Flexible Technologies for Smart Campus

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***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. Bluetooth beacon is a small low-cost, low-power system perfectly closes the gap between GPS & NFC (fig.1) and can ne used for indoor navigation.

Figure 1. Jaalee Beacons

The different fields of application are ample. In general a beacon registration activates the mobile device, and based on UUID an identification of the necessary information at the external device begins [7].

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.

The aim of this paper to suggest a solution for university wireless infrastructure development based on ibeacon.

II. OBSERVATION OF WIRELESS TECHNOLOGIES

There are numerous specifications which are commonly used for indoor navigation. 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 comparison of 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 [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 Energy standard (BLE) [5]:

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.

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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 [7]:

• 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 (fig.2):

1 byte preamble

4 byte access address

2-39 bytes advertising channel PDU

3 bytes CRC

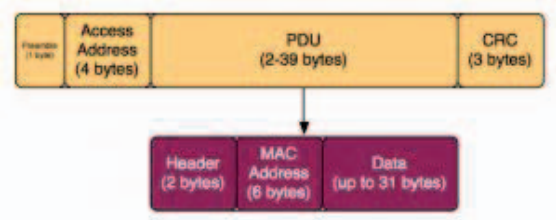

Figure 2. Beacon identification

For application development there are a lot of different solutions as mostly all manufactures of the ibeacons provide SDK for it [5].

More common solutions are – for Core Location Development for IOS 7/8 [5],[7] 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

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.

Smart Campus Application consists from 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 Mobile Application provides users a variety of functionality, allowing working both in on-line mode as in off-line mode detecting buzz from the beacons (fig. 3-4).

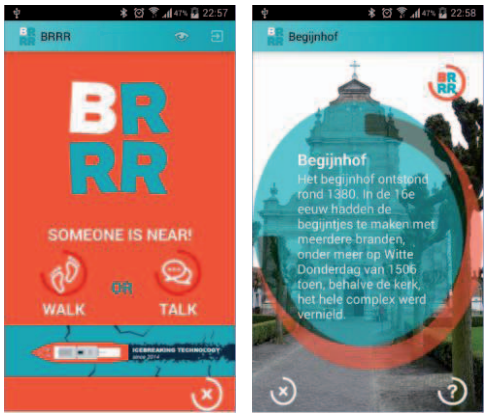

Figure 3. Mobile application interface for Android

As there no common decision in the beacon manufacture the Altbeacon library was chosen for the application development [9]. Local data of earlier met beacons are stored at the database developed with SQLite [10].

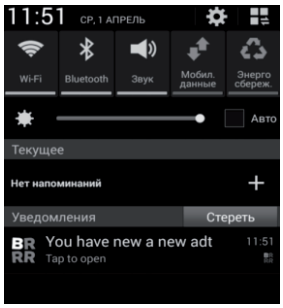

Figure 4. Off-line panel

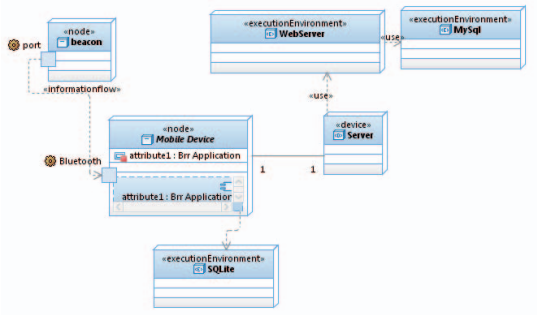

Figure 5. Deployment diagram of the Mobile application

One of the advantages of application – is possibility to register through Facebook account (fig.6).

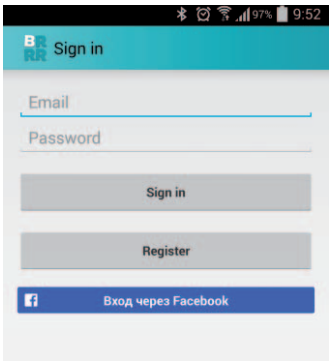

Figure 6. Registration form

For managing local information – putting beacon to the "black list", for proceeding data management application uses the local database. One of the task is to control the time of last synchronization with central database (fig. 7).

For managing the beacon information there are developed the content management system Beacon-CMS. It provides wide range of functionality:

- 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.

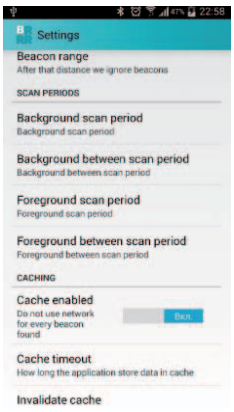

Figure 7. Application Settings

The architecture of Beacon-CMS are based on pattern Model-View-Controller (MVC). There are developed 3 main controllers :

- beacon controller is responsible for all operations with beacons, with views - beacon-list – with beacon lists, beacon-create – for adding new beacon, beacon-update – interface for beacon information updating, beacon-map – displaying beacon map;
- GroupController – controller responsible for all operations with users groups and connected to all necessary views
- UserController – controller which is responsible for separate user data.

CMS provides services for mobile applications for uploading upgraded advertisement information (fig. 8).

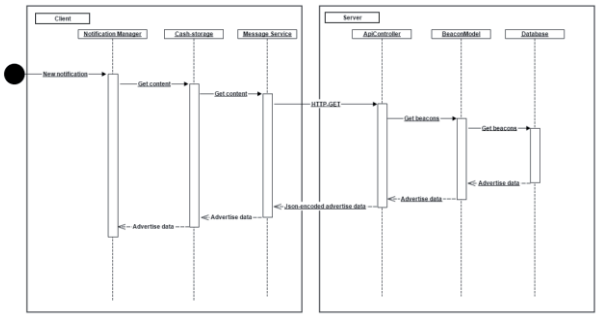

Figure 8. Mobile App and Server Communication

In the system there is implemented hierarchical relationship between user roles. Based on these roles decision is making regarding user access to one or other system functions. Parent role include all functionality allowed to the one lower in hierarchy (fig.9).

Figure 9. User Hierarchy

Lets consider some other Beacon-CMS functions and user interface more detail:

A) It provides the administrator interface and provides all the necessary capabilities to manage users database, 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 (fig.10);

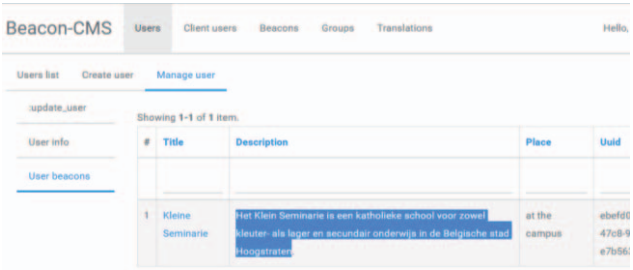

Figure 10. List of appointed beacons

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

C) It 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) Beacon-CMS provides multilingual support – in the system is implemented a flexible and convenient tool for internationalization, which provides 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 (fig11) - 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. 12, 13).

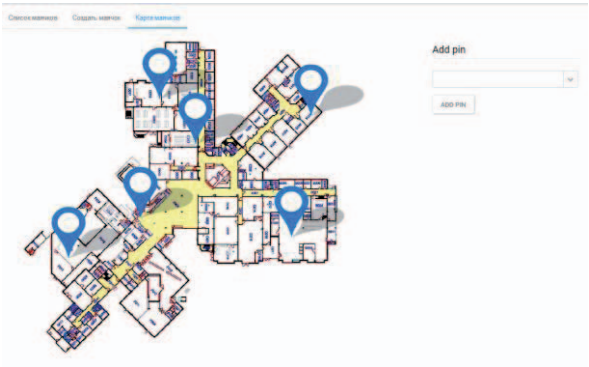

Figure 11. Beacon location

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.

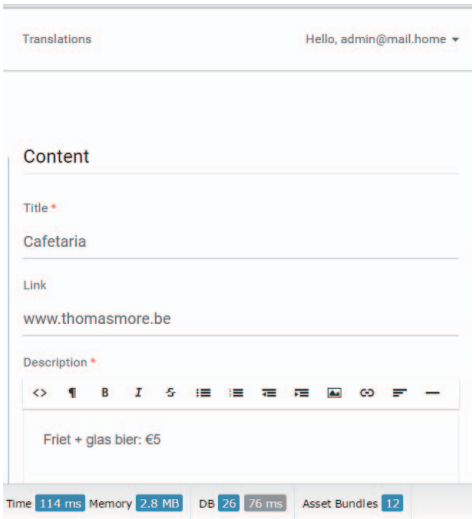

Figure 12. Managing beacon information

Application also allows to collect statistics on most used beacons, time of usage, number of users which detect beacon, users hardware which is received from mobile application

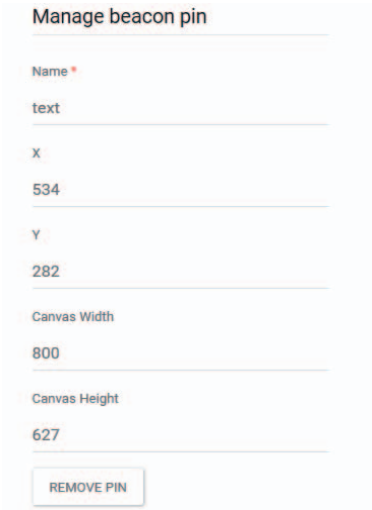

Figure 13. Beacon information administration

Multilanguage adjustment of the user interface (fig. 14) makes Beacon-CMS more flexible as can be easily adjusted to any language.

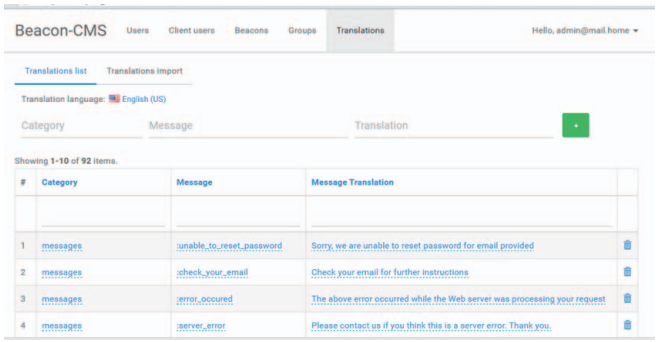

Figure 14. Multilanguage adjustment

It is possible as to correct translation manually inside Beacon-CMS as upload translation from xml file (fig. 15).

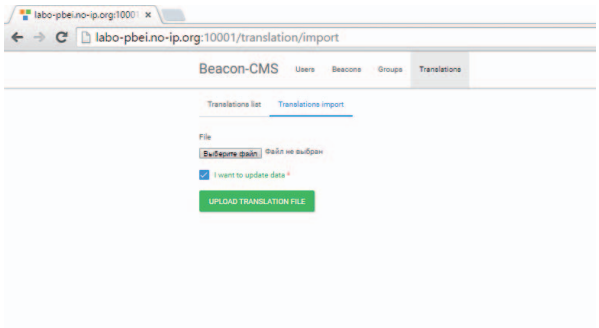

Figure 15. Uploading interface translation

Smart Campus Application is passing open-testing period at Thomas More Mechelen-Antwepen University College (Belgium) [11]. For experiments there were selected Jaalee Beacon developed by Chengdu Jaalee Technology Co [12]. For beacon features adjustment [13] there were developed additional administrative applications for IOS and Android.

V. Conclusions

The authors developed a Hardware and Software solution 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.

Considered in the article design is very flexible and can be easily adopted for other systems with the similar tasks for example Smart City, Smart Warehouse, Smart People.

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