

ASNlab MQTT example using Contiki and Node-RED

Introduction.

This tutorial is a very brief compilation from multiple sources on a subject of implementing MQTT on Contiki based WSN with 6lbr edge router. Node-Red is used as front end.

Basic terms and definitions.

What is MQTT? – “MQTT stands for MQ Telemetry Transport. It is a publish/subscribe, extremely simple and lightweight messaging protocol, designed for constrained devices and low-bandwidth, high-latency or unreliable networks. The design principles are to minimise network bandwidth and device resource requirements whilst also attempting to ensure reliability and some degree of assurance of delivery. These principles also turn out to make the protocol ideal of the emerging “machine-to-machine” (M2M) or “Internet of Things” world of connected devices, and for mobile applications where bandwidth and battery power are at a premium.” – source <http://mqtt.org/faq>

Before you start.

You are required to read the online documents [1], [2], [3] and install and test the software as guided.

Setup and running of 6LoWPAN network.

Following previous tutorials you are required to build and flash the firmware into CC2650 Launchpad (SLIP radio) and one or more CC2650 Sensortag (cc26xx-web-demo). Use the Channel number as assigned to your group and the same on all of your motes. Also note, that the Launchpad firmware has to be done only once, while you will change and customize the Contiki firmware on Sensortags to suit your needs. Connect your SLIP radio into the USB port of Raspberry Pi (RPi), power on the system and connect either locally or through the Remote Desktop as described previously. If your RPi is setup correctly you should see the IP address similar to the one in a picture below.

If you use RPi Virtual Machine make sure that your Launchpad is connected to your guest OS (RPi VM)

One time setup of 6LoWPAN network.

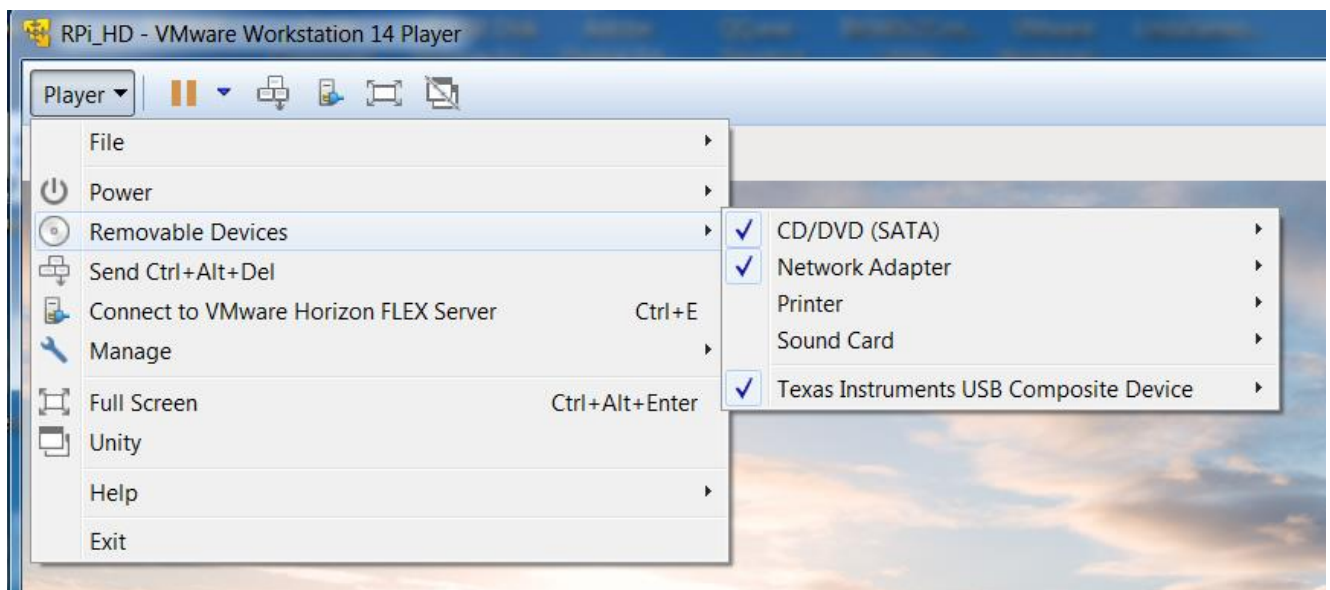
Following part is to be performed only once as the setup to the motes is stored in external memory and stays persistent during power cycling and flash/program memory changes. Additionally all other operations are now included in Node-Red flows and do not require any manual action.

```
root@raspberrypi:~# ifconfig
eth0      Link encap:Ethernet  HWaddr b8:27:eb:01:c9:7e
          inet6 addr: fe80::8943:5157:2336:12a7/64 Scope:Link
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

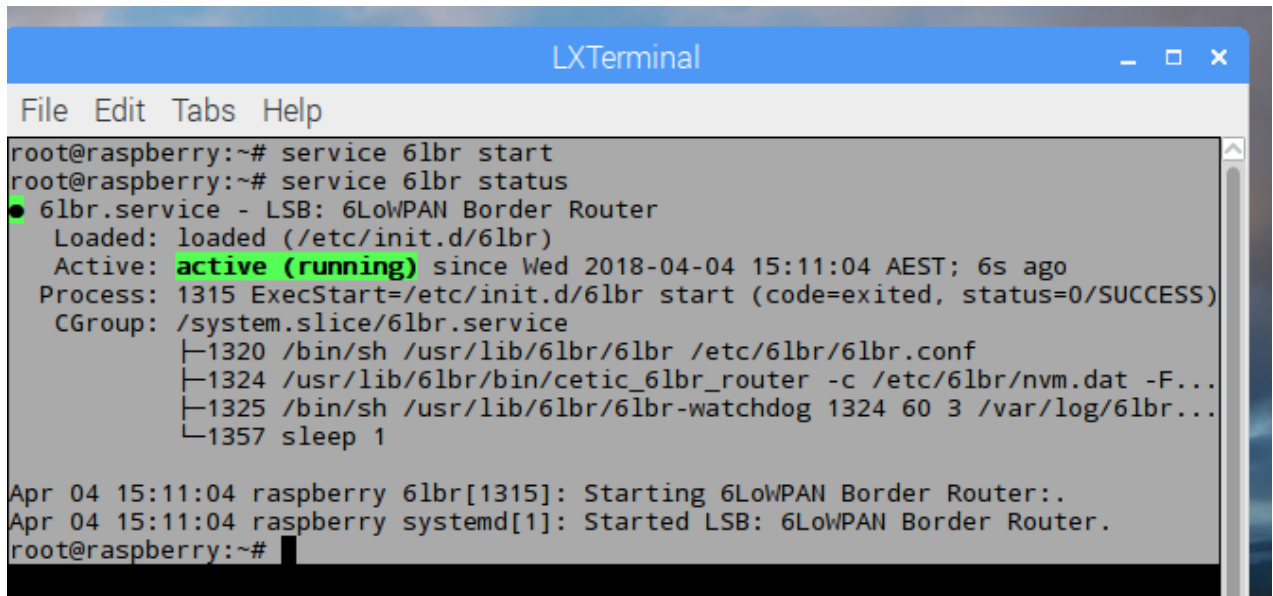
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:144 errors:0 dropped:0 overruns:0 frame:0
          TX packets:144 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:9648 (9.4 KiB)  TX bytes:9648 (9.4 KiB)

wlan0     Link encap:Ethernet  HWaddr b8:27:eb:54:9c:2b
          inet addr:169.254.162.190  Bcast:169.254.255.255  Mask:255.255.0.0
          inet6 addr: fe80::880d:43d2:b0ee:b09f/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:17 errors:0 dropped:0 overruns:0 frame:0
          TX packets:48 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:4582 (4.4 KiB)  TX bytes:8711 (8.5 KiB)

root@raspberrypi:~#
```



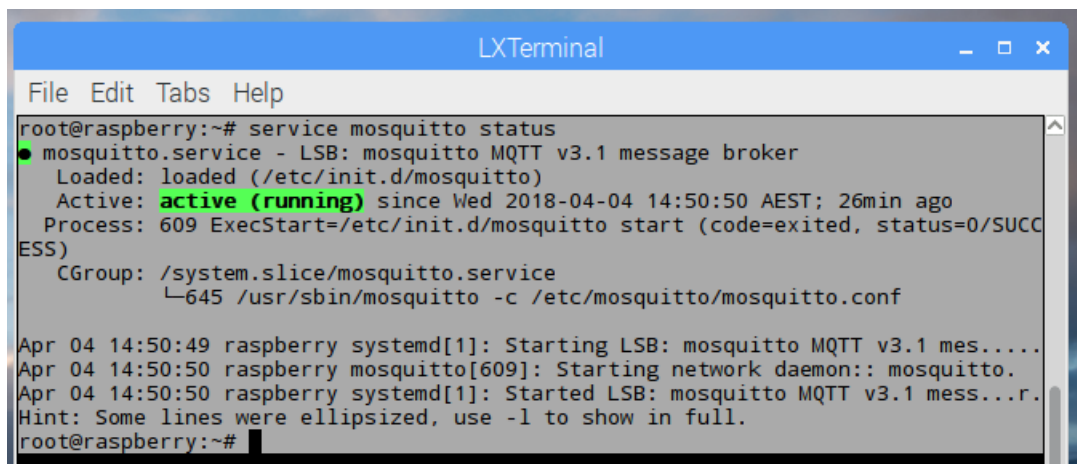
Start 6lbr service and check it



```
LXTerminal
File Edit Tabs Help
root@raspberrypi:~# service 6lbr start
root@raspberrypi:~# service 6lbr status
● 6lbr.service - LSB: 6LoWPAN Border Router
   Loaded: loaded (/etc/init.d/6lbr)
   Active: active (running) since Wed 2018-04-04 15:11:04 AEST; 6s ago
 Process: 1315 ExecStart=/etc/init.d/6lbr start (code=exited, status=0/SUCCESS)
   CGroup: /system.slice/6lbr.service
           └─1320 /bin/sh /usr/lib/6lbr/6lbr /etc/6lbr/6lbr.conf
             └─1324 /usr/lib/6lbr/bin/cetic_6lbr_router -c /etc/6lbr/nvm.dat -F...
             └─1325 /bin/sh /usr/lib/6lbr/6lbr-watchdog 1324 60 3 /var/log/6lbr...
               └─1357 sleep 1

Apr 04 15:11:04 raspberrypi 6lbr[1315]: Starting 6LoWPAN Border Router:.
Apr 04 15:11:04 raspberrypi systemd[1]: Started LSB: 6LoWPAN Border Router.
root@raspberrypi:~#
```

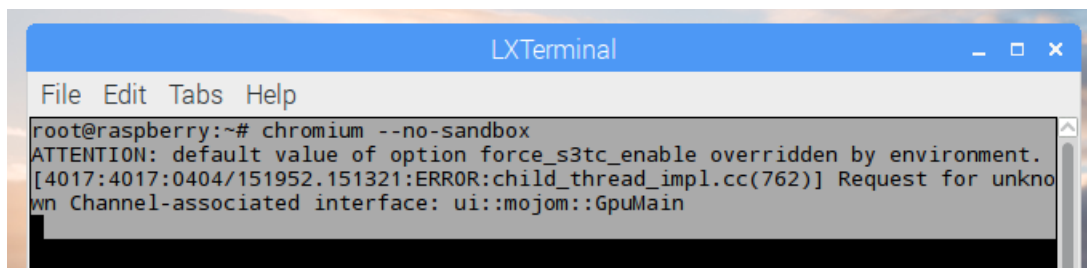
Check if your Mosquitto broker is running



```
LXTerminal
File Edit Tabs Help
root@raspberrypi:~# service mosquitto status
● mosquitto.service - LSB: mosquitto MQTT v3.1 message broker
   Loaded: loaded (/etc/init.d/mosquitto)
   Active: active (running) since Wed 2018-04-04 14:50:50 AEST; 26min ago
 Process: 609 ExecStart=/etc/init.d/mosquitto start (code=exited, status=0/SUCCESS)
   CGroup: /system.slice/mosquitto.service
           └─645 /usr/sbin/mosquitto -c /etc/mosquitto/mosquitto.conf

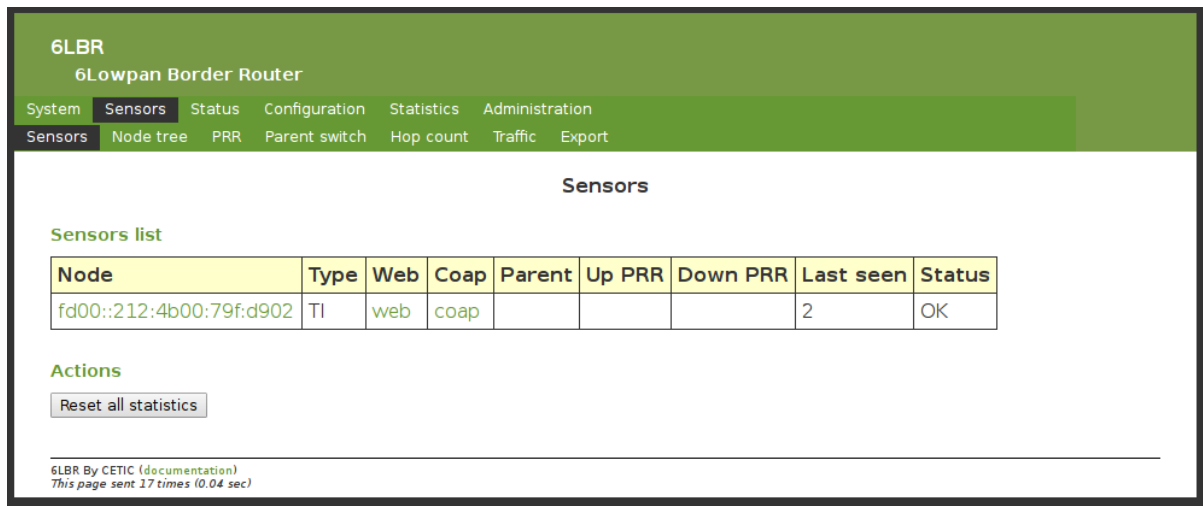
Apr 04 14:50:49 raspberrypi systemd[1]: Starting LSB: mosquitto MQTT v3.1 mes.....
Apr 04 14:50:50 raspberrypi mosquitto[609]: Starting network daemon:: mosquitto.
Apr 04 14:50:50 raspberrypi systemd[1]: Started LSB: mosquitto MQTT v3.1 mess...r.
Hint: Some lines were ellipsized, use -l to show in full.
root@raspberrypi:~#
```

Open the web browser



```
LXTerminal
File Edit Tabs Help
root@raspberrypi:~# chromium --no-sandbox
ATTENTION: default value of option force_s3tc_enable overridden by environment.
[4017:4017:0404/151952.151321:ERROR:child_thread_impl.cc(762)] Request for unknown Channel-associated interface: ui::mojom::GpuMain
```

Open the web link



The screenshot shows the 6LBR web interface. At the top, there's a green header with '6LBR' and '6Lowpan Border Router'. Below it is a navigation bar with tabs: System, Sensors (selected), Status, Configuration, Statistics, and Administration. Under the Sensors tab, there are sub-tabs: Sensors, Node tree, PRR, Parent switch, Hop count, Traffic, and Export. The main content area is titled 'Sensors' and contains a 'Sensors list' section with a table. The table has columns: Node, Type, Web, Coap, Parent, Up PRR, Down PRR, Last seen, and Status. There is one row with the Node 'fd00::212:4b00:79f:d902', Type 'TI', Web 'web', Coap 'coap', and Status 'OK'. Below the table is an 'Actions' section with a button 'Reset all statistics'. At the bottom, there is a footer with '6LBR By CETIC (documentation)' and 'This page sent 17 times (0.04 sec)'.

Node	Type	Web	Coap	Parent	Up PRR	Down PRR	Last seen	Status
fd00::212:4b00:79f:d902	TI	web	coap				2	OK

Open the MQTT/IBM Cloud Config and change the Broker IP to bbbb::101 and Interval (secs) to required values and then click submit button

We need to create some routes, the easiest way to do it is to start and stop the nodejs application:

```
root@raspberrypi:/www/CoAPwebserver_28_11_2016# cd /www
root@raspberrypi:/www# ls
CoAPwebserver_28_11_2016  webserver01
root@raspberrypi:/www# cd CoAPwebserver_28_11_2016
root@raspberrypi:/www/CoAPwebserver_28_11_2016# node app.js
PhDwebserver version 15/07/2016
This platform is linux
saved0S is: linux
server0S is: linux
coap0 server created @: 15:54:58
```

```
Express server listening on: 192.168.1.7 : 3000
user_count: 1
socket is connected @: 15:56:49
coap0 server reopen @: 15:56:49
coap1 server reopen @: 15:56:49
coap2 server reopen @: 15:56:49
coap3 server reopen @: 15:56:49
coap4 server reopen @: 15:56:49
checking the 6LoWPAN border router...
software for new 6lbr version
Initial Neighbour Discovery
ND 15:56:50
6LoWPAN Border Router is running:
table length is 18
motes_num = 1
[ 'fd00::212:4b00:79f:d902' ]
no service discovery here, wait for websockets
^C
root@raspberrypi:/www/CoAPwebserver_28_11_2016#
```

Press CTRL-C to terminate

Check ifconfig

```
tap0    Link encap:Ethernet  HWaddr 02:0a:0b:0c:0d:0e
        inet addr:169.254.77.32  Bcast:169.254.255.255  Mask:255.255.0.0
        inet6 addr: fe80::b0fa:866e:73cd:21ca/64 Scope:Link
        inet6 addr: bbbb::bfc2:cd88:d32b:3fb9/64 Scope:Global
        inet6 addr: fe80::a:bff:fe0c:d0e/64 Scope:Link
        inet6 addr: bbbb::101/64 Scope:Global
        UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
        RX packets:4056 errors:0 dropped:0 overruns:0 frame:0
        TX packets:4330 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:500
        RX bytes:544591 (531.8 KiB)  TX bytes:363380 (354.8 KiB)

root@raspberrypi:/www/CoAPwebserver_28_11_2016#
```

The address `bbbb::101` is the IPv6 address of our Mosquitto broker and is programmed into the notes

The end of one time setup of 6LoWPAN network.

Node-Red flow.

Now we will create a Node-Red flow.

It is assume that you are already familiar with Node-Red, if not please refer to previous tutorials and links given. You are given an example flow for your study, analysis and reference.

Run Node-Red on RPi with a command `node-red-start`

```
root@raspberrypi:~# node-red-start

Start Node-RED

Once Node-RED has started, point a browser at http://172.19.115.56:1880
On Pi Node-RED works better with the Firefox or Chrome browser

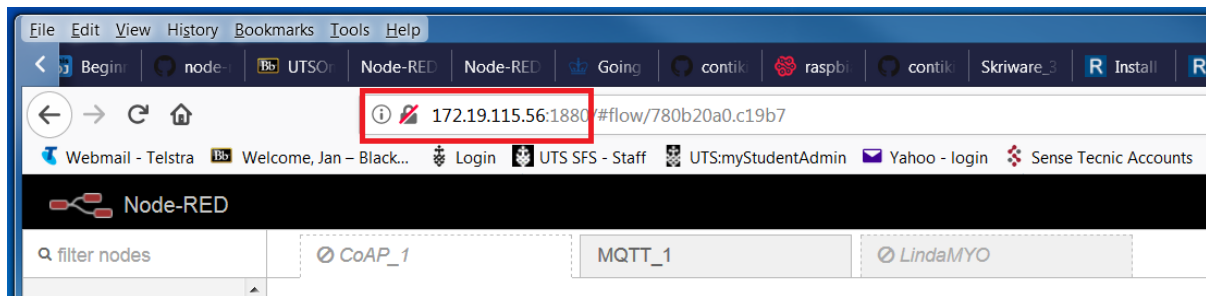
Use sudo systemctl enable nodered.service to autostart Node-RED at every boot
Use sudo systemctl disable nodered.service to disable autostart on boot

To find more nodes and example flows - go to http://flows.nodered.org
5 Apr 10:33:47 - [info]

Welcome to Node-RED
=====

5 Apr 10:33:47 - [info] Node-RED version: v0.17.5
5 Apr 10:33:47 - [info] Node.js version: v8.11.1
5 Apr 10:33:47 - [info] Linux 4.14.31-v7+ arm LE
5 Apr 10:33:48 - [info] Loading palette nodes
5 Apr 10:33:52 - [info] Dashboard version 2.6.2 started at /ui
5 Apr 10:33:54 - [info] Settings file : /root/.node-red/settings.js
5 Apr 10:33:54 - [info] User directory : /root/.node-red
5 Apr 10:33:54 - [info] Flows file : /root/.node-red/flows_raspberrypi.json
5 Apr 10:33:55 - [info] Server now running at http://127.0.0.1:1880/
5 Apr 10:33:55 - [info] Starting flows
5 Apr 10:33:55 - [info] Started flows
5 Apr 10:33:55 - [info] [mqtt-broker:55ed84f.974347c] Connected to broker: mqtt://localhost:1883
```

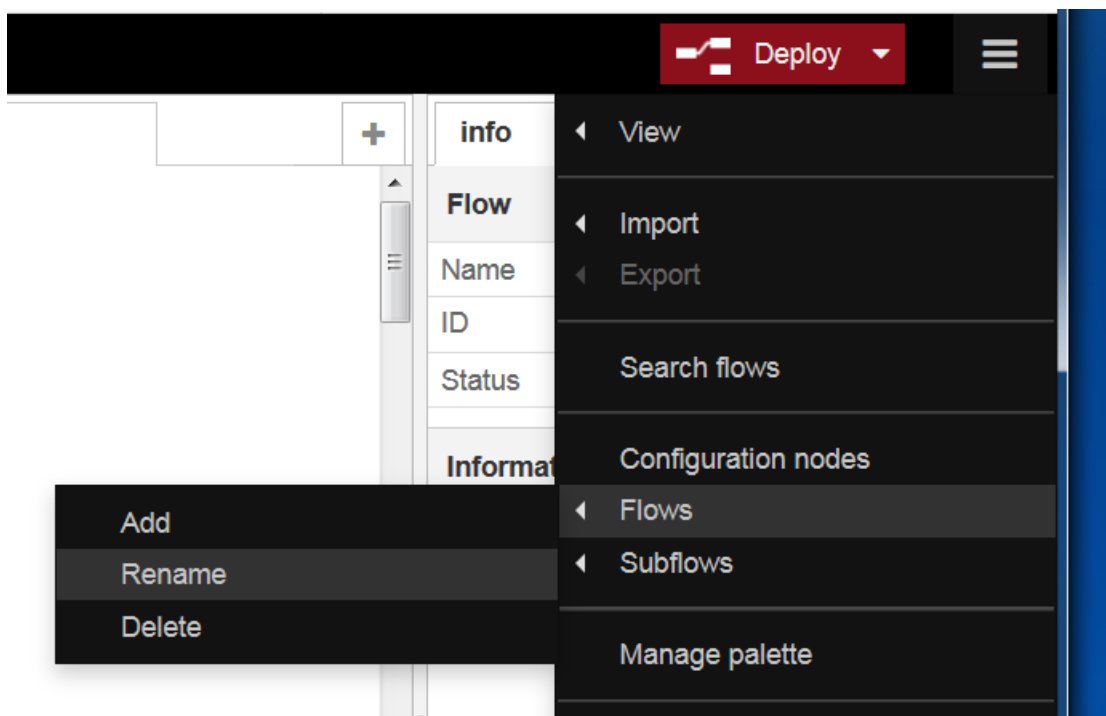
On your desktop PC open the browser and type the address given by Node-Red in this example it is 192.168.1.7:1880



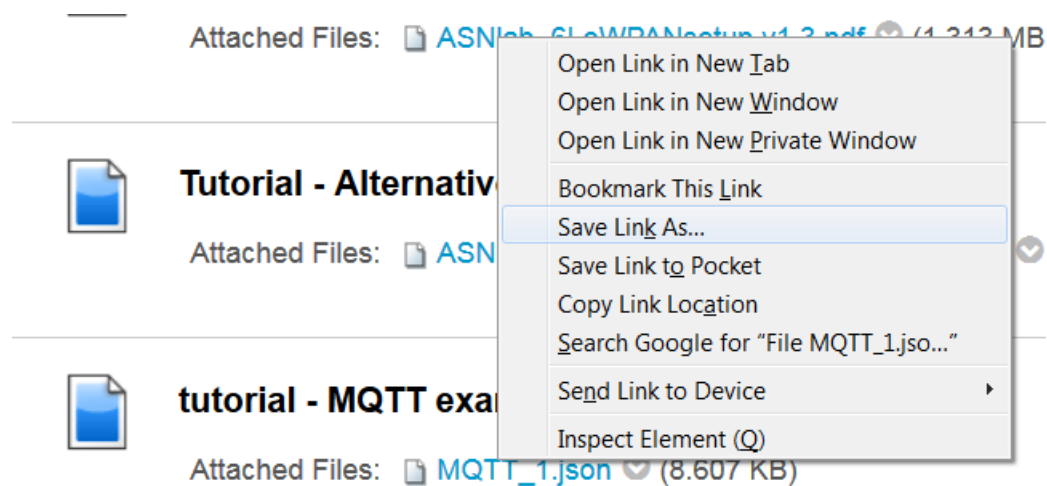
Create a new tab by clicking the + button



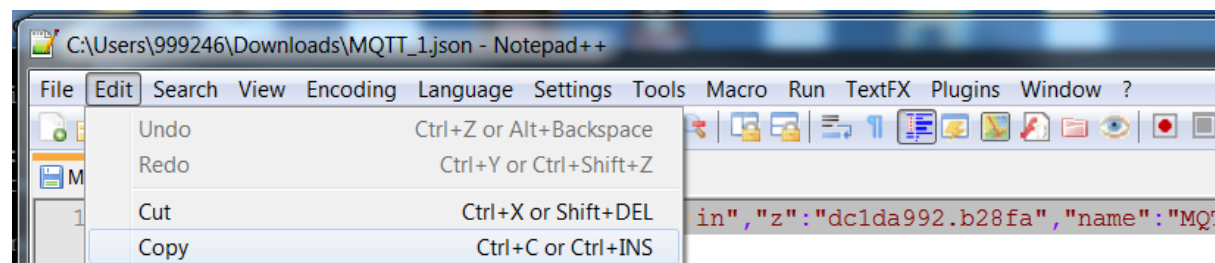
From the hamburger menu select Flows > Rename and give it a name MQTT_1



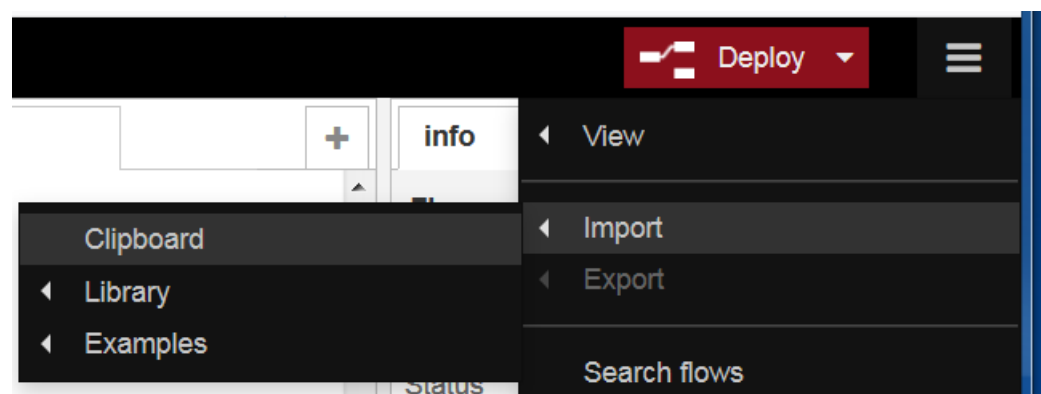
Download the file MQTT1.json from UTsonline and save it on your local PC



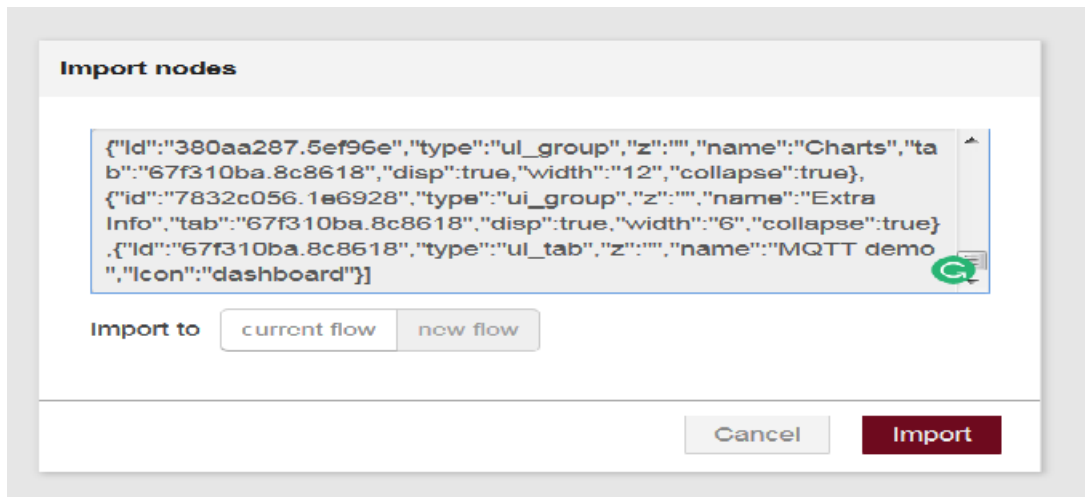
Open it from your favourite editor and copy into clipboard



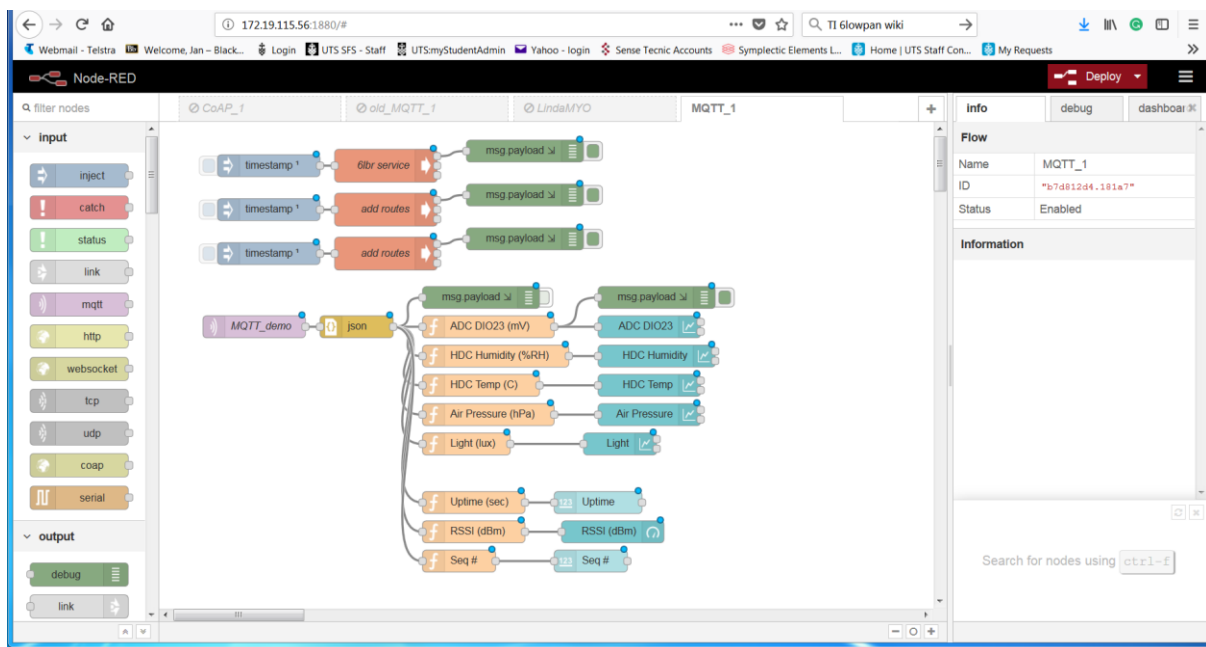
From your browser Import from Clipboard



Paste and Import

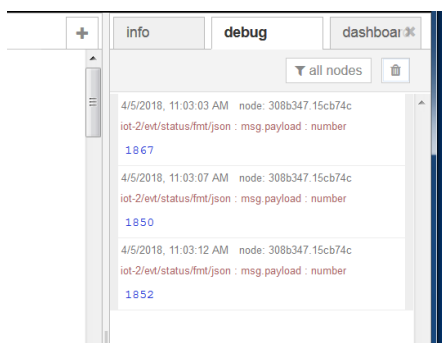


You should see the following picture

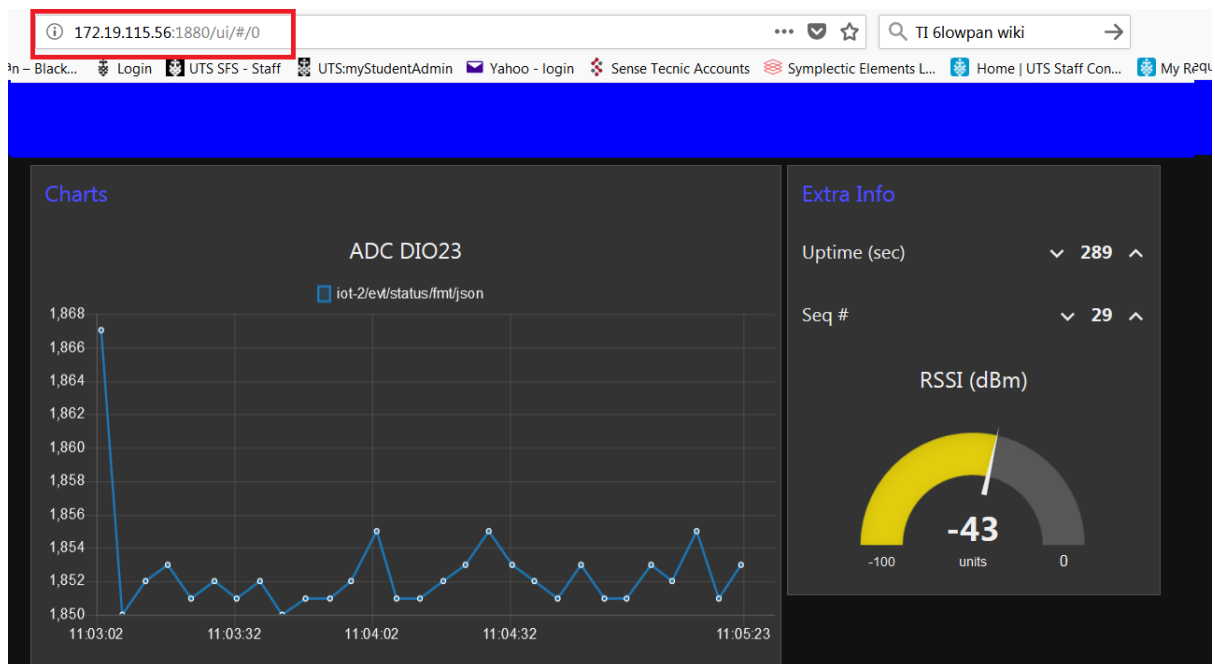
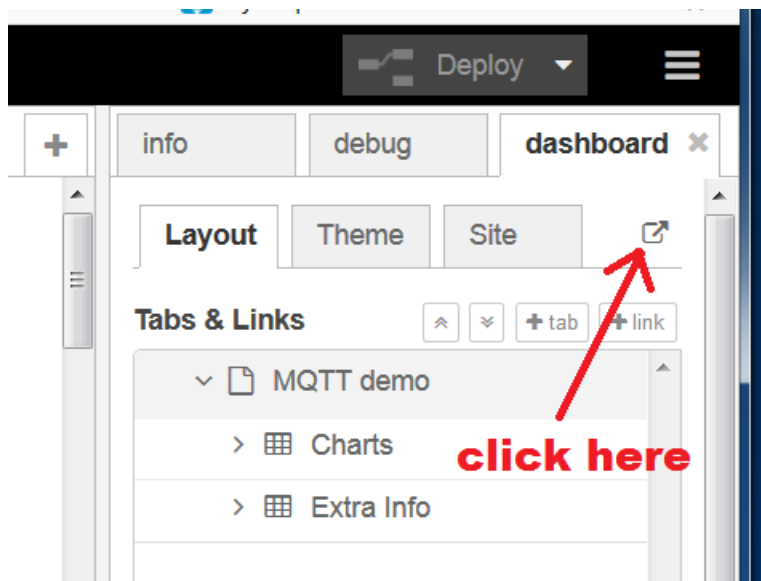


Click on the Deploy button

The example debug message is shown, you can disable it



Switch into the UI tab on your browser



Note, that you can change the Device Config for a particular mote

[Index] [Device Config] [MQTT/IBM Cloud Config] [IBM Quickstart]

Sensors

Battery Temp: ☐ ☐

Battery Volt: ☐ ☐

ADC DIO23: ☐ ☐

Air Pressure: ☐ ☐

Air Temp: ☐ ☐

Object Temp: ☐ ☐

Ambient Temp: ☐ ☐

Light: ☐ ☐

HDC Humidity: ☐ ☐

HDC Temp: ☐ ☐

Acc X: ☐ ☐

Acc Y: ☐ ☐

Acc Z: ☐ ☐

Gyro X: ☐ ☐

Gyro Y: ☐ ☐

Gyro Z: ☐ ☐

RSSI Probing

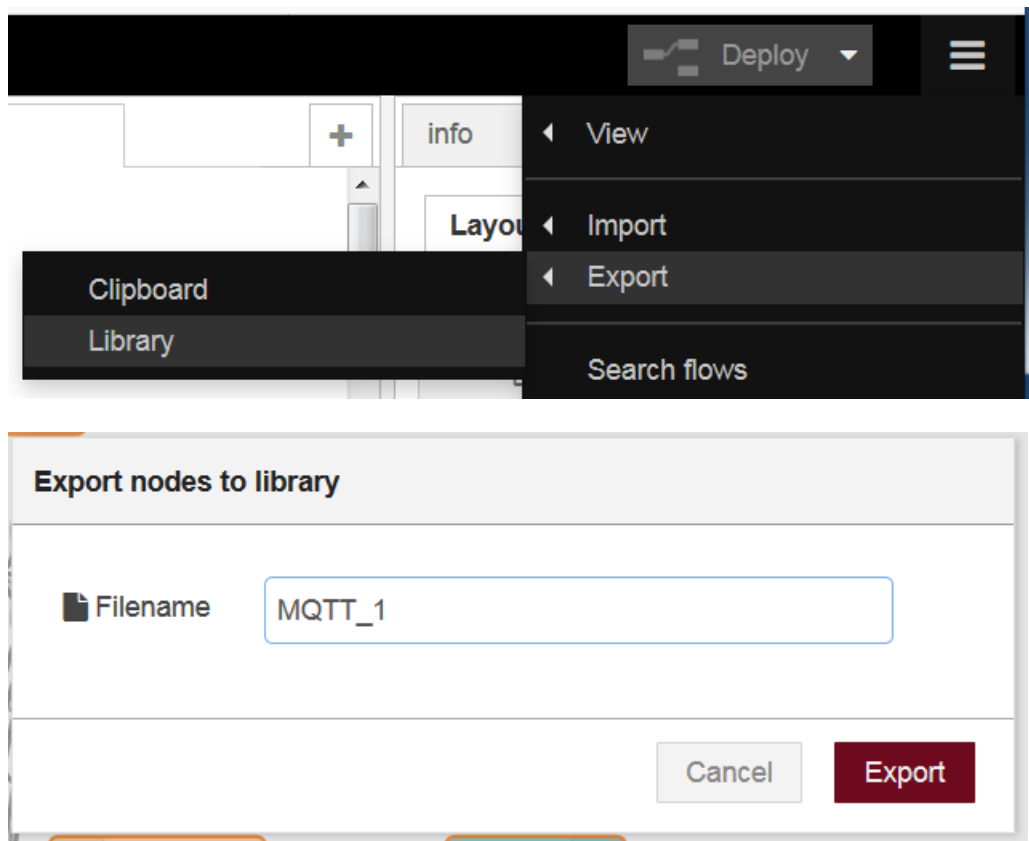
Period (secs):

Actions

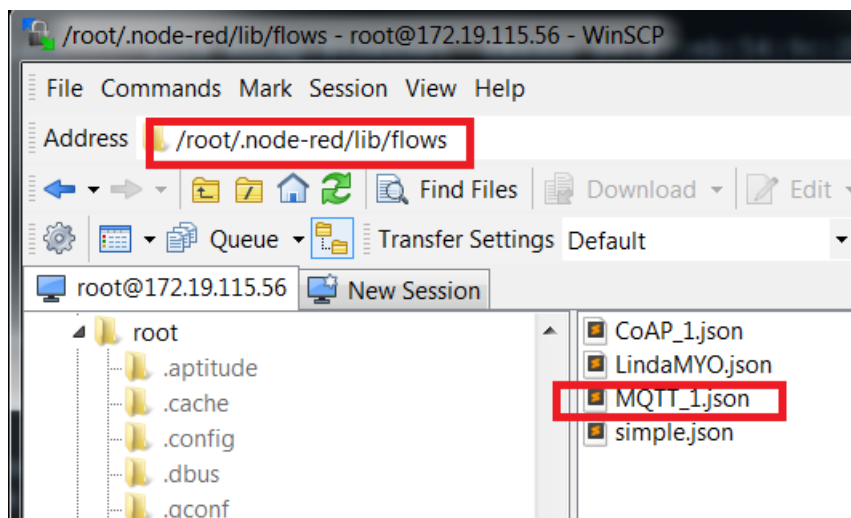
```
4 Apr 16:27:23 - [info] [debug:678cccd9.8d1404] 2018-04-16T16:27:23.000Z
4 Apr 16:27:23 - [info] [debug:49a00cee.abb174] 2018-04-16T16:27:23.000Z
{ d:
  { myName: 'TI CC2650 SensorTag',
    'Seq #': 536,
    'Uptime (sec)': 2689,
    'Def Route': 'fe80::212:4b00:7b1:6687',
    'RSSI (dBm)': -53,
    'Battery Temp (C)': 26,
    'Battery Volt (mV)': 3292,
    'ADC DI023 (mV)': 2009,
    'Air Pressure (hPa)': 1014.7,
    'Air Temp (C)': 29.69,
    'Object Temp (C)': 19.156,
    'Ambient Temp (C)': 28.906,
    'Light (lux)': 891.52,
    'HDC Humidity (%RH)': 52.67,
    'HDC Temp (C)': 28.99,
    'Acc X (G)': -0.22,
    'Acc Y (G)': -0.06,
    'Acc Z (G)': 1.04,
    'Gyro X (deg per sec)': 3.7,
    'Gyro Y (deg per sec)': 3.45,
    'Gyro Z (deg per sec)': -5.86 } }
4 Apr 16:27:25 - [info] Stopping flows
```

Currently all sensors readings are send:

Please note, that you can save the flow into library by exporting it



It is saved then into RPi file system



Congratulations, you have created successfully the MQTT example flow

This is the end of the MQTT example tutorial

References:

1. What is MQTT and How it Works <https://randomnerdtutorials.com/what-is-mqtt-and-how-it-works/>
2. How to Install Mosquitto Broker on Raspberry Pi <https://randomnerdtutorials.com/how-to-install-mosquitto-broker-on-raspberry-pi/>
3. Testing Mosquitto Broker and Client on Raspberry Pi <https://randomnerdtutorials.com/testing-mosquitto-broker-and-client-on-raspbbery-pi/>
4. TI 6LoWPAN wiki <http://processors.wiki.ti.com/index.php/Contiki-6LOWPAN>