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Distributed Rate Control Algorithm for VANETs (DRCV)

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ABSTRACT

This paper presents Distributed Rate Control for VANETs (DRCV), a distributed light-weight congestion control algorithm tailored for safety messages. DRCV monitors and estimates channel load and controls the packet rate of outgoing periodic packets. A new approach called Fast Drop is adopted to promptly drop the rate of periodic packets when event-driven safety packets are detected. Simulations show the effectiveness of DRCV in increasing packet reception probabilities and achieving efficient channel usage.

Categories and Subject Descriptors

C.2 [**Comouter-communication networks**]: Wireless communication

General Terms

Algorithms, Performance

Keywords

VANET, congestion control, inter-vehicle communication

1. INTRODUCTION

Inter-vehicle communication is an enabling technology for road-safety applications. To support these applications, vehicles broadcast periodic safety messages and Event-Driven (ED) safety messages via vehicular on-board units [5] [1]. Critical ED messages targeted for a geographical area usually require high reliability and low latency. Therefore, it is fundamental to have proper algorithms for congestion control in order to meet these requirements. It is well known that TCP is not suitable for congestion control in VANETs. Even though a number of variants of TCP have been proposed, they do not meet the requirements of safety message dissemination [3]. There are only limited studies focusing on congestion control for safety messages [4].

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In this paper we propose an algorithm called Distributed Rate Control for VANETs (DRCV) designed for safety messages. DRCV is characterized by low complexity and overhead. Especially, an approach called Fast Drop is adopted to promptly drop the rate of periodic messages when ED safety messages are detected. The rest of the paper first introduces the framework for DRCV, and then presents the DRCV algorithm with some performance results and conclusion.

2. FRAMEWORK

DRCV is based on the framework illustrated in Figure 1, which assumes that ED messages have a higher priority than periodic (PER) messages. A module implementing DRCV is located in the network layer. The monitoring sub-module acquires information such as the number of neighbors, channel busy time and the number of received periodic messages. The currently allowed rate is also sent to the Facilities layer that is reponsible for generating and adjusting the rate of periodic messages by means of cross-layer communications (Information Connector).

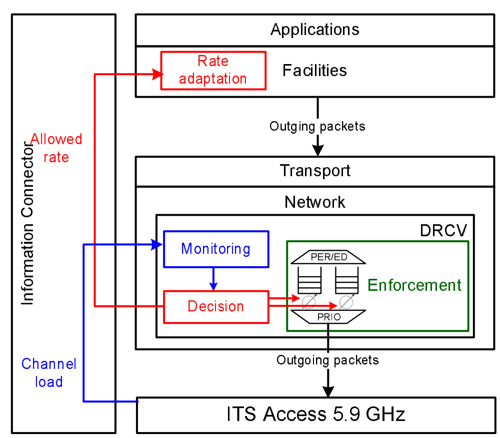

Figure 1: DRCV framework

3. DESCRIPTION OF DRCV

The DRCV algorithm consists of three parts: channel monitoring, future load estimation and action. Channel monitoring is performed periodically in a distributed way, i.e. each node locally monitors channel load continuously. At the end of each monitor interval, estimation of the load in the next monitor interval is made and based on it, action is taken by each node. In this paper we consider two types of metrics for channel load: the total Data Packet Rate (DPR) of periodic messages and the Channel Busy Time (CBT) observed by a node.

DRCV controls the sending rate in two steps: 1) Each node dynamically sets the aggregate target channel load of periodic messages generated by itself and all its neighbors. 2) Each node locally controls its sending rate of periodic messages in order to reach the aggregate target channel load set in the first step. In the **first step** DRCV actually partitions the channel capacity between ED and periodic messages. The maximum threshold for periodic messages is set to Th_{max}, and the minimum threshold is Th_{min} The actual target channel load th_{PER} is chosen between Th_{max} and Th_{min} by each node at the end of each monitoring interval. DRCV has two alternative strategies to select th_{PER}. In *DRCV Preventive*(DRCV-P), th_{PER} is statically set to Th_{min} in order to reserve all of the remaining channel capacity for ED messages. In *DRCV Fast Drop* (DRCV-FD), a novel policy is applied which dynamically adapts th_{PER} as illustrated in Figure 3. As soon as an ED message is received during a monitoring interval, DRCV-FD enters the Fast Drop phase, i.e. th_{PER} immediately drops from Th_{max} to Th_{min}. The threshold th_{PER} is kept until no ED messages are received during an entire monitoring interval. Afterward, th_{PER} is increased gradually in each monitoring interval until it reaches Th_{max}.

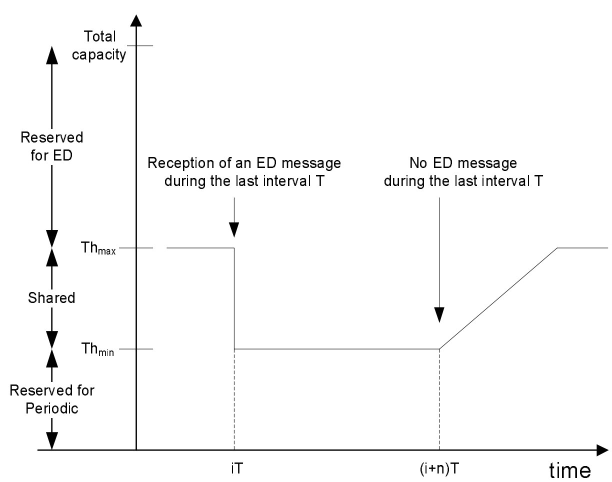

Figure 2: DRCV Fast Drop scheme

In the **second step** of DRCV, each node locally controls its sending rate of periodic messages in order to keep the aggregate load below th_{PER} based on the monitored channel load as well as the number of neighbors. When the value of th_{PER} varies slowly, DRCV changes its rate by only a single step at the end of every monitoring interval. During the Fast Drop phase, each node drops its local sending rate by half at the end of the monitor interval.

4. PERFORMANCE EVALUATION

The simulation tool used in our work is `ns-2.31`. The IEEE 802.11 MAC and PHY extensions `Mac802_11Ext` and `WirelessPhyExt` described in [2] were adopted. Simulations have been carried out and results show the effectiveness of DRCV in reducing the channel load and improving packet reception probabilities. To highlight the benefits of DRCV, we show here the results of a simulation scenario with two short bursts of ED messages, i.e. in each burst ED messages are sent at the frequency of 10Hz for 500ms. We observe that as soon as a burst starts, DRCV-FD immediately cuts the traffic load by half, and as soon as no ED message is detected, DRCV-FD linearly increases the load of periodic messages up to the predefined maximum threshold.

Table 1 shows the percentage of vehicles located within the Carrier-Sensing range of the source node that correctly receive an ED message during a burst. It can be observed that DRCV increases the reception probability by about 15% compared to the case without rate control. We can further notice that DRCV-FD offers approximately the same results as DRCV-P while having a better usage of available bandwidth.

	1^{st} ED burst	2^{nd} ED burst
No Rate Control	74.98%	75.34%
DRCV-P	88.92%	91.31%
DRCV-FD	88.56%	90.46%

Table 1: Reception probability

5. CONCLUSIONS

We propose an algorithm called DRCV. It controls the packet rate of periodic messages in two steps, which correspond to controlling the bandwidth sharing between periodic and ED packets as well as among differnt nodes. Especially, the Fast Drop approach is adopted to cope with unexpected ED messages. Simulations show that DRCV increases the message reception probabilities and provides efficient usage of bandwidth.

6. REFERENCES

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