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Research of SimBet Routing Protocol for Mobile Social Networks

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Abstract: Mobile social networks which use social characteristics of mobile nodes to deliver messages are a type of Delay Tolerant Networks. SimBet protocol can be used in MSNs. The two characteristics and their combined effection SimBet metric in the SimBet protocol are carfully studied. The similarity metric indicates how many common nodes are shared by two nodes. The betweenness metric indicates the role a node takes in the paths to other nodes in the topology. Different scenarios with diverse adjustive value of parameters are simulated with MATLAB. The performance shows that SimBet protocol has good performance for Mobile Social Networks.

1. Introduction

The connections of nodes in Delay Tolerant Networks (DTNs) are partially and intermittently. As a sort of DTNs, the mobile social networks (MSNs) take advantage of social characteristics of mobile nodes to deliver messages in the network. SimBet protocol can be used in MSNs, which exploits the similarity and betweenness of nodes to make the routing decision. In this paper, we study similarity metric, betweenness metric and SimBet metric carefully, discuss the routing strategy with SimBet protocol, and finally build different simulation scenarios to test the performance of SimBet protocol.

2. Metrics in SimBet Protocol

2.1 Similarity metric

The similarity metric is first discussed by Liben-Nowell in [1] and further explored by E.Daly in [2]. The similarity metric indicates how many common nodes are shared by two nodes.

If node x contacts with some nodes, which are in a node set $N(x)$. $N(y)$ is the set of nodes with which node y contacts. The nodes which are involved both with nodes x and y is in node set $P(x,y)$, which can be described as equation (1).

$$P(x,y)=\left|N(x)\cap N(y)\right| \tag{1}$$

The similarity metric between nodes x and y can be calculated by counting the number of elements in $P(x,y)$.

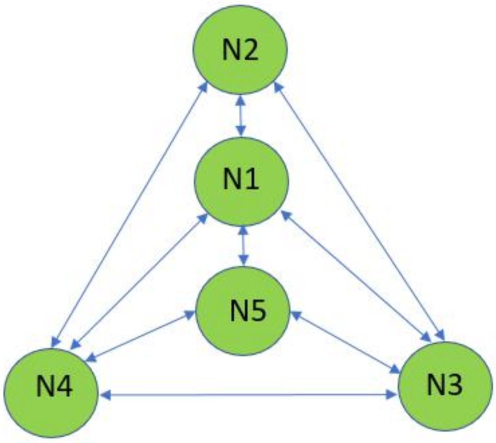


Fig. 1 Example of connections between nodes

Take Fig.1 as an example, node N_1 has connections with N_2, N_3, N_4, N_5 and node N_2 has connections with N_1, N_3, N_4. The relations can be described as $N(N_1)=\{N_2,N_3,N_4,N_5\}$ and

$N(N_2)=\{N_1,N_3,N_4\}$. It is easily to get the set of the same contacted nodes with N_1 and N_2 $P(N_1,N_2)=\{N_3,N_4\}$. So the similarity metric value between nodes N_1 and N_2 are two.

2.2 Betweenness metric

Betweenness metric is introduced by Freeman in [3]. As one of three centrality measures presented by Freeman, betweenness indicates the role a node takes in the paths to other nodes in the topology. Betweenness is further explored by Marsden in [4] , Everett in [5] and E.Daly in [2].

The egocentric betweenness metric value can be obtained as follows. The connections of node N_i and other nodes it encounters can be depicted by an adjacency matrix $SimMatrixN_i$, which is called adjacency matrix of N_i . The relationships between each two of N_i and its involved nodes are arranged orderly both in longitudinal and lateral direction in the matrix. a_{xy} is the x line and the y column element in $SimMatrixN_i$ and its value is settled as equation (2). The maximum value of x and y is the same and is determined by the total number of N_i and its encountered nodes. It is noted that in addition to line indication, x and y also means the name of node. Obviously, $SimMatrixN_i$ is a symmetric matrix.

$$a_{xy}=\begin{cases}1 & \text{if node x encounters y}\\ 0 & \text{else}\end{cases} \tag{2}$$

As represented in [5], an intermediate value $BetValueMatrixN_i$ can be obtained if calculated as (3).

$$BetValueMatrixN_i = SimMatrixN_i{}^2 \times \left[1 - SimMatrixN_i\right] \tag{3}$$

The egocentric betweenness metric value of node N_i is the summation of the reciprocals of all the values of elements in $BetValueMatrixN_i$.

The nodes and relationships in Fig.1 are used as an example to describe the previous conceptions. Node N_1 has connections with N_2 , N_3 , N_4 , N_5 , the elements in the adjacency matrix of N_1 $SimMatrixN_1$ is calculated by (2) and the result is showed as Fig.2. The intermediate value of N_1 $BetValueMatrixN_i$ can be acquired by (3) and the result is showed as Fig.3. So the egocentric betweenness metric value of node N_1 is 0.33.

$$\text{SimMatrixN}_1= \begin{array}{c|ccccc|} & N_1 & N_2 & N_3 & N_4 & N_5 \\ \hline N_1 & 0 & 1 & 1 & 1 & 1 \\ N_2 & 1 & 0 & 1 & 1 & 0 \\ N_3 & 1 & 1 & 0 & 1 & 1 \\ N_4 & 1 & 1 & 1 & 0 & 1 \\ N_5 & 1 & 0 & 1 & 1 & 0 \\ \hline \end{array}$$

Fig. 2 SimMatrixN1

$$\text{BetValueMatrixN}_1= \begin{array}{c|ccccc|} & N_1 & N_2 & N_3 & N_4 & N_5 \\ \hline N_1 & 0 & 0 & 0 & 0 & 0 \\ N_2 & 0 & 0 & 0 & 0 & 3 \\ N_3 & 0 & 0 & 0 & 0 & 0 \\ N_4 & 0 & 0 & 0 & 0 & 0 \\ N_5 & 0 & 0 & 0 & 0 & 0 \\ \hline \end{array}$$

Fig. 3 BetValueMatrixN1

2.3 SimBet metric

The SimBet metric is first presented by E.Daly in [2]. Suppose node n has a piece of message whose destination is node d. The decision whether forward the message to node m is made by the combined effect of similarity metric value and betweenness metric value of node n and m. The similarity metric utility of node n $SimUtil_n(d)$ in comparison with node m for forwarding the message whose destination is node d is described by (4). The betweenness metric utility of node n $BetUtil_n$ is described by (5). The SimBet metric utility value of node n is calculated as (6), in which α and β are adjustive parameters, and $\alpha+\beta=1$.

$$SimUtil_n(d)=\frac{Sim_n(d)}{Sim_n(d)+Sim_m(d)} \tag{4}$$

$$BetUtil_n = \frac{Bet_n}{Bet_n + Bet_m} \qquad (5)$$

$$SimBetUtil_n(d) = \alpha SimUtil_n(d) + \beta BetUtil_n \qquad (6)$$

3. Routing strategy with SimBet protocol

When node n and node m are moving, the distance detection between n and m is carried out. If the distance between n and m is less than a predefined value, the two nodes are said to be encountered. When the two nodes meet, they exchange the information which include all the destinations of their messages. If node m is the destination of some messages from node n, node n sends the messages to node m directly. If node d is the destination of some messages from node n, the similarity utility of node n with respect to node d and node m is computed as (4), and betweenness utility of node n is calculated as (5), and finally, SimBet utility of node n is obtained as (6). If the SimBet utility of node n for node d is higher than node m, all the messages whose destination are node d from node m are delivered to node n, and node m deletes all the delivered messages.

4. Performance Results

4.1 Simulation Setup

The Random Waypoint Mobility(RWM)[6] model is used in the simulation. The nodes under RWM model adopt random movements and stops at the beginning of simulation. The speeds of nodes are picked randomly from a specified value range set which defines the maximum and minimum value. The moving directions of nodes are also chosen randomly. After arrival at destination, the nodes will pause for a predefined time. When the time is up, the nodes continues the activities as described previously.

The simulation area S_a covers 1000*1000 meters and there are N nodes in it. Each node chooses a speed V_n between 0.1 and 20 meters per second and chooses a direction angle θ_n between -180 to 180 randomly. The detection range of two nodes R is 30 meters which means two nodes are able to contact with each other with wireless technology within the range. The duration for refreshing parameters T_r is 600 seconds. After T_r, the velocity and direction of nodes are refreshed. The simulation time T is 24 hours. The message generate time T_m is the first quarter time of T and the rest time of T is for message transferring. Scenarios with different parameters of SimBet utility adjustive parameters α and β are considered.

The values of the above mentioned parameters are showed in table 1.

Table 1 Parameters for simulation

Parameter	Value	Unit
S_a	1000*1000	m^2
N	80	nodes
V_n	[0.1 20]	m/s
θ_n	[-180 180]	degrees
R	30	m
T_r	600	s
T	24	hours
T_m	T/4	hours

4.2 Simulation performance

Figures 4 to 9 are obtained under the condition that the adjustive parameters (α , β) are (0.5, 0.5). Fig.4 is the curves of performance of messages generating and forwarding. ‘Generated Messages’ shows the total number of messages generated by all nodes. As it shows, at the end of T/4, messages are all generated. ‘Received Messages’ means the number of messages received by the destination node. ‘Received in Direct Contact’ represents messages which are sent from source node to destination node directly. ‘Received Through Relay’ shows messages which are successfully delivered to destination indirectly. ‘Unforwarded messages’ are messages that are failed to be delivered. By indirect contact with source node, most messages are successfully delivered to the destination node messages with the help of relay nodes.

Fig.5 is the message delivery ratio. The line with cross on it means the division result of number of received messages and number of messages created at one simulation time point. The line with rectangle is the division result of number of received messages and maximum number of messages created.

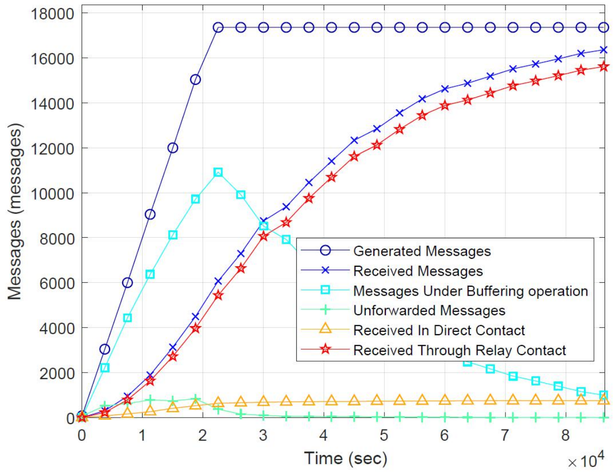


Fig.4 Performance of messages generating and forwarding

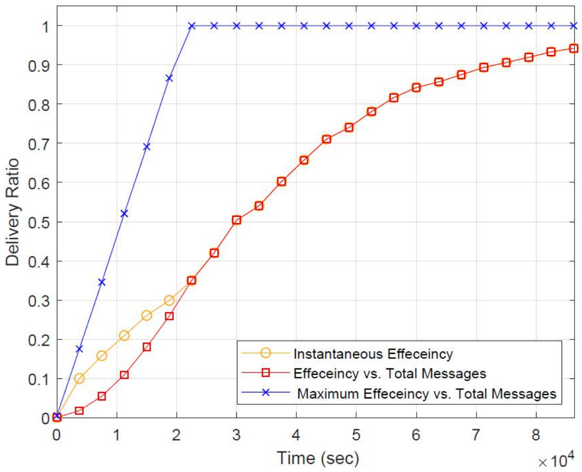


Fig.5 Message delivery ratio

Fig.6 shows the average number of hops for a piece of message delivered successfully from source node to destination node.

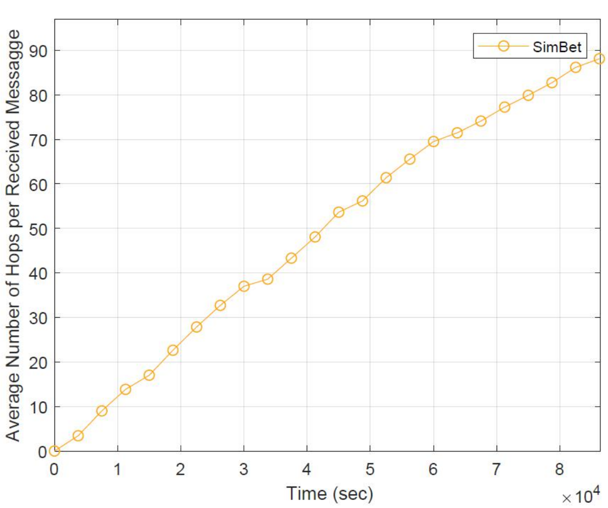


Fig.6 Average number of hops

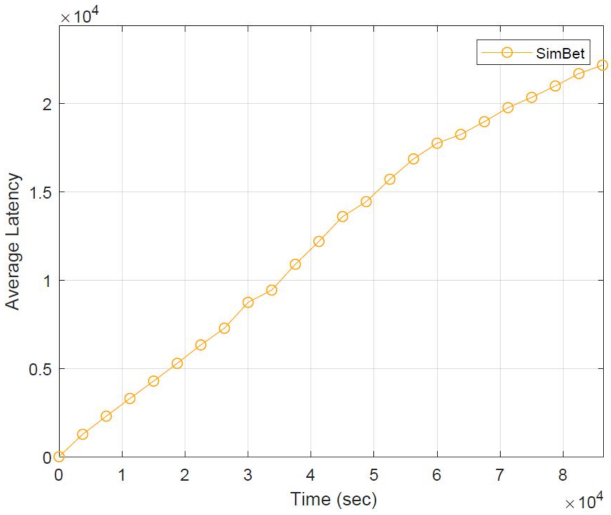
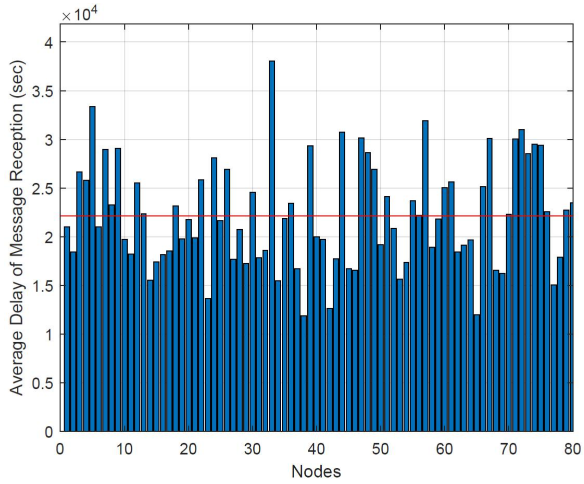


Fig.7Average latency for all received messages

Fig.7 is the average latency for all received messages. At one time point of simulation time, the reception delay of each message of each node is added together. The average latency at the time is obtained by averaging the summation. As it shows in Fig.7, the average latency at simulation time point 3000 seconds is about 8700 seconds and at the end of simulation time is about 22000 seconds.

Fig.8 is the average reception delay of received messages at each node. The summation of reception delay of received messages of one node is easily acquired. The average delay of messages reception at the node can be obtained when the summation is divided by the length of the received messages of the node. The maximum delay value is about 38000 seconds and the minimum delay value is about 12000 seconds. The horizontal line in Fig.8 depicts the general average reception delay of all the nodes. Its value is about 22000 seconds.

Fig.9 is the average delay of messages received at each node from each source. Each bar shows the delay of all messages from source node X to destination node Y.



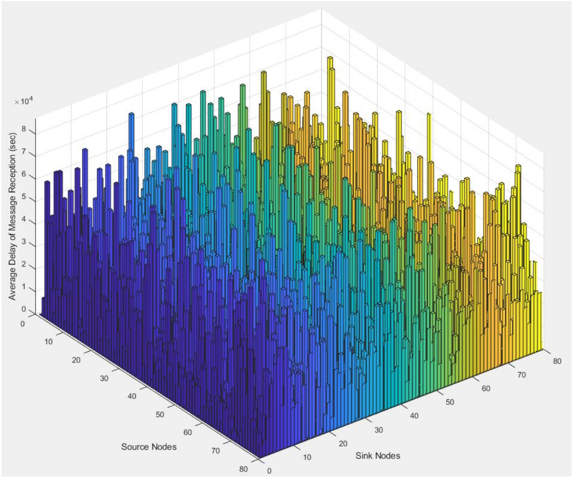
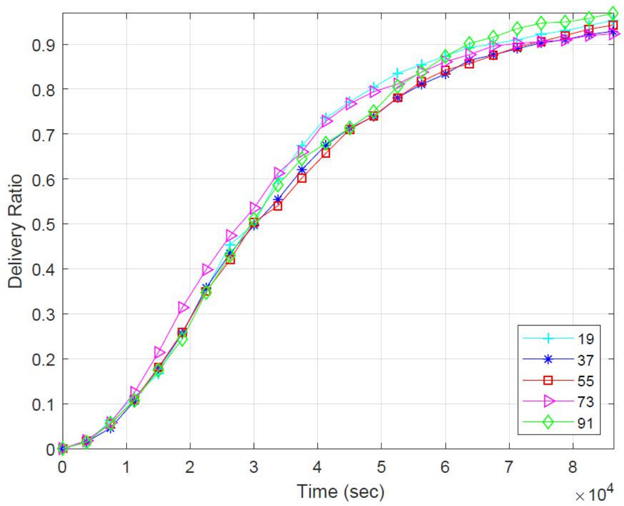


Fig.8 Average delay of messages reception at each node

Fig.9 Average delay of messages reception of destination node versus source node

Figures 10-12 are results with different adjustive parameters (α , β). (α , β) of the line with cross, star, rectangle, triangle and rhombus are set as (0.1,0.9), (0.3,0.7), (0.5,0.5), (0.7,0.3), (0.9,0.1). Fig.10 shows the delivery ratios, Fig.11 is the average delay and Fig.12 is the average number of hops with different adjustive parameters.



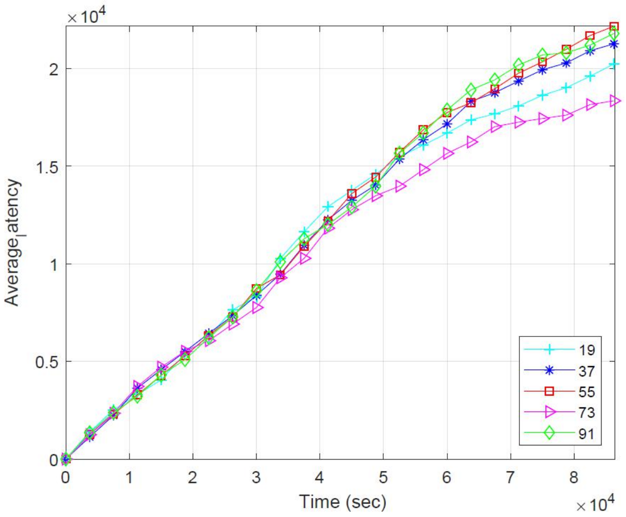


Fig.10 Delivery ratio with different adjustive parameters

Fig.11 Average delay with different adjustive parameters

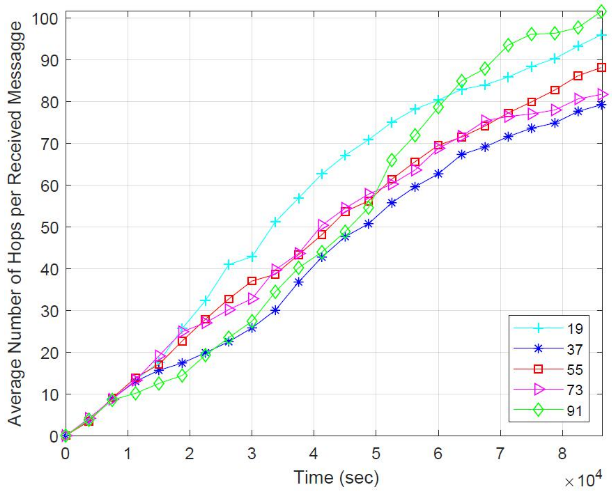


Fig.12 Average number of hops with different adjustive parameters

5. Conclusion

This paper studys similarity metric, betweenness metric and SimBet metric, which are characteristic parameters in the SimBet protocol. The protocol exploits the similarity and betweenness of nodes to make the routing decision. The simulations in different scenarios are done and the performance shows that with proper adjustive parameters, SimBet protocol has good performance for Mobile Social Networks.

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