Two-hop ACK Forward Algorithm with Alternative Copies in DTN

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Abstract. The Delay/Disruption-Tolerant Network (DTN) was short of effective methods to avoid routing hole region when encountered it. Direct at such two problems, a two-hop ACK forward algorithm with alternative copies was presented in this paper. According to simulation results, the performance of this algorithm was superior to comparing algorithms such as the Spray and Wait, etc. in terms of the delivery ratio, the average delay and the network overhead; moreover, this algorithm had a strong applicability in vehicle ad hoc networks (VANET).

1. Introduction

As an end-to-end network architecture[1] which adopts a message exchange mechanism of "Carrying-Storage-Forwarding", DTN is featured with rapid node movement speed, frequent network topology changes, intermittent network connections and large end-to-end delay, etc.[2]. The concept of DTN originally stems from the Inter-Planet Network (IPN)[3] and it has been widely applied into fields of in-vehicle network[4], the earthquake rescue communication[5], the communication in remote mountain areas[6], the undersea detection and forest fire prevention, etc..

2. Problem Description

Occasionally, the routing hole[7] phenomenon takes place in DTN (as shown in Figure 1) and it usually occurs under the circumstances that the distribution of node density is uneven, some nodes moves to areas out of the range of communication zone and the next-hop node breaks down etc.. In an actual in-vehicle network, if the communication among the motorcade is obstructed by buildings or mountains, etc., or, it goes beyond the communication range, routing hole is thus generated when message-carrying nodes are unable to search out the next-hop node which is more appropriate than itself so that the message cannot be forwarded to the destination node continuously. Therefore, communication quality is impacted.

3. Algorithm Description

The routing algorithm based on single-copy location takes no account of the pressure on network overhead brought about by flooding. In this paper, a two-hop ACK forward routing algorithm with alternative copies (2HAR) is presented to improve the single-copy algorithm direct at routing hole
problem. When a node is unable to seek out the next-hop forwarding node which is more appropriate than it, its previous hop node takes the responsibility to find another node for information forwarding, so as to complete message rollback behaviors and avoid the routing hole.

3.1 Basic Thoughts

Node A sends out information to the next-hop node B; meanwhile, it reserves a copy of such information for backup. After Node B succeeds in receiving and forwarding this information to the next-hop node, ACK message is then transmitted to A which is the previous hop node of B; the alternative information copy is removed after the ACK message is received by A. So far, hop forwarding is fulfilled. However, if A sends out information to B and receives no ACK message after waits for a while, Node B will be regarded as having encountered with routing hole; thus, A will seek out another node for forwarding and keeps an alternative of the information (as shown in Figure 2). The two-hop ACK mechanism guarantees that the next-hop node is able to forward the information successfully after receives it. As a result, coherence of a communication path can be further protected.

Figure 2. Two-hop ACK Forward Algorithm with Alternative Copies.

3.2 Routing Process

The routing process consists of answer messages ACK1 and ACK2 (as shown in Figure 3). ACK1 refers to the acknowledgement given after the next-hop node succeeds in receiving the information sent out by the last hop node; while ACK2 is the response to the last hop node after the node forward the information once again and also receives the ACK1 successfully. In other words, receiving ACK2 is an important basis for the previous hop node to remove alternative copies, or backup the information again and seek out another path for forwarding. In this process, two timers named Timer1 and Timer2 are set and they correspond to the longest time of the node waiting for two acknowledgement messages, ACK1 and ACK2.

In the case that a certain node fails to forward the information successfully due to routing hole or other factors, such information will be kept by such a node; when an appropriate next-hop node appears, or when the communication paths becomes smooth, it will be forwarded. However, if the lifetime of such information is over, the overdue information will be removed by the node in conformity with its cache space management mechanism. As this algorithm can increase chances of survival for information near the routing hole, communication quality of the entire network is improved.

4. Simulation & Analysis

4.1 Simulation Scene Setup

Nowadays, self-driving group travel has become a novel tour fashion gradually. Destinations of a self-driving travel motorcade are usually suburbs or fields far away from the city. As such areas are open and flat, road has a little influence on motorcade maneuver and the path can be determined freely and optionally.
This situation conforms to Community-based Opportunity Network Mobility Model in which all nodes are related to each other. Considering a self-driving travel, instead of moving forward without aims, the motorcade goes to several sites within a certain area purposefully and this is similar to the concept of community.

Specific parameter settings are given in Table 1 below.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of Scene</td>
<td>5000m×5000m</td>
</tr>
<tr>
<td>Size of Message</td>
<td>100Kb</td>
</tr>
<tr>
<td>Link Bandwidth</td>
<td>1Mbps</td>
</tr>
<tr>
<td>Quantity of Nodes</td>
<td>20</td>
</tr>
<tr>
<td>Analogue Simulation Time</td>
<td>600s</td>
</tr>
<tr>
<td>Node Movement Speed</td>
<td>(0,80)km/h</td>
</tr>
<tr>
<td>Life Cycle of Messages</td>
<td>30s</td>
</tr>
<tr>
<td>Node Buffer Space</td>
<td>100M</td>
</tr>
<tr>
<td>Interval for Nodes to Generate Information</td>
<td>5s</td>
</tr>
<tr>
<td>Communication Distance</td>
<td>100m</td>
</tr>
<tr>
<td>Routing Algorithm</td>
<td>Epidemic, Spray and Wait, 2HAR</td>
</tr>
</tbody>
</table>

### 4.2 Simulation Results & Analysis

1. **Delivery Ratio**
   
   It can be seen from the figure 5 that delivery ratios of such three algorithms are all on the rise. Regarding the Epidemic (Epi) algorithm, it employs a manner of infection transmission to make each node within a network has opportunities to deliver information; hence, this algorithm has the highest delivery ratio. For the Spray and Wait (SAW) algorithm, the main reason why its delivery ratio is not high is the small information transmission range caused by the limited upper limit on information copies; meanwhile, as the density of nodes in the scene is not as high as that in a city, its delivery ratio is low by contrast. With respect to the 2HAR algorithm, thanks to its routing hole avoidance mechanism, paths can be expanded spontaneously during information transmission under the circumstance of sparse nodes so as to generate more forwarding chances; as a result, the delivery ratio of it is not low.

2. **Transmission Delay**

   In a scene of sparse nodes, transmission delay of the SAW algorithm is the largest because the information dissemination scope is under restrains together with uncertain time used to seek the next-hop node. The 2HAR algorithm is able to avoid the randomness possessed with by the SAW algorithm by combining geographical location information; as a result, the information can find the next appropriate hop node in a more accurate manner and information forwarding can be forwarded as well. In addition, thanks to the void back-off mechanism of it, communication blocking caused by blind information transmission can also be avoided. Therefore, the transmission delay of the 2HAR algorithm is far smaller than that of the SAW algorithm. Concerning the Epi algorithm which has the smallest time delay, due to its flooding transmission mechanism, information can be rapidly spread from corner to corner within the network and delays of seeking the next-hop node and transmission cost the shortest time; moreover, if no congestions are taken into account, Epi algorithm has the optimal performance in this link in a scene of sparse nodes.

3. **Network Overhead**

   With respect to the Epi algorithm which employs the flooding mechanism itself, although it can be guaranteed that almost all nodes are able to receive information, the majority of them are unnecessary information forwarding which occupies both memory space and resources and increase its corresponding network overhead. During simulation, it is found that the number of copies approaches the threshold value over a period of time as well despite that the SAW algorithm controls the upper limit of the number; at the same time, network overhead goes up. In this aspect, the 2HAR algorithm is superior. Essentially, single-message transmission fairly saves network resources; even when routing hole is encountered with, the quantity of copies rises when the information is around the routing hole region without impacting the overall network performance; as a result, the network overhead of 2HAR algorithm is the smallest.
5. Conclusions

Although the Epi algorithm has some advantages in terms of delivery ratio and transmission delay, it is only limited to a situation of a few nodes; if the quantity of them reaches a certain value giving rise to network congestion, communication effectiveness generated by this algorithm will become poor. In comparison, the overall performance of 2HAR algorithm is rather favorable; in addition to unobvious network congestion problems, there is also no need to take flooding into consideration; moreover, not only can the communication quality be guaranteed, but its applicability is very strong.

References


