

# Evolution in 5G NR V2X Technology – A Detailed Look at Enhancements in 3GPP Releases 17 and 18

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## Abstract

The evolution of Vehicle-to-Everything (V2X) communication within the 3rd Generation Partnership Project (3GPP) framework has progressed from Long Term Evolution Vehicle-to-Everything (LTE-V2X) to Fifth Generation New Radio Vehicle-to-Everything (5G NR-V2X), aiming to support advanced V2X applications. Releases 17 and 18 improve 5G NR-V2X with multicast Uu transmission for better resource use and advanced V2X application like map updates and High Definition (HD) video downloads. They also integrate Artificial Intelligence and Machine Learning (AI/ML) for enhanced performance and efficiency, using dynamic resource selection and power consumption reduction strategies. These enhancements signify a transition towards more advanced and efficient V2X systems capable of supporting diverse cooperative automated driving applications.

**Keywords**– 5G NR-V2X, 5G Advanced, V2X communication, 3GPP Release 17, 3GPP Release 18.

## I. Introduction

The advancement from LTE-V2X to 5G NR-V2X within the 3GPP framework marks a crucial evolution for cooperative automated driving [1]. LTE-V2X set the stage in Releases 14 and 15, while 5G introduced NR-V2X in Release 16, supporting advanced V2X applications. Ongoing improvements in Releases 17 and 18 aim to enhance 5G NR-V2X capabilities, signaling a shift toward more sophisticated and efficient V2X systems for diverse cooperative automated driving applications.

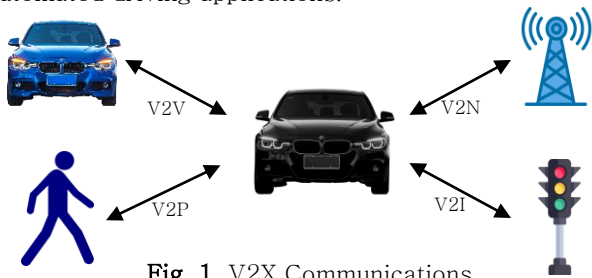


Fig. 1. V2X Communications.

LTE-V2X began with Release 14, initially linked to 4G LTE. Later, from Release 15 onward, it transitioned to 5G-V2X within the 5G framework [2]. Release 15 established use cases and requirements, while Release 16, concluded in June 2020, outlined the first NR V2X specifications, including sidelink. Ongoing enhancements to sidelink 5G NR-V2X are anticipated in Release 17 by 2022.

The 3GPP is now focused on Release 18 for 5G-Advanced, with deployments expected by 2025 [3]. This will support advanced applications like metaverse, XR, virtual reality, and augmented reality, meeting demanding Ultra Reliable Low Latency Communication (URLLC) standards. 5G-Advanced will use AI to improve network intelligence and adaptability. The evolution of 5G NR enhances support for new verticals and use cases, including Reduced-Capability UE, Multicast Broadcast Services (MBS), extended frequency bands, and Non-Terrestrial Networks. Also,

5G-Advanced ensures full backward compatibility with prior 3GPP releases for smooth system interaction.

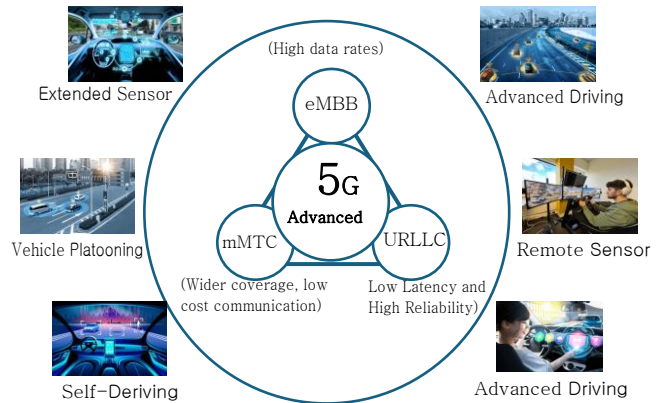


Fig. 2. 5G-Advanced V2X Evolution.

## II. 3GPP Releases 17 & 18 Ongoing Challenges in the Context of V2X

### A. Improving Vehicular Communication through Sidelink Relay Evolution

In 3GPP Release 17, improvements in sidelink communication are introduced, focusing on relay capabilities to extend coverage in areas with weak Uu signals and enabling UE-to-UE relaying for enhanced V2V communication. Release 17 addresses challenges like message broadcast flood to increase reliability and enhance message transmission efficiency. Meanwhile, Release 18 shifts its focus towards multi-hop Vehicle User Equipment (V-UE) relay to further enhance coverage expansion. Efforts concentrate on V-UE relay discovery and selection for smooth multi-hop communication, aiming for seamless service during transitions between V-UE and network relaying, utilizing PC-5 and Uu interfaces for both relay types.

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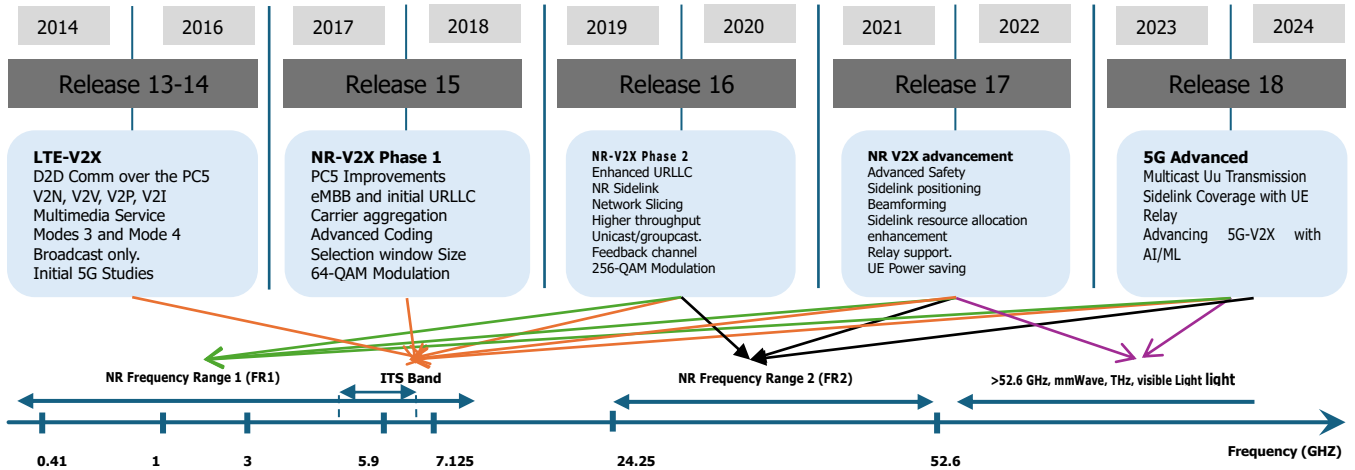


Fig. 3. Standardization Evolution: From LTE-V2X to 5G Advanced NR-V2X within 3GPP.

### B. Multicast Uu Transmission Support

Release 18 improves V2X applications with multicast Uu transmission, benefiting map updates and HD video downloads. Future research may explore group resource scheduling and dynamic switching for seamless service. Release 17 focuses on Uu multicast, crucial for advanced eV2X applications like sensor monitoring and HD map updates, ensuring efficient content delivery. Multicast Broadcast Services enhance user experience by tailoring information dissemination to diverse needs like group scheduling and mobility support.

### C. Enhancement of Mode 2 for Power Consumption Reduction

In Release 17 enhances NR sidelink mode 2 to reduce power consumption in V2X communication for UE devices like pedestrians' and cyclists' devices [4]. The new version includes partial sensing and random resource selection to save energy. However, additional research is needed to compare its performance with the traditional mode, offering a potential direction for future investigation.

### D. Enhancing 5G NR-V2X Communication with AI/ML Integration

AI/ML is revolutionizing the next generation of NR technology, extending beyond 5G-Advanced LTE. Through radio virtualization, virtual radios (VRs) are created with customizable physical layer parameters, dynamically adapting to diverse requirements. AI enables seamless creation and switching between VRs in real-time, optimizing performance by adjusting bandwidth allocation as needed. Moreover, in V2X Mode 2, AI-driven dynamic resource allocation, as introduced in 3GPP Releases 16 and 17, ensures efficient aperiodic message transmission through real-time adjustment of the sensing window size, thus improving resource utilization.

## III. Conclusions

This paper summarizes the enhancements implemented in 3GPP Release 17 and presents an outlook for 3GPP Release 18. Integrating AI/ML, supporting multicast Uu transmission, and enhancing sidelink relay and power efficiency showcase the commitment to advanced V2X systems. Future

research might explore group-based resource scheduling and dynamic switching between unicast and multicast delivery for better service. Releases 17 and 18 focus on improving sidelink communications, resource allocation, and UE relaying to tackle power consumption, coverage, and positioning issues, supporting various demands in V2X communication.

### Acknowledgment

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