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Location Management System for the Socially Disadvantaged Using Wearable Device Shoes

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Abstract

The families of patients who are socially disadvantaged are always anxious about their relatives being able to return home every time they leave the house. Although a variety of location management systems have been proposed to deal with such issues, these systems have a limited service range or even cause inconvenience for the socially disadvantaged by making them always carry a device, together with the possibility of getting lost. To resolve this issue, this study designed and implemented a location management system for the socially disadvantaged by attaching a GPS receiver and a CDMA modem on their shoes in order to register the location of a socially disadvantaged person to a server in real-time, which allows a guardian to identify his/her family member's location from any place, at any time. In addition, the developed system has been verified by a core function test.

Keywords*: GPS Shoes, Location Management System, Location Tracking*

1. Introduction

In Korea, more than 30,000 people were missing each year from 2011 to 2015 [1]. The number of elderly people with dementia has also been increasing as the population is rapidly aging, with 576,000 people with dementia in 2013. As of 2011, there were approximately 5 million Alzheimer's disease patients in U.S. It is expected that the number of Alzheimer's disease patients will reach 20 million by 2050. According to a study, it is reported that at least 60% of patients with Alzheimer's disease were lost more than once and 70% of them were lost more than twice. It is also reported that women, who is another group of socially disadvantaged people, have been frequently exposed to a crime recently.

For a family with a socially disadvantaged member, anxiety dramatically increases if he/she goes out and does not return home. Although many methods to deal with such difficult situations have been developed, they have a limited service range or cause inconvenience for the socially disadvantaged by making them always carry a device, together with the possibility of getting lost.

To remove these problems, it is necessary to develop a method that does not require having to attach a device to the body of the socially disadvantaged (hereinafter called as "Subscribers") and does not have a limited service range.

The purpose of this study is to develop a location management system for the socially disadvantaged, which consists of a subscriber's terminal (to be attached to shoes) that collects location information from GPS and transmits it to a server through a CDMA network or the Internet, a location server that regularly saves the current location of a

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subscriber and a guardian's terminal that accesses a location server and identifies the current location of a subscriber through a smart phone.

2. Relevant Studies

This chapter investigates the advantages and disadvantages of existing location management systems that have been already studied or developed.

2.1. GPS Running Shoes for Alzheimer's disease Patients [2]

GPS running shoes for Alzheimer's disease patients have been developed jointly by GTX, the specialized U.S. GPS company, and Atrix, the shoe maker. As GPS shoes help in identifying the current position of a wearer, it can prevent people from going missing. The shoes transmit a tracking signal through an antenna to a satellite. A satellite sends the current position of a subscriber to his/her family or relative on the screen of a smart phone or a computer. However, a tracking signal can be meaningless if the signal is sent every 10 or 30 minutes because it is important to identify the movement path of a subscriber in real-time. In addition, it is necessary to improve relevant technology, such as the strength of a signal in communication with a satellite, the battery capacity for signal transmission, and the cost of satellite communication.

2.2. Smart Shoes for the Visually Handicapped [3]

A haptic navigation device translates an instruction to an electric signal using voice recognition software. The location of a subscriber is identified by a smart phone app. A vibrator inside shoes vibrates toward a direction of destination in the event that a subscriber needs to change a direction. Therefore, a subscriber just follows a vibrating direction. However, the problem of this product is that it requires a subscriber to always carry a smart phone with him/her.

2.3. Location Management System without Shoes Related Functions

There are several location management systems already available; a location tracking system based on location recognition using near field communication technology [4], QR code [5], Bluetooth technology [6], and a smart location management system for the socially disadvantaged of Yangsansi [7]. However, these systems are only available within a place where certain wireless environment (WiFi, Bluetooth, or Zigbee) is provided and a QR code must be scanned using a subscriber's smart phone to activate a service [8].

3. System Design

3.1. Structure Diagram

The location management system for the socially disadvantaged consists of a subscriber's terminals, guardian's terminals, a location server and Google's map server as shown in Figure 1. In addition, a mobile communication network or the Internet is necessary to connect them to each other. A subscriber's terminal installed in the subscriber's shoes receives location information from a GPS satellite and transmits it to a server through a CDMA modem. A guardian's terminal allows a guardian to check or track a subscriber's location on the screen of his/her smart phone. A location server consists of a web server with the operator's GUI, a database to manage the information of a subscriber's location, and Middleware server to parse a subscriber's location information and save it to a database. Google Map server generally refers to a GIS system managed by Google, which displays a certain location on a map through API.

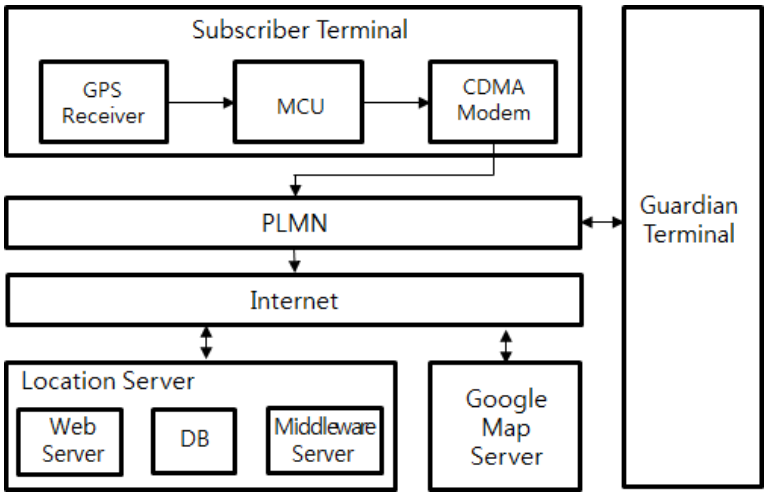


Figure 1. Structure Diagram of Location Management System for the Socially Disadvantaged

3.2. Control Procedures

3.2.1 Communication Procedures between CDMA Modem and Location Server

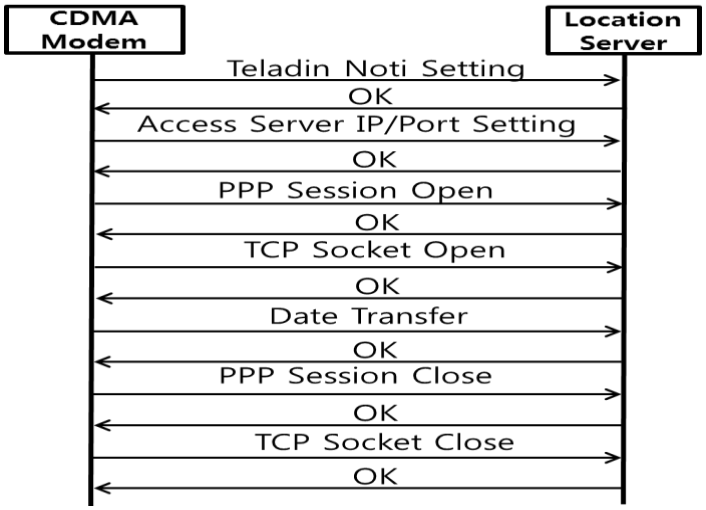


Figure 2. Communication Procedures between CDMA Modem and Location Server

As shown in Figure 2, parsed data is transmitted through AT Command from a CDMA modem to a location server. When a command to set Teladin Noti is sent to a server, it responds with “OK”. The IP address and Port number of a server to be connected are set and sent to a server. Then, a server responds with “OK”. When a PPP Session opening command is sent to a server, it responds with an IP address for it. When a TCP Session opening command is sent, an attempt to connect with a server is made. If a TCP connection with a server is established, parsed data can be sent. PPP Session and TCP Session are closed after all data are transmitted.

3.2.2. Subscriber's Location Information Collecting Procedures

As shown in Figure 3, a subscriber's terminal sends a Conn_req message to a middleware server through a TCP socket and receives an ACK response from the server. Next, a subscriber's terminal sends a Loc_Info message containing location information to a middleware server. A middleware server transmits the information to a database.

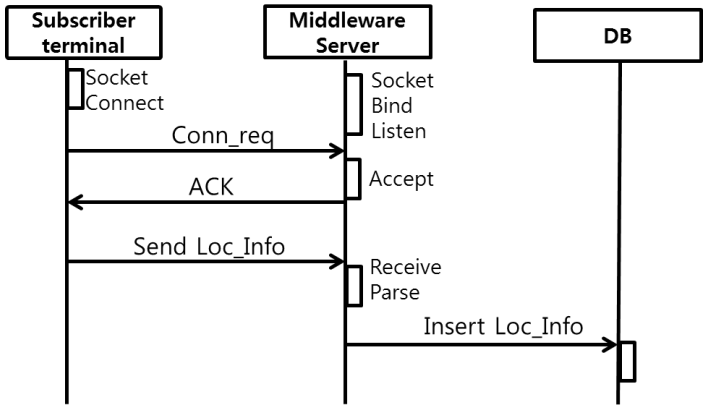


Figure 3. Subscriber's Location Information Collecting Procedures

3.2.3. Tracking Subscriber's Location by Guardian

Figure 4 shows the procedures of tracking a subscriber's location by a guardian.

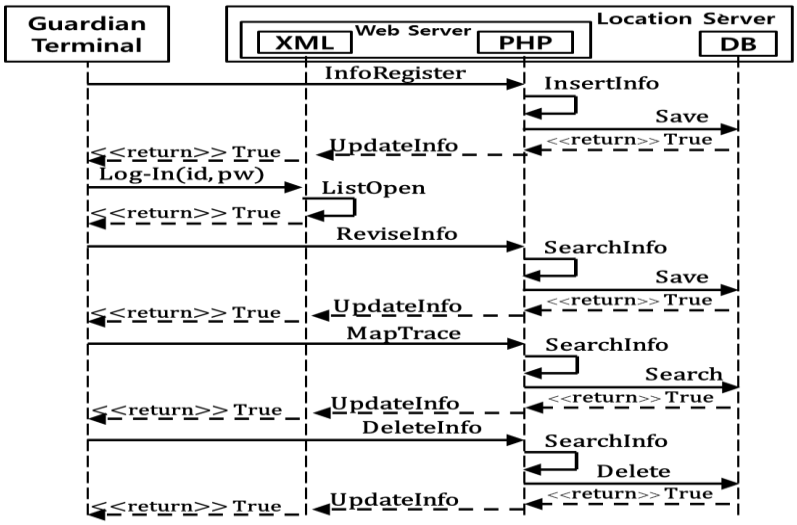


Figure 4. Tracking Subscriber's Location by Guardian

For tracking a subscriber's location, a guardian must join the service through the application of a terminal. A guardian saves his/her information and subscriber's information to DB through WebServer's PHP by InfoRegister. The procedures are quickly processed without connecting the guardian's terminal with a DB by updating WebServer's XML using information saved to a DB in each step.

To request log-in, a guardian who subscribed to the service inputs the ID and Password that were provided in the subscription process. Then, the log-in request can be approved after comparing them to information saved to WebServer's XML.

After successful log-in, a guardian can select a function among ReviseInfo, MapTrace and DeleteInfo. In each step, a guardian can request ReviseInfo, MapTrace or DeleteInfo to DB through WebServer's PHP.

3.3. Operation Process by Physical Substance

3.3.1. Subscriber's Terminal

The MCU in a subscriber's terminal reads a GPGGA value among GPS information received from a satellite through a GPS receiver, which is needed to track the location of a subscriber, and extract the current time, the latitude, and the longitude. The phone number of a subscriber and the character '#' are added to the front and the back of the extracted value, respectively, to create a 45-byte subscriber's location information packet, as shown in Figure 5.

Subscriber number	UTC time	Longitude	Latitude	Final mark
01220487401	144807.211	3732.6624	12701.3549	#

Figure 5. Format of Subscriber's Location Information

After that, the MCU connects with a server through an IP address and a port predetermined according to the communication procedures, based on TCP/IP over CDMA, between a CDMA modem and a server and sends a subscriber's location information packet to a server.

3.3.2. Guardian's Terminal

MainActivity.Class is executed when a guardian runs the application using his/her smart phone, as indicated in Figure 6.

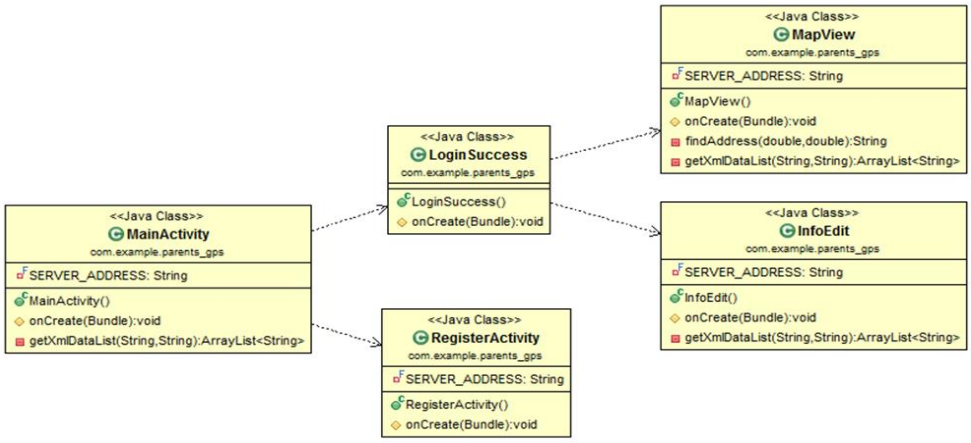
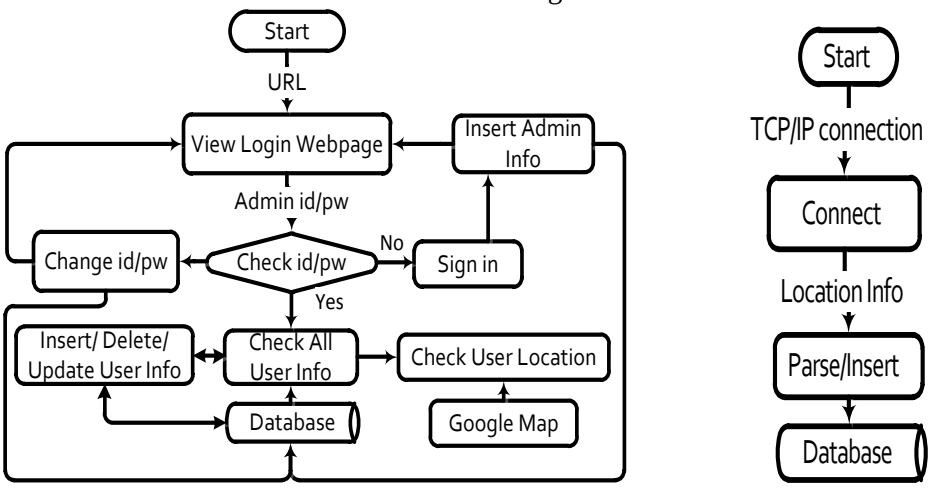


Figure 6. Workflow of Guardian's Terminal

To join this application, a guardian runs RegisterActivity.Class or inputs his/her ID and Password if he/she has already joined the service. In this case, LoginSuccess.Class is executed if the input values are matched with the values he/she provided during the subscription process. After successful log-in, he/she can run MapView.Class to obtain subscriber's location information and InfoEdit.Class to modify or delete subscription information.

3.3.3. Location Server

The workflow of a location server is shown in Figure 7.



(a) Workflow of Web Server (b) Workflow of Middleware Server

Figure 7. Workflow of Location Server

The operation of location server is shown in "a" of Figure 7 when the operator accepts to location server. The operation of middleware server is shown in "b" of Figure 7.

An operator uses a URL to access to a web server shown. An operator accesses a web server by joining as a member or providing ID and Password. An operator checks the information of a user (a guardian or a subscriber) recorded in DB. An operator can insert new user's information or delete and update existing information in DB. Location values are shown using Google Map API to check the subscriber's location.

For a server to collect location information from a subscriber's terminal, they must be connected through a predetermined IP address and port number, as shown in "b" of Figure 7. Location information received from a subscriber's terminal is regularly saved to DB through middleware. Location of a subscriber is checked by an operator who checks a location value of subscriber's terminal saved in the above mentioned manner and extracts the movement path and the current location of a subscriber.

As indicated in Figure 8, a guardian can retrieve, insert, delete, and update a guardian and subscriber's information by accessing to DB through TCP/IP communication. In addition, a guardian can check the current location of a subscriber from DB.

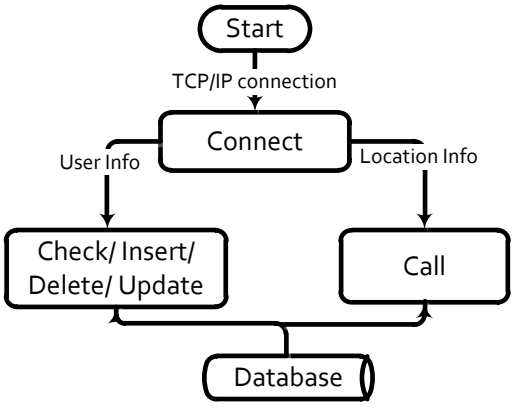


Figure 8. Workflow between Server and Guardian's Terminal

4. System Implementation

4.1. Subscriber's Terminal

Figure 9 shows a hardware implementation result for a subscriber's terminal developed in this study, which is inserted in a subscriber's shoe. The size of the subscriber's terminal is 48mm * 48 mm * 20mm.

Figure 9. A Developed Subscriber's Terminal

4.2. Guardian's Terminal

Several functions including log-in, sign-in, guardian's information search, guardian's information change, subscriber's information search, and subscriber's location tracking are implemented in a guardian's terminal. Figure 10 shows a subscriber's location tracking function implemented in a guardian's terminal by this study

Figure 10. Implementation of Subscriber's Location Tracking Function in Guardian's Terminal

4.3. Location Server

A web server is configured by PHP in CGI language based on HTML 5 while a DB is implemented by MySQL and middleware is created by C#.

The screen of implementation of a subscriber's and guardian's information management function on a guardian's terminal is shown in Figure 11.

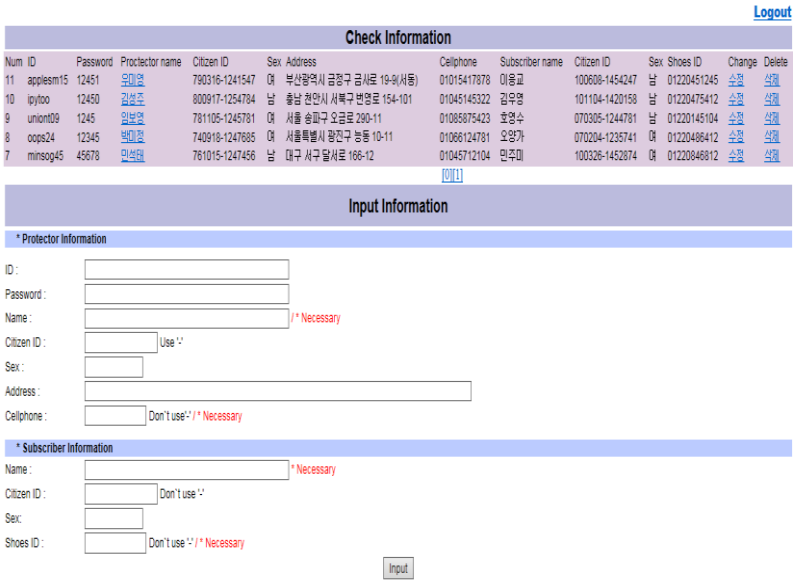


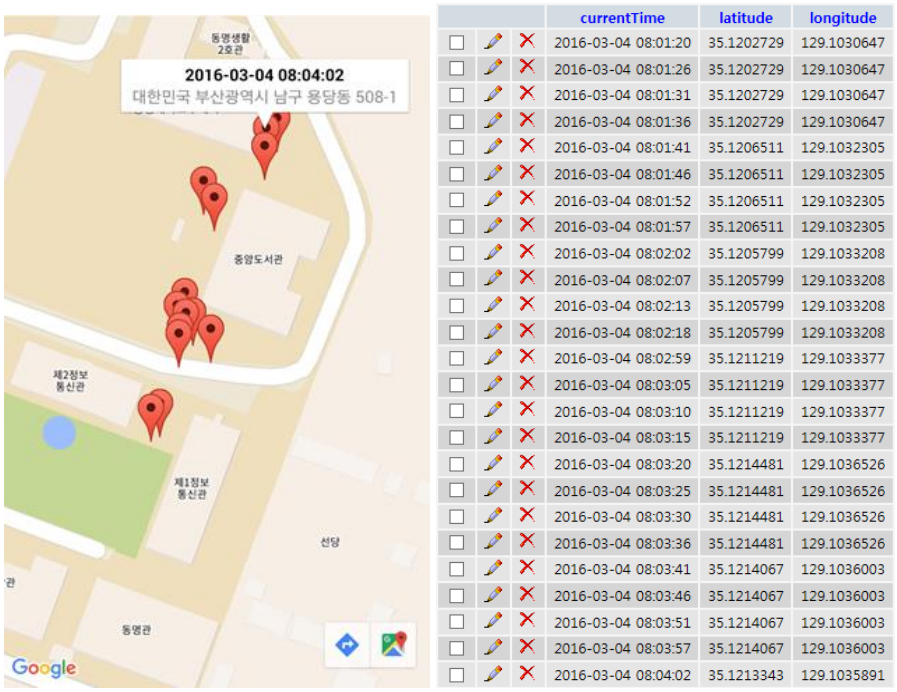
Figure 11. Subscriber Location Checking System

5. Test Results

Tests for subscriber's location management system using GPS shoes were separately conducted for the guardian side and the server side. A test for the subscriber side is replaced by checking the normality of a value of subscriber's location information that can be identified on a guardian's terminal. The test results for core functions are as follows.

5.1. Test for Subscriber's Location Tracking Function on Guardian's Terminal

In order for a guardian to track a subscriber's location on his/her terminal, the subscriber's information including the time, the longitude, and the latitude shall be imported from a server. Figure 12 displays a subscriber's location on a map of guardian's terminal, using location information received from a server. It is found that a subscriber's location can be tracked over time, comparing to a value of DB information.



	currentTime	latitude	longitude
	2016-03-04 08:01:20	35.1202729	129.1030647
	2016-03-04 08:01:26	35.1202729	129.1030647
	2016-03-04 08:01:31	35.1202729	129.1030647
	2016-03-04 08:01:36	35.1202729	129.1030647
	2016-03-04 08:01:41	35.1206511	129.1032305
	2016-03-04 08:01:46	35.1206511	129.1032305
	2016-03-04 08:01:52	35.1206511	129.1032305
	2016-03-04 08:01:57	35.1206511	129.1032305
	2016-03-04 08:02:02	35.1205799	129.1033208
	2016-03-04 08:02:07	35.1205799	129.1033208
	2016-03-04 08:02:13	35.1205799	129.1033208
	2016-03-04 08:02:18	35.1205799	129.1033208
	2016-03-04 08:02:59	35.1211219	129.1033377
	2016-03-04 08:03:05	35.1211219	129.1033377
	2016-03-04 08:03:10	35.1211219	129.1033377
	2016-03-04 08:03:15	35.1211219	129.1033377
	2016-03-04 08:03:20	35.1214481	129.1036526
	2016-03-04 08:03:25	35.1214481	129.1036526
	2016-03-04 08:03:30	35.1214481	129.1036526
	2016-03-04 08:03:36	35.1214481	129.1036526
	2016-03-04 08:03:41	35.1214067	129.1036003
	2016-03-04 08:03:46	35.1214067	129.1036003
	2016-03-04 08:03:51	35.1214067	129.1036003
	2016-03-04 08:03:57	35.1214067	129.1036003
	2016-03-04 08:04:02	35.1213343	129.1035891

(a) Screen for Subscriber's Position Tracking (b) Values of Subscriber's Position Information

Figure 12. Test Results of Subscriber's Location Tracking Function on Guardian's Terminal

5.2. Test for Subscriber's Location Information Collecting and Location Tracking Function on Server

Figure 13 shows the results of subscriber's location information that is identified by a location server, which is regularly sent to a location server by a subscriber's terminal. It is found that the subscriber moved to four locations in order. The staying duration and the time will be shown if you click a water drop shape. With this test, it is confirmed that these functions are correctly working.

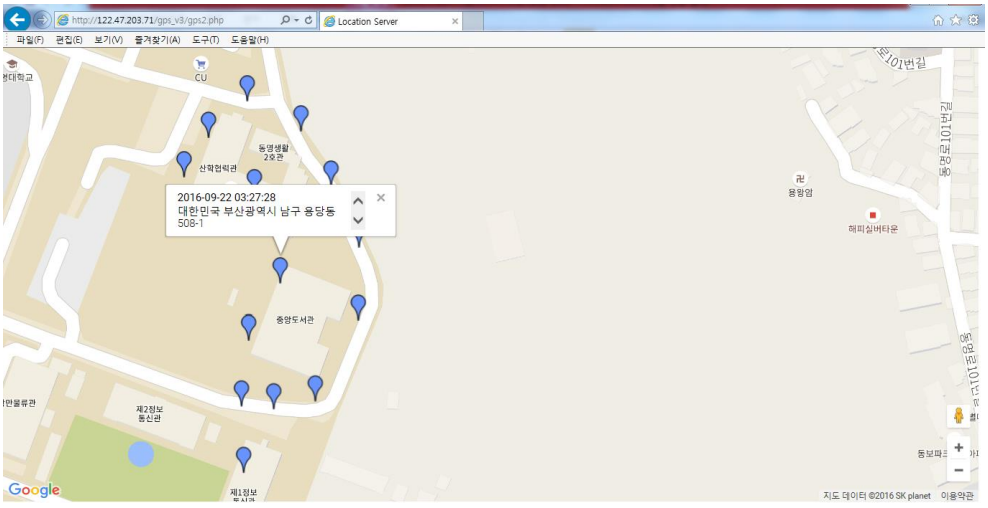


Figure 13. Test Results of Subscriber's Location Tracking Function from Location Server

6. Conclusion

For a family with a socially disadvantaged person, anxiety will dramatically increase if he/she goes out and does not return home. To resolve this issue, it is necessary to develop a method that does not require attaching a device to the body of the socially disadvantaged and does not have a limited service range.

This study designed and implemented a location management system for the socially disadvantaged, which consists of a subscriber's terminal, a location server and a guardian's terminal. According to the test results, it is confirmed that location information of a subscriber's terminal is well saved to a server and a subscriber's location tracking function is working properly. This system can protect the socially disadvantaged and reduce their family's anxiety by allowing their guardian to easily check the location of subscriber through their smart phone from any place, at any time.

Making a device smaller to attach it to children's shoes and improving the quality of product to the level of commercial service by adding more functions and supplementing performance are tasks reserved for future studies.

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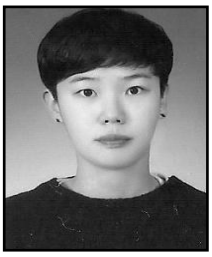

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