Energy Saving Multipath Traffic Aware routing For Wireless Sensor Networks

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Abstract- *Wireless sensor networks have many characteristics such as limited energy resources, low bandwidth and unreliable links. Due to these characteristics there are many challenges in the design of sensor networks. Routing in WSN is very challenging task. Multipath establishes several paths for data transmission quite than single path. Due to this data delivery is high with low traffic rate. In this paper, propose new energy saving multipath traffic aware routing algorithm (ESMTR). The proposed system routing based on ESMTR make use of load balancing and traffic ware routing in multipath transfer the data. ESMTR calculates link strength to discover its next best hop. To achieve high delivery ratio with low energy consumption, data is forwarded along a multiple path to save energy, and a high data delivery ratio is achieved in this simulation results shows that the proposed protocol is more energy saving than previous protocol in providing efficient resource utilization. Our preliminary simulation results show that ESMTR algorithm results in good overall performance, saving energy and transferring data efficiently.*

Keywords- Traffic aware routing, Statistical Traffic Pattern Discovery System for MANETs (STARS), energy saving multipath traffic aware routing algorithm (ESMTR), Dynamic, Topology

I. INTRODUCTION

Wireless sensor network consists of various smarttiny devices called sensor nodes and these nodes monitor the environment by measuring parameters such as temperature, pressure humidity that are used in target tracking, healthcare services etc. Sensor nodes sense target area and transmit their collected information to the sink node. Resource limitations of the sensor nodes, unreliability of low-power wireless links in combination with various performance demands of different applications impose many challenges in designing efficient communication protocols for wireless sensor networks. The main aim is to discover ways for route setup and reliable relaying of data from the sensor nodes to the sink to increase the network lifetime. Numerous routing protocols have been proposed by researchers to improve performance of many applications.

In single-path routing, for each data packet, there is only one copy travelling along one path in the network. While in multi-path routing, multiple copies of one packet are transmitted in parallel along different paths to the same destination. Existing major routing protocols for wireless sensor networks include LEACH [1], Directed Diffusion [2], Energy Aware Routing [3], Rumor [4], Braided [5], and MESH etc.

Braided builds multiple paths for a data delivery, but only one of them is used, while others are maintained as backup paths. Directed Diffusion can be single-pathor multi-path routing depending on how many paths are reinforced by sink node. Energy aware routing and Rumor routing are single-path ones. Generally, single path routing is simple and consumes less energy than multi- path routing. However, a single path failure will cause a break of transmission and hence completely destroy the delivery. Consequently, more and more researchers are resorting to multi-path routing for delivery success. For instance, sending the same data packet along two fully node-disjointed paths (if they exist) almost doubles the delivery ratio. Using n-fully node-disjointed paths (n>2) can further increase the delivery ratio in approximate proportion to n. Moreover, if we relax the requirement for disjointed-ness, partial or interwoven multi-path routing schemes have shown higher resilience to single path failure theoretically and experimentally [6]. However, determining the width of multi-path routing (for instance, the value of n in n-fully node-disjointed paths) before transmission is not so easy, because sensor network topologies often change unpredictably due to sudden node malfunction, environmental physical damage and impulsive strong external interference. Large 'n' values can ensure success of deliveries, but may cause unnecessary energy waste. In contrast, a small 'n' value saves energy, but may not guarantee the highly demanded delivery ratio. Another disadvantage of a large 'n' value is that: the larger the 'n' value is, the more traffic is generated for one data packet delivery, which may cause network congestion. Given that the simplest CSMA scheme is used at the MAC layer, more traffic means alonger back off delay waiting for transmission and more collisions induced in the wireless channel. Unless the source nodes are notified of path quality in a certain way, it is impossible to adjust the optimal k value dynamically to adapt to unpredictable network topology changes.

II. RELATEDWORK

Multipath routing or so-called “traffic distribution” is an active field of research on QoS-aware routing protocols for wired and wireless networks. In recent years, this method has also been used as an effective approach to provide QoS in wireless ad hoc and sensor networks.

The existing multipath routing protocol based on AOMDV [7]. The main objectives of this protocol are to improve energy efficiency and reduce end-to-end latency through load balancing and using cross-layer information. In order to reduce the end-to-end latency of data forwarding, each node utilizes the information provided by the MAC layer to transmit its packets to the neighboring node that wakes up earlier. Since the nodes are aware of their neighbors’ schedules, per-hop latency is reduced and the interference problem is addressed at the MAC layer. Nevertheless, the MAC protocol requires the frequent exchange of control packets to update neighbors’ schedules. Moreover, this protocol has the main disadvantage of ad hoc-based routing protocols: the whole path information should be propagated throughout the network.

In contrast to the methods that use data redundancy (either through packet replication or through coding), the protocol proposed in this paper uses the estimated link quality metric to reduce data transmission overhead and improve end-to-end reliability. Furthermore, the existing approaches rely on specific hardware or a network conflict graph to cope with the inter-path interference problem while the proposed approach uses the broadcast nature of the wireless medium to estimate inter-path interference and establish interference minimized paths in a localized manner. Finally, since the existing protocols mainly utilize the node residual battery life to determine the optimal traffic rate of the paths, they do not account for the effects of wireless interference on the capacity of individual paths. Through including the experienced interference level in the load balancing algorithm, we consider the 4) Source node use multipath routing schemes to distribute the traffic.

This chapter explains the concept of proposed Energy Efficient Routing protocol with a Guaranteed Delivery with an example.

Here assume that N identical nodes are randomly distributed in the sensing environment. Each sensor node is assigned a unique ID. Each sensor nodes have same battery power. Furthermore, we assume that each sensor node is able to compute its residual energy, and its available buffer size, as well as calculate signal-to-noise ratio (SNR) between itself and neighboring nodes.

The proposed multipath routing protocol is composed of three phases: (1) initialization phase, (2) route discovery and establishment phase, and (3) route maintenance phase. In the initialization phase, each node acquires its neighborhood information. This information will be used in the route discovery and establishment phase to find the best next-hop node towards the sink. The route discovery and establishment phase is triggered whenever an event is detected.

III. PROPOSED MODEL

Certain assumptions are made to design the proposed protocol.

1) All the nodes need not know topology of the network and, synchronization amongst all nodes is not required.
2) Each node is given a node ID and only has the addresses of the nodes that come under its range.
3) WSN consists of several sensor nodes deployed randomly in a region with a singles ink.

The outcome of this phase is multiple interference-minimized paths between the source and sink. Finally, the route maintenance phase handles path failures during data transmission. The rest of this section provides the detailed operations of each phase.

3.1 Network Model

A Wireless Sensor Network consisting of N nodes is generated by random placement of the nodes within the given area. Each of these nodes has the fixed communication range and has fixed buffer and energy availability. All the nodes are static. Fixed sink is placed at one of the corners of the network. All the sensor nodes are aware of the sink position and the distance between itself and the sink. Multi-hop routing is considered.

3.2 Initialization Model

In the initialization phase, each node obtains its neighborhood information, which also includes the ETX cost of its neighbors towards the sink. The ETX value of a link indicates the required number of transmissions for successful packet reception at the receiver. The ETX value of a link is defined as follows:

Where p and q are the probabilities of forward and backward packet reception over that link, respectively. Thus, ETX is affected by the link loss ratio, the difference between forward and backward reception rates, and the interference level of successive links (i.e., intra-path interference).

When a node receives a cost included packet, it records the retrieved cost as the accumulated ETX cost (i.e., accETX) of the respective neighboring node. For example, when node i receives a broadcast packet from node j, it saves the cost included in this packet as the accumulated ETX cost of node j to the sink. Then, node i calculates its own accumulated ETX value to the sink node asfollows:

Node i should broadcast the newly calculated accumulated ETX cost if it is lower than the current cost of node i towards the sink. In fact, whenever a node receives a broadcast packet from one of its neighbors, it should calculate its accumulated ETX cost through that node and broadcast that value if it is lower than its current ETX cost towards the sink

3.3 Route discovery and establishment Model

The source node starts the route discovery by transmitting a route request packet (Route_request) towards the sink node. Whenever a node receives a Route_request packet, it computes the transmission cost for the neighboring nodes which are not included in any path from the current source to the sink. This limitation avoids nodes being shared on different paths for the same source node. Then, it forwards the Route_request packet to the neighboring node with minimum cost. Node i computes the transmission cost through node j asfollows:

In Eq. (3), $accETX_j$ is the ETX cost of node j to the sink, which is contained in the neighborhood table of node i. $p_{i,j}$ and $q_{i,j}$ are the forward and backward packet reception rates between node i and node j, respectively. $resBatt_j$ is the remaining battery level of node j expressed in percentage. Interference $Level_j$ is the maximum interference level that node j has experienced.

3.4 Route maintenance Model

Since in event-driven applications data packets should be transmitted after event detection, the period of data transmission and, therefore the chance of node failure is lower than that of monitoring applications in which there is frequent data transmission from all the nodes to the sink. However, due to the dynamics of wireless networks, the potential effects of link failure should be considered. According to the packet transmission mechanism at the data link layer, if a node on an active path does not receive the ACK packet from the next hop node after k efforts, it notifies the network layer about the link failure. Assuming at least two efforts for a perfect link (i.e., pi,j=1), k can be calculated using the geometric distribution:

After link failure detection, an error message will be transmitted to the source node through the reverse path. Upon reception of this message at the source node, it disables the path from which this message has been received and redistributes traffic over the remaining paths. Furthermore, to prevent performance degradation, the source node initiates a new route discovery and establishment process.

IV. ENERGY SAVING MULTIPATH TRAFFIC AWAREROUTING

Algorithm Implementation

The proposed system to use non-linear prediction model to predict the WSNs traffic. Non-linear prediction model mainly includes SNR model. SNR model can effectively improve prediction accuracy of the network traffic But this model has some fatal deficiencies, such as slow convergence and only getting local sub-optimal solution. The prediction models, namely wavelet neural network (ESMTR), shows better performance in training and adaptation efficiency than other neural networks, and it is easy to determine its structure and avoid to settling in local minimum. The propose a load balancing algorithm for better utilization of each route resources. After discovering multiple paths, source node begins to transmit data message to sink node. Source node then removes the error route and selects the next best available paths from the routing table and resumes the transmission process. If all the routes contained in the routing table are failed then source broad cast are quest message for the sink to initiate a route discovery message. This technique improves the message delivery and improves resource utilization that always finds a way to deliver the data to the sink.

The message to be transferred is split into segments (S1, S2, and S3...SN-1) and some error control bits are added to the original message. These segmented messages are sent out across the k best available paths. While performing all above operations, Route_reply packet is send to update strength of each node and hence total node strength of each path. This information is used to compare total strength of path used in subset of k with total strength of path available in N. If there is a change to their last broadcast value then path having low cost value in subset of k will be replaced with path available in N. A similar operation is applied according to the residual battery and node strength values whenever they are changed more than 10% compared to their last broadcast values.

For the purpose of routing, intermediate nodes are selected by comparing their energy level with threshold energy, if the node has maximum energy it is selected for routing. For routing, each node will have the addresses and distances of the sink and their neighboring nodes. Packets are marked by their originators with their destinations locations. As a result, a forwarding node can make a locally optimal, greedy choice in choosing a packet's next hop. Specifically, if a node knows its radio neighbor's positions, the locally optimal choice of next hop is the neighbor geographically closest to the packet's destination. Forwarding in this regime follows successively closer geographic hops, until the destination is reached.

Algorithm 1 Algorithm to process the HELLO message

1: Set tabH: hash table of messages, tabN: table of neighbors, tabS: table of sinks
2: Input seq : message sequence, sID : sender ID, sT : sender type, h : hop count, fwdID : forward node ID, fwdE : forward nodeenergy
3: IF (seq, sID) exists in tabH 4: RETURN
5: IF fwdID exists in tabN
6: update the entry (fwdID, fwdE) in tabN 7: ELSE
8: create new entry (fwdID, fwdE) in tabN 9: IF (sT == SINK)
10: IF (sID exists in tabS) 11: IF (h <tabS.sID.h) 12: tabS.sID.h = h
13: ELSE
14: create new entry(sID, h) in tabS
15: h = h + 1; fwdID = current node ID;
16: fwdE = current node normalized energy level
17: broadcast HELLO message to the neighbors
18: RETURN

Algorithm 2 Algorithm to process the REQUEST message by a regular intermediate node

1: Set tabN: table of neighbors, tabR: routing table, nodeS: neighboring node selected as the next hop, minLP: the minimum link cost
2: Input seq : message sequence, srcID : source ID, skID : sink ID, p : path cost, rID : route ID, fwdID : forward node ID, fwdE : forward node energy
3: Initialize minLP = 0xFFFF, nodeS = NULL 4: IF (srcID, skID) does not exist in tabR
5: create new entry (srcID, skID) in tabR 6: IF (skID exists in tabN)
7: update tabR with (srcID, skID, rID) 8: nodeS = skID
9: ELSE
10: WHILE (not reach the end of tabN)
11: IF (the neighbor node x has not been selected for the path that connects srcID and skID)
12: LP = link cost to the neighbor node x 13: IF (LP <minLP)
14: nodeS = x 15: minLP = LP
16: ELSE
17: point to the next neighboring node in tabN 18: IF (nodeS != NULL)
19: fwdID = current node ID;
20: fwdE = current node normalized energy level 21: p = p + minLP
22: send REQUEST message to nodeS
23: update the entry (fwdID, fwdE) in tabN
24: RETURN
Experimental Result

V. PERFORMANCE EVALUATIONS

We used NS2 [19] to implement our routing protocol and compare it with STARS (Statistical Traffic Pattern Discovery System for MANETs). A two dimensional square area is used for node deployment. The network consists of Common sensor node, access point and sink node. Nodes are randomly deployed in area. No of common sensor nodes sense the data from temperature and carbon monoxide application data generator. Source node sends the request message to the neighboring nodes to discover multiple paths. Total node strength of each pathis calculated and data transfers take place.The disseminating time, takes transmission power, receiving power, initial energy of various types of node in network is same. The main experiment parameters are Number of Nodes, Topology size, Initial energy, Sending power, receiving power, packet size. Parameters like Number of Nodes can vary at the time of implementation and different scenarios can be studied and compared to get the optimized results.

Table 1.1 Simulation parameters

Parameter	Value
Area Dimension	500*500 meters
Number Of Nodes	10-50
Simulation Time	3 , 6 & 9 Minute
Initial Battery Power	100 jole
Transmission Range	25m
MAC layer	IEEE 802.11
Network Simulator	NS2

The first performance metric we would like to measure is the Packet Delivery Ratio(PDR). It is calculated using the formula:

PDR= (Total Number of Received Packet / Total Number of Sent Packet) * 100

The second performance metric we would like to measure is the packet transmission Delay . It is calculated using the formula:

Delay= (Packet Received Time- Packet Sent Time)

Table 1.2 Packet Delivery Ratio

Protocols	No of Nodes						
	20	30	40	50	60	70	80
STARTS	50	53	61	70	73	71	69
ESMTR	62	67	85	83	81	84	85

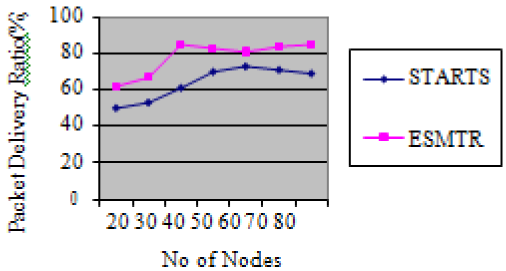

Fig 1.1 shows packet delivery ratio against the number of nodes. It shows that the improved proposed protocol has a better throughput in the TTL time range of 20 to 80 nodes (above 20%).

Table 1.2 Compare Throughputs

Protocols	No of Nodes						
	20	30	40	50	60	70	80
STARTS	4.1	4.2	3.8	4.1	4.8	5.2	6.7
ESMTR	4.8	4.5	3.86	4.7	5.3	6.6	7.4

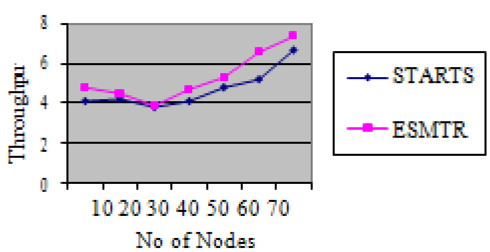

Fig. 1.2 show throughput against the number of nodes. It shows that when the number of nodes is 40, the improved Proposed has fewer throughputs than regular Existing.

Table 1.3 Ends to End delays

Protocols	No ofNodes						
	20	30	40	50	60	70	80
STARTS	4.8	4.2	3.9	3.5	2.7	2.3	2.0
ESMTR	4.3	3.6	3.1	2.7	2.1	1.8	1.2

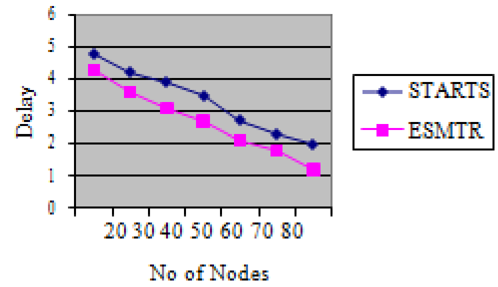

Fig. 1.3 show delay against the number of nodes. It shows that when the number of nodes low it take more delay time. The proposed has lower delay value compared to existing.

VI. CONCLUSION

In this paper, we proposed an energy saving multipath traffic aware routing algorithm (ESMTR) to improve data delivery ratio and decreases delay. ESMTR discovers multipath for transmission of data from source to sink. We have also used load balancing algorithm that make effective use of resources and node strength is used as routing metric. Through computer simulation, we have evaluated and studied the performance of our routing protocol and compared it with STARS protocol. Simulation results have shown that our protocol achieves more energy savings, lower average delay and higher data delivery ratio than STARS protocol.

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