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Clustering Algorithms in Mobile Wireless Sensor Networks – A Survey

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Abstract: Mobile Wireless Sensor Network has grown tremendously and become a hot Research Area. The most important feature of Mobile Wireless Sensor Networks is that the sensor nodes are small devices with limited processing, low power and can change their location. The main concern of clustering approaches for Mobile Wireless Sensor Networks is to prolong the battery life of the individual sensors by reducing the energy consumption and increasing the network lifetime. There is a need for a powerful algorithm to elect a Cluster Head which remains a challenge of research tasks in many research works that take into account the mobility of the network. This paper analyses various Clustering algorithms and concludes with the comparison of performance of the algorithms based on some of the parameters like Residual Energy, Mobility, Degree and Distance.

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I. INTRODUCTION

Mobile Wireless Sensor Networks (MWSNs) [1] consist of a large number of tiny mobile sensors nodes that are randomly deployed in a significant area to sense the event. The mobile sensor nodes communicate with each other to form a network. The nodes sense the data and send it to the Base Station. MWSNs are becoming useful in a variety of potential civil and military applications, such as intrusion detection, habitat, environmental monitoring, disaster recovery, hazard and structural monitoring, traffic control, inventory management in factory environments and health related applications, etc The most important feature of MWSN is that the sensor nodes are small in size and has limited processing, low power and has the ability to change their location. In mobility, life time of the sensor nodes is the most critical parameter which can be increased by reducing the energy consumption of each nodes. This can be accomplished by using an energy efficient algorithm.

Clustering [2] is an energy efficient technique where the sensor nodes are divided into non overlapping groups. Each group is governed by a node referred to as Cluster Head (CH) with all the nodes within a cluster referred to as Cluster Members (CM). Cluster Head (CH) collects the data from all the member nodes and aggregates the data collected from the member nodes and sends it to the Base Station. Clustering is used to reduce the energy consumption among the sensor nodes thereby increasing the lifetime of the nodes.

This paper presents a comprehensive review and discuss some of the prominent clustering algorithms that have been developed for MWSNs[3]. The goals of this survey are summarized as follows: (1) To create awareness about the existence of Clustering Algorithms in MWSNs (2) To focus the challenges in MWSN (3) To provide a brief taxonomy of some of the prominent Clustering Algorithms (4) To highlight the comparison of different Clustering Algorithms.

In this study, we present a comprehensive survey of different clustering algorithms in recent years. This paper is organized as follows: Section II provides an overview of challenges in MWSNs. Section III outlines the taxonomy of some of the famous clustering algorithms in MWSN. In Section IV, we present a comparison of different Clustering algorithms in MWSN. Finally, Section V summarizes and concludes this paper.

II. CHALLENGES IN MOBILE WIRELESS SENSOR NETWORKS

In Mobile Wireless Sensor Networks, due to mobility, it is important to analyze the common research challenges[4][5][6], which are as follows :

2.1 Localization

As the nodes are mobile in nature, it is important to continuously obtain their position as they traverse the sensing region. This requires additional time and energy, as well as the availability of a rapid localization service.

2.2 Network Coverage

One of the significant factor in the design and application of MWSNs is sensor coverage measured by the overall area that the network is currently monitoring. Sensor coverage is closely related to the quality of service that the network can provide, and it will decrease due to undesirable sensor deployment and sensor failures. Critical application like disaster areas, toxic regions or battlefields will make the initial deployment obviously far from having the desirable features of full coverage. Moreover, natural limitations (e.g., battery depletions, hardware defects) and external harsh environments (e.g., wind, fire) strongly affect the lifetime of sensors.

2.3 Dynamic Network Topology

The nodes are generally mobile in MWSNs, the topology is dynamic. New routing and Medium Access Control (MAC) protocols are needed in MWSNs. In dynamic topologies, the position data become outdated quickly, and route discovery must repeatedly be performed at a substantial cost in terms of power, time, and bandwidth.

2.4 Energy Consumption

The sensor nodes in a Mobile Wireless Sensor Networks (MWSNs) [7][8][9]are resource constrained with limited energy for the reason that it is fixed in a remote area and is unable to refill the battery. Designing the energy efficient algorithm is a great challenge due to the topological change of the networks and resource limitation in the environment. In order to conserve energy and increase network lifetime, the node should minimize the energy dissipation and optimize communication.

2.5 Mobility of Sensor Nodes and Sink

In MWSNs, as sensor are in mobility, different mobile entities need different data gathering methods. There are data gathering issues with mobile base stations, mobile relay nodes, and mobile sensor nodes. There are sensor control methods to deliver data to the sink energy-efficiently, considering node failures using broadcasting information. They do not consider node failures, fault tolerance, delay in data delivery in such network are research issues. Some MWSNs use mobile base stations, which traverse the sensing region to collect data, or position themselves so that the number of transmission hops is minimized for the sensor nodes.

III. CLUSTERING ALGORITHMS IN MOBILE WIRELESS SENSOR NETWORKS

3.1 EEDBC-M

Energy Efficient Density Based Clustering Algorithm-Mobile [10] is an enhancement of the LEACH-Mobile protocol. The algorithm uses an optimal clustering technique with a use of Density Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm for generating well-formed Clusters.

The Cluster Heads are nominated by considering the residual energy, mobility and density of the Mobile Sensor Nodes. The Cluster Head keeps record of the node with maximum power at current round. It reduces the consumption of energy during each round. This algorithm reveals a better performance in terms of various metrics such as Energy Consumption, Network lifetime, Throughput, Delay and Data Delivery Ratio.

3.2 SAEECS

Secure And Energy-Efficient Clustering Scheme (SAEECS) [11][12] with data aggregation in Mobile Wireless Sensor Networks is an energy efficient clustering scheme with aggregation of information to save the bandwidth requirement which in turn prologs the network lifetime. The proposed scheme is processed in two-stages. In the first stage of clustering, all nodes calculate their potential score based on the similarity of movement, residual energy and density in distributed manner. Each node decides whether it should become a cluster head or not, by employing a potential score. In the second stages, every node choose its cluster head among those cluster head candidates. A node with higher potential score is chosen as a cluster head. When a cluster member wants to transmit the data to the Cluster Head and security is provided using RSA algorithm.

3.3 EECA-M2

Energy Efficient Clustering Algorithm for Mobile Wireless Sensor Networks [13] focuses the network with nodes whose mobility changes with time. This algorithm mainly on four metrics namely degree of the node, energy consumption of the node, distance between the node and Base Station and Mobility of the node. EECA-M2, is aimed at electing a Cluster Head with minimum weight calculated based on the Degree, Distance, Energy and Mobility. The algorithm reduces the energy consumption and thereby increases the lifetime of a network.

3.4 CAREDR

Clustering Algorithm Based on Residual Energy Difference Ratio [14] is an energy efficient clustering algorithm based on residual energy difference ratio is presented to improve system performance. The residual energy of sensor nodes and average residual energy of system are considered in the residual energy difference ratio, which effectively avoid the nodes with low residual energy being selected as cluster heads. An energy-optimal scheme is used in cluster formation phase to minimize energy consumption. As it is a dynamic algorithm, the system dynamically clusters the sensor nodes according to the data transmission delays. It makes the whole system adapt to the random mobility of sensor nodes. It is a dynamic and energy efficient algorithm which improves the lifetime, throughput rate and energy efficiency.

3.5 EECHSS

Energy Efficient Cluster Head Selection Scheme in Mobile Wireless Sensor Networks [15] is an energy efficient based on the residual energy and randomized selection of the node, who is not assigned as a Cluster Head in previous round. The algorithm shows significant improvements in terms of energy consumption of sensor nodes, enhanced network lifetime and efficient data gathering due to less energy consumption during data transmission.

TABLE 1. List of Clustering Algorithms in Mobile Wireless Sensor Network

S. No.	Clustering Technique	Parameters Used
1	**EEDBC-M**	Residual Energy, Mobility, Density
2	**SAEECS**	Residual Energy, Mobility, Density
3	**EECA-M2**	Degree, Distance, Energy and Mobility
4	**CAREDR**	Residual Energy
5	**EECHSS**	Residual Energy

Table 1 lists out the various clustering techniques and the parameters used in the algorithms. The first three techniques EEDBC-M and SAEECS uses the Residual Energy, Mobility and Density as parameters for selecting a Cluster Head. The Cluster Head is selected based on the Degree, Distance, Energy and Mobility in EECA-M2. The Cluster Head Selection in the Clustering techniques, CAREDR and EECHSS is based on Residual Energy.

TABLE 2. Energy Consumption of EEDBC-MOBILE Vs EECA-M2 Algorithms

S. No.	No. of Nodes	Energy Consumption (Joules)	
		EEDBC-MOBILE	EECA-M2
1	**10**	**0.0089**	**0.0036**
2	**30**	**0.0279**	**0.0053**
3	**50**	**0.0402**	**0.0049**
4	**70**	**0.0712**	**0.0055**
5	**100**	**0.0925**	**0.0056**

Table 2 represents the Energy consumption of EEDBC-MOBILE and EECA-M2 algorithms based on the number of nodes in the simulation area. The energy consumption of EECA-M2 is lesser than EEDBC-MOBILE algorithm. EECA-M2 is energy efficient compared to EEDBC-MOBILE.

TABLE 3. Energy Consumption of CAREDR, EECHSS and SAEECS

S. No.	Time (Sec)	CAREDR (Joules)	Time (Sec)	EECHSS (Joules)	Time(Sec)	SAEECS (Joules)
1	**10**	**18.8**	**10**	**0.003785**	**10**	**0.0169141**
2	**20**	**24.8**	**20**	**0.01191**	**20**	**0.0390625**
3	**30**	**53.6**	**30**	**0.018056**	**30**	**0.078125**

Table 3 represents the energy consumption of various energy efficient clustering algorithms. It reveals that the energy consumption of EECHS is lesser that CAREDR and SAEECS. The energy consumption of CAREDR is more compared to EECHSS and SAEECS.

IV. CONCLUSION

In Mobile Wireless Sensor Networks, the sensor nodes are in mobility, as a result clustering is performed more frequently and hence there is more loss of energy due to mobility. Although, various Energy Efficient Clustering algorithms exists for Mobile Wireless Sensor Network, energy needs to be saved at each level of communication and processing. The challenges of various clustering algorithms are enlightened. A list of algorithms used for clustering in Mobile Wireless Sensor Network with their respective parameters and techniques are listed. Beside the selection of a Cluster Heads, a fine clustering algorithm needs to cover the issues of optimal cluster size and optimal number of Cluster Heads. Energy consumption based on the number of nodes are compared with EEDBC-M and EECA-M2 algorithms. Energy consumption based on time intervals are revealed for clustering algorithms, CAREDR, EECHSS and SAEECS. Although many of these clustering techniques look promising, there are still many challenges that need to be solved in the sensor networks. Therefore, further investigation is required to develop a scheme that will extend the lifetime of the MWSNs in order to improve the energy consumption of the sensors and at the same time it will ensure the network connectivity and prolong the network life time.

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