Resilient IEEE802.15.4MAC Protocol for Multi-Hop Mesh Wireless Sensor Network

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***Abstract*—The success of a modern power grid system is inevitably based on the integration of a smart data exchange amid several devices in power production, transportation, dispatching and loads. For large coverage data exchange, a distributed multi-hop mesh is structured from low voltage distribution boards to the substations. Thus, being cheap, less power intake, easy set-up and operating in a free licensed spectrum, ZigBee/IEEE802.15.4 makes the most suitable wireless protocol for communicating in power grid systems. Nevertheless, IEEE802.15.4MAC protocol lacks a mechanism to enable a multi-hop mesh network with efficient energy and quality of service (QoS). Hence, in this paper, a Multi-Hop Mesh IEEE802.15.4MAC protocol is designed for a large coverage data exchange. This developed model provides a resilient network with energy efficiency and QoS. Hence, the IEEE802.15.4 super_frame standard_structure is modified by swapping the contention_free period (CFP) and contention_access period (CAP) for time sensitive applications. For network resilience, a Reserved_Broadcast Duration_Slot (RB_DS) is introduced in the active super_frame standard_structure as beacon_offset reference time computation. Finally, for the network performance analysis, the developed Markov chain_Model with retry and saturated traffic regime without feedback is run on NS-2 simulator. Here, the hidden terminal problem is not considered since it is assumed that all nodes can "hear" each other. The simulation results are encouraging as the developed IEEE802.15.4MAC protocol is capable of improving the time delivery delay up to 35.7%.**

***Index Terms*—Resilient; Multi-Hop Mesh; IEEE802.15.4MAC Protocol; Zigbee; Wireless Sensor Network.**

I. INTRODUCTION

The today power system has been in use for many years. Thus, several elements are close to their lifespan limit. The modern power grid system known as smart grid is a power network based on hi-tech production, transportation and dispatching of electricity to users more proficiently. In modern grid, the power dispatcher section controls and auto-adjusts the services of all devices from production to dispatching sections through power communication grid [1]. The keystone of a modern power grid is its use of full-duplex communication networks for data exchange amid its various units. The smart grid dispatcher section is made up of intelligent devices such as smart meters, Advanced Metering Infrastructure (AMI) gateways and repeaters [2]. Due to its cost-effective sensing, wireless sensor network (WSN) is one of the best communication remedies for various applications in smart grid dispatcher sections. For large coverage, sensors form a multi-hop mesh linkage to proficiently convey data for lengthy distances [3].

Being one of the best etiquettes for WSNs, ZigBee/IEEE802.15.4 is a low cost, stout, easy to set-up, low bandwidth requirement protocol and it works in the 2.4GHz unrestricted Industrial, Scientific and Medical (ISM) radio frequency range [4]. Nevertheless, for data exchange, the IEEE802.15.4MAC sub-layer provides two procedures: no-beacon asynchronous and beacon synchronous style. In fact, in the no-beacon asynchronous style, sensors remain active permanently, which may quickly drain battery power. Moreover, in this no-beacon style, there is no certainty of data conveyance. However, all transportations are completed after the accomplishment of a no slotted_carrier_sense multiple access with collision_avoidance (CSMA_CA) process. In contrast, the beacon style provides guarantee of data delivery. All transportations are completed after accomplishing a slotted CSMA_CA process. In fact, the use of synchronization mode in the beacon style permits sensors to be inactive amidst harmonized transportation, which leads to network energy proficiency [5].

In fact, the IEEE802.15.4MAC protocol restricts the no-beacon style to star topology (one_hop limited) or cluster_tree topology (less scalable and robust) [6]. Therefore, this paper designs a Multi-Hop Mesh IEEE802.15.4MAC protocol based on beacon_mode for time-sensitive applications in power grid distribution systems.

II. MODEL DESCRIPTION

IEEE802.15.4 network uses Full_Function_Device (F.F.D) and Reduced_Function_Device (R.F.D) as nodes. F.F.D or beacon_node works as Personal_Area_Network_ Coordinators (PANcs), Cluster_Head (C_H) or Routers. R.F.D or no-beacon node may simply work as front_end_devices [7].

The IEEE802.15.4 super_frame structure in Figure 1 involves a CAP in which nodes with ordinary data contest for canal entry by experiencing a slotted CSMA_CA process and a CFP which holds the Guaranteed_Time_Slot (G.T.S) for time restricted data [8].