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Cooperative channel assignment for VANETs based on multiagent reinforcement learning

Key words: Vehicular ad-hoc networks; Reinforcement learning; Dynamic channel assignment; Multichannel

Corresponding author: Kun-xian ZHENG
E-mail: zhengkunxian@buaa.edu.cn
ORCID: https://orcid.org/0000-0002-2887-9294

Motivation

- Dynamic channel assignment (DCA) plays a key role in extending vehicular ad-hoc network capacity and mitigating congestion. However, channel assignment under vehicular direct communication scenarios faces mutual influence of large-scale nodes, the lack of centralized coordination, unknown global state information, and other challenges.
- Although the existing reinforcement learning (RL) theory has achieved success in a variety of domains, its applicability has been previously focused on gaming or robotic control domains or other domains, where system features can be handcrafted. Few efforts have been made to explore the applicability of RL theory in promoting joint channel selection and medium access control (MAC) layer backoff for vehicle-to-vehicle (V2V) communication and networking.

Main idea

- To solve this problem, a multiagent RL based cooperative DCA (RL-CDCA) mechanism is proposed. Specifically, each vehicular node can successfully learn the proper strategies of channel selection and backoff adaptation from the real-time channel state information (CSI) using two cooperative RL models. In addition, neural networks are constructed as nonlinear Q-function approximators, which facilitates the mapping of the continuously sensed input to the mixed policy output. Nodes are driven to locally share and incorporate their individual rewards such that they can optimize their policies in a distributed collaborative manner.

Method

1. Scenario of multiple coexisting communication node pairs (CNPs) driven by multiagent RL-CDCA

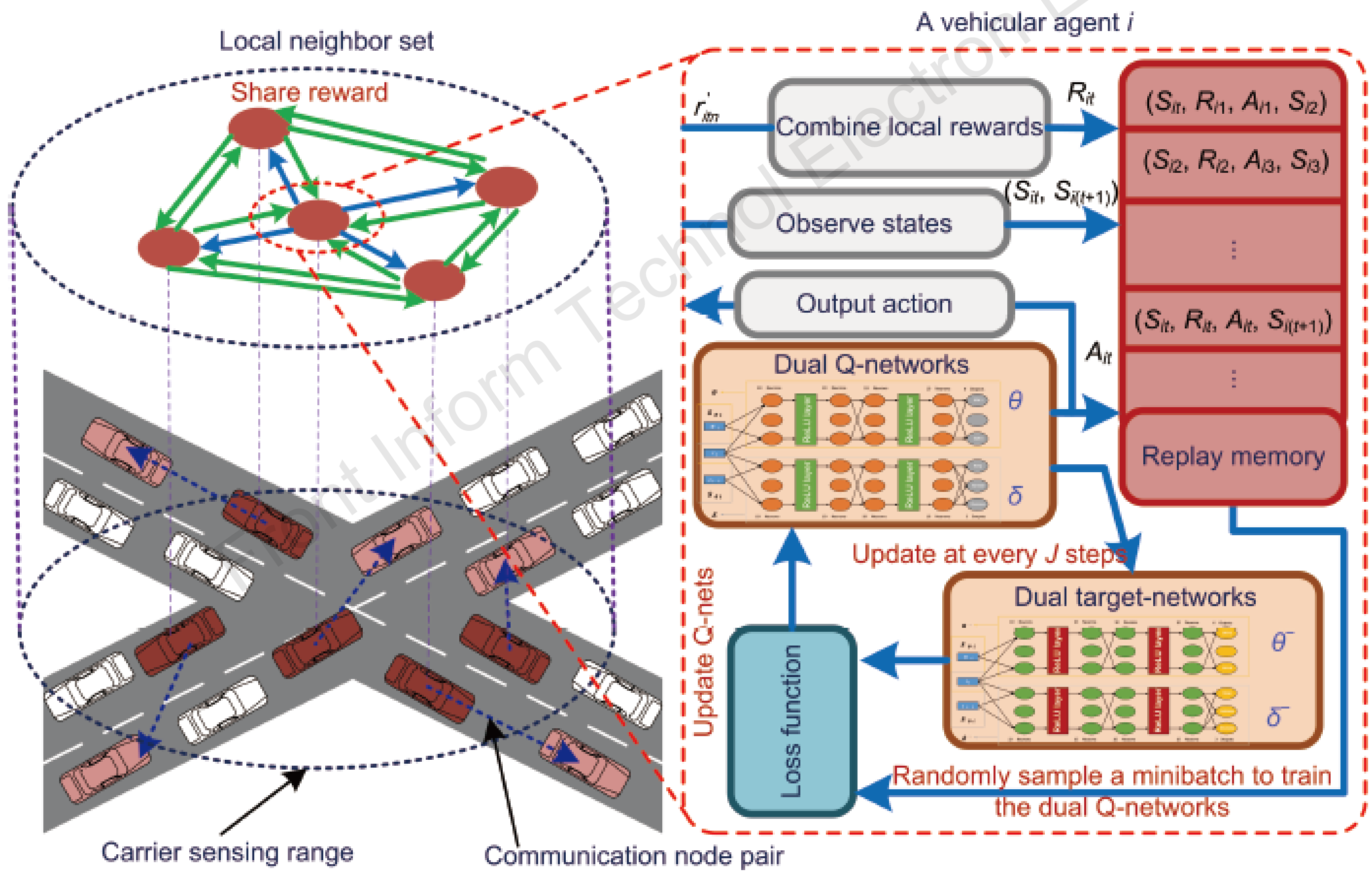

Fig. 2 Scenario of multiple coexisting communication node pairs (CNPs) driven by multiagent RL-CDCA

2. Simulation scenario

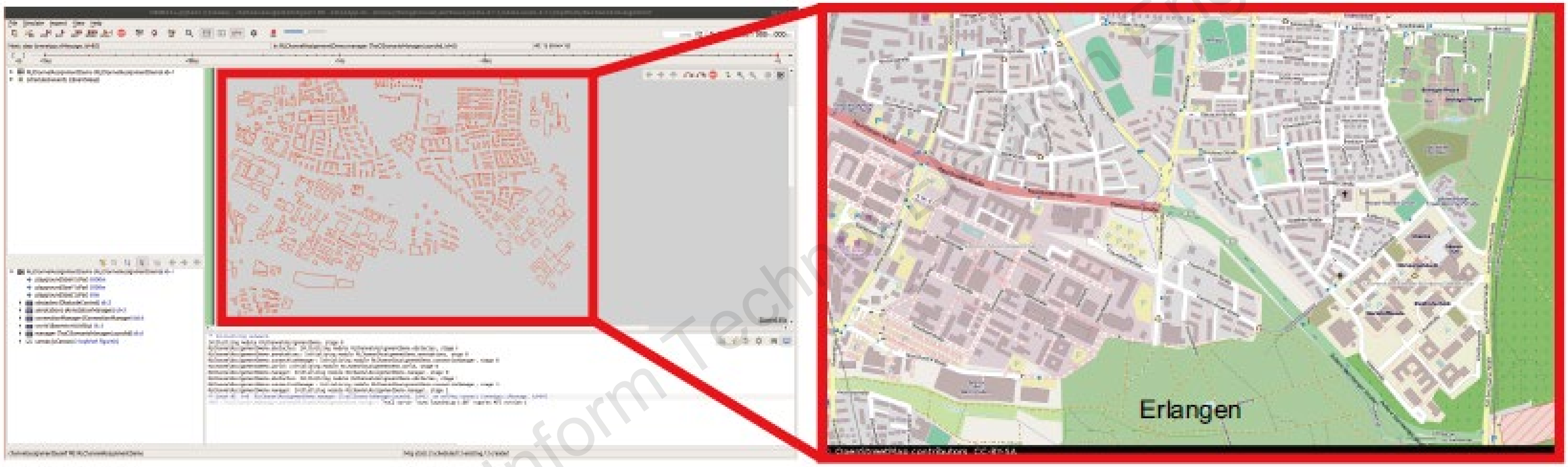

Fig. 3 Simulation scenario

Major results

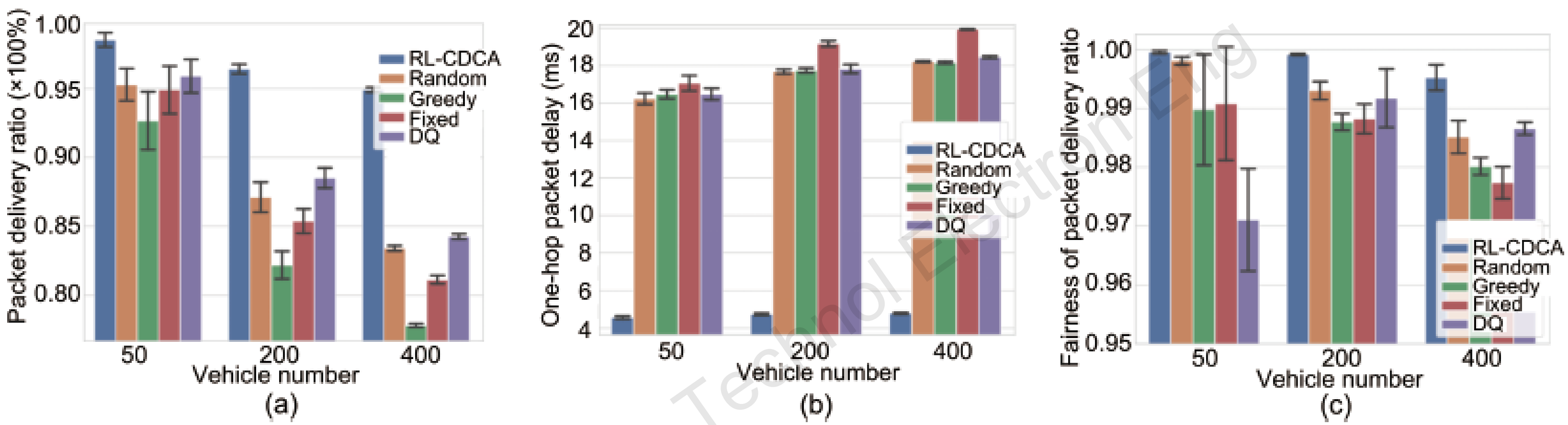

Fig. 6 Simulation results of different methods: (a) packet delivery ratio; (b) one-hop packet delay; (c) fairness of packet delivery ratio

Simulation results showed that the proposed multiagent RL-CDCA can better reduce the one-hop packet delay by no less than 73.73%, improve the packet delivery ratio by no less than 12.66% on average in a highly dense situation, and improve the fairness of global network resource allocation when compared with four existing mechanisms.

Major results (Cont'd)

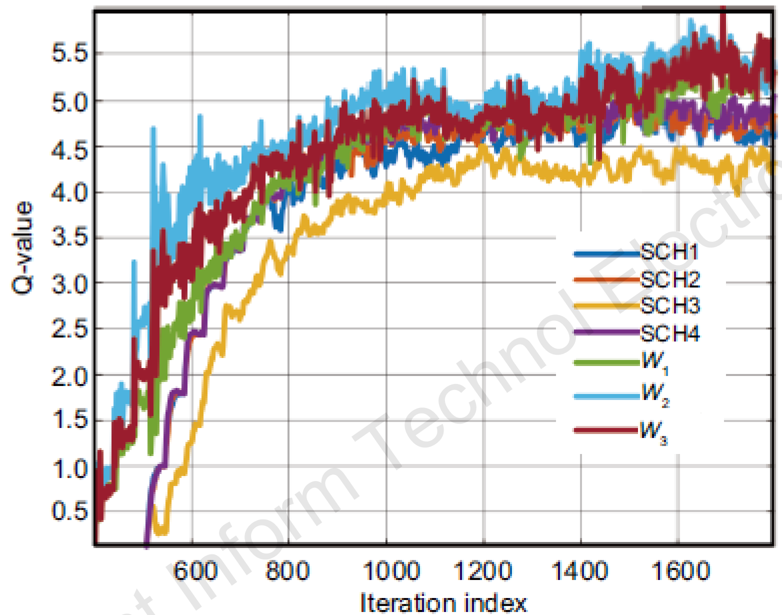

Fig. 5 Convergence performance of the multiagnet RL-CDCA

It can be seen that the Q-values of different actions converge to a steady state after about 1000 iterations.

Conclusions

- We have applied a dual RL framework to jointly optimize the decision-making behaviors of channel selection and backoff adaptation in DSRC-based vehicular communications.
- We have used the consensus reward to replace the global reward, which is difficult to achieve because of the short CCH interval. The consensus reward is the key to multiagent collaborative optimization in DSRC-based scenarios.
- Simulation results showed that the proposed method significantly outperforms four existing methods in terms of efficiency and fairness.
- The results in this study can be used to develop optimal channel access control and next node selection strategies for efficient and reliable multi-hop routing applications. Another research direction is to extend the multiagent channel assignment optimization paradigm to more complex cooperation situations, where multi-hop routing should be carefully modeled and integrated into the policy learning and decision-making processes.