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# Energy Efficient Routing Based Load Balancing Approach for Wireless Sensor Networks

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**ABSTRACT:** Wireless Sensor Networks (WSN) consists of sensor devices of low cost and small size based on the advancement of microsensor technology. It has many desirable characteristics, including easy deployment and self-organization, and is becoming increasingly important in modern society. The sensor nodes are battery-operated, most of which are not rechargeable, and cease to function once the battery expires. Owing to logistical issues such as remoteness or inaccessibility of distribution areas, it is not straightforward to replace sensor nodes with expired batteries. The applications of WSNs range from important societal issues such as environmental surveillance, intelligent transportation, disaster relief, and health care to military issues including battlefield biological and nuclear monitoring as well as target tracking. In the research work, it is designed that Load balancing based Energy Efficient Routing Approach (LEERA) to improve the network lifetime. The system model states that nodes are aware of location and energy level. Each node should know the probabilities of packet sending and receiving calculation before the packet transmission. Energy of sensor nodes may get depleted due to link quality degradation. The concept of load balancing is determined. The simulation results show that improvement over the EDAL, EMRTEM and ADAPT protocol.

## I.INTRODUCTION

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.

In many WSN applications, the deployment of sensor nodes is performed in an ad hoc fashion without careful planning and engineering. Once deployed, the sensor nodes must be able to autonomously organize themselves into a wireless communication network. Sensor nodes are battery-powered and are expected to operate without attendance for a relatively long period of time. In most cases it is very difficult and even impossible to change or recharge batteries for the sensor nodes. WSNs are characterized with denser levels of sensor node deployment, higher unreliability of sensor nodes, and sever power, computation, and memory constraints. Thus, the unique characteristics and constraints present many new challenges for the development and application of WSNs.

Due to the severe energy constraints of large number of densely deployed sensor nodes, it requires a suite of network protocols to implement various network control and management functions such as synchronization, node localization, and network security. The traditional routing protocols have several shortcomings when applied to WSNs, which are mainly due to the energy-constrained nature of such networks. For example, flooding is a technique in which a given node broadcasts data and control packets that it has received to the rest of the nodes in the network. This process

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repeats until the destination node is reached. Note that this technique does not take into account the energy constraint imposed by WSNs. Sensor nodes are organized in a random manner in Figure 1.1.

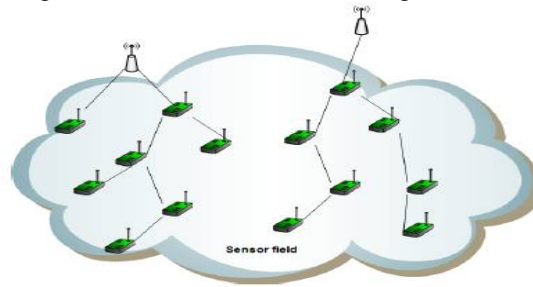


Figure 1.1 Architecture of Wireless Sensor Networks

As a result, when used for data routing in WSNs, it leads to the problems such as implosion and overlap. Given that flooding is a blind technique, duplicated packets may keep circulate in the network, and hence sensors will receive those duplicated packets, causing an implosion problem. Also, when two sensors sense the same region and broadcast their sensed data at the same time, their neighbors will receive duplicated packets. To overcome the shortcomings of flooding, another technique known as gossiping can be applied. In gossiping, upon receiving a packet, a sensor would select randomly one of its neighbors and send the packet to it. The same process repeats until all sensors receive this packet. Using gossiping, a given sensor would receive only one copy of a packet being sent. While gossiping tackles the implosion problem, there is a significant delay for a packet to reach all sensors in a network. Furthermore, these inconveniences are highlighted when the number of nodes in the network increases.

## 1.1 Minimum Energy Communication Network (MECN):

MECN is a location-based protocol for achieving minimum energy for randomly deployed ad hoc networks, which attempts to set up and maintain a minimum energy network with mobile sensors. It is self-reconfiguring protocol that maintains network connectivity in spite of sensor mobility. It computes an optimal spanning tree rooted at the sink, called minimum power topology, which contains only the minimum power paths from each sensor to the sink. It is based on the positions of sensors on the plane and consists of two main phases, namely, enclosure graph construction and cost distribution. For a stationary network, in the first phase (enclosure graph construction), MECN constructs a sparse graph, called an enclosure graph, based on the immediate locality of the sensors. An enclosure graph is a directed graph that includes all the sensors as its vertex set and whose edge set is the union of all edges between the sensors and the neighbors located in their enclosure regions. In other words, a sensor will not consider the sensors located in its relay regions as potential candidate forwarders of its sensed data to the sink. In the second phase (cost distribution), non-optimal links of the enclosure graph are simply eliminated and the resulting graph is a minimum power topology. This graph has a directed path from each sensor to the sink and consumes the least total power among all graphs having directed paths from each sensor to the sink. Each sensor broadcasts its cost to its neighbors, where the cost of a node is the minimum power required for this sensor to establish a directed path to the sink.

While MECN is a self-reconfiguring protocol, and hence is fault tolerant (in the case of mobile networks), it suffers from a severe battery depletion problem when applied to static networks. MECN does not take into consideration the available energy at each sensor, and hence the optimal cost links are static. In other words, a sensor will always use the same neighbor to transmit or forward sensed data to the sink. For this reason, this neighbor would die very quickly and the network thus becomes disconnected. To address this problem, the enclosure graph and thus the minimum power topology should be dynamic based on the residual energy of the sensors.

## 1.2 Small Minimum-Energy Communication Network (SMECN):

SMECN is a routing protocol proposed to improve MECN, in which a minimal graph is characterized with regard to the minimum energy property. This property implies that for any pair of sensors in a graph associated with a network, there is a minimum energy-efficient path between them; that is, a path that has the smallest cost in terms of energy consumption over all possible paths between this pair of sensors. Their characterization of a graph with respect to the minimum energy property is intuitive. In SMECN protocol, every sensor discovers its immediate neighbors by broadcasting a neighbor discovery message using some initial power that is updated incrementally. Specifically, the

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immediate neighbors of a given sensor are computed analytically. Then, a sensor starts broadcasting a neighbor discovery message with some initial power  $p$  and checks whether the theoretical set of immediate neighbors is a subset of the set of sensors that replied to that neighbor discovery message. If this is the case, the sensor will use the corresponding power  $p$  to communicate with its immediate neighbors. Otherwise, it increments  $p$  and rebroadcasts its neighbor discovery message.

## 1.3 Low-energy adaptive clustering hierarchy (LEACH):

LEACH is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. In LEACH, the clustering task is rotated among the nodes, based on duration. Direct communication is used by each cluster head (CH) to forward the data to the base station (BS). It uses clusters to prolong the life of the wireless sensor network. LEACH is based on an aggregation (or fusion) technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the a network into several cluster of sensors, which are constructed by using localized coordination and control not only to reduce the amount of data that are transmitted to the sink, but also to make routing and data dissemination more scalable and robust. LEACH uses a randomize rotation of high-energy CH position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and dieing quickly. The operation of LEACH is divided into rounds having two phases each namely (i) a setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation and (ii) a steady-state phase for data aggregation, compression, and transmission to the sink. LEACH is completely distributed and requires no global knowledge of network. It reduces energy consumption by (a) minimizing the communication cost between sensors and their cluster heads and (b) turning off non-head nodes as much as possible. LEACH uses single-hop routing where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption. While LEACH helps the sensors within their cluster dissipate their energy slowly, the CHs consume a larger amount of energy when they are located farther away from the sink. Also, LEACH clustering terminates in a finite number of iterations, but does not guarantee good CH distribution and assumes uniform energy consumption for CHs.

## II.LITERATURE SURVEY

### LITERATURE SURVEY ON ENERGY BASED ROUTING PROTOCOLS FOR WSN:

Directed diffusion is data-centric routing protocol for collecting and publishing the information in WSNs. It was developed to address the requirement of the data flowing from the sink towards the sensors that is when the sink requested particular information from these sensors (Intanagonwiwat et al 2000). Its main objective was to extend the network life time by realizing essential energy saving. To fulfill this objective, it had to keep the interaction among the nodes within a limited environment by message exchanging. Localized interaction that provided multi-path delivery was a unique feature of this protocol. This unique feature, with the ability of the nodes to respond to the queries of the sink, resulted in considerable energy savings .In Directed Diffusion, the initial interest contained a low data rate. However, an important overhead was caused during the flooding operation of interest propagation phase. It was, generally, based on a flat topology. Hence, scalability and congestion (especially in the nodes that near to the sink) problems existed and overhead increase at the sensors during the matching process for the data and queries.

Mario Di Francesco et al (2011) developed an ADAPTive and cross-layer framework for reliable and energy-efficient data collection in WSNs based on the IEEE 802.15.4/ZigBee standards. The framework involved an energy-aware ADAPTation module that captured the application's reliability requirements and goal was to minimize the energy consumption. It supported both single-hop and multi-hop networking scenarios. Latency was very high due to non availability of optimal route found in multi-hop communication. Moreover, in this scheme, energy was spent for only transmission and not for retransmission. Location based methodology was adopted in this scheme but more energy was spent for reliable routing.

Energy-Efficient Sensor Routing (EESR) is a flat routing algorithm (Oh & Chae 2007) proposed especially to reduce the energy consumption and data latency, and to provide scalability in the WSN. Nodes were located inside the region. After the nodes were deployed, the Base Station sent the relative direction information and sector ID of each node, each node then constructed its EESR table. Once a node detects an event, to select the next node to deliver the event, it

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investigated the sector ID of all the neighbor nodes within 1-hop in its EESR table. The scalability of this routing was not suitable for large scale networks and energy consumption of this algorithm was more during the route maintenance.

Mohamed Watfa et al (2008) EEIA: Energy Efficient Indexed Aggregation in Smart Wireless Sensor Networks developed an energy efficient approach to query processing by implementing new optimization techniques applied to in-network aggregation to ensure efficiency, competence and effectiveness. The mode of aggregating queries was efficiently executed over WSNs in a distributed manner. This distributed approach performed better in terms of energy reduction and network lifetime. Energy efficiency of this approach was fine, but scalability was very limited.

Gossiping is data-relay protocol, and, like Flooding protocol, does not need routing tables and topology maintenance. It was produced as an enhancement for Flooding and to overcome the drawbacks of implosion. In Flooding, a node broadcast the data to all of its neighbors even if the received node had just received the same data from another node. The broadcasting continued until the data was received by the destination (Akyildiz & Canvuran 2010). However, in Gossiping, a node randomly chose one of its neighbors to forward the packet to, and once the selected neighbor node received the packet, in turn it choose another random neighbor and forwarded the packet to them. This process continued until the destination or the number of hops had been exceeded. As a result, only the selected nodes/neighbors forwarded the received packet to the sink. Unlike Flooding, Gossiping served well at one-to-one communication situations but not at one-to-many. The next hop neighbor was randomly chosen, which meant that it may include the source itself. The packet travelled through these selected neighbors until it reached the sink or when the number of hops was exceeded. It suffered from packet loss.

Juan Capella et al (2011) Historical Building Monitoring Using an Energy-Efficient Scalable Wireless Sensor Network Architecture explored a proposed architecture with a new routing protocol to provide better scalability, reliability, deployment properties and energy minimization. Novel node sensors designed for monitoring wooden masterpieces and historical buildings, to perform an early detection of pests, were presented. These sensors have shown highly satisfactory result in the detection of termites and low power consumption. There was no optimal route found in this scheme.

Yuping Dong et al (2011) proposed an energy efficient routing algorithm for WSN. In this algorithm, they divided the sensor nodes into several scheduling sets and let them work alternatively. In this way, the sensors did not have to be active all the time which saved a lot of energy. When choosing the next sensor to forward the information to, they considered both the distance from the base station to the sensor and its current energy level, So that the network power consumption will be distributed among the sensors. When the network did not have enough sensors that had sufficient energy to run, it automatically generated new scheduling sets. Scheduling was adopted here for all the routes but no optimal route was demonstrated due to lack of energy.

Multi path Multi SPEED (MMSPEED) was an extension of the SPEED protocol (Felemban & Lee 2006). It was characterized by offering multi-speed transmission and the establishment of more than one path to the destination. Indeed, for each offered speed, a QoS level and an additional path can be set to improve the quality of traffic. This protocol allowed sending packets with respect to end delay parameter required by the applications to avoid congestion and reduce the packet loss rate. It was designed to provide probabilistic QoS differentiation with respect to timeliness and reliability domains. For the timely delivery of packets, MMSPEED provided multiple delivery speed options for each incoming packet. Thus, the protocol was scalable and adaptable to large networks. However this protocol does not suit large scale networks due to excessive packet loss occurs.

Ming Lu et al (2007) proposed an Energy-Efficient Multipath Routing Protocol for Wireless Sensor Networks which distributed network traffic over multiple node-disjoint paths. Selected source node transmitted multiple route – request message to the neighboring nodes. Interference level experienced by the intermediate nodes along the nearby paths and the effects on the network performance was disregarded.

Hurni et al (2008) proposed Energy-Efficient Multi-Path Routing in WSNs which achieved energy efficient and low latency communication in WSN using cross layer information. Route table management strategy was used to construct only hop count optimal paths towards destination node. It utilized the information provided by the MAC layer to reduce data transmission latency, delay and interference. It required all the sensor nodes to be aware of the timing information of their neighboring nodes. This protocol flooded the whole information throughout the network during route discovery phase, which imposed significant overhead to the resource limited sensor nodes.

Energy Constrained Multi-Path routing (ECMP) (Antoine Bagula et al 2008) extends the MCMP protocol by formulating the QoS routing problem as an energy optimization problem constrained by reliability, play-back delay,

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and geo-spatial path selection constraints. This protocol traded between minimum number of hops and minimum energy by selecting the path that satisfied the QoS requirements and minimized energy consumption. There was no reliable routing adopted in this routing.

An energy efficient and QoS aware multipath routing protocol namely Energy-Efficient and QoS-based Multipath Routing Protocol (EQSR) that maximized the network lifetime through balancing energy consumption across multiple nodes, used the concept of service differentiation to allow high important traffic to reach the sink node within an acceptable delay, reduced the end to end delay through spreading out the traffic across multiple paths, and increased the throughput through introducing data redundancy. To forward reliable data, (Yahya et al 2009) considered multipath forwarding with optimum link quality. EQSR used the residual energy, node available buffer size, and Signal-to-Noise Ratio (SNR) to predict the best next hop through the paths construction phase. Due to link failures and node failures the energy level of network increased unlimitedly.

Radi et al (2011) proposed Low-Interference Energy-Efficient Multipath Routing Protocol (LIEMRO) to improve the performance demands such as delay, data deliver ratio throughput and lifetime of event-driven sensor networks through construction of an adequate number of interference-minimized paths. LIEMRO utilizes an adaptive iterative approach to construct a sufficient number of node-disjoint paths with minimum interference from each event area towards the sink node. This protocol utilizes a dynamic path maintenance mechanism to monitor the quality of the active paths during network operation and regulates the injected traffic rate of the paths according to the latest perceived paths quality. Therefore, it accounts for the temporal variations of the low-power wireless links and adjusts traffic distribution accordingly. However, LIEMRO does not consider the effects of buffer capacity and service rate of the active nodes to estimate and adjust the traffic rate of the active paths.

In this proposed multipath protocol, load balancing, energy based routing, disjoint path update and route discovery based on path energy and route maintenance are implemented based on network transmission range. It is shown that the proposed protocol achieves better performance than the above said protocols and routing schemes.

## III. ENERGY EFFICIENT ROUTING BASED . LOAD BALANCING APPROACH FOR WIRELESS SENSOR NETWORKS

In the proposed algorithm Load Balancing based Energy Efficient Routing Approach (LEERA) in WSNs, there are 8 steps to achieve the minimal energy consumption through multipath routing tree. Here we added parent node, route node selection, finding multipath routing tree for message length queries and minimizing the average energy consumption. The alternative recovery approach is included in the proposed algorithm which offers the route redundancy to eliminate the need for route repair like node and link failure sessions.

Step 1:

No

de which is having highest remaining energy is selected as a root node.

Step 2:

Root node broadcasts the route control and data messages to neighbor nodes. These messages contain root ID.

Step 3:

Neighbor nodes receive the messages and choose the parent node as its root node.

Step 4:

If node k having child nodes which is lesser than the maximum child nodes ( $k.\text{child node} < n.\text{max child node}$ ), the node k calculates the path energy and broadcast the message to all neighbors.

Step 5:

If node k sender's path energy average > parent's path energy average

THEN

Node k selects the sender as its new parent with minimum cost tree.

ELSE

Node k does not select its parent with minimum cost tree. Minimum cost tree is defined as the tree in which all accumulative node cost of all nodes between the destination node.

Step 6: Load balancing approach



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In this step we are finding the multipath routing tree for longer message length aggregate queries. Here we use the concept of minimum spanning tree approach to find multiple trees. Here the transmission range of each sensor is identical.

Consider the sensor network  $G$  consists of sensor nodes with initial energy  $IE$  at each node. It consists of potential number of stages  $M$ .

- Suppose the tree is used at stage  $A$ , the network lifetime is where  
 $\tau_A \leftarrow MDST(G, IE/M)$ ;
- for  $i$   $B$  to  $M$  do  
 $\tau_i \leftarrow 0$  (Initial duration of stage  $i$ )
- For each  $v \in V$  do (Small child nodes belongs to Maximum Child nodes) compute the residual energy  $\Delta E_i(v)$  ;  
 $\tau_i^A \leftarrow NMDST(G, IE / M + \Delta E_i(v))$   
 $\tau_i^A$  is the network lifetime developed by degree spanning tree using NMDST algorithm.
- If  $\tau_A < \tau_i^A$  (checking the degree constrained tree will result in a longer duration of stage  $i$ ) then  
 $\tau_i \leftarrow \tau_i^A$  ;  
else  
 $\tau_i \leftarrow \tau_A$  ;  
end if;  
end for;

The network life time is delivered by the proposed algorithm is longer than but at least as long as one delivered by the algorithm for finding the multi routing tree.

Step 7: Minimizing the Energy Consumption

The estimation of energy for both packet ( $E_{pkt}^{mn}$ ) and acknowledgement packets ( $E_{ack}^{mn}$ ) are also determined as follows

$$E_{pkt}^{mn} = \lambda \times d_{mn}^r \times \tau_{pkt} \quad (4)$$

$$E_{ack}^{mn} = \lambda \times d_{mn}^r \times \tau_{ack} \quad (5)$$

Here,  $d_{mn}$  is the distance between the source node  $m$  and destination node  $n$ . is the approximated simulation value. and are the delay on transmission of both acknowledgement and data packets.

The total energy is calculated for transmitting a packet is given by,

$$E_{mn} = \sum_{k=1}^{n-1} \lambda \times d_{k(k+1)}^r \times (\tau_{pkts} + \tau_{ack}) + \sum_{k=1}^{n-1} \lambda \times d_{kk+1}^r \times (\tau_{pkts} + \tau_{ack}) \\ + \sum_{k=1}^{n-1} \lambda \times d_{k(k+1)}^r \times (\tau_{pkts} + \tau_{ack} + \tau_{rs} + \tau_{cs}) \quad (6)$$

In the above equation,  $k$  is the single route and  $k+1$  is the nearest multipath route in case if any link break occurs. and are the delay occurs on request to send, clear to send packets.

Node Energy consumption (EN) measures the average energy dissipated by the node in order to transmit a data packet from the source to the sink. It is calculated as,

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$$E_N = \frac{\sum_{p=1}^M (e_{p,init} - e_{p,res})}{D}$$

$$M \sum_{q=1}^{data N_q}$$

Where M is the number of nodes,  $e_{p,init}$  and  $e_{p,res}$  are respectively the initial energy and residual energy levels of node p, D is the number of destination nodes and  $data N_q$  is the number of data packets received by destination q.

Let  $p_0, q_0$  denotes the coordinates of the access point in sensor networks and  $p_i, q_i$  be the coordinates of the  $i$ th sensor nodes. The distance between the access point and the  $i$ th sensor node is given by,

$$d_i = \sqrt{(p_0 - p_i)^2 + (q_0 - q_i)^2}$$

If F is the set of sensor nodes, the energy consumed by the active sensor nodes,

$$E_{ti} = E_0 \sum_{i \in A} d_i^\beta$$

$$(p_0, q_0) = \text{avg} \min_{p,q} E_i$$

Here  $E_{ti}$  is the energy used by its sensor node and  $E_0$  be the energy needed to transmit one unit of data.

The average energy is minimized at  $\frac{\partial E}{\partial p}$  at  $p = p_0$  and  $\frac{\partial E}{\partial q}$  at  $q = q_0 = 0$  where the condition executes at

$$\max_{i \in A} E_{ti} \rightarrow \min$$

Step 8: Data collection phase

Input: A k-layered graph G, a message size vector per node q, and a root r

output: A data gathering tree T

Step 1:

$Y = \varnothing$  ;

Step 2:

Create a flow network f on G as follows:

- Set the flow demand per node u as  $q(u)$
- Create a source node and connect it to all other nodes in the network
- Set the capacity of all edges to m

Step 3:

Search for a minimum m such that in the resulting flow f, all demands are satisfied

Step 4:

If a node u delivers its flow using only one parent v in f, add  $e_{u,v}$  to T and remove  $e_{u,v}$  from f

Step 5:

for i = k to 2 do

- Select edges between layers i to i - 1 that transfer positive amount of flow
- Using those edges, find a perfect matching between the nodes in layer i to the nodes in layer i - 1
- Add the matched edges to T and remove them from f

Step 6:

return T

## IV.PERFORMANCE ANALYSIS

We use Network Simulator (NS 2.34) to simulate our proposed algorithm. 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 coding or by writing the C++ Program. In either way, the tool helps to prove our theory analytically.

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In our simulation, 100 sensor nodes move in a 1200 meter x 1200 meter square region for 100 seconds simulation time. All nodes have the same transmission range of 200 meters. The simulation settings and parameters are summarized in table 4.1.

Simulation Settings and parameters of LEERA

No. of Nodes	100
Area Size	1200 X 1200 sq.m
Mac	802.15.4
Radio Range	200m
Simulation Time	100 sec
Traffic Source	CBR
Packet Size	80 bytes
Mobility Model	Random Way Point
Transmitter Amplifier	150 pJ/bit/m <sup>2</sup>
Package rate	6 pkt/s
Protocol	LEACH

## 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 the ratio of packet received to packet sent successfully. This metric indicates both the loss ratio of the routing protocol and the effort required to receive data. In the ideal scenario the ratio should be equal to 1. If the ratio falls significantly below the ideal ratio, then it could be an indication of some faults in the protocol design. However, if the ratio is higher than the ideal ratio, then it is an indication that the sink receives a data packet more than once. It is not desirable because reception of duplicate packets consumes the network's valuable resources. The relative number of duplicates received by the sink is also important because based on that number the sink, can possibly take an appropriate action to reduce the redundancy.

**Throughput:** It is defined as the number of packets received successfully. The simulation results are presented in the next part. We compare our proposed approach LEERA with EDAL, EMRTEM and ADAPT in presence of energy consumption. Figure 4.1 shows the results of energy consumption for varying the number of nodes from 10 to 100. From the results, we can see that LEERA scheme has minimal energy consumption than EDAL, EMRTEM and ADAPT scheme.

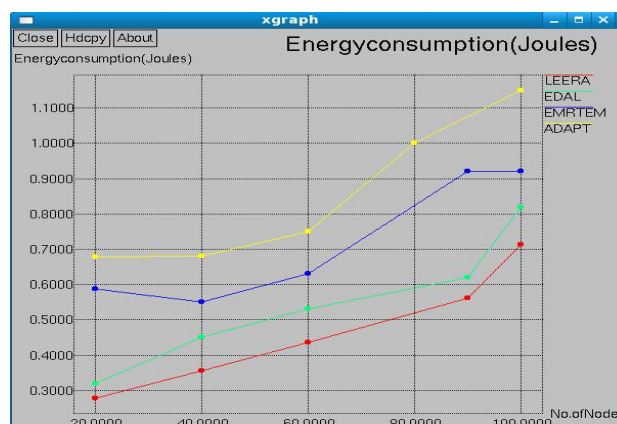


Figure 4.1 Energy consumption Vs No. of Nodes



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Figure 4.2 shows the results of control overhead for varying the time from 10 to 50 ms. From the results, we can see that LEERA has minimal control overhead than EDAL, EMRTEM and ADAPT scheme.

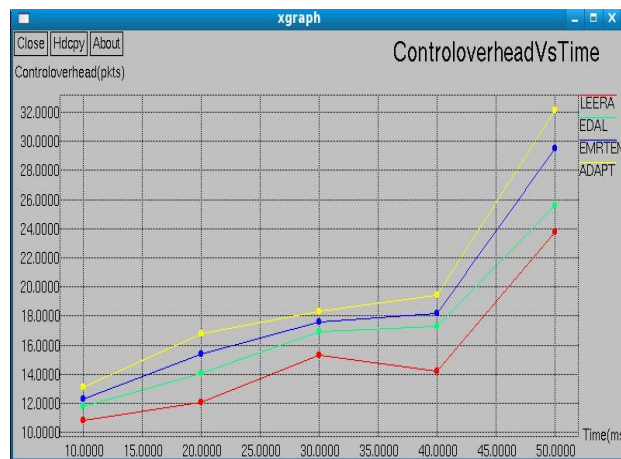


Figure 4.2 Control overhead Vs Time

Figure 4.3 presents the network lifetime comparison for LEERA, EDAL, EMRTEM and ADAPT. It is clearly seen that number of epochs consumed by LEERA is high compared to existing schemes.

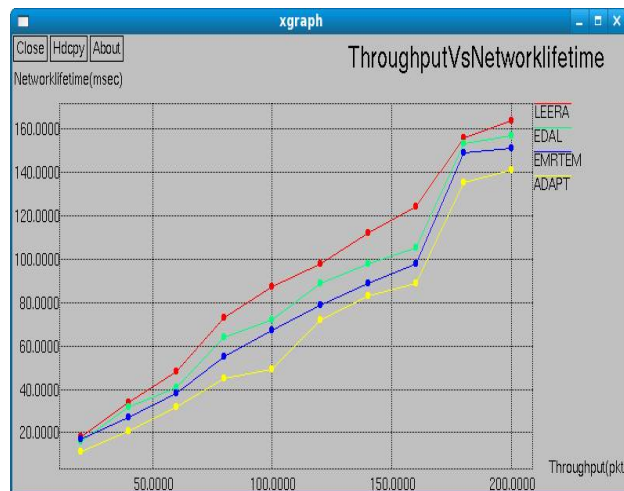


Figure 4.3 Network Lifetime Vs Throughput

Figure 4.4, presents the comparison of data delivery ratio. It is clearly shown that the data delivery ratio of LEERA is higher than EDAL, EMRTEM and ADAPT scheme.

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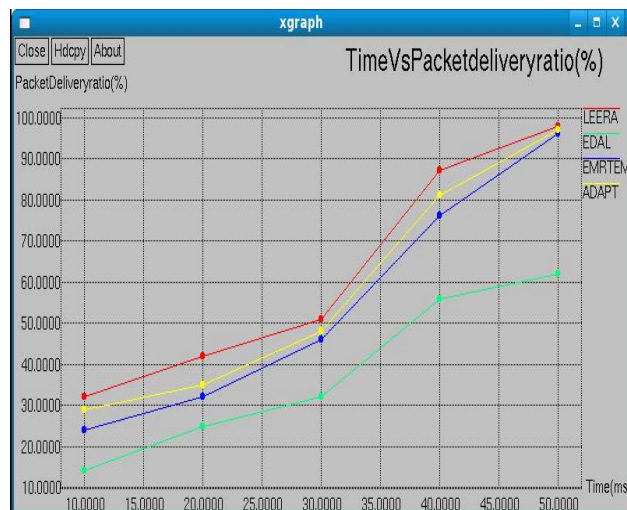


Figure 4.4 Throughput Vs Data delivery ratio

Figure 4.5 shows the results of End to end delay Vs Pause time. From the results, we can see that LEERA scheme has slightly lower delay than EDAL, EMRTEM and ADAPT schemes.

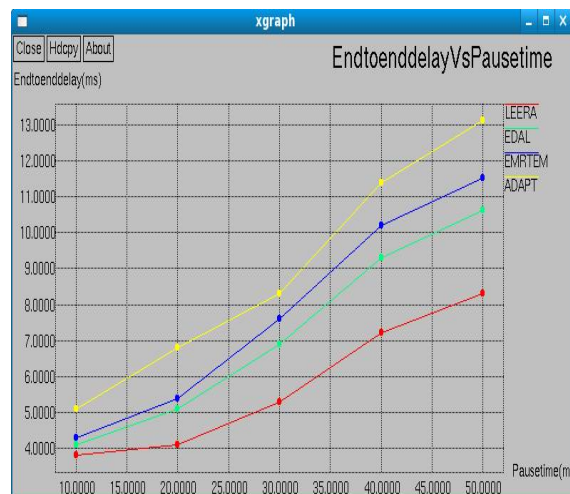


Figure 4.5 End to end delay Vs Pause time

Figure 4.6, presents the comparison of fault tolerant rate. It is clearly shown that the fault tolerant rate of LEERA is higher than EDAL, EMRTEM and ADAPT scheme.

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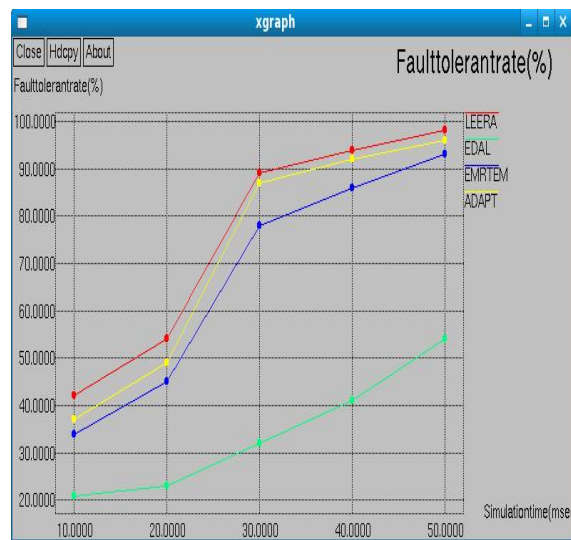


Figure 4.6 Fault tolerant rate Vs Simulation time

## V.CONCLUSION

Wireless sensor network (WSN) is widely considered as one of the most important technologies for the twenty-first century. In the past decades, it has received tremendous attention from both academia and industry all over the world. A WSN typically consists of a large number of low-cost, low-power, and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities. These sensor nodes communicate over short distance via a wireless medium and collaborate to accomplish a common task, for example, environment monitoring, military surveillance, and industrial process control. The basic philosophy behind WSNs is that, while the capability of each individual sensor node is limited, the aggregate power of the entire network is sufficient for the required mission.

Energy conservation is critical in Wireless Sensor Networks. Replacing or recharging batteries is not an option for sensors deployed in hostile environments. Generally, communication electronics in the sensor utilizes most energy. Stability is one of the major concerns in advancement of Wireless Sensor Networks (WSN). A number of applications of WSN require guaranteed sensing, coverage and connectivity throughout its operational period. Death of the first node might cause instability in the network. Therefore, all of the sensor nodes in the network must be alive to achieve the goal during that period. One of the major obstacles to ensure these phenomena is unbalanced energy consumption rate. When fairness is not considered in routing process, network will be partitioned very soon and then the network performance will be decreased.

In this research work, it is developed that a Load Balancing based Energy Efficient Routing Approach (LEERA) is proposed to prolong the sensor network lifetime in WSN. In first phase, the cluster routing is established to ensure load balancing and longer network lifetime. In second phase, multipath routing is deployed with clustering to avoid network failures and congestion. In third phase, the path stability and energy consumption of wireless sensor nodes are determined. In this phase, the energy consumption threshold model is developed and mathematical model of path reliability is proposed.

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