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A Methodology for Reliability In Wireless Sensor Network with ASSR Technique

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Abstract—As communication technology and smart manufacturing have developed, the industrial internet of things (IIoT) has gained considerable attention from academia and industry. Wireless sensor networks (WSNs) have many advantages with broad applications in many areas including environmental mon-itoring, which makes it a very important part of IIoT. However, energy depletion and hardware malfunctions can lead to node failures in WSNs. The industrial environment can also impact the wireless channel transmission, leading to network reliability problems, even with tightly coupled control and data planes in traditional networks, which obviously also enhances network management cost and complexity. In this paper, we introduce a new software defined network (SDN), and modify this network to propose a framework called the improved software defined wireless sensor network (improved SD-WSN). This proposed framework can address the following issues. 1) For a large scale heterogeneous network, it solves the problem of network management and smooth merging of a WSN into IIoT. 2) The network coverage problem is solved which improves the network reliability. 3) The framework addresses node failure due to various problems, particularly related to energy consumption. Therefore, it is necessary to improve the reliability of wireless sensor networks, by developing certain schemes to reduce energy consumption and the delay time of network nodes under IIoT conditions. Experiments have shown that the improved approach significantly reduces the energy consumption of nodes and the delaytime, thus improving there liability of WSN.

Index Terms—Industrial internet of things (IIoT), reliability, software defined network (SDN), wireless sensor network(WSN).

I. INTRODUCTION

Sensor Wireless Networks (WSNs) are a kind of ad hoc network made up of hundreds or thousands sensor nodes that cooperate to route packets to a particular node (sink node) capable of mediating the communication between the WSN and an external network, e.g., the Internet. The location of nodes in a sensor network may not be predetermined and usually have a unique sensor node called Base Station (BS). All member nodes will forward data to BS either directly or through multi hop transmission. A base station may be either static or dynamic sensor node and provides wireless connectivity to its users. It is usually more capable than other sensor nodes in the WSN [1], [2] (see Fig. 1).

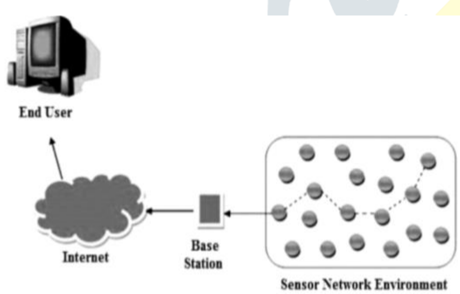

Figure 1: Wireless Sensor Network [3]

Commonly deployed in environments whose access is hard, sensor nodes have limited resources of processing, storage, transmission, and battery. In such places, it is painful to replace a sensor node when it fails or when the battery is over. Therefore, to plan the WSN deployment is a crucial activity.An initial step to planning a WSN is to assess the power consumption of application and communication protocols running on the sensor nodes.By analyzing this assessment, it is possible to infer the WSN lifetime.

However, this is not sufficient as the WSN can have the energy to perform for days, but some nodes may be unable to communicate with the sink node. In other words, some portions of the network can be dead in the case the batteries of some nodes are drained. As existing solutions [4, 5, 6, 7] usually calculate the reliability of WSNs considering the failure of communication links and nodes, if a node fails (stops working) due to the scarcity of energy, the WSN's reliability is affected by the node's power consumption. An approach to face this problem is to evaluate the WSN's reliability integrated with the power consumption. If this evaluation is ignored, the WSN could not perform as planned.

This paper thus, presents existing techniques that focus on energy efficiency of the network and reliability of the data transfer. Section II presents brief survey of such techniques with one techniques presented in detail in section III. Finally the paper is concluded in section IV.

II. LITERATURE REVIEW

Reliable energy efficient data transmission in WSNs to prolong the network lifetime is an important and challenging issue. In general, there are several approaches like multi-path routing and source coding, automatic repeat request, used for providing reliable data transfer in WSNs. But the overhead and performance of such end-to-end single-path approaches are often dominated by congestion as well as some poor-quality links or nodes on the path. That is, these traditional approaches are not able to quickly and properly react in this multi-hop wireless environment. To cope with the above issues, in this paper [8] the authorspropose an energy efficient reliable data transfer scheme named as “Adaptive Sectoring Scheme for Reliability (ASSR)” for WSNs. In this approach, the given sensor field is divided into sectors activated one at a time by the occurrence of an event. To minimize the congestion as well as to increase the throughput with maximum packet delivery ratio, the sectoring process is adjusted dynamically to ensure reliable data transmission. Simulation experiments show that the proposed scheme leads to an improvement of the reliability and energy consumption.

In this paper [9], the authors introduce a new software defined network (SDN), and modify this network to propose a framework called the improved software defined wireless sensor network (improved SD-WSN). This proposed framework can address the following issues. 1) For a large scale heterogeneous network, it solves the problem of network management and smooth merging of a WSN into IIoT. 2) The network coverage problem is solved which improves the network reliability. 3) The framework addresses node failure due to various problems, particularly related to energy consumption. Therefore, it is necessary to improve the reliability of wireless sensor networks, by developing certain schemes to reduce energy consumption and the delay time of network nodes under IIoT conditions. Experiments have shown that the improved approach significantly reduces the energy consumption of nodes and the delay time, thus improving the reliability of WSN.

A central concern is the lack of consolidated solutions that enable a person to evaluate the power consumption of applications and the network stack also considering their reliabilities. To solve this problem, the authorsin [10] introduce a fully automatic solution to design power consumption aware WSN applications and communication protocols. The solution presented in this paper comprises a methodology to evaluate the power consumption based on the integration of formal models, a set of power consumption and reliability models, a sensitivity analysis strategy to select WSN configurations and a toolbox named EDEN to fully support the proposed methodology. This solution allows accurately estimating the power consumption of WSN applications and the network stack in an automated way.

This paper [11] validates the vulnerability of secret sharing schemes under the relaxation of a secure area around the BS. The authorspropose a new way of combining the energy-efficient Shamir’s ramp secret sharing (SRSS) method with round-reduced AES symmetric encryption, termed as ‘split hop AES (SHAES)’, to address the CN attack problem. This paper theoretically analyzes the energy efficiency and security of the proposed approach, and shows that the proposed combination achieves both semantic security and reliability in an energy-efficient way.

In this article [12], a grid-based reliable multi-hop routing approach for wireless sensor networks is proposed. In order to minimize and balance the energy consumption, our proposed protocol, grid-based reliable multi-hop routing protocol, optimizes the cluster head election process by combining individual ability which consists of node's residual energy and node's location, and local cognition which can balance energy consumption among clusters via a consultative mechanism based on cluster head's lifetime expectancy, while considering data forwarding delay and reliable transmission of data. Simulation results show that grid-based reliable multi-hop routing protocol has improved stability period as compared to other protocols. Meanwhile, grid-based reliable multi-hop routing protocol has better performance in energy efficiency, data forwarding delay, and reliable transmission of data.

This paper [13] presents the design and implementation of a cluster based networkapproach using Novel Information Criterion (NIC) and Credible Data Aggregation (CDA) algorithms. Inorder to improveenergy utilization and set up a fully connected set of nodes, every sub-cluster is connected using the finest techniquesof a connected dominating set. In some cases, poor connectivity still exists, for whichrelay nodesare used. The proposed method,Secure Aggregated Reliable Routing Protocol(SARRP) applies the above-mentioned principles to maintain effective energy utilization and reliable transmission of the sensed data.

Authors in [14] argued that existing routing protocols lack the ability to formally guarantee quantitative properties of reliability and timeliness at the same time.For the purpose of solving the problem mentioned above, a reliability and timeliness guaranteed opportunistic routing (RTGOR) is proposed. RTGOR considers the transmission time and the link delay as the QoS parameters to improve the transmission performance. Both reliability and timeliness requirements could be provided quantitatively for mission-critical applications in the RTGOR algorithm, and the complexity has not been increased. The major contributions are as follows: The expected transmission delay (ETD) based on the bidirectional transmission success rate is defined as the routing metric, and the lower delay node is selected as the next hop of transmission to provide the best delay guarantee.Two-level lists selection method is defined. On the premise of ensuring reliability and timeliness, the scale of the forwarder list is minimized, the network load is reduced, and the communication ability of the network is improved.A complete design and implementation of RTGOR on the Opportunistic Network Environment (ONE) simulator platform. Through performance comparisons, we demonstrate a substantial reliability and timeliness improvement of RTGOR under different scales of network nodes.

The objective of this paper [15] is to assess the reliability of a wireless sensor network (WSN) equipped with mini photovoltaic cells (PV-WSN), simulating forest fire conditions. Their assessment considers the hardware specifications of WSN sensors, photovoltaic (PV) cells, rechargeable batteries, communication protocols, and elements required for efficient fire detection. Their study's main assumptions are that: the PV-WSN is structured randomly with one sink per cluster and identical sensors used, random losses due to environmental interference to the network and variability of PV-cell orientation are accounted for, the shape of forest fire propagation is uniform and elliptical, the surrounding vegetation is homogeneous, and packets lost during transmission are retransmitted with the use of a dynamic source routing protocol. Physical hardware specifications were included in the reliability assessments for each network type and a realistic battery re-charge/depletion scenario based on sensor states, sun availability, and PV efficiency was considered for a PV-WSN. They developed a simulator to study and to compare how the PV-WSN behaved differently under different forest fire conditions. Their results support the use of a PV-WSN, as network lifetime can be efficiently prolonged in the context of large-scale fire detection with this setup.

In this work [16], the authors have proposed a reliable and efficient environmental monitoring system in ponds using wireless sensor network and cellular communication technologies. They have designed a hardware and software ecosystem that can limit the data loss yet save the energy consumption of nodes. A lightweight protocol acknowledges data transmission among the nodes. Data are transmitted to the cloud using a cellular protocol to reduce power consumption. Information in the cloud is mining so that realtime warning notifications can be sent to users. If the values are reaching the threshold, the server will send an alarm signal to the pond's owner phone, enable him to take corrective actions in a timely manner. Besides, the client application system also provides the feature to help the user to manage the trend of a physical environment such as shrimp ponds by viewing charts of the collected data by hours, days, and months. They have deployed their system using IEEE 802.15.4 Standard, ZigBEE, KIT CC2530 of Texas Instrument, and tested the system with temperature and pH level sensors. Their experimental results demonstrated that the proposed system have a low rate of data loss and long energy life with low cost while it can provide real-time data for water quality monitoring.

III.ADAPTIVE SECTORING SCHEME FOR RELIABILITY (ASSR)

The authors in "Energy Efficient Reliable Data Transmission in Resource Constrained Ad-Hoc Communication Networks"explainedASSR algorithm, the aim is to achieve desired reliability by using an adaptive sectoring scheme. In this method, the given sensor field is divided into some sectors and one at a time are activated only the sectors in which an event occurs. After the occurrence of an event, the nodes within the active sector in which the event occurred participate in the data transmission process and send the required data to their respective sector head (SH) which is ultimately forwarded to the destination sink node.

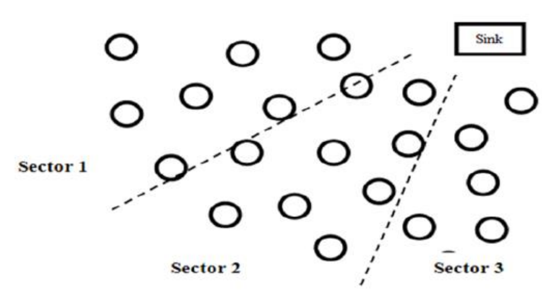

Figure 2: Sectoring scheme for WSN [8]

Figure 2shows the layout after application of the sectoring method where the sensor field is divided into three different sectors. If an event occurs in any one of these sectors, only the current sector is activated which belongs to that event, and all other remaining nodes remain in idle conditions i.e. they do not take part in the data transmission process.

This algorithm modifies the basic AODV protocol. In this approach, we monitor the reliability of WSN. We define two reliabilities: one as the desired reliability - Rd and the other as the observed reliability - Ro. Rd is the ratio between the number of received packets and the packet delivery ratio(PDR). Ro is the ratio between the number of received packets and the packets send. Based on these two parameters, the algorithm dynamically adjusts the sector angle θ. Let max(Δθ) be the maximum angle of θ, dθ the incremental angle of the current sector, θ(n) the new angle and θ(c) the current angle of the sector. Considering the Sink node in the Corner, divide the given area into N number of sectors. The nodes that are close to the sink are declared as Sector Heads (SHs). If an event occurs in a particular sector, then the nodes present in this sector are activated. The remaining sector nodes are kept in idle condition. If an event occurs activate current sector nodes. Other sector nodes remain in idle conditions. Send the data packets to sink through SH. If the observed reliability is less than desired reliability then rotate the sector dynamically to find the shortest path and avoid congestion considering Ro and Rd. Data packets are transferred to the sink via their respective SHs.

During data transfer, the source node transmits data packets to the destination. The path taken by packets for the data transmission process usually is the shortest path among all available paths. In some cases this leads to congestion resulting in packets loss, thus demanding retransmission. In such cases the sector angle θ is updated dynamically so as to increase or decrease the sector size and ultimately neighboring nodes at the boundaries are included in the communication path if necessary. This will help to avoid congestion and again to transmit data packets by the shortest distance possible. The data send by the nodes will be collected at their respective SH and from there it is forwarded to sink node. With this adaptive sectoring algorithm the AODV algorithm practically is applied to only one sector. It works within this sector and doesn't choose paths outside it. In this case less control overhead is required as the route request and route reply messages are limited only to the given sector. The single hop node from the sink which is the SH persists as long as the network exists. Due to this specific sectoring approach congestion is avoided ultimately helping to minimize energy consumption by the network nodes.

IV. CONCLUSION

Wireless ad hoc networks consist of nodes that are operated by low battery. When these networks have more than one source nodes, the routing protocol followed by these nodes causes congestion in the network leading to reliability issues. Therefore considering that energy and reliability are major issues in the network, this paper has presented the techniques that offer solution to these problems. Sectoring scheme is one such method that divides the network into sectors and bounds the broadcasting in respective sector thereby resulting in lesser energy consumption and more reliability. However, work can be done on this sectoring scheme in context of increasing the reliability of the network.

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RESULTS AND DISCUSSION

The aim of the study is to achieve reliability in wireless ad hoc networks. To achieve this, the adaptive sectoring scheme was modified. The proposed modification as well as to check the effectiveness of the proposed scheme against the existing scheme, both the schemes were implemented in network simulator 2.35. The network simulator uses tool command language to create the network. Furthermore, all the routing protocols are inbuilt in NS2 and are hard coded in c++ libraries. The output in this tool is achieved in network animator which shows the video or animation of the network behavior under the simulated protocol or algorithm. The graphs are created using xgraph tool.

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