ENERGY CONSERVATION USING DISJOINT MULTIPATH ALGORITHM FOR HETEROGENEOUS WIRELESS SENSOR NETWORK

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Abstract**—**Due to increased mobility of network nodes, routing in Wireless Sensor networks (WSN) is a difficult task. In order to provide reliable data transfer and to improve fault tolerant multipath routing is employed. However selecting optimal disjoint path is a very serious issue. In this study, a disjoint multipath fault tolerant algorithm (DFA) is presented as routing algorithm in WSN. The network is equipped with a ordinary sensor nodes, with limited battery power and supernodes, which have more power reserves but are fewer in number due to their higher cost. This algorithm finds disjoint paths with no extra over head. The simulation result shows that the proposed method can find a better fault tolerant disjoint path set in WSN. The simulation results are compared with existing algorithms like scheduling, sleep-awake and on-demand algorithms. Experimental results show that the proposed algorithm provides better performance in both reliability and fault tolerant capability.

Keywords— Wireless Sensor Network, Node-Disjoint, Scheduling, sleep and awake, On-Demand, Quality of Service

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I. INTRODUCTION

Recent decades have witnessed the increased use of wireless sensor network [1] in variety of long term and critical applications like object tracking, performance monitoring, Battlefield surveillance and many others. A sensor network consists of several numbers of nodes, which are typically self-organized to do a specific task. Compared to high end technologies [4][5], sensor nodes are low cost, miniature and easily deployed. However the energy reserves available to the sensor nodes are limited. Hence the gap between increase in sensor node deployment and limited energy reserves has to be properly addressed in network design. On the other hand the bandwidth available for sensor nodes is also limited because of radio interference, network congestions and node faults and makes it unreliable. Therefore there is a need to keep the network traffic carrying capacity at a reasonable level by making the network fault tolerant [3][7].

Conventional routing algorithms use a distinct path among the communicating nodes in the network. Path failure results in finding of fresh routes, which leads to unnecessary delay and affects the quality of service (QoS) of the WSNs. In order to overcome increased route discovery latency and route discovery attempts, a set of redundant paths is used. In order to increase reliability of the path, the correlation of failure between the paths should be as low as possible. Hence the path selected should be short and disjoint [9] i.e., none of the nodes are shared with other paths. Thus if any nodes in the path gets failed means it will not affect data communication in other paths and thereby improving the reliability of the network making it more fault tolerant to link breakages.

Power efficiency and Network life time are also essential properties for WSNs [2] in order to maintain network functions properly in case energy depletion, or hardware malfunctions. In this paper, the performance of the DFA algorithm is measured and is compared with other algorithms like Scheduling algorithm, Sleep awake algorithm and on demand algorithm and the experimental results shows that the performance of DFA algorithm is better in all aspects when compared with above protocols.

II. DISJOINT MULTIPATH FAULT TOLERANT ALGORITHM

The proposed solution uses two simple steps to calculate disjoint path set:

1. Discovery of Paths: Finding all paths between Sender and receiving node.
2. Selection of Path set: Finding the most reliable disjoint path set by DFA algorithm.

A. Path Discovery Algorithm

Initially the source node broadcasts Route request (RREQ) packet to all the neighboring nodes in the network.

The RREQ packet has the following fields:

Record	Prob	Max_Hop

Fig 2.1 RREQ Packet

Record: This field records the order of hops taken by the RREQ packets.

Prob : This field records the path reliability.

Max_hop: The maximum number of hops that a packet can pass through the network before it is discarded.

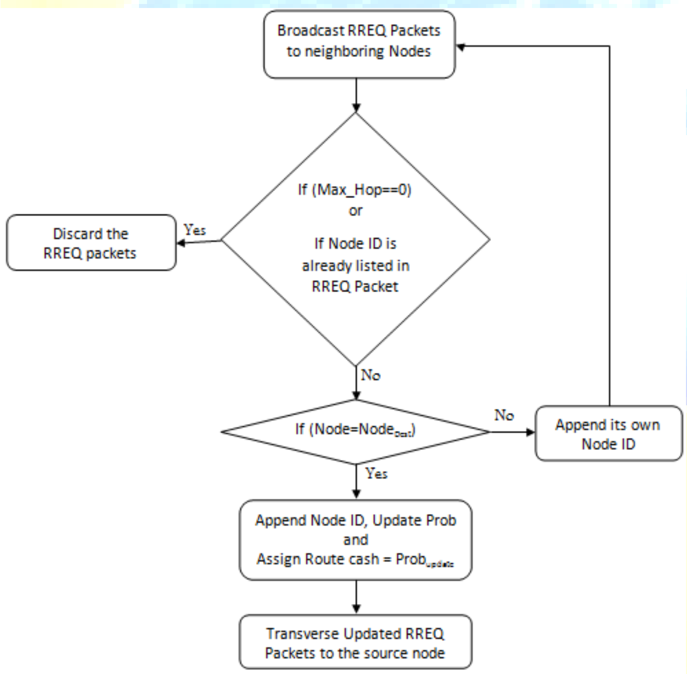

Fig 2.2 Route discovery Flow Diagram

B. Selection of path sets:

The reliability of the path sets are calculated and then the reliability of discovered paths is normalized by

$$npr_i = \frac{prel_i}{prel_{\max}}$$

Where, $prel_{max}$ is the highest path reliability along all paths in the route cache. Then, the destination node will make an (n x n) matrix called disjointedness matrix, d, from all of the paths in its route cache. n is the total number of RREQ packets received from a specific source. Disjointedness matrix is defined as follows to find node-disjoint path set.

$Node\_disjoint_{nm} = 0$ if no nodes are being shared by $path_i$ and $path_j$

1 Otherwise

And from the Disjointedness matrix, the rows having maximum null elements are considered to be most reliable path among all paths.

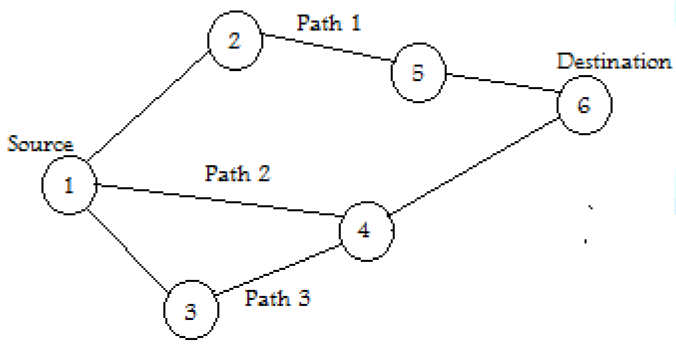

Fig 2.3 Network Topology

In the figure 2.3, there are three paths available between source to destination node. The Disjointedness matrix is given by $ND_{nm} = \begin{bmatrix} 000 \\ 010 \\ 001 \end{bmatrix}$. In the above figure path 2 and path 3 are sharing same node 4. Hence the reliability of these paths are less compare to the path 1 since the probability of failure of this node is more as the node involves more data transmission from path 2 and path 3. Therefore path 1 is selected for data transfer between source and destination node.

III. SIMULATION AND EXPERIMENTAL RESULTS

A. *Network Model*

We consider randomly distributed wireless sensor network with two layer architecture as shown in figure 3.1. The upper layers consist of M number of supernodes with huge energy reserves and memories and are located in known positions. The bottom layer consists of N number of ordinary sensor nodes with limited power reserves and processing capacity with M≤ N.

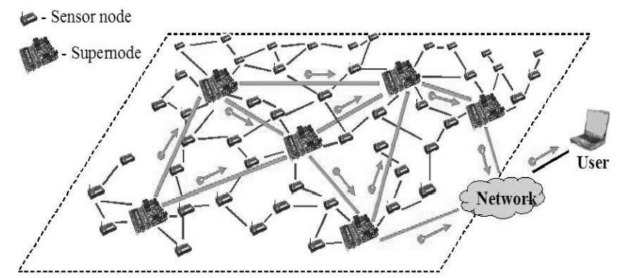

Fig 3.1 Heterogeneous Network Model

It is assumed that data transmission from sensor to supernode is a successful delivery. Let R_{max} be the transmission range of sensor node. Thus the networks topology consists of undirected weighted graph G= (V,E), where V ={ v1, v2, v3, …, v_{n+m} } number of nodes and E = { (v_i ,v_j) | dist(v_i ,v_j) < R_{max} } is the set of edges, where dist(v_i,v_j) depicts the distance between nodes v_i and v_j. The first N nodes in V are the energy-constrained sensor nodes and the last M nodes are the resource-rich supernodes.It is assumed that the total number of sensor nodes are always greater than supernodes and we are interested in supernode to supernode transmission.

B. Definition of network Parameters

All nodes start the experiment at a random location within a rectangular working area of 1,000 x 500 m and move as defined by the random waypoint model. For this, each node selects a random destination within the working area and moves linearly to that location at a predefined speed. After reaching its destination, it pauses for a specified time period (pause time) and then the node selects a new random location and continues the process again. In the present study, each node pauses at the current position for 5 s and the speed of individual nodes varies from 0 to 20 m/s. We have run simulations for a network with 30 mobile hosts, operating at transmission ranges (R) varying from 100 to 300 m.

C. Experimental Results

The algorithm is simulated using Network simulator-2.34 in fedora operating system. For the purpose of evaluating the efficiency of the proposed routing method, it has been applied to networks with different parameters (Throughput, Delay). The results are then compared with other algorithms like Scheduling algorithm, Sleep awake algorithm and on demand algorithm.

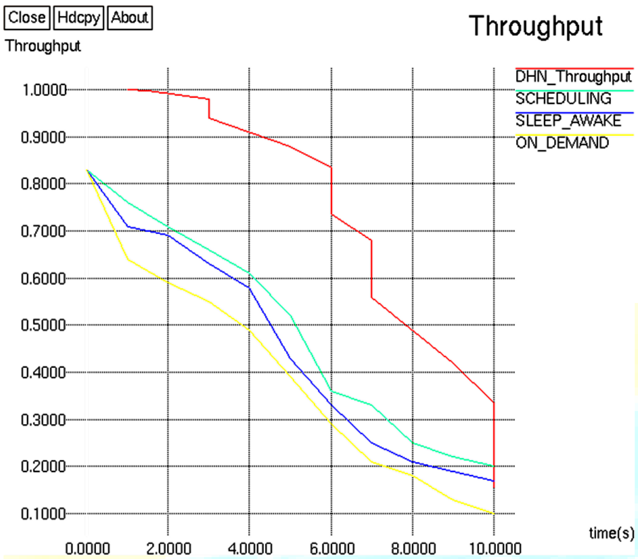

Figure 3.1 Throughput vs Time

Figure 3.1 Shows Throughput for Disjoint Multipath Heterogeneous network which decreases due to increase in congestion with increase in time. Hence it is not delivered to destination node which increases packet loss. Therefore the Throughput decreases with increase in time.

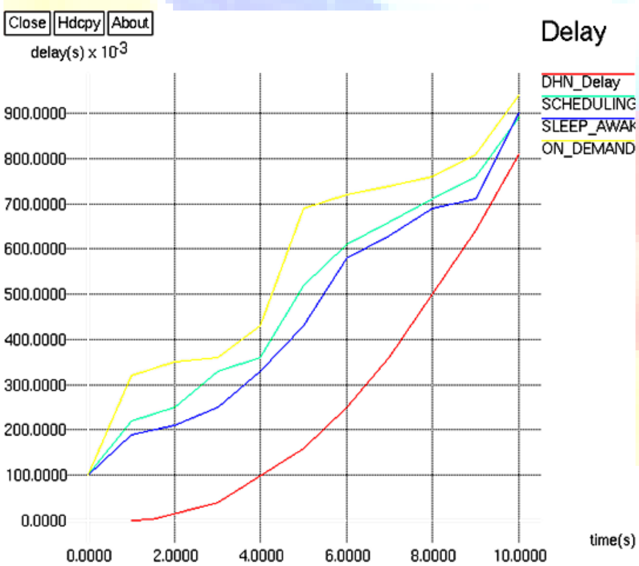

Figure 3.2 Delay vs time

Figure 3.2 Shows that delay occurred in network due to congestion over time. Her delay is increased as the data traffic time increases. Since the amount of data increases from time to tine the network gets congested. However this delay is comparatively low when compared to other protocols.

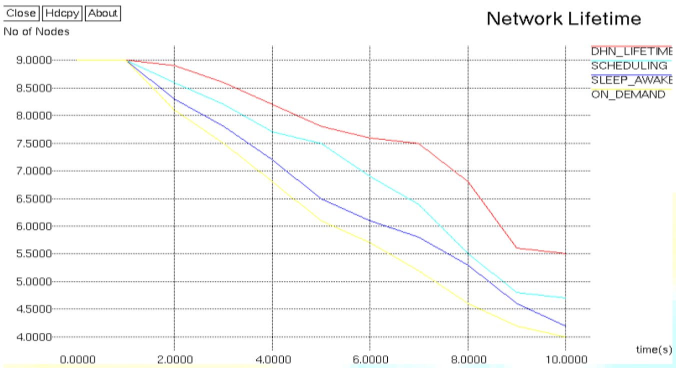

Fig 3.3 Network Lifetime

Figure 3.3 shows the network life time of the heterogeneous network. The network lifetime purely depends on the residual energy and lifetime of total number nodes present in the network. As the data transmission increases with time, the residual energy of the sensor node keeps on decreasing with time. Thus the node dies with time in a homogenous network. Since we considers heterogeneous network having supernodes, the long distance data transmission is carried by neighboring supernode and saving the residual energy of the sensor node for further data transmission. This increases the overall network lifetime of the wireless sensor network when compare to other algorithms like Scheduling algorithm, Sleep awake algorithm and on demand algorithm.

IV. CONCLUSION

Due to dynamic nature of the network topology and resource limitations, designing an efficient routing protocol for WSN is a challenging task. Multipath routing can provide reliable communication in WSN. The intention of this research has been to find as many disjoint paths as possible that are most reliable in a heterogeneous network. In the proposed algorithm, disjoint multipath fault tolerant algorithm has been used to find the most reliable path set that are fault tolerant to node failures or link breakage. The algorithm provides improved throughput in data transfer for a prolonged network lifetime and also it reduces overall delay in the network which makes it better communication protocol for long distance communication.

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