International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: http://dx.doi.org/10.7324/IJASRE.2017.32564

Vol.3 (11) December-2017

Trust Mechanism Protocol for Automatic Smart Irrigation System Using WSN

K Boopathi raja[1], EM Alaghusooriya[2], K Anitha[3], C R Anjana[4], V Hari narayanan[5]

[1]Assistant professor, [2-5]UG Scholars

Department of ECE, SNS College of Technology

Coimbatore, Tamil Nadu

India

ABSTRACT

Irrigation is an essential practice in many agricultural cropping systems in semiarid and arid areas, and efficient water applications and management are major concerns. Self-propelled centre pivot and linear-move irrigation systems generally apply water quite uniformly; however, substantial variations in soil properties and water availability exist across most fields. In these cases, the ability to apply site-specific irrigation management to match spatially and temporally variable conditions can increase application efficiencies, reduce environmental impacts, and even improve yields. The objective of this paper is to design and implementation of trust mechanism protocol in wireless sensor networks. This protocol is used to detect the node failure problem that occurs in the WSN and to implement this for monitoring network in agricultural fields. In our proposed system we monitor the field conditions and control the crop irrigation with node failure protocol and using wireless connections. The communication is done by ZigBee router; hence it is cost effective and also need not manual monitoring using android applications when compared to other system. It increases the reliability of the structure. However, the farmland irrigation in our country still adopts extensive manual operations which will result in wastage of water resources which will be overcome in this paper. It can also accurately collect the soil temperature, humidity, air temperature, water pump operation and water level indication. This will also be implemented in vertical gardening's. This protocol could be implemented in all type of WSN application.

Keywords: Zigbee, WSN, Sensors, Node failure protocol.

I. INTRODUCTION

India is a country of agriculture and it is backbone of Indian economy. Irrigation is heart of agriculture. The irrigated agriculture is one of the primary water consumers in most parts of the world. The irrigation is the artificial application of water to the soil for assisting in growing crops.

A Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature sound pressure etc., and to cooperatively pass their data through the network to a main location The WSN is built of nodes from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. The topology of the WSN can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

Node failure means a node in a wireless network fail to communicate because of any physical damage or power problem. Trust mechanism protocol which is programmed in both slave and master. Initially master send the beacon signal to individual node and waiting for acknowledgement, by checking this it will identify the failure nodes. The objective of this paper is to design the protocol for node failure problems in wireless sensor network and implement in an application. Here we are going to implement this protocol for monitoring network in agricultural field or vertical gardens.

II. EXISTING SYSTEM

In past few years, automatic irrigation system has seen a rapid growth in terms of technology. At present cost-saving technology, labor-saving are the addressing key issues in irrigation. This gives a review of these systems based on existing technologies and also proposes an economical and generic automatic irrigation system. Irrigation system has become a popular research with the greenhouse effect. People are utilizing the merits of embedded system into monitoring and Control system for an intelligent irrigation system because of lots of advantages. Monitoring parameters of temperature and humidity is an important means for obtaining high-quality environment. Remote monitoring is an effective method in order to avoid interference environment and improve efficiency. Today, Ethernet network, RF module and ZigBee wireless network are used to transmit data in remote monitoring System. ZigBee is wireless network with special agreement. While WSN dispenses with the substantial costs of wiring, the ZigBee WSN technologies are most suitable for agriculture applications comparing with Wi-Fi and Bluetooth. Highly robustness for the interferences has made Bluetooth as a highly versatile and attractive technology among other short range wireless technologies.

From the below Table I, it is concluded that designing a remote monitoring and control system that satisfies all the parameters simultaneously is a complicated task. Each proposed methodology has its own merits and demerits. However, there is still a possibility of designing a cost effective system which has an improved performance in most of the respects that will work optimally in many different applications.

Table I. Classification Of Existing Systems

Technology	Main MCU system	Monitor Station	Modules Interfaced	Tools	Code
ZigBee	JN5121	PC	RS232	Keil IDE	Java, C
Internet	Intel 80C196KC	PC	None	Keil IDE	C51
Bluetooth	Atmega64	PC	TDK blu2i	AVR studio	C
Bluetooth	Atmega168	Mobile	Bluegiga WT11	AVR studio, Symbian OS	Python
Bluetooth	AVR Atmega32	Mobile	CBOEMSPA312	AVR studio, eclipse 3.2.2	C, Java
RF	PIC18F452	PC	Sony Ericsson GM47	Valcon	Visual C net 2008 editor
Fuzzy logic	STC12C5A32S2	PC	STC12C5608,STC 12C5608AD	Fuzzy COPE	C,C++
GSM	MSP430F149	PC	Siemens TC35	C430 IDE	C
GPRS	C8051F310	PC, Mobile	CC1020	GPRS Module	Python
GSM	8051 family	PC	Nokia FBUS	Keil IDE, Linux OS	C, Java
Wi-Fi	ARM	PC, Mobile	Siemens TC35,CC1100	Keil IDE, Linux OS	C51
WSN	PIC16F877	PC	LCD	IDE & MikroC compiler	MikroC
Photovoltaic system	MSP430	Mobile	GM862QUAD-PY,CC2430	MATLAB and PSpice	C, Python
GSM-WSN	8051 family	PC, Mobile	Siemens TC35,CC1100	Keil IDE	C51

The system is scalable and allows any number of different devices to be added with no major changes in its core. But it is not efficient in situations which have strong real time requirements. The system has its application in situations where the amount of data to be transferred is mandatory.

ZigBee is a wireless network with special agreement. While WSN dispenses with the substantial costs of wiring, the ZigBee WSN technologies are most suitable for agriculture applications comparing with Wi-Fi and Bluetooth. The technology for remote monitoring and control systems using ZigBee protocol provides easy wireless installation of sensors at a lower cost and also increases reliability using mesh networks.

From the below Table II, it clearly shows the comparison of characteristics of protocols.

TABLE 2. COMPARISON OF CHARACTERISTICS OF PROTOCOLS

Protocol	Bluetooth	UWB	ZigBee
Nominal range	10m	10-102m	10-1000m
Basic cell	Piconet	Piconet	Star
Extension of the basic cell	Scatternet	Peer-Peer	Cluster tree, Mesh
Max number of cell nodes	8	236	>65000
Success metrics	Cost, convenience	Throughput, power, cost	Reliability, power consumption, cost
Application focus	Cable replacement	Monitoring, data network	Monitoring, control

III. PROPOSED SYSTEM

The traditional irrigation method can not only result in the waste of water, but also can waste the labor force by the extensive nature of the operation. Remote monitoring system can reduce the costs in agriculture by lowering labor force drastically and transfer of agricultural labor. Currently, automation technology has got great development. This paper mainly adopts ZigBee and configuration technology to design an automatic irrigation control system. The overall diagram of our proposed system is shown in Fig 1.

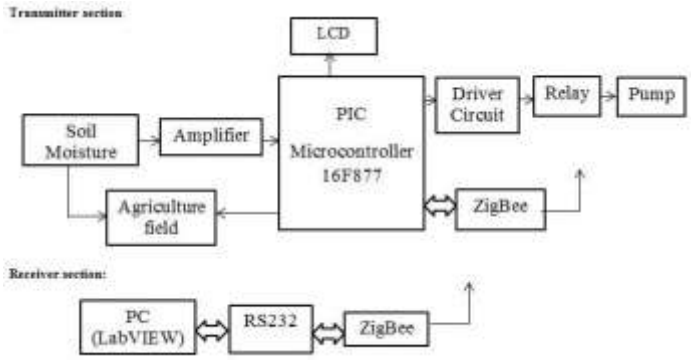

Figure 1. Block diagram.

A. Soil Moisture Sensor

Soil moisture sensors measure the water content in soil. A soil moisture probe is made up of multiple soil moisture sensors. Measuring soil moisture is important in agriculture to help farmers manage their irrigation systems more efficiently. Not only are farmers able to generally use less water to grow a crop, they are able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages Besides agriculture, there are many other disciplines using soil moisture sensors. Golf courses are now using sensors to increase the efficiencies of their irrigation systems to prevent over watering and leaching of fertilizers and other chemicals offsite.

B. Amplifier

An electronic amplifier is a device for increasing the power of a signal. It does this by taking energy from a power supply and controlling the output to match the input signal shape but with larger amplitude. In this sense, an amplifier may be considered as modulating the output of the power supply. Here we use inverting amplifier as a gain amplifier. We can change the gain by adjusting the value of feedback resistance value. The feedback between the output and the inverting input terminal produces a closed loop circuit to the amplifier resulting in the gain of the amplifier now being called its closed-loop gain**.**

C. Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. Relays allow one circuit to switch a second circuit which can be completely separate from the first. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical. . Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

D. Driver Circuit

In electronics, a driver is an electrical circuit or other electronic component used to control another circuit or other component, such as a high power transistor. It controls the high-power transistors in AC-to-DC voltage converters. An amplifier can also be considered the driver for loudspeakers, or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages.

E. Serial Interconnection

In telecommunications, RS-232 is a standard for serial binary data interconnection between a DTE (Data Terminal Equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used in computer serial ports. Many modern devices can exceed this speed 38,400 and 57,600 bit/s being common and 115,200 and 230,400 bit/s making occasional appearances while still using RS-232 compatible signal levels.

F. ZigBee

The mission of the ZigBee working group is to bring about the existence of a broad range of interoperable consumer devices by establishing open industry specifications for unlicensed, untethered peripheral, control and entertainment devices requiring the lowest cost and lowest power consumption communications between compliant devices anywhere in and around the home. It operates in the 2.4 GHz radio band- the same band as Bluetooth, microwaves and some other devices. It is capable of connecting 255 devices per network. The specification supports data transmission rates of up to 250 Kbps at a range of up to 30 meters.

ZigBee is an established set of specifications for wireless personal area networking (WPAN), i.e., Digital radio connections between computers and related devices. WPAN low rate or ZigBee provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. ZigBee makes possible completely networked homes where all devices are able to communicate and be controlled by a single unit. ZigBee coordinator in each network is used to act as the router to other networks, and can be likened to the root of a (network) tree. It is designed to store information about the network. ZigBee employs either of two modes, beacon or non-beacon to enable the to-and-fro data traffic.

ZigBee technology is designed to best suit these applications, for the reason that it enables reduced costs of development, very fast market adoption. With ZigBee designed to enable two-way communications, not only will the consumer be able to monitor and keep track of domestic utilities usage, but also feed it to a computer system for data analysis. A recent analyst report issued by West Technology Research Solutions estimates that by the year 2008, annual shipments for ZigBee chipsets into the home automation segment alone will exceed 339 million units, and will show up in light switches, fire and smoke detectors, thermostats, appliances in the kitchen, video and audio remote controls, landscaping, and security systems.

TABLE 3. COMPARISON OF TRANSMITTED POWER

Protocols	Transmitted power(watt)
Bluetooth	0.1
UWB	0.04
Zigbee	0.0063
Wi-Fi	1
Wi-Max	0.25
GSM/GPRS	2

From Table III, it is noted that when the distance between the transmitter and the receiver increases, the received power decreases, this is justified by the power loss in the path. The ZigBee, UWB and Bluetooth have low power consumption while Wi-Max, Wi-Fi and GPRS absorb more power due to theirs high communication range reason.

G. Microcontroller

Microcontroller is a general purpose device, which integrates a number of the components of a microprocessor system on to single chip. A microcontroller combines on to the same microchip:

The CPU core.

Memory (both ROM and RAM).

Some parallel digital I/O.

Microcontrollers are smaller in size, consumes less power and inexpensive. Micro controller is a standalone unit which can perform functions on its own without any requirement for additional hardware like I/O ports and external memory. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory.

Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc., are some of the memories of which FLASH is the most recently developed. Technology that is used in pic16f877 is flash technology, so that data is retained even when the power is switched off. Easy programming and erasing are other features of pic16f877. Fig 2, shows the pin diagram of pic16f877 microcontroller.

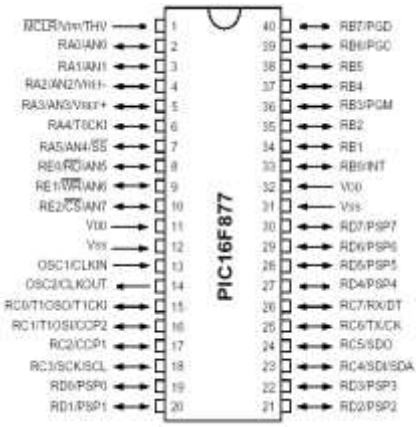

Figure 2. Pin diagram of pic16f877.

H. LCD Display

Liquid crystal displays (LCD) have materials which combine the properties of both liquids and crystals. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters. The LCD's are lightweight with only a few millimetres thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD does don't generate light and so light is needed to read the display. The LCD's used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The LCD's have even started replacing the cathode ray tubes used for the display of text and graphics, and also in small TV applications.

I. LED

In Light Emitting Diodes, electrical energy flowing through it is directly converted into light energy. Light Emitting Diodes are the most widely used semiconductor diodes among all the different types of semiconductor diodes available today. Light emitting diodes emit either visible light or invisible infrared light when forward biased. The LED's which emit invisible infrared light are used for remote controls. A light Emitting Diode (LED) is an optical semiconductor device that emits light when voltage is applied.

J. Power Supply

The power supply should be of +5V, with maximum allowable transients of 10mv. To achieve a better or suitable contrast for the display, the voltage at pin 3 should be adjusted properly. A module should not be inserted or removed from a live circuit. The ground terminal of the power supply must be isolated properly so that no voltage is induced in it. The module should be isolated from the other circuits, so that stray voltages are not induced, which could cause a flickering display.

K. LabVIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine the order of program execution, Lab VIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the virtual instruments and functions. Lab VIEW also has built-in features for connecting your application to the Internet using the Lab VIEW web server and software standards such as TCP/IP networking and ActiveX. LabVIEW contains comprehensive libraries for data collection, analysis, presentation, and storage. LabVIEW includes traditional program development tools. You can set breakpoints, animate program execution, and single-step through the program to make debugging and development easier. LabVIEW gives you the flexibility and performance of a powerful programming language without the associated difficulty and complexity.

L. MP Lab

MP Lab IDE is an integrated development environment that provides development engineers with the flexibility to develop and debug firmware for various microchip devices.MP Lab IDE is a Windows-based Integrated Development Environment for the Microchip Technology Incorporated PIC microcontroller (MCU) and as pic digital signal controller (DSC) families. MP Lab SIM is a discrete-event simulator for the PIC microcontroller (MCU) families. It is integrated into MP Lab IDE integrated

development environment. The MP Lab SIM debugging tool is designed to model operation of microchip technology's PIC microcontrollers to assist users in debugging software for these devices.

M. Proteus

Proteus 8 is a single application with many service modules offering different functionality (schematic capture, PCB layout, etc.). Application framework hosts all of the functionality of Proteus. The common database contains information about parts used. A part can contain both a schematic component and a PCB footprint as well both user and system properties.

IV. SIMULATION RESULT

The below Fig 3, shows that the simulation output of automatic irrigation system by the usage of moisture sensor. Here a single node (sensor) is taken into account. We have used pic 16f877a microcontroller which in turn is interfaced with the LCD display. The pic microcontroller consist of an inbuilt ADC which gets an analog input signals from the sensors and converts it into digital signals which is being given to the LCD display. When the moisture content goes below the desired level, the motor automatically gets ON and vice versa. Here the virtual terminal is used for transmitting and receiving informations. In our paper, we are additionally going to detect the node failure problem which is implemented in the hardware but it cannot be shown in this simulation. During the implementation of hardware, we make use of the ZigBee module for transmitting and receiving information in WSN.

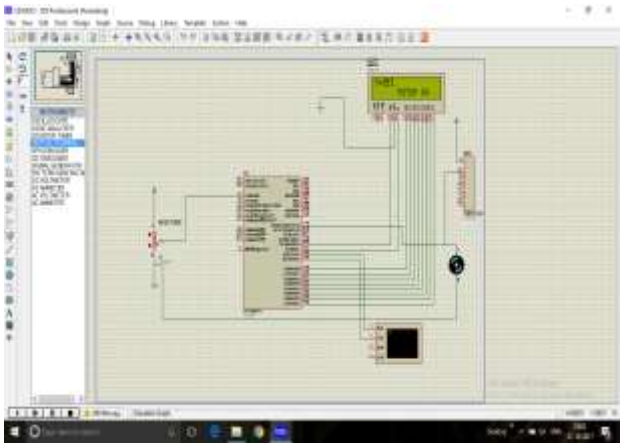

Figure 3. Simulation Output.

V. CONCLUSION AND FUTURE WORK

In order to conserve the water used for agriculture, this paper is very useful. The field conditions can be monitored from the farm house itself with the help of this automatic irrigation system. Using ZigBee technology it is possible to send as well as receive easily and also it eliminates the cost of network usage in WSN. The wireless sensor network can be widened by adding n number of nodes based on the size of the field. This reduces the manual labor. This system is feasible and cost effective for optimizing water resources for agricultural production. To extend the range, we make use of the routers. Further, humidity and temperature sensor can also be used in this system. Therefore, our future work is to implement ‘n’ number of sensor nodes using Raspberry pi which makes the system further more accurate and reliable.

REFERENCES

[1] Joaquin Gutierrez, Juan Francisco Villa-Medina, Alejandra Nieto Garibay and Miguel Angel Porta-Gandar, ”Automated Irrigation System using a Wireless Sensor Network and GPRS Module”, IEEE Transactions on Instrumentation and Measurement, vol.63, no.1, January 2014.

[2] R.valulabranan, M.Karthikeyan, V.Sasikala,” Automatic Irrigation System on Sensing Soil Moisture Content”, International Research Journal of Engineering and technology (IRJET) vol: 03 issue: 03, March 2016.

[3] V. Sri Jahnavi and Shaik Fayaz Ahamed, “Smart Wireless Sensor Network for Automated Greenhouse”, Article in IETE Journal of Research , January 2015

[4] Tamoghna Ojha a, Sudip Misra a, Narendra Singh Raghuwanshi b, “Wireless sensor networks for agriculture: The state-of-the-art in practice and future challenges Computers and Electronics in Agriculture 118 (66–84), 2015.

[5] D. M. Khatri, P. R. Indurkar, Deweshvree Rane, "Review Paper Based On Automatic Irrigation System Based On Rf Module", Volume 1, IJAICT, ISSN 2348 – 9928, 2015.
[6] D.Babu Rajendra Prasad,Sunil.N.Drupad.V,Madhu.CN,Yashavantha BK,"GSM Based Smart Agriculture System with Auto Solar tracking",International Journel of Electrical And Electronics Research,vol3,issue2,April-June 2015.
[7] Aprajita Anand1, Akansha Parasar2, Assoc. Prof. A Prabhakar3, "Gsm Based Agriculture Monitoring System", International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 03 | March -2017.
[8] Bhakti B. Bakle1, Prof. Amol R. Wagh2, "Smart Irrigation System Using Wireless Sensor Network and GPRS Module", International Journal of Modern Trends in Engineering and Research e-ISSN No.:2349-9745, Date: 2-4 July, 2015.
[9] Pavithra D.S,M.S.Srinath,"GSM based Automatic Irrigation Control System for Efficient Use of Resources and Crop Planning by using an Android Mobile" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume11, Issue 4 ver.1, Jul-Aug 2014.
[10] Purnima and S.R.N.Reddy. "Design of Remote Monitoring and Control System with Automatic Irrigation System using GSM-Bluetooth", International Journal of Computer Applications (0975-888) Volume 47-no.12, June 2012.
[11] Venkata Naga Rohit Gunturi,"Micro Controller based Automatic Plant Irrigation System", International Journal of Advancements in Research and Technology Volume 2, issue 4, April 2013.
[12] Mehamed Ahmed Addurrahman, Gebremedhn Mehari Gebru and Tsigabu Teame Bezabih Et Al., "Sensor based Automatic Irrigation Management System", International Journal of Computer and Information Technology(ISSN:2279-0764) Volume 04-Issue 03, May 2015.
[13] Vasif Ahmed and Siddharth A. Ladhake; "Design of ultra low cost cell phone based embedded system for irrigation"; IEEE Transactions on Consumer Electronics, Vol.55, No. 2 , pp. 718-721, 2010.
[14] Shinghal, K., Noor, A., Srivastava, N., and Singh, R.,"Wireless sensor networks in agriculture for potato farming", International Journal of Engineering, Science and Technology, Vol. 2, No. 8, pp. 3955-3963, 2010.
[15] Gautam, I., and Reddy, S. R. N.,Innovative, "GSM-Bluetooth based remote controlled embedded system for irrigation", International Journal of Computer Applications, Vol. 47, No. 8, pp. 1, 2012.
[16] Yunseop Kim,Robert.G.Evans,William.M.Iverson, "Remote sensing and control of an irrigation system using a distributed wireless sensor network", IEEE Transactions on Instrumentation Measurement vol57, issue 7, July 2008.
[17] Suhinthan Maheswararajah, Saman K. Halgamuge, Member, IEEE, Kithsiri B. Dassanayake, and David Chapman, "Management of Orphaned-Nodes in Wireless Sensor Networks for Smart Irrigation Systems", IEEE Transactions on Signal Processing, Vol. 59, No. 10, October 2011.
[18] Sabrine Khriji1, Dhouha El Houssaini1, Mohamed Wassim Jmal2, Christian Viehweger3, Mohamed Abid2, Olfa Kanoun3, "Precision Irrigation Based On Wireless Sensor Network", IET Science, Measurement and Technology, ISSN 1751-8822, 17th January 2014.
[19] Mahta Moghaddam, Fellow, IEEE, Dara Entekhabi, Senior Member, IEEE, Yuriy Goykhman, Member, IEEE, Ke Li, Mingyan Liu, Senior Member, IEEE, Aditya Mahajan, Ashutosh Nayyar, David Shuman, Member, IEEE, and Demosthenis Teneketzis, Fellow, IEEE, "A Wireless Soil Moisture Smart Sensor Web Using Physics-Based Optimal Control: Concept and Initial Demonstrations", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Vol. 3, No. 4, December 2010.
[20] A. Araujo, J. Garcia-Palacios, J. Blesa, F. Tirado, E. Romero, A. Samartin, and O. Nieto-Taladriz, "Wireless measurement system for structural health monitoring with high time-synchronization accuracy," IEEE Trans. Instrum. Meas., vol. 61, no. 3, pp. 801 810, Mar. 2012.
[21] H.-C.Lee,Y.-M.Fang, B.-J. Lee, and C.-T. King, "The tube: A rapidly deployable wireless sensor platform for supervising pollution of emergency work," IEEE Trans. Instrum. Meas., vol. 61, no. 10, pp. 2776–2786, Oct. 2012.
[22] R. Yan, H. Sun, and Y. Qian, "Energy-aware sensor node design with its application in wireless sensor networks," IEEE Trans. Instrum. Meas., vol. 62, no. 5, pp. 1183–1191, May 2013.
[23] R.Young et al., "Soil moisture and meteorological observations from the Murrumbidgee catchment," Dept. Civil Environ. Eng., Univ. Melbourne, Melbourne, Australia, Tech. Rep., May 2008. Observation of Murrumbidgee Catchment.pdf, accessed on Oct. 8, 2013.
[24] Perera, A.: 'zigbee wireless soil moisture sensor design for vineyard management system'. Master's thesis, Auckland University of Technology, New Zealand, 2010.
[25] Nilesh Kuchekar, Rajendraprasad Pagare, "Android based Water Deployment System for Irrigation using Wireless Sensor Network & GSM module", International Journal of Science and Research (IJSR)- (ISSN: 2319- 7064), Volume 4, Issue 7, Edition. 93, July 2015.
[26] R.suresh, S.Gopinath, K.Govindaraju, T.Devika, N.suthanthiravanitha, "GSM based Automated Irrigation Control using Raingun Irrigation System", International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 2, February 2014.

[27] E. Esakki madura, V. Venkatesa kumar, "Smart Agriculture System By Using Zigbee Technology", International Journal Of Engineering And Computer Science Issn:2319-7242 Volume 6 issue 4, page no. 20880-20887 Index copernicus value (2015): 58.10, April 2017.
[28] Chakkor Saad, Baghouri Mostafa, El,Ahmadi Cheikh, Hajraoui Abderrahmane, "Comparative Performance Analysis of Wireless Communication Protocols for Intelligent Sensors and Their Applications", (IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 5, No. 4, 2014.
[29] Diksha s.dasare, punam s.kale, priyanka r.kale, hemanat mande, mr. Hiralal solunke, "Automatic Irrigation Control System", International Journal for Technological Research in Engineering volume 4, issue 8, april-2017.
[30] P. Manimaran, Mr. D. Yasar Arfath, "An Intelligent Smart Irrigation System Using WSN and GPRS Module", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 6) pp 3987-3992, 2016.
[31] Vimal. P, Priyanka. V, Rajyasree. M, santhiyadevi. P. T, Jagadeeshraja. M, suthanthiravanitha. N, "A Novel Approach For Automatic Irrigation And Fertigation Using Embedded System, " International Journal Of Vlsi And Embedded Systems-ijvesvol 05, Article 03257; March 2014.