Excavation Balance Routing Algorithm Simulation Based on Fuzzy Ant Colony

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Abstract: This paper proposes a new fuzzy ant colony routing strategy based on ant colony algorithm to realize the exploration-excavation capability balance. It uses the fuzzy control system based on likelihood inference to calculate the local heuristic information. At the same time, according to the traditional ant colony routing algorithm, it calculates the pheromone value of different paths, and finally makes a routing decision based on the proportion of both.

1. Introduction

The DTN network describes an opportunity network that takes network segmentation and delay routing as normal [1-3]. Chapter 2 presents a FRA routing algorithm that has nothing to do with historical experience. The node obtains the metrics related to the current motion state, and obtains the current heuristic information value through the fuzzy inference system to help select the route. The premise of this method is that the network topology changes abnormally, and the historical experience of the node does not help the current situation [4, 5].

In fact, the initial changes in deployment are more serious. After being deployed to a suitable location, the topology structure will be relatively stable, thus forming a fully usable link for a period of time [6]. If you still blindly rely on local heuristic information, routing strategies that increase the transfer rate by increasing the number of copies will cause unnecessary communication costs. Therefore, we need to find an optimal balance strategy to meet the different situations where the topology structure is stable or changes drastically [7, 8].

Based on ant colony algorithm, this paper proposes a new type of Ant Colony based Fuzy Routing (ACFR) to achieve the balance of exploration and excavation capabilities. Heuristic information and Pheromone pheromone are the two most important concepts. The local heuristic information is calculated using a fuzzy control system based on likelihood inference; at the same time, the pheromone values of different paths are calculated according to the traditional ant colony routing algorithm. Finally, make a routing decision based on the proportion of the two.

2. Acfr Routing Algorithm

2.1 Model construction

The traditional routing algorithm based on ant colony modeling can't be applied to the air sensor network immediately. It can handle the exception of occasional link disconnection, but it can't adapt to the disconnected normal network. The ant colony algorithm focuses on the accumulation of historical experience, usually has a quick convergence, easy to stagnate and precocious, which makes it more adept at exploring the optimal solution, and is not conducive to exploring the entire solution space. DTN networks often require excellent exploration capabilities, using every contact opportunity around them to find possible forwarding opportunities. In the FRA, the heuristic information value is used as the only reference standard for the selection of forwarding nodes. It focuses on the current network conditions while ignoring the history of network routing experience.

ACFR uses a combination of the two methods. Path selection is determined not only by the pheromone value, but also by local heuristic information. The calculation of heuristic information is still determined by the fuzzy inference system, and the balance of the two uses a dynamic adaptive adjustment method.

In ACFR, the node periodically sends a certain amount of ant agents to update the network pheromone table. Figure 1 shows this process. s represents the source node, and d is the destination node. A certain amount of path finding ants go through the current node i to find the path of the destination node. In the initial state, node i has a total of 4 neighbor nodes, and each has the same probability of selection. When the destination node d is found, the pathfinding ant dies, generates a corresponding return ant, and returns from the original route according to the source route, and updates the pheromone value along the way. The ant sent from node i will release the pheromone pheromone on return.

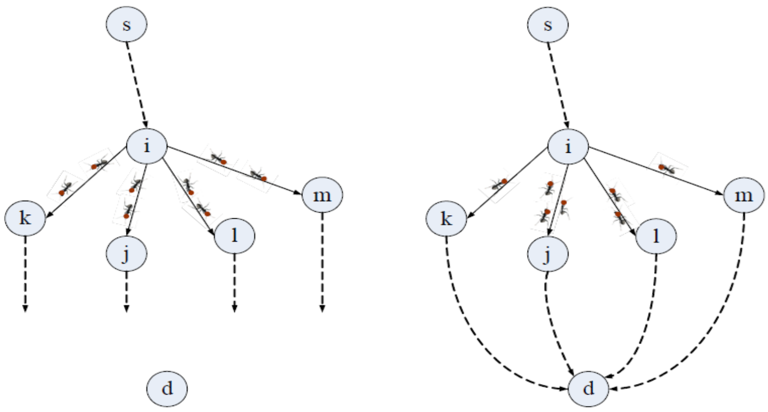

Fig. 1 Ant search path

Take node i as a reference point and examine edges (i, j). This indicates that there are a total of n pheromone pheromone concentrations on the back (i, j) of node i.

The routing algorithm degenerates into the FRA routing model. Under normal circumstances, it is necessary to weigh the proportion of the two and achieve adaptive adjustment.

2.2 Adaptive exploration - digging the balance mechanism

In order to obtain the minimum number of return ants, n_{min}, required to reach a certain probability value, first make the following assumptions:

(1) The first n_{min} return ants returning to node i all come from edge (i, j). It makes sense to do this. If there are ants on the way from other neighbors, according to the previous formula, the concentration of pheromone pheromone in edge (i, j) becomes smaller, then the minimum number of ants to achieve a certain probability value must be greater than n_{min}.

(2) Calculate specific probability values using the traditional ant colony routing model without considering heuristic information values. The ACFR determines the value of the exploratory-excavation balance parameter based on the number of return ants. In the ideal case of communication, min n is the lower limit value of the required ant number. Considering heuristic information increases computational complexity, and the uncertainty of neighboring nodes makes it more difficult to evaluate.

3. Simulation Experiment

3.1 Parameter setting

In the experiment, each node cache is set to 250M, the communication radius is 100m, and the SimpleBroadcast communication interface is used. The transmission speed is 250kb/s. Nodes are at rest or in motion, with speeds ranging from 0 to 5 m/s. In addition, the message generator generates 1 packet every 10-15 intervals, and its size is 10~100k. Without loss of generality, the Random Waypoint motion model is used to randomly generate zig-zag paths that do not affect each other. The size of the simulation experiment area is 2000×2000 m^2.

Take r = 0.3, set the probability threshold pupper and plower, respectively 0.7 and 0.3, ACFR dynamically calculate nmin and n'min according to the number of neighbors. Taken $n_f = 2n_{min}$, each time the network condition needs to be explored, the node sends nf path ants. When the return ant ratio φ ≥ 0.5, the full ant colony routing model is used.

In addition to ACFR, the other five well-known routing algorithms implemented in ONE are also considered: First Contact (FC), Direct Delivery (DD), Epidemic (EP), Spray and Wait (SW), and Prophet (PR). For each strategy, multiple experiments were performed and then the statistical average results were compared.

3.2 Analysis of results

In the first set of experiments, a total of 90 nodes were placed in the area. Set the simulation time to 6000s. During this time, the message generator generated a total of 500 packets. Table 1 lists the total number of packets successfully delivered by each protocol. Since there is no limit on buffering and bandwidth, the EP passes 439 packets, greatly ahead of other routing tactics; ACFR passes a total of 416 packets, followed by it; while DD and FC, due to their simple implementation, only deliver separately. Because the total number of packets simulated by each protocol is the same, the more packets that are successfully delivered, the higher the success rate of delivery. Table 2 shows the statistical data of the success rate of the reporting module of the ONE simulator. It can be seen that this result is consistent with the trend of changes in Table 1.

Table 1 Comparison of Total Number of Successfully Passed Packets

Time/Contrast	1000 s	2000 s	3000 s	4000 s	5000 s	6000 s
Direct Delivery	4	24	38	60	102	131
First Contact	9	31	58	87	134	181
Epidemic	38	125	206	281	357	439
Spray And Wait	17	69	136	198	287	351
Prophet	14	100	189	257	339	412
ACFR	27	111	194	271	345	416

Table 2 Comparison of Delivery Success Rate

Time/Contrast	1000 s	2000 s	3000 s	4000 s	5000 s	6000 s
Direct Delivery	4.82%	14.37%	15.26%	18.02%	24.52%	26.2%
First Contact	10.84%	18.56%	23.29%	26.13%	32.21%	36.2%
Epidemic	45.78%	74.85%	82.73%	84.38%	85.82%	87.8%
Spray And Wait	20.48%	41.32%	54.62%	59.46%	68.99%	70.2%
Prophet	16.87%	59.88%	75.9%	77.18%	81.49%	82.4%
ACFR	32.53%	66.46%	77.91%	81.38%	82.93%	83.2%

In addition to transmission efficiency, the throughput cost of each strategy should also be compared, that is, the consumption of network resources. Here, the total number of data packets forwarded during the entire routing process is calculated, that is, the total number of data packet copies that are involved in forwarding when all links are available. The greater the number of copies, the greater the probability of delivery, but at the same time it will bring more unnecessary network consumption. As can be seen from Table 3, due to the use of a single-copy policy, DD only transfers data packets when it encounters the destination node, so its throughput is much smaller than other routing policies, and only a total of 131 packets are forwarded. Packets. The maximum transfer success rate reached by the EP is at the same time a great network throughput. A total of 39,082 data packets are transmitted in the 6000s, and this throughput is not allowed in practical situations. ACFR effectively achieves a balance between transfer rate and throughput, demonstrating superior performance. Another indicator of evaluation is the average delay of messages. As an important metric for evaluating the service quality of routing protocols, ACFR exhibits a satisfactory transmission speed compared with other routing protocols, as shown in Table 4.

Table 3 Comparison of the Total Number of Forward Packets

Time/Contrast	1000 s	2000 s	3000 s	4000 s	5000 s	6000 s
Direct Delivery	4	24	38	60	102	131
First Contact	625	2222	4201	6305	8410	11089
Epidemic	3399	11182	18251	25043	30959	39082
Spray And Wait	344	851	1299	1723	2216	2707
Prophet	519	4496	10729	17733	23659	30198
ACFR	612	3903	7542	12352	17954	23583

Table 4 Average Delay Comparison

Time/Contrast	1000 s	2000 s	3000 s	4000 s	5000 s	6000 s
Direct Delivery	343.325	684.4458	798.4132	957.6117	1397.5412	1595.1992
First Contact	203.6778	657.671	807.581	1008.8816	1140.6925	1480.9099
Epidemic	339.4632	493.644	502.8621	501.8021	526.1983	548.3986
Spray And Wait	292.6647	602.2246	798.9007	898.0364	1025.4631	1124.8764
Prophet	315.9929	727.376	775.3735	753.0712	782.8947	808.9058
ACFR	230.4123	520.1252	620.3421	631.6823	630.4183	632.324

The second set of experiments tested the performance of routing protocols in different scale network environments. Keeping the simulation parameters unchanged, the message generator generated the same number of packets to be delivered within 6000 s. The network scale grew from 20 nodes to 100 nodes. Compared with the entire simulation area, the coverage rate of one node is 0.79%, and the network scale has increased from 15.8% (20) to 79% (100). Tables 5 and 6 respectively report the success ratios and average delays of routing protocols for different scales. In general, the greater the number of nodes, the higher the success rate of routing and the lower the average latency of packet delivery. This is because the more nodes there are, the more neighboring nodes there are and the greater the range of decision-making options. Regardless of the scale, ACFR has excellent performance. This is because ACFR mechanisms combined with pheromone values and heuristic information can be used to adapt to networks of different sizes: The fewer nodes are, the more sparse are the networks, and the more severe the network partition is. At this time, ACFR mainly relies on heuristic information for routing. The more nodes, the more dense the network, the more path selectivity, ACFR mainly rely on the historical experience embodied in pheromone to help the routing of data packets.

Table 5 Comparison of Delivery Success Rate

Time/Contrast	20	40	60	80	100
Direct Delivery	27.24%	27.89%	28%	26.92%	28.66%
First Contact	29.42%	25.9%	31%	34.01%	32.87%
Epidemic	64.81%	80.28%	84%	89.27%	88.78%
Spray And Wait	55.47%	63.15%	69.6%	73.08%	71.74%
Prophet	50.7%	72.51%	79.6%	83%	85.57%
ACFR	60.02%	78.1%	82.57%	84.96%	87.41%

Table 6Average Delay Comparison

Time/Contrast	20	40	60	80	100
DirectDelivery	1486.9781	1790.7386	1490.1836	1577.4654	1660.9699
FirstContact	1765.1703	1780.3885	1578.6955	1621.6202	1496.8037
Epidemic	1432.016	997.228	692.5231	596.5846	502.1158
SprayAndWait	1501.1341	1316.0233	1141.4851	1122.5291	1106.6774
Prophet	1815.1635	1493.5717	1002.0568	888.5717	744.9098
ACFR	1500.432	1123.4243	843.1542	683.7091	596.2461

In summary, the pheromone value used in ACFR is combined with heuristic information and adaptive weighting can be adapted to networks of all sizes. Experimental simulation proves its effectiveness.

4. Conclusion

Ant colony algorithm is a distributed self-organizing algorithm. Each ant's search process is independent of each other and communicates only through pheromones. It starts an independent solution search at multiple points in the problem space simultaneously, which not only increases the reliability of the algorithm, but also makes the algorithm have a strong global search capability.

This article discusses the ant colony routing algorithm. Compared with other strategies, the ant colony routing strategy does not require a high initial condition of the network. That is, the result of the ant colony algorithm does not depend on the selection of the initial route, and it does not require manual adjustment during the search process. It has strong robustness. Sex. Corresponding to the DTN network formed in the air, the local heuristic information valuesin the ant colony algorithm probability selection formulae will play an important role. The ACFR algorithm proposed in this chapter is an organic combination of FRA's fuzzy inference, and uses a dynamic exploration-excavation balance weight adaptive adjustment mechanism. Experimental simulations show that ACFR performs well in terms of transfer success rate and average delay compared to the traditional DTN routing protocol.

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