

LOW-COST LORA GATEWAY: A STEP-BY-STEP TUTORIAL



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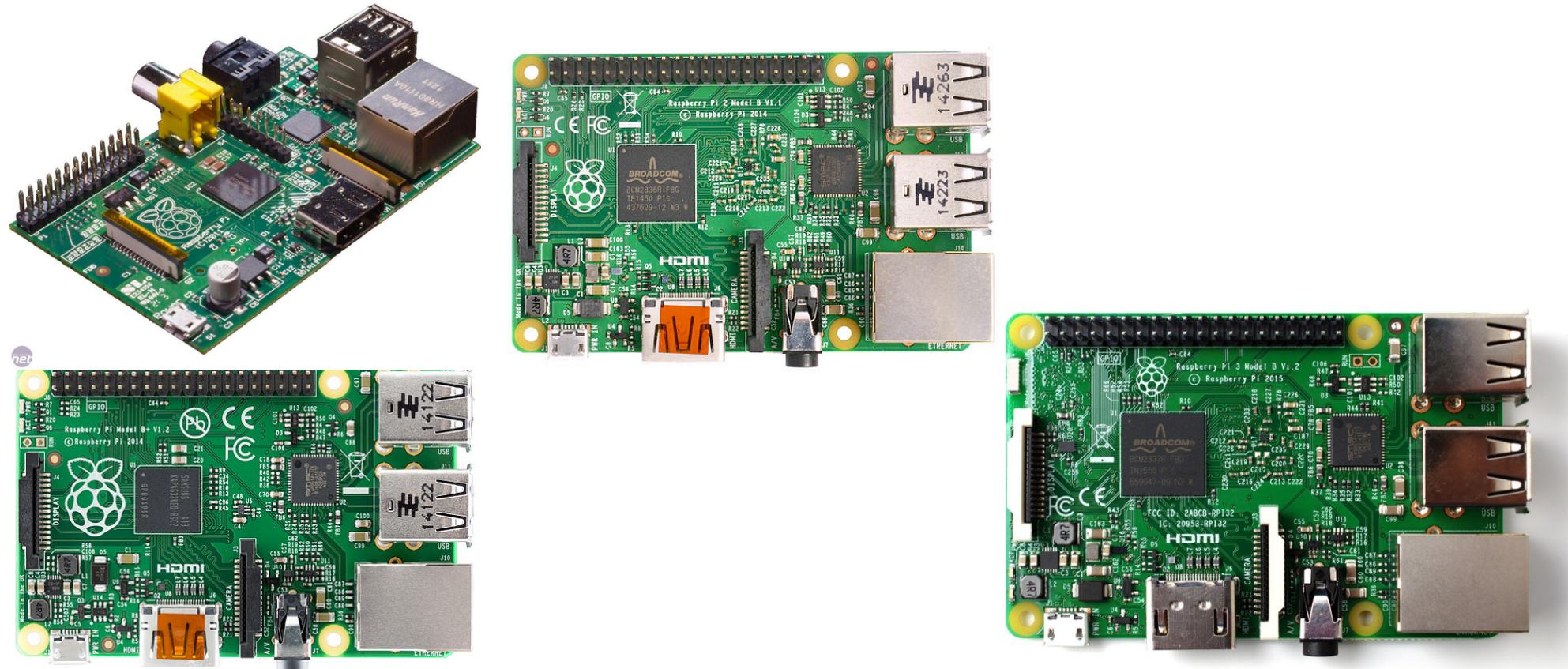
CONTENTS

- ❑ We will show how to build a low-cost LoRa gateway to collect data from end-devices
- ❑ The device part will be shown in a separate tutorial
- ❑ The hardware platform is a Raspberry PI. RPI 1B/B+, 2B and 3B have been successfully tested
- ❑ Let's get started...

ASSEMBLING THE HARDWARE

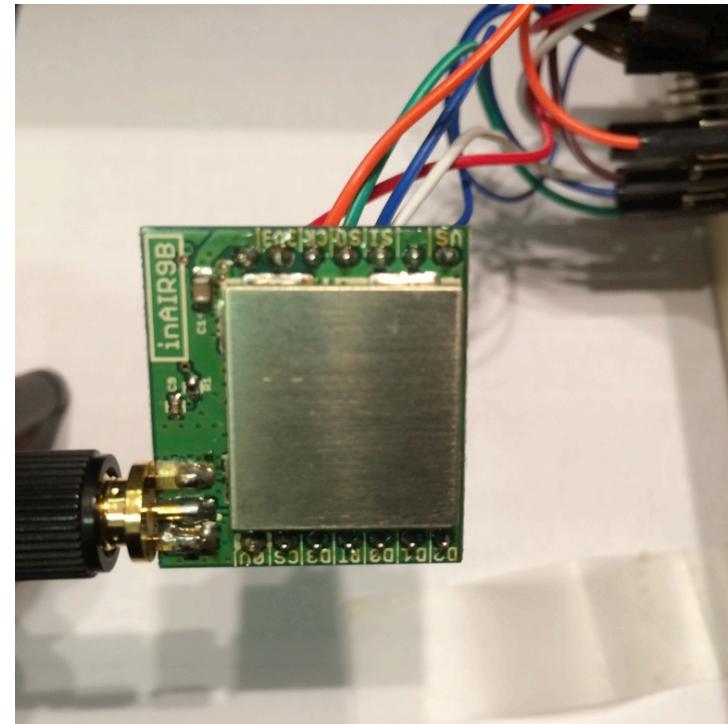
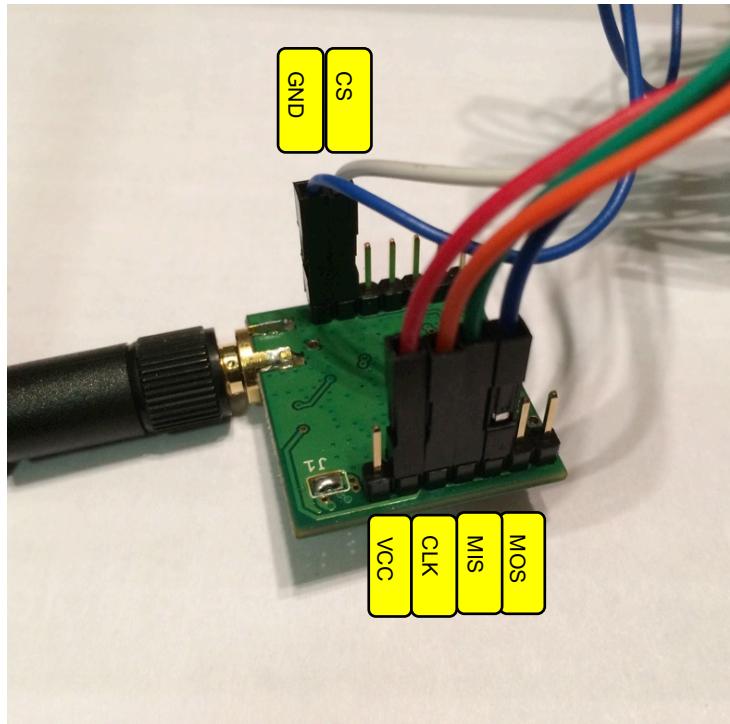


GET THE RASPBERRY



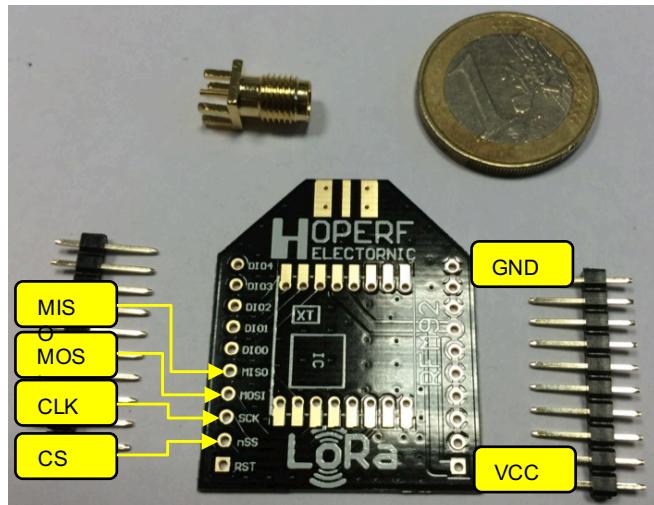
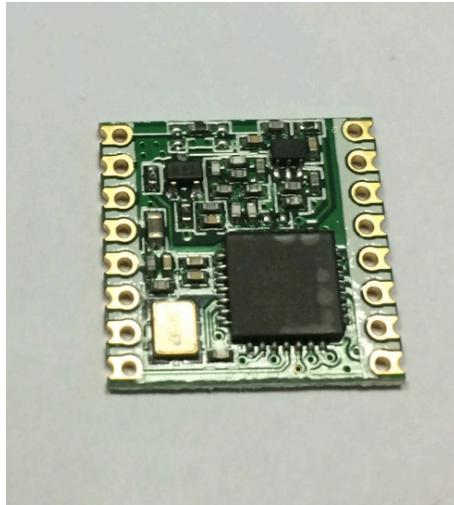
You can use Raspberry 1 model B or B+ or Raspberry 2 model B or Raspberry 3 model B. The most important useful feature is the Ethernet interface for easy Internet connection. You can use WiFi to get Internet connection by adding a WiFi USB dongle. With the Raspberry 3, WiFi and Bluetooth are embedded on the board.

NOW THE RADIO MODULE (1)



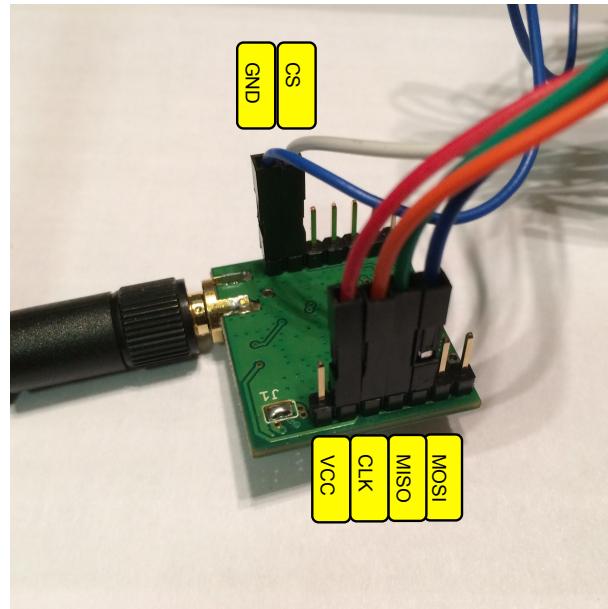
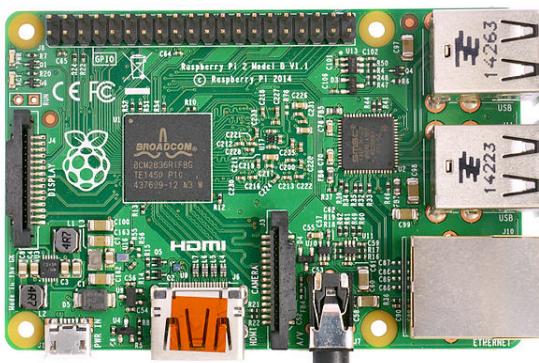
If you go for the inAir9 from Modtronix, then the header pins can come fully assembled. Take the 6mm header pins to have enough length to connect F/F breadboard cables (left). Connect the SPI pins with the F/F cables. Try to use different colors. I use the following colors: MOSI (blue), MISO (green), CS (white), CLK (orange). Then connect also the VCC (red) and the GND (black or any other dark color) of the radio board.

NOW THE RADIO MODULE (2)



If you take the HopeRF RFM 92W/95W you will need the adaptor breakout and you have to go though some delicate but simple soldering tasks! It is not difficult but you have to trained a bit before! Then, like for the inAir9, use F/F breadboard cable to connect the SPI pins, using different colors as explained previously.

CONNECTING THE RADIO MODULE (1)



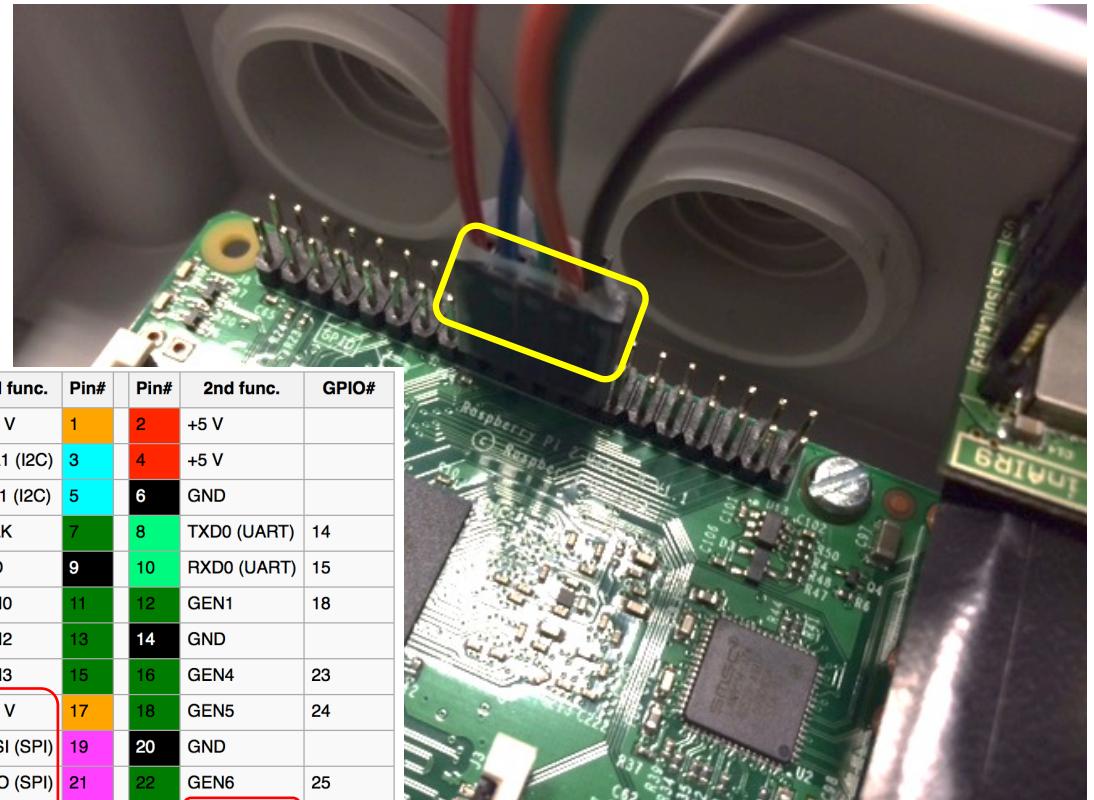
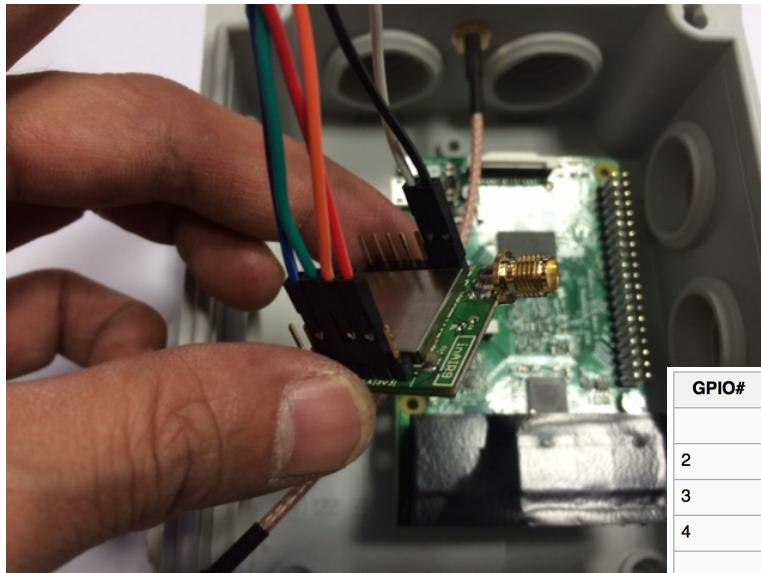
GPIO#	2nd func.	Pin#	Pin#	2nd func.	GPIO#
	+3.3 V	1	2	+5 V	
2	SDA1 (I2C)	3	4	+5 V	
3	SCL1 (I2C)	5	6	GND	
4	GCLK	7	8	TXD0 (UART)	14
	GND	9	10	RXD0 (UART)	15
17	GEN0	11	12	GEN1	18
27	GEN2	13	14	GND	
22	GEN3	15	16	GEN4	23
	+3.3 V	17	18	GEN5	24
10	MOSI (SPI)	19	20	GND	
9	MISO (SPI)	21	22	GEN6	25
11	SCLK (SPI)	23	24	CE0_N (SPI)	8
	GND	25	26	CE1_N (SPI)	7

(RPI 1 Models A and B stop here)

EEPROM	ID_SD	27	28	ID_SC	EEPROM
5	N/A	29	30	GND	
6	N/A	31	32		12
13	N/A	33	34	GND	
19	N/A	35	36	N/A	16
26	N/A	37	38	Digital IN	20
	GND	39	40	Digital OUT	21

Depending on the model, you can have the « short » or the « long » GPIO interface. However, the SPI pins are at the same location therefore it does not change the way you connect the radio module if you take pin 1 as the reference. Connect the SPI pins (MOSI, MISO, CLK, CS) of the radio to the corresponding pins on the RPI. Note that CS goes to CE0_N on the RPI.

CONNECTING THE RADIO MODULE (2)



GPIO#	2nd func.	Pin#	Pin#	2nd func.	GPIO#
	+3.3 V	1	2	+5 V	
2	SDA1 (I2C)	3	4	+5 V	
3	SCL1 (I2C)	5	6	GND	
4	GCLK	7	8	TXD0 (UART)	14
	GND	9	10	RXD0 (UART)	15
17	GEN0	11	12	GEN1	18
27	GEN2	13	14	GND	
22	GEN3	15	16	GEN4	23
	+3.3 V	17	18	GEN5	24
10	MOSI (SPI)	19	20	GND	
9	MISO (SPI)	21	22	GEN6	25
11	SCLK (SPI)	23	24	CE0_N (SPI)	8
	GND	25	26	CE1_N (SPI)	7

(RPi 1 Models A and B stop here)

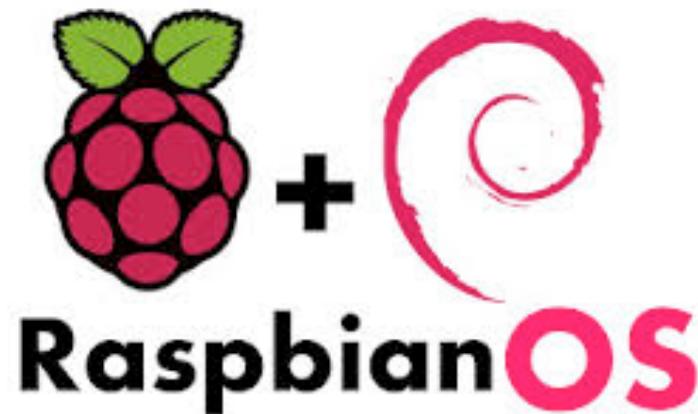
EEPROM	ID_SD	27	28	ID_SC	EEPROM
5	N/A	29	30	GND	
6	N/A	31	32		12
13	N/A	33	34	GND	
19	N/A	35	36	N/A	16
26	N/A	37	38	Digital IN	20
	GND	39	40	Digital OUT	21

PUT IT IN A BOX



You can have a more integrated version, with a box for outdoor usage and PoE splitter to power the Raspberry with the Ethernet cable. See how we also use a DC-DC converter to get the 5V for the RPI.

GETTING, COMPILING & INSTALLING THE SOFTWARE



INSTALLING THE OS



We use the Raspbian OS. Install it on an SD card. There are many tutorials on the Internet for such procedure. Alternatively, we provide the full image to burn on the SD card. It's 8GB!

<http://cpham.perso.univ-pau.fr/LORA/WAZIUP/raspberrypi-jessie-WAZIUP-demo.dmg.zip>



GETTING THE LORA SPECIFIC GW SOFTWARE

CongducPham / LowCostLoRaGw

Code Issues 6 Pull requests 0 Pulse Graphs

Low-cost LoRa gateway with SX1272 and Raspberry

11 commits 1 branch 0 releases

Branch: master New pull request New file Find file HTTPS https://github.com/CongducPham/LowCostLoRaGw.git

Congduc Pham modified some low-power info

Arduino modified some low-power info

Raspberry modified some low-power info

.DS_Store changes in the SX1272 lib, gateway and temperature example

README.md modified some low-power info

Branch: master LowCostLoRaGw / Raspberry /	
Congduc Pham modified some low-power info	
..	
.DS_Store	modified some low-power info
SX1272.cpp	Added Teensy support
SX1272.h	Added Teensy support
arduPi.cpp	First commit
arduPi.h	changes in the SX1272 lib, gateway and temperature example
arduPi_pi2.cpp	First commit
arduPi_pi2.h	First commit
bcm2835.h	First commit
log_gw.py	change python scripts name
lora_gateway.cpp	modified some low-power info
makefile	modified some low-power info
post_processing_gw.py	added some low-power info
radio.makefile	changes in the SX1272 lib to get SNR in ACK packet

```
> mkdir lora_gateway  
> git clone https://github.com/CongducPham/LowCostLoRaGw.git  
> cp LowCostLoRaGw/Raspberry/* lora_gateway/
```

Log in the RPI (ssh) and create a directory called lora_gateway. Get the LoRa RPI library from our github: <https://github.com/CongducPham/LowCostLoRaGw> (right) then copy all the files of the github's Raspberry folder into the lora_gateway folder.

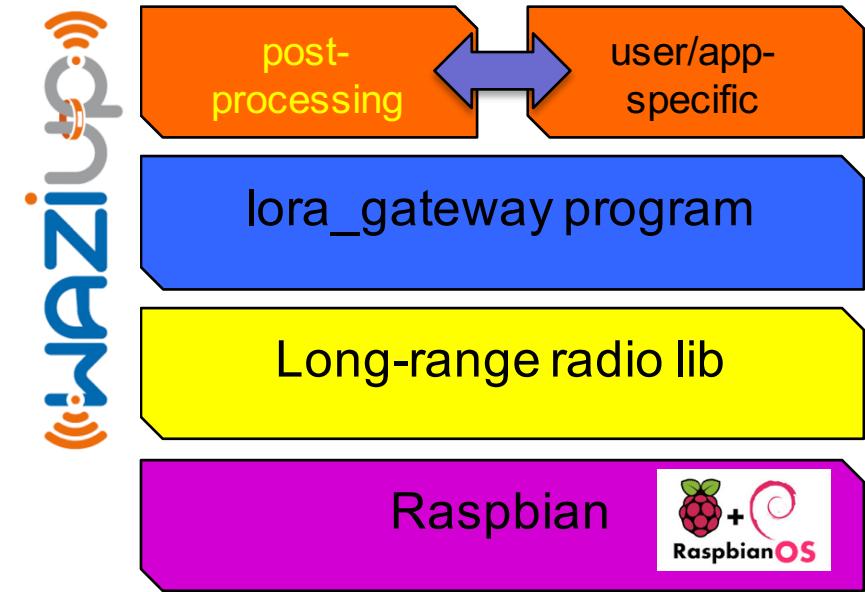
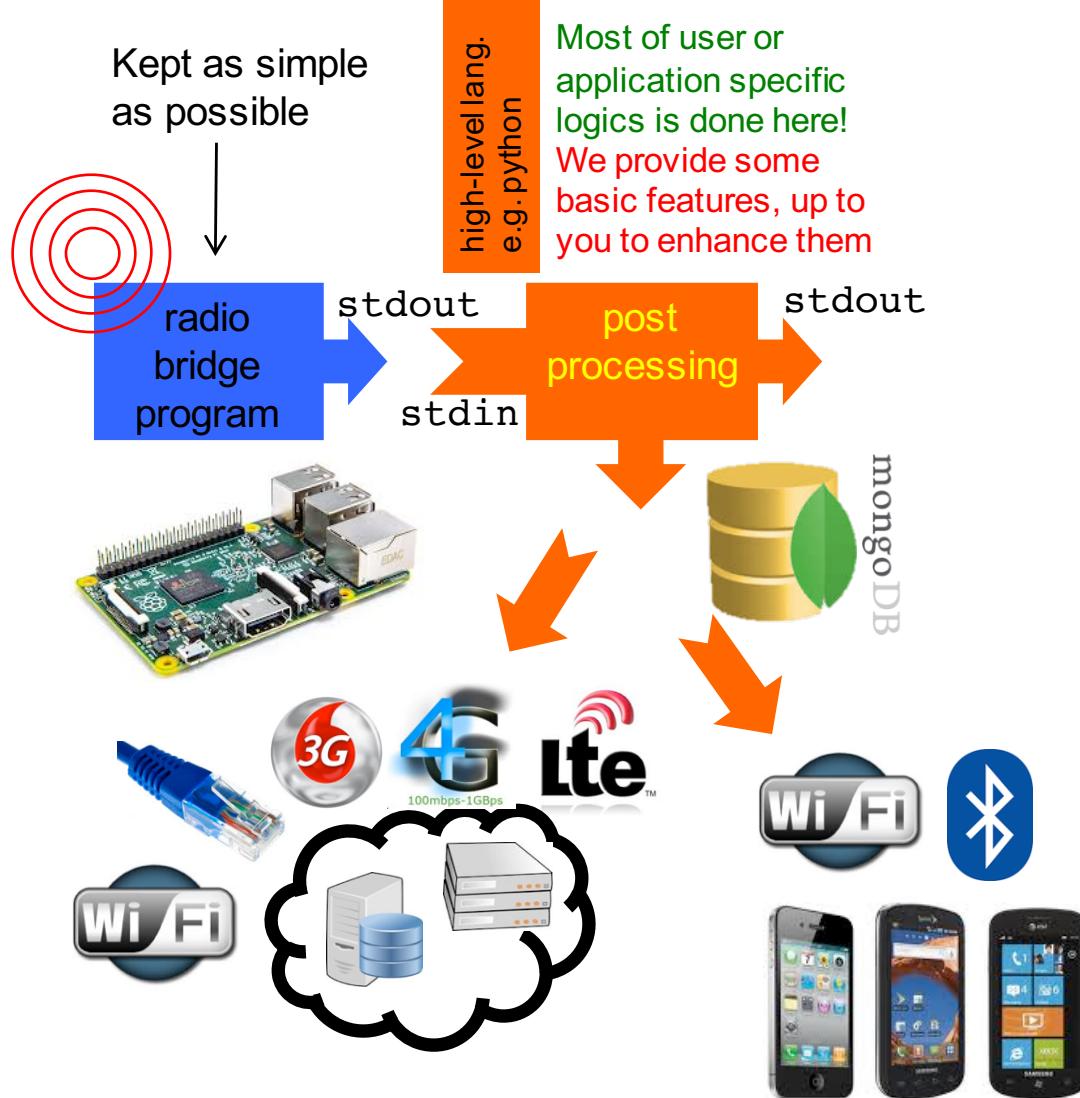
COMPILING THE GW SOFTWARE

```
> cd lora_gateway  
> make lora_gateway  
g++ -DRASPBERRY -DIS_RCV_GATEWAY -c lora_gateway.cpp -o lora_gateway.o  
g++ -c arduPi.cpp -o arduPi.o  
g++ -c SX1272.cpp -o SX1272.o  
g++ -lrt -lpthread lora_gateway.o arduPi.o SX1272.o -o lora_gateway
```

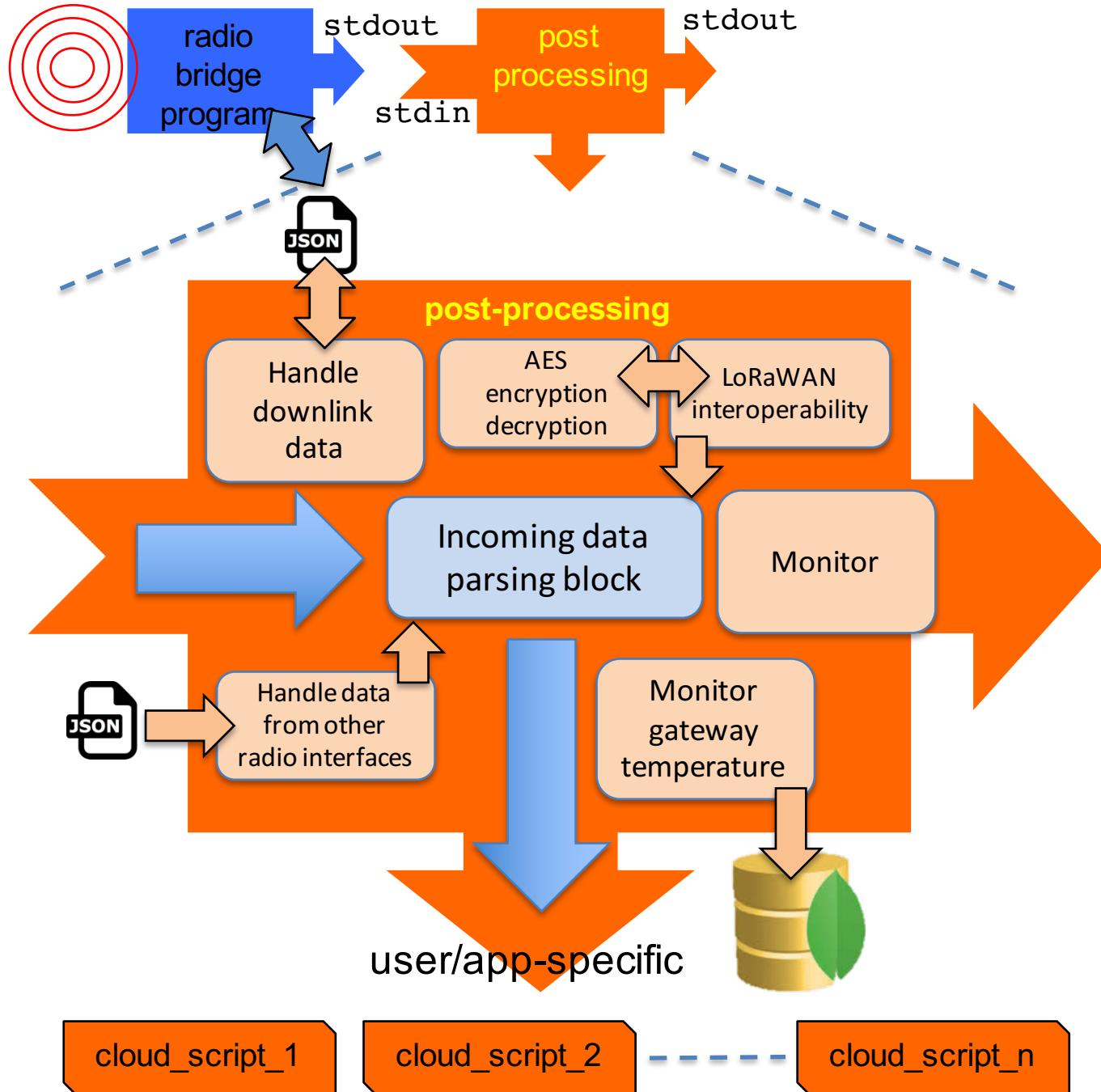
If you have a RPI 2, then type:

```
> make lora_gateway_pi2
```

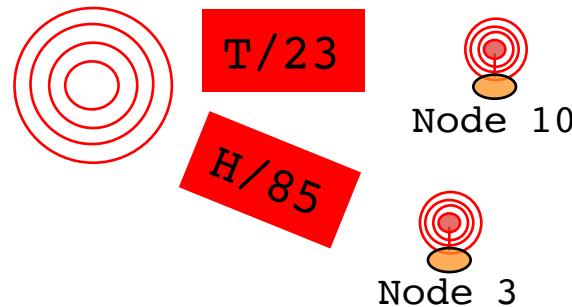
OUR LOW-COST GATEWAY ARCHITECTURE



POST-PROCESSING BLOCK



STARTING THE BASIC GATEWAY



```
> sudo ./lora_gateway
Power ON: state 0
LoRa mode: 1
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge

--- rxlora. dst=1 type=0x10 src=10 seq=0 len=4 SNR=9 RSSIpkt=-54
^p1,16,10,0,4,9,-54
T/23
--- rxlora. dst=1 type=0x10 src=3 seq=0 len=4 SNR=8 RSSIpkt=-54
^p1,16,3,0,4,8,-54
H/85
```

POST-PROCESSING RECEIVED DATA

```
> sudo ./lora_gateway | python ./post_processing_gw.py
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge
--- rxlora. dst=1 type=0x10 src=10 seq=0 len=4 SNR=9 RSSIpkt=-54
^p1,16,10,0,5,9,-54
Rcv ctrl packet info 1,16,10,0,4,9,-54
(dst=1 type=0x10 src=10 seq=0 len=4 SNR=9 RSSI=-54)
T/23
--- rxlora. dst=1 type=0x10 src=3 seq=0 len=4 SNR=8 RSSIpkt=-54
^p1,16,3,0,5,8,-54
Rcv ctrl packet info 1,16,3,0,4,8,-54
(dst=1 type=0x10 src=3 seq=0 len=5 SNR=8 RSSI=-54)
H/85
```

All lines that are not prefixed by specific character sequence are displayed unchanged

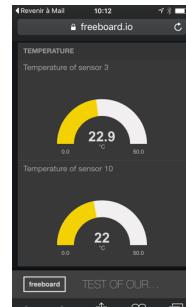
Rcv ctrl packet info 1,16,10,0,4,9,-54 ← **^p1,16,10,0,5,9,-54**

^p1,16,3,0,5,8,-54 ← **^p1,16,3,0,4,8,-54**

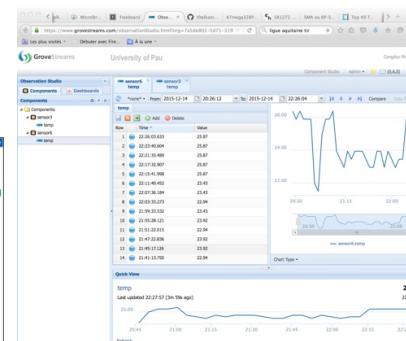
^p provides information on the last received packet: dst, type, src, seq, len, SNR & RSSI

Pre-defined sequences inserted by the gateway or the end-device allow for information exchanged between the gateway and the post-processing program

GATEWAY TO CLOUD



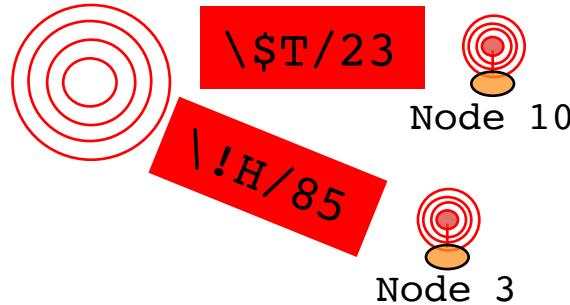
freeboard
FIWARE



GroveStreams
SensorCloud™

Data received at the gateway can be pushed to IoT clouds. We provide python script examples for many IoT cloud platforms. Most of clouds with REST API can be easily integrated.

LOG RECEIVED MESSAGES USING CLOUD SERVICES



```
> sudo ./lora_gateway | python ./post_processing_gw.py
Power ON: state 0
LoRa mode: 4
Setting mode: state 0
Channel CH_10_868: state 0
Power M: state 0
Get Preamble Length: state 0
Preamble Length: 8
LoRa addr 1 : state 0
SX1272/76 configured as LR-BS. Waiting RF input for transparent RF-serial bridge

--- rxlora. dst=1 type=0x10 src=10 seq=0 len=6 SNR=9 RSSIpkt=-54
Rcv ctrl packet info 1,16,10,0,6,9,-54
(dst=1 type=0x10 src=10 seq=0 len=6 SNR=9 RSSI=-54)
rcv msg to log (\$) on dropbox : T/23
--- rxlora. dst=1 type=0x10 src=3 seq=0 len=6 SNR=8 RSSIpkt=-54
Rcv ctrl packet info 1,16,3,0,6,8,-54
(dst=1 type=0x10 src=3 seq=0 len=6 SNR=8 RSSI=-54)
rcv msg to upload (!) on cloud : H/85
```

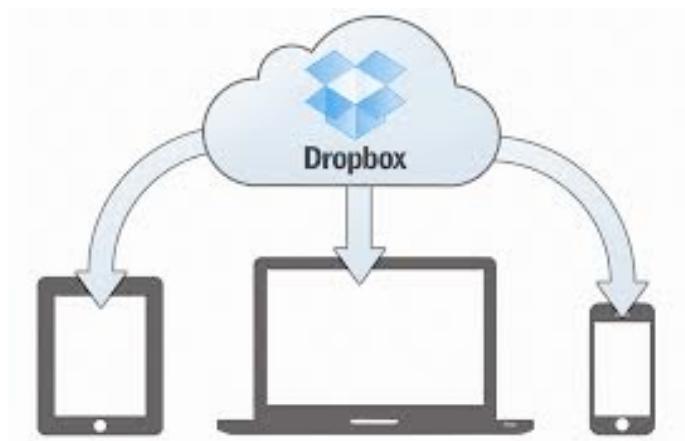
\\$ or ! before the data indicates that the data should be logged on a file or a cloud. It is up to the end-device to decide which option

USING Dropbox

- ❑ A message starting with '\\$' is logged in a file 'telemetry.log' in a folder shared through Dropbox

```
(src=10 seq=0 len=6 SNR=9 RSSI=-54) 2015-11-04T10:14:30.328413> T/23  
(src=10 seq=1 len=8 SNR=8 RSSI=-54) 2015-11-04T10:14:37.443350> T/23.2  
(src=10 seq=2 len=6 SNR=8 RSSI=-53) 2015-11-04T10:16:23.343657> T/24  
...
```

\\$T/23
Node 10



USING ThingSpeak

- ❑ A message starting with '\!' is uploaded on a cloud, e.g. ThingSpeak



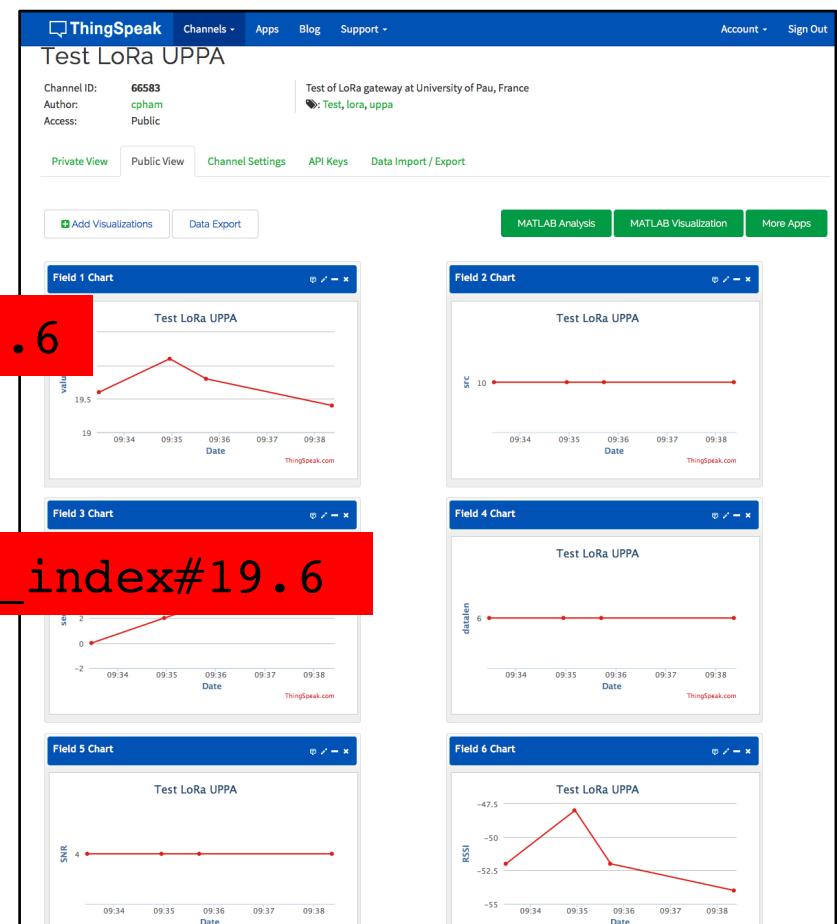
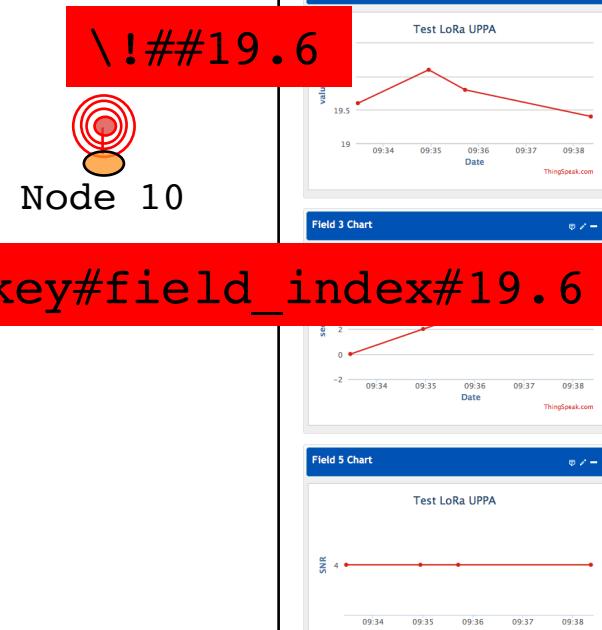
ThingSpeak

User: cpham

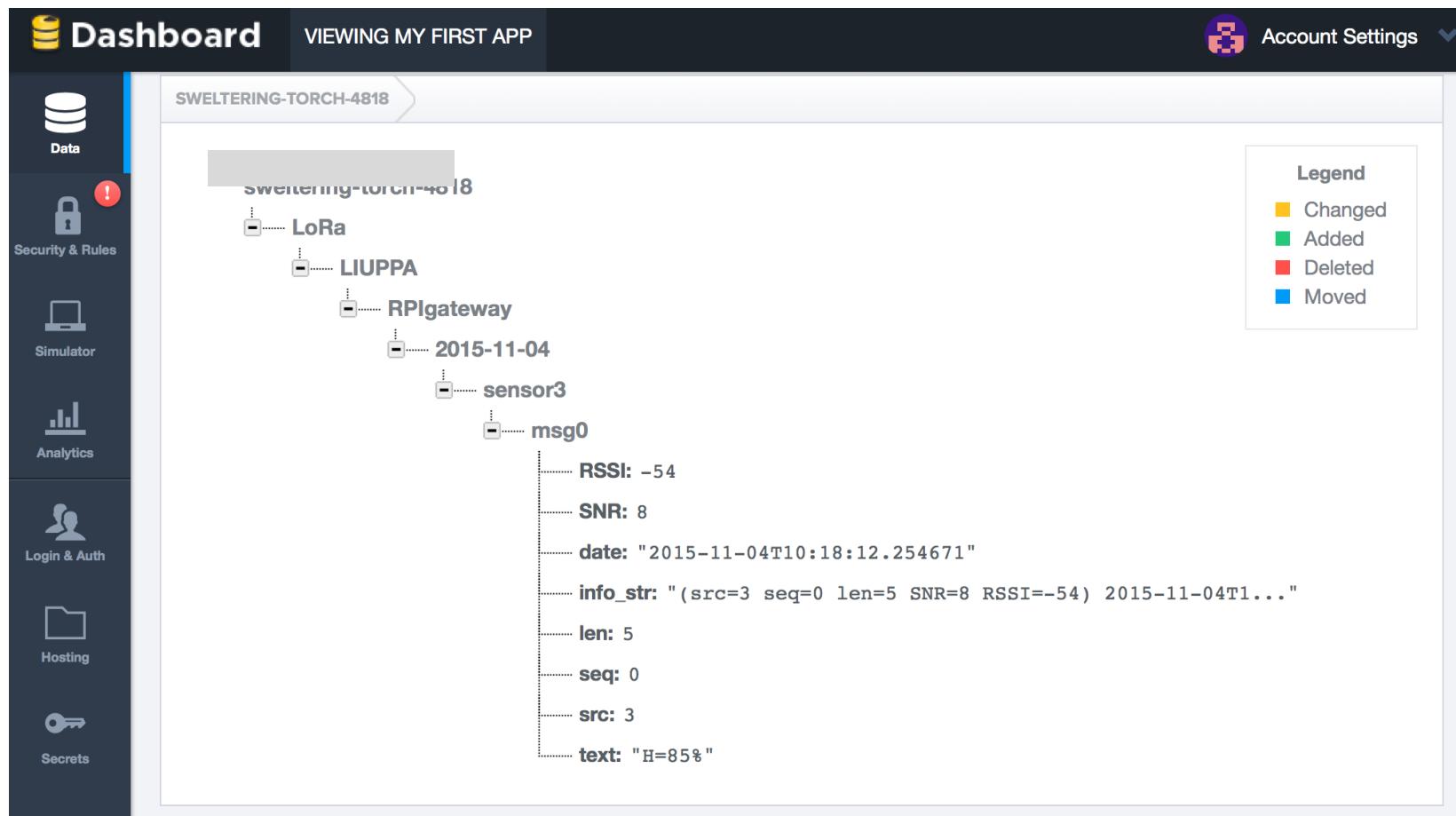
Test LoRa UPPA

Channel ID: 66583
Author: cpham
Test of LoRa gateway at University of Pau, France

Test, lora, uppa



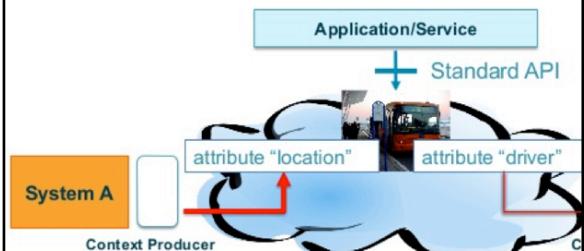
USING Firebase



❑ FIWARE support has been added with EGM script

A non-intrusive approach is required

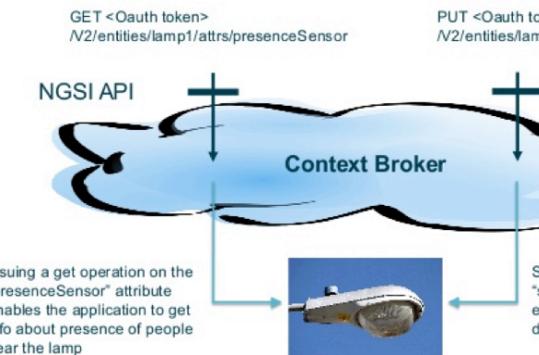
- Capable to integrate with existing or future systems dealing with management of municipal services without impact in their architectures
- Info about attributes of one entity may come from different systems, which work either as Context Producers or Context Consumers
- Applications rely on a single model adapting to system



Figures from FIWARE

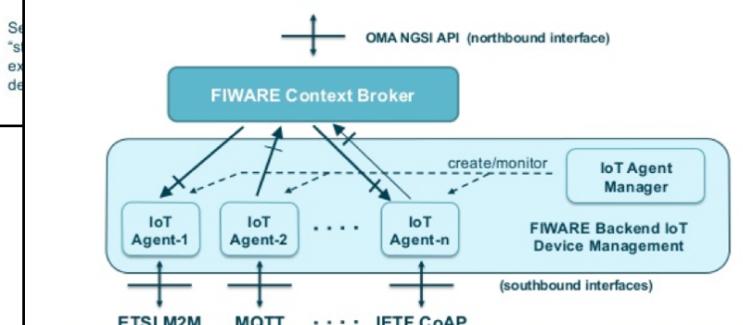
Connecting to the Internet of Things

- Capturing data from, or Acting upon, IoT devices should be as easy as to read/change the value of attributes linked to context entities



Integration with sensor networks

- FIWARE NGSI is capable to deal with the wide variety of IoT protocols today
- Rather than trying to solve the battle of standards at IoT level, it brings a standard where no standard exists today: context information management



FREEBOARD IOT CLOUD WITH FIWARE

freeboard

+ ADD PANE

START TUTORIAL

DATASOURCES

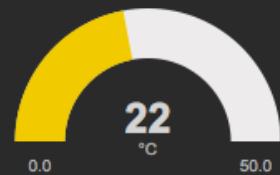
MyDevice	never		
fiware testing of sensor3	09:13:39		
fiware testing of sensor10	09:14:34		

ADD

▲

TEMPERATURE

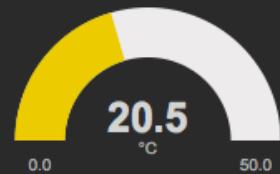
Temperature of sensor 3



22 °C

0.0 50.0

Temperature of sensor 10



20.5 °C

0.0 50.0

◀ Revenir à Mail 10:12 thingspeak.com

ThingSpeak

Field 1 Chart

Temp for sensor 3

T from sensor 3 (office): 22.94

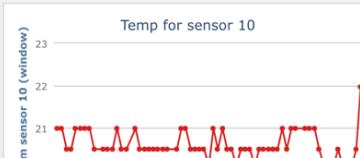
Fri Dec 04 2015 10:10:32 GMT+0100



Date

Field 2 Chart

Temp for sensor 10



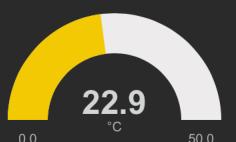
Date

Field 5 Chart

◀ Revenir à Mail 10:12 freeboard.io

TEMPERATURE

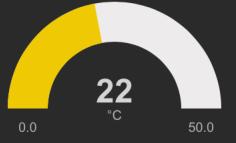
Temperature of sensor 3



22.9 °C

0.0 50.0

Temperature of sensor 10



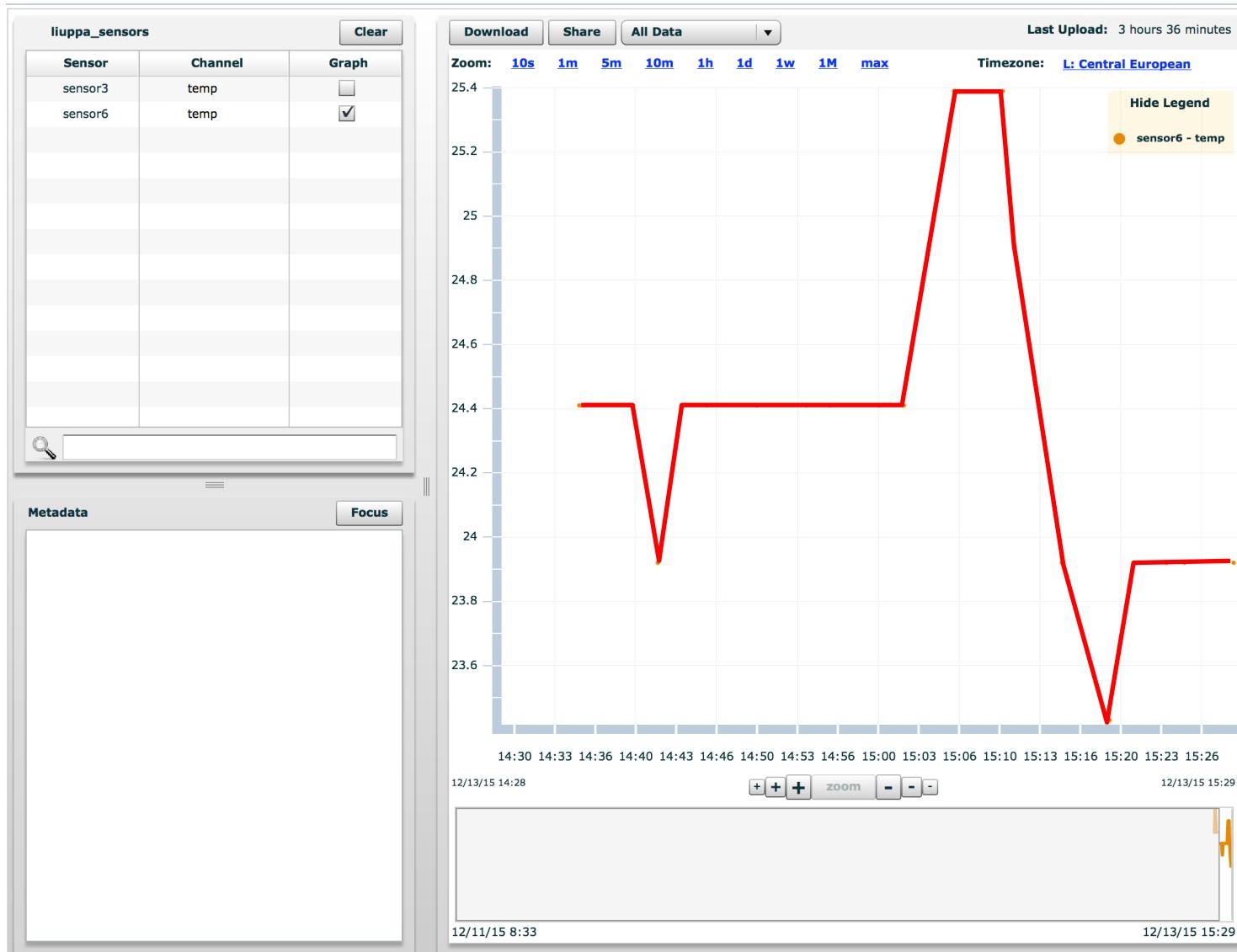
22 °C

0.0 50.0

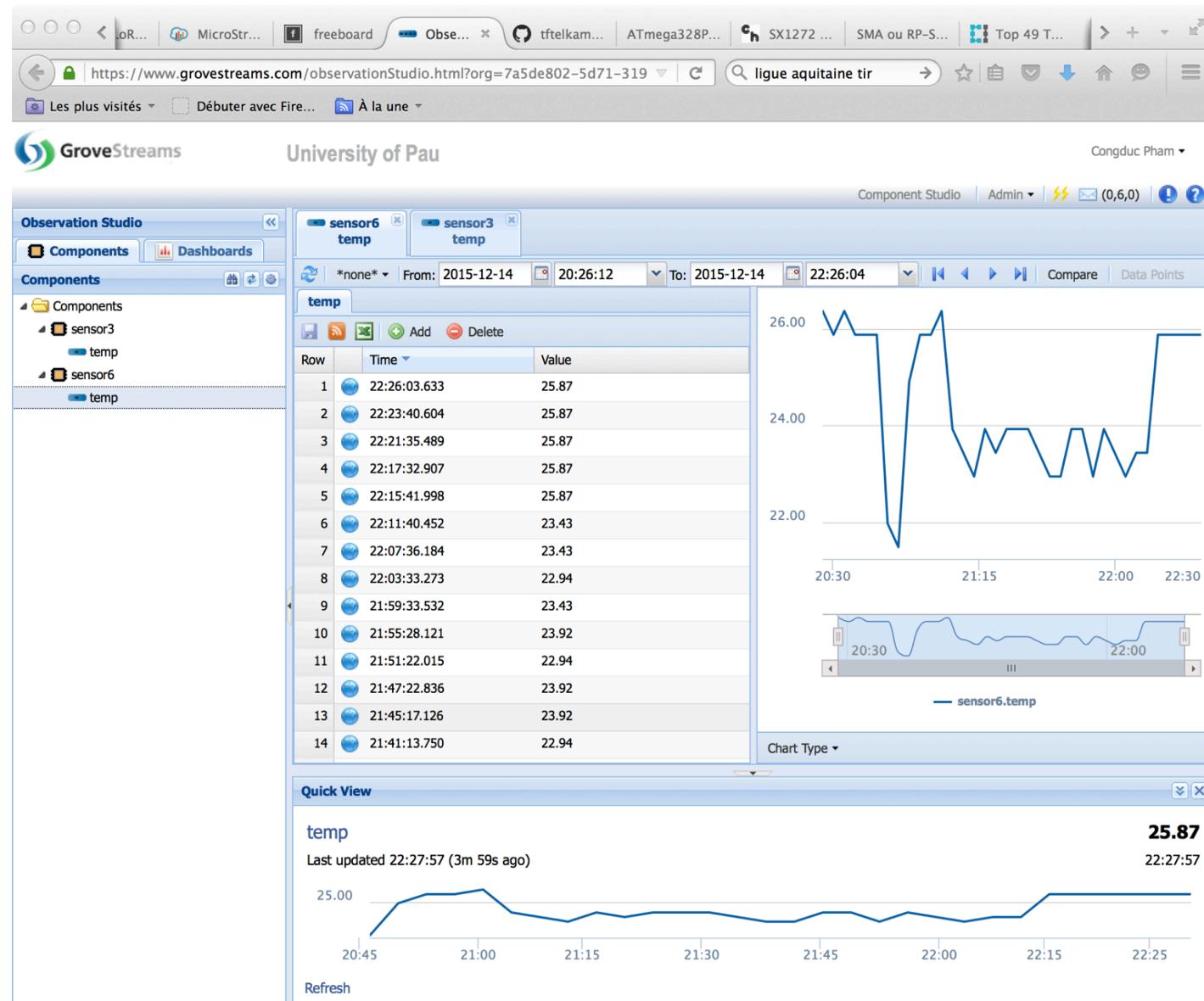
freeboard TEST OF OUR...

< >

 SensorCloud™ DEVICES ACCOUNT CSV UPLOADER DATA SETTINGS MATHENGINE® USE JS VIEWER congduc.pham@univ-pau.fr LOG OUT



USING GroveStreams



CLOUDS.JSON

```
{  
  "clouds": [  
    {  
      "notice": "do not remove the MongoDB cloud declaration",  
      "name": "Local gateway MongoDB",  
      "script": "python CloudMongoDB.py",  
      "type": "database",  
      "max_months_to_store": 2,  
      "enabled": false  
    },  
    {  
      "name": "WAZIUP Orion cloud",  
      "script": "python CloudWAZIUP.py",  
      "type": "iotcloud",  
      "write_key": "",  
      "enabled": true  
    },  
    {  
      "name": "ThingSpeak cloud",  
      "script": "python CloudThingSpeak.py",  
      "type": "iotcloud",  
      "write_key": "",  
      "enabled": true  
    },  
    {  
      "name": "GroveStreams cloud",  
      "script": "python CloudGroveStreams.py",  
      "type": "iotcloud",  
      "write_key": "",  
      "enabled": true  
    },  
    {  
      "name": "Firebase cloud",  
      "script": "python CloudFireBase.py",  
      "type": "jsoncloud",  
      "write_key": "",  
      "enabled": true  
    },  
    {  
      "name": "example template",  
      "script": "name of your script, preceded by the script launcher",  
      "type": "whatever you want FYI",  
      "server": "",  
      "login": "",  
      "password": "",  
      "folder": "",  
      "write_key": "",  
      "enabled": false  
    }  
  ]  
}
```

For each cloud, you have to provide a script and the launcher program (e.g. python)

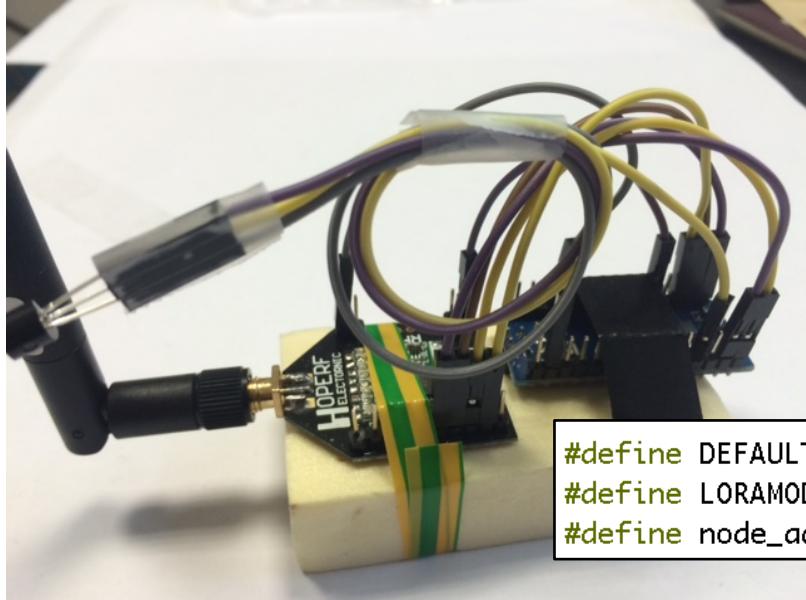
Enabled clouds will be called by the post-processing stage

WRITE YOUR OWN CLOUD SCRIPT

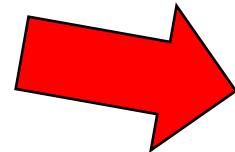
- ❑ Use our templates to write your own cloud script
 - ❑ CloudMongoDB.py, CloudThingSpeak.py,
CloudFireBase.py, CloudGroveStreams.py,
CloudWAZIUP.py
- ❑ A cloud script is called with 5 arguments
 - ldata: the received data
 - e.g. #4#TC/21.5 as 1st argument (sys.argv[1] in python)
 - pdata: packet information
 - e.g. "1,16,3,0,10,8,-45" as 2nd argument (sys.argv[2] in python)
 - interpreted as dst,ptype,src,seq,len,SNR,RSSI for the last received packet
 - rdata: the LoRa radio information
 - e.g. "500,5,12" as 3rd argument (sys.argv[3] in python)
 - interpreted as bw,cr,sf for the last received packet
 - tdata: the timestamp information
 - e.g. "2016-10-04T02:03:28.783385" as 4th argument (sys.argv[4] in python)
 - gwid: the gateway id
 - e.g. 00000027EBBEDA21 as 5th argument (sys.argv[5] in python)

These parameters are passed to the script. It is up to the cloud script to use these parameters or not.

DEFAULT CONFIGURATION



\!##TC/18.5



The default configuration in the Arduino_LoRa_temp example is:

Send packets to the gateway (one or many if in range)
LoRa mode 1 & Node short address is 6

The default gateway configuration is also LoRa mode 1

STANDALONE GATEWAY



SSH TO THE GATEWAY

- ❑ If you connected the gateway to your LAN or laptop then the gateway got an IP address. Use this address to connect with SSH to the gateway
- ❑ Use ssh pi@RPI_ADDR, where RPI_ADDR is the IP address assigned to the gateway
- ❑ Login password is loragateway if you installed from the SD card image

SSH TO THE GATEWAY WITH WiFi

- ❑ The gateway is also configured as a WiFi access point with address 192.168.200.1
- ❑ Select the WAZIUP_PI_GW_xxxxxxxxxx WiFi
- ❑ WiFi password is loragateway
- ❑ Then ssh pi@192.168.200.1
- ❑ Login password is loragateway



```
cpham — pi@raspberrypi: ~/lora_gateway —
MacBookProRetina-de-Congduc-Pham:~ cpham$ ssh pi@192.168.200.1
pi@192.168.200.1's password:

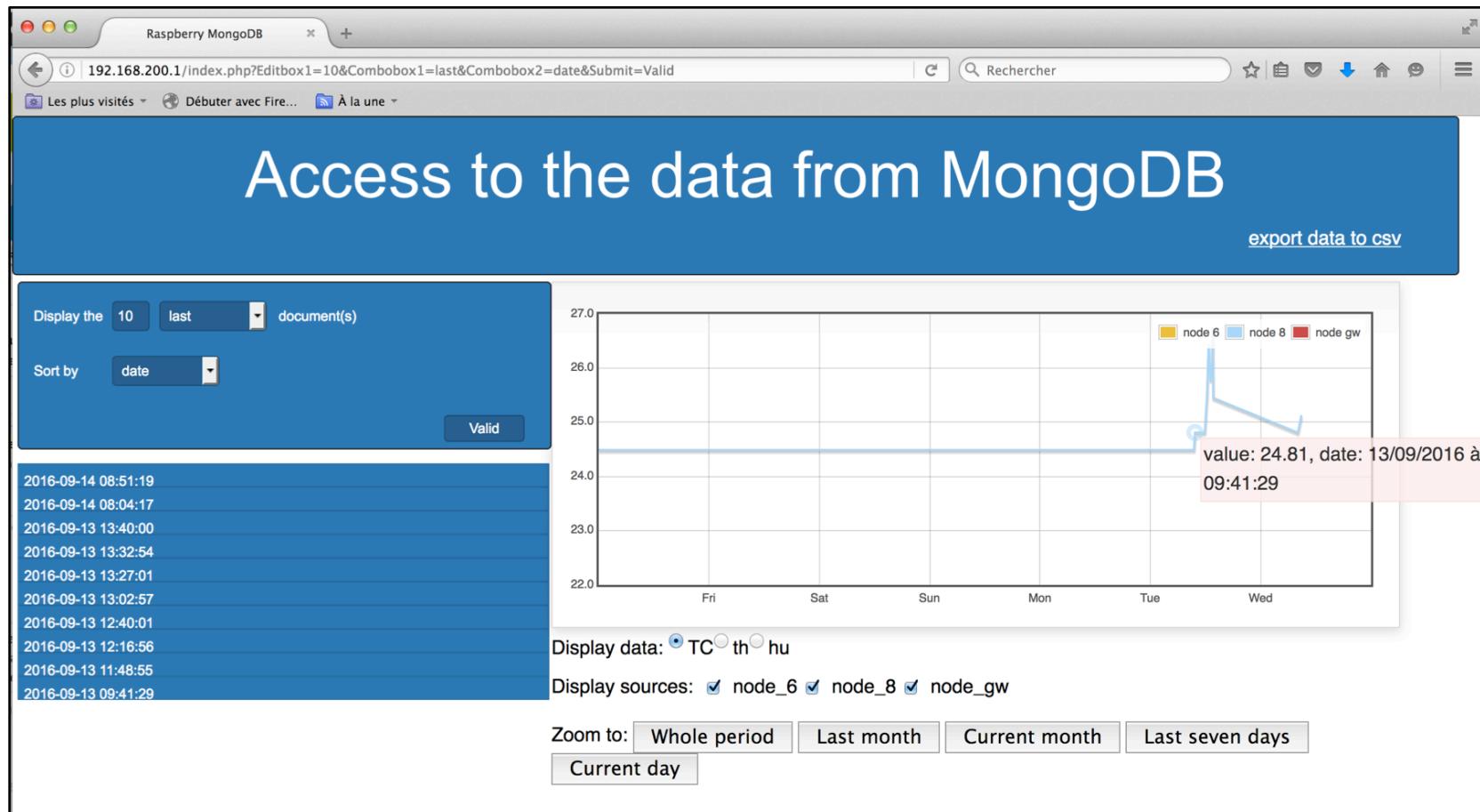
The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Thu Aug  4 17:19:00 2016 from 192.168.200.102
pi@raspberrypi:~ $ cd lora_gateway/
pi@raspberrypi:~/lora_gateway $ ll
total 864
-rw----- 1 pi    pi    44155 Aug  3 16:55 arduPi.cpp
-rw----- 1 pi    pi    16715 Aug  3 16:55 arduPi.h
-rw-r--r-- 1 pi    pi    35164 Aug  3 17:01 arduPi.o
-rw----- 1 pi    pi    43310 Aug  3 16:55 arduPi_pi2.cpp
-rw----- 1 pi    pi    14043 Aug  3 16:55 arduPi_pi2.h
-rw----- 1 pi    pi    77976 Aug  3 16:55 bcm2835.h
```

CONNECT TO THE EMBEDDED WEB SERVER

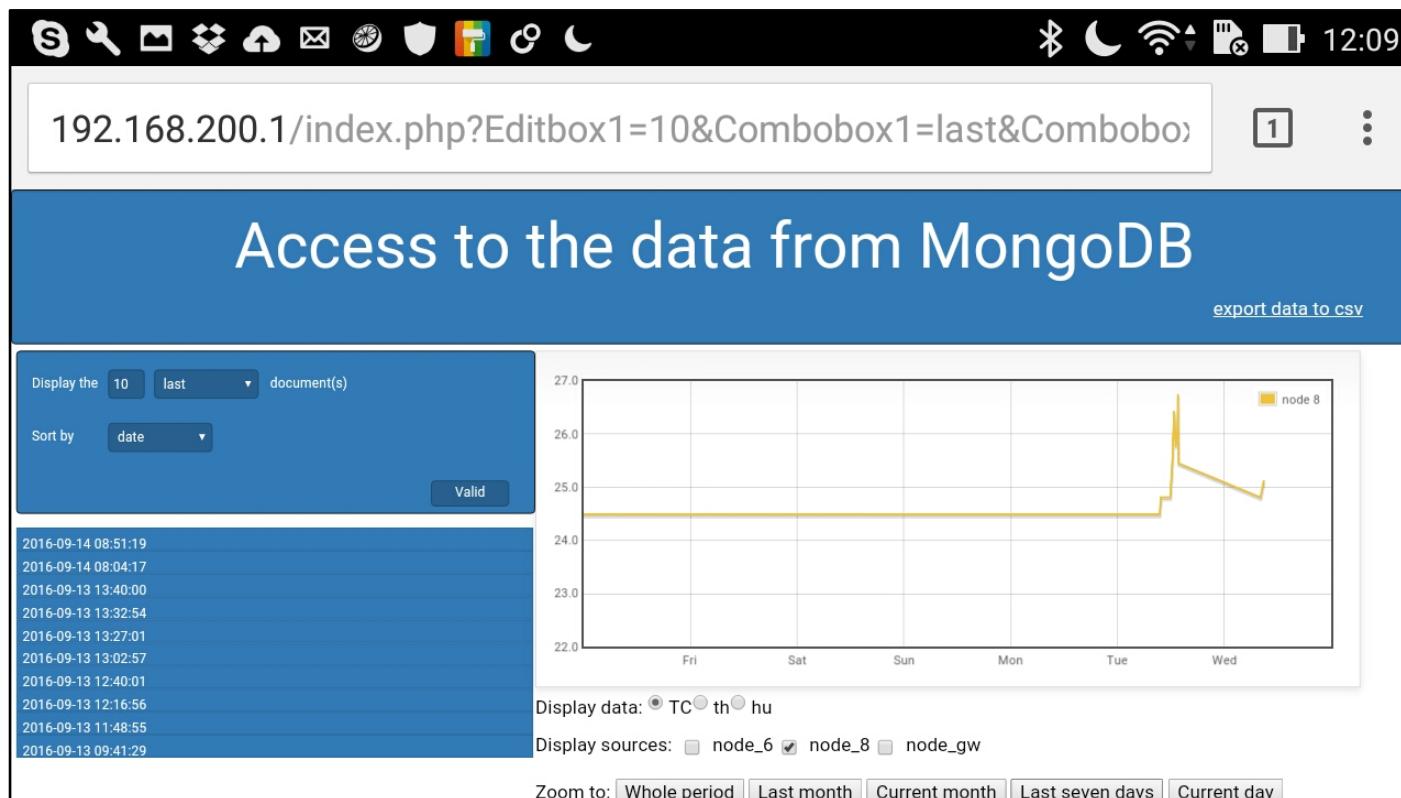
- On the WiFi interface
 - Gateway address is 192.168.200.1
- On the Ethernet interface
 - Gateway address is the IP address assigned by the DHCP server (of your LAN or laptop)
- Choose any of these solutions and open a web browser to enter the gateway IP address in the URL bar
 - <http://192.168.200.1>

DATA FROM THE LOCAL WEB SERVER

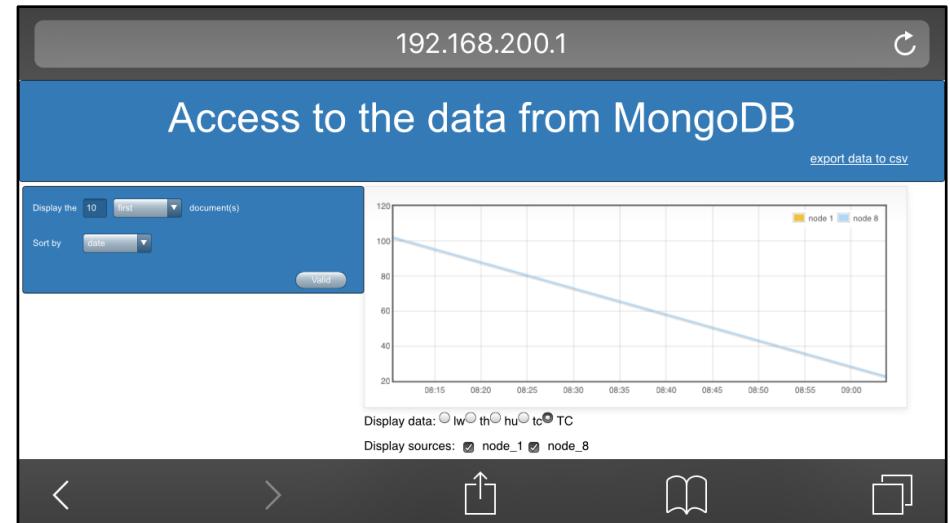
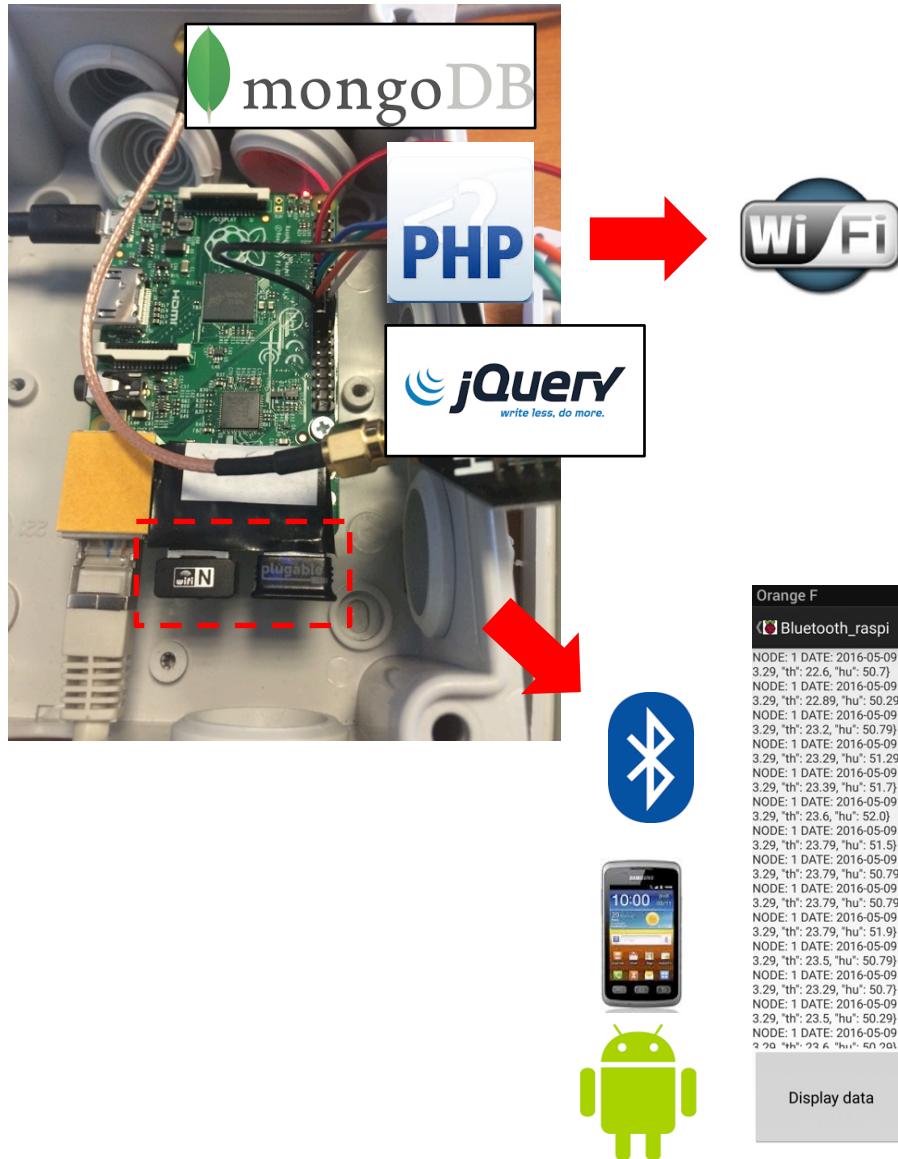


VISUALIZE IT ON YOUR SMARTPHONE!

- Don't forget to join the WAZIUP_PI_GW_xxxxxxxxxx WiFi



RUNNING THE GATEWAY WITHOUT INTERNET ACCESS



Orange F * N 10:34

Bluetooth_raspi

```

NODE: 1 DATE: 2016-05-09 08:04:59.807000 DATA: {"lw": 3.29, "th": 22.6, "hu": 50.7}
NODE: 1 DATE: 2016-05-09 08:28:52.993000 DATA: {"lw": 3.29, "th": 22.89, "hu": 50.29}
NODE: 1 DATE: 2016-05-09 08:53:04.317000 DATA: {"lw": 3.29, "th": 23.2, "hu": 50.79}
NODE: 1 DATE: 2016-05-09 09:05:00.997000 DATA: {"lw": 3.29, "th": 23.29, "hu": 51.29}
NODE: 1 DATE: 2016-05-09 09:17:24.482000 DATA: {"lw": 3.29, "th": 23.39, "hu": 51.7}
NODE: 1 DATE: 2016-05-09 09:41:27.437000 DATA: {"lw": 3.29, "th": 23.6, "hu": 52.0}
NODE: 1 DATE: 2016-05-09 10:05:39.032000 DATA: {"lw": 3.29, "th": 23.79, "hu": 51.5}
NODE: 1 DATE: 2016-05-09 10:17:45.186000 DATA: {"lw": 3.29, "th": 23.79, "hu": 50.79}
NODE: 1 DATE: 2016-05-09 10:29:24.285000 DATA: {"lw": 3.29, "th": 23.79, "hu": 50.79}
NODE: 1 DATE: 2016-05-09 10:53:09.347000 DATA: {"lw": 3.29, "th": 23.79, "hu": 51.9}
NODE: 1 DATE: 2016-05-09 11:17:02.953000 DATA: {"lw": 3.29, "th": 23.5, "hu": 50.79}
NODE: 1 DATE: 2016-05-09 11:52:53.334000 DATA: {"lw": 3.29, "th": 23.29, "hu": 50.7}
NODE: 1 DATE: 2016-05-09 12:04:32.437000 DATA: {"lw": 3.29, "th": 23.5, "hu": 50.29}
NODE: 1 DATE: 2016-05-09 12:16:56.116000 DATA: {"lw": 3.29, "th": 22.6, "hu": 50.29}

```

Display data Retrieve data in a csv file

Orange F * N 10:37

Bluetooth_raspi

NODES PREFERENCES

1 check to retrieve its data

8 check to retrieve its data

DATES PREFERENCES

Pick a begin date
Retrieve data since 09-05-2016

Pick an end date
Retrieve data until 17-05-2016

Display data Retrieve data in a csv file

Orange F * N 10:39

Bluetooth_raspi

Creating .csv file with the data received...
File 17-05-2016_10h39m36s.csv created and saved in the folder /storage/emulated/0/Raspberry_local_data

Display data Retrieve data in a csv file