Clustering approaches in Wireless Sensor Networks: A Survey

Zeeshan M. Kanuga, Ketan R. Tandel

***Abstract*— The design of sustainable wireless sensor networks (WSN) is a very challenging issue. On the single hand, energy constrained sensors are required to work autonomously for long periods. Nevertheless, it may be cost-prohibitive to replace used up batteries or even impossible in hostile environments. On the other hand, unlike other networks, WSNs are designed for specific applications which range from small-size healthcare surveillance systems to large-scale environmental monitoring. Therefore, any WSN deployment has to meet a lot of requirements that differs from one application to another. In this setting, a host of research work has been taken in parliamentary procedure to suggest resolutions to the energy-saving problem. A WSN are a specialized wireless network made up of a large number of sensors and at least one base station. In the WSN Reliable routing of packets from the sensor node to its base station is the most important task for the networks. The routing protocols used for the other networks cannot be used here due to its battery powered nodes. In WSN fundamental problem is the unbalance energy consumption of nodes, because of this it will -reduce the lifetime of the network. Management of energy in WSN can reduce the energy consumption. This paper gives an overview of the different routing strategies used in wireless sensor networks and gives a brief working model of energy efficient routing protocols in WSN with clustering strategy.**

***Index Terms*— Wireless sensor networks, mobility, energy efficiency, clustering, Base Station (BS), Cell Header (CH), intercluster communication, intra- cluster communication, Mobile Agent(MA).**

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are one of the most important technologies that will change the world, in that such network provide us fine granular observation about physical world where we are living [5]. Typical sensor node are able to carry out sensing, computation and communication making it useful for number of application such as environment monitoring, health, disaster and health care for providing relief, conference, file exchanging, controlling product quality etc. [1], [5], [6]

Among all this scope one major application of sensor network has to collect information periodically from remote location and send back to base station (BS). For all this purpose sensor node have to use their battery power [3]. The network can keep operating until the battery power is sufficient. But it is also very difficult to recharge or replace battery in sensor network. Hence one important problem in WSNs is how prolong network lifetime with constrained energy [3].

In order to save energy, it is useful to fuse sense data into more meaningful information before transmitting to sink. This is because sensor nodes are expanded heavily, it might generate huge redundant data and similar data from multiple nodes so before transmission of data it can combine all this similar data so that required number of transmission to the base station can be reduced [3]. Another issue is that most sensor nodes are unable to communicate with sink because of large distance between them and limited communication capacity multi-hop communication is basic routing in WSN [1]. In WSN each and every node start transmitting and receiving data in the network, so that data collision and congestion will be experienced, therefor node will drain out there energy very quickly [6].

Sensor node which are closer to sink exhaust their energy more quickly as compared to another nodes. So that unbalance energy consumption is critical problem that need to solve, to avoid early collapse of network due to death of some critical node [6].

WSNs constrains thousands of sensor nodes where the cluster hierarchy is more efficient to manage data among all the nodes in cluster, same data available between neighbor is increase cluster hierarchy and reduce data redundancy by fusion process [6]. Most nodes turnoff there communication for reduce their energy consumption under clustering hierarchy.

In the next section, we discuss the different classifications of clustering techniques and enumerate a set of attributes for categorizing published algorithms. In Section III and IV comprises of approaches for Heuristic and Weighted approach, Section V and section VI describes Hierarchical and Grid approach. Section VII describe the performance of proposed algorithm Finally, Section VIII concludes the paper.

II. CLUSTERING APPROACHES IN WIRELESS SENSOR NETWORKS

A. Heuristic Approach:

Heuristic approach is based on giving two approaches to resolve problems

- Setup cluster with minimal amount of time
- Finding optimal solution

Zeeshan M. Kanuga, Department of Electronics & Communication, Sardar Vallabhbhai Patel Institute of Technology, Vasad, Gujarat, India, Tel: 8460588848.

Ketan R, Tandel, Assistant Professor Department of Electronics & Communication, Sardar Vallabhbhai Patel Institute of Technology, Vasad, Gujarat, India, Tel: 9427866585.

This means that this approach is based on reasonable performance not on the matrix.

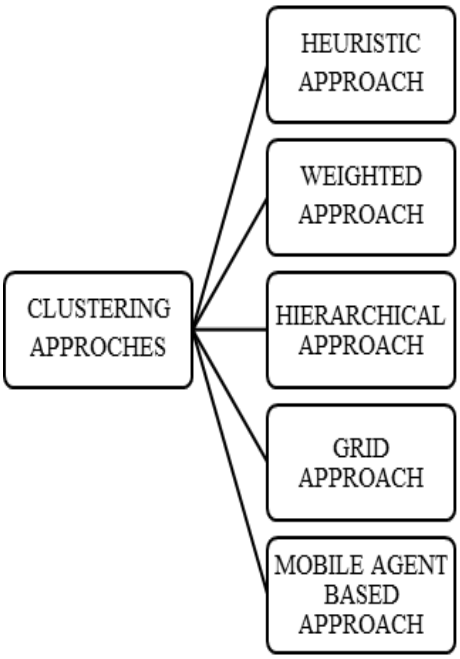

Fig. 1. Clustering Approaches in Wireless Sensor Networks

B. *Weighted Approach*

Weighted approach is based on the weight of the node available with maximum energy. If reelection of cluster happens it will consume energy so node with maximum weighted is elected in this approach.

C. *Hierarchical Approach*

Hierarchical Approach is a method of cluster analysis which seeks to build a hierarchy of clusters. Strategies for hierarchical clustering generally fall into two types:

- Agglomerative: This is a "bottom up" approach: each observation starts in its own cluster, and pairs of clusters are merged as one moves up the hierarchy.
- Divisive: This is a "top down" approach: all observations start in one cluster, and splits are performed recursively as one moves down the hierarchy.

D. *Grid Approach*

Grid-based approaches are popular for mining clusters in a large multidimensional space where in clusters are regarded as denser regions than their surroundings. The great advantage of grid-based clustering is its significant reduction of the computational complexity, especially for clustering very large data sets.

E. *Mobile Agent based approach*

Mobile Agent is most reliable approach for collection of data effectively. Mobile agent act as selection of clusterhead from different computation and geography of nature. It will migrate from one node to another according to network situation.

III. Heuristic Approach

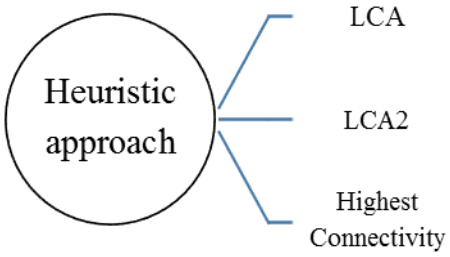

Fig. 2. Types of Heuristic Approach

A. *Linked Cluster Algorithm (LCA)*

LCA was first developed for wired network then used for wireless network. In LCA there are two ways to select ClusterHead first is node has highest ID number in group of all the nodes. And second way is none of its neighbor has clusterhead then it will become a ClusterHead [12].

B. *Link cluster Algorithm 2 (LCA2)*

LCA2 is the concept to eliminate unnecessary clusterhead selected in LCA. They select concept of node is being covered or uncovered. A node is being considered covered if one of its neighbor is ClusterHead. In LCA2 ClusterHead is start selected by considering lowest node ID among non-covered nodes [12].

C. *Highest Connectivity*

This algorithm is similar to LCA. This algorithm checks connectivity with is neighbor nodes instead of select highest ID number. Node with highest connectivity is selected as ClusterHead [12].

IV. Weighted Approach

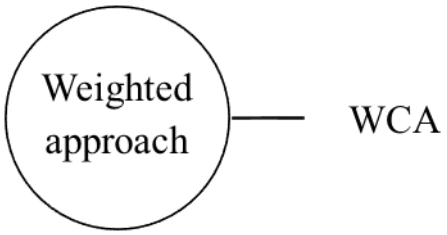

Fig. 3. Types of Weighted Approach

A. *Weighted clustering Algorithm (WCA)*

In this algorithm we can change the weight of the cluster and manage up to ClusterHead can handle all the nodes available in cluster.

$$W_v = w_1\Delta_v + w_2 D_v + w_3 M_v + w_4 P_v$$

Here W_1, W_2, W_3, W_4 are the weighting parameter selected based on specific application. The combined weight is calculate by each node and broadcast across network. The node with smallest W_v is selected as ClusterHead [11].

Here D_v is distance from neighbor and directly proportional to energy consumption, M_v is mobility of node, node with slowest mobility is selected as ClusterHead, P_v is

directly proportional to power, if one node is selected as ClusterHead then it will not selected as ClusterHead once again [11].

V. Hierarchical Approach

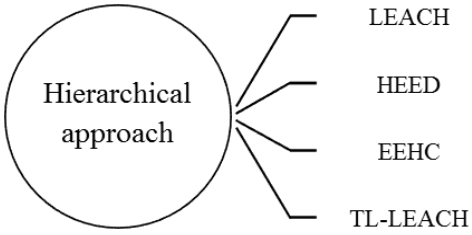

Fig. 4. Types of Hierarchical Approach

A. *LEACH*

Low energy adaptive clustering hierarchy (LEACH) forms clusters by using a distributed algorithm, where nodes make autonomous decisions without any centralized control. All nodes have a chance to become CHs to balance the energy spent per round by each sensor node. Initially a node decides to be a CH with a probability "*p*" (*p* is the desired percentage of CH nodes in the sensor population) and broadcasts its decision [7]. Specifically, after its election, each CH broadcasts an advertisement message to the other nodes and each one of the other (non-CH) nodes determines a cluster to belong to, by choosing the CH that can be reached using the least communication energy (based on the signal strength of each CH message).

B. *TL-LEACH*

Two-Level Hierarchy LEACH utilizes two levels of ClusterHeads (primary and secondary). In this algorithm, the primary ClusterHead in each cluster communicates with the secondaries, and the corresponding secondaries communicate with the nodes in their sub-cluster. Data-fusion can be performed as in LEACH. In addition, communication within a cluster is still scheduled using TDMA time-slots. The formation of a round will consist of first selecting the principal and secondary ClusterHeads using the same mechanism as LEACH, with the a priori chance of being upgraded to a primary ClusterHead less than that of a secondary node [8]. Communication of data from source node to sink is achieved in two steps

1) Secondary nodes collect data from nodes in their respective clusters. Data-fusion can be performed at this level [8].

2) Primary nodes collect data from their respective secondary clusters. Data-fusion can also be implemented at the primary clusterhead level [8].

The two-level structure of TL-LEACH reduces the amount of nodes that need to transmit to the base station, effectively reducing the total energy usage.

C. *EEHC*

Energy Efficient Hierarchical Clustering (EEHC), the main objective of this algorithm was to shortcomings of one-hop random algorithm by extending the cluster architecture to multiple hops. In this algorithm each sensor in the network becomes a clusterhead (CH) with probability p and advertises itself as a clusterhead to the sensors within its radio range. We call these clusterheads the volunteer clusterheads. This advertisement is reach up to k hops away from CH. Any sensor neither selected as CH or within cluster range is elect as CH called as forced CH. since all the sensors within a cluster are at most k hops away from the cluster-head, the clusterhead can transmit the aggregated information to the base station after every t units of time. This limit on the number of hops thus allows the cluster-heads to schedule their transmissions. The energy used in this algorithm is based on value of p and k [7].

D. *HEED*

Hybrid Energy-Efficient Distributed Clustering (HEED) is a hierarchical, distributed, clustering scheme in which a single-hop communication has been done within each cluster. Whereas multi-hop communication is allowed between CHs and the BS. CH nodes are chosen based on two basic parameters (1) residual energy (2) intracluster communication cost. Maximum residual energy node is selected as ClusterHead whereas intracluster communication is based on node degree [7].

VI. Grid Approach

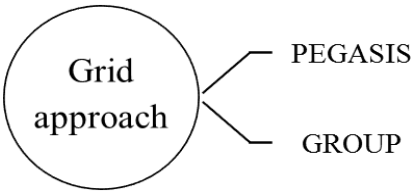

Fig. 5. Types of Grid Approach

A. *PEGASIS*

Power-Efficient Gathering in Sensor Information Systems (PEGASIS), this algorithm establish energy saving in cluster not by directly forming cluster. The main idea in PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS. This approach will distribute the energy load evenly among the sensor nodes in the network. Resulting in an energy improvement versus the hierarchical clustering approach [9].

B. *GROUP*

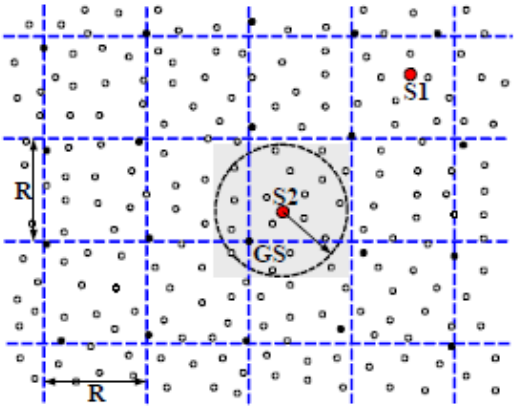

Fig. 6. Group of cluster grid [10]

Group based algorithm is also known as grid algorithm. In this algorithm sink node randomly make grid. ClusterHead

are arrange in grid like manner, data from source to sink is transfer like greed seed (GS) to its ClusterHead and to sink. From greed seed ClusterHead is selected based on residual energy. ClusterHead broadcast collected data to its neighbor ClusterHead [10].

VII. Mobile Agent Based Approach

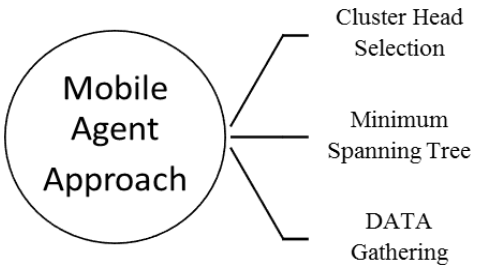

Fig. 7. Types of Mobile Agent Approach

A. *ClusterHead Selection*

The lifetime of WSNs will be affected by the CH, CH consumes more power than a regular node. In cluster Clusterhead plays an important task. Balancing of energy is totally depend on selection of CH [2]. Here selection of CH is mobile. And it is selected based on its residual energy. Node which has higher energy plays a role of clusterhead.

B. *Minimum Spanning Tree (MST)*

Clustering and multi hop routing algorithms are performing at the same stage to decrease control packets. According to non-uniform energy consumption clustering is done. MST evaluates route of data based on node weight, degree and distance. First mobile agent is elect, MA find CH with maximum energy availability on that cluster and according to CH apply MST and find best path to reach data to destination [1]. This is most suitable method to transmission of data.

C. *DATA Gathering*

Mobile agent plays an important role in this method. Minimizing redundant sensor communicating with MA [3]. Mobile agent migrates from one node to another and collect all data available in node and reaches to sink [4]. By performing this communication cost during data transfer is greatly reduce.

VIII. Performance of Proposed Algorithm

A. *WCA*

It evaluates weight for each node and clusterhead is select based on node degree, distance from neighbor, mobility and available energy. This is most suitable algorithm, after selection of ClusterHead it will re-elect CH when network demand [11].

B. *LEACH [7]*

- It decide which node become ClusterHead and independent of other nodes
- CDMA allows clusters to operate independently, as each cluster is assigned a different code.
- Each node calculates the minimum transmission energy to communicate with its clusterhead and only transmits with that power level.

C. *TL-LEACH*

It improves LEACH protocol by using 2stage of hoping. Energy is improved by smaller distance of travel. By using this data can travel more distance with less power [8].

D. *PEGASIS*

Only one node can transmit data to base station, science the transmission range of base station is large this can improve the energy. Each node is communicate with nearest so energy utilization is less [9].

E. *EEHC*

This is similar to LEACH protocol, in this we can create dynamic cluster size that is more flexible to reach up to sink node [7].

F. *GROUP*

Energy conservation is achieved by the lower transmission distance for upstream data. In LEACH, a clusterhead must transmit data to the base station directly, while in GROUP, data is transmitted short ranges along the upstream path [10].

G. *HEED[7]*

- Reducing the number of nodes that compete for channel access
- Clusterhead updates, regarding cluster topology
- Routing through an overlay among clusterheads, which has a small network diameter.

H. *ClusterHead Selection*

Clusterhead is selected based on residual energy of node available in cluster. Node which has maximum energy is elect as clusterhead [2].

I. *MST*

MST is most suitable method for finding route with minimum cost to reach destination. It find shortest path with maximum energy of node so data can be reach without any loss [1].

IX. Conclusion

In this paper focused on energy consumption of nodes based on clustering architecture. In wireless sensor network energy plays important role to sustain network life. Protocol discussed in this paper offer a promising improvement over conventional cluster architecture. There are lots of factors available in clustering like clusterhead election, single hop and multi hop etc. by applying appropriate scheme energy saving can be done using clustering.

References

[1] Sabet Maryam, Naji Hamid Reza, "A decentralized energy efficient hierarchical cluster-based routing algorithm for wireless sensor networks " AEU - International Journal of Electronics and Communications, Volume 69, Pages 790–799, May 2015

[2] Muhammad Arshad, Mohamad Y. Aalsalem, Farhan A. Siddiqui, "Energy Efficient Cluster Head Selection In Mobile Wireless Sensor Networks" Journal Of Engineering Science And Technology, Vol. 9, Pp.728-746.

[3] Say Sotheara, Kento Aso, Naoto Aomi, and Shigeru Shimamoto, "Effective Data Gathering and Energy Efficient Communication Protocol in Wireless Sensor Networks employing UAV" Wireless Communications and Networking Conference (WCNC), 2014 IEEE, Pages 2342-2347, April 2014

[4] Min Chen, Taekyoung Kwon, Yong Yuan, and Victor C.M. Leung, "Mobile Agent Based Wireless Sensor Networks" JOURNAL OF COMPUTERS, Volume 1, Pages 14-21, April 2006

[5] Chiu-Kuo Liang, Yu-Jie Huang and Jian-Da Lin, "An Energy Efficient Routing Scheme in Wireless Sensor Networks" Computational Science and its Applications, International Conference, Pages 399-404, Aug. 2007

[6] Aboobeker Sidhik Koyamparambil Mammu, Ashwani Sharma, Unai Hernandez-Jayo, and Nekane Sainz "A Novel Cluster-based Energy Efficient Routing in Wireless Sensor Networks" Advanced Information Networking and Applications (AINA), IEEE 27th International Conference, Pages 41-47, March 2013

[7] Basilis Mamalis, Damianos Gavalas, Charalampos Konstantopoulos and Grammati Pantziou, "Clustering in Wireless Sensor Networks", RFID and Sensor Networks, Pages 323-354, 2009

[8] V. Loscrì, G. Morabito, S. Marano, "A Two-Levels Hierarchy for Low-Energy Adaptive Clustering Hierarchy (TL-LEACH)" Vehicular Technology Conference, pages 1809-1813. Sept 2005.

[9] Stephanie Lmdsey and Cauligi S. Raghavendra,"PEGASIS: Power-Efficient GAthering in Sensor Information Systems" Aerospace Conference Proceedings, Pages 1125-1130, Sept 2001.

[10] Liyang Yu, Neng Wang, Wei Zhang and Chunlei Zheng "GROUP: a Grid-clustering Routing Protocol for Wireless Sensor Networks", Wireless Communications, Networking and Mobile Computing, pages 1-5, Sept. 2005.

[11] Mainak Chatterjee, Sajal K. Das And Damla Turgut "WCA: AWeighted Clustering Algorithm for Mobile Ad Hoc Networks", Kluwer Academic Publishers. Pages 193-204. 2002

[12] I. F. Akyildiz,W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Netowrks," IEEE Communications Magazine, vol. 40, no. 8,pp. 102–114, Aug 2002.

Zeeshan M. Kanuga received Bachelor of Engineering degree in Electonics and Telecommunication from Shri S'ad Vidya Mandal Institute of Technology (SVMIT), Bharuch, Gujarat, India. He is currently doing his Master of Engineering from Sardar Vallabhbhai patel Institute of Technology, Vasad, Gujarat, India. His interested field of research is Wireless Sensor Networks.

Ketan R. Tandel received Bachelor of Engineering degree in Electonics and Communication from Government Engineering College, Surat, Gujarat, India. Completed Master of Technology in Electronics & Communication System from Dharmsinh Desai Institute of Technology (DDIT), Nadiad, India. He is Currently Working as Assistant Professor in Electronics & Communication department, SVIT Vasad. His interested field of research is TCP PEACH