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WIRELESS SENSOR NETWORKS BASED-INTERNET OF THING FOR AGRO-CLIMATIC PARAMETERS MONITORING AND REAL-TIME DATA ACQUISITION

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ABSTRACT

The recent advent of internet of things technology with incorporating wireless sensor devices for supervisory, monitoring and security application has necessitated further development of embedded technology, of course, ability to monitor environmental conditions of greenhouse, gardens and farmland is crucial to research for effective seed germination, rapid plant growth and maximizing food production, which is due to some effect ranging from climate variability, soil information and irrigation periods. This paper proposes a real-time data acquisition and monitoring system for effectively monitoring changed in agricultural and environmental parameters using (IEEE 802.11 b/g/n) Wi-Fi, wireless sensor system and Android Web Apps. It is more important and concerned in this research to proffer long way solution to the farmers, agronomist, meteorologist and others based on weather stations, climatic changes and soil conditions. The developed smart agro-climatic parameter monitoring system consists of ATmega2560 controller based measuring units which collects the value of wireless sensor nodes like temperature, humidity, soil moisture and soil pH. These units send their data to the base station (BS), where data are collected and delivered through wireless module to the cloud database using HTTP POST where incoming data are stored. With android Web application, will permit users to view and download a real-time agro-climatic parameters on the dashboard using HTTP GET.

Contribution/ Originality: This article contributes to the work of Agajo, et al. 2015, by adopting low power consumption Wi-Fi technology and web apps. The formula are original from authors which helps in the development of standard IoTs architecture as the primary contribution with soil pH information's and web apps development.

1. INTRODUCTION

Agricultural plants growths and development are highly dependent on seasonal irrigation and fertilizing systems in order to produce large quantity of crops and farm products which are determine or affected by the climatic factors and soil texture [1] such as temperature, humidity, light intensity, soil moisture etc. The effect and importance of climatic changes on the physiological environments and agricultural farm crop is obvious which required regular monitoring for the management of farm production. Naturally, various plant species can grow, germinate or survive on different type of soil texture and the effectiveness applications of organic manure (mixing of fertilizer) to the plants are commonly determine with the testing method of soil values using electrical conductivities (EC) [2]. Although to determine the soil fertility precision based on the two classifications, macronutrient element which are "Nitrogen (N), Phosphorus (P) Potassium (K)" and micronutrient elements such as "Ammonia (NO3), Ammonium (NH4), potassium (K) and Tetra-oxo-phosphate (PO4) with the electrical conductivity (EC) method is very difficult to realize within a short period of time due to mixing techniques and processes involves. Therefore, an application of programmed irrigation and fertilizing system is essential with normal concentrations of mixing fertilizer and amount of water required to improve the crop deficiency like yellowish color of vegetable, stunted growth and red pigment with Nitrogen, Phosphorous and Potassium (NPK).

The designed and development of an embedded system based IoTs for monitoring, supervisory and control involvement has advanced significantly in the last couple of years in the smart technology, since it introduce a new dimension to the world of things, information and communication technologies ICT [3]. The smart embedded system for environmental climatic changes, soil information, monitoring and controlling of smart devices in the smart paradigm such as smart home, smart city, smart agriculture, smart car, smart devices (such as phone, PDA, tablets, laptop and others), smart factory, smart healthcare, and so on have being focusing [4].

Therefore, the pervasive and ubiquitous technology called for their needs in the world of connectivity to provide convenience, comfort, security, interoperability and quality of life. This can be effectively achieved in the platform of IoT with the implementation of various wireless sensor network (WSN) and wireless technologies like, Wi-Fi, Z-waves, Bluetooth, ZigBee for render services of a remote data transfer, sensing and control. These are often being utilized to achieved various levels of intelligence in the embedded system based-internet of things functionality for enabling new forms of communication between things and people, machine to human (M2H) and between thing themselves [5].

The roles of embedded wireless sensor devices with limited CPU, memory and power resources networked that are integrated into IoT will enhance the communication, connectivity and operability among things connected in the ubiquitous architecture and find applications in nearly every field [6]. These embedded systems can be used for the collection of information ranging from natural ecosystems, buildings and factories. Also, in the fields of environmental sensing and urban planning, integration of single–on-chip (SoC) know as controller into the most recent and advance technology embedded systems have change human daily life and activities indeed and changing modern lives like nothing before compare to the last recent decades [7]. The embedded system based-internet of thing for agro-climatic parameters monitoring and soil information proposed in this paper will utilize various sensor nodes for collection of environmental climatic change data and soil information which determine the growth of crops in the farm land such as temperature, humidity, soil moisture and soil pH. Also, the Wi-Fi shield and web application helps in routing packet acquired from the field sensor node to the cloud database.

The rest of this paper is organized as follows: Section 2 describes several related work, in section 3 design methodology for the integration of SWES with cloud database through IoT gateway is presented. The system implementation is discussed in section 4 with detail functions of the system, assembly methods for each module and performance measurements. Section 5 described results and performance measurements of the system, and section present conclusions.

2. RELATED WORK

Several related works has been reviewed from different perspectives in the field of wireless sensor network based IoT for environmental and agricultural monitoring and data acquisition. Therefore, different wireless technology and protocols have been employed for remote monitoring, control and data acquisition as an experimental research platforms.

The author in Tiantian and Weizhu [8] present an integrated data acquisition and intelligent control system based on greenhouse crops and pest monitoring, in order to promote access the information on agricultural zone and to improve the effectiveness and efficiency of farm production. Therefore, the authors proposed the design and implementation of span greenhouse agriculture-based internet of things using GSM module for sending and receiving SMS alert to the farm manager standalone system or portable digital device (PDA) about the certain condition occurrences in the greenhouse environment. In this paper, application of agricultural network information, data acquisition and intelligent control system in greenhouse based on IoT for monitoring and preliminary analysis are linked with the aid of sensor network technology. This system proposed helps to realize the real-time data monitoring, and allow farmers to analyze the information collected but cannot respond to automatic irrigation and water management control system due to its level of intelligent.

An urban climatic system monitoring based on internet of thing using Raspberry Pi, which aid the communication between devices connected in the features of ubiquitous was put together by Rohini and Sushma [9]. This paper uses a stand-alone computer system to provide a dynamic datasheet about environmental climatic parameters. A less power consumption and inexpensive ARM cortex microcontroller was used to enable the communication through Ethernet or Wi-Fi module. The environmental data collected are processed in the embedded system using python language, and the information about the climate can be accessed through the terminal devices that are connected to the internet facility such as Tablet, Laptop or Smartphone. This framework proposed by the authors gives access to real-time information about carbon-dioxide (CO), pressure, harmful air pollution, humidity and temperature in order to improve quality of life and transformation of city management.

The development of inexpensive automated data acquisition system (ADAS) for monitoring temperature and humidity of an urban sites based on internet of things was proposed by Natanael and Gracinete [10]. The paper illustrates an instance of developed a remote automated data acquisition system that will helps to acquired environmental data like temperature and humidity and access at a remote network. ATmega2560 was used as the system controller to implement the ADAS with DHT11sensor to measure climatic changes in temperature and humidity. Also DS3231 RTC module was used for the real-time data collection, and the Ethernet on the Arduino Nano board was used to communicate with server through the web using HTTP requests and respond through Restful API. But, the use of Arduino Nano in this implementation of ubiquitous has limitations of data storage 2KB SRAM, few parameters sample collection, communication problems on the Ethernet due thermal dissipation over the cable that will affect sensed temperature.

The implementation of an automated fertigation web based monitoring: An IoT application was developed by Abidin and Ibrahim [11]. The IoT based monitoring system focuses on the automatic fertigation system in agricultural field, and access data on the web application. Therefore, the system is designed with emergency mode in case of any emergency process to be controlled through GUI web apps that display parameters captured from the field like water level status, valves condition and pipes flow condition. The microprocessor was used to interact with online GUI databases which used to control the communication between the fertigation system and web apps. Although, this system was proposed for the use of automated fertigation and irrigation in the farm land range within 1.0 – 1.5 acres due to the ZigBee wireless technology used for the transmission of signal and receiver (100m).

Micro parameters measurement and a real time video monitoring system for efficient farming using wireless sensor network was proposed by Khakal and Galande [12]. The aim of authors was to sense and recognize any motion around the robot surveillance in the farm using online video, and employed robot arm to measure agricultural parameters such as NPK, temperature element in order to decide fertilizer requirement in the soil environment. All the sensors needed was built around the robot, and the online video mounted on the robot as well for crop pest monitoring and report at the receiver end of the system using GUI. It is reported that the system is efficient for the video monitoring of crop pest and parameters measurement but the system is very expensive, and not mobile or web-based data assessment.

In Agajo, et al. [13] wireless sensor network is proposed which focus on the intense monitoring and variables measurement of soil contents such as soil moisture temperature and humidity for the purpose of gathering and providing soil parameter information about farm land using wireless sensor technology through satellite communication. A database was developed for the efficient data collection and data management using JAVA and ORACLE software. Also, artificial neural network was used for the detection and location of faulty nodes. The model was presented with efficient result but, not a real-time based working principles system, mobile web apps is more suitable access of the soil information for the usefulness of the farmers and agronomist which is not considered. As well, satellite was used as transmission medial which is not suitable for ubiquitous platform when considered mobility, interconnectivity and interoperability between thing. The system is also cost effective for individual implementation.

3. DESIGN METHODOLOGY FOR APPLICATION LAYER PROTOCOLS

The development of smart wireless embedded system (SWES) based internet of thing architecture (such as agriculture, environmental, transportation, healthcare, domestic home devices and so on) for controlling, monitoring and securing comprises of several technology and facilities. All these services, hardware, software and network facilities are integrated into a single unit to aid the performances of smart technology which exist between the IoT gateway and the cloud database like interoperability, interconnectivity, mobility, scalability, security and easy communication among different things.

The summation of several facilities integrated into smart embedded technology based IoTs is mathematically given as;

$$\sum_{k=1}^{n} f(IoTs) = \sum_{k=1}^{n} \sum_{i=1}^{k} (Est) + \sum_{k=1}^{n} \sum_{i=1}^{k} (Nt) + \sum_{k=1}^{n} \sum_{i=1}^{k} (It) \quad (1)$$

where, IoTs = Internet of thing system,

E_{st} =Embedded system technology (mobile phone, PDA, development board etc)

N_t = Network technology (Ethernet, Wi-Fi module)

I_t = Information technology (Web apps, TinyOS, software programs, application protocols)

n = Numbers of additional technology services

For k = 1, 2, 3, 4,…n.

The integration of SWES with cloud database through IoT gateway require configuration and involvements of application layers protocol such as CoAP, HTTP, MQTT, AMPQ, DDS and others. Figure 1 depicted a model for integration and communication techniques between SWES and the cloud through a gateway devices or radio, and the mathematical representation is given as equation (2) to (7).

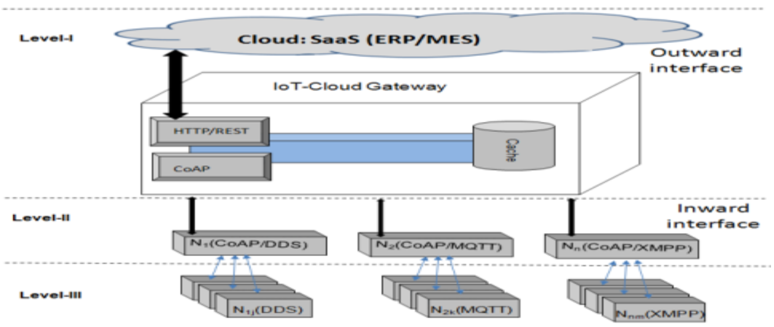

Figure-1. A model for cloud integration with embedded systems through IoT gateway [14]

$$IoT_G = \{N_1, N_2, N_3, \ldots, N_z\} \quad (2)$$

$$N_1(CoAP) = \{N_{11}, N_{12}, N_{13}, \ldots, N_{1i}\}, \qquad (3)$$

$$N_2(HTTP) = \{N_{21}, N_{22} N_{23} \ldots, N_{2i}\}, \qquad (4)$$

$$N_3(MQTT) = \{N_{31}, N_{32} N_{33} \ldots, N_{3k}\}, \qquad (5)$$

$$N_z(AMPQ) = \{N_{z1}, N_{z2}, N_{z3}, \ldots, N_{zm}\}, \qquad (6)$$

$$Cache = \{x_1 N_1 + x_2 N_2 + x_3 N_3 \ldots, x_n N_{zm}\} \qquad (7)$$

where

IoT_G = Internet of Thing gateway

CoAP = Constrained Application Protocol

HTTP = Hypertext Transfer Protocol

MQTT = Message Queue Telemetry Transport

AMPQ = Advanced Message Queuing Protocol

DDS = Data Distribution Service

N = number of systems connected with specific application protocol selected

x = number of messages request protocol (GET/POST) that are translated into the equivalent queries in IoT architecture.

4. SYSTEM IMPLEMENTATION

The model we adopted for this designed and implementation of wireless sensor network based IoT architecture for agro-climatic parameters monitoring system and real-time data acquisition through an android web apps are divided into two major modules, which are hardware system architecture and software development. Both of this components are integrated together to make smart wireless embedded system as innovative, scalable and ubiquitous system.

4.1. Hardware System Description and its Architecture

The hardware system in this paper refers to the smart wireless embedded system (SWES) based internet of thing system (IoTs), which consists of an intelligent micro web server application with on-board chip (AVR ATmega2560 microcontroller), Arduino wireless shield (ESP8266), hardware interface module like LCD and wireless sensor nodes such as DHT 11sensor, soil moisture sensor, soil pH sensor and the Android compatible smart phone. The SWES circuit diagram was designed and simulated in Proteus 8.0 professional ISE, the firmware and the sensor nodes (SNs) is programmed and compiled in the Arduino IDE which all work perfectly as shown in the figure 2 and 3.

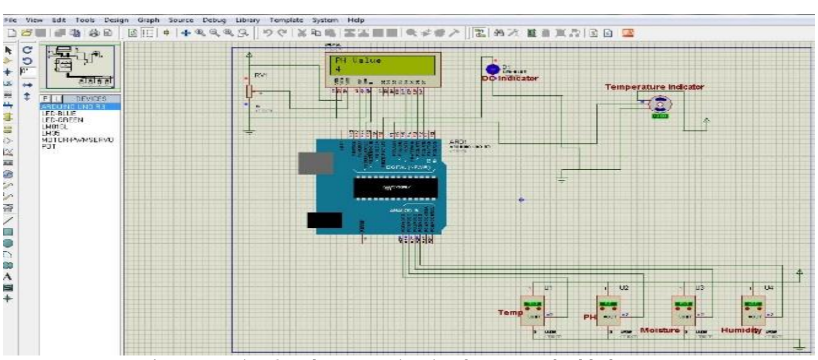

Figure-2. Simulated system circuit of smart embedded system

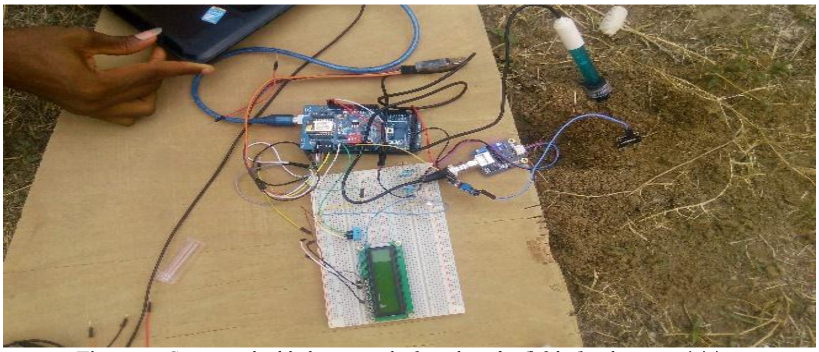

Figure-3. Smart embedded system deployed to the fields for data acquisition

Furthermore, the DHT11 sensor consists of 4 pins (1-VCC, 2-DATA, 3-NC and 4-GND), three of the pins were used while the fourth left unconnected (NC). The ground (GND) pin 4 from the DHT11 sensor is connected to the ground of the Arduino board, the power (VCC) pin 1 is connected to 5v of the Arduino board and the DATA pin 1 is connected to an analogue pin on the Arduino board (A1).

The soil moisture sensor has 3 pins connection (OUT, VCC & GND) as depicted in figure 4. The ground (GND) pin from the Soil moisture sensor is connected to the ground of the Arduino board, the power pin (VCC) is connected to 5v of the Arduino board and the data pin (OUT) is connected to an analogue pin on the Arduino board (A0). Also, the pH sensor also has 3 (VCC, GND & Aout). The GND pin from the PH sensor is connected to the ground of the Arduino board, the Vcc pin is connected to 5v of the Arduino board and the data pin (Aout) is connected to an analogue pin on the Arduino board (A2). Arduino IDE was used to write the code for each of the sensors to work simultaneously and the code was compiled and then loaded onto the microcontroller (ATmega2560) where the result are obtained from serial monitor on the Arduino IDE.

4.1.1. ATmega2560 Controller Unit

The Arduino Mega is a microcontroller board based on the ATmega2560 with 128kb flash memory, SRAM and EEPROM are 8kb and 4kb respectively. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), 16MHz crystal oscillator, ICSP header, and a reset button. The operating voltage is 3.3-5v/50mA.

4.1.2. Analog-To-Digital Converter (ADC)

ADC is a features used to converts an analog voltage level on a microcontroller pin to its equivalent digital value or number. The analog pin connection available on the Atmega2560 microcontroller can be described as (A0 – A5). Therefore, the ratio-metric value of ADC can be expressed as in equation 10.

$$\frac{ADC\ resolution}{System\ Voltage} = \frac{ADC\ reading}{Analog\ voltage\ measured} \quad (8)$$

4.1.3. Soil pH Sensor

The pH soil sensor is used for the measurement of the soils acidity or alkalinity in garden plant or greenhouse environment. Since, different plants require varies pH levels of acidity or alkalinity for growth and development, which influences the nutrient uptake and root growth, and it controls the presence or activity of many micro-organisms. Therefore, testing for pH levels of soil acidity or alkalinity is essential in order to select various plant species or expand the range of plants to be planted. The table 1 contains details analysis range of pH value for acidity, alkalinity and base level of the soil solution.

The pH of a solution activity as the negative $\log_{10}$ of the hydrogen ion $[H^+]$ or the reciprocal $\log_{10}$ of hydrogen ion $[1/H^+]$.

$$H_2O \Leftarrow H^+ + OH^- \quad (9)$$

$$K_w = [H^+]*[OH^-] = 10^{-14} at 23^0 C \quad (10)$$

$$pH = -\log_{10}[H^+] = \log_{10}\left(\frac{1}{[H^+]}\right) \quad (11)$$

where,

K_w = the product ion of water,

[ ] = the activity of each component in moles per liter of solution.

Moreover, the pH level can be determined using either colorimetric or electrometric techniques as given below;

$$E = E^o - \left(\frac{RT}{nF}\right)\log\left[H^+\right] \quad (12)$$

where,

E = electromotive force produced by electrode system

E^o = dependent constant on the electrodes

R = gas constant

T = Absolute temperature

n = number of electrode involved in equilibrium

F = Faraday constant.

The information in the table 4 shows descriptive terms used for specified range of soil pH.

Table-1. Description of specified value of soil pH range

pH Condition	pH Value
Ultra-acid	<3.5
Extremely acid	3.5-4.4
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Slightly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	>9.0

4.1.4. Soil Moisture Sensor

Soil moisture is noted as a significant variable in controlling the exchange of water and heat energy that exist between the land surface and the atmosphere through evaporation and plant transpiration. Of course, soil moisture is considered more important in the development of plant growth due to climate changes and the precipitation which helps in irrigation process. Therefore, the sensor used in determining the level of moisture in a soil is called soil moisture sensor or Hygrometer as depicted in the figure 4. This is used to measure the amount of water associated in a given volume or mass of soil moisture. During the course of the research, we discovered that in a soil moist sample of 100g, it usually contain 1g and 1% concentration of nitrogen (N). Also, the drying soil sample weighs about 67g, means one-third of the moist soil sample was water. Which contain 1.5% nitrogen (N) of the soil sample.

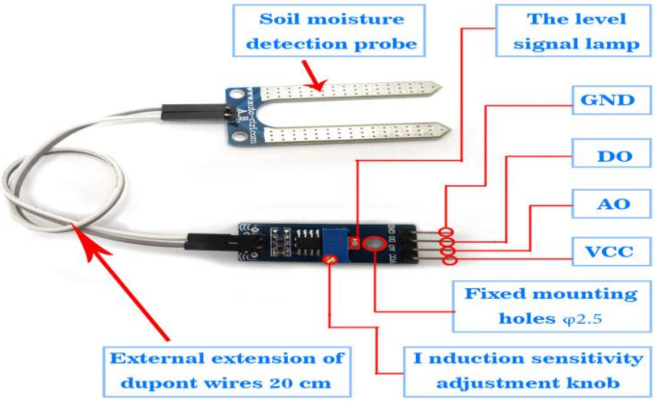

Figure-4. Description of soil moisture sensor

Then, the gravimetric analysis of water concentration in the soil can be calculated as given in the equations;

1. The weight of dry soil can be expressed as in equation 1, which range from (0 to infinity).

$$Wd = \frac{Wg}{Sg} \tag{13}$$

2. Weight of wet soil can be expressed as in equation 2, which range 0 to 1 (0 – 100%).

$$Ww = \frac{Wg}{Wg+Sg} \tag{14}$$

3. The volumetric of soil humid which range from 0 to 1 (0 – 100%) can be calculated as;

$$Wv = Wd * \frac{\rho b}{\rho w} \tag{15}$$

where,

W_d = Weight of dry soil in grams

W_g = Grams of water

S_g = Grams of soil

ρb = density of soil (gram of dry soil/cm^3)

ρw = density of water (gram of water/cm^3)

Since, the output value of moisture sensor is analog voltage that is linear function of moisture content (Mc), the sensor calibration formula is given as;

$$Mc\ (\%) = SC_{Mc} * V_{Mc} \tag{16}$$

where,

SC_{Mc} = Sensor calibration coefficient

V_{Mc} = Output voltage of moisture content

4.2. Software System and Implementation

The software development for the smart embedded technology and android web app are in module with a logically independent part of a program. This program unit is in discrete and identifiable with respect to compiling and loading. Separate system is considered as modular since it consists of discrete components such that each component supports a well-defined abstraction and protocols. The implementation of the system into agricultural field is shown in the figure 5.

Figure-5. Deployment of SWES into the fields

4.2.1. Logical Communication between Embedded Systems and Wi-Fi shield

Using serial communication, the ATMEGA2560 is linked to the WI-FI shield and the AT commands set is then used by the Arduino code to send requests and receive responses from the WI-FI shield. For the purpose of internet connection and data transfer between the MCU and a web server, the HTTP AT command set is used for TCP/IP communication. The first step is to initiate a serial connection between the MCU and the WI-FI shield, and then the TCP/IP mode is set to ON. HTTPINIT function is called and the URL parameter is set to the website address to connect, in this case the PHP file in our web server will process each request and send a response back to the MCU. After setting the URL parameter, the MCU will then send the HTTPACTION command to the WI-FI shield and specify its value to either '1' for HTTPPOST method or '0' for HTTPGET method. On sending the HTTPACTION command with value '0', i.e. HTTPGET, the MCU waits for a few seconds to allow the WI-FI shield sufficient time to receive the entire packets sent by the server. Therefore, figure 6 show details of the system flowchart for the wireless sensor networks based-internet of thing for agro-climatic parameters monitoring and real-time data acquisition.

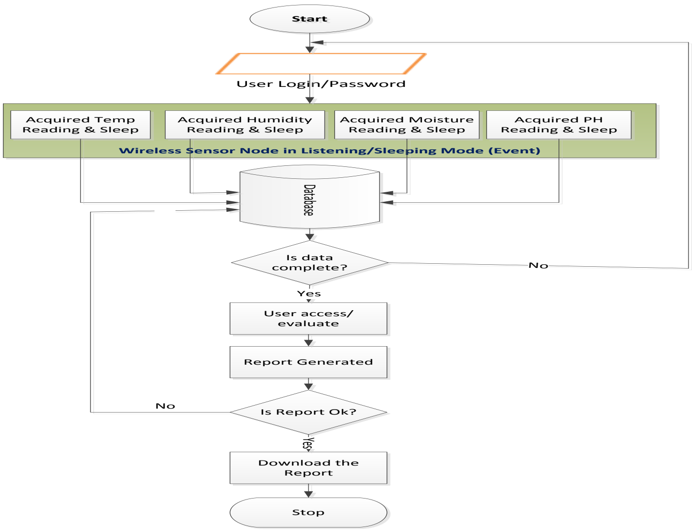

Figure-6. Software development flowchart

5. RESULTS AND DISCUSSIONS

Due to this scenario, smart embedded technology with low power consumption (Arduino board), TinyOS are utilize to be running on this platform to ensures total control of sensor node communication modes and capabilities, optimized power save status, and to enhanced interoperability, and scalability towards hardware advancement. Therefore, different kinds of sensors at least 10 nodes can be allowed for the attachment into a single mote for sensing different environmental parameters.

The data that exist between the IoT gateway and protocol handler are carried out using TCP/IP communication and encapsulated protocol from local area network to the remote interfaces. While, the communication protocol of low level firmware implementation are focuses on the wide area network link due to the connection of gateway to the remote server through service provider access point name (SPAPN) and wireless gateway support node (WGSN). Therefore, the implementation of dynamic session renegotiation (DSR) and Forced session renegotiation (FSR) on the gateway and content management system server (CMSS) will significantly improves the sensor nodes connectivity over the internet and reduced packet loss rates among the sensor nodes.

5.1. Web Application Interface

The web application is designed using PHP for back-end scripting, which takes care of database connection using MySQL queries, URL-routing, calculations etc. to formats the database results so it can be sent to the MCU bitwise. The web URL on receiving a HTTPGET command from the MCU will create a connection to the MySQL database on the web server by send MySQL select query for the information being requested and sends the query result one bit at a time to the MCU. Also, on receiving a HTTPPOST command is used, the PHP web application will then extract the GET array values for the URL string one array item at a time and assigns each of them to a local variable. MySQL connection will be created and insert SQL query to send the data on to the database. Once this query has been executed, the MySQL connection will be terminated. The figure 7 shows the login interface and the online agro-climatic parameter graphic user interface (GUI). Also, the results of agro-climatic parameters acquired from the cloud database and plotted graph of agro-climatic parameters against time are presented in the table 2 and figure 8.

Figure-7. Screenshot of android web apps for login and download interface for agro-climatic parameters acquired in a real-time

Table-2. Parameters reading from sensor nodes.

Time (Min)	Temperature (°C)	Humidity (%)	Soil Moisture (cm^2/ cm^2)	Soil pH
14.00	32.00	57.00	3.00	1.0
14.10	32.00	62.00	101.00	3.5
14.20	30.00	65.00	102.00	4.0
14.30	29.00	67.00	102.00	5.0
14.40	30.00	64.00	89.00	8.5
14.50	31.00	62.00	102.00	8.0
15.00	30.00	67.00	3.00	6.0

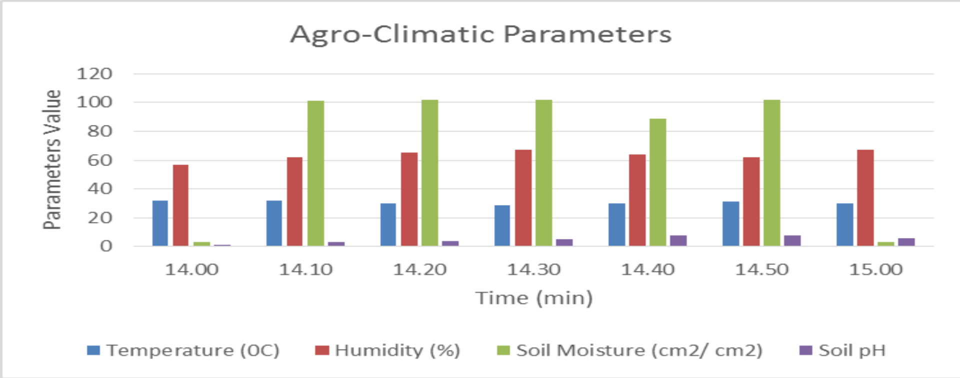

Figure-8. Agro-climatic parameters result

5.2. Real-Time Data Acquisition

The real-time agro-climatic parameters and soil information is acquired through the NetBean IDE 8.2 GUI. This allow the SWES Arduino based to program and compiled in Java native language using Arduino controller.java for the interpretation, and other two module. The Arduino application (Arduino.fxml) for graphic design and the serial module (SerialListner.java) for the establishment of serial communication with SWES Arduino. The result of parameters acquired for each sensor node (Temperature, Humidity, Soil moisture, Voltage and Soil pH) and the composite nodes are plotted and depicted as shown in the figure 9-14.

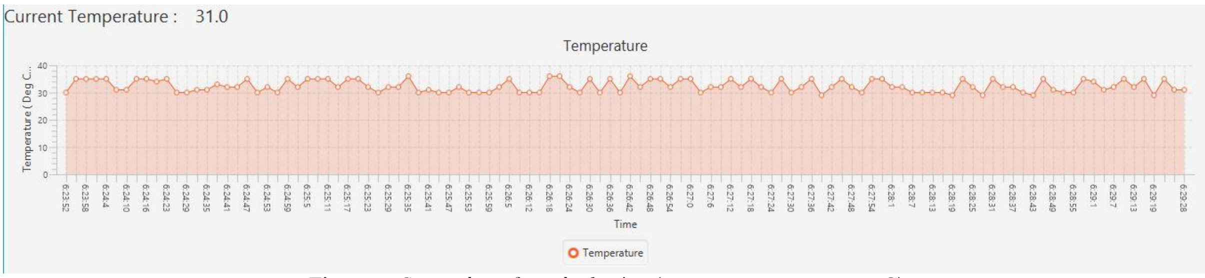

Figure-9. Screenshot of graph plotting (temperature parameters ^{0}C)

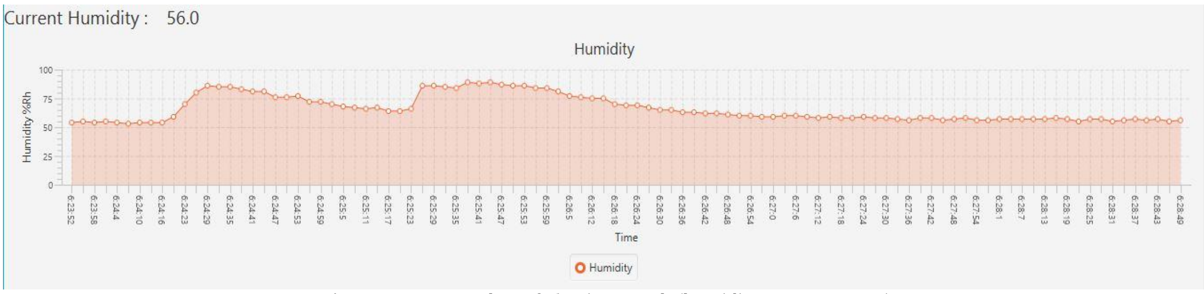

Figure-10. Screenshot of plotting graph (humidity parameters %)

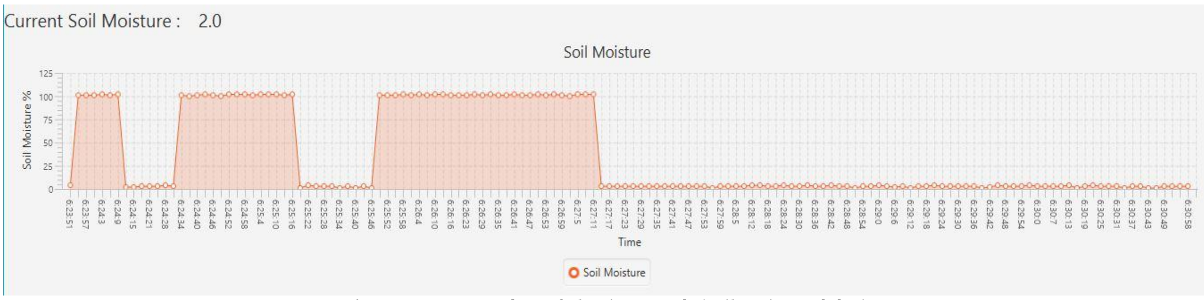

Figure-11. Screenshot of plotting graph (soil moist and dry)

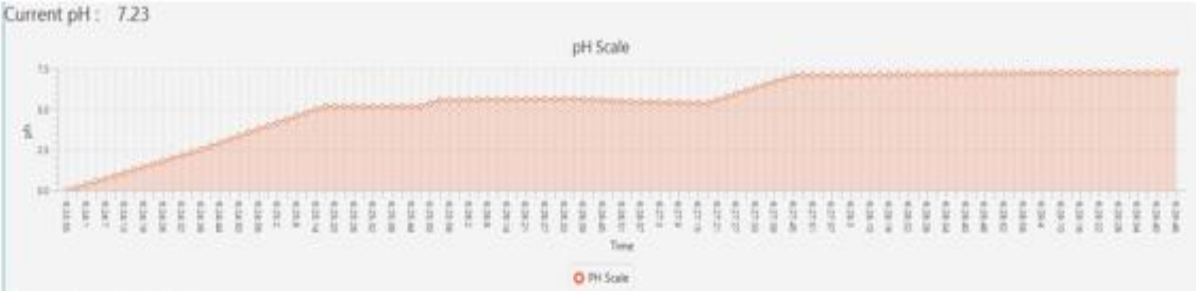

Figure-12. Screenshot of plotting graph (soil pH parameters)

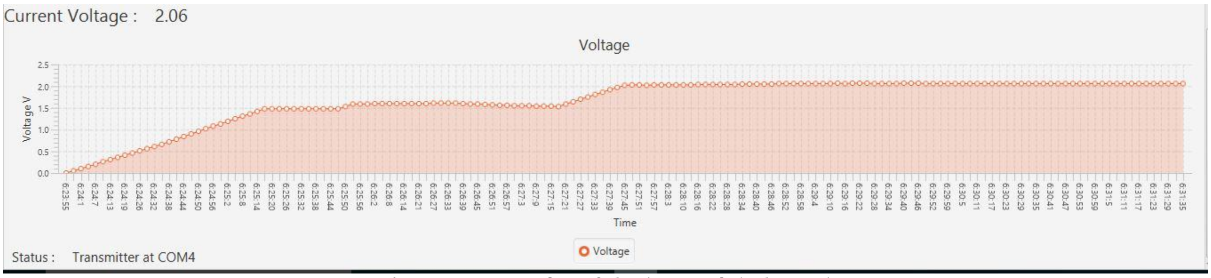

Figure-13. Screenshot of plotting graph (voltage V)

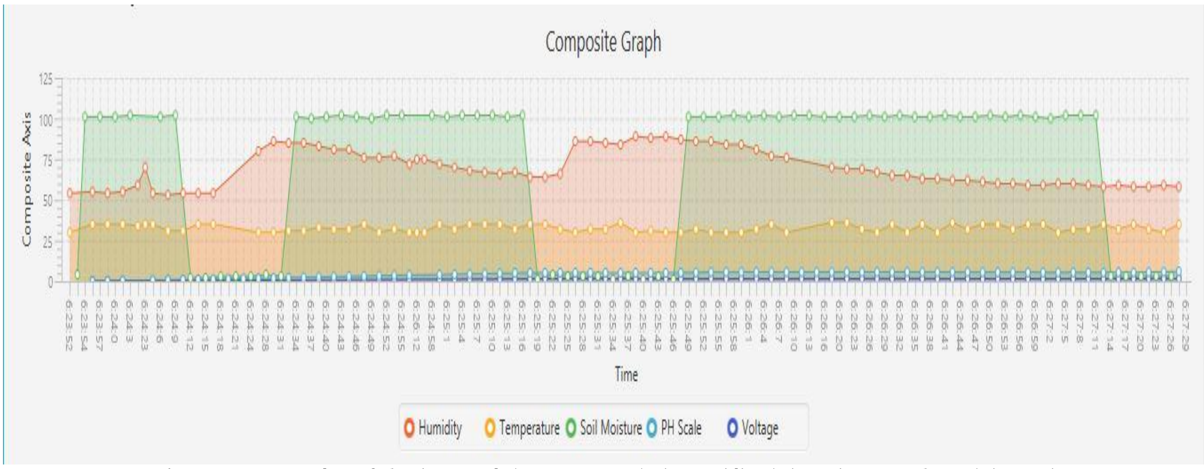

Figure-14. Screenshot of plotting graph (Temperature (^{o}C), Humidity (%), Moisture, Voltage (V) & pH)

6. CONCLUSION

Wireless sensor networks based-internet of thing for agro-climatic parameters monitoring system and real-time data acquisition has been developed to benefits the farmers, agronomist, meteorologist and others. Different modules were integrated together to perform efficient roles of interconnectivity, interoperability and remote monitoring in a real-time basis in the ubiquitous platform. Also, this system utilized a Restful web services application layer protocol and Wi-Fi (IEEE 802.11 b/g/n) technology for communication between field sensors and remote users. The SWES is tested and deployed into the field for sensing of climatic changes and soil information, which was accessed through an android web application. Also, the result of agro-climatic parameters is acquired in a real-time and plotted in the Net Beans IDE using Arduino controller.java for interpretation, java native language for program and compilation. The future works will focus on macro-nutrient soil information analysis using artificial intelligence method for the determination of soil fertility.

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