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MQRP: Mobile Sinks-based QoS-aware Data Gathering Protocol for Wireless Sensor Networks-based Smart Grid Applications in the Context of Industry 4.0-based on Internet of Things

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Abstract: The recent advances in internet of things (IoT) and industrial wireless sensor networks (IWSNs) paradigm provide a promising opportunity for upgrading today's elderly electricity industrial systems and even allow the fourth stage of the industrial revolution, referred to as smart grid industry (SGI) 4.0. In SGI 4.0 paradigm, the WSNs are considered as promising solutions due to their advantages, such as cable replacement, ease of deployment, flexibility, and cost reduction. However, harsh and complex smart grid (SG) environments pose great challenges to guarantee reliable communication for WSNs-based SG applications due to equipment noise, electromagnetic interference, multipath effects and fading in SG environments. This results in deteriorating the quality-of-service (QoS) requirements as well as the network lifetime of multi-hop communication-based WSNs for SG applications. Thus, for SGI 4.0 paradigm to come true, a WSN-based highly reliable communication infrastructure is crucial that will wirelessly connect and integrate power system components for more efficient, reliable, and intelligent operations of the next-generation electricity power grids. To address these challenges, in this paper a novel multi-mobile sinks-based QoS-aware data gathering protocol (called MQRP) for WSNs-based SG applications has been proposed to empower SGI 4.0. The extensive simulations study is carried through a network simulation tool called EstiNet9.0. The obtained experimental facts show that the proposed scheme has not only improved the QoS performance metrics, such as packet delivery ratio, memory utilization, control message overhead, residual energy, network lifetime, and throughput, but also reduced packet error rate and end-to-end delay compared to existing data collection schemes.

Keywords: Internet of things, Industry 4.0, Smart grid industry 4.0, Smart grid, Wireless sensor networks, Mobile sink, Routing protocol.

1. Introduction

Recently, with the rapid development of IoT and services to manufacturing, the fourth stage of the digital industrial technology revolution, namely, Industry 4.0, is believed to be approaching [1]. Industry 4.0, is a rapidly growing field and gaining significant attention from researchers, manufacturers, and application developers in various domains, such as industrial automation and manufacturing [2]. The vision of Industry 4.0 is to make the factories smart enough by connecting and integrating all unconnected physical objects of the traditional factory world through a network for enabling adaptability, flexibility, and efficiency in supply and demand processes between the factories [3]. These industrial upgrades will enable fast, more flexible, and more efficient processes to increase efficiency and productivity of higher-quality goods at low costs. Industry 4.0 will not only make the traditional industry even more immersive and pervasive, but also modify the profile of the workforce ultimately changing the competitiveness of companies and regions worldwide to improve people's lives [4, 5].

In Industry 4.0, the wired or wirelessly connected systems that are physically placed in distant geographical locations and across different industries can interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to changes. This machine-to-machine communication between systems located in different remote places resulting in intranet or internet of things [6]. Currently, most devices within factories are connected based on wired infrastructure working over industrial protocols to streamline management operations due to dynamic reconfigurable industry elements [7]. However, the wireless solutions are increasingly playing a complimentary role to wired solutions for strengthening management and control capabilities of the industry elements. In this regard, IWSNs are an invaluable technology for realizing the vision of Industry 4.0, due to their low cost identifying, sensing, networking, and processing capabilities [8]. The IWSNs provide a virtual layer where the information about the physical factory world can be accessed by any computational system/user placed in a remote location to accomplish some objectives [9]. The main attributes of IWSNs-based networks are to enable smart production reliability and to increase economic benefits with least breakdowns and maintenance cost in a bounded time interval in harsh industrial environments. With these objectives, IWSNs have proved their importance in a wide range of industrial applications, such as healthcare systems, transportation, modern agriculture, steel mills, offshore drilling, underwater applications, oil and gas industry, area surveillance, and several others [10-14].