

Software Development Platform for Programmable Heterogeneous Radio Access Networks

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Abstract— The 5G-PPP COHERENT project [1] focuses on developing a next generation unified control and coordination framework for programmable heterogeneous radio access networks. In this short paper, we briefly present the main components of COHERENT architecture. We also provide a description of the current status of COHERENT Software Development Kit (SDK), which is developed based on the 5G-EmPOWER platform [2,3].

Keywords—5G; software development kit; software defined networking; virtualization, network graphs

I. INTRODUCTION

The COHERENT project [1] focuses on developing a next generation unified control and coordination framework for programmable heterogeneous radio access networks. The design of COHERENT, coupling of network virtualization with software defined networking (SDN) facilitates efficient control and coordination operations using an abstracted network view that can be used for network monitoring and optimization purposes, as well as for sharing physical resources among various virtual operators, introducing new business models and enabling new exploitation opportunities. The abstraction of network states and functions provides a base for the development of COHERENT Software Development Kit (SDK), which enables programmable control and coordination in heterogeneous radio access networks.

The COHERENT Software Development Kit (SDK) is a set of software development tools that allows the creation of mobile network applications and services for different resource allocation schemes in different layers/parts of heterogeneous mobile networks. COHERENT SDK is implemented based on the 5G-EmPOWER [2, 3] platform, which is an open toolkit for SDN and Network Function Virtualization (NFV) research and experimentation in mobile networks. The COHERENT SDK defines a set of Application Programming Interface (APIs) enabling high-level control programs to flexibly control and share resources according to network conditions as well as requirements among multiple network services and operators, so as to achieve efficient network utilization. Enabling network programmability in radio access networks in the COHERENT project is expected to encourage innovations in the mobile industry, facilitate the rapid deployment of novel applications and significantly reduce the operating expense (OPEX) for network management at the radio access network side.

In this short paper, we first briefly recall the general COHERENT architecture and terminology in Section II. Furthermore, we introduce the COHERENT SDK and its

relationship with 5G-EmPOWER platform in Section III. Finally, the future work is presented in Section IV.

II. COHERENT ARCHITECTURE

The overall COHERENT architecture [4] is depicted in Figure 1. In the user plane, the *Radio Transceiver (RT)* is a logical radio access entity with full RAN functions. The *Transport Node (TN)* is the entity located between RTs and core network. COHERENT proposes two main architectural components used as control mechanisms.

The *Central Controller and Coordinator (C3)* is a logically centralized entity in charge of network-wide control and coordination among entities in RAN based on centralized network view. C3 could be implemented with distributed physical control instances sharing network information with each other. Sharing network information among C3 instances creates the logically centralized network view and therefore achieves logical centralized control and coordination.

The *Real-Time Controller (RTC)* is a logical entity in charge of local or region-wide control, targeting real-time control operations, e.g., MAC scheduling. It has local network view. It could run directly on one RT or on a virtualized platform and receives monitoring information gathered from one RT or multiple RTs. Control functionality can be delegated to the RTC agent on the RTs. RTC communicates with an RTC agent/RTC agents on one RT or multiple RTs.

III. COHERENT SOFTWARE DEVELOPMENT KIT

The COHERENT SDK is based on the 5G-EmPOWER platform. 5G-EmPOWER is an open toolkit for SDN/NFV research and experimentation in mobile networks. It is worth noticing that in its current implementation the 5G-EmPOWER fully supports 802.11-based WLANs, while support for LTE small cells is currently being added and will be released. Accordingly, the main control entity in COHERENT, namely C3, for both Enterprise WLANs and cellular networks is implemented on the 5G-EmPOWER platform. The initial release of the COHERENT SDK is described in [5].

The 5G-EmPOWER toolkit consists two parts. First part is a reference C3 implementation supporting the COHERENT northbound interface (NBi) [4]. The second part is an SDK implementing the COHERENT semantic model and abstractions [4]. The SDK provides APIs that can be used to implement control and coordination tasks on top of the C3. We remind the reader that an SDK is typically defined as a set of software development tools that facilitate the creation of software artifacts. In this specific case, the COHERENT SDK

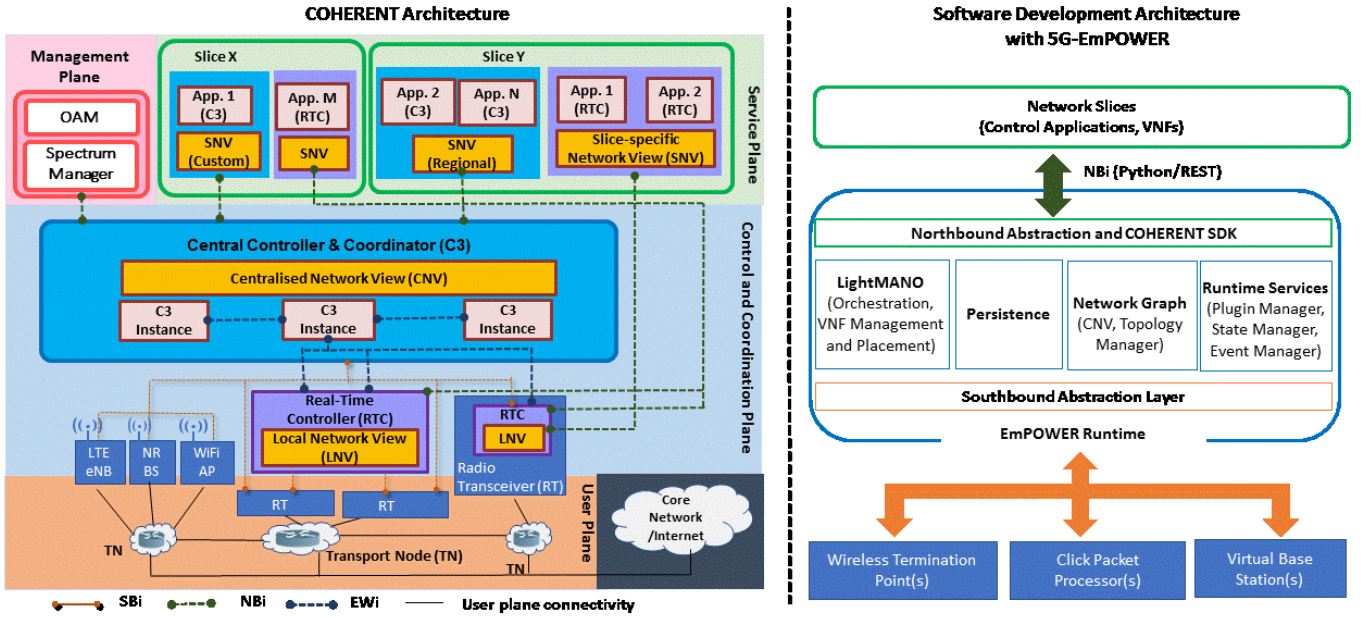


Fig. 1. COHERENT overall architecture and software development architecture with 5G-EmPOWER.

provides programmers with a high-level interface to the programmable mobile networks as opposed to the very low-level interfaces exposed by network elements (i.e. the southbound interface).

Figure 1 shows the mapping between the 5G-EmPOWER and the COHERENT architecture. *C3* maps directly to the *EmPOWER Runtime* while the COHERENT RTs map to the *Wireless Termination Points (WTPs)* (Wi-Fi) and to the *Virtual Base Station (VBS)* (LTE) in the user plane.

In 5G-EmPOWER the physical and virtualized network is abstracted into network slices. Each slice defines a particular network service and consists of a set of Virtualized Network Functions (VNFs) with the associated control logic. Each network slice can be fully customized in order to support the requirements of the service in term of coverage, capacity, latency, and security. We point the reader to [4] for an extensive account on how we address network slicing and multi-tenancy.

The controller implementation leverages the Tornado Web Server [6] as the web framework. The main reason for choosing Tornado is its non-blocking network I/O which allows continuing serving incoming requests, while the others are being processed. In the following, we elaborate on some of the main features of the Controller:

Slicing: The Controller can accommodate multiple virtual networks or slices on top of the same physical infrastructure.

Soft state: The only persistent information stored at the controller is the clients' authentication method and the list of currently defined slices. All the state is kept within the network in a distributed fashion and is synchronized when the network elements connect to the Controller. As a result, the Controller can be hot-swapped with another instance without affecting the

active clients. Moreover, the network itself can still function in its last known state even if the controller becomes unavailable.

Modular architecture: with the exception of the logging subsystem, every other task supported by the controller is implemented as a plug-in (i.e., a Python module).

IV. NEXT STEPS AND FUTURE WORK

In this paper, we introduced the COHERENT SDK, a platform designed to enable programmability in heterogeneous radio access networks. As future work we plan to extend the SDK with a network slicing and spectrum management API. Moreover, we are currently adding support for commercial small cells. Finally, integration with state-of-the-art NFV Management and Orchestration solution is also envisaged.

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