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Wireless Sensor Network and Geographic Information System Based Monitoring System

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Abstract: The needs of accurate information are used to bolster the performance in various fields. The information of temperature and air pressure is still needed for some projects in the department. However, the geographical condition and distance can often hamper to obtain such information. Therefore, it is necessary a system that can determine and monitor the parameters of temperature and air pressure of that geographical circumstances wirelessly. So, the system should be used as a wireless sensor network that is a data transmission technique used on this monitoring system based on a wireless. For these requirements, the transmitter module should integrate with the sensor of temperature and air pressure, Global Positioning System (GPS) module and XBee module. The sensor has been used to capture the circumstance data and the data of position in the map have been provided by GPS module, All of the data would be processed by arduino microcontroller thus, sent the information to the transmitter XBee module. The information then received wirelessly by the receiver XBee module. The received information would be displayed on the google map.

Key words: Air pressure, google map, GPS, temperature, Xbee

INTRODUCTION

The requirement of rapid and accurate information is needed in order to support the performance in various fields. One is the information about the state of an area including air temperature and air pressure. However, the geographical situation and distance may often hamper to obtain such information. Therefore, it is necessary a system that can monitor the change weather of temperature and air pressure wirelessly to make a low cost a system without wired connection. This way could implement a Wireless Sensor Network (WSN) (Wibowo, and Purwacandra, 2015; Sudarmawan and Wibowo, 2014).

The monitoring system based on the WSN can be implemented for measurements in difficulty areas to be reached and it is an effective way. The accuracy of this sensor that is placed in such area makes the advantages of this monitoring system. A data transmission technique in this study is wireless, where the modules used are a two XBees that serve as receiver and transmitter modules. Whereas the sensor module used to capture data of temperature and air pressure is BMP 180 and the controller to process the data is used an Arduino UNO microcontroller. The principle of this system is how to send a data from a sensor and a Global Positioning System (GPS) module to the receiver device via wireless. The obtained data is in the temperature form of celsius degree, the air pressure unit of millibar as well as a longitude and latitude coordinates. Thus the receiver will make the point mark and description on the Google map based on the website. For making point on the Google map, it used a Google Application Program Interface (API). For testing data received from XBee, the application of X-CTU is needed to monitor the sequence of data and it is installed on the Personal Computer (PC) (Wibowo, 2014).

Literature review: A monitoring system is a system that was designed to provide a feedback when the program runs its functionality. This feedback is intended to provide an information or state of the system at that time. In the activity of monitoring, it is used to check the performance and set the target. Monitoring can provide haveinformation to establish the continuity of the process a step towards continuous improvement. In practice, monitoring is performed when a process is underway. The monitoring output aims to determine the suitability of the process that has been running. This is useful in the improvement of the mechanism of processes or activities where monitoring is done.

The monitoring system will provide a good impact when the design and implementation are effective. The following criteria for an effective monitoring system are user-friendly, focus on indicator, well-planned and having procedure to collect and extract data.

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Wireless sensor network: A havewireless sensor network is a number of nodes arranged in a network. Each node has a processing capability such as a microcontroller, Central Processing Unit (CPU) or Digital Signal Processing (DSP) that may contain some types of memory for program, data and flash. A WSN has also a Radio Frequency (RF) transceiver that is usually implementing a single omni-directional antenna and attached some batteries and solar cells as a power supply. It is accommodating a variety of sensors and actuators.

Many applications can be applied using wireless sensor networks, such as data collection of environmental conditions, security monitoring and tracking node. An environment data collection application is one of the studies in collecting data using multiple sensor that captures a set of points in a neighborhood during a certain period of time. Increasing the number of Wireless Sensor Network applications is also accompanied with requiring an issue of low network delay. The current research in the field of WSN mainly concentrated on how to optimize the energy efficiency with attention on the problem of network delay. Several new WSN design is targeted at the applications that require a low data transfer delay and high reliability (Guo *et al*., 2016).

A technological developments lead to the connectivity of the physical environment. Most of the observations has been done in the field involves many factors and parameters to get the most accurate results. If the user want to obtain an information directly in the field, then the problem is the huge costs and a long time to detect the phenomena that appear and it could cause the performance is inefficient and impractical.

Emerging of WSN technology, enabling to obtain a maximum information without having to be in the area of the sensor. The information could be accessed remotely through gadgets such as laptops, remote control, Personal Computer (PC) and so on. There are some advantages to be gained from the implementation of WSN technology, i.e., :

- Practical, because there is no need complicated cable installation and in certain geographic conditions are very favorable compared to wired
- Mobility, because it is possible to move the sensor to obtain more precise measurements without having to worry about changing the design of the room and the room cable arrangement
- Improve an operational efficiency and effective to collect a large amounts of data
- An altenative implementation of low cost a system
- It can collect large amounts of data

Geographic information system: A Geographic Information System (GIS) is an information system used to capturing, storing, managing, analyzing and displaying geographic data that has an integration spatial descriptions of locations on the earth. The geographic information system can be employed to facilitate in getting the data that have been processed and stored as an attribute of a location or object. The data are processed in a GIS consists essentially of spatial data and attribute data in digital form (Sofina and Ehlers, 2016). In this term this system relates to a spatial data and non-spatial data to create a map and analyze such information. There are several advantages using GIS applications, i.e.:

- GIS can be used as the main tools with interactive, interesting and challenging
- GIS uses spatial data and attribute data in an integrated manner
- GIS has abilities to change presentations in various forms
- GIS has the ability to decipher the elements or reconstructed or remodeled contained on the surface of the earth within a few layer or a spatial data

MATERIALS AND METHODS

In the process of a temperature and air pressure monitoring system based on a wireless sensor network and a geographic information systems, it deploys some tools such as a microcontroller, board modules and softwares. The ATmega328 microcontroller on Arduino UNO R3 board is used to be main brain, the additional modules also implemented such as Xbee modules, Global Positioning System (GPS) module and sensor of temperature and air pressure. While the necessary software has a role as a support system.

Arduino UNO R3: An Arduino UNO R3 board is an electronic kit or an open source circuit board in which there is a major component, namely a microcontroller chip premises an AVR type of the Atmel company. The microcontroller itself is a chip or Integrated Circuit (IC) that can be programmed using a computer. This microcontroller board based on ATmega328P which has a 14 digital input/output pins, where 6-pins can be used as a Pulse Width Modulation (PWM), 6 analog inputs, a clock speed of 16 MHz, Universal Serial Bus (USB) connection, power jack, In-Circuit Serial Programming (ICSP) header and a reset button. This board uses the power connected to the computer with a USB cable or external power to the AC-DC adapter or battery. Arduino Uno board can operate on an external power supply of

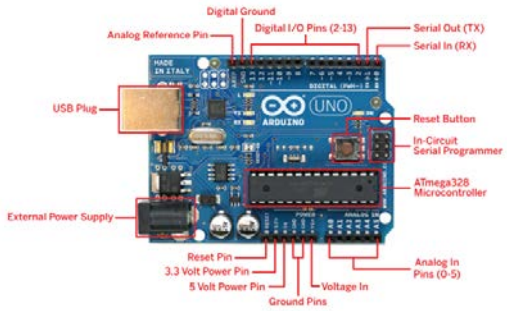

Fig. 1: Arduino board

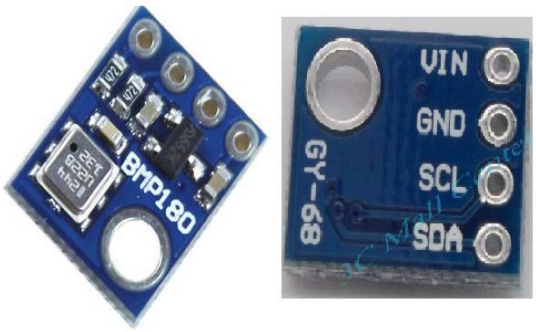

Fig. 2: BMP180 sensor

7-12 volts. But, when it is supplied <5 V, the board may be unstable. The depict of Arduino UNO R3 board is shown in Fig. 1.

An ATmega328P microcontroller has 32 kb of memory but about 0.5 kb is used for the bootloader and also has 2 kb of Static Random Access Memory (SRAM) and 1kb Electrically Erasable Programmable Read-Only Memory (EEPROM) which can be read-written by the EEPROM library. Each digital pin on the Arduino Uno board can be used as input or output (I/O) ports. By using function of PinMode (PM), DigitalWrite (DW) and Digital Read (DR). Each pin operates at a voltage of 5 v and able to give or receive a maximum current and has an internal pull-up resistor of 20-50 kΩ by default or not connected. In addition, some pins have special functions, e.g:

- A serial pin is 0 (for Receive (RX)) and 1 (for Transmit (TX)). The serial data of the microcontroller is a Transistor-Transistor Logic (TTL). This pin is connected to the corresponding pin of the chip of Atmega8U2 USB-to-TTL
- An external interrupts pins are on pin 2 and 3. These pins can be configured to trigger an interrupt on a low value, edge up or down or change in value
- A Pulse Width Mmodulation (PWM) pins are on pin 3, 5, 6, 9, 10 and 11. This provides 8-bit PWM outputs with function of AnalogWrite (AW)
- A Serial Peripheral Interface (SPI) pina are on pin 10 (for SS), 11 (for MOSI), 12 (for MISO) and 13 (for SCK). These pins support an SPI communication using the SPI library
- A Light Emitting diode (LED) is on pin 13 to indicate the signal using LED
- An Arduino Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution namely 1024 different values

BMP180 sensor module: A BMP180 sensor is a digital barometric pressure sensor from Bosch Sensortec performing very high which can be applied to a variety of mobile devices such as smart phones, tablet computers and portable sports equipment. The BMP180 is an upgrade of the BMP085 sensor with many significant improvements, such as smaller size, so the energy is more efficient with very low energy consumption <3 uA and the additional of a new digital interface. The BMP180 is very stable in spite of the voltage supply used. This module is shown in Fig. 2.

GY-GPS6Mv2 module: A GY-GPS6Mv2 module is a module's compact size with 25×35 mm module and 25×25 mm antenna to function as a Global Positioning System (GPS) receiver which can detect the location to capture and process the signals from the navigation satellites. The application of this module covers a navigation system, a data acquisition systems, a location tracking, etc. This module is compatible with the APM2 and APM2.5 with an integrated EEPROM that can be used to store configured data. The interface uses a serial TTL (RX or TX) that can be accessed from the microcontroller that has a Universal Asynchronous Receiver and Transceiver (UART) function or emulation of serial TTL for the Arduino can use a serial communication library. The baud rate is set by default at 9600 bps.

The GPS processor from this module employs a u-blox NEO-6 GPS Module with a high performance of position tracking engine and the latest ROM version of ROM7.03. This module can process up to 50 channels with Cold TTFF (Cold-Start Time-To-First-Fix) time, the time required to determine the position of the shutdown state total of <27 sec and it can be accelerated with the guide features to <3 sec. At a hot start conditions, TTFF time needed to reach <1 sec. The GY-GPS6Mv2 module is shown in Fig. 3.

A high performance is achieved by a special processor is dedicated to collecting a satellite signal data that has up to 2 millions to process data quickly. These processor also employs an advanced Digital Signal

Processing (DSP) to dampen a jamming sources and significantly reduce the effects of multi-path interference.

Fig. 3: GY-GPS6Mv2 module

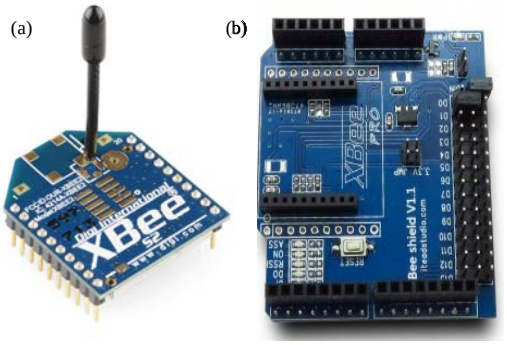

Fig. 4: a) S2mW XBee module; b) its shield

S2mW Xbee module and Xbee shield: An XBee Series 2 modules is device used to communicate between devices with one another. In this study Xbee modules programmed as transmitter or receiver of data to and from the device microcontroller. This module allows a mesh network mesh or point to point. Usually the XBee module to be hosted on the Arduino UNO R3, it requires an XBee shield module. This shield simplifies the task of interfacing with an Arduino and XBee. This shield mode can be set in the Arduino Pro or USB board and are equipped with the wireless communication capabilities using the popular XBee modules. The XBee module is shown in Fig. 4a and its shield is shown in Fig. 4b.

X-CTU: An X-CTU is a Windows-based application that is provided by Digi. This program is designed to interact with the firmware files found on RF Digi products and are used for the user interface. The X-CTU application is used to program the XBee modules as the coordinator and router and also this application is used for monitoring a data communication. This application is shown in Fig. 5.

RealTerm: A RealTerm is a free remote console or a terminal employed to remote a computer using a serial port. The RealTerm is a terminal program designed specifically for capturing, controlling and debugging data. This RealTerm software is used to retrieve data from the receiver port and store them in a specific directory. The extention of files stored on the recording results is txt. The real time data obtained will be recorded by the application. This application is shown in Fig. 6.

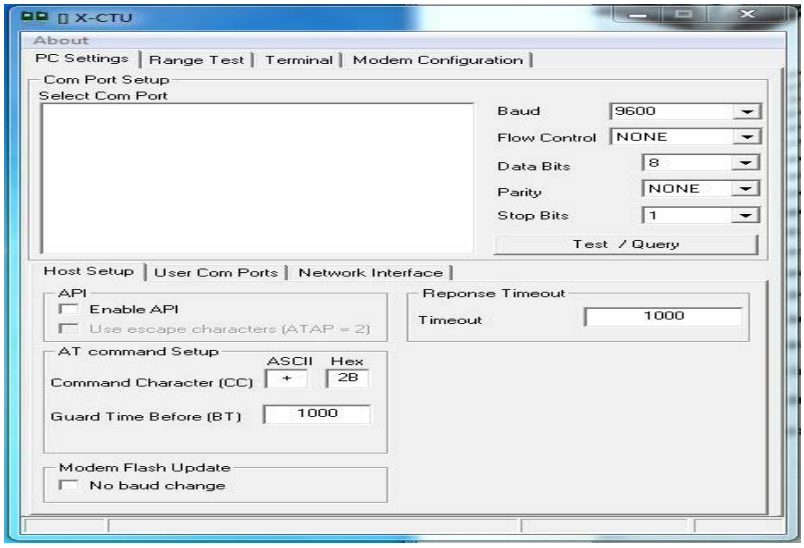

Fig. 5: X-CTU application

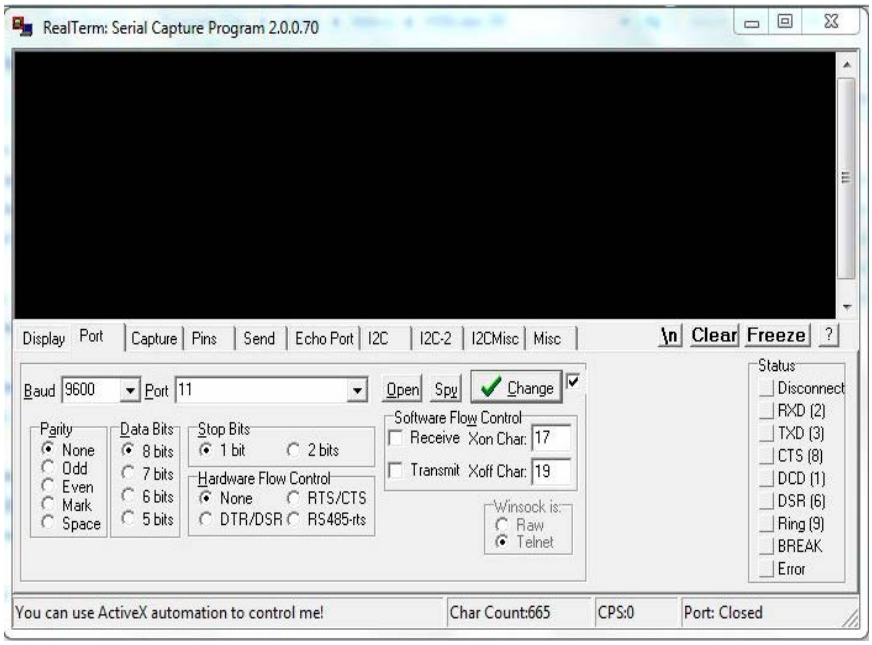

Fig. 6: Realterm application

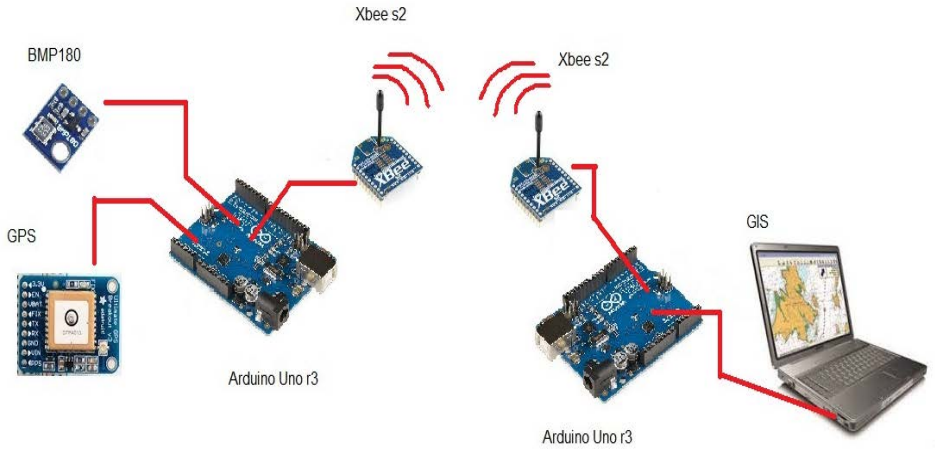

Fig. 7: Global design

Global design: The haveglobal design of monitoring system based on wireless sensor network and geographic information system is shown in Fig. 7.

From Fig. 7. it can be seen that the system is initiated when the microcontroller takes data from the sensors and GPS module, then it will be processed and sent it to the transmitter via XBee module. The receiver will be displayed the data on the computer in the form of Geographic Information Systems (GIS).

RESULTS AND DISCUSSION

The program created using C programming language for microcontroller arduino and for the geographic information system modelled using PHP programming language. For connection between the sensor BMP180 and an Arduino UNO microcontroller, the port of SDA connected to the port 4 of Arduino UNO, SCL connected to the port 5, GND connected to the GND voltage port of 5 v connected to the port of 5 v in the arduino board.

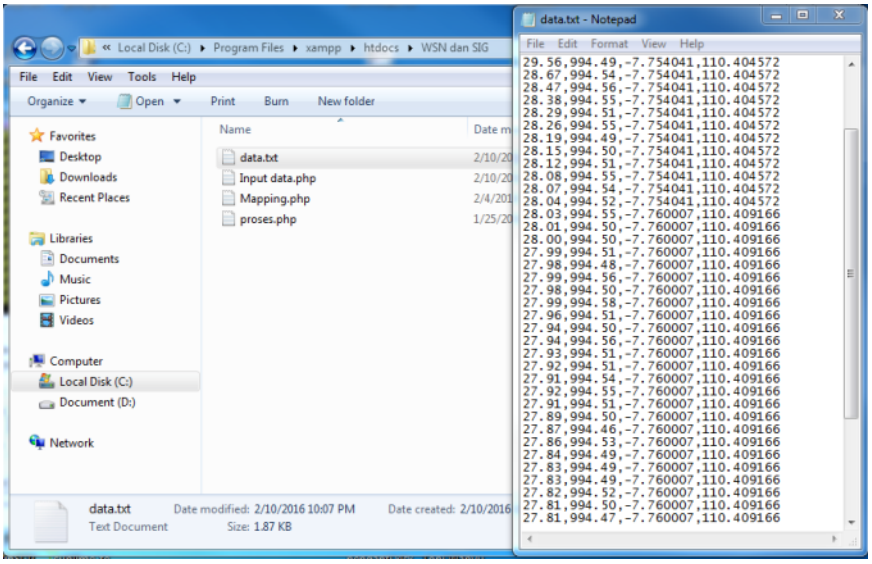

Fig. 8: Received data

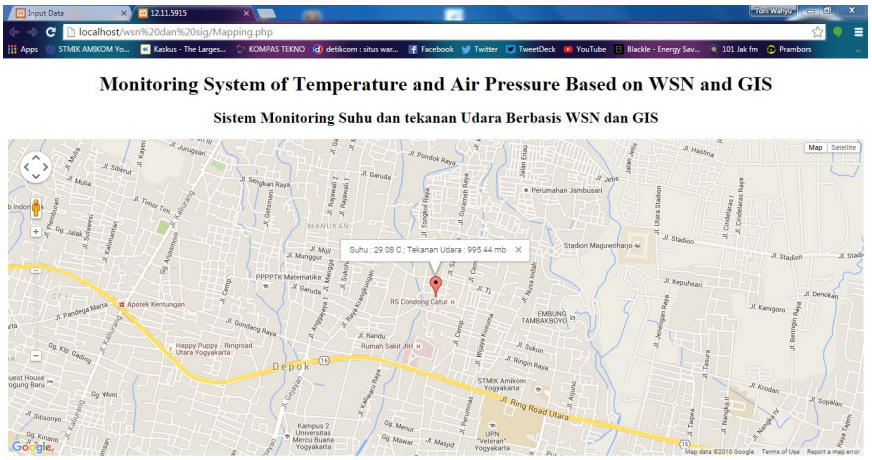

Fig. 9: GIS bhased on web

Testing for this design has been done and the receiver could obtain the data of temperature, air pressure and device position. The raw data that has been captured is shown in Fig. 8. Thus the displayed on the GIS based on web is shown in Fig. 9.

CONCLUSION

The arduino board in this study functioned as the main controller and data processing of monitoring information system of temperature and air pressure based on Wireless Sensor Network (WSN) and Geographic Information System (GIS). The use of the sensor module of BMP180 could detect the value of the temperature and air pressure and the communication between the receiver and transmitter Xbees could be done. The information of the sensor values and location mapping has been performed on Google map as Geographic Information Systems by storing the results in the form of the receiver log of data log and entered on the database.

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REFERENCES

Guo, C., B. Liao, L. Huang and Q. Li, 2016. Convexity of fairness-aware resource allocation in wireless powered communication networks. IEEE Commun. Lett., 20: 474-477.

Sofina, N. and M. Ehlers, 2016. Building change detection using high resolution remotely sensed data and GIS. IEEE J. Selected Topics Applied Earth Observ. Remote Sens. 10.1109/JSTARS.2016.2542074.

Sudarmawan and F.W. Wibowo, 2014. Design of gesture technology implementing wireless sensor network and short message service. Proceedings of the International Conference on Electrical, Electronics, Computer Engineering and their Applications, November 17-19, 2014, Kuala Lumpur, Malaysia, pp: 104-109.

Wibowo, F.W. and P.P. Purwacandra, 2015. Object tracking using initial data to count object image based-on wireless sensor network. Adv. Sci. Lett., 21: 112-118.

Wibowo, F.W., 2014. Pollution instrumentation using global positioning system and data logger based-on propeller. Adv. Sci. Lett., 20: 2082-2086.