Enhancing Network Lifetime in Wireless Sensor Networks: A Survey

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Abstract - Unlike traditional networks, the sensor networks do not have a continuous power supply at their disposal. Rather the individual sensors are battery operated and the lifetime of the individual sensors and thus the overall network depend heavily on duty cycle of these sensors. Analysis on WSNs shows that communication module is the main part which consumes most of the sensor energy and that is why energy conservation is the major optimization goal. The Lifetime of a network can be maximized through many algorithms. This paper is survey about life time Enhancement techniques used in wireless sensor networks. This paper studies the techniques associated with routing and data transmission in WSN which achieves energy efficiency and prolonged lifetime. This paper also showing an algorithm which is a combination of Bacterial foraging optimization algorithm (BFO) which is a Bio-Inspired algorithm and LEACH and HEED protocols which enhances the lifetime of a network by dissipating minimum amount of energy. This study show the result of the techniques and hindrance present in the techniques.

Keywords-- WSN, Bacterial Foraging Optimization, LEACH, HEED

I. INTRODUCTION

Now a days the research on WSNs has concentrated on the design of energy and computationally efficient algorithms and protocols, and the application domain has been confined to simple data-oriented monitoring and reporting applications. WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. WSN combines sensing, computation, and communication in a single tiny device forming a sea of connectivity extending cyberspace reach into the physical world, through advanced mesh networking protocols formed. It is an sensing technology where tiny, autonomous and compact devices called sensor nodes or motes deployed in a remote area to detect phenomena, collect and process data and transmit sensed information to users. The development of low-cost, low-power, a multifunctional sensor has received increasing attention from various industries.
A WSN monitors an environment by sensing its physical properties. It is a network of tiny, autonomous nodes that can acquire process and transmit sensory data over wireless medium. Typically, sensor nodes are grouped in clusters and each cluster has a cluster head. All the nodes forward their sensor data to the cluster head, which in turn routes it to a specialized node called sink node (Base Station) through a multi-hop wireless communication as shown in the fig2. However often the sensor network is very small and consists of a single cluster with a single base station. Other scenarios such as multiple base stations or mobile nodes also possible.

The base-station or sink collects data from all the nodes, and then analyzes this data to draw conclusions about the on-going activity in the area of interest [1]. Sinks or base-stations being powerful data processors can act as gateways to other existing communications infrastructure or to the Internet where a user can have access to the reported data.

II. CLASSIFICATION OF ROUTING PROTOCOLS IN WSNs

WSN Routing Protocols are classified in 4 ways, based on how routing paths are established; according to network structure, according to protocol operation, according to path establishment, Routing paths are established in one of 3 ways, namely proactive, reactive or hybrid. Proactive protocols compute all routes before they are needed with the routes being stored in a node’s routing table. When a route changes, the change is propagated through the network. As a WSN consists of 1000’s of nodes, each node’s routing tables will therefore be huge. Hence, proactive protocols are unsuited for WSNs. Reactive protocols compute routes only when needed. Hybrid protocols combine both ideas [5]. Routing protocols are classified according to following criteria. Hierarchy Role of Nodes in Network: In flat schemes, sensor nodes participate with same role in routing procedures, but, hierarchical routing protocols classify sensor nodes based on their functions. The network is divided into groups/clusters. A leader/cluster head is selected in a group to coordinate the activities in a cluster and communicate with nodes outside the cluster. Node differentiation is either static or dynamic. Data Delivery Model: Depending on application, data gathering and WSN interaction is accomplished in many ways. Data delivery model and according to communications initiator. Figure 3 shows WSN routing protocols classification.
Hierarchical Protocol is also known as cluster-based routing. In these protocols, the nodes can play different roles in the network and normally the protocol includes the creation of clusters. Additionally, designations of tasks for the sensor nodes with different characteristics are also performed. Some hierarchical protocols are discussed here.

LEACH (Low-Energy Adaptive Clustering Hierarchy) [8],[9] shown in fig one of the first and popular hierarchical routing algorithms for sensor networks. The cluster heads themselves are sensor nodes. The choice of sensor nodes to play cluster head role can be made based on certain probabilistic rules, proximity to other nodes, and residual energies in the nodes so as to keep the network lifelong. The algorithm randomly selects cluster heads and rotates the role to distribute the consumption of energy. The idea is to form clusters of sensor nodes based on received signal strength and use cluster heads as routers to the sink. This will save energy since individual nodes spend much less energy than cluster heads, and cluster head role is assigned to different nodes based on a probabilistic rule which evenly assigns this role to different nodes. LEACH has been shown to achieve over a factor of seven reductions in energy dissipation compared to direct communication and a factor of 4 to 8 reduction compared to minimum energy routing.

PEGASIS (Power Efficient GAthering in Sensor Information Systems) [16] is an improvement to the LEACH protocol. Rather than forming multiple clusters, PEGASIS forms chains so that each node in a chain transmits to and receives from a neighbor and only one node in that chain is selected as a leader to transmit to the sink. The chain construction is done in a greedy way. PEGASIS has been shown to outperform LEACH by a factor up to three for different network sizes and topologies. Such gains are achieved through the elimination of overhead caused by dynamic cluster formation in LEACH and by increased data aggregation. PEGASIS however results in more delay for far-off nodes in the chain from the chain leader. This delay issue in LEACH has been addressed in Hierarchical LEACH in [17]. Although the PEGASIS approach avoids the clustering overhead of LEACH, every node needs to be aware of the status of its neighbour so that it knows where to route the data, and this involves overhead for the resulting dynamic topology adjustments.

III. NETWORK LIFETIME FOR ESTIMATION

A. Bio-inspired routing:

In recent years insect sensory systems have been inspirational to new communications and computing paradigms, which have lead to significant advances like bio-inspired routing. The most popular ACO (Ant Colony Optimization) is a colony of artificial ants is used to construct solutions guided by the pheromone trails and heuristic information they are not strong or very intelligent; but they successfully make the colony a highly organized society. Swarms are useful in many optimization problems. A swarm of agents is used in a stochastic algorithm to obtain near optimum solutions to complex, non-linear optimization problems.

Minimum Ant-based Data Fusion Tree (MADFT) is a sink selection heuristic routing algorithm. It is based on ACO for gathering correlated data in WSN. It first assigns ants to source nodes. Then, the route is constructed by one of the ants in which other ants search the nearest point of previous discovered route. The chosen formula is Probability function composed of pheromones and costs in order to find the minimum total cost path. MADFT not only optimizes over both the transmission and fusion costs, but also adopts ant colony system to achieve the optimal solution.
The Many-to-One-Improved Adaptive Routing protocol is an ant colony-based routing protocol. It is specifically designed to route many-to-one sensory data in a multi-hop WSNs.

Swarm Intelligence Optimization Based Routing Algorithm works with the objective to balance global energy consumption and avoiding some node’s premature energy exhausting. The algorithm chooses the nodes with less pheromone as next hop, taking less hop numbers into consideration. The algorithm is different from traditional ant colony algorithms. It is better than the directed diffusion routing protocol both in end-to-end delay and global energy balance. It can effectively balance the global energy consumption and prolong the network lifetime.

B. Bio-inspired algorithm

There are two popular swarm inspired methods: Ant Colony optimization (ACO) and Particle Swarm Optimization (PSO). Proposed by Marco Dorigo et al., ACO is based on foraging behavior of ant colonies [3].

PSO, proposed by Eberhart Kennedy, is inspired by social behavior of flocks of birds and schools of fish [4]. Currently, these nature inspired techniques are being used for finding better quality solutions in optimization problems and formulate better decision making mechanisms. Bacterial Foraging Optimization Algorithm (BFOA) proposed by Passino, is a newcomer in this field. BFO is inspired by social foraging behavior of Escherichia coli bacteria [15].

BFO has been already applied to a number of problems like adaptive control (Kim & Cho, 2005b), harmonic estimation (Mishra, 2005), machine learning (Kim & Cho, 2005a), and optimal power flow scheduling (Tang et al., 2006) [6]. The objective of this paper is to analyze the effect of varying step size of bacterium on its chemotactic behavior. Some computational methodologies have been used to improve the present network routing protocols [6], [7]. Up to now many biologically inspired computational methodologies have received much attention. Bacterial Foraging Optimization Algorithm (BFOA) [8], [9] is a well-known computational methodology which is based on the study of the bacterial foraging behaviors.

Steps of Bacterial Foraging Algorithm:

There are following three steps in Bacterial Foraging Algorithm after the search strategies like swimming and tumbling. They are

1. Chemotaxis:

   This process simulates the movement of an E. coli cell through swimming and tumbling via flagella. Biologically an E. coli bacterium can move in two different ways. It can swim for a period of time in the same direction or it may tumble, and alternate between these two modes of operation for the entire lifetime. Suppose hi(j, k, l) represents ith bacterium at jth chemotactic, kth reproductive and lth elimination–dispersal step. C(i) is the size of the step taken in the random direction specified by the tumble (run length unit) [12].

2. Reproduction:

   In this phase size of population will remain same by the process: each of the healthier bacteria (those yielding higher value of the objective function) sexually split into two bacteria and the least healthy bacteria eventually die, which are then placed in the same location.

3. Elimination and dispersal:

   Impulsive changes in the local environment where a bacterium population lives may occur due to various reasons e.g. a significant rise in temperature may exterminate a group of bacteria that are currently in a region with a high focus of nutrient gradients. Events can take place in such a manner that all the bacteria in a region are killed or a group is dispersed into a new location. To simulate this phenomenon in BFOA some bacteria are liquidated at arbitrary with a very small probability while the new replacements are randomly initialized over the search space [13]. Elimination and dispersal events have the effect of possibly destroying chemotactic progress, but they also have the effect of assisting to place bacteria near good food sources. When the bacteria are moving, they can release the attractant aspartate to congregate into groups and move as concentric patterns of groups with high bacterial density.

If the basic goal is to find the minimum of

$$J(\theta), \theta \in \mathbb{R}^P$$

$\theta$ is the position of a bacterium, and $J(\theta)$ represents an attractant-repellant profile ($J < 0$, $J = 0$, and $J > 0$ represent the presence of nutrients, a neutral medium, and the presence of noxious substances, respectively).

$$P (j, k, l) = \{ \theta i (j, k, l) / i = 1, 2, \ldots S \}$$

Represents the positions of each member in the population of the $S$ bacteria at the $j$th chemotactic step, $k$th reproduction step, and $l$th elimination-dispersal event. $J (i, j, l)$ denotes the cost at the location of the $i$th bacterium θ in $(j, k, l) \in \mathbb{R}^P$.
Nc is the length of the lifetime of the bacteria as measured by the number of chemotactic steps. The tumble step can be represented as follows:

\[ \theta i (j +1, k, l) = \theta i (j, k, l) + C(i) \phi(j) \] (2)

\( \phi(j) \) is generated as a unit length random direction. \( C(i) \) >0 is the size of the step taken in the random direction specified by the tumble. Another chemotactic step of size \( C(i) \) in this same direction will be taken if the cost \( J(i,j+1, k, l) \) at \( \theta i (j+1, k, l) \) is better than at \( \theta i (j, k, l) \). \( Ns \) is the maximum number of chemotactic steps.

Fig 6 Swimming, tumbling, chemo taxis behaviour of bacteria

IV. CONCLUSION

The bio-inspired algorithms are inspired from the nature’s perfection to deal with complex scenarios. So the wireless networks developers are learning from the nature how it’s dealing with problems from ages. In this paper we have surveyed all the proposed energy efficient algorithm which enhances the lifetime of the wireless sensor network. It put forward both advance techniques and some of a bit previous techniques but still some of the improved enhancements needed. Future work can be done by simulating the above stated algorithm by using simulators by setting up the parameters to check whether the algorithm is enhancing the lifetime of the network or not. The performance analysis of the algorithm must be performed by doing the simulations. The first contribution of the scheme is related to use of bacteria foraging algorithm firstly for wsns for enhancing network lifetime of sensor nodes. BFA provides better lifetime for nodes compared to LEACH. It is also seen that BFA is able to provide 100% live nodes for maximum duration. Leach provides a considerably higher lifetime compared to k-means clustering. In addition to dipping energy dissipation, leach successfully distributes energy-usage among every nodes in the network such that the nodes die arbitrarily and at essentially the same rate. BFA is self organizing and each node works independently. Provide efficient and scalable energy reduction.

REFERENCES


