Chapter 14
Modelling Software-Defined Wireless Sensor Network Architectures for Smart Grid Neighborhood Area Networks

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ABSTRACT

In a smart grid machine to machine communication environment, the separation of the control and data planes in the Software Defined Networking (SDN) paradigm increases flexibility, controllability and manageability of the network. A fully integrated SDN based WSN network can play a more prominent role by providing 'last mile' connectivity while serving various Smart Grid applications and offer improved security, guaranteed Quality of Service and flexible interworking capabilities. Hence, more efforts are required to explore the potential role of SDN in Smart Grid communications and thereby ensure its optimum utilization. In this chapter we provide a description of how SDN technology can be used in WSN with an emphasis on its end-to-end network architecture. We then present its novel application to Advanced Metering Infrastructure, Substation Automation, Distributed Energy Resources, Wide Area Measurement Systems, and Roaming of Electric Vehicles in Smart Grids.

INTRODUCTION

Research into Smart Grid (SG) communication networks aims to identify an integrated approach that leverages communication technologies and standards whilst focusing on the management and control of systems found in the existing power grids. Machine to Machine (M2M) communication protocols and standards provide a starting point for the broader development of SG communication networks that can

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be enhanced by abstracting high-level network functionalities. A one stop communication solution is yet to be developed that facilitates reliable and efficient traffic exchange between the different SG domains and supports the deployment of diverse communication network services and applications. Software Defined Networking (SDN) provides a separation of traffic control and the systems that transfer traffic across the network (Yan, Yu, Gong, & Li, 2016). SDN is an approach to the management and control of communication networks that provides a higher level of abstraction of network functionality that is appropriate for use in SGs. SDN provides an efficient, secure, reliable, cheap and flexible topology for SG communications. An SDN based communication architecture for SGs provides the flexibility and low cost necessary to support the transition from the existing power grids to SGs. Another feature of a potential SDN implementation for SG communications is the optional use of different communication technologies for traffic control and traffic transmission systems. Selection of the appropriate communication technologies will depend on the traffic model developed for each of the SG domains. Multiple applications can be incorporated utilizing SDN that has different traffic patterns, processing priorities, and data expiration times.

The future SG is expected to have high system resilience in order to manage a large number of M2M devices that can introduce greater risk of sudden failures or malicious attacks. The pervasive use of new software in different SG domains endangers the power grid by introducing inconsistencies leading to vulnerability. The adaptive network configuration capability of the SDN paradigm would be beneficial for SG as the diverse network can be managed from a single control point. The non-adaptive network configuration of existing M2M networks does not allow run-time modifications or network device configuration to react to sudden attacks. Also, bandwidth demand could increase rapidly with the introduction of new and diverse SG applications. Correspondingly, the horizon for unexpected attacks on future SG networks is likely to increase, though this is mitigated to some extent with SDN because the physical layer switches forward packets based on flow table entries that are set by controllers over separate secure channels.

Wireless Sensor Networks (WSN) have evolved utilizing ubiquitous wireless communication technologies that provide high-speed, low cost and secure M2M communication (Gungor, Lu, & Hancke, 2010). Among the contemporary communication technologies, WSN is particularly suited for use with SG communication networks because of its design for low energy consumption, easy deployment, and Quality of Service (QoS). WSN supports continuous innovation, reduced equipment costs, and open standards that reduce the need for a single vendor solution. For potential SG operators, WSN is an attractive alternative to wireline communication technologies for M2M. A fully integrated SDN based WSN for SG communication networks can offer more than just last-mile connectivity and WSN based radio networks provide SG operators with:

- State-of-the-art Authentication, Authorization and Accounting (AAA) capabilities for real-time energy metering and implementation of various demand response programs;
- Smooth interworking with the existing wired communication infrastructure for substation and feeder automation;
- Flexible network topologies that are used to connect distributed energy resources and perform a wide range of distribution management functions;
- Remote sensor networks for wide area monitoring applications; and
- Real-time data applications for facility coverage, asset tracking and workforce management applications.

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