ABSTRACTION LAYER FOR IMPLEMENTATION OF EXTENSIONS IN PROGRAMMABLE NETWORKS

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Abstract

This deliverable analyses ALIEN resource manager software components and defines its components functionalities. The ALIEN resource manager software will be used to integrate ALIEN devices into OFELIA facility via OFELIA Control Framework. In chapter 1 a basic use case is introduced to help understand the logic of ALIEN device integration into OFELIA facility and build a foundation for software validation for T4.3. In chapter 2 three integration approaches are explained due to variation of integration and for each approach the mechanism is explained. In chapter 3 ALIEN Aggregate Manager (ALIEN AM) which is an extension to the current OFELIA Control Framework is explained and each software component functionality inside the ALIEN AM is defined. The identified components will be developed and implemented in T4.3.

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Executive Summary

Although OFELIA facility has been designed to provide access to users to conduct OpenFlow experiments at transnational scale, the testbeds in OFELIA facility only support OpenFlow v1.0. On the contrary, ALIEN project aims to exploit new OpenFlow features which were introduced in recent versions higher than v 1.0. The ALIEN WP4 activity focuses on integration of ALIEN devices into OFELIA facility and therefore to solve the incompatibility of OpenFlow version between OFELIA facility and ALIEN devices, a time-based solution as an extension to the current OFELIA Control Framework was proposed in D4.1.

Based on the proposal in D4.1, to support all ALIEN devices' integration into OFELIA facility, the following integration solutions are investigated in this report:

- The use of regular OFELIA Control Framework: Layer-0 WDM optical switch at University of Bristol uses this solution and since it is already part of OFELIA facility therefore no development is needed for integration.

- The use of new ALIEN Aggregate Manager in OFELIA Control Framework: this approach will implement an extension to the current OFELIA Control Framework which deploys time-based policies for ALIEN devices and exposes them to OFELIA users according to the policies. The ALIEN Aggregate Manager is composed of several components: For user frontend, a new plugin called TB plugin was defined. This plugin uses the OFELIA Control Framework APIs available for implementing new plugins for the framework. To fallow OFELIA Control Framework development principles, a new component called Time-Based Aggregate Manger was defined which acts as a glue logic to convert OFELIA Control Framework messages into device control messages and vice-versa. Moreover, to enforce the time-based policy to ALIEN devices, a component called OpenFlow GateWay was defined. The OpenFlow GateWay is the main and only access point to ALIEN devices.

- Other consideration: some ALIEN devices (devices at EHU/UPV, DELL and UCL) will not be exposed to OFELIA users directly but they will be connected to a device, which is already being used in OFELIA facility. This will share their data plane to the OFELIA facility but they will be controlled locally.

This report identifies functionality of each integration solution and defines their interfaces towards OFELIA Control Framework.

1 Introduction

This document focuses on extending the current OFELIA Control Framework (OCF) to support the ALIEN devices within OFELIA facility. The ALIEN devices in this context use the HAL [HAL] designed for them to implement OpenFlow protocol for their platforms. The following definitions are for clarification of the terms used in this document:

ALIEN device: a network device which uses the HAL to gain the ability to understand OpenFlow protocol (preferably higher versions of OpenFlow).

ALIEN Island: a network testbed that hosts one or more ALIEN device and other elements such as virtual machines. These elements are exposed for OFELIA users.

To support the ALIEN devices integration into OCF, different components will be designed and developed to make them available for OFELIA users. The new software components are needed due to the reasons explained in D4.1.

All the new software components together will provide an ALIEN-based resource manager that enables the OFELIA users to manage, manipulate and control ALIEN devices via OCF. Although the ALIEN resource manager will expose the ALIEN device to the OFELIA user for experiments, all other elements (e.g. Virtual Machines) which are needed in ALIEN Island for the experiment will be managed by other software components which already exist in OCF.

To clarify and have better understanding of the ALIEN management software for OCF, two basic use cases will be explained. These use cases will demonstrate the logic and relation between ALIEN equipment and OCF and later these use cases will be used as a foundation for the software development to be validated in T4.3.

1.1 Basic use case scenarios for ALIEN islands

In this section the two basic use case scenarios for an integration of ALIEN islands with OFELIA are explained. Both scenarios assume each island is composed of the following components:

- **An OpenFlow-enabled network** that interconnects different data plane elements inside an island (Hosts, OpenFlow controllers and other control frameworks elements)
- **Hosts**: a set of hosts that interact with each other with the following roles:
    - End-point: sends and receives traffic inside a slice. This functionality will be realized by using virtual machines hosted in a server located in an island
    - OpenFlow controller software: ALIEN islands will provide OpenFlow-enabled test-beds, therefore experimenters can deploy own controller entities hosting variety of network applications on top of the controller.

- **The ALIEN OCF proxy** (OpenFlow GateWay): This component will be the only entry point to access the *time-based* resources. It will be in charge of *Hardware Management Plane, Control Plane and Data Plane.*
- **A control network**: The control network will be used by different entities of OCF (OpenFlow controller or OFGW) and facility service hosts to exchange control data. Logically separated control and data plane network will make the network more flexible and easy to be managed.

An integration of the ALIEN Island with OCF at the Control and Management level

Figure 1.1.a shows what it has been considered as a basic use case scenario for ALIEN islands. The diagram shows the components involved to conduct an experiment in ALIEN islands using the extended OCF. At this point the integration is considered at the Control and Management level. The island will not implement data plane interconnectivity towards other OFELIA islands, therefore the experimented will be given with a possibility to compose slices from the island's resources only.

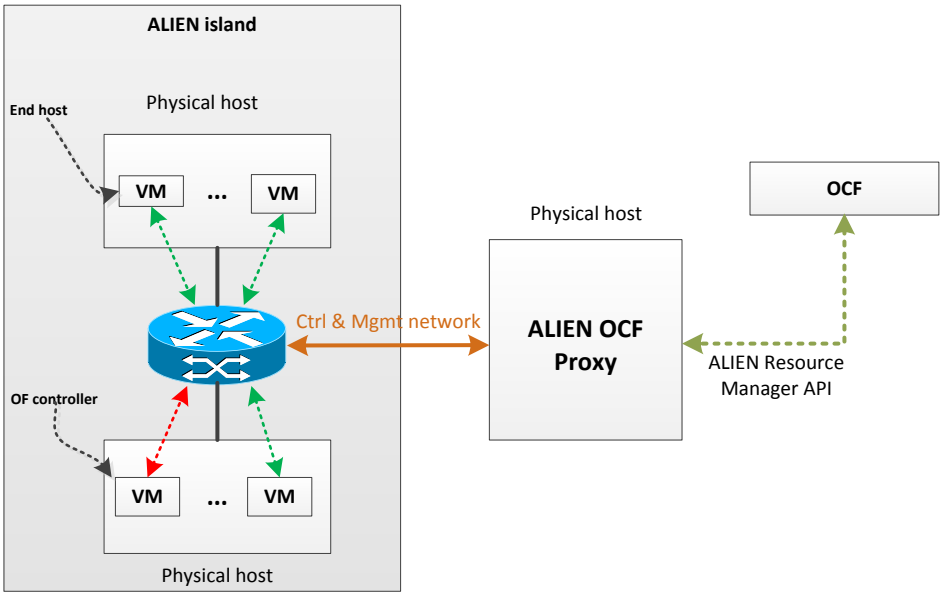

Figure 1.1.a: ALIEN island integration into OCF (Control and Management only)

An integration of the ALIEN Island with OCF at the Control and Management and Data plane level

Figure 1.1.b shows the second use case scenario, which is an extension of the first one with an implementation of interconnectivity between the ALIEN Island and other OFELIA islands. In this scenario the ALIEN Island is connected to other OFELIA islands via ALIEN OCF Proxy (in this document referred to as OpenFlow GateWay – OFGW). Since in OFELIA the slicing mechanism is based on VLAN tagging and ALIEN islands will use untagged traffic (VLAN 1) by default (although it is capable of using tagged traffic) [D4.1], in case of connecting it to other OFELIA islands, all the traffic must pass through the OFGW to get tagged and untagged traffic at ingress/ egress port. The process will be explained in details in the following chapters.

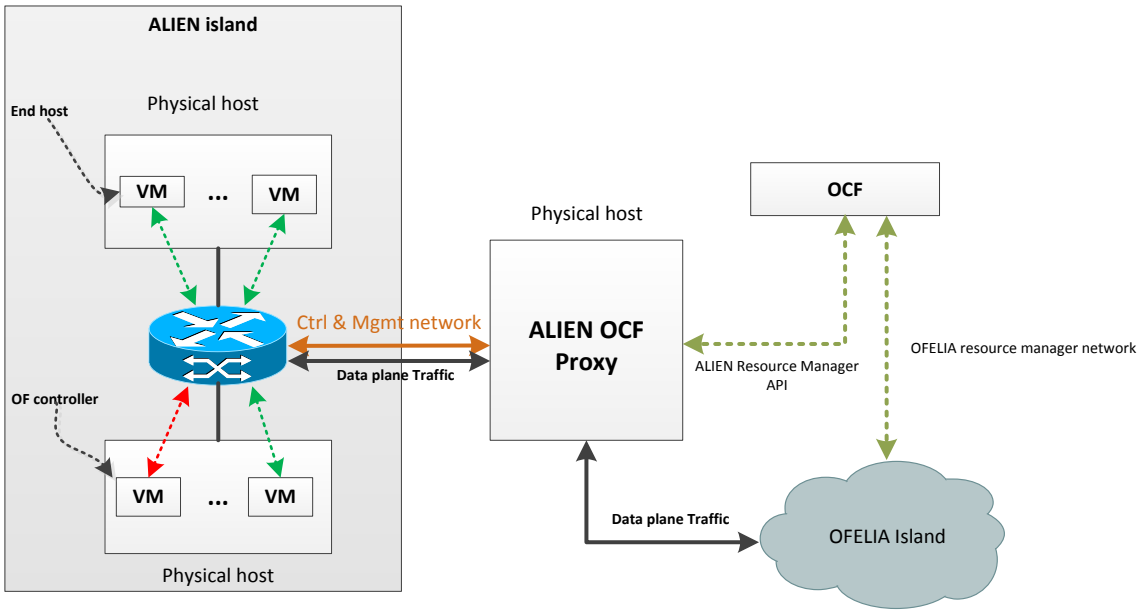

Figure 1.2.b: ALIEN Island integration into OCF with OFELIA Island inter-connectivity

2 ALIEN Integration Solutions

The diversity of hardware platforms and organizational implications in the ALIEN project has led to apply different approaches towards the integration of ALIEN platforms into the OCF. In the following section each integration approach is explained in details.

2.1 The use of the regular OFELIA Control Framework

The Layer-0 switch (WDM ROADM) at Bristol University is the only platform that uses the standard OCF as a method to integrate with OFELIA facility. The layer-0 switch is already part of the OFELIA distributed testbed, integrated into the OCF as part of the OFELIA project. For integration purposes, a dedicated agent has been

developed to represent the platform as an OpenFlow enabled device to users in the OCF to allow them running OpenFlow experiments on the WDM ROADM resources [Figure 1.2].

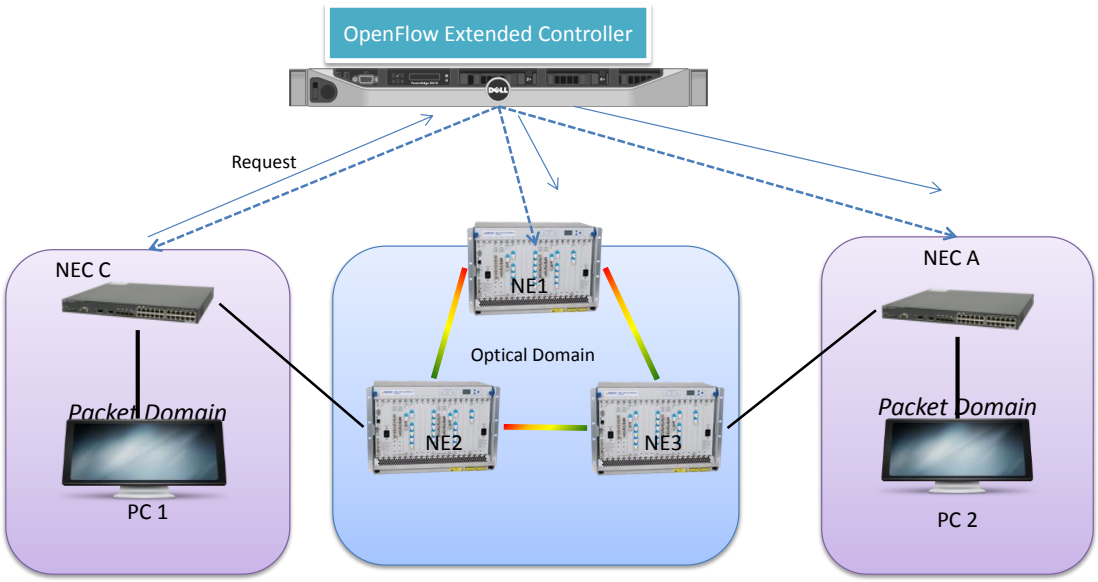

Figure 2.1: Optical Flow based switching in OCF [OFELIA D4.2]

In the OCF the ADVA ROADM could be shared among multiple users by allocating different wavelengths and ports for each user. The allocated wavelength and ports are associated to the user for the period of experiment unless he releases them earlier. The sharing mechanism is similar to time-based solution: the OFELIA user chooses a VLAN tag and sets it on end-switch ports which are connected to the WDM switch ports. Following this configuration, the wavelength configured on optical ports are mapped to the VLAN configured on end-switch ports. The assigned wavelengths and ports on optical switch will not be available during the experiment for other users.

2.2 The use of a new ALIEN Aggregate Manager

Similar to other AMs in OCF [OFELIA D5.2], a new agent is needed to be developed and deployed in testbeds for ALIEN AM. The agent is responsible for collecting and sending information needed by the ALIEN AM and applying policies enforced on ALIEN devices or other OFELIA's entities inside the ALIEN Island by OFELIA users.

As previously discussed in D4.1 [ALIEN D4.1], the necessity of ALIEN AM in OCF comes from the fact that for some devices there are some specific limitations that prevents them to be fully accessible to OFELIA users (e.g. resources cannot be devoted to the OCF exclusively, lack of support for virtualization or lack of support for concurrent access for multiple users). Moreover, the virtualization technology used in the current OCF implementation (FlowVisor) only supports OpenFlow v1.0, where higher versions of OpenFlow are considered for use in ALIEN. To solve these problems, the ALIEN AM will bypass FlowVisor to avoid incompatibility between different versions of the OpenFlow protocol.

The ALIEN AM is a general approach to cover the ALIEN device integration into OCF. Although the integration approach may differ from one ALIEN device to another, a common ALIEN aggregate manager, called Time-Based Aggregate Manager (TBAM), has been proposed and described in D4.1. The Time-Based approach enables users to exploit specific hardware capabilities for each platform by implementing extended OpenFlow versions but it requires each device to be available to one user exclusively at a specific time i.e. the device will not be shared among multiple users at the same time. The TBAM is responsible for providing information about time-based resources such as availability, device status, user/project association with resources, etc.

While the main goal of TBAM is to manage and control the relation between the user, the user's experiment and device accessibility, the information required by TBAM to perform these functions is provided by OpenFlow GateWay (OFGW). The OFGW is the only component that all control and data plane traffic passes through it. The idea behind the OFGW is to isolate the ALIEN islands from the rest of OFELIA islands in order to provide the possibility of integration of newer version of OpenFlow into the OFELIA facility. It also implements a process to adapt the OFELIA slicing mechanism into time-based mechanism.

2.3 Other considerations

Some targeted ALIEN platforms in the project are being used for special purposes (being shared among multiple projects or being used for training) which make them to not be available at all time for third party users. On the other hand, the OFELIA policy requires that all devices have to be accessible 24/7. To solve this problem, those ALIEN devices which cannot participate to OFELIA on the 24/7 basis, will not be directly integrated into the OCF. Instead, they will be available for an experiment on the ad-hoc basis. Data plane connectivity for this equipment will be set up, therefore an experimenter will be capable of using it in an experiment by configuring corresponding OpenFlow controllers within the ALIEN island.

3 Functional specification of the management software for ALIEN

The following chapter introduces the functional specification of the management software developed in ALIEN. In particular, the ALIEN Resource Manager is introduced and detailed. Figure 3.1 shows a general architectural view of ALIEN resource manager components. The blue colour represents the components and their modules that will be developed or extended within the ALIEN timeframe. The list of affected components includes:

- The OpenFlow Gateway (OFGW)
- Time-Based Aggregate Manager (TBAM)
- TB Plugin

In the following section each component and its functionality is explained.

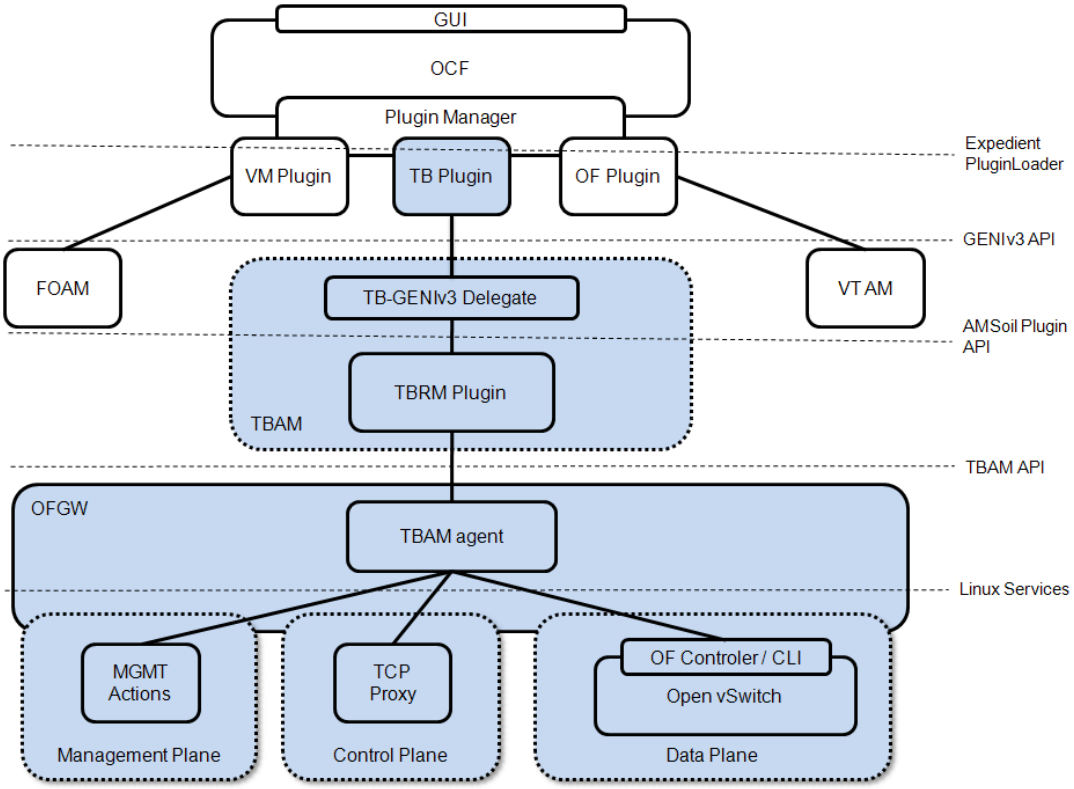

Figure 3.1: The ALIEN resource manager architecture

3.1 The OpenFlow Gateway

The OFGW is the resource manager for the ALIEN devices and represents the only entry point for accessing the ALIEN Island's network resources. It represents a single access point for the management, control and data planes, as depicted in Figure 3.2.

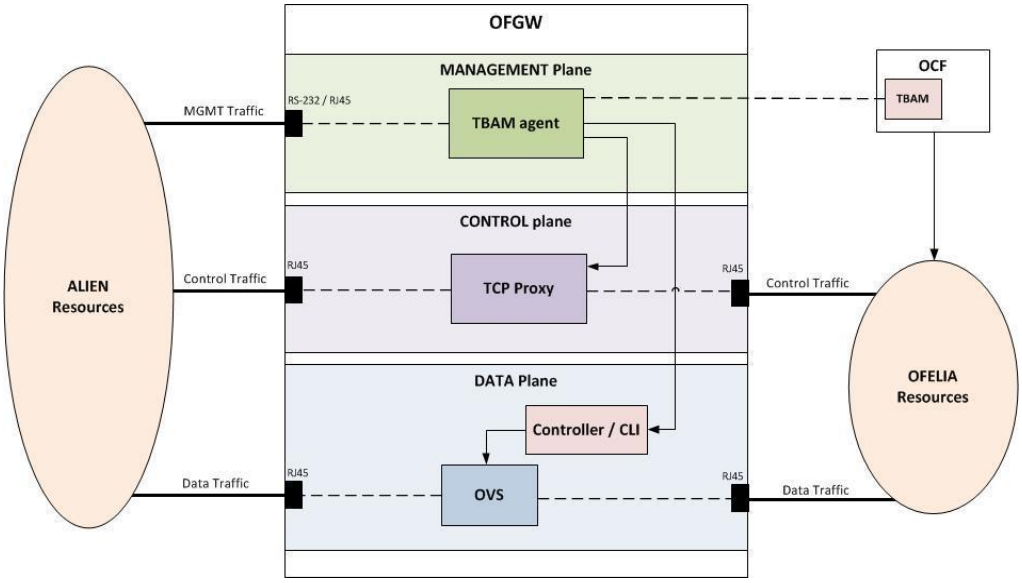

Figure 3.2: High-level architecture of OFGW

Figure 3.3 shows the position of the OFGW in the OCF architecture:

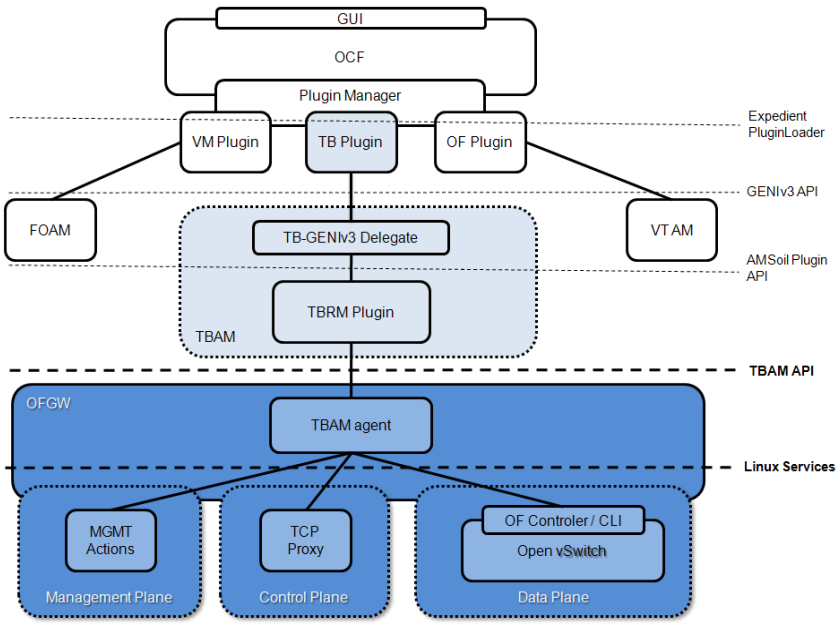

Figure 3.3: OpenFlow Gateway on OCF architecture

3.1.1 Functionality and principles' analysis

3.1.1.1 *The Hardware Management Plane*

The management interface provides an access to a device for the island administrators and users. It is used to perform some initial configuration of a device (e.g. admin account setup, VLANs, port configuration, virtualization server setup, etc.) as well as the configuration of the OpenFlow protocol.

Users use management interfaces to perform custom configurations of devices (if allowed by the administrators), to load/enable specific additional features on a device (e.g. the most recent OpenFlow-enabled firmware) or simply for debugging purposes.

A typical access to a device is done through well-known network protocols like telnet, ssh, http, tftp or by using a management GUI provided by the specific device. The OFGW also provides an access to the network devices through the console port (typically through the RS232 serial port).

3.1.1.2 *Control Plane*

The OFGW will act as a unique entry point for the OpenFlow controller by listening on the default OpenFlow port number (port 6633 at the time of writing but it has been changed to port 6653 in OpenFlow specification v 1.4.0 which is currently under ratification). All network devices of the ALIEN Island will be configured to point

to the OFGW's control plane IP address. An OFGW's internal process, configured through the OCF, will forward the OpenFlow control traffic to the user's controller machine.

3.1.1.3 *Data Plane*

While inside "canonical" OFELIA islands the slicing mechanism used is based on VLAN tagging, within ALIEN we assume that the traffic inside the "time-based" resources is, by default, untagged. However, the use of VLAN tags is also foreseen in ALIEN islands. As traffic inside OFELIA islands must be tagged with the VLAN assigned to the slice, the packets exchanged between OFELIA and ALIEN nodes must go through a tagging/untagging/retagging process performed by the OFGW. For this reason, the OFGW will be equipped with an OpenFlow capable software switch (e.g. OpenVSwitch) and an open-source OF Controller (e.g. Floodlight, Beacon or NOX), directly configured by the OCF.

3.1.2 Implications of the use of the OFGW for other OCF components

The OFGW does not have direct implications on other components of the OCF. In fact, the OCF already provides a mechanism to configure a different controller for each OpenFlow aggregate. Therefore, we can reuse the same mechanism to setup the IP address used by the OFGW to forward the control messages from ALIEN devices to the user's controller and vice-versa.

Since the user may want to use one or more VLANs within the ALIEN Island, we need a graphical module to configure the OFGW's internal controller for mapping the ALIEN VLAN IDs with the OFELIA VLAN IDs. This module should be included into the TB plugin for Expedient.

Finally, the interface with the TBAM aggregate manager must provide the APIs to configure the user's environment on the OFGW, including credentials, access permissions and disk space. However, TBAM will rely on the OFELIA LDAP services in order to manage authentication-related tasks.

3.1.3 Components and architecture design

In this section we introduce the most relevant software modules of the OFGW. These modules are responsible for the management of the three planes, as described above. Figure 3.4 gives an overview of the software architecture of the OFGW.

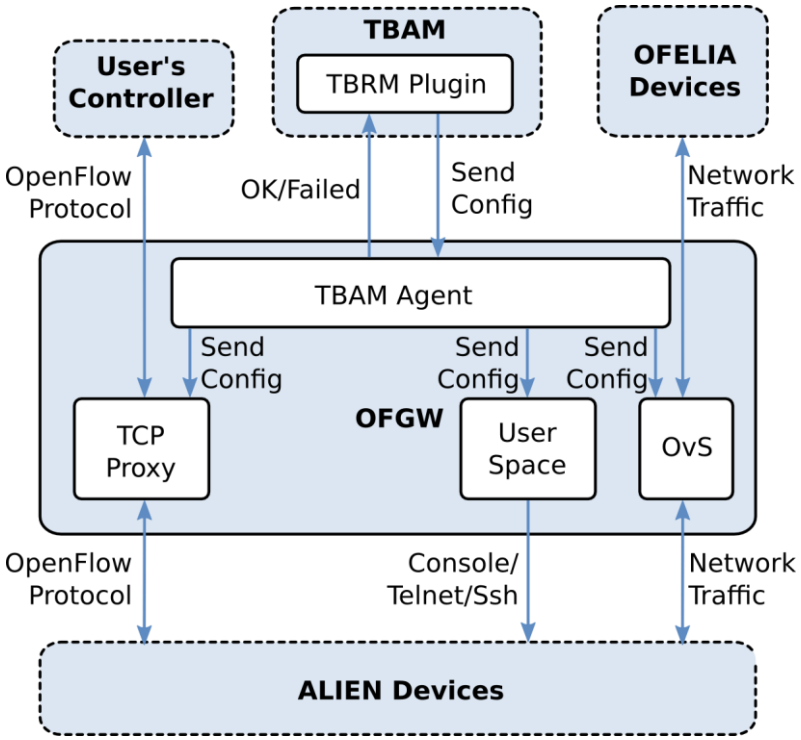

Figure 3.4: The OFGW software architecture

The *TBAM agent* is responsible for the communication with the TBAM component. The agent implements the following functionalities:

1. The TBAM APIs used to receive the configurations from the TBAM and to send information about the status of the ALIEN resources to the TBAM. The configuration parameters includes (among others): (i) the IP/PORT address of the user's controller, (ii) the user's credentials used to create a local account that will be used to access the network devices through the management interface, (iii) the duration of the slice, (iv) the VLAN ID assigned by the OCF to the slice that will be used by the OvS to tag the traffic leaving the ALIEN island towards the OFELIA facility and (v) the VLAN IDs that the user may want to use within the ALIEN island and that must be rewritten by the OvS before the traffic enters the OFELIA facility;
2. The agent that creates the user's account with permissions granted by the administrator of the island during the configuration of the user's slice. Permissions include an access to network devices through a serial port (a read/write access to ttySX ports);
3. The agent that configures/starts/stops the *TCP proxy* daemon which forwards the OpenFlow control traffic from network devices of the island (by default traffic with destination tcp port 6633) to the user's controller and vice-versa.

The *User's space* is a traditional Linux account configured with access credentials received from the TBAM. The account should be created and configured automatically by the TBAM agent at the beginning of the time slot

requested by a user. With this account, the user has access to all devices of the ALIEN Island through the management interfaces.

After the end of the time slot, the account will be accessible for a certain period of time (grace period) to allow the user to collect her/his data produced during the experiment. During the grace period, the user's account does not have access to network devices and when this period expires the account and all its data will be erased.

A special user space, the root account, is used by the island administrators to get access to ALIEN devices through the management interfaces (ttySX, ethX). This account never expires.

As mentioned earlier, traffic leaving the ALIEN Island towards the OFELIA facility must be tagged with the VLAN ID assigned to the user's slice by the OCF. In fact, OFELIA devices are shared among different users and, to prevent interference among experiments of different users, packet must be tagged with different VLAN IDs. The tagging/un-tagging/remapping process is performed by a local instance of *Open vSwitch* which manipulates the traffic entering and exiting two network interfaces of the OFGW: one connected to the ALIEN data plane, the other to the OFELIA data plane. The instance of Open vSwitch is controlled by the *Internal OpenFlow Controller* that receives the configuration for the VLAN tagging/un-tagging/remapping process from the TBAM through the TBAM agent.

3.2 Time-Based Aggregate Manager (TBAM)

The Time-Based Aggregate Manager is a new component in the OCF architecture that implements a new feature enabling sharing resources exclusively for a specified period of time. This type of sharing has been used for years in other ICT sectors, e.g. in GRID computing. The exclusive sharing gives a possibility for new kind of experiments, e.g. testing a new software firmware for ALIEN devices. The TBAM, similar to FOAM and VTAM in the OCF architecture, will be connected to ALIEN resources (via the TBAM agent in the OFGW) and to the Time Based plugin (TB plugin) in the Plugin Manager (as depicted on Figure 3.5).

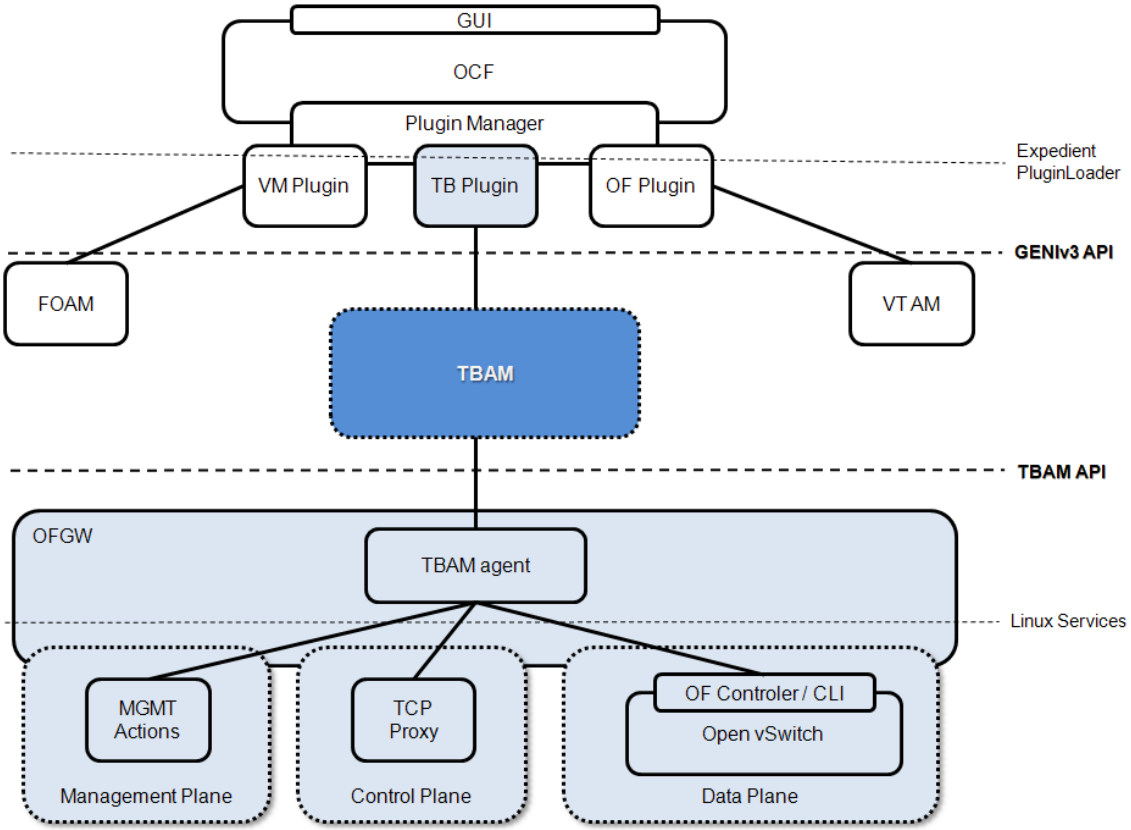

Figure 3.5: The TBAM on the OCF architecture

3.2.1 Functionality and principles' analysis

The TBAM component is responsible for a) identification of network elements in a testbed and b) enforcing time-based policies on devices in the ALIEN island. The element identification process is done without user's intervention. The interaction between the TBAM and the TBAM agent in the OFGW for the resource identification happens automatically and the result will be passed to the TB Plugin. The time-based policy process in the TBAM performs the following tasks:

- Book a specific subset of ALIEN resources for a fixed time period
- Release the resources either automatically at the end of the time interval, or manually if the user wants to leave the project earlier
- Modify the number of booked resources and the project's time schedule
- Inform (via email) the user and the ALIEN resource manager about all the relevant operations executed with their related status
- Manage concurrent requests (e.g. inform the user that another user is interested in the same resources so the experiment owner can release them if unused)

3.2.2 Implication of the use of the TBAM for other OCF components

The extension of the OCF by providing a new time-based sharing mechanism implies extending the OCF architecture. The OCF architecture has been designed as modular and flexible software that can be extended by new aggregate mechanisms. The expansion process can be done by developing a new AM and plugin for the Web GUI. Moreover, OFELIA provids AMSoil - the framework for creating new AMs for testbeds. The AMSoil is a pluggable system which provides a framework to develop new AMs as well as providing helpers for common tasks in the AM development [AMSoil]. This is a non-invasive method for implementing a new time-based sharing mechanism for the OCF. Furthermore, all other OCF features (such as providing northbound GENIv3 API interface) can be easily reused by the new AM by just importing those plugins.

3.2.3 Components and architecture design

The architecture of TBAM is based on the architecture proposed by OFELIA's AMSoil - the framework for creating new AMs. The AMSoil proposes architecture for function-oriented plugins and also provides framework for composing new OCF features using these plugins. The AMSoil plugins are categorized into different types that reflect their role in the architecture. The general classification includes types as follows:

- Core - plugins that compose the AMSoil core services like joined configuration, logging or workers (for enabling dispatching jobs to an external process)
- Delegates - plugins that translate some high-level API into Resource Manager(s) methods (in this case the GENIv3 API)
- Resource Managers - plugins that are responsible for resource instantiation, reservations and resource state management, policy checking, avoiding collisions of resources reservations, throw domain-specific errors
- Functional-specific - plugins providing some new features (e.g. new packages, methods or classes) that can be utilized by other plugins

In the ALIEN project a set of new modules that need to be implemented to build the TBAM has been specified (see Figure 3.6).

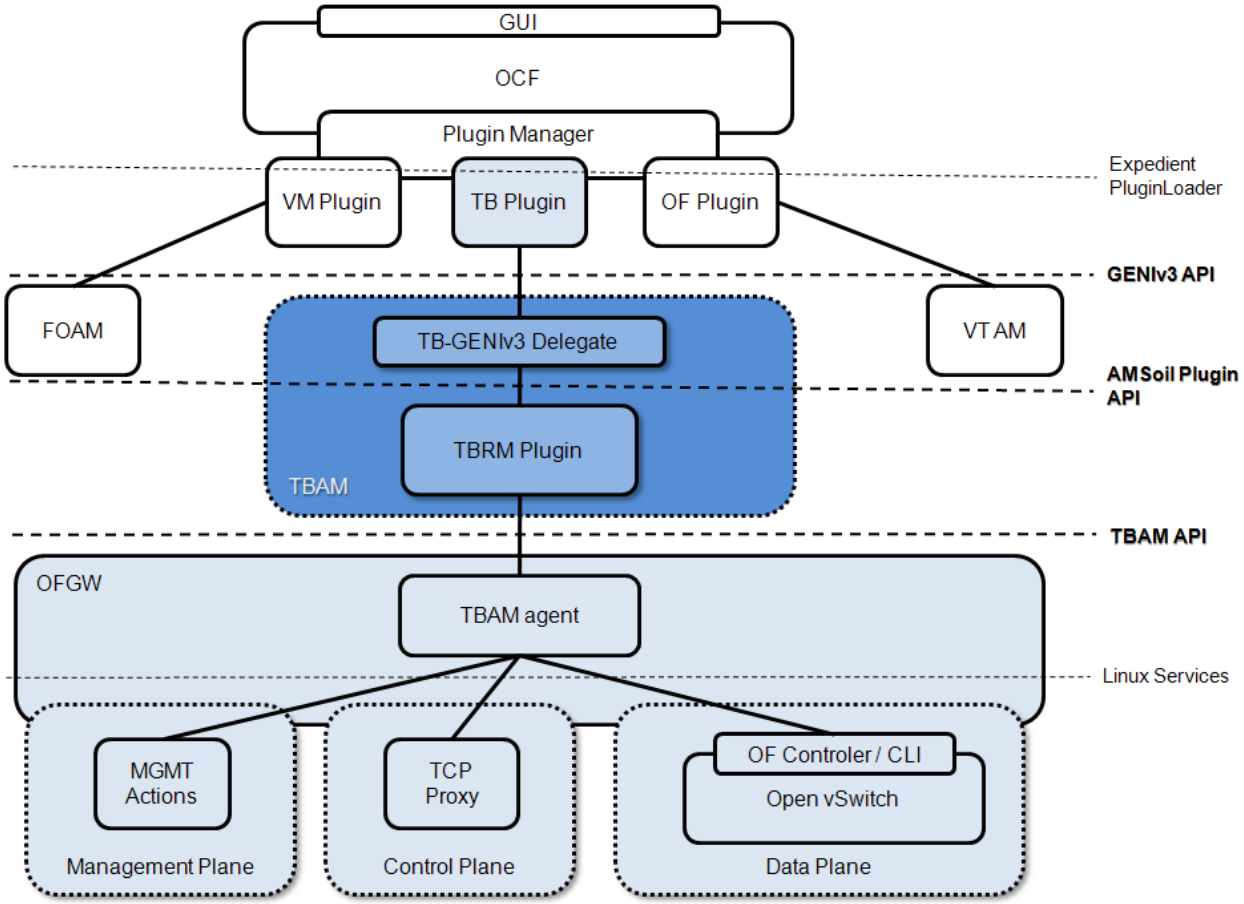

Figure 3.6: TBAM components and interfaces

3.2.3.1 *Components*

The architecture of Time-based Aggregate Manager is composed by several plugins, as described below.

TB-GENIv3 Delegate - is an auxiliary plugin that translates Expedient GENIv3 API messages into specified Time-based Resource Manager methods. It translates the RSpec (Resource Specification [Rspec]) into Time-based Resource Manager values (and back). Moreover, it handles the Resource Manager's exceptions and re-throws them as the GENIv3 method API. The Delegate also specifies authorization privileges with authorization mechanism for all requested actions.

TB Resource Manager Plugin (TBRM Plugin) - is a time-based sharing plugin built with AMSoil framework for managing the persistence of reservations and resource state. It instantiates resources, prevents resource collisions and manages their availability. It also checks policies and in case of failure provides error messages for the GUI through TB Plugin. Moreover, it provides information for TBAM API for configuration changes and receives resource status from TBAM Agent (see 3.1.3).

3.2.3.2 *Interfaces*

The following APIs are used in new plugins and components for ALIEN resource integration into OCF framework:

GENIv3 API - The GENI Aggregate Manager API is specified by GENI group [GENI] which allows to advertise resources and to allocate resources in form of abstract entities:

- Slivers - a collection of resources which has been instantiated within a Slice at a single aggregate.
- Slices - the resource containers. Every valid Sliver belongs to exactly one Slice. [GENI-APIv3]

The resources are described by the RSpec data type [RSpec]. Table 3.1 lists the most important GENIv3 API methods.

Table 3.1: GENI API main methods

Method	Description
GetVersion	Get info about the AM's
ListResources	Info about what AM has to offer
Describe	Info about Sliver
Allocate	Reserve the Slice/Sliver for a short time
Renew	Extend the usage of a Slice/Sliver
Provision	Provision a reservation for a longer time
Status	Get the status of the Sliver
PerformOperationalAction	Change the operational state of the Sliver
Delete	Remove a Slice/Sliver
Shutdown	Emergency Slice stop

AMSoil Plugin API - is an API between the plugins in AMSoil framework. The API basically provides methods to enable communication between other plugins. The communication between the plugins can be implemented by exposing selected methods and attributes to the other plugins. The AMSoil exploits Python libraries which allow exposing methods and attributes into the AMSoil Plugin API interface.

TBAM API - is the TBAM southbound interface. It is exposed by the TBRM Plugin and used to request configuration changes as well as receiving the resources status from TBAM agent.
Figure 3.7 depicts TBAM component diagram.

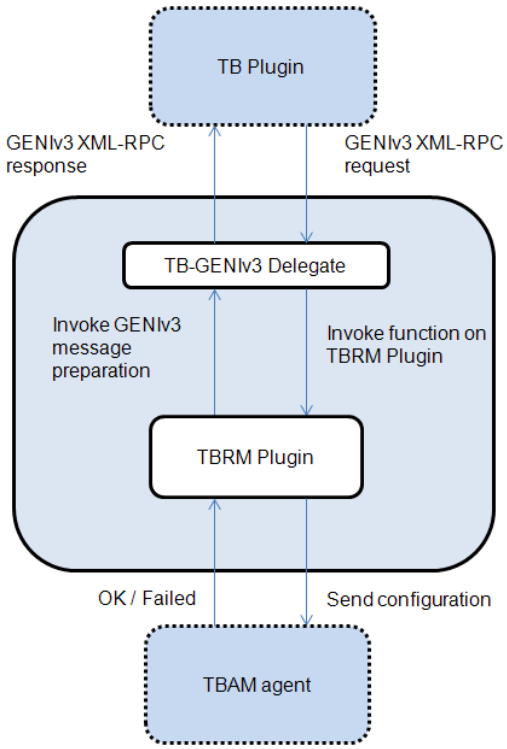

Figure 3.7: TB Aggregate Manager component diagram

3.3 TB Plugin

The TB Plugin is a module that extends the Expedient GUI with the new time-based properties listed in previous section. It provides an interface to the TBAM to deliver user requests in form of GENIv3API messages [GENI-APIv3].

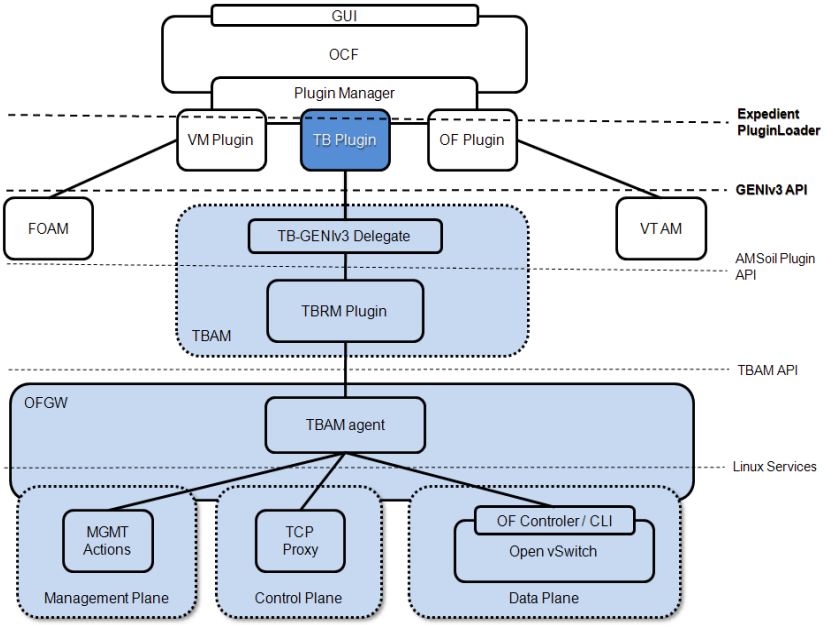

Figure 3.8: TB Plugin on OCF architecture

3.3.1 Functionality and principles' analysis

The current OCF GUI (implemented in Django [Python_Django]) has to be extended to support the new TBAM, both at the user frontend and in the plugin system. In other words, a specific plugin must be implemented to connect the TBAM to the GUI. Moreover, the GUI will be extended to provide management and control functions of the resources exposed by the TBAM. In particular, the web form will allow the user to execute all the functions listed in TBAM functions section e.g. book a specific subset of ALIEN resources for a fixed time period, modify the amount of booked resources and project's time schedule, etc.

3.3.2 Implication for other OCF components

To provide a new type of AM for the OCF, the Expedient (OCF Web Interface) should be extended. The Expedient has been designed to be open for developing new AMs and provides useful mechanisms for extending the GUI. The PluginLoader allows extending the Expedient with new configuration parameters, specific for the new AM. This mechanism allows extending the GUI and communication methods with the AM in order to send resource requests issued by the user.

3.3.3 Components and architecture design

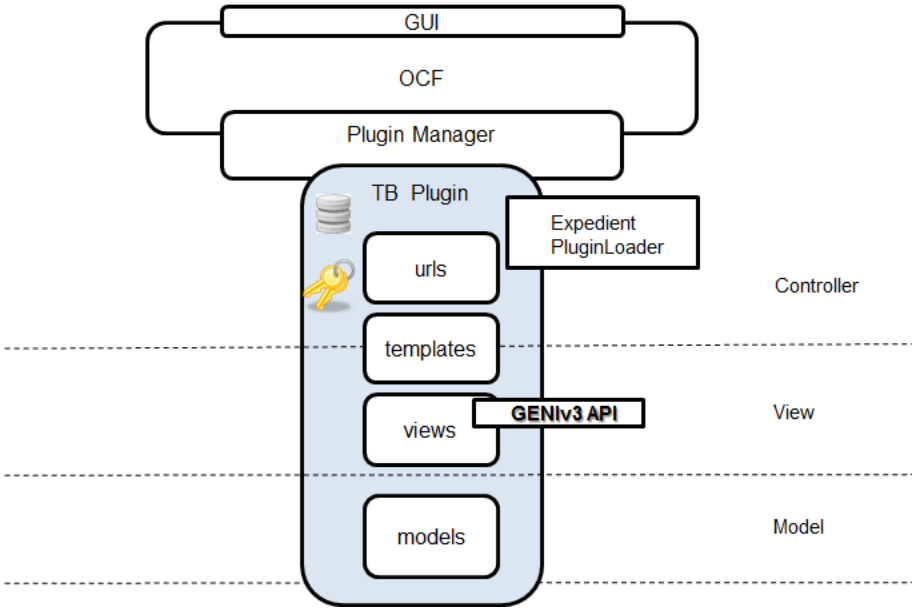

Figure 3.9: TB Plugin software architecture

The component development for the TB Plugin follows the Django application template:

- Views and templates components that organise UI for managing the TBAM and UI for enabling TBAM into OCF. The client side implemented within Views should include interface to GENIv3
- The Urls component controls the access to the service by setting a proper URI to views
- Models represent the data model and actions on specific data which are used in views

The TB plugin will use Django methods (e.g. database access or credentials management) that are already part of Expedient. Figure 3.10 presents the inside of TB Plugin dependencies between software components.

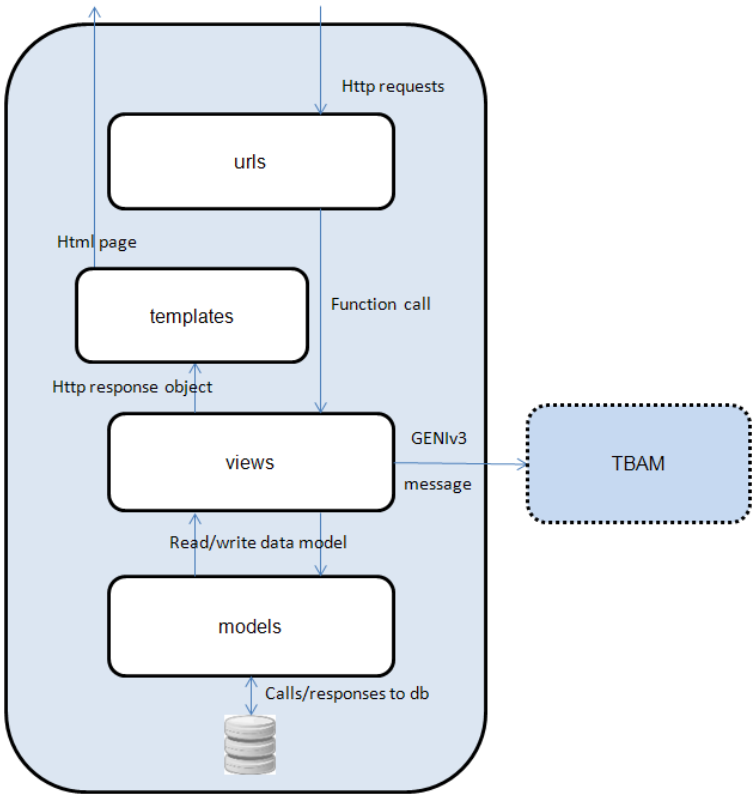

Figure 3.10: TB Plugin component diagram

4 Conclusions

The activities in task 4.2 were focused on identifying the software components required to integrate ALIEN devices into OFELIA facility and make them available for users via the OFELIA portal.

D4.2 provides detailed information about the approaches towards integration of ALIEN hardware into OFELIA facilities and explains pros and cons of each solution. Although the complexity of the integration process is due to several problems identified in this document (e.g. different hardware platforms, OpenFlow version supported by the OCF, etc.), the methods introduced in D4.2 cover all ALIEN device integration into OFELIA facility.

For the Layer-0 WDM switch (UNIVBRIS), the DWDM lab is already was part of OFELIA facility. Therefore no additional development is needed. The device simply uses the HAL to create an OpenFlow software switch and it will be represented in the OFELIA facility as an OpenFlow-enabled device.

ALIEN devices at UPV/EHU, UCL and DELL will connect their data plane to the OFELIA facility. However, all devices will be controlled by local administrator and therefore OFELIA users cannot control and manage them from the portal.

ALIEN devices at PSNC, PUT and EICT will use the ALIEN AM, which is, as explained in this document, an extension to the standard OCF. The ALIEN AM acts as an ALIEN resource manager which enables OFELIA users to control and manage the devices via the OFELIA interface.

The identification and definition of internal ALIEN AM components is based on the solution proposed in D4.1. Some parts of ALIEN AM extensions, in particular the OFGW, have to be developed from scratch to meet the requirements identified earlier in the project and reported in D4.1. Some components, specifically the TB Plugin and the TBAM, will use the OCF API for further developments. Although the software components and their functionalities have been identified in this deliverable, specific details, interfaces and internal logic will be covered in task 4.3 and reported in D4.3.

5 References

[OFELIA D4.2] http://www.fp7-ofelia.eu/assets/Public-Deliverables/OFELIAD42.pdf
[OFELIA D5.2] http://www.fp7-ofelia.eu/assets/Public-Deliverables/OFELIAD5.2Second-version-of-OFELIA-Management-Softwarev2.pdf
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6 Acronyms

[FOAM]	**Flowvisor OpenFlow Aggregate Manager**
[OCF]	**OFELIA Control Framework**
[OFGW]	**OpenFlow GateWay**
[OVS]	**Open vSwitch**
[TB]	**Time-Based**
[TBAM]	**Time-Based Aggregate Manager**
[TBRM]	**Time-Based Resource Manager**
[VT-AM]	**Virtual Technology Aggregate Manager**