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Smart Automatic Cooling System with Reduced Humidity Effect for Pet House During COVID-19 Crisis

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COVID-19 is a pandemic crisis that affects not only human lifestyle but also pet. The crisis halts pets' social activities and they need to stay at home. Some owners prefer to keep their pets in separate pet enclosure/house due to health issue. The pet enclosure should be comfortable as the pets need to stay inside for quite a long time. Besides that, living in middle of the city in Malaysia makes it difficult for people to get a good level of humidity for pets. Thus, this research aims to design and develop an automatic cooling system with reduced humidity effect that can give comfort to the pets for staying many hours inside the pet house. The system relies on Internet of Things (IoT), where the data analysis of the temperature and humidity of pet houses can be done by the users. Particularly, thermoelectric peltier for cooling system, Arduino Uno and NodeMCU ESP8266 Wi-Fi Module are used here. The proposed solution helps to ensure the desired comfort of a pet house, where pet owners can easily and efficiently monitor the temperature and humidity. The system is simple, but it still can help maintaining the health and wellbeing of the pets by reducing the surrounding temperature to 29ºC and humidity to 70%.

Keywords: Automatic cooling system; Internet of Things (IoT); temperature; humidity; pet house

I. INTRODUCTION

The recent COVID-19 pandemic which causes lock down and movement control order in most countries, sees increase in pet adoption worldwide. Pets give their owner companionship and joy. The pet lovers are very concerned about their pet comfort, quality of life and living conditions. Like human, pets are sensitive to temperature and humidity. In areas with significant changes in atmosphere or large temperature shifts between day and night, air-conditioning system helps to prevent the pets from getting a heatstroke (Shih H. Chen, 2008).

The indoor thermal atmosphere is part of an indoor environmental quality aspect that has a strong impact on the comfort and wellbeing of the occupants. Occupants' behaviour and activities are relatively contributing to the effect of global warming because of energy consumption building and carbon emissions (Ismail, 2012). Malaysia, located near to the equator experiences the warm and humid climate condition all year round. The most crucial climatic impact experience in Malaysian buildings are high intensity of solar radiation and high daily air temperature (N. Al-Tamimi, 2011). Apart from these climatic elements, wind and humidity also have significant impact on the indoor thermal comfort of occupants. Due to excessive heat and high air temperature, air-conditioning is frequently used to achieve

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the required indoor thermal comfort. However, the usage of air-conditioning may result in increased energy consumption in buildings (W. Hien, 2000).

Many recent studies involve cooling system, based on smart energy that can balance thermal comfort against energy consumption in a building. The smart cooling system (SCS) is used to combine the general shape of a building with energy consumption and thermal comfort cooling of people. Comparison is done to buildings without SCS (Daneshvar, Y, Sabzehparvar, M & Hashemi, SAH, 2020). An experiment with a 'stay-at-home pets' situation is done, based on secondary evidence on pet care patterns and a decade of ethnographic analysis with Australian households. The demonstration on viewing futures through pet care and entertainment activities changes the conceptualisation of the energy challenges (Yolande Strengers, Sarah Pink & Larissa Nicholls, 2019).

Other than the concept of air cooling, water cooling is based on the idea of finding a medium that can handle and transport heat more effectively than air. Water has an excellent ability to maintain heat while being in a liquid state (B. Y.Masram *et al.*, 2018). A feed forward neural network can be used to control the cooling mechanism, by maintaining temperature within the bamboo-type growing chamber while also considering the external temperature. The average raw data temperature used in the analysis is 60 degrees Celsius. The highest output comes from a feed forward neural network with 10 neurons in the secret layer, according to the results and the actuation process by the neural network to the cooling system is successfully executed (J. -A. V. Magsumbol *et al.,* 2020).

Here, a prototype of automatic cooling system with reduced humidity for pet house was developed using NodeMCU ESP 8266 Wi-Fi module integrated with the Blynk server. The system provides the temperature and humidity gauge of the pet house and combined with a relay for automation control of cooling system. Blynk is a server used in most countries for mobile communication and as an analysis system via graph provided. The cooling system part is developed using thermoelectric peltier which works as thermoelectric cooling system. The prototype is also developed using Arduino Uno R3 that combined with DHT-11 sensor for displaying the reading in LCD. The users are also able to check the temperature and humidity by looking at LCD that attached on the pet house wall.

II. MATERIALS AND METHOD

NodeMCU ESP8266 Wi-Fi module and Arduino UNO are used with Liquid Crystal Display (LCD) display system. The cooling system is built by combining the CPU Cooler 6 Heat pipe Dual-Tower Cooling Fan Radiator, Peltier module, heatsink and DC fan.

A. Approached Methodology

Two units DHT-11 sensor are used to give inputs signal to the NodeMCU and Arduino. DHT-11 sensor can detect the temperature and humidity level of pet house and it will send data to NodeMCU ESP8266 Wi-Fi module and Arduino Uno R3 board to trigger the single relay that controls the power ON or OFF of the cooling system. The relay will turn ON if the temperature is exceeding 29 °C and will turn OFF when the temperature is lower than 29°C. Figure 1 shows the flowchart of the automatic cooling system. The proposed system design function is shown in Figure 1.

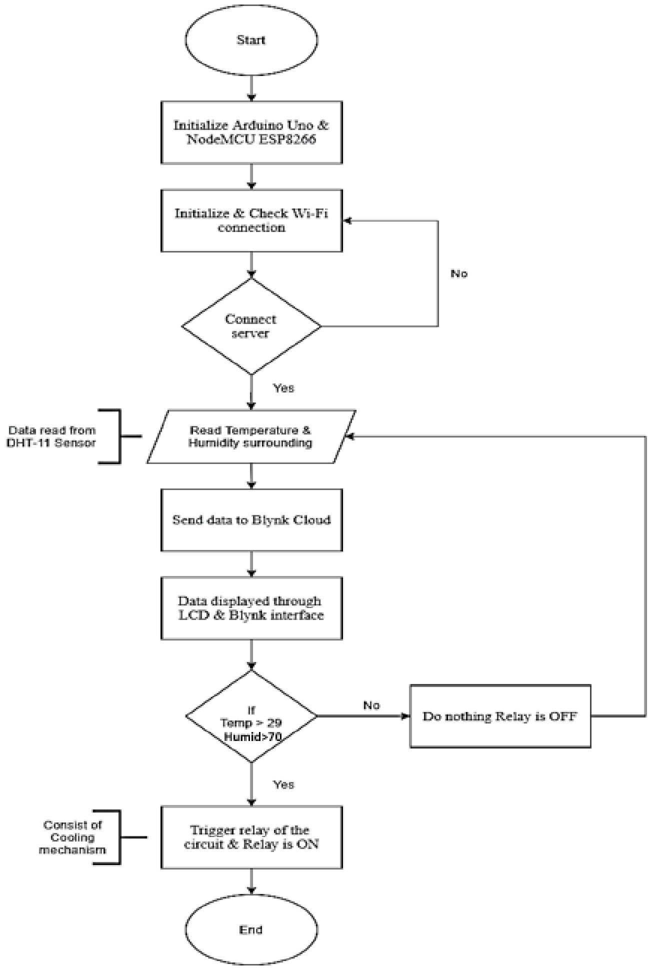

Figure 1. The proposed design system function

B. Hardware Components

NodeMCU ESP8266 has been selected as the Wi-Fi module to allow the microcontroller access to a Wi-Fi network. The system can send/receive the data of temperature and humidity detected by DHT-11 sensor through the Wi-Fi module. The temperature and humidity reading are transferred into gauge and visualised through graph for data analysis into Blynk. Furthermore, if the temperature is higher than the maximum level that have been set, the cooling system will turn on to reduce the temperature and humidity. Figure 2 shows the schematic diagram connection of NodeMCU ESP8266 Wi-Fi module.

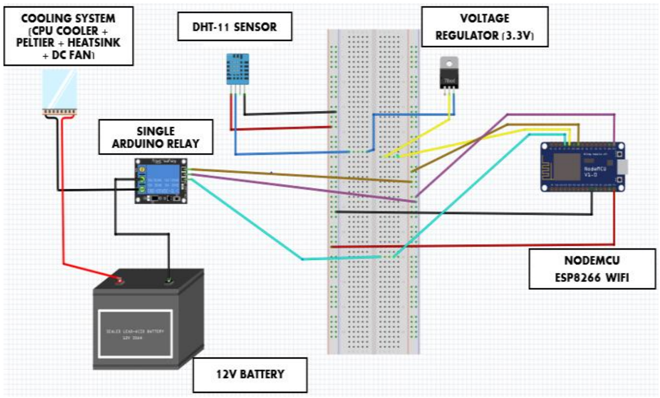

Figure 2. The proposed design system function

Here, Arduino UNO is used to collect data from the DHT-11 sensor and transferred to the Liquid Crystal Display (LCD) for displaying the value of temperature and humidity. Figure 3 shows the schematic diagram of Arduino UNO connection with DHT-11 sensor and Liquid Crystal Display (LCD).

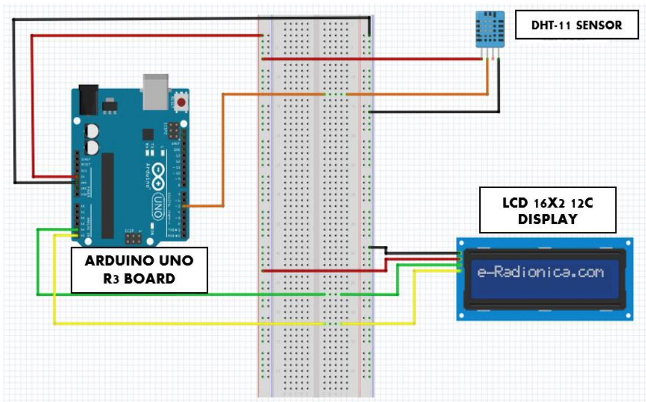

Figure 3. Schematic diagram of Arduino Uno connection with the DHT-11 sensor and LCD

The cooling system is designed as a low-cost automatic cooling system to reduce the temperature and humidity. The system is designed without compressor which compresses the gas to produce cool air. This cooling system uses thermoelectric peltier system which only uses electric to form heat and cool side of the peltier plate. Thus, heatsink is attached to cool the side of peltier plate and form cool air. The DC fan plays an important role as a blower to blow the cool air into the pet house. However, the hot side of the peltier plate is attached with CPU Cooler 6 heat pipe dual-tower fan radiator which absorbs and reduces the heat of the hot side of peltier plate. The hot air is released outside of the pet house. The cooling system is tested with 12 V as shown in Figure 4.

Figure 4. The cooling system

The silica gel desiccant is attached to the wall of the cooling system 3D case to reduce the humidity. The prototype of the proposed system is shown in Figure 5.

Figure 5. The prototype of the proposed system

C. Software Libraries and Programming Language

The blynk server is applied in the system where the NodeMCU ESP8266 is programmed using the C language to instruct the NodeMCU ESP8266 (Wi-Fi module). The Wi-Fi module controls the whole system by interfacing with the hardware devices that embedded on it. The remaining of the hardware devices are connected to the cooling system. NodeMCU ESP8266 controls the main part of the proposed system including temperature, humidity and cooling system. Then the Arduino UNO is applied to display temperature and humidity of the cooling system. The system can send data through the Blynk server to the smartphone using the programmed NodeMCU ESP8266.

D. Sending Data to Blynk Apps

Blynk is a digital dashboard that allows people to easily build their own graphic interface (Mazalan & Nabilah, 2019). Blynk supports hardware used in project applications and stand-alone applications that are not integrated in a shield or board. Blynk can be connected online if Arduino has a Wi-Fi, Ethernet or the ESP8266 chip to connect to the Internet. The Blynk server is a Java-based Open-Source netty server, which provides notification between Blynk mobile application and specific microcontroller boards. Blynk Cloud is Java-based software that uses plain TCP / IP sockets and runs on our server. By default, blynk iOS and android applications are connected to blynk cloud and each blynk user can have free access.

III. RESULTS AND DISCUSSION

The output from DHT-11 sensor is sent to the Blynk cloud in the Blynk apps in real time. The users can monitor the level of temperature and humidity of the pet house for the pet comfort. Generally, comfortable indoor temperature is between 24°C to 28°C and humidity is between 40% to 70% (measured in Relative Humidity (RH) based on Malaysia standard (Budhaditya Biswas *et al.,* 2019). The microcontroller is used to control temperature automatically for the pet house. When the temperature of the pet house is over 27°C, the cooling system is automatically 'ON' to reduce the temperature and humidity by single relay. The humidity of pet house is reduced by the silica gel that is attached at the wall of the heatsink case. The proposed cooling system does not function like traditional air conditioner that works with compressor and gas to reduce the temperature and humidity. However, the proposed low-cost automatic cooling system can achieve similar effect as normal air condition.

The Blynk app allows the authorised user to access their measured data through as shown in Figure 6. The user needs to register their user ID and enter the Auth Token, Wi-Fi name, and Wi-Fi password to view the parameters displayed in a real-time. Furthermore, the result can be displayed in the form of graphical representation. The parameters such as temperature and humidity are measured in different time selection. The time taken is from 5, 15, 30 and 60 minutes. The test is measured several times to monitor the air quality.

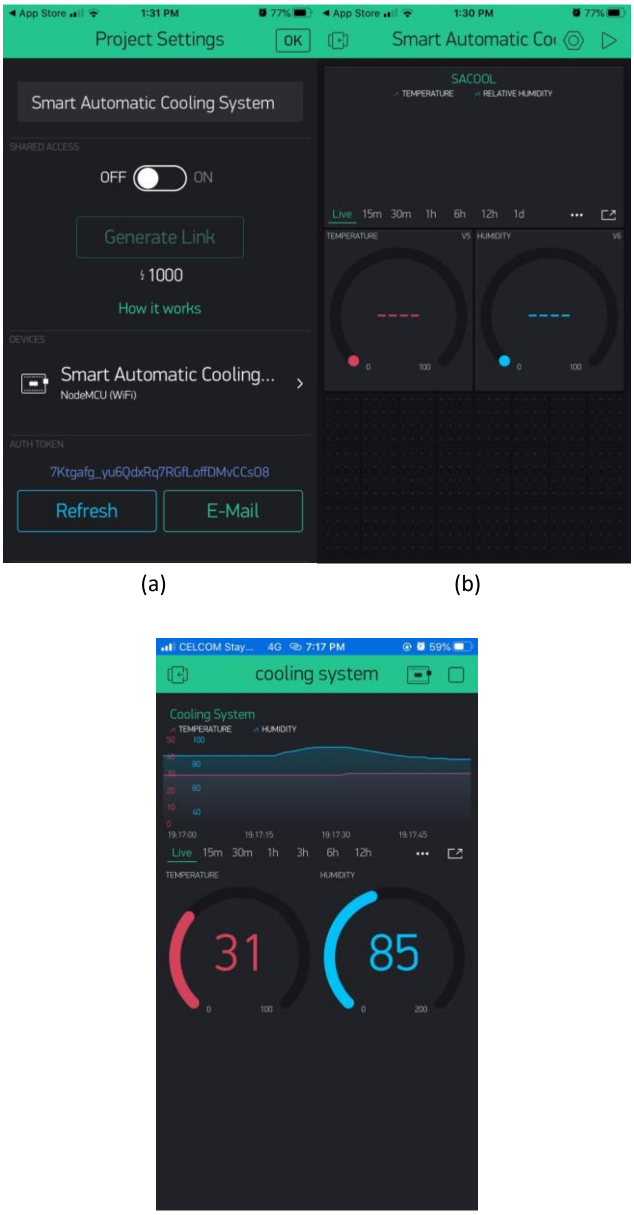

Figure 6. The Blynk app; (a) setting the project, (b) dashboard for cooling system and (c) dashboard shows the reading for humidity and temperature

DHT-11 sensor is sensitive to temperature and humidity. The data is sent to the Blynk app through the Blynk server. The automation and the cooling system need 12 V of power and 10 A. The minimum current of the cooling system is 5A.

Temperature and humidity of the pet house are analysed based on time. The reading of the temperature and humidity of the pet house for 5 minutes,15 minutes 30 minutes, and 1 hour (60 minutes) are collected and presented in Figure 7 until Figure 14. The measurement of the pet house is 109cm (Length) x 70cm (Wide) x 92cm (Height). The data analysis is done by comparing temperature and humidity of the pet house with and without the cooling system. Figure 7 and Figure 8 show the temperature and humidity taken in 5 minutes through the Blynk server. The temperature and humidity of the pet house are displayed in Blynk apps of the smartphone. Meanwhile, Figure 9 and Figure 10 depict the temperature and humidity taken in 15 minutes. Figure 11 to Figure 14 show temperature and humidity taken for 30 minutes and 60 minutes. In 60 minutes, the proposed system is still able to reduce the temperature and humidity from 33°C to 27°C of temperature and 85%- 65% of RH.

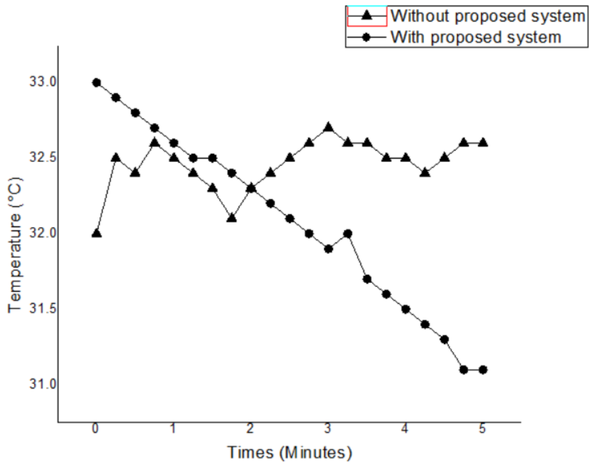

Figure 7. Temperature taken in 5 minutes

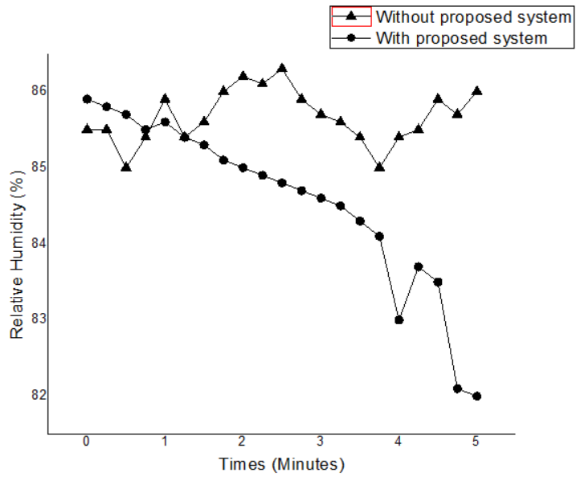

Figure 8. Humidity taken in 5 minutes

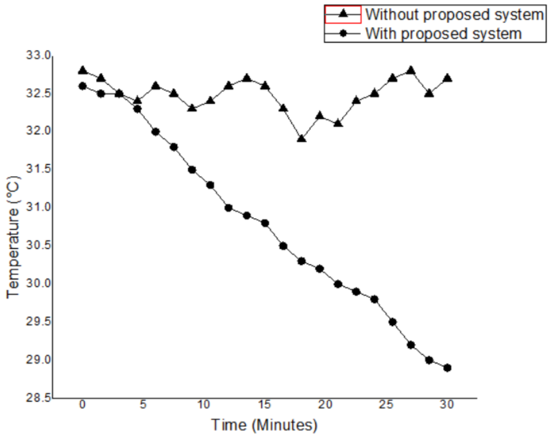

Figure 9. Temperature taken in 15 minutes

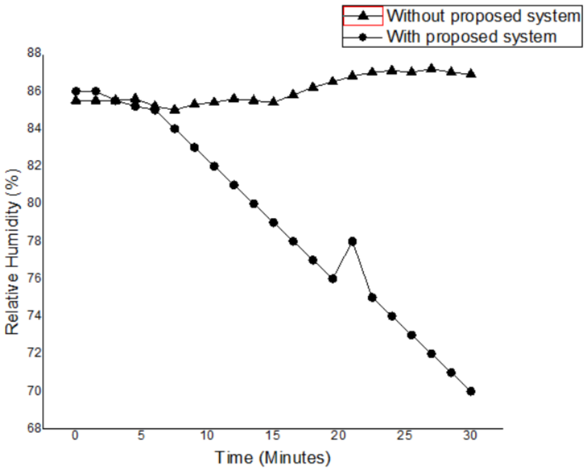

Figure 10. Humidity taken in 15 minutes

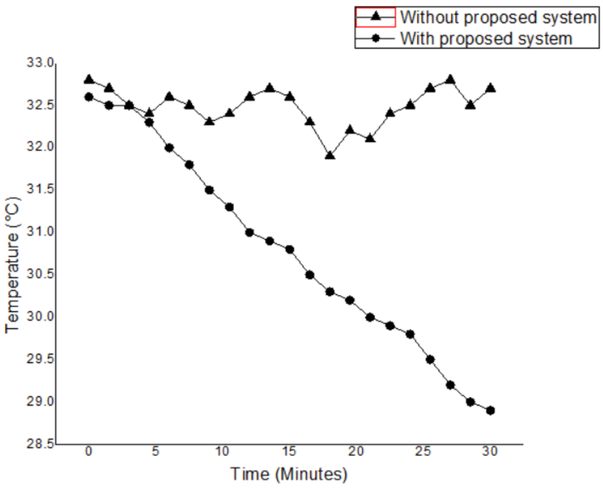

Figure 11. Temperature taken in 30 minutes

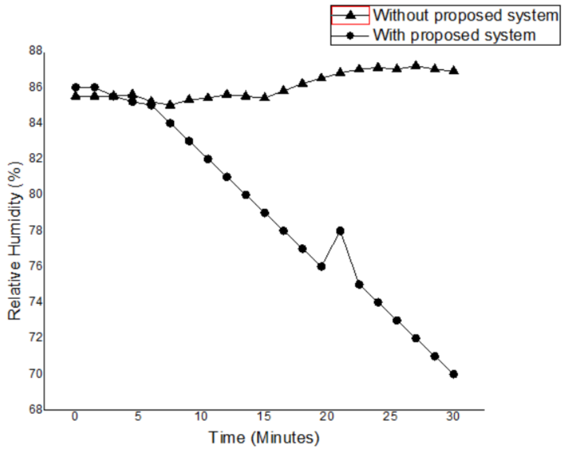

Figure 12. Humidity taken in 30 minutes

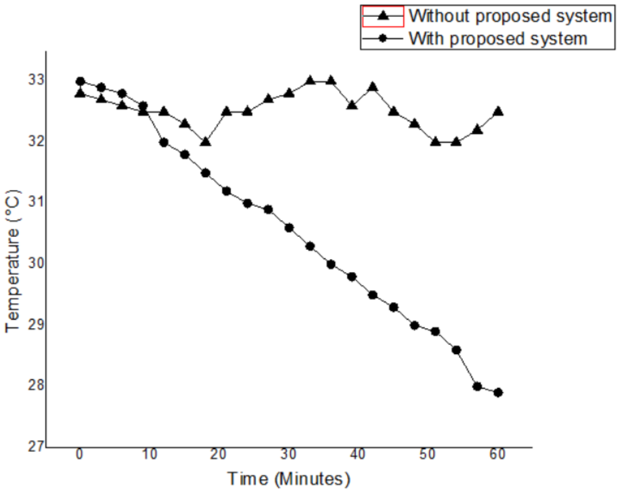

Figure 13. Temperature taken in 60 minutes (1 Hour)

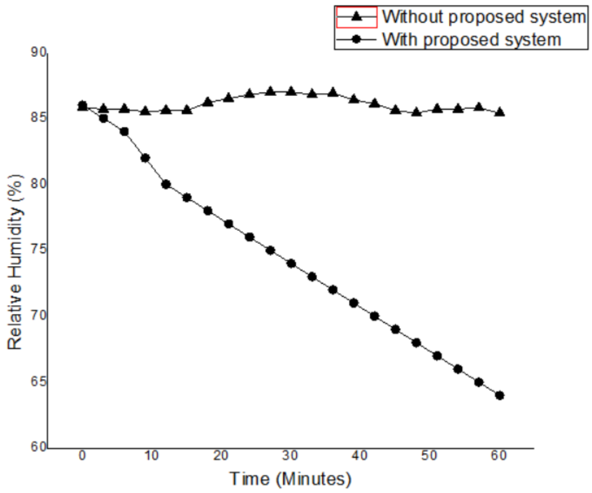

Figure 14. Humidity taken in 60 minutes (1 Hour)

This proposed system clearly can reduce the surrounding temperature to 29°C and humidity to 70%. The reduced temperature of the system can be attributed to thermoelectric cooling technology using peltier module. The cooling system in this prototype can be accomplished when the direct current passes through one or more pairs of n-and p-type semiconductor content. In cooling mode, direct current will move via the n and p junction of the semiconductor material. The temperature of the interconnecting conductor is lowered as the heat is drained from the atmosphere. Such heat removal from the air (cooling) happens as electrons travel from a low energy level in a p-type material through the interconnecting conductor to a higher energy level in an n-type material. The absorbed heat is transmitted via the semiconductor materials through electrons to the other end of the junction where the electron is released as it returns to a lower energy level in the p-type material (Riffat, 2003; Mukhopadhyay *et al.,* 2014). When the temperature difference between the hot and cold ends of the semiconductor material is established, a voltage is generated. The voltage is directly proportional to the temperature differential. The proportionality constant shall be referred to the Seebeck coefficient (Hamid Elsheikh *et. al.,* 2014; Gou, X. *et. al.,* 2010; Xi, H., L. Luo *et al.,* 2007). The Peltier effect is influenced by the Peltier coefficient, described as the product of the Seebeck semiconductor material coefficient and the absolute temperature. The peltier coefficient corresponds to the cooling effect when the current travels through the semiconductor junction n to p and the heating effect as the current moves through the junction p to n. Reversing the path of the current reverses the temperature between the hot and cold ends of the system (Mukhopadhyay *et al.,* 2014).

The reduced humidity value to 70% can be attributed to the usage of silica gel that is attached to the heatsink. The silica gel works as a drying agent that absorbs humidity and moisture. By reducing humidity and moisture, microorganisms and bacteria also cannot live in the pet house. Thus, pet is comfortable to stay in the house and at the same time, the pet keeper can easily take care of the pet's health.

IV. CONCLUSION

In conclusion, this research is important to assist the pet owners to monitor the comfort level of the pet house in terms of temperature and humidity especially during the pandemic crisis. Basically, Arduino Uno and NodeMCU ESP8266 Wi-Fi Module are used as the system controller, DH-11 sensor is used to sense temperature and humidity whereas peltier and silica gel are used for cooling and absorbing humidity. This study can give benefit to the pet keepers and pet care centres to save energy and time in managing their pets. The pets can live in a pet house with suitable temperature and humidity levels. The proposed system can monitor temperature and humidity of the pet house automatically and remotely. Thus, the pet owner who is going for vacation can remotely ensure the pet's wellbeing through the mobile phone.

V. ACKNOWLEDGEMENT

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VI. REFERENCES

Budhaditya Biswas, 2019, 'Dual Temperature Monitoring and Control using IoT', Department of Electrical Engineering.

BY Masram, A Dhokale, P Shirsat, M Keote & M. dongarwar 2018, 'Smart (Dual) Mode Operating Cooling System. 2018 First International Conference on Secure Cyber Computing and Communication (ICSCCC)', pp. 150-152. doi: 10.1109/ICSCCC.2018.8703360.

Daneshvar, Y, Sabzehparvar, M & Hashemi, SAH 2020, 'Energy efficiency of small buildings with smart cooling system in the summer Front Energy'. doi:10.1007/s11708-020-0699-7.

Givoni, B 1997, 'Climate considerations in building and urban design', USA: Van Nostrand Reinhold, p. 109.

Akila K, Sabitha B, Jayamurugan R, Teveshvar M & Vignesh N 2019, 'Automated License Plate Recognition System using Computer Vision', International Journal of Engineering and Advanced Technology, vol. 8, no. 6, pp. 1878-1881.

Gou, X, H Xiao et al 2010, 'Modelling, experimental study and optimization on low-temperature waste heat thermoelectric generator system', Applied Energy, vol. 87, no. 10, pp. 3131-3136.

Hamid Elsheikh, M, DA Shnawah et al 2014, 'A review on thermoelectric renewable energy: Principle parameters that affect their performance', Renewable and Sustainable Energy Reviews, vol. 30, pp. 337-355.

Ismail, M Abdul Samad, A Rahman & F Yeok 2012, 'Cooling Potentials and CO2 Uptake of Ipomoea Pes-caprae Installed on the Flat Roof of a Single Storey Residential Building in Malaysia', Procedia - Social and Behavioral Sciences, vol. 35, pp. 361-368.

J-A V Magsumbol, MA Rosales, IC Valenzuela, AA Bandala, E Sybingco & EP Dadios 2020, 'Development of a Smart Cooling System using Artificial Neural Network', IEEE 12th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), pp. 1-6. doi: 10.1109/HNICEM51456.2020.9400111.https://www.elecrow.com/rcwl-0516-microwave-radar-sensor-switch-module-body-induction-module-4-28v-100ma.html

Laman Web Rasmi Jabatan Meteorologi Malaysia, viewed 27 July 2020, http://www.met.gov.my.

L Chang & S Doblack 2017, Integrated Heat Pump and Thermoelectric Cooling with A Bladeless Fan, US 2017/0097.168 A1.

N Al-Tamimi & S Syed Fadzil 2011, 'Thermal Performance Analysis for Ventilated and Unventilated Glazed Rooms in Malaysia (Comparing Simulated and Field Data)', Indoor and Built Environment, vol. 20, no. 5, pp. 534-542. doi: 10.1177/1420326x11411235.

Mazalan & Nabilah 2019, Application of Wireless Internet in Networking using NodeMCU and Blynk App, Seminar LIS 2019, Politeknik Mersing Johor.

M Haase & A Amato 2009, 'An investigation of the potential for natural ventilation and building orientation to achieve thermal comfort in warm and humid climates', Solar Energy, vol. 83, no. 3, pp. 389-399. doi: 10.1016/j.solener.2008.08.015.

Mukhopadhyay, S, SP Datta et al 2014, 'Performance of An Off-Board Test Rig for An Automotive Air Conditioning System', International Journal of Air-Conditioning and Refrigeration, vol. 21, no. 3, p. 1350020.

Randall, T 2006, Environmental Design, 3rd edn, Taylor & Francis Inc. Robinson, New York.

R Priyadarsini, W Hien & C Wai David 2008, 'Microclimatic modelling of the urban thermal environment of Singapore to mitigate urban heat island', Solar Energy, vol. 82, no. 8, pp. 727-745. doi: 10.1016/j.solener.2008.02.008.

Shih H Chen, Patent Application Publication Chen 2008, Air-Conditioning Device for Pet and Pet House Having the Same, US 2008O10521.3A1.

T Sookchaiya, V Monyakul & S Thepa 2010, 'Assessment of the thermal environment effects on human comfort and health for the development of novel air conditioning system in tropical regions', Energy and Buildings, vol. 42, no. 10, pp. 1692-1702. doi: 10.1016/j.enbuild.2010.04.012.

W Hien, L Poh & H Feriadi 2000, 'The use of performance-based simulation tools for building design and evaluation — a Singapore perspective', Building and Environment, vol. 35, no. 8, pp. 709-736. doi: 10.1016/s0360-1323(99)00059-1.

Xi, H, L Luo et al 2007, 'Development and applications of solar-based thermoelectric technologies', Renewable and Sustainable Energy Reviews, vol. 11, no. 5, pp. 923-936.

Yeang, K et al 2006, Ecodesign - a manual for ecological design", Wiley-Academy (London), [Accessed 27 July 2020].

Y Strengers, Sarah P, La Nicholls 2019, 'Smart energy futures and social practice imaginaries: Forecasting scenarios for pet care in Australian homes', Energy Research & Social Science, vol. 48, pp. 108-115.