Development a low cost and fast deployment solution for air quality and weather monitoring system based on Wireless Sensor Networks (WSN)

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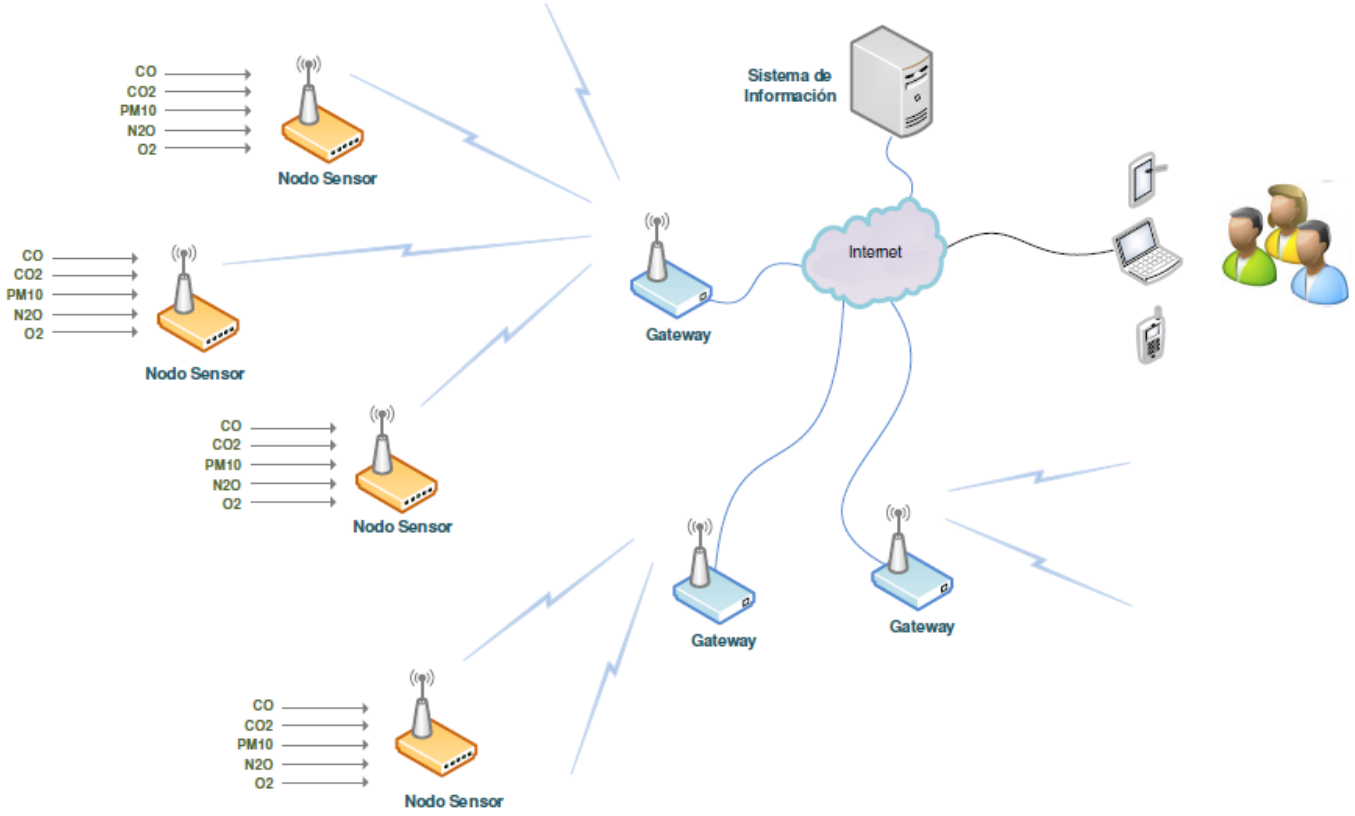
Motivation

- Lima is the **most** air polluted city in Latinoamerica according to WHO.
- According to WHO, one-eighth of the total deaths in the world is caused by air pollution.
- The Peruvian authorities (DIGESA and SENAMHI) measure the air quality in intervals of months and at specific locations due to the expensive equipment and limited movement of the continuous air quality monitoring stations.
- There is no culture of air quality awareness in the population.

Proposed design of air quality solution based on WSN

A Wireless Sensor Network (WSN) is a viable solution for the problem describe due to the following facts:

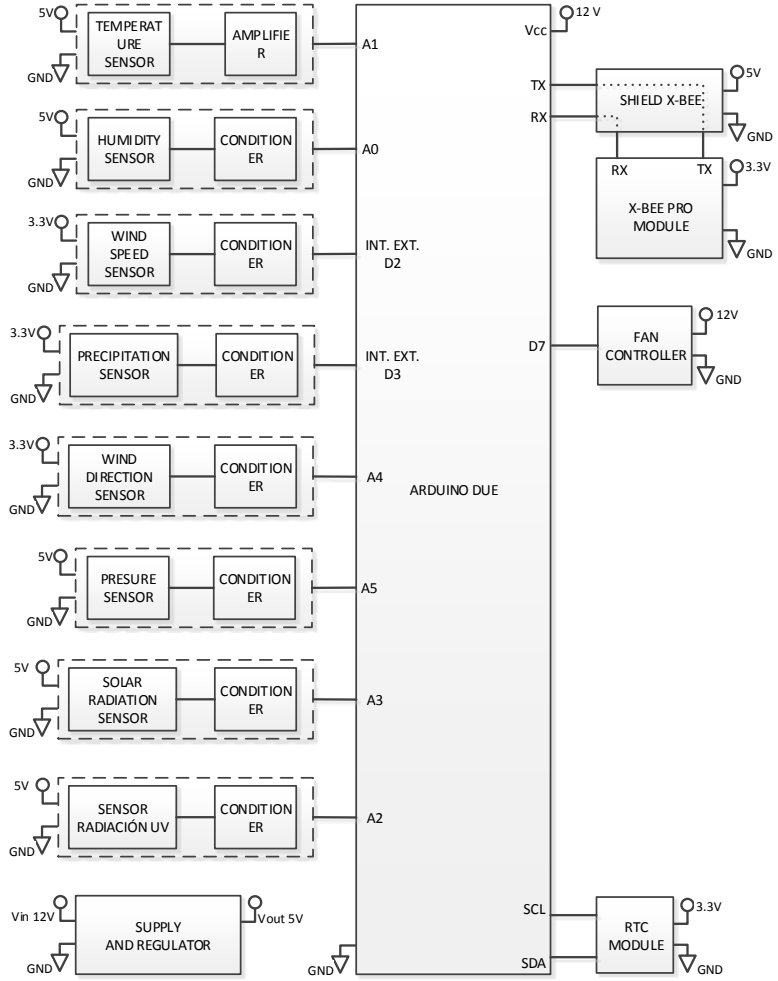
1) Cover a large area.
2) Provide data about AQ continuously.
3) Be energetically autonomous.
4) Be relative inexpensive.



Conceptually schematic of the solution.

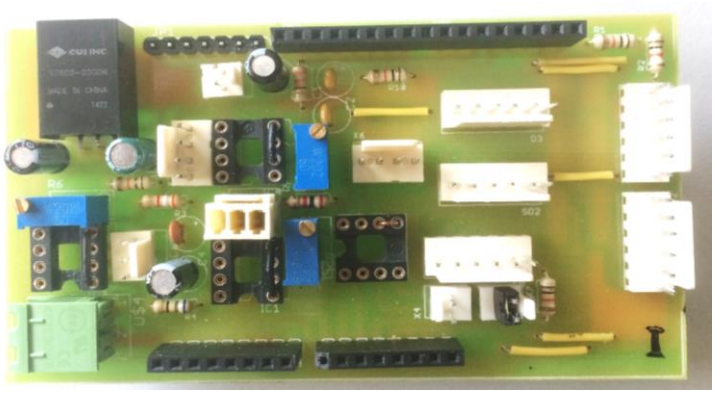
Proposed design of the weather node

- The proposed design of the Weather Node is based on an Arduino Due.
- The radio selected was a Xbee PRO 900 HP.
- The parameters measured by the weather node are:
  - Temperature
  - Humidity
  - Wind speed
  - Wind direction
  - Precipitation
  - Pressure
  - Solar radiation
  - UV radiation



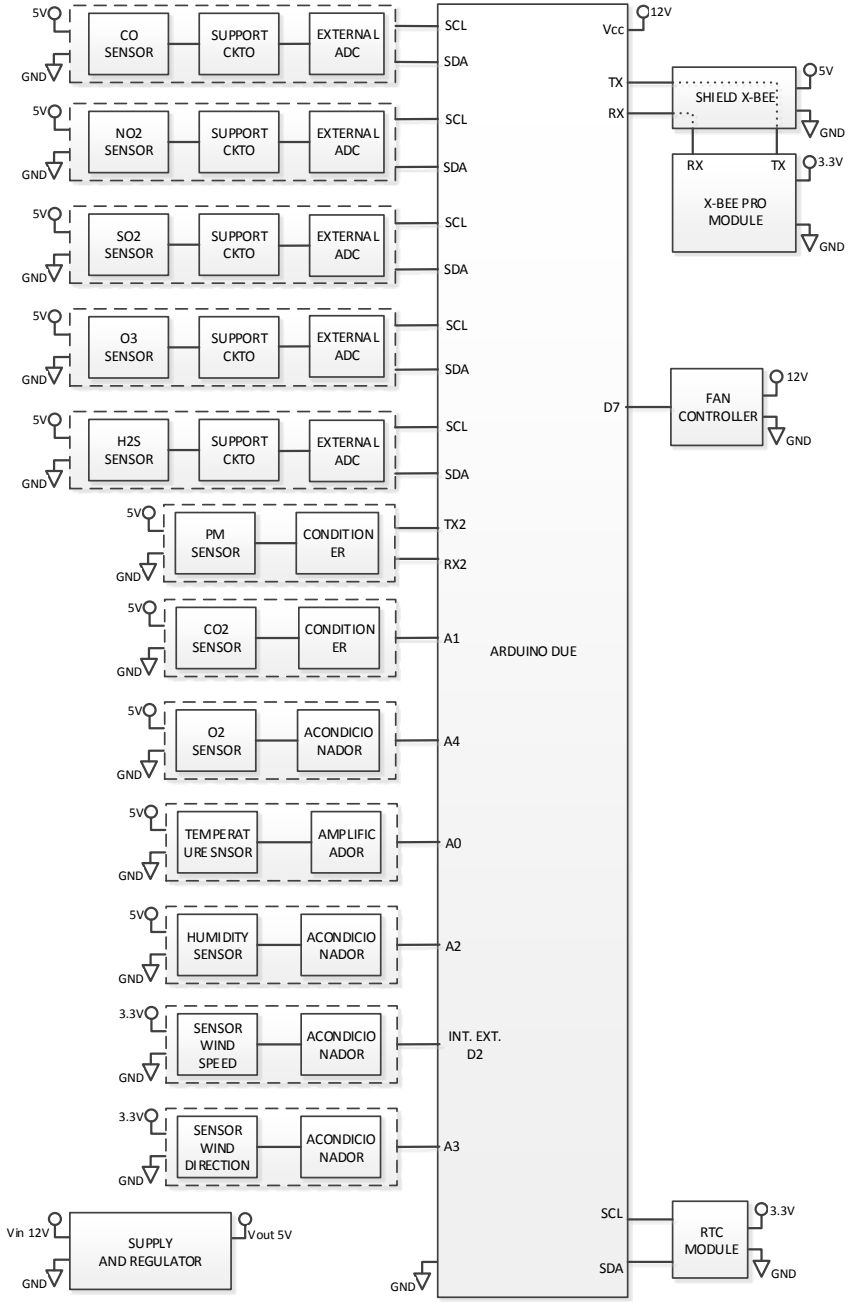
Proposed design of the air quality node

- The proposed design of the air quality node was also based on an Arduino Due.
- The radio selected was a also Xbee PRO 900 HP.
- For the gas sensors a custom board for signal conditioner and Analog-to-Digital conversion.
- The parameters measure by the AQ node are: Carbon monoxide (CO), Nitrogen dioxide ($NO_{2)}$, Sulfur dioxide (SO_2), Ozone (O_3), Hydrogen sulfide (H_2S), Particulate matter (PM10, PM2.5), Carbon dioxide (CO_2), Oxigen (O_2), temperature, humidity, wind speed and wind direction.



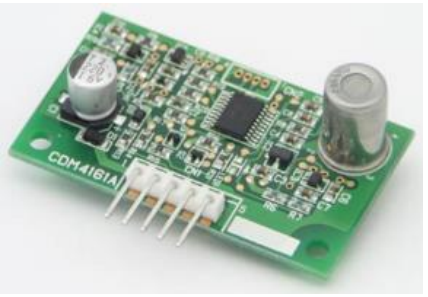
Signal conditioner and ADC board.

Arduino Due+Xbee Shield+Custom board

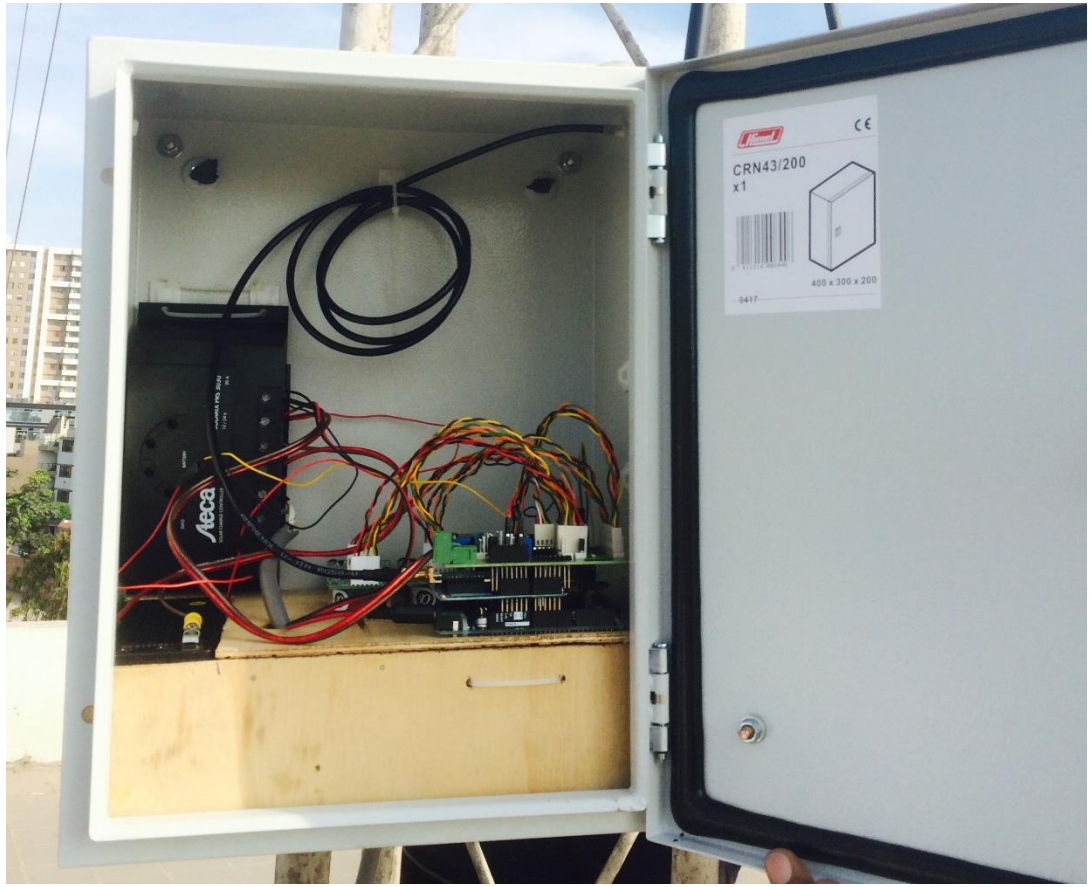


Sensors used

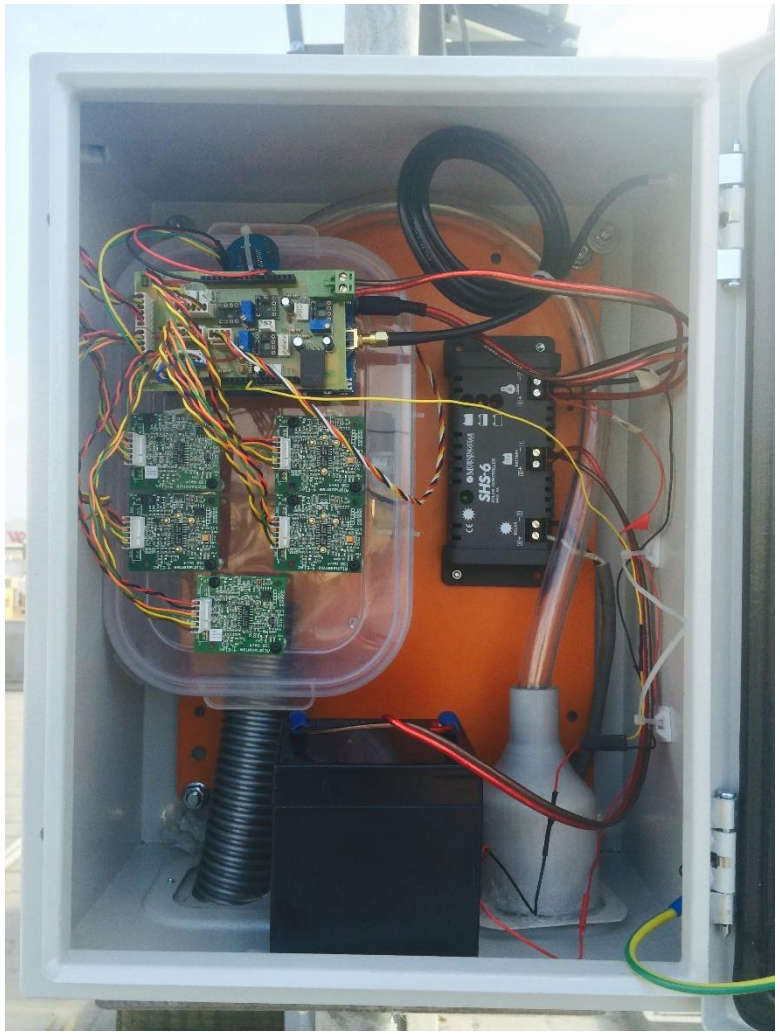
Parameter	Brand	Model
CO	Alphasense	CO-B4
NO_2	Alphasense	NO2-B4
SO_2	Alphasense	SO2-B4
O_3	Alphasense	O3-B4
H_2S	Alphasense	H2S-B4
PM10 & PM2.5	Cubic	AM3004
CO_2	Figaro	CDM4161A
O_2	Figaro	KE-25
Temperature	Texas Instruments	LM35
Humidity	Measurement Specialties In	HTM2500L
Wind speed	Sparkfun	Weather meters
Wind direction	Sparkfun	Weather meters
Precipitation	Sparkfun	Weather meters
Pressure	Freescale Semiconductor	MPX4115A
Solar radiation	Apogee Instruments	SQ-110
UV radiation	Apogee Instruments	SU-100



Implementation AQ nodes version 1

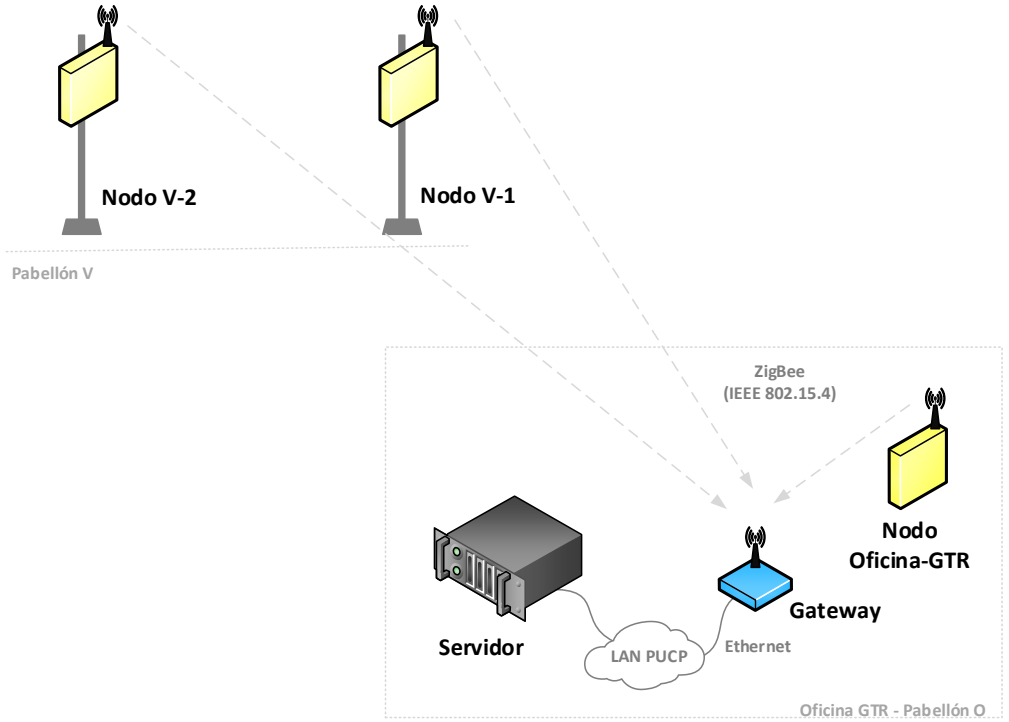


Structure for the sensors made out of wood.



Structure made out of plastic.

First deployment



Conceptual View of the WSN.

Map of the deployment.

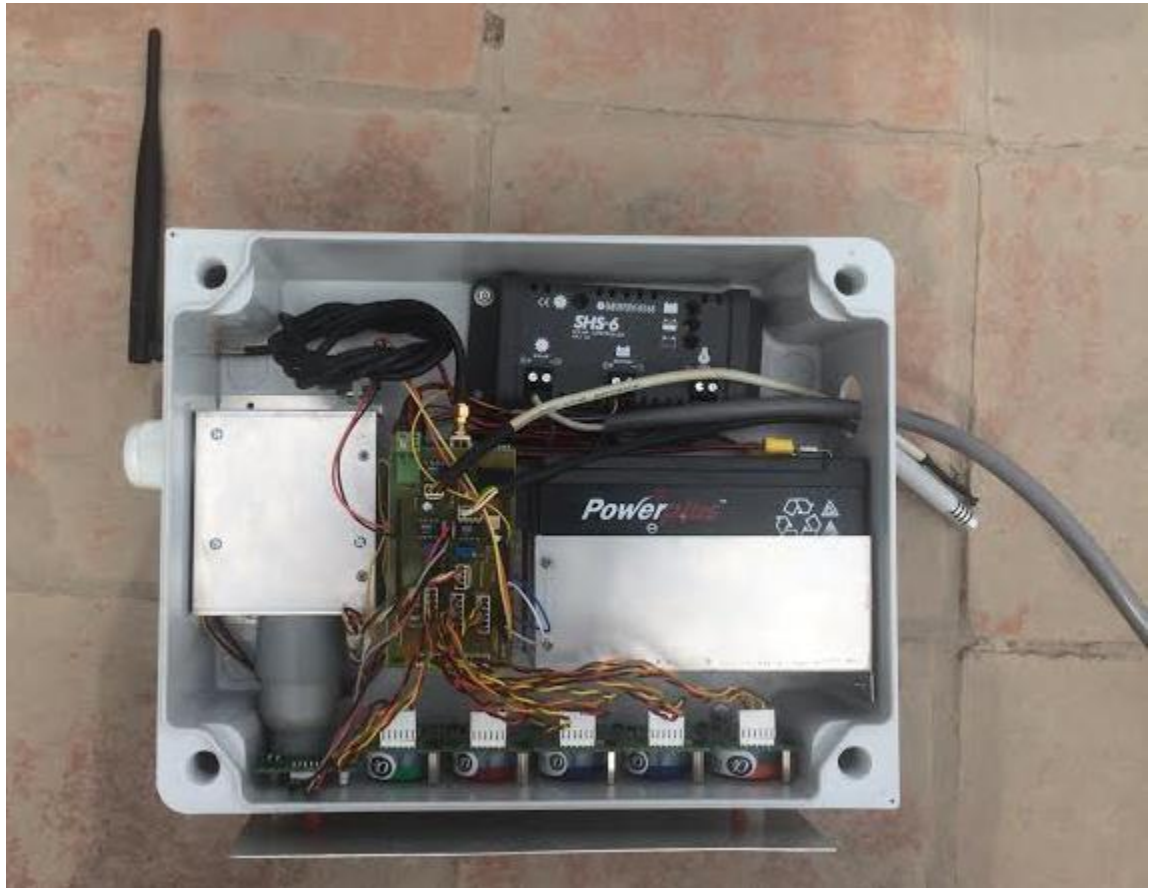
First deployment

AQ Node V1 at V Hall

Weather Node at V Hall

AQ Node V2 at V Hall

Air quality node version 2

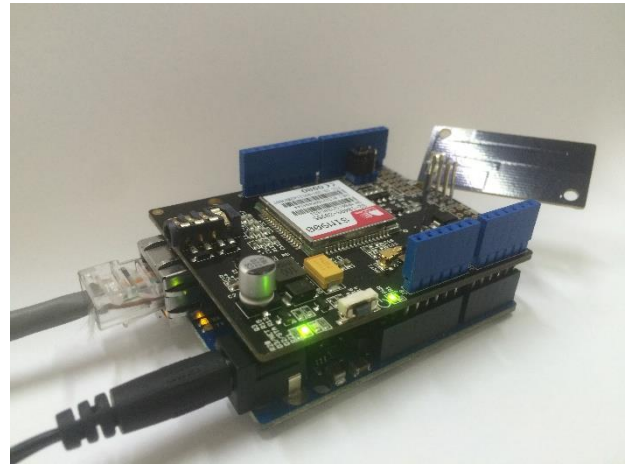


Inside View of AQ Node V2

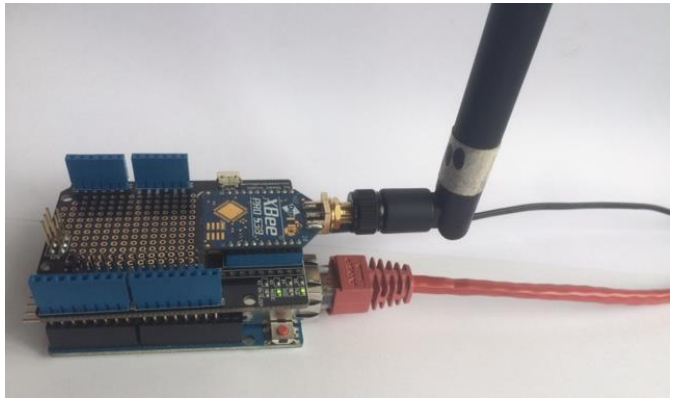
Outside View of AQ Node V2

Gateway

- Three gateways were developed and tested.
- A Xbee-Ethernet Gateway based Arduino Ethernet.
- A pair of two Gateway using GSM communication. A Xbee-GSM Gateway which forwards the WSN data to a server side GSM-Ethernet Gateway.
- For the Xbee-GSM Gateway the ITEAD Gboard Pro was used. In the server side a GSM shield with an Arduino Ethernet was used.



GSM-Ethernet Gateway.

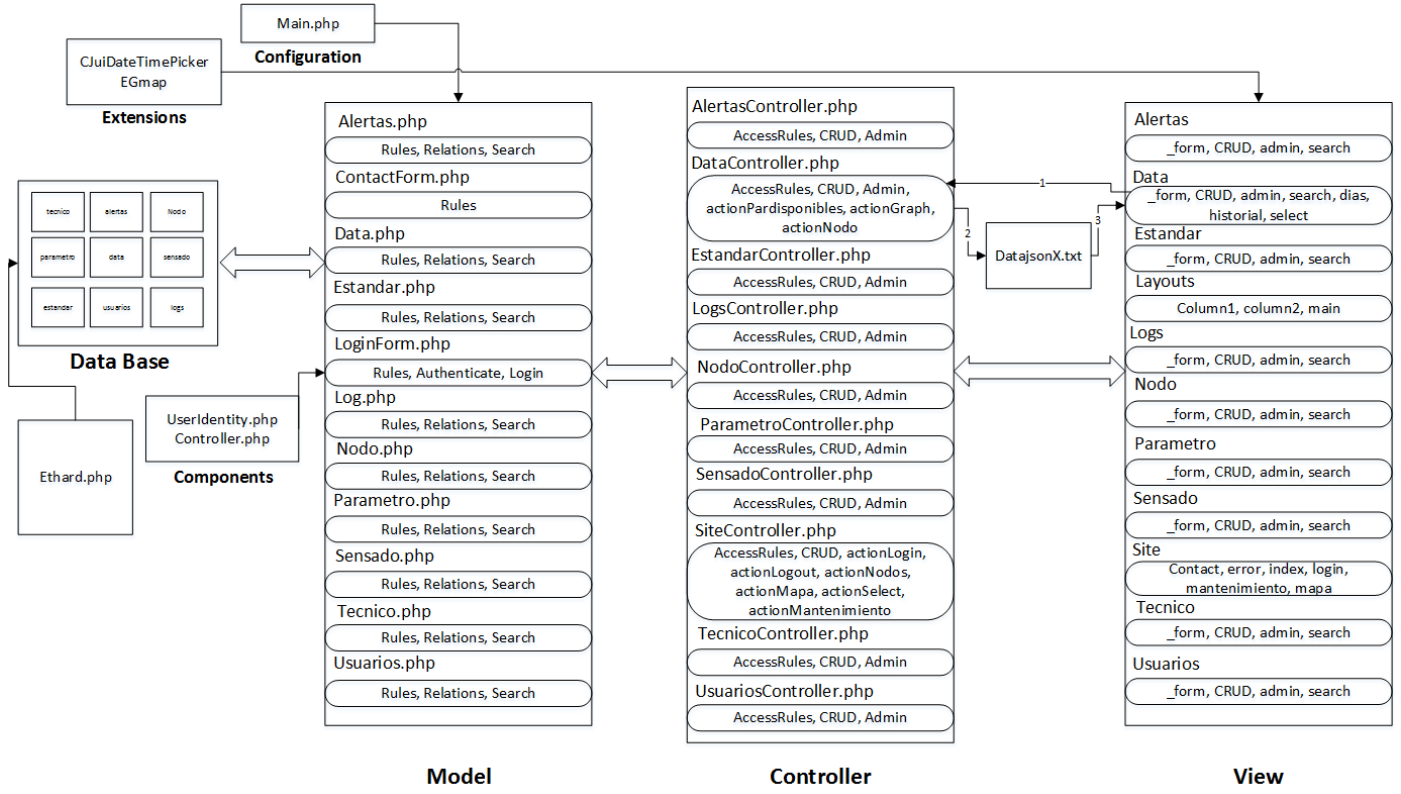


Xbee-Ethernet Gateway.

Xbee-GSM Gateway.

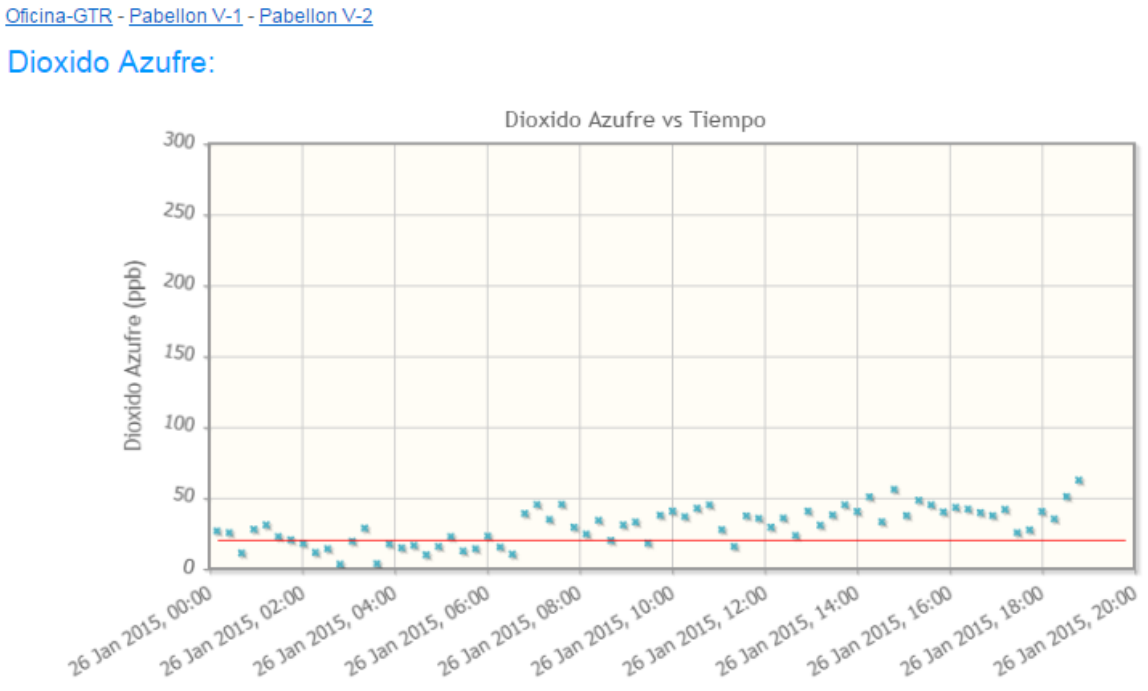
Information system

- The Information System (IS) is based on the PHP based Yii Framework which uses MVC software architecture.
- The server runs on a LAMP (Linux, Apache, MySQL and PHP) on top of a HP ProLiant DL320e Gen8.
- The user interface is user-friendly and allow maintenance of the WSN, view real-time AQ, history search, map view, etc.

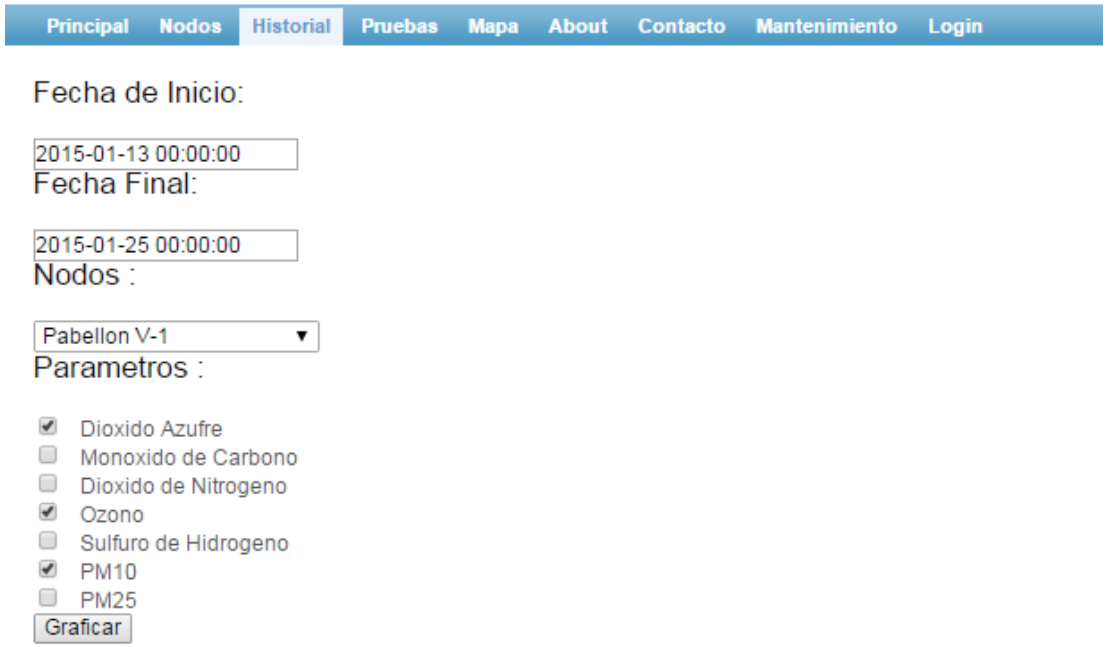


Software architecture of the information system.

Information system

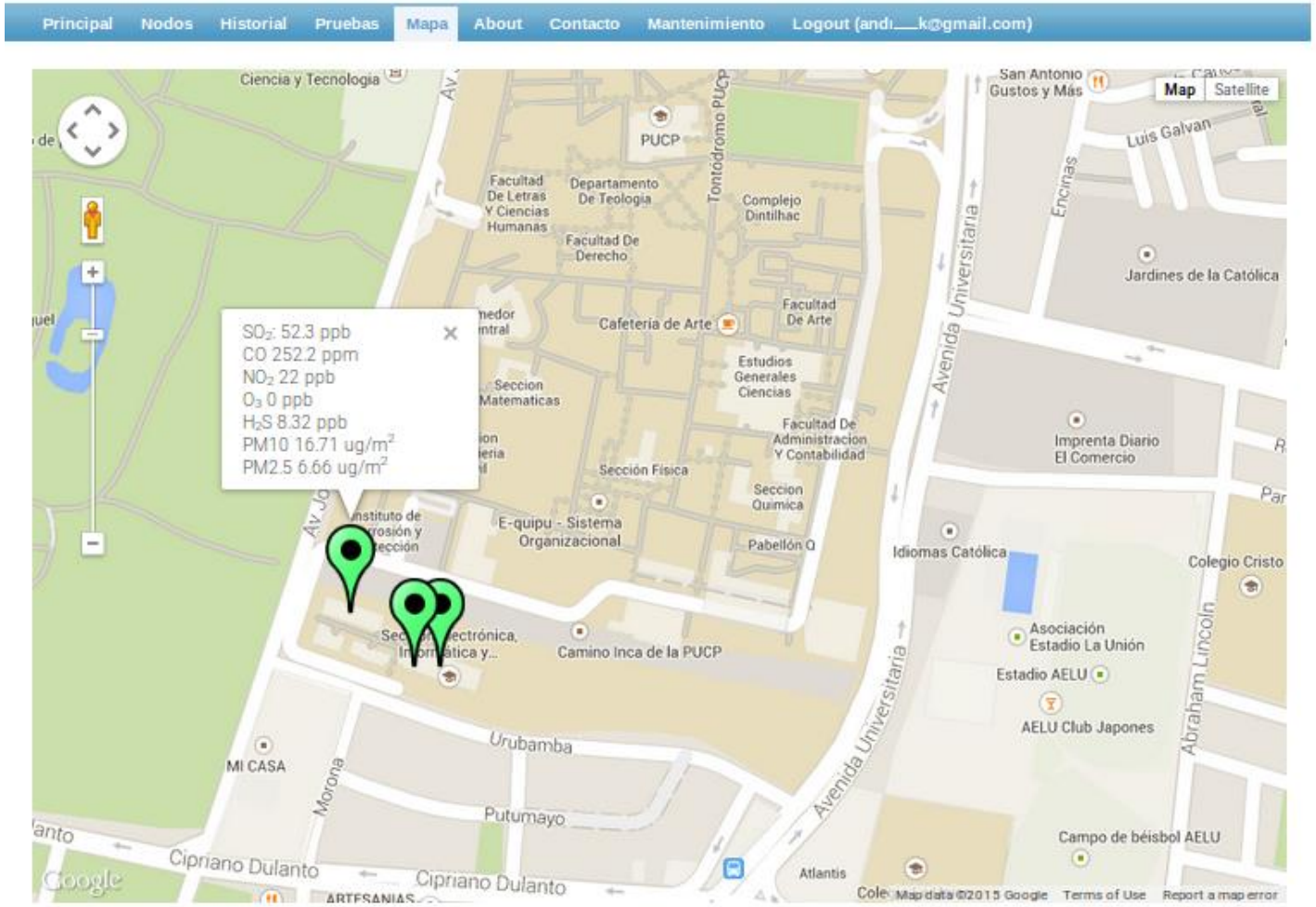


Daily gas motorization.



Custom date, node and parameter selection.

Information system



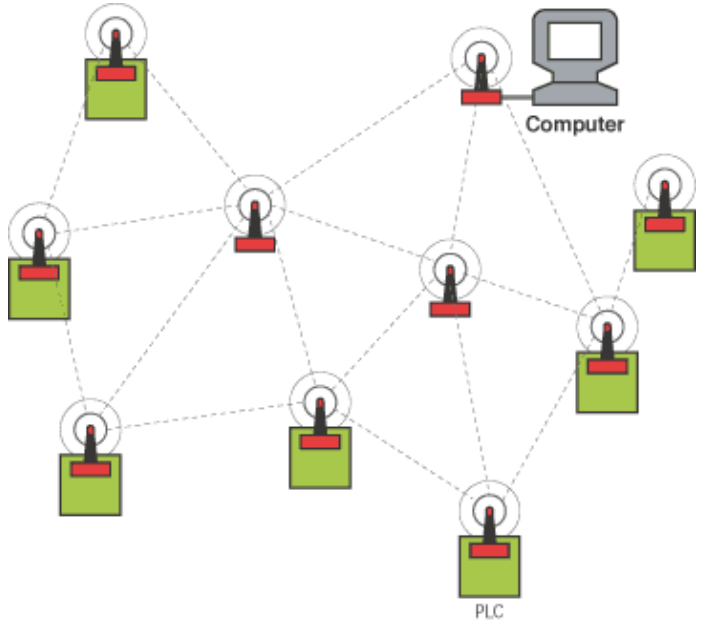
Map view of the AQ nodes indicating the last measurements.

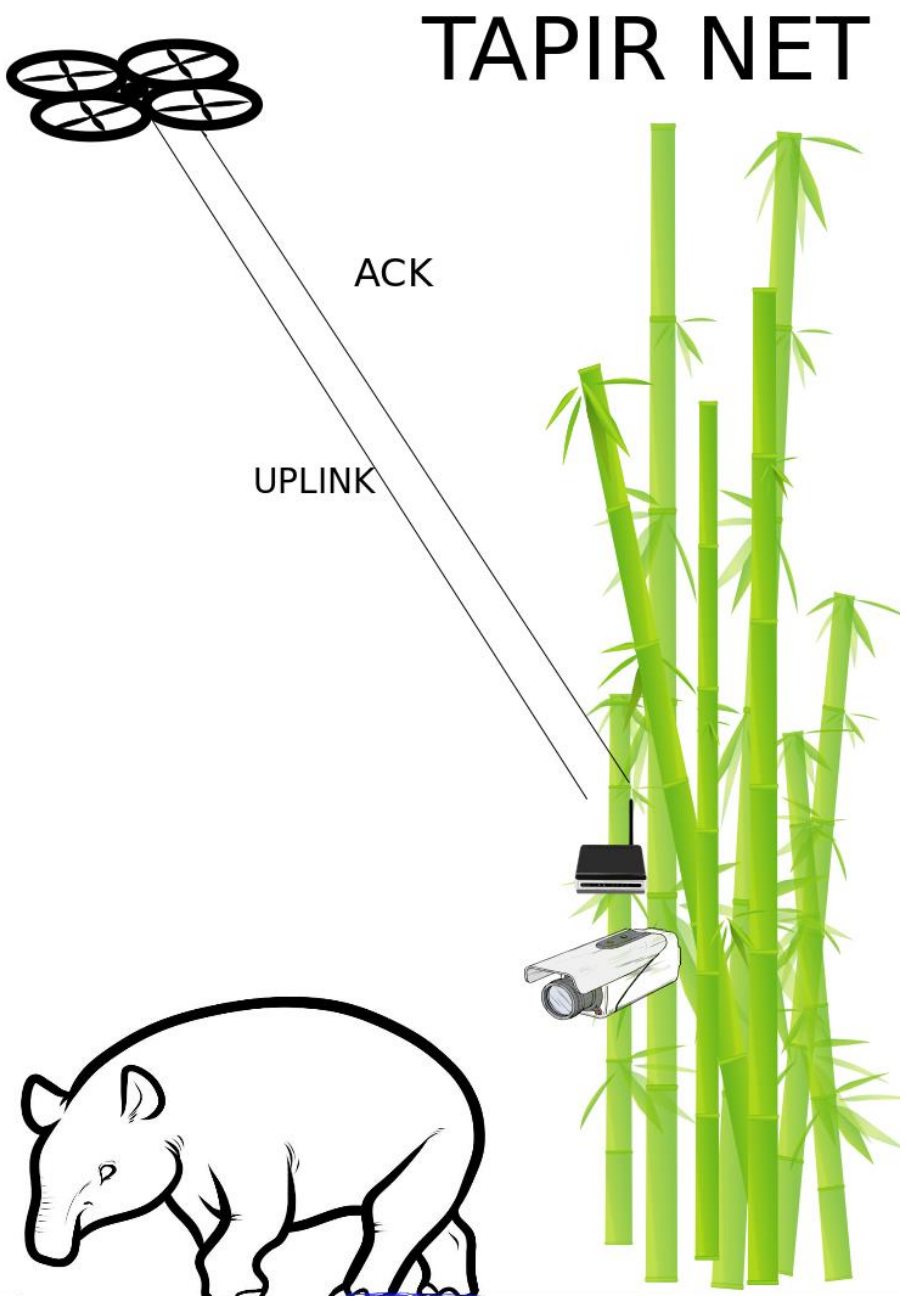
Other projects of WSN being developed at GTR

1) TapirNet: **T**ropical wildlife images **A**chieved by CMOS cameras and **P**assive **I**nfra**R**ed sensors in a wireless **net**work. In order to estimate the economic value of the wildlife in the Allpahuayo-Mishana reserve. This project proposes the use wireless transmission and low cost CMOS cameras to gather pictures of wild animals in the reserve to help researches to keep an animal inventory. By using wireless transmission many nodes can be installed to cover a great area in the jungle and have the images transmitted to a central node where the researcher can have access to all the pictures.

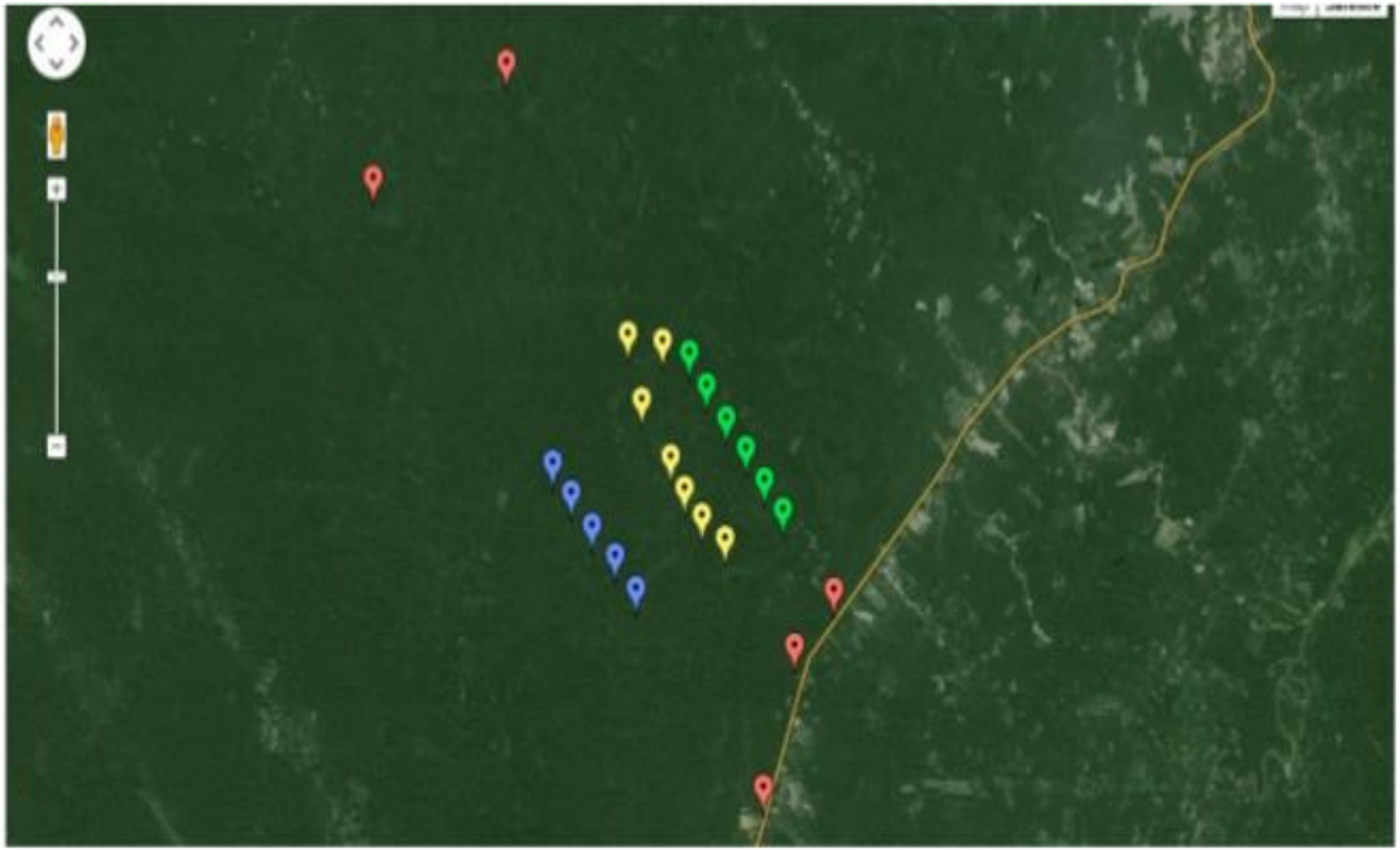
2) Hot Houses: The "hot houses" project implements solutions to build warm and comfortable housing in cold weather zone (Peruvian highlands) by reducing the necessity of in-house firewood based heating which produces toxic smokes. As a way to validate the improvements of using this new technology a WSN was deployed in two communities (Langui, Cusco and Tantamaco, Puno). The WSN deployed senses internal and external temperature, wind speed, wind direction, humidity, pressure, precipitation and solar radiation. Each WSN consist of 25 nodes with a point-multipoint topology. The Gateway sends the information to the server by SMS.

1. The TapirDuino cameras are placed in strategic places of a way that motivates the animals to go through .
2. Each time an animal passes by that way (action zone) the TapirDuino will take a picture.
3. At the end of each day the information gather by each node is transmitted to the sink node.
4. Weekly a UAV will travel from Iquitos to the intervention zone and will collect all the information from the sink node.





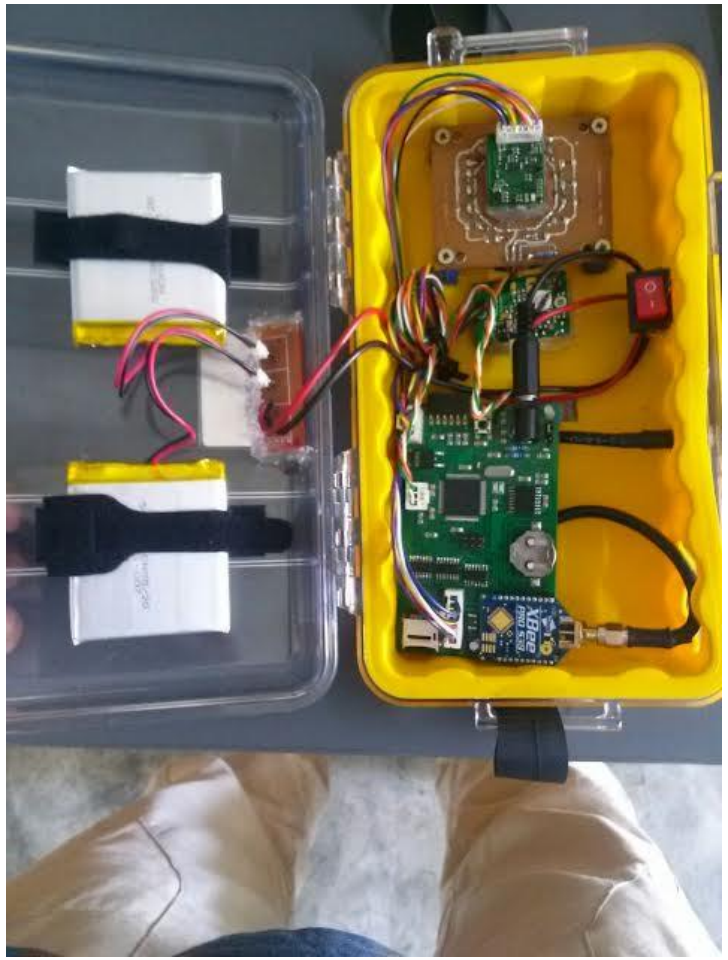
Allpahuayo – Mishana Reserve



WSN mesh-topology for the deployment.

TapirDuino

TapirDuino outside view.



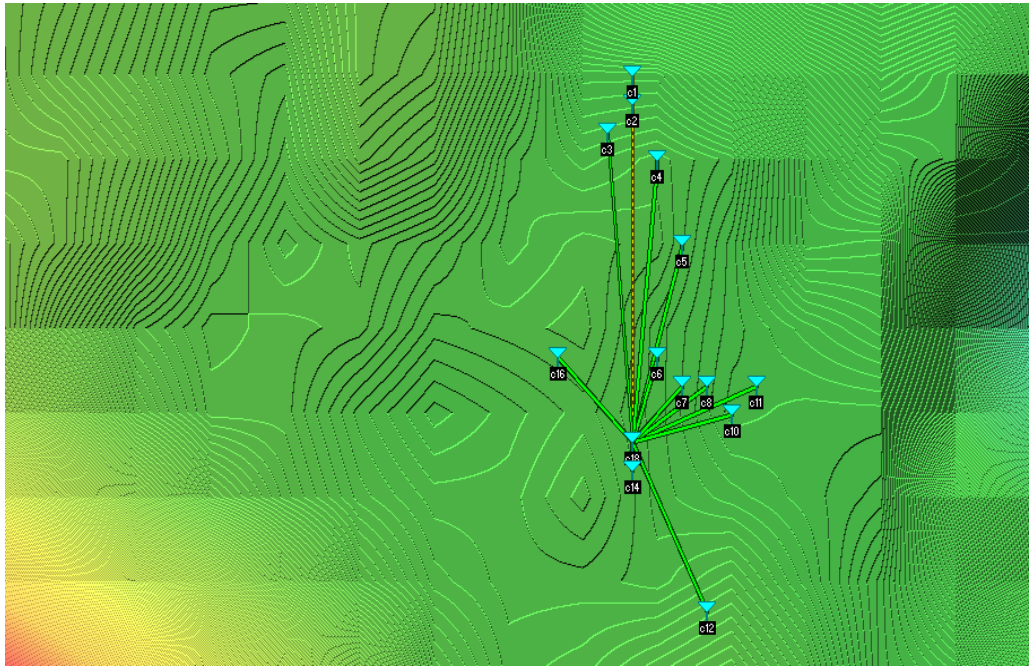
TapirDuino inside view.

Hot Houses

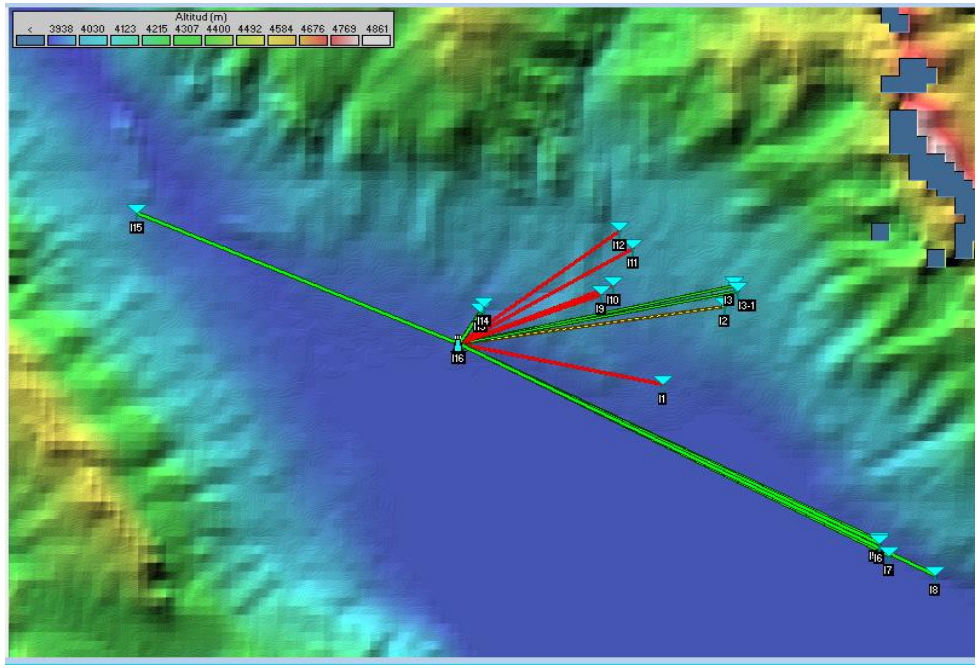
Hot house’s technique called “Hot Wall”.

Hot house’s techniques.

Hot Houses: Deployment simulation



Wireless network topology in Tanta Maco.



Wireless network topology in Langui.

Hot Houses: Deployment

Hot house node deployed.

Hot house node deployed.

Thank You