An Efficient Non-ACK Routing Protocol in Wireless Sensor Network

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Abstract

This paper discusses the direct transmission scheme with no acknowledge (NACK). A sensor sends data to another node or cluster head which, normally, will send a message back to ensure whether or not the data can be sent and received. Conditions for data sent may be vary so that this paper only considers the condition that data sends with no acknowledge. Simulation reveals the energy performance is about 33% better compared to the transmission scheme with ACK in LEACH. Here, failure of data sent or received is ignored. Base station can, however, handle the failure data sent.

Keywords: Acknowledge, LEACH, Protocol.

1. Introduction

Sensors send and receive data for each other. The main purpose for sensors is to collect useful data back to the base station. During the data sent and received, sensor needs much energy to support itself in order to have longer surveillance [3]. However, sensors supplied with city power are not paid much attention on energy saving of sensors. That is because sensors are going to be deployed to the place where its battery is hard to be rechargeable. In order to have the sensing data back to base station, wireless and networking technique [4] are reasonable applied especially in routing protocol scheme. Therefore, energy consumption [9] [10] becomes more and more important to be discussed. Traditionally, sensors directly send data back to base station and its energy will be run out quickly [1]. The solution of multi-hop [2] [8], however, can have better energy performance compared to the direct transmission technique. Sensors in these two techniques consume different energy which means sensors cannot evenly consume their energy. The result of these two techniques show some sensor nodes run out of energy very quick first. So, clustering-based network could be useful for unevenly energy consumption of sensors. In year 2002 [2], LEACH (Low Energy Adaptive Clustering Hierarchy) shows better performance than others' before. It uses probability and randomly cluster head choosing method to extend its networking lifetime. Papers [5]-[7] published later on also compared to the LEACH protocol. However, these schemes use the transmission with *ACK* to ensure that data can send back to the base station. However, sending data back to the base station with *ACK* and *NACK* will be discussed in this paper. This paper ignores nodes' failure sent data back.

2. Network Model

This paper uses the network scheme discussed in [2]. The transmission energy consumption, E_{TX} , from a node to cluster head is shown below.

$$E_{TX} = l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{toCH}^2 . \quad (1)$$

Moreover, the received energy consumption, E_{RX} , from one node to another node is shown below.

$$E_{RX} = l \cdot E_{elec} , \quad (2)$$

where l represents message (bits) sent between two nodes. Here, assumption of free space d^2 is applied. ε_{fs} represents an amplified transmitting energy in free space. Parameters used for simulation in this paper are the following lists:

Notation	Description
E_o = 0.5J/bit	Initial energy for every node
E_{elec} = 50nJ/bit	Per bit energy consumption
E_{DA} = 5nJ/bit	Energy of data aggregation
ε_{fs} = 10pJ/bit/m^2	Amplified transmitting energy

In order to ensure the data can be sent back to the cluster head, the node received data needs to send a confirmed message back, *ACK*. This takes more energy as shown below.

$$\begin{aligned} E_{A_Node} &= E_{TX} + E_{RX} \\ &= l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{toCH}^2 + l \cdot E_{elec} \\ &= 2 * l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{toCH}^2 \end{aligned} \quad (3)$$

Equation (2) is assumed that the amount of sent data from one node to another node is equal to the received data from one node to another node. The reason why the energy needs to be counted twice is data sent to another node consumes the *ACK* data to ensure that the data can be sent out. In reality, amount of *ACK* data is much less than the original sending data. Therefore, $\frac{1}{10}$ of the amount of *ACK* data is assumed as shown below.

$$\begin{aligned} E_{A_Node} &= E_{TX} + E_{RX} \\ &= l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{toCH}^2 + \frac{1}{10} \cdot l \cdot E_{elec} \\ &= 1.1 \cdot l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{toCH}^2 \end{aligned} \quad (4)$$

However, with *NACK* scheme, every node can directly send the data back to the base station. This will not consume the *ACK* energy and, therefore, the network lifetime can be extended. The consumed energy with *NACK* is shown below.

$$E_{A_Node_NACK} = l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{toCH}^2 \quad (5)$$

Moreover, supposed there are n nodes in a cluster. Every node sends its data to the cluster head and the cluster head consumes the energy as shown below.

$$E_{Total_CH} = n \cdot l \cdot E_{elec} \quad (6)$$

Also, as the cluster head receives the data, the optimal consumed energy from the cluster head to all its node member is shown below.

$$E_{OptCHMember} = l \cdot E_{elec} + l \cdot \varepsilon_{fs} d_{Max_toCH}^2 \quad (7)$$

3. Simulation results with *ACK*

First, 100 nodes are randomly deployed into 100 m * 100 m as shown in Fig. 1. In this paper, Matlab is used as a simulator.

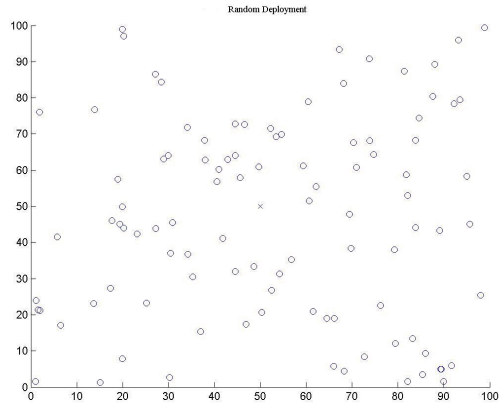

Fig. 1: 100 nodes are randomly deployed.

Fig. 2 shows the formation of clusters and how many nodes are still alive there. Here, "o" denotes a node is still alive where as ". " denotes node is no longer alive and "* " denotes a cluster head. Also, node's color represents which node belongs to which cluster. It is obvious that energy usage for nodes far away from the base station is less than those nodes closer to the base station.

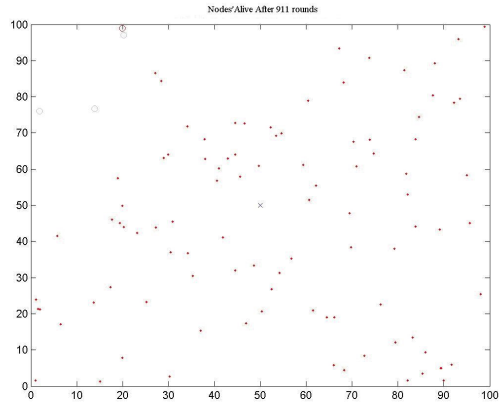

Fig. 2: Round 750

Fig. 3 shows nodes' lifetime in every round. Simulation show that the first node ran out of its energy at round 750 and the last node died at the round 1050. This shows no matter how far node is, energy usage for every round is almost the same.

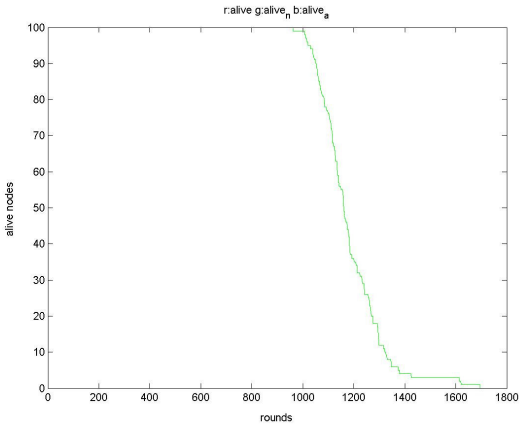

Fig. 3: Nodes' lifetime in rounds.

Fig. 4 shows that total packets are sent from cluster head to base station. Before the first node ran out of the energy, packets sent from cluster head to base station are the same. However, once first node starts running out of its energy, the total amount of packets to send back to the base station would be down.

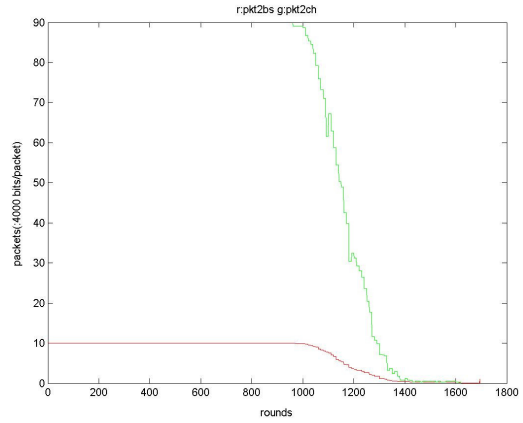

Fig. 4: packets to BS/CH.

With the probability to select the cluster head, numbers of cluster head are different for every round. Therefore, Fig. 5 shows the statistics which represents the amount of cluster head in every round. In this figure, there are totally 750 rounds as sampling. Simulation shows that more than hundreds times of 10 cluster heads are chosen. Moreover, with the probability to randomly select the cluster head, it was assumed every node should be the cluster head once. Hence, Fig. 8 proves this assumption.

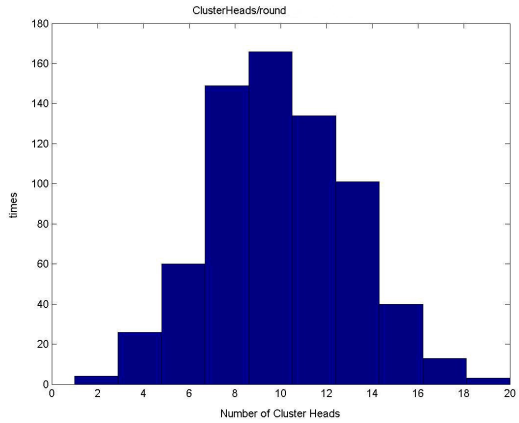

Fig. 5: Statistic of cluster head in 750 rounds.

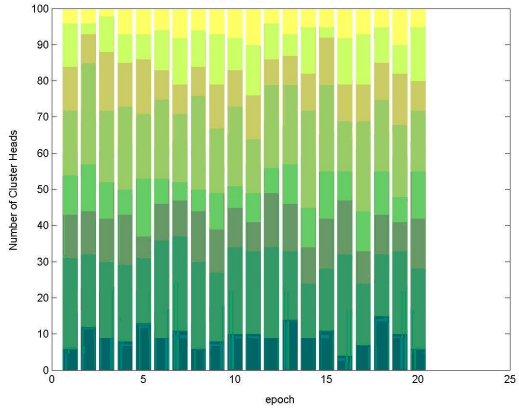

Fig. 6: Cluster head in the first 20 epochs.

In order to dissipate the energy from every node, probability and random variable are used for this simulation. Fig. 7 shows that before 800 rounds, energy can be dissipated evenly. Moreover, after first node ran out of its energy, the total energy is not much left.

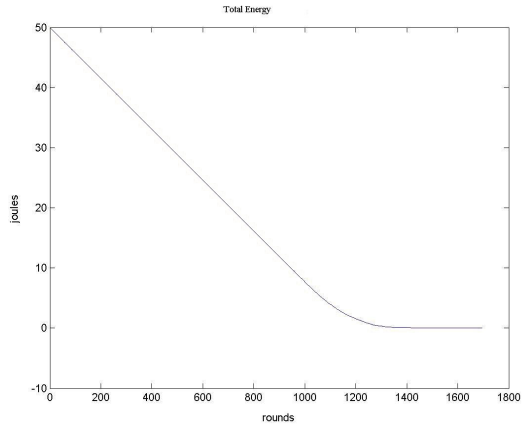

Fig. 7: Total energy changed in every round.

4. Simulation results with no *ACK (NACK)*

First, 100 nodes are randomly deployed into 100 m * 100 m as with no ACK shown in Fig. 8. In this paper, Matlab is used as a simulator.

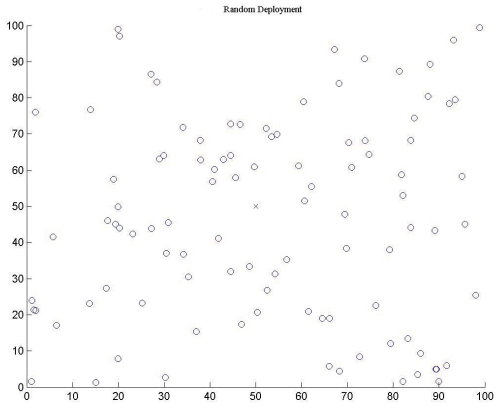

Fig. 8: 100 nodes random deployed.

Fig. 9 shows the formation of clusters and how many nodes are still alive there. Here, "o" denotes a node is still alive where as ". " denotes node is no longer alive and "* " denotes a cluster head. Also, node's color represents which node belongs to which cluster. It is obvious that energy usage for nodes far away from the base station is less than those nodes closer to the base station. Compared to the Fig. 2, with *NACK* scheme, more nodes are still alive.

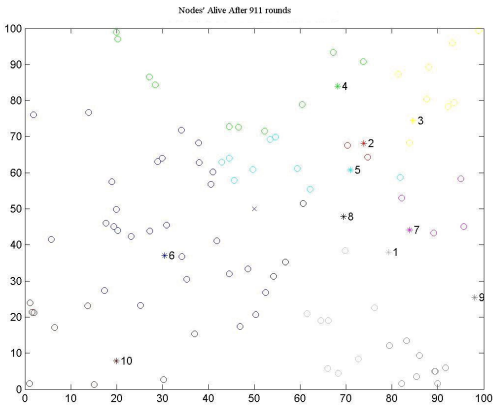

Fig. 9: Round 911.

Fig. 10 shows nodes' lifetime in every round. Simulation show that the first node ran out of its energy at round 911 and the last node died at the round 1695. This shows no matter how far node is, energy usage for every round is almost the same.

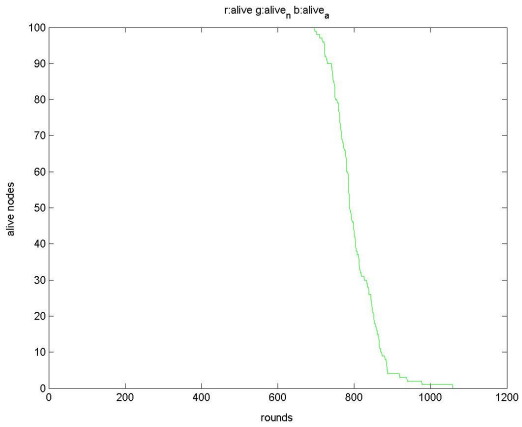

Fig. 10: Nodes' lifetime in rounds.

Fig. 11 shows that total packets are sent from cluster head to base station. Before the first node ran out of the energy, packets sent from cluster head to base station are the same. However, once first node starts running out of its energy, the total amount of packets to send back to the base station would be down.

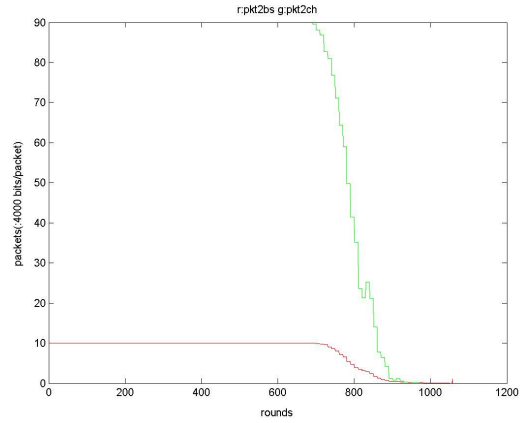

Fig. 11: packets to BS/CH.

With the probability to select the cluster head, numbers of cluster head are different for every round. Therefore, Fig. 12 shows the statistics which represents the amount of cluster head in every round. In this figure, there are totally 961 rounds as sampling. Simulation shows that more than hundreds times of 10 cluster heads are chosen. Moreover, with the probability to randomly select the cluster head, it was assumed every node should be the cluster head once. Hence, Fig. 13 proves this assumption.

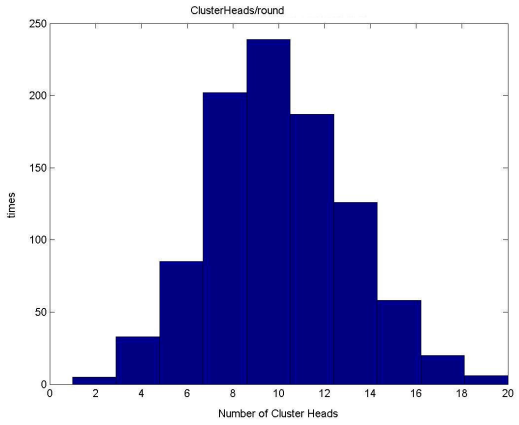

Fig. 12: Statistic of cluster head in 961 rounds.

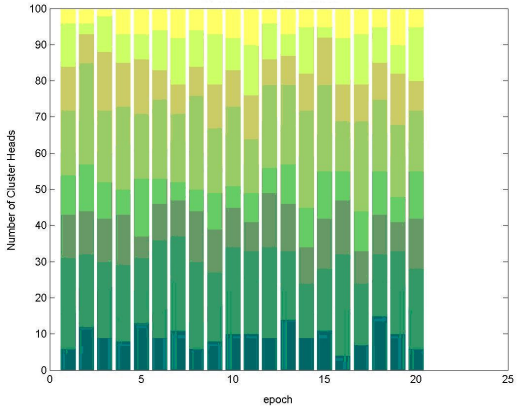

Fig. 13: Cluster head in the first 20 epochs.

In order to dissipate the energy from every node, probability and random variable are used for this simulation. Fig. 14 shows that before 1200 rounds, energy can be dissipated evenly. Moreover, after first node ran out of its energy, the total energy is not much left.

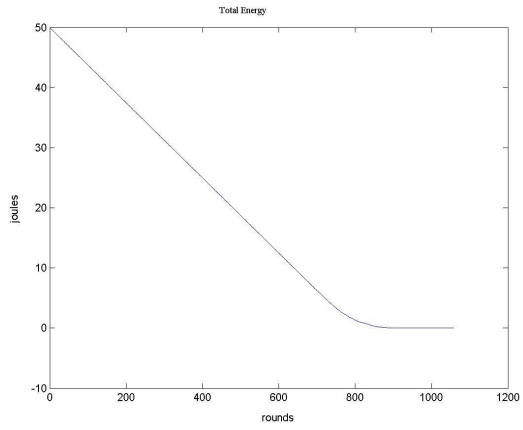

Fig. 14: Total energy changed in every round.

5. Simulation discussion

In this paper, 100 sensor nodes are deployed in the range of 100m * 100 m. The base station is set at the center of this area. By comparison between Fig. 3 and Fig. 10, Fig. 10 is about 33% better performances than the Fig. 3 which means the routing protocol with *NACK* is much better than the scheme with *ACK*. Also, nodes' lifetime at the round 750 shown in Fig. 2 is not many node's alive as the round 911 in Fig. 9 which also reveals the network lifetime by the routing protocol with *NACK* can be extended. Moreover, the number of optimal cluster heads for these two different schemes are the same.

6. Conclusion

This paper proposes a routing protocol with no acknowledge (*NACK*) and simulation results reveal its performance is about 33% better than the scheme with *ACK*. The reason why a wireless sensor network needs a routing protocol with *NACK* is it has the characteristic of faster speed to send data back to the base station and it can save much energy. However, in order to make sure whether or not a sensing data can be surely sent back to station, base station can play the role of judging which node is failure to send data back.

7. References

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