

Installing and Managing WIMEA-ICT Automatic Weather Station (AWS)

Technical and User Manual

Version 1.0

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1. Introduction

This is a technical manual for WIMEA-ICT Automatic Weather Station (AWS). The AWS is based on Wireless Sensor Networks (WSN). The AWS prototype consists of 4 wireless sensor nodes and a Raspberry Pi acting as a gateway. The sink node has a wired connection to the raspberry Pi. The sensors are connected to the nodes as follows:

- i. The 10m node has wind direction and speed and solar insolation sensors. The node is installed 10m from the ground.
- ii. The 2m node has air temperature and humidity sensor (SHT25 sensor). The SHT25 sensor is installed 2m from the ground along the AWS 10m stand.
- iii. The ground node has the soil temperature, soil moisture sensor and rain gauge. The soil sensors are in the soil while the rain gauge is either on the ground or close to the ground.
- iv. The sink node has an atmospheric pressure sensor and is attached to and powered by the Raspberry Pi forming a gateway. The gateway is powered through its USB port using a 5V AC-DC adapter.

2. Wireless sensor Node

2.1 Features of RSS2 Mote

WIMEA-ICT AWS uses a radio sensor node/mote, also called RSS2 mote from radio sensors [1]. Figures 1 and 2 show the back and front views of the node

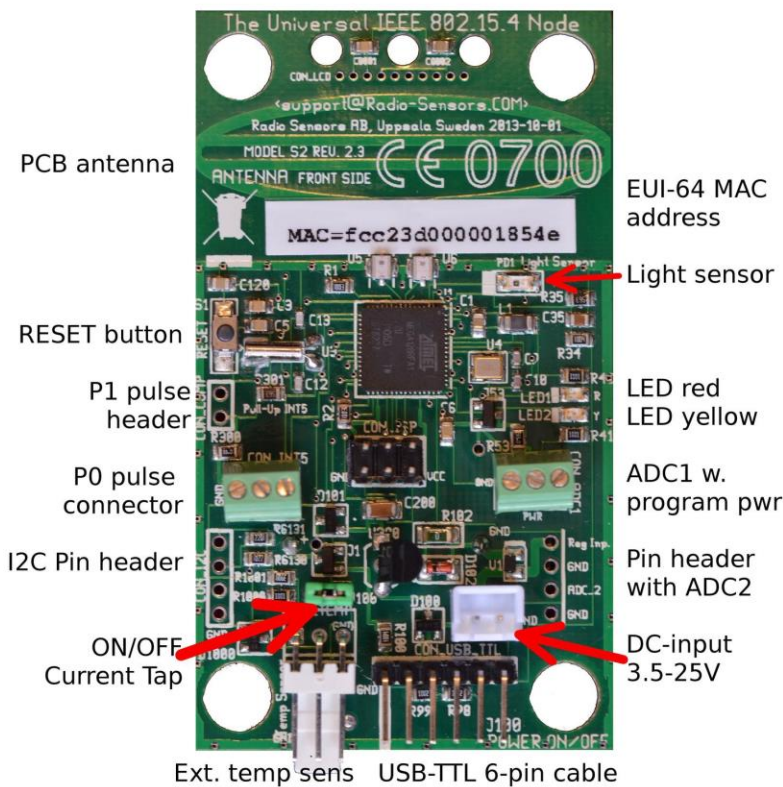


Figure 1 Front side of RSS2 Mote

Sensors may be attached to interfaces including INT5, ADC1 etc. The reset button is used to reset the mote. This is normally done during writing the bootloader. When configuring the mote, an FTDI cable in may be connected to the mote through a USB-TTL 6-pin connector. Figure 3 and 4 show ftd1 cable.

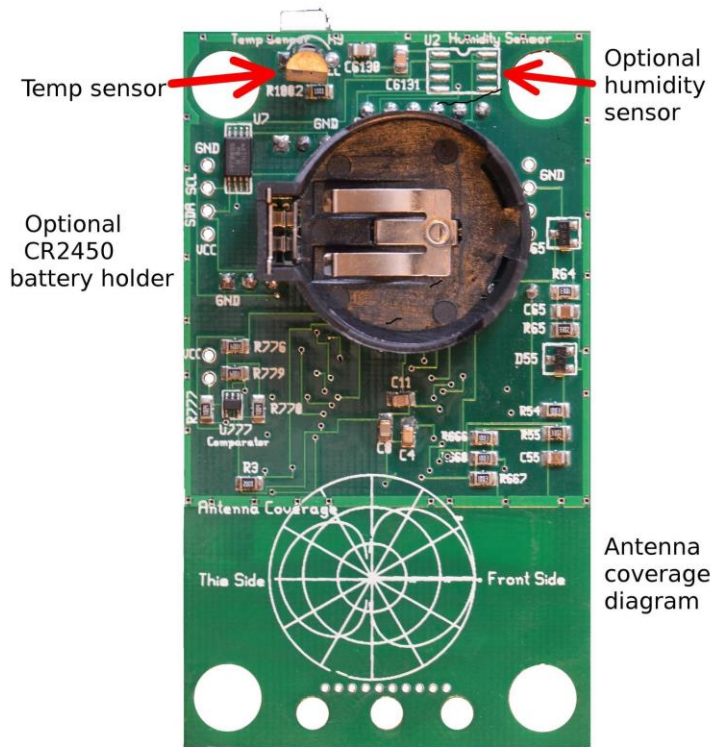


Figure 2 Back side of RSS2 Mote

The mote uses IEEE 802.15.4 wireless protocol to communicate i.e. receive and send packets. When installing the AWS, the antenna coverage label must face the sink node for a good signal.



Figure 3 FTDI cable showing the two ends



Figure 4 Head of FTDI Cable, which connects to the Mote

2.2 Configuring the RSS2 Mote

In order to configure the mote, connect the mote to a computer running an ssh client like putty using an ftdi cable. In case of linux, other serial communication clients like minicom may be used. First check the serial port used by the mote under device manager as in Figure 5 .

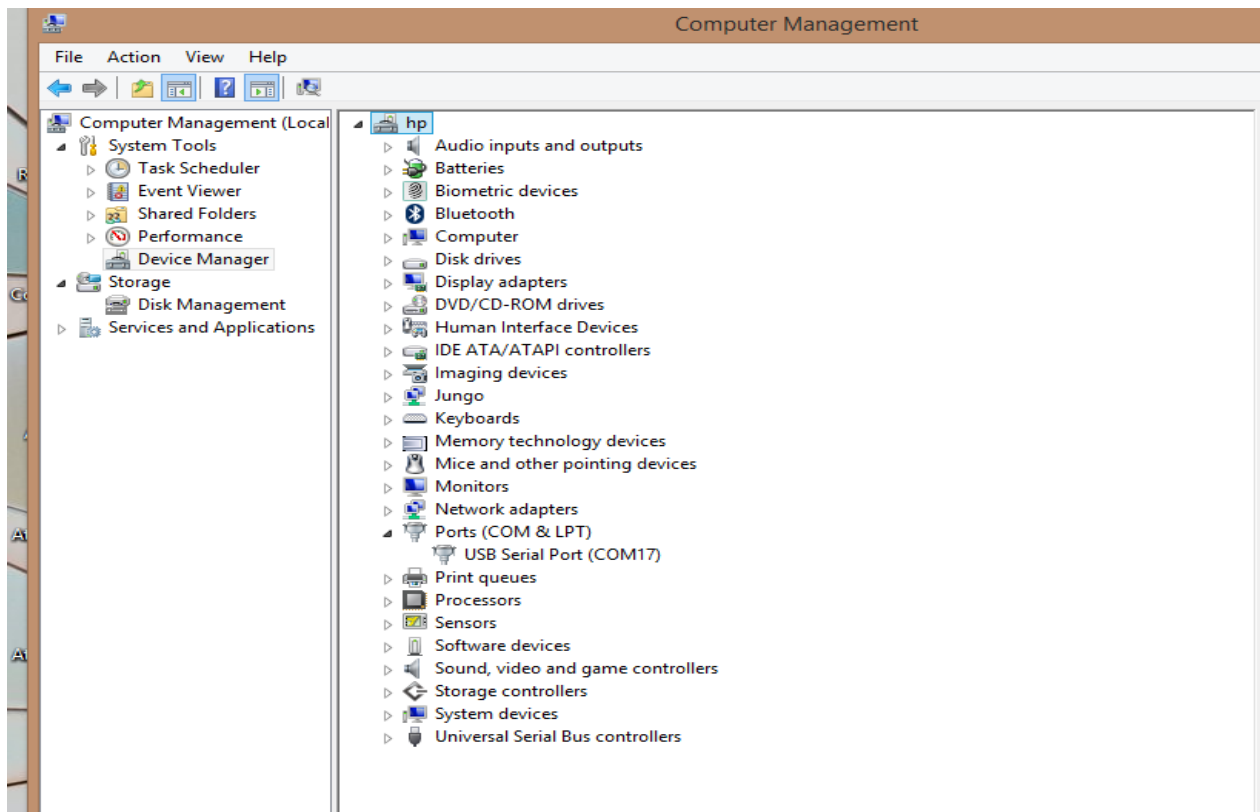


Figure 5 Device manager showing COM17 Port in windows after connecting the mote via ftdi cable

After identifying the COM port, use a client of your choice. For example, putty as per Figure 6. Under Connection Type, select Serial. Ensure that the speed is 38400. Select Open and interact with the serial Interface.

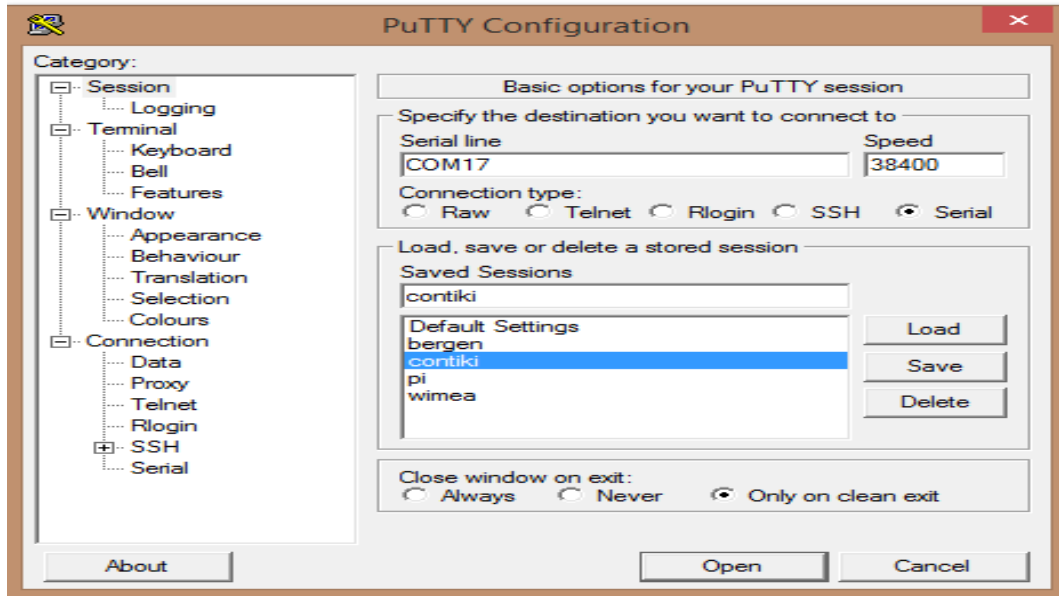


Figure 6 Putty, a serial client opting to use com port 17.

After pressing the Open button, you will be able to interact with the mote via keyboard commands. Figure 7 shows a sample of commands provided during the mote configuration. Follow the commands to perform configuration.

```

h-help
ri- How often the reporting is done, in seconds eg ri 60 – report every 1 minute
re –display report mask ,
eg re #0 txt,e64,t (sets the report number 0 to report node name, mac address and
temperature )
ss- Display system summary

```

Figure 7 Connecting the Mote to Raspberry Pi GPIO pins using jumper wires

3. Gateway Configuration

The gateway is a combination of a node, also known as a sink because of its function and Raspberry pi. The gateway enables the AWS to connect to the Internet. Connecting the AWS to Internet enables users to remotely access it. The sink collects data from all other nodes and stores it on the raspberry pi. Using any uplink option/ Internet connection method, the data may be accessed from anywhere at any time.

3.1 Installing and setting up the raspberry Pi

The raspberry Pi is equipped with many interfaces including USB ports (4), HDMI port, power slot and SD card slot among others. It however does not have a monitor. The HDMI interface provides a connection of the raspberry pi to a computer using HDMI to VGA cable. A keyboard and mouse may also be connected to the raspberry pi via the USB interfaces.

There are various operating systems, which may be installed on the raspberry pi. The operating systems should reside on an SD card, which is placed in the SD card slot. First, the operating system must be set up on the SD card, An example of an OS is Rasbian Wheezy.

Install Win32DiskImager on your computer. The software will help to write the operating system to the SD card. Follow instructions on[2].

After writing the OS, insert the SD card into the raspberry pi and power it. More instructions on setting up the raspberry pi may be found at [3].

3.2 Connecting Node to Raspberry Pi

The following Figures show how the RSS2 mote is connected to the raspberry pi using female jumper wires.

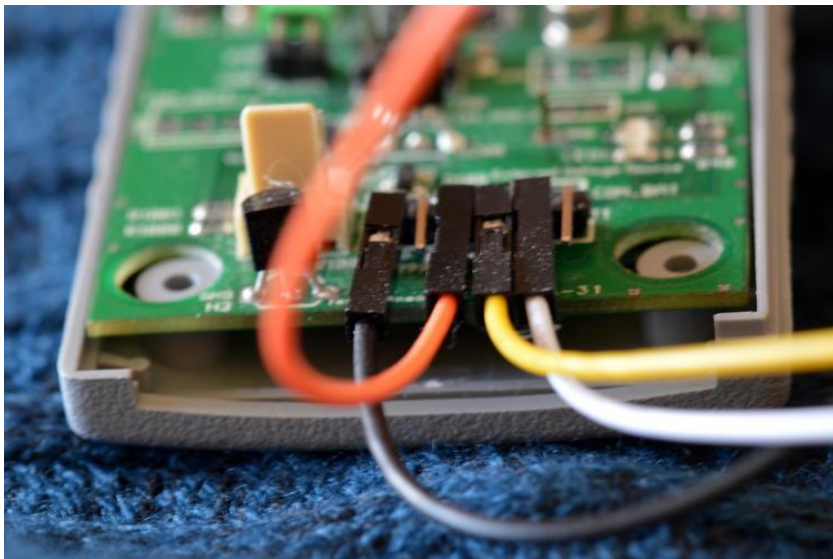


Figure 8 Part of the RSS2 Mote showing how which pins are connected to the raspberry Pi

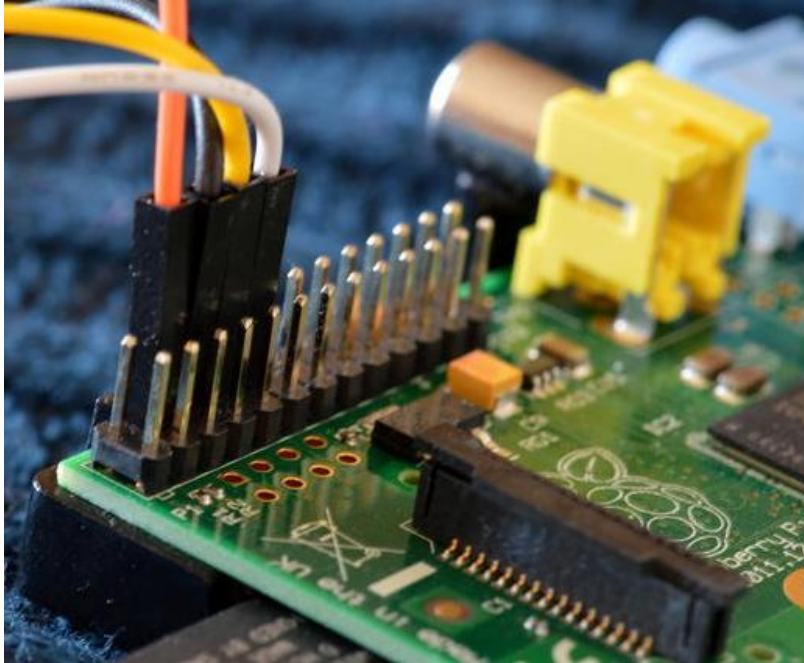


Figure 9 Part of the Raspberry Pi showing the GPIO pins to which the node pins are connected using jumper wires

An alternative option of connecting the node to the raspberry pi is by using an ftdi cable. I.e. connect the USB of the cable to the USB port of the raspberry pi

3.3 Connecting Gateway to Internet

There are various ways of connecting the raspberry pi to Internet. These include

1. Using cable via ther Ethernet interface
2. Wifi, by attaching a wifi dongle to the raspberry pi
3. Using a USB modem
4. Etc

Options 1 requires no configuration, while option 2 requires limited configurations. Option 3 requires massive configurations and details are given in this document.

3.3.1 Configuring Raspberry Pi to Connect to Internet Using a USB Modem

Below is a list of required software for the raspberry Pi

Table 1 Required Raspberry Pi software

Software	Function
ppp	Manages connection between the Raspberry Pi and 3g Provider
Sakis3g	Connects to 3G Internet via a configured Sim card
UMTSkeeper	To reconnect the 3G dongle using sakis3g script if connection drops

Although the Raspberry pi has an Ethernet port for Internet connection, in the absence of cable, alternatives including using wifi and USB modems may be used

To configure the raspberry pi to access Internet using usb modem, perform the following tasks:-

- i. Edit `/etc/network/interfaces` to have the following
`Auto usb0`
`Allow-hotplug usb0`
`Iface usb0 inet dhcp`
- ii. In case of a smart mobile phone, set USB tethering and check connection by pinging any site.(Optional step but may help to access Internet before configuring the modem)
- iii. Follow instructions on [4] to set up sakis 3g on the raspberry pi
- iv. Install ppp
- v. Install umtskeeper `sudo wget http://zool33.uni-graz.at/petz/umtkeeper/src/umtskeeper.tar.gz`

4. Data

4.1 Acquiring data from AWS

Given an active Internet connection, the AWS data may be accessed via SSH or a web page, which runs on the gateway, a raspberry Pi. For a gateway with a public IP address, SSH access may be performed through direct SSH using IP address or domain name, username and password of the raspberry Pi. Different SSH clients may be used including putty, which has versions for both windows and Linux. Linux users may issue the SSH commands via the terminal.

A gateway using a dynamic or private address may not be directly accessed remotely. It can however be accessed through reverse tunneling, which enables the gateway traffic to go through a public IP server. While at the public IP server, the pi may be accessed. follow instructions on [5] to configure reverse tunneling on the gateway. Also, ensure that the raspberry pi's SSH public key is added to the public servers authorized keys to enable raspberry pi to login into server without asking for a password. Refer to [6] to configure password-less SSH access from raspberry pi to server.

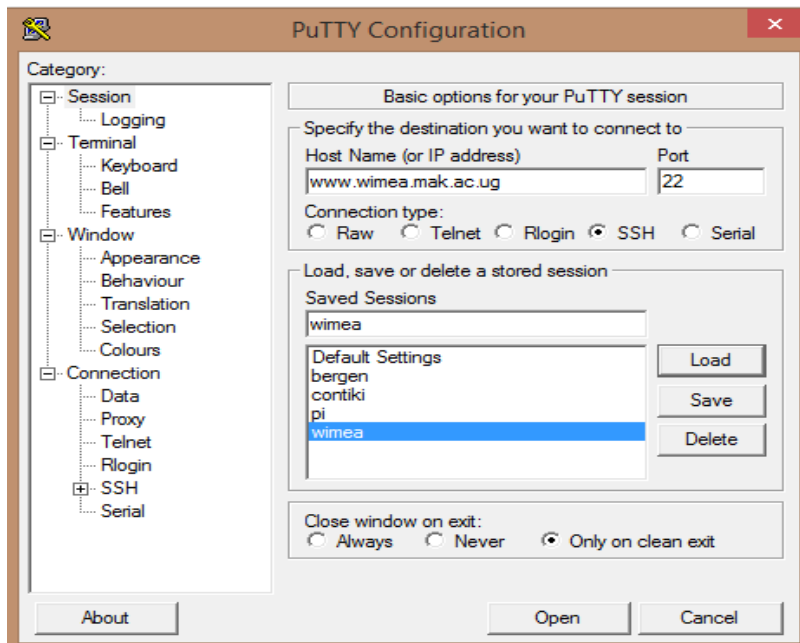


Figure 10 Using putty, an ssh client to access the public IP server

4.2 Data Analysis

Data is recorded in a text file, containing key/value pairs, organized in rows. Each row represents a transmission of a mixture of weather parameters, voltage and network information and starts with a date and time in the first two columns. Figure 2 shows a sample text file for a WIMEA-ICT AWS

```

2016-12-06 09:28:08 TZ=UTC UT=1481016488 GW_LAT=32.57100 GW_LON=0.32920 &:
TXT=makg2-2m E64=fcc23d00000182b5 PS=1 V_MCU=2.92 V_IN=3.68 T_SHT2X=29.61
RH_SHT2X=36.15 [ADDR=31.193 SEQ=103 TTL=15 RSSI=24 LQI=255 DRP=0.00]
2016-12-06 09:28:08 TZ=UTC UT=1481016488 GW_LAT=32.57100 GW_LON=0.32920 &:
TXT=makg2-2m E64=fcc23d00000182b5 PS=1 V_MCU=2.92 V_IN=3.68 T_SHT2X=29.61
RH_SHT2X=36.15 [ADDR=31.193 SEQ=103 TTL=14 RSSI=1 LQI=255 DRP=0.00]
2016-12-06 09:28:08 TZ=UTC UT=1481016488 GW_LAT=32.57100 GW_LON=0.32920 &:
TXT=makg2-gnd PS=1 P0=0x0 P0_LST60=0 UP=0x16108 V_A1=0.04 V_A2=2.95
[ADDR=133.199 SEQ=204 TTL=15 RSSI=26 LQI=255 DRP=0.00]
2016-12-06 09:28:08 TZ=UTC UT=1481016488 GW_LAT=32.57100 GW_LON=0.32920 &:
TXT=makg2-gnd PS=1 P0=0x0 P0_LST60=0 UP=0x16108 V_A1=0.04 V_A2=2.95
[ADDR=133.199 SEQ=204 TTL=14 RSSI=2 LQI=255 DRP=0.00]
2016-12-06 09:28:08 TZ=UTC UT=1481016488 GW_LAT=32.57100 GW_LON=0.32920 &:
TXT=makg2-gnd PS=1 T=33.25 T1=27.06 V_MCU=3.00 V_IN=3.85 [ADDR=133.199 SEQ=205
TTL=15 RSSI=26 LQI=255 DRP=0.00]

```

Figure 11 Sample WIMEA-ICT AWS text file

Besides date and time, there are other columns such as those in Table 1

Table 2 WIMEA-ICT AWS Database file key representations

Node	Abbreviation	Parameter
To All Nodes	TZ	Timezone
	GW_LAT	Gateway Latitude
	GW_LON	Gateway Longitude
	TXT	Text assigned to node for identification purposes
	E64	Mac Address of Node
10m		
	V_MCU	Microcontroller Voltage
	P0_T	
	V_A1	Wind Speed
	V_A2	Wind direction
	T	Temperature sensor reading
2m	T_SHT2X	Temperature reading from SHT 25
	RH_SHT2X	Humidity reading from SHT25

	V_MCU	Microcontroller Voltage
GND	PS	Power save indicator
	T	Air temperature reading
	T1	Soil temperature
	V_MCU	MCU input voltage
	V_IN	Input voltage
	V_A1	Soil moisture
Sink		

4.3 Data Extraction

Before data analysis, extracting and formatting it is necessary especially for benchmarking or research purposes. In order to format, organize or filter out required data, seltag a software, which is compiled with sensd [7] is used. Sensd can be downloaded from

For example, in order to format 2m data to display columns containing date, temperature and relative humidity, issue the following seltag command , extracted from data_file and writing sorted data to 2m.dat

```
more data_file.dat | grep 2m | grep ^20 | seltag -sel T_SHT2X=%s RH_SHT2X=%s | grep -v Miss >> 2m.dat
```

The formatted data may help in plotting data

References

- [1] "Radio sensors." [Online]. Available: radio-sensors.com.
- [2] "How to Make a Raspberry Pi disk image to SD card with win32diskimager." [Online]. Available: <http://raspi.tv/2012/how-to-make-a-raspberry-pi-disk-image-to-sd-card-with-win32diskimager>.
- [3] "Ultimate Raspberry Pi Configuration Guide." [Online]. Available: <http://www.instructables.com/id/Ultimate-Raspberry-Pi-Configuration-Guide/?ALLSTEPS>.
- [4] "Raspberry Pi as a 3g (Huawei E303) wireless (Edimax EW-7811Un) router."
- [5] "Raspberry Pi: Phoning Home Using a Reverse Remote Ssh Tunnel." [Online]. Available: <https://www.tunnelsup.com/raspberry-pi-phoning-home-using-a-reverse-remote-ssh-tunnel/>.
- [6] "Passwordless SSH access."
- [7] "WSN sensor daemon and supporting utilities."

