A SDN/NFV based C-RAN architecture for 5G Mobile Networks

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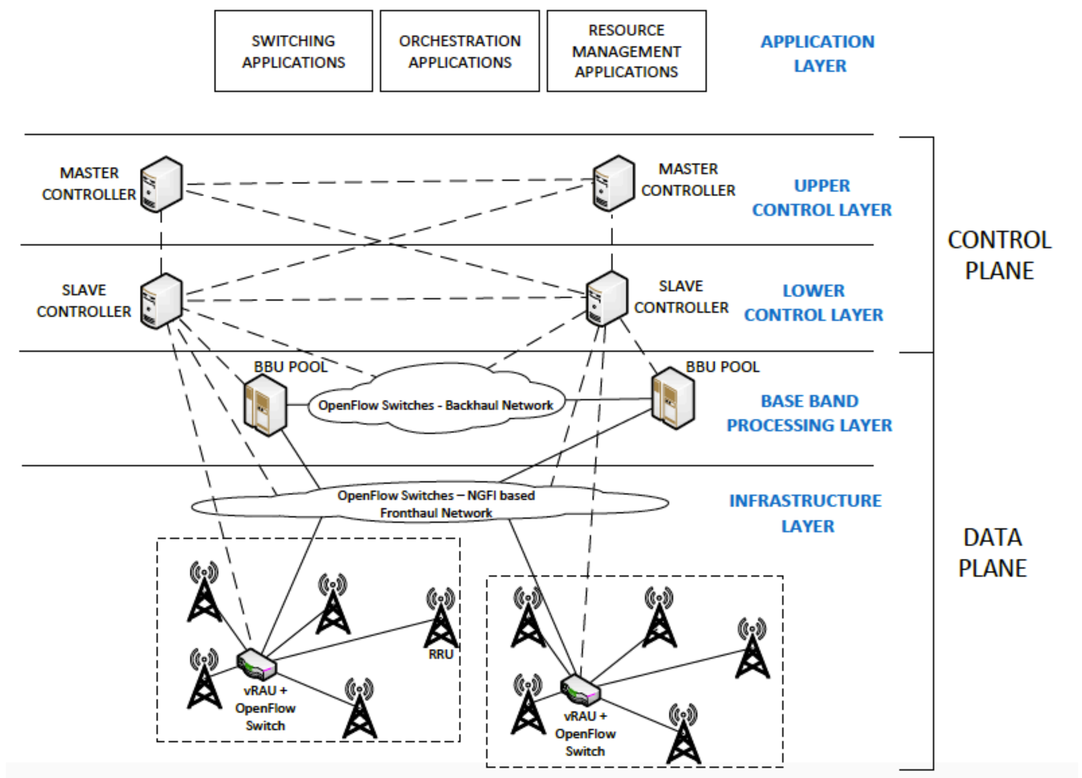
Research topic

The scope of the research activity is to investigate the impact of the Software Defined Networking (SDN), Network Function Virtualization (NFV) in future mobile networks, focusing on Radio Resource Management (RRM) in Cloud/Virtual Radio Access Networks (C/V-RAN). A RAN architecture redesign to address critical elements in resource management and to achieve the 5G mobile network requirements is needed. C-RAN, SDN, NFV technologies are recognized as key enabling solutions for the future mobile networks. As contributions a hierarchical layered software-defined architecture for future 5G networks and Slicing Orchestrator are proposed.

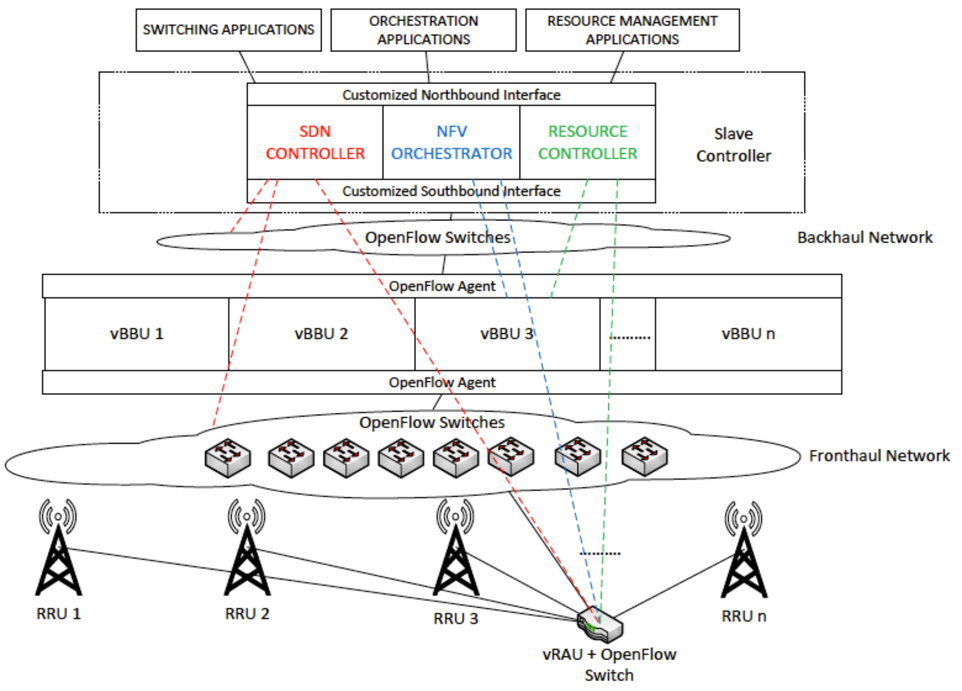
Proposed SDN/NFV C-RAN Architecture

A hierarchical layered architecture for future 5G networks is proposed. The solution exploits the SDN/NFV features, in order to deploy a programmable and virtualized architecture. We aim to propose new features facilitating the SDN/NFV integration in wireless/mobile environment. The considered scenario concerns a Public Land Mobile Network (PLMN) area. The hierarchical architecture includes different logical layers, as shown in figure. A brief description of the proposed architecture is provided. We design the data plane as the infrastructure and baseband processing layers as a NGFI based architecture, deploying an edge aggregation unit inspired by the RAU. This assumption permits to deploy an Ethernet-based fronthaul network. In order to deploy a flexible, programmable and virtualized RAN, as novelty we propose to softwarize and to virtualize the RAU. The softwarization is achieved through a dedicated agent on the RAN entities. The agent, in a Software Defined fashion, interprets the controller directives. This enhancement permits to apply configurable and dynamic functional splitting options and to manage the slicing.



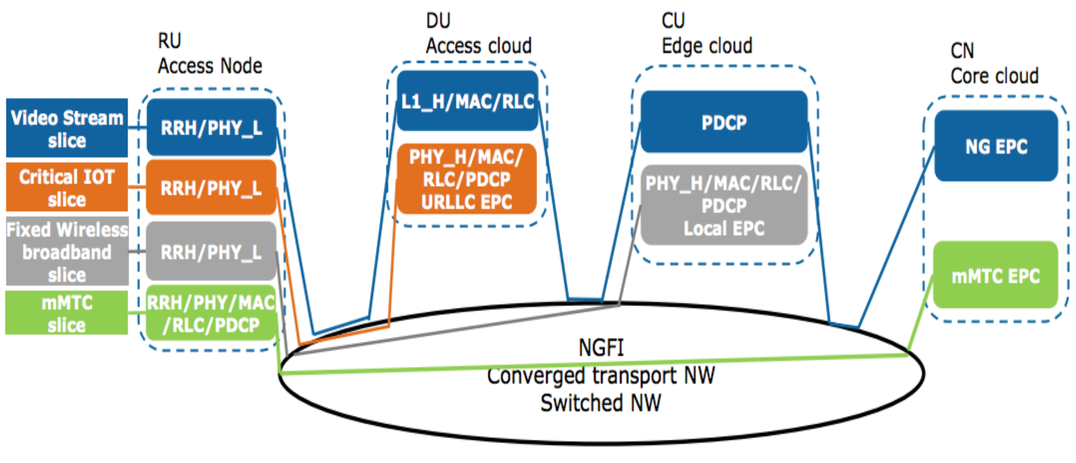
Proposed Controller

The control layer is composed of a set of logically centralized but physically distributed Slave Controllers and Master Controllers. Master Controllers, forming the upper control layer and located in remote sites, manage a group of macro cells, keep into account long-time scale and less fine grained parameters, while acting as reference entities for Slave Controllers. Slave Controllers, forming the lower control layer, located in edge sites, as opposed to Master Controllers, keep into account short-time scale and more fine grained parameters, while acting as management entity for a group of cells. As shown in figure, the proposed Slave Controller focuses on three different features. The corresponding three logical areas are: the SDN Controller, the NFV Orchestrator and the Resource Controller. We design the SDN Controller logical area as strictly related to the particular designed fronthaul network, enabling a programmable forwarding in fronthaul network, both in Single-RAT and in Multi-RAT RAN. The NFV Orchestrator logical area is designed in order to dynamically allocate computational resources. The Resource Controller logical area is designed to allocate radio resources on the basis of instantaneous requirements in terms of achievable capacity, required data rate and link state, through the related resource management algorithms, implementing a dynamic slicing.



Proposed Slicing Orchestrator

We design the Slicing Orchestrator in order to fulfill the specific requirements related to different types of communications, e.g., eMBB, URLLC and mMTC. The softwarized RAN entities sent reports regarding the RAN state to the controller, in order to construct an overview of the RAN state in terms of locations, type of service and QoS parameters related to each specific UE. The Slicing Application, running on top of the Slicing Orchestrator, takes these reports as input parameters, dynamically computing the most suitable functional splitting option. Exploiting these outputs, the controller dictates optimum choices in terms of forwarding rules, resource allocation and virtual function instantiation/migration related to the chosen functional splitting option. The mapping between the slicing request and the related optimal choices could be performed creating on the fly a configuration or imposing a configuration used in the past, working in a learning-based fashion.



Work in progress and future goals

We design a testbed setup through the OpenAirInterface (OAI) simulation and emulation platform, deploying the RAN entities in a virtualized fashion. The OAI platform is an open source software platform provided by the OpenAirInterface Software Alliance. In particular, the related code is written in C, running on Linux operating system. The OAI platform permits to prototype and to test new 5G features based on an open-source software-based implementation of the Long Term Evolution (LTE) network protocol stack. The LTE RAN part is implemented in the openairinterface5g module and contains the eNB and UE related code, whereas the LTE Core Network part is implemented in the openaircn module. The various configuration options permits to deploy an experimental setup exploiting the three OAI elements (OAI UE, OAI eNB and OAI EPC) in a software-based solution or in a real environment. We deploy the proposed data plane through the openairinterface5g module and the openaircn module in two different virtualization technologies, e.g., Virtual Machines (VMs) and Docker Containers. We implement the proposed control plane through the SDN controller available on the OAI emulation platform, namely FlexRAN, by making the appropriate enhancements. In future works we aim to evaluate the propose SDN/NFV C-RAN architecture and the Slicing Orchestrator, deploying the RAN entities, namely OAI UE and OAI eNB, by means of USRP devices, in order to test radio resource managements applications in a real-time fashion.

Publications

- G. C. Valastro, D. Panno and S. Riolo, "A SDN/NFV based C-RAN architecture for 5G Mobile Networks," *2018 International Conference on Selected Topics in Mobile and Wireless Networking (MoWNeT)*, June 2018, pp. 1-8.
- G. C. Valastro, D. Panno, "A Service-oriented RAN slicing learning Orchestrator based on SDN/NFV," *Submitted*
- E. Catania, A. La Corte, D. Panno, G. C. Valastro, "Evaluation of IoT Privacy in Ultra-Dense Networks," *Submitted*