An Efficient Clustered Multipath Routing to improve lifespan in WSN

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Abstract

A wireless sensor network with a large number of tiny sensor nodes can be used as an effective way for gathering data in various environments. One of the significant challenges in the wireless sensor network is the energy saving and increasing the lifetime of the network. In order to increase the energy of the nodes it is necessary to implement energy routing algorithms. The main goal of this paper is to propose a novel way by using clustered multipath routing to improve the lifespan of sensor networks.

Keywords: *sensor nodes, energy, multipath, network.*

1. Introduction

Recent advances in microelectro mechanical systems, technology and wireless communications have led to small and low cost sensor network. The sensor network may comprise many application areas such as health monitoring, environmental monitoring including temperature, humidity, lightning condition, pressure etc. Additionally, many domain applications such as factory automation, chemical pollution monitoring, oil and gas remote monitoring, building sensor and security adopt sensor computing.

A mobile wireless sensor network consists of tiny sensor nodes which has three basic components: a sensing subsystem for data acquisition from the physical surrounding environment, a subsystem for local data processing and storing a wireless transmission subsystem for data transmission. Furthermore, a battery is critical for a sensor node. All the sensors send data that they have sensed from the given region to the base station. The very important issue in this action is energy efficiency. There are other factors related to energy efficiency directly or indirectly like having a good routing protocol.

The path selected by nodes to send data is very affective because energy resources are limited and routing protocol

should pay attention to this fact and has to send data in the path which doesn't lead the nodes to loss much energy. Clustering is a technique used to reduce energy consumption of network nodes. The main contribution of this paper is using a multipath routing to send the data from one cluster to other clusters. The remaining of this paper is organized as follow: Section 2 guides an idea on prior works done in this area. Section 3 gives details about cluster formation and multipath routing, Section 4 presents simulation results and performance analysis and Section 5 presents conclusions and future work.

2. Related Work

Wireless sensor networks have attracted much research in recent years. In order to minimize the energy consumption in WSN's several energy efficient routing protocols and algorithms has been developed [1, 2]. Several researches have focused to provide energy efficiency routing protocols for wireless sensor network.

Another major issue in sensor networking is routing. The majority of the routing protocols can be classified into data centric, hierarchical, location based, network flow. Energy sensor node is assumed to know its own position as well as that of its neighbors which can be obtained with some localization schemes [7] [8]. Each node can forward packets to its neighbors within its transmission range that are closer to the sink node than itself.

A routing protocol for sensor networks should have scalability, data aggregation, network dynamics, low complexity, energy efficiency, fault tolerance and multiple paths. Multipath routing in ad hoc networks has been

proposed in [17], [18], [19], [20]. For monitoring burst events a multipath routing protocol based on dynamic clustering and ant colony optimization is proposed in [13]. Partitioning the whole network into smaller areas can turn the network into an easily controllable and manageable infrastructure, and such grouping of sensors is the clustering. The main purpose of clustering is to use the network resources more efficiently, reduce overheads and provide a scalable architecture.

The cluster head plays its major role which mange's all other node belonging to its group. Due to this it may quickly cause energy fatigue. There has been some published work related to the cluster formation and the selection of cluster head [9] 10]. Generally, the clustering methods can be categorized into static and dynamic clustering. The static clustering aims at minimizing the total energy spent during the formation of the clusters for a set of network [11]. The dynamic clustering also deals with the same energy efficiency problem like increase the lifetime of nodes, selecting the cluster head as in [12].

Some non uniform sensor deployment strategies have been proposed. Lian etal [3] focused on increasing the total data capacity by only considering the energy spent on the data transmissions. Reducing energy consumptions due to wasteful sources has been primarily addressed in the content of adaptive MAC protocols such as PAMAS (Power Aware Multi-Access Protocol) [4] and S-MAC [5,6].

In [14] the author uses a light weight minimum hop routing to send the packets from cluster head to another. Unequal clustering model [15] has focused on heterogeneous network where cluster head are deployed at some pre-computed locations. The authors B.Chen et al in article [16], proposes an algorithm to turn off the nodes based on the necessity for neighbor's connectivity. It intends to reduce the system energy consumption without significantly diminishing the connectivity of the network.
In the existing shortest path algorithm [21] the data is forwarded from a remote sensor node to other nodes. The nodes are randomly placed and at some instance of time, collision of data packet, path breaking occurs.

3. Proposed Work

Routing in wireless sensor network is a demanding task. This demand has led to many routing protocols. Most of these protocols find the minimum energy path or the shortest path routing. Always using these paths will soon make those nodes to lose their lifetime.

Multipath routing will distribute the traffic among multiple paths instead of routing through a single path. The proposed plan in this article is to first find out the neighbour node list and then to find the multiple path from the neighbour nodes. The data packets are distributed through the multiple paths to the destination. The work is been divided into 4 stages:

(i) Initialization stage
(ii) Finding neighbour nodes
(iii) Finding multipath
(iv) Maintenance stage

(i)Initialization Stage

In this stage, the nodes are first clustered and the "HELLO" packet message is send to all the nodes. The node which has more energy is elected as cluster head (CH). The remaining nodes are treated as member nodes of that cluster. The node which has the next energy level to the cluster head is treated as next_CH. In situation like when the cluster head loses its energy level below the threshold value, then the next_CH will act as the cluster head and the current head goes to sleep mode.

When the system starts its operation, regular nodes send out collected data to the cluster head, and then the cluster head forwards data to the base station through its neighboring cluster heads using the dynamic routing mechanism to save energy (Fig. 1).

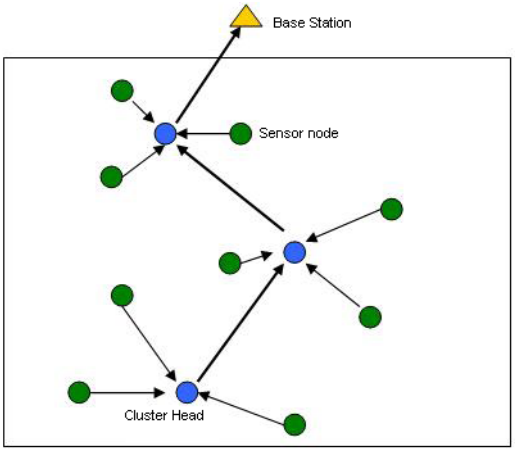

Fig. 1 Clustered wireless sensor network

After sending the data, the cluster head may lose some energy. The remaining energy of the cluster head is calculated by the formula.

Remaining energy = I.E. – ((No. of packets transmitted * T.E.) + (No. of packets received * E.C.))

Where
I.E. – initial energy of the node
T.E - transmission energy to transmit the packet
E.C. – energy consumed by receiving a packet

If the remaining energy < energy of NEXT_CH, then a MSG from the current head is passed to the NEXT_CH to act as the cluster head for the next iteration. If the remaining energy > energy of NEXT_CH, then there will be no change in the election of cluster head.

(ii) Finding neighbour nodes

Before finding the multipath, create a neighbour table for the source nodes.

The steps are as follows:

max_node -number of nodes in the network
x,y -positions of the current node
node_id -node number
th – threshold energy
R- residual energy of the node
G_node – nodes within the transmission range of current node
Trans_range – transmission range

The steps are as follows:

1. Get the value of maximum nodes in each cluster
2. Get the position of source node
3. Let the source node be with node id =0
4. Find the distance between the source node and all other nodes using the distance formula

$$dis = \sqrt{(y_2-y_1)^2 + (x_2-x_1)^2}$$

where (x_1,y_1) are the positions of the source node and (x_2,y_2) are the positions of the node from which the distance is to be calculate.
5. if(dis<trans_range) then update the neighbours of the source node in the neighbour list

In case if the distance is within the transmission range and the node energy is greater than the threshold energy then update the neighbour list of the source node. Consider the following figure.2, node1 is acting as the source and node11 is the destination.

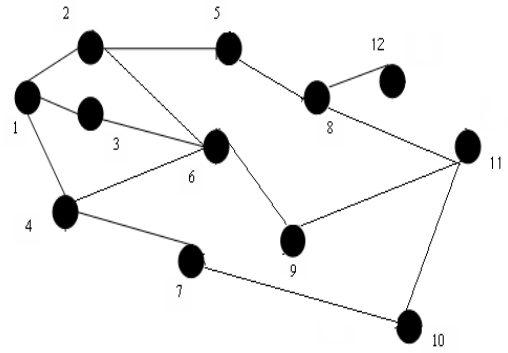

Fig.2: Network model

For the above figure, the neighbour list is as follows:

Table 1: Neighbour list

Node	Neighbour list
1	2,3,4
2	1,5,6
3	1,6
4	1,6,7
5	2,8
6	2,3,4,9
7	4,9,10
8	5,11,12
9	6,11
10	7,11
11	8,9,10
12	8,11

(iii) Finding multipath

The next step is to find out the available path for the source to reach the destination in such a way that no node is repeated in the way. By using the neighbour list all possible paths without any repeated node is found out.

Considering the figure we can get the available path for the source node1 as
Node 1->2->5->8->11
Node 1->3->6->9->11
Node1->4->7->10->11

In all these paths no node is repeated or duplicated. Since the data packets are send through 3 different paths there is no chance for traffic or collision in the network. After finding the path, a RREQ message is send to the destination from the source. Once when the RREP

message reached the source, the source node can deliver its data to the destination node through the paths. In case, during the iteration of data packets, if the cluster head energy level decreases below the threshold level, the next_CH will act as the CH and the previous node goes to sleep mode. However in due cases, these paths may even break due to the nature of network topology in sensor network. In order to maintain a reliable network connection route maintenance is more important.

(iv) Maintenance stage

When sending the data from the source to destination, there can occur any breakage in the route. The node which discovers the link breakage between two nodes, it sends a route error (RERR) message to the backward direction to the source node. From the neighbour list table, the source node uses an alternate valid route.

4. Simulation Results And Performance Analysis

(i) Simulation Results

To validate the performance of mulitpath, we simulated it in NS2 and utilize a network with 50 nodes randomly deployed between (x=0, y=0) and (x=100, y=100) and basestation at (50,175). The bandwidth of channel is set to 1 Mb/s. The clustering of the nodes is performed and one node is elected as CH from each cluster (blue color nodes as member nodes, red color nodes are cluster head). The below fig 3 shows how are nodes are clustered.

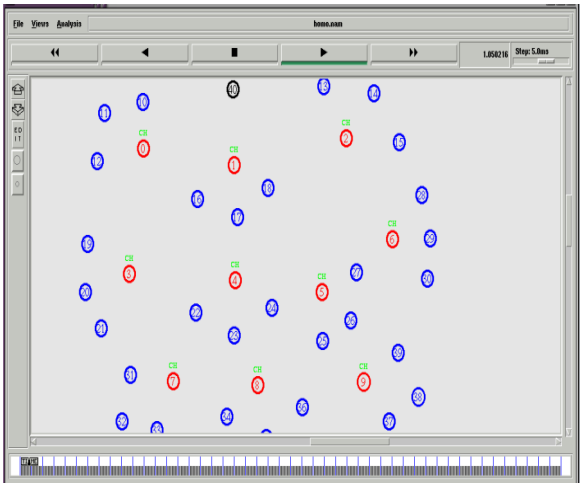

Fig.3. Nodes are clustered

The data is been transferred from the source node 8 to the destination node 1 through three different routes which is shown in the figure 4.

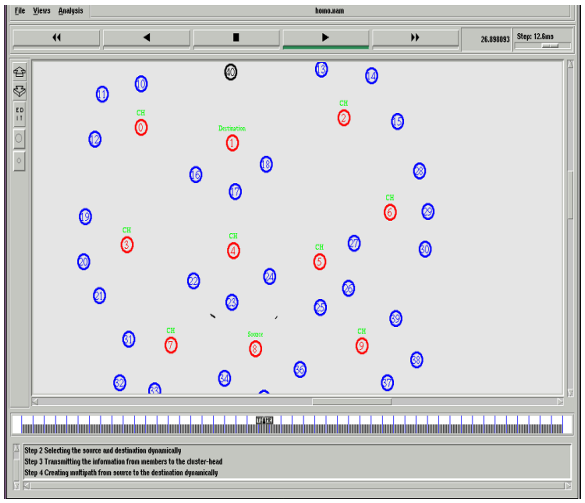

Fig.4 Data is transferred from source to destination

During transmission of data, if the cluster head loses its energy, the next_CH act as the cluster head. As shown in the fig.5 the node 8 loses its energy, so node 34 is acted as clustered head. Node 8 goes to sleep mode, is shown in green color.

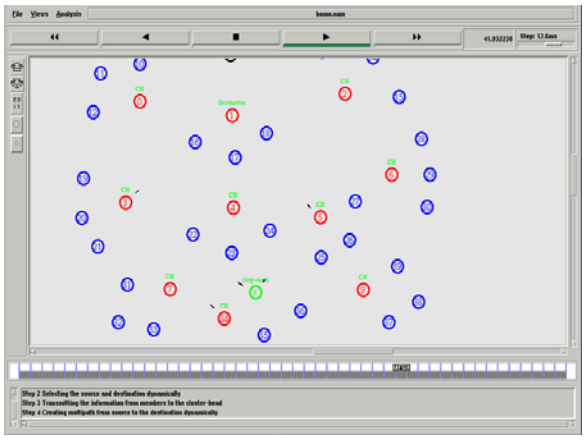

Fig.5. Node 8 goes to sleep node

(ii) Performance Analysis

The results of the proposed system are compared with the existing shortest path algorithm. The proposed system

proves that it uses only less amount of energy while sending the data. The fig.6 shows that the total remaining energy is more than the existing energy.

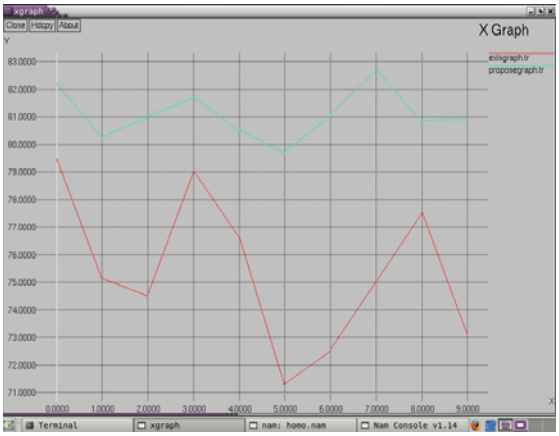

Fig.6 Remaining lifetime of nodes

The fig.7 shows that the proposed system loses only 25% of packet loses when compared to the existing system.

Fig.7 Comparison of energy drop

5. Conclusion & Future Scope

Here we introduced a novel method to utilize the energy of the nodes through clustered multipath routing. The energy efficiency and ease of deployment makes this algorithm a desirable for wireless sensor networks. The simulation result shows that the energy has been saved, so that the lifetime of the nodes is also increased. There are also future works we would like to focus on. The algorithm has to be further investigating in multipath routing for larger number of nodes.

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