Spectrum and RAN Sharing in 5G Networks – a COHERENT Approach

Dorin Panaitopol, Antiono Cipriano
Thales Communications and Security, Paris, France

Karol Kowalik
INEA, Poznañ, Poland

Kostas Katsalis, Navid Nikaien, Chia-Yu Chang
EURECOM, Sophia Antipolis, France

Heikki Kokkinen,
Fairspectrum, Helsinki, Finland

Tao Chen
VTT, Oulu, Finlnad
Paris, France

George Agapiou
OTE, Athens, Greece

Fang–Chun Kuo
Travelping, Germany

Adrian Kliks
Poznan University of Technology, Poznan, Poland

***Abstract*—This paper discusses the challenges associated with the spectrum and radio access network (RAN) sharing in the next generation wireless systems. The considered scenarios assumes the virtualization of the network, where numerous metrics characterizing various features are abstracted and represented in form of a network graph. The latter is used by the by the dedicated entity, called centralized coordinator and controller, for realization of the sharing functionality. This paper addresses the use cases considered within the COHERENT project.**

***Keywords*—spectrum sharing; RAN sharing; network virtualization; network slicing**

I. Virtualization of Resources

The coupling of network virtualization with SDN control facilitates efficient operation using abstract network views (which are referred to as network graphs) that can be used for a) network monitoring and optimization and b) for sharing of physical resources among various virtual operators, introducing new business models and enabling new exploitation opportunities. In that perspective the key challenge is to verify the above mentioned opportunities in practical realizations. Within the COHERENT project[1], which deals with the abovementioned research challenges, several use cases have been identified, and the following two have been selected among others for implantation in the integrated testbed environment: spectrum sharing and RAN sharing [1]-[2]. In the following we present these two use cases in more detailed way.

[1] Coordinated Control and Spectrum Management for 5G Heterogeneous Radio Access Networks, COHERENT, Grant Agreement No. : 671639, http://www.ict-coherent.eu/

II. Use Cases for Spectrum Sharing

Due to the potentially large area to be considered, we scope and analyze the spectrum sharing use cases in the following sub use cases: spectrum sharing within the COHERENT-controlled and non-COHERENT-controlled network. The considered testbed for spectrum management in the virtualized scenario is presented in figure below.

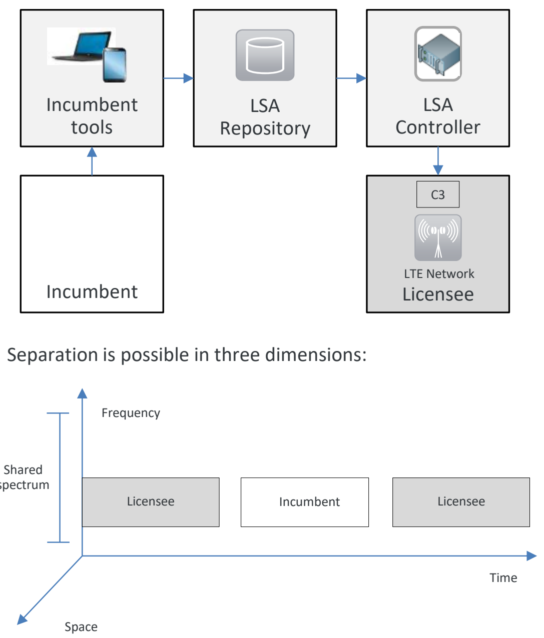

Fig. 1. Realization of the spectrum sharing testbed

The spectrum usage of the Incumbent user is managed by the Incumbent tools which may rely on informing incumbent or it may include a sensing function. The LTE mobile network with commercial components is Licensee. Spectrum sharing is implemented by Licensed Shared Access (LSA) Controller and LSA Repository. The system demonstrates LSA spectrum sharing with the COHERENT architecture. The spectrum is sliced in a way that whenever the spectrum at a certain location is not in use by the incumbent, it can be utilized by MNO for mobile broadband. Automatic deployment and evacuation of such a secondary network is covered by this test case. Separation is possible in one (or more) of the three dimensions, i.e. in time, space and frequency domain.

An important aspect which needs to be addressed when sharing spectrum is how to deal with legacy radio technologies. Legacy hardware may expose only limited functionality making it difficult to control in order to facilitate spectrum sharing. In this use case we demonstrate limitations and feasibility of spectrum sharing schemes when dealing with legacy hardware. For this use case we exploit two commercial networks: a) WiMAX and microwave network (located in Poland) and b) TD-LTE network (located in Greece).

III. Use Case for Network Slicing

A network slice is a logical network that comprises a set of Network Functions and the corresponding resources required to provide End-to-End support for specific network services, network applications and radio configurations of wireless access systems. The network services may be specific to some particular use cases or business applications. A network slice can span all domains of the network: software programs running on cloud nodes, specific configurations of the transport network, a dedicated radio access configuration, as well as settings of wireless access entities. Different network slices may contain different network applications and configuration settings, and it can be shared by multiple (virtual) network operators.

A network operator may provision a network slice to a customer, e.g. a corporate or a government agency, in order to isolate the communications and to provide extended robustness, with differentiated quality of service per slice (URLLC, eMBB or MTC). Then, different scheduling operations may apply per network slice basis, which means a complete separation of slices not only at Core Network (CN) level but also at Radio Access Network (RAN) level, including PHY and/or MAC layers. The operator may also decide to differentiate between different subgroups of the same customer, with respect to their service requirements for voice, video, or small data transmission. For example, different teams of public safety officers may need to be connected to different instances (with different characteristics in terms of security and/or robustness, and/or latency) of the network slice reserved for that public safety agency. Then, the slice could scale up until a certain degree, but if more capacity is required the network could instantiate an additional slice (e.g. a spare slice). In the case when an additional slice is created from already used resources, it may be necessary to preempt it, which may increase the number of blocked services and decrease the QoS for some other existent users, which has to be avoided to a certain extent. Another challenge is to define the size of the slice and to find the trade-off between the number of users and the number of slices, as a function of service type.

In the COHERENT framework we define a complete set of parameters to be used for APIs on the south-bound and north-bound interface in order to instantiate, configure and control the slices. The definition of such APIs and their time-scale is useful explicitly for RAN re-configuration with respect to both operator and user needs, in a very flexible manner. Different phases can be involved, such as time-constrained phases (but not-time-critical, such as slice preparation or slice instantiation phases) or more time-critical (such as run-time phase where scheduling operation may be involved). The time-constrained phases may refer to preparation phase which may correspond for example to the creation of a slice, or may refer to instantiation phase which may correspond for example to the configuration of shared/dedicated resources to be used per slice. In any case, both time-constrained and time-critical phases may require different instantiation procedures and different control levels, by different entities. Another challenge is for example to identify those entities and impact with respect to legacy equipment.

IV. Summary

The experimental evaluation of the COHERENT platform will rely on the implementation of the test case specifications, the development of the COHERENT solution and the COHERENT testbed deployment. The test cases which have been specified in this paper, namely Spectrum Sharing and RAN Sharing are specified to indicate the expected capabilities of the overall COHERENT platform. A number of challenges must be addressed towards building the integrated COHERENT solution. With respect to the spectrum and RAN sharing, with particular considerations towards Network Slicing concept and considering that the physical infrastructure is shared among several operators, one operator cannot interfere with actions from another operator using the same physical infrastructure. In order to address this challenge, centralized coordination and control mechanisms must automate and guarantee isolation between different virtual infrastructure operators (i.e. MVNOs) and consistency / integrity of the network at any given instant (e.g. several virtual network operators may lead to inconsistencies of the network due to malicious configurations by one of them).

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References

[1] COHERENT, Deliverable D2.1, "Use cases and architecture", delivered M4

[2] COHERENT, Deliverable D2.2, "System architecture and abstractions for mobile networks", delivered M12