# Activities on Multimodal MaaS to Solve the First Mile/Last Mile Problem—NTT DOCOMO's Next-generation Mobility Service

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**Abstract**

This article introduces NTT DOCOMO's activities that use artificial intelligence and cross-industrial collaboration to achieve sustainable communities and smart cities and solve the first mile/last mile (FM/LM) problem—the shortage of the FM/LM connection to public transportation—that is seriously affecting both resident and tourist transport services.

*Keywords: next-generation mobility service, AI Taxi, AI Bus*

## 1. Introduction

With the emergence of CASE (connected, autonomous, shared, and electric), the automobile industry is undergoing major transformation, the kind that is said to occur only once every hundred years. This transformation along with the entry of companies from outside the industry is compelling automakers to make vigorous effort to create businesses for next-generation mobility services [1].

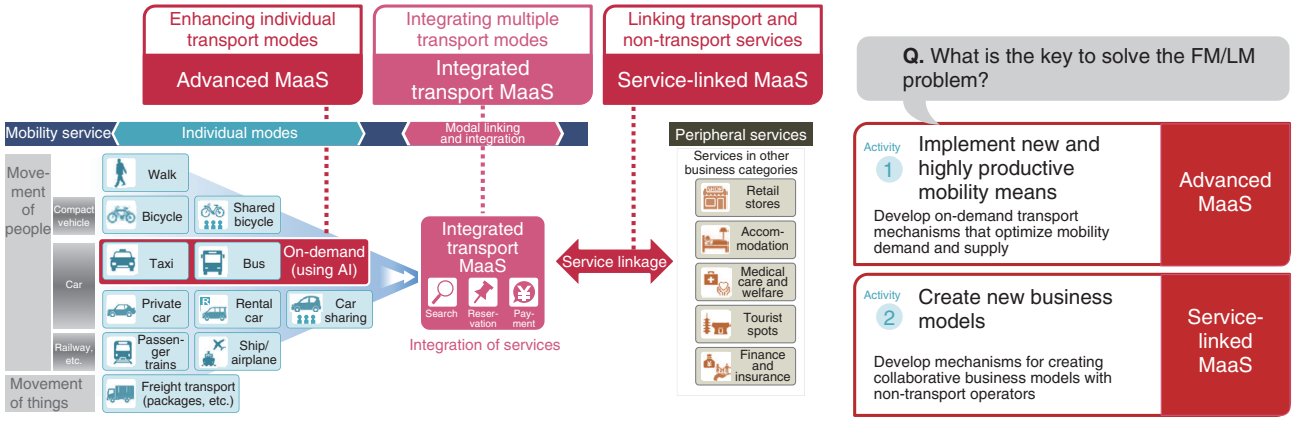
As part of this effort, a concept of next-generation mobility, called mobility as a service (MaaS), was proposed in Europe. It is intended to solve mobility-related problems, such as traffic congestion and carbon dioxide emissions, through a shift from mobility centering on use of private vehicles to use of a wide range of public mobility means, such as railway, bus, taxi, bicycle sharing, and car sharing. Many activities have already started, such as attempts to improve convenience by providing services that seamlessly integrate all travel processes, from reservation to fare payment. In Japan, there is an urgent need to solve the first mile/last mile (FM/LM) problem—the shortage of the FM/LM connection to public transportation—that is seriously affecting both resident and tourist transport services.

NTT DOCOMO initiated its promotion of a bicycle-sharing business in 2010 and has been providing the bicycle-sharing service DOCOMO BIKE SHARE since 2015. NTT DOCOMO has been approaching MaaS from three angles, as shown in **Fig. 1**: advanced MaaS, integrated transport MaaS, and service-linked MaaS (mobility × service). Given the urgency of tackling the FM/LM problem, NTT DOCOMO has given priority to studying the use of artificial intelligence (AI) to optimize vehicle assignment in an on-demand transport system, as part of advanced MaaS.

This article introduces AI Taxi [2] and AI Bus [3] as examples of advanced MaaS and describes NTT DOCOMO's efforts to reinforce the mobility business by linking mobility and services using AI Bus as an example of service-linked MaaS.

## 2. Advanced MaaS: AI Taxi

We developed a technology for forecasting taxi demand in each area of a city from historical taxi-operation data and statistical data on the locations of crowds. A taxi service using this technology has been in commercial service since February 2018 under the




Source: NTT DOCOMO revisions to materials from Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Working Group for New Mobility Services in Cities and Regional Areas"

Fig. 1. NTT DOCOMO's approach to MaaS—Initiatives toward solving mobility problems.

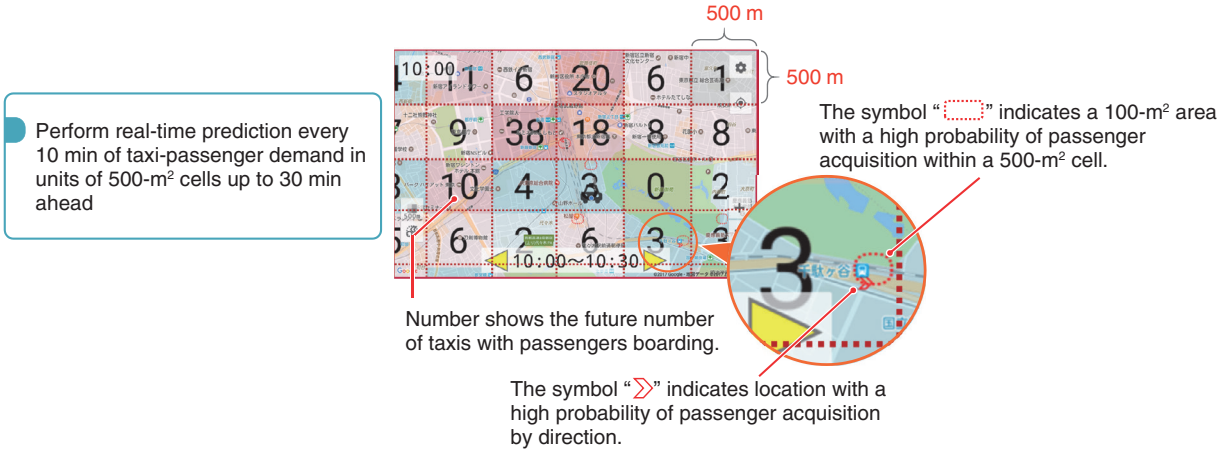



Fig. 2. AI Taxi service scheme.

name of "AI Taxi."

### 2.1 Demand forecast based on demographic data

In addition to using historical taxi-operation data and weather data, AI Taxi forecasts taxi demand using demographic data obtained from Near-Future People Flow Prediction, a technology based on the NTT Group's AI technology "corevo®", that identifies the distribution and flow of people all around the country. Taxi demand up to 30 minutes later in each grid area of 500 square meters is forecast. The forecast data are sent to taxi drivers every 10 minutes so that many taxis can be assigned to high demand areas (**Fig. 2**). Even when there is an unexpected delay in train operation or a special event, taxi demand can be forecast accurately, something which was previously difficult to achieve based on taxi drivers' experience and intuition alone. Even novice drivers with little familiarity with the area can efficiently find passengers and increase the boarding ratio because they can check changing demand in real time. Taxi users can also benefit from having a shortened waiting time.

### 2.2 Use of a hybrid model

Some correlations are known to exist between a change in population in an area and taxi demand. For example, (i) taxi demand depends on the type of area. It increases when the number of people begins to

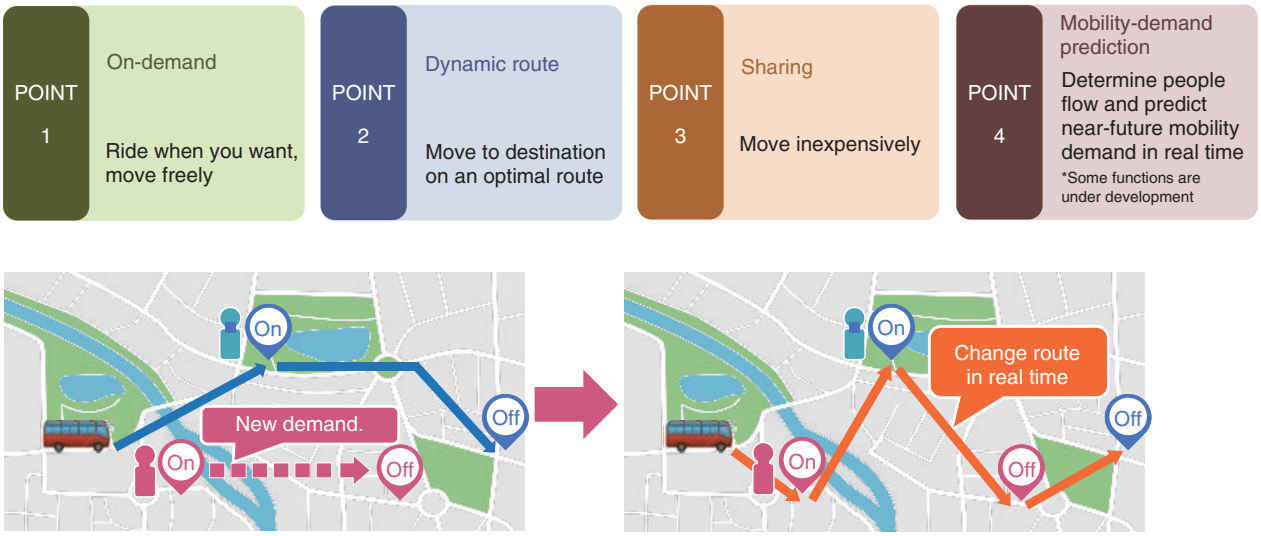



Fig. 3. AI Bus initiatives.

grow in an office district and when it begins to decrease in a shopping and entertainment district. (ii) Taxi demand depends on the type of event, which in turn determines the attributes of people who gather for the event. In a multipurpose stadium, taxi demand increases to a greater extent when people come to watch a baseball game than when people come to watch a girl band perform.

Since correlations between taxi demand and other factors, such as area type or event type, are varied, AI Taxi adopts a hybrid model, in which the results from a multivariate autoregressive model[*1], which is a time-series prediction model, and the results from deep learning[*2] are compared, and the one with a higher level of accuracy is selected.

## 3. Advanced MaaS: AI Bus

An on-demand transport system, AI Bus, has been in commercial service since April 2019. It improves operational efficiency for transport system operators and mobility convenience for users.

### 3.1 Efficient on-demand bus assignment using AI

AI Bus is an on-demand transport system that enables users to go to their desired destinations at the time they want. Users reserve a bus ride via a smartphone app, web browser, or call center, specifying their desired boarding time, destination, and the number of accompanying passengers. The system recalculates the running route of each bus in response to new reservations, which can arise at any time, and notifies drivers of the latest bus-operation plan. In this recalculation, the AI assigns buses and selects routes that are optimal for the current demand under the condition that prospective passengers who have already made reservations will not experience an unduly long waiting time (**Fig. 3**).

Since the bus-operation plan selects only those routes that connect the points where passengers board or alight, the travel time is shorter than in a conventional fixed-time, fixed-route bus service. Furthermore, since AI Bus allows multiple users to share a ride, the user can travel at lower cost than taking a taxi.

### 3.2 Function to recommend a potential service area based on demand forecast

As with AI Taxi, AI Bus forecasts demand in each area based on historical bus-operation data and demographic data and diverts buses to high-demand areas under the condition mentioned above (**Fig. 4**). It has an additional function to reduce passengers' waiting time and improve operational efficiency by notifying drivers of the place where they are to wait when the bus is empty. The collection of learning data is required to enable this function. However, it is difficult

*1 Multivariate autoregressive model: An autoregressive model with an extension to incorporate multivariate data. It is also called a vector autoregression model.

*2 Deep learning: A machine-learning method using a multi-layer neural network.

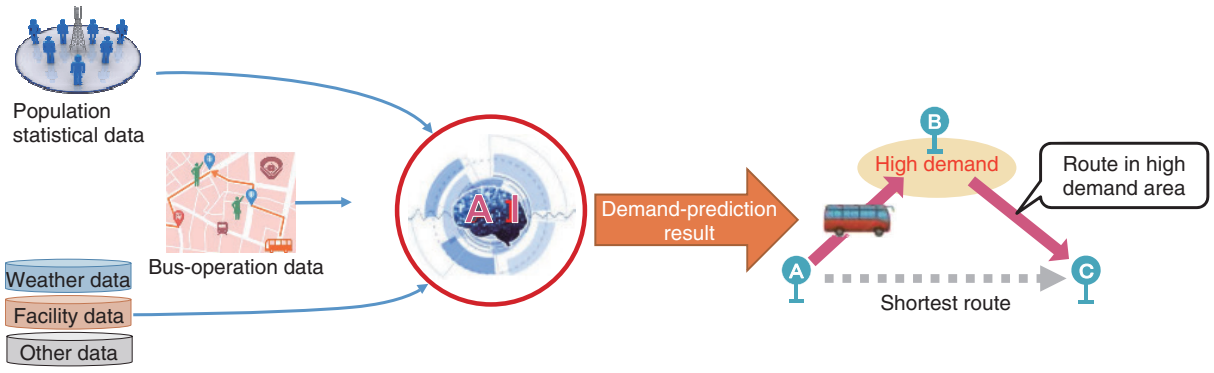



Fig. 4. Recommendation of driving routes/waiting spots based on passenger-demand prediction.

to accumulate learning data because the number of buses involved is small in comparison to the number of taxis. To solve this problem, AI Bus uses XGBoost (eXtreme Gradient Boosting)[*3] for ensemble learning[*4] so that a demand-forecast model can be developed quickly.

## 4. Service-linked MaaS: creating mobility × service business using AI Bus

Two activities on advanced MaaS have been described above. Besides cost optimization, another key to maintaining and reinforcing on-demand bus services is to develop new revenue sources. As an example of service-linked MaaS, a mobility × service business is created by linking AI Bus to the businesses of other companies.

### 4.1 Linkage of AI Bus to stores

Most transport systems do not carry passengers to their final destinations but to nearby stations or bus stops. Therefore, it has been difficult to link a mobility service with passenger activities. With AI Bus, however, users can select their destinations using a smartphone app or web browser, then be transported there, so it is possible to directly provide passengers with a smooth excursion and information about nearby facilities.

A demonstration experiment is being conducted to assist stores in attracting customers. The demonstration system provides a store-management portal, which carries information about stores and other facilities and distributes coupons in real time. The system also visualizes future mobility demand using Near-Future People Flow Prediction so that store owners can find out the number and attributes of prospective visitors and how these prospective visitors have browsed information about their stores (**Fig. 5**).

### 4.2 Linkage between AI Bus and services of other companies

The reservation function of AI Bus is provided through an application programming interface so that the mobility service can be linked to, and enrich, services provided by companies in other business categories, such as retail, accommodation, medical care and welfare, sightseeing spots, finance, and insurance. From services provided by other companies, users can reserve on-demand bus rides and specify the boarding time, boarding and alighting points, and number of accompanying passengers.

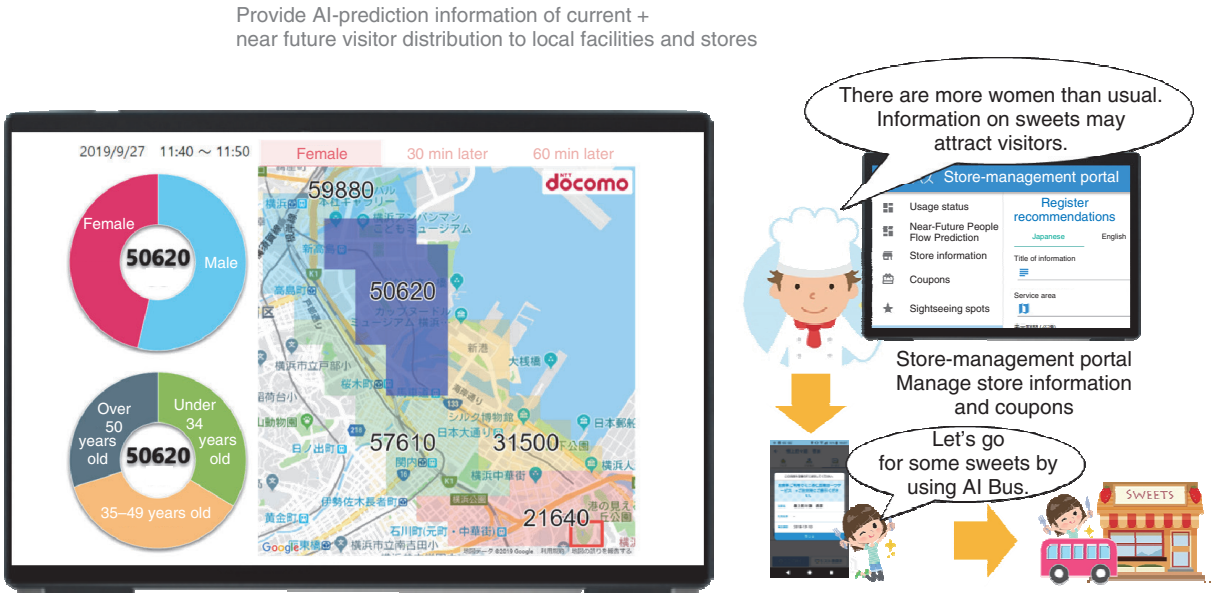
For example, if AI Bus is linked to a medical care system of a hospital, users can reserve a ride on an on-demand bus after settling accounts for examination at the hospital, so they can take a bus at the most convenient time and return home. AI Bus can also be linked to a hospital's reservation management system so that users are reminded of the need to go to the hospital one day before their next examination and can also reserve a ride on an on-demand bus for the examination day.

## 5. Conclusion

This article introduced AI Taxi and AI Bus, which are advanced MaaS platforms being developed by

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

*4 Ensemble learning: A method that builds different models and, in making predictions, integrates the prediction results of these models. This method is expected to improve predictive ability for unknown data.




Store-management portal
Information about people staying in an area (gender and age group)

Note: Screenshot during FY2019 Yokohama MaaS trial
Note: Functional upgrade and provision are being prepared (as of October 2019)

Fig. 5. Customer-management support tool for stores and facilities.

NTT DOCOMO. It also gave examples of service-linked MaaS, which is intended to reinforce business through mobility × service linkage made possible by AI Bus. Looking forward, we will contribute to solving social problems, such as the need to revitalize local economies, by refining mobility services and adding value using the latest AI technologies and expanding MaaS service areas through intensified cooperation with municipalities and transport system operators.

## References

[1] H. Fukai, "Toward Safer and More Comfortable Mobility Services for Anyone, at Anytime and Anyplace –Next-generation Mobility Services at NTT DOCOMO–," NTT DOCOMO Technical Journal, Vol. 21, No. 4, pp. 4–7, Apr. 2020.
[2] S. Kawasaki, S, Ishiguro, Y. Fukazawa, M. Fujita, R. Suzuki, and A. Makishima, "AI Taxi –Taxi Passenger Demand Prediction Technology for Optimizing Traffic–," NTT DOCOMO Technical Journal, Vol. 20, No. 2, pp. 14–21, Nov. 2018.
[3] S. Mizoguchi, M. Takeichi, T. Kamiyama, and S. Kawasaki, "MaaS at NTT DOCOMO –Finding Solutions to Social Problems in Mobility–," NTT DOCOMO Technical Journal, Vol. 21, No. 4, pp. 8–17, Apr. 2020.

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