International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 3 Issue: 6

ISSN: 2321-8169
3804 - 3808

Dynamic Load Balancing protocols in WSN

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***Abstract*—** In recent times, significant amount of research has been done in the vast area of wireless sensors networks (WSNs) owing to their multi dimensional applications in disaster management, health-care, monitoring systems, underwater application and many more. The major focus of research has been to enhance the life of the wireless sensor network via increasing the lifetime of each sensor node as a sudden or unpredictable 'death' of a node may bring the whole network down. To prevent this kind of disaster taking place we review in this paper various approaches which aim to enhance the lifetime of the WSN by dynamically distributing the load among the nodes and some other energy aware routing protocols too.

Keywords- *Wireless sensor networks, load balancing, network lifetime, routing, energy aware, self-organized, energy-balance*

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I. INTRODUCTION

The deployment of wireless technology has increased manifold due to its low cost implementation and easy maintenance. The scope of wireless now is not only limited to research and industrial purpose but now attracts areas of personal use as well such as for measuring temperature, humidity and other things.[1] The technology which has emerged rapidly out of the wireless infrastructure is Wireless Sensor Networks (WSN's). The prominent reason in the increased demand of WSN is due to its capability to operate in tough environments and that too with a better level of performance in respect of other technologies. A WSN consists of a few ten to a thousands of nodes deployed over an area which vary according to the application requirement.

Here we refer to the sensor network model shown in Fig. 1 and which consists of one sink node (or gateway sensor node) and a number of sensor nodes which are deployed over a geographical area also known as sensing field. Data is transferred from sensor nodes to the sink in a multi-hop communication manner [1].

In a WSN the sensor nodes are required to sense and send data further to the gateway or sink node. Now we need to understand that the most important thing in a WSN is to elongate the life of the network by distributing the load evenly among all the nodes so that no node suffers from overloading of data and more importantly does not collapse down. So as the load is evenly distributed among the nodes it results in less energy consumption thus dramatically improving the lifetime of the nodes and eventually the network's lifetime.

The rest of this paper is structured as follows: Section II reviews some approaches in the literature that perform load balancing in WSN. Section III present Dynamic Load Balancing Protocol (DLBP) that improves and overcomes the exiting protocols in terms of network success ratio, overhead and lifetime. Section IV draws conclusions and presents avenues for future work.

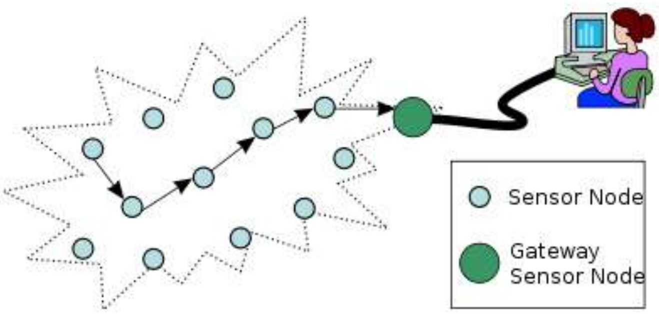

Figure 1 WSN Architecture

II. LITERATURE REVIEW

Message transmission takes out most of the sensor's energy; so there exist works that aim to find new techniques to route data with minimum effort so as to save sensors' energy. According to [2] the method to enhance the lifetime of the WSN is by achieving the balancing of load on all nodes at every level, especially those nodes which are very near to the sink. There exist numerous techniques to achieve load balancing in WSNs. In this section we discuss some of them.

A. Achieve Load Balancing by Constructing a Balanced Tree

In [3], construction of a load balanced network topology leads to the load balancing in WSN. Balanced Low-Latency

Converge-Cast Tree (BLLCT) attains bottom-to-top load balancing. Each node has many parents and the child selects one of the candidate parents according to number of children and its energy. This algorithm demands extra processing and extra computing energy. The idea in [3] is based on AODV-Shortest path Algorithm [3]. Here in this algorithm the node which has less candidate parents chooses the path to route data before other nodes that have even more choices.

BLLCT is all dependent on the construction of a load balanced tree from the beginning.

B. Achieve Load Balancing by Calculating Next Hop Weight

In [4], the lifetime of the network is equal to when any of its node's energy is entirely consumed. Level of a node is called node-grade. Which means the sink node is in the highest grade while its children are in first grade. A node has to send message to the higher grade node if that node wants to send it to the sink till it reaches the sink. Selecting the next hop relies on the weight of that link; the weight is determined by using distance (grade) of the node, and remaining energy. Depending on the distance between two nodes and energy of the neighboring node the weight of each node from the neighbors is calculated. Then a possibility of node to be selected as next hop is calculated and the node with the highest possibility is selected as the next hop. The calculation of weight of the next hop just before sending a message is used in many protocols such as [5] and [6]. The issue is the generated delay before sending every new message.

C. Load Balancing Techniques based on clustering the Network Nodes

Clustering is done to create small groups of neighbor nodes and it is known as a cluster. The connection to the network of each cluster is made through one of its nodes called cluster head. In [8], a clustering technique is used to make the network balanced and enhance its lifetime by having sleeping periods for cluster heads. It can be inferred from the above approaches that we need formulate a protocol that gains from the strengths of the existing protocols as constructing a balanced tree in first phase and keep updating data about neighbors. While, this protocol remove the weaknesses by overcoming the delay before sending messages, help in elimination of control packets, and keep updating the load on all the network nodes until it reaches stability stages. This is the main aim of introducing a Dynamic Load Balancing Protocol (DLBP)

D. Load Balancing Techniques Inspired from Animals Behavior

By studying the behavior of animals researchers are encouraged to develop innovative ideas that are taken from the animals. In [7] a routing protocol is presented that is inspired from ant's behavior. Ants generally attempt to find the best path to their home. New paths are generated on demand; information of data about routes is stored in sensor nodes.

III. DLBP

The authors in [9] have proposed a dynamic load balancing protocol for WSNs. Dynamic Load Balancing Protocol (DLBP) is an energy aware routing protocol that makes exploitation of all network nodes by balancing the load among the nodes in order to achieve the twin goal of balancing the load and prolonging the lifetime of WSN. DLBP has three phases:

A. Tree Construction Phase

In first phase it succeeds in building a tree, in which the main task is to find a path from every node to the sink. It is able to achieve better performance by removing unnecessary messages during the construction of the tree. It limits number of children for parent node; other enhancements are to remove control messages.

B. Data Filteration Phase

The nodes which are located almost in same area may sense the same event. This can result in redundant data being sent to the sink. In order to prolong the lifetime of WSN it reduces the data to be sent as transferring of data takes up most of the node's energy. It occurs only when parent is sure about data being redundant and from same location. It uses some historical records to compare the data coming at the parent node from the children.

C. Dynamic Load Balancing Phase

This phase presents an idea for load balancing while transferring data from source to destination. Most of the existing techniques which apply the technique of load balancing in WSNs, consider load balancing initially or at the topology construction phase with an assumption that the sensing rate is same for all nodes. But in DLBP the load balancing of WSN continues even after sensors start collecting data from the environment and sending them to the sink. DLBP also overcomes complex computations and prevents delay in messages before being sent.

ISSN: 2321-8169
3804 - 3808

During the first phase of tree construction DLBP attempts to look for at least one main path from any node to the sink node. While neighbors table is also implemented to find other paths to the sink. Each path to the sink has a cost associated with it. An initial link cost (value) is given which could be increased when needed. A node takes the best option if it has many options and uses it unless a change in its cost takes place. Fig. 1 shows in a simple way the cost calculation in DLBP. First, link cost is set to one and total cost is set equal to the number of hops toward the sink. The cost is updated according to the loads. In DLBP, a node may

have some alternative paths but every node has at least one path to the sink, through its neighbors. The data messages are generally sent through the path with the lowest cost. If there are number of paths that are of same cost then different options are available and it helps in distributing the load on multiple paths. DLBP keeps a watch on the

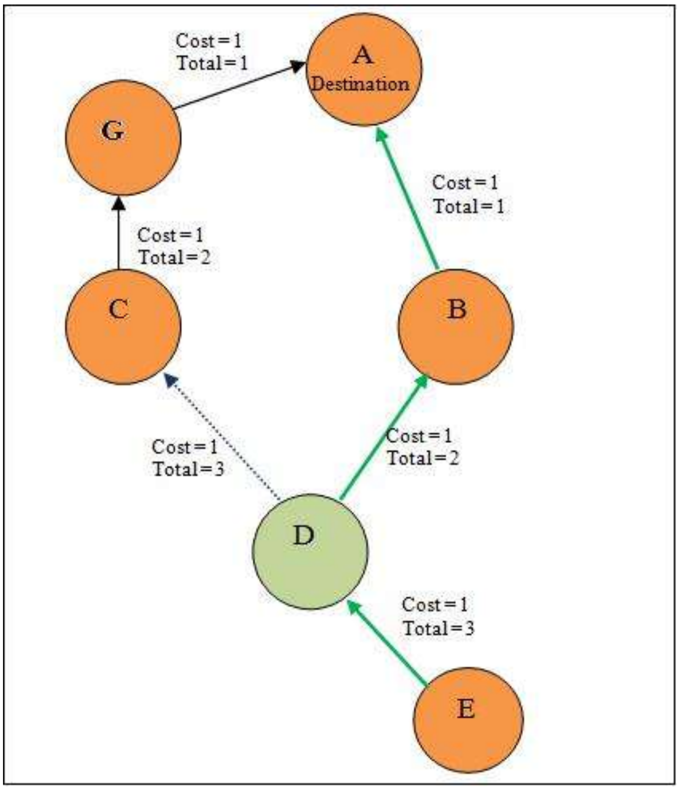

Figure 2 DLBP accumulated link cost

paths and then increases the cost of any high loaded path such that nodes which use that path seek for an alternative path. With this, the load is divided on all available paths and is not sent through the only one path.

IV. ELECTING A TEMPLATE (HEADING 2)

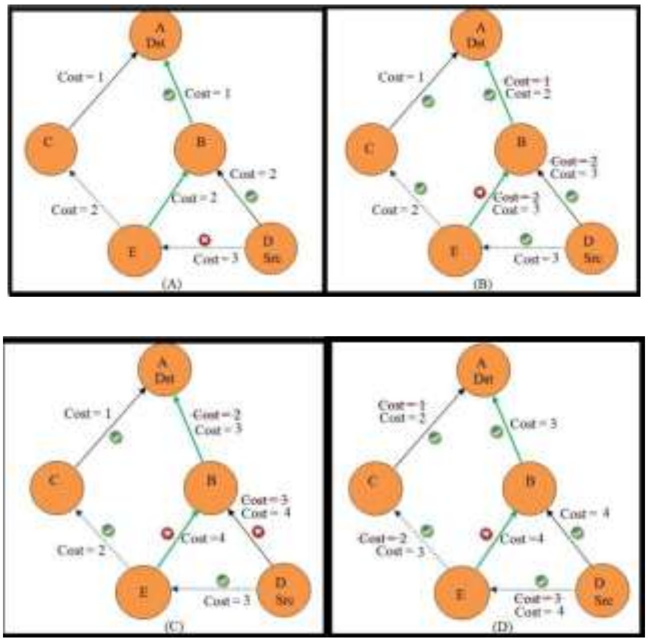

Figure 3: In this figure path is chosen based on link cost. The next hop selected is the link with minimum cost. Note that true sign represents the paths with lowest cost, and cross represents the paths with higher costs that are not selected unless there is no other option.

Now we discuss in Figure 3; four different scenarios which are possible as the links are updated and the costs of the links are adjusted dynamically.

In figure 3 (A), D is the source node and A is the destination so it looks for the paths available to send the data. There are two choices either through E or B . As the link D to B is of lower cost it sends the data through that link instead of sending the data through high cost link. So the D-B-A link is the link with lowest cost.

Now in Figure 2, if a child node wants to communicate with parent node then it calculates the total cost which is needed to send data up to the destination or the sink node. Here A is destination and supposes E wants to send data so it calculates total link cost. Here initially all links have initial cost of 1 which is updated further on. So from node E to node A the total accumulated cost is 3, similarly total cost is calculated for each node.

In Fig. 3 (B) the cost of link B-A is increased, so the links D-B and E-B also increase their costs. Change of the cost gives node D more options to route its data. Now it can send data through node B or through node E alternatively. Nodes B and E are said to be the best next hop in the neighbors table of node D and all packets from node D are routed through these two options. In Figures 2 (C) and (D) other changes take place

ISSN: 2321-8169
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on cost among various links, therefore, routing paths keep changing dynamically..

V. GSTEB (GENERAL SELF-ORGANIZED TREE BASED ENERGY BALANCE ROUTING PROTOCOL)

The penultimate goal of GSTEB is to enhance the lifetime of network, in which a routing tree is constructed using a process where, for every round, Base Station selects and assigns a root node and all sensor nodes are broadcasted the information about the base station. Then, every node selects its parent node by taking into consideration only itself and its neighbor's information, thereby making GSTEB a dynamic protocol.

GSTEB being a self-organized protocol makes consumption of very little amount of energy in every round in order to change topography for achieving the purpose of balanced energy consumption. Transmit delay is kept short by making use of a single TDMA time slot for transmitting data by all leaf nodes.

GSTEB has three phases comprising Initial Phase, Tree construction Phase, Self Organized Data Collecting and Transmitting Phase and Information Exchange Phase. [14]

A. Initial Phase

The initialization of all new parameters takes place in initial phase. This phase has three steps.

Step1: In this step Energy level is computed using

$$EL(I) = \lfloor \text{residue energy}(I)/\alpha \rfloor \quad (1)$$

Where, EL is a parameter for load balance which is just an estimated value rather being true one and α is a constant which shows minimum energy unit and can be altered on our demand.

Step2: After step1, each node will send a packet containing preamble, coordinate information, Energy Level of a node to its neighboring nodes in a circle with certain radius Rc, during nodes own time slot.

Step3: After Step2, each node has a information table regarding its neighbor's and broadcast this table in their own time slot.Now each node will have two tables in their memory one table having information about neighbors and other containing information of neighbor's neighbor.

B. Tree Construction Phase

The following two steps are done to form routing tree in each

Round:

Step1: BS selects the root node and the root node ID is broadcast to all other nodes in the network. The node with largest energy residue is chosen as root node. This node collects all data, combines them and transmits the fused data to BS. By using data fusion technique much less energy consumption takes place.

Step2: Now each node will select their respective parent node using EL and coordinates with criteria that the distance between the root and node should not be larger than the distance between the parent and the node itself.

C. Self-Organized Data Collecting and Transmitting Phase

After the construction of routing tree, all sensor nodes gather information in order to generate a DATA_PKT that will be forwarded to base station. In this phase TDMA and FHSS techniques are used. This phase is divided into several different time slots and in each time slot only leaf node will send it's DATA_PKT to respective parent node. Parent node will fuse all the received data from its child nodes and will send this packet in subsequent time slot acting itself as a leaf node. FHSS is applied in each time slot so that the communication interference can be reduced. TDMA time slot is divided into three different segments

Segment 1: In this segment communication interference for parent node is checked for this a beacon having a leaf node ID is sent by a leaf node to the parent node. Due to is three seperate situations arise and divide a parent into three types. In first situation, at a particular time slot the leaf node will receive nothing if no leaf node wants to send data to parent node. In second situation if more than one node wants to send data to parent node an incorrect beacon is received by leaf node and in third situation if only one leaf node wants to transmit data to parent node then a leaf node receives a correct beacon.

Segment 2: In this segment the leaf nodes which can communicate with their parent node are confirmed and the parent node goes to sleep mode for first situation and a control packet chooses a child node to transmit data in next slot is sent by parent node to all the child nodes for the second situation. And for third situation a control packet asking to transmit data is sent to leaf node.

Segment 3: In this the parent node receives the data from the permitted leaf node while all other leaf nodes turn to sleep mode.

D .Information Exchange Phase

As all the nodes are battery operated and they need to create and send a DATA_PKT in every round so their energy may exhaust and node may die thus affecting the network topology So a dying node must inform all other nodes about its status, this process is also segregated into time slots and a dying node will compute a random delay in each time slot so that only one node broadcasts in this slot. When the delay ends these nodes will broadcast this packet to whole network .In this time slot all other nodes monitor the channel and modify their table when they receive this packet and if no such packet is received next round gets started.

VI. RESULTS AND CONCLUSION

Dynamic Load Balancing Protocol (DLBP) and General Self-organized Tree-Based Energy-Balance routing protocol are energy aware routing protocols for WSNs which use dynamic load balancing techniques to elongate the network's lifetime. DLBP after constructing the tree uses filtering technique to lessen the number of messages and to eliminate redundant data packets. During data routing phase DLBP eliminates the control packets and achieves the load balancing on the network. As a result of these three phases, DLBP has prolonged the lifetime of WSN by 20% in comparison to Xue's algorithm. The routing overhead decreases by 72%, and network success ratio also increases by 16%. While GSTEB outperforms HEED [11], PEGASIS [12], TREEPSI [13] and TBC [15], GSTEB being a self-organized protocol, consumes little amount of energy in each round to alter the topography in order to balance the energy consumption. To ensure that the transmitting delay is short all the leaf nodes can transmit data in the same TDMA time slot. GSTEB prolongs the lifetime by 100% to 300% compared with PEGASIS. Three related works must receive attention in the future. First, building of a mathematical model for DLBP; second, simulation of network total throughput and third, consideration of security issues for DLBP.G STEB can be further improved by making certain changes and a comparative study of these two DLBP & GSTEB can be done.

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