www.pipelinepub.com
Volume 21, Issue 4

How V2X Could Complement Autonomous Driving

By: Holger Rosier

Vehicle to Everything (V2X) communications gives car passengers, advanced driver assistance systems (ADAS), and autonomous driving (AD) systems access to third-party and OEM digital services and applications. V2X devices act as an interface to the digital world, offering the ability to provide software and firmware updates over the air, provide real-time traffic information, deliver on-demand infotainment and entertainment content, and enable many other applications.

In principle, a vehicle can use its sensors to drive automated without a radio link to external systems. However, vehicle-to-vehicle (V2V) communication and access to external data sources via dedicated infrastructure (V2I) such as Road Side Units (RSUs) or cellular networks (V2N) will improve comfort and safety even further. Several automated driving functions require accurate position information. For always having highly accurate position data, GNSS position correction data are transmitted over cellular networks to the ADAS/AD system, including the lane-level navigation in urban environments with complex road layouts. Data transmitted via V2X communications is also considered as additional sensor information and enhances automated driving, making it smoother and more comfortable. For instance, the ADAS/AD is supported by knowing the latest information about road geometry. It has information about the traffic situation in real time and can consider temporary road closures and changes due to road work and other incidents.

Challenges in Implementing New Digital Services

The industry faces several challenges in implementing new digital services. First is the challenge of data availability and interfaces. Providing traffic-related data should not stop at the boundaries of a single car manufacturer, especially for safety-related information. In addition, the interface used to exchange data must be known and recognised by the industry.

The second challenge is trust. How do the driver and ADAS/AD function know that the data provided is from a trusted source and is not corrupted? How, for example, can private and public road operators and transportation agencies ensure that the information provided by a RSU about the status of traffic lights at an intersection is correct once installed? This can range from on-off testing and possibly certification in the R&D process to field testing at regular intervals.

Conformance and interoperability are also challenging when implementing new digital services. V2X radios must be proven to comply with relevant industry standards and regulatory requirements. Only tested interoperability ensures that V2X devices from different road users can transmit, exchange, and understand data, messages, and information.

A consensus among all stakeholders is also necessary and often challenging. Cellular networks and their communication services are common today. However, the direct V2X communications between road users is a special facet of cellular architectures that goes beyond the network-centric approach. This promises to make the system more robust to potential failures of the cellular systems, and thus generally independent of any cellular network operator. This technology requires an industry agreement to implement and operate direct communications for vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) communications.

Differences Between V2X Based on WLAN Technology or Based on Cellular Technology

LAN and cellular communication technologies are not interoperable at the radio level. WLAN is aimed at shorter-range communications in the unlicensed spectrum, initially developed for consumer electronic applications. Cellular technology originally focussed on radio access for long-range communications in the licensed spectrum. Both technologies are making steady technological progress to support new and emerging applications, often combined with demands for throughput improvements and support for lower transmission latency. Both radio systems will continue to serve their market niches. For example, WLAN solutions will continue to be used in industry, homes and offices for short-range communication in the unlicensed spectrum. This enables an easy way of data exchange without expensive installations. Mobile radio systems, on the other hand, can provide communication services over a wide area, including mobile access to the internet.

The cellular system is the technology of choice for providing voice and data services over wide area, considering mobile scenarios. The centralized controlled access to the radio system operated by base stations with cell planning allows improved interference management and admission control. This makes the system well suited to operating different applications with different quality of service (QoS) requirements in terms of throughput, latency and reliability. In addition, there is a well-established and mature ecosystem around the cellular system, offering a wide range of services and applications from consumer to enterprise, even with private network installations.

Cellular technology has supported direct short-range communications for several years, providing an alternative technology to WLAN for V2X communications. Car manufacturers are deploying cellular direct communication devices in China. The U.S.

FCC recently signed a new rule to permit cellular V2X direct communications in the license-exempt frequency spectrum at 5.9GHz. Korea has decided for cellular technology for V2X communications too.

Currently, the two large automotive markets, the U.S. and China, have opted for cellular V2X technology. In Europe and some other regions, frequency regulation allows both WLAN and cellular technologies to operate in the 5.9GHz frequency for direct communication.

Which V2X Applications Benefit from 5G Connectivity

If V2X solutions support 5G technology, they will not only benefit from higher data throughput, but also from higher transmission reliability. This would, for instance, enable constantly updated and detailed traffic information can be given to ADAS/AD systems. Further, high-resolution navigation maps can be upgraded recurrently, a process which requires communications service with higher data throughput. Functions such as remote-controlled driving or automated parking, which are available already today, are additional use cases that benefit from 5G connectivity services, mainly from improved transmission reliability. However, providing nationwide 5G connectivity with higher performance even to consumers in rural areas is a challenging task from an economic perspective.

Future 6G technology may enable the transmission of high-resolution sensor data combined with data communications. Sensor and communications applications will further benefit in the future from the newly allocated frequency spectrum for 6G services. Data transmission will be improved by integrated sensor applications, while radar operations can benefit from the coordination of interference.

How to Implement a Zero-Trust Approach in V2X Communications

Besides communication technique, cyber security is always an important issue when there are interfaces to external data sources. For instance, no malicious physical radio signal should lead to signal interference or decrease signal decoding performance. These signals could prevent V2X communications from normal operation. Exposure of false traffic information may decrease transport system efficiency and may lead vehicles and drivers to make false conclusions. V2X devices operated in vehicles, for example, might intentionally be turned into a different system so that they look like another device, maybe a RSU, to allow a device to transmit information under false identity.

Carmakers and suppliers are requested to define countermeasures to identify false information and false identity. V2X devices detected as compromised must be excluded from any further operation. That means, V2X communications needs a zero-trust approach by design. Countermeasures against misuse of V2X communications and exposure to false traffic information is considered by the automotive industry as part of the development process of ADAS/AD and automotive functions. Basically, no one-time information will per se be trusted that is received over a single interface.

Digital certificates are commonly used in Intelligent Transport Systems (ITS) to increase the level of trust. Each V2X message must be signed to ensure data integrity and to limit operation of potentially compromised V2X system to a shorter time. Certificates must be changed and renewed regularly. Renewal is only granted to V2X stations which are not blacklisted, marked as compromised, or have been changed in the meantime without any official approval. Operation of certificate enrollment, message signing, and discarding of messages which have an invalid signature, are examples of usually tested functions in lab test setups. Furthermore, system response in terms of overloaded conditions is usually assessed as part of the development process to avoid successful denial of service attacks. Established connections and data exchanges made by V2X devices are monitored and analyzed to preclude data and information misuse by untrusted parties. This is done in the lab as well as in the field under normal operation with the aid of mobile network test equipment.

Privacy was considered in the development of ITS from the very beginning. Automotive services which exploit direct V2X communications for V2V, V2I, and V2P communications make use of “pseudonymity.” Labels like communication addresses, which allow identification and tracking of users, are changed regularly to avoid any persistent identifiers. Hence, longer term vehicle tracking by listening to transmitted messages becomes difficult, at least over the V2X direct communications.

How Can V2X Systems Be Updated Throughout Their Entire Life Cycle

One last point is the long lifespan of vehicles and V2X systems accordingly. In average, the lifespan of vehicles is over ten years. This is significantly longer than the lifespan of a smartphone and presents another challenge for the associated hardware and software. During this time span, there will come up several generations of mobile technology on the market.

Staying within the same technology generation is usually not a big effort, as the versions are backwards compatible. But upgrading to a new technology, such as from 4G to 5G and to the future 6G, requires additional adjustments to remain compatible. Integrating all technology generations is a straightforward approach that is also used in smartphones. However, there must be a migration path for this.