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A Use-Case for Mobile Location Services with IndoorGML - Indoor Navigation for Visually Impaired People

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Abstract

This OGC Discussion Paper provides a navigation use-case for the use of IndoorGML for mobile location services (MLS). In particular, the Discussion Paper explains how the OGC IndoorGML standard can be applied to a MLS application for visually impaired people in indoor space. Finally, a prototype development of the application on Android smart phone is described in this report.

Keywords

OGCdoc, OGC documents, IndoorGML, MLS, navigation, visually impaired

A Use-Case for Mobile Location Services with IndoorGML – Indoor Navigation for Visually Impaired People

1 Introduction

1.1 Scope

This OGC® Discussion Paper describes a use-case of MLS (Mobile Location Services) to study how the OGC® IndoorGML standard can be applied to practical applications. In particular, the Paper focuses on an application of smart phones for guiding visually impaired people in indoor spaces with a voice-based navigation map implemented using IndoorGML. A prototype, called VIM (Voice-based Indoor navigation Map) is presented in this document. The prototype was developed on the Android OS for smart phones with the TalkBack[1] function. Among mobile location services, it falls into the following classifications;

- Transportation mode: pedestrian
- Place type: indoor space (e.g. subway)
- Type of services: navigation
- Constraints: visually impaired

1.2 Document contributor contact points

This engineering report is written by a collaboration between Pusan National University and Realtime Tech company funded by Geo-Content and 3D DBMS.

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1.3 Future work

Since this Discussion Paper is based on a prototype development, which will be improved with real site tests, subsequent versions of this report will contain more practical issues

1 http://www.androidcentral.com/what-google-talk-back

about voice-based indoor navigation maps for visually impaired people. In particular, we expect that the following considerations are to be taken for robust services;

- Inter-level navigation: In this report, we did not consider the movement between levels in a building, such as via lifts or stairs. For more convenient and seamless service, features for inter-level navigations are required.
- Integration of accurate indoor positioning technologies: Current indoor positioning methods do not support accuracy to the level that indoor pedestrians require for indoor navigation. This is the reason that the braille block networks have been used for an alternative for the prototype. However, we expect that sufficient accuracy can be provided in the near future and therefore we will be able to rely on the indoor positioning method. At that time a certain component of the data model of VIM (Voice-based Indoor navigation Map) should be modified accordingly.
- Improved user-interface: VIM is the first version of prototype. Improvements to the user-interface with repeated field tests based on the feedbacks from real users are required.

1.4 Forward

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

2 References

The following document is referenced in this document.

OGC 14-005r3, *OGC® IndoorGML*

3 Conventions

3.1 Abbreviated terms

The following abbreviated terms are used in this engineering report;

IndoorGML	Indoor Geographic Markup Language
OGC	Open Geospatial Consortium
POI	Point of Interests

UML Unified Modeling Language

VIM Voice-based Indoor navigation Maps

3.2 UML notation

Most diagrams that appear in this standard are presented using the Unified Modeling Language (UML) static structure diagram.

3.3 Used parts of other documents

This document uses significant parts of the paper published in [3]. To reduce the need to refer to that document, this document copies some of those parts with small modifications.

4 Voice-based Indoor Navigation Maps

Recent progress in mobile device and geospatial information technologies provides a platform for diverse navigation information services. In particular, car navigation and pedestrian navigation have become very popular as a smart phone application. These navigation and map services using smart phones are very useful for people with reduced mobility, including visually impaired people [4]. For example the BlindSquare service [1] provides pedestrian navigation services with smart phones for visually impaired people based on OpenStreetMap [9] data and iOS VoiceOver [10], which is a voice-based user-interface.

However, these services are mostly limited to outdoor space whereas most of our daily life is spent in indoor space. For this reason, we present a prototype of indoor route map service developed using TalkBack [8], which is voice-based user-interface in the Android OS. This prototype service, called VIM (Voice-based Indoor Map) assumes a braille block network of the indoor space, which is common in public indoor spaces in metropolitan cities such as subway stations.

This Discussion Paper is organized as follows:

- Clause 5: Briefly discuss the requirements of voice navigation indoor maps for visually impaired people.
- Clause 6: The basic design concepts are described.
- Clause 7: The data model used for the prototype is presented.
- Clause 8: The prototype implementation is described.
- Clause 9: Conclusion.

5 Requirements of Voice-based Indoor Navigation Map

Unlike ordinary indoor navigation and map services, indoor map services for visually impaired people have specific requirements [7]. We considered these requirements as the starting point of design and implementation of our prototype.

- Requirement 1 - providing environmental information: It is very important to provide environmental information to visually impaired users of the prototype so that they quickly recognize the environmental situations around them. While non-visually impaired people easily figure out the environment by a quick look around them, visually impaired people need explicit verbal information about the environment. Even though the environment may be irrelevant to the navigation, the user may have better understanding about the environment and feel more comfortable and safe with the environmental information.
- Requirement 2 - separation of turning from walking: While non-visually impaired people do not separate turning and walking during movement, we need to provide turning and walking guide instructions in separate ways.
- Requirement 3 - using smart phones: One of our goals is to provide indoor navigation maps without any additional equipment except smart phones. Therefore, the prototype should exploit the functions offered by smart phones.
- Requirement 4 - braille block: Our prototype does not use any indoor positioning method due to accuracy problem. In order to replace indoor positioning methods, braille blocks are used as an alternative. In most metropolitan cities, braille block networks are provided in public places such as subway stations and they may serve as excellent guiding paths.
- Requirement 5 - international standards: In order to provide VIM service, we need additional data sets such as indoor navigation networks and Points of Interests (POI). However, collecting such data sets covering an entire city would be very expensive and sharing these data set and interoperability between services become a critical issue. For this reason, we employ IndoorGML. IndoorGML defines a fundamental data model for indoor navigation network and easily be extended to meet the requirements of VIM service.

6 Key Design Concepts for VIM

In this section, we investigate how the requirements given in the previous section were considered in designing the prototype for the user-interface and data model.

6.1 Braille Block Network

In Seoul and other metropolitan cities in Korea, braille block networks are installed in public places and pedestrian roads to guide visually impaired people. The braille blocks are classified as stop block and walk block (Figure 1), which indicate a stop warning sign and walking straight sign respectively. Stop block must be installed at any location, where a stop is required for turning, intersections, or stop warning before important facilities or obstacles such as elevator, stairs, doors. By using these types of braille blocks, navigation network can be implemented as shown in figure 2.

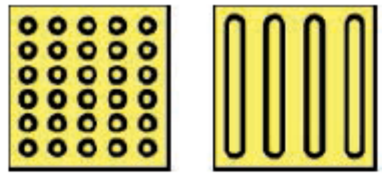

Figure 1 — Braille Blocks: Stop (left) and Walk (right)

Figure 2 — Braille Block Network

Stop blocks and walk blocks are considered as nodes and edges of navigation network, respectively. Consequently a navigation network in indoor space is composed of nodes and edges defined by two types of braille blocks, where nodes and edges may contain additional attributes necessary for indoor maps of visually impaired people. Note that the navigational network is a directed graph since direction is an important property in navigation.

6.2 Three Guiding Instructions – Walk, Stop, and Turn

As discussed in Section 5, turning and walking should be clearly separated in guiding the navigation of visually impaired people for safety reasons. In particular, this distinction is very important in providing navigation instructions based on the braille network. The navigation instruction is classified into *turn left, turn right, go straight*, and *stop*. Turn left and turn right can be parameterized for the turning angle such as “turn right 45 degrees” and go straight is given with a distance. For example, the navigation instructions for figure 3 are to be given as (1) go straight 4 meters, (2) stop and turn right 90 degrees, (3) go straight 4 meters. Note that “stop and turn right 90 degrees” can be simply merged into “turn right 90 degrees” since “stop” is required before every turn.

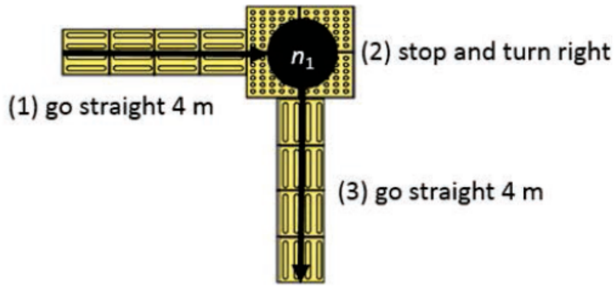

Figure 3 — Turning and Walking

6.3 Landmark Information

In order to inform the user of his/her environmental information as discussed in Section 5, Requirement 1, landmark information is also given in addition to navigation instructions. Landmarks includes POIs, obstacles, and other important features. When providing landmark information, we consider two aspects. First, the landmark information must be given early enough before arriving at the relevant position. Second the directional topology information from the current walking edge is also given to user. In figure 4, we assume that the user is walking through the edge e_{12} from node n_1 to node n_2, and object *A*, *B*, and *C* are landmarks. Then the landmark information of object *A* is given as “Object *A* is at the right side on the path”, ”Object *B* is at the left side on the path”, and “Object *C* is at the left side over the path”. The directional topology of landmark from the current edge is classified into the following categories;

- case 1: left side on the path,
- case 2: right side on the path,
- case 3: left side over the path, and
- case 4: right side over the path

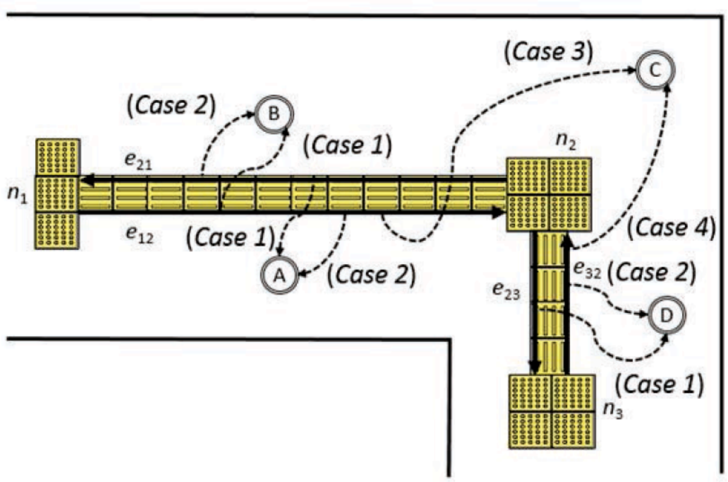

Figure 4 – Four Directional Topologies of Landmark

6.4 Landmark Information

We used IndoorGML to provide a framework for the indoor navigation network, which is a fundamental requirement of our prototype. IndoorGML properly supports the braille network and extensions required by VIM service. From this data model, we defined an extension to represent the guiding instructions and landmarks.

7 VIM Data Model

In this section the data model for VIM is presented. The data model is defined as an extension of the IndoorGML Core module reflecting the design concepts that we investigated in Section 6. The UML diagram of the extension is shown in figure 5.

- Edge-based Instruction: Navigation instructions may be associated with either nodes or edges in a navigation network. Since the movements of users are more properly reflected by edges than nodes, we assign the information about navigation instruction to edges. Each edge of the network contains information for voice instruction(s) for navigation and landmarks. Therefore, if a routing path between two positions in indoor space is found, we are given a sequence of edges (e_1, e_2, ..., e_k), where each edge in the sequence contains proper voice navigation instructions and landmarks.
- Directed Graph: Since voice navigation instructions should be given depending on the walking direction, the navigation network is defined as a directed graph. A single edge in braille block network is therefore split as shown in Figure 6. When making a navigation network, we need to pay attention on each intersection and turning node. For example in figure 6 we see that two turning actions happen at node n_1, left turn from e_2 to e_1, and right turn from the opposite direction. As previously discussed, any navigation instruction on action should be associated with an edge and node n1 must be split into n_{11} and n_{12} and two edges e_{31} and e_{32} with different directions being added as shown in Figure 6.

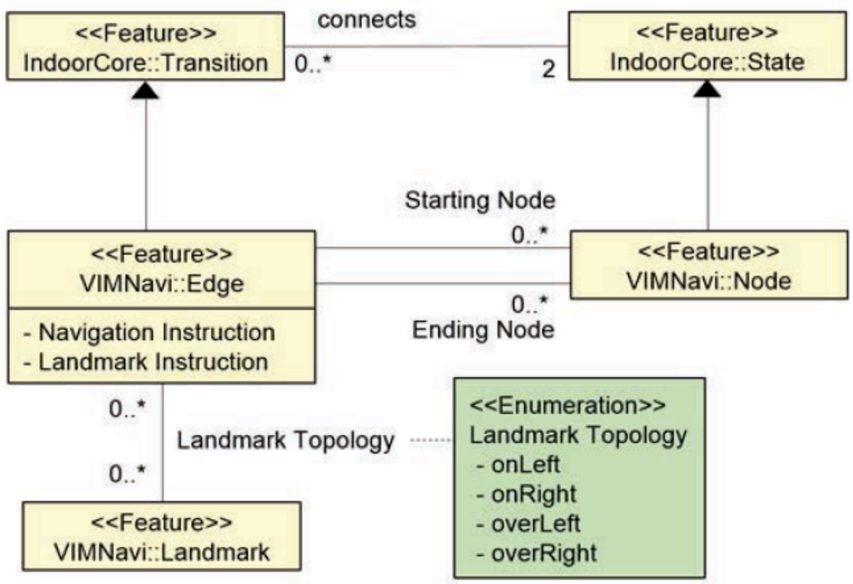

Figure 5 — Extension of IndoorGML Core Module for VIM

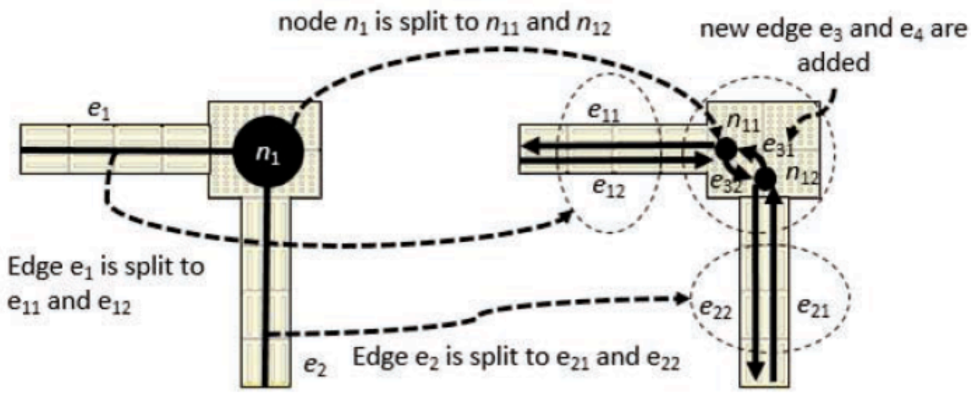

Figure 6 — Splitting Nodes and Edges

8 Implementation

In order to validate our prototype, we applied the approach to a real subway station in Seoul. A part of the site map is briefly shown in Figure 7. Yellow lines and yellow small squares indicate walking blocks and stop blocks on a given route path, respectively. All databases for VIM service are downloaded from a central data server and locally stored on an Android smart phone The prototype then runs as a standalone application once the databases are downloaded. The user-interface was developed using the Android TalkBack functions for visually impaired people. As other navigation or map services, VIM starts with specifying the site name, starting and destination points as shown in Figure 8. Then VIM provides a sequence of navigation guiding instructions for the routing path and user can listen to the instruction of each edge of the network as shown in Figure 9. It also allows users to repeat the instructions.

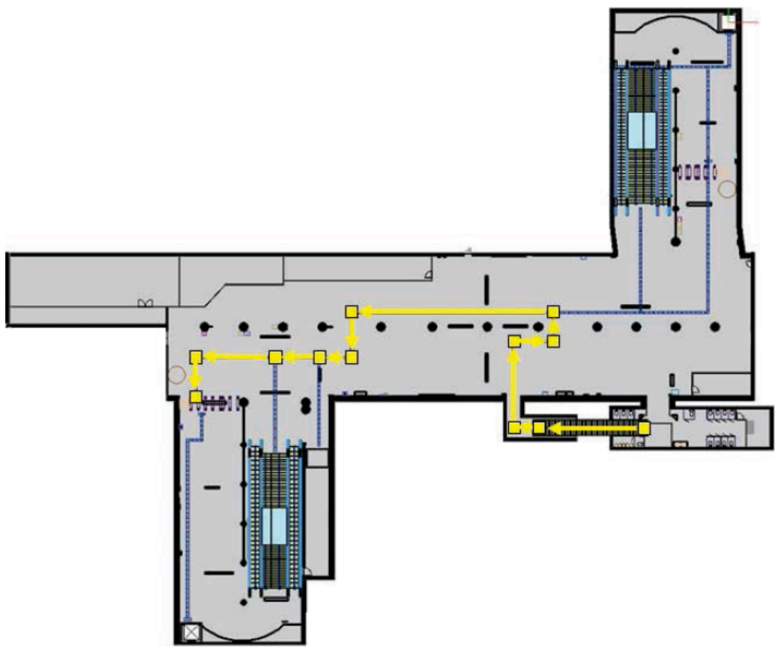

Figure 7 – Example of Navigation Map in a Subway Station in Seoul

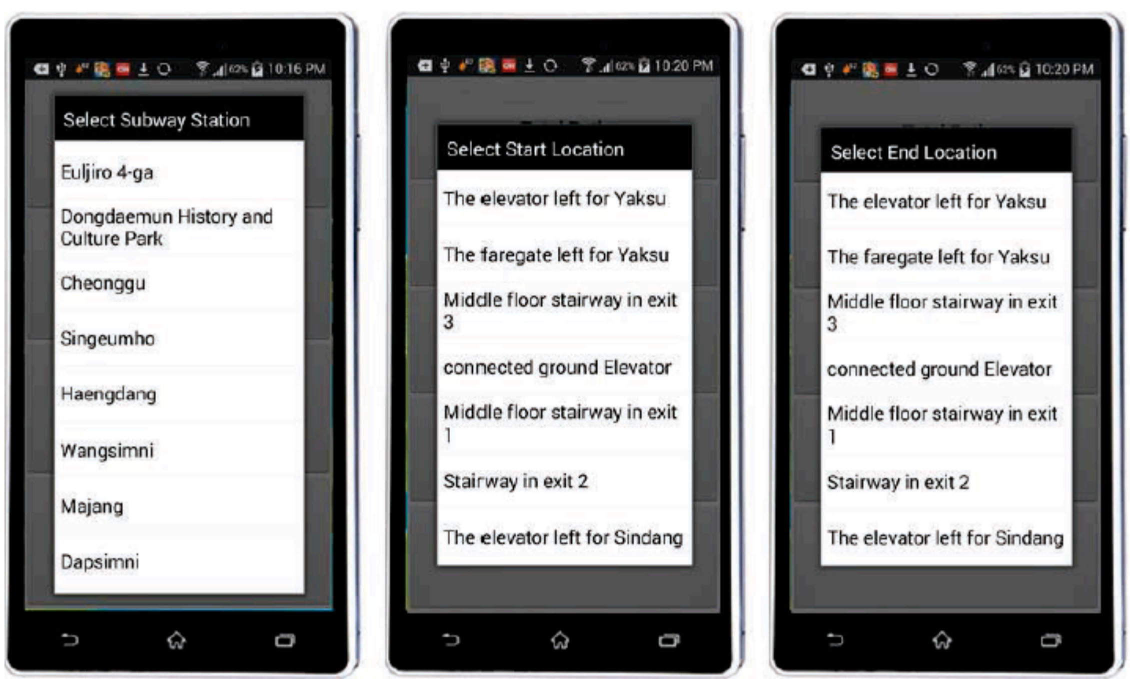

Figure 8 – User-Interface to Select Source and Destination (in text)

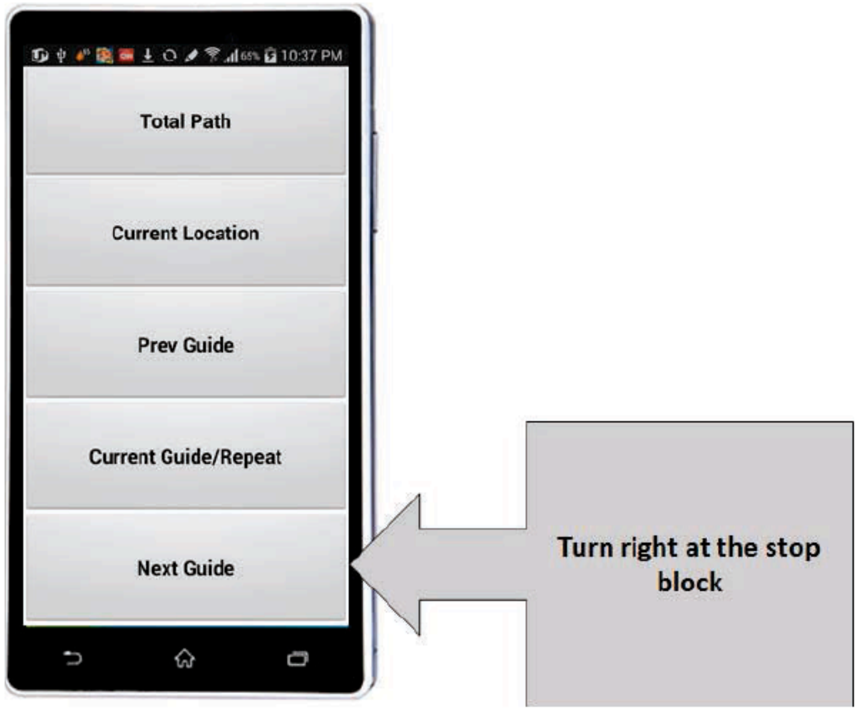

Figure 9 – A Sample of Voice Route Instruction

9 Conclusion

In this paper, we presented a prototype and design concepts for a voice-based indoor navigation map service. In considering the requirements for indoor navigation for visually impaired people, a prototype called VIM (Voice-based Indoor Map) was developed. The main features of the prototypes are as follows;

- indoor navigation using braille block networks
- voice-based instruction by TalkBack of Android OS, and
- data model extended from IndoorGML Core Module.

VIM is only a first step toward an indoor navigation map service for visually impaired people and there are several working items for future work. First, an intensive experiment by real visually impaired people to discover weak points in the prototype and then determining what improvements are required. Second, when there is sufficient accuracy for the safety of users, incorporating indoor positioning techniques into our prototype. Third, we need to strengthen VIM for the case when the braille block networks are not complete. Due to several reasons, braille blocks are often removed and the networks are disconnected in certain cases.

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Revision history

Date	Release	Editor	Primary clauses modified	Description
Aug. 20, 2014		Hyung-Gyu Ryu, Taehoon Kim		Version published in [8]
Aug. 24 2015	1.0	Ki-Joune Li, Hack-Cheol Kim		Modification for OGC ER
Aug. 27 2015	1.0-r1	Ki-Joune Li,	Cover Page	Adding doc. Number and editors
Oct 22, 2015		Carl Reed	Various	Edits for publication.