Development of Data Collection Platform for Running Cars by using 920MHz LoRa Communication in Urban Area

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SUMMARY The MaaS (Mobility as a Service), which collects, analyzes, and utilizes various data obtained various types of vehicles, is expected to solve various problems about traffic jams, autonomous driving, social community, etc. In today's IoT (Internet of Things) and the MaaS infrastructures, however, data ownership is owned by the vendor created on-board sensor, such as car-navigation systems and driving recorders, and not everyone can easily leverage the data. Therefore, it is necessary to collect various information from sensors mounted on a vehicle at a low cost and effective. This paper proposes the data collection platform using the LoRa and Wi-Fi from running cars. Through the demonstration experiment in the urban area, we clarified the acquisition performance of GPS data of cars by LoRa communication and the importance of data collection using Wi-Fi.

key words: *LoRa communication, LPWA, MaaS, Internet, Wi-Fi*

1. Introduction

With the spreading of IoT technologies, we receive various contributions by using various types of devices, such as smartphones, tablet PCs, and sensors. One of the important elements of data utilization is MaaS, which utilizes data acquired from various vehicles. The MaaS is expected to solve problems related to vehicles and social issues, including local communities, through information obtained from vehicles worldwide. However, the data obtained from these vehicles are not available to everyone. For example, the data of car-navigation systems with LTE/4G interfaces is primarily owned by vendors created the systems, not vehicle deployment businesses such as rental cars and taxis do not have the data. Therefore, there is a need for a vehicle data collection system that is easy to collect data related to vehicles and low running costs for vehicle deployment businesses.

Therefore, we propose the data collection platform using Low Power Wide Area (LPWA) and Wi-Fi from running cars. The platform consists of an on-board transmitter with GPS modules and various sensors, a receiver, and a data storage server as shown in Fig.1. We assume that the collected data by the on-board transmitter are various types of data, such as temperature, humidity, and 3-axis acceleration, etc. These data are divided into two categories: real-time and non-real-time. In our platform, the real-time data is collected by LPWA, while the non-real-time data is collected by WLANs. To evaluate our proposed platform's effectiveness, five on-board transmitters, the receiver, and the server were implemented. Then we collected the data of five cars in the urban area of Kitakyushu-city, Fukuoka, Japan.

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2. Proposed platform

Figure 1 shows the structure of the proposed platform. This platform is composed of an on-board transmitter installed in a running car, a receiver that gets information from the transmitter, and a data storage server for collecting data. The on-board transmitter is equipped with the GPS module, various sensors, and LoRa and Wi-Fi interfaces. The transmitter sends a part of the GPS information and sensor data to the receiver in real-time by the LoRa communication. Furthermore, the transmitter stores all data from the GPS module and various sensors, and then the transmitter sends all data as a backup using Wi-Fi when the transmitter can connect some Wi-Fi access points.

Here, focusing on data transmission by LoRa communication, the transmission rate can be changed by Spreading Factor (SF). So it is necessary to decide the optimal transmission interval of each on-board transmitter depending on the transmission rate according to the regulation of 920MHz bands in Japan (We can only transmit for 360s in 3600s). The transmission interval I is calculated by the following (1):

$$I = \frac{3600 * B}{360 * R_{SF_x}} \tag{1}$$

where B is the transmit data size [bit] and R_{SF_x} indicates the transmit rate for the SF x.

Next, we introduce the timing adjustment scheme to avoid channel conflicts among each on-board transmitter. Each on-board transmitter set a transmission offset time O set autonomously based on the unique ID allocated to each transmitter in advance. The offset time O is calculated by the following (2):

$$O = \frac{(I + \alpha) * (i - 1)}{N} \tag{2}$$

where N is the number of transmitters expected to be in a particular space, and we assume that the value of N is known in advance in this paper. α indicates the given period for I. I is a transmission interval in an ideal value, and we

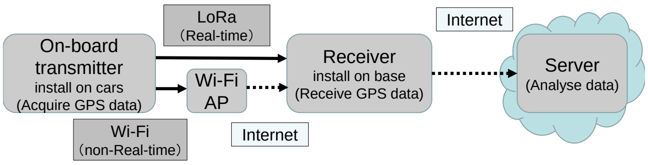

Fig. 1 Proposed system

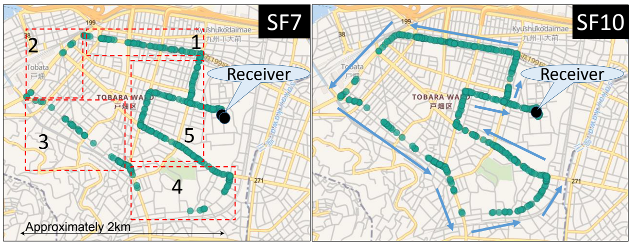

Fig. 2 Data Collection Results by LoRa Communication.

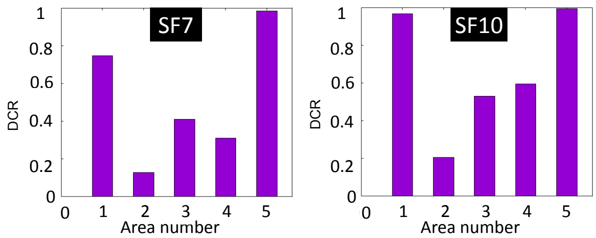

Fig. 3 Data Collection Rate of Each Area.

add the expected overhead, such as the addition of a header for a frame and carrier sense period, as a given period α to allow leeway within regulatory restrictions. Then, each the on-board transmitter starts data transmission at a time obtained by adding the offset time O to the determined data transmission start time. Thus, channel collisions among the on-board transmitters are suppressed as much as possible.

3. Performance Evaluation

Five on-board transmitters, one receiver, and the server were implemented to evaluate our proposed platform's effectiveness. Then we collected the data of five cars in the urban area of Kitakyushu-city, Fukuoka, Japan. The on-board transmitters and the receiver are implemented by Raspberry Pi 3 Model B+, and we adopted the RM-92A as the LoRa interface and the SIM28ML as the GPS module. The receiver receives the data via LoRa or Wi-Fi communications and transmits it to the data storage server. In this experiment, the on-board transmitter was installed on the dashboard in a car. The receiver was installed on the roof of the building with 30m height. This building was made to be a starting point and a returning point of five cars. The SF value is set to 7 and 10. N is set to 5 based on the number of transmitters. The transmission interval of $I + \alpha$ was set to 20s to allow greater leeway in the regulation of the transmission period. Moreover, the transmitter set the time by the GPS module, and all transmitters can synchronize the time and set the O based on (2).

Figure 2 shows the results of the data collection rate (DCR), which is an average value of five cars via LoRa communication, with SF7 (left) and SF10 (right). Here, we introduced Elasticsearch as a database and Kibana as a visualization tool on the map to visualize the collected data. From these results, the DCR of SF10 was improved by 17.4 % for the whole route than SF7. To discuss the DCR in detail, we divided the route into five sections, as shown in the left side of Fig.2, and investigated each DCR.

Figure 3 shows the DCR results of each area. As shown in Fig.3, the DCR of areas 2, 3, and 4 were less than 60% in both SF7 and SF10. It is considered that the influence of landform and building lowered the communication performance of LoRa. Focusing on these areas' characteristics, there are tall buildings between the transmitters and the receiver in area 2, area 3 has dense low houses, and there is a hill between the transmitters and the receiver in area 4. In areas 1 and 4, there were few tall buildings and little differences in height due to topography. Next, focusing on the DCR for changes in SF values, the DCR in areas 1 and 4 were improved by 22% and 28%, respectively, but the DCR in areas 2 and 3 were only enhanced by 7.8% and 12%. From these results, we can say that the communication performance of LoRa is determined by physical obstacles due to buildings and landforms, and it was difficult to solve the improving of the DCR only by adjusting SF. Moreover, to collect data of running cars in urban areas, it is important to prepare not only real-time data transmission through LoRa communication but also data collection using a WLAN or the like for backup. Note that we were able to obtain all data via WLAN in this experiment.

4. conclusion

In this study, we proposed the data collection platform using LoRa and Wi-Fi communication and showed the problems of LoRa communication in an urban area. In future works, we will examine the application, including the utilization of collected data, and verify this platform's effectiveness through experiments.

Acknowledgment

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