

MULTIPLE MOBILE SINK DATA GATHERING IN WIRELESS SENSOR NETWORKS

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Abstract— Wireless sensor networks have various applications, such as environmental monitoring, structural health monitoring, industrial process control, home automation, and healthcare. It is used to collect data, transmit it wirelessly to a central location, and analyze it to make decisions or take actions based on the collected information. WSNs face a challenge due to excessive energy ingesting in their nodes and network lifespan. The clustering approach is one of the best solutions to solve this issue. Choosing the best Cluster Heads (CHs) can consume less energy in the WSN. An Improved Sunflower Optimization Algorithm (ISOA) for optimizing the data gathering process in a Wireless Sensor Network (WSN) with multiple mobile sinks to select the best cluster head for each sink. ISOA is used to select the best cluster head based on the residual energy, distance to the sink, and number of nodes. The simulation results demonstrate that the proposed approach outperforms existing methods in terms of network lifetime, energy consumption, and data delivery rate. Overall, the proposed algorithm is a promising solution for efficient data gathering in WSNs with multiple mobile sinks.

Keywords—ISOA(Improved Sunflower Optimization Algorithm), WSN(Wireless Sensor Network), Multiple Mobile Sink, Clustering Protocol.

I.INTRODUCTION

Wireless Sensor Networks (WSNs) are composed of a large number of small, low-cost and low-power sensor nodes that are distributed in a specific area to monitor and collect data from the environment. In many applications of WSNs, the collected data needs to be transferred to one or more sink nodes for further processing and analysis. Traditionally, a single sink node is used to collect data from all sensor nodes in the network.

Wireless Sensor Networks (WSNs) have emerged as a promising technology for a wide range of applications, including environmental monitoring,

military surveillance, health monitoring, and home automation. In WSNs, a large number of sensor nodes are deployed in a specific area to collect data and transmit it to a sink node. However, in some scenarios, the use of a single sink node may not be sufficient due to various reasons such as limited transmission range, energy constraints, and network congestion. In such cases, multiple mobile sink nodes can be used for data gathering, which can provide better coverage, improved network lifetime, and reduced energy consumption.

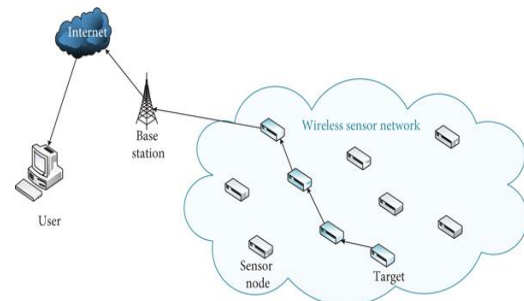


Fig.1 Wireless Sensor Network

The concept of using multiple mobile sink nodes for data gathering in WSNs has gained significant attention in recent years. Several studies have proposed various techniques and protocols to achieve efficient data gathering using multiple mobile sink nodes. The primary goal of these techniques is to ensure that data is collected from all sensor nodes in the network while minimizing the energy consumption and maximizing the network lifetime.

Network clustering splits the network into some groups known as clusters. Each cluster contains several sensor nodes. Among these nodes, there is

one node is chosen to be the cluster head (CH). The CH works as a local BS, which is responsible for collecting the data from other nodes and sending it back to the remote BS (as the cloud in WSN). Choosing the optimal CHs will conserve more energy over the wireless sensor network, so the network will run longer. A new SI algorithm is proposed to minimize the energy consumption of the nodes and increase their lifetime. Metaheuristic algorithm to increase the coverage rate. Multiple mobile sinks are used to increase the network lifetime. A Wireless Sensor Network (WSN) is defined by sensor, which are small devices that can perceive their surroundings and relay sensory information to a central position.

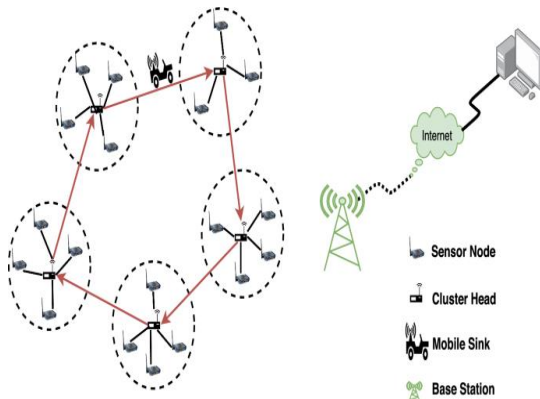


Fig.2 Mobile Sink in Wireless sensor network

This paper focuses on the concept of multiple mobile sink nodes for data gathering in WSNs. We discuss the advantages and challenges of using multiple mobile sink nodes and review the existing techniques and protocols proposed in the literature. Additionally, we present a comparative analysis of these techniques based on various performance metrics such as energy consumption, network lifetime, and data collection efficiency.

II. LITERATURE SURVEY

In wireless sensor networks, there are two distinct types of nodes called sink nodes and data collection and forwarding nodes. The data collection nodes are involved in the gathering of information from a large sensing area. In such a scenario, the number of nodes required for data collection, communication and coordination change with respect to application. Therefore, node deployment, data collection, routing and mobility are important issues to be addressed in the design of WSN. In this work, new algorithms for data collections and effective routing are proposed. This chapter provides a survey of related works in the areas of data collection and energy-efficient routing using clustering techniques.

G.A.Senthil proposed "Improved Cluster Head Selection for Data Aggregation in Sensor Networks," Wireless Sensor Networks (WSN) are a difficult rising innovation because of their degree, low preparing power, and related low vitality. WSN

directing contrasts from traditional steering in fixed systems. It needs foundation, has untrustworthy remote connections, sensor hubs may come up short and directing conventions need to meet extreme vitality sparing prerequisites. Information total in WSN successfully spares restricted assets. The objective of information total calculations is assembling and collecting information in a vitality proficient way so organize life is improved. Bunching is utilized to expand a sensor organize life by diminishing vitality utilization. This examination proposes a superior bunch head choice in sensor systems for proficient information collection. The proposed calculation depends on Local hunt and consolidated in Low Energy Adaptive Cluster Hierarchy protocol (LEACH)[1].

J. Chandra proposed "Particle Swarm Optimization Method for Energy Efficient Secondary Grid Cluster Head Selection to Avoid Energy Holes in WSN," Energy efficiency in randomly deployed Wireless Sensor Networks (WSN) is affected by high consumption of energy due to sensing, data transmission, propagation delay, coverage and, connectivity, resulting in energy depletion at the sensor nodes. In a multi-hop network, the nodes near to the sink will see a drop in energy at a faster rate leading to break in the connectivity chain, resulting in reconfiguration of the Network. This energy hole issue can reduce by employing energy-optimized clustering techniques and the best optimal cluster head selection based on the higher residual energy levels in the nodes. In this paper, Particle swarm optimization is used to select primary and secondary cluster head for grid Sectorized-clustered network to overcome the energy hole problem to extend the network lifetime. Also, it is proposed to compare the performance of the developed energy aware grid clustering algorithm with modified sectoring, Grid Sectoring and Two cluster head selection methods with a best optimization technique [5].

C. Wang proposed "Energy-Efficient Routing Protocol Based on Multi-Threshold Segmentation in Wireless Sensors Networks for Precision Agriculture," Wireless sensor networks (WSNs), one of the fundamental technologies of the Internet of Things (IoT), can provide sensing and communication services efficiently for IoT-based applications, especially energy-limited applications. Clustering routing protocol plays an important role in reducing energy consumption and prolonging network lifetime. The cluster formation and cluster head selection are the key to improving the performance of the clustering routing protocol. An energy-efficient routing protocol based on multi-threshold segmentation (EERPMS) was proposed in this paper to improve the rationality of the cluster formation and cluster heads selection. In the stage of cluster formation, inspired by multi-threshold image

segmentation, an innovative node clustering algorithm was developed. In the stage of cluster heads selection, aiming at minimizing the network energy consumption, a calculation theory of the optimal number and location of cluster heads was established. Furthermore, a novel cluster head selection algorithm was constructed based on the residual energy and optimal location of cluster heads. Simulation results show that EERPMS can improve the distribution uniformity of cluster heads, prolong the network lifetime and save up to 64.50%, 58.60% and 56.15% network energy as compared to RLEACH, CRPFCM and FIGWO protocols respectively [6].

III. PROPOSED SYSTEM

Despite the presence of all these works in literature, there are many issues which are yet to be solved due to the limitations in the existing work with respect to data collection, energy consumption, clustering and routing. Therefore, new energy efficient routing techniques are proposed in this study for effective routing in wireless sensor networks. The major contribution of this research work includes the proposal of a new Sleeping Cluster based ISOA for Wireless Sensor Networks, proposal of a combined cluster based tree Routing for Energy Efficient Data Collection in Wireless Sensor Networks with Mobile Sink and the development of a new mathematical model based energy efficient routing with prediction of mobile sink in wireless sensor networks. System Architecture consists of seven major parts namely Sensor Nodes, Data Collection, Sink Node, Routing system, Existing Approaches, Proposed Algorithms and Analysis.

A. CLUSTER MECHANISM

Clustered communication has been considered as one key technology for supporting machine-to-machine (M2M) wireless networks, existing clustering techniques have predominantly been designed with the objectives of maximizing the service quality for individual machines. Many M2M applications, however, are characterized by the large amount of correlated data to transport, and hence existing “machine-centric” clustering techniques fail to effectively address the “big data” problem introduced by these M2M applications.

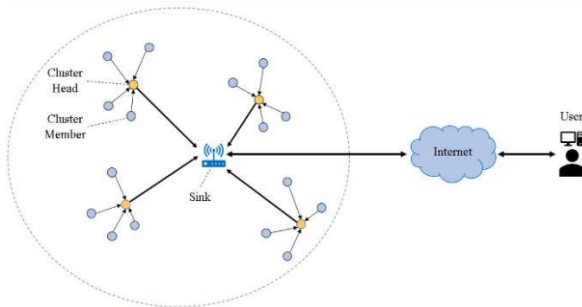


Fig.3 Cluster mechanism

In this, the concept of “data-centric” clustering to exploit the correlation of data to be gathered by a large number of machines. First formulated an optimization problem for the target problem that involves cluster formation and power control. Then proposed an anytime algorithm for solving the optimization problem iteratively in two phases. Compared with other approaches for cluster formation, shown through evaluation that data-centric clustering can achieve noticeable performance gain for dense M2M communications with big data.

B. IMPROVED SUNFLOWER OPTIMIZATION ALGORITHM

As energy is considered one of the most valuable resources in the IoT, our work aims to achieve effective management of energy utilization, which will lead to an expansion in the lifespan of the IoT network. We can do this by applying the clustering approach, where the optimal choice for the CHs in the IoT network will lead to consuming less energy. Consequently, The network will operate for a longer time. In our ISOA algorithm, clustering happens in two steps: Selection of CHs then formation of the clusters. We will explain these two steps in the following subsections.

SELECTION OF CLUSTER HEADS

The selection process of the CHs in the proposed ISOA algorithm takes place by applying a different fitness function, which based on a number of parameters as demonstrated in the following:

- **Average distance between CHs and SNs.** It refers to the summation of the distances between each CH_j (CH_j) and all SNs s_i . Then we calculate their average as shown in Equation 1

$$\frac{1}{m} \sum_{i=1}^N distance(s_i, CH_j) \quad (1)$$

where m refers to the number of CHs and N is the total number of SNs. When each node transmits data to its CH, it consumes some energy. For that, we have to select CHs near all the remaining SNs to reduce the consumed energy.

- **Average distance between CHs and BS.** It points to the Distance between each CH_j (CH_j) and the BS (BS) divided by the number of CHs (m) as written in Equation 2.

$$\frac{1}{m} distance(CH_j, BS) \quad (2)$$

Consequently, we can merge Equation 1 and Equation 2 in Equation 3 (named it $f_{distance}$) because we want to minimize the distances between cluster heads and nodes and the distance between the base station and each cluster head.

$$\text{Min } f_{\text{distance}} = \sum_{j=1}^m \frac{1}{m} \left(\sum_{i=1}^N \text{distance}(s_i, CH_j) + \text{distance}(CH_j, BS) \right) \quad (3)$$

Total energy for CHs. This parameter refers to the sum of the current energy for all the picked CHs. Our purpose is to maximize this sum to pick the optimal CHs. In another word, we aim to minimize the inverse of this sum as shown in Equation 4 (named it f_{energy}). Because each node expenses some energy when transmitting the data. It is important to pick the CHs from the nodes that own more energy than other nodes.

$$\text{Min } f_{\text{energy}} = \frac{1}{\sum_{j=1}^m (E_{CH_j})} \quad (4)$$

$E(CH_j)$ is the current value of energy for a cluster head j where $(1 \leq j \leq m)$.

From the previous two functions f_{distance} and f_{energy} we can form the fitness function by merging these functions into one function called F_{fitness} as shown in Equation 5

$$\begin{aligned} M F_{\text{fitness}} &= \alpha \times f_{\text{distance}} \\ &+ (1 - \alpha) \times f_{\text{energy}} \quad (5) \\ 0 &< f_{\text{distance}}, f_{\text{energy}} < 1 \end{aligned}$$

For selecting the optimal CHs, we aim to minimize the value of the fitness function in Equation 5. The smaller the fitness value, the best CH position we have.

IV. RESULTS AND DISCUSSION

In this section the performance of proposed protocol (ISOA) was compared with Predictive routing protocol (PR) and Elastic Routing protocol (ER) which uses geographical information of the sink and sensor nodes. The communication range of sensor nodes and sink are 5m and 30m respectively.

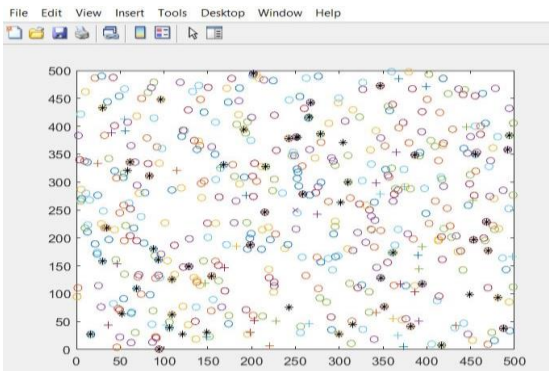


Fig.4 Deployment of nodes

For the performance comparison, packet delivery ratio and energy consumption of WSN under varying speed of mobile sink and scalability enhancement are applied. The data packet delivery ratio is defined as the ratio between number of packets delivered and number of packets generated by the source cluster. The energy consumption is defined as the total energy consumption for state transition (sleep to wake up), prediction of future location of the sink and routing the data packets.

Simulation Environments

The performances of the protocols are compared with simulations implemented in network simulator. The sensor network is considered as a square sensing field of size 500 X 500 m² and the mobile sink follows controlled sink mobility pattern with the speed of 10m /sec. To measure the energy consumption in communication First Order Radio energy model [19] which uses 50 nJ/ bit for running the radio circuit consisting of transmitter and receiver, 100pJ/bit/m² is used for transmitting amplifier circuit as shown in Table 1. Simulations are conducted for 100 seconds with the varied sink speed starting from 10m to 25m/sec and the number of sensor node varies from 100 to 500.

Table 1 Simulation parameters

Header Size	25 bytes
Data Size	500 bytes
Number of Nodes	500
Energy	0.5J
Simulation Area	500 X 500m
Simulation period	100 sec.

Simulation Results with Scalability of Sensor Nodes

Fig.5 shows energy consumption of network while varying the number of sensor nodes in four different routing protocols. Since the Elastic routing (ER) does not use flooding process throughout the network for updating the sink's new location, it shows best performance in energy consumption.

At the same time energy consumption of Predictive routing (PR) protocol is slightly higher than elastic routing, since the sink uses limited broadcasting of its new location to the 1 hop neighbors. Combined Cluster based Tree Routing Protocol (CCBTR) consumes more energy when there is an increase in number of wireless sensor nodes because of sink query registration process and in finding the location of mobile sink too. When compared to the above 3 routing protocols (PR, ER, CCBTR), the proposed routing protocol (ISOA) consumes less energy because only cluster heads are involved in finding the sink's new location, not the sensor nodes.

Table 2 Energy consumption of wireless sensor network with increasing scalability

EnergyConsumption(J)				
No.of Nodes	PR	ER	ISOA	CCBTR
100	0.52	0.41	0.33	0.61
150	0.59	0.49	0.4	0.67
200	0.63	0.53	0.43	0.74
250	0.7	0.59	0.48	0.81
300	0.83	0.63	0.54	0.9
350	0.9	0.72	0.62	0.97
400	0.95	0.8	0.7	1.3
450	1	0.9	0.8	1.9
500	1.7	1.4	1	2.5

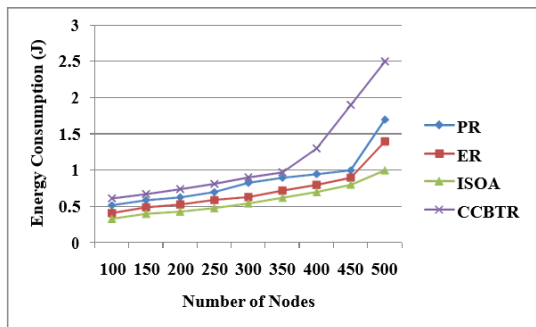


Fig.5 Energy consumption of the network with increasing scalability.

Table 2 shows the energy consumption of wireless sensor network with increasing scalability for the 4 different protocols. At maximum number of wireless sensor nodes (500) ISOA consumes less energy of 41.1% with PR, 28.17% with ER and 60% with CCBTR.

Table 3 Packet delivery ratio with increasing scalability

Packet Delivery Ratio(%)				
No.of Nodes	PR	ER	ISOA	CCBTR
100	38	25	45	32
150	43	30	51	38
200	47	34	56	43
250	52	37	59	47
300	62	50	68	58
350	70	55	75	64
400	76	63	85	70

Table 3 shows packet delivery ratio with increasing scalability off our different protocols with varying number of sensor nodes. Fig.2 shows packet delivery ratio of four different protocols with varying number of sensor nodes. The Elastic routing

(ER) shows drastic fall in delivering the data packets, since it is designed for a communication model where a single source is responsible for sending the data packets to the sink continuously. The predictive routing (PR) protocol shows improved data packet delivery ratio when compared to elastic routing. The Combined Cluster based Tree Routing (CCBTR) protocol also shows considerable rise in packet delivery ratio when compared to ER protocol. The proposed routing protocol (ISOA) shows higher packet delivery ratio when compared to other three routing protocols since the clusterheads are responsible for sending the data packet to the sink.

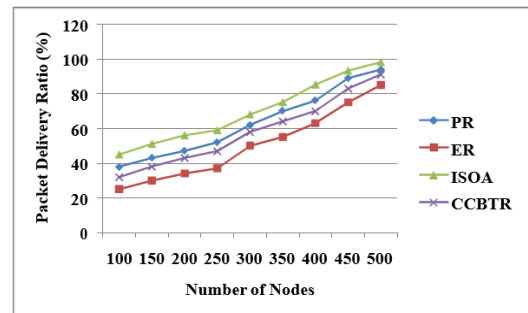


Fig.6 Packet delivery ratio with increasing scalability

Due to the increase in scalability of sensor nodes a greater number of clusters could be formed and multiple paths could also be available for sending the data to sink. Instead of sending the data through sensor nodes clusterhead takes the responsibility of collecting, processing and sending the data to sink with fewer hops.

Table 4 Delay in packet delivery

No.of Mobile Sinks	Delay(msec.)	
	ISOA	SEA
1	1590	1670
2	1600	1705
3	1650	1712
4	1675	1727
5	1697	1739
6	1720	1772
7	1738	1783
8	1750	1794
9	1785	1813

Table 4 shows the Delay in packet delivery which means the time difference between the time at which the mobile sink receives the data and the time at which the sensor node transmits a data.

Fig.7 Shows delay in packet delivery for SEA and ISOA. Since there is an increase in number of mobile sinks delay is reduced when compared to SEA in terms of 4.7%, 2.4% & 1.54% less with 1, 5 and 9 mobile sinks at the same time packet delivery ratio is improved.

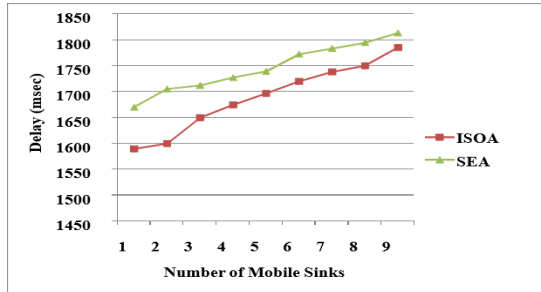


Fig.7 Delay in packet delivery

V.CONCLUSION AND FUTURE SCOPE

Wireless sensor networks with mobile sink approach have been given more attention on the basis of their energy efficiency and capability of supporting various remote area applications using WSN. The proposed routing protocol (ISOA) with mobile sink reduces energy consumption based on the mathematical model and maintains higher data packet delivery ratio along with the mobility and signal strength constraints. The proposed routing protocol doesn't use periodic broadcasting mechanism for updating the sink's new location. This method makes the cluster heads to find the future location of sink based on the information (current location, speed and direction) provided by the sink to the cluster heads in its surrounding area using kinematic equations. Simulation results show that the proposed routing protocol provides improved performance compared to the already existing routing protocols namely, Elastic routing (ER), Predictive routing (PR) and Combined Cluster based Tree Routing (CCBTR). In future the proposed routing protocol (ISOA) could be enhanced with cluster head mobility based upon the distance between the cluster head and sink to improve the energy efficiency in routing and lifetime of WSN.

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