Javier Gozalvez
Editor-in-Chief

Welcome to the June 2023 Issue

This issue of *IEEE Vehicular Technology Magazine* includes nine open call articles that cover a variety of 6G candidate technologies [reconfigurable intelligent surfaces, nonterrestrial networks (NTNs), artificial intelligence (AI)/machine learning (ML) for wireless communications, and vehicle-to-everything (V2X) networks] as well as connected and automated mobility systems [lidar, in-vehicle programmable networks, in-vehicle cybersecurity, in-vehicle architectures for joint safety- and security-critical aspects, and trusted unmanned aerial vehicle (UAV) swarm networks].

Reconfigurable intelligent surfaces (RISs) have been one of the major focal points for 6G research in recent years. The community has already shown the potential of RISs for communications. However, a RIS also has a strong potential for both communication and localization since the adoption of a RIS for localization represents a more cost- and energy-efficient solution than solutions based on multiantenna base stations (BSs) and relays because of its simpler hardware implementation and minimal deployment and maintenance efforts. Keykhosravi et al. [A1] present an overview of RIS-enabled localization scenarios, considering various numbers of RISs, single-antenna or multiantenna BSs, narrowband or wideband transmissions, and near- and far-field operations. The authors show the potential of RIS localization with an experimental setup at 60 GHz for one of the considered RIS-enabled scenarios and highlight future research directions and open challenges specific to RIS-enabled localization and sensing.

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Satellite communications are expected to be an essential component of future 6G NTNs because of their global coverage. As satellites can extend connectivity where terrestrial networks cannot, it is expected that satellite communications and NTNs will facilitate emerging applications, such as urban air mobility, among others. The article by Kim et al. [A2] analyzes the application of network virtualization and slicing for satellite networks. Satellite network slicing can enable a substrate satellite network to support diverse services. In this context, the authors propose and evaluate candidate satellite network slice planning (SNSP) methods over megaconstellated satellite networks to reserve the network resources for virtual networks during the required service time. The article also identifies key parameters and current system bottlenecks for SNSPs and discusses system efficiency and existing tradeoffs as well as open issues for satellite network slicing.

AI/ML will be another fundamental technology enabler in the design of 6G networks, and this is illustrated in the article by Zhang and Heath Jr. [A3]. The article addresses the challenge of establishing and maintaining millimeter-wave (mmWave) links resulting from changes in environment, user mobility, or channel conditions. These changes may require a reconfiguration of mmWave links that involves searching for the adequate system parameters (under environmental uncertainties) from a finite set of options supported by the mmWave hardware and communication protocols. Finding the adequate configuration is critical to achieve the benefits of mmWave communications (including high throughputs), but this cannot be achieved at a large overhead cost, and it is unrealistic to search for the optimal solution at each point in time because of the dynamics in the environment and mobility in the network. The authors propose the use of the multiarmed bandit (MAB) framework to intelligently search out the optimal configuration in mmWave and subterahertz (sub-THz) wireless communication networks because of its small sample and computational complexity. MAB is a reinforcement learning framework that guides a decision maker to sequentially select one action from a set of actions. The authors show how the MAB framework can be used, for example, to dynamically learn the optimal beam sweeping period, beamwidth, and beam directions with sample- and computation-efficient bandit algorithms. The authors also highlight future research directions for using MAB in mmWave designs and operation, and they argue that similar ideas can be applied to sub-THz systems.

The design of 6G V2X communications is the focus of the article by Bazzi et al. [A4]. The authors propose and evaluate the use of nonorthogonal multiple access for sidelink cellular V2X (C-V2X) communications. The proposal seeks to address the challenges experienced with orthogonal multiple access resource allocation processes due to imperfect channel sensing and vehicle coordination when vehicles autonomously select the resources. According to the authors, these distributed decisions can generate interference and collisions under high-load conditions because of the limitations of half-duplex transceivers on board, vehicle mobility, and hidden terminal phenomena. The study evaluates the gains achievable over conventional schemes with successive interference cancellation on top of the legacy C-V2X sidelink resource allocation under the autonomous mode of operation.

The following five articles focus on future connected and automated mobility systems. In [A5], Kim and Yi present the design and implementation of a 3D lidar perception framework for autonomous driving that includes detection and tracking modules. The detection module distinguishes and categorizes surrounding objects, while the tracking module estimates the dynamic state of the moving objects. The lidar perception framework presented by the authors includes two detection modules operating in parallel. The first module uses a convolutional gated recurrent unit-based residual network to repredict 3D objects following a continuous single-frame detection network and a vision-fusion methodology based on 2D projection for postprocessing. The second module uses geometric model-free area cluster detection to cope with false-negative cases of unclassified objects from the first module and a cluster variance-based ground removal to prevent false positives. The authors then apply a kinematic model-based particle filter to estimate the dynamic states of detection. The authors analyze the complete lidar-based perception framework (including detection and tracking and several postprocessing methods) in an urban autonomous driving environment and show that it can successfully detect and estimate the state of objects and manage false detections with real-time operational capability.

In [A6], Nayak et al. explore the application of programmable data planes in automotive electrical and electronic architectures. These architectures are evolving toward domain or zonal architectures with centralization of computing capabilities to support advanced functionalities for connected and automated driving. These functionalities require large amounts of data, and there is a trend to decouple software from the hardware so that functionalities can be independently evolved following a service-oriented-architecture approach that can benefit from the use of software over-the-air updates. In this context, the software-defined networking paradigm is being explored to improve the programmability of in-vehicular networks. The authors explore the possibilities of programmable data plane technologies in automotive architectures and present a case study on implementing a distributed feedback control loop using the Scalable Service-Oriented Middleware over Internet Protocol, an automotive service-oriented communication middleware. The authors show how programmable data plane technologies can bring significant improvements to the design and performance of automotive applications, and they highlight the challenges that must be tackled to achieve these improvements.

Kayashima et al. also address in-vehicle networks in their article [A7], which focuses on the increasing threats of cyberattacks on vehicles by proposing a risk-based security design methodology that derives cybersecurity requirements for threat-detection mechanisms. The methodology can also help identify where detection attack methods should be implemented in in-vehicle networks to effectively detect intrusion attacks and respond to the various threats that occur in connected vehicles. The authors also discuss evaluation metrics for the monitoring points identified by the proposed security design methodology. The proposal is aligned with worldwide regulations and standards put in place by the International Organization for Standardization/Society of Automotive Engineers to address automotive cybersecurity threats.

Security and safety in connected automated vehicles (CAVs) are two interrelated critical issues, and the article by Li et al. [A8] proposes a dynamic heterogeneous redundancy (DHR) scheme for in-vehicle networks in CAVs to achieve both safety and security in the presence of functional failures or cyberattacks. The proposal relies on each safety- and security-critical in-vehicle component to employ a DHR architecture constructed with multiple heterogeneous executors with the same function. With redundancy, the functional safety can be achieved when one executor fails. For security, the DHR architecture uses a consensus mechanism to detect an abnormal component and eliminates threats through a dynamic reconstruction mechanism. The authors build a DHR prototype on an automated bus to showcase the potential of DHR, and they discuss open questions and challenges yet to be resolved.

The article by Yang et al. [A9] also addresses security attacks but related to UAV swarms. A UAV swarm is a group of multifunction UAVs with swarm intelligence and the capacity to self-organize in networks. The cooperation of UAVs within a networked UAV swarm can help perform more complex tasks in emergency or rescue mission scenarios, among others. A resilient operation of UAV swarms requires protecting them from security attacks generated by internal malicious or manipulated UAVs that can, for example, drop received data packets silently in black- or gray-hole attacks by exploiting the underlying intermittent network connections.

The authors propose tackling these threats with a blockchain-based mechanism to build trusted networks in challenging environments characterized by the dynamic topology and limited resources of UAV swarm networks. The proposal includes mechanisms to provide lightweight consensus and trustworthiness evaluation, identify malicious UAV nodes, and prevent routing data through malicious nodes. The final objective is to isolate threats and allow only trusted UAVs to participate in network decisions and provide services for other swarm nodes.

I hope that you will enjoy reading this issue. Please don't hesitate to get in touch if you have any comments, ideas, or proposals to improve *IEEE Vehicular Technology Magazine*.

Appendix: Related Articles

[A1] K. Keykhosravi et al., "Leveraging RIS-enabled smart signal propagation for solving infeasible localization problems: Scenarios, key research directions, and open challenges," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 20–28, Jun. 2023, doi: 10.1109/MVT.2023.3237004.

[A2] T. Kim, J. Kwak, and J. P. Choi, "Satellite network slice planning: Architecture, performance analysis, and open issues," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 29–38, Jun. 2023, doi: 10.1109/MVT.2023.3238515.

[A3] Y. Zhang and R. W. Heath Jr., "Multi-armed bandit for link configuration in millimeter-wave networks: An approach for solving sequential decision-making problems," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 39–49, Jun. 2023, doi: 10.1109/MVT.2023.3237940.

[A4] A. Bazzi et al., "Toward 6G vehicle-to-everything sidelink: Nonorthogonal multiple access in the autonomous mode," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 50–59, Jun. 2023, doi: 10.1109/MVT.2023.3252278.

[A5] J. Kim and K. Yi, "Lidar object perception framework for urban autonomous driving: Detection and state tracking based on convolutional gated recurrent unit and statistical approach," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 60–68, Jun. 2023, doi: 10.1109/MVT.2023.3236480.

[A6] N. Nayak et al., "Reimagining automotive service oriented communication: A case study on programmable data planes," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 69–79, Jun. 2023, doi: 10.1109/MVT.2022.3225787.

[A7] M. Kayashima, N. Kawaguchi, K. Ideguchi, and N. Morita, "An extraction and validity evaluation method proposal for monitoring points for in-vehicle systems: Deriving cybersecurity requirements," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 80–88, Jun. 2023, doi: 10.1109/MVT.2022.3219239.

[A8] Y. Li, Q. Liu, W. Zhuang, Y. Zhou, C. Cao, and J. Wu, "Dynamic heterogeneous redundancy-based joint safety and security for connected automated vehicles: Preliminary simulation and field test results," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 89–97, Jun. 2023, doi: 10.1109/MVT.2023.3263334.

[A9] J. Yang, X. Liu, X. Jiang, Y. Zhang, S. Chen, and H. He, "Toward trusted unmanned aerial vehicle swarm networks: A blockchain-based approach," *IEEE Veh. Technol. Mag.*, vol. 18, no. 2, pp. 98–108, Jun. 2023, doi: 10.1109/MVT.2023.3242834.

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