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An Efficient Data Aggregation Protocol Based on Dynamic Routing for Wireless Sensor Network

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***Abstract*—Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specially designed for WSN's where energy awareness is an essential design issue. The focus however has been given to the routing protocols which might differ depending on the application and network architecture. We have worked on a dynamic data aggregation routing protocol, named DABDR, which has brought improvements in routing, but not much attention is given to timing problem. So we have mainly worked to reduce delay and overhead and also have tried to give a proposal to make sure whether all data have been aggregated or not to make data aggregation more efficient. The paper concludes with possible future research areas.**

***Index Terms*— DABDR, Sensor Network, Data Aggregation, Dynamic Routing Protocol.**

I. INTRODUCTION

A sensor network is a communication infrastructure or group of specialized transducers to monitor record and respond to any phenomena or diverse locations [18]. Sensors can generally monitor temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital body functions [10]. Sensor network's communication infrastructure and protocols are different and challenging from recent Internet-based system because of their requirements and limitations [3].With the advancement of technology, sensor network is implemented with small, low cost, low power, multifunctional, distributed sensors [2]. Each sensor node has ability to perform a limited amount of processing. But when sensor nodes are coordinated with other nodes, they can perform some specific action. In WSN applications, it is usual to locate nodes close or inside the observed phenomenon. This concept of network needs new network protocols which adjust to the new raised requirements. Traditional ad-hoc techniques can not cover those requirements because they cannot adjust to the design principles of this kind of networks that take into account power constraints [2], [12].

Recently, technologies have developed rapidly. However, with the limitation of costs and size, the process capability, bandwidth and battery capacity of sensor nodes is still small. Especially, in many applications, sensor nodes are deployed in unreachable environments so that it is difficult to supplement battery capacity. Therefore, it is necessary to consider how to save resources of sensor nodes with the purpose of prolonging network lifetime [8].

Routing in sensor networks is very challenging due to several characteristics that distinguish them from contemporary communication and wireless ad hoc networks [4].

- First of all, it is not possible to build a global addressing scheme for the deployment of sheer number of sensor nodes.
- Second, in contrary to typical communication networks almost all applications of sensor networks require the flow of sensed data from multiple regions (sources) to a particular sink (command center).
- Third, generated data traffic has significant redundancy in it since multiple sensors may generate same data within the vicinity of a phenomenon.
- Fourth, sensor nodes are tightly constrained in terms of transmission power, on-board energy, processing capacity and storage and thus require careful resource management.

Due to such differences, many new algorithms have been proposed for the problem of routing data in sensor networks.

Depending on the application, different architectures and design goals/constraints have been considered for sensor networks.

Data aggregation is defined as the process of aggregating the data from multiple sensors to eliminate redundant transmission and provide fused information to the base station. Data aggregation usually involves the fusion of data from multiple sensor nodes at intermediate nodes and transmission of the aggregated data to the base station. Data aggregation attempts to collect the most critical data from the sensors and make it available to the sink in an

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energy efficient manner with minimum data latency. Data latency is important in many applications such as environment monitoring where the freshness of data is also an important factor. Many studies on data aggregation have come forward recent years. One simple strategy is that sensor nodes send all data to sink directly. Since nodes in sensor networks are usually much dense, an event will be monitored by many nodes and thus data redundancy rate is high. Furthermore, in order to satisfy the data accuracy required by applications it is not necessary to send all the raw data collected by sensor nodes to sink. Data aggregation will aggregate data packets in intermediate nodes and thus reduce communication consumption [14]. Therefore, data aggregation is necessary and reasonable in sensor networks.

The main challenge of data aggregation is how to keep resource utilization efficient by reducing communication among nodes [11]. It is critical to develop energy efficient data aggregation algorithms so that network lifetime is enhanced. There are several factors which determine the energy efficiency of a sensor network such as network architecture, the data aggregation mechanism and underlying routing protocol [1], [13]. Routing scheme is an important issue required to be considered when designing data aggregation protocol because it determines how data packets flowing to sink. Since aggregation is executed at intermediate nodes of the path through which data flows to sink, routing scheme plays a critical role in whether data aggregation can efficiently reducing communication among nodes or not.

Since sensor nodes might generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions would be reduced. Data aggregation is the combination of data from different sources by using functions such as suppression (eliminating duplicates), min, max and average [15]. Some of these functions can be performed either partially or fully in each sensor node, by allowing sensor nodes to conduct in-network data reduction. Recognizing that computation would be less energy consuming than communication substantial energy savings can be obtained through data aggregation. This technique has been used to achieve energy efficiency and traffic optimization in a number of routing protocols. In some network architectures, all aggregation functions are assigned to more powerful and specialized nodes.

Most of the routing schemes in present data aggregation protocols are static, that is, how data will flow to sink is determined before data being collected. There is a data aggregation protocol based on dynamic routing named DABDR, is proposed in [16], to make data aggregation more efficient. In [16], dynamic routing technics are proposed for data aggregation, but much attention is not given to timing problem. So, we have proposed how to reduce delay and overhead and also try to make sure whether all data have been aggregated or not, to make data aggregation more efficient.

This paper is organized as follows: Section II provides the literature review. The proposed solution is presented in section III. Section IV represents the conclusion. Section V depicts results and Section VI mentions the future work.

II. Background and Related Works

A. Data Aggregation and Static Routing

Routing schemes in present data aggregation protocols are static, that is, how data will flow to sink is determined before data being collected. Present data aggregation protocols mainly based on three kinds of routing schemes which respectively organize sensor networks into clusters, a chain or a tree. Cluster-based data aggregation protocols organize sensor nodes into clusters, a Chain, a tree.

Cluster has a designated sensor node as the cluster head which aggregates data from all the sensors in the cluster and transmits the concise digest to the sink. The typical examples are LEACH [6] and HEED [17]. The distinct of these two protocols are the method of selecting cluster heads. LEACH assumes all the nodes have same amount of energy capacity in each election round. The main goal of HEED is to form efficient clusters for maximizing network lifetime. Cluster –head selection is based on a combination of node residual energy of each node and a secondary parameter which depends on the node proximity to its neighbors or node degree [4]. Compared with the scheme that all the sensor nodes directly transmit all the data to sink, cluster-based data aggregation protocols reduce the amount of information that is transmitted to the sink and thus save energy [4], [7].

One disadvantage of cluster-based data aggregation protocols is that if sensor nodes are far away from their cluster head, they might expend excessive energy in communication. Further improvements in energy efficiency can be obtained if sensors transmit only to close neighbors.

Chain-based data aggregation protocols organize sensor nodes as a chain along which data flow to sink. The key idea behind chain-based data aggregation is that each node transmits only to its closest neighbor. The chain can be constructed by employing a greedy algorithm or the sink can determine the chain in a centralized manner. Greedy chain formation assumes that all nodes have global knowledge of the network. A typical chain-based data aggregation protocol PEGASIS employ the greedy algorithm to construct the chain. The distances that most of the nodes transmit are much less compared to LEACH, in which nodes transmit to its cluster head. Hence, PEGASIS protocol has considerable energy savings compared to LEACH [4].

Tree-based data aggregation protocols organize sensor nodes into a tree where data aggregation is performed at intermediate nodes along the tree and a concise representation of the data is transmitted to the root node which is usually the sink. One of the main aspects of tree-based networks is the construction of an energy efficient data-aggregation tree.

Yet, present tree-based routing schemes will determine routing paths only by considering some constant parameters such as-- distances between nodes, residual energy of nodes and so on [9]. The routing paths cannot change with the range and contents of collected data and thus will not make data aggregation efficient.

B. Data Aggregation Protocol Based On Dynamic Routing (DABDR)

Data aggregation has been proposed as one method for reducing energy consumption in sensor networks. One critical factor in data aggregation is routing. Most of the present routing schemes for data aggregation are all static and thus cannot change when data packets flowing to sink. There is a data aggregation protocol based on dynamic routing (DABDR) is proposed in [16]. The dynamic routing in DABDR is based on two potential fields: *Depth potential field* and *DA queue length potential field*. Depth potential field is to make packets flowing to sink and DA queue length potential field is to make packets more concentrated in spate and thus data aggregation will be more efficient. Simulations in 100m*100m network show that DABDR is 10 times better than protocol without data aggregation and 2 times better than data aggregation protocols based on shortest past tree in terms of energy consumption [16].

Two main problems need to be considered to design a data aggregation protocol: routing scheme and timing scheme. Routing scheme determines the path along which packets flow to sink. Timing scheme determines when aggregation will be executed. In DABDR, routing will organize some nodes in sensor network into a tree. Each parent will wait packets from its children for a specific time according to the timing scheme and then execute aggregation.

In DABDR protocol, routing of packets is determined by the hybrid potential field. There is a queue, called *DA queue* which stores data packets that will be aggregated. A long DA queue of a node indicates that the node is a good place to execute aggregation because data aggregation will be more efficient in terms of energy consumption if data packets are more concentrated in spate. Hence, two potential fields: depth potential field and queue length potential field has been constructed [16]. Depth potential field is to ensure the direction of data flowing is from sampling nodes to sink. And queue length potential field is to make data packets flowing to nodes with long DA queue length so that data packets are concentrated in spate and thus to make data aggregation more efficient. Here, it is assumed that all the packets in sensor network can be aggregated. In other words, there is only one application in the sensor network.

The main timing strategies proposed so far in the literature can be classified as below [16]:

- Periodic simple aggregation works by having each node wait a pre-defined period of time, aggregate all data items received, and send out a single packet containing the result.
- Periodic per-hop aggregation mechanisms have node sends aggregated data as soon as the node hears from all of its children. A timeout is used in case some children's packets are lost.
- Periodic per-hop adjusted uses the same basic principle of periodic per-hop but schedules a node's timeout based on its position in the distribution tree that is rooted at sink and spanning all reporting nodes as well as some intermediate nodes.

A data aggregation protocol taking a timer scheme that falls into the periodic per-hop adjusted category, has been proposed in [16].

III. Proposed solution on DABDR

Though DABDR has brought solutions to static routing problems for data aggregation on sensor networks, much attention is not given to timing problem. Also there dynamic routing may face problems, like- more overhead. DABDR is mainly based on periodic per hop adjusted category and mainly focused on this.

Data aggregation based on dynamic routing is sampled in Fig.1. Green arrows represent the possible path if employing present tree-based data aggregation protocols. Data generated at flow to sink along the orange arrow is anticipated.

As shown in Fig.1, if routing scheme just selects a minimum path in terms of distance, then data generated at region 1 and region 2 will flow to sink along two different offsets of the routing tree. But if data generated at region 2 flow along the orange arrows, data aggregation will be more efficient in terms of total energy consumption of the sensor network. To achieve this, node needs to know some dynamic information in the process of data flowing to sink

In this paper, we have solved those timing and overhead problems.

A. First Approach—Solution of Overhead and timing problem for Dynamic Routing

We have presented first algorithm to solve the timing and overhead problem based on Problems on DABDR:
1. Dynamic routing means more overhead.
2. Report data in all rounds causes network traffic

Periodic synchronization algorithms for data aggregation can be classified into several groups as discussed below. Periodic simple aggregation means that each node waits a predetermined amount of time, aggregates all data received, and then forwards the data toward the host node. Such an algorithm is simple to implement, but does not guarantee accuracy of the data. Periodic per-hop aggregation means that each node waits until it receives data from all children, aggregates the data, and then forwards it toward the host node. This approach requires the use of a timeout in case some of the children do not respond to the query.

Periodic per-hop adjusted is similar to the per-hop approach, except the timeout is based on the node's position in the routing tree. Nodes lower in the routing tree should experience a timeout before nodes closer to the host.

Our approach

- To reduce the amount of information that must propagate through the network.
- To reduce delay

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Algorithm on DABDR of First Approach:

- Start
- Each node senses its own data along with it; it tries to communicates with its neighbor's data
- According to the function all nodes will update its value with that.
- Only one node will send data
- If no data is reported then another node will be involved and so on
- If data is reported then parent will send data to its parent and finally host
- Then host will send the final value to all
- End

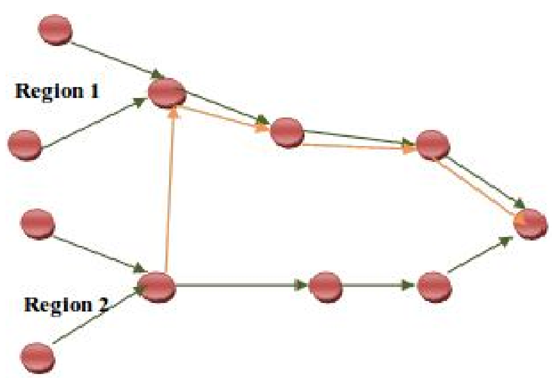

Fig. 1. Data aggregation on DABDR

Flow chart of the first approach is given below:

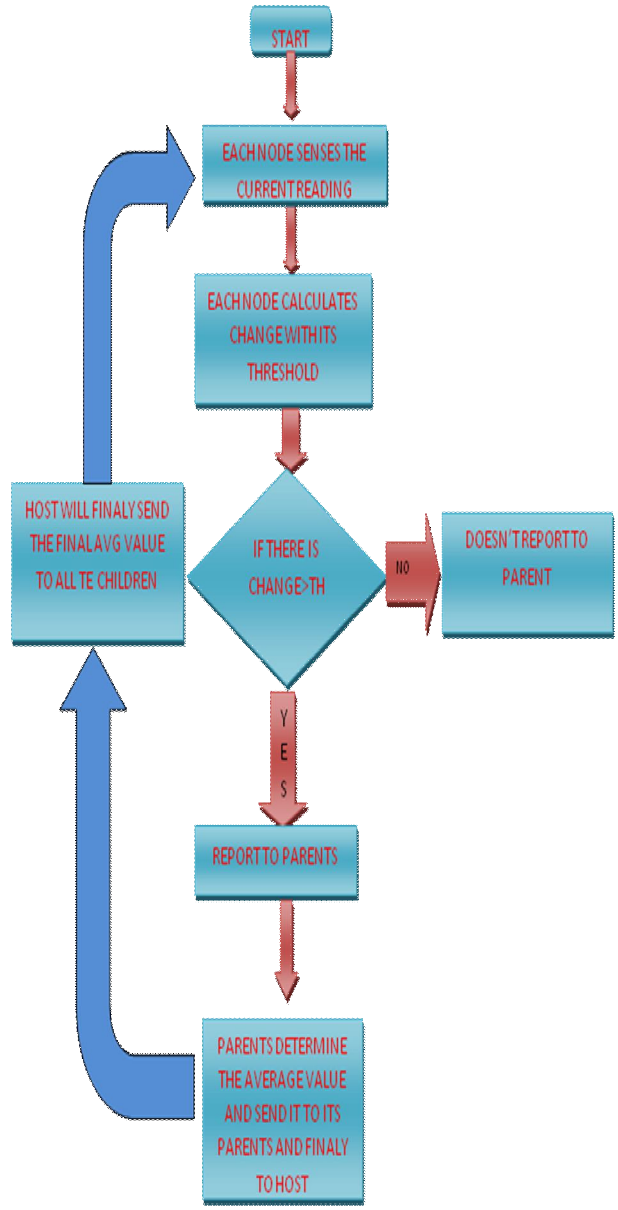

Fig. 2. Flowchart on first approach

B. Second Approach: Solution on DABDR, if Any node can fail to send data.

Our Approach:

- We want to ensure every node holds that value which is required.
- So only one report is required for that. So if any node fails, another node will be involved until reporting. Besides sensing own data nodes will also try to listen data of the neighbors. According to the function, the node will update its data with that.

Here we only considered max, min value for data aggregation of dynamic routing, if any node fails to send data.

- Start
- Each node stores previous record and also a threshold would be included with each query(threshold determines how much change needs to happen to report)
- Sense current reading
- If any change more than threshold then it reports otherwise doesn't report.
- If a node doesn't report then the parent stores last reported value of it
- The parent calculates the average of the values of the nodes and send to its parent and thus finally to host
- Then the host sends the final average value to the children by which the threshold is determined

Algorithm on DABDR of Second Approach:

C. Third Approach: Solution on DABDR of all data have been aggregated

This DABDR technique only assumes that all data have been aggregated

Our Approach:

To make confirmation whether all data have been aggregated.

Algorithm on DABDR of Third Approach:

- Start
- By count function determine how many nodes are concentrated in queue
- Initialize i with count
- Each time data will be aggregated i will be decremented.
- If i=0 reporting finished go to next round
- If i! =0 not all data have been aggregated again ask for data
- End

IV. CONCLUSION

Routing in sensor networks is a new area of research, with a limited, but rapidly growing set of research results. In this paper, we presented a comprehensive survey of routing techniques in wireless sensor networks which have been presented in the literature. They have the common objective of trying to extend the lifetime of the sensor network, while not compromising data delivery.

Overall, the routing techniques are classified based on the network structure into categories: hierarchical, and location based routing protocols. Furthermore, these protocols are classified into multipath-based, query-based, negotiation-based, or QoS-based routing techniques depending on the protocol operation. We also highlight the design tradeoffs between energy and communication overhead savings in some of the routing paradigm, as well as the advantages and disadvantages of each routing technique. Although many of these routing techniques look promising, there are still many challenges that need to be solved in the sensor networks. We highlighted those challenges and pinpointed future research directions in this regard.

Flow chart for second approach is given below:

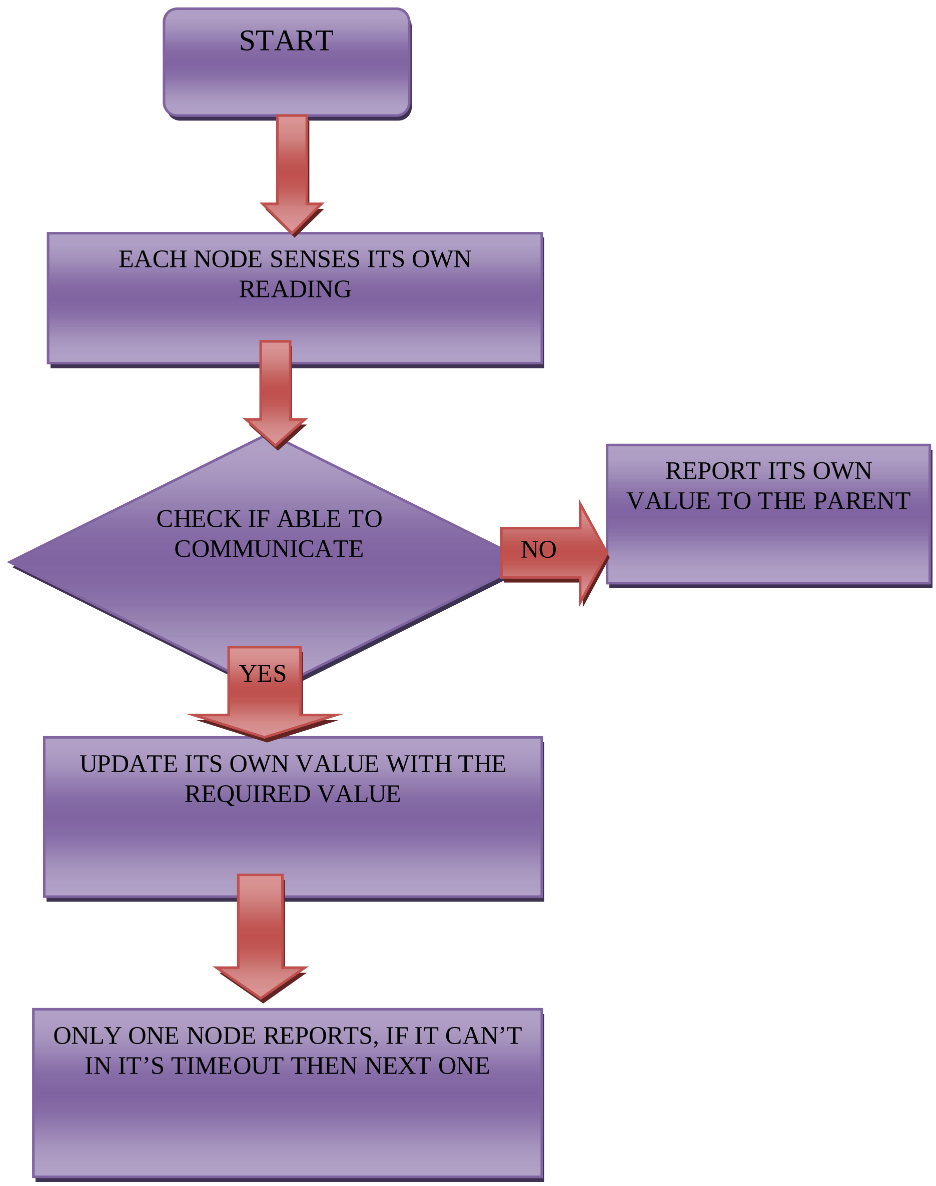

Fig. 3. Flowchart on second approach

Flow chart for third approach is given below:-

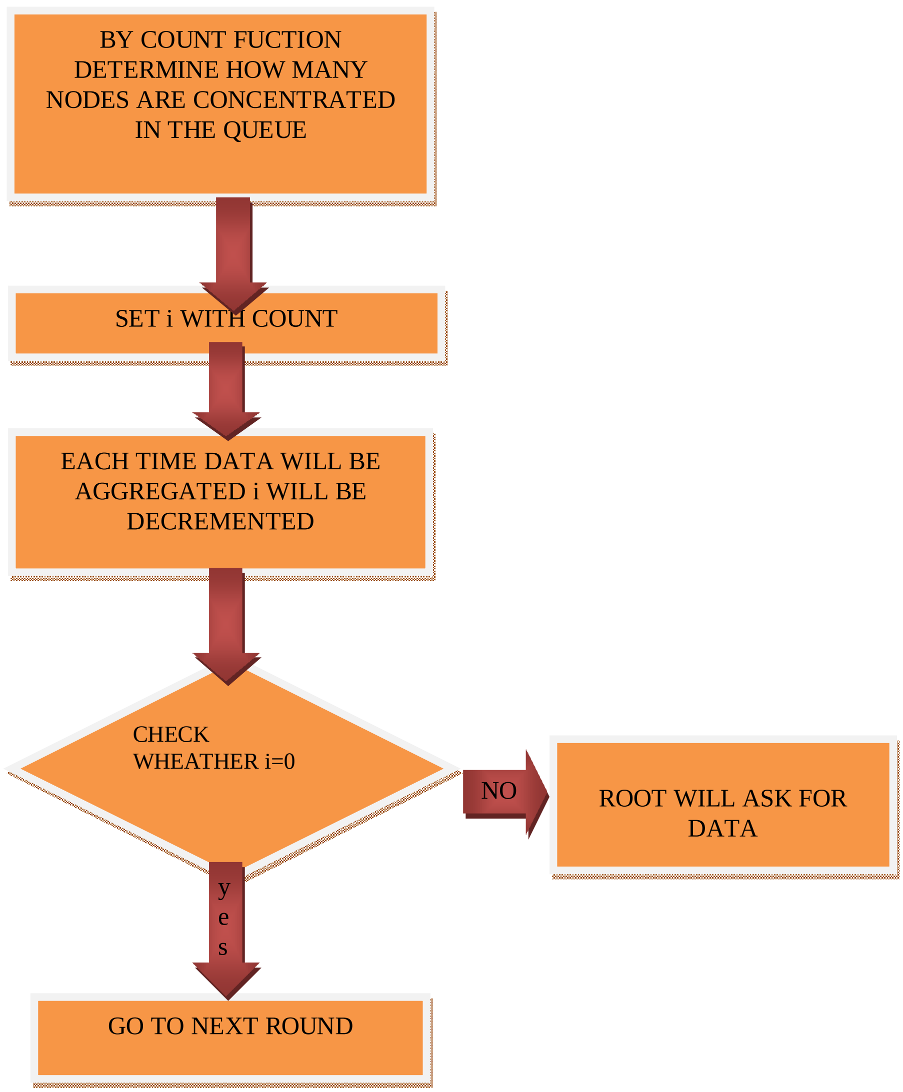

Fig. 4. Flowchart on third approach

This dynamic routing will formulate a tree rooted at sink. To determine when parent nodes execute aggregation, it proposes a timer scheme that falls into periodic per-hop adjusted category.

Though this protocol solves much in routing problem still has not given much attention to timing problem and as it is dynamic, more overhead problems can be caused. So we have proposed an algorithm to reduce overhead and to solve timing problem.

V. RESULT

As dynamic routing means more overhead so our first algorithm will be helpful for that. As the parents and host are only sending the common average value instead of individuals reading for this only one data is being sent or received by nodes instead of multiple data. It's also helpful to reduce time involving each query. As not in all rounds it's important to send data so when only there is significant change it is reporting.

Our second algorithm mainly focuses on getting max, min or median value. Sometimes many nodes fail to send data due to various reasons. May be nodes can die or any other reason. But the data maybe important for this if only max, min or median value is required all nodes can hold only the required data and any node can report that not involving all nodes and it only requires to report once. If once reported not to spend any more time for that data. Thus it solves network traffic, delay and also makes it more energy efficient.

Our third algorithm focuses on queue to make sure all data are aggregated in the queue for which we have raised an algorithm which will make confirmation whether all data has been reported or not.

VI. FUTURE WORK

We also plan to modify our DABDR to apply sensor networks which have many applications at the same time. We also think to have a dynamic tree; as if same tree is being used it may not be much efficient.

REFERENCES

[1] Mohamed Watfa , William Daher and Hisham Al Azar, A Sensor Network Data Aggregation Technique.

[2] Ian F. Akyildiz, Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayirci, A Survey on Sensor Networks Georgia Institute of Technology

[3] Rajashree.V.Biradar (1) , V.C .Patil (2) , Dr. S. R. Sawant (3) , Dr. R. R. Mudholkar , Classification And Comparison Of Routing Protocols In Wireless Sensor Networks Special Issue on Ubiquitous Computing Security Systems, UbiCC Journal – Volume 4

[4] Jamal N. Al-Karaki Ahmed E. Kamal, Routing Techniques in Wireless Sensor Networks: A Survey

[5] Laiali Almazaydeh, Eman Abdelfattah, Manal Al- Bzoor, and Amer Al-Rahayfeh, Performance Evaluation Of Routing Protocols In Wireless Sensor Networks

[6] W. R. Heinzelman, "Application-Specific Protocol Architecture for Wireless Networks," Ph.D. Thesis, Massachusetts Institute of Technology, June 2000.

[7] Kemal Akkaya and Mohamed Younis A Survey on Routing Protocols for Wireless Sensor Networks

[8] Archana Bharathidasan, Vijay Anand Sai Ponduru, Sensor Networks: An Overview,

[9] José Carlos Castillo, Teresa Olivares and Luis Orozco-Barbosa, Routing protocols for wireless sensor networks, Technical Report,

[10] F. L. LEWIS Wireless Sensor Networks.

[11] Ramesh Rajagopalan and Pramod K. Varshney, Data aggregation techniques in sensor networks: A survey .

[12] R. Jurdak, C. V. Lopes, P. Baldiy, A Framework for Modeling Sensor Networks, 19th Annual ACM Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA'04), 2004.

[13] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, Energy-Efficient Communication Protocol for Wireless Microsensor Networks, IEEE Proceedings of the IEEE International Conference on System Sciences, 2000.

[14] Bhaskar Krishnamachari, Deborah Estrin, Stephen Wicker, The Impact of Data Aggregation in Wireless Sensor Networks.

[15] Mohamed Watfa , William Daher and Hisham Al Azar, A Sensor Network Data Aggregation Technique , International Journal of Computer Theory and Engineering, Vol. 1, No. 1, April 2009

[16] Zhang Jiao, Ren Fengyuan, He Tao, Lin Chuang, Data Aggregation Protocol Based on Dynamic Routing in Wireless Sensor Networks,

[17] O. Younis and S. Fahmy, "HEED: a Hybrid, Energy Efficient, Distributed Clustering Approach for Ad Hoc Sensor networks,"IEEE Trans. Mobile Computing, vol. 3, no. 4, Dec. 2004, pp.366–79.

[18] Definition Of Sensor Network: Searchdatacenter.Com Definitions, Http://Searchdatacenter.Techtarget.Com/Sdefinition/0,,Sid80_Gci119 2055,00.Html

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