Brazil and Europe unite forces and testbeds for the Internet of the future

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***Abstract*—In October 2011 a new, ambitious project was launched, named FIBRE (Future Internet testbeds experimentation between Brazil and Europe). Its main goal is to create common space between Brazil and EU for Future Internet experimental research into network infrastructure and distributed applications, by building and operating a federated EU-Brazil Future Internet experimental facility. Apart from bridging partners from two continents, the project brings together different technologies, including OpenFlow, wireless and optical communications. This teaser presents FIBRE's objectives and demonstrates its public utility in the development of a showcase. Finally, some challenges that are in our research agenda are proposed to the community.**

***Index Terms*—FIBRE; Future Internet; testbeds; SDN; OpenFlow**

I. INTRODUCTION

FIBRE - Future Internet testeds/experimentation between BRazil and Europe [5] (2011-2013) is a research project (STREP) co-funded by the European Commission under the FP7 Cooperation Programme and the National Council for Scientific and Technological Development of Brazil (CNPq).

Programmable testbed networks can lower the barrier to entry for new ideas, increasing the rate of innovation in network infrastructure. Virtualisation of networks is accomplished by the use of virtual routers and the multiplexing of links between them. These programmable testbed networks call for programmable switches and routers that, using virtualisation, can process information flows for multiple isolated experimental networks simultaneously. It is envisaged that a researcher will be allocated a slice of resources across the whole network, consisting of a portion of network links, packet processing elements (e.g. routers) and end-hosts; researchers programme their slices to behave as they wish. A slice could extend across the backbone, into access networks, into college campuses, industrial research labs, and include wireless networks, sensor networks, and may (or should) include real users of the applications it supports. Such a testbed facility may serve a widespread community of researchers and users.

II. FIBRE OBJECTIVES

The main objective of the FIBRE project is the design, implementation and validation of a shared Future Internet (FI) research facility, enabling experimental research into network infrastructure and distributed applications. Currently such facilities already are operated, or are being built following similar designs, by nine institutions in Brazil and 4 in Europe, located in France, Greece, Spain and UK. We expect that such a federated large-scale experimental facility will enable and encourage closer and more extensive bilateral cooperation in FI research and experimentation, as well as strengthening the participation of both communities in the increasingly important global collaborations in this important area of network research and development. In order to achieve this goal the project will carry out four main activities:

- The development and operation of a new experimental facility in Brazil, including the setup of equipment to support experimentation with various technologies (fixed layer 2 and layer 3, wireless, optical) as well as the design and implementation of a control framework to automate the use and operation of the testbed.
- The development and operation of a FI facility in Europe based on enhancements and the federation of two existing infrastructures: OFELIA [2] and OneLab [4]. Two OFELIA islands (i2CAT/Spain and UEssex/UK) and the UTH's NITOS [6] testbed will be enhanced by i) adding more physical resources (servers, OpenFlow-enabled switches and access points) to be able to cope with a bigger number of users and different use cases, ii) improving its respective control frameworks (based on the OFELIA control framework and OMF [1]) and iii) adding more manpower to operate the facilities.
- The federation of the Brazilian and European experimental facilities, both at the physical connectivity and control framework level, to support the provisioning of slices using resources from both testbeds.
- The design and implementation of pilot applications of public utility that demonstrate the power of a shared Europe-Brazil FI experimental facility.

It is planned the deployment of three use case scenarios (a.k.a. project showcases) to validade the testbed and demonstrate the public utility of FIBRE infrastructure. In the next section, one of these showcases is briefly presented.

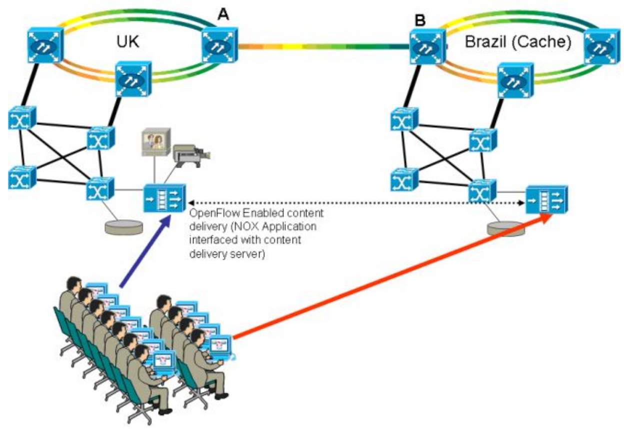

Figure 1. High-definition content delivery

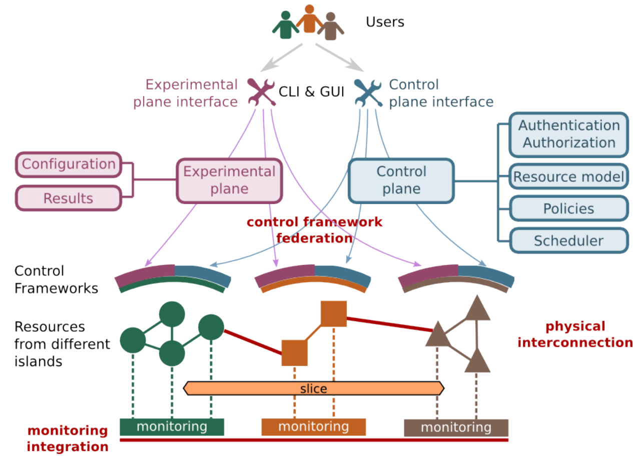

Figure 2. FIBRE architecture proposal

III. Showcase: High definition content delivery across different sites

Summary Scenario (storyline): The content delivery servers in a content delivery network (CDN) can interface to a custom OpenFlow-based application (i.e., NOX application [3]) which monitors the performance of the content delivery servers and if the performance metrics of these servers is passing a threshold, the NOX application will re-route some of the clients of the current server to the another server. The client re-routing will be facilitated by NOX application, which is able to control (i.e., properly changing the flow table of) the OpenFlow enabled network infrastructure.

Goal: This use-case exploits the flexibility provided by "OpenFlow" and "Flow Routing" to balance the clients/users of a high-definition video streaming service from one delivery site (content delivery server) to another site. In this showcase, Brazil and UK will host one content delivery server (CDS) each. Figure 1 illustrates this scenario.

Hardware Requirements:

- OpenFlow enabled islands in UK and Brazil
- 4K streaming or high quality streaming for ordinary users
- 4K Projection facility or ordinary clients (stream player)
- OpenFlow Controller Requirements:
- NOX application interfaced with the Content Delivery Servers to monitor the performance of the CDS and trigger the re-routing of some clients to the other site.

Use case features:

1) Note that the bandwidth on link of the link A-B is not a bottleneck in this use-case. In fact, we can assume that the bandwidth of link A-B is enough, but the bottleneck that triggers the re-routing of clients is the load on content delivery server.
2) Note that the direction of the traffic on link A-B is from A to B for sending the cache copy to Brazil site and from B to A for re-directed clients (from Europe to Brazil, which receive the cache copy).
3) In IP based (not OpenFlow) paradigm, you cannot easily re-direct some of the clients to another content delivery server, while using the OpenFlow, the intelligent content delivery server can selectively re-direct some of the clients to another site.
4) The OpenFlow enabled content delivery servers open the doors for many different criteria that we can include in addition to considering the content delivery server, which is closer to the client.
5) It is somehow counter intuitive that you can relief the load on your content delivery server by sending them to another (quite remote) point (given that bandwidth is not a limitation). The interesting point here is that the link between UK-Brazil exists, which could be however underutilised. So it is possible to push some of the users' traffic to that link to increase the link utilization. Also, note that the direction of content caching is from A to B and clients will just download from B to A direction.

IV. Conclusions

With the globalisation of experimental FI research, there has been considerable interest in the federation of distinct testbed facilities, in order to permit carrying out experiments that span multiple testbeds.

FIBRE researchers are facing the big challenge of federating autonomous islands - managed by different Control Frameworks - while providing a single infrastructure view for the users. In the proposed architecture, depicted in Figure 2, physical resources are shared between federated islands and all CFs are federated through a Federation Control Plane. An instrumentation and measurement framework, able to integrate data from the different islands and CFs is also being developed.

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