A wireless sensor routing and security protocol by BP neural network and ant colony optimization algorithm

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ABSTRACT

This paper introduces the wireless sensor network routing protocol and its security, and introduces the main several kinds of routing protocols, including the data centric routing protocol, hierarchical routing protocols and location-based routing protocol, finally according to the analysis of routing protocol common attack method. Ant colony algorithm is a distributed parallel algorithm. A single ant search process is independent of each other, easy to fall into local optimum. BP neural network is essentially a simple steepest descent static optimization algorithm. This paper proposed wireless sensor routing and security protocol based on BP neural network and ant colony optimization algorithm.

Keywords: BP neural network, Ant colony optimization, Wireless sensor routing, Security protocol.
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INTRODUCTION

Application of wireless sensor networks usually has higher requirements for safety, so security is always a hotspot in wireless sensor networks. The safety of wireless sensor network has a very high demand in most application environments, so security becomes the key problem to restrict the further application of wireless sensor network. However, due to the characteristics of wireless sensor it, to realize the security of wireless sensor network is not an easy thing. The characteristics of the wireless sensor network has brought new requirements for the safety, so that the majority of security mechanisms and protocols to the applications, network layer routing protocol provides routing service key for the wireless sensor networks, the routing attacks may lead to paralysis of the entire network. Routing security directly affects the safety and availability of wireless sensor network, so is the focus of the whole wireless sensor network security research.

Different wireless protocol of wireless sensor network with the traditional, it is restricted by the energy consumption, and can only get the local topology information, because of these two reasons, routing protocol for wireless sensor must be able to choose the appropriate path based on local network information [1]. Sensor due to the application of correlation it strong, routing protocol in different applications varies greatly, no routing protocol. The routing protocol of wireless routers should have the following characteristics: (1) the energy priority. Need to take into account the energy consumption of the nodes and the network energy balancing problem using. (2) Based on local topology information. WSN in order to save communication energy usually adopts multi hop mode of communication.

Ant colony optimization algorithm for the problem solving speed, global optimization and a high degree of self organizational characteristics, reasonable combination, the establishment of rapid demand extremely similar with low energy consumption, self-organizing wireless sensor networks in large scale network routing, contribute to the establishment of the data centric aggregation routing. In this paper, using a variety of ant colony algorithm, cross layer optimization design based on adaptive link access efficiency, and it is according to the statistics obtained and the load queue length state information of the MAC layer, integrated routing design the access efficiency

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characterization of wireless channel and the node load metrics.

BP neural network is a multilayer feed forward neural network, transfer the neuron is S type function, output continuous 0 to 1 between, it can be realized from any nonlinear mapping from input to output. Due to the weight adjustment using the back propagation learning algorithm, so it is often called the BP (Back Propagation Network). At present, in the practical application of the artificial neural network, most of the neural network model using BP network is slow and its change form. It is also the core part of front network, embodies the essence of the artificial neural network.

This paper proposed wireless sensor routing and security protocol based on BP neural network and ant colony optimization algorithm, this protocol has the following characteristics: a) sensor nodes to save multiple shortest paths to reach the gateway node, each communication, using round robin choose the shortest path for communication, so that the data transmission load balancing distributed in a plurality of routing path, avoid network conflict, saves the node energy consumption; b) of each sensor node is formed automatically by the parent node routing path, and saves the control information to establish the routing of the energy consumption of sensor nodes; c) save multiple arrives at the gateway node will not because of the failure of most the path of the resulting communication interrupt, increased road shortest path.

1. Research on Wireless Sensor Routing and Security Protocol
The routing protocol for a lot of WSN can be used to classify them from different angles. If you need to know in advance from the node of its own geographical location of view, can be divided into geographical location aided routing and non geographic location aided routing; routing query initiated from the strategy, can be divided into proactive routing and reactive routing; from the point of view of the network topology map, can be divided into flat routing and hierarchical routing; object the routing protocol is different, can be divided into query routing (to the sensor nodes from the Sink) and aggregation routing (from the sensor to the Sink); from the point of view of the operation characteristics of routing protocols, also can be divided into QoS routing, secure routing and multi-path routing [2].

Wireless sensor network architecture is shown in figure 1. Wireless sensor network system usually consists of sensor nodes, sink nodes and monitoring center (including the host server and user access management terminal). A large number of sensor nodes in the specified random walk in the detection region. The sensor node will detect the information in a multi hop relay transmission to the sink node.

Wireless sensor network is a dynamic network, the network may have new nodes join; will continue to have quit because of battery depletion or node failure. In the wireless communication system, sensor networks, the hierarchical structure of the protocol stack, in order to maintain the flexibility of the system to provide powerful functions at the same time. The whole protocol stack as shown in Figure 1, divided into physical layer, data link layer, network layer, transport layer, application layer five layer, contains the power management module, mobile management module, and task management module.
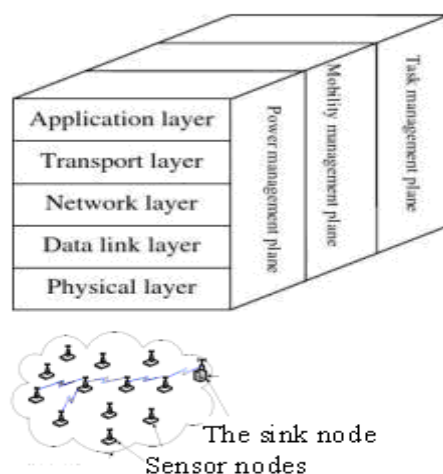

Fig. 1. The whole protocol stack and architecture of WSN

The sink nodeFlat routing protocol, logic structure plane structure, nodes are equal, by local operation and feedback information to generate routing. When the sink node sends the query is to some areas and waits for the data from the acquisition in these areas of the sensor, the data are not adopting the global ID, but to the description of attribute

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based naming mechanism. The advantages are simple structure, flat routing robustness (fault tolerance routing mechanism) good, disadvantage is the lack of optimal management of communication resources, and the dynamics of the network's reaction speed is slow.

The passive routing in dynamic network environment, there is no need to maintain to all other nodes. It is only in the absence of go to the node that "on-demand" route discovery. Reactive routing protocols according to the request of network packets, passive search is from the source node to the destination node routing. When there is no packet transfer request, the router is in a quiescent state, does not need to exchange routing information. The topology and the routing table of contents according to the need, it may just be a part of the whole topology information. It has the advantages of routing information broadcast does not require periodic, save some cyber source. Drawback is that a data packet is sent, if not to a destination node routing, packets need to wait for the delay caused by the route discovery.

Sensor network is composed of sensor nodes, sink nodes and events of three parts were monitored. Because the mobile sensor is difficult to be organized, so a lot of network structure hypotheses sensor node is fixed. On the basis of need is to have sinks and CH (gateways). As the optimization problem of route stability, coupled with the energy and bandwidth problems to send and receive information, management of mobile node becomes the new challenges to routing management [3]. Information is dynamic information and static information. Among them, monitoring static event allows the network to work in the trigger mode, only when the external conditions change will carry out transmission; monitoring of dynamic events require periodic reports, and find out the useful information from it, transmission to sink node.

Routing backbone network includes a gateway node and a plurality of intermediate nodes. The gateway node for connecting external networks and sensor networks, gateway node has no parent node, can contain multiple sub nodes; intermediate nodes for sensor nodes send sensing data, an intermediate node can contain more than one parent node and sub nodes, intermediate nodes according to a round robin scheduling algorithm is processed by the routing backbone routing to the gateway the node selection different parent node sensed data.

Directed diffusion routing is a typical data centric communication protocol, which is closely associated with the application. The basic idea is that sensor nodes have data represented by the value of the property, when the Sink point data to be collected, send an Interests message to the whole network, flooding. Have a sensor node attributes and Interests matching data mark the data according to the reverse path Interests to Sink. In this way, the Sink requires no data will no longer send, greatly reducing the transmission of redundant information, save the network energy, prolong the network time. Directed diffusion routing protocol can be divided into periodic interest diffusion gradient path, establishment and strengthening of three stages.

In the Directed Diffusion, it is to repair the path. After the path of a plurality of data source to the Sink node, Sink node can be selected for data transmission enhanced one path, while maintaining a low speed data transmission path. When the high-speed route, is through the enhanced path fails, Sink nodes can enhance the slow path, ensure the data source node to the Sink node. While maintaining low velocity path needs to consume some energy, but at the time of the failure, can save a lot of energy cost. For the fault frequently network, maintain a low path is very good.
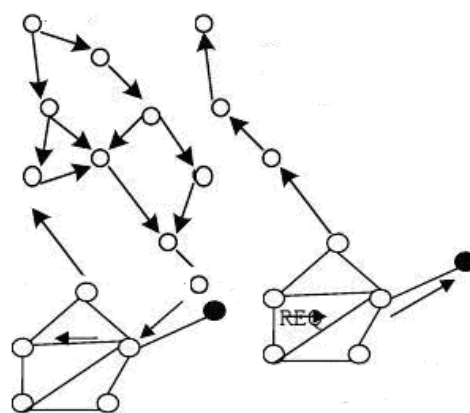

Fig. 2. Directed Diffusion routing principle

Such treatment will eventually in the entire network node for the sink request to create a temporary "gradient" field, according to the "gradient" field, a plurality of data from the source to the sink node in the path, and then select the

reinforced one, for data transmission. Figure 2 describes the working principle of Directed Diffusion model.

In the DD network protocol, node can use the optimal path to the selected cache to achieve energy saving. The cache technology can improve the effectiveness, robustness and collaboration between the sensor nodes in scalability; this also is the essence of DD model. A study on WSN routing protocol is in the milepost DD algorithm, which is the biggest characteristic of the network gradient concept. The advantage of DD algorithm: analysis of simulation results shows, network gradient and localization algorithm in wireless sensor network routing, can well meet the WSN of energy efficiency, robustness and scalability requirements.

SPIN is a group based on the negotiation and communication protocol is energy adaptive function. It has two characteristics as follows: (1) each node needs through consultation to determine whether other nodes need the data before sending data, at the same time, each node through metadata (meta-data) to determine whether to accept data in the presence of duplicate information. (2) The network nodes must be real-time monitoring of local energy consumption, according to the running time energy level changes in work patterns to extend the node itself and the whole network.

Wireless sensor network protocol stack also includes energy management platform, mobile platform and task management platform [4]. The management platform allows sensor nodes can work according to the energy efficient way, forwarding data in sensor networks mobile nodes, and support multi task and resource sharing. The related function of each layer protocol and platform are as follows:

1) Physical layer modulation signal to provide a simple and robust and wireless transceiver technology;

2) Data link layer is responsible for data frame, frame control, medium access and error control;
3) The network layer is responsible for routing generation and routing;
4) Transmission control the transport layer is responsible for the data flow, to ensure the quality of service is an important part of communication through.

This is the main characteristic of the SPIN algorithm. Each node in the received data, nodes broadcast in the data, the main problem, 3 algorithms, using blind algorithm using it. SPIN is to transfer data and resources of the overlapping of resources more effectively, SPIN algorithm, each node knows only its one hop neighbor nodes, thus the network topology change localization of it. SPIN algorithm in energy consumption and data redundancy to but the ratio of flooding algorithm 35%., the data broadcast method cannot ensure the effective transmission of data. For example, if you want to get data node and has a data source node distance, node two between the data the expectation is smaller.

This negotiation mechanism and energy adaptive mechanism of SPIN protocol can well solve the problem of traditional Flooding and Gossiping protocol information explosion, information by the duplication and waste of resources and other issues. The shortcoming of SPIN protocol is data advertisement mechanism (ADV) can not guarantee reliable transmission of data, so the intrusion detection needs in regular intervals and reliable transfer of data application system, SPIN routing mechanism is as shown in Figure 3.
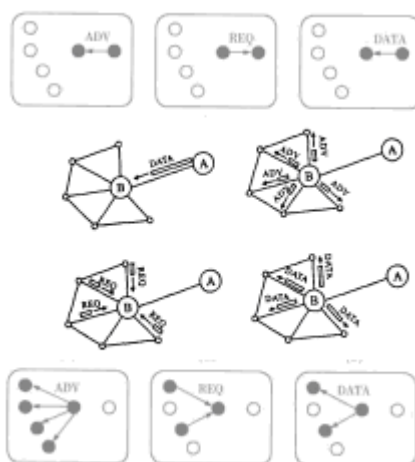

Fig. 3. SPIN routing mechanism

Advantages of directed diffusion algorithm is that, the data centric work, only for data transmission between

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neighbor nodes, does not need to address of the node set. Each node capable of data fusion, it is storage and collection. It can buffer the data, so that it can better save energy, reduce the delay. Data transmission and has no special requirements for network topology (for dynamic network), so that the protocol can save more energy for wireless sensor networks.

In wireless sensor networks, a large number of sensor nodes are densely distributed in a region which, news may require several nodes to reach the destination, and the sensor network is dynamic and multi hop structure, require that each node should have routing function. Because each node's routing node potential, therefore more vulnerable is to attack, the network security [5]. The network layer routing protocol provides routing service key for the wireless sensor networks, secure routing algorithm can directly influence the safety and availability of wireless sensor network.

The SAR protocol is the first of a QoS (quality of service, is a kind of network security mechanism, to solve a technical network delay and congestion) routing protocol consciousness. It is characterized by the routing decision must take into consideration not only to each path of the energy, but also relates to the end to delay requirement and outgoing packet priority end.

The GPSR protocol is a routing protocol based on the typical location. The use of GPSR protocol, network node knows its geographic position and be unified addressing, each node using the greedy algorithm as far as possible along the straight forward data. To produce or receive data node to calculate the Euclidean distance neighbor node closest to the destination node forwarding data, but the data will get no closer than the destination node region (called empty), cause data cannot be transferred, when this occurs, the empty peripheral nodes can be detected, and the use of the right hand rule along the cavity around the transmission to solve this problem.

The protocol avoids the establishment, maintenance, in the node routing tables, only rely on direct neighbor node routing, is almost a stateless protocol; and the use of close to the shortest Euclidean distance routing, data transmission delay is small; and to ensure that as long as the network connectivity is not destroyed, must be able to find up to routing. But the drawback is that, when the sink point and the source nodes in the network are concentrated in two areas, due to traffic imbalance can lead to the failure of some nodes, thus destroying the network connectivity; the GPS positioning system or other positioning methods need to assist the computing node position information.

Geographic routing through the introduction of the geographical location information of nodes, reduce the number of deficiencies in the topological routing algorithm. Usually, each node by using the GPS (Global Positioning System) or other similar positioning method is to obtain location information to their own. Every node in the network only needs to know the location information of neighbor nodes and the communication radius. Routes are established only by a number of single hop topology information can be completed.

In GEAR routing protocol, the position information of nodes can be forged. Node location information can be forged; the path contains a known in data flow. Because of the choice of the path, the need to consider the energy information of the node, so an attacker can always claim that their energy is the largest state, to improve themselves to become the probability of forwarding nodes, and then the selective forwarding attack methods, to achieve the purpose of the attack. The attacker can also be used for Sybil attacks, to improve themselves to be probabilistic forwarding nodes.

Boundary location routing algorithm requires only a few nodes with precise location information, location routing mechanism can make correct routing. The basic idea is to through the node a can get accurate location information (called letters punctuation), to determine a global coordinate system. Through an iterative algorithm, calculate the position in the coordinate system of the other nodes, when all nodes to determine the coordinates, you can choose the appropriate routing using a greedy algorithm. Therefore, the key part of the agreement is established using beacon node coordinates and determines the location in the coordinate system of the other nodes.

Research on wireless sensor network protocols is also using the location information of the node. In the network layer of wireless sensor network node, because no global flag, can design a routing algorithm based on node position; in the application layer, according to the position of the node, wireless sensor network system can intelligently select some specific nodes to complete the task, so as to reduce the energy consumption of the whole system, improve the survival time.

2. Wireless Sensor Routing and Security Protocol by BP Neural Network and Ant Colony Optimization Algorithm

Ant colony optimization (ACO) is used to solve the well-known traveling salesman problem (TSP) heuristic algorithm is put forward, which is a heuristic intelligent evolutionary algorithm for simulating the behavior of ants searching for food [6]. The ant colony optimization algorithm with positive feedback, distributed parallel computer system, strong robustness, and can be used to solve the optimal path based on distributed network computing, such as routing, load balancing and multiplex transmission in the computer network and so on.

In the process of route search, ant the list is used to compare an access node is visited, in order to prevent the search process in the state of death cycle, and continuously update the hop count and the length of the path, so that compared with the other ants, get the optimal path. At the same time, in the practical application, too large for the list, nodes need to spend more energy to deal with data and memory management, this paper puts forward the list is improved as follows: each ant M. Time nodes to access the last two only stored and spending, because the path ants are not preserved, requiring each node to save the node to receive and send the ant's serial number. So when a forward ant passed by the node, the node will query the ant's serial number.

Ant colony optimization routing algorithm is for wireless sensor network routing optimization [7]. The basic idea is the basic ant colony algorithm ant is divided into two or more populations, using multiple ant colony parallel executive search task, through the interaction between different ant pheromone and the end-to-end delay, node load and access efficiency as the path heuristic value, and then periodically replace the optimal solution of pheromone updates, to ensure the diversity of solutions, robust optimization and routing implementation of cyber source.

BP neural network, the transfer function of neurons is S type function, output for continuous quantity [8]. It can be achieved from any nonlinear mapping from input to output. BP neural network is based on neural network model, the error back propagation thought, through error between the network output and the desired output, the network error guiding network layer neuron threshold correction direction, so that the network output and the expected output as close as possible, the network output error is minimized.

BP neural network topology, including input layer, it is hidden layer (input) (hide layer) and the output layer (output layer). The number of the input neurons is determined by the properties of sample dimension, the number of output layer neurons is determined by the number of sample classification. The hidden layer number and the number of neurons in each layer are specified by the user. Each layer comprises a plurality of neurons; each neuron contains a threshold, to alter neuronal activity. Each neuron has input and output. The input layer inputs and outputs are sample attribute values, its structure as shown in Figure 4 as shown.
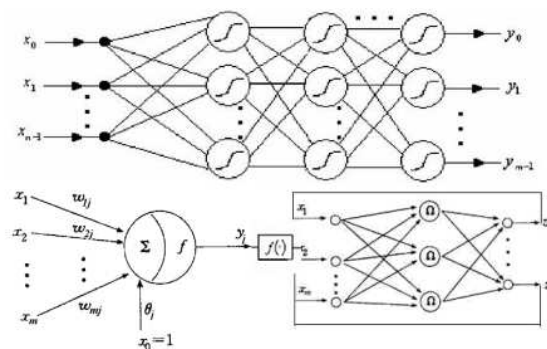

Fig. 4. BP neural network structure diagram

The standard BP algorithm (error back propagation) is a descent algorithm optimization based gradient, using supervised learning training network [9]. The guiding ideology of the learning rule is: Amendment to the network weights and threshold will decline along the direction of the fastest performance function -- the negative gradient direction, the formula is as follows.

$$Err_j = O_j(1-O_j)(T_j-O_j) \tag{1}$$

$$Err_j = O_j(1-O_j)\sum_k Err_k w_{kj} \tag{2}$$

Where O_j is the actual output of unit j, but T_j is the real output based on known class label j given training sample,

W_{kj} is the connection weights, a higher level of K unit to unit of J, but Err_k is the unit of error K.

The advantages of flat routing protocol is simple to implement, but it also has poor in scalability, topological structure of wireless sensor network is usually composed of tens of thousands of nodes distribution at a point within the region, the scale of network is very large. In contrast, hierarchical routing protocol because of its good expandability, suitable for large-scale wireless sensor networks. The reason why hierarchical routing protocol is superior to the flat routing protocol: hierarchical routing protocol to all nodes are divided into a number of clusters, each cluster has a cluster head node and a plurality of members. The member nodes in the collection of effective information, not the purpose of transmitting information, but to send a message to their slot in the cluster head node distribution, information transmission is completed, the node can enter the sleep state, waiting for the information collected to start or transmission time arrival.

The basic idea of secure routing protocol proposed by this paper is to extend the network life cycle, only needs to carry on the communication between nodes and their nearest neighbors. The communication process between the node and sink point is in turn, only when all the nodes communicate with sink, nodes that a new round of alternate communication. Because this turns communication mechanism so that the energy consumption is uniformly distributed to each node and it is thus reducing the consumed energy transmission.

According to the sensor network environment can be divided into static structure and dynamic structure of two. Static sensor networks, sensor nodes and Sink nodes are stationary. The sensor node and the Sink node dynamic sensor networks are mobile, the other sensor nodes are stationary and Sink nodes can be mobile can also create a dynamic model. To routing protocol design is for application specific work environment.

This protocol is based on data query, to set up a safe path sink node to the event area according to the regional location, without the use of flood propagation mode. At the same time, each node can obtain information about their location, and location information of neighbor nodes mechanism obtained through Hello message simple exchange. Confidentiality of the message exchange between nodes by the security mechanism to ensure the link layer, routing protocols in network layer in not be considered. In the agreement, first by the sink node sends a query command, according to regional location query command is transmitted to the region from the nearest sink node, other nodes of the node to query command spread to the region; then the reverse path monitoring data to the sink node along the query message transmission. As the resistance of Wormhole and Sybil attack, adding a series of security mechanism in the routing update phase and data forwarding.

CONCLUSION

Security routing protocol designed in this paper is mainly to solve the geographic routing protocol attack method. Because the dynamic design protocol support network, and may have a legitimate node at a time by non neighbor nodes become neighbors. This kind of joint will be found in the route update protocol, and verify the authenticity of these nodes by geographical location, to determine the new neighbor nodes are real, or attack nodes are similar to the sinkhole or wormhole attack.

In order to effectively reflect the level of network congestion, with multiple ant colony algorithm and ant algorithm is used to re routing optimization of load sensor network nodes to queue packets in the buffer overflow situation of statistics. In the beginning of the implementation of ACO algorithm when the congestion rate increased gradually, along with the increment of simulation time, network congestion rate gradually decreased, the algorithm is prone to converge to suboptimal solutions, therefore in the convergence to the steady state when the congestion degree maintained at a high level.

Multiple ant colony algorithm for congestion this rate is low, the transmission of the data packet reaches the high success rate, the joining node load so as to reflect on the wireless sensor network cross layer routing as path selection criterion advantage, choose different types of pheromone release the ants in the transmission to search the optimal path, which can make the data flow distributed to a number of possible paths, alleviate the congestion degree of load is large network, to meet the reliability requirements of wireless sensor networks and realize the load balance of the network.

BP algorithm using the gradient descent method, from a starting point slope along the error function gradually meet the minimum error value, so in the process of training, may be in a small area, local minimum. The minimum change to each direction is the error increases, so that training is unable to escape the local minima.

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