Top Level Newsletter: Connected Vehicle

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Editor-in-Chief: Kay Das, IEEE Life Member,
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Vol 34: This issue includes articles on:
(1) Steering toward full vehicle autonomy
(2) 5G Radio Access Network (RAN) Slicing

General Notes
This series of newsletters is intended to provide the IEEE member with a top level briefing of the many different subjects relevant to the research, development and innovation of the connected vehicle.

The objective is to provide a platform for fast learning and quick overview so that the reader may be guided to the next levels of detail and gain insight into correlations between the entries to enable growth of the technology. Intended audiences are those that desire a quick introduction to the subject and who may wish to take it further and deepen their knowledge. This includes those in industry, academia or government and the public at large. Descriptions will include a range of flavors from technical detail to broad industry and administrative issues. A (soft) limit of 300 to 600 words is usually set for each entry, but not rigorously exercised.

As descriptions are not exhaustive, hyperlinks are occasionally provided to give the reader a first means of delving into the next level of detail. The reader is encouraged to develop a first level understanding of the topic in view. The emphasis is on brief, clear and contained text. There will be no diagrams in order to keep the publication concise and podcast-friendly. Related topics in the case of Connected Vehicle technology, such as 5G cellular and the Internet of Things will be included. The terms Connected Vehicle and Automated Driving will be used inter-changeably. Articles from other published sources than IEEE that add to the information value will occasionally be included.

This newsletter forms part of the regional Advanced Technology Initiative (ATI) of which connected vehicles form a constituent part. Technical articles solely from IEEE journals/magazines are referred to by their Digital Object Identifier (DOI) or corresponding https link. The link for each article is provided. Those readers who wish to delve further to the complete paper and have access to IEEE Explore (www.ieeexplore.ieee.org) may download complete articles of interest. Those who subscribe to the relevant IEEE society and receive the journal may already have physical or electronic copies. In case of difficulty please contact the editor at kaydas@mac.com. The objective is to provide *top level guidance* on the subject of interest. As this is a collection of summaries of already published articles and serves to further widen audiences for the benefit of each publication, no copyright issues are foreseen.

Readers are encouraged to develop their own onward sources of information, discover and draw inferences, join the dots, and further develop the technology. Entries in the newsletter are normally either editorials or summaries or abstracts of articles. Where a deepening of knowledge is desired, reading the full article is recommended.

1. Steering toward full vehicle autonomy (Silviu Tuca, Autonomous Vehicle Product Line Manager, Keysight Technologies)

Published in: SAE Autonomous Vehicle Engineering Newsletter October 14, 2022. SILVIU TUCA

Radar scene emulation helps bridge the gap between simulation and real-world testing of autonomous systems for SAE Level 4 capability. The vision of fully autonomous vehicles (SAE Levels 4 and 5) is fast approaching. Making this vision a reality requires automotive OEMs to move beyond the current levels of vehicle autonomy to deliver on the promise of highly efficient transportation systems, more driver freedom and improved passenger safety.

While road testing is a vital part of the development process, the cost, time, and challenge of repeatability makes relying on real-world road testing alone unrealistic. Using this approach, it would take hundreds of years for vehicles to be reliable enough to navigate urban and rural roadways safely 100% of the time.

Additionally, current in-lab test solutions deliver an incomplete view of driving scenarios and mask the complexity of the real-world due to their limited horizontal or vertical field-of-view (FoV), minimum simulated distance, and number of echoes per simulated target capabilities.

Keysight Technologies recognized this problem in 2021 when it introduced its Radar Scene Emulator, enabling OEMs to lab-test complex, real-world driving scenarios while accelerating the overall speed of test. The company has kept its technology apace with current gaps. The full traffic-scene emulator combines hundreds of miniature radio frequency (RF) front ends into a scalable emulation screen representing up to 512 objects and distances as close as 1.5 meter (4.9 ft.).

On the path to Level 4

Shifting testing of complex driving scenarios from the road to the lab accelerates the speed of testing. For OEMs who need to realize new advanced driver assistance systems (ADAS) functionality – and for ADAS/Autonomous driving (AD) developers who value safety first — the Radar Scene Emulator and Keysight's Autonomous Drive Emulation platform provide a high level of resolution.

Road testing of the complete integrated system within a prototype or road-legal vehicle enables OEMs to validate the final product before bringing it to market. This system is helping to advance the development of better trained algorithms, with the goal of greater overall safety on the road.

The most recent data suggests self-driving cars could reduce traffic deaths by as much as 90% . ADAS in current production vehicles have reached SAE L2 and L3, which in most traffic situations require the driver to control the vehicle. Many OEMs and industry experts believe pushing further toward SAE L4 and L5 autonomy — where five represents vehicles not requiring any human interaction — will make our roadways safer.

To achieve the next level in vehicle autonomy, many advancements are required. There will be massive investments in sensor technologies, such as radar, lidar, and camera which will continue to improve environmental scanning. As each sensor type has its own advantages and disadvantages. They will need to complement each other to ensure the object detection process has the required built-in redundancy.

Huge investments in computationally powerful software algorithms are also necessary to combine and carry the large amount of high-resolution sensor data including vehicle-to-everything (V2X) communication inputs. Machine learning (ML) is the established method for training self-improving algorithms and artificial intelligence (AI). Those algorithms are then making decisions to ensure safety in complex traffic situations. Training these algorithms with the most realistic stimuli available, in a repeatable and controlled fashion in the lab, is crucial for their accuracy and their safe deployment.

The testing/simulation gap
Today, a large amount of testing time is spent focused on sensors and their control modules by simulating environments in software or software-in-the-loop (SIL) testing. Road testing of the completely integrated system within a prototype or road-legal vehicle allows OEMs to validate the final product before bringing it to market. Recreating a virtual world in the lab, with accurate rendering of the scenes, plus real radar sensors and signals, will bridge the gap between simulation and road testing.

The challenge today is the emulation of full radar scenes, especially when the scenes are complex and have many variables. The goal is to thoroughly test all driving scenarios in the lab, even the corner cases, before bringing the vehicle to the test track or open roadways. Software simulation is used in the early development cycle. The software ultimately is an abstract view, and it has imperfections and limitations.

Relying only on real-world road testing is also unrealistic because it would take millions of meters for vehicles to become safely reliable to navigate in urban and rural roadways 100% of the time. To truly test the AV/ADAS functionality, it is necessary to control all relevant parameters.

To close the gap between real world testing and simulation, real and physical sensors are needed in the test setup. This complexity must be added to the test to predict how AVs will behave on the road.

The vision is for technology to fully replace the human behind the wheel to enable reliable, accurate, and safe decisions on the road. Software simulation cannot fully test the real sensor response and testing on the track is not repeatable. When emulating radar targets, several technology gaps currently exist:

• Limited number of targets and FoV: A common approach ties each simulated target to a delay line. Even if additional targets are added, only one radar echo is processed at a time. Also, if an antenna array is created, it isn’t possible to simultaneously emulate targets at the extreme ends of the radar module’s field of view. In addition, each movement of the antennas introduces a change in the echo’s angle of arrival (AoA), which might lead to errors and loss of accuracy in rendering targets, if not recalculated.
• Inability to generate objects at distances of <4m: Many test cases, such as the New Car Assessment Program’s (NCAP) Vulnerable Road User Protection — AEB Pedestrian, require object emulation very close to the radar unit. Most of the target simulation solutions existing on the market today are designed for long distances.
• Lower resolution between objects: Until recently, target simulators could only generate one object as one radar signature – this leaves gaps in scene details. For example, on a crowded multi-lane boulevard, test equipment must accurately tell the difference between all the traffic participants. With only one echo per object, the algorithm might not be able to tell the difference between a bicycle and a lamp post.

New technology needed
Full-scene emulation in the lab is key to developing the robust radar sensors and algorithms needed to realize ADAS capabilities on the path to full vehicle autonomy. One method is to shift from an approach centered on object detection via target simulation to traffic-scene emulation. This will enable the ability to emulate complex scenarios, including coexisting high-resolution objects, with a wide field of view and a reduced minimum object distance.

Real life vehicles are in fact extended objects, whose dimensions span multiple radar sensor resolution cells. As a result, the radar sensors report multiple detections of these objects in a single scan. Object tracking algorithms are employed to identify and cluster these detections into objects. Realistic emulation of such objects by means of multiple radar echoes enables pushing the boundaries of the algorithm’s and correctly identifying complex objects on the road.

The sensor's entire FoV must be covered to achieve high test coverage and run comprehensive test scenarios. A wide FoV is needed, ideally with RF front ends that are static in space, to enable reproducible and accurate AoA validation. Similarly, it is important to test the radar sensor's ability to notice object's heights and traffic on multi-layered roads. A practical example — the autonomous vehicle must not apply the brakes when another vehicle is crossing on an overpass, but correctly detect the overpass and drive underneath it instead.

Realistic traffic scenes require the emulation of objects very close to the radar unit. For example, at a stoplight where cars are no more than two meters apart, bikes might move into the lane or pedestrians might suddenly cross the road. Passing this test is critical for the safety features of an ADAS/AD.

Object separation, the ability to distinguish between obstacles on the road, is another test area for a smoother and faster transition to L4 and L5 vehicles. For example, a radar detection algorithm will need to differentiate between a guard rail and a pedestrian while the car is driving on a highway.

Greater confidence in ADAS functionality

More targets, shorter minimum distance, higher resolution, and a continuous field of view are essential to real world testing. In the lab, this will enable an increase in test coverage to not only save time, but safely run and repeat test scenarios.

A traditional radar target simulator (RTS) will return one reflection independent of distance while a radar scene emulator increases the number of reflections as the vehicle gets closer, also known as dynamic resolution. This means the number of objects varies with the distance of the object.

AD and ADAS software decisions must be based on the complete picture, not only on what the test equipment allows. New radar emulation technology is one more way to shift testing of complex driving scenarios from the road to the lab. (1518 words) To learn more, visit https://www.keysight.com/find/DiscoverRSE.

2. 5G Radio Access Network Slicing: System-Level Evaluation and Management, (Ioannis Belikaidis et al)

Published in: IEEE Vehicular Technology Magazine (Volume 14 Issue 4, December 2019, pp 49-55)

Abstract: In 5G wireless networks, different types of services will be handled, including critical communications such as ultrareliable, low-latency communications (URLLC) and high-bit-rate communications [e.g. enhanced mobile broadband (eMBB) traffic]. To effectively handle such different types with diverse requirements, operators are working on network slicing concepts for dedicating resources to these services. As such, the purpose of this article is to design, develop, and validate mechanisms for creating and deciding on the dynamic resource allocation of network slices.

Our proposed algorithm reconfigures and adjusts the slices so as to provide appropriate quality-of-service (QoS) levels toward mobile client nodes, and we evaluate its impact to resource usage and latency.

This push toward 5G is motivated by a combination of business requirements and technology trends that can efficiently boost the performance of various parts of the infrastructure.

Background: The wireless world has seen huge progress over the past three decades. Currently, tremendous resources are allocated for conceptualizing and realizing 5G wireless/mobile communications. This push toward 5G is motivated by a combination of business requirements and technology trends that can efficiently boost the performance of various parts of the infrastructure. Services are associated with numerous verticals sectors (e.g., energy, health, media provision, and water/environment management). Due to their heterogeneous QoS requirements, services are categorized with respect to aspects such as whether they involve eMBB traffic or require URLLC. There are pushes to essentially advance the management intelligence to achieve constantly agile (reactive/proactive, automated/prescriptive, fast, reliable, and trustworthy) and, therefore, more efficient system behavior. At first, all these will lead to a complex 5G radio access network (RAN). To efficiently provide diverse services/QoS levels through the complex and powerful network, the notion of network slicing has been introduced. This work is motivated by the fact that different types of services (e.g., eMBB and URLLC) require a certain number of resources to be effectively served. Through network slicing, it will be possible to allocate resources (either dedicated or shared) to services separately and meet specific requirements.

Considering the number of topics currently studied in various publications, we propose an algorithm for creating and deciding on the dynamic resource allocation of network slices. Our proposed algorithm reconfigures and adjusts the slices so as to provide appropriate QoS levels to mobile client nodes. Also, one novel aspect is that the algorithm distinguishes types of services (e.g., URLLC or eMBB) to prioritize allocation to critical traffic. Furthermore, slicing preemption (i.e., preemption of resources from noncritical activities to serve critical activities if possible) is pursued through the provided algorithm.

Network Slicing Definition and Requirements: In general terms, a slice can be seen as a logical network that relies on a subset of the physical resources of a network. In this respect, there can be 5G RAN slicing as well as the slicing of other segments to support end-to-end connectivity. Consequently, a network may be partitioned into a set of slices. Each slice needs to be adequate for delivering a specific service. A network slice is a virtual network created on top of a physical network in such a way that it gives the illusion the slice tenant operates its own dedicated physical network. Also, it is a self-contained network with its own virtual resources, topology, traffic flow, and provisioning rules. Network slicing is a concept to allow differentiated treatment depending on each customer requirement. With slicing, it is possible for mobile network operators to consider customers as belonging to different tenant types, with each having different service requirements that govern in terms of what slice types each tenant is eligible to use based on a service-level agreement (SLA) and subscriptions. Additionally, the system allows the operator to create, modify, delete, define, or even update the services supported in each network slice. A device may be assigned to a slice based on the subscription, device type, and services provided by the network or removed and assigned to a different slice if required.

Scenario Description: For purpose of this study, a scenario made up of moving vehicles and users is considered. With this scenario, it is possible to show the impact of decisions on both URLLC and eMBB slices due to the fact that, for moving vehicle commands, URLLC slices are of ultimate importance, while for passengers or pedestrians (PEDs) eMBB slices are utilized for transmission of content and so on. The allocation of resources is initially prioritized for URLLC slice based on their critical nature, and the remaining resources are allocated to eMBB slices, which may serve high-definition video traffic, browsing, and so on. (754 words)
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