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Agriculture Field Monitoring using Wireless Sensor Networks to Improving Crop Production

J.Infantial Rubala[1], D. Anitha[2]
PG Student[1], Assistant Professor[2]
Department of CSE
Government College of Engineering, Tirunelveli, Tamilnadu, India

Abstract:
The wireless sensor network (WSN) is now a day widely used to build decision support for overcome many problems in real world. One of the most interesting fields having an increasing need of decision support systems is precision agriculture (PA). The purpose of this paper is to design and develop an agricultural monitoring system using wireless sensor network to increase the productivity and quality of farming without observing it for all the time manually. Temperature, humidity and water levels are the most important factors for the productivity, growth, and quality of plants in agriculture. The temperature, humidity and water level sensors are deployed to gather the temperature and humidity values. The sensor has to transmit the gathered information through the wireless communication network to the data server (cloud). The IOT gateway is in charge of the communication between the remote control serial devices and central control system. The farmers or the agriculture experts can observe the measurements from the web simultaneously. With the continuous monitoring of many environmental parameters, the grower can analyse the optimal environmental conditions to achieve maximum crop productiveness, for the better productivity and to achieve remarkable energy savings.

Keywords: Global Standards Initiative (GSI), Internet of Things (IOT), Precision Agriculture (PA), Wireless Sensors Network (WSN), Wireless Sensor and Actuator Network (WSAN).

1. INTRODUCTION

Wireless Sensor Networks (WSN), sometimes called Wireless Sensor And Actuator Network (WSAN) is a wireless network consisting of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes. To cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. When deployed in the field, the microprocessor automatically initializes communication with every other node in range, creating an ad hoc mesh network for relaying information to and from the gateway node. This negates the need for costly and ungainly wiring between nodes, instead relying on the flexibility of mesh networking algorithms to transport information from node to node.

A. USE OF WIRELESS SENSOR NETWORKS IN PRECISION AGRICULTURE

In this paper a Precision Agriculture has the benefit of providing real time feed-back on a number of different crop and site variables. As its name implies, Precision Agriculture is precise in both the size of the crop area it monitors as well as in the delivery amounts of water, fertilizer, etc. This technology can isolate a single plant for monitoring in the tens or hundreds of square feet. The WSN system requires a centralized control unit with user interface. Precision Agriculture requires a unique software model for each geographical area, the intrinsic soil type and the particular crop or plants. For example, each location will receive its own optimum amount of water, fertilizer and pesticide. It's generally recommended that data collection be done on an hourly basis. Frequent data collection doesn't't provide additional useful information for the software model and becomes a burden to the Wireless Sensor Network in terms of power consumption and data transmission. Less frequent monitoring may be acceptable for certain slow growth crops and areas that have very stable, uniform climate conditions. The data collection, monitoring and materials application to the crops allows for higher yields and lower cost, with less impact to the environment. Each area receives only what is required for its particular space, and at the appropriate time and duration. A general Agricultural application can be employed for: Large crop area monitoring, Forest / Vegetation monitoring, Forest fire prevention, Biomass studies, Tracking Animals, Crop Yield Improvement

B. WSN SYSTEM ARCHITECTURE

Wireless sensor networks pose unique challenges with regards to unit power consumption, heat transfer and overall size, so the security protocols used for sensor data protection must be efficient, resource friendly and fast. Formal verification is the process used to enable trust and security issues to be verified in relation to security protocol design for the information communications sector. This research program combines these topics and is concerned with the design and formal testing/ verification of cryptographic based security protocols suitable for use with wireless sensor systems to perform tasks such as: key agreement, key transport and node authentication. The WSN is erect 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 usually 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. A sensor node may vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of real microscopic features have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost restrictionon sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a easily understood star network to an advanced multi-hop wireless mesh network.

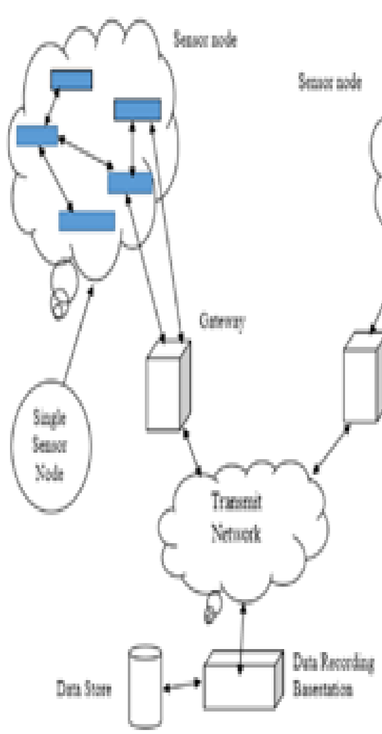

Figure. 1. WSN architecture

C. SENSORS

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. Sensors are sophisticated devices that are frequently used to detect and respond to electrical or optical signals. A Sensor converts the physical parameter (for example: temperature, blood pressure, humidity, speed, etc.) into a signal which can be measured electrically. The use of sensor in precision agriculture. Sensors have been used in precision agriculture to monitor and collect data of soil water availability, soil compaction, soil fertility, leaf temperature, leaf area index, plant water status, local climate data, insect-disease-weed infestation etc. Thesedata's can be collected by using

Different types of sensors.

Criteria to choose a sensor

There are certain features which have to be considered when we choose a sensor.

They are as given below:

1. Accuracy

2. Environmental condition - usually has limits for temperature/ humidity

3. Range - Measurement limit of sensor

4. Calibration - Essential for most of the measuring devices as the readings changes time

5. Resolution - Smallest increment detected by the sensor
6. Cost

7. Repeatability - The reading that varies is repeatedly measured under the same environment

Types of sensor deployment in precision agriculture:

TEMPERATURE SENSOR (LM35)

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). It can measure temperature more accurately than a using a thermostat.

HUMIDITY SENSOR HR 202

Humidity is an integrated circuit sensor that can be used to measure the presence of water in land. The HR202 is a new kind of humidity-sensitive resistor made from organic macromolecule materials, it can be used in occasions like: hospitals, storage, workshop, textile industry etc. The humidity sensor with its output proportional to the temperature (in RH %). The operating temperature range is from20-95%RH.

WATER LEVEL SENSOR

Water level floats sensor, also known as float balls, are spherical, cylindrical, belong or similarly shaped objects, made from either rigid or flexible material, that are buoyant in water and other liquids. They are non-electrical hardware frequently used as visual sight-indicators for surface demarcation and level measurement. They may also be incorporated into switch mechanisms or translucent fluid-tubes as a component in monitoring or controlling liquid level.

C. IoT (INTERNET OF THINGS)

The Internet of things (IoT) is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society. “The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

E. INTEGRATION OF ARM PROCESSOR (LPC 2148)

LPC2148 is the widely used IC from ARM-7 family. It is manufactured by Philips and it is pre-loaded with many inbuilt peripherals making it more efficient and a reliable option for the beginners as well as high end application developer. LPC2148 has 32kB on chip SRAM and 512 KB on chip FLASH memory. It has inbuilt support up to 2kB end point USB RAM also. This huge amount of memory is well suited for almost all the applications. LPC2148 need minimum below listed hardware to work properly.

1. Power Supply
2. Crystal Oscillator
3. Reset Circuit
4. RTC crystal oscillator
5. UART

II. PROPOSED SYSTEM WORK

In the proposed system the greenhouse parameters like temperature, water level and humidity are monitor from the agriculture land and uploaded to server system using IoT gateways technology. In this the sensors are interfaced with the ARM7 Processors. The sensor values will be continuously uploaded to the system using IoT gateway.

III. CONTROLFLOW OF WORK

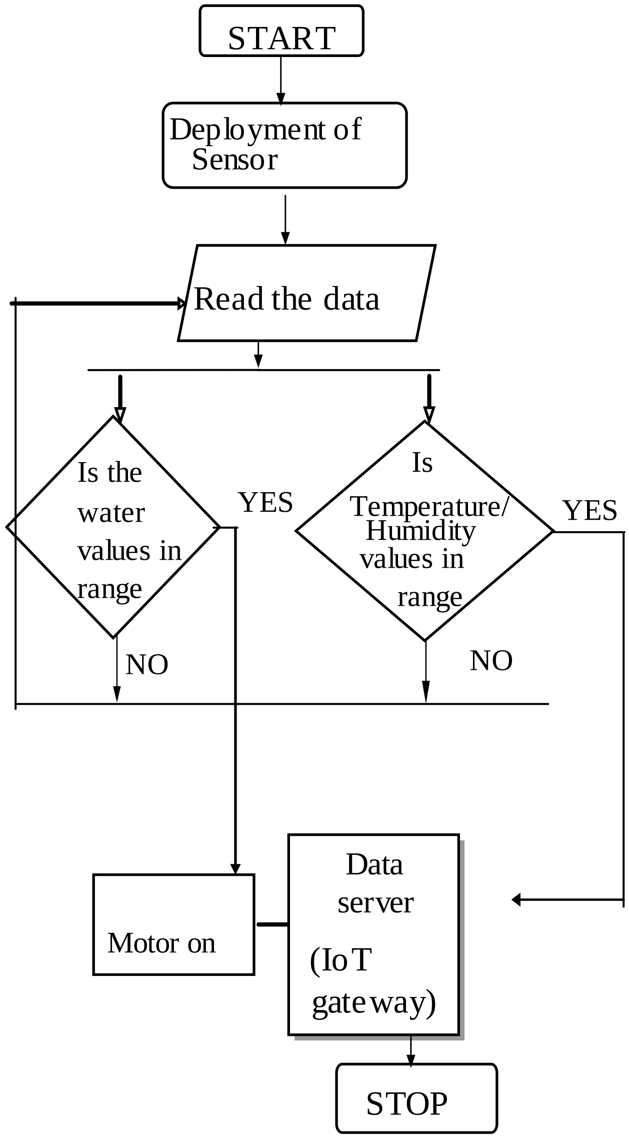

Figure.2. Flow chart

IV. IMPLEMENTAION

The purpose of the ARM7 processor is that it connects all the components associated with the Development kit. Number of pins in this processor is 64. Each pin is assigned with particular component of the kit for performing particular function. The threshold value of the sensors is set in this LPC 2148 processor which is responsible for the automatic ON and OFF of the motor which is coupled with the pump for pumping water to the agricultural land. The temperature threshold value will be updated to server or system, through IoT for every 1 minute from the integrated development kit. LM35 temperature sensors use amplifier at the right converts absolute temperature (measured in Kelvin) into either Fahrenheit or Celsius depend on it configurations. The two resistors are calibrated in the factory to produce a highly accurate temperature sensor. The integrated circuit has many transistors in it -- two in the middle, some in each amplifier, some in the constant current source, and some in the curvature compensation circuit. The humidity sensor measures the moisture level in the soil. The threshold value is reached (1 RH%-100 RH%) this limits can be set in the microcontroller if its goes above beyond 10 RH% conditions will be abnormal otherwise moisture level will be in normal conditions. The values can have updated to system through IoT gateway. The features of humidity sensor are Excellent linearity, low power consumption, wide measurement range, quick response, anti-pollution, high stability, high performance price ratio. Water level indicator is used to measure the water level in irrigation land. In the water level sensor value measure by using scale level and it's represent in cm. If the water level reaches the bottom of the metal rod it indicates abnormal condition and the control will automatically turn ON, the motor. If the water reaches the certain level the motor can be turn OFF automatically. These statuses can be continuously updated to the system using IoT. The Internet of things (IoT) is the internetworking of physical devices, vehicles, buildings and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. It is an impressive, low cost Wi-Fi module suitable for adding Wi-Fi functionality to an existing microcontroller project via a UART serial connection. The module can even be reprogrammed to act as a standalone Wi-Fi. IoT requires 3.3V power–do not power it with 5 volts. It needs to communicate via serial at 3.3V and does not have 5V tolerant inputs, so you need level conversion to communicate with a 5V microcontroller. Configure the IoT using SIM card (of any service provider). It will automatically configure IP address using DHCP (Dynamic Host Configuration Protocol). Each IoT module has the unique ID (Device Identification). In the development stage itself they integrate code for transmitter and receiver operations such that gather data from multiple sensors by using microcontroller and these values can be send to the IoT modules. By using below link update the integrated sensors value in browsers for every 1 minute.

LINK: http://www.iotclouddata.com/project/140/iot15view.php
140-unique Id for IoT module

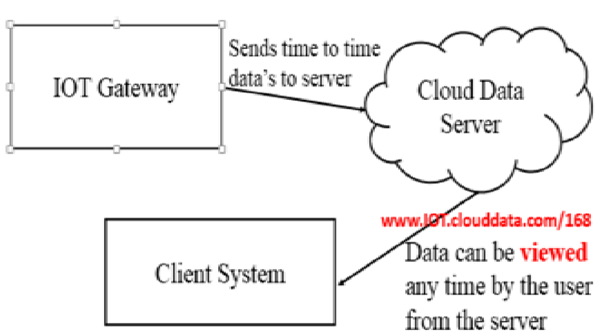

Figure.3. Gateway work flow

V. RESULTS

In the below figure represented what are the components used for developing kit implementation. They are

1. LCD
2. LPC 2148
3. HR 202
4. LM 35
5. Water Level Indicator

A. DEVELOPMENT KIT

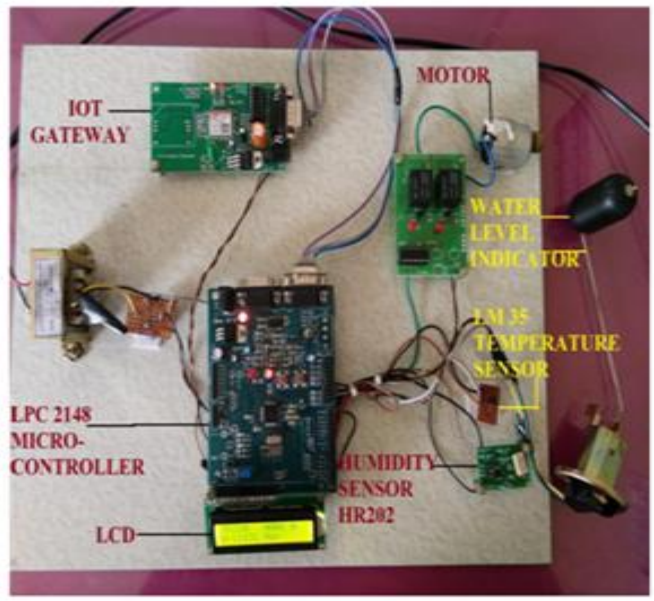

Figure.4. Normal condition of temperature, humidity and water level

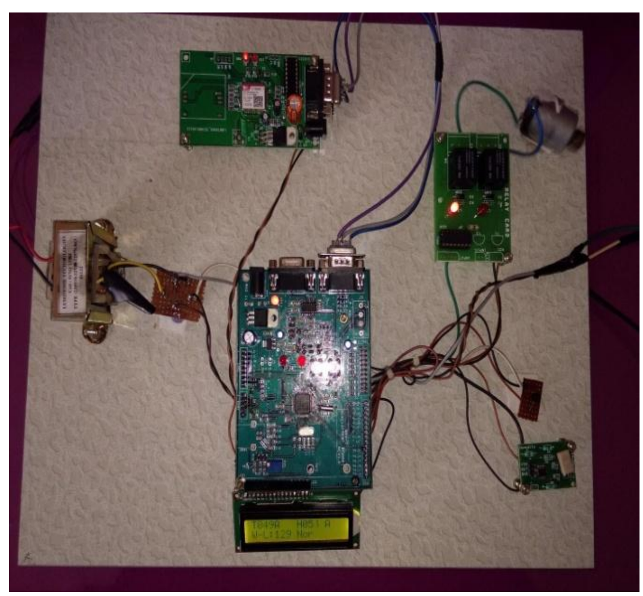

Figure. 5. Abnormal condition of temperature, humidity and water level

In the above figure represents the abnormal condition about temperature and humidity sensors. In this situation the motor can be ON automatically and when it goes to normal the pump motor will be OFF.

B. UPDATED VALUE

In the below figure represent the value of different types of sensors and updated to system in browsers through IoT gateways. These have three status values such as indicate Log ID, Data, Log Date, and Log Time. Time standard used in IoT module is World Clock format i.e. value calculated based on (original time + 5.30 in hours).

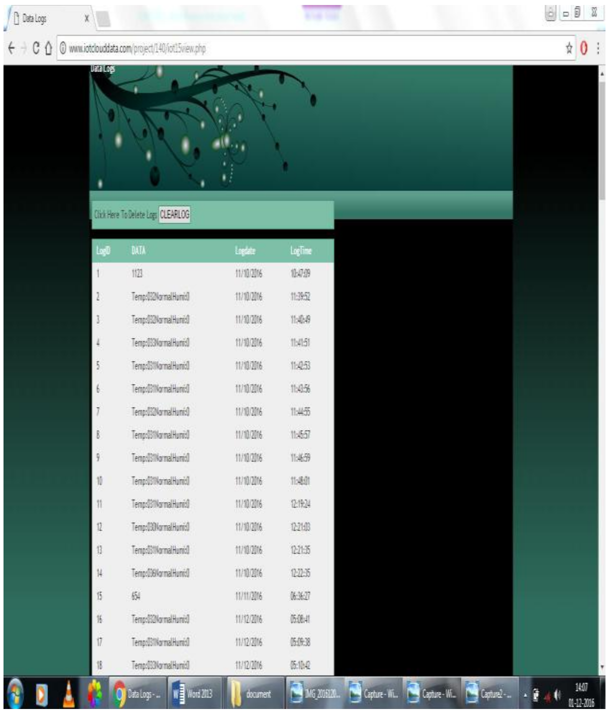

Figure.6. Basic view of IoT

Click Here To Delete Logs CLEARLOG

LogID	DATA	Logdate	LogTime
1	1123	11/10/2016	10:47:09
2	Temp:032NormalHumi:0	11/10/2016	11:39:52
3	Temp:032NormalHumi:0	11/10/2016	11:40:49
4	Temp:033NormalHumi:0	11/10/2016	11:41:51
5	Temp:031NormalHumi:0	11/10/2016	11:42:53
6	Temp:031NormalHumi:0	11/10/2016	11:43:56
7	Temp:032NormalHumi:0	11/10/2016	11:44:55
8	Temp:031NormalHumi:0	11/10/2016	11:45:57
9	Temp:031NormalHumi:0	11/10/2016	11:46:59
10	Temp:031NormalHumi:0	11/10/2016	11:48:01
11	Temp:031NormalHumi:0	11/10/2016	12:19:24
12	Temp:030NormalHumi:0	11/10/2016	12:21:03
13	Temp:031NormalHumi:0	11/10/2016	12:21:35
14	Temp:036NormalHumi:0	11/10/2016	12:22:35

Figure.7. Normal values are updated in data logs through iot gateway

15	654	11/11/2016	06:36:27
16	Temp:032NormalHumi:0	11/12/2016	05:08:41
17	Temp:031NormalHumi:0	11/12/2016	05:09:38
18	Temp:033NormalHumi:0	11/12/2016	05:10:42
19	Temp:032NormalHumi:0	11/12/2016	05:11:35
20	Temp:032NormalHumi:0	11/12/2016	05:12:26
21	Temp:033NormalHumi:0	11/12/2016	05:13:17
22	Temp:037NormalHumi:0	11/12/2016	05:14:19
23	Temp:031NormalHumi:0	11/12/2016	05:24:47
24	Temp:032NormalHumi:0	11/12/2016	05:25:47
25	Temp:032NormalHumi:1	11/12/2016	05:26:35
26	Temp:032NormalHumi:0	11/12/2016	05:27:24
27	Temp:031NormalHumi:0	11/12/2016	05:28:31
28	Temp:051HighHumi:007	11/12/2016	05:29:22

Figure.8. Abnormal values are updated in data logs through iot gateway

VI. CONCLUSION

This paper presents a crop monitoring system based on wireless sensor network. IoT has important significance in promoting agricultural information. ARM 7 processor is integrating with the sensors (temperature, humidity and water level) used for agriculture monitoring and crops production. Depending upon the threshold value motor is controlled automatically. The monitored crop details are uploaded to the cloud via the IoT gateway. Hence the farmers can easily to access and control the agricultural production, whereas saving the input materials, improving efficiency, productivity and profitability in farming production system.

VII. FURTURE ENHANCEMENT

As depending on these parameter values farmer can easily decide which fungicides and pesticides are used for improving crop production. If favourable weather condition and the probability of disease is detected, then it very helpful for farmers to prevent infection of disease and reduce the cost of production.

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