Adaptive Probabilistic Broadcasting for Floating Content

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Abstract. Floating Content (FC) is emerged by bounded geographical zone in a mobile ad hoc network (MANET) to live in the anchor zone (AZ) for special applications such as emergency messages and traffic information for some time. To improve the availability, accessibility and reduce the number of FC duplication, the adaptive probabilistic broadcasting for FC (APFC) based on the number of neighbours and the informed node location is proposed. When a node without FC enters the transmission radius of informed node that is with FC. By exchanged message with the new node, the informed node obtains the information of the new node and its own neighbours. The informed node calculates the transmission probability \( p \) based on the collected neighbour information. Then the node automatically selects whether to use APFC or broadcast the FC according to the current position. The algorithm is simulated in different randomly networks. The results show that this algorithm outperforms other broadcasting algorithms in FC duplication.

1. Introduction

Information such as emergency messages, traffic information should live in a bounded geographical area for the appointed time to replicate the information to new nodes that move into the anchor zone (AZ). To hover information within the AZ, Floating Content (FC)\textsuperscript{[1]} is proposed, and a more detailed description is provided by G Di\textsuperscript{[2]}. The formal definition of floating content is later given on the SUTC 2008\textsuperscript{[3]}. As shown in figure 1, the yellow line area is called the anchor zone (AZ), and the center point is the anchor point. The informed node holds FC, such as node 1. Nodes without FC are called uninformed nodes as node 6.

FC is a location-based service for vehicular applications. MANET\textsuperscript{[4]} such as VANET (Vehicular Ad hoc Network) is a temporary infrastructure less dynamic network\textsuperscript{[5]}. The communication and content distribution of VANET has attracted extensive attention\textsuperscript{[6,7]}. To forward message in a MANET or VANET, epidemic routing was used\textsuperscript{[8,9]}. When a node without FC enters into the radius of an informed node through node mobility, two nodes sends message to each other. XY shuai proposed using neighbor trigger to forward FC\textsuperscript{[10]}. Andreas Xeros\textsuperscript{[11]} proposed a floating scheme applying adaptive probabilistic flooding to forward FC in AZ. The algorithm used epidemic route inside the AZ and probabilistic broadcasting outside the AZ. Vehicles outside the AZ received the FC then flooding the FC with probability \( p \) as equation (1).

\[
p = e^{-\frac{d^2}{2\sigma^2}}
\]  

To keep the FC alive in the anchor area and reduce the VANET load, Liu\textsuperscript{[12]} proposed HBID (Hovering-Based Information Dissemination) scheme based on location and speed of all neighbors. The
simulation shows the HBID is effective for 1-way entrance of urban highway. The node encounter rate and broadcast duration are important factors to improve floating performance. The paper [13] proposed an effective approach to share with FC according to radius adjustment.

A FC will live in the anchor area for a period time. The message should be rebroadcasted to the uninformed nodes entering the zone in time. For the accessibility and availability of FC, it is very important for informed nodes to broadcast duplicate to their 1-hop neighbors in time. Redundant broadcasts increase the load of MANET, aggravate the network conflict and lead to delay growth of packet. Adaptive probability broadcasting scheme reduces large number of redundant duplicate of FC. This paper proposed APFC can not only deliver message in time but also effectively decrease the number of duplicate. APFC calculates the broadcast probability $p$ according to the number of neighbors of itself and the requesting node. Then the node can choose whether to use APFC or traditional broadcast according to the location.

2. Algorithm of adaptive probabilistic broadcasting for FC (APFC)

2.1 Algorithm principle

If the network adopts traditional broadcasting, it will lead to redundant information or broadcast storm. Here, we propose the new broadcasting scheme. The APFC should not only consider the availability of FC in the anchor region, but also reduce the number of replications. The goals are to 1) accessibility, 2) availability, 3) minimize rebroadcast. In the same situation, if the node with FC has more neighbors without information, the replication it sends will make more uninformed nodes get it, so the node has the priority of transmission. Any node with information in the anchor area may broadcast FC. If multiple adjacent nodes transmit at the same time, conflicts will occur. If a node's neighbors have more nodes with FC, it is necessary to reduce the sending probability of these nodes. This can reduce the conflict and rebroadcast.

![Figure 1. Safe area and critical area](image)

We divide anchor area into safe area and critical area. The figure 1 shows the different areas. The radius of safe area is $R_s$, and the area exceeds the $R_s$ is critical area. Nodes in this area, such as node 5, will not move out of the anchor area for a short time, and they will have more opportunities to broadcast FC. However, node 2 and node 4 are in the critical area, which will leave the anchor area soon. After leaving, FC will be discarded. These nodes should try their best to keep FC in the anchor area.
2.2 Whole flowchart
In the safe area nodes with FC disseminate FC to 1-hop neighbors with APFC. The critical area is close to the boundary of the anchor area, and the nodes in the critical area broadcast FC to the 1-hop neighbors. The figure 2 depicts the whole flowchart.

![Flowchart Image]

Figure 2. Flowchart

2.3 Algorithm process
Assume that some nodes with FC are in the anchor area, and several nodes without FC enter the anchor area, as shown in figure 3. The new node without FC will exchange information with neighbor nodes with FC through neighbor discovery. A node with FC can transmit FC to its 1-hop neighbors without FC.

![Node Diagram Image]

Figure 3. Floating Content System

Node 6 without FC enters the anchor area. First, it starts neighbor discovery process to broadcast Hello message. The message contains node ID. Neighbors that receive the Hello response a FCS (FC Summary) message that contains FC ID and node ID. According to the received FCS messages, node 6 knows that node 1 and node 2 have FC. Then node 6 updates the neighbor list and counts the number of 1-hop nodes with FC (FNum) and nodes without FC (NNum) respectively. Node 6 multicasts CR (Content Request) message with FC ID and FRNum (the number of nodes with FC) to node 1 and node
2. After receiving CR, node 1 and node respectively compute the probability $p$. The probability $p$ is given as follow.

$$
\rho = \frac{NNum}{FRNum + FNum}
$$

(2)

Where $NNum$ is the number of 1-hop nodes without FC, $FNum$ is the number of 1-hop nodes with FC, $FRNum$ is the number of 1-hop nodes with FC in the received CR. $Num$ is the number of 1-hop neighbor nodes. The $FNum$, $NNum$, received $FRNum$ and $Num$ of node 1, node 2 and node 6 in the figure 4 are shown in the following table 1.

| Table 1. Number of Neighbor | Node 1 | Node 2 | Node 6 |
|----------------------------|--------|--------|--------|
| $FNum$                     | 4      | 5      | 2      |
| $NNum$                     | 2      | 3      | 4      |
| $FRNum$                    | 2      | 2      | NULL   |
| $Num$                      | 6      | 8      | 6      |

Node 1 calculates the probability by equation (2), $p1 = 2 / (4+2) = 1/3 = 0.33$. Node 2 calculates the probability, $p2 = 3 / (2+5) = 3/7 = 0.43$. The probability that node 2 sends FC is greater than that of node 1. The node 1 will broadcast the FC with $p1$. The node 2 will flooding the FC with $p2$. If node 2 successfully broadcasts FC, nodes 6, 7, and 8 will receive the FC replication. While node 1 broadcast successfully, only two nodes 5 and 6 received the duplicate. Process as shown in Figure 4.

![Figure 4. Algorithm Process](image)

2.4 Algorithm of APFC

Each node uses the neighbor list to store the total number of neighbors, the number of neighbors with FC, and the number of neighbors without FC. FC list stores the received FC information such as ID. The nodes in the communication radius run neighbor discovery procedure to find neighbors. A new node without FC exchanges information as follow when it enters the anchor area.

Procedure

Send Hello package to discover neighbor;
Receive FCS; /*if FC ID is not NULL, FC exists*/
Update neighbor list and FC list;
If has a new FC ID then
while (not receive FC)
    Send CR;
    Wait;
    Receive data
EndWhile
Endif
If receive FC then
    become a relay to send replication
Endif
Endprocedure

The informed node broadcast the FC with probability $p$. If the informed node in critical area then the $p$ is 1 otherwise the $p$ is obtained by equation (2). The procedure of informed node as follow.
Procedure
    Discover neighbor;
    Update owe neighbor node list and FC list;
    Send FCS
    If receive CR
        Then
            Compute ($p$) by Equation (2); /*compute probability $p$ */
            Send FC with $p$
        Endif
Endprocedure

3. Simulation
Mobile ad hoc topology can be modeled by random graph (RG). The network with 20, 40, 60, 80, 100 nodes is randomly generated in the anchor area. The number of FC transmitted by APFC, broadcast, no repeat broadcast(1-Broadcast) and fixed probability broadcast(p-Broadcast) is compared by simulation. The number of rebroadcast is shown in figure 5. The results show the APFC is less than others.

![Comparison of the number of replication](image)

Figure 5. Comparison of the number of replication.

4. Summary
In this paper, we proposed an adaptive probability broadcasting for FC in a AZ. The proposed algorithm is based on the number of neighbor and the informed node location. When a new node without FC enters the range of informed node in the safe area, the APFC will be triggered with probability $p$. Any informed node will broadcast the FC when it is in the critical area and is about to leave the anchor area. The results of simulation show this algorithm outperforms others in terms of the number of replications.

In the future, we will use machine learning to optimize the transmission probability $p$ and build a more realistic simulation environment by using mobility model.
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