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MaaS at NTT DOCOMO —Finding Solutions to Social Problems in Mobility—

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The new concept of MaaS targeting the movement of people will provide a seamless service that uses ICT to coordinate various means of mobility such as trains, buses, taxis, and rental bikes and integrate all steps from making a reservation to paying the fare. Amid this trend toward next-generation mobility, NTT DOCOMO is promoting MaaS initiatives in the three areas of advanced mobility, integrated mobility, and service linking (mobility × services). In this article, we describe an overview of the key technologies in each of these categories and NTT DOCOMO's approach to MaaS business development.

1. Introduction

Problems related to mobility are not limited to eliminating traffic jams or congestion at major transport terminals. They extend to maintaining routes in public transportation and providing mobility for people in areas with a small residential population where establishing new routes is difficult and for elderly residents who cannot easily use a private car. In addition, the increase in tourists visiting Japan is already generating new problems such as severe traffic jams in areas where tourists tend to congregate (**Figure 1**). A solution to these problems that is now attracting attention is Mobility as a Service (MaaS), which is a new concept in mobility that aims to integrate different means of mobility such as trains, buses, taxis, and rental bikes. NTT DOCOMO is promoting initiatives in

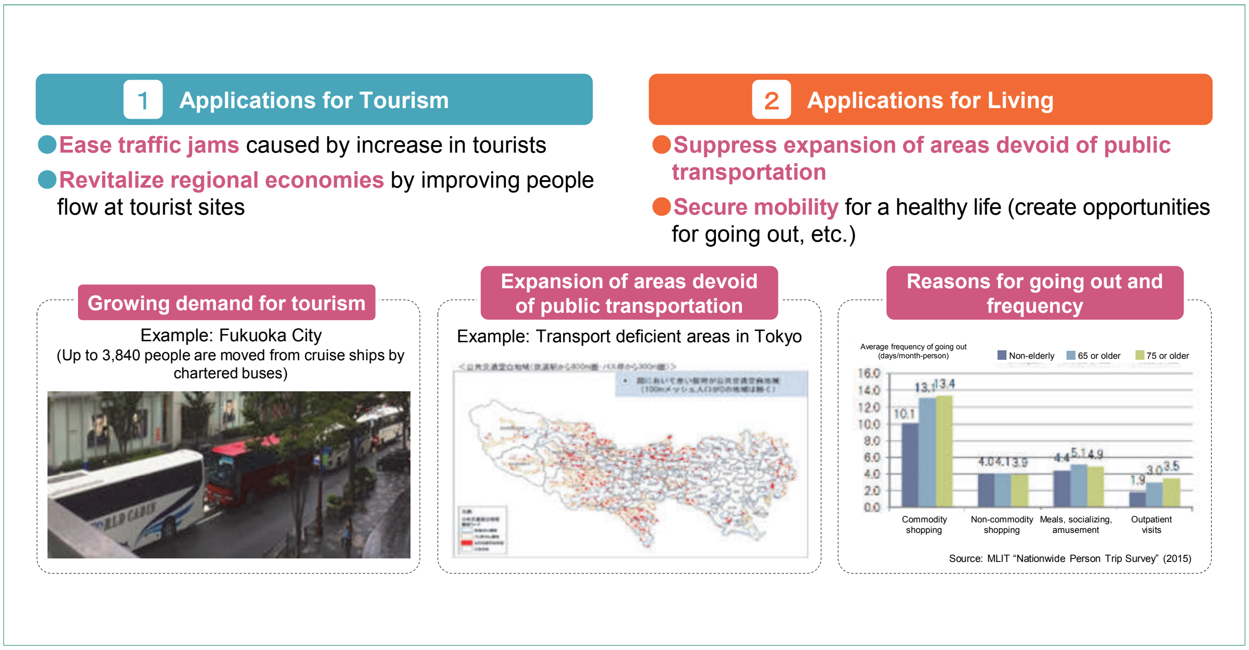


Figure 1 Background to MaaS initiatives at NTT DOCOMO—severe mobility problems—

the three categories of mobility enhancement, mobility integration, and service linking (mobility × services). In this article, we provide an overview of a real-time version of Mobile Spatial Statistics*1 [1] (population statistical data) using the mechanism of NTT DOCOMO's mobile phone network and describe technology that can improve mobility efficiency in combination with AI technology. We also describe NTT DOCOMO's approach to MaaS business development.

2. MaaS Initiatives at NTT DOCOMO

In simple terms, NTT DOCOMO thinks of MaaS as a means of "solving diverse social problems related to mobility in Japan." With this in mind, it classifies MaaS into the following three types as targets of development:

- Advanced MaaS

  Enhancing individual modes of transportation for personal movement such as walking, bicycling, riding a bus, and riding a taxi
- Integrated MaaS

  Integrating multiple modes of transportation typified by Finland's Whim*2 platform
- Service-linking MaaS

  Linking transportation with peripheral services such as retail sales, lodging, amusement, medical care and welfare, and finance and insurance

Among the above, the most urgent problem that NTT DOCOMO needs to address lies in the first-mile and last-mile of transportation (secondary transportation). For this reason, NTT DOCOMO is first studying advanced means of dispatching in on-demand transportation using AI technology in

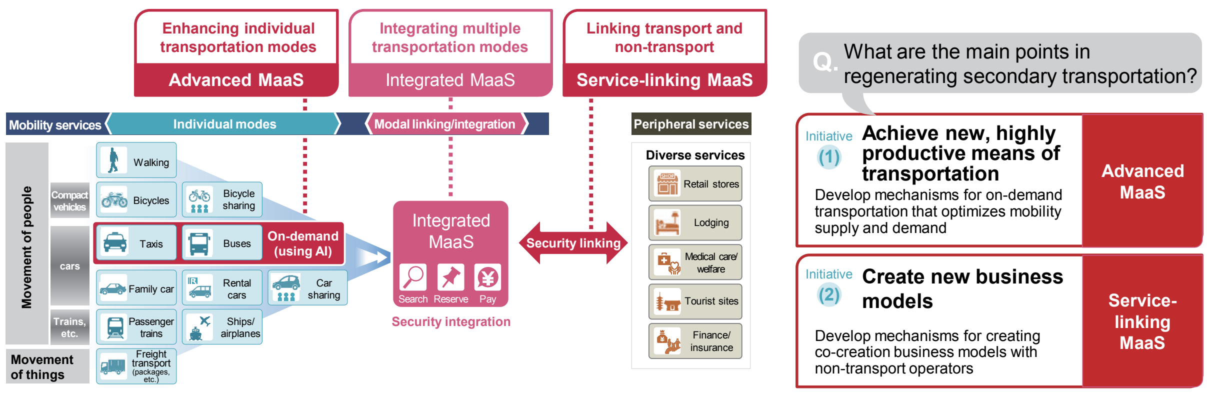
*1 Mobile Spatial Statistics: Population statistical data generated according to the "Mobile Spatial Statistics Guidelines," from NTT DOCOMO mobile network operations data. Population distributions on a grid and by municipal boundaries are estimated such that individual users cannot be identified, using an estimation of the number of mobile phones currently in each base-station area and adjusting based on base-station area data, NTT DOCOMO phone usage rates and other information.

*2 Whim: A MaaS solution developed by the Finnish startup MaaS Global. The Whim platform provides the world's first service to seamlessly connect different modes of transportation via a single application.

the area of "advanced MaaS."

Furthermore, to achieve sustainable means of secondary transportation, NTT DOCOMO is conducting parallel studies on the creation of new business models in the area of "service-linking MaaS" that combines mobility services with services in other industries (**Figure 2**).

To give two examples, NTT DOCOMO has already implemented AI Taxi [2] that optimizes mobility supply through demand prediction and AI Bus*3 [3] that optimizes mobility supply and creates business in the form of "mobility × services (referrals)" (**Figure 3**).



*NTT DOCOMO revisions to materials from MLIT "Working Group for New Mobility Services in Cities and Regional Areas"

Figure 2 NTT DOCOMO's approach to MaaS—initiatives toward solving mobility problems—

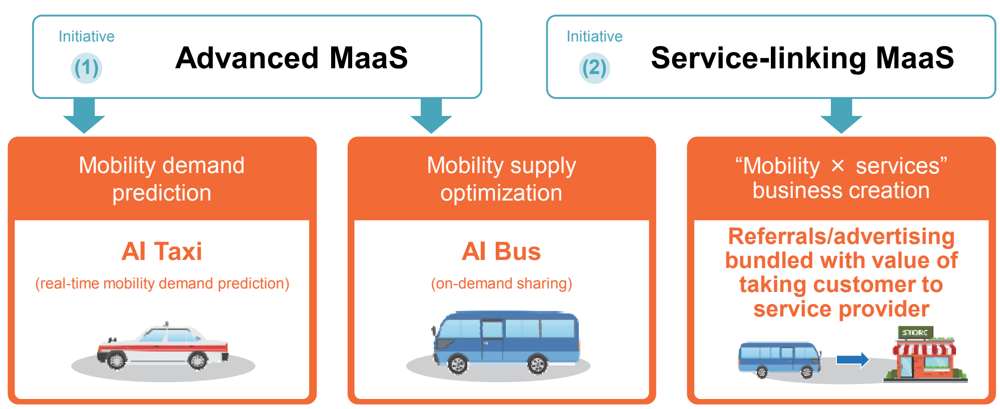


Figure 3 NTT DOCOMO MaaS initiatives

*3 AI Bus: A trademark or registered trademark of NTT DOCOMO, Inc.

3. Advanced MaaS: AI Taxi —Mobility Demand Prediction—

NTT DOCOMO is rolling out a service called AI Taxi with the aim of optimizing the dispatching of taxis. It has been providing the service commercially since February 2018 after developing technology for predicting mobility demand for taxi services and conducting business trials. AI Taxi predicts taxi passenger demand up to 30 minutes into the future in units of 500 m squared cells. This prediction data is provided to taxi operators every ten minutes so that taxis can be dispatched to areas of high demand based on prediction results (**Figure 4**). In addition to shortening the time for customers to find an empty taxi, this service is expected to benefit taxi operators too by reducing the time that their taxis are empty and maximizing the time that they are occupied (the state in which they are carrying passengers) thereby increasing revenue.

3.1 Improving Accuracy of Demand Prediction Using Population Statistical Data

The prediction of taxi passenger demand makes use of population statistical data in addition to actual passenger data from the past, weather forecasts, etc. This makes for more accurate prediction even under unexpected conditions such as train delays or one-time events that are difficult to predict solely on the basis of past results (**Figure 5**). Furthermore, since it is known that correlations can be observed between changes in population and changes in taxi passenger demand even in normal periods, using change in population as input data makes it possible to predict change in passenger demand.

3.2 Hybrid Prediction Technique

The prediction technique in AI Taxi uses a prediction model that combines a multivariate auto-regressive model*4, a type of time-series prediction

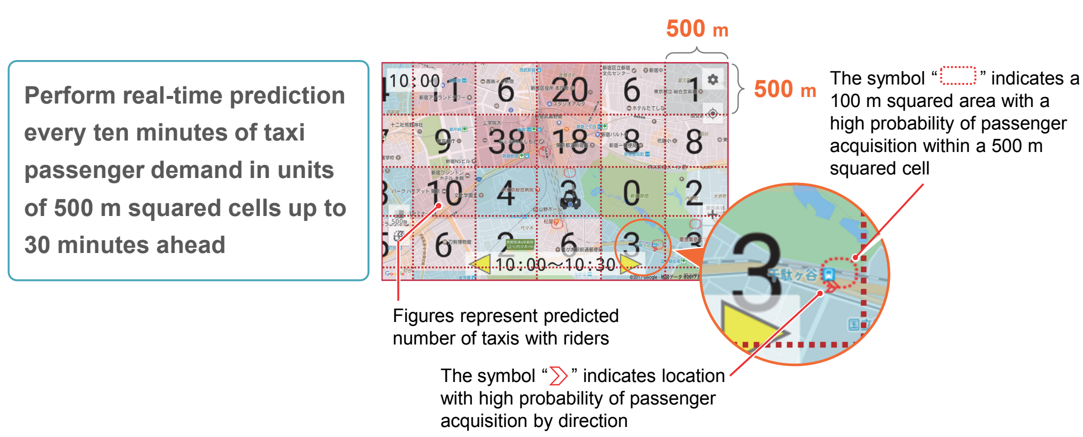


Figure 4 AI Taxi service scheme

*4 **Multivariate auto-regressive model:** An auto-regressive model extended for multiple variables. Also called a vector auto-regressive model.

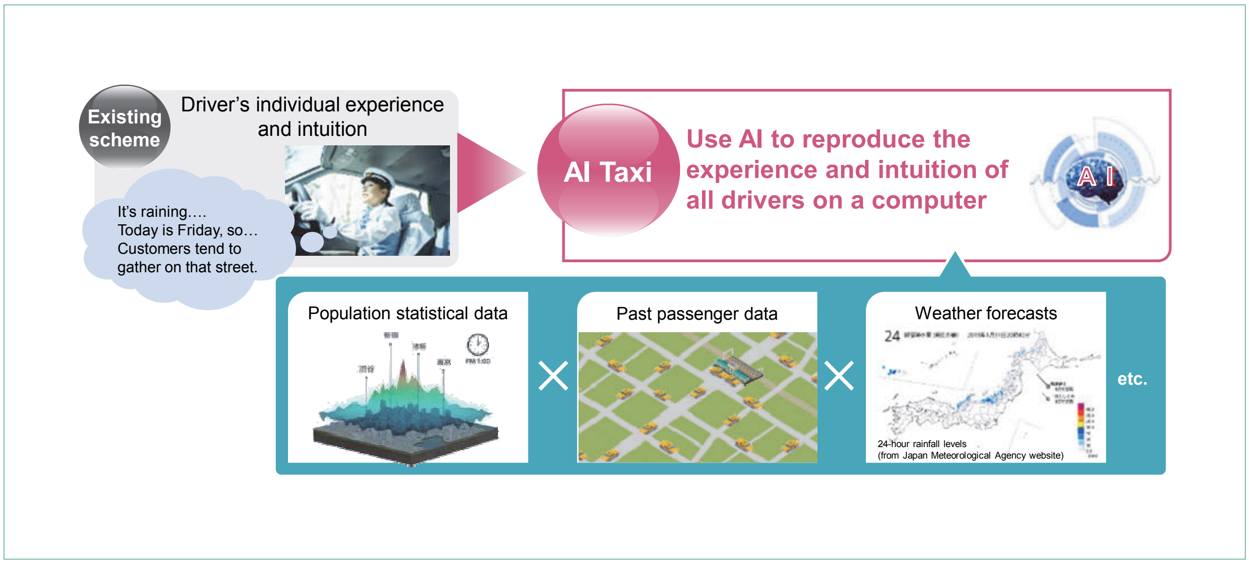


Figure 5 AI Taxi initiative

model, and a deep learning*5 model [4]. Although correlations can be observed between changes in population and changes in passenger demand, there are some cases in which passenger demand increases with increase in population and others in which passenger demand increases with decrease in population depending on the area. In addition, the time delay in passenger demand following a fluctuation in population depends on the area. For example, given an area in which other transportation facilities exist such as a train station, taxi passenger demand will soon increase along with an increase in population. However, given an area in which commercial facilities or event venues exist, it may take several hours for passenger demand to increase since potential passengers will stay in those facilities for a certain amount of time. In this way, our technique is combined with deep learning that can mechanically extract features so that data having area-specific correlations can be handled correctly.

4. Advanced MaaS: AI Bus —Mobility Supply Optimization—

AI Bus is an on-demand transportation system that can take you where you want to go when you want to go (**Figure 6**). It enables a user to reserve a ride through a dedicated smartphone app by simply specifying ride time and pickup and drop-off points without having to worry about bus routes or schedules.

4.1 Efficient On-demand Dispatching Using AI

Achieving efficient on-demand dispatching in response to real-time ride requests requires that optimal vehicle allocation and operating routes be computed using AI. Having each driver operate the bus according to an operating plan calculated and presented by AI at any time makes for pickup and drop-off that can meet user mobility demand in the most efficient manner. This operating plan

*5 Deep learning: A method of machine learning using a multi-layered neural network.

takes the shortest route between the pickup and drop-off points and makes it unnecessary to drive in intervals having no users, which shortens travel time compared with conventional fixed-schedule/fixed-route buses. Furthermore, as a shared type of transportation service that assumes simultaneous use by multiple riders, AI Bus can lower the cost per trip and provide a relatively inexpensive service compared with individual means of conveyance such as taxis.

4.2 Operating Area Recommendation Function Based on Demand Prediction

To further improve operating efficiency, NTT DOCOMO has achieved an "operating area recommendation function based on demand prediction" (**Figure 7**). In

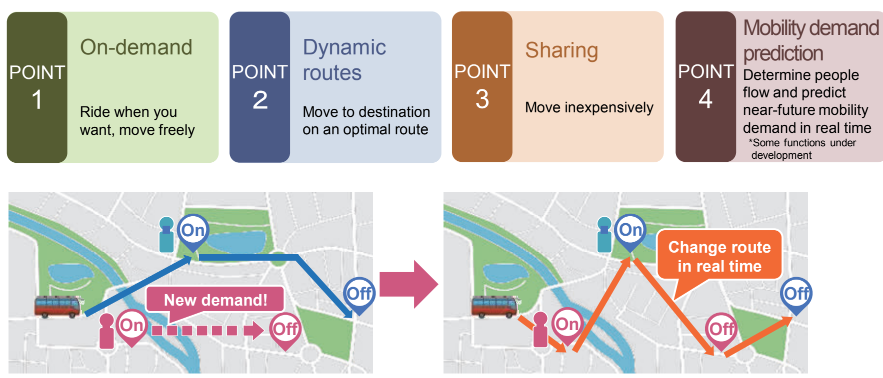


Figure 6 AI Bus initiative

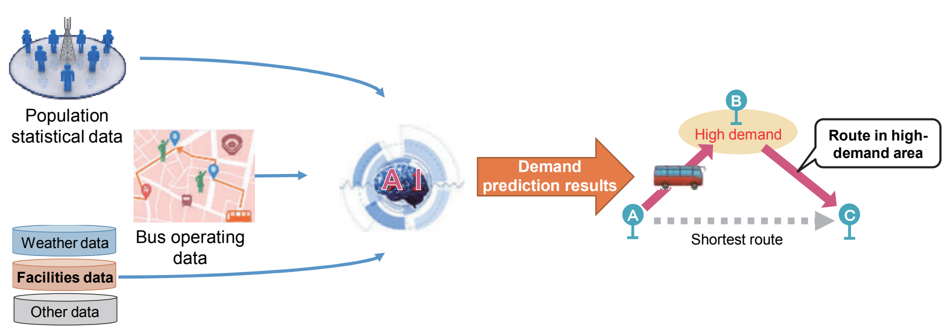


Figure 7 Recommendation of routes or waiting points by passenger demand prediction

on-demand dispatching described above, the operating plan of each vehicle is recomputed whenever a new ride reservation comes in from a user. At this time, however, the plan must be updated without causing a major delay in the picking up and dropping off of confirmed users such as those already on the bus in transit. There is consequently concern as a result of this constraint that pickup for new users will be put off even if seats are available especially when many ride reservations are coming in all at once. To solve this problem, the proposed function predicts the number of reservations in each area and presents drivers with recommended routes or waiting points in high-demand areas. As a result, drivers take routes that make the rounds of high-demand areas while satisfying the above constraint instead of only running between pickup and drop-off points by the shortest route based on existing predictions. Additionally, having empty vehicles wait in standby mode in high-demand areas should make it possible to shorten user wait time and accommodate more users.

As in the case of AI Taxi, AI Bus uses past passenger data, population statistical data, etc. to construct a demand prediction model, but as a learning algorithm, it adopts eXtreme Gradient Boosting (XGBoost)*6 [5], which is a type of ensemble learning*7 especially effective for fast learning. The reason for using this requirement is as follows.

To make this recommendation function effective, a period is needed for collecting model-training data after commencing actual use of the service in the target region. From a business perspective, however, it is desirable to construct a model as early as possible to make this function effective. With this in mind, and considering that the amount of data obtained in a one- or two-month period is small, we adopted this technique to achieve predictions having fluctuations in results as small as possible.

5. Service-linking MaaS: "Mobility × Services" Business Creation via AI Bus

In this section, we first present an example of using MaaS for creating a convenient and low-priced tourism mobility experience (**Figure 8**) and then describe a mechanism for new business creation through "service-linking MaaS" that links mobility with services in other industries.

5.1 Tourism Mobility Experience by MaaS

When wanting to visit a tourist site for the first time, it's difficult for a tourist to select an optimal travel route to that destination without being familiar with that area. Furthermore, considering that the trip may require connections over multiple routes, the complexity involved may prompt the tourist to simply give up on the trip. With this in mind, we considered a method that would provide the tourist with another means of mobility. This method would uncover latent mobility needs that existing means of transportation cannot easily satisfy and make it easier for a tourist to move about.

In this method, the tourist uses a rider application to get information on the desired destination such as a tourist site or commercial facility and calls an AI Bus (secondary transportation) that can take the tourist from a nearby pickup point to the destination in an on-demand manner. In this way,

*6 XGBoost: A type of ensemble learning that has been attracting attention in recent years.

*7 Ensemble learning: A technique that constructs a number of different models and integrates the prediction results of those models at prediction time. This approach is expected to enhance prediction performance with respect to unknown data.

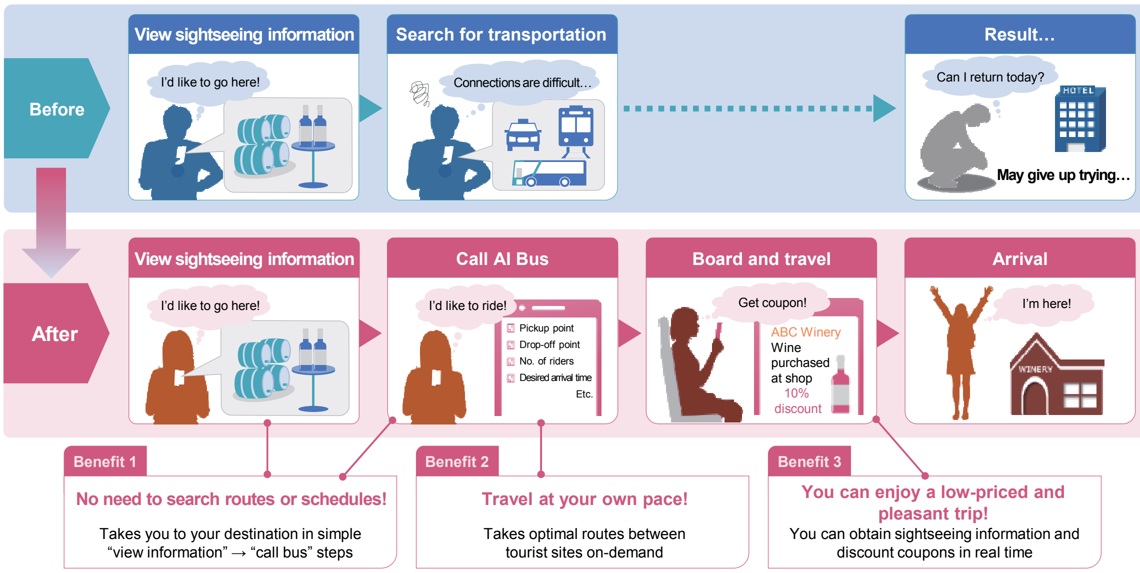


Figure 8 Convenient and low-priced tourism mobility experience by service-linking MaaS

the tourist has no need to check routes or schedules and can easily get to the desired destination at one's own pace. Additionally, the user can obtain sightseeing information on the destination and surrounding area and discount coupons as well while waiting to be picked up by the AI Bus or while riding. This makes for a leisurely tour while enabling the user to receive discount services in meals, shopping, etc.

At the same time, NTT DOCOMO is providing a store management portal for stores as a support tool for attracting customers. This portal applies near-future people flow prediction*8 [6] using corevo®*9 AI technology from the NTT Group to enable stores to reference the number and attributes of visitors as a visual representation of future mobility demand and to understand how people are checking and browsing through information on one's own store on the Web. A retail store or commercial establishment can use this portal to deliver coupon information in real time along with announcements and a description of its business with the feeling of a blog via the rider application used by tourists (Figure 9).

5.2 Expanded Linking of Mobility and Other Services through API Development

In addition to the above, we aim to promote business creation in the form of "mobility × services," and to this end, we have converted the function dealing with AI Bus reservations to an application programming interface (API)*10 to enable linking with peripheral services in other industries such as retail sales, lodging, medical care and welfare,

*8 Near-future people flow prediction: A trademark or registered trademark of NTT DOCOMO, Inc.

*9 corevo®: A registered trademark of Nippon Telegraph and Telephone Corporation.

*10 API: A general-purpose interface for using functions and data.

Figure 9 Yokohama MaaS trial: Screen shots of store management portal

sightseeing, finance, and insurance. In this way, we have created a mechanism that enables a peripheral service to specify pickup and drop-off points, number of riders, desired time of pickup, etc. and to reserve a vehicle thereby making it easy to dispatch an available AI Bus.

For example, this mechanism could be linked to a hospital system so that an AI Bus could be arranged as a means of taking a patient home in conjunction with payment procedures after an examination. The mechanism could also be linked with the hospital's reservation system to send the patient a reminder on the day before the patient's next examination and to reserve an AI Bus for the day of the examination if needed.

Our plan is to promote business creation in the form of "mobility × services" by expanding the linking of mobility with services in other industries as demonstrated by this example of linking with hospital services.

6. Conclusion

In this article, we described MaaS initiatives at NTT DOCOMO while providing overviews of relevant technologies. With an eye toward future technology development, we plan to study ways of improving accuracy and providing new added value through advanced AI technologies based on real-world data from the field and population statistical data.

Furthermore, in parallel with such technical enhancements, we will strive to build relationships between local governments and transport operators and expand the MaaS coverage area. We also aim to develop diverse methods for providing MaaS systems and to support the creation of new business such as by expanding business partnerships with peripheral services.

From here on, as self-driving reaches the practical level, the concept of mobility and its business structure will surely undergo major changes. At that time, we feel that the technologies and service scenarios introduced here will become indispensable to modern mobility. At NTT DOCOMO, we plan to boost our efforts in MaaS development to contribute to the solving of social problems such as by making mobility even more convenient for all and revitalizing regional economies.

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