Precision Farming Based on IoT

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Abstract— In the recent times Wireless Sensor Networks (WSNs) [1] are used in making of decision making systems in which there is a need of good practical observation. Agriculture is one of the fields in which there is a huge need for decision making systems. Currently in the field of agriculture due to improper knowledge of the field conditions and without proper knowledge of prerequisites for a particular crop, farmers are not able to able to convert their hard work into better yields and profits [2]. And with the inefficient monitoring it leads to poor yields and loss of cost. Currently there is no particular solution to this problem other than some systems which have certain disadvantages like high cost, manual and onsite control, complex interface, hardware oriented, user and environment demanding, unpredictable quality and quantity etc. This paper proposes a system called Georletos (Farmer Helper), an advance monitoring system which is very easy to use and help in enhancing crop yield and productivity of field along with the awareness of farmers about the various parameters for a particular crop. The Georletos system makes use of WSNs along with the concept of Internet of Things (IoT) [3] which makes it possible for the farmer to get information about the field and crop conditions at any time and at any place. It provides an advantage of internet use which makes it possible to get the field and crop information at any place and give the farmers a comparison between standard data and on field data so that farmers can take an efficient decision which can improve the field productivity. The paper provides description about precision farming based on IoT approach which provides quality services to farmers.

Key words: Wireless Sensor Network, Intenet of Things, Precision Farming

I. Introduction

Today farmers face various problems in agriculture field during the cultivation of crop. As most of the agricultural operations in large parts are carried on by human hand using basic and conventional tools and implements without any modern technology, it usually results in irregular use of fertilizers and inefficient use of water supply. Basically, farmers have limited knowledge of their fields and they work on hit and trial method which is not an efficient method. Sometime crops over irrigated and sometimes get very less supply of water which results in low productivity. Also, due to overuse of fertilizers there is a change in pH level of the soil which is not good for the crops [4].

Today, agricultural practices lacks the innovative methods and advance technology implementation. All these problems are responsible to think for such a system which could provide better decision support to the farmers.

This paper give details about the system which overcomes some of the existing problems in the field of agricultural regarding field monitoring and decision making of farmers. Presented system basically takes the use of Wireless Sensor Networks (WSNs) along with the Internet of Things (IoT) concept to help the farmers in monitoring their fields and crops and made them able to take decisions according to the condition of field at a particular period of time so that crop can get accurate amount of necessary things and makes best use of resources. With IoT it has an added advantage of overcoming on site monitoring as using internet farmers can monitor their fields from anywhere. So, along with the improvement in productivity, it also reduces the labor work.

The rest of this paper is organized as follows: Section 2 give the details about precision farming, Internet of Things (IoT) and Wireless Sensor Networks (WSNs). Section 3 contains the related work in accordance with the existing systems and also give the importance of WSN and precision farming. Section 4 give all the details about the presented system and at last section 5 will present the conclusion and future scope.

II. WSN and IOT in Precision Farming

A. *Precision Farming*

Precision farming can be defined as practicing farming with the help of newer technologies and advancements in the field of components used in agriculture. Precision farming provides a software oriented way of farming in which a farmer can control all the equipment through a computer system or mobile phone and also compare various parameters of the soil of the field with the standard data which is beneficial for a certain crop. Precision farming gives a user friendly environment through certain smart network technologies which could result in high quality and quantity of crops.

Remote sensing, global positioning system, and geographic information system are some of the technologies used in the precision farming. Precision farming involves the comparison of different soil parameters like amount of macronutrients such as NPK, soil moisture, soil temperature etc. with the standard amount needed for a certain crop. Main technology used in the precision farming is WSN i.e. wireless sensor networks. It composed of different types of sensor nodes for different purposes and these sensor nodes are deployed in various parts of the field.

B. *Wireless Sensor Network (WSN)*

1) *Overview*

In the recent time, WSN term is being used frequently in the precision farming methods. WSN is basically a network of sensor nodes connected wirelessly through some communication protocol and gives the information about sensors readings over a wireless network like internet. WSN is basically divided into three main parts, first is sensing i.e. the working of sensors used in the system, second is processing i.e. how the sensor readings are processed and converted from analog to digital form (like using ADC and a microcontroller) and third is communication, this part tells about the communication technologies like ZigBee, Bluetooth, WiMAX, GPRS etc. used in the system to put the data on the wireless network.

2) WSN Diagram

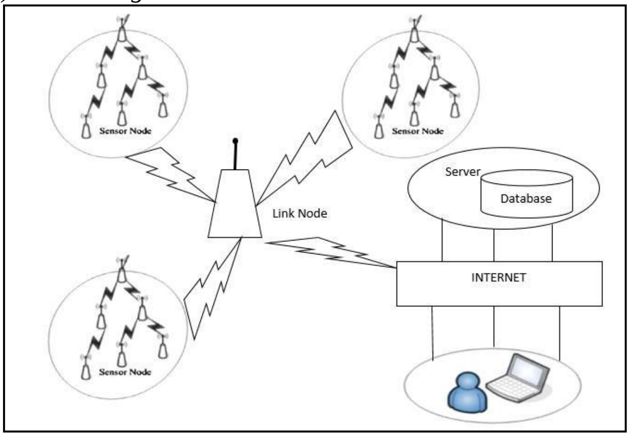

Fig. 1: WSN Diagram

This WSN diagram describes various sensor nodes linked to internet by using the link node such as Bluetooth, GPRS etc. Sensor nodes consists of the sensors and the microcontrollers used for the processing of sensor data. User can view the sensor data on a PC or a device which can access data on internet.

As a result of its features and abilities, WSN has several applications and several advantages over traditional data collection schemes such as:

- Real-time data can be accessed from the remote site and analyzed and a real-time reaction taken upon it.
- Closed loop control ability (automation).
- Larger coverage area and high temporal and spatial resolution.
- Improved accuracy.
- Phenomena can be observed unobtrusively.
- Negative weather conditions do not affect a researcher's work.
- Sensor nodes are small in size and weight and require no wiring which means that they are easy to install in most locations and applications.
- Usable for monitoring environments as contrasting as outbreaks of fire as well as glacier and also in rugged terrain, harsh, and inaccessible places.

C. Internet of Things

Internet of things is a network of physical objects or things embedded with electronics, software, sensors, and connectivity to enable objects to exchange data with the production, operator or other connected devices.

The Internet of Things allows objects to be sensed and controlled remotely across existing network for more direct interaction between the physical world and computer-based systems which results in improved efficiency, accuracy and economic benefit.

III. RELATED WORK

A. Technologies and Standards Used In Agriculture

Several communication technologies have been proposed for use in agriculture and some of these technologies are being compared in this section. Also several sensors which are used in the field of agriculture are being compared in this section.

1) Wireless Communication

a) Zig Bee [6]

ZigBee Alliance was established in August, 2001,The ZigBee specification, officially named ZigBee 2007.It offers full wireless mesh networking capable of supporting more than 64,000 devices on a single network. It's designed to connect the widest range of devices, in any industry, into a single control network

b) Wi-Fi [7]

Wi-Fi stands for Wireless Fidelity. Wi-Fi is based on the IEEE 802.11 family of standards and is primarily a local area networking (LAN) technology designed to provide in-building broadband coverage. Current Wi-Fi systems support a peak physical-layer data rate of 54 Mbps and typically provide indoor coverage over a distance of 100 feet. Wi-Fi has become the de facto standard for last mile broadband connectivity in homes, offices, and public hotspot locations.

c) Bluetooth [8]

Bluetooth is a standard used in links of radio of short scope, destined to replace wired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Bluetooth technology can be used at home, in the office, in the car, etc.

d) Wi MAX [9]

Wi MAX is one of the hottest broadband wireless technologies today. Wi MAX systems are expected to deliver broadband access services to residential and enterprise customers in an economical way.

e) WI Media [10]

The WI Media UWB specifications provide the technical details of the operation of a 480Mb/s PHY and a fully distributed MAC.

f) GPRS [11]

General Packet Radio System is also known as GPRS is a third-generation step toward internet access. GPRS is also known as GSM-IP that is a Global-System Mobile Communications Internet Protocol as it keeps the users of this system online, allows to make voice calls, and access internet on-the-go. Even Time-Division Multiple Access (TDMA) users get benefit from this system, as it provides packet radio access.

g) NFC [12]

NFC stands for near Field communication. Near Field Communications (NFC) is a short-range wireless technology that allows mobile devices to actively interact with passive physical objects and other active mobile devices, connecting the physical world to mobile services in ways that empower and Benet users. We will also be using the term "Tap 'n Go" because it clearly conveys a visual image in which this technology is intended to be used.

h) HIPERLAN [13]

HIPERLAN stands for HIgh PErformance Radio LAN HIPERLAN is a new standard for Radio LANs developed in Europe by ETSI HIPERLAN is an interoperability standard which specifies a common air interface MAC and PHY layers in OSI model.

i) LTE [14]

LTE or Long Term Evolution is the brand name given to the efforts of 3GPP 4th Generation technology development efforts mostly in Europe and UMB (Ultra-Mobile Broadband) is the brand name for similar efforts by 3GPP2 in North America. LTE is the natural upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks.

j) HSPA+ [15]

High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) optimize UMTS for packet data services in downlink and uplink, respectively. Together, they are referred to as High Speed Packet Access (HSPA).

k) EDGE [16]

EDGE stands for Enhanced Data Rates for GSM Evolution. EDGE is a technology that gives GSM Networks the capacity to handle services for 3G. EDGE was developed to enable the transmission of large amounts of data at peak rates of up to 472kbps. Users should experience average speeds of 80 kbps to 130 kbps.

S N O.	Name of communication technologies	Transmission range	Frequency band	Data Rate	Energy Consumption	COST
1	ZigBee	10-20 m	868/915 MHz, 2.4 GHz	20–250 kbps	Low	Low
2	WiFi	20–100 m	2.4 GHz	2–54 Mbps	High	High
3	Bluetooth	8–10 m	2.4 GHz	1–24 Mbps	Medium	Low
4	Wimax	<50km	2–66 GHz	0.4–1 Gbps	Medium	High
5	WiMedia	short-range multimedia file transfers	3.1-10.6 GHz	480 Mbit/s	Low	Medium
6	GPRS	Entire GSM coverage area	865 MHz, 2.4 GHz	50–100 kbps	Medium	Medium
7	NFC	less than 20 m	13.56 MHz	424 kbps	Medium	High
8	Hiperlan	50 m	5-5.30 GHz	54 Mbit/s	Low	Low
9	Irda	up to 1m	2.5GHz	4Mb/s	Low	Low
10	LTE	Entire LTE coverage area	1900 MHz - 1920 MHz	50 Mbit/s	High	High
11	HSPA+	--------	850 / 2100 MHZ	168 Mbps	High	High
12	IBURST	Long and Medium range	1780 to 1800 MHz	up to 40M bps	Medium	Medium
13	IMT	--------	1900-2100 MHZ	200 kbit/s	High	High
14	ANTUMB	20-100m	5.9 GHz	420 kbps	Low	Medium
15	EDGE	Entire GSM coverage area	390.2 – 399.8 MHZ	473.6 kbps	Low	Medium

Table 1: Comparison of different communication technologies

2) Specific Sensors Used In Agriculture

In this section, we discuss the various application specific sensors which empower the wireless sensing platforms. For better classification, we divide these sensors in three main categories—

1) Soil related sensors
2) Environment related sensors
3) Plant related sensors

S. N O	Name of Sensors	Soil moisture	Rain/ water flow	Water level	Soil temperature	Conductivity
1	Hydra probe II soil sensor[17]					
2	Tipping bucket rain gage[18]	×		×	×	×
3	THERM200[19]	×	×	×		×
4	Pogo portable soil sensor[20]			×		
5	ECH2O EC-5[21]		×	×	×	×
6	EC-250[22]					
7	AquaTrak 5000[23]	×	×		×	×
8	WET-2[24]	×	×	×		
9	VH-400[25]		×		×	×
10	SHT7[26]	×	×	×		
11	WaterScout SMEC 300 Soil Moisture[27]		×	×		
12	DS18B20 Digital soil temperature sensor[28]	×				×
13	TMP36 - Analog Temperature sensor[29]	×	×			
14	3950 NTC[30]		×	×		×
15	MLX90614 soil moisture sensor[30]		×			
16	MCP9700 soil	×		×		

	humidity sensor[30]					
17	LM35 soil temperature sensor [31]	×	×	×		×
18	TH150 Soil Moisture Probe[31]			×		×
19	TH2O Portable Soil Moisture sensor[31]		×		×	
20	TMP100[31]	×		×		×
21	10HS Soil Moisture Sensor[32]		×	×		×
22	5TE Soil Moisture, Temperature, & Electrical Conductivity sensor[32]		×	×		
23	RT-1 Soil Temperature Sensor[32]	×		×		×
24	MPS-6 Calibrated Water Potential Sensor[32]	×			×	
25	TS1 Smart Tensiometer[32]		×	×	×	

Table 2: Comparison of different sensors: soil related

S NO.	Name of sensors	Humidity	Ambient temperature	Atmospheric pressure	Wind speed	Solar radiation
1	WXT520 compact weather station					×
2	CM-100 compact weather station					×
3	Met Station One (MSO) weather station					×
4	CS300-L Pyranometer	×	×	×	×	
5	RG13/RG13H	×	×	×		×
6	Met One Series 380 rain gauge	×	×	×		×
7	XFAM-115KPASR				×	×
8	All-In-One (AIO) Weather Sensor					×
9	LI-200 Pyranometer	×	×	×	×	

Table 3: Comparison of different sensors: Environment related

IV. GEORLETOS IN PRECISION FARMING

Georletos system which is presented in this paper is a combination of both Wireless Sensor Networks (WSNs) and Internet of Things. Georletos word here is being derived from two Greek words and it means “farmer helper”. This system is basically divided into two parts, one is Analytical and Transmitter Unit and other is Receiver and Uploading Unit. Analytical and Transmitter Unit consists of the sensor nodes along with a microcontroller and a wireless data transmitter whereas at the Receiver and Uploading Unit side, there is a microcomputer which is acting as a server along with the operations of General Purpose Input Output (GPIO). Basically, in the Georletos system various field parameters like soil moisture, soil temperature and soil pH are analyzed using certain sensor nodes and then with the help of microcontroller and the wireless data transmitter this sensor data is transmitted to the Receiver and Uploading Unit for further processing. At the Receiver and Uploading Unit, along with the wireless data receiver a microcomputer takes the data and save it in memory and further upload this data on the webpages which are created for the simple interface purpose. Also the webpages, which are created to see the sensor readings, have standard data for each and every crop a farmer wants to produce. So after getting the sensor values, the farmer can compare the values with the standard data and can take decisions accordingly. These webpages can be accessed over the internet from anywhere and at any time in any device which supports internet and is having an internet browser. These webpages are basically created to give the farmer an easy interface so that the comparison with the standard data can be done easily.

A. Analytical and Transmitter Unit

In this unit, the main hardware which is used is as follows: A microcontroller (AT mega 16) [33], three sensor nodes (soil moisture sensor, soil temperature sensor, and soil pH sensor), 16*2 LCD for display and one wireless data transmitter (HC-05 Bluetooth).

1) Overview

The microcontroller AT mega 16 takes the values from three sensors in the analog form and by using ADC converts those values in digital form so that they can be processed and transmitted easily. As the receiver side accepts data in serial form so the AT mega 16 sends this data in serial form by using Universal Asynchronous Receiver Transmitter (UART) protocol and through Bluetooth (HC-05) [34] the data is transmitted wirelessly to the Receiver and Uploading Unit. Also a 16*2 LCD is provided along with the microcontroller to verify the data at the receiver side.

2) Block Diagram

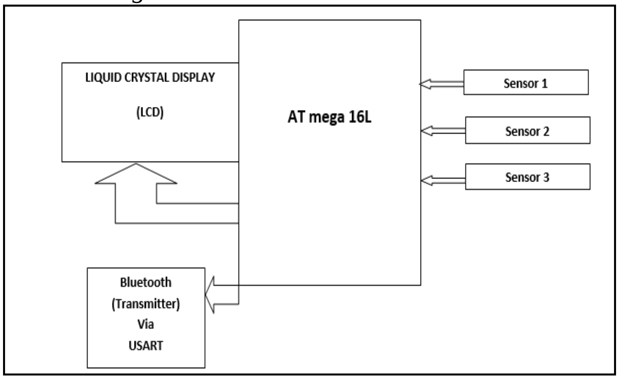

Fig. 2: Analytical and Transmitter Unit Block Diagram

- Moisture sensor, pH sensor and temperature sensor are connected to the port A of AT mega 16 as only port A is available for ADC (analog to digital convertor) purposes in AT mega 16 microcontroller.
- Port B is connected to LCD for the observation of sensor values.
- Port D of AT mega 16 is connected to the Bluetooth HC-05 as the port D is available for the UART (Universal Asynchronous Receiver Transmitter) communication protocol.

3) Schematic Diagram

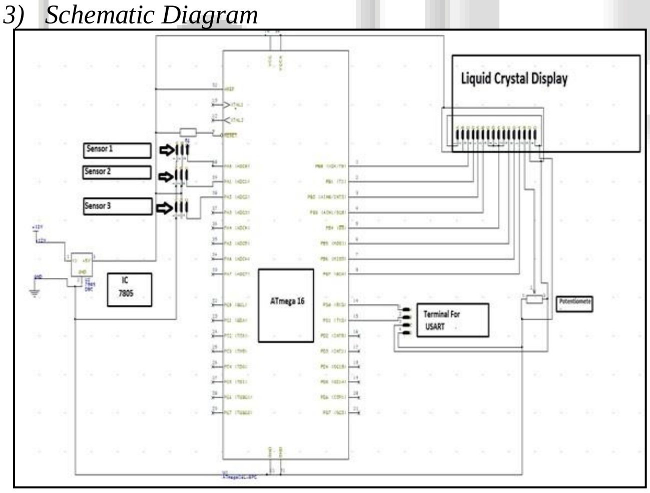

Fig. 3: Circuit Diagram of Analytical and Transmitter Unit

B. Receiver and Uploading Unit

In this unit, the main hardware which is used is as follows: A microcomputer (Raspberry Pi Model B+) [35], and one wireless data receiver (HC-05 Bluetooth).

1) Overview

Data from the analytical and transmitter unit comes in serial format, for which Bluetooth HC-05 is used at the receiver and uploading unit so that it can accept data in the same format in which it is sent. After getting the data serially Bluetooth transfers this data to Raspberry Pi through the UART0_RXD (pin 10) of GPIO header of Raspberry Pi. This data is read by the UART0_RXD pin only after running the python script for serial communication through Raspberry Pi terminal window by using command python serialread3.py where Serialread3.py is the name of script created for the serial communication through UART. After reading, all the data will be saved into a file and it is also being done by the python scripting. To analyze all the data sent by the analytical and transmitter unit in an efficient manner, a webpage is created using HTML and CSS. This webpage provides a better user interface through which user can easily analyze the data and compare it with the standard data. The data is uploaded on the webpage through PHP scripting. And the webpages can be accessed from anywhere using any device which supports internet.

2) Block Diagram

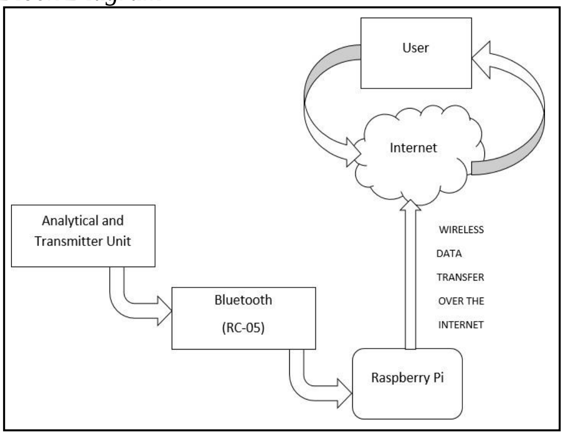

Fig. 4: Block Diagram of Receiver and Uploading Unit

Bluetooth (HC-05) takes the wireless data in serial form from the Bluetooth across the Analytical and Transmitter Unit, the pairing of these two Bluetooth is done by the use AT commands so that whenever they come in each other's range they get automatically paired.

After receiving the data, Bluetooth forwards it to the microcomputer (Raspberry Pi) through its General Purpose Input Output (GPIO) pins using Universal Asynchronous Receiver Transmitter (UART) protocol so that they can be transferred on the internet and can be accessed using a web browser by entering the IP address of Raspberry Pi.

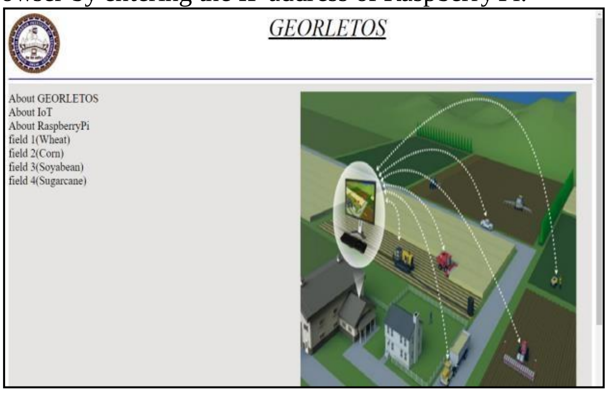

Fig: 5: Main Webpage

Fig. 6: Field 1 (Wheat)

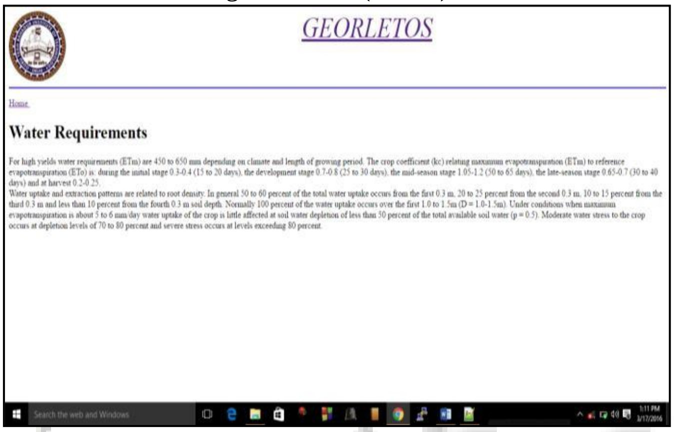

Fig. 7: Water Requirements for Wheat

Fig. 8: Nutrient Requirements for Wheat

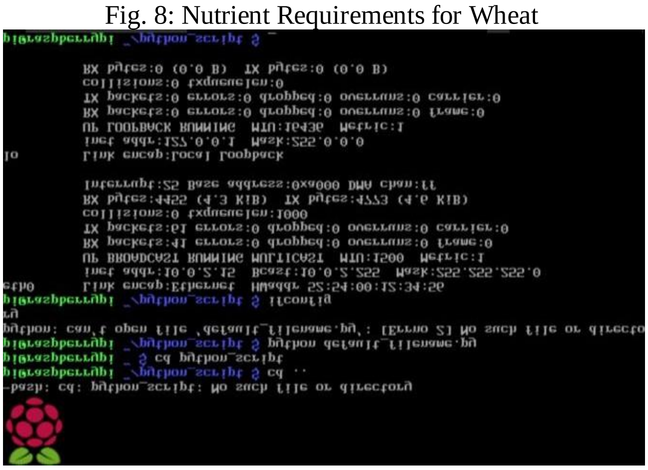

Fig. 9: Viewing IP Address of Raspberry Pi

V. CONCLUSION

An Internet of Things (IoT) based precision farming system has been created and tested which mainly overcomes some of the disadvantages of the existing systems like high cost, manual and onsite control, complex interface, hardware oriented, user and environment demanding nature and the property that existing systems gives information but doesn't say anything about how to use this information. It can help farmers to increase their crop yield by comparing the standard data with their field data and can improve their field in terms of various parameters like moisture level need, pH range etc. which will be beneficial to increase the productivity. This proposed system can be extended by integrating it with smart irrigation system and UAV monitoring of crops.

e.g. If a certain part of the field is moisture depleted then using internet based system it can be monitored from anywhere and amount of water needed is provided.

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