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# Towards an open source architecture for multi-operator LTE core networks

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ABSTRACT

The deployment of a new mobile telecommunication operator and its operation can lead to very high costs and a long entry time to business market. Sharing LTE network infrastructures and adopting network virtualization technologies are of paramount importance to reduce both capital and operational costs of future mobile networks. However, the number of openly available and realistic implementations to study and enhance such sharing technologies is simply inexistent. This paper proposes an architecture for enabling the sharing of Long Term Evolution (LTE) infrastructures based on Multi-Operator Core Network (MOCN), a well-known specification where different evolved Node B (eNB) base stations are shared among multiple mobile telecommunication operators in order to reduce capital (CAPEX) and operational (OPEX) costs. Technical details of the proposed architecture are described in this contribution. The proposed architecture has been implemented and validated. This contribution constitutes the first open source implementation available of an LTE-Emulator with infrastructure sharing capabilities. It also provides a complete empirical study of the effects of sharing eNBs between different providers. Results show an average overhead around 1.5% when sharing technologies are being utilized whereas the reduction of capital costs is ranging between 50% and 87% for a scenario where 8 telecommunication operators are sharing the infrastructure.



## 1. Introduction

The small number of players that attempt to enter in the mobile telecommunication market (a.k.a. telcos) is directly related with the very high costs associated with the acquisition and deployment of telecommunication infrastructures. While the current existing telcos continue to expand and improve their existing infrastructures in order to cope with the growing users' needs, strategies to enable the reduction of capital and operational expenditures are required to keep pace with such growing demands.

Indeed, along the years, telcos have been mainly relying on their proprietary resources (e.g. base stations, radio spectrums, transmission lines, and core networks) as well as a variety of evolving technologies (from 2G/GSM to 4G/LTE) to offer satisfactory communication services to their users. Among the different mobile networking technologies, LTE-Advanced (Long Term Evolution-Advanced) constitutes the latest and most advanced technology for mobile telecommunication operators.

Typically, the deployment of a new mobile telco requires the replication of the entire expensive mobile network infrastructure. To tackle this issue, network virtualization and technologies for infrastructure sharing can play important roles in reducing the deployment and operational costs of future mobile telcos.

This paper presents a new architecture for sharing the Evolved Node B (eNB) – the key element in the LTE architecture acting as intelligent base station responsible of the control of radio communications. The new architecture is based on the Multi-Operator Core Network (MOCN) standard; a 3GPP infrastructure sharing model where different telcos share the same Radio Access Network (RAN).

The main contributions of this paper are: (1) an approach for implementing LTE eNBs sharing, therefore reducing OPEX for new deployments and increasing competitiveness in the business market; (2) the design, development, and validation of the first open source implementation available for emulating LTE architectures with MOCN capabilities; (3) a complete empirical study of the performance and scalability implications of sharing LTE infrastructures among different telco providers. These results provide valuable insights to new mobile telcos wishing to make

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informed decisions about the possibility of adopting infrastructure-sharing technologies.

The rest of the paper is organised as follows: Section 2 gives background information about the LTE architecture and sharing technologies for mobile infrastructures. Section 3 presents a review of the state-of-the-art in relation to LTE infrastructure sharing technologies. Following that, Section 4 introduces the proposed approach to achieve the MOCN LTE infrastructure sharing architecture. Section 5 describes the implementation aspects of the proposed architecture. Section 6 presents and discusses the validation results carried out over the prototyped architecture. Finally, Section 7 presents our conclusions and a highlight of future work.

## 2. Background information on the LTE architecture and mobile infrastructures' sharing

### 2.1. LTE architecture overview

Fig. 1 shows an overview of the latest LTE-Advanced architecture and its main components. The LTE architecture is defined by the 3rd Generation Partnership Project (3GPP) (3rd Generation Partnership Project, 1999) where telecommunications standards are unified by their development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, and TTC) and provide the specifications to build up such technology. Indeed, LTE-Advanced is the latest and most advanced technology for mobile telco infrastructures, where the radio interface has been completely redesigned and does not constitute a mere evolution of GSM, UMTS, or HSPA. The main enhancements provided by LTE-Advanced are related to high spectral efficiency, high peak data rates, short round trip time, as well as flexibility in terms of frequency and bandwidth. The highest theoretical peak data rate in the uplink is 75 Mbps, whereas the downlink data rate is 300 Mbps.

The main components of the LTE-Advanced architecture are

- User Equipment (UE): The mobile phone used by end users.
- Evolved Node B (eNB): An intelligent base station responsible of controlling radio communications with multiple devices within the cell, in addition to handling handover decisions, admission control, and cell control, among other things.
- Mobile Management Entity (MME): It handles the signaling related to mobility and security operations. It is a key component of the control plane of the network.
- Home Subscriber Server (HSS): It is a database where all mobile users' related information is stored. Examples of information stored in the HSS includes: the International Mobile Subscriber Identity (IMSI); Encryption Keys; Invoice Details; and Subscription Details.
- PDN Gateway (PGW): It is responsible for IP address allocation to UEs. It also acts as an anchor between 3GPP and non-3GPP technologies.

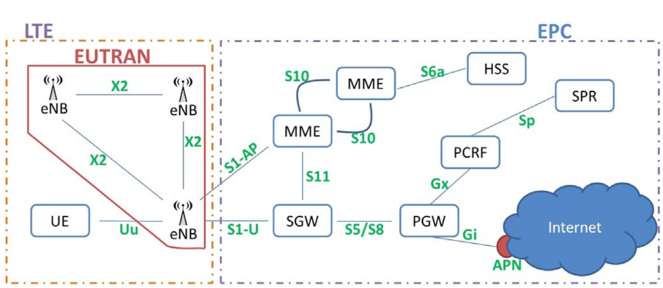


**Fig. 1.** Overview of LTE architecture.

- Serving Gateway (SGW): It is in charge of forwarding data between the eNB and the PGW. It plays the role of a mobile anchor acting as a gateway for the data plane. The MME is responsible of choosing the SGW for a UE during the first attachment of the device. It is a key component of the data plane.
- Subscription Profile Repository (SPR): The SPR is a central repository where the network policies, subscription types, and quality of service (QoS) data related to all LTE devices are stored.
- Policy Charging and Rules Function (PCRF): The PCRF is in charge of Network Control and QoS management. It uses the information available in the SPR to enforce networking policies within the LTE network.
- The LTE consists of two main planes: The Control Plane and the User Plane.
- The Control Plane handles radio-specific functionality where UEs and other architectural components are configured and managed to make proper usage of the Data channel (such as network attachment, security control, and authentication). The main protocols used in the control plane are: S1-AP (European Telecommunications Standards Institute, 2011), S10 (European Telecommunications Standards Institute, 2014), S11 (European Telecommunications Standards Institute, 2014), S6a (Oracle, 2014), Gx, SP, Uu. These protocols are used to enable communication between all the architectural components previously described, as depicted in Fig. 1.
- The Data Plane represents the data channel used for end-to-end exchange of information. The main protocols used in the data plane are: X2, Uu, S1-U (European Telecommunications Standards Institute, 2014), S5/S8 (European Telecommunications Standards Institute, 2014), and Gi.

For a detailed overview of the different LTE architectural components, reference (Dahlman et al., 2013) can be consulted.

### 2.2. Mobile infrastructure sharing

There are two approaches for implementing the sharing of mobile infrastructures: passive and active sharing (3GPP, 2013). In passive sharing, the equipment shared between different mobile operators is limited to the passive network elements such as radio masts, power supplies, cabinets, towers, security alarms, etc. Active sharing extends the list of shared equipment to include the transport infrastructure (fiber, cables, etc.), baseband processing resources, and potentially the radio spectrum (only supported in some sharing architectures). Three approaches have been proposed in the literature for active Mobile Infrastructure Sharing: The Multi-Operator Radio Access Network (MORAN) (Vadada, 2011) standard; the 3GPP-Multi-Operator Core Network (MOCN) standard (3GPP, 2013); and the Gateway Core Network (GWCN) architecture (3GPP, 2013). The Multi-Operator Radio Access Network (MORAN) standard proposes an architecture where the eNBs are shared, while the core network is proprietary to each provider. The MORAN standard also proposed the sharing of the Radio Access Network (RAN), using dedicated radio frequencies assigned to each telco. In this approach, telcos can independently control cell-level parameters – A feature that enables service differentiation. The 3GPP-Multi-Operator Core Network (MOCN) standard allows the sharing of the same architectural elements as MORAN. However, with MOCN, the telcos also share frequencies, feature that is not supported in MORAN. This prevents the telcos from being able to control their networks at the cell level. The Gateway Core Network (GWCN) architecture is focused on sharing not only the eNBs but also the Core Network between multiple operators, including the MMEs, SGW, and PGW components. Fig. 2a highlights the differences between MORAN and MOCN, while Fig. 2b depicts the architectural components shared in both MORAN/MOCN and