AWARE ANT ROUTING ALGORITHM IN MOBILE PEER-TO-PEER NETWORKS

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Abstract—In order to reduce the available energy of network aware node and prolong its network lifetime, an aware ant routing algorithm is proposed in this paper. Aware node energy, link quality and link survivability is combined as the routing standard to achieve the purpose of improving network performance in this algorithm. The ant optimization is introduced and any cast mechanism based on the pheromone is adopted in routing discovery process. The experimental result shows that the algorithm can find the effective path in time and reduce energy consumption.

Index Terms—Network Model; Route Discovery; Residual Energy; Packet

I. INTRODUCTION

In recent years, peer-to-peer computing model has achieved great success in wire network. With the rapid development of mobile communication technology, a variety of mobile devices continue to emerge and the corresponding processing capacity is also growing stronger. Peer-to-peer computing gradually extends to the mobile field, becoming a new kind of application network—mobile peer-to-peer networks. Mobile peer-to-peer network has convenient deployment and strong self-organization and a strong application, bringing new development space for peer-to-peer model. Mobile peer-to-peer network often operates peer-to-peer computing in a mobile self-organizing environment, which is a network system built temporarily for specific user to use in disaster rescue and so on. Routing is an important issue in computer network study and routing algorithm should design according to the network characteristics [1-2]. Therefore, the important issue that the mobile peer-to-peer network is facing is that how to design effective routing algorithm according to its characteristics.

In recent years, researchers have proposed a lot of routing algorithm based on network information perception. Network information of perception can be divided into two categories: nodes related information and network level information. The former includes the node energy, node locations and other information. The latter includes the link quality, link survival time, traffic load, topology changes and other information [3]. A perception message may correspond to multiple different perception parameters. For example, link quality can be described through four different parameters: the received signal strength indicator, SINR, packet delivery ratio and bit error rate. Each parameter has its own characteristics. Even sensing the same parameters, the choice of metrics may be different, such as the five different metrics about network consumption proposed by Singh and others. Notably, perception contains two meanings: perception information and corresponding handling. For the same perception information, there may be multiple handling mechanism. Meanwhile, the perception objectives are not independent of each other and a routing algorithm can be based on multiple perception parameters simultaneously.

Energy is the most important resource of node. At present, many routing algorithm reduce the energy difference between nodes through sensing available energy of node to balance distribution of node energy and prolong network survival time. For example, Hussein and others proposed ARAMA, the node energy information perceived according to the routing request packets evaluate the corresponding path to further update the routing information from intermediate node to target node in order to balance the energy resource of node [4]. Jhong and others proposed CAARMA based on ARAMA, judging whether the neighbor node will be shifted out of communication range according to the perceived signal strength select a good alternate path in advance to reduce packet loss [5-6].

Intuitively, the path quality is the best routing criteria. For example, CRP proposed by Tran and others judge the node congestion through regularly detecting the usage of buffer of the link layer, and divide it into three grades. After determining congestion of the main path, to establish a bypass to the first non-congested node of the downstream of primary path in time to reduce delay and distribute the traffic on the main path and bypass to relieve congestion. The node of CALRA proposed by Zheng and others judges the link load state through sensing the utilization of interface queue cache of MAC (Medium Access Control) layer and calculating the ratio of their average packet transmission delay to the average estimated delay of node in path [7]. And, reward system is introduced according to the congestion in network to balance network load. ETX proposed by Couto and others calculates the link quality through transmission times that correctly transmitting (including retransmission) a data packet in link requires [8].
Network topology has an important impact on the routing performance. Some routing algorithms make node have a clearer understanding for network topology through sensing location information so that a more suitable path is selected. For example, the nodes in GPS proposed by Karp and others can sense their location information and be unified addressing so that the data forwarding can go along a straight line as far as possible by using greedy algorithm. LAODV proposed by Wu and others, based on AODV, senses its location information through the location technologies such as GPS and so on. Meanwhile, to sense the position of neighbor through HELLO division so that the routing discovery is made through the way to combine the revised greedy forwarding of flooding and location information. Some routing algorithm know the change of network topology through sensing path stability. For example, MUDOR-AS proposed by Sakhaee and others takes the relationship of relative movement between the nodes as stability parameter and the nodes obtain the Doppler frequency shift between nodes through periodically exchanged packet of nodes [9]. PGLS proposed by Xiao and others directly takes the distance between two nodes as the link stability parameter, combines with rumors mechanism and then a pseudo-rumor routing algorithm based on link stability is proposed. MASR proposed by Hu and others takes effective link time as the stability parameter. Through bilaterally assessing the link valid time and node mobility status changes, asynchronous notification and multipath routing based on link stability maintaining is triggered to ensure the stability of routing [10]. Some routing algorithms sense network topology changes through other parameters. For example, ARPM proposed by Seba takes perceived change rate of surrounding neighbor nodes as measure parameter of topology change, so that the reactive / active route is carried out in the high / low movement separately [11]. EAGER proposed by Zhao and others divide the network into honeycomb, route in honeycomb is maintained by initiative and the route between the honeycomb is built by demand. According to the message arrival rate and the rate of change of topology, the size of honeycomb is adjusted dynamically.

Ant colony algorithm is a heuristic algorithm proposed by Italian scholar Marco Dorigo inspired by the foraging behavior of real ants in 1991 [12]. Each ant search dependently in candidate solution space and realize the communication of each with the deepening of the search, it eventually converges to the optimal solution. As is a typical representative of swarm intelligence, in recent years, ant colony algorithm has been widely used in the design of routing protocol. Currently there are two main ways of application: one is to use the trace of ant pheromone to make routing selection, such as ARA, ARAMA etc.; another is to use the mobile agents to traverse the network to collect routing information, such as Ant-AODV and so on. And ARA and the traditional demanding route protocol in mobile network such as AODV are very similar. The demand of source node generates forward ant of similar route request to broadcast routing. After the intermediate node receives fant, update the pheromone to source node in reverse. After the destination node receives fant, it generates the backward ant of corresponding similar route reply. Bant returns to source node along the path of fant in reverse and updates the pheromone from intermediate node to destination node in this way. After the available route is built from source node to destination node through fant and bant, packet finds route based on the probability of pheromone. ARA don’t consider the factor of node energy, which may lead to the imbalance of node energy in network and other problems. Fant in ARAMA finds route based on probabilistic unicast of pheromone and heuristic information. Destination node evaluate the path based on the hop and node energy collected by fant and other information. Bant updates the pheromone according to the evaluation information. In the mobile network of changeable topology, the unicast route of fant probability cannot guarantee to find suitable path in time and brings about the delay growth of routing establishment and other problems [13].

The related research about the issue of ant colony routing has been already done. Since DiCaro and others proposed the ant colony based on the cable network in early time, many scholars have used the ant colony algorithm to solve routing problems of all kinds of networks. And a series of algorithms in MANET are most representative. These algorithms achieve good results in the transmission delay and network congestion and other aspects. In wireless sensor network, Zhang Y and others respectively proposed three kinds of ant colony routing algorithm based on AntNet [14]. The node distance is used to build heuristic factors and evaluate the delay of distributed sensor network, total energy consumption, energy efficiency and others in this paper. In addition, Huawei Liang and others used residual energy of neighbor nodes and routing hop to build ant colony algorithm [15]. It guarantees the minimum energy consumption and balance to a certain degree, but the algorithm can only achieve the balance of local energy consumption because of the use of energy of neighbor nodes in the design of the algorithm. Tu Z and others used the total energy that massage passing consumed in routing to build ant colony algorithm. It can make the network consumption minimized but the balance of consumption not guaranteed. Zheng Wei and others used the residual energy of neighbor nodes and the distance between neighbor nodes to describe the ant colony routing algorithm, only guaranteeing the local minimum and local balance of energy consumption [7]. Camilo T and others improved the update process of pheromone and considered the energy consumption of all nodes in routing, so it made some improvement in the balance of energy of the whole network, but the specific quantitative analysis of routing features was not done [4]. In addition, evaluation criteria of these algorithms mainly are the average energy consumption of network nodes and the number of remaining working nodes.

Based on the above analysis, a new routing algorithm based on perception is proposed in this paper. Through
sensing node energy, link quality and link survivability, the algorithm combines all three as the route selection criteria to achieve the purpose of improving network performance. In addition, the ant optimization is introduced and an anycast mechanism based on pheromone is adopted in routing discovery process, which can not only find effective path in time but also reduce the energy consumption. In route, automatic balance of probabilistic route and fast routing convergence of deterministic route is combined

This paper mainly did expand and innovative job in the following aspects:

1. In order to reduce the available energy of network aware node and prolong its network lifetime, an aware ant routing algorithm is proposed in this paper. Through sensing node energy, link quality and link survivability, the network energy can be balanced effectively and packet delivery ratio can be improved. This algorithm adopts an anycast mechanism based on pheromone in routing discovery process, which can find effective routing paths in time and save energy. When evaluating built routing paths, this algorithm not only considers the energy of every node on routing paths, but also considers quality of links and link survivability. It combines the load balancing of probability routing and fast convergence of deterministic routing.

2. To further validate the correctness and validity of aware ant routing algorithm proposed in this paper, the simulation experiment is made. The experiment adopts the network simulation software NS2 to design related experiment, comparing with AODV and ARAMA algorithm. The simulation result shows that the algorithm in this paper can achieve traffic balance to avoid congestion and find effective path in time to reduce energy consumption of perception nodes.

II. MODEL AND DESCRIPTION

A. Network Model

Node movement follows the Random Waypoint mobile model; Furthermore, the initial energy isomer automatically exit the network in energy depletion; nodes cannot obtain location information; nodes follow the Two-Ray Ground propagation model. To facilitate analysis, we set several network parameters: $e$ indicates the network diameter (take hops as a unit), $x_i$ represents the number of neighbor node of the node $i$, $y_i$ represents a collection of neighbor node of the node $i$, $x$ represents the number of nodes in the network

B. Description of Problem

To improve the performance of the mobile peer-to-peer network, an efficient routing algorithm should also have the following characteristics simultaneously: (1) to try to avoid using broadcast mechanism. Although broadcast mechanism is simple to achieve and can guarantee to find the target node in any case, but it often involves a lot of irrelevant nodes, resulting in a waste of energy; (2) to balance energy distribution of nodes in the network to avoid excessive energy consumption of some nodes, resulting in voids and isolated network; (3) to avoid congestion region in the network and balance traffic; (4) to evaluate the quality and survival performance of the links in the network. Link quality can reflect the current state of the network; link survival performance can reflect the trend of the network.

In the study of routing algorithm of current mobile peer-to-peer network, the existing work can not meet the requirements of the above points. For example, route request packet of ARAMA goes forward according to unicast probability of path quality. While the broadcast is avoided, it is difficult to ensure the time to find the destination node in time, and it needs more consideration of the network congestion and link quality; CALRA only considers the congestion in the network, but does not consider the node energy. Nearly, many early routing algorithms ignore the important limiting factor--the node energy, and the algorithms that consider the node energy do not consider routing overhead and node mobility. More importantly, most of them assume node energy isomorphism, although it does not meet the actual network conditions.

III. AWARE ANT ROUTING ALGORITHM

Because having the characteristic of self-organization, robustness, Ant optimization idea is very suitable for the design of adaptive routing algorithm, i.e., by movement of ants in the network, the pheromone is left in the path they passed, and the decision is made according to the available pheromone and some heuristic information. Routing algorithms can be divided into four parts: route discovery, routing maintain, data packets sending and pheromone evaporation.

A. Routing Discovery

Route discovery's mission is to discover the valid path from the source node to the destination node. In order to better save energy, the demand routing method is adopted, that is, only when the node needs communication, the valid path is established. When the source node needs to send a packet, firstly it should judge whether there is a valid route to the destination node. if there is, then the packet is sent directly, or the forward ant (forward ant, fant)is generated. The forward ant is equivalent to the routing request packet of traditional routing algorithm, finding ways in the network according to pheromone and heuristic information and collecting network information simultaneously. After reaching the destination node, the destination node evaluate corresponding path according to the collected information and generate corresponding backward ant (backward ant, bant).The backward ant return back and update the pheromone of the nodes along the path. After receiving the backward ants, the source node establish one or several valid route to the destination node.

Traditional demand routing protocols are achieved by means of broadcast mechanism. Broadcast mechanism can guarantee to quickly find a valid path in any case, but it could easily lead to a waste of energy, so many improved protocols have given up using the broadcast
mechanism. For example, ARAMA uses unicast mechanism; SARAS (Simple Ant Routing Algorithm) uses controller neighbor broadcast mechanism, only one neighbor node forwarding route request packet. The anycast mechanism based on pheromone is used in this paper:

$$u_{i,j} = \begin{cases} 
1, & \tau_{x,y}^k \neq 0 \\
\sum_{i=1}^{r} e_{x,y}, \tau_{x,y}^k = 0 
\end{cases} \quad (1)$$

Formula (1) represents that the mid-node i choose the neighbor node j as the probability of the next hop node of forward ant d. After each intermediate node receive the forwarding ants, it judge that whether there is the pheromone to the destination node firstly. If there is, then there may be a valid path between two nodes, so forwarding it. Otherwise, forwarding according to local heuristic information probability from itself to surrounding neighbor nodes. In the formula, \( \tau_{x,y}^k \) represents the corresponding pheromone value of path from neighbor node j to destination node e; \( u_{i,j} \) represents the queue length (the number of bits waiting to be sent) from connection node i to neighbor node y in link.

The core of routing algorithm is routing mechanism. The evaluation for the path mainly focuses on two aspects: the path quality and path survivability. Path quality is the merit and demerit of path and mainly refers to the delivery ratio of path for packet. For example, ARAMA evaluate the path quality according to the hops and energy and other information that forward ants collected along the way; Zhuang Lin integrate the bandwidth, delivery ratio and node load and many other indicators to determine the path quality. Path survivability is probability of path that remains valid in future survival cycle. The path with long survival cycle have high stability in data transmission, reducing the impact of node mobility and others on routing process. For example, Chen L and others judge that the node with smallest change of the neighbor node has good stability according to historical information between neighbor nodes.

For the mobile peer-to-peer network that topology changes dynamically, the evaluation of path should not only consider both paths link quality, but also consider the link survivability. At the same time, the evaluation methods cannot be too complicated. Of course, the problem of limited energy nodes cannot be forgot.

In the process of advancing, the forward ants collect information of nodes along the path to reflect the quality of the corresponding path. Except for the path state, good quality evaluation parameters should also include the energy situation and future state of forecast link along the path the routing path to their own circumstances, should include node along the link and forecast future energy situation, such as whether the congestion the survival cycle of link forecast. In order to minimize the size of the forward ants, we apply a normalization form to show:

$$p_i = \alpha_1 \times V_{e,i} + \alpha_2 \times V_{p,i} + \alpha_3 \times V_{j,i} \quad (2)$$

$$V_{p,i} = \frac{\text{num}_\text{rec}_\text{hello}}{\text{num}_\text{send}_\text{hello}} \quad (3)$$

Formula (2) represents the routing information of node i. In the formula, \( \alpha_1, \alpha_2, \alpha_3 \) represents the respective corresponding weight of the residual energy of node, link quality and link survivability, \( \alpha_1 + \alpha_2 + \alpha_3 = 1 \).

Formula (3) represents the ratio of residual energy of node and the average residual energy of the surrounding nodes. Many algorithms use node energy utilization as a measure of node energy, but it only applies to the case of node energy isomorphism. As mobile peer-to-peer network use HELLO mechanisms to ensure connectivity, therefore, to add the current energy information to the HELLO packet sent periodically, then the node i can get the average residual energy of \( m_i \) node around.

$$E_{e,i} = \frac{\sum_{j=1}^{\text{num}_\text{remaining}} e_{j,\text{remaining}}}{m_i} \quad (4)$$

The ratio is in accordance with trapezoid distribution, as it shows in Figure 1.

Figure 1. Ratio of node residual energy and the average residual energy of the surrounding nodes

Formula (5) indicates the link quality, Vlavianos A and others prove that PDR is the most common and accurate link quality measure by experiment and it can be achieved by HELLO mechanism.

Formula (6) indicates the forecast of link survivability. As the node in mobile peer-to-peer network changes dynamically, so the change of quality of the link between nodes is usually in normal distribution. As it shows in Figure 2, when the distance between nodes achieve minimum, link quality is optimal.

Figure 2. Link life (link quality) normally distributed

According to Two-Ra Ground propagation model, it is known that
\[ I_b = I_i \times e_b \times e_n \times \frac{I_i^2}{D^2} \]

In the formula, \( I_b \) represents the signal power received by the receiving node, \( I_i \) indicates the signal power of transmitting node, \( e_b \) represents the antenna gain of the transmitting node, \( e_n \) represents the antenna gain of the receiving node, \( I_i \) represents the height of the antenna of receiving node, \( D \) represents the distance between transmitting node and the receiving node. \( e_b, e_n \) and \( e_i \) are constants. If \( P_t \) does not change, \( P_r \) and \( D \) is in inversely proportion. The node distance is predicted through the change trend received by intermediate nodes, then the link survivability of link is determined.

\[ I_{b_{\text{new}}} = \lambda \times I_{b_{\text{old}}} + (1-\lambda) \times I_{b_{\text{new}}} \]  \hspace{1cm} (5)

In the formula, \( I_{b_{\text{new}}} \) represents the signal energy received by node, \( \lambda \) represents the smoothing parameter. Therefore, as the distance between two nodes decreased, the corresponding link survivability increases. On the contrary, the link survivability decreases.

The normalization information of each link obtained by forward ants is multiplied to be the information of the entire path. It is shown in the following formula:

\[ Q_{\text{path}} = \prod_{i \in \text{path}} Q_i \]  \hspace{1cm} (6)

Since \( Q \in [0,1] \), so \( Q_{\text{path}} \in [0,1] \), and implies the hop information.

After the destination node receives the forward ants, it can evaluate according to collected path information and then generate corresponding backward ants. Perishing forward ants, and then backward ants return to resource node along the path of forward ants, and update the pheromone from middle node to the nodes of downstream along the way:

\[ \lambda'_{x,y} = \lambda'_{x,y} + k(e) \]  \hspace{1cm} (7)

Formula (9) represents that an intermediate node \( x \) update the pheromone value from neighbor \( j \) to destination node \( d \) after receiving the backward ants from the last hop node \( y \). In the formula, \( k(e) = Q_{\text{path}} \times \Delta \lambda \) represents strengthened incremental value, \( \Delta \lambda \) is a constant for increasing the absolute value of the increment of pheromone. \( k(e) \) and the evaluation information of corresponding link are in direct proportion. The higher evaluation of the links is, the more the pheromone increment is, the better they are able to attract the following packets.

To improve performance, whether forward the forwarding ants, the intermediate nodes will update their pheromone values from itself to the upstream node reversely:

\[ \lambda'_{x,y} = \lambda'_{x,y} + k(e) \]  \hspace{1cm} (8)

\[ \text{B. Route Maintenance} \]

Routing maintenance includes two parts: routing refresh and routing failure handling.

Routing refresh is the effective way to identify and maintain the route that is using currently. There are mainly three methods: using the control packet, data packet and automatic update based on routing lifespan.

To reduce overhead, using the method that packet refresh routing, that is, when sending a packet successfully, the nodes along the way will automatically update the corresponding pheromone:

\[ \lambda'_{x,y} = \lambda_{x,y} + \lambda' \]

In the formula, \( \lambda' \) indicates pheromone values that updates automatically.

Routing failure handling is the method that the routing protocol needs to be fixed in order to ensure correct packet delivery because of node mobility and other factors that lead to link failure.

It mainly includes local repair and repair of the source node. The former is creating a new route to destination node through detecting route of node failure to replace invalid route; the latter is generating a route error packet and reversely pass it to source node through detecting the node of route failure to find way again by source node.

In routing failure handling, ant algorithm has a natural advantage, namely, to maintain multiple paths simultaneously. So, if node find the routing failure, it will find other paths to destination node automatically, if exists, then using it directly; otherwise local repair id performed to establish an effective routing as soon as possible. The local repair process is similar to route discovery.

\[ \text{C. Packet Transmission} \]

Data transmission is the method of sending packets based on received routing information.

\[ \lambda_{x} = \begin{cases} 0, & (\text{random\_num}>\beta) \land (\lambda'_{x,y}(\eta_{x,y}) = \max_{\eta_{x,y}} \left\{ \lambda'_{x,y}(\eta_{x,y}) \right\}) \\ 1, & (\text{random\_num} \leq \beta) \land (\lambda'_{x,y}(\eta_{x,y}) = \max_{\eta_{x,y}} \left\{ \lambda'_{x,y}(\eta_{x,y}) \right\}) \end{cases} \]  \hspace{1cm} (9)

Formula (9) indicates that node \( x \) choose the neighbor node \( y \) as the probability of next node of packet that destination node is \( e \). We use the combination of probabilistic routing and deterministic routing. When the generated random number is greater than the threshold value, then the deterministic method is used, that is to select the best path for forwarding and make full use of the results of the finding of path; otherwise, to select between multiple effective next hop nodes according to the pheromone and heuristic information probability and bring the natural advantage of automatic balance of ant algorithm. In the formula, \( \lambda_{x} \) represents the local heuristic information of link from node \( x \) to neighbor node \( y \). The congestion of buffer array of the link is used to show as:
\[ \lambda_{x,y} = 1 - \frac{e_{x,y}}{\sum_{k \neq y} e_{x,y}} \]  
(10)

Heuristic information \( \lambda_{x,y} \) is the normalized function of \( \lambda_{x,y} \) in [0, 1]. random_num \( r \) is a random decimal that is automatically generated, between [0, 1]; \( \lambda_{i} \) is the threshold that the intermediate node determines how to choose its own path. Packet makes routing decision through combining long-term learning process and instantaneous heuristic information. \( q_{\text{allowed}} \) represents the set of node \( x \) of the next hop node that can arrive the destination node \( d \) and meet the requirements. \( \alpha \) and \( \beta \) is the corresponding weight of pheromone value and heuristic information.

D. Pheromone Evaporation

Ant routing algorithm also has a special mechanism: the pheromone evaporation. As pheromone evaporation is individual behavior with no communication between nodes. Therefore, this paper take method of performing regularly evaporation mechanisms.

\[ \lambda_{x,y}^{d} = (1-q)\times\lambda_{x,y}^{d} \]  
(11)

In the formula, \( q \) is the evaporation coefficient.

E. Algorithm Analysis

Lemma 1. Route discovery process can ensure the detection of a valid route in time and lower overhead.

Route discovery is achieved by forward ants according to pheromone and heuristic information. It can be divided into four cases specifically: no information, pheromone, heuristic information and pheromone + heuristic information.

When network is just established, there is no information, neither the pheromone, nor any heuristic information, then forward ants perform broadcast mechanism, which is equivalent to AODV; With the operation of the network, when a node wants to send packets to a new node, at this point, there may be no pheromone but only heuristic information, then the intermediate node forward according to the probability of heuristic information. Haas Z J and others proves that as these intermediate nodes can forward the forward ants to the destination node \( d \) and meet the requirements. The forwarding probability of 1 can ensure that the probability of having a valid route to destination node is high. The forwarding probability of 1 can ensure that these intermediate nodes can forward the forward ants to valid path in time.

Lemma 2. The time complexity of route discovery process is \( O(N) \). Forward ants store the information into the stack \( O(1) \) in intermediate node; the pheromone that update to upstream node reversely is \( O(d') \), entering into the output link queue \( O(1) \). Thus, the worst time complexity of a forward ant during the movement from source node to destination node is \( O(d'2) \). During the process that the backward ants return along the way of forward ants, the operation need to be performed in each intermediate node to get the next hop node \( O(1) \). The pheromone that is updating to the downstream is \( O(d') \), entering the output link queue \( O(1) \), then the worst time complexity of a backward ant in the movement is \( O(d'2) \). Therefore, the time complexity of routing discovery process is \( O(d'2) = O(N) \).
A forward ant from the source node to the destination node’s movement during the worst time complexity is $O(d^2)$. After the ant along the path prior to reverse during the return, at each intermediate node to perform the operation to obtain the next-hop node stack $O(1)$, updates to the downstream node forward the pheromone is $O(d')$, into the output link queue $O(1)$, then a backward ants during exercise worst time complexity is $O(d^2)$. Therefore, the route discovery process, the time complexity is $O(d^2) = O(N)$.

IV. EXPERIMENTAL SIMULATION AND ANALYSIS

A. Experimental Setup

The network simulation software NS2 is used to design related experiment to verify the performance of SAARA (Self-Aware Ant Routing Algorithm). The parameter setup of network environment is shown in Table 1; the parameter of the algorithm is shown in Table 2. We choose AODV and ARAMA to do comparison.

<table>
<thead>
<tr>
<th>TABLE I. NETWORK ENVIRONMENT PARAMETER</th>
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<tbody>
<tr>
<td>parameter</td>
</tr>
<tr>
<td>number of node</td>
</tr>
<tr>
<td>network range</td>
</tr>
<tr>
<td>maximum transmission range</td>
</tr>
<tr>
<td>propagation model</td>
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<tr>
<td>speed range of movement of node</td>
</tr>
<tr>
<td>modeling time</td>
</tr>
<tr>
<td>residence time of node</td>
</tr>
<tr>
<td>connection number of CBR</td>
</tr>
<tr>
<td>size of data packet</td>
</tr>
<tr>
<td>transmitting consumption</td>
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<tr>
<td>receiving consumption</td>
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<tr>
<th>TABLE II. ALGORITHM PARAMETER</th>
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</thead>
<tbody>
<tr>
<td>parameter</td>
</tr>
<tr>
<td>$a_1$, $a_2$, $a_3$</td>
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<tr>
<td>$\lambda$</td>
</tr>
<tr>
<td>$\Delta y$</td>
</tr>
<tr>
<td>$r'$</td>
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<tr>
<td>$\alpha \times \beta$</td>
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<tr>
<td>$\alpha_1$</td>
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<td>$q$</td>
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</table>

B. Experimental Result and Analysis

Setting the initial energy of all nodes are $32J$ to test the performance of node energy isomorphism. Figure 3 (a) indicates that the packet delivery ratio changes differently with node residence time. AODV is directly used after the shortest path is found, if it is not valid because of node mobility, then the way will be found again after the energy of node in the path. As the energy limit is out of consideration, so the speed gap of node energy consumption seriously affects the performance; Although ARAMA considers the energy utilization of node along the way, but it use unicast mechanism to find way, so the performance is slightly better than AODV in dynamic condition but slightly worse in static condition; SAARA considers not only the node energy but also the link quality and link survivability. What need to pay attention is that, because of energy limit, the performance in static condition may lower than the performance in dynamic condition as the dynamic environment balance the energy distribution objectively.

Figure 3. The performance of isomorphism of initial energy of node

Setting the initial energy of the node averagely distribute in 30J ~ 50J in order to test the performance of isomeric node energy. Figure 4 (a) indicates different changes of packet delivery ratio in different residence time. Figure 4 (b) represents different changes of average routing overhead in different residence time. Since ARAMA is designed for the environment of isomorphic environment, so the difference of performance between AODV and ARAMA is greater. The way of SAARA to sense node energy give it the ability to adapt the isomeric condition.

Figure 4. The performance of isomism of initial energy of node

Figure 5 is the change of energy standard deviation of node (isomorphism/isomerism) during the process of network operation under dynamic environment. It can be seen that ARAMA and SAARA are better than AODV because the information of node energy is considered. In Figure 5 (a), the initial energy of nodes are $32J$, so the effect of energy difference factor is less. The main consideration is number of path hop and other quality information. The standard deviation of energy grows rapidly, but to a certain extent, the factor of energy affects the growth. In the figure, the standard deviation of energy of SAARA plummets is because that some node energy may be quickly exhausted in the shortest path and forced to choose another path.

In Figure 5 (b), the initial energy of node is between $32J$~$52J$. With the operation of the network, standard deviation of node energy of SAARA has been decreased; and ARAMA aims at isomorphic condition and only
selects the node that the proportion of remaining energy is higher, not

<table>
<thead>
<tr>
<th>The node energy standard deviation</th>
<th>The node energy standard deviation</th>
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<tr>
<td>Network running time/s</td>
<td>Network running time/s</td>
</tr>
<tr>
<td>0 100 300 500 1000</td>
<td>0 100 300 500 1000</td>
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</tbody>
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Figure 5. Necessarily the absolute value of remaining energy is higher

V. CONCLUSION

An aware ant routing algorithm is proposed in this paper for mobile peer-to-peer network. It presents a perception ant routing algorithms. Aware node energy, link quality and link survivability is combined as the routing standard to achieve the purpose of improving network performance in this algorithm. The ant optimization is introduced and an anycast mechanism based on the pheromone is adopted in routing discovery process. The algorithm in this paper can achieve traffic balance to avoid congestion and find effective way in time to reduce consumption of perception node.

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