Asian Journal of Information Technology 15 (2): 312-322, 2016
ISSN: 1682-3915

A Novel Technique for Improving Cluster Head Lifetime in Mobile Wireless Sensor Networks

M. Sangeetha and A. Sabari
Department of Information Technology, KSR College of Technology, Tiruchengode, India

Abstract: Prolonging the network life time in mobile wireless sensor networks has become a real challenge in research ground. Cluster head selection has become an inevitable pre-phase for any network environment. Such selected cluster heads does not pose with higher lifetime leading to many distortions. In this study, we propose a nested zone-division mobility protocol for enhancing the lifetime of the elected zone heads using two phases such as setup phase and steady state phase. In setup phase, the zone head nodes for each cluster is selected based on impactual factors such as mobility, residual energy, maximum power-uphold, remoteness and selected frequency intending a load balanced cluster organization scheme with extended lifetime. The scalability and flexibility towards node density is accounted based on greedy approach for cluster formation. In steady state phase, routing and aggregation are experimented. Simulation results shows that the zone head nodes outperforms other existing protocols with higher lifetime and improved throughput when nested zone-division mobility protocol is applied.

Key words: Mobile wireless sensor networks, dynamic clustering, nested zone-division, mobility, split and merge, packet delivery, lifetime, energy consumption

INTRODUCTION

A mobile wireless sensor network consists of a large number of battery-powered, resource-constrained wireless sensor nodes which might be randomly deployed in close proximity to the phenomenon for sensing and collecting the desired data from the surroundings (Akyildiz *et al*., 2002). Most of the sensors protocols use clusters in order to provide energy efficiency and to extend the network lifetime. Each cluster first elects a node as the Cluster Head (CH), later the other sensor nodes join the proper clusters according to the signal strength from cluster heads.

The operation of cluster heads is divided into rounds, each round consists of a cluster set-up phase to form clusters and a steady-state phase where the cluster heads aggregate the data received from their cluster members and send the aggregated data to the base station. After a round, new cluster head is being selected and process is repeated. This data transfer can be performed in two alternative ways. Either directly, in the case, in which the cluster head is located close to the sink or via intermediate cluster heads. The sink may further communicate with a task manager node via the internet or satellite network. In earlier days, the wireless sensor network nodes are static in nature and also permanently in its location. It has been carried out for a lengthy period of time (Akkaya and Younis, 2005). It produces many researches mainly focus on energy consumption in WSN sensor nodes considered as static node. However, recent years have witnessed an increasing interest in dynamic cluster based MWSNs in many applications, including animal tracking, habitat monitoring, search and rescue, tracking vehicles, disaster response and military field surveillance. However, the deployment of MWSNs still requires the solution to a number of technical challenges imposed by simple sensor devices: small storage capacity, low processing power, limited battery lifetime and short radio range which is discussed by Lehsaini *et al*. (2008), Awwad *et al*. (2010), Asim *et al* . (2014) and Zeb *et al*. (2014).

A wireless sensor network can be divided into two types: static and dynamic. A static-based network is considered as a structured way of networking. It is seen as an efficient way of establishing a communication route between sensor nodes in the network (Sangeetha *et al*., 2014). Moreover a dynamic refers to the node mobility that can allow new nodes can join and existing nodes to leave from the network at a specific interval of time without interrupting data flow. A feature that is important in every dynamic routing protocol is to adapt to topology changes very quickly and to maintain the network in functions.

For MWSNs, node mobility is an important factor in the design of an effective routing algorithm. For this

Corresponding Author: M. Sangeetha, Department of Information Technology, KSR College of Technology, Tiruchengode, India

reason, many recent researches have been put mobility characterization model into realtime environments (Hong *et al*., 1999; Nasser*et al*., 2013). In general, there are three different mobility models are exist: random model, semi-deterministic model and deterministic model. In the random movement, the mobility of node is totally erratic and each new movement can be completely independent of the previous movement. In the semi-deterministic movement, even though the individual nodes do not have a specified direction, it is possible to see a general pattern of a column evolving with it in what is called a column model. In the deterministic movement, the mobile nodes mostly move in the same direction and then the deviation of the direction vectors associated with any two positions would be zero (Nasser *et al*., 2013).

The basic objective of clustering consist of two important phases: cluster formation and cluster preservation. A cluster is shaped once a node or a group of nodes join an existing cluster-based network and cluster preservation is executed to handle node (s)' leaving or even re-joining in the network (Zeb *et al*., 2014). Generally, organization of nodes into a cluster is quite difficult due to mobility. Therefore, most of the researchers are focusing energy optimization and load balancing as a crucial issue to prolong the lifetime of the entire network. Our proposed ZMC technique uses a random mobility model for each sensor to move in and out of the zone. Also, it uses the parameter called speed rangeto determine the speediness of a sensor which determine the mobility factor. This Mobility factor considered as an essential parameter for the ZH selection and cluster formation in MWSNs.

The main aim of this study is CH load is considered and equally shared for each cluster to prolong the lifetime of CH. Also includes load balancing, wherein, the request is routed to one of the clusters in the zone as per the split and merge algorithm.

Literature review: Heinzelman *et al*. (2002) proposed Low-Energy Adaptive Clustering Hierarchy (LEACH) algorithm for clustering.It has been the most representative energy-efficient distributed clustering algorithm in WSNs for the past ten years. Nevertheless, it still has many problems:

- Without considering the residual energy of nodes
- Selecting cluster heads unevenly
- Bringing mass uncertain factors with randomly selected cluster heads and the way of cluster formation
- Producing non uniform energy consumption
- Its single hop routing only
- LEACH does not really support the movement of nodes

Currently, there are many improved LEACH-based algorithms projected, such as Power-Efficient Gathering in Sensor Information Systems (PEGASIS), Threshold sensitive Energy Efficient sensor Network protocol (TEEN) and Hybrid Energy Efficient Distributed clustering approach (HEED).

All assume the sensor network is a brand of fixed network; perform poorly in mobile environments (Akkaya and Younis, 2005).

LEACH-Mobile (LEACH-M) protocol (Kim and Chung, 2006) adding features to the existing LEACH protocol for supporting the sensor node's mobility in WSN. In LEACH-M protocol, where cluster formation and CH selection mechanism is same as LEACH. It ensures the communication of a node with a CH even if the node is in motion by transmitting data Request packet from CH to the sensor node in its allocated time slot using a TDMA scheme. However, LEACH-M handles node mobility by assuming that the CHs are stationary. Hence, it's not considered efficient in terms of energy consumptions and data delivery rate because a large number of packets are lost if the CH keeps moving before the selecting a new CH for the next round. Also LEACH-Mobile has fixed TDMA time slot schedule, each node keeps its allocated time slot even if it has no data to send or move out of the cluster. When sensor nodes from other cluster enters a new cluster, it cannot join the cluster because all the time slots are reserved.

LEACH-Mobile-Enhanced (LEACH-ME) protocol (Kumar *et al*., 2008) is to a great extent of LEACH-M (Kim and Chung, 2006) that the cluster heads are from the group of mobile nodes having minimum node mobility factor. The modified cluster heads election process, makes sure that the clusters are disturbed minimally in the event of movement of cluster heads. Furthermore, mobility factor is a function of distance between nodes, it is calculated by multiplying the node's velocity with the time required to move a node from a position to another. For this purpose, an additional timeslot known as ACTIVE slot is assigned at some stage in TDMA scheduling, where all member nodes wake up concurrently, transmit their IDs with timestamp information and receive their neighboring nodes IDs by setting a time out. This modified CHs election process provides a minimal data loss in case of node's mobility. In steady phase, a sensor node might not receive data Request that is sent by the CH due to mobility and since the new locationis out of the range of CH. In this case, if

CH does not receive any acknowledgement from sensornodein two time slots in consecutive frames then nodeis declared as mobile and its allocated time slot will be deleted andjoins in a new cluster. The performance of LEACH-ME is better than LEACH-M in successful data transmissions and energy consumption.

CBR-Mobile (Awwad *et al*., 2011) supports the sensor node's mobility by adaptively reassigning the time slots according to sensor nodes mobility and traffic. Two owners are created for each time slot that is original owner and alternative owner, such that CBR-Mobile can work adaptively to sensor node's mobility and traffic. It is significantly increasing the packet delivery ratio in comparison with the LEACH-Mobile protocol.

Cluster-based Energy-efficient Scheme (CES) for MWSNs (Lehsaini *et al*., 2008) considered mobility factor,weighing k-density and residual energy as the parameters for cluster-head election. The CES scheme carried out a periodical cluster-head determination process after each round. Moreover, CES enables the foundation of balanced 2-hop clusters whose size ranges between two thresholds called upper and lower thresholds.

The ASMC (Zhang *et al*., 2012) protocol was proposed to regulate the uneven cluster density for mobile nodes. It implements the split and merge algorithm to achieve the reliability in extendable network. The split and merge algorithm uses optimization threshold value to avoid load imbalance. The algorithm considers load equalization for creating balanced cluster (clusters with equal number of nodes). Because reconfiguration of cluster head for load balancing in wireless sensor networks (Zeb *et al*., 2014) increases the network lifetime by fairly distributing the cluster heads.

Moreover, the above mentioned protocols are failing to achieve the balanced clusters and prolong the CH lifetime. Therefore, it is a very challenging issue to find a fine solution for maximizing the lifetime of CH with minimization of power consumption. However, in LEACH-M and LEACH-ME protocols splitting and merging of nodes is not followed. This obviously leads to cluster overloading i.e. imbalanced clusters. In this paper we address this issue and tried to balance the clusters using split and merge algorithm (Zhang *et al*., 2012).

Shortcomings; randomized clustering model: The following are the shortcomings that are keenly identified in LEACH-M and LEACH-ME protocols. These two prorocols are considered for comparasion because only in LEACH-M and LEACH-ME, not only clustering process but also sensor nodes are dynamic.

Aggregation: The sizes of clusters, in terms of number of nodes per cluster are highly variable. This results in the requirement of larger or variable sized packets for the aggregation of data.

Energy: There are some clusters in the network which are extended covering very large regions. It means that there must be several nodes communicating with CH at a time spending higher energy.

Rounds/rotations: If the clusters are not in the similar sizes, loads cannot be scattered more evenly within each cluster. Also, it takes frequent CH rounds for large amount of clusters.

Reduced throughput: For large region of clusters, CMs taken longer transmission path to reach the CH.

Location and longer transmission path: In many of the dynamic clustering protocols like (Awwad *et al*., 2010; Lehsaini *et al*., 2008), the location of the CHs is not considered in the CH selection criteria. So, many nodes take multi-hops with longer transmission path to reach the destination, i.e., CH.

No timeslot: When nodes moves to new cluster LEACH-M fails to control and update the CM. Though, this is addressed in LEACH-ME, it still lacks efficient co-ordination among nodes.

In the light of the above, it could be determined that there is still a need of new self-organizing solutions to address the above stated problems related to the energy-efficiency and lifetime of WSNs. To handle these challenges, we present a zone based mobility technique which increases the network lifetime and ratio of packet delivery.

MATERIALS AND METHODS

System model: The network model can be described in terms of radio model and mobility model. The radio model talks about the communication media and the characteristics of energy requirements for signal transmission and reception. On the other hand the mobility model talks about the Random Way Mobilty Model (Samal, 2003; Vyas and Mahgoub, 2003) between sensor nodes.

Radio model: We implement the first order radio modelproposed by Heinzelman (2000). This model is composed by two different sub-modules: a transmitter/receiver circuitry (εlec) and a transmitter amplifier (Amp). A sensor node consumes Eelec (nJ/bit) in transmitter or receiver circuitry and EAmp (pJ/bit/m2) in transmitter amplifier. A sensor node expends energy $E_{tx}(k, d)$ in transmitting a k-bit message to distance d (Eq. 1) and $E_{Rx}(k)$ in receiving a k-bit message from a node at distance d (Eq. 2). It is assumed that radio can be turned on or off as and when required, to save energy. Also, the radio spends the minimum energy required to reach the destination. Transmitting cost and Reception cost is same in LEACH-M and ZMC. Transmission cost for ZMC:

$$E_{Tx}(k,d) = E_{Tx\text{-}elec}(k) + E_{Tx\text{-}Amp}(k,d) \qquad (1)$$
$$E_{elec} \times k + €_{elec} \times k \times d^2$$

Reception cost for ZMC:

$$E_{Rx}(k) = E_{Rx-elec}(k) \qquad (2)$$
$$E_{Rx}(k) = E_{elec} \times k$$

Nested Zone division Mobility technique for dynamic Clustering (ZMC): To overcome the variations in the cluster sizes of MWSN, Zone based clustering solutions have been proposed. The proposed algorithm put some features that LEACH-M and LEACH-ME does not support such use:

- Zone division is planted in order to simplify the network topology
- Clusters are split and merged according to the mobility of nodes in a specific zone. This reduces longer transmission path between ZH and sensor nodes
- Outstanding battery power and the number of nodes per cluster are also considered
- Nested Zones are employed to powerfully manage ZH overload and network traffic
- Moreover, data aggregation load is performed effectively in zone wide
- Traffic and mobility adapted techniques enable the sensor nodes lostconnection with their cluster heads to join the new cluster withina shorttime

Assumptions and challenges: In ZMC, we make the following assumptions to facilitate the design of clustering mechanism for MWSNs:

- All the sensor nodes are homogeneous in physical characteristics such as initial energy, antenna gain, Transmitting power, etc
- Each zone and node is assigned a unique identifier
- All the sensor nodes are location-aware. To knowtheir location in the network, sensors can either use Global Position System (GPS) or GPS-free location scheme such as range-based or range free localization schemes (Akcan *et al*., 2006)
- The base station is stationary and zone-heads, cluster-members are mobile
- TDMA is used to avoid collision in intra-zone and inter-zone transmission/reception

Zone formation: Zone division method is familiar that in order to manage the network topology and traffic in an efficient way. Initially the sensor field is divided into equal size of the zones (Square shape). It aims to have uniform distribution of sensor nodes in each cluster and geographic area covered by each zone. As per LEACH, the total number of cluster head node is 5% of the total number of sensor nodes deployed. So, a cumulative of 5 nodes is selected as cluster heads for 100 nodes providing higher throughput (Heinzelman *et al*., 2000). In our approach source bed of 200 nodes are considered with 10 cluster heads. Also, zone division is proposed based on quadratic increase in order to consider equal sized zones like 1^2 = 1 zone, 2^2 = 4 zones, 3^2 = 9 zones, 4^2 = 16 zones, etc.

$$Z_{div} = z^2$$

where z ={1,2,3…} Z_{div} is Zone division and z can be anywhere between 1 and infinity based on density (Fig. 1).

Here, we have considered 200 nodes as discussed. Hence, the toatl zone count required is 3^2~4^2. Upon perfect flooring, we have choosen 3^2, i.e., 9 zones. This minimal zone selection is liable to accommodate 200 nodes and hence was choosen.

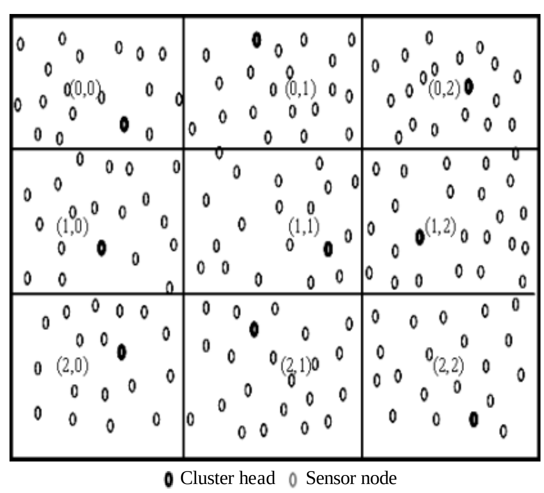

Fig. 1: Zone-cluster based MWSN

In the proposed ZMC scheme we fix a threshold value based on Eq. 3:

$$\text{Maximuim threshold} = \frac{\text{Number of nodes}(200)}{\text{Number of CH}_S(9)} = 22(\text{Thresh}_{max}) \quad (3)$$

This maximum threshold value plays a vital role to form a balanced cluster with optimum size which is discussed in the following section. Also, the size of the zone produces shorter routing paths (smaller number of hops) which produce lower end-to-end delay and high packet delivery during routing phase.

Allocation of zone ID: The base station is in charge of dividing the network area into several virtual zones according to the distance and the ZHs are selected in each zone independently. After the deployment of network nodes, the BS broadcasts the zone-division message in the entire area, including the zone radius (r) in the message. Nodes calculate their remoteness from BS ($rem_{I\text{-}BS}$) based on the received signal strength (Zou *et al*., 2011). Then sensor nodes can get their zone number by the Eq. 4:

$$\text{Zone}(i) = \left\lceil \frac{(rem_{i-BS} - dis_{i-min})}{r} \right\rceil + 1 \quad (4)$$

Apparently, the minimum zone number is 1 and if a zone is farther from the BS, it will have a larger zone number. Every node can get its own zone number with the Eq. 4. Nodes are mobile, so the zone division is executed before the nodes are deployed. Every node can get its own zone number with the Eq. 4. Zone ID is the unique identifier of each zone in the network. Each node only receives the messages that come from the same zone, ignores the others and updates the table.

Zone head selection: In ZMC, the election of zone head makes sure that the zone heads do not die due to prolonged extra work. The zone head purely based on the mobility level. The mobility factor of each sensor in the zone is calculated in terms of average number of times a node moves from one zone to another during a certain period of time and is represented in Eq. 5:

$$\text{Mobility factor } T(i) = \sum_{i=1}^{n} \frac{\text{sensor current field} - \text{Sensor origin field}}{\text{Mobility speed}} \quad (5)$$

The node remoteness will be changed with respect to time and speed which is not predictable. A node with low mobility factor means it either moves with a low speed or moves locally in a precise zone.

Pseudo code 1: zone head selection()

Notations:
Input: The total number of sensor nodes of a zone (a, b) = N, M_{Fact} -Mobility Factor, $Elected_{ZH}$ –Number of times node being elected as ZH, $E_{Residual}$ – Residual Energy
Output: ZONE HEAD (ZH), MEMBER Node –Sensor nodes

```
Begin
for i←1 to N do
if Sensor[i]! = ZONEHEAD then
Sensor[i]←Make ZH
end if
for j ←i +1 to N do
if M FACT [Sensor[i]] > M FACT [Sensor[j ]] then
Sensor[i]←MEMBER Node
break
else if M FACT [Sensor[i]] = M FACT [Sensor[j ]]
then
if Elected ZH[sensor[i]] > ElectedZH[sensor[j ]]
then
Sensor[i]←MEMBER Node
break
else if Elected ZH [sensor[i]] = Elected ZH [sensor[j ]]
if (Sensor[i] = CurrentZH)
then
Sensor[i]←MEMBER Node
break
else if Residual[Sensor[i]] <Residual [Sensor[j]]
then
Sensor[i]←MEMBER Node
break
end if
end if
end if
end for
if Sensor[i] =CurrentZH
then
Sensor[j]←ZH
Elected ZH [Sensor[i]]←
Elected ZH [Sensor[i]] +1
else
Reorganize Sensors in each Zone based on mobility and Reset ZHs
end if
end for
END
```

The node with the smallest mobility factor becomes the next ZH. To initiate the ZH election process, the sensor compares its mobility factor with the mobility factor of the other sensor in its same zone. If the sensor finds a sensor with a less mobility factor, it sets that sensor role as ZH, others considered as CM.

Once the election was over, the ZH broadcast advertisement to another sensor in its same zone. The members receive the advertisement and store a reference to the elected ZH for further use. During the ZH election, if we find two nodes have the same mobility factor, the protocol checks which one of them acted as ZH the least amount of times and select that node as the new ZH. If there is also a tie in the number of times the nodes had been ZHs, the distance to the Base Station (BS) and node with the highest residual energy taking into the consideration. After that the sensor announces its new role as ZH to the other sensor nodes. The members of the zone obtain the messages from ZH and add a reference to its zone maintenance table.

In each zone, ZH receive messages directly from its members and forward to the BS. Also, it acts as a gateway to the BS for remaining ZHs. Over a period of time ZH detects and updates its position whenever nodes joining or leaving from the network. Zone head election procedure is presented in Pseudo code 1.

Adaptive updates of clustering in nested zone : After zone formation, the next step is configuration of clusters. In ZMC Protocol, each zone is considered as the cluster. If number of nodes inside the zone violate the threshold value, split/merge operation is to be performed to avoid global computation. The problem is that the design of such local operations should guarantee that they will not lead to violations of the clustering condition, which is illustrated in Fig. 2. One advantage of performing nested zone division is that it provides solution for ZHs failure and buffer limitation problem. Moreover, aggregation load is reduced in each sensor zone and fixed energy efficiency is possible to obtain in zone wide.

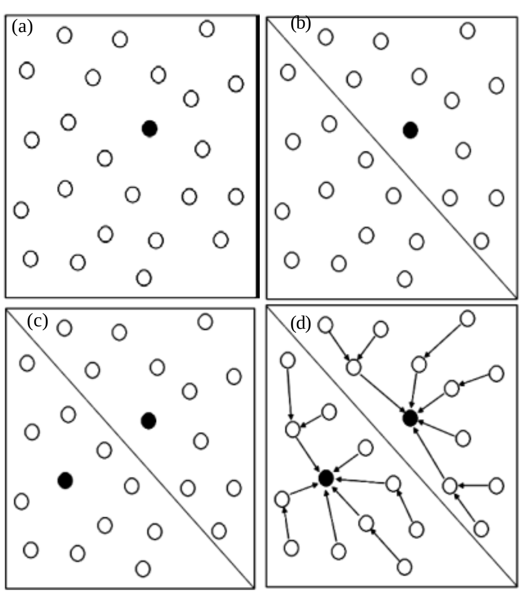

Fig. 2: Illustrating nested none division

When ZH will accept a large amount of nodes as its cluster members, re-clustering within the zone is necessary. This split operation could be performed by ZH in 3 directions:

- Horizontally
- Vertically
- Diagonally to reduce the overhead of ZHs

If the number of CMs of a zone is less than the merging threshold, then merging smaller zones into other zones, in order to minimize energy consumption of transmitting the data packets from the ZHs to the BS using the proposed Pseudo code 2. Finally, to prevent any breakdown of ZHs, a ZH-backup mechanism is implemented to select a new ZH that has less mobility factor in the zone.

To clarify the algorithm, we give an example in Fig. 2 where 24 sensors are spread in a zone (a, b) and maximum thresholdis found in 22 by using Eq. 1 which means that each zone should maintain 22 sensors (Threshold_{max}) to forward its data to the ZHwithin two hops. The initial configuration of nodes is depicted in Fig. 2a. In the first iteration, >22 sensors are found due to mobility which violate the threshold, so split operation (Nested Zone Division) is performed in Fig. 2b. ZHs are found in each nested zone based on less mobility factor and residual energy as in Fig. 2c. Thereafter, data aggregation is carried out in each zone by two hop counts as in Fig. 2d. Finally, all aggregated packets are forwarded to sink.

A initial configuration of nodes B. Nested zone formation C ZH selection in nested zone and D Data aggregation in two hop.

Reclustering in a zone: At the end of each round, clusters and zone heads are re-computed on the basis of the current position of the sensor nodes. This is done by the base station. There is a possibility of fine-tune the number of clusters after each round and this is due to the mobility of the sensor nodes and residual energy.

Pseudocode 2: Splitand Merge ():

```
Notations:
ZH-Cluster Head, CM-Cluster Member,
BC – Broadcast, Con-Req – Connection Request
ADV – Advertisement
      Begin
      if (ZH =TRUE) then
      ZH?fixed for one complete round
      BC (ADV) // broadcast advertisement message by ZH;
       Con-Req (CM); //CM nodes send Connection request
      Join ID (CM); // CM nodes joins the ZH in their zone
```

```
if (ZH =Receive (ADV)) then //ZH receive announcements from CM
in each zone
count=count+1;// Count the number of received announcements
if (count> max threshold)
then Split// ZH forms multiple ZHs (ZHi, ZHj..) according to the
strength of CMs
else
end if
end if
end if
End
```

Routing process in a zone: The MWSNs routing protocol should assure the following requirements such as low power consumption, loop-free routing, minimum delay and maximum throughput in the route discovery process. In ZMC, we consider:

- Only ZHs act as routers for the entire network which avoid the broadcast stormeffect problem
- The route establishment process is commenced by sending vicinity messages from the BS's neighbouring ZHs to the most exterior ZHs in the sensor field
- Instead of storing complete paths in the direction of BS, each ZH stores a list of theZH in the preceding level closest to the BS and selects one of those ZHs as its next hop in the routing process
- The zone head assigns the TDMA time slot for each member node to transmit data and broadcasts the TDMA schedule to all members
- To update the information, there are three classifications used: time-based, distance-based or event-based. Time-based mechanisms update information periodically, distance-based mechanisms update information whenever a node moves for a certain distance and event-based mechanisms update information when an event occurs. In our protocol, we use a combination of time-based and event-based update mechanisms to organize the operations to be performed by the sensors whenever an event occurs or specified interval of time

Data transmission and aggregation: The nodes in the same zone may form multiple zones, if ZH fails to balance the load or accumulate data of all CM nodes due to its buffer limitation. If there are multiple zones, a ZH is elected in each zone and the nodes within a zone send their data to the local ZH. Finally, all ZHs send their cumulative data to the ZHs of the nearest zone. Actually, all nodes send their data to ZH by maintaining a Shortest Path Tree (Cormen *et al*., 2001). This shortest path tree gives the solution to find the minimum hop count limit, within all nodes can send their data to ZH. At last all the ZHs sends their aggregated data to BS (Sink) (Zou *et al*., 2011). To compute the communicationcost in ZMC, the expression proposed:

$$E_{cost} = E_{interzone} + E_{intrazone} + E_{Processing} \quad (6)$$

where, EC_{cost} is the energy required for communication which is estimated by intra zone communications, inter-zone communications and data processing. Then, we find total communication energy consumption per round using Eq. 6.

RESULTS AND DISCUSSION

In this study, performance of the proposed technique compared with existing protocol under various parameter settings via simulations is presented. The Network Simulator (NS-2) was used to carry out the performance study of ZMC with respect to some proven protocols namely LEACH-M and LEACH-ME. A WSN system comprising of 200 nodes was used in the simulation circumstances. All the sensor nodes were randomly deployed in a square region of 100×100 m^2. The co-ordinate of BS is assumed to be at 100×250. The energy consumption due to communication is calculated using the first order energy model described in the previous subsection. We assume that each sensor node is mobile and generates one data packet per round to be transmitted to the BS. The sensor nodes were grouped into clusters consisting of cluster heads that send data to upper level cluster heads in order to finallyreach the BS. Table 1 shows the simulation parameters and their respective values.

Metrics: In order to check the performance of the ZMC technique in terms of its effectiveness, there are different

Table 1:Simulation parameter

Parameters	Values
Network field	1000×1000 m
Number of sensor nodes	200
Base station	100, 250
Data packet size	2000 bits
Sensing range	25 m
Transmission range	10-20 m
Sensor speed	6-10 m sec^{-1} (medium)
Node deployment type	Random deployment
Percentage of cluster head	10%
Mobility model	Random way point Model
Initial energy	2 Joule
The energy consumed to transmit or receive (εelec)	50nJ bit^{-1}
Transmit amplifier (Aamp)	100 pJ/bit/m2
Simulation time	500 sec
Radio model	First order radio model

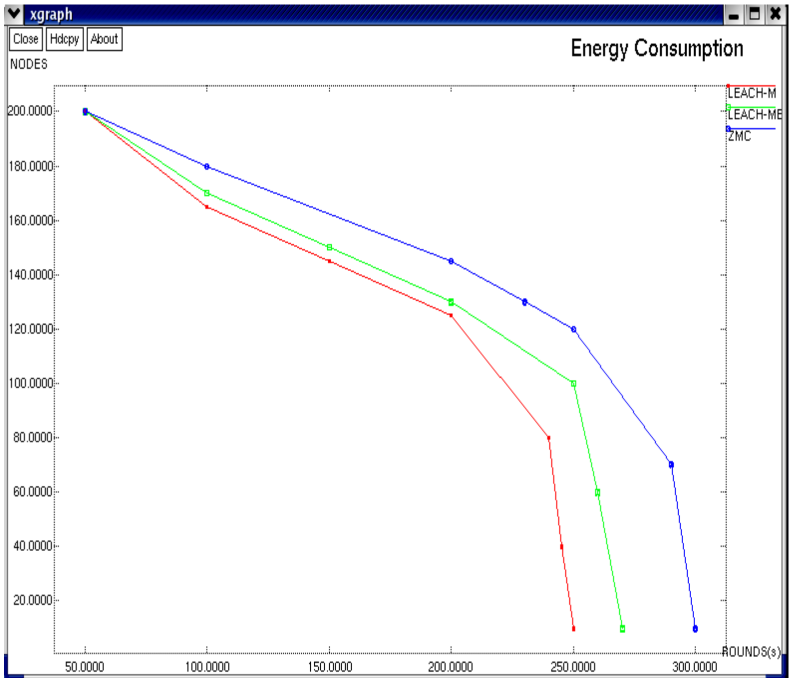

Fig. 3: Comparison of total energy consumption of ZMC with LEACH-M and LEACH-ME

metrics to be used. In this study, we consider total energy consumption, network lifetime and throughput as the parameter for evaluation.

Total energy consumption: The total energy consumptionis defined as the total energy that the nodes of the network consume for sending and receiving the packets. Also, it represented a ratio between the initial energy level and final energy level of node in each zone. The total and average energy consumption for entire zone is calculated as follows:

$$\sum_{i=1}^{n}(E_{init} - E_{final}) \times N_{Zone} \tag{7}$$

Where:

E_{init} = The initial energy level of a node
E_{final} = The final energy level of a node and
N_{zone} = The number of nodes in the entire zone

$$\text{Average energy consumption-zone} = \frac{\text{Total energy consumption-zone}}{\text{Total number of nodes-send/receive packets}} \tag{9}$$

Figure 3 focuses the consumed power of the whole network which intern increase the lifetime of the network. From the graph the number of rounds in x-axis and a number of sensor nodes in y-axis is plotted. Since, we observed that the total energy consumption per packet using ZMC is less than LEACH-M and LEACH-ME. Because the selected ZHs are not overloaded and gathered data from the selected nodes are using minimum hop counts for transferring data to ZH and ZHs to BS.

Network life time: The network lifetime is the time in which the first node of the network runs out of energy. From the graph the number of nodes in x-axis and time in y-axis is plotted. Figure 4 shows that the proposed technique of ZMC gives the better Network lifetime when compared to LEACH-M and LEACH-ME protocols. This may due the following reasons. First, an alternating the role of ZH can balance energy consumption among cluster members. Second, ZMC protocol considered minimum node mobility (Kumar *et al*., 2008) to elect the optimum cluster heads that can save more energy in nodes. Third ZHs can independently transmit their data by choosing the nearest zones.

Throughput: From the graph the number of nodes in x-axis and throughput in y-axis is plotted. Figure 5 depicts the throughput for ZMC, LEACH-M and LEACH-ME. It is noticed that, the ZMC technique achieves higher throughput when the number of mobile nodes are increased. For the first 100 nodes the throughput is less than other existing technics because the threshold value calculated is 100:

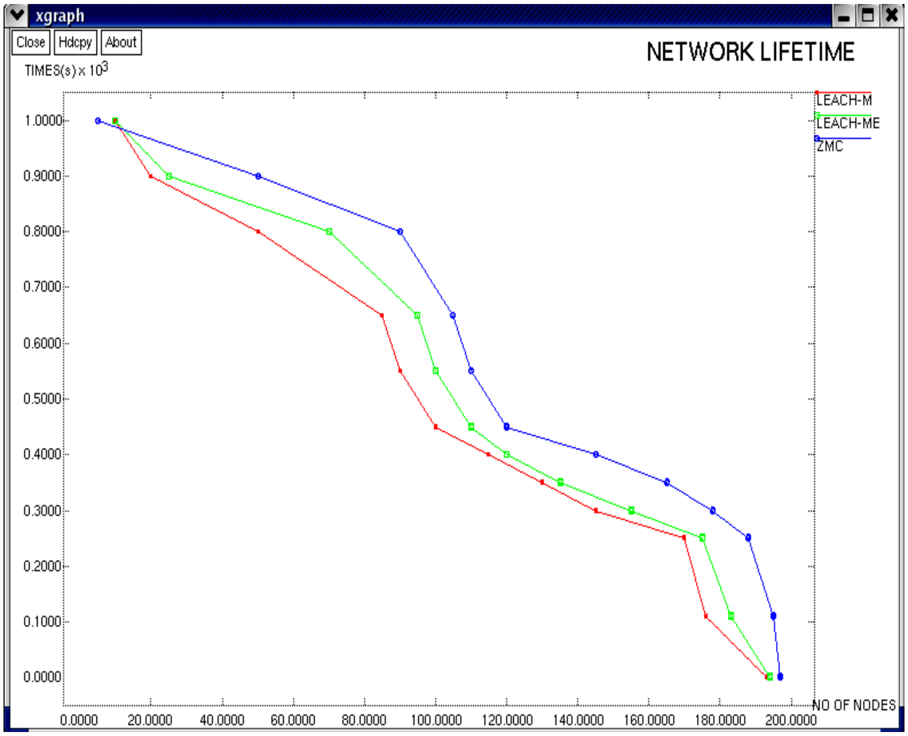

Fig. 4: Comparison of the network lifetime with ZMC, LEACH-M and LEACH-ME

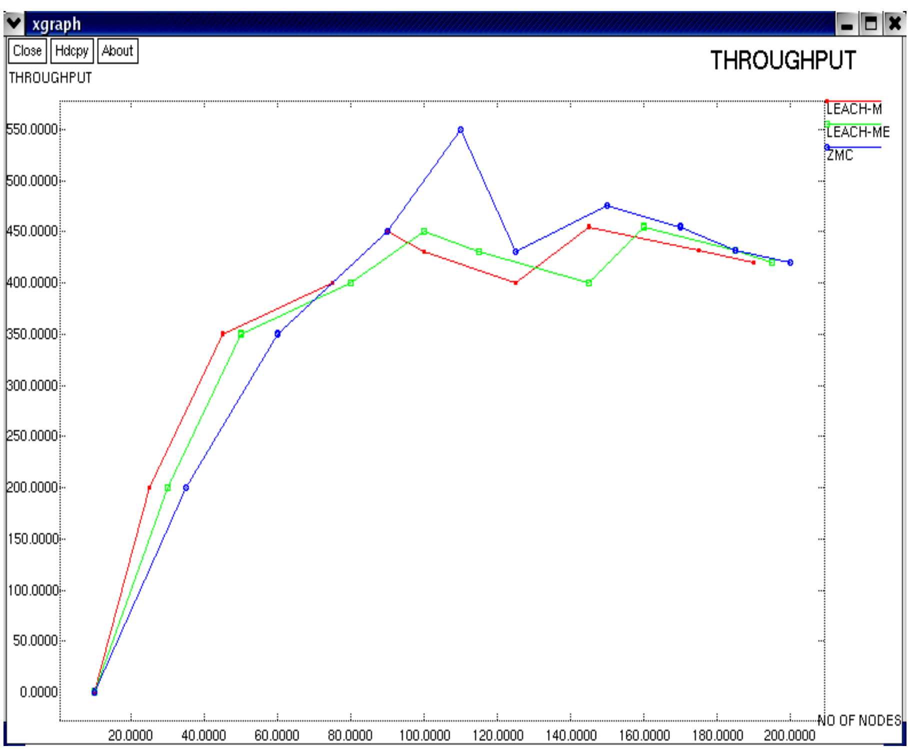

Fig. 5: Comparison of the throughput with ZMC, LEACH-M and LEACH-ME

$$\text{Boundaryvalue} = \frac{\text{Node count}}{\text{Runtime}\{\theta(\text{Split}) + \theta(\text{Merge})\}} \quad (9)$$

The running time for split requires (1)~1 and merge requires (1)~1. Thus the total sum of running time is ~2. Hence, for my simulation, out of 200 nodes, the boundary value obtained is 200/2 = 100. Here, the boundary value gains a maximum of upto 550. It means whenever the node density is high split and merge concept is urged. Still, the throughput gradually started increasing a fewer steps ahead of the boundary value.

CONCLUSION

In this study, we present an energy efficient mobility aware technique for improvising the ZH selection and prolong the lifetime of MWSNs. This type of performance tries to limit the number of sensor nodes in each of the demand cluster zones and lead all sensory data to transmit through the shortest multi hop path towards the ZH. This approach provides a load balanced ZH selection and data gathering scheme which reduce unnecessary data forwarding and total energy consumption in each on demand cluster. The ZMC technique shows significant improvement in the data transfer success rate and energy consumption in the mobile environment compared to LEACH-M and LEACH-ME protocol. We also believe that our technique can offer significant improvement on the performance and energy-efficiency of mobile sensor networks if further research on mobility model is carried out.

ACKNOWLEDGEMENTS

Researcher would like to thank Ms. J. Deepika and T. Shanthipriya for their contribution and initial comments on the manuscript. Also, researchers would like to thank the anonymous reviewers for their detailed reviews.

REFERENCES

Akcan, H., V. Kriakov, H. Bronnimann and A. Delis, 2006. GPS-Free node localization in mobile wireless sensor networks. Proceedings of the 5th ACM International Workshop on Data Engineering for Wireless and Mobile Access, June 25, 2006, ACM, New York, USA., ISBN:1-59593-436-7, pp: 35-42.

Akkaya, K. and M. Younis, 2005. A survey on routing protocols for wireless sensor networks. Ad Hoc Networks, 3: 325-349.

Akyildiz, I.F., W. Su, Y. Sankarasubramaniam and E. Cayirci, 2002. A survey on sensor networks. IEEE Commun. Mag., 40: 102-114.

Awwad, S.A., C.K. Ng and N.K. Noordin, 2010. Cluster based routing protocol with adaptive scheduling for mobility and energy awareness in wireless sensor network. Proc. Asia Pac. Adv. Netw., 30: 57-65.

Awwad, S.A., C.K. Ng, N.K. Noordin and M.F.A. Rasid, 2011. Cluster based routing protocol for mobile nodes in wireless sensor network. Wirel. Pers. Commun., 61: 251-281.

Cormen, T.H., C.E. Leiserson, R.L. Rivest and C. Stein, 2001. Introduction to Algorithms. The MIT Press, USA.

Heinzelman, W., A. Chandrakasan and H. Balakrishnan, 2000. Energy efficient communication protocol for wireless microsensor networks. Proceedings of the 33rd Hawaii International Conference on System Sciences, January 4-7, 2000, Maui, HI., USA., pp: 3005-3014.

Heinzelman, W.B., 2000. Application-specific protocol architectures for wireless networks. Ph.D. Thesis, Massachusetts Institute of Technology.

Heinzelman, W.B., A.P. Chandrakasan and H. Balakrishnan, 2002. An application-specific protocol architecture for wireless microsensor networks. IEEE Trans. Wireless Commun., 1: 660-670.

Hong, X., G. Mario and C.C. Chiang, 1999. A group mobility model for ad hoc wireless networks. Proceedings of the 2nd ACM International Workshop on Modeling Analysis and Simulation of Wireless and Mobile Systems Seattle, Aug. 20, ACM, New York, USA., pp: 53-60.

Kim, D.S. and Y.J. Chung, 2006. Self-organization routing protocol supporting mobile nodes for wireless sensor network. Proceedings of the 1st International Multi-Symposiums on Computer and Computational Sciences, Volume 2, June 20-24, 2006, Hangzhou, China, pp: 622-626.

Kumar, G.S., V. Paul, G. Athithan and K.P. Jacob, 2008. Routing protocol enhancement for handling node mobility in wireless sensor networks. Proceedings of the 2008-2008 IEEE Region 10 Conference TENCON, November 19-21, 2008, IEEE, Hyderabad, India, pp: 1-6.

Lehsaini, M., H. Guyennet and M. Feham, 2008. CES: Cluster-Based Energy-Efficient Scheme for Mobile Wireless Sensor Networks. In: Wireless Sensor and Actor Networks II. Miri, A. (Ed.). Springer US., New York, USA., pp: 13-24.

Nasser, N., A.A. Yatama and K. Saleh, 2013. Zone-based routing protocol with mobility consideration for wireless sensor networks. Telecommun. Syst., 52: 2541-2560.

Samal, S., 2003. Mobility pattern aware routing in mobile ad hoc networks. MSC Thesis, Virginia Polytechnic Institute and State University, USA.

Vyas, N. and I. Mahgoub, 2003. Location and mobility pattern based routing algorithm for mobile ad hoc wireless networks. Simul. Ser., 35: 695-700.

Zeb, A., A.K.M. Islam, S. Komaki and S. Baharun, 2014. Multi-nodes joining for dynamic cluster-based wireless sensor network. Proceedings of the 2014 International Conference on Informatics, Electronics and Vision (ICIEV), May 23-24, 2014, IEEE, Dhaka, Bangladesh, ISBN: 978-1-4799-5179-6, pp: 1-6.

Zhang, Y., K. Li, H. Gu and D. Yang, 2012. Adaptive split-and-merge clustering algorithm for wireless sensor networks. Proc. Eng., 29: 3547-3551.

Zou, Y., H. Zhang and X. Jia, 2011. Zone-divided and energy-balanced clustering routing protocol for wireless sensor networks. Proceedings of the 2011 4th IEEE International Conference on Broadband Network and Multimedia Technology (IC-BNMT), October 28-30, 2011, IEEE, Shenzhen, China, ISBN: 978-1-61284-158-8, pp: 112-117.