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AN ENERGY EFFICIENCY MOBILE CLUSTERING SYSTEM FOR WIRELESS SENSOR NETWORKS

M. Zen Samsono Hadi[1], Aries Pratiarso[1] and Hideyuki Uehara[2]
[1]Politeknik Elektronika Negeri Surabaya, Kampus PENS, Jl. Raya ITS Sukolilo, Surabaya
[2]Toyohashi University of Technology, Japan
E-Mail: zenhadi@eepis-its.edu

ABSTRACT

In recent years, research on wireless sensor networks has increased significantly because it offers the advantage of monitoring a wide variety of environments to detect physical phenomena. Wireless sensor networks consist of many sensor nodes where each sensor node has ability to send, receive and detect phonemena. On the other hand, sensor nodes have limited capabilities such as memory capacity, bandwidth and energy consumption. In this research, we focus on energy consumption in supporting clustering protocol and evaluate it in mobile networks. We use the reference of protocol i.e. LEACH to evaluate our protocol i.e. MN-LEACH. The proposed protocol add feature of LEACH to support mobile nodes as well as to get energy efficiency in each round of the network resource. The performance of MN-LEACH outperforms LEACH because it supports hand-off mechanism.

Keywords: LEACH, mobile network, wireless sensor networks.

1. INTRODUCTION

Wireless sensor networks (WSN) is one type of ad-hoc networks where the implemented node is a smart sensor. The sensor is equipped with advanced sensing functions (thermal, pressure, etc), processor and wireless transceiver. With such properties, WSN technology inspire many applications in all areas such as fire detection, tracking target, monitoring of water quality and traffic management [1] [3] [4].

Network structure in WSN is divided into 3 sections i.e. flat-based, hierarchical-based and location-based [5][6]. In this research, it focuses on the hierarchical clustering where nodes in the cluster will send data to the cluster head then forward the data to the base station. Clustering network is very useful in the network scalability and energy efficiency. In the process, cluster head encounter the greatest reduction of energy because all nodes in the cluster will communicate only with their cluster head (bottleneck).

The most widely used hierarchical clustering algorithm is LEACH (Low-energy Adaptive Clustering Hierarchy) with a distributed method to determine the cluster head and LEACH-C using a centralized method to determine the cluster head [5].

In other research, M-LEACH (Mobile-LEACH) was proposed to support movement of nodes based on LEACH-C protocol. If a node in the coverage of a cluster head move away towards another coverage of cluster head, it will change its cluster head. It means, the protocol supports hand-off mechanism to save the energy during communication between a node with cluster head.

In this paper, we present a different application of M-LEACH. It is implemented in homogeneous environment of mobile node and based on LEACH protocol during determining its cluster head. The protocol will support mobility of nodes by using a hand-off mechanism to permit the nodes changing their cluster head.

2. LEACH PROTOCOL ARCHITECTURE

As a cluster-based protocol, Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol [5] concerns about energy efficiency, where number of generated cluster head become important parameters to achieve the best performance. There are two phases in LEACH/LEACH-C protocol, namely setup phase and steady phase. During setup phase, LEACH choose a node in one cluster as cluster head and to determine cluster head, it can be used a distributed or centralized method. LEACH randomly selects a few number of nodes as cluster head, then the information will be broadcast by the cluster head to all nodes. Cluster heads invite all nodes to join with them based on the strongest signal (RSSI) between nodes and cluster head. In this way, the cluster is formed, after that cluster head create scheduling for data transmission of cluster member based Time Division Multiple Access (TDMA). Based on the TDMA schedule, all nodes in the cluster will know time to send their data and the setup phase is complete. Then the steady state operation (data transmision) can begin.

In the steady phase, all cluster members send the data to the cluster head according to the slots provided. The duration of each slot in data transmission is constant and the number of nodes in the cluster will effect the data transmission time. In this condition, cluster head must be alive to receive the data so that in next round, it must be changed to other nodes to save their energy. Here is a Figure of cluster formation in LEACH protocol.

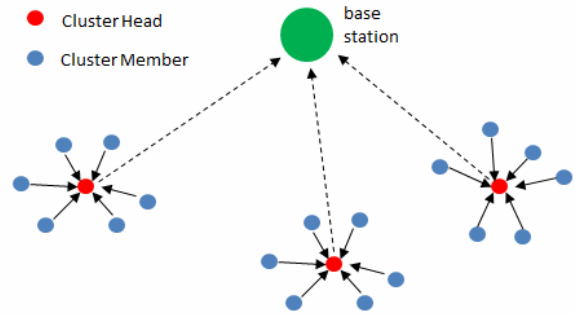


Figure-1. LEACH protocol for WSN schema.

Time-line of LEACH protocol for one round, where adaptive clusters are formed, can be seen in Figure-2.

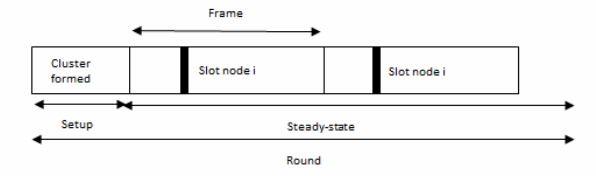


Figure-2. Time-line of LEACH protocol.

Determining cluster heads in the setup phase uses the following formula:

$$T(i) = \begin{cases} \dfrac{p}{1 - p\left(r \bmod (1/p)\right)} & if\ i \in C \\ 0 & otherwise \end{cases} \quad (1)$$

where p is the percentage of cluster head, r is the round number of cluster formation, and C is the set of nodes that are not yet as cluster head in the previous 1/p round.

LEACH-C [5] is centralized method in cluster formation where base station will determine cluster head. In the setup phase, all nodes will send information about their remaining energy levels and current locations to base stations then it chooses the cluster head node based on remaining energy level. By using simulated annealing algorithm, base station selects cluster. The algorithm minimize total energy of non-cluster head nodes by using euclidean distance between nodes and their cluster head. After choosing cluster head nodes, base station will broadcast the information to all nodes. The contains of information are cluster head nodes, cluster member nodes and transmission schedule for each cluster. Then the nodes determine its TDMA slot for their data transmission based on the above information.

3. MOBILE-LEACH PROTOCOL

M-LEACH protocol [7] is development of LEACH-C protocol to support mobility. In a round time of LEACH-C, if a node moves away from its cluster head, it will consume more energy to maintain connection with the current cluster head. It will not cause energy utilization. The protocol supports hand-off mechanism to permit the nodes changing their cluster head to get energy efficiency.

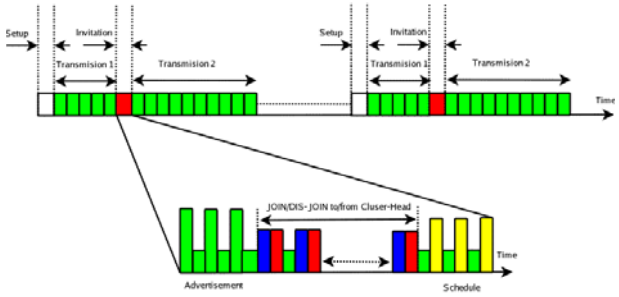


Figure-3. M-LEACH process

In M-LEACH protocol, setup is the inital stage of formation of the cluster head. Transmission 1 is initial stage of cluster head to communicate with nearby nodes. Cluster head nodes broadcast information about its condition to the nearby nodes so that each node make communication to closer cluster head. If a node moves away from the current cluster head, the node will send DISJOIN message to the current cluster head so that time slot of TDMA schedule in old cluster head will be deleted. If the node get closer to another cluster head, the node will send JOIN message to new cluster head. Then the new cluster head creates time slot to that node in order to send its data to the new cluster head.

4. MN-LEACH PROTOCOL

MN-LEACH (Mobile Node - LEACH) protocol is based on LEACH protocol. In LEACH protocol is divided into rounds, where each round is started with setup phase to create clusters, followed by steady phase, where cluster members send data to base station.

In [8] assumed that the protocol is based on LEACH but it supports mobility without GPS based location information and centralized routing protocol.

Different with [8], in the proposed protocol have some assumptions to support the clustering mechanism:

Assumption 1: All nodes are location-aware by using GPS or localization algorithms.

Assumption 2: All nodes are homogeneous in physical characteristics.

Assumption 3: The base station and cluster head are stationary. In the protocol, it only considers the mobility of cluster member.

In the proposed protocol, cluster setup is the same process with LEACH protocol. During setup phase, all cluster member will save position of all cluster head in the list by using GPS or etc. Cluster head node create TDMA schedule to receive the sensed data from cluster member, while non cluster head node send data based on its time slot in the frame of TDMA, then the node sleep for schedule time interval to save its energy. Due to cluster head node is stationary in a round, the position of cluster head is saved temporary in the node and it is deleted to be replaced with the new position after the next round.

The position list of cluster head in the node is very useful to calculate the best distance to the closest cluster head when the node move away from current cluster head. To choose the best distance, we use the euclidean distance formulation:

$$D = \min \left[\sqrt{(x - x_i^c)^2 + (y - y_i^c)^2} \right] \quad (2)$$

where:
x, y are cluster member position moving away from current cluster head.
x_i^c , y_i^c are the position of all cluster-heads and it will be choosen the minimal value of the distance D.

Cluster member will compute the distance based on the list of the cluster head position saved in the Table list. Because the position of cluster heads are stationary, the Table list is no changing in a round. The assumptions looks like in GSM network, where BTS is fixed. This technique supports hand-off mechanism to find the best cluster head to get energy efficiency.

After the cluster member gets the closest cluster head, it sends DIS-JOIN message to the previous cluster head and JOIN message to the new cluster head. The cluster head will be waiting JOIN / DIS-JOIN message from the cluster member and then, the corresponding cluster heads create a new TDMA schedule to the covered cluster member. Cluster member send the sensed data based on its time slot (schedule), and all datas from the covered cluster member are aggregated by cluster head then it is sent to base station. This process is in a round, for the next round, it will start in cluster setup again. Whole process can be seen in Figure-4, and the sequence of flowchart is only for one round.

5. SIMULATION OF MN-LEACH AND RESULTS

We used MATLAB to simulate the protocol with some environment parameters as below:

Table-1. Parameter for simulation.

Parameter	Value
Size of network	100 m x 100 m
Size of packet	500 bytes
E_{elec} (Radio electronics energy)	50 nJ/bit
E_{amp} (Radio amplifier radio)	100 pJ/bit/m2
E_{init} (Initial energy)	0.5 J
Number of nodes	100

Total number of nodes is 100 where the nodes are distributed randomly in area 100 x 100 m. The size of packet is 500 bytes and base station is adjustable. The first experiment, base station is at x = 50, y = 50, then it is changed to x = 50, y = 150. Each node begins with 0.5 Joule of energy.

The experiment evaluate performance of LEACH and MN-LEACH protocol by using mobile nodes. We simulated wireless sensor network to get number of alive nodes during increasing number of round and also to get energy efficiency for increasing number of round. In the beginning of LEACH and MN-LEACH, it is a cluster setup as shown in Figure-5.

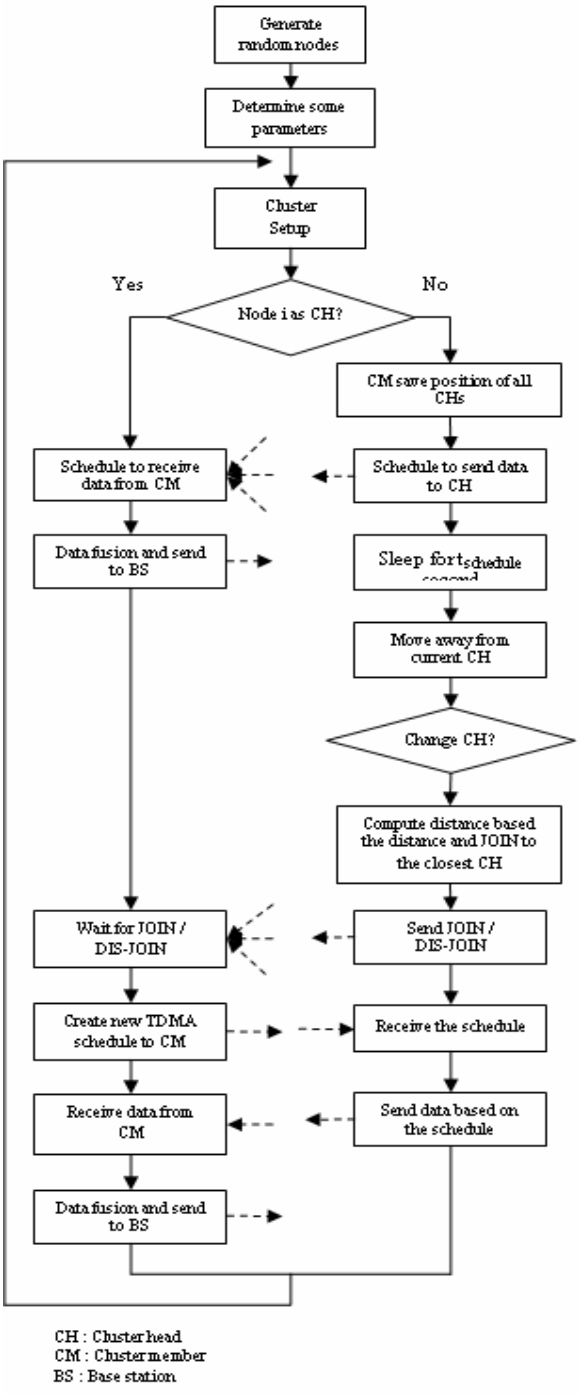


Figure-4. Flowchart of MN-LEACH.

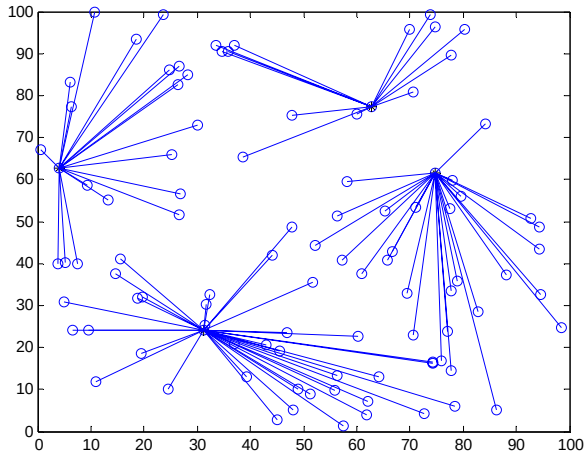
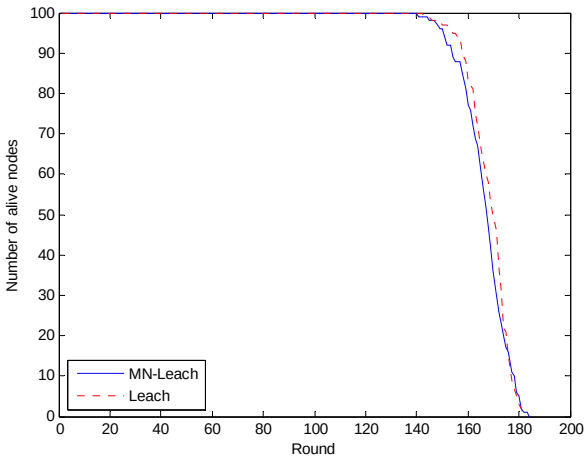
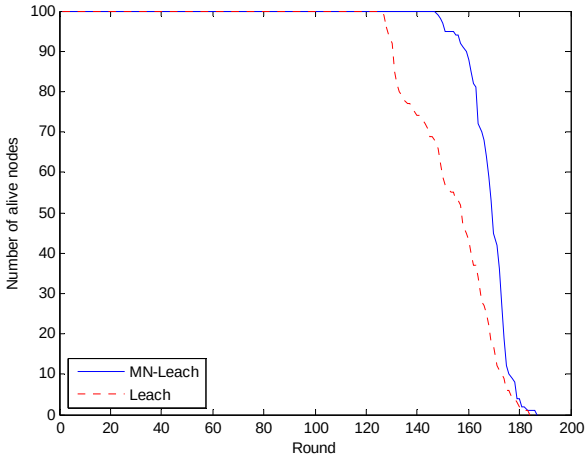


Figure-5. Cluster Setup.

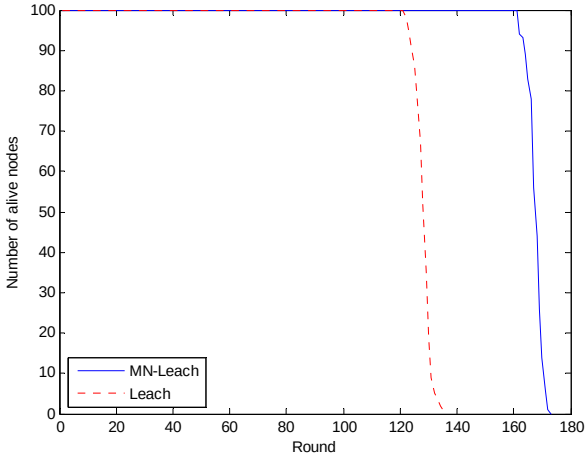
Figure-6 shows number of alive nodes versus round as mobile node increased. Based on the assumption no 3, cluster heads are stationary, so it means the increasing number of mobile nodes referring to the number of cluster member. For example, number of mobile nodes = 100, if number of cluster heads are 5, the number of mobile nodes become 95 nodes. It also shows that LEACH is not as efficient as MN-LEACH where number of mobile nodes increase, performance of LEACH become degrade drastically because LEACH does not support hand-off mechanism during changing base station, node become dead fast.



(a)

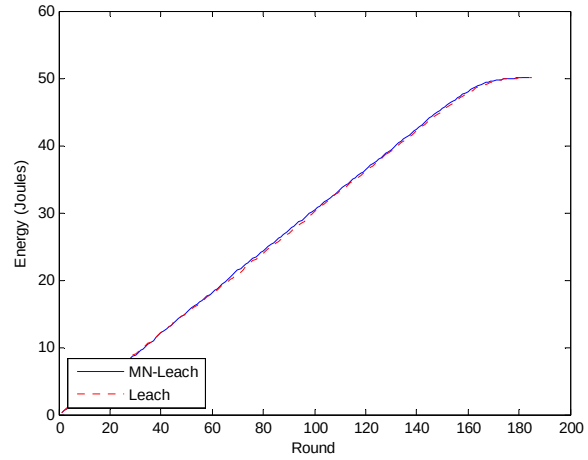


(b)

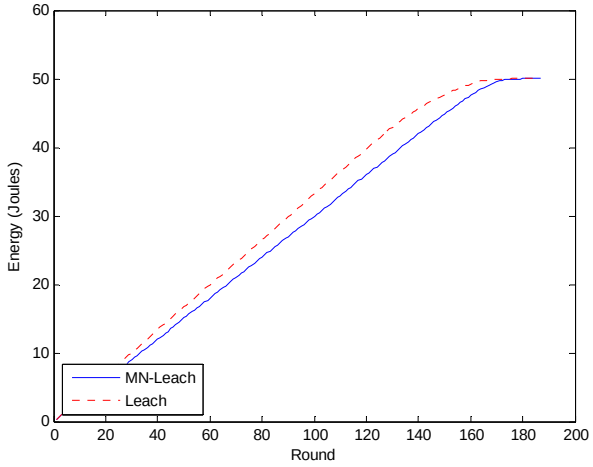


(c)

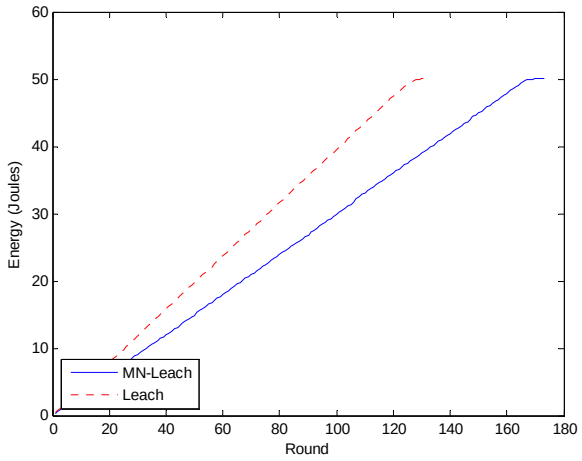
Figure-6. Simulation with limited energy to evaluate number of alive nodes (a) Number of mobile nodes = 0 (b) Number of mobile nodes = 20 (c) Number of mobile nodes = 100



(a)



(b)



(c)

Figure-7. Simulation with limited energy to evaluate energy dissipation versus round (a) Number of mobile nodes = 0 (b) Number of mobile nodes = 20 (c) Number of mobile nodes = 100.

In the Figure-7, it shows that performance of LEACH and MN-LEACH is the same when number of mobile nodes is none, but if number of mobile nodes increase until 100% of number of cluster member, LEACH protocol will need more energy than MN-LEACH. The results of Figure-6 and Figure-7 have strong relation where the more energy is needed, the more node become dead fast. In this experiment shows that all energy of the nodes become run out.

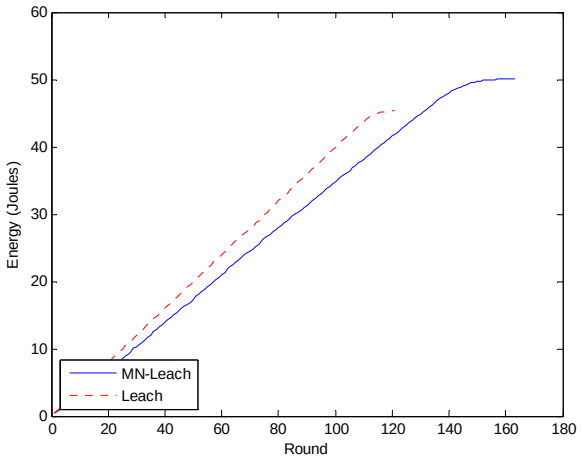


Figure-8. Energy dissipation with location of base station at x=50, y=150.

Figure-8 is to evaluate the energy dissipation when base station is far away from the nodes. The location of base station is at x=50, y=150. It shows that MN-LEACH perform better for the safe energy than LEACH protocol.

6. CONCLUSIONS

In this paper, we present MN-LEACH protocol to support mobile nodes. The MN-LEACH outperforms LEACH by reducing distance between cluster head and cluster member when cluster member move out from current cluster head. It supports hand-off mechanism. Further investigation is needed to support cluster head mobility and implemented in heterogeneous network.

REFERENCES

[1] Hiroaki Taka, Hideyuki Ueahara, Takashi Ohira. 2013. Energy-Efficiency of Sensor Networks in Terms of Network Topology. IEICE Trans. Commun. J96-B(07): 680-689.

[2] Hiroaki Taka, Hideyuki Uehara and Takashi Ohira. 2009. Node Scheduling Method Based on Aggregation Model for Clustering Scheme in Wireless Sensor Networks, Proc. International Symposium on Wireless Personal Multimedia Communications (WPMC 2009), S05-3, Sendai, Sept.

[3] M. Udin Harun A. 2013. Ferry Astika Saputra, M. Zen Samsono Hadi, Alfian Fahmi, Beacon-Enabled IEEE 802.15.4 Wireless Sensor Network Performance, IEEE International Conference on Communications, Network and Satellite (COMNETSAT), Yogyakarta.

[4] M. Zen Samsono Hadi, Nanok Adi S., Taufiqurrahman. 2013. Sistem Monitoring Kecelakaan Mobil Pada Jaringan Vanet Menggunakan Sistem Komunikasi Multi-Hop, Proceeding of Sentia (Seminar Nasional Teknologi Informasi dan Aplikasinya), Politeknik Negeri Malang.

[5] Heinzelman W., Chandrakasan A., Balakrishnan H. 2002. An applicationspecific protocol architecture for wireless microsensor networks. IEEE Trans. Wirel. Commun. 1(4): 660-670.

[6] Sounak Paul, Naveen Kumar Sao. 2011. An Energy Efficient Hybrid Node Scheduling Scheme in Cluster Based Wireless Sensor Networks. Proceedings of the World Congress on Engineering (WCE), Vol II, London UK.

[7] Lan Tien Nguyen, Xavier D., Razvan B, Y. Shinoda. 2008. An Energy Efficient Routing Scheme for Mobile Wireless Sensor Networks. Proceedings of IEEE ISWCS. pp. 562-572.

[8] Do-Seong Kim, Yeong-Jee Chung. 2006. Self-Organization Routing Protocol Supporting Mobile Nodes for Wireless Sensor Network, Computer and Computational Sciences, IMSCCS '06. First International Multi-Symposiums on. 2: 622-626.