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IoT Enabled Smart Cooling System for Server Room

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***Abstract*---Internet of Things (IoT) is upcoming promising technologies that are used for automations in both industries and commercial applications. In most of the organizations, Servers are used to store all sensitive and important data. In runs 24/7 and are involved in background processing. It dissipates abundant heat which may lead to hardware damages and data loss. Hence maintaining a cooling system in the server room becomes mandatory. The existing system used for this purpose need to be automated to adjust the temperature as per the requirement. The objective of this research is to design and develop an IoT enabled automated cooling system for server room. The proposed work is developed using DS18B20 Temperature sensor and Raspberry pi controller. From the performance analysis, it is found that the proposed work outperforms the existing work in terms of accuracy.**

Index Terms:DS18B20, DH11, DH22, LM35, I-ESCS, MCU, MYSQL

I. INTRODUCTION

In the current pandemic situation, the usage of digital technology has become part of everyone's routine. E-learning, E-commerce, E-medicine, E- transaction etc., are some of the applications that demands Internet. Every application operated over internet need a well organized repository system. The servers present in data centre system are core entity that stores and process all sensitive and crucial data. The involvement of electronics is abundant in these system, thus more amount of heat is dissipated during data processing. However, to maintain temperature and humidity, commercial freezers and production lines are used [1]. From the literature [2], the server room temperature is recommended to be maintained between 10°C to 28°C. For better server functionality, it needs to be kept between 20°C to 21°C [3]. The most common issues faced in the server rooms are: Inadequate Temperature Control, Insufficient Ventilation, Imbalanced Moisture Levels, Too Much Jostling, Clutter and Disarray Power Volatility and Acts of Intentional Malice [3].

Existing system has used the DH11 and DH22 sensors to sense the server temperature. These sensors are made by sintering material. The limitations observed in these sensors are to reflect smaller changes in the temperature, larger change in resistance need to be realized. Thus the working mechanism may sometime exhibit unstable output. This in turn affects the accuracy if the application. The key objective of this research is to enhance the accuracy of the application. In this research, DS18B20 water proof sensor is used to achieve the above objective. DS18B20 is a water proof sensor normally specially used in rigid environments namely mines, chemical solutions, soil parameter detection. Due to stable operation of this sensor, the accuracy of the application can be enhanced.

Further, the additional benefits of this sensor are that it can measure temperatures in multiple points with the help of single wire bus protocol. Rest of the paper is organized as follows: Section II details the literatures pertaining to the state of art of the research. Section III presents the proposed methodology. Section IV discusses the result obtained through experimentation. Finally, Section V summarizes the work highlighting the novelty and future directions of the proposed research.

II. LITERATURE SURVEY

Rico Wijaya et al [1], the author developed a server room temperature monitoring system using Raspberry Pi and DHT11 Sensor, the temperature data received from the sensor are successfully transmitted and stored in a database using Raspberry Pi. The stored data is displayed to the user in the graphical form with the help of the web pages. The developed system sent an e-mail alert whenever the temperature falls between the mentioned limit 20°C - 25°C., The accuracy of the developed system is found to be 98.15%.

Dwi Ely Kurniawan et al., [2] designed a system that monitor the temperature and humidity of the server room with the help of DH sensor. The collected data is stored in the MYSQL database using Raspberry pi. The results are shown using PHP. Whenever the temperature and humidity of the room exceed the specified threshold level, the designed system sends a Whatsapps notification to the user.

Moechammad Alvan Prastoyo Utomo et al [4] designed the system using arduino to monitor the temperature and humidity of the server room continuously and display the readings in the website graphically. The system sends notifications to the user through telegram whenever changes in temperature and humidity exceed the

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threshold. Theophilus Wellem et al [5], implemented a microcontroller based system for monitoring server room temperature.

They have used Atmel AVR ATmega 8535 microcontroller and LM35 temperature sensor. In this system, the administrator monitors and controls the appliances through text messages' H Nasution et al [6], designed a system that monitors temperature and humidity of the server room remotely using Lattepanda and ThingSpeak. The system has two parts, the first part is a hardware reading data from the sensor, the second part is sending data to ThingSpeak which access internet using a browser.

Existing systems using the DH11, DH22 and LM35 sensors, DH11 sensor produce the accurate result only when the temperature falls in the range of 0 to 50°C, DH22 sensor produce the accurate result for the temperature range between -40 to 80°C, LM35 gives best accuracy only when the temperature is 25°C. But in the proposed system, the usage of DS18B20 sensor gives accurate results for the temperature range between -10 to 85°C which is the wider range when compared to the existing sensors. Thus the novelty claimed through the proposed work is that providing wider range of temperature sensing.

III. PROPOSED SYSTEM

This sensor is connected with Raspberry Pi using a single wire bus cable. The Raspberry Pi serves as a monitoring node. It stores and displays the temperature. The raspberry Pi is programmed using python language. The proposed I-ESCS uses DS18B20 sensor [5]. Multiple sensors can be connected using single wire bus protocol. This protocol has the capability of controlling multiple one wire devices with single micro controller pin. Single wire protocol follows the master slave architecture. Here the micro controller unit (MCU) act as a master and the DS18B20 sensor act as a slave as shown in Fig. 1 [5].

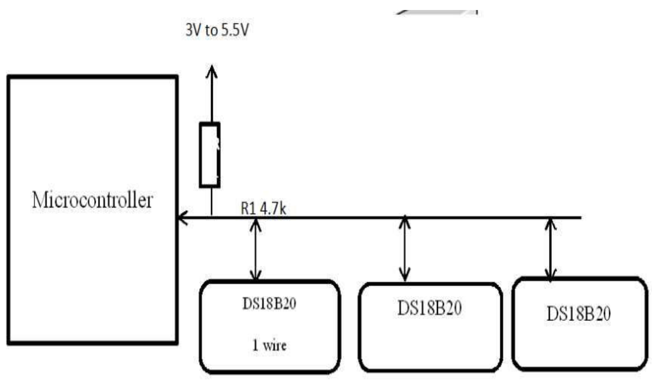

Fig. 1. One wire bus system

This sensor is used to measure the temperature range from -55°C to +125° with an accuracy of ±5°C [5]. Each sensor holds a unique address and requires single pin of the MCU to transfer data. Thus DS18B20 sensor is the best choice for measuring temperature from multiple points without compromising more digital pins on the MCU [6]. The block diagram of the proposed I-ESCS is shown in Fig 2. The temperature in the application can either be measured in Celsius or Fahrenheit.

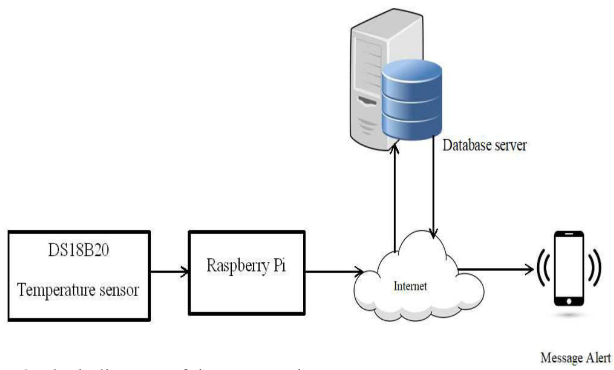

Fig. 2 Block diagram of the proposed I-ESCS

The DS18B20 sensor is initially connected to the Raspberry Pi. The sensor senses the temperature and sends the value to the MCU present in the Raspberry pi, where the sensed value is compared with the threshold value stored in the database. Whenever the temperature falls below the threshold, an alert message is sent to the mentioned administrative personnel.

A. Components Used

The proposed I-ESCS is designed and developed using the following components:

- Raspberry Pi
- DS18B20Sensor
- 4.7 KΩ Resistor
- Jumper cables
- Wi-Fi

Raspberry Pi

Raspberry Pi is a small, low cost, portable, single board computer. It can be plugged with computer, TV monitor, keyboard and mouse [6]. It can control applications and appliances over internet. Thus it can act as an ideal platform for IoT based automation applications. Some of the applications are: Home automation, Smart transportation, Health monitoring, Smart cities, Smart agriculture and Smart car parking etc. Fig 3 shows the Raspberry pi 4 Hardware [7].

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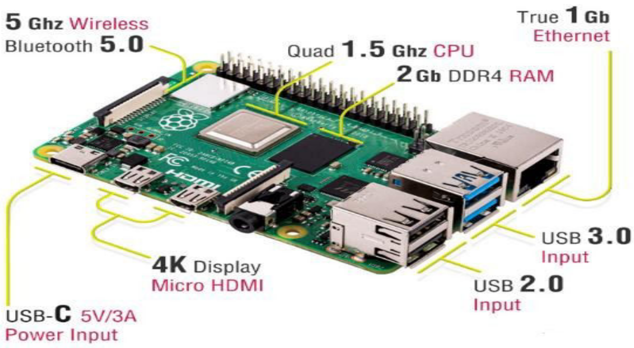

Fig. 3. Hardware specification of Raspberry pi 4

TABLE I. COMPARISON OF DIFFERENT TEMPERATURE SENSORS

Sensor	Parameter	Protocol Type	Supply voltage	Temperature range
DHT11	Temperature & Humidity	One-wire	3-5.5V	0 to 50ºC
DHT22	Temperature & Humidity	One-wire	3-6V	-40 to 80ºC
LM35	Temperature	Analog	4 - 30 V	55 to 150ºC
DS18B20	Temperature	One-wire	3 -5.5V	-55 to 125ºC
BME180	Temperature & Pressure	I2C	Chip: 1.8 - 3.6V Board: 3.3 -5V	0 to 65ºC
BME280	Temperature Humidity & Pressure	I2C SPI	Chip: 1.7 - 3.6V Board: 3.3 - 5V	40 to 85ºC

DS18B20 Sensor

DS18B20 is a kind of temperature sensor which communicates the data through one-wire bus protocol [8]. It includes one data line to communicate with an inner microprocessor. This sensor is fed with direct power supply from data line. It has three pins, pin 1 for ground, pin 2 for vcc, and pin 3 for data as shown in Fig 4. In this application, data is the temperature value which can range from -55°C to +125°C. This sensor is specially used to monitor temperatures from rigid environments such as mines, chemical solutions, Soil, etc [9]. It is water proof; hence it can be applied to water based applications [10]. Table 1 highlights the significance features of DS18B20 sensor compared with other temperature sensors available in market [11].

Fig. 4. DS18B20 sensor

4.7 KΩ Resistor

The 4.7 KΩ Resistor used to connect the right and middle pin of the sensor. This is called a pull up resistor; it is used to ensure that the middle pin is always on.

Jumper Cables

Jumper cables are used to connect the device together in the breadboard [13].

Wi-Fi

Wireless fidelity is used to connect the raspberry pi based user device to the internet to realize the concept of IoT. Remote communication and sending notification messages is accomplished through this [14].

B. Circuit Design

Fig.5 shows the circuit design constructed for the proposed I-ESCS. The VCC and GND Pins of DS18B20 Sensor are connected to 3.3V and GND Pins of Raspberry Pi. DS18B20 can tolerate +5V Supply, hence 4.7KΩ pull up resistor is used between the DQ pin of DS18B20 and 3.3V. Finally, the DQ Pin is connected to GPIO4 (i.e. Physical pin 7) of Raspberry Pi.

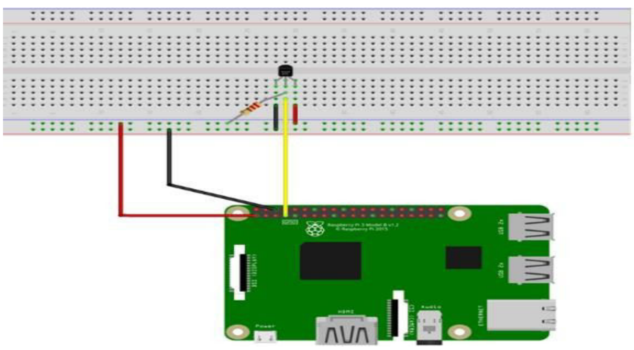

Fig. 5. Circuit design for proposed I-ESCS

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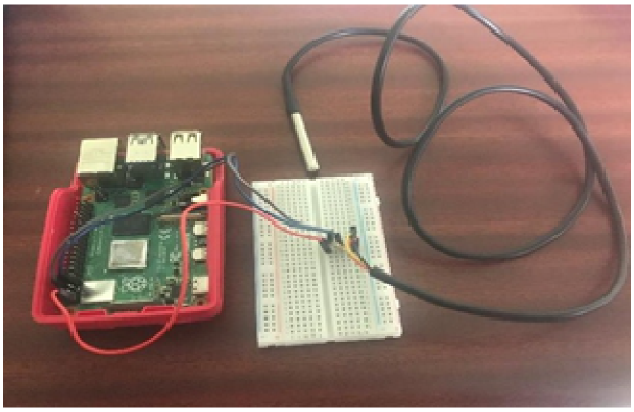

Fig. 6. Experimental Setup for proposed I-ESCS

C. Algorithm involved in Experimentation

Fig 6 illustrates the experimental setup of the proposed I-ESCS. The steps involved are detailed below:

Step1: To enable one wire interface

Enable the one wire interface by modifying the configuration file of Raspberry pi.open the config file using the command

sudonano /boot/config.txt

After that add the statement dt over lay =w1–gpio at the end of the file. Then save and reboot the raspberry pi.

sudo reboot

Step2: Check the working condition of Sensor

To check the working condition of DS18B20, after the raspberry pi is rebooted, type the following commands.

sudomodprobe w1-gpio sudomodprobe w1-therm

Then change the device directory and list of devices under the directory identified by ls command. After that, change the sensor directory from default to user specified.

Step3: Write the python program to convert the temperature to Fahrenheit and Celsius

The function readtemp () is used to read the temperatures in the device file.

```
def readtemp():
    f = open(device_file, 'r')
    lines = f.readlines()
    f.close()
        return lines
```

The gettemp() function is used to process the data from readtemp() function,then the data will converted into Celsius and Fahrenheit temperature.

```
    def gettemp():
        lines = readtemp()
        while lines[0].strip()[-3:] != 'YES':
            time.sleep(0.2)
            lines = readtemp()
        equals_pos = lines[1].find('t=')
        if equals_pos != -1:
            temp_string = lines[1][equals_pos+2:]
            temp_c = float(temp_string) / 1000.0
            temp_f = temp_c * 9.0 / 5.0 + 32.0
            return temp_c, temp_f
```

IV. RESULTS AND DISCUSSION

Fig7 shows the browser that present the temperature parameter read from the environment. Fig8 show the SMS alert generated whenever the temperature crosses 25°C.

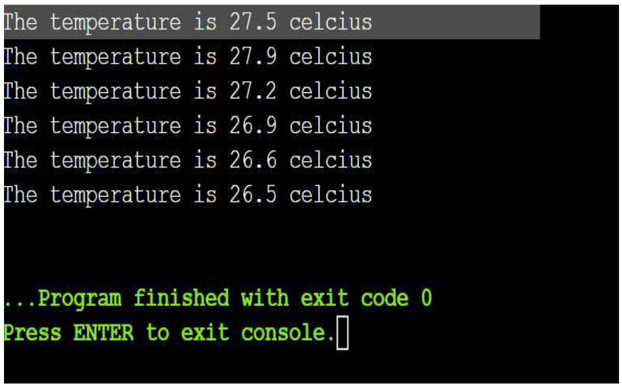

Fig. 7. output of Python interpreter

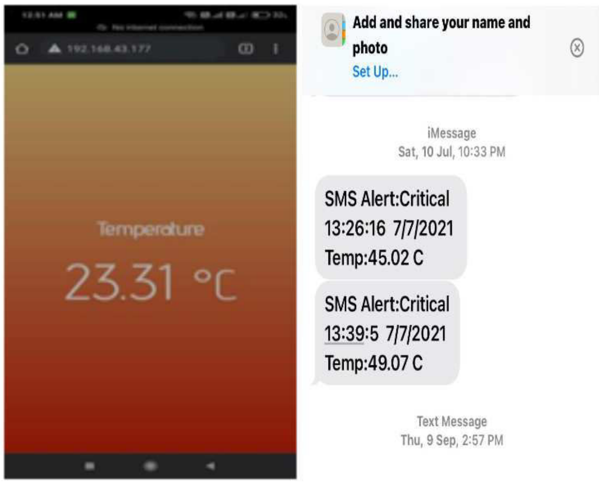

Fig. 8. Temperature monitoring and message alert

Table 2 present the temperature readings measured at different times. The performance of the proposed I-ESCS connected through Wi-Fi, in Fig.9 the graph shows the temperature reading from the sensor over a period of time with 10 minutes' interval.

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TABLE II. TEMPERATURE READINGS MEASURED IN DIFFERENT TIMES

Temperature	System Output
28.3°C	Alert message sent
33.02°C	Alert message sent
24.62°C	No alert message
23.55°C	No alert message
42.33°C	Alert message sent
34.01°C	Alert message sent
31.00°C	Alert message sent

V.PERFORMANCE EVALUATION

The performance of the proposed I-ESCS system is evaluated based on the temperature difference between the temperature measured using digital thermometer and the temperature value received from the DS18B20 sensor over a period of time, from which the average error percentage is calculated. Table 3 shows this comparison. The accuracy of the sensor is 100%-0.17%=99.83%.

TABLE III. DS18B20 TEMPERATURE MEASUREMENT

Thermometer temperature	DS18B20 sensor temperature	Difference(°C)	Average Error %
14	14.05	0.05	0.33
34	34.03	0.03	0.09
44	44.1	0.1	0.21
38	38.04	0.04	0.06
28	28.02	0.02	0.03
Total Average Error			0.17

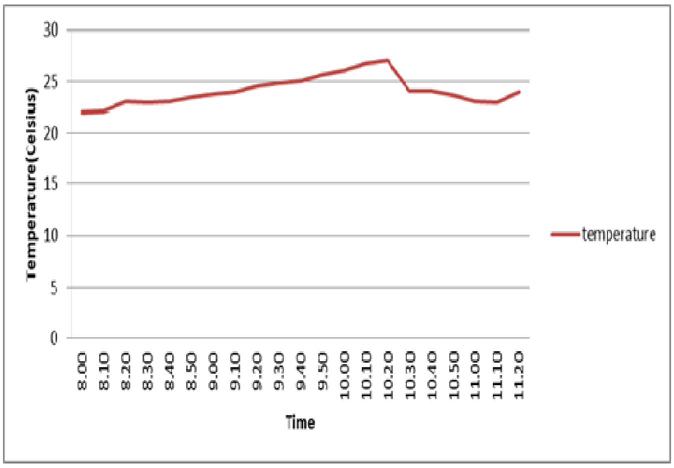

Fig 9: Temperature variation over a period of time

CONCLUSIONS AND FUTURE WORK

Automation of temperature monitoring in server room of data processing centre is an important application to avoid sever getting crashed. As information is resource, improper maintenance may cause damage to the crucial stored data. In this paper, an IoT enabled automation system for server room cooling system is developed using simple DS18B20 temperature sensor and Raspberry pi. The application is completed created using python language. From the performance analysis made, it is found that proposed I-ESCS outperforms the existing system.

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