# SDN/NFV in future mobile networks
# Radio Resource Management in Cloud Radio Access Networks

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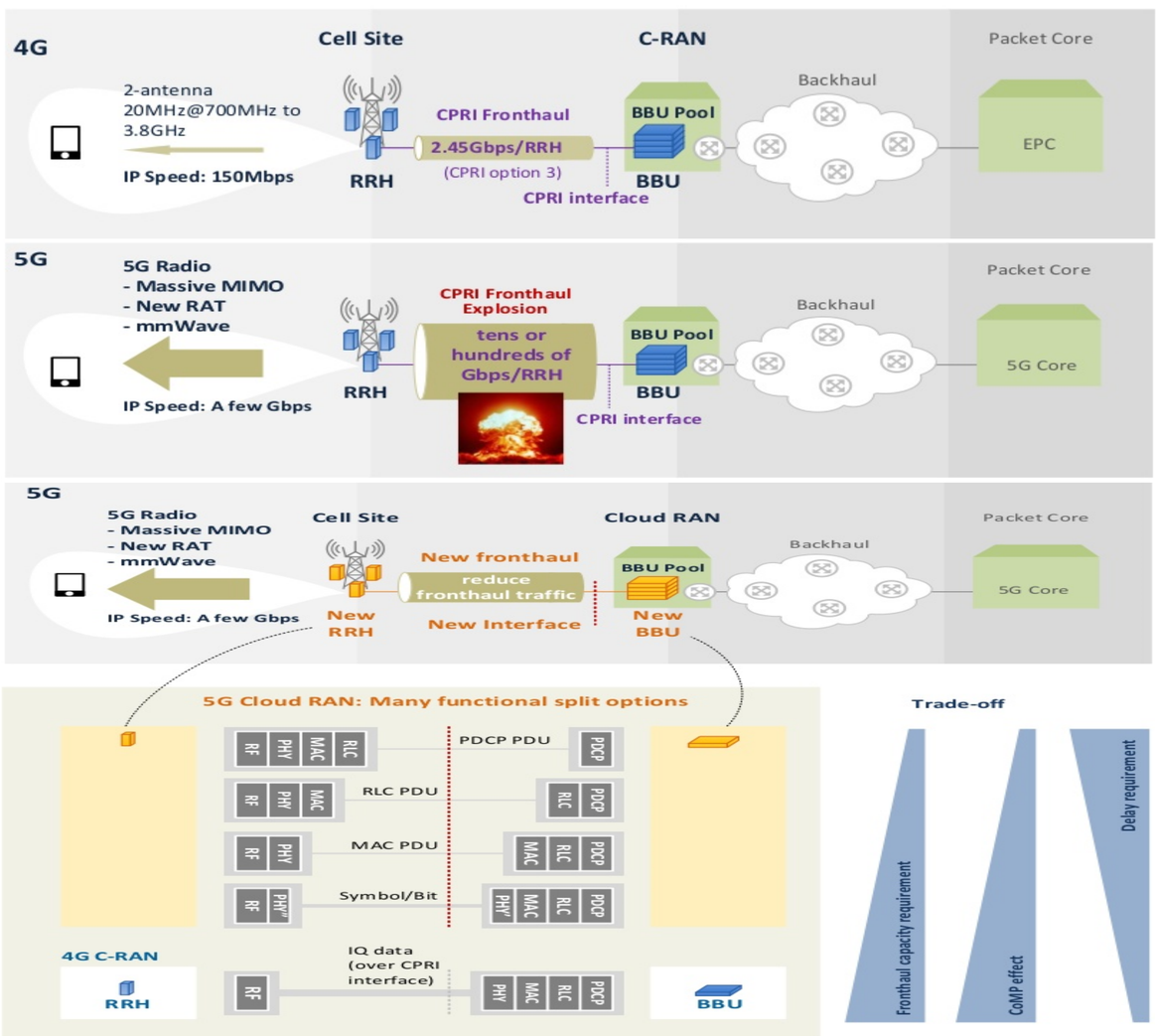
## Research topic

The research activity focuses on Software Defined Networking (SDN)/Network Function Virtualization (NFV) in future mobile networks and Radio Resource Management in Cloud/Virtual Radio Access Networks. C-RAN (Cloud-Radio Access Network) is a new mobile network architecture, which has as its main feature the baseband processing resources centralization in remote locations, called BBU (Base Band Unit) pool, and the radio functionalities RRH (Remote Radio Header) still placed in edge locations. A novel architecture design for Radio Access Networks (RAN) is needed to address critical elements in resources management and to achieve the fifth-generation mobile networks performances. 5G key requirements cannot be achieved without new key features as network slicing, network virtualization, new radio interface/architecture design and radio resources coordination. SDN/NFV are recognized as the enabling technologies to achieve 5G requirements in terms of high throughput and low latency. A new SDN/NFV based architecture for RAN, to address critical elements in radio resources management is proposed.

## C-RAN evolution

The C-RAN scenario is the evolution of the traditional RAN scenario. In traditional RAN, BBUs are located in a distributed mode (co-located with related RRHs). The BBU centralization leads to BBU Pools, where base band computational resources are pooled in a unique location, still hardware-based, namely Centralized-RAN. In a further evolution of Centralized-RAN, BBUs are not only centralized but also virtualized and coordinated by a centralized entity, in order to optimize resource allocation. Generally, in a fronthaul link of a traditional RAN scenario, the interface between RRHs and BBUs is a Common Public Radio Interface (CPRI). The evolution of RAN architecture leads to an evolution of fronthaul and interface designing, since CPRI was developed for local link between BBU and RRH in antenna sites. In addition, 5G bandwidth requirements result in a fronthaul bandwidth of several Gbit/s and in strict delay requirements, so traditional fronthaul and CPRI are not proper solutions.

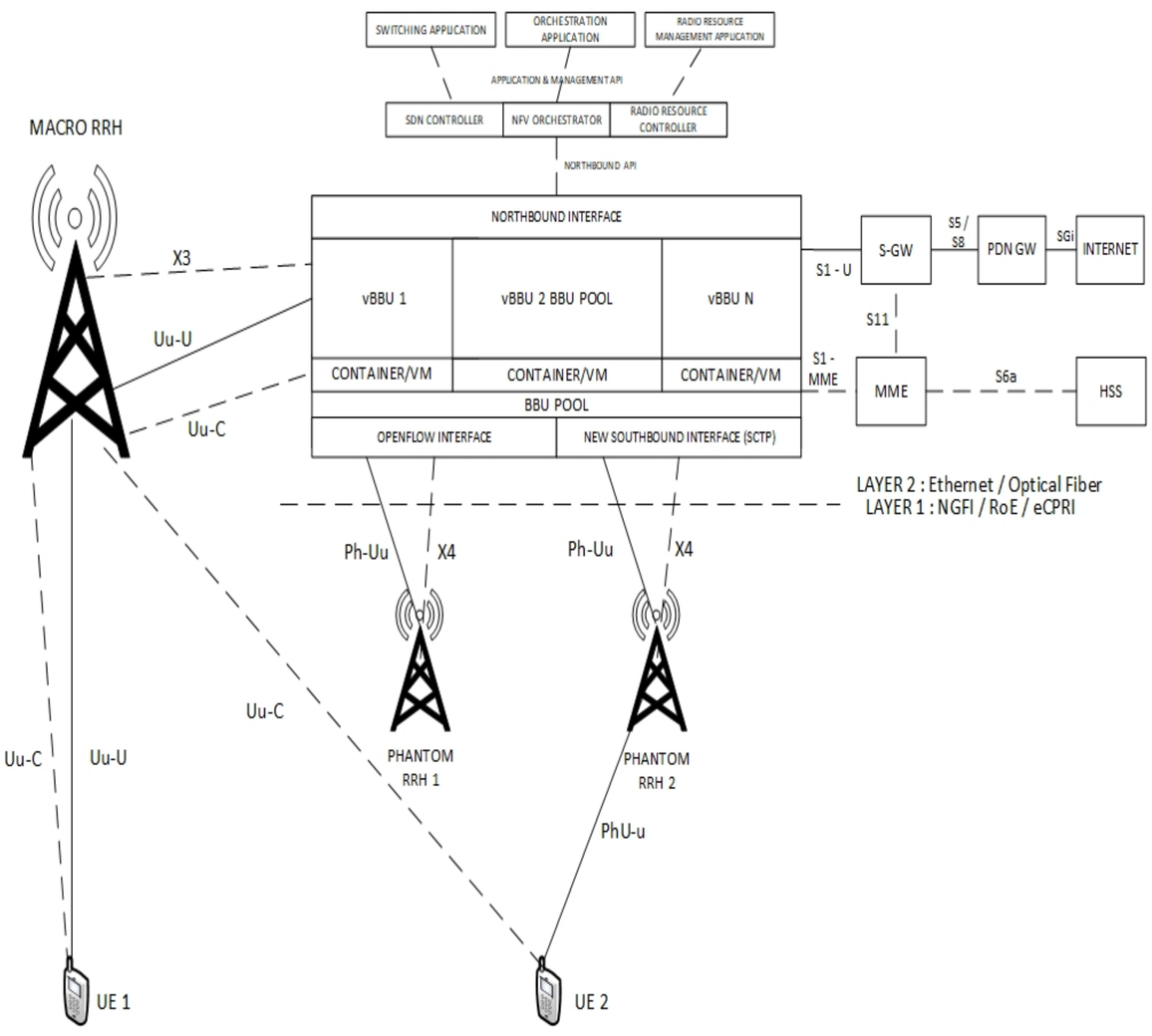



## Proposed Architecture

Software Defined Networking focuses on decoupling control and data plane, Network Function Virtualization performs the abstraction of functionalities from the underlying hardware. Exploiting NFV features and an efficient Ethernet, fiber or microwave fronthaul lead to Cloud-RAN or Virtual-RAN, a solution in which BBU resource pool are also virtualized upon commodity servers. In this research activity a new software-defined architecture for future 5G networks is proposed. SDN and NFV, combined with new RAN and core designing, will be the building blocks of 5G networks. The solution proposed mainly focusing on radio resource allocation and management. SDN/NFV features permit to deploy a programmable and virtualized architecture, in which the data plane is composed of software-defined radio access network (SD-RAN), as a set of SD-Base Stations (SD-BSs) and software-defined core network (SD-CN), as a set of SD-Switches (SD-Ss). The control plane is composed of a set of SDN controllers, each controller takes care of several management aspects concerning a single macro-BS, performing the various functionalities through the SDN controller capabilities. The data plane becomes programmable implementing an Openflow interface and an Openflow agent upon radio access network entities (radio transmission points and user equipments) and fronthaul/backhaul switches. In particular, our proposed controller, focusing on three main features, can be considered as three logical controllers:

- SDN Controller
- NFV Orchestrator
- Radio resource management Controller

On top of our proposed controller run different applications deploying switching, orchestration and radio resource management algorithms.




## Experimentations and results

SDN/NFV enhancements will permit to deploy a programmable RAN, in order to coordinate Multi-RAT base stations (LTE, mmWave), WLAN APs and to implement optimized algorithms for resource management. We are implementing a programmable and virtualized architecture for RAN to deploy SDN/NFV enhancements and to test our proposed radio resource management algorithms, in a real-time-like environment. We realized a first software defined implementation of the proposed LTE RAN architecture trough ns-3 simulator. In particular, we configure and deploy, in order to realize these enhancements, two different ns-3 modules, known in literature as LENA ns-3 LTE Module and OpenFlow 1.3 Module. The LENA ns-3 LTE Module permits to simulate a LTE RAN / LTE-EPC standard architecture. The OpenFlow 1.3 Module is an Openflow based module, deploying the OpenFlow 1.3 protocol in ns-3 simulation model. First results demonstrate the Openflow integration in LTE simulation environment. Future goals are integrating and deploying Software Defined Radio as real-time-like LTE RAN entities.