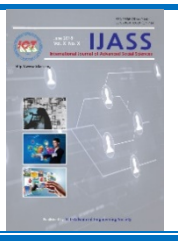
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The Cluster Algorithm for Wireless Sensor Networks Using the Residual Energy and Position

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Abstract

The network lifetime is one of important requirements for many wireless sensor network applications. An effective protocol must be adopted. Based on the extensive analyzing of these algorithms such as LEACH, cluster algorithm for wireless sensor networks based on residual energy and position is presented, named MLEACH. It saves much more energy while forming the cluster according to residual energy of sensors and fringe position within clustering.

Keywords: *Cluster Algorithm, Residual Energy, Fringe Position, LEACH..*

1. Introduction

WSNs consist of hundreds to thousands of low-power multifunctioning sensor nodes, deployed at high density in regions requiring surveillance and monitoring, with limited computational, sensing capabilities and limited power. It is one of important requirements and one of the most challenging problem for many Wireless sensor network applications to prolonged network lifetime [1]. In LEACH, cluster are formed periodically by local coordination and each operation are divided into rounds. LEACHNEW [7] is a new version of LEACH, which modified the threshold of nodes to be cluster head, can avoid the nodes which has low energy to become cluster head.

2. Proposed Algorithm

The cluster head is elected within the cluster when its residual energy is less than a value which is the multiplication the electing coefficient and cluster head's initialization energy this round. To make energy load distribute evenly among all nodes, it is necessary to seek for the maximum residual energy among the nodes within the cluster, and specify it as the cluster head. The node which is near the edges or in the outer zone of the cluster area and whose residual energy is less than a threshold should not be elected to be cluster head to avoid the accumulated transmission energy of more nodes caused by increased distance[2]. A new electing coefficient can be set dynamically after cluster head selection according to number of nodes within cluster and energy dissipative value between cluster head node and member nodes.

The algorithm in this paper is described as follow:

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Step1: Initialize network.
Step2: The cluster head calculates its residual energy, $e_{h,resi\text{-}energy}$
Step3: If $e_{h,resi\text{-}energy}$ is less than the energy difference, $\triangle_{energy}$, a new election is started. $\triangle_{energy}$ is defined as

$$\triangle_{energy} = \varepsilon \times \text{MaxEenergy} \quad (1)$$

where MaxEenergy is the initial residual energy when this node was elected as the cluster head last time, ε the electing coefficient in percentage. The optimal ε value is obtained in our algorithm just as shown in [4]. The election procedure is briefly stated as follows:
step4: seek for the maximum residual energy, MaxResiEergy, among the nodes within the cluster.

$$\text{MaxResiEenrgy} = \max (e_{i,resi\text{-}enery}) \quad (2)$$

Where $e_{i,resi\text{-}enery}$ is the residual energy of node i in the cluster, i the serial number of the node, covering all nodes in the cluster, the node of MaxResiEenrgy's ID is set to k.
Step5: whether node k is at the fringe position of the cluster. If yes, go to step4, seek for the maximum residual energy, but not include node k;
Step6: If node k is not at the fringe position of the cluster , check its residual energy, E_{resi}. If E_{resi} less than threshold value, go to Step4; If not specify the node of MaxResiEenrgy as the new cluster head and substitute the MaxEnergy with MaxResiEenrgy. Repeat Step 2 to 6 until exceeds the assigned value.

2.1 Fringe Coefficient

We define here a variable-Fringe Coefficient(θ) we use in this paper to determinate fringe position. It is defined as follow:

$$\theta = d / R \quad (3)$$

Where d be distance of member node from the clusterhead, R be the radius of clusterhead

Considering that There are a great of nodes in the region, so the distance of member node from the clusterhead d is relatively short, the propagation loss c an be modeled as inversely proportional to d^2 . So it can be calculated from equation (4) as follows:

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \quad (4)$$

where
Pr(d) is the receive power given a transmitter_receiver separation of d
P_t is the transmit power , G_t is the gain of the transmitting antenna
G_r is the gain of the receiving antenna, λ is the wavelength of the carrier signal
d is the distance between the transmitter and the receiver and
$L \geq 1$ is the system loss factor not related to propagation

Assume there are N nodes distributed uniformly in an M×M region, there are K clusters. Under perfect condition, the region should be covered by K clusters. Assume this region are K circle with radius R[3]. Assume the area is same. Therefore, the radius of clusterhead is:

$$R = \sqrt{\frac{c}{K\pi}} M \quad (5)$$

where c be a constant, $c \geq 1$, is set to ensure the clusterhead can cover the region completely.
The fringe Coefficient value we proposed in this paper will be concluded by experiment.

2.2 Selection Coefficient

The electing coefficient (ε)[4] is the key parameter to network lifetime. If it is too high, the residual energy of all nodes will be even in the progress but redundant rounds of election happen. Although the network might work as normal, the network has to endure the intermittently climbing lack of working nodes and the performance will surely be affected. We believe that the performance of network can be guaranteed more reliably when all the nodes

work. The mostly expected result is all the nodes run as long as possible and die at the same time due to exhaustion of energy.

The optical ε value is related to number of nodes (n), energy consumption of cluster head ($ECch$)and energy consumption of cluster member($ECcm$). ε descends when n and $ECcm$ decrease and when $ECch$ increases. Experiment shows that network lifetime can be prolonged when cluster head are electing with the optical ε value. So it can be calculated from equation (4)as follows[5]:

$$\varepsilon = 0.003579 \times n + 0.152 \times ECcm - 0.0291 \times ECch + 0.682 \tag{6}$$

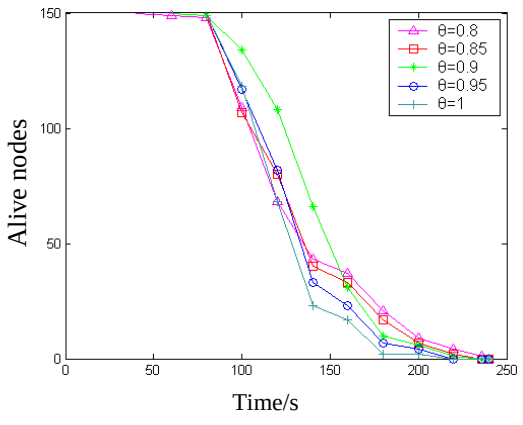
2.3 Optimal Fringe Coefficient

So Optimal Fringe Coefficient will be acquired by experiment [6]. We have simulated the performance of fringe coefficient using the simulation parameters (as specified in Table1) with MATLAB. The simulation parameters are same as in [8]. The all parameters can be changed according to the different simulation positions. Four different positions of number of nodes can be tested .The number of nodes is set as 50, 100, 150 and 200, base station at (50,175).

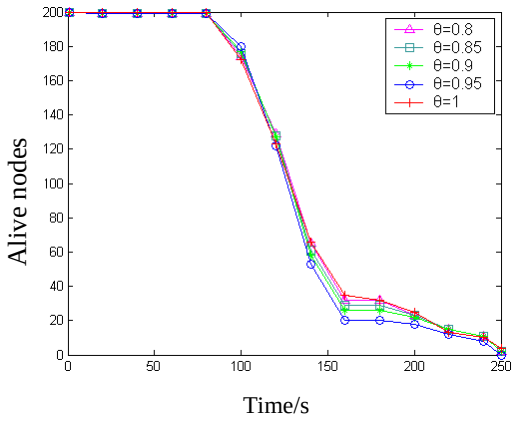
Table1 Transmission Model Parameters Value

Parameters	Value	Parameters	Value
E_{elec}	5nJ/bit	ε_{fs}	10pJ/bit/m^2
Data packet size	4000bit	ε_{mp}	0.0013 pJ/bit/m^4
E_{fusion}	5nJ/bit/message	M	100m
E_{init}	0.1J	p	0.05

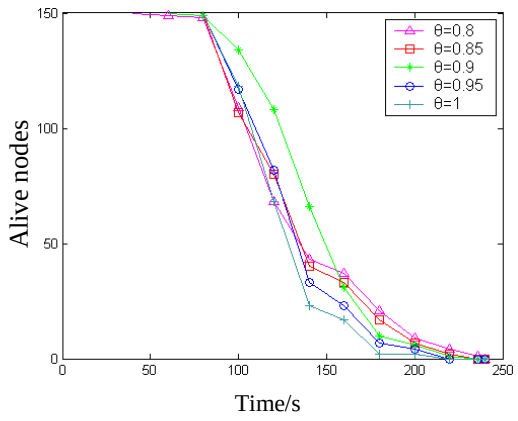
Fig. 1 shows variations of the Fringe Coefficient versus number of nodes. The number of alive nodes per round decrease when time goes up.



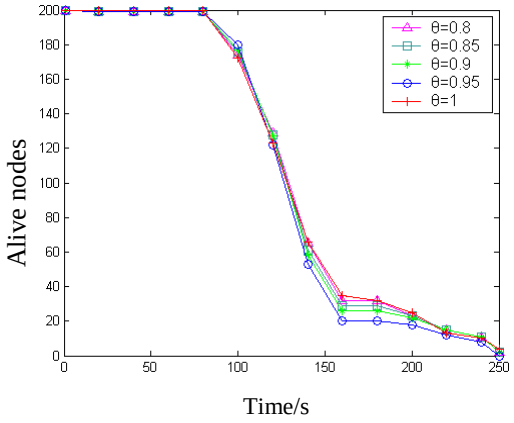
（a）50 nodes



（b）100 nodes



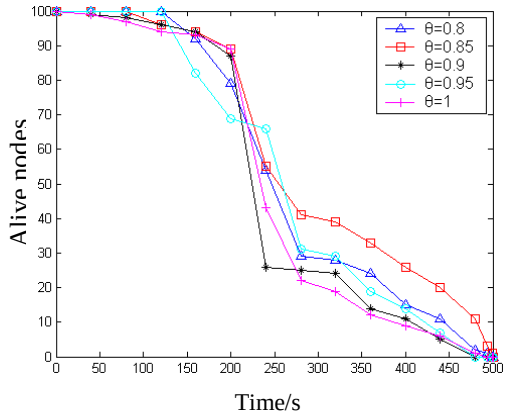
（c）150 nodes



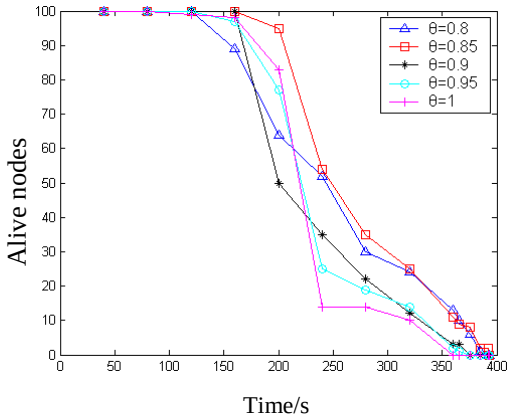
（d）200 nodes

Fig. 1. Fringe Coefficient versus number of alive nodes

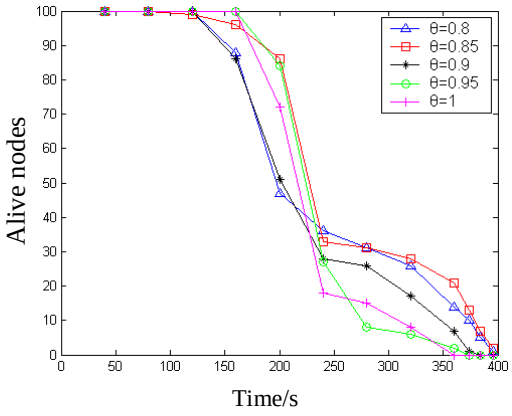
The optimal fringe coefficient in four different position are 0.65, 0.85, 0.90 and 1. We repeat the same experiment, but now the parameter of base station are set at(50, 50)、（50, 150）、(100, 150), the node number is 100.The results are shown in Fig 2.



（a）Base station at(50，50)



（b）Base station at（50，150）



（c）Base station at(100，150）

Fig. 2. Relation of θ vs. base station

The Fringe Coefficient value formula can be expressed passing through many times simulation. The Fringe

Coefficient value formula is described as flows:

$$\theta = \begin{cases} \min(\sqrt{\frac{\pi N}{S \times p}}, \gamma) & R < R_T \\ \min(\sqrt{\frac{\pi N}{S \times p}}, 1) & R > R_T \end{cases} \quad (7)$$

Where is the area of the region; N is the number of nodes in the network; p is percentage of the nodes to be cluster head; R is the radius of cluster head; R_T is maximum communication distance of cluster head; γ is the ratio of R_T and R. Assume S and p is a constant, the more N is, the larger the Fringe Coefficient value is. Table3 shows comparison of result. There is also some error between experiment result and computed result.

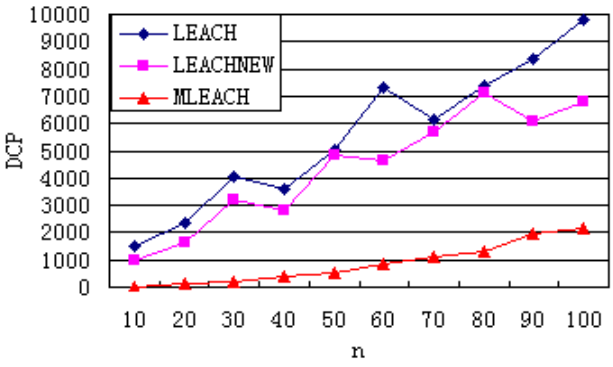
Table 3. The comparison of result

Number of node	Calculated result	experiment result	Error(absolute value)
50	0.5605	0.65	0.0895
100	0.7927	0.85	0.0573
150	0.9708	0.90	0.0708
200	1.1200	1.00	0.1200

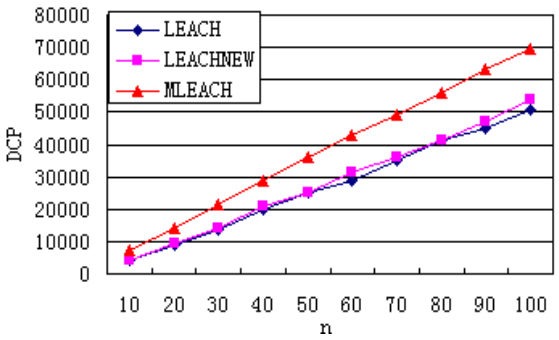
3. Simulation

We use: 1. DCP (data communication procedure) to represent lifetime. DCP means the period of a round of data transfer, including data detection, data transmission and data receipt of a sensor nodes in this cluster ; 2. r. The r means the times of reversion of cluster head.

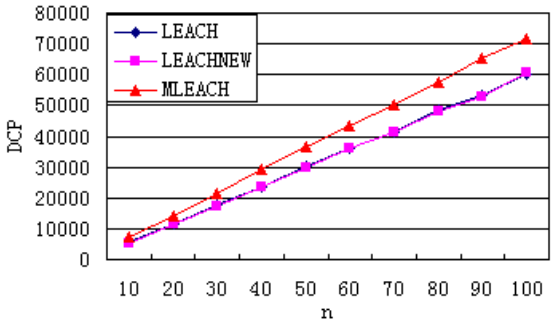
DCP_first and DCP_last mean that DCP when the first node die and the last node die ,△DCP means the difference of DCP_last to DCP_first ; r_first and r_last express that round of the first node die and the last node die. We have simulated the performance of LEACH、LEACHNEW[7]. MLEACH in the same situation with initial energy of 0.2J. The variations of △DCP,DCP_first, DCP_last, r_first and r_last are shown in Fig 3, when the number of nodes increase.



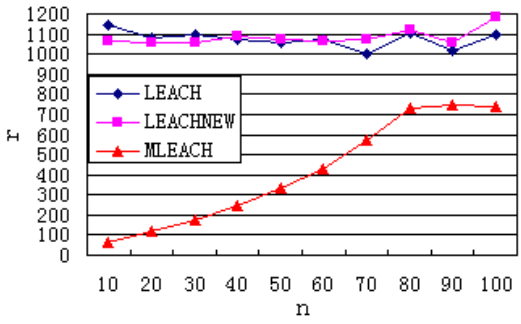
(a) Comparation of DCP



(b) Comparation of DCP fir



(c) Comparation of DCP_last



(d) Comparation of r

Fig. 3. The coparation results of three protocol

In (a), ΔDCP of MLAECH decrease greatly, which mean that all nodes die at the same time due to exhaustion of energy, it can make energy load distribute evenly. The distributed energy load of MLEACH is improved significantly in comparison with that of LEACHNEW and LEACH by 84.53%, 80.36%. In (b), The DCP_first of MLEACH is prolonged significantly in comparison with that of LEACHNEW and LEACH by 43.24%, 37.7%. The larger of DCP_first is, the better superiority of network performance. In (c), The DCP_last of MLEACH is increased significantly in comparison with that of LEACHNEW and LEACH by 21.56%, 21.88%.That is to say that network lifetime is prolonged. In (4), the rotation of the cluster head of MLEACH is decreased greatly, because cluster head are electing with the optical ε value. The simulation results show that this algorithm which is more effective routing protocol prolongs the network lifetime.

4. Conclusion

We proposed MLEACH so the cluster heads are selected according to maximum residual energy of sensors and fringe position within clustering. Improvement of node lifetime is varied for different parameter. The main purpose is to obtain the maximum network lifetime while the initial performance of system should be maintained as possible as normal. The Fringe Coefficient value formula also can be proposed. When the Fringe Coefficient value is adapted in the algorithm, the lifetime can be prolonged while the performance of the network can maintained unabated. Our research motivation is to introduce the application of WSNs into monitoring drought in agricultural production.

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