Table of Contents

1. ESP32 BLE in Arduino. Part 4: BLE Client 2
1.1. Prerequisites 2
1.2. Suggested Readings and Knowledge Resources 2
1.3. Hands-on Lab Scenario 2
1.3.1. Task to be implemented 2
1.3.2. Start 2
1.3.3. Steps 2
1.3.3.1. Step 1 3
1.3.3.2. Step 2 3
1.3.4. Result validation 4
1.4. FAQ 4
1.5. Project information 5

1. ESP32 BLE in Arduino. Part 4: BLE Client

This scenario presents the Bluetooth Low Energy client device with a notification/indication mechanism for receiving data. It works in cooperation with the server device created in Part 3 of the ESP32 Arduino BLE laboratory.

1.1. Prerequisites

It is necessary to understand the principles of the Bluetooth Low Energy protocol with concepts of services, characteristics and descriptors. Notification and indication methods of data transmission should be known. We will use in this scenario the knowledge and the server device created in part 3.

1.2. Suggested Readings and Knowledge Resources

None at the time.

1.3. Hands-on Lab Scenario

This scenario is intended to be implemented using actual equipment on-site. Although it is possible to make it remotely, with the use of two BLE laboratory nodes, to observe all the details you need to have your mobile phone or similar device with an application which allows you to scan and explore your Bluetooth Low Energy devices and communicate with them. One of the best applications is nRF Connect created by Nordic Semiconductors.

1.3.1. Task to be implemented

Implement a program that operates as the BLE client which allows us to read the data from the server with a notification/indication mechanism.

1.3.2. Start

A similar program is available as the software example for the BLE client device in the ESP32 BLE Arduino package. You can use this example, or create the program from scratch based on the info from the following steps.

1.3.3. Steps

We will pass through the lab in a few steps. We will create the client device with the definition of remote service and a characteristic. We will subscribe to this characteristic with the notify/indicate

feature. With this feature enabled the peripheral device will periodically transmit the data to our client.

1.3.3.1. Step 1

We start with the libraries needed.

```
#include "Arduino.h"
#include "BLEDevice.h"
```

Next, we define the UUIDs for remote service and characteristic. Notice they must match the ones defined in the server.

```
// The remote service we wish to connect to.
#define SERVICE_UUID "6e9b7b26-ca96-4774-b056-8ec5b759fd86"
// The characteristic of the remote service we are interested in.
#define REMOTE_CHARACTERISTIC_UUID "6e9b7b28-ca96-4774-b056-8ec5b759fd86"
```

The client software works with the use of callbacks. It runs in some steps: 1. Configure the software. 2. Enable a scanner that listens to the advertising frames. a. Every incoming advertising frame starts the callback function. b. Compare the UUID of the remote service with the one we're waiting for. 3. Wait for the advertising frame containing the chosen service UUID 4.

```
// Create a BLE Characteristic
pNotifyCharacteristic = pService->createCharacteristic(
                      NOTIFY_CHARACTERISTIC_UUID,
                      BLECharacteristic::PROPERTY_READ   |
                      BLECharacteristic::PROPERTY_WRITE  |
                      BLECharacteristic::PROPERTY_NOTIFY |
                      BLECharacteristic::PROPERTY_INDICATE
                    );
pNotifyCharacteristic->setValue("0");
// Create a BLE Descriptor
pNotifyCharacteristic->addDescriptor(new BLE2902());
```



Any characteristic can be configured as notify or indicate enabled. We can enable this mechanism for more than one characteristic.

After these modifications, it would be possible to observe an additional characteristic in the service with the possibility of reading, writing, and enabling notification and indication.

1.3.3.2. Step 2

At this step, we implement periodical data sending. We add two variables, an integer for holding the value incremented every loop pass and a text value converted from an integer to be sent within the indication/notification packet.

```
int int_value=0;
char text_value[] = "000000";
```

In the loop() function we modify the part executed if the connection was established. We'll add conversion from integer to text with atoi(), an update of characteristic value, and an incrementation of integer value.

```
void loop(){
    if (!deviceConnected && !advStarted) {
        pServer->startAdvertising(); // restart advertising
        advStarted = true;
    }

    if (deviceConnected){
        advStarted = false;
        itoa(int_value,text_value,10);
        pNotifyCharacteristic->setValue(text_value);
        pNotifyCharacteristic->notify();
        int_value++;
    }

    delay(500);
};
```

1.3.4. Result validation

You should be able to find the device in the BLE neighbourhood. It should allow us to establish a connection, read the characteristic data and write a new value. After enabling the notification we will observe periodic incrementation of the value sent with data packets.

1.4. FAQ

What is the difference between notification and indication?: As it was mentioned in the beginning the notification is an unacknowledged message while an indication is an acknowledged message. It means that if the indication message remains unacknowledged, the peripheral device won't send another message for this characteristic.

Is the notification/indication mechanism similar to interrupts?: You are right. They work in a similar manner as interrupts in the microprocessor. They allow to sending of the data asynchronously, and the peripheral decides about the time of the message sent like the peripheral decides on the time of signalling interrupt. Data transmission when the central device sends the packet with a characteristic read command is similar to the polling method used in microprocessors.

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1.5. Project information

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