e-Bukid: A IoT Telemetry System with Automated Animal Feeder

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Abstract

This paper focuses on the issue of heat stress and its adverse effects on animals, specifically livestock, and attempts to develop a solution using the Arduino microcontroller. The adverse effects of heat stress towards animals includes the deterioration of the reproductive system of animals, abnormalities in eating behaviors, and so on. The researchers have developed the schematics and the specifications used for the solution to the heat stress dilemma. The schematics include the usage of sensors for humidity and temperature, which can be viewed on a mobile phone application, and an automatic feeder which will operate under a certain time set by the user. This is controlled through a mobile application which also uses push notifications to notify the user about the conditions of the animals. The researcher recommends further analysis through comparison with other products with a similar goal, and additional features to further enhance the current schematic.

Keywords
Temperature, humidity, sensors, heat stress, mobile application, Arduino.

1. Introduction
Varying temperatures have different effects on living beings. For example, according to Para, et al. high temperatures that cause heat stress towards animals have adverse effects on their behavioral patterns, and food intake. This is especially important for livestock, as their food intake and such factors influence the products. Temperature must be monitored often to ensure satisfactory outcome. However, a farmer may have scarce time to constantly monitor the temperature levels for the livestock. This paper presents an inexpensive solution using microcontrollers, specifically Arduino boards. These Arduino boards, through attached sensors, will be able to constantly measure temperature and other parameters relevant to livestock care. This data will then be displayed through a mobile phone application. Included in this system is an automatic feeder, which alleviates the work done by farmers. The application also informs the user of status updates through push notifications on the mobile phone.

2. Review of Related Literature
2.1 Impact of heat stress on the reproduction of farm animals and strategies to ameliorate it
Heat stress not only depends on temperature but also on humidity. Temperature Humidity Index (THI) is a combination of humidity and temperature that is measured by the degree of discomfort experienced by an individual in a warm index, it can also be called the discomfort index. THI is used to maintain the efficiency of the animal to alleviate the Heat Stress. The common sign of Heat Stress is the increased body temperature, and it is about 39.20°C, panting, reduced food intake and disturbed behavioral pattern. That is why farms should implement a proper cooling method when a heat stress occurs. Heat stress can also affect the endocrine function of the body and it can affect the fertility and reproductive efficiency of the animals. The reproductive efficiency of the dairy cattle that experienced heat stress, especially in summer, lowered the fertility in dairy cows (Para et al. 2018)

2.2 Heat stress induces histopathological changes in lymphoid organs of broiler and Philippine native chickens

The poultry industry is important not only for the Philippines but also worldwide as it is one of the sources of meat and the fastest growing sector at that. One of the most tough factors that poultry farmers may encounter is the extreme temperature from climate change. Other researchers have already delved into the animal performance and economic impact of the phenomenon. Lola et al. (2016) carried out the study to describe the effects of heat stress to the avian immune system.

The sample size for the study is 60 chicks composed of 30 broiler chicks and 30 native chicks. The chicks were taken care of at the experimental animal house of the UPLB veterinary teaching hospital. The experiment process done on the chicks was heat induction. From day 1 to 27, the chicks were maintained at ambient environmental temperatures (AET). On day 28, the chicks were grouped into 5 for the broiler chicks and into 10 for the native chicks and were exposed to different temperatures using the AET as the baseline. The chicks were then exposed to a set temperature at days 29 – 35 and a higher temperature at days 43 – 49. The temperature and humidity were recorded on all days. To find out the effects, the chicks were sacrificed by cervical dislocation.

The samples were examined using a light microscope.

In general, the thymus, Bursa of Fabricius, and spleens of the samples have had degenerative changes. The groups exposed to higher temperatures have had more major changes than those exposed to lower temperatures, but it was noted that even ambient temperatures did change on the tissue samples. They have concluded that exposure to temperatures at 30 degrees Celsius or above may already induce pathological lesions in both broiler and native chickens (Lola et al. 2016).

2.3 Stress in Dairy Animals—Heat Stress: Effects on Reproduction

Animals are susceptible to heat stress, especially if they are unsupervised. Heat stress has several negative effects on animals, such as livestock in farms. According to Hansen and Fuquay (2020), notable adverse effects of heat stress are reduced intensity of behavioral estrus, low fertility, compromised fetal development in females, compromised sperm output and increased sperm abnormalities in males. While the paper focuses more on the procedures that can be done once an animal has been exposed or experienced prolonged heat stress, such as improving an embryo's survival through embryo transfer to bypass the effects of heat stress, the paper also indicates a few mitigation approaches to reduce the effects of heat stress. The mitigation methods mentioned included environmental modifications, specifically using housing that contains shade, sprinklers, and fans (Hansen, Peter J., Fuquay, John W. 2020).

2.4 The Effects of Temperature and Humidity on Some Animal Diseases

The study indicates that the role of environmental stress is a large contributing factor to the physiological and mental state of the animals. The study also concluded that sudden weather changes can affect the ability of some organisms to colonize an animal as a host for pathogen survival and host resistance. In a situation that is composed of low temperature, it reduces the ability of the respiratory tract to resist colonization of pathogens and if the environment is damp, respiratory diseases are challenging the pathogens as a result of host resistance. In certain animals the various stresses and environmental factors determine whether animals can develop respiratory diseases. With relation to ventilation, relative humidity, dust, and fluctuating temperatures frequently causes diseases from the animals due to transference and multiplication of microorganisms. Thus, temperature and humidity play a large role in animal's conditions with regards to their physiological stability and increase resistance to pathogens to decrease pathogen survivals (M.J Dennis 2006)

2.5 A Heat Load Index for Dairy Cattle

The heat exchange process with the environment is important when maintaining a stable internal temperature for animals by Hanh et al (as cited by Lees, 2017). Changes in both temperature and humidity influences how an animal responds to a thermal environment, this can affect the performance, health and well-being of an animal. In this study, the temperature humidity index is used to assess the risks of heat stress of animals towards the combined effects of environmental temperature and humidity. The index as shown in **Figure 1.** the impact on livestock; Normal ≤ 74 indicating thermoneutral conditions; Alert 75-78 mild to moderate stress; Danger 79-83 danger moderate to severe stress; Emergency ≥ 84 extreme stress where deaths due to excessive heat load may occur. This study is effective as a basis for managing livestock when planning practices and dealing with different seasons (Lees, J.C. 2017)

Temperature, °C \ Relative Humidity, %	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
21	64	64	64	65	65	65	66	66	66	67	67	67	68	68	68	69	69	69	70	70
22	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71	72	72
23	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74
24	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
26	68	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	76	77	77	78
27	69	69	70	70	71	72	72	73	73	74	75	75	76	76	77	78	78	79	79	80
28	69	70	71	71	72	73	73	74	75	75	76	77	77	78	79	79	80	81	81	82
29	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83	83	84
30	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84	85	86
31	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86	87	88
32	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88	89	90
33	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90	91	92
34	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
36	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96
37	77	78	79	80	82	83	84	85	86	87	88	89	90	91	93	94	95	96	97	98
38	78	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	97	98	99	100
39	79	80	81	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101	102
40	80	81	82	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101	103	104
41	81	82	84	85	86	88	89	90	91	93	94	95	97	98	99	101	102	103	105	106
42	82	83	85	86	87	89	90	92	93	94	96	97	98	100	101	103	104	105	107	108
43	83	84	86	87	89	90	91	93	94	96	97	99	100	101	103	104	106	107	109	110

Figure 1. Livestock Weather Safety Index

2.6 What are IoT systems for real? An experts' survey on software engineering aspects

Internet of Things (IoT) is an emerging technology that permeates our daily lives. IoT is used in health care, transportation, and so on. However, Gianna Reggio, et al. mentions that the existing literature about this topic leads to a lack of common understanding about IoT. In a survey conducted with IoT experts by Reggio, et al. they concluded that the nature of IoT includes the following: that most IoT systems require human intervention, that IoT is commonly applied in Smart Home, Smart Building, Smart Industry, and Smart Cities, that IoT largely favors the cloud, leading to improved reliability, performance, and cost. These improvements are considered highly relevant in the field of IoT. (Gianna Reggio et al. 2020). In a study entitled Distansya: an IoT Platform to Physical Distancing Provision Notification, to design and offer a prototype system that combines inexpensive but effective IoT technology with simple deterrent equipment, a researcher may look into relevant related literatures and studies, and previous projects referring to specific components such as ultrasonic sensors, photoresistors,lidar and other related sensors that do not need to be used simultaneously (Blancaflor et al., 2021).

2.7 Arduino Based Weather Monitoring Telemetry System Using NRF24L01+, 2019

Weather is an important part of the environment. identifying the weather condition and the lack of wireless technology in a weather monitoring system is necessary to identify the weather condition. As shown in **Figure 2**. This study aims to build a weather telemetry system that can acquire and recording the data wirelessly using nRF24L01+ 2.4 GHz RF Module. The system has three sensors that measure the temperature, humidity, light intensity, and atmospheric pressure. The weather monitoring system is implemented using the Arduino Board. The researchers have a graphical user interface that was developed using C#. The software allows the user to display the data in a friendly platform, the basic function of the GUI is to provide a receiver between the system and the pc and will be receiving data to a text file (Rafi Sidqi et al. 2018)

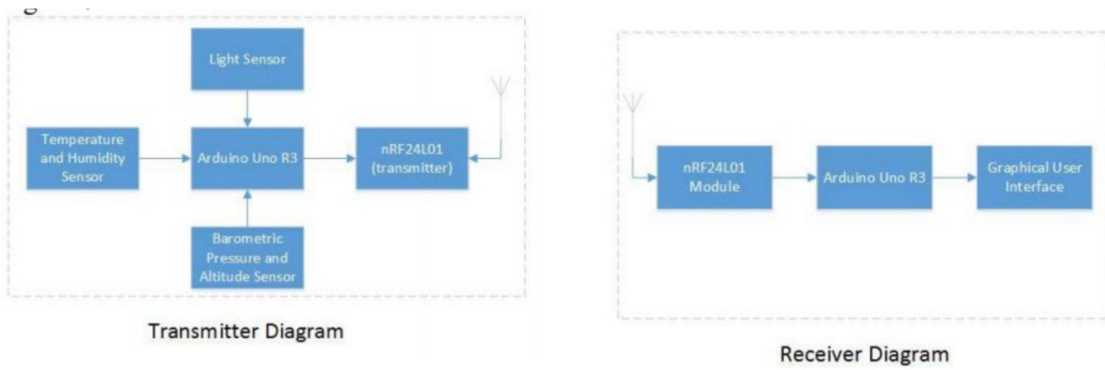

Figure 2. Transmitter and receiver

2.8 Development of IoT Based Weather Reporting System, 2020

Climate plays a vital role in human life as it can affect the lives of anyone at any aspect, changes in temperature and humidity can affect anyone. This study aims to develop a weather report system that displays, analyzes and monitors the weather parameters that are visible to any users in a particular place. This involves hardware such as sensors that will monitor weather parameters like temperature and humidity, and a microcontroller that will analyze, process and display data gathered in an OLED Screen. The researchers also develop a website and mobile application where the data that are being gathered by the sensors are being displayed (Rafi Sidqi et al. 2018)

3. Project Details

3.1 Design Plan Deliverables

Figure 3 shows the Arduino program flow of e-Bukid. Once the Arduino is started, the sensors for temperature and humidity starts afterwards, along with the automatic feeder. Arduino gathers the values of the temperature and humidity from the sensor, and then sends those values to the web server for storage. For the automatic feeder process, it checks the time if it is currently the time specified by the user in the e-Bukid mobile application. If it is, then it deploys the feeder.

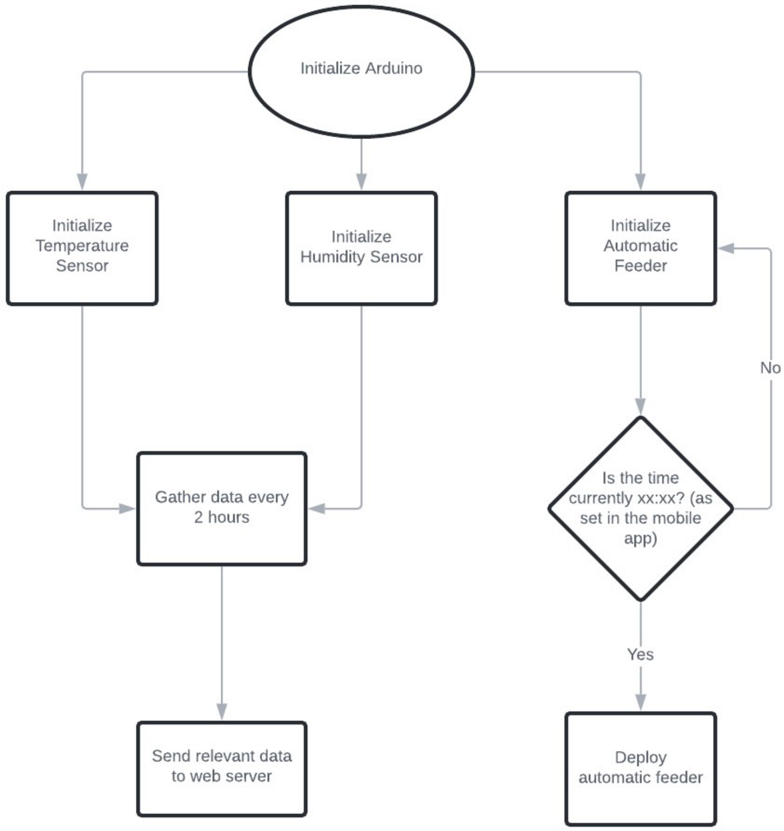

Figure 3. e-Bukid Arduino Program Flowchart

Figure 4 shows the process flowchart of the mobile application. On startup, it retrieves data from the web server. The users can add new cages in the "Barn" section of the application. They can set the animal and its quantity, and the ability to set the time for each cage. For the "View Cages" section, it shows the status of each cage. History shows data from the database, specifically the temperature and humidity, and the time when it was measured. The settings section allows the modification of notification, and other options.

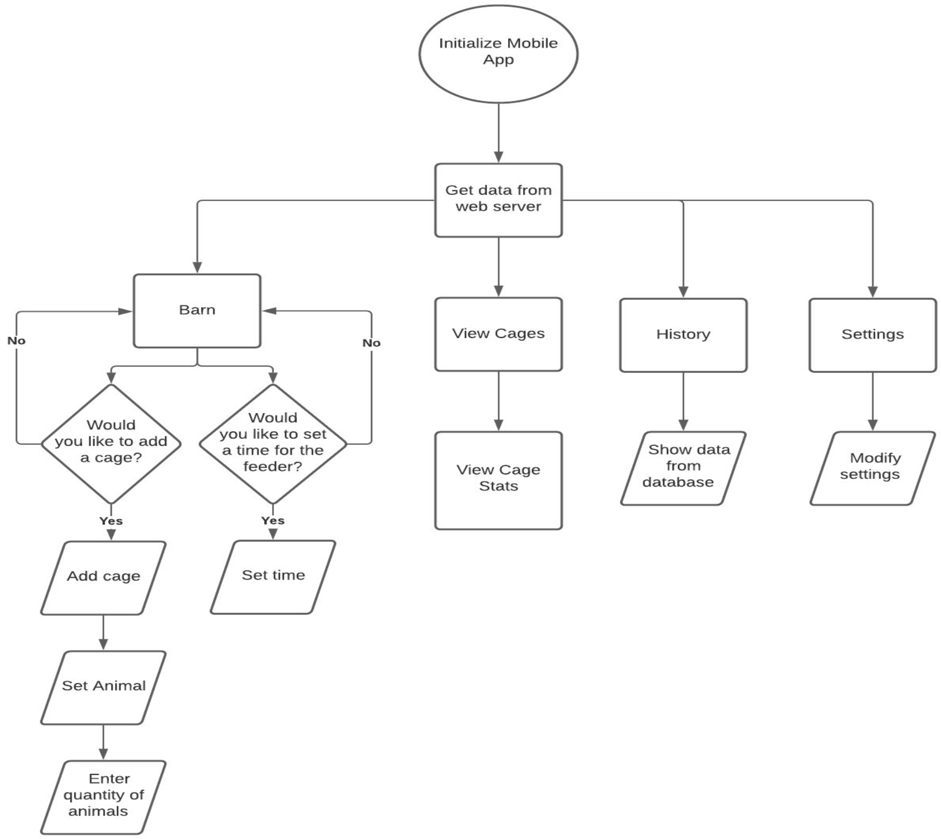

Figure 4. e-Bukid Arduino Flowchart

As shown in **Figure 5,** the site map of the e-Bukid application which consists of 4 frame pages. These frame pages are Home, Barn, Cage Status, History, and Settings.

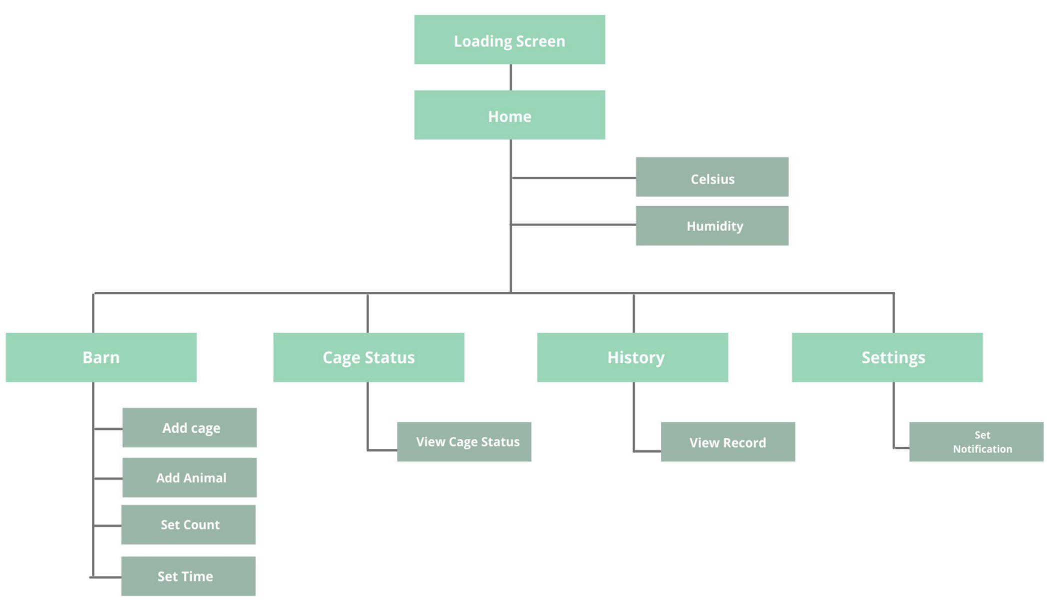

Figure 5. e-Bukid Site map

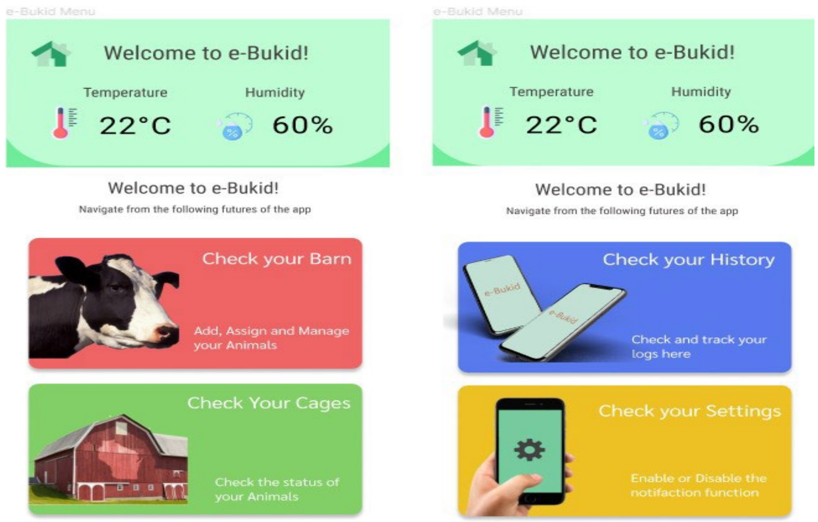

Figure 6. e-Bukid Home Design

As shown in **Figure 6.** This is the menu for the e-Bukid, the app has 4 features, Check you Barn in which the user can add, assign and manage the animals. In Check your cages, the user can check the status of the animals in the assigned cage. Check your history, this is where the user can track and check the logs of the temperature and status of the animal and check your settings, the user can enable and disable the notification function for the app.

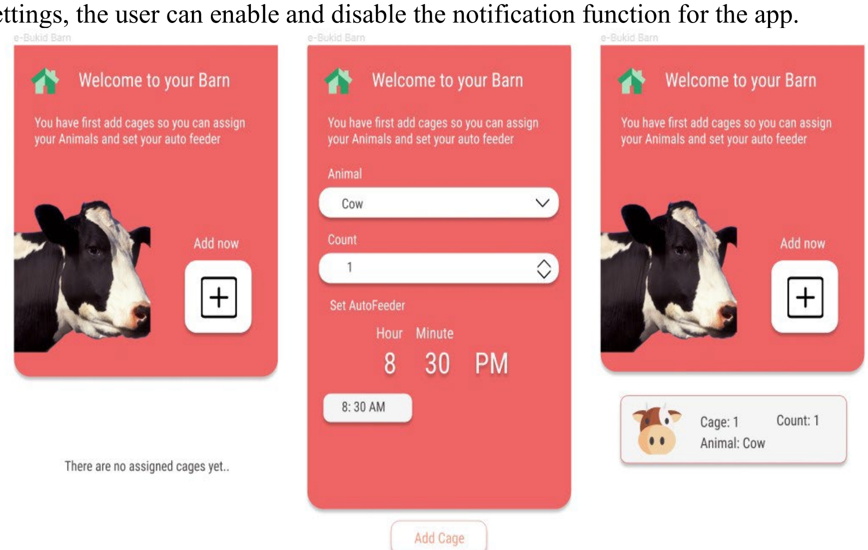

Figure 7. e-Bukid Barn Features

As shown in **Figure 7.** This is the function of Check you barn, it can add, select an animal, set a count and set time for the automatic feeder. After the user successfully added a cage, it will appear at the bottom of the screen.

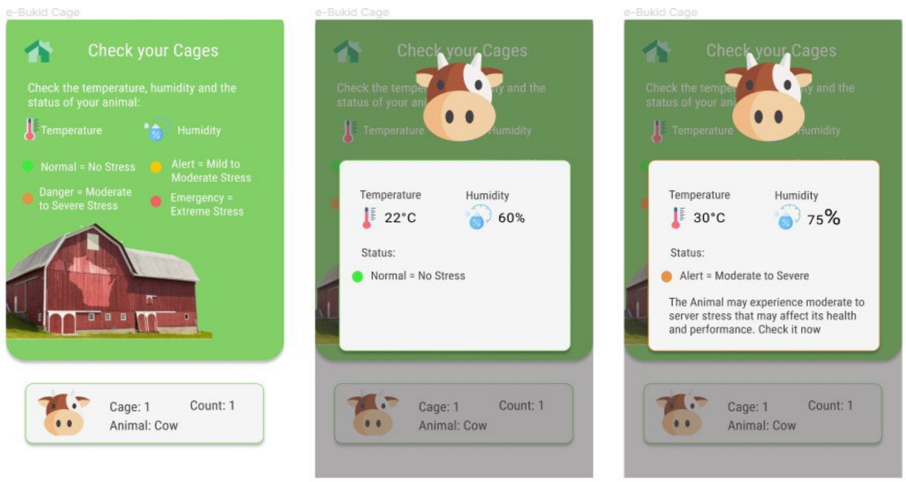

Figure 8. e-Bukid Barn Cage Status

As shown in **Figure 8.** This is the Check your Cages; it has a function that can determine the status of the animal in each cage. If the user clicks on the cage, a window will pop that indicates the temperature, humidity and the status of the animal.

Figure 9. e-Bukid Barn History

In **Figure 9.** It Shows that, above is the E-Bukid Barn History, the function of this is to display logs of the date, time, temperature, humidity, and status of the animal.

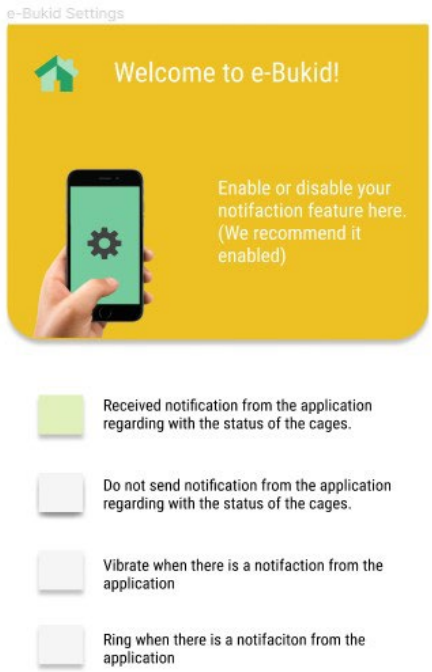

Figure 10. e-Bukid Settings

As shown in **Figure 10.** This is the e-Bukid settings, in this feature the user can choose to turn off the notification of the app, but in default the user will receive notification from the application.

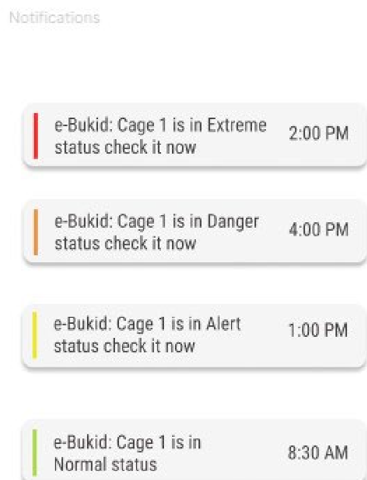

Figure 11. e-Bukid Sample Notifications

As shown in **Figure 11.** This is the sample notification of the e-Bukid application, a color is indicated if the status of the animal is Normal, Alert or in Danger.

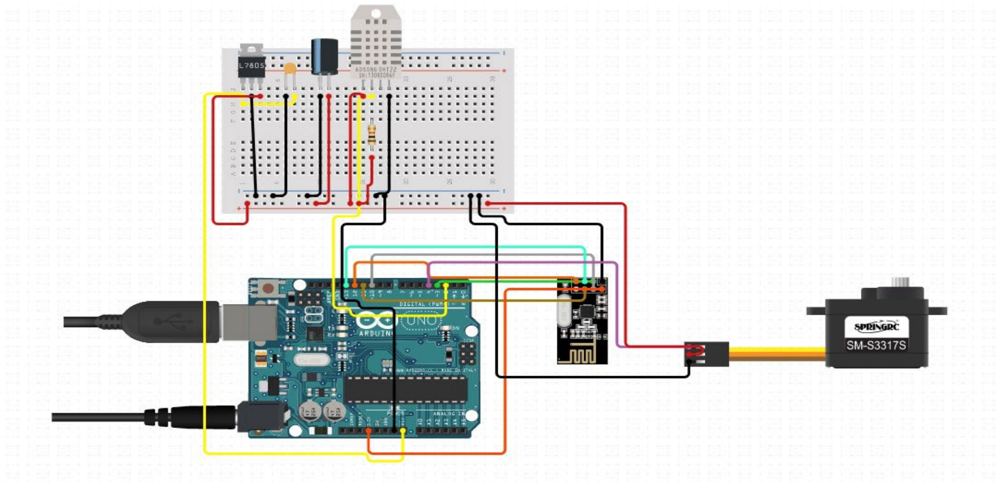

Figure 12. Schematic Diagram

As shown in **Figure 12,** the components that comprise the prototype circuit are the Arduino UNO R3 microcontroller, half-size breadboard (Smart Prototyping 2021), DHT11 sensor, 1uF electrolytic capacitor, 100nF ceramic capacitor, L7805CV voltage regulator, a ROB-10333 servo, and a nRF24L01 wireless transceiver module (Components101 2018). The DHT11 will serve as the temperature and humidity sensor for the barn (Adafruit Industries 2021). The servo opens the hatch for the automatic feeder in accordance with the set times. The voltage regulator and the capacitors serve as stabilizers for the flow of current (Octopart 2021). The nRF24L01 connects the whole circuit to the network so that the user can modify its functions and obtain data for the web server and mobile app.

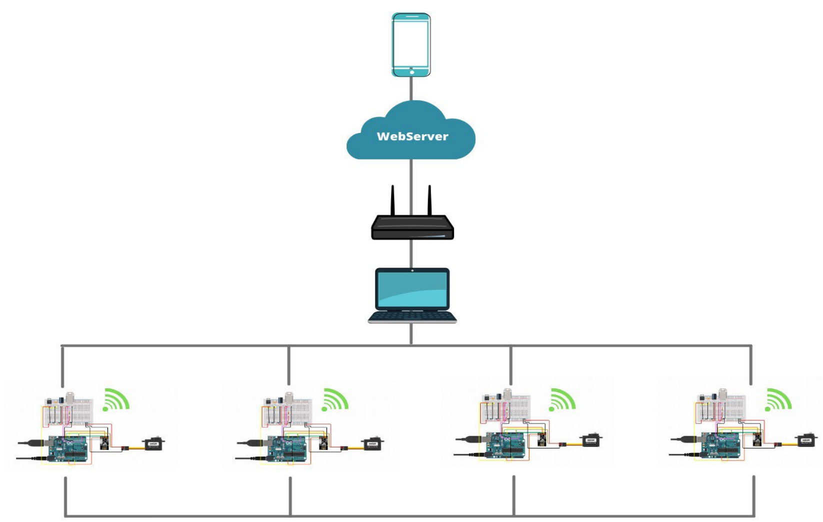

Figure 13. Network Topology

The network topology as shown in **Figure 13.** The project consists of 4 Arduino-controlled circuits that are wirelessly connected to a signal receiver that can send http signals to the router and the web server, which in this case is the laptop. The web server has three tables: one for storing temperature and humidity every 2 hours, another one for storing animal information for the cages including the time to open the hatch for the animals, and the last table for storing historical information. The mobile app contains a dashboard for monitoring the temperature, humidity, and status of the cages and screens for customizing cage information and feeding times. The mobile app also shows the temperature and humidity history logs from the web server.

4. Conclusion

The adverse effects that heat stress poses to animals may end up resulting in a bad outcome for the farmers that take care of them. The researchers have produced a cheap and convenient solution for this problem using Arduino, sensors connected to the Arduino board, and other applications such as the mobile application for data viewing and customization. This alleviates the workload of the farmers in terms of monitoring and maintenance towards the livestock they have. The researchers recommend several details to further improve this research. One is to test the diagrams given by the researchers and comparing it to other products that have similar objectives. Comparisons to its efficiency to cost will inform readers of the optimal hardware solutions for this problem. Second is to have more features that may be useful in growing livestock. At its current state, the solution given by the researchers offers only simple parameters.

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Biography

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