ISSN No:-2456-2165

Mesh Network for Precision Agriculture in the Northern Part of Cameroon

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Abstract:- This paper deals with the collection of information (soil moisture, soil temperature, etc.) in an agricultural plantation athwart a mesh network (a network in which all the hosts are closely connected without a central hierarchy forming a net-like structure) and was carried out at the computer and telecommunications laboratory of the national advanced school of engineering of the University of Maroua in the far north of Cameroon, and was conducted in order to provide farmers with a means of managing agricultural activities and mapping the field by highlighting the heterogeneity of the soil in terms of temperature, moisture and soil chemical properties. The use of wireless sensors is increasingly in demand for supervision and security. These sensors, linked together, form a wireless network, which relies on protocols to communicate and propose programs and embedded networks with a view to enabling actuators (watering can, irrigator, sprayer, etc.) ideally positioned in the plantation, to act optimally to meet the specificities of precision farming. Using the Aurel 433 radio module, we were able to produce two maps to check soil moisture. Thus, the card on which the Radio Module is mounted, which broadcasts a radio signal, is recovered by a receiver. The receiver mounted on the second card allows the information to be displayed on the interface of a PC.

Keywords:- *Mesh Network, Precision Farming, ZigBee, Sensors, Radio Module 433 IN.*

I. INTRODUCTION

Precision Agriculture is a principle of plot management that allows farmers to optimize their yield per hectare. The northern part of Cameroon, characterized by an increased cereal deficit in recent years despite the use of insecticides by aerial and manual spraying, chemical fertilizers, and many other fertilizers aimed at stemming this deficit are proving to be insufficient. In other words, it will be possible to know precisely the heterogeneity within the same plot according to different criteria (variation in soil type or chemical composition, plot temperature, soil moisture content, etc.), thanks to different sensors placed in the plantation. The use of communication services that coexist with network elements such as the Aurel 433 radio module and the ZigBee module based on the mesh network, can provide farmers with technologies that are better adapted to their needs. It is in this sense that we have undertaken in this article a study of the mesh network for precision agriculture in the northern part of Cameroon. We will present the equipment used, the methodological approach, the results obtained, and finally a conclusion followed by perspectives on future work.

II. MATERIALS AND METHODOLOGIES

A. Equipment

❖ *Sensors:*

➢ *Soil Moisture Sensor*

The sensor was used to detect, in the form of an electrical signal, the physical phenomenon in order to represent it. Thus, the sensors were used to generate data relating to the physical environment in order to transform the physical quantity into an electrical quantity.

Fig 1:- Humidity sensor

It uses the two probes to pass the current through, then reads the resistance to get the humidity level. Dry soil is more resistant and less conductive, while water makes the soil wet and facilitates the conduction of current.

➢ *. Ground temperature sensor*

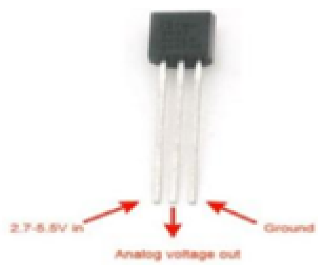

Fig 2:- Ground temperature sensor

Powered with VCC, GND and center pin to one analog input. The signal conversion, one (1) volt corresponds to 100 degrees Celsius (ground temperature) and the reading of the signal from 0 to 5V is coded from 0 to 1023 hence the formula Time = volt *5. /1023*100

- *XBee communication module*

The XBee module is a small radio modem operating on the principle of 802.15.4 and/or ZigBee standards. It is an electronic circuit capable of transmitting and receiving data by RF transmission. It has different communication modes and some electrical functions allowing it to perform tasks usually dedicated to a microcontroller.

Fig 3:- Xbee module

Its RF output power is 10mW (0dbm), indoor range up to 30 meters and outdoor range up to 100 meters in open field, it can be configured to nearly 65,000 different addresses, has point-to-point, multipoint, broadcast communications.

When creating a ZigBee network three types of devices should be considered: ZigBee endpoint device, ZigBee router, ZigBee coordinator.

- *Microcontroller*

The serial port of the microcontroller is a port to which all input and output functions are redirected. This line must be defined at the beginning of the program just after the quartz frequency. The following line is used to configure these ports: #use rs232 (BAUD=9600, xmit=PIN_C6, rcv=PIN_C7) // it configures the serial link of the PIC with a speed of 9600 bauds. For this work, the microcontroller of the PIC 16F877A range was used. These microcontrollers have interesting characteristics both on the available interfaces and on their energy performance.

- *Proteus (ISIS)*

ISIS is a software that allows us to capture and simulate our schematics. It has been used for this purpose for simulations of the different assemblies made.

- *Mplab*

Mplab is an integrated development environment (IDL), which allows the software development of µC peaks and Microchip's peak digital signal controllers. It gathers all the tools needed to set up an application with a microcontroller core. And was used for this purpose.

- *Radio Transmitter Module Aurel 5v 433.92 mhz.*

The Aurel 433.92 module is a radio equipment consisting of a transmitter and a receiver that can communicate with each other. This module, connected to an external antenna, allows the transmission of HiFi signals, radio alert signals or remote-control signals in DTMF.

Fig 4:- 433.92 MHZ receiver module

B. Methodologies

- *Description*

The humidity sensor is used to record information based on the charge and discharge of an RC circuit (a resistor mounted together with a capacitor). The resistance of this sensor varies according to the moisture content of the soil. The measuring chain generates a fixed frequency which charges a capacitor. Then, during the discharge phase, the capacitor sends its energy into the sensor which generates a signal with a frequency that varies according to the water content. The measured frequencies vary from 20Hz when the sensor is dry (lack of soil moisture), to 12.5kHz when the sensor is wet (truly wet soil). After measuring the frequency from the measurement chain, the processor applies algorithms to first find the resistance of the sensor and then the soil moisture value.

- *Structural scheme*

The first step in the production of an electronic map is the entry of the structural diagram. Components are placed using the built-in libraries, but it is sometimes necessary to create new ones. Regularly save connectors for external connections because a label on a wire does not create a component on the circuit board.

- *Netlist*

Once the schematic has been entered, a Netlist must be generated: List of the components used and their connections. But all the components must be associated to a package or a footprint. Most are provided in libraries, but the creation of new fingerprints is often essential.

- *Routing*

The placement of components is of prime importance: it will directly influence the difficulty of routing the board. Place first the components that have constraints mechanical (geographical location on the map, particular location).

- *Tracks tracing*

Tracks can be traced by hand, or thanks to the auto - routing function available on most CAD tools. However, one must not lose sight of the fact that auto - routing often gives worse results than manual routing, or even, if it is not set up correctly, a map that cannot be produced with non-industrial means. During this phase, there are certain rules to be respected, according to the currents circulating in the tracks and the tensions present on them.

➢ *Typon*

The typon is the printing of the tracks on a transparent support (layer, transparent...).

➢ *Loading of components*

First of all, the various components to be used must be pre-loaded and put on hold so that the available components are grouped in libraries classified by themes. After loading the components, establish the connections. To load a component, click on the component icon in the Mode Selection Toolbar, then press the P button on the selector and the Pick devices window will appear. To make the connection easier, check if the Auto connection router option of the tool menu is checked. The ISIS software supports two types of connections, namely manual connection where the cursor is placed on the end of the bracket to be connected, a small cross appears, move the cursor and confirm each change of direction until you reach the point of arrival. In this mode you are free to trace. To stop a connection, click on escape and in the second case, the connection is fast and automatically, you are not free of the connection path so to delete a connection, double-click on the connection to be deleted and to modify the trace of a connection, keep the left mouse button pressed on the place to be modified, then drag to the new position.

➢ *Simulation.*

After entering the diagram, the types of generators, probes and graphs to be used are defined. These useful elements can be found in the Gadget mode. To place a generator, click on the generator icon in the Mode Selection Toolbar. Choose in the Object Selector the type of Generator to connect, then connect it to the point to apply the signal in the editing window. You also choose the Generator characters by clicking on the Generator because each Generator has its own window. To place a probe, click either on the voltage probe or current probe icon on the mode selection toolbar and orient the probe correctly, especially the current one, as the current flow is measured by the direction indicated by the arrow that is part of the probe drawing. You can also configure the probe by clicking on the probe and entering the name of the probe in the name field.

➢ *Compilation*

After configuring the project, the programmer writes its program into one or more text files using the standard language << C >> (the source files).

➢ *C language*

The C language of the CCS compiler has been used to avoid the use of long, tedious assembler-like codes and eliminates some sources of errors. It is adapted to µC PICS, and brings very interesting features.

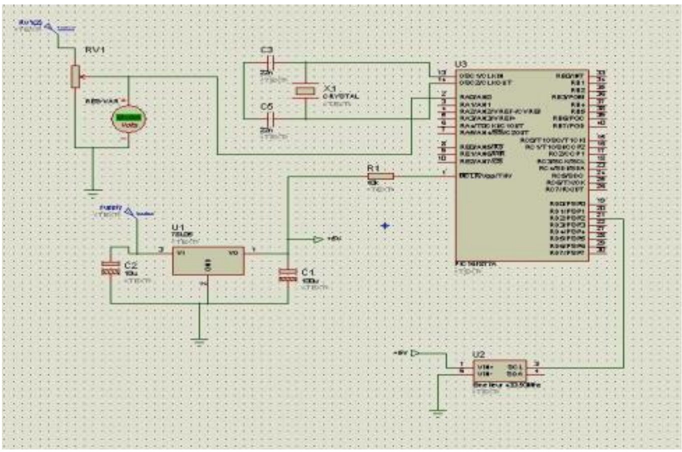

Fig 5:- Mounting the Aurel Radio Module 433 on Proteus

This window (figure below) shows us the simulation of the completed project. It shows us the soil moisture and temperature values provided by the sensors. We used a USB programmer in which the solid program written in C language involving all the information to be provided by all the detection devices well installed in the field. This program was tested before being deployed in the USB programmer and once successfully completed; it was just deployed in the microcontroller integrated in the circuit to generate information from the sensors. This information is then displayed on the user's screen and decisions are made by the user, whether to water the field or spray it

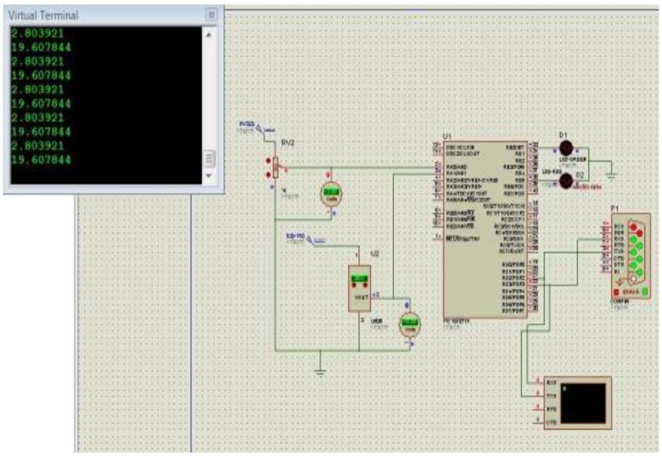

Fig 6:- Simulation on Proteus

➢ *Electronic editing*

An electronic board is a set of components such as: resistors, capacitors or integrated circuits assembled on a plate to form a circuit for a specific use. The assembly below shows two electronic boards made by the Aurel 433 Module (Transmitter/Receiver). The essential element here is the microcontroller which, through its outputs and according to the information received from the different sensors installed in the plantation, generates data that will be displayed on the user's PC.

Fig 7:- Final assembly of components

Its technical characteristics are as follows:

Transmission frequency: 433.92 MHZ
Bandwidth: ±2000KHZ
Consumption :2.5 Ma
Output: 5V / DC
Power supply: 2.4 kbit/s
Sensitivity :100 dBm

➢ *Presentation of the graphical interface*

This interface has been created on Matlab, to display the values of temperature and soil moisture. In this interface, one reads all the information related to the soil temperature returned by the soil temperature sensor well installed in the field, as well as the soil moisture detected by the moisture sensor. The values received allow the users (farmers) to act remotely through the radio module installed.

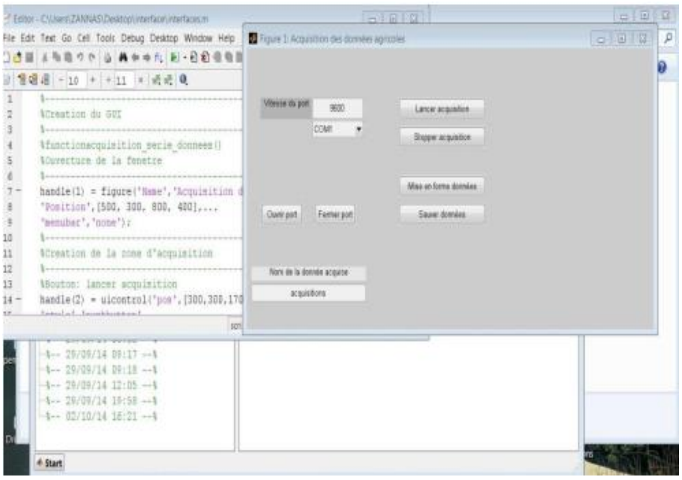

Fig 8:- Agricultural Data Acquisition Window

We were able to test the soil humidity thanks to the two electronic cards made by the Radio Aurel 433.92 MHZ module. The solution proposed via the Radio Aurel 433 module allows users to have information on soil characteristics through the interface of a PC. The implementation of such an architecture will lead to a gain in terms of information. of the soil and this will contribute to increasing agricultural yields in this part of Cameroon's territory and reduce the famine that has prevailed for decades in the north. It is therefore important for the administrator of the application to communicate and analyze the data collected by the maps in order to take measures and anticipate the actions to be carried out.

III. CONCLUSION

In this paper, we have presented the usefulness of the mesh network for precision agriculture in the northern part of Cameroon. By following the methodological approaches, we have shown that the implementation of the Mesh network in the agricultural sector of northern Cameroon, will allow remote consultation, accurate knowledge of soil moisture, soil chemistry and remote watering. To solve the problem related to the food deficit in this part of the Cameroonian territory, we proposed as a simple and practical solution, the Module Radio Aurel 433. This solution allowed us to produce two maps. The Transmitter Radio Module mounted on the first card emits electromagnetic waves, and the second card on which the receiver is mounted allows us to recover the information sent by the transmitter (soil humidity, soil temperature, etc.). The knowledge of these data, allows the users to make decisions and act remotely through radio waves, on the sensors well installed in the field that can either activate the valves through an automatic pumping system to water the plantation, or to replenish the plantation with chemical fertilizer always through a pumping system, without the need for the physical presence of farmers in the field and faster. The implementation of this solution will allow farmers to increase their yield, which will reduce the problem of famine that prevails in this part of the territory.

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