FUTURE INTERNET TESTBEDS EXPERIMENTATION BETWEEN BRAZIL AND EUROPE

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FIBRE-EU

Future Internet testbeds/experimentation between BRazil and Europe – EU

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D3.1 Use case analysis and requirements specification

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Dissemination Level		
PU	Public	✓
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Abstract

The purpose of this deliverable is to define the set of requirements of the FIBRE facility in Europe. This task will lead the further work in the WP3. In this document, a series of use cases which must be supported for some or all of the different European islands in the FIBRE facility (i2CAT, UEssex and UTH) are analysed. Use cases are obtained, on one hand from the Technological Pilots defined in the Description of Work (DoW) of the project, and, on the other hand, from needs identified in each island to provide better functionalities to the Future Internet (FI) research community. The analysis of these use cases will produce a requirements specification in terms of hardware, connections and features that should be provided by the different FIBRE control frameworks that will be used in each island.

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1 Acronyms

AM	Aggregate Manager
AP	Access Point
API	Application Programming Interface
BoD	Bandwidth on Demand
CF	Control Framework
CLI	Command Line Interface
CPqD	Brazil's Telecommunications Research and Development Centre
DoW	Document of Work
DWDM	Dense Wavelength Division Multiplexing
EOCF	Enhanced OFELIA Control Framework
EOMF	Enhanced NITOS Control Framework
EU	European Union
FI	Future Internet
FIBRE	Future Internet testbeds / experimentation between Brazil and Europe
FP7	Seventh Framework Programme
FPGA	Field-programmable Gate Array
Gbps	Gigabits per second
GENI	Global Environment for Network Innovations
GMPLS	Generalized Multi-Protocol Label Switching
HTTP	HyperText Transfer Protocol
ICT	Information and Communication Technologies
IM	Island Manager
LTE	3GPP Long Term Evolution
NITOS	Network Implementation Testbed using Open Source platforms
OCF	OFELIA Control Framework
OEDL	OMF Experiment Description Language
OF	OpenFlow
OFELIA	OpenFlow in Europe: Linking Infrastructure and Applications
OMF	cOntrol and Management Framework (NITOS CF)
OML	OMF Measurement Library
ORBIT	Open-Access Research Testbed for Next-Generation Wireless Networks
OS	Operating System
PHY	An abbreviation for the physical layer of the OSI model
QoS	Quality of Service
ROADM	Reconfigurable Optical Add-Drop Multiplexer
UI	User Interface
VM	Virtual Machine
WDM	Wavelength Division Multiplexing
Wi-Fi	Wireless Fidelity
WiMax	Worldwide Interoperability for Microwave Access
WP	Work Package

WP1	Project Management
WP2	Building and operating the Brazilian facility
WP3	Building and operating the European facility
WP4	Federation of facilities
WP5	Development of technology pilots and showcases
WP6	Dissemination and Collaboration

2 Scope

This document is the result of the task 3.1 of the WP3 of the FIBRE Project. Firstly, this document shows a detailed analysis of the new cases that have to be supported by the different islands (i2CAT, UEssex and UTH).

Secondly, this document shows a requirement specification based on the previous use cases. These requirements must be accomplished by the European implementation of the FIBRE project.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" used in the requirements definitions in this document are to be interpreted as described in RFC 2119 [Bradner 1997].

3 Reference Documents

[Bradner 1997] S. Bradner, "Key words for use in RFCs to Indicate Requirement Levels", RFC 2119, March 1997.
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[D2.1] "FIBRE Deliverable 2.1 Requirement analysis". To be available at "Deliverables" section in the FIBRE's Project Webpage.
http://www.fibre-ict.eu/, accessed on 26/01/2012

[Expedient] "Expedient: A Pluggable Centralized GENI Control Framework" web page at:
http://yuba.stanford.edu/~jnaous/expedient, accessed on 26/01/2012

[FIBRE] "FIBRE Description of Work" document, available under request to WP1.

[OFELIA] "OFELIA Description of Work" document

[OpenFlow] http://www.openflow.org/, accessed on 26/01/2012

[OMF] http://omf.mytestbed.net, accessed on 26/01/2012

[RedIris] http://www.rediris.es/, accessed on 26/01/2012

[Scheduler] http://nitlab.inf.uth.gr/NITlab/index.php/scheduler, accessed on 26/01/2012

4 Basis of FIBRE-EU: present Experimental Facilities description

There is an important fact which determines the work to be done in the FIBRE-EU facility: it is not being deployed from scratch. As described in the FIBRE's Description of Work (DoW) [FIBRE] of the project, the European Future Internet (FI) facility has the goal to extend, improve and federate already existent testbeds located at different partners' venues. For this reason it is convenient to first give a general overview of the starting point from where FIBRE project has begun.

At the same time, these extensions are different depending on the individual facility. For example, in the case of i2CAT and UEssex islands, the new infrastructures will be deployed following the OFELIA architecture [OFELIA], so that although considering specific constraints due to FIBRE related issues, many decisions are already taken and the know-how in the way to work is already obtained. The new two islands will be independent but federable following OFELIA's specifications.

On the other hand, there is NITOS testbed in UTH, which has adopted OMF [OMF] for its control and management functionalities, along with a set of custom tools, the most important of which being the NITOS Scheduler, which is the testbed's reservation and access control software. As explained in the DoW, the main extensions of NITOS within FIBRE in terms of hardware are two: first, the addition of OpenFlow-enabled switches [OpenFLow], which will be connected to its nodes forming a flexible wired experimental network, and second, the deployment of LTE base stations and associating client devices, which will allow for experimentation, including mesoscale wireless access.

4.1 OFELIA TESTBED DESCRIPTION

4.1.1 i2CAT island

Figure 1 shows the hardware resources available at the i2CAT island at Barcelona. The i2CAT FIBRE island will be located in the same premises than i2CAT OFELIA island. This will allow reusing and sharing resources between both testbeds. Although there will be a clear distinction between facilities, they will be managed separately, following different policies.

This infrastructure collocation will allow, depending on load and resources availability, to share resources between testbeds, but always keeping the service level that each facility must provide. The aim is to reach the maximum resources use while maintaining both testbeds differentiated.

Present i2CAT resources for OFELIA (the ones inside dark dashed boxes in Figure 1) consist of 5 NEC OpenFlow-enabled switches plus 5 servers. All components are connected to the rest of them in order to form a maximum physical topology that allows users to define any logical topology they want.

The i2CAT FIBRE testbed will be composed of several servers connected to OpenFlow-enabled switches and OpenFlow-enabled access points (shown in Figure 1 in clear dashed boxes). In addition, i2CAT island may deploy the, or one of the, European hub/s to connect the European FIBRE facility with the Brazilian one through its connection with RedIris [RedIris].

i2CAT island is also connected to the DWDM ring EXPERIMENTA optical network. This optical network is composed of 3 Wonesys Proteus ROADMs distributed through Barcelona, connected by about 60km of dark fibre.

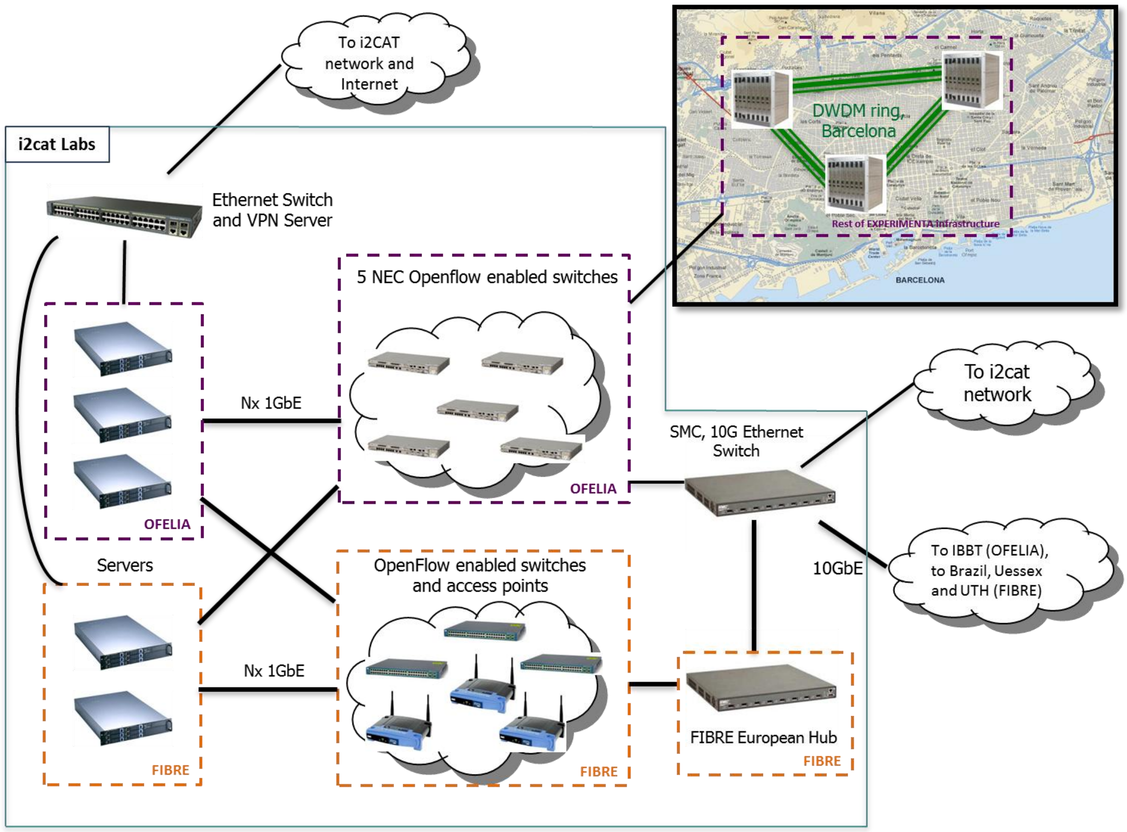

Figure 1 i2CAT OFELIA Testbed and FIBRE facilities

4.1.2 UEssex island

The available resources in UEssex are depicted in Figure 2. These resources are available for both the OFELIA and FIBRE projects, and are collocated in the High Performance Network group laboratory of University of Essex. In spite of this collocation, a clear separation of resources is indicated in Figure 2. Therefore, these resources are maintained and managed under (potentially) different policies. However, depending on the availability and load, it is possible to share some of the resources between two facilities (i.e., OFELIA and FIBRE facilities). This resource sharing will happen if there is no conflict of resource allocation between two facilities. This resource sharing mechanism, will pave the way to utilize some of the OFELIA resources in FIBRE experiments and vice-versa.

The infrastructure at UEssex includes OpenFlow-enabled devices (Ethernet switches [campus and carrier grade] and WDM switching equipment), OpenFlow controllers, Ultra-high-definition video streaming applications, 8K and 4K video contents, scientific applications, general purpose servers to host the technology pilot applications, network attached storage (10TB), multi-layer and multi-protocol traffic generator/analyser, 8K display/projector, 3D 4K display/projector, FPGA-based network processors (Virtex- 4 with 1GE interface), and fibre-switching equipment. During the FIBRE project the feasibility of extending the OpenFlow protocol to a sub-lambda (or multi-granular) switching platform will be investigated. UEssex's island is connected to GEANT and to Janet (dark fibre connectivity), which enables it to also play the role of the European hub of the FIBRE project.

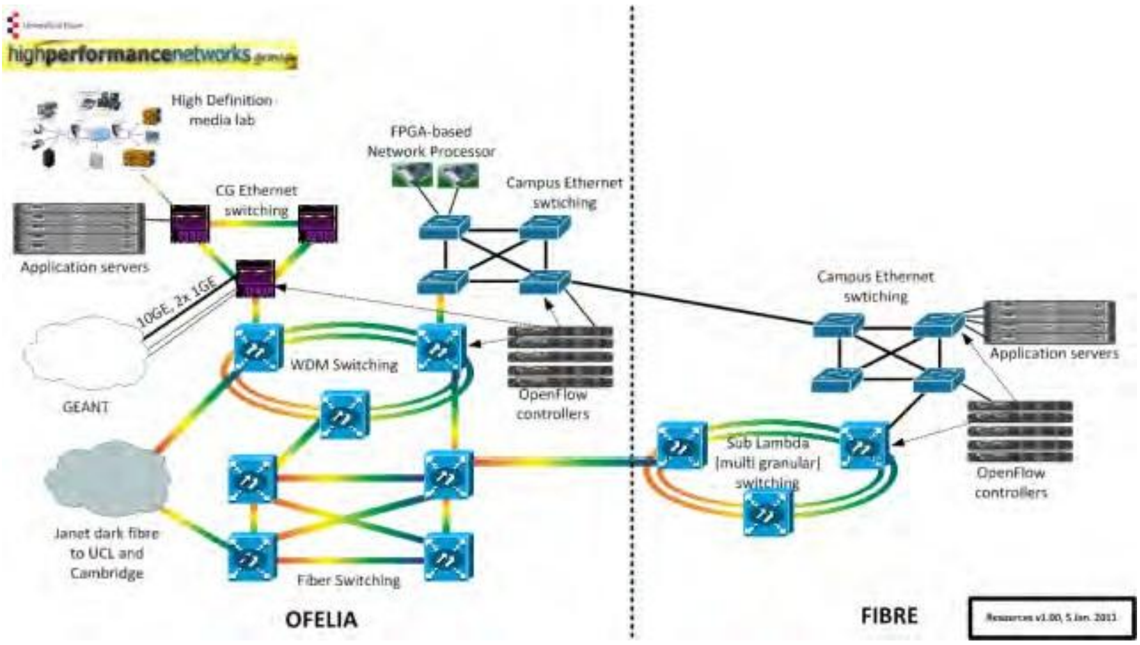

Figure 2: Available UEssex resources

4.1.3 OFELIA Control Framework (OCF)

The OFELIA Control Framework is a piece of software developed in the FP7 OFELIA project as result of the activities of its WP5. Its first development took as departure point and base the GENI's Expedient [Expedient] and Opt-in manager developed by Stanford University.

OCF was originally designed to manage the whole OFELIA facility, with the basic goal of being able to control the OpenFlow and the virtualization equipment available in the basic OFELIA islands, both from the Island Manager's (IM) side to configure and manage the resources, and the researcher's side, to deploy his/her experiments. Nevertheless, its capabilities were increased after the first versions and it is constantly being updated. At the moment it is also available to the public as open software.

FIBRE takes the last version of OCF and will extend it with all the new features identified as FIBRE's requirements, contributing this way to make an enhanced OCF (EOCF), a better and more complete tool to manage FI testbeds.

4.2 NITOS TESTBED DESCRIPTION

4.2.1 UTH's NITOS Testbed

NITOS testbed is designed to achieve reproducibility of experimentation, while also supporting evaluation of protocols and applications in real world environment. It is deployed at the exterior of a University of Thessaly (UTH) campus building, on the two top floors and the rooftop. In the Figure 3 you can see the topology of the testbed.

Figure 3: NITOS testbed

NITOS consists of 50 nodes, equipped with commercial Wi-Fi cards, which are based on Atheros chipsets and support open source Linux drivers. Through this setup, a researcher can modify the MAC and the network layer of the nodes, as well as develop cross-layer protocols. Each node is equipped with two Wi-Fi interfaces. Ten of them are equipped with MIMO (802.11n compatible) Wi-Fi interfaces and also feature USRP (Universal Software Radio Peripheral) boards, which allow for modifications of PHY layer and low level MAC layer functionalities. USB cameras and temperature/humidity sensors attached to several nodes are also among NITOS equipment.

During FIBRE, the testbed will be extended with two OpenFlow switches and an LTE component consisting of base stations, LTE interfaces for the existing nodes and mobile client LTE-enabled devices.

NITOS is already a publicly available testbed, where the reservation of resources takes place via a custom tool called NITOS Scheduler [Scheduler]. This tool also takes care of resource access control and frequency slicing. The testbed has adopted the OMF framework for its control and management functionalities.

4.2.2 OMF

The cOntrol and Management Framework (OMF) for networking facilities, and its companion measurement library, OML, provide a set of methods and tools for experimenters to describe and instrument an experiment, execute it and collect its results. From the facility operator's point of view, OMF provides a set of services to efficiently manage and operate the facility resources (e.g. resetting nodes, retrieving their status information, installing new OS images). This facility control framework manages over 20 facilities in Europe (including NITOS), six WiMAX mesoscale deployments in the US and the ORBIT facility at Rutgers University, for which OMF was originally developed in 2003.

The OMF experiment and resource controllers are free open source tools that execute scripts written in the OMF Experiment Description Language (OEDL) and have been ported to other control frameworks, such as Emulab and PlanetLab.

FIBRE takes OMF and will provide it with new features to accomplish the requirements presented in this document creating an enhanced NITOS CF (EOMF).

5 Use Cases

Use cases provide a description of the possible sequences of interactions between the system under discussion and its external actors, related to a particular goal. In other words use cases describe the behaviour of the system under discussion and thus may be used for defining functional requirements. Non-functional requirements are not addressed by use cases. Furthermore, technical details are not covered by use cases.

The use cases presented in this document are those that imply new features over the existing use cases already supported by the OFELIA islands in i2CAT and UEssex and NITOS testbed in UTH's venue, together with the respective control frameworks, OCF and OMF, and other management tools.

We classify the use cases in the following categories:

- Federation, including federation with the Brazilian facility and joint experimentation between European and Brazilian researchers, and federation between European facilities in order to conform a joined FIBRE facility.
- New features for researchers using the facility.
- New features for island managers.
- Technology Pilots.

Use cases provide a description of the possible sequences of interactions between the system under discussion and its external actors, related to the particular goal. Although this definition does not specify the format of a use case, a template is defined in this document to increase the readability of a use case.

The template contains the following fields:

Use Case ID: Unique identifier for the use case. It has the format UC XXYY, where XX can be FE, RE, IM or TP depending on the category of the use case (FEderation, REsearchers, Island Manager or Technology Pilots) and YY is a sequential number.

Name: Name for the use case

Actors: An actor specifies a role played by a user or any other subject that interacts with the system. It may be a person, a group of people, a computer system, a company, or a point in time. In FIBRE we use the term actor to denote one of the following:

- Experimenter: also known as Researcher. The person who uses FIBRE to run experiments. It is a person from outside the FIBRE project. Its purposes are running and interact with experiments and get data from them.
- Island Manager: the person responsible of the correct operation of the island and its resources. It is a person inside the FIBRE project. He can manage and configure the resources of the island and its connectivity (Administrator).

- Control Framework (CF): A part of the FIBRE system focused on a concrete island. It is treated as an independent actor because each island CF will have its own characteristics although they are part of the same FIBRE system. FIBRE will use enhanced CFs based on OFELIA Control Framework (OCF) in i2CAT and UEssex's facilities and cOntrol and Management Framework (OMF) for NITOS testbed at UTH's venue, these new CFs will be called **EOCF** and **EOMF** (E is for enhanced) respectively. If a use case implies only one of the CFs, it will be specified which one.

It must be specified which actor is the initiator of the use case.

Purpose: Purpose of the use case.

Part of: If the use case is a subtask of one or more generic use cases, here is specified which one it is.

Summary: A short description of the use case.

Preconditions: Conditions that must be true in order to execute a given use case. The precondition is written as a simple assertion about the state of the world at the moment the use case opens.

Course of events: Detailed description of the interaction between actors and system step by step. It is a sequence of steps performed by actors outlined with numbers for better readability. A use case usually describes more than one scenario. Other scenarios are described in the *Alternative course* section. It works like the human natural cognitive ability, starting from a simple case and adding complexity at later stages.

Alternative course: Describes exceptions to the usual course.

Postconditions: Conditions that must be true after execute a given use case. The postcondition is written as a simple assertion about the state of the world after the use case has finished.

Figures: If any support figure is needed to illustrate the use case.

5.1 New features for researchers

5.1.1 Experiment realization using Wi-Fi access points

Use Case ID: UC RE01

Name: Experiment realization using FIBRE Wi-Fi access points in i2CAT island.

Actors: Experimenter (initiator), EOCF

Purpose: The experimenter creates and performs an experiment in which Wi-Fi access points are used.

Summary: An experimenter wants to perform an experiment using Wi-Fi access points at the i2CAT island.

Preconditions:

- Experimenter is registered in the FIBRE facility and is member of an existing project.
- i2CAT island has Wi-Fi access points available for experiments.
- Wi-Fi APs must be OpenFlow enabled and be incorporated in the infrastructure.

Course of events:

1- Experimenter logs into the FIBRE/i2CAT island portal or access through a CLI.
2- Experimenter accesses or creates his project.
3- As owner of the project may add other users to it.
4- The user is able to see the resources available in the testbed and how they are connected so he can select those he needs.
   a. Resources in i2CAT island include Wi-Fi access points.
   b. Experimenter adds Wi-Fi APs as part of his experiment.
   c. User's request is examined by a Policy Manager considering local (island) set of policies.
5- EOCF approves Experimenter's request and creates an isolated slice with the resources solicited.
6- Experimenter starts and conducts his experiment.
7- Experimenter closes experiment when it is finished and releases resources.

Alternative course:

4- If the Experimenter's request does not match island's policies, slice is not created. User is informed about the deny of resources request and he is able to modify his request.

Postconditions:

- An experiment is performed in which reserved resources include Wi-Fi access points.

5.1.2 Experiment monitoring

Use Case ID: UC RE02

Name: Experiment monitoring.

Actors: Experimenter (initiator), Island CF (EOCF or EOMF).

Purpose: The experimenter monitors experiment parameters.

Summary: An experimenter wants to monitor several parameters of the resources of the experiment that is running.

Preconditions:

- Experimenter has a project with an FIBRE experiment defined.

Course of events:

1- Experimenter starts experiment.
2- Island CF reads experiment's variables in several resources:
   a. QoS parameters (bandwidth, delay, losses,..)

   b. Traffic descriptors (peak rate, average source rate, ..)
   c. QoE
   d. VMs status (memory, CPU use, etc.)
3- Island CF stores data in database for later consulting.
4- Island CF shows data in real time to Experimenter.

Postconditions:

- Experiment data is stored in a database and available for consulting.

5.1.3 Experimentation with LTE/3G at UTH island

Use case ID: UC RE03

Name: Experimentation with LTE/3G at UTH island.

Actors: Experimenter (initiator), EOMF.

Purpose: The experimenter setups and conducts an experiment at the UTH island using LTE/3G equipment.

Summary: An experimenter is interested in performing an experiment involving LTE and/or 3G femtocell at the UTH island. He reserves relevant resources including one or more base stations and LTE/3G enabled client devices. He runs the experiment and gathers the results.

Preconditions:

- Experimenter is registered in the FIBRE facility.
- UTH have deployed LTE base stations, 3G femtocell base stations and LTE/3G enabled client devices (fixed nodes and/or mobile handsets) and have made them available to the public for experimentation.

Course of events:

1. Experimenter logs into the UTH island portal.
2. Experimenter checks the availability of the resources he is interested in and reserves them for a given time interval.
   a. LTE/3G resources must appear and must be reservable through the relevant tool (NITOS Scheduler).
3. Experimenter connects to the testbed when his reservation time interval begins and is granted access to his booked resources.
4. Experimenter setups his resources according to the experiment needs (e.g. loads software images, configures base station).
5. Experimenter conducts his experiment.
6. Experimenter accesses measurements recorded/gathered during the experiment in order to evaluate its outcome.
   a. LTE/3G devices (both base stations and clients) must support generation of measurements and collection into a testbed server.
7. Experimenter closes experiment when it is finished and releases resources.

Postconditions:

- An experiment involving LTE/3G technology has been performed at the UTH island.

5.1.4 Simultaneous use of the UTH island's mesoscale base stations by multiple users

Use case ID: UC RE04

Name: Simultaneous use of the NITOS mesoscale base stations by multiple users.

Actors: Experimenters (initiators), EOMF.

Purpose: Multiple experimenters can access mesoscale (LTE/3G femtocell) base stations of NITOS simultaneously.

Summary: Multiple experimenters are able to use the NITOS mesoscale Base Stations simultaneously, without interfering.

Preconditions:

- LTE/3G femtocell base stations have been deployed at the UTH island.
- The experimenters are registered in the FIBRE facility.
- The experimenters wish to run an experiment which includes one or more base stations of NITOS.
- Different experimenters wish to run their experiments during partially or fully overlapping time intervals.

Course of events:

1. Experimenter logs into the NITOS island portal.
2. Experimenter checks the availability of island resources over time.
3. Experimenter sees one or more base stations among the available resources, even though other experimenters might have reserved them for part of the requested time interval.
    a. The availability may possibly be subject to a limited maximum throughput guarantee per base station.
4. Experimenter reserves the base station(s) for the selected time interval.
5. Experimenter connects to the testbed during the reserved time interval and is granted access to the reserved resources, including the base station(s).
6. Experimenter runs the experiment without interfering with other users accessing the base station during the same interval.
7. Experimenter closes experiment when it is finished and releases resources.

Postconditions:

- Multiple experimenters have conducted their experiments successfully and without cross-interference, even though they accessed one or more base stations simultaneously.

5.1.5 Combination of wireless nodes and OpenFlow switches in a single experiment at the UTH island

Use case ID: UC RE05

Name: Combination of wireless nodes and OpenFlow switches in a single experiment at the UTH island.

Actors: Experimenter (initiator), EOMF

Purpose: Successful performance of a combined experiment at the UTH island, involving both wireless non-OpenFlow nodes and OpenFlow switching equipment, through a simple user-friendly procedure.

Summary: An experimenter can setup and run an experiment combining OpenFlow equipment with wireless nodes using a simple and easy-to-use framework. Both types of resources will be available at the UTH island.

Preconditions:

- OpenFlow switches have been deployed at NITOS and the wireless nodes are connected to them physically.
- The OpenFlow control framework and the EOMF control and management framework have been federated and allow for combined experiments.

Course of events:

1. Experimenter logs into the NITOS island portal.
2. Experimenter reserves a time interval for the experiment and also a number of OpenFlow and non-OpenFlow resources, through the EOMF.
    a. The OpenFlow equipment will be available for reservation using the Scheduler.
3. Experimenter connects to the testbed when the time interval for the experiment begins.
4. Experimenter is granted access to the OpenFlow switching equipment reserved and configures the OpenFlow resources in his slice according to his needs. Experimenter can also access and configure the wireless resources in his slice.
5. Experimenter performs his experiment.
6. Experimenter closes experiment when it is finished and releases resources.

Postconditions:

- An experiment involving both OpenFlow switches and non-OpenFlow wireless nodes has been performed at the UTH island.

5.1.6 Provision of link quality and wireless environment information

Use Case ID: UC RE06

Name: Provision of link quality and wireless environment information.

Actors: Experimenter (initiator), Island CF.

Purpose: Experimenter is provided with information regarding the quality of the wireless links and other information relative to the wireless environment (contention level, interference, etc.) of an island featuring wireless resources.

Summary: An experimenter wants to decide which wireless resources of the island are best suited for the purposes of his planned experiment. He is provided with a set of information regarding link quality and other wireless environment parameters, which guide him to make a good selection of resources.

Preconditions:

- Link quality and other wireless environment statistical data are available via the island's portal.
- An experimenter wishes to run an experiment involving wireless resources, but is not familiar with the topology and wireless environment of the island nor the status of its links.

Course of Events:

1. An experimenter visits the island portal and accesses the link quality and environment monitoring webpage.
2. He is provided with a map of the testbed's topology and selects links, in order to see statistical data (mean & variance at different days of the week/hours) of their quality. Additional statistical data of interest, such as contention level, are also available.
3. Based on the information provided, the experimenter selects the particular resources (nodes, frequencies) and time intervals that best fit the needs of his experiment.
4. The experimenter, who is already registered in the island, reserves the resources he is interested in for an available time interval.

Alternative course:

4. The experimenter, who has identified a set of resources and a topology that suit his needs, registers in the island.
5. The experimenter logs into the island portal and reserves the resources he is interested in.

Postconditions:

- The experimenter has reserved resources and has chosen the time interval, if required, for his experiment based on statistical information about the wireless environment provided by the system.

5.1.7 Experiment realization using optical devices in i2CAT island

Use Case ID: UC RE07

Name: Experiment realization using optical devices in i2CAT island.

Actors: Experimenter (initiator), EOCF

Purpose: The experimenter setups and conducts an experiment at the i2CAT island using ROADMs optical devices of the EXPERIMENTA optical ring.

Summary: An experimenter is interested in performing an experiment involving optical devices from the EXPERIMENTA network connected to the i2CAT island. He reserves resources through the EOCF. He runs the experiment and gathers the results.

Preconditions:

- Experimenter is registered in the FIBRE facility.
- i2CAT FIBRE island is connected to the EXPERIMENTA optical network.
- EOCF can manage the Wonesys Proteus devices from the EXPERIMENTA optical network.

Course of events:

1. Experimenter logs into the i2CAT island portal or access through a CLI.
2. Experimenter accesses or creates his project.
3. As owner of the project may add other users to it.
4. Experimenter checks the availability in the testbed of the resources he is interested in and how they are connected so he can select those he needs.
    a. EXPERIMENTA's Wonesys Proteus devices must appear and must be reservable through the EOCF
    b. Experimenter adds optical devices as part of his experiment.
    c. User's request is examined by a Policy Manager considering local (island) set of policies
5. EOCF approves experimenter's request and creates an isolated slice with the resources solicited.
6. Experimenter starts and conducts his experiment.
7. Experimenter closes experiment when it is finished and releases resources.

Alternative course:

4- If the Experimenter's request does not match island's policies, slice is not created. User is informed about the deny of resources request and he is able to modify his request.

Postconditions:

- An experiment is performed in which reserved resources include EXPERIMENTA Wonesys Proteus devices.

5.1.8 Reproducibility of an experiment previously performed in a different island

Use case ID: UC RE08

Name: Reproducibility of an experiment previously performed in different island.

Actors: Experimenter, Island CF (EOCF or EOMF).

Purpose: Ability of an experimenter to verify an algorithm or prototype he wants to test through experimentation in two very similar but different testing environments involving any type of resources (wireless, optical, etc.).

Summary: An experimenter performs an experiment in an island. A similar test environment is available in another island and the experimenter wants to verify his results by reproducing the same experiment in the second island.

Preconditions:

- The experimenter has designed and described an experiment and wishes to evaluate the results in two different islands.
- There are (at least) two similar test environments and topologies, on different islands.

Course of events:

1. The experimenter accesses an island.
2. The experimenter selects an appropriate set of resources for his experiment, based on monitoring data available from the island's interface.
3. The experimenter runs the experiment, which is well-defined, based on an experiment description script.
4. The experimenter collects the results/measurements gathered during the experiment, which are somehow stored.
5. The experimenter accesses a different island, which features resources of the same type as those used in the experiment at the first island.
6. The experimenter selects an appropriate set of resources in the second island, based on monitoring data, and detects a priori differences between the environments of both islands.
7. The experimenter runs the experiment in the second island, using the same experiment description
8. The experimenter collects the results from the conduction of the experiment in the second island.
9. The experimenter manually compares the results from the two experiments, taking into account potential differences in the experimental environments. Relevant conclusions are drawn (e.g. verification of the performance of an algorithm, claim of robustness, etc.)
10. Experimenter closes experiment when it is finished and releases resources.

Postconditions:

- The experimenter has successfully conducted an experiment in two different islands, whose resources include subsets of the same type.
- Valuable conclusions are drawn, e.g. the effect of different environments in the performance of an algorithm.

5.2 New features for Island Managers

5.2.1 Island Policies Management

Use Case ID: UC IM01

Name: Island policies Management

Actors: Island Manager (initiator), Island CF (EOCF or EOMF)

Purpose: the Island Manager manages the usage policies of the island

Summary: Island Manager can add, activate or deactivate, delete or edit policy rules for usage of the resources of the island. The policies are used by the CF to evaluate Experimenter's requests.

Course of events:

1- Island Manager accesses to the Policy Manager page of the island CF portal or through the CLI or others interfaces.
2- Island CF shows a list of existing rules.
3- Island Manager can add new rules or delete, edit, activate or deactivate existing ones.
4- For each resource of the island, Island Manager can define its rules.
   a. Policies are based in conditions over the requests of resources that must be accomplished.
   b. Island Manager can only define policies for resources of the island he manages but can define policies about requests coming from other islands.
5- Island CF will automatically apply island policies to all Experimenter's requests for resources of the island.

5.2.1.1 Add Policy Rule

Use Case ID: UC IM02

Name: Add policy rule.

Actors: Island Manager (initiator), Island CF (EOCF or EOMF).

Purpose: the Island Manager adds a policy rule to the island.

Part of: UC IM01

Summary: Island Manager wants to create a policy rule for the island. Definition of rule allows specifying the conditions, description, message and type of rule.

Course of events:

1- Island Manager accesses to the Policy Manager page of the island CF portal or through the CLI.
2- Island CF shows a list of existing rules.
3- Island Manager selects a new rule.
4- Island CF shows rule definition page.
5- Island Manager creates and specifies rule:

a. Provides conditions to be accomplished by Experimenter's requests.
b. Provides description of the rule.
c. Provides a message to be shown to the Experimenters if his request makes the rule to fail.
d. Provides the type of rule.
e. Activates or deactivates the rule.

6- New rule is added to the list of existing rules.

Postconditions:

- A new policy rule is defined in the island.

5.2.1.2 Remove Policy Rule

Use Case ID: UC IM03

Name: Remove policy rule.

Actors: Island Manager (initiator), Island CF (EOCF or EOMF).

Purpose: the Island Manager removes a policy rule from the island.

Part of: UC IM01

Summary: Island Manager wants to remove a policy rule for the island so it is not available to be applied.

Preconditions:

- A policy rule exists.

Course of events:

1- Island Manager accesses to the Policy management page of the island CF or through the CLI.
2- Island CF shows a list of existing rules.
3- Island Manager selects rule to be removed.
4- Island CF removes rule from the rules list.

Postconditions:

- The policy rule is no longer available to be applied in the island.

5.2.2 Monitoring of Island resources

Use Case ID: UC IM04

Name: Monitoring of Island resources.

Actors: Island Manager (initiator), Island CF (EOCF or EOMF).

Purpose: the Island Manager monitors the resources of the island.

Summary: the Island Manager wants to know the status of the resources of the island.

Preconditions:

- Software services dedicated to the monitoring of resource status have been developed and integrated into the CF of the island.

Course of events:

1- Island Manager consults the status of the resources of the island.
2- Island CF checks status of the resources of the island.
   a. For each resource, CF checks if it is working ok, reservations for experiments, level of usage, time intervals reserved, main parameters, etc.
3- Island CF presents data to the Island Manager.
4- If any resource is not working properly, the Island Manager can take actions to solve the problem.

Alternative course:

1. Island Manager can consult the status of the resources of a single experiment.

5.2.3 Monitoring of island link-level and testbed-level properties

Use Case ID: UC IM05

Name: Monitoring of island link-level and testbed-level resources status.

Actors: Island Manager (Initiator), Island CF (EOCF or EOMF).

Purpose: The island manager monitors link-level and testbed-level properties of his testbed, so as to provide this information to the experimenters.

Summary: The island manager, through appropriate hardware and software tools, monitors link-level and testbed-level properties of its testbed.

Preconditions:

- Link-level and testbed-level hardware and software tools have been deployed in the island

Course of events:

1. Island manager consults the system to obtain statistical data (or live data, depending on the capabilities) related to link-level and/or testbed-level properties (e.g. wireless link quality).

2. Island CF, which is capable of collecting associated data (either on demand or continuously by running as a daemon), returns the requested information.

Postconditions:

- The island manager has a statistical dataset with link-level and testbed-level information and can convey this data to the experimenters.

5.3 Federation with the Brazilian facility

This section covers basic high-level use cases that must be supported in the federated EU-Brazil experimental facility. A more in depth analysis of federation-related use cases and requirements will take place in Task 4.1 (Analysis of the Federation requirements) and the results of this analysis will be reported in detail in D4.1.

5.3.1 Conduction of an experiment involving resources from several islands in Europe

Use Case ID: UC FE01

Name: Conduction of an experiment involving resources from several islands in Europe.

Actors: Experimenter (initiator), Island CF (EOCF or EOMF).

Purpose: The Experimenter wants to create and perform an experiment involving resources from several islands in Europe.

Summary: The Experimenter creates an experiment, requests resources from several islands apart from the one he is connected to, performs the experiment using these resources.

Preconditions:

- Island is federated with other FIBRE islands in Europe.
- Experimenter is registered in one island in Europe.

Course of events:

1- Experimenter logs into the island portal he is registered or accesses through a CLI.
2- Experimenter accesses or creates his project.
3- Experimenter adds resources to the project.
   a. Island CF shows a list of resources in the island and in the other federated islands in Europe.
   b. Experimenter can add aggregates from other islands.
   c. Resources can belong to different islands in Europe.
4- Island CF evaluates Experimenter's requests.
   a. Evaluation is based in policies defined by the Island Manager of each island.
5- Island CF approves Experimenter's request and creates slice with the resources required.
6- Experimenter starts and conducts his experiment.

Alternative course:

4- If the Experimenter's request does not match island's policies, slice is not created. User is informed about the deny of resources request and he is able to modify his request.

Postconditions:

- An experiment is performed in which reserved resources belong to several islands in Europe.

5.3.2 Conduction of an experiment involving both European and Brazilian physical resources

Use Case ID: UC FE02

Name: Conduction of an experiment involving both European and Brazilian physical resources.

Actors: Experimenter, Island CF (EOCF or EOMF).

Purpose: An experimenter is able to perform an experiment involving resources from both European and Brazilian islands.

Summary: The Experimenter creates an experiment, requests resources from several islands both in Europe and Brazil apart from the one he is connected to, performs the experiment using these resources.

Preconditions:

- The European and Brazilian islands are physically interconnected.
- The islands are functionally federated (including all the experiment lifecycle components).

Course of Events:

1- Experimenter logs into the island portal he is registered or access through a CLI.
2- Experimenter access or creates his project.
3- Experimenter adds resources to the project.
   a. Island CF shows a list of aggregates in the island and in the other federated islands including islands from Europe and Brazil.
   b. Experimenter can add aggregates from other islands.
   c. Resources can belong to different islands as they belong to aggregates from other islands.
4- Island CF evaluates Experimenter's requests.
   a. Evaluation is based in policies defined by the Island Manager of each island.
5- Island CF approves Experimenter's request and creates slice with the resources solicited.
6- Experimenter starts and conducts his experiment.

Postconditions:

- An experiment is performed in which reserved resources belong to several islands in Europe and Brazil.

5.4 Technology Pilots

Three technology pilots will be implemented during FIBRE to showcase advance usage scenarios for the FIBRE federated testbed infrastructure. The first pilot is related to wireless networks and seamless mobility with horizontal and vertical handoffs. It is planned to take place in Brazil [D2.1], however UTH, in the European side, will aid in the development of this pilot, by testing some of the envisioned functionalities in its wireless testbed (at a smaller scale). The second and third pilots come from the world of high-speed optical communications and their interaction with OpenFlow switching equipment. They investigate efficient distribution of high-definition content to clients and bandwidth on demand services respectively. UEssex will collaborate with FIBRE partners from Brazil to design and implement these pilots.

5.4.1 Seamless Mobility for Educational Laptops

Use Case ID: UC TP01

Name: Seamless Mobility for Educational Laptops

Organization Involved: UTH

Actors: Experimenter (initiator), Island CF

Purpose: To analyse and utilize the capabilities of programmable wireless networks to augment the seamless handoffs experience on networks formed by mobile users (large quantities of students using low-cost wireless laptops). In particular, to exploit programmability to perform multipath communication and address independence to support various levels of mobility. Moreover, to study, deploy and extend a control and monitoring framework (possibly OMF) to share such large scale distributed mobile network to be used by various network/wireless researchers, including topics such as DTN, social networks, handoffs and ad-hoc routing.

Summary: The recent deployment of 150k educational laptops in 500 Brazilian schools as a pilot for a larger, 56 million host networks covering all children attending public schools in Brazil, created a rich environment of homogeneous, mesh capable, mobile hosts under a single administration. This research intends to leverage this scenario, offering the infrastructure for shared network experimentation. The central purpose is to provide for its users as much as possible a seamless experience on network connectivity, improving this mobile, cooperative network. The ways for doing this is improving mesh models, enhancing handoff latency, using multiple network interfaces and adding support for disconnected operation.

Course of events:

UTH will participate in the design activities and the preparation for this pilot, although the final implementation and showcasing will take place in Brazil. In particular, UTH will:

- test horizontal handoff mechanisms and their performance, using the fixed wireless nodes of NITOS in conjunction with mobile Wi-Fi-enabled devices (laptops, tablets or smartphones).

- test vertical handoff mechanisms, using an LTE base station, several fixed Wi-Fi nodes configured as access-points and mobile devices featuring both an LTE and a Wi-Fi interface.
- test the OMF-OML disconnected experiments functionality, its applicability for DTN scenarios and potential challenges in setting up such experiments.
- work towards the non-intrusive incorporation of OML measurement points in measurement/monitoring software running on client devices of the pilot.
- Investigate interplays between OpenFlow switches and wireless access points related both to the pilot implementation and to the virtualization of the pilot infrastructure.

Figures:

Figure 4 illustrates how students could benefit from seamless mobility by getting access from different places even while moving.

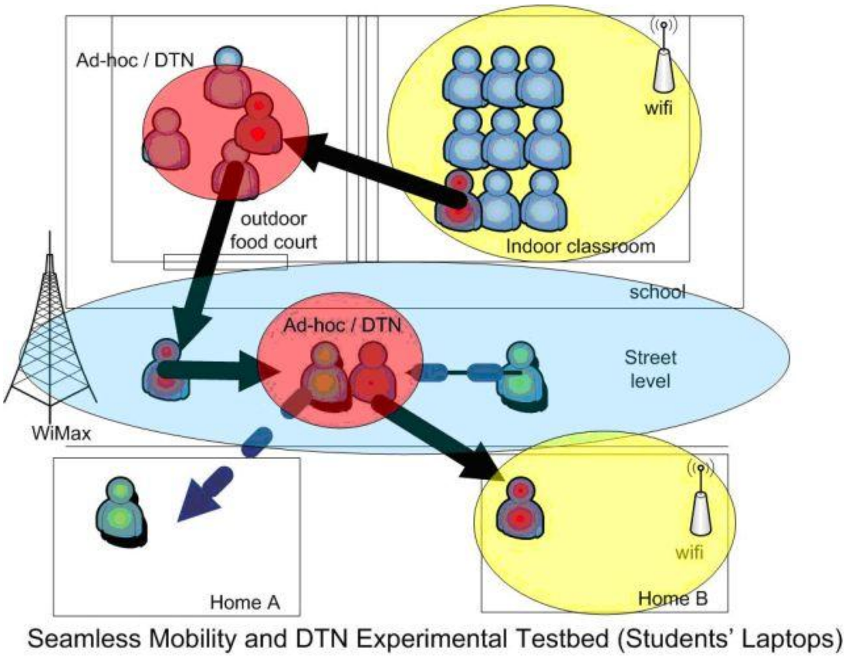

Figure 4 : Seamless mobility test-bed

5.4.2 High definition content delivery across different sites

Use Case ID: UC TP02

Name: High definition content delivery across different sites.

Organization Involved: UEssex.

Actors: Experimenter (initiator), Island CF.

Purpose: 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.

Summary: The content delivery servers in a content delivery network (CDN) can interface to a custom OpenFlow-based application (i.e., NOX application) 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.

Preconditions:

- Individualized operating environment & profile
- The OpenFlow enabled network infrastructure in UK and Brazil site
- The High Definition/High Quality media streaming client/server (codec)
- Content Delivery Servers
- One OpenFlow controller (e.g. NOX)
- NOX application with capability to monitor content delivery servers

Course of events:

In this setup the UK site is responsible for delivering high quality video (e.g., 4K streaming) and the site in Brazil receives a copy of the content (cache). The "Intelligent Content Delivery Server" is OpenFlow enabled and can be considered as a NOX application (assuming that equipment in both sites is OpenFlow enabled). The typical content delivery systems usually re-direct the clients to the (cache) content, which is closer to them. Therefore, for instance during the Olympic Games 2012 (or World CUP 2014), the clients in UK (or even Europe) will be served by the UK site. Now assume that the load on this content delivery server is exceeding a threshold. Using OpenFlow, the content delivery server can re-route some of the clients to another (less crowded, but not necessarily closer) content delivery server (e.g., Brazil site).

Assuming that the NOX application has the network view and also the status of the content delivery servers (monitoring) and assuming that network equipment is OpenFlow enabled, some rule sets on the monitoring component can be defined to trigger the NOX application for user re-routing. In fact, some of the users will be migrated from the current site to the less-'Loaded' sites. This requires close collaboration and interfacing of NOX and monitoring applications. Various performance metrics can be considered on the content delivery side.

NOX application is monitoring the utilization of the servers (and possibly of links, or even energy consumption). So depending on the criteria of interest (load balancing, energy savings, cheaper electricity bills, QoS, failures) NOX application will take the decision and trigger the appropriate actions.

Monitoring:

- NOX application is monitoring the utilization of the servers
- Content Server load
- Delay
- Energy Consumption

Postconditions:

- Based on the traffic load server clients from the UK will be rerouted to Brazil server

Figures:

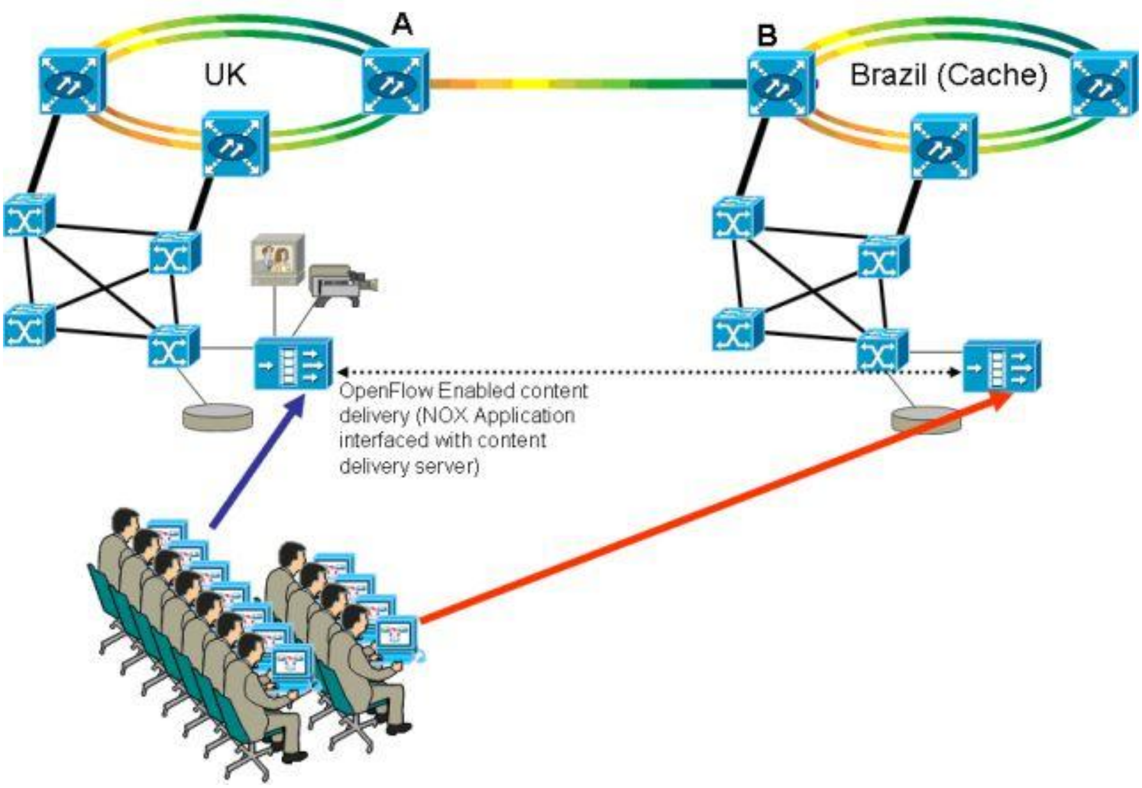

Figure 5 : High-definition content delivery

5.4.3 Bandwidth on Demand through OpenFlow GMPLS in the FIBRE facility

Use Case ID: UC TP03

Name: Bandwidth on Demand through OpenFlow GMPLS in the FIBRE facility

Organization Involved: UEssex

Actors: Experimenter (starter), Island CF

Purpose:

This use-case leverages on the flexibility of the OpenFlow, FlowVisor and GMPLS protocols to implement an open and generalized bandwidth on demand (BoD) service for OpenFlow controllers on virtualized networks.

Summary:

The OpenFlow protocol and the NOX control platform allow to generalize the control of the switching resources of a network node and to implement a flow processing paradigm in the traffic switching. Moreover, the FlowVisor controller allows creating slices of network resources and delegates control of each slice to a different controller. These features may be merged with the effectiveness of GMPLS signalling and routing protocols (e.g. RSVP-TE and OSPF-TE) in the distributed set-up and operation of on-demand network connectivity services.

The UNI interface will act as service access point for the user, willing to deploy dynamic flow reservations across OpenFlow MPLS regions and OpenFlow-enabled optical layer (ref. figure 6).

The GMPLS control plane entities will route and signal the network connectivity services, and in each OpenFlow GMPLS controller the proper flow table configurations will be set up to implement the required switching actions.

Preconditions:

- The OpenFlow enabled network infrastructure in UK and Brazil site, including optical and MPLS switching hardware
- The OSS GMPLS stack developed by the PHOSPHORUS project
- A high-bandwidth application (e.g. streaming as per Pilot 2)
- At least 3 OpenFlow-enabled (or open firmware) ROADMs per islands, with one island in Essex and one island in CPqD
- At least 3 OpenFlow MPLS per island
- One OpenFlow controller (e.g. NOX)

Course of events:

The endpoints of the setup i.e. servers running bandwidth on demand applications will request for the appropriate bandwidth. The OpenFlow controller along with GMPLS stack will not only identify the suitable path for the request but also configure the device in the path to satisfy the request.

Identified 2 approaches for the use case:

OpenFlow overlay on GMPLS/MPLS as described in Figure 6

GMPLS Overlay on OpenFlow as described in Figure 7

Monitoring: Network Monitoring: Bandwidth, Delay

Security: Testbed authenticated users

Figures:

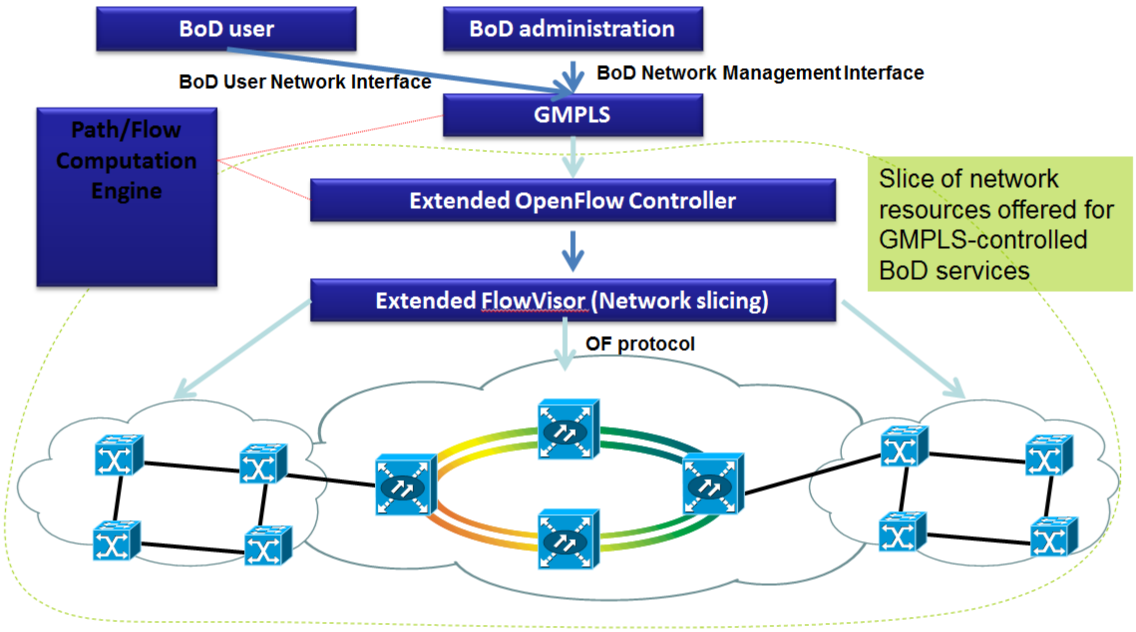

Figure 6 : GMPLS OpenFlow Integration Approach 1 (GMPLS Overlay)

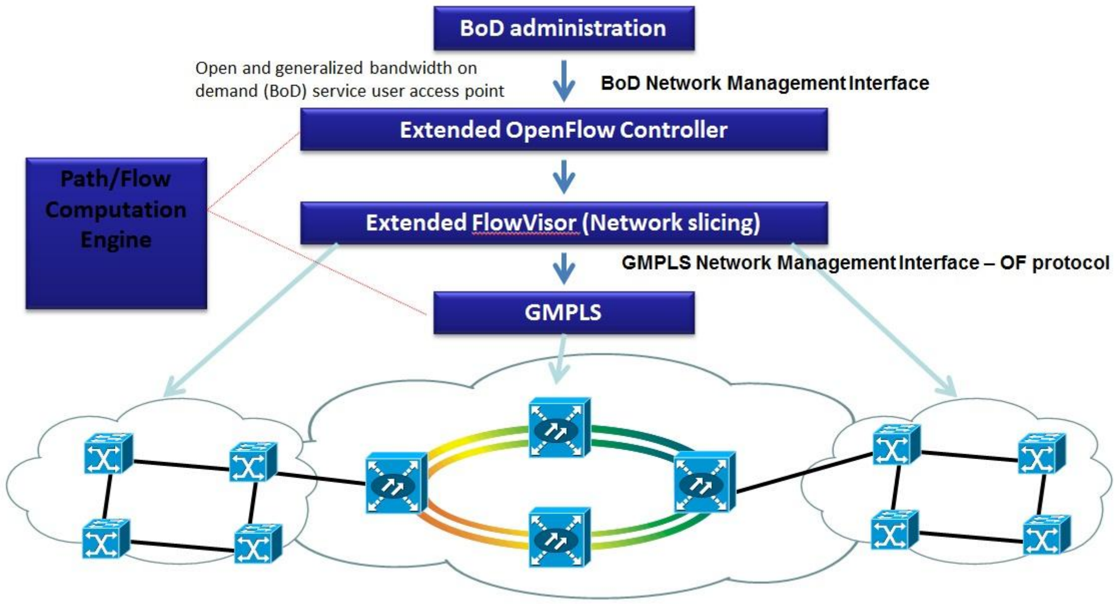

Figure 7: GMPLS OpenFlow Integration Approach 2 (OF overlay)

6 Requirements

The requirements are classified into the following categories:

- Users requirements
- Pilot requirements
- Architectural requirements
- Experiment requirements
- Instrumentation and Measurements requirements
- Infrastructure requirements

The requirement template contains the following fields:

Requirement ID: Unique identifier of the requirement. It has the format Req XXYY, where XX can be US, PI, AR, EX, IM or IF depending on the category of the requirements and YY is a sequential number.

Applied to: Each requirement has specified which of the FIBRE-EU islands (i2CAT, UEssex, UTH or all of them) is applied to.

Description: Short description of the requirement

Type: Functional/Non-Functional

Functional requirements are requirements relevant to technological capability and functionality that the system has to accomplish.

Non-functional requirements describe characteristics of the system that the user cannot affect or (immediately) perceive. They define the performance expectation and quality of service of the system. They are also known as quality requirements.

Additional note: Any observation needed.

6.1 Users requirements

6.1.1 Facility access

Requirement ID: Req US01

Applied to: all

Description: Users will be assigned to an island. Nevertheless, they MUST be able to access to any island of the facility with the same credentials.

Type: Functional

6.1.2 Resource allocation

Requirement ID: Req US02

Applied to: all

Description: FIBRE-EU MAY implement a system to grant resources to a user through his project for a certain amount of time, scheduling and releasing the resources after the granted period.

Type: Functional

6.1.3 FIBRE Islands policies definition

Requirement ID: Req US03

Applied to: all

Description: Island Manager MUST be able to configure policies to rule resources availability. Policies MUST rule both resources and administrative domain levels.

Type: Functional

6.1.4 Scriptable Command Line Interface

Requirement ID: Req US04

Applied to: all

Description: OFELIA CF SHOULD provide a Command Line Interface which exports the same functions available in the web UI, considering user role (experimenter or island manager). This CLI should be callable from a shell script in order to be able to program actions over the facility.

Type: Functional

6.1.5 Resources visualization

Requirement ID: Req US05

Applied to: all

Description: Experimenter MUST be able to visualize all the FIBRE resources in a single screen. The FIBRE-EU system SHALL allow federated organizations to describe resources that they contribute to the federation in a common format.

Type: Functional

Additional note: This requirement includes the resources of all federated islands. The adopted format SHOULD be flexible enough to permit the description of resources from different technologies.

6.1.6 Use of EXPERIMENTA optical devices

Requirement ID: Req US06

Applied to: i2CAT

Description: i2CAT island MUST offer access to EXPERIMENTA Wonesys Proteus optical network devices.

Type: Functional

Additional note: The EXPERIMENTA optical network is independent of OFELIA and FIBRE, although it is physically connected to i2CAT island. EOCF MUST implement a way to offer experimenters to add resources from EXPERIMENTA's optical ring in their experiments, probably by implementing an AM capable to communicate with OpenNaas, an open source platform providing Network as a Service, understood as on demand (commonly user-triggered) provisioning of network resources, which controls this devices.

6.2 Pilot requirements

Technology pilot 1 is performed exclusively in FIBRE-BR islands, so its requirements are not mandatory for FIBRE-EU islands, but Technology pilots 2 and 3 are performed in collaboration between UEssex island and FIBRE-BR islands, so its requirements must be achieved by UEssex island.
In order to run experiments defined in Technology Pilot 2, FIBRE-EU UEssex island MUST provide:

6.2.1 Specific components

Requirement ID: Req PI01

Applied to: UEssex

Description: The FIBRE-EU UEssex island MUST support the following components:

- OpenFlow Ethernet switches
- WDM equipment capable of dynamical reconfiguration using OpenFlow.
- Content Delivery Server
- Content delivery application
- 4K projection facility to properly support experiments with High Definition/High Quality media streaming, which is compatible with the FIBRE UK island Projection Facility.

Type: Functional

6.2.2 Experiment data Storage

Requirement ID: Req PI02

Applied to: UEssex

Description: The FIBRE-EU MUST provide enough space to store 4K experiment data, i.e. 3 or 4 4K-videos (~ 5TB)

Type: Functional

6.2.3 Connectivity

Requirement ID: Req PI03

Applied to: UEssex

Description: Network facilities MUST be provided to connect FIBRE islands (EU and BR) for sending the cache copy to Brazil site and for re-directed clients to the other CDS.

Type: Functional

In order to run experiments defined in Technology Pilot 3, FIBRE-EU UEssex island MUST provide:

6.2.4 Specific components

Requirement ID: Req PI04

Applied to: UEssex

Description: The FIBRE-EU UEssex island MUST support the following components:

- The OpenFlow enabled network infrastructure in UK and Brazil site, including optical and MPLS switching hardware·
- The OSS GMPLS stack developed by the PHOSPHORUS project
- High-bandwidth application (e.g. streaming as per Pilot 2)
- At least 3 OpenFlow-enabled (or open firmware) ROADMs per islands, with one island in Essex and one island in CPqD
- At least 3 OpenFlow MPLS per island
- One OpenFlow controller (e.g. NOX)
- 4K projection facility to properly support experiments with High Definition/High Quality media streaming, which is compatible with the FIBRE UK island Projection Facility.

Type: Functional

6.2.5 Experiment Storage

Requirement ID: Req PI05

Applied to: UEssex

Description: The FIBRE-EU MUST provide enough space to store 4K experiment data, i.e. 3 or 4 4K-videos (~ 5TB)

Type: Functional

6.2.6 Connectivity

Requirement ID: Req PI06

Applied to: UEssex

Description: Network facilities MUST be provided to connect FIBRE islands (EU and BR) for sending the cache copy to Brazil site and for re-directed clients to the other CDS.

Type: Functional

6.3 Architectural requirements

6.3.1 Authentication Management and Access Control

Requirement ID: Req AR01

Applied to: all

Description: FIBRE-EU system SHOULD allow external organizations to authenticate themselves in the facility, allowing requests of its users to be attended by FIBRE-EU system following the arranged policies.

Type: Functional

6.3.2 Federation Management

Requirement ID: Req AR02

Applied to: all

Description: The entire federation framework should be controlled by the different island managers through the EOCF.

Type: Functional

6.3.3 Resource visualization

Requirement ID: Req AR03

Applied to: all

Description: Federated resources should be displayed together with the local ones, indicating the difference.

Type: Functional

6.3.4 Federation

Requirement ID: Req AR04

Applied to: all

Description: Islands MUST be federated allowing an experimenter to allocate resources from different islands in his experiment. The FIBRE-EU architecture MUST enable federation, which is the management and inter-operation of multiple independent islands, which are owned by multiple distinct organizations and possibly using different wired and wireless technologies.

Type: Functional

6.3.5 Federation mechanism

Requirement ID: Req AR05

Applied to: all

Description: Each Island CF MUST offer a way to the other CFs so they can use the resources of the former. Autonomy of individual islands should be intact upon federation i.e. Every island in the FIBRE facility shall be able to operate independently from each other.

Type: Functional

6.3.6 Federation Administration

Requirement ID: Req AR06

Applied to: all

Description: The FIBRE-EU system SHALL allow administrators to manage the federation. This involves activities such as including new islands, installing and updating system federation software, and monitoring the federation in terms of performance, functionality, and security.

Type: Functional

6.3.7 Messaging security

Requirement ID: Req AR07

Applied to: all

Description: System SHALL check validity of messages received from other islands through a validation mechanism.

Type: Functional

6.3.8 Connection Europe-Brazil

Requirement ID: Req AR08

Applied to: all

Description: There MUST be at least one connection between the islands from Europe and Brazil through a central hub in each side.

Type: Functional

6.4 Experiment requirements

6.4.1 Experiment configuration storage

Requirement ID: Req EX01

Applied to: all

Description: System MUST allow the experimenter to save the experiment configuration in a kind of "Previously Executed Experiments" database after experiment is finished so it can be replicated in the future for the same or another experimenter in the same or different island.

Type: Functional

Additional note: Experiment archives SHOULD be made available for other experimenters to validate, re-run and compare results. An experiment archive MUST include a human readable description in a natural language, experimental results and any special considerations for repeating the experiment.

6.4.2 Experiment results storage

Requirement ID: Req EX02

Applied to: all

Description: A FIBRE-EU experimenter MUST be able to archive the experiment setup and its results. Maintaining experiment information is important for post analysis.

Type: Functional

Additional note: An experiment archive MUST include experimental results obtained in previous executions.

6.4.3 Running Experiments status information

Requirement ID: Req EX03

Applied to: all

Description: The FIBRE-EU system MUST provide a basic interface to the experimenter to check the status of his experiment.

Type: Functional

6.4.4 Experimenters registration

Requirement ID: Req EX04

Applied to: all

Description: Experimenter MUST register in a unique FIBRE portal but be able to access all the FIBRE sub administrative domains (islands).

Type: Functional

Additional note: The FIBRE-EU system SHALL provide the means to enable organizations to carry out secure authentication of users from federated organizations, possibly providing different levels of clearance and access according to organization policies and the needs of the users.

6.4.5 Experiment deployment

Requirement ID: Req EX05

Applied to: i2CAT, UEssex

Description: User MUST be able to configure his resources and, for the case of computation resources as VMs, he MUST be able to install any required software or even use his own template to create the VM.

Type: Functional

6.4.6 Experiment running control

Requirement ID: Req EX06

Applied to: all

Description: During an experiment reservation period, a FIBRE-EU experimenter MUST be able to start, pause, stop, or reset an experiment at any given time.

Type: Functional

6.4.7 Experiment configuration

Requirement ID: Req EX07

Applied to: all

Description: The system SHOULD enable an experimenter to change the configuration of the allocated resources during the realization of the experiment.

Type: Functional

6.4.8 Experiment control tool

Requirement ID: Req EX08

Applied to: all

Description: An experiment MUST be able to be programmed in an island through a description file.

Type: Functional

6.5 Instrumentation and Measurements requirements

6.5.1 Experiment monitoring

Requirement ID: Req IM01

Applied to: all

Description: Experimenter MUST be able to access to monitoring data of his experiment (traffic, VMs' status, links status, etc.). These data MUST be kept in a database to later analysis.

Type: Functional

Additional note: The system storage services MUST ensure integrity and availability of the experimenters' data in the lifespan of the experience

6.5.2 Experiment results export

Requirement ID: Req IM02

Applied to: all

Description: Experimenter MUST be able to export the data collected from an experiment to his own database for further use.

Type: Functional

Additional note: The system storage services MUST ensure integrity and availability of the experimenters' data in the lifespan of the experience.

6.5.3 Provisioning and monitoring of other islands

Requirement ID: Req IM03

Applied to: i2CAT, UEssex

Description: CF MUST offer provisioning and monitoring of resources from other islands whatever CF the external island is using (EOCF, EOMF).

Type: Functional

6.5.4 Wireless link quality assessment web tool

Requirement ID: ReqIM04

Applied to: all

Description: A web tool in the island's portal SHALL provide statistical information regarding the quality of the testbed's links and other relevant wireless environment information (e.g. contention level).

Type: Functional

6.6 Infrastructure requirements

6.6.1 i2CAT FIBRE Island infrastructure

Requirement ID: ReqIF01

Applied to: i2CAT

Description: i2CAT FIBRE island MUST have the following minimum infrastructure:

- 3 servers (testing + development, components, VMs hosting).
- 3 OpenFlow-enabled switches.
- 3-4 OpenFlow-enabled Wi-Fi access points.
- Connection to OFELIA island and EXPERIMENTA testbed's ROADMs.

Type: Functional

6.6.2 UEssex FIBRE Island infrastructure

Requirement ID: ReqIF02

Applied to: UEssex

Description: UEssex FIBRE island MUST have the following minimum infrastructure:

- 4 servers (OFELIA CF, VMs hosting, testing+development)
- 4 OpenFlow-Enabled Switches
- Fibre switch & optical ROADMs

Type: Functional

6.6.3 UTH FIBRE Island infrastructure

Requirement ID: ReqIF03

Applied to: UTH

Description: UTH FIBRE island MUST have the following minimum infrastructure:

- UTH SHALL deploy two OpenFlow switches at their island and provide the experimenters with access to them.
- UTH SHALL deploy LTE base stations and 3G femtocell base stations. Client LTE/3G devices will also be deployed (LTE/3G cards at fixed nodes and/or mobile LTE/3G enabled handsets).
- UTH SHALL connect its existing nodes to the OpenFlow switches (exact topology to be defined), forming a configurable experimental wired network

Type: Functional

6.6.4 Future technology insertion

Requirement ID: Req IF04

Applied to: all

Description: FIBRE-EU system MUST provide explicitly defined and extensible system interfaces to facilitate the incorporation of additional technologies.

Type: Functional

6.6.5 Mesoscale Base Station virtualization

Requirement ID: Req IF05

Applied to: UTH

Description: A traffic shaping layer implemented in software SHALL be developed. This layer SHALL shape the traffic entering the scheduling component of the commercial LTE/3G base stations. This setup enables (among other features) the ability to virtualize the base station, so that it can be used by many experimenters simultaneously.

Type: Functional

6.6.6 i2CAT FIBRE island interaction with i2CAT OFELIA island

Requirement ID: Req IF06

Applied to: i2CAT

Description: i2CAT FIBRE island MUST be physically connected to i2CAT OFELIA island in order to share resources but keeping management separately.

Type: Functional

6.6.7 UEssex FIBRE island interaction with UEssex OFELIA island

Requirement ID: Req IF07

Applied to: UEssex

Description: UEssex FIBRE island MUST be physically connected to UEssex OFELIA island in order to share resources but keeping management separately.

Type: Functional