Developing an application communicating with BLE devices on Dusun's gateways

Bluetooth Low Energy (BLE) is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range with Bluetooth. BLE is suitable for IoT applications. Many operating systems support BLE and thus BLE is very popular. The Dusun IoT gateways support most connectivity protocols including BLE (4.x/5.0/Mesh), ZigBee 1.2/3.0, Z-Wave, TCP/UDP, etc. Users can connect the gateway with various BLE devices. As the Dusun gateway is running based on the Linux system, how to implement an application over Bluez stack to 'talk' with BLE devices on Dusun gateways will be presented here.

1. Product Feature Summary

- **System :**
- OS: Linux@ OpenWrt
- Processor: MTK7620A (MIPS24KEc(580MHZ))
- RAM: 128MB
- Flash: 64MB
- **Wireless protocol :**
- LTE-M1
- Bluetooth Low Energy
- Wi-Fi

- Zigbee3.0
- Z-Wave
- **Ethernet**
- WLAN
- LAN

2. System block diagram

Dusun's gateways run Linux OpenWrt system. As depicted in figure 1, Linux support BLE protocol through running the Bluez stack. BlueZ provides support for the core Bluetooth layers and protocols. It is flexible, efficient and uses a modular implementation. The BlueZ stack supports all core Bluetooth protocols and layers now. Users can write BLE applications using Bluez APIs to manipulate BLE devices.

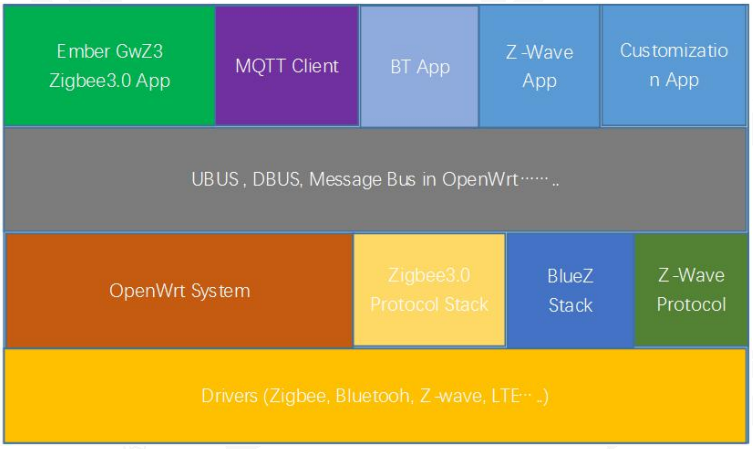


Figure 1 Dusun Gateway system architecture

3. System configuration

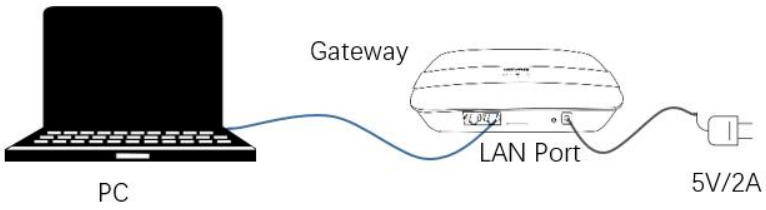
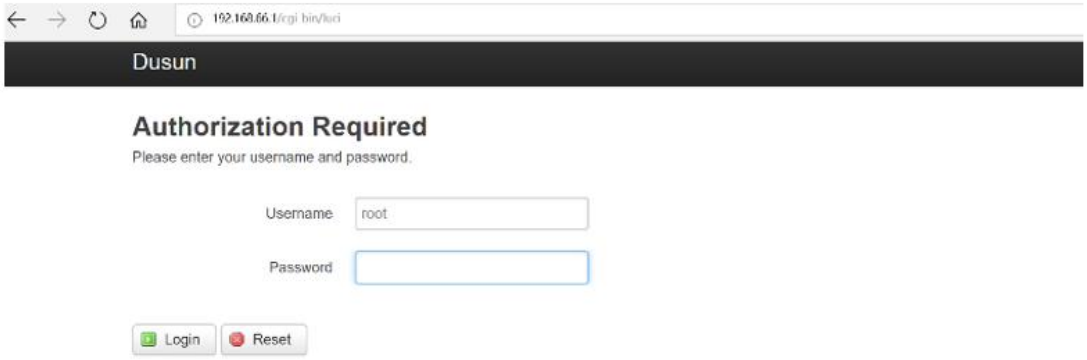


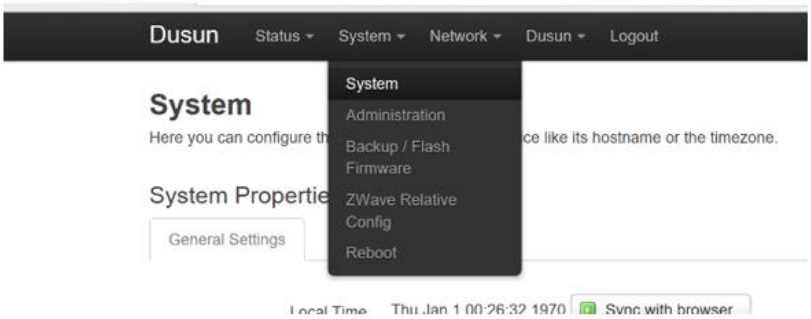
Figure 2 gateway->PC connection diagram

The gateway can be configured following these steps:

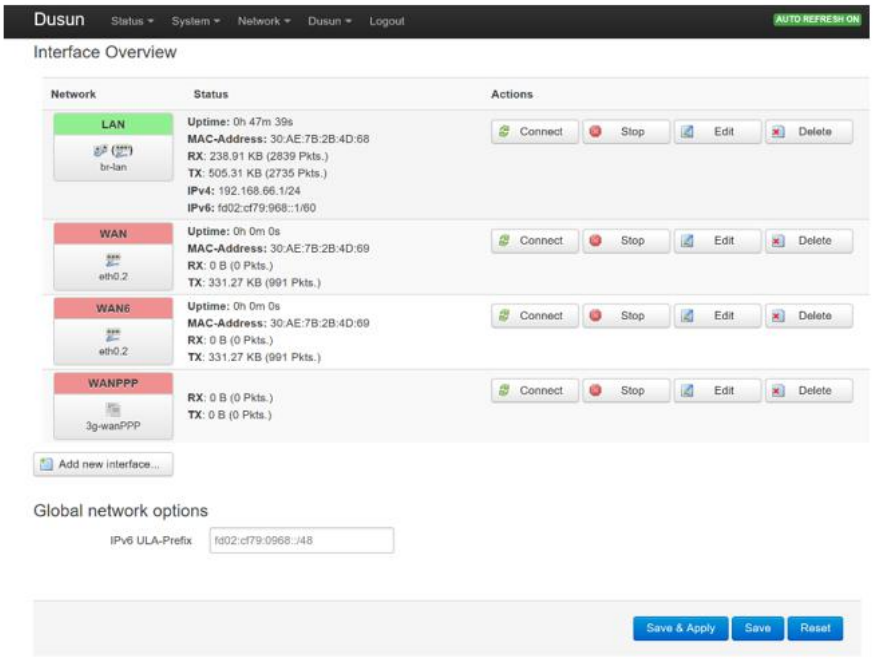
1. Connect the gateway to the PC and power up, according to figure 2;
2. Open a web browser on PC, Input Gateway IP Address: 192.168.66.1 ; Enter the username and Password （Username: root Password: root）, login to the gateway;

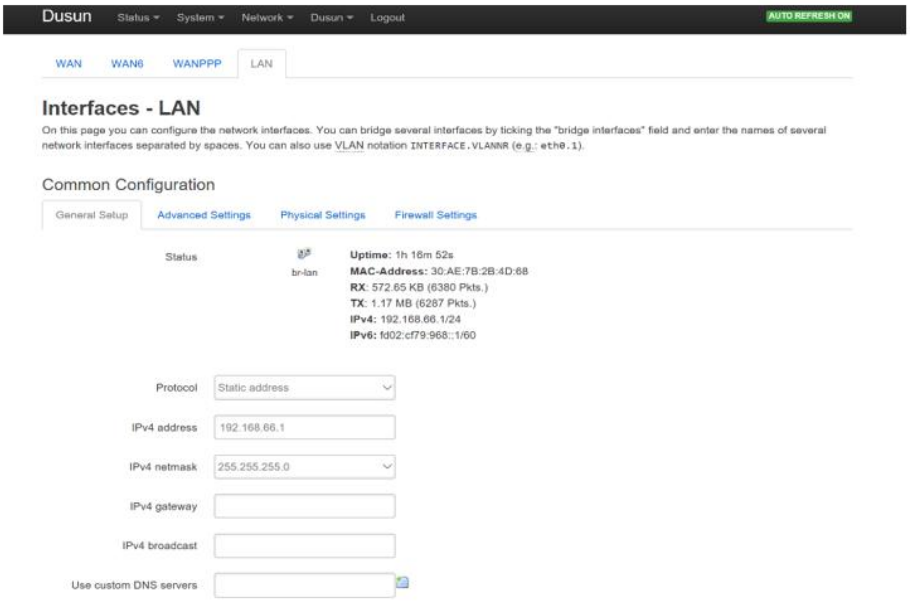


3. Make system configuration at the system menu, the timezone, password and others can be revised here.



4. Configure network at the network sub-memu.





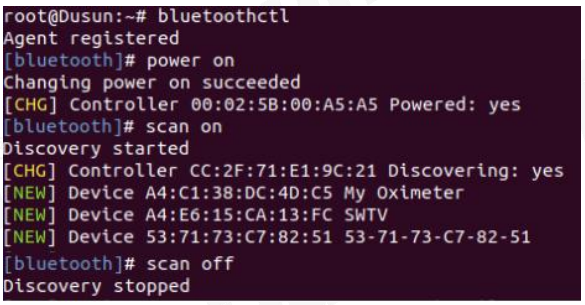
When the configuration is completed please reboot the gateway. Then users can log in the gateway by inputting the following commands in a terminal, and then input your password. IP_addr is the IP addr which user configured above. The default IP is 192.168.66.1. The below figure shows the login scene.

```
ssh root@IP_addr
```

4. Connecting a BLE sensor with Bluetoothctl

The Dusun gateway is installed Bluez version v5.50. Bluez has provided many command utilities for controlling BLE devices. Bluetoothctl is the main command for configuring Bluetooth devices on Linux. Users can use this utility to know more about their BLE devices and are familiar with the connecting steps. An oximeter BLE sensor is used for living example. The steps for connecting and managing the oximeter BLE sensor is shown below:

1. Open Bluetoothctl and scan Bluetooth devices to find the oximeter sensor(whose name is my oximeter).

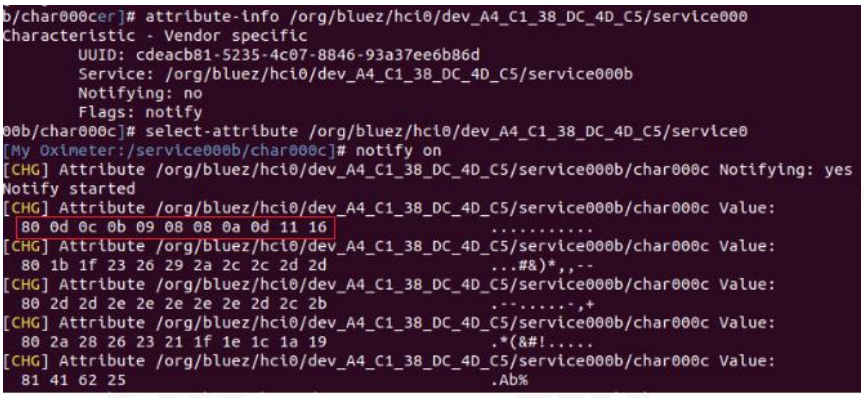


2. Pair the sensor and connect it.

```
[bluetooth]# pair A4:C1:38:DC:4D:C5
Attempting to pair with A4:C1:38:DC:4D:C5
[CHG] Device A4:C1:38:DC:4D:C5 Connected: yes
Failed to pair: org.bluez.Error.AuthenticationFailed
[CHG] Device A4:C1:38:DC:4D:C5 Connected: no
[bluetooth]# connect  A4:C1:38:DC:4D:C5
Attempting to connect to A4:C1:38:DC:4D:C5
[CHG] Device A4:C1:38:DC:4D:C5 Connected: yes
Connection successful
[NEW] Primary Service
        /org/bluez/hci0/dev_A4_C1_38_DC_4D_C5/service0008
        0000180a-0000-1000-8000-00805f9b34fb
        Device Information
[NEW] Characteristic
        /org/bluez/hci0/dev_A4_C1_38_DC_4D_C5/service0008/char0009
        00002a50-0000-1000-8000-00805f9b34fb
        PnP ID
[NEW] Primary Service
        /org/bluez/hci0/dev_A4_C1_38_DC_4D_C5/service000b
        cdeacb80-5235-4c07-8846-93a37ee6b86d
        Vendor specific
[NEW] Characteristic
        /org/bluez/hci0/dev_A4_C1_38_DC_4D_C5/service000b/char000c
        cdeacb81-5235-4c07-8846-93a37ee6b86d
        Vendor specific
[NEW] Characteristic
        /org/bluez/hci0/dev_A4_C1_38_DC_4D_C5/service000b/char0010
        cdeacb82-5235-4c07-8846-93a37ee6b86d
        Vendor specific
```

3. List attributes and select the characteristic for getting data. Use select-attribute and then notify on, the data will be pushed to the command line as the below figure shows.

```
[My Oximeter]# menu gatt
Menu gatt:
Available commands:
-------------------
list-attributes [dev]                                 List attributes
select-attribute <attribute/UUID>                     Select attribute
attribute-info [attribute/UUID]                       Select attribute
read                                                  Read attribute value
write <data=xx xx ...>                                Write attribute value
acquire-write                                         Acquire Write file descriptor
release-write                                         Release Write file descriptor
acquire-notify                                        Acquire Notify file descriptor
release-notify                                        Release Notify file descriptor
notify <on/off>                                       Notify attribute value
register-application [UUID ...]                       Register profile to connect
unregister-application                                Unregister profile
register-service <UUID>                               Register application service.
unregister-service <UUID/object>                      Unregister application service
register-characteristic <UUID> <Flags=read,write,notify...> Register application characteristic
unregister-characteristic <UUID/object>               Unregister application characteristic
register-descriptor <UUID> <Flags=read,write...>      Register application descriptor
unregister-descriptor <UUID/object>                   Unregister application descriptor
back                                                  Return to main menu
version                                               Display version
quit                                                  Quit program
exit                                                  Quit program
help                                                  Display help about this program
[My Oximeter]# list-attributes
Primary Service
        /org/bluez/hci0/dev_A4_C1_38_DC_4D_C5/service0008
        0000180a-0000-1000-8000-00805f9b34fb
        Device Information
```



After these steps, user can know something about the sensor and its BLE profiles which can also be seen from the sensor user manual. Then we will show how to program by using Bluez Dbus APIs to get the sensor data.

5. A sample: communicate with an oximeter BLE sensor using Bluez

We have provided a sample application to get the BLE oximeter sensor data. They include the Bluez Dbus library, and several c program files. The oximeter sensor operating functions is contained in the Oximeter.c. The main function in the main.c is shown as below.

```
int main(int argc, char *argv[])
{
    GError *error = NULL;
    GDBusClient *client;
```

```
    INIT_LOG("HL");
    /*init global data for bluez operation*/
    init_global_data();
    init_curl();
    /*register the drivers you have written*/
    load_healt_drivers();
  /*create a main loop object*/
    main_loop = g_main_loop_new(NULL, FALSE);
    /*set up the dbus connection*/
    dbus_conn = g_dbus_setup_bus(DBUS_BUS_SYSTEM, NULL, NULL);

    /*create a bluez client for dbus connection object*/
    client = g_dbus_client_new(dbus_conn, "org.bluez", "/org/bluez");
  /* set connect/disconnect/signal handler function*/
    g_dbus_client_set_connect_watch(client, connect_handler, NULL);
    g_dbus_client_set_disconnect_watch(client, disconnect_handler, NULL);
    g_dbus_client_set_signal_watch(client, message_handler, NULL);
  /* set proxy handlers*/
    g_dbus_client_set_proxy_handlers(client, proxy_added, proxy_removed,
                                     property_changed, NULL);
  /* set ready */
```

```
    g_dbus_client_set_ready_watch(client, client_ready,   NULL);
  /*running in a loop*/
    g_main_loop_run(main_loop);

  /*release the resources*/
    g_dbus_client_unref(client);
    dbus_connection_unref(dbus_conn);
    g_main_loop_unref(main_loop);
    return 0;
}
```

Users should note the function load_healt_drivers();, in which the function register_health_driver(&Oximeter_driver) is invoked to register the callback functions which process the upcoming events and then get the data the sensor reported. The UUID_Oximeter_SERVICE is the primary service that its characteristic can be read to get oximeter values.

The HealthDriver and BluetoothDeviceCallbacks is defined as

```
typedef struct HealthDriver_
{
    char * name;
```

```
    char * service_uuid;
    struct BluetoothDeviceCallbacks_ * callbacks;
}HealthDriver;
typedef struct BluetoothDeviceCallbacks_
{
    void (*init) (BluetoothDevice * btdev);
    void (*exit) (BluetoothDevice * btdev);
    void (*scan_found)(BluetoothDevice * btdev);
    void (*connect_state_changed) (BluetoothDevice * btdev, bool connected);
    void (*service_added) (BluetoothDevice * btdev, GattService * service);
    void (*characteristics_added) (BluetoothDevice * btdev, GattCharacteristic *
characteristics);
    void (*characteristics_notify)(BluetoothDevice * btdev, GattCharacteristic *
characteristics,
                        const unsigned char * value, int len);
    //void (*property_changed)();
}  BluetoothDeviceCallbacks;
```

In Oximeter.c a BluetoothDeviceCallbacks instance and a HealthDriver instance are defined:

```
static BluetoothDeviceCallbacks Oximeter_callbacks =
```

```
{
    .init = Oximeter_init,
    .connect_state_changed = Oximeter _connect_state_changed,
    .scan_found = Oximeter _scan_found ,
    .characteristics_added = Oximeter_characteristics_added,
    .characteristics_notify = Oximeter_characteristics_notify,
};
#define UUID_Oximeter_SERVICE   "cdeacb80-5235-4c07-8846-93a37ee6b86d"
HealthDriver    Oximeter_driver =
{
    .name = " Oximeter detector",
    .service_uuid =   UUID_ Oximeter_SERVICE,
    .callbacks = &Oximeter _callbacks,
};
```

Oximeter_init,Oximeter_connect_state_changed,Oximeter_scan_found, Oximeter_characteristics_added, Oximeter_characteristics_notify are functions to process connection events when the sensor is connected to the gateway. Oximeter_characteristics_notify process the data notified. **Users should write their own callback functions according to their sensor characteristics to control the sensor.**

6. Run the oximeter sensor sample on the gateway

1) **Get the Openwork toolchain and copy it to a Linux PC.** Get the cross compile OpenWrt-Toolchain from Dusun, whose name is openwrt-sdk-ramips-mt7620_gcc-4.8-linaro_uClibc-0.9.33.2. Linux-x86_64.tar.bz2. Decompress the downloaded OpenWrt Toolchain to a local folder (E.g.: home/software/OpenWrt-SDK).

2) **Compiled the attached code files.**

View our GitHub for the code sample:

https://github.com/dusuniot/Dusun_BLE_Code_Sample

BLE_code_sample_for_development_on_dusun_gateway

Copy the above code file to the Linux PC and decompress it to a folder (E.g.: home/software/test). Open ./BLEsample/example/ folder, and edit the Makefile file to revise the CROSSTOOLDIR to the OpenWrt toolchain directory you created above. This is depicted in Figure 3.

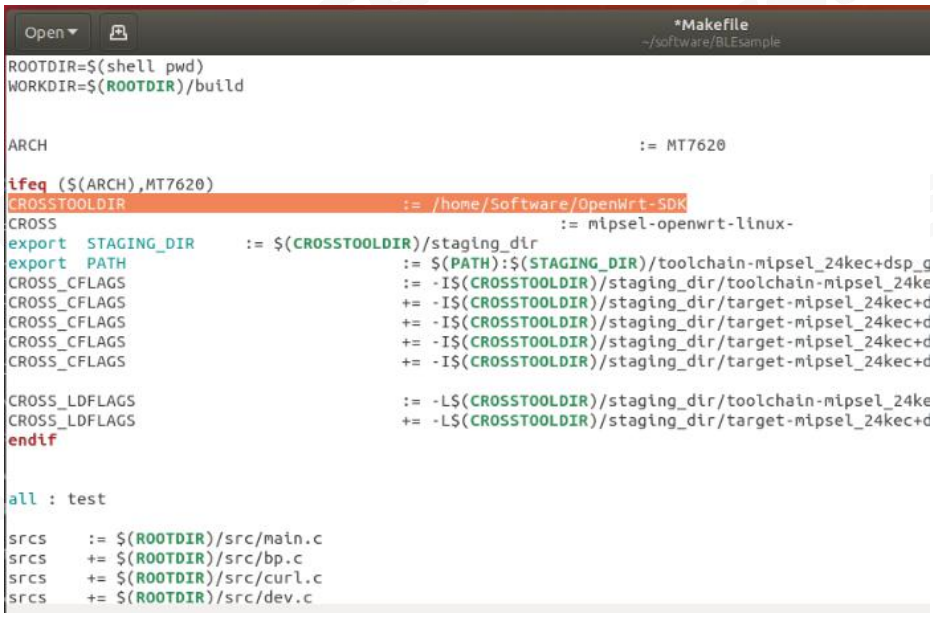


Figure 3 change the CROSSTOODIR path

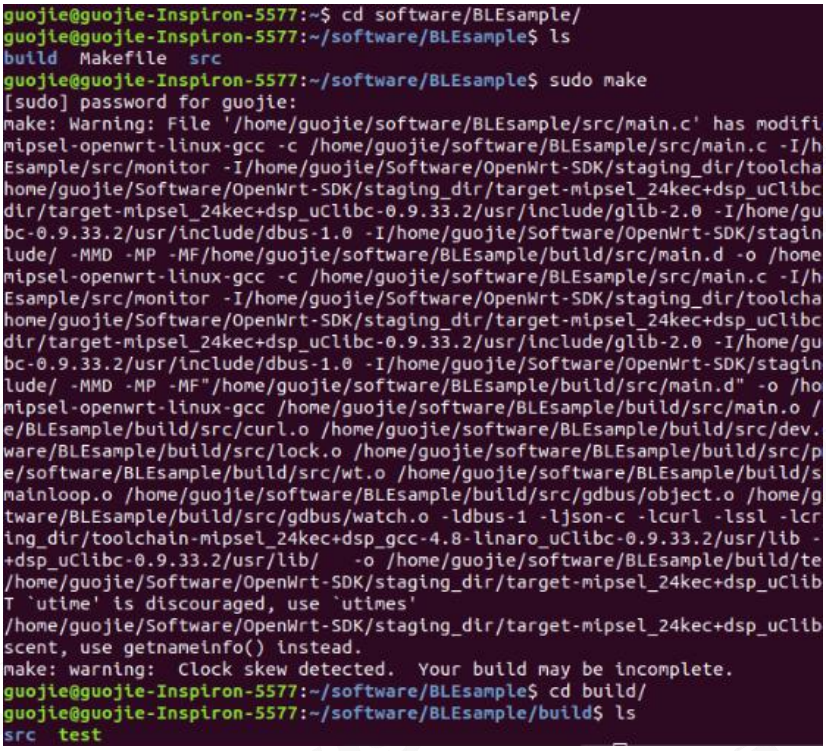


Figure 4 the test application compilation

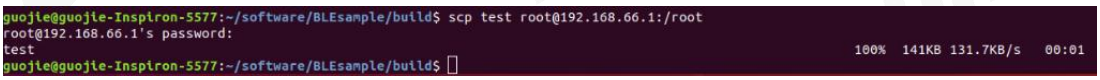
Then open a terminal on the Linux PC, and type the following commands:

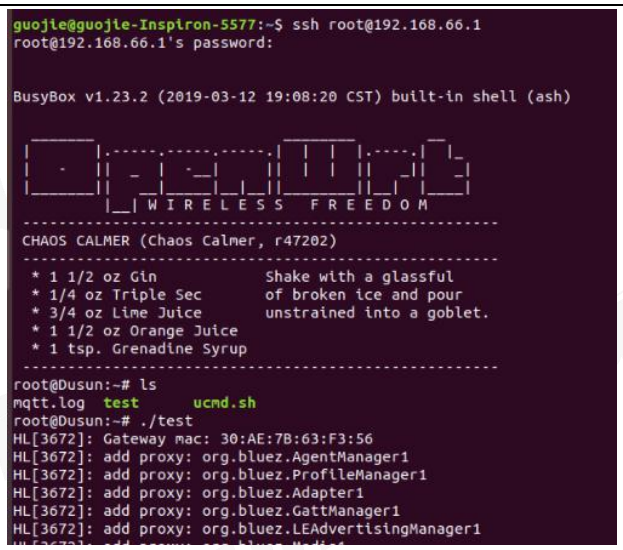
cd BLEsample; sudo make

Finally, the test bin file which can be run in the gateway has been compiled. (Figure 4).

3) **Copy the compiled test bin file into the gateway and run it.** There are some ways one can do it. Under Linux PC, you can use SCP command (scp local_file remote_username @remote_ip:remote_folder) to do it. Make sure the gateway is connected to the same router with PC, then run the following commands:

scp test root@192.168.66.1:/root





Then remote login to the gateway using SSH commands or SSH client (windows: putty or SecureCrt) and run the copied bin file. The login password can be revised following the configuration steps in the above sections. Finally, we power up the oximeter device and run the test file, we can see the data the oximeter notified to the program as the figure 5 shows. The data can be analyzed according to its munual. Figure 6/7 show the sensor and gateway for testing respectively.

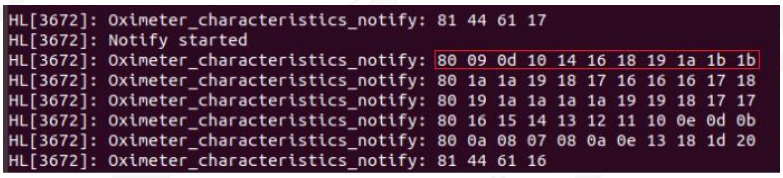


Figure 5 the printed messages when notify callback functions invoked

Figure 6 the oximeter device for testing

Figure 7 the Dusun Gateway for testing