A Replica Distrubution Scheme for Location-dependent Information on Vehicular Ad Hoc Networks

Mariko Yamanaka
Graduate School of Engineering, Shizuoka University
3-5-1 Johoku, Hamamatsu
432-8561, Japan
yamanaka@ishilab.net

Gen Tsuchida
Graduate School of Science and Technology, Shizuoka University
3-5-1 Johoku, Hamamatsu
432-8561, Japan
gen@ishilab.net

Susumu Ishihara
Graduate School of Science and Technology, Shizuoka University
3-5-1 Johoku, Hamamatsu
432-8561, Japan
ishihara@ishilab.net

ABSTRACT

In this paper we propose Road-aware Skip Copy (RSC) method for distributing replicas of location-dependent data on server-less vehicular ad hoc networks in urban areas. In the RSC method, mobile nodes broadcast replicas of data item near intersections in order to distribute replicas to many nodes with small number of broadcasts, and it limits the number of the holder of the replicas by the hop count from the source nodes in order to save the storage. The results of simulations using real map data show that the RSC method achieves higher access success rate than those of conventional methods.

Categories and Subject Descriptors: C.2.2 [Computer-Communication Networks]: Network Protocols

General Terms: Algorithms, Verification

Keywords: data sharing, replica dissemination, location-dependent data, geocasting, intersection

1. INTRODUCTION

Considering mobile nodes share data in ad hoc networks, it is difficult to keep accessibility to data on other nodes due to link disconnections caused by movements of nodes etc. To mitigate this issue, some techniques for distributing replicas of data items to other nodes and making multiple nodes share the replicas have been proposed. We have proposed Skip Copy (SC) method [1] for maintaining location-dependent data collected by mobile nodes and accessed using geocasting on server-less ad hoc networks. However, the SC method was designed without consideration of the characteristics of vehicles' movement and road layout. Therefore it has the possibility that replicas of data items can not be appropriately distributed. In this paper, we propose Road-aware Skip Copy (RSC) method which controls the timings of replica distribution in consideration of the characteristics of vehicle's movement.

2. LOCATION-DEPENDENT DATA DISTRIBUTION METHOD

We focus on a system which vehicles share the location-dependent data from in-vehicle sensors, cameras, etc. and share them on server-less ad hoc networks. For example, a vehicle V_1 generates or receives location-dependent data

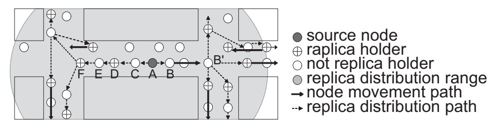


Figure 1: Replica distribution in the RSC method ($s = 2$)

(e.g. a picture of a traffic accident, bargain sale information at a store, etc.) at a position A, then it distributes the replicas of the data item around the position A. These replicas are requested by other vehicles using geocast. By distributing the replicas, even if the vehicle V_1 goes away from position A, other vehicles which want to get a data of position A can get the data by sending a request message to the position. Because this system does not depend on fixed infrastructure, it can perform even within an environment that an infrastructure does not exist or is damaged.

2.1 Skip Copy (SC) method

The SC method is a replica distribution method for sharing location-dependent data which are requested by geocast on mobile ad hoc networks. The key points of the SC method is (i) replicas of data item are distributed sparsely in the *replica distribution range* centered on the birthplace of the data according to the hop count from the source node when they are firstly generated, (ii) the replicas are dynamically relocated when they are forwarded as reply messages. By limiting the number of nodes having a replica of a data item, SC method keeps an accessibility to a data item while using the storage of the nodes effectively and reducing the replica distribution traffic.

In inter-vehicle communication, mobile nodes move along roads fast and the communication may be intercepted by the obstacles such as buildings. Therefore, in SC method, when a node is on a road other than an intersection, areas where replicas are not distributed may exist.

2.2 RSC method

The RSC method controls the timing of the replica distribution so that each node distributes the replicas at intersections where it will be able to distribute the replica to many nodes by one broadcast.

When a node generates a new data item related to its current location, it broadcasts the replica of the data item to its all neighbor nodes (**Fig. 1**: node A). Then it broadcasts the replica again at the first intersection that it reaches.

Each node that receives a replica of a data item decides whether it becomes a *replica holder* which it stores the

VANET'06, September 29, 2006, Los Angeles, California, USA.
ACM 1-59593-540-1/06/0009.

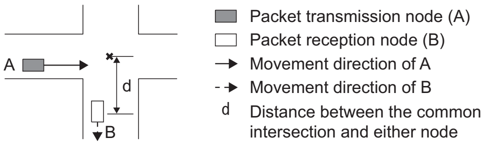


Figure 2: A model of influence by obstacles

replica, and whether it forwards the replica immediately or defers the forwarding until it reaches the next intersection. If the hop count from the source node is a multiple of a skip parameter s, it becomes a replica holder. s is a positive integer and used to control the density of replica holders.

If a node is going away from the birthplace of the data item when it receives a replica, it defers the forwarding of the replica until it reaches the next intersection (Fig. 1: node B, B'). On the other hand, when the node approaches the birthplace of the data item, it re-broadcasts the replica immediately because the replica cannot be distributed in the opposite direction of the traveling direction of the node if the re-broadcast of the replica is deferred (Fig. 1: node C). Consequently, in this case, a lot of nodes receive the replica (Fig. 1: node C∼F) in a short time. Because these nodes move as a cluster after this, not all nodes have to re-broadcast the replica of the data at the next intersection. Therefore, only replica holders re-broadcast the replica at the next intersection.

In addition, in both cases, if a node receives a replica that it has received yet, it discards the replica to avoid redundant traffic. Furthermore, if a replica holder receives a replica which has the same ID of the replica that the node is deferring the distribution and the node is within r_c [m] from an intersection where the node is planning the next replica distribution, the node cancels the re-broadcast of the replica.

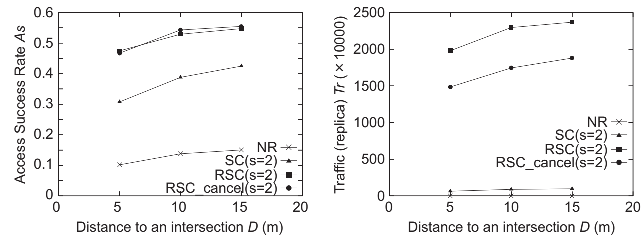
3. SIMULATION

We evaluated the performance of the RSC method in simulations using JiST/SWANS [2]. We used STRAW (Street Random Waypoint) [3] to employ realistic mobility of vehicles in streets that defined by real map data.

3.1 Overview of the simulation model

The simulator places 4000 mobile nodes at random on streets contained in the map of 3000-m-square. The simulation field is divided into 100 pieces with 300m-square sub-areas. 500 nodes of the 4000 nodes generate new data items related to the sub-area where they exist. We set 1000[s] for an expiration time of the data. The 500 nodes also generate a request message. The generation of data items and requests follow Poisson process with a mean interval of 300[s]. Request messages are transmitted through Location Based Multicast (LBM) [4]. Reply messages to the requests are transmitted on the reverse route of the route which the request message has traversed. All nodes have enough storage to store all data items. The communication range is 105[m].

To take into account the effect of obstacles to the communication, we set the condition that nodes can communicate with other node as (i) two nodes are on the same road, (ii) either node is within radius d from their common intersection (**Fig. 2**). In the experiments, we changed the threshold value of the distance from an intersection used to the judgment of the connectivity (D). When D is small, the communication between crossing lanes is difficult.



(a) Access Success Rate (*As*) vs. *D* (b) Traffic of distribution of replica (*Tr*) vs. *D*

Figure 3: Simulation results

3.2 Simulation Results

We compare the following four methods : (i) NR (No Replica): Replicas are not distributed, (ii) SC, (iii) RSC (does not cancel the re-broadcast), (iv) RSC_cancel (cancels the re-broadcast if a node receives the same ID of the replica). The relation between D and A_s, the number of reply data that a source node received or T_r, the number of packets sent for replica distribution is shown in **Fig. 3**. A_s of RSC is higher than that of SC. When $D = 5$ [m], the difference of A_s between RSC and SC is larger compared with when $D = 15$ [m]. This result suggests the effect of RSC that distribute replicas at the intersection. T_r of RSC is larger than that of other methods. This is because distributions of replica are performed repeatedly at the intersections near the birthplace of the original data, while in the SC method, replicas are distributed only just after the data generation or when they are forwarded as reply messages. In addition, T_r of RSC_cancel is much smaller than that of RSC, while they show almost the same A_s. This means that redundant traffic of replica distribution was reduced by the cancel of broadcast of replicas.

4. CONCLUSIONS

We proposed the Road-aware Skip Copy (RSC) method, a replica distribution method in inter-vehicle communications. Simulation results showed that the RSC achieves a high access success rate (A_s) compared with the SC method, within an environment with large influence of obstacles like buildings. Currently, the characteristic of the vehicles' movement is considered only at the replica distribution, so packet losses may happen in the middle of forwarding of requests and reply messages. This caused small A_s about 55% at the best. Further investigation for reducing the replica distribution traffic and the development of effective technique for forwarding request message adapted for road layout will be our future work.

5. ACKNOWLEDGMENTS

This research was partially supported by the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Young Scientists (A), 18680008, 2006.

6. REFERENCES

[1] G. Tsuchida, T. Okino, T. Mizuno and S. Ishihara, "Evaluation of a replication method for data associated with location in mobile ad hoc networks," *ICMU'05*, pp. 116–121, 2005.

[2] JiST – Java in Simulation Time / SWANS – Scalable Wireless Ad hoc Network Simulator: http://jist.ece.cornell.edu/index.html

[3] David R. Choffnes and Fabian E. Bustamante, "An Integrated Mobility and Traffic Model for Vehicular Wireless Networks," *VANET'05*, pp. 69–78, 2005.

[4] Ko, Y. B. and Vaidya, N. H., "Geocasting in Mobile Ad Hoc Networks: Location-Based Multicast Algorithms," *WMCSA'99*, pp.101–110, 1999.