GR551x Sample Service Application and Customization

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Preface

Purpose

This document introduces how to use and verify the sample service example in the GR551x Software Development Kit (SDK), to help users with secondary development.

Audience

This document is intended for:

- GR551x user
- GR551x developer
- GR551x tester
- Hobbyist developer
- Technical writer

Release Notes

This document is the eighth release of *GR551x Sample Service Application and Customization*, corresponding to GR551x System-on-Chip (SoC) series.

Revision History

Version	Date	Description
1.0	2019-12-08	Initial release
1.3	2020-03-16	Updated descriptions in “Add Sample Service to a New Project”.
1.5	2020-05-30	Updated pictures related to the project directory in “Application of Goodix Sample Service”.
1.6	2020-06-30	Updated the document version based on SDK changes.
1.7	2020-12-15	Updated GRToolbox UI figures based on software update.
1.8	2021-04-26	Optimized descriptions in “Application of Goodix Sample Service” and “Creating a Custom Service”.
1.9	2021-08-09	Changed the section "Supported Development Platform" into "Preparation".
2.0	2022-02-20	• Modified the file name of the example firmware based on SDK changes. • Modifed the "Applying Sample Service" section.

Contents

1 Introduction

To maintain the compatibility between all kinds of Bluetooth devices, Bluetooth Special Interest Group (Bluetooth SIG) defines a series of universal standard services in Bluetooth-related fields.

Bluetooth devices of all kinds are able to control the peer Bluetooth devices, or access relevant data easily based on these standard services.

However, in some circumstances, it is necessary to implement your own services. For example, your application may require some new functions which are not supported by these standard services.

This document focuses on the application and modification of a Goodix sample service.

Before getting started, you can refer to the documents as shown in Table 1-1.

Table 1-1 Reference documents

Name	Description
GR551x Developer Guide	Introduces GR551x Software Development Kit (SDK) and how to develop and debug applications based on the SDK.
Bluetooth Core Spec	Offers official Bluetooth standards and core specification from Bluetooth SIG.
J-Link/J-Trace User Guide	Provides J-Link operational instructions. Available at www.segger.com/downloads/jlink/UM08001_JLink.pdf.
Keil User Guide	Offers detailed Keil operational instructions. Available at www.keil.com/support/man/docs/uv4/.

2 Sample Service Overview

GR551x System-on-Chips (SoCs) provide a sample service in compliance with Bluetooth SIG standards for your reference, to implement the basic Write and Notify communications between the Master and the Slave. The information interaction process is presented as below.

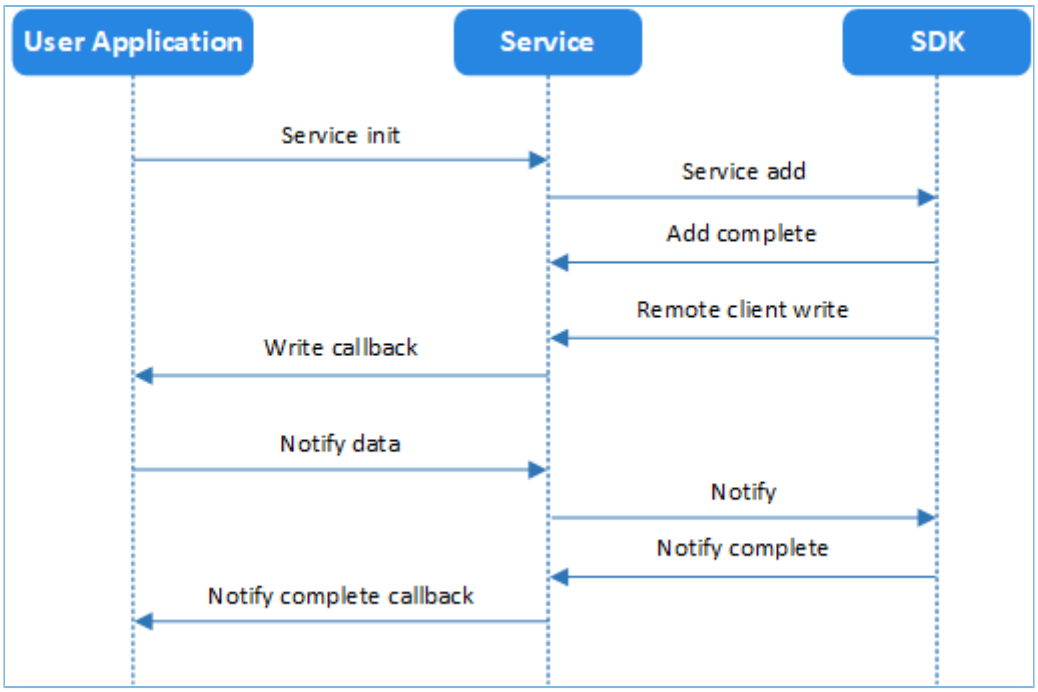

Figure 2-1 Information interaction process of the sample service

The sample service provides two characteristics: RX and TX, with the property as Write and Notify respectively. Detailed comparison between two characteristics is presented in Table 2-1 .

Table 2-1 Sample service characteristics

Characteristic	UUID	Type	Support	Security	Property
Service	A6ED0101-D344-460A-8075-B9E8EC90D71B	128 bits	Mandatory	None	-
RX Characteristic	A6ED0102-D344-460A-8075-B9E8EC90D71B	128 bits	Mandatory	None	Write Without Response
TX Characteristic	A6ED0103-D344-460A-8075-B9E8EC90D71B	128 bits	Mandatory	None	Notify

3 Application of Goodix Sample Service

This chapter introduces how to create a project for the Goodix sample service in Keil.

Note:

SDK_Folder is the root directory of GR551x SDK.

3.1 Preparation

Perform the following tasks before applying the Sample Service.

- **Hardware preparation**

Table 3-1 Hardware preparation

Name	Description
Development board	GR5515 Starter Kit Board (SK Board)
Connection cable	Micro USB 2.0 cable

- **Software preparation**

Table 3-2 Software preparation

Name	Description
Windows	Windows 7/Windows 10
J-Link driver	A J-Link driver. Available at: www.segger.com/downloads/jlink/
Keil MDK5	An integrated development environment (IDE). MDK-ARM 5.20 or later is required. Available at: www.keil.com/download/product/
GRToolbox (iOS)	A Bluetooth Low Energy (Bluetooth LE) debugging tool running on iOS. Available at the App Store.
GRToolbox (Android)	A Bluetooth LE debugging tool. Available in SDK_Folder\tools\GRToolbox

3.2 Creating a Project Based on Template

Open SDK_Folder\projects\ble\ble_peripheral, and copy the ble_app_template folder to the current directory. Rename the original folder and the two files (UVOPTX and UVPROJX format) in the corresponding Keil_5 subfolder as ble_app_template_mine, and open the UVPROJX file in Keil. Taking the GR551x SDK as an example, the file structure of the ble_app_template_mine project is shown in the figure below.

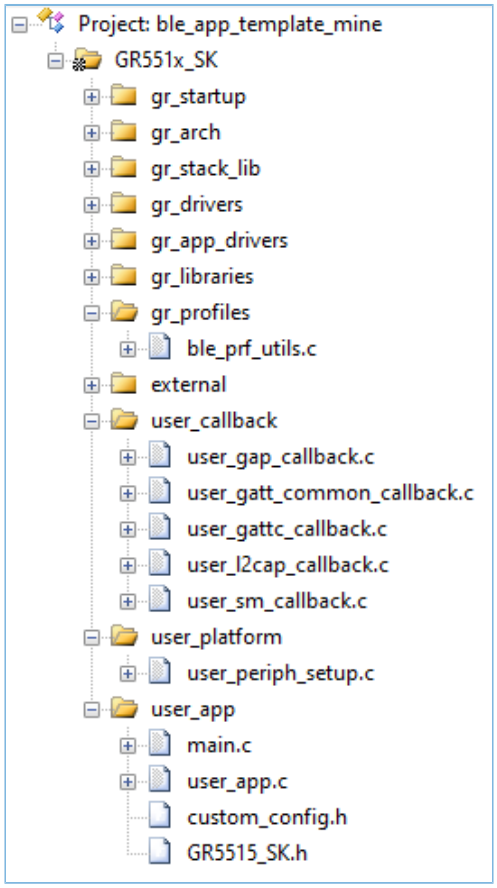

Figure 3-1 ble_app_template_mine project structure directory

Some related files are described in Table 3-3.

Table 3-3 File description of ble_app_template_mine

Group	Description
gr_profiles	Contains profile source files.
user_callback	Contains user-defined Bluetooth LE callback functions.
user_platform	Initializes user peripherals.
user_app	Implements user application logics.

3.3 Adding Sample Service to a New Project

Copy the directory SDK_Folder\components\profiles\sample to SDK_Folder\projects\ble\ble_peripheral\ble_app_template_mine\Src. Follow the steps below to add *sample_service.c* from the copied sample directory to the new project, and start compiling.

1. Add *sample_service.c* to the new project.

   (1). Click the **Options for Target...** icon in the tool bar of Keil.

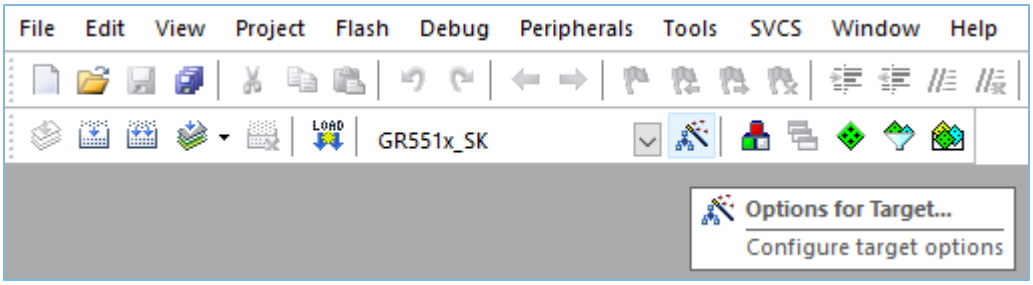

Figure 3-2 Clicking the **Options for Target…** icon

(2). When the **Options for Target xx** window pops up, select the **C/C++** tab page, and click ... next to **Include Paths** to browse paths.

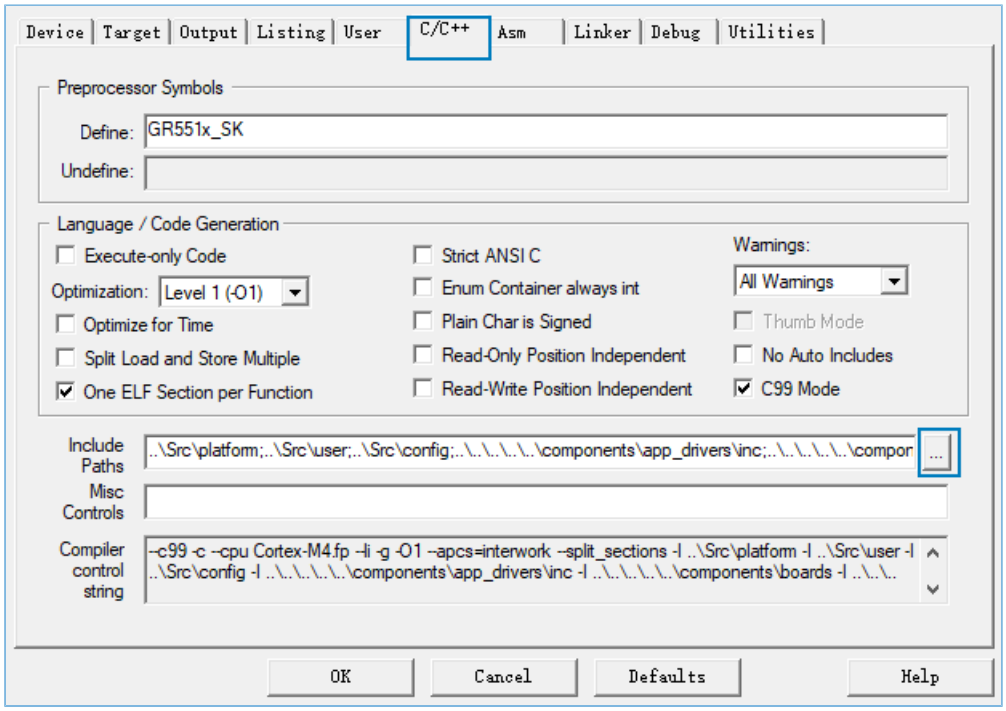

Figure 3-3 Browsing paths

(3). Drag the scroll bar to the bottom of the **Include Paths** list in the **Folder Setup** window, and enter the path of the sample service (`..\Src\sample`); or double-click any empty line at the bottom, click ... in the same line to browse the path for the sample service (`..\Src\sample`), and click **OK**.

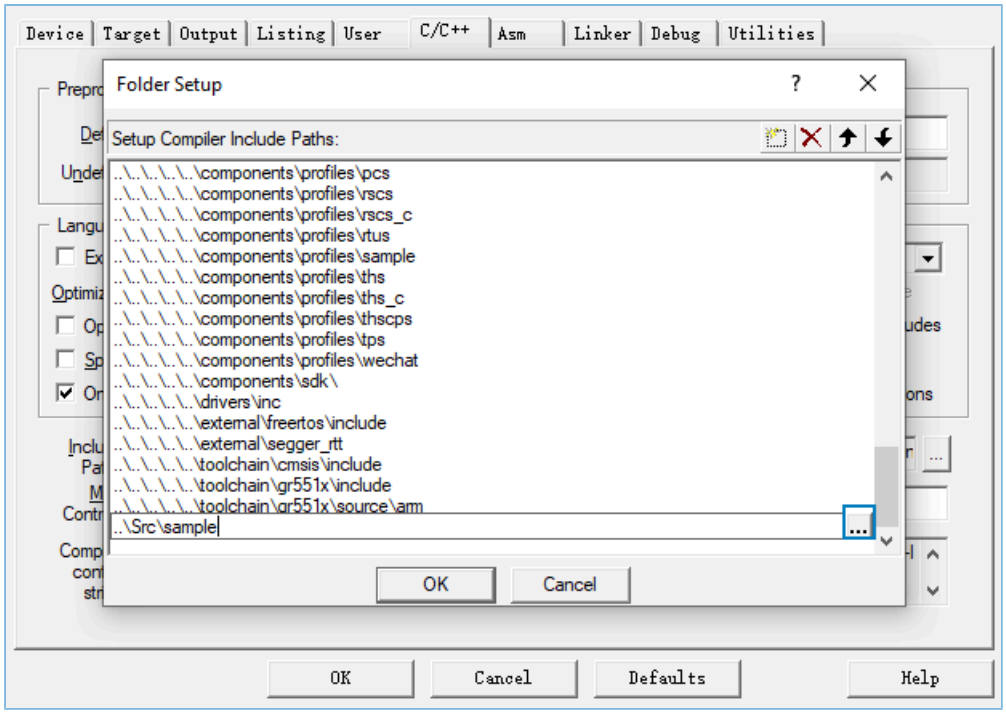

Figure 3-4 Entering the path of the sample service

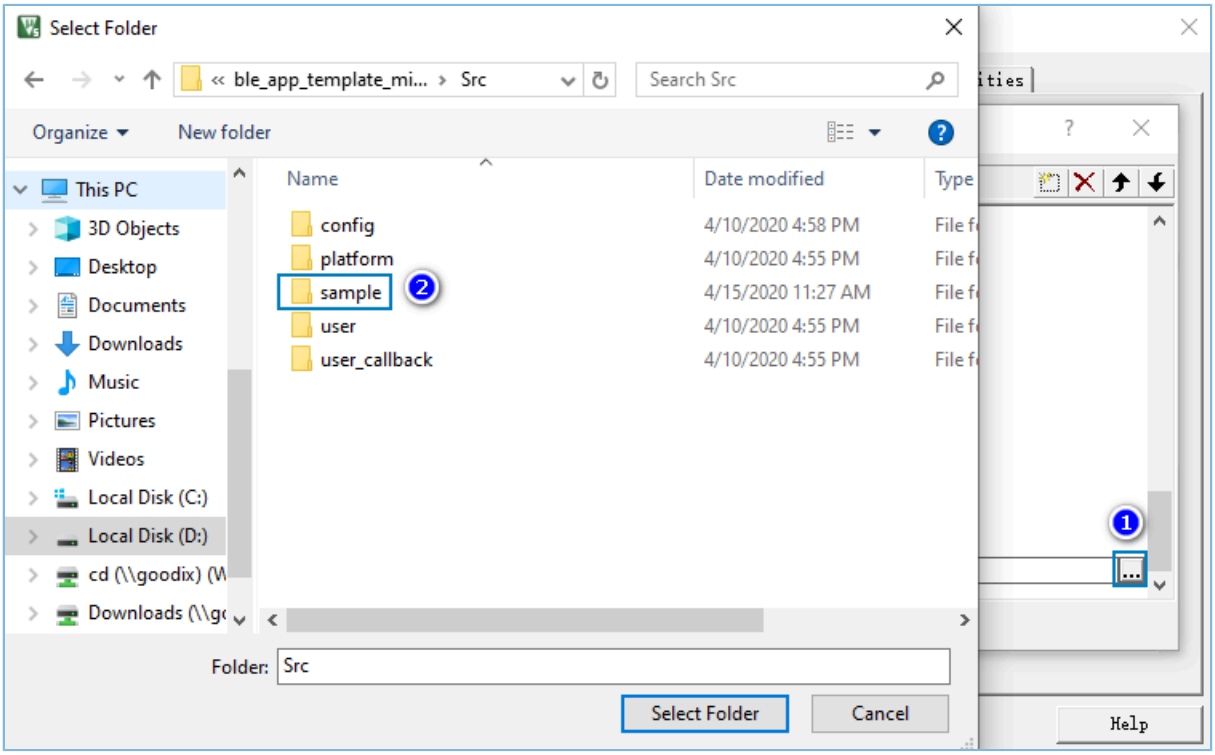

Figure 3-5 Browsing the path of the sample service

2. Add the Sample Service source file *sample_service.c* to Keil project. Select **gr_profiles** in the project directory, right-click and select **Add Existing Files to Groups 'gr_profiles'**. Choose the *sample_service.c* file in the `Src\Sample` directory, and add it to the gr_profiles folder by clicking **Add**.

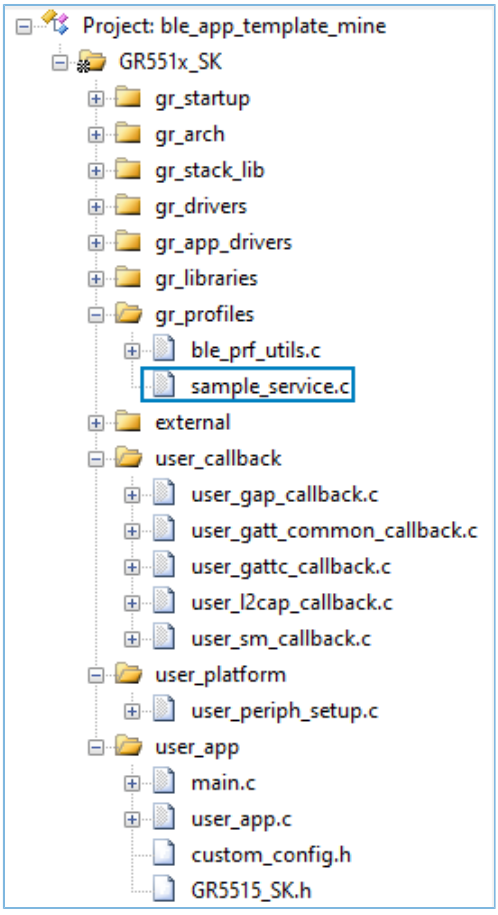

Figure 3-6 Adding the source file of the sample service to Keil project

3.4 Applying Sample Service

This section introduces how to initialize the sample service in the new project (ble_app_template_mine).

Operations in the *user_app.c* file are as below.

- Add header files of the sample service.

```
#include "user_app.h"
#include "gr55xx_sys.h"
#include "app_log.h"
#include "app_error.h"
#include "sample_service.h"
```

- Implement the callback function of the sample service.

```
static void sample_envt_process(samples_evt_t *p_evt)
{
    switch(p_evt->evt_type)
    {
        case SAMPLES_EVT_TX_NOTIFICATION_ENABLED:
            break;
        case SAMPLES_EVT_TX_NOTIFICATION_DISABLED:
            break;
        case SAMPLES_EVT_RX_RECEIVE_DATA:
```

```
            break;
        case SAMPLES_EVT_TX_NOTIFY_COMPLETE:
            break;
        default:break;
    }
}
```

- Initialize the environment variables in the services_init() function and call the samples_service_init() function to add Service.

```
static void services_init(void)
{
    samples_init_t sample_init[1];
    sample_init[0].evt_handler = sample_envt_process;
    samples_service_init(sample_init, 1);
}
```

Note:

The same rules are applicable to adding or applying other services to/in a project. Services are independent from each other, and you can add or apply one or more services at a time.

3.5 Firmware Programming

The source code of the Goodix sample service example is in SDK_Folder\projects\ble\ ble_peripheral\ble_app_template_mine.

You can programme *ble_app_template_mine.bin* to an SK Board through GProgrammer. For details, see *GProgrammer User Manual*.

Note:

- The *ble_app_template_mine.bin* is in SDK_Folder\projects\ble\ble_peripheral\ble_app_template_mine\build\.

3.6 Test and Verification

1. Start GRToolbox to scan and discover the device with the advertising name of **Goodix_Tem**, as shown in Figure 3-7.

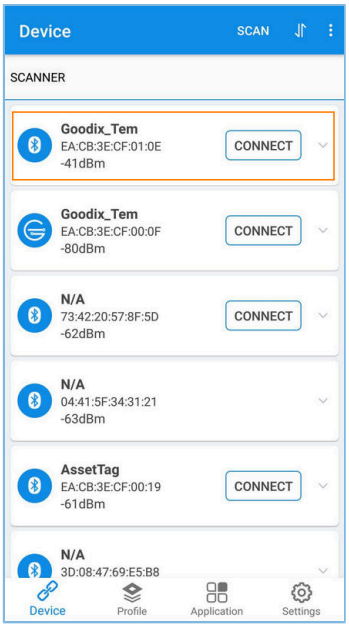

Figure 3-7 Discovering **Goodix_Tem**

Note:

Screenshots of GRToolbox in this document are for reference only, to help users better understand the software operation. In the case of interface differences due to version changes, the interface of GRToolbox in practice shall prevail.

2. Tap **CONNECT** in the **Goodix_Tem** pane to connect the device to an SK Board through Bluetooth, and search for the sample service to check whether the two characteristics (RX and TX) are included in the service.

   If the values displayed under the discovered service are in accordance with the sample service characteristics listed in Table 2-1, the sample service is applied successfully.

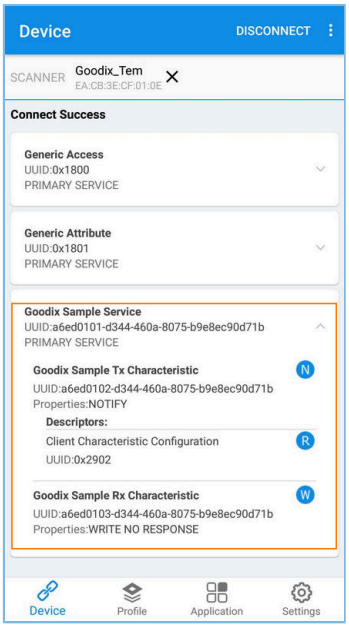

Figure 3-8 Successful application of the sample service

4 Creating a Custom Service

In some applications, standard services cannot meet demands. This chapter introduces how to apply a custom service by adding a new characteristic (with properties of Notify and Write without Response) to the sample service.

Note:

Custom services refer to modified services based on the sample service.

In this chapter, code in bold refers to those of the newly added characteristic, whereas the code not in bold is original.

4.1 Adding a New Characteristic

Follow the steps below to add a new characteristic.

1. Add the UUID of the new characteristic (in the *sample_service.c* file).

```
/**@brief The UUIDs of GUS characteristics. */
#define SAMPLE_SERVER_TX_UUID      {0x1B, 0xD7, 0x90, 0xEC, 0xE8, 0xB9, 0x75, 0x80, 0x0A,
 0x46, 0x44, 0xD3, 0x02, 0x01, 0xED, 0xA6}
#define SAMPLE_SERVER_RX_UUID      {0x1B, 0xD7, 0x90, 0xEC, 0xE8, 0xB9, 0x75, 0x80, 0x0A,
 0x46, 0x44, 0xD3, 0x03, 0x01, 0xED, 0xA6}
#define SAMPLE_SERVER_ADD_UUID     {0x1B, 0xD7, 0x90, 0xEC, 0xE8, 0xB9, 0x75, 0x80, 0x0A,
 0x46, 0x44, 0xD3, 0x04, 0x01, 0xED, 0xA6}
```

2. Add Notify configuration variable of the new characteristic in the environment variable structure system (in the *sample_service.c* file).

```
/**@brief The UUIDs of GUS characteristics. */
/**@brief Samples Service environment variable. */
typedef struct
{
    /**< Sample Service initialization variables. */
    samples_init_t samples_init;
    /**< Service start handle. */
    uint16_t start_hdl;
    /**< TX Character Notification configuration of peer devices. */
    uint16_t tx_ntf_cfg[SAMPLES_CONNECTION_MAX];
    /**< ADD Character Notification configuration of peer devices. */
    uint16_t add_ntf_cfg[SAMPLES_CONNECTION_MAX];
} samples_env_t;
```

3. Add index enumerations of the new characteristic (in the *sample_service.c* file).

```
/**@brief Sample Service Attributes Indexes. */
enum samples_attr_idx_t
{
    SAMPLES_IDX_SVC,

    SAMPLES_IDX_TX_CHAR,
    SAMPLES_IDX_TX_VAL,
    SAMPLES_IDX_TX_CFG,
    SAMPLES_IDX_RX_CHAR,
    SAMPLES_IDX_RX_VAL,
    SAMPLES_IDX_ADD_CHAR,
    SAMPLES_IDX_ADD_VAL,
    SAMPLES_IDX_ADD_CFG,
```

```
    SAMPLES_IDX_NB,
};
```

4. Add return event type of the new characteristic at the application layer (in the *sample_service.h* file).

```
/**@brief Sample Service event type. */
typedef enum
{
    SAMPLES_EVT_INVALID,
    SAMPLES_EVT_TX_NOTIFICATION_ENABLED,
    SAMPLES_EVT_TX_NOTIFICATION_DISABLED,
    SAMPLES_EVT_RX_RECEIVE_DATA,
    SAMPLES_EVT_TX_NOTIFY_COMPLETE,
    SAMPLES_EVT_ADD_NOTIFICATION_ENABLED,
    SAMPLES_EVT_ADD_NOTIFICATION_DISABLED,
    SAMPLES_EVT_ADD_RECEIVE_DATA,
    SAMPLES_EVT_ADD_NOTIFY_COMPLETE,
} samples_evt_type_t
```

5. Define attribute descriptions of the new characteristic (in the *sample_service.c* file).

   After completing all steps above, a new characteristic is generated and displayed on the **Goodix_Tem** connection interface, as shown in Figure 4-2.

```
/**@brief Full SAMPLES Database Description - Used to add attributes into the database. */
static const attm_desc_128_t samples_att_db[SAMPLES_IDX_NB] =
{
    ...
    [SAMPLES_IDX_RX_VAL]    = {SAMPLE_SERVER_RX_UUID,
                               WRITE_CMD_PERM_UNSEC,
                               (ATT_VAL_LOC_USER |
                                ATT_UUID_TYPE_SET(UUID_TYPE_128)),
                                SAMPLES_MAX_DATA_LEN},

    //SAMPLE ADD Characteristic Declaration
    [SAMPLES_IDX_ADD_CHAR] = {ATT_128_CHARACTERISTIC, READ_PERM_UNSEC, 0, 0},
    //SAMPLE ADD Characteristic Value
    [SAMPLES_IDX_ADD_VAL]   = {SAMPLE_SERVER_ADD_UUID,
                               NOTIFY_PERM_UNSEC | WRITE_CMD_PERM_UNSEC,
                               (ATT_VAL_LOC_USER|
                                ATT_UUID_TYPE_SET(UUID_TYPE_128)),
                                SAMPLES_MAX_DATA_LEN},
    //SAMPLE ADD Characteristic - Client Characteristic Configuration Descriptor
    [SAMPLES_IDX_ADD_CFG]   = {ATT_128_CLIENT_CHAR_CFG,
                               READ_PERM_UNSEC | WRITE_REQ_PERM_UNSEC,
                               0,
                               0},
};
```

4.2 Reading and Writing a New Characteristic

1. Add the function of reading the new characteristic to the samples_read_att_cb() function.

```
static void samples_read_att_cb(uint8_t conn_idx, const gatts_read_req_cb_t *p_param)
{
```

```
    ...
    switch (tab_index)
    {
        case SAMPLES_IDX_TX_CFG:
            cfm.length = sizeof(uint16_t);
            cfm.value = (uint8_t *)(&s_samples_env[i].tx_ntf_cfg[conn_idx]);
            break;

        case SAMPLES_IDX_ADD_CFG:
            cfm.length = sizeof(uint16_t);
            cfm.value = (uint8_t *)(&s_samples_env[i].add_ntf_cfg[conn_idx]);
            break;

        default:
            break;
    }

    ble_gatts_read_cfm(conn_idx, &cfm);
}
```

2. Add the function of writing the new characteristic to the samples_write_att_cb() function.

```
static void samples_write_att_cb(uint8_t conn_idx, const gatts_write_req_cb_t *p_param)
{
    ...
    switch (tab_index)
    {
        case SAMPLES_IDX_RX_VAL:
            event.conn_idx = conn_idx;
            event.evt_type = SAMPLES_EVT_RX_RECEIVE_DATA;
            break;
        case SAMPLES_IDX_TX_CFG:
            cccd_value = le16toh(&p_param->value[0]);
            event.conn_idx = conn_idx;
            event.evt_type = (PRF_CLI_START_NTF == cccd_value) ? \
                              SAMPLES_EVT_TX_NOTIFICATION_ENABLED :\
                              SAMPLES_EVT_TX_NOTIFICATION_DISABLED;
                              s_samples_env[i].tx_ntf_cfg[conn_idx]= cccd_value;
            break;
        case SAMPLES_IDX_ADD_VAL:
                event.conn_idx = conn_idx;
                event.evt_type = SAMPLES_EVT_ADD_RECEIVE_DATA;
            break;
        case SAMPLES_IDX_ADD_CFG:
            cccd_value = le16toh(&p_param->value[0]);
            event.conn_idx = conn_idx;
            event.evt_type = (PRF_CLI_START_NTF == cccd_value) ? \
                              SAMPLES_EVT_ADD_NOTIFICATION_ENABLED :\
                              SAMPLES_EVT_ADD_NOTIFICATION_DISABLED;
                              s_samples_env[i].add_ntf_cfg[conn_idx]=cccd_value;
            break;
        default:
            cfm.status = BLE_ATT_ERR_INVALID_HANDLE;
            break;
    }
    ...
}
```

3. Add Client Characteristic Configuration Descriptor (CCCD) settings in the samples_cccd_set_cb() function.

```
static void samples_cccd_set_cb(uint8_t conn_idx, uint16_t handle, uint16_t cccd_value)
{
    ...
    switch (tab_index)
    {
        case SAMPLES_IDX_TX_CFG:
            event.conn_idx = conn_idx;
            event.evt_type = (PRF_CLI_START_NTF == cccd_value) ?\
                              SAMPLES_EVT_TX_NOTIFICATION_ENABLED :\
                              SAMPLES_EVT_TX_NOTIFICATION_DISABLED;
                              s_samples_env[i].tx_ntf_cfg[conn_idx] = cccd_value;
      break;
      case SAMPLES_IDX_ADD_CFG:
            event.conn_idx = conn_idx;
            event.evt_type = (PRF_CLI_START_NTF == cccd_value) ?\
                                SAMPLES_EVT_ADD_NOTIFICATION_ENABLED :\
                                SAMPLES_EVT_ADD_NOTIFICATION_DISABLED;
                                s_samples_env[i].add_ntf_cfg[conn_idx]=cccd_value;
       break;
       default:
            break;
    }
    ...
}
```

4.3 Adding Notify Function to a New Characteristic

Add the Notify function to the new characteristic, and make the declaration in the *sample_service.h* file. The code below is for your reference.

```
sdk_err_t samples_notify_add_data(uint8_t conn_idx, uint8_t ins_idx, uint8_t *p_data,
 uint16_t length)
{
    sdk_err_t  error_code = SDK_ERR_NTF_DISABLED;
    gatts_noti_ind_t send_cmd;

    if (PRF_CLI_START_NTF == s_samples_env[ins_idx].add_ntf_cfg[conn_idx])
    {
        if (ins_idx <= s_samples_ins_cnt)
        {
            // Fill in the parameter structure
            send_cmd.type   = BLE_GATT_NOTIFICATION;
            send_cmd.handle = prf_find_handle_by_idx(SAMPLES_IDX_ADD_VAL,
                                                     s_samples_env[ins_idx].start_hdl,
                                                    (uint8_t *)&s_samples_features);
            // pack measured value in database
            send_cmd.length       = length;
            send_cmd.value        = p_data;
            s_now_ins_cnt         = ins_idx;
            s_now_notify_cmp_type = SAMPLES_EVT_ADD_NOTIFY_COMPLETE;
            // send notification to peer device
            error_code = ble_gatts_noti_ind(conn_idx, &send_cmd);
        }
    }
    return error_code;
}
```

4.4 Applying the Custom Service

To apply and verify the modified sample service, set a one-second timer to accumulate hexadecimal variables. Notify the accumulated value to the Master through the newly added characteristic (UUID: 0x1B, 0xD7, 0x90, 0xEC, 0xE8, 0xB9, 0x75, 0x80, 0x0A,0x46, 0x44, 0xD3, 0x04, 0x01, 0xED, 0xA6; properties: Write Without Response/Notify).

The steps to add a timer in the *user_app.c* file are as below.

1. Add header files of the timer.

```
#include "user_app.h"
#include "gr55xx_sys.h"
#include "app_log.h"
#include "app_error.h"
#include "sample_service.h"
#include "app_timer.h"
```

2. Define the timer ID and a cumulative variable.

```
static app_timer_id_t s_add_timer_id;
static uint16_t s_add_count = 0;
```

3. Create a timer in ble_init_cmp_callback().

```
void ble_init_cmp_callback(void)
{
    ...
    error_code = ble_gap_adv_start(0, &s_gap_adv_time_param);
    APP_ERROR_CHECK(error_code);

    APP_LOG_INFO("Template application example started.");

    app_timer_create(&s_add_timer_id, ATIMER_REPEAT, add_time_out_handler);
}
```

4. Implement the event processing logics of the sample service.

Note:

The timer has a time base of 1 millisecond. Therefore, set the value of the timer to 1000, which means 1 second.

```
static void sample_event_process(samples_evt_t *p_evt)
{
    switch(p_evt->evt_type)
    {
        case SAMPLES_EVT_TX_NOTIFICATION_ENABLED:
            break;
        case SAMPLES_EVT_TX_NOTIFICATION_DISABLED:
            break;
        case SAMPLES_EVT_RX_RECEIVE_DATA:
            break;
        case SAMPLES_EVT_TX_NOTIFY_COMPLETE:
            break;
        case SAMPLES_EVT_ADD_NOTIFICATION_ENABLED:
            app_timer_start(s_add_timer_id, 1000, NULL);
            break;
        case SAMPLES_EVT_ADD_NOTIFICATION_DISABLED:
```

```
            app_timer_stop (s_add_timer_id);
            break;
        case SAMPLES_EVT_ADD_RECEIVE_DATA:
            break;
        case SAMPLES_EVT_ADD_NOTIFY_COMPLETE:
            break;

        default:break;
    }
}
```

5. Implement the timeout handler function of the timer.

```
static void add_time_out_handler(void *p_arg)
{
    s_add_count++;
    samples_notify_add_data(0,0,(uint8_t*)&s_add_count,2);
}
```

4.5 Test and Verification

For details about firmware download, refer to "Section 3.5 Firmware Programming"; for details about hardware and software required for test and verification, refer to "Section 3.1 Preparation". The steps for test and verification are as below.

1. Start the GRToolbox to scan and discover the device with the advertising name of **Goodix_Tem**.

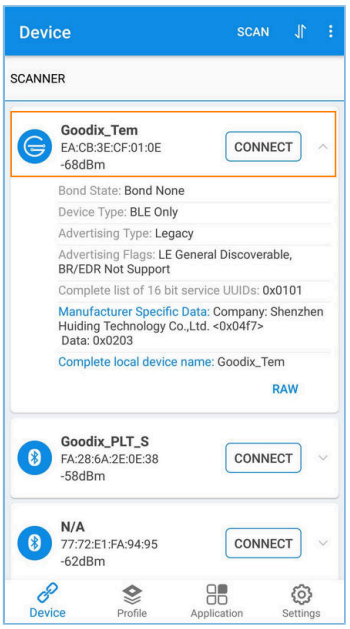

Figure 4-1 Discovering **Goodix_Tem**

2. Tap **CONNECT** in the **Goodix_Tem** pane, to connect the device to an SK Board through Bluetooth. View the characteristics of the sample service to check whether the newly added characteristic is included.

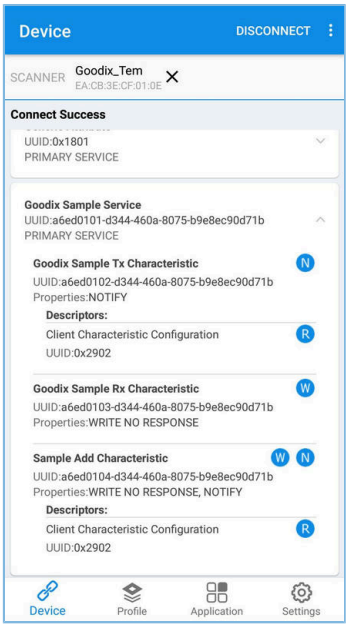

Figure 4-2 Viewing characteristics of the custom sample service

If the sample service includes a characteristic which shares the same UUID and properties with the newly added one, the modification to the sample service is successful.

3. Tap N on the right of **Sample Add Characteristic**. You can observe the value of the Notify characteristic ascends every second from the drop-down list.

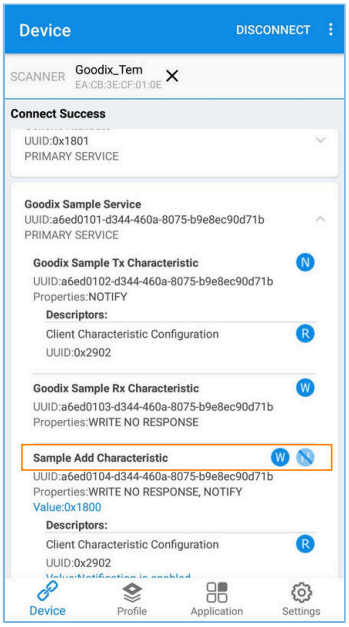

Figure 4-3 Successful application of the custom sample service

The custom sample service is applied successfully, as shown in Figure 4-3.