Load-aware Flooding over Ad Hoc Networks enabling High Message Reachability and Traffic Reduction

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ABSTRACT

There is a high demand for the delivery of high bitrate streaming media such as video or audio information to all nodes on ad hoc networks. To achieve streaming delivery effectively, we have proposed two novel load-aware flooding methods in which a node decides whether to rebroadcast or not based on information on the MAC transmission queue at the node. Since nodes in ad hoc networks are usually battery powered, reducing power consumption is a highly important issue. In this study, we compare the message reachability and the volume of message transmission/reception of our proposal with conventional simple flooding. The results show that our proposed method can reduce traffic and power consumption.

Keywords: Ad hoc network, Flooding, Streaming, Broadcast, Load-aware, Traffic reduction

1 INTRODUCTION

Ad hoc networks are expected to be used to situations such as disasters. In such situations there is high demand for the urgent delivery of high bitrate streaming media, such as video or audio information, to the whole network without the need to establish routing. At present, there is no way to achieve this sort of delivery except by using flooding-based delivery methods. However, simple flooding (SF) methods [1] may not be appropriate because they generate many redundant messages in the network, and many messages are lost due to buffer overflow at nodes or collisions. Moreover, nodes in an ad hoc network are usually battery powered, and such redundant data exchanges accelerate the consumption of the limited battery power. Therefore, the reduction of power consumption is a highly important issue. In the network protocol field, the reduction of redundant transmission/reception is the most important solution to reducing the battery power consumption of nodes.

For the delivery of high bitrate streaming media, we have proposed two novel flooding methods named Load-aware Dynamic Probabilistic Flooding (LDPF) and Load-aware Dynamic Counter-based Flooding (LDCF) [2]. In both these methods, a node decides whether to rebroadcast or not based on information about the size of its MAC transmission queue, which acts as the indicator of its load level. In this paper, we compare the message reachability and total volume of message transmission and reception for LDPF and LDCF through network simulation.

2 PROPOSED METHODS

In this study, we assume nodes in the network are ordinary laptop computers that can communicate with other nodes via an IEEE802.11 series wireless LAN. The following subsection shows the operation of the two methods at a node receiving a message.

2.1 LDPF

A node receiving a message checks the number of packets in its queue (*queue* [packets]). If *queue* is smaller than *q_threshold*, the node is defined as a NOT loaded-node and the rebroadcast decision probability *prob* takes the value of *default_prob*. If the node decides to rebroadcast a message according to *prob*, it rebroadcasts it after a waiting time Random() to avoid data frame collision. On the other hand, if *queue* is greater than *q_threshold*, the node is defined as a loaded-node and *prob* takes the value *loaded_prob*, where *loaded_prob* < *default_prob* < 1.00. If the node decides to rebroadcast the message according to *prob*, it rebroadcasts it after a waiting time defined by Random() * *factor*, in which $factor = 2^n$ where $n = [0, 5]$. The multiplication factor is used to increase the probability of avoiding data frame collision in loaded-nodes. The optimization of *n* is an issue for our future study.

2.2 LDCF

A node receiving a message checks the number of packets in its queue (*queue* [packets]). If *queue* is smaller than *q_threshold*, the node is defined as a NOT loaded-node, the *decision_time* takes the value Random() and the *c_threshold* takes the value *default_c_threshold*. On the other hand, if the queue is greater than *q_threshold*, the node is defined as a loaded-node, the *decision_time* takes the value Random() * *factor* and the *c_threshold* takes the value *loaded_c_threshoold*. After the *decision_time* has passed, if the number of times the same message had been received does not exceed *c_threshold*, the node decides to rebroadcast the message. Then it rebroadcasts it after a *decision_time* defined by Random() * *factor*.Here, *loaded_c_threshold* is smaller than *default_c_threshold*.

Table 1: Rebroadcast probability for LDPF

	P1	P2	P3	P4	P5
default_prob	0.80	0.80	0.60	0.60	0.40
loaded_prob	0.40	0.20	0.20	0.00	0.00

Table 2: Counter threshold value for LDCF

	C1	C2	C3	C4	C5
default_c_threshold	6	6	4	4	2
loaded_c_threshold	4	2	2	1	1

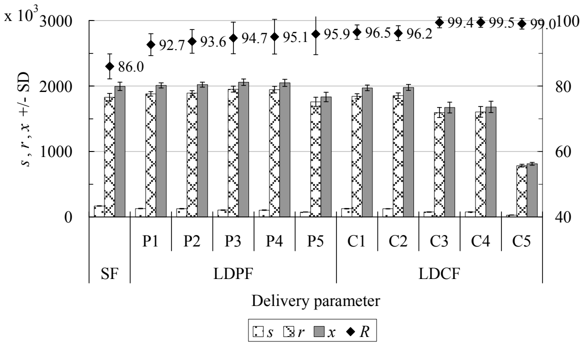

Figure 1: Evaluation result of s, r, x, R

The multiplication factor is given by *factor* = 2^n where n = [0, 5]. As with LDPF, the optimization of n will be the subject of future study.

3 EVALUATION

In this section, based on an evaluation using a network simulator [3], we compare the message reachability and the total volume of transmission and reception for SF, LDPF, and LDCF.

The configuration of the simulation was as follows. The simulation area was 1000x600m. The MAC layer was IEEE802.11b. The data rate was 2Mbps and the transmission power was 0.005W. The packet reception threshold was -85dBm. *q_threshold* was set to 1 and n was set to 5. Random() was assumed to be [0, 20] ms. The total number of nodes was 50, the total number of initiators was 2, and each initiator generated 2000 messages. The size of each message (L2 payload) was 1024 Bytes and the packet generation interval was 32ms, these values being chosen to simulate low-resolution video streaming. Nodes were placed randomly, and. The mobility of the nodes were modeled based on the Random Waypoint Model, and nodes moved at [0, 8] m/s simulating human walking or running speed. The messages generated at an initiator were delivered using SF, LDPF, and LDCF. For LDPF and LDCF, five different combinations of parameters were used as shown in Table 1 and Table 2, respectively.

The evaluation metrics were as described below. Each of the metrics (a)~(d) was measured for each delivery parameter shown in Table 1, and averaged for 10 maps. values are discussed in the following analysis. The metrics were as follows: (a) The number of messages rebroadcast s (For an initiator, the initial broadcast was not counted but relaying broadcasts were counted). (b) The number of messages received r ("receive" means that a message reached the higher layer of the receiving node). (c) The number of messages rebroadcast and received x (The sum of s and r). (d) The message reachability R [%] (The ratio of the nodes that received the message to the total number of nodes, averaged for all generated messages. The high value of R is desirable).

Figure 1 shows the results of the evaluation. The results show that LDCF achieved both a higher R and a lower x than LDPF and SF. In LDPF, a loaded-node broadcasts a message with low probability and the other nodes broadcast a message with the default probability. In contrast, in LDCF, since a node decides whether to rebroadcast or not based on the number of times the same message has been received, rebroadcasting at loaded-nodes is restrained effectively.

4 CONCLUSIONS

In this paper, we have evaluated the message reachability and the total volume of transmission/reception for SF, LDPF, and LDCF. The results shows, i) LDPF achieved similar transmission/reception volume but higher reachability than SF, ii) LDCF achieved less transmission/reception volume and higher reachability than SF, iii) LDCF showed better performance than LDPF. A more detailed analysis of the power consumption related to transmission/reception depending on the type of terminals or network interfaces is left for further study.

ACKNOWLEDGMENTS

This research has been conducted as part of Core Research for Evolutional Science and Technology (CREST), Japan Science and Technology Agency (JST) and Grant-in-Aid for Scientific search KAKENHI (19500064).

REFERENCES

[1] Jorjeta G. Jetcheva, David A. Malts, "A Simple protocol for Multicast and Broadcast in Mobile Ad Hoc Networks", IETF MANET Working Group Internet-Draft, <draft-ietf-manet-simple-mbcast.txt>, 2001

[2] Keisuke Utsu, Hiroshi Sano, Chee Onn Chow, and Hiroshi Ishii, "Proposal of Load-aware Dynamic Flooding over Ad Hoc Networks", IEEE TENCON 2009, THU2.P.14, Singapore, Nov. 2009

[3] The network simulator "OPNET", http://www.opnet.com