OKI's Approach towards Next Generation Mobility Services
-Cooperative ITS and ETC Multi-Purpose Service-

Jumpei Furukawa **Atsushi Satou**
Masaki Kurosu

The world of mobility is said to be in a "once in a 100 years" revolutionary period. Each element of CASE (C: Connected, A: Autonomous/Automated, S: Shared & Services, E: Electric) has evolved due to technological innovations, and players who have not been directly related to mobility have entered the industry creating a state of chaos. Mobility innovations not only make mobility more convenient, but through the use of cutting-edge technologies, they also have the potential to solve social issues and create new business schemes. Additionally, COVID-19 has brought drastic changes in the external environment on a global scale affecting the people's basic lives and working styles.

Under such an environment, OKI is proceeding with initiatives for next-generation mobility services. As a manufacturer that provides infrastructure, OKI is promoting cooperative ITS that supports autonomous vehicles with an aim to implement automated driving more safely into society at a lower cost. OKI is also promoting an ETC multi-purpose service that creates new usage value by taking advantage of ETC technology developed for convenient use of expressways. This article introduces these initiatives.

Industry-Government-Academia Trends Related to Automated Driving

Efforts are accelerating both in Japan and abroad for technological developments and legislations to realize automated driving. At present, automated driving is possible under relatively simple environmental conditions such as on main roadways. The vision of the automated driving implementation in 2020 as presented in Japan's Public-Private ITS Initiative/Roadmaps is shown in **Figure 1**. Industry-government-academia is proceeding with various initiatives in line with these roadmaps[1]. Parts of these initiatives are introduced below.

(1) Government-led initiatives

- Cabinet Office: Invoking technological developments, demonstration experiments, and verification of social acceptability in the first phase "Automated Driving System" and second phase "Automated Driving for Universal Services" of Cross-ministerial Strategic Innovation Promotion Program (SIP).
- Ministry of Economy, Trade and Industry/Ministry of Land, Infrastructure, Transport and Tourism: Invoking R&D in strategically collaborative fields and social implementation projects such as driverless automated driving transport services in specified areas through the Automated Driving Business Study Group.
- Ministry of Land, Infrastructure, Transport and Tourism: Conducting system improvement such as amendments to the Road Transport Vehicle Act and promoting demonstration of automated driving centered on Michi-no-Eki (roadside stations). Study is proceeding on securing driving areas that support automated driving.
- National Police Agency: Promoting system improvements such as amendments to the Road Traffic Act, and provisioning of signal indications and linkage with signal controls.
- Ministry of Internal Affairs and Communications: Promoting the development of info-communication infrastructure that supports automated driving from the standpoint of radio wave administration.

(2) Private sector initiatives

- Japan Automobile Manufacturers Association: Formulated the 2015 Vision of Automated Driving and proceeding with development focused on advanced driving support functions and automated driving on expressways.
- Automakers: While developing automobiles for the globally competitive field, automakers consider safety evaluation, security measures, social acceptability evaluation, etc. as strategically collaborative fields, and they are participating in national projects such as SIP. Various consortia have been formed to develop and deploy new mobility services such as MaaS, which includes automated driving, and technological developments and demonstration experiments are being carried out.
- Venture companies, etc.: Various companies are working with taxi companies or conducting demonstrations with delivery robots, minivans and low-speed shuttles.

(3) University initiatives

- Gunma University, Saitama Institute of Technology, Kanazawa University, Nagoya University, Keio University, and The University of Tokyo among others are carrying out various efforts from research to demonstration of elemental technologies.

Automated driving on expressways (Level 3)

- Able to start automated driving on a main roadway
- Automatic lane keeping, adaptive cruise control, and speed adjustment at a certain speed or below
- Able to finish automated driving on a main roadway

Driverless automated driving transport services in specified areas

- Comparatively simple ODDs (driving environment such as abandoned tracks)
- One person remotely monitors and operates one vehicle or multiple vehicles
- Automated driving system performs operation under remote monitoring, but when abnormality or TOR occurs, remotely monitoring operator or service provider in the vehicle promptly implements the required measures

(Source: Excerpt from Public-Private ITS Initiative/Roadmaps 2020[2])

Figure 1. Vision of the Automated Driving Implementation in 2020

OKI participated in SIP's second phase "Research and development on the collection, integration, and delivery of data of narrow-area and mid-sized-area information" for automated driving, contracted various technical test works from the Ministry of Internal Affairs and Communications to introduce V2X communication[3], and conducted technical demonstrations in Japan Research Institute's "In-town Autonomous Mobility Service Concept Design Consortium." [4), 5)]

Technical Assets for Realizing Automated Driving/Safe Driving Support with Cooperative ITS and OKI's Initiatives

Driving support functions installed on vehicles have considerably advanced. It is possible for vehicles alone to handle driving on main roadways and in places with good visibility and sufficient lane for merging into traffic.

However, at places where merging lanes are short such as urban roadways or places where visibility for merging is poor, it may be difficult to merge into traffic with automated driving using only the driving support function on the vehicle. In order to make automated driving safer, it is vital for vehicles and equipment installed on the roadside to cooperate with each other (cooperative ITS).

Sensing, edge processing, and communications technologies are the technical assets necessary in the roadside equipment to achieve cooperative ITS.

(1) Sensing technology

In order to realize a service that provides smooth merging support to an automated driving vehicle, the entire road conditions must be monitored to take measurements such as the speed and lane of the traveling vehicles, distance between vehicles and vehicle length. Moreover, the measurements must be performed continuously to detect the every-changing road conditions.

Although there are several possible sensing methods including LiDAR (laser), radar and image, the optimum method should be selected based on characteristic and cost. Furthermore, it is necessary to deal with the problem of occlusion in which the vehicles in the background become hidden in the shadows of foreground vehicles.

(2) Edge processing technology

On expressways, the traveling speeds of both the vehicles on main throughway and those trying to merge are high. Under such a circumstance, road conditions measured by the sensors need to be transmitted to the automated driving vehicle with minimal delay. In order to minimize delay, it is best to perform detection processing in the edge processor (**Photo 1**) installed on the roadside and send the information directly to the automated driving vehicle rather than relying on centralized equipment or the cloud.

Photo 1. Example of Edge Processor
(OKI's AI Edge Computer AE2100[6])

(3) Communications technology

As shown in **Figure 2**, communication between a vehicle and something (infrastructure, vehicle, pedestrian, network) is collectively called V2X (Vehicle to Everything). The communication method most suited for V2X will depend on use case, and study is being conducted in cooperation with the national government.

In particular, cellular and DSRC methods are being considered as communication methods for direct communication that require immediacy, and OKI is proceeding with R&D so that it will be ready to respond to either method.

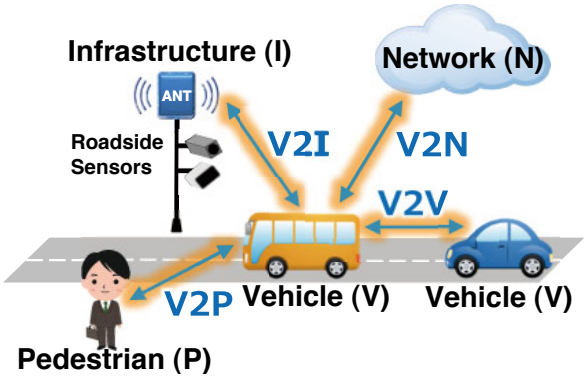

Figure 2. Example of V2X (V2I, V2V, V2P, V2N) Cooperative ITS

On the other hand, if low-speed driving is assumed, such as automated driving service within a new town or other specified regions, immediacy provided with direct communication may not be required. In such use cases, the use of 5G communication is a future possibility (**Figure 3**).

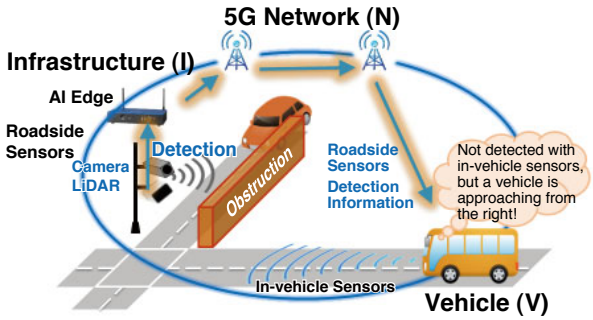

Figure 3. Example of 5G Cooperative ITS

OKI has set up an ITS test course (**Photo 2**) on the grounds of its Honjo Plant to conduct R&D and experiments on these elemental technologies. In addition, it is currently developing a local 5G environment and conducting experiments to explore the possibility of cooperative ITS using 5G.

Photo 2. ITS Test Course

ETC Multi-Purpose Service

ETC, which is used for automatic toll collection on expressways, has become usable in various scenes and services here in Japan due to a system established on November 11, 2019 by the Ministry of Land, Infrastructure, Transport and Tourism. As a result, the spread of ETC will further accelerate, and likely be used as a matter of course at city gas stations, drive-thrus, and parking lots.

Additionally, these movements will play a very important role in the "with COVID-19"/"after COVID-19" society.

Together with co-creation partners, OKI has conducted trial operations at parking lots, car ferry boarding areas, drive-thrus, etc., where services using the ETC mechanism can be deployed, to perform technical verification and service suitability examination in preparation for a full-scale service. As a next step, on October 1, 2020, OKI established "ETC Solutions Corporation (hereinafter, ETC Solutions)," a company to provide ETC multi-purpose services as a business, in a joint investment with Sony Payment Services Inc. and Meitetsucom Co., Ltd[7].

These efforts are expected to accelerate the use of ETC technology in an aim towards the realization of a convenient and comfortable society. OKI will provision small roadside devices usable in a city environment and together with its deployment expertise it will provide customers with a new ETC multi-purpose service (**Figure 4**).

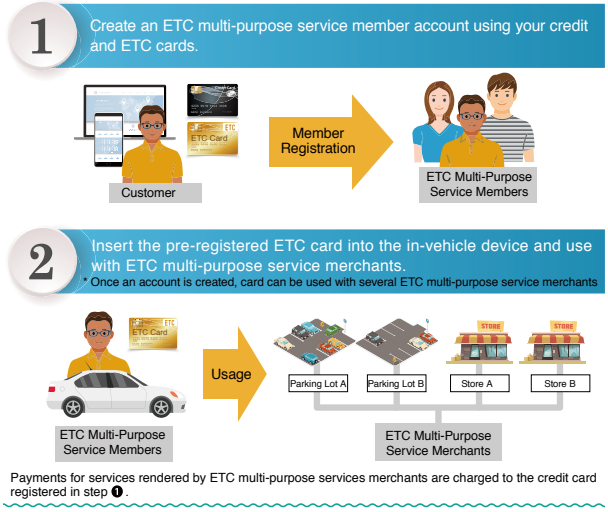

Figure 4. ETC Multi-Purpose Service Usage

Conclusion

OKI is conducting R&D on roadside infrastructure for realizing cooperative ITS to support automated and safe driving. In addition, ETC Solutions was established to

promote ETC multi-purpose service that may play a very important role in the “with COVID-19”/“after COVID-19” society.

In an approach to contribute to the realization of next-generation mobility services, OKI will further drive these initiatives to accelerate the social implementation of automated driving and penetration of ETC multi-purpose service. ◆◆

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Authors

Jumpei Furukawa, Business Development Department-1, Social Infrastructure Solutions Division, Solution Systems Business Group

Atsushi Satou, Business Development Department-1, Social Infrastructure Solutions Division, Solution Systems Business Group

Masaki Kurosu, Traffic Solutions Department-1, Social Infrastructure Solutions Division, Solution Systems Business Group

*1) LocoMobi is a registered trademark of Oki Electric Industry Co., Ltd.

TIPS【Glossary】

CASE
Acronym for the four elements that indicate the current automotive trend (C: Connected, A: Autonomous/Automated, S: Shared & Services, E: Electric).

ITS (Intelligent Transport Systems)
A general term for new advanced traffic systems that integrate people, roads, and vehicles into a single system using the latest information and communication technologies.

ETC (Electronic Toll Collection System)
A system that uses wireless communication to automatically pay toll charges without stopping at the toll booth.

SIP (Cross-ministerial Strategic Innovation Promotion Program)
A national project created by Japan’s Cabinet Office which gives the Council for Science, Technology and Innovation managing authority that crosses the boundaries of ministries and customary fields to advance the promotion of science and technology innovations.

TOR (Take Over Request)
A request to the driver to take over control when it is difficult for the system to continue operation.

MaaS (Mobility as a Service)
The concept of treating movement to a destination as a service. For example, when a person connects to a bus or train as a means to reach a destination, the person does not have to select and purchase tickets for each means of transportation. Instead, the person purchases a service of arriving at the destination, thus the optimum means of transportation is provided.

OKI’s AI edge computer “AE2100”
An AI edge device that is ideal for AI inference processing on the edge side, which is necessary when performing AI analysis of large amount of sensor data and video, or when performing AI analysis that requires real-time performance and reliability.
https://www.oki.com/jp/AIedge/ae2100/ (in Japanese)

V2X (Vehicle to Everything)
A general term for technologies and systems using mutual communication with vehicles. It includes V2V (Vehicle to Vehicle), V2I (Vehicle to Infrastructure) and V2P (Vehicle to Pedestrian).

ODD (Operational Design Domain)
Certain conditions designed to operate an automated driving system, or its function.