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REVIEW ON ENERGY EFFICIENT CLUSTERING PROTOCOLS IN WIRELESS SENSOR NETWORKS

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Abstract: A WSN is a specialized wireless network made up of large number of sensor nodes and at least one base station. The energy constraint of WSNs makes energy saving and prolonging the network lifetime the two most important goals of various routing protocols. Therefore it is necessary to design effective and energy aware protocol in order to increase the network life span. Clustering is a key technique used to extend the lifetime of a sensor network by reducing energy consumption .In this paper; we present a comparative study of various energy efficient clustering protocols. Primary issues which are considered in WSNs are Energy consumption and network life time.
Keywords: WSNs, clustering protocol, energy efficient, network lifetime.

I. INTRODUCTION

A wireless sensor network is a network consists of low-size and low-complex devices referred as sensor nodes that may sense the environment or surroundings and gather the knowledge from the observance field and communicate through wireless links; the information collected is forwarded, via multiple hops relaying to a sink that may use it domestically or connected to alternative networks [1]. The sensor nodes are scattered in a sensor field as shown in Fig. 1.All these scattered sensor nodes has the capability to gather information and route information to the sink and also the end users. Information is routed back to the end user by multihop infrastructure design through the sink as shown in Fig. 1. The sink could communicate with the task manager node via internet or Satellite [2].

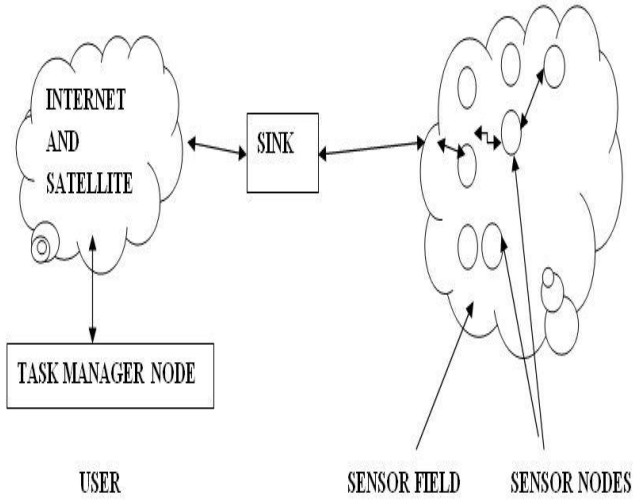

Fig. 1: Sensor nodes

spreaded in a sensor field. In wireless sensor networks, one of the main constraints is limited battery power which plays a great influence on the network lifetime. Several routing protocols have been designed for WSNs to satisfy energy utilization and efficiency requirement. Efficiency, scalability and lifetime of WSNs can be enhanced using clustering. Dividing the sensor networks into small manageable units is called as clustering & this process known as clustering process. In this sensor nodes are organized themselves into clusters and each cluster has one node as cluster head and other nodes are the cluster members. The main role of cluster head is to provide data communication between sensor nodes and the base station efficiently [3].A cluster head is selected for each cluster based on the energy level of that node or distance based. Clustering is useful in reducing the number of exchanged communications in wireless sensor network which results in low consumption of battery power of sensor nodes. This increases the life span of the WSNs [4].

II. SOME EXISTING CLUSTERING PROTOCOL

A. LEACH

Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is projected by .W.R. Heinzelman, A.P Chandrakasan and H. Balakrishnan [5] in 2000. It is one of the mostly used routing protocols in the sensor networks. LEACH protocol divides the total WSN into many clusters. The cluster head is randomly selected, every node to become a cluster head is equal attributable to which energy consumption of whole network is averaged. This will extend the network life cycle in WSNs. Leach is a cyclical algorithm; it provides a conception of round. It runs with several rounds. Each round contains two states: cluster setup state and steady state. In setup state it forms cluster within the self-adaptive mode and the information is transferred in steady state. The selection of cluster head depends on decision made 0 and 1. If the number is smaller than that of the threshold value, the corresponding node becomes a cluster head for the current round.

The threshold is given as:

$$T(n) = \begin{cases} \dfrac{p}{1-p*(r*\bmod 1/p)} & \text{if } n \varepsilon G \\ 0 & \text{else} \end{cases}$$

Here, P is the desired percentage of cluster heads (e.g. is like 3% or 4%), r is that the current round, and G is that the set of nodes that haven't been selected as cluster heads within the last 1/p rounds. By considering this threshold, each node can become the cluster head at some point with 1/p rounds. Nodes that are cluster heads cannot become cluster head for the second-time for 1/p-1 rounds. Therefore, every node has a 1/p probability to be selected as a cluster head in every round. At the end of each round, every normal node that is not a cluster head choose the nearest cluster head and joins that cluster to transmit the information. The cluster heads combine and compress the information and forward it to the base station. Limitation in LEACH protocol is:

a) As the cluster head is randomly selected in this, there are some shortcomings attributable to the likelihood of every node to be selected as cluster head is same. After number of rounds, the node containing greater remaining energy and the node with smaller remaining energy have same probability to be chosen as cluster head. If the node with smaller remaining energy is chosen as cluster head, it will run out of the energy and die quickly, due to which network's robustness can be affected and lifetime of the network becomes short.

B. TEEN

Threshold sensitive Energy Efficient sensor Network (TEEN) protocol is proposed by A. Manjeshwar and D. P. Agarwal [6] in 2001. Nearer nodes form clusters with a cluster head to transmit the collected information to higher layer. Forming the clusters, cluster heads broadcast to 2 threshold values. 1st is hard threshold; it is minimum possible value of an attribute to trigger a sensor node. It permits nodes to transmit the event, if the event happens within the range of interest. Thus a noteworthy reduction of the transmission delay happens. Unless an amendment of minimum soft threshold happens, the node doesn't send a new data packet. Soft threshold prevents from the redundant data transmission. Hence this is suitable for time-critical applications as this protocol is attentive to the rapid changes in the perceived attribute. Problems in TEEN protocol are:

a) TEEN is not appropriate for periodic reports applications since the user might not get any data at all if the values of the attributes may not arrive at the threshold value.

b) If CHs don't seem to be within the communication range of each other, the data may be vanished, because information transmission is accomplished only at CHs.

c) It has an additional overhead and complexity of cluster construction in multiple levels.

C. SEP

Stable Election Protocol (SEP) is founded by G. Smaragdakis, I. Matta and A. Bestavros [7] in 2004 which is a further modification to the LEACH protocol. It is heterogeneous aware protocol, supported weighted election probabilities of every sensor node to become cluster head according to their specific energy. This approach certifies that the cluster head election is arbitrarily selected and distributed based on the fraction of energy of every node assuring a uniform use of the sensor nodes energy. In this protocol, 2 types of nodes (two tier node clustering) are considered. 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 which are far away from the powerful nodes will die first.

D. SEP-E

Stable Election Protocol-Enhanced (SEP-E) is projected by Femi A. Aderohunmu, Jeremiah D. Deng, and Martin K. Purvis [8] in 2009 for WSNs in the presence of energy heterogeneity. Using a heterogeneous three-tier node (advanced, intermediate and normal) setting in a clustering algorithmic approach, nodes elect themselves as cluster heads based on their energy levels, retaining more uniformly distributed energy among sensor nodes. Enhanced SEP is more robust with respect to network life time and resource sharing as compared to SEP due to the addition of intermediate nodes.

E. EECS

Energy Efficient Clustering Scheme (EECS) is introduced in 2005 by M. Ye, C. Li, G. Chen and J. Wu [9]. It is a novel clustering scheme for periodical data collecting applications for WSNs. It elects cluster heads with more residual energy through local radio communication. In the cluster head election phase, a stable number of candidate nodes are elected and compete for cluster heads according to the node residual energy. The competition method is localized without iteration. The process also produces a near uniform distribution of cluster heads. Moreover in the cluster formation phase, a unique approach is introduced to balance the load among cluster heads. It will increase the necessity of global knowledge regarding the distance between the cluster-heads and the base station. Limitations of EECS are:

a) On account of single-hop communication in EECS protocol, long-range transmissions directly from CHs to the BS may lead to huge energy consumption. Thus, it is not suitable for large-range networks.

b) EECS produces more control overhead complexity because all nodes must compete for becoming CHs.

F. DEEC

Distributed Energy Efficient Clustering (DEEC) protocol is designed in 2006 by Q. Li, Z. Qingxin and W. Mingwen [10]. DEEC protocol is a cluster based method for multi-level and 2 level energy heterogeneous wireless sensor networks. The era of being cluster-heads for nodes is according to their initial and residual energy. The nodes with more initial and remaining energy have greater chances of the becoming cluster heads compared to nodes with low energy. Disadvantages of DEEC:

a) Advanced nodes always punish in the protocol, 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.

G. HEED

Hybrid Energy Efficient Distributed clustering (HEED)

protocol is projected by O. Younis and S. Fahmy [11] in 2004. It extends the fundamental scheme of LEACH by using residual energy as primary parameter and network topology features such as node degree, distances to neighbours are used as secondary parameters to shatter the tie between the candidate cluster heads, as a metric for cluster choice to attain power balancing. The clustering process is split into a number of iterations, and in every iteration nodes that are not covered by any cluster head doubles their probability to become a cluster head. As these energy-efficient clustering protocols further enables each node probabilistically and independently decides its role in the clustered network. Moreover it cannot guarantee optimal elected set of cluster heads. Limitations in HEED protocol:

a) Similar to LEACH, the clustering in each round imposes significant overhead in the network. This overhead causes remarkable energy dissipation which results in decreasing the lifetime of the network.

b) It suffers from a subsequent overhead since it needs several iterations to form clusters. Therefore at iteration, a lot of packets are broadcasted.

c) CHs which are near the sink might die earlier because these CHs have huge workload.

H. H-HEED

Heterogeneous Hybrid Energy Efficient Distributed (H-HEED) protocol is proposed by Harneet Kour and Ajay K. Sharma, [1] in 2010. This is basically used in heterogeneous wireless sensor network. H-HEED protocol is employed to extend the network lifetime. The impact of heterogeneity in terms of node energy in wireless sensor network has been stated. H-HEED is the revised version of the HEED protocol in terms of non- homogeneity. Here the cluster head is chosen based on the fraction of residual energy to the utmost energy possessed by the sensor nodes. Head to head communication takes place and unlike energy leveled networks have been formed. The energy efficiency has been verified in terms of the energy needed for the transmission and reception of the data. Here the node substitution takes place in order to reenergize the network and to enhance the network life. Disadvantage of H-HEED is H-HEED can't work or out perform well in the homogenous environment as DEC protocol can do so.

I. DEC

Deterministic energy-efficient clustering (DEC) protocol is described by Aderohunmu F.A., Deng J.D., and Purvis M.K. [12] in 2011. DEC outperforms the probabilistic-based models (LEACH, SEP and SEP-E) by guaranteeing that a fixed number of cluster-heads are elected per round. At different rounds cluster-heads are elected using the local information of their residual energies both homogeneous and heterogeneous networks within each clusters to choose the appropriate cluster-heads. DEC has been able to distribute the energy consumption in the WSN evenly among the nodes; hence the nodes die out almost at the same time.The characteristics of DEC is very desirable as it is close to an ideal solution. Even when we change the number of cluster heads per round, DEC proves to be more robust and more stable than the probabilistic-based models. Overall, DEC improves the lifetime of wireless sensor networks by an order of magnitude which is significant when compared with LEACH, SEP and SEP-E.

III. CONCLUSION

Energy efficiency is one of the major challenges in designing routing protocols for Wireless sensor networks. The energy utilization of the sensors is decreased by data transmission and reception. Therefore, the protocols designed for WSNs should be as energy efficient as much as possible so that it will extend the lifetime of each sensor node, and hence the lifetime of network .Clustering is a good technique to reduce energy consumption and to provide stability in wireless sensor networks. Clustering protocols which are discussed above each have their individual advantages and disadvantages. Depending upon the topology, the routing strategies and protocols can be applied. Every routing protocol has the major objective to reduce the energy consumption and increase the lifetime of the network. By the use of clustering, energy consumption of sensor nodes is maintained in the network and carries out data aggregation by which the number of transmitted messages to base station gets decreased. Hence, we conclude that clustering protocols are much efficient than the other non- clustering routing protocols in making more energy efficient WSNs.

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