Smart Campus based on iBeacon Technology

Dirk Van Merode [1], Galyna Tabunshchyk [2], Kostiantyn Patrakhalko[3], Goncharov Yuriy[3]

[1] Msc, Research Engineer EmSys, Thomas More Mechelen-Antwerpen, Belgium, dirk.vanmerode@thomasmore.be
[2] PhD, Assoc. Prof., Zaporizhzhya National Technical University, Ukraine, galina.tabunshchik@gmail.com
Master Students of Zaporizhzhya National Technical University, Ukraine

***Abstract* — The article considers an example of the advertisement network based on the BLE 4.0, and its facilities for creating the infrastructure for a Smart Campus, where dynamic information is provided for the target audience. The authors provide an analysis of the characteristics and experimental implementation of this system. Moreover, the practical usage of a popular vendor and the needed back-end to provide dynamic usages of the network, both in appearance and content is described. In the paper different wireless technologies are compared in regards to their main feature and field of application. In general the characteristics of a Blue Tooth Low Energy, BLE, are highlighted. This is elaborated upon in the Smart Campus example. The Smart Campus is an indoor wireless network to deliver location and user based dynamic information to the different visitors, teacher or students of a university campus, both for day-to-day use as for specific events. To keep the system interesting and to augment ease-of-use for all kind of users and content providers, a dedicated content management system is developed within the Smart Campus case. The complete system consists of a set of beacons, an application on a smartphone, a database with the related CMS. All is developed in an international cooperation between different universities.**

Keywords — iBeacon, BLE, Mobile Application, Android, CMS

I. INTRODUCTION

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

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].

Figure 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.

II. 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.

III. BLE4 CHARACTERISTICTS

Bluetooth® technology is supported by many different development platforms [3].

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 Energe standard (BLE) [4]:

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, Nexus 7 2013, edition, Nexus 4, HTC Butterfly, Droid DNA, etc.

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

Therefore, the possible states are the following[]:

• 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 devices. 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.

BLE 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

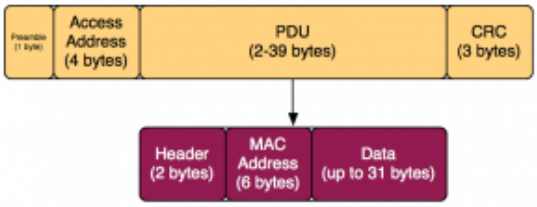

Figure 2 Beacon identification

For application development there are a lot of different solution as mostly all manufactures of the ibeacons provided SDK for it [9,10].

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

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

IV. SMART CAMPUS EXAMPLE

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.

Main components of the developed system consists of three main parts: 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 (figure 4).

Figure 3 Mobile application interface

As there no common decision in the beacon manufacture the Altbeacon library was chosen for the development [6]. Local data of earlier met beacons are stored at the database developed with SQLite[7].

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

For managing beacon information were developed the content management system Beacon-CMS.

Main features of the system are following:

- the control of user access based on roles (RBAC);

- administration user information;

- managing beacons groups;

- managing advertisement information for each beacon or a group;

- multilanguage support;

- interactive map support with location beacons marked on it.

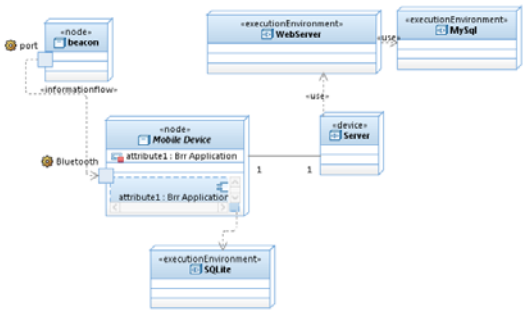

Figure 4 Deployment diagram of the Mobile application

CMS provide services for mobile applications for uploading upgraded advertisement information (fig. 5).

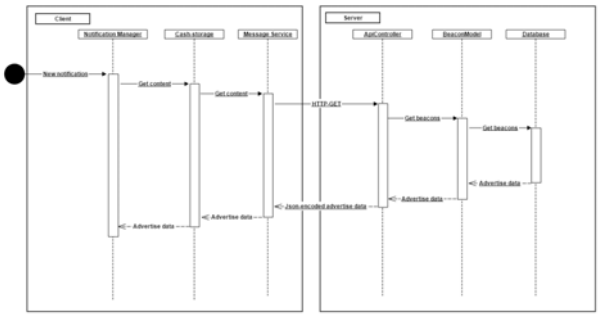

Figure 5 Mobile App and Server Communication

In the system realized hierarchical relationship between user roles. Based on these roles decision is taken regarding user access to one or other system functions. Parent role include all functionality allowed to the one lower in hierarchy.

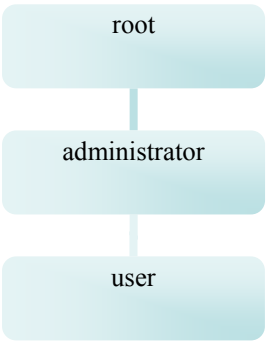

Figure 6 User Hierarchy

Lets consider some other functions more detail:

A) System provides the administrator interface and provide all the necessary capabilities to manage database users, namely:

1) view a list of all users with basic parameters;

2) search for a user by different criteria;

3) sort user list;

4) change the user-specifications;

5) the ability to anchor the user to different beacon groups;

6) the ability to remove a user;

7) the ability to see all available beacons anchored for a user;

Figure 7 List of appointed beacons

B) System provides the interface and provide all the necessary capabilities for managing groups;

C) System provides clear user interface and provide all the necessary features for managing beacons, namely:

1) view a list of all beacons with all specification;

2) search for a beacon on a number of criteria;

3) beacons sort the list by a number of parameters;

4) the ability to change the Beacon specification;

5) ability to remove beacon;

D) System provides multilingual support - the system implement a flexible and convenient tool for internationalization, which enable to provide the following functions on multilingualism:

1) choice of language translation;

2) to see a complete list of available function words for the selected language;

3) sort the list of official word on a number of parameters;

4) download the file in the .xls format to establish the translation;

6) the user should be able to install any language from the list of languages for themselves;

E) System support an interactive map with location beacons marked on it (fig.8) - the system should enable the placement of interactive labels - beacons map / site plan that can have an idea of the geographical location beacons, as well as double

clicks on such a mark the user must go to view / edit content this beacon (fig. 9, 10).

Only the administrator can add remove, delete, mark the pin of the beacon at the map. For User Map is available only in view mode.

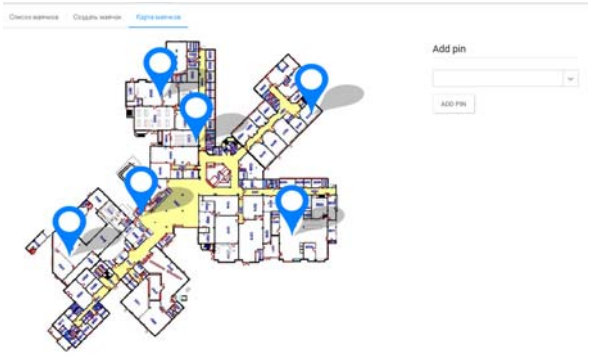

Figure 8 Beacon location

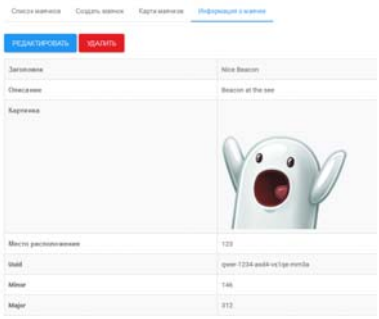

Figure 9 Managing beacon information

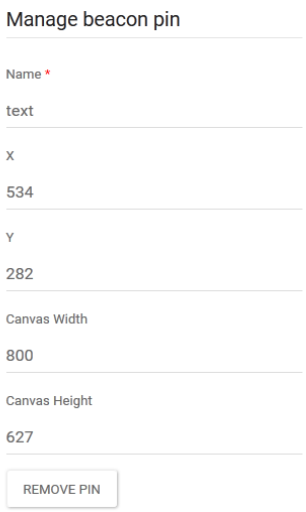

Figure 10 Beacon information administration

V. 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. This way 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 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 allow to create 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 and in the framework of the European Tempus- project 544091-TEMPUS-1-2013-1-BE-TEMPUS-JPCR “Development of Embedded System Courses with implementation of Innovative Virtual approaches for integration of Research, Education and Production in UA, GE, AM” [DesIRE].

REFERENCES

[1] Th. D. Ndie, Cl. Tangha, T. Sangbong, A. F Kufor “Mobile Application Provision Using Bluetooth Wireless Technology”, Journal of Software Engineering and Applications, 2011, 4, pp. 95-105

[2] А. Аникин Обзор современных технологий беспроводной передачи данных в частотных диапазонах ISM (Bluetooth, ZigBee, Wi-Fi) и 434/868 МГц //БЕСПРОВОДНЫЕ ТЕХНОЛОГИИ, №4 2011, -с.6-12.

[3] Bluetooth Smart Technology: Powering the Internet of Things. [Online]. Available: http://www.bluetooth.com/Pages/Bluetooth-Smart.aspx -

[4] A. Cavallini “iBeacons Bible 1.0”, 2014. 15p [Online]. Available: http://meetingofideas.files.wordpress.com/2013/12/ibeacons-bible-1-0.pdf

[5] Guide to iBeacon Hardware. [Online] Available: http://beekn.net/guide-to-ibeacons/

[6] Android Beacon Library [Online] Available http://altbeacon.github.io/android-beacon-library/battery_manager.html

[7] Categorical Index Of SQLite Documents [Online] Available: https://www.sqlite.org/docs.html

[8] Desire project Website. Available: http://www.tempus-desire.eu/

[9] Jaalee community [Online] http://www.jaalee.com/

[10] Indoor-SDK [Online] http://estimote.com/indoor/

[11] iBKS: Bluetooth Advertising Beacons [Online] http://ibeacon.accent-systems.com/

[12] M. Botta, M. Simek “Adaptive Distance Estimation Based on RSSI in 802.15.4 Network”, Radioengineering, Vol. 22, No. 4, Dec. 2013, pp. 1162-1168.