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Numerical Optimization of the Energy Consumption for Wireless Sensor Networks Based on an Improved Ant Colony Algorithm

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ABSTRACT In the current WSN operation process, there are two major problems of data collection difficulty and network energy consumption, which seriously affects the reliability of the WSN. In this paper, the improved ant colony algorithm proposed is compared with other algorithms. Wireless sensor network nodes based on improved ant colony algorithm have lower energy consumption, and sensor nodes have more residual energy. In addition, the energy model, data transmission balance model is established and verified in the WSN transmission target function. The experimental results show that the WSN node after the improved ant colony algorithm is used to help in the determination of the location information of the public node, and then use the location information of the node to make the protocol have effective routing performance and effective target node location discrimination ability. Thus, the improved ant colony algorithm studied in this paper has important practical significance for improving the life cycle/energy consumption of wireless sensor networks. In addition, aiming at the characteristics and routing performance of wireless sensor networks, a low-power routing method based on location and direction is designed to make the message reach the target node accurately and safely, which effectively increases the data packet transmission rate.

INDEX TERMS Ant colony, WSN, residual energy, WSNs, distributed structure.

I. INTRODUCTION

Wireless Sensor Network (WSN) has broad application prospects. With the rapid development of mobile terminal technology and Internet technology, mobile wireless network technology is widely used in data collection and transmission in different fields such as industry, agriculture and service industry. The wireless sensor network is used to detect the temperature and humidity of the surrounding environment. It is usually composed of multiple sensor nodes and an information collection node (Sink). It is arranged in the environment of forests, farmland, civil buildings and other places, such as precision agriculture, forest fire monitoring, and community security monitoring, to collect information of interest [1]. WSN nodes usually have limited energy, and when their energy consumption is exhausted, the nodes fail. Therefore, energy efficiency in wireless sensor networks is very important.

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As the core of wireless sensor networks, many scholars naturally study Wireless Sensor Networks (WSN). Aiming at the energy-saving characteristics of wireless sensor networks, many related routing protocols have been proposed, such as DD [1], PEGASIS [2], [3], GITDC [4], etc. At present, most routing protocols mainly consider energy consumption factors, and the research objectives are single. Unlike wireless sensor networks, WSNs can increase the coverage and reliability of their networks through the mobility of nodes and extend network-working hours. In the WSN, the Sink node is responsible for completing the WSN energy consumption overhead, such as data collection, processing, storage, and so on, which can save energy consumption of the sensing node in the WSN [5]–[7]. Improve the efficiency and service life of mobile wireless networks. The properties of the two WSN nodes are both isomorphic and heterogeneous [8]. Simulation experiments show that if the node uniform distribution strategy is adopted, up to 90% of the energy in the network may be wasted. We call the partial coverage of the network due to premature depletion of its own energy, or the data cannot be sent to the Sink node. As an "energy hollow" phenomenon, especially after the mobile node Sink joins, the WSN network topology dynamically changes, so that the WSN consumes more energy based on the original energy consumption [9]. This will shorten the network life of the WSN. Some scholars have proposed dynamic voltage management technology. The basic idea of this technology is to make all parts of the system run in energy-saving mode as much as possible [10]. The most common management strategy is to turn off the idle module, in which some wireless sensor nodes will be turned off or in a low power state until an event of interest occurs. Some scholars have studied the problem of energy-saving wireless transmission from the perspective of adaptive modulation technology [11]. They adopt adaptive modulation technology to ensure transmission delay performance and energy-saving wireless transmission design strategy in point-to-point communication mode. Based on this, this paper studies the reliability of mobile wireless network based on optimization algorithm.

This paper proves that the wireless sensor network based on improved ant colony optimization algorithm optimizes energy consumption and continuously sends data to the Sink node. The energy imbalance will not be avoided. However, if the number and path of nodes in the WSN are optimized, the network can obtain suboptimal Based on this analysis, this paper proposes a new ant colony WSN optimization strategy and designs a corresponding routing algorithm for obtaining suboptimal energy efficiency. The simulation results show that when the network life cycle is terminated. The energy balance is almost reached among the nodes in the inner loop. This paper contributes an improved ant colony algorithm, which can equalize the energy consumption of each sensor node, thus prolonging the life cycle of the whole network, and effectively alleviating network congestion and reducing the average delay. Finally, the algorithm is implemented and simulated.

TABLE 1. Pheromone routing table.

Pheromone routing table				
Nodes	Adjacent node			
	a 1	a 2	⋯	a k
N1	P 11	P 12	⋯	P 1k
N2	P 21	P 22	⋯	P 2k
⋯				
Nm	P m1	P m2	⋯	P mk

II. NETWORK MODEL AND ASSUMPTION

The ant colony algorithm is a novel heuristic optimization algorithm based on the principle of ant colony system and self-organizing ability [12], [13]. This paper created a network model based on the ant algorithm by releasing the artificial ant colony. In order to link the communication network with the ant algorithm theory, we use the pheromone table, such as Table 1, to replace the routing table in the network node

In Table 1, n is the number of destination nodes that a node can select, and m is the number of neighboring nodes of the node. The "packet prime table" gives the probability of selecting the next node when a node is the destination node, and the probability value in Table 1 is periodically refreshed according to some rule [14].

A_O and A_1 represent two ants. V_O and V_1 are two nodes. There are two paths Upper and Down between them, and the distance of Upper is 2, and the distance of Down is 1. Assume that each path has the same probability (each 0.5) at the initial moment, the pheromone initial value $\tau_0 = 0.1$, $\alpha = 0.6, \beta = 2, Q = 1$ Two ants start looking for the shortest path from V_0. The iteration graph of Ant colony algorithm is shown in Figure 1.

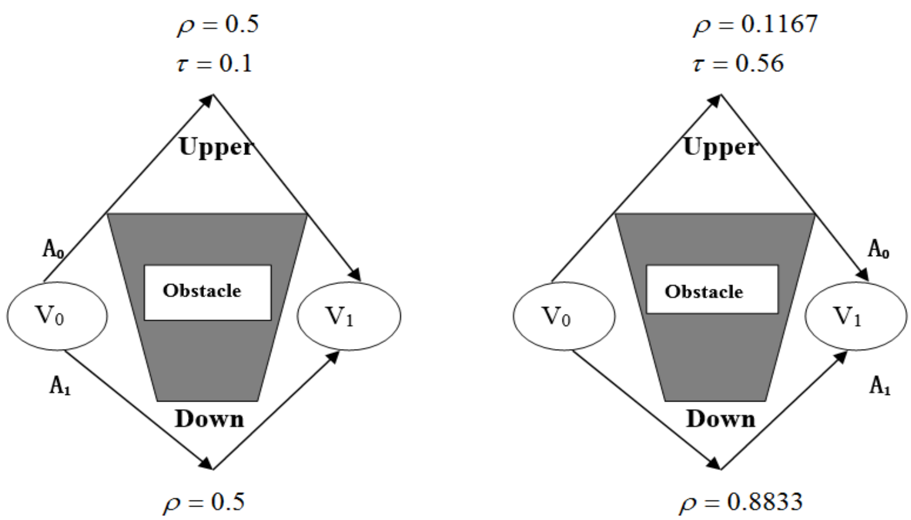

FIGURE 1. The iteration graph of ant colony algorithm.

A. WSN DATA ACQUISITION DESCRIPTION

During the operation of the WSN, the mobile node Sink will carry out information collection work following the WSN pre-set line. Assuming that the mobile node Sink successfully comes within the communication range of the WSN sensor node, the mobile node Sink will receive the data information sent by each sensor node. The specific WSN data collection scenario is shown in Figure 2.

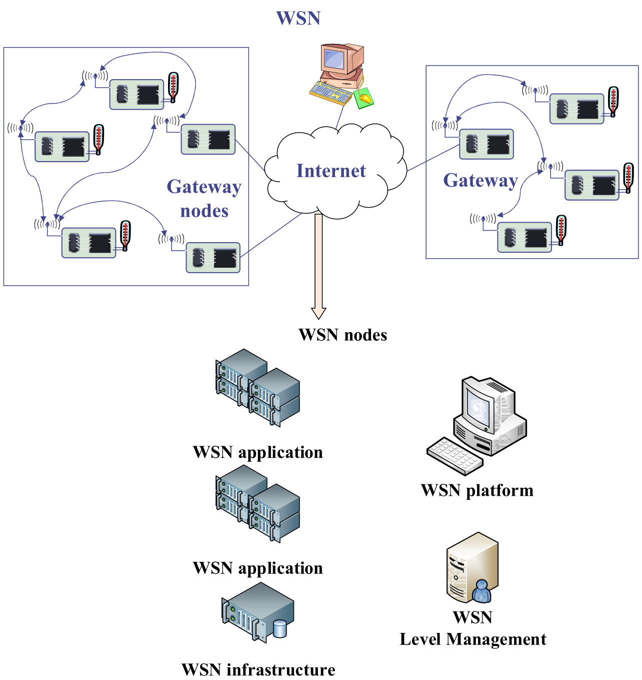

FIGURE 2. The basic framework of the WSN.

It can be seen from Figure 2 that the sensor nodes in the WSN exist in a random form and exist in the same square area. In this area, the deployed sensor nodes cannot move freely, and only the mobile node Sink can move in the monitoring area [13], [15], [16]. In the above collection scenario, each sensor node performs data collection work according to a pre-designed acquisition cycle, and sends the data collection result to the mobile node Sink in time. The specific steps are:

Based on the LEACH clustering protocol, one or several sensor nodes in the area are selected as cluster heads to receive data collected by other nodes. The other nodes mainly send the collected data to the nearest cluster head through the shortest path. 2) After receiving the data sent by other nodes, the cluster head will fuse the data to form a data packet and Temporary storage. 3) When the mobile node Sink accesses, the communication range of the cluster head node, the node will send a data packet to the mobile node Sink, and then the mobile node Sink transmits the data packet to the monitoring center, thereby completing data collection.

B. WIRELESS SENSOR NETWORK ROUTING BASED ON ANT COLONY ALGORITHM

In the wireless sensor, each sensor is a node, and the path to transmit information from the source node to the destination node through the single-hop method is the shortest [17]–[20]. This way is like in the ant colony algorithm, the ant colony passes the source node according to the certain. The method is transferred to the destination node, and the ant colony algorithm is used in the wireless sensor network routing.

1) THE ASSUMPTION OF THE ROUTING ALGORITHM

The infinite sensor network used in this protocol is assumed, first, the initial energy values of the nodes are the same, and the energy is limited. Second, the nodes have certain computing power, so that the information can be processed. The nodes all have unique ID numbers. fourthly, the nodes all use omnidirectional antennas, and the communication range is wider. Fifth, wherein the nodes are not unidirectional links, that is, the nodes A can communicate with the Node B, Node B can also communicate with Node A [21].

2) ENERGY CONSUMPTION MODEL

The three values of $\alpha\beta\gamma$ are unchanged, and they can satisfy the change of the number of traversals during the traversal process. The main purpose of α is to comprehensively measure the proportion of pheromone concentration. Ant s in time t, the set of nodes accessible through node i is allowed by k, where element j is represented as j. j is within the radius of the communication range of node i. j is not accessed for ant k to sink node. The distance is shorter than the distance from i to the sink node, which can effectively shorten the time of the ant from the source node to the sink node and avoid energy consumption.

3) UPDATE OF PHEROMONE

The pheromone update in the ant path uses two global pheromone and local pheromone update strategies. In the process of wireless sensor network routing algorithm, the ant has divided into two types: forward and return. The forward ant moves from the source node according to the state transition formula. The target node is transferred, and each time a path is passed, the pheromone concentration in the path is updated according to the pheromone local update strategy. Then, in order to effectively avoid the concentration of pheromone in the path is too large or too small, so that the convergence of the algorithm is accelerated, the concentration of the pheromone is set between τ min and τ max, and the pheromone concentration formula in the local path is updated. The pheromone value changes as the packet is transmitted over the path. If a packet passes, the value of the pheromone on the path increases, and the pheromone of the path through which no packet passes does not evaporate. The value of $\tau_{i,j}(t)$ is updated by equation (1).

$$\tau_{i,j}(t+\Delta t) = \rho\tau_{i,j}(t) + (1-\rho)\Delta\tau_{i,j}^{k}(t) \tag{1}$$

where: ρ is the pheromone volatilization factor; $\Delta\tau_{i,j}^{k}(t)$ is the pheromone value added on the link (i,j), $\Delta\tau_{i,j}^{k}(t) = Q(^{E_{remain}}/_{E_{\max}})$, Q is a constant, E_{remain} indicates the remaining energy, $E_{\max}$ is the initial energy. The lower the residual energy, the less the pheromone is added, and the possibility of selecting this path is reduced, so that the node that bypasses the node energy is low, and the node energy consumption in the network is balanced.

The ant system provides the best explanation for clarifying the basic idea of the ACO meta heuristic algorithm. With the basic principle of the ant system and the characteristics of the meta-heuristic algorithm, the ACO's meta-heuristic framework can be proposed [22]. By defining the algorithm association of the combinatorial optimization problem, the ACO meta heuristic has a natural basis. In this framework, the ant system is an example of an algorithm and can derive other algorithms. Although other derivative algorithms are proposed separately, the ACO meta heuristic framework is the best generalization for them.

4) ALGORITHM DESIGN OF ACO

In order to achieve energy balance and prolong the network life cycle, it is extremely important to reasonably select the optimal next hop in WSNs of multi-hop communication. Since the gateway nodes in the WSNs are all set up on the water surface, when the common sensor nodes in the water sense the target event information, the data needs to be transmitted to the water surface through multiple hops. This chapter designs an optimization mechanism to ensure the optimal selection of the next hop of the sensor node communication.

The communication radius of the node is as shown in Figure 3. When the node s_i collects the monitoring data, the multi-hop communication method is used to transmit the data upward to the water surface gateway. At this time, the next hop that it can select is an arc. The four nodes in the half are s_1, s_2, s_3, s_4. Most of the previous multi-hop connections use the most recent transmission, that is, s_i will select the node s_1 closest to it as the next hop of communication to reduce the transmission energy generated by the distance. However, when the node s1 is not only the nearest neighbor of the node s_i, the other nodes will pass the

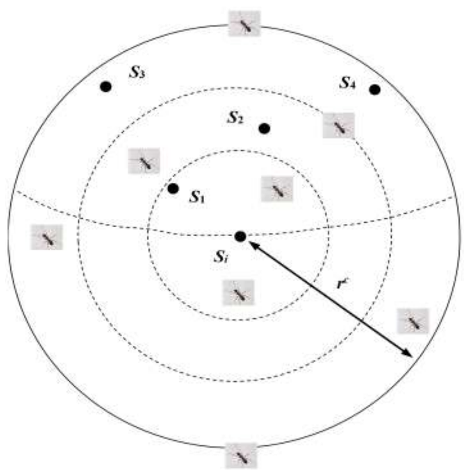

FIGURE 3. Optimal next hop selection diagram of ACO.

data to the node s_1 through the recent transmission selection method, causing the s_1 to be overloaded, easily prematurely crashing, and affecting network performance.

Therefore, in order to achieve load balancing of network communication, when selecting the next hop node for communication, the node s_i should consider not only the spacing d_i between each neighbor node and the node s_i, but also the current communication quality G_i of each neighbor node of the node s_i. Conduct a comprehensive evaluation to select the optimal next hop node.

III. WSN TRANSMISSION TARGET FUNCTION CONSTRUCTION

A. ENERGY MODEL CONSTRUCTION

According to the scene description of Figure 3, combined with the LEACH wireless communication model, the communication model of the mobile node in the WSN network is designed as shown in Figure 4.

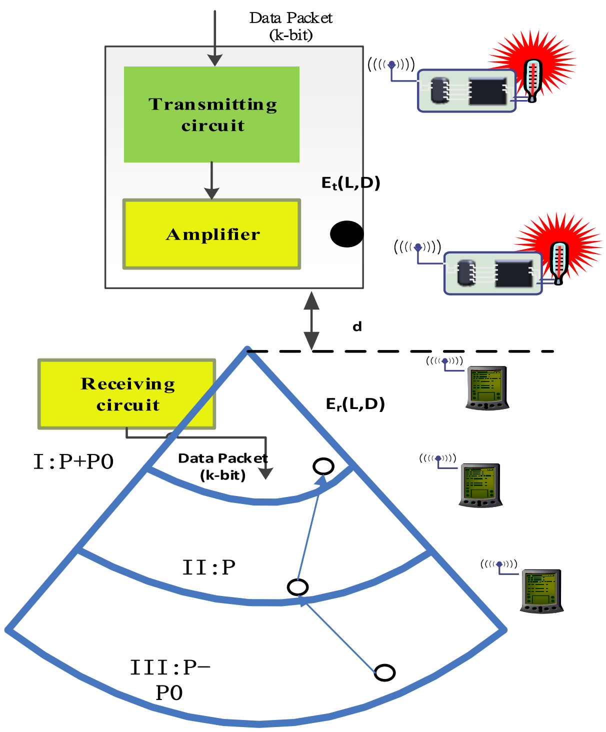

FIGURE 4. Node wireless communication energy consumption model.

It can be seen from Figure 4 that in WSN wireless transmission, the energy consumed is mainly reflected in the transmitting and amplifying parts. The network energy consumption generated by the transmitting circuit part mainly comes from the length of the transmitted data packet l; the power consumption of the amplifying circuit part comes from the data packet transmission distance d.

In the routing algorithm based on ant colony optimization, a routing algorithm based on ant colony optimization is proposed for mobile ad hoc networks. The algorithm makes good use of the adaptability of ant colony algorithm and can effectively carry mobile ad hoc networks [23]. The load ant colony route $G = (V, E)$ is a weighted directed graph of n nodes, $n = |v|$, where V is the set of vertices of the directed graph and E is the set of edges. Ant colony optimization is used to find the shortest path $e(i, j) \in E$ from node Vi to the destination node in graph G, with each pheromone variable $\varphi_{i,j}$. When the ant accesses the node, the variable is modified. The ant on the node Vi uses the pheromone on the node v_d to calculate the probability of the node as the next hop, and N_i is the set of the next hop neighbor node $v_i = v_j$ of the node V_i. The selection probability $\varphi_{i,j}$ is expressed by the following formula:

$$P_{ij} = \begin{cases} \frac{[\varphi_{i,j}]^{\alpha}}{\sum [\varphi_{i,j}]^{\alpha}} \\ 0, \end{cases} \tag{2}$$

Among them: $\alpha \geq 1$. The purpose is to control the ant's exploration behavior.

The transition probability p_{ij} of node Vi satisfies the following restrictions:

$$\sum_{i \in N_i} p_{i,j} = 1; i = 1.2, \cdots, N \tag{3}$$

During route discovery, the ant places a constant amount of pheromone $\Delta\varphi_{i,j}$ on the path that passes. When the ant moves from node v_i to node v_j, change the number of pheromone on the side $e(v_i, v_j)$ according to the following formula:

$$\varphi_{i,j} = (1 \mp \rho)\varphi_{i,j} \pm \rho\Delta\varphi_{i,j}; \rho \in [0, 1] \tag{4}$$

B. DATA BALANCE TRANSFER ALGORITHM FOR WSN NODES

The target event is randomly generated. According to the traffic-based node deployment method, it can be divided into two key monitoring areas as shown in Figure 5. The node si in the key monitoring area 1 wants to forward data to the gateway in multiple hops. However, there are too many

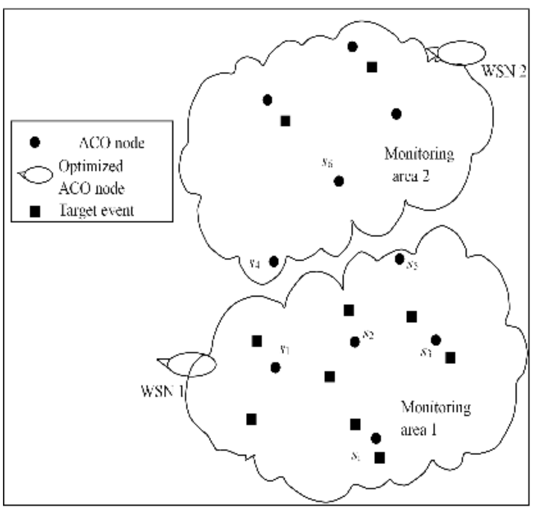

FIGURE 5. Data balanced transmission of WSNs nodes.

events in the key monitoring area 1, and the three neighbor nodes s_1, s_2, and s_3 of the node s_i have reached their maximum working capacity. Receive new data. If the node si forcibly transmits data to any of s_1, s_2, and s_3, it is highly probable that the load will be excessive, resulting in failure. However, the non-neighbor nodes s_4 and s_5 of the node si are relatively idle. At this time, if the data is forwarded by the WSN1 slaved by the node s_i according to the network model, the network communication energy consumption can be effectively adjusted. Therefore, this section further designs a data balance transmission algorithm based on WSNs nodes.

C. ALGORITHM DESIGN OF IMPROVED ACO

In the communication process of WSNs transmission monitoring data, there are mainly three kinds of nodes: common sensor nodes, WSNs nodes and gateway nodes. First define the communication mode in the node data forwarding process [24], [25]. A common sensor node contains two communication modes. First, the ordinary sensor node si transmits data multi-hop to the gateway node on the water surface according to the comprehensive evaluation mechanism. Secondly, the ordinary sensor node si passes the data directly to its subordinate WSN node, is no longer responsible for forwarding other node data, and only monitors the target event within its own perceived range.

When the following two factors are available, the node s_i is switched from the communication mode Pmodel to the communication mode Pmode2. First, s_i consumes less than "Np" and cannot receive forwarding data from other nodes. Second, s_i no neighbor nodes or their neighbors are in communication mode Pmode2 [26]. For WSNs nodes, there are also two communication modes. The WSN node receives the data packet of the ordinary sensor node to which it belongs, selects the next hop node according to the comprehensive evaluation selection mechanism, and transmits the data to the gateway node through multiple hops. There is no suitable next hop around the WSN node that needs to forward data. According to Hypothesis 2, its communication radius and communication power have adjusted as needed, and the data is directly transmitted to the gateway node.

In the data balance transmission algorithm based on WSN node, the optimal mechanism of the non-optimal next hop node that cannot have processed by the WSNs multi-hop communication method based on the optimization mechanism has solved by designing the conversion mechanism of various types of node communication modes.

Figure 6 shows a flow chart of the data balance transmission algorithm based on ACO WSNs nodes.

Initially, the common sensor nodes are in the Pmodel communication mode, and the WSNs nodes are all in the Amodel communication mode. The main process of the algorithm is:

Step 1: The normal sensor node in the working state first senses the monitored target event. When the data needs to be transmitted, the optimization mechanism is called to calculate the current communication quality and distance of the

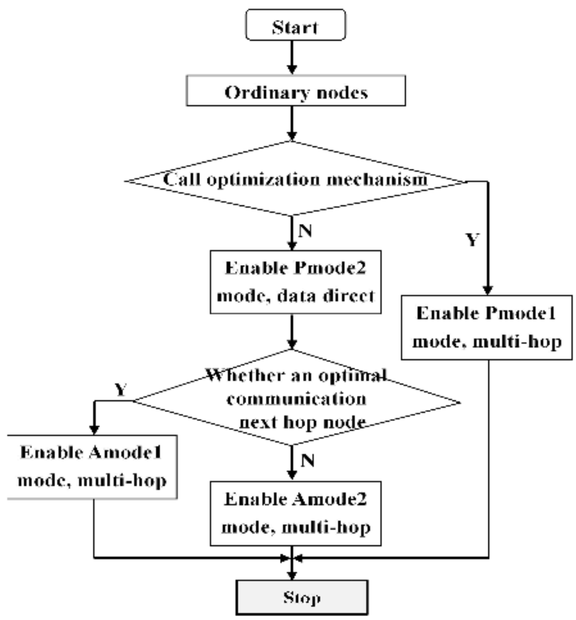

FIGURE 6. Flow chart of the data balance transmission algorithm based on ACO WSNs nodes.

neighbor node, and determine whether there is an optimal neighbor node as the next.

Step 2: If the optimal next hop node is calculated, the node uses the current Pmodel communication mode to transmit data to the optimal next hop node, maintain the Pmodel communication mode, and end the data forwarding.

Step 3: If it is found that the neighboring neighbor nodes are in the maximum workload state and there is no optimal next hop, the node switches its own communication mode to Pmode2, and forwards the data to its own subordinate WSN node.

Step 4: When the WSN node receives the forwarding data, it first uses the current Amodel communication mode, invokes an optimization mechanism, calculates the current communication quality and distance of the neighbor node, and determines whether there is an optimal neighbor node as the next hop.

Step 5: If the optimal next hop node is calculated, the WSN node uses the current Amodel communication mode to transmit data to the optimal next hop node, maintain the Amodel communication mode, and end the data forwarding.

Step 6: If no optimal next hop is found after the calculation, the WSN node switches its own communication mode to Amode2, automatically adjusts its communication radius and communication power as needed, and directly transmits the data to the water surface gateway node.

In particular, when the data that the node needs to forward exceeds the maximum working capacity that can be carried by the node, it can no longer be used as the next hop of other nodes, and directly switches its working mode to Pmode2. At this time, when the si node that needs to forward data finds that its neighbor node sj is already working in Pmode2 mode, it indicates that sj is overloaded, or sj cannot find a suitable neighbor node as its next hop. Then node si does not need to calculate the current communication quality and distance of sj, and automatically gives up the selection of sj.

D. SIMULATION AND RESULT ANALYSIS

Currently, WSNs nodes have been able to equip GPS positioning systems to achieve their own accurate positioning. The method of the previous section only uses WSNs as data forwarding nodes, and does not fully utilize the WSNs node mobility and positioning functions. To this end, this section starts from the node location and direction information, considers the dynamic evolution of the network, and each common node has random mobility. The WSNs node is used to help determine the location information of the common node, and then the location information of the node is used to make the protocol have efficient routing performance and efficient target node location discrimination capability. This section reduces the protocol's buffer size requirements through message priority design, enabling messages to be delivered to the target node accurately and securely [27], [28]. At the same time, under the premise of ensuring the validity and reliability of the protocol, the computational overhead and communication overhead of the protocol operation are reduced as much as possible. The new parameters in the experiment are shown in Table 2.

In this paper, the advantages of packet transmission rate are experimentally verified, and compared with the classical ACO algorithm and the improved ACO algorithm. The packet transfer rate is defined as the ratio of the number of packets passed and the number of packets generated, ie how many packets are sent to the destination [29]. Two sets of experiments have carried out respectively. Experiment 1, the relationship between packet transfer rate and pause time. Experiment 2, the relationship between packet transfer rate and the number of sessions between nodes.

TABLE 2. Experimental parameter setting table.

Symbol	Description	Value
V_{WSN}	WSN moving speed	5m/s
V_s	Sensor random movement speed	0～1m/s
V_{data}	Data transfer rate	2Mbps
T	Simulation time	1000s
P_t	Pause time	0s，20s，50s，100s，300s，600s，900s

Experiment 1: Relationship between packet transfer rate and pause time

The underwater acoustic sensor network has dynamic evolution, and simulates the dynamics of underwater nodes by designing the length of the pause time. The longer the pause, the closer it is to the static situation.

As shown in Figure 7, the packet transfer rate gradually increases as the pause time increases. Obviously, the longer the pause time, the more the nodes are closer to static, the lower the mobility, and the more stable the network. In particular, when the pause time is 100s, the packet transfer rate of the ACO and WSN protocol algorithms in the figure is instantaneously reduced to the lowest state. It can be explained that these algorithms are more suitable for static networks, and the pause time of 100s is not enough for them to establish a stable route transmission path at the initial time. Therefore, the packet transfer rate of ACO and WSN is drastically lowered [30]. The IMPROVED ACO packet transfer rate proposed in this section continues to increase with the increase of the pause time, showing good dynamic adaptability. In general, IMPROVED ACO's packet transfer rate is the largest and most stable compared to the other three routing protocols. It maintains a relatively low packet transfer rate at any pause time.

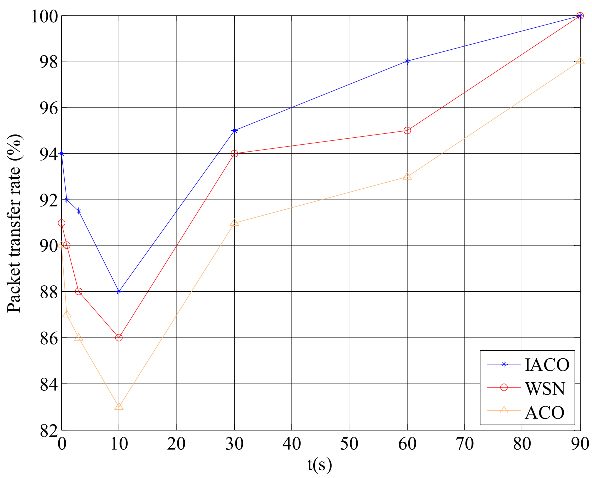

FIGURE 7. Relationship between packet transfer rate and pause time.

Experiment 2: Relationship between packet transfer rate and number of sessions

The more sessions the nodes in the network need to perform, the more packet data that needs to be transmitted, and the greater the interference between them. Experimental comparison of packet transmission rates under different number of sessions can be observed in different protocols for data volume processing.

As shown in Figure 8, all routing protocols show that their energy consumption increases with the number of sessions. The number of sessions determines the existence of routing links between nodes in the network. The improved ACO algorithm (IACO) packet transmission rate proposed in this section has maintained above 93%, which is superior to the other two algorithms.

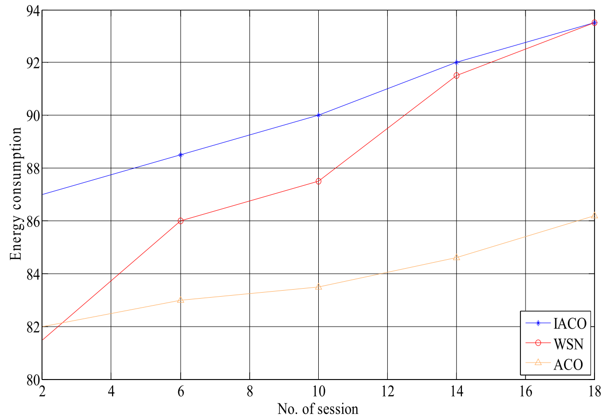

FIGURE 8. Relationship between energy consumption and number of sessions.

The positioning problem in wireless sensor networks is actually an energy optimization problem, the goal of which is to minimize the total estimation error of the WSN positioning problem. The improved ACO algorithm proposed in this paper combines the advantages of path and ant colony algorithm to not only improve the quality of the initial population [31]. In the iterative process, the population quality of the offspring can be improved accordingly, which improves the positioning accuracy of the algorithm, and the application of the binary ant colony algorithm can improve the convergence more quickly. The simulation results show that the improved ACO algorithm has better positioning effect than the traditional ACO algorithm and ordinary WSM, and the convergence speed is fast, which an energy is saving method with greater application value.

E. DATA BALANCED TRANSMISSION OF WSNS NODES

When the problem solved is the probability of occurrence of a random event, or the expected value of a random variable, the probability of the random event can be estimated by the Monte Carlo method at the frequency of occurrence of such event, or the random variable can be obtained. Some digital features are used as solutions to the problem. For the multi-hop communication strategy of WSNs based on optimization mechanism, Monte Carlo method was used to carry out 100 rounds of simulation experiments. The experimental environment is set as follows: 500m × 500m × 200m monitoring area. The WSNs movement model has been constructed at the initial stage, including 200 common sensor nodes and 20 WSNs nodes, randomly generating 300 target events for uneven deployment. Sensor nodes and target events are affected by the ACO model to produce positional changes. In order to evaluate the life cycle of the network and better test the load balancing effect, this chapter divides the time into rounds and assumes that each node generates a data packet in a round of time. Table 3 shows the experimental parameter settings.

TABLE 3. Experimental parameter setting table.

Symbol	Description	Value
r^s	Sensor sensing radius	3m
r^c	Sensor communication radius	5m
r_a^s	WSN sensing radius	18m
r_a^c	WSN communication radius	12m
V_t	Underwater sound propagation speed	1000m/s
Q_e	Energy consumption for sending unit data	0.01J
e	Sensor node initial energy	5J

The experimental parameter settings are respectively carried out in two sets of experiments: the relationship between the node mode-switching threshold "Np" size and the network lifetime; the data balance transmission algorithm based on the WSN node is compared with the network life cycle without the algorithm.

Experiment 3: Relationship between node mode transition threshold "Np" size and network lifetime.

The node mode transition threshold "Np" refers to the automatic switching to the Pmode2 communication mode when the remaining maximum workload of the node is Np. A reasonable mode-switching threshold can effectively maintain the life of the sensor node. In order to maximize the network lifetime, multiple experiments can be performed by changing the node mode switching threshold "Np" size to explore the relationship between "Np" and network lifetime. In the experiment, it is assumed that the initial energy of each common node is 4J, and when the remaining energy of the node is less than 4 × 106 nJ, it is determined that it is no longer working. Therefore, the size of "Np" should be between 4 × 106 nJ and 3 J.

After many experiments take the average value, the solid line in Figure 9 shows the relationship between the value of the remaining maximum workload "Np" and the network life cycle during node mode conversion. It can be seen from the figure that when Np is larger. The network life cycle is longer. The Np is larger, the common sensor nodes almost all adopt the Pmode2 communication mode, and directly transmit data to the associated WSNs. The entire network relies on the WSNs node for communication, and the common node has a long life, and thus the network has a long life cycle. However, at this time, the WSNs transmit too much data, the internal data packet queue is too long, and the value of the ordinary node has not well reflected, resulting in prolonged communication and low quality of the entire network. When Np is too small, the remaining energy of the ordinary node is seriously insufficient, it has used excessively. The communication delay is long, and it is prone to failure, resulting in the termination of network life. Figure 9 shows that when the Np is about 1.6J in the experiment, the average network communication delay is the smallest, and the number of network life cycles is about 1.4*105. Therefore, the conversion threshold of node mode is set to 1.6J in subsequent experiments.

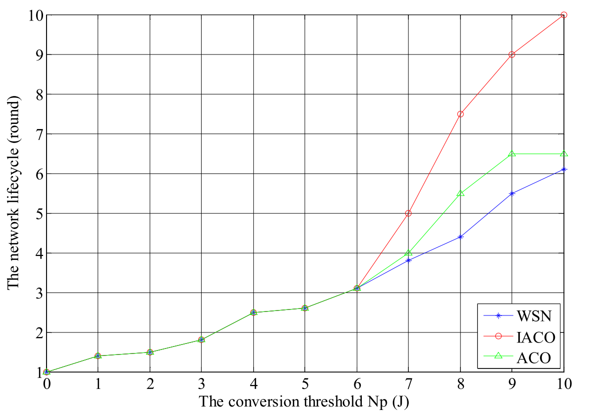

FIGURE 9. Relationship between Np and network lifetime and communication delay.

Experiment 4: The data balance transmission algorithm based on WSNs node is compared with the network life cycle without using the algorithm.

The network of the data balanced transmission algorithm based on the WSNs node is compared with the network using only the optimization mechanism. Multiple experiments were conducted to explore the differences between network life cycles, as shown in Figure 10.

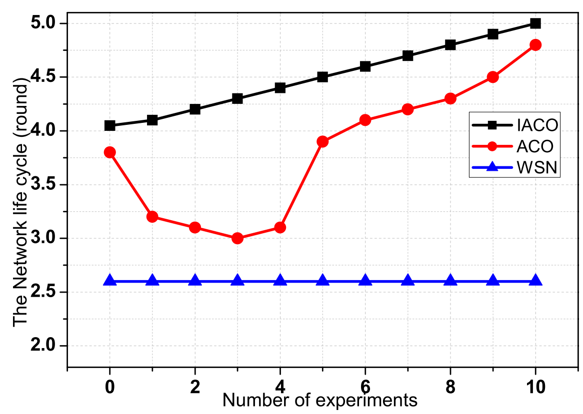

FIGURE 10. The differences among network life cycles.

It can be seen that the network lifetime of the data balance transmission algorithm based on the WSNs node is generally higher than that of the network using only the optimization mechanism. This is because the data balanced transmission algorithm based on WSNs node can better balance the load of the network, so that each node can fully display its own value. After adopting the algorithm, the network life cycle value is stable and maintained at 1.36×10^5. However, the network with only the optimization mechanism has a large fluctuation in the life cycle and poor network robustness.

Finally, in this paper, the performance of the node IACO strategy and node random WSN distribution strategy, and ACO strategy in terms of network energy residual rate are compared by simulation experiments.

Figure 11 shows the network energy residual rate of the network under three different distribution strategies. In the discussion of this paper, the network energy residual rate refers to the sum of the remaining energy in the network and all nodes in the network at the end of the network's life cycle. From Figure 11, we can see that as the network radius increases, the energy residual rate of the network using the IACO strategy decreases, and the energy of the network using the ACO and random WSN distribution strategies. The residual rate is increasing. The energy residual rate of the network using the node IACO strategy is much lower than that of the network using the other two-node distribution strategy. In addition, the random non-uniform distribution strategy is more effective than the uniform distribution strategy. The high-energy efficiency also confirms the effectiveness of the non-uniform distribution strategy relative to the uniform distribution strategy.

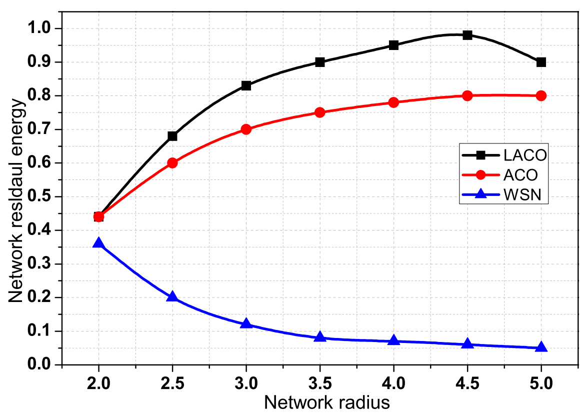

FIGURE 11. Network energy residual rate under different algorithms.

In this paper, kroa100 is used for experimental simulation, and IACS (improved ant colony algorithm), ACS (ant colony algorithm) and WSN (traditional wireless network node) are compared to verify the effectiveness and feasibility of the proposed algorithm. For each instance, 50 independent tests were performed with IACS, ACS, and WSN, and the distance between nodes was kept decimal, and the best solution, worst solution, and average best value found by each algorithm in 50 experiments were recorded.

It can be seen from Figure 12 that the traditional WSN, ACS algorithm has a faster convergence speed, but it is easy to prematurely and falls into the local optimal solution. The IACS solution accuracy is higher than that of the ACS, which makes up for the shortcomings of the traditional

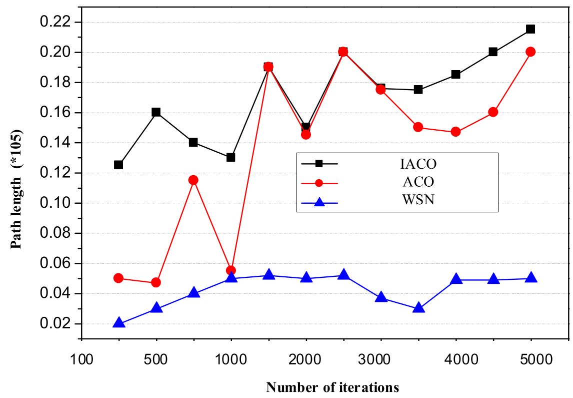

FIGURE 12. The differences among network life cycles.

algorithm and can ensure the accuracy of the solution. It can quickly converge. Experiments show that qubit coding of pheromones can increase the diversity of solutions, help to survey and extract more and better solutions, and avoid premature stagnation of algorithms. It can speed up the convergence of the algorithm and improve the global search ability. For the possibility of falling into the local optimal problem, the neighborhood will transform the solution obtained by the ant each time, expand the search area, and seek a better quality solution.

IV. CONCLUSION

The routing and forwarding design problem of WSNs is an important research point in the field of sensor network topology and energy conservation. Aiming at the load-balancing problem in multi-hop communication, this paper proposes a multi-hop communication method based on optimization mechanism for WSNs, which comprehensively evaluates the distance between nodes and the communication quality of neighbor nodes, selects the next hop for communication, and designs multiple communication. The mode further ensures the balance of data forwarding by using WSNs nodes. In summary, the mobile wireless sensor network (WSN) is the main development trend of mobile wireless networks. The research on the reliability of WSN is equivalent to the research on the reliability of mobile wireless networks. Based on the mastery of mobile wireless networks, this paper finds that the current WSN operation process has two major problems: data collection difficulty and network energy consumption, which seriously affects the reliability of WSN. In this paper, the optimization algorithm of WSN data collection based on artificial bee colony is proposed, and the results of Fig. 8 verify that the algorithm is smaller than other algorithms in energy consumption, which greatly improves the reliability and promotion of the reliable and orderly development of mobile wireless networks.

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