Bluetooth 4.0 Low Energy

Introduction

Bluetooth is a wireless technology standard for exchanging data over short distance. Traditionally, classical bluetooth is designed for streaming data with a high data transfer rates. With the introduction of bluetooth 4.0 low energy technology, it enables new applications and is ideal for applications requiring episodic or periodic transfer of small amounts of data. This paper is a review of current off the shelf development modules , bluetooth 4.0 low energy protocol stack and its implementation and application.

Current development modules

Hong Kong based company RedBearLab develops a easy to use development module called BLE Mini. [1] It requires only a serial port for communication so it supports all major development boards that have UART interface including Arduino, Raspberry Pi, Netduino and BeagleBone so on. The dimension of the BLE Mini is (L)39mm x (W)18.5mm x (H)3.8mm that fits with most smaller Arduino boards such as Mini/Micro/Nano. [1] The power supply of this module include 3.4V to 11V VIN, 5V USB, coin cell battery (2025 or 2032) and 3.7V Li-ion battery. [1] It comes with a pre-loaded firmware code name 'Biscuit' that is developed for TI CC2540 SoC and the source code has been released on github.com. [2] The choice of using Ti's CC2540 SoC let BLE Mini can operate without any external micro controller because CC2540 SoC comes with a high-performance and low-power 8051 micro controller core.[3] Therefore, BLE Mini also supports both Central(Master) or Peripheral(Slave) role in Bluetooth communication. The cost of BLE Mini is $24.9 which is cost compatible with other mainstream bluetooth development modules.

New York based company adafruit develops another popular development module called Bluefruit LE. [5] It requires the use of external micro controller with SPI to drive the board but the board simulates UART service through software. [6] The dimension of the Bluefruit LE is (L)29mm x (W)28mm x (H)0.8mm. [5] Bluefruit LE choose to use Nordic semiconductor nRF8001 chip with ultra low power consumption that can last months to years from a single coin cell.[7] In addition, nRF8001 chip is designed specifically for applications that operate in Peripheral(Slave) role such as proximity tags, remote control or healthcare sensors. Bluefruit LE provides sample iOS code needed for doing simple remote control between the iPhone and Bluefruit LE breakout board. [6] The cost of Bluefruit LE varies from the quantity of purchases. If only purchase one breakout board, the cost is $19.95.

Bluetooth 4.0 Low Energy Protocol Lower Level Stack Overview

The BLE protocol stack is mainly composed of two parts: the Controller and the Host. Controller part comprises of Physical Layer and Link Layer, which is often implemented as a SoC and a integrated radio. The Host position of stack contains the upper layer of the stack including profiles and application API. [9]. Here is a overview of the lower level stack, which is the Controller part:

1. *Physical Layer*

    BLE operates in the 2.4GHz band and defines 40 Radio Frequency (RF) channels with 2 MHz channel spacing. [8] There are two type of channels, advertising channel for device discovery, connection and broadcast and data channel for bidirectional communication for connected device. The maximum data rate of this layer is 1Mbps.

2. *Link Layer*

    BLE can transmit data via broadcast or peer to peer connection. If a device choose to only broadcast data, it advise the data in the advise channel. Another device that aims to only receive data can actively scan the advertising channel without making a connection. Apple's iBeacon technology is a typical application for this. If bidirectional data communication between two devices is needed, a connection between these two devices is needed. The slave device(advertiser) will actively advertise it is a connectable device and once the master device(initiator) see the advertisement, it might transmit a Connection Request message to the slave device. Once the connection is made, both party can communicate via the data channel.

Implementation of Bluetooth Low Energy Controller

Ti's CC2540 SimpleLink Bluetooth Smart Wireless MCU with USB is an example implementation of a Bluetooth Low Energy Controller. It consists a SoC that can process the radio signals and provides a rich set of I/O communication with other part of the system such as UART, USB and SPI so on. The radio frequency range of this is chip is between 2402MHZ and 2480MHZ which is in the range of BLE Protocol Physical Layer's 2MHz channel spacing. [9].

Reference

[1] RedBearLab, *BLE Mini* [Online] .Available: http://redbearlab.com/blemini/

[2] Cheong, *RedBearLab/Biscuit* [Online]. Available: https://github.com/RedBearLab/Biscuit/tree/master/release

[3] Texas Instruments, *CC2540 SimpleLink Bluetooth Smart Wireless MCU with USB* [Online]. Available: http://www.ti.com/product/cc2540

[4] RedBearLab, *RedBearLab/Store* [Online]. Available: http://store.redbearlab.com/products/blemini

[5] Adafruit, *Bluefruit LE - Bluetooth Low Energy (BLE 4.0) - nRF8001 Breakout - v1.0* [Online]. Available: http://www.adafruit.com/product/1697

[6] Adafruit, *Getting Started with the nRF8001 Bluefruit LE Breakout* [Online]. Available: https://learn.adafruit.com/getting-started-with-the-nrf8001-bluefruit-le-breakout?view=all

[7] Nordic Semiconductor, *nRF8001 Specification* [Online]. Available: http://www.nordicsemi.com/eng/Products/Bluetooth-R-low-energy/nRF8001

[8] C. Gomez, J. Oller and J. Paradells, Overview and Evaluation ofBluetooth Low Energy-An Emerging Low-Power WirelessTechnology. Sensors 2012, no. 9, pp. 11734-11753, 2012.

[9] M.Galeev, *Bluetooth 4.0: An introduction to Bluetooth Low Energy—Part II* [Online]. Available: http://www.eetimes.com/document.asp?doc_id=1278966

[10]Texas Instruments, *2.4-GHz Bluetooth low energy System-on-Chip data sheet* [Online]. Available: http://www.ti.com/lit/ds/symlink/cc2540.pdf