

Resilient Farming Infrastructure for Rapid Rural Development

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Abstract

The major occupation of rural settlers is farming. However, due to the primitive farming tools and irrigation methods, farm produce can hardly feed the rural areas not to talk of generating income for the needed development. Besides, the lack of development and sustenance had contributed greatly to the rural to urban migration which is gradually making the rural areas desolate. This paper presents a microcontroller-based Client/Server Irrigation System for very large scale farming. The client terminals are positioned strategically within the farm to monitor the soil moisture and send its readings to the Server terminal through an RF radio. The server terminal compares the received readings with the set threshold to determine if irrigation is required or not. For irrigation to occur, the Server terminal activates the water pump and opens the corresponding water valve that connects to the farm area monitored by the client terminal. This irrigation system is resilient as it adapts to varying weather condition since it will be positioned on the farm. It also guarantees the cultivation of very large farm areas which will ensure rapid rural development through increased income from the sales of the farm produce. Besides, this system conserves the use of scarce water resources.

Keywords: *Resilient, Irrigation System, Client/Server, Rural Development and Soil Moisture.*

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Background to the Study

Rural dwellers are predominately farmers. The development of their society is anchored on the improvement of their wellbeing through their core competence which is farming (Hossain, 2004). With only 40% out of the available 75% arable land in Nigeria been cultivated; there exists room for large small farming especially within the rural areas that will bring meaningful development to the rural areas (Ogunyinka and Olorunsogbon, 2016). However, to achieve the development of the rural areas through farming, there is a need for sustainable agricultural development as described by a 2012 report of European Commission (EU) on agriculture development. In the report, sustainable agriculture was described as the improvement of quality of life in the rural areas, ensuring food supply for the present and future generation and generating sufficient income or wealth for the farmers. For many developing nation, achieving this goal is a major problem because it is anchored on generating sufficient income which farming with primitive tools and irrigation techniques as presently done in the rural area cannot provide. This primitive mode of farming can hardly produce enough food to feed the immediate dependents of the farmers not to talk of leaving enough for income generation. In order to improve on the scale of farming and will leave enough income for the development of the rural areas, there is an urgent need for the development of resilient farming infrastructure that can adapt to weather conditions, conserve water, ensures the cultivation of the available vast arable land and guarantees an all-year farming practice.

To this end, this paper presents a microcontroller- based irrigation infrastructure that uses the Client-Server architecture. In this system client terminal are deployed in the farm to monitor soil, temperature and humidity conditions using appropriate sensors. With the aid of a wireless radio transceiver, the data from the sensors are sent to the server terminal placed at a remote location within the coverage of the wireless transceiver. The received data is processed by the server to determine the need for irrigation based on the set threshold of the Volumetric Water Content (VWC). Based on the comparison of the received data with the set VWC the water pump is triggered ON or OFF by the signal sent from the microcontroller. The use of client-server architecture makes the infrastructure scalable, hence the client terminal can be increased as the farm gets larger within affecting the performance of the server on dealing with irrigation request on the farmland.

Related Works

Irrigation systems researches were aimed at ensuring optimum crop yield and adequate water conservation. The Smart Irrigation Decision Support (SIDS) developed by Hamouda, 2017 uses Wireless Sensor Networks (WSNs) to monitor the crop parameters by attaching Sensor Nodes (SN) to each crop to monitor its soil moisture and temperature. The final output actuators for a proper agricultural activity is activated once the sensed information reaches the server via the sink node that aggregates information passed from SN to SN using the multi-hop communication technique. In a greenhouse irrigation system using WSNs, Harun et.al, 2015 uses sensors to get pH, temperature, humidity and moisture readings and sent reading to a remote server for proper monitoring and analysis. The system triggers the pump and valves for the irrigation process once the moisture data reaches a set threshold value of Volumetric Water Content (VWC). Programmable Logic Controller (PLC), PUNDE et.al, 2017 used a

dry sensor (transistor and metal electrode) and temperature sensor (LM35) to irrigate in a poly house and greenhouse farming. The dry sensor monitors the moisture and water level ratio and sends a signal to the PLC to ON/OFF water motor and sprinkler motor. Similarly, the temperature sensor maintains a temperature value by turning ON/OFF the dc fan based on the signal received by the PLC following the set temperature range. Using IOS/ Android application, Isik et.al, 2017 to monitor and control the irrigation a PLC based irrigation system was designed. The application is used to monitor and control via mobile devices. In a drip irrigation setup, the microcontroller was used to design an irrigation system that monitors the soil moisture and temperature. Once the desired moisture level is reached the sensor signals the microcontroller to turn OFF relays which controls the valve. This irrigation system conserves water by dispersing the required water based on the preset moisture level thresholds (Ashok & Ashok, 2010).

Irrigation System Design

The Client/Server irrigation system is a network of two client terminals located within the farm, connected to a server terminal via an RF Radio. For proper scheduling of the irrigation process, an Arduino microcontroller was used as the heart of the design to coordinate the affairs of the terminal. To communicate with the Arduino, C programming language was used. Fig 1 below shows the design layout of the irrigation system while fig. 2 shows the irrigation system equipment needed for farm setup.

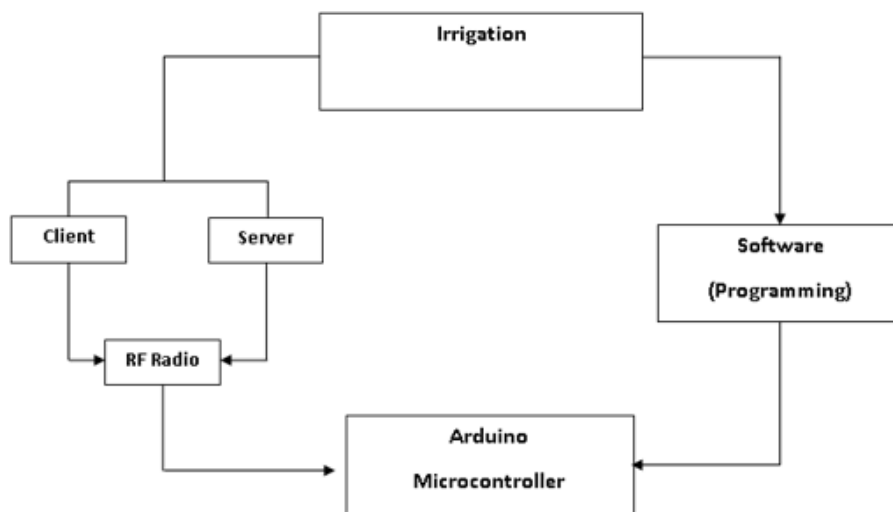


Fig 1: Irrigation System Overview

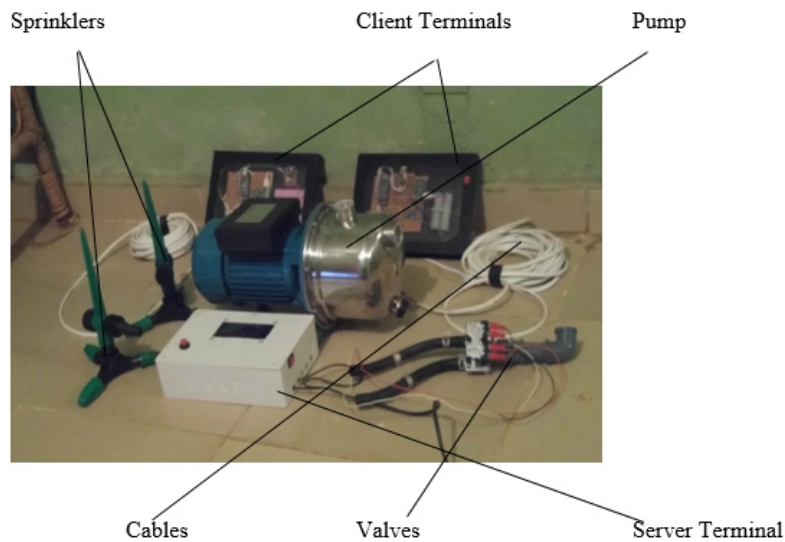


Fig 2: Irrigation System Setup

The Client Terminal

The client terminal is an on-farm irrigation device. As shown in fig. 3, at the heart of the terminal is an Arduino Nano Microcontroller that is powered a rechargeable 5V DC. Soil, temperature and humidity sensors are connected to the microcontroller and their reading are sent through the microcontroller to the server terminal via the wireless radio. The wireless reading also receives command or instructions from the server terminal.

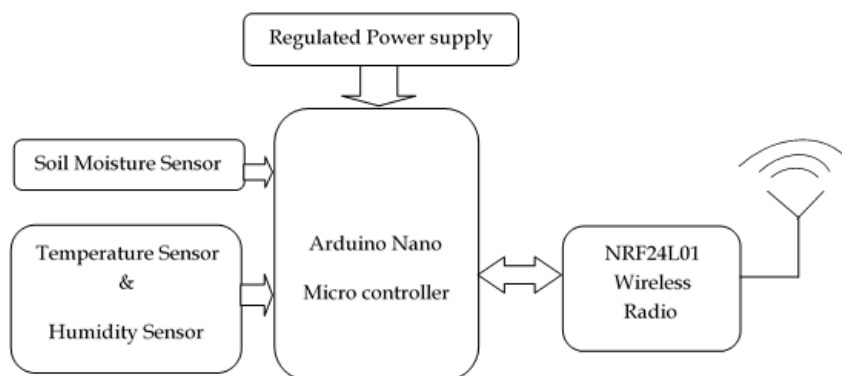


Fig 3: Irrigation System Client Terminal

The Server Terminal

The Server Terminal is an on-farm device that does not reside within the farming area like the Clint Terminal. Using the Line of Sight radio (LoS) connection technique, the radios kept within the range for adequate connections within the terminals. As shown in fig 4, once readings are received with the wireless radio, the microcontroller which is powered by a 5V

rechargeable DC power compares the readings with the set thresholds to determine the action to taken. If irrigation is required, the microcontroller sends signals to the relay driver which then turns ON the pump. Depending on which client terminal requires irrigation based on the set priority the corresponding valve is opened for water to flow to the farm area. The LCD displays the present action been taken while the reset button returns the terminal to initial conditions when the need arises.

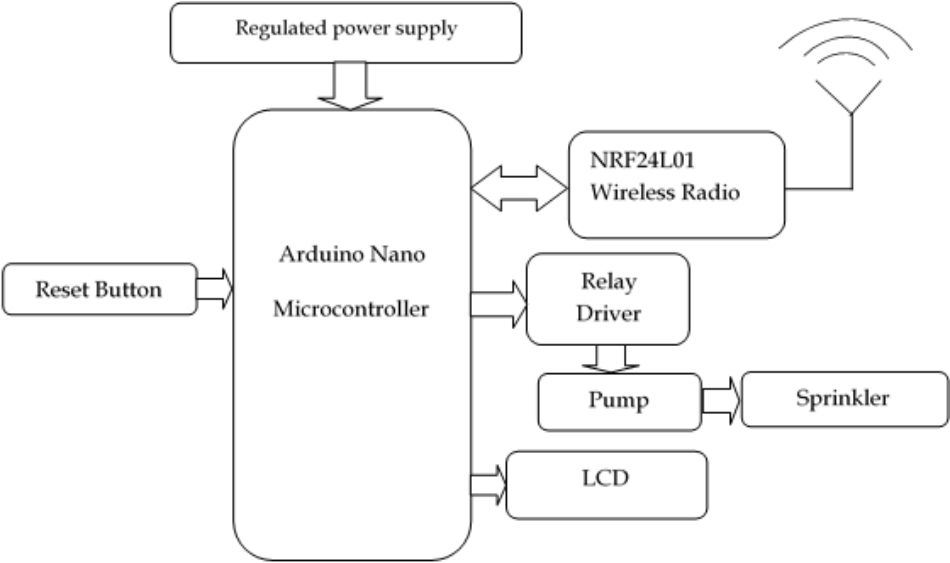


Fig4: The Server Terminal

Operation of the Irrigation System

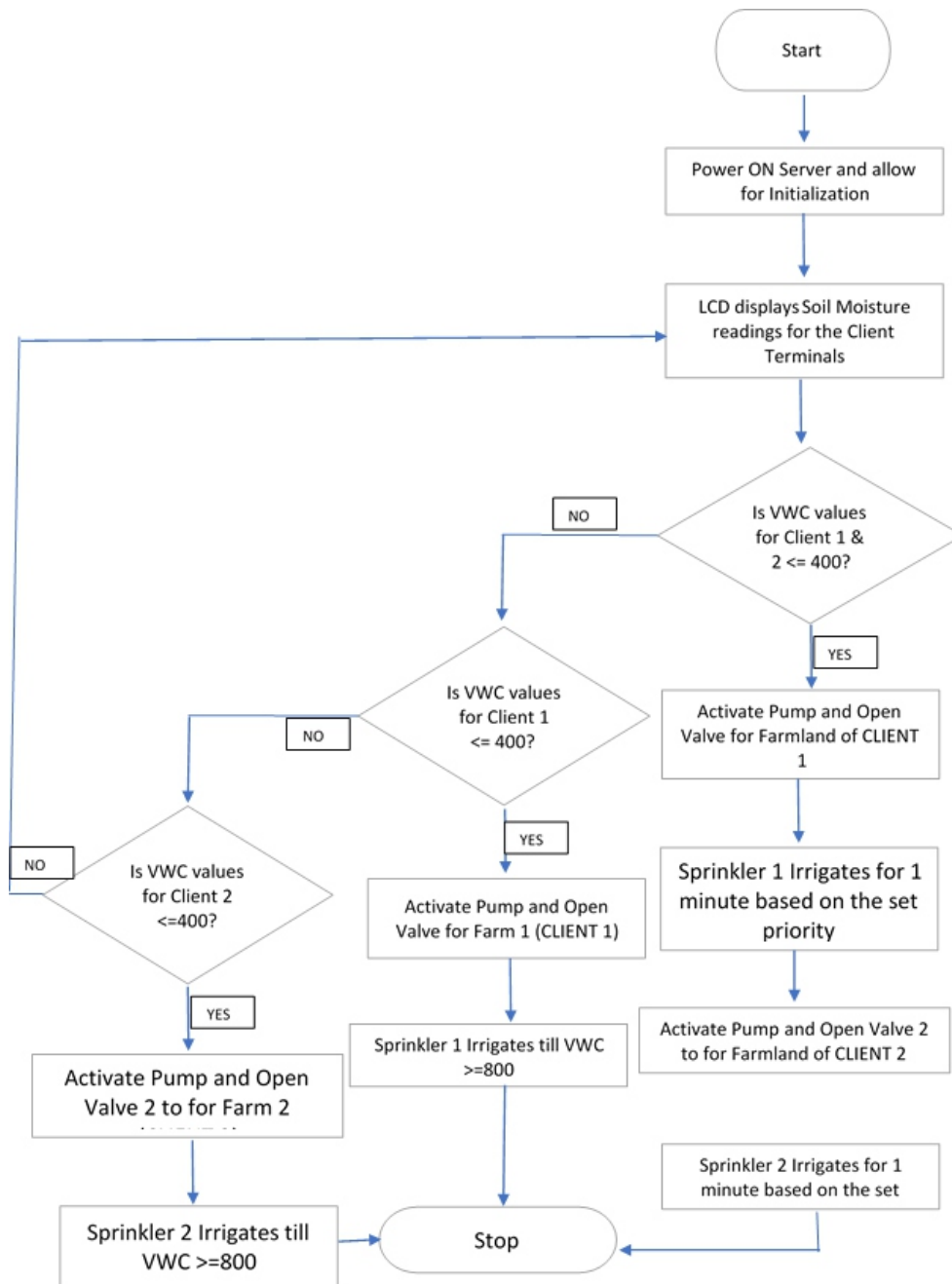


Fig. 5: Flowchart Showing the Operation of the Irrigation System.

The operation of the irrigation system requires that soil sample of the farm where the client terminal will be placed be taken for test to determine the Volumetric Water Content (VWC). The determination of VWC is needed to set the water content threshold from the moisture data that will trigger the pump ON/OFF. For discussion of the working

operation of this irrigation system, a VWC of 400 and 800 thresholds was assumed. When the server is switched ON, it goes through the initialization process then the server LCD (Liquid Crystal Display) shows the soil moisture readings received from both clients situated on different sections of the farmland. At startup, as shown in fig. 5, the clients send the sensors readings to the server for analysis. As programmed, the server then checks if the values for both clients are the same and if so, the server sends a signal to the pump to activate valve 1 of the pump based on priority order assigned to the system to sprinkle water to the farmland covered by client 1 device on the farm. This will be done for one (1) minute before the server switches to the second valve to sprinkle water on farmland covered by client 2 for another minute.

If the soil moisture readings received from both clients are not the same, the server further checks if the soil moisture reading from client 1 is less than the threshold value, if so, the server sends a signal to the pump to activate valve 1 of the pump in order to sprinkle water to the farmland covered by client 1 device on the farm. However, once the VWC threshold reaches 800 the microcontroller sends a signal to turn OFF the pump. If otherwise, the server checks if the soil moisture reading from client 2 is less than the lower threshold value, if so, the server sends a signal to the pump to activate valve 2 of the pump to sprinkle water to the farmland covered by client 2 device on the farm. The pump gets a signal to turn OFF from the microcontroller once the VWC is greater than the upper threshold value. However, if the clients' readings are more than the threshold value, a command is sent back to the LCD to display the current soil moisture reading from both clients and the whole process repeats itself.

For the smooth running of the irrigation system, C language was used to develop codes for the system (client and server respectively). These codes were transferred to the irrigation system through the microcontroller which coordinates and controls the operation of the system.

Advantages of the Irrigation System

The Irrigation System possesses the following advantages;

1. Simplicity in design and installation
2. It finds its usage in all climatic conditions.
3. It works well in all types of soil as the determination of VWC regulates the use of water.
4. It adequately conserves water usage in irrigated farming.
5. Reduces soil erosion and nutrients leaching that may occur due to over-irrigation.
6. Good for large scale farmers whose farmland might have varying soil texture.
7. Guarantees high crop yield due to adequate and frequent supply of water.

Disadvantages of the Irrigation System

The disadvantages of the irrigation system are as shown;

1. Not of economic value to small scale farmers.
2. Deterioration of plastic materials used to construct the casing for the client terminal might be rapid in hot and harsh weather conditions.

3. High setup cost
4. Frequent maintenance required to ensure an efficient operation for optimal crop yield.

Conclusion

The microcontroller irrigation system is a real-time system that monitors the soil, humidity and temperature conditions on the farm continually via a client terminal and sends the most recent readings to the server terminal for analysis and control of the irrigation system via the RF radio link through the microcontroller. This irrigation system is highly scalable as the number of client terminals can be increased to cater for more farmland without affecting the performance of the server terminal. Also, the increase in client terminal does not require an increase in the number of pumps rather an increase in the valve and laying of water pipes to the new farm areas is required. This means that an increase in the farm coverage of this irrigation system will cost less and guarantees the cultivation of more farmland hence, an increase in food production. Also, adequate water conservation is assured as water is dispersed to the required farmland covered by the client whose VWC is less than the lowest threshold value and supply of water ends once the VWC value is above the upper threshold value. In summary, this irrigation system is resilient as it adapts favourably to all weather condition and soil types thus, ensuring regular food production all year round through farming with in turn ensures an increase in income needed for rural development.

Reference

- Ashok P. & K. Ashok. (2010). Microcontroller-Based Drip Irrigation System, *International Journal & Magazine of Engineering, Technology, Management and Research*. ISSN No. 2320-3706
- European Commission Report (2018). *Sustainable agriculture and rural development policy - agricultural development*, Retrieved from: https://ec.europa.eu/europeaid/sectors/food-and-agriculture/sustainable-agriculture-and-rural-development/agricultural-development_en on August 21
- Hamouda, Y. E. M. (2017). Smart irrigation decision support based on fuzzy logic using wireless sensor network, *International Conference on Promising Electronic Technologies (ICPET)*. DOI:10.1109/icpet.2017.26
- Harun, A. N., Kassim, M. R. M., Mat, I., & Ramli, S. S. (2015). *Precision irrigation using wireless sensor network*, International Conference on Smart Sensors and Application (ICSSA). DOI:10.1109/icssa.2015.7322513.
- Hossain, M., (2014). *Poverty alleviation through agriculture and rural development in Bangladesh: Centre for Policy Development, Bangladesh (CPD)*. Retrieved from: <https://www.eldis.org/document/A20674> on August 21, 2018.

- Mehmet, F. I., Yusuf, S., Cemal, Y., Veysel, Ö., & Ercan, N. Y. (2017). *Precision Irrigation System (PIS) Using Sensor Network Technology Integrated with IOS/ Android Application*. Applied Sciences. DOI.org/10.3390/app7090891.
- Ogunyinka, O. I. & Olorunsogbon, B. F. (2016). *ICT & Agriculture: The technical tool Required for repositioning the Nigerian economy*, 5th Academic Staff Union of Polytechnics (ASUP) National Conference. 16 – 19 October, 2016
- Punde, S. S., Vise, M. A, Sanap, M. B. Kamble. A. S. (2017). *PLC Based Irrigation System*. IOSR Journal of Electronics and Communication Engineering. e-ISSN: 2278-2834,p- ISSN: 2278-8735, PP 33-36