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Location Based Energy Efficient Routing for Wireless Sensor Network

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***Abstract*— *In Wireless Sensor Networks, sensed data are reported to the sink by the available nodes in the communication range. The sensed data should be reported to the sink with the frequency expected by the sink. In order to have a communication between source and sink, the proposed energy efficient routing is called as Greedy Location based Cluster Mechanism. Initially nodes are deployed in random manner. Then clusters are formed based on the location of nodes. Cluster head is elected among the candidate nodes. Cluster head is elected based on transmit power. After selecting the cluster head, the data needs to be forwarded to the sink.*

Usually gateway nodes are used to forward the data. Cluster head and gateway nodes consume more energy than the normal nodes. Instead of using gateway nodes to forward the data, GLCM (Greedy Location based Cluster Mechanism) can be used. GLCM considers the location of source and destination nodes. Instead of broadcasting the data, it chooses one hop delivery method by considering the transmission power to reach the destination. Nodes present in the direction of destination will be chosen as the intermediate nodes. Thus the data is forwarded without the presence of gateway node. Hence the energy consumption can be saved which increases the network lifetime. Performance metrics such as delay, Throughput, Packet Delivery Ratio, Energy Consumption are chosen for evaluating efficiency of the proposed GLCM. Simulations are carried out using Mat lab tool. It is evident that the proposed GLCM achieves better performance when compared with energy aware distributed unequal clustering protocol (EADUC).

***Keywords*— *Sensor network, Cluster, Gateway*.

I. INTRODUCTION

Over the years, numerous approaches for routing have been successfully devised. As stated before, they simply send the packet to source and destination. Clustering techniques have been widely applied to real time applications. Their applicability in further improving the quality of network seems to have reached a saturation point. It can no longer handle the increasing complexities posed by clustering techniques and routing mechanisms. Recently, researchers have illustrated the potential for applying routing algorithm approaches to improve the quality of network.

From few years, interest in wireless sensor networks has been in potential use for many applications like border security surveillance, disaster management, field of health and objection detection in remote areas. Sensors are deployed in wide area to operate autonomously for long time in unattended environment. Sensors are equipped with low memory and limited battery power. The main job of wireless sensor nodes is to sense, gather and transmit the data to the center location. This requires the efficient routing paths to be set up between the sink and the sensor nodes which can be satisfied by various routing protocols. Industrialists, Individuals, researchers and students are trying to develop the efficient routing protocols in terms of various qualities of service metrics. To develop the routing protocols, it is necessary to understand the basics of WSN.

II. PROPOSED GREEDY LOCATION BASED CLUSTER MECHANISM

It analyzes various clustering algorithms available and find the energy efficient routing for wireless sensor networks. Cluster head and gateway nodes consume more energy than the normal nodes. Instead of using gateway nodes to forward the data, GLCM (Greedy Location based Cluster Mechanism) can be used. GLCM considers the location of source and destination nodes. Instead of broadcasting the data, it chooses one hop delivery method by considering the transmission power to reach the destination. Nodes present in the direction of destination will be chosen as the intermediate nodes. Thus the data is forwarded without the presence of gateway node. Hence the energy consumption can be saved which increases the network lifetime. Performance metrics such as delay, Throughput, Packet Delivery Ratio, Energy Consumption are chosen for evaluating efficiency of the proposed GLCM. Simulations are carried out using Mat lab tool. It is evident that the proposed GLCM achieves better performance when compared with energy aware distributed unequal clustering protocol (EADUC).

The proposed energy efficient routing is called as Greedy Location based Cluster Mechanism which is depicted in the figure 1. Initially nodes are deployed in random manner. Then clusters are formed based on the location of nodes. Cluster head is elected among the candidate nodes. Cluster head is elected based on transmit power. After selecting the cluster head, the data needs to be forwarded to the sink.

Usually gateway nodes are used to forward the data. Cluster head and gateway nodes consume more energy than the normal nodes. Instead of using gateway nodes to forward the data, GLCM (Greedy Location based Cluster Mechanism) can be used. GLCM considers the location of source and destination nodes. Instead of broadcasting the data, it chooses one hop delivery method by considering the transmission power to reach the destination i.e sink. Nodes present in the direction of destination will be chosen as the intermediate nodes. Thus the data is forwarded without the presence of gateway node. Hence the energy can be saved.

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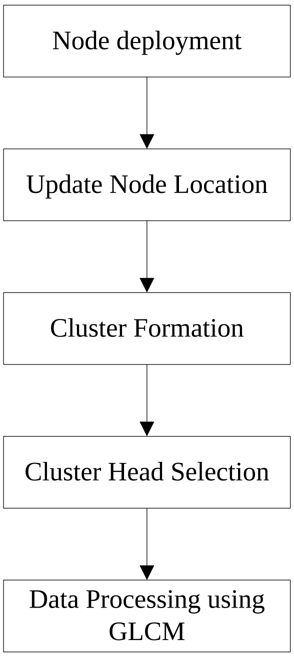

Fig. 1. Architectural diagram for the GLCM.

The pseudo code for the GLCM algorithm is as follows,

if current state of receiver(ST_i^{cur}) is IN
    assign the ID of sender(S_j) to the ID of receiver(S_i)
  if the current state of sender(ST_j^{cur}) is CH
        assign GLCM to ST_i^{cur}
    call Procedure Contention(PC)
    else if ST_j^{cur} = GLCM
            assign CH to ST_i^{cur}
            call PC
else if ST_i^{cur} = OD
    if (ST_j^{cur}=CH) and (ID(i) $\neq$ ID(j))
        assign GLCM to ST_i^{cur}
        call PC
    else
        assign ST_i^{cur} to ST_i^{new}
else assign ST_i^{cur} to ST_i^{new}

Initially all the nodes are in IN state. When an IN node receives messages from either a cluster head node or a gateway node, it changes its cluster identifier as that of the sender, because this IN node and the sender belong to the same cluster. If the sender is a CH node, the IN node then transits its state to GLCM. Otherwise, if the sender is a node, the IN node then transits its state to cluster head candidate (CH). Meanwhile, the IN node enters the contention procedure to calculate its priority and determine its ultimate state.

Nodes which enter CH state during cluster state transition calculates the predicted transmission count (PTX). According to the definition of the PTX, a candidate derives a larger PTX value if it connects to nodes with a higher quality or supports more transmission counts. A cluster head candidate (CH node) calculate the priority using the predicted transmission count, qi depend up on the Greedy Perimeter stateless methods.

The PTX represents the capability of a candidate for persistent transmission to a neighboring node. Because the channel condition of wireless links varies with time, the link reliability often depends on the channel condition. If a node is associated with an unreliable link, data delivery is likely to fail, thereby leading to packet retransmissions. Thus the candidate associated with a stable link is preferred to be selected as a cluster head node.

When a node s_i, receives report message from node s_j , it can derive the PTX, q_{ij}. The q_{ij} is calculated based on the Eq. (1).

$$q_{ij} = \frac{E_i^{res}}{ETX_{ij} . E^{tx}(k, d_{ij})} \tag{1}$$

where E_i^{res} is the residual energy of node s_i . d_{ij} is the distance between nodes s_i and s_j. $E^{tx}(k,d_{ij})$ is the energy consumption for s_i to transmit k-bit message over a distance d_{ij} . Greedy based link Routing mechanism uses the ETX to measure the expected bi-directional transmission count of a link. It is calculated based on the Eq. (2). Let ETX_{ij} be the ETX of the link between s_i and s_j , e_{ij}

$$ETX_{ij} = \frac{1}{p_{ij}^f . p_{ij}^r} \tag{2}$$

where p_{ij}^f and p_{ij}^f denote the forward and reverse delivery ratios from node s_i to node s_j , respectively. The forward delivery ratio is the measured probability that indicates that a data packet successfully arrives at the recipient. The reverse delivery ratio is the probability that indicates that the acknowledgment packet is successfully received. Each node in the Greedy based Link Routing periodically broadcasts a message to obtain the distance (d_{ij}), forward delivery ratio, and reverse delivery ratio of its neighbors, thereby making it possible to determine the ETX.

Transmitter dissipates energy to run the radio electronics and power amplifier. Let $E^{tx}_{elec}(k)$ and $E^{tx}_{amp}(k,d_{ij}^n)$ denote the energy consumption of the radio electronics and power amplifier, respectively, to transmit a k-bit message over a distance d_{ij} . $E^{tx}(k,d_{ij})$ can be derived from the Eq. (3).

$$E^{tx}\left(k, d_{ij}\right) = E^{tx}_{elec}\left(k\right) + E^{tx}_{amp}(k, d_{ij}^n) \tag{3}$$

The PTX (q_{ij}) derives the priority. The pseudo code for the priority calculation is as follows,

The candidate node with highest priority becomes the clusterhead or gateway. After selecting the cluster head or the gateway, it then forwards the received message.

The highest priority is calculated based on the consumption of less energy level using the greedy based link clustering mechanism.

III. Framework for GLCM

- Node Deployment- 100 nodes are deployed. Node 1 is the base station.
- Cluster Formation-Nodes are grouped into clusters based on its location
- ClusterHead Selection-Clusterhead is selected for each cluster.Node which is selected as a clusterhead should

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possess high energy with less distance to its neighbor nodes.

- Data Transfer-Clusterhead of each cluster collects data from its neighbour nodes and forwards it to the sink.

The proposed GLCM is algorithm is as follows

1. Procedure set up ResM > Exchange information with neighbor
2. ID $_{CH}$ ← ID $_{node}$ >Self forms a singleton cluster
3. Send hello message to one- hop neighbors
4. ………….. > Keep Listening to neighbors
5. Receive HELLO messages
6. Establish Resm
7. End Procedure

IV. Implementation And Results

A. Simulation Setup

This section the parameters that have been manipulated, the metrics that have been used for comparison, and the environment that has been used to make the experiments will be discussed in detail (Table I). In this research work four metrics have been used in order to make the comparisons between the two protocols using Mat lab. These metrics are:

1) Packet Delivery Ratio.
2) Average Delay.
3) Residual Energy
4) Throughput

B. Simulation Parameters

The proposed system is implemented using Mat lab simulation area of 100 X 100m with 100 nodes. Nodes move with the maximum speed of 5m/s. 100 meters of total simulation area were selected. The data packet size is 256 kilobytes. In this scenario, GLCM routing method is selected to check the performance of packet delivery ratio, average delay and residual energy.

C. Result Analysis

1) Delay

The end-to-end delay of a packet is defined as the time a packet takes to travel from the source to the destination. The average end-to-end delay is the average of the end-to-end delays taken over all the received packets Eqn (4) is used to find the end to end delay of the packet.

$$delay = \frac{1}{nbx}\sum_{i\in x}\sum_{i\in y}\frac{delay_j}{nby} \quad (4)$$

x: is the set of destination nodes that received data packets.
nbx: is the number of receiver nodes
y: is the set of packets received by node i as the final destination.

The Fig. 2, shows the graph plotted for End-to-End delay using Greedy Based Link Clustering mechanism for energy efficient routing in wireless sensor networks (GLCM) and improved(EADUC).The graph shows that the End-to-End delay of GLCM is less when compared to the End-to- End delay of EADUC method. The performance delay is analyzed. Simulation clearly proven that the proposed method GLCM consume less delay than the existing EADUC.

TABLE I. Pausetime Vs Delay.

Pause time (in seconds)	Packet Delivery Ratio	
	Improved-EADUC	GLCM
10	0.79	0.86
20	0.78	0.84
30	0.78	0.87
40	0.75	0.85
50	0.78	0.86
60	0.77	0.85
70	0.76	0.84
80	0.77	0.81
90	0.78	0.84
100	0.79	0.86

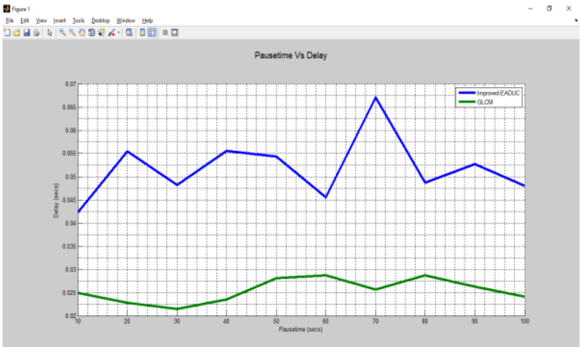

Fig. 2. Pause time Vs Delay.

It is observed that the end-to-end delay in GLCM experiences the highest variation, whereas Improved EADUC shows the least variation. Unlike Improved EADUC, GLCM is not affected by the delay as it is designed to send packets with proper selection of cluster head and router gateway with less power consumption. As shown in Fig. 2, it achieves the lowest delay among Link based Clustering mechanism for energy efficient routing in wireless sensor networks (GLCM).

2) Consumed energy

Consumed energy is used to measures the mean value of the residual energy of all alive sensor nodes when simulation terminates. Sensor nodes have to consume additional battery power to transmit the increased number of report messages. This leads to a reduction of the residual energy of the nodes in the network. As a result, compared with the result of the Improved EADUC, the GLCM achieves a higher residual energy.

TABLE II. Pause time Vs Energy Consumed.

Pause time (in seconds)	Energy Consumed (joules)	
	Improved-EADUC	GLCM
10	0.0881	0.0718
20	0.0886	0.0741
30	0.0872	0.0757
40	0.0871	0.0752
50	0.0854	0.0738
60	0.0855	0.0713
70	0.0852	0.0741
80	0.0881	0.0728
90	0.0889	0.0734
100	0.0880	0.0748

Residual energy is the current energy level of sensor nodes. The residual energy of nodes should always be high to increase the life-time of network. Figure 3 shows that the

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residual energy of nodes in GLCM system is higher than the nodes in the Improved EADUC routing system. Thus the network life-time is increased in the proposed system.

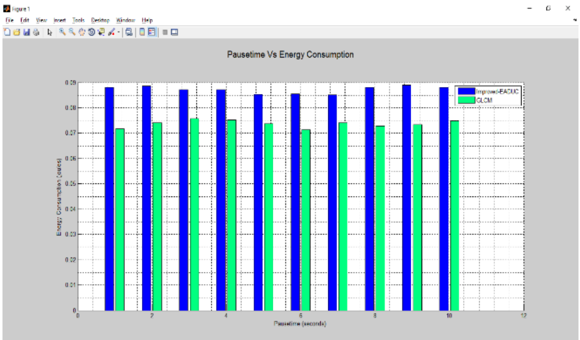

Fig. 3. Pause time Vs Consumed Energy.

GLCM method is reducing the energy utilization and thus saving the power and rising the network lifetime of the network, without disturbing the system capacity.

3) Packet delivery ratio

The packet delivery ratio is the ratio between the numbers of packets received at the destination to the number of packets sent from the source. The greater value of the packet delivery ratio means better performance of the protocol.

Figure 4 illustrates the average packet delivery ratio generated by the proposed Enhanced Greedy Based Link Clustering mechanism for energy efficient routing in wireless sensor networks (GLCM) and the performance is evaluated by Improved-EADUC. The Packet Delivery Ratio (PDR) of GLCM is high when compared to the existing schemes such as Improved-EADUC

The formula for calculating the result analysis percentage is in (eqn 1)

The Fig. 4 shows the graph plotted for packet delivery ratio using Greedy Based Link Clustering mechanism for energy efficient routing in wireless sensor networks (GLCM) and Improved-EADUC. The graph shows that the packet delivery ratio of Greedy Based Link Clustering mechanism (GLCM) is better when compared to the packet delivery ratio of Improved-EADUC. Hence it is concluded that the performance of the packet delivery ratio has increased after implementing the GLCM. The main reason for increase of the packet delivery ratio of GLCM is because Greedy Based Link Clustering mechanism selects the best and efficient cluster head and routing gateway with consume less energy.

In Fig. 4. the packet delivery ratio is measured with varying source-destination distance. The routing method Improved-EADUC experience a decrease in delivery ratio with an increase in the initial source to destination distance. One common factor responsible for selecting the cluster head and routing gateway with consume high energy. As a result, the delivery ratio of GLCM is highest among the Improved-EADUC. However, the update mechanism of the GLCM method enables the source to be connected with the destination through a reliable path. Therefore, the packet delivery ratio of GLCM is maintained high, irrespective of the destination dislocation distance.

TABLE III. Pause time Vs Packet Delivery Ratio.

Pause time (in seconds)	Packet Delivery Ratio	
	Improved-EADUC	GLCM
10	0.79	0.86
20	0.78	0.84
30	0.78	0.87
40	0.75	0.85
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70	0.76	0.84
80	0.77	0.81
90	0.78	0.84
100	0.79	0.86

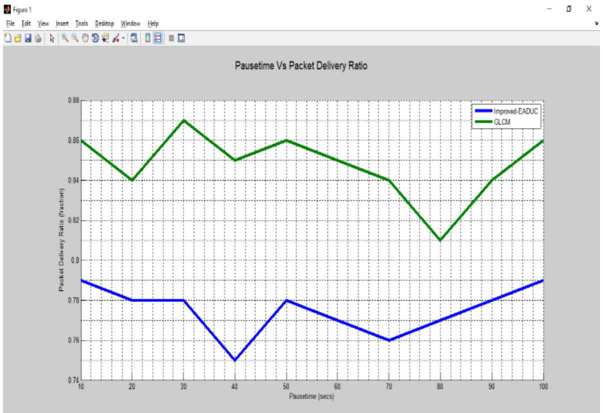

Fig. 4. Packet Delivery ratio curve.

4) Throughput

Throughput is described as the total number of received packets at the destination out of the total packet sent. Throughput is calculated by bytes/sec. if the throughput is high, it means the network performance rate is high because most of the data packets are received successfully at the destination. The throughput of a receiver (per-receiver throughput) is characterized as the proportion of the quantity of bits got over the time contrast between the first and the last got bundles. The normal throughput is the normal of the per-collector throughputs assumed control over every one of the recipients. As in the fig the throughput of GLCM is high when compared to the existing schemes such as Link based routing method. The simulation results show that the GLCM has a better performance than Improved-EADUC especially in throughput.

TABLE IV. Pause time Vs Throughput.

Pause time (in seconds)	Throughput (packets)	
	Improved-EADUC	GLCM
10	101	110
20	200	215
30	300	334
40	384	435
50	499	550
60	591	653
70	681	753
80	788	829
90	899	968
100	1011	1101

S. Jothimani and S. Vydehi, “Location based energy efficient routing for wireless sensor network,” *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 4, pp. 199-203, 2017.

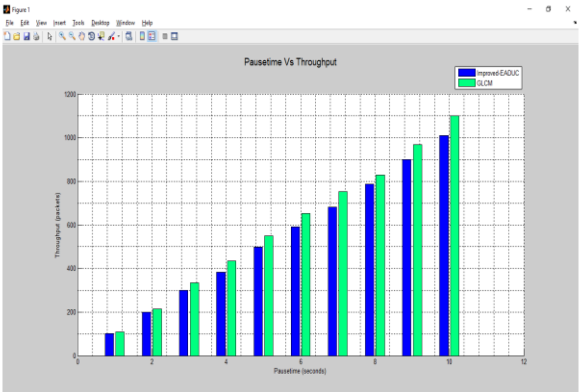

Fig. 5. Throughput.

V. CONCLUSION AND FUTURE WORK

In Wireless Sensor Networks, sensed data are reported to the sink by the available nodes in the communication range. The sensed data should be reported to the sink with the frequency expected by the sink. In order to have a communication between source and sink, the proposed energy efficient routing is called as Greedy Location based Cluster Mechanism. Initially nodes are deployed in random manner. Then clusters are formed based on the location of nodes. Cluster head is elected among the candidate nodes. Cluster head is elected based on transmit power. After selecting the cluster head, the data needs to be forwarded to the sink.

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