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Review of Energy-Efficient Multicast Routing Protocol for Wireless Sensor Networks

[1]Yash Bhindia [2]Prof. Sanket Choudhary
M.Tech Scholar, Assistant Professor
Department of Electronics and Communication Engineering,
Lakshmi Narain College of Technology Excellence, Bhopal, India

Abstract : These days Wireless Sensor Networks (WSN) have been used in various Internet of Things (IoT) applications viz., healthcare monitoring, disaster management, smart buildings, smart farming etc. it is one of the substitutes for solving distinct problems of IoT in various areas. Power efficiency is one of the major issues with sensor networks. In the earlier days, WSN was working on Client Server (CS) model, but for the improvement of energy efficiency, researchers proposed Mobile Agent (MA) based WSN. This paper presents review of energy-efficient multicast routing protocol for wireless sensor networks.

***IndexTerms* - WSN, MA, CS, IOT, Energy, Sensor.**

I. INTRODUCTION

Advancement in micro-electronics system is the major cause for the development of WSN in the era of twenty first century. WSN has become very essential for daily user, without WSN our work would have been very burden or hard. WSN are adept of sensing, transforming and bearing of the information. These sensor nodes are generally arranged in a diverse space like in war space where human are hard to reach. WSN generate large amount of data in form of bits or stream. These nodes contact over a precise range of nodes which are frame in an Ad-hoc structure and get the data to the sink. WSN have many limited resources like limited energy, memory, computation power, communication capacity etc.

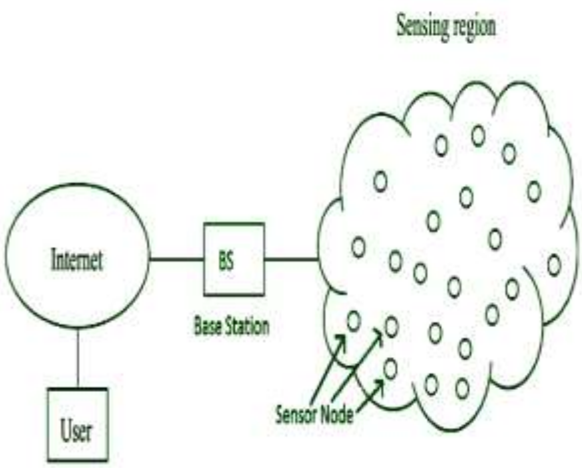

Figure 1: Wireless sensing region

There are several IoT applications which are based on WSNs [1] such as healthcare monitoring, vehicular monitoring, fire forest monitoring, street monitoring, environment monitoring etc. These networks are the form of system that is made of hundreds or thousands of wireless sensors with a significant amount of resources which are used in a very wide range of field. In the previous years, we have seen the use of newly developed protocols for information collection in WSN.

These sensors are distributed in an area which is being observed and information is collected in real time and related to the physical environment [2]. Sensors work on batteries. It is impracticable to change the battery for the network. For increasing the network lifetime, it is very good step for designing the algorithm so that the transmission quantity can be reduced. Numerous endeavours are taken to lessen the number of undesirable transmissions in sensor network. The information accumulation procedures increase energy consumption in WSN.

The information accumulation is a system to join information from different sensor nodes to dispense with repetitive data and give a rich and multi-dimensional perspective on the observing condition. The information accumulation calculation can lessen the quantity of transmission by permitting the aggregator node to transmit just the necessary information, not the excess data.

II. BACKGROUND

W. K. Yun et al.,[1] consider the degrees of the possible data aggregation of neighbor nodes when a node needs to determine the routing path. We propose a novel Q-learning-based data-aggregation-aware energy-efficient routing algorithm. The proposed algorithm uses reinforcement learning to maximize the rewards, defined in terms of the efficiency of the sensor-type-dependent data aggregation, communication energy and node residual energy, at each sensor node to obtain an optimal path. We used sensor-type-dependent aggregation rewards. Finally, we performed simulations to evaluate the performance of the proposed routing method and compared it with that of the conventional energy-aware routing algorithms. Our results indicate that the proposed protocol can successfully reduce the amount of data and extend the lifetime of the WSN.

P. Le Nguyen et al.,[2] propose a novel geographic routing protocol for WSNs, namely, Q-learning Inspired Hole bypassing (QIH), which is lightweight and efficient. QIH's conceptual idea is to leverage Q-learning to estimate the distance from a node to the holes. QIH makes routing decisions following the nodes' residual energy, their estimated distance to the holes, and their distance to the destination. We first confirm the effectiveness of QIH by theoretical analysis. Then, we conduct extensive simulations of QIH in comparison to state-of-the-art protocols. The simulation results show that QIH outperforms the other protocols in terms of network lifetime, packet latency, and energy consumption.

L. Li, Y. Luo et al.,[3] identify a new security issue, called the malicious energy attack, in sustainable wireless communication networks (SWCNs). We show that by providing extra energy to specific nodes, a malicious energy source (MES) can intentionally manipulate the routing path of SWCNs. The efficiency of energy attack depends on which nodes to be attacked. To enhance the efficiency of energy attack, a reinforcement learning technique, Q-Learning, is used to develop an intelligent energy attack (Q-IEA) policy for MES. Through interacting with the network environment, the Q-IEA can intelligently take attack actions without having to know the details of the routing method at the network layer. This function can greatly enhance the adaptability of MES to different routing protocols and network topologies. Simulation results verify that Q-IEA can significantly manipulate the routing path of the targeted traffic on demand.

M. U. Younus et al.,[4] optimize the routing path of SDWSN through RL. A reward function is proposed that includes all required metrics regarding energy efficiency and network quality-of-service (QoS). The agent gets the reward and takes the next action based on the reward received, while the SDWSN controller improves the routing path based on the previous experience. However, the whole network is also controlled remotely through the Web. The performance of the RL-based SDWSN is compared with SDN-based techniques, including Traditional SDN and Energy-Aware Software Defined Networking (EASDN), QR-SDN, TIDE and non SDN-based techniques, such as Q-learning and RL-based Routing (RLBR). The proposed RL-based SDWSN outperforms in terms of lifetime from 8% to 33% and packet delivery ratio (PDR) from 2% to 24%. It is envisioned that this work will help the engineers for achieving the desired WSN performance through efficient routing.

Y. Zhou et al.,[5] define two reward functions (i.e., depth-related and energy-related rewards) for Q-learning with the objective of reducing latency and extending network lifetime. In addition, a new holding time mechanism for packet forwarding is designed according to the priority of forwarding candidate nodes. Furthermore, mathematical analyses are presented to analyze the performance and computational complexity of the proposed routing protocol. Extensive simulation results demonstrate the superiority performance of the proposed routing protocol in terms of the end-to-end delay and the network lifetime.

Z. Fang et al.,[6] propose Q-learning aided ant colony routing protocol (QLACO) to address the issues of energy-efficiency and link instability in UWSNs, which uses both the reward mechanism and artificial ants to determine a global optimal routing selection. QLACO uses the reward function to adapt to the dynamic underwater environment and enhance the packet delivery ratio (PDR). Moreover, we propose an anti-void mechanism to solve the void region dilemma. Simulation results show that QLACO outperforms Q-learning-based energy-efficient and lifetime-aware routing protocol (QELAR) and the depth-based protocol (DBR) in terms of PDR, energy consumption and latency.

Y. Zhou et al.,[7] define two cost functions (depth-related cost and energy-related cost) for Q-learning, in order to reduce delay and extend the network lifetime. In addition, a holding time mechanism for packet forwarding is designed according to the priority of forwarding nodes. The key contribution lies in: 1) a novel Q-learning-based routing protocol for UWSNs; 2) a new holding time mechanism for packet forwarding; and 3) a packet- delivery-ratio-based scheme to further reduce unnecessary transmissions. Extensive simulation results demonstrate superiority performance of our routing protocol in terms of reducing end-to-end delay and extending the network lifetime.

K. Le et al.,[8] main idea is to exploiting Q-learning technique to estimate the distance from a node to the holes. The routing decision is then determined based on the residual energy of the nodes, their estimated distance to the holes, and their distance to the destination. The simulation experiments show that our protocol strongly outperforms state-of-the-art protocols in terms of the network lifetime, packet latency and energy consumption. Specifically, our proposed protocol extends the network lifetime by more than 12% compared to the existing protocols.

Z. Jia et al.,[9] Reliable communication is a critical concern in power-limited energy harvesting wireless sensor networks (EH-WSNs). The communication optimization is needed since the protocols in battery-powered WSNs cannot adapt to the intermittent harvestable energy sources. In this paper, a novel reinforcement learning (RL) based routing algorithm that fully exploits the capability of wake-up radio (WuR) is presented. This routing strategy aims at increasing the packet delivery rate by leveraging wake-up radio devices to enable receiver nodes to make the decentralized forwarding decision. Simulation results show that the performance of the proposed learning approach, which requires only limited knowledge of the energy harvesting process, has only a small degradation compared to the optimal routing decision with full knowledge of energy harvesting process.

N. Wang et al.,[10] propose two energy efficient geocasting protocols based on Q-learning for wireless sensor networks (WSNs), called FERMA-QL and FER-MA-QL-E. We utilize the theorem of Fermat point to find Fermat points in geocasting, the node which is the closest to the Fermat points is selected as the relay nodes. Then, we establish the shared path among gateways, relay nodes and base station by Q-learning for data transmission. In FERMA-QL, the reward is given by the reciprocal of the distance between the received node and the destination node In FERMA-QL-E, the reward is given by the remaining energy of the received node divided by the distance between itself and the destination node. Sensors utilize the shared path to forward their data to achieve goal of reduce energy consumption. Simulation result shows that the proposed FERMA-QL and FERMA-QL-E can efficiently extend the life-time of the WSN.

X. Zhang, et al.,[11] propose the Q-learning based optimal routing and power allocation policies through learning from the history of the energy harvesting process while satisfying the heterogeneous statistical delay-bounded QoS constraints over multihop big-data relay networks. In particular, under the heterogeneous statistical delay-bounded QoS requirements, we formulate the end-to-end effective-capacity optimization problem for the battery-free energy harvesting based big-data multihop relay networks. Then, we apply the Markov decision process as well as Q-learning methods for deriving the optimal multihop routing algorithms over big-data multihop relay networks.

X. Li, et al.,[12] shows the purpose of addressing the problem and enhancing the robustness of dynamic network, in this paper, we propose a novel routing protocol, based on multi-agent reinforcement learning (MARL) for underwater optical sensor networks. The network is firstly modeled as a multi-agent system and the protocol based on reinforcement learning algorithm is designed to realize dynamic route selection by information interacting between adjacent nodes and maximize the network lifetime. The simulation results demonstrate that MARL has lower energy consumption and higher delivery ratio (about 95%) in a dynamic topology than the existing Q-learning, QDTR and AODV routing protocols.

III. CHALLENGES AND APPLICATION S

A. Challenges

CR-WSNs differ from conventional WSNs in many aspects. Because protecting the right of PUs is the main concern in CR-WSN, it has many new challenges including the challenges in the conventional WSNs. This section discusses the challenges affecting the design of a CR-WSN CR-WSN is a new paradigm in a WS network arena that utilizes the spectrum resource efficiently for burst traffic. The system has the capability of packet loss reduction, power waste reduction, high degree of buffer management, and has better communication quality.

B. Applications

Currently, the number of wireless sensors deployed for different applications has increased. In WSN, data traffic is usually correlated both temporally and spatially. When any event occurs, WSNs generate packet bursts and they remain silent when there is no event. These temporal and spatial correlations introduce to the design challenge of the communication protocols for WSN. With the intelligent communication protocols in CR-WSN, it is possible that the wireless sensors deployed for the same purpose use the spectrum of different incumbents in spatially overlapping regions. This is possible with cooperative communication among SUs, which obviously mitigates interference issues.

IV. CONCLUSION

As a successful technology to serve in urban areas, wireless sensor networks still have a lot of ground to cover because energy constrained sensors with compromised processing ability need to effectively operate in diverse environment of multiple applications. To use small, lightweight and portable sensors for multitasking, we need appropriate protocols which enable sensors to work properly by avoiding overkill so that energy levels of sensor nodes are not depleted. Therefore, we opine that efficient operation may be achieved by rendering some of the sensor nodes for data aggregation in one situation, whereas another scenario would call for a few nodes to act as data relays instead of aggregators. Similarly, the selection of routing protocols would vary depending upon whether the intended operation is location assisted or mobility based. We have discussed and categorized routing protocols in this paper which may serve as a selection guideline in terms of their operational mechanism and utility.

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