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Review Paper on Energy Efficient Clustering Protocols for Extending Wireless Sensor Network's Life

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Abstract— The wireless sensor networks (WSNs.) contains sensor nodes having limited battery life. This sensor nodes collects the data and passes to the base station. So, there should be some mechanisms that that will increase the overall life time of whole network. Grouping (clustering) of the sensor nodes is the best technique to minimize the energy wastage in WSNs. If we apply best clustering technique in proper way, than there will be increments in lifetime of WSNs. There are many algorithms have been developed to minimize energy consumption of sensor nodes. To minimize the energy consumption of sensor nodes, the data transfer path should be shortest and optimal. This paper contains classification of efficient clustering algorithms, in terms of energy, in WSNs. The main aim of this paper is to present a survey on clustering algorithms WSNs.

Keywords— Clustering, Network lifetime, Wireless sensor networks (WSNs), Cluster Head (CH), Base Station (BS), Clustering algorithms.

I. INTRODUCTION

A Wireless Sensor Networks[6] is a wide area of research now a days. WSNs is useful on the area or environment where it is difficult to stay long time or mostly not possible to stay. WSNs have the ability of sensing, processing, communication. Sensor nodes of WSNs collect the data for particular events and transfer it to BS from where user can get data. The WSNs can contain thousands of sensor nodes. This sensor nodes have characteristic like limited battery life time, heterogeneity, mobility. All this things affects the life time of WSNs. Each sensor nodes contains a wireless transmitter/receiver, a microcontroller and a battery. In WSNs each sensor nodes collect data from the environment for particular events. This data are then sends to the cluster head. Cluster head is the node which is the head of a particular cluster of sensor node and responsible for all thing happen in it's own cluster. After collecting the data all sensor heads pass the data to base station. And at the end, end user gets the aggregated data from base station. Here base station is define as main data collection node and it is the link between sensor node and end user. Base station does not have power limitations. It have information about all the sensor node in network. Mostly the cluster heads are selected base two parameters, first one is energy level of node and second one is distance of sensor node from base station. There applications of WSNs like inventory management, home security, medical monitoring, Biological, radiological, etc.

II. CLUSTERING

Since wireless sensor network does not have facility for recharging the battery of sensor node, we should find technique by which we can prolong the life time of wireless sensor network. Grouping of sensor nodes in proper way is called clustering. It is proven that by applying better clustering technique we can prolong the life time of WSNs. There are some algorithms for clustering in WSNs. Different algorithms have different-different strategy for making clusters and then choosing cluster head. If we have minimal number of clusters and proper cluster heads in each cluster. A CH may be elected by the sensors in a cluster or pre-assigned by the network designer. By applying clustering and selecting CH for communication with BS, energy of member node of clusters is not wastage much more that require in case of direct communication with BS. Because energy dissipation will be more in case of long distance transmission.

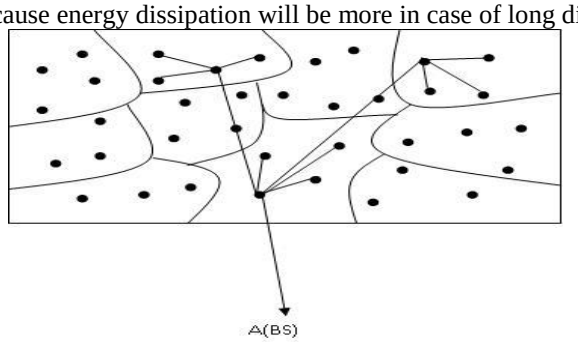

Fig.1: Passing data in case of clustering of WSNs

III. ADVANTAGES OF CLUSTERING IN WIRELESS SENSOR NETWORK

- Increase the life time of WSNs.
- Energy dissipation in the network will be minimum.
- Less number of nodes take part in communication with BS.
- Large number of nodes are maintain easily
- Resource utilization is more efficient.

IV. CLUSTERING ALGORITHMS

A. Low Energy Adaptive Clustering Hierarchy(LEACH)

LEACH is very basic protocol for clustering in WSNs. It is provided by W.R. Heinzelman[1]. It is a single level clustering scheme. In LEACH cluster heads are selected and then based on signal strength receive by nodes clusters are created. This cluster heads performs data aggregation and sends it to the base station. There are two phases in LEACH. First is Set-up phase. It is also called as clustering phase. Second is Steady-state phase. It is also called as transmission phase.

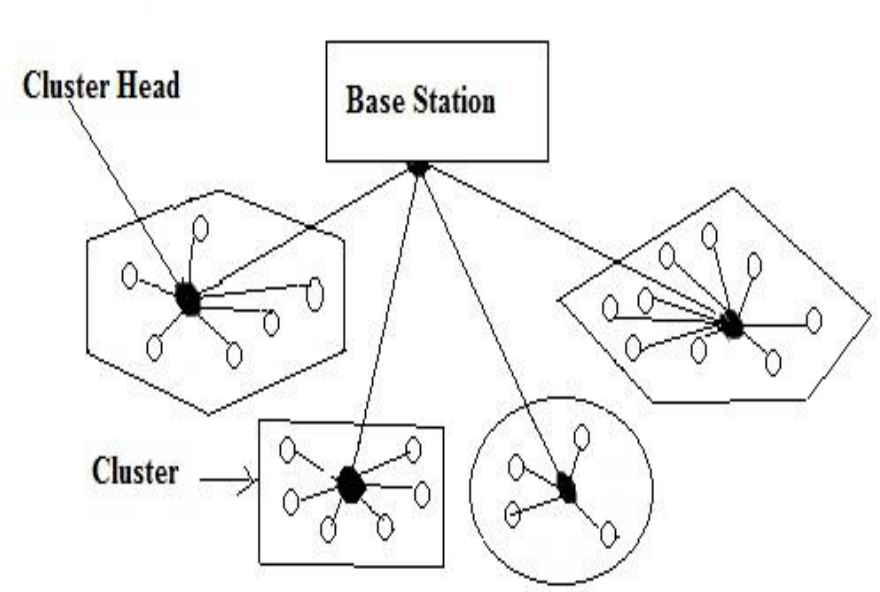

Fig.2: Clustering mechanism of LEACH in WSN

During the Set-up phase each node randomly selects the number between 0 to 1. If the number is less than the threshold T(n), than that particular node is selected as cluster head for that round.
T(n) is computed as:

$$T(n) = \begin{cases} \dfrac{p}{1 - p\,(r \bmod \frac{1}{p})}, & if\ n \in G \\ 0, & Otherwise \end{cases} \qquad (1)$$

Where p is the desired percentage for becoming CH, r is the current round, and G is the collection of nodes that in the last 1/p rounds have not been elected as a CH.

After electing CHs, every CH announces all sensor nodes in the network that it is the new CH. When each node receives the announcement, it chooses its desired cluster to join based on the signal strength of the announcement from the CHs to it. So, the sensor nodes inform their appropriate CH to join it. After that, CH give schedule for data transmission. It uses TDMA scheme to allocate time slots, for sending data, to member nodes.

In Steady-state phase data collected by member sensor nodes are sends to the CH whenever its time slots come[7]. After sending data to CH each member sensor nodes goes to sleep mode until next time slot for sending data is not come. But CH have to remain in active mode for all time so that it can receive data from all member sensor nodes. When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal[3]. The strength of LEACH is in its CH rotation mechanism and data aggregation. But one important problem with LEACH is that it does not offer any guarantee about number of cluster head nodes in every round[4][7]. LEACH also doesn't care about the energy consumption in intra-clusters communication. So clusters formation and its structure in LEACH may not be optimal. LEACH is also not applicable to large region. It also assumes homogenous behaviour of sensor nodes.

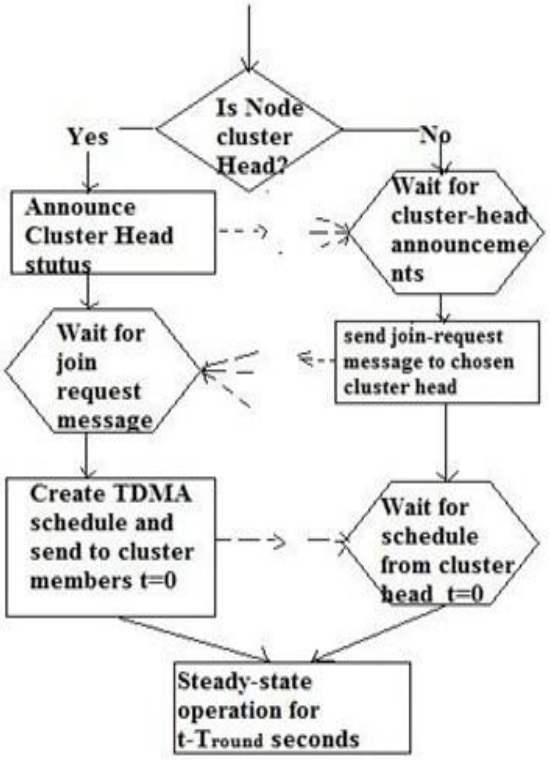

Fig.3: Flow chart of Set-up phase of the LEACH

B. Low Energy Adaptive Clustering Hierarchy Centralized(LEACH-C)

LEACH-C is a base station cluster formation algorithm. It has different cluster head selection process than perform in LEACH. During setup phase, each node sends its current location and residual energy to base station. The assumption usually is that each node has a GPS receiver. Base station estimates the threshold energy level from the collected energy information and selects the nodes with higher energy than this threshold level as possible cluster heads. The problem of determining the optimal number of cluster heads is an NP-Hard problem. LEACH-C makes use of Simulated Annealing algorithm to address this problem. After selection, base station broadcasts the message along with selected Cluster Head‘s ID to all nodes. If a node's cluster head ID matches its own ID, the node is a cluster head otherwise it's a normal node and can go to sleep until data transmission phase. Here the problem is, base station is responsible for calculating average energy level and in case any one of the node fails to communicate with base station due to far away from base station then the successful probability of CH selection is less. LEACH-C is more efficient than LEACH . LEACH-C delivers about 40% more data per unit energy than LEACH, because the BS has global knowledge of the location and energy level of all nodes in the network [1].

C. An Energy-Efficient Multi-level Clustering Algorithm for Large-scale WSNs (EEMC)

EEMC[5] is a multi-level clustering protocol. It is for aims to minimize the power consumption in the network as they use multi-level clustering. So, we can say, it is a extension of two level clustering techniques. EEMC contains two phases: first one is Set-up phase and second one is Transmission phase. Here Set-up phase works in top down fashion and Transmission phase works in bottom up fashion. This two phases work as follow:

1. Set-up phase: In this phase clusters of sensor nodes are created in top to bottom fashion. First level-i clusters are created and then level-(i+1) clusters are created and so on. Means starting from level-1 than level-2,....., to level n. Initially all active sensor nodes sends the message to base station(BS), which contains the information about energy level remaining of each sensor nodes and location of the particular sensor node. After receiving this messages BS evaluate the total energy remains in whole network.BS than sends the messages to each sensor nodes that contain information of total energy remains in network and total reciprocal of the distance from all nodes to the BS. Once all nodes receives this information message from BS, all nodes set probability of becoming cluster head for first level. Here the nodes, which have higher energy and closer to BS, have high probability of becoming CH. So the nodes which are closer to BS and/or have higher energy remaining becomes CH.

Now the level-1 CHs announces message in its radio range. So whichever nodes receives this message joins the CH by giving its remaining energy information to CH. Now in each clusters same clustering process is repeated, which perform in deciding level-1 CH, to create level-2 clusters. And in this way further levels are created.

2. Transmission Phase: In the Transmission phase it works as bottom up style. Data collected by low level cluster's normal nodes are submitted to lowest level CH(level-n). After receiving data from normal nodes it transfers data to next higher level's CH.(level- (n-1)). And in this way CH at level-1 gets aggregated data at last, which is than responsible to sends aggregated data to BS direct. So, Here each nodes including CH node will perform the 1-hop communication with

other node. Here total cost for transmitting data from normal nodes to BS is equal to the total energy required to transmit data by each node to the next higher level node from normal node of level-n to CH node of level-1 and then from level-1 to BS. So here we can say that Transmission phase is larger than Set up phase.

Here after creating the clusters the member nodes of clusters have to choices of becoming CH of next level cluster or becoming member node of current or next level cluster. This technique creates stable clusters[9]. In the case of small number of sensor nodes in WSNs, this scenario will become costly. Here in best case the minimum energy consumption for any node will be 1-unit scale. One problem with this technique is that, in case when any normal node comes under the radio range of two CH. So cluster overlapping may results.

D. Modified LEACH Algorithm

This is modified version of basic LEACH protocol proposed by S. Taruna and Sakshi Shringi[2]. In this algorithm they modified the formula of calculating threshold value used for cluster head selection and also present one more new phase which is use in calculating every new threshold values for next round. The three phases are the Set up phase, the Steady state phase and the pre-Set up phase.

1.Set up phase: Initially all sensor nodes generates random probability(p) for becoming CH. BS station calculates the threshold value T(n) as follows:

$$T(n) = 1\begin{cases} \dfrac{P_t \cdot E_{res}}{P_t\,(r \bmod 1)\_\, E_{max}}, if\ n \in G\ (2) \\ 0, \end{cases}$$

Where, r is current round number, P_t is the desired percentage of cluster heads, E_{res} is current residual energy of node, G is the set of nodes that have not been cluster-heads in the last 1/ P_t rounds, E_{max} is maximum residual energy of entire network

If p < P_t then that node becomes CH and broadcasts the message to all other neighbour nodes. The neighbour nodes, which are nearest to CH joins that CH and the clusters are created.

2.Steady state phase: In this phase each member nodes sends data to the CH with the information of its current residual energy also.

3.Pre-Set up phase: This phase is perform at the end time of each current rounds. CH sends the information of maximum residual energy of each member nodes of its own cluster to BS. BS than calculates the total remaining energy of whole network (E_{max}) and sends back this information to each CH. CHs then sends this message to their member nodes which stores this information to use it in calculating T(n) for next round. And after all this gets finish the current round also terminated.

This algorithm works better than original LEACH protocol.

E. Mode Selection clustering Protocol

This protocol[8] uses mechanism of BCDCP(Base Station Controlled Dynamic Clustering Protocol) and BIDRP(Base Station Initiated Dynamic Routing Protocol) and improves WSNs life time. In this protocol initially each nodes sends information about its energy level and location to BS. BS creates clusters having all clusters equal number of nodes and the node with highest energy level is selected as CH in particular clusters. This CH selection and cluster creation process is same as used in BCDCP protocol[10]. After creation of clusters the leader node is selected which is responsible to send final aggregated data to BS. The leader node is selected by following formula:

$$R_{ED} = {}^{E_{Rm}}/_{Level_n}\ (3)$$

Where, R_{ED} is ration of energy distance, E_{Rm} is energy remaining of cluster head node and $Level_n$ is level where cluster head is located.

The CH node for which the value of R_{ED} is highest is selected as leader node for whole WSNs. After selecting leader node the layer are created. The level where leader node is located is selected as layer-0. The level adjacent to layer-0 is become layer-1. In this way layers are decided. Now the data are transmitted from higher layer's CH node to lower layer's CH node. For example from layer-1 to layer-0. Here there is a possibility of having more than one CH node in one layer. In that case the center node is selected which is responsible for collecting data from its own layer's CH node and for receiving aggregated data from higher layer's centre node and pass it to lower layer's center node. The center node is selected by using following formula:

$$R_{ELC} = {}^{E_{Rm}}/_{(d_{CH}\ -\ d_{LC(L)})}\ (4)$$

Where, R_{ELC} is ratio energy of layer center, E_{Rm} is energy remaining of the cluster head, d_{CH} is distance from the cluster head and $d_{LC(L)}$ is distance from the layer center node in the lower layer.

The CH node for which the value of R_{ELC} is high is become the center node.

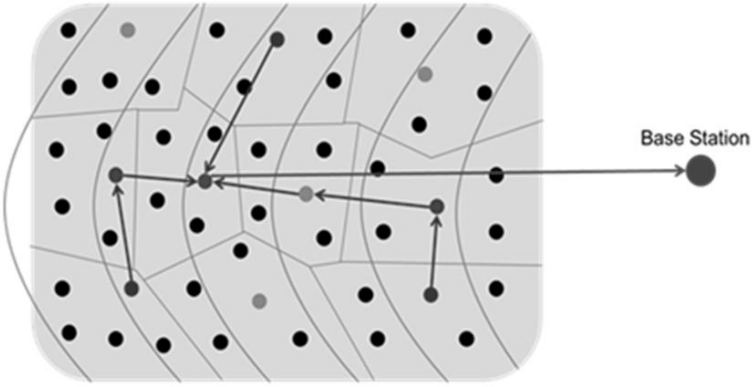

Fig.4: Architecture of mode selection clustering protocol

V. CONCLUSION

In this paper, description of various clustering algorithm is shown. From that we can decide that, in wireless sensor networks, cluster head selection and making clusters are very crucial tasks. Also the placement of CH node very important. Because of having limitation on power of sensor node, cluster head should be elected based on residual energy and distance from base station as well. So by considering this much parameters, the life time of WSNs can be prolong.

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