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A Wireless Mesh Multipath Routing Protocol Based on Sorting Ant Colony Algorithm

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Abstract

In this paper, the traditional ant colony algorithm has a slow convergence rate for routing optimization of Mesh networks. A multi-path routing protocol based on improved ant colony algorithm, Fortified Ant protocol, is proposed. The protocol first adds a sorting algorithm based on the ant colony algorithm, and introduces the concept of elite ants to improve the speed of routing optimization. Secondly, this paper also studies the multipath transmission of self-organizing networks. The simulation results show that compared with ADOV, DSR and AOC routing algorithms, the algorithm can quickly find multiple paths with better quality, with fast convergence and overhead. Less advantage.

Key words: Wireless Mesh network; Ant colony algorithm; Sorting algorithm; Multipath routing; Fortified Ant

1. Introduction

Wireless Mesh network is a kind of self-organizing network, mainly composed of two parts, respectively is wireless router (Mesh routers) and wireless client (Mesh clients), Mesh router constitute the backbone network, Mesh clients through the Internet backbone network connection.Under the communication environment of wireless mesh network, the topology of mesh network is relatively stable, so it has great research value in the temporary arrangement of communication network.

As the future of wireless Mesh networks has gradually been recognized by many scholars, many experts have studied the multipath routing methods of wireless Mesh networks, and many have achieved certain results. In [1], a multi-path routing discovery method based on particle swarm optimization for wireless mesh networks is proposed.

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The congestion prediction degree and node forwarding goodness function are defined as the fitness function of the particle swarm algorithm model to ensure the validity of the calculated path. High efficiency. Literature [2] mainly studies the feasibility of ant colony algorithm applied to route optimization in Mesh networks. Simulation experiments show that ant colony algorithm can be used for route optimization of Mesh networks, and its optimization speed is fast, and it can achieve global optimization.

In this paper, on the basis of above research, in view of the traditional Ant colony algorithm optimization is slow and single path routing is easy to lose data grouping problem, put forward a kind of Ant colony algorithm based on sorting multipath routing protocols - Fortified Ant protocol.

2. QoS Routing Model of Wireless Mesh Network

2.1 WMN Network Multi-Constrained QoS Routing Model

Definition 1. Use S= (P,R) to represent the Mesh network model in a scene, where P represents the set of network nodes,R represents the set of node links, and R is the transmitting range of WMN network node $p \in P$,d represents the distance between two adjacent nodes. If d≤r, it indicates that there is a link r between the two adjacent nodes, and r∈R.

Definition 2. Given S= (P,R), all path sets between source node a∈P and destination node b∈P are denoted as G, and path sets contain corresponding node set P and link set R. QoS of the whole process is described as follows:

Delay:

$$Delay(g) = \sum_{p \in P(g)} Delay(g) + \sum_{r \in R(g)} Delay(g)$$

Bandwidth:

$$BandWidth(g) = \min\{BandWidth(p), p \in P(g)\}$$

Packet loss rate:

$$Loss(g) = 1 - \prod_{p \in P(g)} (1 - Loss(p))$$

Cost:

$$Cost(g) = |P(g)|$$

Here the cost is the number of hops of the link found by route optimization.In WMN, the fundamental purpose of the algorithm is to solve the following QoS constraints and solve the minimum cost path g'.

Delay(g')≦D;
Bandwidth(g')≦B;
Loss(g')≦L;
Cost(g') is the smallest((1)(2)(3) are satisfied).
Where D is the delay constraint, B is the bandwidth constraint, and L is the packet loss rate constraint.

3. Fortified Ant Protocol

The Fortified Ant protocol introduces a sorting algorithm in the traditional ant colony algorithm. The top ants can release more pheromones. The ranking weights are calculated by adding the path length, the channel signal-to-noise ratio and the node's current load size. Decide to optimize the optimal path for ant colony optimization. Secondly, this protocol attempts to join the multipath transmission method to find the optimal two routes parallel transmission between the source node and the destination node, so as to enhance the timeliness and reliability of the protocol.

3.1 State Transfer Rules

The ant's state transition rule is, in layman's terms, the rule of an element j (node) from an element i (node).
In the ant colony algorithm, the ants k (k=1, 2, 3, ..., m) are all selected according to a given probability formula to select adjacent next hop nodes.The main influence factors of this probability formula are information. Prime concentration and expected value of the node.The node that each ant k walks through will be recorded through the taboo table, the purpose of the taboo table is to prevent the ants from repeatedly selecting the same node and logging to the node of the taboo table. The ants will not select until all nodes in the model are passed by the same k ant.The following is the ant's state transition formula, denoted by $P_{ij}^k(t)$, where k is the ant currently looking for a path, i and j respectively represent the current node and a selectable next hop node:

$$P_{ij}^k(t)=\begin{cases}\dfrac{[\tau_{ij}(t)]^{\alpha}\bullet[\eta_{ij}(t)]^{\beta}}{\sum_{s\in J_{k(i)}}[\tau_{is}(t)]^{\alpha}\bullet[\eta_{is}]^{\beta}}, & j\in J_k(i)\\ 0, & Others\end{cases} \tag{1}$$

In this formula α and β in the equation are two weighting factors, α represents the weighting factor of the pheromone, and β represents the weighting factor of the expected value of the node. $\eta_{\mathrm{ij}}(t)$ is the node expectation function, expressed as:

$$\eta_{ij}(t)=0.4\frac{1}{cost(i,j)}+0.3\frac{S}{N}+0.3\frac{1}{G} \tag{2}$$

3.2 Partial Update Rules for Pheromones

The partial update method is performed after each ant completes a selection, and the update formula is:

$$\tau_{\mathrm{ij}}(t+n)=(1-\rho)\bullet\tau_{ij}+\rho\bullet\tau_0 \tag{3}$$

Where ρ represents the pheromone volatilization coefficient, then 1-ρ represents the pheromone residual factor, ρ has a value range of: $\rho\in[0,1)$; τ_0 is the initial pheromone concentration.

3.3 Sort-Based Pheromone Global Update Rules

When all ants complete a trip, the pheromone on each side is updated according to the following formula:

$$\tau_{ij}(t+n)=(1-\rho)\bullet\tau_{ij}(t)+\Delta\tau_{ij} \tag{4}$$

$$\Delta\tau_{ij}=\sum_{k=1}^{m}\Delta\tau_{ij}^k \tag{5}$$

$$\Delta\tau_{ij}^k=\begin{cases}\dfrac{Q}{L_k}\\ 0\end{cases} \tag{6}$$

Where Q is a normal number and L_k is the length of the path taken by the kth ant in this tour.

In this paper, in order to speed up the convergence of ant colony optimization, combined with the elite ant sorting method of reference [22], the redefinition is as follows:

$$\Delta\tau_{ij} = \sum_{r=1}^{w-1}(w-r)\Delta\tau_{ij} + w\Delta\tau_{ij}^{bs} \tag{7}$$

$$\Delta\tau_{ij}^{r} = \begin{cases} \frac{1}{L_r}, (i,j) \in T^r \\ 0, Others \end{cases} \tag{8}$$

Where L_r represents the length of the travel path of the ant ranked as the rth position, and $\Delta\tau_{ij}^{bs}$ represents the value of the optimal path pheromone quantity.

The pheromone global update rule in this paper is based on the Rank-Based Ant System. Only the ant and elite ants in the pre-w-1 position allow the pheromone to be released on the path. The known optimal path gives the strongest feedback, multiplied by the coefficient w; and the ant ranked the rth is multiplied by the coefficient "w-r" (≥0).

3.3 Multipath Transmission

In the route maintenance, the HELLO message is used to monitor the link state of the current node to the next hop node in the active route. The Fortified Ant protocol is designed to implement a route maintenance method, which implements this method from three aspects: enabling backup path, local route recovery, and source node route reconstruction.

Enable backup path: When the intermediate node i detects that the link with the next hop node is broken, the node i that caches the backup route will enable the backup route.

Local route recovery: If node i is closer to destination node d, then the data packet from source node s is buffered and local repair is attempted. Source node route reconstruction: If node i is still far away from destination node d, the data packet is discarded, and the failed primary route to next hop node n is deleted and the error message packet is broadcast.

4. Simulation

In order to detect the performance of the Fortified Ant protocol, this paper uses the network simulation software NS2 to simulate the algorithm protocol, and with the basic ant colony algorithm (ACO), dynamic source routing protocol (DSR) and wireless ad hoc network on-demand plane distance vector routing Protocol (AODV) discovery algorithms are compared.

4.1 Simulation Content

(1) Route discovery time.
(2) Average end-to-end delay.
(3) Transmission success rate.

4.2 Simulation Environment Settings

The simulation is simulated with the current mainstream network simulation software NS2. The initial conditions of the simulation set the wireless nodes randomly distributed in a rectangular area of 1000m*1000m. The transmission range of each node is 250m. The Random waypoint model is called as the moving model of the node. In this paper, the Mesh nodes are not moved, so The speed is set to 0m/s. In the simulation experiment, the source node and the destination node are randomly generated, and the duration is set to 40s. The protocol used by the MAC layer is the IEEE802.11 communication protocol. The available channel for each node is 6, the bandwidth of each channel ranges from 20 Mb/s to 100 Mb/s, and the bandwidth required for wireless services is 5 Mb/s to 25 Mb/s, all of which are randomly generated. The time for each simulation was set to 3000s, and all simulation results were averages of 60 independent experimental simulations.

4.3 Result Analysis

Figure 1 shows the relationship between the source and destination node links of the three protocols and the number of nodes in the area. It can be seen that the simulation results of the Fortified Ant protocol proposed in this paper are significantly better than the traditional ant colony algorithm (ACO) and dynamic source routing protocol (DSR). It can be seen that adding the sorting based on the ant colony algorithm can effectively accelerate the Mesh network. Routing optimization speed.

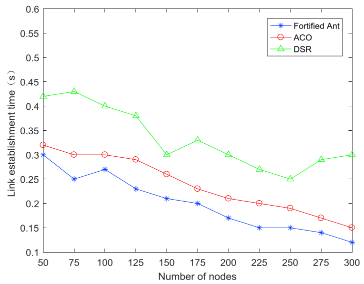

Figure.1 Link establishment time comparison diagram of the three protocols

Figure 2 shows a graph of the average link delay for the three protocols and the number of links within the network. In this simulation, when the number of nodes in the area is fixed, different numbers of source nodes and destination nodes are randomly generated, the number of links in the mesh network is increased, and then the link delays simulated by the three protocols are compared, and the Fortified is obviously The simulation effect of the Ant protocol is better.

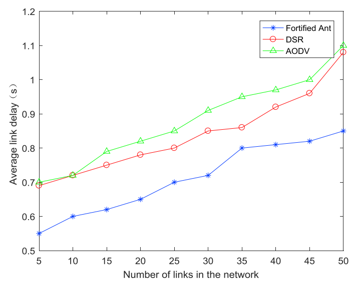

Figure.2 Comparison of average link delay of the three protocols

Finally, the successful transmission power of the three protocols under different link numbers is simulated, and the simulation results of Figure 3 are obtained. It can be seen that the transmission success rate of the protocol with multipath transmission is obviously higher than that of the single path transmission. The Fortified Ant protocol is also effective in this simulation. It can be seen that the Fortified Ant protocol can be better applied to the Mesh' network environment.

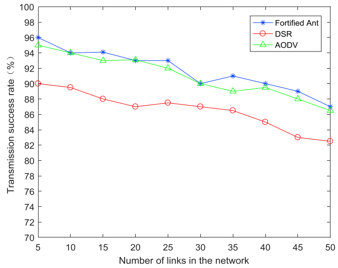

Fig.ure3 Comparison chart of transmission success rate of the three protocols

5. Conclusion

This paper mainly studies the multipath routing problem of wireless Mesh networks, and proposes an improved ant colony algorithm protocol, Fortified Ant protocol. Based on the ant colony algorithm, this algorithm introduces the optimization of sorting method, which can speed up the optimal routing path. It is found that two good transmission paths are found between the source node and the destination node for parallel transmission, and three route maintenance methods are used for data transmission maintenance according to actual conditions.

The experimental results show that the link lookup speed of the Fortified Ant protocol is significantly faster than the traditional ant colony algorithm, and the average end-to-end delay and transmission success rate of the protocol is significantly better than the two protocols of AODV and AOMDV.

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