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Geographic-Aware Energy Efficient Forwarding Node Selection for Throughput Improvement in Wireless Sensor Networks

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Abstract: **Wireless Sensor Networks (WSNs) provides a new model for sensing and spreading information from different environments, with the possibility to serve numerous and various applications. Wireless sensor network is a collection of various small micro-electro-mechanical devices. These small devices have sensors, capability of computation, supply of power and the wireless transmitter and receiver. Existing schemes are prolonging network lifetime or improving throughput which are not focused on location of wireless devices since wireless devices can change its location there are major disadvantage in clustering the nodes. The proposed process focus on dynamic clustering mechanism for geographic aware multilayer cluster design for energy efficient forwarding node selection, cluster heads rotation and both inter-cluster and intra-cluster geographic routing. To improve throughput, role of cluster head is rotated among various nodes based on threshold levels which reduces the number of dropped packets.**

Keywords: **Wireless Sensor Networks (WSN), Clustering, Static Cluster, Dynamic Cluster, Network Lifetime.**

I. INTRODUCTION

Wireless networking is comprised of number of numerous sensors and they are interlinked or connected with each other for performing the same function collectively or cooperatively for the sake of checking and balancing the environmental factors. This type of networking is called as Wireless Sensor Networking. With the growth and advancement in Micro-Electro-Mechanical System (MEMS) technology and wireless communication technology, there is a noticeable advancement in wireless sensor networks (WSNs). WSN incorporates huge number of small sensor nodes that are disseminated in big area consisting of base stations (BSs) or powerful sinks which gather information from these small sensor nodes. Every sensor node has restricted supply of power and also has the ability of processing of data, wireless communication and sensing of information.

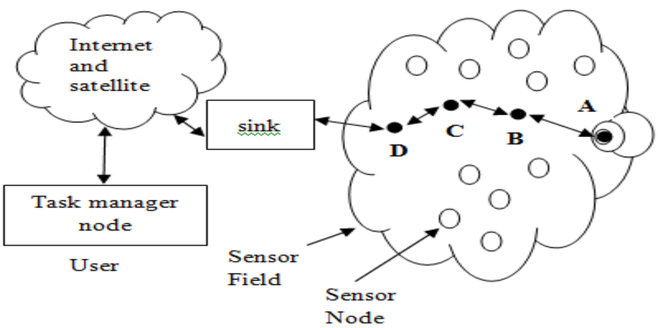

Fig.1.1 Wireless Sensor Networks

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Every sensor node gathers the data and forwards the data to the base station. It is not necessary for the nodes to communicate at the similar time and also they can communicate with the nodes which are closer. To handle the messages routing in between the sensor nodes, there is routing protocol in the network. This routing protocol likewise endeavours to get messages to the base station in an energy productive way. The master node is a base station. The base station may correspond with the other sensor nodes.

Grouping sensor nodes into clusters has been widely adopted by the research community to satisfy the above scalability objective and generally achieve high energy efficiency and prolong network lifetime in large-scale WSN environments. The corresponding hierarchical routing and data gathering protocols imply cluster-based organization of the sensor nodes in order that data fusion and aggregation are possible, thus leading to significant energy savings. In the hierarchical network structure each cluster has a leader, which is also called the cluster head (CH) and several common sensor nodes (SN) as members.

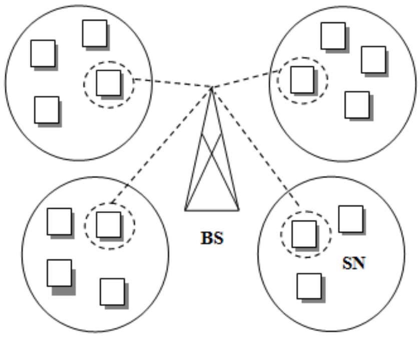

Fig.1.2: Cluster Based Model

The cluster formation process eventually leads to a two-level hierarchy where the CH nodes form the higher level and the cluster-member nodes form the lower level. The sensor nodes periodically transmit their data to the corresponding CH nodes. The CH nodes aggregate the data (thus decreasing the total number of relayed packets) and transmit them to the base station (BS) either directly or through the intermediate communication with other CH nodes.

II. RELATED WORK

An energy-aware distributed unequal clustering protocol (EADUC) in multi hop heterogeneous wireless sensor networks. It elects cluster heads based on the ratio between the average residual energy of neighbor nodes and the residual energy of the node itself, and uses uneven competition ranges to construct clusters of uneven sizes. The cluster heads closer to the BS have smaller cluster sizes to preserve some energy for the inter-cluster data forwarding, which can balance the energy consumption among cluster heads and prolong the network lifetime[6]. The whole operation is divided into rounds, where each round contents setup phase and data transmission phase just like LEACH.

To form a clustering topology, the setup phase is divided into three sub phases: neighbor node information collection phase, cluster head competition phase, and cluster formation phase; In the data transmission phase, cluster members collect local data from the environment, and send the collected data to the cluster heads, cluster heads receive and aggregate the data from their cluster members, and then send the aggregated data to the next hop nodes based on the routing tree we have constructed. Data transmission phase should be longer than setup phase to save the overhead of the algorithm and prolong the lifetime of the network.

Threshold Based Load Balancing Protocol for Energy Efficient Routing in WSN (TLPER) specifically target the scalable, fault tolerant and load balancing feature by synergistic mating of multi hop and direct routing, energy efficient, load balancing and role transfer threshold and multi Assistant Cluster Heads (ACH). [5]Homogenous sensor nodes, same initial energy level, deterministic deployment, centrally preselected cluster heads (CH) and preselected ACHs. Each node may know its neighboring nodes as well as its Vicinity Head (VH). The term Vicinity Head applies to CH and ACH. At initial stage, selection of CH and ACH is on hand. Due to the homogenous nature of nodes, the node having the more neighbors is designated as Vicinity Head (VH).

LEACH uses single-hop communication; it cannot be deployed in networks spread over large distances. Cluster heads are elected only on the basis of probability, not taking energy into consideration, LEACH cannot provide actual load balancing. Cluster heads are elected on the basis of probability, uniform distribution cannot be ensured. So, there is a chance that the elected cluster heads are concentrated in one part of the network and some nodes might not have any cluster heads in their vicinity. The idea of dynamic clustering brings extra overhead.

III. PREVIOUS IMPLEMENTATION

MCDA:

Multilayer Cluster Designing Algorithm (MCDA) is a hybrid approach in its communication architecture (CA) perspective and architectural design (AD) perspective [2]. The available CAs in the literature has flat-based and cluster-based network architectures. The cluster-based network architecture has two main approaches: centralized and distributed. MCDA uses multilayered approach comprising a first flat layer in the footprint of the base station and the subsequent clustered layers. Any clustering algorithm normally comprises three phases, namely set-up phase, steady phase and routing phase. The first one is related to cluster designing where all communication process works for cluster designing. In literature this phase comprises CH election/selection, CM selection and route establishment. This phase is called off-line phase or passive phase since all messaging is of control packets and no data are traversed in the network. The other phases come in operational or active phases and data are actually in the network for aggregation and routing.

Clustered Layer Design:

Second layer nodes elect the node with highest node density as their decision maker node. Time slots are assigned to these nodes based on the Time Division Multiple Access (TDMA) technique. When the first node of the second layer communicates its nodal density to a decision maker node, it assigns a sequence number with postfix counter “0” to this packet. All the recipient nodes of the second layer nodes save this packet sequence number and become a part of the same group. All the nodes having packets with the same packet sequence number are included in the same group. Only those nodes of a group communicate their nodal density to decision maker nodes which have highest nodal density than their previous nodes.

These nodes increment the postfix counter, that provides a two advantage: (i) to let the other member nodes of the same group know about their nodal density; (ii) to let the non-member nodes know that they should neither continue this postfix counting nor should they save any information about other group’s member nodes. This postfix counter assists the packet sequence number in separating the members of one group from other. The node right after the last member of first group communicates to its decision maker node and assigns a new packet sequence number with postfix counter “0”. After collecting the nodal density of the second layer’s selected nodes, the decision maker nodes elect the CH having the highest nodal density among the second layer’s addressed nodes.

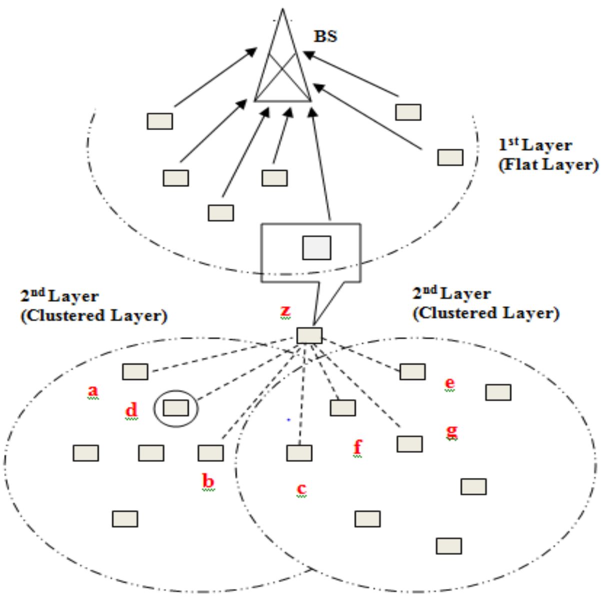

Fig.1.3: Layer Designing in MCDA

Static Cluster:

The static clustering methods aims only at minimizing the energy spend during the formation of the cluster for the given parameters. The network parameters are not changed.

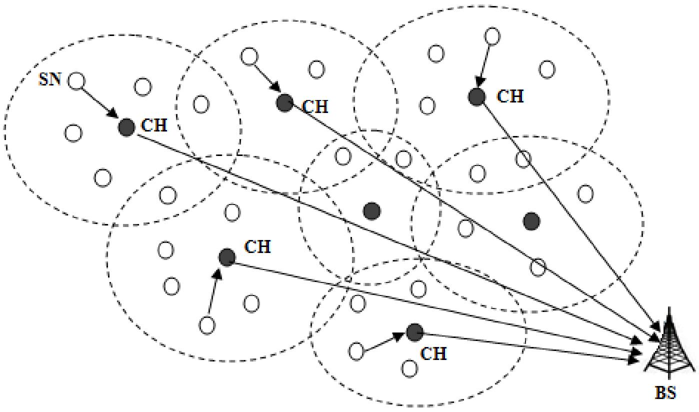

Fig.1.4: Static Cluster in WSN

IV. PROPOSED SYSTEM

G-MCDA:

Even though the existing MCDA algorithm has many metric it also has some de-metrics which is mentioned to overcome this problem geographic aware clustering mechanism and cost-effective routing is added by making some changes to the existing MCDA. In the neighbor prediction unlike existing MCDA it takes the number of nodes in its neighbor with their geographic coordinate so that it will help us to find the distance and direction of corresponding neighbor node. At the clustering phase (i.e.) at layer-2 instead of using sequence number for clustering it uses distance to create the clustering region which is more accurate than previous technique. At Cluster member selection routing process is more effective because of geographic aware routing because it will choose the best path to transfer data according to its current location.

Cluster Formation:

Modified K-means is an exclusive clustering algorithm and it is the one of the simplest unsupervised learning algorithms that solve the clustering problem. Wireless Sensor Network has number of nodes, which are randomly scattered over the sensor network. The location information of each node is required, because it is essential to know where the information is sensed in the sensor network. The sensor nodes which are deployed in the sensor network, knows their location information. The coordinates (xi, yi) of each sensor node are used to estimate the distance between two sensor nodes. The distance between reference nodes is computed by using this formula,

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

Where, (x1, y1) and (x2, y2) are the coordinates of the reference node.

Based on minimum distance and highest energy, the sensor nodes are clustered by using Modified K means clustering algorithm. In the first step, randomly select c cluster head with their xi, yi coordinates. Then calculate the distance between each sensor node and the randomly selected cluster head and also get the energy of each node. Assign the sensor nodes to the cluster head whose distance from the cluster head is minimum of all the cluster heads and has the highest residual energy. In the next step, re-compute the cluster head by using centroid method. Calculate the sum of all x coordinate of sensor node in the cluster and divide it by the number of cluster nodes, similarly for y coordinate. This is the centroid method.

Cluster Head Selection:

The sensor nodes are arranged into several clusters and in each clusters, one of the sensor nodes is chosen to be cluster head (CH). After the formation of cluster, re-compute the Centroid of the clusters resulting from the calculated distance. Calculate the Centroid point of each cluster in the wireless sensor network. The Centroid point is the new coordinate which is not equal to any position of sensor node in the wireless sensor network. So, this new coordinate cannot be select as a cluster head, because it is a location based clustering scheme. The current position of the cluster head should be known. After finding the Centroid position, find the minimum distance between the Centroid position and the cluster members. The sensor nodes which have the minimum distance from the Centroid point is a new cluster head.

In some cases, if a cluster head gets down, when the threshold value becomes less than the fixed threshold value, recomputed the cluster head based on minimum distance and highest energy. Cluster head which is high energy node present in the cluster. This selected high energy will serve as CH for that particular cluster for a period till the node energy reaches a minimum threshold value. Once the minimum threshold value is reached, selection of CH is performed in the same cluster. Now, selection of cluster is based on residual energy of the node. That is node having high residual energy is elected as CH and the process continue.

Calculate the new cluster center using:

$C(x) = \frac{1}{cl}\sum_{j=1}^{cl}(xi)$

Similarly for y coordinate.

$C(y) = \frac{1}{cl}\sum_{j=1}^{cl}(yi)$

Where, C(x) and C(y) is the x and y coordinates of the cluster centre.

Routing Protocol:

Routing is the process of selecting paths in a wireless sensor network along which to send network traffic. Ad-hoc On Demand Distance Vector (AODV) is a distance vector routing protocol. It is a reactive routing protocol; therefore, routes are determined only when needed. In this paper, the modified K means Clustering algorithm is added to the existing AODV protocol, to form a new K-AODV where K represents the K means clustering algorithm. Routing takes place between the cluster head and the cluster members and also between the cluster head and the base station. There is no direct communication between the cluster members and the base station. The Cluster members forward the packets to the respective cluster heads and the cluster head will forward the packets to the base station. If the base station is far away from the cluster head, multi-hop communication will takes place. The cluster head will forward the packets to the nearest cluster head and this nearest cluster head will send the packets to the base station.

Dynamic Cluster:

Dynamic clustering also aims to minimize the energy consumption by changing the network parameters (Node position, Node distance, Cluster member).

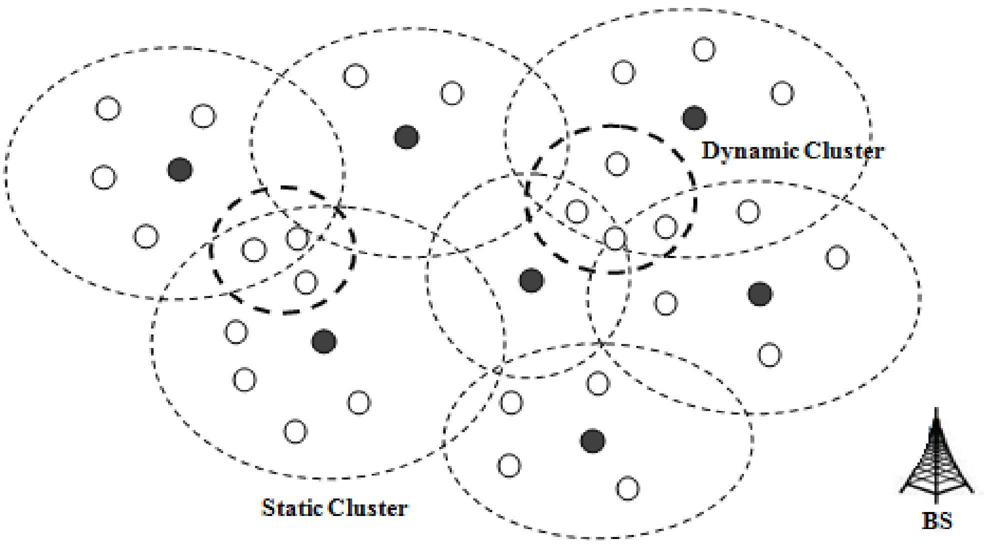

Fig.1.5: Dynamic Cluster in WSN

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V. SIMULATION RESULT

This experiment was done using the NS2 simulation software and the properties configured

TABLE.I: Simulation Parameters

Parameter	Description
Routing Protocols	G-MCDA
Channel Type	Wireless Channel
Network Interface Type	Phy/wirelessphy
MAC type	802.11
Max packet in IFQ	50
No of mobile nodes	15
Simulator	NS 2.35
Data Rate	4 Packets/S
TCP/IP Layer	Network Layer
Node to Node Distance	Random
Node Type	Homogenous
Ground Initial Energy of Node	100J

With the Help of the NS-2 Simulator tool to prove the following performance metrics like:

1. Average Energy consumption in forwarding node selection

2. Average Energy consumption for transmitting one packet from source to destination

3. Total energy consumption in cluster design

The present nodes need to know the neigh boring node and it has to select an neigh boring node as the forwarding node energy consumed at this process is taken and are plotted in the graph which shows G-MCDA has lower power conception.

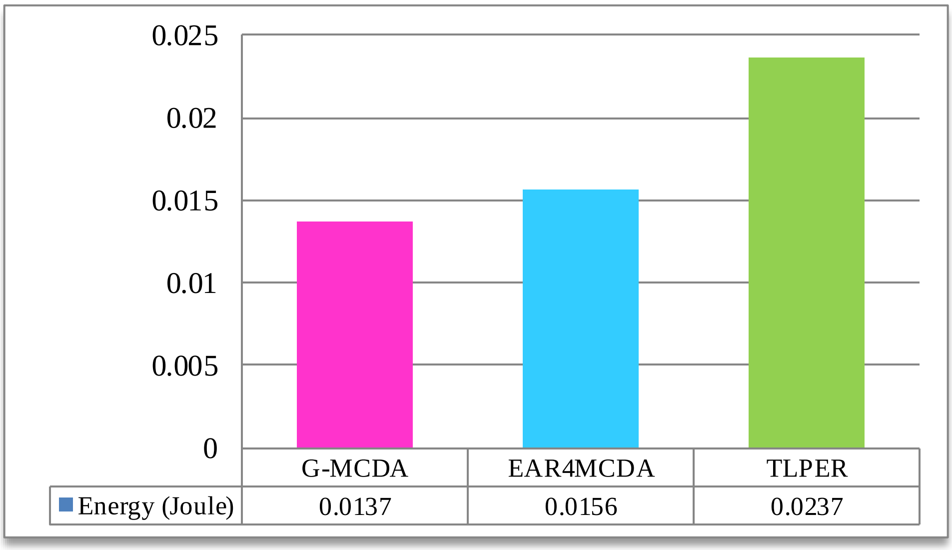

Fig.1.6: Energy Consumption in Forwarding Node Selection

The data transmitted from source to destination has many power conception criteria like route selection, forwarding node selection, distance of the nodes etc. These aspects are included in this measurement and are plotted in the graph which shows that the proposed protocol consumes less than the existing system.

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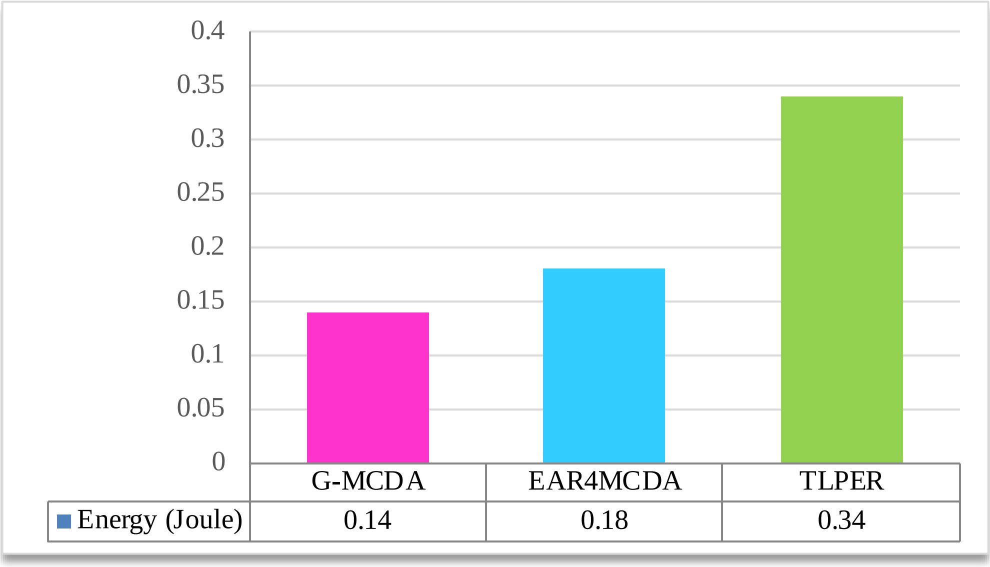

Fig.1.7: Energy Consumption for transmitting one packet from source to destination

Before the start of the operational phase of the network, it needs to be setup for it. Measured the energy that is consumed in designing the clusters, *i.e* making the network ready for the operational phase and are plotted in the graph.

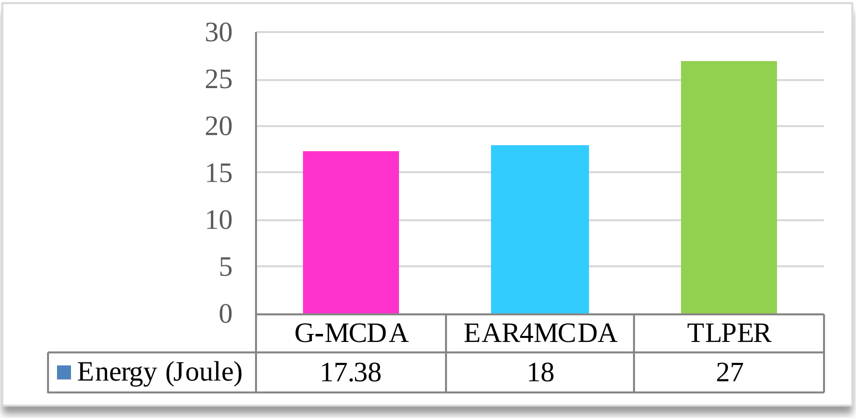

Fig.1.8: Energy Consumption in Cluster Design

VI. CONCLUSION

Clustering is an important issue in Wireless Sensor Network. Information gathering and routing are carried out based on the position of the sensor node. It can be easily achieved by enabling GPS in every node. The sensors nodes are deployed in the wireless sensor network which aware of their own position information. By knowing the position of the entire sensor node in the WSN, cluster the sensor nodes based on the energy, shortest path distance. The cluster head will be selected based on Centroid Position Clustering of nodes by using modified k-means clustering algorithm can minimize the residual energy and maximize the performance. It improves the network lifetime and reduces network traffic. To further improve the energy conception and routing efficiency AODV routing which is dynamic, self-starting, multi-hop routing between mobile nodes also it avoids counting to infinity problem. The proposed protocol is experimented using the NS2 simulator and the values are plotted in the graph which shows that the proposed protocol consumes less energy.

VII. FUTURE ENHANCEMENT

Geographic forwarding strategies are based on packet loss models derived from real data measurements. Although, the results shown here are for a specific model; the framework, strategies and conclusions are quite robust and can be applied to other models as well. As a matter of fact, an earlier version of this paper used a channel model based on this is less accurate than the current model. Even though the earlier model has a more uniform distribution of packet loss rates, the main results and conclusions observed are consistent between the two models. Key results from our study indicate that the some loss in packet rate. Efficient geographic forwarding strategies do take advantage of links in the high variance transitional region both for energy-efficiency and to minimize route disconnections. So efficient reliable strategies could be combined with this algorithm to make it energy efficient as well as reliable. Therefore the above model would result in less energy as well as reliable.

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