# Applications of Java Computing Technology to GPS/GIS-based AVL(Automated Vehicle Location) System

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***Abstract***—Nowadays, GIS, as multi-discipline information system, is closely linked with GPS application in conjunction with GIS-T or Logistics GIS. With this R&D trend, GPS/GIS application system for AVL is newly developed in this study. This AVL is designed and implemented by using pure Java computing technology towards coming Car-equipped wireless Internet PC age, and main features of Java are included at this system: Platform independence, Multi-thread processing, and Object-Oriented paradigm. While, because core modules of this AVL are based on GIS spatial engine, unlike other commercial AVLs, large spatial database problem handling digital image/spatial information and attribute information and direct access problem of GIS data is easily dealt with: this system can directly access external database by using JDBC: MS Access for desktop version and Oracle for W/S version. Finally, it is thought that Java-based AVL, one of GPS/GIS applications, can be easily extended into other prospective GIS applications: Land surveyor supporting system, Flight tracking system, 3D facility management system with GPS, and so forth.

## Ⅰ. Introduction

Nowadays, GIS(Geographic Information System), as multi-discipline information system, is closely linked with GPS application in conjunction with GIS-T (GIS for Transportation) or Logistics Especially, GIS plays two important roles in transportation planning and analysis: firstly, the use of GIS in processing geographically related data; and secondly, the use of GIS for performing spatial analysis, not only for obtaining new information, but also to augment decision support by allowing the development of 'what-if'scenarios[1]. And, in order to allocate vehicles efficiently or give business directions to each vehicle accurately from the base station, the position of each vehicle must be correctly understood. The most popular method used today in positioning vehicles are GPS(Global Positioning System) and a method using wheel speed sensors, gyro scope, etc[2]. With this R&D trend, GPS/GIS application system for AVL(Automated Vehicle Locator) is newly developed in this study. This AVL is designed and implemented by using pure Java computing technology towards coming Car-equipped wireless Internet PC age, and main features of Java are included at this system: Platform independence, Multi-thread processing, and Object-Oriented paradigm. While, because core modules of this AVL are based on GIS spatial engine, unlike other commercial AVLs, large spatial database problem handling digital image/spatial information and attribute information and direct access problem of GIS data is easily dealt with. Major components of GIS engine in this system are composed of Fetchering module, Save/Storage module, and Updating module; In GUI(Graphical User Interface) component, three parts of Index window, Working (Area) window, and Vehicle window consist in. Among them, Index window supports digital map searching linked spatial database, and Working Area window and Vehicle window do working area zoning, vehicle searching, facilities searching, multiple vehicles' loci displaying, real-time reporting, and feature managing. Especially, GIS functionality in this system is feature handling of node, chain, polygon, and text and spatial analysis of network analysis. Furthermore, this system can directly access external database by using JDBC(Java Database Connectivity): MS Access for desktop version and Oracle for W/S version. Finally, it is thought that Java-based AVL, one of GPS/GIS applications, can be easily extended into other prospective GIS applications: Land surveyor supporting system, Flight tracking system, 3D facility management system with GPS, and so forth. This developed AVL system may provide the opportunity to provide dynamic scheduling and other service enhancements, and to manage their vehicles more effectively.

## Ⅱ. AVL Components

The AVL System offers traveling information, traffic information, and others to driver of vehicle in order to shorten the time taken in traveling and reduce the cost covered. It consists of three basic attributes, each

representing a different technology[2,3,4]. AVL systems provide a means to locate the vehicles. The highly precise global positioning satellite system (GPS) is the preferred method for vehicle location. Second, they provide a means to communicate the location to the service or security provider. This requires mobile data telemetry. Third, they analyze the information from the vehicles to provide it with commercial or other value. This is accomplished with GIS(Geographic Information System) software which plots the vehicle locations (spatial information) on suitable maps. GIS software links location information with data based information(aspatial attribute information). GIS Software also provides real time links to existing CAD(Computer Aided Dispatch) or MIS(Management Information System) software. These AVL system provides three strong benefits to a transit agency[5]. The first benefit is the availability of necessary data to optimize routes. This optimization allows for reduction in runs, fewer vehicles deployed and improved on time performance. The second benefit is improved safety. AVL can significantly shorten the time required for emergency vehicles to respond to an incident. The third benefit is improved on-time performance. The availability of accurate and timely vehicle location provides dispatchers with the required information to better manage the on-time performance of the fleet. This data also provides passengers with real time information about vehicle arrival times. Figure 1 is shown the concept of GPS-based AVL.

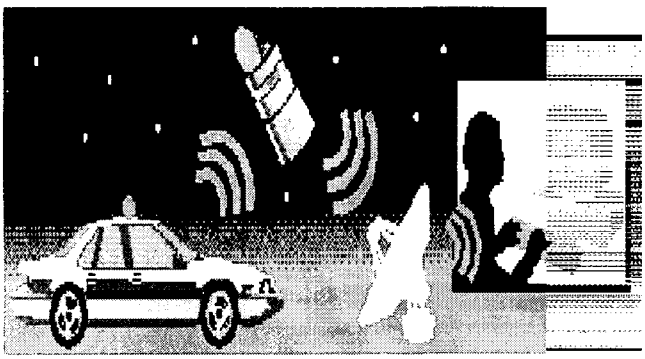

Figure 1. Concept of GPS-based AVL

## III. Wireless Communication

The wireless data communication is the key to a good AVL system. An AVL client usually has radios or mobile phones in place for voice and data communications. There are many wireless data services to consider. Candidates in the market today include Cellular, RAM Mobile Data, Ardis, and Cellular Digital Packet Data(CDPD). Also available are wireless local area network(WLAN) spread spectrum and Specialized Mobile Radio(SMR) systems, PCS, TRS(trunked radio systemss), and satellite systems[5,6]. Within each, there are many options to choose from. In this study, because the PCS network covered a whole country and it could communicate letter, digital data as well as voice, we used the PCS network as wireless data communication component.

## IV. GIS Component

The AVL analyze the information from the vehicles to provide it with commercial or other value. This is accomplished with GIS(geographic information system) software which plots the vehicle locations on suitable maps. In this study, this GIS component of AVL is designed and implemented by using pure Java computing technology towards coming Car-equipped wireless Internet PC age, and main features of Java are included at this system : Platform independence, multi-thread processing, and object-oriented paradigm. Figure 2 is shown the block diagram of GIS component.

### A. Vector Data set

In this study, we used 11 vector data set in dxf(Data eXchange Format) file format and the maps drawn on a scale of 1 to 5,000. They were made by NGI(National Geography Institute) and They covered a division of Taejon, the fourth biggest city in Korea.

### B. Spatial Engine

This spatial engine consists of 5 basic elements : Database Manager, Spatial Operator, Query Processor, Topology Builder, spatial indexing manager. The database manager and spatial indexing manager is one of core parts of spatial engine which could handle spatial data sets and attribute data sets in relational database and spatial indexing information. As shown in Figure 2, spatial engine performs data management by using spatial indexing, spatial operation to help various spatial analysis, and SQL-based spatial operation.

#### 1. Database Manager

The proposed database Manager contains several tables : spatial data table, attribute data table, attribute-spatial join table, feature definition table, and spatial indexing file within relational database through JDBC.

Spatial data table is for spatial information composed of 16 features to present geographic object. We defined these features by using object-oriented concept[7,8]. And they are divided into 4 subtypes of the feature : node feature class, chain feature class, polygon feature class, text feature class. The node feature class has 8 elements : Hospital, School, Executive Agency, Gas Station, Police Station, and Other Agency. Each node feature is represented as a GIF(Graphics Interchange Format) image format on screen. The chain feature class has 8 elements : Stream Center Line, Stream Boundary, National Road Center Line, National Road Boundary, City Road Center Line, and City Road Boundary. The polygon feature class has 2 elements : Lake and Apartment. The last, the text feature class has 3 elements : Road Name, Dong

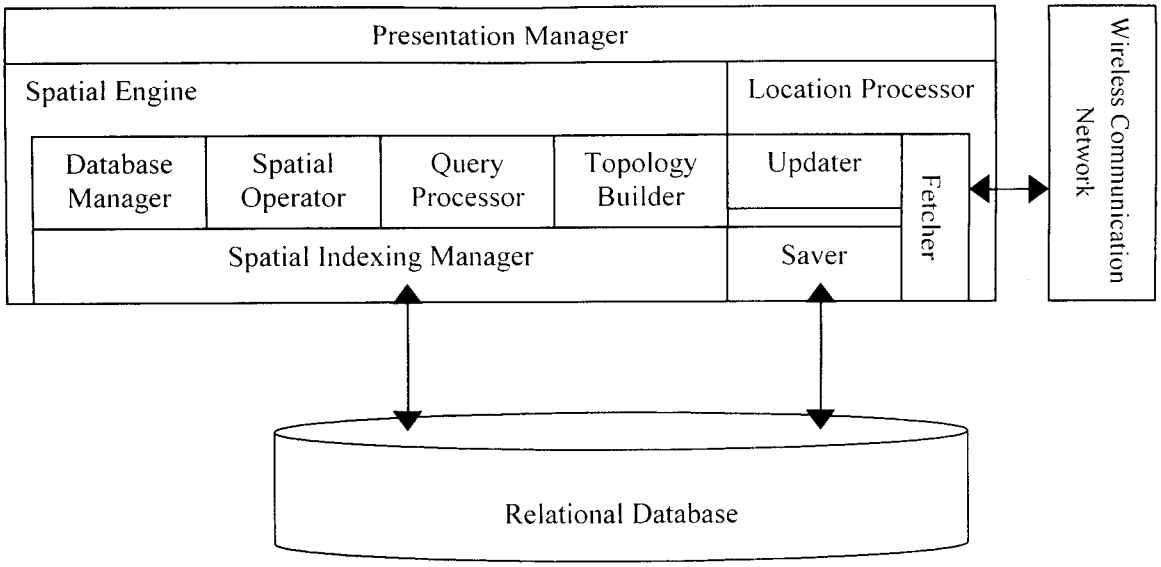


Figure 2. The block diagram of GIS component

Name, and Gu Name. Consequently, we implemented the feature hierarchy by using depth-4 tree structure.

Spatial information within primitive tables means geometric information such as XY coordinates, length, area, and perimeter and topology information such as left/right polygon ID, start/end node, besides indexing information such as MBR(Minimum Bounding Rectangle). Attribute data table stores real feature information such as school, road, hospital; by using attribute-spatial join table, it is connected with spatial data table. While, database manager is for management of FDT(Feature Definition Table) and indexing table, and they works as management of all feature with database and spatial indexing information of R*-tree, respectively. Therefore, a complete feature with feature-based data manage system can be represented as spatial data table, attribute data table, attribute-spatial join data table, and indexing table.

## 2. Spatial Indexing Manager

The spatial indexing, another core part of spatial engine, enables the spatial engine to handle the large volume of GIS data. This system provides spatial indexing function based on R*-tree[9,10]. R*-tree indexing method is primarily implemented by MBR(Minimum Bounding Rectangle), and is tree-typed indexing methodology related to storage of clustered adjacent spatial data into same location. Main function of Indexing manager is fast spatial information searching with respect to spatial tables of each geographic feature class. For this process, indexing manager has several methods: creation/removal of indexing information, and update of indexing information when spatial data insertion/ deletion. There are 4 spatial information searching types that indexing manager support : containing searching, contained searching, intersect searching, and exact matching

## 3. Spatial Operator

At the early stages of development, GISs were envisioned to provide functions such as acquiring, storing, data conversion, manipulation, and presenting geographic data for decision making. According to ESRI's definition, in addition to others mentioned above, a complete GIS must provide spatial analysis functions. Indeed, it is the spatial analysis capability that differentiates GIS from desktop mapping software[11]. We developed several spatial operators for complex and advanced geo-processing : near, adjacency, connectivity, containment, contained, buffering, and short path routing. These GIS functions are used for spatial editing, single spatial analysis, and complex spatial analysis to generate thematic layers; in this system, spatial analysis operation process with spatial indexing manager can be carried out as the two steps: filtering phase and refinement phase.

## C. Location Processor

The location processor roles data flow controller. This AVL system uses the GPS satellite as a positioning method of vehicle. The vehicle as an AVL client has GPS receiver and mobile phones in place for voice and data communications. And it communicate its own location data to Control Center through wireless communication network, especially PCS(Personal Communication Service) network. Control Center receives the location information of vehicles, and saves it into database, and represents the location on screen. This location processor has three major elements, Fetcher, Saver, Updater and the are designed and implemented by using Thread method of Java to manage a great number of vehicle. They have two significant features. One is independence each other , the other is simultaneous operation. When one of them acts, others do not stop and operate their duty, too.

1. Fetcher

A vehicle receiving its own position on the earth from GPS satellite is sending continuously its location to Central Control Center through PCS Network. If Control Center does not save the positioning data, the AVL system loses the location information of vehicle. However, it is inefficient to save all positioning data to be transmitted from vehicle, because it needs a massive storage device. Therefore, the filtering phase for extracting the valuable information as a vehicle location needs. The Fetcher roles filtering. It uses three information for filtering positioning data. One is direction moved, another is distance moved, and the third is elapsed time. Fetcher search all positioning data and extract a valuable location information by using these three filtering method.

2. Saver

This saves the filtered positioning data into database. We make a unique table for each vehicle, and attached the positioning data to the table by the identifier of vehicle. The AVL system developed in this study support MS-Access for PC and Oracle for workstation platform. Because we implemented the database access method using JDBC(Java Database Connectivity)[5,6], our system can be easily ported or linked other external database supporting standard SQL such as Informix, Sybase, DB2. The saved location data is used for tracing vehicle for a day. It also is combined with other attribute data of vehicle and the combined data make complete vehicle information.

3. Updater

This displays concurrently the location information of a large number of vehicles on suitable maps in screen. As this AVL system response user's request, one positioning information of each vehicle is saved in temporary storage for fast searching the vehicle to be selected by user and representing it on screen.

## V. Conclusion

GIS/GPS-based AVL system is developed in this study. It has spatial engine and location processor. The former enables AVL to handle large volume of geographic object. And the latter enables that to control vehicle's location flow. All of them designed and implemented by pure Java applet; therefore, it works at independent environment, especially under Web-environment. The spatial engine is composed of database manager, spatial indexing manager, and spatial operator. As for GIS data set, feature-based methodology by relational database is used so as to perform spatial analysis for vector-based layers. The location processor has two significant features. One is independence each other , the other is simultaneous operation. We also used the PCS network by means of communication network. In the future, we will develop sender which can communicate between Central Center and vehicle with Car-equipped Internet PC.

## VI. References


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