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SMART-CAMPUS INFRASTRUCTURE DEVELOPMENT BASED ON BLE 4.0

Abstract. *Contemporary wireless technologies for data transmission is considered in the article, in particular capabilities provided by WiFi, ZigBee and BLE 4.0. There are provided an example of the advertisement network based on the BLE 4.0, and its facilities for creating infrastructure for Smart Campus.*

Keywords: *BLE 4.0, smart campus, ibeacon, Android, iOS, calibration, mobile application, advertisement*

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РАЗРАБОТКА ИНФРАСТРУКТУРЫ СМАРТ-КАМПУСА НА ОСНОВЕ BLE 4.0

Аннотация *Рассмотрены современные сетевые технологии беспроводной передачи данных, в частности возможности предоставляемые стандартами WiFi, ZigBee и BLE 4.0. Приведен пример реализации сети рекламных объявлений на основе BLE 4.0, и возможности ее использования для создания смарт інфраструктуры высшего учебного заведения.*

Ключевые слова: *BLE 4.0, смарт кампус, ibeacon, Android, iOS, калибровка, мобильное приложение, рекламное сообщение*

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РОЗРОБКА ІНФРАСТРУКТУРИ СМАРТ-КАМПУСА НА ОСНОВІ BLE 4.0

Анотація. *Розглянуто сучасні мережеві технології бездротового передавання даних, зокрема потужності що надаються стандартами WiFi, ZigBee та BLE 4.0. Наведено приклад реалізації мережі рекламних повідомлень, що заована на BLE 4.0, та можливості її використання для створення смарт-інфраструктури вищого навчального закладу.*

Ключові слова: *BLE 4.0, смарт кампус, ibeacon, Android, iOS, калібрування, мобільне застосування, рекламне повідомлення*

Introduction

Bluetooth Low Energy (BLE) is the new specification of Bluetooth available for all new smart phones.

In general a beacon registration activates the mobile device, and based on UUID an identification of the necessary information at the external device begins 5.

Fig. 1. Jaalee Beacons

The different fields of application are ample. Most of the developed applications which use beacons are in advertisement and the retail sector. Users can be informed of an interesting discount when passing the store or even when coming near the gentlemen's department in a clothes shop. In general its solving the tasks of indoor positioning systems and can be used for university wireless infrastructure development.

The idea of this project to suggest a solution of the campus that talk to student where students, high-school graduates, their parents and other visitors can do a guided tour, without an actual guide. So all highlighted places at the campus can talk and demonstrate themselves, and people use their own smart phone as for additional information.

Observation of wireless technologies

The most popular indoor wireless technologies are:

• Wi-Fi: is a local area network (LAN) technology that allows communication between electronic devices over a wireless signal. The IEEE 802.11 standard defines Wi-Fi technology.

• Bluetooth Low Energy: is a wireless personal area network (PAN) defined in the new specification of Bluetooth technology. It is the low-cost and low-power solution of Bluetooth

aimed at fitness, healthcare, security and home entertainment industries.

• ZigBee: is a specification of high level communication protocols based on an IEEE 802.15 standard, used to create personal area networks (PAN) built from small, low-power digital radios. Its network topology is mesh and permits the transmission of data through nodes of a network, reaching long distances but with a small data rate. ZigBee is a lowcost technology.

• Bluetooth: is a wireless technology standard which enables short range wireless communication between fixed and mobile devices and builds wireless personal areas (PAN).

Each of them already has great range on commercial applications [2]. And there are numerous of works devoted to comparing these technologies[3], and all of them recognize that the best compromise in price, distance and speed is provided by BLE.

BLE4 characteristics

BLE devices can be in different operating states and roles depending on its function.

Therefore, the possible states are the following [3]:

• Standby: Does not transmit or receive packets.

• Advertising: Broadcasts advertisements in advertising channels.

• Scanning: Looks for advertisers.

• Initiating: Initiates connection to advertiser.

• Connection:

o Master Role: Communicates with device in the Slave role.

o Slave Role: Communicates with single device in Master Role.

The network topology of BLE is the star type. Master devices can have multiple link layer connections to peripherals (slaves) and simultaneously scan for another device. On the other hand, a slave can have only one link layer connection to one Master.

Moreover, a peripheral can send advertising events without expecting a connection; it is used to show data to the scanners without the need to maintain a long time connection.

Bluetooth Low Energy communication consists of two main parts: advertising and connecting.

Advertising is a one-way discovery mechanism. Devices which want to be discovered can transmit packets of data in intervals from 20 ms to 10 seconds. The shorter the interval, the shorter the battery life, but the faster the device can be discovered. The packets can be up to 47 bytes in length and consist of:

- 1 byte preamble;
- 4 byte access address;
- 2-39 bytes advertising channel PDU;
- 3 bytes CRC.

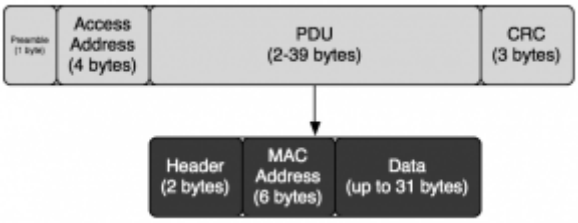

Fig. 2. Beacon identification

Bluetooth® technology is supported by many different development platforms 4.

One of the advantages of iBeacons technology is that both Apple (with iOS and OS X) and Google (with Android) have committed to support for Bluetooth Low Emerge standard (BLE) 1.

Apple's iOS/OS X. The following iDevices – running at least iOS 7 – are supported: iPhone 4S or later, iPad 3 or later, any iPad mini, iPod touch 5th generation or later.

Macs (equipped with at least OS X 10.9 Mavericks): mid-2011 MacBook Air, Mac mini, mid-2012 MacBook Pros.

Earlier Macs can add Bluetooth 4.0 support through a third party USB dongle.

Google's Android. The first version of Android supporting iBeacons is 4.3 (Jelly Bean). Many Android devices already support Bluetooth Low Energy: Samsung Galaxy S3, Samsung Galaxy Note II, HTC One, and Nexus 7 2013, edition, Nexus 4, HTC Butterfly, Droid DNA, etc.

For application development there are a lot of different solution as mostly all manufactures of the beacons provided SDK for it [6; 7].

More common solutions are – for Core Location Development for IOS 7/8 and AltBeacon – an Android library providing APIs to interact with beacons [8].

There are, however some important technical challenges to tackle before getting the most out of all features and commercial options. To be ahead of things and for the technology to mature, the scientific community needs to address the following issues: triangulation for an exact position determination, preciseness of position, preciseness of signal strength, static interference with indoor-usage due to walls, dynamic interference due to people, interference due to multiple beacons in one location, multiple beacon-app users in one location.

Smart campus application

The idea of a Smart Campus for universities is that the campus talks to you. Individual information for students, teachers and visitors is delivered, depending on their profile and time of day.

Developed system consists of three main subsystems: Mobile application for different operational systems iOS, Android; CMS for updating advertisement information; administration system, which consists from different components aimed to adjust hardware characteristics.

Smart Campus is a mobile application which provides users a variety of functionality, allowing working both in on-line mode as in off-line mode detecting buzz from the beacons (Fig. 3).

Fig. 3. Application interface

As there no common decision in the beacon manufacture the Altbeacon library was chosen for the development [8]. Local data of earlier met beacons are stored at the database developed with SQLite [9].

The general application architecture is described at Fig. 4. For all regimes of work a mobile application for Android was developed.

The system is dynamically expandable, it allow easy include additional beacons to the Smart Campus. The beacon database is adapted through a CMS-system. The third subsystem is solved the problems of triangulation for an exact position determination, preciseness of position, preciseness of signal strength, static interference with indoor-usage due to walls.

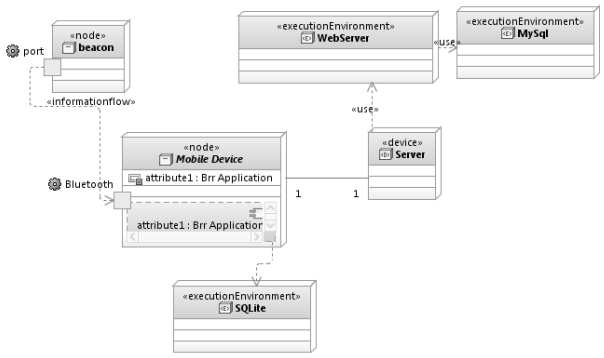

Fig. 4. Deployment diagram of the application

Calibration and Adjustment

Experiments were conducted on testing of the correctness of distance detection and experiments for adjusting these characteristic. The experiments were conducted on the Samsung Galaxy S3 smart phone. As for the Smart Campus infrastructure the following beacons were selected: Jaalee Beacon developed by Chengdu Jaalee Technology Co., Ltd [6] and mini-Beacons. For the experiments, software for distance detecting and adjusting (Fig. 7) was developed, which detects distance with the library method from altbeacon library getDistance() [8], based on RSSI [11].

This means that for real place detection of a beacon location it will need additional time for calibration and preliminary experiments on signal robustness compared to the interfering signals.

So for adjustment of the beacon parameters there were developed mobile applications, which allow classifying the set of the beacons and calibrated them.

Conclusions

The authors suggested the idea of a Smart Campus for universities, where individual information for students, teachers and visitors can be delivered, depending on their profile and time of day. This can be interesting to demonstrate at open days, to prove that technologic campuses are ahead with modern-day technology. So all highlighted places at the campus can talk and demonstrate themselves, and people use their own smartphone as for additional information.

One of the main requirements for university infrastructure is to provide low-cost solution with maximum possibilities.

Bluetooth Low Energy is wireless in-door technology which allows creating different range of applications which make surrounding infrastructure more flexible, more smart.

Suggested solution for smart campus is a result of common work of EMSys Group of Thomas-More Mechelen-Antwerpen and Software Tools Department of Zaporizhzhya National Technical University.

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