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Wireless Sensor Network: A Clustering Approach LEACH and Data Aggregation Protocol

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Abstract: Wireless Sensor Network technology has been one of the most transforming and empowering technologies in recent years. . In wireless sensor network data is transmitted through multihop communication to the sink. Data aggregation is a well-known method in WSN and it is a procedure of collecting and aggregating the data from multiple sensors to eliminate redundant transmission and provide combined information to the base station. This process proceeds for many rounds in collecting these data efficiently that is to reduce the energy cost of data transmission. Conventionally tree-based structured approach is a basic operation for periodically sensing and collecting reports from all sensors nodes and sends it to the sink. Though tree based approach is more efficient way in transferring the data to the sink. It can find the shortest path between the leaf nodes and sink for transmitting the data in order to reduce the energy utilization. It is been known that this paper proposes two algorithms such as Angular Query Region Division Routing Algorithm and Query Region Division Routing Algorithm with LEACH. In Angular algorithm data aggregation protocol are used for sensing and collecting the data. In LEACH, clustering approach is used for collecting the data. This algorithms focus on two problems such as lifetime extension and energy consumption. The experimental results of the two algorithms are illustrated with below using ns2 simulation.

Keywords: Multihop communication; tree structure; Query Region Division Routing; LEACH**.**

I. INTRODUCTION

Wireless Sensor Network has become the most advanced technology in the field of communication and computer research. Wireless Sensor Networks (WSNs) can be defined as a infrastructure less wireless networks to monitor physical or environmental conditions, such as temperature, sound, humidity, vibration, pressure, motion or pollutants and pass their data through the network to a main location or sink where the data can be observed and analyzed. A sink or base station acts like an interface between users and the network. One can retrieve required information from the network by injecting queries and gathering results from the sink.

In the habitat monitoring [2] and civil structure maintenance [3] sink is mainly used for collecting the data and send back the result to the sink. Typically a wireless sensor network built with hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals.

The individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, energy consumption, storage capacity, and communication bandwidth. After the sensor nodes are deployed, they are responsible for collecting the data often with multi-hop communication with them. Data aggregation algorithm is main technique used in WSN for collecting data from sensory nodes.

The main goal of data aggregation algorithms is to collect, gather and aggregate data in an energy efficient manner so that network lifetime is enhanced. As there are variety of aggregation function such as Min, Max, Sum, Avg, Count, Standard Deviation and many other moment of measured data.

The efficiency of data aggregation is mainly determined by the routing structure. Tree based routing structures have also been studied extensively and from different perspective, e.g., in-network processing of aggregate queries, maximizing geographic knowledge, balancing workloads, as well as exploiting knowledge about the mobility of sinks. An approach that combines tree-based and multipath-based routing, called" Tributaries and Deltas", was presented in [7].

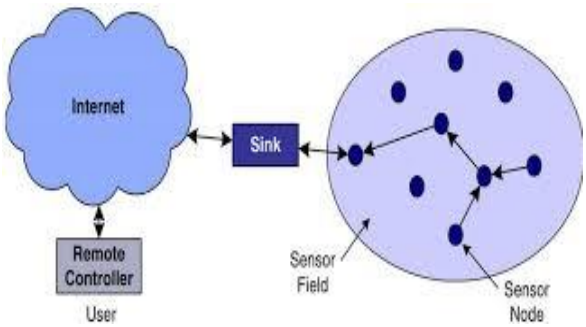

Fig 1. Wireless sensor network

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Tributary-Delta, a novel approach that combines the advantages of the tree and multi-path approaches by running them simultaneously in different regions of the network. Some advantages of Wireless sensor network are:

- Wireless Sensor Network setups can be carried out without any fixed infrastructure.
- Suitable for the non-reachable places such as sea, mountains, rural areas or deep forests.
- Flexible if there is random situation when additional workstation is needed.
- It might accommodate new devices at any time.
- It's flexible to undergo physical partitions.
- It can be accessed by using a centralized monitor.

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II. CLUSTERING APPROACH AND DATA AGGREGATION

A. Clustering Approach

The clustering approach is most important technique in WSN. It is concept of grouping the sensor nodes in the network to form cluster. After cluster formation, Cluster head selection is an important concept. CH can selected based on randomly or by using residual energy and energy level of nodes in each cluster of the network. Clustering mechanism in sensor networks has exposed to reduce the communication overhead by balancing the energy consumption. The Objectives of clustering approach are Load balancing, minimum communication overhead, fault-tolerance, reduction in delay, increase the lifetime of the sensor network.

B. Data Aggregation

This protocol aims at eliminating redundant data transmission and thus improves the lifetime of energy controlled wireless sensor network. In WSN, data transmission took place in multi-hop manner where each node forwards its data to the neighbor node which is nearer to sink. It is a procedure of aggregating the sensor data using aggregation approaches. The general data aggregation algorithm works as shown in the below figure. The algorithm uses the sensor data from the sensor node and then aggregates the data. This aggregated data is transfer to the sink node by selecting the efficient path.

The compensation of data aggregation is: By aggregating the data collected from source node and send it to destination can decrease the number of transmission and it can reduce the energy usage in the sensor network. It can also enhance the robustness and accuracy of information in the network and also it reduces the load traffic in the sensor network.

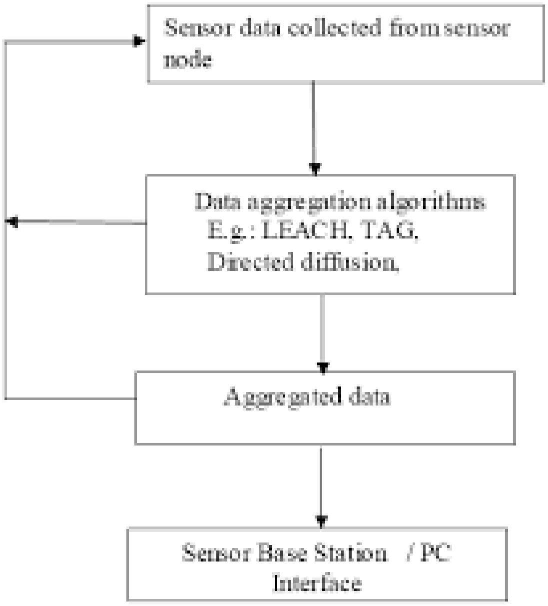

Fig 2.Architecture of Data Aggregation

III.DILEMMA AND QUERY FORMATION

A. Dilemma

If User wants any details regarding information in the network allow, user creates a declarative query over the sensor network, a user connects to one of the sink formulates and submit the query to the sensor network. It adheres to the Tiny-SQL query language. Tiny-SQL query language is a query processing system for extracting information from a network. It describes the data they wish to collect and how they wish to combine, transform, and summarize it.

When the sink node is physically located within the query region for small-scale sensor networks, then the aggregation tree construction is initiated directly at the sink node, which in turn becomes the actual root of the tree. Hence the mechanisms of splitting trees cannot be applicable in this scenario. By separating the sink from the root and establish point to point route from root to the sink.

In the point-to-point route will have to share the nodes of the aggregation tree, effectively doubling their load. On the other hand, will be investigating lifetime gains can be indeed obtained in this scenario. In large scale sensor network the user is interested to sample remote areas of the network, rather than the entire wireless sensor network. Fig. 2 gives an illustrates the large scale sensor network in which the router are constructed.

But it should not cross the construction of aggregation tree area in order to prevent wireless medium contention and to reduce the load. In this figure the network is divided into 3 split trees and their roots in 3 sub query region which is used to ship aggregate the result to the sink. The geographical-based shortest-path routing is used to implement the data transmission [3].

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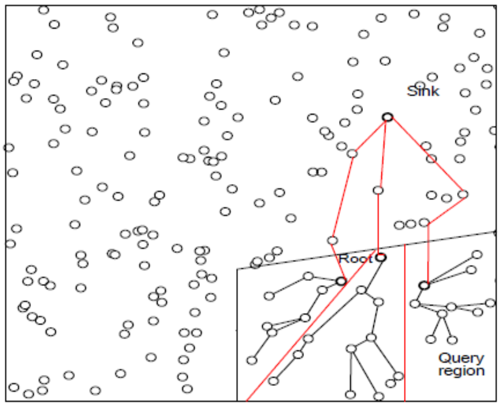

Fig 3. Sink node is physically located outside the Q region then it divided into 3 sub region, one routing tree has been constructed

B. Query Formation

The wireless sensor network consists of N nodes, SN = {S1, S2… SN} and each node is aware of its location, through a GPS or some beacon message. Each node knows the location of its one-hop neighbors, the nodes within its communication range. If nodes are to be static and their geographic locations do not change over time.

A query, Q is specified as a sextuple (Sink, QR, Sval, F, Δ, Type), where:

1. Sink is the ID of the sink node, which is the final destination of all the packets.
2. QR is the geographic region of interest, from which the reading of a particular value is needed;
3. Sval describes the value that needs to be monitored (e.g., temperature);
4. F denotes the sampling frequency for the query;
5. Δ specifies the temporal duration, in terms of an interval [tbegin, tend];
6. Type is a string that specifies the query operation performed like, some aggregate function (e.g., SUM, COUNT, AVG, MEDIANS) or simply gathering the readings of individual nodes.

The Standard geographical routing protocol is used to construct a routing tree at a particular node.

IV. MULTIPATH ROUTING APPROACH WITH DISJOINT TREES

This approach can be used for following purposes: load balancing, energy consumption which in turn prolongs the network lifetime and robustness of the transmission. Compare two algorithms with their impact on the load balancing in terms of energy consumption of the nodes. The benefits in a given sensor network may gain when multiple trees are used for routing the results of a given query Q pertaining to a geographic region. In Fig. 2 presents a scenario in which the readings of the sensors in a region Q are transmitted to a sink. Hence, the routing is executed using multiple trees combined with the GPSR (Greedy Perimeter Stateless Routing) paths. Consequently, the two ways in which the set of nodes can be split into subsets in Q that will form multiple trees that will transmit with disjoint trees parallelly.

A. Angular Query Region Division Routing Algorithm

this algorithm based on the user's query the network region is divided and data aggregation can get performed. The algorithm can be classified into four stages :(1) dividing query area, (2) distributing query message(3)constructing routing trees and (4) collecting sensor readings. Consider Fig. 3 can be the example of this algorithm.

In (1) rectangle ABCD represents the query area and S is sink node. The ∠ASB is divided into n equal parts by angular bisector segment, which have passed through the query area ABCD and the region will be divided into n sub-regions. In geographic routing based query message multicast protocol and an itinerary based data collection protocol, which saves energy of distributing query messages with the query area broadcast query messages. The data collection protocol returns the results back to the sink through geographic routing protocol, which reduces the number of data forwarding.

In (2) the sink node sends query message to the close neighborhood nodes of each query sub region. In fig 3. the red nodes are called root nodes. A root node sends a message to entire queried region. From that message the aggregation root's level is assigned which depends on how many hops away from the root. Initially the aggregation root's level is zero. Any node without an assigned level that receives this message then its own level to be plus one with their respective message level.

In (3) the node which is closest to the aggregation root is chosen as parent node. Based on the query message within the sub query area, a number of routing tree have been constructed with the aggregation root node (i.e) red node.

In (4) each node continuously sense the data in the network and it is routed towards the root and finally to the sink or query node. Routing tree structure is used to transmit the data towards the sink level by level.

In this case, each node has one and only one parent but parent node can have multiple children as shown in Fig.3.The intermediate nodes of the tree are not applicable to parent child communication.

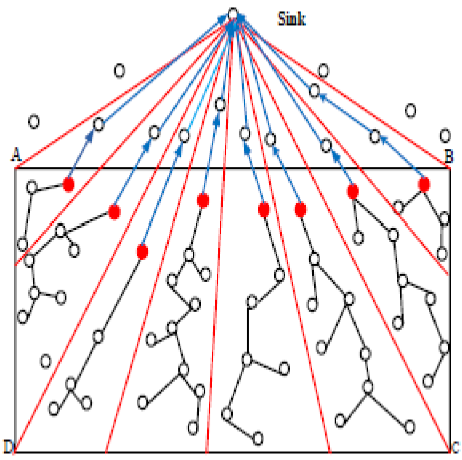

Fig. 4. The angular query region division

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At each intermediate node, the aggregation function (MAX, MIN, AVG, SD, COUNT, MEDIAN) can be applied based on the query specification before transmitting the data to the sink. The collected data is transmitted to the parent along the routing tree in level by level until to the red nodes. The data collection protocol returns the result back to the sink through geographical routing protocol. Geographical routing protocol uses location information to formulate an efficient route search toward the destination. It is very suitable to sensor networks, where data aggregation is a useful technique to minimize the number of transmissions toward the base station. Some merits of geographical routing are it is scalable and supports mobility. It can posses minimum overhead.

B. Query Region Division Routing Algorithm with LEACH

LEACH (Low Energy Adaptive Clustering Hierarchy), a clustering based protocol that minimizes energy consumption in sensor network. This algorithm adopts two ways to transfer data both inter and intra regions for avoiding routing hole in the network. It outperforms classical clustering algorithms by using adaptive clusters and rotating cluster heads allowing the energy requirements of system to be distributed among all nodes.

It consists of two phase: (i) Setup phase (ii) Steady state phase. In this algorithm nodes are organized into sub-regions that communicate along with tree structure towards to local root and then to global sink respectively.

During Setup phase, cluster formation and cluster head selection can be takes place. Here the sensor network is clustered based on user's query. After the cluster formation one node in each cluster will selected randomly then choosing that node as a clustered head in each region.

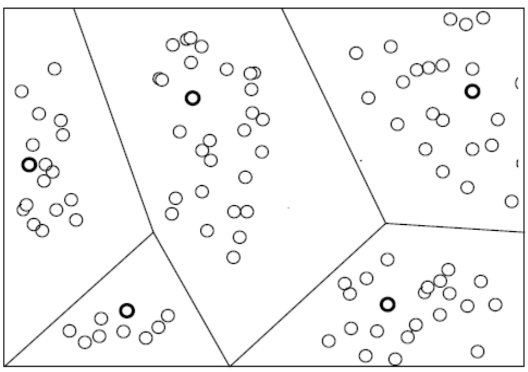

Fig. 5. Query region division routing algorithm with LEACH

During Steady state phase, each cluster nodes sends their data to each cluster head in cluster formation. Each cluster node communicates with cluster head via single hop communication. Finally each cluster head aggregates the collected data and send it to base station or sink. After sometime, the network goes back to the setup phase respectively. If Clusters are selected randomly, this results in uneven distribution of Clusters. For e.g. some clusters have more nodes and some have lesser nodes. Some cluster heads at the center of the cluster and some cluster heads may be in the edge of the cluster; this phenomenon can cause an increase in energy consumption and have great impact on the performance of the entire network. This is main demerits in this algorithm.

V.COMPARSION BETWEEN ANGULAR AND LEACH ALGORITHMS

The Comparison between two algorithms and their experimental result and their evaluation of this paper will be illustrated below:

Comparison between algorithms

Fig 6-9 shows the comparison of energy consumption in terms of no. of sensor nodes, region division, PDR ratio and the size of sensor data between these two algorithms. Angular Query Region Division Routing Algorithm is slightly outperforms than that of LEACH algorithm. The path of sensing data from all node and return the result back to the sink node is shorter in angle algorithm than that of LEACH algorithm; nevertheless energy consumption will greatly get reduced. In LEACH, the randomly selected cluster head can cause many problems in the network such as which does not take energy consumption of the different nodes within the cluster and also to any reason Cluster head dies, the cluster will become useless because the data gathered by the cluster nodes would never reach its destination i.e. Base Station. In angle algorithm when the number of the query sub-region becomes larger, and when all the query sub-regional angles satisfy the controlled condition, the sensory data from all nodes are able to be aggregated within the query area, which results in better quality of packet delivery fraction. Since the node sends query message and collect sensing data, both have a gradual increase of energy consumption. Fig.8 illustrates the energy consumption with the increase of the size of the sensory data. Whenever increase in the number of sub query regions, the number of the root nodes becomes more in the query region. The distance between the intermediate nodes and the aggregated rooted nodes is closer to the sink node.

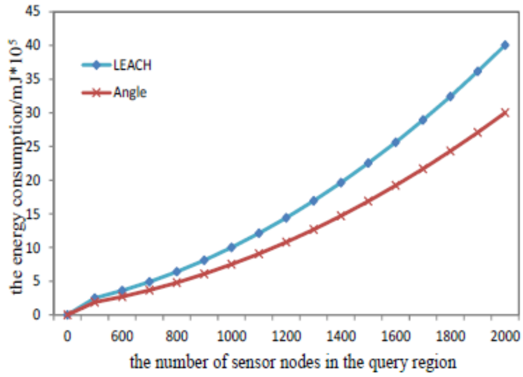

Fig 6. The energy consumption as function of no. of sensor nodes

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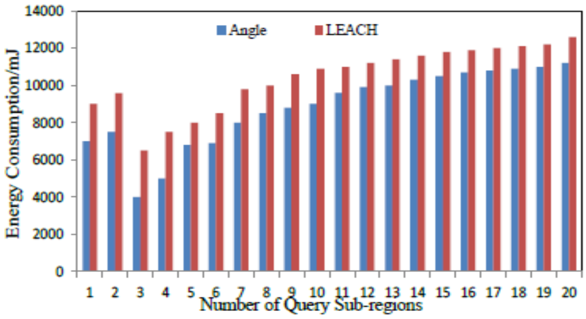

Fig 7.Comparison of the energy consumption based on the region division

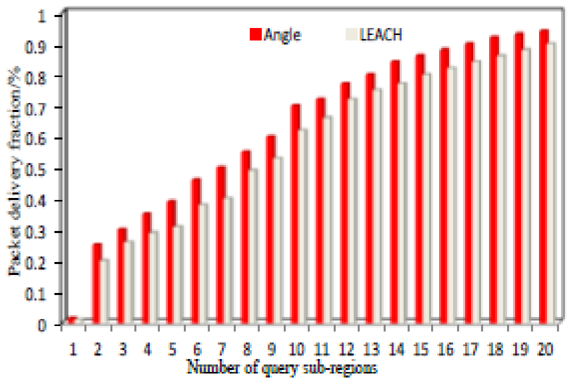

Fig 8. Comparison of the successful PDR ratio based on the region division

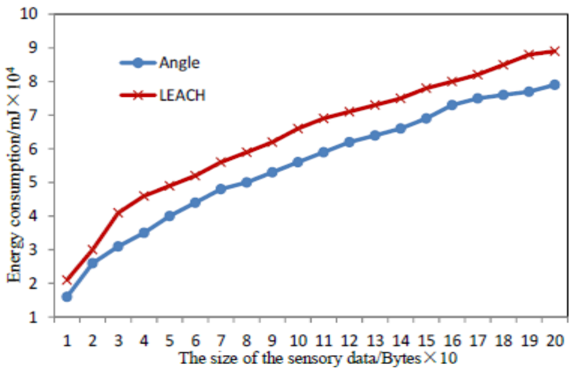

Fig 9.The energy consumption as function of the size of sensor data

VI CONCLUSION

In this paper presented the comprehensive study on the LEACH and angular division routing algorithm in WSN. These two algorithms focus on optimizing performance evaluation such as an energy consumption and network lifetime. The trade-off between energy consumption and lifetime of the sensor network has been highlighted. Hence these algorithms are more suitable for maximizing network lifetime in large scale sensor networks.

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