Featured Articles

Realizing Smart Mobility Using Probe Data

Tatsuya Okubo
Koichiro Yoshioka
Akiyuki Nakamura
Naoyuki Taniguchi

OVERVIEW: The rapid increase in cars, motorbikes, and other road traffic, particularly in the parts of Asia experiencing strong economic growth, is resulting in chronic traffic congestion due to the inability of infrastructure construction to keep up with demand. Because the side effects of this congestion include harm to the environment and economic costs, national governments around the world have recognized it as a major problem. Unfortunately, funding the large investment required to build road infrastructure of a similar standard to developed economies is difficult. Hitachi markets ITSs to emerging economies that are based on the use of probe data and able to be adopted at low cost. Hitachi is also looking to utilize these systems not just in traffic applications but also for a wide variety of social innovations in areas such as logistics or urban planning by using probe technology, so that it can help provide safer and more comfortable lives and contribute to the progress of a society that is conscious of the environment.

INTRODUCTION

THE major cities of Asia are experiencing ongoing rapid growth. Issues such as damage to the environment and economic costs are becoming societal problems in these cities as increasing vehicle use results in chronic traffic congestion. To minimize these problems, it is important to proceed with urban planning and road planning measures that include the construction of the road network and the provision of public transportation, and to do so with reference to congestion and other traffic information.

Over time, devices such as roadside sensors and closed-circuit television (CCTV) have been installed to provide a way of collecting traffic information, particularly in developed economies. However, installing these roadside sensors and other devices along roads over a wide area is expensive, and impractical for emerging economies that struggle to obtain adequate investment for road infrastructure.

In response, Hitachi is working on the implementation of intelligent transport systems (ITSs) that use probe technology and that can typically be installed more quickly and less costly than these older methods. Hitachi has been working on research and development of a variety of ITSs since the 1990s[1), 2)], and has implemented demonstration systems that use probe technology, in countries like the Socialist Republic of Viet Nam and the Republic of Turkey as well as in Japan, with the aim of building up know-how and to verifying their effectiveness.

Also, by using this probe technology, there is scope for deploying these systems not just for traffic applications but also in a wide variety of other areas such as logistics or urban planning to help make society safer and more secure.

This article gives an overview of an ITS that uses probe technology, and describes an overseas demonstration project and the deployment of the system in social innovation businesses that utilize probe technology.

USE OF PROBE TECHNOLOGY FOR TRAFFIC MANAGEMENT

This section gives an overview of an ITS that uses probe technology and describes how traffic information is generated, which is the core technology of the system.

Overview of System that Uses Probe Technology and its Application

The ITS that uses probe technology collects global positioning system (GPS) data (position, speed, time, and other data) from on-board units (OBUs) installed in probe cars. The collected data is sent to a data center

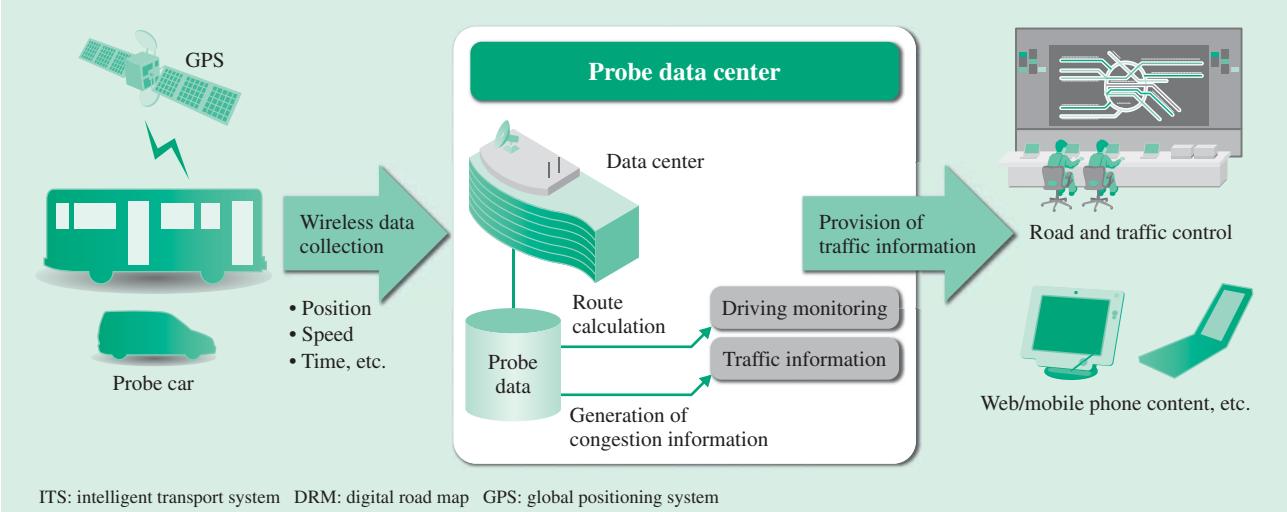

Fig. 1—Overview of ITS Based on Probe Data.
The data center collects driving records, including position information, from probe cars fitted with on-board GPS units and matches this to a DRM. The traffic information obtained by collating this data is then used in applications such as traffic control or the distribution of traffic congestion updates.

via communication methods such as mobile phones or dedicated short-range communication (DSRC) (see Fig. 1). This is stored in a database in such forms as driving records or behavior information. The GPS position data is matched to a digital road map (DRM) (map matching); a calculation is performed to estimate the vehicle's route; and the travel time, speed, and other parameters are also calculated. The system then collates data from a number of vehicles to generate congestion data for each section of road.

The generated traffic information is used for a variety of traffic management tasks, including traffic control, distribution of congestion updates, electronic road pricing (ERP), vehicle behavior management, and road planning.

Technique for Generating Traffic Information from Low-density Position Data

In emerging economies, it is sometimes the case when using probe technology to generate traffic information that the volume of data and density of coverage is inadequate. Reasons for this might include the number of OBUs collecting GPS data being low or the frequency of collection being limited due to the cost cap of communications. When the probe data coverage density is low, it can be difficult to determine the route followed because there may be more than one possibility for traveling between consecutive GPS positioning points.

In response, Hitachi's map matching technique can generate traffic information more accurately and for a wider area from a small quantity of data by using GPS data from a number of locations to estimate the route traveled[3] (see Fig. 2).

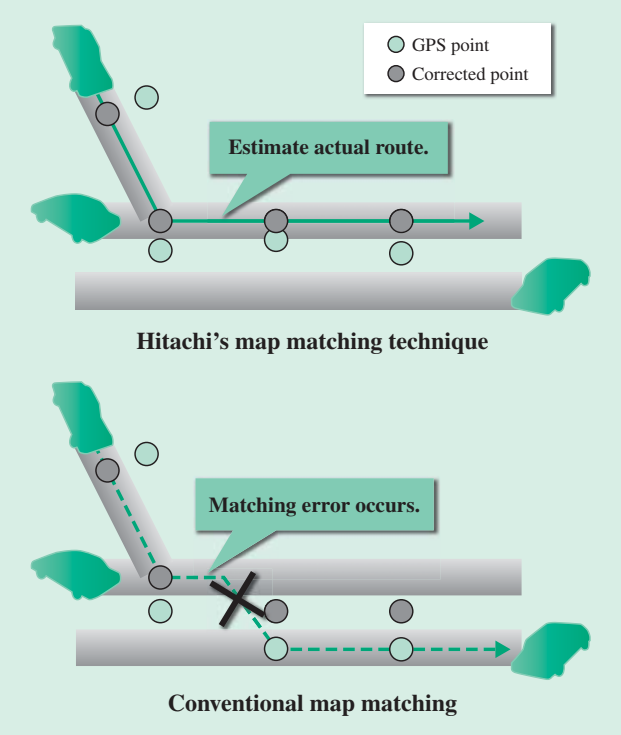

Fig. 2—Hitachi Map Matching Technique.
Rather than matching each GPS position to the map independently, the technique performs highly accurate map matching even when working with a small quantity of probe data by using a number of GPS positions to estimate the route traveled and matching this to the roads along the route.

OVERSEAS PROJECTS

This section describes demonstration projects in Viet Nam and Turkey.

Probe Data System in Viet Nam

Hanoi, Viet Nam, currently uses surveillance cameras to assess road traffic conditions. There is also a prospect of their implementing an ITS using probe technology to collect more accurate information less costly.

For two years from 2011 to 2012, Hitachi participated in the FY2011 and FY2012 projects for the facilitation of trade and investment (demonstration projects and general projects) of the Ministry of Economy, Trade and Industry. This involved a demonstration project that collected and processed probe data from taxis to assess traffic congestion in Hanoi and obtain useful information for road and transportation planning.

By matching taxi probe data (300 vehicles in the first year, 800 vehicles in the second) to a DRM and calculating and displaying the traffic information for each section of road and time period, the demonstration project produced data, graphics, and other forms of information that could be used to assess the overall traffic situation in Hanoi (see Fig. 3).

The demonstration project achieved an accuracy of congestion identification (a traffic information indicator) of approximately 70% and confirmed that traffic information obtained from taxi probe data could be used for tasks such as traffic control.

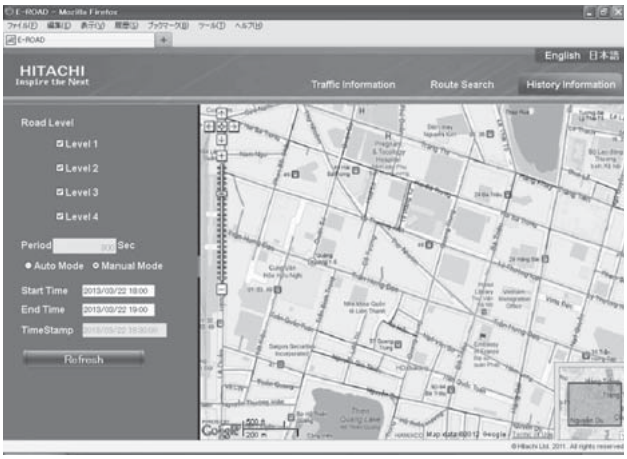

Fig. 3—Traffic Information Display Tool Used in Hanoi Demonstration Project.
The tool can display the traffic information for each section of road for any time period.

Probe Data System in Turkey

Although Istanbul, Turkey, has a traffic control system that uses roadside sensors and CCTV cameras, chronic traffic congestion is a serious problem in the city.

Because use of roadside sensors to assess traffic conditions is only available along certain main roads in the current system, solving the city's congestion problem will require the collection of detailed traffic information that includes minor roads.

Also, because parts of Istanbul are designated as world heritage sites, it is difficult to undertake major work such as road building or widening. As a result, the city of Istanbul has set out to solve its congestion problems by adopting ITS technology rather than by embarking on major road works.

Hitachi has been using probe technology to operate a model business since August 2013 through a demonstration project (FY2013 project of the Ministry of Land, Infrastructure, Transport and Tourism for using model businesses to study the viability of overseas deployment of ITS technology).

This project involves use of a demonstration system that generates traffic information using probe data from 2,000 buses, and that includes a function for determining the fastest route between any two points. Planned work includes conducting road tests and other measures to verify the system's accuracy, and demonstrating that Hitachi's model business has the technology to help resolve Istanbul's traffic issues (to be completed by March 2014).

It is hoped that the spread of congestion can be minimized in the future by giving the public access to the traffic information provided by the model business. It is also hoped that the system will improve public convenience by, for example, shortening the time taken by emergency and other vehicles to reach their destination by providing them with fastest-route information.

DEPLOYMENT OF SOCIAL INNOVATION BUSINESS BASED AROUND PROBE DATA

In addition to OBUs, probe data can also be collected from GPS-equipped smartphones or smartcards. This data can then be processed to enable the measurement and management of the movement of people and vehicles of various types, such as cars, buses, and trains. There is also the potential to extend the use of this technology beyond traffic applications to include a wide variety of social innovation businesses in areas such as logistics or urban planning.

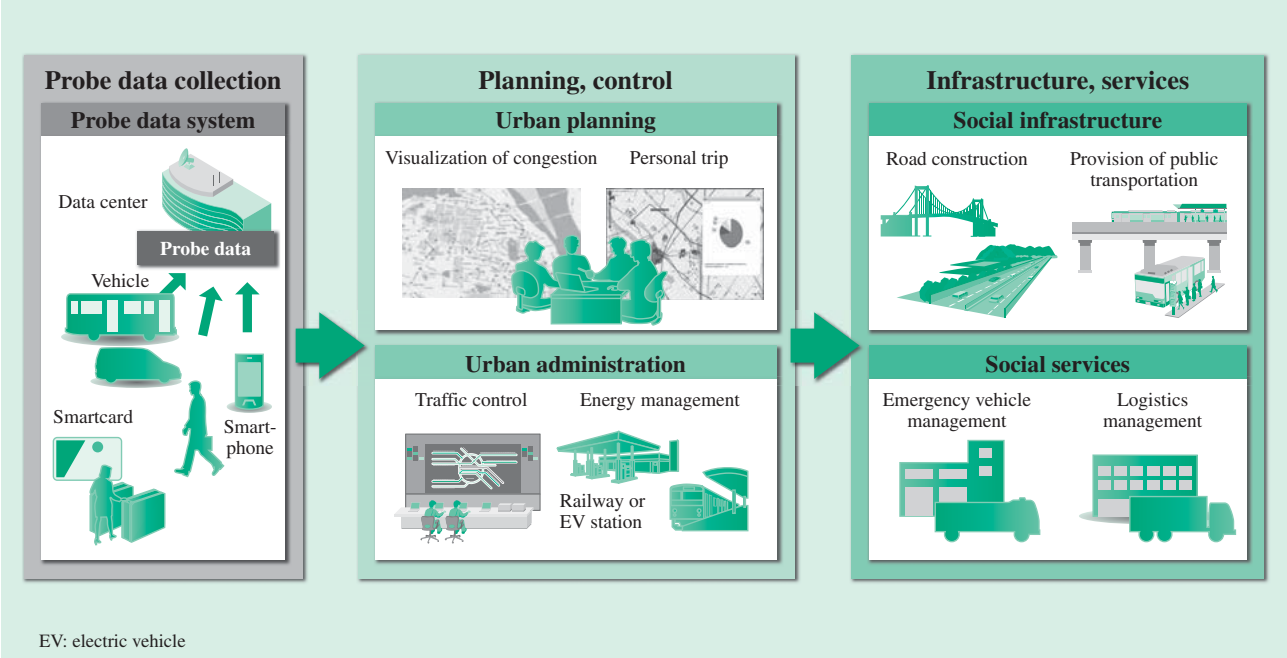

Fig. 4—Use of Probe Data System in Smart Mobility Solutions.
It is possible to determine and manage the flow of traffic and people based on probe data collected from a variety of devices, including smartphones and smartcards as well as OBUs. This can be further developed to make a contribution to society that influences people's lives directly by optimizing activities such as logistics or urban planning.

Hitachi uses the term "smart mobility solutions" to refer to solutions like these that apply its processing techniques to a wide variety of information and deliver a wide variety of services (see Fig. 4).

This section describes examples of smart mobility solutions for a variety of fields.

Traffic Applications

Traffic restrictions, weather information, and CCTV camera footage collected at a center along with traffic information based on probe data collected from vehicle OBUs can be used for traffic control tasks such as monitoring congestion or accidents in realtime. Also, congestion can be mitigated and traffic flow encouraged to follow normal patterns by the realtime distribution of collected traffic information to variable message signs (VMSs), the web, or smartphones and other user devices.

Logistics Applications

Efficient logistics requires control to take account of current traffic conditions.

In addition to its use for providing realtime congestion updates, probe technology can also contribute to efficient logistics through its ability to indicate the fastest route based on congestion information.

In another example, there are restrictions on the routes available to special-purpose vehicles (SPVs) that exceed the standard rules on size or gross weight due to the load they place on roads and bridges. In emerging economies in particular, where there is a strong need to reduce road maintenance costs, the probe data from SPVs can be used to determine which routes they take and to monitor whether they are operating in accordance with the law.

Urban and Road Planning Applications

In the case of urban planning, personal trip information obtained from GPS-equipped smartphones or smartcards can be analyzed to determine such things as population densities, travel routes, and means of travel in a city[4]. This can help achieve objectives such as optimizing the provision of public transportation such as trains or buses, improving accessibility to important sites, or controlling the flow of people to revitalize commerce.

In the case of road planning, travel times for each section of road calculated from probe data can be used as the basis for presenting a visual representation of the areas able to be reached from a central location within particular times (the "accessible area"). Through the use of this information to identify where to undertake work, this can lead to effective road improvements that relieve urban congestion.

CONCLUSIONS

This article has described the features of a Hitachi system for using probe data to generate traffic information, the steps being taken toward its commercialization, and its application in Hitachi's Social Innovation Business.

Vehicle use is growing rapidly in the major cities of Asia as their economies grow, creating an urgent need for ways of generating traffic information efficiently. Hitachi believes that the use of smart mobility solutions based around probe data can provide a safer and more comfortable way of life and achieve urban development that is conscious of the environment.

REFERENCES

(1) T. Yokota et al., "Generation of Traffic Information System Based on Probe Car Information," Hitachi Hyoron **88**, pp. 628–633 (Aug. 2006) in Japanese.
(2) T. Fushiki et al., "Formulation and Validation of Model for Calculating the Number of Probe Cars Considering Traffic Information Update Frequency," IEEJ Transactions D **126-D**, No. 6, pp. 741–747 (2006) in Japanese.
(3) K. Yamane et al., "Performance Evaluation of Estimation of Traffic from Probe Data Collection Frequency," Transaction of the 25th Conference of the Japan Society of Traffic Engineers (Oct. 2005) in Japanese.
(4) H. Ohashi et al., "Modality Classification Method Based on the Model of Vibration Generation while Vehicles are Running," ACM SIGSPATIAL IWCTS (2013).

ABOUT THE AUTHORS

Tatsuya Okubo
Public Business Promotion Department, Innovative Business Operation, Government & Public Corporation Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in the development of traffic management solutions and their global deployment through demonstration projects and other initiatives.

Koichiro Yoshioka
Public Business Promotion Department, Innovative Business Operation, Government & Public Corporation Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in consulting aimed at the global deployment of traffic management solutions.

Akiyuki Nakamura
Public Business Promotion Department, Innovative Business Operation, Government & Public Corporation Information Systems Division, Information & Telecommunication Systems Company, Hitachi, Ltd. He is currently engaged in the demonstrating and consulting of traffic management solutions in emerging economies.

Naoyuki Taniguchi
Business and Engineering Solutions Division, Social Business Solutions Division, Social Innovation Business Project Division, Hitachi, Ltd. He is currently engaged in solution engineering for urban transportation.