Energy Based Controlled Nodes Mobility for Efficient Design of a Wireless Sensor Network

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Abstract- Among the many techniques of improving the performance of a wireless sensor network (WSN) in terms of critical metrics such as its lifetime and data delay, exploiting the mobility of some of the network components has been recently observed to be among the most promising techniques. In this paper, an algorithm for controlling sensor nodes mobility is proposed namely Energy Based Controlled Nodes Mobility (EBCNM). EBCNM tries to move nodes in a way that insures energy and load balancing among nodes hence, increasing the network lifetime. The performance of EBCNM is evaluated and compared with static nodes and random movements of nodes using NS2 network simulator. Results show a network lifetime improvement ranges from 31%- up to 120%, and packet delivery ratio improvement ranges from 43%- up to 115%.

Keywords – Controlled Mobility Algorithms, Network Lifetime, Nodes Mobility, NS2 Network Simulator, Wireless Sensor Networks.

I. INTRODUCTION

Wireless sensor networks (WSNs) consist of a lot of small devices which have tasks to be done like sensing, processing, radio transmission and reception [1]. Problems of WSNs include: coverage [2], energy [3], etc. WSNs have limited energy resources of sensor nodes. A typical sensor node has generally irreplaceable limited capacity battery attached to the programming interface board. Consuming less amount of energy is the most critical condition when designing any sensor network algorithm or protocol. Since the energy is the most precious resource, and in most of the applications, replacing the batteries are very hard or impractical, utilizing each node's energy and total energy of the network becomes much more important for a given task [3].

Several schemes were proposed in the literature in order to minimize the total energy consumption in the network for improving the network lifetime such as power adjusting when transmitting messages [3], developing energy efficient MAC or routing protocols [5, 6], minimizing the number of messages traveling in the network (since most of the energy is consumed when transmitting data packets), putting some sensor nodes into sleep mode and using only a necessary set of them for sensing and communication [7]. Mobility is considered one of the most important solutions of the energy problem. By moving the network components, the energy consumption is better balanced among the nodes and therefore, the network lifetime is improved [8].

There are three types of mobility: random, predictable and controlled mobility [9]. In this paper, a modified controlled mobility algorithm is proposed for controlling sensor nodes mobility and compared with that of static (no mobility) and random mobility of nodes.

The rest of the paper is organized as follows. Static and random nodes mobility algorithms are discussed in section II. The proposed controlled nodes mobility algorithm is presented in section III. Simulation results are presented and discussed in section IV. Finally the main concluding remarks are given in section V.

II. STATIC AND RANDOM NODES MOBILITY ALGORITHMS

In this paper, the performance of the proposed algorithm is compared with the performance of the normal wireless sensor network (static network) that includes a static sink and static nodes. It will also be compared with

two random movement algorithms namely random nodes mobility algorithm and 10% random nodes mobility algorithm.

In random nodes mobility algorithm, one of the sink's neighbor nodes will be chosen randomly to be swapped its position with a randomly chosen node from the network and this operation will be repeated periodically. While in 10% random nodes mobility algorithm, ten percent of the nodes will be chosen randomly to move to random new positions. The time at which they move will be chosen randomly.

III. Proposed Energy Based Controlled Nodes Mobility (EBCNM) Algorithm

EBCNM swaps the positions of the nodes around the sink with the positions of their neighbors according to the energy levels of the nodes and the energy levels of their neighbors. EBCNM has two stages: network construction and energy checking and movement. In the network construction stage, sensor nodes are located inside a squared area in a grid fashion and the sink node is located at the center of the network area as shown in figure 1.

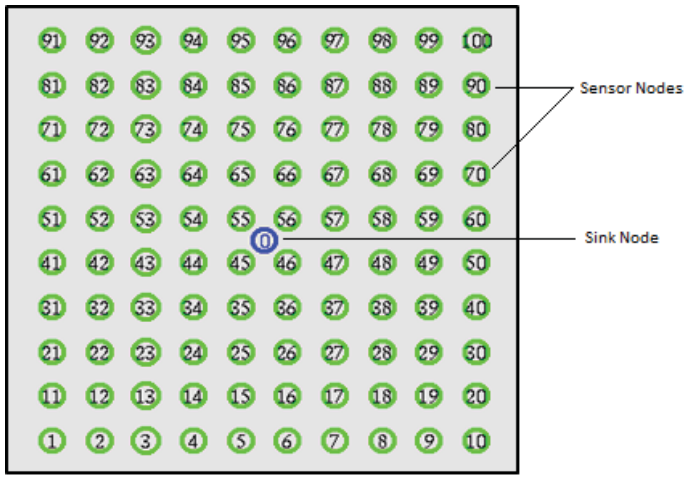

Figure 1. Network Construction

The network is assumed to be partitioned into circles around the sink as shown in figure 2. In energy checking and movement stage, first the distance from the sink to each node is calculated to specify the nodes of each circle. Then the remaining energy of those nodes is checked. If the remaining energy is less than a given threshold, that node will look for a neighbor node from the next circle with higher energy level to be swapped with. This operation is performed circle by circle until all circles are completed and will be repeated periodically. The number of circles depends on the number of nodes in the network. The EBCNM algorithm is explained in the flowchart shown in figure 3.

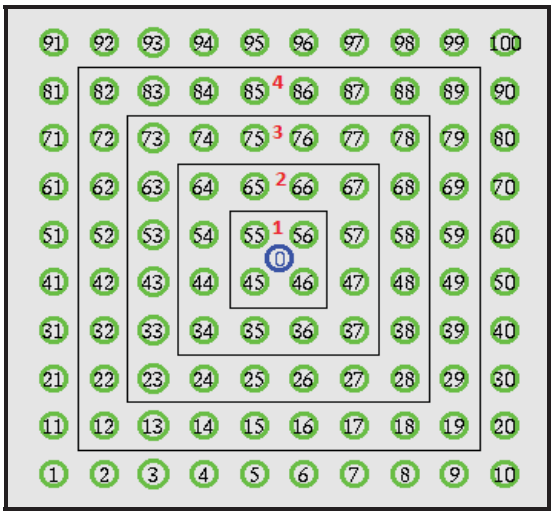

Figure 2. Circles Partitioning

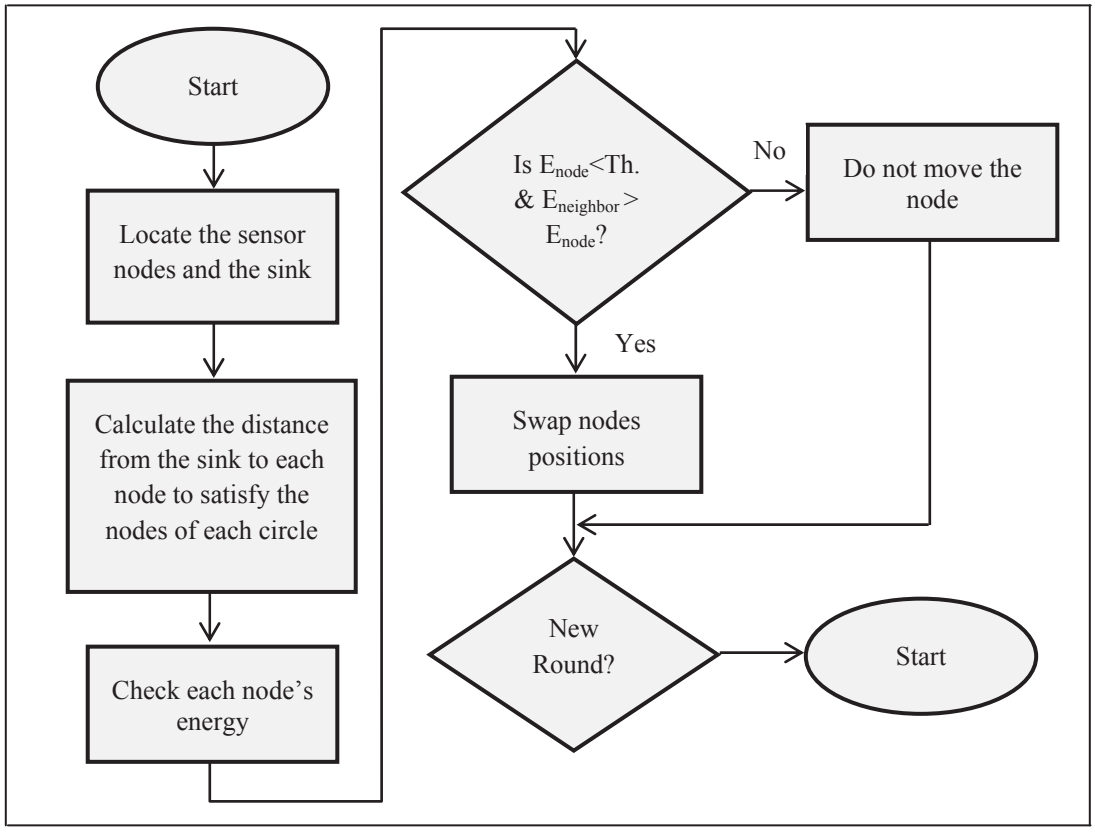

Figure 3. Flowchart of EBCNM Algorithm

IV. Simulation Results

A. *Simulation Parameters*

The simulation was performed in NS2. The simulation parameters are listed in table 1.

Table -1 Simulation Parameters

Parameter	Value
Simulation Time	6000 seconds
Simulation Area	400 × 400 m^2
Number of nodes	64, 100, 144 and 196
Routing Protocol	AODV
MAC Layer	IEEE 802.11
Propagation Model	Two ray ground model
Initial Energy for Nodes	3 J
Initial Energy for Sink	1000 J
Transmission Power	14.8 mw
Receiving Power	12.5 mw
Mobility Round	every 400 seconds

B. Results and Performance Analysis

The performance of the proposed algorithm is evaluated in term of network lifetime, packet delivery ratio and average end-to-end delay. The network lifetime for each algorithm is shown in figure 4. Compared with static network algorithm, all the other strategies improve the network lifetime for 64 and 100 nodes. However, for 144 and 196 nodes, random nodes and 10% random nodes achieves smaller value of lifetime due to the random movement that may cause the network to be disconnected. EBCNM algorithm achieves much more values of lifetime than the other three strategies due to energy balancing through controlled mobility. Figure 4 show that the lifetime improvement of EBCNM algorithm over static algorithm is about 31% - to-120%.

Packet delivery ratio is shown in figure 5. The best packet delivery ratio is achieved by EBCNM algorithm. The least packet delivery ratio is achieved by static algorithm because as the sink's neighbor nodes begin to die, they will not be able to deliver packets to the sink.

Average end to end delay is shown in figure 6. The smallest delay is achieved by static algorithm since there is no movement. As the movement increases, the delay will also be increased.

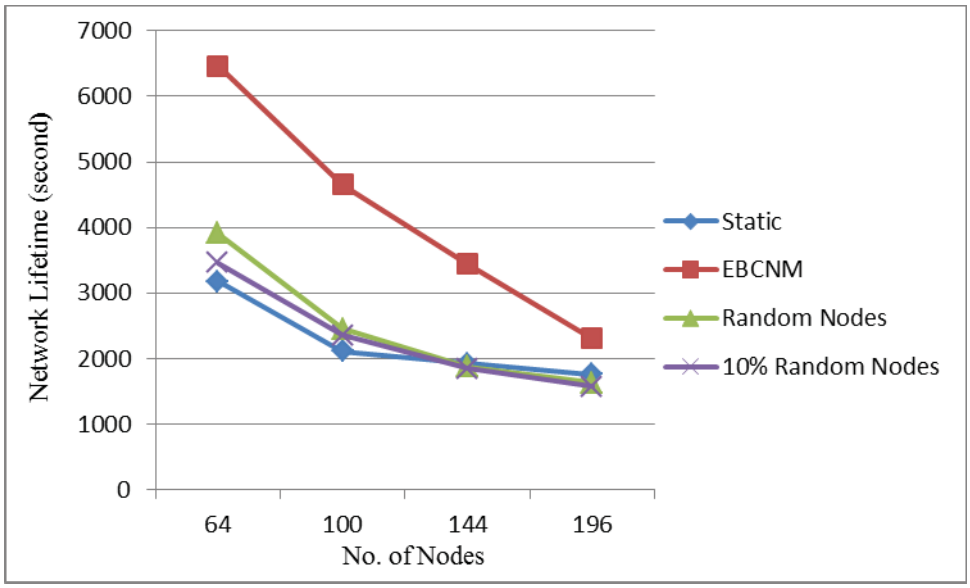

Figure 4. Network Lifetime with different number of nodes

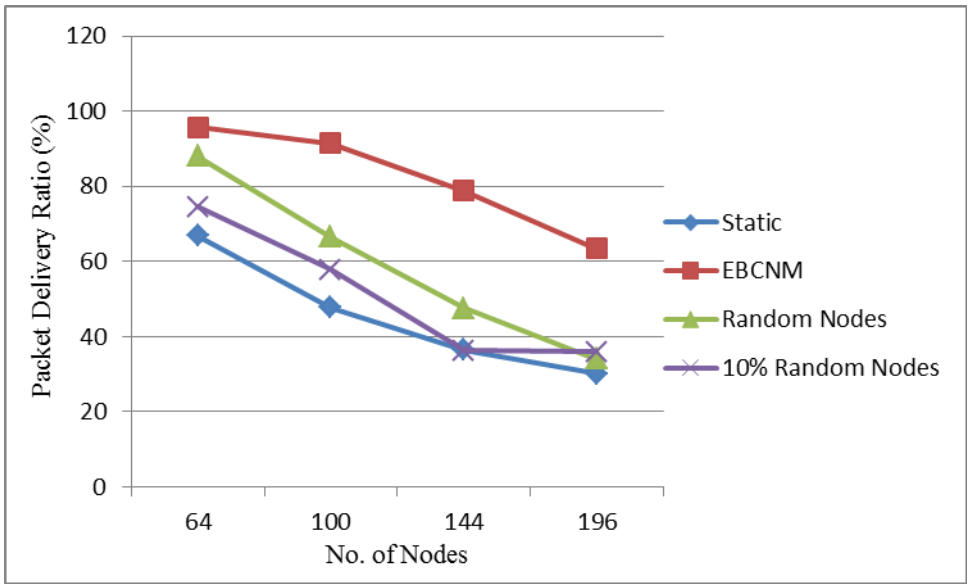

Figure 5. Packet Delivery Ratio with different number of nodes

Table 2 shows the percentage of lifetime improvements for nodes mobility algorithms over static algorithm for different number of nodes (64, 100, 144 and 196) nodes.

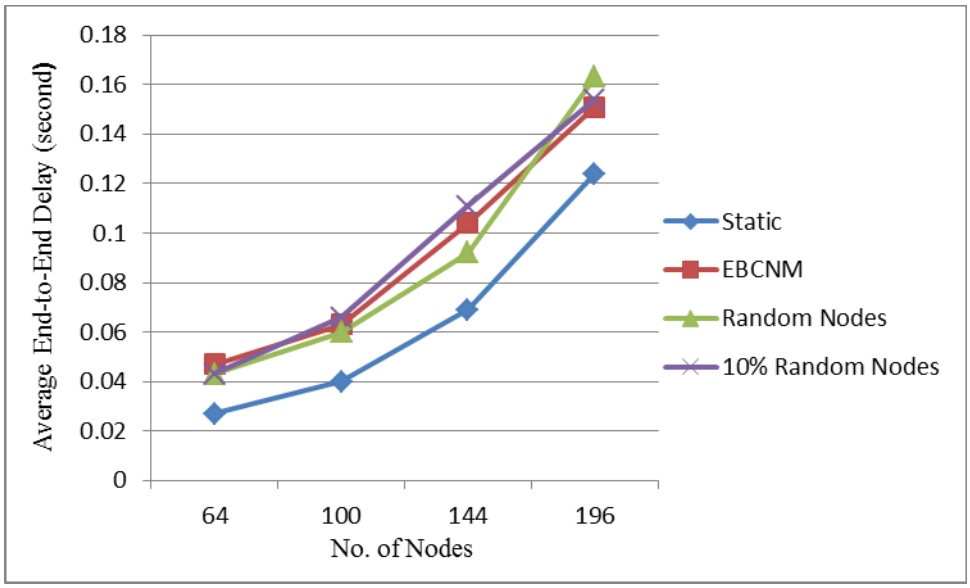

Figure 6. Average End-to-End Delay with different number of nodes

Table -2 Percentages of Lifetime Improvements over Static Algorithm

No. of Nodes	EBCNM	Random Nodes	10% Random Nodes
64	103.73%	23.19%	9.09%
100	120.59%	16.04%	11.56%
144	78.77%	0%	0%
196	31.00%	0%	0%

V. CONCLUSION

In this paper, controlled nodes mobility algorithm has been introduced to improve the network lifetime of wireless sensor networks. Since the nodes near the sink deplete their energy much faster than the other nodes through the traffic overload, the controlled mobility aims to improve the network lifetime by balancing the energy consumption among the nodes. EBCNM algorithm controls the nodes mobility according to their remaining energy. The performance of the algorithm is evaluated and compared with static and random nodes movement strategies and it was shown that EBCNM algorithm extends the network lifetime by 13%-103% over static nodes network. EBCNM algorithm also improves the packet delivery ratio by 43%-110% but gives slightly higher delay values.

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