International Journal on Future Revolution in Computer Science & Communication Engineering
Volume: 4 Issue: 3
ISSN: 2454-4248
98 – 101

Mobility Based Routing Scheme for Wireless Sensor Networks

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***Abstract*—** A large number of sensing units are arranged together to form a Wireless Sensor Network (WSN). Sensing units are capable of sensing and sending the data to the sink node. WSN is usually formed in areas where human intervention is not possible. So efficient nodes are desired, which can work for longer lifetime along with least energy consumption. WSN arrangement can be static or dynamic. In static WSN, the nodes are fixed at a location for sensing in the field of interest. In dynamic WSN nodes can be mobile they can move over periodic time to cover larger area. This paper proposes Dynamic Routing protocol based on nodes mobility. Proposed work considers Data fusion and aggregation at every node. Similar data is deleted every time and heterogeneous data is forwarded to next hop based on routing algorithm. The movement of sensor nodes is limited per span of time. Routing tables are also generated periodically. Proposed routing technique is adding coverage enhancement and also compares the lifetime of the proposed scheme with static counterpart.

Keywords- *Routing, Heterogeneity, Wireless sensor networks, WSN, Mobility and Aggregation.*

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I. INTRODUCTION

Wireless sensor networks (WSN) are having number of devices that are tightly coupled with the real time physical environment. These sensor nodes (SN) are distributed in various ecological areas. SNs are placed in the areas where human intervention is not possible. Nodes are deployed for surveillance in the environments such as temperature or humidity measurement. The WSN is having many applications including disaster management, habitat monitoring, military surveillance, agriculture, detecting the intrusion and health monitoring.

Due to non accessibility by humans, it is very difficult to deploy the nodes in such areas. Also, SNs are having many limitations such as limited power, limited bandwidth, shorter lifetime, real time data assessment. Due to limited energy, soon they are going to relapse and charging or battery replacement is not possible.

So for the efficient WSN, techniques should be designed in such a fashion that it will efficiently utilize the available energy for the longer lifetime of the network. While working with WSNs, first and foremost necessity is the good deployment technique. Many deployment schemes are proposed in last decades which claim efficient utilization of resources in the deployment, effective time taken in the deployment. Node deployment can be done as random and uniform. Random deployment is done by scattering the nodes over the field of interest from the sky through robots or helicopter [1-3]. This type of deployment is commonly used in some unreachable areas, dangerous area, forests, flooded regions, battlefields, disaster affected regions, and area where wildlife study is done, which require complete coverage. After the deployment one must apply a good routing technique for increasing the network lifetime and the reducing the power consumption. Many routing techniques are proposed in last decades. Some algorithms involve the direct transfer of data from sensor node to sink node. Few were proposed which were using clustering to get the better lifetime by decreasing the power involved in direct transmission. While few techniques were categorized based on trees or tiering to improve network lifetime. This paper proposes a routing algorithm considers the node mobility issue. For node mobility dynamic routing algorithm is used. The other sections of the paper are divided as follows; the next section is the literature survey. The section following the second one describes the proposed technique with flow chart. The fourth section covers result and implementation. Last sections conclude the paper.

II. LITERATURE SURVEY

Authors in [4] proposed first clustering approach where the network was divided in to clusters (5% of the total nodes). Each cluster was supposed to have a cluster head (CH) which receives data from the cluster, aggregates the data and transmits it to Base Station (BS). CH is rotated after each round to balance the load on all nodes of the network. Due to this rotation network achieves 8X improvement but selects CH on rotational basis only without checking node's capability.

In [5] authors proposed TEEN protocol, based on the variation in the environmental factors. Sensor node transmits data only if change in the environment factor goes beyond the threshold. After crossing this threshold, sensor node continuously senses data and report for even a small change in the factor too. this leads to lesser message transmission to BS hence improvement in network lifetime.

Authors in [6] proposed routing protocol by forming a chain among the sensor nodes of the network. No criteria were defined while forming the chain among the nodes resulting in more transmission delay. Also if one node dies in between the functioning, data of the whole network is lost.

Tan et. al. proposed PEDAP [7], a minimum spanning tree-based protocol. This method was centralized algorithm governed by the BS. This technique was used for data gathering and also for computing routing information. All the computational tasks were done by BS and during the operation dead nodes were also discarded after certain number of rounds.

Authors in [8] proposed tiering scheme based on distance of nodes from BS. Nodes closer to the BS are in the higher tiers and are preferred for data transmission to BS. These nodes aggregate data of the network and transfer data to BS on rotational basis.

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Authors in [9] created minimum spanning tree among the sensor nodes to reduce transmission energy to its least level. This scheme was incorporating least cost of the network along with having some transmission delay in terms of number of nodes in the network.

Authors in [10] concentrated on the sensor network with the mobility of the nodes for data sources as well as sinks in a direction. Nodes and sink use a predefined path and data delivery was scheduled according to the position of the ink resulting improvement in network lifetime.

Authors in [11] proposed a centralized tree based routing approach in which clusters was uniformly formed. Selection of Ch is done by BS and is based rotational basis. Along with rotation, node with higher energy is considered as a parameter for the candidate of CH. Main aim of the approach is to transmit the data to BS in multi-hops by minimizing the distance between the communicating nodes.

Author in [12] worked on heterogeneous WSN where a relay node with higher energy transmits aggregated data to BS. The nodes were connected with each other by forming Minimum spanning tree to transmit packet to a relay node which transmits aggregated data to BS. This scheme was intern able to double the network lifetime in context with its homogeneous counterpart.

Author in [13] worked on clustered Heterogeneous Sensor Networks with Mobile Sink with minimum spanning tree structure. Nodes with High Energy (HE) were used as CH & that with Low Energy nodes as Non-CH. Data is gathered with the help of a mobile sink circulated around the network. This scheme transmits data in 5 hops to BS.

III. ENERGY MODEL

A. Sensor Radio Model

Proposed technique runs on the first order radio model [11] based on the running circuitry of the electronics, transmission power consumed for transmitting and amplification of signal and receiving circuitry, as illustrated in figure1. Details of the parameters are given in the subsequent sections.

1) Transmission of data

ETx(k, d) = Eelec * k+ Eamp * k,

Where Eamp is the amplification energy so total transmission cost is elaborated as:

$$E_{Tx}(k,d) = \begin{cases} E_{elec} * k + \varepsilon_{fs} * k * d^2 & \text{d≤d0 within the network} \\ E_{elec} * k + \varepsilon_{mp} * k * d^4 & \text{d>d0 to the BS} \end{cases}$$

Where $\varepsilon_{fs}, \varepsilon_{mp}$ are free space and multi path space coefficients.

In the proposed technique, only one node is responsible for gathering the network data via multi-hops and transmitting the aggregated data to BS. Role of this head node is rotated when energy of node goes below threshold. for this head node multi path model is used and free space model is referred for nodes within the network.

2) Receiving the data

$$E_{Rx}(k,d) = E_{elec} * k$$

Here k is the message size in bits between the nodes separated by distance d.

It is clear from the computation that most of the energy is consumed in transmission of data. So, larger is the distance between communicating nodes, more will be the energy consumed.

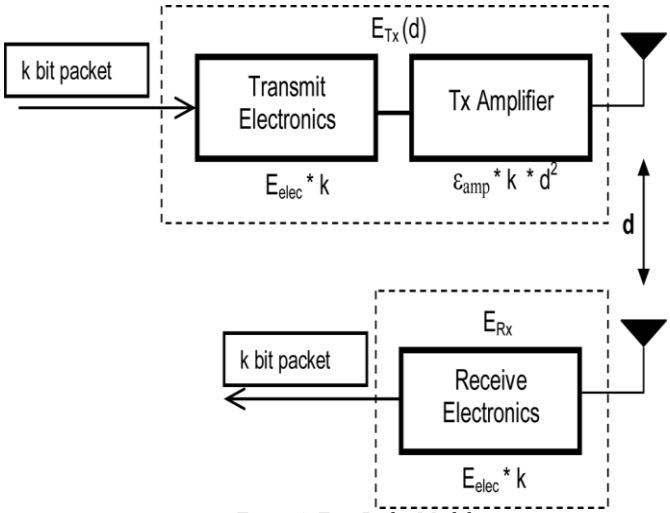

Figure 1. First Radio Model

B. Proposed Technique

Proposed protocol works by dividing the field of interest in to three equally portioned regions based on the distance of a node from the BS. Working scenario is defined in the following steps

1. Disperse nodes randomly and allocate tier based on distance from BS (closest from BS is tier1).
2. Compute transmission cost of all nodes w.r.t.to BS and rest senor nodes.
3. for each round of operation
   - 3.1 Choose a node as CH such that energy [node]> threshold.
   - 3.2 Deduct transmission cost of every node.
   - 3.3 Deduct receiving cost for CH.
   - 3.4 Deduct transmission cost of CH to BS.
4. Keep on repeating step 3 until a node possesses energy more than transmission energy along with keeping record on the round when a node stops functioning.
5. If threshold>dead_energy, redefine threshold and go to step 3 otherwise terminate.

C. Workflow of simulation

The Simulation is executed after initializing the starting values (like energy, position of SNs) based on the parameters given in table1, then is repeated until any node is capable of transmitting data to its reporting head. Steps of flow chart are illustrated in figure 2.

Proposed technique is implemented on two types of nodes viz static and dynamic. In static, nodes are fixed after deployment but in dynamic, nodes are mobile, i.e. nodes can change their positions after deployment. The movement of the nodes is considered to be random [14] based on the environmental factors only, where a node can slightly change its position in any direction w.r.t. current position.

Working of the proposed technique is same in both of the cases, except the difference of movement of nodes in dynamic

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nodes after certain interval. This movement is shown with different color in the flow chart of figure 2.

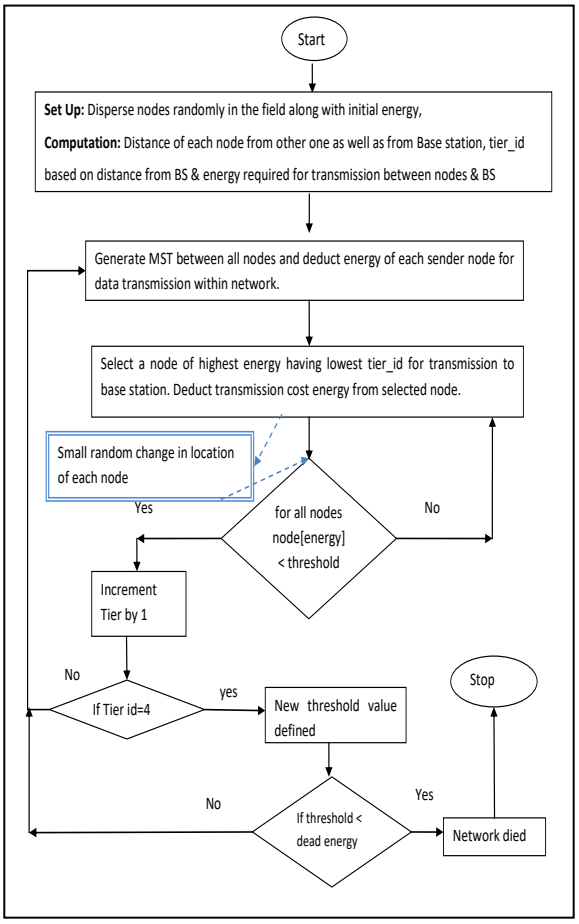

Figure 2. Flow Chart

D. Simulation Environment

Parameter set up for the implementation of the proposed technique are shown in table1.

Table 1. Simulation Environment

Parameter	Value
E_{elec}	50nj/bit
$E_{free\ space}$	10pj/bit/m^2
$E_{multi\ path}$	0.0013pj/bit/m^4
Packet Size	2000 bits
Sensing Area (m)	50*50
BS(X,Y)	50,175
Number of Nodes	50
Node Energy	0.25-1.0 J

IV. RESULTS

Proposed technique is simulated with parameters as specified in Table 1. Results are analyzed with dynamic & static deployment of nodes and are illustrated in Table 2. Comparison graph of the same is also depicted in figure 3.

As it is clear from the table 2 as well as from the bar graph, network with enhanced energy will survive more than network with lesser energy. These results describe lifetime of the network in a random scenario depicting First Node Died (FND), Half Node Died (HND), Last Node Died (LND). The time till all nodes are working (till FND) is the stable network lifetime and data obtained till this round is most reliable.

Table 2. Lifetime of the proposed scheme with different energy levels, with & without mobility

Energy	With Mobility			Without Mobility		
	FND	HND	LND	FND	HND	LND
0.25	498	1376	1448	627	1118	1165
0.5	1046	3020	3137	1252	2342	2398
1	1878	6732	6838	3244	4707	4778

LND is the moment where at least one node of the network possesses sufficient energy to sense & transmit data to destination. A fraction of energy level is defined as dead energy, whenever energy of the node goes below this point; node is considered to be dead and is discarded.

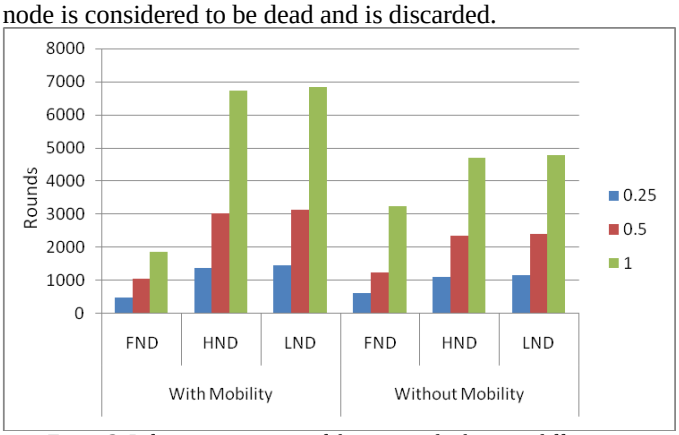

Figure 3. Lifetime comparison of the proposed scheme at different energy levels; with & without mobility

Table3. Lifetime comparison of the proposed scheme with exiting techniques

Energy	Protocol	FND	HND	LND
0.25	Direct	54	76	117
	LEACH	402	523	635
	PEGASIS	788	1041	1096
	Proposed-Static	627	1118	1165
	Proposed-Dynamic	498	1376	1448
0.5	Direct	108	152	235
	LEACH	803	1036	1208
	PEGASIS	1578	2082	2192
	Proposed-Static	1252	2342	2398
	Proposed-Dynamic	1046	3020	3137
1	Direct	215	304	471
	LEACH	1610	2055	2351
	PEGASIS	3159	4165	4379
	Proposed-Static	3244	4707	4778
	Proposed-Dynamic	1878	6732	6838

 ISSN: 2454-4248
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Proposed technique is represented in two modes, network with mobility of nodes and network with static nodes (after deployment). Nodes mobility is assumed to be based on the environment factors without any energy loss. Mobility is considered to be in random fashion in a small fraction w.r.t. current position. These two modes are also compared with exiting techniques. Results of existing techniques are referred from [15]. As illustrated in figure, proposed technique produces better results w.r.t. exiting techniques. Better lifespan of the network is due to uniform load dispersal on the nodes of the network. When Cluster head node losses its energy below threshold, role of cluster head is transferred to other node. So the load on nodes is kept on rotating to all nodes leading to better lifetime of the proposed scheme. Lifetime comparison of the proposed scheme is illustrated in figure 4.

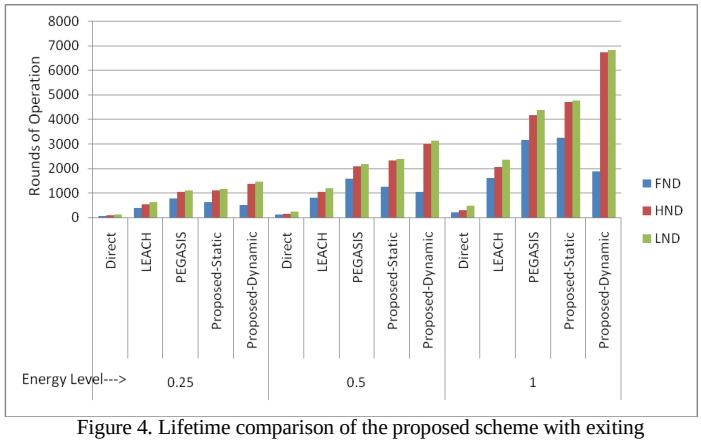

Figure 4. Lifetime comparison of the proposed scheme with exiting techniques

V. *Conclusion & Future Scope*

Many approaches were defined in the literature working on the routing techniques. These techniques were significantly improving the lifetime of the network. Many schemes were focusing to gather data at a node and transmitting the aggregated data. Proposed scheme focuses on gathering the data at CH level connected via minimum spanning tree approach. Also, proposed scheme incorporates mobility in the nodes and compares the results with its static counterpart. the network with mobile nodes proves to be more efficient in terms of lifetime as well as network coverage.

In context of future scope, different mobility models can be incorporated and compared on behalf of the network coverage ratio and lifetime.

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