Chapter 18
Can LTE-A Support Real-Time Smart Meter Traffic in the Smart Grid?
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ABSTRACT
The chapter investigates the scheduling load added on a long-term evolution (LTE) and/or LTE-Advanced (LTE-A) network when automatic meter reading (AMR) in advanced metering infrastructures (AMI) is performed using internet of things (IoT) deployments of smart meters in the smart grid. First, radio resource management algorithms to perform dynamic scheduling of the meter transmissions are proposed and shown to allow the accommodation of a large number of smart meters within a limited coverage area. Then, potential techniques for reducing the signaling load between the meters and base stations are proposed and analyzed. Afterwards, advanced concepts from LTE-A, namely carrier aggregation (CA) and relay stations (RSs) are investigated in conjunction with the proposed algorithms in order to accommodate a larger number of smart meters without disturbing cellular communications.

INTRODUCTION
Current power grids are having a hard time coping with the increasing power consumption and thus are becoming unsustainable. This motivates the ongoing activities and research related to developing a “Smart Grid” (Bannister & Beckett, 2009).

The main purposes of the smart grid are to add intelligence to the grid in order to perform self-coordination, self-awareness, self-healing, and self-reconfiguration, to boost the deployment of renewable energy sources, to augment the efficiency of power generation, transmission, and usage, in addition to shifting and customizing consumers’ energy demands by managing peak loads via demand response (DR) techniques. This necessitates advanced distribution automation and dynamic pricing models relying on automatic meter reading (AMR) and advanced metering infrastructure (AMI) (Lo & Ansari, 2012).

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An AMI is one of the main features in smart power grids. It depends on AMR for measuring, collecting, and analyzing energy usage data (Fatemieh et al., 2010), which would represent an essential component of the Big Data era. The deployment of smart meters has several important benefits. For example, it allows real-time information feedback, thus leading to more accurate billing. Furthermore, it allows reducing the peak power demand through the implementation of demand response programs (SUPERGEN, 2012). To perform this interaction with smart meters, a communication media is needed. AMI communications consist mainly of two networks (Purva et al., 2011):

- **A Home Area Network (HAN):** In this network, power consuming devices inside the home communicate with the power supplier. In most common forms, this takes place via a gateway integrated into the smart power meter. Low power wireless transceivers or in home power line communications (PLC) can be used to carry these communications.

- **A Neighborhood Area Network (NAN):** This network mainly serves to connect energy meters to data aggregators/collectors. Different means can be used to establish this link. This connection can be performed wirelessly, by a data wired connection to the smart meter, or over the power lines via PLC technology. Once the data reaches the aggregation stations, these can then communicate with the power utility’s central servers using leased access lines, wireless microwave links, or PLC.

This chapter presents an AMR/AMI communication approach that can be applied either to directly transmit the data from the smart meters to the utility servers, or to transmit data collected by aggregators to these servers. The proposed approach implements radio resource management (RRM) in an orthogonal frequency division multiple access (OFDMA) system, using the channel state information (CSI) to optimize performance.

An overview of the most relevant works in the literature is presented next, and the differences with the proposed approach are outlined, before proceeding with the rest of the chapter.

In (ON Semiconductor, 2011), PLC is suggested for communications between smart meters and a concentrator that relays the data using GPRS to a central information system. However, PLC faces the challenge of the lack of capacity at higher frequencies (SUPERGEN, 2012). Furthermore, measurements have shown that the characteristics of the PLC channel vary significantly between different countries or regions, due to different wiring practices and loads connected to the system (Bannister & Beckett, 2009). Hence, a solution suitable for one country might not be suitable for another. OFDMA was proposed in (Bannister & Beckett, 2009) to enhance the throughput and reliability of PLC. Although significant enhancements were reached, it was noted in (Bannister & Beckett, 2009) that more sophisticated channel estimation and adaptive feedback techniques are needed in order to further enhance throughput and reliability.

Wireless communications could be thought of as the most cost-efficient solution for smart meter deployments, especially when compared to laying additional cables or to using PLC data communications, which would require an upgrade to the power distribution hardware (Purva et al., 2011). Thus, thousands of meters can form a mesh network and communicate using protocols in the public industrial scientific and medical (ISM) frequency bands. The role of the mesh network would be to route the meter data to an aggregator, which in turn relays this data to the power utility, generally using cellular data services such as GPRS (Fatemieh et al., 2010). However, mesh networks face significant challenges related to