# Monitoring the hidden: TimeMap

**Claudio Allocchio (GARR)**
**And GN5-1 WP6 T3 team**
TimeMap-dev@lists.geant.org

# Outline

- Why Timemap
- Current status
- Beyond observation: anomaly detection
- Further development

# What are we talking about?

**How is the road ahead today?**

**And how is it is in average?**

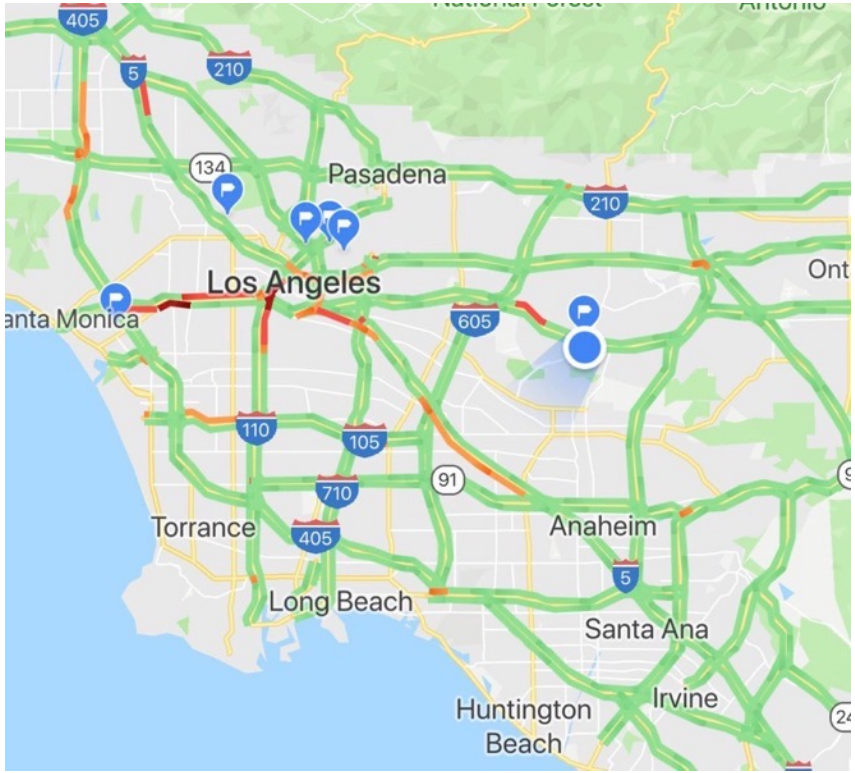
# “Road report: on HWY 101 there are 364 vehicles per minute”

it may
Be nice
…

# “Road report: on HWY 101 there are 364 vehicles per minute”


**Or…**
**Lots of Stop & Go**

# “Road report: on HWY 101 there are queues at the red spots”




**…but we also like to know transit times**

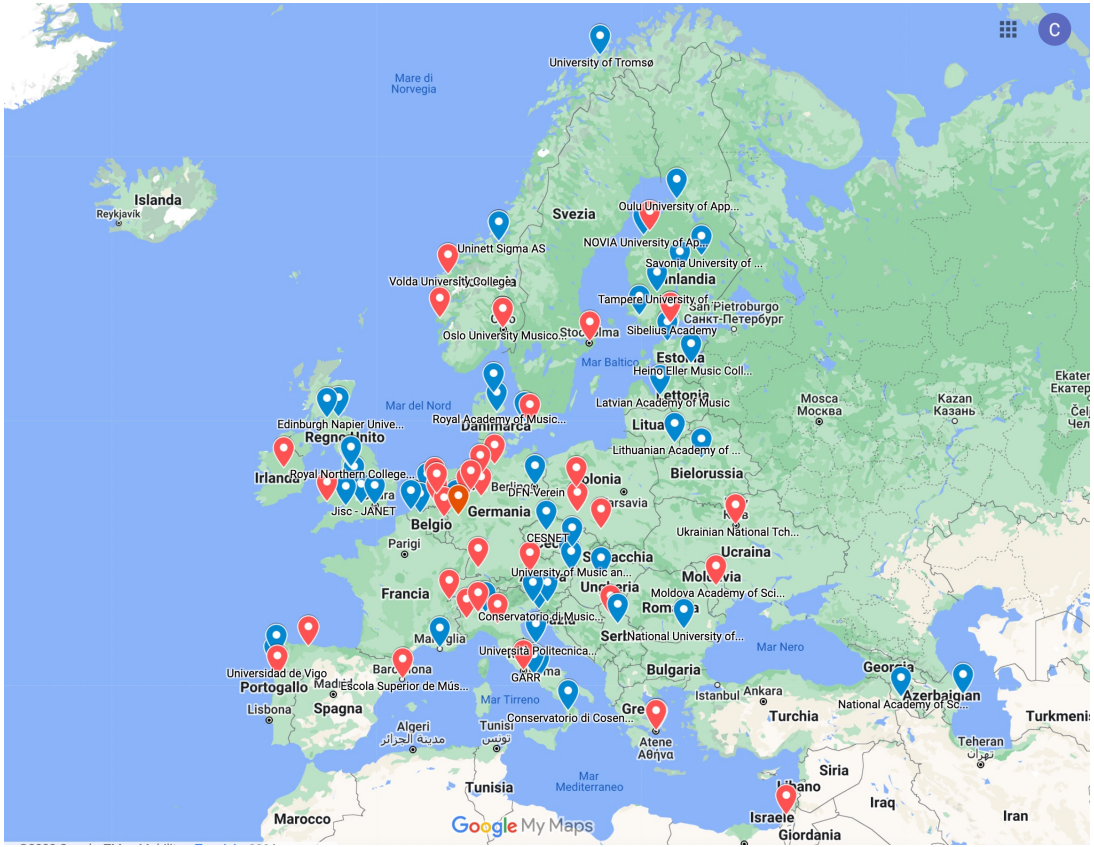
# Network Traffic: what do we usually have?


**But this is OK for bulk data transfers**

# NOT for real time applications which are sensitive to Latency & Jitter!

# Can my application set the cruise control on and live happily?

# Applications which need “cruise control” on are on fast rise!

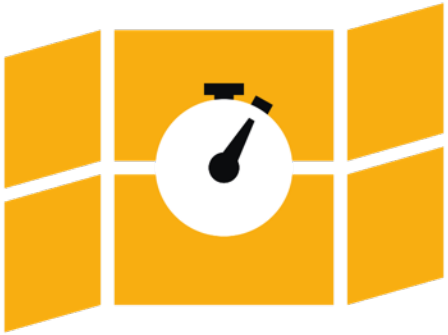



- **LoLa**

**+ 32%**

## We need to monitor ”the hidden”:

- latency
- jitter



TimeMap

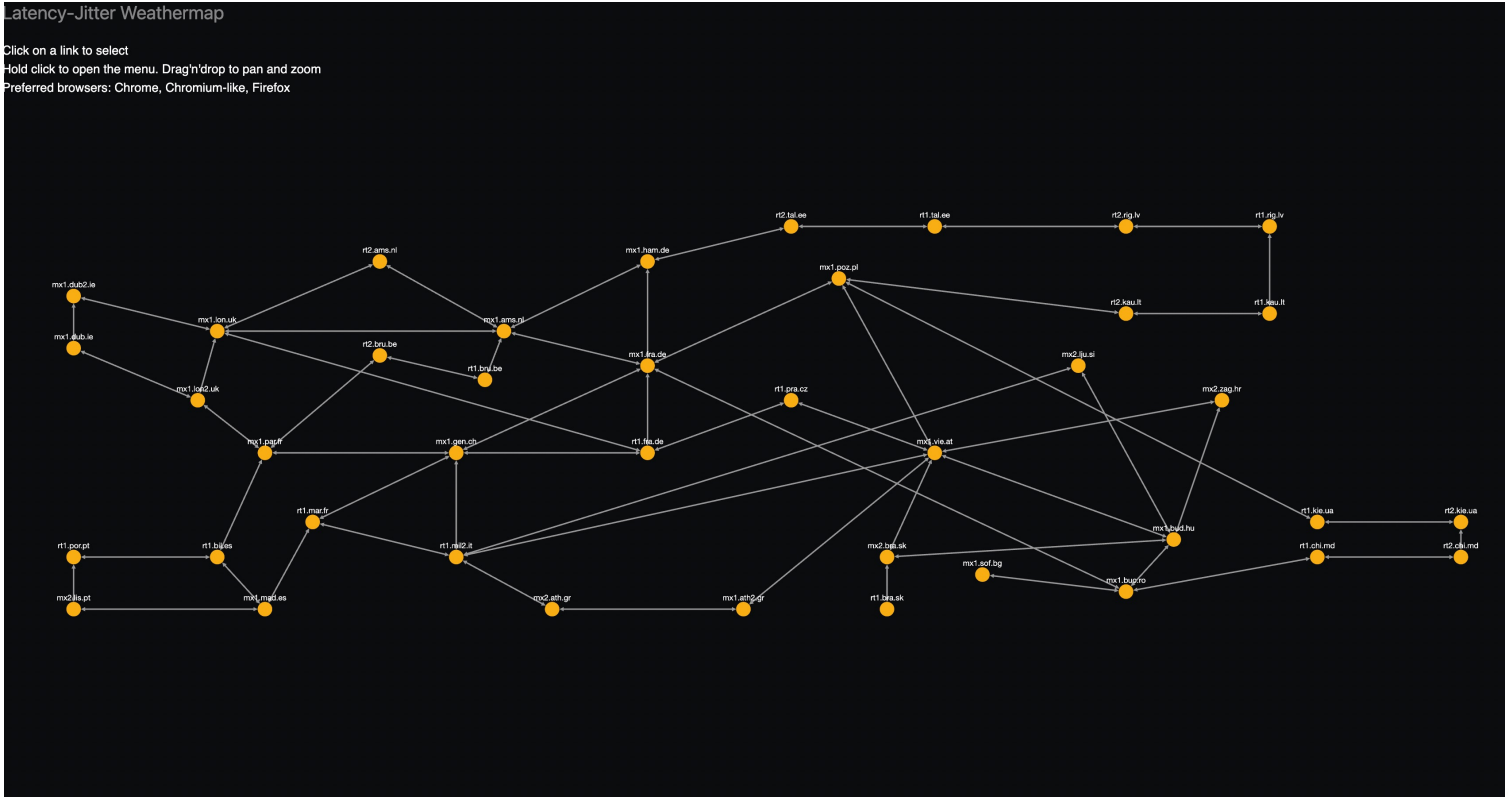
## We need to keep track of ”the hidden”:

- historic series

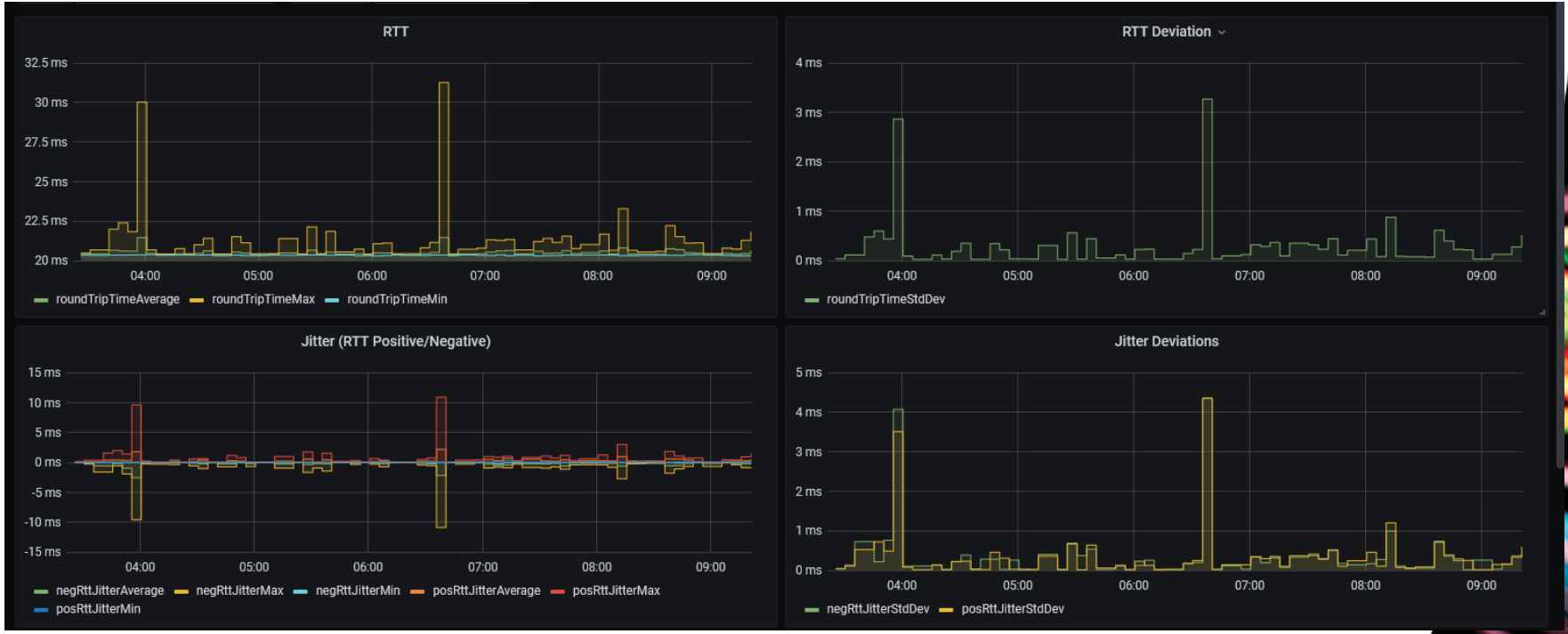
## We need to find anomalies in “the hidden”

- machine learning
- alarms
- call the Police!  … well, call the NOC people!

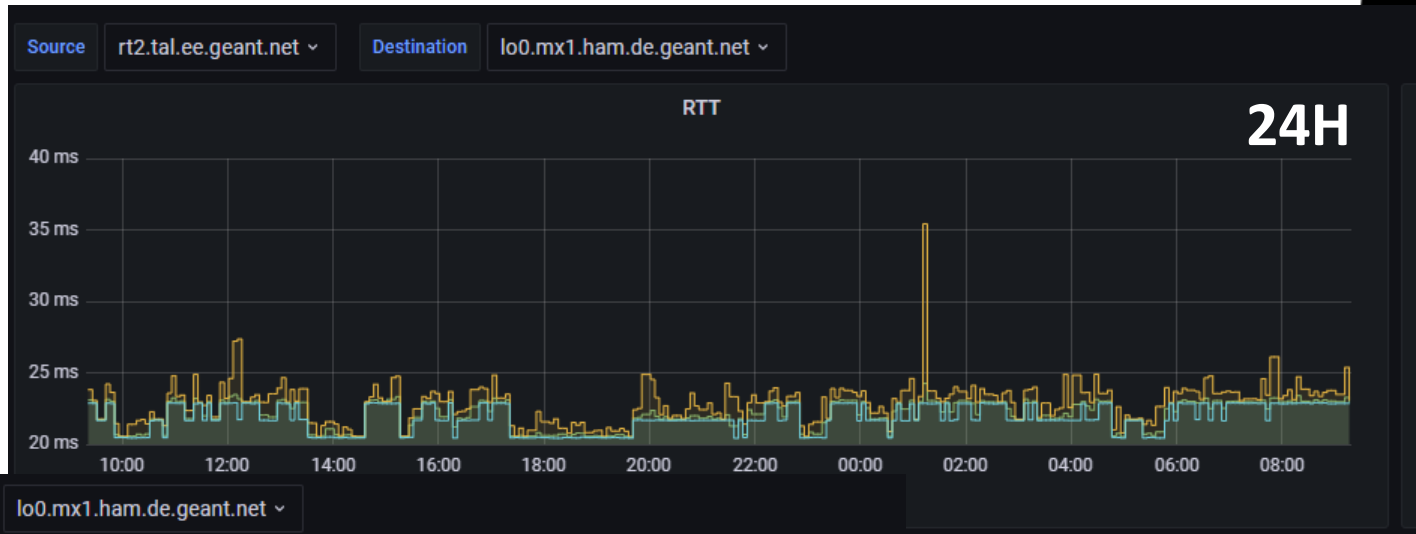
# The entry map page: click on link (TWAMP) or router (anomalies)

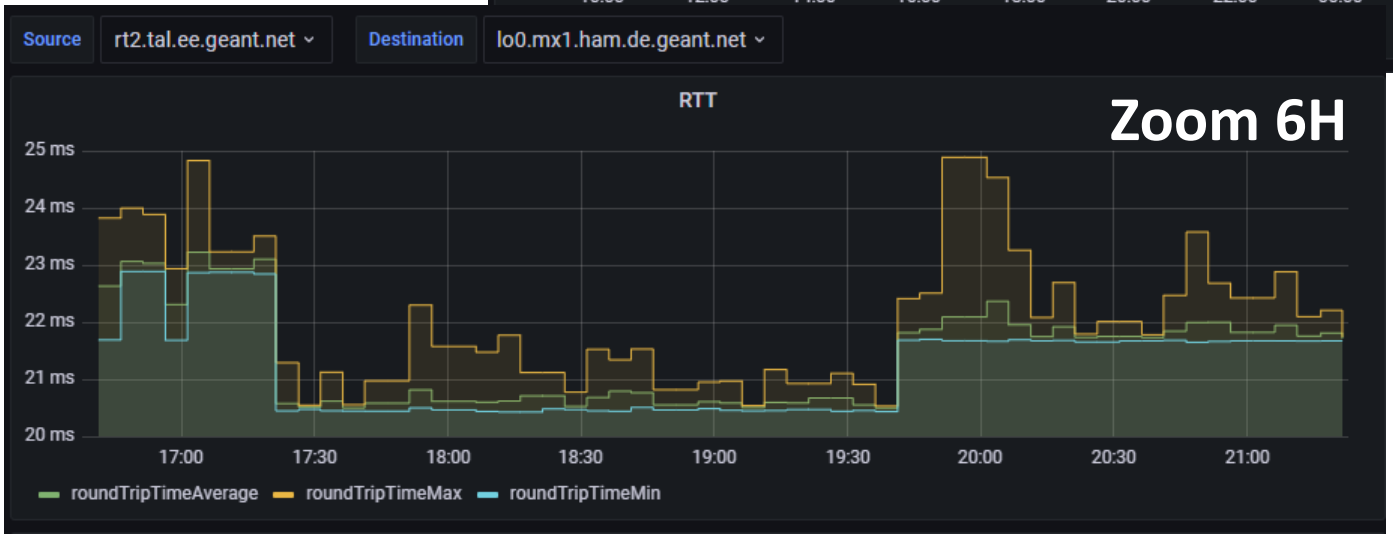


# Periodic events

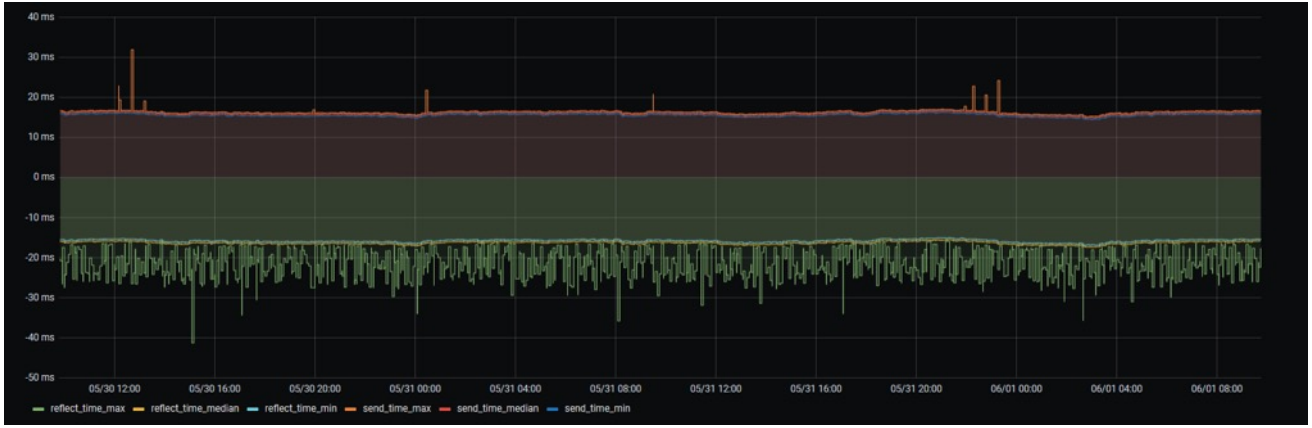


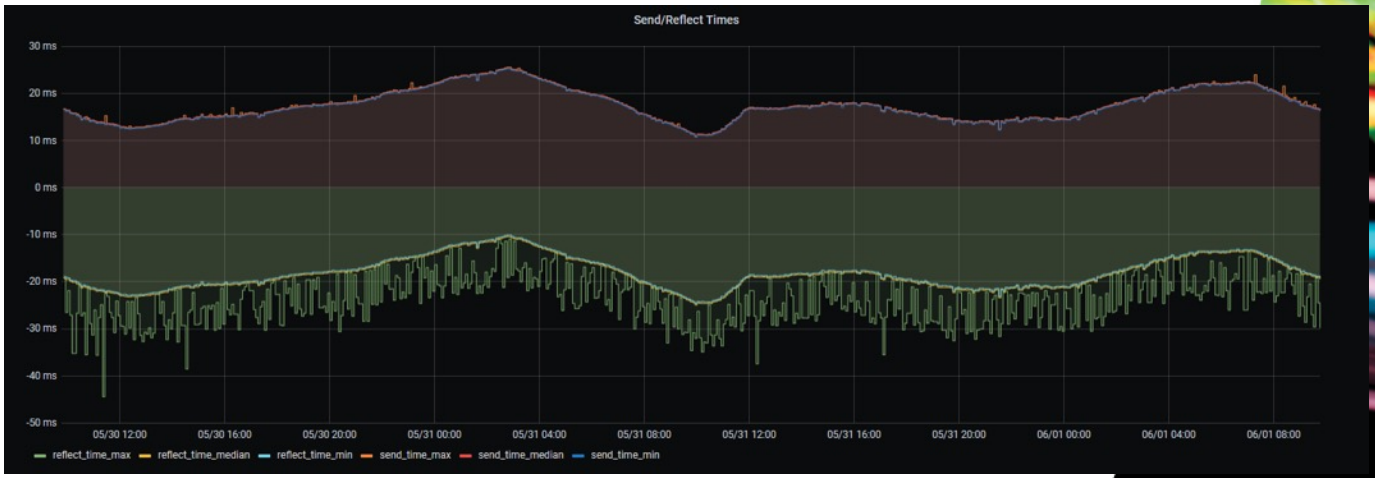
# Re-routing


Source
rt2.tal.ee.geant.net
Destination
lo0.mx1.ham.de.geant.net
RTT
24H
40 ms
35 ms
30 ms
25 ms
20 ms
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
02:00
04:00
06:00
08:00

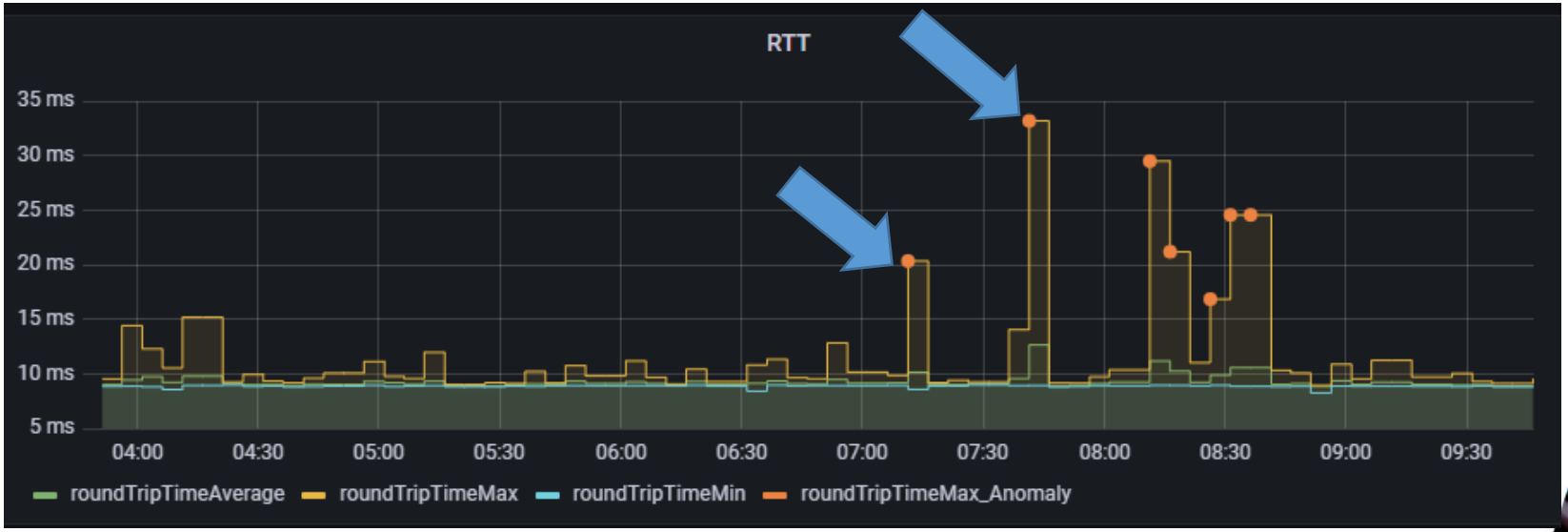

Source
rt2.tal.ee.geant.net
Destination
lo0.mx1.ham.de.geant.net
RTT
Zoom 6H
25 ms
24 ms
23 ms
22 ms
21 ms
20 ms
17:00
17:30
18:00
18:30
19:00
19:30
20:00
20:30
21:00
roundTripTimeAverage
roundTripTimeMax
roundTripTimeMin

# Trends (clocks shifting?)

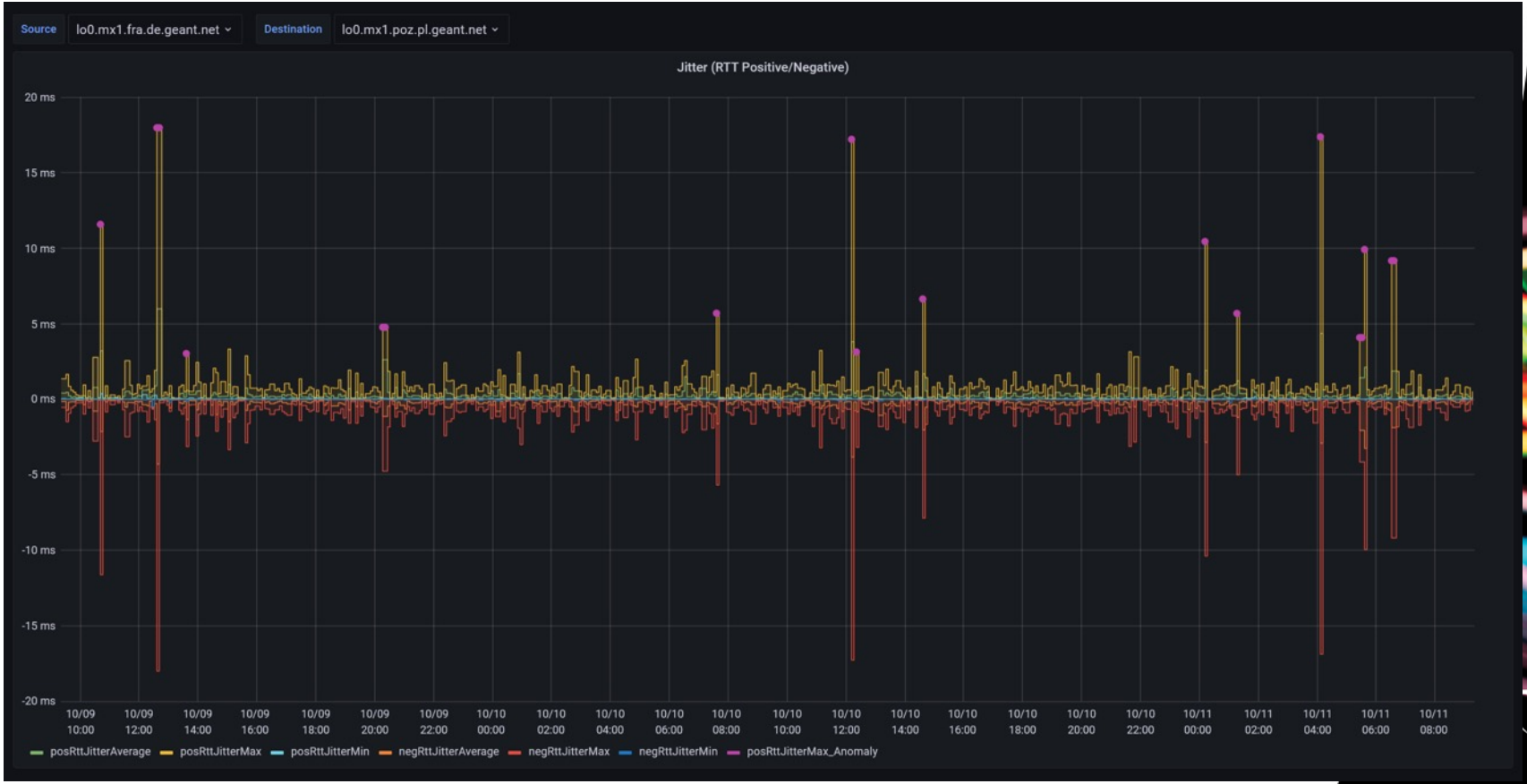


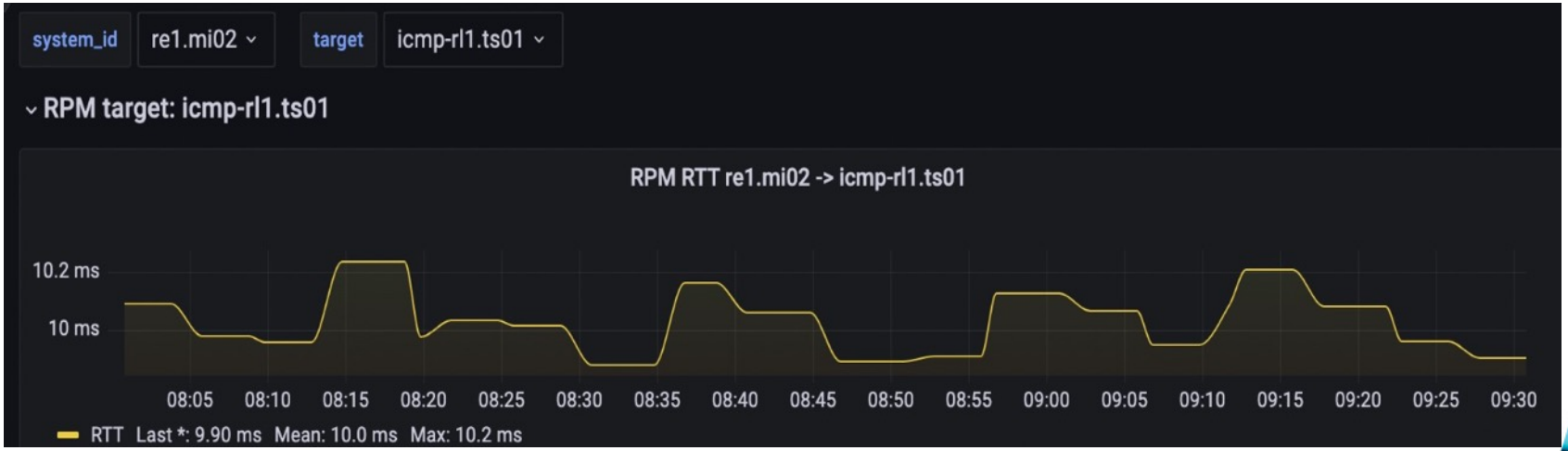
# Anomaly Detection (AD) in Timemap



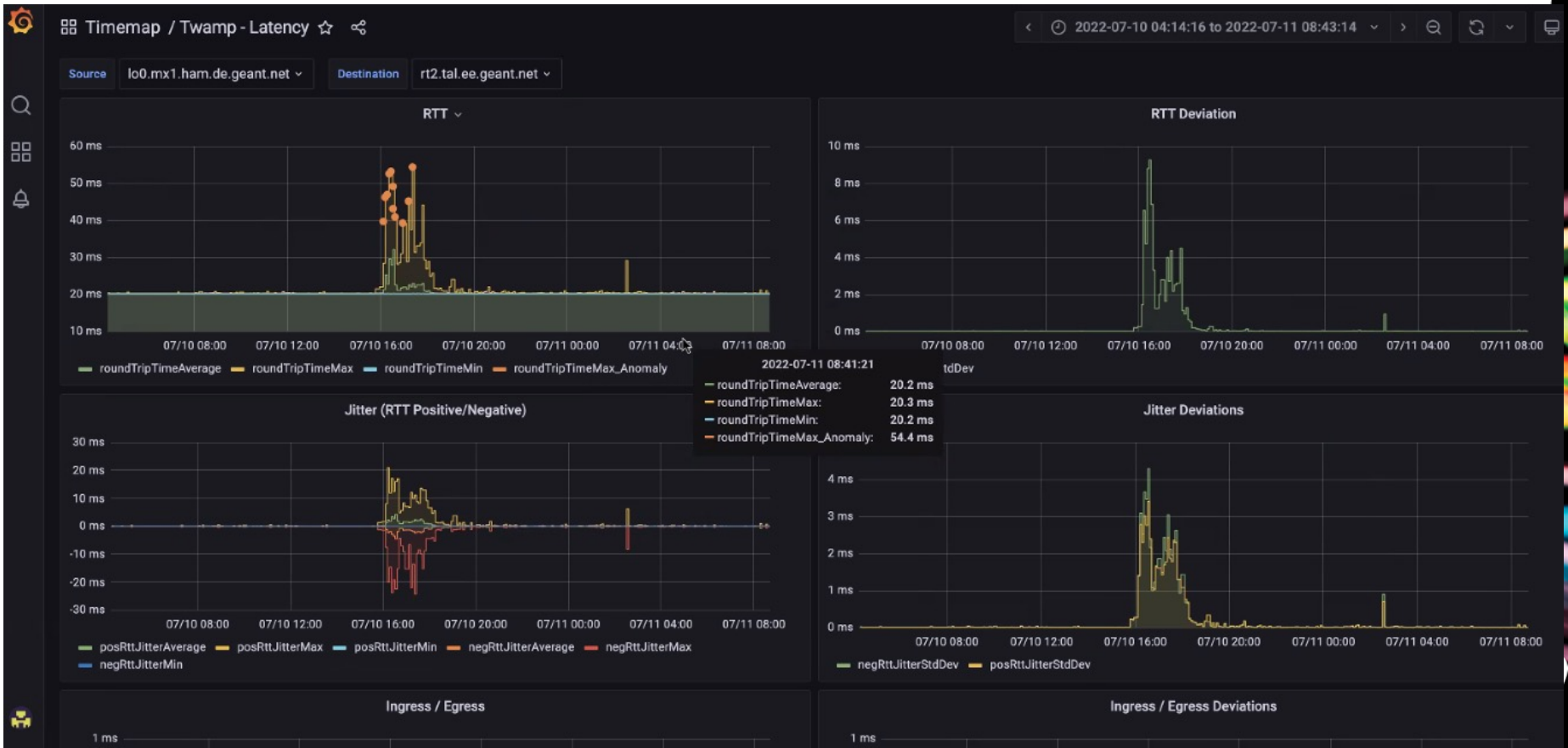
# One more plot



# Equal Cost Multipath Protocol (ECMP) effects

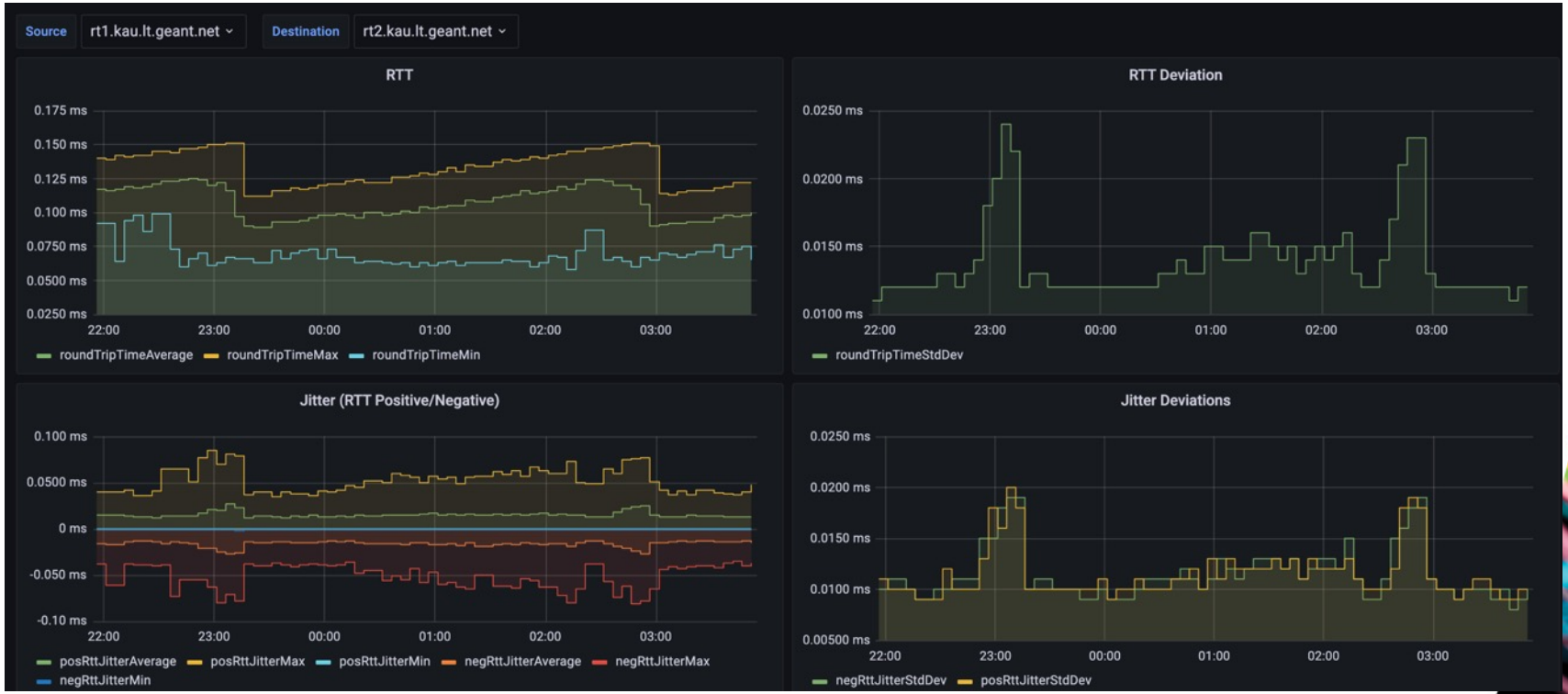


# «non-identified event»



# This happens on any Juniper… explanation?

# «non-identified event»

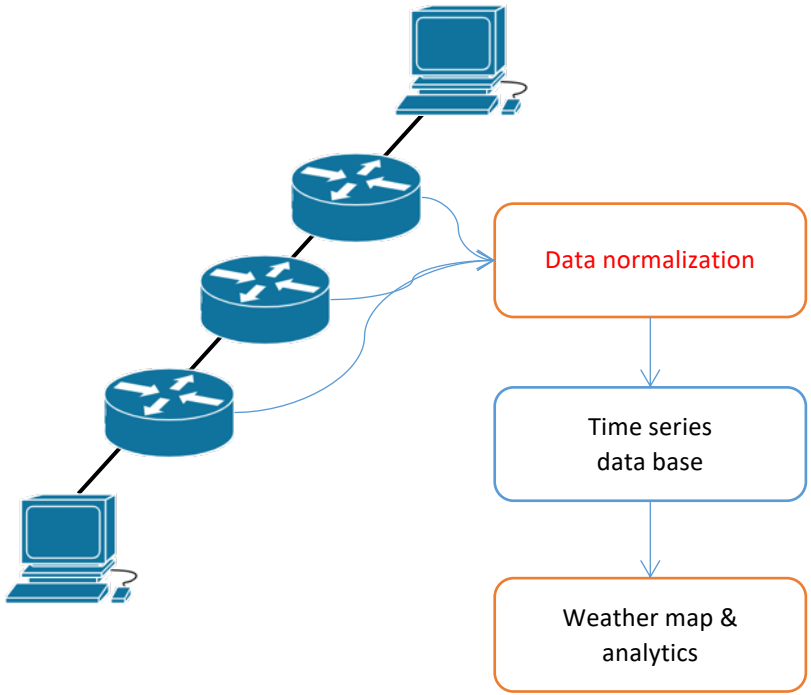


# So in GN4-3, WP6 T1 we designed TimeMap!

## Architecture requirements

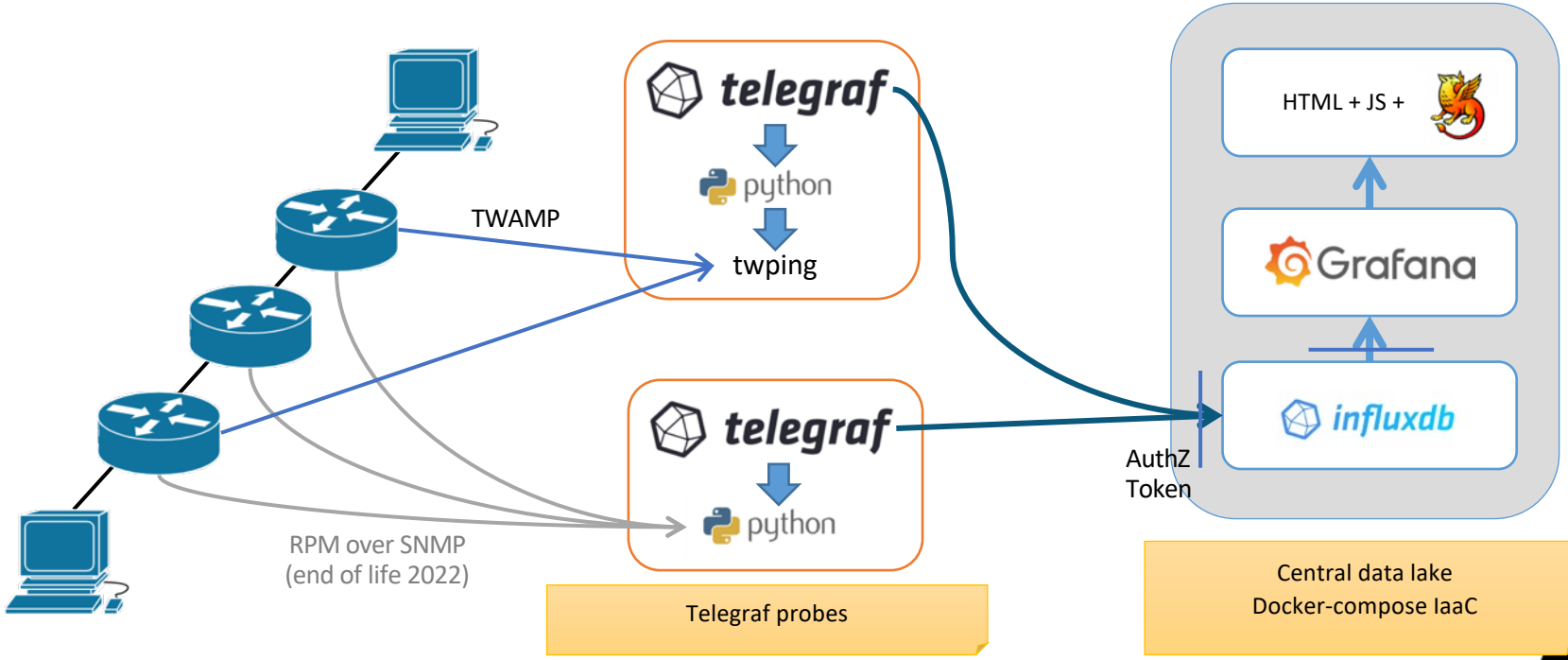
- Scalable and portable system
- Network architecture neutral
- Based on monitoring standard specifications
- Based on Open Source components
- Modular containerized system
- Easy to deploy
- With federated access control

# TIMEMAP architecture and features

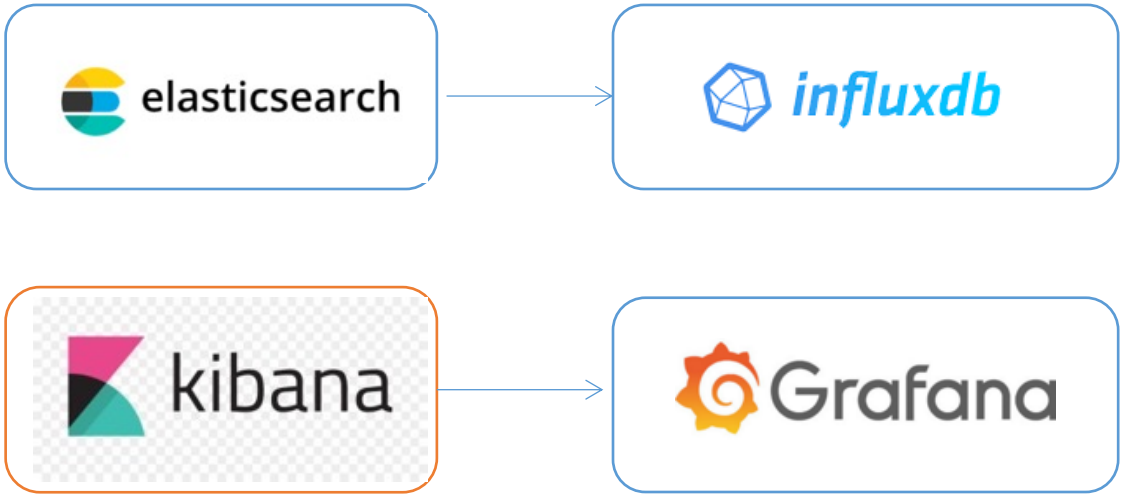



- Latency & Jitter data collection
  - TWAMP from all backbone routers
  - TWAMP from selected PerfSonar installations
  - RPM from all backbone routers (EoL 2022)
- Simplicity: almost zero footprint
  - Docker + Linux packages
  - Minimal custom code
  - Dynamic weather map GUI
- Security
  - eduGAIN authentication
  - Role Based Access Control
  - multi-tenancy

# TIMEMAP v1 architecture – 1+ year of data taking



# Flexibility: from prototype to production modules:

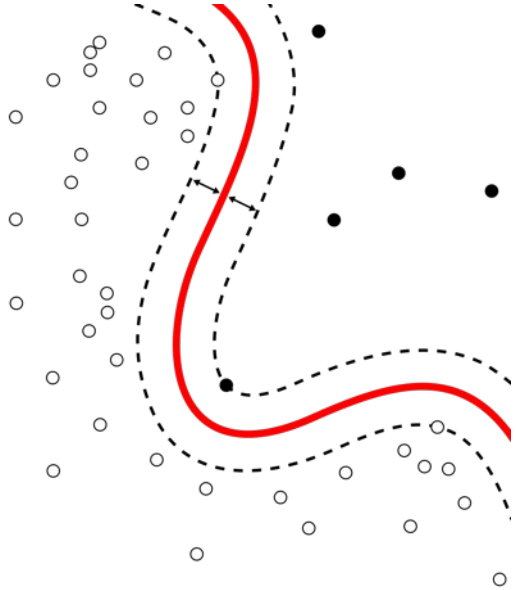


# An “offline” view of the service (before we try go live!)

# The research: Anomaly Detection (AD) in Timemap requirements

- Move beyond the simple observation
  - AD for Analytics and Alerting
  - Co-occurring events correlation

- Requirements on AD machine learning
  - Real-time or micro-batch learning/inference
  - Robust estimation
  - Light footprint

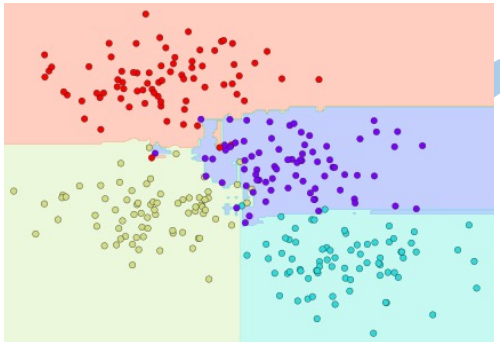


# Anomaly Detection in Timemap – toolset

- Anomaly Detection, in short
  - Std.Dev classification
  - Unsupervised
  - Sensible to overfit

- Streaming ML in Python
  https://riverml.xyz

Half-space Random Trees

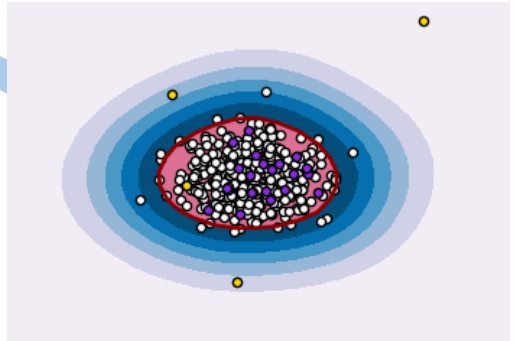


$3\sigma$

$3\sigma$

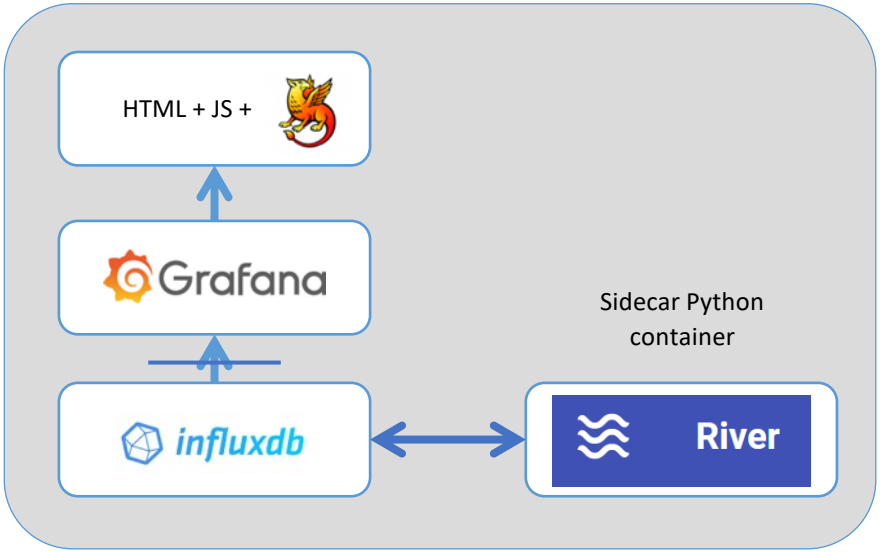
Model bagging

One-class Support Vector Machine

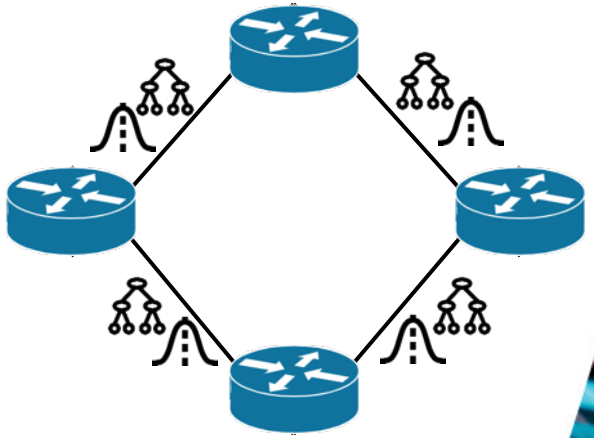


# Anomaly Detection in Timemap – architecture

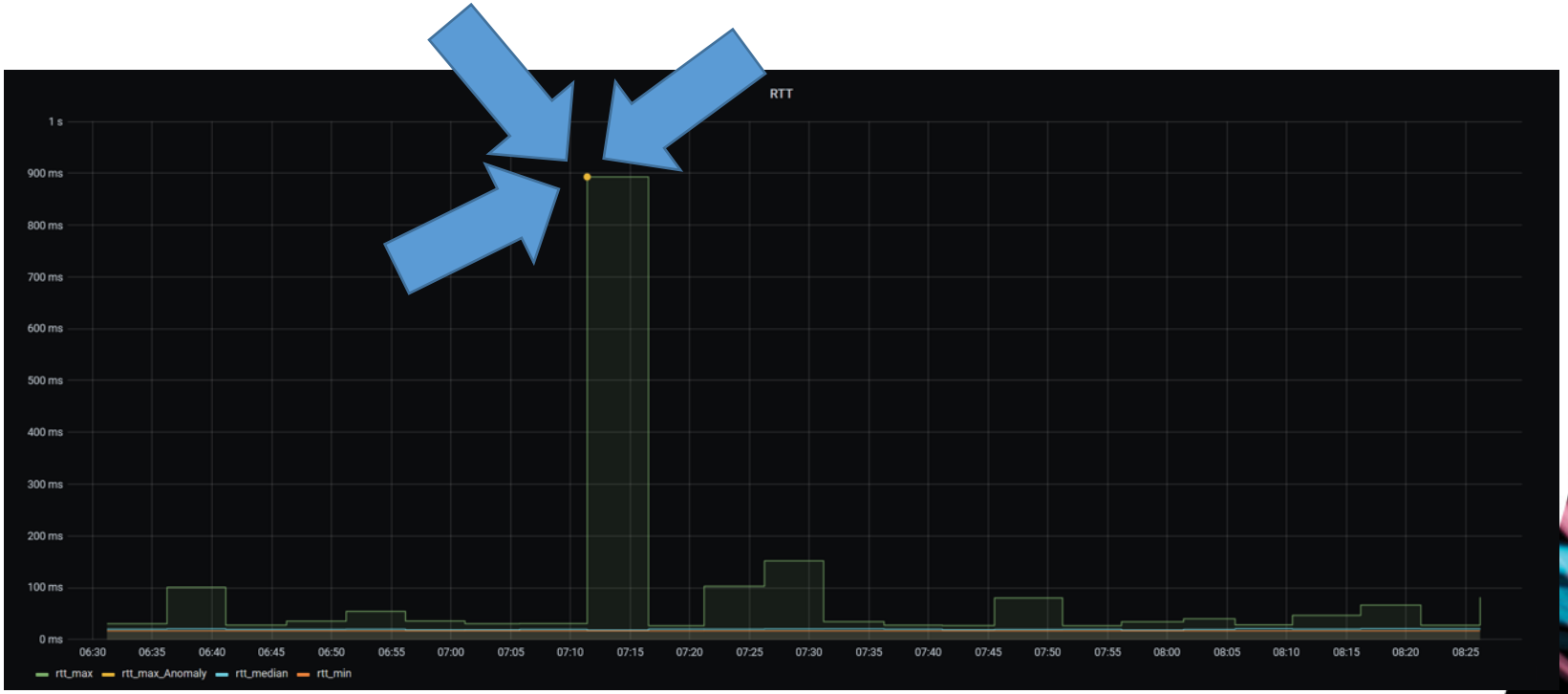
Software architecture extension




Network topology and ML models



# Almost the same look and feel



# Next steps on Anomaly Detection

- Issues with current models
  - Overfitting and concept drifting
  - Identify when anomalies end

- Explore richer models
  - Signal processing – train filters, anomalies as high frequencies
  - Nowcasting – training models, anomalies as deviations
  - Models selection & hyperparameters optimization
  - And more …

# More about TimeMap

- The service on GEANT backbone

**https://timemap.geant.org/**

- Documentation: source code, user and admin guides, customization

**https://gitlab.geant.org/gn4-3-wp6-t1-lola/timemap_public**

https://timemap.geant.org

# Current Status

- TimeMap is a new service in production for GÉANT

- Next steps
  - More deployments @NRENs
    - Timemap @ GARR
    - DeIC is deploying TimeMap
    - Sikt is assessing TimeMap
  - Anomaly Detection
    - Up and running, Streaming ML, multi-model over network topology
    - About 200 lines of code in a Docker image
    - New feature-rich algorithms in development
  - New usage
    - Inter-Domain
    - Measure not only 1 segment (a path or a part of path)
    - Improve anomaly detection for BGP rerouting, clock drifting, …
    - Characterize the behavior model for a link thanks to AI (ambitious)

# Just to repeat …

- The service on GEANT backbone

**https://timemap.geant.org/**

- Documentation: source code, user and admin guides, customization

**https://gitlab.geant.org/gn4-3-wp6-t1-lola/timemap_public**

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# Thank you!

# Do you have any questions?

**Claudio.Allocchio@garr.it**

**TimeMap-dev@lists.geant.org**

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