

Preface

In the recent years, cellular networks have witnessed a significant increase in bandwidth-intensive and data-centric applications. Moreover, non-uniform user density and variations in the traffic types pose additional challenges to provide adequate Quality of Service (QoS) to all the users. With wireless communications approaching physical layer spectral efficiency limits, new approaches are being investigated at the network layer to address the requirements of QoS. Heterogeneous network or HetNet is one such approach. Heterogeneous network typically comprises of several low-power nodes which may be overlaid over an umbrella macro-cell network. Moreover, these low-power nodes may have different Radio Access Technologies (RAT). Thus, heterogeneous network could cover the span from cellular entities such as macro base stations, relay, pico, and femto nodes to non-cellular networks such as Wi-fi and plethora of sensor nodes eventually connecting to various Internet of Things (IoT) devices.

In this book, we consider the initial stage of heterogeneous networks and focus on meeting the mobility challenges posed by the overlay of low-powered cellular nodes in the context of Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) standard. This book is the first of its kind, compiling information on the LTE standard, which has been enhanced to address new mobility-related challenges in heterogeneous networks. Mobility management refers to the handover (HO) of a mobile user from one base station node to another in a cellular network. The objective of mobility management is to ensure continuous coverage by associating an appropriate base station node for a mobile user such that the desired QoS is maintained. While HetNets are intended to provide very high spectral efficiency and seamless coverage, the increased cell density and irregular network topology make mobility management a complex task in HetNets.

While mobility management in homogeneous networks is well understood, LTE standards are being enhanced to address the HetNet-specific mobility management challenges. This book identifies the related challenges and discusses solutions and the simulation methodology for modeling HetNet mobility cutting-edge information that was previously accessible only in the form of 3GPP specifications and documents and research papers. The book reviews the current LTE mobility framework,

discusses some of the changes for enhancing mobility management in HetNets, and describes the measurement procedures, handover mechanisms and HO success/failure scenarios.

The book addresses these aspects in a succinct and easy to understand format, offering a valuable resource for researchers and professionals working in the area of HetNet mobility and a ready reference guide for practicing engineers and researchers. We have tried our level best to make this book self-contained and only for the well-known topics, have referred to the literature. Readers will find lucid explanation of the intricate mobility management related 3GPP procedures in this book.

In Chap. 1, we introduce the LTE cellular and heterogeneous network. We review the LTE architecture and describe the functionality split between different elements in the core and radio access networks. In Chap. 2, we emphasize the mobility management procedures as per the 3GPP standard. In this chapter, the network entry and connection setup procedures are explained along with details of the Radio Resource Control (RRC) states of the User Equipment (UE). We describe the handover procedures, signaling, and radio link management issues. Further, we explain the details of measurement performed by UE which assist in mobility management. We also discuss issues in mobility state estimation, which is required to appropriately set the measurement configurations in order to achieve improved handover performance.

In Chap. 3, we illustrate the 3GPP simulation and modeling aspects, which are important to understand the basic framework of LTE HetNets. The 3GPP specified models to illustrate the mobility scenarios in HetNet are discussed. It includes the models for topology, user mobility, handover, radio link failures, etc.

The initial releases of LTE focused on macro deployments but from Release 10 onwards, there has been increased emphasis on HetNets. HetNet deployment scenarios will differ depending on the network requirement in terms of coverage, traffic density etc. The coverage of low-power eNBs and macro eNB may be overlapping/non-overlapping. Based on the need of coverage/capacity improvement in indoor/outdoor environment, low-power eNBs may be deployed indoors/outdoors. Specifically, hotspot coverage can be provided by sparse deployment of low-power eNBs, while overall coverage improvement can be achieved by dense deployment of low-power eNBs. In Chap. 4, we consider all these HetNet deployment scenarios and the resulting system requirements and challenges associated with each of them. We discuss various deployment specific challenges and other issues such as mechanisms for small cell discovery and detection, and methods to achieve energy efficiency at network level and UE level. We also throw light on the features available in the 3GPP for cell range expansion and enhanced inter-cell interference coordination. Finally, we highlight the key performance considerations in HetNets including handover performance, achieving energy efficiency, and self-organization.

We then address the enhancements techniques that can be applied to the existing mechanism to improve the mobility performance for both UE and network. We begin with simple enhancements like consideration to handover failure events in the mobility state estimation because even the HO failure events are potential indicators

of user mobility. Next, we consider assigning different weights for different HO events and analyze the behavior. Here, it is interesting to observe the role of cell sizes and different types of HO events in estimating UE speed. Finally, we illustrate the impact of UE trajectory on mobility state estimation. Thus, a couple of enhancement strategies for mobility state estimation are described, and their performances are compared in Chap. 5.

Lastly, we focus on how optimizations in the mobility-related parameters help in further improvement of the mobility performance. We elucidate those mobility-related parameters that can be optimized to improve the overall handover performance in HetNet scenarios. This includes scaling of various thresholds and timers, determining mobility state estimation procedures and various measurement configurations.

We hope you will enjoy reading this book and it will help you build the foundation to work on the mobility management aspects of heterogeneous cellular network. Happy reading!

Mumbai, India
Pune, India
Bengaluru, India
November 2016

Abhay Karandikar
Nadeem Akhtar
Mahima Mehta

Mobility Management in LTE Heterogeneous Networks

Karandikar, A.; Akhtar, N.; Mehta, M.

2017, XIX, 96 p. 62 illus., Hardcover

ISBN: 978-981-10-4354-3