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# Energy based Logical Multipath Routing for Improving Network Lifetime in Wireless Sensor Networks

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**Abstract :** *Wireless Sensor Network (WSN) are set of thousands or more micro sensor nodes having the capability to process, gather and transmit data to any one of the designed base station.WSN is that they have limited battery power, storage and data processing capabilities. Out of these the primary challenge is energy limitation and prolonging the network lifetime especially for sensors deployed in environments like battlefield surveillance, weather monitoring, disaster management that are not easily accessible. In this paper, energy based Logical Multipath Routing (ELMR) is proposed to prolong the sensor network lifetime. Simulations using network simulator NS2 have been conducted to study the behavior of the routing algorithm for five different node distribution patterns. Simulation result shows that the proposed scheme effectively reduces and balances the energy consumption among the nodes, and thus significantly extends the network lifetime compared to the existing schemes such as LEACH. The proposed technique outperforms previous method in terms of energy efficiency and network life time.*

**Keywords:** *Energy efficient, multi tree, network lifetime, LEACH, Wireless sensor networks.*

## INTRODUCTION

A huge number of nodes are used to create a sensor network and these nodes are arranged densely to each other to monitor them. The data is collected by the each node and transmits that information back to the sink. WSN comes under Low Range Wireless Personal Area Network (LR-WPAN) group. These nodes consist of CPU, memory, battery and transceiver. The size of each sensor node may vary based on the applications. The network should have the self-organizing capability because the positions of individual nodes are not known initially. Cooperation among the nodes is the main feature of this network. The group of nodes cooperates to distribute the gathered information to their neighbor users in this network. The important application areas of the sensor networks are the military areas, natural disaster and in health. In addition, this network is used to monitor the light, temperature, humidity and other environmental factors for the civil applications.

Wireless sensor network is one of the major research areas in computer network field today. A wireless sensor network consists of tiny sensing devices, which normally run on battery power. Sensor nodes are densely deployed in the region of interest. Each device has sensing and wireless communication capabilities, which enable it to sense and gather information from the environment and then send the data and messages to other nodes in the sensor network or to the remote base station. Considering the limited energy capabilities of an individual sensor, a sensor node can sense only up to very limited area, so a wireless sensor network has a large number of sensor nodes deployed in very high density (up to 20nodes/m), which causes severe problems such as scalability, redundancy, radio channel contention, and limited energy.



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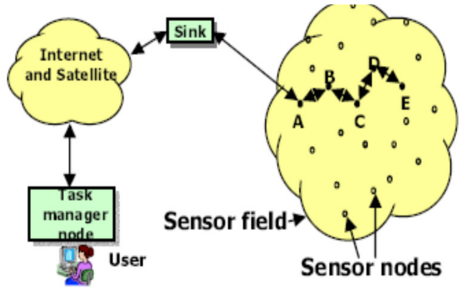


Fig:1 Architecture of sensor network

Also, the importance is due to that numerous applications can benefit from the WSN, such as healthcare, environmental, forest fire and military applications, etc (Akyildiz et al., 2002; Akkaya and younis,2005).

Fig 1. Shows a typical architecture in which sensor nodes are shown as small circles. Each sensor node typically consists of the five components such as sensor unit, analog digital convertor (ADC), central processing unit (CPU), power unit, and communication unit. ADC is a translator that tells the CPU what the sensor unit has sensed, and also informs the sensor unit what to do. Communication unit's task is to receive command or query from, and transmit data from CPU to outside world. CPU is the most complex unit. It interprets the command or query to ADC, monitors and controls power if necessary, processes received data, computes the next hop to the sink, etc.

Wireless sensor networks have unique characteristics rather than other networks. Sensor nodes have many constraints such as computational power, storage capacity, communication range, and limited energy source. Of course, the main constraint is energy source. Energy source which is dedicated to sensor nodes is limited and in most of applications, it is not rechargeable. Energy determines the network lifetime. A wireless sensor network can perform its tasks while its nodes have enough energy. Therefore, if energy consumption is reduced the network lifetime will be prolonged. Prolonging network lifetime leads to using network advantages longer. In this paper tree based routing mechanism is presented to improve the lifetime of the network.

**Related work:** The routing protocols proposed for WSNs are classified considering several architectural factors. Routing protocols for Wireless Sensor Networks (WSNs) are mainly classified into two categories: Network Structure Based protocols and Protocol Operation Based protocols. The network structure based protocols depend on the system architecture of the network. These protocols are classified into three categories: Data centric or flat routing protocols, Hierarchical routing protocols, and Location based routing protocols. Protocol operation based protocols are classified into five categories: negotiation based routing protocol; Multi-path based routing protocol, Query-based routing protocol, Qos -based routing protocol, and Coherent-based routing protocol (Breslau et al., 2000).

## Materials and Methods

Among various approaches proposed for energy efficient WSNs, the clustering approach in which data gathered by one representative sensor of each group of sensors allows good scalability for the sensor network consisting of hundreds or thousands of nodes. Another advantage of the clustering approach is balanced energy consumption among the nodes and thus increased network lifetime. The chain-based approach tries to save the energy forming a chain from the source to the sink, and thus only one node will be transmitting data to the BS in any given transmission time-frame. Here data fusion occurs at every node in the sensor network which allows all relevant information to permeate across the network. The tree-based approach reduces the transmission power in each node by sending the sensed data only to the parent node located nearby. After the root node aggregates the data, it transmits the data to the BS (Kyung Tae Kim et al., 2010)

LEACH, is one of the most popular hierarchical routing algorithm for sensor networks. It forms clusters of the sensor nodes and selects heads as router. Although this protocol can increase energy efficiency, there are some limitations. For instance, each node can transmit directly to the cluster head and sink because LEACH uses a single-hop routing. Therefore, it is not applicable to networks deployed in large regions. Consequently, robustness and simplicity of routing protocols are essential consideration for multi-hop routing (Vidhyapriya and Vanathi, 2007)

In Tree-based Efficient Protocol for Sensor Information (TREEPSI), a root node is selected before data transmission occurs. There are two ways to build the tree path (Satapathy and Sarma, 2006). One is computing the path centrally by the sink which broadcasts it afterward. The other is running the same tree construction algorithm in each node. At the initial phase, the root node visits other nodes using a standard tree traversal algorithm. Then the data transmission phase begins from the leaf nodes towards the root node which sends the collected data to the sink. The process continues until the root node dies when a new root node is elected. The

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communication distance between the nodes in TREEPSI is shorter than PEGASIS which allows it to reduce power consumption about 30% compared to PEGASIS.

Tree based routing protocol (TBRP) for mobile sensor network is presented. Here optimum mobility pattern is proposed for maximum energy (Mrityunjay singh et al., 2010)

**The Proposed Logical Tree Based Routing:** Tree based routing structure have many advantages. Tree routing is simplified routing algorithm and in tree routing inner nodes communication is limited to parent-child links only. It does not need to shake hands continually in order to grantee that the packets have been received between nodes. It only requires to forward packets to their parents along the tree and therefore, tree routing eliminates path searching and updating. The logical tree based routing protocol is proposed. The algorithm consists of Tree initialization phase, Tree formation phase, data forwarding and Tree maintenance phase.

**Tree Initialization Phase:** In the initial phase, the sink broadcasts a message which contains the information about x and y coordinates. This location information is called as location message which consist of sink x and sink y. The location message is sent to all the nodes in the network. All the nodes will receive this location message.

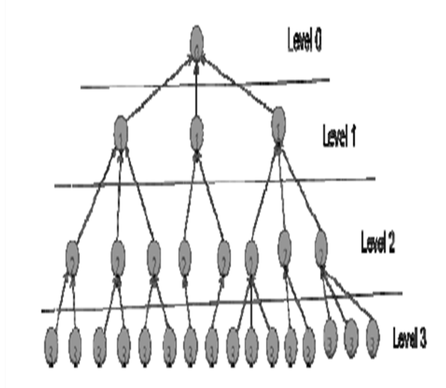


Fig 2. Tree Creation Process

**Tree Formation Phase:** After receiving the message, the nodes calculates the distance from the sink according to

$$D=\sqrt{(x_1-x_2)^2+(y_1-y_2)^2}$$

According to the distance calculated nodes assign level to itself. The sink node is assigned as level 0.In this algorithm, it is designed as for the nodes from (0 – 150) m distance it is called as Level 1.For the distance between (150 – 300) m it is assigned as level 2 and so on.

In this algorithm each node sends one hop broadcast message. After assigning level, each node sends one hop broadcast message called as joint request (join_ req) packet to all the nodes, which contains the node id and levels. The join_req message is received by all the neighbor nodes. The immediate lower level node accepts the join_req. But, the equal level nodes and higher level nodes rejects the join_req message. The node which accepts the join_req message sends reply called as tree_accept message as a unicast. After node receives tree_accept message it assigns its parent Id as the source of tree_accept message. Sometimes two immediate lower level nodes receive join_req and tree_accept message simultaneously. So for this purpose the distance between receiver node and the parent node is calculated. Comparing the distance the node which has shortest distance is selected as a parent node.

**Data Forwarding Phase:** After the tree formation phase, is the transmission phase. In this phase, no routing table, route request message and route reply message. When transmission starts it just forwards the parent Id and parent node. Finally the node near to the base station sends the collected data to the base station.

**Tree Maintenance Phase:** In maintenance phase, parent timer is designed which checks periodically the parent Id with the neighboring nodes. If the node changes its position, the parent timer initiates join_req message to all its neighbours. As a reply if the node receives the tree_accept message, then the node changes its routing path.

## Proposed Routing Algorithm

1. N= Total number of nodes

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2. Sink Node Broadcast Message
Sink node Broadcast location information to all nodes
For (i=0; i<n; i++)
{
Sendmsg (location information)
}
3. All the Senor Nodes Receives Location Message
Each sensor receives location message and stores the sink position
Sink_dist=sqrt ($[si(x)\text{-}sink(x)]^2 + [si(y)\text{-}sink(y)]^2$)

4. Calculation of Node Level
Level =0 if (0<sink_dist≤150)
Level =1 if (1<sink_dist≤300)
Level =2 if (2<sink_dist≤450)
Level =3 if (3<sink_dist≤600)
Level =4 if (4<sink_dist≤750) ……

5. Tree Creation Proceess
Send Treejoinmsg
Si= send tree join xpos ypos level
Select parent node
If ((Parent_dist==1000)||(cr_tree ==1))
Parent_dist = dist(x,y)
Par _x =X;
Par _y= Y;
else
if ((Parent_dist!=1000)&&(Parent_dist < dist(x,y)||(cr_tree ==1))
Parent =dist;
Parent_dist = dist(x,y)
Par_ x =X;
Par _y= Y;

6. Receive Acknowledgement
Selected as parent

7. Data transfer

Set next _hop=parent node ID
Forward Data up to the sink

## Results and Discussion

In this study, capability of the protocol is analyzed by the result of simulation in NS -2.The scene is as follow: There are 50, 60,70,80,90,100 nodes in a 1500X1500 square area.

Table 1. Simulation Parameters

| **Parameter** | ***Value*** |
|---|---|
| Simulation time(s) | 1000 |
| Routing Protocol | LEACH,LTRP |
| Propagation Model | TwoRayGround |
| Mac Type | 802.11 |
| Link Layer Type | LL |
| Interface Type | Queue/Drop tail |
| Number of Nodes | 60,70,80,90,100. |
| Traffic Type | CBR |
| Packet Size | 512 Bytes |
| Time Interval | 0.01 |
| Area | 1500mx1500m |

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**Performance Metrics:** For simulation results the following performance metrics have being used in our simulations as shown below:

**Normalized Routing Load:** Normalized routing load is the number of routing packets transmitted per data packet sent to the destination. Also each forwarded packet is counted as one transmission. This metric is also highly correlated with the number of route changes occurred in the simulation.

**Routing Overhead:** Normalized routing overhead is the total number of routing packets divided by total number of delivered data packets

**Energy consumption:** The total energy consumed by all the nodes in the network for finding the target information.

**Network life Time:** is defined as the time data can be transferred before a sensor node gets completely drained of its energy.

**Node distribution patterns:** The following figure shows, the five distribution patterns simulated. Pattern 1 shown in Fig. 3 the sink node is placed in center with an area covering 1500x1500m.Pattern 2 shown in Fig.4 the sink node is placed at the upper left of the scenario.

Pattern 3 shown in Fig.5 shows the sink is placed at upper right, pattern 4 where the sink is placed at down left which is shown in Fig.6, and Fig.7 shows the sink is placed at downright which is pattern 5.

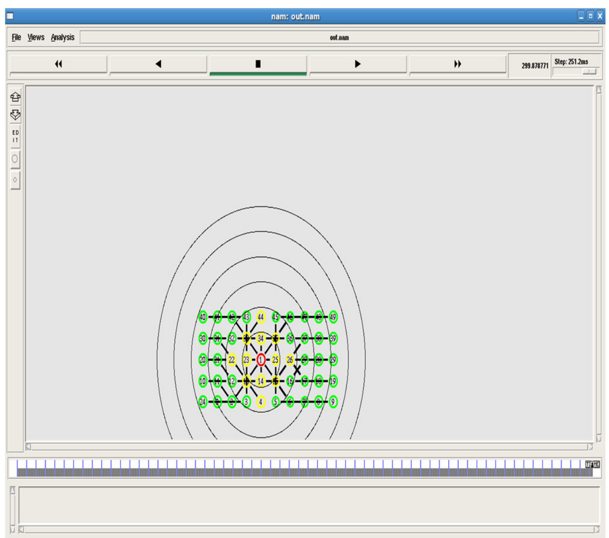


Fig .3. The sink node is placed in center

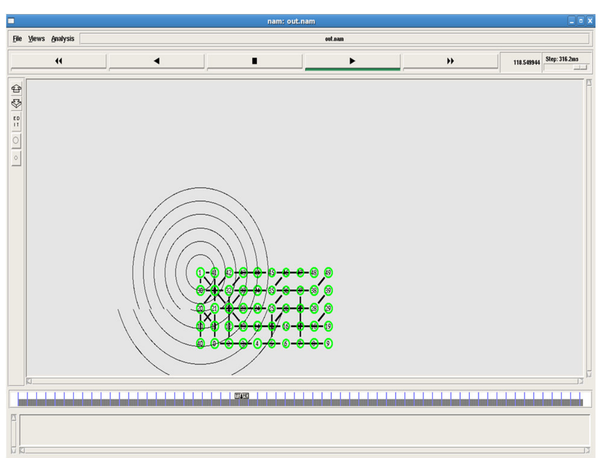


Fig 4. The sink node is placed at the upper left

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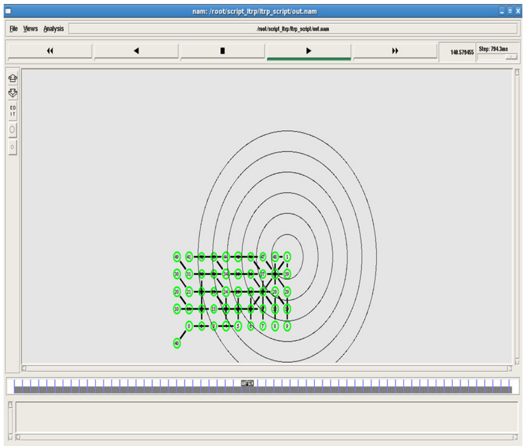

Fig 5. The sink node is placed at the upper right

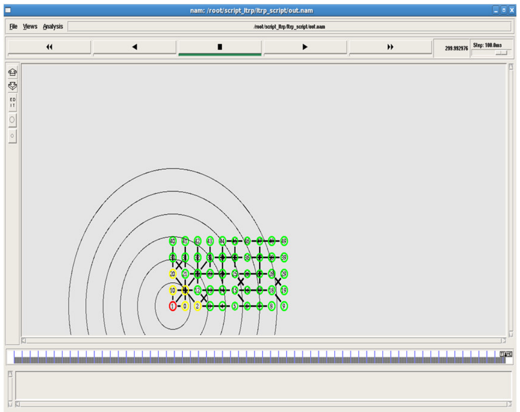

Fig 6. The sink is placed at down left

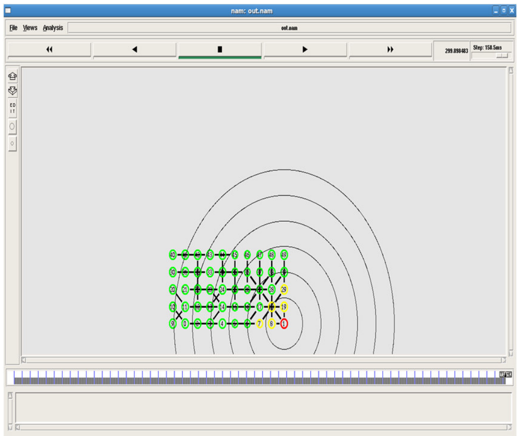

Fig 7. The sink is placed at down right

## Conclusion

A wireless sensor network consists of light-weight, low power, small size sensor nodes. Due to low-cost of nodes, the deployment can be in order of magnitude of thousands to million nodes. The nodes can be deployed either in random fashion or a pre-engineered way. In this research work, logical multi tree based routing algorithm is proposed to extend network lifetime of WSN. We construct tree formation for five different sink node positions in the network. For all patterns tree is formed and energy efficiency is increased. The

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performance of logical tree based routing algorithm has improved lifetime compared to LEACH. By simulation results, the proposed multi tree based routing performs better than the existing techniques. Our future work will continue on multicast routing with multi tree approach to enhance energy efficiency in wireless sensor networks.

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