Mobile Sensor Network for Air Quality Mapping

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***Abstract*—The aim of this work is to develop a mobile system, and not too much expensive, to be placed in the top of buses or taxis, making possible to measure air quality in wide areas, the measurements are made trough several electronic sensors, the time and geographical position of the measurement is obtained trough GPS (Global Positioning System), and the data collected from the station is transmitted to a central station trough the GSM (Global System for Mobile Communications) network, or can be download from a nearby computer through the IEEE 802.11 (wifi). These system also opens the possibility for creating geographical maps with the air quality information represented on the map, due to the wide area coverage than can be achieved by portable autonomous air quality monitoring stations. The measurement of the gases concentrations and the discrimination of the present pollutants are to be made through various electronic gas sensors, merging the data obtained from the several sensors to make possible identify the different gases presents in the atmosphere.**

***Index Terms*—Air quality monitoring, autonomous stations, air pollution maps, embedded system for sensor networks.**

I. Introduction

THE project described in this article is about the remote measurement of air pollution, the measurements data transmission, design especially for urban areas. This project is done as the work referent to the thesis of the course Electronics engineering of the Instituto Superior Tecnico, at TagusPark, but this work is part of a project called Urbisnet, maintained by Instituto Superior Tecnico, and Instituto de Telecomunicações, Instituto de Sistemas e Robotica, Institudo de Soldadura e Qualidade. This project is supported by FCT (Fundação para a Ciência e Tecnologia) under the contract PTDC/EEA-CRO/104243/2008.

II. Most Usual Air Pollutants and Legislation

A. Air Pollution (Definition)

Air pollution means the presence in the exterior atmospheres of one or more contaminants, or their combination in quantities or with a duration such that can be harmful to human life, vegetable life, animal life, or property. The air contaminants include smokes, vapors, paper ashes, dust, soot, carbon smokes, gases, mist, radioactive materials and toxic chemical products.

B. Composition of dry atmosphere (by volume) in the troposphere area

(in accordance with the source Poluição Atmosférica (Um Manual Universitário) – João Gomes)

TABLE I
COMPOSITION OF DRY ATMOSPHERE (BY VOLUME) IN THE TROPOSPHERE AREA.

Symbol	Gas	Concentration by volume
N_2	Nitrogen	78.08%
O_2	Oxigen	20.95%
Ar	Argon	0.93%
CO_2	Carbon Dioxide	340 ppm
Ne	Neon	18.18ppm
He	Helium	5.24ppm
CH_4	Methane	1.5ppm
Kr	Krypton	1.14ppm
H_2	Hydrogen	0.5ppm
N_2O	Nitrous Oxide	0.4ppm
Xe	Xenon	0.09ppm

C. Conversion from $\mu g/m^3$ to ppm

Units used to measure gas concentrations in the atmosphere:

The usual units used to measure gas concentration are ppm or mg/m^3 or $\mu g/m^3$, these are related by the equation:

$$\frac{c[\mu g/m^3]}{c[ppm]} = (M \bullet P)/(R \bullet T) \tag{1}$$

R-Universal constant for the gases (8.314J/(mol•K))
T-Atmosphere temperature in Kelvin (K)
P-Atmospheric pressure (Pa)
M-Molar mass of the gas (g/mol)

Standard values for the atmosphere at sea level: T=0ºC=273K, P=101325Pa, R=8.314J/(mol•K)

Using the values stated and knowing the molar mass for each gas the flowing table is obtained:

TABLE II
CONVERSION FACTOR FORM µg/m^3 TO PPM,
FOR T=0ºC, AT SEA LEVEL, [µg /(PPM•m3)]

Symbol	Gas	Conversion factor
H_2	Hydrogen	89
He	Helium	178
CH_4	Methane	712
CO	Carbon Monoxide	1259
O_3	Ozone	2140
NO	Nitric Oxide	1960
NO_2	Nitrogen Dioxide	2050
NH_2	Amonia	760
SO_2	Sulfur Dioxide	2860
H_2S	Hydrogen Sulfide	1520

D. Legislation of air pollution

With the propose to define and establish objectives to the environment air, the framework directive 96/62/CE, created the base principles to a common strategy, as a way of prevent and reduce the noxious effects to human health and the environment, and also to evaluate the air quality in EU-member states, and inform the general public. This was planned to be achieved through threshold values to alarm situations, and the improvement of the environment air in the situations where it is not satisfactory. The base principles defined in the directive are: The definition of objectives to the quality of environment air, establish common methods and criteria of air quality evaluation, gather information about air quality and disclose (spread) the information, assure that air quality is good, and implement corrective strategies whenever it's found that air quality isn't in accordance with the standards. After this directive several decree/laws were emitted (in the Portuguese Republic). This documents regulates the competent authorities, were it is described the appropriate measures in order to achieve the objectives of the management policy of air quality, threshold values of the pollutant emissions to industrial facilities, reference and threshold values for each pollutant gas, and also many other aspects.

Here are presented the threshold values used to evaluate air pollution:

Concentration classes associated to the IQAr (air quality index) for each pollutant (year 2005), source Agência Portugusa do Ambiente. The designations in Portuguese are: Bad-Mau, Weak-Fraco, Average-Médio, Good-Bom, Excellent-Muito Bom. (min stands for minimum, and max stands for maximum).

TABLE III

Class \ Pollutant	NO_2 (µg/m^3)		O_3 (µg/m^3)		PM10 (µg/m^3)		SO_2 (µg/m^3)		CO (µg/m^3)	
	min	max	min	max	min	max	min	max	min	max
Bad	400	-	240	-	120	-	500	-	10000	-
Weak	250	399	180	239	50	119	350	499	8500	9999
Average	140	249	120	179	35	49	210	349	7000	8499
Good	100	139	60	119	20	34	140	209	5000	6999
Excellent	0	99	0	59	0	19	0	139	0	4999

III. EXISTENT SYSTEMS TO MONITOR AIR QUALITY IN URBAN AREAS

The conventional systems to monitor air pollution in urban areas are based in container style monitoring stations, or also mobile station incorporated in a modified trailer to accommodate the instruments and air circuits. These stations have a large size and usually their construction involves a large monetary cost. Most of the data collected by the stations is transmitted to a central database, not requiring personnel to operate the stations, but the methods used usually require some maintenance and calibration process that can be made only by qualified personnel. Following is a list of the main features of these types of stations:

A. Average station size

The average size of the majority of the stations currently used in Air Quality monitoring networks, are about $16m^3$ (4m × 2m × 2m). There are some reduced size versions of this station but the size mentioned is the usual and is actually necessary to accommodate the instruments (usually there is a distinct instrument for each type of gas to be monitored by the station), and other equipment used for the operation of the station, such as pure gas cylinder used for the calibration of the instruments, air pump for the air circuits used to connect the samplers placed on the roof of the station to the individual measurement instruments, computer to remotely command the instruments, read the results and send the data to a central database, etc... The fixed stations based on this kind of structure can require a lot of space for all the apparatus as can be seen on figure 1.

Fig. 1. Outside of the fixed station to monitor air pollution at Laranjeiro, part of Rede de Qualidade do Ar de Lisboa e Vale do Tejo.

B. Average power consumption

The manufacturer of PM10 measurement instrument (Environment SA is the usual manufacturer of the instruments used in Portuguese stations) states that its instruments has a power consumption of 330W (pump included). Each station usually has at least 4 of this kind of instruments, one instrument for each type of air pollutant (the PM10 is the one with higher power consumption because of its heavy use of air circuits). In addition, those instruments usually use a computer for control and data transmission, a air pump, some extra sensors (eg. temperature), and sometimes also a air conditioning system, etc..., According to my estimations the average power consumption for a station of this kind must be in the order of the 1000W.

C. Methods used to measure each air pollutant

The usual methods used to measure Air pollutants are: (although there are other possible methods for the measurement of the same pollutants presented here.)

PM10 - Tapered Element Oscillating Microbalance, Beta Attenuation monitor, Gravimetric monitor

CO – IR Absorption

SO_2 – UV fluorescence

O_3 – UV absorption

NO/NO_x – Chemiluminescence

These methods usually require expensive equipment, that occupies large amounts of space, and has high power consumption due to the air pumps, motors, valves to make the air flow (see Fig. 2.11 as an example). The methods listed usually require some maintenance and calibration process that can be made only by qualified personnel.

There are also compact systems, similar to the one developed at this project, that are equipped with gas sensors, and geographic positioning systems, and communication systems. The company Libelium has stations that are modular, modules can be assembled to have a system with an 8MHz microprocessor, 8KB RAM, 128KB flash memory, GPS module, GSM/GPRS module, 802.15.4 zigbee. These station have the following sensors available to be mounted CO, CO2, CH4, O2, H2, NH3, C4H10, CH3CH2OH, C6H5CH3, H2S, NO2, O3, Volatile organic compounds, Hydrocarbons, atmospheric pressure, humidity and temperature.

The stations made by Libelium are quite similar to the specification required by the project proposed but miss some of the requirements of the Urbisnet project, for example being equipped with an more powerful processor, having a computer running an operating system, having a wifi(IEEE 802.11) interface.

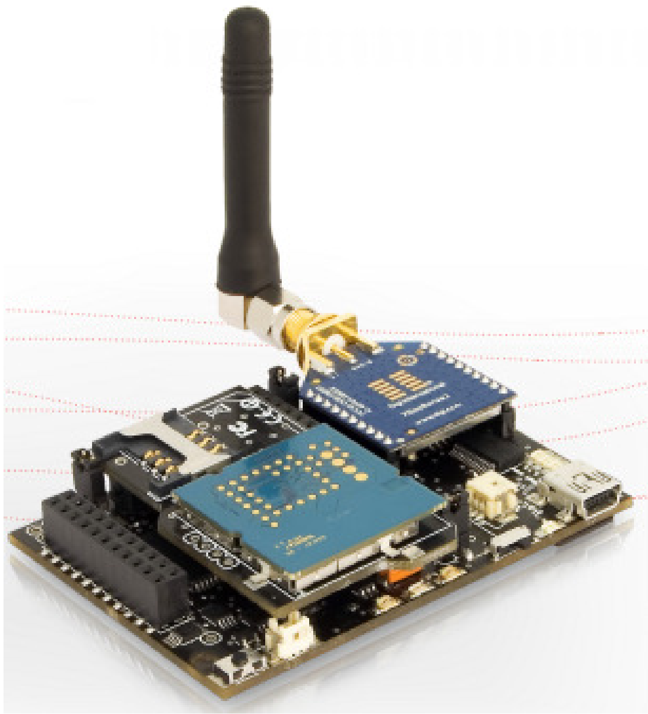

Fig. 2 – Libelium Waspmote station, with GSM, zigbee,

GPS, 8-bit microprocessor

IV. Hardware System Design

A. System Architecture

The purpose of this work was to create a mobile air quality monitoring station. Having in mind that the goal is to make moderate cost and portable system to measure the air pollution, and also store and transmit the data of the measurements. The best way to achieve this goal is by using a digital system that can store sensor data correspondent to large periods of time, and that can be integrated with the existent technology to make possible the transmission of the data to a central station. To achieve this goal it was determined that the following hardware components had to be used and integrated into a single system:

Gas sensors (CO_2,CO,O_3,SO_2,NO_2)
Temperature and humidity sensors
Analog-to-Digital conversion
Microprocessor
Data storage
WiFi and GPRS communication systems
Global Positioning System receiver module
The architecture of the system is illustrated at Fig. 3.

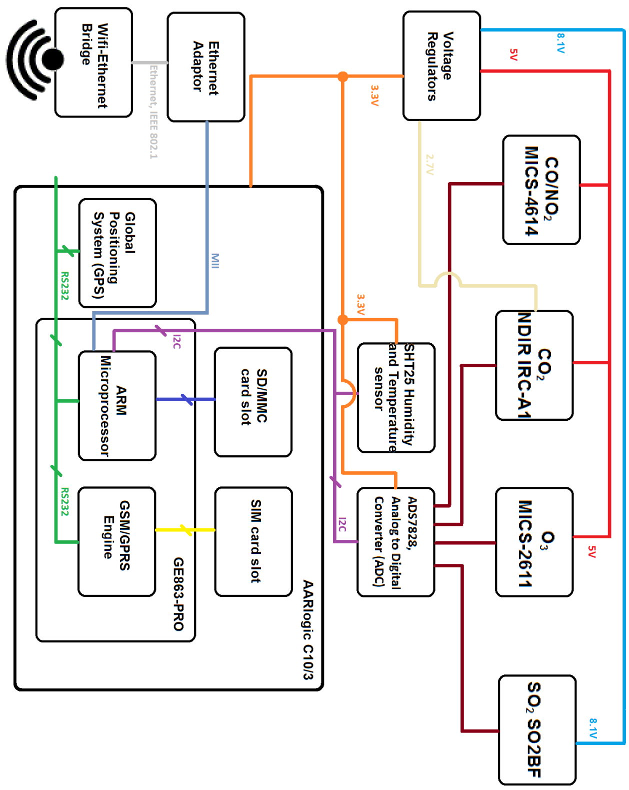

Fig. 3 – Functional diagram of the air quality monitoring station.

B. Gas sensors

Here the different gas sensors chosen are described. There is a preference for sensors with low cost because the air quality monitoring station should be suitable for mass production for the possibility of making pollution maps. Also the sensors should have a small to medium size to be integrated in the station, making the station size appropriate to be placed at the roof of buses or cars. It is also desired a fast response time for the sensors, because the air quality monitoring station is intended for measurements while the station is in motion, thus having a fast changing atmosphere.

It should be understood that it may not be possible to find available sensors that maximize all the refereed characteristics, but the choices made were having in mind all these concerns.

CO and NO_2 sensor:

The chosen sensors was the MICS-4514, these sensors are solid-state devices composed of sintered metal oxides which detect gas through an increase in electrical conductivity when reducing gases are absorbed on the sensor's surface. This sensors are both in the same SMD package, and have a small size. The MICS-4514 includes two sensor chips with independent heaters and independent sensitive layers. One sensor chip detects oxidising gases (OX) and the other sensor detects reducing gases (RED). In order to be able to make exact measurements with MICS-4514 is necessary to take into account the effects that humidity and temperature have on the characteristic curve of the sensor resistance versus gas concentration.

O_3 sensor:

The chosen sensors was the MICS-2611, the sensor is a solid-state device composed of sintered metal oxides which detect gas through an increase in electrical conductivity when ozone is adsorbed on the sensor's surface. In order to be able to make exact measurements with MICS-2611 is necessary to take into account the effects that humidity and temperature make on the characteristic curve of the sensor resistance versus gas concentration.

SO_2 sensor:

The chosen sensor was the Alphasense SO2-BF, this is an electrochemical cells that operate in the amperometric mode. That is, it generates a current that is proportional to the fractional volume of the toxic gas, in this case SO_2.

The sensor for SO_2 is used mounted on a board also manufactured by Alphasense that is called Analogue transmitter board. This board places an adequate voltage on the sensor pins and amplifies the sensor current that is proportional to the gas concentration, the transmitter board has two potentiometers that make possible to adjust the sensor current in clean atmosphere and the gain of the current amplification made on the board.

CO_2 sensor:

The chosen sensor was the Alphasense NDIR IRC-A1,

Alphasense IRC-A1 sensors use the principle of Non-Dispersive Infra-Red (NDIR) to determine gas concentration. Each sensor consists of an infrared source, optical cavity, dual

channel detector and internal thermistor.
This sensors should have an superior accuracy and selectivity in the measurements of CO_2 in comparison with the electronic sensors that are going to be used for the other gases, because of their principle of operation based on spectroscopy.

C. Humidity and temperature sensor

The chosen sensor was the Sensirion SHT25, this is a small chip with the temperature and humidity sensors on it, it is a pre-calibrated sensor that has a digital interface, transmitting the measured data through a I2C bus. The humidity measurement resolution is 0.04 %RH (12bit), the temperature measurement resolution is 0.01 ºC (14bit).

V. The Station Enclosure

An appropriate box for the station must be chosen, the box should protect the hardware that is inside from the water of the rain, but at the same time allow the outside air to flow through the box, so that the sensors can detect the gases present on the atmosphere, and make readings of humidity and temperature, the ventilation may also be important in days were the station is subjected to long hours under the exposure of the sun light that can cause an overheating of the station. So the choosen box was a box sold at the Farnell website, that has the appropriate dimentions, and that had also an adequate price 36€. The box has the dimensions 22cm x 16,5 cm x 5,15 cm, is made of Aluminum, inside the box there are longitudinal holders on the sides, that allow for the PCBs to be inserted on the box an stay placed like if they were shelfs. The box also comes with two apertures, on front and back, these apertures come with lids that make the box a closed space, the lids are supported by 4 bolts.

As one of the requirements is that the box must allow the air to flow through the box, these lids had to be replaced by lids that were developed and built by me. I also developed a system for the lids that also blocks the entrance of the rain to the inside space of the box. These system for the lids is composed of 2 lids for each entrance with the ventilation holes misaligned, and with an sponge to block water droplets and large particles of dust.

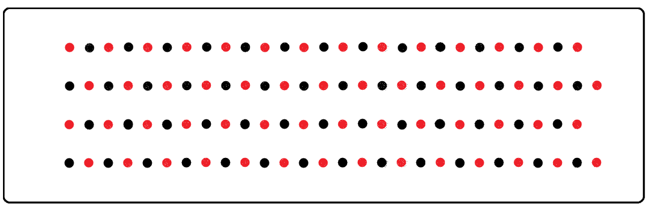

Fig. 4 – Drawing of 2 overlapping lids for covering only one aperture, as you can see the holes on the outside lid are misaligned with the holes of the inside lid.

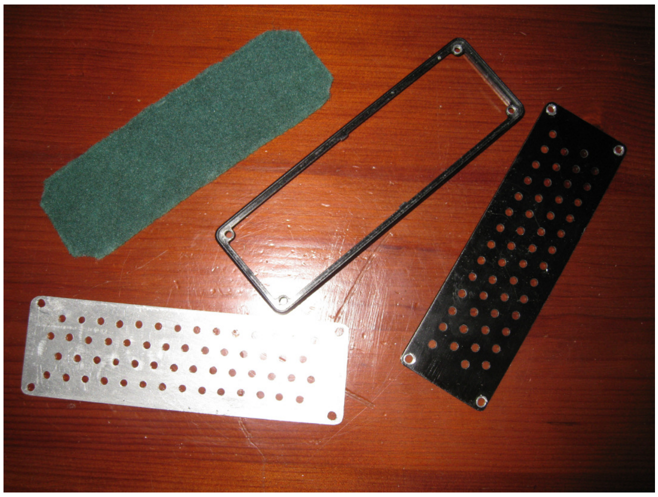

Fig. 5 – The lids and the green sponge

This design allows for the entrance of air and protects from the rain that falls on the top of the box. To get a good protection from the rain the user should cover the small gap that exists between the lid and the box with teflon tape(the type of tape used in plumbing to prevent leaks in the pipes junctions), and then screw the bolts to tighten the lids to the box. The teflon tape placed on the edges of the box should have at least 3 layers to have some volume making the box have a good insulation against the rain.

It was made a test with the box closed with the dual lids and the teflon tape on a bath shower, with water jet hitting the box from the top and with maximum angle from the vertical of 30º for a duration of 3 minutes. A large piece of hygienic paper was previously placed inside the box, after the test was finished the paper was dry.

The fact that the electronic boards of the station are suspended on the the longitudinal holders, makes more difficult for the board to catch any water droplets from the rain.

VI. The Ethernet-wifi Bridge

It is used an ethernet-wifi bridge to implement the wifi interface on the station. The selected hardware was the ASUS WL-330gE. The WL-330gE was selected because it's very configurable, it can work in 4 different modes: repeater, access point, Ethernet-wifi bridge, router. It was chosed also because of it's small size, that is about what was available inside the box of the portable pollution measurement station. It is appropriate also because it allows the installation of the Open-WRT Linux firmware, allowing complete device customization and control if required by the project objectives.

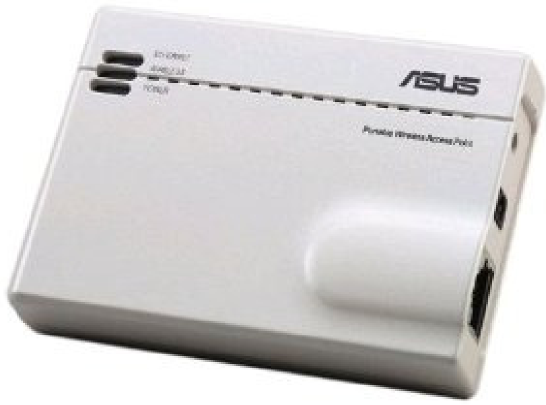

Fig. 5 – Router, Ethernet bridge, repeater, Access point, WL-330gE.

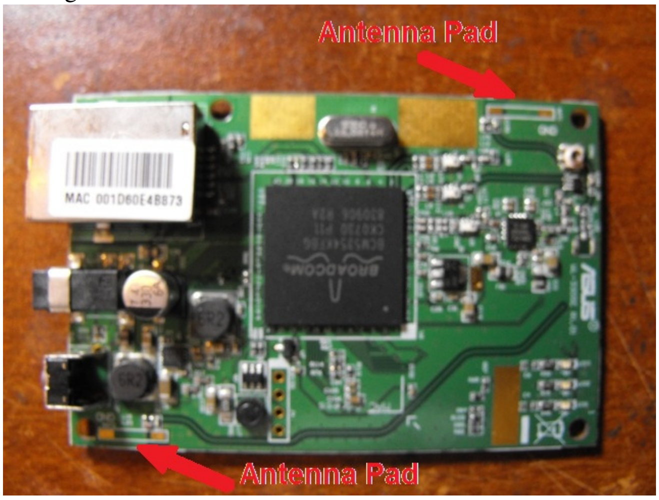

Fig. 6 – Inside view WL-330gE.

The WL-330gE has built in wifi antennas, but also has pads on the PCB available to solder 2 extra wifi antennas.

The WL-330gE has a supply voltage of +5V, but the supply voltage of the station is 12V, so a commutated voltage converter was used to obtain 5V from the 12V. The voltage converter used is the TL2575-05, and it requires the additional components to work:330mH coil, 330mF capacitor, 100mF capacitor, a Schottky diode.

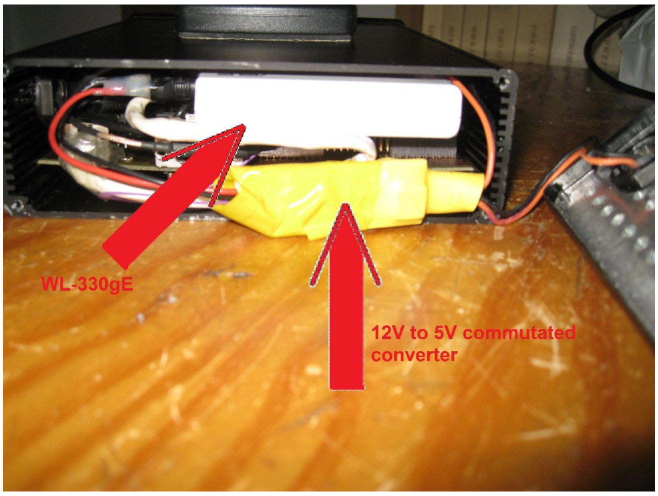

Fig. 7 – WL-330gE and the 12V to 5V converter placed inside the box of the station.

VII. The Electronic Hardware for the Urbisnet Station

There were developed two boards for the Urbisnet Station. A main board with a socket for the C10/3 board from Round Solutions, the SHT25 humidity and temperature sensor, voltage regulators for -3.3V, -2.1V, +2.85V, +3.3V, +4V, +5V, 8.08V, the ADS7828 Analog to Digital converter, and a auto-start circuit to start the GSM module of the C10/3 when the power is switched on, an Ethernet interface, a serial port that gives access to the console of the Linux running in the ARM.

The 2º board is a board with gas sensors that can e connected to the primary board with a flat cable, the sensors included in this board are for CO_2,CO,NO_2,O_3,SO_2. The sensor boards also includes the electronic circuits appropriate to make the sensors works and to extract a voltage that is directly proportional to the sensor output. This sensor board is connected to the main board with a flat cable making it easy to be replaced by a different board with different sensors .

It was measured the power consumption of the station, when is in stand-by and when making measurements and transmitting data. It was found that the power consumption is almost constant and independently of being in stand-by or making measurements and transmitting data. The measured power consumption was 7.5W when using an input voltage of 11V.

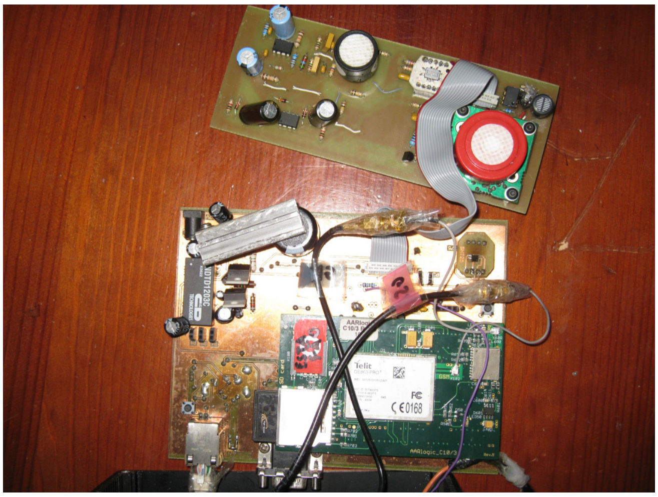

Fig. 8 – The main board and the sensor board.

Fig. 9 – Urbisnet Station, top view

VIII. THE SOFTWARE INTERFACE

The station can communicate by wifi(IEEE 802.11) and GSM SMS messages, with these communications the station can interface with a PC, a server that receives communications from several Stations, or with a network of similar stations and routers that send data to a central server.

The implemented software is aimed to make the data transmission directly to a PC. The software for the PC has the ability to show the received measurements from the Urbisnet Station, and to send new configurations for the Urbisnet station. When the program starts is shown a window asking the user to select the type of communications, it can be WIFI or GSM.

In case the communication is being made with WIFI the computer must have installed a wifi network interface, the user then must connect to the wifi network broadcasted by the station. After being connect to the network the user can open a telnet connection on port 23, to the station being able to control the station directly by the Linux console of the Urbisnet Station. In the program for the Urbisnet the user should specify the IP address of the station, the port used to upload the station configurations and to download the data obtained by the sensors. The program Urbisnet for the PC is made to work with a program that should be running on the station called Urbisnet_Station. The Urbisnet_Station program is always listening for new configurations sent by the PC, and acts accordingly to the configurations.

In case the communications is being made with GSM the computer must have a serial port(or a serial to USB adapter), this serial port should be connected to a GSM board that can be interfaced with AT commands, allowing this way to send configurations and to receive data from the sensors.

The Urbisnet_Station program that runs in the station, is configured by the PC to work with GSM or WIFI communications.

The user can check the credit of the SIM inserted on the GSM interface for the PC, connected by the serial port, by sending a CUSD command, that can be typed of the text box CUSD code, and clicking the Send CUSD button.

The user can check the credit of the SIM inserted on the C10/3 by opening a telnet connection to the Urbisnet_Station, and then executing the program Send_CUSD, with the appropriate SD command.

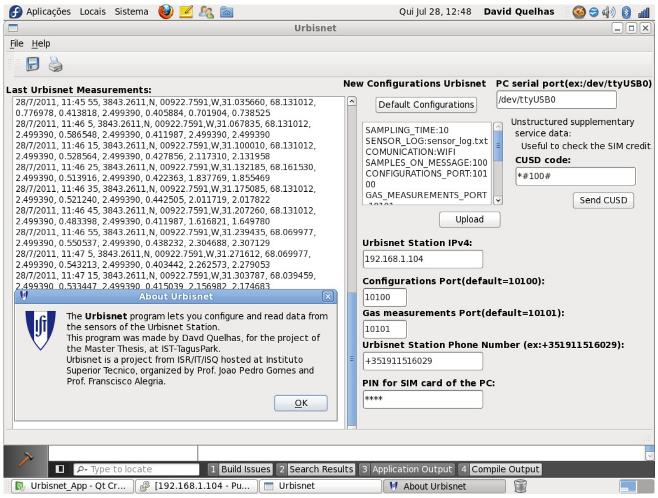

Fig. 10 – Main window of the Urbisnet program on the PC.

The Urbisnet program on the PC has the ability to send a configurations file to the Urbisnet Station, this file is called config_Urbisnet_Station.txt, this file is located on the Urbisnet Station on the same folder were is the program Urbisnet_Station. Every time the Urbisnet_Station program is started on the station, this file is read and the Urbisnet_Station program will operate in accordance with those configurations.

This is an example of such file:

Urbisnet configuration file
SAMPLING_TIME:10
SENSOR_LOG:sensor_log.txt
COMUNICATION:WIFI
SAMPLES_ON_MESSAGE:6
CONFIGURATIONS_PORT:10100

GAS_MEASUREMENTS_PORT:10101
PC_SERVER_IPv4:192.168.1.101
PC_SERVER_PHONE:+351911516109
STATION_SIM_PIN:2038
SMS_CENTER:+351911616161

IX. TRIALS OF THE MOBILE AIR QUALITY STATION

It was programed a sensor calibration at the ISQ (Instituto de Soldadura e Qualidade). The program had the objective to calibrate all the gas sensors, for the gas concentration range usual on the measurement of outside air quality.
The sensors used with the station were made available to me by Prof. Francisco Alegria, the only sensor that was selected by me was the Alphasense CO2 IRC-A1 NDIR.
At the sensor calibration tests, it was quickly discovered that the SO2-BF was sensible to SO_2 concentrations much higher that the concentration range used on the measurement of air quality. So this sensor couldn't be used to accomplish the project objectives.

The sensors for O_3, CO, NO_2, are based on metal oxide crystal that absorb negatively charged oxygen molecules.

These kind of sensors are very sensitive to several environmental conditions like temperature, humidity, atmospheric pressure. Also these sensors never are sensitive to only one air pollutant, they are designed to be more sensitive to one pollutant, but are always sensitive to several air pollutants which makes the measurement of small concentrations like the ones on the measurement of the air quality very difficult. So these sensors were declared by me and by Prof. Francisco Alegria inappropriate to the measurement of outside air quality.

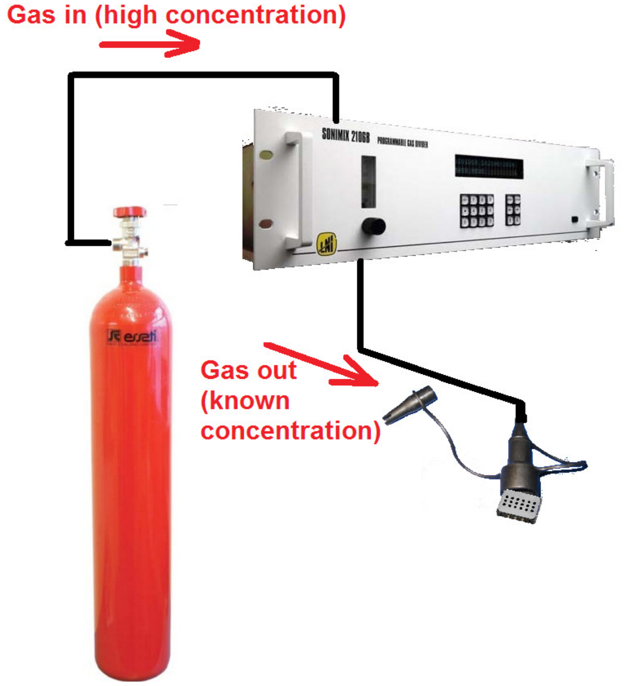

Fig. 11 – Diagram of the apparatus used to calibrate the MICS-4514 CO and NO_2 gas sensor.

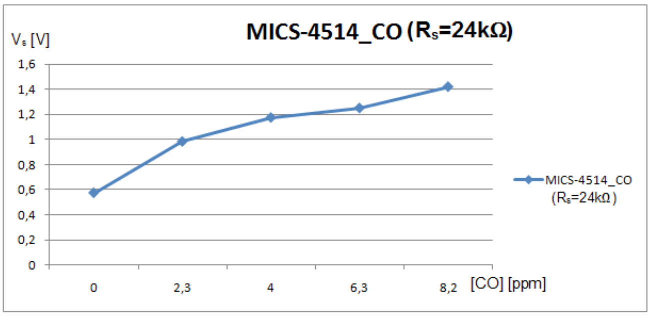

Fig. 12 – Graph of the data obtained in the calibration MICS-4514 CO sensor, when stimulated with different concentrations of CO in a normal atmosphere.

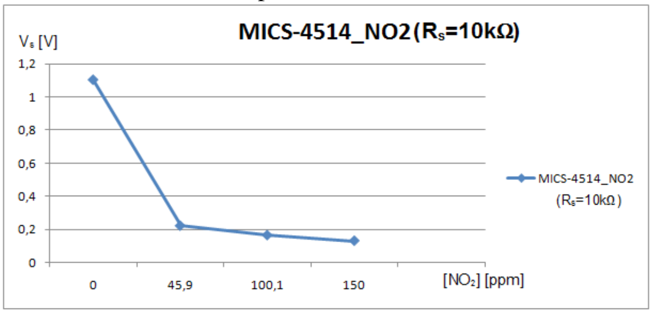

Fig. 13 – Graph of the data obtained in the calibration MICS-4514 NO_2 sensor, when stimulated with different concentrations of NO_2 in a normal atmosphere.

The sensor for CO_2, the NDIR IRC-A1 is based on the absorption of infrared light by the CO_2 gas. This sensor has an active and a reference channel, so it has some immunity to all the environmental conditions that can affect the sensor output. This behavior was clearly observed at the tests made at ISQ, the sensor output was substantially increased on the active and reference channel by the nitrogen atmosphere, but was only observed a difference between the active and reference channel when it was present the CO_2 gas.
The calibration for the CO_2 sensor was made not in the sealed compartment, it used a small cup to cover the sensor with the gas tube connected to the top of the cup, like this the output isn't so strongly affected by the pure nitrogen or the atmospheric pressure present inside the sealed compartment.

TABLE IV
CALIBRATION DATA FOR THE IRC-A1 CO2 SENSOR

[CO_2] (ppm)	Activo_NDIR (V)	Referência_NDIR (V)
0	0.749512	0.741577
2502	0.69038	0.739136
4991	0.6073	0.69519
7505	0.59204	0.698242
10000	0.554199	0.690918

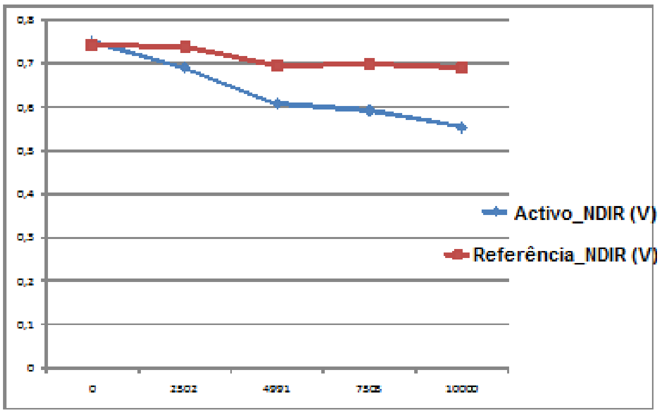

Fig. 14 – Graph of the CO_2 sensor output related to the gas concentration.

X. ALTERNATIVE GAS SENSORS

The user of the station can easily change the sensor's board of the Urbisnet Station, this can be achieved by disconnecting the flat cable from the sensor board and connecting to another sensor board designed to work with the Urbisnet Station. This way different sensors can be used to measure air pollution, possibly the user is available to spend some extra money on sensors and buy sensors more selective and more appropriate to measure low concentrations.

The best sensors found that would have a size and mode of operation compatible with the station build are:

SO_2: Alphasense has recently developed a sensor for measuring low concentrations of SO_2, that is very selective and also has a size that is within the dimensions required for the work, , the only negative aspect of the sensor is that it requires a large signal conditioning circuit. The sensor is the SO2-B4, it's an electrochemical cell with 4 electrodes, that has a resolution for measuring SO_2 of 0.005ppm.

Fig. 15 – SO2-B4 Sulfur Dioxide, Alphasense

CO: E2V manufactures a CO gas sensor suitable to measure low concentrations of CO that also has a high selectivity, it is the EC4-500-CO. This sensor is an electrochemical cell, with a resolution for CO of 1ppm. It also has a size that is compatible with the station.

Fig. 16 – EC4-500-CO, CO gas sensor, E2V

O_3: For the measurement of O_3 there is a new design of gas sensor that is under development and isn't yet as far as I know on sale, it is based on the resistance variation, the sensor is made from indium oxide nanoparticles, with an integrated near ultraviolet LED that stimulates the sensor. This kind of sensor doesn't requires to be heated, and so the problems related to temperature change don't exist. In accordance with the researchers the sensor can read concentrations as low as 30ppb.

These sensors has I know are developed by the Fraunhofer Institute for Applied Solid State Physics, Freiburg, Germany.

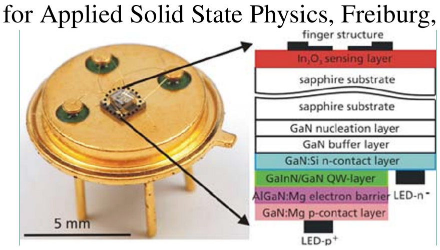

Fig. 17 – New gas sensor, O_3 gas sensor

XI. CONCLUSION

The Station is developed to a state that is fully functional, for the exception of measuring gas concentration, because of the the problems encountered on gas sensor calibration and on the sensor itself. Anyway I don't think that is very problematic, because in future work for the Urbisnet project, there can be done several changes to solve this issues. The board with sensors, can be easily replaced with another board because it's connected to the main board with a flat cable. So different gas sensors can be used with the current hardware, possibly more adequate sensors to measure low gas concentrations and with good selectivity to specify which gases are present in the atmosphere. Of course such sensors would be much more expensive, and probability will occupy more volume, but I don't think that would made the station economically unviable.

ACKNOWLEDGMENT

I would like to thanks to my Thesis Supervisor, Prof. Francisco Algeria for the guidance and for the opportunity to work in this project, that I think is an interesting project and of value for today environmental problems.

I would like also too express a special thanks for Mr. João Pina dos Santos, for all the support and advice that he has given to me, and also because a large part of the work requires the construction of the equipment and of Printed Circuit Boards, that are only possible for me with the equipment available at the workshop and PCB laboratory of Instituto Superior Tecnico, Taguspark, whose he is responsible for the student access.

I would also like to thank the following people:

Prof. Moises Piedade, Eng. José Calhariz, Jorge Candeias, Ricardo Borges, Prof. Gonçalo Tavares, João Graça, Fabio Gameiro, Ana Rita Guilherme, João Cabeleira, Carla Duarte, Engº Luís Miguel de Jesus, Grant Gayed, Hanley Tim.

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