Building a WiFi localisation node

Identifying the components

Our bill of materials (Complete Workshop set available at TinyTronics)

- RFM Module RFM95W (868 Mhz)
- Wemos Lora PCB (https://github.com/hallard/WeMos-Lora)
- Wemos D1 mini v3 – ESP8266
- Micro USB cable

Starting up the Arduino Environment

You may skip this step if you have:

- **Arduino installed with ESP8266 support**
- **LMIC 'Charles' version installed**

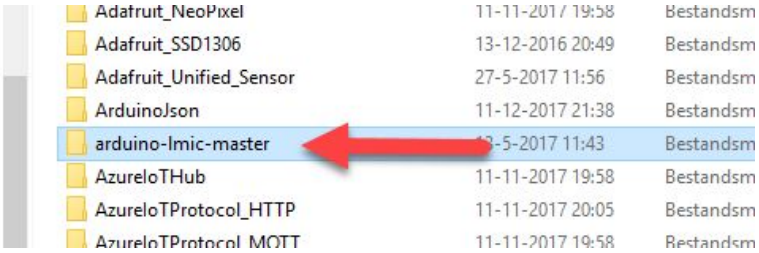
Setup the Arduino Environment. To use the ESP8266 we need the ESP toolchain. Installation instructions can be found here: https://github.com/esp8266/Arduino/

Installing with Boards Manager

Starting with 1.6.4, Arduino allows installation of third-party platform packages using Boards Manager. We have packages available for Windows, Mac OS, and Linux (32 and 64 bit).

- Install the current upstream Arduino IDE at the 1.8 level or later. The current version is at the Arduino website.
- Start Arduino and open Preferences window.
- Enter `http://arduino.esp8266.com/stable/package_esp8266com_index.json` into *Additional Board Manager URLs* field. You can add multiple URLs, separating them with commas.
- Open Boards Manager from Tools > Board menu and install *esp8266* platform (and don't forget to select your ESP8266 board from Tools > Board menu after installation).

Close your Arduino IDE software. Remove (if already installed) the current LMIC library. We will use the 'Charles' version of the library. This one is compatible with your other projects, but has some special functionality needed for the WeMos LoRa board (supporting one input pin for the three DIO pins).



Download the new library and install the .zip file with library manager:

1. Goto https://github.com/ch2i/arduino-lmic
2. Choose 'Clone or download'
3. Download ZIP
4. Mark the location
5. Go to Arduino IDE
6. Select 'Sketch->Include Library->Add .ZIP Library'
7. Select the downloaded Arduino-lmic-master.zip file from your download location

Change the 'lmic_project_config.h' file in the project_config folder (remove the remark from CFG_eu868 and add them to CFG_us915):

```
//#define CFG_us915 1
#define CFG_eu868 1
#define CFG_sx1276_radio 1
```

Download the Sketch from https://github.com/galagaking/Wemos_Node/WiFiLocalisation.ino

The Things Network Dashboard

Your applications and devices can be managed by The Things Network Dashboard.

Create an Account

To use the dashboard, you need a The Things Network account. You can create an account here:

https://account.thethingsnetwork.org/users/login .

After registering and validating your email address, you will be able to log in to The Things Network Dashboard.

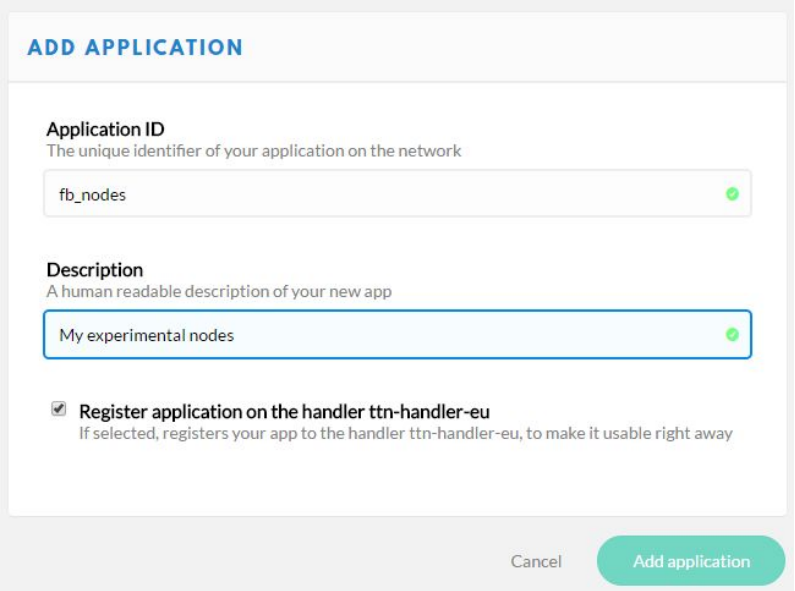
Create an Application

https://console.thethingsnetwork.org/applications

Choose 'add application'

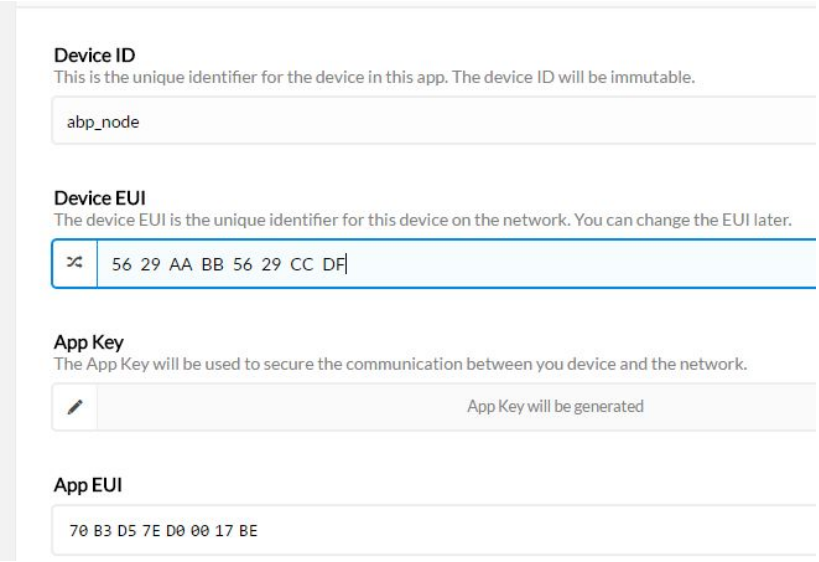
Give your Application a unique ID. You can use ONLY lowercase! You can add an unique number to get uniqueness over the ttn network (this is a global ID). If you already use an application you better add another one, because of the specific Payload Function needed here.

Your description can be any description you like.



ABP

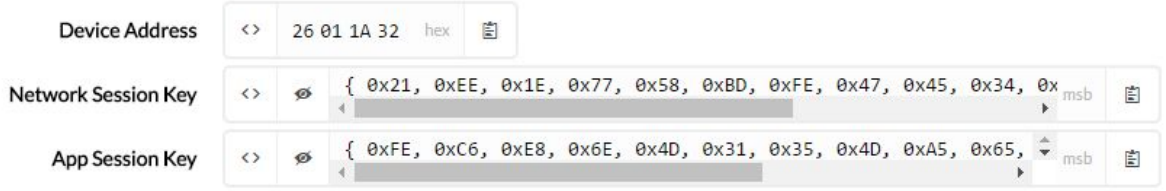
Activation by Personalization (ABP) is a method where the security keys are stored in the device. Not as safe as the OTAA method, but for experiments it works OK. There is no join procedure, nodes will work right away.



Choose *Register the device.*

Now edit the settings of the device and choose ABP (OTAA will be selected by default)

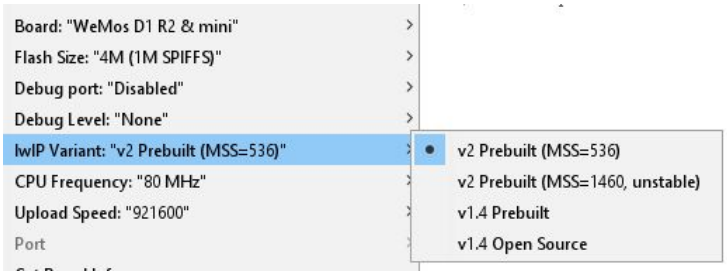
Select ‘save’. Now some values are system generated and we have to copy them to our code. Get the code from https://github.com/galagaking/Wemos_Node We use the Wemos_Node.ino example here.



- Copy the Device Address as a HEX value to DEVADDR in the example, so 26 01 1A 32 will be 0x26011A32.
- Copy the Network Session Key as MSB to NWSKEY.
- Copy the App Session Key as MSB to APPSKEY.

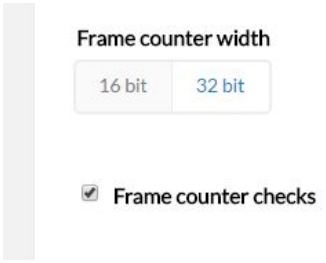
```
// LoRaWAN NwkSKey, network session key, AppSKey, application session key, end-device address
static const PROGMEM u1_t NWKSKEY[16] = { 0x21, 0xEE, 0x1E, 0x77, 0x58, 0xBD, 0xFE, 0x47, 0x4
static const PROGMEM u1_t APPSKEY[16] = { 0xFE, 0xC6, 0xE8, 0x6E, 0x4D, 0x31, 0x35, 0x4D, 0xA
// LoRaWAN end-device address (DevAddr)
static const u4_t DEVADDR = 0x260[illegible]2 ; // <-- Change this address for every node!
```

Select the Wemos board in the Arduino IDE (no debug port, lwIP v2 Prebuilt, CPU 80 Mhz, Upload speed 921200)



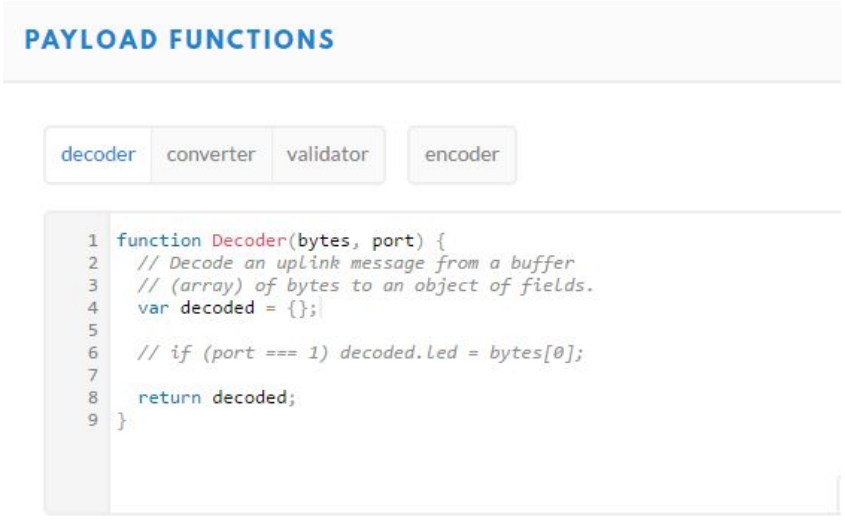
Compile and upload the code. Check in the dashboard the working.

You might want to uncheck the frame counter check



If the frame counter is checked, you must respect the sequence number, and probably copied packages are refused on the network. Though restarting you node, and thereby resetting the frame counter, will disable your node. So to get this working, you have to disable this check by unchecking this box.

To get the right display format, we can create a decoder in our application. Select your application and open the 'Payload Functions':



Enter the function below, overwriting the standard function

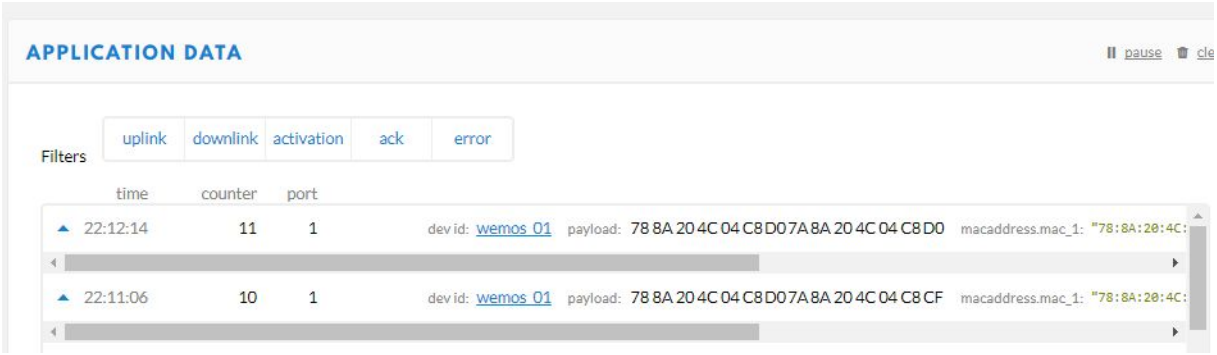
```
var hexChar = ["0", "1", "2", "3", "4", "5", "6", "7","8", "9", "A", "B", "C",
"D", "E", "F"];

function byteToHex(b) {
  return hexChar[(b >> 4) & 0x0f] + hexChar[b & 0x0f];
}
function hexToInt(hex) {
  var num=hex;
  if (num>0x7F) {
    num=num-0x100;
  }
  return num;
}
function Decoder(bytes) {
```



```
  var mac1="";
  for (i = 0; i < 6; i++) {
    mac1 += byteToHex(bytes[i]);
    if (i<5) { mac1+=':';}
}
var rssi1=hexToInt(bytes[6]);
  var mac2="";
  for (i = 0; i < 6; i++) {
    mac2 += byteToHex(bytes[i+7]);
    if (i<5) { mac2+=':';}
}
var rssi2=hexToInt(bytes[13]);
 return {
    macaddress: {
      mac_1: mac1,
      rssi_1:rssi1,
      mac_2: mac2,
      rssi_2:rssi2,
    },
   };
}
```

First test the function with two dummy bytes CE D0, And then Save the function.

Return to your data and look what happens:



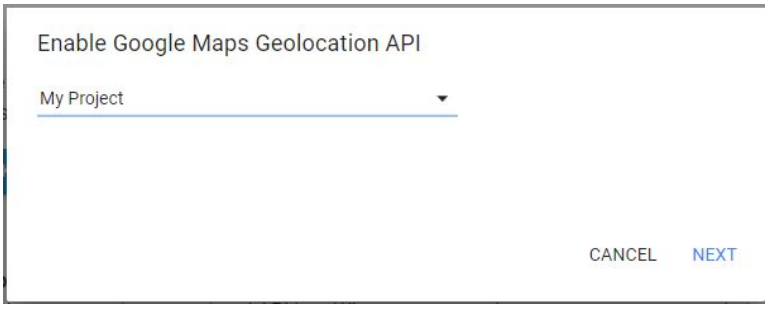
The payload contains two BSSIDs and two RSSI values.

Node Red

Now we have to decode these BSSID values to a position on a map. We will use Node Red and Google for this.

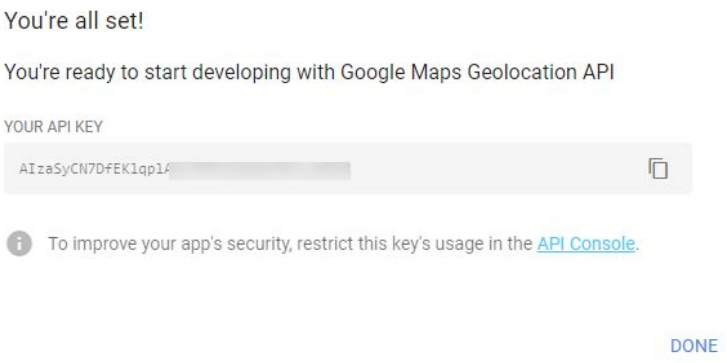
Get a Google API key

Go to https://developers.google.com/maps/documentation/geolocation/get-api-key



Click ‘Next’

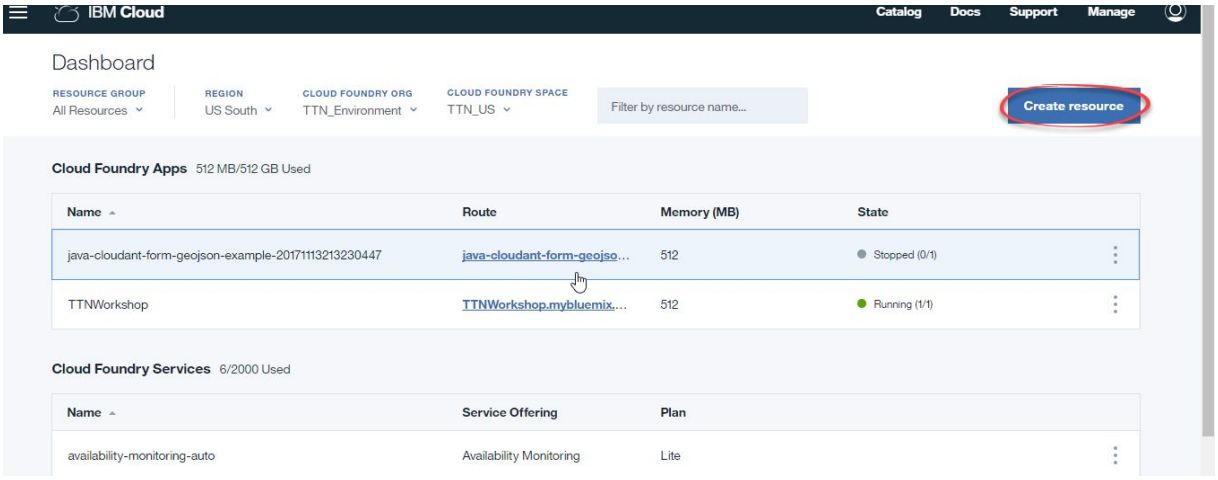
Your API key is here, store it for future use:



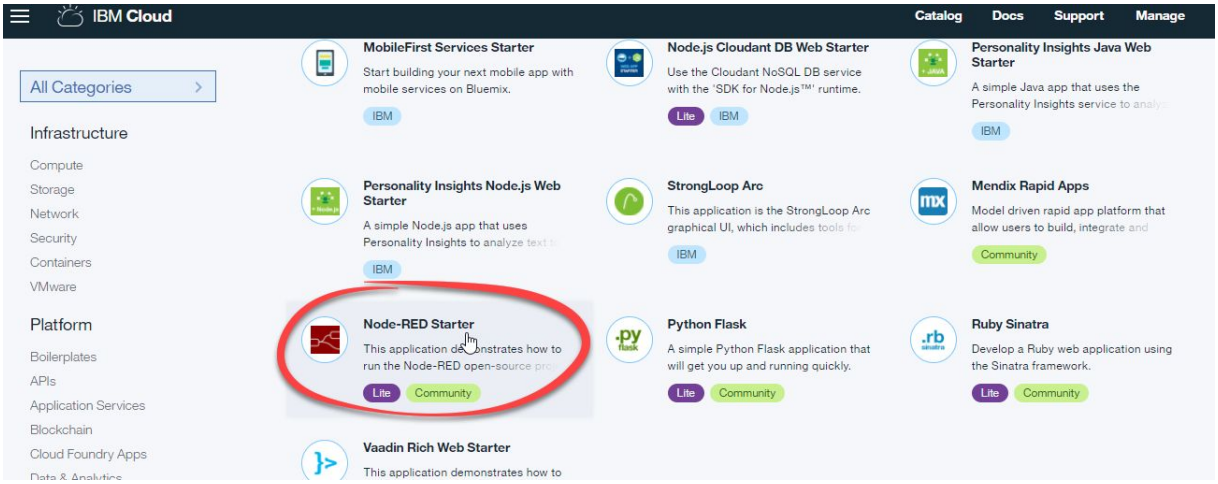
Create a new ‘Flow’ in Node Red with ‘+’

Create an App in BlueMix

An App is a functionality installed on the BlueMix platform. In the main dashboard choose ‘Create Resource’.

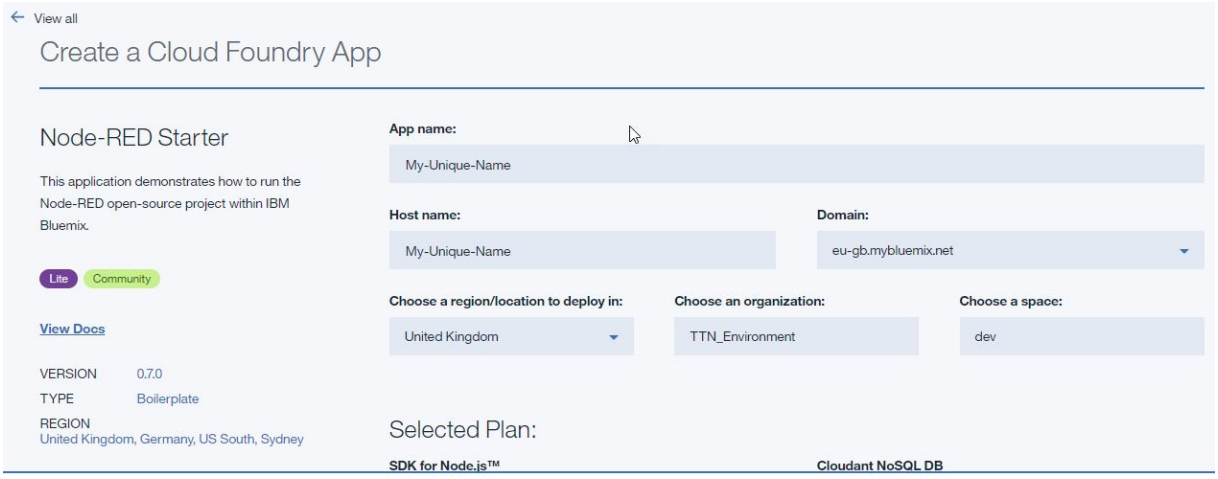


In the next screen we choose ‘Node-Red Starter’



Select ‘Node-RED Starter’:

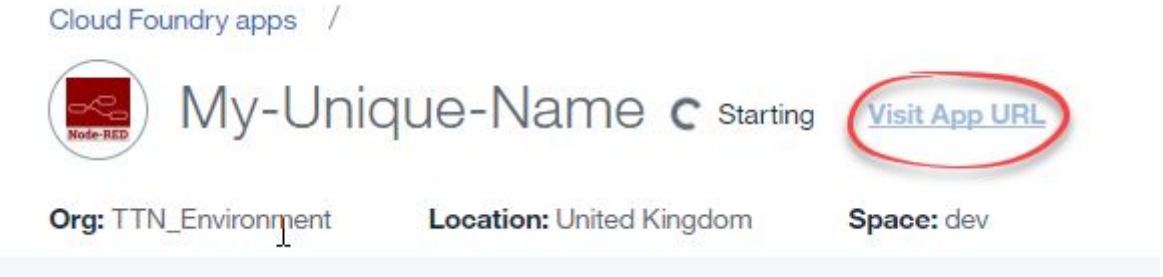
Now you need a hostname for your Node-Red server instance, so this should be globally unique! The App name is just unique for your own environment. Be creative!



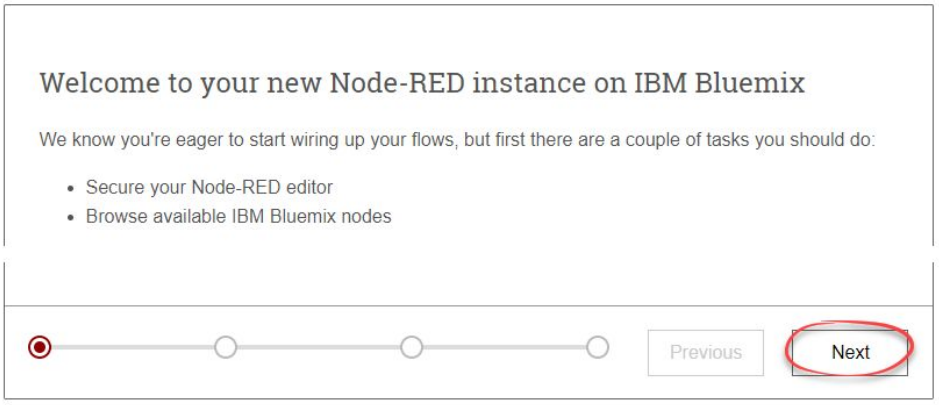
Choose ‘Create’ , this will create a Node-RED instance.

Your Node-RED server will be created and started. It can last up to 5 minutes!

After the creation you can select the ‘app url’:



A screen appears, asking you to secure your Node-Red editor



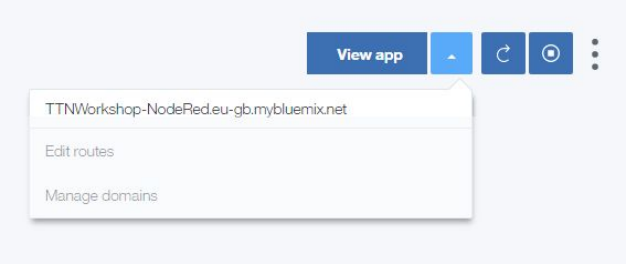
Enter (and remember) a username and password

If you do not enter any password, your Node-Red instance will be worldwide open and available!

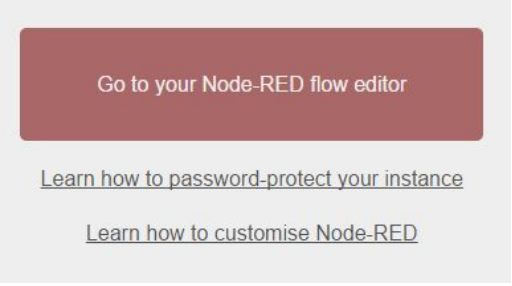
Skip the next info screen ‘Browse available IBM Bluemix nodes’.

Now press ‘Finish’ to finish the installation.

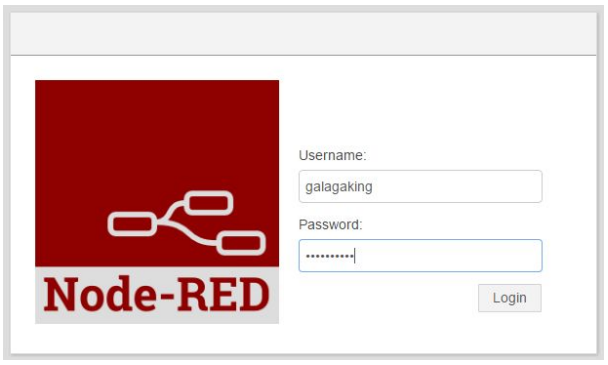
Access your Node-Red server



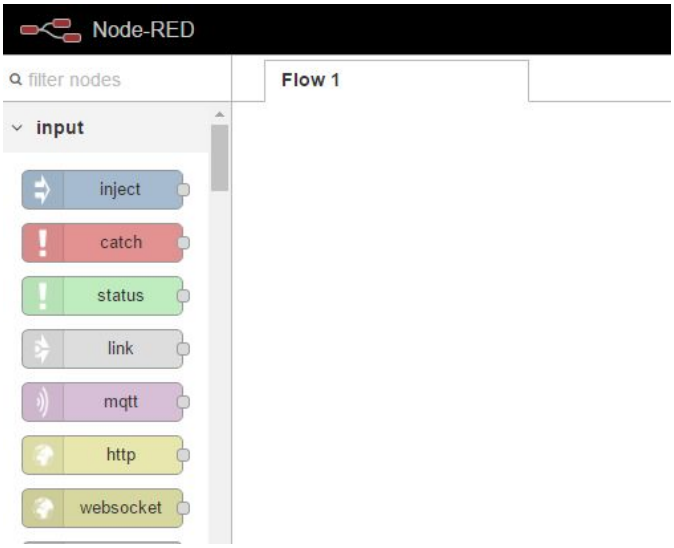
Select the name of your server, you can also use this URL to access your Node-Red server.



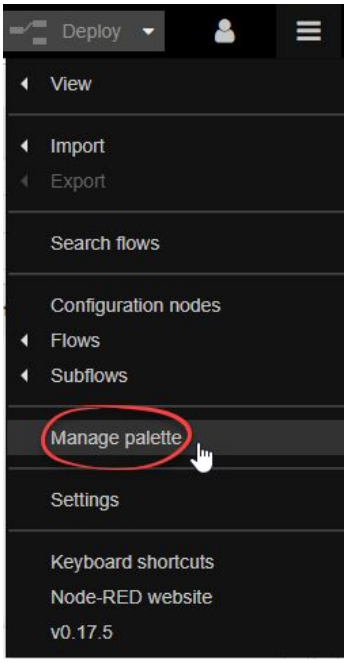
Now you have to enter your previous password:



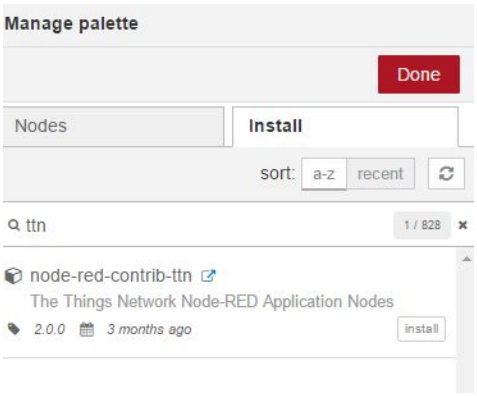
Your Node-Red is nearly ready to roll!



Now select the top right menu:



Choose manage Palette



- Search for TTN in the Install tab and click install to install the TTN nodes.
- Click again install on the warning screen.
- Search for Worldmap, and install.
- ‘Done’ to exit the palette management.

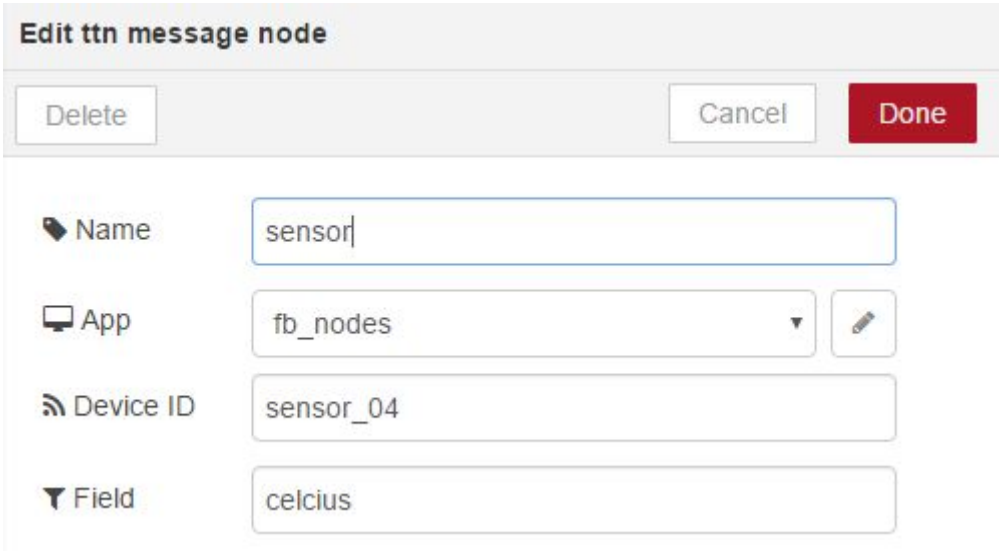
TTN nodes can now be added in your Node-Red flow.

Node Red introduction

We start with a clean ‘flow’. Remove any flows with the Menu->Flows->Delete function.

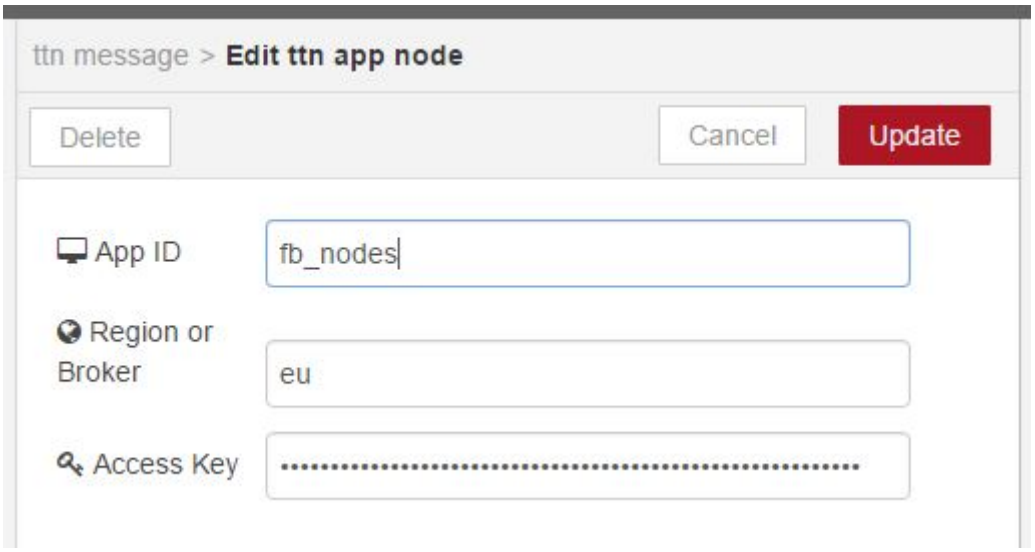
Add a TTN message node by drag and drop it on your flow screen.

By double clicking on the TTN message node you can change the values:



The name can be any name,

App refers to your TTN console. With the Pencil you can add your application here:



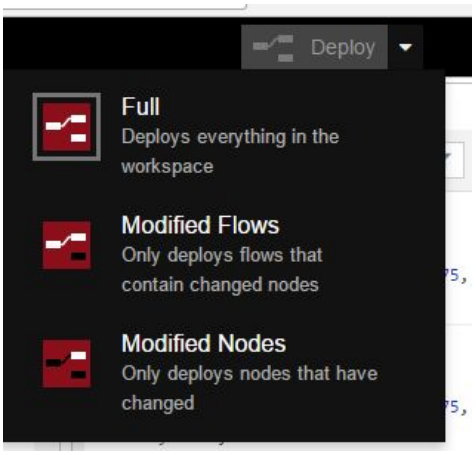
- App ID is the written name ‘Application ID’ from the TTN console
- Region is eu (you have to fill this in!!)
- Access Key is a copy of the access key of your application (access key of application, default key).
- Check Update and select your App in the previous screen.
- Device ID is the Device ID in TTN console

You can select fields you want to have as an input for your flow, the names depend on your Payload Function. If you do not have a payload function loaded, you can use an empty ‘field’, all the output will be shown.

Now add a ‘Debug’ output node to your flow and connect the both with a wire:

Select msg.payload by double clicking on the debug node and activate it by clicking on the button on the right.

Now activate your flow with Deploy:



You will see the results of your node appear in the right debug column.

Google Geolocation

Now will will create a request to Google based on these MAC addresses and our Google API key.

Create a 'Function' object with the function 'AskGoogle.js' on Github (copy / paste from this text will NOT work!).

```
var google_apikey = "FILL_IN_YOUR_GOOGLE_API_KEY";

var dev_url =
"https://www.googleapis.com/geolocation/v1/geolocate?key="+google_apikey;

var data =
    {
  "considerIp": "false",
  "wifiAccessPoints": [
    {
      "macAddress": msg.payload.macaddress.mac_1,
      "signalStrength": msg.payload.macaddress.rssi_1,
     // "signalToNoiseRatio": 0
    },
    {
      "macAddress": msg.payload.macaddress.mac_2,
      "signalStrength": msg.payload.macaddress.rssi_2,
```

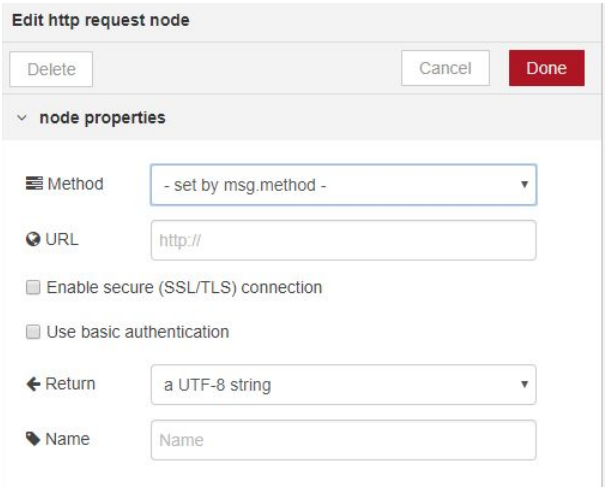


```
      // "signalToNoiseRatio": 0
    }
  ]
};
var msg = {
    "method" : "POST",
    "url" : dev_url,
    "headers" : {
        "Content-Type": "application/json",
  //      "X-M2X-KEY": google_api_key
    },
    "payload" : JSON.stringify(data)
};

return msg;
```

In the first line, fill in your Google API Key.

Connect this function with the node.

The next node is a HTTP request node. Because we created our request in a function, this one has just the Method: -set by msg.method-. All the parameters will be filled in by the msg object.



To convert the Google Output back to JSON we will just add a JSON function. Add a Debug node to show the results.

You will see the debug flow running. Google will respond with your location (by clicking on the

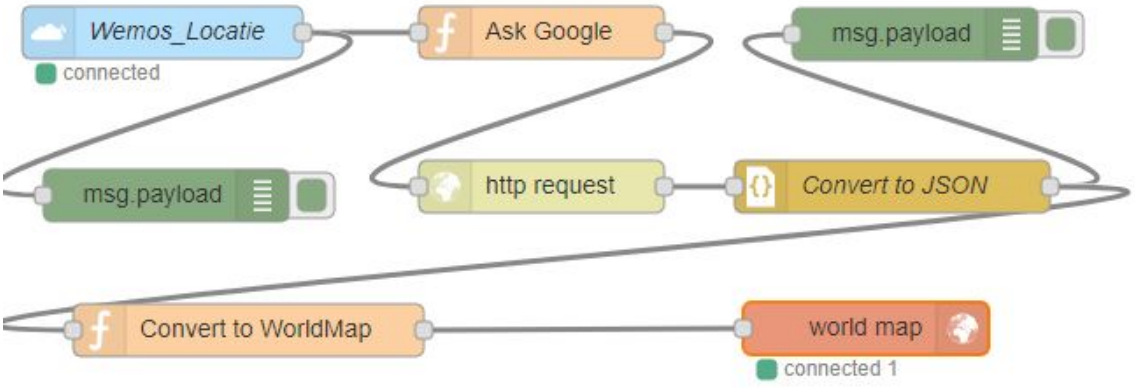
arrows you open the objects), showing Lat and Lng and accuracy.

WorldMap

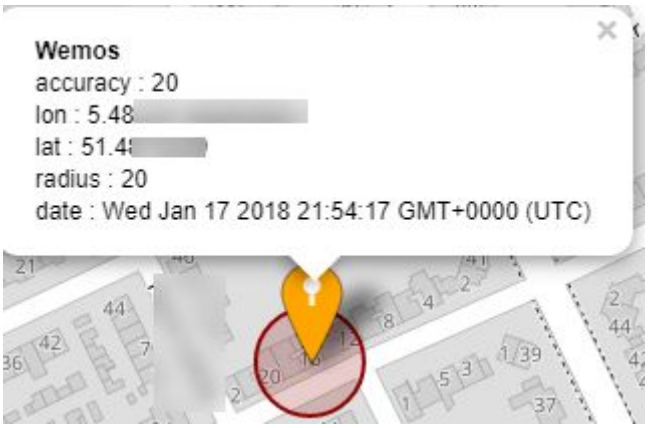
To display the info we install 'WorldMap' from the palette. WorlMap needs a different input format so we have to convert this by adding a function 'PutWorldMap.js' on github:

```
var msg1 = {};
msg1.payload=msg.payload;
msg1.payload.lon= msg.payload.location.lng;
msg1.payload.lat=msg.payload.location.lat;
delete msg.payload.location;
msg1.payload.name="Wemos";
msg1.payload.icon = "map-pin";
msg1.payload.iconColor = "orange";
msg1.payload.radius=msg.payload.accuracy;
msg1.payload.date=Date().toString();
return msg1;
```

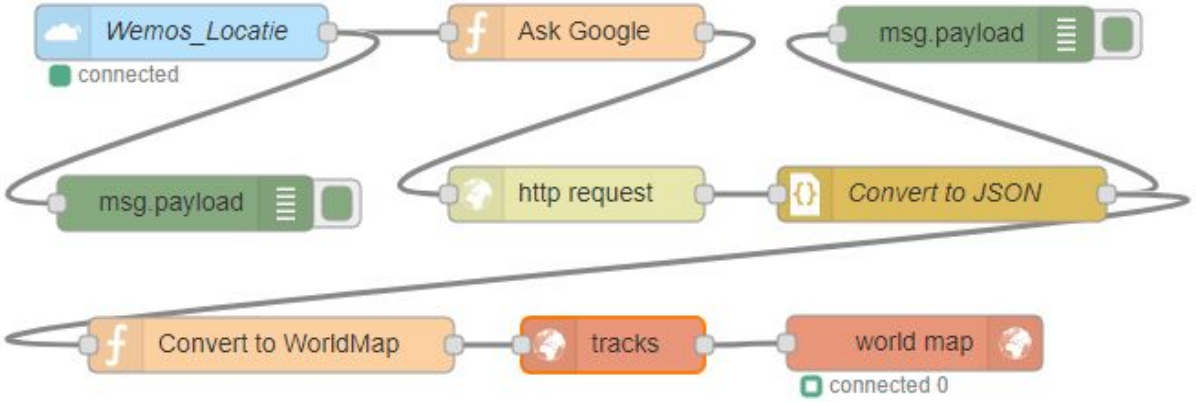
We add a color, a circle for the accuracy and a date. Our flow will look like this:



To show the 'WorldMap' press CTRL-SHIFT-M, or add '/worldmap' to your NodeRed URL:



To keep track of your position you can add the 'Tracks' node:



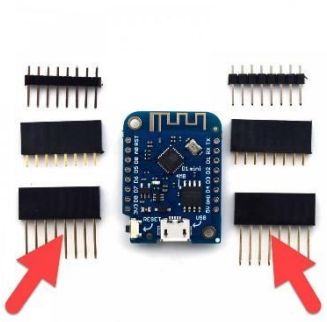
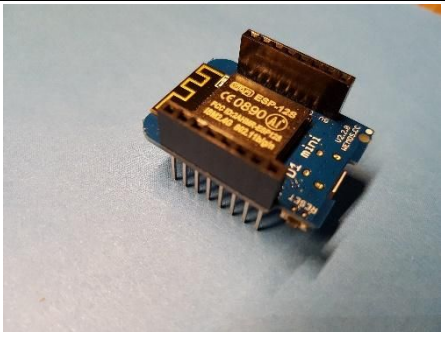
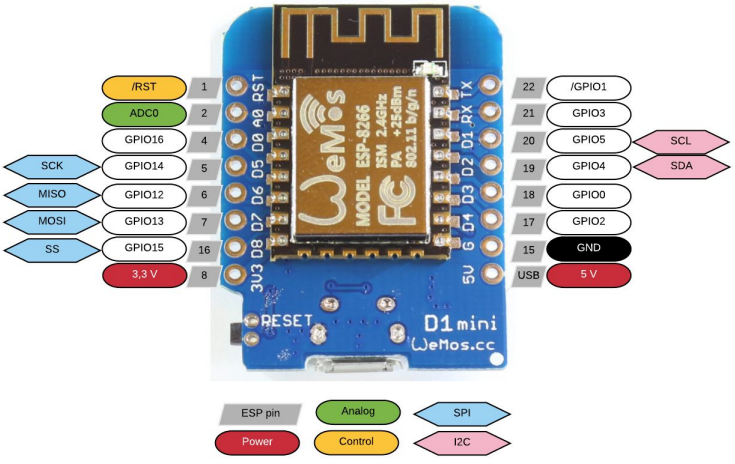
Thanks to Charles-Henri Hallard / Ch2i for his cooperation and sharing his PCB design for workshop purposes.

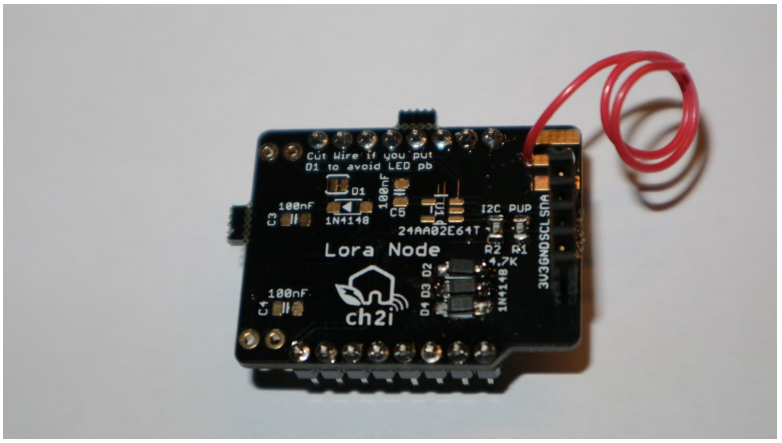
Frank Beks

February 2017

The Wemos Stack

Wemos (http://www.wemos.cc) offers a broad range of ‘stackable’ modules (displays, LEDs, buttons, power and processor boards) to be ‘stacked’ to your favourite application. We will use the Wemos D1 ESP8266 module and the ‘WeMos-Lora’ board. This offers a module which can connect to both WiFi networks as to LoRaWAN. As long as the right pins are connected, you can ‘stack’ it in different ways. We will use the experimental setup with the ‘through-the-hole’ pins.

Use the ‘long’ headers	
The processor will be on top, the switch on the bottem right with 3v3 power on the left and 5v power on the right pin.	
Pinout looking on the top of the module, 3v3 on the lower left, 5v on the lower right.	

Solder the two headers on the same side as the RFM95 radio, pins facing down. Mount a 868 Mhz Antenna (82mm) on the antenna pin. If you do not use the pre-soldered version, you have to mount RFM95, D2, D3, D4 (1n4148), R1, R2 (4k7), C1 (1uF) and C2 (10uF). You can use the i2c bus connector or add the ws2812 LEDs as well, but they are not used here.	
Cut a piece of wire, length 82.2 mm. This is a ¼ wave length antenna.	Wavelength =300/868 = 0.3456m Wavelength /4 = 0,0864 m correction 0.95*0.0864=0.0822m (to determine the precise length you can do some experiments, or use proper test equipment like a SWR meter)
Now you can 'stack' the two modules as shown. Mark the 'notch' on the lower right corner!