Development of Vehicle Management System using Location Data Collected by 920MHz LoRa

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Daiki Nobayashi[1], Yasufumi Niwa[1], Kazuya Tsukamoto[1], and Takeshi Ikenaga[1]
[1] Kyushu Institute of Technology, Fukuoka, Japan
nova@ecs.kyutech.ac.jp, niwa.yasufumi543@mail.kyutech.jp, tsukamoto@cse.kyutech.ac.jp, ike@ecs.kyutech.ac.jp

***Abstract*—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 this paper, we propose the vehicle management system at a low cost and effecivery using LoRa and Wi-Fi communication. Furthermore, we propose the application to estimate the arrival time assuming the use by a rental car company. The effectiveness of the proposed method is evaluated through demonstration experiments.**

***Index Terms*—LoRa communication, LPWA, Applications, MaaS**

I. Introduction

As one application example of IoT (Internet of Things) technology, MaaS (Mobility as a Service) is expected to solve traffic and environmental problems by collecting and utilizing enormous data obtained from vehicles [1]. However, the data obtained from vehicles is not directly available to everyone. For example, the data of a car navigation system equipped with LTE/4G are owned by the vendor that developed it. Therefore, the vehicle deployment business cannot directly handle the car navigation system's data, and it is necessary to purchase the data from the vendor. In this paper, we propose a vehicle management system and application that enables anyone, including the vehicle deployment business, to collect and utilize vehicle data at low cost and efficiency. We then evaluate the effectiveness of the proposed system through demonstration experiments in urban areas.

II. Proposed System

Figure 1 shows an overview of our proposed vehicle management system and application. This proposed system consists of on-board GPS transmitters (Hereinafter, we call just GPS transmitter) with LoRa and Wi-Fi interfaces, receivers of GPS data, the database server that stores the GPS data from receivers, and applications that analyze and utilize the stored data. The GPS transmitter transmits GPS data to the receiver in real-time using LoRa communication. However, since the performance of the packet delivery of LoRa communication may degrade due to the influence of the physical environment, the GPS transmitter stores all GPS data locally and transmits them to the receiver at the time of the Wi-Fi connection. The receiver receiving the GPS data from GPS transmitters sends them to the server connected to the Internet. The detailed functionality of the GPS transmitter and receiver has been evaluated in previous studies [2].

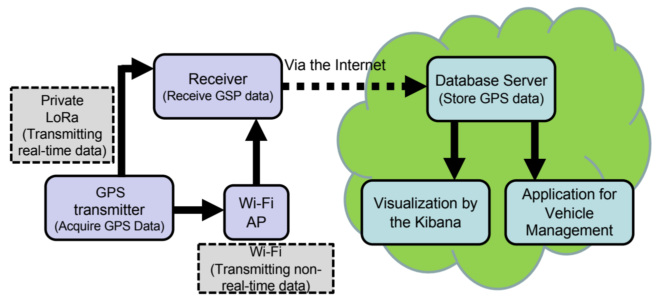

Fig. 1: An Overview of Our Proposed System.

It is necessary for the database software to flexibly deal with not only GPS but also various general-purpose data and to process an enormous amount of data quickly. For this reason, we adopted Elasticsearch, a full-text search engine that can process data at high speed, as a database. Elasticsearch also facilitates real-time analysis using visualization tools (Kibana, etc.).

Furthermore, in this paper, we focus on a car rental company as an example of using accumulated GPS data, and implement a return time prediction application for rent-a-cars based on GPS data. In this application, gas stations (GS) near a return point of a rent-a-car (car rental office) are set in advance. When the real-time GPS data from the GPS transmitter reaches the database, the application extracts the rent-a-car to be returned from the GPS data and then uses Google's Direction API to find a route to the return point via GS. Finally, the application calculates the estimated remaining time to arrival taking into account the fueling time of the rent-a-car. This will allow the operator in the rental car office to prepare for the return operation based on the estimated remaining time to arrival, resulting in improved operational efficiency.

III. Experimental Evaluations

To show the effectiveness of the proposed system, we conducted a running experiment of a car in an urban area, Kitakyushu-city, Fukuoka, Japan. Each details of this experiment shows in Table I. The GPS transmitter and the receiver were implemented using Raspberry Pi 3 Model B+, RF-Link's RM-92A as the LoRa interface, and SIMCom's SIM28ML as the GPS module. LoRa's transmit power is set to 13dBm, and the spreading factor (SF) is set to 12. The GPS transmitter

Fig. 2: Receiving Data from Wi-Fi.

Fig. 3: Receiving Data from Private LoRa.

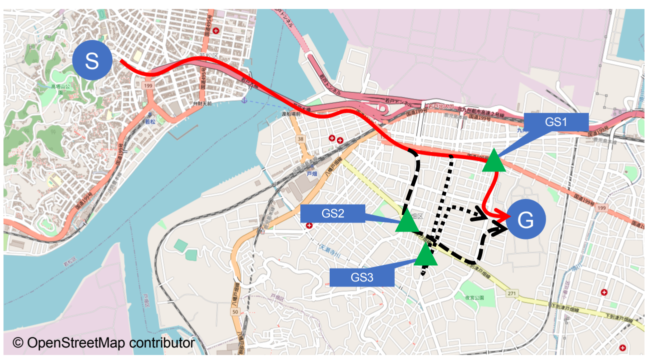

Fig. 4: Extracted Routes from the Applications.

stores GPS data every second and sends the latest GPS data to the receiver via LoRa every five seconds. The database server is constructed using the HPE ProLiant Gen10 DL360 and is set to receive GPS data from the GPS transmitters via the receiver. The data received by the server is stored in Elasticsearch and visualized by Kibana. First, Figs. 2 and 3 show the results of driving data visualization using Kibana by Wi-Fi and LoRa, respectively. Since the data via Wi-Fi include all GPS data, it indicates the vehicle's trajectory. On the other hand, we confirmed that the transmission position's environment caused the loss of data by LoRa. From this result, we confirmed that our proposed system could analyze and visualize the driving data transmitted from the vehicle in real-time.

Next, we show the experimental results of a return time

TABLE I: Experimental Specification.

Item	Value or Details
Main-board	Raspberry Pi 3 Model B+
Modules of LoRa	RM-92A
Modules of GPS	SIM28ML
LoRa's Tx Power	13dBm (20mW)
LoRa's SF	SF12
GPS acquisition interval	1s
LoRa's Tx interval	5s
Database Server	HPE ProLiant Gen10 DL360
Database	Elasticsearch
Visualization Tools	Kibana

TABLE II: The result of Estimated remaining time to arrival.

Via point	Remaining time to arrival
GS1	26 min.
GS2	30 min.
GS3	31 min.

prediction application. In Fig.4, S is the point of departure (GPS data reception position), G is the point of return, and the three green triangles are gas stations, respectively. The arrows indicate the route by the application from S to G via GS in Fig.4. Furthermore, TABLE II shows the estimated remaining time to arrival at the return point of each route. The refueling time was assumed to be fixed at ten minutes. From TABLE II, we confirmed that the application estimates the time of arrival to the return point through each gas station in real-time. Moreover, in the experiment, since the route via GS1 is the shortest estimated remaining time to arrival, it is possible to improve the rent-a-car return operation's efficiency by notifying the operator of the rental car office.

IV. Conclusion

In this paper, we proposed and implemented a vehicle management system to collect and utilize GPS data from vehicles. Furthermore, as an application example, we developed a return time prediction application. The feasibility is shown through experiments. In future works, we will develop more practical applications such as automatic extraction of data (GS Position, etc.) required for calculating accurate return time and conduct demonstration experiments using a large number of vehicles to evaluate their effectiveness.

Acknowledgement

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