Intelligent Cooling System

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***Abstract* — The paper written consists of the solution for the major problem experienced these days, that is, energy consumption by electrical appliances. The paper introduces the concept of intelligent air handling units which will analyze and manage the parameters important to maintain the cooling effect in the commercial and industrial buildings. The air handling unit is to be deployed at Heta Datain office, M5 Laxmi Nagar, Nagpur. The primary aim is to monitor the input power to the chiller and its thermal efficiency concerning each section and minimize the energy consumption. For this, various parameters such as temperature, humidity, the flow of air and level of water in the air handling unit are monitored in real-time using sensors and Wi-Fi. Along with this, weather conditions outside the room, the temperature inside the room where the air handling unit is present, power consumption, speed of air and ambient light is taken into consideration for monitoring. In this project, we have used an 8.5 TR chiller to supply cool air to various sections through ducting wherein Fan Control Unit is used to control the temperature in the space where it is installed. The receiver will retrieve that data and send the control commands to the chiller. Real-time data of all the parameters are extracted by using various sensors and displayed on the dashboard of an android application. In this way, the monitoring and control of the chilled water-cooling system will take place. Technologies such as Native Script and Angular are used in developing the android application. JSON and PHP are used for parsing and fetching the data respectively. After the data is received and displayed on the android application screen, the analysis of the data is to be done. Analyzing the data will help us to propose a solution in favor of implementing ways that will reduce energy consumption. Overall, we are specifically working on reducing the energy consumption of an air handling unit used in industries for the cooling effect.**

Keywords* — *air handling unit, reduced energy consumption, intelligent cooling system

I. INTRODUCTION

This paper introduces an intelligent air handling unit which analyses and manages the parameters important to maintain the cooling effect in the buildings or industries. Here, we will specifically talk about the energy consumption of the air handling unit used in industries for the cooling effect. What a wonder it would be if an electric appliance becomes smarter and can contribute to the conservation of the energy.

Suppose a room consisting of an air handling unit of 10 ton which is more than sufficient. So, what if the chiller, present in the air handling unit, adjusts its temperature and the flow of air all by itself according to the weather conditions outside the room and the temperature inside the room where the air handling unit is present. To achieve this, we have come up with a solution for which a user-friendly interface in the form of an android application is developed by us for controlling the appliances from anywhere, anytime using the concept of the Internet of Things (IoT).

The chilled water-cooling system is widely used commercially, industrially, in homes, apartments, hotels, etc.

II. MAKING THE SYSTEM INTELLIGENT

The primary aim of the project is making the air handling unit intelligent which can be operated from any remote location through the access of internet connection. Making the system intelligent ensures that the system is under control of the owner or the person handling it, which in turn ensures that energy is conserved or we can say that the energy is consumed less. Constant monitoring of the air handling will also result in monitoring of the entire machine or setup in which the air handling unit is deployed.

Here, in this project along with the air handling unit, other subunits will send data through sensors and will be monitored in real-time. For example, the temperature and humidity of the room are monitored where the air handling unit is present.

Along with this, making the system intelligent also counts in the prior adjustment of the parameters or the adjustment done in real-time to handle the system. For example, if the user is going to come back home in an hour and he/she wants the room to cool when he/she comes home, then he/she should be able to do that through the application by operating and adjusting the parameters. This will save energy in a way that the user can handle the system and switch off or on whenever it is not in use.

Looking into this from an industrial point of view, this monitoring will contribute in huge ways to the industry in consuming less energy and conserving more. This can be achieved by data analysis done on the data received from the sensors.

III. SOFTWARE SYSTEM

A. Technologies and Softwares Used

- *Angular*

Angular is TypeScript based open source web application framework for building applications on mobile and web.

- *Arduino IDE*

Arduino Integrated Development Environment is an open-source platform in which we can write code in C and C++ and upload programs to Arduino compatible boards.

- *C language*

C language is a general-purpose programming language used to develop databases, operating systems, etc. Here, we have used C language for coding in Arduino IDE.

- *CSS*

Cascading style sheet (CSS) is a style sheet language used for describing the presentation of a document written in HTML. It is specifically to format the layout of web pages.

- *JSON*

JavaScript Object Notation (JSON) is an open-standard file format or data interchange format that uses human-readable text to transmit data objects consisting of attribute-value pairs and array data types.

- *MySQL*

MySQL is an open-source relational database management system. It is free and open-source software. MySQL is a popular database used with PHP.

- *NativeScript*

NativeScript is an open-source framework to develop apps on the Apple iOS and Android platforms. NativeScript apps are built using JavaScript or TypeScript, which transforms JavaScript. NativeScript supports Angular and Vue.

- *PHP*

PHP is a popular general-purpose scripting language that is especially suited to web development. It is an open-source language and can be embedded into HTML.

- *Visual Studio Code*

Visual Studio Code is a source code editor that can be used with a variety of programming languages like Java, JavaScript, Node.js, etc.

B. Flow of Application

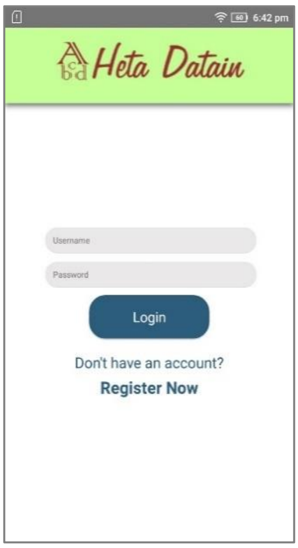
The data obtained from the sensors is displayed on the dashboard of the android application. The android application is developed using Angular 7, JavaScript and Native script using Visual Studio Code as the environment for programming.

Before finalizing the domain for designing the application, a comparison was done looking forward to the good look & feel as well as the user-friendly interface and efficiency of the application. When compared between Android and Native script, the latter one won the debate since it was the one by using which we can design the application, for Android as well as iOS, and website with the same code with some minor changes.

So, the application is designed using native script along with Angular 7.

We have designed the database using MySQL. PHP is being used for the database connection. At the initial level, to define the number of users and to provide security, the registration and login pages are designed (Fig 1 and Fig 2). For this, we have used the MySQL database and the connection is done using various queries. After the registration, the user will be able to login using a username and password. The validation of the registration and login page is done using PHP. The dashboard is designed using HTML, CSS, Angular where the data generated by the sensors is displayed on it. The data generated by various sensors will be stored in a memory card as well as the cloud or database. The memory card is used for backup storage purposes. The data in the database or cloud is sent using the HTTP request-response method. After storing the data on the cloud, using the HTTP request method in the PHP link, data is fetched from the database or cloud.

The data fetched is in JSON which is in the key-value pair format. So, it needs to be decoded and the value needs to be separated from the key for displaying it on the dashboard. The designed dashboard consists of various parameters (Fig 3. Dashboard of Module 1 & Fig 4. Dashboard of Module 2). These text fields have the ids which are further used for storing the values received by hitting the PHP links. These stored values get updated after every fixed interval of time to get the latest value and store in the database. The current date is displayed by default on the dashboard. Otherwise, if the user wants to view the data of the particular date, the current date changes to this one.



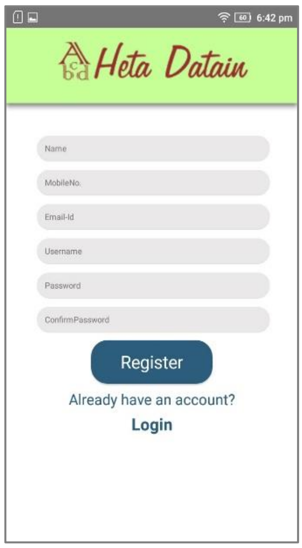


Fig 1. Login Screen   Fig 2. Registration Screen

There are two modules, which we can call daughters both of which are connected to a mother. This entire setup will be placed beside the air handling unit. Both the daughters have the same set of sensors with 1-2 different ones. The sensors will capture the data of the necessary parameters. The Mother also switches between two daughters. Id of Daughter-1 is 1 and that of Daughter-2 is 2.

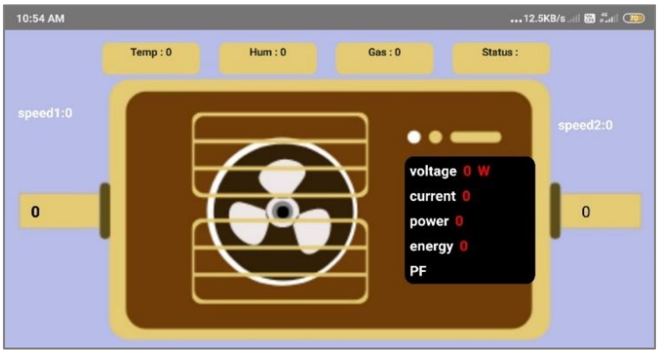


Fig 3. Dashboard of Module 1

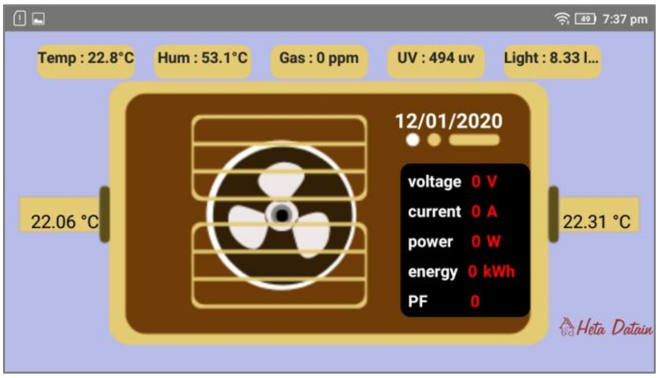


Fig 4. Dashboard of Module 2

IV. HARDWARE SYSTEM

A. Sensors Used

- *BH1750*

  It is an ambient light sensor that gives a digital output. It is used to collect the data of ambient light and adjust the brightness of the displays in devices like mobile.

- *DHT22*

  It is a temperature and humidity sensor that gives a digital output. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air.

- *DS18B20*

  It is a temperature sensor which can be easily connected to an Arduino digital input.

- *Infrared proximity sensor*

  Proximity Sensor is used to detect objects and obstacles in front of the sensor. The sensor keeps transmitting infrared light and when any object comes near, it is detected by the sensor by monitoring the reflected light from the object.

- *MQ135*

  It is an air quality sensor used to sense a wide range of gases like NH3, CO2, Benzene, etc.

- *NodeMCU*

  NodeMCU is a low-cost open-source IoT platform. It has open-source prototyping board designs available.

- *RELAY*

  Relay are switches that open or close electronically.

- *RS485*

  It is a three-phase energy meter that measures the energy of the three-phase network and other parameters such as voltage, current, power, power factor, frequency, etc.

- *UV radiation sensor*

  It is used to detect the intensity of the incident ultraviolet radiation.

B. Daughter 1

In this module, the NodeMCU reads the data coming from all the sensors. DHT22 is used for measuring the temperature & humidity. It will be placed in a section. Two sensors are used for measuring the temperature of water in the chiller tank. Two Infrared proximity sensors are used to measure the speed of fan blades in the air handling unit. The gas sensor is used for measuring the amount of carbon dioxide in the air in a section. An RS485 energy meter is used which monitors different parameters of electric supply to any machine. We are considering only 5 parameters, that is, voltage, current, energy, power and power factor. Relay is supposed to be used for switching the supply OFF if any critical condition occurs. After getting all these parameters, the daughter sends them to the mother which is again a NodeMCU.

Fig 5. Hardware box of Daughter 1

C. Daughter 2

In this module, the NodeMCU reads the data coming from all the sensors. DHT22 is used for measuring the temperature & humidity. It will be placed in a section. Two sensors are used for measuring the temperature of water in the chiller tank.

The UV sensor is used to calculate the amount of UV radiation. A light sensor is used to calculate the ambient light. An RS485 energy meter is used which monitors different parameters of electric supply to any machine. We are considering only 5 parameters, that is, voltage, current, energy, power and power factor. Relay is supposed to be used for switching the supply OFF if any critical condition occurs. After getting all these parameters, the daughter sends them to the mother which is again a NodeMCU.

Fig 6. Hardware box of Daughter 2

The Mother then sends that data to a virtual private server, i.e., cloud as well as stores it in SD card. SD card is used as a backup option which we will be useful in case of unfortunate data loss or for any further requirement.

Below is the TABLE I that has given units of all the parameters in which it is measured.

TABLE I. UNITS OF PARAMETERS

Sr.no	Parameter	Unit
1.	Ambient Light	Lux
2.	Current	Amperes
3.	Frequency	Hertz
4.	Gas	ppm
5.	Humidity	° Celsius
6.	Power	kilo Watt
7.	Temperature	° Celsius

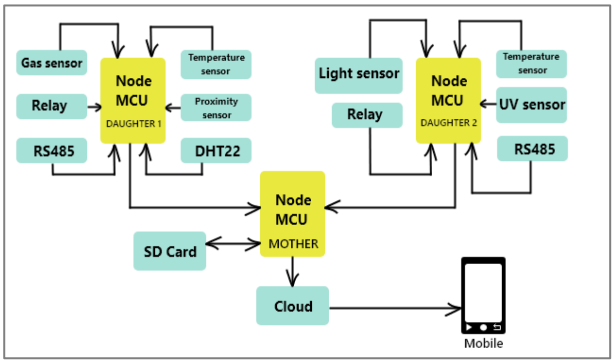


Fig 9. Architecture of the system

V. ARCHITECTURE OF THE SYSTEM

As shown in Fig 10, the air handling unit has two NodeMCU, which we can call daughters. Both the daughters have a set of 4-5 sensors connected to it which collects data in real-time and sends it to another NodeMCU, which we can call Mother.

The mother sends and stores the data received in the SD Card as well as the cloud. The data is fetched from the cloud in a key-value pair format. The key-value format helps to store the data individually of every parameter. The data is then displayed on the dashboard separately of each module. After the data is fetched and displayed on the dashboard, the user can also view the data in the graph to get a quick visual representation. Fig 7 and Fig 8 shows the graph of ambient light and UV. The X-axis of the graph shows the time in 24-hour format with a certain time interval. The Y-axis shows the parameter of which the graph is to be displayed.

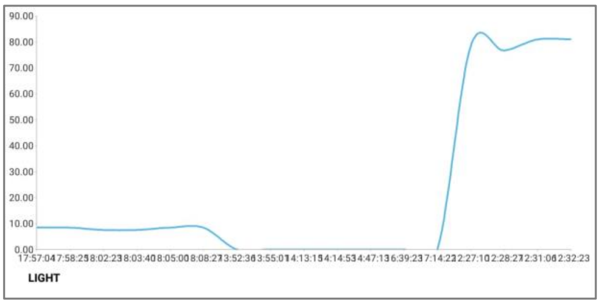


Fig 7. Graph of Ambient Light

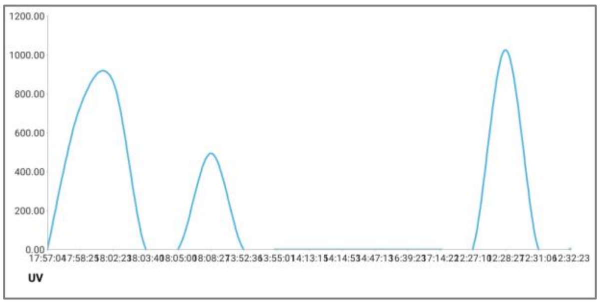


Fig 8. Graph of UV

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REFERENCES

[1] Siddharth Goyal, Prabir Barooah - Energy-efficient control of an air handling unit for a single-zone VAV systemAir Conditionin Systems -https://www.airconditioning-systems.com/air-handling-unit.html
[2] Paul Evans – Air Handling Units explained – The Engineering Mindset
[3] ‘Nonlinear Control of a Heating, Ventilating, and Air Conditioning System with Thermal Load Estimation’ Betzaida Arg¨uello-Serrano and Miguel V´elez-Reyes, *Member, IEEE* TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY, VOL. 7, NO. 1, JANUARY 1999
[4] ‘Influence of Temperature and Humidity Control in Air Conditioning on Indoor Environment Quality and Human Feeling.’Yu ping sun, neng Zhu
[5] ‘Modeling and optimization of HVAC energy consumption’ Andrew Kusiak, Mingyang Li, Fan Tang
[6] ‘Analysis of Air Conditioning Energy Saving Measures’ Si Qi Li, Rui Li