Chapter 4
Self-Organization Activities in LTE-Advanced Networks

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ABSTRACT
A major challenge in the context of LTE networks is a cost-effective network operation, which can be done by carefully controlling the network Operational Expenses (OPEX). Therefore, to minimize OPEX costs while optimizing network performance, Self-Organizing Network (SON) principles were proposed. These networks are the main focus of this chapter, which highlights the state of art and provides a comprehensive investigation of current research efforts in the field of SONs. A major contribution of the chapter is the handling of SON use cases, going through their challenges, solutions, and open research questions. The chapter also presents efforts to provide coordination frameworks between SON use cases and routines. An additional essential contribution of the chapter is the description of SON activities within 3GPP.

1. INTRODUCTION
The satisfaction of the always increasing demands of broadband applications and new services, the better support of mobility, the less costs, etc. are the main drivers standing behind the standardization and development of 4th Generation (4G) mobile communication networks, termed Long Term Evolution (LTE), which aim at providing incredible customer experience (Dahlman, Parkvall, & Skoeld, 2011). Researchers expect that the number of LTE subscribers will reach the base of 3G/UMTS networks (1.087 million subscribers) by the year 2015 (Garza, Ashai, Monturus & Syputa, 2010).

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A major challenge in LTE networks is a cost-effective provision of new services. Sure, this necessitates carefully controlling the Capital Expenditures (CAPEX) associated with the infrastructure and also the Operational Expenses (OPEX) resulting from operating this infrastructure. Cost-effectiveness gets more crucial when one considers the additional cost resulting from the expected affordable operation of overlaid multi-standard networks (2G, 3G, 4G, etc.). While CAPEX costs remain an important issue for network operators and are normally affected by factors outside their control (the cost of new technologies for instance), OPEX costs become more significant part in the cost structure. 3G mobile communication technologies have shown that the contribution of network-related OPEX costs to the total cost associated with the network is ~30%, see (Motorola, 2009). So, operators need to keep their OPEX costs minimized, while enhancing the performance of their networks (Ramiro & Hamied, 2012). Note that OPEX costs strongly relate to the solutions implemented in the infrastructure. This implies that OPEX costs reduction requires implementing adequate solutions that, for sure, will be best if self-organized.

The release being standardized by the 3rd Generation Project Partnership (3GPP) (3GPP, 2013) with self-organization capabilities is termed LTE-Advanced (Dahlman, Parkvall, & Skoeld, 2011). This standard aims at minimizing OPEX costs, while maximizing resource usage, network capacity, etc. To further contribute to Self-Organizing Networks (SONs), the Next Generation Mobile Networks (NGMN) alliance was also constructed. This alliance has summarized SONs requirements in a number of operation use cases, see Ramiro and Hamied (2012) and Lehser (2008).

This chapter focuses on the principles and activities of SONs. It provides in section 2 a thorough overview of SONs functionalities. Following that, the chapter handles in section 3 the main SON activities done in the scope of 3GPP going through the activities in releases 9, 10, 11 and even beyond. Section 4 investigates coordination frameworks that coordinate between various SON activities to guarantee systems’ stability and reliability in addition to performance optimization. Furthermore, the chapter provides in section 5 various SON use cases going through their goals, proposed solutions and research challenges. Finally, the chapter summarizes with the main results.

2. SON FUNCTIONALITIES

There are different schemes proposed to categorize SON functionalities, see NGMN (2006), NGMN (2008), and NGMN (2008a). Throughout this chapter, we will use the wide-accepted categorization provided in Ramiro and Hamied (2012), which states that SON functionalities are categorized into five categories, namely self-planning, self-deployment, self-optimization, self-healing and SON enablers. Figure 1 provides a summarized view of these categories and their corresponding routines.

*Self-planning* functionalities group the functions that cover the derivation of settings for new network nodes, the selection of site locations and hardware configuration including radio and transport parameters. Radio parameters include an initial selection of handover settings, Random Access Channel (RACH) settings, Paging Channel (PCH) settings, the configuration of new evolved NodeBs (eNBs) with suitable Physical Cell Identities (PCIs), the determination of an initial Neighbor Cell Relation (NCR) list, etc. Transport parameters enable starting tunnels between new network nodes and other network entities, so that further configurations can be received. Transport parameters include IP addresses, Virtual Local Area Network (VLAN) identifiers, QoS settings, etc. Self-planning functionalities also take care of determining which nodes must update their databases, white and black lists, etc. Note that the functions related to...
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