Development of Hybrid-Type Navigation System

Tomohiro SAKAI
Yohei OKAMOTO
Shoji FUJIMOTO
Katsuyuki NAKAI

Abstract

The environment surrounding in-vehicle devices is going through a revolutionary change. Along with the popularization of smartphones, the connection between the Internet and a user is growing more than ever. In addition, due to changes in our values and lifestyles, the values required for a car navigation system (hereinafter, referred as navigation system) is also gradually changing.

Under such circumstances, as the first model of the Future Link™ connected services that provide a new mobility life by linking data of "people," "vehicles," and "society" together, we have developed a hybrid-type navigation system that is constantly communicating with a center, based on the concept that anyone can easily start using up-to-date information required for the navigation system immediately after purchase, further, anyone can use it without being aware of connection.

This paper introduces the background of product concept, requirements for the hybrid-type navigation system and concrete solutions for achieving them.

1 Introduction

Nowadays, the environment surrounding in-vehicle devices is going through a revolutionary change. Mobile phones have been replaced by smartphones, and the connection between the Internet and a user is growing more than ever. Similarly, in in-vehicle devices, it is expected that services fit for user needs will be provided in the future by utilizing information from various sensors and information terminals/generic services (**Fig. 1**).

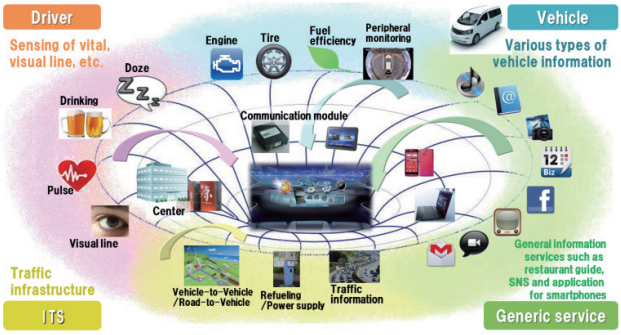

Fig.1 Overview of In-vehicle Connected Devices

In addition, due to changes of sense of values and lifestyles, the forms of navigation systems will be changed. We expect that the navigation systems will be shifted from non-connected navigation systems such as stand-alone type navigation systems to communication-linked navigation systems, that is, connected navigation systems capable of utilizing external new information by communication linkage such as navigation systems linked with mobile phones/smartphones, center completion type navigation systems and hybrid-type navigation systems capable of properly using the stand-alone/center, and that such navigation system will be the mainstream of the future (**Fig. 2**).

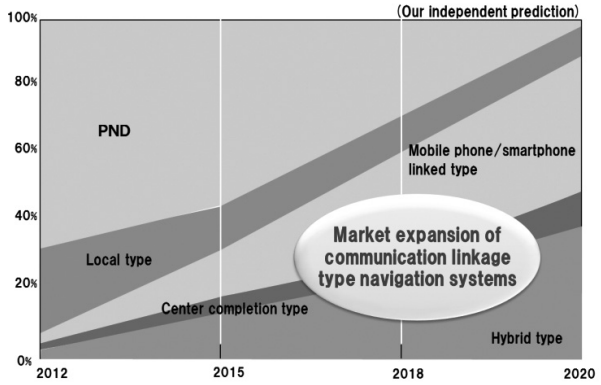

Fig.2 Changes in Form of Navigation Systems

In particular, the Japanese navigation system market has evolved by taking the functions such as comfort, safety and convenience. Among them, there are strong user demands for the essential of navigation systems such as the latest map and the operability (**Fig. 3**).

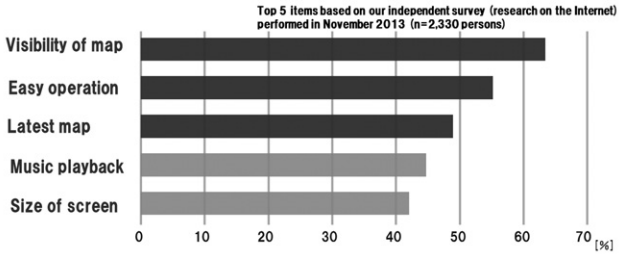

Fig.3 User's Needs for Navigation Systems

In order to respond to these environment changes and embody user demands, as the first model of the Future Link™ connected services that provide a new mobility life by linking data of "people," "vehicles," and "society" together, the hybrid-type navigation system capable of communication linkage was developed.

2 Product outline

The hybrid-type navigation system is defined as a system which obtains the latest information from a center through communication and seamlessly realizes functions similar to conventional non-connected navigation systems even outside the communication area.

In addition, the development concepts were to realize "anyone can easily start using the new map which is highly demanded by users (up-to-date information) immediately after purchase" and "the user can easily operate the in-vehicle device without being aware of connection".

In order to realize the hybrid-type navigation system, the in-vehicle device requires means for communicating with the center. As the means, a smartphone or a communication unit is conceivable. In order to realize "anyone can easily start using it immediately after purchase", in this product, linkage using the communication unit which requires no labor for connection with the in-vehicle device was adopted.

The product development was carried out by setting the following two main functions.

<Automatic map update>

Eliminate any and all troublesome user operations, and monthly provide the latest map.

<Center-linked information search>

・Free word search

Search the destination based on up-to-date information stored in the center.

・Parking lot search around the destination

Search parking lots around the destination with real-time full/vacancy information.

Measures for realizing the above functions will be described in the following chapters.

3 Classification of Hybrid-Type Navigation Systems

There are various types of approaches to realize the mechanism of the hybrid-type navigation system, and the approaches can be classified into the following patterns depending on fine function arrangement.

(1) Online type

The center basically performs all the processing and

cash information of map is stored in the in-vehicle device. According to this, even outside the area, route guidance can be performed for a short period. This is the type common in smartphone applications (**Fig. 4**).

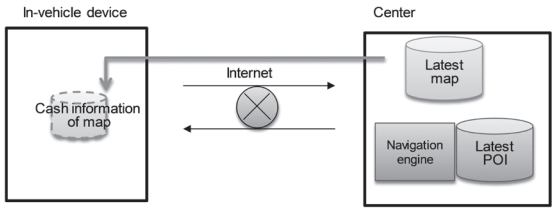

Fig.4 Example of Online Type System Architecture

(2) Content synchronous-type

The latest facility information and road information are obtained from the center, and operations such as map display, route search and route guidance are performed by the in-vehicle device (**Fig. 5**).

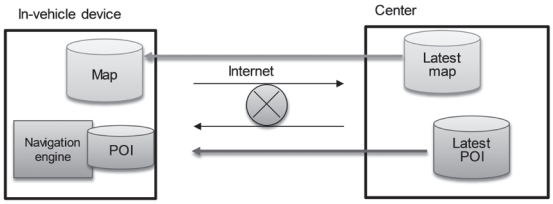

Fig.5 Example of Contents Synchronous Type System Architecture

(3) Smartphone integrated (multimodal) type

The in-vehicle device and the smartphone each have a communication function and a navigation engine. They share the user information via the center, and the seamless guidance to the destination can be continued both outside and inside the vehicle. In addition to the integration of the center and the in-vehicle device, this is the integrated type of the in-vehicle device and the smartphone (**Fig. 6**).

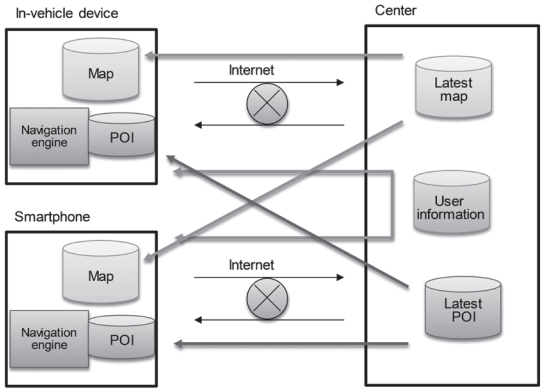

Fig.6 Example of Smartphone Integrated Type System Architecture

Although the hybrid-type navigation systems can be classified into the three patterns described above, with regard to our hybrid-type navigation system, firstly, we started the development as the content synchronous type system. This judgment was made based on the concept guiding with the latest information at any time, upon taking over the conventional usability. However, the hybrid-type navigation system is the system which optimally evolves in accordance with changes in the world such as the development situation of communication infrastructures and, in the future, depending on grades or customers, selection of optimal arrangement of appropriate hybrid functions becomes necessary.

4 System Architecture

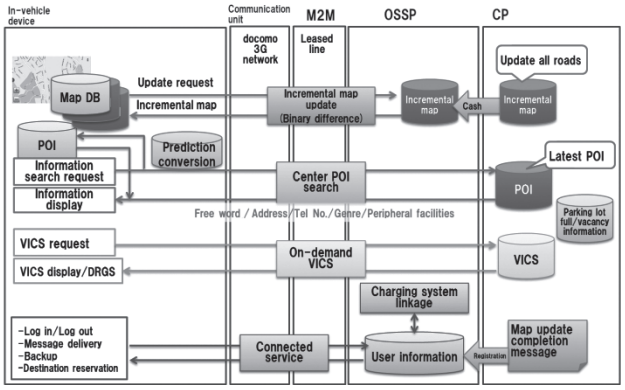

Fig.7 Functional Layout of Hybrid-Type Navigation System for Autumn 2014 Aftermarket Model (JAPAN)

In this chapter, the system architecture of the content synchronous type is explained in detail. In order to realize in-vehicle devices connected to the external environment, components such as an in-vehicle device, a communication unit, our center OSSP (One Stop Service Platform), and a CP (Contents Provider) are required (**Fig. 7**).

(1) In-vehicle device

In addition to the conventional navigation functions, it has the following functions: a communication function, a map updating function, a map version management function, a cache function of results obtained from the center, a predictive conversion function and a log-in information management function.

(2) Communication unit

A communication unit for the 3G network of NTT docomo (hereinafter referred to as "docomo"). The communication traffic can be shared by all users. This unit has only a modem function of up and down of data as a pipe for communication, and is not involved with the data contents. It should be noted that the communication charge is free until the end of October 2017. Troublesome contract procedures are unnecessary when the user purchases this product, and the user can use this unit immediately after purchase.

(3) M2M Platform (docomo)

The M2M Platform collectively manages the state and use status of the communication unit, which uses our services, at the control center. The leased line ensures secure connection between the docomo network and the OSSP.

(4) OSSP

The OSSP plays a role of relay between the in-vehicle device and the CP. The OSSP manages the user information and collects log information, and utilizes such information for service improvement in the future. In order to respond to the simultaneous access load during map

update, a load distribution function is provided. The cloud technology of FUJITSU is utilized.

(5) CP

This is the server for performing search of the latest facilities. The real-time parking lot full/vacancy information and the on-demand VICS information are obtained from here. The in-vehicle device always accesses here via the OSSP. This time, the server of the TOYOTA MAPMASTER is utilized.

5 Automatic Map Update

Although there are map update services of other companies which deliver information on all roads by limiting covered areas or deliver information on all roads which are national roads or higher ranked roads, FUJITSU TEN is the first company providing the service which delivers information on all roads throughout the country. In order to realize the mission of "completing map update without being aware of connection", the following measures were adopted.

- **Size reduction by selecting the data covered by map update**
- **The map is mesh-divided and difference data is updated**
- **Minimizing influences on the response during normal use**
- **Notification message delivery of map update completion**

5.1 Size Reduction by Selecting the Data Covered by Map Update

Table 1 shows the data covered by automatic map update.

Table 1 Data Covered by Automatic Map Update

Data	Subject
Road	○ (All roads throughout the country)
Expressway rough map	○
City map	×
VICS link	○
POI	× (Always latest by center search)
Toll table	○
Guidance image	×※
Guidance voice	×※

※Delivery system is provided in preparation for emergency

As a result of thoroughly pursuing the real-time property of content synchronization, with regard to the information for route guidance such as road information and toll tables, the database of the in-vehicle device is monthly updated, and with regard to the POI (Point of Interest), the latest information is obtained from the center for each search.

5.2 The Map is Mesh-Divided and Difference Data is Updated

Although the size of the map data originally installed is approximately 8 GB, among them, changes monthly occurs in data of several tens of MB to the maximum 900 MB. If this size of data is monthly delivered from the center, the communication charge becomes huge and it takes a long time to update. In order to reduce the processing time while suppressing the cost with small communication traffic, the map format was improved to respond to incremental map update (**Fig. 8**).

The map data which was originally one file for the entire country is divided by meshes having a size appropriate for difference delivery. With regard to areas requiring no update, nothing is delivered. With regard to areas covered by map update, the difference patch data which extracts only the differences of the change points of the areas is prepared, and the prepared data is delivered from the center in a compressed format. The in-vehicle device expands the downloaded data, the difference data is patch-applied to the original data, and thereby generating new data. According to this, the communication traffic of difference update per month could be reduced to 30 MB or less.

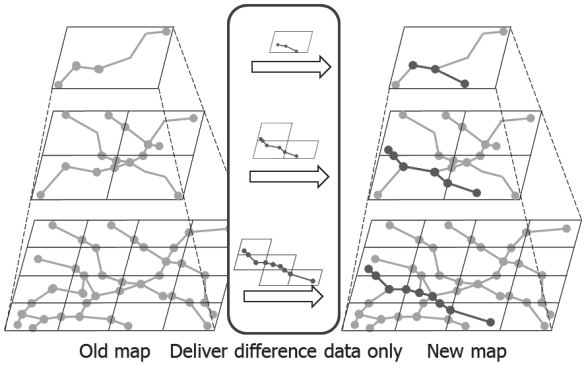

Fig.8 Incremental Map Update Method

5.3 Minimizing Influences on the Response during Normal Use

The data was actually prepared by using the method described in the preceding section, and the test was performed. As a result, downloading was completed within 15 minutes. However, it took more than 2 hours to perform expansion processing after that, the navigation operation was heavy compared with the normal time, and the response became worse. In such a configuration, it cannot be said that "without being aware of connection" is realized. Thus, by performing processing after ACC-OFF in which other functions do not operate at all, we could eliminate the influences on the response and reduce the processing time. The algorithm of the update processing was also accelerated, and the time necessary for one update could be reduced to about 5 minutes (**Fig. 9**).

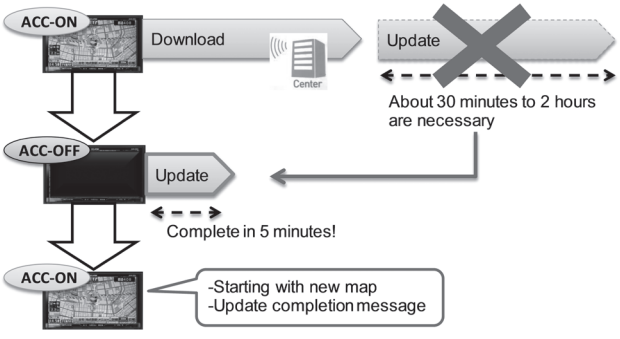

Fig.9 Map Update after ACC-OFF

In addition, although there is a case where the downloading process is interrupted due to ACC-OFF or a case where the updating process is interrupted due to ACC-ON, in order to make users not being aware of such situations at all, a resume function allowing the restart of the processes from the interrupted point is mounted, and a mechanism which does not generate useless communication traffic and processing time was adopted.

5.4 Notification Message Delivery of Map Update Completion

If the incremental map update is performed on the background, there occurs a problem that the user cannot know when the update is completed and does not feel that he/she uses the latest map (the merit of map update). As means for solving this problem, a system for delivering the "notification message" after completing the map update was constructed. **Table 2** shows the contents of the messages.

Table 2 Contents of Update Completion Message

Highway/ toll road	Names of roads newly opened
	Names of interchanges, SA and PA newly opened
Local road	Route No. newly opened
	Names of cities, towns and villages of newly opened sections

In addition, we considered that the use opportunities of message delivery are increased if the vehicle is on roads around his/her home and users can feel the merit of map update more, and the following messages are notified:

- **When his/her home is registered, update information of the prefecture where his/her home is located and the adjacent prefectures**
- **When his/her home is not registered, update information of the entire country**

By performing various actions described above, we have achieved our concept: "completing map update without being aware of connection."

6 Center-linked Information Search

Next, in the destination search, which is one of the most important elements among navigation functions, the "Free Word Search" newly using the center was adopted. According to this, the latest facilities opened after purchasing the product are registered at the center at any time and can be searched.

In addition, a function of searching parking lots around the destination, which utilizes the capability of obtaining parking lot full/vacancy information in real time, is mounted.

6.1 Free Word Search

With regard to the "Free Word Search", we carried out the development aiming to "obtain results intended by the user from a large stock of information stored in the center without time and effort". Two systems, that is, a "system for saving time and effort" and a "system for obtaining intended results", which are the points of the development are explained below.

Based on our wish to realize a using method with no sense of incompatibility with the case where the user usually performs search using personal computers or smartphones, in this "Free Word Search", a system capable of performing search using a plurality of words was aimed. However, different from personal computers and smartphones, inputting many letters in the vehicle is a troublesome work, and the driver feels stressed.

Therefore, as a system for saving time and effort, an "input predictive conversion function" was mounted. A dictionary is installed in the product, and, when a [prediction candidate] button is pushed after inputting letters, a list of words related to the letters are extracted and displayed. Accordingly, it became possible to input keywords intended by the user with a small number of times (**Fig. 10**).

Fig.10 Screen of Free Word Search

Next, the input keyword is transmitted to the CP, and the keyword is analyzed. In the keyword analysis, it is checked whether each of the received keywords can be converted into an address, a genre name, a brand name and the like, and an ambiguous facility name is corrected/supplemented. Taking such analysis results into consideration, matching facilities are retrieved.

As a result, the user can get the information which he/she wants.

6.2 Parking Lot Search around Destination

The parking lot search around the destination is a function of automatically searching parking lots when the vehicle is at 2 km before the destination and displaying the result during the navigation to the destination (**Fig. 11**).

Fig.11 Outline of Parking Lot Search around Destination

There is a case where although the vehicle arrives at the destination, an appropriate place for parking cannot be found in a short time. Thus, a function capable of searching parking lots around the destination with real-time parking lot full/vacancy information from the in-vehicle device is mounted. There are three points in this function.

(1) In terms of adopting a form in which a user selects whether or not performing the automatic parking lot search, the selection can be performed immediately before starting navigation at the time of setting the

destination. This is because we think that there is a case in which it is not necessary to find parking lots depending on places (in a case where parking lots are provided to facilities such as large shopping centers). In addition, when going back to home, the parking lot search is not performed.

(2) By setting vehicle information (full length/full width/full height), it becomes possible to narrow the search results only to places where the vehicle can be parked. According to this, the user can select a parking lot among parking lots fitted to the size of the vehicle.

(3) Parking lot icons are classified and displayed by colors linked with the full/vacancy information. When the corresponding parking lots are found, a message is displayed. When the [display] button is pushed, icons of peripheral parking lots are displayed on the map (**Fig. 12**). According to this, the HMI considering the safety was realized in which the positional relationship with the destination and places where the vehicle can be parked can be identified at first glance.

Fig.12 Screen on Which Parking Lot Icons are Displayed

6.3 Display of Center Search Result

Based on the communication connection status, it is automatically judged which of the center search and the local search should be used, and the search result is displayed on the screen. However, since the information cannot be determined as the information obtained from the center only by looking the search result, the configuration is adopted in which the icon for informing the user that the information is the up-to-date information obtained through the center search is displayed on the screen (**Fig. 13**).

Fig.13 Icons Showing Center Search Result

7 Conclusion

The development of the main functions of the autumn 2014 aftermarket model was explained. In terms of users, we could realize the functions/product which can be easily used by anyone immediately after purchasing the product such as automatic map update not requiring user operations and labor.

In order to continuously evolve the hybrid-type navigation system, we will continue to improve the usability and provide new contents/services.

In addition, we would like to embody the Future Link™ connected services that provide a new mobility life, and to carry out the product development which can make driving more fun and more active.

Future Link™ is the trademark of FUJITSU TEN Limited.

Profiles of Writers

Tomohiro SAKAI
CI/SS Business Dept.
Product Planning Group.

Yohei OKAMOTO
Connected Vehicle Service Development Dept.
SS Engineering Group.

Shoji FUJIMOTO
Manager of Connected Vehicle Service Development Dept.
SS Engineering Group.

Katsuyuki NAKAI
Project General Manager of CI/SS Business Dept.
Product Planning Group.