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Spatial Scheme for Improving the Network Lifetime of WSN

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Abstract: For different application areas, there are different technical issues that researchers are currently resolving. Sensor devices use small, low-powered and limited battery. So, recent researches have underlined the efficient energy saving protocol. Clustering techniques in WSNs are very popular and effective solution for saving energy. This study shows an energy effective clustering and data management for aggregation based on W-LEACH (Weighted-Low Energy Adaptive Clustering Hierarchy). W-LEACH is a data-stream aggregation algorithm for WSNs that extends LEACH algorithm, one of popular cluster-based hierarchy protocol. This study proposed the new method to get weights of each sensor nodes in order to increase the lifetime of network. We simulate our new algorithm to evaluate the effects of newly added weighting factor and compare the network's performance in terms of lifetime.

Key words: WSNs, energy saving, LEACH, W-LEACH, sensor, nodes, weighting

INTRODUCTION

WNSs combine sensor technology, signal processing, computation and wireless networking capability in an integrated system. Scales will range from local to global with applications including medicine, security, factory automation, environmental monitoring, and condition-based maintenance (Akyildiz *et al*., 2002). This can enable hundreds or thousands of sensors per user, resulting in many new network design challenges. Usually sensor nodes are battery driven and hence operate on an extremely frugal energy budget. Clustering and data aggregation techniques can provide the WSNs with good solutions for energy optimization. Scalable clustering can efficiently organize WSNs (Heinzelman, 2000). In clustering systems, Cluster-Heads (CHs) collect the information which nodes in its cluster measure. And they aggregate and fuse these data before transmitting the data to the Base-Station (BS). However, in these series of processes CHs consume a higher rate of energy. Therefore CHs must be selected evenly and handled wisely to prolong the lifespan of the entire network (Heinzelman *et al*., 2002). LEACH deploys all nodes randomly in total sensor field and each sensor sends the measured data to its CH every round. These result in a higher energy drain at some nodes and sending redundant data which are correlated spatially and temporally (Akyildiz *et al*., 2004). W-LECH addresses the data aggregation algorithm for spatially correlated data with density weighting factor. In W-LEACH algorithm the nodes far from base-station use higher rate of energy. This causes WSNs to shorten the lifetime of the entire network. The main focus of this study is to address these problems and develop a framework to find the optimal weighting factors which nodes should send data and become CH from the perspective of maximizing the network's lifetime. The rest of the study is organized as follows (Handy *et al*., 2002; Abdulsalam and Kamel, 2010).

Literature review

Extension algorithms of LEACH: A number of algorithm to extend the lifetime of sensor networks have been proposed in literature. PEGASIS is a protocol based on a new chain, where each node communicates only with a closest node instead of directly communicating with BS (Lindsey *et al*., 2002). A hybrid protocol APTEEN which allows for comprehensive information retrieval and the nodes in such a network not only react to time-critical situations but also give an overall picture of the network at periodic intervals in a very energy efficient manner (Manjeshwar *et al*., 2002). However, appropriate cluster head election mechanisms are required to reduce the energy consumption and enhance the lifetime of the network. The researchers in extend LEACH's stochastic cluster heads selection algorithm by adding a deterministic component and change the probability of a node becoming a CH by considering the remaining energy of alive sensor nodes (Heinzelman *et al*., 2002). In LEACH-C, the cluster formation is done at the beginning

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of each round using a centralized algorithm by BS (Heinzelman *et al*., 2000). Although the energy cost for cluster formation is higher in LEACH-C, the overall performance may be better than LEACH due to improved cluster formation by BS.

W-LEACH: W-LEACH addresses a data aggregation algorithm to increase the average lifetime for sensor nodes which leads to increase the entire network lifetime. W-LEACH also consists of a setup phase and a steady state phase. In the setup phase, W-LEACH selects CHs. Each CH is chosen based on a weight value that is assigned to each sensor without taking into consideration whether or not this sensor was a CH for previous near rounds. After all CHs are chosen, W-LEACH chooses sensors in each cluster to send data to its CH. And the candidates for sending data to CHs are also chosen based on their weights. Unlike LEACH, all nodes don't send data to its CH. Some nodes in dense areas don't send data with a specific probability. To select CHs based on specific weighting factors, node's density and remaining energy of each node, leads to extend the lifetime of networks regardless whether node distribution is uniform or not. As a many of round progress, nodes far from BS will start to die. As rounds progress more and more, more nodes far from BS will die. The area far from BS can't be covered. This causes the coverage problem. So this problem must be considered to cover the area far from BS. The weight of each sensor in W-LEACH can be calculated by Eq. 1:

$$w_i = \begin{cases} e_i * d_i & \text{if } d_i > d_{thresh} \\ d_i & \text{otherwise} \end{cases} \quad (1)$$

Where:

d_i = (1+number of alive sensors in specific range)/n for $1 \leq i \leq n$

d_{thresh} = A density threshold to define the set of sensors in very low density areas

MATERIALS AND METHODS

The proposed agorithm: As mentioned W-LEACH, we consider a WSN which distributes n nodes randomly. A weight, w_i assigned to each sensor, s_i is based on three factors, that is the remaining energy, E_i the density d_{Di} and distance between sensor s_i and BS, d_{Bi} which newly added in order to solve the coverage mentioned above section. The remaining energy E_i is the energy left in sensor s_i at every round time t. The density d_{Di} represents the ratio of the number of alive sensors that are within an average distance between two sensors of s_i to the total number of alive sensors in the network n at every round time t. The values of densities are therefore, updated through rounds depending on whether or not other sensors in their ranges die. We introduce the new weighting factor, d_{Bi}. The nodes serving as CHs are over-loaded with the long range transmissions to the BS as well as due to the extra processing necessary for data process such as data compression and aggregation. A way to secure balanced energy consumption is to take into account the distance between CHs and BS. The energy consumption in WSNs is inversely proportional to data transmitting distance. Therefore this distance factor d_{Bi} is added to its weight inversely proportionally. But we simulate the proportional adding effect of distance factor too. The newly proposed weight of each sensor can be calculated by Eq. 2 and 3:

$$w_i = \begin{cases} \dfrac{d_{Bi}}{d_{B_{Max}}} * E_{Ri} * d_{Di} & \text{if } d_i > d_{thresh} \\ d_i & \text{otherwise} \end{cases} \quad (2)$$

$$w_i = \begin{cases} (1 - \dfrac{d_{Bi}}{d_{B_{Max}}}) * E_{Ri} * d_{Di} & \text{if } d_i > d_{thresh} \\ d_i & \text{otherwise} \end{cases} \quad (3)$$

Where:

d_i = (1+number of alive sensors in specific range)/n for, $1 \leq i \leq n$

d_{thresh} = A density threshold to define the set of sensors in very low density areas d_{BMax} is a maximum distance among distances between sensors and BS

The newly proposed algorithm procedure as follows. Initially, all sensors have same energy, 1J. The weights are calculated based on the Eq. 2/3. A fixed 5% of sensors with high weights are chosen to be CHs. 50% of sensors with low weights in each cluster are chosen to send data to their CHs. Next procedures are same to W-LEACH.

RESULTS AND DISCUSSIONS

We simulate both LEACH and W-LEACH using Matlab. We apply 1st order radio propagation model for the sensor's energy consumption for transmitting/ receiving data. For simulations, parameters and values are shown in Table 1 and 2.

Sensor distribution (s): Figure 1 a-c, shows the screenshots of the sensor distribution at FND (First Node Dead) round. Figure 2 a-c captures the snapshots

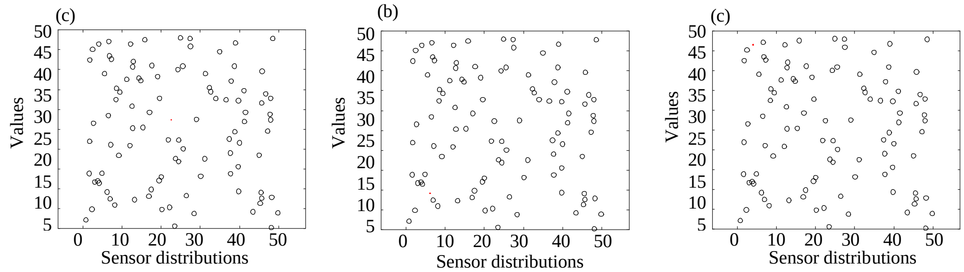

Fig. 1: Sensor distribution at FND for: a) W-LEACH; b) Eq. 2 and c) Eq. 3

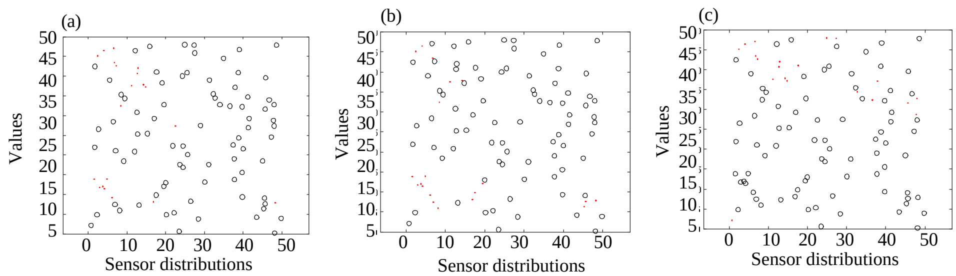

Fig. 2: Sensor distribution at 80% nodes alive round for: a) W-LEACH; b) Eq. 2 and c Eq. 3

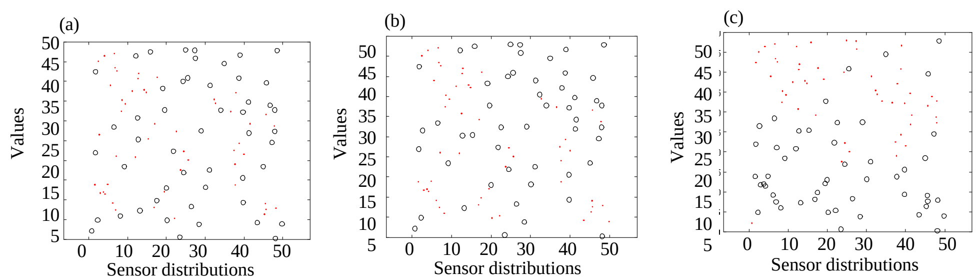

Fig. 3: Sensor distribution at 50% nodes alive round for: a) W-LEACH; b) Eq. 2 and c Eq. 3

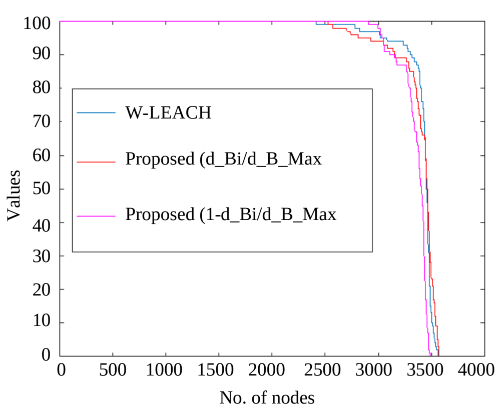

Fig. 4: Number of nodes alive versus rounds

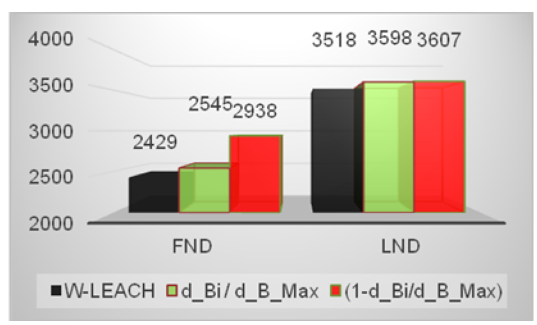

Fig. 5: FND and LND

for W-LEACH and 2 proposed algorithm at the round which 80% of nodes are alive. Figure 3 a-c shows captures snapshots for W-LEACH and 2 proposed algorithm at the round which 50% of nodes are alive. As the simulation results show, W-LEACH and 2 proposed algorithm are similar.

FND and LND (Last Node Dead)-performances: Figure 4 and 5 present the alive nodes versus rounds and FND/LND for W-LEACH and 2 proposed algorithms. The proposed algorithms perform better than W-LEACH by saving the lives of more sensors through rounds. It keeps most of the sensors in the network alive towards later rounds of the entire network lifetime.

CONCLUSION

In this study, we proposed an energy saving algorithm for WSNs with data aggregation. The proposed algorithms extends W-LEACH by adding another weighting factor. We analyzed W-LEACH first and modified weighting factor newly. This leads nodes which are selected CHs to save the energy consumptions. Consequently these energy saving prolong the entire network lifetime. Simulated results shows that proposed algorithms outperform W-LEACH with respect to FND and LND. We do not consider non-uniform distribution sensor field. We consider this as future study.

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