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Knowledge Based Scheduling and Drop Policy in Vehicular Delay Tolerant Networks

Masumeh Marzaei Afshord

Department of Computer Science, Islamic Azad University, Shabestar Branch, Shabestar, Iran

Abstract: Vehicular Delay Tolerant Network (VDTN) is an application of Delay Tolerant Network (DTN) where movement of vehicles is used for connectivity. In order to increase delivery probability, message replication is performed by most routing protocols of VDTN which imposes high memory overhead on network nodes. In addition, disseminated data units in VDTNs are bundles which can often be large. For these reasons, efficient scheduling and drop policies are required to improve the overall performance of the network. Most conventional scheduling and drop policies make a decision based on just message criteria. In this paper, we propose a scheduling and drop policy that in addition to message criteria, utilizes both knowledge of the free space of the neighbor node's buffer and the segment traffic where the node is located and makes a decision based on them smartly. The proposed buffer management policy forwards messages according to the free space of the neighbor node's buffer. It also uses the knowledge of segment traffic to select a message for sending or dropping. Using simulation, we show our buffer management policy outperforms conventional policies in terms of delivery probability of message and number of drops.

Key words: Buffer Management · Drop Policy · Epidemic Routing · Scheduling Policy · Delay Tolerant Networks

INTRODUCTION

Delay Tolerant Networks (DTNs) make communication possible in challenging environments. Some features of these environments include intermittent connectivity, long delays, high loss rates and frequent partitioning. Vehicular Delay Tolerant Networks (VDTNs) are the new kind of DTN networks where the mobility of vehicles provides connectivity in disconnected scenarios. Vehicles store messages on their buffers while waiting for new opportunities to forward messages to suitable next hop or the final destination [1]. Routing protocols of VDTN replicate messages across multiple nodes of the network (paths) in order to increase the delivery rate and decrease average latency. In a network with limited resources, the combination of long term storage and message replication reduce the overall performance of network and increase the requirement for efficient buffer management policies [1]. A lot of buffer management policies are presented in the past. FIFO policy orders messages to be forwarded at a contact opportunity based on their entry time into the node's buffer [2]. In cases of buffer congestion, drops the message has been stored for the longest period of time in a node's buffer [2]. Random policy selects a message to forward or remove in a random order [2, 1]. Lifetime desc-asc policy sorts messages based on their TTL in a descending order and forwards the message with the highest TTL first [1]. The idea of this policy is that messages with high TTL have higher probability to reach the final destination before they expire. When the buffer is full, messages are sorted based on their TTL in an ascending order and messages with the least TTL are removed [1], since the messages with smaller TTL have a less probability to reach its final destination before their TTL expires.

All of the above mentioned policies make a decision based on just message criteria. Our purpose is determining the policy which considering the neighboring environment of nodes and some of message criteria improves overall performance of the network. For this reason, we propose Knowledge Based Scheduling and Drop (KBSD) policy. We have evaluated the performance of our KBSD buffer management policy. Simulation results show KBSD policy increases the delivery rate and decreases the number of drops.

Corrseponding Author: Masumeh Marzaei Afshord, Department of Computer Science, Islamic Azad University, Shabestar Branch, Shabestar, Iran. Tel: +09143023661.

Msgid	Msgsize	MsgTTL	Msgid	Msgsize	MsgTTL
M1	120K	95	M11	200K	80
M2	350K	120	M12	520K	100
M3	450K	30	M13	400K	30
M4	180K	70	M14	300K	50
M5	100K	55	M15	100K	40
M6	600K	80	M16	600K	90
Free Space=520K			Free Space=200K		
(A)			(B)		

Fig. 1: Buffer space of two nodes A and B

Problem Description

Proposed Scheduling Policy: In a contact opportunity, our scheduling policy considers free space of receiver node's buffer and forwards a message with equal or smaller size than it. Therefore it reduces number of drops. The knowledge of free space of receiver node's buffer is obtained based on HELLO-RESPONSE technique. The sender node periodically sends HELLO messages in order to make a connection. If the receiver node gets the HELLO message, it will send a RESPONSE message. This message will also contain information about free space of the buffer [3].

As shown in Figure 1, if the buffer of the sender node (node A) includes multiple messages equal to or less than the free space of the receiver node's buffer (node B), the scheduling policy makes a decision based on the traffic on the segment where the sender node is located in addition to the free space of the receiver node's buffer. In this case, based on the segment traffic, it forwards the message either with the least or the highest TTL among messages equal to or less than the free space of the node B's buffer.

According to the proposed scheduling policy, if the segment traffic of node A is low or medium, the message with the highest TTL in the buffer of node A (M1) is forwarded among messages M1, M4 and M5. The reason for forwarding the message with the highest TTL is the low traffic of segment leads to low contact opportunities in the segment and also high waiting time in buffers, Therefore the possibility of crossing current segment by messages with the high TTL before their TTL expires, is more than the possibility of crossing current segment by messages with the low TTL. But if the segment traffic is heavy, the message with the least TTL is selected to forward (M5). In this case, heavy traffic on the segment leads to high contact opportunities in the segment and low waiting time in buffers. For this reason, it is possible that messages with the low TTL can traverse current segment before they expire. So it is given an opportunity to messages with the low TTL.

In order to obtain the knowledge of the segment traffic, the traffic oracle is used [4]. Based on the Cartesian coordinate of each node, this oracle obtains the related segment and determines the traffic amount including the number of nodes in that segment.

If the size of all messages in the buffer of the sender node is larger than the free space of the receiver node's buffer, the proposed scheduling policy makes a decision based on just the segment traffic on the sender node.

MsgId	Msg Size
M1	120K
M2	300K
M3	400K
M4	230K
M5	600K
M6	600K

Proposed Drop Policy: According to drop policy, the message that is equal to or larger than the size of the input message is dropped when buffer is full [5]. When there are multiple messages that are equal to or larger than the size of the input message, the proposed drop policy makes a decision based on the traffic on the segment where the node is located in addition to the size of the input message. Based on traffic, it drops the message either with the least or the highest TTL among messages that are equal to or larger than the size of the input message. Assume in Figure 1, message M2 is sent. In this case, our policy determines the segment traffic of node B by using the traffic oracle. If the segment traffic on the node is low or medium, it drops the message with the least TTL in buffer (M13) among messages M12, M13 and M16. The reason for selecting the message with the least TTL is that possibility of crossing current segment by messages with the high TTL before they expire is more than possibility of crossing by low TTL messages. If the segment traffic is heavy, the message with the highest TTL is selected to drop (M12) because it is possible that low TTL messages can traverse current segment before they expire. Therefore in order to give opportunity to low TTL messages, high TTL messages are selected to drop.

Table 1: Simulation parameters

Number of vehicles	100-150-200
Buffer size	30 MB
Transmission rate	6Mbps
Transmission range	30 m
Vehicle random speed	30-50km/h
Message TTL	60 minute
Random waiting time of vehicles	5-15minutes
Message generation rate	5-15 seconds
message size Random	500KB-1MB
Movement model	Shortest path map based movement
Simulation time	12 hours
Area of Simulation	6000m*6000m

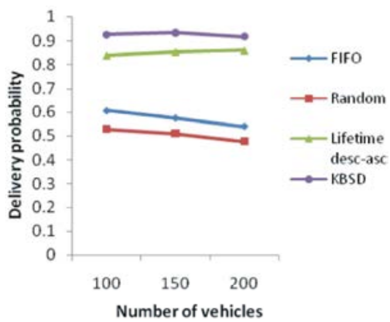

Fig. 2: Delivery probability

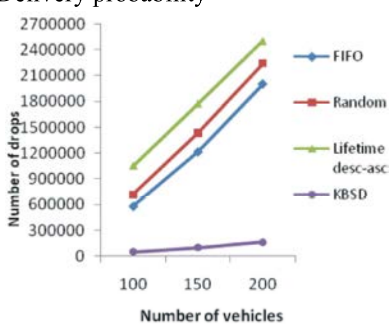

Fig. 3: Number of drops

If the size of all messages in the buffer of node B is smaller than the size of the input message, the proposed drop policy makes a decision based on just the segment traffic.

Simulation Settings and Results: In this section, we compare performance of KBSD policy with FIFO, Random and Lifetime desc-asc policies. The simulation tool used in this evaluation is the Opportunistic Network Environment (ONE) simulator [6]. The performance metrics considered in the simulation are the message delivery probability (measured as the ratio of the delivered messages to the sent messages[2, 1, 5]) and the number of drops. To evaluate, the Epidemic routing protocol is used [8, 9].

Table 1 shows simulation settings. We have defined the number of vehicles less than 6 in one segment as low traffic, the number of vehicles from 6 to 8 as medium traffic and the number of vehicles higher than 8 as high traffic.

Performance Evaluation: Figure 2 shows the delivery rate of messages. The KBSD policy makes a decision based on features of the neighboring environment of nodes smartly and reduces the number of dropped messages. Consequently, it increases the delivery possibility of messages. By increasing the number of vehicles, contact opportunities also are increased and vehicles can exchange more messages, so the delivery rate is increased. However, when the number of vehicles in comparison to the environment is increased more than usual, the number of exchanging messages become high on the network and competition for resources is increased. Therefore, the delivery rate can be reduced.

Figure 3 shows the number of drops. The KBSD policy forwards a message based on free space of neighbor node's buffer. Therefore, the neighbor node receives the message with the least number of drops. In addition, it makes a decision based on the size of input message which leads to reduce the number of drops. By increasing the number of vehicles, the competition for network resources is increased and thereby the number of drops is increased.

CONCLUSION AND FUTURE WORK

In this paper, the KBSD buffer management policy was presented. This policy utilizes two knowledge of free space of the neighbor node's buffer and traffic amount of the segment in which node is located and makes a decision based on them smartly. The performance of KBSD policy was compared with some other policies. Results showed that the KBSD policy increases message delivery probability and decreases number of drops.

In future works, other knowledge of environment and message criteria can be used.

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