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Wireless Sensor Network Based Low Power Embedded System Design For Automated Irrigation System Using MSP430

Mr. Patil Vikas Anandrao.
M Tech. Student (Digital Systems)
Rajarambapu Institute of Technology, sakharale, 415414

Prof. R. T. Patil.
Associate Professor
Rajarambapu Institute of Technology, sakharale, 415414

Abstract

Now a day's due to global warming and climate changes there are challenging situations in field of agriculture. To reduce the cost and improve the productivity along with product quality the automisation in the field of agriculture is indeed necessary, which will also reduce the farmer's efforts. This paper proposes a design of a wireless sensor network (WSN) with the help of MSP430 controller which is able to monitor the temperature, humidity, soil moisture and status of rain in an agriculture environment. This system also controls the water supply demand to crops depending upon present climate conditions within the crop field. This system utilizes low power, cost effective microcontroller MSP430, a temperature sensor LM35, humidity sensor SYSH220, rain detector, soil moisture sensor for sensing the field climate parameters and a wireless Zigbee transceiver for remote logging of data at central location to control the climate state with the help of motor and valve control circuitry.

***Keywords**: wireless sensor network, MSP430 controller, Zigbee, LM35, SYSH220.*

1. Introduction

India being an agricultural country needs some innovation in the field of agriculture. Now a day's the demand of farm products Increasing due to population growth and limited resources of irrigation. The water has made the field irrigation management system as an important element of agricultural activity. Traditional methods of irrigation not only require water in quantity but percentage of water wastage is also high. Globally water is becoming a scarce resource that instigating the need of controlled crop irrigation.

Due to uneven natural distribution of rain water it is very crucial for farmers to monitor and control the equal distribution of water to all crops in the whole farm or as per the requirement of the crop. There is no ideal irrigation method available which may be suitable for all weather conditions, soil structure and variety of crops cultures. It is observed that farmers have to bear huge financial loss because of wrong prediction of weather and incorrect irrigation method to crops.

Several different methods are now being used like drip irrigation, sprinkler irrigation etc. that provide controlled water supply but some software support is also needed for decision making like where and how much watering is desired. Such intelligent irrigation is an essential part of smart agriculture. Different framework to develop intelligent and autonomous systems been offered specifically for agriculture domain.

The proposed system is intended to provide portable, scalable and affordable solution to achieve optimized usage of water supply. It collects on field data like atmosphere temperature and soil moisture with the help of Wireless Sensor Networks (WSN). The collected data stored in the centralized data server. On the basis of these data, an expert system generates a decision about the need of water irrigation in the field. Optimized usage of water reduces the wastage of water and also increases the production.

2. The System Structure

2.1. Overall System Architecture

The system architecture is as shown in figure.1. System consists of slave1, 2, 3 as sensor nodes and master control unit with wireless zigbee module.

The master node will collect the information of temperature, humidity, soil moisture, rain detection these parameters from slave nodes and depending on values of slave sensor nodes, the PC or master will give command to the motor and valve driver circuitry of slave 1 through wireless Zigbee module and then motor valves will start doing operation.

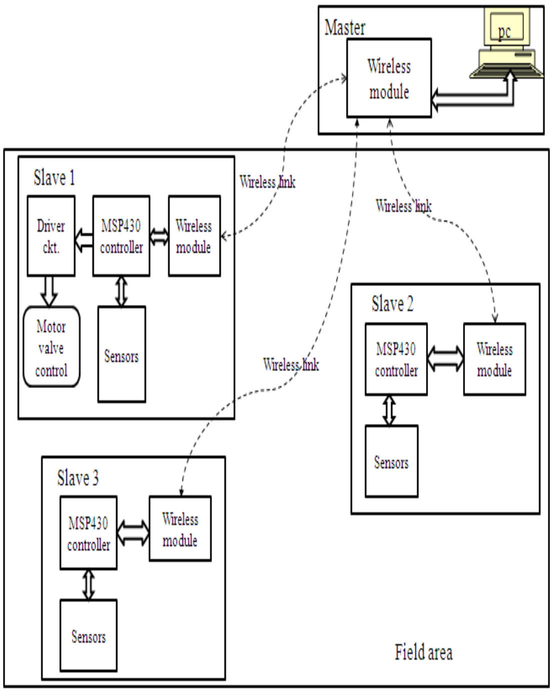


Figure.1 System architecture

2.2. Master Node Architecture

The master node architecture is as shown in figure.2. The master node and the slave nodes will be deployed with unique ID. The master node will send request packet to slave node ID via zigbee wireless module. In response the requested slave sensor node sends the data packet of four type's sensors values to the master node ID which provides routing security to the network.

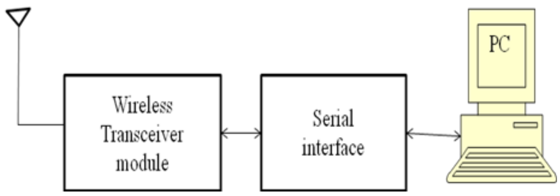


Figure.2 Master node architecture

2.3. Slave Sensor Node Architecture

The proposed node system of wireless sensor network consists of Zigbee wireless transceiver module, low power MSP430 as MCU of the system and sensors of temperature, humidity, rain detection and soil moisture and motor valve control circuit for controlling the solenoid valves. SPI serial communication port connects the Zigbee wireless communication module and the microcontroller module. The Slave sensor node architecture is as shown in figure.3.

The slave node 1 is same as slave node 2 and 3 only the motor valve control circuitry is absent in slave node 2 and 3 which is used to control the valve mechanism.

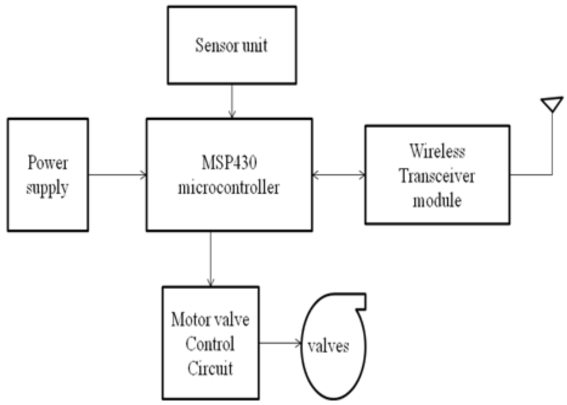


Figure.3 Slave sensor node Architecture

The MSP430 controller is low power and cost effective and uses five low-power modes. The MSP430G2553 series are ultra-low-power mixed signal microcontrollers with built-in 16-bit timers, up to 24 I/O touch-sense-enabled pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface. In addition have a 10-bit analog-to-digital (A/D) converter.

Wireless Zigbee module Tarang F4 is IEEE 802.15.4 compatible wireless communications standard. It operates on 3.3v. Its operating frequency is ISM 2.4 GHz. RF data rate is 250 kbps. Indoor Communication range is 100 ft (30 m) and outdoor line-of-sight range is 300 ft (90 m).

The Soil moisture sensor circuit designed uses a 5V supply, two copper leads as the sensor probes. It gives a voltage output corresponding to the conductivity of the soil. Soil depends upon the amount of moisture present in it. It increases with increase in the water content of the soil.

The humidity sensor module SY-SH220 converts relative humidity (30-90%RH) to voltage with linearity of 0.33mV/%RH and can be used in weather monitoring application.

The rain detector is a small piece of PC board etched to the pattern. The traces are very close to each other, but never touching. The circuit is open circuit before raining and after raining the circuit becomes short so we will get sudden drop of voltage.

The temperature sensor LM35 is precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature as + 10mV/°C. The LM35 is rated to operate over a −55° to +150°C temperature range.

3. wireless Sensor Network

Consider the sensor node routing protocols where each sensor communicates either directly or indirectly with a base station. The protocol provided for a multi-hop scenario where the range of a base station is extended employing nodes that are adjacent to the base station to serve as intermediaries for non-adjacent nodes.

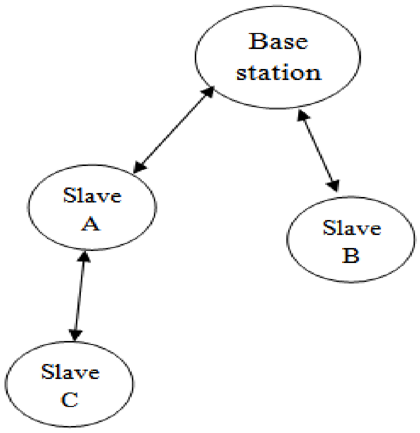


Figure.4 Base station, adjacent sensor nodes A, B and non adjacent node C

Figure 4 shows the network module in which base station is adjacent with slave A, B and non adjacent with slave C.

Start of frame	Senders address	Receivers address	Command or data	End of frame

Preamble header payload

Figure.5 Message format

Figure.5 shows the message format in which the preamble contains the address of the sending node. The header contains the recipient's address. The payload contains a command or data exchanged between the node and the base station. The base station is deployed with the unique ID and symmetric encryption key of each node in the micro sensor network. Similarly, each node is deployed with the unique ID that it shares with the base station and its clock is synchronized with the base station's clock.

3.1. Data Transmission In Adjacent Node

A node is called an adjacent node if it is within the broadcast range of the base station. The base station sends a REQUEST command for sensor data to each node. If the node A REPLY with a sensor values, then the node A is adjacent to the base station and the base station adds that node to its route table. This is illustrated in figure 6.

	Start of frame	Senders address	Receivers address	Command or Data	End of frame
BS → A	0X0A	Address of BS	Address of A	REQ command for sensor data	0X0D
BS ← A	0X0A	Address of A	Address of BS	REPLY with sensor Data	0X0D

Fig. 6 Data transmission in adjacent node

3.2. Data Transmission in Non Adjacent Node

A non-adjacent node is one which is not reachable directly by the base station (Figure.7). The base station tries all the adjacent nodes to reach the non-adjacent node.

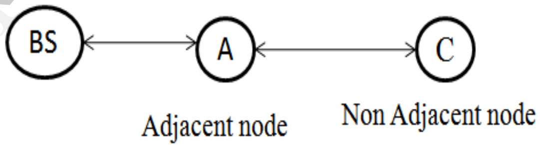


Figure.7 Network model

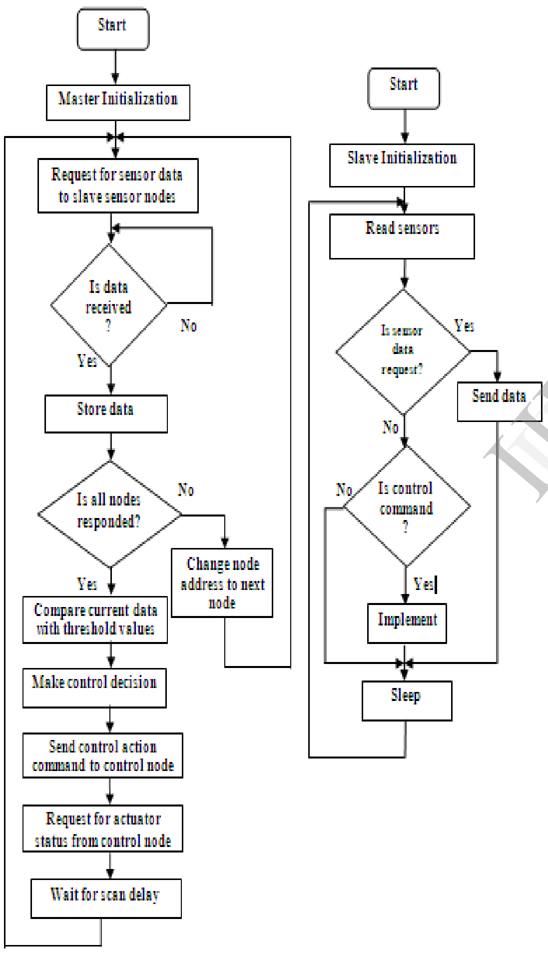
The base station sends a message containing the REQUEST command to be forwarded to the non-adjacent node, to each of the adjacent nodes. The adjacent node adds the address of slave C at Header and transmits the new message to the non-adjacent node which contains the REQUEST command (figure.8).

	Start of frame	Senders address	Receivers address	Command or data	End of frame
BS → A	0X0A	Address of BS	Address of A	REQ command for sensor data	0X0D
A → C	0X0A	Address of A	Address of C	REQ command for sensor data	0X0D
A ← C	0X0A	Address of C	Address of A	REPLY with sensor Data	0X0D
BS ← A	0X0A	Address of A	Address of BS	REPLY with sensor Data	0X0D

Figure.8 Data transmission in non adjacent node

To respond to the REQUEST command, the non adjacent node C constructs a REPLY message with measured sensor values and shares it with the base station. The message is transmitted adding the adjacent nodes address to the header and address of C at preamble In turn, the adjacent node receives the transmission which changes the header as address of Base Station and adds the preamble as an address of A and transmits it to the base station. The base station after receiving the REPLY adds the adjacent node A as one of the route to reach the non-adjacent node C.

4. The Software Structure



(a) (b)

Figure.9 Flow chart of (a) master node and (b) salve node

The program of slave sensor node controller is designed to collect the soil moisture, temperature, rain detection and humidity information, and communicate with the master node every 2 minutes by the wireless Zigbee transceiver module. The master also have to decide whether the farmland needs to be irrigated according the threshold values of temperature and moisture set by the remote computer. All controllers will be at the sleep mode when off work. Above Figure.9 shows the flow chart of master and salve node.

5. Results

Wireless Zigbee module is configured as master or base station. It is connected with the host PC via serial port. Data received by host PC is shown on the screen by the GUI (Graphical User Interface) developed in Visual Basic 6 shown in figure 10 below. It shows the temperature, detected rain, humidity and soil moisture information of every sensor node and depending on set points it operates the valve circuitry.

Figure.10 Graphical User Interface

This system also displays sensor data on the LCD which is connected to slave sensor nodes. Figure 11 shows the slave sensor node in which four sensors, LCD, Zigbee module are connected to msp430 board.

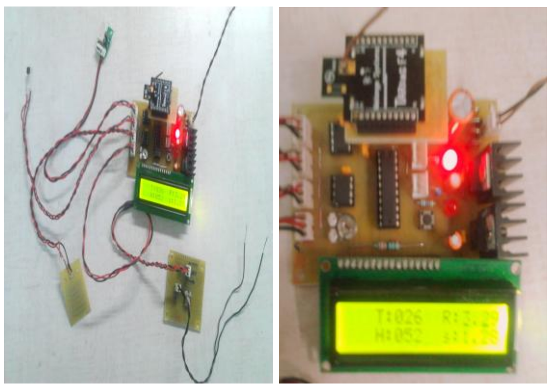


Figure.11 slave sensor node

5.1. Temperature Sensor (LM 35)

Table.1. Readings of Temperature sensor (LM 35)

Operating voltage	Condition	Output of sensor
5v	Normal	270mV
5v	Extreme	380mv

5.2. Humidity Sensor (SY-SH220)

Table.2. Readings of Humidity Sensor (SY-SH220)

Operating voltage	Condition	Output of sensor
5v	Normal	60
5v	Extreme	80

5.3. Soil moisture Sensor

Table.3 Readings of Soil moisture Sensor

Operating voltage	Condition	Output of sensor
5v	Normal	DRY
5v	Extreme	WET

5.4. Rain Detector

Table.4 Readings of Rain detector

Operating voltage	Condition	Output of sensor
5v	Normal	NO RAIN
5v	Extreme	RAIN

6. Conclusion

Increase in the productivity and overall profitability in agriculture is a need of the day. An efficient usage of water in the field is the key to achieve these. Proposed irrigation management system provides the intelligent way to provide water to only those places where it is needed and in the required quantity. Wireless Sensor Network works can be used as backbone to the proposed system and this system adopts MSP430 MCU with super low energy consumption.

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Authors:

Mr. Vikas A. Patil received BE Electronics from Rajarambapu Institute of Technology, Sakharale and now studying M.Tech (Digital Systems) in Rajarambapu Institute of Technology, Sakharale.

Prof. R.T. Patil received the ME in Electronics and currently working as associate professor in Rajarambapu Institute of Technology, Sakharale. His area of specialization is VLSI, Embedded Systems, Microprocessor and Microcontroller.