BSmart: A Service Platform for Rapid Development of Beacon-based Applications

Jae-Hwan Jin[1], WooGun Lee[2], Hyeong-Seo Koo[3], Myung-Joon Lee[4]

[1,2,4]*Department of Electrical/Electronic and Computer Engineering,*
University of Ulsan, 93, Daehak-ro, Nam-gu, Ulsan 44610, Republic of Korea
[3]*NinePlatform Co., Ulsan Science Park, 21, Maegoksaneop-ro, Bukgu,*
Ulsan 44222, Republic of Korea
[1]*jjhok2000@gmail.com, [2]justinwk11@gmail.com, [3]control@ninecorp.kr,*
[4]*mjlee@ulsan.ac.kr (corresponding author)*

Abstract

As of now, BLE beacons are considered as one of the key technology revolutions to provide object identifications and trajectories of objects with low energy. The services leveraging BLE beacons include in-door positioning service, smart home, mobile advertising and context-aware services. The more popular such services are the more useful easy and rapid development of such services becomes. In this paper, we present a service platform named BSmart, which supports the core functionalities required for beacon-based services through the associated RESTful Web services. These RESTful Web services provide the functions of beacon/user management, beacon data update/filtering, beacon data searching/monitoring, and alarm notification. With the help of the BSmart platform, developers of services using BLE beacons can rapidly build their services without implementation of core functions related with BLE beacons.

Keywords: BLE Beacon, Beacon-based Service, Service Platform, RESTful Web Service

1. Introduction

BLE beacons[1] are generally small devices with Bluetooth power which can transmit signals to devices at short range. Recently, BLE beacons are widely adopted in a variety of application areas including the O2O(Online-to-Offline, Offline-to-Online) services, being considered as one of key technology revolutions in realizing object identifications and object trajectories with low energy. The services leveraging BLE beacons include O2O marketing for in-store visitors, in-door positioning service, smart home, mobile advertising and context-aware services[2]. Since such services are getting a lot of attention and is becoming more popular, easy and rapid development of such services becomes more important and useful. Unfortunately, as of now, building such services usually requires considerable amount of time and costs with repeated work.

To address this issue, in this paper, we present a service platform called BSmart, which supports the core functionalities required for beacon-based services through the associated RESTful Web services. This paper is the extension of our previous work[3]. In general, beacon-based services include the identification service using the data broadcasted by beacons and the location-based service using the locations of beacons. Basically, the platform provides the RESTful Web services for managing beacons and users of the beacons. It also provides the RESTful Web services for updating and filtering the data from beacons. In addition, the functionalities for searching and monitoring beacon data, and alarm notification according to the constraints of beacon data are provided since those functionalities are usually required for beacon-based applications. The BSmart platform

enables developers of services using BLE beacons to build their services in an efficient way without implementation of core functions related with BLE beacons.

The rest of this paper is organized as follows. We summarize background knowledge on BLE beacons in Section 2. In Section 3, system architecture and features of the BSmart platform is presented. In the next section, the method of building beacon-based applications using the platform was described. Finally, the authors conclude the paper in Section 5.

2. Background

2.1. BLE Beacon

Bluetooth Low Energy (BLE) beacon is a small device broadcasting a non-connectable signal to nearby Bluetooth devices. According to the Bluetooth 4.0 specification, a beacon advertises up to 31 bytes data in the signal, which can be used in various circumstances and applications. In addition, a device receiving the broadcasting signal can determine the intensity of the signal. So, the device can estimate the distance from the beacon by comparing the intensity to the reference value of TX Power byte delivered in the advertising data. Thanks to this technology, a lot of indoor positioning systems and object tracking systems have been developed. In comparison to the short distance coverage (up to 20 cm) of the NFC technology, BLE technology works up to 50m. As of now, iBeacon[4], AltBeacon[5] and Eddystone[6] are popularly used.
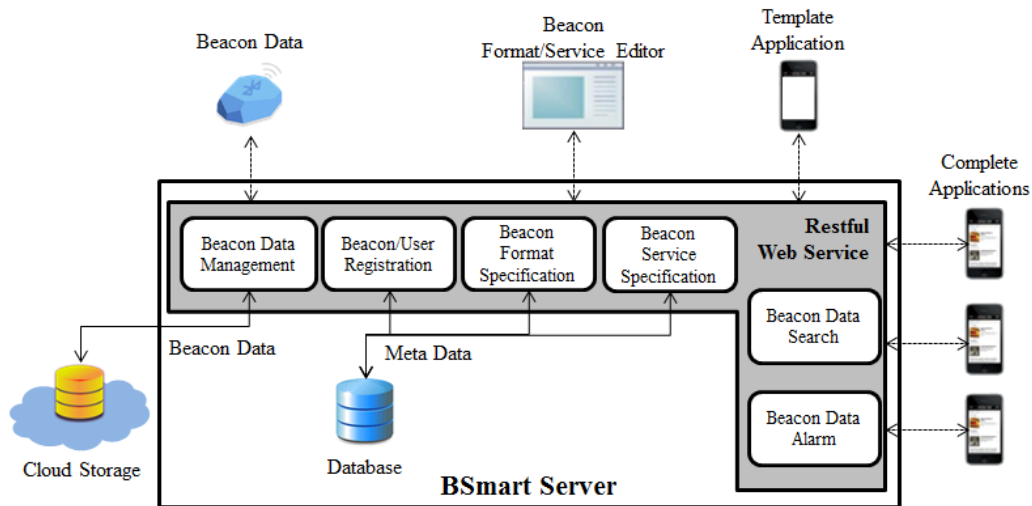
2.2. Beacon-based Service

Usually, services based on BLE beacons utilize the data advertised by beacons or the locations of beacons and users. The location-based service obtains the distance between beacons and receivers through the strength of the received signal. The services of this type[7, 8] includes a coupon providing system in off-line markets, automatic checking system for student's attendance in school and seat location providing system for theatres or large stadiums. The services using the short data advertised by beacons generally use the identification information, URL address or customized data from the delivered data.

3. Beacon-based Service Platform

3.1. BSmart Service Platform

In this section, we describe the BSmart service platform, which provides the basic functionalities usually required for beacon-based services. The core functions of BSmart are provided as the associated RESTful Web services. The core functions are composed of beacon/user management, beacon data update/filtering, beacon data searching/monitoring, and alarm notification. In addition, BSmart receives specifications for BLE beacon formats created from the beacon format specification editor[9], utilizing the specification to identify the meaning of each field in the format. BSmart also receives specifications for beacon services created from the beacon service specification editor[9], using the specification to build the associated beacon-based application in an automatic way. These specifications are stored into the database for further services. The platform stores the real beacon data from the BLE beacons in the field into the OpenStack cloud storage. Figure 1 shows the structure of the BSmart platform.

Figure 1. System Architecture of BSmart Service Platform

Based on the stored specifications of a beacon format and the related service, the platform extracts the needed parameters for providing the Restful Web services to the target application. The platform provides the functions for monitoring the values of the fields defined in the beacon format from the actual beacons in associated with the stored specification and application. In addition, the values from beacons can be filtered by the filters designated when specifying the related services, being stored into the cloud storage managed by the platform. To build the complete target application, the platform incorporates the extracted parameters into the template service application[9], which is the skeletal beacon-based application implemented as an HTML5 application

3.2. Web Services of the Platform

The BSmart platform provides the RESTful Web services for the core functions such as beacon/user management, beacon data update/filtering, beacon data searching/monitoring, and alarm notification. By combining these Web Services appropriately, service developers can easily build their custom services based on BLE beacons. Each of these applications can be identified by the ID of the application, which is registered to the platform in advance. Table 1 describes the main Web services provided by the platform.

Table 1. RESTful Web Services of BSmart Service Platform

Category	URL Prefix	Method	Description
Beacon Format Specification	/formatSpec	POST, PUT GET, DELETE	Manages beacon format specifications.
Beacon Service Specification	/appSpec	POST, PUT GET, DELETE	Manages beacon services specifications such as service type, filter and alarm.
User/Beacon Registration	/baconReg	POST, PUT GET, DELETE	Manages user profile and beacon device information.

Beacon Data Search	/BSSearch	GET	Searches beacon data for a period of time.
	/BSMonitor	GET	Searches latest beacon data
Beacon Data Alarm	/appAlarm	GET	Notified to the specified alarm condition in beacon service specification.
Beacon Data Management	/beaconManage	POST	Stores beacon data in Bsmart server.

4. Method of Developing Beacon-based Services Using BSmart

Using the specifications from the beacon format specification editor and the service specification editor, the BSmart platform enables service developers to generate typical beacon-based applications in an automated way. Figure 2 displays the steps for building these typical applications.
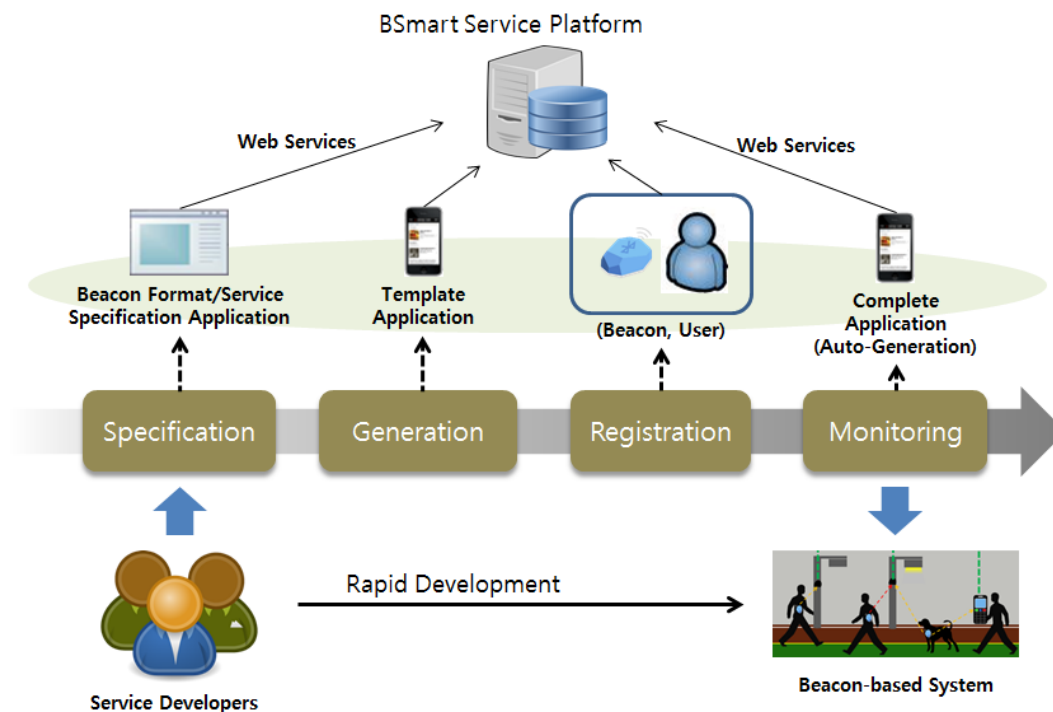
Figure 2. Process of Building Beacon-based Service

The following is the explanation of the steps in Figure 2.

1) Specification: The service developer specifies the beacon format of the beacons to be used in the actual environment through the beacon format editor. The related beacon service is also specified through the beacon service specification editor.

2) Generation: Analyzing these specifications, the platform generates the complete target HTML5 application, which uses the core functions provided by the platform through the related Web services. The generated application is based on the template application previously built in the platform as the skeletal beacon-based application.

3) Registration: The service developer registers each beacon to be used in the actual environment and the user related with the beacon into the platform via the User/Beacon Registration Web service.

4) Monitoring: Through the generated application, the users and the service developer can monitor the position of beacons and user, retrieving the past beacon data during a certain time period with the meaningful names and descriptions obtained from the related specifications.

5. Development of Beacon-based Service Using BSmart

In this section, we describe a beacon-based factory patrol service built using BSmart, which provides patrol history and monitoring function to the appropriate factory manager. Figure 3 displays the process of using the service.
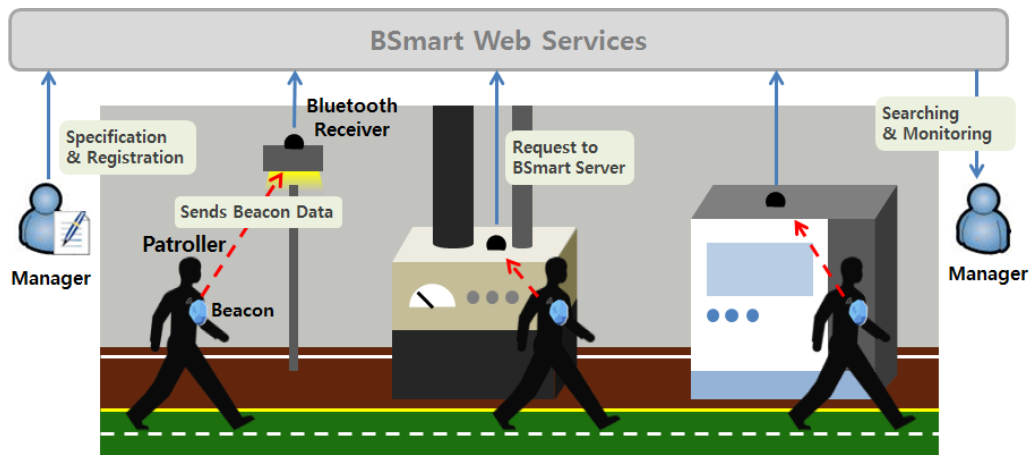

Figure 3. Process of Factory Patrol Service

5.1. Specification and Registration

To develop a service through BSmart, the developer specifies the format of the beacons to be used in the service. Then the developer also specifies the functions required in the service, registering the associated service actors such as users, beacon devices and receivers into the BSmart platform. In this factory patrol service, the process is as follows.

1) Through the format specification editor, the developer selects the iBeacon format as the format of the beacons used by the factory patrollers.

2) Through the service specification editor, the developer selects the route of patrollers and monitoring the beacon devices as the services for the factory manager.

3) Through the registration application, the developer registers each beacon to be used in the service and the information of the associated patrollers into the platform.

The Web services of BSmart during the above steps are listed in Table 2.

Table 2. BSmart Web Services Used in Spec-Editors and Registration App

Tools	Usage Web Services
Beacon Format Specification Editor	- Beacon Format Specification (GET/POST/PUT/DELETE)
Beacon Service Specification Editor	- Beacon Format Specification (GET) - Beacon Service Specification (GET/POST/PUT/DELETE)
Environment Registration App	- User/Beacon Registration (GET/POST/PUT/DELETE)

5.2. Complete Application

The complete application for the factory patrol service is created by the platform through inserting the information derived from the specifications into the template applications properly. The factory manager can use the service application for obtaining the trajectories of patrollers and monitoring the current positions. Figure 4 shows a sample trajectory of a patroller on the Google map generated by the complete application.
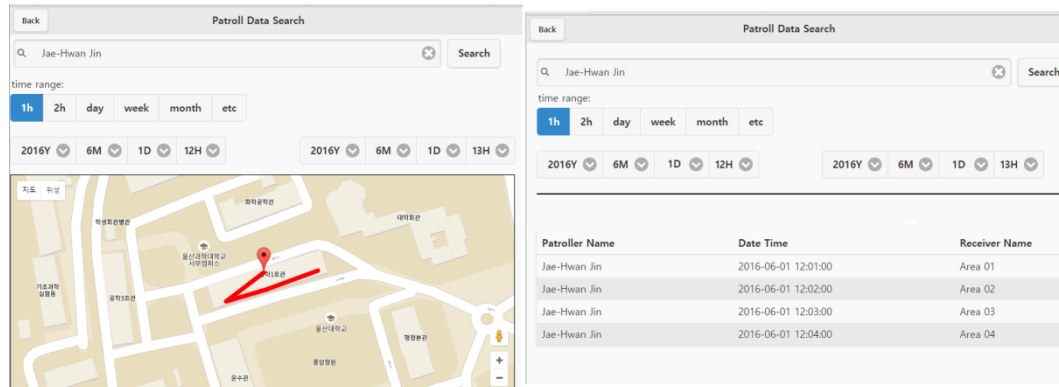
Figure 4. Sample Trajectory of a Patroller

The factory manager can search the name of a patroller, obtaining the list of the patrol time and the GPS location as a result. The result can be shown as a trajectory on the Google map by the service application. The monitoring function obtains the most recent beacon data at a predetermined time interval from the platform, displaying the results as a list or a trajectory on the Google map. These functions are accomplished using the Web services of BSmart platform as described in the Table 3.

Table 3. BSmart Web Services Used in Complete Application

Functions	Usage Web Services
Patrol Data Search	- Beacon Service Specification (GET) - Beacon Format Specification (GET) - Beacon Data Search - Search (GET)
Patrol Monitoring	- Beacon Service Specification (GET) - Beacon Format Specification (GET) - Beacon Data Search - Monitoring (GET)

6. Conclusion

BSmart is a service platform designed for easy and rapid development of applications based on the BLE beacon technology. Since applications using BLE beacons usually need location-based services such as monitoring object locations or visualizing trajectories, the core functions supported by the BSmart platform would be sufficient for developers to build simple beacon-based applications. Basically, the platform is used as a tool for automatic generation of an application in association with the information on the beacon data format used in the application and the information on the functionalities needed in the application.

In addition, since all of the core functions of the platform are provided by the RESTful Web services, service developers can easily integrate the beacon-based services from the platform into their target services in any kinds of application domains. We believe that BSmart would be very useful to generate beacon-based

applications rapidly with cheap cost, helping more people benefit from the new IoT technology.

Acknowledgments

References

[1] Bluetooth 4.0 Spec, http://www.bluetooth.org/Technical/Specifications/adopted.html
[2] Y. M. Kwon, J. S. Park, H. J. Lee and M. G. Kim, "Beacon-Based O2O Marketing for Financial Insitutions", International Journal of Industrial Distribution & Business., vol. 5, no. 4, **(2014)**, pp. 23-29.
[3] J. H. Jin, W. G. Lee, H. S. Koo and M. J. Lee, "A Service Platform for Rapid Development of Beacon-based Applications", Proceedings of Advanced Science and Technology Letters(ASTL), vol. 129, **(2016)**, pp. 11-14.
[4] Apple iBeacon, http://developer.apple.com/ibeacon
[5] AltBeacon, http://altbeacon.org
[6] Google Eddystone, http://developers.google.com/beacons/eddystone
[7] P. Misra, S. Raza, V. Rajaraman, J. Warrior and T. Voigt, "Security Challenges in Indoor Location Sensing using Bluetooth LE Broadcast", The 12th European Conference on Wireless Sensor Networks 2015, **(2015)**, pp. 11-12.
[8] M. Y. Bae and D. J. Cho, "Design and Implementation of Automatic Attendance Check System Using BLE Beacon", International Journal of Multimedia and Ubiquitous Engineering, vol. 10, no. 10, **(2015)**, pp. 177-186.
[9] Y. U. Ha, J. H. Jin, H. S. Koo and M. J. Lee, "Automatic Generation of BLE Beacon Application Based on Specification of Beacon Format and Service", Advanced Science and Technology Letters(ASTL), vol. 129, **(2016)**, pp. 15-18.

Authors

Jae-Hwan Jin, is a Ph.D. student in the School of Electrical Engineering at the University of Ulsan in Korea. He received his M.S. from the University of Ulsan in Korea. His research interests include Beacon-based service, cloud storage service and collaborative system.

WooGun Lee, is a M.S. student in the School of Electrical Engineering at the University of Ulsan in Korea. He received his B.S. from the University of Ulsan in Korea. His research interests include Beacon-based service, mobile web application and collaborative system.

Hyeong-Seo Koo, is an entrepreneur running a small business. He received a master's degree from the University of Ulsan. While working in the company was responsible for the Embedded software and M2M system development, and the establishment in 2013 based on these experiences in the process of building a business that M2M / IoT service platform.

Myung-Joon Lee, is a professor in the School of Electrical Engineering at the University of Ulsan in Korea. He received his Ph.D. from the Kaist (Korea Advanced Institute of Science and Technology) in Korea. He has (co-)authored more than 200 research publications including numerous works on collaborative system, distributed system and biological system.