Energy Efficient Self-Scheduling Algorithm For Wireless Sensor Networks

Singaram M, Finney Daniel Shadrach S, Sathish Kumar N, Chandraprasad V

Abstract: The goal of this work is to preserve full coverage-target area while minimising the number of active nodes.The nodes which are available in the wireless sensor networks consumes more energy even when the nodes are not sensing or covering the target area. Radio energy models are being used to find the energy consumed during access of the nodes at various modes like transmit, receive, idle and sleep mode. When the nodes enters the sleep state and doesn't sense or cover any target area then there will be an occurrence of blind point and that particular spot where the blind point occurs can be said as an blind spot. The issue of energy saving is significant since in a battery-operated wireless node, the battery energy is finite and a node can only transmit a finite number of bits. The maximum number of bits that can be sent is defined by the total battery energy divided by the required energy per bit. The blind point can be removed using the back of mechanism and that's the major part of the work.

Index Terms: Blind spot, Energy efficient, Energy saving, Radio energy models, Scheduling algorithm, Wireless node, Wireless sensor networks.

1 Introduction

Network lifetime is one of the most critical issues in Wireless sensor networks (WSNs) since most sensors equipped with non-rechargeable batteries with limited energy. WSNs are typically used to monitor a field of interest to detect movement, temperature changes, precipitation etc. The nodes are typically equipped with power-constrained batteries, which are often difficult, expensive and even impossible to be replaced once the nodes are deployed. Therefore energy awareness becomes the key research challenge for sensor network protocols. The energy consumed by a node depends on its state. Each node may be in one of four states: transmit, receive, idle (when the node keeps listening to the medium even when no messages are being transmitted) and finally sleep state (where the radio module is switched off: no communication is possible). [1] It seems to be more adequate to leave the node at the sleep state most of the time. Recent research showed that significant energy savings can be achieved by scheduling node's activities in high-density WSNs. Specifically, some nodes are scheduled to sleep whereas the remaining ones provide continuous monitoring.

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The main issue here is how to minimize the number of active nodes in order to maximize the network lifetime and at the same time to ensure the required quality of service (QoS) for applications. Particularly, coverage may be considered as the measure of the QoS of the sensing function for a WSN. The proposed work aims at optimizing the functioning of the WSN, while conserving, as long as possible, the full coverage of the target area, by preserving the redundant nodes. Thus, a self-scheduling algorithm is introduced.

2 Coverage And Lifetime Issues

Coverage problem [2] may be divided into three categories depending on what exactly an attempting to monitor: Area coverage, Target coverage, Barrier coverage. This paper considers the area coverage problem Since sleeping state is the least power consuming state, keeping the nodes in sleep state is a very good way to save the energy. However, full coverage area must be ensured when some nodes are sleeping. To divide the nodes into disjoint sets such that every state can individually and successively monitoring the task. These sets are successively activated, and all the nodes, not belonging to the active set, will be in the sleep state. Generally, such algorithms are centralized based on a full knowledge of the network topology, which increases the cost of the algorithm. Such a solution is not a reliable because of the failure of nodes. As centralized solution are not adequate to WSNS, especially those including large number of nodes, because of their expensive energy cost, distributed and particularly localized algorithms were more privileged. [6] In order to ensure that each point in a sensor field is covered by at least k-sensors, a subset of sensors are selected for ensuring k-coverage of a wireless sensor network.[7][8] In a dense wireless sensor network, many methods only activate a subset of sensors responsible for surveillance in order to prolong the network lifetime. A centralized method is proposed to partition sensors into mutually exclusive sets such that sensors in each set fully cover the entire sensor field.

3 Energy Remaining Greedy Scheduling lgorithm

3.1 Introduction

The algorithm considers the problem of nodes scheduling while preserving the full coverage of a target area. [4] Particularly, it aims at circumventing some shortcomings of the existing work. Mainly, it aims at achieving balanced energy depletion among nodes exchanging a minimum amount of messages for the nodes scheduling, while preserving the full coverage of the target area using minimum active nodes. Indeed, the massive use of a particular subset of nodes may induce their premature death, which reduces the WSN lifetime. The proposed energy remaining greedy scheduling (ERGS) algorithm is based on this observation. It is a localized self-scheduling algorithm which considers only one-hop neighborhood knowledge. Before its presentation, the hypotheses and the objectives, considered for its development, will be introduced.

3.2 Objectives

The ERGS algorithm aims to provide full coverage over an area of interest while minimizing the number of active nodes. Thus, it maximizes the duration of the coverage and, consequently the WSN lifetime. Such decisions must be done using minimum knowledge and messages exchange, and must ensure the robustness of the decisions despite the loss of messages. To meet these objectives, a subset of active nodes is periodically selected. Based on the ERGS algorithm, each node decides by itself whether it must be active taking into account: its remaining energy level, its one-hop neighborhood information (energy level and information explored by the coverage verification algorithm as e.g. the nodes location), the coverage rate of its sensing area and the decisions already taken by a subset of its one-hop neighbours.

3.3 Principles of the Ergs Algorithm

Each node contributes to the coverage of the target area only through its sensing area. Thus, if each node guarantees the full coverage of its sensing area by a subset of 'working' neighbours before entering its sleep state, then the coverage of the target area will be preserved after the deactivation of the redundant nodes. So, each node can self-schedule its activity based on localized information. However, if all nodes simultaneously make decisions, blind points may appear, Node 1 finds that its sensing area can be covered by nodes 2–4. According to the eligibility rule, node 1 turns itself off. While at the same time, node 4 also finds that its sensing area can be covered by nodes 1, 5 and 6. Believing node 1 is still working, node 4 turns itself off too. Thus, a blind point occurs after turning off both nodes 1 and 4, as in figure 1). To avoid the problem of blind points, most of distributed scheduling algorithms exchange additional messages when using negotiation, a node, finding that its sensing area is covered by a subset of its neighbors, must request for deactivation permission. In this case, it will send a specific message to each of its sponsors to take permission. If one of the sponsors meanwhile decides to deactivate, all the sent messages will have uselessly consumed energy. [1][2] When observing the example of figure 1, [3] the blind point could be avoided if only node 4 or node 1 has considered the other one to the verification of its eligibility. Thus, it is easy to conclude that any two neighbour nodes should not simultaneously consider themselves. To achieve this objective, a notion of priority must be introduced between nodes. This priority avoids the use of additional messages and allows remaining robust despite the loss of messages while ensuring the avoidance of blind points. Such priority must introduce a unique order between neighbours which may be locally computed. Thereby, in the example of Figure.1, based on this priority only node 1 or node 4 will consider the other nodes in its eligibility computation.

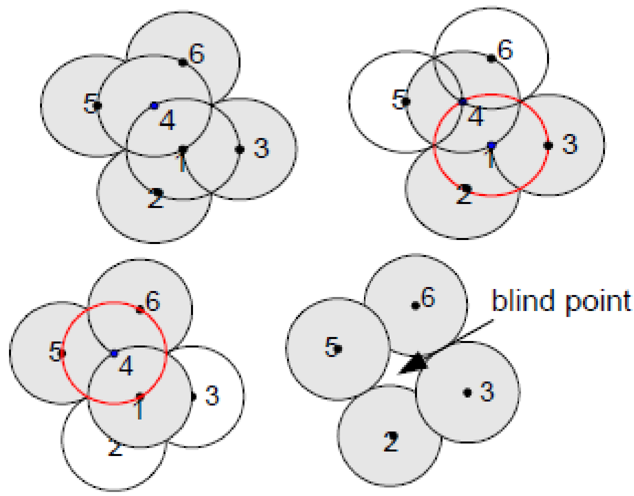

Fig. 1. Occurrence of a blind point

a) Original sensing area covered by nodes 1–6
b) Node 1 turns off itself by the eligibility rules
c) Node 4 turns off itself by the eligibility rules
d) Occurrence of a blind point

4 Performance Evaluation Of The Algorithm

This principle reduces the complexity of the proposed algorithm (from the operation and number of exchanged messages point of view). Another advantage of this algorithm is the consideration of the nodes remaining energy. So it helps to maintain balanced energy depletion among nodes, which can considerably increase the whole WSN lifetime (as shown through the simulation results).

TABLE 1
Specification Of Scenarios

Properties	Value
Number of nodes	25
Data Rate	2Mbps
Number of packets sent	40
Scenario area	750x750 meters
Antenna Model	Omni directional
MAC protocol	IEEE 802.11
Transport layer	UDP
Application layer	FTP Agent
Simulation start time	0.1s
Simulation end time	9.0s

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5 Energy Consumption

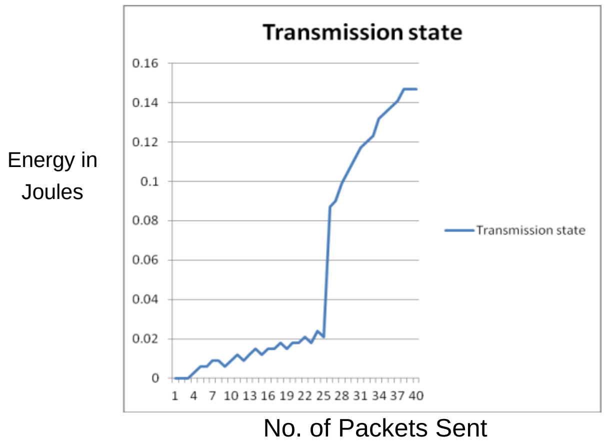

Fig. 2. Energy Consumption in Transmission State

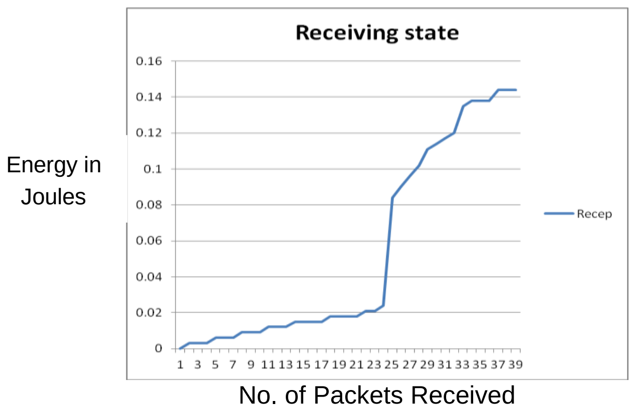

Fig. 3. Energy Consumption in Reception State

Energy consumption in reception state being calculated between energy in Joules Vs No. of Packet received

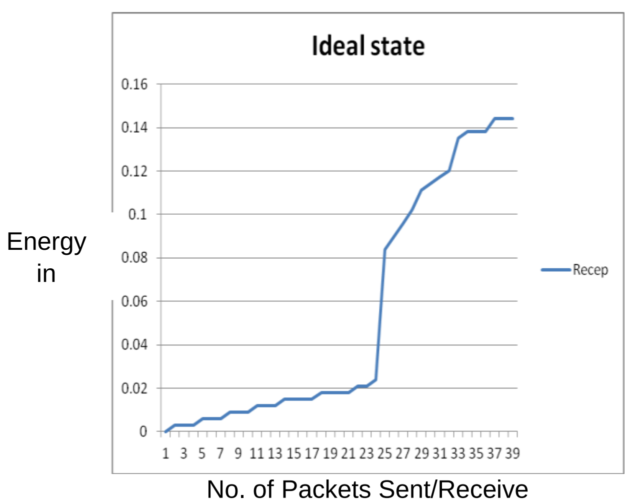

Fig. 4. Energy Consumption in Idle State

Energy consumption in idle state being calculated between energy in Joules Vs No. of packets sent/received

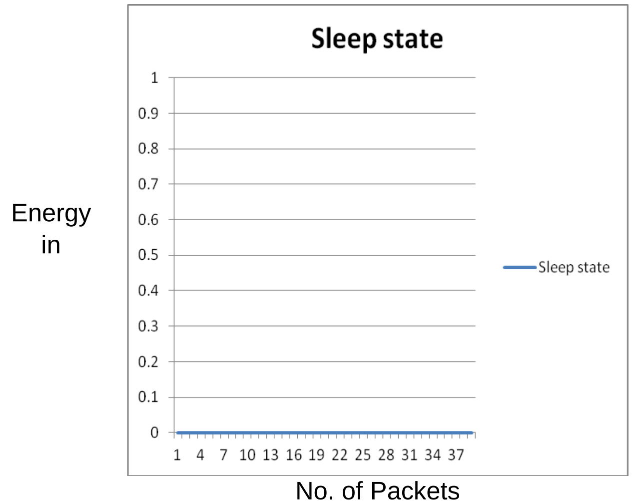

Fig. 5. Energy Consumption in Sleep State

In the sleep state energy was not dissipated even 0.1 joules. The algorithm used to verify the coverage of the sensing area assumes that each node is able to know its location information.

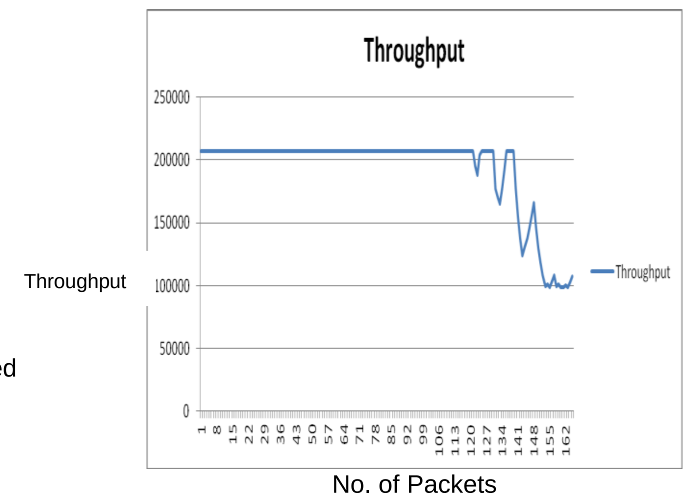

Fig. 6. Throughput

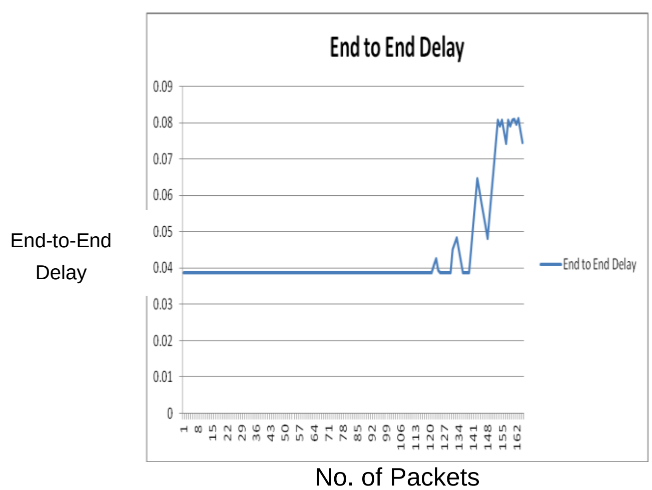

Fig. 7 End-to-End Delay

This disadvantage may be circumventing if there is an exact algorithm allowing such verification without this assumption. To our knowledge it is not yet the case, as there is no algorithm functioning without such assumption.

6 CONCLUSION

In this paper, the problems of energy conservation and full sensing coverage in large WSNs where nodes are randomly deployed have been addressed. Specifically, an original algorithm, the ERGS algorithm, has been introduced based on a wake-up scheduling concept allowing one to extend the lifetime of the WSN. The ERGS algorithm relies on the novel idea of exploiting the remaining energy in making decision on which node has to enter sleep state. The first main feature of the ERGS algorithm consists in applying an equity principle by balancing the remaining energy of nodes. This has contributed to extend the WSN lifetime. The second main feature consists in avoiding negotiation phases, as decision to enter sleep state uses a computed priority based on one-hop neighborhood knowledge. This contributes not only to extend WSN lifetime as message exchanges are reduced, but also to avoid blind points and then to preserve the full coverage of the target area. The simulation studies presented in this paper allowed to verify the contributions of the ERGS algorithm and to evaluate the gains.

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