Chapter 10
Self–Organization and Optimization in Heterogenous Networks

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ABSTRACT
Driven by the continuous growth of wireless and mobile communication users, Long Term Evolution (LTE) and Long Term evolution-Advanced (LTE-A) have taken up densification of network as a new paradigm to meet the growing capacity demands. Small cells come with the advantage of enhanced coverage in indoor and hard reach areas and offer traffic offloading capacity in hotspots. However, there are challenges of interference management and self-adaptability with the overlaying macro cellular network since most small cell base stations are user deployed and do not have centralized control on their configuration and operation. The purpose of this chapter is to elaborate the concept of heterogeneous network and Self Organization Network (SON) in LTE-A. The various use cases of SON that can benefit the heterogeneous network have been discussed laying emphasis on interference management use case. Further the current trend of research in this field has been highlighted. It provides a holistic picture of the heterogeneous network and SON in LTE-A and upcoming mobile communication generations.

INTRODUCTION
With an exponential increase in mobile traffic in recent times, the need to enhance cellular capacity has been a major issue of focus for mobile operators as well as in the field of research. Literature has suggested three conventional ways to address the need for increased cellular capacity. The first is to utilize more frequency bandwidth, the second is by making use of spectrally efficient transmission techniques through air interface and the last is by spatial frequency reuse which employs more number of transmitters and receivers at closely spaced distance. It has been established that increasing spectral reuse
increases the capacity more than the first two methods combined (Chandrashekhar, 2008). Densification of network is the new paradigm of Long Term Evolution-A (LTE-A) to meet the high traffic demand and need for seamless service in indoor environments such as homes, offices, and dense hotspots like airports or stadium and isolated areas. Network densification means under laying the existing macro cellular network with small cells like micro cells, pico cells and femto cells thus resulting in a heterogeneous topology. Traffic load from macro cellular network can be offloaded to these small cells to increase the network capacity. Also, such small cells can give better coverage in indoor environments as well as hotspots. Another advantage of small cells is that they use low cost, low power base station as the coverage radius is limited up to a few meters. Thus they offer energy saving as well. However, there are certain issues that have to be handled in dense network deployment. Due to the close proximity of femto cells in a dense deployment and spectrum sharing between cells belonging to different tiers, there are serious issues of interference in a heterogeneous network. The interference management techniques devised for heterogenous networks are called the enhanced Inter Cell Interference Coordination (eICIC) and methods include algorithms for resource allocation, controlling transmit power or beamforming.

Deployment and operation of multi-tier cellular network is a complicated task and needs to consider multiple stages of planning, dimensioning, testing, installation and failure maintenance and correction and pre and post launch optimization. In a dense mobile network, all these activities may become labour extensive as well as expensive. Often these small cells are user deployed and network planning and management of such cells cannot be accomplished centrally. Another major challenge is the delay that may be incorporated due to human intervention in these manual maintenance activities. Consequently, the network becomes inefficient in terms of throughput and reliability of operation. This in turn lowers the Quality of Service (QoS) and increases dissatisfaction at the customer end. Therefore, with increasing densification of cellular networks, the mobile operators are facing the challenge of providing high quality services to users while reducing its CAPital EXpenditure (CAPEX) and OPerational EXpenditures (OPEX). These challenges prompt the need for an automated system wherein, maintenance and operation of the system may be managed by the network itself according to the system dynamics.

The human intervention in network operation and maintenance can be reduced to a great extent by incorporating self-configuration and self-optimization mechanisms in the network. With this objective, the Self Organizing Network (SON) has been introduced as part of Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) to operate with automated features like self-configuration, self-healing and self-optimization (3G Americas, 2009; 4G Americas, 2011). While self-configuration and optimization are mainly useful in the initial deployment phase of a new or extended cellular network, self-healing helps in automatic detection and adjustment of parameters in the later operational phase. A major source of SON development is the industry forum Next Generations Mobile Networks (NGMN). NGMN had established the initial set of requirements of SON and several use cases were later identified to cover multiple aspects of network operation such as planning, deployment, optimization and maintenance. SON concepts have been included in the LTE standards from the first release of the technology (3GPP Release 8) and its scope has been expanding in the subsequent releases (Release 9, 10 and 11). While the first release mainly includes the initial use cases of deployment phase like Automatic Software Download, Automatic Neighbour Relation (ANR), and Automatic Physical Cell Identity (PCI) assignment, the subsequent releases include optimization use cases like coverage and capacity optimization, mobility optimization, random access channel optimization and load balancing optimization and self-healing.