ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 6, June 2018

IoT Based Greenhouse Monitoring System Implementation using Data Compressive Sensing Protocol in WSN

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ABSTRACT: As plant grows, it needs certain environmental parameters for its proper growth like humidity, temperature, light,etc.Also, Automated Greenhouse Monitoring ignores the need of human operators to take care of the plants. To monitor the Greenhouse parameters like humidity, temperature, soil moisture, a control system based on WSN is needed. An IoT based control system is comprised of greenhouse data acquisition PIC Microcontroller, along with temperature, humidity and moisture sensor. In the Wireless sensor network, there may be possibility of failure of nodes because of the power drained or addition of new nodes or may be change in location of nodes due to physical movement, which further results in collision and energy consumption. Compressive sensing (CS) can reduce the number of data transmissions and balance the traffic load of the networks. Compressive sensing is used for reducing the energy consumption of sensor nodes and also to reduce the congestion in the network. This increases the efficiency of the network system.

KEYWORDS: Internet of Things(IoT); Compressive Sensing(CS);Wireless Sensor Network(WSN)

I.INTRODUCTION

The development of agriculture must take the path of modern agriculture. With the rapid development of economy, the agricultural technology research and application has been paid more and more attention, especially the greenhouse has become an important part of efficient agriculture. Greenhouse is a said to be a place that creates the best conditions for plant growth, can change plant growth and avoid influence on plant growth due to outside changing seasons and severe weather. The optimum condition of crop growth is obtained on the basis of taking full use of natural resources by changing greenhouse environment factors such as temperature, humidity, light, and CO_2 concentration [1]

Consequently the yield and quality of crops is forcing agriculture, industry and the information industry to pursue common goals, which are to maximize agricultural output whilst maintaining quality. At present, domestic agricultural greenhouse management mainly uses a traditional mode of manual management, this is based on experience to periodically and manually adjust the light, temperature, humidity as well as irrigation, fertilization and to use artificial cultivation. This method not only leads to higher management costs, but also brings a series of problems, such as low production efficiency, waste of resources and environmental pollution. In view of the disadvantages of present agricultural greenhouse management, the use of information technology to make this management more efficient and intelligent is an important task in the information field.

Networking technology is a new generation of information technology, it is the use of the internet or LAN technology to combine sensors, controllers and computers to connect people and ‘things’, thereby obtaining data, and enabling remote control and intelligent network management [4]. The development of software and hardware provides the technical requisites for intelligent agricultural greenhouses, which means it is possible to widely implement smart systems in greenhouses. Temperature sensors are well developed, so though temperature sensing combined with communication technology, one can communicate temperature information through a wireless network. At the same

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time, air humidity, soil moisture, light and other sensors are being further developed and these sensors and communication technology provide the necessary useful hardware for use in greenhouses.

Wireless Sensor Networks (WSNs) are made up of tiny energy sensor nodes, so the main challenging process is to retain the energy level of those nodes for a long period. But, the main problem in wireless sensor technologies are the constrained energy resources (e.g. battery, processing capacity), and they should work as long as possible in the environment while collecting and sending data to the central station. One of the aims in sensor networks research is to reduce the amount of energy consumed by sensor nodes by reducing the communication in the network.

The number of data transmissions can be reduced by using compressive sensing which further balances the traffic load throughout networks. Researchers and industries both are working on the mechanism to prolong the lifetime of the node's battery. In communication routing algorithms decides which node has to be selected for communication and thus plays very important role in communication system[2]

II.EXPERIMENTAL MODEL

In the developed system WSN is reconfigured using RF communication. Here the system consists of 1 Master and 2 slave's structure. In this network data compression protocol is used.

The Figure 1. depicts the block diagram of the system. The system consist of PIC microcontroller and various sensors.

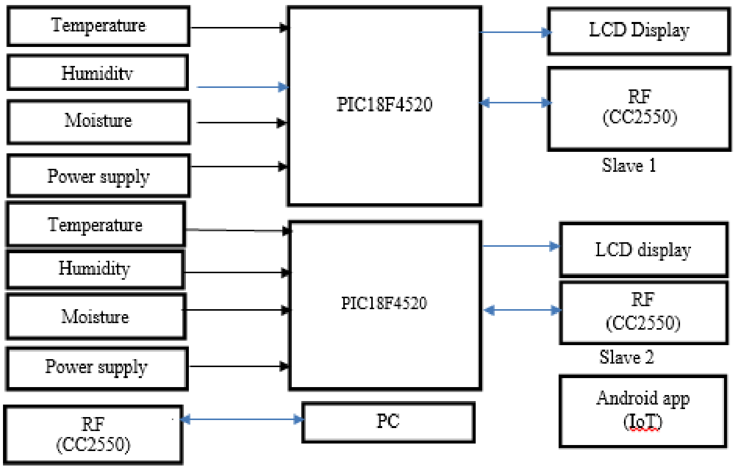

Figure 1: Block Diagram of Proposed System

In the greenhouse monitoring system, the communication occurs from slave side to master side. If access is given to all the slaves to transmit the data frames directly to master, then the whole network will be flooded with data frames, causing congestion, which further reduces the overall efficiency of the WSN[6]

To counter these limitations, a data compression protocol is proposed, in which the slaves transmit their frames to their nearest neighbour who is closer to the master. The nest slave will then combine the previous slave's data frame with its own data frame to construct a new data frame. This data frame will have the data of both the slaves with a identifier. In this way, the data is compressed as the frame id is forwarded in the network, until finally it reaches the destination (Master).

III.PERFORMANCE ANALYSIS USING COMPRESSIVE SENSING

Assume a network of n nodes and each node acquires sample di, such as temperature, humidity,soil moisture. Usually, the goal of the WSN is to collect the vector at the sink,

$$A = [A1 \dots An]T \qquad (1)$$

Using CS, data can be collected such as,

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$d= [d1 \ldots dm]T$ (2)

Let's illustrate the idea of CS in WSNs, through an example shown in Figure 2, which is a small fraction of a whole routing topology. The routing topology forms data gathering routing tree and collects data at the sink node. In compressive sensing, sampled data is transmitted from leaf node to root node in sequence.

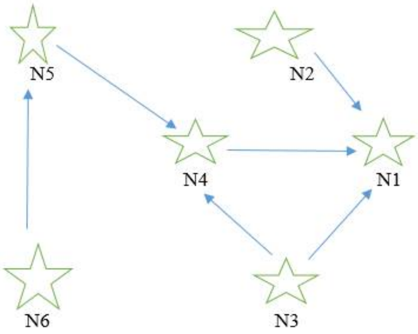

Figure 2: Data gathering with compressive sensing by nodes

Figure 2, shows the data gathering with compressive sensing by six nodes.

Consider a network having 6 nodes N_6, it collects its sampled data D_6,and generates a length L vector,

$A_6= [\ A_{16}\ A_{12.......}A_{l6}]^T$ (4)

which is the 6th column of sampling matrix A_{6L*N}.

Then N_6 computes its compressed data A_6d_6 which is expressed as,

$A_6d_6= [\ A_{16}\ d_6,A_{26}d_{6.......}A_{L6}d_6]^T$ (5)

and transmits the L data,

$A_5d_5= [\ A_{15}\ d_{5.......}A_{L5}d_5]^T$ (6)

and adds A_6d_6 to its parent node N_4.

Finally N_1 receives the compressed data,

$\sum_{j=1}^{6} = Aijdj$ (7)

and forwards its to the sink .

IV. SYSTEM TESTING

Data acquisition test

In the greenhouse monitoring system three different sensors are used for plant monitoring mainly, temperature,soil moisture and humidity sensor. One master and two slave structure is implemented. When the supply is on the sensors collects the data, the parent node will collect the compressed data from its child node.

Software simulation test

For software simulation of greenhouse monitoring MPLAB IDE software is used, after writing the code, it is debugged and code is built up successfully. For downloading the program in PIC microcontroller, picall v0.16 software is used.

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Interfacing result on LCD

Analog to Digital Converter (ADC) is used to convert the voltage from the sensors to the digital systems so that the result will be displayed on the LCD screen in digital form. Different readings have been taken at different times. As well as when the soil is sandy, slurry gives different moisture reading. For soil moisture electrodes are used, which when putted in the soil gives the reading. Temperature sensor LM35 gives temperature reading in analog form which is converted into digital via ADC.

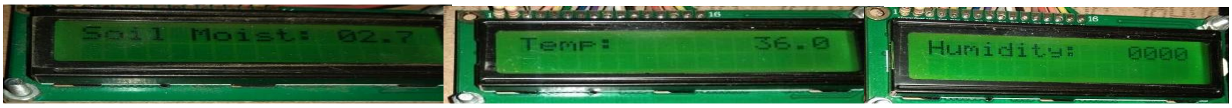

Figure 3: Temperature ,Soil Moisture and Humidity recorded on LCD display

Figure 3, shows the current reading of temperature, soil moisture and humidity displayed on LCD screen,which is collected by the sensors. The humidity reading is not stable because of the humidity in our environment is always changing and the temperature reading shows the stable data.

Server Side monitoring function test

First of all the RF module is initialized. For server side PC is used as the master, and at the router side two slaves. The Rf module is used for transmission and reception, for this UART protocol is used .When the connection is established both the LEDs blinks denoting the transmission and reception of data from router to server side.

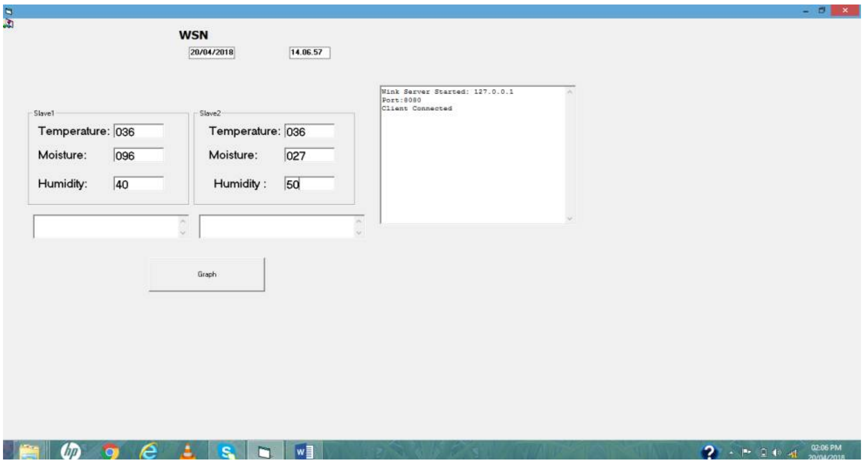

Figure 4:Output recorded on GUI

Figure 4, illustrate GUI developed by visual studio 2006 which receive data sent by greenhouse. And save it to internal database then display it as shown in Figure.

 DOI:10.15662/IJAREEIE.2018.0706003

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Vol. 7, Issue 6, June 2018

Graph Generated on GUI

Following graphs shows the temperature, moisture and humidity recorded in greenhouse.

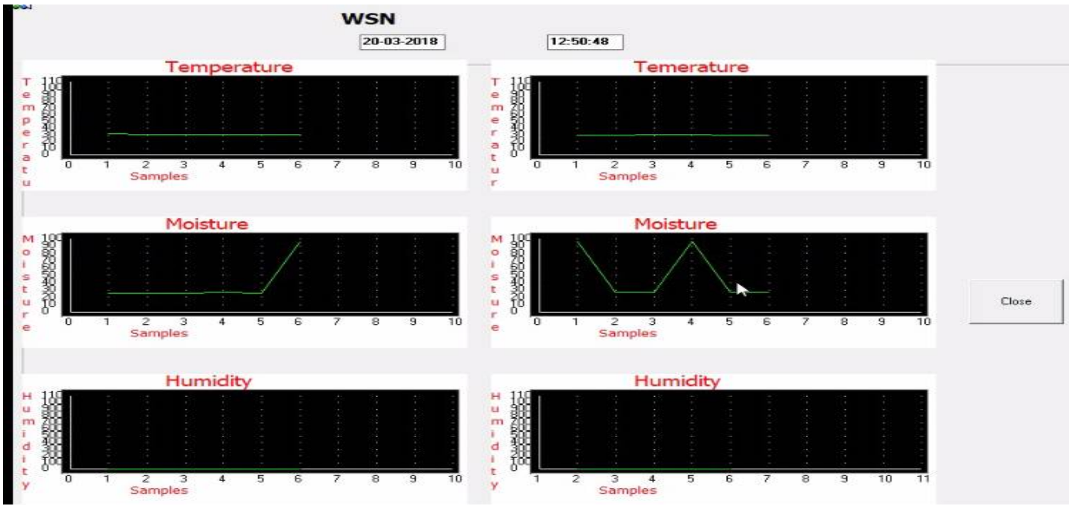

Figure 5: Graphical data recorded on GUI

Figure 5, represents the parameters monitored in greenhouse, the first graph shows the temperature reading for 10 different samples for slave 1 and slave 2 respectively, recorded on date 20/03/2018. The temperature noted is between 30^{o}C and 40^{o}C.The temperature doesn't vary much because it remains constant for long day. The second graph shows the moisture recorded which is 27 at the start for slave 1 for 10 different samples, which means that the soil is dry. Whereas when the soil is slurry it shows the reading as 96.

V. RESULT AND DISCUSSION

The results are summarised in the following tables:

Table 1: Experimental results of greenhouse temperature data recorded for slave 1 and slave 2

Sr.No.	Samples	Slave 1 Temp in ^{0}C	Slave 2 Temp in ^{0}C	Thermometer Temp in ^{0}C
1	S_1	31	32	34
2	S_2	31.5	33	34
3	S_3	35	35	36
4	S_4	35.5	36	36
5	S_5	36	36.5	40
	Avg	33.8	34.4	35.3
	SD	2.361	1.81	1.20

Table 1, shows the readings of temperature sensor noted on LCD .The data recorded in the morning was 31^{0}C and 32^{0}C for slave and slave 2 respectively, in comparison with the room thermometer the temperature recorded was 34^{0}C.

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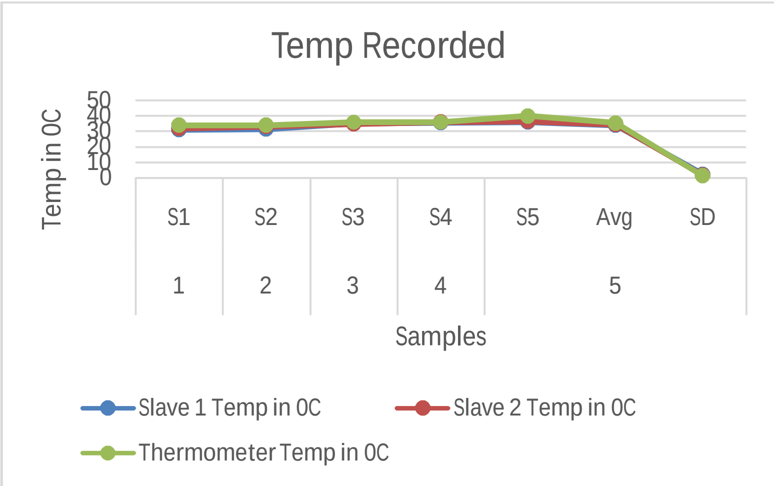

Figure 6: Graph of No.of samples of slave 1&2 Vs Temperature Recorded

Figure 6,shows the temperature recorded for five different samples for slave 1 and 2 respectively. The average and standard deviation is 33.8 and 34.4 respectively.

Table 2: Experimental results of greenhouse Soil Moisture data recorded for slave 1 and slave 2

Sr.No	Samples	Soil Type	Slave 1	Slave 2
1	S_1	Dry	2.7	2.6
2	S_2	Slurry	2.7	9.4
3	S_3	Sandy	00	1
	Avg.		1.8	4.33
	SD		1.55	4.66

Above Table2, shows the soil moisture reading recorded in greenhouse monitoring plant, when the soil is dry the moisture is 2.6 for slave 1 and 2.7 for slave 2.While, when the soil is slurry the moisture content increases and data recorded was 2.7 and 9.4 respectively. Whereas, when the soil is sandy the moisture content was little and data recorded was 00%Rh and 1%Rh respectively. The Avg. obtained is 1.8 and 4.33 and SD is 1.55 and 4.66 for slave 1 and slave 2 respectively.

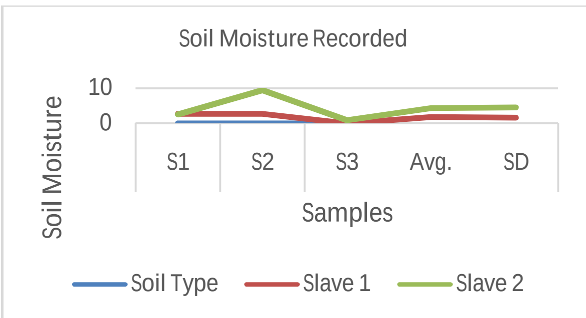

Figure 7: Graph of No. of samples of slave 1&2 vs Soil Moisture Recorded

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Vol. 7, Issue 6, June 2018

Table 3: Experimental results of greenhouse Humidity data recorded for slave 1 and slave 2

Sr.No	Samples	Slave 1 in % Rh	Slave 2 in % Rh
1	S_1	00	00
2	S_2	10	11
3	S_3	40	50
	Avg.	16.66	20.33
	SD	21.21	27.57

Table 3, shows the humidity recorded in greenhouse monitoring plant, the slave 1 and slave 2 readings are little different because the humidity in the environment is not stable it changes frequently, unlike temperature which remains constant. At the start the humidity recorded was zero whereas after successive implementation the recorded data was 10%Rh for slave 1 and 11%Rh for slave 2.Average and standard deviation is calculated and shown in table.

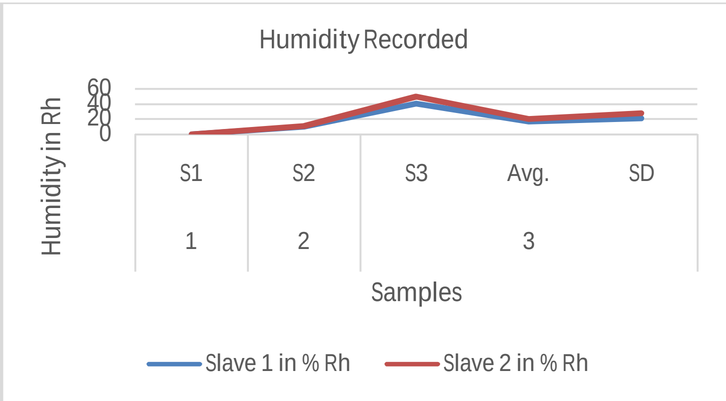

Figure 8: Graph of No.of samples of slave 1&2 vs Humidity Recorded

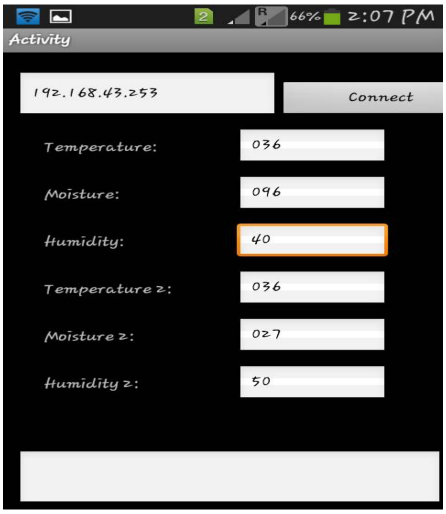

Figure 9: Data recorded on android app

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Figure 9, shows the output displayed on app during greenhouse monitoring. The readings for slave1 and slave 2 is same which is displayed on LCD, GUI of visual studio as well as on the android app. This data can be accessed at long distance, provided by the distance set in the Rf module.

Using this, the greenhouse readings can be monitored at far away distance. The results obtained are shown inthe figure 9,which shows that when the data does not change for long time it will not display the readings on the app. In the code, the tolerance value has set 10% for all the sensors which means that the master will check that whether the temperature is incremented or decremented by 10 values. If yes, then only the data will be display on the app. This shows the redundant data is transferred avoiding collision in the network. Which reduces the energy loss.

VI. CONCLUSION& FUTURE SCOPE

Wireless sensor network is a valuable tool used for increasing the energy efficiency of the greenhouse environment without disturbing the quality of life. An IoT based greenhouse monitoring system is established using data compressive sensing protocol in WSN. This is low cost and energy efficient system. The data is collected by the nodes, each node is assigned a slave ID which collects the nest slave's data and sends it to master. But sometimes there occurs collision in the network. This collision is avoided using compressive Sensing protocol. Using this, the sensors collect the data used for greenhouse monitoring. Temperature,soil moisture and humidity data was recorded ,this data obtained was in analog form, which was converted to digital via ADC and further displayed on LCD. The software simulation was done using the MPLAB IDE.

Using visual studio, GUI was constructed which displays the reading monitored in greenhouse .Also variation in the graph was observed according to data collected. An android app was developed so that data can be monitored at long distance. Connection was established between the master and the phone. When the data was constant, no data was observed on the phone. But when the data goes beyond or increases by 10%, then the readings are displayed on the app. This means that the data was compressed and send collectively,which avoids the redundancy in the network as well as increases the energy efficiency.

The Smart Greenhouse can be further upgraded in many ways and can be used in wide agricultural applications. It can be placed and operated in any of the environmental conditions to grow any kind of vegetation. Non-conventional energy sources such as solar panels, wind mills are used to supply power to the automatic greenhouse equipments and peltier effect for cooling purpose.Soil-less farming can be performed to further improve the nutritional value. Integration of farming with IoT can make it much more efficient and profitable activity. Smart Greenhouse has a bright future scope in agriculture field and it will create a revolution in the way the agriculture is carried out in India.

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