Smart Agriculture System using Adhoc Networking among Firebird V Bots

Article · October 2016

2 authors, including:

Gayatri Sakya
JSS Academy of Technical Education

Academic Science

International Journal of Innovations & Advancement in Computer Science
IJIACS
ISSN 2347 – 8616
Volume 5, Issue 10
October 2016

Smart Agriculture System using Adhoc Networking among Firebird V Bots

Gayatri Sakya , **Ankit Gautam**
JSSATE, Noida JSSATE, Noida

Abstract. The increasing population and its increasing demand of resources have made it necessary to utilize the resources efficiently and effectively. Thus in recent years the manual systems are becoming automated and intelligent to cope up with this increasing demand of country. Our paper aims at achieving this by developing a Smart Agriculture Field using wireless sensor nodes which are deployed in the feild. In this paper, we have developed ad hoc networking among firebird V nodes in order to implement Smart Agriculture System. The agricultural field proposed here prefers automatic control system and provide adequate irrigation to specific area. Proposed system is primarily designed for wide range of control applications and to replace the existing traditional technologies used in agriculture. The designed system control parameters are temperature and soil moisture however the presence of toxic gas in atmosphere and water quality also plays an important role in cultivation of crops. The proposed system is based on wireless sensor nodes for the sensing the field parameters of irrigation system like temperature and soil moisture. The proposed system uses multihop networking for the field area communication and also provides required facility to the field using Firebird V robot.

Keywords: Automated agricultural system, Microcontroller, Firebird V robot, Dig mesh Technology, Wireless sensor networking.

1 Introduction

Nowadays, agriculture system is trying to adopt the latest technology for efficient farming. In large scale agriculture systems, the Manual collection of data for desired factors is difficult and also requires high manpower. It is not continuous but can be done only at some interval of time. Also the requirement of water is not equally demanded at all locations in the field every time. The damaging of the crop can also be avoided by continues monitoring the need of urea and other nutrients in the fields. The automated fire alarm systems are also needed for prompt action, when at any part of fields, there is fire. So once the full field is deployed with wireless sensor nodes equipped with the required smoke sensors, moisture sensors and the toxic gases sensors etc then the monitoring of the field will become continuous. The information can be collected at any base station and the robots can be prepared for automatic irrigation, automatic urea distribution, crop cutting, firefighting etc. The need for intelligent farming especially in developing countries like India has grown to a greater extent. The Zigbee technology is majorly used nowadays for transferring information in wireless sensor nodes. Wireless sensor nodes deployment is possible in critical locations which enable their monitoring all the time without human life risk. Research is also continued in the direction of developing application specific protocols for wireless sensor networks, so that they can be efficiently used in agriculture fields for critical applications. With these protocols one can ensures quicker response times to take actions in adverse conditions. The proposed system in this paper is designed in three phases. One is the proposed design of wireless sensor nodes to monitor the data required for automation of agriculture system. And the second is distributing the whole field in grid of specified distance. And the third is to programming of the firebird V robots to provided services to the field according to the data gathered. The f Dig mesh technology for communication is used for providing the Adhoc networking among the Firebird V robots. So they can also provide information to each other about the required services.

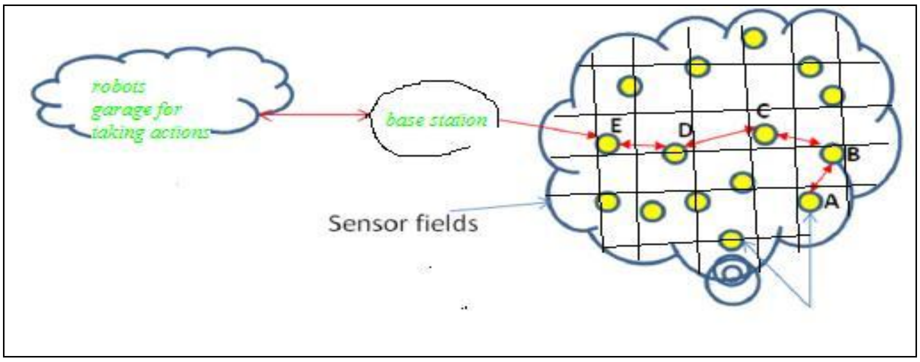

Fig. 1 Proposed automated agriculture system.

1.1 Transceivers for wireless sensor nodes

Here in the paper we have used Zigbee technology, International Standard 802.15.4, typically operating at 2.4 GHz. Zigbee transceivers are commonly used in wireless sensor nodes as transceivers for transferring information from one node to another. . Zigbee is good for mesh network in low-power wireless local area networks (WLANs) that cover a large area. It provide high data throughput in applications where the duty cycle is low and low power consumption is an important consideration .Zigbee is based on the Institute of Electrical and Electronics Engineers Standards Association's 802.15 specification. It operates on the IEEE 802.15.4 physical radio specification and in unlicensed radio frequency bands, including 2.4GHz, 900 MHz and 868 MHz The specifications are maintained and updated by the Zigbee Alliance.

Zigbee supports three topologies shown in Fig 1, namely, (i) star, (ii) mesh and (iii) cluster-tree as illustrated in "Fig.1". In star topology, each end node is connected to the coordinator and communication is carried out by Zigbee Coordinator. In mesh topology, each device communicates with any other device within its radio range or through multi-hop. In cluster tree topology, there is a single routing path between any devices.

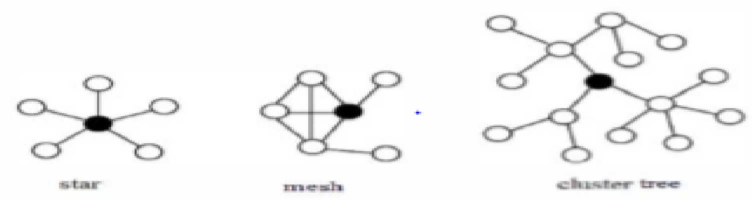

Fig. 1 Zigbee topology

For purpose of proposed system we using mesh topologies.

The XBee and XBee-PRO DigiMesh 2.4 RF Modules are prepared for fulfilling the needs of low-cost, low-power wireless sensor networks .The modules operate within the ISM 2.4 MHz frequency band. .For larger networks up to 1000+ nodes, Digi offers RF Optimization Services to assist with proper network configuration.

Digimesh provide advanced networking and security like

1. Retries and acknowledgments,
2. Optional self-routing, self-healing mesh, networking available, DSSS (Direct Sequencing Spread Spectrum).
3. It also easy to use no configuration necessary for out of box RF communications, AT and API command modes for configuring the module and Small form factor.

Zigbee 802.15.4 provides the physical and MAC layer protocols, in the data rates of 250 kb/s, 40kb/s and 20kb/s.

International Journal of Innovations & Advancement in Computer Science
IJIACS
ISSN 2347 – 8616
Volume 5, Issue 10
October 2016

In multihop and critical scenarios the Zigbee protocol not find very efficient in wireless sensor networks [11].The SMAC protocol can further be used in such scenarios [11] where in delays should be less with better throughput.

So a sensor node when designed should also take care of reliable data delivery and timely reporting to the base station. Research is also going on SMAC to improve its performance further.

1.2 The Firebird V nodes for developing the robots to provide the services to the agriculture fields.

Firebird V robot is microcontroller based robotic platform designed by NEX Robotics and Embedded Real-Time Systems lab, CSE IIT Bombay. It's a very good Research Platform; which provide an excellent environment for experimentation, developing the software code and test them in the prototype model first. We can use it for multipurpose applications since it allow us to work using multiple processors such as 8051, AVR, PIC and ARM7 etc. Modular sensor pods can be mounted on the platform as dictated by intended applications. For other features of the kit, the user can refer to the manuals available on the site of e-Yantra project.

Fig. 2 a Firebird V ATMEGA 2560 from e-Yantra, IIT Bombay

2 Proposed Agriculture System Design

The design of proposed system is divided in two parts.

1. Mesh networking within the nodes deployed in field with one aggregator node.
2. And another one is mesh network within the firebird V robot with same aggregator node. The networking of whole system is called as Ad-hoc networking.

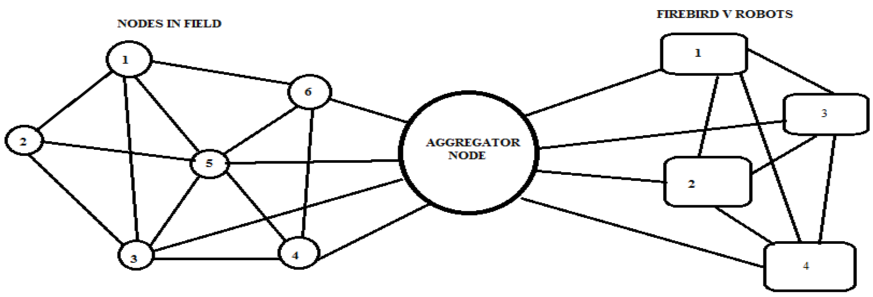

Fig. 3 The proposed Agriculture system

Here in this proposed system in figure 3, the wireless sensor nodes are deployed in the field,and aggregator works as base station. The information reached to the base station is then used by the firebird V robots, to provide the required services to the field.

2.1 Proposed design of Wireless senor nodes

For monitoring the agriculture field, numbers of nodes are deploy in field which continuously monitoring the field. The proposed system design of each node is consist of different type of sensing unit such as temperature, humidity, gas as well as the water level of well. The nodes should have a microcontroller along with multichannel ADC. [2] So the microcontroller will use its I/O pins for collecting the sensor's data obtained from different type of sensor as well as for converting the analog data into digital one and will send it further to other microcontroller through a transceiver. Nodes are in mesh network so they are able to transmit and receive data through Xbee transceivers.

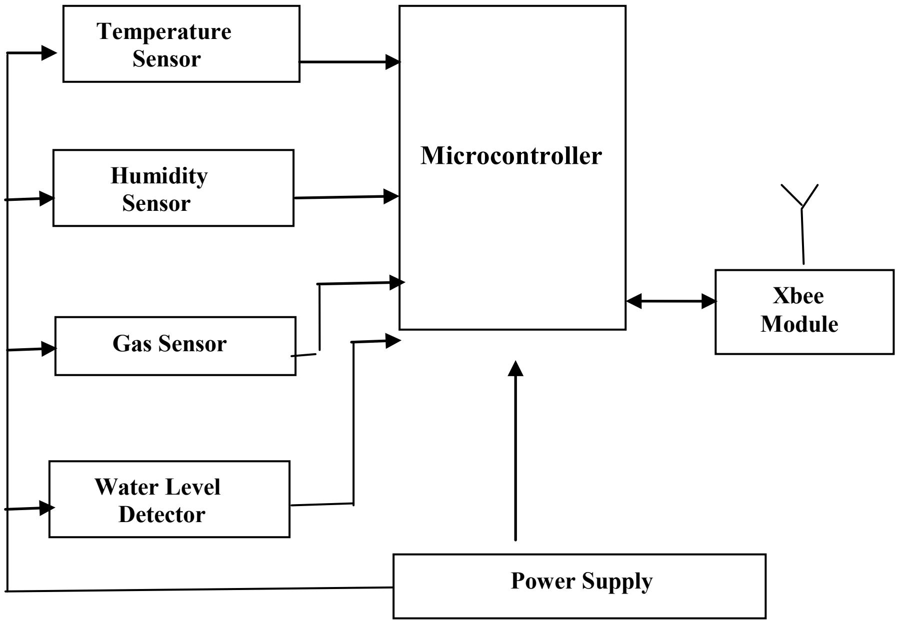

Fig. 4 proposed wireless sensor node

The node send data to aggregator node which analysis the data and alert the system if there is any need of services is required (like water etc.)

Each firebird V robot is also in communication with nodes and aggregator node in mesh network. As a service is needed then according to it is has to control the resources in the field and has to serve for example switching on the water pump in that area or put the urea in the specific area. If two different service is required at same time then second service is has to wait for completion of first.

3 Hardware used in the Model

3.1 Microcontroller and sensors

The proposed system uses **ATmega16** which is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. Atmega16 is based on enhanced RISC (Reduced Instruction Set Computing, Know more about RISC and CISC Architecture) architecture. Most of the instructions execute in one machine cycle. Atmega16 can work on a maximum frequency of 16MHz. ATmega16 has 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. The endurance cycle of flash memory and EEPROM is 10,000 and 100,000, respectively.

ATmega16 [6] is a 40 pin microcontroller. There are 32 I/O (input/output) lines which are divided into four 8-bit ports designated as PORTA, PORTB, PORTC and PORTD.

3.2 Temperature Sensor

The LM35 is an IC sensor that can be used to measure temperature with an electrical output proportional to the temperature. It is used to measure temperature more accurately than a using a thermostat. The sensor circuitry is sealed and not subject to oxidation. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. [3][4]This sensor is used to monitor surrounding temperature. It gives the idea about the increase or decrease in the temperature of surrounding. If the temperature changes it is observed on LCD.

3.3 Humidity Sensor

Humidity is an expression of the amount of water vapors in air. It is an invisible gas that varies between 1 - 4% of our atmosphere by volume. SYHS-220 sensor module converts relative humidity (30-90%RH) to voltage and can be used in weather monitoring application. This sensor is used to monitor humidity i.e. moisture present in the surrounding.

3.4 Gas Sensor

This sensor is to sense the toxic gas like carbon monoxide present in the air. The MQ-7 can detect CO-gas concentrations anywhere from 20 to 2000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is an analog resistance. The drive circuit is very simple; all you need to do is power the heater coil with 5V, add a load resistance, and connect the output to an ADC.

3.5 Water Level Detector

This is used to detect/sense the water level of the well. The sensor will detect the amount of water present in the well. If the water level goes below minimum level or above maximum level a control signal is send to LCD. In addition to this a message is send to an observer situated at the remote place.

ATmega16 has various in-built peripherals like USART, ADC, Analog Comparator, SPI, JTAG etc. Each I/O pin has an alternative task related to in-built peripherals

4 Configuring the Zigbee Modules

4.1 Using X-CTU

The Xbee Digimesh [8] modules are used for establishing a network in Ad-hoc topology. These modules are configured by using a software X-CTU. X-CTU is developed by NEX Robotics (used Version 6.2.0.6). X-CTU provide simple GUI shown in figure 5, and interact with firmware files for Digi's RF products.

On opening the X-CTU software we can connect our XBee module to the PC via data cable. Select one option from X-CTU windows ADD DEVICE OR DISCOVER DEVICES.

The software automatically detects every peripherals device connected to PC. Select your Xbee modules and click next) after the radio modules are added, select a radio module from the list to display its properties. Now we can edit its properties according to use.
Description of basic properties used for establishing Ad-Hoc Network-

CH is Operating Channel;

ID is Network ID,

MT Broadcast Multi-Transmits,

RR Unicast Retries

While using the X-CTU software we can check weather our modules are communicating with each other or not by using console log feature.

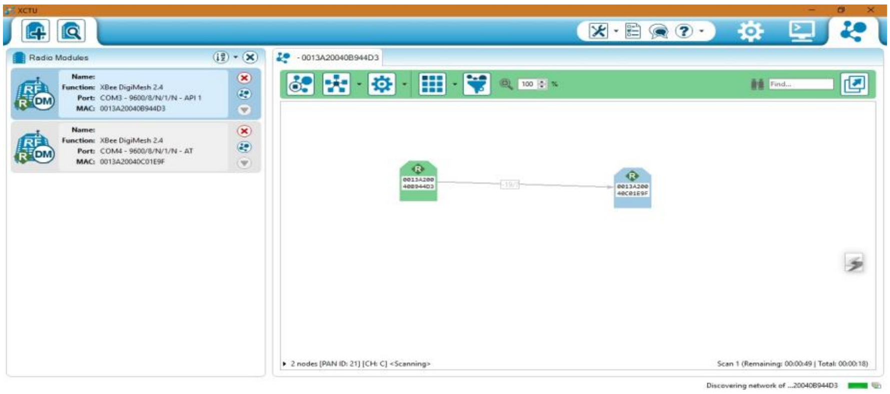

Fig. 5 Terminal Window showing connection among two Zigbee using X-CTU

X-CTU (6.2.0.6) also offers to observe the connection topology. This can be enabled by configuring modules on API mode operation and after that go to network search tap in X-CTU software and start searching,

4.2 The flow of control of proposed model

First task to sense the field with using the various sensors deploy in field. After sensing the field these sensor send data to microcontroller which analysis the data and decide the service is required or not. This is done by taking a threshold value. If sensed value is crossed threshold value then service is required.

After analyzing if service is needed then microcontroller communicated with coordinator and request for service. The coordinator will processes the received signal and initiate the providing service. The data which coordinator received will have a field coordinates and type of service is required in that place. The coordinator select the robot according to type of service required and then field coordinates to robot where robot has to provide service.

4.3 Travelling of Robots in the field

Everything needs a desired path to travel from one place to another to do their work. In humans we have eyes to analysis surroundings and decide the way on which we travelled. For Firebird V robot it will use its sensors to get surrounding details and sensor data provided to microcontroller. The microcontrollers will analysis the data accordingly. On running proposed system whenever there is need of a service in the agriculture fields the desired robot (according to service) will be go there and provide service.

For traveling from start of the field to desired area of the field, we use grid solving techniques. We divide the agriculture field in different block as a grid shown in figure 6.

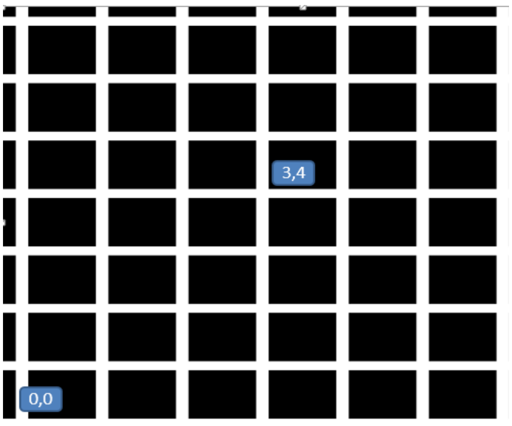

Fig. 6. Breaking Field in grid

Let’s take an example, after dividing field in grid suppose service is required at point (3, 4). Now taking one corner as starting point as (0, 0). Now a service is needed at point (3, 4). So the robot will start moving form (0, 0) point and first is cover 3 points in x-axis then take a 90 degree left turn and go 4 point in y-axis and provide service. We can also do this in opposite order.

There is so many ways for making grid in field but for our proposed system we going to use either of two ways. First one is making physical grid in the field another way is making imaginary grid.

For imaginary grid we can make this with the help of sensors. Here we have Firebird V robot which came with two position encoder sensors one with each wheel. We can use position encoder sensor for measuring the distance travelled by robot and to identify its position after travelling distance.

Here one important requirement is robot have both moving motor in synchronization, means robot should able to move straight direction with zero degree deviation, for doing this we can use PWM (pulse width modulation).

Let take an example for proper illustration, suppose field is divided in square grid. Each block in grid is square of 10m. Same as above service required at point (3, 4). Now robot will start from starting point (0, 0). Then robot has to travel 3 blocks in x-axis. Using position encoder sensor we can measure 10m distance easily to travel 3 blocks robot has to cover 10m distance 3 time after that it take 90 degree turn to y-axis and cover 10m distance 4 times to reached destination.

4.4 Velocity Control Using PWM

Velocity of the Firebird V robot is can be controlled by using PWD (pulse width modulation) technique.

4.5 Position Encoder Math

Position encoders give position / velocity feedback to the robot. It is used in closed loop to control robot’s position and velocity. [7] Position encoder of the motor C1 is connected to the INT7 pin of the ATMEGA2560 microcontroller via soldering pad P1. INT7 interrupt pin is also connected to bootloader switch and TSOP1738 (via pad on microcontroller socket). If you want to use position encoder of C1, then make sure that bootloader code is removed from the ATMEGA2560 microcontroller and soldering pad for TSOP1738 connection on the microcontroller socket is open. After these two precautions are taken, solder pad P1 on the main board to connect C1 motor's position encoder to the ATMEGA2560 microcontroller socket. This is very important. If not done then because of pulse from C1 motor's position encoder, ATMEGA2560 microcontroller will go in to boot mode.

Case-1 Robot is moving forward or backward (encoder resolution is in mm)

Wheel diameter: 5.1cm

Wheel circumference: 5.1cm * 3.14 = 16.014cm = 160.14mm Number slots on the encoder disc: 30

Position encoder resolution: 163.2 mm / 30 = 5.44mm / pulse.

Case 2: Robot is turning with one wheel rotating clockwise while other wheel is rotating anti clockwise. Center of rotation is in the center of line passing through wheel axel and both wheels are rotating in opposite direction (encoder resolution is in degrees)

Distance between Wheels = 15cm

Radius of Circle formed in 3600 rotation of Robot =

Distance between Wheels / 2 = 7.5 cm

Distance Covered by Robot in 3600 Rotation =

Circumference of Circle traced = 2 x 7.5 x 3.14 = 47.1 cm or 471mm

Number of wheel rotations of in 3600 rotation of robot = Circumference of Traced Circle / Circumference of Wheel

= 471 / 160.14 = 2.941

Total pulses in 3600 Rotation of Robot
=Number of slots on the encoder disc / Number of wheel
rotations of in 3600 rotation of robot = 30 x 2.941
= 88.23 (approximately 88)
Position Encoder Resolution in Degrees = 360 / 88
= 4.090 degrees per count.

Case 3: Robot is turning with one wheel stationary while other wheel is rotating clockwise or anti clockwise. Center of rotation is center of the stationary wheel (encoder resolution is in degrees)

In this case only one wheel is rotating and other wheel is stationary so robot will complete its 3600 rotation with stationary wheel as its center.

Radius of Circle formed in 3600 rotation of Robot
= Distance between Wheels = 15 cm
Distance Covered by Robot in 3600 Rotation
= Circumference of Circle traced = 2 x 15 x 3.14 = 94.20 cm or 942 mm
Number of wheel rotations of in 3600 rotation of robot
= Circumference of Traced Circle / Circumference of Wheel
= 942 / 160.14 = 5.882
Total pulses in 3600 Rotation of Robot
= Number of slots on the encoder disc / Number of wheel
Rotations of in 3600 rotation of robot
= 30 x 5.882 = 176.46 (approximately 176
Position Encoder Resolution in Degrees = 360 /176
= 2.045 degrees per count

5 Conclusion

The concept of Ad-Hoc networking using Zigbee protocol can be implemented not only in agriculture field but also in various domains. Home automation, commercial building security, Environmental monitoring. Healthcare medical monitoring, Vehicle monitoring are some of the areas where this technology can be implemented effectively. These smart systems can be easily implemented in small local area networks to meet the requirement of people. Ad-Hoc/Mesh topology has a higher communications overhead than the star topology, which can result in increased latency and lower end-to-end performance. Moreover, meshed routing requires more complex network protocols. This means the routers require more embedded resources, which can result in increased power consumption and costs. In addition to this, to dynamically configure XBee module as receiver or transmitter as per the situation is in itself a challenging task. These challenges need to be handled carefully so that the system developed is not only reliable but also efficient. Automatizations of systems have become the need of the hour due to rapid increase in the population. Thus, in this scenario projects like Smart Agriculture System could be highly beneficial. This ever increasing demand of people have somewhere made it compulsory to develop such systems where needs could not only be satisfied effectively and efficiently but also with less human interference. Research has been constantly going on, in this field of wireless communication but the real challenge comes in commercially utilizing it. More and more such systems should be practically implemented.

References

1. Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., Cayirci, E., “A Survey on Sensor Networks,” *IEEE Communications Magazine*, Vol. 40, Issue 8, pp. 102-114, August 2002.
2. Yick, J., Mukherjee, B., Ghosal, D., “Wireless Sensor Network Survey,” *Elsevier Computer Networks*, Vol. 52, Issue 12, pp. 2292–2330, 2008.
3. T.Kalaivani, Aallirani, P.Priya, “A Survey on Zigbee Based Wireless Sensor Networks in Agriculture”: Department of ECE, 2011 IEEE.9
4. Wang Qing Hui, Bian Li Juan, Pang Yu jun, “Design of the temperature monitoring system based on ZigBee wireless sensor network College of Information Technology”, 2011 IEEE.
5. Huang Feng Yi. Design of the temperature monitoring system based on ZigBee wireless sensor network (Master thesis) [J] Shanghai Jiao Tong University, 2010
6. Yu Chengbo, Cui Yanzhe, Zhang Lian, Yang Shuqiang, “ZigBee Wireless Sensor Network in Environmental Monitoring Applications”, 2009 IEEE.
7. Swarup S. Mathurkar, D. S. Chaudhari, “A Review on Smart Sensors Based Monitoring System for Agriculture”, Volume-2, Issue-4, March, IJITEE 2013.
8. ww1.microchip.com “ATMEGA 16 Datasheet”
9. Mohini Reddy, Vidya Sawant WSN based Parameter Monitoring and Control System for DC Motor. Volume-3, Issue-9, February 2014
10. http://ftp1.digi.com/support/documentation/90 001003_A.pdf
11. S. Otoum, M. Ahmed and H. T. Mouftah,"Sensor Medium Access Control (SMAC)-based epilepsy patients monitoring system," Electrical and Computer Engineering (CCECE), 2015 IEEE 28th Canadian Conference on, Halifax, NS, 2015, pp. 1109-1114.
12. www.nex-robotics.com
13. www.e-yantra.org