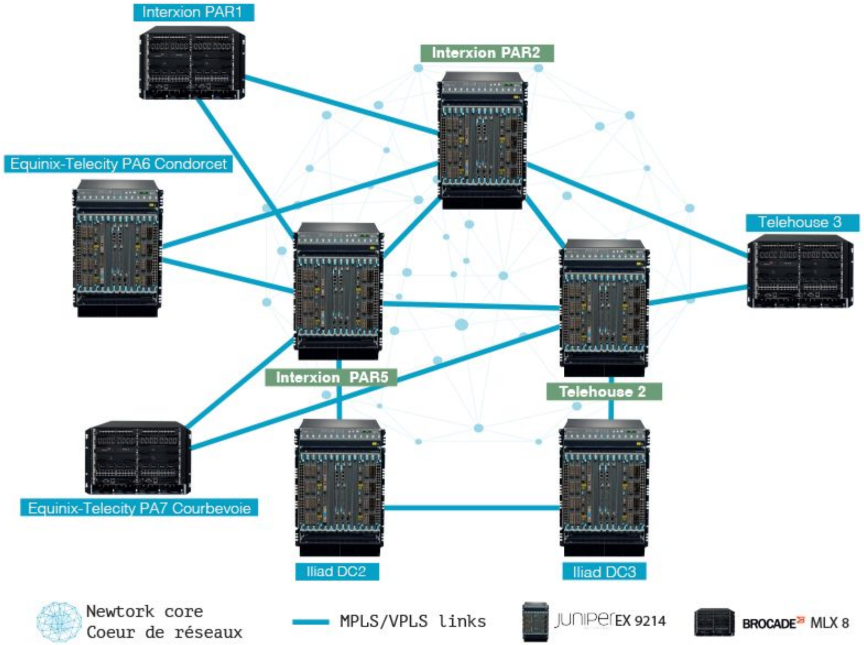
- Previous message (by thread): [outages] AT&T outage in Texas?
- Next message (by thread): [outages] Telehouse North - Major Problems
- **Messages sorted by:** [date] [thread] [subject] [author]

```
We've just had 3 links drop simultaneously to (different)
equipment in Telehouse North.

Fibre link to Vodafone - port is down
BGP peering to GTT is dropped
Copper link to BT - port is down

Anyone else seeing anything? We spoke to BT and they have
confirmed a "major national problem".
```

- ASes try to crowd-source the detection and localization of outages.
- Inadequate transparency/responsiveness from infrastructure operators.

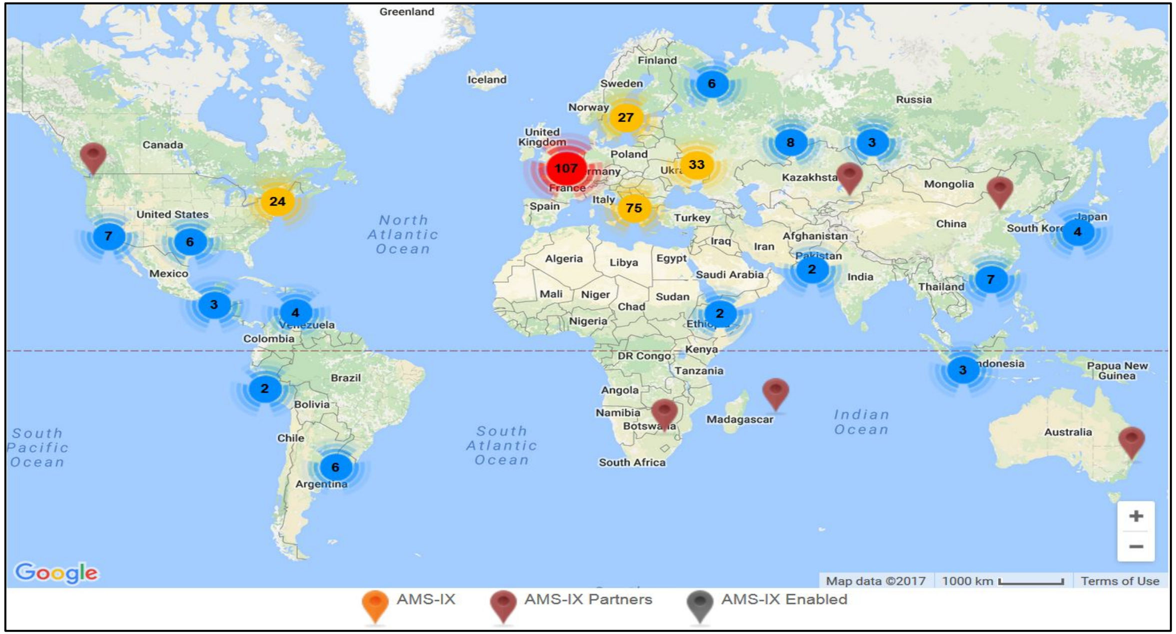
Symbiotic and interdependent infrastructures





https://www.franceix.net/en/technical/infrastructure/

Remote peering extends the reach of IXPs and CFs beyond their local market



Global footprint of AMS-IX

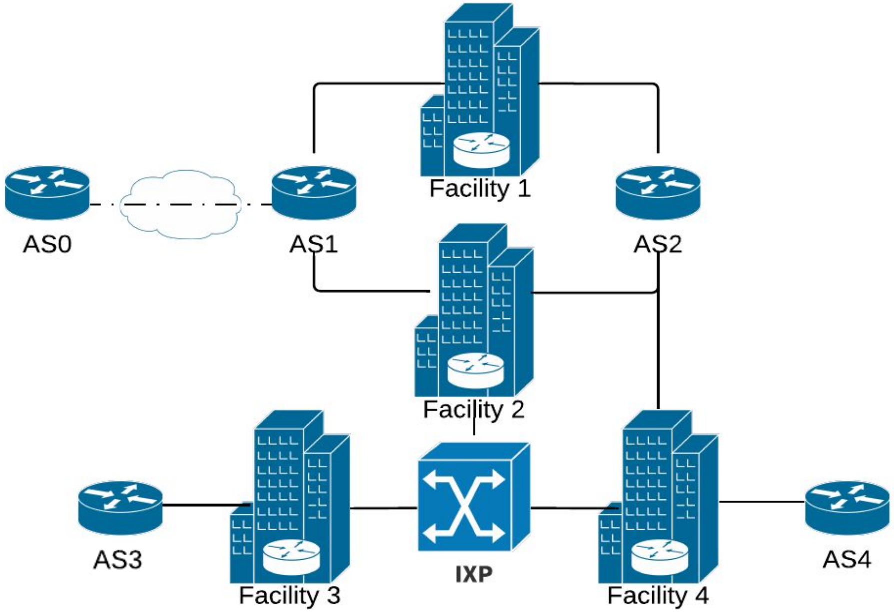
https://ams-ix.net/connect-to-ams-ix/peering-around-the-globe

Our Research Goals

1. Outage detection:
    - *Timely,* at the *finest granularity* possible
2. Outage localization:
    - Distinguish *cascading effects* from outage *source*
3. Outage tracking:
    - Determine duration, shifts in routing paths, geographic spread

Challenges in detecting infrastructure outages

Actual incident



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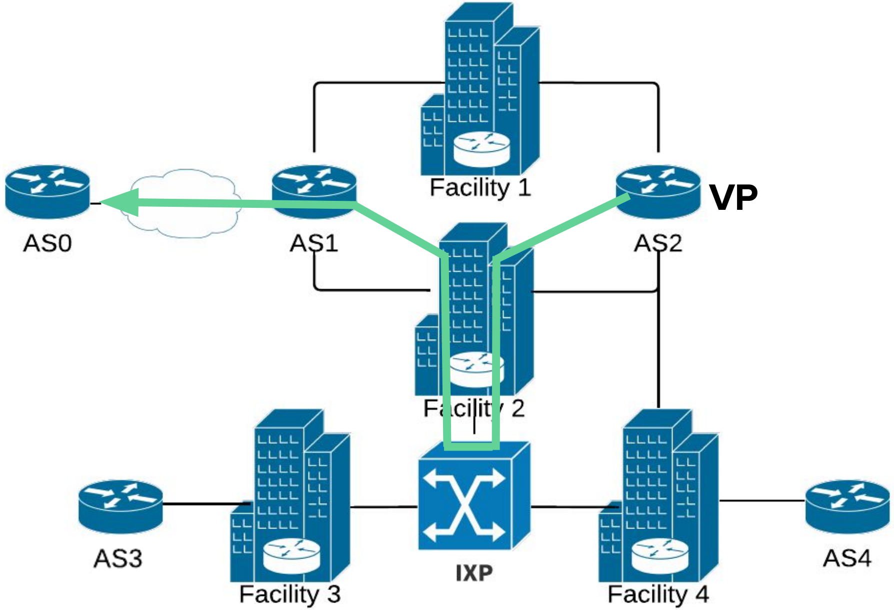
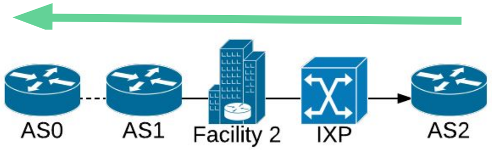


Observed paths

Before outage



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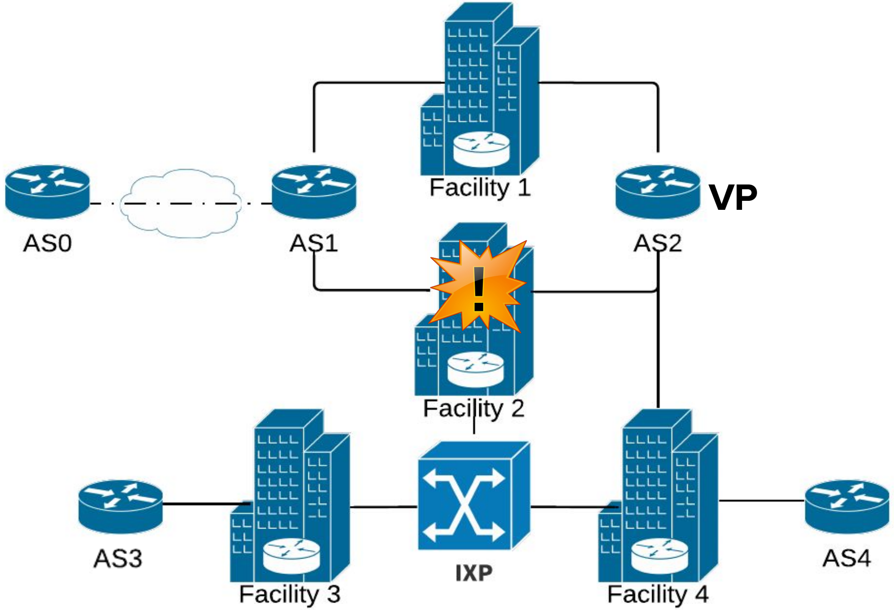

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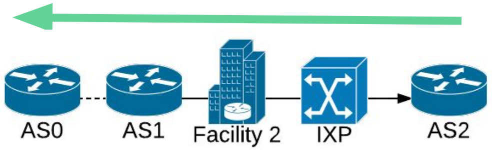

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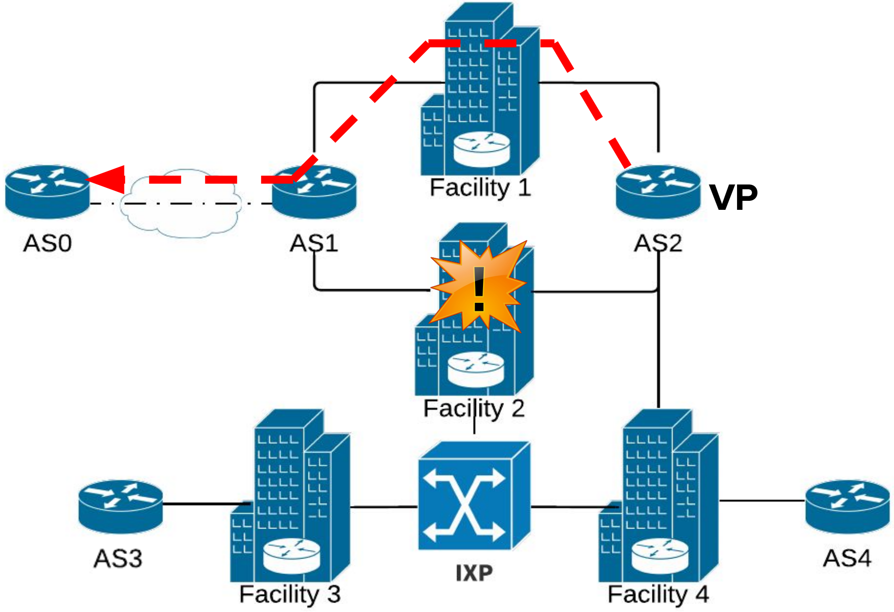
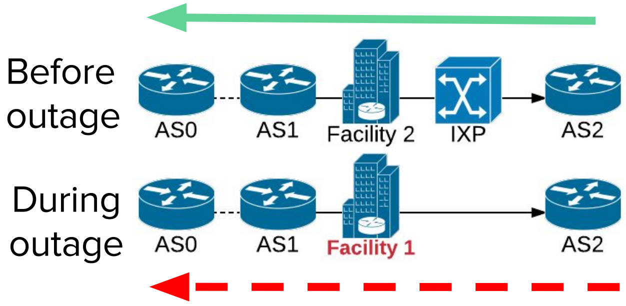


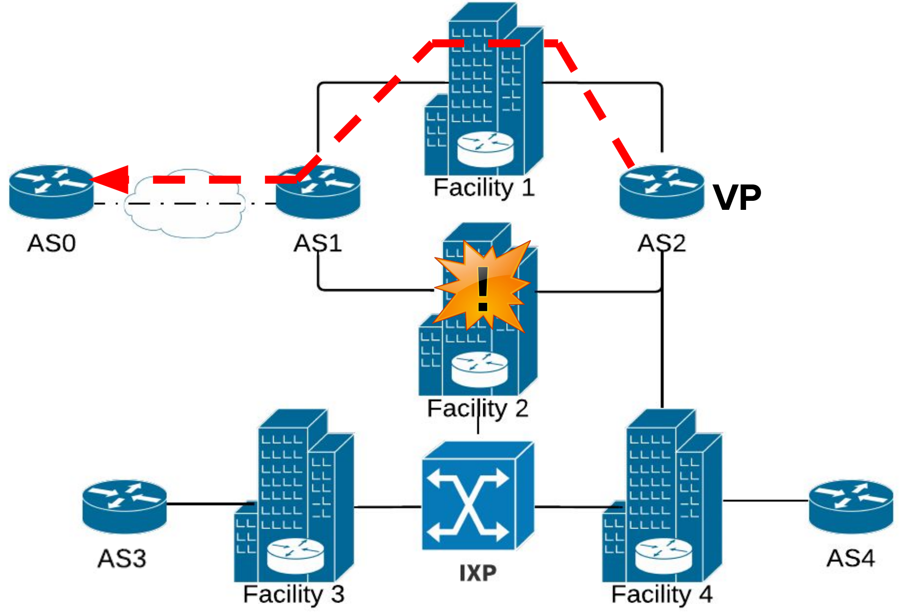
Observed paths



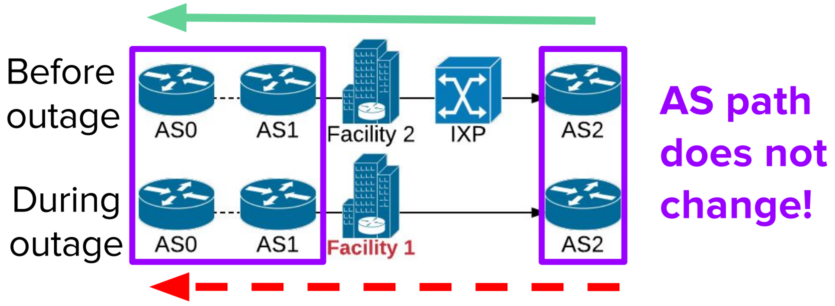
Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes

Actual incident



Observed paths



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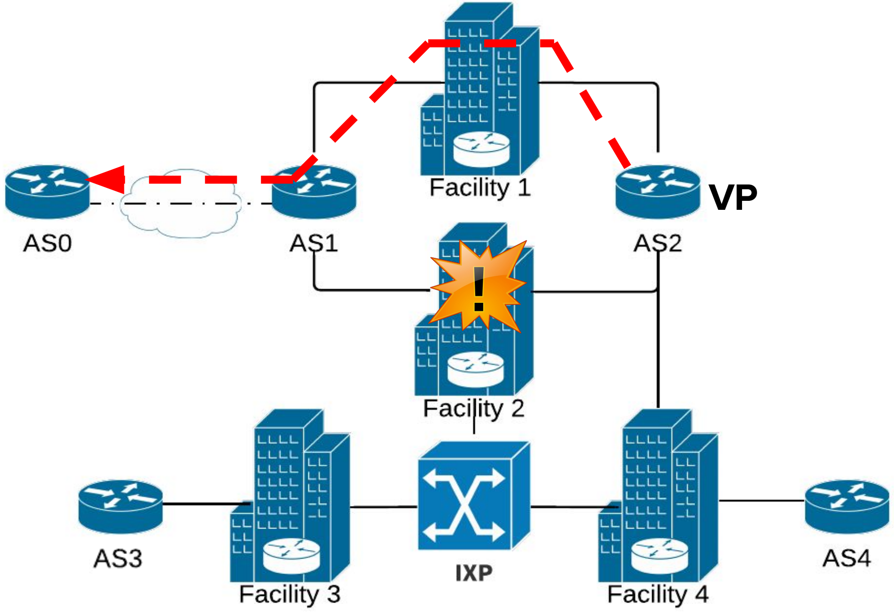
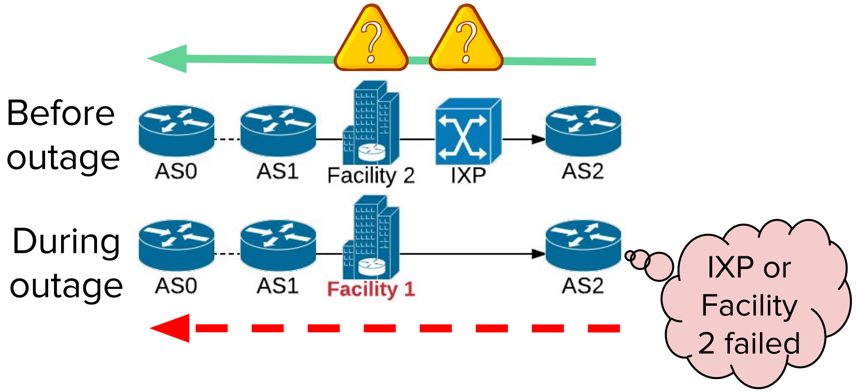
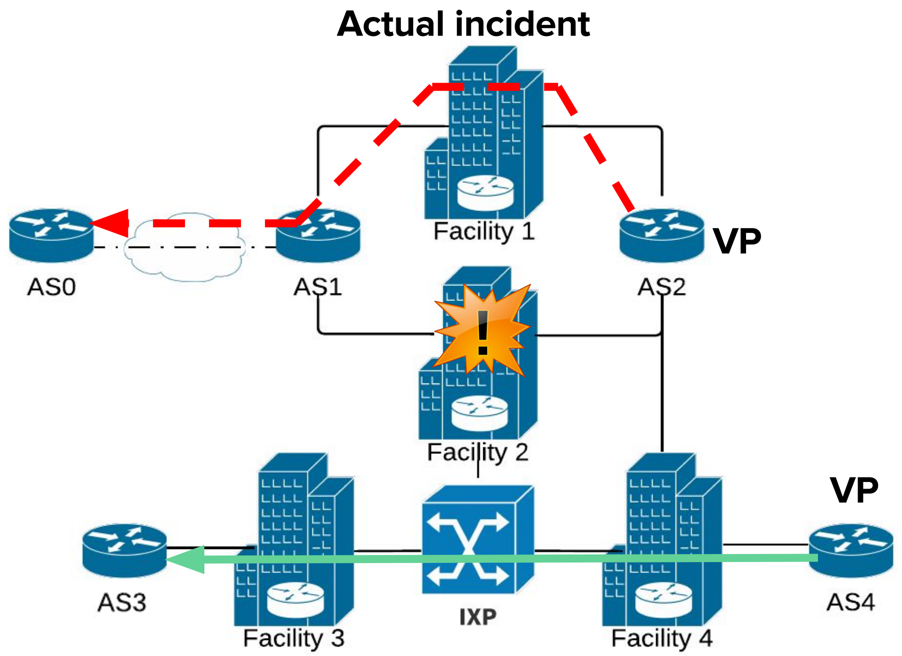


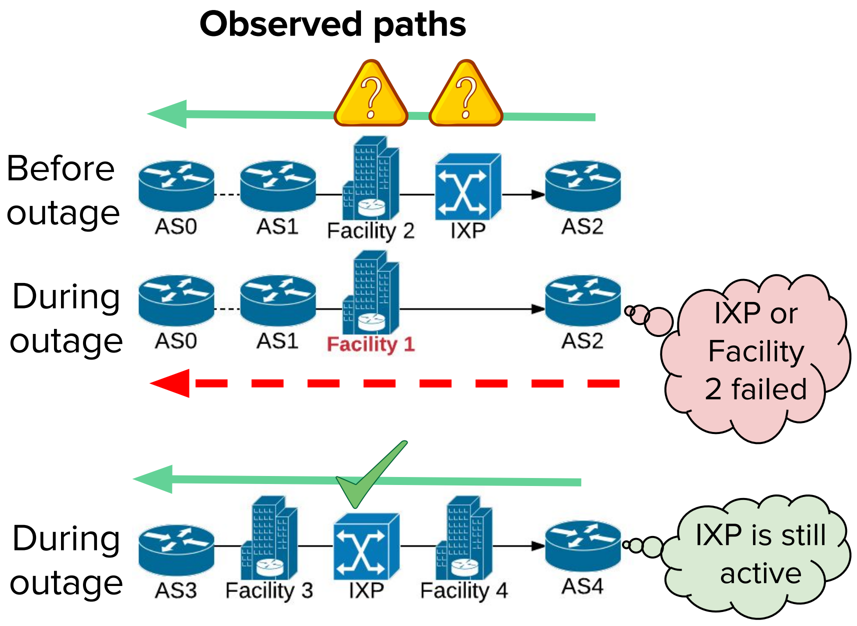
Observed paths



Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes
2. Correlating the paths from multiple vantage points

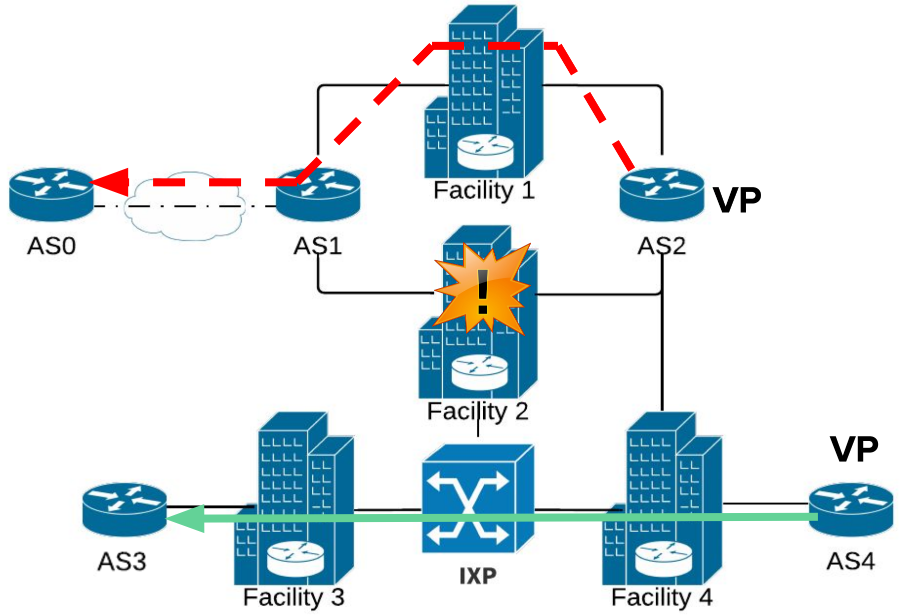




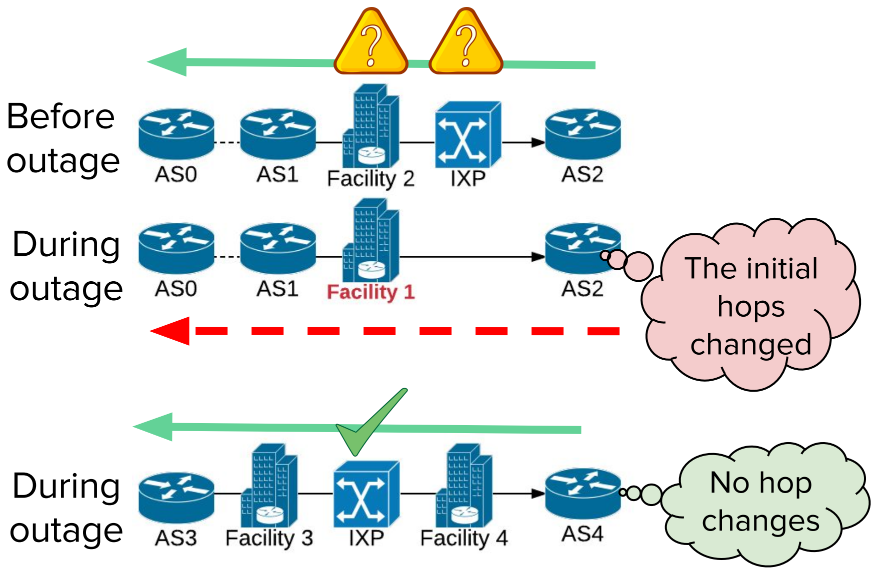
Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes
2. Correlating the paths from multiple vantage points
3. Continuous monitoring of the routing system

Actual incident



Observed paths

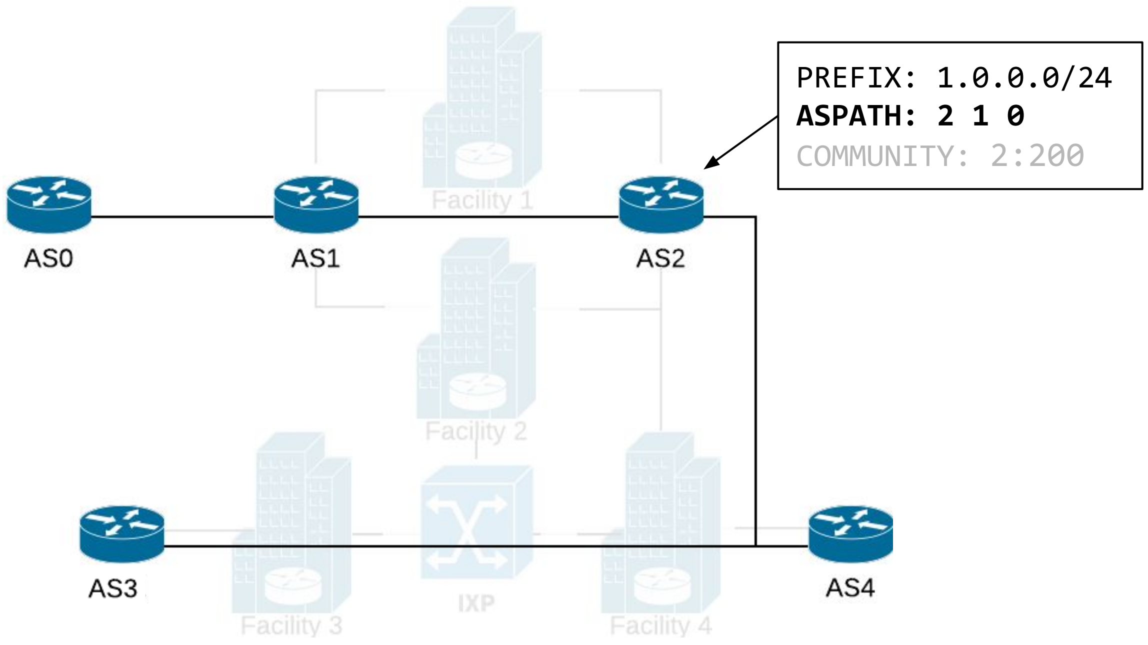


Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes ✗ BGP ✓ Traceroute
2. Correlating the paths from multiple vantage points ✓ BGP ✗ Traceroute
3. Continuous monitoring of the routing system ✓ BGP ✗ Traceroute

Can we combine **continuous passive** measurements with **fine-grained** topology discovery?

Deciphering location metadata in BGP



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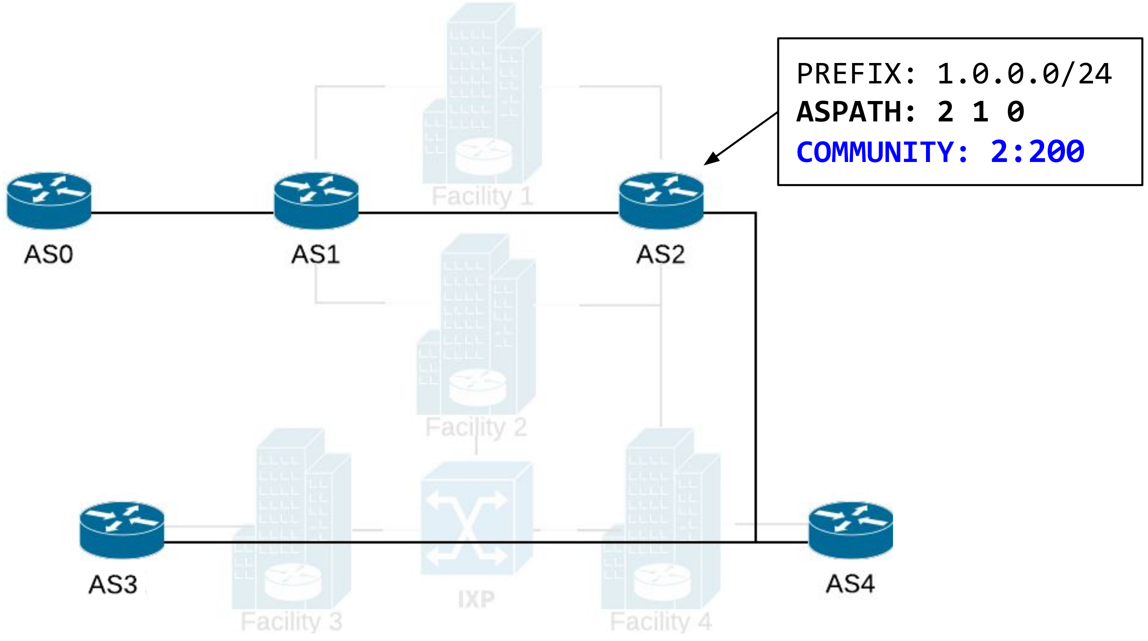
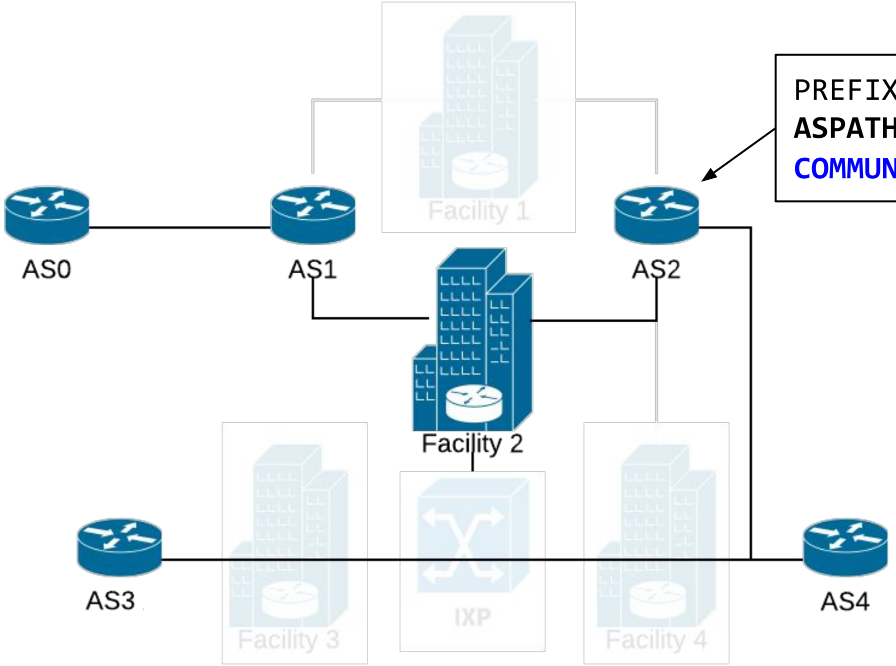


<u>BGP Communities:</u>

- Optional attribute
- 32-bit numerical values
- Encodes **arbitrary** metadata

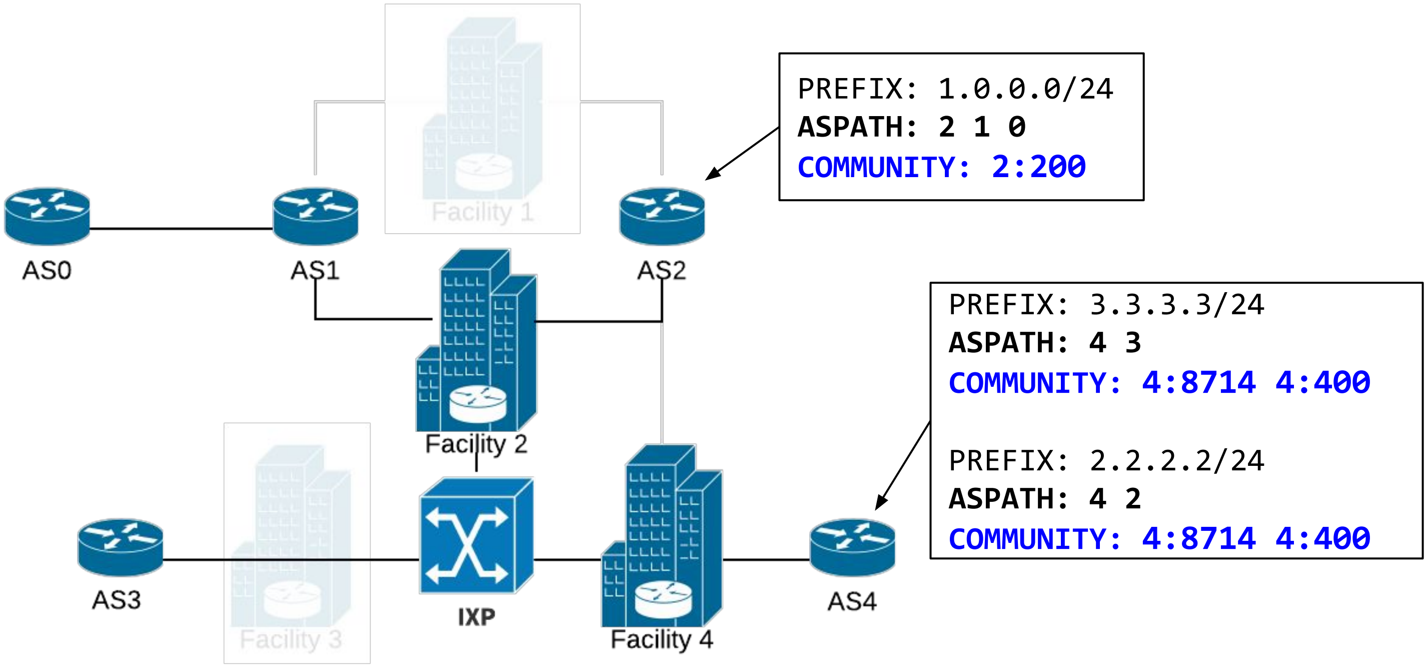
Deciphering location metadata in BGP




```
PREFIX: 1.0.0.0/24
ASPATH: 2 1 0
COMMUNITY: 2:200
```

The BGP Community 2:200 is used to tag routes received at Facility 2

Deciphering location metadata in BGP



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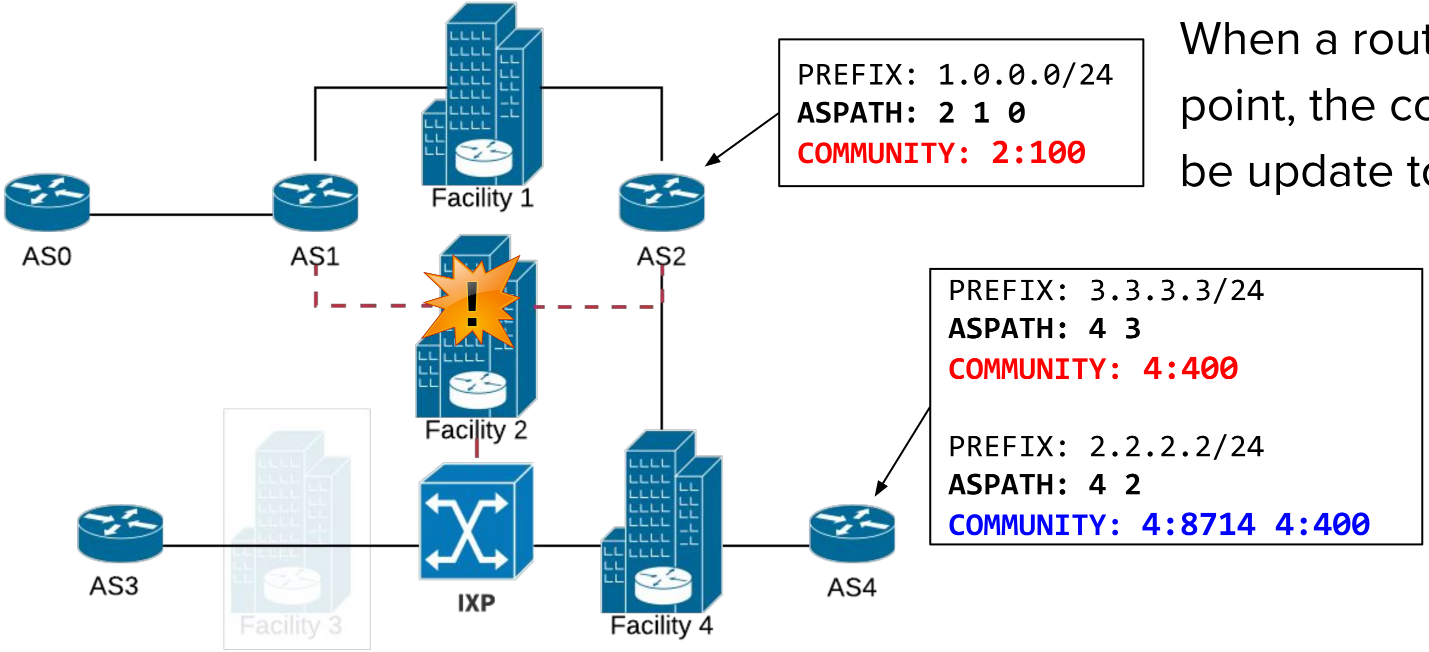


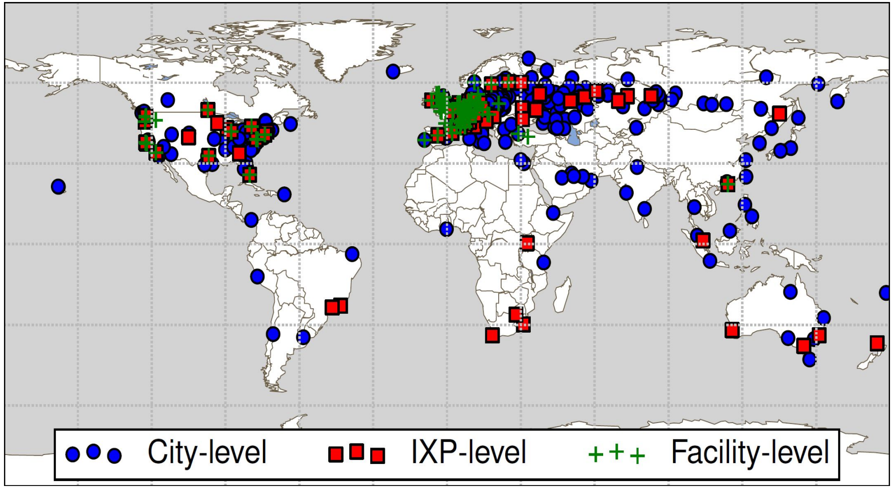
When a route changes ingress point, the community values will be update to reflect the change.

Interpreting BGP Communities

- Community values **not standardized**.
- Documentation in public data sources:
    - WHOIS, NOCs websites
- Natural Language Tools to extract the interpretations

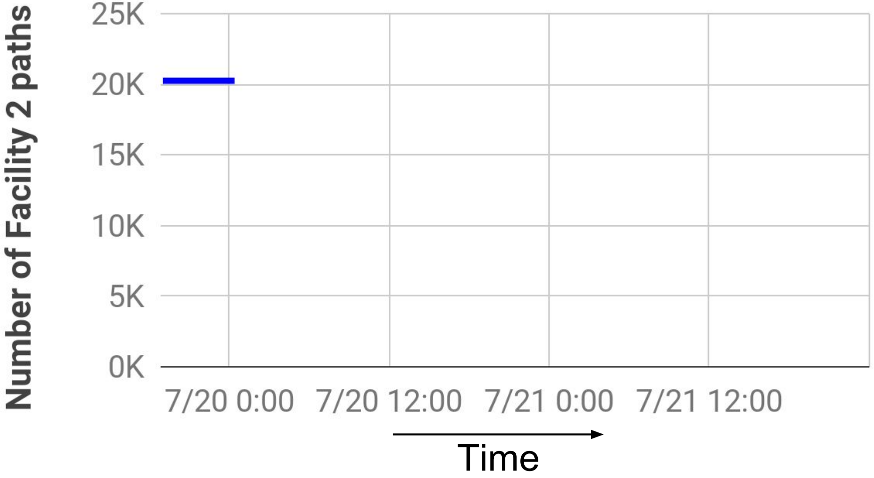
```
remarks:        +-----------------------------------------------------+
remarks:        |   INBOUND COMMUNITIES                               |
remarks:        +-----------------------------------------------------+
remarks:        20886:100      received from Upstream
remarks:        20886:120      received from Peering
remarks:        20886:130      received from Private Peering
remarks:        20886:150      received from Customer
remarks:        20886:200      received local
remarks:
remarks:        20886:4000     received in Bonn
remarks:        20886:4010     received in Duesseldorf
remarks:        20886:4020     received in Frankfurt
remarks:        20886:4030     received in Berlin
remarks:        20886:4100     received in Amsterdam
remarks:
remarks:        20886:5000     received from PeeringPoint DE-CIX
remarks:        20886:5010     received from PeeringPoint ECIX-DUS
remarks:        20886:5020     received from PeeringPoint KleyReX
remarks:        20886:5100     received from PeeringPoint AMS-IX
remarks:
remarks:        20886:6000     received from Level3
remarks:        20886:6010     received from LambdaNet/euNetworks
remarks:        20886:6020     received from TNG
remarks:        20886:6030     received from DTAG
remarks:        20886:6060     received from Telefonica Deutschland
remarks:        20886:6080     received from QSC
remarks:
```

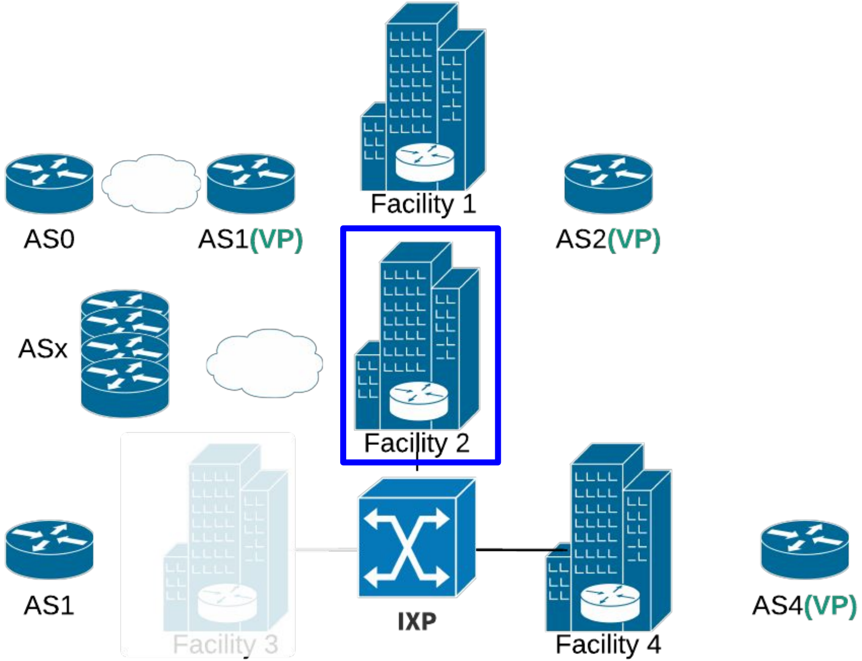
Topological coverage



- **3,049** communities by 468 ASes.
- ~**50%** of IPv4 and ~**30%** of IPv6 paths annotated with at least one Community in our dictionary.
- **24%** of the facilities in PeeringDB, **98%** of the facilities with at least 20 members.

Passive outage detection: Initialization





For each vantage point **(VP)** collect all the **stable** BGP routes tagged with the communities of the target facility (Facility 2)

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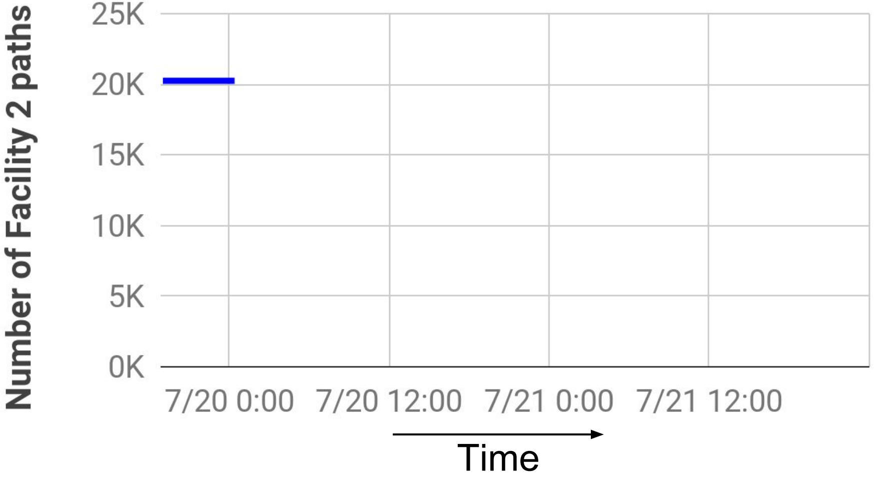

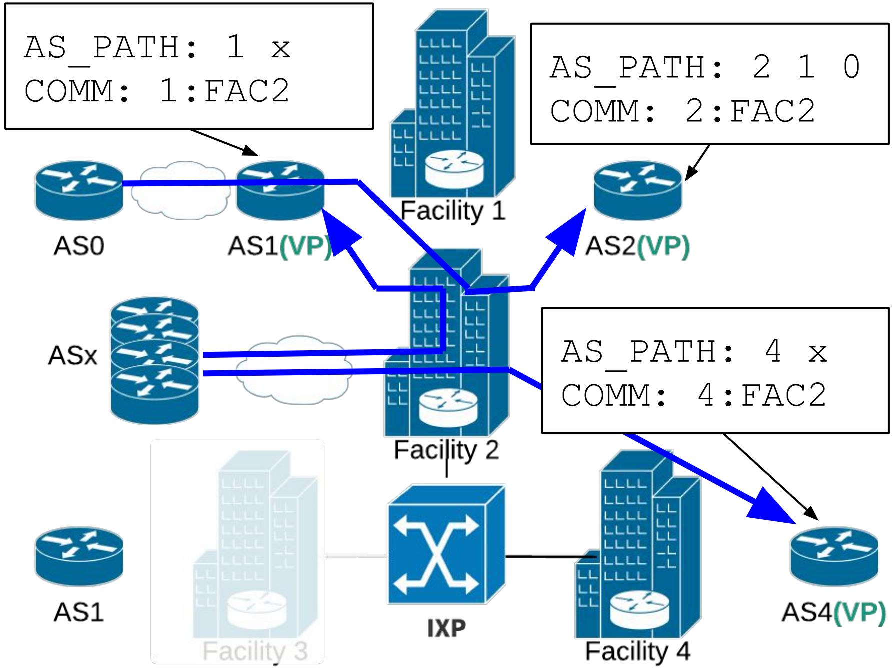

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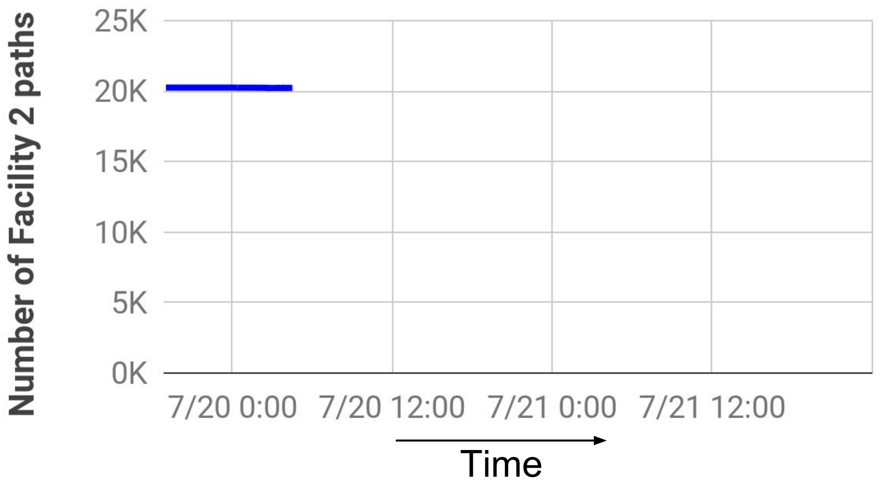
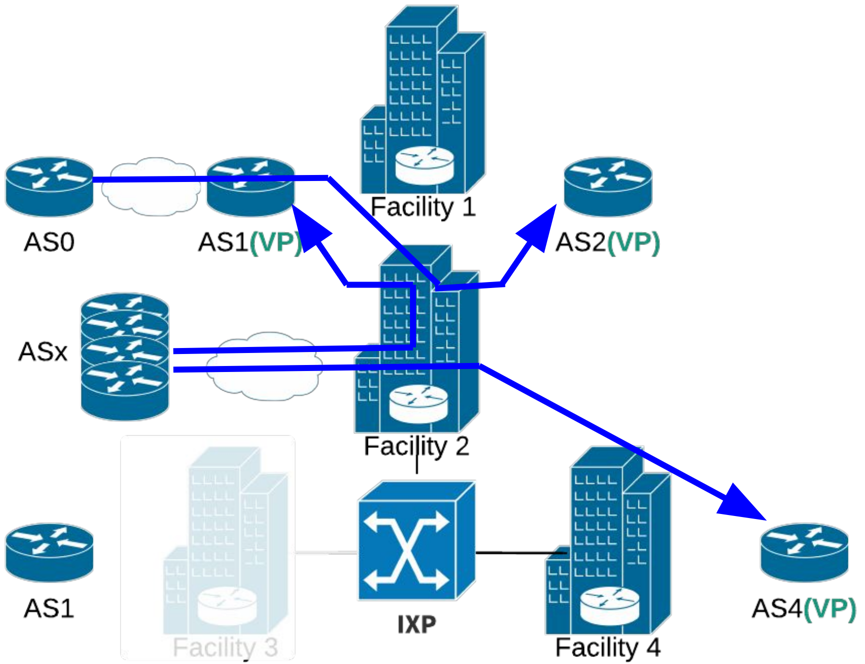
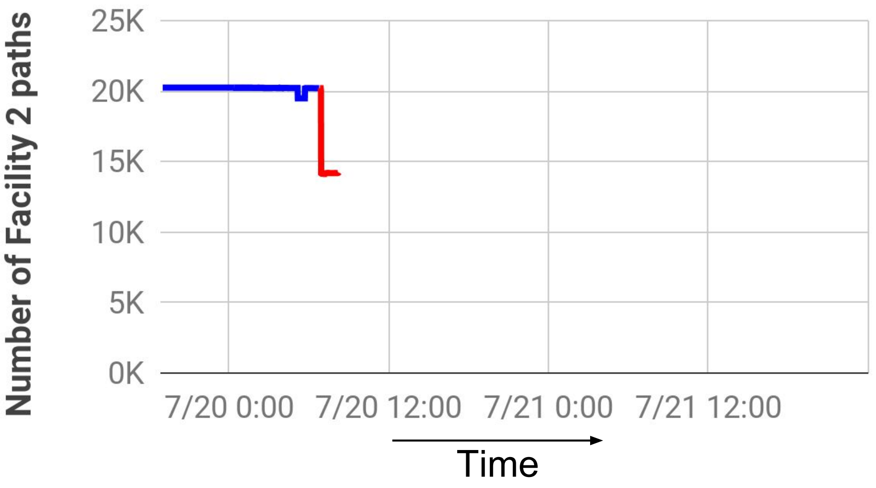
Passive outage detection: Monitoring

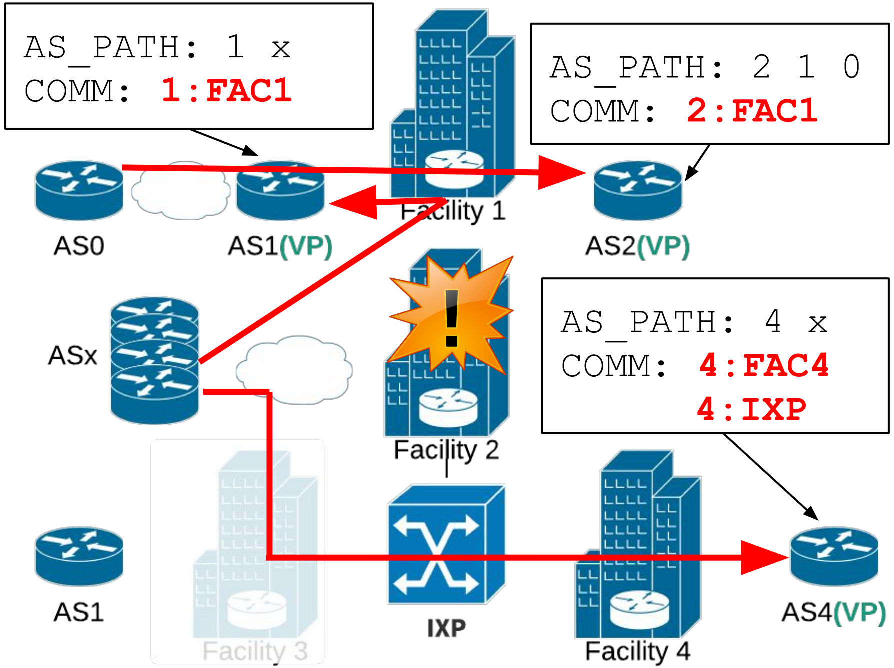




Track the BGP updates of the stable paths for changes in the communities values that indicate ingress point change.

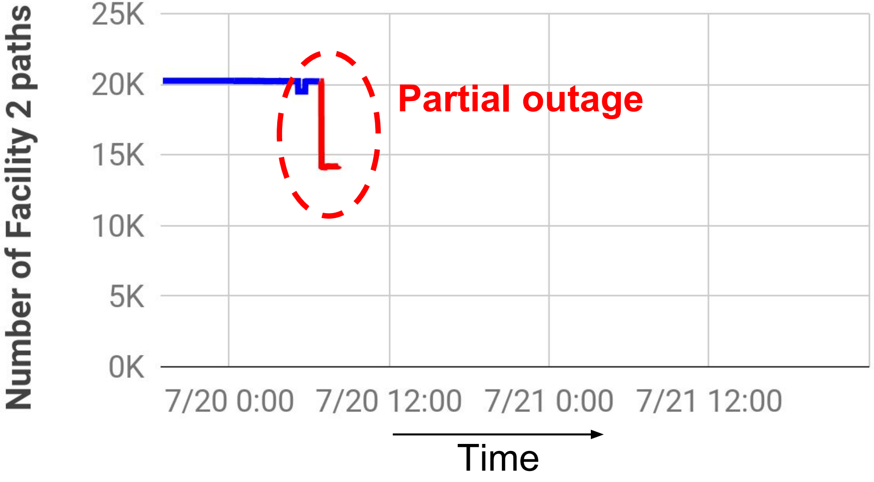
Passive outage detection: Outage signal

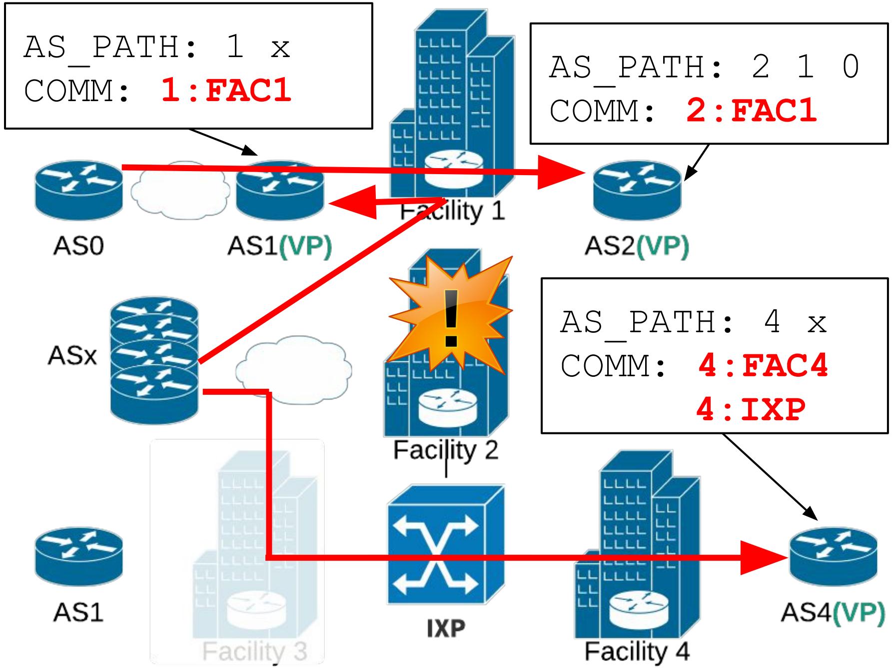




- Concurrent changes of communities values for the same facility.
- **Indication** of outage but not final inference yet!

Passive outage detection: Outage signal





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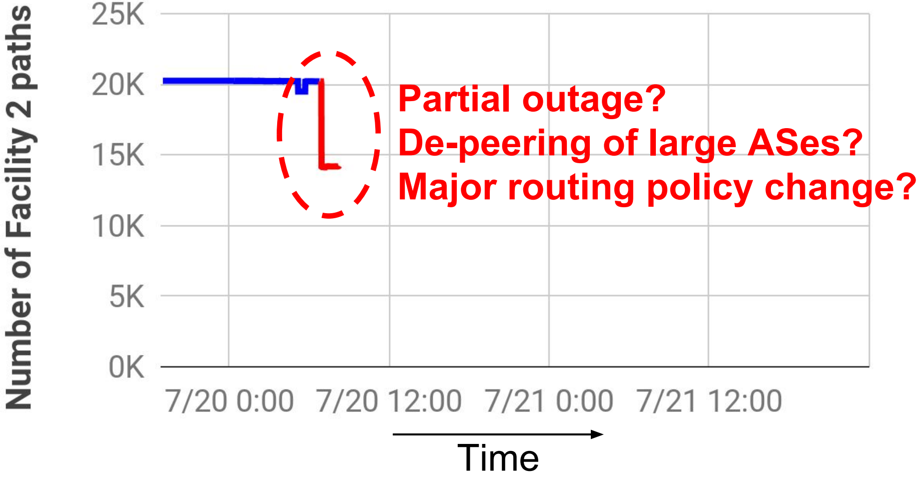

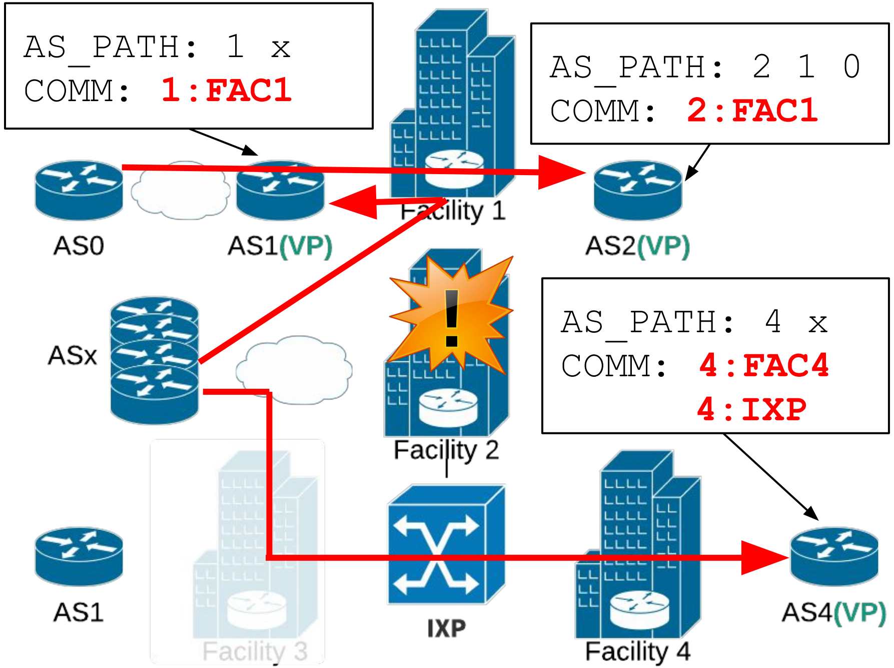

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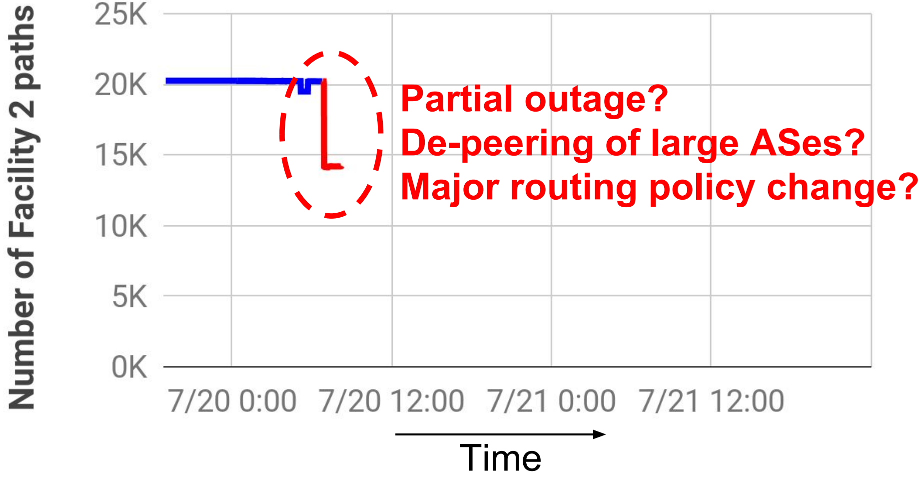
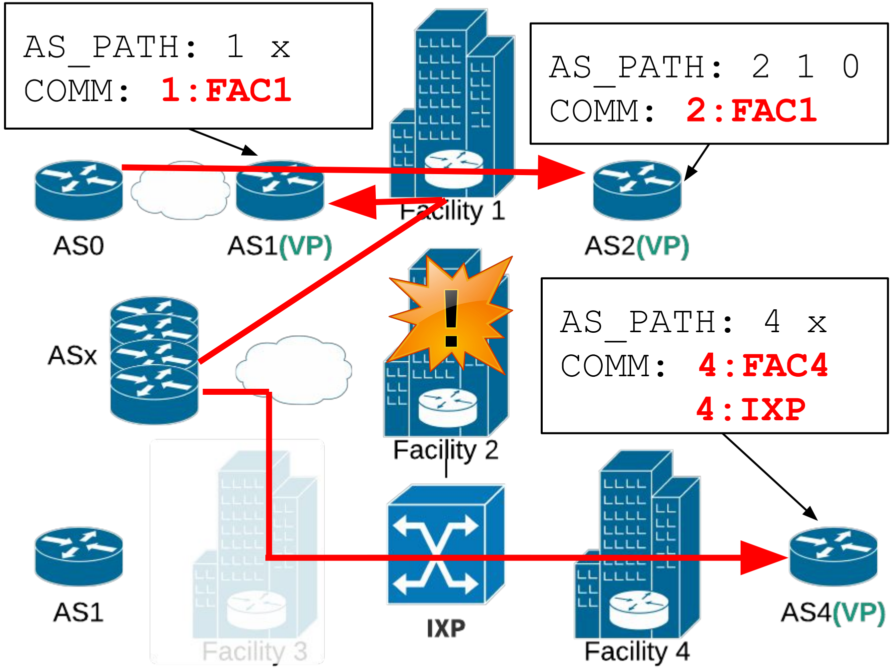
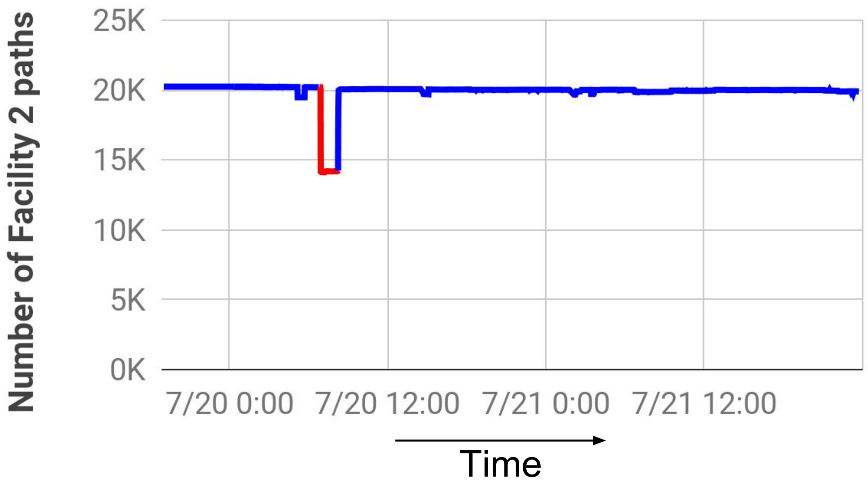


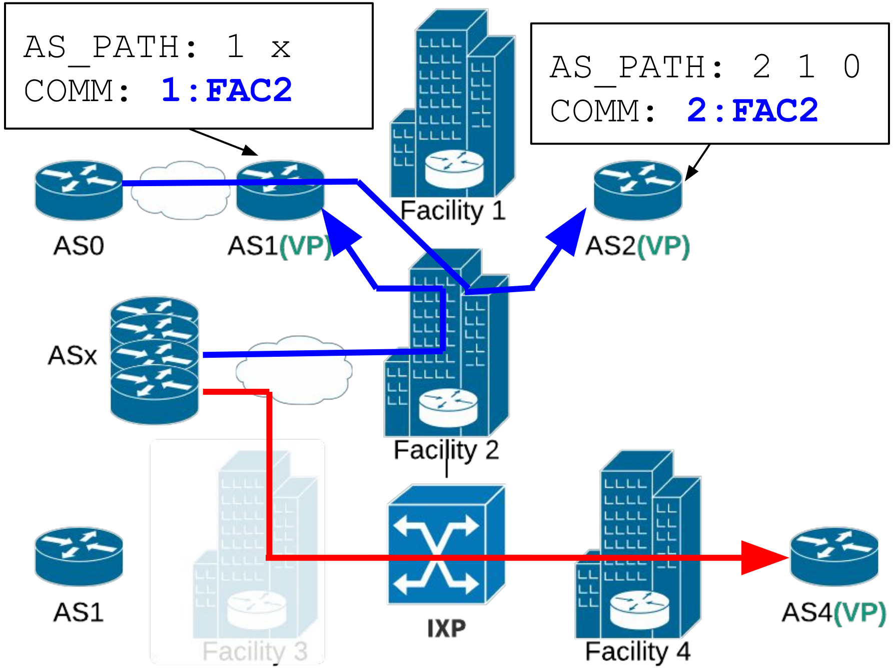


Signal investigation:

- Targeted active measurements.
- How disjoint are the affected paths?
- How many ASes and links have been affected?

Passive outage detection: Outage tracking

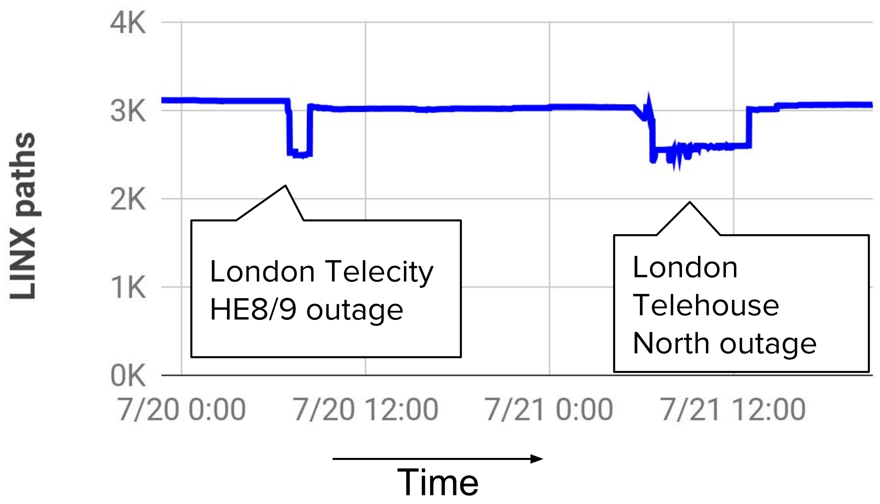


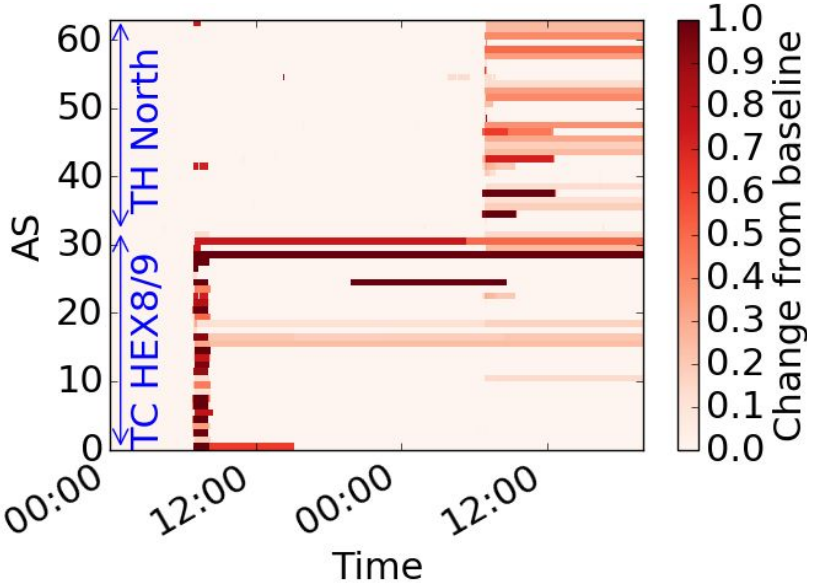


End of outage inferred when the majority of paths return to the original facility.

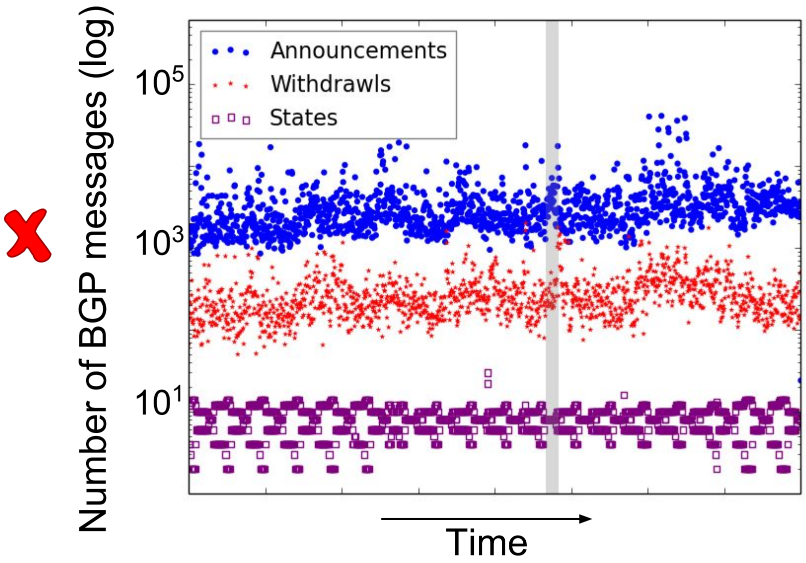
Outage source disambiguation and localization

Paths not investigated in aggregated manner, but at the granularity of separate (AS, Facility) co-locations.





De-noising of BGP routing activity



The aggregated activity of BGP messages (updates, withdrawals, states) provides no outage indication.

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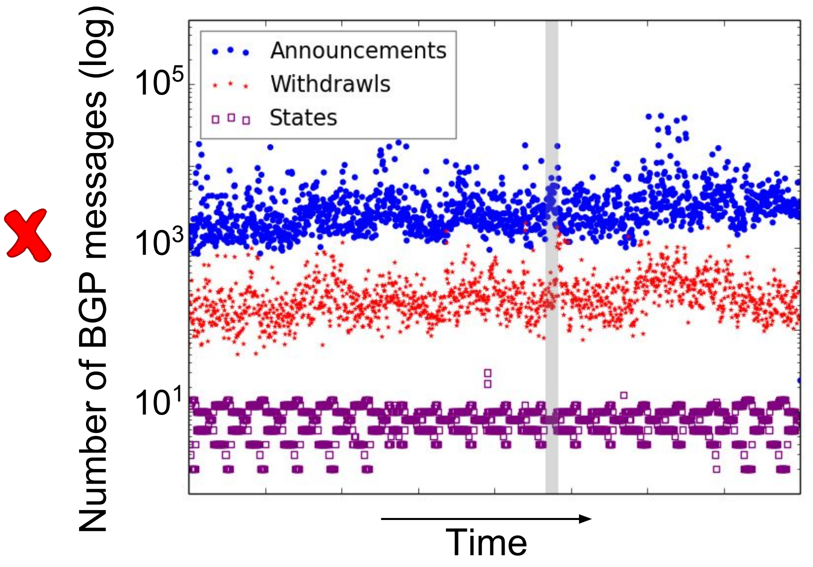

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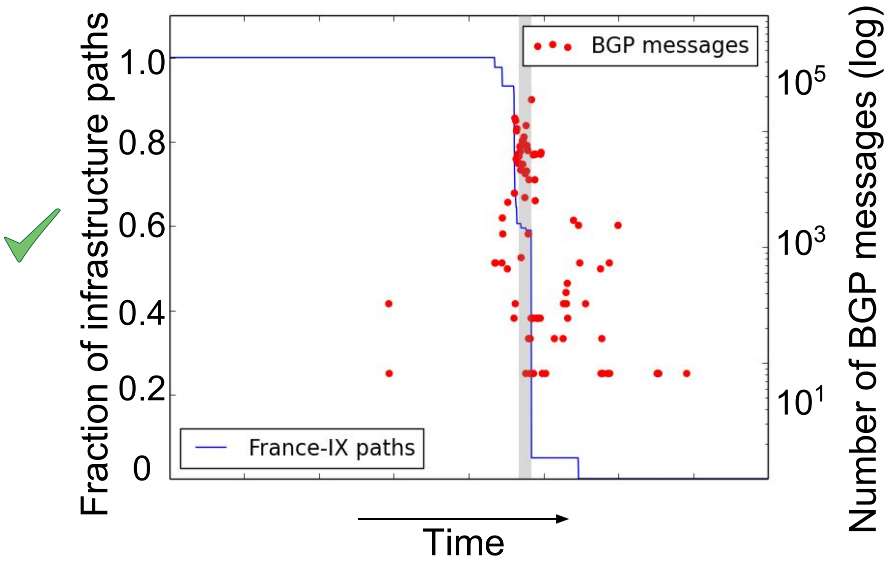
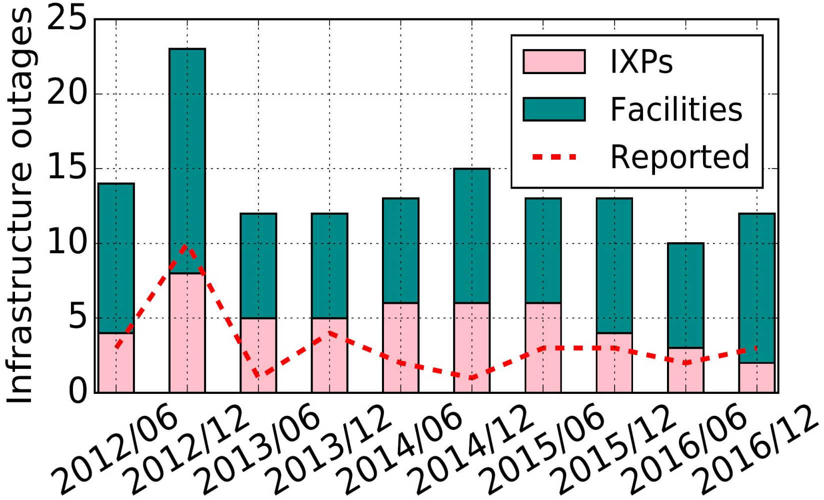


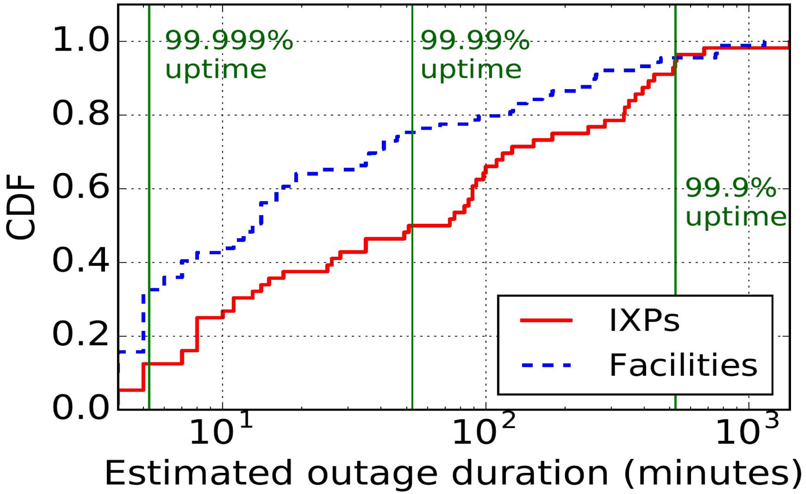
The BGP activity filtered using communities provides **strong outage signal**.

Detecting peering infrastructure outages in the wild



- **159** outages in 5 years of BGP data
  - **76%** of the outages not reported in popular mailing lists/websites
- Validation through status reports, direct feedback, social media
  - **90%** accuracy, **93%** precision (for trackable PoPs)

Effect of outages on Service Level Agreements

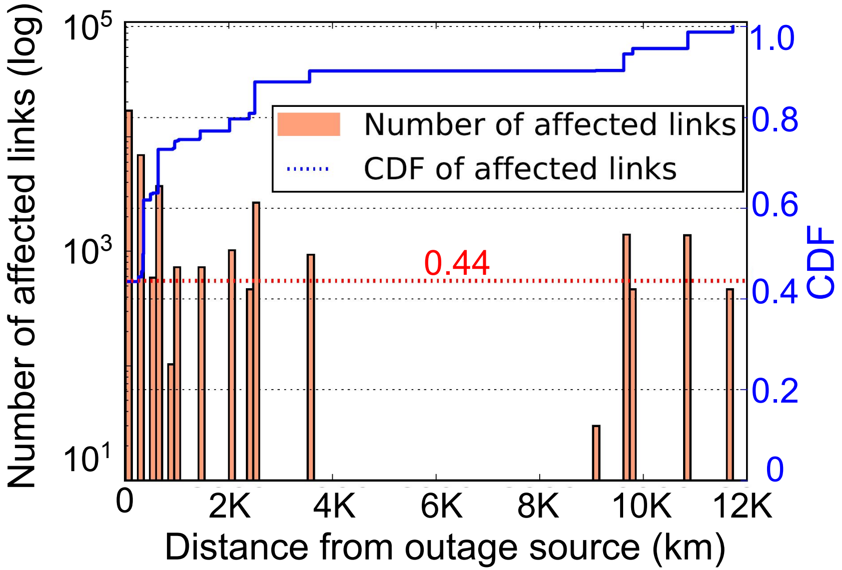


~**70%** of failed facilities below 99.999% uptime

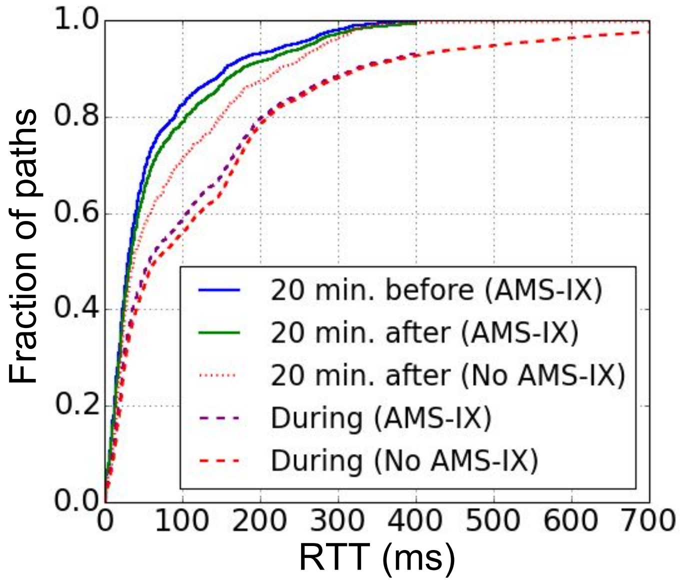
~50% of failed IXPs below 99.99% uptime

5% of failed infrastructures below 99.9% uptime!

Measuring the impact of outages



> **56 %** of the affected links in different country, > **20%** in different continent!



50% increase in the number of paths with end-to-end RTT > **100 ms** during the AMS-IX outage.

Conclusions

- **Timely** and **accurate** infrastructure-level outage detection through **passive** BGP monitoring
- Majority of outages not (widely) reported
- Remote peering and infrastructure interdependencies **amplify** the impact of local incidents
- **Hard evidence** on outages can improve accountability, transparency and resilience strategies

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Detecting Peering Infrastructure Outages in the Wild

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ABSTRACT

Peering infrastructures, namely, colocation facilities and Internet exchange points, are located in every major city, have hundreds of network members, and support hundreds of thousands of interconnections around the globe. These infrastructures are well provisioned and managed, but outages have to be expected, e.g., due to power failures, human errors, attacks, and natural disasters. However, little is known about the *frequency* and *impact* of outages at these critical infrastructures with high peering concentration.

1 INTRODUCTION

Today, our economy as well as our social life, rely on the smooth and uninterrupted operation of the Internet. While the Internet has shown an amazing resilience as a whole, even short outages can have a significant impact on a subset of the Internet user population. Past major Internet outages have been studied in depth, including outages due to network component failure, e.g., hardware, software, and configuration failures in routers [98], optical layer outages [47], natural disasters [20, 23, 35, 56, 84], and nation-wide censorship [23,