Introduction

RARE[1] is an acronym with a rich history[2] in the European Research and Education(R&E) networking community. The acronym **RARE** (Router for Academia Research & Education) dates from 1987 and was the first name for the fledgling European R&E organization before becoming **TERENA** and later GÉANT[3]. The RARE motto was "Networking the Networkers"! The project is funded by the GÉANT 4th program project and hence the EU. The goal of our RARE project is to create a modern open router platform that can quickly be adapted to meet the numerous challenging use cases from our R&E community. This paper outlines some of the latest challenges facing the R&E network community today, and describes the corresponding solution utilizing the RARE platform. The following questions that we asked to ourselves when we initiated the project 2 years ago:

- What are the R&E use cases that could benefit from RARE?
- What are the problems we would like to address and how can RARE help to overcome these challenges?

This paper presents the RARE vision and will also provide the reader with a high-level understanding of the RARE architecture and how this modular architecture lends itself to the rapid development and automated testing of new protocols and features. While the RARE team is working on several use cases, this paper will focus on the use of RARE as a fully featured router platform for P4 hardware devices such as Tofino.

The RARE Mission Statement

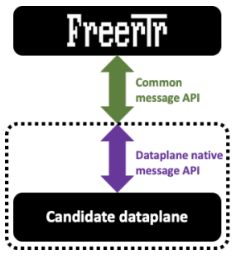
The RARE project aims to provide an open, programmable router platform which will meet the challenging demands of the future R&E networking use cases.

Examples of some of the R&E use cases we are working on:

- Route Reflector on virtual or bare metal server
- High speed(10/100Gbit/s) University Border router on bare metal and P4 hardware
- Small routers for schools CPE on platforms similar to Dell VEP hardware.
- Source routing for R&E networks
- Telemetry for IP networks.
- Inband Network Telemetry (INT) for P4 networks.
- BIER (Bit Index Explicit Replication) Multicast forwarding using encapsulation for MPLS and Ethernet [5]
- PolKa (Source routing in P4 networks using Polynomials) [6]
- Multidomain networking architectures with the GNA-G and Caltech for future solutions for CERN data transfers

RARE/freeRtr overall architecture

RARE utilizes the freeRtr control plane. The relationship between RARE and freeRtr[4] is similar to GNU/Linux relationship where GNU is part of the Free Software Foundation project and Linux is the kernel used. Similarly, RARE is the umbrella project using the control plane of freeRtr. The RARE/freeRtr architecture consists of 3 components:



- Open source Control Plane

FreeRtr[4] open source control plane is used. FreeRtr provides all the features and protocols expected from an enterprise grade router operating system, with many unique features such as support for P4 hardware devices and bespoke, novel protocols.

- Programmable Data Plane

BMv2 is supported today for development purposes as well as Intel® Tofino™for when you have access to hardware.

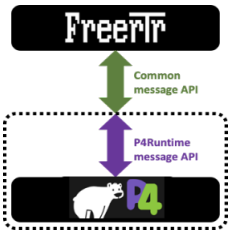
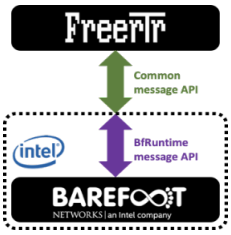
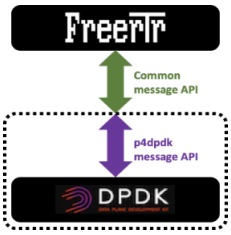
- Interface between the control plane and the dataplane

BMv2 and Intel® Tofino™ are using respectively the P4Runtime and BfRuntime API, thereby enabling

	programmable access from the control plane. freeRtr implements a simple text message API. The dataplanes are thus seamlessly interchangeable from the freeRtr perspective.

RARE/freeRtr value proposition

The following is the result of the RARE team's hard work. Special care has been taken to make the solution simple and sustainable.

	BMv2 is the target we are using to validate code logic. We started by implementing BMv2 as we did not have access to real capable hardware when we started the project. This has proven to be very useful as it allows us to automate our nightly unit testing. BMv2 has this convenience to have unlimited stages, resource memory which lets us focus solely on working on packet code forwarding algorithms. BMv2 and Intel® Tofino™ code base share the same skeleton, coding style and it is a very convenient approach for users who start learning P4 with BMv2.
	While BMv2 is great for algorithm sketching and educational purposes. The RARE/freeRtr Tofino image using bf_switchd allows for the forwarding of packets to verify the dataplane without requiring Tofino hardware. There is one significant difference compared to BMv2. The Tofino will try to forward your packet as fast as possible (6.4 Tbps). To that end your program has to be adjusted in terms of resource usages. This is why Intel® Tofino™ has this concept of profiles that corresponds to specific resources allocation.
	While porting the RARE code to Tofino™, we discovered that the Intel® Tofino™ hardware platform was not suitable for lower bit rate use cases when complex network features are required. In order to resolve this "gap" for non-P4 hardware we came to the conclusion that RARE had to implement its own dataplane: hence we now have available P4DPDK for RARE. This provides DPDK forwarding speeds for the SOHO/CAMPUS/MAN use case. This P4DPDK dataplane boast of "infinite" (read as much as the hardware has) amount of resources but of course we are talking about nx1GE, nx10GE, 100GE rates maximum. Not Terabits per second.

In Summary

As a domain-specific language, P4 has enabled access to the programmable dataplane for the first time. User applications, which were limited in terms of throughput in the past, now have the ability to run at hardware line rate ranging from nx1G → nx1 Tbps! The RARE/freeRtr open source router operating system provides a networking swiss army knife solution based on P4 language. New targets devices that combine hybrid technologies such FPGA and Intel® Tofino™ alongside technology like DPDK, RDMA will unlock the door to new use cases.

Ressources:

[1] https://wiki.geant.org/display/RARE/Home
[2] A History of International Research Networking: The People who Made it Happen. ISBN: 978-3-527-32710-2
[3] https://www.geant.org/
[4] www.freertr.net.
[5] https://datatracker.ietf.org/wg/bier/about/
[6] https://ieeexplore.ieee.org/document/9165501