

ALPEN ADRIA UNIVERSITY OF KLAGENFURT



FACULTY OF INFORMATION AND COMMUNICATIONS
ENGINEERING

Department of Networked and Embedded Systems

Getting started with Saturn System

Author
Alberto ZANDARA

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1 Introduction

The Saturn system is a technological solution designed for agricultural parameters monitoring. The system is conceived to be integrated in a smart agriculture system in order to achieve a reliable and simple crops data collection.

It consists in a low power sensor network based on the 802.15.4 communication protocol. The system is composed by two types of device: the **Dominus** and the **Agricola**.

The Agricola consists in a 802.15.4 endpoint device that physically collects data from the environment. The Dominus is an 802.15.4 coordinator acting as a gateway to forward the Agricolae's data over the internet and organize it on an online UI to make it easily accessible by the end user.

2 Hardware configuration

In this section will be explained the necessary hardware operations in order to reproduce a working Saturn-system. The necessary devices are: some programmable circuit boards equipped by a micro-controller to be configured as Agricolae (in this paper the chosen board is the Waspote¹ because of its low power RTC hibernation feature), a Linux machine with UART interface to be configured as Dominus (in this paper an Ubuntu computer), sensors for data collection (in this paper: UVM30A, a raindrops sensor, BMP280, DS1820, GY30 and a capacitive soil moisture sensor) and 802.15.4 transceivers (in this paper Xbee-PRO S1² firmware version 1xEF).

2.1 Agricola

As mentioned before, the Agricola module consists practically in a Waspote board with an 802.15.4 transceiver and a bunch of sensors connected. The transceiver must be plugged in its dedicated slot on the Waspote board³, while the other sensors need to be connected to the expansion PINs as follow:

¹Atmega 1281 board designed by Libelium: <https://www.libelium.com/iot-products/waspote/>

²Designed by DIGI: <https://www.digi.com/resources/documentation/digidocs/pdfs/90000982.pdf>

³More informations: <https://development.libelium.com/waspote-technical-guide/802-15-4-zigbee-rf-modules#xbee-3-802-15-4>

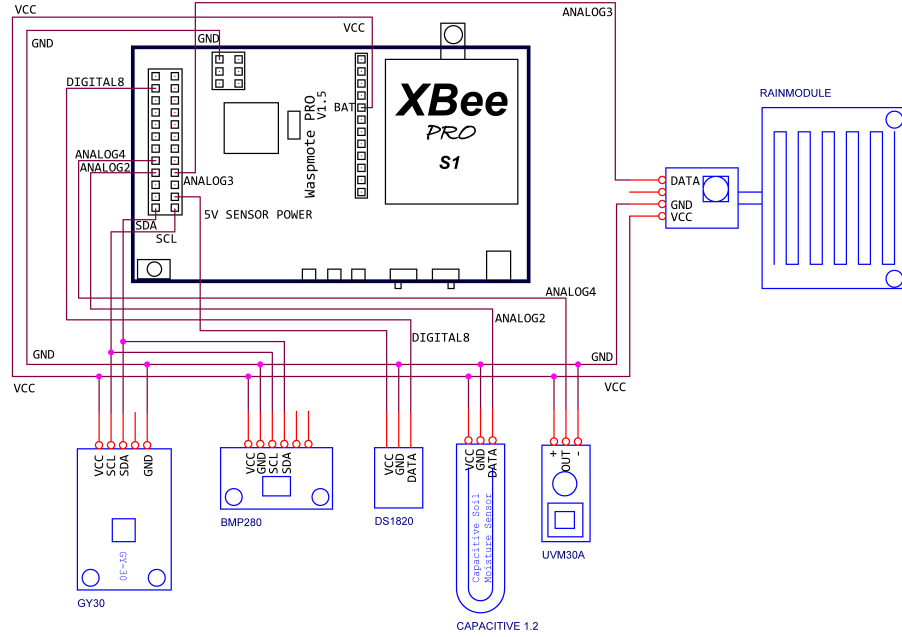


Figure 1: Agricola sensors connections.

2.2 Dominus

The Dominus is a gateway between the 802.15.4 sensors network and the internet network. The selected platform to perform this task is a Linux machine. Ideally the Dominus should be an embedded solution like an Onion Omega2+ that is equipped of an UART interface and can be easily integrated in a single board [2] with the 802.15.4 transceiver.

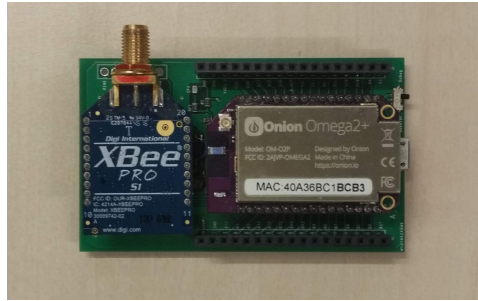


Figure 2: Dominus mockup.

In this preliminary phase the Linux machine used is instead a laptop with

Kubuntu 20.04 LTS.

3 Software configuration

The programming language used to implement the system are essentially 2: **C++** (a slightly modified version, the same used for Arduino) and **Javascript**. In the first phase it is necessary to ensure that the Xbee transceiver are adjusted as 802.15.4 modules, in API 2 mode, in Endpoint configuration and with the 1xEF firmware installed. All these operation can be performed thanks to XCTU⁴, the Xbee configuration program. Once that this settings are adjusted it's possible to proceed with the Agricola and the Dominus configuration.

3.1 Agricola

The Agricola need to be programmed with the dedicated Waspnote IDE, available for free on the Libelium website⁵. The IDE is rather incomplete and it needs some modification in order to compile the Agricola source code. In fact, strings are not officially supported and in order to make them available is necessary to download the official arduino libraries WString.cpp and Wstring.h available for free on Google Git⁶. Once the libraries have been downloaded, it is necessary to modify them slightly in order for them to work. In **WString.cpp** it is necessary to comment the line `#include "WProgram.h"`, in **WString.h** it is required to add `#include "wiring.h"`. Once that the IDE has been properly modified the source code can be downloaded from Github⁷ and uploaded to the Agricola through the Waspnote IDE.

⁴Download link: https://www.digi.com/resources/documentation/digidocs/90001526/tasks/t_download_and_install_xctu.html

⁵Available for several operative systems: <https://development.libelium.com/waspnote-ide-v06/>

⁶Download WString.cpp and Wstring.h from here: <https://android.googlesource.com/platform/external/arduino/+d5790d78880d4bd60be277ee20e53a851aa8c116/hardware/arduino/cores/arduino>

⁷Download link: <https://github.com/AlbertoZandara/Saturn-system/blob/main/AgroEP.pde>

3.2 Dominus

For the Dominus the situation is a little more complex, in first instance it is necessary to install Node-RED. On the website⁸ of the application are reported all the different installation methods that change according to the Linux operative system of destination. In this case, in Kubuntu, it is possible to use the script command:

```
bash <(curl -sL https://raw.githubusercontent.com/node-red/raspbian-deb-package/master/resources/update-nodejs-and-nodered)
```

After that it is necessary to set an authentication for the UI and for the Node-RED management dashboard. In order to do that the following commands have to be issued:

```
cd /.node-red
sudo npm install -g node-red-admin
node-red-admin YOUR_PASSWORD
```

The last command will return an hash code (YOUR_HASH) that need to be inserted in the Node-RED settings file:

```
nano /.node-red/settings.js
```

In this document there is a commented space that needs to be uncommented and modified as follow:

```
adminAuth: {
  type: "credentials",
  users: [{
    username: "YOUR_USER",
    password: "YOUR_HASH",
    permissions: "*"
  }]
},
```

And some lines after, for the UI encryption, also:

```
httpNodeAuth: {user:"YOUR_USER",pass:"YOUR_HASH"},
```

After that, Node-RED need to be set as a system service to execute iut at the start-up

```
sudo systemctl enable nodered.service
```

Once all this operations has been performed it is necessary to import the

⁸More information here: <https://nodered.org/docs/getting-started/local>

actual Dominus program that can be downloaded from Github⁹. To import the just downloaded Node-RED flow, it is required to open the Node-RED control panel, available from the browser at <http://localhost:1880>, and than go in the upper-right menu -> Import -> Clipboard and than open the downloaded flow. Now the Dominus is correctly setted but the UI is only available at <http://localhost:1880/ui> and it is not accessible from the internet. In order to make the UI accessible to the internet it is necessary to connect the Linux machine to a network and perform a port-forwarding. Otherwise, a temporary solution is to use Ngrok¹⁰ and mirror the port 1880 on the internet.

The system is now configured and ready for use.

4 Instructions for use

The procedure to add new Agricolaes in the system is straightforward. In first instance the user has to open the UI on its laptop, tablet or smartphone using a browser and opening the UI url. After that, opening the Settings tab in the upper-left corner menu [3a], it is possible to pair new Agricolaes. In the first form [3b] the advanced user can set the communications features to avoid possible collisions or interferences with other systems, while the non-expert user can leave this spaces empty and simply press "SUBMIT".

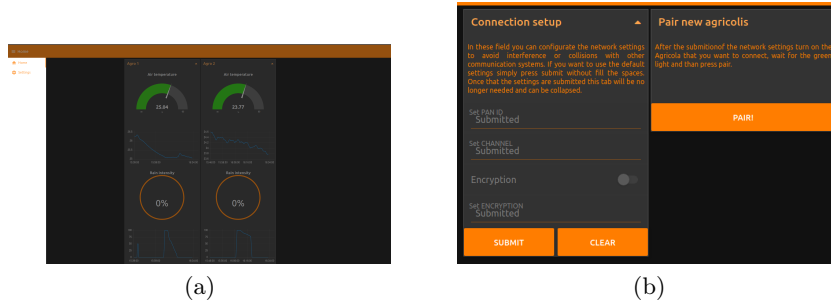


Figure 3: Upper-left corner menu (a) and Settings tab (b).

After the submission of the network settings the user must turn on the first Agricola to be connected. To activate an Agricola it is necessary to:

⁹Download link: https://github.com/AlbertoZandara/Saturn-system/blob/main/Node-RED_flow_final_rev.json

¹⁰For more information: <https://ngrok.com/download>

1. Turn the main switch to the right and the hibernate switch to the left.
2. Plug the battery to the Agricola.
3. Turn the main switch to the the left.
4. Wait for the green LED to light on and turn the hibernate switch to the right.

After this procedure the user has simply to press the "PAIR" button on the UI and the Agricola will be connected to the Dominus and all the information will be displayed on the Home tab in the upper-left corner menu [4].



Figure 4: Saturn-system working dashboard.