Available online at www.sciencedirect.com
ScienceDirect
Procedia Computer Science 92 (2016) 425 – 430
Procedia Computer Science

2nd International Conference on Intelligent Computing, Communication & Convergence

(ICCC-2016)

Srikanta Patnaik, Editor in Chief

Conference Organized by Interscience Institute of Management and Technology

Bhubaneswar, Odisha, India

An energy efficient approach to extend network life time of wireless sensor networks

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Abstract

The energy consumption in wireless sensor networks is a significant matter and there are many ways to conserve energy. The use of mobile sensors is of great relevance to minimize the total energy dissipation in communication and overhead control packets. In a WSN, sensor nodes deliver sensed data back to the sink via multi hopping. The sensor nodes near the sink will usually consume more battery power than others; consequently, these nodes will quickly drain out their battery energy and decrease in the network lifetime of the WSN. The presence of mobile sinks causes increased energy reduction in their proximity, due to more relay load under multi hop communication. Moreover, node deployment technique can also be used to improve the life time of the network. Performance comparisons have been done by simulations between different routing protocols and our approach show efficient results.

Peer-review under responsibility of the Organizing Committee of ICCC 2016

Keywords: Wireless sensor networks, Energy hole problem, Node deployment, mobile sink, Average Energy, Network lifetime.

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Peer-review under responsibility of the Organizing Committee of ICCC 2016
doi:10.1016/j.procs.2016.07.332

1. Introduction

Node deployment is an significant issue in wireless sensor networks (WSNs) [10] because it has an important impact on the performance of the network. There are two deployment methods: 1) random and 2) deterministic deployments [11].

In the random, the sensor nodes are usually scattered by aircraft and results in a randomized distribution. In a Wireless sensor network, sensor nodes send the sensed data back to the sink via multi-hopping. In predetermined deployment, the locations of node are specified [8].The sensor nodes close to the sink will generally consume more energy than other node leading to a phenomena known as **energy hole problem**. Therefore shorten the network lifetime of the WSN. The presence of mobile sinks causes less energy consumption in their proximity. So, node deployment technique can also be used to improve the life time of the network.

Network lifetime can be defined as the time from the start of network functioning to the instant when the first node in the network runs out of energy [4-7].One approach for network lifetime maximization is to reduce node's transmission power in order to reach their farthest selected neighbour, which not only save energy but can also improve network throughput. However, because of the reducing the transmission range may strongly affect the network connectivity due to the decline of the number of neighbour nodes connected to a given one (called node degree). Another efficient means of conserving energy is to schedule nodes to sleep mode (i.e., turning off their radios) when they are not needed, without changing global connectivity and spatial coverage of the sensing field.
The main objective of this research is to investigate the effectiveness of existing approaches as well as our approach for solving energy consumption problem based on Sink mobility and Node deployment strategy.
Energy conservation in sensor has two aspects:

1) Both device and protocol (algorithm) in use should be highly efficient.
2) The rate of energy consumption in different parts of the network should be even.

2. Related Work

There are several parameters based on which the performance of WSNs can be analyzed. Some of these parameters are as follows. There are various methods to improve the Network life time:

Node deployment technique: Given some sensor nodes that can be deterministically deployed, where to deploy them and how to schedule them so as to achieve the required target coverage level and increase the network lifetime. One of the basic requirement of node placement is to accomplish desired coverage and connectivity. NODE deployment is one of the most critical issues in wireless sensor networks (WSNs).
Node deployment can be divided into continued-point based deployment and grid point based one. Due to specific advantages, the latter becomes necessary in a broad range of applications [1], [2]. The fundamental requirement of node placement is to achieve desired coverage and connectivity, where coverage is to guarantee that every point of interest (PoI) is monitored by at least one sensor, and connectivity is to ensure sufficient routing paths [3].

Sink mobility: The task of the sink is processing the data for the final users. Sink mobility is considered as one of the way to reduce energy consumption. Sensors can send data to sink through single hop or long distance transmission. WSNs with mobile sinks have attracted a lot of interest recently [9]–[10]. PEGASIS-Based routing protocol (MIEEPB) has been presented in [9]. MIEEPB introduces the sink mobility in the multi-chain model and divides the sensor field into four regions, therefore achieving smaller chains and decreasing load on the leader nodes. The sink moves along its trajectory and stays for a time at fixed location in each region to guarantee data collection. A new optimizing LEACH clustering algorithm with mobile sink and rendezvous nodes was introduced in [10]. This algorithm combines the use of the LEACH algorithm, mobile sink and rendezvous points to preserve the benefits of the LEACH algorithm and improve the CH selection process. Moreover, it decreases energy consumption in WSNs further than in traditional LEACH, especially when the network is large.

3. Network model

3.1. Radio-energy dissipation model

In order to analyze the different data delivery models, we first have to define the energy needed for transmitting and receiving messages in the wireless sensor network. For this purpose we use the same radio-energy dissipation model (Fig. 1) as the one used in [2, 3].

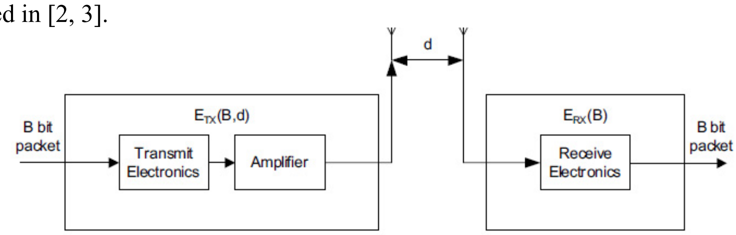

Fig.1 Radio-energy dissipation model

$$E_{Tx}(B,d) = E_{Tx\text{-}elec}(k) + E_{Tx\text{-}amp}(B,d)$$

$$= \begin{cases} B\,E_{elec} + E_{fs}\,B\,d^2, & \text{if } d<d_0 \\ B\,E_{elec} + E_{mp}\,B\,d^4, & \text{if } d\geq d_0 \end{cases}$$

$$E_{Rx}(B) = E_{Rx\text{-}elec}(k) = B\ E_{elec}$$

Where $d_0=\sqrt{E_{fs}/E_{mp}}$ denote the threshold distance.
Where, B = length of message in bits
d = distance between the transmitter and receiver node
where E_{elec} is the energy dissipated per bit of the transmitter or receiver, E_{fs} and E_{mp} depend on the transmitter amplifier model used and d is the distance between the sender and the receiver [4].

3.2 Assumptions

All sensor nodes are static and uniformly distributed for grid deployment and for square area the nodes are randomly deployed. The sink node is mobile for all network scenarios. The networks have same initial energy as well as same energy requirement for sensing, processing, transmitting and receiving sensory data. Node is considered dead if its residual energy crosses a threshold energy level.

Table 1.Parameter Value.

Simulation Parameter	**Value**
No. of Nodes	100
Node's initial Energy	2 J
E_{elec}	50×10^{-9} J/Bit
E_{amp}	100×10^{-12} J
E_{fs}	10 pJ/bit/m^2
E_{mp}	.0013 pJ/bit/m^4
Packet Size	500 Bytes
Broadcast Message Size	100 Byets

4. Simulation and Results

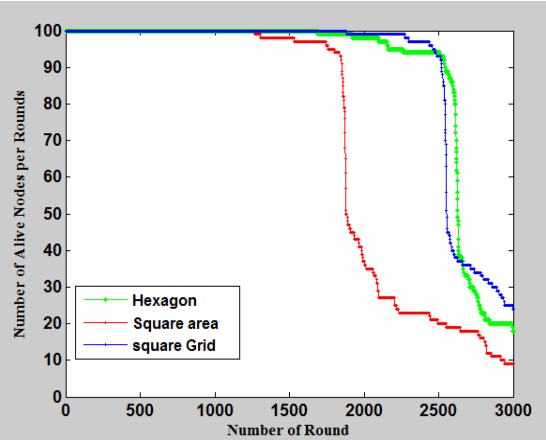

Fig. 2. No. of alive nodes vs rounds(3000)

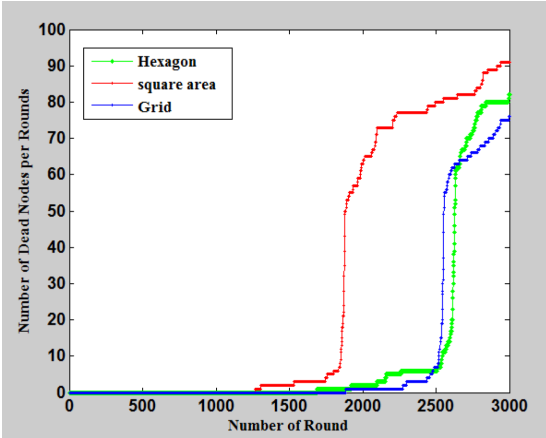

Fig.3. No. of dead nodes vs rounds(3000)

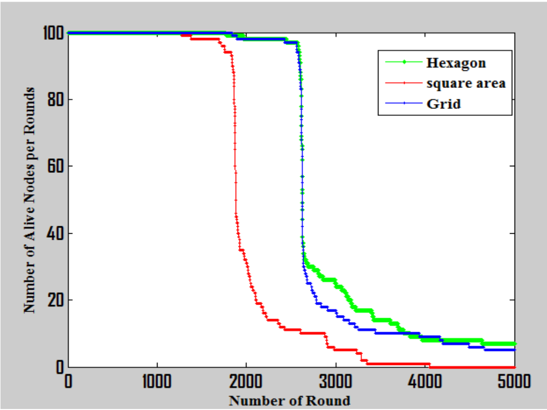

Fig. 4. No. of alive nodes vs rounds(5000)

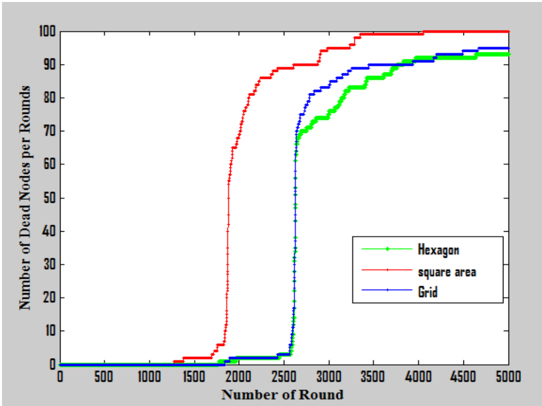

Fig. 5. No. of alive nodes vs rounds(5000)

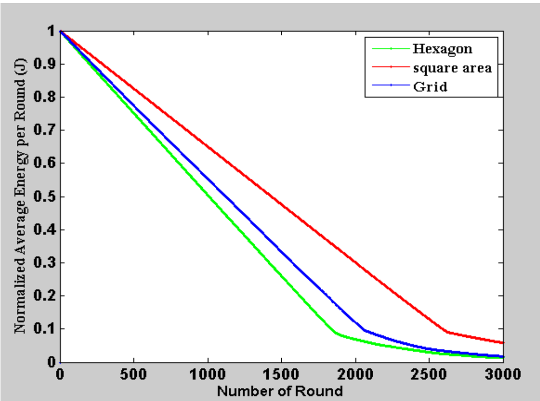

Fig. 6. Normalized Average Energy per Round(3000)

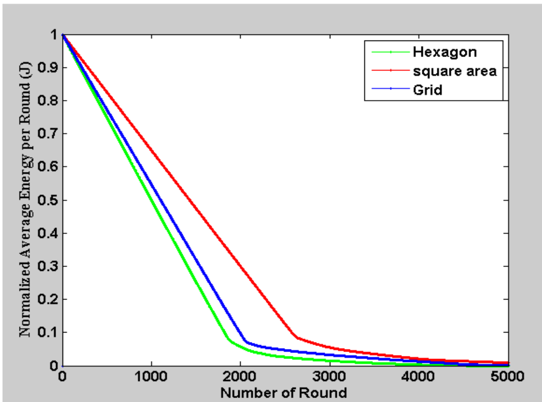

Fig. 7. Normalized Average Energy per Round (5000)

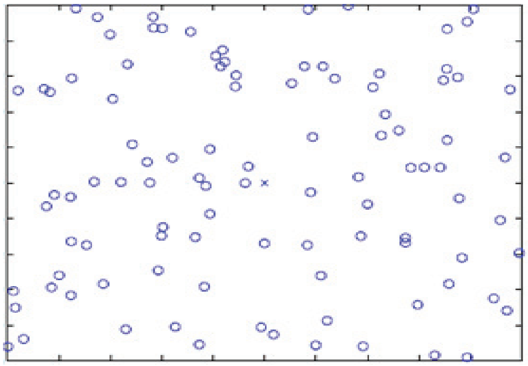

Fig. 8.Random Deployment

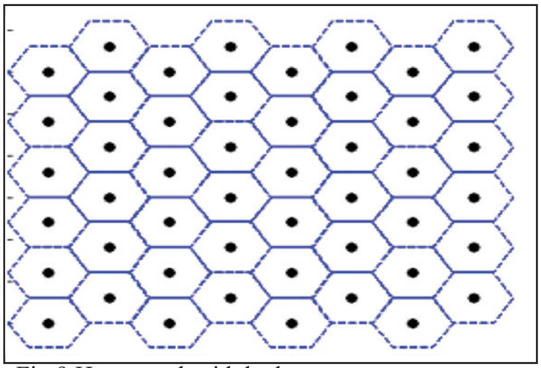

Fig.9 Hexagonal grid deployment

The following metrics are used to evaluate the performance [9], [10], [13], [14]:

- *Network Lifetime:* The time interval from the start of network operation until the death of the last alive sensor.
- *Stability Period:* The time interval from the start of network operation until the death of the first sensor.
- *Instability Period:* The time interval from the death of the first sensor until the death of the last sensor.
- *First Dead Node (FDN):* The number of rounds after which the first sensor is died.
- *Last Dead Node (LDN):* The number of rounds after which all sensor nodes are died.
- *Number of Alive Nodes per Round:* The number of nodes that have not yet expended all of their energies.

In Fig 8. There is a random deployment of sensor node and Fig 9. show grid deployment. The three deployment scenario Random deployment node in a square area, predetermined deployment of node in rectangular grid and hexagonal grid deployment. The Sink mobility is also considered in order to reduce energy hole problem. Mobile sink improves the network lifetime and stability period by spreading the load of nodes that are closer to the sink. In our simulations, all the nodes have equal amount of initial energy. The nodes are termed as dead, if they losses all of their energy therefore, they drop transmitting or receiving capabilities. The deployment strategy is location wise predetermined which can be used in such application where exact positioning of the node is required. Nodes are deployed in such a way to ensure coverage and connectivity.

In hexagonal grid deployment, the node is placed at the center of each cell and this ensure the coverage and connectivity is maintained. The results(Fig 2-7) show predetermined node deployment as well as mobile sink greatly improves the network life time for grid deployment. The energy of all the nodes in the network for grid deployment decreases more slowly than the random deployment.

5. Conclusion

The paper investigated Random deployment node in a square area, predetermined deployment of node in rectangular grid and hexagonal grid deployment strategy along with mobile sink that have significant advantages to enhance the network lifetime of wireless sensor network. Hexagonal grid deployment show better result because coverage and connectivity is maintained. The simulation results show dominance of predetermined node deployment strategy and sink mobility over random node deployment. Finally the simulation results are compared with one of the existing strategy taking network life time and energy as performance metrics.The comparative results improves the network lifetime as well as energy consumption.

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