Performance Assessment of Radio Frequency Based Centralized Wireless Sensor Network to an Agriculture Field

K. Jayaweerarathna, H.L.T.T. Dinuka*, D.A. Chathurika, R.W.R.V. Mettananda, K.W.J. Charith and S.H.K.K. Gunawickrama

Department of Electrical and Information Engineering, University of Ruhuna, Hapugala, Galle, Sri Lanka

Abstract

The newly emerged wireless sensor network (WSN) technology has spread rapidly into agriculture and farming industry, seeking this cost effective technology to improve its production and enhance agriculture yield standard through environmental monitoring. This agricultural environment monitoring system could monitor the environmental information on the outdoors remotely and it could be expected that, it will contribute for increasing crop yields and improving quality of the agriculture field by supporting the decision making of crop producers through analysis of the collected information. This system consists of set of sensor nodes and one centralized controller. Sensor nodes gather environmental conditions temperature, relative humidity and soil moisture of the field and transmit those data to a centralized controller. Centralized controller gathers all the data coming from each and every sensor node then sends those data to the server. Received data are stored in the database in the PC and allow it to be analyzed and displayed as needed. Each and every node and centralized controller are powered by solar panels and battery backup which are established near each and every unit. According to the results, it gives more accurate temperature and humidity measurement of the field. This is a very low cost system with low power consumption and therefore can be an ideal system for a developing country like Sri Lanka.

Key words: Agriculture, Humidity, Temperature, Wireless sensor network

Introduction

Agriculture is most ancient activity of the citizens in Sri Lanka which is very vital to the country. These days, farmers start to enhance their farm and try to improve their production, quality and profit. To get maximum profit, farmers should use their resources optimally so that they need to forecast environmental conditions and other requirements according to the plant. To achieve this, farmers needs to use new technology. Xia (2011) has shown that using traditional agriculture techniques farmers face lot of problems, mainly poor real-time data acquisition, small amount of sampled data, difficulty in providing varying measurement rate, small monitoring coverage area, and excessive manpower requirement.

Then the concept of precision agriculture has been around for some time. Precision Agriculture Monitor System is an intelligent system which can monitor the agricultural environments of crops and provides service to farmers. Palma *et al.* (2010) have shown that the WSNs have become the most suitable technology to fit an invasive method of monitoring the agricultural environment. Using those systems, farmers can collect environmental information such as temperature, humidity, barometric pressure, soil moisture and pH. Those collected data can be stored in a database and those data will provide suitable information for farmers to take decisions. The time, energy and required employees of the farm decrease by large amount and allow faster deployment and installation of various types of sensors. Also farmers can get decisions at the right time. So that, some farmers practicing different type of WSNs but the problem is those systems are very expensive and farmers should pay extra money to the service providers because those systems use satellite and telephone network to transfer collected data to the database.

Corresponding author: dinuka.liyanage.lk@ieee.org

Our main object is to develop a WSN which does not use satellite or telephone network to transfer collected data to the data base. Other objectives are to reduce the operational and maintenance cost than the current approaches.

Materials and Methods

This proposed system consists of 3 main sections. Those are,

1. Sensor node and power supply unit
2. Centralized unit
3. Sever with MSQL database.

Every sensor node takes three parameters from the field; those are temperature, humidity and soil moisture. These measurements are taken through the DHT22 (digital temperature and humidity sensors) and soil moisture sensor. These sensors are connected to the Arduino measured data transmit to the centralized unit through the nRF24L01+ antenna. This antenna uses a 2.4 GHz radio frequency to transmit data. Each sensor node is kept sleep while it is not operating to saves the power.

Solar power is used to power up the nodes. Power supply unit has two solar panels and two rechargeable lithium - ion batteries (2x3.7 V) and a power management unit. Rechargeable batteries are charged by solar cells. Under bright sunlight, the battery bank charged while supplying power to the sensor nodes directly from the solar panel. When the sunlight is insufficient to power up the sensor node, batteries supply power to the node while discharging the batteries. To swing between two power sources the power management system is used. Arduino detect battery level and send to the centralized unit. Figure 1 shows the sensor node architecture.

Centralized unit consist of nRF24L01+ transceiver which is connected to the Arduino micro controller. NRF24L01+ transceiver receives the data transmitted by each sensor node. Centralized unit re-transmit those data to the MYSQL data base through the nRF24L01+ transceiver. Centralized unit has a LCD display, which shows current status of the network and it has a LED indicator to indicate any failure node. If all

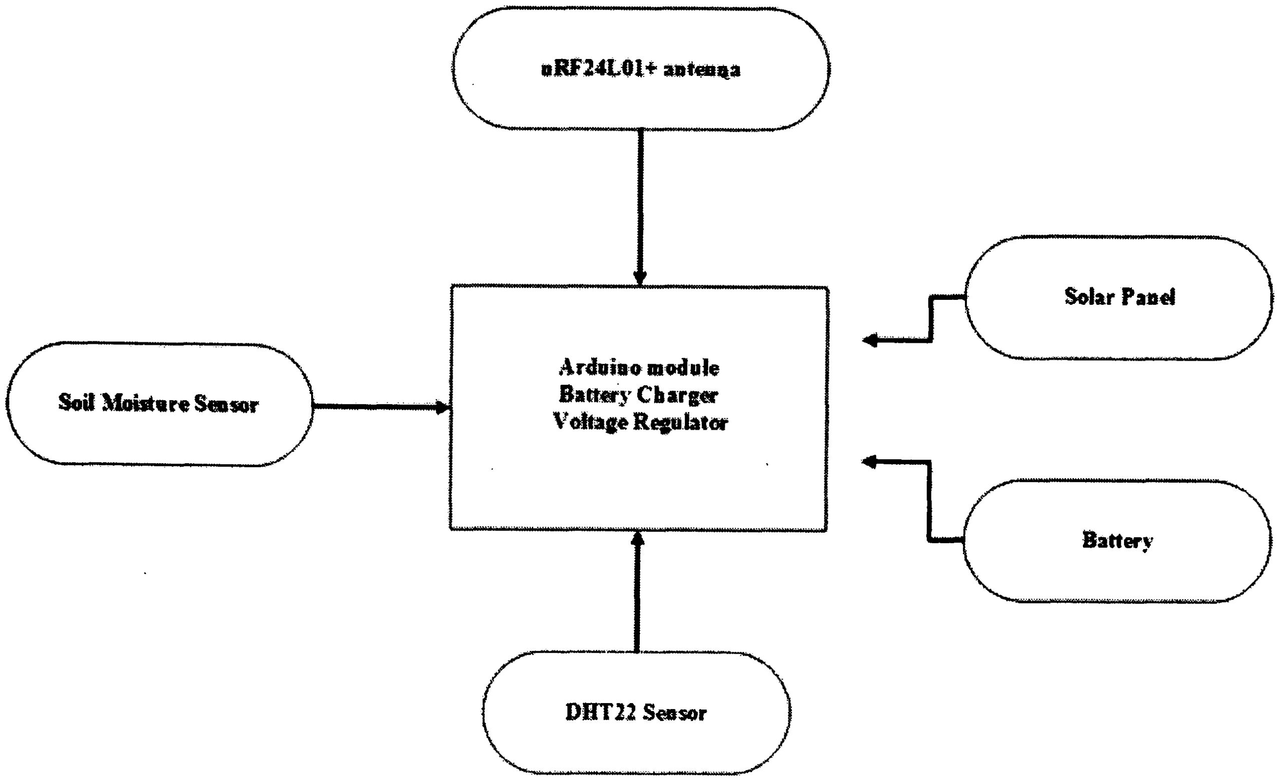

Figure 1. Architecture of the sensor node

nodes are working properly, green LED blinks and if there is any failure, red LED blinks under the node number.

Sever side consists with an Arduino micro controller and nRF24L01+ transceiver. This unit serially communicate with server and the sever stored these data in mySQL database. The interface between the server and Arduino micro controller is made by the C# programming language.

Results and Discussion

In this study, WSN is developed with three sensor node, one centralized unit and MySQL data base. This study was mainly considered on battery performance and accuracy of the DHT22 sensor collected data and soil moisture sensor measurements. Using these results created WSN mesh network can be evaluated. Every node transmits data directly to the centralized unit or through other sensor nodes. If some nodes are at 50 m away from the centralized unit, it sends data thorough the near sensor node. Every node connects to the six neighbor nodes and using those nodes collected data transmit to the centralized unit. According to network design, network can increase their number of nodes without any problem.

Sensor node and centralized unit use solar power and battery power. It use the 12 V, 10 W solar panel and two 3.7 V, 3000 mAh lithium-ion batteries. Solar use to recharge batteries and supply power to the node if it has enough power. Figure 2 shows the battery performance with the time when the node works at full load without sleeping.

According to the Figure 2, batteries were able to power up sensor node nearly 5 hours and after that node data transmission was stoped. During this period, sensors get data every 2 seconds and transmit those data to the centralized unit. In this time period, solar panels disconnected from the sensor node. Fully charged batteries start at nearly 8 V because lithium-ion batteries can charge to 4 V whether they marked as 3.7 V. Two batteries connected in series to give 6 V to Arduino micro controller. In this type of network, power consumption is very important thing. Here, main power consuming equipment is Arduino micro controller and antenna. NRF24L01+ antenna needs 3.3

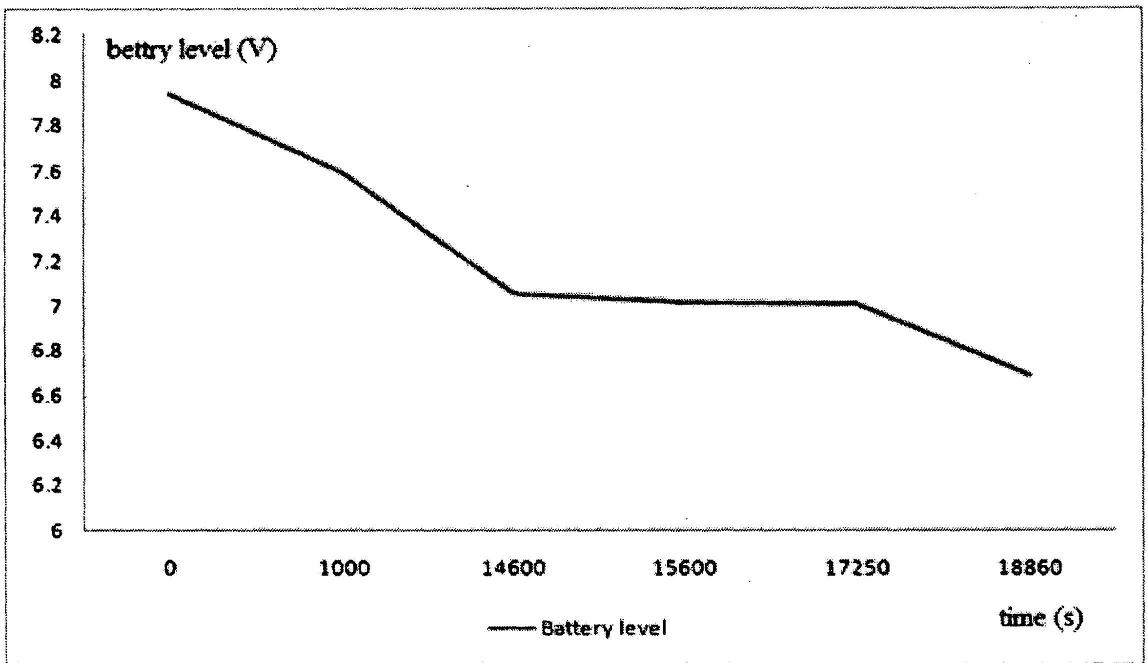

Figure 2. Battery performance of the unit with time

V for operation and current, and this varies with the transmitting distance.Power required to the antenna is very small. Temperature and humidity are measured by the DHT22 sensor. Using this type of sensor, we can get very accurate measurements of temperature and humidity.

Soil moisture sensor measures water content in the field. It will give analoge output according to the field water level. Therefore, soil moisture sensor was calibrated using dry soil moisture test. Then sensor output and water content graph was created. Using this graph water content in the field can be taken.

The current study has discovered battery performance for sensor nodes, antenna current and sensor error. The study suggests that sensor battery performance has somewhat low but, it can be avoided coupling two more batteries parallel to the existing one and increasing data collecting time period where during

Table 1. Performance of Temperature, humidity and soil moisture levels

Performance of temperature			**Performance of humidity**			**Soil moisture level**	
Wsn value	**Thermometer reading**	**Error**	**Wsn value**	**Wet and dry Thermometer reading**	**Error**	**Soil moisture level (%)**	**Sensor output**
28	28	0	80	78	2	5.263158	1022.1
30	30	0	75	74	1	9.505703	1021.5
32	31	1	72	69	3	14.00778	1009.2
33	33	0	68	66	2	18.85246	970.9
35	34	1	66	63	3	24.4898	872.2
38	37	1	63	61	2	30.56769	745.1
39	36	3	59	58	1	32.88591	549.9
42	39	3	55	53	2	38.46154	400.6
44	40	4	47	45	2	43.78109	359.6
46	45	1	44	40	4	49.5283	359.8
47	46	1					
51	51	0					
52	53	-1					
53	55	-2					
57	58	-1					
59	60	-1					
60	62	-2					

that time, Arduino and the antenna will move to the sleep mode. Errors can be further minimised using more accurate sensors. In this study, authors used only humidity, temperature and soil moisture parameters but, other required parameters can also be measured with this system using relevant sensors. With the operating time duration, it was able to be seen that sensors were affected by reduction of accuracy due to the wear and tear, and environmental effects.

When new sensor node locates in the field, it automatically detects neighbour nodes and connects to the network. Best thing of this study is the implementing cost of the network is very low. There is no need to pay extra rent to the services providers for satellite or telephone network. This is very cheap considering existing WSN price. It is proposed large scale farms to install this system to get more profit. In this study authors choose all electronic devices and software in order to design a low cost network.

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