Virtualizing the LTE Evolved Packet Core (EPC)

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The EU FP7 Mobile Cloud Networking research project [1], is focusing on the use of cloud computing concepts to achieve virtualization of the 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) system. In particular, the integration of cloud computing benefits in an LTE system can be realized by: (1) extending the cloud computing concept beyond the typical (*macro*) datacenters towards new smaller (*micro*) datacenters that are distributed within the E-UTRAN (Evolved UMTS Terrestrial Radio Access Network) and the EPC (Evolved Packet Core), and (2) deploying and running cloud-based (*virtualized*) E-UTRAN, denoted as RAN as a Service (RANaaS), and EPC, denoted as EPC as a Service (EPCaaS). This creates the capability for mobile operators to use Network Function Virtualization (NFV) concepts [2] in order to virtualize and decentralize their core network to be able to cope with the upcoming traffic demands. The most important cloud computing principles integrated in this virtualized LTE system are the support of **on-demand provisioning** of LTE components and **on-demand elasticity**, allowing the virtualized LTE components to scale automatically, based on the data traffic load that they need to support. This scaling process can be controlled by real-time monitoring, or by predicting the mobility of LTE users as well as the bandwidth (data traffic) they are going to generate on certain locations and future moments in time.

The objective of this presentation is to demonstrate the feasibility of on-demand creation of cloud-based elastic mobile core networks, along with their lifecycle management. For this purpose, the presentation focuses on the key elements to realize the architectural vision of EPC as a Service (EPCaaS), see [3], which is an implementation option of the Evolved Packet Core (EPC) as specified by 3GPP specifications, and which can be deployed in cloud environments. To meet a number of challenging requirements associated with the implementation of an EPC mobile core network over a cloud infrastructure, this presentation discusses a number of different options, for implementing EPC in a cloud computing environment and providing it "as a Service" (aaS), each with different characteristics, advantages and disadvantages.

Several high level virtualization can be distinguished. However, in this presentation a set of considerations regarding the suitability for running the specific 3GPP EPC functions in a cloud infrastructure were identified, which resulted into two high-level virtualization models:

- Full virtualization, where all the control plane and user plane functional entities are implemented in Virtual Machines (VMs). The user data must "traverse" the hardware, hypervisor and Operating System of the VMs. The routing and processing of the user plane is fully "contained" in the cloud, controlled and managed by the MCN Management and Orchestration framework.
- Partial virtualization, where only control plane functional entities are implemented in VMs, while user traffic is forwarded and handled by high performance hardware switches. The MCN orchestration framework, as described in [4], manages the control plane VMs, and controls the forwarding of user plane on the hardware switches, for example using SDN (Service Defined Networking), e.g. OpenFlow, see [5].

These two approaches are in line with the original design of EPC in clearly separating user data processing functional entities, i.e., S-GW (Serving Gateway) and P-GW (Packet Data Network Gateway) from control plane functional entities, e.g., MME (Mobility Management Entity), that are responsible for user mobility management, location update, security, and data session set-up. Today, both types of entities are typically implemented in hardware based devices, but specialized for the different types of processing.

The presentation will focus on the implementation options associated with the "Full Virtualization" approach, in order to demonstrate that both throughput-demanding services and control/latency sensitive/computational-intensive services can be supported over cloudified mobile core networks.

Finally, a thorough analysis comparing the different implementation options is also presented.

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