A Review on Various Energy Efficient Clustering Protocols of WSN

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ABSTRACT
In recent years, the applications of Wireless Sensor Networks (WSNs) have been increased tremendously. In WSNs mechanism used to enlarge the lifespan of network and provide more efficient functioning procedures that is clustering. Clustering is a procedure to subdivide the sensing field of sensor network into number of clusters. Each cluster selects a leader or hear called cluster head. A cluster head might be elected by the sensor node withinthe cluster or may be pre-assigned by the network administrator. Optimized Clustering can save lot of energy in the network. In our paper we have surveyed various clustering protocols for wireless sensor networks and compared on various parameters like cluster count, cluster size, cluster density, message count, node deployment, heterogeneity of nodes, locationawareness and cluster head selection process etc. In this paper a survey of various popular WSN protocol has been reviewed, majorly LEACH, SEP, HEED & DEEC.

Keywords
Cluster count, cluster size, lifetime,LEACH, SEP, HEED & DEEC.

1.INTRODUCTION

Recent developments in the areas of Micro Electro Mechanical Systems (MEMS), wireless communication and low power designs have enabled the small sized battery operated sensor nodes. A WSN is a set of sensor nodes deployed in a physical area and connected through wireless links. A sensor node consists of mainly four units that are sensing, communication, processing and power supply. The sensing circuitry measures the different parameters from the environment like temperature, humidity, pressure etc and converts them into an electrical signal. Processing of such signals reveals some properties about the objects or events happening in the surrounding of sensors. After processing these signals can be transmitted to destination (base station) by using radio transmitter either directly or through an intermediate gateway. The basic features of a sensor network are self organizing capability, dynamic network topology, limited battery power, short range broadcast communication, nodes mobility, routing and large scale of deployment. Due to the capability of self organization and wireless communication, sensor networks are expected to be used in civil, commercial and military applications such as surveillance, climate and habitat monitoring, vehicle tracking, disaster management, medical observation and acoustic data gathering. There are many challenges in wireless sensor networks. The key challenge is to maximize the stability as well as lifetime of network. It is not feasible to replace the batteries of hundreds or thousands of sensor nodes after deployment. In sensor network, grouping of sensor nodes into a cluster is called clustering. Every cluster has a leader called cluster head. A cluster head may be pre assigned or elected by the members of the cluster. A cluster head collects the data from the nodes within cluster and transfer to destination (base station). The clustering techniques widely perused by researchers increase the lifetime as well as scalability objectives. Many clustering protocols can be use to create hierarchical structure that reduces the path cost when communicating with the base station.

2.CLASSIFICATION OF CLUSTERING PROTOCOLS

In this section we discuss the set of attributes can be used to differentiate clustering protocols for wireless sensor networks [3, 10].

2.1Clustering Method

The two basic approaches for the co-ordination of entire clustering process are distributed and centralized. In distributed clustering, where each sensor node can run their own algorithm and takes the decision of becoming cluster head. In centralized clustering, a centralized authority groups the nodes to form clusters and cluster heads. Sometimes hybrid scheme can also be implemented.

2.2Cluster Properties

In clustering approaches, there are some characteristics for the cluster formation. The following are characteristics that are related to the internal structure of the cluster.

2.2.1Cluster count

Cluster count is the number of clusters formed in a round. More number of cluster lead to small size cluster distribution, which is better in term of energy consumption. In some clustering approaches, the selection of cluster heads are pre assigned from the deployed sensor nodes for fixed clusters or cluster heads can be selected randomly results in variable number of clusters.

2.2.2Cluster size

Cluster size is the maximum path length among the member nodes from cluster head. Small sized cluster is better in term of energy consumption because it

minimizes transmission distance and load of cluster head. In some clustering approaches, cluster size is fixed when cluster are fixed throughout the life time, otherwise it is variable for each cluster.

2.2.3Cluster Density

Cluster density is defined as proportion of the number of cluster member in the cluster and cluster area. There is big challenge to minimize the energy consumption of cluster heads in dense clusters. Some of the clustering approach use fixed clustering always has sparse density of cluster, but in dynamic clustering approaches cluster density variable.

2.2.4Message count

Message count is the number of message transmission is requiring for cluster head selection. More number of message transmission lead to large amount of energy consumption for cluster head selection procedure. There are many algorithms which is nonprobabilistic, require the message transmission for cluster head selection.

2.2.5 Stability

If the members of a cluster are not fixed the clustering schemes are said to be adaptive. Otherwise we can consider as fixed because the cluster count are not varied throughout the clustering process. The fixed cluster count increases the stability of a sensor network.

2.2.6 Intra-cluster topology

It indicates the communication within the cluster as direct or multihop. It may be single hop or multihop from sensor node to sensor node or sensor node to cluster head. However this communication also depends on the sensor's range. This limited range bounded the cluster head count.

2.2.7 Inter-cluster head connectivity

It indicates the capabilities of sensor nodes /cluster heads communication to base station. If the cluster heads are not having long haul communication capabilities, clustering schemes has to ensure some intermediate provision of routing to base station.

2.3Cluster-Head Capabilities

The capabilities of cluster heads in clustering schemes influence the overall clustering process in terms of stability and lifetime of sensor network. The following are some attributes for differentiating the clustering schemes.

2.3.1 Node Type

At the time of deployment some of the sensor nodes are pre assigned as cluster heads on the basis of more energy, communication and computation resources.

2.3.2 Mobility

The mobility of cluster heads in sensor networks can be assigned on the basis of objectives defined in clustering schemes. If the cluster heads are mobile, we can use this to make balanced cluster for better network performance. Mobile cluster heads can also be relocatable if there is any need in the sensor network.

2.3.3 Role

The role of cluster heads in the sensor networks can act as a relay for the information generated by the cluster members or perform the task of aggregation or fusion of data.

2.4Cluster Head Selection

Cluster heads can be pre-assigned or picked randomly from the deployed set of nodes [3].

2.4.1 Probability Based

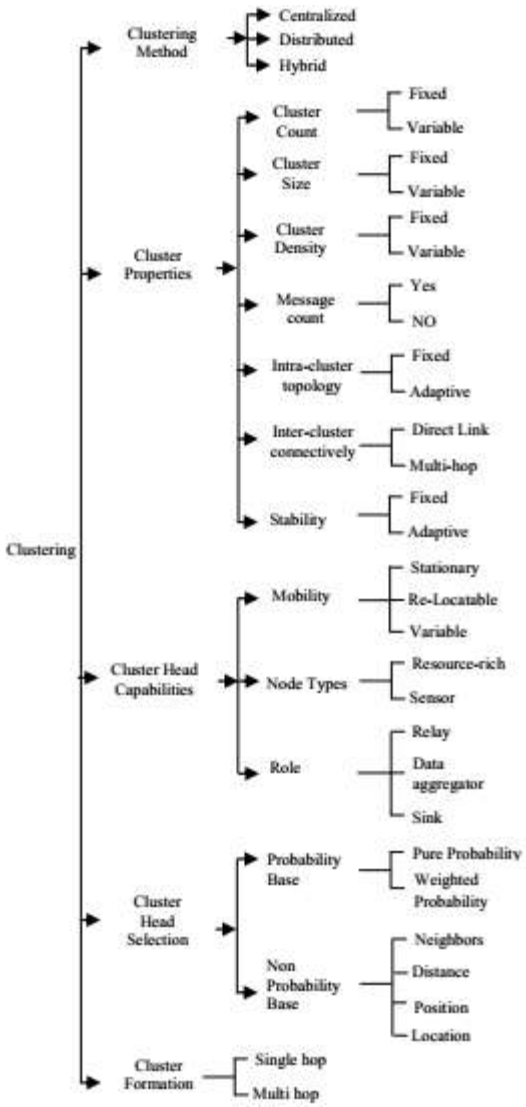
In probability based clustering algorithms, each sensor node uses pre assigned probability to determine the initial cluster heads.

2.4.2 Non Probability Based

In nonprobability based clustering algorithms more specific criteria for cluster head selection and cluster formation are primarily considered which are mainly based on the sensor nodes proximity, connectivity and degree etc.

2.5Cluster Formation

In cluster formation process the cluster heads will broadcast request packet to the sensor nodes come in radio range to form cluster. In single hop nodes transmits to the cluster head directly and in multi hop all sensor node will send their data through neighbor node. Fig. 1 summarizes the classification of different attributes of clustering in wireless sensor networks.



3. Clustering Algorithms & Protocols for WSN

There are several different ways to distinguish and classify theclustering algorithms used in WSN. Most of the knownclustering algorithms for WSNs can bedistinguished on thebasis of cluster head selection process.

3.1. Probabilistic (random or weighted) clustering algorithms

In the category of probabilistic selection clustering algorithma priori probability assigned to each sensor node is used todetermine the initial cluster heads or other type randomselection procedure [16].The probabilities initially assigned toeach node often serve as the primary criterion in ordertodecide individually on their election as cluster heads.However other secondary criteria may also be consideredeither during cluster head election process i.e. the residualenergy, initial energy, average network energy etc. Beyondthe high energy efficiency, the clustering algorithms of thiscategory usually achieve faster execution or convergencetimes and reduced volume of exchanged messages.

3.2. Non probabilistic clustering algorithms

In the category of non-probabilistic clustering algorithms,more specific criteria for cluster head election and clusterformation are primarily considered. They are mainly based onthe sensor nodes proximity, connectivity, position, locationand degree etc. They are also depends on the informationreceived from other closely located nodes. This type ofalgorithms generally requires more exchanges of messagesand probably graphs traversing in some extent, thus leadingsometimes to worse time complexity than probabilistic orrandom clustering algorithms. One the contrary, thesealgorithms are usually more reliable toward the direction ofextracting robust and well-balanced clusters. In addition tonode proximity, some algorithms also use a combination ofmetrics such as the remaining energy transmission power, andmobility (forming corresponding combined weights) toachieve more generalized goals than single-criterionprotocols.

3.3. Probabilistic Clustering Protocols

Low-Energy Adaptive Clustering Hierarchy (LEACH)

W. B. Heinzelman et al. proposed first well known clustering protocol LEACH for wireless sensor networks [1]. Inthis sensors are organized into clusters and randomly selectafew nodes as cluster head with a certain probability ofbecoming a cluster heads per round. The task of being acluster head is rotated between nodes. The rotation role balances the energy dissipation of the nodes in the networks.LEACH is a distributed algorithm but cluster count (clusterhead) is not fixed in each round per epoch. Due to distributedalgorithm each node is capable to select itself as a cluster headby choosing random number. There is possibility that eachnode choose same number for cluster head selection, due torandomness property of random number generator. So clusterhead count is varying in each round.

Advantages in the LEACH protocol are:

1. It is one of the mostly used hierarchical routing algorithms in sensor networks.
2. LEACH protocol erstwhile divides the total wireless sensor network into many clusters. Any node that act as a CH in present round cannot be selected as the CH again; therefore each node can share the load equally which is imposed on Cluster heads.
3. The cluster head node is selected randomly and chance of every node to be selected as cluster head is equally attributable to which energy consumption of whole network is averaged. Thus LEACH will extend the network life cycle.

Problems within the LEACH protocol are:

1) The cluster head node is randomly selected in LEACH protocol. There are some drawbacks attributable to the

likelihood of every node to be selected as cluster head is same. After numerous rounds, the node with greater remaining energy and the node with smaller remaining energy have same probability to be chosen as cluster head. If the node which has smaller remaining energy is chosen as cluster head, it'll run out of the energy and die more quickly, due to which network's robustness can be affected and life of the network become short.

2) The standard LEACH Protocol divides clusters randomly, additionally results in uneven distribution of clusters simply. Finally, the divided clusters might not be the simplest or best. As an example some clusters have large number of nodes than others whereas some clusters have fewer nodes. Some cluster heads may be within the relatively central of clusters whereas some clusters heads may be in the edge of clusters far away from members. These phenomena will enhance the energy consumption and make harsh impact on the total performance of the network.

3) In steady state, cluster head usually transmit information to the sink or base station directly. Cluster head that is farther from the sink communicate with the sink directly mostly spend a plenty of energy. Thus it'll crash earlier as a result of it runs out of energy. Particularly in the midst of the enlargement of the dimensions of the network, these effects have an impact on the network life seriously

Hybrid Energy-Efficient Distributed Clustering (HEED)

O. Younis and S. Fahmy projected HEED protocol in 2004[18]. It extends the fundamental or the basic scheme of LEACH by using residual energy as primaryparameter and network topology features such as node degree, distances to neighbors are only used as secondaryparameters to shatter the tie between the candidate cluster heads, as a metric for cluster choice to attain power balancing.The clustering process is divided into a number of iterations, and in every iteration nodes that are not covered by anycluster head doubles their probability of becoming a cluster head. As these energy efficient clustering protocols furtherenables each node to probabilistically and independently decide its role in the clustered network. Moreover, they cannotguarantee optimal elected set of cluster heads.

Advantages of HEED protocol are:

1. It is a distributed clustering method that takes the advantage of the use of the two important parameters for CH election.
2. Low power levels of clusters endorse an increase in spatial reuse while high power levels of clusters are needed for inter-cluster communication. This imparts uniform CH distribution across the network and load balancing.
3. In a multi-hop fashion, communication between CHs and BS provides more energy conservation and scalability in contrast with the single-hop fashion, i.e long range communication directly from CHs to the sink, as within the LEACH protocol.

Limitations with HEED protocol:

1. Tentative CHs that do not become final CHs leave some uncovered nodes. Based on implementation of HEED, these nodes are forced to become a CH and these forced CHs may not have any member associated with them or may be in range of other CHs. As a result, more CHs are generated than the expected number and this also responsible for unbalanced energy consumption in the network.
2. Similar to LEACH, the clustering in each round imposes significant overhead in the network. This overhead causes remarkable energy dissipation which results in reducing the network lifetime.
3. HEED suffers from a subsequent overhead since it needs several iterations to form the clusters. Therefore at iteration, a lot of packets are broadcasted.
4. Some CHs, particularly near the sink, have huge workload and might die earlier.

Stable Election Protocol (SEP)

In 2004, G. Smaragdakis, I. Matta and A. Bestavros [20] projected SEP protocol. Thisprotocol is also a further modification to the LEACH protocol. It's heterogeneous aware protocol, supported weightedelection probabilities of every node to become cluster head according to their specific energy. This approach certifies thatthe cluster head election is arbitrarily selected and distributed based on the fraction of energy of every node assuring auniform use of the nodes energy. In this protocol, two types of nodes (two tier in clustering) and two-levelhierarchies wereconsidered.

Advantage of SEP:

1. SEP does not require any universal knowledge of energy at each election round.

Disadvantages of SEP:

1. The shortcoming of SEP method is that the election of the cluster heads among the two type of nodes is not dynamic, which results that the nodes that are far away from the powerful nodes will die first.

Distributed Energy Efficient Clustering Protocol (DEEC)

In 2006, Q. Li, Z. Qingxin and W. Mingwen [11] projected DEEC protocol. DEEC protocol is a cluster based method for multi level and 2 level energy heterogeneous wireless sensor networks. In this scheme, the cluster heads are chosen using the probability based on the ratio between residualenergy of every node and the average energy of the network. The era of being cluster-heads for nodes are entirelydifferent according to their initial and residual energy. The nodes with more initial andremaining energy have greater chances of the becoming cluster heads compared to nodes with low energy.

Advantages of DEEC:

1. DEEC doesn't need any universal knowledge of energy at each election round.

2. In contrast to SEP and LEACH, DEEC will perform well in multi-level heterogeneous wireless network

Disadvantages of DEEC:

1. Advanced nodes always punish in the DEEC, particularly when their residual energy reduced and when they come in the range of the normal nodes. During this position, the advanced nodes die rapidly than the others.

4. Summary

DEEC	HEED	SEP	LEACH	Clustering Approach		
Random	Random	Random	Random	Node Deployment Uniform / Random		
Y	N	Y	N	Heterogeneity (Y/N)		
Two/ Multi	-	Two	-	Heterogeneity Level		
D	D	D	D	Clustering Method Distributed (D)/ Centralized (C) /Hybrid (H)		
N	N	N	N	Location Awareness (Y/N)		
F	F	F	F	Cluster Head Mobility Fixed (F)/ Mobile (M)		
V	V	V	V	Cluster Count Variable (V) /Fixed (F)	Clustering Properties	
V	V	V	V	Cluster Size Variable (V) /Fixed (F)		
V	V	V	V	Cluster Density Variable (V) /Fixed (F)		
N	N	N	N	Message Count Yes (Y) /NO (N)		
Single Hop	Single Hop	Single Hop	Single Hop	Intra-cluster Topology		
Direct Link	Direct Link	Direct Link	Direct Link	Connectivity of CH to BS		
-	Y	-	Y	Pure Probability (Y/N)	Probability Based	CH Selection based On
Y	-	Y	-	Weighted Probability(Y/N)		
-	-	-	-	Neighbor (Y/N)	Non Probability Based	
-	-	-	-	Distance (Y/N)		
-	-	-	-	Location (Y/N)		

5. Conclusion

In this paper a survey of various popular WSN protocol has been reviewed, majorly LEACH, SEP, HEED & DEEC. A comparative study of various protocols on the basis of various parameters has been performed. The findings of this paper are that DEEC protocol has scope of further improvements in its cluster head election process, since LEACH and other protocols has more limitations and DEEC is the advanced version of WSN protocol clustering algorithms. We can make change in heterogeneity of cluster head election in DEEC for making it more energy efficient.

REFERENCES

[1] M. Sajid et-al, "A new Linear Cluster Handling (LCH) Technique towards Energy Efficiency in Linear WSN's", 29th IEEE International Bhurban Conference on Advanced Information Networking and Applications, Pp. 389 – 393, 2015.

[2] Mahmoud M. Salim, Hussein A. Elsayed, Salwa H. El Ramly, "PR-LEACH: Approach for balancing Energy Dissipation of LEACH protocol for Wireless Sensor Networks", 31st National Radio Science Conference (NRSC), IEEE, 2014.

[3] TrianaMugiaRahayu, Sang-Gon Lee, Hoon-Jae Lee, "Survey on LEACH-based Security Protocols", 16th IEEE International Conference on Advanced Communication Technology (ICACT), Pyeongchang, 2014.

[4] Asha Ahlawat, Vineeta Malik, "An Extended Vice-Cluster Selection Approach to Improve V-Leach Protocol in WSN", 3rd IEEE International Conference on Advanced Computing & Communication Technologies, 2013.

[5] K. Latif, M. Jaffar, N. Javaid, M. N. Saqib, U. Qasim , Z. A. Khan, "Performance Analysis of Hierarchical Routing Protocols in Wireless Sensor Networks", 7th IEEE International Conference on Broadband, Wireless Computing, Communication and Applications, 2012.

[6] Mohammed Abo-Zahhad, Sabah M. Ahmed, Nabil Sabor and Shigenobu Sasaki, "A New Energy-Efficient Adaptive Clustering Protocol Based on Genetic Algorithm for Improving the Lifetime and the Stable Period of Wireless Sensor Networks", International Journal of Energy, Information and Communications Vol.5, Issue 3 (2014), pp.47-72.

[7] S. K. Singh, M. P. Singh and D. K. Singh, "Routing Protocols in Wireless Sensor Networks – A Survey", Int. Journal of Computer Science and Engineering Survey (IJCSES), vol. 1, no. 2, (2010) November, pp. 63-83.

[8] S. A. Sayyadi, R. Senemar and H. Teimuri, "Elect Distance Efficient Cluster Heads for Improvement Performance of LEACH Protocol", 2nd International Conference on Computational Techniques and Artificial Intelligence (ICCTAI'2013), Dubai, (2013) March 17-18, pp. 179-183.

[9] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks," IEEE Transactions on Wireless Communications, vol. 1, no. 4, (2002) October, pp. 660-670.

[10] F. Xiangning and S. Yulin, "Improvement on LEACH Protocol of Wireless Sensor Network", Conference on Sensor Technologies and Applications, Valencia, (2007) October 14-20, pp. 260-264.

[11] V. Loscrì, G. Morabito and S. Marano, "A Two-Level Hierarchy for Low-Energy Adaptive Clustering Hierarchy", IEEE 62nd Vehicular Technology Conference, (2005) September 25-28, pp. 1809-1813.

[12] M. B. Young, A. Al-zou'bi, Y. Khamayseh and W. Mardini, "Improvement on LEACH Protocol of Wireless Sensor Network (VLEACH)", International Journal of Digital

Content Technology and Its Applications, vol. 3, no. 2, (2009), pp. 132-136.
[13] J. L. Liu and C. V. Ravishankar, "LEACH-GA: Genetic Algorithm-Based Energy-Efficient Adaptive Clustering Protocol for Wireless Sensor Networks", Int. J. of Machine Learning and Computing, vol. 1, no. 1, (2011) April, pp. 79-85.
[14] K. Go. Vijayvargiya and V. Shrivastava, "An Amend Implementation on LEACH protocol based on Energy Hierarchy", International Journal of Current Engineering and Technology, vol. 2, no. 4, (2012) December, pp. 427-431 .
[15] R. Halke and V. A. Kulkarni, "En-LEACH Routing Protocol for Wireless Sensor Network", International Journal of Engineering Research and Applications (IJERA), vol. 2, no. 4, (2012) August, pp. 2099-2102.
[16] J. S. Brunda, B. S. Manjunath, B. R. Savitha and P. Ullas, "Energy Aware Threshold based Efficient Clustering (EATEC) for Wireless Sensor Network", International Journal of Computer Technology and Electronics Engineering (IJCTEE), vol. 2, no. 4, (2012) August, pp. 25-30.
[17] W. Liu and L. Wang, "An improved algorithm based on LEACH protocol", Journal of Applied Mechanics and Materials, vol. 347, (2013), pp. 2725-2727.
[18] K. Pawar, V. Pawar and T. Sharma, "Enhancement of LEACH Protocol Using Energy Heterogeneity Concept", International Journal of Emerging Trends and Technology in Computer Science (IJETTCS), vol. 2, no. 1, (2013) February, pp. 49-56.
[19] P. Bakaraniya and S. Mehta, "K-LEACH: An improved LEACH Protocol for Lifetime Improvement in WSN", International Journal of Engineering Trends and Technology (IJETT), vol. 4, no. 5, (2013) May, pp. 1521-1526.
[20] G. Smaragdakis, I. Matta and A. Bestavros, "SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks", Second International Workshop on Sensor and Actor Network Protocols and Applications (SANPA), (2004).