

Technology for Updating Digital Map Using Differential Data

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ABSTRACT

In recent years, the increase in performance of car navigation systems has led to a corresponding increase in the size of the map data, which in turn has led to the use of a hard disk drive (HDD) as the data storage medium.

Map data should be regularly updated to include newly constructed roads, facilities, and the like. Currently, this updating procedure is facilitated through removal of the HDD; hence, the navigation system cannot be used during the process.

Now, by employing a new data storage structure, a simple, convenient, and quick method has been developed to update the data without removing the HDD.

1. Introduction

The purpose of the car navigation system is to guide the user to the destination safely and comfortably. In order to enhance this functionality, the types and amount of data has increased every year. For example, it provides city map data that shows the shapes of houses and blocks of land, and search data with the types of shops and businesses and telephone numbers so they can be found. As this data has increased, so has the storage media changed, from the initial CD-ROM to DVD-ROM format, which can hold approximately 12 times the amount of data, then to hard disk drives (HDD) that can hold several times more data and can be read from and written to at higher rates of speed, anytime. Since 2003, Honda has fitted HDDs to all navigation systems fitted in the factory for the Japanese market.

Until now, in order to update the data stored on the HDD, the dealer has removed the HDD from the navigation system and the data has been rewritten. For this reason, it has been necessary to have the dealer visit the user twice; once to have the HDD removed and again to have it reinstalled⁽¹⁾ (Fig. 1). Also, because the HDD is removed, there is the further inconvenience of being unable to use the navigation system during this time.

Incorporating a high speed communications interface,

and rewriting all the data without removing the HDD was also considered; however, there was the issue wherein rewriting 13 GB or so of data takes about two hours. To reduce this rewrite time, the database was completely revised with the adoption of a new file structure. The result was that by receiving a DVD-ROM from the dealer, the data rewrite could not only be performed while driving the vehicle, but the downtime of the navigation system could be reduced to 20 to 30 minutes. The technology adopted to achieve this is described below.

2. Navigation System Data Structure

Digital map data, used by the navigation system and comprised of data for display, and road data that shows the orientation and location of the vehicle, is defined by points (nodes) and their joining lines (links) that make up each individual road. This data, along with data showing the connecting relations where two or more roads intersect, is stored in the database (Fig. 2).

In addition to the data used to display the map on the screen, there are various types of data, optimized according to function, such as destination search data and route calculation network data, which determines the guide route.

The search data performs searches based on names or

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telephone numbers to specify a building location as the destination. The number of possible buildings throughout the whole of Japan can be as many as 10 000 000. For example, when entering a name, one character at a time, during a destination search by Japanese KANA character, processing takes a considerable amount of time, as a search is made for matching data as each character is entered. For this reason, the data is structured to enable quick processing in response to the user interface.

Route calculation network data has route weighting information (link cost) applied at each junction. When the route calculations start after setting the destination, this data is used to determine the shortest route from the current position to the destination using the Dijkstra method⁽²⁾, or other calculation methods, to calculate the route. The data is layered and processing using data obtained by pre-calculation of intermediate routes for each area also takes place. It has the ability to calculate the route with a small amount of processing (Fig. 3).

3. Map Update Issues

A characteristic of the previous map data for the navigation system described above is that it has a structure that comprises groups of combined data, ranging in size from tens to hundreds of megabytes. Location information is determined from the actual data's relative address information^{(3), (4)} (Fig. 4).

Display of navigation information is made possible by

taking the node and link connection information for the displayed road and looking at each of the various pieces of data, indicated by the relative address information, one at a time, and reconstructing the data as connected roads.

Figure 5 shows an example in which a road (Road #2) branching off a highway (Road #1) has ceased to exist and a new road (Road #3) has been added.

First, the data forming the branch road (Road #2) is deleted. Then the data forming the new branch road (Road #3) is added, and a new intersection (Node #7) is added to the highway (Road #1). With the previous data structure, this would be inconvenient because simply inserting, adding, or deleting data would result in misalignment of the address information of the data sequence, introducing data reading inconsistencies.

Furthermore, as this map data structure was a single large data mass, change to even one part would necessitate rewriting the entire data, and the navigation system could not be used until this rewriting had finished.

4. Data Structure for Differential Data Update

Unlike previous map data that employs the method of using a relative address for relevant actual data, this time, as shown in Fig. 6, finely divided file data for elements of the map structure, such as scale (level) and region (mesh), is accessed.

With the previous map data, even if the update only changed one part of the map data, it was necessary to

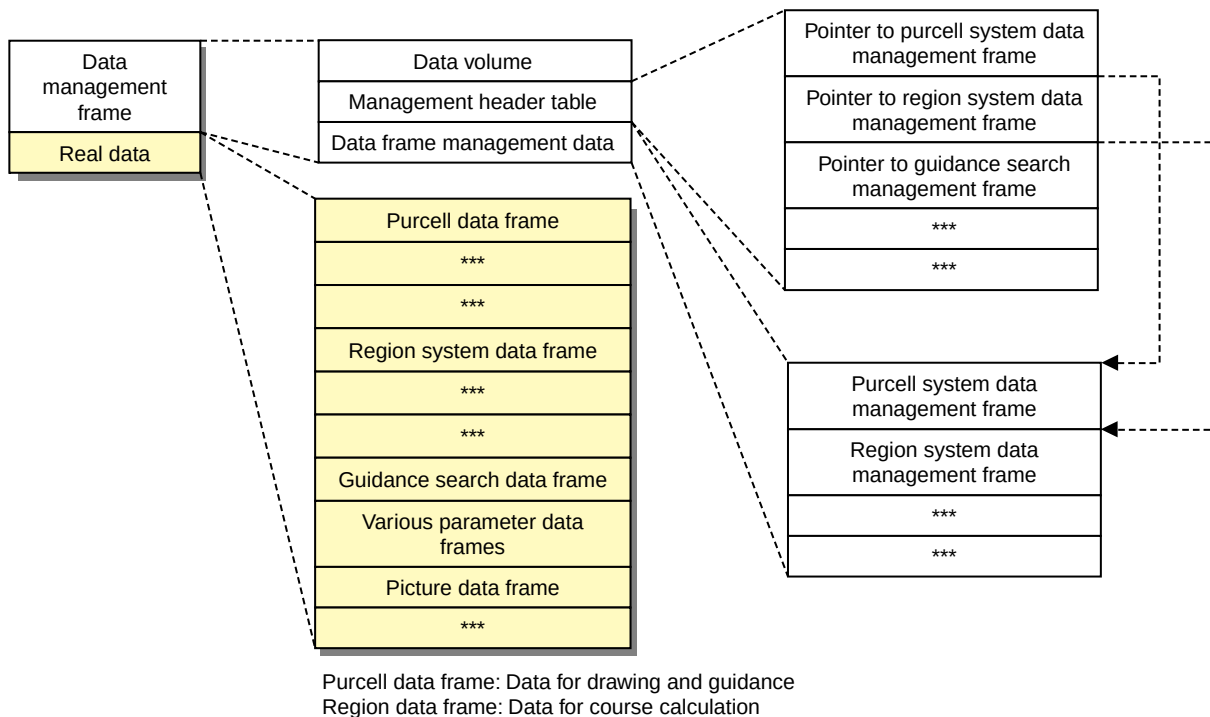


Fig. 4 Data structure of whole digital map data

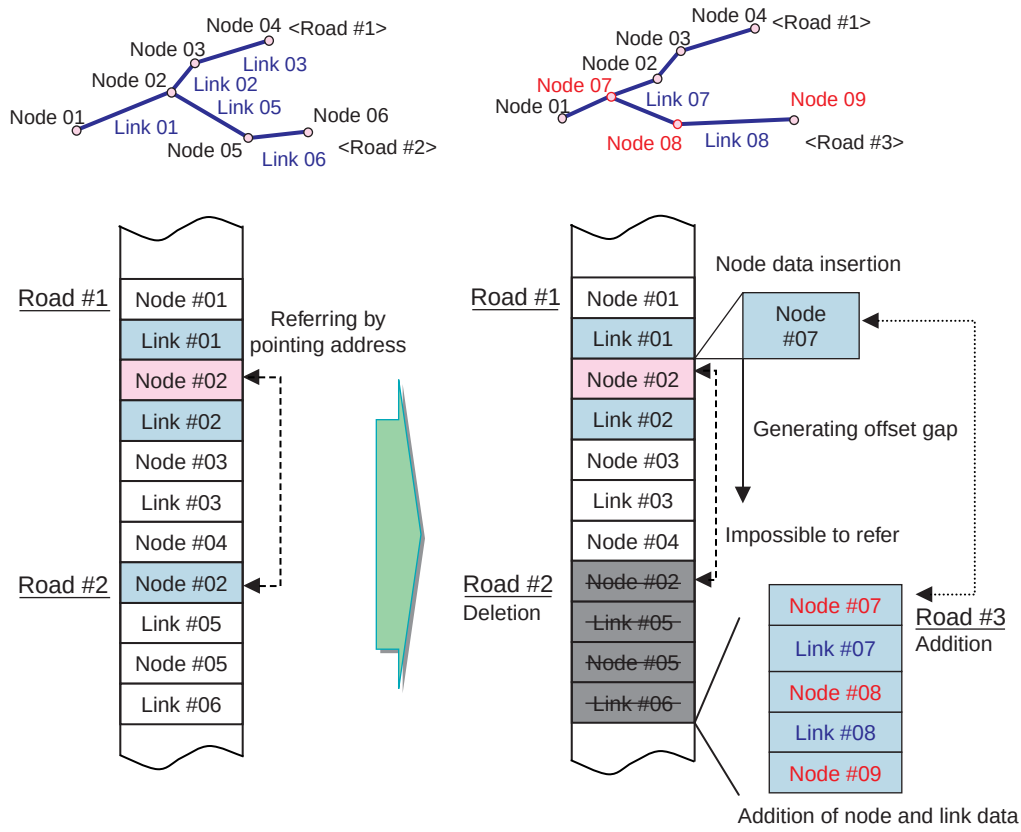


Fig. 5 Present digital map data structure issues

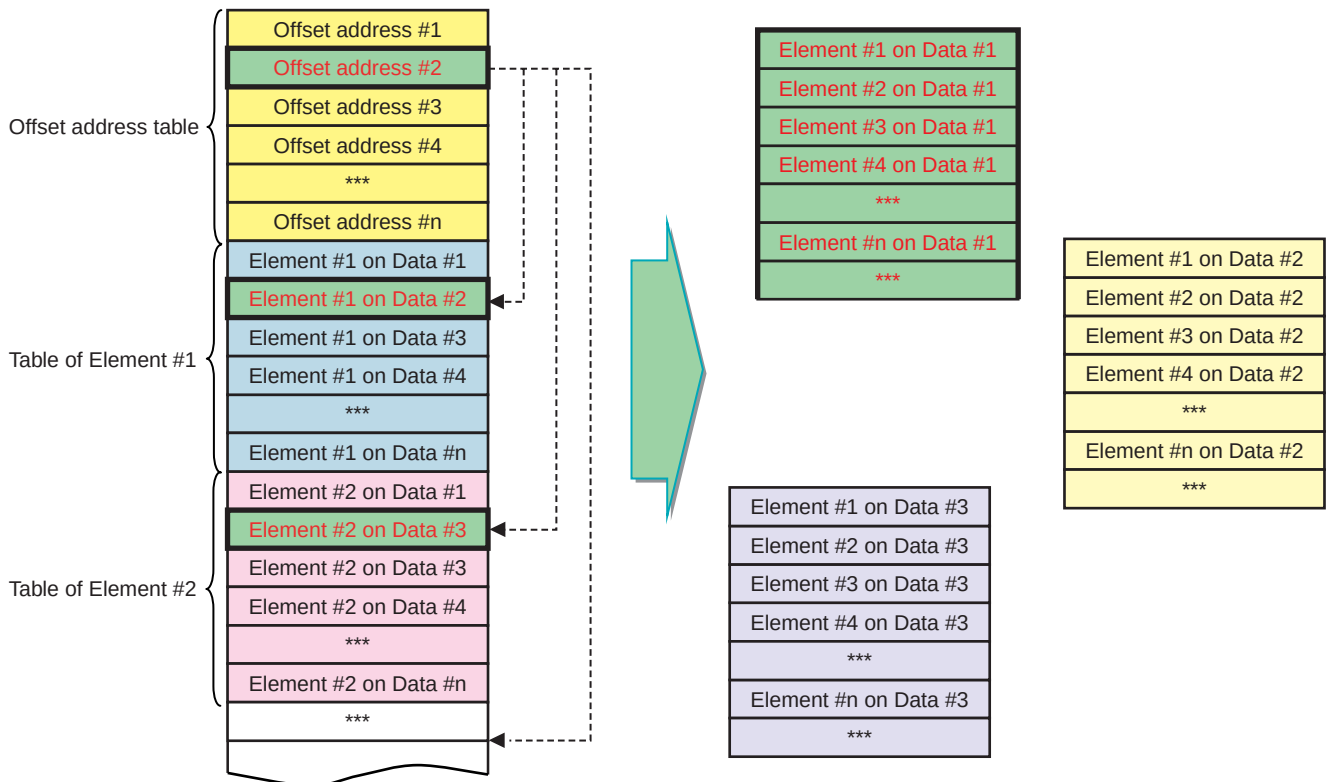


Fig. 6 File composition of differential digital map data

update the entire data. By finely dividing the files, only the file that has changed needs to be updated and the size of the data necessary to perform an update is also reduced.

5. Data Update

The process of updating after receipt of differential data will be described with reference to Fig. 7.

The map provider's server compares the same map data version as that of the navigation system with the latest version of map data to determine the differential data. This data is then brought to the navigation system by cell phone communication or by physical media, such as CD-ROM or DVD-ROM. The navigation system then uses this differential data to perform the updating process on the map data.

The map data is finely divided up into multiple files, one for each level or mesh.

As shown in Fig. 8, when updating, each file that makes up the map data is checked to see if it needs to be updated and the rewriting process is performed based on the differential data information.

Even in the case of the file being updated, the process is performed so that for the elements within the file structure that do not require updating the data is used as is, and only the elements that need updating are rewritten (Fig. 9).

By these means, it has become feasible to rewrite using only a small amount of differential data.

With the previous map data structure, data could not be used until all the files, ranging in size from tens to hundreds of megabytes, had been rewritten. By making full use of the advantages of fine file division, the updating process can be performed as a background task

while the navigation system is in use. In other words, it has now become feasible to firstly update higher priority map data, such as the data for the vicinity of the current location, and then update other files as necessary, when the processing load is lighter.

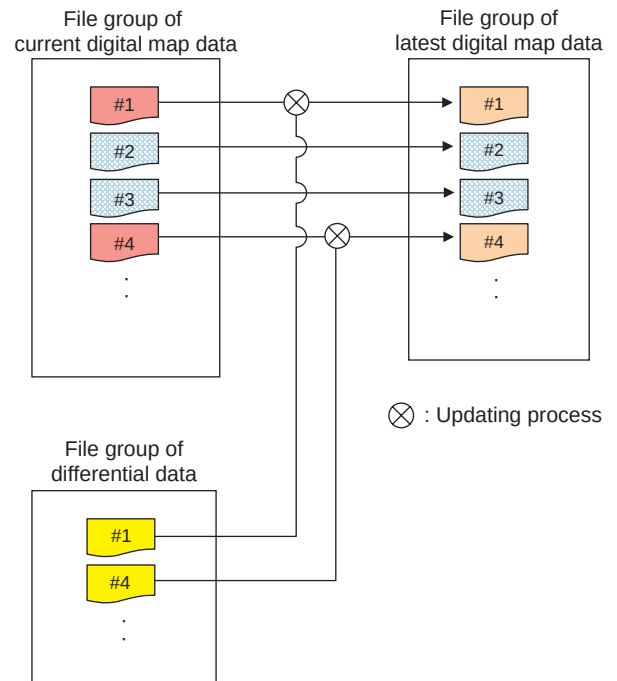


Fig. 8 Updating operation by differential digital map data

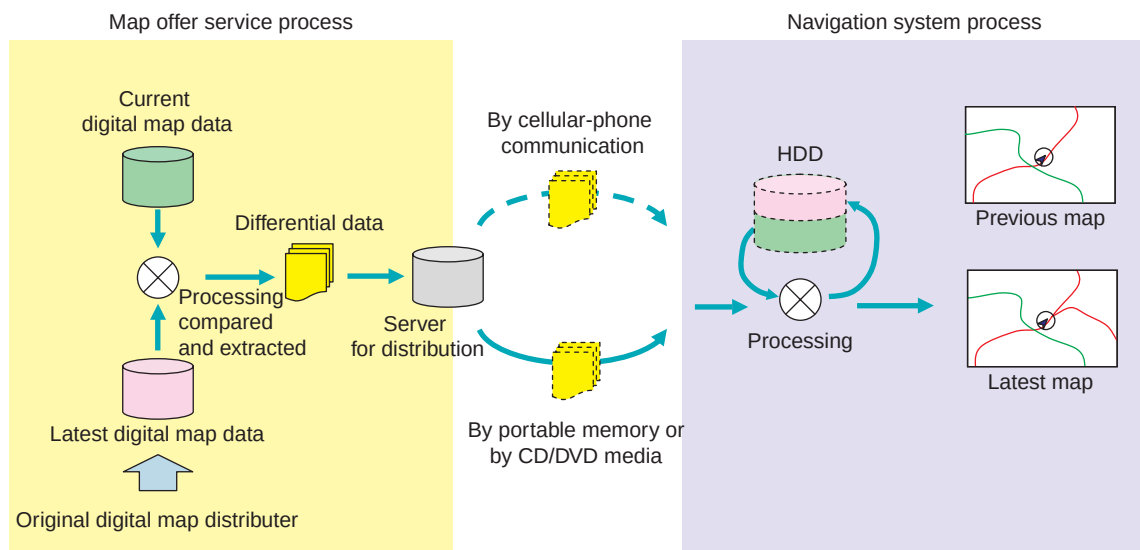


Fig. 7 Updating system by differential digital map data

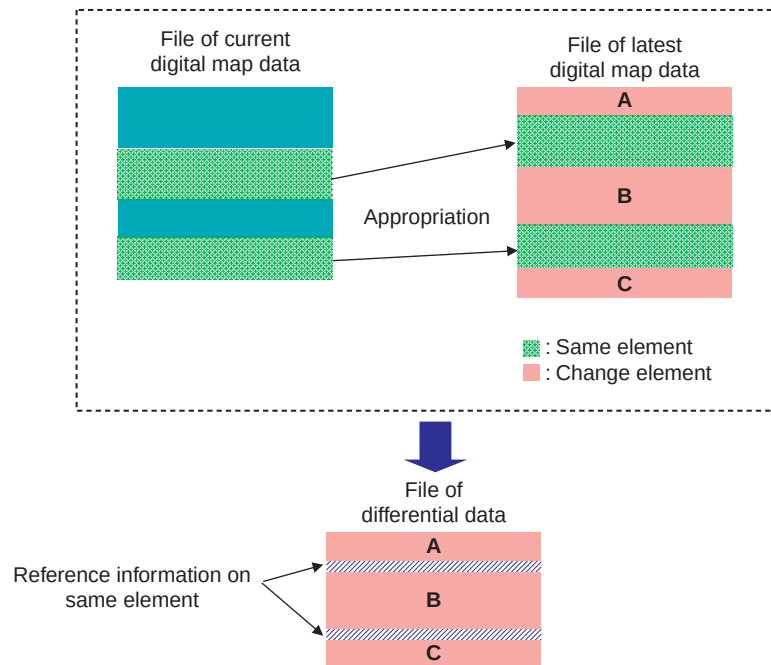


Fig. 9 Structure of differential digital map data

6. Conclusions

Map data updating has been made more convenient by introducing the following technical enhancements:

(1) Fine division of map data

The amount of differential data provided for update has been reduced by finely dividing the previous data structure, which comprised data of the order of several hundred megabytes, into files ranging in size from between several hundred kilobytes to several megabytes. On the other hand, as the increase in the number of files also results in a corresponding increase in the memory requirements of the navigation application, the optimum number was set to make the overall system easy to handle.

(2) Differential data structure

The differential file for map update does not simply rewrite the file, but is also designed so that elements within the file structure that are unchanged are used as they are, further reducing the size of the differential file provided.

(3) Update process prioritization

By setting application process prioritization, it has become feasible to perform the updating process as a background task. This was achieved as a synergistic effect resulting from the fine division of the differential file. As a result of these developments, a system has been achieved that allows the user to easily rewrite the latest map by simply obtaining a CD-ROM or DVD-ROM without the need to repeatedly visit the dealer. Furthermore, the navigation system downtime has been kept to within around 20 to 30 minutes.

References

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