Bluetooth Low Energy in Arduino 101

1st Edition

Tony Gaitatzis

BackupBrain Publishing, 2017

ISBN: 978-1-7751280-6-9

backupbrain.co

Bluetooth Low Energy in Arduino 101

by Tony Gaitatzis

backupbrain@gmail.com

Services and Characteristics

Before data can be transmitted back and forth between a Central and Peripheral, the Peripheral must host a GATT Profile. That is, the Peripheral must have Services and Characteristics.

Identifying Services and Characteristics

Each Service and Characteristic is identified by a Universally Unique Identifier (UUID). The UUID follows the pattern 0000XXXX-0000-1000-8000-00805f9b34fb, so that a 32-bit UUID 00002a56-0000-1000-8000-00805f9b34fb can be represented as 0x2a56.

Some UUIDs are reserved for specific use. For instance any Characteristic with the 16-bit UUID 0x2a35 (or the 32-bit UUID 00002a35-0000-1000-8000-00805f9b34fb) is implied to be a blood pressure reading.

For a list of reserved Service UUIDs, see ***Appendix IV: Reserved GATT Services***.

For a list of reserved Characteristic UUIDs, see ***Appendix V: Reserved GATT Characteristics***.

Generic Attribute Profile

Services and Characteristics describe a tree of data access points on the peripheral. The tree of Services and Characteristics is known as the Generic Attribute (GATT) Profile. It may be useful to think of the GATT as being similar to a folder and file tree (Figure 6-1).

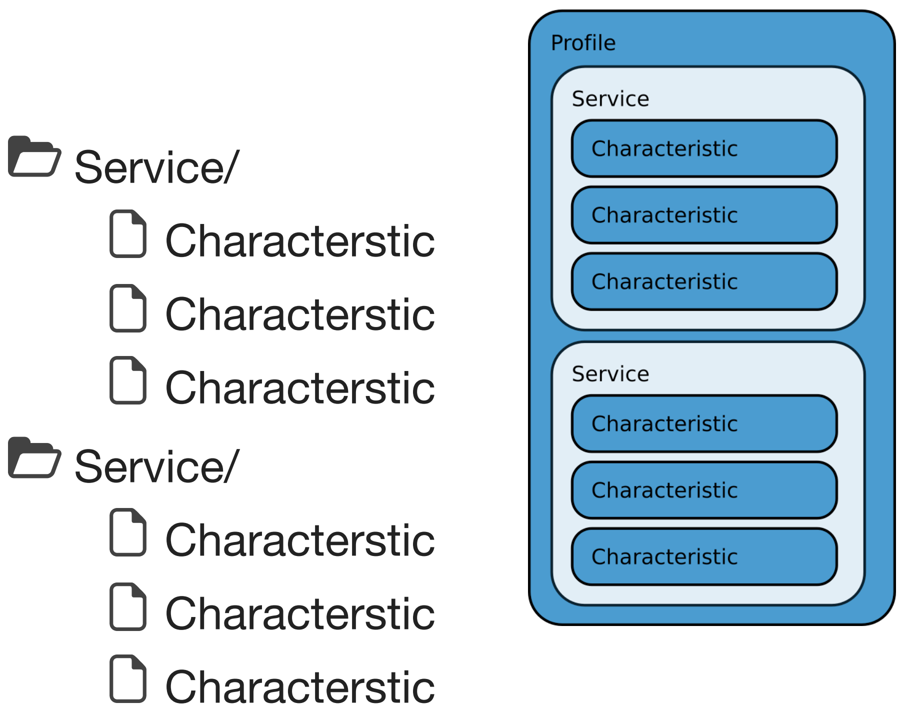


Figure 6-1. GATT Profile filesystem metaphor

Characteristics act as channels that can be communicated on, and Services act as containers for Characteristics. A top level Service is called a Primary service, and a Service that is within another Service is called a Secondary Service.

Permissions

Characteristics can be configured with the following attributes, which define what the Characteristic is capable of doing (Table 6-1):

Table 6-1. Characteristic Permissions

Descriptor	Description
Read	Central can read this Characteristic, Peripheral can set the value.
Write	Central can write to this Characteristic, Peripheral will be notified when the Characteristic value changes and Central will be notified when the write operation has occurred.
Notify	Central will be notified when Peripheral changes the value.

Because the GATT Profile is hosted on the Peripheral, the terms used to describe a Characteristic's permissions are relative to how the Peripheral accesses that Characteristic. Therefore, when a Central uploads data to the Peripheral, the Peripheral can "read" from the Characteristic. The Peripheral "writes" new data to the Characteristic, and can "notify" the Central that the data is altered.

Data Length and Speed

It is worth noting that Bluetooth Low Energy has a maximum data packet size of 20 bytes, with a 1 Mbit/s speed.

Programming the Peripheral

The Generic Attribute Profile is defined by setting the UUID and permissions of the Peripheral's Services and Characteristics.

Characteristics can be configured with the following permissions (Table 6-2):

Table 6-2. BLECharacteristic Permissions

Value	Permission	Description
BleRead	**Read**	Central can read data altered by the Peripheral
BleWrite	**Write**	Central can send data, Peripheral reads
BleNotify	**Notify**	Central is notified as a result of a change

Characteristics have a maximum length of 20 bytes. Since 16 bit and 8-bit data types are easy to pass around in C++, we will be using uint16_t (unsigned 16-bit integer) and uint8_t (unsigned 8-bit integer) values in the examples. Any data type including custom byte buffers can be transmitted and assembled over BLE.

Define a Service with UUID 180c (an unregistered generic UUID):

```
BLEService service("180C");
```

or

```
BLEService service("0000180C-000-1000-8000-00805f9-b34fb");
```

The first method lets the Peripheral automatically generate most of the UUID, and the second method forces the Peripheral to use a particular UUID. The first method is simpler but less precise. The second method is precise and useful for projects where there is a need to share the UUID with outside people or APIs.

Note: Certain UUIDs are unavailable for use. If a bad UUID is chosen, the Peripheral may crash without warning.

There are several types of Characteristic available in Arduino 101, depending on the type of data you need to transmit. Arrays, Integers, Floats, Booleans, and other data types have their own Characteristic constructors.

For instance, this 2-byte long Characteristic with UUID 1801 can be read by a Central and can notify the Central of changes:

```
BLECharacteristic readCharacteristic(
    “1801”, BLERead | BLENotify, 2
);
```

This 8-byte long Characteristic with UUID 2A56 (Digital Characteristic) can be written to by the Central:

```
BLECharacteristic writeCharacteristic(“2A56”, BLEWrite, 8);
```

Here are some examples of various data type specific Characteristics that can be created:

```
int properties = BLERead | BLEWrite | BLENotify;
BLEBoolCharacteristic \
    booleanCharacteristic(UUID, properties, maxLen);
BLEIntCharacteristic \
    integerDataCharacteristicName(UUID, properties, maxLen);
BLEUnsignedIntCharacteristic \
    yourCharacteristicName(UUID, properties, maxLen);
BLELongCharacteristic \
    yourCharacteristicName(UUID, properties, maxLen);
BLEUnsignedLongCharacteristic \
    yourCharacteristicName(UUID, properties, maxLen);
BLEFloatCharacteristic \
    yourCharacteristicName(UUID, properties, maxLen);
```

The Services and Characteristics are added to the GATT Profile via the BLEPeripheral. By adding the two Characteristics after the Service, they are assumed to be part of the same Service. This must happen before blePeripheral.begin().

```
...
```

```
BLEPeripheral blePeripheral;
...
blePeripheral.setAdvertisedServiceUuid(service.uuid());  // add service UUID
blePeripheral.addAttribute(service);   // Add the BLE Heart Rate service
blePeripheral.addAttribute(readCharacteristic); // add read characteristic
blePeripheral.addAttribute(writeCharacteristic); // add read characteristic
blePeripheral.begin();
...
```

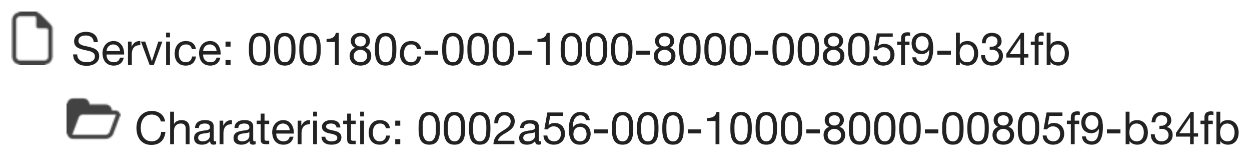
Putting It All Together

Create a new sketch named ble_characteristics and copy the following code.

Example 6-1. sketches/ble_characteristics/ble_characteristics.ino

```
#include "CurieBle.h"
static const char* bluetoothDeviceName = "MyDevice";
// Unregulated Service
static const char* serviceUuid = "180C";
// Unregulated Charactersitic
static const char* characteristicUuid = "2A56";
// 20 byte transmission
static const int   characteristicTransmissionLength = 20;
// create a service
BLEService service(serviceUuid);
// create a characteristic with Read and write attributes
BLECharacteristic characteristic(
  characteristicUuid,
  BLERead | BLEWrite,
  characteristicTransmissionLength
);
BLEPeripheral blePeripheral;
void setup() {
  blePeripheral.setLocalName(bluetoothDeviceName);
  Serial.println(bluetoothDeviceName);
  blePeripheral.setAdvertisedServiceUuid(service.uuid()); // attach service
  blePeripheral.addAttribute(service);
  blePeripheral.addAttribute(characteristic); // attach characteristic
  blePeripheral.begin();
}
void loop() {}
```

When run, this sketch will create a Peripheral that advertises as “MyDevice” and will have a GATT profile featuring a single Characteristic with read and write permissions (Figure 6-2).



Service: 000180c-000-1000-8000-00805f9-b34fb
Charateristic: 0002a56-000-1000-8000-00805f9-b34fb

Figure 6-2. GATT Profile hosted on the Arduino 101

Example code

The code for this chapter is available online at: https://github.com/BluetoothLowEnergyInArduino101/Chapter06

Other Books in this Series