APPLICATION NOTE

Atmel AT06700: LED Commercial Lighting Kit and Gateway Software User's Guide

Atmel 8/32-bit Microcontroller

Description

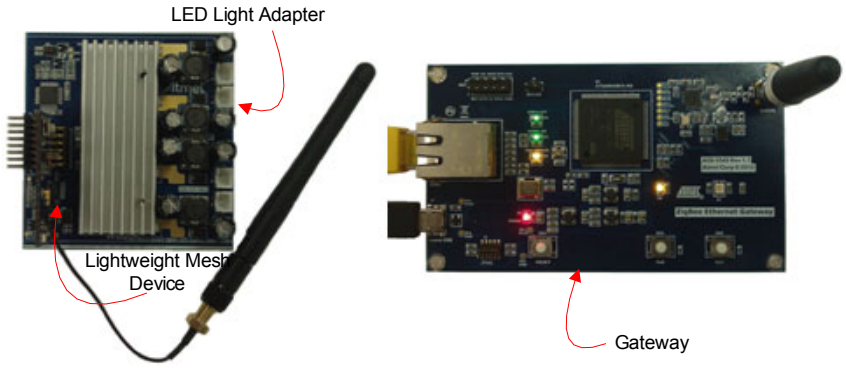
This application note describes the achievement of LED commercial light application function which includes light control, information collection and link maintaining. It enables the Atmel® AVR® wireless MCU and ARM® MCU user to get start using Atmel proprietary lightweight mesh software stack and understand how to configure, use and integrate the devices in their own design.

A getting started guide in Chapter 5 provides detailed setup and operation of preprogrammed firmware.

Features

- Atmel ATSAM3X8E ARM Microcontroller, AT86RF231 Transceiver
- Atmel ATMEGA256RFR2 Microcontroller
- Atmel proprietary Lightweight Mesh software stack V1.01
- Lightweight IP stack V1.4.0
- Light control, information collection and link maintaining

Figure 1. LED Commercial Light Kit and Gateway.



The lightweight Mesh version is V1.01. Refer to Atmel AVR2130: Lightweight Mesh Developer Guide and Atmel AVR2131: Lightweight Mesh Getting Started Guide for detailed lightweight Mesh introduction.

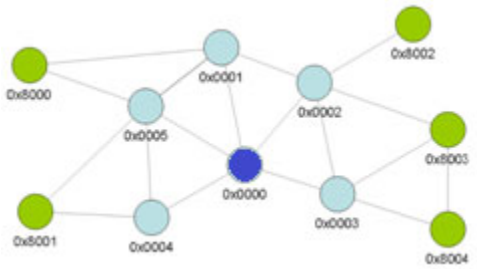
For this reference design, the hardware design files (schematic, BOM, and PCB Gerber) and software source code can be downloaded from Atmel website. The provided hardware documentation can be used with not limitations to manufacture the reference hardware solution for the design.

Table of Contents

1. Overview

The LED Commercial light based on lightweight Mesh stack protocol communicating is designed to passively receive data /command from a Coordinator (except the device request link command), it means the communication beginner is always a Coordinator. A device can be set as an “End device” or a “Router”, when a device is set to a Router, this device (Router) should route the data from a Coordinator or from an End device/Router if the target address is not for itself. A typical application scenario is shown in Figure 1-1.

Figure 1-1. Typical Lightweight Mesh Network Application Scenario



1.1 Coordinator (Gateway kit)

The Coordinator which address is 0x0000 is in charge of:

- Periodically collect Devices’ information, based on the device link list then report to PC server
- Transfer PC server command to a device
- Device’s request link command response and maintains device link list

Coordinator is usually integrated into TCP/IP-to-Lightweight Mesh Gateway. There are two roles for Gateway, TCP/IP client for TCP/IP communication and Coordinator for lightweight Mesh communication.

1.2 Device (Lighting Kit)

The Device which could be End device or Router is deployed into LED commercial light for LED controlling and information report through lightweight communication. Two responsibilities for the Device:

- Request device link
- Executes control command and responses query command from Coordinator

If the Device is configured as a Router it would route the data from a Coordinator or from an End device/Router if the target address is not for itself.

1.3 LED Light Adapter

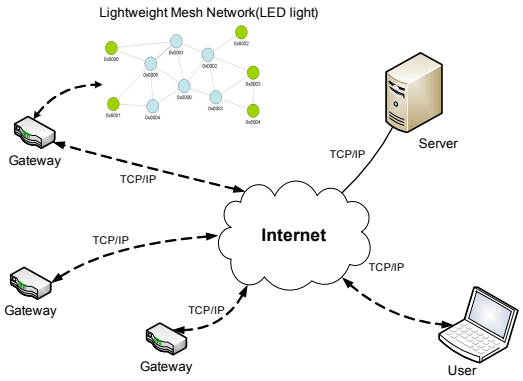
LED light adapter which is made by ATxmega8E5 is the power supply of LED light. In this application, we don’t plan to introduce the function of LED light adapter and how to achieve the function. The elf file has been provided for its programming. Refer to Section 5.3 Program the Target Board for the specific LED light adapter program operation.

1.4 The Whole System Topology

The system usually includes four parts: LED light, Gateway, TCP/IP Server and User (TCP/IP Client). The Gateway would periodically communicate with Server for LED light information uploading after connected with the Server. The Server and User can control LED light and collect LED light information through communicating with Gateway, but the User can’t directly communicate with Gateway, it needs data transfer through the Server after collected with the Server.

Refer to Figure 1-2 for the whole system topology.

Figure 1-2. The Whole System Topology



2. Development Tools

To program or debug the preprogrammed firmware, the following development tool chain is needed:

- Atmel Studio 6. Version: 6.1.2514 - beta or above
- Atmel Software Framework. Version: 3.5.1 or above
- Programming and debugging device: Atmel JTAGICE3, SAM-ICE™ JTAG
- SAM-ICE Adapter: a minimized (1.27mm pitch 10-pin header) adapter for Atmel SAM-ICE. For more details refer to Atmel AVR2033: SAM-ICE Adapter - Hardware User Manual
- JTAGICE3 adapter: 50-mil 6-pin

3. Gateway Firmware Introduction

The Gateway is based on Atmel ATSAM3X8E microcontroller and Atmel AT86RF231 2.4GHz radio transceiver. For gateway hardware design details, refer to Atmel AT2200: ZigBee® to Ethernet and Wi-Fi Gateway with SAM3X - Hardware User's Guide.

3.1 Inside the Applications

There are two tasks in Gateway firmware, lightweight IP application task and lightweight Mesh application task. The LED commercial light application task is integrated into lightweight IP application task. The content of main () function is shown below:

```
int main(void)
{
	sysclk_init();
	board_init();
	ledsInit();
	/* Bring up the Ethernet interface & initializes timer 0, channel 0 */
	LwIP_Init();
	while(1){
		/* Check if any packets are available and process if they are
		* ready. That function also manages the lwIP timers */
		LwIP_App_Task_Hander();
		/* lwMesh initialization, Check if any packets are available and
process if they are
		 ready. also manages the LwMesh task and timers*/
		LwMesh_App_Task_handler();
	}
	/* Never reached */
	return 0;
}
```

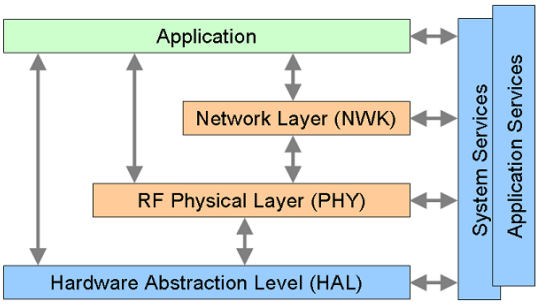
Function sysclk_init(),board_init() and ledsInit() is respectively used to initialize MCU system clock, target board configuration, and network status indicator LED initialization. Function LwIP_Init() , LwIP_App_Task_Hander() and LwMesh_App_Task_handler() have been described in the code comment above.

3.1.1 Lightweight Mesh Task

Atmel lightweight Mesh is the easy-to-use proprietary low power wireless mesh network protocol from Atmel. It is designed to work with all Atmel IEEE® 802.15.4 transceivers and SoCs. To find more detailed information about the lightweight Mesh architecture and application development process, refer to Atmel AVR2130: Lightweight Mesh Developer Guide.

The software block diagram lightweight Mesh software stack is given in Figure 3-1.

Figure 3-1. The Lightweight Mesh Software Block Diagram



Currently the public release version of lightweight Mesh software stack works with AVR®-based MCUs, but given its extreme portability and low resource requirements, it can be run on almost any Atmel MCU. In this application, it's integrated into ATSAM3X8E MCU for Gateway and ATmega256RFR2 for the LED commercial light, the version is v1.01.

In order to improve the efficiency of Gateway information collection, maximum Device quantity is limited; the default is 200, 50 for Router and 150 for End device. So the Router address is from 0x0001 to 0x0032 and the End device is from 0x8001 to 0x8096.

Lightweight Mesh application task includes two parts: lightweight Mesh initialization SYS_Init() and lightweight Mesh task handle SYS_TaskHandler():

Function LwMeshApp_Init() is as below:

```
static void LwMeshApp_Init(void)
{
	/* Config LwMesh */
	SYS_Init();
	NWK_SetAddr(APP_ADDR);
	NWK_SetPanId(APP_PANID);
	PHY_SetChannel(APP_CHANNEL);
	PHY_SetRxState(true);
	NWK_OpenEndpoint(APP_ENDPOINT, rf_rx_handler);

	nwk_data_req.dstEndpoint = 1;
	nwk_data_req.srcEndpoint = 2;
	nwk_data_req.options = 0;
	nwk_data_req.confirm = rf_tx_finish_handler;
}
```

SYS_Init(), is called to initialize lightweight Mesh system stack and specific hardware interface configuration. Function NWK_SetAddr() is used for lightweight Mesh Device address initialization. APP_ADDR Macro has two functions: one for configuring Device address, another is to identify the Device is a Router (<0x8000) or an End device (>=0x8000). For Gateway, Macro APP_ADDR must be 0 (Coordinator).

In order to create communication between Gateway and Device, The Gateway and Device must be configured as same Personal Area Network ID, Physical Channel and Application Endpoint through function NWK_SetPanId(), PHY_SetChannel() and NWK_OpenEndpoint ().

Macro APP_PANID with a range of 0-65535 is to predefine Personal Area Network ID number; Macro APP_CHANNEL must be in the range of 11-26 for configuring communication Physical Channel number, for the specific channel frequency, refers to AT86RF231 or Atmega256RFR2 datasheet. Macro APP_ENDPOINT with a range of 0-15 is to set the Application Endpoint number, the callback function of lightweight Mesh data receive handle rf_rx_handler() is also initialized through function NWK_OpenEndpoint ().

nwk_data_req.confirm = rf_tx_finish_handler is used to set lightweight Mesh application layer data send finished callback function.

Function SYS_TaskHandler() is responsible for running lightweight mesh stack. Function NWK_DataReq() is responsible for sending lightweight mesh application layer data. Make sure that the lightweight Mesh is idle (NWK_Busy() is used to detect whether the lightweight Mesh is busy or not) before sending application layer data.

3.1.2 Lightweight IP Task

Lightweight IP is free third party software stack mainly for embedded operation platform, Refer to lightweight IP website for more information.

Lightweight IP application task mainly includes two parts: lightweight IP initialization LwIP_Init() and lightweight IP task handle LwIP_App_Task_Hander().

Function LwIP_Init() is in charge of lightweight IP stack initialization lwip_init() and Ethernet hardware interface initialization ethernet_configure_interface(). We use static local IP address in this application, so the Ethernet hardware initialization includes IP address initialization, subnet mask initialization, default gateway address initialization and MAC address initialization. See following code in function LwIP_Init() below.

```
/* Default ip addr */
      IP4_ADDR(&x_ip_addr, ETHERNET_CONF_IPADDR0, ETHERNET_CONF_IPADDR1,
                  ETHERNET_CONF_IPADDR2, ETHERNET_CONF_IPADDR3);

      /* Default subnet mask */
      IP4_ADDR(&x_net_mask, ETHERNET_CONF_NET_MASK0, ETHERNET_CONF_NET_MASK1,
                  ETHERNET_CONF_NET_MASK2, ETHERNET_CONF_NET_MASK3);

      /* Default gateway addr */
      IP4_ADDR(&x_gateway, ETHERNET_CONF_GATEWAY_ADDR0,
                  ETHERNET_CONF_GATEWAY_ADDR1,
                  ETHERNET_CONF_GATEWAY_ADDR2,
                  ETHERNET_CONF_GATEWAY_ADDR3);

      netif_add(&gs_net_if, &x_ip_addr, &x_net_mask, &x_gateway, NULL,
                  ethernetif_init, ethernet_input);
```

Function ethernetif_init() called by function tcp_client_init() is responsible for the MAC address initialization and server address initialization. The default server IP address is 192.168.1.58 and Port is 4008 as below.

```
static void static void tcp_client_init(void)
{
      struct ip_addr ipaddr;
      IP4_ADDR(&ipaddr,192,168,1,58);
```

```
            struct tcp_pcb *pcb;
            pcb = tcp_new();
            gs_pcb = pcb;
            if (pcb != NULL) {
                  tcp_err(pcb, tcp_err_handler);
                  tcp_bind(pcb, &gs_net_if.ip_addr, 0);
                  tcp_connect(pcb, &ipaddr, 4008, tcp_client_connected);
            }
      }
```

Lightweight IP task handle LwIP_App_Task_Hander() is in charge of lightweight IP stack polling and lightweight IP stack timers updating through function ethernetif_input() and timers_update().

Callback function tcp_client_received() is responsible for receiving and handling TCP/IP application layer data and function tcp_write() is called for sending application layer data to TCP/IP server.

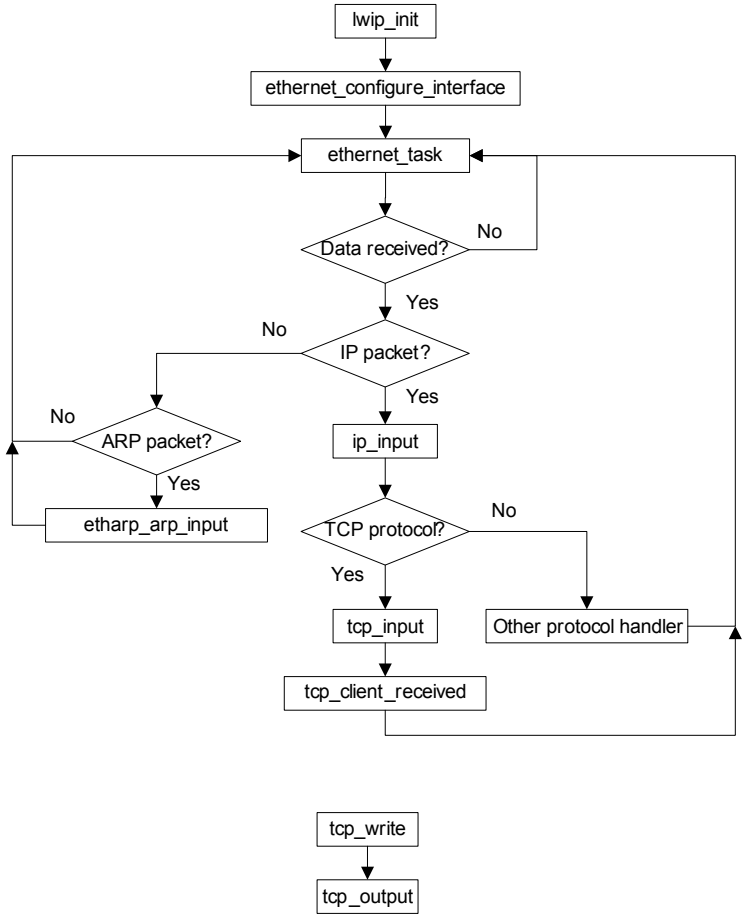
Function tcp_client_connected() is invoked when a TCP/IP connection is established. It sends a string to TCP/IP server after successful connection and set TCP client in receiving state by registering a callback function tcp_client_received().

Function status_callback() is the callback function for a status change in default network interface. It initializes the Gateway as TCP/IP client by calling tcp_client_init().

Function tcp_err_handler() is the callback function for TCP error handler. It re-initializes Gateway to TCP/IP client if connection is aborted or connection reset occurs in lightweight IP.

Refer to Figure 3-2 for specific lightweight IP stack running mechanism.

Figure 3-2. Lightweight IP Task Flow Diagram



3.1.3 Application Layer Task

Gateway application task mainly includes three functions:

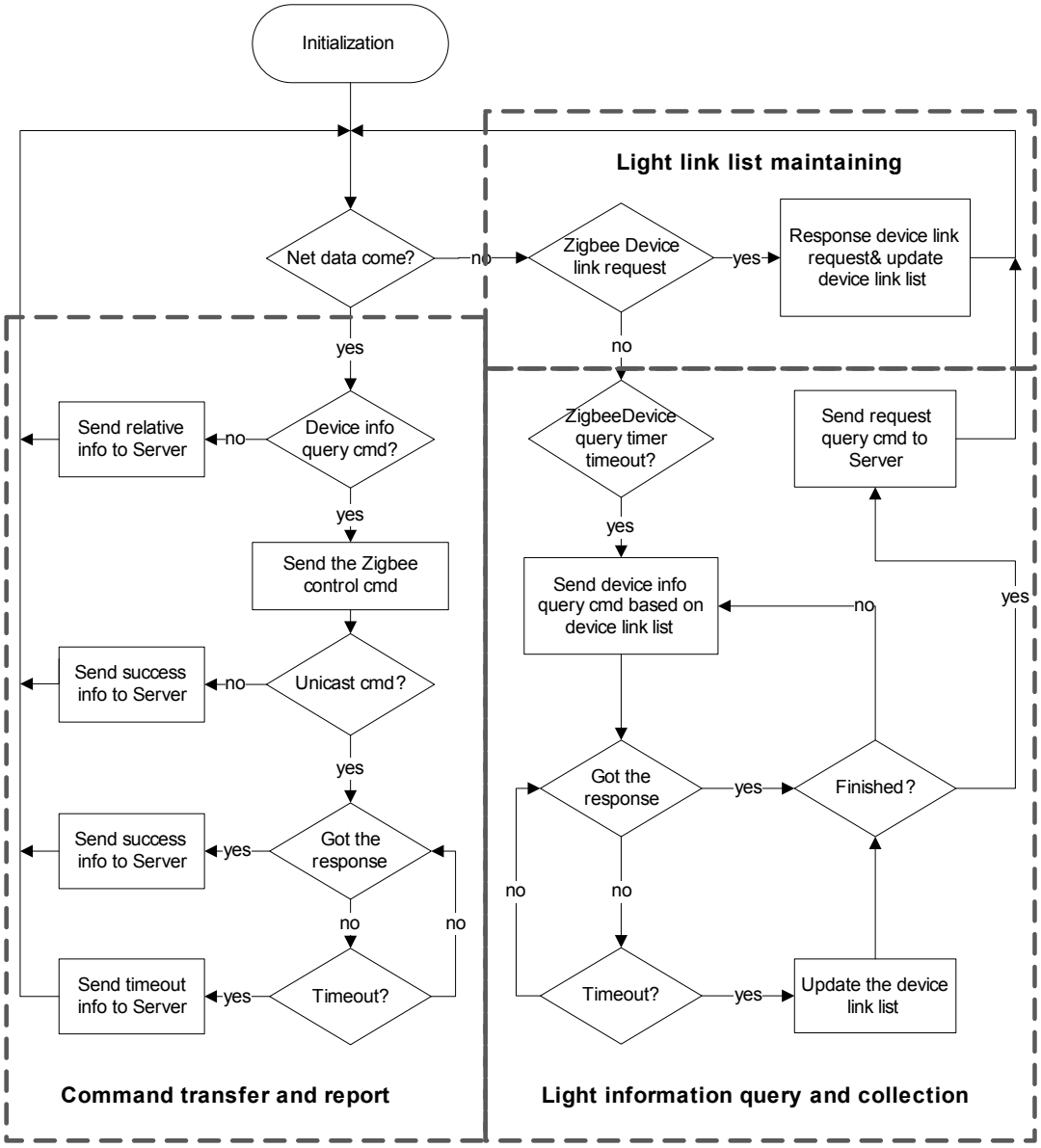
1. TCP/IP server command transfer and response TCP/IP Server query command.
2. LED light information periodic query, collection and report.
3. LED light link list maintaining.

TCP/IP Server command transfer and query command is based on the lightweight IP task, according to predefined command set, application task decides whether the command should be transferred to LED light through lightweight Mesh or not. For specific command definition, refer to Section 6.2 Communication Command Set.

There are two timer handle functions rfDataQueryTimerHandler() and rfDataCollectionTimerHandler() for LED light information query. rfDataQueryTimerHandler () is to periodically start LED light information query and rfDataCollectionTimerHandler() is to start a timer to collect selected LED light information.

Refer to Figure 3-3 for the application task running mechanism.

Figure 3-3. Gateway Application Task Flow Diagram



3.2 Main API Introduction

3.2.1 Lightweight Mesh APIs

The main APIs used in this application are as follows.

- SYS_Init()

  It initializes lightweight Mesh HAL, PHY, NWK layer and system timer. It is called from board_init().

- SYS_TaskHandler()

  It is the core API of lightweight Mesh. The PHY, NWK and system timer task handlers are called in this API.

- LwMesh_App_Task_Handler()

  It is the application layer task handler of lightweight Mesh, also includes lightweight Mesh initialization and lightweight Mesh core stack running.

- rf_rx_handler()

  The callback function registered by NWK_ NWK_OpenEndpoint(). It is called when valid data was received from lightweight Mesh low level layer.

- NWK_DataReq()

  It is called for lightweight Mesh data sending, before calling this function, make sure that the network is idle through calling NWK_Busy().

- rf_tx_finish_handler()

  It is initialized in LwMeshApp_Init(). It is called when the data sending is completed.

- appRfNetworkTimeoutTimerHandler()

  It is a timer timeout task handler of application layer and is used to indicate the waiting response data timeout when the sending command is uni-cast command which needs a response.

- appDataReceivedTimerHandler()

  It is used to indicate through LED blinking that the system is receiving data through lightweight stack.

- appDataTransmitedTimerHandler()

  It is used to indicate through LED blinking that the system is sending data through lightweight stack.

For more details about other APIs in lightweight Mesh, refer to the software package and documents inside. The latest lightweight Mesh Software Stack package can be downloaded from http://www.atmel.com/tools/LIGHTWEIGHT_MESH.aspx.

3.2.2 Lightweight IP APIs

The main APIs of lightweight IP used in application are as follows:

- LwIP_Init()

  It initializes lightweight IP Ethernet interface, related hardware and device link list.

- LwIP_App_Task_Hander()

  The lightweight IP Ethernet task handle, it polls the Ethernet tasks periodically; handles data transfer between lightweight IP and lightweight Mesh, Device (LED light) data query and device link list maintaining.

- tcp_client_init()

  It initializes the gateway as TCP/IP client. By default, static IP is assigned to gateway and a port number is bound. In this function, it tries to connect to TCP/IP server with the default parameters.

- tcp_client_received()

  It's the callback function invoked whenever a data packet is received from lightweight IP. For Gateway, it stores data received from TCP/IP server in a buffer.

- tcp_client_connected()

  It's the callback function invoked when a TCP connection is established. It sends a string to TCP server after successful connection and set TCP client in receiving state by registering a callback function tcp_client_received() in tcp_recv().

- tcp_err_handler()

  It's the callback function for TCP error handle. It re-initializes Gateway to TCP/IP client if connection is aborted or connection reset occurs in lightweight IP.

- status_callback()

  It's the callback function for a status change in default network interface. It initializes the Gateway as TCP/IP client by calling tcp_client_init().

- rfDataQueryStartTimerHandler()

  It is callback function for starting LED light information query. It is triggered by function timers_update() through global timer table gs_timers_table[].

- rfDataCollectionTimerHandler()

  It is callback function for collecting LED light information after starting data query timer. It is triggered by function timers_update() through global timer table gs_timers_table[].

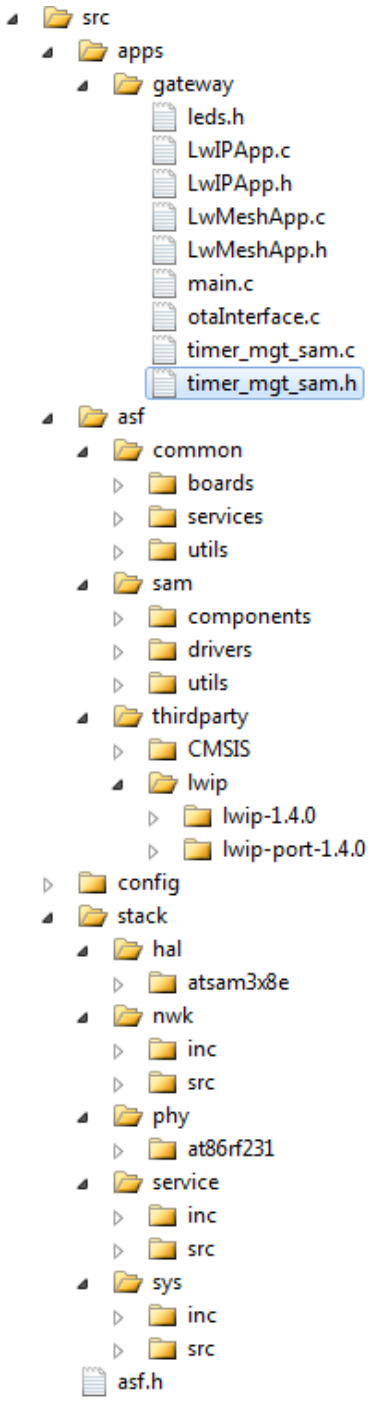
For more details about lightweight IP APIs, refer to lightweight IP stack.

3.3 Software Package Content

The Gateway is developed based on ASF. The directory structure of the software package integrates ASF structure and lightweight Mesh Software stack structure. For details of the structure of ASF, refer to Atmel AVR4029: Atmel Software Framework - Getting Started. For the structure of lightweight Mesh, refer to Atmel AVR2130: Lightweight Mesh Developer Guide.

The Gateway directory structure is shown as follows:

Figure 3-4. Gateway Directory Structure



4. Device Firmware Introduction

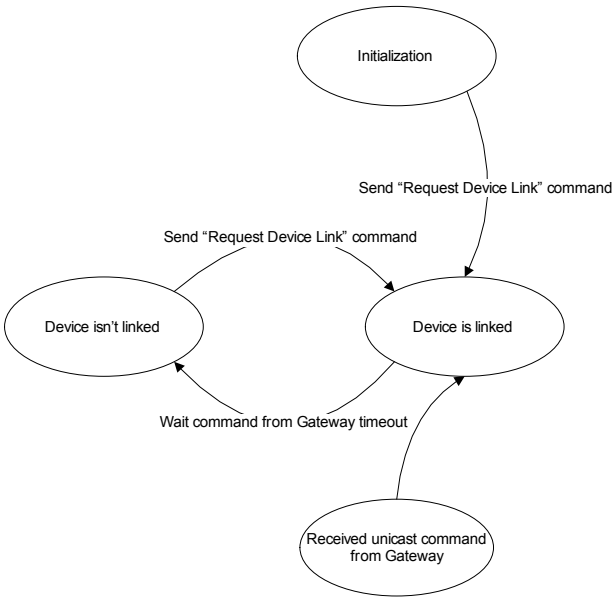
In this application, Device is in charge of LED commercial light management and communicating with Gateway through lightweight Mesh. The lightweight Mesh stack has been described in Gateway Function Introduction section, so in this section, we would focus on Device link mechanism and LED light management from Device side.

4.1 Device Link Mechanism

In order to decrease possibility of the communication confliction between different devices, the random number generator is used to produce the random time for requesting device link. Macro NET_REQUEST_LINK_TIME_WINDOW is used to limit the time window, the default random time is from 0 to 32767 milliseconds.

Before using random number generator, the predefined Macro PHY_ENABLE_RANDOM_NUMBER_GENERATOR must be enabled. Because the Gateway is designed to periodically query device information, so there is a timer insides the Device to monitor the unicast data from the Gateway. If no data for NET_LOST_LINK_TIMEOUT milliseconds, the Device would enter “no link “state, then the request data link function would be triggered. Figure 4-1 describes the transfer of device link state.

Figure 4-1. Device Link Status



4.2 LED Light Management

Led light management includes five functions in this application:

- LED self test: There is a dedicated timer TestTimer and function TestTimerHander() for LED self function test.LED dimming value would be set from 0% to 100% then go back to 0% smoothly in the given time after pressing the onboard button
- LED timing control: The LED would be controlled by the preset timing value after enabling the timing settings through communicating
- LED manual control: The LED would be controlled through communication control command
- LED autonomously control by light sensor: The LED would be controlled by the onboard light sensor autonomously
- Real time LED information collection: The system would collect the LED information periodically

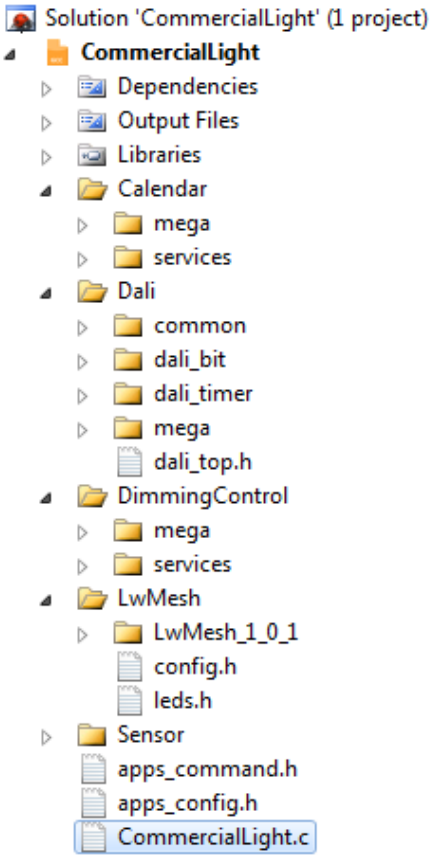
4.3 Main API Introduction

- APP_TaskHandler()
  is in charge of lightweight Mesh initialization and application function initialization.
- appDataInd()
  is used for lightweight Mesh receiving data and handling.
- appNetworkStatusTimerHandler()
  is responsible for lightweight Mesh network status indictor and device link state timeout timing.
- userKeyTimerHandler()
  is used to judge whether the onboard button has been pressed down; it is designed for LED self test function.
- appLinkingTimerHandler()
  is called for Device link request.
- appnetDataIndictorTimerHandler()
  is used for receiving data indictor through LED display.
- appCalendarReadTimerHandler()
  is called to periodically update system time through reading calendar chip data.
- appParameterUpdateTimerHandler()
  is responsible for triggering LED parameters collection periodically.

4.4 Software Package Content

The LED light directory structure is as follows:

Figure 4-2. LED Light Directory Structure



5. Getting Started Guide

In this chapter, it gives a step-by-step guide to configure the lightweight Mesh and lightweight IP and run the preprogrammed firmware. It would have two sections for lightweight Mesh and lightweight IP configuration and preprogrammed firmware.

5.1 Lightweight Mesh Parameters Configuration

Open the config.h file.

Figure 5-1. Device Lightweight Mesh Configuration

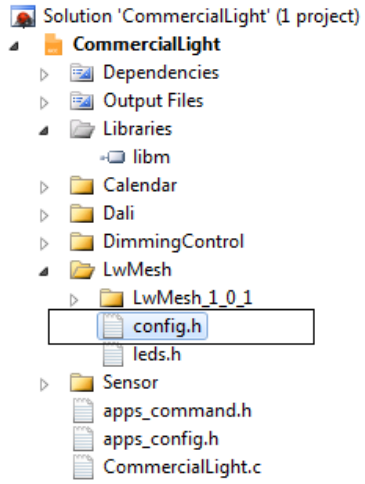
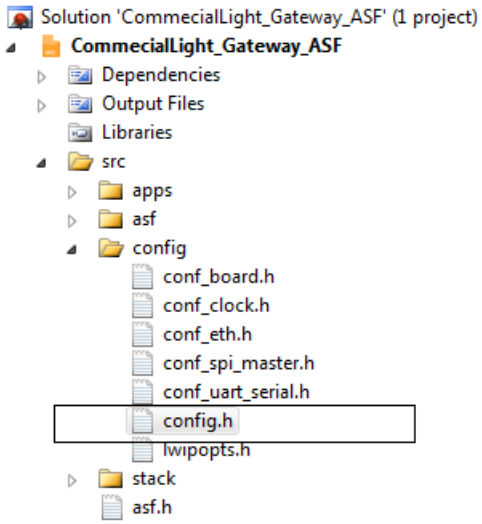


Figure 5-2. Gateway Lightweight Mesh Configuration



To start communication between End device, Router and Coordinator, the same APP_CHANNEL (frequency band), APP_PANID (Personal Area Network ID), and APP_ENDPOINT (Application Endpoint) should be set. The default configuration of End device, Router, and Coordinator in this application is:

1. APP_CHANNEL = 0x0D
2. APP_PANID = 0x1234
3. APP_ENDPOINT = 1

Polling method in the Gateway is used to query the device information in the list. So the Device quantity would affect the scan efficiency of the Gateway. In this application, the maximum Device quantity is 200, 50 for Router, and 150 for End device. You can revise the predefine value through the Macro: MAX_ROUTER_NUM and MAX_END_DEVICE_NUM in LwIPApp.h in Gateway project. The specific configuration requirement is as below:

- End Device (LED light): 0x8000<APP_ADDRESS <0x8096
- Router (LED light): APP_ADDRESS <0x0033
- Coordinator (Gateway): APP_ADDRESS = 0x0000

The End device or Router configuration is only used for LED light.

Note that same device address (APP_ADDRESS) in same network is not allowed.

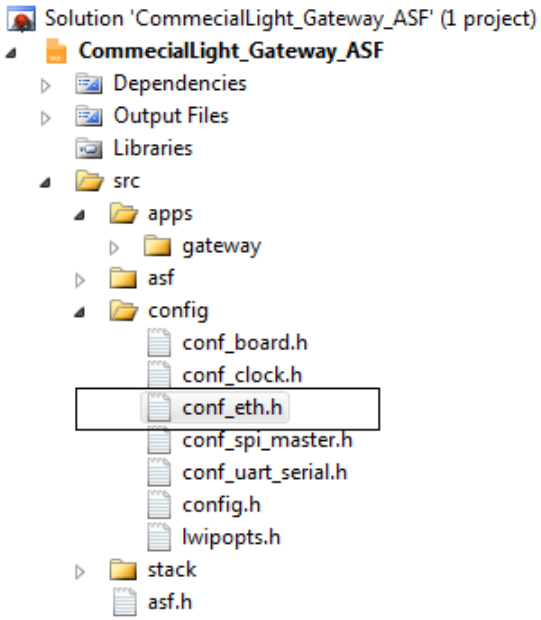
5.2 Lightweight IP Parameters Configuration

Refer to Figure 5-3 directory, open the src/apps/config/Conf_eth.h file. The MAC address, local IP address, and network mask configuration are as follows.

Note that every device must have an exclusive MAC address and local IP address in a network.

```
/** MAC address definition. The MAC address must be unique on the network. */
#define ETHERNET_CONF_ETHADDR0                          0x00
#define ETHERNET_CONF_ETHADDR1                          0x04
#define ETHERNET_CONF_ETHADDR2                          0x25
#define ETHERNET_CONF_ETHADDR3                          0x1C
#define ETHERNET_CONF_ETHADDR4                          0xA0
#define ETHERNET_CONF_ETHADDR5                          0x02

/** WAN Address: 192.168.1.50 */

/* The IP address being used. */
#define ETHERNET_CONF_IPADDR0                           192
#define ETHERNET_CONF_IPADDR1                           168
#define ETHERNET_CONF_IPADDR2                           1
#define ETHERNET_CONF_IPADDR3                           102

/** WAN gateway: 192.168.1.1 */

/*! The gateway address being used. */
#define ETHERNET_CONF_GATEWAY_ADDR0         192
#define ETHERNET_CONF_GATEWAY_ADDR1         168
#define ETHERNET_CONF_GATEWAY_ADDR2         1
#define ETHERNET_CONF_GATEWAY_ADDR3         1

/** The network mask being used. */
#define ETHERNET_CONF_NET_MASK0                         255
#define ETHERNET_CONF_NET_MASK1                         255
#define ETHERNET_CONF_NET_MASK2                         255
#define ETHERNET_CONF_NET_MASK3                         0
```

Figure 5-3. Gateway Lightweight IP Configuration



For the Server IP address and Port settings, refer to function tcp_client_init() in src/apps/gateway/LwIPApp.c file as follows.

```
static void static void tcp_client_init(void)
{
            …
            IP4_ADDR(&ipaddr,192,168,1,58);
            …
            tcp_connect(pcb, &ipaddr, 4008, tcp_client_connected);
}
```

The default Server IP address is 192.168.1.58, Port is 4008.

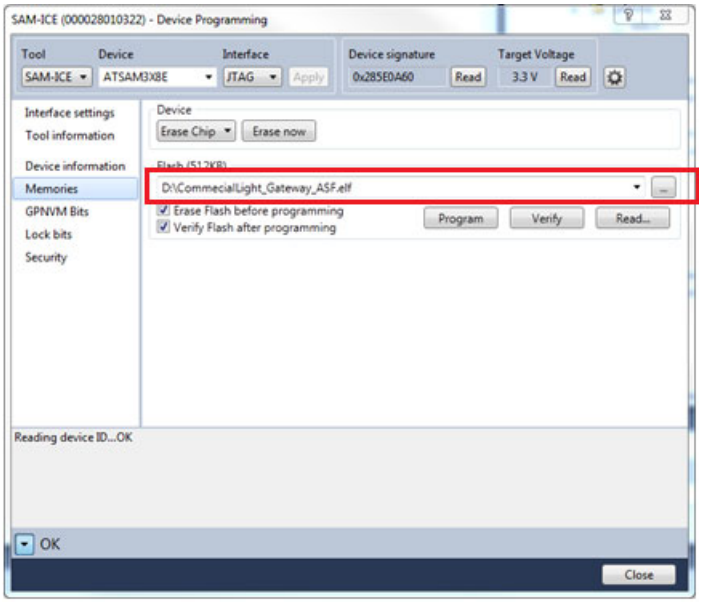
5.3 Program the Target Board

Along with this document, three .elf files are provided. Gateway (CommecialLight_Gateway_ASF.elf), LED Commercial light (CommercialLight.elf) and LED light adapter (BuckE5.elf).

To program the Gateway, SAM-ICE adaptor mentioned in Chapter 2 is needed. The steps are:

1. Connect SAM-ICE to the SAM-ICE adapter.
2. Connect SAM-ICE adapter to the Gateway programming header J2.
3. Power the Gateway via the USB cable.
4. Open Atmel Studio and select menu “Tools -> Device Programming”.
5. Choose SAM-ICE for Tool, ATSAM3X8E for Device and JTAG for Interface, and then click “Apply” button.
6. Click the Device signature “Read” button to check if the connection is correct.
7. Select the Memories tab and then select the pre-built image for the Gateway from “…” in Flash section.
8. Click Program. If the pre-built image is downloaded to the board, message “Verifying Flash…OK” appears.

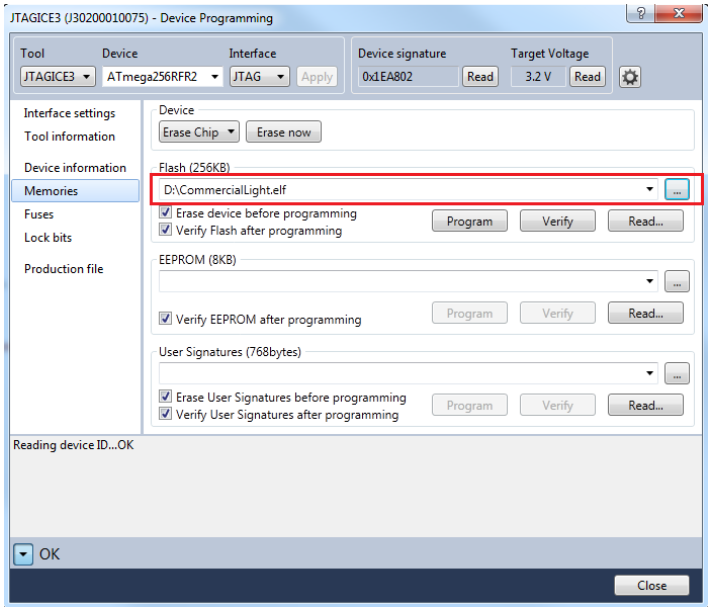
Figure 5-4. Program the Gateway



To program the LED Commercial light, the steps are:

1. Connect JTAG ICE3 adapter to the Lightweight Mesh device JTAG interface.
2. Power the JTAG ICE3 via the USB cable.
3. Open Atmel Studio and select menu “Tools -> Device Programming”.
4. Choose JTAG ICE3 for Tool, ATmega256RFR2 for Device and JTAG for Interface, and then click “Apply” button.
5. Click the Device signature “Read” button to check if the connection is correct.
6. Select the Memories tab and then select the pre-built image for the LED light device from “…” in Flash section.
7. Click Program. If the pre-built image is downloaded to the board, message “Verifying Flash…OK” appears.

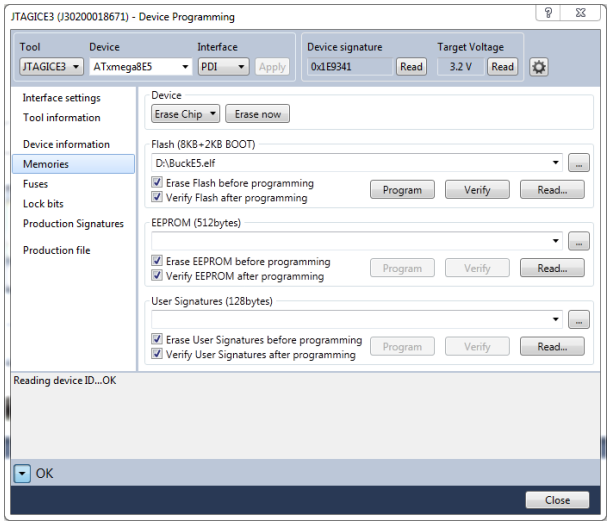
Figure 5-5. Program the LED Light



To program the LED light adapter, the steps are:

1. Connect JTAG ICE3 adapter (50-mil 6-pin) to LED light adapter PDI interface.
2. Power the JTAG ICE3 via the USB cable.
3. Open Atmel Studio and select menu “Tools -> Device Programming”.
4. Choose JTAG ICE3 for Tool, ATXmega8E5 for Device and PDI for Interface, and then click “Apply” button.
5. Click the Device signature “Read” button to check if the connection is correct.
6. Select the Memories tab and then select the pre-built image for the LED light Adapter from “…” in Flash section.
7. Click Program. If the pre-built image is downloaded to the board, message “Verifying Flash…OK” appears.

Figure 5-6. Program the LED Light Adapter



5.4 Connecting to Ethernet

In the preprogrammed firmware, the Gateway Ethernet is configured as below.

- TCP/IP client
- Server IP: 192.168.1.58
  Port: 4008
- Gateway static IP: 192.168.1.102
  Sub net mask: 255.255.255.0
  Default Gateway: 192.168.1.1

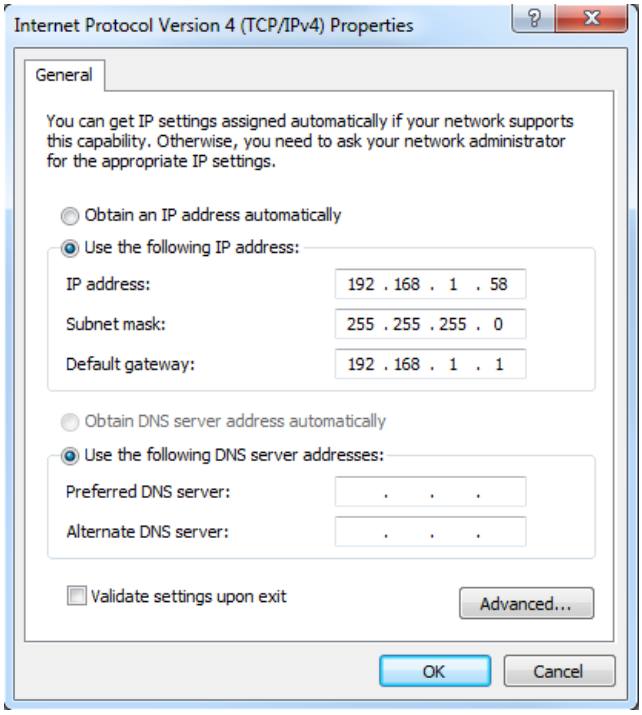
The Server IP and Port can be changed in the Gateway firmware file LwIPApp.c function tcp_client_init().

The Gateway TCP/IP client setting can be changed in file config_eth.h.

To directly connect the Gateway to PC via Ethernet, see the following steps:

1. Configure PC IP address to 192.168.1.58
   Sub net mask: 255.255.255.0
   Default Gateway: 192.168.1.1 as shown in Figure 5-7.

Figure 5-7. PC Server IP Address Configuration



2. Connect the Ethernet cable between the Gateway and the PC.
3. Power on the Gateway via the USB cable. Successful Ethernet connection is indicated by LED D6 (blink) on the Gateway.
4. Open a third party Socket tools (such as TCP/UDP Socket debug tools). Create a TCP server service and the listening Port is set to 4008. Starting listening and send command to the client after connected.

6. Application Layer Communication Introduction

6.1 Communication Method

In this application the communication includes two parts:

1. TCP/IP communication between TCP/IP Server and TCP/IP Client (Gateway).
2. Lightweight Mesh communication between Gateway (Coordinator) and LED commercial light (End device/Router).

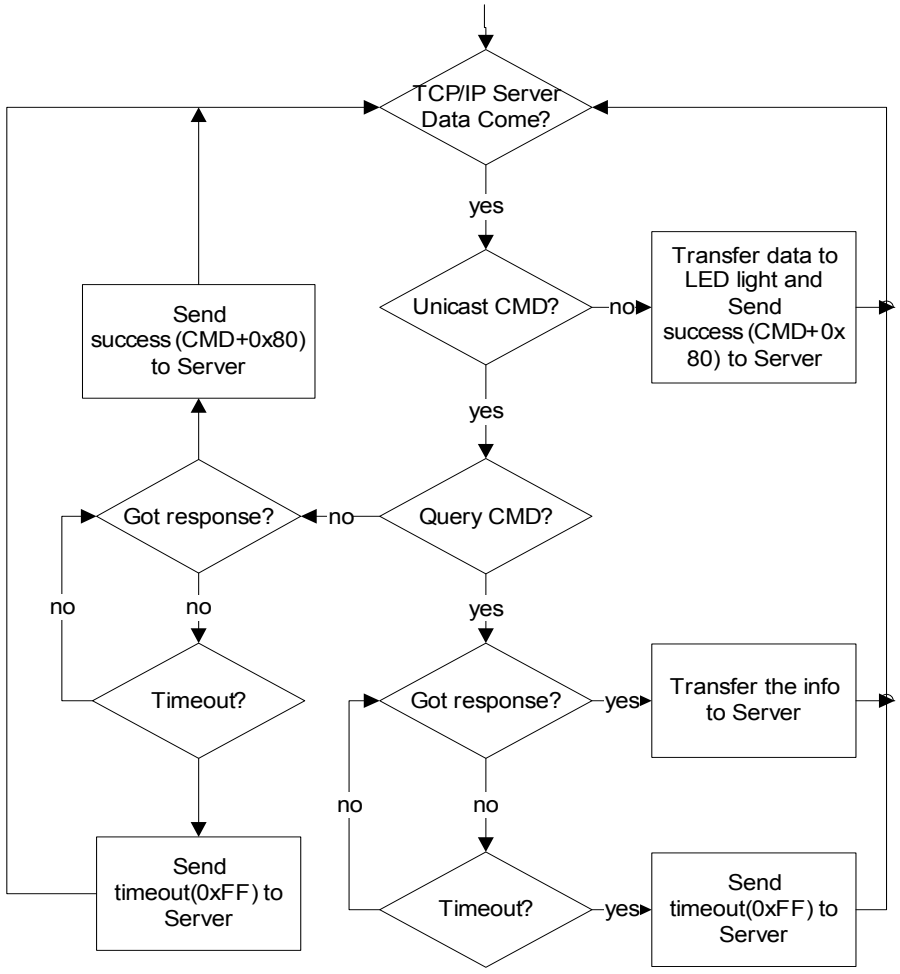
From the communication property, the command includes broadcast command and unicast command. Refer to Appendix A.2 for command property. When Gateway receives a broadcast command, it would transfer this command and responses TCP/IP Server with “success (command + 0x80)”.

When Gateway receives a unicast command, it would transfer the command and waiting for the response from LED light device based on the specific command:

1. If this is a query command, the LED light responses the specific information to Gateway, and then the Gateway transfers this information to TCP/IP Server.
2. If this is a control / configuration command, the LED light responses the Gateway with “success (command + 0x80)”, and then the Gateway responses the TCP/IP Server with “success (command + 0x80)”.

If no response from LED light for a set time, the Gateway responses TCP/IP Server with “timeout (0xFF)”.

Figure 6-1. Gateway Command Handle Flow Diagram



The lightweight IP and lightweight Mesh share the same command set and data package structure. The difference is that lightweight IP communication needs an extra data head and target address.

Note that the data length in the cell below is 8 bits.

Communication data pack definition between TCP/IP Server and TCP/IP Client (Gateway) is as below.

Table 6-1. TCP /IP Data Package Definition

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA…	DATAn-1	Checksum
0x04	0x0D								

ADDRH…L: target Device address.

LEN = n + 2

Checksum = SUM (HEAD0 …DATA) MOD 256

Communication data package definition between Gateway (Coordinator) and LED light (End device/Router) is as below.

Table 6-2. Lightweight Mesh Data Package Definition

LEN	CMD	DATA0	DATA…	DATAn-1	Checksum

LEN = n + 2

Checksum = SUM (LEN …DATA) MOD 256

6.2 Communication Command Set

6.2.1 Device Link Request (CMD_DEV_LINK_REQ)

The initiator is LED light to notice the Gateway that a LED light device is online and request link. After receives the request, the Gateway would update device link list, responses the LED light.

After LED light device received the response, the LED light would stop sending this command until the LED light waiting device information query timeout.

Note that this command only occurs between Gateway and LED light device through lightweight Mesh.

Table 6-3. Device Link Request

LEN	CMD	DATA0	DATA1	Checksum
4	0x80	0	0	

Table 6-4. Device Link Request Response

LEN	CMD	DATA0	DATA1	Checksum
4	0x00	0	0	

6.2.2 Request Command Query (CMD_CMD_QUERY_REQ)

According to the attached data content, the Gateway Request Command Query command includes three functions:

1. No command request. It is mainly for maintaining connection with TCP/IP Server.
2. Request Device Status Query. After the Gateway completely collects the device information in the list, it would send the Request Command Query command to TCP/IP Server.
3. Request Time Sync.

Table 6-5. Request Command Query

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	Checksum
0x04	0x0D	0x00	0x00	3	0x01	Request	

- Request:

  0: No command request.

  1: Request Device Status Query.

  2: Request Time Sync.

Note that this command only occurs between Gateway and TCP/IP Server through lightweight IP.

6.2.3 LED Light Grouping (CMD_LED_GROUPING)

This command is to group the single LED light for LED light group control.

Table 6-6. LED Light Grouping

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	Checksum
0x04	0x0D			3	0x04	GROUP	

- GROUP: LED light new group number.

Table 6-7. LED Light Grouping Response

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	Checksum
0x04	0x0D			3	0x84	GROUP	

6.2.4 Device Status Query (CMD_DEV_STAT_REQ)

The TCP/IP Server should send Device Status Query command after received Request Device Information Query (CMD_CMD_QUERY_REQ); the Gateway would response the connected device information according the attached data type.

Table 6-8. Device Status Query

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	Checksum
0x04	0x0D	0x00	0x00	3	0x11	Request	

- Request:

  0x00: Request Device Status.

  0x01: Request Device Link Status.

Table 6-9. Device Status Query Response (Request Device Status)

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	DATA2	DATA3
0x04	0x0D	0x00	0x00	14	0x91	0x01	GROUP	RESERVD	CTR_MODE

DATA4	DATA5	DATA6	DATA7	DATA8	DATA9	DATA10	DATA11	Checksum
ALARML	ALARMH	TEMPL	TEMPH	DIM0	DIM1	DIM2	DIM3	

- GROUP: Current device group number
- CTR_MODE: Current device LED control Mode

  0x00: LED light manual control through sending LED control command.

  0x01: Timing control through sending timing setting and control command.

  0x02: Autonomously controlled by on-board light sensor.

- ALARM: Alarm information report, reserved in this application
- TEMP: Device temperature in 0.1K
- DIMx: Channel x dimming value in percent

Table 6-10. Device Status Query Response (Request Device Link Status)

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	Checksum
0x04	0x0D	0x00	0x00	4	0x91	0x00	CONN	

- CONN:

  0x00: Disconnected.

  0x01: Connected.

6.2.5 Single LED Control (CMD_LED_SINGLE_CTRL)

Table 6-11. Signal LED Control

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	DATA2	DATA3	DATA4	Checksum
0x04	0x0D			7	0x20	CTR_MODE	DIM0	DIM1	DIM2	DIM3	

- CTR_MODE: Current device LED control Mode

  0x00: LED light manual control through sending LED control command.

  0x01: Enable timing control.

  0x02: Autonomously controlled by on-board light sensor.
- DIMx: Channel x dimming value in percent

Table 6-12. Single LED Control Response

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	Checksum
0x04	0x0D			2	0xA0	

6.2.6 Group LED Control (CMD_LED_ GROUP_CTRL)

Table 6-13. Group LED Control

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	DATA2	DATA3	DATA4
0x04	0x0D	0x00	0x00	8	0x21	GROUP	CTR_MODE	DIM0	DIM1	DIM2

DATA5	Checksum
DIM3	

- GROUP: Target device group number.
- CTR_MODE: Current device LED control Mode

  0x00: LED light manual control through sending LED control command.

  0x01: Enable group timing control.

  0x02: Autonomously controlled by on-board light sensor.
- DIMx: Channel x dimming value in percent

6.2.7 Time Synchronization (CMD_TIME_SYNC)

Table 6-14. Time Synchronization

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	DATA2	DATA3	DATA4
0x04	0x0D	0x00	0x00	8	0x40	YEAR	MONTH	DAY	HOUR	MINUTE

DATA5	Checksum
SECOND	

The LED light integrates an onboard calendar; this command is used to update LED light system time.

6.2.8 Single LED Timing Set (CMD_ LED _SINGLE_TIMING_SET)

Table 6-15. Single LED Timing Set

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	DATA2	DATA3
0x04	0x0D	0x00	0x00	9	0x41	CTR_MODE	HOUR_ON	MINUTE_ON	SECOND_ON

DATA4	DATA5	DATA5	Checksum
HOUR_OFF	MINUTE_OFF	SECOND_OFF	

The single LED timing would take effect when the CTR_MODE = 0x01(Timing Control Mode).

6.2.9 Group LED Timing Set (CMD_ LED _GROUP_TIMING_SET)

Table 6-16. Group LED Timing Set

HEAD0	HEAD1	ADDRH	ADDRL	LEN	CMD	DATA0	DATA1	DATA2	DATA3
0x04	0x0D	0x00	0x00	10	0x42	GROUP	CTR_MODE	HOUR_ON	MINUTE_ON

DATA4	DATA5	DATA6	DATA7	Checksum
SECOND_ON	HOUR_OFF	MINUTE_OFF	SECOND_OFF	

The Group LED timing would take effect when the CTR_MODE = 0x01(Timing Control Mode).

Appendix A. Additional Information

A.1 Lightweight Mesh Configuration

Table A-1 lists the Lightweight Mesh Software Stack configuration used in this reference design and this configuration can be modified in src/config/config.h.

Table A-1. Lightweight Mesh Options

Option	Value	Description
APP_ADDR		Node network address. It should be 0 for the Gateway; 0x0001 to 0x0032 for Router; 0x8001 to 0x8096 for End device.
APP_CHANNEL	0x0D	Radio transceiver channel. Valid range for 2.4GHz radios is 11 – 26 (0x0B – 0x1A)
APP_PAN_ID	0x1234	Network identifier (0-65535)
APP_ENDPOINT	1	Application main data communication endpoint (0-16)
NWK_BUFFERS_AMOUNT	3	Number of buffers reserved for stack operation

A.2 Application Communication Command Set

Table A-2. Command Set

No	CMD	Value	Property	Description
1	CMD_DEV_LINK_REQ	0x00	Unicast	Only for lightweight Mesh layer communication
2	CMD_CMD_QUERY_REQ	0x01	Unicast	Only for TCP/IP layer communication
3	CMD_LED_GROUPING	0x04	Unicast	
4	CMD_DEV_STAT_REQ	0x11	Unicast	Only for lightweight Mesh layer communication
5	CMD_LED_ SINGLE _CTRL	0x20	Unicast	
6	CMD_LED_ GROUP_CTRL	0x21	Broadcast	
7	CMD_TIME_SYNC	0x40	Broadcast	
8	CMD_ LED _SINGLE_TIMMING_SET	0x41	Unicast	
9	CMD_ LED _GROUP_TIMMING_SET	0x42	Broadcast	

Appendix B. Revision History

Doc. Rev.	Date	Comments
42236A	02/2014	Initial document release

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