

Minimizing the Impact of Buffer Overflow in DTN

Dohyung Kim, Hanjin Park and Ikjun Yeom
Department of Computer Science, KAIST

Email: dhkim@cnlab.kaist.ac.kr; hjpark@cnlab.kaist.ac.kr; yeom@cs.kaist.ac.kr

Abstract

In epidemic routing for a DTN, it is well-known that message drop degrades the delivery ratio. To minimize the degradation, we need to protect messages with a small number of copies in a DTN. In this paper, we propose a new drop policy which drops a message with the largest expected number of copies first to minimize the impact of message drop.

1 Introduction

Delay/Disruption Tolerant Network (DTN) is an emerging technology for communication without network infrastructure. In a DTN, nodes play a role of relaying messages. Unlike Mobile Ad-Hoc network (MANET), it is assumed that a DTN can be partitioned frequently, and the partition can last for a long time due to nodes' mobility and sparse distribution. In a DTN, messages are delivered with a 'store, carry and forward' manner. Each node carries messages and duplicates them to new nodes encountered. For achieving high delivery ratio, each node should carry as many messages as possible, so that the buffer is fully occupied by packets.

For increasing the delivery ratio in a DTN, it is critical to select messages to be discarded upon a full buffer. It is obvious that the best choice is to pick a message which is the least likely to be delivered to the final destination eventually. In a random topology of a DTN, however, it might be impossible to predict that. As alternatives, there have been proposed several drop policies in [1, 2] for buffer management schemes, in which four types of intuitive drop policies are suggested as follows: 1) DL (Drop Last): discard the newly received message first; 2) DF (Drop Front): discard the oldest message in the queue first; 3) DO (Drop Oldest): discard the message with the shortest remaining lifetime first; 4) DY (Drop Youngest): discard the message with the largest remaining lifetime first.

In [3], it has been shown that the DF and DO policies show the better performance in delivery ratio and latency among different drop policies in epidemic routing. The ra-

tionale behind this result is that an old message is likely to be duplicated to more nodes, and discarding a copy of it may decrease the overall delivery ratio less. Inspired by [3], we develop a new drop policy to improve the DF and DO policy in this paper. Whereas the DF and DO policies implicitly drop the message with a largest number of copies, the proposed policy actively estimates the copy number of a message from the encountering rate of nodes holding a copy of the message. With this policy, we expect that the delivery ratio of a DTN can be improved with minimizing the impact of message drop.

2 The proposed drop policy

To minimize the impact of message drop, the packet with smallest number of copies should be dropped. For achieving this purpose, we develop a method to compare the number of possible copies of a message in this section.

While deriving our method, we assume that the probability of encountering rate of two nodes follows Poisson distribution with parameter λ , where λ is the average number of encounters of new nodes in a time unit T . Similar assumption has been made in [2]. When node i duplicates a copy of a message, M , to node j , node i calculates the possibility that node j cannot duplicate M to other node further. This is the same as the probability that node j cannot encounter other nodes within the remaining lifetime of M .

$$P\{M \text{ cannot be forwarded from } j \mid j \text{ receives } M \text{ from } i\} \quad (1) \\ = 1 - (1 - e^{-\lambda_j R_{ij}}) = e^{-\lambda_j R_{ij}}$$

where R_{ij} is the remaining lifetime of M when node j receives M from node i , and λ_j is λ for node j . We use this probability as a metric to compare the number of possible copies among messages in a DTN.

Now, we describe how to maintain this metric at each buffer according to the scenario described in Fig.???. Basically the metric is contained by the message, and transmitted to other nodes when they exchange the message list. Suppose that node i is the source of a message, M . The initial metric for M at node i is $e^{-\lambda_i R}$, where R is the initial

TTL of M . When node i meets node j with λ_j and duplicates a copy of M to node j , the metrics of M in both nodes are updated to $e^{-(\lambda_i R + \lambda_j R_{ij})}$, because probability that M cannot be duplicated any further can be expressed by the multiplication of both independent probabilities. When node i meets node k , both has $e^{-(\lambda_i R + \lambda_j R_{ij} + \lambda_k R_{ik})}$ for the metric of M . Later on, when node j encounters node k which already has a copy of M , both nodes compares the metric of M and update it into the minimum of the two, $e^{-(\lambda_i R + \lambda_j R_{ij} + \lambda_k R_{ik})}$. The proposed scheme automatically gives priority to the source messages (generated from a node), which is required to achieve high delivery ratio and low latency according to [4].

When buffer frequently becomes full, messages can be dropped at the buffer before expiration of lifetime. Therefore remaining lifetime, R_{ij} , in (1) should be changed into residence time of the message at the buffer before being discarded, R'_{ij} . For that, we maintain exponential weighted moving average of the dropped message's remaining lifetime, Dr . Then we can estimate R'_{ij} as $R_{ij} - Dr$.

3 Performance Evaluation

We simulate the proposed scheme using the Opportunistic Network Environment simulator in [5] which was used in many DTN research. Simulation scenario is arranged in TABLE 3. Message delivery is done in FIFO manner. Three group of nodes with different mobility are deployed in the square topology. We compare the proposed scheme with four typical drop policies mentioned in Section 1 in terms of delivery rate. The result is shown in Fig.1.

Differently from the result in [3], DO policy shows best performance in delivery ratio among four typical schemes. In random waypoint movement model, the oldest message generally has largest number of copies, that DO can outperform DF. For the same reason, though the proposed drop policy achieves the highest delivery ratio, only 1-2% performance improvement is shown.

TABLE 3 compares delivery ratio and latency of the proposed scheme and DO policy in detail. The proposed scheme can deliver the old message which can be dropped in DO, that the latency in the proposed scheme is larger than that in DO.

| | | | |
|----------------|------------------|----------------|-------------|
| Topology | 5km x 5km | sim. time | 12 h |
| # of group | 4 | # of nodes | 15 / group |
| Nodes' speed | 0, 1, 5, 10(m/s) | M size | 0.5MB - 1MB |
| Movement model | random waypoint | TTL of message | 30 min. |
| Tran. speed | 2Mbps | Tran. range | 250m |

Table 1. Simulation scenario

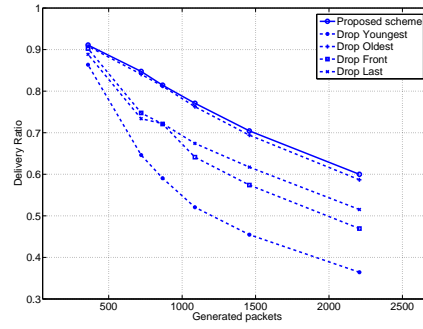


Figure 1. Delivery ratio

| Generated pkts (generation rate) | The proposed scheme | | DO policy | |
|-------------------------------------|---------------------|---------|-------------|---------|
| | deliv. pkts | latency | deliv. pkts | latency |
| 2207 (3 pkt/m) | 1324 | 964.6 | 1295 | 810.1 |
| 1458 (2 pkt/m) | 1027 | 956.4 | 1012 | 833.3 |
| 1087 (1.2pkt/m) | 706 | 891.1 | 704 | 840.3 |
| 721 (1pkt/m) | 611 | 863.3 | 606 | 804.77 |
| 359 (0.5pkt/m) | 327 | 707.5 | 326 | 698.5 |

Table 2. Simulation results

4 Conclusion

We propose a new drop policy to minimize the impact of buffer overflow in DTN. The proposed scheme provides a method to compare the number of possible copies of messages. When buffer overflow happens, a node discards the message with the largest number of copies, which results in high delivery ration in a DTN.

References

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