Chapter 7
Future M2M Communication Networks:
Spectrum Sharing, Random Access and Connectivity

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ABSTRACT

Machine type communications (or Machine-to-Machine / M2M) communications have emerged as an important paradigm in wireless communication networks. The current M2M standardization activities are presented and their implementation in 4G/LTE networks is described in detail. The chapter is divided in three parts that are related to the evolution of the Future M2M communication Networks. The first part focuses on existing random access management schemes for M2M communications that are presented in the literature. The second part is devoted on spectrum sharing methods and on M2M clustering and it presents the spatial distribution of heterogeneous networks and its impact on their connectivity. Finally, the last part refers to energy efficiency issues of the future M2M communication systems and their implementation using distributed power control and MAC/scheduling algorithms.

INTRODUCTION

M2M communication networks are one of the most significant applications of wireless technologies considering the end-to-end communication of massive numbers of devices (such as meter readers, monitoring sensors and others) without the need of human intervention (Chen, & Lien, 2014). More specifically, according to ETSI, the M2M devices represent mobile terminals that are capable of transmitting data autonomously whereas M2M applications refer to automatic applications that involve communication among various devices such as smart sensors, computers etc.

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In contrast to human-based communications (e.g. web streaming etc), M2M communication systems are characterized by enormous number of devices, differentiated required quality of service (QoS), low data rates and short payload transactions, rendering the existing cellular systems inappropriate to use without adequate modifications. Thus, the realization of machine type systems sets many challenges ranging from computation and energy harvesting techniques to communication technologies.

This Chapter aims to provide a survey of the research challenges that have arisen from the emergence of M2M wireless communications. The structure of the Chapter can be separated in three main parts.

The first part presents the M2M network architecture and major issues of the network's physical layer such as signal propagation, interferences and network connectivity. For the spatial distribution of the M2M topology, a Random Geometric Model that reconstructs the random architecture of a M2M network based on several realistic assumptions will be presented. Principles from stochastic geometry will be taken under consideration (Penrose, 2003). Moreover, an overview of spatial models and connectivity models that have been proposed during the last few years and that are widely acceptable will be also presented. Finally, new challenges and approaches for more realistic modelling of the network architecture of M2M communication systems that has been recently suggested will also be considered (Chen, & Lien, 2014). It is important that a theoretical model approximates in high degree the real structure of an M2M communication system so that it can be used as the basis for research in higher levels of the M2M systems. For this reason, in this Chapter, we will also present an overview of crucial parameters at the physical layer that affect the M2M systems' topology, the link availabilities and the throughput performance. A variety of propagation models will be also presented with respect to the physical environment where the M2M systems will be considered, while interference issues will not be neglected (Alouini, & Simon, 2002).

The second part presents an overview of the different alternatives that have been proposed over the last years to solve the problem of random access (RA) in M2M networks. The specific problem has been defined as one of the most challenging issues in order to support the harmonic co-existence of enormous numbers of M2M devices (Hasan, Hossain, & Niyato, 2013). More specifically, the network overload problem appears when the machine type devices try to send their data over the same channel and contend to access the radio channel. To address the specific problem, various solutions have been proposed either as modifications to the existing access schemes of the cellular networks, either introducing schemes for a completely new standard. In this Chapter, the different approaches that have been proposed to ameliorate the performance of the RA channel of LTE are discussed so as to highlight the advantages/disadvantages of each scheme (Laya, Alonso, & Alonso-Zarate, 2014).

The third part addresses performance issues of M2M networks with respect to throughput and energy efficiency. One challenging issue of M2M that reasonably emerges is the deployment of M2M network without causing performance degradation to the existing H2H network, mainly due to co-channel interference. Both orthogonal as well as shared allocation of frequency per time slots Resource Blocks (RBs) can be adopted in a framework of a two-hop communication network for Machine users, establishing an intermediary gateway between the eNodeB (eNB) and the M2M user (Kan, Fanglong, Wenbo,Wei, & Dohler, 2012). Peer-to-Peer (P2P) communication could be also a useful solution for establishing direct links between M2M users. Both coordinated and uncoordinated techniques of power management that adjust to load adaptation have been proposed as solutions to address this issue (Dhillon, Huang, Viswanathan, & Valenzuela, 2013). Moreover, the majority of M2M devices are considered to be