

Interactive on smart classroom system using beacon technology

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ABSTRACT

The emergence of many internet industries ushers in IOT era, and about to bring us to the point of universal connectivity. In the field of education, the IOT technology has a broad applicable prospect for a more interactive and intelligent way by improving the quality of teaching and management. The proposed class affair management system is mean to enrich the interaction between lecturers and students which in an efficient and smart way. Based on the existing model, a layered architecture is proposed to build the beacon based campus management system. Backend device and protocols compose the physical layer to collect the raw data from physical objects. Data link layer and control layer are responsible for forming required package and sending to corresponding layer. Beacon technology used for proposed design applies Bluetooth low energy 4.0 standard which allowing devices exchange data through Bluetooth at an extremely low power consumption-using a single coin cell battery can last for several years. Saved up to 97 percentage energy compared with similar system. The entire proposed platform allows participants to bring personally owned devices to access campus management system. Through location information, teaching activities and personalized information notification can be automatically accomplished, which will inspire the innovation and development of classroom teaching mode. Beacon technology has a great potential that can be completely transplanted into other scenario such as the hypermarket and library.

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1. INTRODUCTION

In the past decades, the booming information technology (such as the Internet of things, cloud computing and big data analytics) has started to change the world. Internet of Things (IoT) connects all goods with internet through information sensing devices [1]. In traditional class management system, all the information stays only inside the database and all the data stream stops only at the website. Students can only interact with the user interface not the classroom itself. In proposed design, beacon is the new way to connect physical things to the Internet, as a result, classroom can be smart and context-aware, providing highly personalized experiences and gathering rich data about what's happening in the real world. Beacon in the classroom forms a sensor network that identifies each specific classroom. By this way, links are established between classrooms and students. In other words, classroom can speak to every student who is passing by.

With the decline in cost of hi-tech hardware and integrated circuit come a revolution in education. Many colleges announced their teaching ushered in a new phase by the deployment of "smart classroom", where the idea was firstly proposed along with IBM introduced its Smarter Planet vision. To meet the design

criteria: Instrumented, Interconnected and Intelligent [2], smart classroom design has draw a wide attention and has been appearing in IOT prospect more frequently.

Starting from four research aspects of designing a smart classroom framework, proposed by J. Zhang [3]. Said the investigation on “smart classroom” could be sort by theory, design, application and standard four aspects as shown as Table 1, the review was classified by using those aspects as the prime factor. Apart from that, the most significant key word had been extracted from titles, abstracts and contexts of each research, as the secondary factor.

Table 1. Four aspects of designing smart classroom.

| Prime factors | Description |
|---------------|---|
| Theory | To build a theoretical framework for smart classroom, outline the design and application of smart classroom, guide on how to define the concept of smart classroom and analyze the relationship between the functionality and usability. |
| Design | To investigate the design principles, methodologies and ideas of smart classroom, for example the framework of smart classroom in physical, spatial layout, and technical system solutions [4]. |
| Application | To research the teaching methods of smart classroom, and learn how to acquire knowledge, perception and skills through these methods. For example, the schooling methods, interaction methods and some case study based on that. |
| Standard | To review the construction criteria, assessment standards and and how to motivate students to take initiatives. For example satisfaction with smart classrooms [5], feedback from teachers and students, quantitative and qualitative analysis. |

Beacon technology was first designed since 2013, when APPLE introduced iBeacon into practical usage at the Apple Worldwide Developers Conference (WWDC) [6]. It rapidly became a new trendy IOT shift in how we connect physical objects together. To elaborate on it, first of all, a Beacon is nothing no more than a small Bluetooth radio transmitter. IoT is is poised to be the internet of beacon with giving thousands of applicable scenarios. Foremost among these is the educational field.

Beacon protocol or BLE 4.0 protocol is composed by 47 bytes of advertising data as shown in Figure 1, 9 bytes of order information included in the field of Protocol Data Unit (PDU), which enables two transmission mode: advertising mode and connection mode. To be more specific, one is that Beacon only chat to you which is the connection mod and other is Beacon spread the contents to all the people around which is the advertising mode. Connection mode emits data segment to request for a private communication between device and Beacon. Advertising mode shares data stream periodically to who is monitoring, the contents in advertising packets are public with no any Cryptograph. For advertising communication channel, address part is always 0x8E89BED6 [7]. For other data channels, the address part is determined by different connections.

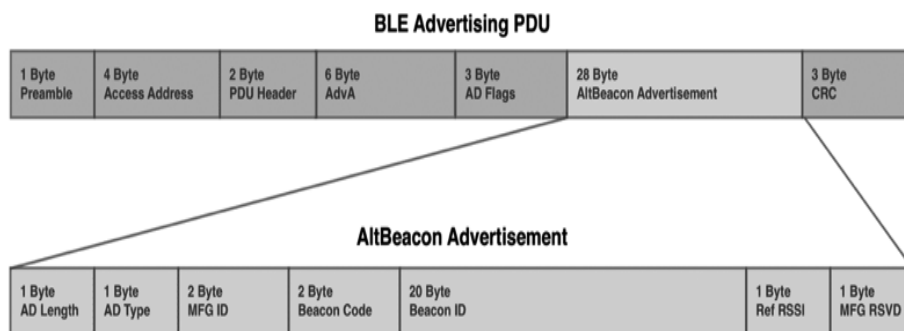


Figure 1. Bluetooth PDU

The traditional campuses have significant defects in interactivity, accessibility, visualization and intelligence. For instance, the lecturers in classrooms can only take attendance by calling the roll, some multimedia classrooms have made few changes by unloading name lists online, but still roll call is inevitable. These outdated methods are either time-consuming or inaccurate. Although some ideas of “smart campus” have been introduced, the interactivity between lecturers and students is ignored. This problem cannot be solved by just simply adding some sensors.

2. RESEARCH METHOD

2.1. Design consideration

The smart classroom platform should be able to perceive the relationship between people, things, places, and objects in the campus [8]. When teachers and students get along with people, things and things in the situation, it will help improve the quality of teaching, work and life of teachers and students. On this basis, design consideration is proposed as follow,

- Practicability: The proposed platform needs to provide better and necessary services along with the desired information. While providing basic services, it is necessary to avoid bringing too much junk information to teachers and students.
- Extensibility: The proposed design platform needs to consider the future development, and the platform must have strong expansibility, for both hardware and software consideration. After the full realization of existing functionality, the platform also needs to provide a convenient interface for the subsequent addition of more personalized services. In order to ensure that the platform can always adapt to the future development of teachers.
- Portability: The service provided by the proposed platform shall be very convenient. Teachers and students can easily get services and easily integrate into the future classroom environment.
- Openness: The platform should be able to easily connect with other platform services to adapt to the rapid development of technology and Internet technology. The platform should provide some interfaces for the third-party platform outside the campus to provide more convenient services for teachers and students.
- Standardization: The proposed platform needs to unify data packs in the system. The subsystems under the platform can only accomplish their related tasks, by the standardized processing and storage of the platform.

2.2. SYSTEM IMPLEMENTATION

Based on Figure 2, few significant methodologies are proposed, academic integration, user identification, position tracing, interactive sensing and all data flow into computing cloud, to realize the whole planned system. Covered by fundamental positioning service, big data computing and cloud service, embedded subsystem, the system can be tested in the practical scenario for hardware and software deployment combining with service implementation.

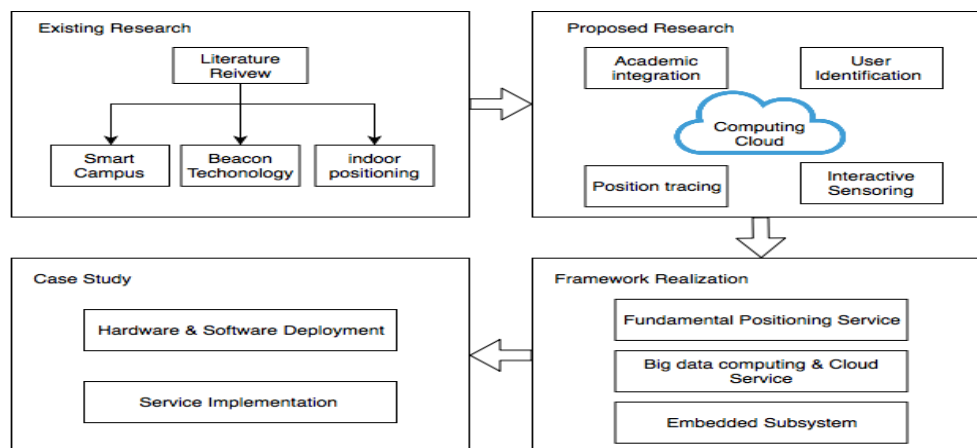


Figure 2. Design flow chart

3. SYSTEM IMPLEMENTATION

3.1. Functionality design

After system initiating, the login module is designed to verify whether the user's user name password is correct. Figure 3 (a) shows the flow in order to prevent students from using their own mobile phone to log into other accounts instead of own attendance in behaviour. Other two main activities are attendance module and personal centre module which functionality can be shown as Figure 3 (b) and (c).

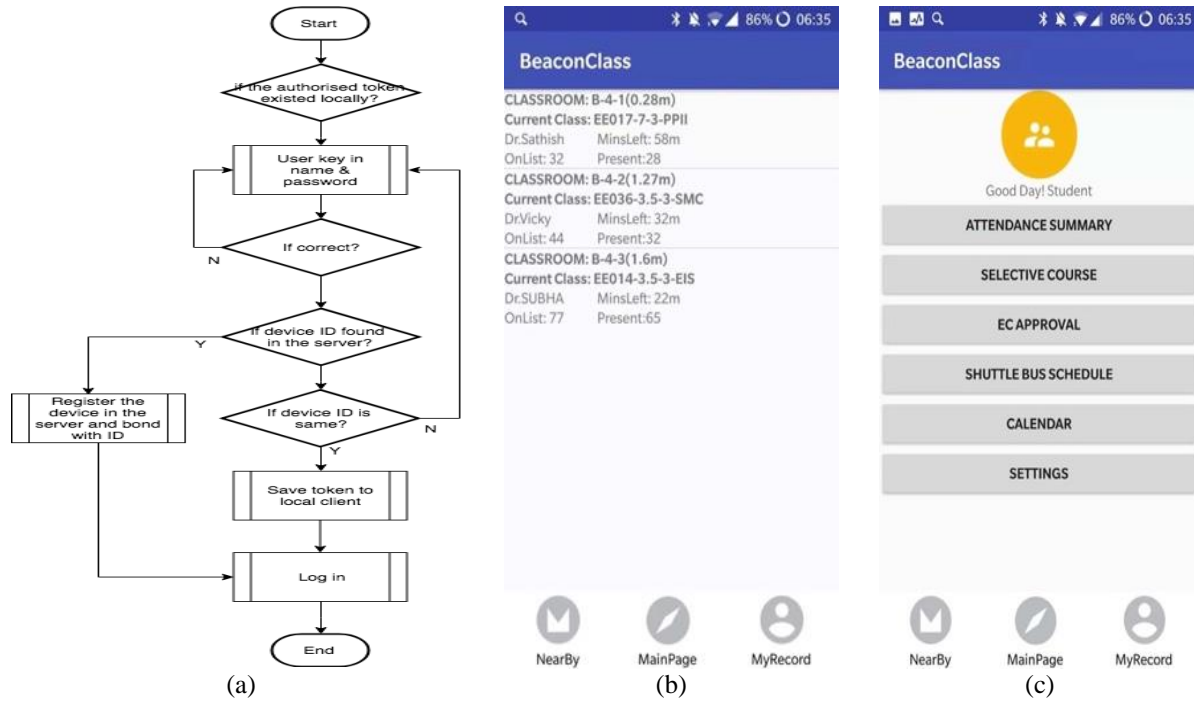


Figure 3. Module design, (a) Log in flow chart (b) Attendance module (c) Personal centre module

3.2. Framework construction

A data stream framework is proposed in this phase where Figure 4 shows the flow of each package between several activities designed in phase one. In the phase, it keeps pairing with the existing receiver and corresponds the communication between beacon network and user-end equipment which allows the physical transmission of data, not only connecting but also matching and packing. All the data found are resided in datalink layer and waited for further processing.

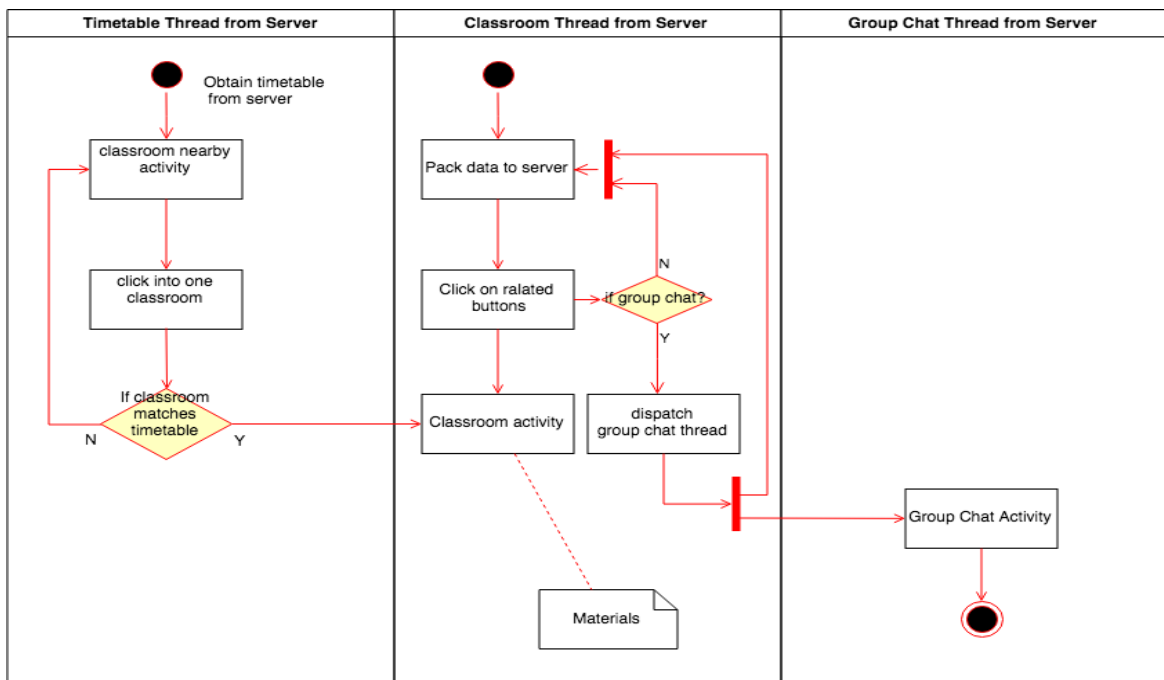


Figure 4. Frame diagram

3.3. Service realization

The bunch of service contains 6 consequences and for each has it own dispatch and return. Inside the diagram, there are four phase though the message to be sent to the receiver. When the message in, it will call chat service and pass to thread service to form in package. The corresponding returns give some feedbacks and verifications. After that, it starts to scan the beacon nearby and try to establish connections. Thus need detect beacon is discoverable and keep the status. Figure 5 shows the entire consequence diagram of the beacon chat service.

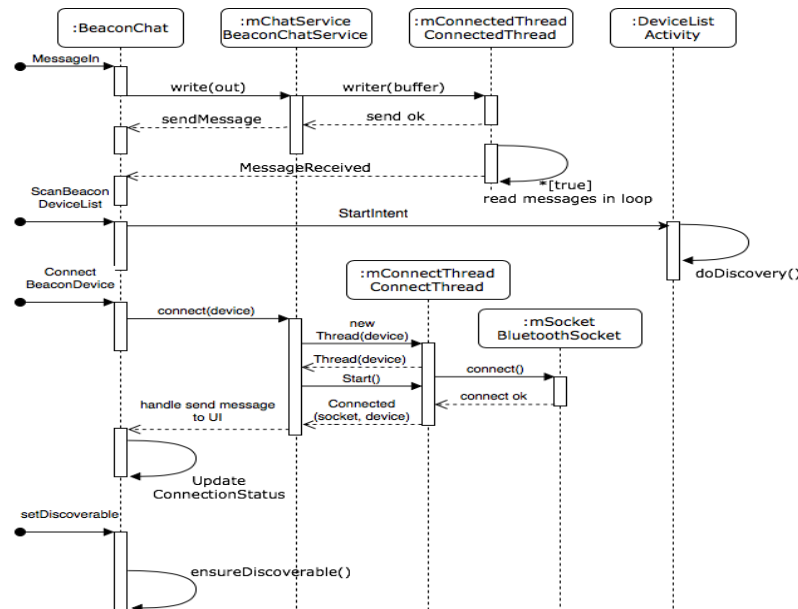


Figure 5. Service consequence diagram

3.4. Overall diagram

The entire project is divided into three hardware, protocol and software as shown in Figure 6. In hardware, a conceptual framework consists of four layer, physical layer, data link layer, control layer and application layer. For a better understanding, these layers are assigned for different service but cooperate in digital communication. The whole hardware circuitry could be neat by applying layer design and it also contribute to develop routine. The proposed system consists of a layered architecture where each layer depicts some functionality which can be carried out by related protocol. It also divides network communication into 4 layers which are as Physical Layer, Application Layer, Control Layer and Data Link Layer.

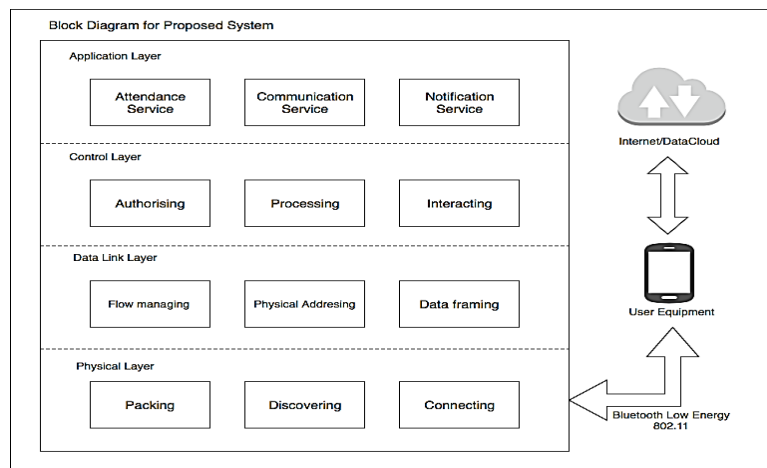


Figure 6. Overall diagram

4. SYSTEM EVALUATION: FINDINGS & TESTING

4.1. Distance sensitive test

The experiment is designed for evaluating the accuracy of distance obtained by beacon. Beacon has a built-in data unit called Received Signal Strength Indicator (RSSI) and are transmitted by beacon device to the Bluetooth device, i.e. smart phone, to acknowledge the distance between beacon and received device. The proposed system conceives all the classrooms are in same floor and the effects by other classrooms from adjacent floor is negligible. By assuming a beacon effective range into 2-dimension map, which radial coordinate and angular coordinate RSSI test could be done separately.

The accuracy is sensitive with varying of the distance, which the longer is the distance between, the lower is the accuracy. But the overall accuracy remains at 72.3% which is acceptable for the real case usage. And the degree of fluctuation is related to the distance. By comparing 3 lines in the chart, the line is almost stable at 3 meters but it fluctuates upon and down at 13 meters. In corresponding of accuracy decreases from 74.5% to 52.6%.

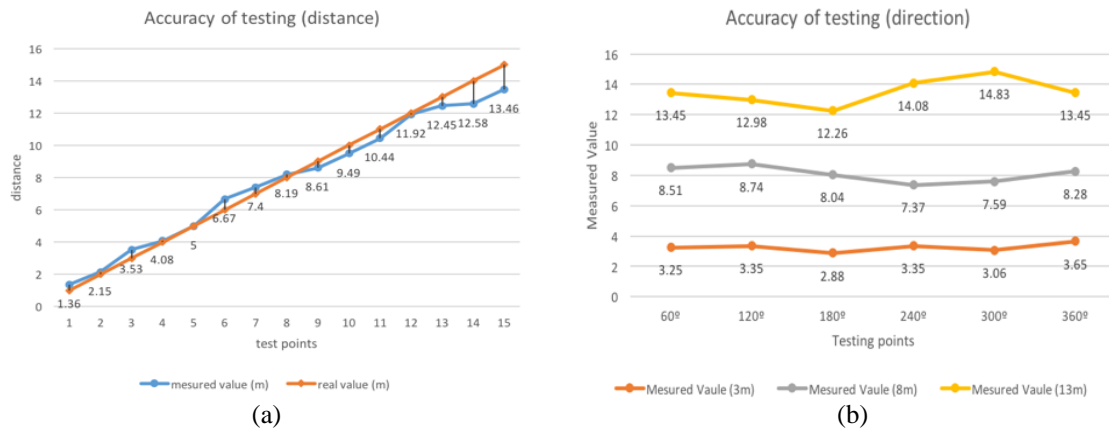


Figure 7. Sensitive test (a) radial test (b) angular test

4.2. System compatibility test

System compatibility test refers to the compatibility test between the designed program and hardware and software. The test is divided into version compatibility test and screen resolution compatibility test. To test whether the software can run friendly in specific hardware platforms, different application software, different operating system platforms, different networks and other environments. Table 2 shows the information collected by device compatibility test and app compatibility test. Both these two tests are automatically generated by the evaluating software for test purpose. The preferred android system is 6 to 8 and each performance is tabulated as below. Due to the hardware limitation, beacon low energy standard can be partially applied on lower android version and mobile model. From the test model of three android devices 62.6% android users can enjoy a good stability and a moderate accuracy from beacon service.

Table 2. Compatibility test

| android version | screen size | Bluetooth receiving power(dB) | generating power(dB) | stability | accuracy |
|-----------------|-------------------|-------------------------------|----------------------|-----------|----------|
| 6 | 4.5 inch (360dp) | -32 | -37 | good | 53% |
| 7 | 5 inch (480 dp) | -53 | -44 | strong | 67% |
| 8 | 5.7 inch (480 dp) | -59 | -51 | perfect | 72% |

4.3. System performance

Table 3 tabulates all the features and its experimental value which is to say that some differences are acceptable and each error can be trace to the specific attribute. The theoretical features are superior than experimental value, by virtue of their interference-free test environment and also the test methodology. Operating frequency and operation voltage are set to Bluetooth Low Energy standard which are involved in standby current and output power. Receiving sensitivity and transmission distance error are sensitive to the environmental interference. However, the experimental results are still excellent which can be apply to the educational scenario given as proposed.

Table 3. Overall performance

| Feature | Theoretical Value | Experimental Value | Remarks |
|------------------------|----------------------|--------------------|--|
| Firmware | iBeacon/Eddystone | - | Version 2.0.1 |
| Battery model | CR2477 | - | Coin battery, 3.0Vdc, 1 pc |
| Operation frequency | 2400-2483.5MHz | 2.45 GHz | Programmable |
| Frequency error | +/- 20KHz | 10% | |
| Modulation | Q-QPSK | - | |
| Standby current | 100 uA | 89 uA | Depends on dust cycle/broadcasting frequency |
| Broadcasting frequency | 900 ms | 874 ms | Duty cycle |
| Output power | 0 dBm | -2dBm | Default setting, programmable |
| Receiving sensitivity | -93dBm | -59dBm | High gain mode |
| Transmission distance | 26 Meters | 15 meters | BER,0.1%, Open Space |
| Antenna | 50 ohm | 50 ohm | On Board/ PCB Antenna |
| Size | 31.08mm*31.08 mm*9mm | - | case size: 39mm*39mm*15mm |
| Operation voltage | 2.0-3.6V | 3 V | Cell phone standardized |

5. CONCLUSION

Currently beacon technology still at the beginning phase of commercial usage, but it has a great potential in the education field. Not only beacon has a preferred specification for education scenario, but also campus networks are emphasized in recent year. Benefiting a lot, a beacon can link the real objects to the visual campus network and also return the instructions back to the objects. It makes beacon much more flexible and appropriate than the old Bluetooth system. Those characteristics even make beacon networks surpass the campus Wi-Fi environment. With the humanity stepping in IoT era, indoor navigation and virtual reality are the key words of the trendy technology. Beacon technology is such a desired technology that keep tracing user location and transmit dispatch and feedback. For indoor localization, beacon can be the fundamental component inside of Wi-Fi router to spot users in real time. And for augmented reality, beacon can be used to relate the actual things into virtual digital signal then analysis to give suggestions.

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