GR5xx Serial Port Profile Example Application

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Preface

Purpose

This document introduces how to use and verify the Serial Port Profile (SPP) example in the Bluetooth Low Energy (Bluetooth LE) GR5xx Software Development Kit (SDK), to help users quickly get started with secondary development.

Audience

This document is intended for:

- GR5xx user
- GR5xx developer
- GR5xx tester
- Hobbyist developer
- Technical writer

Release Notes

This document is the second release of *GR5xx Serial Port Profile Example Application*, corresponding to Bluetooth LE GR5xx System-on-Chip (SoC) series.

Revision History

Version	Date	Description
1.0	2023-01-10	Initial release
3.0	2023-03-30	Updated descriptions about GR5xx SoCs.

Contents

1 Introduction

Serial Port Profile (SPP) defines how to pass through data from virtual serial ports to peer Bluetooth Low Energy (Bluetooth LE) devices by adopting Bluetooth LE technology.

Bluetooth Special Interest Group (Bluetooth SIG) does not define standard profiles for Bluetooth LE serial port pass-through. Therefore, to make Goodix-customized SPP user-friendly, this document introduces how to use and verify the Goodix SPP example in the GR5xx Software Development Kit (SDK).

Before getting started, you can refer to the documents listed below.

Table 1-1 Reference documents

Name	Description
GR5xx Sample Service Application and Customization	Introduces how to apply and customize Goodix Sample Service in developing Bluetooth LE applications based on GR5xx SDK.
Developer guide of the specific GR5xx SoC	Introduces GR5xx 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.
Bluetooth GATT Spec	Provides details about Bluetooth profiles and services. Available at https://www.bluetooth.com/specifications/gatt.
J-Link/J-Trace User Guide	Provides J-Link operational instructions. Available at https://www.segger.com/downloads/jlink/UM08001_JLink.pdf.
Keil User Guide	Offers detailed Keil operational instructions. Available at https://www.keil.com/support/man/docs/uv4/.

2 Profile Overview

Goodix SPP defines two device roles:

- Initiator: the device that issues a connection request to another device
- Acceptor: the device that waits for connection requests from other devices

The figure below shows how the two kinds of devices get connected and pass through data.

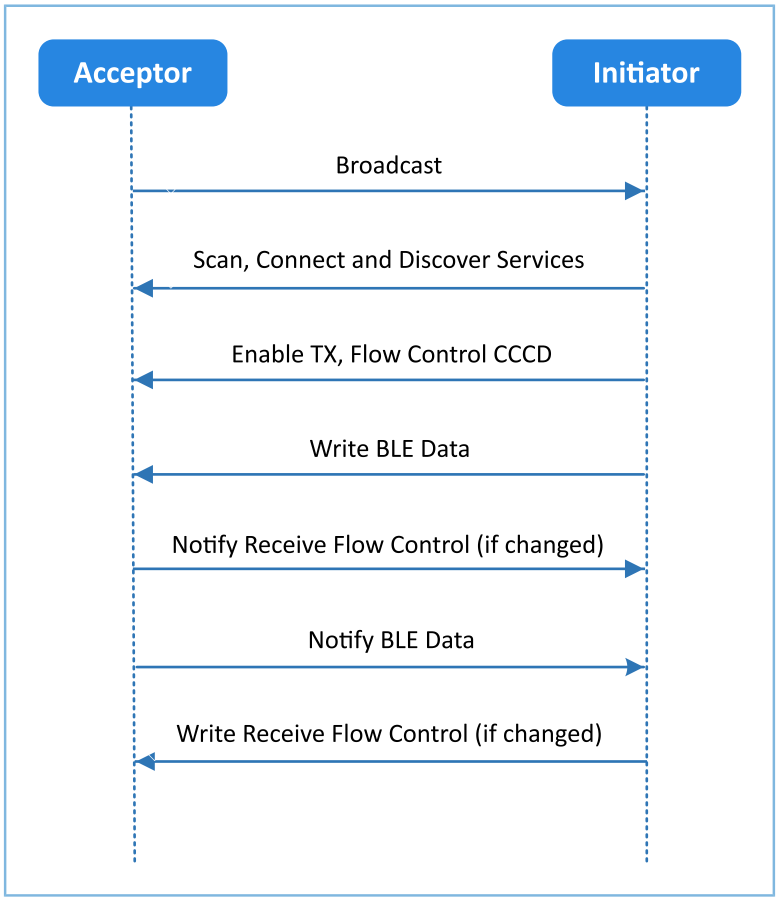

Acceptor
Initiator
Broadcast
Scan, Connect and Discover Services
Enable TX, Flow Control CCCD
Write BLE Data
Notify Receive Flow Control (if changed)
Notify BLE Data
Write Receive Flow Control (if changed)

Figure 2-1 Acceptor-Initiator interaction process

Goodix SPP only defines the data pass-through service of GR5xx System-on-Chips (SoCs) (Goodix UART Service, GUS). The service is customized by Goodix, with the 128-bit vendor-specific UUID of A6ED0201-D344-460A-8075-B9E8EC90D71B to transmit data, and to update Bluetooth LE data flow control.

GUS is characterized by:

- RX characteristic: Receives the written data from the initiator.
- TX characteristic: Sends data through serial ports to the initiator.
- Flow Control characteristic: Updates the capacities of the acceptor and the initiator in receiving Bluetooth LE data (0x00: Cannot receive more Bluetooth LE data; 0x01: Can receive more Bluetooth LE data).

These characteristics are described in detail as follows:

Table 2-1 GUS characteristics

Characteristic	UUID	Type	Support	Security	Property
RX	A6ED0202-D344-460A-8075-B9E8EC90D71B	128 bits	Mandatory	None	Write
TX	A6ED0203-D344-460A-8075-B9E8EC90D71B	128 bits	Mandatory	None	Notify
Flow Control	A6ED0204-D344-460A-8075-B9E8EC90D71B	128 bits	Mandatory	None	Notify and Write

3 Initial Operation

This chapter introduces how to quickly verify an SPP example in the GR5xx SDK.

Note:

SDK_Folder is the root directory of the GR5xx SDK in use.

3.1 Preparation

Perform the following tasks before using and modifying the Goodix SPP example.

- **Hardware preparation**

Table 3-1 Hardware preparation

Name	Description
J-Link debug probe	JTAG emulator launched by SEGGER. For more information, visit https://www.segger.com/products/debug-probes/j-link/
Development board	Starter Kit Board (SK Board) of the corresponding SoC
Connection cable	USB Type C cable (Micro USB 2.0 cable for GR551x SoCs)

- **Software preparation**

Table 3-2 Software preparation

Name	Description
Windows	Windows 7/Windows 10
J-Link driver	A J-Link driver. Available at https://www.segger.com/downloads/jlink/.
Keil MDK5	An integrated development environment (IDE). MDK-ARM 5.20 or later is required. Available at https://www.keil.com/download/product/.
GRToolbox (Android)	A Bluetooth LE debugging tool. Available in `SDK_Folder\tools\GRToolbox`
GRUart (Windows)	A serial port debugging tool. Available in `SDK_Folder\tools\GRUart`.
GProgrammer (Windows)	A programming tool. Available in `SDK_Folder\tools\GProgrammer`.

3.2 Firmware Programming

The source code of the Goodix SPP example is in `SDK_Folder\projects\ble\ble_peripheral\ble_app_uart`.

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

Note:

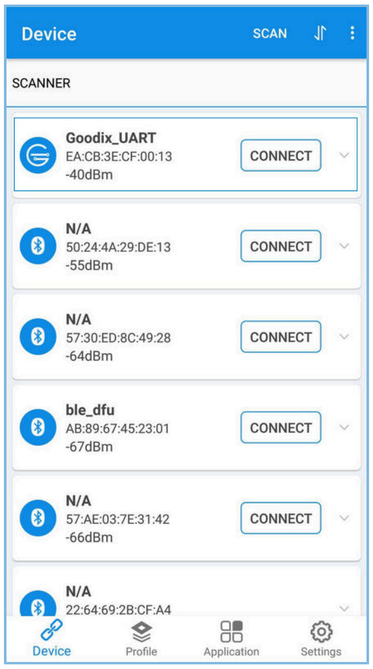
ble_app_uart.bin is in `SDK_Folder\projects\ble\ble_peripheral\ble_app_uart\build`.

3.3 Test and Verification

When an SK Board, GRToolbox, and GRUart are ready, test and verify the SPP example. Steps are described as follows:

1. Connect to the SK Board through GRToolbox.

   Launch GRToolbox on an Android mobile phone to search for the device **Goodix_UART** (advertising name, which can be modified in the *user_app.c* file).



Goodix_UART
EA:CB:3E:CF:00:13
-40dBm

N/A
50:24:4A:29:DE:13
-55dBm

N/A
57:30:ED:8C:49:28
-64dBm

ble_dfu
AB:89:67:45:23:01
-67dBm

N/A
57:AE:03:7E:31:42
-66dBm

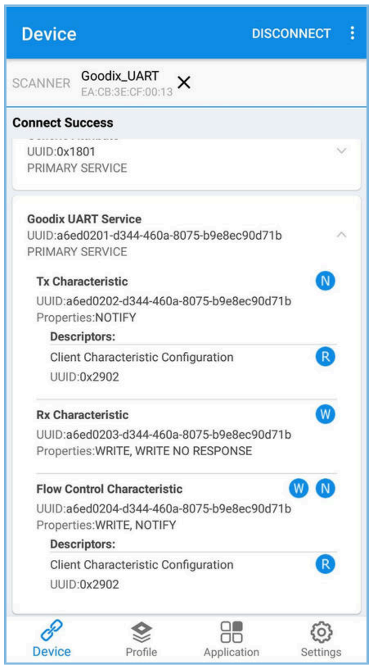
N/A
22:64:69:2B:CF:A4

Figure 3-1 Discovering **Goodix_UART** on the mobile phone

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.

Tap **CONNECT** to connect to **Goodix_UART**, and the screen shows **Goodix UART Service** information, including **TX Characteristic**, **RX Characteristic**, and **Flow Control Characteristic**, as shown in the figure below.



Goodix_UART
EA:CB:3E:CF:00:13

Connect Success

UUID:0x1801
PRIMARY SERVICE

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

Tx Characteristic
UUID:a6ed0202-d344-460a-8075-b9e8ec90d71b
Properties:NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902

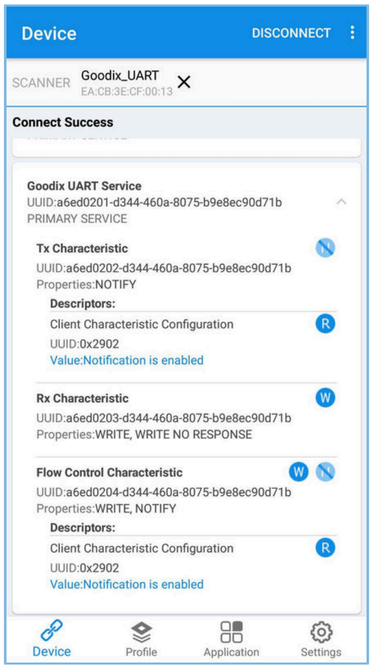
Rx Characteristic
UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902

Figure 3-2 Discovering **Goodix UART Service** on the mobile phone

2. Send data through GRToolbox.

   Enable notifications for **TX Characteristic** and **Flow Control Characteristic** in GUS on the peer device through GRToolbox. The mobile phone displays as below:



Goodix_UART
EA:CB:3E:CF:00:13

Connect Success

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

Tx Characteristic
UUID:a6ed0202-d344-460a-8075-b9e8ec90d71b
Properties:NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Rx Characteristic
UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 3-3 Interface after enabling notifications for **TX Characteristic** and **Flow Control Characteristic**

   Write data (such as **12345678**) to GUS and tap **SEND**.

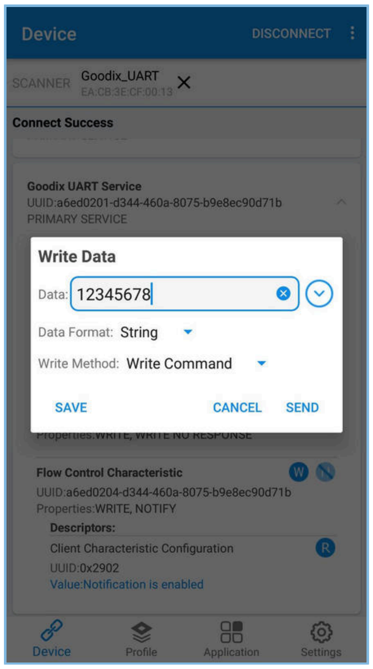
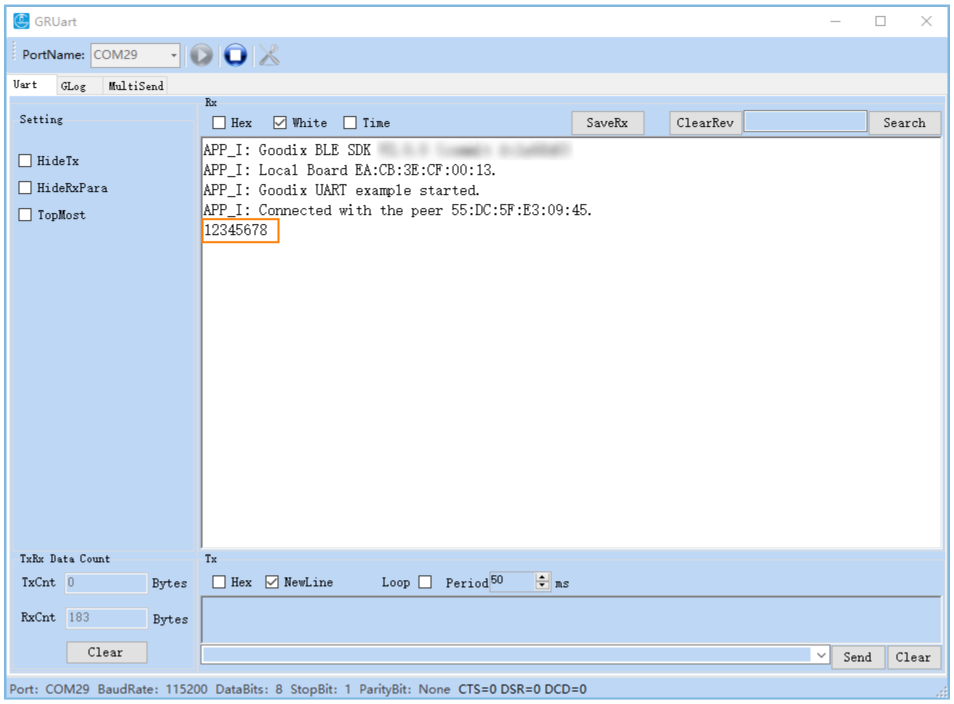


Figure 3-4 Entering **RX Characteristic** attributes

Data sent through GRToolbox is shown in the **Receive Data** area of GRUart, as shown in the figure below.



```
APP_I: Goodix BLE SDK
APP_I: Local Board EA:CB:3E:CF:00:13.
APP_I: Goodix UART example started.
APP_I: Connected with the peer 55:DC:5F:E3:09:45.
12345678
```

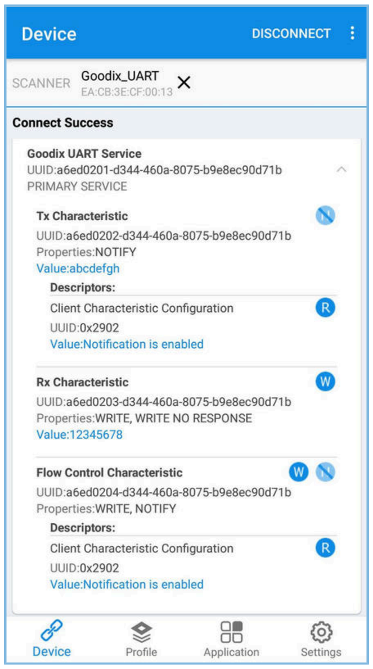
Port: COM29 BaudRate: 115200 DataBits: 8 StopBit: 1 ParityBit: None CTS=0 DSR=0 DCD=0

Figure 3-5 Printing data sent from GRToolbox on GRUart

3. Send data through GRUart.

   Enter **abcdefgh** in the **Send data** pane in GRUart, and click **Send**.

   The **Value** of **TX Characteristic** in GRToolbox shows the data sent from GRUart, as shown in the figure below.



Goodix_UART
EA:CB:3E:CF:00:13

Connect Success

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

Tx Characteristic
UUID:a6ed0202-d344-460a-8075-b9e8ec90d71b
Properties:NOTIFY
Value:abcdefgh
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Rx Characteristic
UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE
Value:12345678

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 3-6 Showing data sent from GRUart on GRToolbox

If the two applications function as described above, the Goodix SPP example runs successfully.

4 Application Details

This chapter introduces the running procedures and major code of the Goodix SPP example.

4.1 Running Procedures

After the initiator discovers and connects to the Goodix SPP example, the main process is shown in the figure below:

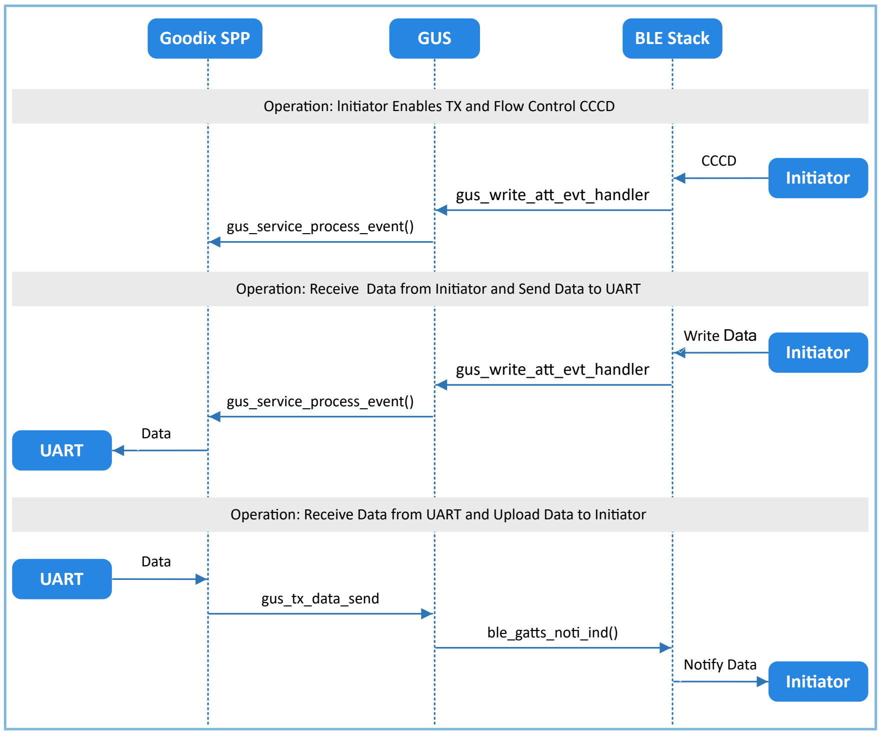

Goodix SPP
GUS
BLE Stack
Operation: Initiator Enables TX and Flow Control CCCD
CCCD
Initiator
gus_write_att_evt_handler
gus_service_process_event()
Operation: Receive Data from Initiator and Send Data to UART
Write Data
Initiator
gus_write_att_evt_handler
gus_service_process_event()
Data
UART
Operation: Receive Data from UART and Upload Data to Initiator
Data
UART
gus_tx_data_send
ble_gatts_noti_ind()
Notify Data
Initiator

Figure 4-1 Running procedures of the Goodix SPP example

4.2 Major Code

The sections below introduce major code related to interactions between the initiator and the acceptor.

4.2.1 Enabling Notification of Data TX & Data Flow Control Characteristics

After the initiator sends a command about enabling the notification of GUS **TX Characteristic** on the acceptor, GUS parses the command and reports the “GUS_EVT_TX_PORT_OPENED” event to the application layer to enable the notification of **TX Characteristic**. This enables the acceptor to transmit data from serial ports to the initiator.

After the initiator sends a command about enabling the notification of GUS Flow Control Characteristic on the acceptor, GUS parses the command and reports the “GUS_EVT_FLOW_CTRL_ENABLE” event to the application layer to enable the notification of Flow Control Characteristic. This enables the acceptor to notify the initiator of the capacity for receiving Bluetooth LE data.

Path: `user_app\user_app.c` under the project directory

Name: gus_service_process_event();

```
static void gus_service_process_event(gus_evt_t *p_evt)
{
    switch (p_evt->evt_type)
    {
        case GUS_EVT_TX_PORT_OPENED:
            transport_flag_set(GUS_TX_NTF_ENABLE, true);
            break;
        case GUS_EVT_FLOW_CTRL_ENABLE:
            transport_flag_set(BLE_FLOW_CTRL_ENABLE, true);
            break;
        ...
    }
}
```

4.2.2 Receiving Data and Transmitting the Data to Serial Ports

After the acceptor receives Bluetooth LE data from the initiator, GUS reports the "GUS_EVT_RX_DATA_RECEIVED" event to the application layer, which calls ble_to_uart_push() to store the data in the corresponding ring buffers.

Path: `user_app\user_app.c` under the project directory

Name: gus_service_process_event();

```
static void gus_service_process_event(gus_evt_t *p_evt)
{
    switch (p_evt->evt_type)
    {
         ...
         case GUS_EVT_TX_DATA_RECEIVED:
             ble_to_uart_push(p_evt->p_data, p_evt->length);
             break;
         ...
    }
}
```

The function transport_schedule() runs in the while loop of the main() function and polls the ring buffers. When new data in the ring buffers is detected, call the transport_uart_data_send() function. The function retrieves data from the ring buffers and transmits the data to serial ports.

Path: `user_app\transport_scheduler.c` under the project directory

Name: transport_uart_data_send()

```
static void transport_uart_data_send(void)
{
    uint16_t read_len;
    uint16_t items_avail;

    items_avail = ring_buffer_items_count_get(&s_ble_rx_ring_buffer);

    if (items_avail > 0)
    {
        read_len = ring_buffer_read(&s_ble_rx_ring_buffer, s_uart_tx_data,
                                    UART_ONCE_SEND_SIZE);
        uart_tx_data_send(s_uart_tx_data, read_len);
    }
}
```

4.2.3 Receiving Data from Serial Ports and Transmitting the Data to Initiator

After receiving data from the serial ports, the acceptor keeps the data received from serial port events in the ring buffers temporarily supported by the uart_evt_handler() function.

Path: `user_platform\user_periph_setup.c` under the project directory

Name: uart_evt_handler();

```
static void uart_evt_handler(app_uart_evt_t *p_evt)
{
    if (APP_UART_EVT_RX_DATA == p_evt->type)
    {
        uart_to_ble_push(s_uart_rx_buffer, p_evt->data.size);

        app_uart_dma_receive_async(APP_UART_ID, s_uart_rx_buffer, UART_RX_BUFFER_SIZE);
    }
    else if (APP_UART_EVT_TX_CPLT == p_evt->type)
    {
        update_ble_flow_ctrl_state();
    }
}
```

When there are no Bluetooth LE data transmission tasks, the function transport_schedule() calls the function transport_ble_data_send() to poll the ring buffers. If there is data to be transmitted in the ring buffers, the Bluetooth LE data transmission tasks are executed.

Path: `user_app\transport_scheduler.c` under the project directory

Name: transport_ble_data_send();

```
static void transport_ble_data_send(void)
{
    uint16_t read_len;
    uint16_t items_avail;

    items_avail = ring_buffer_items_count_get(&s_uart_rx_ring_buffer);

    if (items_avail > 0)
    {
        read_len = ring_buffer_read(&s_uart_rx_ring_buffer, s_ble_tx_data,
                                    s_mtu_size - 3);
        transport_flag_set(BLE_TX_CPLT, false);
        gus_tx_data_send(0, s_ble_tx_data, read_len);
    }
}
```

When one Bluetooth LE data transmission task is completed, GUS reports the "GUS_EVT_TX_DATA_SENT" event to the application layer which calls the function transport_ble_continue_send() to check the ring buffers. If there is data to be transmitted in the ring buffers, the Goodix SPP continues retrieving the data and transmitting the data to the initiator.

Path: `user_app\transport_scheduler.c` under the project directory

Name: transport_ble_continue_send();

```
void transport_ble_continue_send(void)
{
    …
    transport_flag_set(BLE_SCHEDULE_ON, true);
    // Read data from m_uart_rx_ring_buffer and send to peer via BLE.
    if (transport_flag_cfm(BLE_TX_FLOW_ON))
    {
        items_avail = ring_buffer_items_count_get(&s_uart_rx_ring_buffer);

        if (items_avail > 0)
        {
            read_len = ring_buffer_read(&s_uart_rx_ring_buffer, s_ble_tx_data,
                                        s_mtu_size - 3);
            transport_flag_set(BLE_TX_CPLT, false);
            transport_flag_set(BLE_SCHEDULE_ON, false);
            gus_tx_data_send(0, s_ble_tx_data, read_len);
        }
    }
}
```

5 FAQ

This chapter introduces possible problems, reasons, and solutions during verification and application of the Goodix SPP example.

5.1 Why Is the Data Split into Smaller Packets and Transmitted?

- Description

  When the data input through GRUart is more than 20 bytes, the data is split into smaller packets and transmitted in several times.

- Analysis

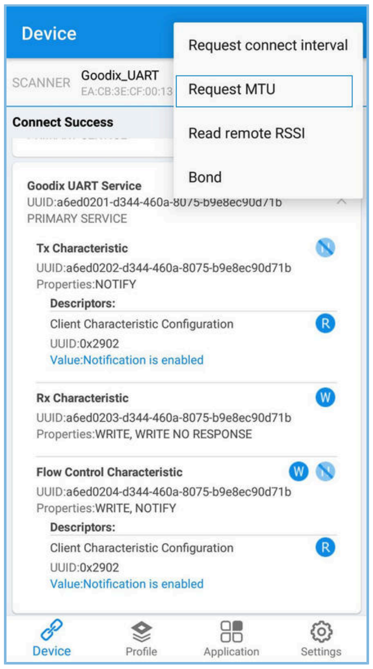
  Before the initiator and the acceptor exchange the maximum transmission unit (MTU), the MTU size is 23 bytes by default, including the 1-byte opcode, and the 2-byte attribute handle. Therefore, the length for one data transmission is limited to 20 bytes.

  When the length of data to be transmitted exceeds 20 bytes, the data is transmitted in sequence and in units of no more than 20 bytes in several times.

  This problem can be solved by modifying the MTU value.

- Solution

  Tap ⋮ > **Request MTU** in the upper-right corner of GRToolbox, as shown in the figure below.



Goodix_UART
EA:CB:3E:CF:00:13
Connect Success

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

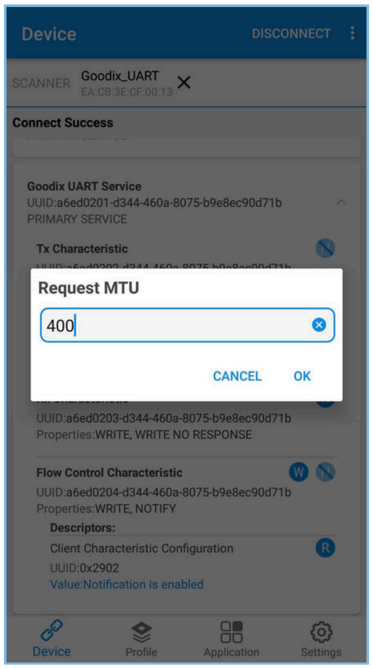
Tx Characteristic
UUID:a6ed0202-d344-460a-8075-b9e8ec90d71b
Properties:NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Rx Characteristic
UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 5-1 Choosing **Request MTU**

Enter a customized MTU value, such as **400** bytes, and tap **OK** to update the value (range of MTU value: 23 bytes to 512 bytes).



Device DISCONNECT

SCANNER Goodix_UART EA:CB:3E:CF:00:13

Connect Success

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

Tx Characteristic

Request MTU

400

CANCEL OK

UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 5-2 Setting the MTU value

5.2 Why Is the Data Sent in String but Received in Hexadecimal?

- Description

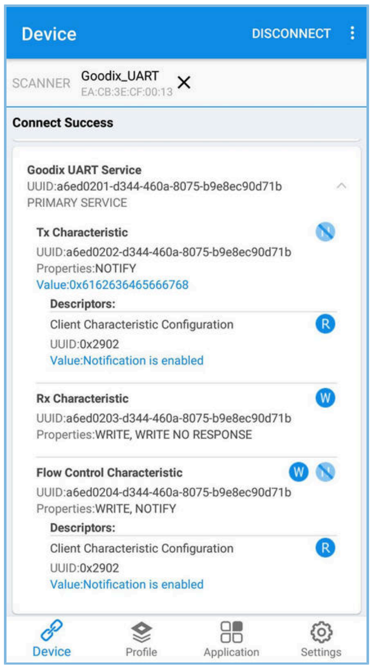
  The data sent through serial ports is in strings (such as “abcdefgh”), but the received data in GRToolbox is in hexadecimal (unit: byte).

- Analysis

  The data format is incorrect in settings.

- Solution

  The data format in GRToolbox (both for received data and transmitted data) can be set in string or in byte. As shown in the figure below, the received data is presented in byte.



Device DISCONNECT

SCANNER Goodix_UART EA:CB:3E:CF:00:13

Connect Success

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

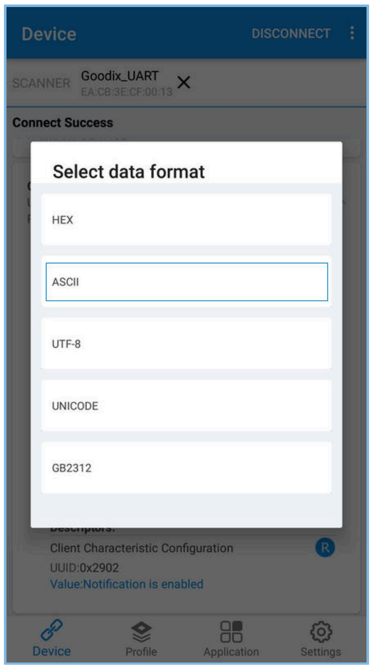
Tx Characteristic
UUID:a6ed0202-d344-460a-8075-b9e8ec90d71b
Properties:NOTIFY
Value:0x6162636465666768
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Rx Characteristic
UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 5-3 Format of received data in GRToolbox (in byte)

Tap **Value** and the data format menu pops up.



Device DISCONNECT

SCANNER Goodix_UART EA:CB:3E:CF:00:13

Connect Success

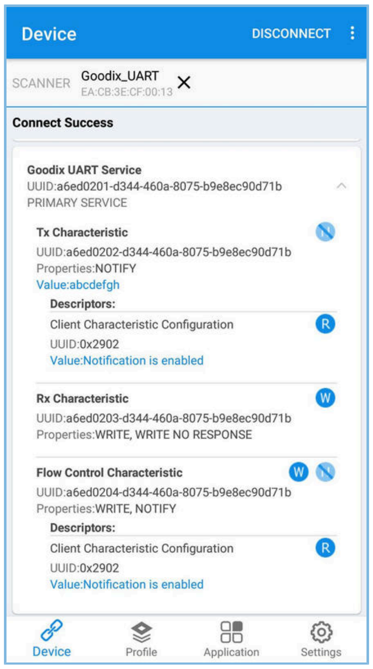
Select data format

HEX
ASCII
UTF-8
UNICODE
GB2312

Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 5-4 Choosing a data format

Choose **ASCII** and tap **Confirm**, and the string “abcdefgh” is presented, as shown in the figure below.


Device DISCONNECT

SCANNER Goodix_UART
EA:CB:3E:CF:00:13

Connect Success

Goodix UART Service
UUID:a6ed0201-d344-460a-8075-b9e8ec90d71b
PRIMARY SERVICE

Tx Characteristic
UUID:a6ed0202-d344-460a-8075-b9e8ec90d71b
Properties:NOTIFY
Value:abcdefgh
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Rx Characteristic
UUID:a6ed0203-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, WRITE NO RESPONSE

Flow Control Characteristic
UUID:a6ed0204-d344-460a-8075-b9e8ec90d71b
Properties:WRITE, NOTIFY
Descriptors:
Client Characteristic Configuration
UUID:0x2902
Value:Notification is enabled

Figure 5-5 Presenting the string “abcdefgh”

6 Appendix: Throughput Test Result

Bluetooth LE throughput tests on Goodix SPP are performed based on an SK Board.

The test results include baud rates for serial ports (115200 bps, 230400 bps, and 460800 bps), and the throughputs in cases of 1 M PHY and 2 M PHY, and in different pass-throughput modes.

Table 6-1 Throughput in different modes

Baud Rate (bps)	Pass-through Mode	1M PHY	2M PHY
115200	accepter → initiator	10.032 KB/s	10.246 KB/s
	accepter ← initiator	10.015 KB/s	10.167 KB/s
	accepter ↔ initiator	19.534 KB/s	19.758 KB/s
230400	accepter → initiator	20.329 KB/s	21.011 KB/s
	accepter ← initiator	20.009 KB/s	19.907 KB/s
	accepter ↔ initiator	40.069 KB/s	41.01 KB/s
460800	accepter → initiator	37.38 KB/s	37.826 KB/s
	accepter ← initiator	37.38 KB/s	37.648 KB/s
	accepter ↔ initiator	70.243 KB/s	71.141 KB/s