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Reliable Point to Multipoint Hierarchical Routing in Scatternet Sensor Network

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----------ABSTRACT----------

In the recent development of communication, Bluetooth Scatternet wireless is a technology developed for wideband local accesses. Bluetooth technology is very popular because of its low cost and easy deployment which is based on IEEE 802.11standards. On the other hand Wireless Sensor Network (WSN) consists of large number of sensor nodes distributed to monitor an environment and each node in a WSN consists of a small CPU, a sensing device and battery. Mostly, the sensor networks are distributed in an inconvenient location and it is difficult to recharge often. So routing in WSN is an important issue to consume energy and as well as to increase the life of the network, since a routing protocol finds the path between sources and sink. Moreover it is a challenging task to schedule the data between nodes in a scatternet in a congestive environment. Here this paper presents a new scheduling method for point to multi- point routing in Scatternet sensor network and the new dynamic routing method designed is cluster-based with hierarchical routing. The efficiency of this method is also compared in terms of energy consumption and the results show that the proposed routing is an energy efficient one which simultaneously increases the lifetime of the network.

Key words: Bluetooth, Dynamic routing, Hierarchical routing, Scatternet, Wireless Sensor Networks.

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I. INTRODUCTION

Wireless communication is one of the fastest-growing technologies. The most widely used wireless techniques are Infrared, Bluetooth and Wi-Fi. The Infrared method is Line Of Sight (LOS) dependent technique and has fewer demerits like power consumption and high radiations inside room environment. The Bluetooth is a wireless technology designed to connect devices of different functions such as telephones, notebooks, printers, and so on . It is an Ad hoc network, which means that the network is formed spontaneously. A Bluetooth device has a built-in short-range radio transmitter with the current data rate of 1Mbps with a 2.4-GHz bandwidth. The objectives of this paper are to design a dynamic routing protocol for Scatternet sensor network, to increase the lifetime and to enhance the reliability [2]. The limitation in the depth of the network of the Bluetooth piconet is only 8 nodes and automatically the best choice is scatternet where the number of nodes can be added to the maximum is 274. On the other hand, sensor network consists of three subsystems namely sensor subsystem, processing subsystem and communication sub system[10]. The sensor subsystem consists of sensitive materials like photovoltaic cells which produces analog signals depending on the environment. In the processing unit the analog values obtained from the sensors is converted into a digital value by the use of analog to digital converter and the signal is processed with the help of digital signal processor before the signal is transmitted to the base station for further use[3]. So when sensor nodes are integrated with the Bluetooth scatternet the problem in increasing lifetime of the node in the network.

II.EXISTING ROUTING PROTOCOLS:

Routing protocols for WSN aims at maximizing the life time of sensor networks and to minimize the energy dissipation while communicating with other sensor nodes [7].

In Geographic routing protocol, according to the location information from neighbor nodes, the source node forwards the data packet and this process continues until it reaches the sink node[13]. Greedy algorithm is used for this method of scheduling, many parameters like time delay to forward the data packet is a major issue[5].

In the cluster based routing protocol the entire network is divided into many clusters. Each

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cluster has one cluster-head and sensor node. The sensor sends data to the cluster-head; the cluster head sends the data to the sink node. This method is energy efficient when the sink node is in the center of the network [1]. When base station is away from the sensor nodes, the energy consumption is high. Here the Cluster head is used to transfer the data to the base station. So the entire cluster will be dead after cluster head is inactive. In point to point hierarchical routing protocol the network is divided into many clusters [4]. Each cluster is at different level and when a data is transferred to sink node the lowest level sends the packet to its higher level. It is continued until it reaches the sink node to achieve reliability and scalability. But it is not energy efficient and maintaining the routing infra structure is also difficult [6].

III. PROPOSED SOLUTION

From the above discussed routing methods it is clear that a routing protocol must be energy efficient. Here a new dynamic routing algorithm is proposed which increases the lifetime of the sensor network [12]. It is a binary tree structured cluster based hierarchical routing protocol. In the binary tree structured wireless sensor network, the root node acts as a base station. Each child in the tree represents a cluster and each cluster is regulated by a cluster-head. In each of the previous cluster based routing method, the same cluster-head is used for the entire communication [9]. So when the energy of the cluster-head becomes zero, then the sensor nodes reside in the same cluster can't communicate with the base station. So the entire network dead. To overcome this problem, in the routing algorithm the cluster-head of each cluster is to be updated for each iteration. To update the cluster-head, the energy consumption of each sensor node is to be observed [8]. The average energy of the cluster is to be calculated. Then the sensor node which has greater energy than the average energy acts as the cluster-head for the next iteration. This process will be continued until the energy of all the sensor nodes are not sufficient to be a cluster-head. The energy consumption of each sensor node will be calculated by the formulae mentioned below in the routing algorithm [11]. The graph results from the simulation will depict the increased lifetime of the wireless sensor network.

IV. SYSTEM ARCHITECTURE OF WSN

The structure of point to multipoint WSN is shown in Figure 1. The structure of the WSN is a binary tree where the root node acts as a sink node. The entire network is divided into many clusters and each circle represents a cluster. Each cluster is governed by a cluster-head node.

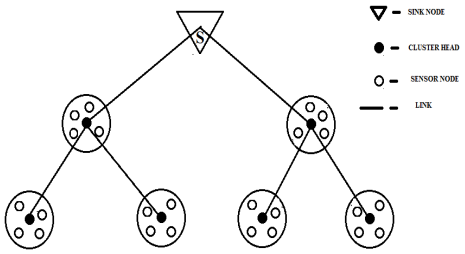

Figure 1: Structure of point to multipoint WSN

4.1 Hierarchical Routing (HR) ALGORITHM

A new proposed dynamic hierarchical routing algorithm illustrated in figure 2 ,which is peculiarly developed for the sensor networks, where the sink node is placed away from the sensor nodes. The three tasks for the proposed routing are Formation of routing tree, Selection of Cluster-head node and Reconstruction of Cluster-head tree network.

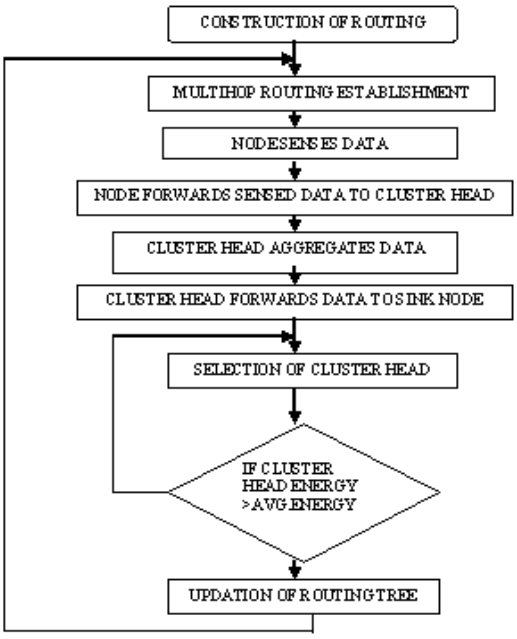

Figure 2: Flow graph of HR algorithm

The proposed HR algorithm comprises the following actions. First one explains about the structure of the routing tree which is a binary tree, establishment of communication between each sensor node and the forwarding data packets from sensor node to sink node through the cluster-head of each cluster. Secondly energy consumption of each sensor node, calculation of average energy of each cluster and the selection of cluster-head for each cluster are studied. Finally updating cluster-head of each cluster and reconstruction of the cluster-head tree structured sensor network are studied.

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4.2 FORMATION OF ROUTING TREE

In this section, the structure of routing tree, communication establishment between the sensor node and cluster-head node, and the transfer of data packets to the sink node are explained.

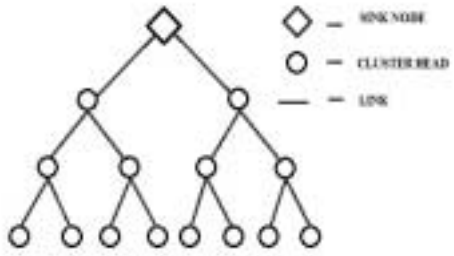

Figure 3 :Structure of routing tree

Figure 3 shows the the routing tree which is a binary structure.The diamond symbol in the binary tree represents the sink node(base station) of a WSN. Each circle in the tree represents a cluster-head of the cluster.In the proposed routing algorithm, the base station is far away from the sensor nodes. So the routing must be an energy efficient. In the proposed sturcture the base station(sink node) acts as a root node of the binary tree. All the sensor nodes in the network are divided into many clusters.Each cluster comprises seven sensor nodes which is shown in Figure 4.One of the sensor node in each cluster acts as a cluster-head. The sensor nodes can send the data packets to the base station only through the cluster-head node. To transfer the sensed data to the base station, first the sensor node must send the data packets to the cluster-head of the cluster and then the cluster-head forwards the data packets to the sink node. In the digram the rectangle and circle represent the cluster-head node and the sensor node respectively.

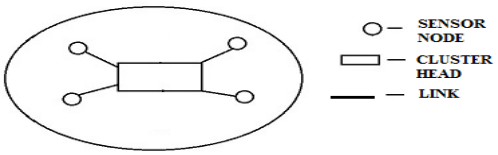

Figure 4:Sturcture of a Cluster

4.3 ROUTING TREE CONSTRUCTION:

To design a binary tree structured WSN, the base station (sink node) acts as a root node. The entire network is divided into many levels by the coverage range of 50m. The level of the root node is assigned to zero. At the beginning it is confirmed that all the sensor nodes in the WSN are active. The sink node (root node) sends its ID, position and node type to its two neighbor's nodes which are in the next level (Level-1). The neighbor nodes who receive the message send their node id, position and level as the acknowledgement to the root node. Now these two nodes become the children for the level-1. The distance between the left child node and right child node are at the range of distance r. Like that the level-i nodes send the message to its two neighbors to receive the ACK from level-i+1 and then they become the children of the previous level. The above steps are continued until there are no more sensor nodes without the level labels.

Now the root node orders their child nodes to form the clusters. Each cluster has five sensor nodes. One of the sensor node acts as a cluster-head node for the first iteration. The child nodes become the cluster-head of each cluster. Then the cluster-head node in each cluster send its id and position to its neighbor nodes persist in the same level. The sensor nodes in the same cluster sends its id, position, level, energy, distance and node type as the acknowledgment to the cluster-head node. These steps are followed by all cluster-head nodes to construct the clusters.

After constructing the binary-tree structured WSN, the sink node (root node) sends a message to its immediate cluster-head nodes to collect the sensed data from all the sensor nodes. Each cluster head maintains a routing table using the obtained information from the sensor nodes. Now the cluster-head in the level-i send this information to its child cluster-head in the level-i+1.So the cluster-head node in the level-i+1collect the sensed data from the sensor nodes and forward it to the cluster-head in level-i. This process is continued until the forwarded data packets to reach to cluster-head in level-1.Finally the cluster-head node in Level-1 forward the data packets to the sink node (base station). The collected data will be processed in the base station.

Whenever there is information exchange between cluster head node and sensor node results reduces the life time of cluster head . In general each nodes in the cluster need not to be active except cluster head. The cluster head is always active so whenever there is an information exchange the cluster head loses more energy compared with other sensor nodes in the cluster. Here for each round of data transmission the same cluster head is used. Thus the sensor network is active until the cluster head has energy to forward data packets. When the cluster-head has no energy then the communication in the sensor network is ended. This routing algorithm provides an alternative solution that, when each round of data transmission is completed the cluster head is to be updated. In each iteration the average energy of the cluster is to be calculated. The sensor node which has greater energy than the average energy that will become the new cluster-head.

4.4 SELECTION OF CLUSTER-HEAD NODE

The energy dissipation of each sensor node is calculated and then the average energy of the cluster is also calculated. Finally the sensor node which has more energy than the average energy of the cluster that becomes the cluster-head for the next iteration. After

receiving the data packets from all the sensor nodes, the sink node sends a message to the next level cluster to update the cluster-head. Then each sensor node calculates the dissipated energy during the data transmission.

4.4.1 Energy Dissipation:

When the data packets are forwarded to the cluster-head then each sensor node calculates the consumed energy by applying the following formulae.

$$\textbf{Normalized Energy} = \frac{n\pi r^2}{1000}$$

n - Number of sensor nodes.
r – Distance

A unit of normalized energy is measured in terms of Joules **(**J**)**.The cost of transmitting a single bit over 100m is equal to the cost of executing 3000 instructions. The Table 1 shows the energy dissipation of all the sensor nodes in respect to the distance between the two sensor nodes. The energy dissipation of sensor nodes is low when sensor nodes are located in small distance.

Table 1: Relation between distance and energy

DISTANCE(METER)	ENERGY(JOULE)
10	0.942
20	3.768
30	8.478
40	15.072
50	23.55
60	33.912
70	46.158

Once the energy consumption of each sensor node is calculated, the cluster-head will calculate the average energy of the cluster by applying the following formulae.

$$\text{Average Energy} = \frac{\text{Sum of the energy of all sensor node}}{\text{Number of sensor nodes}}$$

Now the cluster-head compares the remaining energy of each sensor node with the average energy of the cluster. Then the cluster-head selects the sensor nodes which have more energy than the average energy of the cluster.

The distance between the cluster-head and the sensor node is the second parameter to select the cluster-head for the next iteration. When two sensor nodes have the same energy than the average energy of the cluster then the node which is nearer to the cluster-head that will be selected as the cluster-head for the next iteration. The above steps are applied to all the clusters to select a new cluster-head for the next iteration. From this all the clusters in WSN select its new cluster-head node for the next iteration. In the final mode the selected cluster-head nodes are to be updated in the cluster-head tree.

4.5 RECONSTRUCTION OF CLUSTER-HEAD TREE NETWORK**:**

The selected new cluster-head nodes are to be updated in the cluster-head tree. The cluster-head node sends the information to its sensor nodes as well as the cluster-head of the next level. Then it collects the data from the sensor nodes and the next level cluster-head. Finally, it forwards the data packets to the sink node.

When the message is received from the sink node to the immediate cluster-head node about the updating of the cluster-head tree, then the new cluster-head node for the i^{th} level is selected by applying the previously mentioned formulas to the sensor nodes and the current cluster-head. Now the newly selected cluster-head node will send its address and position to all the sensor nodes in the cluster. Then the sensor nodes will send the acknowledgement to the new cluster-head node. For the next iteration all the sensor nodes in the cluster will send the data to sink node through the newly selected cluster-head node. The information about the new cluster-head is not only updated within the cluster. The new cluster-head also sends its address and position to the next level (Level i+1) cluster-head.

After receiving this message only the cluster-head will be updated in the level i+1. Now the selected cluster-head in the level i+1 sends the acknowledgement to cluster-head of level i. This process is continued until there is no more level in the network to update the cluster-head. Now the cluster-head tree is reconstructed. For the data transmission, the cluster-head in level i+1 sends the collected data to the cluster-head in level i. It forwards the data to the sink node.

The processes explained in the above three modules are executed on the wireless sensor network until the sensor nodes have no more sufficient energy to communicate with the sink node. The problem in any sensor node or a cluster-head node will not affect the entire communication. The information about the defected sensor nodes are updated during the energy calculation. The hierarchical tree structured network achieves the reliability of the wireless sensor network.

The simulation results, performance analysis and the comparison with the previous routing algorithms are to be discussed in the following sections.

V. EXPERIMENTAL ENVIRONMENT

The experiments are conducted on a 31 node scatternet sensor network. The aim of the test bed experiments, in turn, is to evaluate HR algorithm in a real WSN. The transmission range of sensor nodes is 50m and all the sensor nodes are randomly distributed. The root node of the tree acted as a sink node (base station). The other sensor nodes are divided into many clusters. Each cluster comprises five sensor nodes is controlled by a cluster-head. The sensed data is forwarded to the sink

node through only by the cluster-head node. For each iteration the cluster-head is updated.

RESULTS

The simulation results and performance analysis are explained through HR algorithm. For the experimental purpose, 31 nodes are used. Except the sink node, remaining 30 nodes are divided into six clusters. First, the sensor nodes are randomly located with different distance. Each cluster has a cluster head and four sensor nodes. A cluster based binary tree structured WSN is constructed. The sink node acts as a root node and here the sink node is placed far away from the sensor nodes. Sink node is labeled as base station. For each cluster there is a cluster-head which has the details such as energy and distance between adjacent nodes. Initial energy of each node is assigned to 100 J. The energy of the cluster-head node is reduced more than the sensor nodes during the transferring period of data to the sink node. The energy dissipation of each sensor node is calculated using the formulae mentioned in the routing algorithm. For each iteration the cluster-head of each cluster was updated once the data transfer completed. From the obtained values of each iteration, it is known that the lifetime of the wireless sensor network has been improved comparing with the cluster based routing protocol.

Figure 5: Constructed routing tree

Figure 5 shows the structure of the tree structured WSN designed in ns2 simulator. The node marked by blue circle represents the sink node of WSN.

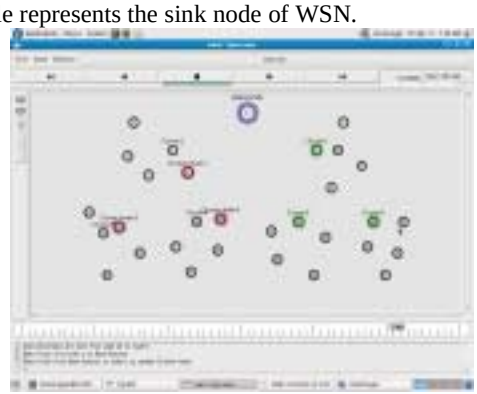

Figure 6: Updated routing tree

Figure 6 shows the updated routing tree after the iteration by applying the HR algorithm.

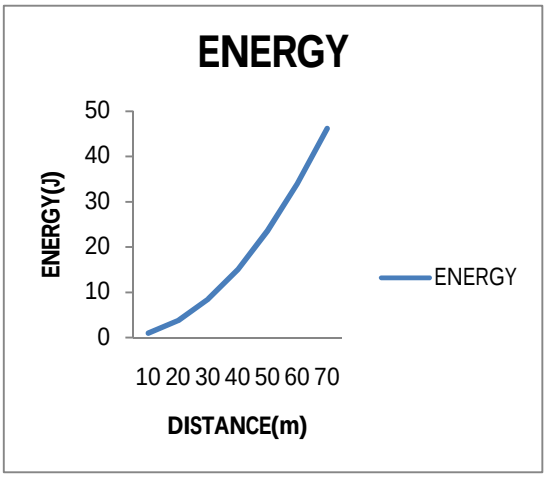

Figure 7: Distance-Energy dissipation graph

In the designed WSN, each sensor node sends the data to the cluster-head and the cluster-head sends the data to the sink node. So all the sensor nodes need some energy to communicate with the base station. The energy consumption of each sensor node is calculated using the formula mentioned in the above routing algorithm. Figure 7 shows the relationship between the distance and energy consumption and it is found that when the distance of a sensor node increases then the energy dissipation also increases.

5.2 PERFORMANCE ANALYSIS OF HR ALGORITHM

In the proposed routing algorithm, for each iteration the energy dissipation of all the sensor nodes is calculated. Then the average energy of a cluster is calculated. The sensor node which has energy more than the average energy will act as a cluster-head for the next iteration. The energy of the cluster-head in a cluster for each iteration is obtained and shown in Figure 8.

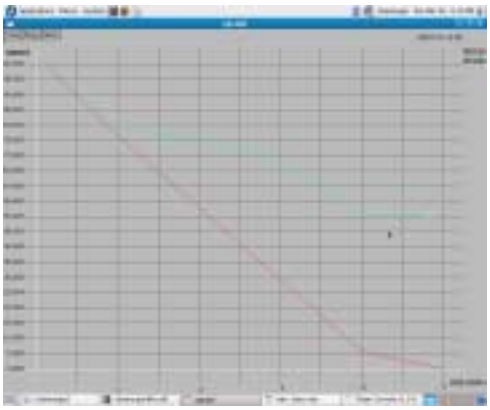

Figure 8: Graph result of HR and cluster-based routing Method

From the obtained values, the graph is compared with the previous cluster-based routing protocol. After the first iteration the cluster head is updated and it is noted

that at the end of the second iteration, the cluster head has 75.51 J energy but in the previous method of routing, after the second iteration the energy of cluster head is 51.4 J. Thus the result shows the increased lifetime of the wireless sensor network.

5.4 COMPARISON OF HR ALGORITM WITH EXISTING METHODS:

Table 2 :Comparison between cluster-based and HR algorithm

Iteration number	Energy of cluster - head In HR algorithm *	Energy of cluster-head in cluster - based algorithm
1	100 J	100 J
2	79 J	76.45 J
3	75.51 J	52.9 J
4	68.93 J	29.35 J
5	51.04 J	5.8 J
6	49.88 J	0

From the conducted experiments the remaining energy of cluster-head for each iteration are noted and compared with the cluster based routing protocol. In the cluster based routing protocol the same cluster-head node is used for entire communication. So the energy consumption takes place in the same cluster-head node. When the energy of the cluster-head becomes zero, then the sensor nodes reside in the same cluster can't communicate with the base station and the entire network will be dead. In our proposed method, for each iteration the cluster-head node is updated. The sensor node which has greater energy among nodes will act as a cluster-head for next iteration. From the simulation experiments, the initial energy is taken as 100J and in each iteration the remaining energy of cluster-head node from both algorithms is noted. The obtained values are shown in the Table 2. In cluster-based routing protocol on the sixth iteration the remaining energy of the cluster-head becomes zero and in our proposed method, on the sixth iteration the cluster-head node has the remaining energy of 49.88J which shows the increased lifetime of WSN.

VI.CONCLUSION:

The point to multi point hierarchical routing algorithm for Scatternet WSN called a dynamic routing method has been implemented for increasing the lifetime of the sensor networks. The simulation result shows that the positive increase in sensor network lifetime has been achieved owing to the cluster head update in the network. The energy distance graph also shows the energy consumption of each sensor node increases the reliability of the network. From the performance analysis graph it is concluded that our new routing algorithm provides more energy efficiency comparing with the previous method. With the proposed routing algorithm the number of piconet can be increased in the WSN and the designed system may be suitable for all surveillance applications.

References:

[1]. Abdul W. Matin , Obidul Islam and Sajid Hussain.(2007), Genetic Algorithm for Energy Efficient Clusters in Wireless Sensor Networks, JOURNAL OF NETWORKS, 2(5), 2007, 87-97.

[2]. Adrian perrig, john stankovic, and david wagner , Security for Wireless Sensor Networks, Communications of the ACM, 47(6), 2004, 53-57.

[3]. Chris Karlof and David Wagner, Secure Routing in Wireless Sensor Networks: Attacks and Countermeasures,,IEEE,2003, 113-127.

[4]. Guihai Chen, Haigang Gong, Jiannong Cao, Lijun Chen, Ming Liu, Yuan Zheng.,An Energy-Aware Protocol for Data Gathering Applications in Wireless Sensor Networks , *Sensors* 2009, 445-462.

[5]. Houda Zeghilet, Moufida Maimour and Nadjib Badache, Energy Efficient Cluster- based Routing in Wireless Sensor Networks, Proc IEEE Infocom,2009 ,701-704.

[6]. Konrad Iwanicki, Maarten van Steen, On Hierarchical Routing in Wireless Sensor Networks, In Proc .IEEE April 2009(San Francisco, California, USA, 133-144.

[7]. Laiali Almazaydeh, Eman Abdelfattah, Manal Al- Bzoor, and Amer Al- Rahayfeh,,Performance Evaluation of Routing Protocols In Wireless Sensor Networks, International Journal of Computer Science and Information Technology, 2(2), 2010, 64-73.

[8]. Piyakul Tillapart, Pratit Santiprabhob, Sanguan Thammarojsakul,ThanachaiThumthawatworn , An Approach to Hybrid Clustering and Routing in Wireless Sensor Networks, IEEEAC paper #1319, Final Version, Updated 2004, 1-8.

[9]. Saleem K,. Fisal N, Hafizah S, Kamilah S, and Rashid R A , A Self-Optimized Multipath Routing Protocol for Wireless Sensor Networks, International Journal of Recent Trends in Engineering, 2(1), 2009, 93-97.

[10]. Saleem K,. Fisal N, Hafizah S, Kamilah S, and Rashid R A ,Rashid, ,Ant based Self-organized Routing Protocol for Wireless Sensor Networks, International Journal of Communication Networks and Information Security , 1(2), 2009, 42-46

[11]. Tarique Haider and Mariam Yusuf, ,A Fuzzy Approach to Energy Optimized Routing for Wireless Sensor Networks, The International Arab Journal of Information Technology, 6(2) , 2009,179-188.

[12]. Vidhyapriya , Dr P T Vanathi,' Energy Efficient Adaptive Multipath Routing for Wireless Sensor

Networks, IAENG International Journal of Computer Science,34(1),2007, 24-31.

[13]. Wang Yu, Zheng Guping,, Advance Detour Strategy for Geographic Routing in Wireless Sensor networks, In Proc of IEEE computer society, 2009, 296-299.

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