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A New Approach in WSN Protocol to Improve Performance of Network

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Abstract

Applications of wireless sensor networks comprise a wide variety of scenarios. A wireless sensor network with a large number of sensor nodes can be used as an effective tool for gathering data in various situations. In most of them, the network is composed of a significant number of nodes deployed in an extensive area in which not all nodes are directly connected. One of the major issues in wireless sensor networks is developing an energy-efficient routing protocol which has a significant impact on the overall lifetime of the sensor network. It is well known that clustering provides an effective method for prolonging the lifetime of a wireless sensor network. This paper provides a new approach in WSN protocol to improve LEACH algorithm to improve the performance of network.

Keyword: - Network, Life Time, Leach Protocol, Cluster head, energy consumption

Introduction

Wireless sensor network (WSN) consists of thousands of small devices (sensor nodes)distributed autonomously to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure and motion at different locations. It is desirable to make these nodes as cheap and energy-efficient as possible on their large numbers to obtain high quality results. Energy plays an important role in wireless sensor networks because nodes are battery operated. Energy is the scarcest resource of WSN nodes, and it determines the lifetime of WSNs. Hence, one of the most important aspects to improve the performance of the WSN network is to minimize the energy consumption and to increase the lifetime of the network which in turn increases the performance of the WSN network. Many efforts have been made to minimize the energy consumption in order to improve the performance of a network. In all the efforts made, Leach is considered as the most popular routing protocol that use cluster based routing in order to minimize the energy consumption. Many LEACH protocols have been developed such as LEACH[4,6],PAMAS[12], LEACH-C, LEACH-E, and LEACH-F [7][8]. This paper presents a new improved LEACH algorithm.

Leach

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical cluster-based routing protocol for wireless sensor network which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (Code division multiple access). Remaining nodes are cluster members.

In LEACH, the clustering task is rotated among the nodes, based on duration. Direct communication is used by each cluster head (CH) to forward the data to the base station (BS). It uses clusters to prolong the life of the wireless sensor network. LEACH is based on an aggregation (or fusion) technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors.

Related work in leach

A. E-LEACH protocol

In the E-LEACH (Energy LEACH) algorithm, the original way of the selection of the cluster heads is random and the round time for the selection is fixed. In the E-LEACH algorithm, we consider the remnant power of the sensor nodes in order to balance network loads and changes the round time depends on the optimal cluster size. The simulation results show that our proposed protocol increases network lifetime at least by 40% when compared with the LEACH algorithm.

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B. TL-LEACH

In LEACH protocol, the CH collects and aggregates data from sensors in its own cluster and passes the information to the BS directly. CH might be located far away from the BS, so it uses most of its energy for transmitting and because it is always on it will die faster than other nodes. A new version of LEACH called Two-level Leach was proposed. In this protocol; CH collects data from other cluster members as original LEACH, but rather than transfer data to the BS directly, it uses one of the CHs that lies between the CH and the BS as a relay station.

C. LEACH-C protocol

LEACH offers no guarantee about the placement and/or number of cluster heads. In [13], an enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the cluster heads throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location (possibly determined using GPS) and residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines which nodes have energy below this average.

D. M-LEACH protocol

In LEACH, Each CH directly communicates with BS no matter the distance between CH and BS. It will consume lot of its energy if the distance is far. On the other hand, Multihop-LEACH protocol selects optimal path between the CH and the BS through other CHs and use these CHs as a relay station to transmit data over through them. First, multi-hop communication is adopted among CHs. Then, according to the selected optimal path, these CHs transmit data to the corresponding CH which is nearest to BS. Finally, this CH sends data to BS. M-LEACH protocol is almost the same as LEACH protocol, only makes communication mode from single hop to multi-hop between CHs and BS.

Protocol performance

The design objective of the routing protocols for wireless sensor networks varies with the network application and operational environment. LEACH protocol is suitable for the WSNs under the following assumptions [3]:

1) All senor nodes are identical and charged with the same amount of initial energy.
2)Every node can directly communicate with every other node, including the sink node.
3) The Sink node is fixed and far away from the wireless network. Thus we can ignore the energy consumed by the sink node. We assume that it always has sufficient energy to operate.
4) Every node has data to transfer in every timeframe. The data transferred by sobering nodes are related and can be fused.
5) Sensor nodes are static.

WSNs are autonomous networks. Sensor nodes are independent with each other. The coordination between nodes is done through wireless communication, which costs much. This is one of the major reasons that the LEACH protocol selects cluster heads randomly. As we discussed before, this approach may cause the waste of energy because of unbalanced cluster head distribution.

To solve this problem, we propose a new approach to selecting cluster heads. We assume that:

1) The network satisfies the pre-conditions of applying LEACH protocol.
2) After deployment, sensors are able to know their positions through GPS, or before deployment, their positions are accurately decided.
3) All nodes are able to adjust data transmission power. If necessary they can communicate with the base stations to acquire the initial setting information of the network.

If we modify the procedure of the calculation of T(n)during the cluster head generation such that cluster heads are produced progressively, then a node could decide if it is suitable to be a new cluster head based on the locations of existing cluster heads and its own location. More specifically, if the node is very close to any existing cluster head, then this node will give up the attempt to be a cluster head. The cluster heads generated with this progressive approach will not be close to each other. However, because some nodes quit the competition for cluster head, the total number of cluster heads can be reduced, which is not good for saving the network energy. Our approach to solving this problem is, when a node is excluded in the cluster head selection, a message is broadcast to other nodes and T(n) will be modified to increase the probability of others nodes being selected as cluster heads.

The modified T(n) is:

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(rmod\left(\frac{1}{p}\right)\right) - pk} & n \in G \\ 0 & others \end{cases}$$

In above equation, k is the number of nodes that are excluded from the cluster head selection due to the location reason, with an initial value of 0. When k

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increases, T(n) increases as well, which will ensure sufficient number of cluster heads will be generated by the progressive algorithm.

To facilitate the explanation of our improved algorithm, we introduce the following notations:

B The base station or node Sink
Si The i-th sensor node
Hj The j-th cluster head
ID(Si) ID of the i-th sensor node
Mem(Cj) Members of the j-th cluster
Mem(Cj)I The i-th members of the j-th cluster
Loc(Si) Location of the i-th sensor node
Delay(Si) Time delay that the i-th sensor node start to compete for a cluster head
Num(Giveup) Number of discarded cluster heads
|| Operation of concatenation

A. Temporal distribution in cluster head selection

After the deployment of sensor nodes, we first acquire all nodes' location information (through GPS technology or known prior to its deployment) and report it to the base station. The base station decides Delay (Si) for every node based on the geographic distribution of all sensor nodes.

Delay(Si) = 0 for those in the region to start first. As illustrated above, nodes in G1 start to compete for cluster heads at time 0, then nodes in G2 start with adelay, and then nodes in G3 start with a delay after nodes in G2 are finished, and so on. During the process, nodes need to send their location information to the base station:

$S_i \rightarrow B$: *ID* (S_i),*Loc*(S_i)

The base station needs to send the delay information toeach node:

$B \rightarrow S_i$: *ID* (S_i), *Delay* (S_i)

B. Selection of cluster heads

Set Num(Giveup) to 0. Start with the nodes in G1. If a cluster head is generated from G1,broadcast a Hello package and Num(Giveup).

$H_j \rightarrow$*broadcast* :*ID* (H_j), *Hello, Num(Giveup)*

When nodes in G1 are finished, consider nodes in G2.

Now the cluster heads generated in G1 are reference points. The distance between a node inG2 and any cluster head in G1 is a factor in selecting the node as a cluster head, as well as the random value of T(n). If all conditions are satisfied, then broadcast the Hello message and Num(Giveup).

$H_j \rightarrow$*broadcast* : *ID* (H_j), *Giveup, Num(Giveup)*

Otherwise, only broadcast Num(Giveup). When nodes in other region receives this message, they will increment Num(Giveup) by 1, and then modify T(n) to increase the probability of being selected as cluster head.

Repeat the above process until all nodes in the network are considered.

Performance analysis

NS2 (Network Simulator 2) is a very popular network simulation platform. It is a discrete event simulator designed for network research. To support the performance analysis of LEACH protocol , W. Heizelmanet al. [14] extended NS by introducing an event-driven simulator. In the simulator the Tcl class Application/LEACH implements all functions for WSNs, including competition for cluster heads and data transmission. When the simulator is loaded with initial network settings, start() function starts to run, which invokes the DecideClusterHead() function to select cluster heads. We made a few modifications on top of the simulator extended by Heizelman.

In order to evaluate the performance of different algorithms, we use two scenarios to simulate the algorithms. In scenario 1, the region size is 100 meters by100 meters, the number of nodes is 100, and the BS is located at（50，175); In scenario 2, 400 sensor nodes are distributed in a 200 meters by 200 meters region and the BS is geographically located at（100，250).

A. Simulation Results

(1) Performance measurements in a wireless sensor network, the computing capacity and stored energy of a node is very limited. In particular, the limited energy affects the lifespan of information quality of the network. For this reason, we evaluate the algorithms based on the efficiency of the network energy consumption. We use two performance indices:

Lifespan: The lifespan of a sensor network is the time span from the beginning of the network operation. It can be measured in three ways: FND (First Node Dies), HNA (Half of the Nodes Alive, and LND (Last Node Dies).

Data accuracy: The accuracy of data received by the BS. The more the data is received, the high the accuracy after data fusion. The data accuracy is measured by the total data sent by all nodes in the lifespan of the network.

(2) Analysis of simulation results

We compare the performance of the original LEACH clustering protocol and our progressive clustering protocol.

Figs. 1shows the change of FND, HNA and LND over the distance between cluster heads. As we can see, the lifespan of the network increases when the distance between cluster heads increases and reaches the cap when the distance is around 35 and 40. After that, when the distances increases further, the number of cluster heads goes down, and the energy consumption of the network goes up, which leads to the decline of the lifespan and data accuracy.

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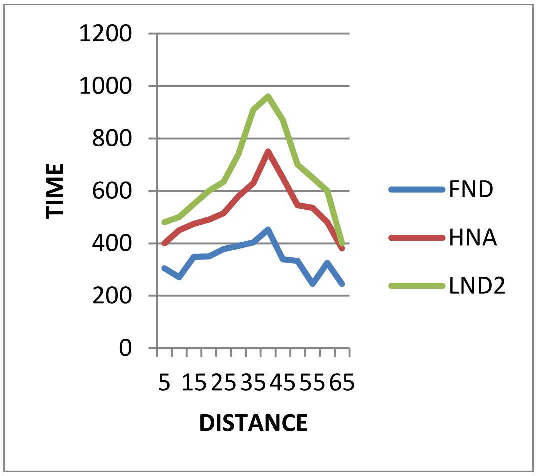

Fig. 1 FND, HNA, LND2 vs. the distance between cluster heads

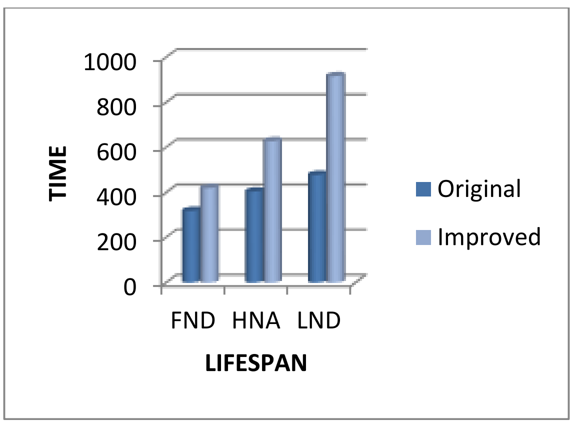

Fig. 2 Comparison of the lifespan of the two protocols

It is clear from the simulation results shown in Fig. 2 that the lifespan of the new progressive clustering protocol is longer than that of the original LEACH protocol. The data transferred with the new protocol is1/3 more than that with the old protocol, and the lifespan of the network with the new protocol is almost doubled compared with that of the old protocol.

Conclusion

In this paper, a well known protocol is considered for wireless sensor networks called LEAH protocol which is the first and the most important protocol in wireless sensor network which uses cluster based broadcasting technique. The cluster head generation algorithm with the original LEACH clustering protocol can cause unbalanced distribution of cluster heads, which often leads to redundant cluster heads in a small region and thus cause the significant loss of energy. To solve this problem, we proposed a progressive algorithm for the cluster head selection. Simulation results show that our algorithm is much more efficient and can double the lifespan of a wireless sensor network. The algorithm can be easily implemented. We simulated the performance of our algorithm in two scenarios, one is a dense network – with 100 nodes distributed in a 100 meters by 100 meters area, the other one is a less dense network – with 200 nodes distributed in a 200 meters by 200 meters area . There is an assumption on the selection of new cluster head and key management scheme, which is the locations of nodes in a network are known. In reality this assumption may not be true. We will improve our protocol to deal with such situations.

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