Research Project

Advances on Cellular vehicle-to-everything (C-V2X) technology: A survey

Description

Vehicle-to-everything (V2X) technology makes the land transportation of tomorrow more efficient, sustainable, and safer. Cellular vehicle-to-everything (C-V2X) technology provides responses to these three big issues of modern transportation; C-V2X can help reduce traffic casualties, improve traffic efficiency, and increase productivity/comfort while driving or being transported. Besides this, it will set the ground for expediting the introduction of levels 4 and 5 of automated driving systems.

The key requirements for V2X services as follows:

1. **Payload:** the amount of data required by a specific service and generated by the application.

2. **Tx rate**: the number of messages per unit time that the transmitter generates and the receiver is expected to receive subject to other relevant requirements (e.g., payload size, latency, communication range, etc.)

3. **Maximum end-to-end latency**: the maximum allowed time between the generation of a message at the transmitter's application and the reception of the message at the receiver's application.

4. **Reliability**: the probability that a transmitted message is correctly received within a specified maximum end-to-end latency subject to other relevant requirements

5. **Data Rate**: the total amount of data that needs to be received by the receiver per unit time.

6. **Required communication range**: the minimum distance between a transmitter and its intended receiver allowing communication with a targeted payload size, maximum latency, reliability, and data rate.

Recently several projects have been established for benchmarking the connected driving messages and networks. The automotive industry is keen on the availability of networks and the interoperability of the communication equipment needed in this globalizing business. Interoperability of the connected and automated driving functions is necessary for the global success of this technology.

The student's work isn't limited, but should at least address the following items:
- Analysis of the capabilities provided by C-V2X in intelligent transportation and automated driving applications
- Study and analysis of envisioned application phases of C-V2X.
- Prospects for C-V2X technologies

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- Technical advances and limitations at present
- Available standards and the interoperability issues focusing on IEEE 802.11 bd, and 3GPP (NR V2X) for Rel. 16 and beyond
- Survey study on the research trends and available solutions
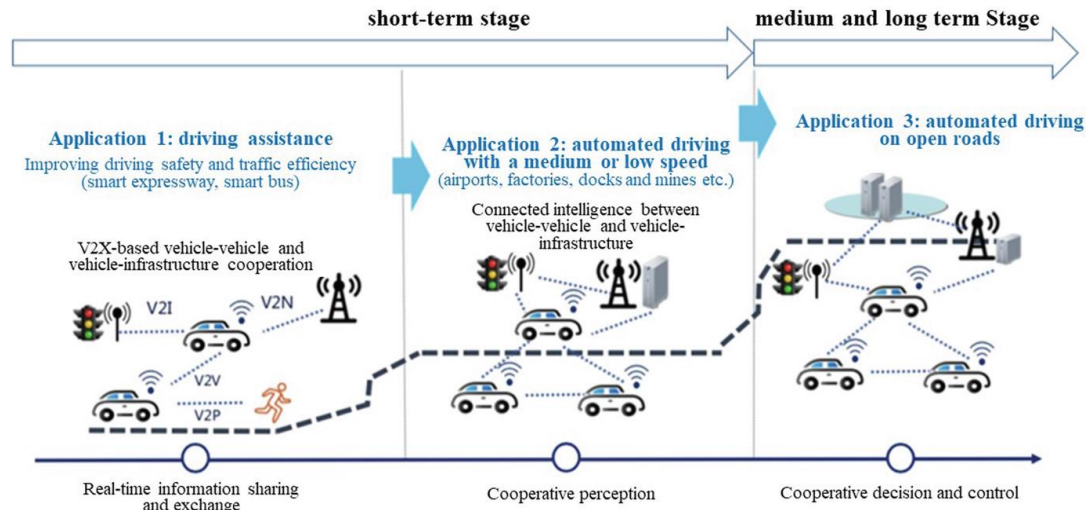- Suggestions for future research including the outlook on 5G NR V2X

Figure 1 The expected industrial application types of C-V2X [1]

Recommended experience

- Basic concept on communications, antennas and propagation, and transceivers
- Basic understanding on frequency spectrum, bands allocation and applications
- Understanding of wireless and cellular communications and standards
- Wireless communication Generations 3G,4G,5G and beyond
- Basic concept on V2X communications
- Basic concept on cooperative communications and data fusion

Literature

[1] Chen, S. et al. (2023). Prospects for C-V2X Applications and Technology Evolution. In: *Cellular Vehicle-to-Everything (C-V2X).* Wireless Networks. Springer, Singapore. https://doi.org/10.1007/978-981-19-5130-5_10

[2] M. Kutila, P. Pyykonen, Q. Huang, W. Deng, W. Lei and E. Pollakis, "C-V2X Supported Automated Driving," *2019 IEEE International Conference on Communications Workshops (ICC Workshops)*, Shanghai, China, 2019, pp. 1-5, doi: 10.1109/ICCW.2019.8756871.

[3] L. Hobert, A. Festag, I. Llatser, L. Altomare, F. Visintainer and A. Kovacs, "Enhancements of V2X communication in support of cooperative autonomous driving," in *IEEE Communications Magazine*, vol. 53, no. 12, pp. 64-70, Dec. 2015, doi: 10.1109/MCOM.2015.7355568.

[4] M. H. C. Garcia *et al*., "A Tutorial on 5G NR V2X Communications," in *IEEE Communications Surveys & Tutorials*, vol. 23, no. 3, pp. 1972-2026, thirdquarter 2021, doi: 10.1109/COMST.2021.3057017.

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