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Glossary

CBRS Citizens Broadband Radio Service

MW microwave

NBI North-bound Interface

NE Network Element

ODL OpenDaylight SDN controller

ONF Open Network Fundation

OTWG Optical Transport Working Group

PoC Proof of Concept

SBI South-bound Interface

SDN Software Defined Network

WT Wireless Transport

WTP Wireless Transport Project

Executive Summary

This white paper provides an overview of the contents and results of Proof of Concept (PoC) conducted from 24th to 28th October 2016 by the Wireless Transport Project of the Open Networking Foundation (ONF) in North Brunswitck (New Jersey - US).

This PoC was focused on demonstrating the capabilities and benefits of utilizing a common Information Model for multi-vendor control of wireless network elements through open management interfaces, as defined in the Wireless Transport Project of ONF Optical Transport Working Group (OTWG) and documented in the technical report TR-532 [3].

The PoC included wide participation from the wireless transport industry including operator representatives, microwave equipment vendors, integrators and applications providers. It follows the second PoC organized in April 2016, where only partial microwave management model was implemented and demonstrated, moreover additional use cases have been shown.

The following new use cases were implemented and were the subject of this PoC for the purpose of demonstrating the aforementioned applications and presented in this whitepaper:

- Closed Loop automation
- Test automation
- Spectrum management

Some applications developed for the second PoC have been enhanced to support the complete WT model:

- Connection and configuration of new microwave devices
- Detection of aberrances (‘Compare’ application)
- Receiving, displaying and storing of alarm and event information

A standard OpenDaylight (ODL) version was used as SDN controller. Mediators were used for translating the information model to vendor specific configurations.

All vendors implemented the model and completed all the test cases successfully demonstrating the viability of the concept for using a common information model for configuring and management of wireless network elements using open management interfaces.

1 Introduction

The third Wireless Transport Proof of Concept (PoC) took place October 24th through the 28th and was hosted by AT&T at Rutgers University WINLAB laboratory in New Brunswick, New Jersey.

The PoC was supported by representatives from the wireless transport eco system including operators, equipment vendors, integrators and applications providers.

The following equipment vendors participated in the PoC with their microwave or millimetre wave equipment:

- Ceragon (15GHz)
- Ericsson (23Ghz & 80GHz)
- NEC (80GHz)
- Nokia (6GHz & 5.8Ghz)
- SIAE (80GHz)
- ZTE (11Ghz)

The following Integrators and Application Providers provided buildings block and applications:

- Brocade
- Frinx
- HCL
- Highstreet Technologies
- Wipro

Content and organizational support for the PoC was provided by the following Operators:

- AT&T (event host as well)
- Deutsche Telekom
- Telefónica

The third wireless transport PoC was an evolution of the second one, completing the implementation of a common information model (developed in ONF by the Wireless Transport Project) and applying it over a variety of wireless link types and architectures. In the proof of concept the vendors supplied both all-indoor, split mount, and full outdoor configurations. The provided wireless links ranged from 5.8Ghz Unlicensed band to 80GHz high capacity, millimetre wave band. Vendors used the netconf via a mediator or native support on the network element.

The primary goal of the third wireless transport PoC was to prove the effectiveness of a common defined model in a multivendor environment. The goal was achieved through the use applications that exercised multivendor control of wireless network elements through open management interfaces (netconf based).

2 SDN Network Architecture and Configuration

2.1 Overview

The SDN architecture and configuration of the test setup in the third Wireless Transport PoC is illustrated in Figure 2 below.

The architecture identifies the main objects which are target of implementation and subsequent verification: the ODL controller (Beryllium SR2), the mediators, the Netconf interface and the northbound applications.

Network deployment included a single SDN controller, an application layer which implements specific functions that are intended to operate over the network via northbound interfaces and a wireless network layer. The wireless network layer was composed of pairs of devices and mediators and interoperates with the controller via Netconf implementing the Yang model defined by ONF in the context of Wireless Transmission project (TR-532). The mediators were devices specific and proprietary to the vendors.

The developed functional information model was incorporated into OpenDaylight via Netconf/YANG plugins able to populate the MD-SAL data store.

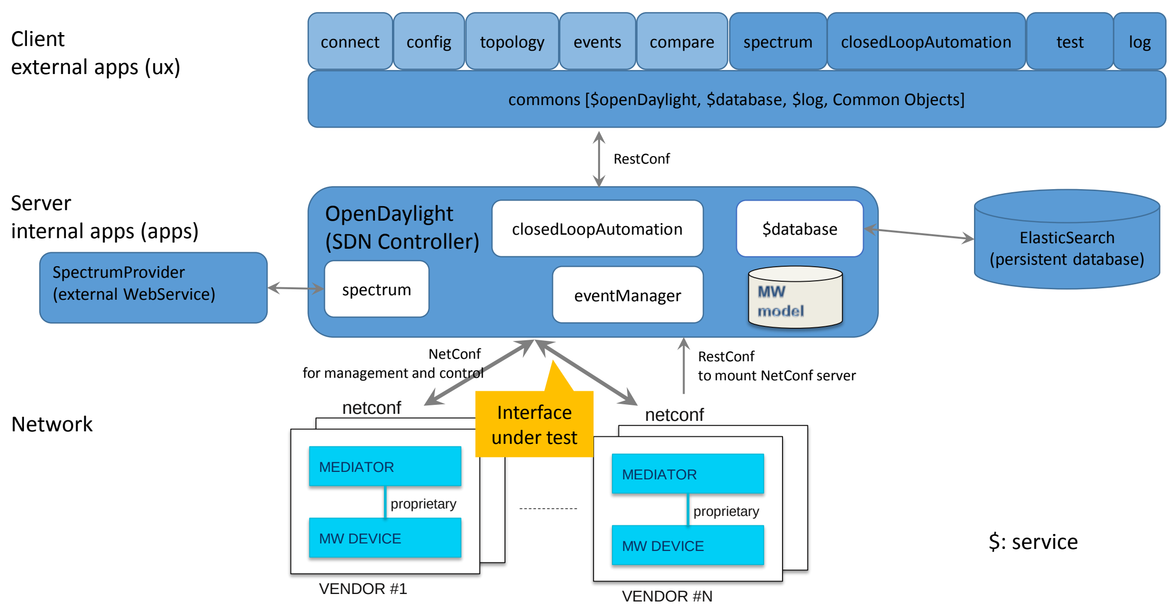

Figure 1: Overview of the SDN Architecture used in the third Wireless Transport PoC

Two ODL installations were tested: one completely open source (downloaded directly from the ODL repository), and one distributed by a partner involved in the PoC (Brocade).

In addition to the mediators required to connect the physical NEs, an NE simulator (“Default Values Mediator”) has been developed completing the activity started for the second WT PoC. It behaves like a generic NE, which allows re-demonstrating the use cases and applications from the PoC without the actual need and installation of physical microwave equipment. This supports Telefonica’s plans on maintaining a server running a demonstration and testing environment for future application developments.

2.2 PoC Test Network Setup

Network elements were connected via real wireless transport links with back-to-back Ethernet cabling (either electrical or optical). Traffic generator was connected to the two end points in order to verify for each use case the status of the traffic and the possible errors or packet losses due to specific commands.

From the control point of view, SDN Controller was instantiated over a virtual machine on Linux server, while 'network element mediators' were instantiated in virtual machine running either on specific hardware (e.g. PC) or in the same server hosting the SDN Controller.

Control channels for each node were out-of-band using local LAN connectivity.

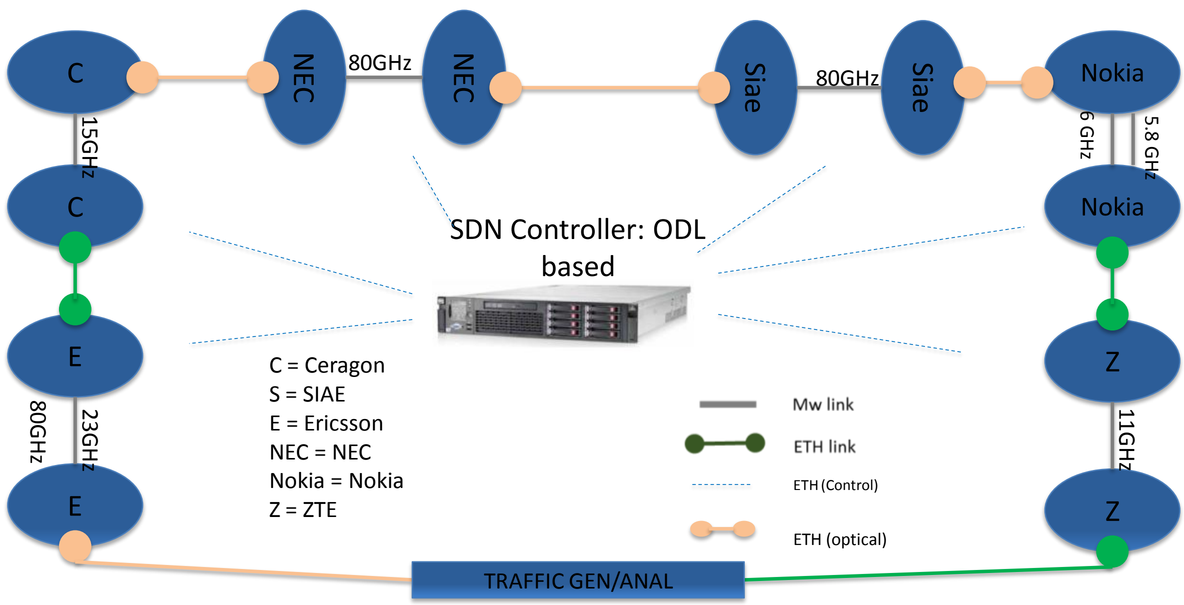

Figure 2: Test bench for the third PoC

Test bench set-up was available some weeks before the PoC execution, allowing a faster integration of the different SW components.

3 Use Cases and Applications

For the third PoC of Wireless transport SDN, some use cases from the second PoC has been refined based on the latest Microwave information model [3]. In addition, new uses cases have been developed and implemented for this third PoC in order demonstrate new wireless transport SDN applications and capabilities illustrating planning and discovery, dynamic view in real time, configuration, discrepancy monitoring and detection, and event handing.

Description of the following enhanced use cases from second PoC as used in this third PoC is detailed in [4]:

- Connection and configuration of new microwave devices
- Detection of aberrances ('Compare' application)
- Receiving, displaying and storing of alarm and event information

The following are the three added uses cases which have been developed and implemented for this third PoC:

- Closed Loop automation
- Test automation
- Spectrum management

Brief description of newly added use cases is provided in the subsections below.

Closed Loop automation

The closed Loop automation use case is developed and implemented in order to demonstrate the capability of the SDN controller to perform automated management functionalities on the network and its elements without the intervention of a human operator. For this purpose, the use case implements a simple task for which the SDN controller (OpenDaylight) executes in response to trigger events.

Three trigger events are thought for this application; external application trigger, timer based trigger or an internal network trigger (either by the SDN controller or an Network elements). The task assigned for this use case is a change of the AirinterfaceName stored in the target NE nodes with a noticeable timestamp indicating the time for which the task is executed.

The external trigger is emulated by applying a push button the GUI demonstration application implemented specifically for this PoC.

The internal trigger is emulated by implementing an application which subscribe to the SDN controller for receiving some specific notification events. In this particular demonstration, the application is registered to receive notifications when a new NetConf server with the capability “MicrowaveModel-ObjectClasses-AirInterface” is mounted into the SDN network. At the receiver of such notification the task is executed accordingly at the target NE.

Test automation

The test automation use case demonstrates an application in which the SDN controller can be used to run tests on the network by executing a set of desired test commends pre-programmed in a test script file and the test results stored in a corresponding logfile for post processing and analysis of the test results. In the PoC, a test script is written to test of a NE in the network under the control of the SDN controller for compliance to the implementation of the ONF wireless IM according to [3].

Spectrum management

The spectrum management use case is used to demonstrate the SDN controller capability in managing the spectrum allocated in its network dynamically. The main purpose of this spectrum management is to reconfigure the allocated frequency channels for each link in the network in order to mitigate high interference conditions by changing operating frequency channels to another with acceptable lower interference level. Change of frequency channel could also be required in response to an external entity (e.g. regulator agency spectrum management and allocation server or database) to evacuate certain frequency channels for other operation. Spectrum management use case is applicable to microwave network operating in unlicensed spectrum, in self-managed block assigned spectrum or in sharing spectrum such as the CBRS 3.5 GHz band in US.

The application implementing the spectrum management use case checks the current assigned and configured frequencies and polarization for each microwave/millimeterwave link and its associated NEs. The application also obtain and maintain information of the NE names and the AirInterface.radioSignalIds under its network control. The application can also access information from a SpectrumProviderService about the expected or planned frequencies. This information can then be used by the application to compare the configured frequencies with the planned Frequencies for each link – in case of a mismatch the application configures the frequencies in the NEs accordingly. Another use scenario for the spectrum management application is if a link (or groups of links) experience high level of interference, the application will reconfigure the allocation of radio channels across the affected links to a newer clean channel that the radio NEs are capable of. The decision and the configuration are all logged in a persistent database. In this PoC the interference conditions is emulated by a push button in the GUI of the spectrum management application.

4 Test Results

Six wireless transport vendors and five integrators and application providers participated successfully in the test. The same south bound interface (Netconf protocol and YANG data models) was used between the OpenDaylight controller and the mediators of all vendors. The interfaces between mediators and network elements were proprietary interfaces which were not considered for testing in this PoC.

The use cases explained in section 3 were successfully tested by performing the following steps for the network elements of each vendor.

After having been started, the mediators announced their network elements to the Controller. The network elements were displayed as “Connected” at the GUI of the Connect application. This application also allowed network elements to be manually connected or disconnected.

The Comparison application showed the planned and actual values of all microwave attributes and highlighted the discrepancies. For the purpose of the PoC discrepancies were provoked by giving “wrong” planned values.

The configuration of the network elements was then manually modified by using the Configuration application. As an example the transmitter of a radio link was switched off. This caused the traffic flow through the chain of network elements to be disrupted (visible at the GUI of the traffic analyzer). The traffic was restored as soon as the transmitter was switched on again.

The configuration changes also triggered the network elements to report events which were forwarded as Netconf notifications to the Controller. The event handling application was used to display these notifications.

Both the closed loop automation application and the spectrum management application demonstrated the overall network view of SDN applications. The closed loop automation application used a timer (simulating the triggering condition) to periodically change the names of all air interfaces in the PoC network. The new values contained the current time stamp so that the modification could be easily monitored.

For the spectrum management application an interference situation was simulated by pressing a button at the GUI. As a consequence the application changed the frequencies of all radio links in the PoC network to new values. The resulting temporary disruption and later restoration of the traffic was again monitored with the traffic analyzer.

The test automation application verified that each mediator complied with the ONF Wireless Transport information model.

5 Conclusions

Operators

The Third PoC has proved to be a significant step towards the releasing of a standard of a common and generic information Model for SDN-enabled Wireless Transport environments, simplifying the operations and control of these network elements, and facilitating the integration of distinct multi-vendor solutions under a common and single control framework. It showed that the information model, effectively covers the different aspects of operating and controlling microwave network element in a SDN network.

It has been demonstrated a unified control and management of six wireless transport vendor products (Ceragon, Ericsson, NEC, Nokia, SIAE, ZTE) implementing the same Information Model (being defined in the context of ONF by the Wireless Transport project, with the participation of those major manufacturers), in an open environment with an OpenDaylight based controller.

It also has demonstrated that this common model can be used to manage and control legacy microwave equipment that currently does not support this information model. That can be done by using an external mediator.

Vendors

The PoC has proved that it is feasible to manage multi-vendor Network Element using the Yang Data models, has been developed by the ONF Wireless Transport project and derive from the above mentioned information model. Moreover, it has been shown that the model effectively generalizes the different aspects of Microwave/Millimeter-wave operating and controlling mechanism, and can be used to operate and control vendor specific Network Elements regardless of their unique implantations.

The PoC has demonstrated how the cooperation in a multi-vendor microwave network could be managed by a single SDN controller. This offers the possibility to operators for developing their own applications on top of an open and modern REST northbound interface, independently from the vendors providing the microwave infrastructure.

Integrators and Application Providers

The demonstrated applications has shown that all vendors implemented the full Netconf common southbound management interface based on a YANG model which includes events handling and that the relevant events are generated as a result of action made by the application.

It also showed that the yang model facilitates the development of reach and variety applications that can control the different aspects of microwave network and to collect a statuses and Performance Monitoring data.

All the applications have been successfully executed over the different vendors equipment. Moreover, some of the applications approached (Via the SDN controller) the different Networks Elements on the same run. It has strengthened the assumption that the information model enables an application that should not be aware of the differences between the Networks Elements.

The choice of OpenDayLight enables the applications to use the inherent North Bound Interface the OpenDayLight generates automatically when a YANG module is introduce to it. It exposes a Restful NBI that derives from the YANG Model. This capability enables the development of application without investing a development effort on the NBI. However, to support other SDN Controllers a development of standard NBI should be consider

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7 References

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