Nature-Inspired Routing Algorithm to Minimize the Energy Consumption in Wireless Sensor Network

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Abstract— Wireless Sensor Networks consists of little nodes with sensing, calculation and wireless transportation capabilities. Energy minimization is the main task of the WSNs as the nodes are battery powered devices. One of the factor that minimizes the energy resource is data transmission from source to destination which may occurs because the route which is selected for the transmission is having inadequate amount of energy in it and if the energy get reduced while doing data transmission the nodes may die out. So, the main attention of this paper is to propose an optimized approach to discover a route with maximum energy for transmitting data in order to minimize the energy consumption in the wireless sensor network.

Key words: wireless sensor networks, routing, optimization algorithms

I. INTRODUCTION

Wireless sensor networks (WSN) consist of hundreds and even thousands of little minute devices that are known as sensor nodes, dispersed separately to monitor substantial or atmospheric conditions, such as warmth, noise, trembling, force and activity in different locations. Each node in a sensor network consists of one or more sensors, a radio transceiver or other wireless devices for communication, a small microcontroller, and an energy source, since in most of the wireless sensor network applications the energy source is a battery [1]. Energy plays a significant role in wireless sensor network, therefore, while developing a routing algorithm for the network the main goal which is to be considered is to consume minimum energy for transmission.

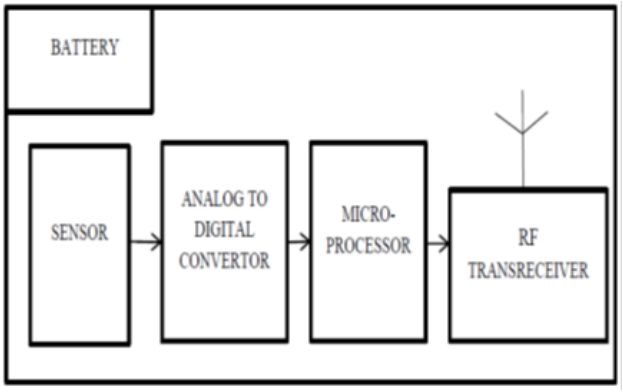

Fig. 1: wireless sensor networks

Accordingly, many routing protocols have been proposed in accordance to minimize the energy expenditure of these nodes. The elementary objective of any routing protocol is to make the network constructive and competent.

A. Routing:

Routing in the wireless sensor networks is very much different from the conventional routing, the various factors are - wireless links are unreliable, there is a no infrastructure, sensor nodes may get failed and routing protocols need to meet energy saving requirements. The main purpose of the routing is to send packets from source to destination efficiently. The number of routing technique has been formed for the transmission process. Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network which divides the nodes into clusters, in each cluster a devoted node with additional privileges called Cluster Head (CH) is accountable for creating and manipulating a TDMA (Time division multiple access) calendar and sending collective data from nodes to the BS where this data is required using CDMA (Code division multiple access). The remaining nodes are considered cluster members. This protocol is separated into rounds; every round consists of two phases;

B. Set-Up Phase:

(1) Advertisement Phase
(2) Cluster Set-up Phase

C. Steady Phase:

(1) Schedule Creation
(2) Data Transmission

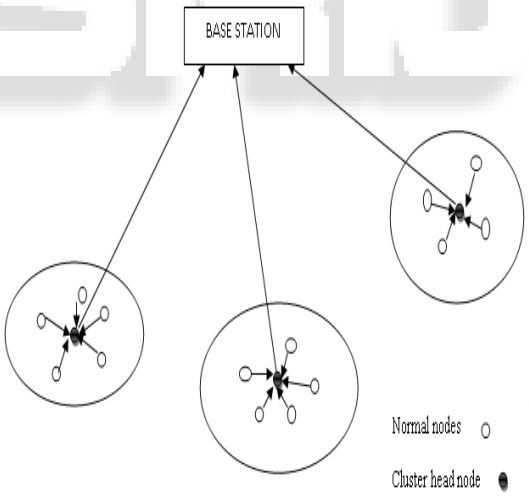

Fig. 2: LEACH Protocol [1]

1) Set Up Phase:

This phase consists of advertisement phase, cluster set up phase and schedule creation phase. In the phase of advertisement the decision for cluster head selection is done in the current round. N nodes takes decision by choosing random number r between 0 and 1. If the value of r is less than threshold value T (n) only then the node can become cluster head for that current round.

The formula for this is:

$$T(n) = \frac{p}{1-p} \times \text{rmod}\left(\frac{1}{p}\right) \quad \text{if } n \in G$$
$$0 \quad \text{otherwise} \quad [1]$$

Where n is given no of nodes; p, the prior probability of a node being chosen as a cluster head;

r = random number between 0 and 1

T (n) =threshold and G is the set of nodes that were not accepted as CH in the last 1/p event

After this calculation the elected CH advertise to the rest of the nodes in the given network and all non CH nodes must keep their receivers on to hear this signal. In cluster set-up phase the non-cluster head nodes chooses its own cluster on the basis of minimum transmission energy requirement for communication. Normal nodes send message using CSMA MAC protocol to their CH that they want to be a member of the cluster. For creating schedule phase CH forms TDMA schedule for each node after receiving messages from them, this indicates that they can transmit their information.

2) Steady State Phase:

This phase performs data transmission. Each node is fixed with TDMA schedule and they can transmit data to their respective CH according to the allocated schedule. After receiving all the information from the nodes CH performs data aggregation to compress the amount of data and sends it to the base station. After certain time a new round begins with each node finding if it should be a CH for this round and advertising this information. In LEACH there is no mechanism to ensure that the elected CHs are uniformly distributed over the given network. So, it may be the case that CHs are concentrated only in one part of the network and some nodes have to bridge long distances to reach the cluster head leading to more energy consumption.

D. Optimization Techniques:

1) Ant Colony Optimization (ACO):

Wireless Sensor Networks consisting of nodes with limited power, and they are deployed to gather useful information from the field. In WSNs it is vital to collect the information finely with minimum consumption of energy. It is activated in routing and tough power supply areas or area that cannot be reached and some non-permanent situations, which do not require fixed network supporting and it can fast deploy with strong anti-damage. In order to overcome the problem we proposed a new technique called Bio-Inspired mechanism for routing. Ant Colony Optimization is one of the Bio-inspired mechanisms whose function totally depend upon the behavior of ants and shortest path is selected on the basis of the route which is travelled maximum no. of times by the ants[5].ACO is a reliable and dynamic protocol. It provides energy-aware, data collecting routing structure in wireless sensor network. It keeps away the network congestion and fast utilization of energy of individual nodes. Then it can increase the life cycle of the whole network. An ACO algorithm minimizes the energy consumption. It betters the routing paths, providing an effective and efficient multi-path data transmission to obtain reliable communications in the case of node faults. Since their introduction in the early 90s, ACO algorithms have been used for many optimization problems. First, classical problems such as assignment problems, graph coloring, scheduling problems, or vehicle routing problems were handled. More recent applications comprise, for example, cell placement problems appearing in circuit design, bioinformatics problems, the design of communication networks, or problems arising in continuous optimization. In current years some researchers have also focused on the application of ACO algorithms to multi-objective problems and to non-static problems.

2) Particle Swarm Optimization (PSO):

As stated earlier, Particle Swarm Optimization (PSO) simulates the behaviors of bird flocking[7]. To understand the phenomena, consider the following example : a group of birds is aimlessly finding food in an area. There is only one bit of food in the area of search. All the birds have no idea where the food is lying. But they have a clue, how distant the food is in every single iteration. So the best plan to find the food is to go after the bird which is closest to the food. PSO gained from this scenario and applied it to find the optimization problems. In Particle Swarm Optimization, each one solution is a "bird" in the finding area. We named it as "particle". All of the particles consist of fitness values which are calculated by the fitness function to be optimized, and have velocities which controls the flying of the particles. The particles move through the problem space by going after the current optimum particles. PSO starts with a group of random particles or solutions and then find for the optima by updating generations. In each single iteration, each particle is updated by adopting two "best" values. The first describes, the best solution (fitness) it has achieved so far. (The fitness value is also getting stored.) This value is known as pbest and other "best" value that is obtained by the particle swarm optimizer is the best value, gained so far by any particle in the population. This best value is a known as global best, in short gbest. When the particle considers part of the population as its topological neighbors, the best value is known as local best, in short lbest. After getting the two best values, the particle's velocity and position get updated by following equations (a) and (b).

$$V_i = wv_i + c_1 \times \text{rand} \times (p_i\text{best} - \text{present}) + c_2 \times \text{rand} \times (g_i\text{best} - \text{present}) \quad (1.1)$$

$$\text{present}_i = \text{present}_i + v_i \quad (1.2)$$

Vi is the particle velocity, present_i is the current particle (solution). $p_i$best and $g_i$best are defined already before. rand is a random number between (0,1). c_1, c_2 are learning factors. Usually $c_1 = c_2 = 2$.[7]

This paper gives an introduction to wireless sensor networks and routing in leach protocol and describes optimization techniques in the section 1, section 2 includes literature work related to it, section 3 discuss the proposed technique followed by conclusion in section 4.

II. RELATED WORK

M. Heinzelman, A. Chandrakasan, and H. Balakrishnan [1] initiates a clustering algorithm for sensor networks known as Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH outlines clusters by means of a distributed algorithm, where nodes create self-directed judgments exclusive of any federal control. LEACH assembles the nodes in the network keen on clusters and prefers one of them like the cluster head. The process of LEACH is separated into rounds. Every round start on through a setup phase after the clusters is controlled, pursued by a steady-state phase when data are conveyed from the nodes to the cluster head and on to the Base Station (BS**). Khushboo Pawar, Vishal Pawar, Tilotma Sharma [3]** presents that the key crisis with the LEACH protocol is

that it needs the user to denote likelihood for utilize with the threshold function. Since the network presentation is exceptionally susceptible to this possibility, and it is very complicated to locate an optimum setting from obtainable knowledge .This work will effort to perk up the performance of the LEACH protocol to extend the network lifetime by expanding stable area. The purpose of this explore work is to amend Leach protocol by bearing in mind the energy level of sensor nodes in the cluster head assortment method in diverse surroundings .Also finding best possible possibility earlier than the set-up phase of the first round for diverse locations of base stations. This effort proposes a development of Low Energy Adaptive Clustering Hierarchy (LEACH) protocol to additional progress its energy efficiency capabilities**. Nguyen Zhu Xia, Longzhe Han, Nguyen Dinh Viet , and Minho Jo [7]** This paper proposes a particle swarm optimization algorithm to optimize a path in wireless sensor networks. Particle swarm optimization finds out effective results in wireless routing in terms of accuracy and data rate than the genetic algorithm. **Yulong Shen, Qingqi Pei , Qijian Xu , Hailin Feng , Jianfeng Ma [5]** This paper describes routing with high efficiency is an important issue in the limited energy resource wireless sensor networks. Ant colony optimization technique is used and its results are compared with LEACH, which represents ACO can reduce the energy consumption of networks and balance the energy consumption between the nodes. **M. Bani Yassein A. Al-zou'bi, Y. Khamayseh, W. Mardini, [4]** presents a new version of LEACH protocol, the cluster encloses; CH (accountable only for conveyance data that is acknowledged from the cluster members to the BS), vice-CH (the node that will turn into a CH of the cluster in case of CH expires), cluster nodes (collecting data from surroundings and throw it to the CH). In the new leach, the CH has been forever on getting data from cluster members, summative these data and then sends it to the BS that may be positioned far away from it. The CH will expire former than the other nodes in the cluster due to getting, overhearing and sending actions. When the CH pass away, the cluster will become ineffective because the data gathered by cluster nodes will never arrive at the base station. In this protocol, in addition having a CH in the cluster, there is a vice-CH that gets the work of the CH when the CH expires for the reasons such as environmental distrubances, software bugging or energy loss. The results show the entire improvement throughout the network in terms of minimum energy consumption and lifetime extension. **Nizar Hadi Abbas, Tarik Zeyad Ismaee[l6]** this paper a novel approach is developed for prolonging the lifespan of sensor networks. The proposed technique is based on biological inspired algorithm particle swarm optimization and ant colony optimization. PSO is modified based on inertial weight and the acceleration and then this modified version PSO is compared with ACO. The results, evaluate that the MPSO is faster than ACO because the update of the parameters is faster in previous one. The simulation results show that the presented approach for power minimization is faster than the previous works by 10 times and network lifetime may get incremented by 8 times. Therefore, better efficiency is obtained by using this modified version throughout the whole network.

III. PROPOSED WORK

Despite the wireless sensor networks are used in a number of applications, but there are some restrictions too, like the transmission range of sensor node is very limited, the processing and storage capabilities of the sensor nodes as well as their energy resources are also limited. One of the major design goals of a sensor network is to perform transmission successfully by managing the energy resource. To carry out this process it is necessary to select a suitable node for the route formation. As the energy resource is limited it is very important to maintain coordination among the nodes. But sometimes while transmitting data packets, nodes die out due to limited energy resources, physical damage, software failure or may get expired due to some environmental issues resulting in affecting the lifetime of the network. In order to avoid this problem we proposed an optimized approach to select a route with maximum energy for packet transfer and minimizing the overall energy consumption by evaluating the network stability with dead node calculation. An area is considered and is divided into the number of cells or clusters. The equal number of nodes are deployed randomly in each cell. Assign the Source and destination cell in the network area. Initial population is generated and to find the route we would be performing the iterations. The iterations are performed using the MRPSO technique as it would help in updating the parameters of the initial population. The criteria to select the optimized route is to choose that path which contains maximum energy. By updating the initial population, we would be getting the P_{best} solution and all these solutions would be considered to obtain g_{best}. Finally the best route after optimization would be obtained, which contains the maximum energy. It is mandatory that the route will follow the each cell of the network and have to choose one node from each cell to reach up to the destination block. Further, the data transmission is performed through this route to check the network's stability on the basis of calculating dead nodes.

IV. CONCLUSION

This paper discussed about wireless sensor networks and the optimization techniques. It focuses on the proposed technique to determine the best route for delivering packets from source node to the destination node and calculating dead nodes to improve the network lifetime. The simulation results save the energy consumption and lengthen the lifetime of network.

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