International Journal of Internet, Broadcasting and Communication Vol.9 No.4 38-43 (2017)
http://dx.doi.org/10.7236/IJIBC.2017.9.4.38

IJIBC 17-4-7

The Routing Algorithm for Wireless Sensor Networks with Random Mobile Nodes

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Abstract

Sensor Networks (WSNs) can be defined as a self-configured and infrastructure-less wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location or base-station where the data can be observed and analyzed. Typically a wireless sensor network contains hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals. A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power components. The individual nodes in a wireless sensor network (WSN) are inherently resource constrained: they have limited processing speed, storage capacity, communication bandwidth and limited-battery power. At present time, most of the research on WSNs has concentrated on the design of energy- and computationally efficient algorithms and protocols

In order to extend the network life-time, in this paper we are looking into a routing protocol, especially LEACH and LEACH-related protocol. LEACH protocol is a representative routing protocol and improves overall network energy efficiency by allowing all nodes to be selected to the cluster head evenly once in a periodic manner. In LEACH, in case of movement of sensor nodes, there is a problem that the data transmission success rate decreases. In order to overcome LEACH's nodes movements, LEACH-Mobile protocol had proposed. But energy consumption increased because it consumes more energy to recognize which nodes moves and re-transfer data.

In this paper we propose the new routing protocol considering nodes' mobility. In order to simulate the proposed protocol, we make a scenario, nodes' movements randomly and compared with the LEACH-Mobile protocol.

Keywords: *Wireless sensor network (WSN), Mobile nodes, LEACH, LEACH-Mobile.*

1. Introduction

Wireless sensor networks are the core technology of ubiquitous networks. Wireless sensor networks are classified into two; the fixed and the mobile networks depend on whether the sensor nodes have been moved or not. The fixed sensor networks mean that the positions of nodes do not change and occasionally are used

Manuscript received: Oct. 10, 2017 / Revised: Oct. 18, 2017 / Accepted: Oct. 25, 2017
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in such as vibration detection of bridges and earthquake detection of buildings. The mobile sensor networks consist of mobile nodes which are changing the locations of nodes, used to detect the earthquake of the seabed (earthquake, heavy rain, tsunami, and typhoon etc.) and to monitor the patient conditions with body sensors attached to the patient.

The routing protocol of wireless sensor networks are classified into the plane routing, location-based routing, and hierarchical routing [1] [2] [3] [4]. The routing protocol used in this paper is the LEACH protocol. The LEACH protocol is the representative protocol among the hierarchical routing protocols [5]. The LEACH protocol improved the energy efficiency of network by clustering method but does not consider the situation of nodes movement. Therefore, if nodes move, data transmission success rate is low.

The LEACH-Mobile protocol is a protocol that improves the problem of movements of nodes [6]. In LEACH-Mobile protocol, the node moved and failed to transfer data, the problem was solved by making the failed node join the re cluster and re transmitting the data. However, energy is consumed additionally for recognition of the moved node and energy consumption is larger than LEACH protocol.

In this paper, we propose a new routing protocol considering sensor nodes' mobility in sensor field to improving the previous issues. The proposed protocol considers mobility by transmitting the GPS-based location information of sensor nodes to the base station. And cluster head is selected based on the residual energy to extend the network lifespan. In order to verify the performance of the proposed protocol, we make a scenario considering sensor nodes' movements and compares with the LEACH-Mobile protocol.

2. Related Researches

2.1 LEACH Protocol

LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is a clustering-based hierarchical routing protocol proposed by Wendi B. Heinzelman [6]. The process of the LEACH protocol consists of a set-up phase and a steady-state phase. In the set-up phase, cluster heads are selected and clusters are formed. A cluster consists of a cluster head and a number of member nodes.

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

In the steady-state phase, member nodes transmit the sensing/collected data to the cluster head which he belongs to according to the TDMA scheme which was set in set-up phase. And each cluster head aggregates the received data from the member nodes and sends them to the base station.

2.2 LEACH-Mobile Protocol

The LEACH-Mobile protocol has been proposed to increase the data transmission success rate, taking into account the movements of nodes within a sensor field [7]. Sensor nodes move randomly at a specific rate within a sensor field. The cluster heads confirm whether the moved node(s) participate in their cluster every round.

The set-up phase of the LEACH-Mobile protocol is equal to that of LEACH protocol and only data transmission scheme of the steady state phase is different from that of LEACH. The cluster heads send a request message to their member nodes to send the collected data. The member nodes which received the transmission request message transmit acknowledgement message to the cluster head and then transmit the data.

If all the member nodes succeed in transmitting data to the cluster head, the next round proceeds. But if the cluster head doesn't receive acknowledgement message from member nodes, the cluster head assumes that the corresponding member nodes have moved out of the cluster and are not present in the cluster. And added the corresponding nodes to the transmission failure list and all cluster heads broadcast to the nodes

"cluster join request message". The moved nodes which were fail to transmit data join the cluster and transmit collected data to the new cluster head.

3. Proposed algorithm

3.1 Cluster Head Selection

The cluster heads selection in the LEACH protocol is performed through Equation (2.1). To select the cluster heads among nodes, the proposed algorithm basically uses same equation and adds to consider two rules: 1) the residual energy of the sensor nodes. The more residual energy nodes have, the more elected as cluster head. 2) The number of cluster heads per round is constant. The method to select cluster heads with newly added two rules shows in Figure 1.

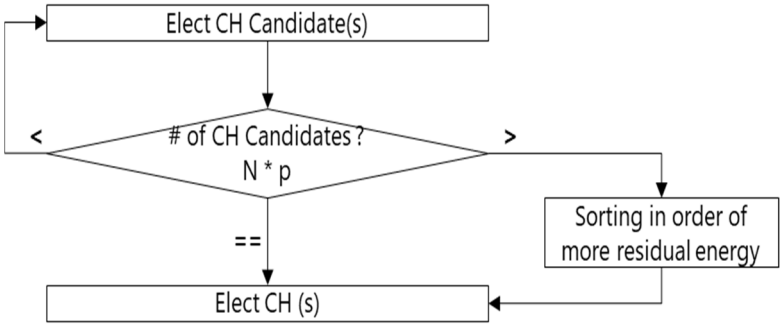

Figure 1. Cluster heads selection

3.2 Sensor Nodes' Mobility

The proposed protocol considers the mobility of sensor nodes' within sensor field. In order to consider the movements of sensor nodes, we utilized GPS location data. We selected cluster headers based-on residual energy. For convenient of simulation, the movements of nodes happen in set-up phase.

The steady-state phase is the same as the data transmission of the LEACH protocol. Unlike the LEACH-Mobile protocol, the proposed protocol does not need the transmission failure list-up operation and the re-transmission of the moved sensor nodes. As a result, the energy consumption of the nodes will be smaller than the energy consumption of the LEACH-Mobile protocol.

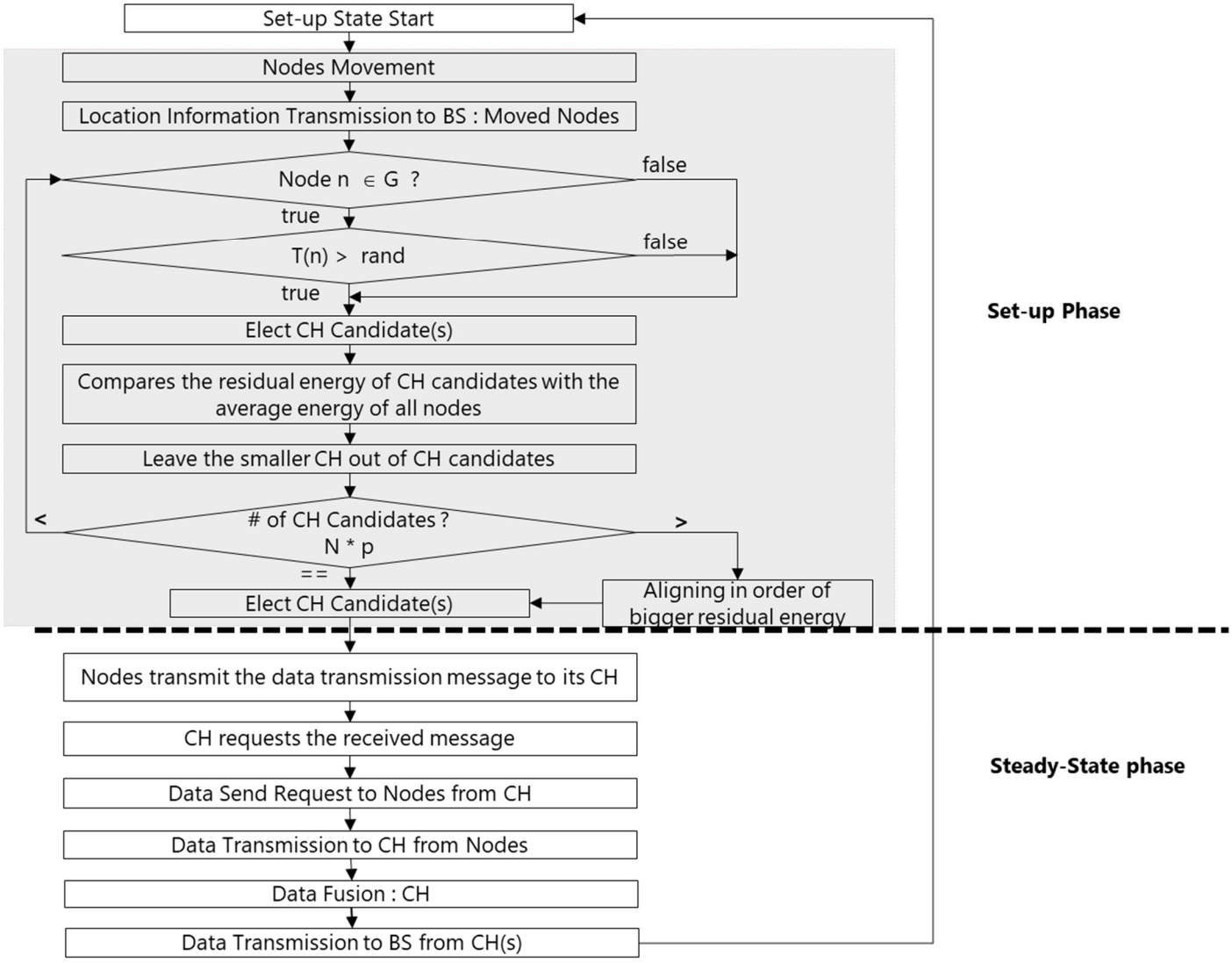

Figure 2. The proposed protocol Flow-chart

4. Simulation Result

In order to compare the proposed protocol with the existing LEACH-Mobile protocol, we simulated a scenario. Overall simulation parameters are described below Table 1 and Table 2. All simulations were performed 10 times to make sure the accuracy of each simulation and averaged the results.

Table 1. Radio model parameters

Parameters	Control Variables
Node initial energy	0.5J
Message size	2000bit
E_{elec}	50nJ/bit
ε_{fs}	10pJ/bit/m^2
ε_{mp}	0.0013pJ/bit/m^4

Table 2. Simulation parameters

Parameters	Control Variables
Field size(m)	100(m)*100(m)
Base station location	(50(m),150(m))
Total nodes	100
Location updating GPS data	16 byte
Cluster selection probability (p)	10%

4.1 Simulations

Scenario is for taking account of the movement of sensor nodes. We simulated 10% increments from when no nodes move (0%) to when all nodes move (100%).

Figure 3 shows the simulated results of FND, HND, and LND of the LEACH-Mobile protocol and the proposed protocol. In case of node movement ratio is low, there is a slight difference in network life between two protocols. However, as the node mobility ratio increases, the results show that the network lifetime of the proposed protocol is longer than that of the LEACH-Mobile protocol.

Figure 4 shows the data transmission success rate according to the movement ratio of sensor nodes. The data transmission success rate of the proposed protocol also have same results of that of LEACH-Mobile protocol regardless of movement ration of sensor nodes'.

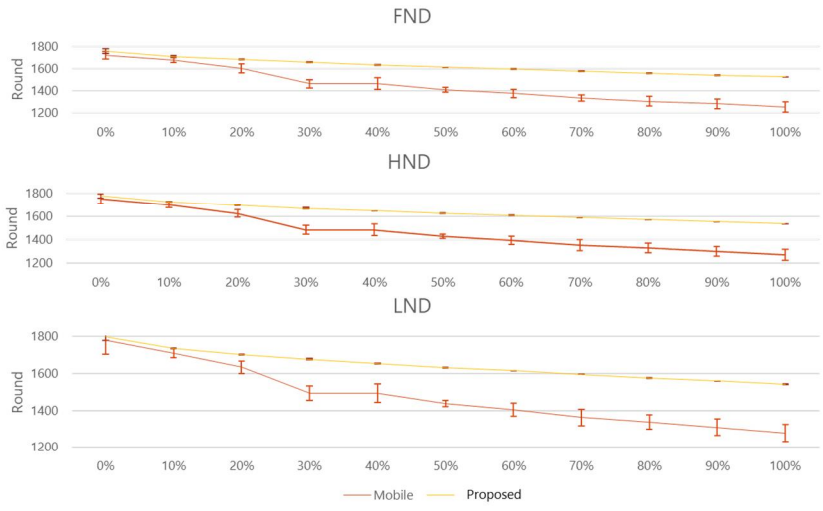

Figure 3. The Comparison of FND, HND and LND

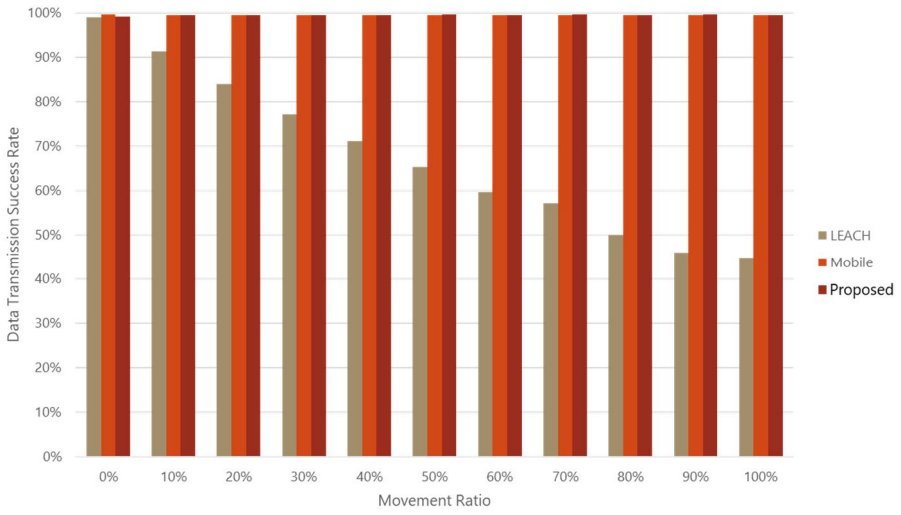

Figure 4. The Comparison of FND, Data Transmission success rate

5. Conclusion

In this paper, we propose the new routing protocol considering nodes movement. In order to consider the movement of nodes, the moved nodes transmit the location data to the base station and select cluster headers based on residual energy of nodes. Compared to the existing LEACH-Mobile protocol, the network lifetime of the proposed protocol improves FND by more than 2% up to 22% when considering only node movement. HND and LND are improved by at least 1% up to 21%.

The standard deviation of FND of the proposed protocol is less than 0.5% as nodes movement ratio increases. This means that the proposed protocol is a stable protocol. The FND attenuation ratio is irregular in the LEACH-Mobile protocol, but the proposed protocol is attenuated within a certain range and is more stable. And the proposed protocol has same performance in data transmission success rate.

With all simulated results, the proposed protocol has more network lifetime and more stable than the LEACH-Mobile protocol.

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