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Load balancing and delay minimizing algorithms in Wireless Sensor Network

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***Abstract*— One of the fast developing technology in wireless technology is wireless sensor network technology .Building block of WSN is sensor node. It has limited power capacity because it is powered by battery. It is very difficult to replace this battery because we mostly deploy any wireless sensor network in hostile area .So optimization of energy consumption is important factor while developing any wireless sensor network protocol. One of the way to control power consumption is to balance network load properly .In this paper current load balancing protocols are discussed and compared .With energy efficiency timely delivery of data is also important .So protocols should provide tread off between energy efficiency and End to End Delay. The aim of paper is to study and analyses existing protocols. We have tried to review protocols which consider both these aspects of any wireless sensor network. The paper will be useful for beginners in this area.**

***Index Terms*—Wireless Sensor Networks, Energy efficiency ,Network lifetime ,End To End Delay, Routing.**

I. INTRODUCTION

In any WSN proper load balancing is very important because if protocol provides proper load balancing then we can improve life of the network .In case of absence of proper load balancing life of network will be minimum because load of network data is not evenly distributed on all the nodes ,so here is possibility of early dying of some nodes .with load balancing another requirement from sensor network is delay minimization .Applications like military surveillance requires fast delivery of data .In such type of application delay is an important factor[1].

When our network or sensing field is very large then use of single sink is not suitable load balancing and it is also difficult to allocate task dynamically to different clusters. To solve this problem use of multiple sink is very useful instead of using single sink. It will provide proper load balancing and data will be delivered in short period of time [1].

One of the useful methods for energy consumption and load balancing is use of clustering. Clustering is used to reduce transmission distance of nodes and to avoid redundancy of data. Clusters are formed by considering their position and considering their residential energy. One node is selected as head node which collects all the data from cluster members and aggregates them and finally forwards it by using routing algorithm[2].

Wireless sensor networks are mostly used for monitoring physical parameters .We can implement WSN for large number of applications, such as military application, habitat monitoring, agriculture application .Each domain has different quality of service requirements from WSN .To gain maximum benefit from the network life of network should be more .So suitable protocols must be developed to improve life of the network .On way is to use cross layer optimization protocols for energy consumption. This produces better energy efficiency than considering only single layer optimization [3].

Combination of clustering approach with optimal TDMA scheduling algorithm will also improves energy efficiency of the system .Hierarchical routing is better to control redundant data. We can also conserve energy by adopting proper duty cycle by keeping nodes active which have data to sense and to transmit and keeping all remaining nodes to sleep state who don't have any data to transmit .Combination of these two methods is useful to improve network life time[4].

Instead of using single sink use of multiple sink is good idea for both energy efficiency and improving performance of the system[6].For better output from any WSN we should consider both energy conservation and minimum delay. To do this tradeoff between energy and delay is important[7] .

An important point related to energy If our routing algorithm increases congestion in the network then it is not useful for energy saving and delay minimizing. Writing protocols which minimizes congestion in the network will also improve performance of the system[8].

Instead of using single approach for improving performance combination of multiple methods is useful .Combination of tree based routing , clustering and fuzzy rules will provide better results[11].

In this paper we have presented review on recent protocols in load balancing and delay minimization. We have tried to summarize them in the form of table for better understanding. We are considered parameters such as size of network, whether sink is static or mobile ,multiple sink or single sink, any special method used ,suitable for large scale or small scale network ,number of nodes and finally simulation tool used.

II. RELATED WORK

Use of multiple sink is good idea for load balancing and for timely delivery of data ,author of work [1] has tried to solve problem of load balancing by using multiple sinks instead of using single sink. They have provided idea of efficient task allocation method in large scale WSN. They have improved data aggregation process by using multiple

sinks. Their results are better in terms of packet delivery ratio, speed of data aggregation and time required for processing and transmission of data. Multiple sinks used are mobile in nature it improves total performance of the system. Their results in MATLA shows that their system performs well than existing load balancing technics [1] .

Work [1] is based on clustering and use of multiple sinks. Another important work is provided in paper [2] This work used concept of clusters similar to LEACH for load balancing but they have also provided solution on security threats on cluster heads such as gray hole attack. Their results shows that their system is better than LEACH .Gray hole attack in which any malicious device can send fake data to the cluster head to engage cluster head in an unnecessary activity .This will increase energy consumption and delay to address this problem author of work [2] created algorithm which first detects node which is responsible for attack and then discards it from the routing process.

Cross layer optimization is better way for energy efficiency and load balancing ,work[3]is based on this approach .With clustering they have also used cross layer approach to improve life of the network .This work focuses on all three main layers at which we can control power consumption .This layers are physical layer ,MAC layer and routing layer .At physical layer they controls transmission power .At Medium Access Layer they have used S-MAC duty cycling and at network layer they have implemented energy efficient routing method This network has capability of dynamically reconfiguration based on current condition of the network and network topology change . They have divided sensing area into the number of cells .Each cell is associated with a group of nodes .This members of cluster have the capability of self-organization. Their simulation result shows that their system is beater performing than the systems which can considers only single layer method [3].

Always combined approach will provide better results than considering only single approach for controlling both energy and delay. Author of work [4] has used such method such that proper scheduling is used first and after that ACO routing is provided by activating only those nodes which are within routing path to the base station and sleeping other nodes. According to their simulation results .Their work is better than existing PASC,MGEAR,LEACH,PASC ACO work[4].

Similar work is provide by author of [5].Node sleeping is good for energy efficiency but it increases unnecessary end to end delay in the WSN .So this author has tried to address this issue by adopting new routing method .Wake up rate is provided with each node ,using this wake up rate relay node is selected for routing purpose. It is very useful to control delay in the network. This works well than heuristic methods[5].Optimal wake up rate is provided because large wake up rate increases extra energy consumption. Data packets are created and forwarded only after detection of event and this avoids unnecessary energy consumption of the sensor node.

Most of load balancing work in WSN is based on use of single sink node .This idea is not useful because node close to the base station or sink will consume energy in fast way. This will creates holes in the network and this will result in early death of network. To avoid this author of work[06]provided concept of multiple sink. When multiple sinks are used then total load is distributed properly. Instead of creating single routing tree they have created multiple routing trees towards each sink in the network. This reduces extra delay and energy consumption , C++ is used to implement their work and results are better than similar work[06]

Author of work [7] considers both these performance aspects and provided tradeoff between End to End delay and energy consumption .New algorithms are provided for inter cluster routing and for intra cluster routing .Two functions are created for both for optimization purpose .Clusters are created in distributed way to evenly distribute network load on all the cluster nodes .Cluster heads are selected by considering both factors energy and delay. They have provided results in two forms theoretical and simulation, both results are same up to some percentage [7]

Congestion free and collision free wireless sensor network provides better output in terms of energy ,delay and minimum packet drop. Author of work[8] has considered and implemented this issue by constructing congestion free routing tree .They have proposed CATopology i.e. congestion avoidance topology by using two methods known as K-Map and K-Graph. Routing on this multi hop routing tree dose not allows more than one packets to reach at same point in the network at same time period .This improves energy efficiency, minimizes end to end delay and also minimizes number of packet drops in the network. They have simulated their work by using OPNET network simulator .Their results are better than similar work[8]

Author of work[9] provides method of cluster formation in distributed way. They have tried to distribute network load on each and every node in the network. They have addressed problem of scalability and energy efficiency. Network simulator 2 is used for implementation purpose .TDMA is also used for performance improvement and sleep wakeup method is used for more energy saving .For selecting cluster head both distance and residential energy of node is considered [9].

Work [10] has provided generic algorithm for load balancing purpose .They have used different strategy for generation of initial population to generate chromosomes which are valid. For proper load balancing they have used fitness function to balance network load properly. Each cluster member node can communicate with cluster head node by using single hope or using multi hope communication. According to the requirement. If node is very close to the head it can communicate directly and if node is not close to cluster head then it can use malt hope path for communication purpose. They have implemented their work in MATLAB and results are better than existing LBCA and MOGA work in terms of energy efficiency[10].

One of the best works for load balancing is GSTEB .It is tree based routing protocol. In GSTEB routing tree is generated dynamically in each round. Here round means time

from sensing data up to the time at which data is delivered to the base station. Work[11]is based on improvement in tree based routing protocol .Author of work[11] has added concept of fuzzy rules for creation of clusters and for selecting proper routing path. Use of fuzzy rule has shown better performance in term of energy efficiency and delay minimization in the WSN. Network simulator 2 is used for implementation purpose. Results show that system performs 10 % to 15 % better than existing HEED and GSTEB system[11].

It is important to minimize energy consumption to improve life of the wireless sensor network .Author of [12] has provided tree based routing method for energy efficient routing purpose. They have divided sensing area into four parts. Each part is termed as quadrant. parent or relay node is selected by considering distance between nodes and residential energy of node ,this makes better relay node selection for minimum energy consumption. TDMA is used for resource allocation purpose .Each cluster head performs TDMA schedule for each node inside the cluster and broad cast this schedule to all cluster members. All cluster members follows this TDMA schedule for data transmission purpose. They have implemented their work by using MATLAB simulator and results are better than existing NRLM and LEACH protocols[12].

Table 1 shows summery of our review.

Protocol	Handles Energy/Delay	Cluster Based	Suitable for large scale	Single/ Multiple sink	Moving/ Static Sink	Network size	Other Factors	Simulator
globular topology[1]	Results for Both	Yes	YES	Multiple	Mobile	500Nodes	Considers Security	MATLAB
CMPR[2]	Results for both	LEACH	YES	Single	Static	100 x 100m	Considers Gray Hole Attack	NS2
TF[3]	Result for Energy	Hierarchies of Clustering	YES	Single	Static	-	Cross Layer	NS2
Ant Colony[4]	Both	-	Not	Single	Static	-	Sleep Wake up	-
Any cast[5]	Both	-	Not	Single	Static	-	Sleep Wake up	-
Multi Sink, Multi hop[6]	Both	Distributed Clustering algorithm	YES	Multiple	Static	150m x 150m	Greedy Algorithm	C/C++ Programming
DCEM[7]	Both	Distributed clustering Method	YES	Single	Static	100m x 100m	TED Tradeoff function	-
CATopology[8]	Energy and Delay	Cluster Tree	YES	Single	Static	100 m x100 m	congestion avoidance topology	OPNET
DEACP[9]	Energy and Delay	Distributed Clustering algorithm	YES	Single	Static	1000 x1000M 200 NODES	Sleep Control Laws	Network Simulator 2
EEGA[10]	Energy	GA Based	YES	Single	Static	75 mx 75 m	Fitness Functions	MATLAB
FGSTEB[11]	Energy and Delay	TREE BASED CLUSTERING	YES	Single Sink	Static	1000M X 1000M 300 NODES	FUZZY RULE	NS2
Quadrant Based[12]	Energy only	In each quadrant	YES	Single	Static	100m x 100m 100 nodes	TDMA	MATLAB 2013

Table 1 :Summary in table format

III. Conclusion

A In this review paper we have analyzed different power saving and delay minimizing protocols mostly those providing tradeoff between Energy efficiency and End to End Delay in wireless sensor networks. Taxonomy is also provided in table format. According to study it is clear that no any single method is sufficient to improve overall performance of any WSN .Protocols developed by combining multiple techniques are better protocols .We can conclude that developing protocols which can combine Cluster based approach , Tree based approach ,use of multiple sinks , mobility and finally cross layer optimization to get better results in terms of energy efficiency and delay minimization and for improving overall performance of the system for any wireless sensor network

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