Global P4 Lab

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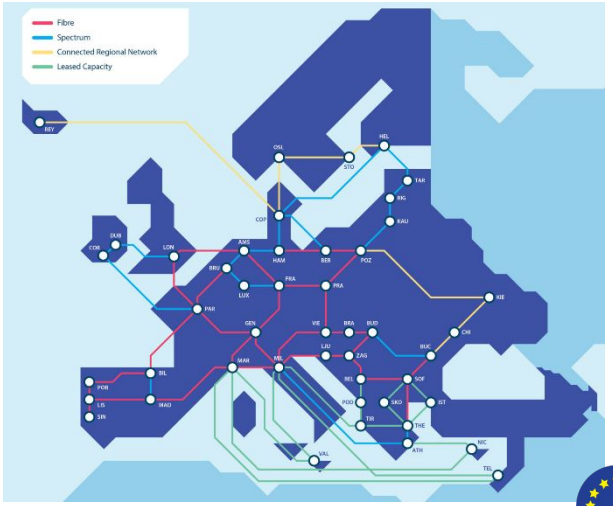
Ivana Golub, PSNC

4th Global Research Platform

October 9-10, Limassol, Cyprus

GÉANT – European Network Infrastructure, Services and Community



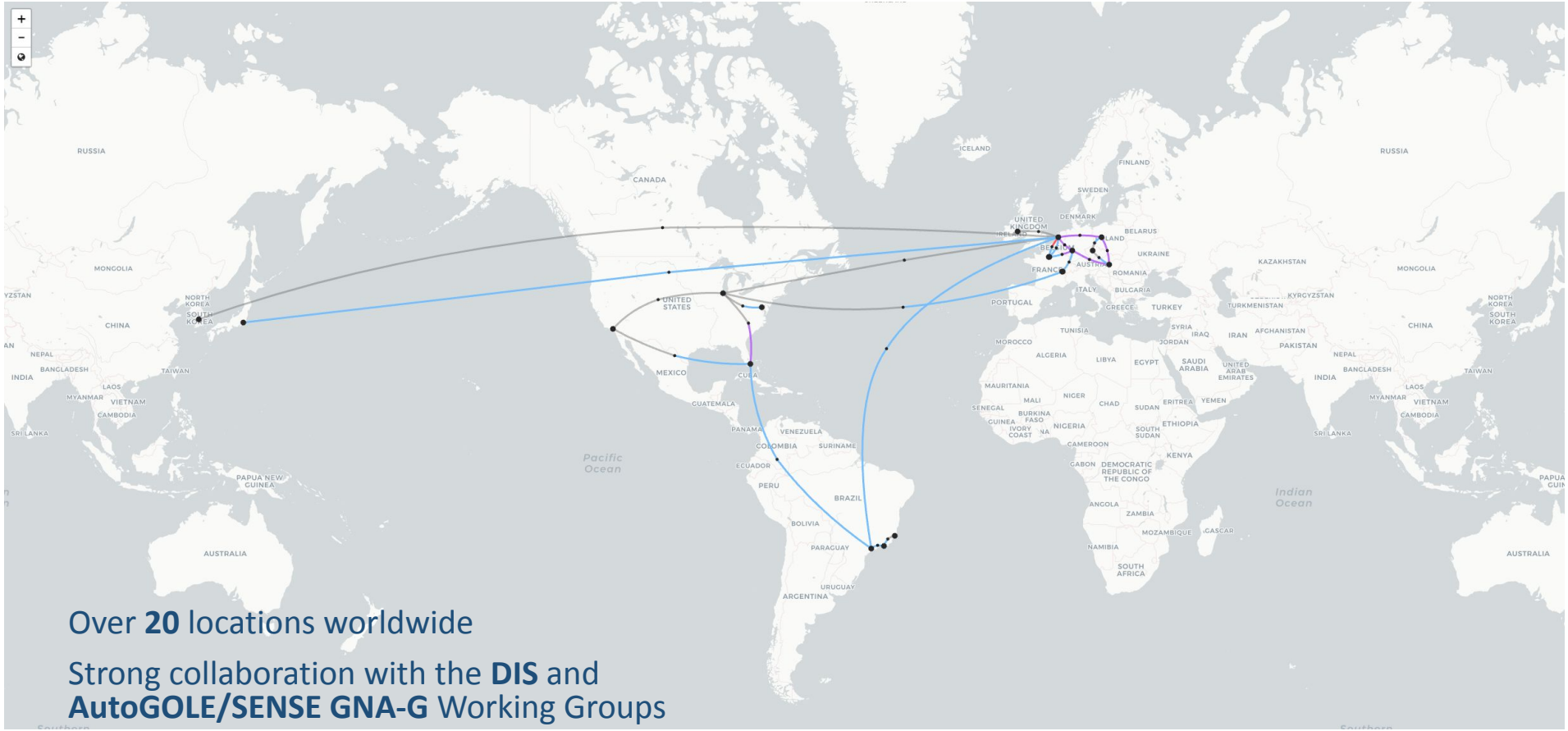
The GÉANT-5 project is under Horizon Europe Research and innovation funding programme until 2027

GÉANT
Networks • Services • People

- High bandwidth, high speed and highly resilient pan-European backbone
- Interconnecting European NRENs
- over 20 years of support for Europe's research and education communities

- 37 partners
- 500 contributors
- 50M users

Global P4 lab: “Persistent Programmable testbed” current footprint [2023/09]



Over **20** locations worldwide

Strong collaboration with the **DIS** and **AutoGOLE/SENSE GNA-G** Working Groups

Global P4 lab: Node types

Available now in GP4L !

3.2/6.4 Tbps

12.8 Tbps

DPDK (intel)

200 Gbps

200 Gbps

Under the radar …

FPGAs

12.8 Tbps

12.8 Tbps

RARE/freeRtr in a nutshell

RARE is an open source routing platform, used to create a network operating system (NOS) on commodity hardware (a white box switch).

RARE uses FreeRtr as a control plane software

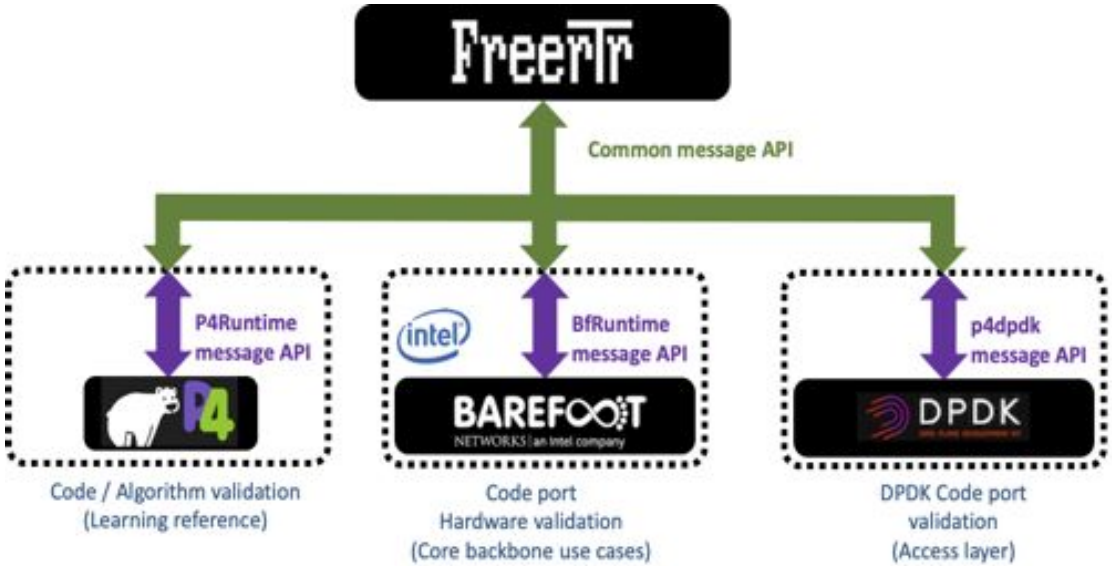
and is thus often referred to as

RARE/freeRtr

More information:
https://wiki.geant.org/display/rare

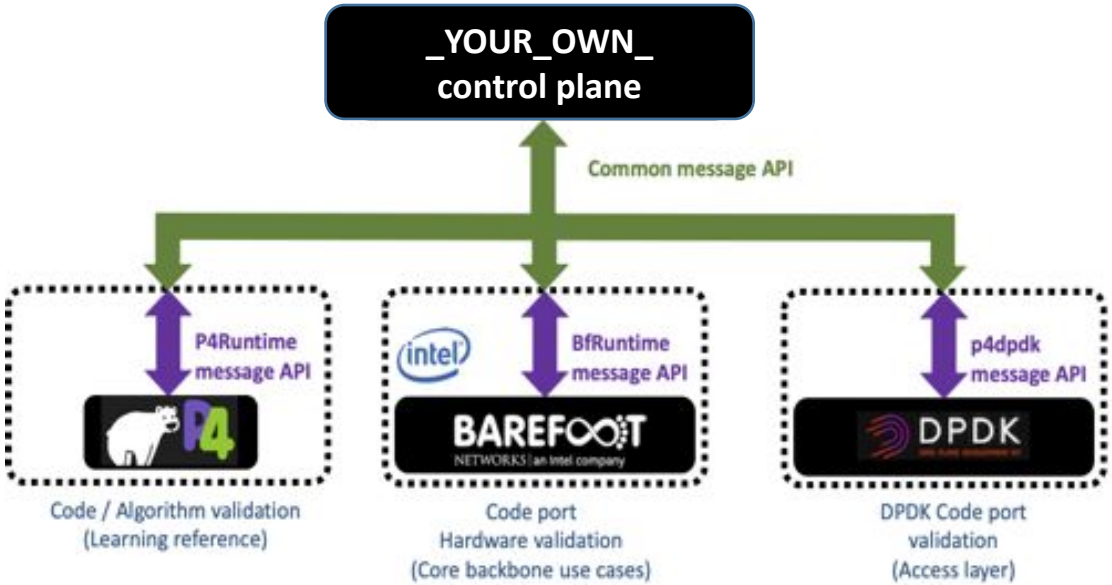
RARE/freeRtr in a nutshell

"One control plane to rule them all …"



RARE/freeRtr in a nutshell

"… Or not !"



RARE - Router for Academia, Research and Education

An open source router OS for R&E use cases

Supports six data planes:

- based on UNIX socket
- Libpcap
- DPDK
- BMv2 (P4)
- INTEL TOFINO ASIC (P4)
- XDP, eXpress Data Path

RARE features (not limited to):

- Interior Routing Protocol
- Dataplane forwarding
- External Routing Protocol
- Link local protocol
- Network management

RARE
rare-users@lists.geant.org
rare-dev@lists.geant.org
rare@lists.geant.org

Complete feature list

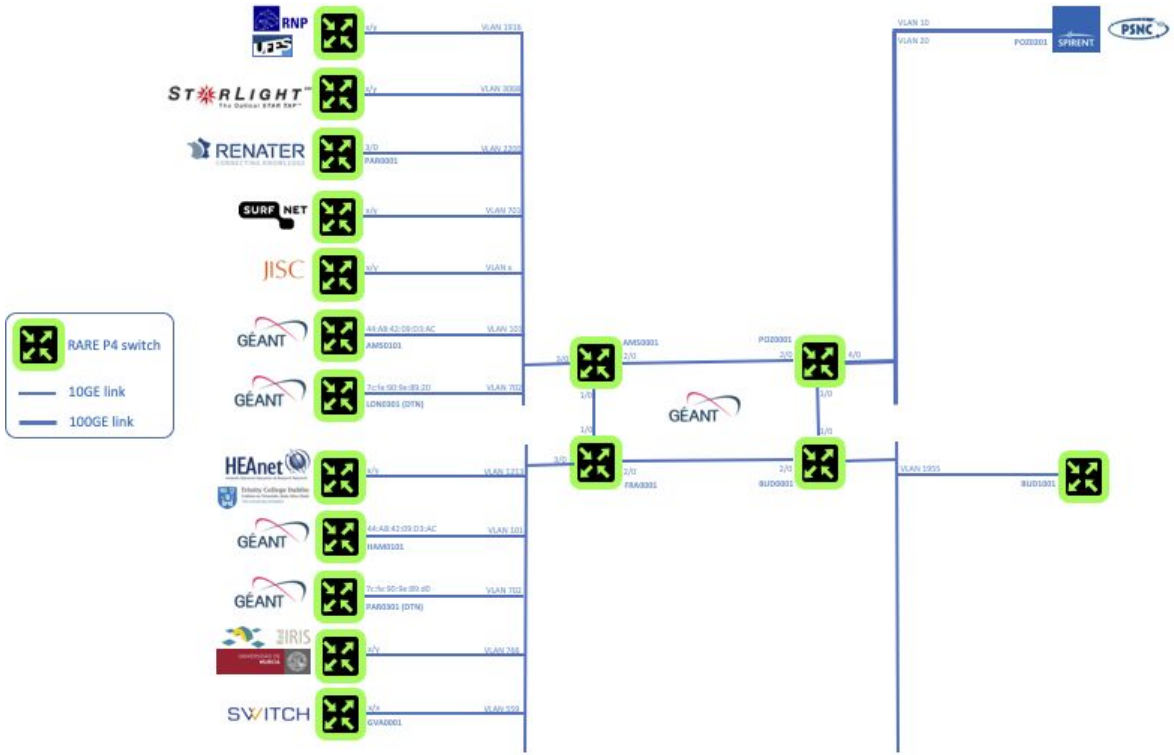
Type	Test #	Name	P4		DPDK	XDP
acl	01	copp	✓	✓	✓	N/A
acl	02	ingress access list	✓	✓	✓	N/A
acl	03	egress access list	✓	✓	✓	N/A
acl	04	nat	✓	✓	✓	N/A
acl	05	vlan ingress access list	✓	✓	✓	N/A
acl	06	vlan egress access list	✓	✓	✓	N/A
acl	07	bundle ingress access list	✓	✓	✓	N/A
acl	08	bundle egress access list	✓	✓	✓	N/A
acl	09	bundle vlan ingress access list	✓	✓	✓	N/A
acl	10	bundle vlan egress access list	✓	✓	✓	N/A
acl	11	bridge ingress access list	✓	✓	✓	N/A
acl	12	bridge egress access list	✓	✓	✓	N/A
acl	13	vlan bridge ingress access list	✓	✓	✓	N/A
acl	14	vlan bridge egress access list	✓	✓	✓	N/A
acl	15	ingress pppoe access list	✓	✓	✓	N/A
acl	16	egress pppoe access list	✓	✓	✓	N/A
acl	17	ingress vlan pppoe access list	✓	✓	✓	N/A
acl	18	egress vlan pppoe access list	✓	✓	✓	N/A
acl	19	hairpin ingress access list	✓	✓	✓	N/A
acl	20	hairpin egress access list	✓	✓	✓	N/A
acl	21	hairpin vlan ingress access list	✓	✓	✓	N/A
acl	22	hairpin vlan egress access list	✓	✓	✓	N/A
acl	23	hairpin pppoe ingress access list	✓	✓	✓	N/A
acl	24	hairpin pppoe egress access list	✓	✓	✓	N/A
acl	25	hairpin vlan pppoe ingress access list	✓	✓	✓	N/A
acl	26	hairpin vlan pppoe egress access list	✓	✓	✓	N/A
acl	27	ingress gre access list	✓	✓	✓	N/A
acl	28	egress gre access list	✓	✓	✓	N/A
acl	29	ingress vlan gre access list	✓	✓	✓	N/A

Liaison with GN5-1 WP6-T2 platform – Global P4 Lab

- December 2019

Liaison with GN5-1 WP6-T2 platform – Global P4 Lab

- December 2020



GP4L - GÉANT P4Lab

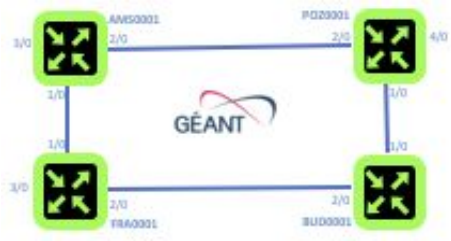
P4 switch-based lab infrastructure interconnected through the GÉANT network

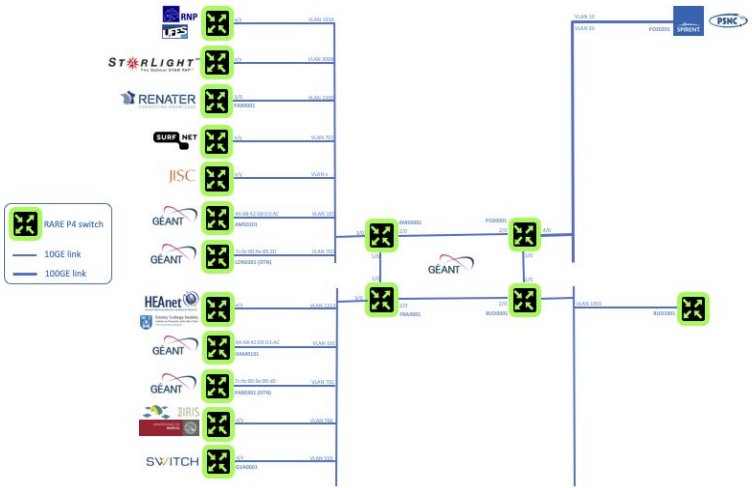
- 4 switches in Europe: AMS, POZ, FRA, BUD

Validation of the RARE/FreeRtr OS routing stack software

World-wide testbed, offering **experimental dataplane programming facilities to researchers** to perform geographically distributed network experiments:

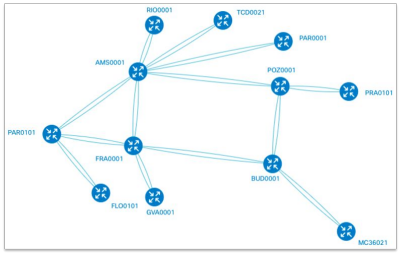
- With the usage of RARE/FreeRtr NOS
- Using a clean slate environment
  (i.e use exclusively GP4L without RARE/FreeRtr dataplane & control plane)



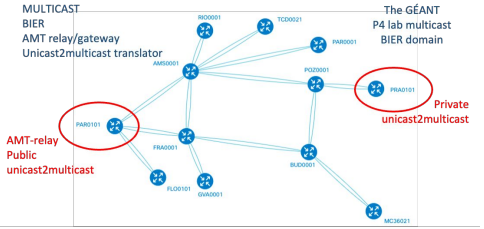


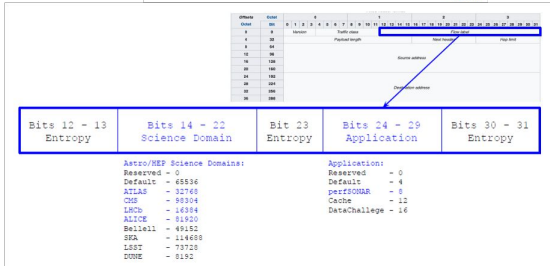
https://wiki.geant.org/display/GP4L

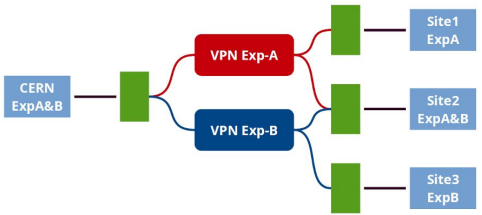
Previous GP4L Use Cases



- Topology Monitoring with BGP-LS
- Next Generation Multicast with AMT relay/gateway and Unicast to Multicast translator, Juniper and Akamai
- Polka - an innovative source routing paradigm, IFES/UFES
- Packet Marking Specification: IPv6 Flow Label, CERN
- SuperComputing22 Demo, GNA-G DIS







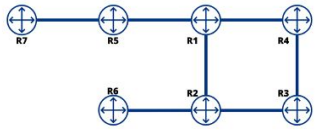


Figure 3. Edge-Core Experiment

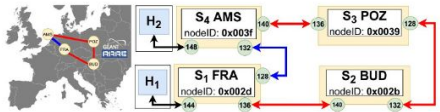
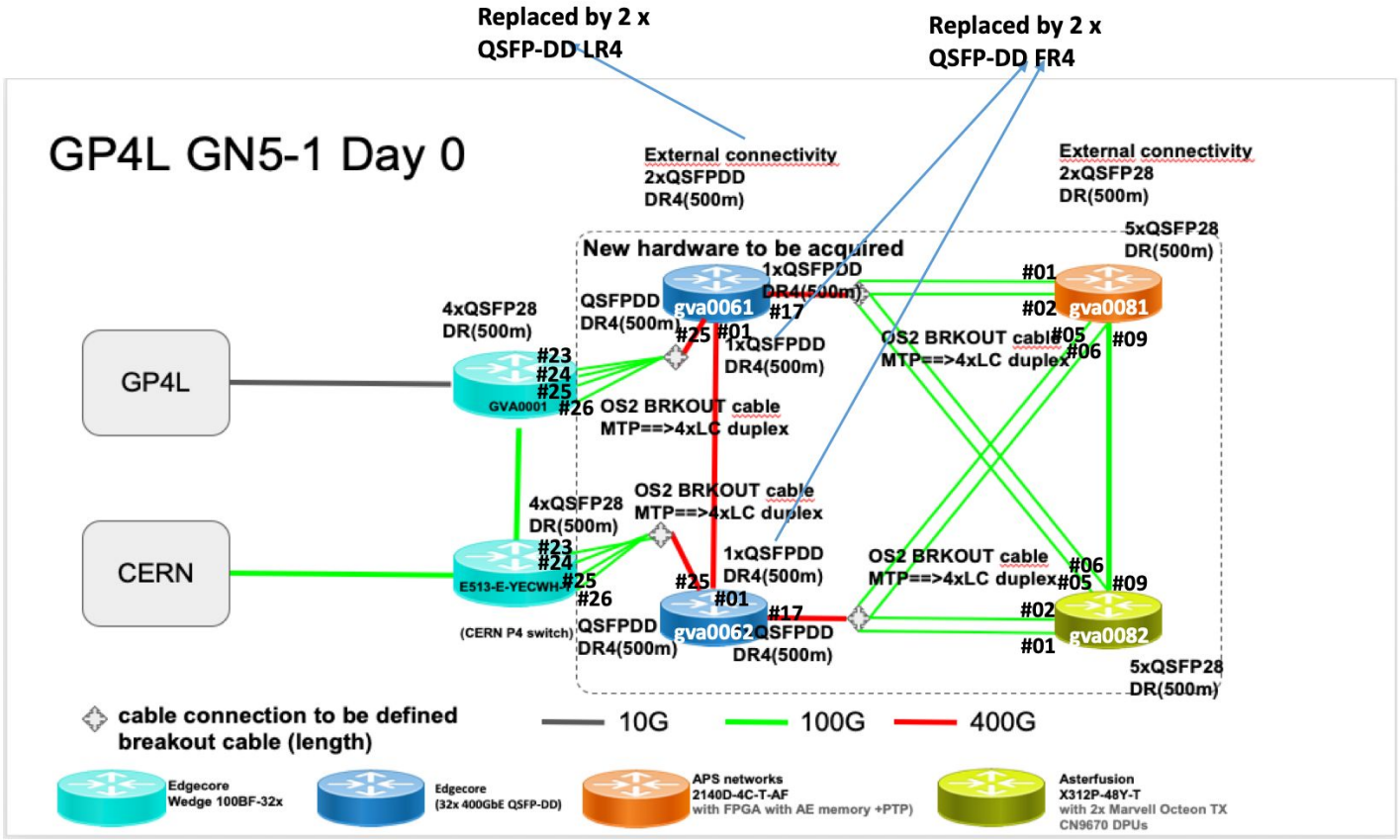
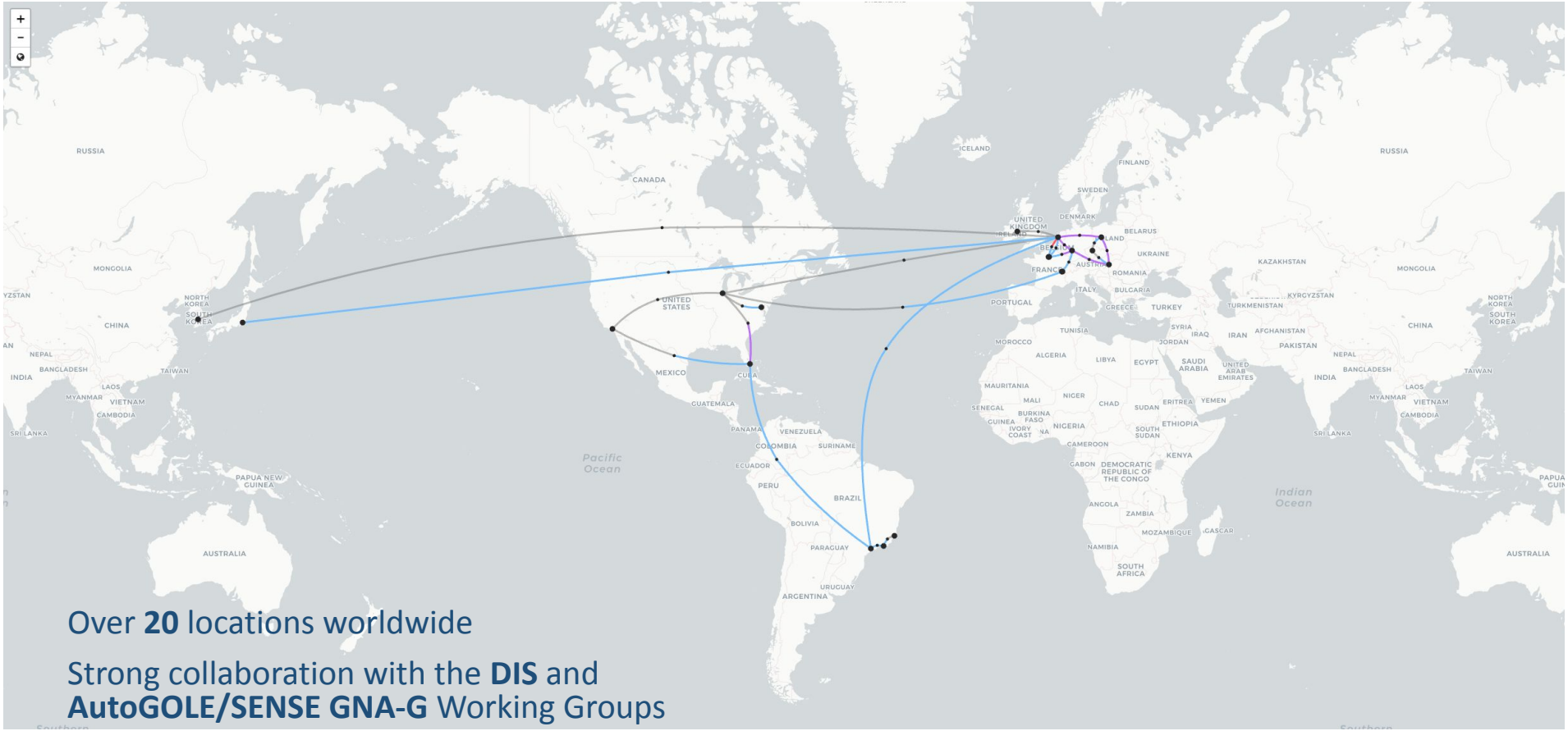


Figure 4. RARE/GEANT testbed

Global P4 lab: Extension at Geneva



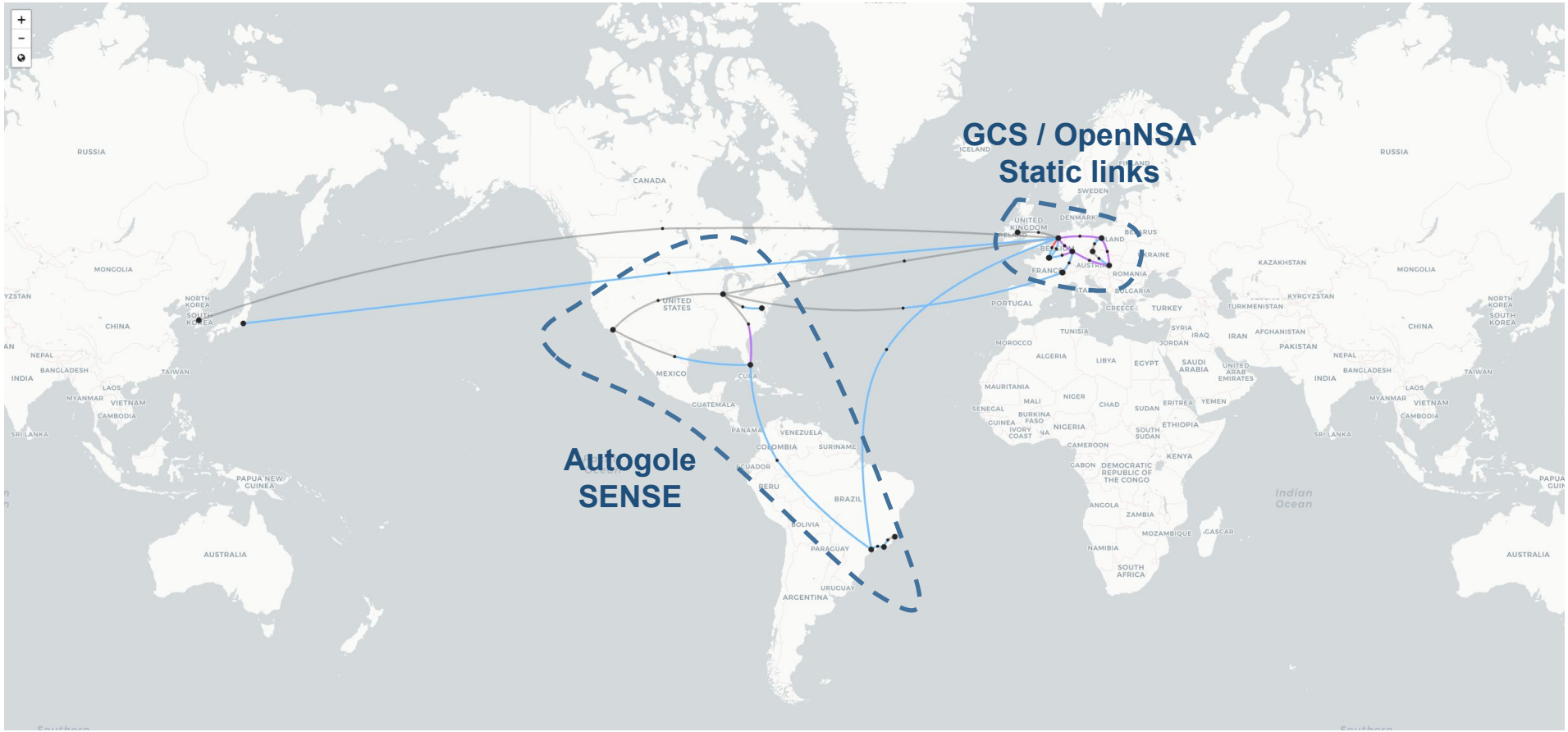
Global P4 lab: “Persistent Programmable testbed” current footprint [2023/09]



Over **20** locations worldwide

Strong collaboration with the **DIS** and **AutoGOLE/SENSE GNA-G** Working Groups

Global P4 lab: Links



GP4L Project in GN5-1 (besides test RARE/freeRTr)

- **User community**
  - Listen user community request
    - Demo wish-list
    - Problem solving approach
  - GP4L as an experimentation facility
    - For representative demo
    - Used to develop new network management component
- **Developer community**
  - Network orchestration (integration of NetBox, Camunda and Uptime Kuma)
  - Network automation
  - Network management components

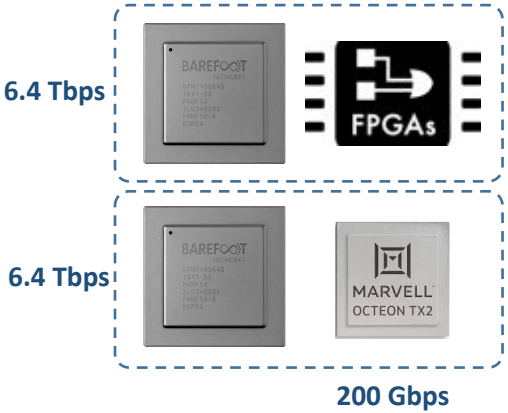
Objective:

INCREASE GP4L platform usage in both Network usage prototyping and facility for network development

RARE/freeRtr feature development

- Feature development
  - Digital twin
  - Orchestration
  - Automation

  …
  - Please share your ideas !
- New targets (and thus new use cases)




12.8 Tbps

12.8 Tbps

12.8 Tbps

200 Gbps

TOFINO-3 is dead, long live TOFINO 1 and 2 !
Dataplane programming is not only about P4 …

RARE/freeRtr Network Management as a Service

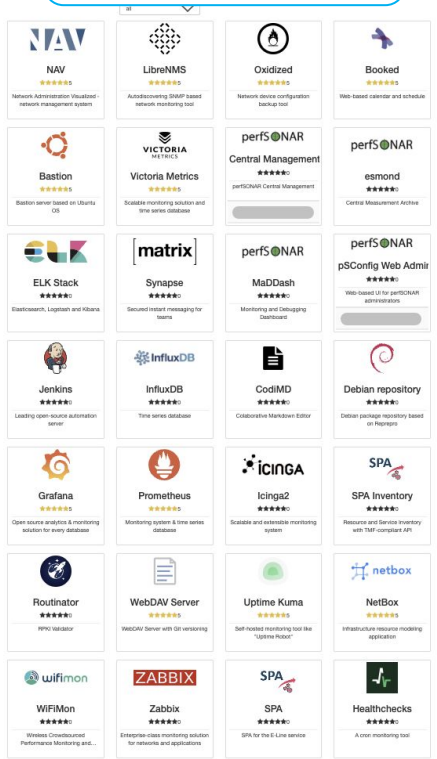
What about
GP4L
monitoring?

NMaaS - Network Management as a Service

A portfolio of network management applications run as dedicated, cloud-based per-user instance

nmaas.eu
nmaas@lists.geant.org

28 applications available, easy to add new tools



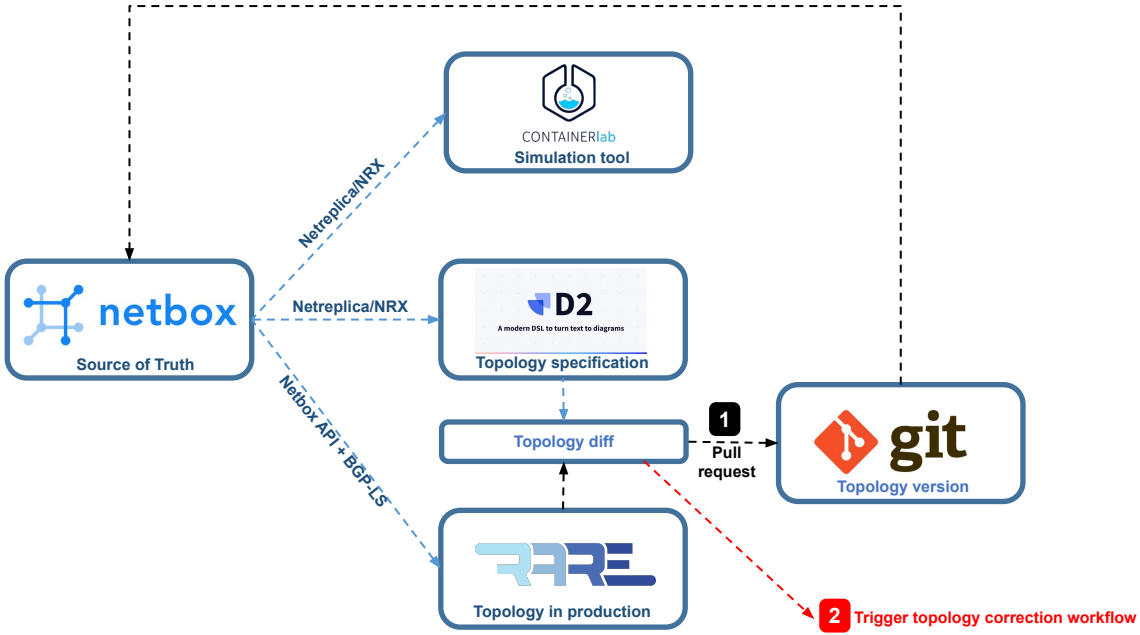
Use cases:

- Network/Equipment Management for Small/Medium size networks/ institutions
- Project-owned equipment
- NMaaS Virtual Lab - **NEW!**

How to use NMaaS?

- Managed service
  - Production NMaaS instance: https://nmaas.eu
  - Sandbox instance: https://nmaas.geant.org
- Self-hosted
  - On your own NMaaS instance: https://docs.nmaas.eu/install-guide
  - On a local machine: https://docs.nmaas.eu/local-vm

GP4L usage: Tools conception “around” the network ecosystem – Digital twin



Via GP4L Automation & Orchestration

GP4L Orchestration: The Goal

Orchestrate different components of the GP4L management environment in a user transparent way

User actions in one management tool trigger automated reactions in other tools/systems/devices

User does not need to do anything other than essential actions

Automation & Orchestration Use Case

User keeps inventory up-to-date = Single Source of Truth

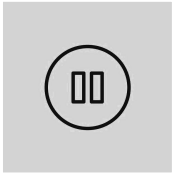
- Essential information for all GP4L devices

Auto devices' health monitoring

Auto network device configuration backup

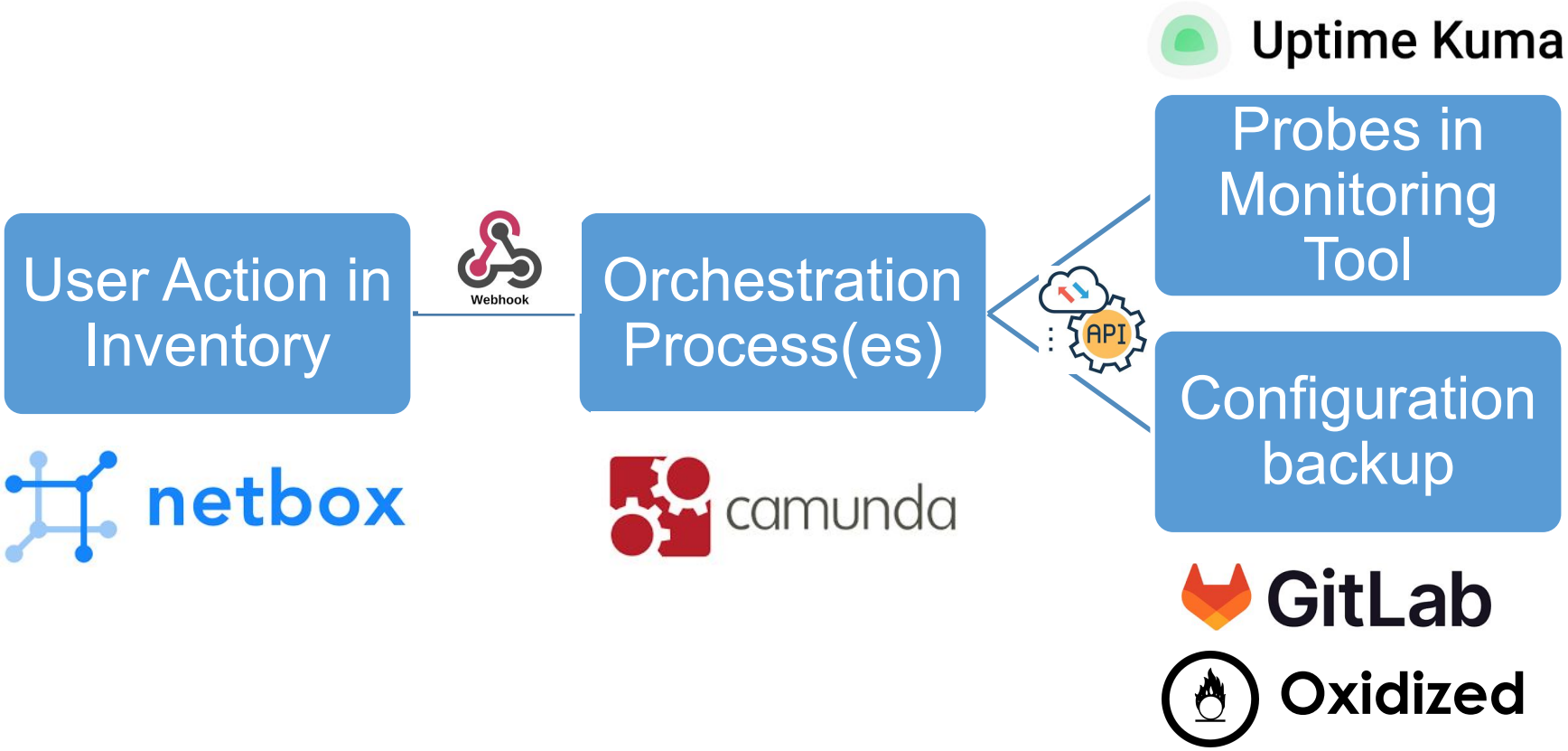
Keep track of any subsequent device changes

Retain history whenever possible

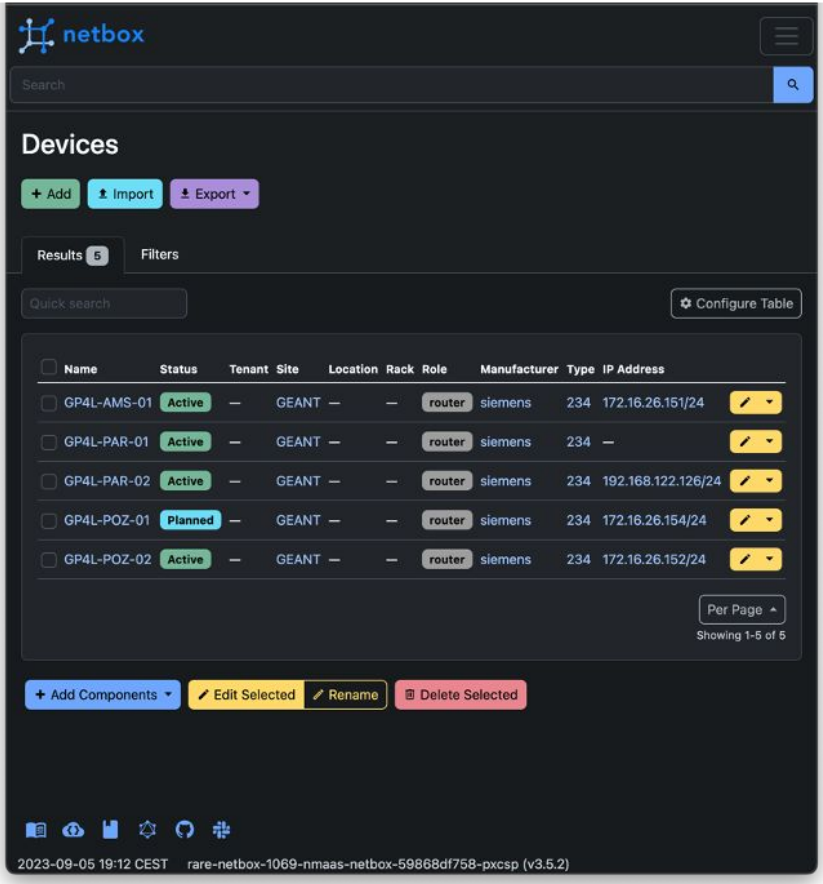


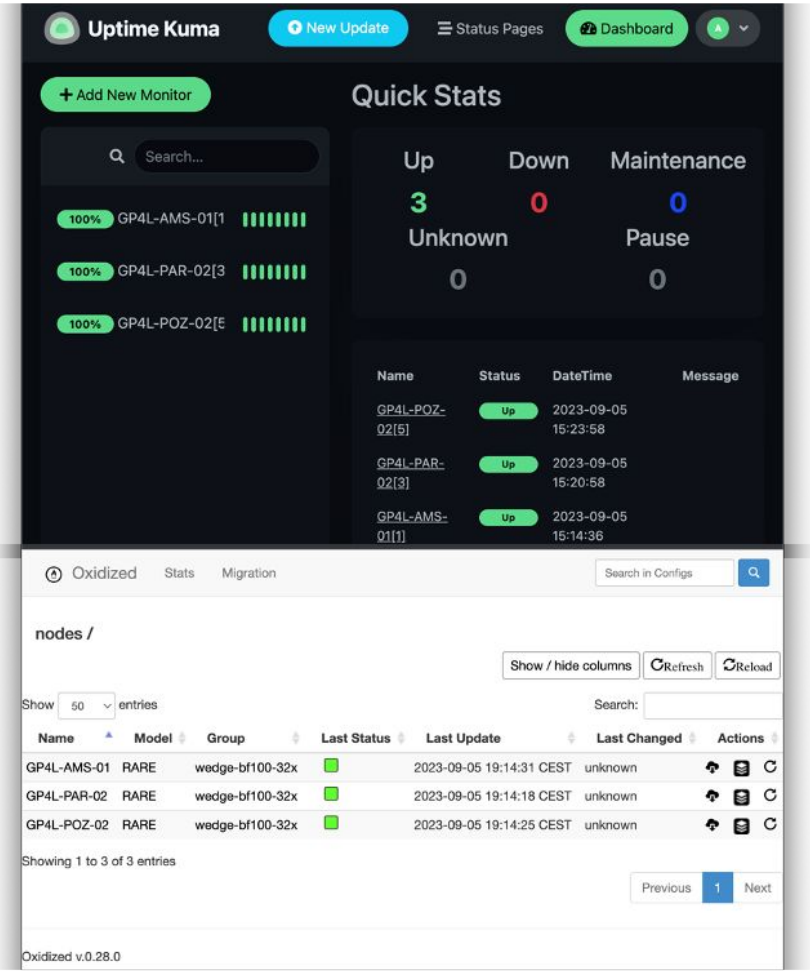
Delete / deactivate = pause

Use Case Tools



Tools


netbox
Search
Devices
+ Add
Import
Export
Results 5
Filters
Quick search
Configure Table
Name Status Tenant Site Location Rack Role Manufacturer Type IP Address
GP4L-AMS-01 Active — GEANT — — router siemens 234 172.16.26.151/24
GP4L-PAR-01 Active — GEANT — — router siemens 234 —
GP4L-PAR-02 Active — GEANT — — router siemens 234 192.168.122.126/24
GP4L-POZ-01 Planned — GEANT — — router siemens 234 172.16.26.154/24
GP4L-POZ-02 Active — GEANT — — router siemens 234 172.16.26.152/24
Per Page
Showing 1-5 of 5
+ Add Components
Edit Selected
Rename
Delete Selected
2023-09-05 19:12 CEST
rare-netbox-1069-nmaas-netbox-59868df758-pxcsp (v3.5.2)


Uptime Kuma
New Update
Status Pages
Dashboard
+ Add New Monitor
Search...
100% GP4L-AMS-01[1
100% GP4L-PAR-02[3
100% GP4L-POZ-02[E
Quick Stats
Up
3
Down
0
Maintenance
0
Unknown
0
Pause
0
Name Status DateTime Message
GP4L-POZ-02[5] Up 2023-09-05 15:23:58
GP4L-PAR-02[3] Up 2023-09-05 15:20:58
GP4L-AMS-01[1] Up 2023-09-05 15:14:36
Oxidized
Stats
Migration
Search in Configs
nodes /
Show / hide columns
Refresh
Reload
Show 50 entries
Search:
Name Model Group Last Status Last Update Last Changed Actions
GP4L-AMS-01 RARE wedge-bf100-32x 2023-09-05 19:14:31 CEST unknown
GP4L-PAR-02 RARE wedge-bf100-32x 2023-09-05 19:14:18 CEST unknown
GP4L-POZ-02 RARE wedge-bf100-32x 2023-09-05 19:14:25 CEST unknown
Showing 1 to 3 of 3 entries
Previous 1 Next
Oxidized v.0.28.0

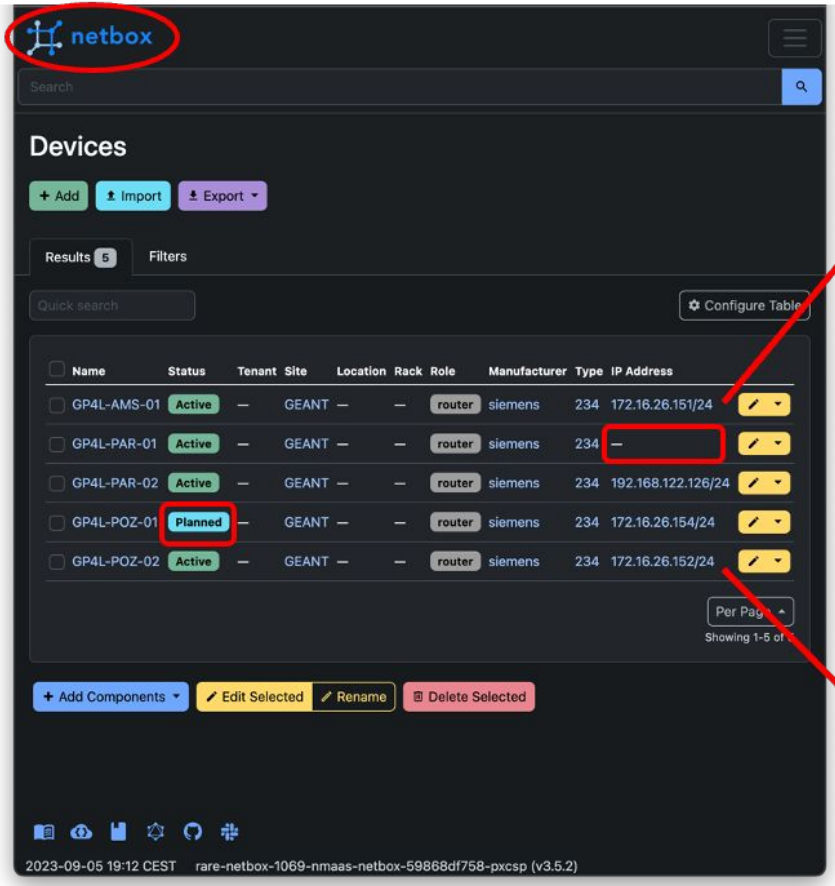
Tracking User Actions

Add new device/interface

Change device/interface properties

Remove device/interface

Tools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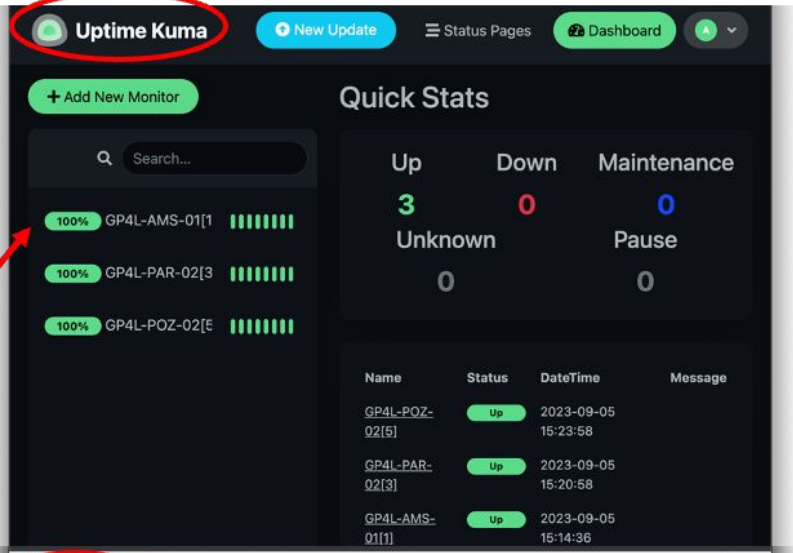
Per Page
Showing 1-5 of
+ Add Components
Edit Selected
Rename
Delete Selected
2023-09-05 19:12 CEST rare-netbox-1069-nmaas-netbox-59868df758-pxcsp (v3.5.2)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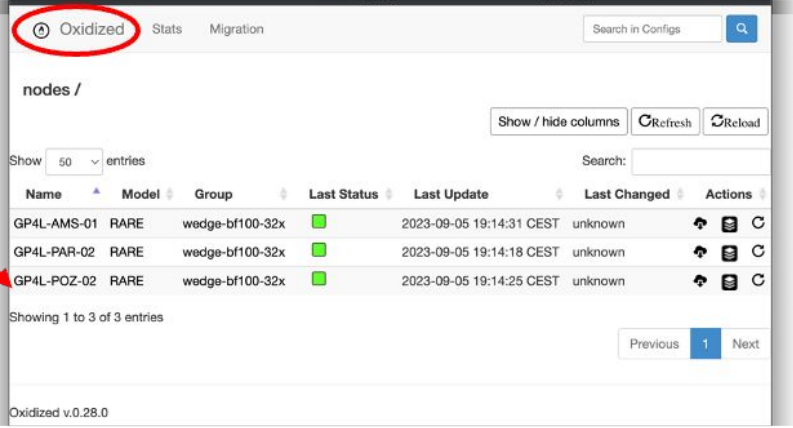
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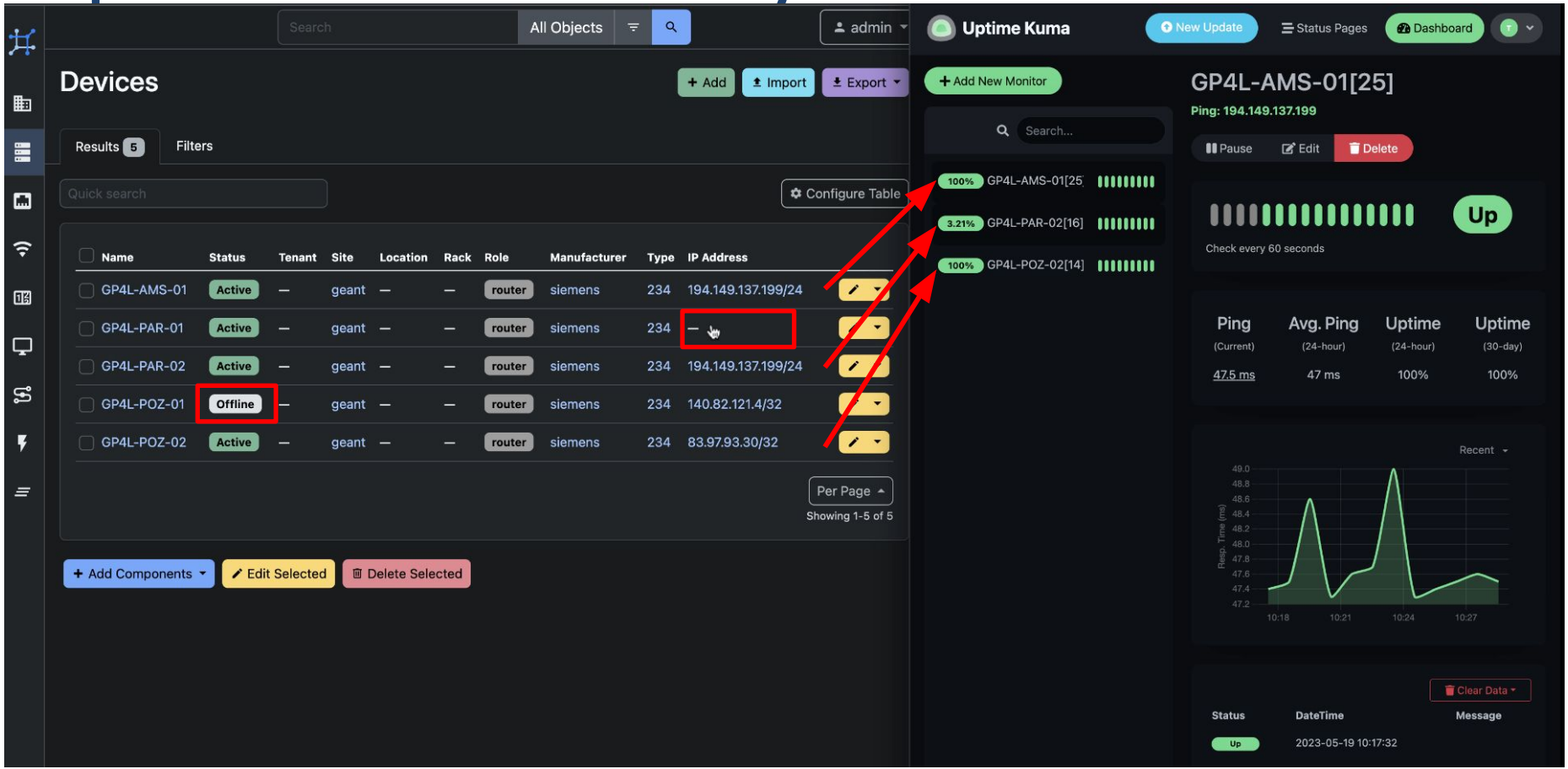
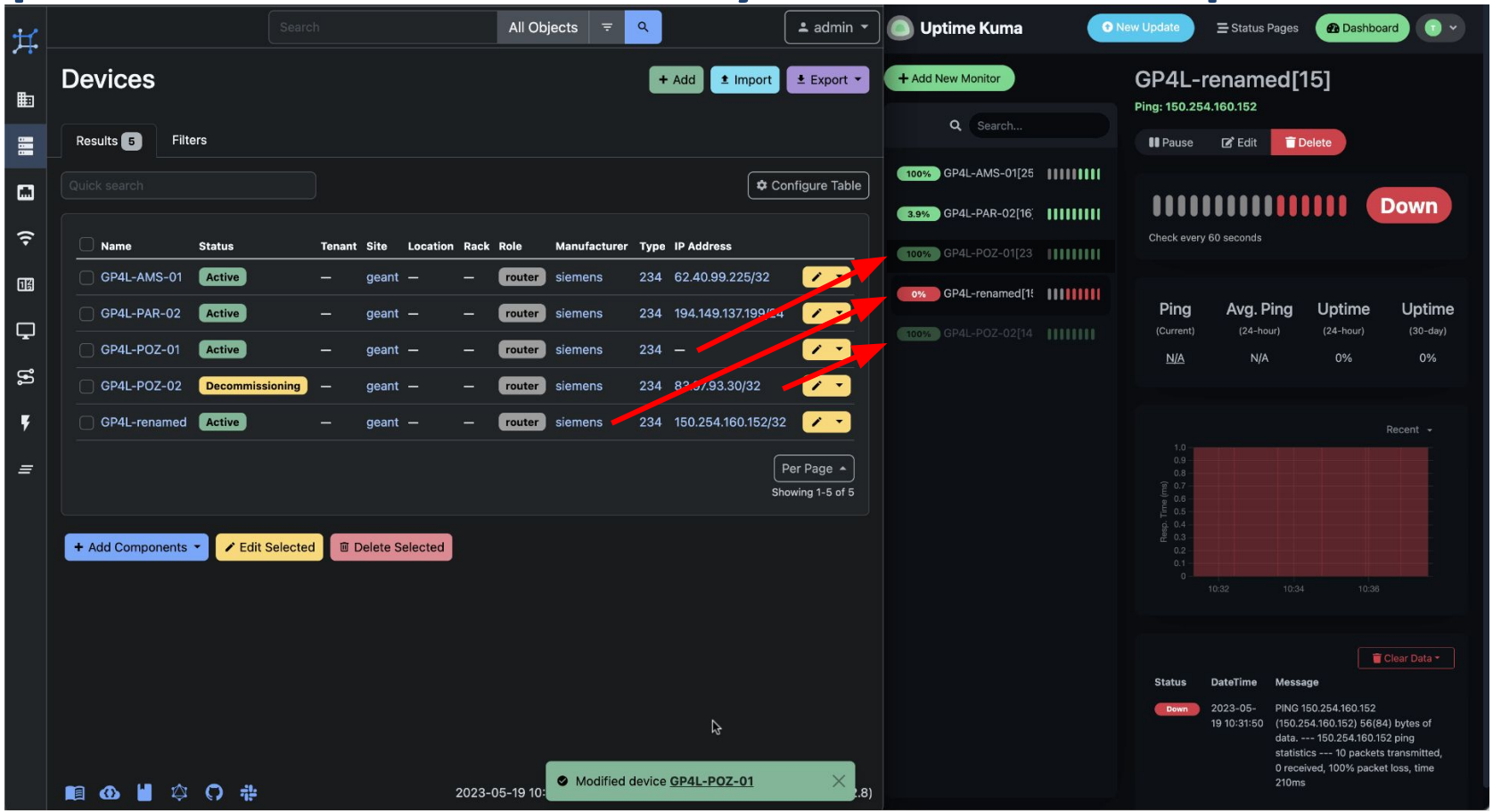
GP4L-PAR-02 RARE wedge-bf100-32x 2023-09-05 19:14:18 CEST unknown
GP4L-POZ-02 RARE wedge-bf100-32x 2023-09-05 19:14:25 CEST unknown
Showing 1 to 3 of 3 entries
Previous 1 Next
Oxidized v.0.28.0

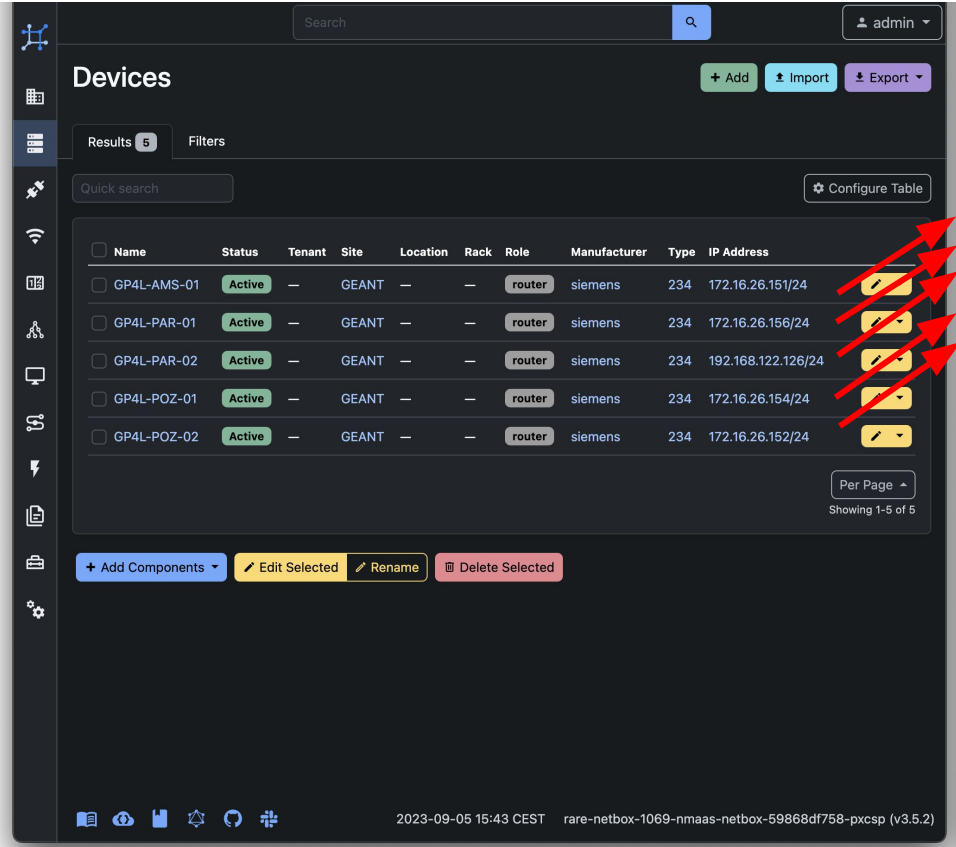
Uptime Kuma information synchronisation

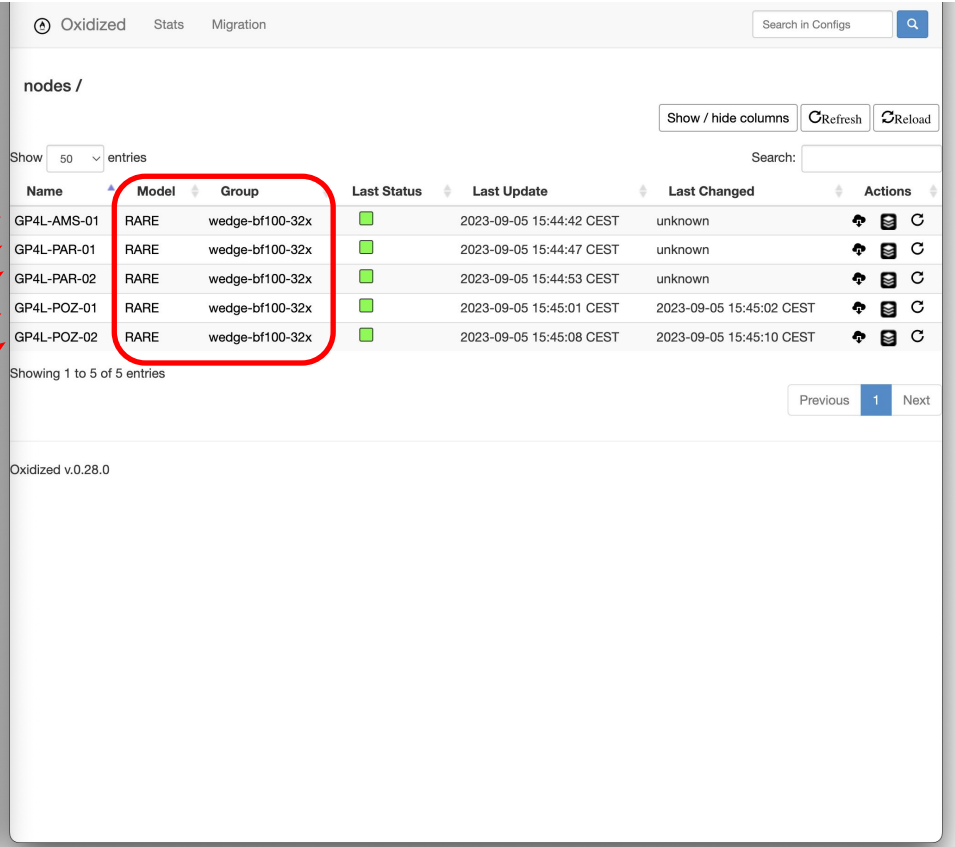


Uptime Kuma information synchronisation – part 2

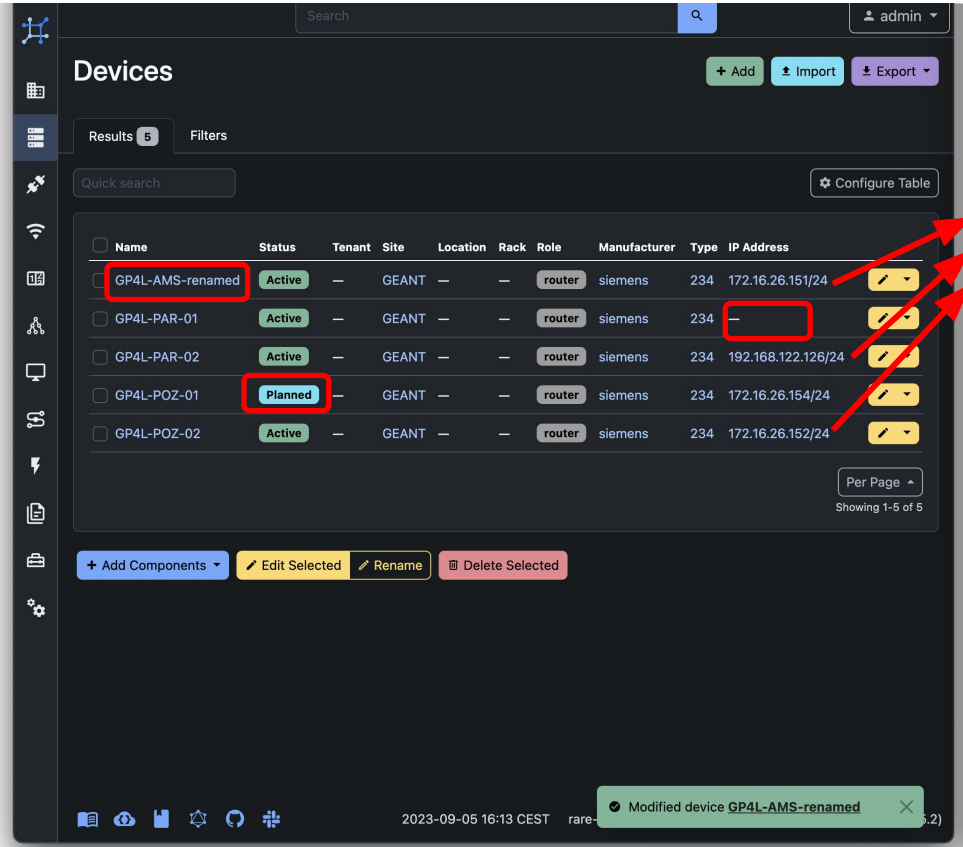


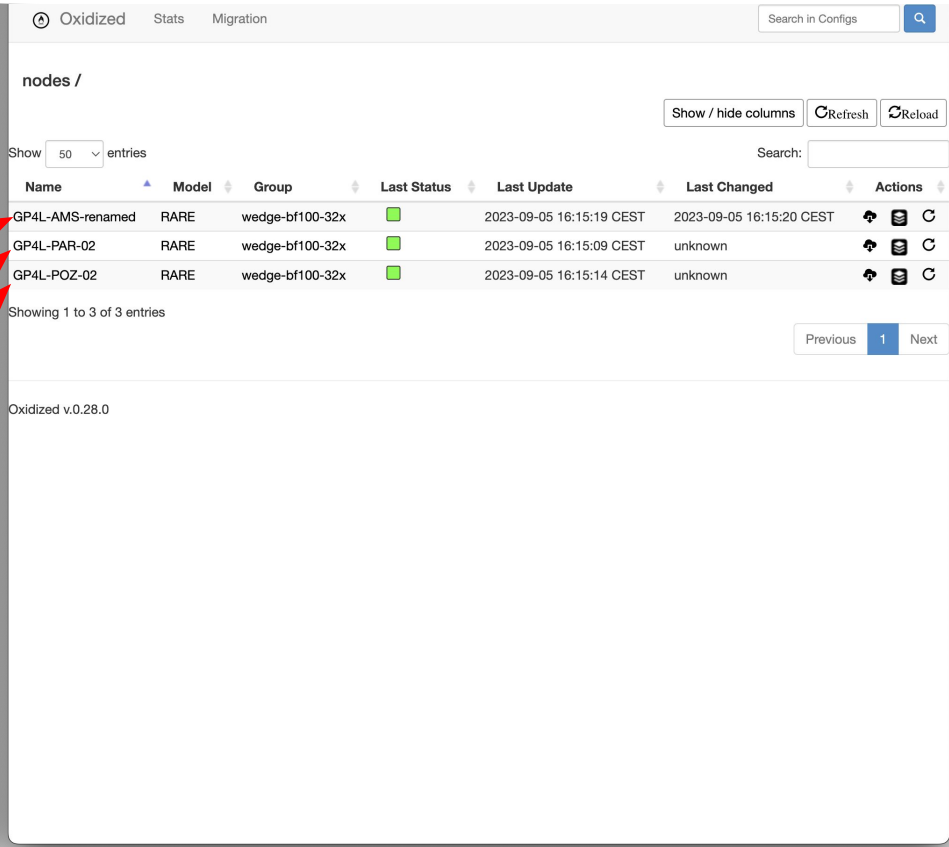
Oxidized information synchronisation





Oxidized information synchronisation – part 2





Ready, Set, Go!

- NetBox
- Oxidized
- Camunda with Uptime Kuma

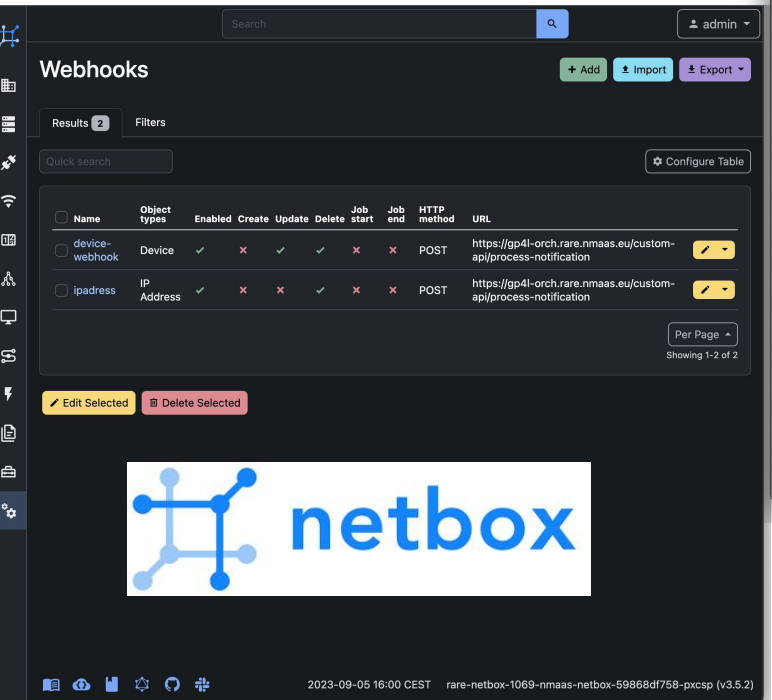
Orchestration configuration

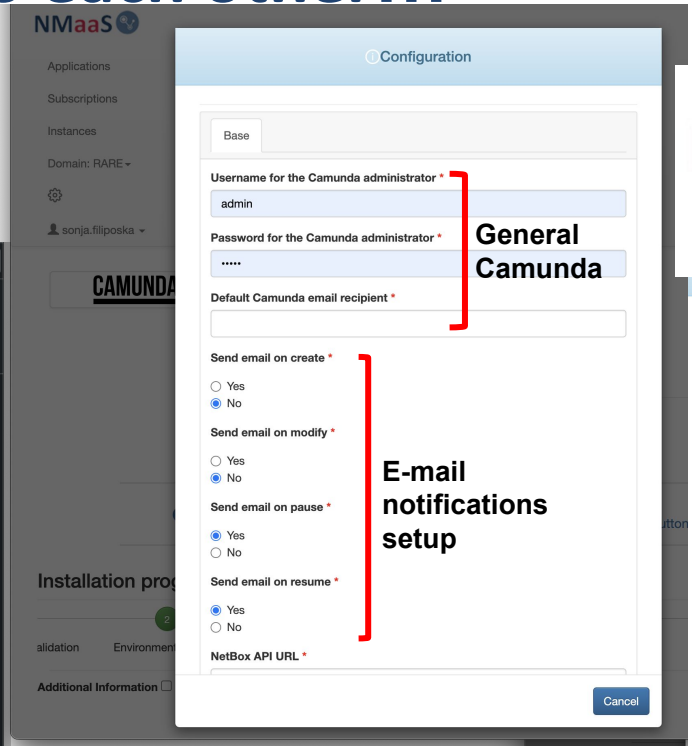
- API points
- webhooks
- ssh key
- user credentials
- e-mail notifications

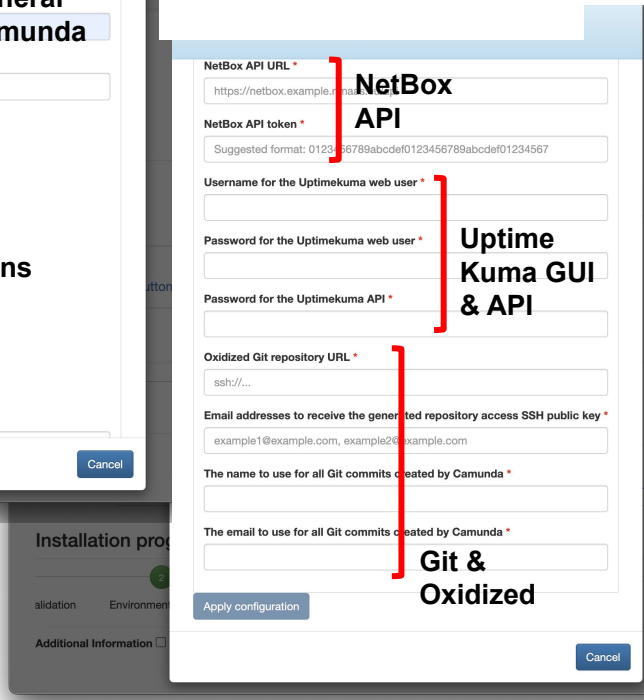
Start using NetBox

synced info in Uptime Kuma and Oxidized

Get the tools to talk to each other…







Future work

This use case targets the GP4L admin side

Next: Introduce automation and orchestration for the GP4L users

- Reservation booking process
- Automated monitoring
- Automated configuration handling

SuperComputing23 Network Research Exhibitions (NREs)

Global P4 Lab

Marcos Schwarz, RNP
Frederic Loui, Renater

This showcase will include demonstrations of new deployed sites and interconnections with other testbeds like FABRIC and BRIDGES, Digital Twin capabilities, automated generation of real time world map topology and also support other NREs that are experimenting with at scale advanced/novel networking protocols and use cases, like PolKA (Polynomial Key-based Architecture) a stateless source routing protocol based on arithmetic operations over a polynomial encoded route label, and IPv6 Flow Label Packet Marking initiative from WLCG, called SciTags.

The GP4L Digital Twin capabilities intend to provide a platform to create automated digital copies of its network, consisting of the full topology or a partial slice of devices and links. It runs 1:1 instance of the same NOS instance that is used on GP4L, which can be used for many use cases:

- Realistic training and testing sandbox environments;
- Flexible development environment for new dataplane features;
- Faithful development of control, management and orchestration solutions which require constant validation and integration;
- Multi-vendor integration tests using other commercial and open NOSes

This Digital Twin solution is being developed based on the follow Open Source projects: Netbox, Netreplica, and Containerlab

Another feature in development is the automated generation of a real time world map dashboard of the network, which will dynamically import the devices and links information and coordinates from a central inventory system (Source of Truth), keeping it up to date with infrastructure changes without manual intervention. This solution is based on integrations between GlobalNOC WorldView Panel, Netbox, and GP4L network monitoring data.

Additionally, we are also applying the digital twin and world map generation at the RNP backbone to also demonstrate its validity with production environments based on brownfield commercial networks and showcasing their multi-vendor and multi-domain capabilities.

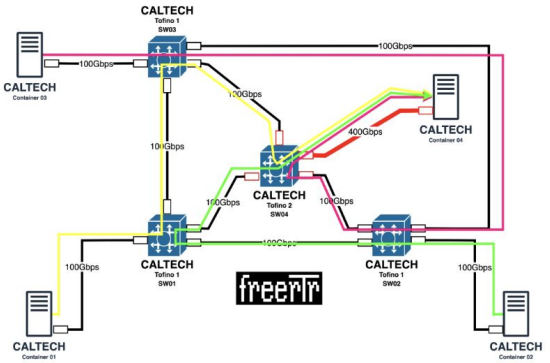
SuperComputing23 Network Research Exhibitions (NREs)

PolKA routing approach to support traffic engineering for data-intensive science

Magnos Martinello, Rafael Guimarães, Everson Scherrer Borges, Cristina Dominicini,
Diego Maffioletti, Jordi Ros-Giralt, Edgar Pontes, Moisés Ribeiro and Harvey Newman

This NRE proposes to demonstrate PolKA functionality to support the TE challenges for data-intensive science. PolKA is a novel source routing approach [1] that explores the Residue Number System (RNS) and Chinese Remainder Theorem (CRT) by performing the forwarding as an arithmetic operation: the remainder of division. PolKA encodes the path in a routeID using the RNS in contrast to the conventional list-based representation, which transports the path information "in clear" inside the packet header. Then, PolKA core nodes use this encoded route label to discover the output ports.

We plan to divide the demonstration of PolKA capabilities into two scenarios: i) in a data-intensive transfer over 100G and 400G network by using PolKA underlay tunnels; ii) in a comparison between segment routing and PolKA over a high-speed intercontinental testbed composed of P4-enabled programmable switches that interconnect DIS research facilities (Europe, South, and North America) employing its controllability of flows to support TE. The flows can be classified, balanced, and steered at the edge using a Policy-Based Routing (PBR) so that TE decisions can be guided by the Quantitative Theory of Bottleneck Structures (QTBS) and GradientGraph (G2)[3] for optimization.

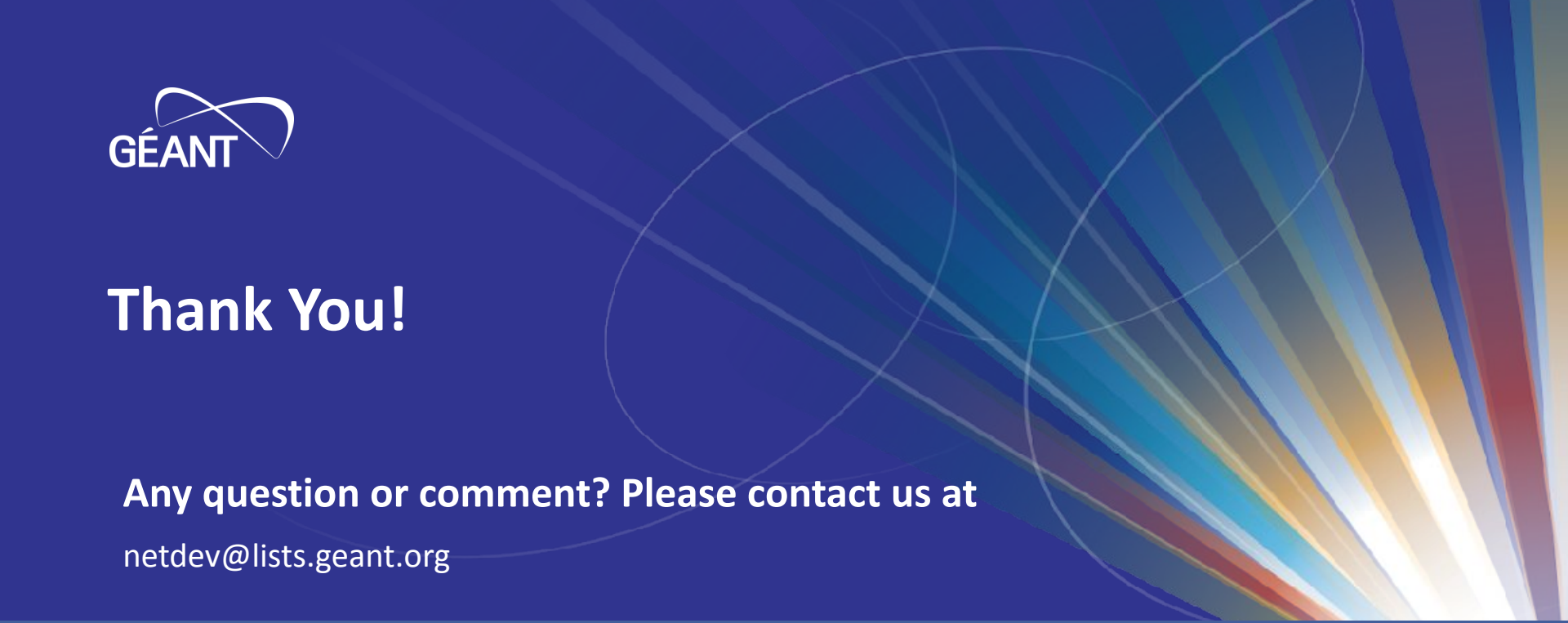


https://sc23.supercomputing.org/scinet/network-research-exhibition/

RARE/freeRtr community support

- **Community channels**
  - Mailing list
    - **rare-users, rare-dev @lists.geant.org**
  - RARE messaging
    - IRC #freertr@DN42
    - rare_freerouter

- **Dissemination**
  - Liaison with international WG (GNA-G, APAN, LHC, UbuntuNet alliance etc.)
  - Conferences
    - SC23/24, IETF hackathon, TNC, APAN, RIPE etc.
  - **Would you like to host a RARE/GP4L Workshop?**



Thank You!

Any question or comment? Please contact us at

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www.geant.org

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