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Research of Energy Resources of Cluster Sensor Network

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Abstract

The actuality of wireless sensor networks determined by the concept of intellectualization of objects such as home, office and industrial premises where a person spends 90% of his time, and the concept of cyber production whose main task is to introduce wireless technology the automation of industrial processes.
Wireless sensor network (WSN) is a self-organizing composed of a large number of sensors that randomly positioned in a region subject to monitoring, and transmit data to each other through wireless communication. Since they are very limited on how to use the energy of nodes effectively, how to balance energy consumption in the network and to extend networks life, are the basis for the design of wireless sensor networks.
Designing and deploying sensor networks requires a variety of complex issues related to different areas of network application. An important challenge for sensor networks is the limited hardware resources of sensors such as computing capacity, memory, and energy, which resolves the important energy resource problem in sensor network design. To save energy sensor network, which is the most limited resource that must be optimized reporting and processing of data, particularly when transmitting data.
Solutions to the energy efficiency of sensor networks can achieved through different approaches from hardware solutions to application of different protocols. Grouping nodes in sensor networks is also an effective approach to reducing the energy consumption of nodes. Clustering algorithms extend the life of the network by avoiding the communication of sensor nodes with the base station over long distances.
The authors researching the energy resources of cluster sensor networks working with the LEACH, N-LEACH and H-LEACH protocol. A comparative analysis of the results is made, establishing differences in the consumption of energy, depending on the used protocol.

Keywords: Wireless sensor networks, Protocols, Energy resources.

1. Introduction

The wireless sensor network (WSN) [1] is self-organizing, composed of a large number of sensors that are randomly located in a monitored region, and transmit data to each other through wireless communication. Sensor nodes depend on battery power, communication capability and power storage capacity. Because they are very limited, questions about how to use nodes energy efficiently, how to balance energy consumption in the network and extend its life are at the center of designing a wireless sensing network.

Sensor nodes are powered by batteries with limited energy resources. Extending network life for these nodes is the most important target for increasing network productivity [1]. Sensor networks can consist of many different types of sensors (seismic, magnetic, etc.). WSN's applications include observing a wide variety of environmental conditions such as temperature, humidity, etc.

The growing complexity of multi-process management systems raises increasingly serious issues related to the ability of people to share and analyze real-time sensor data. However, due to wireless sensor network's limitations in sensor memory, energy resources, calculations, communication and scalability, effective management of the large number of wireless sensor network's data in these areas is an important challenge facing the scientific community and industry [2].
Depending on the network structure, routing in WSN can be divided into: flat-routing (data-oriented), hierarchical-oriented routing and location-based routing. In hierarchical routing, nodes play different roles in the network. Its primary purpose is to maintain low power consumption of sensor nodes by plugging them into multi-hop communication in a particular cluster. Here, aggregation and data synthesis is performed to reduce the number of messages transmitted to the base station (BS).

Here all nodes get the chance to become cluster heads for a certain period (the cluster period) [3]. LEACH is one of the widely used hierarchical protocols for dynamic clustering of sensor networks [3].

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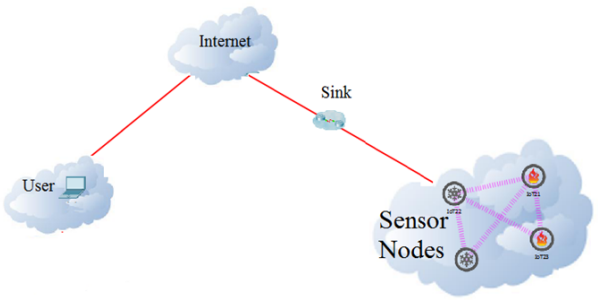

Fig. 1 Wireless Sensor Network Structure

2. Material and method

2.1 Low Energy Adaptive Clustering Hierarchy (LEACH)

All nodes have a certain life cycle during which the nodes have limited energy, in this period of time nodes collect, process, and transmit information. This means that all aspects of the node, from the sensor module to the hardware and the protocols, must be designed to be extremely energy efficient. To reduce energy dissipation, the protocols must be scalable, resistant to failures, and to maximize system life [2].

LEACH is a network protocol based on the TDMA MAC protocol that uses clustering and simple wireless sensor networking (WSN) routing protocol. The advantage of LEACH is to reduce energy consumption by creating and maintaining clusters, thereby increase the life of the wireless sensor network [4].

LEACH uses hierarchical routing for wireless sensor networks to extend network life. All nodes in the network are organized into local clusters, in with one node act as a cluster head. All end nodes transmit their data only to the cluster head. The cluster-head receives data from the end nodes in the cluster, performs data processing functions (e.g., data aggregation), and transmits data to the remote base station. Hence, the cluster-head node should be much more energy efficient. To achieve this energy efficiency level, different variations of LEACH have been created to measure the energy levels of all nodes in the network (through different methods), in order to choose cluster-heads with the highest energy level efficiency. When the cluster head node is damaged, all nodes that have been connected to it lose communication ability [3] [5].

LEACH chooses which sensor nodes to be cluster heads (CH) by rotation in order to avoid energy dissipation of the sensors in the WSN [4]. By rotating, the energy load is evenly distributed between the nodes. LEACH divides the network into rounds. Each round starts with a set-up phase in which the clusters are organized, in the next phase several frames of data are transferred from the nodes to the cluster head and from there to the base station [5].

TDMA protocols create a schedule for network activity: Each node defines several slots in a period, which it uses to obtain a packet from each source to the base station [6].

The properties of LEACH include:

1. Select random cluster heads each round by rotation. Or choosing a cluster head based on the highest energy level sensors
2. Adapting cluster membership
3. Aggregate data in the cluster heads
4. The cluster head communicates directly with the base station
5. Cluster Head communication via TDMA
6. Threshold value

In LEACH, there is 4 various of phases [7]:

Advertisement phase. In cluster formation time, the nodes competing to be selected for cluster heads must choose a random number between 0 and 1. If the random number is less than the threshold, the node will be selected for a cluster head CH. Once all CHs selected, they all maintain the same signal strength. The remain nodes (which are not CHs) receive messages and choose their own CHs, based on signal strength (they receive), with higher signal strength indicating that the node is closer to CH. Higher signal strength / shorter distance requires the smallest transmit power to CH [7].

Cluster setup phase. Based on received signals, the node choose to join with the nearest CH and sends a response to the same CH.

Schedule creation phase. CH maintains a list of its members by requiring Time Division Multiple Access (TDMA) and transmit a schedule for communication to its members [7].

Data transmission phase. The non-CH nodes communicate with the CHs until the radio is active. Once CH has received all data from their slaves, the data is compressed to a singular signal and transmit to the base station. Figure 1 shows the components of a cloud sensor structure including sensor network provider (SNP), cloud service provider (CSP), and cloud service user (CSU). Sensor network provider (SNP) offers different types of sensor nodes (e.g., static sensors, mobile sensors, video sensors) that form WSN, collect various sensor data (e.g., temperature, humidity, motion, sound, vibration, pressure, and movement). Cloud service provider (CSP) provides a powerful cloud consisting of data centers storing and processing sensor data transmitted by wireless sensor network (WSN) [7].

Scheme of the work algorithm LEACH is shown in Figure 2.

2.2 Hierarchical LEACH (H-LEACH) [2]

H-LEACH is used to minimize the energy level by minimizing the transmission distance (longer distance - more energy, less distance - less energy). In the first round H-LECH works like LEACH [7]. In the next rounds a method for optimizing the data transmission distance to a base station [7] is used to select which nodes will become a cluster heads.

2.3 New LEACH (N-LEACH)

N-LEACH originate from LEACH-C [7] (LEACH Centralized) - which is an improved version of LEACH that maintain information for the location and remaining energy value of all nodes and sent it to the base station at each cycle (round). Once the base station has received this information, it calculates the average energy value of all nodes. The nodes with residual energy higher than the average have better chances to become cluster heads [3]. Nodes that are not suitable for cluster heads will join the closest cluster head and transfer data only to that CH [8]. The difference between N-LEACH (New-LEACH) [9] and LEACH is that N-LEACH calculates the difference in residual energy of the nodes after each cycle. The base station calculates the average energy of all nodes. And if the energy of a node is greater than average, that node is selected for a cluster head

[3]. While LEACH assumes that, all nodes have the same amount of energy for each cycle.

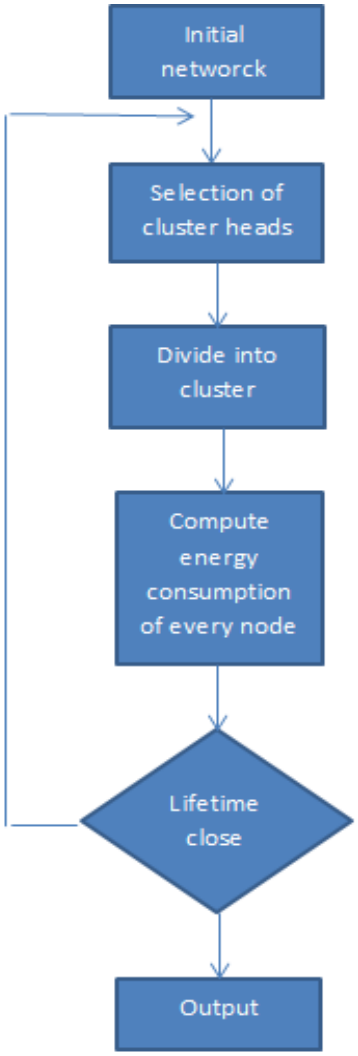

Fig. 2 Scheme of the LEACH protocol In this article, we examine several variations of the leach that save energy in several different ways.

3. Results and discussion

1) Each sensor node has a unique pre-configured ID, a fixed transmission range and an equal amount of incipient energy.
2) Sensor network is proactive [10] and each node generating the same amount of data per unit time. Each unit of data (packet) is with an even length (in the first round).
3) We use equal periods of time called rounds (cycles). At the start of every round, routing information is recalculated, in order to correspond with the topology changes [5].
4) After deploying the network, node battery recharge is impassable.

Algorithm

//*n* is the set of all nodes in a network, *r* is number of rounds, *p* is probability to be a cluster head

Step 1: In the network, all n nodes are located randomly.
Step 2: Initially energy for all nodes is the same.
Step 3: Over 0.5 percent of nodes can be selected for cluster heads randomly. In Leach-N, nodes with higher energy levels are selected for cluster heads. In Leach-H, nodes that are closest to the base station (with the shortest transmission distance) are selected for cluster heads [5].
Step 4: Each non-CH node joins the closest cluster head.
Step 5: The nodes transmit data only to their own cluster head.
Step 6: Each CH transmits the aggregated data to the BS via the shortest path.

IMPLEMENTATION

A. Random Deployment of sensor nodes

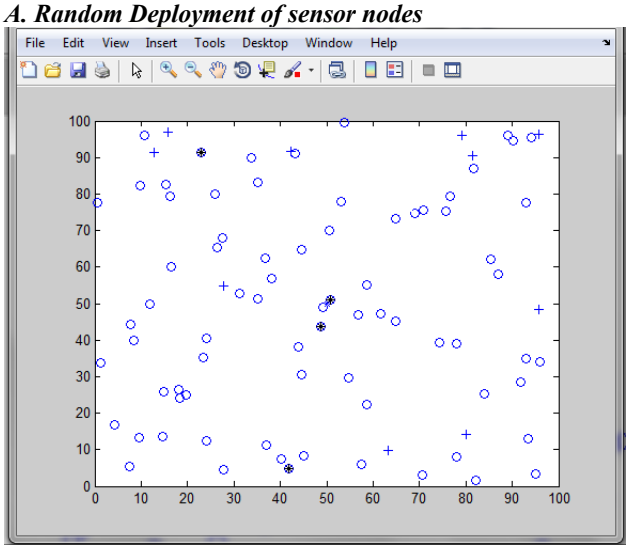

Fig.3. Randomly deployment of sensor nodes in a given area

In Fig.3 all the nodes are randomly deployed in a fixed area of 100m*100m. Base station in placed in the center.

B. Number of received data at base station

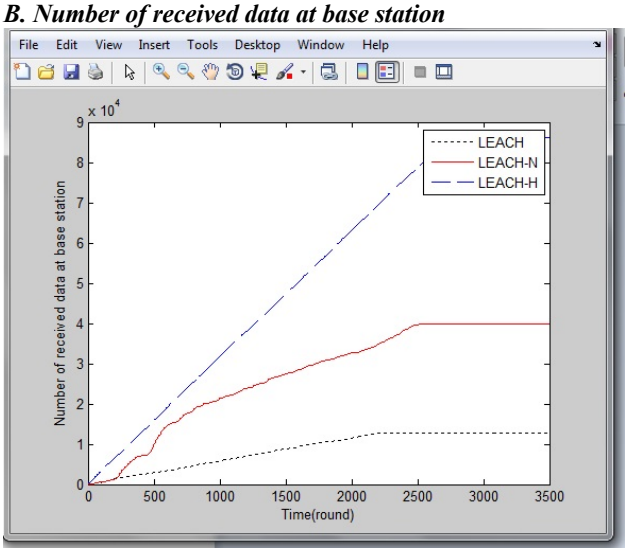

Fig.4 Number of received data at base station in LEACH. LEACH-N and LEACH-H

In Figure 4 we see that in the beginning, there is no much difference in the amount of data package between the tree protocols. However, with the time running, we see that the amount of data package sent by Leach-H is slowly become bigger than that of Leach and Leach-N protocols.

C. Average residual energy of nodes

Figure 5 shows that the average residual energy of nodes in case of LEACH protocol is less than average residual energy of nodes in LEACH-N, which in turn is less than average residual energy of LEACH-H.

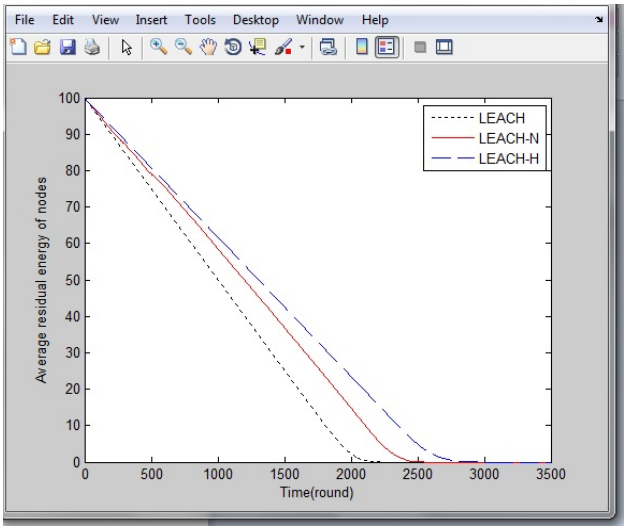

Fig.5 Average residual energy of nodes in LEACH. LEACH-N and LEACH-H

D. Average mean square deviation of residual energy of nodes

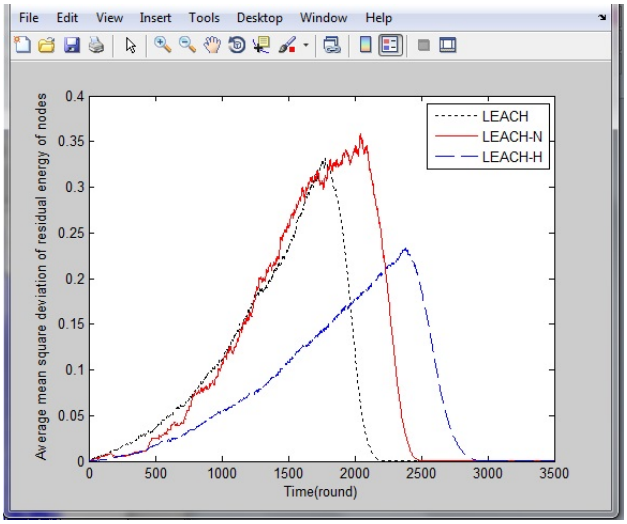

Fig.6 Average mean square deviation of residual energy of nodes in LEACH. LEACH-N and LEACH-H

At the probability of 0.5 for 100 nodes for 3500 rounds (Fig.6), the average mean square deviation of residual energy of nodes for LEACH is highly consumed at around 1500 rounds and finished at around 2000 rounds, in LEACH-N average mean square deviation of residual energy of nodes are highly consumed at around 2000 rounds and finished at around 2500 rounds, and In LEACH-H average mean square deviation of residual energy of nodes are highly consumed at around 2500 rounds and finished at around 3000 rounds.

The results show that the LEACH-H is alive for longest time than the other two protocols.

E. Number of nodes dead

For probability at 0.5 for 100 nodes for 3500 rounds. Form the Fig.7, we see that at around 1500 rounds, the nodes start dying in LEACH, for LEACH-N the nodes start dying at around 2000 rounds, and in the case of LEACH-H nodes start to dying at around 2500. The results show that in the LEACH-H the nodes are alive for longest time than the other two protocols. LEACH-H shows the best results in terms of improve the network lifetime.

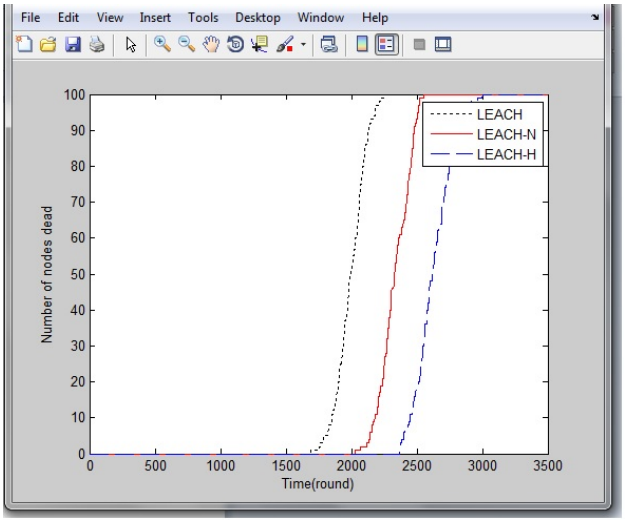

Fig.7 Number of nodes dead in LEACH. LEACH-N and LEACH-H

RESULTS ANALYSIS

1) In the first cycle all nodes start with the same initial energy.

2) In the following cycles, in LEACH-N base station calculates the average energy of all nodes, and the nodes with energy higher than average, become CHs.

3) H-LEACH select cluster heads using a method to optimize the distance for data transmission to a base station.

4) The number of dead nodes per round in LEACH-H is less than in LEACH-N, because LEACH-H use method to optimize data transmission, which is the most energy-intensive process.

4. Conclusions

In WSN the number of dead nodes reflects the network lifetime and stability. Routing in sensor networks is an emerging field of research, which aim is to saves more and more energy.

LEACH use single hop communication, probability based selection of CH in heterogeneous network, energy efficiency, etc.

In this project, we examine the different methods for energy saving, used by the different versions of the LEACH protocol.

Our tests shows that data transmission is the most energy-consuming process in WSN compared to other processes such as data collection, data aggregation, and other process specific for WSN.

LEACH-N and LEACH-H improves the energy efficiency of the network by a different approachs.

LEACH-N protocol saves energy by calculates the difference in residual energy of all nodes in the network after each round, and chose for CHs the nodes with the best residual energy.

While LEACH-H protocol provides longer network lifetime due to its heterogenetic nature. LEACH-H provides longer lifetime for the network by choosing the nodes with minimum transmission distance to become CHs. LEACH-H shows the best results in turms of prolonging network lifetime, because the data transmission is the most energy-

consuming process in sensor networks. Protocols that achieve higher level of energy efficiency, are more suitable for larger networks.

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