Multipath Routing and Data Gathering Scheme for Scalability in Wireless Sensor Networks

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***Abstract*: In Wireless Sensor Networks (WSNs), sensors are organized randomly. Routing in the wireless sensor networks is a demanding assignment. This assignment may lead to a number of routing protocols which effectively use the limited resources available at the sensor nodes. So all the routing protocols will attempt to find the optimal energy path. In order to determine the alternative path quickly, there is need of reduction of energy path and time. Wireless Sensor Networks (WSN) consist of sensor node under the control of base station. Data gathering plays a major role in WSN, whereas network lifetime depends on data collection. In dynamic nature, the nodes are get depleted and it leads to low energy because of data lost. To ensure more data collection rate, effective data collection protocol with stable routing is needed.**

***Keywords*: Data Gathering, Multipath Routing, Wireless Sensor Networks, Energy Consumption, Network Life Time, Residual Energy and Throughput**

I. INTRODUCTION

WSN term can be broadly sensed as devices range from laptops, PDAs or mobile phones to very tiny and simple sensing devices. 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. WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. If WSNs nodes are more powerful or mains-powered devices in the vicinity, it is beneficial to utilize their computation and communication resources for complex algorithms and as gateways to other networks.

II. DESIGN GOALS OF WSN

A. Energy Considerations

During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multihop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi-hop routing becomes unavoidable.

B. Energy Consumption without losing accuracy

Sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on the battery lifetime. In a multihop WSN, each node plays a dual role as data sender and data router. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes and might require rerouting of packets and reorganization of the network.

C. Data Gathering Issus in WSN

A dynamic node can act as neighbor node to deliver packets from sensor node to the base station. The data collector collects the packets from sensor node and pass it to the base station. It causes some delay. Energy consumption is a major issue in WSN. Sensor network consists of sensor node that is deployed in network region. The usage of energy plays major role in WSN and it should be utilized effectively.Balancing the data gathering and energy is a major task in WSN. Multiple sensor node takes more data and it can reduce the energy

D. Challenges of Data Gathering in WSN

Routes are established based on network topology between sensor node and the base station. Without choosing alternative path, the same path can be utilized to pass the data to the base station to save the energy.Many sensor nodes send the data packets to the base station frequently which causes loss of more data, high energy consumption and too delay.

III. PREVIOUS WORK

Kazuhiko Kinoshita etal. [1] discussed the accurate and adaptive energy estimation method. It was not independent of period length. A data gathering scheme was optimized for the environmental energy-based sensor network .
Shanmugam et.al [2] introduced an energy efficient mobile element based data gathering using tinybee. It achieved energy in efficient manner and reduced the latency in data gathering. The dispatch of tinybees by mobile element reduced the tour length of the mobile element. This work was determined based on delay and energy. The work achieved in increasing the network lifetime due to less energy utilized than other algorithms.
Sudhakar and Sangeetha [3] initiated the Delay bounded Sink Mobility (DeSM) problem under sensor node allocation to sinks. A polynomial-time optimal algorithm was used for the origin problem. Extended Sink Scheduling Data Routing (E-SSDR) algorithm was also utilized from allocating schedule to the destination node. A mobile sink scheduling scheme was also enhanced to support large size networks.
Mehala & Balamurugan [4] presented Clustering-based Data aggregation algorithm for Wireless Sensor Networks using two mobile sink, to increase network lifetime and to reduce the transmission distance between each nodes. Based on this method, the sensed data are collected efficiently which minimizes data latency. Wireless sensor networks are used for application oriented tasks.
Roseline & Srinivas [5] proposed secure energy efficient location aware data gathering approach. The properties of node location and energy were used to improve the lifetime of node and network. Elliptic Curve Diffie Hellman Key Exchange was incorporated for securing data gathering between the source and the receiver. The routing was performed based on the neighbor node and the highest energy node selection. The proposed scheme was compared with the existing data gathering scheme without the security measure.
In my previous work [6], a New Multipath Routing Approach is developed which attains energy model, maintenance of optimal energy path, multipath construction phase to make a correct balance between network life time, energy consumption and throughput to the sensor nodes. In the first phase of the scheme, construction of multipath is implemented. In second phase, the optimal energy path is maintained. In third phase, residual energy consumption is increased using energy model. It uses following factors called distance , residual energy, mobility factor, mobility factor and data correlation to favour packet forwarding by maintaining high residual energy consumption for each node.
A New Residual Energy Based Multipath Routing Approach (REMRA) for Wireless Sensor Networks [7] was developed to enhance the energy efficiency and to increase the network life time.
Shilpy Ghai et.al [8] introduced an energy-efficient security protocols to provide strong security and to decrease the energy consumption. The data was compressed and then transmitted it to the other node. With the help of the compression, the energy consumption of the nodes was decreased because fewer amounts of data were spent.
Priyadharshini et.al [9] observed that multiple channel method was helpful in reducing schedule length. The link-based channel assignment schemes had more energy efficient to remove interference. The fundamental limitations due to interference explored techniques reduced the same issue. Once the interference was completely avoided, the achievable schedule length was reduced in the routing tree for aggregated convergecast, and for raw-data convergecast.
Palekar [10] demonstrated a tree based multicast steering convention, MAODV (Multicast Ad hoc On-interest Vector) in lightweight specially appointed systems. The effect of system loaded on MAODV convention, and proposed Multicast Ad hoc On-interest Vector with backup branches to enhance the strength of the MAODV convention by joining focal points of the tree structure and the lattice structure. The shorter tree limbs could enhance as well as build a multicast tree with reinforcement branches.

IV.IMPLEMENTATION OF PROPOSED SCHEME

E. Multipath Construction Phase

- Multipath path construction phase to create a set of neighbors that is the address of all nodes that are able to transmit data from the source.
- In this process route request control messages are exchanged between the nodes. Each sensor node broadcasts the route request packet once and maintains its own routing table. When sensor node broadcasts a data packet to the known neighboring nodes. It does not maintain the whole routing information. It is necessary to store the routing information and it reduces the overhead of sensor node while it requires the proactive protocol.
- The multipath routing protocol has to calculate some information to record in the routing table of sensor node, the energy expense is less than transmit and receive. Furthermore, it supports multipath data forwarding, not using the fixed path. So the energy consumption will be distributed and the lifetime of network is prolonged.
- The major activities in this phase are routing path formation for each node and neighbor table creation. The sink node broadcasts the route request packet to discover the one hop nodes / level 1 nodes, the nodes which are receiving them first.
- Route Request control messages are used to identify nodes in different levels. After a route request message is sent by sink node, the hop count records how many hops it has travelled from the sink.

F. The Format of Route Request Control Message

The Source ID contains the node ID of the message destination; SeqNumber field is a packet sequence. The HopCount field is the number of hops from the sink node which is used to identify nodes in different levels, nodes that can receive the radio signal of sink are defined as one- hop / level 1 nodes, Energy threshold field provides the minimum required energy level for a node to be selected for data transmission, Signal Strength threshold to indicate the minimum distance the node has to be located in order to receive all the data's transmitted to that node and Sink ID indicates the ID of the sink which broadcasts the route request packet.
The hop count field is increased by one each time when a node receives the route request message. When receiving a route request, a node considers itself in level N if the hop count is N. If a smaller hop count like N-1 is received later from a route request with

the same sequence number, as the current remembered, the node updates its level according to the new hop count. Smaller hop count nodes constantly use less energy than others.
Once the HopCount field is incremented, it is compared with the nodes hop value. If HopCount field is smaller than node's hop value, route request message is processed or otherwise drops the message. The corresponding node is then responsible to rebroadcast the route request message to its neighbors.

E. Stability based Multicast Routing
Stability means the node or the path can withstand in the presence of dynamic environment, link failures or node failures etc. If the fault tolerant rate of path is high, the stability will also be high.. Path is discovered based on the acknowledgement received from destination node. Initially Cluster Head (CH) floods a Group Join Request (GJR) packet to all cluster members based on the location information.
Stability is calculated based on the signal strength, path capacity and Signal to Noise Ratio [SNR]. Number of repeated transmissions will be limited once the stability is integrated in all the paths. Signal strength is measured in terms of amount of data can be successfully delivered to the nodes. If the delivery rate is more, then signal strength will be high. Path Capacity (Pc) is derived as,

$$P_c = \frac{\sum \gamma}{\sum \delta}$$

Where γ is number of packets travelling in the path and δ is total number of packets dropped by the paths. If packet dropping is less, path capacity will be more. Stability will be integrated once the high path capacity is arrived. Signal to Noise ratio (SNR) is generally measured based on Bit Error Rate (BER). Both are inversely proportional to each other.

F. Data Gathering Approach

Data gathering is initiated, once the reference point between the cluster head and the cluster member is identified. It means the centrality degree between two nodes should be less than 45 degree. Cluster member initiates this phase to increase the rate of data availability. The steps for data availability is given as,
Step 1: Choose the reference point between the cluster head and cluster member below 45 degree. Reference point is selected if any event occurs. i.e. transmission or reception.
Step 2: The Cluster member node transmits the Enquiry Packet (EP) to the reference point once the event occurs. Enquiry packet includes the following fields i.e. cluster member ID, cluster member size, distance travelled and hop count.
Step 3: Reference point broadcasts Enquiry Reply Packet (ERP) with zero hop count to cluster member nodes.
Step 4: Once the ERP is received by the cluster member nodes, the hop count will be incremented by 1.
Step 5: If the next hop cluster member node is greater than 1, Then compare packet arrival time and packet propagation delay Choose the less packet arrival time and propagation delay Start the data transmission

End if,The Cluster head sends the Stable Path Initiation Request (SPIR) to the cluster member. The Cluster member replies via Stable Path Join Reply (SPJR) as next hop node. Cluster members move in the radio range of reference point and it receives gathered packets from the point. Step 6: If an unknown node enters the cluster region, it sends the request packet to CH. CH authenticates it and sends the approval message. CH also measures whether unknown node is inside the coverage region of reference point or not.
Step 7: CH calculates the data gathering rate (φ) from the cluster members. It is estimated as follows,

$$\varphi = \frac{\sum_{k=0}^{N} f(w_k)}{\sum w}$$

Where Σw is total number of packets. $f(w_k)$ means number of packets gathered.
Step 8 : CH announces data gathering rate to all the cluster member nodes.

G. Proposed Packet Format

Source Id and Destination ID	Data gathering rate	Hop Count	Energy Efficiency	Load balancing rate	CRC
2	2	1	2	2	4

Figure 1: Proposed packet format

V.PERFORMANCE ANALYSIS

Network Simulator (NS2.34) is used to promote the simulate our proposed protocol. Backend language is C++ and Front end language is Tool Command Language (TCL).In the simulation, 120 mobile nodes move in a 1200 meter x 1200 meter square region for 100 seconds simulation time. All nodes have the same transmission range of 260 meters. The simulation settings and parameters are summarized in table 1.

Table 1: Simulation Settings and Parameters

No. of Nodes	120
Area Size	1200 X 1200 m^2
Mac	802.11
Radio Range	260m
Simulation Time	100 sec
Traffic Source	CBR
Packet Size	512 bytes
Package rate	5 pkt/s
Protocol	LEACH

H. Performance Metrics

It is evaluated mainly the performance according to the following metrics.End- to-end delay: The end-to-end-delay is averaged in over all surviving data packets from the sources to the destinations.Data Gathering Rate: It is defined as the making the copies of data items which is shared by several users in a particular point of time.Communication Overhead: It is defined as the number of control packets normalized in the network..The simulation results are presented in the next part. The compare of the proposed protocol FDGS with SDGP, STCDG [18] and LEACH in presence of clustering environment.

Figure 2 shows the results of total energy efficiency for varying the simulation time from 20 to 100 m/sec. From the results, it is understood the scheme FDGS has high energy efficiency than the SDGP, LEACH and STCDG scheme. While adopting the data compression, energy level will be saved. At the same time only active sensor node participates in the data transmission.

Figure. 3, presents the network lifetime comparison for FDGS, SDGP, LEACH, STCDG. It is clearly seen that the number of epochs are consumed by FDGS, is highly compared to SDGP , LEACH and STCDG. Network lifetime is improved based on energy balancing of data gathering nodes and link quality. Fuzzy based decision mechanism is deployed to increase the data gathering.

Fig. 4, presents the comparison of data gathering rate. It is clearly shown that the data gathering rate of FDGS, is higher than SDGP, LEACH and STCDG. The data gathering is improved based on proper maintenance of the cluster region. The Cluster members grasp the data and deliver according to fuzzy routing.

Figure 5 shows the results of Time Vs End to end delay. From the results, it is clearly shown that FDGS scheme has slightly lower delay than SDGP, STCDG and LEACH scheme because of stable data gathering routes.

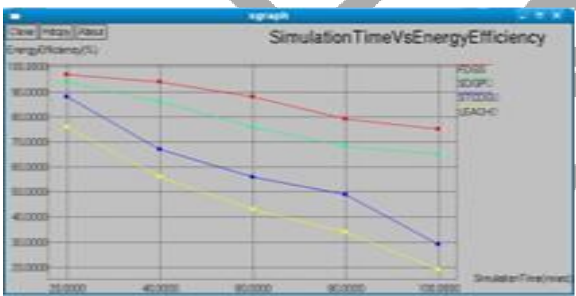

Figure 2: Simulation time Vs energy efficiency

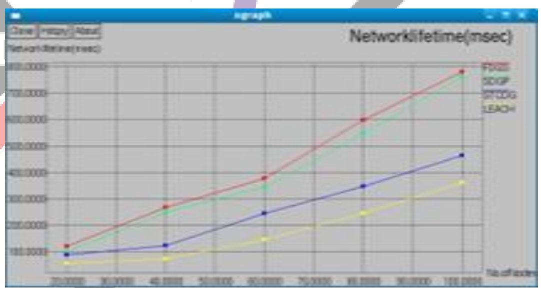

Figure 3: No. of nodes Vs network lifetime

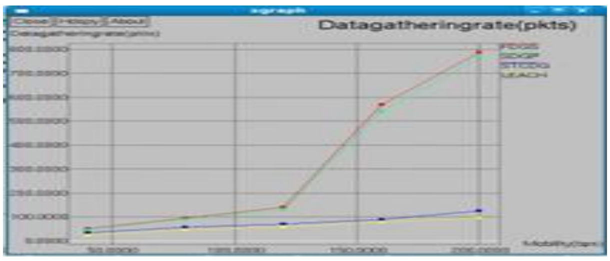

Figure 4: Mobility Vs Data gathering rate

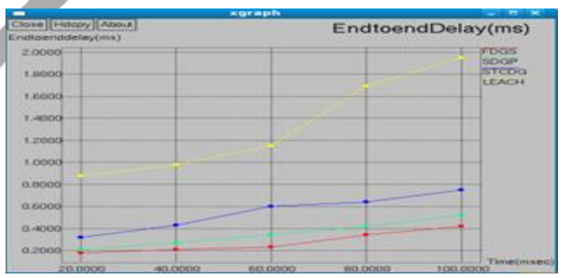

Figure 5: Time Vs End to End delay

VI. **CONCLUSIONS**

In WSNs, the best route is being determined by choosing efficient strategy to forward the data to the base station. Due to that, the node consumes more energy unnecessarily. In this paper, we have developed a New Multipath Routing Approach which attains energy model, maintenance of optimal energy path, multipath construction phase to make a correct balance between network life time, energy consumption and throughput to the sensor nodes. . To increase the network lifetime, many sensor nodes should be deployed to increase data gathering rate. To perform data gathering, the fuzzy decision routing is required to achieve data availability.

In this paper, balancing between the energy consumption and the data gathering is achieved through fuzzy based data gathering route which attains energy model and attains high network life time and throughput to the sensor nodes. it has been demonstrated the data gathering estimation of each node. . By simulation result it has been shown that DGS has achieved high data gathering rate, high network lifetime, high energy efficiency while attaining low delay and low overhead than the existing schemes LEACH and STCDG and the previous work SDGP while varying the number of nodes, simulation time, time and mobility.

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