On-demand Vehicle Route Planning System for Logistics MaaS

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Transportation management systems are one of the business support tools for logistics companies. Conventional systems require manual operation to change the route plan after the vehicle is dispatched, considering its current position and the time of visit to the customer. Therefore, we have developed a vehicle route planning engine and application programming interface (API) that enable real-time modification of the route plan, such as adding new tasks, even after the vehicle is dispatched. In addition, we have developed an automatic vehicle management system that enables users to check the past dispatch results and current task progress. This paper introduces the functions and performance of these systems.

Keywords: logistics, MaaS (Mobility as a Service), vehicle route planning, API (application programming interface)

1. Introduction

Recently, there has been growing demand for logistics services due to the expansion of e-commerce and the increase in online shopping via smartphone. According to the Ministry of Land, Infrastructure, Transport and Tourism in Japan, the delivery volume via door-to-door domestic parcel delivery services in FY2019 was 4.32 billion parcels, which was an increase of 1.0% from the previous year. It is reported that trucking accounted for about 99.2% of the entire delivery volume.[1] More recently, online shopping has further expanded due to the COVID-19 pandemic, resulting in an increase in delivery volume via door-to-door parcel delivery services. According to Yamato Holdings Co., Ltd., the delivery volume of small parcels from April to September 2020 increased by 13.1% year-on-year.[2]

While demand for logistics services has been growing, a labor shortage has become evident in the industry. According to a survey conducted by the Ministry of Health, Labour and Welfare in August 2020, 29% of business establishments in all the industries surveyed responded that they had a labor shortage, while the percentage was 43% in transport and postal activities.[3] According to a report by the Japan Trucking Association, companies that experienced a shortage or slight shortage of truck drivers accounted for 34.5%.[4]

Under these circumstances, efforts have been made to achieve a new mobility service called logistics MaaS*1. According to the Ministry of Economy, Trade and Industry, consolidated delivery and optimization of transport and delivery routes through the use of digital technologies will be required to achieve logistics MaaS.[5] The transport management system (TMS) is one of the main business support tools available for logistics companies. In general, TMS offers such functions as vehicle route planning management, which formulates efficient vehicle route plans, and real-time vehicle management, which utilizes in-vehicle GPS. The conventional vehicle route planning management function mostly focuses on formulating vehicle route plans before vehicles are dispatched. The original plan cannot be changed after vehicles are dispatched. Thus, when adding new tasks, including delivery, pickup, and forwarding, to a plan, the vehicle to which such tasks are assigned must be selected by taking into account the vehicle's arrival time and loading capacity, and the plan for the vehicle must be updated manually. Manual updates are possible when the numbers of vehicles and parcels are small. When the number of vehicles is large or the original plan is complicated, it becomes difficult to formulate an efficient vehicle route plan.

We have long been working on R&D to increase the operational efficiency of logistics companies.[6] We have developed an on-demand vehicle route planning system, which consists of a vehicle route planning API*2 that enables the user to change a plan in real time even when many vehicles are subject to management, and a web app for real-time vehicle management that visualizes the vehicle information and increases the efficiency of the management operations. This paper introduces the functions of the new API and web app, and presents the performance of our vehicle route planning engine.

2. Vehicle Route Planning System

The new vehicle route planning system consists of a vehicle route planning API, which formulates an efficient vehicle route plan based on the available information about

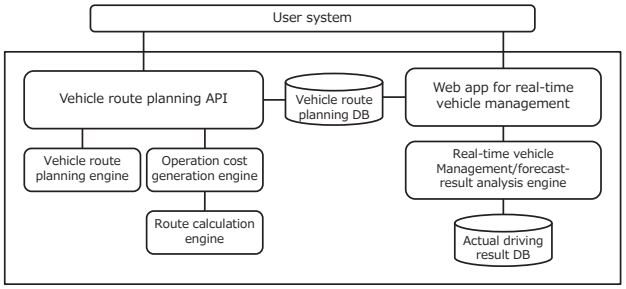

Fig. 1. Configuration of the vehicle route planning system

vehicles and parcels, and a web app for real-time vehicle management, which enables the user to check the plan and the actual operation status on their web browser (Fig. 1).

2-1 Vehicle route planning API

In general, logistics companies deliver parcels by using multiple vehicles. They must plan the assignment of parcels to vehicles and the order of delivery while taking into account the transport cost, such as the driving time and mileage of vehicles (see Fig. 2). When the number of destinations is small, it is relatively easy to formulate a plan. When the numbers of vehicles and parcels are large, and when the time period to visit customers is specified, it is difficult to manually formulate a plan due to the increased complexity. A vehicle route planning API makes it possible to quickly formulate an efficient vehicle route plan even when complex conditions are included.

A vehicle route planning engine formulates an optimal vehicle route plan based on the available information about vehicles and parcels and the information about operation cost generated by the Traffic Vision*3 route distribution engine. The new vehicle route planning engine can formulate a plan by taking into account various conditions. Regarding vehicles, the engine enables the user to specify vehicle models, maximum operation time, and the necessity to return to the operation center if applicable. Regarding parcels, the engine makes it possible to specify the vehicles or vehicle models to which parcels can be assigned and the necessity to load parcels on the previous evening*4 if applicable. The new engine can change the plan after vehicles are dispatched (see Fig. 3).

When a customer makes a sudden delivery request, this function enables the user to automatically select an optimal vehicle and update the plan just by requesting information about the customer and parcel from the API. The API also makes it possible to delete tasks for any parcels from the plan, reformulate the plan when customers are absent, and update the plan for vehicles whose tasks are delayed.

2-2 Web app for real-time vehicle management

The web app for real-time vehicle management is designed to manage information about vehicles and vehicle route planning under centralized management (Fig. 4).

This app enables the user to check the information obtained from in-vehicle devices, such as GPS trackers*5 and smartphones, on a web browser. It also offers functions to calculate the route to each destination and the expected arrival time, automatically determine the arrival at or departure from destinations by using information on the vehicle's position, and automatically send notification emails when the system determines that the plan is likely to be delayed.

To improve the daily vehicle route planning, it is necessary to verify past plans and results from a broad perspective. This app can display a plan and results on a map at the same time so that the user can monitor the driving tendency of each driver and the frequency of delays at the respective visiting points, so as to improve the plan in the future (Fig. 5).

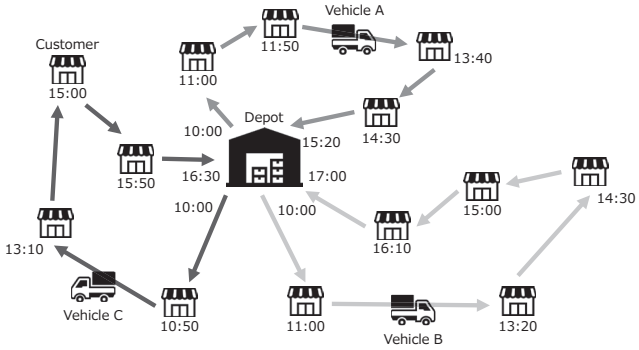

Fig. 2. Example of vehicle route plan

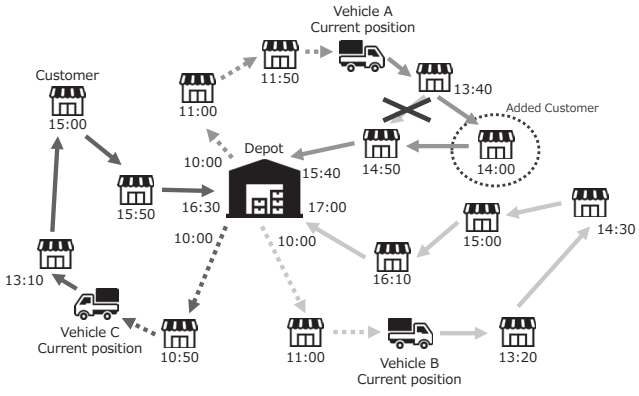

Fig. 3. Vehicle route plan after making changes

Fig. 4. Web app for real-time vehicle management

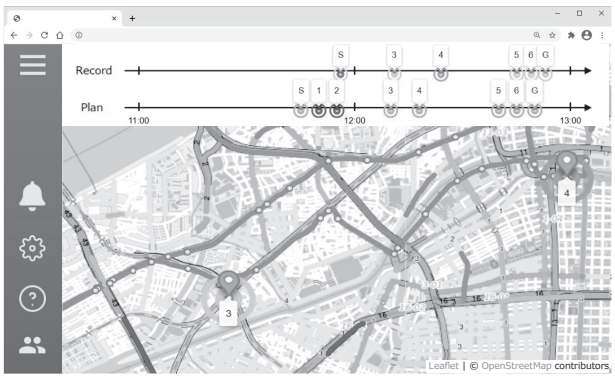

Fig. 5. Display of vehicle route plan and actual work result

The difference between a plan and the results is displayed on a map and time chart using colors that correspond to the magnitude of the difference. By displaying both the difference from the arrival time and the difference from the departure time, the user can quickly determine whether the difference can be attributed to mobility between points or to tasks at the respective points.

3. Performance Evaluation of the Vehicle Route Planning Engine

To investigate the performance of the new vehicle route planning engine, we made an evaluation in comparison with our conventional product. In general, a vehicle route planning engine that can quickly formulate a highly efficient plan is considered to be high-performance. The efficiency of a formulated vehicle route plan is represented by the number of vehicles used in the plan (number of vehicles) and the sum total of the time from departure from the center to return to the center for each vehicle (operation time). The response speed is represented by the time from the startup of the vehicle route planning engine to output of a vehicle route plan (calculation time). Compared to an inefficient vehicle routing and scheduling plan, an efficient vehicle route plan enables logistics companies to reduce the working hours of their drivers, fuel consumption of their vehicles, and tasks required to arrange chartered vehicles*6. From the viewpoint of increasing the efficiency of tasks to formulate a plan, which previously required many hours, the calculation time of an engine is an important factor. Thus, we compared the conventional engine with the new engine in terms of the number of vehicles, operation time, and calculation time.

Multiple sample data sets were created based on an evaluation setting in which the Osaka Prefectural Government Office was the center for vehicles and the municipal elementary schools in Osaka Prefecture were the visiting points to perform tasks. Vehicle route plans were formulated using the conventional engine and the new engine, respectively (Table 1). The operation cost between points was calculated in advance for evaluation by using both the conventional and new engines.

Table 1. Performance of vehicle route planning and actual work result (compared to the conventional vehicle route planning engine)

Evaluation Index	Improvement Rate
Number of Vehicles	- 12.5%
Operating Time	- 5.1%
Calculation Time	- 49.5%

Table 1 shows that the new engine can formulate a more efficient plan more quickly than the conventional engine.

4. Conclusion

This paper introduced the vehicle route planning API, which can change a plan in real time, and the web app for real-time vehicle management, which ensures centralized management of vehicle plans and results. The app makes it possible to formulate vehicle route plans and automate the vehicle management tasks. This significantly increases the efficiency of operations at logistics companies. Use of the API achieves easy linkage with various services, making it possible to meet the various needs of users. We are currently promoting the development of our proprietary integrated vehicle route planning systems that incorporate the API as well as products that link vehicle route planning with real-time vehicle management.

Technical Terms

∗1 MaaS: Abbreviation of Mobility as a Service. This is a new concept for considering mobility, which is achieved by all means of transport, as a service by connecting various transport services through the cloud using ICT.

∗2 API: Abbreviation of application programming interface. Part of the underlying software of an API is made publicly available to share functionality with other software.

∗3 Traffic Vision: Software manufactured by Sumitomo Electric System Solutions Co., Ltd. that provides functions such as address search, map distribution, and route distribution.

∗4 Loading parcels on the previous evening: This is practiced so that a vehicle can be dispatched first thing in the morning on the following day.

∗5 GPS trackers: A device that can send location information acquired by GPS and view the information from a personal computer connected to the Internet.

∗6 Chartered vehicles: Transport and delivery companies temporarily borrow vehicles from other companies to perform transport and delivery operations.

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