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In-vehicle sensor network based on single-board computers for low-cost intelligent transport systems in rural areas

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In an autonomous vehicle society in the 2030s, all vehicles will be connected to the Internet and share information on road traffic conditions. However, fully-supported autonomous cars will not be spread worldwide even in the 2040s, so an add-on system to enable autonomous driving will be required. In addition, the cost of the add-on system should be low enough to be spread in developing countries. Moreover, due to cost and geographical issues, typical mobile communication services may not be available in some areas. In this study, we propose the combination of a low-cost in-vehicle sensor network based on single-board computers (SBCs) and low-power wide-area (LPWA) wireless system-based vehicle-to-everything (V2X) communications to support intelligent transport systems (ITSs) in rural areas.

Figure 1 shows the system block diagram of the in-vehicle sensor network and V2X system. The in-vehicle sensor network consists of SBCs, sensors such as a global navigation satellite system (GNSS) receiver, an optical camera, a data collector for the existing in-vehicle diagnostic system, an LPWA module, and an in-vehicle data server. The SBC performs signal processing for the sensor data and works as a transmitter to an in-vehicle network. The in-vehicle network is configured based on zonal network architecture because the sensors are sparsely distributed in the vehicle. Therefore, the wireline Ethernet and the related protocols are used as physical, link, and network layers in the system. Automotive Ethernet has been standardized with data rates greater than 100 Mbit/s in the IEEE and ISO. The data server in the vehicle receives the collected data. Light-weight signal processing, such as object detection by the camera and machine learning, can be implemented even if total energy consumption is limited in the vehicle environment. This signal processing reduces the data for transmission via the V2X system. Typical LPWA systems such as LoRa, SigFox, Wi-SUN, and so on are designed for the IoT sensor network. Thus, the maximum throughput is strictly limited, up to 100 kbit/s, to realize the long-time operation with the small size of batteries. The throughputs and compression of the data for transmission to infrastructure servers help realize the traffic estimation and optimization of the traffic network in the infrastructure server. In this proposal, all the systems are configured on a private network. We can use the Internet connection with public cloud servers for wide-area traffic network monitoring and control.

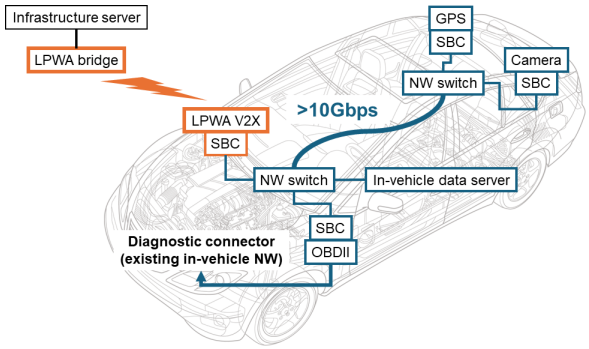

Figure 1. System block diagram of the in-vehicle sensor network and V2X system.

In this presentation, we will discuss the details of the system and requirements and present some experimental results.

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