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DTN Routing Algorithm based on Perceptions of Node Mobile Information

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Abstract

Due to the high mobility of nodes in DTN, the topology is changing forever. On this base, putting forward an efficient routing protocol becomes a hot topic in this area. Focus on the moving character of nodes, putting forward a routing algorithm in DTN (BMI) based on perceptions of node mobile information. This algorithm improved from the classical routing protocol spray and wait. First, change the wait phase to active routing. Then consider the moving information of meeting nodes and purpose nodes, choose a node which has a higher possibility to meet the purpose node. Simulation results show that, this algorithm can significantly improve the delivery ratio and reduce the delay.

***Keywords**: DTN, routing protocol, perceptions of node mobile information, spray and wait*

1. Introduction

DTN [1, 2] has characteristics of high delay, limited node resources, intermittent connection, asymmetric data rates and low SNR. Fall [3] put forward the concept in SIGCOMM, 2003. It becomes a hot topic that putting forward a good routing algorithm [4-7].

The first routing algorithm is called mono-copy routing [8] protocol, that means there is only one copy for a specific message at a time. This method has low overhead and high resource availability, but the delay is usually very large and transmission is unreliable because of the changing topology. The only copy of a specific message usually loses, because of intermittent connection in DTN. That causes a fail delivery. From the above disadvantages, multi copies based routing protocol [9, 10] is put forward. The basic idea is to make copies of the specific message to fulfill the network with copies. This could increase the possibility of successful delivery. Epidemic [11] is a kind of multi copies based routing protocols. It spread the message with a method like infection. Obviously, it costs a lot of resources so that the performance significantly decreases with time increasing. To control the waste of resources caused by flooding, quota based routing protocol is put forward. This could effectively control the number of existing copies of a specific message. Static quota based [12] spray and wait [13] protocol is a classical one.

The protocol separates the transmission progress into two parts: spray and wait. The static quota is decided when the message is produced. In spray phase, when the source node which takes the message meets a node which does not have, the source node delivery half number of copies to the other node and preserve the other half. When the source node has one copy, its spray phase ends and it turns into wait phase. In this phase, source node holds the only copy until it meets the node that it wants to deliver.

2. Related Works

On the basis of spray and wait protocol, some researchers has put forward several improvements. ORWAR [14] uses context to calculate touch window, and copy the message in the sequence of utility value/bit. Multi period spraying [15] extends the single spray phase to several ones, expecting an effective use of resources by infecting several nodes at a same time. Spray and Focus [16] improves the wait phase, forecasts the meeting possibility based on

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Markov location model. All of the above only improve one of the two phases. And spray and forward [17] only considers the meeting at some specific places [18], without considering meeting on the way. From the analysis, put forward a DTN routing algorithm based on perception of nodes moving information. This algorithm is based on spray and wait. Every node maintains an array to store other nodes moving information: location, speed, direction, destination and recording time. Nodes exchange their records when they meet each other. When a routing happens, the source node decides which node is the best one to carry the message according to the moving information stored on the node it meets. Then definite this node as a high utility node and execute the routing algorithm. Experiments show that this algorithm has a higher delivery ratio and lower delay than Epidemic or spray and wait.

3. BMI Routing Algorithm

3.1. Perceptions of Node Mobile Information

Nowadays, most routing protocols in DTN tend to increase the delivery ratio by increasing the number of copies or forecasting the meeting possibility [19]. But most people ignore a more direct method. That is deciding the routing methods based on location, speed, destination and other moving information. This could make the message gradually approach its destination node in a much easier way. For example, in Figure 1, A is a node carrying a message, and the destination node is D. In the communicate radius of A, there are node B and C. The classical spray and wait protocol will randomly choose one from the two nodes and do semi-spray. But obviously, choose B is much better than C. From the above considerations, put forward a method that nodes could percept each other's moving information, such as location, speed, direction, and destination and so on. So the nodes moving perception model is put forward.

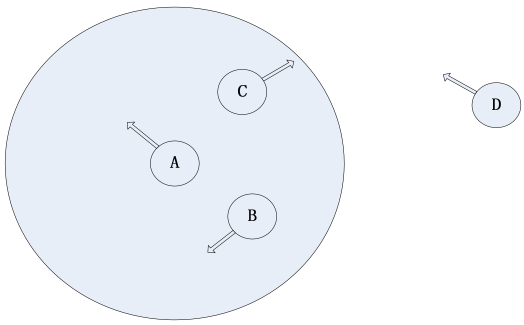

Figure 1. Semi-srapy Figure

	No 1	No 2	No 3	No 4	...	No n
Abscissa	60					
Ordinate	100					
Movement speed (X)	70m/s					
Movement speed (Y)	50m/s	...				
Abscissa of Destination	1800					
Ordinate of Destination	2000					
update time of record	580s					

Figure 2. Tuple Stored Information

Every node in this model stores an array locally. The size of the array is 7N, where N represents the number of nodes in the whole network. In other words, every node stores N seven -tuples. Every tuple looks like this: $< X_O\ Y_O\ V_X\ V_Y\ X_D\ Y_D\ T >$. The tuple stores information as shown in Figure 2. X_O and Y_O represent the location information. V_X and V_Y represent the speed and direction. X_D and Y_D represent whether the node has arrived at the destination. Update time is used to judge the timeliness of this record.

From the beginning, every node only has one record with information. And it is of itself. Other records are blank. When two nodes meet, they exchange their information and fill in the blanks of the other's. If they both have information of the same record, compare T in the two tuples and use the latest one to update the other. Sometimes later, most nodes have all nodes' information in the network.

3.2. The BMI Protocol Improved from Spray and Wait

The classical spray and wait protocol has great blindness both in spray and wait phase as the following three parts:

1. If the source node meets more than one node at a time, randomly choose one of them to spray is blind. A node that will not or be very difficult to meet destination node may be chosen.
2. A node in wait phase may have poor activity, and it may be difficult to meet destination node. So the node is still waiting until destination node occurs. This may cause a fail delivery.
3. A node in wait phase may meet another node which is closely related to destination node. But the node is in wait phase, and it cannot route through other nodes. Lastly, it loses the chance to successfully deliver the message.

Pointing to the above problems, BMI routing protocol improve both the spray and wait phase according to nodes' moving information perception model.

BMI's spray phase: Similar to the spray phase of spray and wait protocol, BMI choose a node to semi-spray. But the difference is it is not a random choose. First, according to the nodes' moving information perception model, source node exchange moving information with the node it meets. So the source node could percept location, speed, direction, and destination of the meeting node and destination node. From this moving information, choose the node which will be the first to approach destination node and do semi-spray. The specific strategies are shown below:

1. According to moving information exchange, percept locations of the meeting node and destination node. The location of meeting node is relatively accurate, and it can be gotten from the corresponding tuple in locally stored array. In other words, the location at the meeting time. Destination node's location could be calculated from Equation 1 and 2.

$$X_n = X_O + (T_n - T_O) \times V_X \tag{1}$$

$$Y_n = Y_O + (T_n - T_O) \times V_Y \tag{2}$$

X_O represents abscissa in the tuple, and T_O represents the tuple's produce time. V_X and V_Y represent the node's horizontal speed and vertical speed. T_n represents current time. X_n and Y_n are destination node's current location that is calculated.

2. Judge after $(T_n - T_O)$ time, whether the destination node has arrived at the destination. First, calculate the time cost from current place to destination from Equation 3. Compare T and $(T_n - T_O)$. If T is greater, that means the node has not arrived at the destination. Otherwise, the node has arrived, and let X_n and Y_n be the destination's abscissa and ordinate. In other words, the destination node is now estimated at the destination and has not any speed.

$$T = \frac{X_D - X_O}{V_X} \quad (3)$$

3. Calculate the relative speed between every meeting node and destination node, as Equation 4 and 5. For example, suppose meeting nodes are B_1 and B_2, destination node is C. Calculate the speed of B_1 and B_2 relative to C.

$$V_{KX} = V_{DX} - V_{OX} \quad (4)$$

$$V_{KY} = V_{DY} - V_{OY} \quad (5)$$

V_{DX} and V_{DY} represent destination node's speed on x axis and y axis. V_{OX} and V_{OY} represent source node's speed on x and y axis.

4. Project B_1 (B_2)'s relative speed on the line between B_1 (B_2) and C. Compare the project speed. The higher speed means this node will approach the destination node faster. And of course, this node is more compatible to carry on the message. Choose this node to do semi-spray.

$$V = V_{KX} \times \sin\theta + V_{KY} \times \cos\theta \quad (6)$$

On the above equation, θ means the angle between y axis and the line between meeting node and destination node.

BMI's wait phase: instead of negative wait in spray and wait, BMI change wait phase into positive routing. When a node has only one copy of a specific message and comes into wait phase, the node compares its moving information and every node's. Similarly execute the 4 steps in semi-spray phase. The difference is this time the comparison is among the meeting nodes and the original node itself. See which node has the greatest speed projection in the line to the destination node. Then give the message to this node to route. If the original node itself has the greatest projection, it holds the message itself.

4. Simulation Experiments

In this passage, THE ONE is used to simulate and estimate performance of the BMI routing protocol. The simulation environment is the default map in THE ONE the map of Helsinki City. The speed of simulated cars is about 3 meters per second. The original location and destination node is randomly chosen in this map. The moving model used is Shortest Path Map Based Movement [20]. In other words, the communication interfaces between nodes are Bluetooth. Detailed configuration is shown below as Table 1.

Table 1. Detailed Configuration

Parameter	Value
Simulation Time	5000s
Simulation Area	4000m×4000m
Node Number	60,80,100,120,140
Moving Speed	3m/s
Stay Time	(0-120）s
Transmission Speed	250Kbps
Transmission Range	50m
Cache Size	50M
Time between two messages	[5,15] [15,25] [25,35] [35,45]
TTL	300

In the same scene, change the number of nodes, the message producing speed of nodes and the initial number of copies. Compare with Direct Delivery Epidemic Spray and Wait. Estimate the performance in the two parts.

1. Delivery possibility = the number of successfully delivered copies / the number of produced copies.
2. Average delay = the average time when the message arrive at the destination node.

4.1. Simulation Results and Data Analyses

To prevent BMI's shaking caused by the increase or decrease of the number of nodes. In this passage, the simulation ran under the environment that the number of nodes was 60, 80, 100, 120, and 140. The default number of copies was 6. Time span between two message produced was [25, 35]. In this scene, Direct Delivery、Epidemic、Spray and Wait were also simulated. The results show as Figure 3 and 4.

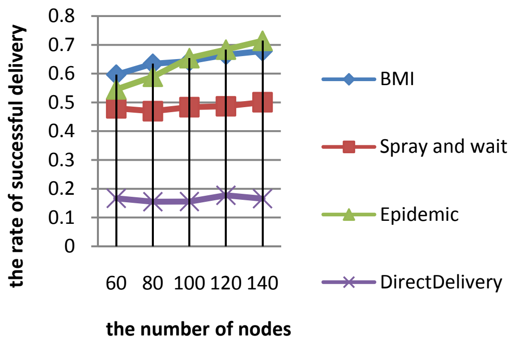

Figure 3. Delivery Figure (Number of Nodes)

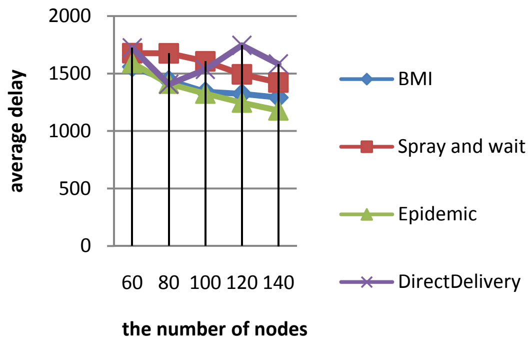

Figure 4. Delay (Number of Nodes)

From Figure 3, BMI has a delivery possibility similar to Epidemic and 1.5 points higher than spray and wait. And the gap is increasing with the increase of number of nodes. From these analyses, BMI has a better delivery performance than the classical spray and wait. From Figure 4, BMI's average delay is very stable. It slightly decreases with the number of nodes growing. It is always lower than spray and wait. It has a better timeliness. From the above, BMI has a better delivery possibility and lower delay than spray and wait in environments with different number of nodes.

To avoid the influence to BMI caused by the initial number of copies, the simulation was done under environment with different initial number of copies. With the number of nodes 100 and producing time span [25, 35], the simulation is done with the initial is 2, 4, 6 or 8. The simulation results are shown as Figure 5 and 6.

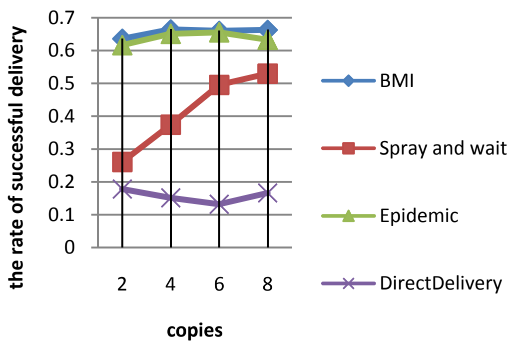

Figure 5. Delivery (Copies)

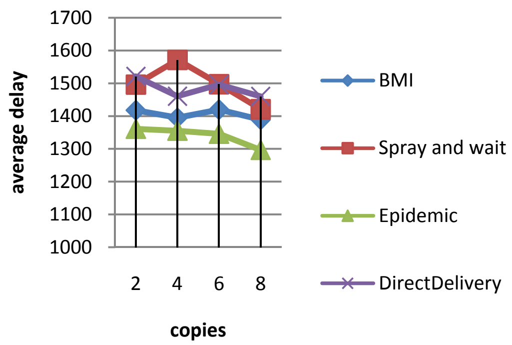

Figure 6. Delay (Copies)

From Figure 5, different initial number of copies did not have a great influence on BMI's performance. The performance was always greater than the other three ones. The delivery ratio was at about 65%. It was slightly greater than Epidemic and much greater than spray and wait. From Figure 6, the average delay of BMI was stable under different initial number of copies. It was smaller than Epidemic and Direct Delivery. But it was a little bigger than spray and wait. From the above, BMI had a better delivery possibility and lower delay than spray and wait in environments with different initial number of copies.

After the influences of different number of nodes and different initial number of copies were avoided, simulations were under different producing speed. The environment was: nodes number 100, initial copies number 6. Estimate the four protocols, as Figure 7 and 8.

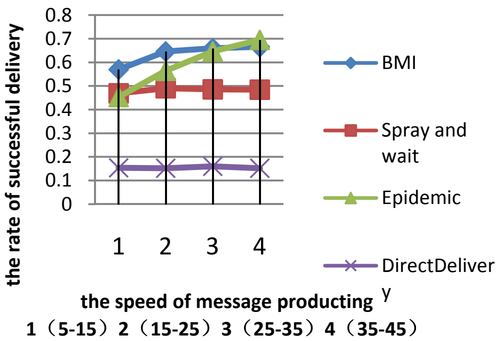

Figure 7. Delivery (Speed)

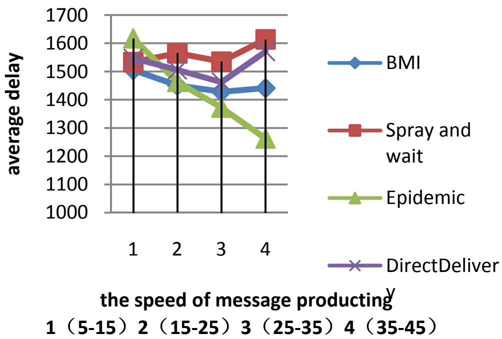

Figure 8. Delay (Speed)

From Figure 7, with the decrease of producing speed, the delivery ratio of spray and wait increased. This may cause by the decrease of used caches and less jams. BMI's was not shaking so much with the change of the speed and always higher, about 70%. So it could be seen that BMI was very stable. From Figure 8, the average delay of Epidemic significantly decreased. It was because nodes caches jam never appeared again. BMI's average delay was always lower than Spray and wait or Direct Delivery. From the above, BMI had a better delivery possibility and lower delay than spray and wait in environments with different producing speed of messages.

5. Conclusion

In this passage, improved the classical spray and wait protocol and introduced node moving information perception model. In spray and wait phase, try to find a node which will earlier approach the destination node by comparing the projection of the source node's relative speed and destination node's relative speed on the line between them. Use this node to route the message. Simulation result showed that this algorithm could significantly improve the delivery ratio and reduce the average delay. But from the experiment, BMI has more initial connections than spray and wait. This may cause a waste on node's energy. It is the next focus on research. But it is acceptable to cost some energy to exchange for a higher delivery ratio and lower average delay.

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