Development of U-CITY Based Convergent Content System Using Bluetooth Low Energy Beacon Sensors

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Abstract

Currently, based on hyper-connected society, thanks to the development of information technology, the utilization of diverse Internet of things communication services and big data is increasing. With regard to the information society infra of the modern society, as the value of data is evaluated to be high, big data based storage, processing, management, and analysis technologies and IoT based integrated operating systems have been constructed and the huge city connection computing termed smart city has been extensively studied. However, the management and processing standards for fragmented data collected through sensing devices built in urban areas have not been sufficient, and studies on the establishment of classification models and standardization models suited to data characteristics have been lacking. Therefore, this study intends to construct a user-oriented Beacon application convergent contents system that integrates the fragmented large-volume data collected from the Beacon sensing devices so that the data can be conveniently managed.

1. Introduction

As composure in people's life has been increasing and demands for app contents for culture, arts, humanities, engineering, and education have been exponentially increasing thanks to the rapid national economic development and increases in individuals' incomes, IT technologies have been rapidly developed so that South Korea is now ranked as an IT powerhouse. Accordingly, the number of convenient contents that provide that provide local information and social life contents has been steadily increasing through qualitative improvement of contents leading to accelerated evolution of domestic and foreign IT technology levels[1]. In addition, thanks to the development of network technologies and increases in smartphone prevalence rates, diverse near field communication network services have been rapidly increasing and diverse near field communication network technologies ranging from RFID/USN and Bluetooth technologies to smart embedded NFC have become issues now[2][3]. Recently, Smart-CITY that can manage data in the entire city and provide IoT technologies through the construction of systems in entire society has been actively researched and developed and has been rapidly emerging as the next generation core technology aiming at the future city in the 21st century[4][5]. However, the near field communication technology has shortcomings such as the fact that it can be applied to only some limited systems due to its constraint conditions in terms of storage spaces and distances to service areas and the fact that it requires simple data and information transmission[6][7]. The 21st

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century is a big-data era when massive data are flooding and measures to maintain, manage, and utilize these data are urgently needed. In the midst of this situation, restrictions on transmission data may cause inconvenience to service expansion. In addition, in the modern society where business marketing is important, there is a lack of cutting-edge application systems for IT-based technologies that can promptly provide marketing information appropriately to customers and users and actively utilize it for customer maintenance and to form stable and convenient human-oriented infra in the society, studies that would combine diverse technologies to develop new convergent technologies required for social order are urgently needed. Therefore, this study aims to present a model for construction of a platform that can support integrated contents services for urban environment for users through applications using the Bluetooth Low-Energy Beacon technology and can conduct big data statistical analyses through the accumulated data transmitted to the Beacon sensor through app interlocking We also propose a platform construction model that can perform analysis. This study will enable personalized marketing through big-data analysis by upgrading existing contents by applying Beacon technology and emphasizing diversity of utilization and contribute to the creative urban marketing convergence service strategies of the national business model.

2. Related Work

The Beacon is a wireless communication device that can transmit information to smart devices detected within short distances using the Bluetooth communication technology. Recently, Bluetooth low energy (BLE) based beacons, which consume less battery like Apple's iBeacon have been emerging as the mainstream [8][9].

Figure 1. Structure of Beacon Services

The beacon service works in a way where the smartphone app receives beacon signals and transmits the signals to the dedicated server and the server identifies the information and displays the information on apps. When installed in shops, the beacon can be utilized as a useful promotional means for information transmission and coupon issue, *etc*. In addition, the beacon is advantageous for the creation of diverse services because location information services can be provided by entering latitude and longitude information into the beacon. Since the beacon automatically locates customers to provide information or services, it has been increasing users' convenience in use, and has been attracting attention as a new core technology in the mobile payment market [10].

Thus far, NFC has been the representative technology in the mobile payment market. NFC provides high levels of security and safety because it enables payments to be made only when the terminal and the payment device have come into contact with each other within a range of 10cm but it has a disadvantage of requiring the installation of expensive NFC readers. On the contrary, the beacon is much more

advantageous from the standpoint of shops in terms of costs because it does not require 'contact' as payments are made through customer information registered by the user in smartphone apps and the beacon, which is relatively cheaper, can be installed in place of the expensive NFC-dedicated reader [11]. Recently, as the area of application of the beacon has been rapidly expanded from marketing for offline sales increases to services utilizing spatial information such as financial services and theme parks, the importance of the beacon has been increasing as a customer contact point for information collection for development of new convergent services and service provision.

3. Proposed Method

The method proposed in this study consists of the implementation of an application as a platform for provision of information to users' smartphones using Bluetooth low energy beacon sensing devices and for provision of consumer analysis through the collection of the service patterns of users registered in the main server and the area of a CMS (Content management system) server that can store and manage the data collected by beacon sensors.

3.1. Application Systems to be Interlocked with Bluetooth Beacons

In this study, the U-CITY type application contents that can be interlocked through Bluetooth sensors were divided into three areas: life contents, cultural contents, and medical contents.
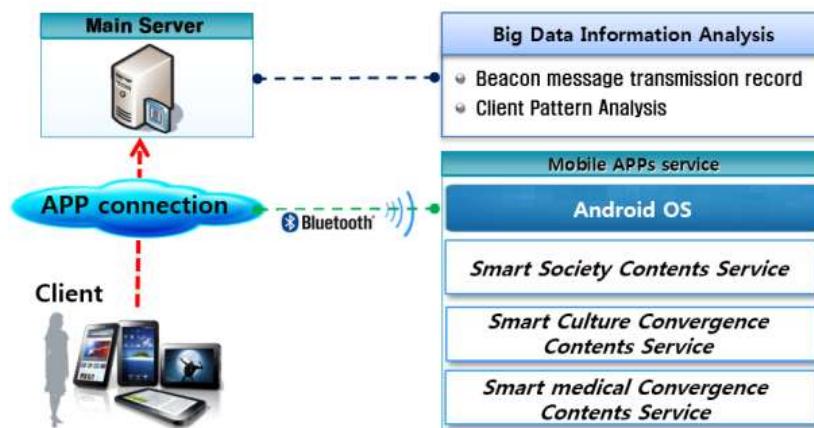

Figure 2. Entire System Block Diagram

When the application has been authenticated, the user will receive data when he/she accesses the network area where the beacon has been established and can be provided with services for contents. In addition, the information on the users provided with the services is recorded in the main server so that pattern analysis can be performed based on the recorded data of the stored unique users.

3.2. Unique Identifier Authentication

The Bluetooth low-energy beacon technology used in this study has a service constraint because it has only the function of unilaterally transmitting the beacon message to the other party due to the characteristics of the Bluetooth devices. However, in this study, the authentication mode is applied to attempt the transmission of beacon messages only to those users who wants to receive the messages, and the transmission data are managed through a separate server. In

addition, also a creative IT convergence system was introduced as a technology that enables intensive management of customers based on user patterns by constructing user information into big data through the main server.

3.3. Broadcasting Technique for Identification of Beacon APPs

The broadcasting element of the Beacon sensor that can be identified in this study utilized the basic techniques of UUID, major, and minor. The universal unique identifier UUID (Unique User Identifier) is used as a key value to identify the visit record of the authenticated users and is specially utilized in the construction of applications. The Major value specifies a specific beacon and use case. In this study, the major value enables identifying the city where the beacon sensors have been built or the range of the actual stores. The minor values allow a more detailed quantitative sub-range of use cases. In this study, the minor values are interpreted as sections of the inside of stores in indoor spaces, seats of a stadium, and quantitative certain areas inside of a fair.

3.4. Application System's Activities by Function Design Model

The application applied in this study was constructed as an Android based application because it is a system that transmits information from a user who accessed the Beacon sensor through mobile-oriented mobility. Excluding the login authentication system and main activities, the information system was designed into the following configuration.

Table 1. Functional Activity Design

Smart Society Contents	Smart Culture Contents	Smart Medical Contents
Product Information	Ticket Information	Medical Information
Coupon Information	Food Corner Information	Medical Staff Information
Sale Information	Grandstand Information	Hospital template Information
Entry Information	Stadium Information	Indoor location Information

- **Smart Society Contents:** Through configuration of product information, coupon information and admission information that can be utilized in U-CITY based daily life, the system is configured into an integrated system that can broadcast the information when the user accesses the beacon sensor.

- **Smart Culture Contents:** These are culture and arts convergent contents consisting of integrated elements that enable users to be provided with information services for stadiums, fairs and performances, etc. through Beacon transmission systems. The users can also receives data such as food corner information, seat information, and ticket information.

- **Smart Medical Contents:** The system is configured into an integrated system that enables the user to receive data such as indoors based location information and medical worker information that can be utilized in medical systems and inside the hospitals.

3.5. Construction of Bluetooth Beacon Management System

To operate a Bluetooth beacon management system, beacon sensing is installed in the selected new area and on-boarding is performed to generate contents campaigns and event

processing. In this study, seven beacon sensors were installed inside the building of I university to conduct an experiment with the beacons.

Name	Country	City	Street	ZIP	Beacons Count	Action
INU	KR	인천	Academy-ro	ASIIKRIKS006IINCHEON	1 Beacon(s)	None ▾

Figure 3. Designation of the Targets of Beacon Sensors

The Figure (A) shows a screen in which the positions where the beacon sensors were installed are recognized based on the postal codes utilizing the open street map, Figure(B) shows the accurate building floor layout of the place where beacon sensors were installed on an image floor plan.

(A) Current positions on the open street map

(B) The floor layout of the building in which the beacon sensors were installed

(C) Beacon sensors' sensing ranges

Figure 4. Open Street Map of Beacon Sensors

Figure(C) shows the positions of the beacon sensors actually installed in the building and the sensing ranges in which objects can be recognized by the beacon sensors according to battery setting.

4. Experiment and Result

4.1. Experimental Environment for Beacon Contents

The development environment in this study was Windows OS 7 and ODROID-C2, which has built-in Ubuntu 16.04 on Kernel 3.14 and Android 5.1x on Kernel 3.14, was used as the experimental equipment for the application.

The specifications of the Bluetooth Module are High Speed v3.0 and Low energy v4.0. As for the performance of the Beacon device, the battery life is one year and the scope of application in which objects can be recognized is 40m.

**Figure 5. Experimental Equipment used in the Development**

4.2. Implementation and Management of Beacon Contents

The initial user must access the application through the authentication mode. If there is no authentication mode, the initial user should access by signing up for membership through e-mail information. This application was designed so that user is provided with the main menu window when the login process has been completed normally and the colors and sizes of the buttons in the layout were set to have maximum visibility and operability for convenience of those users that use mobile devices.


Figure 6. Authentication Procedure and Main Activities

A total of 31 Java classes were generated in this application and each class consists 5 subclasses. Since the system was developed as an integrated composition system that can be generally utilized in U-CITY, the level of utilization of the system can be enhanced in public areas such as department stores, general stores, stadiums, fairs, movie theaters, and hospitals.
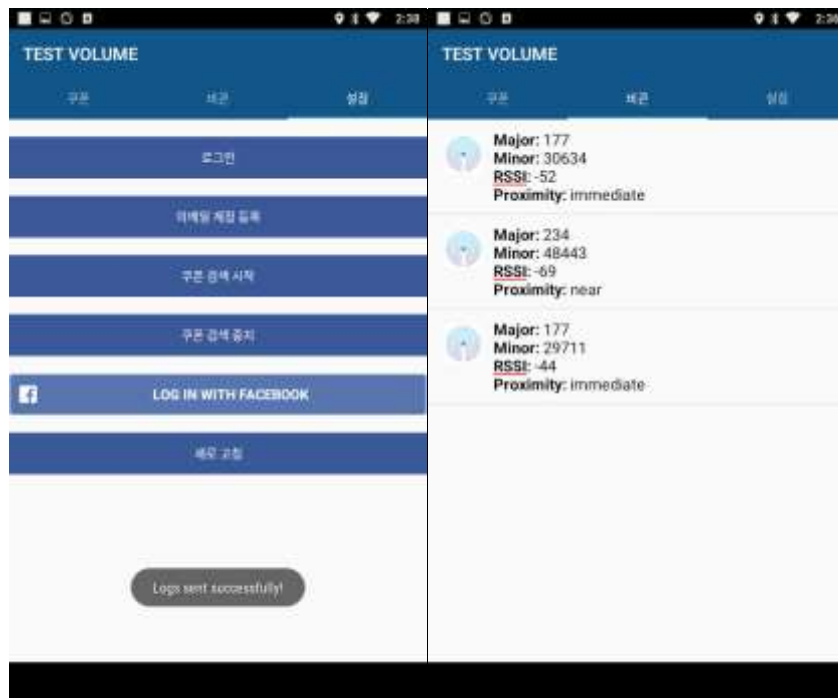
Figure 7. APP Log-in Mode

In this Beacon system, when a user has been authenticated through membership registration, his/her identification code is registered in the main server DB, and the user can be provided with contents such as coupon information and sale information through the relevant ID.
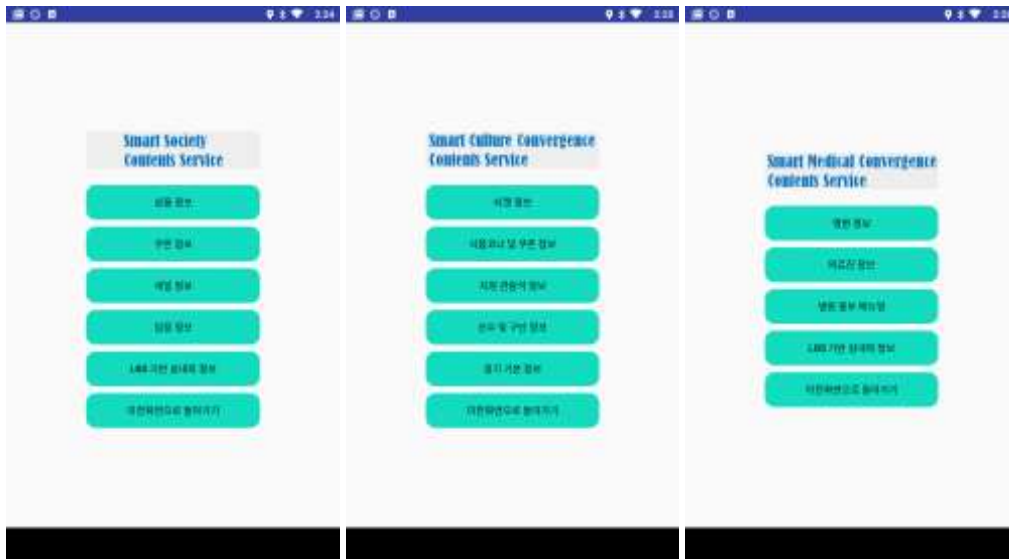
Figure 8. Activity Creation Screen

In addition, as individuals' identification codes are registered, this system has advantages such as the fact that customized marketing is possible and the fact that the location patterns and preferred products in customer information can be analyzed and utilized through the DB.

Figure 9. Beacon CMS and Mobile Device Monitoring

As for the management of beacon devices, beacon devices can be checked in CMS, and the signal communication status, UUID, Major, and Minor of the beacon devices installed at the site can be checked through Token ID authentication. The proximity can be monitored by dividing the distances of beacon devices into 'near, far, and unknown.' In addition, the relevant beacon devices' battery capacity can be checked in real time, which provides convenience for management.
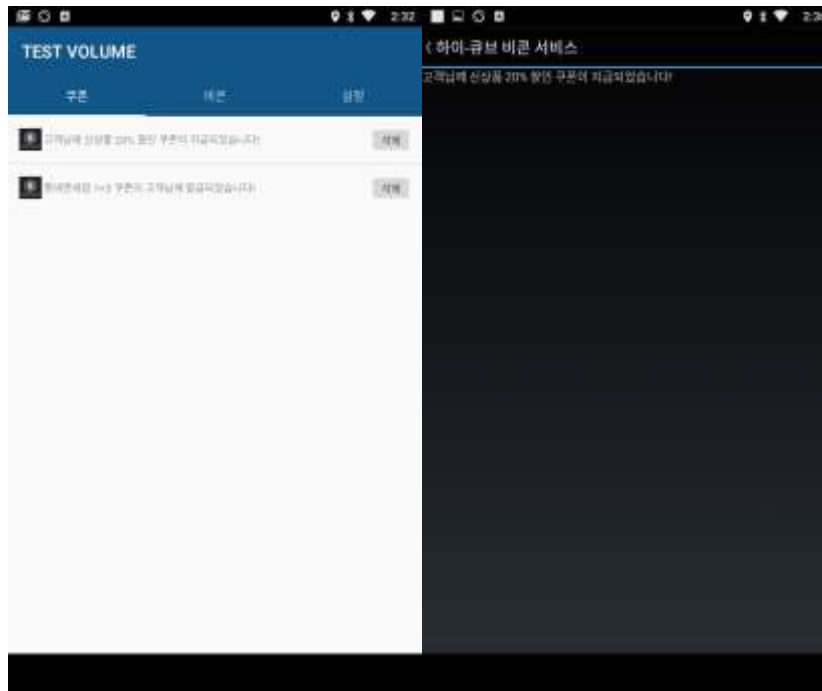
Figure 10. Beacon Coupon Delivery System

5. Conclusion

In this study, convergent contents were developed that will enable the performance of marketing and pattern analysis based on collected data transmitted from beacon sensors through the integrated application functions that enable users to utilize diverse services in U-CITY environments utilizing beacon devices and the management system constructed in the main server. Currently, although diverse beacon services are in progress, data are fragmented due to unified services in certain areas and systems that can integrate such sensing data to enable the analysis and utilization of meaningful data have not been universalized. This study is expected to enable users to simultaneously utilize their life contents, culture arts contents, and medical contents so that beacon device business can be expanded and the practical value of the times of IoT can be enhanced.

Acknowledgment

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