International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

AN EFFICIENT PATH SELECTION FOR FAST DATA COLLECTION IN WSN USING MULTIPLE MOBILE SINK

KULANDAIVEL.R, GOBALAKRISHNAN.J
Information Technology,
Sri Ramakrishna Mission Vidyalaya Polytechnic College,
India.

Abstract : Wireless sensor networks are limited in energy, utilizing the sink mobility has been found a better choice to tackle the limited energy conserved environment, this also may help to balance the node energy. Data dissemination to the mobile sink is a tedious and challenging task, and this creates a scheduling problem too for the resource constrained sensor nodes. This problem has arises due to the dynamic network topology caused by the mobility model. To improve the data collection in energy constrained networks, the system proposes multiple mobile sink ability. This deploys more than one mobile sink in the network environment for optimal and different delay constrained nodes. This denotes a mobile sink is required to visit some sensor nodes or parts of a WSN more frequently than others while ensuring that energy usage is minimized, and all data are collected within a given deadline.

There is a need to extend WRP to the multiple mobile sinks/rovers case in order to improve the scalability. While extending number of mobile sinks, it may involve with many sub problems such as interference and coordination between Mobile sinks. In order to overcome the several existing problems, a novel scheme proposed named as **MMS** a dynamic Multiple Mobile Sink Scheduling Dynamic for fast data collection is proposed. Unlike the existing approaches, this improves data delivery performance by employing multiple mobile sinks and by deploying fine scheduling at strategically important points in the sensor field, the proposed Optimized Mobile Sink Protocol (OMS) does not allow packet drop at such situation. It aims to optimize the trade-off between nodes energy consumption and data delivery.

Keywords: Path Selection, Cloud Computing, WSN, fast data collection, Networking.

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

I. Introduction

Wireless Sensor Networks (WSN) usually contains thousands or hundreds of sensors which are randomly deployed. Sensors are powered by battery, which is an important issue in sensor networks, since routing consumes a lot of energy. Such nodes are deployed in thousands to form a network with capacity to report to a data collection sink (base station) as seen in Figure 1.1. An efficient routing scheme in sensor network is also important. Networking unattended sensor nodes are expected to have significant impact on the efficiency of many military and civil applications such as combat field surveillance, security and disaster management [1].

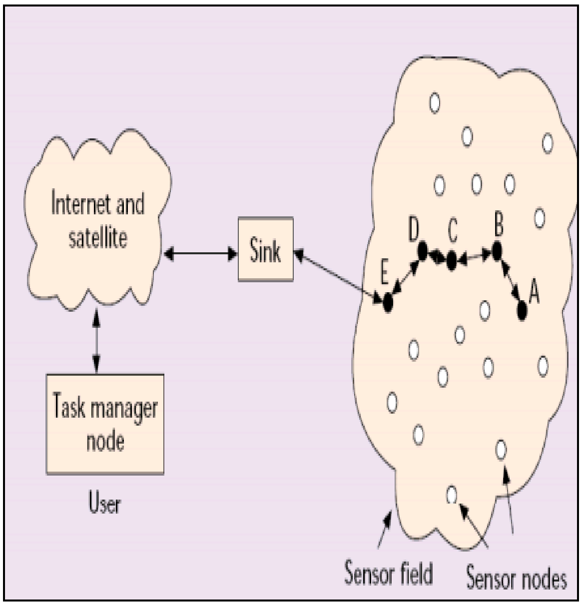


Figure 1.1 Typical Architecture of a Wireless Sensor Network

Figure 1.1 shows the architecture of WSNs, where the sensor nodes (energy constraint) are randomly distributed over the sensor field and the information collected by the nodes are sent to the remote base station called as 'sink' through multi hop communication. This is shown by the bidirectional link and the nodes which are under communication is indicated by the filled circles (A, B, C, D, E). The communication between nodes and the sink are also bidirectional. The user can collect the information through satellite and internet.

These systems process data gathered from multiple sensors to monitor events in an area of interest. For example, in a disaster management's setup a large number of sensors can be dropped by a helicopter. Networking these sensors can assist rescue operations by locating survivors, identifying risky areas and making the rescue crew more aware of the overall situation. Such application of sensor networks not only increases the efficiency of rescue operations but also ensure the safety of the rescue crew. On the military side, applications of sensor networks are numerous [2]. For example, the use of networked set of sensors can be limiting the need for personnel involvement in the usually dangerous reconnaissance missions.

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
SKRGC Since 2012
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

Efficient design and implementation of WSNs has become a hot area of research in recent years, due to the vast potential of sensor networks to enable applications that connect the physical world to the virtual world. By networking large numbers of tiny sensor nodes, it is possible to obtain data about physical phenomena that was difficult or impossible to obtain in more conventional ways [3]. In the coming years, as advances in micro-fabrication technology allow the cost of manufacturing sensor nodes to continue to drop, increasing deployments of wireless sensor networks are expected, with the networks eventually growing to large numbers of nodes (e.g., thousands).

Potential applications for such large-scale wireless sensor networks exist in a variety of fields, including medical monitoring [4], environmental monitoring [5], surveillance, home security, military operations, and industrial machine monitoring. To understand the variety of applications that can be supported by wireless sensor networks, consider the following areas of application given in section 1.3.

EFFICIENT DATA COLLECTION

In a Wireless Sensor Network (WSN), dispersed sensors are usually battery–powered and difficult or impossible to recharge. Constrained by the limited energy supply, collecting sensed data efficiently from each sensor to the sink is becoming one of the most important research challenges. A direct implication of dense deployment is that sensed data between nearby sensors tend to be correlated to the extent that they correspond to intersecting sensed areas. This correlation can be viewed as an indication of redundancy in the collected data. If the data collected from each sensor is sent to the "sink" without any form of processing to remove redundancies, substantial energy (and bandwidth, due to unnecessarily long data transfers) is wasted without good reason.

1.4.1 Load Balancing

Load balancing refers to the mechanism in which data packets are spread in a balanced way across multiple paths from sources to destinations. A balanced traffic distribution can help to optimize network throughput and can allow all nodes to deplete their batteries at a similar rate. The use of multipath routing is a natural way to implement load balancing. However, data spreading across multiple paths must be done by minimizing path interference, since a high rate of radio collisions

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com
Reference ID: IJCS-392
Volume 10, Issue 1, No 2, 2022
ISSN: 2348-6600
PAGE NO: 2688-2700

would nullify the positive effects derived from the use of multiple paths.

1.4.2 Data-Driven Approach

To improve energy efficiency Data-Driven Approaches are implemented. This approach is designed to reduce the number of sampled data by keeping the sensing accuracy within an acceptable range. Generally, data sensing focus on the energy consumption of sensor nodes in two ways:

(i) Excess samples: They result in useless energy consumption, even if the cost of sampling is negligible, because they result in unwanted communication.

(ii) Power consumption of the sensing subsystem: This subsystem requires some energy for its operation. Data driven approach looks into this issue whenever the power consumption of this part is high.

Data-Driven approaches can be implemented by two schemes as shown in Figure 1.3. Specifically, Data-Reduction consider the case of unwanted samples, while Energy-Efficient Data Acquisition schemes mainly focus on reducing the energy spent by the sensing subsystem. Even, some of them can reduce the energy spent for communication as well. The three classifications of data reduction aims at reducing the amount of data to be delivered to the sink node though the principles behind them are different.

In-Network processing performs the function of data accumulation at intermediate nodes between the source and the sink. As a result, the amount of data is reduced while traversing the network towards the sink node. The appropriate In-Network processing technique depends on the specific application. Data Compression scheme can be applied to reduce the amount of information sent by source nodes. In general compression techniques are not suitable for WSNs.

OVERVIEW

Wireless sensor networks (WSNs) are composed of a large number of sensor nodes deployed in a field. They have wide-ranging applications, such as environment monitoring, agriculture, home automation, military, smart transportation and health. Each sensor node has the capability to collect and process data, and to forward any sensed data back to one or more sink nodes via their wireless transceiver in a multi-hop manner. It is equipped with a battery, which may be hard or impractical to replace, given the number of sensor nodes and deployed environment. These constraints have led to intensive research efforts on

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
SKRGC Since 2012
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

designing energy-efficient protocols. In multihop communications, nodes that are near a sink tend to become congested as they are responsible for forwarding data from nodes that are farther away. Thus, the closer a sensor node is to a sink, the faster its battery runs out, whereas those farther away may maintain more than 90% of their initial energy. This leads to non-uniform depletion of energy, which results in network partition due to the formation of energy holes. As a result, the sink becomes disconnected from other nodes, thereby impairing the WSN. So, balancing the energy consumption of sensor nodes to prevent energy holes is a significant concern in WSNs.

II.Literature Review

Many existing methods which uses mobile sink in sensor network have proved that the energy can be efficiently utilized and overall network lifetime can be improved. According to the taxonomy provided in [6], WSN with mobile sink can be divided into two classes: 1) Direct and 2) rendezvous. In the former method mobile sink will collect the data via single hop and focus on minimizing the data collection delays. Whereas in the latter method, mobile sink only visits the RPs with the aim of minimizing the energy consumption. The pitfalls in direct method can be seen when sensor nodes exists in greater number which in turn increases the mobile sink tour length. This results in buffer overflow at the sensors due to data collection delays. To deal with this problem, rendezvous based technique has been proposed.

Taxonomy given in [7] further divides the rendezvous method into 3 classes: 1) Fixed 2) Tree based and 3) Clustering. In fixed [8], sensor nodes are randomly deployed and the sink path is predefined. The nodes that exist within the communication range of mobile sink will acts as RP. In this method, the length of the sink path is independent on the sensor nodes buffer size or application deadline. Hence, the buffer of RPs may overflow or packets may expire before they are collected.

Xing et al. in [9] proposed a tree based algorithm known as RD-VT (rendezvous design with a variable BS track) to find the RP on SMT (Steiner minimum tree), where data will be efficiently buffered and in turn decreasing the sink tour length. The tree based algorithm is a Steiner tree spans a given subset of vertices of a graph. Steiner minimal tree has three major properties which are listed as follows. The first one is No two edges will meet at an angle less than 120 0. Second one is Each Steiner point has degree of 3 and

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

finally No crossing edges. It uses the equilateral triangle and a circle and a line principle to construct a Steiner point for a set containing three points on the minimum spanning tree, which is denoted in [10]. There are two types of Steiner point's, non-terminals and terminals. First type represents real senor nodes and the second one represents a physical position without sensor nodes known as virtual Steiner points. This variable starts with constructing a SMT by considering the sink as root. Then SMT is traversed in pre-order from, until the shortest distance between the visited nodes is equal to the required packet delivery time.

In the studies conducted in [11]–[12], the path of the mobile sink is fixed, and sensor nodes are randomly deployed near the sink's traveling path. Sensor nodes that are inside a mobile sink's communication range play the role of RPs and collect data from other sensor nodes. An example application is a traffic management system where mobile sinks are public buses that roam a city to collect data from sensor nodes placed on buildings. In these approaches, the length of the traveling path is not dependent on the buffer size of sensor nodes or application deadline. Hence, the buffer of RPs may overflow or packets may expire before they are collected by the sink.

Xing *et al.* [13] propose RD-FT, where the movement of a mobile sink is governed by application deadline. They also consider obstacles that restrict the movement of a mobile sink along a predefined path. The objective is to find a set of RPs on the fixed path such that the length of data forwarding paths from sensor nodes to RPs is minimized and that the traveling time between RPs is limited to the required packet delivery time.

III Problem Definition

In this paper existing system, in multi-hop communications, nodes that are near a sink tend to become congested as they are responsible for forwarding data from nodes that are farther away. Thus, the closer a sensor node is to a sink, the faster its battery runs out, whereas those farther away may maintain more than 90% of their initial energy. This leads to non-uniform depletion of energy, which results in network partition due to the formation of energy holes. As a result, the sink becomes disconnected from other nodes, thereby impairing the WSN. Hence, balancing the energy consumption of sensor nodes to prevent energy holes is a critical issue in WSNs. In existing works the limitations such as the maximum number of feasible sites, maximum distance between feasible sites, and minimum halt time govern the movement

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

of a mobile sink and the problem occur to determine how the mobile sink goes about collecting sensed data.

Disadvantages

- Time consumption because a mobile sink visits each sensor node and collects data via a single hop.
- Loss of energy by visiting every node to collect data.
- Intractable and impractical as the resulting because of increasing number of nodes.

Proposed System

To address the above problem stated in chapter 1 and chapter 2, a new method called weighted Optimal Mobile Sink Routing Protocol (OMS) is proposed, whereby each sensor node is assigned in a grid corresponding to its hop distance from the tour and the number of data packets that it forwards to the closest RP. OMS is validated via extensive computer simulation that enables a mobile sink to retrieve all sensed data within a given deadline while conserving the energy expenditure of sensor nodes. The use of OMS, this helps to bound the tour length. This means a subset of sensor nodes are designated as RPs, and non-RP nodes simply forward their data to RPs.

A tour is then computed for the set of RPs, which is called rendezvous is designed for selecting the most suitable RPs that minimize energy consumption in multi-hop communications while meeting a given packet delivery bound. A secondary problem here is to select the set of RPs that result in uniform energy expenditure among sensor nodes to maximize network lifetime.

Advantages

- To minimize energy consumption by reducing multihop transmissions from sensor nodes to RPs.

- By selecting the sensor node that forwards the highest number of data packets and have the longest hop distance from the tour and it reduces the network energy consumption.

- Achieves 45% more energy savings and 29% better distribution of energy consumption between sensor nodes.

- OMS establishes a virtual grid structure that allows the fresh sink position to be easily delivered to the grid and regular nodes to

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

acquire the sink position from the grid with minimal overhead whenever needed.

- The grid structure can be easily regulated. So this mitigating the hotspot problem.
- The mobile sink selects cell header nodes along its path and the CH nodes relay sensor data to the sink.
- In case the sink position information obtained by a sensor node loses its freshness, the sensor data is relayed through the sensor nodes to the current CH node, preventing packet losses. This mechanism is based on progressive sink localization.
- OMS relies on minimal amount of broadcasts; so, it is applicable to be used for sensors utilizing asynchronous low-power MAC protocols designed for WSNs.
- OMS does not have any MAC layer requirements except the support for broadcasts. It can operate with any energy-aware, duty cycling MAC protocol (synchronized or asynchronized).
- OMS is suitable for both event-driven and periodic data reporting applications. It is not querybased so that data are disseminated reliably as they are generated.
- OMS provides fast data delivery due to the quick accessibility of the proposed grid structure, which allows the protocol to be used for time sensitive applications.
- No information about the motion of the sink is required for OMS to operate. It does not rely on predicting the sink's trajectory, and is suitable for the random sink mobility scenarios.

Currently existing wireless sensor networks consist of homogeneous types of sensors, which comprise identical sensors with equal capacity in terms of sensing, computation, communication and power. Hence, they become application specific. In this research, heterogeneous sensor network (HSN) is utilized, which consists of different compositions of sensors, for example, some sensors collect image data, some collect audio signal, some have more processing capabilities and some have more power etc. Thus, various operations are performed simultaneously. Each sensor node communicates wirelessly with a few other local nodes within its radio communication range. Collecting the sensed data from sensor nodes in a wireless sensor

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

network occurs in different ways. The simplest is direct transmission, where each sensor directly sends gathered information to the remote receiver independent of each other. This approach has an inherent scalability problem. A second approach is through multi-hop routing, which has been extensively used for both generic ad-hoc routing networks as well as wireless sensor networks. These multi-hop routing techniques would perform the communications for small number of receivers. The third method is clustering where sensors form clusters dynamically with neighboring sensors. One of the sensors in the cluster will be elected as cluster head. The elected cluster head will be responsible for relaying data from each sensor in the cluster to the remote receiver. In addition, data fusion and data compression can occur in the cluster head by considering the potential correlation among data from neighboring sensors. This clustering approach is widely preferred because it localizes traffic and can potentially be more scalable .

Types of Hardware Heterogeneity:

Hardware heterogeneity is classified into three types, they are

1. Computational heterogeneity
2. Link heterogeneity
3. Energy heterogeneity

Computational heterogeneity, where some nodes have added computational power, link heterogeneity where some nodes can have long distance highly reliable communication links, and energy heterogeneity where nodes have unlimited energy resources.

IV.METHODOLOGY

OMS:

The OMS scheme constructs the grid structure by first partitioning the sensor field into several uniform sized grids which is based on the number of nodes in the sensor field. The motivation behind such portioning is to uniformly distribute the work-load on part of cluster head nodes which consequently results in prolonged network lifetime in multiple mobile sink environments. OMS schemes are beneficial for the easy-accessibility of the grid structure. Both the source nodes and the sinks can reach the grid with minimal number of nodes. In OMS scheme construction of the grid is based on virtualization. So this is not suffers from the high overhead of constructing a separate grid for each source node especially in applications where numerous sensor nodes generate data. OMS is a

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

hierarchical virtual grid based method and it constructs a single combined grid structure for all possible sources. In order to construct the grid structure position knowledge of sensor nodes is essential. Mutually data requests originated from the sink and data announcements originated from the source are propagated through the grid structure.

The OMS selection and re-scheduling process considers the following process.

In this section, the chapter proposes the scheduling process of OMS, a novel grid routing protocol for wireless sensor networks with multiple mobile sink. In this section, the chapter proposes OMS, a novel grid routing protocol for wireless sensor networks with multiple mobile sink. OMS have two roles on sensor nodes: cell header node and sensor node. Cell header nodes form a cell header structure which is a closed loop of single-node width shown in fig 4.1. The common process of OMS is as follows.

(i) Advertisement of sink position to the cell header periodically,

(ii) Sensor nodes obtaining the sink position information from the cell header whenever necessary, and

(iii) Nodes disseminating their data via the cell headers nodes if mobile sink is far else the sensor node transmits directly, which serve as intermediary agents connecting the sink to the network. The three sensor roles are not static, meaning that sensor nodes can change roles cell header the operation of the WSN. Three simple assumptions are made before going into the details of the protocol:

Sink localization:

Sink localization is the process of identifying nearest mobile sink in the region. This procedure calculates distance between each node using the distance based algorithm. The distance calculation technique uses absolute point-to-point distance estimates (range) or angle estimates in location calculation. So, distance-based methods require the additional equipment but through that this can reach much better resolution than in case of range-free ones.In this process the results of the inter node distance calculation is used. The calculated distances are converted into geographic coordinates of network nodes. Different less and more complicated techniques may be used to perform calculations. The coordinates of nodes can be calculated using: geometrical techniques. The

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

OMS is adopted to improve the accuracy of calculated estimates. This algorithm will check the calculated coordinates and distances to improve the accuracy of location and optimize the coordinates and distances.

Deploy the Mobile sensor nodes in the estimated position:

In this process finally the Mobile sinks will be deployed in the estimated locations. So, that this can achieve the better optimized or accurate locations for the sensor nodes. This can also achieve the cost efficiency.

Initial Scheduling process:

In order to handle with dynamic network topology in wireless sensor network, this is generally caused by sink mobility. In those mobile environment every node need to setup their data delivery routes in accordance with the latest location of the mobile sink.

OMS

Input: grid size (g)

Output: Node locations and mobility-path

1. choose the grid size: r
2. set the grid (g) into map and boundary (b)
3. let path start from the initial node i to end node n
4. if the planning path meet the obstacle
5. move along the obstacle and back to next grid point
6. send scheduling process to another mobile sink (Ms)
7. END

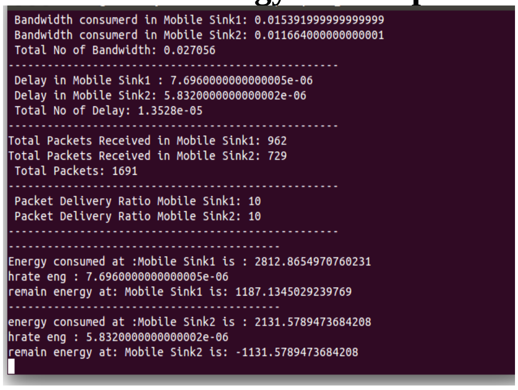
Mobile the sinks should reveal the most recent location to the entire sensor field. Using the OMS scheme, only the set of cell-headers that constitute the virtual backbone structure are responsible for maintaining fresh routes to the latest location of mobile sink and this communicates with multiple mobile sinks. For periodic data collection from the CH, the mobile sink moves around the sensor grid field and collects data via the closest border-line cell-header. T he closest cell- header upon discovering the sink's presence, shares this information with the rest of the cell-headers in a controlled manner.

SIMULATION AND RESULTS

The system simulates the proposed model using NS2. To evaluate the performance of the techniques, the system has developed a NS2-based simulation environment.

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

Energy consumption



CONCLUSION

In Wireless sensor networks data collection from energy constrained nodes is an important task. Mobile sink based data collection techniques has been introduced to perform optimal route planning, data collection scheduling, and fast emergency message gathering by discovering the multiple mobile sinks. This avoids data loss issues in energy restricted nodes by applying grid based data collection and dissemination by sharing the positions of MS with their neighbors and also addressed the selection of energy optimized node with stable path among the neighbors which not only describes the selection of correct position neighbors but also best link stability RPs. Thus overcome the data loss and also data dissemination failures. The availability of MS has been identified with the duration probability of a MS that is subject to link failures caused by MS mobility. The proposed work is implemented using NS-2. The performances are analyzed and addresses that OMS scheme has reduced the packet loss and delay and increases the packet delivery ratio and Energy of the network. In this work to reduce the communication energy, the network was divided into a number of clusters. Also energy heterogeneity is introduced over nodes present in the network. The high energy nodes are always acting as cluster heads and the low energy nodes are member nodes of the cluster. Also the number of cluster heads is fixed, and there is no need for the cluster head selection algorithm to rotate the CH nodes. Hence energy minimization can occur. The one time clustering WRP network is simulated and the result is compared with WRP protocol, which shows that the network lifetime improved by 1.5 times compared to WRP.

FUTURE ENHANCEMENT

1. To increase the merits of the proposed research work, plan to investigate the following issues in our future research:
2. An integrating the OMS in WSN protocol.
3. Simulate these algorithms in various mobility models and radio propagation models.
4. The distributed version of algorithms should be designed.

REFERENCES

[1] Yick, Jennifer, Biswanath Mukherjee, and Dipak Ghosal. "Wireless sensor network survey." Computer networks 52.12 (2008): 2292-2330.

[2] Hof, Hans-Joachim. "Applications of sensor networks." Algorithms for Sensor and Ad Hoc Networks. Springer Berlin Heidelberg, 2007. 1-20.

[3] Bulusu, Nirupama, and Sanjay Jha. Wireless Sensor Network Systems: A Systems Perspective (Artech House Mems and Sensors Library). Artech House Publishers Hardcove: 326 pages, 2005.

International Journal of Computer Science
Scholarly Peer Reviewed Research Journal - PRESS - OPEN ACCESS
ISSN: 2348-6600
http://www.ijcsjournal.com Volume 10, Issue 1, No 2, 2022 ISSN: 2348-6600
Reference ID: IJCS-392 PAGE NO: 2688-2700

[4] Jurik, Andrew D., and Alfred C. Weaver. "Remote medical monitoring."Computer 41.4 (2008): 96-99.

[5] Hughes, Danny, et al. "An intelligent and adaptable grid-based flood monitoring and warning system." Proceedings of the UK eScience All Hands Meeting. 2006.

[6] Lee, Euisin, et al. "Novel service protocol for supporting remote and mobile users in wireless sensor networks with multiple static sinks." Wireless Networks 17.4 (2011): 861-875.

[7] Luo, Jun, et al. "Mobiroute: Routing towards a mobile sink for improving lifetime in sensor networks." Distributed Computing in Sensor Systems. Springer Berlin Heidelberg, 2006. 480-497.

[8] Ekici, Eylem, Yaoyao Gu, and Doruk Bozdag. "Mobility-based communication in wireless sensor networks." IEEE Communications Magazine 44.7 (2006): 56.

[9] Ho, Chih-Ming, and Yu-Chong Tai. "Micro-electro-mechanical-systems (MEMS) and fluid flows." Annual Review of Fluid Mechanics 30.1 (1998): 579-612.

[10] X Li, A Nayak and Stojmenovic, “Sink Mobility in Wireless Sensor Networks”, pp. 153-184, Wiley, Hoboken, NJ, USA, 2010.

[11] Shuai Gao, Hongke Zhang and Sajal K Das, "Efficient Data Collection in Wireless Sensor Networks with Path-Constrained Mobile Sinks", IEEE Transaction on Mobile Computing, Vol. 10, No. 5, April 2011.

[12] Guoliang Xing, Tian Wang, Zhihui Xie and Weijia Jia, “Rendezvous Planning in Wireless Sensor Networks with Mobile Elements”, IEEE Transaction on Mobile Computing, Vol. 7, No. 12, December 2008.

[13] Guoliang Xing, Tian Wang, Weijia Jia and Minming Li, “Rendezvous Design Algorithms for Wireless Sensor Networks with a Mobile Base Station”, ACM Press, Hong Kong, China, 2008.