PAHO-MQTT User Manual

RT-THREAD Documentation Center

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Versions and Revisions

Date	Version	Author	Note
2018-04-28	v0.1	Armink	initial version
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Chapter 1

MQTT Software Package Introduction

Paho MQTT It is a client of the MQTT protocol implemented in Eclipse. This package is in Eclipse paho-mqtt

A set of MQTT client programs designed based on the source code package.

1.1 File Directory Structure

```
pahomqtt
 ÿÿÿÿdocs
ÿ ÿÿÿÿfigures ÿ ÿ api.md ÿ ÿ                    // Document using images
 introduction.md ÿ ÿ                            // API usage instructions
 principle.md ÿ ÿ README.md ÿ ÿ                 // Introduction document
 samples.md ÿ ÿ user-guide.md ÿ                 // Implementation principle
 ÿÿÿÿversion.md ÿÿÿÿ MQTTClient-                // Document structure description
 RT ÿÿÿÿMQTTPacket ÿÿÿÿsamples                  // Package Example
ÿ mqtt_sample.c ÿÿÿÿtests ÿ ÿ                   // Instructions for use
 README.md ÿÿÿÿSConscript                       // Version
                                                // Migrate files
                                                // Source File
                                                // Example code
                                                // Software package application sample code
                                                //mqtt functional test program
      LICENSE                                   // Package License
                                                // Software package instructions
                                                //RT-Thread default build script
```

1.2 RT-Thread Software Package Features

The features of RT-Thread MQTT client are as follows:

• Automatic reconnection after disconnection

The RT-Thread MQTT software package implements a disconnection reconnection mechanism. When the connection is disconnected due to network disconnection or network instability, it will maintain the login status, reconnect, and automatically resubscribe to the topic. This improves the reliability of the connection and increases the ease of use of the software package.

• Pipe model, non-blocking API

It reduces programming difficulty, improves code running efficiency, and is suitable for situations with high concurrency and small data volumes.

• Event callback mechanism

Custom callback functions can be executed when a connection is established, a message is received, or a connection is disconnected.

• TLS encrypted transmission

MQTT can be transmitted using TLS encryption to ensure data security and integrity.

1.3 MQTT Overview

MQTT (Message Queuing Telemetry Transport) is a "lightweight" communication protocol based on the publish/subscribe model. The protocol is built on the TCP/IP protocol and was released by IBM in 1999. The biggest advantage of MQTT is that it can provide real-time and reliable message services for connecting remote devices with very little code and limited bandwidth. As an instant messaging protocol with low overhead and low bandwidth usage, it has a wide range of applications in the Internet of Things, small devices, mobile applications, etc.

MQTT is a client-server based message publish/subscribe transport protocol. The MQTT protocol is lightweight, simple, open and easy to implement, which makes it very widely applicable. In many cases, including restricted environments such as machine-to-machine (M2M) communication and the Internet of Things (IoT). It has been widely used in sensors communicating via satellite links, medical devices that occasionally dial up, smart homes, and some miniaturized devices.

1.4 MQTT Function Introduction

The MQTT protocol runs on top of TCP/IP or other network protocols. It will establish a connection between the client and the server, providing an ordered, lossless, byte-stream-based two-way transmission between the two. When application data is sent through the MQTT network, MQTT will associate the associated quality of service (QoS) and topic name (Topic). Its features include:

1. Use the publish/subscribe messaging model, which provides one-to-many message distribution to achieve decoupling from applications. 2. A message transmission mechanism that shields payload content. 3. There are three qualities of service (QoS) for transmitted messages:

1. At most once, message loss or duplication may occur at this level, and message publishing depends on the underlying TCP/IP network.
   That is: <=1
2. At most once, this level ensures that the message arrives, but the message may be repeated. That is: >= 1 3. Only once,
   ensure that the message arrives only once. That is: = 1. In some billing systems with strict requirements
   This level can be used.

4. Minimize data transmission and protocol exchange (the protocol header is only 2 bytes) to reduce network traffic. 5. Notification mechanism to notify both parties of transmission in case of abnormal interruption.

1.4.1 MQTT Client

An application or device using the MQTT protocol, which always establishes a network connection to the server. The client can:

- Establish a connection with the server • Publish information that other clients may subscribe to
- Receive messages published by other clients • Unsubscribe from subscribed messages

1.4.2 MQTT Server

The MQTT server is called a "message broker" and can be an application or a device. Between message publishers and subscribers, it can:

- Accepts network connections from clients • Receives application information published by clients • Handles subscription and unsubscription requests from clients • Forwards application messages to subscribed clients

1.4.3 Methods in the MQTT protocol

The MQTT protocol defines some methods (also called actions) to represent operations on certain resources. This resource can represent pre-existing data or dynamically generated data, depending on the implementation of the server. Generally speaking, resources refer to files or outputs on the server.

- Connect: Wait for the connection to be established with the server. • Disconnect: Wait for the MQTT client to complete its work and disconnect the TCP/IP session with the server. • Subscribe: Wait for the subscription to be completed. • UnSubscribe: Wait for the server to cancel the client's subscription to one or more Topics. • Publish: The MQTT client sends a message request and returns to the application thread after the message is sent.

1.4.4 Subscriptions, Topics, and Sessions in the MQTT Protocol

- Subscription

  A subscription contains a topic filter and a maximum quality of service (QoS).
  (Session) association. A session can contain multiple subscriptions. Each subscription in each session has a
  different topic filter.

- Session

  After each client establishes a connection with the server, it is a session, and there is stateful interaction between the client and the server.

  The session exists between one network, and may also span multiple continuous network connections between the client and the server.

- Topic Name

  A tag connected to an application message that matches a server's subscription. The server sends the message to
  every client that subscribed to the matching tag.

- Topic Filter

  A wildcard filter for topic names, used in a subscription expression, to indicate that the subscription matches multiple topics.

- Payload

  The specific content received by the message subscriber.

- Application Message

  The MQTT protocol transmits application data over the network. When application messages are transmitted via MQTT, they
  have associated quality of service (QoS) and topics.

- MQTT Control Packet

  A packet of information sent over a network connection. The MQTT specification defines fourteen different types of control messages, one
  of which (the PUBLISH message) is used to transmit application messages.

chapter **2**

MQTT Sample Program

2.1 Example Code Explanation

The following is an explanation of the MQTT sample code provided by RT-Thread. The test server uses the Eclipse test server.

The address is iot.eclipse.org , port 1883, and the sample code for the MQTT function is as follows:

```
#include <stdlib.h>
#include <string.h>
#include <stdint.h>

#include <rtthread.h>

#define DBG_ENABLE
#define DBG_SECTION_NAME        "[MQTT] "
#define DBG_LEVEL               DBG_LOG
#define DBG_COLOR
#include <rtdbg.h>

#include "paho_mqtt.h"
#define MQTT_URI                "tcp://iot.eclipse.org:1883" //Configure test
    server address
#define MQTT_USERNAME           "admin"
#define MQTT_PASSWORD           "admin"
#define MQTT_SUBTOPIC           "/mqtt/test" "/          // Set the subscription topic
#define MQTT_PUBTOPIC           mqtt/test"               // Set the push topic
#define MQTT_WILLMSG            "Goodbye!"               // Set the last words message

/* Define the MQTT client environment structure*/
static MQTTClient client;
```

```
/* MQTT subscription event custom callback
function*/ static void mqtt_sub_callback(MQTTClient *c, MessageData *msg_data) {

    *((char *)msg_data->message->payload + msg_data->message->payloadlen)
        = '\0';
    LOG_D("mqtt sub callback: %.*s %.*s", msg_data-
                >topicName->lenstring.len, msg_data->topicName-
                >lenstring.data, msg_data->message->payloadlen ,
                (char *)msg_data->message->payload);


    return;
}

/* MQTT subscription event default callback
function*/ static void mqtt_sub_default_callback(MQTTClient *c, MessageData
    msg_data)
{
    *((char *)msg_data->message->payload + msg_data->message->payloadlen)
        = '\0';
    LOG_D("mqtt sub default callback: %.*s %.*s", msg_data-
                >topicName->lenstring.len, msg_data->topicName-
                >lenstring.data, msg_data->message-> payloadlen,
                (char *)msg_data->message->payload);

    return;
}

/* MQTT connection event callback
function*/ static void mqtt_connect_callback(MQTTClient *c) {

    LOG_D("inter mqtt_connect_callback!");
}

/* MQTT online event callback function*/
static void mqtt_online_callback(MQTTClient *c) {

    LOG_D("inter mqtt_online_callback!");
}

/* MQTT offline event callback function*/
static void mqtt_offline_callback(MQTTClient *c) {

    LOG_D("inter mqtt_offline_callback!");
}
```

```
/**
 * This function creates and configures the MQTT client.
 *
 * @param void
 *
 * @return none
 */
static void mq_start(void) {

    /* Use MQTTPacket_connectData_initializer to initialize the condata parameters*/
    MQTTPacket_connectData condata = MQTTPacket_connectData_initializer; static char cid[20] =
    { 0 };

    static int is_started = 0; if (is_started)
    {

        return;

    } /* Configure MQTT structure content parameters*/
    {
        client.uri = MQTT_URI;

        /* Generate a random client ID */
        rt_snprintf(cid, sizeof(cid), "rtthread%d", rt_tick_get());

        /* Configure connection
        parameters*/ memcpy(&client.condata, &condata, sizeof(condata));
        client.condata.clientID.cstring = cid;
        client.condata.keepAliveInterval = 60;
        client.condata.cleansession = 1;
        client.condata.username.cstring = MQTT_USERNAME;
        client.condata.password.cstring = MQTT_PASSWORD;

        /* Configure MQTT will parameters*/
        client.condata.willFlag = 1;
        client.condata.will.qos = 1;
        client.condata.will.retained = 0;
        client.condata.will.topicName.cstring = MQTT_PUBTOPIC;
        client.condata.will.message.cstring = MQTT_WILLMSG;

        /* Allocate buffer */
        client.buf_size = client.readbuf_size = 1024; client.buf =
        malloc(client.buf_size); client.readbuf =
        malloc(client.readbuf_size); if (!(client.buf && client.readbuf)) {
```

```
                LOG_E("no memory for MQTT client buffer!"); goto _exit;

            }

            /* Set event callback function */
            client.connect_callback = mqtt_connect_callback; client.online_callback
            = mqtt_online_callback; client.offline_callback = mqtt_offline_callback;


            /* Set up subscription table and event callback function*/
            client.messageHandlers[0].topicFilter = MQTT_SUBTOPIC;
            client.messageHandlers[0].callback = mqtt_sub_callback;
            client.messageHandlers[0].qos = QOS1;

            /* Set the default subscription topic */
            client.defaultMessageHandler = mqtt_sub_default_callback;
        }

        /* Run MQTT client */
        paho_mqtt_start(&client); is_started
        = 1;

_exit:
        return;
}

/**
  * This function pushes a message to a specific MQTT topic.
  *
  * @param send_str publish message
  *
  * @return none
  */
static void mq_publish(const char *send_str) {

        MQTTMessage message;
        const char *msg_str = send_str; const char
        *topic = MQTT_PUBTOPIC;
        message.qos = QOS1;                                    //Message level
        message.retained = 0;
        message.payload = (void *)msg_str;
        message.payloadlen = strlen(message.payload);

        MQTTPublish(&client, topic, &message);

        return;
```

```
}

#ifdef RT_USING_FINSH
#include <finsh.h>
FINSH_FUNCTION_EXPORT(mq_start, startup mqtt client);
FINSH_FUNCTION_EXPORT(mq_publish, publish mqtt msg); #ifdef
FINSH_USING_MSH
MSH_CMD_EXPORT(mq_start, startup mqtt client);

int mq_pub(int argc, char **argv) {

    if (argc != 2) {

        rt_kprintf("More than two input parameters err!\n");
        return 0;

    } mq_publish(argv[1]);

    return 0;
}
MSH_CMD_EXPORT(mq_pub, publish mqtt msg); #endif /
* FINSH_USING_MSH */ #endif /*
RT_USING_FINSH */
```

2.2 Running the Example

Running the above functional sample code in msh can subscribe to topics on the server and push messages to specific topics.

The function sample code running effect is as follows:

- Start the MQTT client, connect to the proxy server and subscribe to the topic:

```
msh />mq_start inter                    /* Start the MQTT client to connect to the Eclipse server*/
mqtt_connect_callback! /* Server connection is successful, call the connection callback function to print the service
    Device information*/
ipv4 address port: 1883 [MQTT]
HOST = 'iot.eclipse.org' msh />[MQTT]
Subscribe #0 /mqtt/test OK! /* Subscribe to topic /mqtt/test successfully*/ inter mqtt_online_callback! /*
MQTT is online successfully, call the online callback function*/
msh />
```

- Publish a message to a specified topic as a publisher:

```
msh />mq_pub hello-rtthread /* Send hello-rtthread message to the specified topic */
msh />mqtt sub callback: /mqtt/test hello-rtthread /* Receive message and execute callback
        function*/
msh />
```

Chapter **3**

How **MQTT** works

3.1 How MQTT protocol works

There are three identities in the MQTT protocol: publisher (Publish), broker (Broker) (server) and subscriber (Subscribe). The publisher and subscriber of the message are both clients, the message broker is the server, and the message publisher can be a subscriber at the same time. The relationship between the three is shown in the following figure:

Figure **3.1:** *MQTT* Working principle diagram

In the actual use of the MQTT protocol, the following process is generally followed:

• The publisher publishes messages to the specified Topic through the proxy server. •

The subscriber subscribes to the required Topic through the proxy server. •

After the subscription is successful, if a publisher publishes a message to the Topic subscribed by the subscriber, the subscriber will receive the proxy message.

The server pushes messages, which enables efficient data exchange.

Chapter 4

MQTT Usage Guide

4.1 Preparation

First, you need to download the MQTT software package and add it to the project. In the BSP directory, use the menucon-fig command to open the env configuration interface. In RT-Thread online packages ÿ IoT - internet of things

Select the Paho MQTT software package, and the operation interface is as shown below:

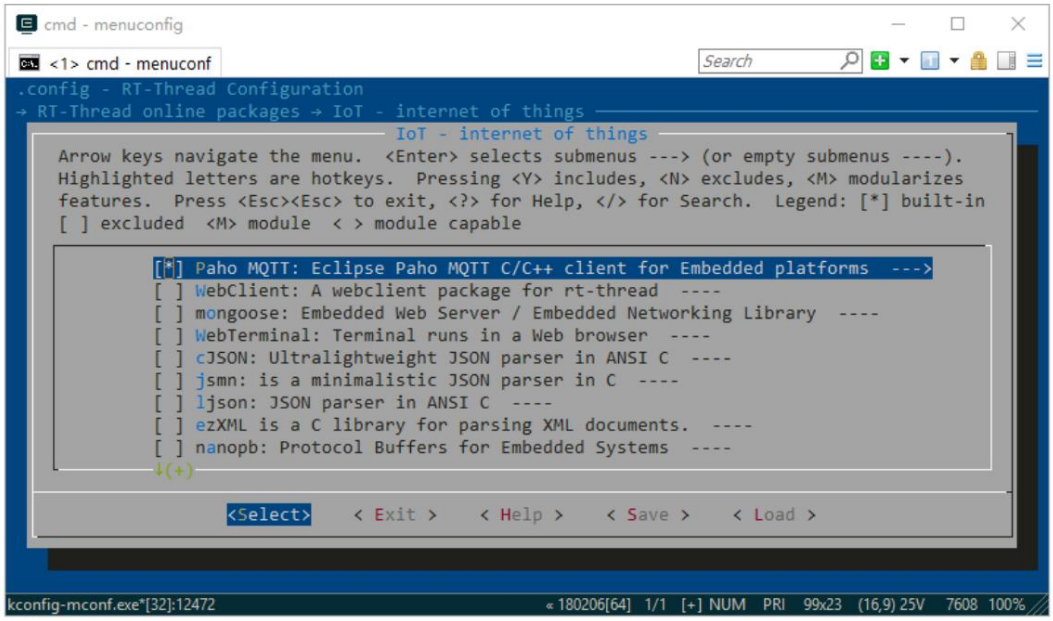

Figure **4.1:** Select *Paho MQTT* Software Packages

Enable functional examples to facilitate testing of MQTT functions:

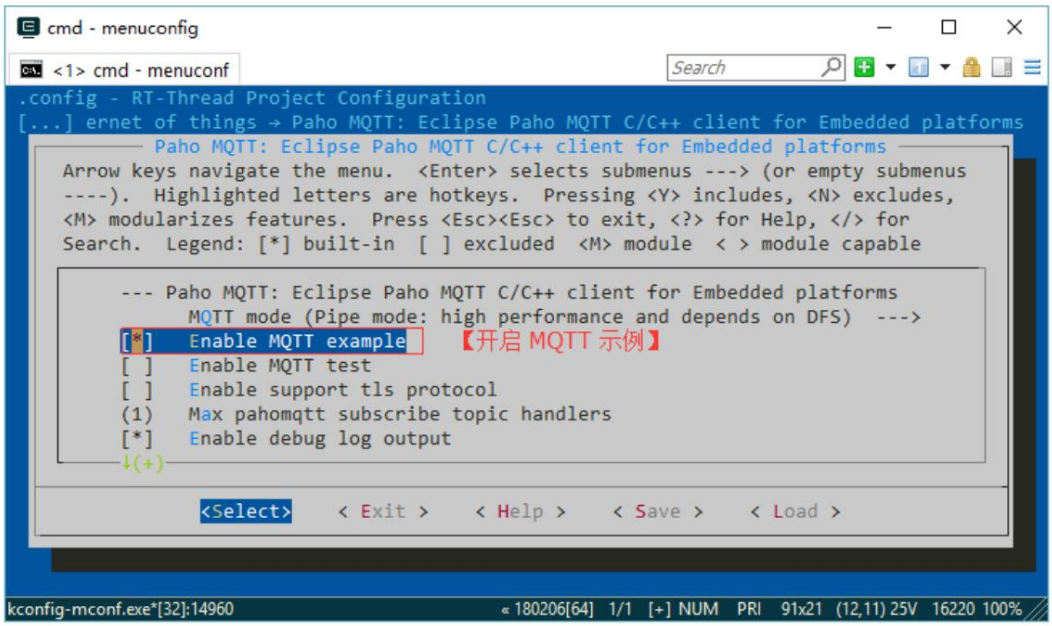

Figure **4.2:** Open *MQTT* Package testing routines

The configuration items are described as follows:

```
--- Paho MQTT: Eclipse Paho MQTT C/C++ client for Embedded platforms
        MQTT mode (Pipe mode: high performance and depends on DFS) --->
            Function
        [*] Enable MQTT example                          #Enable MQTT function example
        [ ] Enable MQTT test                             #Start the MQTT test routine
        [ ] Enable support tls protocol                  # Enable TLS secure transmission option
        (1) Max pahomqtt subscribe topic handlers #Set the maximum number of subscriptions to a topic
        [*] Enable debug log output #Select the software  # Enable debug log output
        version (latest) --->                            package version, the default is the latest version
```

After selecting the appropriate configuration items, use the pkgs --update command to download the software package and add it to the project.

4.2 Usage Process

This section introduces the configuration parameters and usage of the MQTT software package.

4.2.1 Setting proxy information

First, you need to set the proxy server address, user name, password and other necessary information. Take the MQTT sample as an example:

The following settings:

```
#define MQTT_URI "tcp://iot.eclipse.org:1883" //Set up service address
#define MQTT_USERNAME "admin" //Proxy service Username
#define MQTT_PASSWORD device "admin" //Proxy service password
#define MQTT_SUBTOPIC "/mqtt/test" //Subscription Topic
#define MQTT_PUBTOPIC "/mqtt/test" //Push Topic
#define MQTT_WILLMSG "Goodbye!" //Set disconnect notification message
```

4.2.2Configure MQTT client structure

Next, you need to initialize the MQTT package client instance and write the data set in the previous step into the client instance Configuration items, make necessary configurations for the client. In this step, you need to do the following:

- Set the server address, server account, password and other information. The sample code is as follows:

```
/* Configure connection parameters */
memcpy(&client.condata, &condata, sizeof(condata));
client.condata.clientID.cstring = cid;
client.condata.keepAliveInterval = 60;
client.condata.cleansession = 1;
client.condata.username.cstring = MQTT_USERNAME; //Set up account
client.condata.password.cstring = MQTT_PASSWORD; //set password
```

- Set the message level, push topic, and disconnect notification message configurations. The example is as follows:

```
/* Configure disconnect notification message */
client.condata.willFlag = 1;
client.condata.will.qos = 1;
client.condata.will.retained = 0;
client.condata.will.topicName.cstring = MQTT_PUBTOPIC; //Set the push topic
client.condata.will.message.cstring = MQTT_WILLMSG; //Set disconnect notification information
```

- Set the event callback function. Here you need to set the callback function for the event, such as connection success event, online success event, Offline events, etc. The sample code is as follows:

```
/* Set the event callback function. The callback function needs to be written by yourself. In the example, an empty function is left for the callback function.
    */
client.connect_callback = mqtt_connect_callback; client.online_callback =          //Set the connection callback
mqtt_online_callback; client.offline_callback = mqtt_offline_callback;            function //Set the online callback
                                                                                  function //Set the offline callback function
```

• Set up the client subscription table. The MQTT client can subscribe to multiple topics at the same time, so you need to maintain a subscription table. In this step, you need to set parameters for each topic subscription, including the topic name, the subscription callback function, and the message level. The code example is as follows:

```
/* Configure subscription
table*/ client.messageHandlers[0].topicFilter = MQTT_SUBTOPIC; //Set the first subscription
      Topic
client.messageHandlers[0].callback = mqtt_sub_callback; // Set the callback for this subscription
      function
client.messageHandlers[0].qos = QOS1;                                  //Set the subscription message
      grade
/* set default subscribe event callback */ client.defaultMessageHandler
= mqtt_sub_default_callback; //Set a default callback function. If the subscribed Topic does not have a callback
      function set, use the default callback function.
```

4.2.3 Start the MQTT client

After configuring the MQTT client instance, you need to start the client. The code example is as follows:

```
/* Run the MQTT client */
paho_mqtt_start(&client);
```

After starting the MQTT client, the client will automatically connect to the proxy server and automatically subscribe to the set Topic.

Execute the callback function according to the event to process the data.

4.2.4 Push messages to a specified topic

After successfully connecting to the server, you can push messages to the specified Topic through the proxy server.

To set the message content, topic, message level and other configurations, the sample code is as follows:

```
MQTTMessage message;
const char *msg_str = send_str;
const char *topic = MQTT_PUBTOPIC; message.qos =          //Set the specified Topic
QOS1; message.retained = 0;                               //Set the message level

message.payload = (void *)msg_str; message.payloadlen     //Set the message content
= strlen(message.payload);
MQTTPublish(&client, topic, &message);                    //Start pushing messages to the specified Topic
```

4.3 Operation Effect

The demo example can show the functions of connecting to the server, subscribing to a topic, and pushing messages to a specified topic, as shown below:

```
msh />mq_start                                  /* Start the MQTT client to connect to the proxy server
    */
inter mqtt_connect_callback! ipv4 address port: /* Connection successful, run online callback function*/
1883
[MQTT] HOST = 'iot.eclipse.org'
msh />[MQTT] Subscribe
inter mqtt_online_callback! msh />mq_pub        /* Successfully launched, running online callback function*/
hello-rtthread msh />mqtt sub callback: /mqtt/  /* Push message to the specified Topic*/
test hello-rtthread /* Receive the message and execute the callback
    function*/
```

4.4 Notes

Please note that MQTT_USERNAME and MQTT_PASSWORD should be filled in correctly .

The MQTT_PASSWORD is filled in incorrectly, and the MQTT client cannot connect to the MQTT server correctly.

4.5 References

- MQTT official website
- Paho official website
- Introduction to IBM MQTT
- Eclipse paho.mqtt source code

Chapter 5

Introduction to MQTT API

5.1 Subscription List

Paho MQTT uses a subscription list to subscribe to multiple topics. The subscription list is stored in

In the MQTTClient structure instance, configure it before starting MQTT as follows:

```
... // Omit code

MQTTClient client;

... // Omit code

/* set subscribe table and event callback */
client.messageHandlers[0].topicFilter = MQTT_SUBTOPIC;
client.messageHandlers[0].callback = mqtt_sub_callback; client.messageHandlers[0].qos
= QOS1;
```

Please refer to the Samples section for detailed code explanation. The maximum number of subscription lists can be set by the menuconfig

Max pahomqtt subscribe topic handlers option is configured.

5.2 callback

paho-mqtt uses callback to provide users with the working status of MQTT and the processing of related events.

It needs to be registered and used in the MQTTClient structure instance.

callback name	describe
connect_callback	MQTT connection success callback

callback name	describe
online_callback	Callback when the MQTT client successfully goes online
offline_callback	MQTT client disconnection callback
defaultMessageHandler	Default subscription message receiving callback
messageHandlers[x].callback	The corresponding subscription message receiving callback in the subscription list

Users can use the defaultMessageHandler callback to handle received subscription messages by default, or use

messageHandlers subscription list, providing an independent

Subscription message receiving callback.

5.3 MQTT_URI

paho-mqtt provides uri parsing function, which can parse domain name address, ipv4 and ipv6 address, and can parse

For URIs of the tcp:// and ssl:// types, users only need to fill in the available URIs as required.

- Example uri:

```
domain type
tcp://iot.eclipse.org:1883

ipv4 type
tcp://192.168.10.1:1883
ssl://192.168.10.1:1884

ipv6 type
tcp://[fe80::20c:29ff:fe9a:a07e]:1883
ssl://[fe80::20c:29ff:fe9a:a07e]:1884
```

5.4 paho_mqtt_start interface

- Function: Start the MQTT client and subscribe to the corresponding topic according to the configuration items.

- Function prototype:

```
int paho_mqtt_start(MQTTClient *client)
```

• Function parameters:

parameter	describe
client	MQTT client instance object
return	0: Success; Others: Failure

5.5 MQTT Publish Interface

- Function: Publish MQTT messages to the specified Topic.
- Function prototype:

```
int MQTTPublish(MQTTClient *c, const char *topicName, MQTTMessage *
    message)
```

- Function parameters:

parameter	describe
c	MQTT client instance object
topicName	MQTT message publishing topic
message	MQTT message content
return	0: Success; Others: Failure