Combination-mode BLE Device Profile for Connection & Non-connection Methods

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Abstract

In recent years, BLE technology has received extensive attention and has been applied to all aspects of life. The existing BLE device has two methods, one is the connection method, and the other is a non-connection method. The representative profile of the connection method is the proximity file. The most typical example of Non-connection method BLE device is a beacon. However, they are both independent and have their own shortcomings. Connection method device can provide service for only one user, others can't use. Security performance of Non-connection method BLE device is poor and the device can't be controlled by the user. In this paper, a combination-mode BLE device profile design scheme is presented, which combines with the previous two methods, and solves the defaults. And We define a dual purpose advertising package that can be used in a normal environment as well as in a disaster environment. Finally, a unidirectional Control idea is proposed. Through performance evaluation, we found that the device has strong stability and low power consumption.

1. Introduction

Bluetooth low energy is a short-range wireless technology as WIFI and ZigBee[2]. BLE has made a series of optimization for power. It can use a button cell to supply power for a year or even longer. Bluetooth Low Energy uses a short packet to reduce the peak current in the transmission, while the other advantage is to reduce the receive time. BLE technology is widely used in medical treatment and so on. Connection method device is supported in two direction communication. Whether BLE or traditional Bluetooth, one host device can be connected with a number of slave devices. But a slave device can only be connected to one host device. The BLE device is generally used as a slave device to provide services. This means that there is only one user to accept the service. This is very unreasonable. Beacon can send a packet containing beacon ID to many users. Users forward the Beacon ID to the server, and then the data or services that correspond to the Beacon ID are fed back to the users. The beacon can only transmit data and cannot be controlled by the user [5]. When the beacon is started, Beacon ID has been fixed, which makes the information received by the user is relatively simple. In order to solve the above these problems, this paper presents a design of Combination-mode BLE device profile. In Section 2, we introduce connection method device and Non-connection method device. Then we analyze the characteristics of them. We design the combination-mode BLE device and define the dual-purpose advertising packet in section 3. The performance results of combination-mode BLE device are reported in section 4. Finally section 5 gives the conclusion and further works.

2. Related work

2.1 Connection method BLE device

BLE proximity profile is the most typical profile of Connection method. The proximity profile can cause an alarm when a device is far away from the other device, so that the connection between the two devices is broken. This alarm can remind the user to take action to keep the connection between the two devices. This profile requires the Generic Attribute Profile (GATT). This profile defines two roles: one is Proximity Reporter as a GATT server, the other is Proximity Monitor as a GATT client [4]. The Proximity contains several services: TX Power Service, Immediate Alert Service, and Link Loss Service.

- TX Power Service: This service can adjust the transmit power of BLE device to influence the communication distance between the BLE device and mobile device.
- Immediate Alert Service: this service can be triggered by using a button. Alarm levels are set in the handler in advance. When the button is pressed, the corresponding alarm level is sent to mobile phone app by BLE. The application takes different actions according to the alarm level, such as sending a SNS message or ringing a bell.
- Link Loss Service: It will cause the Link Loss event, if its battery is dead or the BLE device is too far away from the mobile device. When the connection is lost, BLE device will inform the APP of mobile device by notification and the mobile device accordance with the event to respond.

2.2 Non-connection method BLE device

The representative of Non-connection method BLE device is a beacon. Beacon is a device that can transmit a small amount of information to central devices through radio signals. If the strength between each signal is stronger, then it covers a wider range [3]. When a central device is close to a beacon, it can scan the signal from the beacon. Beacon is usually stuck to the wall or ceiling or hidden in other objects and is perceived within 70 meters without obstacles. Android 4.3 and above version of the smartphone or tablet can be scan for beacons and wake up apps to trigger an action on your phone or tablet [6]. While Android applications can scan for Beacons, but they must always be in a state of running. At present, beacon is applied in the following aspects. Beacon

can be applied to indoor positioning and navigation. It can also be used to track people or property. It is most widely used in marketing and loyalty, based on the location of advertisements or messages. Beacon enables consumers to pay at stores completely hands-free [1]. The information is transmitted by beacons to announce their presence to nearby devices is advertisement packet. The first 9 bytes of payload data are a fixed data called beacon prefix. The proximity UUID, 16 bytes data on the back of beacon prefix, is used to distinguish between your beacon and someone else's beacon. The major number plays the role to group all your beacons and it is 2 bytes in size. The minor number, the size of two bytes, is used to distinguish each beacon in the group. The TX power is the signal strength that measured at 1 meter far from beacon [5].

3. Design of Combination-mode BLE device profile

3.1 Main Concept of the Combination-mode BLE device profile

In order to solve the problems of existing two methods of BLE device，We designed a combination-mode BLE device，also defines a dual-purpose advertising packet and passive Bi-directional Control the BLE device. In comparison with the connection method BLE device, the design of combination-mode BLE device enables more users to use service. When a connection to master is established, the combination-mode BLE device can provide the master with the services we have already made, such as some services related to smart home. When the combination-mode BLE device is in a state of non-connection, it can send the location information like Beacon ID to beacon users. The dual-purpose advertising packet can not only enable the master to obtain the information of the BLE device and service UUID, but also can transmit the information about location to beacon users. The master can indirectly control the BLE device so that the information obtained by beacon users is more abundant and isn't single.

3.2 Dual-purpose Advertising Packet

We define a dual-purpose advertising packet based on connection method advertisement packet.
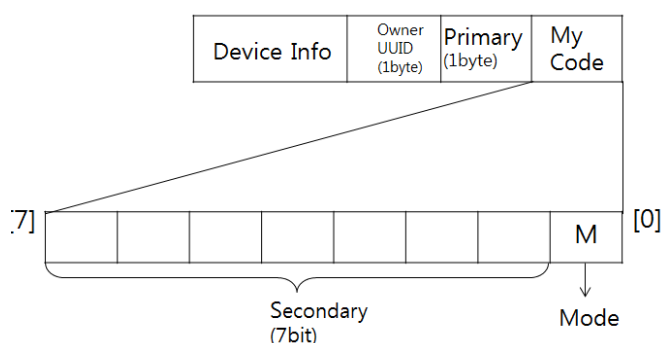

Figure 1 Dual-purpose Advertising packet

We use several bytes to represent device information and services' UUID. The next two bytes are Owner UUID and Primary. Owner UUID is an identifier which should be used to distinguish our BLE devices from others. All our BLE devices would have the same Owner UUID. The primary number is used to group a related set of BLE devices. For example, all BLE devices on the same floor would have the same primary number. That way the application will know on which specific floor the user is. Seven bits of the last byte represent Secondary which is used to identify individual BLE devices. Each BLE device in a room will have a different secondary number, so that we can know where we are exactly. The last bit is called Mode bit which is used to set the device mode: when the value of Mode bit is 0, it means that the device is in the normal mode; when it is 1, it means that it is in a disaster mode.

3.3 Passive Bidirectional Control

According to Beacon ID, beacon users get the corresponding data from the server. However when a beacon is started, Beacon ID has been fixed, which makes the information received by the beacon user is relatively simple. In this paper, beacon users can be indirectly controlled by master. Because master can communicate with combination-mode BLE device in a dual direction, it means that the master can modify Owner UUID, Primary and Secondary of the combination-mode device. And then beacon users receive different location information so that the feedback data that received by beacon users will change with location information.

4. Performance

In order to evaluate performance of the Combination-mode BLE device with indoor positioning system, we have done several experiments. The experiment environment is as follows: BLE Device: BLE nrf51822(4 ea), Smart Device: LG G Pad 7.0 (AndroidOS: 4.4.2) and Samsung S4(AndroidOS: 4.4.2), R version 3.2.0 for the data mining server, MySQL for the database server: 5.5.40-0, window7.

The experiments have been done in our school building. Four combination-mode BLE devices were placed in four different laboratories. Figure 2 shows the location of the combination-mode BLE devices.
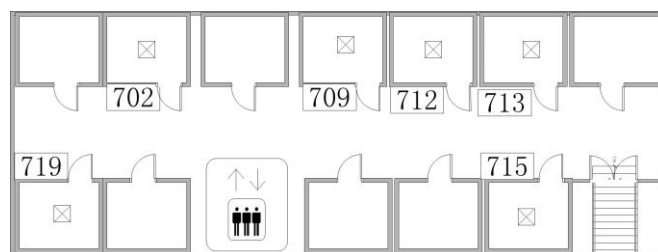

Figure 2 Sketch map of the Experiment Scene

We designed three hypothetical scenarios to test the system. The first hypothetical scenario is broadcasting introduction of their laboratories. When we took smart phones through the four laboratories, we received some broadcast messages.

The second hypothetical scenario, there was a fire just happened in NO.713. When we walk through the four laboratories, we received an escape message in NO.713 and some broadcast messages in the other laboratories.

The third hypothetical scenario, the fire occurred in

No.713 after thirty seconds. We received the escape messages no matter which laboratory we went by.
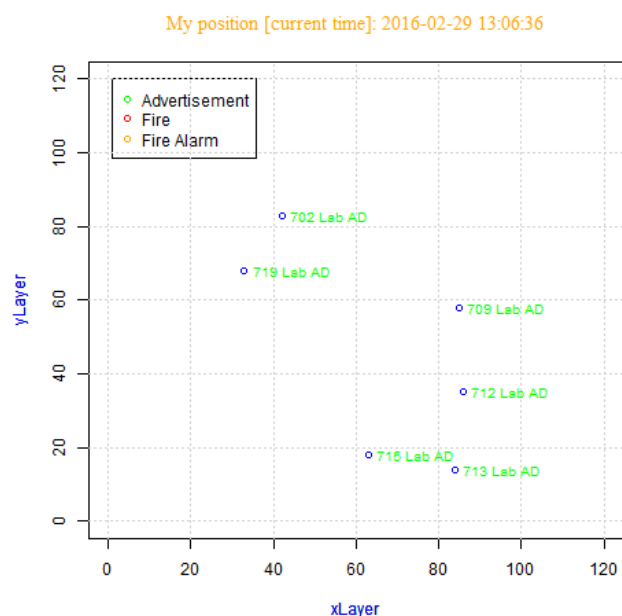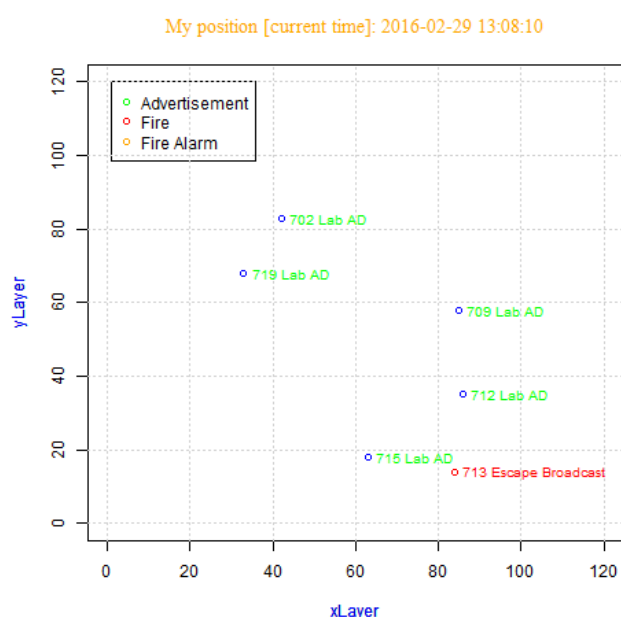

Figure 3 Result of first hypothetical scenario

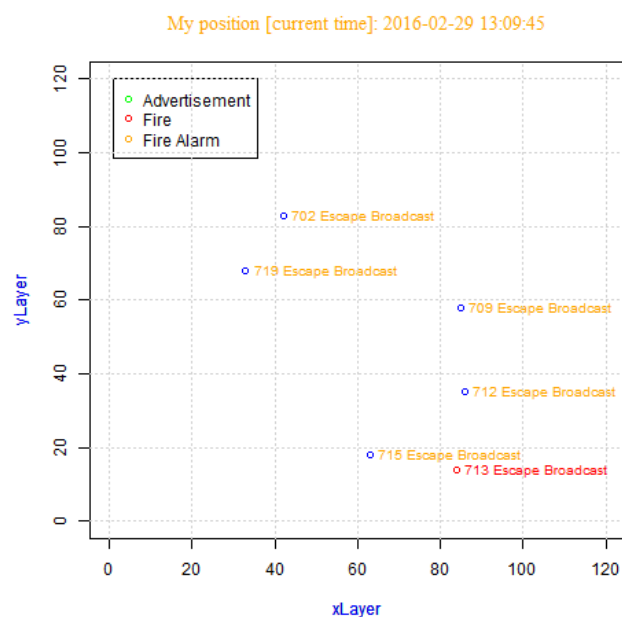**Figure 4** Result of second hypothetical scenario

Figure 5 Result of third hypothetical scenario

5. Conclusion and Future Direction

In this paper, we described combination-mode BLE device profile. Combination-mode BLE device have been designed to provide services for master and beacon users in normal situation or disaster situation. In normal situation, users can receive a message about product introduction or event. In normal situation, users can receive escape message. And beacon users can be indirectly controlled by master.

Reference

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