

# CLUSTER BASED ROUTING PROTOCOLS FOR MOBILE WIRELESS SENSOR NETWORK: A REVIEW

Jaideep Lakhotia, Rajeev Kumar

**Abstract**— Mobile Wireless Sensor Network is having mobile nodes in the network. Both the sensor nodes and mobile sink can be mobile or there can be mixed sensor nodes i.e. mobile as well as static sensor nodes in the network based on the application requirements. Routing in mobile wireless sensor network poses research issues as nodes are mobile, so it needs to send the data according to the routing protocol while it is moving. So the routing protocols have been proposed considering mobile nodes in the network focusing on research issues like packet loss, energy consumption, and delay. In this paper, the cluster based routing protocols that have been proposed for mobile wireless sensor network are discussed and comparison is done among them.

**Index Terms**— Cluster, Mobile wireless sensor network, Routing

## I. INTRODUCTION

Routing in Wireless Sensor Network is one of the most important research issues. Now as the application requirements are changing, they required mobile sensor nodes in the network. Protocols that are designed earlier are not able to handle these mobile sensor nodes as these sensor nodes lose their connectivity in the network or it may consume more energy to send the data which makes these algorithms not feasible or energy inefficient. But from past few years researchers started developing routing protocols based on mobile or mixed sensor nodes in the network. These protocols either dealing with mobile sink and mobile sensor nodes or both. In cluster based routing protocols the sensor nodes are arranged in the cluster. Clustering is being done by the sensor nodes for themselves or the Base Station does the clustering for these sensor nodes. After Cluster formation, it requires the appropriate cluster head for each cluster, for that also either node computes the appropriate cluster head within the cluster or base station determines the cluster head for each cluster. After that these Cluster Head makes TDMA schedule for the sensor nodes in the cluster and then the nodes start sending the data to the cluster head. After that these cluster heads send the data either to the Base Station directly or to another cluster head in multi hop way.

As the sensor nodes can move out of the cluster in which they are present, there is a requirement that the routing protocols that have been designed should handle the mobility of the

sensor nodes so that the data from these sensor nodes successfully received at the Base Station. The sensor node that moves out of the cluster have to determine whether it moves out of the cluster or the node to which it is sending get moved or failed. After demining that it can send the request to join the new cluster and continue sending the data. So routing protocol have been designed for the mobility management of these sensor nodes.

The sensor nodes in the network should know about their location. So for the location sensor nodes either having localization algorithm working on it or they have GPS installed on it. The location helps to determine the mobility of the sensor node. Some algorithm might not need the location to work as it is working on relative distance to send data.

Some of the routing protocols developed so far that considered mobile nodes are LEACH-M[2], LEACHME[3], CBR-M[4], E2R2[6], 2L-LEACH-M[7], FTCPMWSN[8], LFCP-MWSN[9]. All these protocols works on cluster based wireless sensor network with different cluster head selection criteria and different ways to deal with the mobile nodes present in the network. The main focus of these protocols is to use the energy efficiently, packet loss should be less due to mobility, less end to end delay, high throughput and so forth. This paper is organized as follows: In section II, architecture of clustered wireless sensor network is shown; section III describes the Mobile Wireless Sensor Network, In section IV the routing protocols for mobile wireless sensor network has been discussed, In sections V comparison is done among the routing protocols discussed in section IV and in section VI, conclusion determined from this study has been discussed.

## II. ARCHITECTURE OF CLUSTERED WIRELESS NETWORK

Figure 1 shows the architecture of cluster based mobile wireless sensor network. In the figure the mobile nodes are deployed in the region and they are organized into clusters. Every cluster has its own cluster head. And there is a Base Station to receive data from these nodes.

**Mobile Nodes:** The mobile nodes in the network used to sense the region activities and they forward the sensed data to the cluster head in its cluster area.

**Cluster Head:** The cluster head is present in every cluster and it is used to collect the data from mobile nodes present in that cluster. For that cluster head first makes the TDMA schedule

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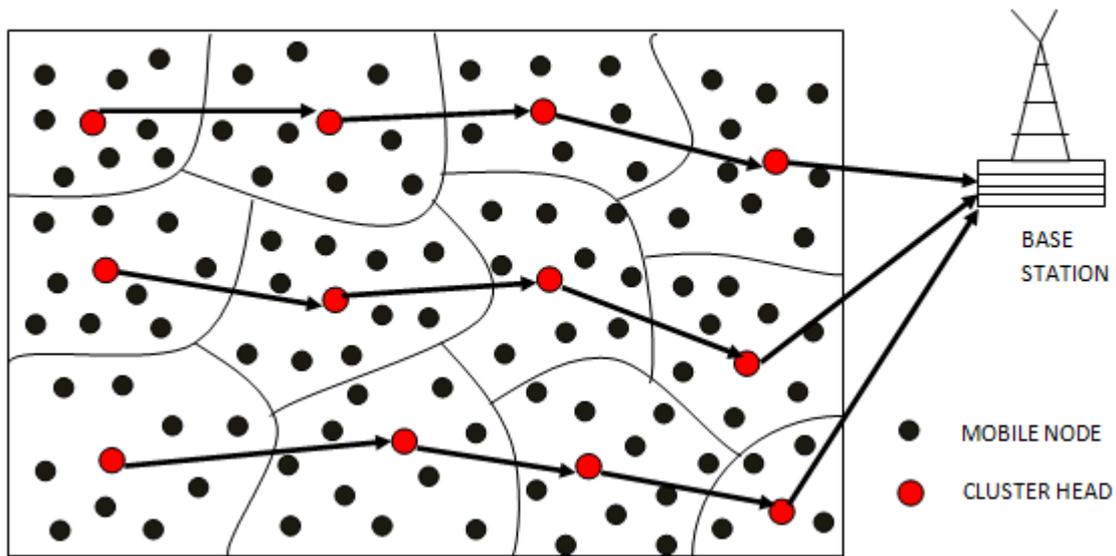


Fig 1: Clustered Wireless Sensor Network

for the mobile nodes and according to which mobile nodes sends the data to the cluster head. The role of cluster head is assigned to one of the robust and reliable node present in that cluster for one or few rounds after which this role is assigned to another node so that energy consumption becomes uniform in the cluster. After receiving that data from the mobile nodes, these cluster heads either send the data directly to the

base station or it send the data to the cluster head which is near to the base station.

**Base Station:** Base Station manages the network and receives data from the nodes in the network and forwards this data to end users.

### III. MOBILE WIRELESS SENSOR NETWORK

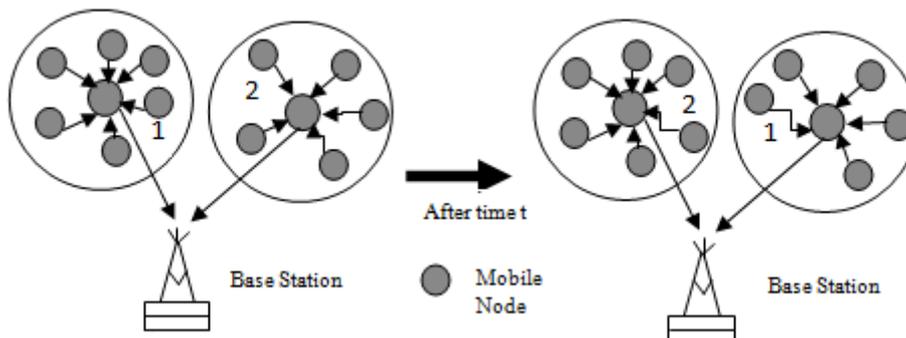


Fig2: Mobile Node changed its position. All the sensor nodes are mobile

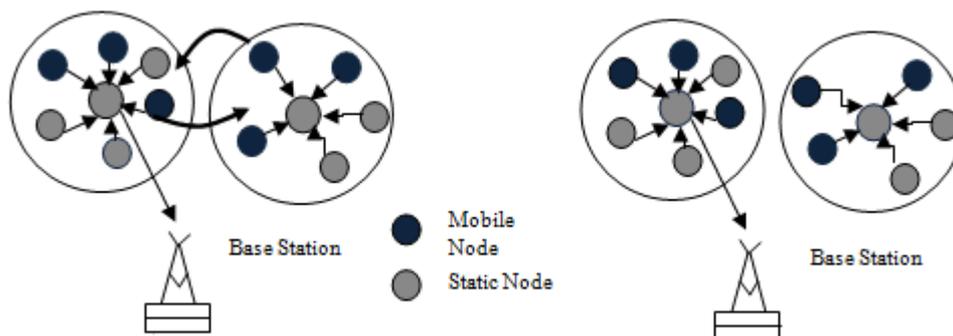


Fig 3: Sensor network with both static and mobile nodes in the network.

In Mobile Wireless Sensor Network as shown in figure 2, nodes can move out of the cluster and may comes in the range of another cluster so it will send the request the new cluster. In figure 3, there are mixed nodes in the network i.e. static as well as mobile sensor nodes which sense the data and forward it towards base station. Mobility in the mobile wireless sensor

network can be achieved by equipping the sensor nodes with object that provides them mobility so that they get their locations [10] or the sensors nodes can move by themselves using springs [11, 12] or wheels [13] or they can be attached to vehicles, animals, robots [14] etc. Sensor nodes may move because of the environmental conditions like air [15].

Researchers have proposed algorithms for mobile sensor network specifically which performs better than the algorithm that are designed for static network when applied to the mobile sensor nodes. Using Mobile sensor nodes offer some of the advantages as follows [16, 10, 17, 12]:

- Topology in Mobile Wireless Sensor Network changes frequently, so there is a need of appropriate Routing Protocols, MAC protocols for it.
- In static WSN, due to failure of the nodes or energy depletion the network make become disconnected causing packet loss in the network, but in MWSN, the nodes can be used to reorganize the network so that packet loss does not occur.
- The lifetime of a sensor network can be increased using mobile sensor nodes [18, 19]
- As the mobile nodes can move, it can track its target in more efficient way.
- Data fidelity can be achieved by MWSN by reducing the number of hops owing to which the probability of error decreases
- MWSN has more channel capacity as compared to static WSN [20]
- In mobile sensor network the nodes can relocated them after initial deployment as per the requirement like coverage.
- Mobility can reduce energy consumption during communication [19]

Some of the routing protocols that have been proposed for cluster based sensor network is discussed below:

- A. **M-LEACH:** In LEACH[1], it considered all the nodes as static so does not work efficiently in case mobile nodes being introduced in sensor network, so for this authors proposed M-LEACH[2] protocol which select cluster head based on mobility, location, residual energy of node. It also distributes cluster head uniformly by dividing sensing area into subareas and it is assumed that node is being installed with GPS so that node's location can be known. Mobile Node detects that it goes out of cluster when it does not receive request from cluster head for two consecutive frames of data transmission phase and then it send join request message for registering with new cluster head. It considers only mobile sensor node and base station is fixed.
- B. **LEACH-ME:** It is another advancement to LEACH[1] protocol and M-LEACH[2] protocol in which cluster head is selected on the basis of no movement of node or it has less relative movement in cluster. It also include extra timeslot in TDMA schedule for mobility calculation based on number of times node moves from one cluster to another, this extra timeslot is added in TDMA schedule on the basis of slot frequency which depend on node movement in the cluster. Here also the node can detect that it goes out of range of current cluster head if it dost not receive data request from cluster head in two consecutive frame of data transmission phase and Cluster Head remove the TDMA time slot for mobile node if it does not receive data from mobile node in two consecutive time slot.
- C. **CBR-M:** It is the cluster based routing for mobile nodes in wireless sensor network. In this protocol the

work is carried out to reduce packet loss occur in [2]. Cluster Head remove the TDMA time slot for mobile node if it does not receive data from mobile node in its allocated time slot. So cluster head rebroadcast the updated TDM schedule to the cluster members in case node is moved from the cluster. The main idea in this protocol is that there should be one cluster free to receive packet from the mobile node that goes out of cluster and cannot receive data request message from its cluster head. The nodes in sensor network wakes up one time slot before the TDMA schedule for it and for the rest of the time it is in sleep mode that saves energy of these nodes.

- D. **ECBR-MWSN:** It is advancement in CBRM[4] protocol in terms of energy efficient cluster head selection. It select cluster head based on primary criteria i.e. low mobility, high residual energy and secondary criteria i.e. distance between node to base station which is used in case of a tie occur after checking primary criteria.
- E. **2L-LEACH-M:** Another protocol is 2L-LEACH-M[6] which is the advancement in LEACH[1] protocol to support mobility and result shows that it improves data transfer rate in comparison to LEACH[1] protocol in mobile node scenario. In this protocol nodes are divided in two levels, Level1 is cluster head level and Level0 is member level. In this cluster member belongs to cluster head nearest to it. Nodes are location aware of itself. If the node moves it send the data and the new cluster head has no TDMA schedule for this node then after finishing current frame cluster head checks whether it receives sensed data from any node for which it has no time schedule, if it receive data from such a node then it include that node in TDMA time schedule.
- F. **E2R2:** This routing protocol considers link failure that can occur due to the movement of mobile nodes. In this Base Station select two deputy cluster head and one cluster head in each cluster. These deputy cluster head in cluster management in case of link failure. A node that cannot send a data to cluster head due to link failure can send it to deputy cluster head and deputy cluster head forwards it to Base Station. Cluster head also keep TDMA slot for these deputy cluster head which is not being used usually it is not used for sensing purpose but for cluster management. In case of link failure between cluster heads, the cluster head can transmit data through its deputy cluster head to base station. It has been analyzed that it performs better than leach protocol in terms of life time and throughput of the network is considered.
- G. **FTCP-MWSN:** It is energy efficient and fault tolerant routing protocol for Mobile wireless sensor network. By this protocol we can actually determine that node is mobile or it get failed. It considers that all node are mobile and there is high probability of a node getting out a cluster and another node coming into the cluster. It does not keep extra time slot for calculating mobility of sensor node rather the node sends its mobility information in the TDMA schedule itself. If the node

ROUTING PROTOCOL	ASSUMPTIONS	CLUSTER HEAD SELECTION	LOCATION AWARE	SCALABILITY	ROBUSTNESS	COMPLEXITY
<b>LEACH-M</b>	<ul style="list-style-type: none"> <li>Cluster Head is stationary after election.</li> <li>Node is declared mobile after two data frames.</li> </ul>	Based on Sensing area and less mobility, high residual energy.	Yes	Limited	Medium	High
<b>LEACH-ME</b>	<ul style="list-style-type: none"> <li>Base Station is fixed. Considered CH as mobile.</li> <li>Node is declared mobile after two consecutive data frame.</li> </ul>	Based on mobility and high residual energy	Yes. Use GPS or other location detection Mechanism.	Medium	High	High
<b>CBR-MWSN</b>	<ul style="list-style-type: none"> <li>Node is declared Mobile after not receiving data in its TDMA schedule.</li> <li>Cluster head keep extra time slot for mobile node to join.</li> <li>One of the CH is free to receive data Fixed Base Station.</li> </ul>	Based on mobility and high residual Energy.	Use GPS to calculate current location so that Base station can communicate with it directly.	Medium	High	High
<b>ECBR-MWSN</b>	<ul style="list-style-type: none"> <li>Mobile Sensor Nodes.</li> <li>Fixed Base Station.</li> <li>Nodes are densely deployed.</li> </ul>	Based on the mobility and residual energy and distance between the node and Cluster head.	Assume node knows its Coordinates.	High	High	High
<b>2L-LEACH-M</b>	<ul style="list-style-type: none"> <li>Fixed Base Station</li> <li>Nodes are classified in two levels. One for Cluster heads and other for members.</li> </ul>	Based on the distance between the node and Cluster head.	Assume node knows its Coordinates.	Medium	High	Medium
<b>E2R2</b>	<ul style="list-style-type: none"> <li>Sensor nodes are mobile and Base station is fixed.</li> <li>Deputy cluster head is used for cluster management.</li> </ul>	Based on residual energy of deputy cluster heads.	Considered location aware	High	High	Medium
<b>FTCP-MWSN</b>	<ul style="list-style-type: none"> <li>Nodes are mobile.</li> <li>High probability of node if it moves out of cluster then another node comes in the cluster.</li> </ul>	Based on residual energy and position of Sensor.	Assumed node knows their Coordinates.	Medium	High	High
<b>LFCP-MWSN</b>	<ul style="list-style-type: none"> <li>All nodes are mobile.</li> <li>Anchor nodes are there in a cluster.</li> <li>Once node is selected as cluster head, it remains in the same cluster.</li> <li>Initially all nodes have same energy levels</li> </ul>	Initially on the basis of energy and position of sensor and then after also considering mobility of node.	Yes using localization algorithm	High	High	High

Table1: Comparison of Routing Protocols for Mobile Wireless Sensor Network.

moves out of cluster at x time interval and same node sends join request in x+1 time interval to another cluster head then it can detect that node is mobile otherwise node get failed and this is calculated by base station as cluster heads inform the Base Station about node ID when it leaves the cluster or it enters the cluster. In this protocol sensor node sends special packet in case it doesn't have data to send and saving the energy in this way. So there is no false detection of mobile node as failed node.

H. **LFCP-MWSN**: It is similar to FTCP-MWSN[ 8] in terms of fault tolerance but it also introduces anchor nodes for calculation of location rather than any GPS installation on sensor nodes. Anchor nodes send its location to mobile nodes so that it can calculate its current position. It reduces energy consumption and end to end delay as compared to M-LEACH[2] and LEACHME[3].

#### IV. COMPARISON OF CLUSTER BASED ROUTING PROTOCOLS FOR MWSN

1. Energy-Efficiency: Protocols should not have high computation overhead and always consume less energy to increase network lifetime.
2. Less end to end delay: There should be less delay in passing the data information forward to the Base Station.
3. Less packet loss: Packet loss occurs due to mobile node should be minimized by the approach.
4. Link management: In case of link failure due to mobility of node the alternate route is to be selected dynamically.
5. Cluster Head selection: Appropriate cluster head selection is important such that nodes in a cluster not consume more energy to send data to cluster head.
6. Location Awareness: Base Station cannot communicate to sensor node if it does not know location of a node. So updating the location is necessary in case of mobile nodes.

#### V. CONCLUSION

Routing in Mobile wireless sensor network is one of the most important research issues now a day. Most of the applications now a day require mobility of the nodes. In this paper routing protocols for Cluster Based wireless sensor network has been studied and based on that comparison is being made. As the mobility is introduced in the sensor network it will consume more energy so that researches have proposed energy efficient routing algorithm to handle the mobility of the sensor nodes. The objective of these routing protocols is not only to improve the network life time but also to reduce end to end delay, reduce packet loss and link management etc.

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