

## Collaborative System Energy Efficiency of the Application of Routing Protocols in Wireless Sensor Network Research

Chen Tao and Lu Min

Shandong Women's University, Shandong Jinan, 250300  
yx6785@163.com

### Abstract

*By comparing several routing protocols for wireless sensor networks, and draw lessons from the idea, put forward a kind of energy efficiency of routing protocol based on collaborative system - NBEERP. NBEERP wireless sensor network by a different set of classes, each class are by a group of head basis points and some common basis points. At a higher level of group head of basis points, to collect data task of colleagues, but receives from the ordinary data transmission and data processing, after pass the data to collect basis points. NBEERP would network cycle is decomposed into several rounds, each rounds according to predetermined strategy on network dynamic of the set of classes to group head points to choose, so that the entire network in the lower levels get longer life cycle energy consumption and high throughput. Through NS2 simulation test platform, proves that this method achieves the goal the routing protocol design.*

**Keywords:** *wireless sensor network; routing protocols; negotiation based energy efficient routing protocol for wireless sensor networks; NS2*

### 1. Introduction

WSN is a kind of wireless network without infrastructure, it combines sensor technology, embedded computing technology, distributed information processing technology and wireless communication technology, able to real-time monitoring, collaboration awareness and gathering network spread area of various environmental or monitoring object information, and to deal with these data, get detailed and accurate information, need these information to the user. Wireless sensor network and the traditional wireless network (such as WLAN and cellular mobile telephone network) have different design goals, the latter in highly mobile environments through optimizing routing and resource management strategy to maximize bandwidth utilization, at the same time to provide users with a certain quality of service guarantees[1-2]. In wireless sensor networks, in addition to a few points need to move beyond, most points are stationary. Because they usually run in people can't close to bad or even dangerous remote environment, energy cannot be replaced, design effective strategy to prolong the lifecycle of the network become the core issue of wireless sensor network. Of course, in theory, the solar cell can persistently supply energy, but in the engineering practice to produce this battery miniaturization and difficult.

At the beginning of the WSN research, people once thought mature Internet technology combined with Ad hoc routing mechanism to the design of WSN is sufficient, but research shows that the wireless sensor network and traditional network has a significantly different technical requirements. The first with data as the center, the latter for the purpose of transmitting data. In order to adapt to a wide range of application, the design of the traditional network follows the edge of the "end-to-end" theory, emphasizes the all function related processing on the backend system network, middle points only responsible for the data packet forwarding, for wireless sensor networks, it is not a

reasonable choice; A number of Ad hoc self-organizing network design of protocols and algorithms are not suitable for wireless sensor network characteristics and application requirements. Most of the WSN basis points is not moving as fast as they can basis points in traditional Ad hoc networks, so there is no need to spend big price frequently updated routing table information; Intermediate points related to the specific application of data processing, integration, and cache and seem to be very necessary.

In densely distributed wireless sensor network, the distance between the adjacent base points is very short, low power consumption of multiple hops communication mode to save power consumption, increased the concealment of the communication at the same time, also to avoid the long distance wireless communication are susceptible to the influence of the outside noise interference, these unique requirements and constraints for sensor network research puts forward a new technical problems. WSN at the forefront of new technology, IEEE has not yet been established standards of WSN group, the international from 2000 began to appear on some reports of sensor network research. However, these research results in the initial stage, the actual demand is still far. In general, our country there is few research on wireless sensor network[3-6]. Because WSN is a new technology, the difference of domestic and international level is not very big, in a timely manner to carry out the influence of future human life at the forefront of science and technology research, social, economic, for the whole country will have great strategic significance.

## 2. Related Works

Wireless networks are usually has two organization forms: infrastructure network and infrastructure network. Also known as the center structure network infrastructure comprises a fixed cable network gateway. Within the scope of the wireless coverage, mobile host cable gateway (fixed) to communicate with base station, and it can move in the process of communication. When mobile host left after the original base station of wireless coverage, it can establish the connection with another base station and the base station to continue to communicate. In this way of networking and communications base station position is fixed. Center structure of the network's main goal is to provide high quality of service and high bandwidth efficiency, cellular wireless systems and wireless LAN is using this form of network organization. No infrastructure network is a wireless network to another means of organization.

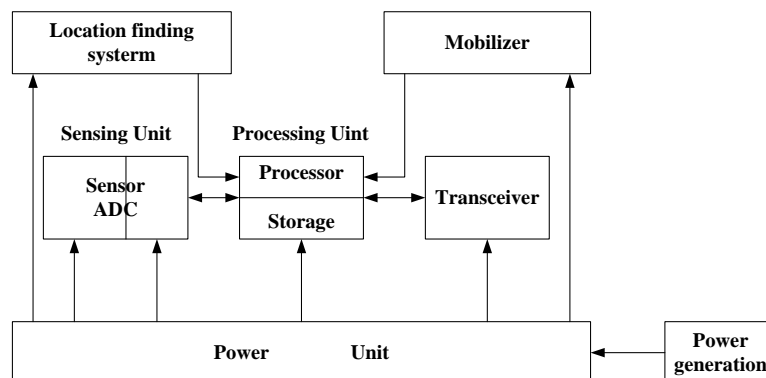
No infrastructure networks, also known as wireless mobile ad-hoc network, ad-hoc network, Ad hoc network. No infrastructure network is a set of mobile base with wireless communication device since creation, self-organization, and the management center network. Basis points can at anytime, anywhere, don't need the support of the existing information network infrastructure, to quickly build up a mobile communication network, each point in the network can be free to move, equal status. To participate in an infrastructure network every basis point need a commitment for other basis for packet forwarding, so the basis of both routers and hosts two functions, as a host, basis points run user-oriented applications; As a router, basis points corresponding routing protocol operation, according to the routing policy and routing table in the data packet forwarding and routing maintenance. After the damaged part of communication network, the distributed control and without center network structure can keep the rest of the communication ability, ensure smooth important communication command, thus has very strong robustness and anti-destroying ability. This network can be run separately, and can be through the gateway access to cable backbone network (such as the Internet).

According to the nature and basis points is frequent and large-scale mobile, no infrastructure network can be divided into mobile Ad hoc networks and wireless sensor networks. In mobile Ad hoc network, the bp is generally portable computer, personal

digital assistants, such as equipment, wireless base can move freely, the topology of the basis points in often changes; In wireless sensor networks, bp is special equipment like wireless sensors, most of the basis points, stillness special basis points will change position. In fact, many documents are not strictly distinguish between Ad hoc networks, wireless Ad hoc networks, mobile Ad hoc networks these terms, for convenience, this article only in mobile Ad hoc networks and WSN contrast said it as a traditional Ad hoc network, is generally referred to as the Ad hoc network.

WSN was originally derived from senior U.S. defense research projects agency of a research project, at that time in the cold war period, in order to monitor the movements of the enemy submarines, need to decorate a large number of sensors in the ocean, the information monitoring by the use of these sensors to real-time monitor the sea submarine action. But due to the limitation of technical conditions at that time, the application of WSN can only limited military projects, it is difficult to get promotion and development. In recent years, along with the wireless communication, microprocessor, MEMS, such as the development of technology, makes the ideal blueprint of wireless sensor network can be realized, its application is more and more widely, various research institutions abroad is also beginning to its research. WSN is a new type of infrastructure network, it is the basis of the special wireless sensor equipment, wireless base statically randomly dispersed in an area. Sensor is responsible for collecting the voice of the area, electromagnetic or seismic signals, and other information, sends them to collect basis points. Collection points has more processing power, it can further processing information, or have greater send range, information can be sent to a large network, the remote user to retrieve this information.

Wireless sensor network is composed of a group of wireless sensors in Ad Hoc way of wireless network, its purpose is collaboration to perceive, collection and processing network coverage in the geographic area perceived object information, and release to the observer. From the above definition as you can see, the wireless sensor, the perceptual object and the observer is the three basic elements of wireless sensor network; Wireless is between sensors, sensor and communication mode between observer, is used to establish a communication path between sensor and observer; Collaborative perception, acquisition, processing, distribution awareness information is the basic function of WSN; A set of limited wireless sensor able to complete large collaborative perception tasks are important features of the WSN; Some or all of the basis of wireless sensor network can be mobile, wireless sensor network topology structure will move as the basis and dynamic change constantly, in Ad Hoc way to communicate between basis points, each point can act as the role of the router, and every point a dynamic search, orientation and the ability to restore the connection. Sensor by power supply, perception of parts, processing parts, transceiver components and software of this a few parts as shown in figure 1:



**Figure 1. Wireless Sensor Structure**

WSN directly affects the performance of its availability, how to evaluate the performance of WSN is a problem needs to be further studied. Below, we discuss several evaluation of wireless sensor network performance standards, these standards have not reach the level of practical, need further modeling and quantitative.

**Energy efficiency:** the energy efficiency of wireless sensor network is the network under the condition of limited energy to deal with the number of requests, energy efficiency is an important performance index of WSN, so far, the energy efficiency of wireless sensor network has not been modeling and quantification, also do not have generally accepted standards, the need for in-depth study;

**Life cycle:** the life cycle of wireless sensor network is to point to start from the network to provide observers need to the duration of the information so far, many factors affect the life cycle of sensor network, includes the hardware factors also includes the software factors, the need for in-depth study. In the design of the sensor network hardware and software, we must give full consideration to energy efficiency, maximize the network lifetime;

**The time delay,** the delay time of wireless sensor network is when the observer request the time to answer it receives information need, the influencing factors of wireless sensor network time delay also has a lot of. Time delay is closely related to the application, directly affect the availability and application scope of wireless sensor network, the current related research is very few, the need for in-depth study;

**Perceived accuracy:** perception of accuracy of WSN refers to the accuracy of the observer receives sensory information. The precision of the sensor, information processing method, the network communication protocol will have an effect on perception, precision, etc. Perception precision, time delay and has a close relationship between energy consumption. In the design of WSN, we need to weigh the gain and loss, the three can make the system under the condition of minimum energy costs to maximize perception accuracy, reduce time delay;

**Extensibility:** wireless sensor network scalability performance in the number of sensors, network coverage, life cycle, time delay, perception of accuracy of extensible limit, given the level of scalability, wireless sensor network must support the extensibility mechanism and method of level. There is no scalable accurate description and standards, also need to be further in-depth study;

**Fault tolerance:** sensors in wireless sensor networks are often due to environment or run out of power supply failure, due to the environment or other reasons, physical maintenance or replacement failure sensor is often difficult or impossible. As a result, the hardware and software of the WSN must have a very strong fault tolerance. When the network hardware and software failure, the system can automatically adjust or automatic refactoring correct mistakes, guarantee the normal work of the network. Wireless sensor network fault tolerance need further modeling and quantitative, fault tolerance and there is close relationship between energy efficiency, we in the design of wireless sensor networks, the need to weigh the pros and cons of both.

The classification of the wireless sensor network routing protocol basically the continuation of the traditional classification method of the Ad hoc network can be classified to different according to different angles. According to the routing strategy point of view, can be divided into two types, active routing and passive routing;

According to the logical structure of network management routing protocols can be divided into two categories, planar routing and hierarchical routing. First. Active routing: active routing routing discovery strategy is similar to the traditional routing protocols, basis points through group periodically broadcast routing information, exchange routing information, take the initiative to find routing, at the same time, the basis must maintain all points to the entire network routing. It has the advantage that when bp needs to send data grouping, as long as there is routing to objective basis points, the time delay is small.

Defect is active routing cost bigger overhead, as far as possible enables the routing updates to follow the current topology changes, wasted some resources to build and rebuild the used no routing. And, the topology of the dynamic change may make these routing updates become outdated information, routing protocol. In a state of convergence. The traditional routing protocol such as RIP, OSPF belong to active routing protocols. Active routing protocols generally includes "neighbor points detection" and "routing broadcast" process.

Radio Hello packet router to the communication port cycle, to realize the neighbor points detection. In distance vector algorithm, although there is no explicit basis points detection process, but with neighboring points in distance vector routing table, implied the adjacent point detection. Second. Passive routing: in contrast to the active routing, passive routing thought in the dynamic change of network environment, there is no need to maintain routing to all other points. It only when there is no purpose to bp routing "on-demand" when to route discovery[7-8]. Passive routing protocol based on network packet transfer requests, passively search from the source points to the routing objective basis points. When there is no packet transfer request, the router is in a state of silent, do not need to exchange routing information. Topology and on-demand routing table establishment, it may simply be part of the whole topology information. It has the advantage of not need periodic routing information broadcasting, save network resources. Sends the data packet is weakness, if there is no routing to objective basis points, data packet needs to wait for time delay caused by route discovery. Passive routing protocols mainly include "routing discovery" and "routing maintenance" two processes.

When the source points need to get to the objective basis of routing, and which by and not in the routing table, routing discovery process is activated. A router with the method of flood, broadcast to the entire network routing request packet. When there is a route request packet arrival destination basis, objective basis points will be issued to the source point routing request response message. So, between the source and objective basis points will establish a two-way "path". Active path delay is defined as the time needed for routing building. As the change of topological structure, when a period of activity on the path link interrupt occurs, the routing maintenance process is started. Routing maintenance can use two different strategies: starting from the breakpoint to repair the source path or bp to restart the routing process is established. Passive routing protocols is ad-hoc network routing protocol type, it can reduce routing consumption, improve the network throughput. However, the uncertainty of passive routing protocols with potential, including whether target points to the uncertainty and routing delay uncertainty is established. Plane routing: flat structure refers to the network status is the same on all the points in routing function, no layered management mechanism are introduced. Flat structure routing is no special points in the network, the advantages of the network flow evenly dispersed in the network, routing algorithm easy to implement. Defect is scalability small, to a certain extent, limits the size of the network.4. Hierarchical routing: corresponding to the planar routing protocol is a hierarchical routing protocol[9].

The concept of hierarchical routing protocol USES the set of sensor basis points to a hierarchy. A number of the adjacent base points constitute a group, each group has a group of the first. Through the gateway communication between different groups. The gateway can be set first may also be other group members. Gateway is the connection between the upper backbone network, communication between all the groups are forward through the backbone. Hierarchical routing protocols including group agreement, group maintenance protocol, routing protocols in the group and routing protocol between four parts. A group to resolve how to effectively make mobile base on the dynamic distributed network environment to gather in groups, it is the key to the hierarchical routing protocol. Group maintenance agreement to solve in basis points in the process of mobile group structure maintenance, including mobile base points out and join the group, the rise and fall of

group, and other functions. Hierarchical routing protocol is suitable for WSN, but the group process will produce a certain amount of energy consumption, how to produce effective set of classes is what scholars study around the problem. Wireless sensor network routing protocol is currently abroad research hot spot, a variety of routing protocols under different application environment and the performance evaluation index.

### 3. NBEERP based Wireless Sensor Network Routing Protocol Design

As a result of the design of WSN goal difference is very big, therefore, we apply to this agreement of wireless sensor network to do the following hypothesis:

- 1) Basis point does not exist between the one-way link that points to A and B points communication, B basis points will also be able to communicate with A basis;
- 2) The basis of the initial energy values are equal; In the early part of the network life cycle, each point has enough energy and collection basis points communication; Each point has a power control device, can according to the size of the communication distance adjusting the transmission power;
- 3) Every basis point adopts omnidirectional antennas;

Hierarchical clustering, based on the collaborative system, adopted collection type combined with decentralized, multiple routing maintenance, low power dynamic adaptive on-demand routing protocols, we analyze NBEERP agreement below.

Hierarchy. We originally the sensor basis points of equal status according to the different conditions the location and energy, according to the need of the size of the network and application, divided into different levels. Establish a hierarchical network structure model, the key problems is to make a science of plane network group, group head of basis points centered constitute a hierarchical structure, and will be in the network basis points according to certain strategy assigned to different groups, to establish the hierarchical WSN. The whole wireless sensor network is divided into different groups, group in the class basis points at different levels, the basis of energy is higher at a higher level, undertake the task of more, not only for perception and transmitted to the upper base their new data, but also the interim basis points lower the transmission of data, data fusion. Energy at a low point in the lower level, only perceives and transmitted to the upper base. The routing table of each basis point just to maintain their upper information basis points. Hierarchical model of mathematical description is as follows:

Plane wireless sensor network can be abstracted as a connected graph  $D = (V, E)$ ,  $V$  in the network basis points set,  $E$  said the two-way link between the two point sets. For a graph  $D = (V, E)$ , has the positive integer  $k$ , meet the conditions of  $1 \leq |V| \leq k$ .

Definition 1: a hierarchical network structure model of a depth of  $L (L \geq 1)$   $V$  is set, it can be said for  $V = \{P_1, P_2, \dots, P_l\}$ . Said the first  $l$  layer bp collection, apparently,

$$|V| = \sum_{i=1}^l |P_i|$$

Define 2:  $P_i = \{v_1, v_2, \dots, v_x\}$  expressed as a set of nodes in the  $i$ th layer,  $C_i = \{v_{ij}\}$  said the case of the nodes in the  $i$ th layer,  $|C_i| = \sum_{j=1}^{|P_i|} |C_{ij}|$  I said  $v_{i0}$  cluster head nodes, said  $v_{ij}$  common node, obviously there are

For any of  $P_i$  layer structure to meet the following conditions:

$$(1) \bigcup_{i=1}^n C_i = P_i, \text{ every basis points belong to different groups.}$$

(2)  $|C_i \cap C_j| = \emptyset$ , there is no overlap between the two groups.

(3)  $|C_i| \geq 2$ , a number of points in the group must be greater than or equal to 2.

Adopt the way of collection type combined with decentralized form a set of classes. Routing according to the routing information is based on which the global or local and divided into global type to choose size or isolated type diameter, global type chosen path is divided into collection type to choose size and distributed. Assemble type chosen path by a large computer to calculate the routing of the whole network system, and notify the routers, its shortcoming is easy to cause the crowded around the large computer data, large computer damage will cause the entire network paralysis; Decentralized choose diameter by each router via radio or other communication way to understand the global information, calculate their own path. In most cases in the network, such as the Internet and the traditional Ad hoc network, are distributed to choose size, this is done in order to avoid damage in large computers will cause the entire network paralysis[10-13]. In wireless sensor networks, due to the particularity of basis points, it means that the existence of network; No collection basis points, the network there would be no existence. Appropriate use of the special basis points, will effectively improve the network throughput, reduce energy consumption of sensor points, prolong the network life cycle. Relative to the sensor basis, collection basis points with unlimited energy, computing power and storage capacity is very strong, can run complex algorithm, and the entire network condition has a more comprehensive understanding, can generate an optimal set of classes.

Look from time, we put the whole process of data processing in WSN according to the time dimension subdivided into different rounds, each rounds consists of group formation and data transmission phase. In the early stages of the life cycle of WSN, bp energy is more abundant, in order to gain a better throughput, we use the pool type set of classes forming process, using the advantage of bp, in each of the rounds of group class into a stage, from collection basis according to the current network topology and the energy dispersion of different basis points, the entire wireless sensor network is divided into different groups, each group class consists of a set of basis points and some common basis points, only to its normal group in the group first basis points to transmit data, group first basis points to transmit data collection points.

Collection basis points, although can generate optimal group, must want to know the current state of the each point in the network, such as basis points of ID, location, the available energy, and how many times as a group of first-class information, inevitably and every basis point interactive communication. In the later stages of the life cycle of wireless sensor network, the energy is relatively poor, in order to get a longer network life cycle, we adopt distributed formation, since the set of classes, namely the collection points are no longer involved in the formation of the group, while the sensor by broadcasting their own weights between basis points, their elected group head, for data transmission.

Based on the collaborative system. In data transmission phase, group with the method of metadata consultative group head base points transfer their own data, group head point to receive all the common basis points within the transmission of data, after data fusion, to transmit data collection points.

Maintain multiple routing. In order to guarantee the reliability of the routing, each set of classes of ordinary bp maintains a spare set of first points of the information, once this group first basis points due to abnormal failure (in actual application of this kind of situation is likely to happen), immediately join the standby basis points in the first group,

realized to collect basis points more than routing, guarantee the robustness of routing;

Low power dynamic adaptive. Metadata is data describing the data from the sensor base attribute, much smaller than collect data, in our design, metadata is only about one over twenty of the data size, transmission metadata need to consume less energy. Every ordinary energy use in the group control, during their own slots, just open the sending device, for data transmission; When does not belong to his own groove, close the sending device. Every once in a set of classes are conducted by rounds of dynamic division and group head of basis points to choose, to make every basis point group head of equality of opportunity. Combination of using these methods to realize the basis points "sleep" mechanism, to avoid the invalid data transmission, effectively save the energy

#### 4. NBEERP Simulation Test

In the NS2 simulation environment, we use 150 wireless sensor and a fixed position of base points, randomly dispersed in the wireless sensor basis points to 150 x 150 m<sup>2</sup> floor area, collect basis points away from the area. Each wireless sensor basis points of the initial energy of 5J, and packet size of 700 bytes, metadata size of 35 bytes.

In wireless channel, the wireless signal strength with the alpha time of receiving, the distance between the transmitter power is reduced, called distance power loss slope. The slope or path collection based on wireless sensors and wireless sensor and receiving, transmitter distance between points is different, can use free space propagation and multipath attenuation model. If receive, the distance between the transmitter is less than a critical value, use the free space model. For wireless sensor networks, there is no unified standard to measure different routing protocols, according to the actual situation, we use the following parameters to measure the effects of NBEERP[14-15].

Total collection basis points received packets: this parameter shows the collection basis points in the process of running receives the total number of transmission of packets from group head basis.

Survival basis points number: this parameter shows that with the passage of time, still alive and the total number of the base of is routing protocol is belong to the energy efficiency is one of the most important indicators.

The results of one test, for example to illustrate:

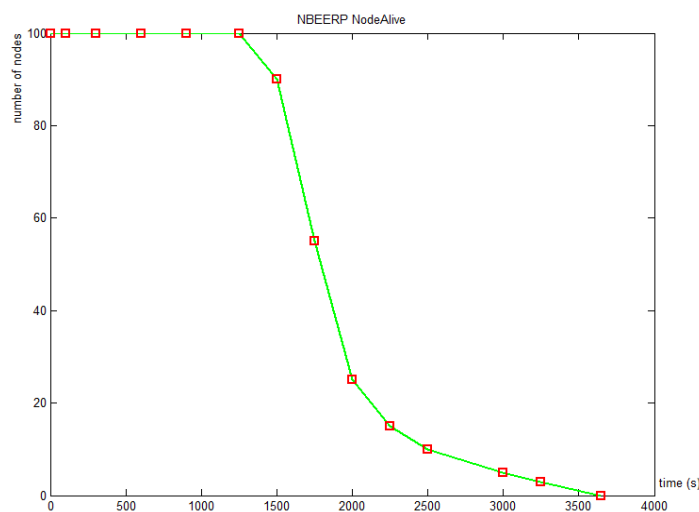
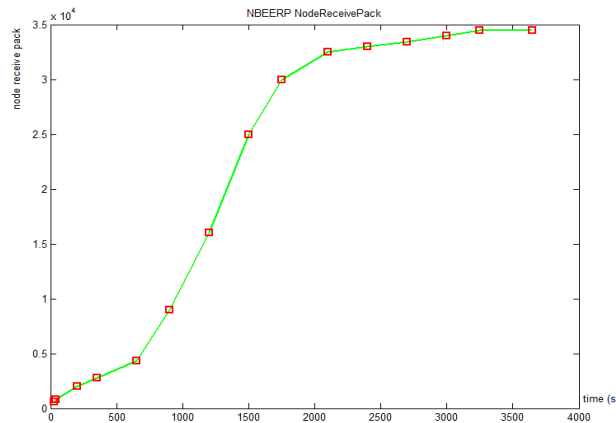


Figure 2. Survival Basis Points Number



As can be seen from the figure 2, over time, due to the consumption of energy, base gradually die. During the 0 seconds to 2100 seconds, we adopt type grouping algorithm, during the 1200 seconds to 2100 seconds, die with a large number of basis points have run out of energy; In 2100 seconds, survival basis points remaining only 30% of the total number of points, so in 2100 seconds to 3600 seconds, we adopt decentralized group algorithm. 2100 seconds to 3600 seconds, when we adopt distributed group algorithm, speed greatly slow death, shows our distributed group algorithm effectively prolong the life cycle of the entire network.



**Figure 3. Collect basis Points Total Number of Packets Received**

As can be seen from the figure 3, during the period of 0 seconds to 2100 seconds, we use pooling type grouping algorithm; Due to collect basis points with a clear understanding of the global topological, formed the effective set of classes, so the collection basis points received packets to grow rapidly. After 210 seconds, due to the massive death basis points, we adopt distributed group algorithm, bp between their elected groups such as collection basis points of class effectively, plus points continue to death, collection basis points received packets slow growth.

## 5. Conclusion

Because WSN is a new technology, in such a special field of research work is less, this article first to the concept, system structure, the characteristics of wireless sensor network and give a brief introduction of research progress abroad. Then, the current routing protocol proposed by several foreign scholars made a careful analysis, find the idea worthy of learning. Then, designed a hierarchical collection, based on the collaborative system, adopt type combined with decentralized, multiple routing maintenance, low power dynamic adaptive on-demand routing protocols, NBEERP design and operating process are analyzed in detail. Finally using ns2 platform to NBEERP simulated test, proved NBEERP basic reached the design requirements.

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## Authors



**Chen Tao**, received the master's degree in computer engineering from Computer Science School of Shandong University, China in 2009. He is now severing in Shandong Women's University, with the professional title of experimentalist. Besides daily teaching activities, he is currently researching on computer network and database, as well as responsible for several scientific study projects in provincial and department level.



**Lu Min**, she graduated from Shandong Formal University, and received the master degree in 2014. She is now working at Shandong Women's University, with the title of lecturer. She is engaged in teaching and informational student management, and has presided over and participated in several research tasks of provincial and departmental level research project.