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Smart Irrigation System based on Client Server Method

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Abstract: ***In this paper, a client server irrigation system is introduced that uses sensors to sense the environment conditions such as the temperature and moisture of the soil then make proper decision based on aggregated data from sensors and available information about plants, soil and plant Evapotranspiration (ET) that relate to the geographic area and the month of planting then make some calculations to give the suitable amount of water to the plant. This method saves the water amount that consumed when the traditional irrigation method is used. In addition, it reduces the time and effort that required in traditional irrigation method. Farther, the proposed method enables the monitoring of the plant conditions 24 hours and 7 days a week. The results of applying this method were promising***

Keywords: Client–server, Nodemcu, Esp8266, Irrigation schedule, irrigation system, Arduino IDE..

1. Introduction

Client-server model can serve the flexibility of adding or removing nodes from the wireless sensor network. There are two disconnected networks, the first one serve gathering the data from nodes and delivering it to the main station and the second one is used for sending the commands from the main station to the actuator (server) or from any device that connected to the server network. Irrigation has evolved over the ages from primitive methods that rely on irrigation from the water coming from rain to irrigate the plants to rely on the rivers to irrigate the plants. This primitive method continued until the industrial revolution was started. Engines and pumps were used instead of some primitive methods that was used to raise water from the river to the level of agricultural land; the world then began to invest in the field of irrigation and conservation of water for agriculture and developed irrigation methods like sprinkling and drip irrigation. Later began to develop special machines for irrigation control, which was based on time as irrigation timers. then evolved to another type that use a specific table and then evolved into controllers based on sensors to investigate the condition of the soil and the amount of water needed for irrigation and other depends on the weather and developme2nt is still ongoing in order to save water to the maximum extent.

2. Related Works

The authors in [1] proposed system uses multiple modules to do many tasks like user interface module, network communication module, data collection module, data processing module and system configuration module and database access module, the paper dose not focus on irrigation just on data grapping and monitoring of the state of system.

In [2], the proposal focused on the use of a wireless sensor system for lower effort and remote controlled watering system. The summarized framework has 3 units in particular: Sensor Unit (SU), Valve Unit (VU), and Base Station Unit (BSU). The framework has a few centric points, for example, averting moisture anxiety of trees, reducing of over the top water utilization, guaranteeing of fast developing weeds and disparaging calcification.

In [3], a different framework discussed and then proposed a framework model to check utilizing in Wireless Sensor Network (WSN) that used to help the farmer to increase the yield. The researcher try to validate multi types of commercial irrigation systems to figure the best of them. All of the studied types use the threshold method to irrigate that is not scientific in the reality.

The system in [4], is Simple. It measures different environmental conditions and it tries to estimate if there is a disease in the plant, there is ambiguity of how to diagnosis the disease and how to irrigate.

The system in [5], proposed agriculture management system for gaining data about agricultural environment by using sensor network. The system gathered sensors data about climate and soil. But, It did not observe irrigation process; only monitor environment, and soil parameters.

The research in [6], suggested a generic algorithm for irrigation scheduling management for micro-irrigation technique which were: sprinkler and drip. This method provided estimation of needed plant water, irrigation frequency, irrigation frequency time duration required to estimated irrigation scheduling for a crop.

The author in [7] proposed a strategies to estimate water quantity needed by cultures. it present WSN architecture to use in smart irrigation , then experimentally tested it , by using fuzzy rules to estimate irrigation time that based on humidity and temp of the air that is not accurate method in reality.

The authors in [8] proposed a system composed from Raspberry pi, Arduino, Xbee and relay. It uses drip irrigation and ultrasound sensor and solenoid, the ultrasound used to control filling the water tank, the system is simple but not tested in real field and uses the threshold method to control irrigation.

The research in [9] proposed smart sprinkle system, it monitor moisture level in soil to irrigate or not, it uses weather data to delay irrigation if there is rain will happen soon, also there is manual control option from user to irrigate or not, GPRS used to send commands to the system, its more suitable to home uses but not for large farms. It's also uses threshold method too.

The research in [10] presents a survey paper more than other thing , it compare between two of commercial irrigation controllers like Weathermatic SL 1600 and Hunter pro c and its options ,then it prefer the Hunter pro c , and also it just focus on water saving in its judgment and forget the most important factor that is the field yield .

In [11] the author proposed a system that monitor soil moisture to determine the soil state and try to estimate the soil ph state to determine the crop type that can be used, the estimation method is by using camera to take photo to the soil and analysis it is drawbacks that the methods used is not accurate method for estimation of ph and it uses the threshold method also.

The author in [12] proposed a model that called smart photovoltaic irrigation manager that was developed using Matlab, it uses the photovoltaic energy so it reduces the demand of energy and reduce costs, the drawback of this research that irrigation not the main focus.

The research in [13] focuses on smart agriculture and reducing wastage in water, fertilizers and increases crop yield ,the researcher proposed a system to monitor field using sensors and control the irrigation based on soil moisture level . it still using the old type method that uses the threshold to control irrigation.

The research in [14] discusses the implementation of soil moisture sensor to automate the sprinkler system using predefined threshold value (15%) to turn pump on when it reach (45%) it turn it off , it uses the same outdated threshold method.

3. Proposed System

There are different types of sensors that are appropriate to be used in irrigation process (or agriculture). In this proposal many sensors are use which are explained as follows:

- Soil moisture sensor that used to measures the volume of water in soil.
- The humidity and temperature sensor (DHT22): it's combined from capacitive humidity sensor that measure the humidity of air and a thermistor to measure the temperature of air.
- Light Dependent Resistor (LDR) which is a variable resistor that change its resistance depending on the intensity of light, when the intensity increased the resistance decreased and vice versa.

All of those sensors are connected to the ESP8266 microcontroller which is enabled with Wi-Fi transmitter. All of these hardware components are work together and each sensor named here as (node or mote). A software program is developed and executed in ESP8266 microcontroller to control the hardware parts. The node has been placed near the plant to sense its environment, the node connected wirelessly to the main station via ESP8266 microcontroller that work as access point and server at the same time the ESP8266 module communicate via serial communication with the main station. The proposed system is shown in (fig 1), every sensor node is responsible on retrieving the environment values that implement (soil moisture, air humidity, air temperature, sun light brightness).

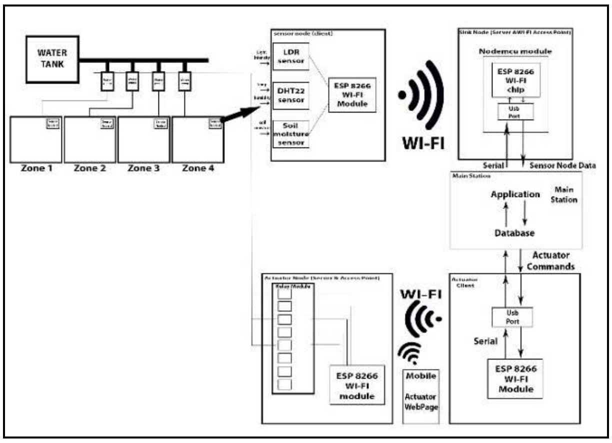

Figure 1: Configuration of an Irrigation system

The planted area is divided into zones where each zone include the sensors of (soil moisture, air humidity, air temperature, sun light brightness). This division is performed based on sensing range of sensors to get accurate readings. All the parameters belong to the specified zone is gripped then sent to the sink node via wireless link (using the ESP8266 module). The data of every sensor node is then formed and sent from sink node to the main station via serial connection. The main station take the data and process them using an application to make decision about the irrigation and in the same time save the values in database. The decision command passed to an ESP8266 module via serial connection then transformed to the actuator node via wireless connection. Then the actuator node which controls the water pumps by using the relay module.

Figure 2: The Sensors in Field (Zone)

A. Sensor Node

The sensor node or mote can be deployed in-field to form wireless sensor network for plant irrigation system. Where filed is divided into a number of zones. Each zone includes one of each type of used sensors as shown in (fig 2). ESP8266 plays two rules as wireless transceiver and microcontroller. It's the primarily element that serve the wireless communication and also control the sensors, like soil moisture sensor that senses the soil wetness, the DHT22 sensor that senses two climate parameters: the air humidity and air temperature, and also the LDR resistor sensor that senses the sun light intensity. These data all together helps in figuring the amount of water in soil at the root zone of the plant, also the condition of the plant.

The components (Table 1) are powdered by 12 v batteries that recharged either from AC TO DC charger or by solar panel, so there is no need to replace battery for long time. These components designed to minimize the power consumption for the project.

Table 1: Components of Sensor Node

Part	*Descrption*
ESP8266	Microcontroller & Transceiver
FC-28 Soil sensor	Soil moisture sensor
DHT22 Sensor	Humidity & Temperature sensor
LDR resistor	Light Intensity sensor
12v	Batteries

B. Sink node

The data packets coming from wireless sensor node received by sink node that is just another ESP8266 that also serve as wireless receiver and microcontroller. The data received as message from sensor node(client) then sent to the main station via serial connection , the sink node(server) responsibility is just grapping the data from the sensor nodes(clients) and sent it to the main station for processing it by the application and save it in the database. Table 2 shows the used wireless mechanism in sink node.

Table 2: Wireless Mechanism in Sink Node

Part	**Description**
Esp8266	Wi-Fi Receiver & Microcontroller
USB-ESP8266 Wi-Fi Adapter Module	USB-Serial Module

C. Actuator Node (server)

This part of network extend the network definition from WSN to WSAN. It consist of ESP8266 module, 8-channel relay module that connected to the pumps that irrigate zones via pipes. Table 3 shows the components of actuator node. Every pipe has a 5 nozzles in its end. The actuator node serves as wireless access point that any client can connect to it by using user name and password for security reason. The actuator node can receive commands from any client directly and that is the way that the main station sent the commands by to the actuator node. For simplifying the process the actuator node (server) has a webpage that any client can enter, Figure 3 shows actuator node and figure 4 shows actuator node webpage where from that page we can manually switch the irrigation on or off for all zones. That webpage can be entered just after connecting to the access point (actuator node) and provide username and password then we use the IP address of the server to retrieve the page. That IP is 192.168.4.1 then the webpage will showed to the user. Any mobile phone or a laptop can be used or any Wi-Fi capable device.

Table 3: Components of Actuator Node

Part	*Descrption*
ESP8266	Microcontroller & Transceiver
8 channel relay module	Relay module
12v pumps	Pumps
12v 17 AH	Batteries

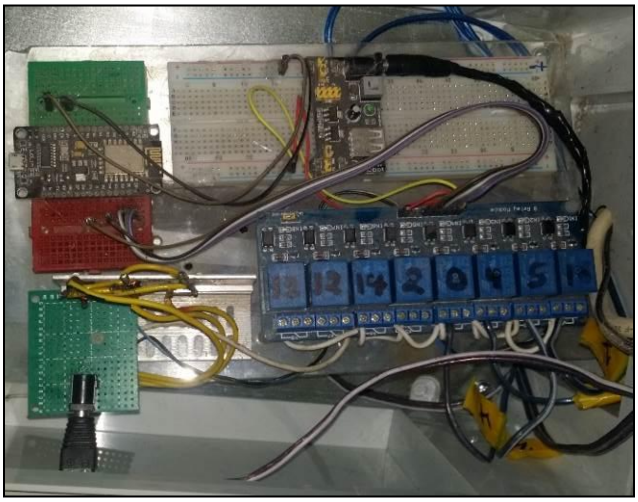

Figure 3: Actuator node.

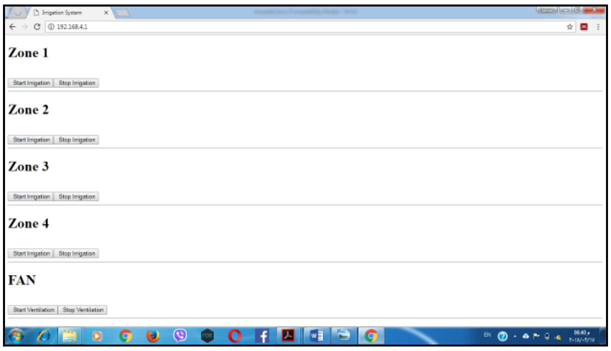

Figure 4: Actuator node webpage

D. Database Configuration

In this project, the database has built by using local MYSQL (WAMP Application for windows). There were some difficulties in implementing MYSQL in the Visual.Net environment, but the future development opportunities of project will solve this issue by using a local website that connect to the same Database and use its data at the same time enable the users from controlling the system.

The Database consists of four tables (crop_info, crop_water_req, irrigation_sched, sensor_data) each table contains different fields that used for multi-purpose in the proposed system. Figure 5 shows the fields of the four tables in database.

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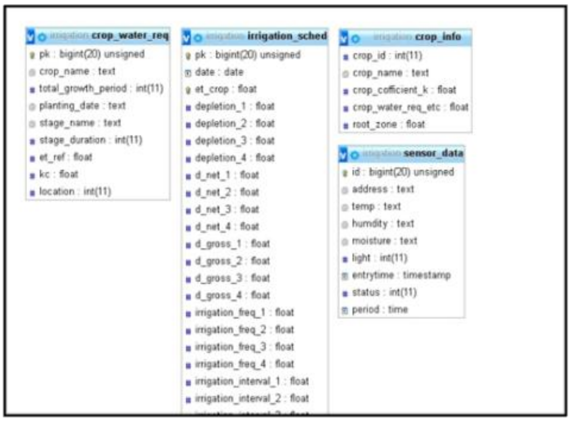

Figure 5: The Database configuration

The first table crop_water_req grapes the data about the crop that related to water requirement for that crop. The second table Irrigation_sched holds all data related to irrigation scheduling calculation and parameters. The third table crop_info maintains data about crop properties like name root zone depth, crop coefficient, crop water requirement. The fourth table sensor_data holds all data sensed from the zones like temperature, humidity, moisture, light and a time stamp for the time of grapping the data.

E. *Proposed Algorithm*

The adopted algorithm of the proposed system can be represented as a flowchart shown in Figure 6.

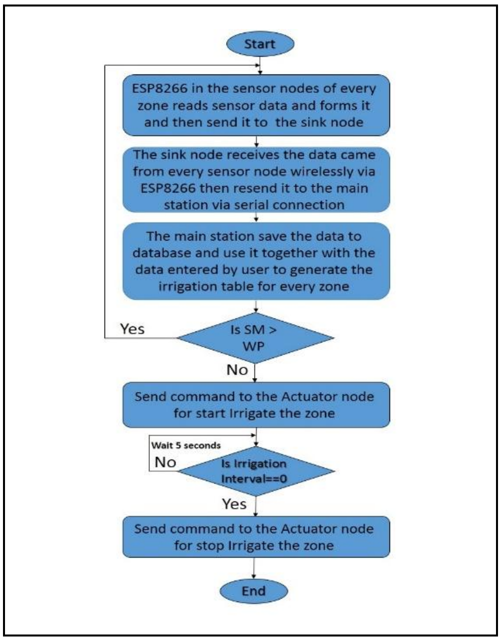

Figure 6: The Algorithm Flowchart of the Proposed System.

After power up the system, the ESP8266 (sensor node) begins sending the readings of the considered sensors to the sink node (to the main station) . The main station in turn gathers the data and calculates irrigation schedule then send the commands wirelessly to the actuator to do the work.

F. Irrigation Table

The calculation of irrigation table is depending on many factors that must be known with the using standard equations Sometimes the first equation output may is the seconds input, like that ,the calculations produce three parameters that control the irrigation process that are : irrigation frequency ,irrigation interval and irrigation time .

The first equation: $TAW = 1000(Fc - Wp) \times \text{RD}$ (1) [15]

Where TAW is the total available soil water in the root of the plant [mm], Fc is the water level at field capacity for the soil [$m3$ / $m3$], Wp is the water level at wilting point of the plant [$m3$ / $m3$], RD is the rooting depth [m].

Second equation : $\%=[(-Sm)(Fc-Wp)] \times 100\%$ (2) [16]

The percentage soil moisture depletion ratio, Fc is the water level in soil at field capacity [$m3$ / $m3$], Wp is the water level in soil at wilting point of the plant [$m3$ / $m3$], is current soil moisture [$m3$ / $m3$].

Third equation : $d_{net}=(Fc - Sm) \times \text{RD}$ (3) [17]

where d_{net} is current net irrigation amount [mm], Sm is current soil moisture [$m3$ / $m3$], RD is root depth [m].

Fourth equation : $d_{gross}=(100\times d_{net})/ET°$ (4) [17]

Where d_{gross} is total water applied [mm], d_{net} is percentage of d_{gross} and is really needs by a plant [mm], $ET°$ is reference evapotranspiration [mm/day].

Fifth equation : $CWR=K_c * ET_o$ (5) [18]

Where CWR is the crop water requirements [mm/day] , K_c is the crop coefficient, ET_o is the reference evapotranspiration [mm/day] .

Sixth equation : $RAW = P \times TAW$ (6) [19]

Where RAW is the readily available soil water in the root zone [mm], p represents average fraction of Total Available Soil Water (TAW) that can be depleted from the root zone before moisture stress (reduction in ET) occurs.

Seventh equation : $IF=S_m/ d_{net}$ (7) [17]

Where IF is irrigation frequency, Sm is soil moisture [$m3$ / $m3$], $dnet$ is net irrigation requirement [mm].

Eighth equation: $II=d_{net}/$ CWR (8) [20]

where II is irrigation interval (day), d_{net} is net irrigation [mm], CWR crop water requirements [mm/day].

Ninth equation : $T=d_{net}/ (q\times N \times E)$ (9) [20]

Where T is irrigation time [minute], d_{net} is net irrigation [mm], q is nozzle discharge rate [l/s], N is number of nozzles, E is system efficiency and it's for drip irrigation =90% .

4. Experimental Results

The system tested in real world. During the irrigation process, sensing devices continue detecting the plant conditions. The moisture sensor placed about 30 to 50 cm from the root of the plant to the maximum extent. The location of the plant and its impact on the climatic conditions at the plant site predicts the use of temperature and humidity sensors, as well as the type of soil and its suitability to the plant type and the extent of the vessels in the amount of water to prevent contamination of pests and diseases.

5. Conclusions

An automatic drip irrigation system has been introduced. This system changed the hard irrigation process to more flexible and result in water, time and effort conserving. The farmer can start irrigation based on received data from sensor without having to see the plant visually or based on its appearance determines whether it needs irrigation. Physically, the proposed system consists of two main parts: controller server side with sensors nodes and client side connected to main computer. The sensor node consist of ESP8266 connected with soil moisture, temperature, humidity (DHT22), LDR.

The main objective of the proposed system was producing an irrigation scheduling table for a specific plant with full control mission on the pumps of water used in drip method. In addition, real-time monitoring of irrigation continued for 24 hours 7 days a week. Microsoft VS vb.net that is used for designing the GUI of the system and MYSQL to build the database.

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