An Improved Optimization Approaches for Homogeneous and Heterogeneous Hierarchical Clustering in WSN

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Abstract— Remote sensor organizes is an asset requirements arrange in which all sensor hubs have restricted assets and vitality information must be accumulated to decrease the measure of traffic in the system. To increase the network lifetime by grouping of sensor nodes into clusters and electing cluster head (CHs) for all the clusters is done using clustering method. CHs gather the information from individual group's hubs and forward the collected information to the base station. A major challenge in WSN to select appropriate cluster heads. Clustering is gathering of hubs in free groups and each cluster contains at least one group head dependent on web size. The sensed data will transfer to the separate cluster heads and retransfer the collected data to base station. By maintain the long space transmission nodes through base station, Clustering Algorithms can be used. In this paper, we categorize all up-to-date and published works based on how the users can access various clustering approaches are discussed with working of few clustering algorithms and distinguish them based on performance of algorithm.

Keywords: Aggregated data, Cluster Head, Clustering, Network Lifetime, Network Size, Wireless sensor network

I. Introduction

Wireless Sensor Networks have been widely deployed in a variety of fields viz. military environment monitoring, inventory control, human-centric applications , agriculture, structural health monitoring etc. [1]. WSN comprises a large number of tiny nodes and base station performs a wide range of tasks such as sensing, computation and wireless communication capabilities. These nodes are battery operated and it is difficult to replace or recharge batteries of nodes in large-scale structure. WSN nodes are also deployed in hostile environments where human participate is infeasible or risky [2]. It eventually leads to the difficult for replacing or recharging batteries of the sensor nodes. It also impose the requirement of extending the lifetime of a given sensor network to serve the very purpose of underlying application for a longer duration. Several techniques have been developed to extend the lifetime of WSN such as cluster head selection [3], routing protocols [4], data aggregation [5] etc. WSNs comprise of spatially disseminated self-ruling sensors conveyed over an area important to watch some wonder through either some arbitrary or key techniques. Considerable amount of work has enabled the design, the implementation, and the deployment of these sensor network tailored to the unique requirement of sensing networks tailored to the unique requirement of sensing and monitoring in real-time applications. These node have on-board wireless modules which consist of microcontroller, trans-receiver and power and memory units. A sensor mode is mounted on the hub with various kinds of sensors relying upon the sort of utilization, for example, ecological checking, reconnaissance, military applications, robotization in transportation, wellbeing and modern applications [6]. One of the stringent necessities of these hub is the productive utilization of the put away vitality. A few calculations have been intended for proficient administration of hubs vitality in WSNs utilizing each different grouping plans. WSN divides cluster each various clustering schemes [7] and [8]. WSN divides cluster each having a coordinator responsible for gathering the data from the nodes and sensing it to the sink. Sensors are frequently conveyed thickly to fulfil the inclusion prerequisites, which empowers certain hubs to enter the rest mode in this manner permitting critical vitality investment funds. The group heads can be chosen haphazardly or dependent on at least one criteria. Determination of CH to a great extent influences WSN lifetime Perfect bunch head is the one which has the most elevated remaining vitality, the greatest number of neighbour hubs, and the littlest good ways from base station. Simultaneous consideration of all these criteria in CHs selection is tedious task and can be solved using multiple attribute decision making approach [9], [10].

This paper surveys advances on cluster head selection techniques for energy efficient routing in WSNs. To the best of our knowledge, this is the first endeavour to provide a comprehensive overview of the selection of cluster head based on network size. The node transmit sensed data to the respective CHs, which in turn transmit the aggregated data to the base station. We hope that researcher will benefit from the survey and use it as a starting point to further expand the research by avoiding long distance communication of nodes to base station.

The organization of this paper is as mentioned below, Section 2 discussed about the reviews on the state-of-the-art network in addressing the techniques to design effective and efficient clustering routing protocols for WSNs in the past few years. Section 3, explains about the description of the proposal given in the literature on the different clustering algorithms homogenous and heterogeneous WSN. Section 4, does a comparative analysis of various algorithms, and section 5, concludes the paper.

II. Clustering in Wireless Sensor Networks

Clustering is a key techniques used to extend the lifetime of a sensor network by reducing energy consumption [11]. A sensor network can be made scalable by forming cluster. Leader of the cluster is often referred to as the CH. A CH might be chosen by the sensors in a group or pre-allotted by the system architect. Different bunching calculations have

been explicitly intended for WSNs for versatility and effective correspondence. The concept of cluster based routing is also utilized to perform energy-efficient routing inWSNs. In a hierarchical architecture, higher energy nodes can be used and send the information while low energy nodes can be used to perform the sensing. Clustering reduces the size of the routing table stored at the individual nodes by localizing the route set up within the cluster. Bunching can save transmission capacity since it restricts the extent of between group collaborations to CHs and keeps away from excess trade of messages among sensor hubs. CH can lessen the pace of vitality utilization by planning exercises in the group. System structural parameters like in-arrange information handling, hub organization and abilities are ideal. Grouping targets like burden adjusting and adaptation to non-critical failure, expanded availability, decreased postponement, least bunch check, maximal system life span are additionally portrayed concerning the homogenous WSN and heterogeneous systems.

A. *Classification of Clustering Attributes:*

Network architectural parameters like in-network data processing, node deployment and capabilities are best described in [12]. Bunching goals like burden adjusting and adaptation to internal failure, expanded availability, decreased postponement, least group check, network, diminished deferral, least bunch tally, maximal system life span are additionally depicted regarding the homogenous WSNs. Clustering schemes strive to achieve some characteristics can be related to the internal structure of the cluster or how it relates to the internal structure of the cluster or how it relates to others. The following are the relevant attributes. The two types of clustering algorithm are homogenous hierarchical and heterogeneous hierarchical clustering techniques.

III. REVIEW ON HOMOGENEOUS AND HETEROGENEOUS HIERARCHICAL CLUSTERING ALGORITHMS:

A. *Homogeneous Clustering:*

In homogeneous WSN, all nodes contain the same initial energy. The hierarchical routing scheme maximizes the lifetime of WSN by reducing the communication distance between sensor nodes and base station. In this scheme, few of the nodes elects themselves as CH and each CH serves a set of non-CH nodes called member nodes for a specific duration termed as round. Non-CH hubs transmit their information to either chose CH or BS whichever is vitality proficient. This reduces the long distance communication of non-CH nodes and increases the lifetime of WSNs. However, the increase in the overhead on selected CH as it collects data from non-CH nodes associated with it and transmits aggregated data to BS. This outcome in quick vitality consumption of CH hubs and thus, the job of the CH ought to be on a revolution premise.

1) LEACH:

In Low Energy Adaptive Clustering Hierarchy (LEACH) each node is a part of local cluster which is organized by CH also called Local Base station. The sensor node transmit monitoring data to its respective CH which in turn transmits those data to main BS after applying some processing functions with data. CH which in turn transmits those data to main BS after applying some processing functions with data. Since the CH performs various functions compared with other nodes. There are two phases of LEACH protocol such as set-up-phase and steady-phase. In set-up phase, cluster heads are selected by the process as described below. The node with highest probability is considered as cluster head. In steady phase, the CH broadcasts advertisement message Carrier Sense Multiple Access (CSMA) MAC protocol and nodes decide their CH by analysing received signal strength of different cluster.

2) ALEACH:

ALEACH is an approach which is distributed in nature and improves the lifetime of WSN by avoiding long-distance communication with BS. This protocol elects cluster heads without knowing the exact location of the nodes. It doesn't assume current state of any of the nodes to elect CHs. The protocol works in two phases: cluster setup and steady state phase. Nodes elect themselves as CH during cluster setup phase. Like LEACH, nodes assume a random number and it is compared with threshold value.

3) HEED:

Hybrid Energy Efficient and Distributed (HEED), is a distributed clustering protocol designed for ad hoc sensor networks. It has four essential objectives as follows: (a) increasing network lifetime by the distribution of energy utilization (b) Ending the clustering process inside a steady number of iterations (c) reducing the control overhead and (d) selecting well - distributed cluster heads and optimum clusters. HEED periodically selects CH based on the following parameters: i) Left over energy of every sensor node as first parameter and ii) and the is intra-cluster correspondence cost as second parameter The first parameter is used to elect the initial set of cluster heads and the second parameter is utilized for breaking constraints. The grouping procedure requires a few rounds at every sensor node. A selected sensor node broadcasts it as a tentative cluster - head or final cluster head. A sensor node receiving the cluster - head list chooses CH based on the cluster head with the lowest cost from this set CHs. Every node then doubles its CH proband precedes the subsequent step. If a node ends the HEED execution without electing itself to become a CH or joining a cluster, then announces itself as a final CH. A tentative cluster - head node can act as a regular node during later iteration if it listens from a lower cost cluster head. A node can be chosen as a CH during successive clustering intervals if the remaining energy is high with lower cost. HEED does not have to do neighbour revelation repeatedly. The distribution of energy utilization in HEED, increases the lifespan of all the nodes thus supporting steadiness of the neighbour set. . The HEED clustering increases the lifetime over LEACH clustering as LEACH selects cluster heads which may bring about quick demise of some nodes. The final CH selected in HEED is very much distributed across the network and the communication cost is reduced.

4) EDACH:

Energy driven adaptive clustering hierarchy (EDACH) algorithm in which each node calculates the threshold value. However, the value of p differs for each node depending

upon its location from BS. P can take one of three segment values termed as near, medium and far.

5) PASC-ECO:

This is an energy efficient algorithm named Power Aware scheduling and Clustering algorithm based on ant colony optimization (PASC-ACO). The protocol divides network area into zones. All nodes are active during each round and selects a random delay before it announces that it is a CH with the response to the CH announcement. CH prepares the TDMA scheduled on the basis of energy information received by it and announces to its member nodes. ACO based scheduling algorithm is used to transmit data from each CH to sink using multi-hop communication. This phase is termed as data communication phase.

6) Data Dissemination on Ant Swarms:

A hybrid protocol of TCCA clustering scheme along with an election scheme and it is termed as T-ANT algorithm. LEACH protocol also works in two phases. During cluster setup phase, sink releases a number of ants which chooses one of its neighbours randomly. The movement of ants is limited by time-to-leave (TTL) field and CS clock. The TTL field is reduced by one as soon as ant reaches to the new neighbour. The ant is allowed to travel as deep as possible in the network providing that the two following factors should be fulfilled. The hubs have a subterranean insect go about as CH for the current round and they illuminate same to different hubs by making a declaration. Upon reception of the CH announcement, each node records parameters like distance (hop count) to this CH, CH id and sender id as the parent etc. The node then rebroadcasts the packet by setting necessary parameters if TTL field permits. The protocol is a distributed in nature and achieves the separation and alignment behaviour with two desired swarm behaviour.

B. Heterogeneous Clustering:

LEACH like homogeneous protocols fail to provide prolonged network lifetime in heterogeneous environments wherein all the nodes of a number do not have same initial energy. Hence, there is a necessity to design different protocols that can be functioned in heterogeneous environments.

1) ALEACH:

Advanced Low Energy Adaptive Clustering Hierarchy (A-LEACH) uses heterogeneous architecture by providing number of times more energy tom fraction of nodes called CAG i.e. nodes selected as cluster heads or gateways. A-LEACH uses the similar approach in LEACH to select CH. Each node work as gateway nodes except those are selected as a CH for the current round. These node facilitate to increase the stability period to the maximum extent possible.

2) MS LEACH:

In Distance based multi single low energy adaptive clustering hierarchy (MS LEACH) proposed a heterogeneous routing protocol which aims to improve the lifetime of the WSN. The MS LEACH protocol uses two-hop communication to transmit data from CH to sink if the distance between CH to sink is larger than average distance of all the CHs from sink, otherwise the protocol uses direct communication between CH and sink.

3) SEP:

There are two types of nodes in Stable Election protocol (SEP) such as normal nodes and advance nodes. Advance nodes contain more energy than the normal nodes. In heterogeneous two level hierarchical network each sensor nodes selects cluster heads based on its initial energy when compared to other nodes. SEP does not require any global knowledge of energy election round. SEP is dynamic in that it doesn't expect any earlier appropriation of the various degrees of vitality in the sensor hubs. It is consider as only asymptotic i.e. for even small sized networks this analysis applies equally. At last SEP is versatile as it doesn't require any information on the specific situation of every hub in the field.

4) DEEC:

(Distributed Energy Efficient Clustering) is a protocol that works at two levels of energy. It has better stability period than SEP protocol. The DEEC elects the cluster heads by a probability based on the ratio between residual energy of each node and the average energy of the network. The epochs of being cluster heads for nodes are different based on the initial and residual energy. The nodes which are having high initial and residual energy will get more chances to be the cluster head than the nodes with low energy. Hence, the advance nodes will have more chances to be cluster heads than the normal nodes.

5) DDEEC

(Developed Distributed Energy Efficient Clustering) is a protocol which has 30% better than SEP and 15% better than DEEC in terms of network lifetime and stability period. This protocol also works at two levels of energy and overcomes the drawbacks of the DEEC. DEEC uses CH selection based on the ratio between residual energy of each node and the average energy of the network. For rotating epoch, round numbers for every node differs by its initial and residual energy. DEEC adjusts the pivoting age of every node to its energy. To become a cluster heads the node should have high initial and residual energy. During stability period, DEEC can extend lifetime of its network. This choice penalizes always the advanced nodes, especially when their residual energy depletes and become in the range of the normal nodes. Such situation will make the advanced nodes to lose their energy and become inactive when compared to normal nodes. The DDEEC balances the cluster head selection overall network nodes following their residual energy. Hence, at initial stage advanced nodes will become cluster heads, as their energy is getting exhausted becomes like normal nodes, these advance nodes will elect their cluster head as normal nodes does.

6) SEEC:

A Sable and Energy-Efficient Clustering (SEEC) protocol for heterogeneous WSNs has been in proposed. A network consists of m advanced node and n normal nodes. Hence, the network is made of total N nodes where N=m+n. The m advanced nodes act as cluster heads throughout the lifetime of the network.BS and advanced nodes are away with equal distance to each other's. Due to this CHs receives the transmitted data from normal nodes and then retransmitted to BS. The M-SEEC protocol with three-levels of

heterogeneity and three levels of data transmission is also addressed.

IV. COMPARATIVE ANALYSIS

Table 1 shows the discussed popular block cluster based routing protocol by including (reference and year, author, approach, merits and demerits) in the below mentioned proposed approaches. Table.2 shows the grid cluster based routing in Wireless sensor networks.

Author	Ref/Year	Algorithm	Merits	Limitations
Heinzelman W.R et al.	[13] 2000	LEACH	– Each node has equal chance to become CH but cannot be selected as CH in subsequent round so load is shared between nodes. – LEACH uses TDMA so it keeps CHs from unnecessary collisions.	– LEACH use single hop communication so it can't use in large scale networks – CH are elected on the basis of probability so uniform distribution cannot be ensured and it cannot provide load balancing.
O.Younis et al.	[14] 2004	HEED	– Fully distributed routing scheme. – HEED achieve load balancing and uniform CH distribution – HEED achieves high energy efficiency and scalability by communicating in multi-hop way.	– Unbalanced energy consumption due to more CH. – Massive overhead due to multiple rounds. – Additional overhead due to several epochs.
S. Soro et al.	[15] 2005	UCS	– Nodes in cluster can be variable. – UCS is bi-layered model and two hop inter cluster communications.	– It is limited by assumption that CHs are predetermined as well as network is not homogeneous. – Residual energy of nodes is not considered and not sufficient for large range networks.
M. Ye et al.	[16] 2005	EECS	– EECS constructs more balanced network in term of energy consumption and communication load. – Use dynamic sizing of clusters.	– Lot of overhead due to global information for communication. – Single hop communication consume lot of energy.
F. Tang et al.	[17] 2010	OCM	– Less energy consumption compared with LEACH	– Chain head selection criterion.
M. B. Yassein et al.	[18] 2009	LEACH-VF	– Solve the problem of area with overlapped sensing coverage and sensing hole. – In LEACH-VF some nodes can be moved to coverage inside the cluster.	– Poor energy efficiency. – Load balancing is not up to the mark.
A. Manjeshwar et al.	[19] 2009	TEEN	– Data transmission can be controlled by varying two thresholds – Well suited for time critical applications.	– The node will not communicate, whenever threshold are not meet. – Data may be lost if CHs are not able to communicate with each other.

Table1: Summary of merits and limitations of block cluster based routing protocol

Author	Ref/Year	Algorithm	Merits	Limitations
L. Buttyan et al.	[20]2007	PANEL	– Panel is energy efficient that ensure load balancing and long network lifetime. – Supports asynchronous applications.	– To determine geographic position information, special conditions are needed, which is not always available.
Y.Xu et al.	[21] 2001	GAF	– GAF increase the network lifetime by saving energy – Routing fidelity is maintained.	– Large traffic injection and delay is not predictable.
Guimaraes et al.	[22] 2018	Optimim-path forest clustering	– Different meta-heuristic driven optimization is	– OPF-AD uses the power of connectivity among

			compared for OPF-AD parameters fine-tuning. – OPF-AD and MGD obtained are more stable and reliable.	samples to build clusters that encode such information.
Jin Wang et al.	[23] 2017	Energy-efficient cluster based dynamic routes adjustment (EECDRA)	– Minimizes the routes reconstruction cost of the sensor nodes while maintaining optimal routes to the latest location of mobile sinks. – The cluster head rotation mechanism alleviated the hotspot problem effectively.	– The relocation conditions are met after long time, and the protocol is not good at prolonging network lifetime.
Jin Wang et al.	[24] 2019	An asynchronous clustering and mobile data gathering based on Timer mechanism (ACMDGTM)	– The location and residual energy are both considered when selecting cluster heads. – The mobile sink searches the optimal moving path according to the data overflow time and moving time from cluster head.	– The mobile sink can visit the overlapping area of nodes rather than visiting one by one.
Xiaokang wang et al.	[25] 2019	A tensor-based big driven routing recommendation.	– A routing recommendation method using tensor matching operations for computing a new routing path.	– The artificial intelligence techniques to automatically control, manage and orchestrate the routing path in heterogeneous networks.

Table 2: Grid Cluster based routing protocols

V. CONCLUSION

Wireless Sensor networks have engrossing concern for civil and military applications. Environmental monitoring, border protection, battle-field, and security surveillance are some of the examples. To implement these applications a lot many sensors are required for architecture and network management. To support grouping nodes into clusters, scalability has been popular method in WSNs. In this work, we surveyed the state of research and classified the different clustering methods. This survey paper includes the various cluster based routing protocols by focusing on the merits and limitations of different cluster based routing protocols and represent them in tabular form. On the basis of comparison between different schemes, it is clear that cluster based routing protocols are useful in performance improvement of WSN. This survey will be useful for the researched group those interested in the development, modification or optimization of routing algorithms for WSNs.

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