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Software Defined Neighborhood Area Network for Smart Grid Applications

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***Abstract*—Information gathered from the Smart Grid (SG) devices located in end user premises provides a valuable resource that can be used to modify the behavior of SG applications. Decentralized and distributed deployment of neighborhood area network (NAN) devices makes it a challenge to manage SG efficiently. The NAN communication network architecture should be designed to aggregate and disseminate information among different SG domains. In this paper, we present a communication framework for NAN based on wireless sensor networks using the software defined networking paradigm. The data plane devices, such as smart meters, intelligent electronic devices, sensors, and switches are controlled via an optimized controller hierarchy deployed using a separate control plane. An analytical model is developed to determine the number of switches and controllers required for the NAN and the results of several test scenarios are presented. A Castalia based simulation model was used to analyze the performance of modified NAN performance.**

***Index Terms*— Advanced metering infrastructure, neighborhood area network, smart grid, software defined networking, wireless sensor network**

1. Introduction

The conventional power grids are on the verge of being upgraded to become Smart Grids (SG). Any changes in power grids are challenging due to its diversified and enormous network size, functionality, and standard specifications. The power grids need to accommodate state of the art SG applications and implement the applications for the benefit of consumers, business, industry, utility service providers and other stakeholders. Challenges remain before the development and implementation of SG applications will proceed apace, including selecting the appropriate communication technologies, network architecture, security, and regulation. SGs will be capable of transmitting electrical power both in forward and reverse direction in the distribution domain [1]. Large scale projects to generate power from renewable sources [2][3] are increasing the motivation to upgrade the power grid into a SG. Adding more renewable energy sources with synchronization with the existing power generators may reduce the substantial domestic and commercial demand load and decrease costs over time. Smart distribution grid applications [4] such as advanced meter infrastructure (AMI) [5], demand response (DR) [6], distributed energy resources (DER) [7] and vehicle to grid (V2G) [8] have the potential to contribute to the day-to-day fluctuating power demands. With modeling of the SG applications it is becoming evident there is a need for new technologies to be used to facilitate increased communications capability.

The SG transformation process will be focused on the design of the communications network. Real-time monitoring and control of the large-scale intelligent device implementation requires improved traffic engineering and data management, with latency becoming a critical factor. Also, to improve security, efficiency, and the reliability of the power network, a robust communication network that enables autonomous system operations is a necessity. Developing a communications network and systems for SGs could be facilitated by the emergence of the software defined networking (SDN) paradigm.

Networking devices in the current power grids are generally designed to serve an individual or selected number of applications. The primary objective of the networking devices is to enable machine to machine (M2M) communication, using an approach known as hardware-centric networking. Hardware-centric networking faces scalability and controllability challenges because the devices are generally static and cannot be dynamically updated with changed or new features. In an emergency scenario for example, it is difficult to re-configure network settings in a timely and effective manner. Over time, the non-adaptive network configuration of large M2M networks is prone to security degredation. The lack of a real-time grid monitoring capacity contributes to poor quality of service (QoS). The limited network control capability has driven the move towards SG communication networks utilizing SDN because it offers improved network control and programmability. SG communication networks that are based on SDN provide a more efficiently, flexible and dynamic environment for M2M communications [9]. The SDN based communications network separates the control and data planes to improve the control mechanism whilst

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