ENERGY AWARE LOAD BALANCED MULTICAST ROUTING IN WIRELESS SENSOR NETWORKS(EALBMR)

Sreevidya R C[1], Jalaja G[2], Sajitha N[3], Akshitha K[4], Savitha G[5]
[1,2,3,4]*BNM Institute of Technology,* [5]*R V Institute of Technology*
[1]*sreevidyarc@bnmit.in,* [2]*jalajag@bnmit.in,* [3]*sajithan@bnmit.in,* [4]*akshithakatkeri@bnmit.in,* [5]*savithamadhusudhan@gmail.com*

Abstract: Wireless Sensor Network are unusual breed of wireless networks where the sensor nodes are primarily involved in sensing the tasks. Multicast routing refers to the routing scenario which has a single source node and multiple sink nodes. Energy awareness between the sensor nodes and balancing load between the cluster heads and cluster members is proposed in the paper. The life span of the network can be extended by proposed methodology. The data aggregated at the clusters and forwarding of data through the feed node helps in effective utilization of the available energy. The simulation experiment proves that the proposed model is more energy efficient where the nodes are aware of the available energy and balances the load at each node

***Keywords*: Wireless Sensor Network, Multicast routing, Energy aware, Load balancing.**

1. Introduction

In current era an efficient design of a Wireless Sensor Network (WSN)[1] has become a leading area of research. By applying signal processing approaches, the current conditions of the surrounding objects and environment of the sensor node can be assessed. Large numbers of sensor nodes have the ability to perform accurate sensing functionalities. WSN have wide applications in the field of imaging, weather monitoring, intrusion detection, tactical surveillance, monitoring ambient conditions such as movement, temperature, light, sound, disaster management, inventory control etc. The deployment of sensor nodes is done in both randomized fashion or it is manually planned. The main performance issue of WSN is its limited node energy supply. Energy awareness in WSN is not just confined in network layer, where energy efficient routing protocols are required, but, it is required in all the layers of WSN.

The OSI model has been predominantly used in WSN architecture. The architectural model discussed incorporates five main layers and three cross layers. Commonly in sensor network five layers includes physical, data link, network, transport and application. The three cross planes included are power management, task management and mobility management. These layers of the WSN as shown in fig.1 are stated to accomplish the network and make the sensors coordinate in attempt to optimize the network's performance The main performance issue of WSN is its limited node energy supply. The current research in this area has extensively investigated the novel methods to eliminate energy consumption, and prolong the connectivity of the network. Energy awareness in WSN is not just confined in network layer, where energy efficient routing protocols are required, but, it is required in all the layers of WSN

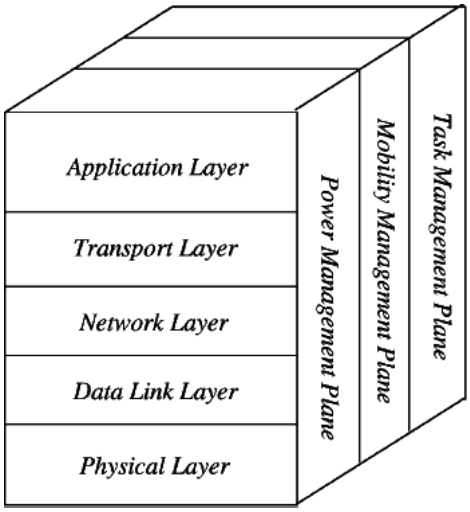

Fig 1: Layered approach

Sensors that are used in WSN are visual, infrared, Low sampling rate, thermal, radar, seismic, magnetic and acoustic sensors to track a wide range of environmental conditions. Sensor nodes will be used for continuous sensing, event identification, event detection, and local actuator control. Environmental, home, health, military, commercial areas are some of the applications in WSN.

2. Multicast Routing

The use of multicast is fascinating because it allows you to send the same report to multiple sink,, as seen in fig 2.

Incorporation of multicast will lead to reduction of usage of bandwidth in many of the applications listed: data duplication, tasks and commands to a particular group of sensors, queries to different sensors and so on. [6]

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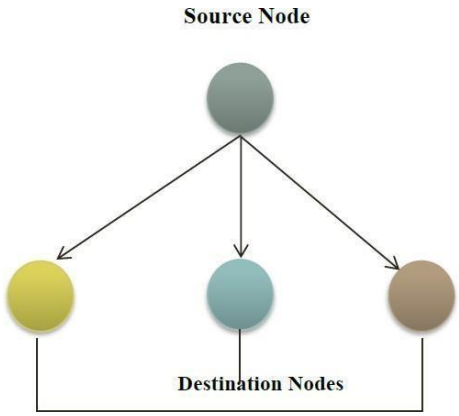

Fig 2: Multicast Routing Scenario

The notion of multicast is premised on the idea of a group. A group of receivers expresses their desire to receive a specific data stream.[2]. Different routing protocols exist where some use techniques like flooding, source based trees or shared tree algorithms. There are many scenarios in which it is necessary to send the same information to a group of sensor nodes when using multicast. Multicast routing can be classified into:

- Tree Based Routing Protocol
- Energy Based Routing Protocol
- Cluster Based Approach
- Steiner Based multicast routing protocols

Cluster based approach- The approach mainly helps in multicast communication.

In cluster Based Approach the energy efficiency is deployed in sensor networks randomly, where cluster head (CH) is in charge of each cluster. The cluster head coordinates with cluster members y receiving messages from other sensor nodes in the cluster and communicates with destination node. The sensor nodes communicate easily with each other and for long communication

The members of cluster will communicate with each other straight forward without any error, but very long distance communication will involve CH messages. A round is a brief period of time during which clusters are sustained. An election phase and a data transfer phase make up a round. Following the election process, each cluster head is discovered. There is a chance that various node will act as a cluster head [3]. Most of the cluster will pull down the span time of its life but very few will be retained for large number of rounds. As a result of the effective distribution of nodes, the number of head elections is reduced, and the load on long-range transmissions is reduced.

3. Related Work

Energy efficient and scalable routing is performed using multicast routing in Wireless Sensor Network. The structured view of nodes themselves organize into various groups, where each group has a leader. The node with leading energy factor processes and forwards to the sink. Abid Ali Minhas, et al projected the comparison of various routing protocols in perspective of energy efficiency. They compare tree based protocols and cluster based protocols [4].

Weiliang Li, Jianjun Hao work improves the throughput of the network and reduce the control overhead by using Tree-based multicast routing [5]. The multicast communication in wireless sensor networks happen between the sensor devices and several sink nodes. The multicast routing protocols in the Adhoc environment is discussed for load balancing. The protocol ensures high performance and robustness when the network load is increased. The packet delivery ratio is high and low latency with low control overhead is achieved. E.M Belding-Royer, C E Perkins have emphasized on distance vector routing using the multicast approach with dynamic movement of the hosts [6] [7].

The differences can cause changes in the links between any two stations, resulting in an unsustainable moving topological structure. By dynamically inspecting each node, each will be able to perform rerouting in order to forward messages. [8]. Juan A. Sanchez et al. projected GMR [9], A geographic multicast routing protocol. The protocol proposed the neighbor selection through cost approach. It estimates the efficiency by finding the packet delivery ratio and optimization of the tree. The localized algorithm [10] fabricates the multicast tree on the basis of spiral tree, and then considers multicast routing with duplicate routes. The method is quite dense which chooses the direct route with the most of diverted nodes. Qingfeng Huang et al. [11] disusses the concept of space and time complexity in forwarding of message.

4. Energy Awareness And Load Balancing

Since the nodes get operated with limited battery power sensor networks are power constrained. Some of the nodes die early due to limited battery and the communication between the nodes is disconnected. Awareness among the nodes should be present where the available energy in the node is utilized efficiently. The routing protocol should distribute the energy evenly over all the available nodes. The overall transmission and receiving power should be minimized. In the sensor network the nodes are constrained by limited energy for their operation. Due to this they have a very short lifetime. Each node consumes a certain amount of energy for transmission and reception of data. If the node consumes more energy the lifespan of the node decreases and leads to the disconnection from the network. The node which consumes more energy gets drained up ending in network disconnection when the communication fails at the end points. If the intermediate nodes suffer from energy constraints the network connection becomes sparser leading to network partitioning. So, each

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node in the sensor networks participating in the communication should be aware of the energy consumed in transmission and reception process. Each time the node receives an acknowledgement for the available remaining energy. Based on this the node can stop the additional activities of participating in routing [12] and forwarding process of other nodes data. They participate in their own transmission process of data. The proposed methodology focuses on creating awareness among the nodes in the network through sending acknowledgements about the remaining energy and the number of neighboring nodes in the network. According to the recent works energy awareness in the sensor nodes could be presented in different ways. One such approach would be possible through clustering approach. The sensor nodes are divided into many different clusters and the energy is balanced through the cluster head selection process to extend the network lifetime. One of the best way to extend the network lifetime is through clustering approach which involves transmission of data to the base station through data aggregation and fusion techniques. In the process, the data aggregated and fused through proper techniques reduces the overall energy consumption. The nodes in the cluster are divided into high energy nodes and low energy nodes. The high energy nodes become the cluster heads and collect the data from the other nodes which are the cluster members. The low energy nodes sense the data in the close proximity range.

5. Energy Model

Any sending node will have four states which they belong to. It can be either in sleep state, idle state, transmit state or receive state. The overall energy can be measured as E.

$$E = I_E - (S_E + R_E + T_E) \quad (1)$$

$$= I_E - (S_W S_T + R_W R_T + T_W T_T)$$

$$= I_E - (S_W(S_L/R) + R_W(R_L/R) + T_W T_T)$$

E-Total Energy I_E- Initial Energy

R-Data Transfer Rate R_T- Receiving Time T_T- Ideal Time

T_W-Energy transmitted n watts S_T-Sending time

R_L- Length of the received packet

The data transmission among the nodes in the network has to be balanced efficiently. In the large scale network energy consumed to perform data transmission can be balanced by employing multihop communication between cluster heads. If the cluster heads are located far away from the base stations they consume more energy in data transmission due to single hop communication. The energy consumption linearly increases as the distance of the transmission increases. So, it is a good communication technique to enhance to multihop process between cluster head nodes so that considerable amount of energy consumption can be reduced. In the process of communication one of the cluster heads can be treated as a feed node where the aggregated data acts as the feed to the next cluster head. The message it carries with it is the available energy and the neighbor node details of its cluster. Based on the distance taken by the feed node to communicate the energy consumption ca be reduced and load balancing can be done in the network. In the process one of the cluster head is chosen as the feed node which can forward the data through. The feed node should have the maximum energy to forward the data and should be nearer to the cluster members.

$$E_{feed} = \frac{Dist_{(CH->FN)} + \text{No. of Cluster members}}{R_E} \quad (2)$$

E_{feed}-Energy at the feed node

$Dist_{(CH->FN)}$- Distance from cluster head to feed node

R_E – Remaining energy

6. Simulation

Simulation of the proposed approach was performed on network simulator NS2[13]. Certain parameters were evaluated to observe the performance of the proposed methodology and was compared against the standard benchmark protocol LEACH.

Table 1: Simulation Parameter

Parameters	Values
Area of simulation	500X500
Base station locations	(150,50) (100,100) (130,80)
Initial Energy	2J
Mobility Model	Random
Communication bandwidth	1Mbps
Time of each round	20s
Size of packet	500Bytes
Simulation time	2000s
Traffic Pattern	CBR

7. Experimental Analysis

To evaluate the performance different topology scenarios were considered of varying number of nodes such as 20, 50, 80, and 100. Random point model was used for simulations with CBR traffic generated and multiple sinks. Sinks were placed at different points to analyse four metrics in the trusted environment.

The fig 3 indicates the graph specified for different nodes and the energy consumed at each round. The x-axis indicates the total number of nodes and the y-axis indicates the energy consumption in joules. The graph lines are specified in different colors. The green line indicates the values w.r.t the LEACH and the red line indicates the value of the proposed energy aware and load balanced method (EALB).

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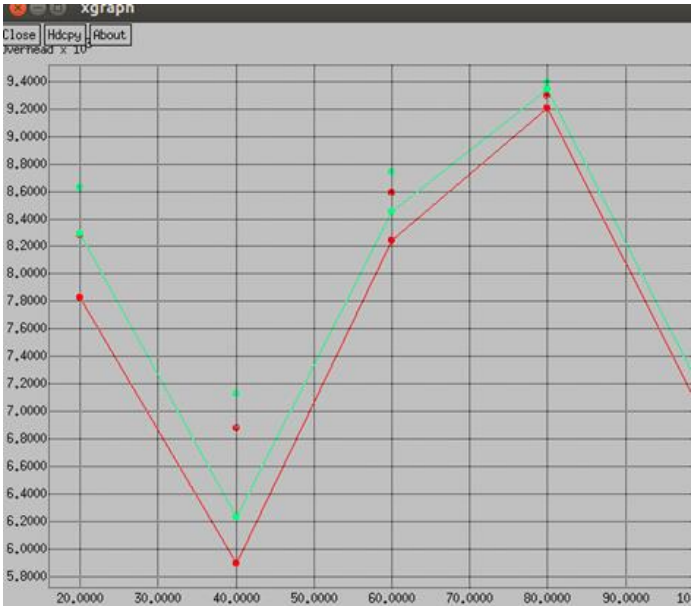

Fig. 3: Energy and Number of Nodes

The fig 4 indicates the graph specified for different nodes and the delay at each round. The x-axis indicates the total number of nodes and the y-axis indicates the delay in ms. The graph lines are specified in different colors. The green line indicates the values
w.r.t the LEACH and the red line indicates the value of the proposed energy aware and load balanced method (EALBMR)

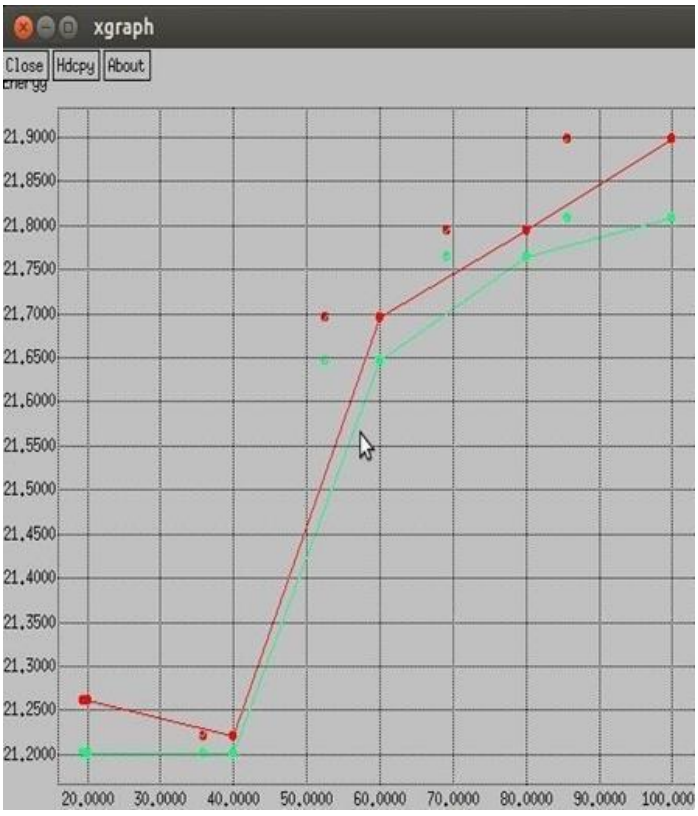

Fig.4: Delay and Number of Nodes

The fig 5 indicates the graph specified for different nodes and the routing overhead at each round. The x-axis indicates the total number of nodes and the y-axis indicates the delay in ms. The graph lines are specified in different colors. The green line indicates the values w.r.t the LEACH and the red line indicates the value of the proposed energy aware and load balanced method (EALBMR).

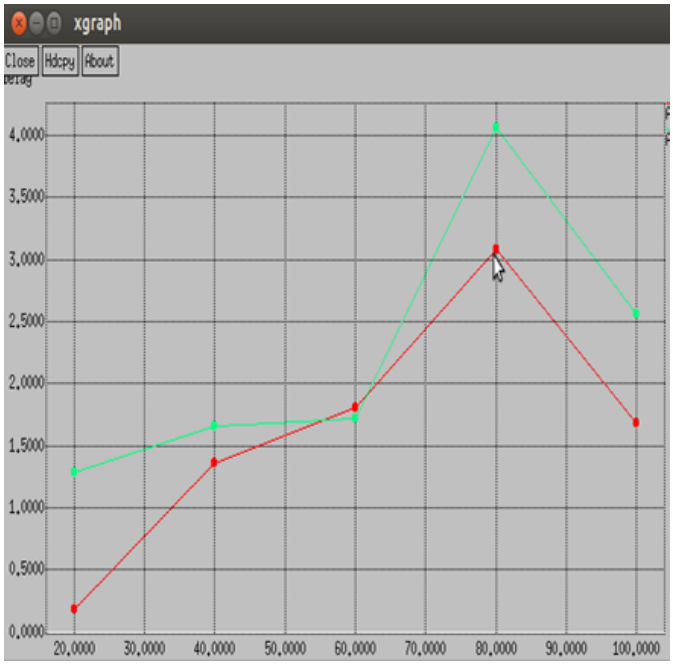

Fig.5: Routing overhead and number of nodes

8. Conclusion & Future Work

Wireless Sensor Network is used in environments where wired networks cannot be deployed and the wired setup is not possible. The WSNs have limited computation and communication resources with limited battery power. Clustering approach helps in data gathering from different nodes and routed further to multiple sinks or base stations. The data aggregation makes use of multi hop technique. The nodes in the network are made energy aware and load balancing is done at the clusters which increase the lifetime of the network. In the future, energy efficient cooperative communication could be carried out for multicast routing

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