Deep Reinforcement Learning for NR-V2X Mode 2

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***Abstract*—The third-generation partnership project (3GPP) introduced Mode 4 for distributed resource scheduling in C-V2X in its Rel. 14. Further amendments have been made by the 3GPP and Mode 2 is introduced alternative to Mode 4 in NR-V2X in its Rel .16. 3GPP proposed semi-persistent resource scheduling for distributed resource assignment in mode 4 and mode 2. Vehicles select the resources using semi-persistent scheduling based on their local observations. Resource contention occurs, since more than one vehicle may select simultaneously the same resource based on the local observation. To avoid resource contention, we proposed deep reinforcement learning-based resource scheduling in NR-V2X mode 2.**

***Index Terms*—C-V2X, NR-V2X, Semi-Persistent Scheduling (SPS), Cooperative Awareness Messages (CAMs)**

I. Introduction

Long Term Evolution Vehicle-to-Everything (LTE-V2X) communication is a key component of the next generation of automotive technologies. This technology allows connected and autonomous vehicles to receive information from their surroundings. 3GPP in Rel 16 and 17, continued to work on the standardization of V2X communications using the new radio, known as NR-V2X. Similar to C-V2X, this technology provides two transmission modes: Mode 1 and Mode 2. In Mode 1, the resources are allocated by the gNB, while in Mode 2, the vehicles utilize a semi-persistent scheduling algorithm to determine their resource reservation [1].

Vehicles scan the last 1000 subframes in order to select the resource for its packet transmission. While performing the scanning, vehicle discards the potential candidate resources that could be selected for the cooperative awareness message transmission (CAM) where the receive signal strength (RSSI) is greater than the threshold. Vehicles also discard those resources which are already reserved based on the resource reservation interval (RRI) and resource retransmission counter (RC).

II. Deep Reinforcement Learning-based Resource Selection

Machine learning has opened up a vast number of possibilities for developing new solutions in various domains. For instance, in vehicular communications, the ability to find the optimal solution has been greatly beneficial. We map the semi-persistent resource scheduling problem to reinforcement learning. For distributed resource assignment we consider the muti-agent. Each vehicle is modeled as an agent and observes it state. The State of the Vehicle is given in equation (1).

$$S_i(t) = \{RSSI_1, RSSI_2, \ldots, RSSI_R\} \tag{1}$$

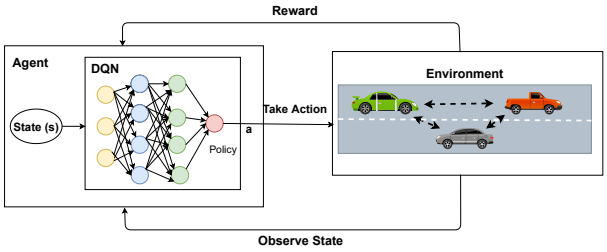

Fig. 1. Deep reinforcement learning based resource scheduling

Fig. 1 shows the deep reinforcement learning based resource scheduling. Each state of the agent concatenates to form the global state. We perform the centralized training and the distributed execution is performed by the vehicle. The action space set consists of resource blocks given in equation (2).

$$A = \{1, 2, 3, \ldots, R\} \tag{2}$$

Each vehicle selects one resource block from the action space for its transmission. The reward function is formalized to avoid resource contention. Therefore, the reward function consists of two parts: the first part emphasizes selecting the resources that ensure minimum interference and the second part considers the capacity of the neighboring vehicles as well. For centralized training, the state vector is collected by the roadside units via the PC-5 interface.

$$R = \sum_{j,i \in V} (C_i + C_{j,j \neq i}) \tag{3}$$

III. Conclusions

We proposed deep reinforcement learning for distributed resource scheduling in C-V2X and NR-V2X. In this paper, we model distributed resource scheduling into reinforcement learning-based problem-solving. Due to the explicit relation between reward and action, we expect the vehicles will select the resource which may avoid the resource contention.

References

[1] M. M. Saad, M. T. R. Khan, S. H. A. Shah, and D. Kim, "Advancements in vehicular communication technologies: C-v2x and nr-v2x comparison," *IEEE Communications Magazine*, vol. 59, no. 8, pp. 107–113, 2021.