DWM1001 Gateway Quick Deployment Guide

Create a centralised network by adding gateways to a DRTLS system

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DOCUMENT INFORMATION

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Note: For the purpose of this document, "**DWM1001**" can also refer to "**DWM1001C**". The only difference between both modules is that **DWM1001C** is certified and its OTP memory is calibrated to comply with FCC/ETSI regulations.

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(3) Decawave Software consists of the following components (a) to (d) inclusive:

(a) The **Decawave Positioning and Networking Stack** ("PANS"), available as a library accompanied by source code that allows a level of user customisation. The PANS software is pre-installed and runs on the Module as supplied, and enables mobile "tags", fixed "anchors" and "gateways" that together deliver the DWM1001 Two-Way-Ranging Real Time Location System ("DRTLS") Network.

(b) The **Decawave DRTLS Manager** which is an Android™ application for configuration of DRTLS nodes (nodes based on the Module) over Bluetooth™.

(c) The **Decawave DRTLS Gateway Application** which supplies a gateway function (on a Raspberry Pi ®) routing DRTLS location and sensor data traffic onto an IP based network (e.g. LAN), and consists of the following components:
- DRTLS Gateway Linux Kernel Module
- DRTLS Gateway Daemon
- DTRLS Gateway Proxy
- DRTLS Gateway MQTT Broker
- DRTLS Gateway Web Manager

(d) **Example Host API functions**, also designed to run on a Raspberry Pi, which show how to drive the Module from an external host microprocessor.

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1 OVERVIEW

This document explains how to quickly add gateways and networking functionalities to a RTLS system based on the Positioning And Networking Stack (PANS) for the DWM1001.

Adding gateways to a PANS network offers augmented features such as RTLS system configuration and monitoring from a web-manager or interfacing with an MQTT broker.

The following software and hardware components are required to deploy a PANS network with gateways (also known as PANS R2 – Release 2).

Software:

- DWM1001_PANS_R2.1.hex
- DRTLS Android Manager : DRTLS_Android_Manager_R2.1.apk
- Raspberry Pi Model 3B Raspbian image: DRTLS_raspbian_R2.1.img

Software Tools: (license free)

- Segger J-Flash Lite for re-Flashing DWM1001-DEV boards
- Etcher – for writing the Raspbian image file to an SD card
- Advanced IP Scanner – for finding the Raspberry Pi's network IP address
- SSH client such as TeraTerm or PuTTY for communicating with the Raspberry Pi

Hardware:

- MDEK1001 Kit (containing 12 DWM1001 development boards.)
- Raspberry Pi 3 model B (R3B) with a power supply and eventually ethernet cable
- 16 GB micro-SD card and a micro-SD card reader
- 2x13 GPIO Header (long pin) for Raspberry Pi 3 model B
- A PC running Windows

Important notes:
The DRTLS gateway application is currently compatible with Raspberry Pi 3 model B only. The Raspberry Pi 3B+ model is not supported.

The pre-installed software on DRTLS_raspbian_R2.1.img *are only promised to work with the provided Linux system. Any update of the Linux system may lead to unpredictable behavior.*

The user is free to use any suitable software in order to interact with a DWM1001 device. The software mentioned through the document are recommendation only and not mandatory.

2 DWM1001 UPDATE

The first step consists in updating each DWM1001-DEV with the latest version of PANS firmware for DWM1001. To do so, download Segger J-Flash Lite for windows, see https://www.segger.com/products/debug-probes/j-link/technology/flash-download.

Connect the DWM1001-DEV to a computer through the USB interface and follow the steps below:

1. Launch J-Flash Lite

2. Select the NRF52832_XXAA target, SWD interface and 1000 kHz clock speed (see Figure 1)

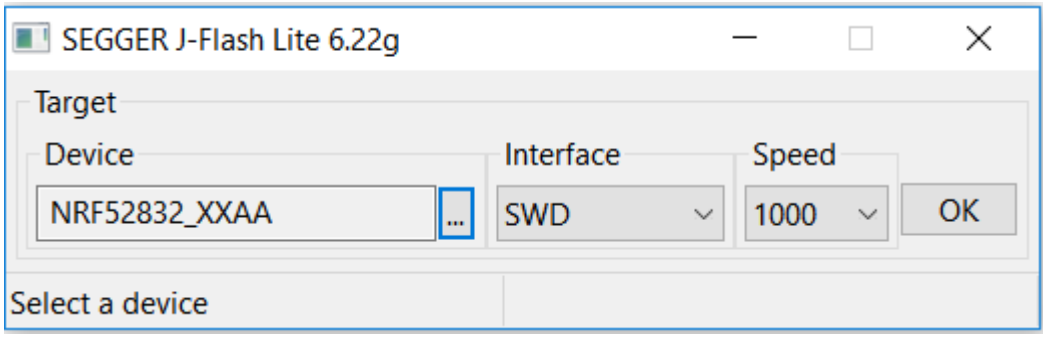

Figure 1 : Segger J-Flash configuration

3. Select “DWM1001_PANS_R2.1.hex” as data file and click on “Program Device”

Devices can be flashed successively without quitting J-Flash Lite. To quickly flash multiple DWM1001-DEV boards, it is only necessary to disconnect the flashed board, connect a new one over USB and click on “Program Device” again.

3 CREATE AN RTLS NETWORK

3.1 Using the DRTLS Android manager

Download the latest version of the DRTLS Manger from the Google Play store.

In order to configure the DWM1001-DEV devices and create a UWB RTLS system, please follow the instructions from:

- https://www.youtube.com/watch?v=hI8EaU5nOmI&t=11s
- http://v.youku.com/v_show/id_XMzQ4NjM2Njc1Mg==.html?spm=a2h0k.8191407.0.0&from=s1.8-1-1.2
- The MDEK1001_Quick_Start_Guide: https://www.decawave.com/product/dwm1001-module

The correct configuration of the RTLS network can be verified in the DRTLS Manager from the "Network" tab. Verify that the number of anchors and tags is correct.
The network PAN ID is also provided as "Network Id". As the PAN ID is required for bridge node setup, it should be recorded. In the example below, the PAN ID is 0x8395. (see Figure 2)

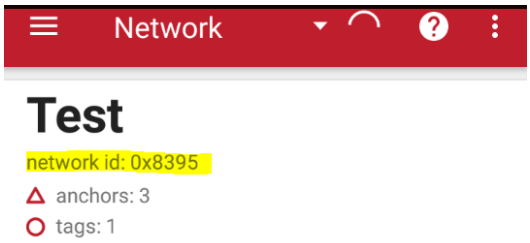

Figure 2: PAN ID definition in DRTLS Manager

3.2 Using the UART shell mode

PANS firmware offers APIs to create a network and configure nodes directly over the UART. For advanced users, this method can be faster than configuring over the DRTLS Manager.

Follow the instruction below to enable the UART shell mode:

1. Download and install TeraTerm for Windows: https://osdn.net/projects/ttssh2/releases/

2. Connect the DWM1001-DEV to the PC over USB and launch TeraTerm. Click on the "Setup Tab", select "Serial Port". The serial port configuration should be as defined as in Figure 3. Please note the port number may vary as it depends on the PC configuration.

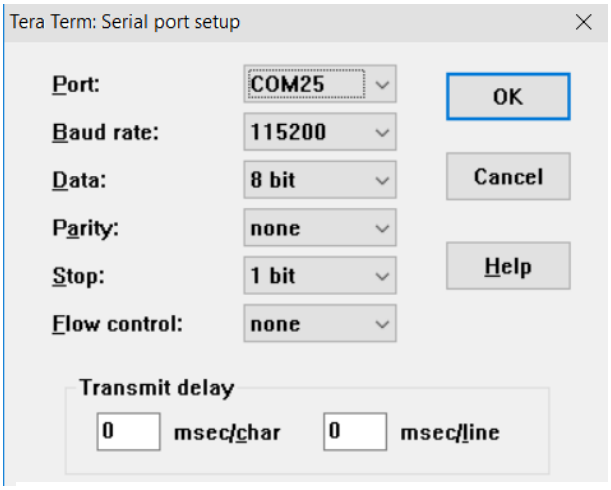

Figure 3: UART configuration for serial connection with TeraTerm

3. Connect to the virtual com port selected by the computer (may differ from the COM25 value in this example.) Click on "File" tab, "New Connection" and select "Serial". The port value should be set automatically, but ensure it corresponds to the DWM1001 in case there are several virtual com ports. Click "OK".

4. In the shell, press "Enter" key twice in order to start the DWM1001 UART shell mode. If failed, try again. The device answer should match Figure 4:

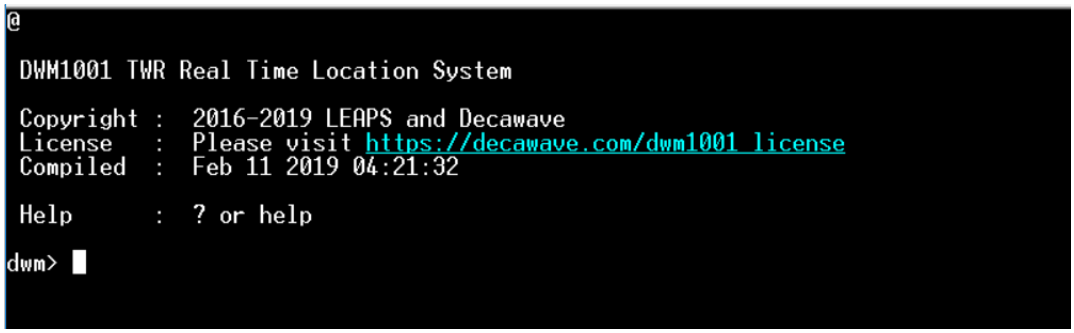

Figure 4: UART Shell header text after successful connection

A PANS based network is made of several nodes running in different functional modes:

- Initiator: anchor that will initiate the network. A network must contain at least one.
- Anchor: used as reference to calculate tags position with trilateration.
- Tag: mobile node to be tracked within the system.

Configure the initiator:

Figure 5 shows configuration of an initiator with UART shell.

```
dwm> nis 0x1234
nis: ok
dwm> aps 0 0 1800
aps: ok
dwm> nmi


 DWM1001 TWR Real Time Location System

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 Compiled  :  Feb 11 2019 04:21:32

 Help      :  ? or help

dwm> si
[000002.970 INF] sys: fw2 fw_ver=x01030001 cfg_ver=x00010700
[000002.970 INF] uwb0: panid=x1234 addr=xDECAA671D2A38207
[000002.980 INF] mode: ani (act,real)
[000002.980 INF] uwbmac: connected
[000002.980 INF] uwbmac: bh disconnected
[000002.990 INF] cfg: sync=0 fwup=0 ble=1 leds=1 init=1 upd_rate_stat=120 label=DW8207
[000003.000 INF] enc: off
[000003.000 INF] ble: addr=D6:6B:BB:7A:4B:40
dwm>
```

Figure 5: Initiator configuration with UART shell

The commands to configure an initiator are:

- `nis 0x1234`: setup the node PAN ID to 0x1234
- `aps 0 0 1800`: setup the node coordinates to x=0 y=0 z= 1.8m
- `nmi`: configure the node as initiator and reset the device. The UART shell mode must be re-entered as described previously, by sending “Enter” twice

The `si` command provides information about the node status, in particular its running mode and label.

Configure an anchor:

The Figure 6 shows configuration of an anchor with UART shell:

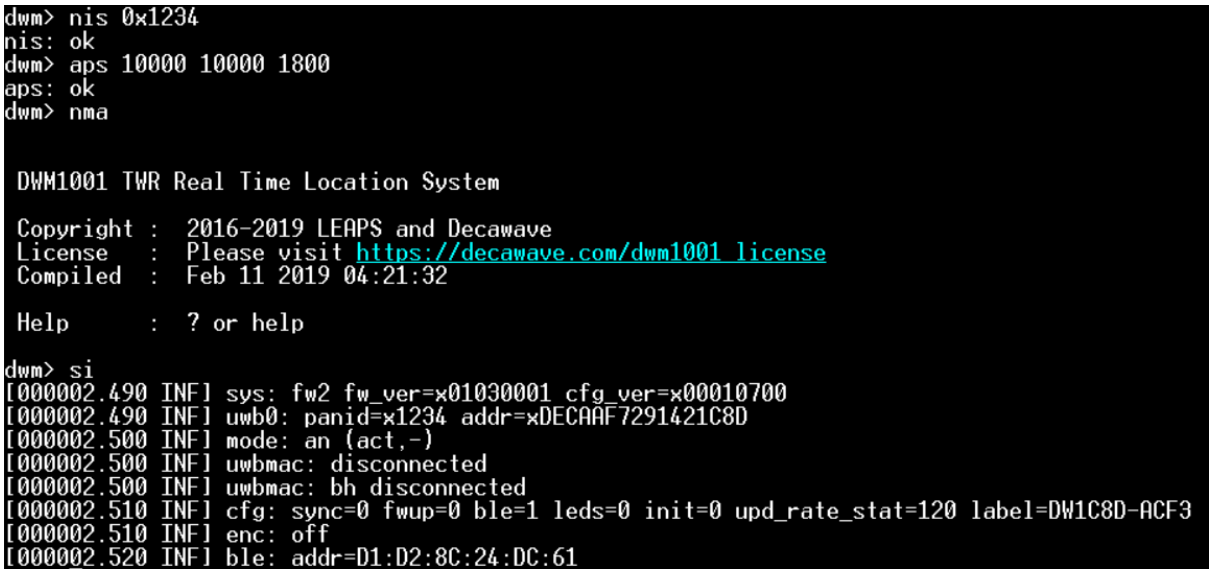

Figure 6: Anchor configuration with UART shell

The commands to configure an anchor are:

- `nis` and `aps`, as previously described
- `nma`: configure the node as an anchor and reset the device. The UART shell mode must be re-entered as described previously, by sending “Enter” twice

The `si` command provides information about the node status, in particular its running mode and label.

Configure a tag:

The Figure 7 shows configuration of a tag with the UART shell:

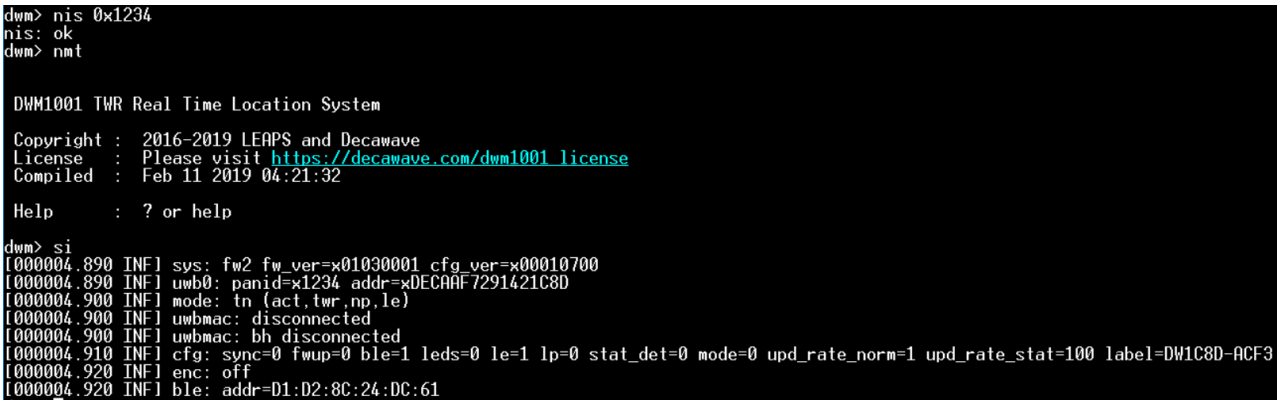

Figure 7: Tag configuration with UART shell

The commands to configure a tag are:

- `nis` as previously described
- `nmt`: configure the node as a tag and reset the device. The UART shell mode must be re-entered as described previously, by sending “Enter” twice

The `si` command provides information about the node status, in particular its running mode and label.

The creation of a network as described in the previous steps will enable location of tags across the system. The location can be retrieved from an active tag or passive anchor, over UART, SPI interface, or from the Bluetooth interface with the DRTLS Manager for examples.

In the following section, we will add a gateway node in order to create a centralized network. It will enable network configuration and monitoring from a web-manager.

4 GATEWAY SETUP AND CONFIGURATION

A gateway consists of a DWM1001-DEV and a Raspberry Pi 3 model B (R3B). The DW1001-DEV must be configured as a bridge node.

4.1 Bridge node setup and configuration

The bridge node requires a DWM1001-DEV, which can be extracted from a MDEK1001 unit. Remove the DWM1001-Dev from the plastic enclosure by unscrewing it (three screws).
The battery connector can be removed as the R3B provides power to the board.

In order to connect the DWM1001-DEV pcb to the R3B, it is necessary to solder a 2x13 GPIO header (long pins) onto the pcb. Please see Figure 8 for reference.

Figure 8: Photo on the DWM1001-DEV with additional long ping header

In order to configure the bridge node, please setup a serial connection as described in section 3.2 and use the following commands:

1. Send “Enter” twice to enter UART shell mode
2. Send “`nis 0x1234`” to set the PanId and associate the bridge node with the network (0x1234 is only an example, the actual value may differ)
3. Send “`nmb`” to set the device as a bridge node.
4. The correct configuration can be verified using the command “`si`” after restarting the UART shell mode

4.2 Setup the raspberry pi 3 model B

The next step consists of flashing the provided Raspberry Pi image to the micro-SD card. To do so, download “etcher”, free of charge:
https://etcher.io/

Connect the micro-SD card to the computer and launch etcher. In “select image”, chose “DRTLS_raspbian_R2.1.img” file. The sd-card should automatically be detected. Click on “flash”.

The R3B can be connected to a network over either WIFI or ethernet. If WIFI is selected, it is possible to perform network configuration directly on the SD card, before booting the R3B.

To configure the WIFI network, open the SD card in the windows explorer. By default, it will be called “boot”. Create a file “wpa_supplicant.conf” in the boot directory using a text editor tool such as notepad. Note .conf must be the file extension and not only part of the name.

Copy the following in the wpa_supplicant.conf file previously created, altering the ssid and psk field with your network credentials.

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev

network={
    ssid="YOUR_NETWORK_NAME"
    psk="YOUR_PASSWORD"
    key_mgmt=WPA-PSK
}
```

Insert the SD card in the R3B and connect it to a power supply. The R3B will automatically join the network over ethernet or WIFI depending on the preferred method.

In order to identify the IP address of the R3B, please download and install Advanced IP Scanner (free software):
https://www.advanced-ip-scanner.com/

Open Advanced IP scanner and perform IP exploration with the keyword “raspberry”. If you are not sure about your network IP address baseline (192.168.x.x), please find it by checking your PC IP address.

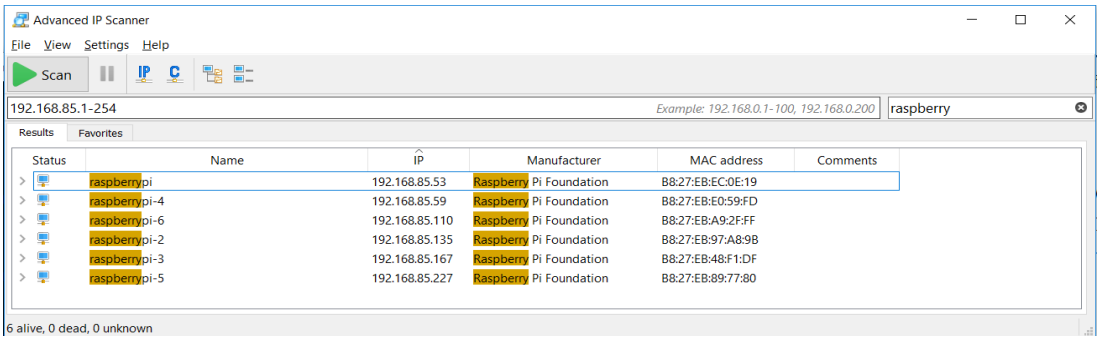

Figure 9: IP exploration with Advanced IP Scanner

On Figure 9, multiple R3Bs are connected to the network. Please note the IP address of each R3B belonging to you and connected to you network (you may have only one at this stage) as this address will be necessary to configure the gateway over SSH and access the MQTT broker and web-manager.

To create the gateway, the bridge node (DWM1001-DEV) must be attached the R3B. See Figure 10.

Figure 10: Gateway: R3B plus bridge node (DWM1001-DEV)

4.3 Connect to the R3B from Windows through SSH connection

It is possible to connect remotely to the R3B from Windows using an SSH connection. The R3B and the host computer must be connected to the same network.

The SSH connection can be setup using TeraTerm, previously downloaded.

Launch TeraTerm and select TCP/IP connection. Connect to the device using the IP address from section 4.2 . See Figure 11 for detailed setup.

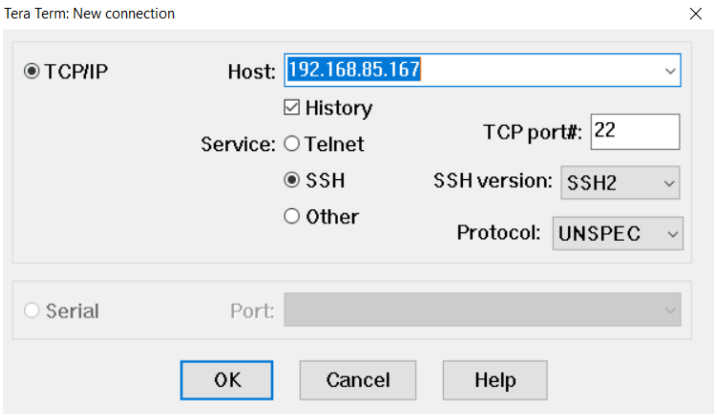

Figure 11: SSH connection to R3B with TeraTerm

The credentials to use for connection are:

Login: pi
Password: raspberry

As shown in Figure 12, the TeraTerm shell is now running on the R3B allowing the user to control it remotely.

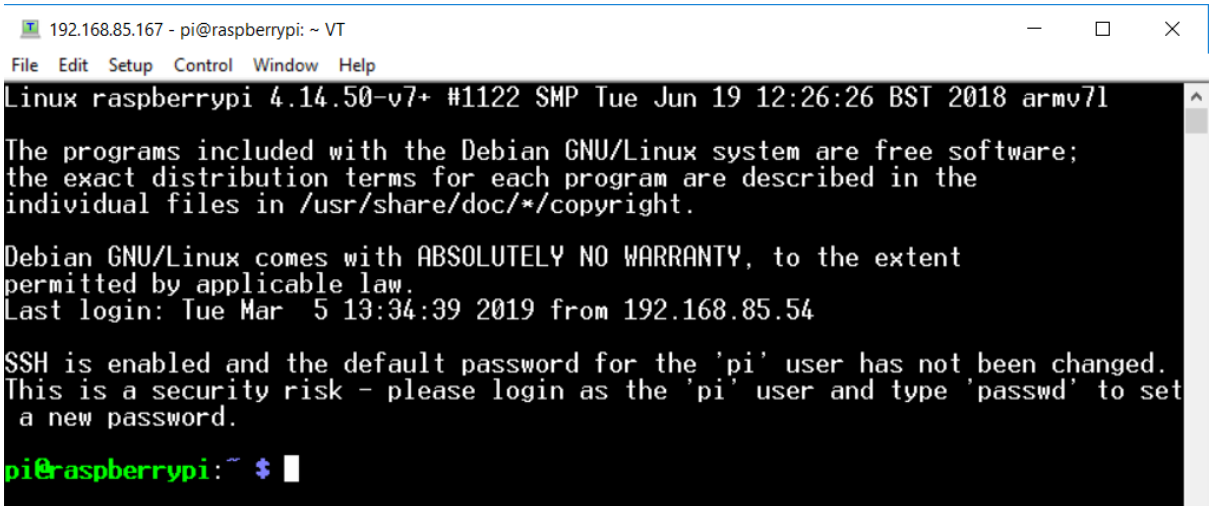

Figure 12: SSH shell after successful connection to the R3B

4.4 Gateway configuration

In order to join the RTLS network previously created, the gateway PanId must be configured. The configuration scripts can be found under the directory `/etc/dwm1001/`.

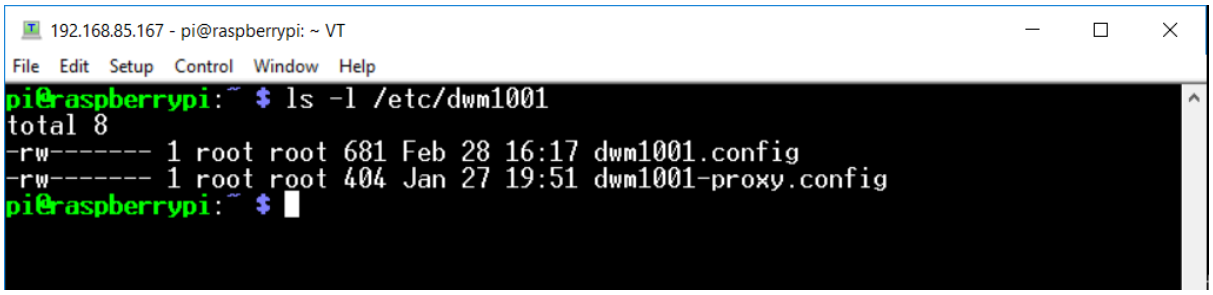

Figure 13: Gateway configuration scripts

There are two configuration scripts:

- dwm1001.config: configuration of bridge node characteristics such as PAN ID, AES encryption key, node mode. Configuration of proxy server host IP address when using multiple gateways across a network.
- dwm1001-proxy.config: configuration of MQTT server host IP address. In most cases this file should not be modified.

The configuration files must be open with administrator access rights to allow changes. When connecting over SSH, `nano` or `vi` text editors can be used:

- `sudo nano /etc/dwm1001/dwm1001.conf`
- `sudo vi /etc/dwm1001/dwm1001.conf` (vim knowledge preferable)

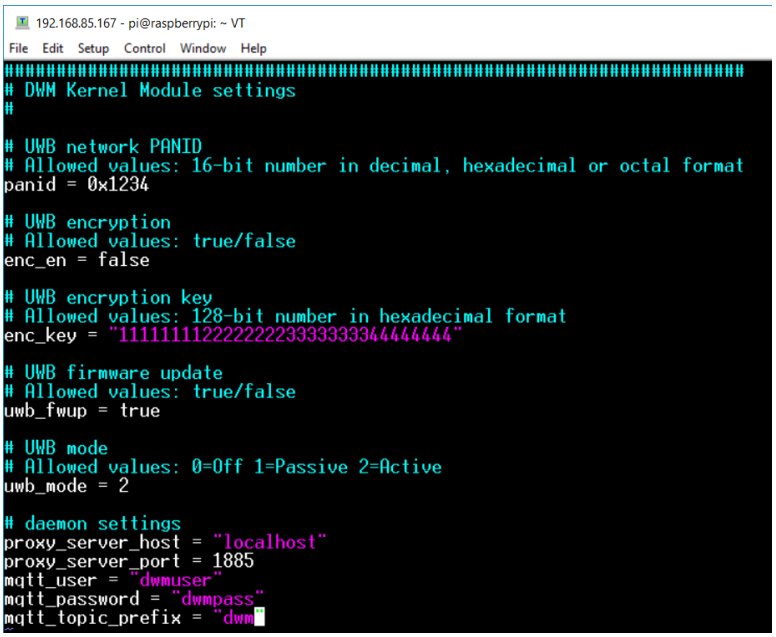

Figure 14: Content of DWM1001.conf configuration script

A minimum configuration is to set the network PAN ID as shown in Figure 14.

4.5 Multiple Gateway configuration

For medium to large RTLS network, multiple gateways will be required to achieve good UWB coverage across the network.

Additional gateways must report the data they collect to the gateway hosting the proxy server. To do so, we must provide the proxy host gateway IP address to any other gateways within the system. This is done in the dwm1001.conf file.

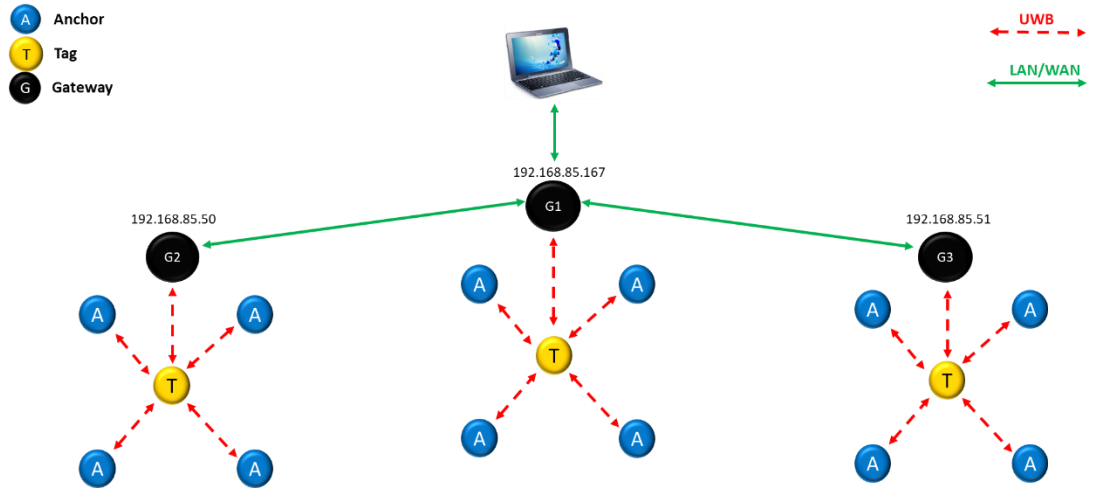

Figure 15:Example of multiple gateway RTLS network

Figure 15 presents a typical multi-gateway network built with PANS. It contains the following gateways:

- G1 – IP address 192.168.85.167
- G2 – IP address 192.168.85.50
- G3 – IP address 192.168.85.51

Considering the example above, G1 is the proxy-server host. Thus, the configuration files of both G2 and G3 must refer to G1's IP address.

The configuration file /etc/dwm1001/dwm1001.conf for nodes G2 and G3 must be modified as shown in Figure 16.

```
# daemon settings
proxy_server_host = "192.168.85.167"
proxy_server_port = 1885
mqtt_user = "dwmuser"
mqtt_password = "dwmpass"
mqtt_topic_prefix = "dwm"
~
~
```

Figure 16: Configuration of IP address for multiple gateways

G1 configuration file should not be modified and the field "`proxy_server_host`" should refer to "`localhost`".

5 NETWORK MONITORING

By adding the gateway function to the PANS RTLS system, it is easy to configure and monitor the network remotely. This is brought in by two new software components: the web-manager GUI and the MQTT broker.

5.1 DRTLS Web-Manager

In order to connect to the web-manager, it is necessary to connect to the proxy-server host IP address using a web browser such as Google Chrome or Mozilla Firefox.

Figure 17**Error! Reference source not found.** is a snapshot of the web-manager graphical interface.

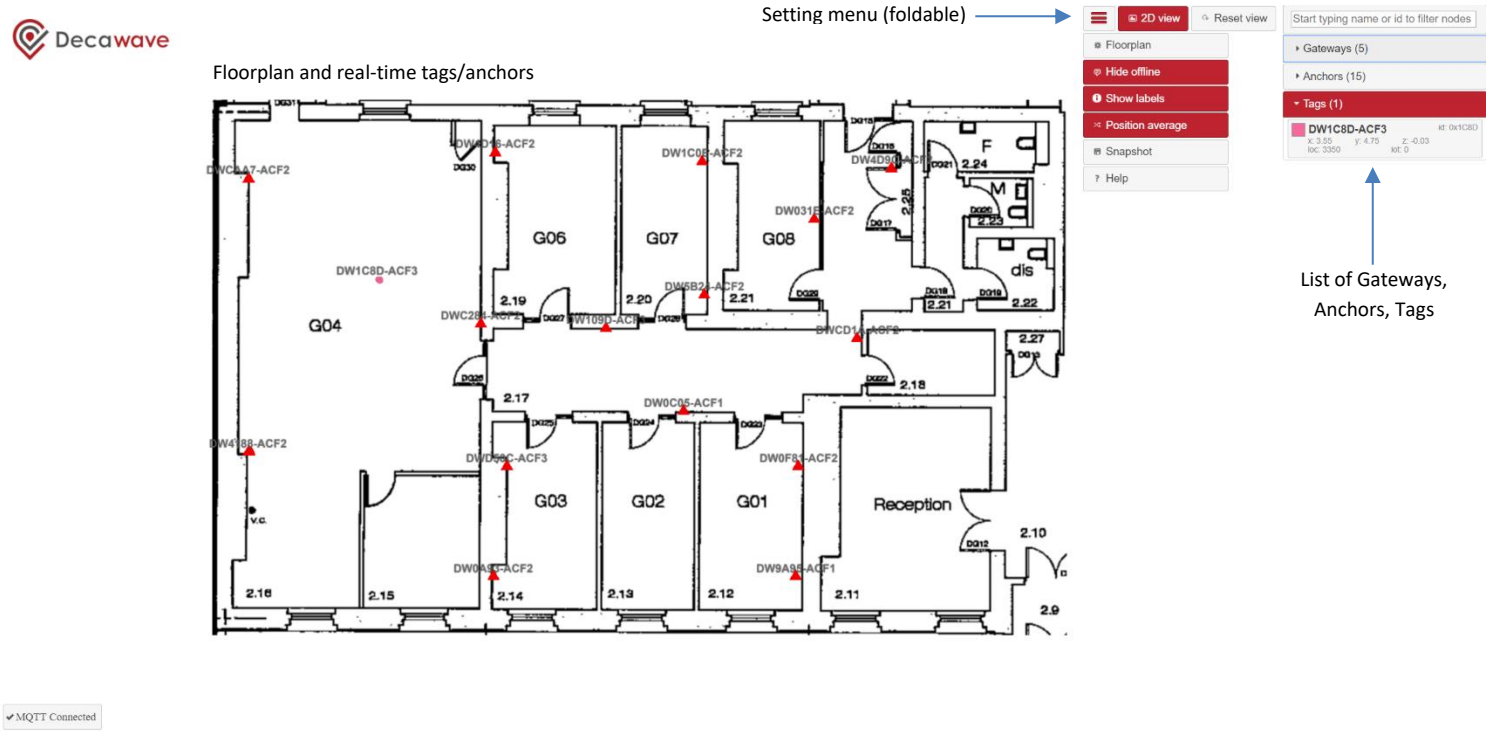

Figure 17: Web-manager graphical interface

The web-manager contains the following widgets:

- Lists of gateways, anchors and tag within the network
- Main widget displaying a floorplan and position of anchors (red triangle) and tags (colored dot)
- A foldable setting menu allowing floorplan changes, hide offline nodes, display or hide node's label, display average tag position or raw tag position.

Floorplan update:

The web-manager is setup with a default floorplan that can be modified from the web-manager interface directly. To do so, open the setting menu and select the “Floorplan” tab. Figure 18 shows the floorplan configuration window:

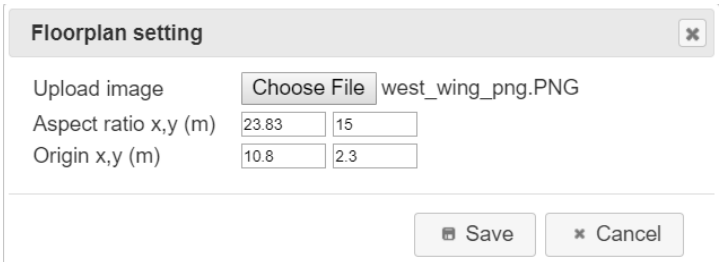

Figure 18: Floorplan configuration window

The floorplan image to be uploaded must be in PNG format.
The aspect ratio should match the length and width of the real-world floorplan in meters. The origin is used to set the offset from the center of the system (0,0) points.
It may require a few iterations to find the “Origin” and “Aspect ratio” permitting to display the custom floorplan correctly.

Anchor configuration:

The anchor configuration tab can be opened either by directly clicking the anchor on the floorplan or by selecting it from the list of anchors.

Key anchor characteristics can be set from the web-manager.

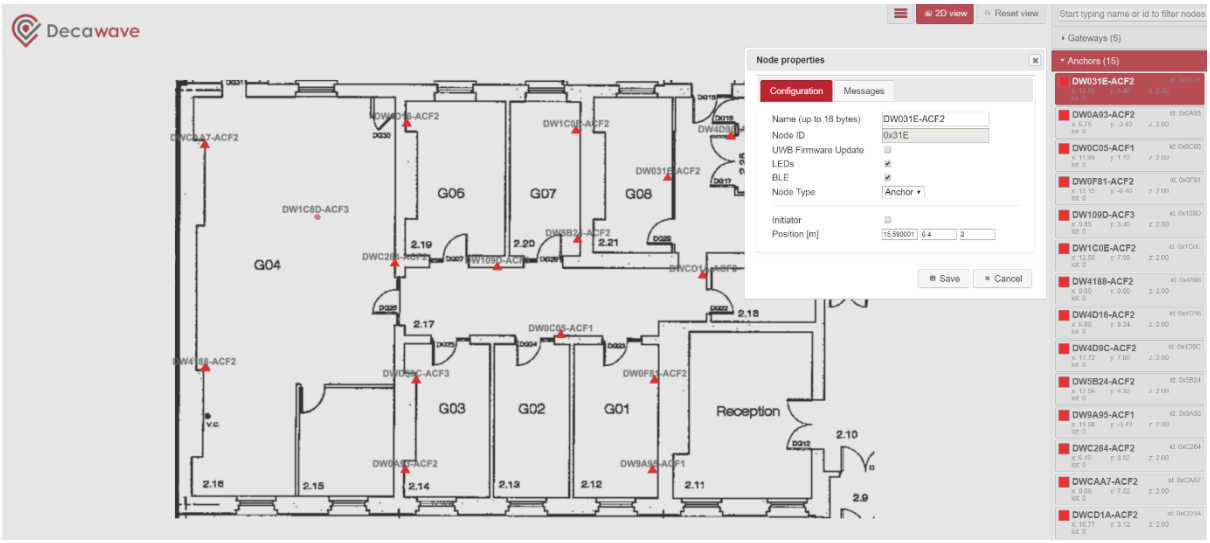

Figure 19: Anchor configuration tab

Tag configuration:

The tag configuration tab can be opened either by clicking the tag on the floorplan or by selecting it from the list of tags.

Key tag characteristics can be set from the web-manager.

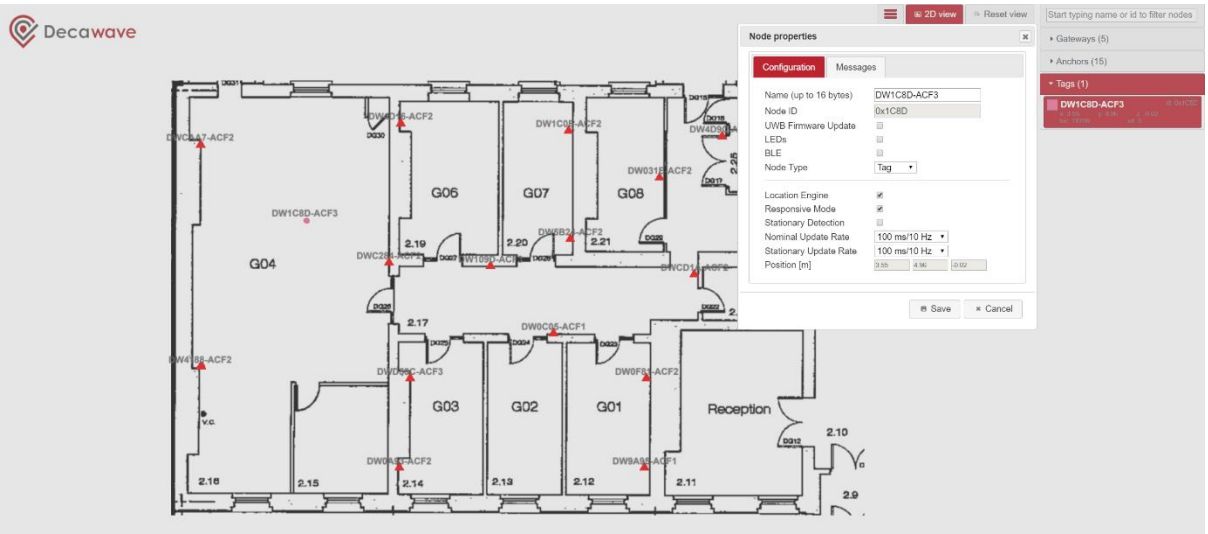

Figure 20: Tag configuration tab

Uplink/Downlink data transfer:

Adding a gateway to a PANS network enables the possibility to exchange data other than location between gateways and nodes within the systems. This non-location data is called “IoT Data”

From the web-manager, it is possible to send IoT data to a node under the node properties window, in the “messages” tab. The data sent to the tag can be observed on the UART shell after using the “`udi`” command. Data is sent as hexadecimal.

From a node UART shell, it is possible to send IoT data using the command “`UUI`”. For example, “`uui 1234 1`” will send the data 0x1234. On the web-manager, the correct reception of the data can be verified under the node properties window, in the “messages” tab.

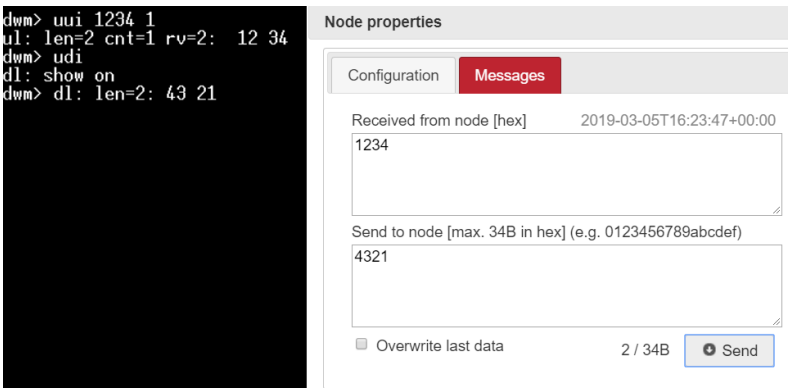

Figure 21: Uplink/Downlink IoT data between gateway and nodes

Figure 21 shows the exchange of data between a node and the gateway. The node first sends the data 0x1234. This is configured from the UART shell with the command "`uui`". On the web-manager, "1234" is displayed under the node properties window, in the "messages" tab.

Second, on the node UART shell, the command "`udi`" is used to display received IoT data. Then data 0x4321 is sent from the web-manager towards the node. It can be observed in the node UART shell, confirming the correct reception of data.

5.2 MQTT Broker

The MQTT connectivity protocol is used in order to interface the RTLS system with the cloud. It allows several clients to connect to a broker and publish/subscribe to topics. Devices belonging to the network can publish or listen to various topics such as device localization, configuration or IoT data (non-location data, e.g. sensor data from nodes).

A convenient tool to explore the MQTT broker is MQTT.fx (Apache license):here

To connect to the MQTT broker with MQTT.fx, launch the program and click on the parameter symbol. In the “Broker Address” setting, enter the proxy host gateway IP address.
Apply changes, close the configuration window and click on “connect”.
See Figure 22 for configuration details.

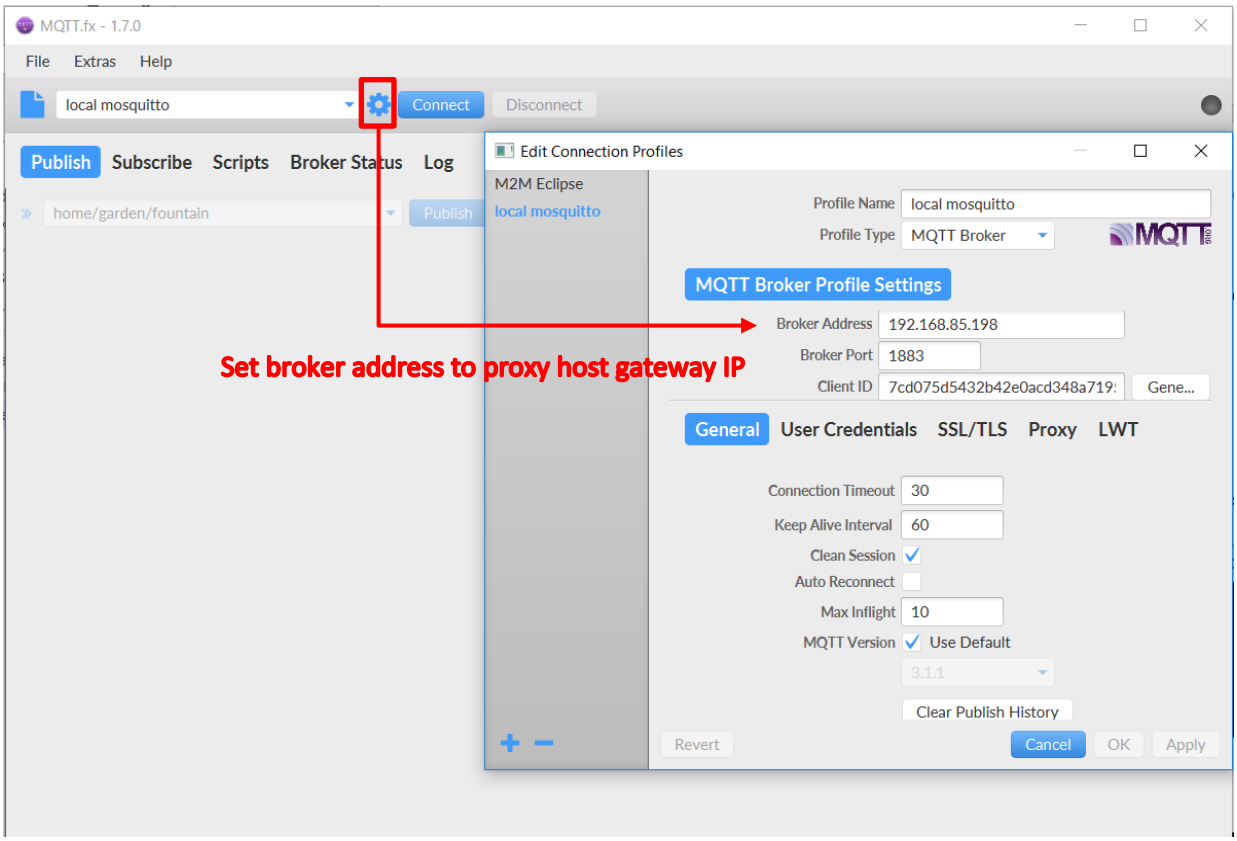

Figure 22: Configuration of MQTT.fx to connect to the MQTT broker

Once connected to the MQTT broker, it is possible to scan for the different topics available. Open the “Subscribe tab” and click on “scan”. If the RTLS network is active, several topics should exist and be detected. It is then possible to subscribe to one of the topics to observe its content. Below is an example of a tag location topic subscription. See Figure 23 for more details.

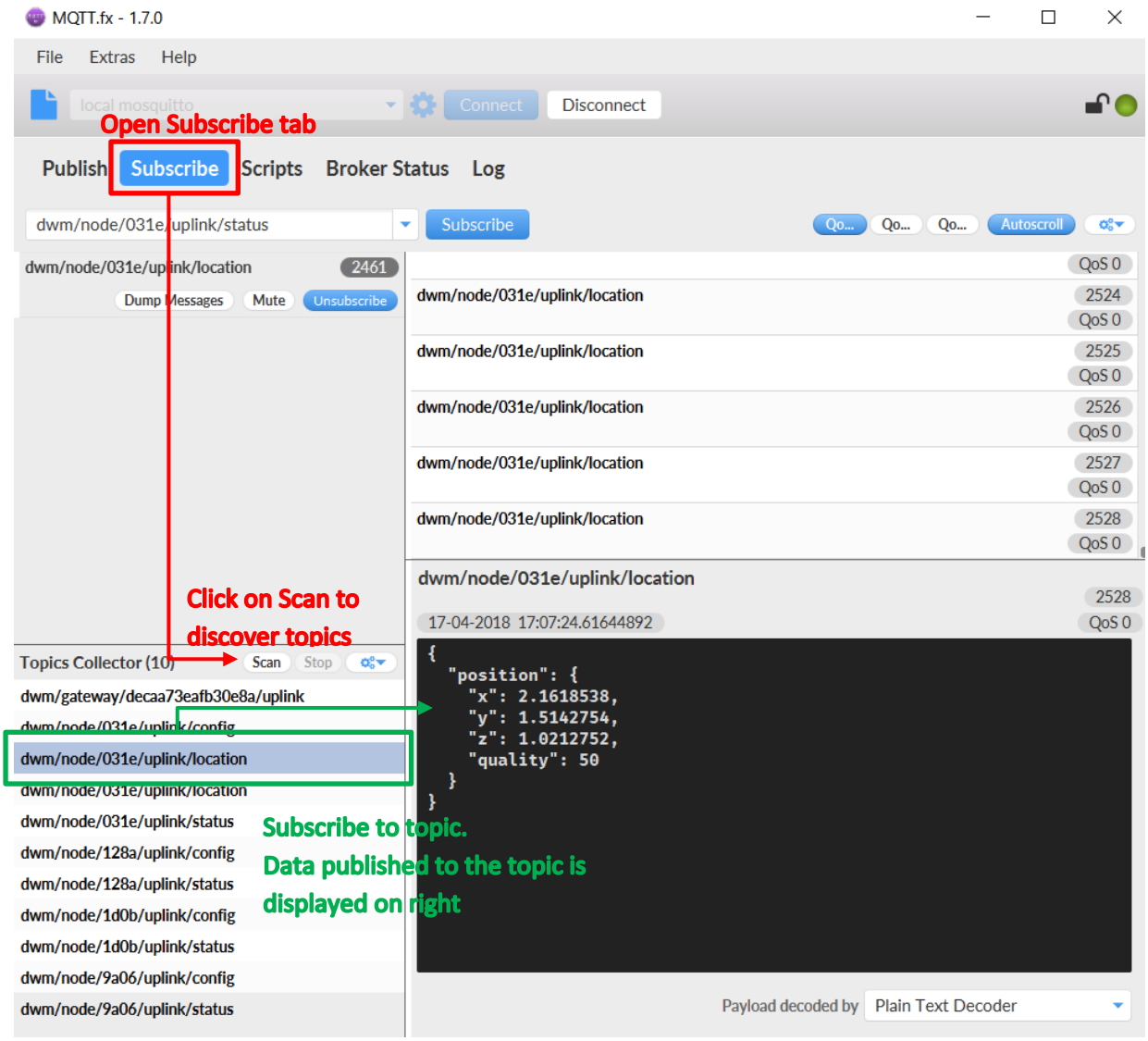

Figure 23: MQTT.fx interface to collect data and interact with MQTT broker

6 DOCUMENT HISTORY

Table 1: Document History

Revision	Date	Description
1.1	29-09-2020	Update to 2.1 release
1.0	05-03-2019	Update document to latest R2 features
0.2	16-07-2018	Updated with new logo
0.1	18-04-2018	Initial release.

7 FURTHER INFORMATION

Decawave develops semiconductors solutions, software, modules, reference designs - that enable real-time, ultra-accurate, ultra-reliable local area micro-location services. Decawave's technology enables an entirely new class of easy to implement, highly secure, intelligent location functionality and services for IoT and smart consumer products and applications.

For further information on this or any other Decawave product, please refer to our website (http://www.decawave.com)