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Applications of Wireless Sensor Network in Smart Grid: A Review

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ABSTRACT

Network lifetime is, arguably, the most important performance metric in wireless sensor networks. Since wireless sensor networks nodes are battery operated, in general, optimal utilization of the limited battery energy is vital for prolonging the network lifetime. Energy budget of WSNs is dominated by the energy dissipation on communication, So that the optimization of all aspects of WSN communication and networking is the overarching goal. Smart grid is a green technology that allows the integration of renewable energy sources and demand response management. Internet of Things (IoT) and Machine-to-Machine (M2M) communications are the major drivers of smart grid deployment and applications, particularly in residential and commercial buildings. In this paper we present the survey for the wireless sensor network and their applications and the performance.

Keywords: Wireless Sensor Network, Neighbor area network, Quality of Service, IEEE.

INTRODUCTION

A wireless sensor network (WSN) is a group of sensor nodes which are deployed in a field to monitor physical conditions autonomously. WSNs can measure various physical conditions like sound, temperature, pressure, humidity, load, speed etc. After sensing the data sensor nodes pass this information to a base station or sink following a particular routing pattern. The number of sensor nodes in a WSN can vary from a few to hundreds or thousands in numbers depending on the application. A sensor node consists of many components, a microprocessor or a microcontroller to control the operation of node, a radio transceiver to transmit and receive information, an ADC converter to convert analog information to digital and vice versa and a power source [2].

In wireless sensor network, the network structure can be divided into three main protocols; flat-based routing, hierarchical-based routing and location-based routing. Flat-based routing usually involves sensor nodes that has equal roles that works together to perform sensing task. In this protocol, data centric routing and attribute-based naming are used in most routing protocols in order to create a more efficient communication. Hierarchical-based routing provides more efficient routing where the sensor nodes are usually clustered and led by cluster heads which can process and aggregate more with the sensor nodes senses data [1].

The use of wireless sensor networks is increasing day by day and at the same time it faces the problem of energy constraints in terms of limited battery lifetime. As each node depends on energy for its activities, this has become a major issue in wireless sensor networks. The failure of one node can interrupt the entire system or application. Every sensing node can be in active (for receiving and transmission activities), idle and sleep modes. In active mode nodes consume energy when receiving or transmitting data. In idle mode, the nodes consume almost the same amount of energy as in active mode, while in sleep mode, the nodes shutdown the radio to save the energy. The following steps can be taken to save energy caused by communication in wireless sensor networks [2].

To schedule the state of the nodes (i.e. transmitting, receiving, idle or sleep). Changing the transmission range between the sensing nodes. Using efficient routing and data collecting methods. Avoiding the handling of unwanted data as in the case of overhearing. In WSNs the only source of life for the nodes is the battery. Communicating with other nodes or sensing activities consumes a lot of energy in processing the data and transmitting the collected data to the sink. In many cases (e.g. surveillance applications), it is undesirable to replace the batteries that are depleted or drained of energy.

Most wireless sensor networks (WSNs) are composed of cheap battery-powered devices that are able to sense their environment and to communicate with each other in a wireless manner. Their low-cost and energetic autonomy has enabled environmental monitoring applications to emerge in the recent years. For instance, WSNs have been used for wildlife tracking and monitoring. In order to last for years with the current technology, it is crucial to save nodes energy in a WSN. As the radio module of a sensor node generally needs several times more energy than its processor, many researchers have focused on implementing energy-efficient communication protocols, where sensor nodes go to sleep mode periodically[5].

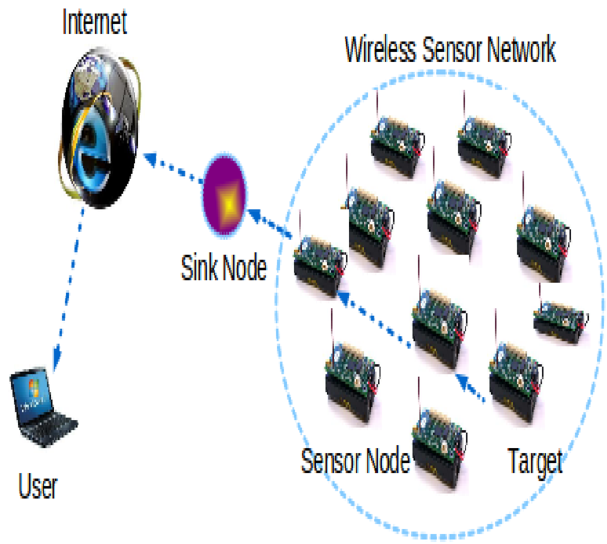

Figure 1: Wireless Sensor Networks.

The rest of this paper is organized as follows in the first section we describe an introduction of about the Smart grid and their applications. In section II we discuss about the clustering in wireless sensor Networks. In section III we discuss about the Zigbee routing protocol. In section IV we discuss about the rich literature for the packet optimization in smart grid using wireless sensor networks, finally in section V we conclude the about our paper which is based on the literature survey and specify the future scope.

II CLUSTERING IN WSN

In order to support data aggregation through efficient network organization, nodes can be partitioned into a number of small groups called clusters. This phenomenon of grouping sensor nodes into clusters is called clustering [26]. Every cluster would have a leader, commonly referred to as cluster-head (CH). A CH may be elected by the sensor nodes in the cluster or pre-assigned by the network designer [27]. A CH may also be just one of the sensors or a node that is generally richer in resources. The cluster membership may be fixed or variable.

There are several advantages in clustering phenomenon. The basic advantage is that, it supports network scalability. It can localize the route setup within the cluster [26]. Clustering can also conserve communication bandwidth. Moreover, clustering can stabilize the network topology at the level of sensors and thus cuts on topology maintenance overhead [28]. The CH can also implement optimized management strategies to prolong the battery life of the individual sensors and to maximize the network lifetime. A CH can schedule activities in the cluster so that the nodes can switch to the low-power sleep mode most of the time and reduce the rate of energy consumption. Furthermore, a CH can aggregate the data collected by the sensors in its cluster.

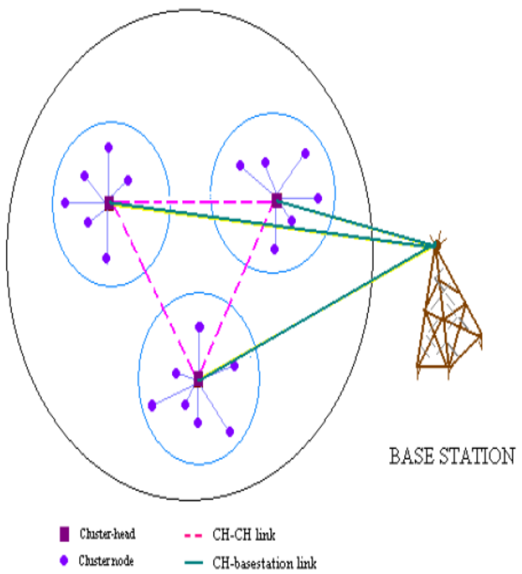

Figure 2: Schematic diagram of clustering mechanism.

III ZIGBEE

ZIGBEE is a worldwide standard of wireless personal area network targeted to low-power, cost-effective, reliable, and scalable products and applications. Different from the other personal area network standards such as Bluetooth, UWB, and Wireless USB, ZigBee provides the low power wireless mesh networking and supports up to thousands of devices in a network. Based on these characteristics, ZigBee Alliance has extended the applications to the diverse areas such as smart home, building automation, health care, smart energy, telecommunication, and retail services [1].

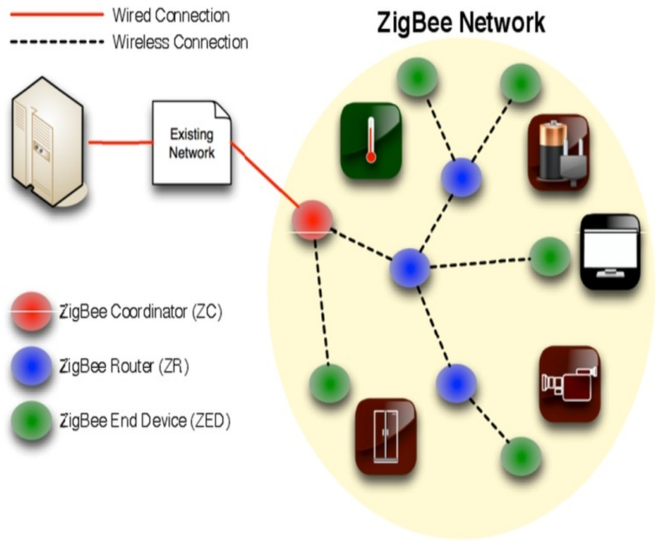

Figure 3: ZigBee Networks.

The ZigBee network layer, which is the core of the standard, provides dynamic network formation, addressing, routing, and network management functions. ZigBee supports up to 64,000 devices in a network with the multi-hop tree and mesh topologies as well as star topology. Every node is assigned a unique 16-bit short address dynamically using either distributed addressing or stochastic addressing scheme. The routing protocols of ZigBee are diverse so that a system or users can choose the optimal routing strategy according to the applications.

IV RELATED WORK

In this section we discuss about the rich literature survey for the packet optimization in smart grid using wireless sensor networks.

[1] In this study, they construct a detailed link layer model by employing the characteristics of Tmote Sky WSN nodes and channel characteristics based on actual measurements of SG path loss for various environments. A novel mixed integer programming framework is created by using the aforementioned link layer model for WSN lifetime maximization by joint optimization of transmission power level and data packet size.

[2] This paper has provided an overview on the role satellite communications can play in different smart grid scenarios. The use of satellite solutions is becoming more and more economically feasible, as the cost of the satellite equipment and the prices of the relevant services are continuously decreasing. In addition, satellite communication services are distance insensitive and scale well with the increase of the area to cover, making them attractive for deployments over wide areas.

[3] In this paper we derived a multi-class traffic model and used it to analyze the energy consumption of some recent and base line MAC protocols in low data rate delay-tolerant WMSNs. They modeled the energy consumption of MAC protocols from different categories including asynchronous (sender-initiated and receiver-initiated), and synchronous (locally and globally) MAC protocols. The derived models allow us to compare the performance of MAC protocols as a function of the network topology, the density of multimedia nodes and the sampling rates.

[4] In our project they successfully included automatic priority scheduling of appliances and have managed to reduce the peak load which is the main objective of the project. Furthermore, they elaborated on the performance of the WSHAN in terms of packet delivery ratio and delay.To enhance performance of the network we have used simulation to decrease the packet size which results in decreasing the delay ratio and increasing the delivery ratio. Finally, they propose to fuse artificial intelligence (AI) with system to make it user-friendly.

[6] In this paper, the design of an event-driven middleware for general purpose services in Smart Grid is presented. The main purpose is to provide a peer-to-peer (P2P) distributed software infrastructure to allow the access of new multiple and authorized actors to Smart Grid's information in order to provide new services. To achieve this, the proposed middleware has been designed to be i) event-based, ii) reliable, and ii) secure from malicious Information and Communication Technology (ICT) attacks, as well as iv) to enable hardware independent interoperability between heterogeneous technologies. To demonstrate practical deployment, a numerical case study applied to the whole UK distribution network is presented and the capabilities of the proposed infrastructure are discussed.

[7] One of the main messages brought by this paper is that the study of the performance of the LTE access in case of massive M2M traffic requires a fundamentally different approach compared to the study of human-type traffic. Specifically, in M2M, it is necessary to take into account the features of the actual channels used to exchange signaling information, such as PRACH, PDCCH and PUSCH. In case of small payloads, the main limitations are posed by PDCCH or PRACH if the system bandwidth is very large.

[8] In this paper, they first present an analysis of reliability in sensor actor networks, and lay out the factors that affect reliability. They then propose a scheme, where actor nodes cooperate to reach a global estimate under interruptions due to licensed user interference, i.e., consensus. They show that consensus improves reliability compared to local estimation of event features. They further show that convergence rate depends on connectivity of actors. Our analyses are generic and can be applied to inhomogeneous licensed user activity and interference on channels. A simulation study is presented to support our analyses and demonstrate the performance of proposed scheme in achieving consensus and mitigating disagreement among actor nodes.

[9] In this paper, they study the joint optimization of control and communication systems incorporating their efficient abstractions practically used in real world scenarios. The proposed framework allows including any non-decreasing function of the power consumption of the nodes as the objective, any modulation scheme and any scheduling algorithm. They first introduce an exact solution method based on the analysis of the optimality conditions and smart enumeration techniques.

[10] In this paper, they first propose a hybrid wireless mesh protocol (HWMP) based neighbor area network (NAN) QoS aware routing scheme, named HWMP-NQ, to meet the QoS requirements by applying an integrated routing metric to route decision with effective link condition probing and queue optimization. To further improve the reliability of the proposed HWMP-NQ, they present a multi-gateway backup routing scheme along with a routing reliability correction factor to mitigate the impact of routing oscillations.

[11] In this article, they evaluate the requirements and key design challenges for routing and MAC protocols in the CR-based smart grid. they also provide a review of research carried out to date for routing and MAC protocols for the CR-based smart grid. Cognitive radio technology can facilitate communication in smart grid applications through dynamic spectrum access.

[12] This article serves as a comprehensive survey on SDN-based smart grid. In this article, they first discuss taxonomy of advantages of SDN-based smart grid. They then discuss SDN based smart grid architectures, along with case studies. Their article provides an in-depth discussion on multicasting and routing schemes for SDN-based smart grid.

[13] In this paper they presents the honey bee mating optimization-based routing and cooperative channel assignment algorithms have been proposed. The developed framework significantly decreases the probability of packet loss and preserves high link quality among sensor nodes in harsh smart grid spectrum environments. The proposed approach performance has been evaluated in terms of packet delivery ratio, delay, and energy consumption demonstrating that it has successfully addressed the QoS requirements of most of the SG applications presented.

[14] In this paper, they consider the utilization of TV White Spaces (TVWS) by small Cognitive Radio (CR) network operators to support the communication needs of various smart grid applications. They first propose multi-tier communication network architecture for smart metering applications in dense urban environments. Their measurement campaign, without any competition from other CR operators, reveals that the communication architecture can achieve more than 1Mbps data rates using the free unlicensed TVWS spectrum.

V CONCLUSIONS

Due to diversity and applicability of wireless sensor network grow in different field such as battle field, medical field and many more application based on dynamic infrastructure and controlled topology. The work processing of wireless sensor network consumed more power for the processing of data and life of sensor consumed more energy. Energy consumed more during path finding and data transmission operations terms as routing. Routing is the most challenging issue and direct concern to energy in WSN comparable with ad hoc and cellular network.

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