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The Location-Based LEACH Mobile Algorithm Considering Mobility of Wireless Sensor Nodes

[1]Seong Pil Jang, [2]Dai Yeol Yun and [3]Jong-Yong Lee
[1]Department of Information System, Graduate School of Information Contents,
Kwangwoon University, Kwangwoon-ro 20, Nowon-gu, Seoul, Korea
[2]Department of Plasma Bioscience and Display,
Graduate School, Kwangwoon University, 01897 Seoul, Korea
[3]Ingenium College of Liberal Arts, Kwangwoon University, 01897 Seoul, Korea

Abstract: In this study, we propose an algorithm considering node movement and considering the variable number. LEACH is an energy efficient protocol but has a disadvantage in that the success rate of data transmission is low because it does not consider the mobility of nodes. LEACH-Mobile is the protocol that improved this. Since, LEACH-Mobile retransmits data that failed to transmit, it has a disadvantage that it consumes more energy than LEACH and does not consider the situation where the number of nodes is variable. The cluster head is selected based on the residual energy of the node in consideration of the situation where the number of nodes is variable. In this study, we compare LEACH-Mobile with the proposed algorithm by simulating the environment in which the number of nodes changes in each round and nodes move every round.

Key words: WSN, mobile, node, LEACH, LEACH-Mobile, clustering

INTRODUCTION

Recently, the wireless sensor network (Hani and Ijjeh, 2013; Lee *et al*., 2014) has developed into a network in which the position of wireless sensor nodes can be changed by adding mobility in a network composed of fixed sensors (Gauta *et al*., 2015). A representative protocol of a fixed sensor network is LEACH, a clustering-based routing protocol (Heinzelman *et al*., 2000, 2002; Kim *et al*., 2016). LEACH forms a cluster of cluster heads and member nodes. The cluster head plays a role of fusing the data of the member nodes in the cluster and transmitting them to the base station and the node that plays the role of the cluster head changes every round of the cluster head.

This LEACH is one of the energy efficient protocols but because it considers only fixed conditions, the transfer success rate drops sharply when the node moves. LEACH-Mobile is a protocol that improves the disadvantage of low transmission rate (Kim and Chung, 2006; Jang *et al*., 2017).

LEACH-Mobile has the same data transmission rate as that of the existing LEACH. However, the nodes that have failed to transmit are checked separately and join the changed cluster. However, since the transmission is repeated many times, the transmission success rate is high as compared with the existing LEACH but there is a disadvantage that the energy consumption is larger.

The proposed protocol compares the average of the residual energy with the node when selecting the cluster head. When the cluster head is selected it is selected when it is high and when the cluster head is selected, the location information of the moved node is transmitted to the base station. The cluster is configured to collect data and transmit it to the base station. Simulation results show that the lifetime of the network is improved by comparing LEACH and LEACH-Mobile with proposed algorithms when nodes move from 0-100%.

Literature review

LEACH: LEACH (Low Energy Adaptive Clustering Hierarchy) is a clustering-based hierarchical routing protocol proposed by Heinzelman *et al*. (2000). The LEACH process uses the probability threshold T(n) to select a random value between 0 and 1 of the node to be smaller than the T(n) to select the cluster head. The cluster head is formed around the selected cluster head and the member nodes in the cluster transmit data to the cluster head and the cluster head transmits the received data to the base station by fusion (Fig. 1) (Eq. 1):

Corresponding Author: Seong Pil Jang, Department of Information System, Graduate School of Information Contents, Kwangwoon University, Kwangwoon-ro 20, Nowon-gu, Seoul, Korea

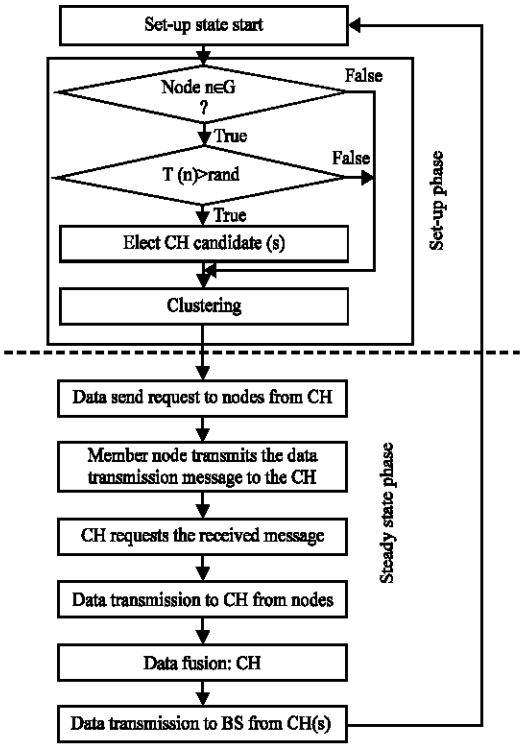

Fig. 1: LEACH flow chart

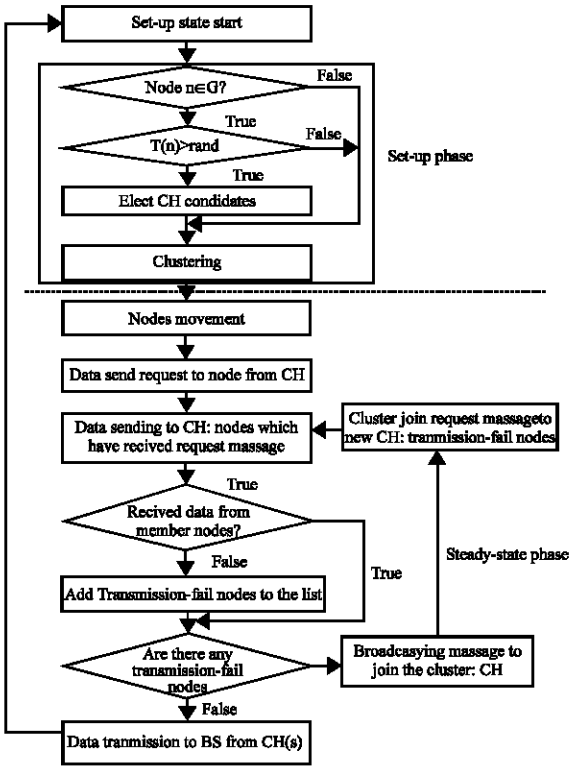

Fig. 2: LEACH-Mobile flow chart

$$T(n) = \begin{cases} \dfrac{p}{1-p(r \bmod \frac{1}{p})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

The cluster head of the LEACH can be selected again as the cluster head once all the nodes have been selected as the cluster head.The energy consumption of the cluster head increases as the lifetime of the network grows. However, since LEACH does not consider nodes to move, the data transmission success rate is low in a situation where a node moves so that it can be used only in a limited situation where a fixed network is applied.

LEACH-Mobile: LEACH-Mobile is a protocol proposed by Do-Seong Kim. LEACH-Mobile has been proposed to increase the success rate of data transmission in mobility-centered environment. LEACH-mobile has added a mobile node with mobility to complement the data transmission success rate by confirming whether the mobile node participates in the cluster in the mobility-centered environment. The set-up phase and the steady-stage phase of LEACH-mobile are shown in Fig. 2.

The set-up phase is not different from the existing LEACH but there are many differences in the steady-state phase. After the cluster heads are elected, the nodes move after the cluster is configured. The cluster head transmits a data transmission request message to the member node in the cluster and when the member node receives the message, it transmits a message that it has received the data and then transmits the data to the cluster head. If the cluster head does not receive any message from the member node, the cluster head determines that the member node does not exist in the cluster and moves to the outside and adds the corresponding member node to the transmission fail list.

If there is no member node added to the transmission failure list after all the nodes have passed through this process, the process returns to the set-up phase again. However, if there is a member node, the failed node joins the cluster again and retransmits it. And the data transmission success rate when the node position is changed is improved.

Since, the failed node transmits data again, it consumes more energy than the existing LEACH and considering the environmentthe node moves we do not consider the situation where the number of nodes is variable so we propose LEACH-VMN.

MATERIALS AND METHODS

Proposed algorithm: In the proposed LEACH-VMN, the data transfer success rate is high even when the node

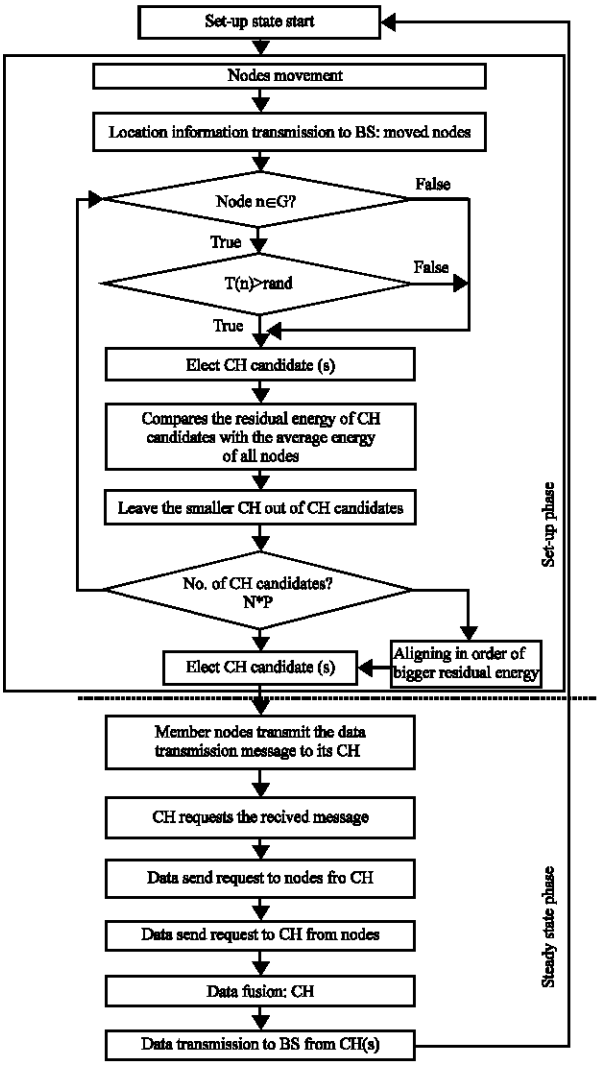

Fig. 3: LEACH-VMN flow chart

moves, considering the mobility of the node. When the cluster head is selected based on the remaining energy considering the variable number of nodes when the number of nodes is variable, due to the variable having a lot of residual energy, LEACH-VMN selects the cluster head based on the added node and the lifetime of the network is improved than that of LEACH-Mobile. A flowchart of the LEACH-VMN is shown in Fig. 3.

Proposed protocol is different LEACH-Mobile, the proposed protocol starts the set-up phase and considers the mobility of the node by transmitting the location information of the moved node to the base station before selecting the cluster head. After transmitting the location information of the node to the base station, a comparison is made as to whether the node to be selected belongs to the G value. Next, it is compared with the random value of the node between T(n) and 0-1 and the value of the node should be smaller but it is selected as the cluster head candidate.

The residual energy of the candidate node is compared with the total residual energy average so that the residual energy should be higher than the average of the remaining residual energy but the candidate is not selected if it is not candidate.

In order to uniformly select cluster heads, the number of cluster heads is equalized and selected. If the number of candidates is less than the number of homogeneous numbers (live all node*probability of selection), compare them again with the G value. If the number is more than the equal number, the remaining energy will be sorted and selected in descending order. If the number is equal to the number, the cluster head selected.

The steady-state phase is the same as LEACH and the member node transmits data to the cluster head and the cluster head transmits the data of the received member node to the base station by fusion.

RESULTS AND DISCUSSION

Simulation result: Using the MATLAB simulation tool, we simulated protocols with parameters described in Table 1-3 simulated protocols ten times and averaged results to make sure the consistency of simulation results. We considered only the mobility of nodes in simulation 1 and the mobility of nodes and variance of nodes number simultaneously in simulation 2. Every 200 rounds in simulation 2, the number of nodes is increased by 30 nodes and decreased by 20 repeatedly which continues until FND occurs.

Figure 4 shows the success rate of data transmission of 3 protocols in simulation scenario 1. The success rate of data transmission of LEACH decreases sharply as the mobile nodes ratio increases and the differences of success rate of data transmission between LEACH-Mobile and the proposed algorithm from mobile nodes ratio 0-100 are almost zero.

Figure 5 shows the results for simulation 1. Comparison of network lifetimes of LEACH-Mobile and LEACH-VMN protocols shows that the network lifetime of LEACH-VMN is longer.

Figure 6 shows FND of two protocols under simulation scenario 2 (Kwon and Roh, 2009). The comparison of network lifetimes of LEACH-Mobile and LEACH-VMN protocol shows that the network lifetime of LEACH-VMN is much longer.

Figure 7 shows the 3D simulation result of simulation scenario 2. In case of LEACH-Mobile, the energy of newly added nodes are 0.5 (J) and the residual energy

Table 1: Simulation scenario 1

Parameters	Variables
Sensor field size	100×100 m
Location of base-station	50, 150 m
Number of total/initial nodes	100/100
Initial energy of node	0.5 (J)
Probability of cluster selection (p)	0.1
Packet size (bit)	2000
mobile nodes ratio	0~100%

Table 2: Simulation scenario 2

Parameters	Variables
Sensor field size	100×100 m
Location of base-station	50, 150 m
Number of initial nodes	50
Initial energy of node	0.5 J
Location data	16 bit
Probability of cluster selection (p)	0.1
Packet size	2000
mobile nodes ratio	0~100%
Rounds	No. of nodes
Variance of nodes number	
0~200	50
201~400	80(+30)
401~600	60(-20)
601~800	90(+30)
801~1000	70(-20)
1001~1200	100(+30)
~FND	

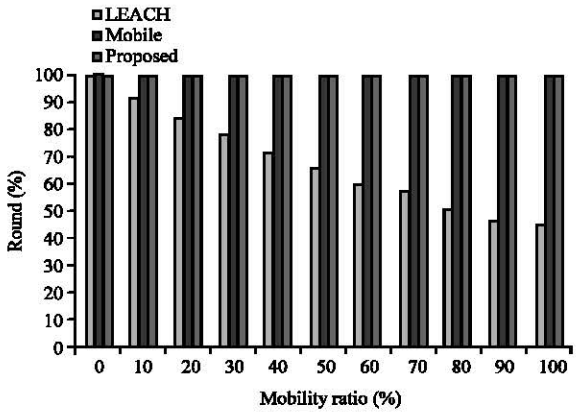

Fig. 4: Comparison of transmission success rate

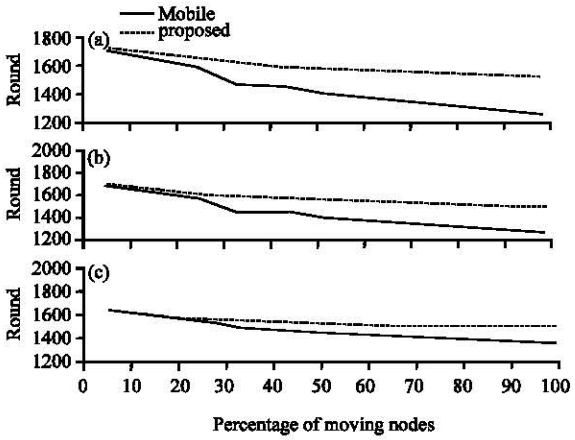

Fig. 5: Simulation result: a) FND; b) HND and c) LND

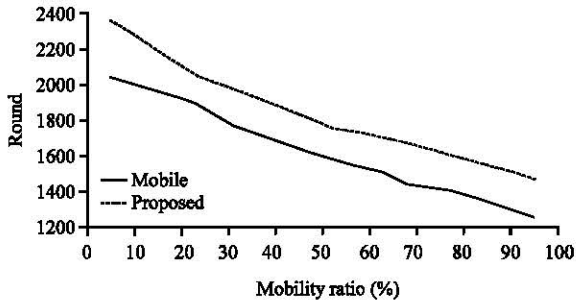

Fig. 6: Simulation 2 result to FND

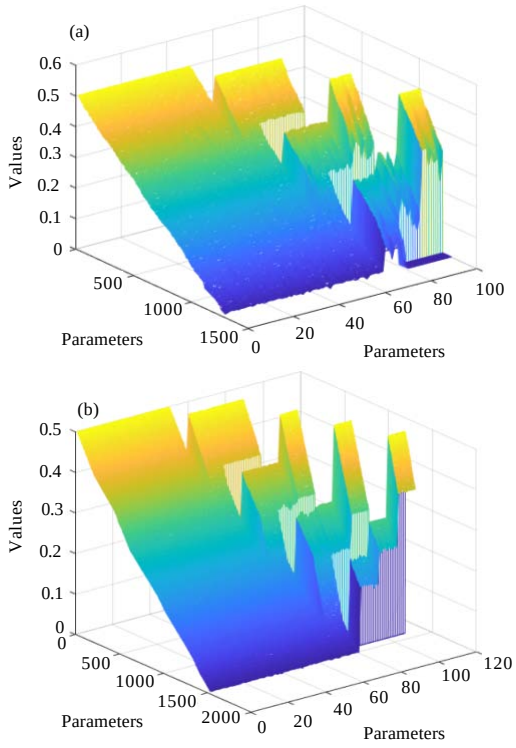

Fig. 7: Simulation 2_3d graph to FND

of outgoing nodes from sensor field is not considered and all existing nodes in sensor field have same chance to outgo regardless of their residual energy. As rounds run, the remaining energy of the nodes is unequal. It could cause to decrease the network lifetime. But LEACH-VMN selects the cluster head based on the residual energy. Therefore, the residual energy of the nodes is equalized by being selected with added nodes. This scheme makes the lifetime of LEACH-VMN extend.

CONCLUSION

In this study, we propose a LEACH-VMN that overcomes the disadvantages of not considering

environment where the number of nodes of LEACH-Mobile is variable. Considering only the moving situation, we can see that the proposed algorithm has longer network lifetime than LEACH-Mobile. In this case, after the cluster is configured in LEACH-Mobile, if the node leaves the cluster and fails to transmit data, it joins the cluster again and retransmits it which increases the data transmission success rate. A cluster, on the other hand, consists of moving nodes to increase the success rate of data transmission.

For LEACH-Mobile, the setting step is the same as for LEACH. Even if a node is added in a situation where the node is variable, the residual energy of the added node is uneven because all nodes are selected as the cluster head. On the other hand in the case of the proposed algorithm, when the cluster head is selected in the set-up phase the remaining energy of the cluster head to be selected and the average residual energy of the entire node are compared with each other. In this study, we compared the proposed algorithm with LEACH and LEACH-Mobile and confirmed that the data transmission success rate of the proposed algorithm is superior to LEACH and the lifetime of the network is improved compared to LEACH-Mobile. The number of nodes is variable. In other words, other algorithms that take into account variable number of nodes can use this approach to improve additional performance.

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