

Development of FUJITSU TEN's First SD Memory Card Navigation System, AVN Lite, and its Linkage Service

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Abstract

Since 1997, when FUJITSU TEN released an all-in-one unit consisting of Audio, Visual, and Navigation ahead of the industry, "AVN" has become synonymous with in-dash and all-in-one navigation system. On the other hand, recently, on-dash navigation system (PND: Portable Navigation Device) that provides only basic function of navigation system at a low price has been penetrating the market and the market needs for low-end models have been growing.

With the motto, "secure," "easy," and "fun," FUJITSU TEN therefore planned and developed "AVN Lite" that offers the necessary and sufficient functions at a reasonable price including the path search and audio assist which are the basic functions of the car navigation system, storing the map data in the SD card, and also including CD, One-Seg, etc. as AV functions, and we released the "AVN Lite" in October 2008.

The navigation system using the method that stores the map data in the SD card is the first product of this kind for FUJITSU TEN. We introduce the problems and solutions for adoption of the SD card as the storage media, and various services linked to this product in this article.

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Introduction

"AVN," released in 1997 as ECLIPSE brand, has become the standard configuration of a car navigation system due to the emergence of other manufacturers and its adoption by automotive manufacturers.

Since then, we have advanced the development seeking the high added value consistently with the technological evolution, but on the other hand, many users require the car navigation system that provides its primary functions at a reasonable price as typified by PND.

Based on these needs from the market, we have planned and developed the reasonably-priced "AVN Lite" that incorporates the necessary and sufficient functions including path search and audio assist which are the basic function of the car navigation system, and also including CD and One-seg and others as AV functions with the motto, "secure," "easy," and "fun" in order to have the AVN used by a wide range of people.

We introduce the development concept, technology, and implementation method in this article.

2

Intention of Development and Summary of Product

After comparing the features of a navigation system with full specifications as typified by "AVN" with those of PND, we considered the functions required for new products category, "AVN Lite," and formulated the product concept with keywords, "secure," "easy," "fun."



Fig.1 AVN Lite

1) Secure

- Acquire the vehicle position with vehicle speed sensor and gyroscope as well as GPS. Allow safe driving on an unknown road.
- Support parking and putting a car into the garage with connection of rear view camera sold separately.
- Give audio assist for the distance and intersection name at which to turn.

2) Easy

- Give easy-to-see double-screen display and display each operation screen of navigation and AV.
- Widely indicate the button to be often used. Ensure and easy destination search.

- Carefully select and arrange four basic buttons of "present location," volume, etc. at the bottom of the navigation device.



Fig.2 Double-screen Display

3) Fun

- With 7-inch wide screen, and receiving One-seg broadcasting with realistic sensation in a car.
- Play favorite music anytime and anywhere with CD playback and iPod connection.
- Obtain the hot place and vacancy information of parking with KEITAI-Link service using a mobile phone.

Also, since the beginning, we have made product planning considering the use for other than the mass merchandiser market. We incorporated the functions for the rental car (AVN118MRE) and corporations (AVN118MCO) into the product specifications and developed WEB services and PC applications linked to the product.

3

Development of New Services

This product intends to differentiate the functions for each destination to deliver by WEB services and PC applications linked to AVN Lite. Especially for rental car (AVN118MRE) and corporations (AVN118MCO), dedicated PC applications are sold separately, and searching data and menu indication of AVN Lite can be customized (Fig. 3). The dedicated PC application (APR118MRE) for AVN Lite for car rental companies allows individual customization specialized to the needs of car rental companies, including the individual addition/edit/deletion of the data of service offices of car rental companies, rewriting the opening image, and so forth. Also the dedicated PC application (APR118MCO) for AVN Lite for corporations allows display of the list of customers to visit on the navigation screen by creating the data of customers to visit on PC and writing it on SD card, in order to support the visiting activities as typified by route sales with navigation system.

In this article, we explain the various service and applications linked to AVN Lite individually.

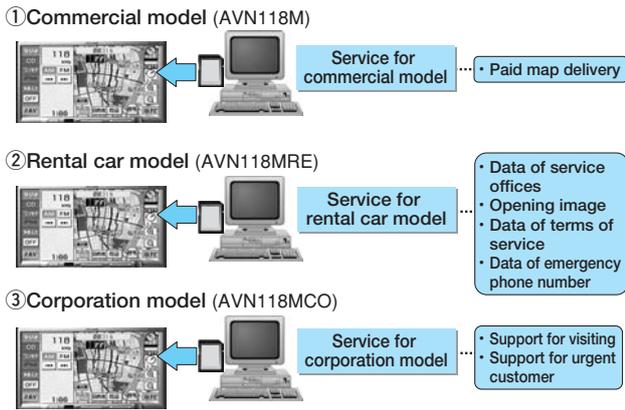


Fig.3 Linkage Service for Each Destination



Fig.4 MyPage

3.1 Service for Commercial Model (AVN118M)

We have offered the information providing service (MyPage) using WEB for users of commercial model (AVN118M) since October 2008.

AVN118M users can obtain their own user ID and password to log into MyPage by completing the user registration in the page of "users support" in Fujitsu Ten's website after purchasing the product. Once users obtain their own user ID and password, they can log into MyPage and receive various service (Fig. 4).

In MyPage, the users can view the list of their own products and information for each product. And the users of AVN118M can use "compensation version map data download service" in MyPage. In AVN118M, various data necessary for navigation including map data, POI (Point of Interest and facility information) etc. is stored in SD card. The SD card is a writable media, differing from the existing map media, so it has a risk of damage or losing data. Even if perchance the data stored in the SD card is damaged, the qualified users registered in MyPage can download the same data as the data before being damaged from the compensation version map data download service, and can restore the data.

The data stored in the SD card is composed of various format file such as map, POI, audio etc. In this service, these multiple data are combined into one data, and this data is compressed to shorten the downloading time and to restore at one time.

This service allows a rapid response to the problem of data loss concerned when the SD card is used as a storage media of navigation system.

We will extend MyPage as a WEB service providing "convenience" and "secure" to our users.

3.2 Service for Rental Car Model (AVN118MRE)

AVN118MRE is a special model providing various functions specialized in utilization of navigation system in a rental car. This model allows customizing the functions by using the dedicated application (APR118MRE: sold separately). The customizable functions with the dedicated application are as follow:

- ① Editing data of service offices
- ② Editing data of facilities
- ③ Editing data of notification
- ④ Editing data of terms of service
- ⑤ Editing opening image

In this article, we introduce these functions respectively.

① Editing data of service offices

The car rental companies strongly required the system not to include other car rental companies in the search target when customers search the location of car rental company with a navigation system. This model satisfied the requirement by creating data with dedicated application in advance. In advance, a category "XX Car Rental Company" using the application is created, and in this category, the data of service office of XX Car Rental Company is stored. Only the service offices of XX Car Rental Company will display if the category "XX Car Rental Company" is selected on the navigation screen. This function is also welcomed because the company can edit the data flexibly by itself if a service office is newly established or consolidated.

② Editing data of facilities

As in the editing function of service office data mentioned above, the car rental companies can upload the local and seasonal information not originally stored in the navigation system by creating the original data of sightseeing areas or events. Especially in most service offices in Hokkaido or Okinawa where the utilization ratio for sightseeing is high, the companies create the original sightseeing brochures and list the address or map code of destinations on these brochures. The rental car users

operate the navigation system and set the destinations with these brochures. In this case, there are following problems: for safety reasons, it is not desirable that the users operate the navigation system while looking at the brochure, and operation of address search or map code search becomes complicated. However, use of this editing function can provide the latest information on the navigation screen, so the users of rental car can receive "convenience" and "security."

Screen of setting support tool

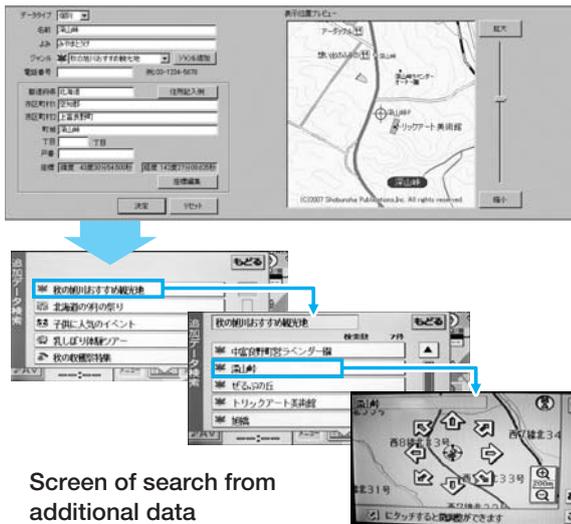


Fig.5 Application Screen for Rental Car

③Editing data of notification

Most car rental companies give information (emergency phone number for occurrence of accident, or cautions for use of rental car) that they should deliver to their users with printed paper, or affix a caution seal in the car. This model can display such notification on the navigation screen with special button, and can customize the message to be displayed using the application.

④Editing data of terms of service

The rental car users confirm the terms of service with papers in advance. This model displays the terms of service on the navigation screen when the navigation system is started and encourages users to reconfirm them. The terms of service can be changed using the application.

⑤Editing opening image

The car rental companies strongly require that the logo of their own companies is indicated on the opening image when the navigation system is started. This application prepares the opening image in advance and can change the indication freely, checking the indication image of the navigation screen using a PC screen.

3.3 Service for Corporation Model (AVN118MCO)

AVN118MCO is a special model incorporating the functions specialized in use of navigation system for cor-

porations. This model can customize its functions using the dedicated application (APR118MCO: sold separately).

To support the sales operations mostly, AVN118MCO incorporates the function that loads the data of customers to visit (created at the office in advance) into the navigation system and sets the destinations easily, along with a function that transfers the data of urgent customer to visit from the office to the mobile phone of sales person who sends the data to the navigation system using e-mail of the mobile phone easily. A dedicated application must be installed in PC of the office to utilize these functions. Here are the main functions of this application.

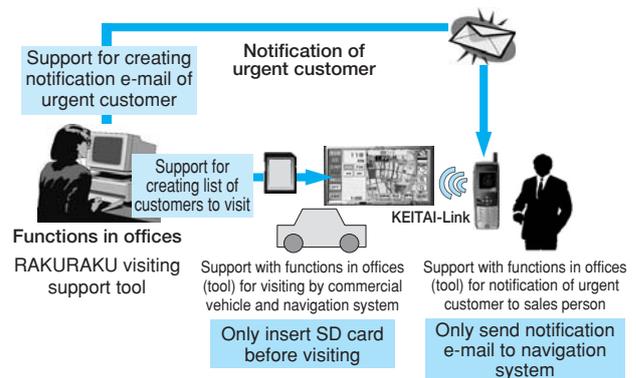


Fig.6 Service for Corporations

①Support for creating list of customer to visit

The destinations can be set easily based on the customers list on the navigation screen by editing the data of customers to visit with PC of the office in advance and storing the data into the SD card. In general, most customers lists are compiled as a database. This application can load the data of customers to visit in CSV format based on the database of the customers list.

The location information of customers to visit is set by converting their addresses to latitude/longitude. However, if sales person moves by car, the location of latitude/longitude that is set based on the address of customer to visit is not always the destination to visit. For example, in the delivery business, the place of unloading may be the place of delivery designated by the customer, or the parking area may be located away from the customer's office. In such cases, the center location on the map specified by latitude/longitude, converted from address, is changed to the given locations mentioned above to allow guiding to the most appropriate place for each customer.

In addition, the data of customers to visit stored into the SD card includes the customer's information, so the data is written into the SD card after it is encrypted on the application. Therefore, even if the SD card is lost, the information leakage can be prevented because the contents of the SD card cannot be accessed.

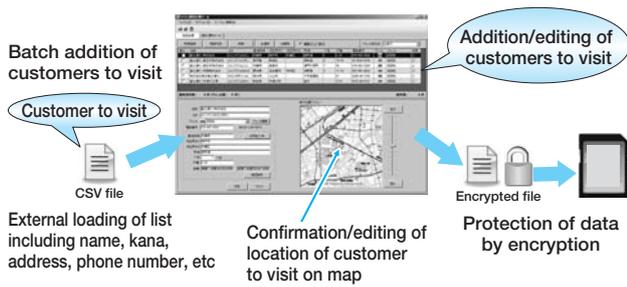


Fig.7 Application Screen for Corporations

②Support for creating notification e-mail of urgent customers

For urgent customers to visit, this application can send an e-mail of their data to the mobile phone of a sales person.

When the data of urgent customers to visit is created at the office using this application, the code, which includes the latitude/longitude information of customers, to link to the mobile phone application using the KEITAI-Link service, which is adopted in our commercial model, is automatically produced.

Then an e-mail text including the produced code is sent to the mobile phone of the sales person, using an e-mail function of client PC.

When the mobile phone receives the notification e-mail of urgent customers produced by this application, the dedicated application to link to the navigation system is started by clicking the link, "send to navigation system," shown in the e-mail text (if download is not done in advance, transferred to the page for download).

Next, the screen page of AVN118MCO is transferred to the screen page of "destination reception screen" of KEITAI-Link so that the urgent customer to visit shown in the e-mail text can be set as a destination easily, using the infrared function of the mobile phone.

In the past, the destination of urgent customer to visit was directed by an e-mail or telephone. However it was difficult to direct the specific location accurately, so the system for information transmission of precise location was required. This function solves such existing problems by using our KEITAI-Link service developed for our commercial model, and contributes to efficient corporate business.

4 Terminal Development

AVNLite displays the navigation map by loading the map data from the SD card. The main problems for adoption of the SD card as the storage media are as follows:

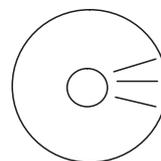
(1) Speed deterioration of reading map data caused by file system

(2) Deterioration of the SD memory caused by file access

In this article, we introduce the solutions.

4.1 Improvement of read speed of map data

The navigation software of AVNLite is based on the specification that loads the map data from the existing CD or DVD. CD and DVD are a read-only media and not rewritable, so the storage location for each data is fixed when the media is created. Therefore, the data is directly accessed to load the map data at high speed and to display the map without the file system. Also for map format, the data reference location on CD or DVD is written as an absolute storage location on these media, using such characteristics.



CD and DVD (without file system)

1. Obtain the initial address of each data from management area of file system.
2. Based on that, access the map data.

(Map data position
=file initial address
+position from top-of-file

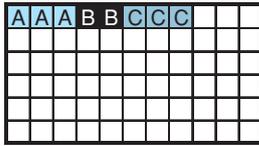
Fig.8 Access to CD and DVD

However, if the map data is stored in the rewritable SD card, a delay in reading occurs since the file system must be interposed to access when the map data is loaded.

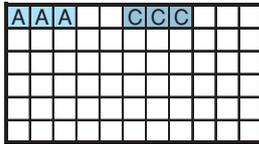
This is because the SD card is a writable and erasable media, and the whole media is controlled for each block of a certain size by file system to use the media effectively. When the file is written, unused block is searched and a certain number of blocks are selected depending on the file size to be written. The selected blocks do not need to be adjacent to each other, and it does not matter even if the blocks are positioned discretely since the file system controls the access of file. The media can be used effectively by writing the file in the nonadjacent block. For example, when the file with size of ten blocks is written, ten empty blocks are required. If the file cannot be written in the nonadjacent block, the file with size of ten blocks can be written only when ten empty blocks are aligned sequentially, even if the whole media has capacity.

However, this control method has a disadvantage of occurrence of file fragment. If writing/erasing of file with various size is repeated, the written file is divided finely and recorded. In this case, frequent access to the management area of file system is required, so this causes the deterioration of access speed. This is one of the reasons that the speed of HDD used for a long time in Windows and others slows down. Therefore, periodical use of a defragmentation tool is recommended.

1. File "A", "B", and "C" are written.



2. File "B" is deleted. (Blocks become empty.)



3. File "D" is written. (Written discretely)

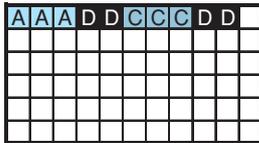


Fig.9 Fragment

This problem of defragmentation occurs in AVNLite too, adopting the SD card as a storage media of map data.



SD card (with file system)

1. Obtain the initial address of each data from management area of file system.
2. Obtain the data position following the link on file system (Link is provided one for one block. If the data, which is positioned 500 blocks ahead from the top-of-file, is accessed, 500 accesses to file system is required.)

Fig.10 Access to SD Card

We considered the method to access data without file system, assuming the map data file continuity as with CD and DVD. On that premise, only one access to file system is required on start-up. However, this cannot be assumed in the normal SD card, so we considered as follows:

(1) System of file access

When the map data is referred with the SD card or HDD, it is impossible to specify the reference location with the absolute storage location of media. At first, the file is specified, and then the position of top-of-file is specified.

Therefore, we incorporated the system that converts the data reference inside the file into the absolute location inside the media without the file system on the assumption that the SD card of map data has no fragmentation.

(2) Acquisition of SD card of map data without fragmentation

To meet the condition that the SD card of map data has no fragmentation, we needed to ask our supplier of

SD card of map data to guarantee the writing without fragmentation as data storage specification. We received their great cooperation, and would like to take this opportunity to thank them.

(3) Operation of SD card of map data created by users

AVNLite adopts the function of digital rights management (DRM) to avoid illegal copying of map data. The SD card of map data illegally copied by users is not authenticated by DRM before AVNLite loads the map data. Therefore, even if the SD card of map data includes the fragmentation by illegal operation of users, AVNLite does not load the map data to prevent defects.

(4) Map data update by compensation version map data download service

In the compensation version map data download service mentioned in 3.1, the users can download the map data from WEB server and update the map data stored in the SD card. We introduce the solutions for fragmentation with this service in 5.2.

4.2 Guarantee of SD card's life

Flash memory generally used for the SD card has the limitation of number of writings, and the more the number of writings, the more errors.

AVNLite does not have function of data writing into the SD card, so no problem occurs. However, the flash memory has limitations of number of readings as well. The more number of readings, the more errors. Therefore, the system to reduce the number of data readings of the SD card is required.

(1) Reduction of access to file system management area (FAT)

In data access processing to the SD card, FAT is accessed most often, and the number of accesses to FAT needs to be reduced. As mentioned in 4.1, AVNLite achieved the access without file system, and it requires only one access to FAT when it is started. After that, the whole map data can be accessed freely by using the copy of FAT cached in the internal memory. This system reduced the number of accesses to FAT.

(2) Optimization of holding method of internal memory in management area of map data

The map data also has the management area, and based on this data, individual map data is accessed. However, there are multiple management areas, and some of them are not necessary. Therefore, assuming the usage scene of AVNLite, we set priorities based on the use frequency of each management data and reduced the number of accesses.

Table 1 Improvement of the SD Access Number

Scene	Annual mileage	Frequency	Destination setting	Neighboring facility searching	The number of accesses before countermeasure (for one travel)	The number of accesses after countermeasure (for one travel)
Commuting	15,600 km	5days/week	2 times (company, home)	None	375	12
Leisure		2days/week	5 times (Address, phone number)	2 times (Gas station, convenience stre)	2,094	15
Business	39,000 km	5days/week	12 times (Address, phone number)	None	3,034	28

(3) Optimization of cache

There is a method, called cache, to reduce the number of accesses to the external media. The data loaded once is held in the memory inside the AVNLite, and from the second time, the data held in the internal memory is accessed so as to reduce the number of accesses to the external media. However, the capacity of internal memory is limited, so how long the data is held needs to be decided in order of priority based on the data characteristics to be loaded. We performed such optimization.

Using three methods mentioned above, we reduced the number of accesses to the SD card. Further we measured the number of accesses in three usage scenes of the AVNLite (Table 1) and confirmed the improvement effect.

5 Application Development

We explain the main technology (map file compression, map file copy, POI data encryption, and map code conversion) that is adopted in the development of map data download service for after market (hereinafter, referred to as map DL) and dedicated application for rental car model and corporations model (hereinafter referred to as support application).

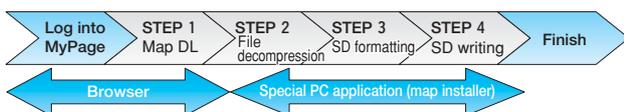


Fig.11 Flow of Map DL Service for Mass Merchandiser Market

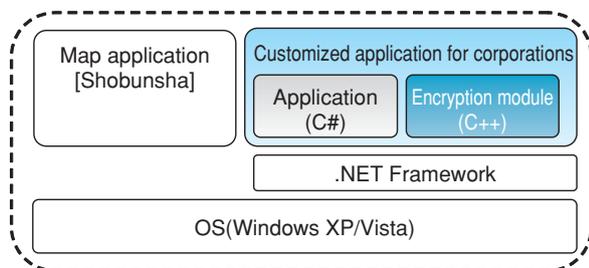


Fig.12 Application Configuration for Corporations

5.1 Map file compression

The file size of map data (version 2008) for commercial model is 3.5GB or more, and it takes two hours or more to download it via the communication line (ADSL /

medium speed [effective speed: around 4Mbps]) that is currently mainstream.

We therefore considered the most appropriate compression format for map file and shortened the download time (within two hours).

5.1.1 Selection of most appropriate compression format

The representative algorithms used for the file compression are shown in Table 2.

Table 2 List of Compression Technology

Compression format	Outline	Developer
ZIP	World standard compression format	Phillip W. Kats
CAB	Windows standard compression format	Microsoft Corporation
GZ	Compression format used in UNIX	Jean-Loup Gailly and Mark Adler
BZ2	Compression format generally used in UNIX	Julian Seward
LZH	Standard compression format in 1990s in Japan	Haruyasu Yoshizaki
DGCA	Compression format strong in text data	Shinichi Tsuruta
RAR	Compression format strong in multimedia	Eugene Roshal
7z	Compression format capable of high compression than ZIP	Igor Pavlov

We compressed the actual map (LOADING.KWI) and compared the compression characteristics.

Table 3 Experimental Result of Each Compression Technology

Compression performance	Compression format	Before compression (Megabyte)	After compression (Megabyte)	Compression rate (%)	Compression software
High ↑ ↓ Low	7z	57.32	24.99	44%	Lhaz
	RAR	57.32	27.62	48%	WinRAR
	DGCA	57.32	28.73	50%	Explzh
	BZ2	57.32	29.91	52%	Lhaz
	LZH	57.32	30.85	54%	Explzh
	CAB	57.32	31.34	55%	Lhaz
	ZIP	57.32	31.36	55%	Explzh
	GZ	57.32	31.42	55%	Explzh

Table 4 Result of Commercial Map (version 2008) Compression

Compression format	Before compression (Gigabyte)	After compression (Gigabyte)	Compression rate (%)	Compression software
7z	3.55	1.87	53%	Explzh

Table 5 Observation Environment

User environment	
OS	Windows Vista
CPU	Intel Celeron M 523 (933MHz)
Memory	2GB
Communication line	ADSL/medium speed (effective speed: 4Mbps)

Table 6 Observation Result

Download	File decompression	SD formatting	SD writing	Total
63 min	13 min, 20 sec	7 min, 10 sec	7 min, 50 sec	1.5 hrs

We found that the download time of map data that is compressed by "7z" is reduced to 1.5 hours, and achieved the initial targeted value.

5.2 Map file copy

As mentioned in 4.2, AVN Lite does not refer to FAT when loading map file from the SD card.

Therefore, the map file needs to be allocated in the continuous area physically by each individual file. However, in general PC (OS: Windows), the allocation in continuous area is not guaranteed due to the file cache when the multiple files are copied concurrently.

Hence, we adopted defragmentation method in the application for map file restoration (map installer) to reallocate the fragmented file in the continuous area and to guarantee the continuity of individual file.

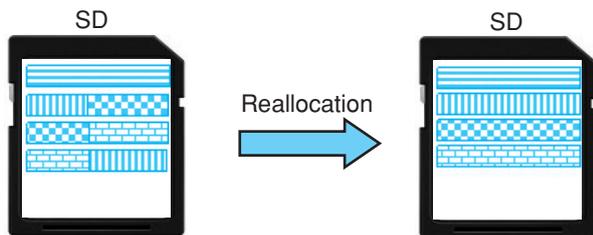


Fig.13 Image of Defragmentation

By this map installer, the map data that the car navigation system can read from the SD card correctly is created, and map data download service with WEB is achieved.

5.3 POI data encryption

POI data includes the customer information (address, phone number, etc.), so the data is encrypted to prevent the information leakage when the data is lost.

Therefore, in the support application (RAKURAKU visiting support tool), the module to encrypt the POI data is invoked from the application via .NET Framework.

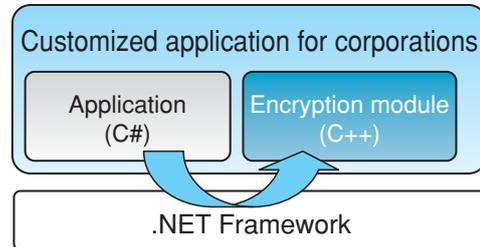


Fig.14 Image of Invoking Module for Encryption

Thus by modularizing the encryption process, the application is not affected, even if the encryption system is changed.

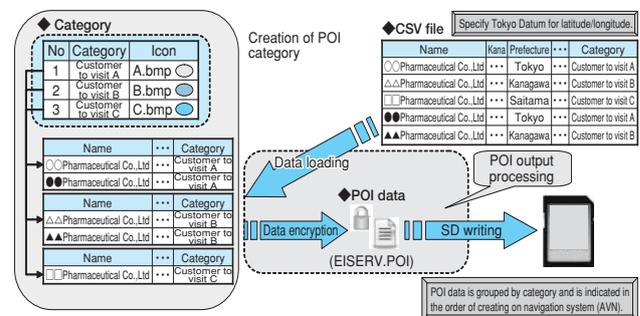


Fig.15 Flow of POI Data Creation

5.4 Map code conversion

The preemptive notification e-mail service for corporation model requires the system to convert the position information (latitude/longitude) to the map code to link to the existing service (KEITAI-Link).

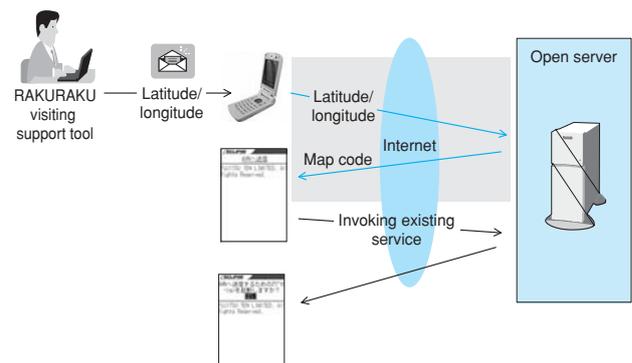


Fig.16 Flow of Preemptive Notification Email Service

Hence, we established the interface (assist) to invoke the map code conversion library on Fujitsu Ten's open server and add it to the existing WEB application to realize this function.

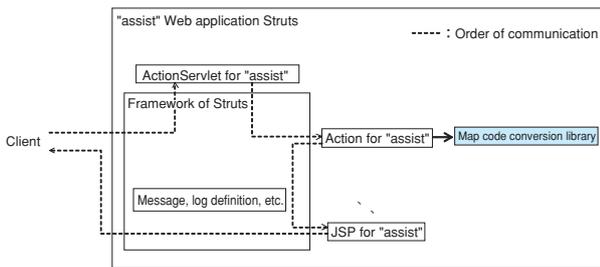


Fig.17 Application Configuration of Public Server

We set the access limitation in this interface (assist) to prevent the access of terminal other than mobile phone. In addition, we added the authentication key to input parameter to identify the invoking from the preemptive notification e-mail for corporation model, and to strengthen the security.

6 Conclusion

Completing the development, we released AVNLite in October 2008. It is with great pleasure that we can report that the AVNLite is highly appreciated in the market. It is tribute to all parties concerned inside/outside the company, who supported its rapid development. I would like to take this opportunity to thank them. In the future, we will make efforts to continue providing "convenience" and "secure" to our customers by enriching our WEB service and strengthening the functions of linkage applications.

Profiles of Writers



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