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REVIEW PAPER

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REVIEW ON SINK MOBILITY BASED OPTIMIZED HETEROGENEOUS WIRELESS SENSOR NETWORK

Harmeet Singh
Computer Science Engineering Department,
CTIEMT, Jalandhar, India

Ashish Kumar Luhach
Computer Science Engineering Department,
CTIEMT, Jalandhar, India

Harjit Pal Singh
Electronics and Communication Engineering Department,
CTIEMT, Jalandhar, India

Vikas Khullar
Computer Science Engineering Department,
CTIEMT, Jalandhar, India

Abstract: Wireless Sensor Network (WSN) has been extraordinary in facilitating human being by taking a control over the each aspects of modern technology. WSN has limited power constraints which makes it limited in its applicability. The routing if made energy efficient, sensor network might runs for longer duration. Heterogeneous WSN is one of the modes of WSN which has made it possible to achieve enhanced stability period. Furthermore, it is being studied that sink mobility not only enhances the network lifetime but also improves the quality of service of the network by reducing the end to end packet delay. It is being studied that very few work is done in the direction of achieving the enhanced network lifetime by using sink mobility based heterogeneous WSN. This paper reviews the sink mobility based networks along with the network using cluster head selection in heterogeneous WSN. The optimization algorithms are also studied which helps in optimized path selection for moving sink.

Keywords: Introduction to WSN, Routing, applications of WSN, Heterogeneous WSN, honey bee optimization algorithms

I. INTRODUCTION

A wireless sensor network (WSN) (sometimes called a wireless sensor and actor network (WSAN) are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on [1].

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The Propagation technique between the hops of the network can be routing or flooding.

A. Homogeneous Vs Heterogeneous routing protocols

When all of the nodes are same in configuration, then the network is said to be homogeneous otherwise it is said to be heterogeneous. Advantages of heterogeneous over the homogeneous protocols are discussed as following.

i. **No homogeneity exits in real:** Homogeneous routing protocols assume the homogeneity in the network. Ideally the homogeneity doesn't exist in real. So the assumptions limit its applicability on the real platform.
ii. It is due to the different manufacturing differences that get induced in the same configuration nodes. So assuming them to be homogeneous is a challenging task when it is implemented for real.
iii. The minute difference in the energy of the nodes is induced when those nodes are deployed in uneven physical terrain and gets connected with each other. So it creates heterogeneity in the network.
iv. **Why heterogeneity needed?** The clustering topology in the network, assigns different roles for the data collection to the different nodes. Like, Cluster Head will be consuming more energy as compared to the other nodes. So it is always favorable to introduce the high energy nodes in the network to preserve their energy. So that network lifetime can be enhanced.
v. **Benefits:** With heterogeneity in the network, the selection of Cluster Heads will be among high energy nodes making it easier for preserving energy of the nodes. CHs will be collecting data for longer duration efficiently unlike to the homogeneous routing protocols.

vi. **Stability Period:** Stability Period (no. of rounds completed till first node dies) is achieved after covering much more number of rounds as compared to the homogeneous networks. It favors the applicability of the routing protocols for those time critical applications.

II. RELATED WORK

Heterogeneous routing protocols are really significant in enhancing network lifetime and are stated as below.

A. SEP (Selection Election Protocol)

Georgios Smaagdakis, Ibrahim Matta and Azer Bestavros [2] proposed SEP (Stable Election Protocol) in which there two types of nodes called normal nodes and advance nodes with advance nodes having (1+a) more energy than the normal nodes. Every sensor node in a heterogeneous two-level hierarchical network independently elects itself as a cluster head based on its initial energy relative to that of other nodes. The probabilities for nodes to be cluster head is given by equation (1):

$$p=\begin{cases}\frac{P_{opt}}{1+am} & \text{for normal nodes;}\\ \frac{P_{opt}(1+a)}{1+am} & \text{for advance nodes;}\end{cases} \quad (1)$$

SEP does not require any global knowledge of energy at every election round. SEP is dynamic in that it does not assume any prior distribution of the different levels of energy in the sensor nodes. Furthermore, the analysis of SEP is not only asymptotic, i.e. the analysis applies equally well to small sized networks. Finally SEP is scalable as it does not require any knowledge of the exact position of each node in the field.

B. DEEC (Distributed Energy-Efficient Clustering)

Li Qing, Qingxin Zhu and Mingwen Wang [3] proposed this protocol which also works at two levels of energy as in case of SEP protocol and has better stability period than SEP protocol. In DEEC, the cluster heads are elected by a probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster heads for nodes are different according to their initial and residual energy. The nodes with high initial and residual energy will have more chances to be the cluster heads than the nodes with low energy. So, the advance nodes have more chances to be cluster heads than the normal nodes. The probabilities of normal, advance and super nodes are given by equation (2):

$$p=\begin{cases}\frac{P_{opt}\,E_i(r)}{(1+am)\,\bar{E}(r)} & \text{for normal nodes;}\\ \frac{P_{opt}(1+a)\,E_i(r)}{(1+am)\,\bar{E}(r)} & \text{for advance nodes;}\end{cases} \quad (2)$$

where $E_i(r)$ is the residual energy of the node 's_i' at round 'r', $\bar{E}(r)$ is the average energy at round 'r' of the network which is determined a priori before the deployment of the nodes in the network. Finally, the simulation results shows that DEEC achieves longer lifetime and more effective messages than other previous protocols.

C. EDEEC (Enhanced Distributed Energy Efficient Clustering)

Parul Saini and Ajay K. Sharma [4] proposed EDEEC protocol which works on the same principle of DEEC but adds a third type of node called super node which has (1+b) times more energy than normal node. Advance nodes have (1+a) times more energy than normal nodes. Due to this third node, the heterogeneity of the network increases from two to three. Traditionally as per previous protocols, in this protocol too, cluster head selection uses the same threshold technique and the advance and normal nodes have same probabilities. Difference is just that this protocol has a probability formula for super nodes too.

$$p=\begin{cases}\frac{P_{opt}\,E_i(r)}{1+m(a+m_0 b)\bar{E}(r)} & \text{for normal nodes;}\\ \frac{P_{opt}(1+a)\,E_i(r)}{1+m(a+m_0 b)\bar{E}(r)} & \text{for advanced nodes;}\\ \frac{P_{opt}(1+b)\,E_i(r)}{1+m(a+m_0 b)\bar{E}(r)} & \text{for Super nodes;}\end{cases} \quad (3)$$

The simulations show that this protocol is better than SEP, which is also extended to three levels but based on its own principle, in terms of network lifetime and stability period.

D. Balanced Energy Efficient Network Integrated Super Heterogeneous (BEENISH) Protocol

The concept of exploiting heterogeneity originated from the protocol SEP and since then there have been various advancement in utilizing the various levels of energy possessing sensor nodes. The research work is being done in the direction of utilizing four types of heterogeneous sensor nodes in the BEENISH protocol. The selection of cluster head is on the basis of residual energy level of the nodes with respect to the average energy of network as similar to DEEC. However, DEEC is based on two types of nodes; normal and advance nodes. BEENISH uses the concept of four types of nodes; normal, advance, super and ultra-super nodes [5].

$$P(i)=\begin{cases}\frac{P_{opt}*E_i}{(1+m(a+m_0(-a+b+m_1(-b+u))))*E_a} & \text{for norm nodes}\\ \frac{P_{opt}*E_i*(1+a)}{1+m(a+m_0(-a+b+m_1(-b+u)))*E_a} & \text{for adv nodes}\\ \frac{P_{opt}*E_i*(1+b)}{1+m(a+m_0(-a+b+m_1(-b+u)))*E_a} & \text{for sup nodes}\\ \frac{P_{opt}*E_i*(1+u)}{1+m(a+m_0(-a+b+m_1(-b+u)))*E_a} & \text{for ult nodes}\end{cases} \quad (4)$$

E. iM-BEENISH [6]

iM-BEENISH works in three phases:

a. Identification of energy heterogeneous nodes, applying various probabilistic formulae for cluster head selection.
b. CH selection is done on the basis of energy basis, a threshold concept is introduced for improving the BEENISH protocol that's why improved version of BEENISH is termed as i-BEENISH
c. Mobility is introduced on the basis of maximizing the stop time for the sink. When sink moves it doesn't collect data, but when it stops it collects data. So the maximization function is used in the i-MBEENISH protocol which drives it.

F. Optimization in WSN

There are various optimization techniques which are incorporated in WSN to enhance the network lifetime by working on some specific parameters. Some tend to optimize the routing path or some optimize the Cluster Head selection in the clustering strategies of WSN.

a. Ant Colony Optimization (ACO)

Ants efficiently search for an area containing food. There is some degree of communication among the ants using trails, just enough to keep them from wandering off completely in a random direction. By this minimal communication they can remind each other that they are not moving alone but are cooperated by the team-mates. Ants divide tasks among its individuals members like finding food, feeding the brood and defending the nest. All this is not achieved by central control but by stigmergy (indirect communication). Stigmergy describes an indirect communication by leaving marks in the environment. These marks can be the structures that are built or markers which are used for the purpose of communication (typically pheromones which are excreted by the insects and which acts as footprints for the other individuals). The marks left by the colony act as stimuli for the individuals and can initiate certain actions.

A head is selected based on two aspects, the pheromone value associated with each node and its visibility. Visibility refers to the number of nodes that will be covered if the node is added into the head set. Visibility keeps changing as topology changes. The pheromone value associated with a node is updated for each iteration of the algorithm. For each iteration, a node is selected as the head and the next head is selected based on the pheromone and visibility of its neighbour nodes. This process continues until all the nodes in the network are covered. A node is said to be covered if it is a cluster head or falls in the range of an already selected head.

Each time a node is selected as a head, its pheromone value is updated. Thus, possibility of a node to be selected as head depends on the pheromone value and visibility which changes as the algorithm proceeds through the various iterations [7].

b. Honey Bees Optimization Algorithm

Honey bee colony extends themselves over long distances in multiple directions in order to achieve large number of food sources. The foraging process starts in a colony by sending the scout bees to search for the promising flower patches. There is a random movement of scout bees from one patch to another [8].

When the scout bees return to the hive, they found a patch which is measured above a certain quality threshold and deposit their pollen or nectar and then they move to the dance floor to perform the waggle dance. The waggle dance is for colony communication and it contains the information of flower patch i.e. the direction in which the patch is found, distance of flower patch from hive and its quality fitness. This information is useful for sending the bees to the flower patches without using maps. The waggle dance enables the colony to determine the fitness of various patches according to the food quality and amount of energy required to harvest it. After the waggle dance, the scout bee moves back towards to the flower patch with other bees i.e. follower bees that were waiting inside hive. Then more follower bees are sent to the more promising patches which allow the colony to gather the food more efficiently and quickly. The bees monitor the food level while harvesting from the flower patch. This is important to decide the next waggle dance when they return to hive.

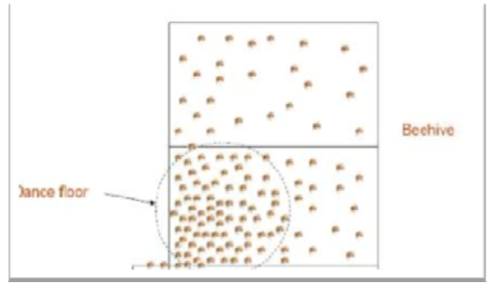

Fig.1 Natural behavior of honey bee

Honey Bees algorithm performs random search along with the neighborhood search for both functional and combinatorial optimization. The main aim of this algorithm is to find an optimal solution by the honey bees' natural foraging behavior. Here, various parameters are1 required in general i.e. scout bees (n), selected sites in visited sites (m), stopping criteria, best sites in selected sites(e), initial patch size that includes the size of the network and its neighborhood, bees for selected sites, bees for (m-e) sites.

Bees are randomly placed in a space and then the evaluation of bee's fitness is done. Now, the bees with highest fit nesses are the selected bees and the bees that visit the sites are selected for the neighborhood search. Now for the selected sites, recruit bees and evaluate fitness's. Fittest bees from each patch are selected.

Remaining bees are randomly assigned in search space and then their fitness is evaluated. The steps are further repeated until the stopping criterion is met. The bees' algorithm is used in various applications such as data clustering, pattern recognition in neural networks, engineering.

In a sensor network the nodes lying near the sink have to forward the data of their own along with the data of the nodes which are far away from the sink, as a consequence of which the nodes nearby the sink got depleted in terms of their energies. This depletion of energy of the nearby nodes results in the network isolation or in other words the HOT SPOT problem. Using sink mobility this problem will be mitigated to a significant level i.e. the energy consumption of the nearby nodes is balanced. There are also some biological protocols which are used to enhance the performance of the sensor network in terms of network lifetime, throughput and quality of service.

III. CONCLUSION

This paper has focused on reviewing the various heterogeneous routing protocols, along with the basic introduction of WSN covering its applications. In the heterogeneous WSN, the main emphasis has been on the cluster heads selection by modifying the various probabilistic selection of CH. i-BEENISH protocol is an improved version of BEENISH protocol. It has been energy efficient in the selection of Cluster Head in the heterogeneous mode of WSN. It has worked on the four levels of energy heterogeneity. The important aspect that it has worked on is the avoidance of penalizing the advanced nodes for the frequent selection as a cluster head. From the retrospective survey for exploring the BEENISH variants, it is concluded that these protocols doesn't really explore the sink mobility in an optimized scenario.

Therefore it is proposed to optimize the sink mobility in the network by considering the parameters of energy, distance and node density. Sink mobility not only helps in collection of data in an efficient manner but also it ensures the reliability of data collection. Optimization of sink mobility will help in enhancing the stability period and network lifetime because of the better load balancing in the network.

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