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RELIABLE UNEQUAL CLUSTERING ALGORITHM FOR WSN

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Abstract: In Wireless Sensor Networks, designing an energy-efficient and reliable connection between the nodes is a greater challenge due to the frequent changes in network topology. Existing cluster based mobility algorithms considered only the energy efficiency of sensor nodes. However, the reliability of sensor nodes is an important to identify the failure of data links between the sensor nodes. The proposed algorithm predicts the movement of sensor nodes based on the previous movement history based on the Integrated Double Exponential Smoothing model. It uses two different smoothing factors to estimate the current moving location of each sensor node and use it as a forecast of future value. The proposed algorithm is simulated in NS2.34 and compared with LEACH-M. The results show that the proposed an algorithm efficiently increases the network lifetime and provides a reliable connection between the cluster head and cluster members.

Keywords: Unequal Clustering, Mobility Prediction, Network Lifetime.

1. INTRODUCTION

The Wireless Sensor Network is a self-organized multihop system of wireless nodes that can communicate with each other without pre-existing infrastructure [1]. One of the most important design goals of WSNs is to minimize the energy consumption of the network. If the sensor nodes are mobile, it further complicates the design of the network.

Moving sensor tracking is an active research area in WSNs due to its practical use in a wide variety of applications [2] including military and environmental monitoring applications. The challenges in cluster a based mobile environment are:

- Impossibility of keeping the Cluster Members within the cluster on all the time
- Mobility leads to be frequent re-clustering, which result in a considerable energy consumption.
- A node cannot start the data transmission immediately after joining into new clusters, because it should find the members of the new cluster and decide how to communicate with that. This will consume more energy.

When tracking the moving sensor nodes, the nodes are required to detect and track the moving status of the node and report their discoveries to the application. In order to increase the network lifetime and the network reliability, we proposed, an Unequal Cluster Based Mobility Prediction Scheme for WSN. The location of a moving sensor node can be predicted based on the previous moving history of sensor nodes based on the Integrated Double Exponential Smoothing Model. The proposed work is compared with LEACH-M and studied thoroughly for several speeds ranging from low to high movement for both linear and angular moving directions.

This paper makes two major contributions. First, we present a cluster formation technique, which facilitates unequal clustering to a avoid hot spot problem. Secondly, future moving location of each sensor

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node is predicted at the discrete interval of time using Integrated Double Exponential Smoothing Model. For every transmission, a new path is selected based on the future location of a moving sensor node to maintain the reliable connection and to avoid unnecessary link failure.

The rest of the paper is organized as follows: in the next section, we discuss the related work. Section III describes proposed work, in section IV discuss the experimental results finally we conclude the paper in section V.

2. RELATED WORKS

The attribute node mobility is a significant one in WSN. The mobile nodes may follow different mobility patterns such as individual random mobility, group mobility that may affect the link between the sensor nodes. Therefore, the mobility model may have an important factor on the reliable network and network lifetime. Several mobility models have been used to identify the link failure and out of coverage of sensor nodes. Some of these models are following:

Clustering and fault tolerance for target tracking using wireless sensor networks (LEACH-M) [3], the reliability is achieved by allowing fault tolerance with minimum energy consumption and high tracking probability by varying the number of supervisor nodes, cluster heads and target speed. This mechanism is applicable for the specific members of cluster head failures, and supervisor node fault tolerance is applicable to under the condition of at least m degree of deployment redundancy.

An efficient clustering scheme for Data Aggregation considering mobility in MWSN [4] focuses on minimizing the number of nodes that move away from the current Cluster Head before the next cluster formation. The Cluster Heads are selected based upon the mobility, energy and density. The similar average speed and average moving direction for Cluster Head and Cluster Member are maintained by Mahalanobis distance model. In Reliable location Aware Routing Protocol for MWSN [5] uses a special packet, which are sent by cluster members of the cluster to Cluster Head when Cluster Member has no sensed event to send to Cluster Head but these special packets allow to detect the mobility and failure of member nodes within a cluster.

LEACH Mobile (LEACH-M) [6], the mobile nodes declare the membership of a cluster as, they more and to confirm whether a mobile sensor node is able to communicate with a specific Cluster Head with a time slot. In LEACH-M, clusters are dynamically formed every time the sensor mores and there is a chance of overhead in the cluster maintenance. LEACH-M handles node mobility by assuming that the CHs are stationary. Hence, LEACH-M is not an efficient in terms of energy consumptions and data delivery rate because a large number of packets are lost if the CH keeps moving before selecting a new CH for the next round

LEACH Mobile Enhanced Protocol (LEACH-ME) [7], which enhance the LEACH-M based on the mobility metric remoteness for Cluster Head selection. They calculate mobility factor based on the number of times a node moves from a cluster to another cluster. The performance of LEACH-ME is better than LEACH-M in successful data transmissions in different mobility factors. However, LEACH-M is not energy efficient since it consumes energy for determining mobility factor in active slots.

In Cluster Based Energy-Efficient Scheme (CSE) [8] was designed based on LEACH protocol. The CES relies on weighing k-density, the residual energy and the mobility parameters for the Cluster Head selection. It reflects the new Cluster Head as the Cluster Head that moves to another cluster. In Adaptive

Prediction-based Tracking (APT) [9] scheme is proposed that enables tracking in the sensor network to achieve a certain level of self-cognition for modifying the tracking time interval for movement patterns with acceleration, which results in significantly decreasing the network power consumption and achieving a smaller miss probability.

From the discussion above, clearly most of the target tracking and mobility prediction protocols using existing clustering algorithms lack fault tolerance, although these issues might have to or better be tackled all together. There are many other clustering protocols, which considering both stationary and mobile sensor nodes, such as DCTC [10], ADCT [11], CET [12], are not discussed here. Although they are considered as energy efficient, most of them are not fault tolerant. Our proposed algorithm addresses clustering, link availability between cluster head and cluster members by predicting future location of sensor nodes.

3. PROPOSED WORK

3.1 Network Model

To meet the requirements of energy-efficient monitoring, we describe our proposed model with the following basic assumptions: the sensor nodes are randomly deployed in a square field and are made stationery. Each node is assigned unique identifiers. The moving location of each sensor node is monitored at discrete intervals. Sensor nodes do not have GPS equipment and cannot get any location information, but the relative distance between two nodes can be calculated according to the received signal strength.

Nodes in the networks are organized into the form of clusters. Cluster heads perform the function of data aggregation and are responsible for the resultant data transmission to the BS. There is only one BS in the networks, and wireless transmission power is controllable.

RUCA Clustering

RUCA is a distributed unequal clustering algorithm, which is an extension of previous work UCAPN [13]. UCAPN is a distributed unequal clustering algorithm, which is used to construct the unequal clustering for avoiding the hot spot problem.

3.2 Mobility Model

WSN is self-organized i.e., The nodes are deployed and managed independently of any pre-existing infrastructure, while it automatically determines its own configuration parameters such as position identification, power consumption, routing and addressing. The mobility attribute of WSN is very significant one [14]. The sensor nodes may follow different mobility patterns such as individual random mobility, group mobility, etc., They may affect the connectivity between the sensor nodes. Therefore, the mobility model may have an important factor on maintain the link between the sensor nodes and increase the network performance. To maintain the network scalability, the future location of each sensor node can be predicted accurately.

The mobility of the sensor nodes can be measured (i) based on signal strength, (ii) based upon the link availability. The strength of the signal for each sensor node can be measured by the radio model at any discrete interval of time.

Construct the unequal clustering using UCAPN and choose the Cluster Head with high residual energy. Mobility is an important factor in deciding the Cluster Head. When the Cluster Head move fast, the nodes may be disconnected from the Cluster Head and may join in another existing cluster. The mobility speed of every node S_i can be calculated by the following formula:

$$MS_{si} = \frac{\sqrt{(x_t - x_{t-1})^2 + (y_t - y_{t-1})^2}}{\Delta t} \tag{1}$$

Where (x_t, y_t) and (y_{t-1},y_{t-1}) are the coordinate position of node S_i at a time t and $t-1$. is the interval time between t and t–1.

The sensor node can travel either in linear or in an angular movement. During t time, the locations of the node are estimated for the linear movement of the sensor node S_i is

$$x_t = x_{t-1} + v_x + (a^*t_{t-1})$$
$$y_t = y_{t-1} + v_y + (a * t_{t-1}) \tag{2}$$

Where (x_t, y_t) is a new coordinate position of node S_i, (x_{t-1}, y_{t-1}) is previous location of node S_i. v_x and v_y are the initial linear velocity of the node S_i and a is the acceleration.

The angular movement of the sensor node S_i can be calculated by the following formula:

$$x_t = x_{t-1} + \omega + (\alpha * t_{t-1})$$
$$y_t = y_{t-1} + \omega + (\alpha * t_{t-1}) \tag{3}$$

Where (x_t, y_t) is a new coordinate position of node S_i, (x_{t-1}, y_{t-1}) is previous location of node S_i. ω is the initial angular velocity of the node S_i and α is the angular acceleration.

Prediction based approach tries to estimate the future location of each sensor node by Double Exponential Smoothing Model integrated with Linear Regression to initialize the values.

3.3 Integrated Double Exponential Smoothing Model (IDES):

Here we show how a new forecast is derived from the basis of the previous forecast and of the observed data. On the basis of $a_{i,t-1}$ and of $b_{i,t-1}$, the future location of node i has been computed at time t. Now we are at time t. We observed $D_{i,t}$, and we must compute $a_{i,b}$, and $b_{i,t}$ so that a new location for sensor node i can be determined.

$$a_{i,t} = \alpha D_{i,t} + (1 - \alpha)(a_{i,t-1}) + b_{i,t-1}) \tag{4}$$

$$b_{i,t} = \beta(a_{i,t} - a_{i,t-1}) + (1 - \beta)b_{i,t-1} \tag{5}$$

Where $D_{i,t}$ is an observed demand, $a_{i,t}$ is the current estimation of intercept, $b_{i,t}$ is the current estimation slope, $a_{i,t-1}$ is the last estimation of slope and $b_{i,t-1}$ is the last estimation of the slope.

Where α is the data smoothing factor, $0 < \alpha < 1$, and β is the trend smoothing factor, $0 < \beta < 1$.

$$M_{i,t} = ai, t - 1 + bi, t - 1 \tag{6}$$

The model parameters a and b is also to determine. The first data of model parameters a and b can be initialised by the linear regression. Where a is the intercept at time 0 and b the slope. Here however, the parameters $a_{i,t-1}$ and $b_{i,t-1}$ where $a_{i,t-1}$ is the intercept at time $t-1$ and $b_{i,t-1}$ is the estimated slope for the interval [$t-1$, t]. For the slope, we choose a value between the previous slopes for sensor node i,

$b_{i,\,t-1}$, and the slope of the line passing by $a_{i,\,t-1}$ and $a_{i,\,t}$. That is, $b_{i,\,t}$ is a compromise between $b_{i,\,t-1}$ and $(a_{i,\,t} - a_{i,\,t-1})$. Both compromises are ruled by smoothing factors a and b.

To predict the future location of moving sensor node to be consumed during time t using the previous values, we adopt five historical trajectory points to deduce the target's next possible location. It is assumed that the sample period is a constant. Considering the sensor node *i* at time *t*, the required data are $M_{i,\,t}$, $M_{i,\,t+1}$, $M_{i,\,t+2}$, $M_{i,\,t+3}$, $M_{i,\,t+4}$ respectively. The next location, $M_{i,t+5}$ can be approximated by the equation (6),

$$M_{i,\,t+5} = a_{i,\,t+4} + b_{i,\,t+4} \tag{7}$$

Consider the node *u* and *v*, the speed and moving direction for both the linear and angular direction of a node *u* and *v* can be calculated by using the formula (1), (2) and (3). Based on the node's previous movement history, the future location of sensor nodes can be predicted by the formula (7).

To check whether the node is available within the cluster or not, assign a threshold location level T_L for each sensor node S_i within the cluster C_i. If the node S_i reaches the threshold location level, then the node Si disconnected from the current cluster and join into the next nearest cluster.

The probability of link availability $L_{u,\,v}$ between the sensor nodes *u* and *v* can be calculated by the following formula:

$$L_{u,v} = \begin{cases} 1 & \text{iff } M_t > T_L \\ -1 & \text{iff } M_t < E_r \\ 0 & \text{iff } M_t = M_{t-1} \end{cases} \tag{8}$$

Which indicates the probability that the link <*u*, *v*> will be continuously available from time *t* to *t* + 1 or not. The calculation of $L_{u,\,v}$ is divided into three parts (i) the link availability $L_{u,v}$ when the speed and moving direction of the nodes *u* and *v* remain unchanged from time *t* to *t* + 1. (ii) The link availability $L_{u,\,v,}$ when the speed and moving direction are changed and the estimated location level is less than the threshold location level. (iii) The link availability $L_{u,\,v,}$ when the speed and moving direction are changed and the estimated location level is greater than the threshold location level. An accurate estimation of (ii) and (iii) is not easy due to difficulties in learning the changes in link status caused by change in nodes movement.

4. SIMULATION AND RESULTS

We stimulated a wireless sensor network in a 200m*200m space and with an equal distribution of 100 sensors randomly by using NS2.34. The BS is positioned at the midpoint of the simulation area. After deployment, the BS is immobile and all the other sensor nodes are mobile. In IDES model, we have to identify the parameters a, b, α and β to estimate the energy level of each sensor node. In our simulation, we choose the smallest value of α for stability of forecast around 0.1 to 0.7. We evaluate the performance of our algorithm with LEACH-M. There is five metrics are chosen for comparison: Network lifetime, Re-clustering rate, Link Availability, Energy Consumption and Prediction Accuracy.

(i) **Network lifetime:** The network lifetime in clustering algorithm always depends upon the lifetime of the clusters. If the lifetime of the cluster is increased, the lifetime of the overall network will also increase. In this simulation, we study the impact on the node speed and movement on the cluster duration. The average cluster time is measured in seconds as the host speed ranges from 1 km/h to 20 km/h. In a proposed algorithm, the following figures show that the cluster lifetime reduces as the mobility speeds increases.

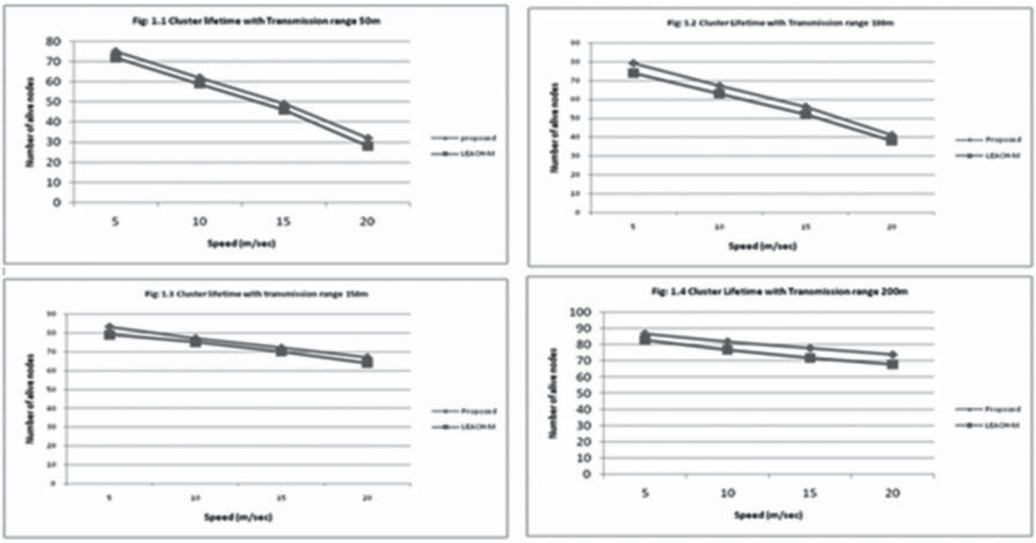

Figure 1.1, Figure 1.2, Figure 1.3 and Figure 1.4 shows that lifetime of the clusters for various transmission range with various speed.

The experiment is repeated with different transmission range 50m, 100m, 150m and 200m. The results show that the cluster lifetime is improved when we increase the transmission range. When the radio transmission of Cluster Head increases, its neighbor nodes are connected to Cluster Head for a longer time, and this extends the network lifetime.

(ii) **Re-affliation rate:** Re-clustering rate means probability that the number of times a cluster member changes it's Cluster Head and joined to a new cluster in a given time. In this experiment, we assumed that 100 sensor nodes are travelled within the square field of 500m*500m. The node can travel in both linear and angular movement. The average re-clustering rate is measured by changing the nodes speed from 1km/h to 20 km/h. The fig.2 shows that the re-clustering rate increases with the mobility speed of the host increases the mobile nodes leave their clusters faster as the node speeds increases.

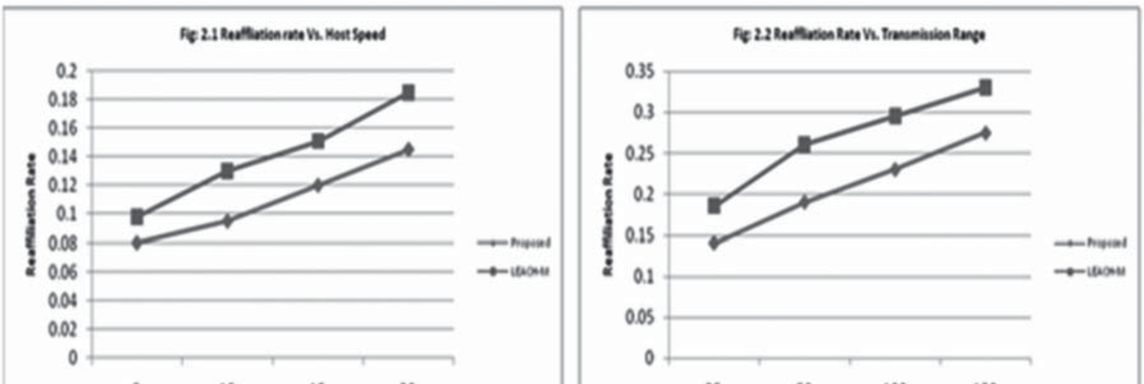

Figure 2.1 and Figure 2.2 Shows the Reaffiliation rate for Host Speed and Transmission Range

The same experiment is repeated on the radio transmission range on the re-clustering rate. In this simulation, the maximum node speed is 10 m/sec, and the transmission range varies from 25m to 150m with the simulation are of 500m*500m. Re-clustering rate is decreased when increasing the transmission range increases.

(iii) **Link Availability:** The Link Availability is the probability that the link between the sensor nodes will be continuously available in a given amount of time. The numbers of connected nodes are decreased when increasing the speed of the sensor nodes rapidly. The fig. 3 shows that the percentage of link availability is increased when compared with the LEACH-M.

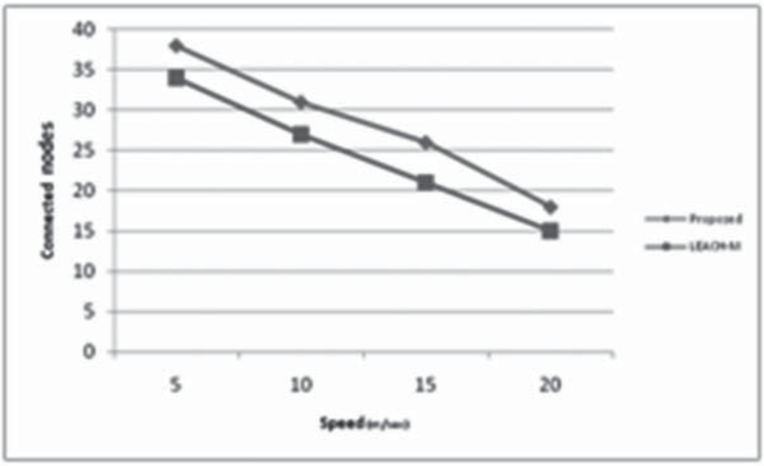

Figure 3. Link Availability

(iv) **Prediction Accuracy:** The performance of the clustering scheme is heavily dependent on the accuracy of the prediction algorithm. The decision to allow nodes to join a cluster is based on the future position of the nodes in the network, as estimated by the mobility prediction algorithm. We define the prediction accuracy as the fraction of times a prediction turns out to be incorrect, i.e., the fraction of times a node leaves a cluster without satisfying its admission criteria. The fig4 shows fluctuations in the percentage of fault prediction with the increase of network size in different rounds. The fig. 4 shows percentage of fault prediction by assigning various values of δ. δ = 0.1, 0.2, 0.3, 0.4. Fig 4 describes the number of nodes leaves from its cluster increases when increasing the number of rounds over 100 nodes deployed into the sensor field. The prediction accuracy of the proposed algorithm is higher than LEACH-M.

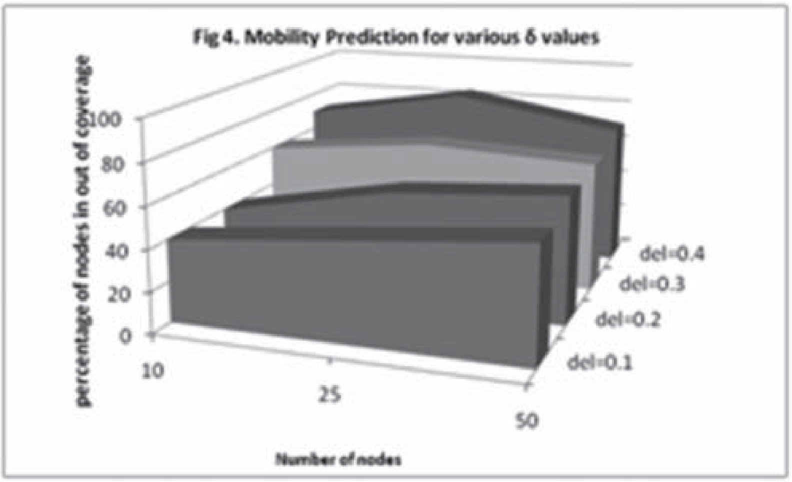

Figure 4. Mobility Prediction for various 6 values

(v) **Energy Consumption:** Fig. 5 shows the comparison of energy consumption when the moving speed varies from 1 m/s to 20 m/s. To evaluate the energy efficiency of the proposed algorithm, we compare the energy consumption of the proposed algorithm to existing approach LEACH-M. The energy consumption presented here does not include the energy consumed for the failure recovery. Although

LEACH-M is the most energy-efficient target tracking approach, it suffers the boundary problem which results in a high probability of missing the target. Note that the performances between proposed algorithm and LEACH-M are very close. However, LEACH-M is designed to solve the boundary problem in unequal cluster-based networks, which implicitly takes the advantages of the cluster structure. For example, data can be easily routed from a node to the sink or another node with a low delay, which is also important for target tracking.

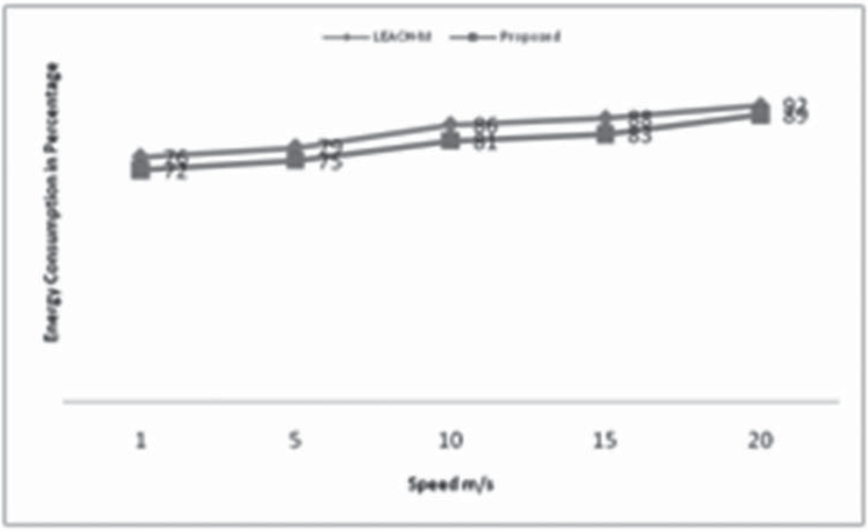

Figure 5. Engery Consumption for Proposed vs. LEACH-M

5. CONCLUSION

In this paper, we have proposed an Unequal Cluster Based Mobility Prediction Scheme for WSN. The metric speed and moving direction for both the linear and angular movement is considered. The nodes future movement are predicted based on the movement of previous history using the Integrated Double Exponential Smoothing in terms of network lifetime and the network reliability. The simulation results show that our proposed algorithm achieves the following efficiently compared than the LEACH-M: i) the frequent re-clustering is reduced, when increasing the transmission range. ii) When the transmission range is large, it provides an efficient reliable and lifetime of the sensor networks. iii) When increases the number of nodes, it is difficult to predict the node movement within the clusters.

References

1. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Networks", *IEEE Communications Magazine*, vol. 40, no. 8, pp. 102-114, 2002.
2. Hyunsook Kim, Eunhwa Kim, and Kijun Han, "An Energy Efficient Tracking Method in Wireless Sensor Networks" Y. Koucheryavy, J. Harju, V.B. Iversen (Eds.): NEW2AN 2006, LNCS 4003, pp. 278 – 286, 2006. © Springer-Verlag Berlin Heidelberg 2006
3. Shio Kumar Singh, M P Singh and D K Singh, " Routing protocols in Wireless Sensor Networks- A survey," IJCSES, vol. 1, pp. 63–83, November 2010
4. Hyunsook Kim "An Efficient Clustering Scheme for Data Aggregation Considering Mobility in Mobile Wireless Sensor Networks" International Journal of Control and Automation Vol. 6, No. 1, February, 2013 pp.222-233
5. H. W. Tsai, C. P. Chu, T. S. Chen. Mobile object tracking in wireless sensor networks. *Computer Communications*, 2007, 30(8): 1811–1825.
6. L. Karim1 N. Nasser, "Reliable location-aware routing protocol for mobile wireless sensor network", IET Commun., 2012, Vol. 6, Iss. 14, pp. 2149–2158, doi: 10.1049/iet-com.2011.0696

7. D. S. Kim and Y. J. Chung, "Self-Organization Routing Protocol Supporting Mobile Nodes for Wireless Sensor Network", Proceedings on the 1st International Multi-Symposiums on Computer and Computational Sciences, **(2006)**, pp. 622-626.

8. G. S. Kumar, M. V. V. Paul, K. P. Jacob, "Mobility metric based leach-mobile protocol", Proceedings on the 16th International Conference on Advanced Computing and Communications, **(2008)** , pp. 248-253.

9. M. Lehsaini1, H. Guyennet and M. Feham, "CES: Cluster-based Energy-efficient Scheme for Mobile Wireless Sensor Networks", Wireless Sensor and Actor Networks II, the International Federation for Information Processing, vol. 264, **(2008)**, pp. 13-24.

10. Mohammad-Taghi Abdizadeh, Hadi Jamali Rad and Bahman Abolhassani, "A New Adaptive Prediction-Based Tracking Scheme for Wireless Sensor Networks", 2009 Seventh Annual Communication Networks and Services Research Conference, Pg:335-341,May2009.

11. Wensheng Zhang, "DCTC: Dynamic Convoy Tree-Based Collaboration for Target Tracking in Sensor Networks", IEEE transactions on wireless communications, vol. 3, no. 5, September 2004.

12. Hyunsook Kim, "An Efficient Clustering Scheme for Data Aggregation Considering Mobility in Mobile Wireless Sensor Networks", International Journal of Control and Automation Vol. 6, No. 1, February, 2013

13. Ganesan Vennira SelviRajendran Manoharan," Unequal Clustering Algorithm for WSN to Prolong the Network Lifetime (UCAPN)", 2013 4th International Conference on Intelligent Systems, Modelling and Simulation, 2166-0662/13 $26.00 © 2013 IEEE DOI 10.1109/ISMS.2013.134,pg no. 456-461.

14. Guojun Wang, Md. Zakirul Alam Bhuiyan and Li Zhang, "Two-level cooperative and energy-efficient tracking algorithm in wireless sensor networks", Concurrency and Computation: Practice and Experience, September 2009.