Enabling Offloading in 5G Networks

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***Abstract*— The COHERENT project focuses on developing a next generation unified control and coordination framework for heterogeneous radio access networks. A set of use cases reflect the different perspectives of the COHERENT actors and highlight the benefits and new opportunities that could derive from the overall COHERENT framework. In this paper, we focus on an offloading scenario for load balancing among LTE and Wi-Fi networks.**

Keywords—COHERENT; 5G; use cases; offloading; load balancing; software defined networking; virtualization, network graphs.

I. INTRODUCTION

The COHERENT project [1] focuses on developing a next generation unified control and coordination framework for heterogeneous radio access networks. COHERENT adopts the concept of resource and service virtualization across technology domains, while the key innovation of the project is the development of a unified programmable control framework used to coordinate the underlying heterogeneous mobile networks (LTE and Wi-Fi) as a whole.

The COHERENT coupling of network virtualization with software defined networking (SDN) control facilitates efficient operation using abstract network views (which are referred to as network graphs) that can be used for network monitoring and optimization, as well as for sharing of physical resources among various virtual operators, introducing new business models and enabling new exploitation opportunities. The potentials of network virtualization and SDN could be applied in several domains, such as offloading and load balancing.

Offloading has been proposed as a candidate solution for improving the cellular utilization by delivering data originally targeted for cellular networks via complementary network technologies [2], [3]. This promising solution can significantly lower the operational cost of a network operator, especially when existing deployed infrastructure is exploited.

The paper is organized as follows: Section II presents a set of use case groups that the COHERENT could be applied. Section III briefly presents two main architectural components, which are used as control mechanisms. Section IV focuses on an offloading use case for load balancing purposes.

II. COHERENT USE CASES

The use cases reflect the different perspectives of the COHERENT actors and highlight the benefits and new opportunities that could derive from the overall COHERENT framework. Below, we present a set of use cases where the COHERENT approach could be applied:

Offloading for load balancing: In this use case we consider an open design platform for LTE and Wi-Fi load balancing or/and offloading scenarios based on network information interworking.

Spectrum management*:* Due to the potentially large area to be considered, we identify a set of sub use cases:

- Spectrum sharing within the Coherent architecture;
- Spectrum sharing between microwave links and WiMAX networks, and;
- Spectrum sharing between two TD-LTE networks.

RAN sharing: In this use case we exploit the unique programmability features of OpenAirInterface (OAI) by considering scenarios where the eNodeB is virtualized and supports concurrent operation of multiple Mobile Virtual Network Operators (MVNOs) with specific scheduling principles per operator.

Throughput improvement: In this use case we consider for per-user-throughput improvement using distributed antennas designs (DAS). This paradigm includes deployment of RRH, UE pairing based on a selection transmission technique for improving/maintaining per user throughput and coverage extension.

III. ARCHITECTURAL CONTROL COMPONENTS

COHERENT proposes two main architectural components used as control mechanisms.

The *Central Controller and Coordinator (C3)* is a logically centralized entity in charge of logical centralized 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 instance creates the logically centralized network view and therefore achieves logical centralized control and coordination.

The *Real-Time Controller (RTC)* is logical entity in charge of local or region-wide control, targeting at real-time control operations, e.g., MAC scheduling. It has local network view. It could run directly on one Radio Transceiver (RT) or on a virtualized platform and receives monitoring information gathered from one RT or multiple RTs. It can delegate control functionality to the RTC agent on the RTs. RTC communicates with an RTC agent/RTC agents on one RT or multiple RTs. A more detailed analysis for COHERENT architecture is presented in [4].

IV. Load Balancing and Offloading Scenario

The unprecedented increase in the mobile data traffic volume, as well as the need for network coverage expansion are major concerns for mobile operators. Hence, it is becoming important to be able to offload data from the mobile network to the Wi-Fi network. Today 20% of data is landing on Wi-Fi in outdoor environment while 60% of data is landing in Wi-Fi in indoor environments. In highly populated areas even an 80% of data is landing in Wi-Fi networks. Therefore, the offloading from an eNodeB to Wi-Fi AP can lead to be able to load balance the overloaded commercial eNodeBs.

To show in COHERENT that services like video and voice can be offloaded from a mobile to a Wi-Fi network which can lead to load balance the mobile and cellular networks. Today, in commercial networks it has been proven that these services like voice over LTE (VoLTE) and video over LTE (ViLTE), which are IMS-based services that can offer mobility and value added services, can be offloaded from a commercial mobile network to Wi-Fi network and have VoWiFi and VIoLTE respectively. The offloading process for application services is shown in Figure 1.

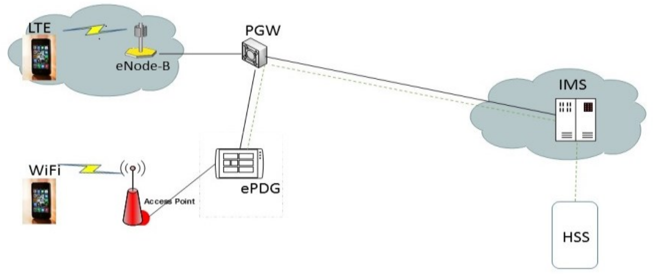

Fig. 1. The offloading process between eNodeB and WiFi

The requirements at the process of load balancing between eNodeB and Wi-Fi can be as:

- A common user interface when he is using a service through the mobile or Wi-Fi network.
- Seamless service connectivity between the two networks.
- The latency at the offloading-load balancing process should be minimum.

The abstraction parameters that can be utilized from the physical interface are the basic ones for example for Wi-Fi are:

- RSSI, access point transmit power, frequency bandwidth, etc., while for the mobile interface the abstraction parameters can be CQI, QCI, BW, Pt, etc.
- Available Node Capacity = Available bandwidth x Spectral efficiency
- Available bandwidth (in Hz) indicates the amount of frequency resources that are available at RAN node. Available bandwidth is also impacted by backhaul load, control channel capacity, HW load, and current QoS satisfaction requirements.
- Spectral efficiency (in (bits/s)/Hz) is the average bit rate that can be transmitted over a given bandwidth. It is a measure how efficiently frequency resources are utilized at RAN node. Both available bandwidth and spectral efficiency are measured and averaged before reporting. Reporting and averaging is executed in time-scale of seconds.
- SINR: The channel measurements are technology-specific. LTE UE measurements are RSRP and RSRQ, while Wi-Fi measurements are RSSI, respectively. Technology-specific measurements should be abstracted to SINR be comparable.

The connection of the abstractions and the mapping of the network graph to the application layer is shown in Figure 2.

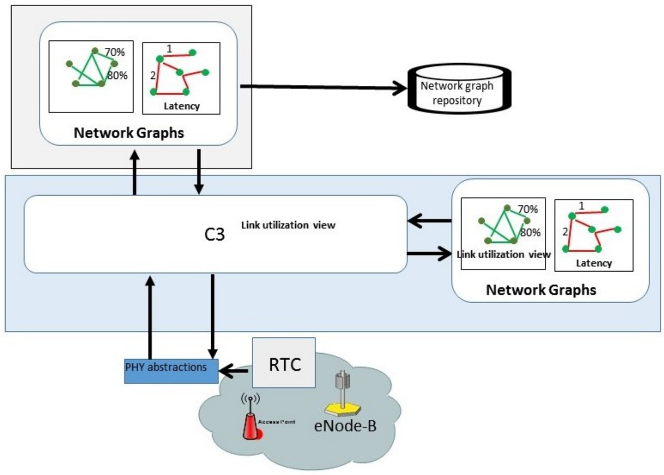

Fig. 2. Network graph mapping to the upper layer

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