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ASURVEY ON CLUSTER BASED LOAD BALANCINGAPPROACHESFOR WIRELESSSENSOR NETWORK

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ABSTRACT

Wireless sensor network (WSN) is becoming a very interesting field of research in recent days. It has wide area of research due to various issues caused by the hardware capabilities of sensing nodes such as memory, power, and computing capabilities. One of the major issues is to concentrate on the energy consumption of the sensing node which determines the lifetime of the network. One of such problem is called Hot-spot problem, in which the best channel to the sink are overloaded with traffic and thus causing the nodes to deplete their energy quicker than the energy of other nodes in the network. Clustering algorithms along with sink mobility widely support for equal distribution of the load in the network. In order to overcome this problem various load balancing algorithms are discussed for improving the lifetime of the network.

Indexing terms/Keywords

WSN, Sensor node, Clustering, Load balancing, Applications.

Academic Discipline And Sub-Disciplines

Engineering, Technology

SUBJECT CLASSIFICATION

Mathematics Subject Classification

TYPE (METHOD/APPROACH)

Literary Analysis; Survey/Interview

1. INTRODUCTION

Wireless sensor networks (WSNs) consist of large number of sensor nodes deployed randomly in major cases of application. In very few applications the position of the nodes are predefined. The various applications are monitoring temperature, military application, tracking, smart buildings, medical/ health care, forest fire, wildlife monitoring and so on. The major role is played by the sensing nodes. The sensing node comprises of power, controller and memory and radio transceiver. In dense network various problem arises when compared to small network areas [1, 2].

The distinctive characteristics of WSN [3, 4] sensor nodes can be deployed both in small and on large scale. These networks are scalable and some of the limitations are battery power, bandwidth and memory. Wireless sensor networks have the ability to deal with node failures. One of the unique features is the mobility of nodes. They also have dynamic network topology.

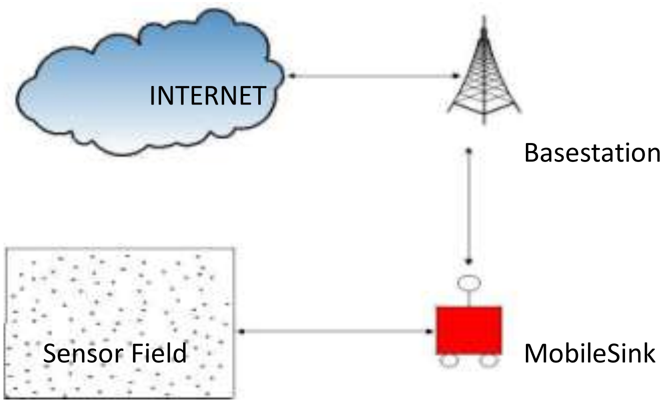

Figure 1:WirelessSensorNetworkModel

Base Station: Base station acts as a main data collection node for the entire sensor network. It is the bridge between the sensor network and the end user. The base station is energy unconstrained.

Sensor Node: It is the core component of wireless sensor network. It has the capability of sensing, processing, routing, etc. [5].

Sensing Field: The area which consists of large number of nodes randomly deployed for various applications.

Sink: Sink may be static or mobile data collector and it is also energy unconstrained. Mobile sink shows more advantages over static sink

2. NEED FOR CLUSTERING

A WSN is supposed to operate unattended for a long time after deployment. This requirement drives the design of clustering protocols. Each cluster contains one Cluster Head (CH) and several Cluster Members (CMs). All CMs are one hop away from the respective CHs. A CM links only with its own CH to transmit/receive packets. They communicate in cyclic super frames where the CH sends a beacon message in the beginning of every super frame to coordinate intra-cluster communications. Figure 2 shows the basic model of clustering.

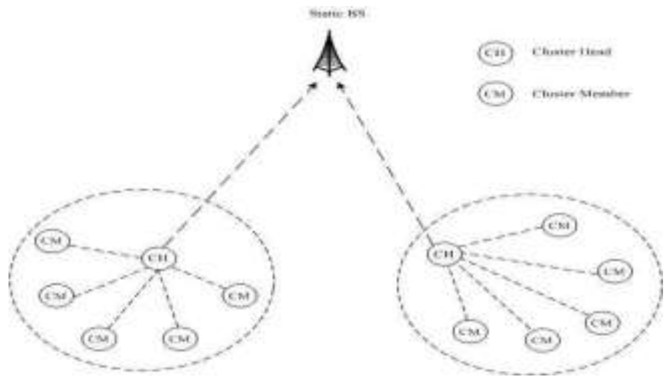

Figure2:BasicModelofClustering

3. NEED FORSINK MOBILITY

Mobile wireless sensor networks (MWSNs) have recently launched a growing popular class of WSN in which mobility plays a key role in the execution of the application [6]. In recent years, mobility has become an important area of research for the WSN community. The increasing capabilities and the decreasing costs of mobile sensors make mobile sensor networks possible and practical. Although WSN deployments were never envisioned to be fully static, mobility was initially regarded as having several challenges that needed to be overcome, including connectivity, coverage, and energy consumption, among others. However, recent studies have been showing mobility in a more favourable light.

A WSN is usually deployed with static sensor nodes to perform monitoring missions in the region of interest. However, due to the dynamic changes of events and hostile environment, a pure static WSN could face the following severe problems:

I. The initial deployment of a WSN may not guarantee complete coverage of the sensing field and connectivity of the whole network. Usually, sensor nodes may be scattered in a hostile region from the aircraft or by robots [7]. However, these randomly deployed sensors could not guarantee to cover the whole area and may be partitioned into several non-connected sub networks, even though we scatter a huge amount of nodes. Moreover, the dynamic change of regions of interest and the existence of obstacles could make the problem become more difficult.

II. Sensor nodes are usually battery-powered and prone to errors. As some nodes die due to the exhaustion of their energy, there could exist holes in the WSN's coverage. In addition, these dead nodes may break the network connectivity. However, in many scenarios, it is quite difficult to recharge sensor nodes or deploy new nodes to replace these death nodes.

III. WSN may be required to support multiple missions under various conditions [6]. For example, in an object tracking application, sufficient sensor nodes should be deployed along the track of the target, while in a boundary detection mission; there should be adequate nodes along the pre-described perimeter.

These different requirements cannot be easily satisfied by deploying a large amount of sensor nodes, since provisioning for all possible combinations of mission requirements could not be economically feasible.

IV. Some applications may need sophisticated (and thus expensive) sensors to involve in. For example, one can image that in a military application, pressure sensors may be deployed along the boundary to detect whether any enemy intrudes in. However, these sensors can only report something passing but cannot describe what passes through them. In this case, more sophisticated sensing devices like cameras should be required to obtain more information. Nevertheless, it is infeasible to equip camera on each node because of their large number. Figure 3 shows introducing mobility to some or all the nodes in a WSN, we can enhance its capability and flexibility to support multiple missions and to handle the aforementioned problems.

The entire network rely on this energy to detect an event, collect information from environment, data aggregation and communicate with base station or sink to deliver the collected information.

The main challenges are how to maximize the network lifetime using minimum energy resource. Research has shown that nodes near the sink deplete their battery power faster than the nodes apart due to heavy overhead of messages from nodes that are far away from sink node. Sensors nearby sink are shared by more sensors to sink paths therefore consume more energy.

The result is the nodes nearby sink nodes deplete their energy faster than the other nodes which leads to premature disconnection of the networks and sink got isolated from the network, while all other nodes are fully operational along with the sink. This problem is known as hotspot problem, leads to a premature disconnection of the network.

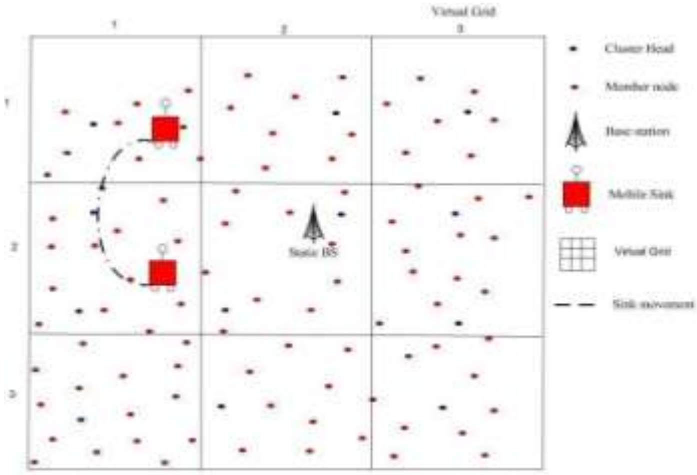

Figure 3 Sink Mobility

In recent approaches, to reduce energy consumption, researchers focus on shifting the burden from the sensors to the sink node. In contrast to a traditional WSN model where the sink nodes remain stationary somewhere in the network and passively receive data from the sensor nodes and in Mobile Sink WSN (MSWSN) the sink node is mobile and traverse the network field actively to look for the sensors which are sending data and move closer to them. The idea behind this sink mobility is to shift the burden of data processing and energy consumption from the sensors to the sink node in order to extend the network lifetime as sink nodes are generally much more fertile in computational power and energy supply. Transmission range is an important parameter to determine energy consumption in data communication, active movements of sink nodes closer to active sensors result in reduced transmission distances, and fewer intermediate nodes to relay data. Therefore, the energy consumption tends to be more evenly distributed in the network and the “Hotspot” problem is alleviated. And the performance of network can be improved in terms of lifetime better coverage and quick response time.

3.1 WSN with Static Sink

In the early days, a typical WSN was composed of static sensor nodes and a static sink placed inside the observed region. In such a setup, the major energy consumer is the communication module of each node. In practice, multihop communication is required for sending data from sources to sink nodes. Consequently, the energy consumption depends on the communication distance.

One way to reduce the communication distance is to deploy multiple static sinks and to program each sensor node such that it routes data to the closest sink. This reduces the average path length from source to sink and hence results in smaller *Ebar* compared to the case of single static sink. On the other hand, reduction in *Emax*is also observed because routing load on the nodes located in the vicinity of a single sink also gets distributed among all the nodes located in the vicinity of multiple static sinks.

The model to deploying multiple static sinks was introduced. These static sinks partition the WSN into small subfields each with one static sink.

By simulation the above scheme leads to energy efficiency and better data delivery ratio compared to schemes based on a single sink. However, a major problem with multiple static sinks is that one has to decide where to deploy them inside the monitored region so that the data relaying load can be balanced amongst the nodes. Vincze et al. consider this problem in as an instance of the well-known “*facility location problem*” where for a given number of facilities and customers the optimal position for the placement of the facilities has to be identified so that all facilities are evenly burdened. If the positions of the static sinks are given, then the solution of this problem can be used for finding the optimal partitioning of the field.

However, even if we assume location optimal deployment of static sinks, the nodes close to a sink will deplete their energy rather rapidly. Adding some mobile sinks to a set of static sinks has been shown to improve the data delivery rate and to reduce energy dissipation of the sensor nodes.

3.2 WSN with Mobile Sink

Another approach for extending the lifetime of the nodes close to the sink is the utilization of a mobile sink. In some aspects, this is similar to using several static sinks – however, using several static sinks requires additional global communication for collecting all data at a single final point.

In order to overcome the shortcomings observed for a static sink, the use of a mobile sink has been proposed. A mobile sink can follow different types of mobility patterns in the sensor field, such as random mobility, predictable/fixed path mobility, or controlled mobility, which has consequences with respect to energy efficiency and data collection strategies.

4. RELATED WORK

4.1 Clustering Algorithm and Sink Mobility Approaches

Clustering is one of the prominent techniques used for balancing load in wireless sensor network. This protocol comes under the tier of hierarchal routing. LEACH (Low Energy Adaptive ClusteringHierarchy) [5, 11] is one of the first energy efficient hierarchical clustering protocol and leading renovation on reviewing new clustering techniques. It serves as the basic platform for establishing several new clustering methods. This protocol serves in conserving the energy dissipation as the job of forming cluster happens in a defined cyclic pattern. Each Cluster Head (CH) communicates directly to forward data to the base station (BS). It is known as Head to Head communication. This protocol divides the network into different forms of clusters with various sizes that piles up useful information to the sink. LEACH mainly has two phases: A Setup phase for the formation of clusters and a steady phase for data collection and transmission to the sink. The energy dissipation is considerably high for selecting CHs and communication between the CHs.

LEACH-Z (LEACH-Zones) [6] this enhanced protocol of LEACH divides the sensing region into Zones. The zones comprises of clusters in varying sizes with which the clusters closer to the base stations are larger and the clusters far away forms smaller in sizes. In this protocol the sensing region is segregated into four parts namely near, mid, far, and very far. These divisions are made based on the distance between the sensor nodes and the base station. After the partition of zones the number of nodes in each part is counted and the CHs are elected as per the LEACH protocol. If there exist two or more CHs, it computes the distances between a node and thee CH and gets attached to the closest CH to the base station. The zone having only one CH forms its cluster in the same part. The zone with no CH joins with the closest CH of the next part. Even though LEACH-Z shows improved performs over original LEACH protocol, the formation of cluster are uneven in sizes which also becomes a major factor affecting energy of the nodes for communication and data transmission.

HEED (Hybrid Energy-Efficient, Distributed Clustering) [7, 12] was designed to use residual energy as a metric for CH election and formation to manage traffic in the network. Here the nodes deployed are assumed to be homogenous.

In other words all the nodes are equipped with same characteristics such as power, transmission range,and it does not require special node capabilities such as location awareness. Thus creating well distributed clusters. This protocol increases energy efficiency and prolong network lifetime. Intra clustering communication cost is also a clustering parameter as cost refers to the power levels are permissible for transmission within cluster. Intra clustering communication is the communication within cluster. Here the random CH selection causes communication overhead; periodic CH rotation needs extra energy to reorganize clusters.

A Mobile Sink Based Uneven Clustering Algorithm [3] is a combined approach for clustering protocol with mobile sink strategy. Here the nodes deployed are stationary, location-aware; adjust the transmission power based on distance. The movable sink is energy unconstrained that moves in a predefined path at some constant speed. The various locations of the sink are set in advance. Uneven clustering algorithm which aims at improving the network performance is distributed clustering similar to the original LEACH. The CH selections are based on its competitive range and residual energy. Rest of the sensor nodes enters sleeping mode until the end of CHs finalization process. This algorithm includes both inter-cluster and intra clustering phases. The clusters closer to the sink are smaller in sizes. Multi-hop communication protocol is being used with addition to defining threshold value based on distance. The mobile sink can conserver relatively more energy which compared with the sink moving randomly.

Controlled Sink Mobility category under the classification based on movement of sink had shown high degree of chance in prolongation of network lifetime in WSNs.

Mainly it has supported in reducing the traffic of the network and thereby resolving the hot-spot problem [8]. NP-hard is the well-known single objective problem of maximizing the lifetime of the network. Here, Optimal Sink Trajectory (OST) is the multiple-objective optimization problem which has the plan of designing trajectories of multiple mobile sink. Geometric Sink Trajectory (GST), the main portion focused on is minimizing the maximum Euclidean distance. It uses a polar grid which is a geometricprincipled approach for equal segmentation of the sensing region. Providing multiple mobile sink may result in increase of message overhead and which indirectly consumes extra energy and economically high.

A potential model using a mobile sink and uneven clustering algorithm for wireless sensor networks [7] in which the two major issues are explained. Firstly, improving the energy efficiency and secondly, prolonging network lifetime. These are main challenging research issue for wireless sensor networks (WSNs). On adding mobility technology into WSNs has drawn increasing attention. The combination of the uneven clustering algorithm with mobile sink strategy and propose the model of mobile sink based uneven clustering algorithm. First, the study of uneven clustering algorithm with a fixed sink node located at the center of a rectangle network. And the evaluation was made to read the performance of energy consumption and network lifetime, and compare the algorithm with LEACH. Then the use of mobile sink node instead of fixed sink node to collect fused data under similar environment had been carried out. Thus the mobile sink node can efficiently mitigate hot spots near sink node as sink node moves either randomly or along a predetermined fixed path.

The concept of a node centric load balancing algorithm for wireless sensor network [8] which explains,by spreading the workload across a sensor network, load balancing reduces hot spots in the sensor network and increases the energy lifetime of the sensor network. A model of design a node-centric algorithm that constructs a load balanced tree in sensor networks of asymmetric architecture. It utilizes a Chebyshev Sum metric to evaluate via simulation the balance of the routing trees produced by the algorithm. It is found that the algorithm achieves routing trees that are more effectively balanced than the routing based on breadth-first search (BFS) and shortest-path obtained by Dijkstra's algorithm.

An efficient approach demonstrates which explains the use of a mobile sink for quality data collection in energy harvesting sensor networks [9] that studies of data collection in an energy harvesting sensor network where sensors are deployed along a given path and a mobile sink travels along the path periodically for data collection. Such a typical application scenario is to employ a mobile vehicle for traffic surveillance of a given highway. As the sensor in the network are powered by renewable energy source, the time-varying characteristics of energy harvesting poses great challenges on the design of efficient routing protocols for data collection in harvesting sensor network. A novel optimization problem as a network utility maximization problem, by incorporating multi-rate communication mechanism between sensors and the mobile sink and show the NP-hardness of the problem. Then a novel centralized algorithm is devised for it, assuming that the global knowledge of the entire network is available. A distributed solution to the problem without the global knowledge assumption was also developed. The algorithm shows better improvements.

Rotated hybrid, energy-efficient and distributed (R-HEED) [10] clustering protocol in WSN that explains about the clustering approach which has been considered as one of the most effective methods to prolong the network lifetime in WSNs. Hybrid, Energy-Efficient, and Distributed clustering approach (HEED) is considered one of the most energy-efficient clustering algorithms that uses intra-communication cost and residual energy to elect the Cluster Heads (CHs). This approach aim at examining different inter-cluster routing protocols over HEED and evaluate their performance. Moreover, Rotated HEED (RHEED) is the enhanced version of HEED. The modified version conducts the setup phase according to certain rules and schedule, with HEED performs this step at the beginning of some rounds. At the beginning of every round the CHs wait a pre-defined period of time to receive a re-clustering message from the BS. If they do not receive the re-clustering message, they will continue rotating the cluster head within the same cluster. The RHEED outperforms the HEED protocol by more than 20% in term of network lifetime and residual energy.

CONCLUSION

In this paper, we review various clustering algorithms and sink mobility approaches for wireless sensor network. In WSN the energy consumption increases due to heavy traffic of the network which leads into network partition. The above problems motivates to concentrate on designing better energy efficient algorithm which reduces the network traffic i.e., in other words hot-spot problem. Thereby consuming minimum energy and increasing the lifetime of the network.

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