# Automated Irrigation System Using a Wireless Sensor Network and GPRS Module

Ms.Kardile S.V [1], Mr.Manoj Kumar[2], Mr.P.Balaramudu [3]
PG Students[1], Asst. Professor [2, 3] (VLSI and Embedded systems)
Dept. of Electronics and Telecommunication
Sahyadri Valley College of Engineering Rajuri, Tal.: Junner, Pune, Maharashtra, India

*Abstract*— **This project probes into the design of the automated irrigation system based on pic microcontroller. This embedded project is to design and develop a low cost feature which is based on embedded platform for water irrigation system. Optimum use of water is main objective of this irrigation system to reduce water consumption. This project uses temperature and soil moisture sensors to detect the water quantity present in agriculture and water level sensor for detect water level in tank. This system utilizes water level sensor, humidity Sensor, Zigbee modem, GPRS and microcontrollers viz.pic. The Purpose of this project is to provide embedded based system for irrigation to reduce the manual monitoring of the field and get the information in the form of GPRS. The implementation was to demonstrate that the automatic irrigation can be used to reduce water use.**

*Index Terms*—**Automation, GPRS, GPS, irrigation, measurement, water resources, wireless sensor networks (WSNs).**

## I. INTRODUCTION

Indian economy is basically depends on agriculture. Agriculture uses most of available fresh water resources and this use of fresh water resources will continue to be increases because of population growth and increased food demand. As there is no unexpected usage of water, a lot of water is saved from being wasted. There is an urgent need to create strategies based on science and technology for sustainable use of water, including technical, agronomic, managerial, and institutional improvements. There are many systems to achieve water savings in various crops, from basic ones to more technologically advanced ones. Efficient water management is a major concern in many cropping systems in semiarid and arid areas. Distributed in-field sensor-based irrigation systems offer a potential solution to support site-specific irrigation management that allows producers to maximize their productivity while saving water. This paper describes details of the design and instrumentation of variable rate irrigation, a wireless sensor network, and software for real-time in-field sensing and control of a site-specific precision linear-move

irrigation system Irrigation systems can also be automated through information on volumetric water content of soil, using dielectric moisture sensors to control actuators and save water, instead of a predetermined irrigation schedule at a particular time of the day and with a specific duration. Increased labor costs, stricter environmental regulations and increased competition for water resources from urban areas provide strong motivation for efficient Irrigation system. The automated irrigation system is feasible and cost effective for optimizing water resources for agricultural production. Using the automated irrigation system we can prove that the use of water can be reduced for different agricultural production.
Agriculture plays the major role in economics and survival of people in India. Nowadays Indian agriculture faces a two major problem. They are as follows we know government has promoted a free supply of electricity for farmers to run their motors and pumps for irrigation purpose. But it is found that the farmers misusing the electricity to run their home appliances such as radio, TV, fans, etc. This misuse of electricity has brought a considerable problem for government to supply free electricity. The main aim of this project is to design low cost Automated Irrigation System using a Wireless Sensor Network and GPRS Module. The Purpose of this project is to provide embedded based system for irrigation to reduce the manual monitoring of the field and get the information in the form of GPRS. This proposed system recognizes whether the free electricity has been used other than electric motors for pumping water and if so electricity is being misused, it shuts the total supply for the farmers through a tripping circuit. By using wireless networks we can intimate the electricity board about these mal practices. The development of this project at experimental scale within rural areas is presented and the implementation was to demonstrate that the automatic irrigation can be used to reduce water use.

The automated irrigation system has consisted of two components (Fig 1), they are wireless sensor units (WSUs)[9] and a wireless information unit (WIU). That allowed the transfer of soil moisture[1] and temperature data can be transferred from WSU to WIU that uses ZigBee technology. The WIU has also consisted of GPRS module to transmit the data to a web page via the mobile network.

In this paper, the development of the deployment of an automated irrigation system based on microcontrollers and wireless communication at experimental scale within rural areas is presented. The aim of the implementation was to demonstrate that the automatic irrigation can be used to reduce water use. The implementation is a photovoltaic powered automated irrigation system that consists of a distributed wireless network of soil moisture and temperature sensors deployed in plant root zones. Each sensor node involved a soil-moisture probe, a temperature probe, a microcontroller for data acquisition, and a radio transceiver; the sensor measurements are transmitted to a microcontroller-based receiver. This gateway permits the automated activation of irrigation when the threshold values of soil moisture and temperature are reached. Communication between the sensor nodes and the data receiver is via the Zigbee protocol [65]. This receiver unit also has a duplex communication link based on a cellular-Internet interface, using general packet radio service (GPRS) protocol, which is a packet-oriented mobile data service used in 2G and 3G cellular global system for mobile communications (GSM).

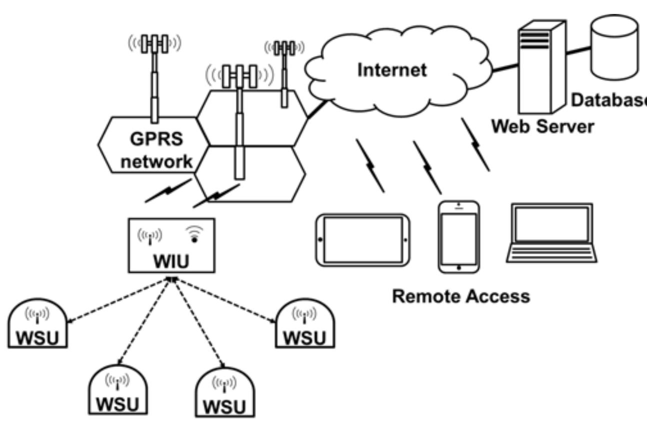



Fig. 1. Configuration of the automated irrigation system. WSUs and a WIU, based on microcontroller, ZigBee, and GPRS technologies.

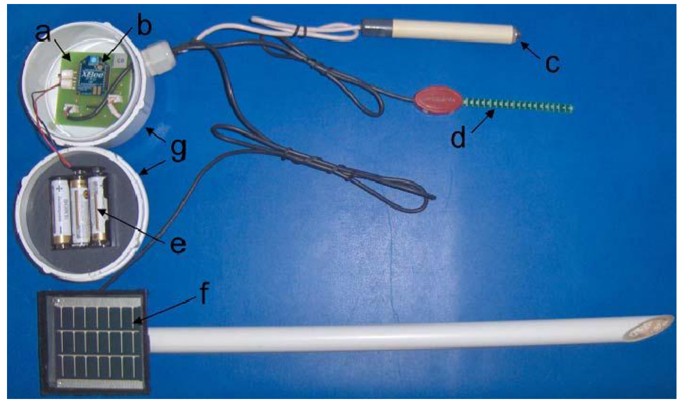



Fig. 2. WSU. (a) Electronic component PCB. (b) Radio modem ZigBee.
(c) Temperature sensor. (d) Moisture sensor. (e) Rechargeable batteries.
(f) Photovoltaic cell. (g) Polyvinyl chloride container.

## II. RELATED WORK

With the rapid development of agriculture in China, many automatic technologies have been introduced into agricultural productions in the research institutions and national agricultural parks. However, the common farmers, occupying 64 percent of the population, are still using traditional tools because of their low education level and the high cost of advanced instruments. Lishui, which is generally accepted as the place where was originated the technology of mushroom in the world, is the biggest producing area of the edible fungus in China, and the output of the edible fungus accounts for about 45 percent in the country. Jew's ear is a very popular variety of the edible fungus. The key factor affecting Jew's ear planting lies in irrigation which up to now mainly depends on manual work and thus, with such low efficiency, badly restricts the edible fungus production. So, there are now pressing needs for intelligent irrigation system with low-cost, easy operation and high reliability. A reduction in water use under scheduled systems also have been achieved, using soil sensor and an evaporimeter, which allowed for the adjustment of irrigation to the daily fluctuations in weather or volumetric substrate moisture content

## III. METHOD

There are different methods to get done water of smaller size in different farming the years produce, from basic one to more technology-wise increased ones. watering system systems can also be control through information on water What is in of using soil moisture sensors to control actuators and but for water, instead of a preselected watering system list of details at one time of the day and with a special time.

We explored an economical automatic irrigation system based on wireless sensor network for Jew's ear planting.

While WSN dispenses with the substantial costs of wiring, the ZigBee WSN technologies[10] are most suitable for agricultural application comparing with Wi-Fi and Bluetooth, which work at similar frequencies as ZigBee [13]. We have successfully applied the ZigBee wireless technology to greenhouse management in our previous researches [11-12]. Now we are focusing on the study of its application to intelligent irrigation.

## III. PROPOSED SYSTEMS

- Control from remote places.
- Maintain the humidity.
- Maintain the Temperature.

### *A. Wireless design of low-cost irrigation system using ZigBee technology-*

Labor-saving and water-saving technology is a key issue in irrigation. A wireless solution for intelligent field irrigation system dedicated to Jew's-ear planting in Lishui, Zhejiang, China, based on ZigBee technology was proposed . Instead of conventional wired connection, the wireless design made the system easy installation and maintenance. The hardware architecture and software algorithm of wireless sensor/actuator node and portable controller, acting as the end device and coordinator in ZigBee wireless sensor network respectively. The long-time smooth and proper running of the system in the field proved its high reliability and practicability. As an explorative application of wireless sensor network in irrigation management. But having some disadvantages which will be recoverd in the next system.

### *B. Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network-*

Efficient water management is a major concern in many cropping systems in semi arid and arid areas. Distributed in-field sensor-based irrigation systems offer a potential solution to support site-specific irrigation management that allows producers to maximize their productivity while saving water. This system describes details of the design and instrumentation of variable rate irrigation, a wireless sensor network, and software for real-time in-field sensing and control of a site-specific precision linear-move irrigation system. Field conditions were site-specifically monitored by six in-field sensor stations distributed across the field based on a soil property map, and periodically sampled and wirelessly transmitted to a base station. An irrigation machine was converted to be electronically controlled by a programming logic controller that updates geo referenced location of sprinklers from a differential Global Positioning System (GPS) and wirelessly communicates with a computer at the base station. Communication signals from the sensor network and irrigation controller to the base station were successfully. interfaced using low-cost Bluetooth wireless radio communication. Graphic user interface-based software developed in this system offered stable remote access to field conditions and real-time control and monitoring of the variable-rate irrigation controller.

## IV. AUTOMATED IRRIGATION SYSTEM

The automated irrigation system hereby reported, consisted of two components (Fig. 1), wireless sensor units (WSUs) and a wireless information unit (WIU), linked by radio transceivers that allowed the transfer of soil moisture and temperature data, implementing a WSN that uses ZigBee technology. The WIU has also a GPRS module to transmit the data to a web server via the public mobile network. The information can be remotely monitored online through a graphical application through Internet access devices.

### *A. Wireless Sensor Unit*

A WSU is consist of a RF transceiver, different sensors, a microcontroller, and power sources[9]. Several WSUs can be deployed in-field to configure a distributed sensor network for the automated irrigation system. Each unit is based on the microcontroller PIC24FJ64GB004 that controls the radio modem XBee Pro S2 (Digi International, Eden Prairie, MN) and processes information from the soil-moisture sensor VH400, and the temperature sensor DS1822 (Maxim Integrated, San Jose, CA). These components are powered by rechargeable AA 2000-mAh Ni-MH Cycle Energy batteries (SONY, Australia). The charge is maintained by a photovoltaic panel MPT4.8-75 to achieve full energy autonomy. The microcontroller, radio modem, rechargeable batteries, and electronic components were encapsulated in a waterproof Polyvinyl chloride (PVC) container (Fig. 2). These components were selected to minimize the power consumption for the proposed application.

The WSUs were configured such as end devices to deploy a networking topology point-to-point based on a coordinator that was implemented by the XBee radio modem of the WIU. The ZigBee device has the following characteristics:
1) It must join a ZigBee module before it can transmit or receive data.
2) Cannot allow other devices to join the network.
3) Always transmit and receive data from one node to another node.
5) It can enter low power modes to conserve power.

Flowchart of wireless sensor unit (WSU) for monitoring the soil moisture and temperature is as shown below:

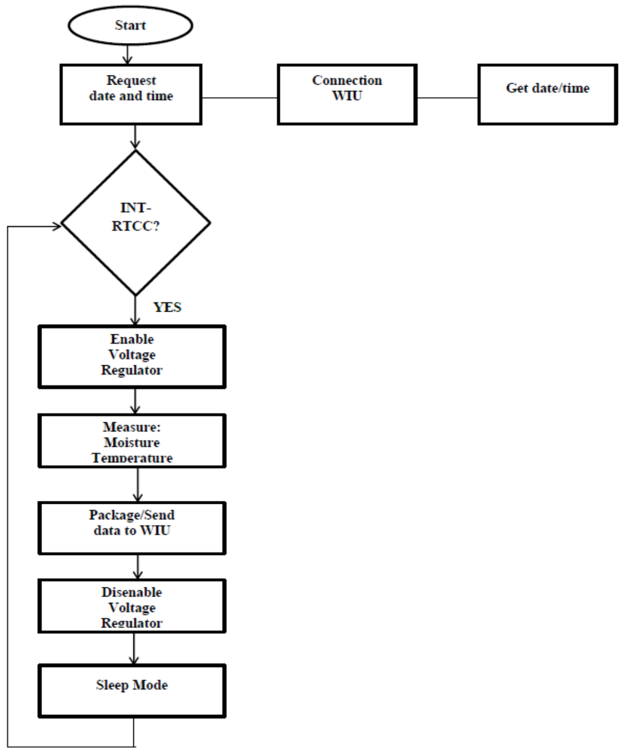


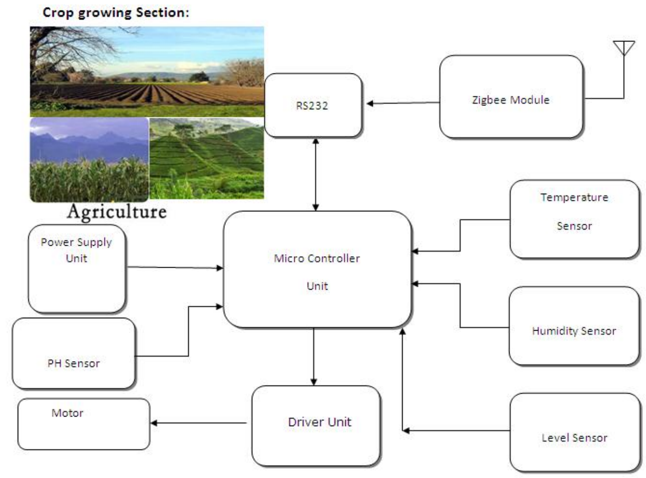

Fig.3 Flowchart of wireless sensor unit (WSU) for monitoring the soil moisture and temperature

*B. Wireless Information Unit(WIU)*

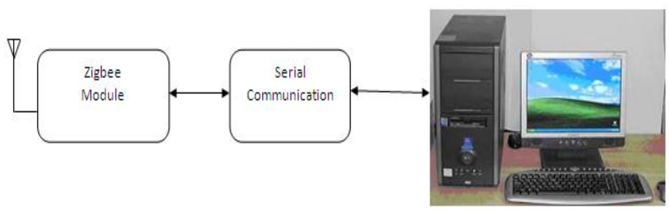
The soil moisture and temperature data from each WSU are received, identified, recorded, and analyzed in the WIU. The WIU consists of a master microcontroller PIC24FJ64GB004, an ZigBee radio modem, a GPRS module MTSMC-G2-SP (MultiTech Systems, Mounds View, MN), an RS-232 interface MAX3235E (Maxim Integrated, San Jose, CA), two electronic relays, two 12 V dc 1100 GPH Live well pumps (Rule-Industries, Gloucester, MA) for driving the water of the tanks, and a deep cycle 12 V at 100-Ah rechargeable battery L-24M/DC-140 (LTH, Mexico), which is recharged by a solar panel KC130TM of 12 V at 130 W (Kyocera, Scottsdale, AZ) through a PWM charge controller SCI-120 (Syscom, Mexico). All the WIU electronic components were encapsulated in a waterproof PVC box as shown in Figs. 5 and 6. The WIU can be located up to 1500-m line-of-sight from the WSUs placed in the field.

## IV. BLOCK DIAGRAM

In-Field Sensing Stations:




Base Station:




## VI. BLOCK DIAGRAM DESCRIPTION

*A. PIC 16F877A:*

Microchip, the second largest 8-bit microcontroller supplier in the world, (Motorola is ranked No: 1) is the manufacturer of the PIC microcontroller and a number of other embedded control solutions. PIC microcontrollers are based on Harvard architecture. Harvard architecture has the program memory and data memory as separate memories which are accessed using the same bus. PIC microcontrollers have a data memory bus of 8-bit and a program memory bus of 12, 14 or 16 bit length depending on the family. All PIC microcontrollers have a mix of different on-chip peripherals like A/D converters, Comparators, weak pull-ups, PWM modules, UARTs, Timers, SPI, I2C, USB, LCD, and CAN etc.

PIC microcontrollers come in various sizes, from the 6-pin smallest microcontroller in the world to the high pin count, high memory devices. But from a student's/hobbyist's perspective the 16F series of PICs are the most ideal to start with and out of them the PIC16F84 seems to be the most popular microcontroller.

*a. Special Features:*

• 100,000 erase/write cycle Enhanced Flash program memory typical
• 1,000,000 erase/write cycle Data EEPROM memory typical
• Data EEPROM Retention > 40 years
• Self-reprogrammable under software control
• In-Circuit Serial Programming™ (ICSP™) via two pins

- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options

*B. Serial Communication-*

Serial communication is basically the transmission or reception of data one bit at a time. Today's computers generally address data in bytes or some multiple thereof. A byte contains 8 bits. A bit is basically either a logical 1 or zero. Every character on this page is actually expressed internally as one byte. The serial port is used to convert each byte to a stream of ones and zeroes as well as to convert a stream of ones and zeroes to bytes. The serial port contains a electronic chip called a Universal Asynchronous Receiver/Transmitter (UART) that actually does the conversion.

When transmitting a byte, the UART (serial port) first sends a START bit which is a positive voltage (0), followed by the data (general 8 bits, but could be 5, 6, 7, or 8 bits) followed by one or two STOP bits which is a negative(1) voltage. when transmitting a character there are other characteristics other than the baud rate that must be known or that must be setup. The first characteristic is the length of the byte that will be transmitted. This length in general can be anywhere from 5 to 8 bits. The second characteristic is parity. The parity characteristic can be even, odd, mark, space, or none. If even parity, then the last data bit transmitted will be a logical 1 if the data transmitted had an even amount of 0 bits. If odd parity, then the last data bit transmitted will be a logical 1 if the data transmitted had an odd amount of 0 bits. The third characteristic is the amount of stop bits. This value in general is 1 or 2. Assume we want to send the letter 'A' over the serial port. The binary representation of the letter 'A' is 01000001. Remembering that bits are transmitted from least significant bit (LSB) to most significant bit (MSB), the bit stream transmitted would be as follows for the line characteristics 8 bits, no parity, 1 stop bit and 9600 baud. LSB (0 1 0 0 0 0 0 1 0 1) MSB.

The above discussion was concerned with the "electrical/logical" characteristics of the data stream. We will expand the discussion to line protocol. Serial communication can be half duplex or full duplex. Full duplex communication means that a device can receive and transmit data at the same time. Half duplex means that the device cannot send and receive at the same time. It can do them both, but not at the same time. Half duplex communication is all but outdated except for a very small focused set of applications.

Half duplex serial communication needs at a minimum two wires, signal ground and the data line. Full duplex serial communication needs at a minimum three wires, signal ground, transmit data line, and receive data line. The RS232 specification governs the physical and electrical characteristics of serial communications. This specification defines several additional signals that are asserted (set to logical (1) for information and control beyond the data signal

*C. Null Modem*

Serial communications with RS232. One of the oldest and most widely spread communication methods in computer world. The way this type of communication can be performed is pretty well defined in standards[13]s. I.e. with one exception. The standards show the use of DTE/DCE communication, the way a computer should communicate with a peripheral device like a modem. For your information, DTE means Data Terminal Equipment (computers etc.) where DCE is the abbreviation of Data Communication Equipment (modems).

One of the main uses of serial communication today where no modem is involved—a serial null modem configuration with DTE/DTE communication—is not so well defined, especially when it comes to flow control. The terminology null modem for the situation where two computers communicate directly is so often used nowadays, that most people don't realize anymore the origin of the phrase and that a null modem connection is an exception, not the rule.

A safe option when finalizing your figures is to strip out the fonts before you save the files, creating "outline" type. This converts fonts to artwork what will appear uniformly on any screen.

amed similarly to figures, except that '.t' is inserted in-between the author's name and the table number. For example, author Anderson's first three tables would be named ander.t1.tif, ander.t2.ps, ander.t3.eps.

Author photographs should be named using the first five characters of the pictured author's last name. For example, four author photographs for a paper may be named: oppen.ps, moshc.tif, chen.eps, and duran.pdf.

If two authors or more have the same last name, their first initial(s) can be substituted for the fifth, fourth, third... letters of their surname until the degree where there is differentiation. For example, two authors Michael and Monica Oppenheimer's photos would be namedoppmi.tif, and oppmo.eps.

## VII. SOFTWARE TOOLS

Mplab IDE

Pic Kit2 Programmer

Orcad- Capture

Layout

*a) Mplab IDE-*

MPLAB IDE is a Windows Operating System (OS) software program that runs on a PC to develop applications for Microchip microcontrollers and digital signal controllers. It is called an Integrated Development Environment, or IDE, because it provides a single integrated "environment" to develop code for embedded microcontrollers.

*b) ORCAD*

ORCAD really consists of tools. Capture is used for design entry in schematic form. You will probably be already familiar with looking at circuits in this form from working with other tools in your university courses. Layout is a tool for designing the physical layout of components and circuits on a PCB.

## VIII. HARDWARE TOOLS

1. Zigbee
2. Temperature sensor.
3. MAX 232.
4. GPS.

*a) Zigbee-*

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth[14]. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee is a low-cost, low-power, wireless mesh networking standard. First, the low cost allows the technology to be widely deployed in wireless control and monitoring applications. Second, the low power-usage allows longer life with smaller batteries. Third, the mesh networking provides high reliability and more extensive range.

*b) Max 232-*

MAX-232 is primary used for people building electronics with an RS-232 interface. Serial RS-232 communication works with voltages (-15V ... -3V for high) and +3V ... +15V for low) which are not compatible with normal computer logic voltages. To receive serial data from an RS-232 interface the voltage has to be reduced, and the low and high voltage level inverted. In the other direction (sending data from some logic over RS-232) the low logic voltage has to be "bumped up", and a negative voltage has to be generated, too. A standard serial interfacing for PC, RS232C, requires negative logic, i.e., logic '1' is -3V to -12V and logic '0' is +3V to +12V. To convert TTL logic, say, TxD and RxD pins of the microchip chips thus need a converter chip. A MAX232 chip has long been using in many microchip boards. It provides 2-channel RS232C port and requires external 10uF capacitors. Carefully check the polarity of capacitor when soldering the board.

*c) GPS-*

The Global Positioning System (GPS)[14] is a space-based global navigation satellite system (GNSS) that provides reliable location and time information in all weather and at all times and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver. In addition to GPS other systems are in use or under development. The Russian GLObal NAvigation Satellite System (GLONASS) was for use by the Russian military only until 2007. There are also the planned Chinese Compass navigation system and Galileo positioning system of the European Union (EU). GPS was created and realized by the U.S. Department of Defense (USDOD) and was originally run with 24 satellites. It was established in 1973 to overcome the limitations of previous navigation systems. A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth[14]. Each satellite continually transmits messages that include

- the time the message was transmitted
- precise orbital information (the ephemeris)
- the general system health and rough orbits of all GPS satellites (the almanac).

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites' locations are used with the possible aid of trilateration, depending on the algorithm is used, to compute the position of the receiver. This position is then displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units show derived information such as direction and speed, calculated from position changes.

Three satellites might seem enough to solve for position because space has three dimensions and a position near the Earth's surface can be assumed. However, even a very small clock error multiplied by the very large speed of light- the speed that the satellite signals propagate-results in a large positional error. Therefore receivers use four or more satellites to solve for the receiver's location and time. The very accurately computed time is effectively hidden by most GPS applications, which use only the location. A few specialized GPS applications[15] do however use the time; these include time transfer, traffic signal timing, and synchronization of cell phone base stations.

## IX. CONCLUSION

The automated irrigation system implemented was found to be feasible and cost effective for optimizing water resources for agricultural production. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability. The automated irrigation system developed proves that the use of water can be diminished for a given amount of fresh biomass production. The use of solar power in this irrigation system is pertinent and significantly important for organic crops and other agricultural products that are geographically isolated, where the investment in electric power supply would be expensive.

## ACKNOWLEDGMENT

This paper is aimed towards implementation of WSN and GPRS for irrigation ststem by suggesting solutions for various problems faced while implementing WSN in real world. All requirements are to be achieved from WSN and functional specifications are studied here

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