

SMART LIVING USING BLUETOOTH-BASED ANDROID SMARTPHONE

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ABSTRACT

With the development of modern technology and Android Smartphone, Smart Living is gradually changing people's life. Bluetooth technology, which aims to exchange data wirelessly in a short distance using short-wavelength radio transmissions, is providing a necessary technology to create convenience, intelligence and controllability. In this paper, a new Smart Living system called home lighting control system using Bluetooth-based Android Smartphone is proposed and prototyped. First Smartphone, Smart Living and Bluetooth technology are reviewed. Second the system architecture, communication protocol and hardware design are described. Then the design of a Bluetooth-based Smartphone application and the prototype are presented. It is shown that Android Smartphone can provide a platform to implement Bluetooth-based application for Smart Living.

KEYWORDS

Android smartphone, Smart Living, Bluetooth module, single chip microcomputer, home automation

1. INTRODUCTION

Nowadays, smartphones are becoming more powerful with reinforced processors, larger storage capabilities, richer entertainment functions and more communication methods. Bluetooth, which is mainly used for data exchange, add new features to smartphones. Bluetooth technology, created by telecom vendor Ericsson in 1994 [1], shows its advantage by integrating with smartphones. It has changed how people use digital devices at home or office, and has transferred traditional wired digital devices into wireless devices. A host Bluetooth device is capable of communicating with up to seven Bluetooth modules at the same time through one link [2]. Considering its normal working area of within eight meters, it is especially useful in a home environment. Thanks to Bluetooth technology and other similar techniques, the concept of Smart Living has offered better opportunity in convenience, comfort and security which includes centralized control of air conditioning, , lighting, heating and cooling at home, and service robots[3] [4]. With dramatic increase in smartphone users, smartphones have gradually turned into an all-purpose portable device and provided people for their daily use [5].

In recent years, an open-source platform Android has been widely used in smartphones [6]. Android has a complete software package consisting of an operating system, middleware layer, and core applications. Different from other existing platforms like iOS (iPhone OS), it comes with Software Development Kit (SDK), which provides essential tools and Application

Programming Interfaces (APIs) for developers to build new applications for Android platform in Java. And also Android platform has support for Bluetooth network stack, which allows Bluetooth-enabled devices to communicate wirelessly with each other in a short distance [7]. In this paper, it aims to develop a Bluetooth-based application for the proposed home lighting control system using an open-source Android Development Tools (ADT), Android SDK (Software Development Kit) and Java Development Kit (JDK).

2. BACKGROUND AND RELATED WORK

With rapid development of information technology, the concept of Smart Living has been put forward and emerged as an attractive field for researchers and investors in the past decades. In 2006, Tom and Sitteproposed a reference model named Family System[8] which is used to describe a set of family processes, such as managing finance, planning and preparing meals, family health care, education, household maintenance, generating income and recreation and social life maintenance in Home Automation (HA), as well as their relationships, and interaction with external elements. The model of Family System can be a very useful platform for further research into creating Smart Living to help people in daily life [8].

Bluetooth technology has been one of important technologies to home automation or Smart Living. It is a wireless technology developed to replace cables on devices like mobile phones and PCs. Although "cable-replacement" could create a point-to-point communication, Bluetooth allows wireless devices to be able to communicate with each other within range. The network of a set of Bluetooth devices is called "piconet" [9], which is an ideal technology to network a smart modern home.

Recently, more and more Smart Living applications based on Android and Bluetooth have been developed [9]. Android system equips with SDK and APIs for developers to build new applications. With Bluetooth already integrated into Android system, many Smart Living systems are constructed under Android system. For example, Potts and Sukittanon built an Android application to lock/unlock doors remotely through Bluetooth[10]. However for a home automation system, currently many devices such as lamps and TVs don't have Bluetooth module embedded in the devices, so a suitable Bluetooth module and microcontroller need to be sought out from the marketplace [11] [12] so that a Bluetooth-based Android application can then be built using JAVA based development tool like the Eclipse or Netbeans.

3. SYSTEM DESIGN

3.1. System Architecture

In the proposed home lighting control system, a small "piconet" is established using a microchip and several Bluetooth modules BF10-A [13] [14]. The system is developed under Android platform to monitor and control home lighting via Bluetooth-enabled application. A master-slave structure is adopted in the system architecture where a Bluetooth-enabled Android phone is served as a host controller while other Bluetooth devices, for this instance, switches, linked to the home lighting system are slave devices. The microchip controller is set in a polling status and constantly checks any input command every 500 millisecond from the Android phone application. If it receives a command to instruct the microchip to change the lighting status, the microchip sends a command to the master controller through the Bluetooth

International Journal of Wireless & Mobile Networks (IJWMN) Vol. 5, No. 1, February 2013
 module. Then the Bluetooth application executes the controls lighting operation (on or off).
 The detail of the system architecture is shown in Figure 1:

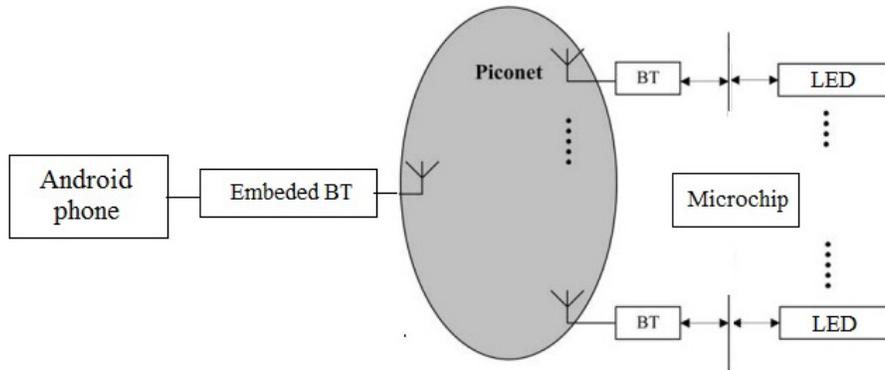


Figure 1. System Architecture

3.2. Communication Protocol

An Android phone sends its command to the client Bluetooth-enabled devices through an embedded Bluetooth module. The phone is used as a host controller which establishes their communication with Bluetooth modules via BF10-A. The communication between the master and slave Bluetooth devices covers the processes of device power-up and data exchange whereas the protocol is established in the Bluetooth software stack. The protocol layer model is specified by the Bluetooth Special Interest Group (SIG) to support the common communication between different Bluetooth devices [14].

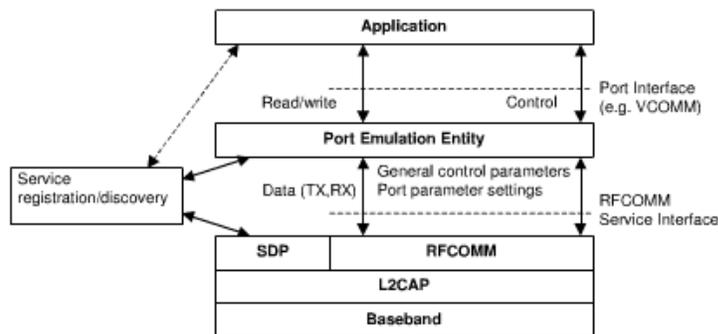


Figure 2. Bluetooth communication protocol [14]

Considering the environments and requirements of the Smart Living, the Bluetooth protocol architecture used in the application adopts the Logical Link Control and Adaptation Protocol (L2CAP), Session Description Protocol (SDP) and Radio Frequency COMMunication

International Journal of Wireless & Mobile Networks (IJWMN) Vol. 5, No. 1, February 2013 (RFCOMM). Besides these protocols, an upper level protocol Serial Port Profile(SPP) is used to communicate with the application layer. Bluetooth device power-up process adopts SDP protocol to require states of the Bluetooth module while the L2CAP protocol provides data exchange service to the Bluetooth application. SSP is used on the upper level to communicate with the application layer.

3.3 Hardware Design

The overall hardware design schematic is shown in Figure 3. The slave Bluetooth module [15] BF10-A communicates with Bluetooth-enabled phone through the SPP channel, each slave module is interfaced with the lighting system with the microchip controller which aims to decode the commands transferred from the host controller to control the lighting, and on the other side, tries to gather light status and encode it to send feedback to the master controller. UART interface P3.0 and P3.1 of the microchip is directly linked to UART_TX and UART_RX which provides the function of exchanging data. P1.0 common IO is used to control the lighting through a mediate relay in case of high current.

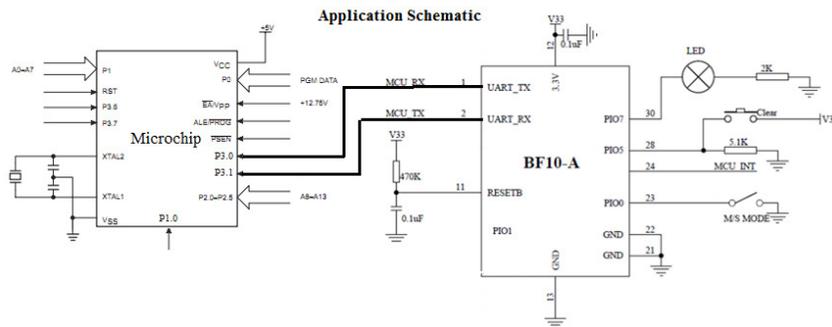


Figure 3. Hardware design schematics [13]

4. BLUETOOTH-BASED APPLICATION

The Bluetooth lighting control and monitor application provides four main functions to the phone user, namely:

- Device registration
- Lighting status monitoring
- Lighting control
- Diagnostics utility

4.1. Application Configuration

Prior to implementation of Bluetooth-based application on the phone, several software packages are required [16] [17], which include Java Development Kit (JDK), the Eclipse software environment, Android Development Tools (ADT) and Android SDK (Software Development Kit). These open-source software packages can be downloaded from:

- www.eclipse.org (The Eclipse)

- developer.android.com (ADT and SDK)
- www.oracle.com (JDK)

The Bluetooth server application is developed in Java using the Eclipse integrated development environment (IDE) which ensures the easy and quick development of the application.

4.2 IDE (Integrated Development Environment)

The proposed application on the Android phone is based on J2SE architecture and Bluetooth network technology. The entire home lighting control system consists of a master server and several clients. Followings are the steps to build the application:

- Set up Bluetooth adapter
- Find surrounding Bluetooth devices in the range
- Connect to the Bluetooth devices
- Exchange data between the master and the slave devices

The Android Bluetooth APIs are available in Java SDK *android.bluetooth* package.

4.2.1 Setting up Bluetooth adapter

The class *BluetoothAdapter* of SDK package *android.bluetooth* is used as an entry point for all Bluetooth interaction. By this, all the Bluetooth devices can be discovered. Then the Bluetooth devices are initialised according to their MAC address and finally a *BluetoothServerSocket* is created to receive echo from the surrounding Bluetooth devices. The codes used to set up a Bluetooth adapter and to enable the Bluetooth communication is listed as below [18]:

```
BluetoothAdapter myBluetooth = BluetoothAdapter.getDefaultAdapter();
If (myBluetooth == null) {Prove the found device do not support Bluetooth}
Else if (myBluetooth.isEnabled())
{Intent enableBtIntent = new
Intent (BluetoothAdapter.ACTION_REQUEST_ENABLE);
startActivityForResult (enableBtIntent, REQUEST_ENABLE_BT);}
```

4.2.2 Finding surrounding Bluetooth modules

After setting up the Bluetooth adapter, the next step is to find the Bluetooth-enabled lighting devices by searching the matched Bluetooth modules. Before finding a device, it needs to query the list of the matched devices to make sure whether the demanded device is known to the server. The following code is used to pair devices and fetch the device name [19].

```
Set <BluetoothDevice> myPairedDevices = myBluetooth.getBondedDevices();
If (myPairedDevices.size() > 0) {
For (BluetoothDevice device : myPairedDevices)
{ myArrayAdapter.add (device.getName()+"\n"+ device.getAddress()) } }
```

The function *getBondedDevices* returns a set of *BluetoothDevice* representing paired devices. When the query result is obtained, the coding below is used to find all the Bluetooth modules [20]:

```
// Create a BroadcastReceiver for ACTION_FOUND
private final BroadcastReceiver mReceiver = new BroadcastReceiver() {
```

```

public void onReceive(Context context, Intent intent) {
    String action = intent.getAction();
    if (BluetoothDevice.ACTION_FOUND.equals(action)) {
        // When discovery finds a device,
        // Get the BluetoothDevice object from the Intent
        BluetoothDevice device =
            intent.getParcelableExtra(BluetoothDevice.EXTRA_DEVICE);
        mAdapter.add(device.getName() + "\n" +
            device.getAddress());
    }
}
// Register the BroadcastReceiver
IntentFilter filter = new IntentFilter(BluetoothDevice.ACTION_FOUND);
registerReceiver(mReceiver, filter);

```

4.2.3. Establish communication between the Bluetooth devices

The Android phone must be assigned as the server in order to execute the application and the Bluetooth modules and a server-side mechanism are implemented to control lighting. Then the server opens a server socket, sends and receives commands through the established connection. The *BluetoothSocket* class is used for the server to receive the commands when an incoming connection is accepted. The microchip used in the design plays the role of the client and it opens an RFCOMM channel to the server. The server socket listens for an incoming connection request from the clients and when one request is accepted, a *BluetoothSocket* object is created.

Following steps are to set up a server socket and accept a connection:

- Call *listen UsingRfcommWithServiceRecord(String, UUID)* to get a *BluetoothServerSocket*.
- Call *accept()* to Start listening to connection requests.
- Call *close()* to end the program.

4.3 Graphical User Interface design



Figure 4. Prototype GUI of the Android phone application

In order to control the home lighting, four lights are defined in the GUI. First, click the “Open Bluetooth” button to switch on Bluetooth adapter while the application is running. Click on the "Search lights" button to find the matched lights with Bluetooth devices, four devices at most, the lights automatically flash on or off according to the Bluetooth feedback received from the lights. To control the assigned light, choose either "ON" or "OFF" as shown in Figure 4, the phone then sends its command to the lights through Bluetooth communication. Finally, the user can press the "Exit" button to terminate all running threads and exit the application.

5. CONCLUSION

The objective of the paper is to realise the Smart Living, more specifically the home lighting control system using Bluetooth technology. The system has been successfully designed and prototyped to monitor and control the lighting status using an Android Bluetooth-enabled phone and Bluetooth modules via BF10-A. The microchip is used to assist gathering status of the lighting and provides interface to control the lighting. The Bluetooth module sends and receives commands from the Bluetooth-enabled phone and RFCOMM protocol is used in communication among Bluetooth devices. Android system JDK is used to develop the system, which is proved to be very efficient and convenient. It is concluded that Smart Living will gradually turn into a reality that consumers can control their home remotely and wirelessly[21].

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