International Journal of Latest Research in Science and Technology **ISSN (Online):2278-5299**
Volume 3, Issue 4: Page No.81-87. July-August 2014
https://www.mnkpublication.com/journal/ijlrst/index.php

A MULTI SENSOR SYSTEM FOR TEMPERATURE MONITORING IN A GREENHOUSE USING REMOTE COMMUNICATION

[1]Heldi Hastriyandi, [2]Kudang B.Seminar, [1]Heru Sukoco
[1]Departementof Computer Science, Bogor Agricultural University, Bogor, Indonesia
[2]Departement of Mechanical and Biosystem Engineering, Bogor Agricultural University, Bogor, Indonesia

Abstract: Greenhouse technology is an alternative solution for controlling micro conditions to plants. The change of air temperature within a greenhouse is one of the vital parameters that needs to be monitored. Recent temperature monitoring systems still use a single temperature sensor placed at one of the observation locations to detect temperature change in a relatively wide space greenhouse with uneven temperature distribution. The objective of the study is to develop a system for monitoring the temperature in the greenhouse by placing multiple temperature sensors at several observation positions. The proposed system allows more representative and comprehensive obervations for conducting an analysis of the temperature changes using wireless communication. In addition the temperature in greenhouse can be monitored optimally .

Keywords: Greenhouse, MultiSensor System, Temperature, Monitoring Systems, Wireless Technology.

I. INTRODUCTION

Greenhouse technology or plants house is an alternative solution to control the micro-climatic conditions to plant [5]. Greenhouse is a building in which the cultivation of plants by setting some parameters that can be adjusted to the needs of growth and development of plants. The use of greenhouses in the cultivation of plants is one way to provide an optimum environment for plant growth. Furthermore, it was stated that the use of a greenhouse (plants house) allows for modification of the environment is not suitable for plant growth becomes the optimum conditions for plant growth [6].

The plants will provide a physiological response due to its interaction with the environment. The parameter of environment in a greenhouse include air temperature. Each plant has a different maximum temperature limits for optimal development. Temperature affects the life activities of such plants in the process of photosynthesis, respiration, transpiration, growth, pollination, fertilization, and fallen fruit. The difference in rate and direction of heat exchange that occurs between the building and the surrounding environment greenhouse is also one of the causes of different microclimate in the greenhouse [6]. The greenhouse will have increased and heat loss both in radiation, convection and conduction. This heat transfer may occur through the roof, walls, vents, appliances, flooring and ground under the greenhouse. Greenhouse effect [7] and the heat exchange that occurs in the greenhouse [6], need a system that can monitor the temperature changes.

The change of temperature occur in the greenhouse aspecialy temperature conditions that occur mainly around the plant and around the roof, walls, and floors. As result, it need a monitoring system that can to monitor the changes in real time. Detecting air temperature in a greenhouse buildings using only a single temperature sensor still has some weaknesses such monitoring and temperature distribution, ie, the sensor only detects and monitors the temperature at one location in relatively large greenhouse, so that the air temperature monitoring is not optimal [3] [4] [9].

Based on the simulation results of the air temperature in greenhouse using CFD software (Computational Fluid Dynamics) [7], it showed that the distribution occurred within a greenhouse air temperature and heat distribution is uneven. The development a monitoring system to detect the distribution of the temperature change in the greenhouse was conducted by placing multiple temperature sensors at several locations observation that allows for temperature monitoring analysis more representative and comprehensive in building greenhouses, especially the temperature around the plant, roof, walls , and the floor, so that the distribution of air temperature in the greenhouse can be monitored optimally. The study proposes to development of temperature monitoring system in greenhouse based on wireless communication by using multi temperature sensors.

II. RELATED WORK

In this section, we envisaged several related works from this domain. We focus on a multi sensor system and wireless sensor network communication.

The development of wireless sensor node for greenhouse monitoring system can be done by integrating three sensors platform provided by Sensinode company, ie SHT75 to detect the temperature and humidity, TAOS TSL262R to detect the intensity of light, and Figaro's TGS4161 sensors to detect CO_2. The platform protocols used in this research is a 6LoWPAN protocol which has one part of a private network with a wireless packet transmission

Publication History
Manuscript Received : 20 August 2014
Manuscript Accepted : 28 August 2014
Revision Received : 29 August 2014
Manuscript Published : 31 August 2014

systems using IEEE 802.15.15.4 network (zigbee network) [1].

ZigBee technology is a wireless communication technology which has the advantages including low power consumption, has high fault tolerance, and flexible. ZigBee technology on a large scale known as wireless sensor network. This study was conducted in two stages, the first stage consists of building a network, nodes joining, and collect the data. The second stage consists of: data processing, conserve the network information, and configuration of the communication with the host computer (base server). The design stage of ZigBee wireless sensor network was conducted by four parts: ZigBee node hardware design, interface design, software design on the coordinator side and software design on the processor side. In this study, the protocol used is Modbus protocol model and communication used between processor and server is a type of serial [11].

Build a prototype WSN with multiple parameters include air temperature, humidity, rainfall intensity and wind speed. In this study used LM35 sensor to detect air temperature because it has good linearity is the sensor has good a linear voltage characteristics, this sensor has a sensitivity that is able to adjust the input voltage changes that affect the output temperature, the sensor has a minimum drift is able to give the same reading for the same input over the years [10].

ZigBee technology is a solution for the monitoring and control system in a greenhouse by using wireless communication. Zigbee technology consists of design wireless nodes, forming a network and design software system. The control system in the greenhouse consists of perform data acquisition of the parameters that occur in the greenhouse through the sensor, perform data processing and compare with the desired results, and perform control of the system based on the results obtained in the data processing. ZigBee technology has three topologies: star topology, peer-to-peer topology, and cluster tree topology. Star topology is also called the Private Area Network (PAN), which acts as a central part of the node network coordinator that manages the communication with the local unit. In this study also compared several kinds of communications standards that are used in building wireless sensor network (WSN) consisting of: Wi-Fi, bluetooth, and zigbee. Zigbee communications has several advantages over other, ie, cheaper price, smaller data rate so that the power consumption required is relatively smaller at 30 mA, and zigbee can save the battery life of up to several months or even years [2].

Agricultural development will be intelligent and automated using wireless sensor networks. In the future this system can be adapted to the agricultural production management system, which integrates data acquisition systems, digital data transmission, and data analysis process. The parameters used in this study include air temperature, humidity, and light intensity, Data communication system used is composed of a wireless communication consists of RF and base band. The monitoring system is built propose a method to obtain information of data acquisition, information processing and utilization of information using WSN consist of sink nodes and sub node. Sink nodes that function to process the data and sub-nodes (node Adjusted) which serves to control the heating devices such as engines, while the sensor distributed in the glasshouse. Sink node also has the function receives control from the operator who connected via the Internet, so that users can perform remote on monitoring system. WSN application of modern agricultural systems more profitable including improving production methods, production management becomes more effective and increase agricultural production [12].

III. METHODOLOGY/ EXPERIMENTAL

Greenhouse Temperature Monitoring System

The design phase of the system consists of three main parts include design a prototype sensor node router module, design of wireless data acquisition and software interface design of web-based applications. Figure 1 shows the stages of system design.

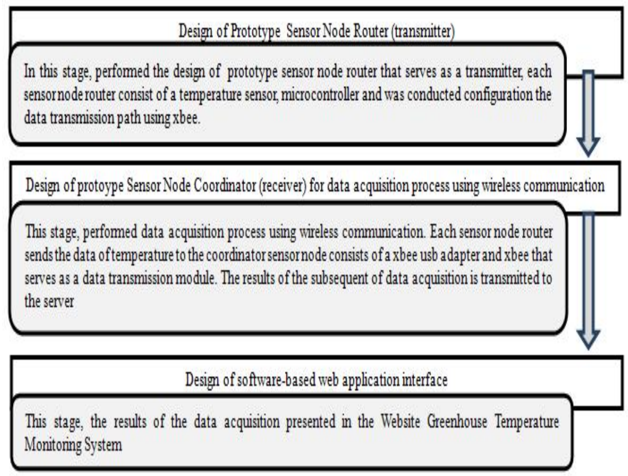

Figure 1. Stages Design of a Multi Sensor System for Temperature Monitoringin Greenhouse Based on Wireless Communication

Design of Prototype a Multi-Sensor System for Monitoring Temperature in a Greenhouse

A multi-sensor system for monitoring temperature in the greenhouse is defined as a set of integrated hardware that can perform data acquisition of the temperature data from each location of the a sensor node router, then transmitted wirelessly to the sensor node coordinator (receiver). The result of the acquisition data sent to a server (base station) and displayed in the form of a web application. Figure 2 shows a block diagram of a multi-sensor system for monitoring the temperature in the greenhouse based on wireless communication comprising: a sensor node router, sensor node coordinator and server (base station).

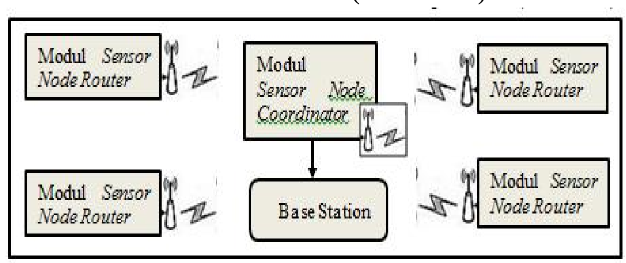

Figure 2. A block diagram of a multi sensor system for temperature monitoring in greenhouse based on wireless communication

Measurements and observations of the temperature inside the greenhouse can be divided into several zones such as locational zone, functional zones, distribution zones, zones form a pattern [8]. Measurements on location zone consists of zone of roof, zone of wall, and zone of floor, measuring the functional zone is an area on the form of the plant consists of the roots, leaves, stems and fruit. Distribution zone is a form representation of the temperature in the greenhouse. Figure (3) the placement design of sensor node router module and Figure (4) show the placement temperature sensor in greenhouse.

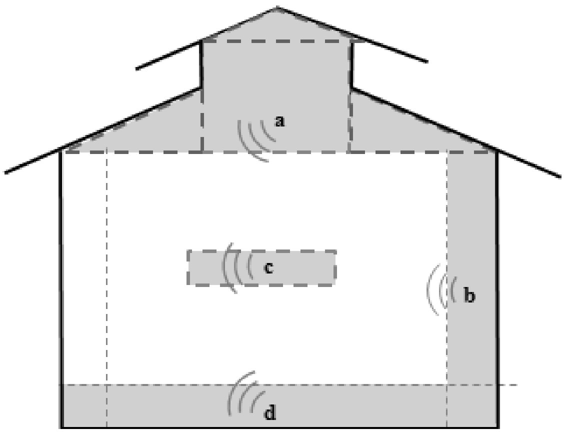

Fig 3. Placement design of sensor node router module with wireless communication (a). zone of roof, (b). zone of wall (c). zone of plants, (d). zone of floor

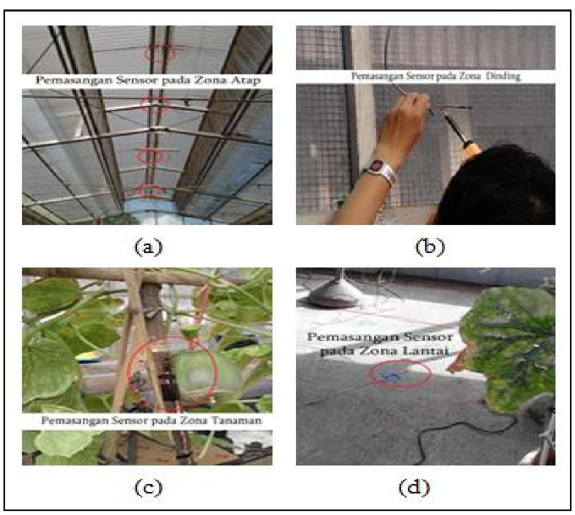

Fig 4. Placement design of sensor node router module with wireless communication : (a). zone of roof, (b). zone of wall (c). zone of plants, (d). zone of floor

Design Hardware of Prototype Sensor Node Router Module (Transmitter)

This section consists of LM35 temperature sensor, microcontroler DFRobot Leonardo module with xbee socket and xbee series 2 module (transmitter). Figure (5) shows the sensor node router module (transmitter).Figure (6) shows the schematic circuit of LM35 temperature sensor is connected to the microcontroller DFRobot Leonardo module.

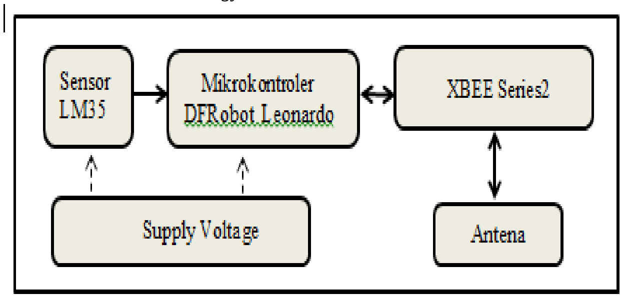

Fig 5. Sensor node router module (transmitter)

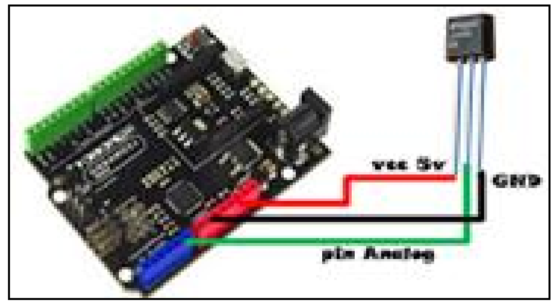

Fig 6. Sensor node router microcontroler DFRobot Leonardo with LM35 temperature sensor

Installation of LM35 temperature sensor on microcontroller DFRobot Leonardo module can be explained as follows: Vcc voltage at LM35 temperature sensor is obtained by connecting the 5V Vcc pinto the 5V pin, analog data pinto analog pins (e.g A0), and GND pin to GND pin on the microcontroller DFRobot Leonardo module. Each prototype of the sensor node router consists of four LM35 temperature sensor. Figure (7) shows the circuit schematic of four LM35 temperature sensor is connected to Vcc, GND and analog pins A0, A1, A2, A3 on microcontroller DFRobot Leonardo module.

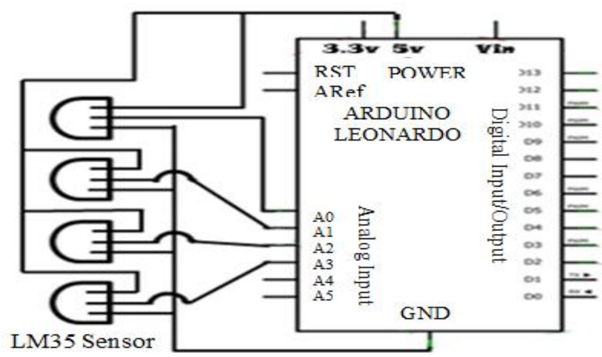

Fig 7. Schematic circuit four LM35 temperature sensor on microcontroller DFRobot Leonardo module

Table 1. Composition of the pins used in the circuit with LM35 temperature sensor

Pin	Information
5V	VCC pin
GND	Ground pin
A0	data pin Temperature Sensor 1
A1	data pin Temperature Sensor 2
A2	data pin Temperature Sensor 3
A3	data pin Temperature Sensor 4

Implementation of the Software Design for Microcontroller DFRobot Leonardo

Microcontroller DfRobot Leonardo module using analog to digital converter (ADC) with a resolution of 10 bits, so there are 2^{10} = 1024 digital values. The voltage value used by the microcontroller is 5 volts, then the value of power supply on the temperature sensor between 0-5 volt is equivalent to 0-1024 digital value. Calculation of the resolution value can be formulated as follows: 5volt/1024 = 0.0048 volts, it means any increase voltage by 4.8828125 millivolts thenthe digital value will be increase by 1.

Here is the Pseudocode programming on microcontroler DFRobot Leonardomodule

1. Declare variables (data type: float): Sensor1, Sensor2, Sensor3, Sensor4, and the average of temperature value
2. Perform initialization:
   initialization mode serial communication
   initialization setting baudrate pinMode analog
   initialization: Sensor 1, Sensor 2, Sensor 3, and Sensor 4
3. Perform the reading of input pinMode analog data sensor1, Sensor 2, Sensor3, and Sensor 4
4. Perform data analog conversion pinMode analog to temperature value
   Calculate the average of temperature value Input value of the delivery time (time delay)
5. Print the value of the temperature and the average of temperature value to serial Communication

Design of Data Acquisition Using Wireless Communication

After making the design of the sensor node router module, the next step is to design the sensor node coordinator module (receiver) to perform wireless data acquisition. The following are the stages in designing sensor node coordinator that function for wireless data acquisition. Sensor node coordinator module (receiver) and server can be seen in Figure (8) and Figure (9).

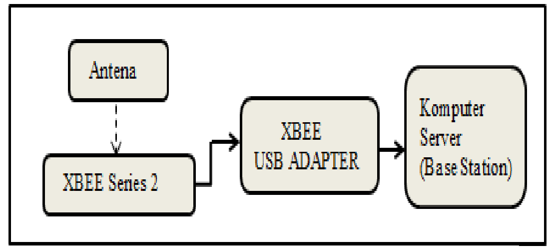

Fig 8. Sensor node coordinator module (receiver) and server

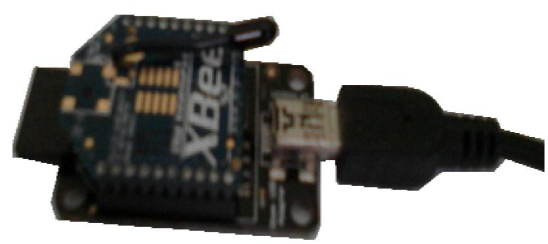

Fig 9. Implementation of the hardware on the sensor node coordinator

Implementation of the Interface of Software-Based on Web Applications

In this stage, the design interface of software-based on web application that is used to display the data in real time and non real time in the form of a datalog through the browser. The design is done using the PHP programming language, database creation using MySQL and Apache webserver. Web page is a page of the site which is commonly accessed by users in general. In general, the website is created as a front-end applications such as object-oriented programming (OOP).

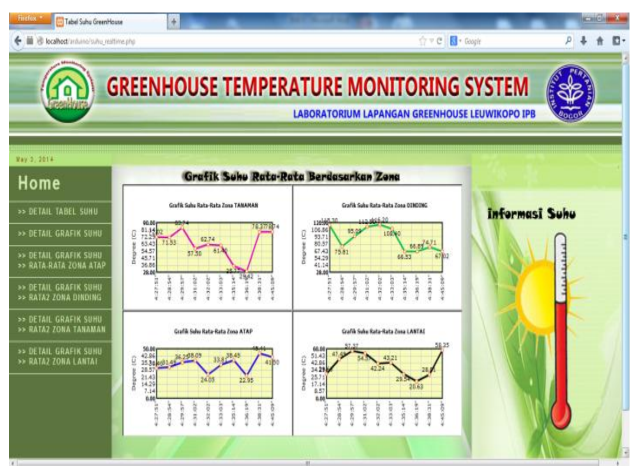

Fig 10. Websites a multi sensor system for realtime temperature monitoring in a greenhouse

IV. RESULT

Testing Results of the Sensor Node Router

After the LM35 temperature sensor has been connected to the analog pins and microcontroler DFRobot Leonardo module has been programmed, the next step is to test the serial communication by using a usb cable. The test is performed each sensor node router to be placed in several locations of observation, if the temperature sensor readings and data can be display the temperature conditions that occur in each zone and the desired output data structure is correct, it means that the series has been going well. Format of the data structure serves to facilitate in the parsing process the data into database. Format of the data structure to parsing process can be seen in Table 2 and Figure (11) shows the test results of the data structure view sensor node routers with serial communication using the USB cable to hyperterminal application.

TABLE 2. Elementary of the data structures in the design of the sensor node router

Sensor Zone	sensor 1	sensor 2	sensor 3	sensor 4	Average of temmparture value

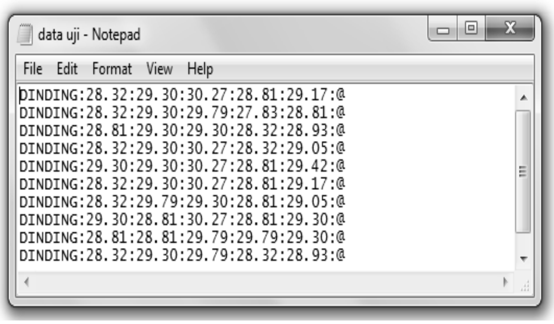
data uji - Notepad
File Edit Format View Help
DINDING:28.32:29.30:30.27:28.81:29.17:@
DINDING:28.32:29.30:29.79:27.83:28.81:@
DINDING:28.81:29.30:29.30:28.32:28.93:@
DINDING:28.32:29.30:30.27:28.32:29.05:@
DINDING:29.30:29.30:30.27:28.81:29.42:@
DINDING:28.32:29.30:30.27:28.81:29.17:@
DINDING:28.32:29.79:29.30:28.81:29.05:@
DINDING:29.30:28.81:30.27:28.81:29.30:@
DINDING:28.81:28.81:29.79:29.79:29.30:@
DINDING:28.32:29.30:29.79:28.32:28.93:@

Fig 11. Results of testing the sensor node router with a serial communication using the usb cable

Test results indicate that a sensor node router can work well with the data showing four temperature sensors, avarage of temperature value and corresponding data structure format desired. This test was also performed on each sensor node router that will be placed in each observation zones consis of; zone of roof, zone of wall , zone of plants, and zone of floor.

Testing Results Data Acquisition Design Using Wireless Communication

After xbee receiver in the sensor nodes coodinator programmed and put it on the xbee usb adapter. The next step is to test the wireless communication, if the process of data acquisition from each sensor node router can be well received and in accordance with the format of the data structure in desired then the circuit has been able to run well.

Figure (12) shows the results of testing the temperature data acquisition using wireless communication in hyperterminal application.

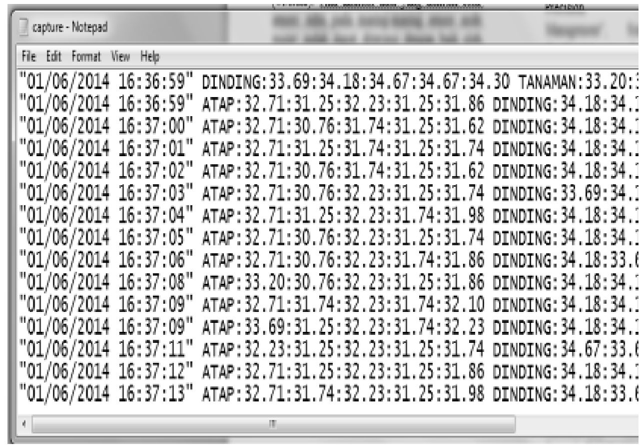
capture - Notepad
File Edit Format View Help
"01/06/2014 16:36:59" DINDING:33.69:34.18:34.67:34.67:34.30 TANAMAN:33.20:
"01/06/2014 16:36:59" ATAP:32.71:31.25:32.23:31.25:31.86 DINDING:34.18:34.
"01/06/2014 16:37:00" ATAP:32.71:30.76:31.74:31.25:31.62 DINDING:34.18:34.
"01/06/2014 16:37:01" ATAP:32.71:31.25:31.74:31.25:31.74 DINDING:34.18:34.
"01/06/2014 16:37:02" ATAP:32.71:30.76:31.74:31.25:31.62 DINDING:34.18:34.
"01/06/2014 16:37:03" ATAP:32.71:30.76:32.23:31.25:31.74 DINDING:33.69:34.
"01/06/2014 16:37:04" ATAP:32.71:31.25:32.23:31.74:31.98 DINDING:34.18:34.
"01/06/2014 16:37:05" ATAP:32.71:30.76:32.23:31.25:31.74 DINDING:34.18:34.
"01/06/2014 16:37:06" ATAP:32.71:30.76:32.23:31.74:31.86 DINDING:34.18:33.
"01/06/2014 16:37:08" ATAP:33.20:30.76:32.23:31.25:31.86 DINDING:34.18:34.
"01/06/2014 16:37:09" ATAP:32.71:31.74:32.23:31.74:32.10 DINDING:34.18:34.
"01/06/2014 16:37:09" ATAP:33.69:31.25:32.23:31.74:32.23 DINDING:34.18:34.
"01/06/2014 16:37:11" ATAP:32.23:31.25:32.23:31.25:31.74 DINDING:34.67:33.
"01/06/2014 16:37:12" ATAP:32.71:31.25:32.23:31.25:31.86 DINDING:34.18:34.
"01/06/2014 16:37:13" ATAP:32.71:31.74:32.23:31.25:31.98 DINDING:34.18:33.

Fig 12. Results of testing data acquisition using wireless communication

Testing Real-Time Monitoring Module On Website

Realtime monitoring module on the website make it easy to monitor each temperature zone in a greenhouse include zone of roof, zone of wall , zone of plants, and zone of floor.Select real time monitoring menu and select the desired zone to monitored. Real time monitoring menu contains information about real time the temperature graph from four observation zones in a greenhouse. The graph is displayed in real time with a Asynchronous JavaScript and XML techniques (AJAX), so that the user does not need to reload the browser. Figure 13 - 16 shows an example results of the chart in real time of temperature measurements each observation zones on the web application.

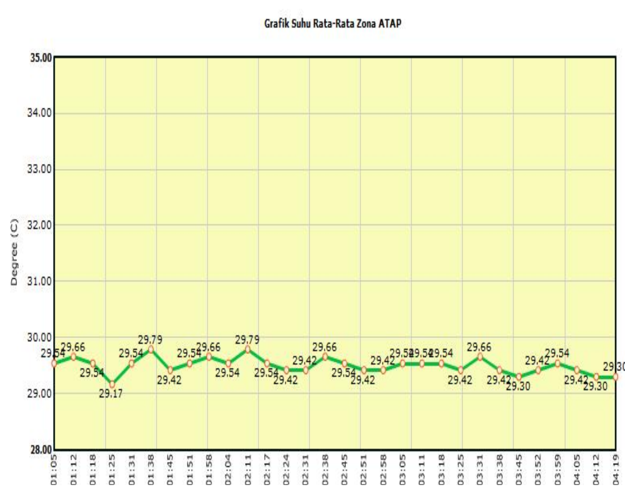

Fig 13. Example results realtime chart of temperature measurement in the zone of roof

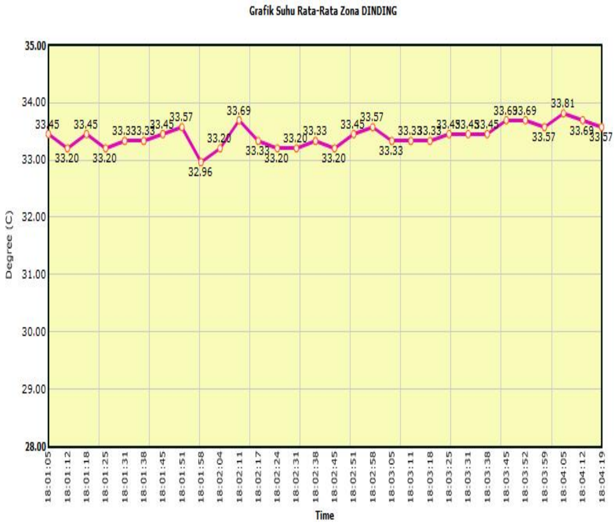

Fig14. Example results realtime chart of temperature measurement in the zone of wall

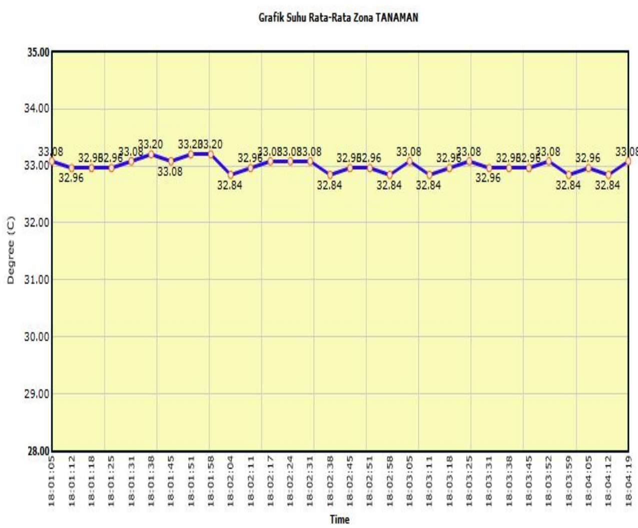

Fig15. Example results realtime chart of temperature measurement in the zone of plant

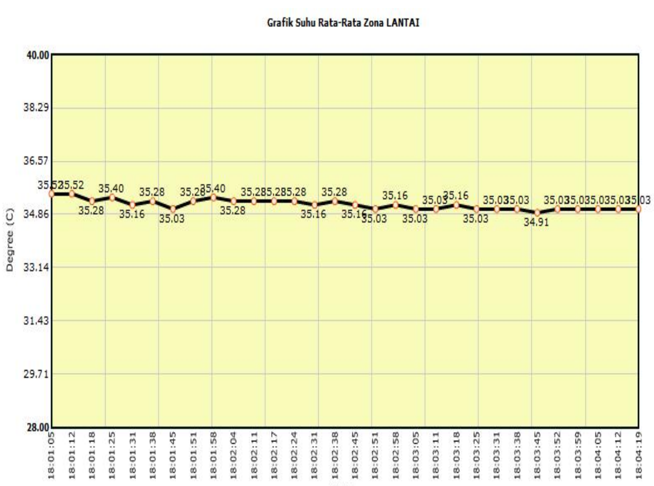

Fig16. Example results realtime chart of temperature measurement in the zone of floor

V. CONCLUSIONS AND FUTURE WORK

We have been successfully developed a multi sensor system for temperature monitoring in a greenhouse based on wireless communication. The system consists of three main parts including a sensor node router (transmitter), a sensor node coordinator (receiver) for data acquisition process using wireless communication, and web application interface. The developed system can provide information in real time and non-real time about the temperature distribution within a greenhouse. In our experimental testing, temperature monitoring was conducted at all observation zones including roof zones , wall zones, plants zone, and floor zone in parallel allowing more comprehensive view of temperature distribution and patterns. This multi sensor system can be applied to monitor other parameters in a greenhouse such as light intensity, humidity, wind speed simultaneously for a greenhouse monitoring and control purposes. This system can also be implemented in mobile platform environment using a minicomputer (raspberry pi) as a server that can be accessed by various Android smartphone systems.

REFERENCES

[1] Ahonen T, Virrankoski R, and Elmusrati M., “Greenhouse Monitoring with Wireless Sensor Network” Mechtronic and Embedded Systems and Applications. IEEE/ASME International Conference 1-4244-2368-2/08/ IEEE, 2008

[2] Al adwan, Ibrahim, Munaf SN, “ The Use of ZigBee Wireless Network for Monitoring and Controlling Greenhouse Climate”, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, 2012

[3] Anjar Rinaldi, “Rancang Bangun Sistem Monitoring Parameter Lingkungan Mikro Pada Rumah Kaca (*Greenhouse*) Berbasis Internet”, [skripsi], Bogor (ID) : Institut Pertanian Bogor, 2006

[4] Chusnul Arif, “Sistem Monitoring Pertumbuhan Tanaman dan Lingkungan Mikro di dalam Greenhouse Menggunakan Field Server”, [skripsi], Bogor (ID) : Institut Pertanian Bogor, 2009

[5] Haryono, “Pedoman Umum Adaptasi Perubahan Iklim Sektor Pertanian”, Badan Penelitian dan Pengembangan Pertanian Kementrian Pertanian, 2011

[6] Herry Suhardiyanto, “Teknologi Rumah Tanaman untuk lklim Tropika Basah Pemodelan dan Pengendalian Lingkungan”. ISBN 978-979-493-1684, Institut Pertanian Bogor, Press Bogor. Indonesia, 2009

[7] Resti Nurianingsih, “Analisis pola aliran dan distribusi suhu udara pada rumah tanaman standard peak menggunakan Computational Fluid Dynamics (CFD)”, [skripsi], Bogor (ID) : Institut Pertanian Bogor, 2011

[8] Seminar Kudang Boro, Suhardiyanto Herry, Soedodo Hardjoamidjojo. "A Supervisory Control System for Greenhouse, Regional Computer Science Postgraduate Conference (ReCSPC'M)", 2006

[9] Tri Wahyuni Apriyani, Sistem Kendali Jarak Jauh Lingkungan Mikro dalam Rumah Kaca (*Greenhouse*) Berbasis Teknologi Telepon Seluler. [skripsi]. Bogor (ID) : Institut Pertanian Bogor, 2006

[10] Vrushali M, R. Deore, Prof. VM Umale, "Wireless Monitoring of the GreenHouse System Using Embedded Controllers", International Journal of Scientific & Engineering Research, Volume 3, 1 ISSN 2229-5518, . 2005

[11] Yanfei Liu, Chengbo Yu, Cheng Wang, "An Improved Design of Zigbee Wireless Sensor Network. Computer Science and Information Technology", 2nd IEEE International Conference on. 978-1-4244-4520/IEEE, 2009

[12] Zhang Ying, "Design of The Node System of Wireless Sensor Network And Its Application In Digital Agriculture", International Conference on Computer Distributed Control and Intelligent Environmental Monitoring. 978-0-7695-4350-5/11/ IEEE, 2011