Zig Bee Technology and Sensor Network in Irrigation Control Monitoring System

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Abstract: ***In this part of my research we developed a system which will tackle part of the problem by trying to improve the efficiency of water use in irrigation systems which include the design of decision support software and its integration with an in-field wireless sensor network to implement water pumping irrigation control via Zig bee Technology In our system we have tried to automate the water pumping system to pump the water whenever the prescribed water level or humidity of the soil goes down below prescribed threshold for which water level sensor & Humidity sensor has been taken into account . If the water level is increased beyond the prescribed level during rain or flood, our system automatically lets the extra water and recycles them back to the water tank. Our system also senses the wind speed to predict any storm, other natural calamities and warns the farmer by sending him an SMS using a GSM Technology. For safety purpose we also have fire and temperature sensors to alert the farmer on any kind of such eventualities. The prescribed water level for a crop varies depending on different crops and nature of the soil, so we have developed a user interface to feed the type of soil and crop to automatically set the water level. The farmer is able to control and monitor the field using his PC which is connected to the control system via Zig bee in this situation the web interface provides an excellent platform from which to develop the system. The portability of this technology means that the system could be controlled from anywhere in the world (This phenomena is my complete research).***

Keywords: Zig bee, GSM, SMS, Sensor**,** A Farmer

1. Introduction

Agriculture in Tanzania is playing a major role in contribution to the country economy and is highly dependent on water resources. After the liberalization of the economy in last two decades, increased food production and traditional and non-traditional exports created greater demand of water for irrigation. As it has been known that water resources are getting dried all over the world Water restrictions have been in place in most places for several years now to try to limit water consumption. Common methods of water distribution can be enhanced or replaced by using recent technological advances. I hope to use it to improve the efficiency of water distribution, to automate the process of irrigation management, to provide an easy to use programming and reporting interface, and to provide a scalable, versatile base from which to expand or modify if needed. One of the main drawbacks with the old fashioned auto timer system is that they do not cater for changing environmental conditions. Temperature, wind, rainfall and other elements can dramatically affect the amount of water needed to sustain a plants health. If these elements were monitored and used to influence the watering cycles, then the water used should be more effective. Another aspect of regular irrigation systems that could be improved is its user interface. Once the basic requirements of the project had been established (sensor driven, Zig bee interface, high automation), the lengthy process of deciding what hardware to use and what software should tie it all together was undertaken. This took a quite some time as there were many alternatives on the market to choose from. Eventually a microcontroller was chosen for the heart of the system. A PC based solution could have been designed easier but a microcontroller based solution meant that the system was more independent and hopefully more reliable, with cheaper running costs. Most of the sensors needed for the system have been cheaply produced using discrete components in conjunction with an analogue to digital converter.

2. Schematic Diagram

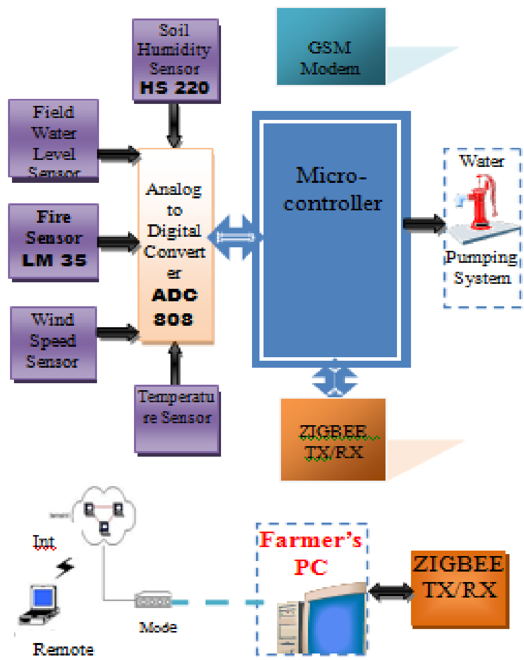

Figure 1: Block diagram of irrigation monitor & control using distributed Wireless Sensor network

2.1 The Microcontroller

Despite it's relatively old age, the 8051 is one of the most popular microcontrollers in use today. Many derivative microcontrollers have since been developed that are based on--and compatible with--the 8051. Thus, the ability to program an 8051 is an important skill for anyone who plans to develop products that will take advantage of microcontrollers. A micro-controller can be compared to a small standalone computer; it is a very powerful device, which is capable of executing a series of pre-programmed tasks and interacting with other hardware devices [2]. Being packed in a tiny integrated circuit (IC) whose size and weight is usually negligible, it is becoming the perfect controller for irrigation monitor and control using wireless distributed sensor network. A single microcontroller can be sufficient to control the entire system. Any microcontroller contains a memory to store the program to be executed, and a number of input/output lines that can be used to interact with other devices, like reading the state of a sensor or controlling [1].

2.2 GSM Technology

The Global System for Mobile communications (GSM) is the most popular standard for mobile phones in the world. The GSM platform is a hugely successful wireless technology and an unprecedented story of global achievement and cooperation. Most GSM systems operate in the 900 MHz and 1.8 GHz frequency bands, except in North America where they operate in the 1.9 GHz band.

In my system the GSM is playing a role of giving an a notification to the farmer regarding the status of the field for instance if the field catch fire the smoke sensor will sensor and the SMS will be sent to the farmer stating that there is a "fire in the farmer" others SMS is about while the Pump system is on or off message will be sent to the farmer stating that "Motor is ON" & "Motor is OFF" also for wind parameter SMS stating "Wind is High on the Field " and for Flood alert SMS is "Flood" .

A unique feature of GSM, found in older and analog system, is a Short Message Service (SMS) which .SMS is a bidirectional service for short alphanumeric (up to 160bytes) messages. For point-to-point SMS a message can be sent to another subscriber to the service, and an acknowledgment of receipt is provided to the sender. MS can also be used in a cell-broadcast mode, for sending alert messages during natural calamities like fire and flood. Messages can also be stored in the SIM card for later retrieval [4].

2.3 Zig bee Technology

The past several years have witnessed a rapid growth of wireless networking. However, up to now wireless networking has been mainly focused on high-speed communications, and relatively long range applications such as the IEEE 802.11 Wireless Local Area Network (WLAN) standards. The first well known standard focusing on Low-Rate Wireless Personal Area Networks (LR-WPAN) was Bluetooth. However it has limited capacity for networking of many nodes. There are many wireless monitoring and control applications in industrial and home environments which require longer battery life, lower data rates and less complexity than those from existing standards. For such wireless applications, a new standard called IEEE 802.15.4 has been developed by IEEE. The new standard is also called Zig Bee, when additional stack layers defined by the Zig Bee Alliance are used. The low-cost hardware is 802.15.4 Standard compatible at the over-the-air level by its design, but as communication services become more complex or have higher levels of compatibility with standards, the software and development demands can become more costly. As with any product, a wireless application can have varying demands of cost, performance, and time-to-market goals, and these will drive the selection of the communication services. Two parts,

2.3.1 Zig bee Protocol Architecture

ZigBee stack architecture follows the standard Open Systems Interconnection (OSI) reference model, Zig bee's protocol stack is structured in layers. The first two layers, physical (PHY) and media access (MAC), are defined by the IEEE 802.15.4 standard. The layers above them are defined by the ZigBee Alliance. The model has five layers namely are Physical (PHY) layer, Media access control (MAC)layer, Network (NWK) and security layers ,Application framework and Application profiles

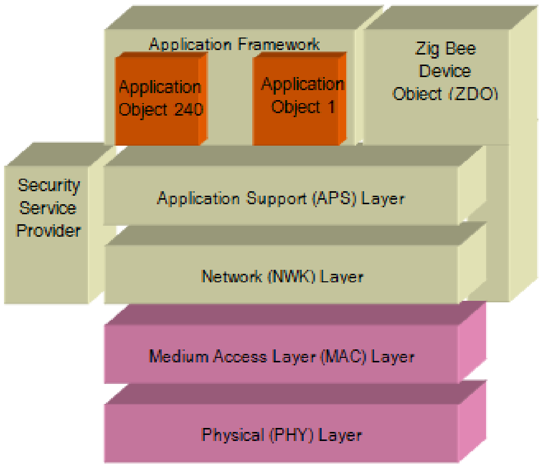

Figure 2: Zig bee Stack Model

2.3.2 Serial Communication

The XBee ZNet 2.5 OEM RF Modules interface to a host device through a logic-level asynchronous serial port (figure 2-4). Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device (For example: Through a Digi proprietary RS-232 or USB interface board).

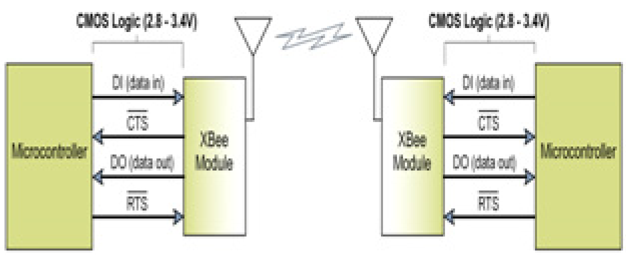

Figure 3: System Data Flow

2.3.3 Model of Operation

(a) **Idle mode:** When not receiving or transmitting data, the RF module is in idle mode. In Idle Mode, the RF module is also checking for valid RF data.
(b) **Receive mode**: If a valid RF packet is received, the data is transferred to the serial transmit buffer.
(c) **Transmitting mode:** When serial data is received and is ready for packetization, the RF module will exit Idle Mode and attempt to transmit the data (figure 2-7). The destination address determines which node(s) will receive the data. Prior to transmitting the data, the module ensures that a 16-bit network address and route to the destination node have been established. If the destination 16-bit network address is not known, network address discovery will take place.

Figure 4: 2-6 Zig bee Module

2.4 Sensor Network

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example temperature sensor, humidity sensor, water level sensor etc.

2.4.1 Temperature Sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The temperature sensor LM35 is used to measure the temperature around the field. In case of events like fire in the field, this sensor will detect and respond to very high temperature. The system's response is to send an SMS alert to the farmer. The farmer will quickly call emergency service an act on time.

2.4.2 Humidity Sensor

A humidity sensor senses relative humidity. This means that it measures both soil temperature and moisture. Relative humidity, expressed as a percent, is the ratio of actual moisture in the soil to the highest amount of moisture soil at that temperature can hold. The warmer the soil is, the more moisture it can hold, so relative humidity changes with fluctuations in temperature. The most common type of humidity sensor uses what is called "capacitive measurement." This system relies on electrical capacitance, or the ability of two nearby electrical conductors to create an electrical field between them. The sensor itself is composed of two metal plates with a non-conductive polymer film between them. The film collects moisture from the air, and the moisture causes minute changes in the voltage between the two plates. The changes in voltage are converted into digital readings showing the amount of moisture in the air.

2.4.3 Soil Moisture Sensor

A predefined moisture threshold is used as a reference to control the water pumping if needed. If the water level is less than a predefined value then our sensor will detect this and will inform the system to pump the water. On the other hand if it exceeds the threshold value and the water pump is ON then our system will switch OFF the water pump. This will allow efficient usage of water. Soil moisture levels can be expressed in terms of soil water content.

Soil water content: Most commonly expressed as percent water by weight, percent water by volume or inches of water per foot of soil. Other units such as inches of water per inch of soil also are used [10].

(a) **Water content by weight** is determined by dividing the weight of water in the soil by the dry weight of the soil. It can be converted to percent by multiplying by 100%.
(b) **Water content by volume** is obtained by multiplying the water content by weight by the bulk density of the soil. Bulk density of the soil is the relative weight of the dry soil to the weight of an equal volume of water. Bulk density for typical soils usually varies between 1.5 and 1.6.
(c) **Inches of water per foot** of soil is obtained by multiplying the water content by volume by 12 inches per foot. It also can be expressed as inches of water per inch of soil which is equivalent to the water content by volume. By determining this value for each layer of soil, the total water in the soil profile can be estimated.

2.5 I2C Protocol

The AT24C01A/02SC/04SC/08SC/16SC provides1024/2048/4096/8192/16384 bits of serial, electrically-erasable and programmable read-only memory (EEPROM) organized as 128/256/512/1024/2048 words of 8 bits each. The devices are optimized for use in smart card applications where low-power and low-voltage operation may be essential. The devices are available in several standard ISO 7816 smart card modules (see Ordering Information). The entire family is available in both high-voltage (4.5V to 5.5V) and low-voltage (2.7V to 5.5V) versions. All devices are functionally equivalent to Atmel serial EEPROM products offered in standard IC packages (PDIP, SOIC, EIAJ, LAP), with the exception of the slave address and Write Protect functions, which are not required for smart card applications

3. Zig bee & System Flow Diagram

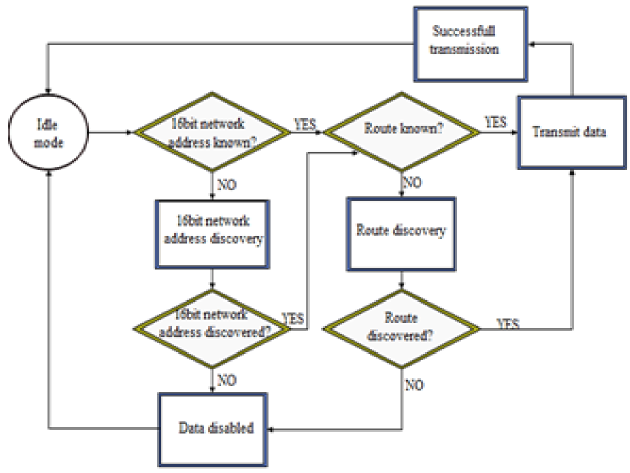

Figure 5: Flow of transmit mode sequence of Zig bee

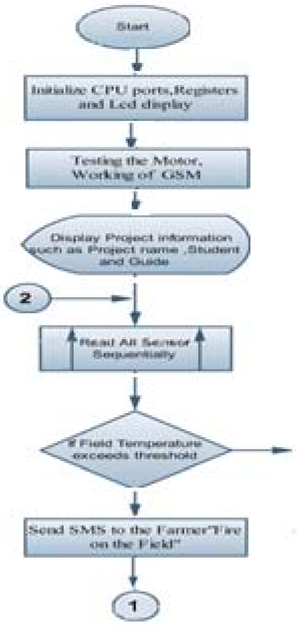

Figure 6: System Flow Diagram

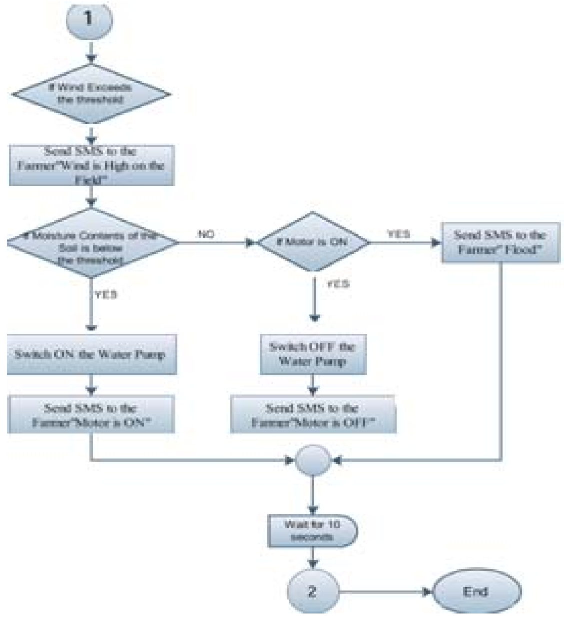

Figure 7: Main Menu

If the Farmer entered his or her choice as "1", he or she will be able to monitor the current sensor values; the following output screen displays the current reading of the sensors such as Humidity, temperature, wind speed, water level and soil moisture.

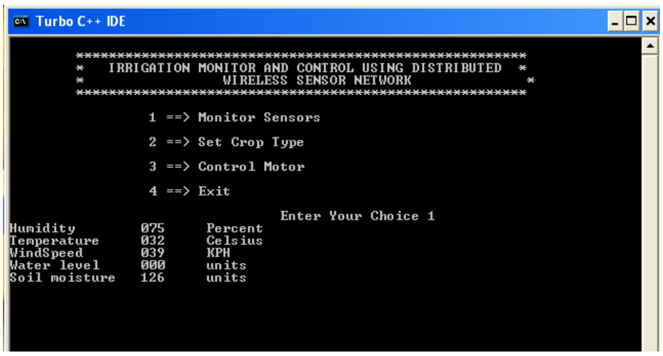

Figure 8: Sensor Value Display

4. Result and Analysis

While at home the farmer has the ability to Monitor the Sensors, set crop type and control the valve from his home PC using the platform which was designed by using C&C++ [3]. These choices are labeled as 1, 2, 3 or 4 as shown in the figure below.

Let's say in the main menu, the farmer selects choice 2.He will be able to select the soil and crop types. The soil type may contain red soil, black soil or brown soil. Also for a particular soil type, any crop type is selected. After making one of these choices he or she will observe the threshold value. Different combinations of soil and crop types will be displayed on the screen of fig 9.

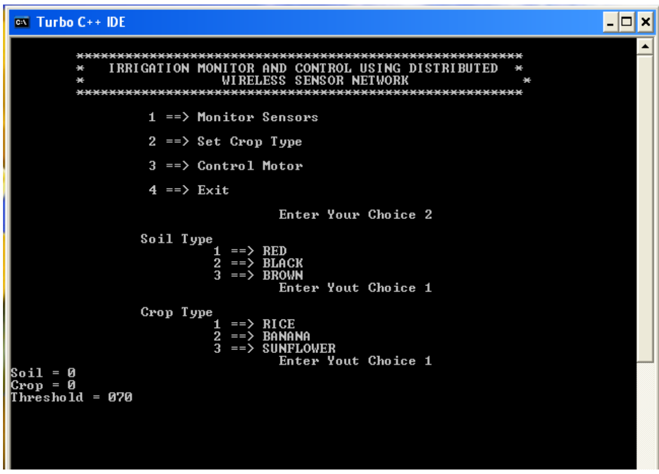

Figure 9: Setting Soil and Crop type

Choice 3 of the main menu allows the farmer to manually turn ON and OFF the motor. This is shown in figure 10

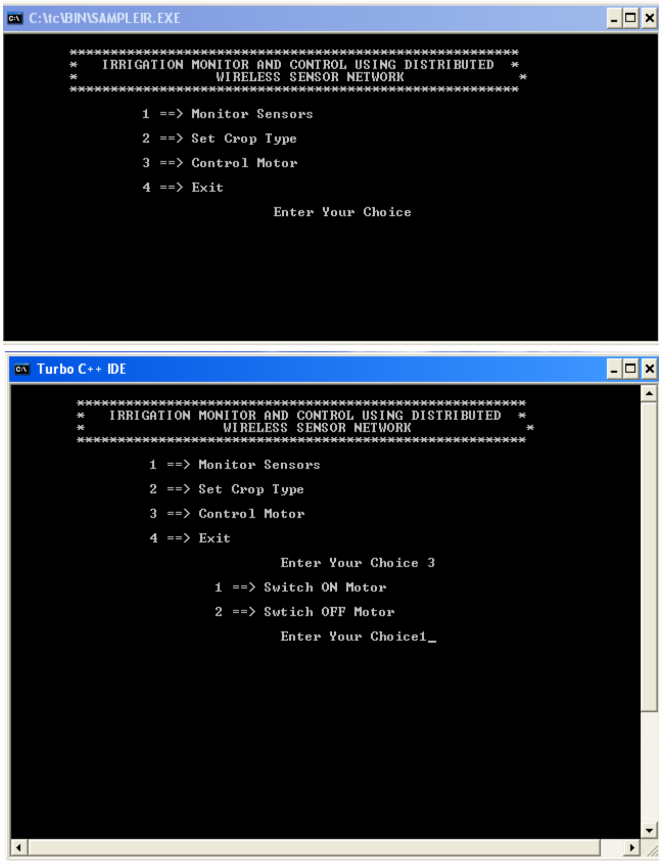

Figure 10: Manual Motor Control

5. Conclusion

What we managed to discover in the process of design and implementation of our project is that by combining the technologies of automation in the area of reticulation and weather sensing equipment, more efficient water delivery can be made possible. This can be achieved while maintaining simplicity, ease of use and ease of Implementation. The use of Zig bee allows the flexibility in the system from the farmer point of view. The GSM interface used will be helpful for the farmer to receive notifications of the events occurring in the field and also about environmental changes near the field like cyclone, fire in the field and flood. Microcontroller has been reasonably easy to get up and developing as well as being very flexible. Occasionally the microcontroller would need resetting, which meant disconnecting the power source and reapplying it seconds later. This could have been caused by power supply fluctuations, faulty components, moisture in the controller or an undiscovered fault. We found it a bit disappointing that soil moisture sensors were priced out of reach as they could have simplified the process of estimating water requirements for the vegetation.

6. Future Scope

With the phenomenal growth of the Internet in the last decade , the use of a web browser interface has not only become the standard for viewing pages on the World Wide Web but has become more pervasive as a means of collecting user input or providing the output / status of control systems. The scope of improvement of my project is that web interface provides an excellent platform from which to develop the system. The portability of this technology means that the system could be controlled from anywhere in the world [6]. At the end of my research I will be able to describes how Web Technology enhancement in water management and instrumentation of 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 several in-field sensor stations distributed across the field based on a soil property map, and periodically sampled and wirelessly transmitted to a base station using Zig bee technology

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Author Profile

Lewis Ndaro is holding a BE EC from Acharya Institute of Technology under Visvesvarayah Technological University, Belgam Karnataka, India. During 2006-2010 and M.E degrees student in Electronics Engineering from Tianjin University of Technology and Education, Tianjin City, P.R China respectively from 2011-2014, he worked at Bam International as IT support Engineer, Later on he decided to go for further study in the area of Signal and Information processing, his area of interest is in Embedded domain, communication and wireless access network domain,. He is also a Microsoft Certified Technology Specialist (MCTS). He is now work as independent ICT consultant