Testing Car2x Applications

Requirements for Test Tools Based on Example of the Road Works Warning

Carmakers plan to introduce Car2x communication in production vehicles starting in 2015. Car2x application development, which has already begun, poses new challenges in the execution of component and application tests. This article derives related requirements for test tools based on the example of the Car2x "Road Works Warning" application.

Intelligent and safe – that is how the German Transportation Minister described the expressways of the future in mid-June of this year. These objectives are to be achieved by introducing intelligent transport systems and services (C-ITS, "Cooperative Intelligent Transport Systems") that are based on Car2x communication. What is meant here is communication between vehicles and the infrastructure with the aims of improved safety on roads and early avoidance of traffic jams. As a first step, warning trailers will be equipped with the necessary Car2x technology for radio transmission of road works information to vehicles.

The scenario of the Road Works Warning is one of the Car2x applications already defined by the European Telecommunications Standards Institute (ETSI) [1], and plans call for technically implementing it starting in 2015. Here, the warning trailer sends its information in real time to vehicles within WLAN radio range per the WLAN standard IEEE802.11p (ITS-G5) **(Figure 1)**. A 5.9 GHz frequency band is available, which was specifically reserved for ITS-G5 usage. The GeoNetworking protocol specified by ETSI [2] is responsible for packet routing in ad-hoc networks; the information about the highway construction zone is contained in standardized application messages [3].

They include the "Decentralized Environmental Notification Message" (DENM), which contains all necessary information about an event (road works warning, end of traffic jam warning, etc.) and is only sent at the onset of the relevant event. Here, the ITS station transmits general information about event status and position and about the applicable duration and zone. For the Car2x "Road Works Warning" application, the warning trailer also sends information on the speed limit and lane closures, which are dynamically modified as a function of construction zone status and topology.

The ITS stations use the "Cooperative Awareness Message" (CAM) to periodically transmit their own status information such as position and driving direction, speed and acceleration information as well as status information about the vehicle lighting of the ITS station. Since all ITS stations send this information, the information lets the warning trailer perform such tasks as calculating the traffic density at the construction zone so that it can modify the

speed limit in the construction zone accordingly or route traffic jam information to the central traffic control office.

Onboard Functionality of the Construction Zone Application

When a vehicle receives a construction zone specific DENM, it checks the message for relevance. It requires information such as the position, speed and driving direction of the vehicle to do this. Ideally, map data that describe the vehicle's environment more precisely will also be available. This information is typically supplied via the in-vehicle bus systems such as CAN and Ethernet.

In checking for relevance, information such as the time stamp lets the vehicle determine whether the received message is still valid. The location of the construction zone and of the vehicle is used to determine whether the construction zone is located along the driving route. If the message is relevant to the vehicle, the data is forwarded to the actual construction zone application. It ensures, for example, that other applications such as driver assistance systems or HMIs are supplied with necessary data when the vehicle enters the defined construction zone.

Increasing Efficiency with Test Tools?

To comprehensively test a construction zone application in the vehicle, application-relevant data for all necessary test scenarios must be provided to the application, and these scenarios must precisely match those of real driving situations. By using test tools, testers do not have to perform complex tests in the real environment. In early test phases, it is often impossible to conduct real tests, because not all components are available.

During development and test phases, it is even sufficient to simply provide the application developer with suitable data from just the communication perspective for testing. This involves creating a simulated environment for the ECU under test in test tools. This ECU can be put in all of the states to be tested using simulated functions and components.

This means that a "simulated road works warning trailer" is needed to test the construction zone application in the vehicle. It can be configured for each individual test so that different scenarios of lane closures and speed limits are possible, for example, and can serve as the foundation for tests. In parallel, the construction zone application is stimulated with data on a vehicle's geographic position, direction vector and speed for each individual test case. The test tool also simulates the motion profiles of the vehicle and generates the related CAN frames for stimulation. Afterwards, it provides this data to the construction zone application via the ECU's CAN bus interface **(Figure 2)**.

Test Tool Requirements for Car2x Applications

For a tool to be used effectively in testing Car2x applications, it must fulfill a number of requirements. The test tool must be able to send and receive WLAN data packets conformant to the

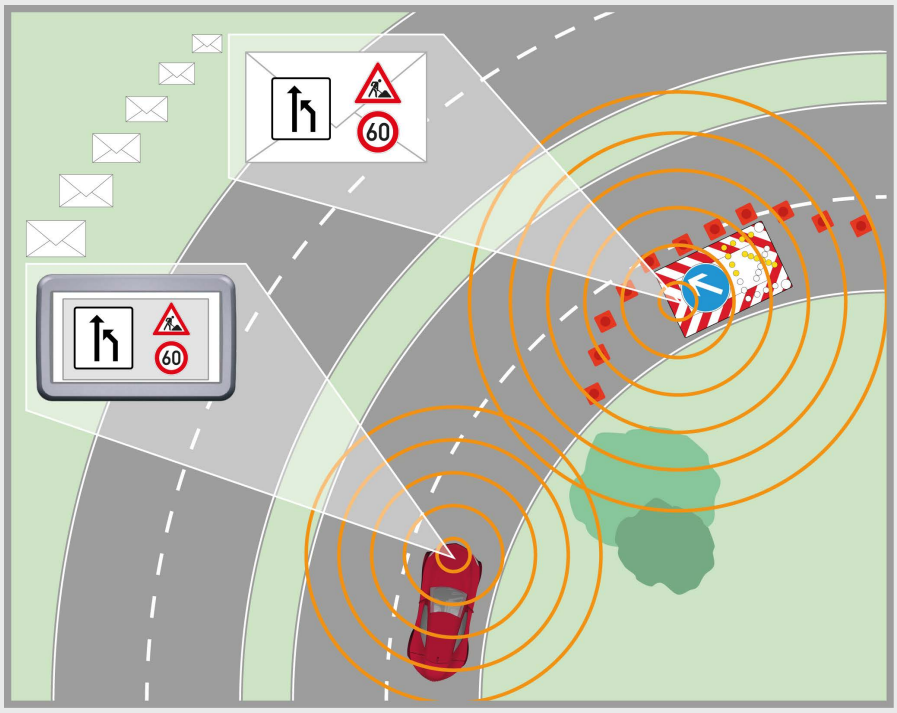

Figure 1:
Simplified representation of communication in a construction zone scenario.

IEEE802.11p (ITS-G5) standard over the WLAN channels defined for this purpose. This includes the test tool's ability to interpret protocol-specific information such as GeoNetworking. It must be possible to access signals and data fields of the application messages, which are described in ASN.1 (Abstract Syntax Notation.1) and are coded by the PER method (Packed Encoding Rules). A description of this information in a database that the test tool can read offers maximum flexibility here and simplifies the process of modifying data if changes are necessary. The database description serves here as the foundation for test generation. Using a database approach for creating and executing tests has already proven itself in established automotive networks.

In order to use an environmental simulation for stimulation purposes during the test, a programming tool is needed to create simulated nodes. Ideally, the tool would offer a Car2x-specific function library, which makes it possible to create and send application messages, set and read their signals and data fields, and execute PER coding of data before sending. Functions for generating UTC time stamps, which are frequently needed in the Car2x environment are helpful too. This makes it possible to configure valid construction zone specific DENMs for each individual test case.

An integrated test environment simplifies test execution. The tests are created with the help of editors and Car2x-specific function libraries and can simply be duplicated and modified for other test scenarios. Test flow control then handles execution of the selected tests and documentation of the results in a test report.

Since a lot of geographical positions are processed in the Car2x environment, it is extremely helpful to visualize them on a map. Information from the DENM is also intrepreted and displayed on this map **(Figure 3)**. At a glance this makes it easy to see exactly where the construction zone and vehicle are located, whether the relevance zones and waypoints are coded correctly, and what information is transmitted in the message regarding lane closures.

The construction zone application, or the ECU, obtains this information via internal vehicle networks such as CAN and Ethernet and externally via ITS-G5. Therefore, the test tool must support this process as well as offer multibus capability.

Summary

Car2x technology is not only being studied in the research departments of OEMs, but also by production development departments are now exploring how this technology might offer added value and how it might be used to better support driver assistance systems. The quality of these new functions must be assured by suitable test tools.

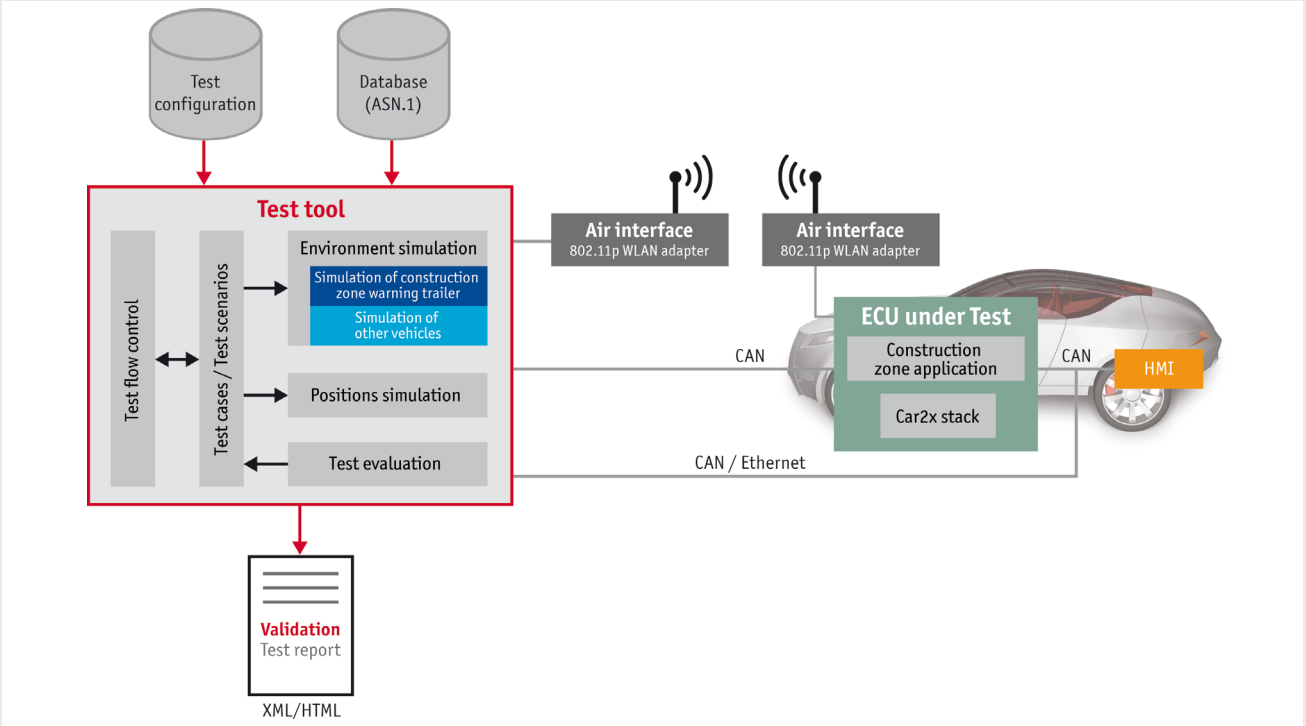

Figure 2: Schematic layout of a Car2x test scenario: The construction zone warning application is stimulated by the test tool to test functionality in various scenarios.

At this point, Vector supports the introduction of this technology in production vehicles with its CANoe.Car2x development and test tool. Along with tests for automotive networks such as CAN, FlexRay and Ethernet, tests can also be developed for the Car2x environment. They assist in developing and integrating Car2x technology in vehicles and in the infrastructure. With the signing of the Memorandum of Understanding initiated by the CAR 2 CAR Communication Consortium [4] Vector is assuring its customers that future test tool requirements will be implemented as well.

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Literature references:

[1] ETSI TR 102 638 V1.1.1 (2009-06)
[2] ETSI EN 302 636-1 V1.1.0 (2010-03)
[3] ETSI TS 102 637-2 V1.2.1 (2011-03), ETSI TS 102 637-3 V1.1.1 (2010-09)
[4] Memorandum of Understanding, CAR 2 CAR Communication Consortium, Version 4.01.02 (2011-06-27)

Links:

Vector solutions for Car2x: www.vector.com/vi_car2x_solutions_en.html
Product information CANoe.Car2x: www.vector.com/vi_canoe_car2x_en.html

Thomas Löffler
(Graduate Engineer) is group leader and product manager for the ITS/Car2x area at Vector Informatik GmbH.

Cathleen Kunze
(Graduate Engineer) works as a technical writer for Car2x at Vector Informatik GmbH.

>> Contact information of the Vector Group:
www.vector.com/contact

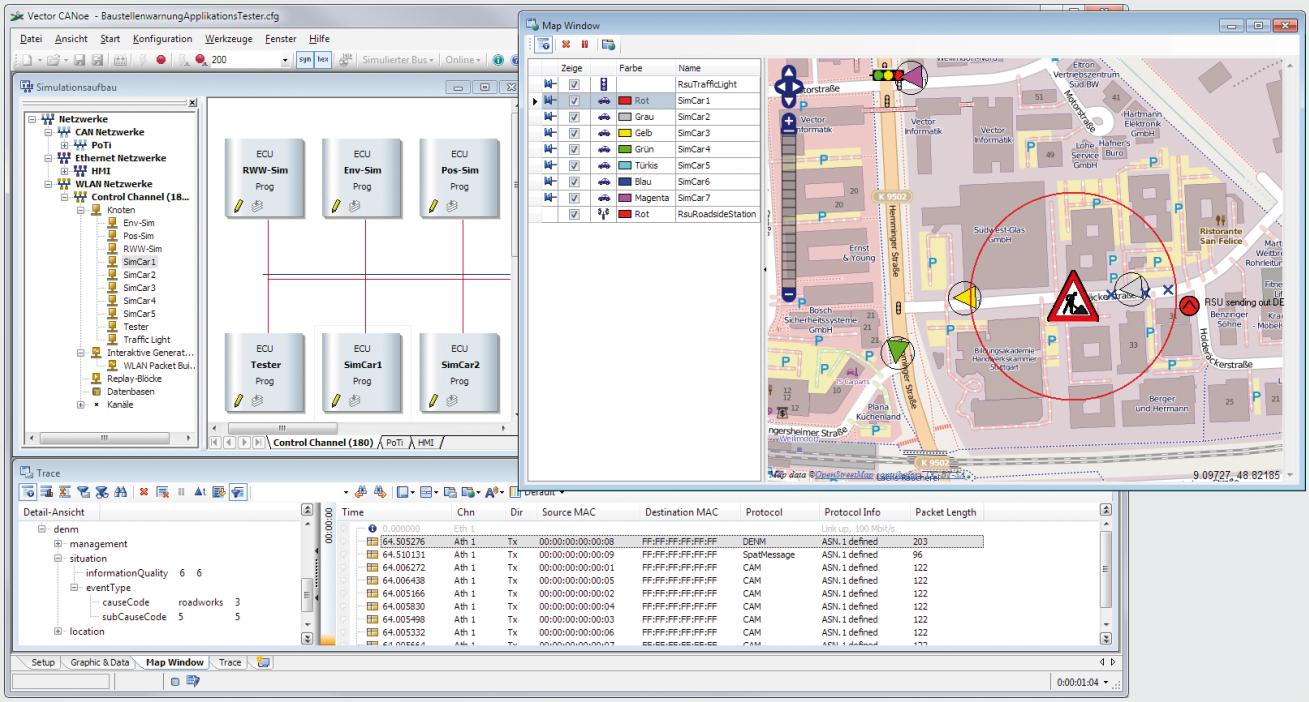

Figure 3: The entire test scenario can be implemented and visualized in CANoe.Car2x. Clear representation of the ITS stations in the map window with a display of the driving direction.