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Original article

Construction of Indoor and Outdoor Spatial Information Integration Service System based on Vector Model

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Abstract

In order to overcome the problem that outdoor and indoor spatial information service are separately utilized, an integration service system of spatial information that is linked from outdoor to indoor has been implemented. As a result of the study, "0001.xml" corresponding to the file index key value, which is the service connection information in the building information of the destination, was extracted from the prototype verification of the system, the search word of 'Kim AB' was transmitted to the indoor map server and converted from the outdoor map service to the indoor map service through confirmation of the navigation service connected information, using service linkage information and search words of the indoor map service was confirmed that the route was displayed from the entrance of the building to the destination in the building through the linkage search DB (Database) table and the search query. Therefore, through this study was examined the possibility of linking indoor and outdoor DB through vector spatial information integration service system. The indoor map and the map engine were implemented based on the same vector map format as the outdoor map engine, it was confirmed that the connectivity of the map engine can be applied.

Keywords : Indoor Spatial Information Service, Building Object Information, Indoor Map Service, Integration Service of Spatial Information

1. Introduction

Today, outdoor navigation map services are widely available in a variety of functions, and many efforts are also being made to provide services for indoor spatial information. Recently, the complexity of diversification of indoor space due to the construction of cutting-edge cities such as U-City (Ubiquitous City), U-Ecocity, smart-city has added additional temporal and economic costs, demand for location services of indoor spatial is on a gradual increase (Yoon and Hwang, 2015), the navigation is expanding into the indoor spatial and the service for it is perceived as natural. Also, as shown in the indoor spatial information standard of OGC (Open Geospatial Consortium) and in the technology trends related to various outdoor web services, it is expected to enter into the era of indoor and outdoor spatial information integration service (Kwon and Kim, 2013).

Based on the CityGML, the OGC's three-dimensional city model standard, detail 4 (LOD 4: Level of Detail 4), the standardization of indoor spatial currently suggests a geometric and semantic model standard of indoor spatial (OGC, 2012(a)), by defining the IFC (Industrial Foundation Classes) as a standard, BuildingSmart refers to expressing the architectural elements of indoor spatial (BuildingSMART, 2013). Currently, there are various types of formats such as GML, KML (Keyhole Markup

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Language), IFC, GeoJSON, and GeoRSS to represent indoor spatial among these, OGC of CityGML and IndoorGML is defined as standard (OGC, 2012(b); OGC, 2014). CityGML is limited in the representation of detailed connectivity and topological connectivity in offices, corridors. There is a limit to the search of indoor spatial and the analysis of spatial (Li and Lee, 2013). IndoorGML is intended to represent walls, doors, stairways, etc. of objects existing in 3-dimensional indoor spatials of other indoor and outdoor buildings, but there is a limit to expressing all contents independently (Li *et al*., 2015). For these reasons, Given that GML is not well utilized in a variety of spatial information web applications as an international standard that may be of great interest to many general users. JSON is easier to handle than based XML (Extensible Markup Language) data formats, because of Javascript, its performance is also known to be good (Park and Lee, 2008).

Until recently, it is only possible to access geographic information that adds vector geographic information of WFS (Web Feature Service) to image-based WMS (Web Map Service) and it is a fact that there are limitations in the bird view such as 3D expression which is the basic use of the map, new backgrounds at enlargement and reduction, modification and customization of background data. Namely, Because it is a format that expands data from XML base for the purpose of expressing spatial information as a vector form to support specific geographic information. It takes up a lot of data spatial, although some types of information such as buildings and such services as roads, route lines and tracking can be expressed. It has a partial limitation because it requires a very large amount of data to display a lot of information at one time like an actual map. To overcome the disadvantages of service linkage, display capacity, and customization for user convenience. There are a lot of studies related to algorithms and systems for linking smooth web services in various formats such as GML, KML, GeoJSON, and GeoRSS (Han, 2014; Kim *et al*., 2013). Among them, GeoJSON format allows user to directly modify, insert and update information of original map data and customize it, that can share various information expressions as object-based text, by eliminating unnecessary tags and header information. It can reduce the size of the map to speed up the map display and include a variety of map information, thereby improving the quality of the map.

However, previous studies have focused on indoor navigation systems and algorithms rather than on indoor and outdoor spatial information services (Kim *et al*., 2014; Zhou *et al*., 2013). The studies on the vector map implementation have been very limited so far. There is little study on the vector map implementation using the GeoJSON format, which facilitates capacity minimization, smooth customization, and exchange of objects between different systems, in order to complement the disadvantages of the various spatial information formats mentioned above. Also, it is difficult to find the previous studies that integrate indoor and outdoor into one service.

Therefore, in this study, as an early stage for integrating indoor and outdoor individual spatial information systems and applying a unified service, to express an integrate various indoor map formats such as GML, KML, IFC, GeoRSS. It can fully support real life patterns and different formats of outdoor maps, such as binary, raster data, etc., utilized in most commercial navigation which indoor and outdoor maps were designed with GeoJSON, an unified engine was applied. Also, for the purpose of verifying interrelated search of different indoor and outdoor, by verifying and reproducing the hypothetical scenario, setting the departure point based on the outdoor map service and set the destination in the indoor map data, the applicability of vector spatial information integration service system has been shown.

2. Service Design and Construction

2.1 Service design process

In this study, for spatial services related to separately existing indoor and outdoor services as shown in Fig. 1, through the establishment of integrated spatial information service between two services by finding a common link, it tried verify the possibility of providing as an indoor and outdoor integrated spatial service.

The indoor spatial information was constructed around the 2nd building of the engineering College, Kyungpook National University. The outdoor information was linked with the navigation data using Mappy of MN soft company.

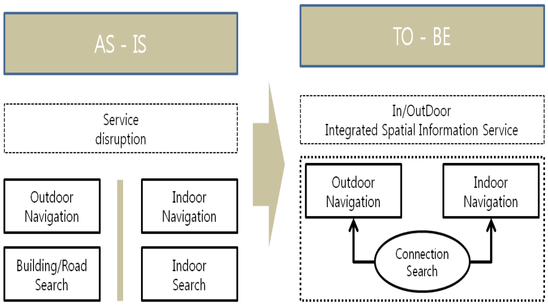


Fig. 1. Service design purpose

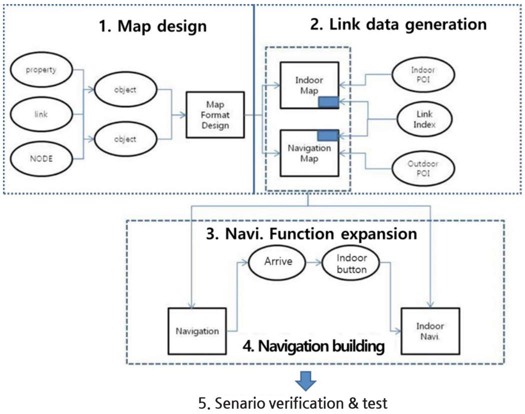


Fig. 2. The flow chart of study design

First, regarding the system design, the outdoor service such as navigation were designed through function buttons and service linkage engine module that could be linked with indoor service, the indoor service extracts the same attributes as the outdoor spatial and creates a link to connect the spatial information.

And leveraging GeoJSON's ease of insertion, deletion, and customization of information, by inserting the connection information of the indoor outdoor map, by removing unnecessary information other than attribute information and graphic information and by reducing the size of the map, it optimized the map display performance. GeoJSON is a geospatial data interchange format based on JavaScript object notation, it is very advantageous in the web environment because it adopts the syntax of JavaScript. In addition, GeoJSON is composed of text that is easy for human to read and write. Programming language and platform are independent of each other, for that reason make it easy to exchange objects between different systems. As shown in Fig. 5, the map is minimized by constructing object, which is the minimum information that can be displayed, point/line/plane information and coordinate information. In this study, the steps for outdoor service, indoor service, indoor/outdoor spatial information connection are verified by spatial object unit, and it linked this to all the services. The flow chart of the design is shown in Fig. 2.

2.2 Indoor map design

First, the target building for the indoor map design was Kyungpook National University Engineering Building No. 2 in Sangyeok-dong, Buk-gu, Daegu. To build indoor spatial information, it is necessary to filter each layer by using the digital map and the architectural drawing. The geometry and position of Kyungpook National University Engineering Building No. 2 were extracted from coordinate information of points, lines, and planes from the drawing. And by securing the attribute data that could represent the indoor spatial, the attributes for the points, lines, and faces of the extracted information were defined, then they converted to data that could be served through re-filtering.

Using QGIS 2.1.4 version as shown in Fig. 3, the objectized numerical data constructed from the shape file was converted. And using objectified service groups was possible to utilize services such as indoor route search through the building details and the departure/destination setting. Also, all extracted point, line, and plane information were used as a graphic group for viewers, and information that could be used as a service in a graphic group was classified as a service group. Here, the graphic group means coordinate information that can form points, lines, and faces, and the service group refers to objectized data of linear and planar shapes composed of coordinate information.

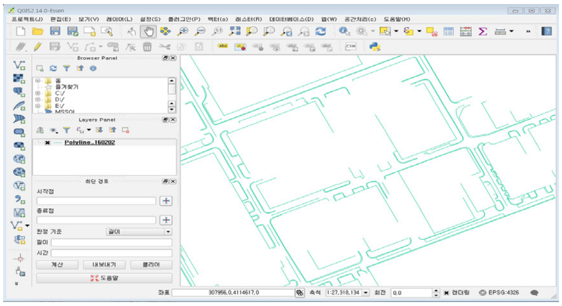
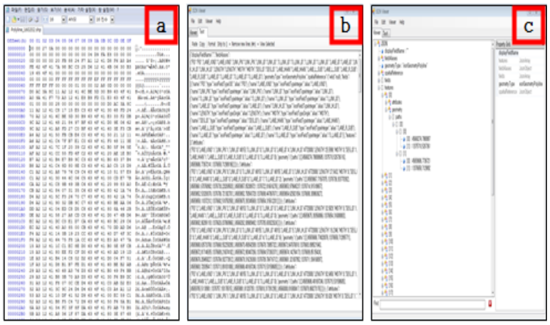


Fig. 3. Indoor numerical map (QGIS)

After the secured numerical map data is changed to the JSON format and analysis for classification is performed in order to extract necessary attributes, it converted .shp format maps to JSON format. Fig. 4 shows a screen confirming the result through the JSON viewer. JSON map transformation methods can be built with JSON through programming, or there is a way to take advantage of the JSON file conversion feature in QGIS. In this study, it performed file conversion using QGIS 2.1.4 version.



(a) original shape data (b) JSON conversion data (c) JSON property tree

Fig. 4. Checking results with JSON viewer

By combining the classified graphic group and service group after the conversion, information-centered indoor map was designed and constructed, the service group was divided into branch information, object attribute information, a network for indoor path search, each service information was combined with attribute information and corresponding graphic information.

For example, Building A has as sub-attributes 1. Line/Plane information, 2. coordinate column information [{"x": "000", "y": "000"}, {"x": "000", "y" "000"}, {"x": "000", "y": "000"}, {"x": "000", "y": "000" 3. service linkage index.

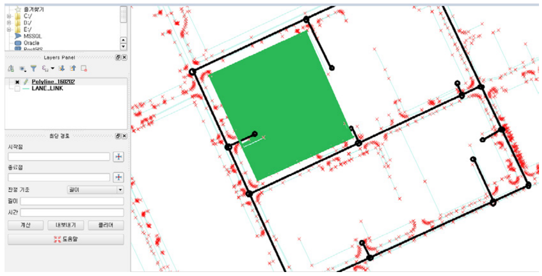


Fig. 5. Process of polygon data and services link working

Fig. 5 shows the interpolation point and polyline information of the file in converted JSON data, assuming the green surface is lab A to apply the linkage based on this data, line/surface information is stored as a surface in the beginning. Next, the coordinate column information stores the coordinates of the four vertices. The index of the server DB (Database) information table is then stored, service linkage indexes being used to link detailed information. The server DB stores detailed information such as locations registered in the building A, registered personal names, telephone numbers, this information can be called up through the service association index.

Also, it can be linked to the starting/destination setting

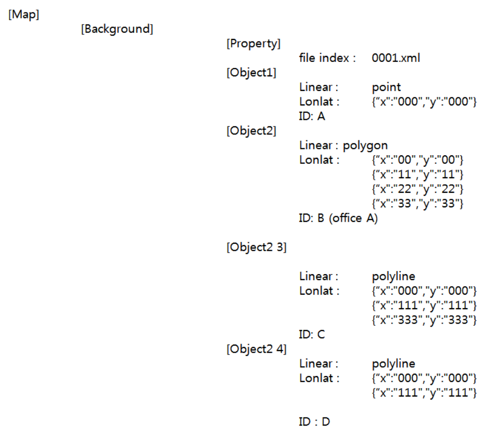


Fig. 6. Indoor map design combining graphic and service groups

or retrieval of the route guidance for navigating the indoor map route. The black line in Fig. 5 is the screen sampled to construct the network data for route search, a path is created from a row of links from a building entrance to a specific location inside the building which is the destination.

This combination of paths is also included in the detailed information registered in Building A, the map was constructed as shown in Fig. 6 according to the JSON format.

2.3 Structure of indoor and outdoor linkage system

In the same system of applications, engines, data layers, depending on the type of the service, it is designed to access different service data servers. As shown in Fig. 7, the point of connection according to the service type can be directly controlled by the user by providing buttons on the UI (User Interface). Basically, based on location information that can be judged by the application, upon entering a certain radius (less than 30 m) of the destination of the outdoor service, an automatic linkage is possible, but in this study, the link button is activated as shown in Fig. 7 and it was designed in a way to select a clear motion by clicking on it. In the UI of the application, the indoor and outdoor buttons are recognized by the user, divided into active/inactive according to the service.

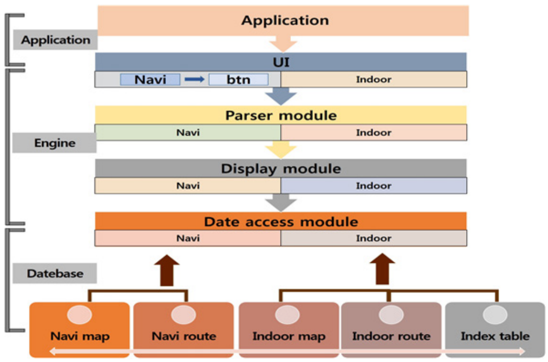


Fig. 7. Service structure of indoor and outdoor integrated system

The display engine uses node/link, coordinates, point/line/surface, theme information which are the essential elements for drawing, this information is displayed on the screen, extracted from each parser module and delivered to the display engine.

By accessing the outdoor map server and the outdoor map navigation server, the outdoor service is parsing data through the data access module, by accessing the indoor map server and indoor map path search server and other data servers for linking indoor and outdoor services, the indoor service is parsing data through the data access module. When information for drawing is extracted in each parsing module, the information that can be displayed on the screen is processed into a common format capable of displaying indoor and outdoor maps and delivered to the display engine.

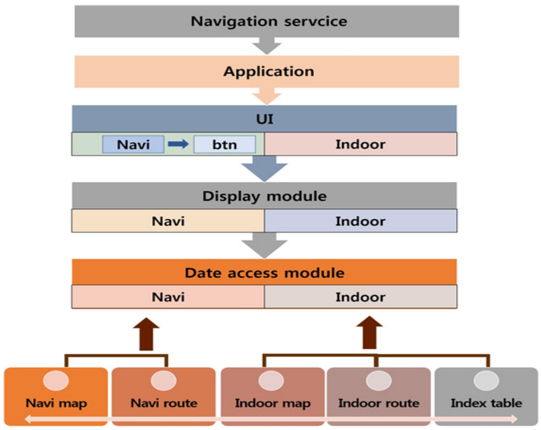


Fig. 8. Data and service flows from vehicle to destination

In the integrated service structure of Fig. 7, the data and the service flow from the vehicle to the destination (that is, from the entrance of the building, the starting point of the indoor service, to the final destination in the building) proceed as shown in Fig. 8. The steps for linkage from outdoor service to indoor service are started through the buttons of Navi UI.

2.4 Inserting linkage information of map and indoor data

The connection between the map and the LBS (Location Based Service) service is done by GeoJSON, using the connection information between objects in the map. Line/surface information indicates how the graphic elements are drawn, pictures are drawn using coordinate column information. The ID information in the object is connected to the service information of the server DB, so that the indoor information service becomes possible by linking location-based and spatial information.

For example, In Fig. 5, office A is a rectangular shape with four coordinates, as shown in Table 1, the detailed information was retrieved from the server DB whose ID value is B, connected to the places with location 205 and extension 1234.

Table 1. File name: 0001.xml (sample design)

ID	Extension	Room	Building	Etc
B	1234	205	Engineering 2	
F	1235	401	Engineering 2	
G	1236	203	Engineering 2	
H	1237	210	Engineering 2	

Fig. 9 shows the interpolation points based on the link data shown in Fig. 5, the index is assigned based on the generated interpolation point, each index column coordinate value (x, y) is obtained. The generated interpolation point-based index is shown in Table 2.

The starting point for the indoor route navigation is the entrance to the building, the destination will be a specific office and classroom within the building. An index is assigned to a location point of a portion to be a starting point and a destination of the indoor route search, a table storing information such as a position corresponding to the given index and an extension number is generated, the connectivity of spatial information was insured. Fig. 9 is a screen that shows the entrance points of indoor building and the office location points for test verification, the extracted points become the destination information of the indoor route search such as office 205 or 203. When conducting an indoor route search for office 205, the indoor route search coordinate column of Table 2 is searched, looking for the location in File 0001.xml in Table 2 and having the corresponding ID value. The path from the entrance to office 205 corresponds to the interpolation point index column information of the second record, the combination of the interpolation points corresponding thereto becomes the result of the path search.

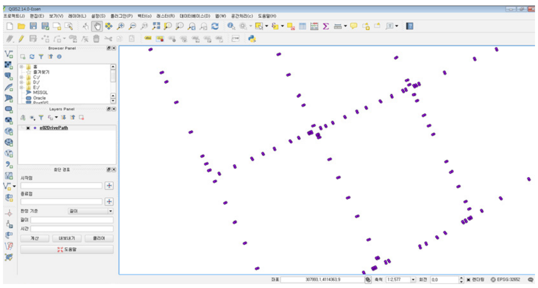


Fig. 9. Create interpolation points for indoor path search

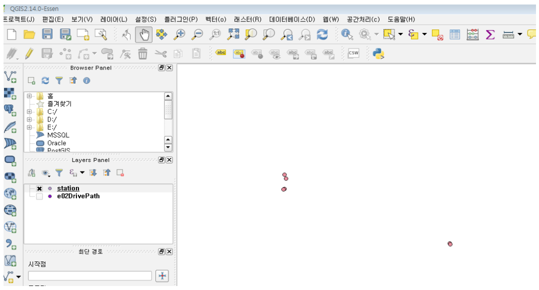


Fig. 10. Extracting the origin/destination point of indoor location

Table 2. Indoor path navigation coordinate column index table

No.	Start point	End point	ID	Path planing
1	A1	B1	A	29>30>31>32>33>34>35>36>37>101>102>103>104>105>106>110>111>112>130>131>132>133>134>135
2	A1	B2	B	29>30>42>43>44>45>46>47>48>49>50>80>81>83>84>85>86>87
3	A1	C1	F	29>30>42>43>45>62>63>64>65>66
4	A1	D1	G	29>30>31>32>33>19>18>17>16>15>14>13>12
5	A1	D2	H	29>1>2>3>4>5>6
6	A1	D3	K	29>1>2>3>10>11>12>13>14>15>16

3. Service Implementation and Validation

3.1 Implementing integrated services

The service of this study is divided into three stages of outdoor service, indoor service, link to indoor/outdoor connection, by linking these three steps, the entire service is made available. First, outdoor services utilize navigation, when the current position of the user approaches the destination of the navigation and makes an arrival determination, the indoor map buttons and the indoor service prototypes that can be connected to indoor service were made. Table 3 shows the implementation flow of the indoor service unit.

Table 3. Indoor service unit implementation flow chart

1. User position
1.1 The user enters a doorway.
1.2 Indoor application activation, when user is in GPS accuracy (30 m) from entrance
1.3 Start indoor application
2. Indoor search
2.1 Search with room.205 or name search or extension.
2.2 Search from 0001.xml file.
2.3 Search response - find id (b) or name (kim.A.B).
3. Detail information.
3.1 Search response - the department, position, e-mail, extension and room.
4. Request route planning.
4.1 Search index id (b) from path planning table.
4.2 Search response - field 2.
5. Display route planning line.
5.1 Display line from a1 (entrance) to b2 (room.205).

When JSON-based indoor map is constructed and the link of information is secured within the map data, service utilization becomes possible, by connecting the navigation service and outdoor data, the indoor spatial information data to link the services was designed. spatial information data was generated as an Excel file, to ensure the connectivity of external data to the JSON indoor map property values, the service index attribute was added. The value of the service index consists of the file name, the contents of the spatial information are defined as follows. Table 4 shows sample data in which spatial data is constructed.

Table 4. File name: 0001.xml (department of spatial information building registration information)

ID	Depart-ment	Name	Position	E-mail	Exten-sion	Room	Building
B	Spatial info.	Kim AB	Professor	kim@mail	1234	205	Engineering 2
F	Spatial info.	Lee CD	Student	lee@mail	1235	401	Engineering 2
G	Spatial info.	Choi EF	Student	choi@mail	1236	203	Engineering 2
H	Spatial info.	Park GH	Student	park@mail	1237	210	Engineering 2

The index value of the map data and the file name of the spatial data are configured to have the same value, this file name is specified as the key value. In the search pattern, the position input value and the spatial input value are entered, and the rule corresponding to the spatial input value is a name or an extension number of the field attributes in Table 4, the data that will be the output and the input value of the indoor map will be the value corresponding to the address field and an indoor route search is performed. Table 5 shows the result of the linkage between building registration information and path search result information.

Table 5. Linkage between building registration information and path search result information

ID	Department	Name	Position	E-mail	Extension	Room
B	Spatial info.	Kim AB	Professor	kim@mail	1234	205

No.	Start point	End point	ID	Path planning
2	A1	B2	B	29>30>42>43>44>45>46>47>48>49>50

3.2 Integration services scenario

Table 6. Service scenario design table

<table>
<tr><td rowspan="8">Design</td><td></td><td colspan="3">Outdoor</td><td colspan="3">Indoor</td><td rowspan="12">⇒</td><td rowspan="12">In/outdoor integrated location based service</td></tr>
<tr><td>Search</td><td>Start</td><td>→</td><td>End</td><td>Start</td><td>→</td><td>End</td></tr>
<tr><td>DB</td><td colspan="2"></td><td colspan="2">Search table</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Map engine</td><td colspan="3">Navi. Map engine</td><td colspan="3">Indoor map engine</td></tr>
<tr><td colspan="3">.shp → .json</td><td colspan="3">.shp → .json</td></tr>
<tr><td colspan="6">Web based map engine JSON</td></tr>
<tr><td rowspan="2">Service</td><td colspan="2">Navi.</td><td colspan="2">Center search</td><td colspan="2">Indoor navi</td></tr>
<tr><td colspan="2">LBS</td><td colspan="2">Spatial search</td><td colspan="2">LBS</td></tr>
<tr><td rowspan="4">Verification</td><td rowspan="4">Prototype demo</td><td>Daegu station</td><td>→</td><td>Kyungbuk univ.</td><td>Enterance</td><td>→</td><td>Room</td></tr>
<tr><td colspan="2"></td><td colspan="2">Db table</td><td colspan="2"></td></tr>
<tr><td>Kyungbuk univ. Kim ab
Kyungbuk univ. 1234
Kyungbuk univ. Room 205</td><td colspan="4">→</td><td>Arrive at room.</td></tr>
<tr><td>Start service</td><td colspan="4">→</td><td>End of service</td></tr>
</table>

Using location-based and spatial information with designed data and applications, a scenario to verify the integrated service research methodology from outdoor to indoor has been implemented as Table 6. A prototype application that integrates the outdoor navigation application with the indoor web application was created, in order to integrate the outdoor and the indoor, a DB table that secures connectivity to the server was designed. The destination of the outdoor navigation becomes the same as the starting point of indoor, and to naturally connect to the service, a search table such as Table 4, which is a link of search, is required.

In order for outdoor navigation and indoor navigation applications to work together, the same map drawing structure format is required, a map engine to draw it is need. The same map engine was implemented by building an outdoor JSON map and an indoor JSON map with the design structure as shown in Fig. 5.

The search word was a combination of navigation destination and indoor spatial information such as "Kyungpook National University Kim AB" or "Kyungpook National University 205", the starting point of the verification scenario was Daegu Station. In the application, Kyungpook National University was extracted from the destination search word and the outdoor navigation was performed to Kyungpook National University. When the current position in the outdoor navigation approached the destination radius of 30m, which is considered an arrival, a server DB search was performed. As shown in Table 5, "Kim AB" was found in the search word table and a table of path coordinate columns corresponding to ID value B was extracted. An indoor map is displayed by changing to an indoor application and a path search is performed.

3.3 Analysis and verification

The verification of this study is based on inputting a search word in an outdoor navigation and setting it to arrive at a specific location from an outdoor departure place. The starting point is Daegu Station, the final destination is a specific spatial in a building, Kyungpook National University. The keyword "Kim AB, the 2nd building of the Engineering College, Kyungpook National University" at Daegu Station was searched.

Fig. 10 shows the route search results from the departing Daegu Station to the destination of the 2nd building of the Engineering College in the outdoor navigation, shows the screen running on the routes.

Fig. 11. Outdoor navigation (starting/driving)

Fig. 12. Outdoor navigation (destination access/arrival)

When the vehicle approaches the 2nd building, without ending the route guidance, as shown on the right side of Fig. 11, the 'Indoor Map' button is displayed at the bottom right corner and the indoor map is connected. The button display range is when the current position is within 50 m radius of the destination. Fig. 12 shows the screen changed to the indoor map when the indoor map button is clicked on.

When the button is displayed, whether there is a search term that matches the file name: 0001.xml (department of spatial information building registration information) is checked. A field whose ID is B is extracted and the corresponding network information and related information are retrieved.

Fig. 13 shows the route from the departure point A1 (building entrance) to the destination B2 (number 205) extracted from the search result.

Fig. 13. Indoor/outdoor map switching (outdoor map/indoor map)

In prototype verification of the system, if you search for your destination as "Kim AB, Kyungpook National University" 0001.xml corresponding to the file index key value, which is the service connection information, was extracted in the building information of the 2nd building of the Engineering College, Kyungpook National University,

Fig. 14. Indoor map (on the go/destination)

and the search word 'Kim AB' was transmitted to the indoor map server, by checking the service connection information, the change from outdoor map service to indoor map service was done. For an integrated linkage transition, verification of implementation of connection function to check whether the indoor service was connected when the outdoor navigation approaches the destination and through the indoor search DB, the integrated service that connects the indoor and the outdoor service by expressing the route from the building entrance to the specific location in the building was possible.

4. Conclusion

In this study, in order to overcome the problem that the outdoor and indoor spatial information service are utilized independently, for the purposes similar to the real world patterns, a method of providing the integrated information service of indoor and outdoor linkage information from indoor to outdoor is proposed.

In order to provide the result of the connected route search by the existing individual route search and to build a map and engine that unifies various indoor map formats such as GML, KML, IFC, GeoRSS, outdoor map formats such as binary and raster and to facilitate the insertion, deletion and customization of information, the map and the engine were designed and constructed in the same GeoJSON format.

To build the system and to apply the indoor/outdoor integration service, first, in information of the indoor and outdoor maps, unnecessary elements other than attribute information and graphic information were all removed from the information, to optimize the different performance of the indoor and outdoor map display, the size of the map was reduced. Also, to connect the outdoor and indoor service, service connection information was inserted into the object information such as the building that can be used as the starting point and the destination to confirm whether the indoor map is linked to the object information.

In the prototype verification of the system thus constructed, using service linkage information and indoor map service search words, through the linkage search DB table and search query, the path from the building entrance to the destination inside the building was represented and the interoperability problem between the indoor and outdoor spatial information integration service has been resolved.

Therefore, through this study, implementation and applicability of service prototypes which are connected from outdoor to indoor in a vector spatial information integration service system and the indoor map and map engine are implemented on the same map format as the outdoor map engine, and the possibility that map engine connectivity has been proven.

More than anything, in this study, through the extension of the connectivity of spatially separated services, that expected the scope of spatial research will become possible not only in the indoor and outdoor of the land, but also in the air, ocean, spatial.

However, in the transition to the indoor service, GPS (Global Positioning System) accuracy should be ensured so that the natural service linkage from outdoor to indoor is possible, and because there is not enough information related to the indoor map and the verification was performed using a limited sample DB, the possibility of expanding to various services is limited, so further study is needed.

Also, by linking personal information and extending the connection between personal schedule and spatial in a service and people-centered indoor spatial, extension to various services and linkage methods that can take advantage of more detailed and narrow spatial, such as searching for items in a warehouse of a building will be needed.

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