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Cluster head selection in mobile wireless sensor networks: a survey

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***Abstract*- Wireless sensor networks have made the task of surveillance and detection easy up to greater extent. And mobile wireless sensor network is an advancement of wireless sensor network in a way to fulfil requirements of current surveillance techniques more appropriately. In this survey paper, we have considered an important part of mobile wireless sensor network i.e. clustering. So far proposed and implemented algorithms for clustering in mobile wireless sensor network is discussed here with the consideration of LEACH as a basic algorithm for clustering in wireless sensor network.**

Keywords*: *Mobile wireless sensor network, clustering, cluster head, LEACH

I. Introduction

Mobile wireless sensor network has come into existence as a solution to many problems where human intervention becomes quite difficult. There are some places or incidents which need to be monitored constantly such as nuclear power plant [1], wild life activities [2] [3], military applications, traffic patterns [4] and many more but due to the lack of human power and unpleasant working conditions; we need assistance of wireless sensor network. Suppose a research is going on the topic 'animal conservation' and hence we need to put each animal in a particular forest under observation. In such a case assigning a man for each animal is quite tedious and impractical job, therefore a mobile wireless sensor network is formed by putting a wireless sensor with each animal [5].

Data mules [6] provide little mobility in static wireless sensor network where nodes are sparsely deployed. A mobile data collector having rechargeable battery called Mule collects data from sensor nodes and sends to base station. In this situation sensor nodes are exempted from sending information, hence energy is saved to a large extent. But with different scenario, in mobile wireless sensor network, sensor nodes relocate themselves with the intention of covering area to be monitored or to replace uncharged or defective sensor nodes. In such a network, topology may change after time 't' as illustrated in figure 1.

In some situations, sensors are just dropped from a height or thrown parabolic and supposed to position themselves to track something or monitor an area. In such cases energy becomes a vital issue for sensor nodes as they do not contain any battery recharging facility as well as they are very small in size hence cannot resist high battery capacity. In that environment, energy needs to be conserved at each step either sensing or processing or communicating or moving. The Sensor nodes are grouped to form clusters and a Cluster Head (CH) is decided either by base station otherwise by nodes itself. It has been observed that clustering plays an important role in energy saving with better resource allocation.

Section 2 describes LEACH algorithm for wireless sensor network, section 3 illustrates various clustering techniques used in mobile wireless sensor network and section 4 concludes this survey paper.

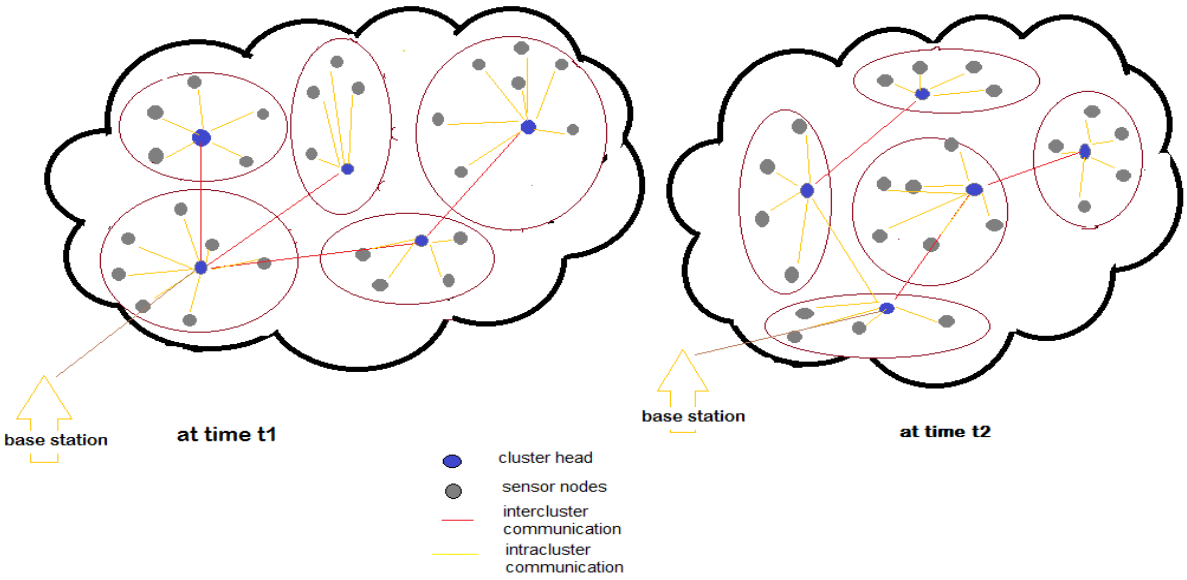

Fig. 1 Architecture of Mobile Wireless Sensor Network

II. Background

Before going to list the algorithms specially designed for mobile wireless sensor networks, LEACH algorithm for static wireless sensor networks need to be discussed as some of the algorithms are advancement of LEACH algorithm.

LEACH (low-energy adaptive clustering hierarchy)-

In LEACH [7], each node is a part of local cluster which is organized by Cluster Head also called local Base Station (BS). The sensor nodes sends monitored data to its respective CH and CH sends those data to main BS after applying some processing functions with data. Since, the CH need to do more work than other nodes, it is obvious that CH will prone to lack of energy sooner with respect to other nodes. To avoid such situation, LEACH performs randomized rotation of CH by using algorithm in several rounds. There are two phases of LEACH protocol- set-up phase and steady phase. In set-up phase cluster heads are selected with the process described below.

Suppose there are 'N' nodes in the sensor network and 'k' is the expected number of CHs in a round. Each sensor node 'i' in round 'r" elects itself as a cluster head with the following probability--

$$P_i(t) = \begin{cases} k \Big/ \left(N - k * \left(r \bmod \frac{N}{k}\right)\right), & Ci\,(t) = 1 \\ 0, & Ci\,(t) = 0 \end{cases} \quad (1)$$

Where, C_i (t) is 0 if a node is not chosen as cluster head in (r mod (N/k)) rounds otherwise 1. Every node needs to be cluster head once in (N/k) rounds on an average for maintaining equal energy dissipation throughout the network. The node with highest probability is considered as cluster head.

In steady phase, the cluster head broadcasts advertisement message using CSMA (Carrier Sense Multiple Access) MAC protocol and nodes decides their cluster head by analyzing

received signal strength of different cluster heads.

III. Clustering Algorithms In Mobile Sensor Network

A. *LEACH-M (LEACH-Mobile)-*

LEACH-Mobile protocol [8] was developed by Do-Seong Kim and Yeong-Jee Chung in 2006. All nodes are assumed to be time synchronized and they start set-up phase together. The set-up phase of LEACH-Mobile is same as LEACH but steady phase differs in some manner. Since, sensor nodes are mobile in the network; hence it is possible that after certain time it might have been moved from the cluster in which it was belonging previously. Therefore, in steady-state phase before sending data to cluster head each node uses its first frame of TDMA schedule for sending data request to cluster head and if node does not get response from cluster head in that time slot, it sends join-request message in consequent time slot. After receiving join-ack messages from cluster heads, on the basis of received signal strength node decides in which cluster it belongs.

B. *LEACH-ME (Leach-mobile-enhanced)-*

The basic idea behind LEACH-M is to check if a node is able to communicate with the cluster head or not. With the consideration of fact that after sometime that cluster head may go out of cluster due to node's mobile nature, LEACH-ME included new parameter 'mobility'. In LEACH-ME algorithm [9], a node with the value of Role 1 (1 if node is cluster head otherwise 0 if a general node) keeps following information along with Mobility factor (calculated on the basis of remoteness) -

1. Member list- references of all other nodes in cluster
2. TDMA schedule- list of time slots for exchanging information from node to cluster head

There is a location vector n_i (t) for each node at time t and distance between two nodes is calculated in terms of difference between location vector of two nodes.

Before the election of cluster head, current cluster head awakes all nodes for calculating their respective Mobility factor. Each node calculates and broadcasts its id and time stamp and waits for the reply of neighbouring node. The node with minimum mobility factor is elected as cluster head.

C. *LUDC (Location-Unaware Distributed Clustering)-*

In this distributed algorithm [10], there is concept of Zone Head with cluster head. The zone head is one which acts as a bridge between cluster head and base station. When a node wants to join a zone head, it sends a request message to respective zone head. If zone head is able to accommodate that node it sends confirmation message to node, otherwise it checks if there is any connected node with lower quality of link than requested node. Zone head sends command to lower quality linked node to join other zone, if it is allowed, zone head sends confirmation to requested node otherwise declines the request. The same process is followed with cluster head. In second scenario, when a node gets zone head or cluster head advertisement message from more than one node, it decides its cluster head on the basis of energy level of node, mobility , quality of link and quality of received signal strength using fuzzy logic.

D. *ACE-C (Algorithm for Cluster-head Election with Counting)*

In this algorithm [11], if there is total N number of sensor nodes then each sensor node is assigned an Id ranging from 0 to N-1. The algorithm works on the basis that each node has to be cluster head and hence round-robin technique for cluster head election is used. If there should be C number of cluster heads in each round, then the nodes elected as cluster head will again be elected after time t. For example, in a particular network, if 5 cluster heads have to be selected and nodes with ids 5,6,7,8 are selected in round 1 then after completion of round-robin time these nodes will again be selected as cluster heads. The round-robin time for this algorithm depends on the number of nodes present in network. If a node dies which was going to be elected as cluster head, the sensor node from subsequent time interval is elected as cluster head. Even though this algorithm does not consider

location or mobility of sensor nodes; it well-suits mobile wireless sensor network.

E. *ACE-L (Algorithm for Cluster-head Election with Location)*

The algorithm [11] is particularly designed for mobile wireless sensor network. Since the location of nodes changes, same numbers of fixed refernce points are taken as number of cluster heads. The closest reference point from senor node is assumed as Main reference point (MRP) and with the distance between current location of node and MRP, delay time is calculated. Each node sets its delay time to acquire channel and node with shortest delay time acquires channel. As soon as node acquires channel it broadcasts the message that it has been elected as cluster head. When other nodes get message they stop running algorithm. It can be inferred that node with shortest distance form reference point and shortest delay time is elected as cluster head. The performance of this algorithm varies for mobility model being used.

IV. Conclusion

In mobile wireless sensor network, due to mobility in sensor nodes clustering needs to be performed more frequently than the static wireless sensor network hence there is more loss of energy as well as mobility also consumes energy. Although efficient algorithms for clustering in mobile wireless sensor network exists there, though energy need to be saved at each level of communication and processing. Table 1 lists the algorithms used for clustering in mobile wireless sensor network with their respective parameters and techniques. Beside the selection of a capable cluster heads, a fine clustering algorithm needs to cover the issues of optimal cluster size and optimal number of cluster heads. Depending upon topology of network, multi hop clustering provides better energy efficiency than single hop clustering therefore as a future work we can propose an algorithm for multi hop clustering in mobile wireless sensor network. In LEACH-ME protocol, the authors have given the concept of mobility factor which can be calculated on the basis of two parameters either with transition count or degree of remoteness. But the authors have taken into account degree of remoteness for implementation purpose; therefore an algorithm can be designed on the transition count basis. Although the transition count will not give real time inference but it will need low overhead than degree of remoteness as well as prior knowledge of topology will not be required.

TABLE 1. List of Clustering Techniques in Mobile Wireless Sensor Network

Name of Algorithm	List of parameters	Technique
LUDC	Energy level, Mobility, Quality of link, Quality of received signal	Fuzzy approach
Leach-mobile	No of times chosen as cluster head, Received signal strength	Homogeneity, probability
Leach-mobile-enhanced	Mobility, Role, Member list	Comparison
ACE-C	counting	Round-robin
ACE-L	Location, delay time	Radio Channel-acquiring

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