International Journal Of

Recent Scientific Research

ISSN: 0976-3031

Volume: 7(5) May -2016

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THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 7, Issue, 5, pp. 11382-11385, May, 2016

International Journal of Recent Scientific Research

Research Article

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ARTICLE INFO

Article History:

Received 17th February, 2016
Received in revised form 21st March, 2016
Accepted 06th April, 2016
Published online 28th May, 2016

Key Word

WSN, layered network, data collection, load balanced clustering

ABSTRACT

Wireless Sensor Networks (WSNs) are widely used for different applications such as monitoring and surveillance in both civilian and military domains. Mobile data collection has significant impact on the performance of WSN. Therefore it is essential to have mechanisms to improve it. In this paper we proposed a three-layered approach that is used to collect data in wireless sensor network. The three layers include sensor layer which is made up of collection of sensors, cluster head layer which is made up of all cluster heads, and the mobile collector layer. The proposed approach also takes care of distributed load balanced clustering. The aim of the proposed approach is to achieve scalable solution with low data collection latency and energy efficiency. While sensors are organized into clusters the distributed algorithm is applied so as to ensure that the efficiency of the network is achieved. We built a prototype application using Microsoft .NET which simulates the proposed approach. The empirical results revealed that the proposed layered approach is energy efficient, scalable and achieves low latency in data collection.

INTRODUCTION

The availability of low-cost sensors made the WSN to be easier to establish and deploy. WSN is widely used across the world for different purposes. The main reason for which WSN is used is sensing. It is a collection of sensor nodes that sense data and sends to base station or sink. The data collection approach is many to one. When data collection is important, the sensors are densely deployed in a geographical area. As sensors depend on the battery power it is important to ensure that they use less energy. On the other hand the data collection latency is also important. The life of the battery is very important for the success of the network. In this paper a WSN is built with three different layers. The layered approach is used to save energy and also decrease data collection time.

The proposed solution includes a load balanced clustering of sensor nodes. The distributed clustering algorithm is used to ensure that the energy is efficiently utilized and the network is scalable. The distributed algorithm is responsible to organize sensor nodes into different clusters. Each cluster has its cluster head. The load of intra-cluster aggregation is balanced. We used the concept of mobile collector which is meant for optimized data collection in the WSN. It is responsible to collect data from cluster heads. Our contributions are as follows.

- We built a WSN with three layers namely sensor layer, CH layer and mobile collector layer.
- We proposed a distributed load balanced clustering algorithm that is worked out in each sensor for self configuration with respect to clustering decisions. This will have impact on the energy efficiency.
- We built a prototype application using Microsoft .NET platform to simulate and demonstrate the proof of concept.

The remainder of the paper is structured as follows. Section II provides review of literature. Section III presents the proposed system in detail. Section IV presents experimental results while section V concludes the paper.

Related Works

This section provides the related work on the research topic related to mobile data gathering in WSN. The concept of data gathering and relay routing became important in WSN. Relay routing is the process of routing messages while the clustering is a process of grouping similar objects in order to have clusters with high intra-similarity and low inter-similarity ideally. The nodes in WSN send data to sink in multi-hop fashion. The deployments of relay nodes were studied in [2] for elongate network life time. A coordinated transfer of schedule by using alternative routes is explored in [1] in order to avoid congestion in the network. In [4] maximum-lifetime data gathering tree is constructed through an algorithm which starts from an arbitrary tree and then reduces the load on the bottleneck nodes iteratively.

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The Collection Tree Protocol (CTP) was evaluated in [3]. The CTP computes wireless routes in order to map with wireless link status in such a way that the scheme satisfies efficiency, robustness and reliability irrespective of hardware being used. There is some issue here. When any node which is located on the critical path is subject to an attack which depletes its energy, the data collection performance of the network is reduced. There is another way used to have clusters that can effectively reduce the number of relays ([8], [7], [6], and [5]. Such scheme is proposed in [5] known as LEACH which is minimum executed clusters. However, it has no guarantee to provide suitable cluster head (CH).

Later on in [6] HEED scheme was proposed which combines the cost and residual energy in order to have a metric which can be used for cluster head selection. Thus the scheme was able to produce well informed and well distributed cluster heads and the generated clusters are said to be compact. In [7] the clustering scheme was said to be efficient with loss wireless network that is based on the link quality. The d-hop clustering was addressed in [8] in which each node contains a cluster head at d-hops away. In the entire cluster base schemes mentioned here a cluster head acts as an aggregation point and also acts as scheduler or controller for something known as in-network processing.

Efficient scheduling of cluster heads is considered in [9] for avoiding collisions. The correlation of sensing data is considered [12] and in [11] also the same concept is used. The spatio-temporal correlation concept is used by the cluster-heads in order to minimize the readings thus saving energy in the network. Nevertheless, it is possible to consider the traditional single-head clustering to do so. In this paper a load balanced multi-head clustering is proposed. Mobile data collections when compared with that of static sink has many benefits such as balancing energy consumptions. Control data mules were proposed to traverse the sensing field and thus collect data from all the nodes which are nearby and exhibit multi-hop transmissions.

In case of sensor networks that are uniformly distributed, such schemes work well. In order to achieve more robust scheme for data gathering in [10], an efficient moving path planning algorithm was proposed. A single-hop data gathering scheme was proposed in [13] for high uniformity in energy consumption. The rationale behind this is the mobile collection known as SenCar is configured to stop at select locations and obtain data from the sensors. The schedule of mobile elements was studied in [15] with no data loss due to the problem of buffer overflow. Latency of the scheme may be increased though it utilizes more mobile collectors. In [14] the data gathering process is optimized as it could find shortest moving tour.

The feasibility of using MIMO techniques was explored in [19], [18] and [17]. The MIMO is sued as there is difficulty in having multiple antennas on a sensor node. The MIMO based scheduling algorithms can help in coordinating transmissions in WSN. Such demonstrations can be found in [16]. Optimization of modulation and transmission time was made to compensate energy usage in [19]. In this paper, we design and implement a framework that enables an improved form of MIMO known as MU-MIMO.

Proposed Work

We proposed a framework with three layers for WSN. The layered approach makes the system as energy efficient and scalable. The layers in the system are as shown in Figure 1. The first layer is sensor layer which is the collection of deployed sensors. These sensors are deployed using a distributed load balanced clustering algorithm which ensures energy consumption in network communications. The second layer is CH layer. It is the collection of cluster heads in the WSN. The third layer is very important which takes care of energy efficient data collection. The third layer is known as mobile collector layer which reduces the data collection latency. The framework is shown in Figure 1. It shows a collection of sensors organized into clusters. Each cluster has its own cluster head. There is data transmission to sink which is the place where data is gathered. This kind of network is very useful in the real world as it is used in many applications. The sensor nodes are responsible to collect data from neighbourhood. The CH is responsible to get data from sensors. The mobile collector is used to collect data from CH and send the data to sink of the network.

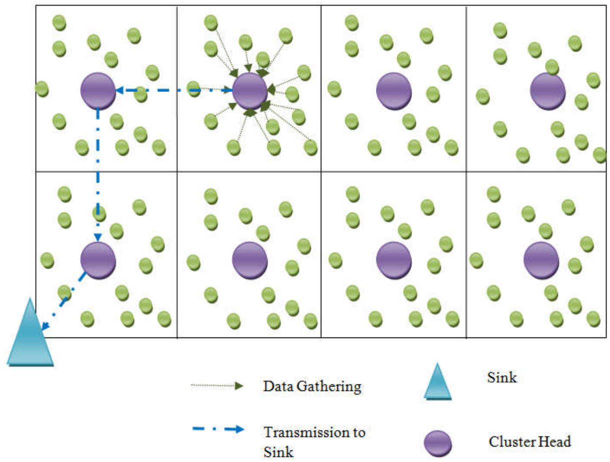

Figure 1 –Overview of the proposed framework

As shown in Figure 1, the three layered network is formed and simulated using Windows Forms based GUI built in Microsoft.NET platform. The network is simulated in such a way that the sensor nodes are automatically configured using distributed load balanced clustering. Each layer in the network has its own responsibilities as described above. The subsequent section provides details of the implementation.

Implementation

The following algorithm is used to implement the proposed scheme. The algorithm is presented in Figure 2 in the form of flow chart. First of all a network topology is created. Then the source node id is used to transmit data to destination. In the process, the system takes care of neighbour selection, forming a routing table, status claim, and cluster formation. If the cluster is successfully created, then cluster head is selected. If not the cluster creation work is continued. After forming all clusters with respective cluster heads, the synchronization of cluster heads is taken place. Then data aggregation is carried out. Finally the performance is evaluated. Two performance improvements are expected. First one is energy efficiency and second one is scalable solution of low latency data collection.

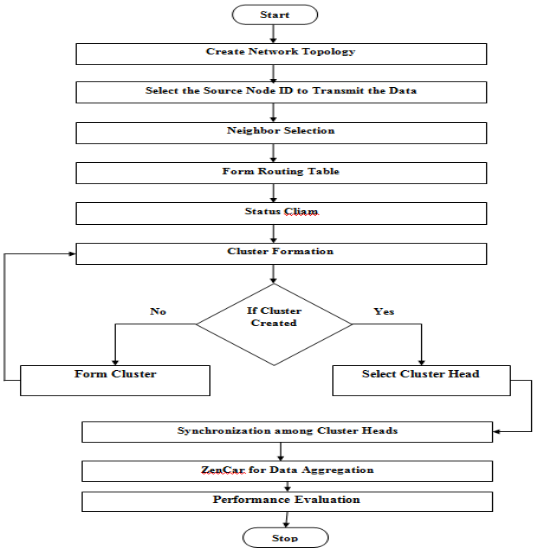

Figure 2 Proposed algorithm

As can be seen in Figure 2, the algorithm is visualized. The algorithm is used in the realization of a WSN that takes care of distributed load balanced clustering of sensor nodes with cluster selection process and the means of ensuring the low latency data collection in the WSN.

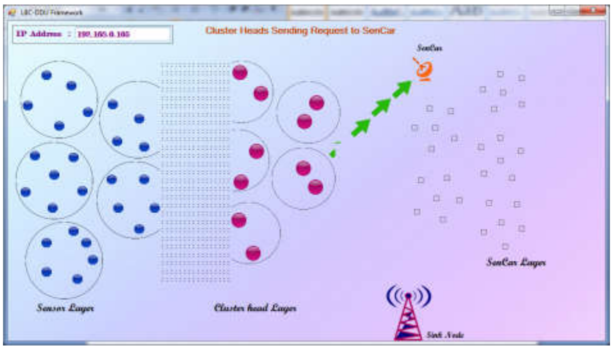

Figure 3 Simulates the three layered approach

As shown in Figure 3, it is evident that there are three layers such as sensor layer, cluster head layer and mobile data collector layer. There is sink node in the simulation which is meant for receiving data from the sensors in general.

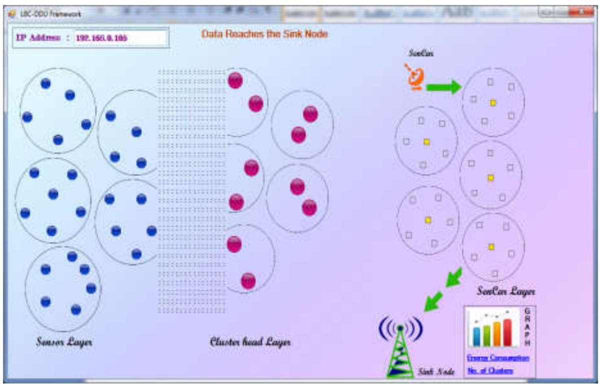

Figure 4 Simulates the three layered approach with data transmission

As shown in Figure 4, it is evident that there are three layers such as sensor layer, cluster head layer and mobile data collector layer. There is sink node in the simulation which is meant for receiving data from the sensors in general. The network demonstrates the simulation of data movement from source to destination.

EXPERIMENTAL RESULTS

This section provides results in terms of energy consumption, the number of clusters formed, and energy consumption with different approaches. The results revealed that the proposed solution is capable of achieving low energy consumption and low data collection latency besides high scalability.

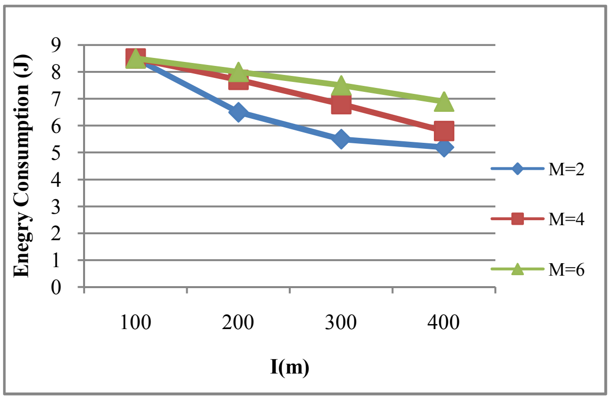

Figure 5 Performance comparison with different M

As shown in Figure 5, it is evident that the energy consumption is decreased when M value is decreased.

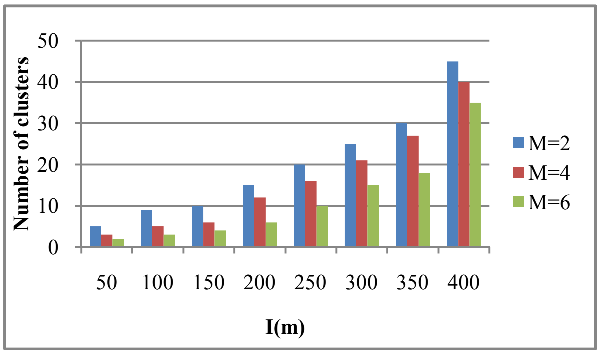

Figure 6 Performance comparison with different M vs. number of clusters

As shown in Figure 6, it is evident that the number of clusters is decreased when M value is decreased.

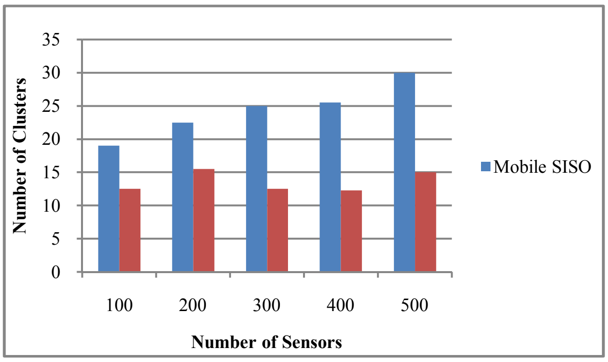

Figure 7 Performance comparison with number of sensors vs. number of clusters

As shown in Figure 6, it is evident that the number of clusters is decreased for second approach while the first approach reflects more number of clusters.

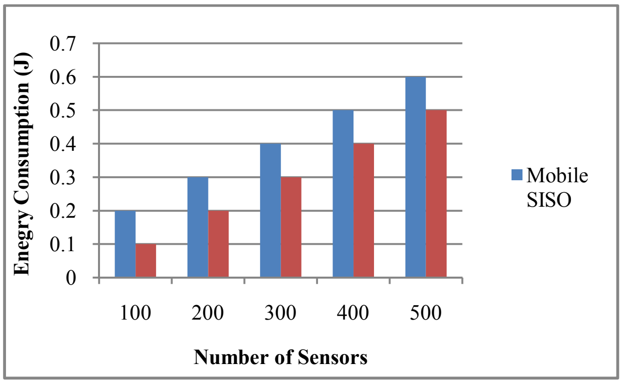

Figure 8 Performance comparison with number of sensors vs. energy consumption

As shown in Figure 6, it is evident that the energy consumption is increased when number of sensors is increased. The energy consumption of the first approach is more than the second approach.

CONCLUSIONS ND FUTURE WORK

In this paper we studied the concept of mobile data collection and energy efficiency in the WSN. We proposed a framework with three layers in the network. The three layers include sensor layer which is made up of collection of sensors, cluster head layer which is made up of all cluster heads, and the mobile collector layer. The proposed approach also takes care of distributed load balanced clustering. The aim of the proposed approach is to achieve scalable solution with low data collection latency and energy efficiency. While sensors are organized into clusters the distributed algorithm is applied so as to ensure that the efficiency of the network is achieved. We built a prototype application using Microsoft .NET which simulates the proposed approach. The empirical results revealed that the proposed layered approach is energy efficient, scalable and achieves low latency in data collection. This research is further extended to improve the proposed framework for security to protect it from different kinds of attacks besides energy efficient data collection.

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ISSN 0976-3031

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