RARE and ~~GÉANT~~ (GLOBAL) P4 Lab (aka GP4L)

Ivana Golub (PSNC)

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27 STF meeting

October 19-20 2022

Zurich, Switzerland / SWITCH

www.geant.org

GÉANT RARE P4 testbed

- GÉANT project environment
- RARE
- GÉANT P4 Lab
- Global P4 Lab
- GP4L Use Cases
- Looking Ahead

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					

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

Router for Academia, Research and Education (RARE)

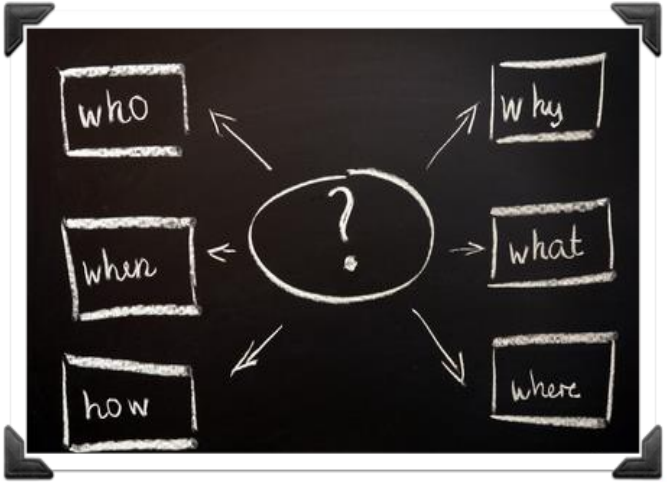
RARE is an open source routing platform, used to create a network operating system (NOS) on commodity hardware (a white box switch).

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

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

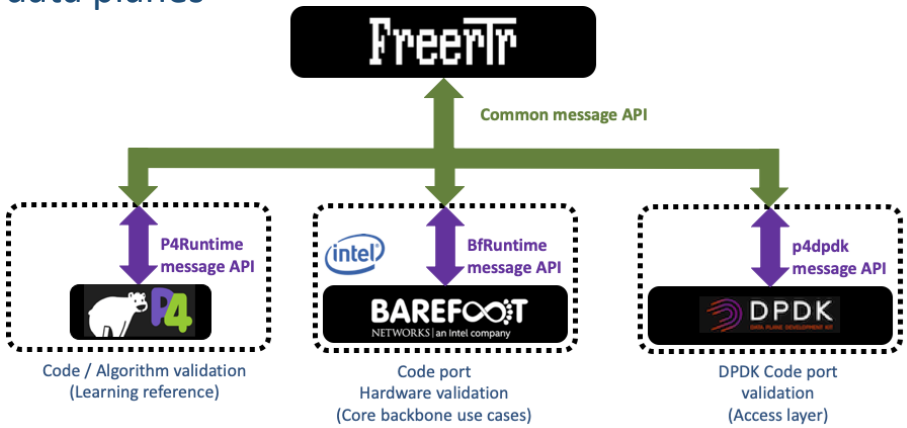
Why RARE?

- 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

TOFINO 2™
12.8 Tbps
32x400 GE ports

TOFINO 3™
25.6 Tbps
64x400 GE ports

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

TOFINO 1 ™
6.4 Tbps

RARE IPv4/IPv6 Features

Include, but 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

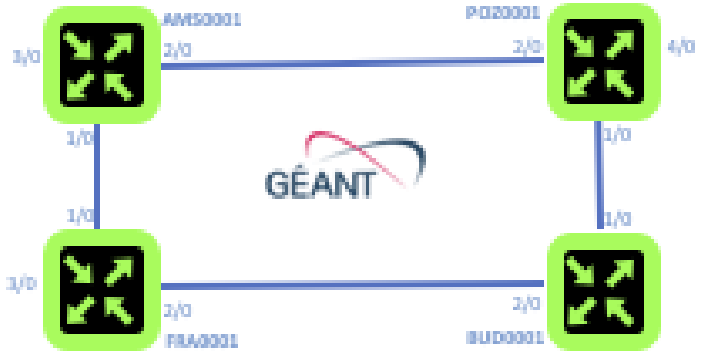
GÉANT P4 Lab – GP4L

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

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

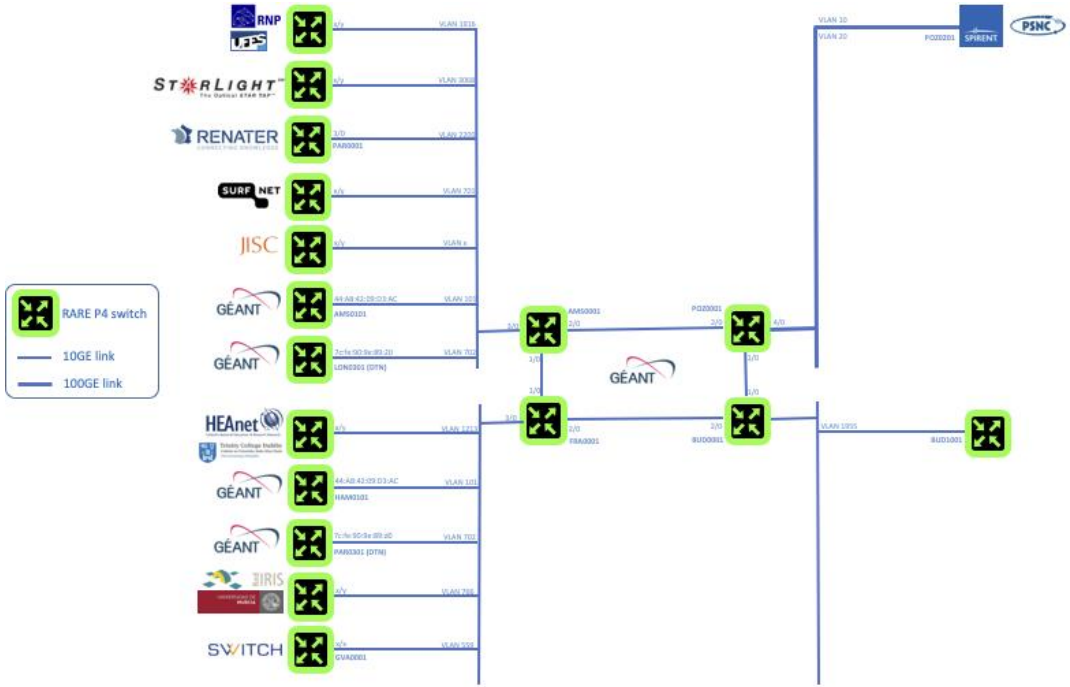
With growing interest, offering **experimental dataplane programming facilities to researchers** to perform geographically distributed network experiments:

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

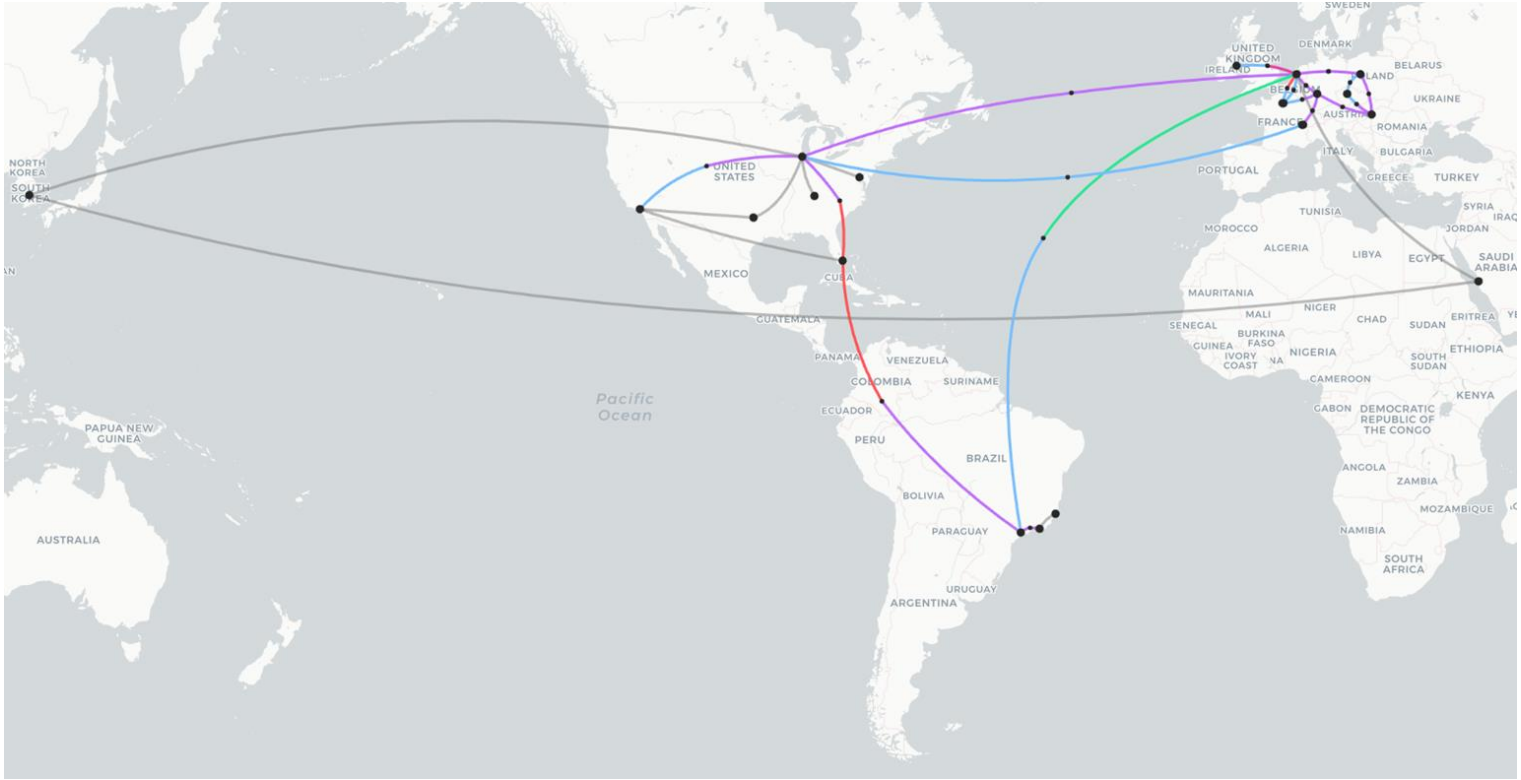


GP4L
GÉANT P4 LAB

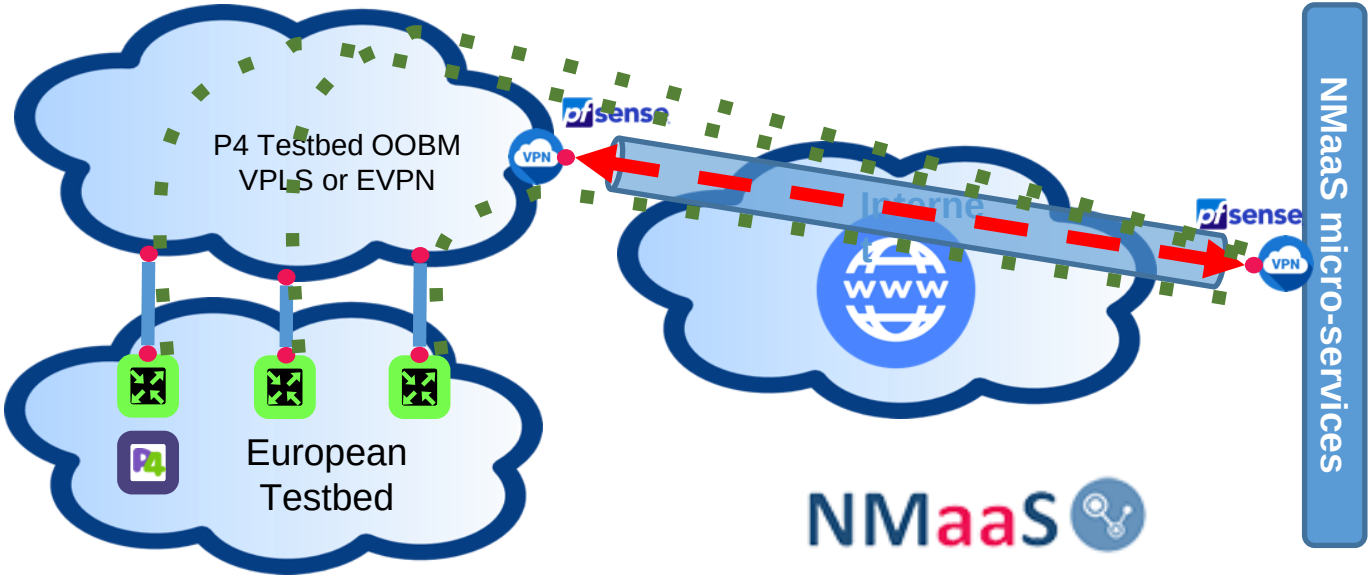
GP4L Going Global



GP4L October 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 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

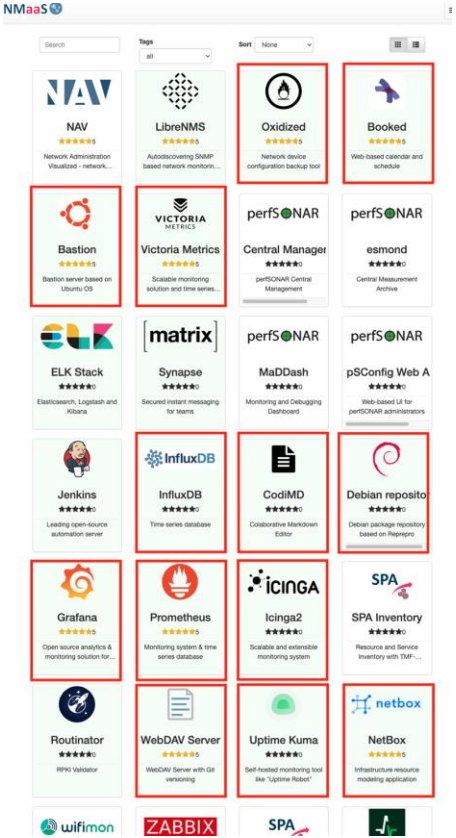
NMaaS Usage

- 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

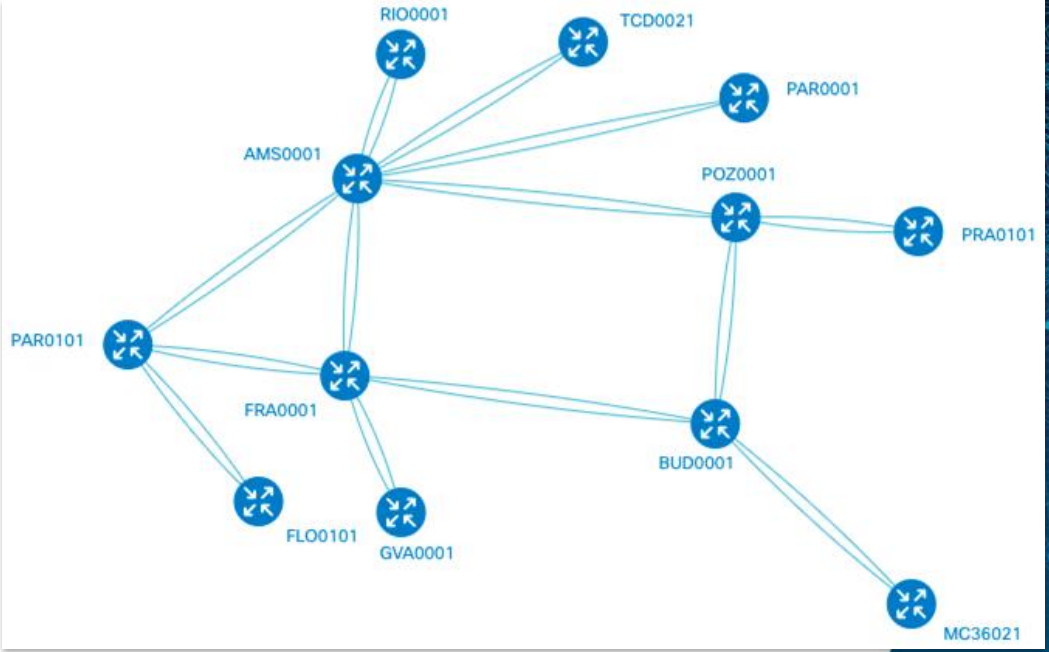
- Topology Monitoring with BGP-LS
- Next Generation Multicast with AMT relay/gateway and Unicast to Multicast translator, Juniper and Akamai
- Polka - an innovative source routing paradigm, IFES/UFES
- Packet Marking Specification: IPv6 Flow Label, CERN
- SuperComputing22 Demo, GNA-G DIS

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

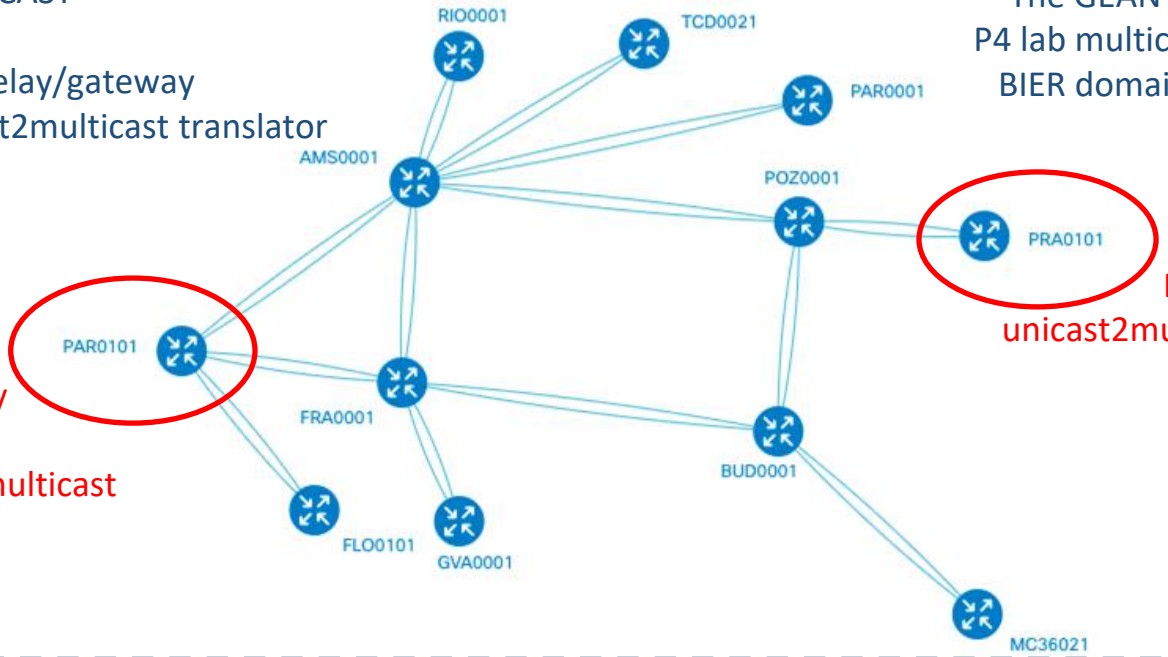
Available at: http://gp4l.geant.org



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

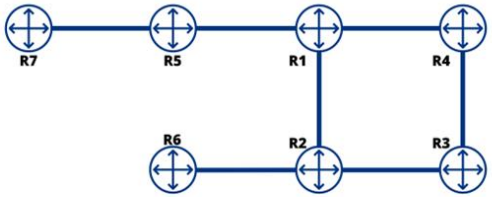


Figure 3. Edge-Core Experiment

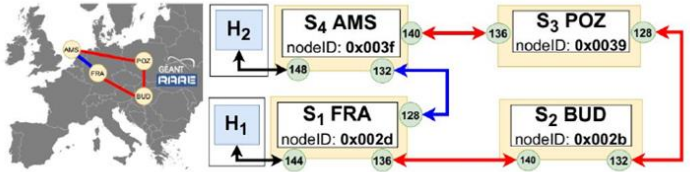
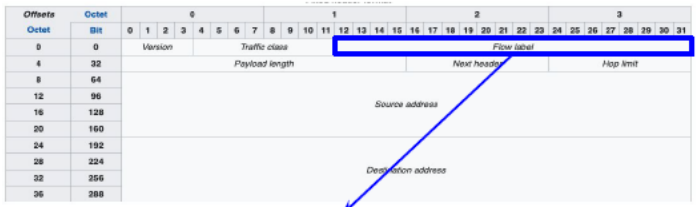


Figure 4. RARE/GEANT testbed

***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

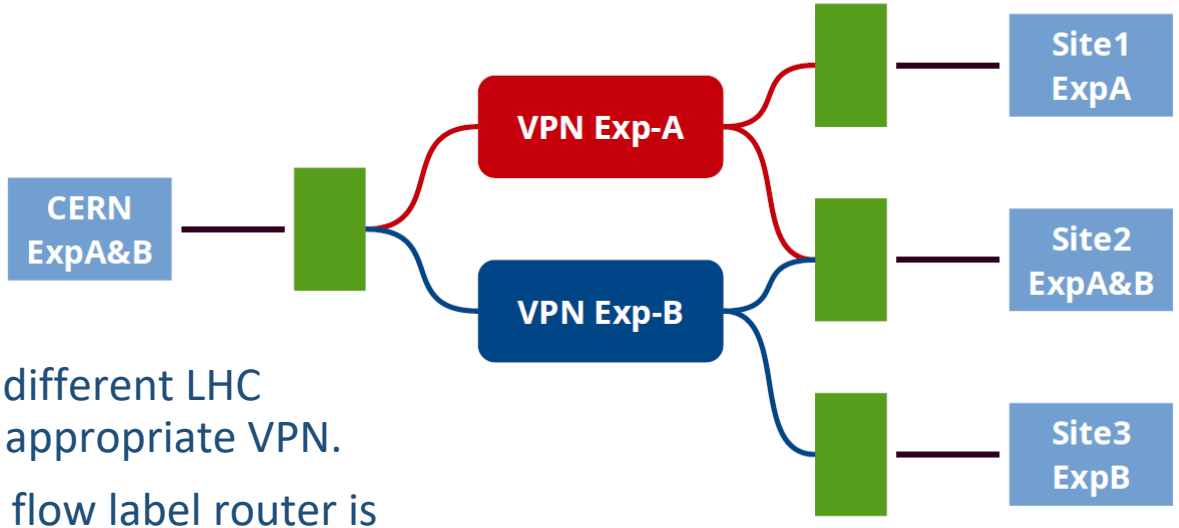


Bits 12 - 13 Entropy	Bits 14 - 22 Science Domain	Bit 23 Entropy	Bits 24 - 29 Application	Bits 30 - 31 Entropy

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.

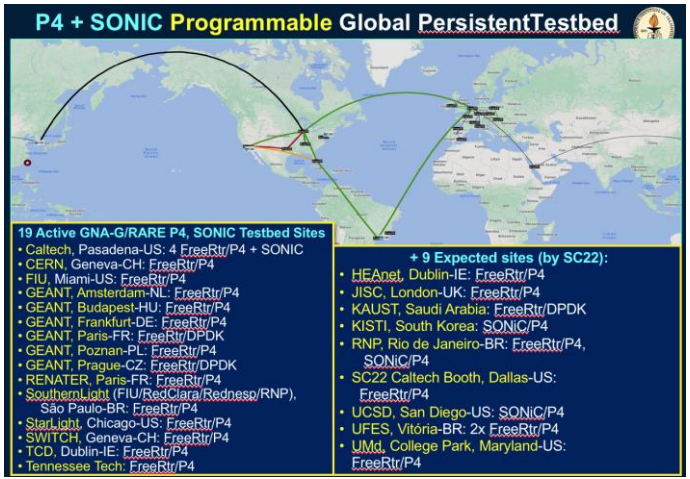
- A prototype of a flow label router is being developed using a P4 programmable switch (EdgeCore Wedge100BF-32QS with an Intel Tofino processor)

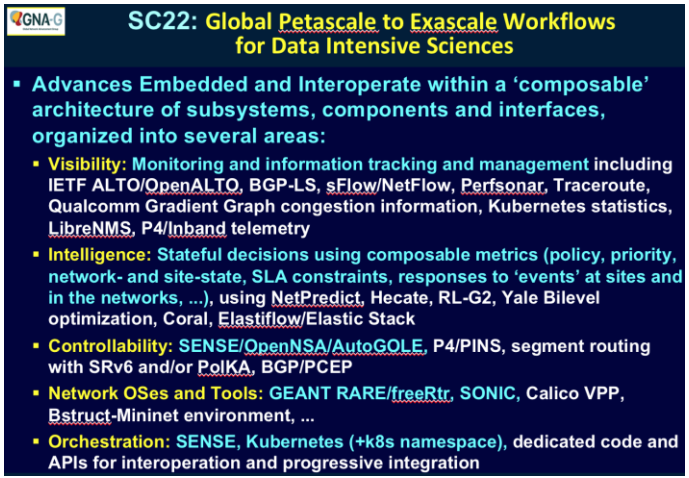
SuperComputing22 Demo

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**

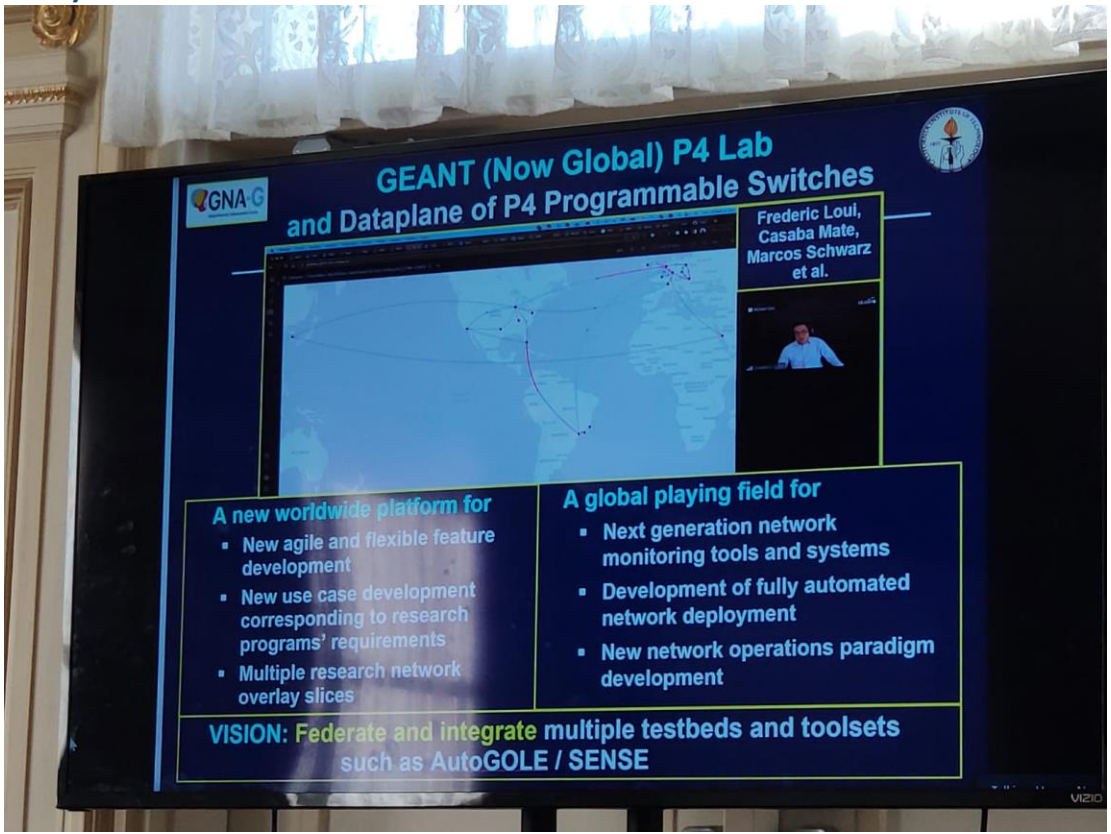




Slides: by courtesy of Harvey Newman, Caltech

RARE/freeRtr and GP4L at 3rd GRP (Salt Lake City)

(Thanks Ivana !)



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

GÉANT
Networks • Services • People

Thank you

Any questions?

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www.geant.org

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