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Monitoring the Environmental Temperature Using Arduino and Telegram

M Wujut Hariyanto[1], Ade Hendri Hendrawan[2], Ritzkal[3]
[1, 2, 3] Laboratorium Net Centric Computing, Program Studi Teknik Informatika, Universitas Ibn Khaldun Bogor, Indonesia
[1]wujutariyanto@gmail.com, [2]hendri@uika-bogor.ac.id, [3]ritzkal@ft.uika-bogor.ac.id

Abstract*— The temperature of the air is the state of hot air caused by the heat of the sun. Factors that affect the amount of solar heat received by the earth are cloud, the surface plane, the angle of the sun, and the length of the sun's exposure. The heat of the earth's surface by solar radiation affects the heat of the air. Earth's surface air temperature varies because sunlight spreads unevenly on the earth's surface. The research aimed to design and implement a series of tools that can measure the ambient temperature and provide information about the environmental temperature via telegram. The methods used in this research were analyses consisting of needs analysis, and analysis of how it worked. Hardware and software implementations were also applied. The research carried out several tests, including tests on the DHT11 sensor, LED light, LCD i2c, Ethernet Shield, and Telegram test. The integration test on the LCD showed that when the temperature was below or the same as 25˚C, the green LED would be ON and the red LED OFF, which indicated that it was cold temperature. Conversely, when the temperature was the same or above 30˚C, the red LED would be ON, and the green LED OFF, indicating that the temperature was hot. The second test was to compare digital and analog sensors. The comparison values of the digital and analog temperatures were 1.1˚C, and the humidity was 23.1% RH. The highest temperature obtained from the system per day was 34˚C, and the lowest temperature was 23˚C.

Keywords*— *Monitoring, Temperature, Environment, Telegram

I. Introduction

The temperature of the air is the state of hot air caused by the heat of the sun. Factors that influence the amount of solar heat received by the earth are cloud, surface plane, the angle of the incident ray, and the length of the sun's irradiation. The surface heat of the earth by solar radiation affects the heat of the air. Air temperatures on the surface of the earth vary because sunlight spreads unevenly on the surface of the earth.

Climate characteristics on the earth's surface differ from one place to another, influenced by the position relative to the sun's orbit (latitude position), the presence of the ocean, wind patterns, the shape of the earth's land surface, and vegetation density. The rotation of the earth around the sun and on its axis causes the entire earth's surface to receive solar radiation alternately. Solar radiation affects the average temperature in each region. The greater the amount of radiation energy received by an area, the higher the surface temperature in that region. The temperature will fluctuate significantly in every 24 hours. The maximum air temperature is reached sometime after the maximum light intensity is reached when the light beam falls perpendicular at midday. That is why the air temperature on the earth's surface is different from one place to another. Besides, the air temperature obtained in each environment from solar radiation is not the same.

Some researchers have conducted air temperature monitoring studies using a microcontroller, such as Rerkratn, who investigated the ZigBee-based wireless temperature monitoring system for shrimp ponds based on ZigBee technology [1], and Yumang who studied the ZigBee-based server room temperature and humidity monitoring using thermal imaging. Monitoring the temperature and real-time humidity of the computer server room was very important to ensure that server performance was not affected due to excessive room temperature and humidity [2]. Punetha used the wireless approach for real-time remote monitoring systems to examine environmental parameters using the feasibility of GSM modules. The wireless approach to monitoring remote areas which have large areas and therefore, was difficult to be managed by individuals due to the lack of information [3]. Erdenechimeg examined the wireless monitoring method for diabetic foot temperature using a FLIR infrared camera, a BME280 temperature sensor, and an embedded board [4]. Latiff monitored the condition of the ZnO surge arrester that runs out at the temperature distribution under various design conditions by developing a 132 kV surge arrester model to simulate thermal distribution under normal conditions and overvoltage conditions using different surge arrester parameters [5].

The ultra-low-power CMOS smart temperature sensor for clinical temperature monitoring investigated by Tao Wu performed an ultra-low-power and a high-accuracy CMOS smart temperature sensor for clinical temperature monitoring applications [6]. A fine-grained temperature monitoring system for sustainable geothermal drill holes examined by Cozzini demonstrated an installation of an accurate and stable temperature monitoring system in a geothermal drill hole [7]. Temperature monitoring and temperature deposition induced calibration of errors in chemical-organic chemical vapor deposition carried out by Yan showed that in the process of semiconductor coating growth by metal-organic chemical vapor deposition (MOCVD), temperature measurement errors occurred due to deposition at the reactor display port [8]. Ali accomplished on accessing on-chip temperature health monitors using the IEEE 1687 standard using three temperature monitors together with an IJTAG controller online temperature measurements using the IJTAG network interface [9]. Wen examined the RFID-based skin temperature monitoring patch by developing RFID based conductive fabrics for temperature sensing and demonstrated their use by measuring variations in skin temperature [10].

Wang experimented remote temperature monitoring system from cable connection by designing a GPRS-based real-time cable connection temperature monitoring system integrated with computer technology, micro control technology, and digital sensor technology [11]. Jenkins researched the monitoring of conductor temperatures to increase the capacity of transmission network infrastructure elements. The system to monitor current and temperature of conductors was combined with Lidar surveys, and the modeling of power lines during operation under certain conditions provided the ability to determine the maximum current allowed for each operating condition and a tool to control the condition of the conductors in real-time [12]. Vlase studied the local monitoring system for the temperature permitted for medium-voltage using metal-covered switchgear and control gear. The monitoring system would act when the temperature exceeded the permitted heat. The electrical insulation materials, power supply cables, and control gears were covered by metal casings to eliminate damage caused by the exceeding temperatures and increase the security of energy supplies [13]. Khan studied the effect of temperature variations on remote pressure readings in a wireless intracranial pressure monitoring system. The implant pressure monitoring system was an urgent approach for home monitoring of intracranial pressure in the long run [15].

The multi-node temperature measurement system for online monitoring of bee colonies implemented by Zacepins consisted of two parts, namely a remote measurement node for real-time bee temperature measurement and a webserver to summarize measurements and demonstrations to end-users [16]. Printed temperature sensors for health monitoring investigated by Honda developed high temperature-sensitive printed sensors by synthesizing poly (3, 4-ethylene dioxythiophene) poly (styrene sulfonate) (PEDOT: PSS) and carbon nanotube (CNTs) ink compositions on flexible substrates [17]. The temperature dependence of torque and bending modes in the 6H-SiC microdisk resonator investigated by Yang using experimental calibrations for the temperature frequency coefficient (TCf) in a 6H-silicon carbide (SiC) single microdisk resonator based on smart cutting technology [18]. A nonintrusive temperature measurement system to estimate body temperature in the bed studied by Sim found that the existing internal body temperature monitoring system was too invasive to be implemented for a long time [19]. The on-line monitoring system based on MODBUS for temperature measurement on the smart grid was studied by Yaguang Guo to meet the demands of the smart grid, which required to implement control, sensing, and communication technology into the power system. It was found that it was very necessary to design an online monitoring system for temperature measurement [20].

Inspired by the research conducted on monitoring systems, a device to monitor air temperature easily, a monitoring system using the Arduino Uno ATMega 328 was designed by providing temperature information using a series of devices connected to the network using LAN cables. The LAN worked not only in its operational area, but also in interaction with other LAN networks, for example, with other corporate networks, the Internet, and others. An LCD sensor configured using a microcontroller would send the temperature information to the Telegram when the sensor detects the ambient temperature, and the temperature information would be sent to the Telegram within two minutes.

II. Methods

The systems block diagram is shown in Figure 1. The method used was to monitor the ambient temperature using the DHT11 [21]–[26] sensor to measure the temperature in the environment. The microcontroller used was an Arduino Uno for controlling the environmental temperature monitoring system [27]–[30]. The results obtained from the sensor would be displayed on the 16x2 i2c LCD. The study of the workings of the system was carried out to find out how the system work and further schematic design of the network were created to determine the flow path of temperature data transmission obtained. The test on the software implementation to control the Arduino Uno system was conducted to find out whether there was an error or not. After everything has run well, the data would be displayed on the LCD and sent to Telegram within two minutes.

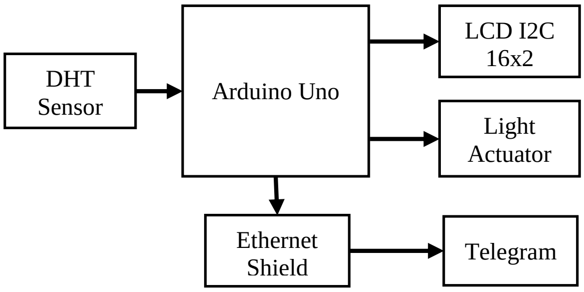

Fig. 1. Overall System Block Diagram

The design of the hardware design was block diagrams and schematic circuits to describe the interconnected devices. The DHT11 sensor as the Arduino Uno R3 temperature input was used as a microcontroller. The results would be displayed on the 16x2 i2c LCD, while the LED worked as output shown the temperature below or the same as 25°C or the same as or above 30°C. The Ethernet shield served as the network link to the server using LAN cable.

A. *Flow system*

Figure 2 illustrates the system flowchart consisting of several parts in which each part is divided based on work processes. All components were assembled or installed properly to ensure that the system could work satisfactorily.

The network design used in the research aimed to provide an overview of network processes and data communication processes as illustrated in Figure 3. It shows that first, the data go through the server and are switched by the Switched D-Link Des 24 port and sent to the research router then to Indotrans router. The data are then transmitted by the antenna FT and ISP Indotrans, received by Telkomsel BTS via the internet. Finally, the Telkomsel BTS processed the registered number on the telegram account

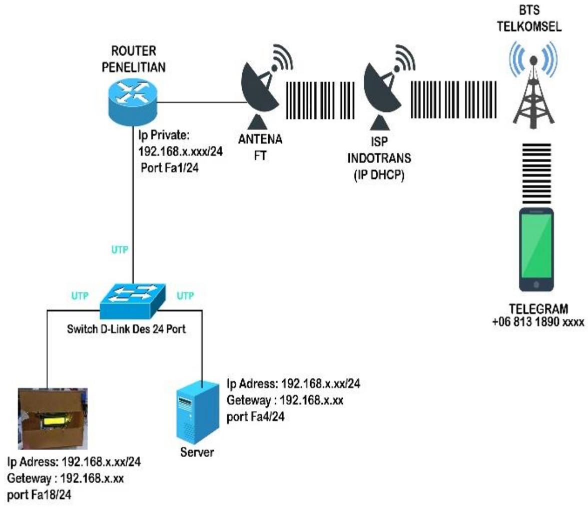

Fig. 2. Schematic Design of Networks [31][32]

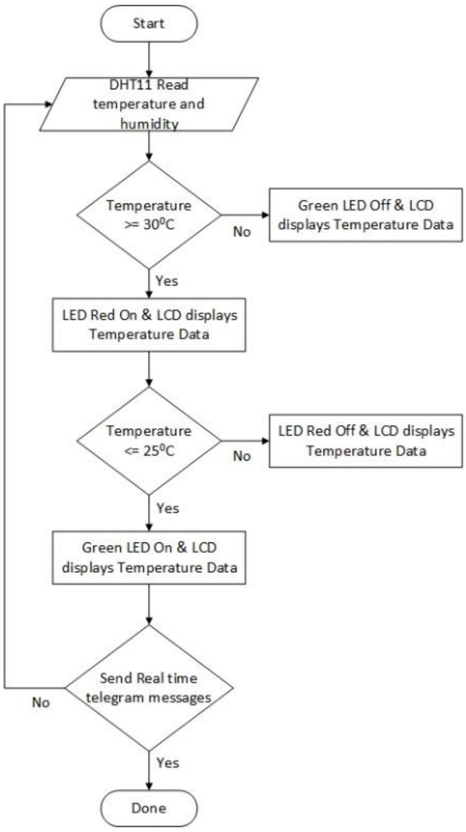

Fig. 3. System Flowchart

B. Soft Implementation

A Library <DHT11> was needed for the two devices to communicate in C language, the Arduino programming language, by connecting between the predetermined Arduino Uno connected to the other side of the Jumper cable to DHT11. The following codes are the Arduino program source codes.

```
void setup() {
  Serial.begin(9600);
  lcd.begin(16, 2);
  pinMode(LEDred, OUTPUT);
  pinMode(LEDgreen, OUTPUT);
  Ethernet.begin(mac, ip, server, gateway);
}

void loop() {
  int humidity = dht.readHumidity();
  int temperature = dht.readTemperature();
  lcd.setCursor(0, 0);
  lcd.print("Suhu: ");
  lcd.print(temperature);
  lcd.print(" C");
  lcd.setCursor(0,1);
  lcd.print("Kelembapan: ");
  lcd.print(humidity);
  lcd.print("%");
  Serial.print("Suhu: ");
  Serial.print(temperature);
  delay(1000);

  if (temperature>=30) {
    digitalWrite(LEDgreen, LOW);
    digitalWrite(LEDred, HIGH);
   } else if (temperature <= 25) {
     digitalWrite(LEDgreen, HIGH);
     digitalWrite(LEDred, LOW);
     }
 }
```

III. Result and Discussion

After designing and installing each component, a test on each hardware contained in the temperature monitoring was carried out, namely the tests on DHT sensor, database, and LED.

A. DHT sensor test

The DHT11 sensor in the monitoring system was the input sensor, the only input sensor. In the test, the sensor was placed next to the box, and it read the temperature and humidity of the surrounding. The DHT11 sensor test result (Figure 4) showed that the sensor read the temperature of 21ºC and humidity of 65%.

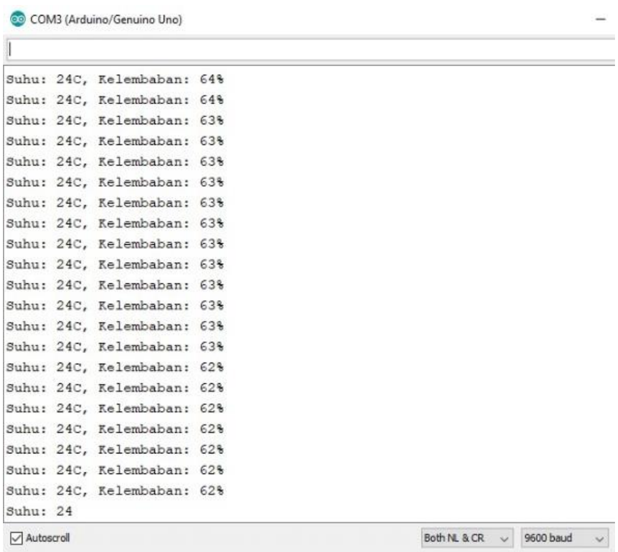

Fig. 4. Shield Ethernet testing

B. *LED light test*

The LED light test aimed to find out the output produced by the LED when the system was running. When the green LED was ON, it indicated a low temperature, and while the red LED was ON, it indicated a high temperature. Figure 5 shows the LED test results.

Fig. 5. LED Test

C. *Testing i2C LCD*

The i2C LCD test was to find out how the LCD displayed the temperature and humidity. Figure 6 shows the LCD displaying the test result of the DHT11 sensor with a 26°C temperature and 54% humidity.

Fig. 6. LCD testing

D. *Database Testing*

Figure 7 displays a localhost interface, which is the result of the Telegram application stored in MySQL.

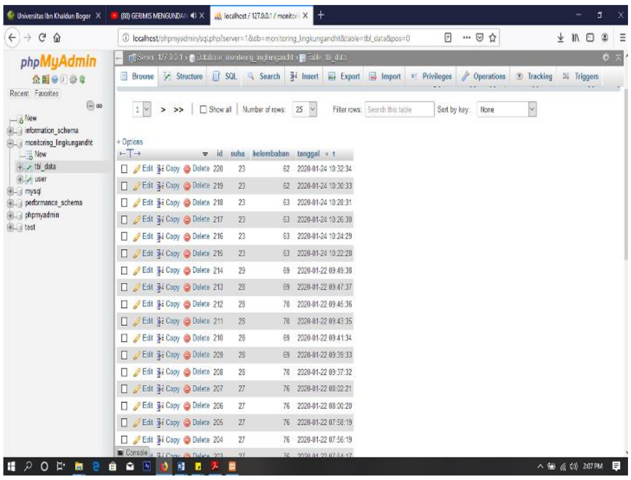

Fig. 7. MySQL Database Interface

E. *LED Component Integration Test Results*

Table 1 presents the integration between the LED components consisting of DHT11 green LED and red LED. When the temperature is below <= 25˚C, the green LED is ON, and the red LED is OFF. When the temperature is above >= 30˚C, the red LED is ON, and the green LED is OFF, and when the temperature is at a range between 25˚C - 30˚C, the red LED is OFF, and the green LED is ON-OFF. To see the results of the system test, Table 1 presents the results of the integration of the notification system components.

TABLE I. TEST RESULTS FOR LED COMPONENT INTEGRATION

Temperature	LED Green	LED Red
<=25˚C	ON	OFF
>=30˚C	OFF	ON
25˚C - 30˚C	OFF	OFF

F. *The test results of the Telegram application*

The test was aimed to examine the environmental temperature monitoring system that entered in the telegram. The test results obtained were 27˚C at 68% humidity and 28˚C at 61% humidity at 14:05, as seen in Figure 8.

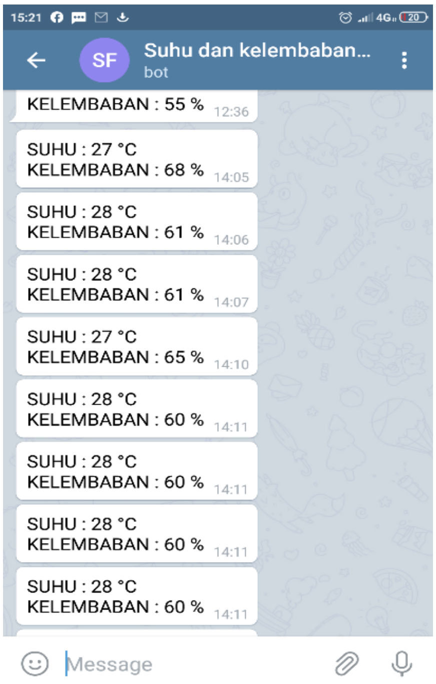

Fig. 8. Telegram application Test

G. *System test results*

The testing phase of the DHT11 Sensor was carried out from 08: 00 to 20:00 within a week and reached the highest temperature of 34°C on Sunday and Monday at 13:00 and the lowest temperature of 23˚C on Tuesday, Wednesday, and Friday at 20:00. Table 2 presents the system test results obtained from each change in temperature sent to the telegram. Table 2 presents the system test results.

TABLE II. SYSTEM TEST RESULTS

Days	Morning		Noon		Afternoon		Evening	
	08	09	13	14	16	17	19	20
Monday 24-11-2019	25° 27° 28°	28° 29° 30°	33° 34° 33°	30° 29° 28°	29° 28° 27°	27° 26° 25°	25° 24° 25°	25° 24° 26°
Monday 25-11-2019	29° 28° 27°	28° 29° 30°	30° 33° 34°	29° 28° 26°	25° 26° 27°	25° 26° 27°	27° 28° 27°	27° 26° 25°
Tuesday 26-11-2019	30° 29° 28°	29° 30° 29°	30° 29° 27°	27° 26° 26°	26° 27° 28°	24° 25° 26°	26° 27° 28°	23° 24° 25°
Wednesday 27-11-2019	28° 29° 30°	29° 30° 29°	30° 29° 28°	29° 30° 28°	30° 29° 28°	28° 29° 30°	26° 27° 28°	23° 24° 25°
Thursday 28-11-2019	30° 29° 29°	30° 31° 32°	32° 32° 30°	30° 29° 28°	30° 29° 27°	27° 26° 25°	26° 27° 28°	27° 28° 29°
Friday 29-11-2019	29° 30°	28° 30° 29°	29° 30° 31°	29° 28° 27°	27° 28° 27°	27° 26° 26°	26° 25° 26°	25° 24° 23°
Saturday 30-11-2019	30° 31° 30°	30° 30° 29°	30° 31° 32°	33° 32° 33°	30° 29° 28°	28° 27° 26°	25° 26° 27°	25° 23° 24°

IV. CONCLUSION

Based on the research conducted, it is found that the series of the tool designed could determine the ambient temperature satisfactorily. The testing phases have been carried out to examine and ensure that the units function properly. The results demonstrated that monitoring the environmental temperature using Arduino and Telegram application is functioning per intended design, and meeting the overall project objectives. Some typical applications of the equipment can be used for monitoring and recording the temperature such as in farming, laboratory, office, and home. The project is successfully implemented within a timeframe.

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