Path Stability based Load balancing in Wireless Sensor Networks

M. Sivakumar[1], J. Divakaran[2]
[1, 2] Department of ECE
[1, 2] Karpagam College of Engineering, Coimbatore.

Abstract- *Energy efficiency is a major issue in Wireless Sensor Networks. Due to path failure, sensor nodes consume high energy. So, the performance of the networks is totally degraded. To overcome this issue, we proposed New Adaptive Reporting Protocol (NARP). It attains both throughput and network connectivity while keeping the nodes moving in dynamic manner. The scheme consists of two phases. In fist phase, we proposed multipath routing to provide load balancing to improve the throughput. The proposed multipath contains the route discovery process and route maintenance process. During route selection, the minimum power consumption route is chosen to set the maximum power efficiency. In second phase, the path stability is determined to improve the network connectivity and reduce the packet losses. Here the sensor nodes are assigned with the constant codewords and different time slots. By using the extensive simulation results using the discrete event simulator, the proposed NARP achieves higher packet delivery ratio, network lifetime, less energy consumption, overhead and delay than the existing scheme GSTEB.*

Keywords:- WSN, NARP, Energy Consumption, Path stability, Scheduling priority, multipath routing, Network lifetime, overhead and end to end delay

I. INTRODUCTION

A. Wireless Sensor Networks

Wireless sensor network (WSN) is a group of sensor nodes (SNs) working in uncontrolled areas and organized into cooperative network. It is composed of huge number of sensor nodes which can monitor the environment by collecting, processing as well as transmitting collected data to the remote sink node through direct or multi hop transmission. WSNs have attracted lots of attention in recent years due to their wide applications such as battlefield surveillance, inventory and wildlife monitoring, smart home and healthcare etc. Each node has processing capability, a radio, sensors, memory and a battery. Since the sensor nodes are usually operated by a limited battery power which may not be replaceable once deployed, it is therefore, vital that the sensor network is energy balanced in order to ensure an extended network lifetime and efficient data gathering.

To minimize the energy consumption, there is a need of path stability in sensor nodes. For that we proposed multipath routing based path stability to make a balance between the network connectivity and energy efficiency.

II. IMPLEMENTATION OF MAS ALGORITHM

In our proposed protocol multipath routing based path stability is used to provide energy optimization. The schemes are explained below.

A. Multipath Routing

Node supports with number of sensor nodes in its neighbourhood without relying on a single node to forward a message. If any failure of message arrival, it can be sent on alternative path or on multipath in parallel. So the impact of isolated failures is reduced. In the proposed scheme, multipath routing has been used mostly for fault tolerance and load balancing, and for failure recovery. The communication between sensor node and its neighbor node happens either through a direct communication path or through at most one neighbor. This guarantees that on any communication path between two nodes, there exist two disjoint authentication paths. The following procedure is for message forwarding in multipath routing. Consider a message travelling a path A_0; $A_{1,}$ A2…….A_k is authenticated twice before it is forwarded. A_0 creates Message Authentication Code (MAC) intended for nodes A_1 and A_2. A_0 can only reach A_1 directly and relies on S1 to transmit the MAC intended for S2. Before S1 forwards the message, it creates two new authentication codes itself for A_2 and A_3. It is continued until the message reaches its final destination. Before a node forwards a message, it checks the authentication codes from the two preceding nodes.

The main aim of proposed scheme is to discover the minimum power-limitation route. The power limitation of a route is decided by the node which has the minimum energy in that route. So compared with the minimum node energy in any other route, the minimum node energy in the minimum power-limitation route has more energy. In other words, the value of that node's energy is the maximum of all minimum node energy in all selectable routes.

In routing Process of proposed adapting reporting protocol, The following assumptions are made:

1. A node can find the value of its current energy.
2. Links are bidirectional.

III. NARP PROTOCOL

A. Route Discovery

In NARP, nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges.

Step1:

When the source node wants to send a message to the destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node. The source node disseminates a route request (RREQ) to its neighbors. The RREQ includes such information as destination Internet ID, power boundary (the minimum energy of all nodes in the current found route), destination sequence number, hop count, lifetime, Message Authentication Code (MAC) is for providing certificate authority to the nodes and Cyclic Redundancy Code (CRC) for error detection and correction. The destination sequence number field in the RREQ message is the last-known destination sequence number for this destination and is copied from the destination sequence number field in the routing table. If no sequence number is known, the unknown sequence number flag must be set. The power boundary is equal to the source's energy. The hop count field is set to zero. When the neighbor node receives the packet, it will forward the packet if it matches.

Step 2:

When a node receives the RREQ from its neighbors, it first increases the hop count value in the RREQ by one, to account for the new hop through the intermediate node. The creator sequence number contained in the RREQ must be compared to the corresponding destination sequence number in the route table entry. If the creator sequence number of the RREQ is not less than the existing value, the node compares the power boundary contained in the RREQ to its current energy to get the minimum. If the creator sequence number contained in the RREQ is greater than the existing value in its route table, the relay node creates a new entry with the sequence number of the RREQ If the creator sequence number contained in the RREQ is equal to the existing value in its route table, the power boundary of the RREQ must be compared to the corresponding power boundary in the route table entry. If the power boundary contained in the RREQ is greater than the power boundary in the route table entry, the node updates the entry with the information contained in the RREQ.

During the process of forwarding the RREQ, intermediate nodes record in their route tables the addresses of neighbors from which the first copy of the broadcast packet was received, so establishing a reserve path. If the same RREQs are later received, these packets are silently discarded.

Step 3:

Once the RREQ has arrived at the destination node or an intermediate node with an active route to the destination, the destination or intermediate node generates a route reply (RREP) packet. If the generating node is an intermediate node, it has an active route to the destination; the destination sequence number in the node's existing route table entry for the destination is not less than the destination sequence number of the RREQ. If the generating node is the destination itself, it must update its own sequence number to the maximum of its current sequence number and the destination sequence number in the RREQ packet immediately. When generating an RREP message, a node smears the destination IP address, creator sequence number, and power boundary from the RREQ message into the corresponding fields in the RREP message.

Step 4:

When a node receives the RREP from its neighbors, it first increases the hop count value in the RREP by one like,
Hop count = Hop count +1

When the RREP reaches the source, the hop count represents the distance, in hops, of the destination node from the source node. The creator sequence number enclosed in the RREP must be compared to the corresponding destination sequence number in the route table entry. If the originator sequence number of the RREP is not less than the existing value, the node compares the power boundary contained in the RREP to its current energy to get the minimum, and then updates the power boundary of the RREP with the minimum. The power boundary field in the route table entry is set to the power boundary contained in the RREP.

B. Route Maintenance

A node uses a Hello message, which is a periodic local broadcast by a node to inform each sensor node in its neighbourhood to maintain the local connectivity. A node should use Hello messages if it is part of an active route. If, within the past delete period, it has received a Hello message from a neighbor and then does not receive any packets from that neighbor for more than allowed-Hello-loss Hello-interval milliseconds, the node should assume that the link to this neighbor is currently lost. The node should send a route error (RERR) message to all precursors indicating which link is failed. Then the source initiates another route search process to find a new path to the destination or start the local repair.

C. Proposed packet format

Source ID	Destination ID	Scheduling Status	Network Connectivity Status	Energy Conservation Ratio	CRC
2	2	4	4	4	2

Figure 1.Proposed Packet format

In fig 1. the proposed packet format is shown. Here the source and destination node ID carries 2 bytes. Third one is scheduling status of the node. The scheduling status induces the whether the transmission of packets are travelled with highest link priority and least hop distance. In fourth field, the network connectivity status is indicated. It determines how much of the connection status between various clusters with the current cluster. It also determines whether packet is assigned with correct time slot. In fifth, the energy conservation ratio is allotted to ensure minimum energy consumption. The last filed CRC i.e. Cyclic Redundancy Check which is for error correction and detection in the packet while transmission and reception.

IV. PERFORMANCE ANALYSIS

We use Network Simulator (NS 2.34) to simulate our proposed NSEES algorithm. Network Simulator-2(NS2.34) is used in this work for simulation.NS2 is one of the best simulation tools available for Wireless sensor Networks. We can easily implement the designed protocols either by using the oTCL (Tool command Language) coding or by writing the C++ Program. In either way, the tool helps to prove our theory analytically.

In our simulation, 200 sensor nodes move in a 1300 meter x 1300 meter square region for 60 seconds simulation time. All nodes have the same transmission range of 500 meters. Our simulation settings and parameters are summarized in table 2.

A. Performance Metrics

We evaluate mainly the performance according to the following metrics.

End-to-end delay: The end-to-end-delay is averaged over all surviving data packets from the sources to the destinations.

Packet Delivery Ratio: It is defined as the ratio of packet received with respect to the packet sent.

Throughput: It is defined as the number of packets received at a particular point of time.

The simulation results are presented. We compare our proposed algorithm MAS with existing schemes like GSTEB [15] and our previously proposed scheme NARP achieves better performance in the presence of energy consumption.

Table1. Simulation settings and parameters of proposed algorithm.

No. of Nodes	200
Area Size	1200 X 1200
Mac	802.11
Radio Range	500m
Simulation Time	60 sec
Traffic Source	CBR
Packet Size	512 bytes
Mobility Model	Random Way Point
Protocol	LEACH

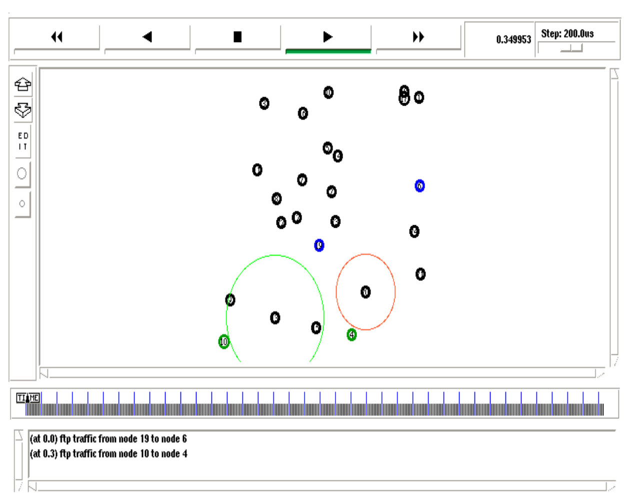

Figure 2. Topology of the proposed scheme

Figure 2 shows that the proposed scheme topology for ensuring the multipath routing. Source node sends the packet to destination node via intermediate nodes. In case if the node failure occurs, the node choose the alternative path to reach correct delivery of packets.

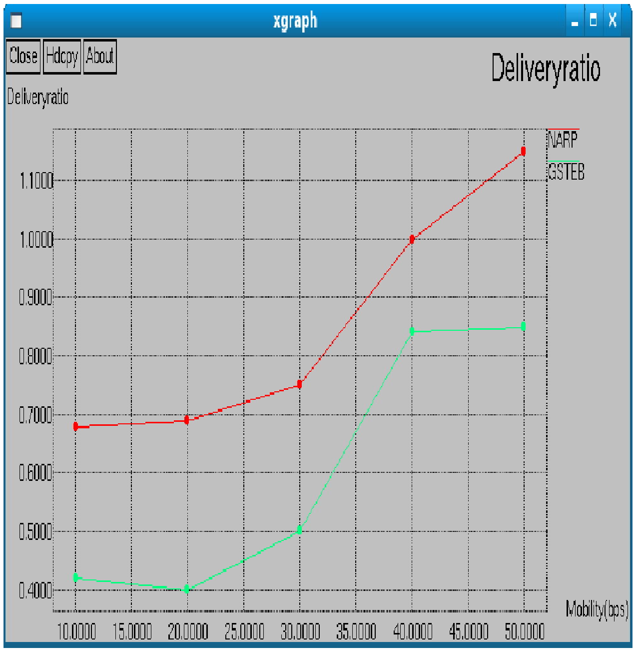

Figure 3. Mobility Vs Delivery Ratio

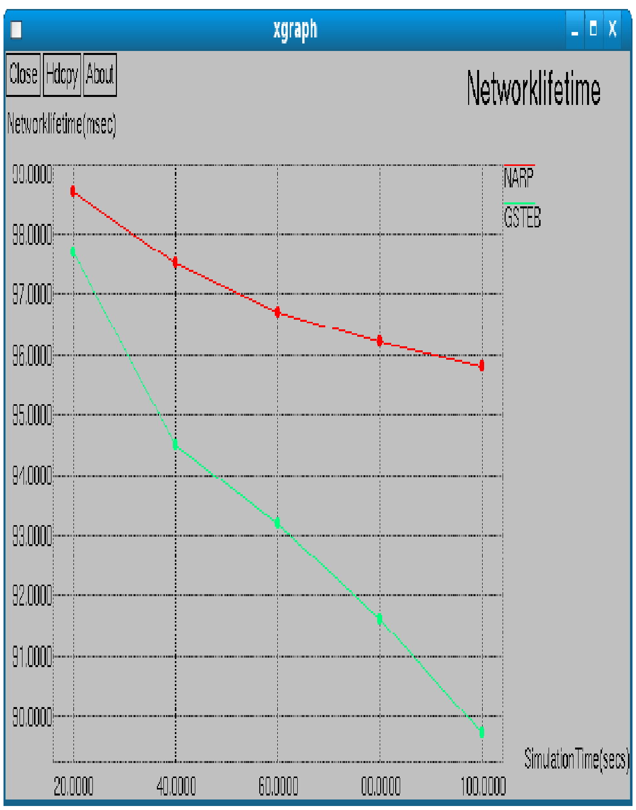

Figure 4. Simulation time Vs Network Lifetime

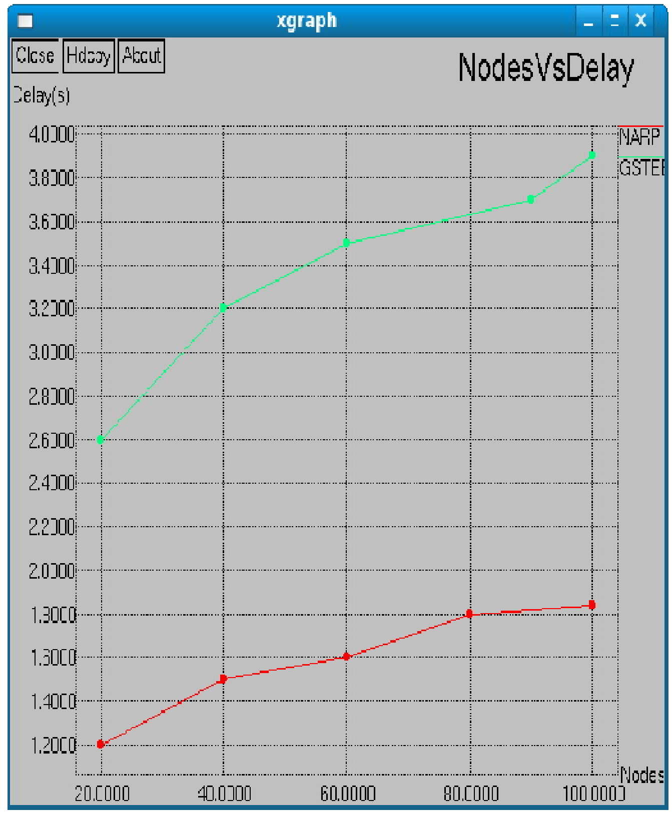

Figure 5. No.of Nodes Vs Delay

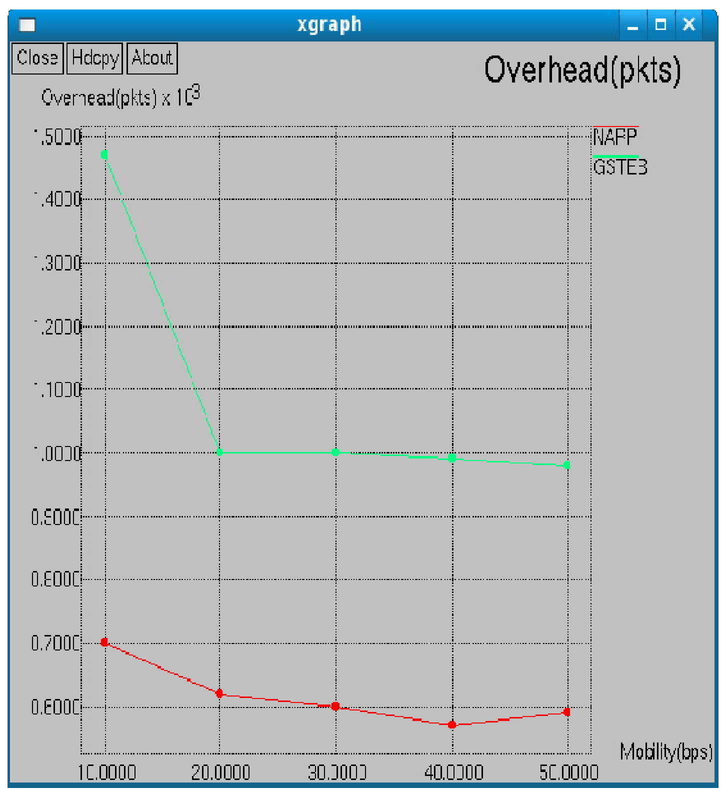

Figure 6. Mobility Vs Overhead

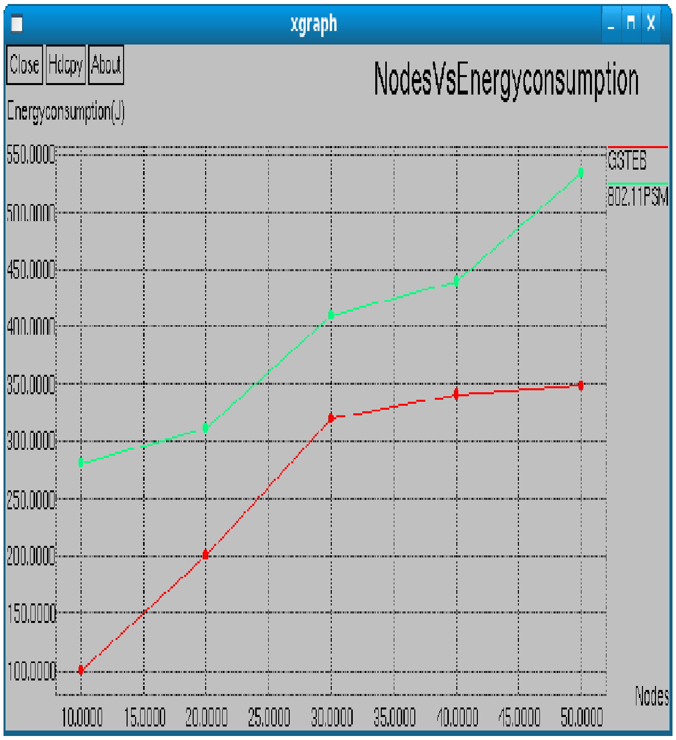

Figure 7. No.of Nodes Vs Energy Consumption

From figure 3 to figure 7 it shows that the Network Connectivity, Packet Delivery Ratio, Network lifetime, End to end delay, overhead and energy consumption of NARP are better compared to the previous scheme GSTEB. The proposed scheme NARP achieves high network connectivity ratio, delivery ratio, network lifetime, low end to end delay, low overhead and low energy consumption while varying the number of nodes, simulation time, mobility.

V. CONCLUSION

In WSNs, the nodes are totally distributed in a random manner. The control may be issued by base station or without any base station. Here we focus on to improve the path stability model to avoid the packet drop and to improve energy efficiency. So we propose NARP protocol to provide the multipath routing based scheduling to maximize the network connectivity ratio and throughput. In first phase multipath routing is proposed. Here the load balancing is well improved. In second phase, path stability model is proposed to avoid packet drops. Each packet attains the time slots which are sent through the highest link scheduling priority. The scheduling status, connectivity status and energy conservation ratio is verified using our proposed scheme. By using NS2, a discrete event simulator, our scheme achieves high connectivity ratio and delivery ratio, low overhead, low end to end delay and minimum energy consumption while varying the time, throughput, number of nodes and mobility than the existing scheme NARP.

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