Internet of Things and Wireless Sensor Network a Technological Marvel in better Monitoring of Cows

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***Abstract*— Internet of Things and Wireless Sensor Network are two technological advancements, and they have been performing great in minimizing workforce and increasing productivity in all the fields. So using these technologies in monitoring the health of cattle would yield visible benefits to the dairy farmers. Also, the contribution of researchers for effective cattle management is endless. This paper presents a design which enables monitoring the cows in a herd with the use of a sound sensor since the sound is the most critical sense for the cows to express their mind. The sensor is neck banded and senses the sound whenever the cow calls. The sensed data is analyzed and compared with the sample data which helps to identify whether the cow's call is expressing its illness. In case of illness call, the information is sent to the manager in the herd for immediate action, and also it is stored in the cloud that enables the owner of the herd to monitor the health of cows remotely. Hence the illness caused by any factor is identified quickly, and the cow gets treated without delay, moreover spreading of the disease to other cows is avoided. The proposed design is simulated in cisco packet tracer and simulation results are illustrated further to implement the design in real time.**

***Keywords*— Internet of Things, Wireless Sensor Network, Sound Sensor, Cattle monitoring, Cloud, Wi-Fi Protocol.**

I. INTRODUCTION

Internet of things (IoT) makes almost everything possible by connecting things on the Internet. It allows the smart things connected on the Internet to communicate information with each other and to forward the data to a gateway that enables remote monitoring of anything [16]. Though the privacy and security of this technology are still questionable, the applications of the Internet of things are enormous [15]. One of the applications is monitoring the health of a human remotely. While the internet of things could help in monitoring the health of a human being who can speak and express their illness, why not for the cattle who cannot speak? Yes, Cattle management has become a specific application of the Internet of Things.

To improve productivity in livestock, monitoring the health of cattle becomes essential. In a small dairy farm environment, it is the usual work of a farmer to monitor the health of the cattle by their activities. Also, even the farmer can pay attention to an individual cow with ease. However, in case of a larger farm, things become complicated to monitor and maintain the health of cattle and even a minor delay may result in rapid spread of disease to other cows and sometimes cattle may happen to die. So, for the efficient and productive management of livestock both sensor technology and internet of things might be utilized effectively and that might lead to the connected cows [11]. However, using these technologies for cattle management is depends on the economic status of dairy farmers. The dairy farmers who expect more productivity and relaxed management could invest in technologies.

The role of Wireless Sensor Network in the Internet of things is vital. The wireless sensor networks consist of sensors which sense the environment and send the data to the gateway node or sink node by which the user of the application can monitor the particular environment [21]. As the internet of things, the wireless sensor network is also with many challenges such as effective utilization of sensors, energy management, communication range, and storage [22]. So when integrating both the internet of things and wireless sensor networks, it is essential to consider these challenges.

The sensors used for the IoT applications are enormous, and the sound sensor is used in applications where the sound is to be sensed. The sensor technology is being integrated with wearable computing currently. The history of wearable technology started with the watch for humans [17] and paved the way to experiment the technology on animals too. Since the sensing technology generates big data, many kinds of research are on the way for better handling of data. The cloud technology could be a better solution for handling the vast amount of data. Cloud computing provides services like infrastructure, software, and applications [20]. So the effective use of these technologies can help to monitor the cattle.

Hence, this paper proposes a method where IoT, sound sensor, wireless network, and the cloud are utilized for monitoring the health of the cows in the herd that can be technically sound and economically beneficial to the dairy farmers. The proposed design is also simulated in cisco packet tracer for further understanding of cattle management.

The paper is organized as follows; section II explores the related work done in the cattle management, section III

describes the methodology, section IV discusses the results of the simulation and finally section V concludes this paper.

II. Related Work

The research work on cattle management has already been going on among the researchers in Agriculture, IOT and Sensor network. Some of the works which motivated to bring out such an idea are discussed here.

C. J. Rutten et al. have analyzed, compared and summarized the publications on sensors for dairy cows against different levels mastitis, fertility, locomotion, and metabolism. They conclude by mentioning the number of research work done for each level, and they report the ones where a maximum number of researches are carried out. This paper is the right start for the researchers those wish to do their research in cattle management. Amruta et al., have described various sensors that make the transition from traditional farm management to an automated system. A. Kumar and G.P. Hancke have developed a ZigBee based animal health monitoring system where rumination, body temperature, and heart rate are used as parameters to analyze the health of animals that live in the environment with different temperature and humidity level.

G.H. Meen et al. [5] have made a study on Dairy Cows to analyze the Sound of Cows by recordings Audios and Videos using microphones and cameras respectively. They have mentioned that their work is the first step towards using Sound Analysis as a tool to analyze the behavior of dairy cows. The same authors [4] have further analyzed the correlation between vocalization and behavior of dairy cows in detail. They have used ethogram to identify the behavioral patterns of cows. Their experiment results are based on the frequency of calls and related behavior.

James C. et al. [3] examined the sheep vocalization by categorizing the sheep into Adults, Juveniles and mixed. They have collected the real-time data using a Song Meter (SM3) and classified them using SVM (Support Vector Machine) and also tested the classified data to prove that the sheep vocalization can be detected and classified easily.

Suresh Neethirajan [2] has described, compared and analyzed various wearable technologies and bio-Sensing technologies that can be used for the animal health management system. He has also described recent developments in livestock management. As far as the sound analyzer is concerned, he has mentioned the contribution of sound sensors in a few pieces of research.

J. Suganthi Jemila and S. Suja Priyadharsini [1] have analyzed the grazing activities chew, bite and chew bite with the help of Accelerometer Sensor for Cattle heath monitory purpose. A. Rahman et al., have made a study to identify how the sensed data is classified into different behaviors of cattle. They have used Stratified Cross Validation approach (SCV), and leave-out-one–animal (LOOA) approaches to evaluate the performance of classification and proved that SCV is more accurate than LOOA.

Hence all the researches mentioned above are analyzing the various types of sensors, technologies, approaches and algorithms for effective cattle management, however, without these technologies how the dairy farmers managed the cows in earlier days. Merely by the sound or the calls from the cow, farmers understood everything. Only one thing may bring a downfall to this traditional approach is an increase in the number of cows. So this paper proposes a method that uses the traditional way of understanding the cow's health at the same time monitoring the cows many in numbers with the use of sound sensor and Internet of Things.

III. Methodology

A. Data Collection and Analysis

This paper develops a design and simulates it for cattle monitoring. However, real-time implementation of the proposed design requires the proper collection of data and careful analysis that brings out useful data. Hence, this section explains the data collection method as follows;

A sound sensing node is developed to sense the sound of the cows when they are ill. For bringing out a valid result, firstly the cows in the herd with abnormal behavior or the cows that are brought to the veterinary hospitals are observed. The behavior and corresponding activity can be learned from ethogram [4], and the initial stage of any disease and the related behaviors of the cows can be learned from the cow specialist. Then the cows are with the initial stage of different kinds of diseases are selected. Also, the developed sensing node is neck banded with these cows. The sensor senses the call of cow and noise is filtered out. Then, the decibel value of the call is calculated. This process is repeated for ‘n' number of cows that are in the initial stage of any disease.

Next, the calculated decibel values from different calls of cows, and the range of values that denotes the illness are derived. It is identified that irrespective of the disease the cows call almost at the same level. The sound level of calves is a bit less than the level of the adult cows. The range of decibel values identified is used as samples to compare with real-time data. Table I shows that the classification of cows and their corresponding call values with the conditions used to predict the illness.

TABLE I
THE ANALYSIS RESULT OF ‘CALL' VALUES AND CONDITIONS

Classification of Cows	**Maximum Decibel value**	**Minimum Decibel value**	**The condition for being ill with the disease**
Adults	x	y	Sensed value > y && Sensed value < x
Calves	a	b	Sensed value > a && Sensed value < b

B. Requirements for Environment Set up

1) *Sound Sensor:* The sound sensor is used to detect the sound intensity of the environment [18] [19]. It has got a microphone that records the sound from the source. There are a variety of sound sensors at the market and Fig. 1 shows the

one [18]. The sensor which will be suitable for the cows can be chosen. The proposed method uses the sound sensor available in the simulation environment. In the simulated herd environment, the sensor detects the sound from the cows and calculates the decibel value. It is connected to the analog slot of the microcontroller in order to inform the user of the monitoring application.

Fig. 1 Sound sensor

2) *Microcontroller:* In a herd environment, two types of microcontrollers are used, Arduino Microcontroller and Raspberry Pi Microcontroller. The first one is used to connect the sound sensor and to process the data sensed by it. The controller processes the sensed value, and if the value indicates that the cow is diseased, it sends the signal to Raspberry Pi microcontroller with the help of wireless protocol. The second controller receives the signals from the Arduino microcontroller and actuates the LCD for local monitoring. Also, it sends the data to the gateway node which enables remote monitoring of cows in the herd. The simulation uses MCU (Microcontroller Unit), the one like Arduino Uno and SBC (Single Board Controller), the other one like the Raspberry controller. Fig. 2 shows the Arduino and Raspberry controllers respectively.

Fig. 2 Arduino Uno and Raspberry Pi controllers

3) *Wireless Protocol:* Choosing the appropriate protocol for IoT communication is essential. There are a few protocols that enable communication between IoT devices; they are discussed in Table II [12], [13], and [14]. Generally, IoT devices require a protocol that consumes less bandwidth. However, according to the requirements of the applications and availability of resources, the protocol can be chosen. The simulation uses the Wi-Fi protocol.

TABLE III
WIRELESS PROTOCOLS FOR INTERNET OF THINGS

Wireless Protocol	**General Feature**	**Data rate**	**Range**	**Freq.**
Bluetooth Low Energy (BLE) or Bluetooth Smart	Short-range communication Technology	1Mbps	5 to 150m	2.4 GHz
ZigBee	Allows smart things to work securely	250 Kbps	10 to 100m	2.4 GHz
Wi-Fi	Radio Wireless Technology	150-200Mbps, maximum 600Mbps	50m	2.4 GHz and 5GHZ
Cellular Technology (GSM, 3G, 4G)	Suitable for applications that send a small amount of data	35-70kbps(GPRS) 120-384kbps(EDGE) 384kbps-2Mbps(UMTS) 3-10MBPS (LTE)	35km to 200km	in MHZ
LoRaWAN (Long Range Wide Area Network)	Used for smart cities with millions of devices	0.3 – 50 kbps	2-5Km (Urban) 15Km(Suburban)	Various

4) *Gateway:* The gateway is a node responsible for forwarding the data sent by the microcontroller to the cloud and for allowing the user to access the data in the herd environment from being anywhere. Implementing security on the gateway node is essential as this is the entry and exit point for the IoT environment. In the simulation environment, the gateway node is protected with WPA2-PSK (Wi-Fi Protected Access 2- Pre-Shared Key) authentication method.

5) *Cloud Storage:* Cloud technology provides a solution to store a large amount of data generated from billions of IoT devices [16]. The IoT applications can also be stored in the

Cloud database, and users can access the IoT applications from anywhere. Amazon, IBM, Oracle, Microsoft, and Google are some of the Cloud Service Providers [20]. In the event of monitoring and controlling remotely, the cloud plays a vital role.

6) *User Application:* An application is to be developed for detecting the sickness in the cows, and the same can be deployed in the cloud environment to enable remote monitoring. The proposed work utilizes the default application available in the simulation environment with some changes.

C. Deployment of Design in Real-time

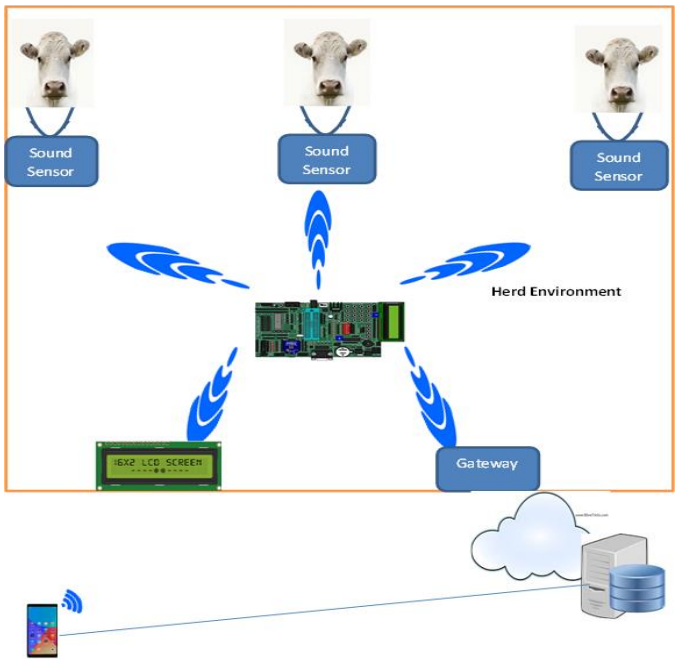

Fig. 3 Design of cow health monitoring environment

Fig. 3 presents the design of a cow health monitoring environment. The cows in the herd are neck banded with the sound sensors, and each sensor is given an identification number that is linked with the cows. In order to avoid the sensor sensing the surrounding noise, it is recommended to have a uni-directional antenna in the sensing node. Whenever the cow makes a call, the sensor senses the sound and passes the signal to the Arduino microcontroller with which the sensor connected. The microcontroller calculates the decibel value from the call using the level of sound as follows;

value (x) $=10 * \log_{10}(V2/V1)^2$

$x= 20 \log_{10} (V2/V1)$; where V2 is output voltage, and V1 is amplified input voltage.

The controller is programmed to compare the decibel value with the predefined range of values derived from samples of diseased cows. If the decibel value does not match with the predefined value, then the cow is considered to be normal, and no further process is carried out. Else the microcontroller sends the signal to Raspberry Pi microcontroller with the help of the Wi-Fi protocol. This controller actuates the alarm and displays the particular cow's identifier along with the notification message. Also, it forwards the data to the gateway node from where the data is stored in the cloud for remote access by the devices that have installed the cloud-based user application.

IV. RESULTS AND DISCUSSION

The proposed work is simulated in cisco packet tracer. In the packet tracer environment, a 'thing' is created to denote the cow. Then, to increase and decrease the volume of the cow's call, a potentiometer is attached with that 'thing.' Next, the sound sensor is connected in the microcontroller that functions like the Arduino UNO board, and the sensor is placed near a 'thing' cow. The procedure is followed for each cow connected in the environment. Then all the controllers are connected with the Single Board Controller (SBC) which is like a Raspberry Pi Controller using Wi-Fi protocol. The SBC controller is connected with LCD Display, Alarm and also with the gateway node. The gateway node is in turn connected with the Internet through which it can communicate with the cloud application. The proposed work uses the default application available in the packet tracer with a few modifications of necessary conditions. The microcontrollers are programmed in JavaScript in order to process the received data and send the signal to the intended nodes. In a remote environment, a mobile phone with an Internet connection which is considered to be the phone of the herd owner is placed. Fig. 4 depicts the simulation set up.

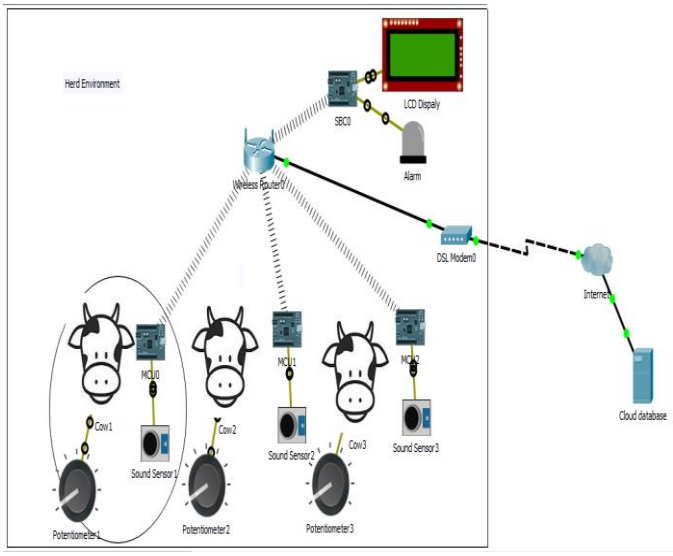

Fig. 4 Herd simulation set up

Upon setting up the environment, the potentiometer is operated to enable the cow to make a call, which is sensed by

the sound sensor and the microcontroller calculates the total decibel value. As the proposed work is simulated, some range of theoretical values is considered as the factors for denoting the illness of cows. However, in real time, the values derived from the data collection methodology mentioned in Section III could be used. Fig. 5 shows how the design reacts when a diseased how makes a call. The arrows in Fig. 5 point the arrows in The differences between Fig. 4 and Fig. 5

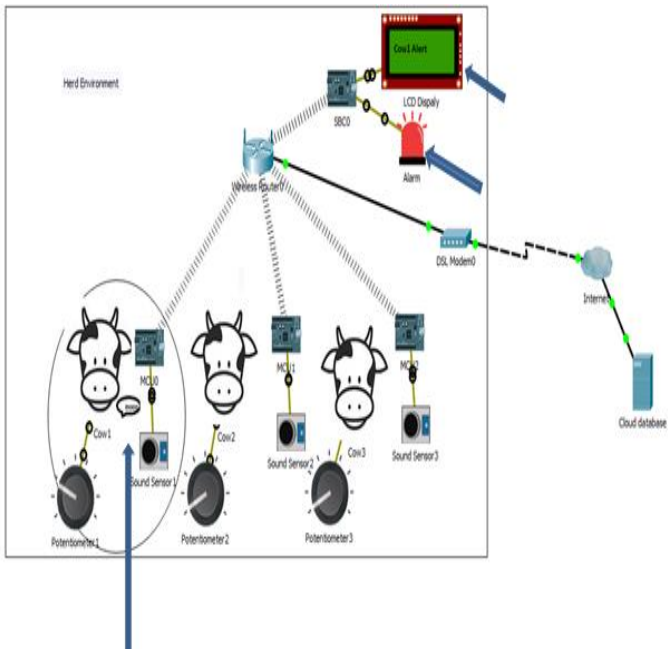

Fig. 5 Monitoring of diseased cow in the herd

The SBC actuates the alarm and the Controller also displays the alert on a particular cow with the identification number in LCD. Hence the system helps the person who is in charge of the herd to get notified via a display and to go in person to check the health status of the particular cow.

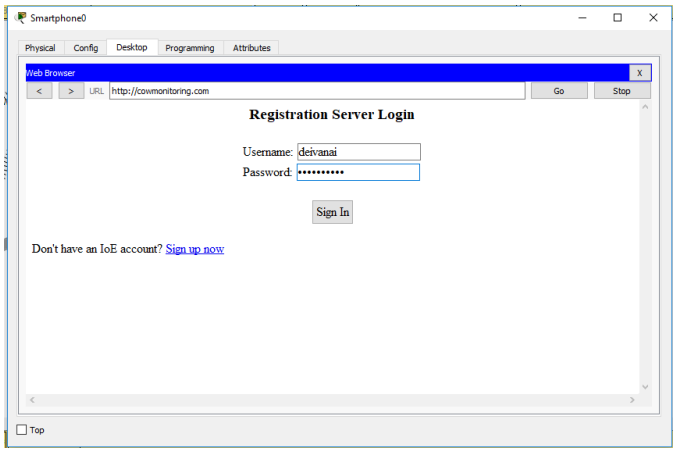

Fig. 6 Login Page of cow monitoring application

The remote herd owner can also check the status of the herd with his phone Fig. 6 shows that the herd owner is accessing the cow monitoring application deployed in the cloud server via the internet in his/her phone. The website name is cowmonitoring.com, and it requests a username and password from the owner. Upon verifying both, it displays the status of connected cows as shown in Fig. 7. In that figure, the signal value 0 denotes that the cow is abnormal and -1 denotes that the cow is normal.

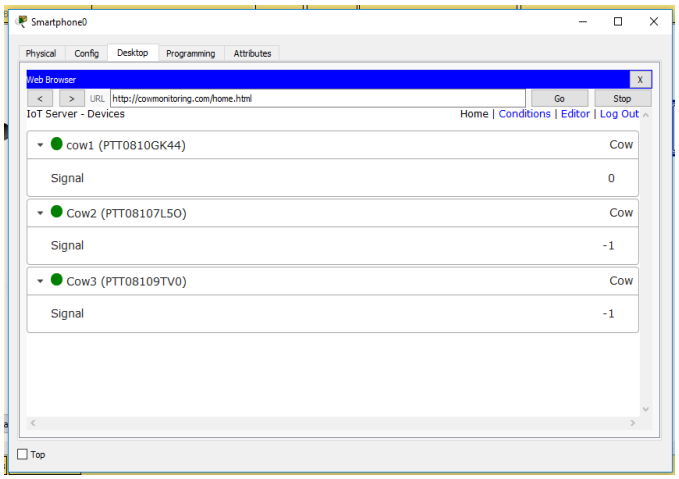

Fig. 5 Remote Monitoring of status of the cows

Hence, the simulation results show that the deployment of the proposed method in real time with a few modifications when compared to the simulation would be helpful for the dairy farmers for better monitoring of cow health.

V. Conclusions

Technologies are changing the way people do their work. Technology enabled Cattle management may sound complicated for the countryside dairy owners, but it has provided farmers with apparent benefits in many countries. This paper has attempted to monitor the health of cows with the use of sound sensor and Internet of Things. The proposed design has been simulated with cisco packet tracer, and it has tried to make it up to real-time implementation. The work is limited to only early detection of disease with the sound sensor. It may be extended to using wearable sensors which may reduce the noise level generated from the usual sound sensor.

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