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Article

Performance Comparison of Heterogeneous EESAA in Two and Three Dimensional Wireless Sensor Networks

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Abstract: Wireless Sensor Network is the network of limited power, computational and storage sensing devices called sensors. These sensors sense and send out data to other sensors present in the network. A considerable amount of energy is dissipated in these tasks. Clustered techniques have been employed to optimize energy consumption in the energy constrained wireless sensor networks. The paper presents analysis of heterogeneous Energy Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol in three dimensional spaces of a WSN in order to prolong the network lifetime. The reason behind 3D space, instead of 2D plane is its feasible and practical equivalence to the real world.

Keywords: 2D plane; 3D space; Cube; Dead Node; Network Lifetime

1. Introduction

A wireless sensor network (WSN) is generally composed of a large number of small autonomous sensor devices that can sense the environmental conditions. Each sensor node is limited in power, computational capacities and storage memory [1].WSNs are used in various application like medical engineering, traffic control, habitat monitoring, military reconnaissance, forest fire detections, transport

monitoring etc. Sensor nodes are deployed in the network on the basis of their applications. Due to the increasing demand of WSNs, they are gradually more prepared to do the more complex functions, but they still require battery operated sensors to judiciously use the constrained energy in order to improve the lifetime of the network. To overcome from these problems of energy dissipation various clustering algorithms were proposed. The whole network of nodes is alienated into a number of clusters; the data fusion and aggregation is performed by the cluster head, receiving the data from nodes and then transmitting it to the BS. Clustering helps in diminution of redundancy and enhancement over the lifetime of the network [2]. There are many hierarchical protocols that use the clusters to balance the consumption of energy in WSNs. In this paper, the heterogeneous clustered Energy Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol is evaluated in three dimensional spaces in order to prolong the network stability and its lifetime. The three dimensional (3D) design is more specific and practically relevant to the real world [3].

2. Energy Efficient Sleep Awake Aware (EESAA) Intelligent Sensor Network Routing Protocol

In wireless sensor networks, the energy limitations of nodes play a decisive role in designing any protocol for implementation. Many techniques have been projected to operate energy of sensor nodes in a better way. Hierarchical cluster routing has special advantages related to scalability and competent communication. In clustering process, some nodes have elevated energy as evaluate to other sensor nodes and are selected as cluster heads (CHs). In this section, EESAA routing protocol has been proposed in two and three dimensional wireless sensor network. The major aim of this routing protocol is to lessen the energy consumption, enhance the network lifetime and stability in order to successful data delivery rate. Sending same data two times to base station cause energy loss, extra overhead on sink and decreases the network lifetime. For this purpose, the concept of pairing is introduced. Sensor nodes which are at minimum distance between them and have same relevance will form a pair for sense the data continuously and communication [4].

In EESAA technique, CHs selection is done on the basis of residual energy of sensor nodes.CH of current round will predict the CH for next round. Sensor nodes are equipped with global positioning system and measure their location from it and send the information to base station. Then BS transmits pairing information to all the nodes in network. According to this proposed scheme, it minimizes the energy consumption by switching the nodes between sleep and active mode during distinct communication interval. Data sensing and communication is take place during active mode while the transceiver of sleep mode is off to minimize the energy dissipation. Overhearing and idle listening is also avoided by switching the node in sleep mode [5]. Initially CHs selection is done on the basis of LEACH routing protocol while for the other rounds in done on the basis of residual energy. As a result it enhances the lifetime of network, stability and optimizes the energy consumption.

3. Network and Energy Consumption Model

In this paper, we have analyzed the EESAA routing protocol on the basis of network and energy model [6]. The equations (2) and (3) are used to calculate transmission and receiving energies for k bit packet. The E_{elec} denotes the energy of electronic circuit, depends on the following factors such as the digital coding, filtering and spreading of the signal. ε denotes the transmitter amplifier. For free space propagation, $\in=\in_{fs}$, when $\lambda=2$

is taken while for multipath space propagation, $\in=\in_{fsmp}$, λ=4.d is distance between the transmitter to receiver and d_o being the threshold distance.

$$E_{Tx}(k,d) = \{kE_{elec} + k \in_{fs} d^2, d < d_0\} \quad (2)$$

$$E_{Tx}(k,d) = \{kE_{elec} + k \in_{fsmp} d^4, d \geq d_0\} \quad (3)$$

$$E_{Rx}(d) = kE_{elec} \quad (4)$$

4. Implementation of Heterogeneous EESAA in Two and Three Dimensional Wireless Sensor Networks

A Two Dimensional (2D) plane is a geometric two parameter model which gives the limited result and observation to some extent while a Three Dimensional (3D) space is a geometric three parameter model of the physical universe [7]. The three dimensions can be labeled by a combination of three, chosen from the terms length, width, height, depth and breadth. The real world implementations and applications involves the three dimensional views. This three dimensional view gives added information and lets to comprise a more proficient system of the wireless sensor networks. For each node, the three coordinates i.e. (x, y, z) have been taken, for specifying its location in the network [8].

5. Performance Evaluation

All simulations have been implemented using MATLAB R2013a [9]. The performance of the heterogeneous EESAA protocol in 2D and 3D WSN has been evaluated.

5.1. Simulation Parameters of EESAA

The following parameters are taken in the implementation of the protocols. The x, y and z are taken as the three dimensions, having 100 unit lengths at each side, with fixed number of 100 nodes deployed in the network area of 100x100 with BS at (50, 50) and 100x100x100 with BS at (50, 50, 50). Each node has initial energy of 0.5J and cluster head probability is 0.1. Percentage of nodes that are advanced is 0.1 and algorithm is run for 5000 simulation rounds. Transmission and Reception Energy of each node is 50*0.000000001J/bit, Dissipation Energy is 10*0.000000000001J/bit and Data Aggregation Energy is 5 nJ/bit. Each node carry data message of 4000 bits and control message of 500 bits.

5.2. Simulation Results

The simulation results have been observed for heterogeneous EESAA in two and three dimensional spaces. We have studied the effect on the network lifetime by analyzing the round numbers for the three cases on the basis of observing the round numbers when the first node and the last node of the network dies for 5000 simulation round and the total number of nodes which die after 3000 simulation rounds.

5.2.1. Network Lifetime (on the basis of alive nodes)

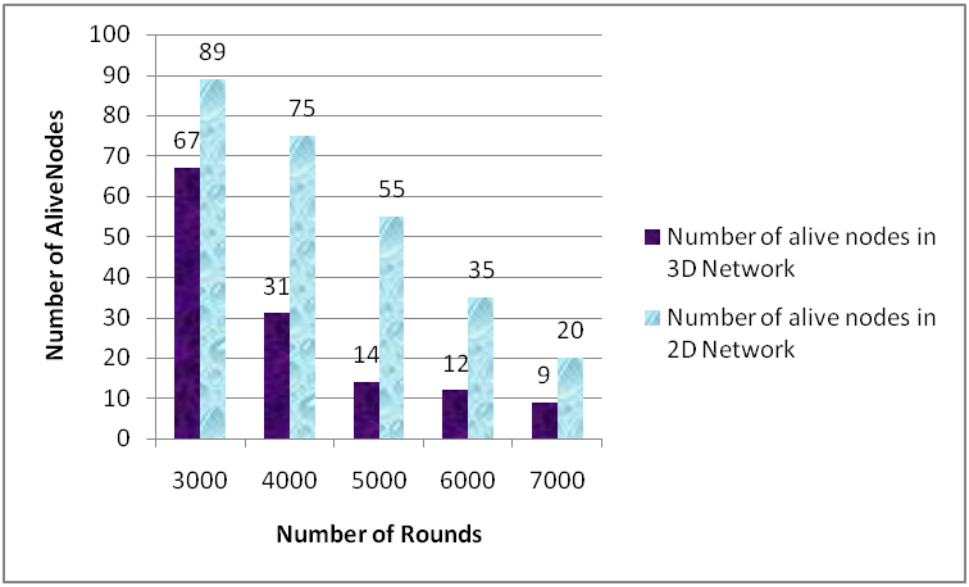
For evaluating the network lifetime, we have observed the round numbers v/s alive nodes in the network.. The round number when the first nodes die for both 2D and 3D network on each simulation run has been taken for the two different cases for the simulation round of 7000 as shown in Table 1. The

comparison shown in Figure 1 depicts that when the heterogeneous EESAA in 3D is considered; taking the network area as cube of 100x100x100 the number of alive nodes is less as compared to 2D network.

Table 1 Network Lifetime (On The Basis Of Alive Nodes)

Round Numbers	Number of alive nodes in 3D Network	Number of alive nodes in 2D Network
3000	67	89
4000	31	75
5000	14	55
6000	12	35
7000	9	20

Figure 1. Alive nodes for 2D and 3D network



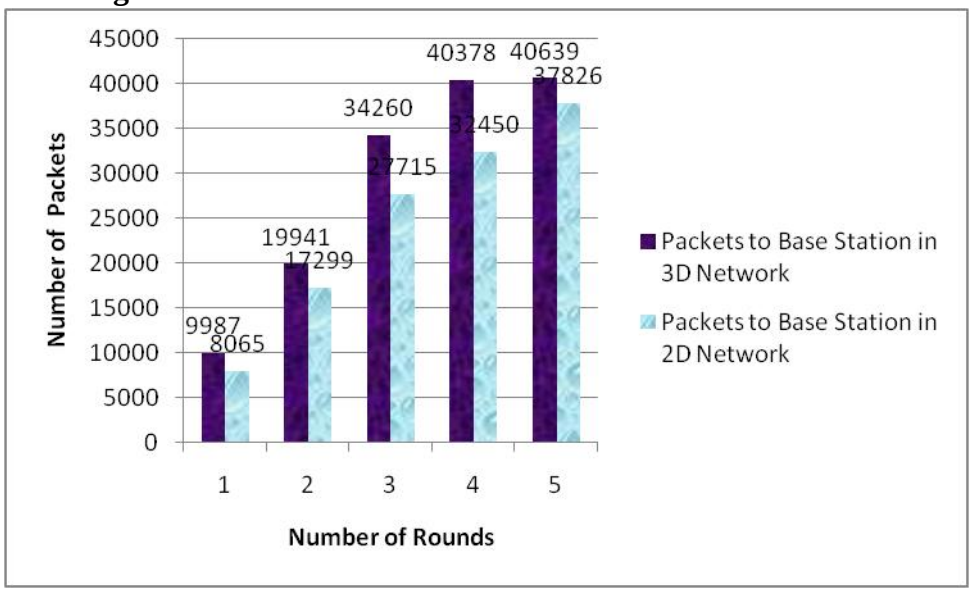
5.2.2. Network Stability (on the basis of data delivery)

In Figure 2 it is depicted that EESAA has a prolong stability period as compared to the other protocols. Table 2 depicts that in heterogeneous 3D network the successful transmission of packets to base station is more as compared to 2D network.

Table 2.Network Stability (On The Basis Of Data Delivery)

Round Numbers	Packets to Base Station in 3D Network	Packets to Base Station in 2D Network
3000	9987	8065
4000	19941	17299
5000	34260	27715
6000	40378	32450
7000	40639	37826

Figure 2. Packet to Base Station nodes for 2D and 3D network



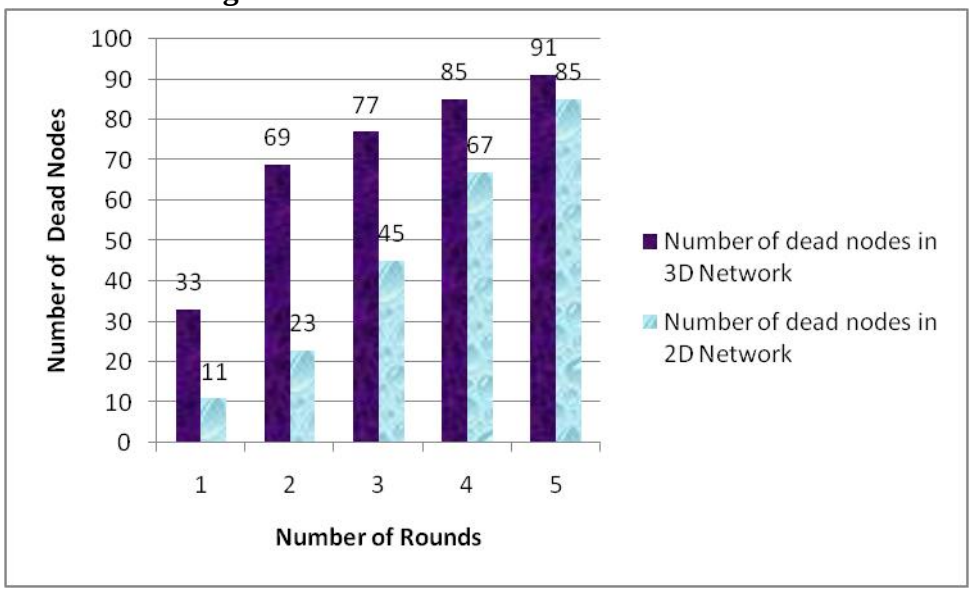
5.2.3. Network Lifetime (on the basis of dead node)

For evaluating the network lifetime, we have observed the round numbers when any of the nodes dies in the network shown in Table 3. The round number when the first nodes die for both 2D and 3D network on each simulation run have been taken for the two different cases up to simulation round of 7000 The comparison shown in Figure3 depicts that when the heterogeneous EESAA in 3D is considered, taking the network area as cube of 100x100x100 the number of dead nodes is more as compare to 2D network

Table 3. Round Number when Node Dies in 2D and 3D Network

Round Numbers	**Number of dead nodes in 3D Network**	**Number of dead nodes in 2D Network**
3000	33	11
4000	69	23
5000	77	45
6000	85	67
7000	91	85

Figure3. Dead nodes for 2D and 3D network



6. Conclusion

In this paper, the heterogeneous EESAA routing protocol has been implemented in 3D network where third parameter of height is considered along with length and width. In EESAA, CHs selection is done on the basis of residual energy and nodes are switched between sleep and active mode. Overhearing and idle listening is also avoided by switching the sensor nodes to sleep mode. It is evaluated that EESAA heterogeneous systems significantly lessen the energy consumption and increases the total network lifetime and stability of the wireless sensor network. Simulation results show that there is considerable enhancement in all these parameters. It may be concluded that the heterogeneous wireless sensor networks are more suitable for real life applications as compared to the homogeneous counterpart. Further, we can work on optimizing the energy dissipation of heterogeneous 3D network.

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