RARE and the GÉANT P4 Testbed

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1st HR NOG

November 10 2022

Zagreb, Croatia

www.geant.org

RARE and the GÉANT P4 Testbed - Agenda

PSNC and the GÉANT project environment

RARE, the GÉANT P4 Lab and the Global P4 Lab

GP4L Use Cases

Looking Ahead

Poznań Supercomputing and Networking Center

Centre of e-Infrastructure

- National Research and Education Network PIONIER
- Research Metropolitan Area Network - POZMAN
- HPC Center
- Data repositories and Digital Libraries federation

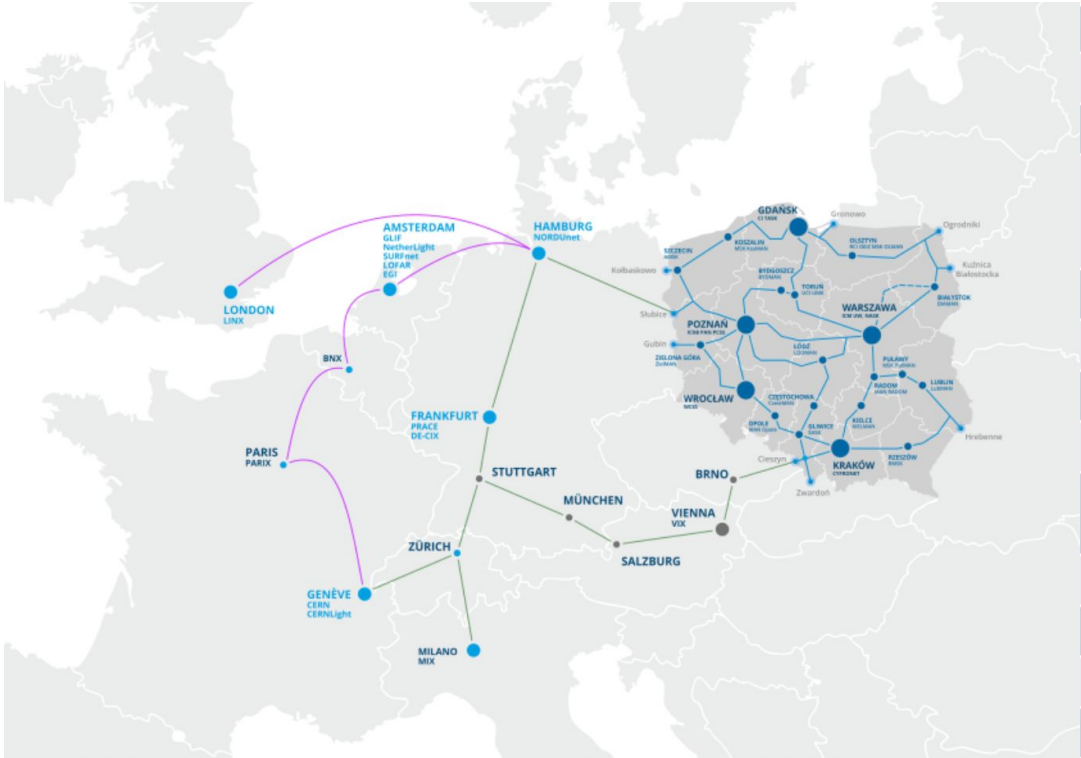
Centre of Research & Development

- New Generation Networks
- HPC, Grids & Clouds
- New media and visualisation technologies
- Knowledge Platforms
- Cyber Security
- Quantum Networking, Communication and Computing

PSNC in numbers

470	20	29	16+	75	80+
employees	laboratories	years of operation	fields of activity	current projects	projects in Horizon 2020

PSNC Network - PIONIER Connectivity



Type of connected unit	Number of units
Research institutions	221
Universities	196
Post-secondary schools	21
High schools, secondary schools, primary schools and vocational schools	234
Healthcare	59
Public safety	27
Goverment administration	27
Provincial administration	59
District, municipality and city administration	73
Other administration	9
Court and public prosecutor's office	26
Cultural institutions	104
Other educational	27

~10 000 km of fiber in total

The GÉANT Project

GÉANT's vision is to ensure **equal** network **access for all scientists across Europe to** the research **infrastructures and** the **e-infrastructure resources** available to them.

A part of the European Union's Horizon 2020 research and innovation programme - GÉANT 2020 Framework Partnership Agreement (FPA)

500 contributors from 40 partners - European R&E Institutions

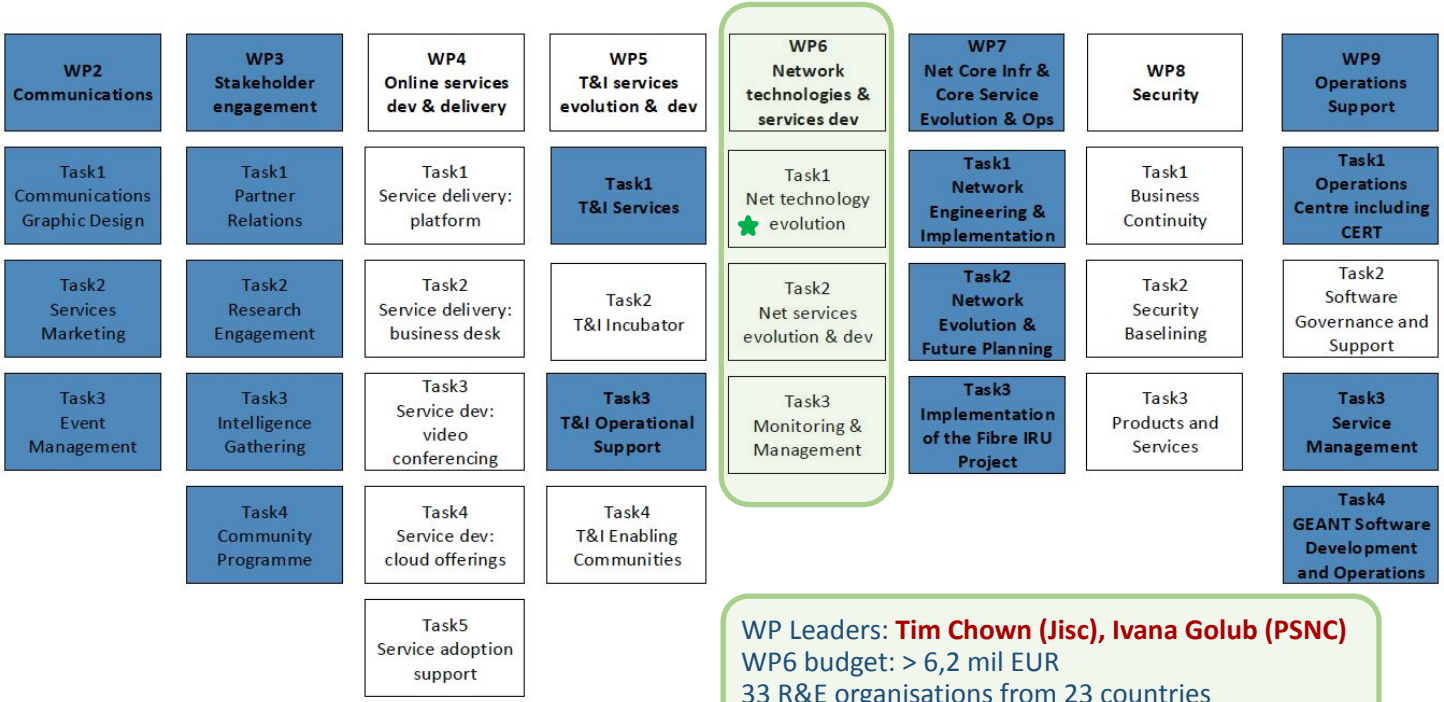
50 M users

GN4-3 duration: 1 Jan 2019 – 31 December 2022

The GÉANT Project Structure

WP2 Communications	WP3 Stakeholder engagement	WP4 Online services dev & delivery	WP5 T&I services evolution & dev	WP6 Network technologies & services dev	WP7 Net Core Infr & Core Service Evolution & Ops	WP8 Security	WP9 Operations Support
Task1 Communications Graphic Design	Task1 Partner Relations	Task1 Service delivery: platform	**Task1 T&I Services**	Task1 Net technology evolution	**Task1 Network Engineering & Implementation**	Task1 Business Continuity	**Task1 Operations Centre including CERT**
Task2 Services Marketing	Task2 Research Engagement	Task2 Service delivery: business desk	Task2 T&I Incubator	Task2 Net services evolution & dev	**Task2 Network Evolution & Future Planning**	Task2 Security Baselining	Task2 Software Governance and Support
Task3 Event Management	Task3 Intelligence Gathering	Task3 Service dev: video conferencing	**Task3 T&I Operational Support**	Task3 Monitoring & Management	**Task3 Implementation of the Fibre IRU Project**	Task3 Products and Services	**Task3 Service Management**
	Task4 Community Programme	Task4 Service dev: cloud offerings	Task4 T&I Enabling Communities				**Task4 GEANT Software Development and Operations**
		Task5 Service adoption support					

The GÉANT Project Structure



WP Leaders: **Tim Chown (Jisc), Ivana Golub (PSNC)**
WP6 budget: > 6,2 mil EUR
33 R&E organisations from 23 countries
88 team members

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

Router for Academia, Research and Education (RARE)

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

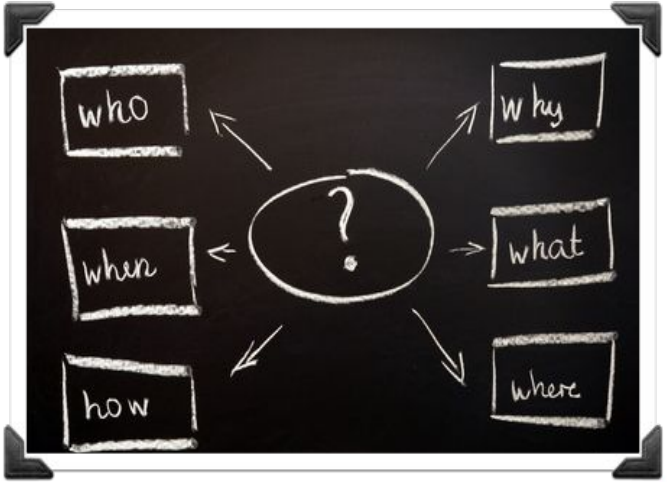
RARE uses FreeRtr as a control plane software and is thus often referred to as RARE/FreeRtr

FreeRtr

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

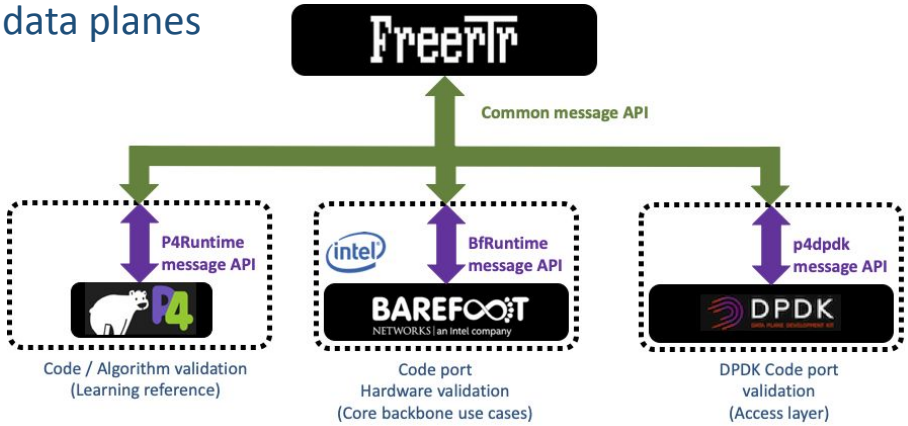
Why RARE?

- Needs of network-aware applications and application-aware network
- Reduce vendor lock-in
- Ability to implement ad-hoc features
- Ability for use-case based solutions
- Reduce digital divide with affordable network solution without functionality trade-off



RARE/FreeRtr Basics

- Free and open source routing platform
- Controls the data plane by managing entries in Match Action Unit (MAU) tables
- Every routed interface must be in a virtual routing table, every layer interface in a bridge table
- One control, several data planes
- Exports control plane computation results to DPDK or hardware switches
- Uses Data Plane Programming (DPP) Language such as **P**rogramming **P**rotocol-independent **P**acket **P**rocessors: **P4** language



Programming Protocol-independent Packet Processors: P4 language

Language for **programming the data plane** of network devices

- Define how packets are processed
- P4 program structure: header types, parser/deparser, match-action tables, user-defined metadata and intrinsic metadata

Domain-specific language designed to be implementable on a large variety of targets

- Programmable network interface cards, FPGAs, software switches and hardware ASICs

P4 Programmable Switches

EdgeCore Wedge100BF-32QS:

100GbE Data Center Switch

- Bare-Metal Hardware
- L2/L3 Switching
- 32xQSFP28 Ports

Data-Plane Programmability

- Intel Tofino Switch Silicon
- Barefoot Networks

Quad-Pipe Programmable Packet Processing Pipeline

- 6.4 Tbps Total Bandwidth

CPU: Intelx86 Xeon 2.0GHz

- 8-core/48GB/2TB SSD

RARE IPv4/IPv6 Features

Include, but are not limited to:

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

Supported platforms:

- BMv2, TOFINO, DPDK, XDP

List updated regularly:

- https://wiki.geant.org/display/rare

For more features or details, contact:

- rare-users@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

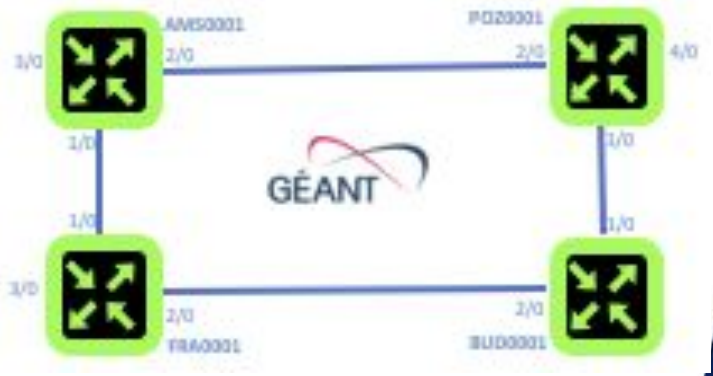
GÉANT P4 Lab – GP4L

Initially aimed to **validate the RARE/FreeRtr** open source routing stack software

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

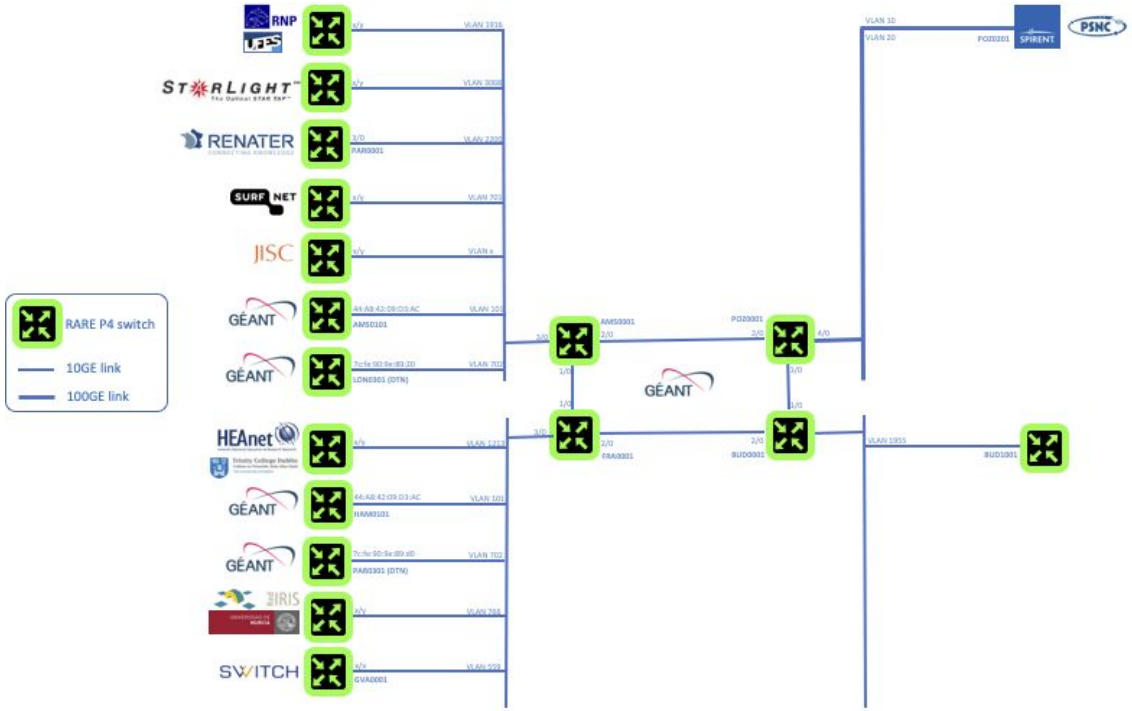
With growing interest, offering **experimental dataplane programming facilities to researchers** to perform geographically distributed network experiments:

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



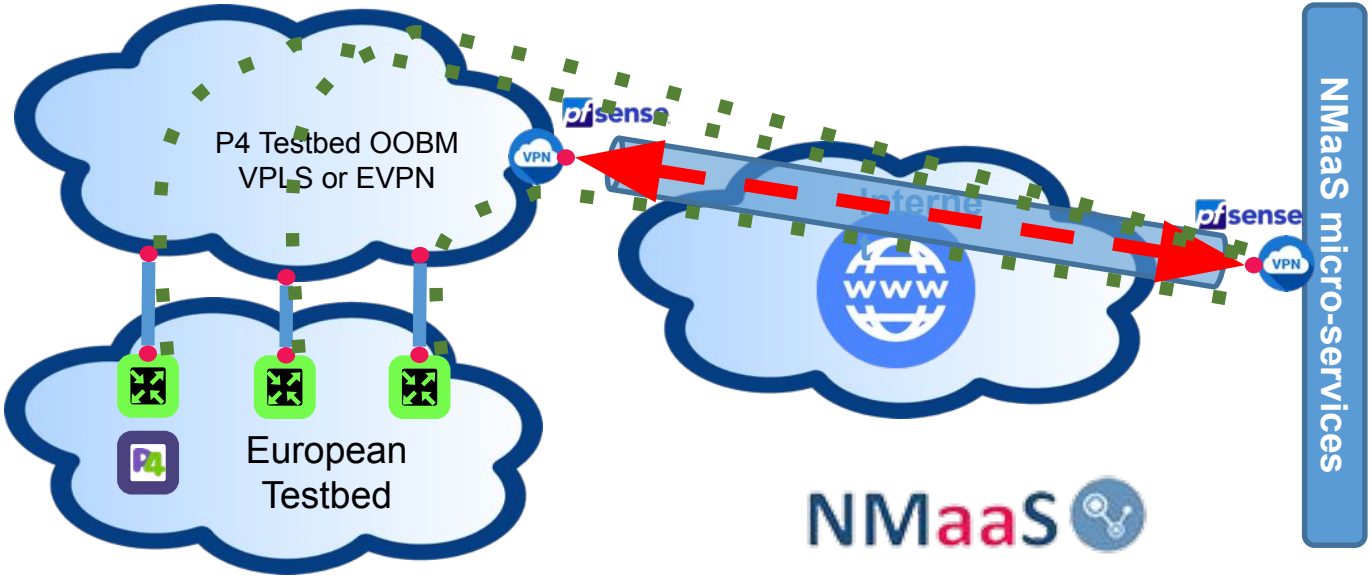
GP4L
GÉANT P4 LAB

GP4L Going Global



Global P4 Lab November 2022

GP4L Monitoring and Management Using GÉANT NMaaS Service



Network Management as a Service:
https://nmaas.eu
https://wiki.geant.org/display/NMaaS

Network Management as a Service (NMaaS)

NMaaS

Network Management as a Service (NMaaS) provides a portfolio of network management applications run as dedicated per-user instances in the cloud.

GÉANT's NMaaS service includes three aspects: providing, managing and maintaining the infrastructure of the NMaaS service portal, platform and selected tools, supporting users in using the system, and the selected tools for monitoring their networks via NMaaS, as well as supporting users that contribute their software to NMaaS system.

Target users

NMaaS users are organisations that do not want to own NMS infrastructure themselves and/or want to outsource network management, as well as organisations and/or individuals that are searching for quality network management software or who want to share their software within the community.

NMaaS Marketplace

NMaaS Marketplace is a catalogue of available open source tools, supported by community, distributed free, chosen by administration. There is also place for your application choice - you can propose new applications.

NMaaS is a platform for network management providing

- A portfolio of network management and monitoring applications
- Per-user, secured network monitoring infrastructure
- Dockerised images implemented through a Kubernetes cluster

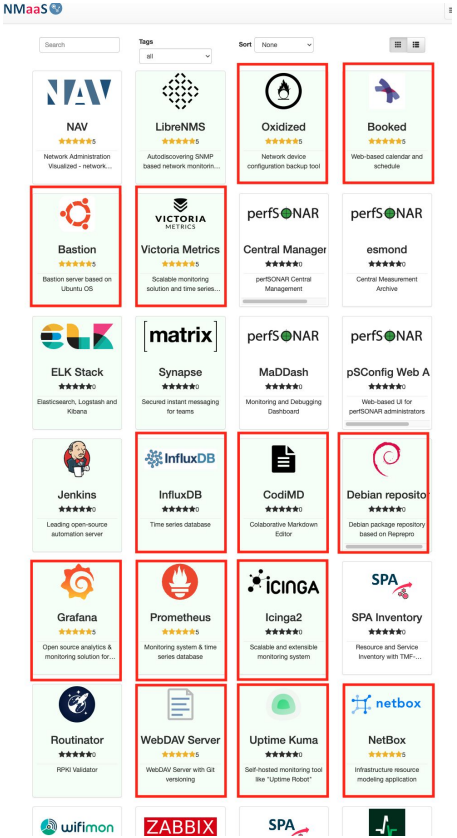
NMaaS Usage

- On GÉANT instances or deployed locally
- NMaaS sandbox instance in GÉANT: https://nmaas.geant.org/
- NMaaS production instance in PSNC: https://nmaas.eu/

NMaaS Update

- Version 1.5.1 released
- The work on providing IPv6 support is ongoing
- NMaaS OAV Architecture Analysis was published

NMaaS Tools Portfolio for GP4L Monitoring and Management



NMaaS

Network Management as a Service:

https://nmaas.eu

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

GP4L Use cases

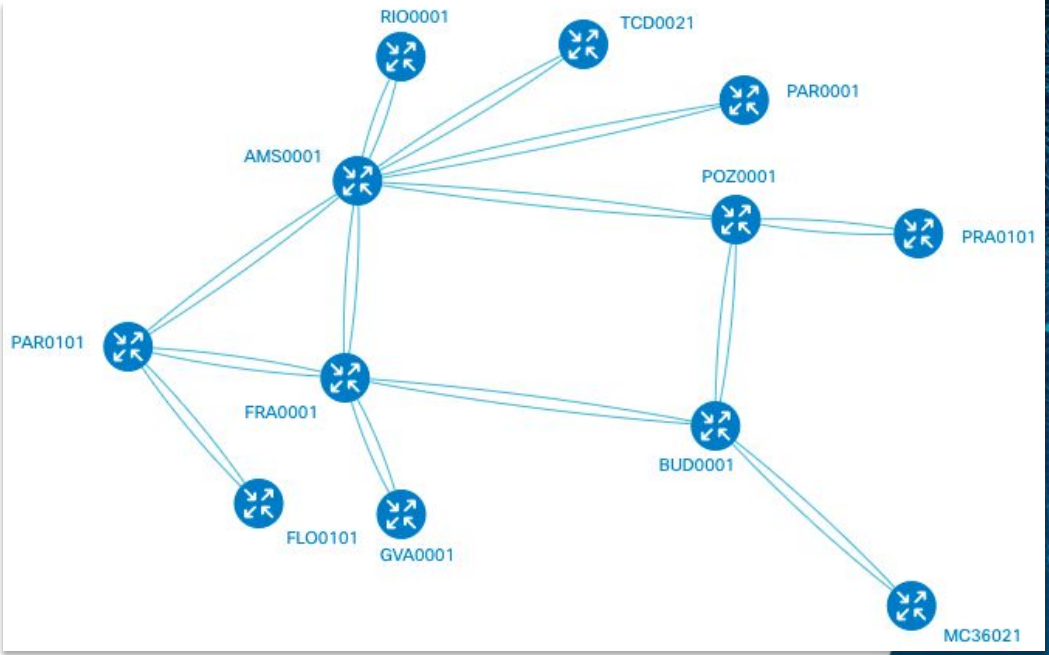
- Topology Monitoring with BGP-LS
- Next Generation Multicast with AMT relay/gateway and Unicast to Multicast translator, Juniper and Akamai
- Polka - an innovative source routing paradigm, IFES/UFES
- Packet Marking Specification: IPv6 Flow Label, CERN
- SuperComputing22 Demo, GNA-G DIS

Topology monitoring with BGP-LS

Network topology rendering using BGP-LS

- BGP-LS feed translated to a JSON model
- The model then used to visualise as a map
- Per-minute updates

Available at: http://gp4l.geant.org



GP4L AMT relay / AMT gateway / Unicast --> Multicast

MULTICAST
BIER
AMT relay/gateway
Unicast2multicast translator

The GÉANT
P4 lab multicast
BIER domain

Private
unicast2multicast

AMT-relay
Public unicast2multicast

[VLC 4 needed][https://nightlies.videolan.org/] -->
vlc amt://62.40.109.31@232.123.86.28:1234 --amt-relay amt-relay.geant.org

PolKA - Polynomial Key-based Architecture for Source Routing in Network Fabrics

- GP4L has been used to validate a Research Paper describing a innovative source routing paradigm: Polka
- After successful publication of Polka paper, it has been decided to implement this routing paradigm to RARE/FreeRtr routing stack

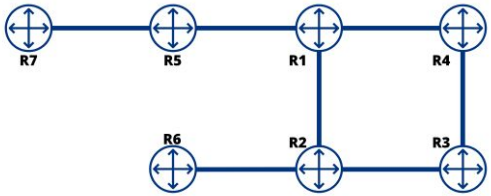


Figure 3. Edge-Core Experiment

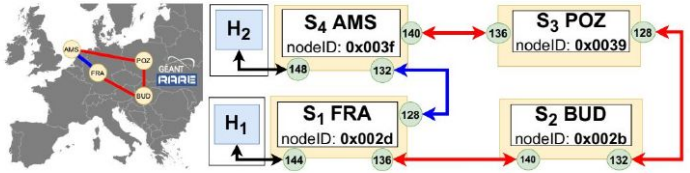
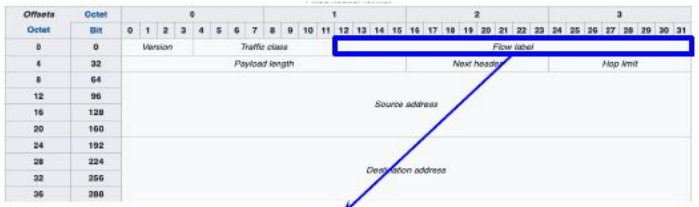


Figure 4. RARE/GEANT testbed

***Figure source**: https://sol.sbc.org.br/index.php/wpeif/article/download/21490/21314/ by Federal Institute of Education Science and Technology of Espírito Santo, and Federal University of Espírito Santo, Espírito Santo, Brazil*

Packet Marking Specification: IPv6 Flow Label

- A packet marking technique proposed by the Research Network Technology WG
- Identifying the LHC experiment and the application that has generated a transmission packet
- The Experiment-Application tag inserted in the IPv6 packet header flow label field
- Primary goal: traffic count,
  but special routing polices could be applied
- Flow label field of IPv6 header: 20 bits
  - 5 entropy bits to match RFC 6436
  - 9 bits to define the science domain
  - bits to define the application/type of traffic

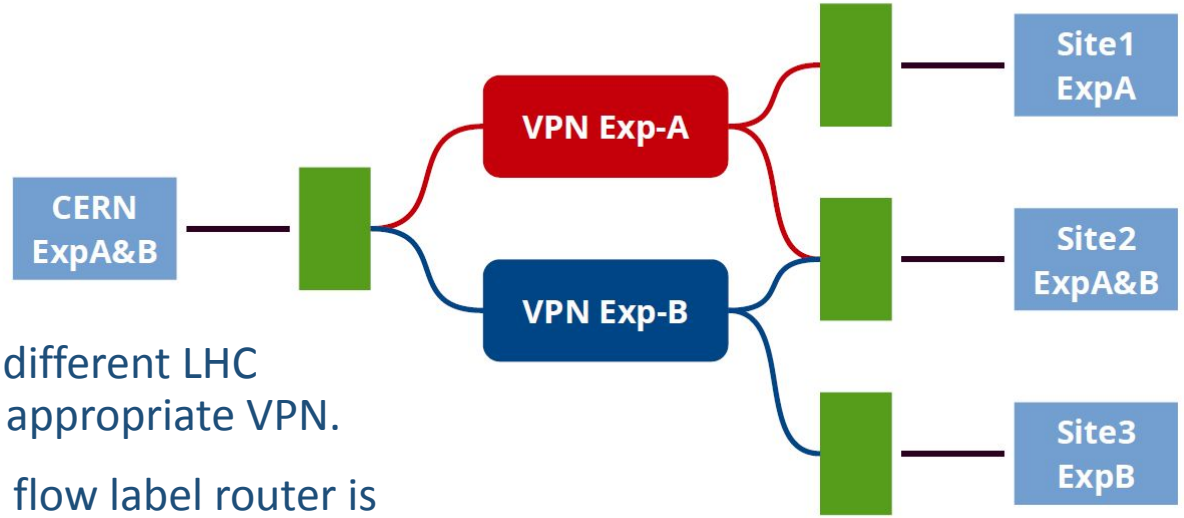


Bits 12 - 13 Entropy	Bits 14 - 22 Science Domain	Bit 23 Entropy	Bits 24 - 29 Application	Bits 30 - 31 Entropy

Astro/HEP Science Domains:
Reserved - 0
Default - 65536
ATLAS - 32768
CMS - 98304
LHCb - 16384
ALICE - 81920
Belle II - 49152
SKA - 114688
LSST - 73728
DUNE - 8192

Application:
Reserved - 0
Default - 4
perfSONAR - 8
Cache - 12
DataChallege - 16

MultiONE multiple “LHCONEs”: Traffic separation with IPv6 flow labels

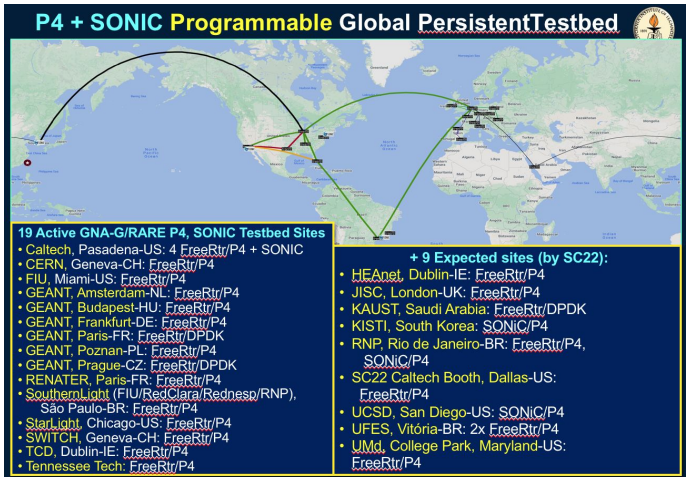


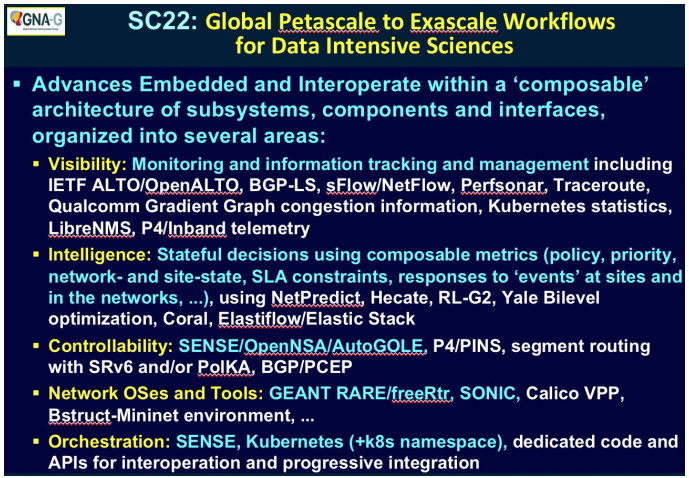
Routing traffic of the different LHC experiments into the appropriate VPN.

- A prototype of a flow label router is being developed using a P4 programmable switch (EdgeCore Wedge100BF-32QS with an Intel Tofino processor)

SuperComputing22 Demo using GP4L

- Over **20** locations expected in the SC22 **Global P4Lab**, including the GÉANT P4 Lab
- Several areas in scope: Visibility, Intelligence, Controllability, NOS and tools, Orchestration
- In collaboration with the GNA-G Data Intensive Sciences Working group – **GNA-G DIS WG**





Slides: by courtesy of Harvey Newman, Caltech

Global Network Advancement Group (GNA-G)

- A community of Research & Education (R&E) network professionals worldwide
- Working together to align resources and achieve efficient global interconnections for global science collaborations and transnational education
- Work is done in Working Groups:
  - AutoGOLE/SENSE
  - Data Intensive Science
  - GREN Map
  - GNA-G Routing WG
  - GREN Connecting offshore students
  - Network Automation

https://www.gna-g.net/

Special Interest Group - Network Operations Centre (SIG-NOC)

An **open forum for network operators** to exchange technical and business oriented information, knowledge, ideas and best practices.

More information: SIG-NOC wiki

Next meeting: 16-17 November 2022, Paris
Registration: https://events.geant.org/event/1296/

Looking ahead

Validate your use case with GP4L!

Orchestrate and automate GP4L:
Lab reservation
Persistent testbed interaction at global scale

New hardware:
TOFINO2, NVIDIA DPU, P4 SmartNIC, TOFINO/FPGA

Global worldwide footprint:
Interconnection with other persistent testbed

New idea:
Validate new use cases
Focus on use case scalability
100/400 GE DTN automation
Control plane scalability

And more …

Useful Links

Documentation:

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

RARE/FreeRtr: https://wiki.geant.org/display/RARE
https://blog.freertr.org
https://docs.freertr.org
https://blog.freertr.org

GÉANT NETDEV: https://wiki.geant.org/display/NETDEV

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Project: gp4l@lists.geant.org, rare@lists.geant.org

Find out more about the NETDEV work

Production services

Development

Presentations

Recordings

White Papers

OAV Community Portal

Code repositories

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

NETDEV Home

Created by Linda Ness, last modified by Susanne Naegele-Jackson on May 28, 2021

GN4-3-WP6: Network Technologies and Services Development

This work package is mainly oriented towards prototyping and piloting new network services. It undertakes evaluation of new and promising network technology in the areas of network infrastructures and network services innovation. In addition, it is responsible for Network Management and Monitoring services and their evolution (provision of operational services).

Objectives

- Enhancements to the existing and/or creation of new services/products/tools through the assessment, validation and implementation of relevant network technologies and services.
- Building and maintaining consensus in the GÉANT community on a future direction for architectures for orchestrating and automating deployment of network services, and on the necessary monitoring and management platforms to support both the services and their underlying network infrastructure(s).
- Promoting wider adoption of general service orchestration and automation principles within the NREN community through consensus building discussions, workshops and dissemination activities.
- Enhancing GÉANT and NREN knowledge transfer through a variety of dissemination activities related to network technologies and services, and network monitoring and management and to build communities of interest around those services and technologies.

GÉANT WP6

WP6 Production Services

- WiFiMon
- NMaaS
- perfSONAR
- Performance Measurement Platform (PMP)

WP6 Production Software

- Service Provider Architecture (SPA)

Digital Architecture & Automation

- OAV Architectures
- Orchestration, Automation and Virtualisation (OAV)
- OAV Training Portal

Applied Automation

- Campus Network Management-as-a-Service
- OAV Community Portal

Research & Development

- Optical Time and Frequency Networks (OTFN)
- Quantum Key Distribution (QKD)
- RARE - Router for Academia Research and Education
- In-Band Network Telemetry (INT)
- DTN - Data Transfer Nodes
- White Boxing

Deliverables and Milestones

OAV Training

Digital Architecture Mapping

More about our work @ upcoming events

2022

- 16-17 November — 17th SIG-NOC
- 23 November — GNA-G Community VC (6-8 am UTC & 8-10 pm UTC)
- 24 November — In-band Network Telemetry infoshare
- 25 November — Quantum Key Distribution deployments infoshare
- 28 November — Argus infoshare
- 1-2 December — Quantum Internet Hackathon
- 8 December — I2 TechEx:
  * Time and Frequency Services in NREN Networks
  * Monitoring the Hidden: TimeMap
  * Network Automation eAcademy

2023

- 14 April — Celebrating The World Quantum Day

https://events.geant.org/

GÉANT
Networks • Services • People

Thank you

Any questions?

Email: ***netdev@lists.geant.org***

www.geant.org

The research leading to these results has received funding from
the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 856726 (GN4-3).