Message Cache Management Optimization Research for Community-based Opportunistic Network

Chengbing Huang[1,3, a], Ping Jiang[2, b]

[1]Aba Teachers College, Sichuan Wenchuan 623002, China;

[2] Huang Xu Vocational Secondary School, Sikchuan Deyang 618007, China;

[3] Abazhou Ashi Technology Co., Ltd., Sichuan Wenchuan 623000, China.

[a]24951699@QQ.com, [b]253667487@QQ.com

Abstract. In this paper, we propose a community-based message cache management strategy, which can adaptively control the copy of the control message. In this paper, we propose a community-based message cache management strategy, which can adaptively control the copy of the control message. In this paper, we propose a community-based message cache management strategy. And after the message reaches the destination node for the first time, the node receiving the message sends a feedback message informing the node in the other community to delete the stored copy of the message and provide a buffer for the delivery of other messages, so the algorithm Can control the number of message copies. The simulation results show that the strategy is superior to Epdemic algorithm and Self - Adaptive Epdemic algorithm in the same transmission condition, routing cost and propagation delay.

Keywords: opportunistic network; community; buffer management; Feedback.

1. Introduction

With the advancement of technology, a large number of smart handheld communication devices have emerged, so researchers have begun to study how to interconnect these communication devices to form a network. For example, if a vehicle traveling on a road is equipped with an electronic chip, it can be used to form a wireless vehicle network for road traffic; a mobile phone equipped with a Wi-Fi or Bluetooth interface, an iPad, etc. can constitute a local self-organizing network for data sharing or collaborative access to the Internet. However, these self-organizing networks have many common problems in the actual situation, such as small node node density, fast node movement speed, and signal failure. As a result, the network cannot fully realize interconnection in most cases. At the same time, if the source node and the destination node are not in the same connected area, and the traditional wireless network routing algorithm for message forwarding will not enable the message to arrive accurately. The emergence of the opportunity network [1, 2, 3] just solves this problem. It regards the mobile characteristics of the nodes in the network, the connection discontinuity of the nodes, and the changes of the network topology as normal, and makes full use of the movable of the nodes. Features to solve communication problems in different regions.

The opportunistic network does not require full interconnection between the various modules in the network as a whole, which also satisfies the characteristics of the self-organizing network. The nodes in the opportunistic network are often distributed in different sub-areas and these areas are not connected. Therefore, there may be no communication link between the source node and the destination node, and the movement of the node brings different nodes. Intercommunication, thus achieving communication. Nodes in the opportunistic network pass information in a "storage-carry-forward" manner. The most obvious shortcoming of the opportunistic network is that the transmission delay is large, and the advantage is that the transmission cost of the message is low, and communication can be performed without using the network infrastructure.

An important research direction in the opportunistic network is the network of smart devices that people carry. Because the social relationship between people is relatively stable and dependent on each other, this opportunity network characteristic is faster than the ordinary opportunity network node, and the network topology is constantly changing. The movement of nodes in such an opportunistic network is slow and relatively concentrated, and nodes often roam in fixed places. This article is called a community. The community can be a classroom in a school, a library in a city, or a meeting room of a company. In the community, the nodes are relatively dense and encounter frequently. The number of encounters between nodes in different communities is small and the probability of encountering is not large, but some nodes can be active between different communities, so that nodes in different communities can send messages. Forwarding.

2. Related Work

The core issue of network technology is the routing problem. The communication link between the source node and the destination node in the opportunistic network is usually incomplete. The nature of the routing problem in the opportunistic network is the decision problem of selecting the next hop forwarding node, which is quite different from the traditional network that establishes and maintains routes according to the network status. Researchers have proposed many routing algorithms using node mobility features, such as Epdemic [4], PROPHET [5], and Spray and Wait [6]. These algorithms are based on the idea of putting multiple copies of the same message into the network. If a copy arrives at the destination node, the message is transmitted successfully. Appropriate increase in the number of copies can improve the message transmission success rate and reduce the transmission delay; however, too many copies will occupy too much node memory, resulting in excessive node energy consumption. It is therefore important to effectively manage and control the number of message copies.

The BUBBLE algorithm [7] is a community-based single-copy routing algorithm proposed by Pan Hui et al., which is suitable for tolerant delay networks. The moving model of the node in the BUBBLE algorithm is the real moving trajectory in real life. The algorithm first calculates the activity of the node, and selects the relay node for message forwarding according to the size of the activity. At the same time, the algorithm ranks in the system and community according to the activity level, in order to design the global and community sorting table. The routing policy for transmitting a message is: the source node forwards the message to a node whose global activity is larger than itself. When the message is delivered to a relay node that belongs to the same community as the destination node, the relay node continues to rank according to the size of the activity. The message is forwarded, but at this time it is based on the ranking of the community sorting table until the message reaches the destination node. The algorithm forwards the message through the communication opportunities brought about by the social relationship between people, and makes full use of the characteristics that the nodes with high activity and the nodes with low activity have more chances to meet. The algorithm is a single-copy strategy. Although it effectively controls the number of copies of messages in the network, it also increases the transmission delay of messages.

Aiming at the characteristics of community opportunity network, this paper proposes a community-based message cache management strategy-Buffer-Adaptive Epdemic (hereinafter referred to as BA-Epdemic) algorithm. Based on the Self-Adaptive Epdemic [8,9] (hereinafter referred to as SA-Epdemic) routing algorithm, the algorithm first calculates the P value that can reflect the saturation of the surrounding nodes, and then injects a copy of the message into the network according to the P value. After the message is transmitted to the community where the destination node is located, the first node that receives the message will broadcast a feedback message to the nodes of other communities to delete the copy of the message carried. This can reduce the waste of resources and provide space for the transmission of other information, reduce transmission delay and transmission overhead, and improve the success rate of message transmission. The policy node mobility model is based on the community characteristics of people, and nodes are divided into different communities.

3. Message Caching Strategy based on Community Opportunity Network

3.1 Creation of Community Opportunity Network Mobility Model [10]

Most of the node movement models are based on two assumptions: (1) each node in the network can move to an arbitrary position with equal probability, and (2) all nodes have the same mobility characteristics. But a lot of research on the fact-based network movement trajectory proves that these two assumptions are difficult to establish in reality [11]. In order to make the node movement with community characteristics closer to reality in the simulation, this paper proposes a community-based node movement model, in which the node movement is divided into two stages: (1) local community stage, and (2) roaming stage. . The two phases alternately as the node moves. The model is described in detail as follows:

Each node belongs to a local community C_l, which uses the classic mobile mode Random Waypoint in the community.

Local Community Epoch: The node is restricted to move within the local community C_l, and the length of its movement is $\overline{L_r}$, and the state at which the node is located at this time is called the local state S_1.

Roaming Epoch: The node moves most of the time in the community C_l, and sometimes moves to other communities. The node's movement time outside the C_l is expected to be $\overline{L_l}$, and the state of the node at this time is called the roaming state S_r.

The movement of the nodes forms a sequence of local community phases and roaming phases.

Local Community Probability: If the previous phase node is in the local community state is S_l, the probability that the next phase node is still in the local community state is still S_l, and the probability of roaming is $1-p_l$.

Local Community Probability If the previous phase node is in the roaming phase state is the roaming state S_r, the probability that the next phase node is still roaming is p_r, and the probability of moving in the local community is 1-pr.

Based on the observation of the moving characteristics of various real node movement trajectories in real life, this model expresses the above-mentioned node-moving model with community characteristics as two state Markov chains, as shown in Figure 1.

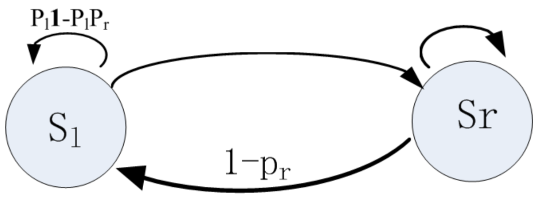

Figure 1. node state change diagram

According to the Markov chain diagram of the above-mentioned node state changes, Markov chain theory can be obtained: the probability that a node is in a local state at any given stage is:

$$p_l = \frac{1-p_r}{2-p_l-p_r} \tag{1}$$

The probability that a node is roaming at any given stage is:

$$p_r = \frac{1-p_r}{2-p_l-p_r} \tag{2}$$

Nodes running with the above model tend to have local characteristics, that is, their majority time is in the local community, the probability p_l>60%; sometimes the node will also leave the local community to roam in other areas, the probability of roaming is pr. Different nodes can have different parameter values (p_l, p_r), which is in line with the feature change modeling of nodes moving over a wide range.

3.2 Message Caching Strategy based on Community Opportunity Network Mobility Model

3.2.1 Controlling the Number of Message Copies

When using the Epdemic routing algorithm for inter-community messaging, the number of message copies in a community is too large, so that the cache of a large number of nodes is saturated. When a node receives a new message, it has to discard the old message. However, the old message may not have been successfully transmitted, which leads to the performance degradation of the Epdemic routing algorithm. Therefore, reasonable control of the number of message copies in the network will effectively improve the delivery rate of the message.

An effective algorithm for controlling message copies, SA-Epdemic, has been proposed in the paper [8]. The algorithm is as follows:

(1) Each node maintains a field to hold the threshold λ. If the percentage of occupancy in the node cache exceeds the threshold λ, the node buffer is considered saturated.

When node i meets any node j, node i first obtains j and the surrounding node cache status, and counts the number of nodes N_{ai} that the node i contacts, and the number of buffered saturated nodes N_{ei}.

(2) Calculation $pi = N_{ei} / N_{ei}$, Know by its definition.

(3) Node i follows the Pi value and then copies the message and sends it to the node it is in contact with.

When the SA-Epdemic routing algorithm is used for message transmission, the Pi value can reflect the saturation of the surrounding node cache. Injecting the message replica into the network according to the Pi value can obviously suppress the general occurrence of the cache saturation, so that more messages are transmitted.

Although the above algorithm can indeed suppress the occurrence of cache saturation in a small number of cases, in the case of a wide variety of messages, the actual transmission requirements will not be met, and a lot of information may not be transmitted because there is no cache space. Therefore, an effective deletion method is adopted to delete the information that has been delivered to the destination node in its cache, and to provide storage space for information that does not reach the destination node, which will greatly improve the transmission performance.

3.2.2 Feedback Message Delivery

When the destination community receives the message for the first time, the node receiving the message sends a feedback message notifying that the node in the community has deleted the copy of the message it carries. The benefit of this is to provide buffer space for the transmission of other messages, reducing unnecessary energy consumption.

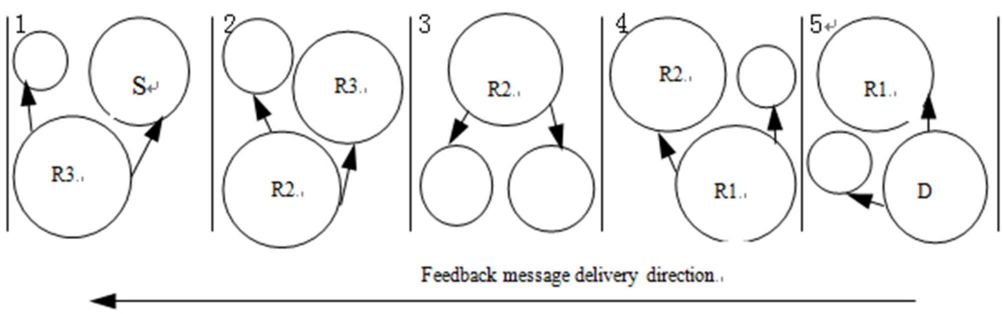

Figure 2. Feedback message sent

As shown in FIG. 2, after receiving the message, the node D in the destination community (the community where the destination node is located) sends feedback information to the node R1. Since R1 will roam between the communities numbered 4 and 5, node R1 will send the feedback information it carries to the nodes in the community numbered 4. Node R2 will roam in the communities numbered 2, 3, and 4, so R2 will send the feedback information to the nodes in the community numbered 2, 3, and 4. Node R3 will roam between the communities numbered 1, 2, so node R3 will send the feedback information to the nodes in the community numbered 1, 2, and all nodes in the community 1, 2, 3, and 4 will be Receive feedback. The node that receives the feedback information checks its own cache and deletes the message copy that has been transferred to the destination community. The purpose of the feedback information is to inform the node to delete the copy of the message it has carried that has reached the destination community. In addition to the destination community, the first time other communities receive feedback information is completed by active nodes roaming in different communities, as shown in Figure 2, R1, R2, and R3.

3.2.3 Improvement of Buffer Threshold λ

In the SA-Epdemic algorithm, if the node cache exceeds the threshold λ, it is considered that the node cache is not receiving other messages, which helps to control the number of message copies and node energy overhead. But this also causes the node to not receive feedback messages, and the saturated node will not be able to delete the copy of the message it carries. In the BA-Epdemic algorithm, the above scheme is changed to if the node cache exceeds the threshold, only the feedback message is received, and no other messages are received. This helps to reuse the saturated node for message transmission. The threshold is set to receive a small feedback message. For example, if the node cache size is 10M, the feedback information size is 5KB, and the threshold size is 9M, the node will not receive or buffer overflow because the feedback information is too large. .

4. Simulation and Results Analysis

4.1 Simulation Environment Settings

In this paper, the performance of the algorithm is simulated by the simulator ONE [12], and the simulation results are compared with the Epdemic algorithm and the algorithm SA-Epdemic. Since the algorithm calculates the Pi value at the beginning of the network operation, the simulation starts with 1000 seconds of warm-up. The community layout is 4*4, with random distribution of network nodes between all nodes. In order to make the moving model of the node closer to the real situation, this paper simulates the real network moving trajectory with reference to the simulation scene set by the SF [13, 14] algorithm. The nodes in the network are divided into two categories, one is called a local node, and the number accounts for 80% of the total number of network nodes. They spend most of the time moving in the local community, and their Pl takes values between [0.8, 0.95]. At the same time, the local node also roams in other communities in the network, and its Pr takes values between [0.1, 0.2]; the other is called roaming nodes, which accounts for 20% of the total number of nodes in the network. Such nodes are often in the network. In other communities roaming, the value of Pr is distributed between [0.3, 0.4], and the roaming node still moves within the local community most of the time, and its Pl takes value between [0.7, 0.8]. Other main simulation parameters are shown in Table 1.

Table 1. Main simulation parameters

parameter name	Parameter value
Simulation time /h	12
Community area /m^2	400*400
Number of communities	4
Number of nodes in the community	9
Community node movement model	Random-Waypoint
Node communication radius /m	20
Node movement speed /(m/**s**)	2~6
Node cache size /M	10
Node cache threshold λ	90
Node life cycle /h	5
Node feedback message size /kb	5

4.2 Experimental Results and Analysis

4.2.1 The Relationship between the Number of Messages and the Success Rate of Transmission

The experiment is based on the simulation scenario. The number of source nodes is 9, and the number of messages generated by the source node is 50 to 1000.

As shown in FIG. 3, when the number of messages is 50, the Epdemic algorithm, the SA-Epdemic algorithm, and the BA-Epdemic algorithm themselves have little difference in transmission success rate. This is because the small number of messages does not cause the cache saturation of the node to occur. Even if the redundant copy is not deleted, the node stores and forwards the information, which is consistent with the theoretical analysis before the experiment. When the number of messages exceeds a certain number (more than 50), the cache saturation of the nodes generally occurs, and the newly generated information has no redundant buffer space. At this time, sending the feedback information by broadcasting to delete the redundant copies will significantly improve the transmission success rate.

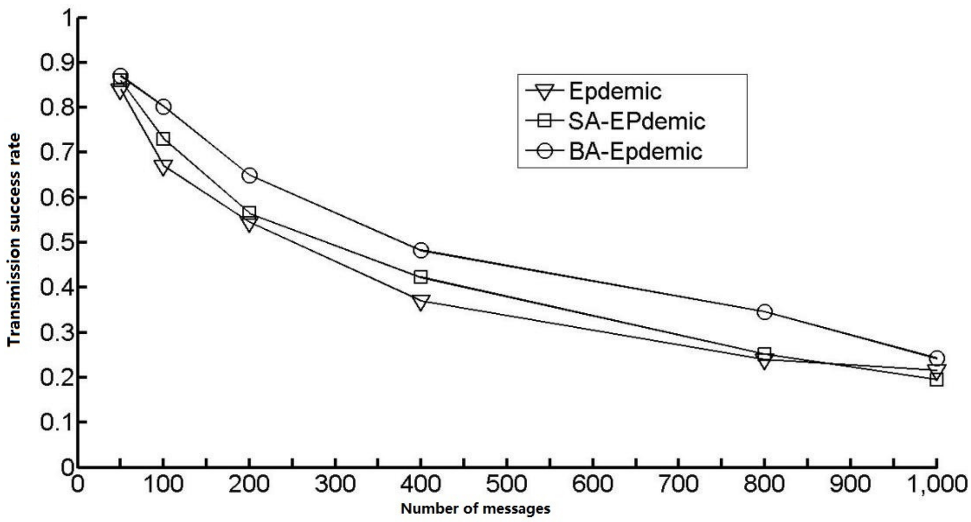

Figure 3

4.2.2 The Relationship between the Number of Messages and Routing Overhead

The experiment is based on the simulation scenario. The number of source nodes is 9, and the number of messages generated by the source node is 50 to 1000.

The results shown in Figure 4 show that when the number of messages is 50, the routing overhead is relatively large. This is because when the number of message copies in the network is relatively small, node cache saturation does not occur generally; the node has more cache space for multiple storage and forwarding of messages. After receiving the message, the node in the destination community sends a feedback message to inform other nodes in the network to delete the copy of the message in the cache to reduce unnecessary forwarding and reduce routing overhead. When the number of messages generated by the source node is gradually increasing, a large number of nodes in the network are cached saturated, so that newly generated messages cannot be cached. Therefore, the number of times the message is forwarded is reduced, and the routing overhead is reduced. However, the broadcast feedback information can still delete the information that has reached the destination node (or the node in the destination community), so that the network node has a buffer space for message transmission. Therefore, when the number of messages exceeds 800, the routing overhead of the BA-Epdemic algorithm is greater than that of the SA-Epdemic algorithm.

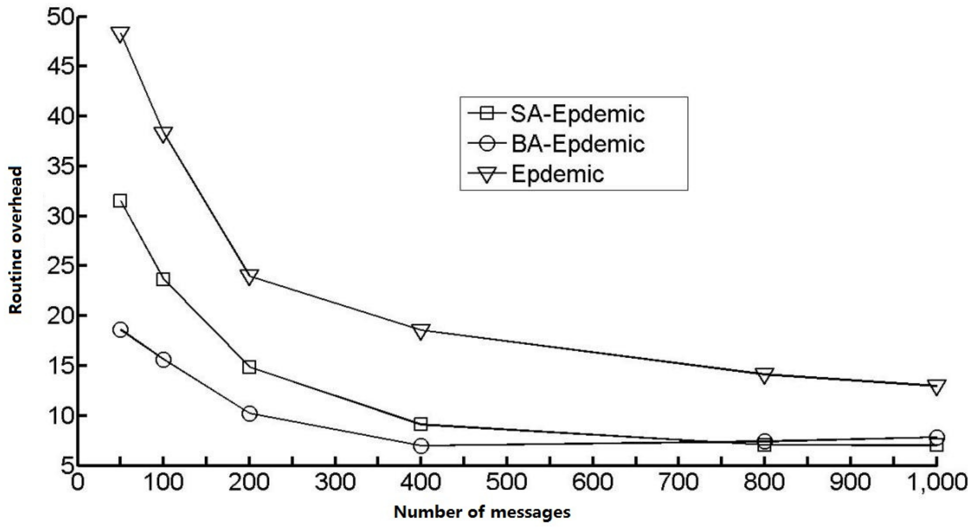

Figure 4

4.2.3 The Relationship between the Number of Messages and the Transmission Delay

The experiment is based on the simulation scenario. The number of source nodes is 9, and the number of messages generated by the source node is 50 to 1000.

As shown in FIG. 5, when the number of messages is between 50200, the message transmission delay is continuously increased. This is because the node cache is saturated, the message is waiting in the source node, and the feedback message in the network is relatively small, thereby increasing the transmission delay. As the copy of the message increases and the message continues to reach the destination community, more feedback will be distributed in the network, causing the message to be transmitted to have more cache space for caching and propagation. Therefore, under the combined effect of the two, the transmission delay is continuously reduced.

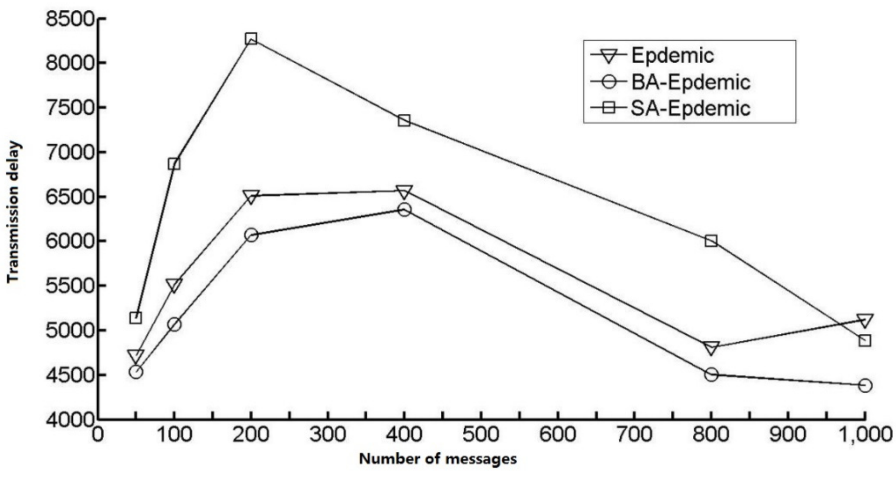

Figure 5

5. Conclusion

The community opportunity network message cache management strategy proposed in this paper enables the message to be transmitted in the community opportunity network with lower routing overhead and higher transmission success rate. This paper first analyzes the development of current opportunistic networks and several classical routing algorithms, as well as the problems of these routing algorithms applied in the community opportunity network, and proposes the BA-Epdemic algorithm for the characteristics of node mobility in the community. The experimental results show that the BA-Epdemic algorithm can better control the number of message copies, which makes the message transmission success rate, routing overhead and transmission delay significantly improved compared with the Epdemic algorithm and the SA-Epdemic algorithm.

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