Chapter 6
Massive Access Control in Machine-to-Machine Communications

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ABSTRACT

This chapter proposes a new hybrid MAC protocol for direct communication among M2M devices with gateway coordination. The proposed protocol combines the benefits of both contention-based and reservation-based MAC schemes. The authors assume that the contention and reservation portion of M2M devices is a frame structure, which is comprised of two sections: contention interval (CI) and transmission interval (TI). The CI duration follows p-persistent CSMA mechanism, which allows M2M devices to contend for the transmission slots with equal priorities. After contention, only those devices which have won time-slots are allowed to transmit data packets during TI. In the proposed MAC scheme, the TI duration follows TDMA mechanism. Each M2M transmitter device and its corresponding one-hop distant receiver communicate using IEEE 802.11 DCF protocol within each TDMA slot to overcome various limitations of TDMA mechanism. The authors evaluate the performance of the proposed hybrid MAC protocol in terms of aggregate throughput, average transmission delay, channel utility, and energy consumption.

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INTRODUCTION

Machine-to-machine (M2M) communication is a new communication model, where a large number of "intelligent-devices" communicate with each other with the help of wired/wireless networks, and can make collaborative decisions without direct human intervention (Verma et al, 2016, Chen et al, 2012; Igarashi et al, 2012). Machine-to-Machine (M2M) communication has its origin in the supervisory control and data acquisition(SCADA) systems, where sensors and other devices being connected through wired or radio frequency networks are used with computers to monitor and control industrial processes. A key factor behind the growth of M2M communications today is the pervasive accessibility of low cost, ubiquitous connectivity. We have already become used to low cost, high-speed home and commercial internet access. Now-a-days, in many regions around the globe, 3G and LTE mobile networks provide almost similar access speeds at highly competitive prices. The logic behind M2M communications is based on two observations. First, a networked device becomes more valuable than an isolated one. Second, when a large number of machines are networked/interconnected together, they produce entirely new autonomous and intelligent applications. For these reasons, M2M communication has quickly become a new area for research in academics and a market changing force for a wide variety of real-time monitoring applications in industry such as smart grids, home area networks, e-healthcare, intelligent transportation systems, environmental monitoring, and manufacturing applications. The system model of M2M communications is shown in Figure 1, which consists of three interlinked domains. These are M2M device domain, network domain, and application domain (Rongxing et al, 2011). In M2M domain, an M2M area network is formed by the collaboration of a large number of M2M devices (e.g. sensors, actuators, smart meters etc.) and M2M gateways. These M2M devices collect the sensory data by sensing techniques from different part in the M2M domain and collaboratively make intelligent decisions to transmit the sensory and monitored data to an M2M gateway. The M2M gateway itself is an "intelligent device", which receives the sensory data and efficiently manages the received data packets. It forwards the data packets through efficient paths by single-hop or multi-hop channels via a network domain to the back-end server of the application domain. If the M2M domain contains multiple gateways, they can further communicate with each other to make collaborative decisions (P2P model). Furthermore, the network domain acts as an interface between M2M domain and application domain. In network domain, long-range wired/wireless network protocols (e.g. Wi-MAX, 3G/4G cellular networks) are used to provide cost-efficient and reliable channels with wide coverage to transmit the sensory data from M2M domain to the application domain. Lastly, the application domain consists of a back-end server and M2M application clients. The back-end server is the main component of M2M communications model and acts as an integration point to store all the sensory data transmitted from the device domain. It also provides the real-time monitoring data to various client applications for real-time Remote Monitoring Management (RMM), i.e. smart metering, e-health care, and traffic monitoring. The back-end server can also vary for different applications; e.g., in smart grids, the control center acts as the back-end server, whereas in e-healthcare systems, the back-end server is the M2M health-monitoring server.

Limiting our focus on M2M domain only, due to the presence of full mechanical automation among devices, and their ability to support a large number of ubiquitous characteristics (Lien et al, 2011) with better cost efficiency, this communication paradigm has rapidly become a market changing force for a broad range of real-time monitoring and pervasive applications (Cao et al, 2008; Chen et al, 2010; Gau & Cheng, 2013; Lien et al, 2013; Yu et al, 2013; Zhang et al, 2012; Zhang et al, 2011). Some of the important characteristics of M2M communications are,

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