

1 global.config

```
{
  "SX130x_conf": {
    "spidev_path": "/dev/spidev0.0",
    "lorawan_public": true,
    "clksrc": 0,
    "antenna_gain": 0, /* antenna gain, in dBi */
    "full_duplex": false,
    "precision_timestamp": {
      "enable": false,
      "max_ts_metrics": 255,
      "nb_symbols": 1
    },
  },
  "radio_0": {
    "enable": true,
    "type": "SX1250",
    "single_input_mode": true,
    "freq": 470600000,
    "rssi_offset": -207.0,
    "rssi_tcomp": {"coeff_a": 0, "coeff_b": 0, "coeff_c": 20.41,
"coeff_d": 2162.56, "coeff_e": 0},
    "tx_enable": true,
    "tx_freq_min": 470000000,
    "tx_freq_max": 510000000,
    "tx_gain_lut": [
      {"rf_power": -6, "pa_gain": 0, "pwr_idx": 0},
      {"rf_power": -3, "pa_gain": 0, "pwr_idx": 1},
      {"rf_power": 0, "pa_gain": 0, "pwr_idx": 2},
      {"rf_power": 3, "pa_gain": 1, "pwr_idx": 3},
      {"rf_power": 6, "pa_gain": 1, "pwr_idx": 4},
      {"rf_power": 10, "pa_gain": 1, "pwr_idx": 5},
      {"rf_power": 11, "pa_gain": 1, "pwr_idx": 6},
      {"rf_power": 12, "pa_gain": 2, "pwr_idx": 7},
      {"rf_power": 13, "pa_gain": 1, "pwr_idx": 8},
      {"rf_power": 14, "pa_gain": 2, "pwr_idx": 9},
      {"rf_power": 16, "pa_gain": 2, "pwr_idx": 10},
      {"rf_power": 20, "pa_gain": 3, "pwr_idx": 11},
      {"rf_power": 23, "pa_gain": 3, "pwr_idx": 12},
      {"rf_power": 25, "pa_gain": 3, "pwr_idx": 13},
      {"rf_power": 26, "pa_gain": 3, "pwr_idx": 14},
      {"rf_power": 27, "pa_gain": 3, "pwr_idx": 15}
    ]
  },
  "radio_1": {
    "enable": true,
    "type": "SX1250",
    "single_input_mode": true,
    "freq": 471400000,
    "rssi_offset": -207.0,
  },
}
```

```

        "rssi_tcomp": {"coeff_a": 0, "coeff_b": 0, "coeff_c": 20.41,
"coeff_d": 2162.56, "coeff_e": 0},
        "tx_enable": false
    },
    "chan_multiSF_0": {"enable": true, "radio": 0, "if": -300000},
    "chan_multiSF_1": {"enable": true, "radio": 0, "if": -100000},
    "chan_multiSF_2": {"enable": true, "radio": 0, "if": 100000},
    "chan_multiSF_3": {"enable": true, "radio": 0, "if": 300000},
    "chan_multiSF_4": {"enable": true, "radio": 1, "if": -300000},
    "chan_multiSF_5": {"enable": true, "radio": 1, "if": -100000},
    "chan_multiSF_6": {"enable": true, "radio": 1, "if": 100000},
    "chan_multiSF_7": {"enable": true, "radio": 1, "if": 300000},
    "chan_Lora_std": {"enable": true, "radio": 1, "if": -200000, "bandwidth":
250000, "spread_factor": 7,
                    "implicit_hdr": false, "implicit_payload_length": 17,
"implicit_crc_en": false, "implicit_coderate": 1},
    "chan_FSK": {"enable": true, "radio": 1, "if": 300000, "bandwidth":
125000, "datarate": 50000}
},

"gateway_conf": {
    "gateway_ID": "fffedca6320e9516",
    /* change with default server address/ports */
    "server_address": "loragw.things.qcloud.com",
    "serv_port_up": 1700,
    "serv_port_down": 1700,
    /* adjust the following parameters for your network */
    "keepalive_interval": 10,
    "stat_interval": 30,
    "push_timeout_ms": 100,
    /* forward only valid packets */
    "forward_crc_valid": true,
    "forward_crc_error": false,
    "forward_crc_disabled": false,
    /* Beacons parameters */
    "beacon_period": 0,
    "beacon_freq_hz": 869525000,
    "beacon_datarate": 9,
    "beacon_bw_hz": 125000,
    "beacon_power": 14,
    "beacon_infodesc": 0
},

"debug_conf": {
    "ref_payload": [
        {"id": "0xCAFE1234"},
        {"id": "0xCAFE2345"}
    ],
    "log_file": "loragw_hal.log"
}
}

```

2 外部函数调用

2.1 c library function

```
#include <stdint.h>          /* C99 types */
#include <stdbool.h>          /* bool type */
#include <stdio.h>            /* printf, fprintf, snprintf, fopen, fputs */
#include <inttypes.h>         /* PRIx64, PRIu64... */

#include <string.h>           /* memset */
#include <signal.h>           /* sigaction */
#include <time.h>             /* time, clock_gettime, strftime, gmtime */
#include <sys/time.h>         /* timeval */
#include <unistd.h>           /* getopt, access */
#include <stdlib.h>           /* atoi, exit */
#include <errno.h>            /* error messages */
#include <math.h>             /* modf */

#include <sys/socket.h>       /* socket specific definitions */
#include <netinet/in.h>       /* INET constants and stuff */
#include <arpa/inet.h>        /* IP address conversion stuff */
#include <netdb.h>            /* gai_strerror */

#include <pthread.h>
```

2.1.1 复杂函数

2.1.1.1 thread

1. pthread_mutex_lock()/pthread_mutex_unlock()
2.
 - time()
 - gmtime()
 - strftime()
 - clock_gettime

2.1.1.2 socket

1. setsockopt()
2. recv

2.2 libtools

```
#include "parson.h" //.. / libtools / src / parson.c
#include "base64.h" //.. / libtools / src / base64.c
```

2.2.1 复杂函数

Json prase

2.3 libloragw

```
#include "loragw_hal.h" //.. / libloragw / src / loragw_hal.c
#include "loragw_aux.h" //.. / libloragw / src / loragw_aux.c
#include "loragw_reg.h" //.. / libloragw / src / loragw_reg.c
#include "loragw_gps.h" //.. / libloragw / src / loragw_gps.c
```

2.4 jitqueue

```
#include "jitqueue.h" //.. / packet_forwarder / src / jitqueue.c
#include "trace.h" //.. / packet_forwarder / inc / trace.h
```

Just-In-Time" downlink scheduling

2.4.1 TX scheduling

TX在RF chain上实现，即jit_queue与其有关

1. TX packet: txpkt
2. Beacon: beacon_pkt

jit_enqueue: 对应THREAD 2: thread_down

jit_peek: 对应THREAD 3: thread_jit

jit_dequeue: 对应THREAD 3: thread_jit

Possible failures that may occur and that have to be reported to the server are: ...

通过send_tx_ack完成

3 内部程序调用与线程理解

3.1 理论

main:

1. usage
2. parse_SX130x_configuration
3. parse_gateway_configuration
4. parse_debug_configuration
5. sig_handler
6. 5 threads

2~4显示固定内容, thread_up显示UPSTREAM json内容, main显示5 threads得到的统计内容

```
/* --- THREAD 1: RECEIVING PACKETS AND FORWARDING THEM ----- */
```

```
thread_up:
```

1. sig_handler
 2. difftimespec
-

```
/* --- THREAD 2: POLLING SERVER AND ENQUEUEING PACKETS IN JIT QUEUE ----- */
```

```
thread_down:
```

1. sig_handler
 2. difftimespec
 3. crc16
 4. get_tx_gain_lut_index
 5. send_tx_ack
-

```
/* --- THREAD 3: CHECKING PACKETS TO BE SENT FROM JIT QUEUE AND SEND THEM --- */
```

```
thread_jit:
```

1. sig_handler
 2. print_tx_status
-

```
/* --- THREAD 4: PARSE GPS MESSAGE AND KEEP GATEWAY IN SYNC ----- */
```

```
thread_gps:
```

1. gps_process_sync、
 2. gps_process_coords
-

```
/* --- THREAD 5: CHECK TIME REFERENCE AND CALCULATE XTAL CORRECTION ----- */
```

```
thread_valid:
```

1. sig_handler
-

3.2 实证

```
//main(): display version informations
*** Packet Forwarder ***
Version: 1.0.5
*** SX1302 HAL library version info ***
Version: 1.0.5;
***
```

```
//main(): display host endianness
INFO: Little endian host
INFO: found configuration file global_conf.json, parsing it

//parse_SX130x_configuration(): point to the gateway configuration object
INFO: global_conf.json does contain a JSON object named SX130x_conf, parsing
SX1302 parameters
INFO: spidev_path /dev/spidev0.0, lorawan_public 1, clksrc 0, full_duplex 0
INFO: antenna_gain 0 dBi
INFO: Configuring legacy timestamp
INFO: Configuring Tx Gain LUT for rf_chain 0 with 16 indexes for sx1250
INFO: radio 0 enabled (type SX1250), center frequency 474600000, RSSI offset
-207.000000, tx enabled 1, single input mode 1
INFO: radio 1 enabled (type SX1250), center frequency 475400000, RSSI offset
-207.000000, tx enabled 0, single input mode 1
INFO: Lora multi-SF channel 0> radio 0, IF -300000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 1> radio 0, IF -100000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 2> radio 0, IF 100000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 3> radio 0, IF 300000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 4> radio 1, IF -300000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 5> radio 1, IF -100000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 6> radio 1, IF 100000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora multi-SF channel 7> radio 1, IF 300000 Hz, 125 kHz bw, SF 5 to 12
INFO: Lora std channel> radio 1, IF -200000 Hz, 250000 Hz bw, SF 7, Explicit
header
INFO: FSK channel> radio 1, IF 300000 Hz, 125000 Hz bw, 50000 bps datarate

//parse_gateway_configuration(): point to the gateway configuration object
INFO: global_conf.json does contain a JSON object named gateway_conf, parsing
gateway parameters
INFO: gateway MAC address is configured to 0016C001FF10D3F6
INFO: server hostname or IP address is configured to "47.110.36.225"
INFO: upstream port is configured to "1700"
INFO: downstream port is configured to "1700"
INFO: downstream keep-alive interval is configured to 10 seconds
INFO: statistics display interval is configured to 30 seconds
INFO: upstream PUSH_DATA time-out is configured to 100 ms
INFO: packets received with a valid CRC will be forwarded
INFO: packets received with a CRC error will NOT be forwarded
INFO: packets received with no CRC will NOT be forwarded
INFO: Beacons period is configured to 0 seconds
INFO: Beacons signal will be emitted at 869525000 Hz
INFO: Beacons datarate is set to SF9
INFO: Beacons modulation bandwidth is set to 125000Hz
INFO: Beacons TX power is set to 14dBm
INFO: Beacons information descriptor is set to 0

//parse_debug_configuration(): point to the gateway configuration object
INFO: global_conf.json does contain a JSON object named debug_conf, parsing debug
parameters
INFO: got 2 debug reference payload
INFO: reference payload ID 0 is 0xCAFE1234
INFO: reference payload ID 1 is 0xCAFE2345
INFO: setting debug log file name to loragw_hal.log
```

```
//main(): Board reset
CoreCell reset through GPIO7...

//?
INFO: Configuring SX1250_0 in single input mode
INFO: Configuring SX1250_1 in single input mode

//main(): starting the concentrator
INFO: [main] concentrator started, packet can now be received
INFO: concentrator EUI: 0x0016c001ff10d3f6
```

```
//thread_up(): start of JSON structure
INFO: Received pkt from mote: 1350200C (fcnt=13)

JSON up: {"rxpk":
[{"jver":1,"tmst":137795171,"chan":4,"rfch":1,"freq":475.100000,"mid":0,"stat":1,"
modu":"LORA","datr":"SF12Bw125","codr":"4/5","rssi":-84,"lsnr":-5.0,"foff":786,"r
ssi":-80,"size":13,"data":"gQwgUBMADQANAKvN7w=="}}}

//thread_up(): send datagram to server + wait for acknowledge (in 2 times, to
catch extra packets)
INFO: [up] PUSH_ACK received in 40ms

//thread_down(): if the datagram is an ACK, check token
INFO: [down] PULL_ACK received in 34ms

//main(): display a report (status report)
##### 2020-10-18 10:49:51 GMT #####

### [UPSTREAM] ###
# RF packets received by concentrator: 1 //thread_up
# CRC_OK: 100.00%, CRC_FAIL: 0.00%, NO_CRC: 0.00% //thread_up
# RF packets forwarded: 1 (13 bytes) //thread_up(thread_up)
# PUSH_DATA datagrams sent: 2 (360 bytes) //PUSH_DATA: thread_up(thread_up)
# PUSH_DATA acknowledged: 100.00% //PUSH_ACK: thread_up

### [DOWNSTREAM] ###
# PULL_DATA sent: 3 (100.00%) //PULL_DATA(PULL_ACK): thread_down
# PULL_RESP(onse) datagrams received: 0 (0 bytes) //PULL_RESP:
thread_down(thread_down)
/*一个RF都没有发送当然没有出现任何错误了*/
# RF packets sent to concentrator: 0 (0 bytes) //thread_jit/thread_down
# TX errors: 0 //TX_ACK: thread_jit: lgw_send
# TX rejected... //TX_ACK: thread_down: send_tx_ack

### SX1302 Status ###
# SX1302 counter (INST): 150921885
# SX1302 counter (PPS): 0
```

```
# BEACON queued: 0 //thread_down: jit_enqueue
# BEACON sent so far: 0 //thread_jit: jit_peek/jit_dequeue
# BEACON rejected: 0 //thread_down: jit_enqueue

### [JIT] ###
src/jitqueue.c:442:jit_print_queue(): INFO: [jit] queue is empty //thread_down
#-----
src/jitqueue.c:442:jit_print_queue(): INFO: [jit] queue is empty //thread_down

### [GPS] ###
# GPS sync is disabled
### Concentrator temperature 0 C ###
##### END #####
```

```
//main(): generate a JSON report (will be sent to server by upstream thread)
JSON up: {"stat":{"time":"2020-10-18 10:49:51
GMT","rxnb":1,"rxok":1,"rxfw":1,"ackr":100.0,"dwnb":0,"txnb":0,"temp":0.0}}

//thread_up(): send datagram to server + wait for acknowledge (in 2 times, to
catch extra packets)
INFO: [up] PUSH_ACK received in 34ms

//thread_down(): if the datagram is an ACK, check token
INFO: [down] PULL_ACK received in 35ms
INFO: [down] PULL_ACK received in 37ms
```

```
//thread_up()
INFO: End of upstream thread

//main(): if an exit signal was received, try to quit properly + Board reset
INFO: concentrator stopped successfully
CoreCell reset through GPIO7...
INFO: Exiting packet forwarder program
```

3.3 Communication process

1. [PROTOCOL](#)
2. [LoRaWAN Network Server Demonstration: Gateway to Server Interface Definition](#)
3. [LoRaWAN Network Server Demonstration: Inter-Server interface definition](#)

4 修改c程序完成后想要让脚本跟着修改

在gw1302s执行make clean all, 调用所有helper program的make clean 再执行make install, 调用所有helper program的make install, 把可执行程序都scp到gw1302s/bin中

5 问题

- ☐ GPS相关, 如reference
- ☐ 温度相关
- ☐ 变量含义