RAK439 Porting Manual V1.2

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Content

1. Hardware Platform Resources

The required resources of MCU peripheral are as follows:

- one SPI Interface
- one external interrupt pin
- one reset module pin
- one control module power switch pin (optional)
- one upward counter to handle time-out of internal driver

The memory of RAK439 driver library without OS are occupied as below:

- Flash takes up about 35K bytes
- RAM
  Global variables, static variables: 740 bytes
  Stack: allocate at least 4K bytes (one RX buffer, one socket buffer, four scan buffers)

2. Driver Library Parameters

2.1 Indroduction of Driver Library Parameters

```
typedef struct
{
    bool  spi_int_enable;          // customer can choose enable or disenable spi int event
                                   // driver
    uint8_t rx_queue_num;          // rx buffer queue num >= 1
    uint8_t socket_max_num;        // module support socket numbers max 8
    uint8_t scan_max_num;          // scan result buffer numbers normal : 10 if you need more
                                   // can raise it
    uint8_t tcp_retry_num;         // tcp backoff retry numbers
    char*    host_name;            // module host name ,you can see it in router clients when
                                   // DHCP success
    char*    country_code;         // set module country code ,CN (1-13),JS(1-14),UP(1-11)
    struct   driver_cb_ driver_cb; // platform related driver used
    struct   app_cb_ app_cb;       // application related callback info
}rw_DriverParams_t;
```

Parameter Description:

- spi_int_enable：when not use os, if set spi_int_enable true, present the module have enabled the external irq, so mcu must connect to the module's irq pin; if set spi_int_enable false, present the module have disabled the external irq, so mcu must not connect to the module's irq pin. When use os, the module use external irq pin forcibly.

- rx_queue_num: number of RX buffer >= 1, one RX buffer is 1664 bytes, driver allocates memory from heap when RAK439 load drivers (execute rw_sysDriverInit) , release memory when uninstall the drivers (execute rw_sysDriverDeinit).
- socket_max_num: number of socket, maximum is 8, one socket buffer is 48 bytes, driver allocates memory from heap when RAK439 load drivers (execute rw_sysDriverInit) , release memory when uninstall the drivers (execute rw_sysDriverDeinit).
- scan_max_num: the number of scanned buffer, at least four. One scan buffer is 44 bytes, in STA mode, when RAK439 is connecting to the router (execute rw_wlanConnect) driver will allocate memory from heap, and release memory after connection; when user application scans (execute rw_wlanNetworkScan), driver will allocate memory from heap, but does not release memory, so users need to manually release the memory after the scaninfo is useless.
- tcp_retry_num：tcp retransmission max time interval is $2^{tcp_retry_num+1}$s。
- host_name: after DHCP , the hostname displayed in router client list
- country_code: module country code, CN (1-13)，JP(1-14)，US(1-11)
- driver_cb: platform dependent interface
- app_cb: application callback interface

2.2 Platform Dependent Interface

Users implemente the interfaces in the application for RAK439 driver to call

```
struct driver_cb_
{
    rw_HwInit_          hw_init;
    rw_HwInit_          hw_deinit;
    rw_PowerUpDown_     hw_power;
    rw_Malloc_          driver_malloc;
    rw_Free_            driver_free;
    rw_TimeDelay_       time_delay;
    rw_Stamp_           Stamp_get;
    rw_ToggleIrq_       toggle_irq;
    rw_SpiIoBuffer_     spi_io_buffer;
    rw_AssertFunc_      driver_assert;
};
```

2.2.1. hw_init

```
hw_init   Type typedef uint32_t(*rw_HwInit_)( void )
```

Return Value

SPI clock

Description

Hardware interface initialization -

Initialize the pin that controls RAK439 power switch (optional);

Initialize the pin that resets RAK439;

Initialize SPI interface;

Initialize external interrupt pin.

This function is to be called when RAK439 loads drivers (execute rw_sysDriverInit).

2.2.2. hw_deinit

```
hw_deinit   Tpye typedef uint32_t(*rw_HwInit_)( void )
```

Return Value

N/A

Description

Hardware interface deinitialization -

Close SPI clock.

This function is to be called when RAK439 uninstalls drivers (executen rw_sysDriverDeinit) or reset drives (execute rw_sysDriverReset).

2.2.3. hw_power

```
hw_power   Type typedef void(*rw_PowerUpDown_)( uint8_t status )
```

Parameter

[in] **status** 0: power off; 1: power on

Return Value

N/A

Description

Module RAK439 powers on and resets, powers off and resets

Power on and reset – lower RAK439 power switch pin (optional); pull up RAK439 reset pin.

Power off and reset – pull up RAK439 power switch (optional); lower RAK439 reset pin.

2.2.4. driver_malloc

```
driver_malloc   Type typedef void*(*rw_Malloc_)( uint32_t size )
```

Parameter

[in] **size** Memory size to be allocated

Return Value

Point to the pointer that allocates memory

Description

To allocate memory

2.2.5. driver_free

```
driver_free   Type typedef void(*rw_Free_)( void* data )
```

Parameter

[in] **data** Point to the memory to be freed

Return Value

N/A

Description

To free memory

2.2.6. time_delay

```
time_delay   Type typedef void(*rw_TimeDelay_)( int ms )
```

Parameter

[in] **ms** Delay in ms

Return Value

N/A

Description

Delay function

2.2.7. Stamp_get

```
Stamp_get   Type typedef rw_stamp_t(*rw_Stamp_)( void )
```

Return Value

rw_stamp_t --uint32_t

Description

Get the current tick number, unit is ms, RAK439 driver will use this function to determine the timeout.

2.2.8. toggle_irq

```
toggle_irq   Type typedef void(*rw_ToggleIrq_)( uint8_t enable )
```

Parameter

[in] **enable** 1: Enable external interrupt 0: Disable external interrupt

Return Value

N/A

Description

Enable, disable external interrupt

2.2.9. spi_io_buffer

```
spi_io_buffer   Type typedef void(*rw_SpiIoBuffer_)( uint8_t* write,
                                                      uint8_t* read,
                                                      uint16_t len )
```

Parameter

[in] **write** Write data to RAK439 module

[out] **read** Read data from RAK439 module

[in] **len** Data length

Return Value

N/A

Description

MCU transmits data with module RAK439 through SPI interface

When read = NULL, write ! = NULL when, MCU writes data to RAK439;
When read ! = NULL, write = NULL, MCU reads data from RAK439;
When read! = NULL, write! = NULL, MCU reads and writes data.

2.2.10. driver_assert

```
driver_assert   Type  typedef void(*rw_AssertFunc_)( const char* file,
                                                      int line );
```

Parameter

[out] **file** Error file

[out] **line** The line where the error is

Return Value

N/A

Description

Print the error information from wifi driver

2.3 Application Callback Interface

The callback event that RAK439 driver returns to user application

```
struct app_cb_
{
    rw_WlanConnEvent_   conn_cb;
    rw_WlanScan_        scan_cb;
    rw_WlanEasyWps_     easy_wps_cb;
    rw_IpDhcp_          dhcp_cb;
    rw_DnsResult_       dns_cb;
};
```

2.3.1. conn_cb

```
conn_cb   Type typedef void(*rw_WlanConnEvent_)( uint8_t event,
                                                 rw_WlanConnect_t* wlan_info,
                                                 RW_DISCONNECT_REASON dis_reasoncode )
```

Parameter

[out] **event** callback event type

CONN_STATUS_STA_CONNECTED conntected to router successfully

CONN_STATUS_STA_DISCONNECT disconnected to router

CONN_STATUS_AP_ESTABLISH created AP successfully

CONN_STATUS_AP_CLT_CONNECTED client is connected to AP

CONN_STATUS_AP_CLT_DISCONNECT client is disconnected to AP

[out] **wlan_info** Router information, including bssid, channel, ssid, passwords, encryption methods.

[out] **dis_reasoncode** Network disconnection reason

Return Value

N/A

Description

callback of wlan connection event

2.3.2. scan_cb

```
scan_cb   Type typedef void(*rw_WlanScan_)( rw_WlanNetworkInfoList_t* scan_info )
```

Parameter

[out] **scan_info** router information scanned

Return Value

N/A

Description

Scan event callback. After the scanned information has been processed in callback function free the corresponding memory.

2.3.3. easy_wps_cb

```
easy_wps_cb   Type typedef void(*rw_WlanEasyWps_)( rw_WlanEasyConfigWpsResponse_t
                                                    *pResponse, int status)
```

Parameter

[out] **pResponse** Save the acquired router information

[out] **status** easyconfig or WPS succeed or not

Return Value

N/A

Description

easyconfig or WPS event callbacks

2.3.4. dhcp_cb

```
dhcp_cb   Type typedef void(*rw_IpDhcp_)( rw_IpConfig_t* addr,
                                           int status )
```

Parameter

[out] **addr** Save the acquired IP information

[out] **status** IP acquired successfully or not

Return Value

N/A

Description

dhcp connection event callback

2.3.5. dns_cb

```
dns_cb   Type typedef void(*rw_DnsResult_) ( int dnsIp )
```

Parameter

[out] **dnsIp** IP address got via DNS

Return Value

N/A

Description

DNS event callback

3. Introduction of Driver Library OS Interface

3.1 Task Interface

3.1.1. rw_creat_task

```
void* rw_creat_task(RW_OS_TASK_PTR p_task)
```

Parameter

[in] **p_task** Function pointer, pointing to the task to be created

Return Value

pointer, pointing to task handle

Description

Task creating function

3.1.2. rw_del_task

```
int rw_del_task(void* p_tcb)
```

Parameter

[in] **p_tcb** task handle

Return Value

RW_OS_OK

RW_OS_ERROR

Description

Task deleting function

3.2 Mutex Interface

3.2.1. rw_creat_mutex

```
void* rw_creat_mutex(void)
```

Parameter

N/A

Return Value

Pointing to the pointer of created mutex

Description

Mutex creating function

3.2.2. rw_del_mutex

```
int rw_del_mutex(void* p_mutex)
```

Parameter

[in] **p_mutex** pointing to the pointer of mutex

Return Value

RW_OS_OK

RW_OS_ERROR

Description

Mutex deleting function

3.2.3. rw_lock_mutex

```
int rw_lock_mutex (  void* p_mutex,
                     uint32_t timeout
                   )
```

Parameter

[in] **p_mutex** pointing to the pointer of mutex

[in] **timeout** block timeout: 0 presents wait forever

Return Value

RW_OS_OK

RW_OS_ERROR

Description

Mutex lock function

3.2.4. rw_unlock_mutex

```
int rw_unlock_mutex(void* p_mutex)
```

Parameter

[in] **p_mutex** pointing to the pointer of mutex

Return Value

RW_OS_OK

RW_OS_ERROR

Description

Mutex unlock function

3.3 Semaphore Interface

3.3.1. rw_creat_sem

```
void* rw_creat_sem(void)
```

Parameter

N/A

Return Value

pointing to the semaphore to be created

Description

Semaphore creating function

3.3.2. rw_del_sem

```
int rw_del_sem(void* p_sem)
```

Parameter

[in] **p_sem** pointing to the pointer of semaphore

Return Value

RW_OS_OK

RW_OS_ERROR

Description

Semaphore deleting function

3.3.3. rw_post_sem

```
int rw_post_sem(void* p_sem)
```

Parameter

[in] **p_sem** pointing to the pointer of semaphore

Return Value

RW_OS_OK

RW_OS_ERROR

Description

Semaphore releasing function

3.3.4. rw_pend_sem

```
int rw_pend_sem ( void* p_sem,
                  uint32_t timeout
                )
```

Parameter

[in] **p_sem** pointing to the pointer of semaphore

[in] **timeout** block timeout: 0 presents wait forever

Return Value

RW_OS_OK

RW_OS_TIME_OUT

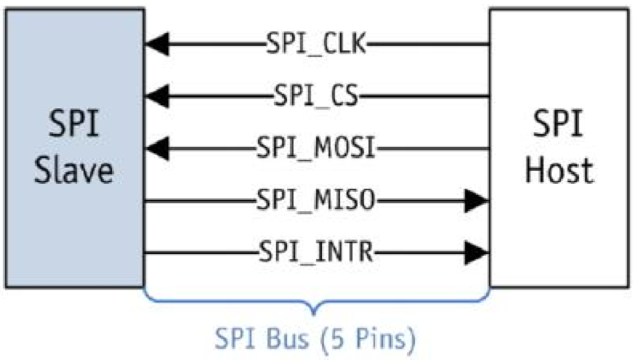
RW_OS_ERROR

Description

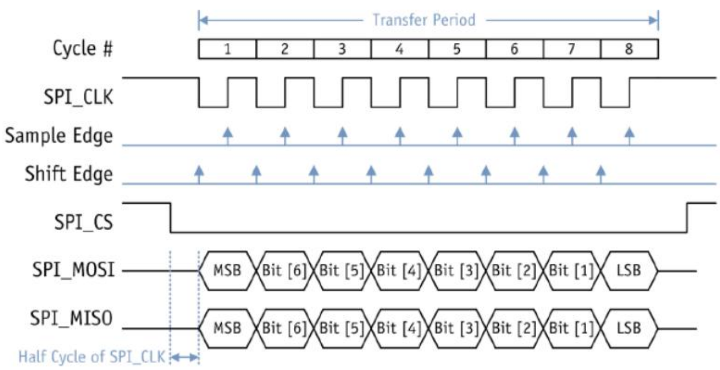
Semaphore blocking function

4. RAK439 SPI Interface

The SPI interface of SPI Host and RAK439 are as shown below:



SPI Timing:



SPI Description:

- SPI clock is with maximum 24Mhz.

- Module is in SPI slave mode.
- SPI transfer order is MSB first (MSB).
- When SPI clock is idle, power level is high, the polarity is 1 (CPOL = 1); send data on the SPI clock rising edge (SPI_MOSI), send data on the falling edge (SPI_MISO), the phase is 1 (CHPA = 1).
- Data length of SPI transmit is 8 bit

When call rw_sysDriverInit function, the start of the spi data：

```
send=44 recv=b4
send=0 recv=b4
send=0 recv=b4
send=80 recv=b4
send=c2 recv=b4
send=0 recv=b4
send=0 recv=c
send=0 recv=5b
```

receive 5b presents spi interface is working properly, a poor contact of spi interface or power supply shortage will make the mcu can not receive 5b.

The front 7 bytes that different modules received may be different, but a same module received the 7 bytes is same every time.

The above data will not print by default in project. When debugging you can enable the print by modify the _spi_io_buffer function in below:

```
static void _spi_io_buffer(uint8_t* write, uint8_t* read, uint16_t len)
{
    uint8_t   dummy;
    int       i = 0;

    SPI_SetSS(WIFI_SPI, SPI_SS0);
#ifdef RW_SPI_DMA

#else
    if (read == NULL){
      for (i = 0; i < len; i++) {
        while (WIFI_SPI->STATUS & SPI_STATUS_TX_FULL);
        WIFI_SPI->TX0 = write[i];
//    printf("send=%x      ",write[i]);
        while (WIFI_SPI->STATUS & SPI_STATUS_RX_EMPTY);
        dummy = WIFI_SPI->RX0;
//    printf("recv dummy=%x\r\n",dummy);
      }
    } else {
      for (i = 0; i < len; i++) {
        while (WIFI_SPI->STATUS & SPI_STATUS_TX_FULL);
        if (write == NULL) {
          WIFI_SPI->TX0 = dummy;
//    printf("send dummy=%x  ",dummy);
        } else {
          WIFI_SPI->TX0 = write[i];
//     printf("send=%x  ",write[i]);
        }
        while (WIFI_SPI->STATUS & SPI_STATUS_RX_EMPTY);
        read[i] = WIFI_SPI->RX0;
//    printf("recv=%x\r\n",read[i]);
      }
    }
#endif

    SPI_ClrSS(WIFI_SPI, SPI_SS0);
}
```

5. RAK439 External Interrupt

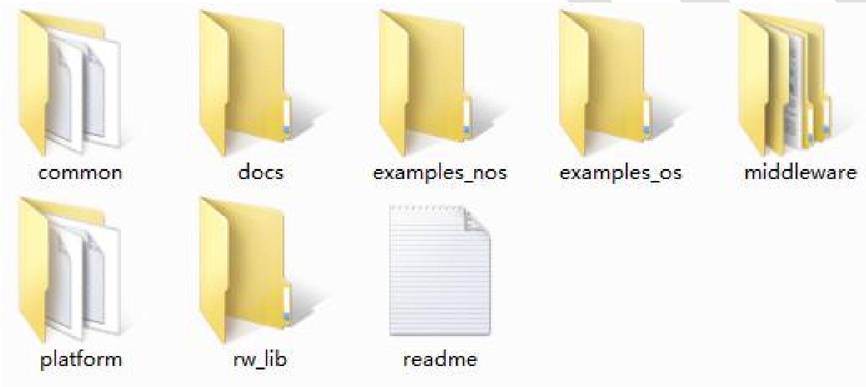
The external interrupt pin is set to be enabled by falling edge

6. STM32F4 Platform Porting Example

6.1 Software Package Introduction

In this Porting, the MCU is stm32f411, stm32 library is STM32F4xx_StdPeriph_Driver, version V1.5.0.

The package migrated is RAK439_STM32F4xx_SDK_1_0_0, the folders are as shown below:

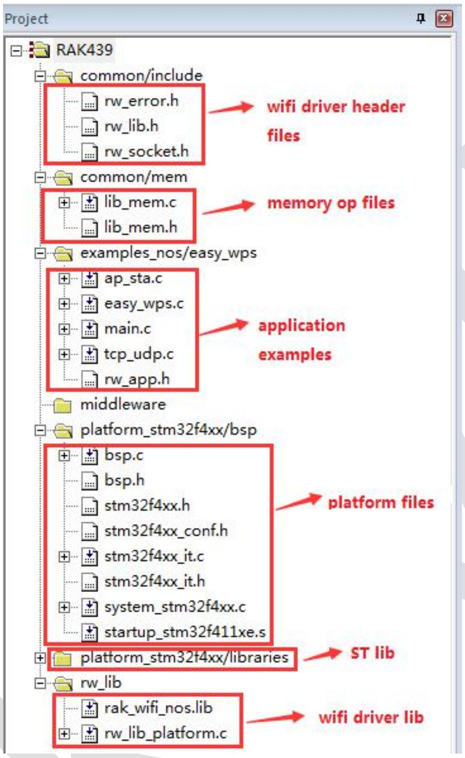


/common	Files in the folder are platform-independent.
/common/include	This folder is the error code header, Wi-Fi driver library header , socket header
/common/mem	This folder is a memory operation program。
/common/rw_os	This folder is interface program of Wi-Fi driver library OS.
/docs	This folder includes the related software documents.
/examples_nos	non-OS sample program in this folder, support KEIL and IAR.
/examples_os	OS sample program in this folder, support KEIL and IAR
/middleware	separate middleware code, including FreeRTOS, PolarSSL etc.
/platform/bsp	non-OS , platform-dependent files
/platform/bsp_os	OS , platform-dependent files.
/platform/ST	ST standard library
/platform/rw_lib_platform.c	non-OS, the interface between Wi-Fi driver library and hardware platforms
/platform/rw_lib_platform_os.c	OS, the interface between Wi-Fi driver library and hardware platforms

/rw_lib Wi-Fi driver library file

6.2 Porting Steps in Non-OS

Below is example program in non-OS:



File rw_lib_platform.c is the interface between RAK439 driver library file the hardware platform, it is critical file to the Porting.

void wifi_init_params (rw_DriverParams_t * params) - This function is responsible for initializing RAK439 drive parameters, including the hardware interface function, time management function, memory management function, RAK439 callback function and system operating parameters.

```
void wifi_init_params(rw_DriverParams_t* params)
{
    // Hardware interface function
    params->driver_cb.hw_init = _init_interface;           // Initialize GPIO, SPI,
external interruption
    params->driver_cb.hw_deinit = _deinit_interface;       // SPI deinitialization - Close
SPI clock
    params->driver_cb.hw_power = _power_up_down;           //power on, power off
    params->driver_cb.spi_io_buffer = _spi_io_buffer;      // SPI host transmits data with
WiFi module
    params->driver_cb.toggle_irq = _ext_interrupt;         // External interruption On,
Off
```

```
    // Time management function
    params->driver_cb.time_delay = delay_ms;              // Delay function
    params->driver_cb.Stamp_get = get_stamp;              // Get System Time

    // Memory management function
    params->driver_cb.driver_free = vPortFree;            // Release memory
    params->driver_cb.driver_malloc = pvPortMalloc;       // Allocate memory

    //wifi callback funtion
    params->app_cb.conn_cb = connect_callback;            // callback event of connecting
to router
    params->app_cb.scan_cb = scan_callback;               // Scan callback event
    params->app_cb.dhcp_cb = ip_callback;                 //Get IP callback event
    params->app_cb.dns_cb = dns_ipcallback;               //dns callback
    params->app_cb.easy_wps_cb = wps_easy_callback;       //WPS, easyconfig callback
events
    params->app_cb.tcpc_cb = tcpclient_callback;          //tcp callback event

    // System operating parameters setup
    params->rx_queue_num = 1;            // number of receive data buffer
    params->scan_max_num = 10;           // number of scan buffer
    params->socket_max_num = 8;          //number of socket buffer
    params->country_code = "CN";         // Module country code, CN (1-13), JP(1-14),
                                                          US(1-11)
    params->host_name = "rakmodule";    // After DHCP, the host name of module displayed
                                        in the router client list
}
```

- memory management function, Wi-Fi callback function, system operating parameters settings is independent with hardware platform, users can use the default settings.
- Time management function will be implemented according to different hardware platforms. Single-chip of stm32f411 in this Porting comes with a 24 systick, the API that operates this systick also in ST library; users can refer to the Porting.
- hardware interface function is associated with hardware platform, is also the most important part of the Porting. The following will detail the various hardware interface functions.

6.2.1. hw_init Implementation

GPIO, SPI, external interrupt initialization

```
static uint32_t _init_interface(void)
```

```
{
  WIFI_GPIO_Init();           // Initialize Wi-Fi module power switch pins (optional), reset
pin, SPI chip select pin
  WIFI_SPI_Init ();           // Initialize SPI Host
  WIFI_INT_Init ();           // Initialize the external interrupt pin connected with Wi-Fi
module
}
```

1. GPIO pin Initialization - Initialize WiFi module power switch pins (optional), reset pin, SPI chip select pin.

```
void WIFI_GPIO_Init(void)
{
  GPIO_InitTypeDef  GPIO_InitStructure;
  /* GPIOA GPIOB Peripheral clock enable */
  RCC_AHB1PeriphClockCmd(WIFI_PWD_GPIO_CLK|WIFI_CS_GPIO_CLK, ENABLE);   // Enable GPIO
Clock /* Initialize Wi-Fi module power switch pin, optional */
#if defined (USE_WIFI_POWER_FET)
  RCC_AHB1PeriphClockCmd(WIFI_FET_GPIO_CLK, ENABLE);
  GPIO_InitStructure.GPIO_Pin = WIFI_FET_PIN;
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_OUT;
  GPIO_InitStructure.GPIO_OType = GPIO_OType_PP;
  GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;
  GPIO_InitStructure.GPIO_PuPd = GPIO_PuPd_UP;
  GPIO_Init(WIFI_FET_GPIO_PORT, &GPIO_InitStructure);
  GPIO_WriteBit(WIFI_FET_GPIO_PORT, WIFI_FET_PIN, Bit_SET);
#endif
  /* Initialize reset pin */
  GPIO_InitStructure.GPIO_Pin = WIFI_PWD_PIN;
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_OUT;
  GPIO_InitStructure.GPIO_OType = GPIO_OType_PP;
  GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;
  GPIO_InitStructure.GPIO_PuPd = GPIO_PuPd_UP;
  GPIO_Init(WIFI_PWD_GPIO_PORT, &GPIO_InitStructure);
  GPIO_WriteBit(WIFI_PWD_GPIO_PORT, WIFI_PWD_PIN, Bit_RESET);
  /* Initialize SPI chip select pin */
  GPIO_InitStructure.GPIO_Pin = WIFI_CS_PIN;
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_OUT;
  GPIO_InitStructure.GPIO_OType = GPIO_OType_PP;
  GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;
  GPIO_InitStructure.GPIO_PuPd = GPIO_PuPd_NOPULL;
  GPIO_Init(WIFI_CS_GPIO_PORT, &GPIO_InitStructure);
  GPIO_WriteBit(WIFI_CS_GPIO_PORT, WIFI_CS_PIN, Bit_SET);
```

```
}
```

2. SPI host initialization

SPI Initialization: configuration as SPI master, full-duplex mode, CHPA = 1 CPOL = 1, 8-bit data transfer, descending bit order.

```
void SPI1_Config(void)
{
  GPIO_InitTypeDef GPIO_InitStructure;
  SPI_InitTypeDef  SPI_InitStructure;
  /*!< Enable the SPI clock */
  WIFI_SPI_CLK_INIT(WIFI_SPI_CLK, ENABLE);
  /*!< Enable GPIO clocks */
  RCC_AHB1PeriphClockCmd(WIFI_SPI_SCK_GPIO_CLK | WIFI_SPI_MISO_GPIO_CLK |
                        WIFI_SPI_MOSI_GPIO_CLK , ENABLE);
  /*!< SPI pins configuration *************************************************/
  /*!< Connect SPI pins to AF */
  GPIO_PinAFConfig(WIFI_SPI_SCK_GPIO_PORT, WIFI_SPI_SCK_SOURCE, WIFI_SPI_SCK_AF);
  GPIO_PinAFConfig(WIFI_SPI_MISO_GPIO_PORT, WIFI_SPI_MISO_SOURCE, WIFI_SPI_MISO_AF);
  GPIO_PinAFConfig(WIFI_SPI_MOSI_GPIO_PORT, WIFI_SPI_MOSI_SOURCE, WIFI_SPI_MOSI_AF);
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_AF;
  GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;
  GPIO_InitStructure.GPIO_OType = GPIO_OType_PP;
  GPIO_InitStructure.GPIO_PuPd  = GPIO_PuPd_DOWN;
  /*!< SPI SCK pin configuration */
  GPIO_InitStructure.GPIO_Pin = WIFI_SPI_SCK_PIN;
  GPIO_Init(WIFI_SPI_SCK_GPIO_PORT, &GPIO_InitStructure);
  /*!< SPI MOSI pin configuration */
  GPIO_InitStructure.GPIO_Pin =  WIFI_SPI_MOSI_PIN;
  GPIO_Init(WIFI_SPI_MOSI_GPIO_PORT, &GPIO_InitStructure);
  /*!< SPI MISO pin configuration */
  GPIO_InitStructure.GPIO_Pin =  WIFI_SPI_MISO_PIN;
  GPIO_Init(WIFI_SPI_MISO_GPIO_PORT, &GPIO_InitStructure);
  /*!< SPI configuration */
  SPI_InitStructure.SPI_Direction = SPI_Direction_2Lines_FullDuplex;     // Full-duplex
mode
  SPI_InitStructure.SPI_Mode = SPI_Mode_Master;                          // Host Mode
  SPI_InitStructure.SPI_DataSize = SPI_DataSize_8b;                      //8 bit data
transfer
  SPI_InitStructure.SPI_CPOL = SPI_CPOL_High;                            //CPOL=1
  SPI_InitStructure.SPI_CPHA = SPI_CPHA_2Edge;                           //CPHA=1
  SPI_InitStructure.SPI_NSS = SPI_NSS_Soft;
  SPI_InitStructure.SPI_BaudRatePrescaler = SPI_BaudRatePrescaler_4;    //96M/4
```

```
  SPI_InitStructure.SPI_FirstBit = SPI_FirstBit_MSB;                   //first bit
  SPI_InitStructure.SPI_CRCPolynomial = 7;
  SPI_Init(WIFI_SPI, &SPI_InitStructure);
  /*!< Enable the WIFI_SPI  */
  SPI_Cmd(WIFI_SPI, ENABLE);}                                           //enable SPI1
```

3. External interrupt pin initialization

```
void WIFI_INT_Init (void)
{
  EXTI_InitTypeDef   EXTI_InitStructure;
  GPIO_InitTypeDef   GPIO_InitStructure;
  NVIC_InitTypeDef   NVIC_InitStructure;
  /* Enable GPIOB clock */
  RCC_AHB1PeriphClockCmd(RCC_AHB1Periph_GPIOB, ENABLE);
  /* Configure PB0 pin as input floating */
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_IN;
  GPIO_InitStructure.GPIO_PuPd = GPIO_PuPd_NOPULL;
  GPIO_InitStructure.GPIO_Pin = WIFI_INT_PIN;
  GPIO_Init(WIFI_INT_GPIO_PORT, &GPIO_InitStructure);
  /* Enable SYSCFG clock */
  /* Connect EXTI Line0 to PB0 pin */
  RCC_APB2PeriphClockCmd(RCC_APB2Periph_SYSCFG, ENABLE);
  SYSCFG_EXTILineConfig(WIFI_INT_GPIO_EXTI_PORT, WIFI_INT_EXTI_PIN_SOURCE);
  /* Configure EXTI Line0 */
  EXTI_InitStructure.EXTI_Line = WIFI_INT_EXTI_LINE;
  EXTI_InitStructure.EXTI_Mode = EXTI_Mode_Interrupt;
  EXTI_InitStructure.EXTI_Trigger = EXTI_Trigger_Falling;
  EXTI_InitStructure.EXTI_LineCmd = ENABLE;
  EXTI_Init(&EXTI_InitStructure);
  /* Enable and set EXTI Line0 Interrupt to the lowest priority */
  NVIC_InitStructure.NVIC_IRQChannel = WIFI_INT_EXTI_IRQN;
  NVIC_InitStructure.NVIC_IRQChannelPreemptionPriority = 0x00;
  NVIC_InitStructure.NVIC_IRQChannelSubPriority = 0x00;
  NVIC_InitStructure.NVIC_IRQChannelCmd = ENABLE;
  NVIC_Init(&NVIC_InitStructure);
}
```

4. External interruption service program

```
void EXTI0_IRQHandler(void)
{
```

```
  if(EXTI_GetITStatus(WIFI_INT_EXTI_LINE) != RESET)
  {
    /* Clear the EXTI line 0 pending bit */
    EXTI_ClearITPendingBit(WIFI_INT_EXTI_LINE);
    DRIVER_INT_HANDLE();                // This function is implemented in rak_wifi_nos.lib
  }
}
```

6.2.2. spi_io_buffer Implementation

SPI host transmits data with RAK439 via SPI for function implementation

```
static void _spi_io_buffer(uint8_t* write, uint8_t* read, uint16_t len)
{
  uint32_t i;
  uint8_t dummy;
  uint8_t recv;
  GPIO_WriteBit(WIFI_CS_GPIO_PORT, WIFI_CS_PIN, Bit_RESET);// Lower SPI chip select,
select RAK439 module
  if(read == NULL) {
    for(i=0;i<len;i++) {
      while((WIFI_SPI->SR&SPI_FLAG_TXE)==RESET);
      if(write == NULL) {
        WIFI_SPI->DR = dummy;
      }else {
        WIFI_SPI->DR = write[i];                  // write is not empty, write data to RAK439
      }
      while((WIFI_SPI->SR&SPI_FLAG_RXNE)==RESET);
      recv = WIFI_SPI->DR;
    }
  }
  else {                                          // read is not empty, read data from RAK439
    for(i=0;i<len;i++) {
      while((WIFI_SPI->SR&SPI_FLAG_TXE)==RESET);
      if(write == NULL) {
        WIFI_SPI->DR = dummy;
      }else {
        WIFI_SPI->DR = write[i];
      }
      while((WIFI_SPI->SR&SPI_FLAG_RXNE)==RESET);
      read[i] = WIFI_SPI->DR;
    }
```

```
  }
  GPIO_WriteBit(WIFI_CS_GPIO_PORT, WIFI_CS_PIN, Bit_SET); // pull up SPI chip select line
}
```

6.2.3. toggle_irq Implementation

Enable, disable external interrupt function implementation

```
static void _ext_interrupt(uint8_t enable)
{
    if (enable){
        NVIC_EnableIRQ(WIFI_INT_EXTI_IRQN);
    }
    else{
        NVIC_DisableIRQ(WIFI_INT_EXTI_IRQN);
    }
}
```

6.2.4. hw_power Implementation

Power-off, power-on function implementation

```
static void _power_up_down(uint8_t status)
{
   if (status) {
#if defined (USE_WIFI_POWER_FET)
      GPIO_WriteBit(WIFI_FET_GPIO_PORT, WIFI_FET_PIN, Bit_RESET);
#endif
      delay_ms(10);
      GPIO_WriteBit(WIFI_PWD_GPIO_PORT, WIFI_PWD_PIN, Bit_SET);
  } else {
#if defined (USE_WIFI_POWER_FET)
      GPIO_WriteBit(WIFI_FET_GPIO_PORT, WIFI_FET_PIN, Bit_SET);
#endi
      GPIO_WriteBit(WIFI_PWD_GPIO_PORT, WIFI_PWD_PIN, Bit_RESET);
  }
}
```

6.2.5. hw_deinit Implementation

deinitialization implementation of SPI interface

```
static void _deinit_interface(void)
{
  WIFI_SPI_Deinit();
  return 0;
}
void WIFI_SPI_Deinit(void)
{
  GPIO_InitTypeDef GPIO_InitStructure;
  /*!< Disable the WIFI_SPI  ****************************************************/
  SPI_Cmd(WIFI_SPI, DISABLE);
  /*!< DeInitializes the WIFI_SPI *******************************************/
  SPI_I2S_DeInit(WIFI_SPI);
  /*!< WIFI_SPI Periph clock disable ****************************************/
  WIFI_SPI_CLK_INIT(WIFI_SPI_CLK, DISABLE);
  /*!< Configure all pins used by the SPI as input floating *******************/
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_IN;
  GPIO_InitStructure.GPIO_PuPd = GPIO_PuPd_NOPULL;

  GPIO_InitStructure.GPIO_Pin = WIFI_SPI_SCK_PIN;
  GPIO_Init(WIFI_SPI_SCK_GPIO_PORT, &GPIO_InitStructure);

  GPIO_InitStructure.GPIO_Pin = WIFI_SPI_MISO_PIN;
  GPIO_Init(WIFI_SPI_MISO_GPIO_PORT, &GPIO_InitStructure);

  GPIO_InitStructure.GPIO_Pin = WIFI_SPI_MOSI_PIN;
  GPIO_Init(WIFI_SPI_MOSI_GPIO_PORT, &GPIO_InitStructure);

  GPIO_InitStructure.GPIO_Pin = WIFI_CS_PIN;
  GPIO_Init(WIFI_CS_GPIO_PORT, &GPIO_InitStructure);
}
```

6.3 Non-OS Program Introduction

The example problem in the folder /examples_nos includes:

- AP & STA Networking
- One key networking --easyconfig, WPS networking
- Socket Communications --tcp server, tcp client, udp server, udp client

6.3.1. Example Introduction of AP & STA Networking:

1. STA Mode - Running this program only need to modify the AP name and password to be connected

```
int rw_network_startSTA(void)
{
   ...
   conn.ssid = "Nescafe";              // modify it to be the AP name connected
   conn.psk = "1234567890";            //modify AP password
   ...
}
```

Serial print information:

```
main.c:32  Host platform init...success
226  main.c:43  rak wifi LibVersion:1.0.4-2.1.39                // wifi library
version
230  main.c:45  rak wifi module-MAC:60:C5:A8:60:03:79            // Module mac address
2646  rw_lib_platform.c:23  connect_callback event = 0x0         //event of router
connection
2652  rw_lib_platform.c:28  ---------connected AP info list---------
2658  rw_lib_platform.c:29  bssid = 8C:21:0A:D8:1C:0C
2664  rw_lib_platform.c:35  channel =6
2668  rw_lib_platform.c:36  ssid =Nescafe
2672  rw_lib_platform.c:37  psk =1234567890
2677  rw_lib_platform.c:38  sec_mode =1
2681  rw_lib_platform.c:39  auth_mode =4
2685  rw_lib_platform.c:43  ---------CONN_STATUS_STA_CONNECTED--------
3641  rw_lib_platform.c:70  ipquery success addr = 0xc0a80a6a      //dhcp success event
```

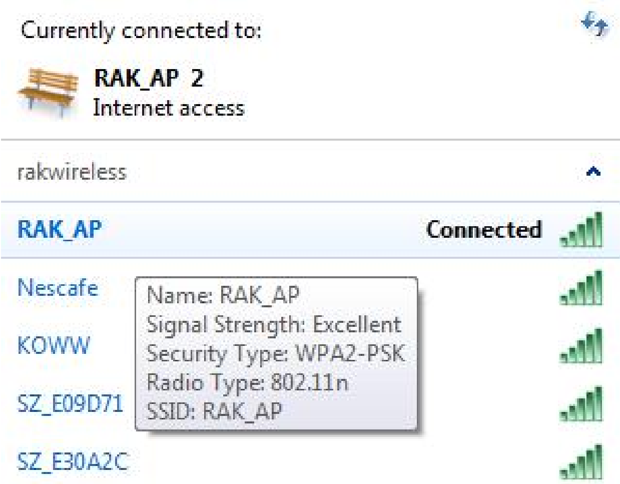
2. Soft AP mode - program will create a RAK_AP hot by default, password 1234567890

```
int rw_network_startAP(void)
{
   ...
   conn.ssid = "RAK_AP";                          //AP name
   conn.psk = "1234567890";                       //AP password
   ...
}
```

Serial print information:

```
 main.c:32  Host platform init...success
226  main.c:43  rak wifi LibVersion:1.0.4-2.1.39                 // wifi library
version
230  main.c:45  rak wifi module-MAC:60:C5:A8:60:03:79             //wifi module mac
address
3363  rw_lib_platform.c:23  connect_callback event = 0x2          //creating AP
success event
3369  rw_lib_platform.c:51  ---------CONN_STATUS_AP_ESTABLISH--------
242418  rw_lib_platform.c:23  connect_callback event = 0x3        // Client is
connected successfully
242424  rw_lib_platform.c:54  ---------CONN_STATUS_AP_CLT_CONNECTED--------
```

PC is connected to module soft AP successfully as shown below:



6.3.2. Example of A key configuration:

One key configuration can be implemented via easyconfig on the phone, also via pressing the WPS button of route.

1. Easyconfig configuration

```
app_demo_ctx.easywps_mode = CONFIG_EASY;                     //easyconfig mode
rw_network_startConfig(app_demo_ctx.easywps_mode);           //enable easyconfig
```

Serial print information:

```
 main.c:32  Host platform init...success
226  main.c:43  rak wifi LibVersion:1.0.4-2.1.39             // wifi library version
230  main.c:45  rak wifi module-MAC:60:C5:A8:60:03:79         //wifi module mac
236  main.c:57  rw_network_startConfig ...                    //enable easyconfig
```

```
41163  rw_lib_platform.c:110  bssid = 8C:21:0A:D8:1C:0C
41169  rw_lib_platform.c:116  channel =6
41173  rw_lib_platform.c:117  ssid =Nescafe
41178  rw_lib_platform.c:118  psk =1234567890
42921  rw_lib_platform.c:23  connect_callback event = 0x0        // event of router
connection
42926  rw_lib_platform.c:28  ---------connected AP info list---------
42933  rw_lib_platform.c:29  bssid = 8C:21:0A:D8:1C:0C
42939  rw_lib_platform.c:35  channel =6
42943  rw_lib_platform.c:36  ssid =Nescafe
42947  rw_lib_platform.c:37  psk =1234567890
42952  rw_lib_platform.c:38  sec_mode =1
42956  rw_lib_platform.c:39  auth_mode =4
42960  rw_lib_platform.c:42  ---------CONN_STATUS_STA_CONNECTED--------
44580  rw_lib_platform.c:69  ipquery success addr = 0xc0a80a75   //dhcp success event
44588  easy_wps.c:29  RAK_UdpServer sockfd = 0 creat          //create udp server, port
25000
44998  easy_wps.c:49  recvfrom 0xc0a80a6e:25000 on sockfd=0 data_len=16 :@LT_EAS
Y_DEVICE@
45007  easy_wps.c:72  local Discovery Response                //send mac and IP to phone
```

If easyconfig is successful, phone app will show mac and ip address of the module, as shown below:

2. WPS Configuration

```
app_demo_ctx.easywps_mode = CONFIG_WPS;                        //WPS mode
```

```
rw_network_startConfig(app_demo_ctx.easywps_mode);              //enable easyconfig
```

Serial print information:

```
main.c:32  Host platform init...success
226  main.c:43  rak wifi LibVersion:1.0.4-2.1.39
230  main.c:45  rak wifi module-MAC:60:C5:A8:60:03:79
236  main.c:57  rw_network_startConfig ...                      // enter WPS
configuration status
14337  rw_lib_platform.c:111  bssid = 8C:21:0A:D8:1C:0C
14342  rw_lib_platform.c:117  channel =0
14346  rw_lib_platform.c:118  ssid =Nescafe
14351  rw_lib_platform.c:119  psk =1234567890
17014  rw_lib_platform.c:23  connect_callback event = 0x0       // event of router
connection
17020  rw_lib_platform.c:28  ---------connected AP info list---------
17027  rw_lib_platform.c:29  bssid = 8C:21:0A:D8:1C:0C
17033  rw_lib_platform.c:35  channel =6
17037  rw_lib_platform.c:36  ssid =Nescafe
17041  rw_lib_platform.c:37  psk =1234567890
17046  rw_lib_platform.c:38  sec_mode =1
17050  rw_lib_platform.c:39  auth_mode =4
17054  rw_lib_platform.c:43  ---------CONN_STATUS_STA_CONNECTED--------
18178  rw_lib_platform.c:70  ipquery success addr = 0xc0a80a6a  //dhcp success event
18186  easy_wps.c:29  RAK_UdpServer sockfd = 0 creat            //creat udp server
```

6.3.3. Introduction of Socket Communication Example

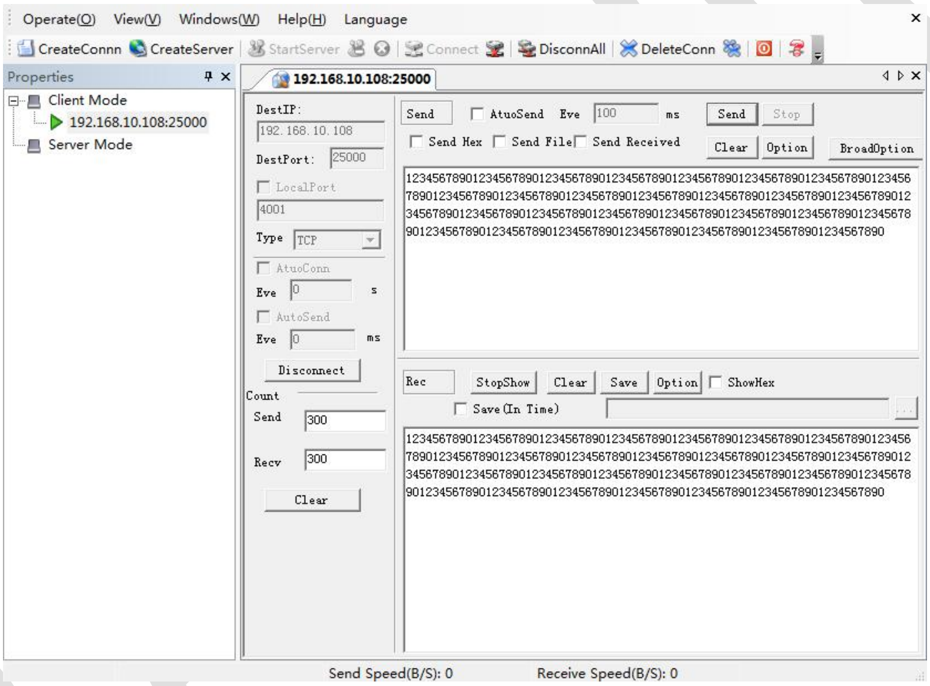
After module is connected to router and successfully obtained IP, it will create a TCP server;
Create a TCP client connected to the module, and regularly send data to the module on the computer;
Module sends data back to the computer after it receives data.

Serial print information:

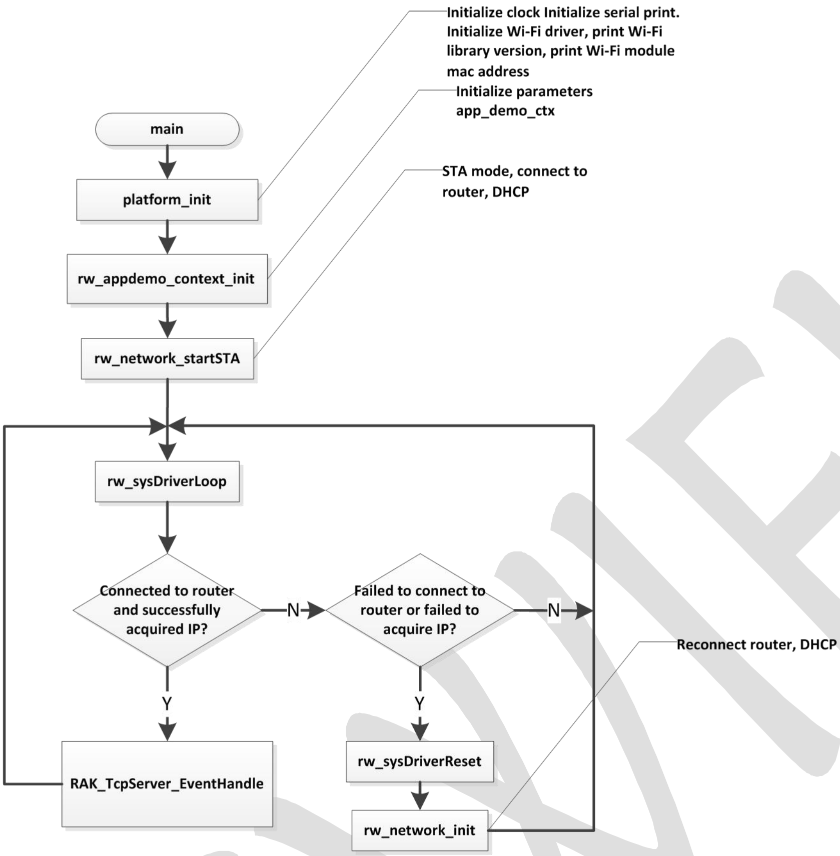
```
 main.c:32  Host platform init...success
226  main.c:43  rak wifi LibVersion:1.0.4-2.1.39
230  main.c:45  rak wifi module-MAC:60:C5:A8:60:03:79
2662  rw_lib_platform.c:23  connect_callback event = 0x0            // event of router
connection
2668  rw_lib_platform.c:28  ---------connected AP info list---------
2675  rw_lib_platform.c:29  bssid = 8C:21:0A:D8:1C:0C
```

```
2680  rw_lib_platform.c:35  channel =6
2684  rw_lib_platform.c:36  ssid =Nescafe
2689  rw_lib_platform.c:37  psk =1234567890
2694  rw_lib_platform.c:38  sec_mode =1
2698  rw_lib_platform.c:39  auth_mode =4
2702  rw_lib_platform.c:43  ---------CONN_STATUS_STA_CONNECTED--------
3832  rw_lib_platform.c:70  ipquery success addr = 0xc0a80a6a       //dhcp success event
3841  tcp_udp.c:207  RAK_TcpServer sockfd = 0 creat                //create tcp server
58804  tcp_udp.c:173  recv new sockfd=1 from ip=0xc0a824ad ,port=45466  //tcp client is
connected
                                                                       //successfully
```

Socket sends and receives data, as shown below:



Flow diagram of socket communications example:



6.4 Porting Steps in OS

Operating system is FreeRTOS. Similar with the Porting in non-OS, the Porting in FreeRTOS also needs to start from rw_lib_platform_os.c, pay attention to the following points:

- the priority of external interrupt cannot be higher than configMAX_SYSCALL_INTERRUPT_PRIORITY (the smaller the value, the higher the priority), if use priority grouping function NVIC_PriorityGroupConfig priority in ST library, then set priority group to four, priority value> = 5; if use NVIC_SetPriorityGrouping in CMSIS library, set priority group to any value, set priority value> = 5. For details, refer to http://www.freertos.org/RTOS-Cortex-M3-M4.html
- time_delay, Stamp_get are to be implemented with system functions in the OS
- driver_free, driver_malloc are to be implemented with system functions in the OS
- only conn_cb, easy_wps_cb are callback

The following is the OS interface implementation of Wi-Fi driver library, using the cmsis_os interface of stm32, This interface encapsulates operating system, so that the user's application code can be easily migrated to different operating systems.

6.4.1. rw_creat_task Implementation

```
void* rw_creat_task(RW_OS_TASK_PTR p_task)
{
   osThreadId p_tcb;                                        //point to task handle
   // Define task start information - task name, task code address, priority, stack size
   osThreadDef(task_wifi, (os_pthread)p_task, osPriorityHigh, 0,
                configMINIMAL_STACK_SIZE * 7);
   //create task
   p_tcb = osThreadCreate (osThread(task_wifi), NULL);
   return p_tcb;
}
```

6.4.2. rw_del_task Implementation

```
int rw_del_task(void* p_tcb)
{
   osThreadTerminate(p_tcb);                                //delete task
   return RW_OS_OK;
}
```

6.4.3. rw_creat_mutex Implementation

```
void* rw_creat_mutex(void)
{
   osMutexId p_mutex;
   p_mutex = osMutexCreate(osMutex(mutex));                 // create mutex
   return (void *)p_mutex;
}
```

6.4.4. rw_del_mutex

```
int rw_del_mutex(void* p_mutex)
{
   osMutexDelete(p_mutex);                                  //delete mutex
   return RW_OS_OK;
```

```
}
```

6.4.5. rw_lock_mutex Implementation

```
int rw_lock_mutex(void* p_mutex, uint32_t timeout)
{
  if(timeout == 0) {
    timeout = osWaitForever;
  }
  osMutexWait(p_mutex,timeout);                                 //lock mutex
  return RW_OS_OK;
}
```

6.4.6. rw_unlock_mutex Implementation

```
int rw_unlock_mutex(void* p_mutex)
{
   osMutexRelease(p_mutex);                                     //free mutex
   return RW_OS_OK;
}
```

6.4.7. rw_creat_sem Implementation

```
void* rw_creat_sem(void)
{
   osSemaphoreId p_sem;
   p_sem = osSemaphoreCreate(osSemaphore(sem),1);           // create binary semaphore
   return p_sem;
}
```

6.4.8. rw_del_sem Implementation

```
int rw_del_sem(void* p_sem)
{
   osSemaphoreDelete(p_sem);                                    //delete binary semaphore
```

```
  return RW_OS_OK;
}
```

6.4.9. rw_post_sem Implementation

```
int rw_post_sem(void* p_sem)
{
  osSemaphoreRelease(p_sem);                         //free binary semaphore
  return RW_OS_OK;
}
```

6.4.10. rw_pend_sem Implemenation

```
int rw_pend_sem(void* p_sem, uint32_t timeout)
{
  int oserr;
  if(timeout == 0) {
    timeout = osWaitForever;
  }
  oserr = osSemaphoreWait(p_sem,timeout);            //wait binary semaphore
  if(oserr == osOK) {
    return RW_OS_OK;
  } else if(oserr == osErrorOS) {
    return RW_OS_TIME_OUT;
  }
  return RW_OS_ERROR;
}
```

6.5 OS Program Introduction

The example problem in the folder /examples_nos includes:

- AP & STA Networking
- One key networking --easyconfig, WPS networking
- Socket Communications --tcp server, tcp client, udp server, udp client

6.5.1. Example Introduction of AP & STA Networking:

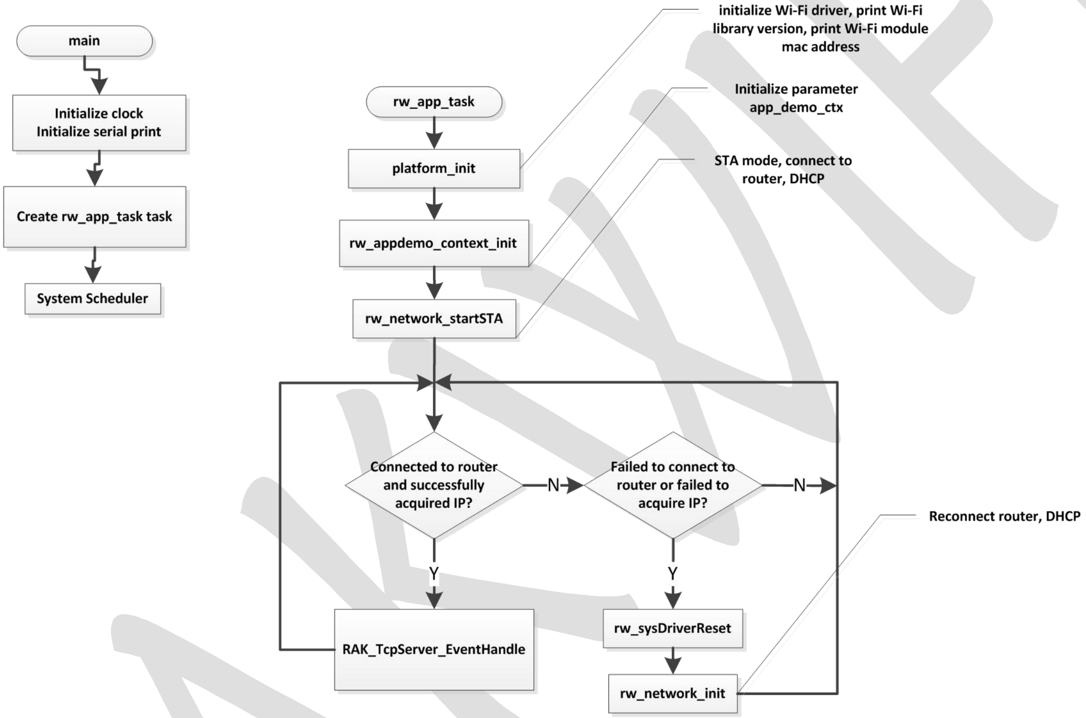
Same as 6.3.1

6.5.2. Example of A key configuration:

Same as 6.3.2

6.5.3. Introduction of Socket Communication Example

Flow diagram of socket communications example:



7. Sales and Service

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8. Revision History

Version No.	Modification	Date
V1.0	Initial draft	2015-05-23
V1.1	1. driver lib param add api_int_enable and tcp_retry_num 2. app callback interface delete tcp_cb 3. os interface modify rw_lock_mutex and rw_pend_sem 4. spi interface part adds wifi driver initialize the start of the spi data	2015-06-29
V1.2	1. OS part add UCOSiii and FreeRTOS 2. SPI part add how to print the spi initialize data	2015-11-6