The Next Generation of the FIBRE Software Architecture

Danielle Caled[1], Tiago Salmito[1], João F. Santos[2], Leandro Ciuffo[1], José Rezende[1], Iara Machado[1]

[1]Diretoria de Pesquisa e Desenvolvimento – Rede Nacional de Ensino e Pesquisa.

[2]CONNECT Centre – Trinity College Dublin, Ireland.

{danielle.vieira, tiago.salmito, iara, leandro.ciuffo}@rnp.br[1]

jose.rezende@rnp.br[1], facocalj@tcd.ie[2]

Abstract. *The FIBRE testbed is a large-scale research facility for experimentation on Future Internet technologies. To address specific requirements of the Brazilian federation, it was decided to commence a new development phase in which FIBRE would have its architecture completely revised. This paper presents an overview of the next generation of the software architecture envisioned for the FIBRE testbed.*

1. Introduction

The FIBRE testbed[1] is a research facility focused on network experimentation operated independently by Brazilian academic institutions and lead by the National Education and Research Network (RNP). As of today (March 2017), FIBRE is a federation of 14 experimentation islands and hosts 282 users from at least 55 different organizations. Each island has a common nucleus of OpenFlow-capable switches, together with their controllers, a cluster of compute and storage servers, and optionally a cluster of wireless nodes.

As the FIBRE testbed was designed and built as an outcome of an EU-Brazil collaboration project, its original software stack is mainly inherited from the former OFELIA project[2] (2010-2013). Due to the growth of the FIBRE testbed with new experimentation islands joining the federation and also the introduction of new types of resources (e.g. wireless sensors, software-defined radios, NetFPGA servers with bare metal access, etc.), it was mandatory to redesign the FIBRE software architecture in order to deal with such a heterogeneous environment.

In early 2016, after FIBRE having financed 6 prospective short-term projects [1], and according to requirements recommended by users, it was decided to redesign the architecture of the FIBRE testbed based on 6 fundamentals[3]: full domain of the software; the adoption of a single control and management framework; improvements in user experience; authentication supported by identity federations; accounting and monitoring; and extensibility and integration of other types of resources. This decision not only led to the adoption of *cOntrol and Management Framework version 6.0* (OMF6) [3], but also to the development of a new Experimentation Portal in conjunction with a collection of services for supporting federation, accountability, and user authorization and authentication.

[1]https://www.fibre.org.br/
[2]http://www.fp7-ofelia.eu/about-ofelia/
[3]https://www.fibre.org.br/fibre-aiming-at-upgrading-to-omf6-by-2017/

This paper builds on the work described in [1] by presenting an analysis of the adoption of the OMF6 control framework. In addition, it describes the components that form the next generation of the architecture planned to be deployed in FIBRE testbed in the near future.

The rest of this paper is organized as follows: Section 2 presents the new architecture envisioned for the next phase of the FIBRE project. Section 3 and 4 describe the components developed specifically to meet the requirements of the FIBRE testbed, respectively the Experimentation Portal and Clearinghouse. Finally, in Section 5 we give some concluding remarks.

2. FIBRE's Software Architecture Redesign

The redesign of the software architecture was driven by a careful examination of the notion of experiments and testbeds in the networking field. The current architecture of FIBRE testbed employs three different control frameworks, depending on the type of resource one desires to use. The employment of multiple control frameworks hindered user experience and increased the complexity of the testbed and its operational expenses, thus the FIBRE steering committee decided to adopt OMF6 as the sole control framework running in the FIBRE testbed [1].

The basic idea behind the design of OMF6 is that "everything is a resource", this approach allowed a more natural and generic architecture. However, specific requirements of the FIBRE environment demanded the development of additional components complementary to OMF6, namely the *Experimentation Portal* and the *Clearinghouse* (CH). Figure 1 depicts the main components of the new generation of the FIBRE architecture, which we describe next.

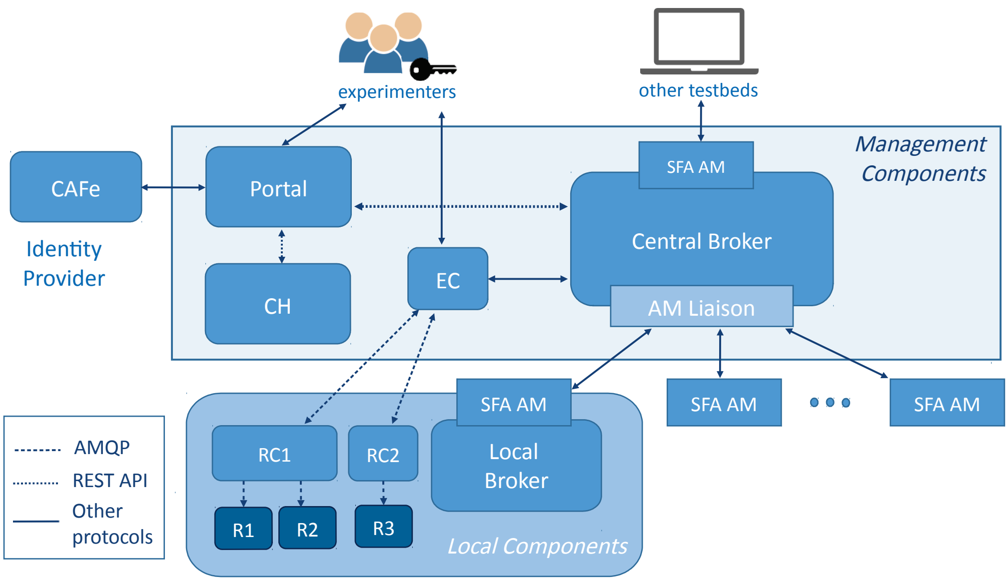

Figure 1. FIBRE's Functional Architecture

The components of the architecture are structured in two categories: *local components*, that run in each experimentation island enabling them to have direct control of local resources, and *management components* that interact with the underlying infrastructure to expose interfaces for experimenters and other federated testbeds compatible with a *SFA Aggregate Manager API* (SFA AM).

The highest-level components of the architecture run at the management layer. Together, both Experimentation Portal and CH deal with user interaction and credential management, establishing an interface between experimenters and OMF6 components. While the Experimentation Portal was developed specifically to the FIBRE testbed, the CH was implemented according to GENI's Clearinghouse specification[4].

The *Central Broker* is responsible for aggregating and advertising resources available in the testbed. It is also responsible for resource reservation and provision in due time. The *AM Liaison* implements the core functionality of the Central Broker. It acts as the communication interface between Central Broker and Local Brokers by using their respective SFA Aggregate Manager API.

The *Experiment Controller* (EC) is the control entity responsible for orchestrating experiments described by scripts written in OMF Experiment Description Language (OEDL) [2]. A publish-and-subscribe message system is adopted for handling communications between resources and the entities interacting with them. Participants can create topics, subscribe to them and publish messages to them using AMQP[5], an open standard application layer protocol for message-oriented middlewares.

The *Local Brokers* expose a *SFA AM API* that allows discovering, aggregating and advertising local resources to the Central Broker. Each island must deploy their Local Broker to schedule and create reservations of its resources in the Experimentation Portal.

Resource Controllers (RCs) are proxies that intermediate message exchange between EC and local resources. They are responsible for controlling the life cycle of resources under their governance. They create instances of resources and send arbitrary control messages to them. These local resources may represent virtual machines, dedicated wireless enabled nodes, specialized sensors or OpenFlow resources (*R1*, *R2* and *R3* in Figure 1).

3. Experimentation Portal

The *Experimentation Portal* is a web interface built specifically to the FIBRE testbed that allows users to allocate and interact with the resources of each available island through a browser. Experimenters may create and manage shared projects, build experiments and add supported resources to them through the portal. The Experimentation Portal simplifies the use of the federation because it mediates the required interactions among CH, Broker and experimenters.

To use its services, experimenters must be authenticated. Given the diversity of users we intend to reach with FIBRE, experimenters may use the authentication granted by the Brazilian academic identity federation called *Comunidade Acadêmica Federada*[6] (CAFe), however, the portal supports local authentication to researchers who are not contemplated with a federated account. The Experimentation Portal is also designed to be

[4]http://groups.geni.net/geni/wiki/GeniClearinghouse
[5]https://www.amqp.org/
[6]http://portal.rnp.br/web/servicos/cafe

compatible with other Shibboleth identity federations.

The Experimentation Portal interacts with OMF6 Central Broker both for resource discovery and reservation through a REST API exposed by the Central Broker. OMF6 resources are only available for use during the period reserved and granted to experimenters by the local broker.

4. FIBRE Clearinghouse

The FIBRE Clearinghouse provides a collection of related services supporting the federation among experiments, resource aggregates and the underlying services of the testbed, offering services for federated authentication, user authorization and accountability. Its purpose is to manage user information and certificates, acting as the trust anchor in the federation, as it generates the credentials that grant user authorization across the other modules of the FIBRE architecture.

The CH manages projects and experimenters identities, as well as their privileges in each project context. The highest-level authentication and authorization processes are performed via the exchange of credentials between Experimentation Portal and CH.

The communication between the Experimentation Portal and the CH is again done through a REST API, which enables the management of accounts, projects and slices in the Experimentation Portal web interface. This API allows experimenters to retrieve their credentials necessary to access the OMF6 Central Broker and the OMF6 Experiment Controller.

5. Conclusion

This paper presented an overview of the next generation of the software architecture to be adopted in FIBRE testbed. This overview provided a short description of the components that form the architecture and the adoption of the OMF6 control framework. The transition to OMF6 will be as smooth as possible, with FIBRE supporting both OMF6 and the legacy control frameworks in the meantime.

The FIBRE testbed aims to be open to any researcher, professor or student interested in using the testbed for experimentation or education purposes. With a proper infrastructure to support collaboration with other projects, we expect to integrate FIBRE with other testbeds or testbed federations, more prominently the GENI and OFELIA testbed federations.

References

[1] L. Ciuffo, T. Salmito, J. Rezende, and I. Machado. Testbed fibre: Passado, presente e perspectivas. In *Anais do WPEIF 2016 Workshop de Pesquisa Experimental da Internet do Futuro*, pages 3–6, 2016.

[2] T. Rakotoarivelo, M. Ott, G. Jourjon, and I. Seskar. Omf: A control and management framework for networking testbeds. *SIGOPS Oper. Syst. Rev.*, 43(4):54–59, Jan. 2010.

[3] D. Stavropoulos, A. Dadoukis, T. Rakotoarivelo, M. Ott, T. Korakis, and L. Tassiulas. Design, architecture and implementation of a resource discovery, reservation and provisioning framework for testbeds. In *2015 13th International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt)*, 2015.