Computer Networks 64 (2014) 38–54

Contents lists available at ScienceDirect

Computer Networks

journal homepage: www.elsevier.com/locate/comnet

Use of contact duration for message forwarding in intermittently connected mobile networks

Sun-Hyun Kim [a], Yeonsik Jeong [b], Seung-Jae Han [a,*]

[a] Dept. of Computer Science, Yonsei University, Seoul, Republic of Korea
[b] Dept. of Multimedia System Engineering, SungKongHoe University, Seoul, Republic of Korea

ARTICLE INFO

Article history:
Received 22 July 2013
Received in revised form 4 January 2014
Accepted 24 January 2014
Available online 7 February 2014

Keywords:
DTN routing
Forwarding failure
Contact duration
Message fragmentation

ABSTRACT

Several routing schemes have been proposed for intermittently connected mobile networks. In these schemes, a node carries a message and forwards the message to another node when they meet. To increase the delivery success rate and reduce the message delivery delay, the node to forward the message is selected based on such criteria as the probability that the node is likely to meet the destination. However, even if a node is suitable under such criteria, the contact duration may be too short to complete the message forwarding, which is called 'forwarding failure' in this paper. The risk of forwarding failure due to link disconnection during transmission has been mostly ignored in the existing routing schemes. In this paper we focus on avoiding forwarding failure. To this end, a large message is divided into smaller fragments, and we present a mathematical model to derive the optimal fragment size that minimizes message delivery delay. We then present a run-time algorithm which determines whether a current message fragment should be forwarded to a node encountered. Contact duration with the candidate node is estimated for this decision. Delayed forwarding and transmission power adjustment is incorporated into this algorithm to enhance energy efficiency of message forwarding. The benefits and feasibility of the proposed scheme are extensively evaluated by simulations and experiments.

1. Introduction

In intermittently connected mobile networks, disruption of link connectivity is inevitable and therefore they are more suitable for Delay/Disruption Tolerant Network (DTN) services. Many DTN routing schemes have been developed for such networks, and the *carry and forward* approach is commonly adopted in which a node carries data and forwards it to another node when they meet. When two nodes approach to each other within the transmission range, a wireless link may be established between the two nodes. The link will be disconnected when the two nodes move away from each other. The duration that the wireless link lasts (termed *contact duration*) is determined by several factors including the speed of mobile nodes and the relative approach angle. In conjunction with the wireless link quality which decides the data transmission rate, the contact duration determines the amount of data that can be forwarded over the temporary wireless link between the two nodes. If the contact duration is too short or data transmission rate is too low, the forwarding of data between the two nodes will be interrupted as the link is disconnected. In such a situation, only partial data will be forwarded.

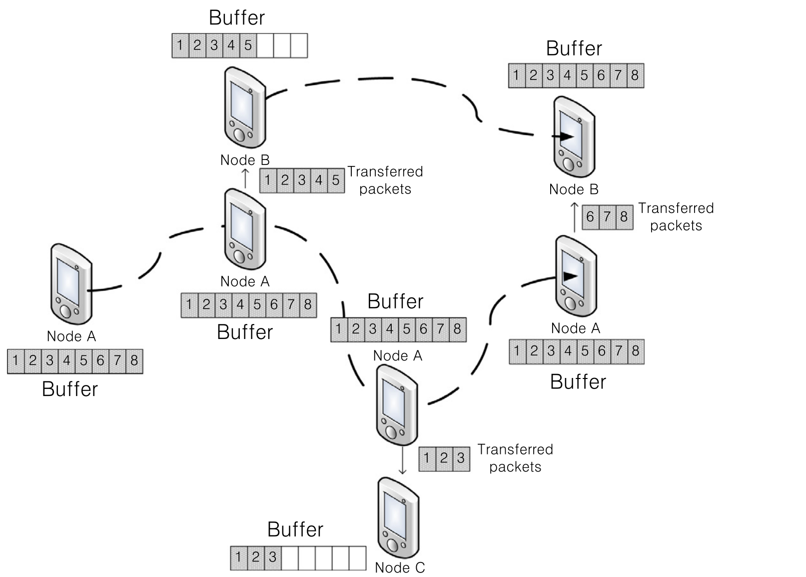
The existing researches on DTN routing typically do not consider the issue of partial data forwarding. It is assumed

* Corresponding author. Tel.: +82 2 2123 5723.
E-mail addresses: molkey@cs.yonsei.ac.kr (S.-H. Kim), ysjeong@skhu.ac.kr (Y. Jeong), sjhan@cs.yonsei.ac.kr (S.-J. Han).

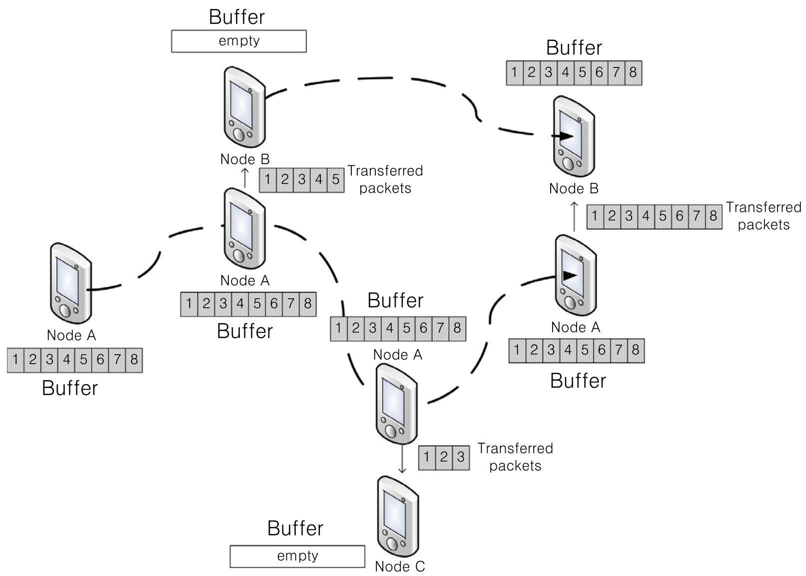
http://dx.doi.org/10.1016/j.comnet.2014.01.007
1389-1286/

that the size of data to be delivered is small and the contact duration is sufficiently large. Under this assumption, the neighbor nodes to which a message is forwarded are selected based on such criteria as the strength of social tie or the probability that the neighbor node will meet the destination node. However, if the size of data is big, forwarding of the entire data may not always be successful. Partially forwarded data is of little use. Let us explain the consequence of partial data forwarding with an example.

Consider that node A carries a message of eight packets long and wants to forward a copy of the message to the nodes that it encounters. In Fig. 1(a), it is depicted that node A meets node B first, then meets node C, and meets node B again. The duration of each contact is too short and only partial data forwarding is possible at the initial encounter. When node B meets node A at the second time, node B receives a full copy of the message, but node C has only a partial copy of the message. If node C meets another node, it may forward only part of the its data, resulting further fragmentation of data. When node C meets the destination node, it can forward only the partial copy, and the destination has to wait until it meets another node that carries the missing part of the message. However, if data forwarding between two nodes is executed by sending



(a) When partial data forwarding is allowed



(b) When only full data forwarding is allowed

Fig. 1. Partial vs. full data forwarding upon a contact.