

O-RAN enabled V2X Communications: Use Case and Research Trend

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Abstract—Vehicular communications integrated with the radio access network (RAN) are expected to play an important role in the evolution of 5G and future 6G cellular networks. However, existing RAN architectures lack the capability needed to support the strict performance requirements of vehicle-to-everything (V2X) services. In this context, Open RAN (O-RAN) has emerged as a promising solution, offering enhanced reliability and Quality of Service (QoS) support. Recent research has focused on leveraging the O-RAN Intelligent Controller (RIC) to optimize V2X performance. This paper investigates the V2X use case defined by the O-RAN Alliance and reviews research trends on O-RAN-enabled V2X communications.

Index Terms—O-RAN, V2X, architecture, research trends

I. INTRODUCTION

Vehicular communications integrated with the radio access network (RAN) are expected to play an important role in the evolution of 5G and future 6G cellular networks. However, existing RAN architectures lack the flexibility and capability needed to support the strict performance requirements of vehicle-to-everything (V2X) services [1].

Open RAN (O-RAN) architecture has emerged as a promising solution for enabling reliable Vehicle-to-Everything (V2X) communications. It also plays a crucial role in meeting strict Quality of Service (QoS) requirements [2]. Recent studies have increasingly focused on enhancing the performance of V2X communications by leveraging the intelligent control capabilities of O-RAN. This paper examines the V2X use case proposed by the O-RAN Alliance and recent research trends on O-RAN technology for V2X.

II. V2X USE CASE IN O-RAN

To address anomalous Handover (HO) sequences in V2X communications, the O-RAN Alliance defined a context-based dynamic HO management use case. This approach utilizes two complementary mechanisms: long-term analytics and real-time optimization.

The long-term analytics function is implemented in the Non-RT RIC. V2X mobility and HO event data collected by the V2X Application Server (AS) are delivered to the Non-RT RIC through the O1 interface. Hence, Non-RT RIC can identify causes of HO anomalies and discover optimal HO sequences. The analysis results are stored in a database to support subsequent decision-making.

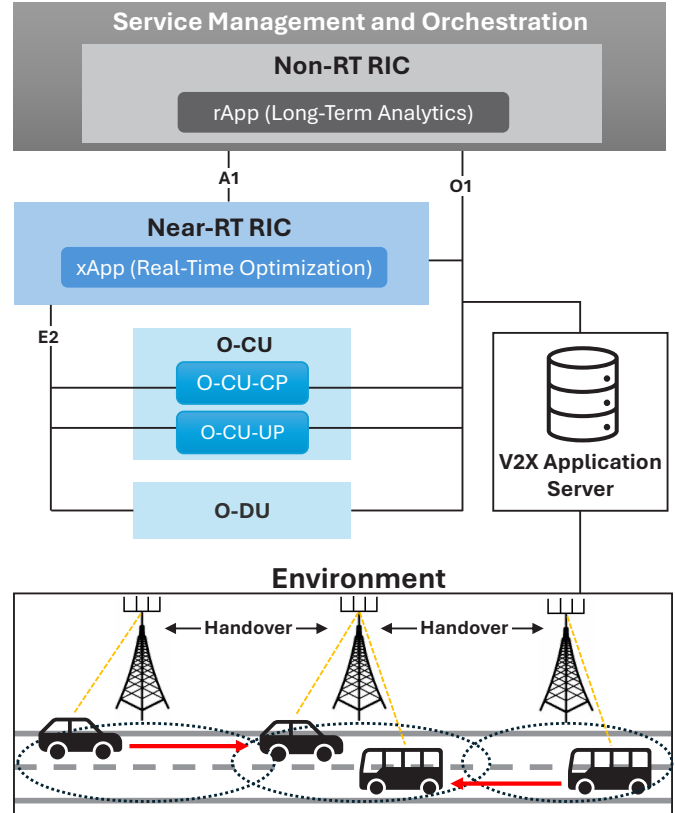


Fig. 1. Handover management by O-RAN components

The real-time optimization process is carried out at the Near-RT RIC. This process utilizes a pre-trained ML model that exploits real-time mobility context (e.g., position, speed, and direction) to predict abnormal HO events. Leveraging the predicted mobility context, the Near-RT RIC updates User-specific Neighbour Relation Tables (User-NRTs). This dynamic update improves the handover performance for V2X users.

The data utilized by both functions include Cooperative Awareness Messages (CAMs), navigation, geo data, and radio metrics such as Reference Signal Receive Power (RSRP), Reference Signal Receive Quality (RSRQ).

III. RESEARCH TRENDS

In [1], the authors proposed mobi-O-RAN to solve the problems of mmWave beam selection, dynamic radio resource management, and V2V connectivity optimization. Beam management reduced system overhead by up to 50% through probability-based beam selection leveraging vehicle location and environmental data. Network slicing and resource optimization achieved a twofold increase in throughput and reduced the collision rate compared to 3GPP Mode 2. In the V2X connectivity improvement problem, the xApp-based multi-hop relay approach maintained entire vehicle connectivity even under stringent SNR constraints.

The authors in [3] proposed a traffic steering and resource management framework for V2X. This approach leverages O-RAN's policy control and RIC-enabled intelligence to address the challenges of high mobility and diverse service requirements. Short-term user equipment-base station (UE-BS) connection optimization and long-term policy-based traffic management are achieved through a two-layer architecture. This structure integrates a Traffic Steering xApp (TS-xApp) deployed in the Near-RT RIC with a Traffic Management rApp (TM-rApp) operating in the Non-RT RIC. The proposed structure utilizes O-RAN's Enrichment Information (EI) to perform contextual adaptive control. The authors show that this method reduces HO in various V2X scenarios and maintains service quality.

The authors in [2] proposed O-RAN enabled V2X architecture to address the connectivity, delay, and control requirements. It enables reliable selection of mmWave relay nodes through data exchange in the sub-6 GHz band, which supports high reliability and low delay communication. Authors developed V2X simulation framework by extending the NS-3 simulator and validated through an xApp-driven relay selection scenario. Experiments show that the proposed method maintains low delay and overhead, and achieves up to 60% reliability improvement compared to the decentralized method.

In [4], the authors proposed FOM-5G to address the cell overload problem that arises in the vehicle communication environment. FOM-5G integrates Mobility Load Balancing (MLB) at the network layer and V2X Application Congestion Control (ACC) at the application layer to address vehicle congestion. It selects the most effective response method based on historical congestion pattern data. Authors show that, using actual vehicle movement data from Cologne, Germany, the proposed model effectively alleviates cell overload in both urban and suburban environments. Furthermore, it improves V2X Quality of Experience (QoE), enabling high vehicle safety and efficient wireless resource management.

The authors in [5] proposed a multi-service resource allocation strategy to satisfy various QoS requirements of V2X services. The overall problem is decomposed into two sub-problems: inter-slice resource allocation and intra-slice resource scheduling. To solve the inter-slice resource allocation problem, a heuristic algorithm was employed. Authors

designed Real-Time Service Scheduling (RTSS) and Non-Real Time Service Scheduling (NRTSS) to address intra-slice resource scheduling problem. Experiments show that the proposed method improves the Age of Information (AoI) of the proportional fairness (PF) service by 15% and the transmission rate of the NRT service by 7.39%, compared to the modified largest weighted delay first (M-LWDF) algorithm.

The authors in [6] proposed an O-RAN-based dynamic RAN slicing optimization framework to satisfy the QoS requirements of V2X services. Customized functional segmentation (FS) is selected for each slice and packet duplication (PD) techniques are used to improve the reliability of communication. The optimization problem was modeled as a Mixed Integer Programming (MIP) problem. Benders decomposition was applied to accelerate solution performance while ensuring global optimality. Simulation results show that the proposed method achieves demand throughput up to 42% higher than the existing technique, while involving only a 6% increase in spectral resources.

IV. CONCLUSION

This paper reviewed the communication types of V2X and recent research trends in O-RAN-based V2X communication optimization. Recent studies focus on beam management, dynamic resource allocation, and slicing optimization techniques to enhance network performance. These techniques help ensure service quality by improving throughput and reducing latency. Future work will focus on enhancing interpretability by applying eXplainable AI (XAI) to O-RAN enabled V2X communication.

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