

Load Balancing Techniques in Wireless Sensor Networks: A Comparative Study

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Abstract—Wireless sensor networks have become an important area for research and development. Wireless sensor networks (WSN) have potential in the fields of monitoring, transportation, health care etc. Sensors are not deployed uniformly since they are generally constrained in on-board energy supply. Hence management of network lifetime is crucial in WSN. Many challenges are there in wireless sensor networks such as quality of service parameter improvement, energy efficiency, heterogeneity, distributed processing, low bandwidth communication, Load balancing etc. In this research load balancing issue is considered for improving the performance of WSN. Load balancing does not involve equally distributing load on all nodes of the network rather it focuses more on a strategy to balance load on particular nodes depending on the current status of the network to increase the lifetime of nodes and the network. Several techniques are used in wireless sensor networks for load balancing. This research study focuses on cluster based, protocol based and algorithm based methodologies for load balancing. Finally the comparisons of different methods used in load balancing in WSN are discussed. Using suitable techniques performance of load balancing can be improved in WSN.

Keywords: WSN, QOS, TDMA, CH, LEACH and Diffusion.

I. INTRODUCTION

It's an era of networks everything depends on network. Many network applications are there example internet television, mobile networks etc. As demand increases it leads researcher to work on it. Wireless sensor networks is one of the leading technology many applications are using WSN. Wireless sensor networks spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to co-operatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance, today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. Many algorithms and technologies are used in Wireless sensor networks. Fig 1 shows the basic structure of WSN. Components of basic structure are as follows

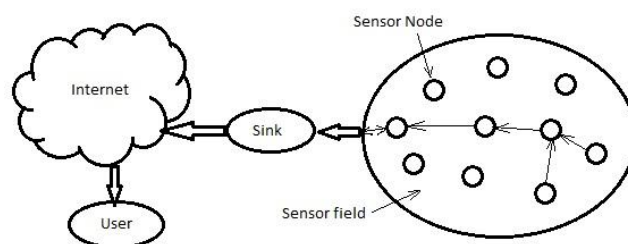


Fig. 1: Basic Structure of WSN

Sensor: It is a converter which is used to measure physical conditions. Sensor work is sensing the data, processing and communicating.

Sensor field: For sensing the data there will be particular area in that area sensor will sense the data which is called as sensor field.

Sink node: Some time it is called as base station. It consists of unlimited available energy.

Many issues are there in WSN

Load balancing: Load balancing does not involve distributing load on all nodes of the network rather it focuses more on a strategy to balance load on particular nodes depending on the current status of the network to increase the lifetime of nodes and the network.

Energy efficiency: It is main constraint in the WSN due to its size, it has less memory to store energy so need to use efficiently.

QOS parameters improvement: Throughput, delay etc.

Distributed Processing: Sensors are distributed in Ad-hoc manner so aggregating the sensed data is one of the challenges in WSN.

In wireless sensor networks still many issues are there. In this survey Load balancing issue is considered. Load balancing typically is not equally distributing load on all nodes in the network, it involves identifying the optimal load on nodes of the network to increase its lifetime. This paper describes about load balancing techniques such as cluster based, protocol based and algorithm based. Section II discuss about the literature survey, section III comparative study. Section IV discusses proposed work and paper ends with conclusion and future work.

II LITERATURE SURVEY

A. Cluster based methods

Cluster based communication

Information collection is one of the main problems in wireless sensor networks [1]. Sensing the data is not the big thing here how the sensed data efficiently send to the sink is the main thing. In this paper it describes cluster based communication protocol instead of single hop used multi-hop communication. There are three phase in cluster communication protocol shown in fig 2. First phase Initialization phase here all nodes will communicate each other and they will form layers depends on distance from the base station. Second phase is again sub divided into cluster head selection, cluster formation and TDMA schedule. Two factors are considered very important here number of nodes in cluster and cluster head position. Cluster phase will starts with cluster head then cluster formation due to more clusters there will be intra cluster collision to reduce it cluster head creates a TDMA schedule. Third phase is data transmission, data collected by the cluster member will send to the cluster heads after aggregating all data will be send to the base station. This process will repeat for every round from the first phase.

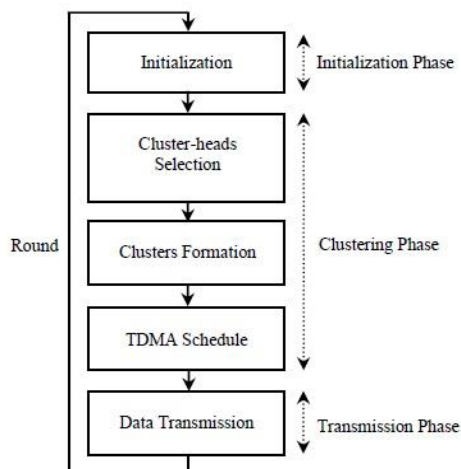


Fig. 2: Clustered based communication protocol

Clustering

In this approach assuming that it is heterogeneous network with all sensor nodes [2] are having different processing power and energy levels. Here considered 3 parameters are important i.e. initial energy, threshold value and location. In deployed nodes which are having high initial energy and processing power nodes are selected, cluster heads are selected according to their location. Each CH defines its communication range in terms of power level to form cluster. Some nodes with similar energy and processing power in the CH range are asked to go to sleep and information about those nodes is maintained with the CH. The cluster head will send hello request to nodes within

range nodes to become cluster member. This process will be repeated to all cluster heads. After cluster formation sensed data from cluster members to cluster heads then base station communication may be direct or using intermediate nodes. This process will perform 4 phases Initialization Phase, Steady State Phase, Final Phase and Cluster Reconfiguration Phase.

B. Protocol based methods

SLB protocol implementation using pseudo link

Fig 3 explains about network architecture for secure load balancing protocol.

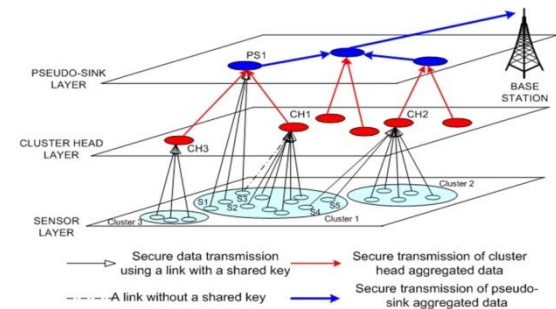


Fig. 3: Network architecture for SLB protocol

Secure load balancing in wireless sensor network [3]. It consists of 3 layers: first layer sensor layer and second layer cluster head layer and third layer pseudo sink layer. In first layer sensor nodes sense the data the sensed data will be gathered and send to the cluster heads. Considered threshold value if sensor nodes data rate is below the threshold then sensor node will send its data to the pseudo-sink rather than its cluster heads. So it helps to send the data and measurements on time. SLB improves the data aggregation efficiency by aggregating the data.

Load balancing using leach protocol

Wireless sensor network is a kind of ad-hoc network [4] which consists of distributed sensors to monitor physical and environmental conditions which are of autonomous type. Low Energy Adaptive Clustering Hierarchy (LEACH) protocol, LEACH protocol is one such protocol to extend the lifetime of WSN by forming clusters for routing in a large scale network. Sensor will sense the data and sensed data is aggregated then it will send the data through cluster heads the problem is, there is a possibility of selecting the less energy cluster node as a cluster head due to random selection of cluster head so they introduced a new method i.e. replacing in the place of node which loses its energy. Considered threshold value when sensor node energy level beyond the threshold value then alternative node replace the load node which extends the lifetime of entire network and avoid network lifetime.

Multi-path routing

Directed diffusion (DD) is a data-centric routing protocol [5] based on purely local interactions between individual network nodes. This protocol uses application-specific context for data aggregation and dissemination. Therefore, it can be completely matched to the application requirements in a large distributed sensor network. Many works have been recently done to improve the energy efficiency of this protocol. Multipath routing for implementing load-balancing and increasing the energy efficiency of the routing algorithm. Author has proposed four methods for constructing multiple paths between sinks and sources: SMDD, DPMDD, BPMDD and SPMD and also four different approaches were presented to improve the efficiency of such algorithms: RFI, RDI, LFI and HI. In wireless sensor networks sensor nodes are distributed in Adhoc manner if sensed data is transferred to a sink through the same path particular nodes will suffer more load on nodes instead of sending the sensed data from same path creating multi path which reduce load on nodes.

C. Algorithm based methods

Energy efficient load balancing algorithm

Presents an energy-efficient [6] load balancing algorithm for Wireless Sensor Networks. The algorithm specifies that only the nodes which have residual energy above a threshold can take part in routing, and that residual energy is to be updated at the highest opportunistic rate supported by the network. The algorithm was tested on and showed improvements to hierarchical data aggregation and basic directed diffusion; the proposed method updates residual energy during reinforced data transmission, the highest data rate in both protocols, by allowing neighbor nodes to promiscuously snoop traffic. Which show that the proposed method has lower residual energy variance (25longer) than hierarchical data aggregation and basic directed diffusion methods, respectively. In addition, interest message flooding was reduced and network lifetime was increased by allowing only the nodes that have residual energy above a threshold to take part in interest propagation.

Geographical load balancing algorithm

Recently the application domains of wireless sensor networks [7] have grown exponentially. Traditional routing algorithm generates traffic related to route discovery to destination. Geographic routing algorithms exploit location information well but the problem of congestion and collision throttle its full employment for resource constrained wireless sensor networks. We present a Geographic Load Balanced Routing (GLBR), explores a technique Load balancing for WSNs which can be a viable solution to the challenges of geographic routing. Load balancing can be realized through two approaches. GLBR defines parameters based on communication overhead at sensor nodes and wireless link status through which load can be balanced across whole network. GLBR approach exploits the existing Geographic Routing approach i.e. Greedy forwarding by considering not only the distance between next hop and destination as single parameter for packet forwarding but also considered overhead at node. When

load at a node is high GLBR looks for an alternate option for packet forwarding. Thus GLBR divert traffic to obviate congestion and hence avoid disconnections in the network.

Optimized Hybrid Ant Colony and Greedy Algorithm

WSN is a vast area for research and development numerous number techniques exist in this field.WSN is a network comprising of wireless linked sensor nodes [8]. For load balancing combined two algorithms those are Ant colony and greedy algorithm. Main objective of hybrid algorithm is to energy conservation. Greedy algorithm will find the shortest path based on energy of cluster in ascending order and ant algorithm work is to ping each cluster for their energy and allocate traffic to the each cluster. Fig 4 explain that every node will have some threshold value, greedy algorithm find the optimal path from source to destination on behalf of current energy utilization ,shortest path from source to destination depends on cluster’s energy value not the shortest path from one node to another. After some time energy of the node will decrease then ant colony algorithm will shift the traffic on basis of greedy algorithm thus it will balance the load. In this paper an algorithm by integrating techniques such as greedy algorithm and Ant Colony Optimization (ACO) thus making it a hybrid approach in balancing load in a WSN.

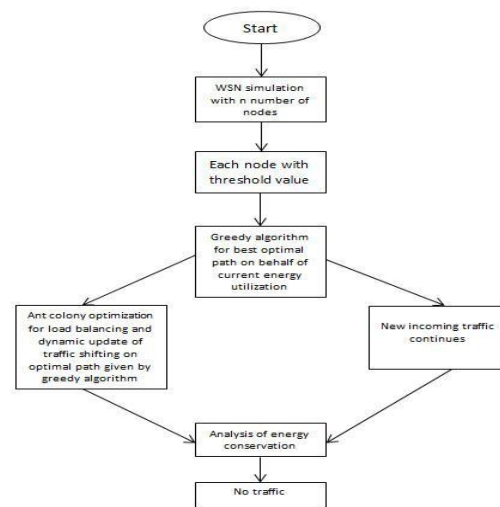


Fig. 4: Flow graph of Hybrid Ant Colony and Greedy Algorithm

III. COMPARATIVE STUDY

The following table’s shows Comparative study of three different methodologies such as Cluster based, protocol based and algorithm based. Table I describes about cluster based methods. In this table two methods are discussed. Table II describes about protocol based. Here three methods are discussed. Table III describes about Algorithm based methods. Three methods are discussed in this table.

TABLE I
CLUSTER BASED

Paper Title	Authors	Tool Used	Parameters Implemented and Methods	Results	Limitations
Cluster based Communication Protocol For Load-Balancing in Wireless Sensor Networks	Mohammed A. Merzoug Abdallah Boukerram	OMNeT+ +	Methods: cluster based communication Protocol. Parameters: Energy consumption, Maximization of network lifetime, data Delivery to the sink.	Increase in network Lifetime	Some nodes will have high energy load which nodes are near to the sink because through that node only data Will send.
Load Balancing Based approach to improve lifetime of wireless sensor network	Dipak Wajgi1 Dr. Nileshsingh V. Thakur2	Matlab	Method: clustering Parameters: Extending the lifetime of sensor node, load balance decreases energy consumption.	This approach will increase the network lifetime and will provide high throughput.	Planned to be extended for parameters and scenarios like coverage, fault tolerance, impact of aggregation and mobility of nodes.

TABLE II
PROTOCOL BASED

Paper Title	Authors	Tool Used	Parameters Implemented and Methods	Results	Limitations
Load-Balancing Using Multi-path Directed Diffusion in Wireless Sensor Networks	Arash Nasiri Eghbali Mehdi Dehghan	Ns2	Method: Multi path Routing. Parameters: Constructing multi path between source and destination to reduce load on nodes.	Through using MDD, the lifetime of the network Connections between the sources and the sink will be increased	Selecting the node while constructing the path without considering the energy of the nodes
Secure Load Balancing via Hierarchical Data Aggregation in Heterogeneous Sensor Networks	Suat Ozdemir	QualNet	Method:SLB protocol implement using pseudo link.Parameters:Data accuracy, bandwidth utilization, secure communication, load balancing	Secure Load Balancing (SLB) protocol and introduces pseudo-sinks in order to improve data accuracy and bandwidth utilization of wireless sensor networks.	Secure communication can be possible if lifetime of nodes increase
Implementation of Load Balancing in Leach Protocol for Wireless Sensor Networks	R. Ramesh, R. M. Dilip Charaan,N. T. Mohan Kumar, and E. Uma	Ns2	Method: load balancing using leach protocol. Parameters: Network lifetime, data aggregation.	LEACH protocol has been implemented with 40 nodes in network simulator-2 and its Packet Delivery Ratio(PDR) and energy level has been observed which is better than that of existing LEACH	The integration of ASLEEP protocol into LEACH can yield a prolonged network lifetime and good data aggregation policy.

TABLE III
ALGORITHM BASED

Paper Title	Authors	Tool Used	Parameters Implemented and Methods	Results	Limitations
Load balancing Algorithm for wireless sensor Networks.	S. Wijedasa, S. Rizvi, K. Ferens	Java simulator	Method: Energy efficiency load balancing Algorithm. Parameters: Residual energy, network lifetime	Network lifetime Increased	Evaluating the same algorithm with many sinks and many sources to verify the algorithms scalability assertion
Geographic Load Balanced Routing in Wireless Sensor Networks.	Robin Guleria Ankit Kumar Jain	Ns2	Method: Geographical load Balancing algorithm. Parameters: Not only (considering the shortest path it will check) over head of the packet.	GLBR divert traffic to obviate congestion and hence avoid disconnections in the network.	location estimation in GLBR for introducing mobility is itself a Challenge.
Optimized Hybrid Ant Colony and Greedy Algorithm Technique based Load Balancing for Energy Conservation in WSN	Mamta Tewari Kunwar Singh Vaisla	Java simulator	Method: Optimized Hybrid Ant Colony and Greedy Algorithm Parameters: Finding best optimal path basis on energy and threshold value.	The life time has increased and throughput came out to be marginally better.	Need to implement in real environment.

IV. PROPOSED METHOD

In this proposed method integration of Adaptive Staggered LEEP Protocol (ASLEEP) to LEACH protocol is initially designed and shown in Fig 5 which explains about high level design of Load balancing approach.

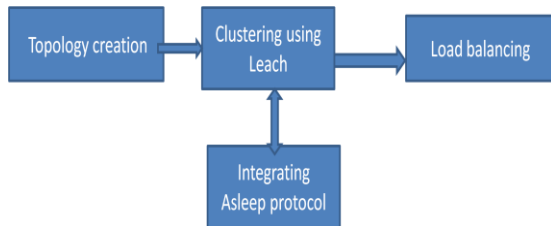


Fig. 5: High level design

Topology creation: Creating topology using ns2.33

Clustering using LEACH: LEACH protocol used for cluster formation.

Integrating Asleep protocol: Introducing new method here i.e. integrating asleep protocol to LEACH

Load balancing: Integrating Asleep protocol to the LEACH increase the performance of load balancing.

V. CONCLUSION

Wireless sensor networks consist of protocols and algorithms with self-organizing capabilities. A wireless sensor network is having many challenges so this research focuses mainly on Load balancing issue in wireless sensor networks. This paper discusses about different techniques used in load balancing such as cluster based, algorithm based and protocol based. Comparisons of these techniques are also described. Performance of these techniques can be improved with suitable techniques. Future work concentrates on improving the performance of load balancing by integrating Adaptive Staggered LEEP Protocol (ASLEEP) to LEACH protocol and implementing these protocols using NS2 simulator.

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