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Energy-Efficient Algorithm in an Improved Software-Defined Wireless Sensor Network

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ABSTRACT: Wireless sensor networks are a category of networks where real time applications are implemented with respect to use and advantage. Creating a network is always a first challenge and implementing in real time and using it is the next challenge. Also energy maintenance and power consumption along with finding out malicious nodes and intrusion in the network is the most difficult task. The objective is to detect intrusion which is used to find malicious nodes and reduce the energy consumption of nodes with providing security. Energy consumption of nodes with solution to find out malicious nodes in the network with co-operative bait detection scheme(CBDS) and ad-hoc on demand distance vector routing protocol (AODV) resulting in increase the efficiency of the system and to reduce the cost of the system. To propose a new system which will work in detecting and preventing intrusions with effectiveness to enhance the safe working of a sensor network?

KEYWORDS: SD-WSNs, AODV,CBDS, WSN, energy-efficient algorithm.

I. INTRODUCTION

Traditional wireless sensor networks (WSNs) operate as distributed networks. Because of their flexible deployment, convenient access and low cost, WSNs are widely used in many fields, and many sensor nodes are equipped with various types of sensors to provide services, including temperature monitoring, humidity monitoring and even audio and video monitoring, among others. However, in most WSNs, sensors and communication module are typically powered by batteries, and replacing the depleted batteries is cost prohibitive or even impossible. The energy constraints have caused formidable challenges for the network lifetime of the entire WSN system, which substantially limits the applications of WSNs. Therefore, designing an energy-efficient algorithm to control the transmission energy balance of all the nodes is of particular importance.

A. TRADITIONAL ENERGY-EFFICIENT ALGORITHMS

Many energy-efficient algorithms to improve the energy efficiency of WSNs have recently been presented. The authors are therefore herewith provided surveys of energy-efficient algorithms applied in WSNs, and they provided surveys of the energy-efficient routing protocols for WSNs. They divided the energy-efficient algorithms into various categories: radio optimization, data reduction, sleep-wakeup schemes, charging solutions and energy-efficient routing. Each category covers a variety of newly proposed algorithms, which have greatly promoted the research on energy efficiency in WSNs.

B.THE INTRODUCTION OF GAME THEORY AND ITS INSUFFICIENCY

Among all the latest energy-efficient algorithm studies, most researchers focus on the routing and data transmission schemes. As the foundation of WSNs, energy-efficient routing has become a hot topic in energy-saving areas, and in recent years, game theory has emerged as a key tool for designing novel energy-efficient routing algorithms. Game theory provides a powerful tool for describing the phenomenon of competition and cooperation between rational decision makers In the latest studies, many researchers have introduced a game-theoretic approach to energy conservation. proposed an efficient and rapid convergence coalition formation algorithm to obtain the stable coalition partition in the game, a reliable coalition formation routing (RCFR) protocol was designed to enhance the packet delivery ratio, and the algorithm decreased the routing establishing time and balanced energy introduced a game

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theoretic method, namely cooperative Game-based Fuzzy Q-learning (G-FQL), which implements cooperative defence counter-attack scenarios for the sink node and the base station to operate as rational decision-maker players through a game theory strategy. designed an evolutionary game theoretical resource control protocol (EGRC) for WSNs, which developed a non-cooperative game containing a large number of sensors as players for alleviating and controlling congestion in a WSN by utilizing the available resources and controlling the radio transmission power. In [8], Sun *et al.* proposed an energy-balanced unequal clustering routing protocol based on game theory named GBUC, attempting to achieve energy balance and improve network performance. A topology control and routing algorithm based on non-cooperative game theory in UWSNs was presented which can optimize the network structure and prolong the network life cycle. used game theory to propose an efficient routing scheme in a WSN that considers the signal-to-interference-plus-noise ratio (SINR) to determine the most optimal paths, and the WSNs in this paper were modelled as a dynamic, non-cooperative and incomplete information game with the static sensor nodes as the players in the network.

However, all the above game-theoretic energy-efficient algorithms are based on distributed schemes, and the disadvantages are as follows. 1) The edge nodes have a great probability of failure in one routing discovery procedure, which makes the energy-efficient schemes invalid; 2) In distributed routing algorithms, more routing overhead is necessary to guarantee the success of giving a suitable path to the sink node, which can result in considerable energy waste; 3) In a distributed architecture, all the nodes need to have calculation ability, and the redundant energy consumption is high; Finally, 4) there is no flexibility to adjust the deployment in a game-theoretic algorithm without high energy loss in each node. To further reduce energy consumption and make game theory more suitable for WSNs, one feasible approach is to adopt centralized control algorithms. In fact, in most WSNs, the sensor nodes are stationary, and the connection relations between sensor nodes rarely change. Frequent routing discovery process in distributed routing algorithms becomes less necessary. Moreover, the sink node in WSNs is generally better equipped than the sensor nodes, the computing power and energy reserves of the sink node can be much stronger than other nodes. The above characteristics make it possible to apply a centralized control routing scheme, which is the main idea of integrate an SDN into WSNs. SDN decouples the control plane from the data plane, thus moving the control logic from the node to a central controller. A WSN is a great platform for low-rate wireless personal area networks with little resources and short communication ranges . As the scale of WSNs expand, several challenges arise, such as network management and heterogeneous-node networks. The SDN approach to WSNs seeks to alleviate most of the challenges and ultimately foster efficiency and sustainability in WSNs.

C. SDN EMBEDDED AS A SOLUTION

Some SDN-based WSNs architectures have been pro-posed [There are two major architectures: two-layer architecture and three-layer architecture The feasibility and the advantages and disadvantages of SD-WSNs have been analysed in detail. They provided a survey of related works considering both SDN and centralized non-SDN approaches to network management and control, examined the challenges and opportunities for SD-WSNs, and provided an architectural proposal for an SD-WSNs. developed a platform in which the data plane and the control plane are separated. By adding the SDN into WSNs, the sensor nodes perform only forwarding and do not make any routing decisions, thereby reducing energy usage. The authors in [12] presents a comprehensive review of the SD-WSNs literature. Challenges such as energy, communication, routing, security and configuration are summarized. Many SDN can be referenced. provided a survey of the software-defined net-work function virtualization (NFV) architecture, which benefits a wide range of applications (e.g., service chaining) and is becoming the dominant form of network function virtualization. The logic of packet forwarding is determined by the SDN controller and is implemented in the forwarding devices through forwarding tables. Efficient protocols can be utilized as standardized interfaces in communicating between the centralized controller and distributed forwarding devices. the state of the art on the application of SDN and NFV to internet of things (IoT) was investigated, some general SDN-NFV-enabled IoT architectures are reviewed, and the feasibility of applying SDN to WSNs is described. These literatures can be referred to in the realization of SD-WSNs. These authors investigated three issues, namely, sensor activation, task mapping and sensing scheduling by the centralized control algorithms. The three issues are jointly considered and formulated as a mixed-integer with quadratic constraints programming (MIQP) problem, which is then reformulated into a mixed-integer linear programming

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(MILP) formulation with low computation complexity via linearization. And an efficient online algorithm using local optimization is developed to deal with dynamic events. The proposed online algorithm approaches the globally optimized network energy efficiency with much lower rescheduling time and control overhead. The authors propose a multi-controller load balancing approach called Hybrid Flow in SD-WSNs, which adopts the method of distribution and centralization and designs a double threshold approach to evenly allocate the load. We found that the energy-efficient algorithms are easier to implement in SD-WSNs than in traditional WSNs. However, the aforementioned SDN-based energy-efficient algorithms are based on the ideal SD-WSNs and ignore the process of integrating SDN and WSNs. A new SD-WSNs architecture and a customized game-theoretic energy-efficient algorithm urgently need to be designed.

D. COGNITIVE RADIO FOR SECURE CHANNEL

There are several surveys in literature discussing cognitive radio approaches for WSNs. A survey on multichannel assignment protocols in WSNs is presented in which is further extended. present a review and categorization of existing Intrusion Detection and Prevention Systems (IDPS) schemes in terms of traditional artificial computational intelligence with a multi-agent sup-port. overviewed the recent proposals for spectrum sharing and routing in wireless networks, spectrum sensing and spectrum sharing cooperate with each other to enhance spectrum efficiency.

The establishment of a secure channel in the SD-WSNs is a key issue, which can be propagated by the cognitive radio. An intelligent and distributed channel selection strategy for efficient data dissemination in multi-hop cognitive radio network has been which can be used to choose the optimal channel as a secure channel. The channel bonding algorithm in can utilizes the white spaces hence, furthermore, the bonding channel can minimizing the re-transmissions, which can meet the performance requirements of secure channel.

In this paper, we introduce a new SD-WSNs architecture as a novel and feasible solution to achieve the integration of SDN and WSNs. Based on this novel SD-WSNs architecture, a game-theoretic energy-efficient algorithm is designed, and the distributed and centralized control The sensor nodes do not run the distributed routing algorithms; they simply receive the forwarding rules and the one way table, which has greatly reduced their calculation pressure. The controller generates the secure channel using the shortest path method, and it generates forwarding rules (including the normal channel) using the new algorithm as described in the next section, whose foundation is the topology information and the minimum transmission power features of the SD-WSNs architecture are applied flexibly, which can improve the energy efficiency and increase the network lifetime.

The main contributions of this paper are as follows:

A comprehensive analysis of the feasibility of the integration between SDN and WSNs and the defects in recent SD-WSNs are summarized.

A novel SD-WSNs architecture is presented, which is capable of achieving the integration of SDN and WSNs. A game-theoretic and energy-efficient algorithm is realized, and the detailed steps for applying this innovative algorithm to SD-WSNs are described.

The remainder of this paper is organized as follows. In section II, the feasibility of applying SDN in WSNs is analysed, and the novel SD-WSNs architecture is introduced. In section III, the design of our game-theoretic and energy-efficient algorithm is presented. Simulation scenarios and the results are analysed in section IV. Finally, we conclude this paper in section V.

II. DESIGN OF THE INNOVATIVE SD-WSNs ARCHITECTURE

In this paper, the involved WSNs are considered to be special application-oriented communication networks. In the scenarios where the novel SD-WSNs are adopted, the sensor nodes should be stationary or have low mobility after

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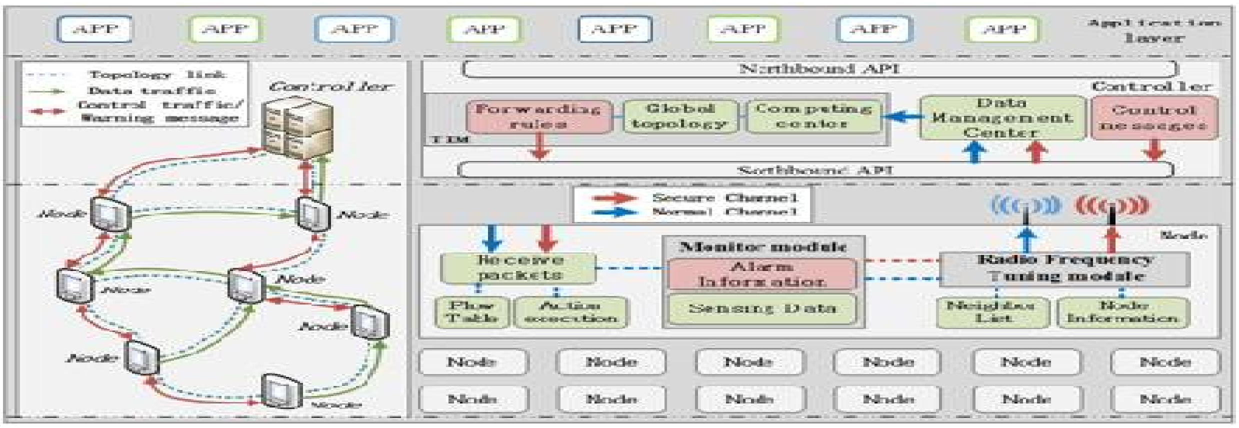
being deployed. SDN was designed to improve the management of wired networks, such as data centres. The network is divided into a control plane and a data plane, and the programmable network switches in the data plane are simplified as forwarding devices. The controller in the control plane runs centralized control software to manage the entire networks . By simplifying the function of network switches, the network is easier to manage, and the efficiency of network switches is improved. The core idea of an SDN is feasible for applying in WSNs because of the following:

1. The sink node and sensor nodes in WSNs can correspond to the controller and switches in an SDN. The network structure can be divided into two layers, as shown in Figure 1. In an SDN, the controller runs the centralized control software to manage the entire net-works, whereas the switches simply forward packets according to their one way tables. In WSNs, the sink node is responsible for collecting sensing data from all the sensor nodes, whereas the sensor nodes simply collect the environment data and send them to the sink node, additional, the sensor nodes in WSNs have to bear the work of routing discovery. The structural similarity makes it possible to integrate WSNs and SDN.

2. The controller in an SDN has a very strong computing capability, and the functions of the network switches are greatly simplified. This feature is similar in WSNs because the sink node is always better equipped with adequate energy, whereas all the sensor nodes have limited energy and calculation resources.



ARCHITECTURE OF THE INNOVATIVE SD-WNS

3) NETWORK LIFETIME

The below figure shows the number of dead nodes of different algorithms versus the simulation time. The number of dead nodes, which directly reacts the network lifetime, increases continuously with the passage of time. In this paper we de ne the network lifetime as the time from the beginning to the time when the rest dead node appears.

As shown in the below graph, we can easily observe that OPGEA has a longer network lifetime than the other algorithms, which is represented by the time corresponding to the starting point of each curve, and the curve of OPGEA starts later than those of the other algorithms. The reason can be found that the energy consumption in the OPGEA is evenly distributed there will be no node to prematurely deplete its energy.

The E-TORA and the LEACH-C can have a longer network life-time than the shortest-path algorithm, as the energy efficiency is higher. The sensor nodes around the controller with the same distance deplete their energy at almost the same time, the slope of the curve reacts this property because the curve of OPGEA is steeper, i.e. more nodes will become dead nodes in a shorter period of time. There are more nodes that are blacked out in a short period of time, which means the energy consumption of the node is very close.

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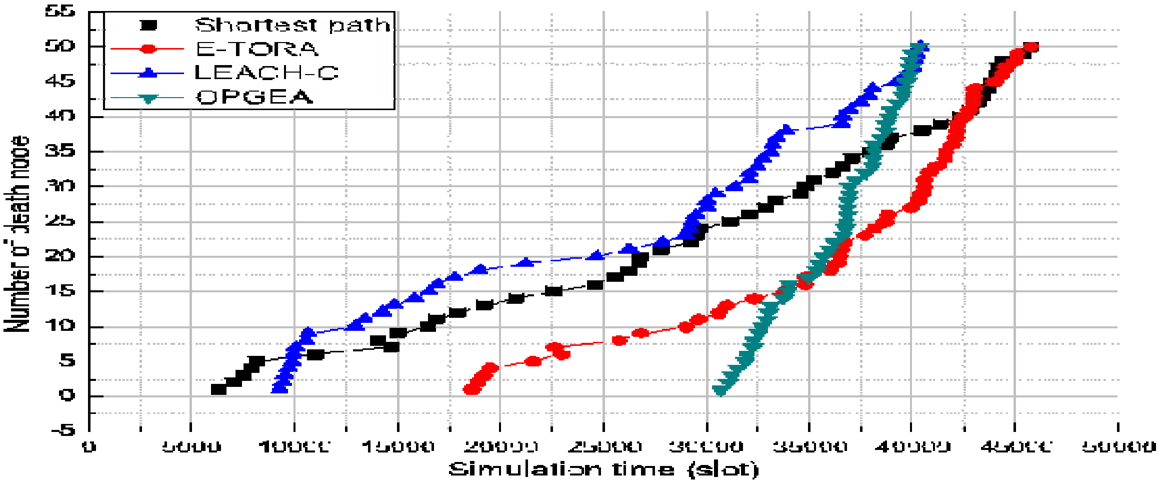

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V. CONCLUSION

In this paper, we conceived an innovative SD-WSNs architecture that fully considers the particularity of traditional WSNs and the superiority of SDN. The SD-WSNs architecture is primarily applicable to the case of massive low-mobility nodes, and the advantage of centralized control in SD-WSNs will greatly reduce the computational requirements of sensor nodes, thereby reducing the energy consumption of all the sensor nodes. Based on the SD-WSNs architecture, a game-theoretic and energy-efficient algorithm is presented, i.e., OPGEA. OPGEA is designed based on the concept of OPG in game theory, which takes the residual energy of sensor nodes into consideration and introduces node .

In this algorithm, the energy consumption of the nodes can be balanced, and the lifetime of the network can be extended. The simulation results show that our algorithm performs better in balancing energy consumption, prolonging network lifetime and increasing energy efficiency than other existing algorithms. Further studies will focus on the design of the SD-WSNs hardware platform, and the OPGEA can be applied to this platform to implement low-power WSNs.

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