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The Improved Efficiency Network Life-time in TEEN

WooSuk Lee*, Seong Ro Lee**, and Jong-Yong Lee***,+

**Dept. of Plasma Bioscience and Display, KwangWoon University Graduate School, Seoul, Korea.*
***Dept. of Information & Electronics Engineering, Mokpo National University, Korea.*
****Dept. of Culture, KwangWoon University, Seoul, Korea.*
E-mail: leewoosuk@kw.ac.kr, srlee@mokpo.ac.kr, jyonglee@kw.ac.kr

Abstract

In this paper, we're compared network protocol which is network lifetime longer when using LEACH Protocol, SEP, and TEEN in a heterogeneous Wireless Sensor Network with a Large Sensor Area. Also, we propose a method of divided layer the wide-area sensor filed and transmitting a multi-hop to improve the network lifetime. And we're compared network protocol which is network lifetime more improved apply the proposed method to LEACH Protocol, SEP, and TEEN. We tried to compare results, TEEN showed the best network lifetime. Apply the proposed method to divided the sensor field, L-TEEN (Layered TEEN)'s network lifetime rates of improvement is highest.

Keywords: *WSN, BSN, WBAN, LEACH, SEP, TEEN, L-LEACH, L-SEP, L-TEEN*

1. Introduction

Wireless Sensor Network [1, 2, 6] is a network of Sensor Nodes which are consisting of Wireless. One of those utilizing wireless sensor network is a BSN. There are Homogeneous Network and Heterogeneous Network of the Wireless Sensor Network Type. Homogeneous Network is the same amount of energy of all nodes. Heterogeneous Network is nodes have different amounts of energy. According to the characteristics of the Wireless Sensor Network, it has been focused the study of the network lifetime. Various Protocols have been proposed to solve the problem of the network lifetime. It is to take advantage of the Wireless Sensor Network Protocol can improve the energy efficiency during the communication between the wireless device configured BSN. The typical protocol is LEACH Protocol, and continuously to improve and extend the LEACH Protocol. In addition, SEP and TEEN is proposed based on the concept of LEACH Protocol. LEACH Protocol is equally the energy consumption of sensor nodes selected by the Cluster Head random method. But LEACH Protocol does not guarantee to create ideal cluster. SEP is basically a Heterogeneous Network based Protocol and operations similar to LEACH Protocol, but the Normal Node and Advanced Node gives the threshold formula with a different Weighting factor. TEEN also operations similar to

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+ Corresponding Author: jyonglee@kw.ac.kr
Tel: +82-2-940-5289
Department of Culture, Kwangwoon University, 20 Kwangwoon-ro, Nowon-gu, Seoul 139-701, Korea

LEACH Protocol, but Sensor Nodes are do not have a data to be transmitted on a periodic basis. TEEN is a protocol for Reactive Sensor Network.

In this paper, the network lifetime which is better compared to the protocol in Heterogeneous Network with wide-area Sensor Field using each protocols for Wireless Sensor Networks to improve the network lifetime which is LEACH, SEP, and TEEN. Especially, proposed method of divided layer. Proposed method is divided the transmission distance of the Cluster Head which is far from the Base Station and transmitting a multi-hop, reducing the transmission distance of the Cluster Head which is far away from the Base Station to improve the network lifetime. And when applied proposed method to each of the Wireless Sensor Network Protocol, network lifetime compared is higher in any Wireless Sensor Network Protocol.

2. Body

2.1 Heterogeneous Network

Heterogeneous Network is dissimilar Homogeneous Network like the energy of all nodes in the same. It does not assume that the initial energy of all of the nodes are same. The initial energy has more nodes than the Normal Nodes referred to as Advanced Node. The ratio of the Advanced Node is m% of the entire nodes. If the total number of nodes is n, the number of Normal Node having an initial energy value (e_0) is $n\times(1-m)$, the number of Advanced Node having more α times energy is $n\times m$.

2.2 LEACH (Low-Energy Adaptive Clustering Hierarchy) Protocol [3]

LEACH Protocol is a Hierarchical Cluster based Routing Protocol. Dividing the sensor field into a cluster, and one node to the Cluster Head role in each Cluster. LEACH Protocol has Set-up phase and Steady-state phase. Set-up phase is election Cluster Head. And Steady-state phase is substantially transfer process. Cluster Head Nodes are consumes a lot of energy because the collection and transmission data of the Cluster Member Nodes. LEACH Protocol is replaced by the Cluster at periods, for the purpose of uniformly dispersing the energy consumption. In Set-up phase, selecting a Cluster Head by using the formula (1).

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

In formula (1), r is current round. If the set G is empty, there are no more nodes to be a Cluster Head, add to set G to all nodes in the remaining energy can be a Cluster Head. G is a set refers to a set of nodes that do not belong to their elected as Cluster Head. When the start of each round is determined, using a random number between 0 and 1. And verify that each of the nodes to ensure that independently of n is set in the G. If the random number is less than the threshold $T(n)$ is a Cluster Head Node in the current round.

2.3 SEP (A Stable Election Protocol for clustered heterogeneous wireless sensor networks) [4]

SEP is basically a Heterogeneous Network based Protocol and operations similar to LEACH Protocol, but the Normal Node and Advanced Node gives the threshold formula with a different Weighting factor.

$$T(s)=\begin{cases}\frac{p_{opt}}{1-p_{opt}\left(r \bmod \frac{1}{p_{opt}}\right)} & \text{if } n \in G \\ 0 & \text{otherwise}\end{cases} \quad (2)$$

Each node may be a Cluster Head in the Cluster selected by probability of p_{opt}. In SEP, all nodes are selected Cluster Head in cycle is called the Epoch. On average, $n \times p_{opt}$ nodes are must be a Cluster Head Node in each round on epoch. If the set G in current round on same epoch is empty, there are no more nodes to be a cluster head, add to set G to all nodes in the remaining energy can be a Cluster Head. G is a set refers to a set of nodes that do not belong to their elected as Cluster Head. To the Cluster Heads in each round is maintained at a certain number, Nodes in every round on epoch that belong to the set G in each round on same epoch has the opportunity to become a Cluster Head Node. When the start of each round is determined, using a random number between 0 and 1. And verify that each of the nodes to ensure that independently of s is set in the set G. If the random number is less than the threshold $T(s)$ is a Cluster Head Node in the current round. In Formula (2), r is current round. It assigns an optimized probability weight at p_{opt}. $n \times (1+\alpha m)$ Node's energy is equal to the initial energy of the Normal Node. The average number of Cluster Head in round on epoch should be equal to $n \times p_{opt}$, because in order to maintain the minimum energy consumption in each round on epoch. In Heterogeneous Scenario, the average number of the Cluster Head in round on epoch is $n \times (1+\alpha \cdot m) \times p_{nrm}$.

$$p_{nrm}=\frac{p_{opt}}{1+\alpha \times m},\ p_{adv}=\frac{p_{opt}}{1+\alpha \times m} \times (1+\alpha) \quad (3)$$

Probability weighted formula for Normal Node (p_{nrm}) and Advanced Node (p_{adv}) is Formula (3).

$$T(s_{nrm})=\begin{cases}\frac{p_{nrm}}{1-p_{nrm}\left(r \bmod \frac{1}{p_{nrm}}\right)} & \text{if } n \in G' \\ 0 & \text{otherwise}\end{cases},\ T(s_{adv})=\begin{cases}\frac{p_{adv}}{1-p_{adv}\left(r \bmod \frac{1}{p_{adv}}\right)} & \text{if } n \in G'' \\ 0 & \text{otherwise}\end{cases} \quad (4)$$

In Formula (4), r is current round, G' is a set of nodes that are not within a Cluster Head last $\frac{1}{p_{nrm}}$ round on epoch. And $T(s_{nrm})$ is thresholds that apply to the Normal Nodes. This ensures that the Normal Node that is the Cluster Head exactly once in every $\frac{1}{p_{opt}} \times (1+\alpha \times m)$ round on epoch. The average number of the Cluster Head on epoch is $n \times (1-m) \times p_{nrm}$.

G'' is a set of nodes that are not within a Cluster Head last $\frac{1}{p_{adv}}$ round on epoch. And $T(s_{adv})$ is thresholds that apply to the Advanced Nodes. This ensures that the Advanced Node that is the Cluster Head exactly once in every $\frac{1}{p_{opt}} \times \frac{1+\alpha \times m}{1+\alpha}$ round. This period is defined as a Sub-epoch.

Each epoch has $1+\alpha$ of Sub-epoch. As a result, Advanced Node in Heterogeneous epoch becomes a Cluster Head are exactly $1+\alpha$. The average number of the Cluster Head in round on epoch is $n \times m \times p_{adv}$.

2.4 TEEN (Threshold sensitive Energy Efficient sensor Network protocol) [5]

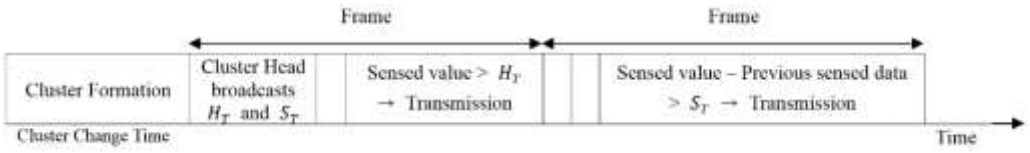

Figure 1. Timeline of TEEN

TEEN also operations similar to LEACH Protocol, but Sensor Nodes are do not have a data to be transmitted on a periodic basis. Therefore, TEEN is a protocol for Reactive Sensor Network.

TEEN is formed using the clustering method of LEACH Protocol, but data transmission phase is to use different method of LEACH Protocol. Figure 1 is a Timeline of TEEN.

In TEEN, it determines whether the current sensed value transmission according to the Cluster Head broadcasting threshold H_T and S_T when sensor nodes in the cluster change time. If the value of the sensed data for the first time exceeds H_T, stores and transmits the time slot. If the value of the sensed data from the subsequent transmission it is greater than stored value S_T, stores and transmits the time slot.

2.5 Divided Layer [7]

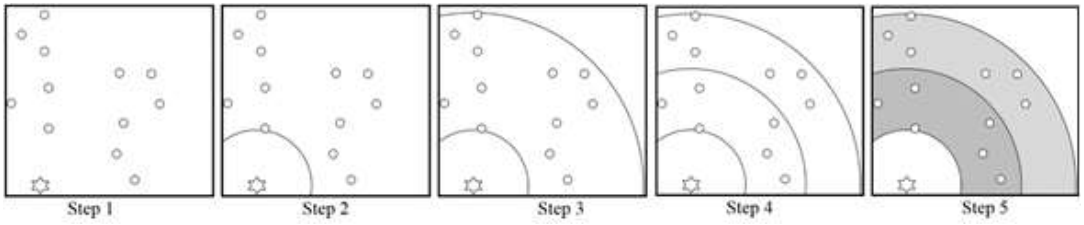

Figure 2. Step of Division Layer

- *Step 1*: It is assumed that the sensor node is shown on the left in the sensor field. The circle is a sensor node, and the Base Station is shown as a Star.
- *Step 2*: Measure the distance to the closest node from Base Station.
- *Step 3*: Measure the distance to the farthest node from Base Station.
- *Step 4*: Using the mid-point of distance between the closest node from Base Station and the farthest node from Base Station, Divided the sensor field layer.
- *Step 5*: The layer of light gray which is far from the Base Station, we called the Outer Layer. And layer of dark gray which is near from the Base Station, we called the Inner Layer.

After the divided Layer, it performs the clustering as using protocols like LEACH, TEEN and SEP in each layer. After it completed the clustering each layer, member nodes in the cluster are sent their sensing data to the cluster head. Cluster Head Nodes are aggregation the received data from the member node.

Cluster Head Nodes in the Outer Layer are transmitted aggregation data to the closest Cluster Head Node in the Inner Layer. Then, Cluster Head Nodes in the Inner Layer aggregates the data of the Outer Layer. Finally, Cluster Head Nodes in the Inner Layer are transmitted data to the Base Station.

3. Simulation and Result

Table 1. Simulation parameters

Parameter	Value	Parameter	Value
Numbers of Sensor Nodes(n)	100, 200	Initial Energy(e_0)	0.5J
Sensor Field	1000 x 1000	Size of Packet	1000bits
Ratio of Advanced Node(m)	20%	Data Aggregation(E_{DA})	5nJ/bit/signal
Probability of Cluster selection (p)	10%	Energy dissipation to run the radio device(E_{elec})	50nJ/bit
Advanced Node Additional Energy (α)	3	Free space model of Transmitter Amplifier(ε_{fs})	10pJ/bit/m^2
Position of Base Station	0 x 0		

We are simulated with MATLAB to evaluate the performance of protocols as mentioned before. It uses First order radio model as a transmission model. In Table 1 indicates the parameters of first order radio model and parameters of this simulation. We do an experiment on two different size of sensor nodes, sensor field has 100 and 200 of sensor node. This sensor node has placed randomly. If same number of sensor node, same the position of the sensor node and compared to the network lifetime.

First, it compared the network lifetime of LEACH Protocol, SEP, and TEEN.

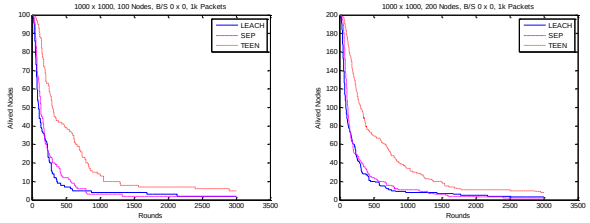

Figure 3. Network lifetime comparison of Protocol

If number of sensor node is 100, SEP has increased up to 131% network lifetime than LEACH Protocol. TEEN has increased up to 322% network lifetime than SEP, and increased up to 303% network lifetime than LEACH Protocol. If number of sensor node is 200, SEP has increased up to 283% network lifetime than LEACH Protocol. TEEN has increased up to 341% network lifetime than SEP, and increased up to 323% network lifetime than LEACH Protocol.

Table 2. Network lifetime comparison of Protocol

Sensor Nodes	100					200				
Node Alive Ratio	FND	80%	50%	30%	LND	FND	80%	50%	30%	LND
LEACH Protocol	23	56	101	220		12	52	96	207	
SEP	25	69	132	200		34	75	121	194	
TEEN	54	149	306	644		12	144	310	662	

Next, it compared the network lifetime improvement ratio of applying the proposed method with LEACH

Protocol, SEP, and TEEN

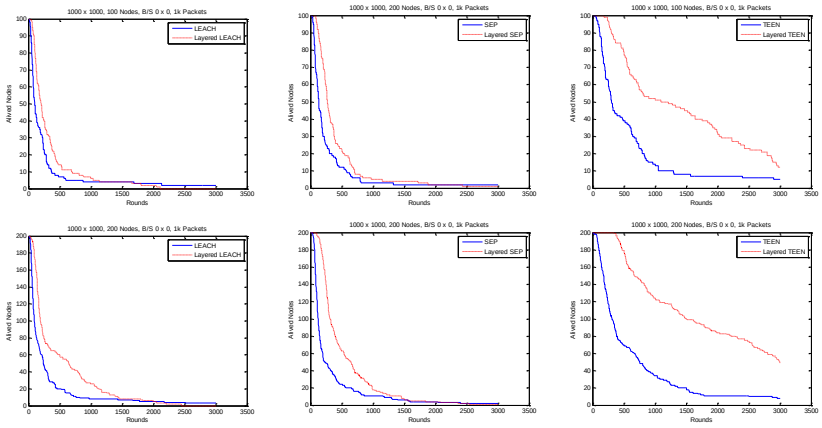

Figure 4. Network lifetime improvement compared to the each protocol

Table 3. Network lifetime improvement compared to the each protocol

Sensor Nodes			100					200		
Node Alive Ratio	FND	80%	50%	30%	LND	FND	80%	50%	30%	LND
LEACH Protocol	23	56	101	220		12	52	96	207	
L-LEACH	45	105	202	342		31	121	192	481	
Improvement Ratio	196%	188%	200%	155%		258%	233%	200%	232%	
SEP	25	69	132	200		34	75	121	194	
L-SEP	85	167	268	379		93	175	234	534	
Improvement Ratio	340%	242%	203%	190%		274%	233%	193%	275%	
TEEN	54	149	306	644		12	144	310	662	
L-TEEN	178	488	1094	2030		341	574	1499	2803	
Improvement Ratio	330%	328%	358%	315%		2842%	399%	484%	423%	

Finally, it compared the network lifetime of applying the proposed method with LEACH Protocol, SEP, and TEEN.

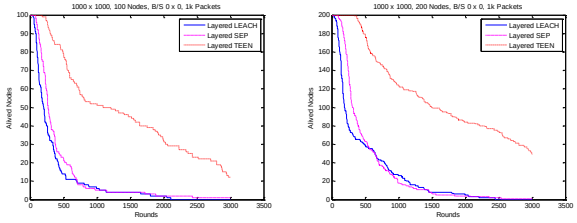

Figure 5. Network lifetime comparison of Protocol applied the proposed method

If number of sensor node is 100, L-SEP has increased up to 189% network lifetime than L-LEACH. L-TEEN has increased up to 536% network lifetime than L-SEP, and increased up to 594% network lifetime than L-LEACH. If number of sensor node is 200, L-SEP has increased up to 300% network lifetime than

L-LEACH. L-TEEN has increased up to 641% network lifetime than L-SEP, and increased up to 1100% network lifetime than L-LEACH.

Table 4. Network lifetime comparison of Protocol applied the proposed method

Sensor Nodes			100					200		
Node Alive Ratio	FND	80%	50%	30%	LND	FND	80%	50%	30%	LND
L-LEACH	45	105	202	342	2111	31	121	192	481	2452
L-SEP	85	167	268	379		93	175	234	534	
L-TEEN	178	488	1094	2030		341	574	1499	2803	

4. Conclusions

In Simulation result, Network lifetime is better order as TEEN, SEP, LEACH Protocol in Heterogeneous Network with Wide-area sensor field. Using protocol applied the proposed method, network lifetime improved order rate is high as TEEN, SEP, LEACH Protocol.

Therefore, Wireless Sensor Network Protocol which has longest network lifetime in Heterogeneous Network with Wide-area sensor field is Layered-TEEN.

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