

Dialog SDK 5.0.3 培训材料2

自定义协议

2016.2



...personal
...portable
...connected

BLE自定义协议



BLE协议概览

自定义协议源代码分析

显示输出

BLE自定义协议



- **开始前的建议...**
 - 看一下培训教程1关于barebone应用工程的介绍
- **在这个教程里将会学到 ...**
 - 理解通用属性规范（GATT）的基本概念
 - 什么是服务器端和GATT协议下的客户端？
 - 协议，自定义协议，自定义服务和属性定义
 - GATT自定义协议应用消息流程图
 - 关于构建自定义数据库的基本知识
 - 如何在自定义服务数据库里创建一个属性
- **接下来...**
 - 深入学习培训教程的参考文档部分



BLE 自定义协议



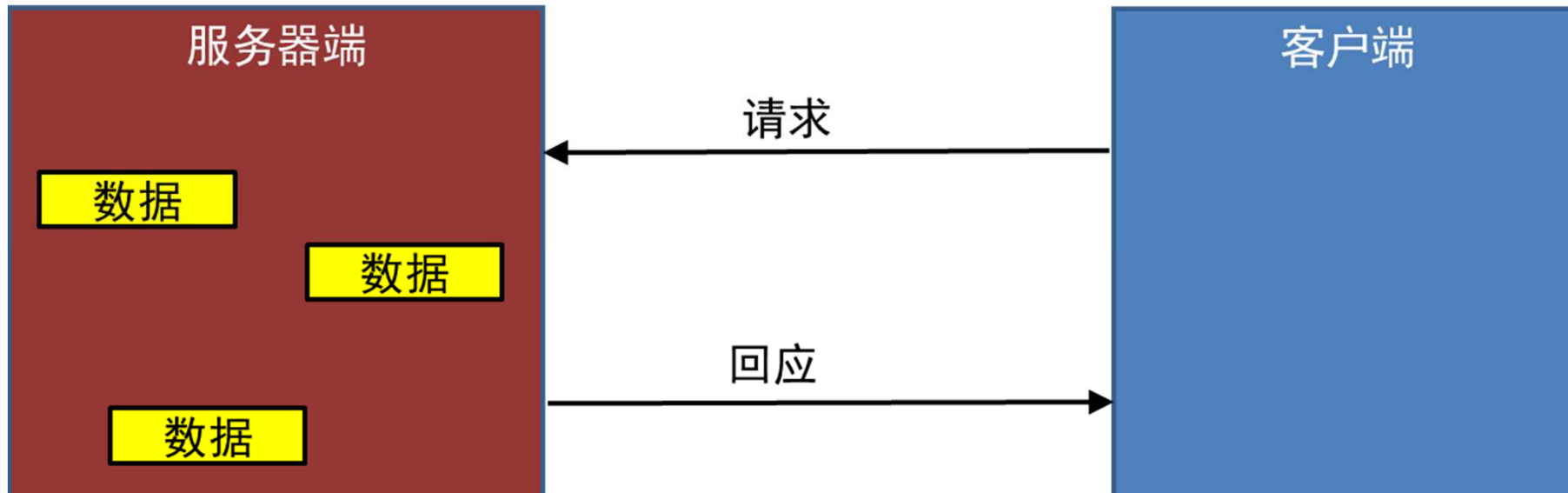
BLE 协议概览

- 低功耗蓝牙(BLE)协议是一组规范关于蓝牙应用行为的标准定义，它是构建在通用属性协议(GATT)上的。
- BLE profile 遵循特定的结构，使得(服务器/外围设备)端能够给(客户端/中央设备)端提供信息接口，用来描述本身的性能和如何获取这些信息的途径。
- 服务器端是数据的拥有者，大多数情况下作为外围设备端。
- 客户端是数据的消费者，大多数情况下作为中央设备端 (智能手机和平板)。
- <https://developer.bluetooth.org/gatt/services/Pages/ServicesHome.aspx>

自定义服务内容

通用属性协议（GATT）

- 客户端/服务器 架构
 - 服务器端存储数据，通常在GAP协议里作为外部设备端
 - 客户端从服务器端申请数据，在GAP协议里作为中央控制端
- 服务器端采用属性的形态开放数据访问接口



BLE 自定义协议

BLE 协议概览

- 一个BLE 协议可以包含一个或多个服务.
- 服务通常会把数据分包成逻辑实体，并且包含特定的字段，这些字段被称为属性.
- 一个服务可以有一个或多个属性。服务之间通过UUID来进行区分，UUID可以有16-bit（BLE官方服务采用）或者128-bit(自定义服务)两种形式
- 属性是在GATT交互数据里最底层的概念，只有一个数据点
- 属性之间也通过UUID（16bit/128bit）来区分，应用场景类似服务。你可以随意使用SIG官方的标准属性（这可以在各种BLE设备里做到通用），或者定义你自己设定的属性（不具有通用性，只能你自己的外设和软件能够解析）



BLE 自定义协议



自定义协议服务和源码讨论

显示输出

自定义服务内容

自定义服务涉及的协议实例

- 这个实例会展示
 - Barebone应用工程
 - 128 bit UUID的自定义服务移植
 - 如何访问自定义的服务数据库
 - 这份教程描述了如何逐步建立和广播新的属性特性
- IDE 环境，使用 KEIL 5
- Dialog semiconductor SDK 版本 5.0.3
- 工程位置: 5.0.3\projects\target_apps\ble_examples\ble_app_profile



自定义服务内容

target_apps\ble_examples\ble_app_profile 工程描述了

- 检查custom profile database的访问权限.
- 检查设备的广播包名字.
- 采用DISS服务.
- 检查自定义服务下的属性设定.

自定义服务内容

自定义服务协议下的基本消息交互流程

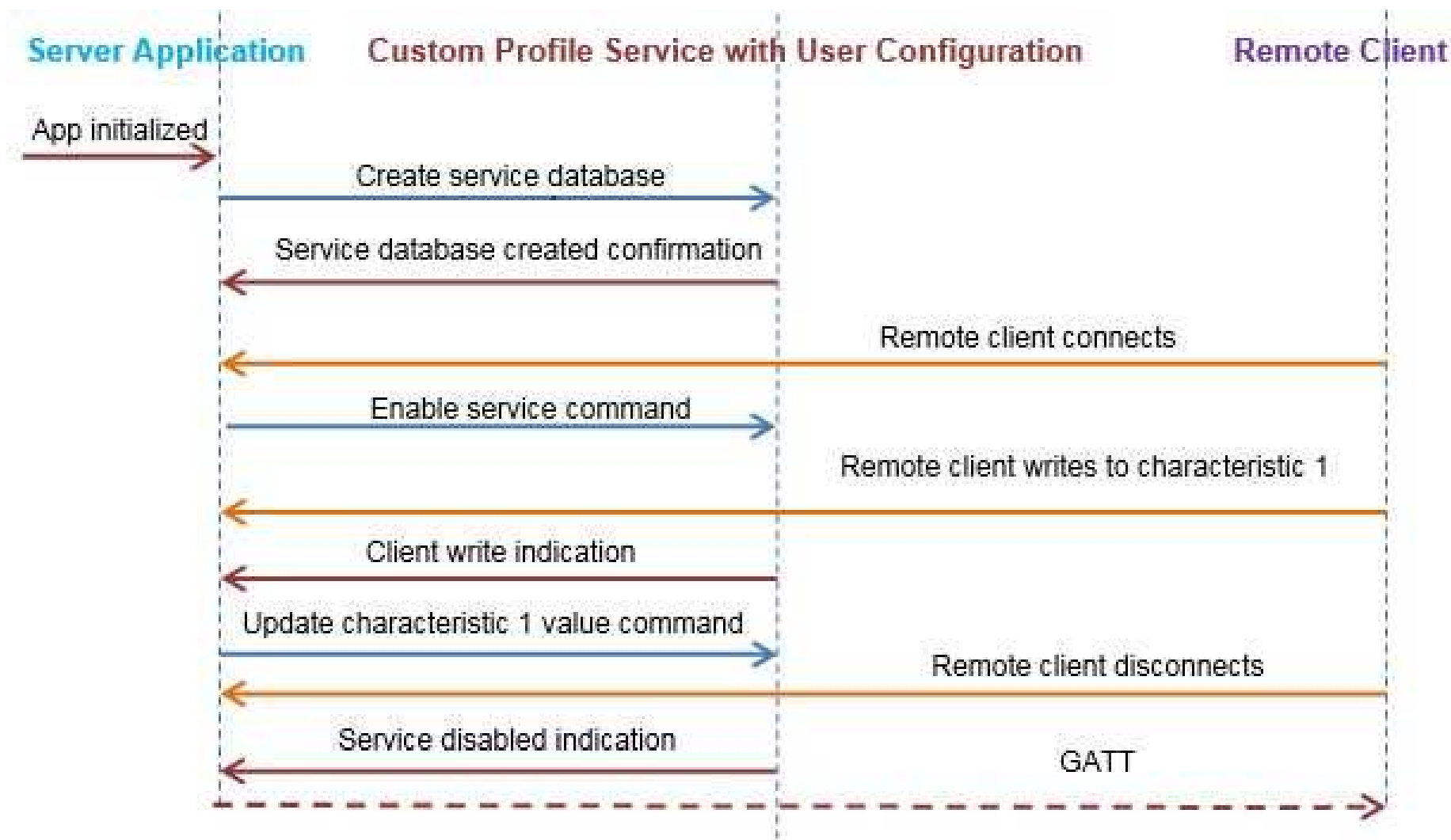
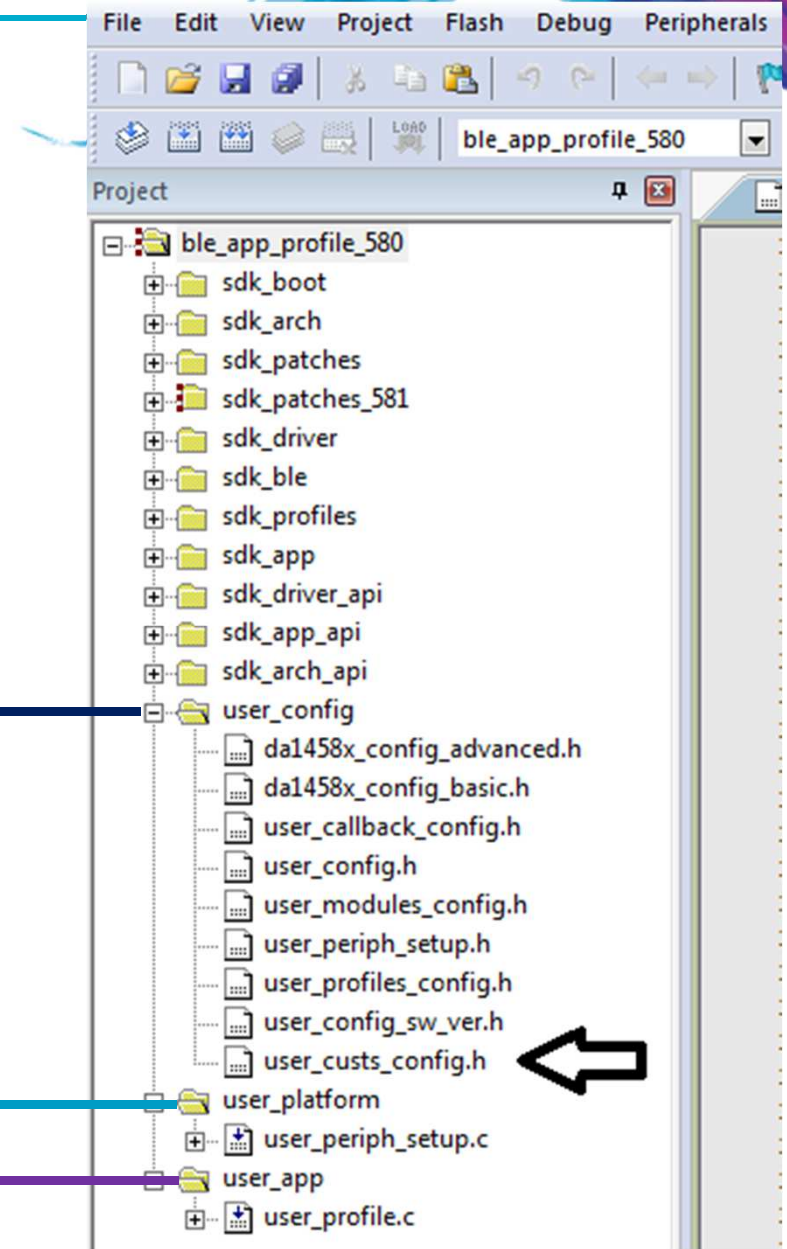


Figure: Message flow diagram

自定义服务内容

Keil 5 IDE ble_app_profile.uvprojx 工程布局

- 组 ***user_config***, ***user_platform*** and ***user_app***.
- 这些组里包含有配置信息



自定义服务内容

一些重要文件的描述

```
/* Holds DA14580/581/583 basic configuration settings. */
da1458x_config_basic.h

/* Holds DA14580/581/583 advanced configuration settings. */
da1458x_config_advanced.h

/* Holds user specific information about software version. */
user_config_sw_ver.h

/* Defines which application modules are included or excluded from the user's application. */
user_modules_config.h

    /* The Device information application profile is excluded. */
    #define EXCLUDE_DLG_PROXR          (1)
    /* The Device information application profile is included. */
    #define EXCLUDE_DLG_CUSTS1       (0)

    /* Note: */
    /* This setting has no effect if the respective module is a BLE Profile */
    /* that is not used in the user's application. */

/* Callback functions that handle various events or operations. */
user_callback_config.h

/* Holds advertising parameters, connection parameters, etc. */
user_config.h
```



自定义服务内容

一些重要文件的描述

```
/* Defines which BLE profiles (Bluetooth SIG adopted or custom ones) will be included in user's application.
   each header file denotes the respective BLE profile*/
```

user_profiles_config.h

```
    #includce "diss.h"           // Includes Device Information Service.
    #include "custs1.h"         // Includes Custom service.
```

```
/* Defines the structure of the Custom profile database structure and
   cust_prf_funcs[] array, which contains the Custom profile API functions calls.*/
```

user_custs_config.h

```
/* Holds hardware related settings relative to the used Development Kit. */
```

user_periph_setup.h

```
/* Source code file that handles peripheral (GPIO, UART, SPI, etc.)
   configuration and initialization relative to the Development Kit.*/
```

user_periph_setup.c

自定义服务内容

按步骤添加属性

TODO 1 - 修改默认蓝牙地址 BD_ADDRESS, 地址在BLE网络上需要做到唯一。

```
/* @file da1458x_config_advanced.h */
```

```
/* copy and paste in code step 1 change the BLE device address */  
#define CFG_NVDS_TAG_BD_ADDRESS          {0x19, 0x00, 0x00, 0x00, 0x00, 0x19}
```

TODO 2 - 在应用代码里检查和定义DLG_CUST1模块信息

```
/* @file user_modules_config.h */
```

```
#define EXCLUDE_DLG_SPOTAR              (1)          /* excluded */  
/* copy and paste in code step 2 define DLG_CUST1 module in your application code */  
#define EXCLUDE_DLG_CUSTS1             (0)          /* included */
```

TODO 3 - 检查和添加头文件cust1.h到应用代码里用于激活自定义profile

```
/* @file user_profiles_config.h */
```

```
#include "diss.h"  
/* copy and paste in code step 3 add custs1.h */  
#include "custs1.h"
```



自定义服务内容

按步骤添加属性

TODO 4 - 添加广播内容和修改广播设备名字

```
/* @file user_config.h */

/* default sleep mode. Possible values ARCH_SLEEP_OFF, ARCH_EXT_SLEEP_ON, ARCH_DEEP_SLEEP_ON
   ARCH_EXT_SLEEP_ON, ARCH_DEEP_SLEEP_ON - You cannot debug in these modes
*/
const static sleep_state_t app_default_sleep_mode = ARCH_SLEEP_OFF;
//-----NON-CONNECTABLE & UNDIRECTED ADVERTISE RELATED COMMON -- //
/// Advertising service data
/// dev step 5 explanation of the following 3 items

#define USER_ADVERTISE_DATA ("\x03"\
    ADV_TYPE_COMPLETE_LIST_16BIT_SERVICE_IDS\
    ADV_UUID_DEVICE_INFORMATION_SERVICE\
    "\x11" // The next section takes hex x11 = decimal 17 bytes
    ADV_TYPE_COMPLETE_LIST_128BIT_SERVICE_IDS // Shows complete list of 128 bit Service IDs
    "\x2F\x2A\x93\xA6\xBD\xD8\x41\x52\xAC\x0B\x10\x99\x2E\xC6\xFE\xED") // Your Custom Service UUID
/// Note- Custom service UUID is shown from right to left <-- EDFEC6...2F in the client LightBlue iOS app GUI
/* copy and paste in code step 4 change your advertising device name */
#define USER_DEVICE_NAME ("A-CUST1")
```



自定义服务内容

按步骤添加属性

TODO 5 - 概览现有的BLE协议对应的自定义服务属性值和特性

NAME	PROPERTIES	LENGTH	DESCRIPTION
Control Point	WRITE	1	Accept commands from peer
LED State	WRITE NO RESPONSE	1	Toggles a LED connected to a GPIO
ADC Value 1	READ, NOTIFY	2	Reads sample from an ADC channel
ADC Value 2	READ	2	Reads sample from an ADC channel
Button State	READ, NOTIFY	1	Reads the current state of a push button connected a GPIO
Indicate able	READ, INDICATE	20	Demonstrate indications
Long Value	READ, WRITE, NOTIFY	50	Demonstrate writes to long characteristic value

BLE 自定义 profile



按步骤添加属性

- 属性带有名字
 - 在客户端的扫描应用界面上会显示名字.
- 属性含有值
 - 最多512字节, 固定或可变长度的数组.
- 属性带有句柄
 - 用于client端访问特定属性的接口.
- 属性带有描述
 - <<UUID>>, 描述具体数值的意义
 - 由 GAP, GATT, 或者用户自定义属性标准来决定
 - 举例来说, “Accept commands from peer” 是关于控制点属性的描述
- 属性带有访问权限
 - 读, 写, 通知等.

自定义服务内容

按步骤添加属性

TODO 6 - UUID信息

```
/* @file user_custs_config.h */
```

```
/* step 5 and step 6 info:: 128 bit Service UUID this is displayed from Right to Left in the client scanner device */  
#define DEF_CUST1_SVC_UUID_128 {0x2F, 0x2A, 0x93, 0xA6, 0xBD, 0xD8, 0x41, 0x52, 0xAC, 0x0B, 0x10, 0x99, 0x2E, 0xC6,  
0xFE, 0xED} /* Displayed as EDFEC62E99100BAC5241D8BDA6932A2F */
```

TODO 7 - 添加控制点属性的UUID

```
/* @file user_custs_config.h */
```

```
#define DEF_CUST1_LONG_VALUE_UUID_128 {0x8C, 0x09, 0xE0, 0xD1, 0x81, 0x54, 0x42, 0x40, 0x8E, 0x4F, 0xD2, 0xB3,  
0x77, 0xE3, 0x2A, 0x77}  
/* copy and paste in code step 7 define your control point */  
#define DEF_CUST1_YOUR_CTRL_POINT_UUID_128 {0x34, 0x33, 0x32, 0x31, 0x30, 0x29, 0x28, 0x27, 0x26, 0x25, 0x24, 0x23,  
0x22, 0x21, 0x20, 0x19}
```

自定义服务内容

按步骤添加属性

TODO 8 - 添加自定义控制点数据的长度

```
/* @file user_custs_config.h */
```

```
#define DEF_CUST1_LONG_VALUE_CHAR_LEN      50
/* copy and paste in code step 8 define your control point data length */
#define DEF_CUST1_YOUR_CTRL_POINT_CHAR_LEN  1
```

TODO 9 - 添加自定义属性的注释字符串

```
/* @file user_custs_config.h */
```

```
#define CUST1_LONG_VALUE_CHAR_USER_DESC    "Long Value"
/* copy and paste in code step 9 define your characteristic description name */
#define CUST1_YOUR_CONTROL_POINT_USER_DESC "Your Ctrl Point"
```

自定义服务内容

按步骤添加属性

TODO 10 - 添加自定义服务数据库里属性的枚举列表值

```
/* @file user_custs_config.h */
```

```
enum
{
    ...
    CUST1_IDX_LONG_VALUE_CHAR,
    CUST1_IDX_LONG_VALUE_VAL,
    CUST1_IDX_LONG_VALUE_NTF_CFG,
    CUST1_IDX_LONG_VALUE_USER_DESC,

    /* copy and paste in code step 10 add your characteristic */
    CUST1_IDX_YOUR_CONTROL_POINT_CHAR,
    CUST1_IDX_YOUR_CONTROL_POINT_VAL,
    CUST1_IDX_YOUR_CONTROL_POINT_USER_DESC,
    CUST1_IDX_NB
};
```

自定义服务内容

按步骤添加属性

TODO 11 - 申明和添加自定义服务属性的值

```
/* @file user_custs_config.h */  
  
static uint8_t CUST1_LONG_VALUE_UUID_128[ATT_UUID_128_LEN] = DEF_CUST1_LONG_VALUE_UUID_128;  
  
/* copy and paste in code step 11 declare and assign custom server attribute value */  
static uint8_t CUST1_YOUR_CTRL_POINT_UUID_128[ATT_UUID_128_LEN] = DEF_CUST1_YOUR_CTRL_POINT_UUID_128;
```

TODO 12 - 添加包含访问权限，句柄和UUID的属性说明

```
/* @file user_custs_config.h */  
  
static const struct att_char128_desc custs1_long_value_char = {ATT_CHAR_PROP_RD | ATT_CHAR_PROP_WR |  
ATT_CHAR_PROP_NTF,  
{0, 0},  
DEF_CUST1_LONG_VALUE_UUID_128};  
  
/* copy and paste in code step 12 */  
/* Add your characteristic description with permission properties, handler and UUID */  
  
static const struct att_char128_desc custs1_your_ctrl_point_char = {ATT_CHAR_PROP_WR,  
{0, 0},  
DEF_CUST1_YOUR_CTRL_POINT_UUID_128};
```

BLE自定义协议

自定义服务内容

Profile

源码可以在文件user_custs_config.h找到

Service UUID

Characteristic

Properties

Handler

UUID

```
static const struct att_char128_desc custs1_ctrl_point_char = {  
  
    ATT_CHAR_PROP_WR,  
    {0, 0},  
    DEF_CUST1_CTRL_POINT_UUID_128  
  
};
```

自定义服务内容

按步骤添加属性

TODO 13 -在用户自定义服务数据库里，添加自定义属性申明，值和注释说明

```
/* @file user_custs_config.h */
```

```
/// Full CUSTOM1 Database Description - Used to add attributes into the database
static const struct attm_desc_128 custs1_att_db[CUST1_IDX_NB] =
{
    ...
    // Long Value Characteristic Declaration
    [CUST1_IDX_LONG_VALUE_CHAR]      = {(uint8_t*)&att_decl_char, ATT_UUID_16_LEN, PERM(RD, ENABLE),
                                         sizeof(custs1_long_value_char), sizeof(custs1_long_value_char),
                                         (uint8_t*)&custs1_long_value_char},

    // Long Value Characteristic Value
    [CUST1_IDX_LONG_VALUE_VAL]      = {CUST1_LONG_VALUE_UUID_128, ATT_UUID_128_LEN, PERM(RD, ENABLE) | PERM(WR,
ENABLE) | PERM(NTF, ENABLE),
                                         DEF_CUST1_LONG_VALUE_CHAR_LEN, 0, NULL},

    // Long Value Client Characteristic Configuration Descriptor
    [CUST1_IDX_LONG_VALUE_NTF_CFG]  = {(uint8_t*)&att_decl_cfg, ATT_UUID_16_LEN, PERM(RD, ENABLE) | PERM(WR,
ENABLE),
                                         sizeof(uint16_t), 0, NULL},

    // Long Value Characteristic User Description
    [CUST1_IDX_LONG_VALUE_USER_DESC] = {(uint8_t*)&att_decl_user_desc, ATT_UUID_16_LEN, PERM(RD, ENABLE),
                                         sizeof(CUST1_LONG_VALUE_CHAR_USER_DESC) - 1,
sizeof(CUST1_LONG_VALUE_CHAR_USER_DESC) - 1, CUST1_LONG_VALUE_CHAR_USER_DESC},
}
```

自定义服务内容

按步骤添加属性

TODO 13 - 在用户自定义服务数据库里，添加自定义属性申明，值和注释说明

```
/* @file user_custs_config.h */
```

```
/* copy and paste in code step 13 add your characteristic declaration, value and description in database attributes
*/

// Your Control Point Characteristic Declaration
[CUST1_IDX_YOUR_CONTROL_POINT_CHAR] = {(uint8_t*)&att_decl_char, ATT_UUID_16_LEN, PERM(RD, ENABLE),
sizeof(custs1_your_ctrl_point_char),
sizeof(custs1_your_ctrl_point_char), (uint8_t*)&custs1_your_ctrl_point_char},
// Your Control Point Characteristic Value
[CUST1_IDX_YOUR_CONTROL_POINT_VAL] = {CUST1_YOUR_CTRL_POINT_UUID_128, ATT_UUID_128_LEN, PERM(WR, ENABLE),
DEF_CUST1_YOUR_CTRL_POINT_CHAR_LEN, 0, NULL},
// Your Control Point Characteristic User Description
[CUST1_IDX_YOUR_CONTROL_POINT_USER_DESC] = {(uint8_t*)&att_decl_user_desc, ATT_UUID_16_LEN, PERM(RD, ENABLE),
sizeof(CUST1_YOUR_CONTROL_POINT_USER_DESC) - 1,
sizeof(CUST1_YOUR_CONTROL_POINT_USER_DESC) - 1, CUST1_YOUR_CONTROL_POINT_USER_DESC},
};
```

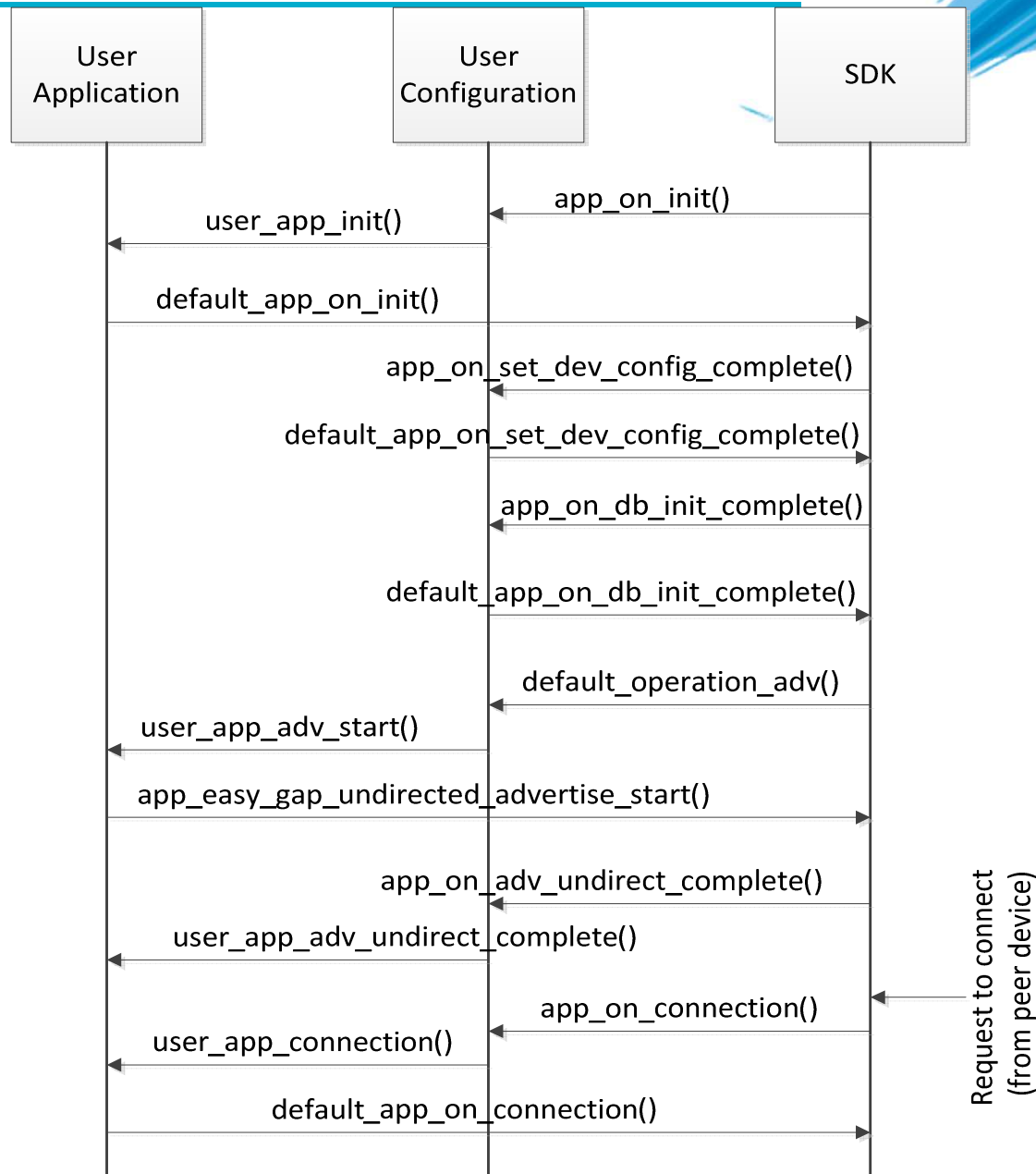

自定义服务内容

工作机理？

- 在整个BLE应用交互周期内，会有一些事件，需要用特定的方式来处理
- 在处理特定事件时，SDK可以很灵活的调用默认的或者用户自定义的接口来处理特定事件（`user_catch_rest_hndl`）
- 在处理机制上，SDK提供注册callback函数的接口，来处理每个消息或操作
- 在用户空间的的头文件，“`user_callback_config.h`”，记录callback函数的注册接口。

自定义服务内容

抽象代码流程图



自定义服务内容

`user_callback_config.h` 重要函数讨论

```
static const struct arch_main_loop_callbacks user_app_main_loop_callbacks = {  
    .app_on_init                = user_app_init,   
    .app_on_ble_powered        = NULL,   
    .app_on_sytem_powered      = NULL,   
    .app_before_sleep          = NULL,   
    .app_validate_sleep        = NULL,   
    .app_going_to_sleep        = NULL,   
    .app_resume_from_sleep     = NULL,   
};  
  
void user_app_init(void)  
{  
    // Initialize Manufacturer Specific Data  
    mnf_data_init();  
    // Initialize default services and set sleep mode  
    default_app_on_init();  
}
```

自定义服务内容

概览 `user_callback_config.h`

```
static const struct app_callbacks user_app_callbacks = {  
    // Handle connection request indication, if no connection has been established restart advertising  
    .app_on_connection          = user_app_connection,  
    .app_on_disconnect         = user_app_disconnect, // Restart Advertising  
    /* Add the first required service in the database  
       if database initialized then  
       No service to add in the DB -> Start Advertising */  
    .app_on_set_dev_config_complete = default_app_on_set_dev_config_complete,  
    /* If advertising was canceled for any reason other than connection establishment  
       then update advertising data and start advertising again */  
    .app_on_adv_undirect_complete  = user_app_adv_undirect_complete,  
    // database initialization is completed, then set the initial values of service characteristics programmatically  
    .app_on_db_init_complete       = default_app_on_db_init_complete,  
    .app_on_scanning_completed     = NULL, // NULL indicated this indication will not be handled by Dialog SDK;  
    .app_on_adv_report_ind         = NULL, // either implement it or use the existing code based on your requirement  
};  
  
// Handles the messages that are not handled by the SDK internal mechanisms.  
static const catch_rest_event_func_t app_process_catch_rest_cb = (catch_rest_event_func_t)user_catch_rest_hdl;
```

自定义服务内容

user_custs_config.h

添加custom1 server函数的callback列表.

```
/// Custom1/2 server function callback table this is linking point of your database and DA1458x SDK5.0.3
static const struct cust_prf_func_callbacks cust_prf_funcs[] =
{
#if (BLE_CUSTOM1_SERVER)
  { TASK_CUSTS1,
    custs1_att_db,
    CUST1_IDX_NB,
    #if (BLE_APP_PRESENT)
      app_custs1_create_db, app_custs1_enable,
    #else
      NULL, NULL,
    #endif
    custs1_init, NULL
  },
#endif
#if (BLE_CUSTOM2_SERVER)
  { TASK_CUSTS2,
    NULL,
    0,
    #if (BLE_APP_PRESENT)
      app_custs2_create_db, app_custs2_enable,
    #else
      NULL, NULL,
    #endif
    custs2_init, NULL
  },
#endif
  {TASK_NONE, NULL, 0, NULL, NULL, NULL, NULL}, // DO NOT MOVE. Must always be last
};

/// Structure of custom profile call back function table.
struct cust_prf_func_callbacks
{
  /// Profile Task ID.
  enum KE_TASK_TYPE      task_id;
  /// pointer to the custom database table defined by user
  const struct attm_desc_128 *att_db;
  /// max number of attributes in custom database
  const uint8_t max_nb_att;
  /// Pointer to the custom database create function defined by
  user
  prf_func_void_t      db_create_func;
  /// Pointer to the custom profile enable function defined by user
  prf_func_uint16_t    enable_func;
  /// Pointer to the custom profile initialization function
  prf_func_void_t      init_func;
  /// Pointer to the validation function defined by user
  prf_func_validate_t  value_wr_validation_func;
};
```



BLE 内容

你会看到输出内容

- The LightBlue iOS 应用可以用来连接 iPad/iPod/iPhone 设备，其中 iPad/iPod/iPhone 作为 BLE 主控，而应用设备则作为 BLE 外设，名字内容由 “USER_DEVICE_NAME” 字段定义。
- 设备信息服务（DISS）默认需要被添加。在一些扫描设备里，这个服务会被作为名字服务，有特定的 UUID 字段（0A 18）。
- 连接建上之后，设备的服务属性可以被手机访问提取。



BLE 内容

你会看到的输出结果

iPad 5:57 p.m. 86%
LightBlue Peripheral Clone

DIALOG-PRFL
UUID: AF4CFEBA-7473-2DC2-5C63-1468E64873E6

Connected

ADVERTISEMENT DATA Show

Device Information

- Manufacturer Name String
Dialog Semi >
- Model Number String
DA1458x >
- Firmware Revision String
v_5.0.1.141 >
- Software Revision String
x.y.z >
- System ID
<123456ff fe9abcde> >
- PnP ID
<01d20080 050001> >

UUID: EDFEC62E-9910-0BAC-5241-D8BDA6932A2F → DEF_CUST1_SVC_UUID_128

Control Point
Properties: Write
UUID: 2D86686A-53DC-25B3-0C4A-F0E10C8DEE20 → ATT_CHAR_PROP_WR → DEF_CUST1_CTRL_POINT_UUID_128

LED State
Properties: Write Without Response
UUID: 5A87B4EF-3BFA-76A8-E642-92933C31434F >

ADC Value 1
Properties: Read Notify
UUID: 15005991-B131-3396-014C-664C9867B917 >

ADC Value 2
Properties: Read
UUID: 6EB675AB-8BD1-1B9A-7444-621E52EC6823 >

Button State

Log

Find out yourself – Your Ctrl Point GOOD LUCK \(\^_\^)/



BLE 内容

输出内容

- **注意:** 在当前或者之后的实例里，设备可以被连接。设备被连上之后意味着别的扫描设备将无法定位当前设备—建议你只连接自己的设备。

- **注意:** 一些扫描设备（特别是Apple设备）也许不会在显示端更新获得的名字-为了修正这一点，有必要重启蓝牙功能。

BLE 内容

参考文档

- <https://developer.bluetooth.org/gatt/Pages/default.aspx>
- <https://www.bluetooth.com/specifications/adopted-specifications>
- <http://support.dialog-semiconductor.com/connectivity>
- https://www.wikiwand.com/en/Universally_unique_identifier
- **Register with Dialog semiconductor to get enormous development support**
 - <http://support.dialog-semiconductor.com/user/register>

The Power To Be...

??????



... personal
... portable
... connected