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Study the Automated System for Tracking the Movement Of Feeding Cows in the Cloud

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Abstract— Nowadays, in order to improve productivity and make sure that animals are healthy, it is crucial to use current technology in agriculture. A revolutionary technology that integrates the IoT, cloud, data analytics, & automated feeding cow tracking in the cloud is a game-changer for managing and overseeing cattle operations on a daily basis. Many tasks related to cattle raising are still done by hand on farms today. Specifically, most farms depend on the farmer's eye for animal health rather than on machinery. It is possible for managers to forecast the health of farm animals based on data collected from monitoring their behavior. We present a WSN-based livestock monitoring system in this article. With the use of internet of things (IoT) devices and cloud computing, the suggested system can keep tabs on livestock. The livestock's movements were tracked by attaching IoT collars on their necks. By uploading data from livestock observation systems to cloud platforms, farming managers can keep tabs on real-time data. We found out through testing that the suggested method can keep tabs on farm animals in real time.

Keywords- Tracking, Farms, Animals, Livestock Monitoring System, WSN, IoT, Cloud.

I. INTRODUCTION

Livestock producers make up a significant portion of the country's food industry. Livestock production accounts for around 34% of agricultural output in poor nations, while it accounts for 50% in affluent nations, according to a survey [1]. Livestock management strategies & shifts in consumer preferences have contributed to a sustained uptick in livestock output during the past few decades [2]. But currently there are a lot of rules that animal farms have to follow [3]. Preventing epidemics, having effective management, making sure food is safe, and taking care of animals are all necessities. The several demands listed above necessitate careful management of numerous elements by those involved in raising livestock. But it's hard to keep tabs on every single animal in an animal farm all day, every day [4]. A lot of the time, the managers of livestock farms rely on their own experiences when it comes to managing the animals. Keeping a big herd under control requires a lot of resources, including people. Furthermore, there are cases where ocular inspection of animals' health statuses is inadequate. Precise livestock farming (PLF) could be the answer for a livestock company dealing with this issue [5, 6]. PLF refers to the technique of managing farm animals through the use of cutting-edge information technology. Wireless sensor network (WSN) and Internet of Things (IoT) technologies have found several applications as a result of the fast development of information technology. Miniaturized embedded boards and WSN technologies allow for inexpensive animal monitoring in animal husbandry. When compared to eye monitoring by farm managers, using IT technology is more efficient & accurate [7]. Not only can the herd at the distant location be monitored, but the health of each individual animal can also be tracked in real time. Furthermore, a farm administrator can receive the measured data instantly [8, 9]. A WSN-based animal monitoring system is depicted in Figure 1.

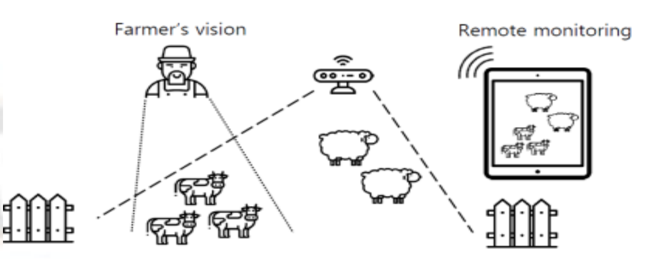


Fig.1: Utilizing WSN for Animal Monitoring.

The WSN technology for animal tracking has the potential to greatly benefit livestock farms [11, 12, 14]. Following is a breakdown of the advantages into three groups. To begin, by keeping tabs on each animal, we can assess the overall health of the herd and cut down on the spread of disease. Second, real-time data collection on the farm environment allows for the maintenance of an ideal environment for cattle. Third, tracking the movement of livestock while they graze can help you avoid losing any of them. When cattle are grazing across a wide area, their precise whereabouts may be tracked in real time by affixing a GPS tracker to their bodies. Several applications can benefit from the resulting location data. Primarily, livestock's position data can be utilized to gather them from wide-area grazing when it's time to return them to the barn. Secondly, by tracking the animals' movements, the farm manager can understand their patterns. You may find out where the animals graze by looking at these patterns. Lastly, the isolation of nearby animals in the event of an infectious disease outbreak is a viable solution to the problem of epidemic disease development. This allows for safer methods of animal management.

We develop and execute a system for keeping tabs on farm animals in this research. Reducing the amount of infrastructure needed to deploy the system is the goal. We therefore suggest a WSN-based approach for keeping tabs on animals in cattle farms. Considering the data's processing power and potential for future scalability, the suggested solution implemented a cloud platform. Livestock relocating locations are recorded by the system in real-time. Herds of edible cows typically graze vast expanses of grassland [10]. It is possible to diagnose illness in cows if they do not buck at regular intervals. This data can help farm management determine the health state and distinguish between different animals. Management also has the ability to track when animals wander off the property while they are grazing.

II. ANIMAL MONITORING

In the early days of the Internet of Things (IoT), the ZebraNet project created a method for collecting data on animals [24]. Researchers studying animal ecology were able to access data collected from animals in the wild through this technique. The system's primary objective was to track and analyze zebra populations spread out across Kenya's expansive landscape. There wasn't a cellular network that covered the whole region when the project started. This is why the node-to-base-station data transmission utilized an ad hoc architecture. The data was acquired and relayed to the base station by all nodes except one. While most projects assume a stationary base station collecting data from a specific area, this one operated under the assumption that the station was moving around on a regular basis. The project's base station, which was installed on a vehicle, gathered data from the nodes in the vicinity.

A GPS tracker was attached to the zebra's necklace so researchers could track its every step. Two communication devices comprised up this sensor node, allowing for the adjustment and utilization of energy. Originally designed for multi-hop transmission, the original communication device had a short-distance range. This apparatus was employed for low-power, short-range communication within a 100-meter radius. To stay in touch with the base station over wide range communication in 8 km, additional communication equipment was utilized. This sensor node may be outside of the base station's range, even if it could communicate over great distances. To get around this issue, it was conceivable to send data via a different node instead of sending it straight to the base station. The prior transmission strategy was utilized by ZebraNet through the usage of flooding a protocol & history-based protocol [24]. In Figure 2, we can see how ZebraNet is structured.

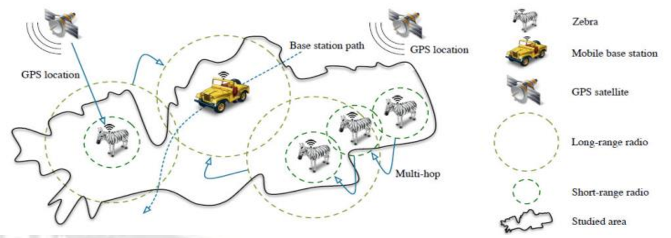


Fig.2: The framework of the ZebraNet.

According to Nadimi's research, an Artificial Neural Network can keep tabs on all the animals and relay data in the most effective way [13]. Since the health status of livestock farm animals may be inferred from their behavior and data, a farmer can, for instance, choose a new grazing spot for an animal based on its moving radius. Animal herds in Europe were the subjects of this observational study. Ad hoc WSNs built on MCUs with built-in wireless receivers were employed. The device measured and tracked the movement path or head movement of every animal. Numerous sensor devices served as nodes in the system's sensor network, collecting and relaying data about the surrounding environment. Every node in this system functions as a router in a network that relies on ad hoc topology and uses a multi-hop architecture. Surrounding a central node in the network are two relay nodes and one gateway. Data can be directly transmitted from the sensor node to the gateway or redirected using the relay node, depending on our system's design. A ZigBee-based WSN design is shown in Figure 3.

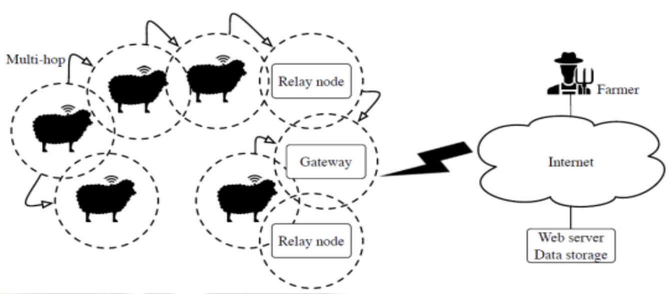


Fig.3: Using ZigBee for WSN Architecture

III. SYSTEM FOR TRACKING ANIMALS ON THE CLOUD

The suggested tracking system's architecture is detailed in this section. There are three parts to the system. The first one goes over the specifics of the WSN architecture's network topology & communication. Second, the data sent by the WSN is handled by the Cloud platform. While the base station is typically responsible for data collection & processing in WSN setups, the cloud platform is utilized for this purpose in this paper. The data processing actually happens on the cloud platform, while WSN component is responsible for collecting & transmitting the data produced by the nodes. Data processing & system status can be seen graphically using the user interface. Here are the three components and some facts about them, as seen in Figure 4.

3.1 WSN Layer

Figure 4 shows the WSN layer. Getting the data collected at each node into the cloud is the main goal of configuring the WSN. A node is defined in this study as an animal donning a sensor necklace. Using a GPS receiver, each node periodically obtains location data. When there are a lot of animals there, they tend to congregate into groups & establish leaders. What evolved into a dominant species has not changed. The sink node was chosen as the animal leader in accordance with prior research [10]. Farm management had previously chosen which animals would serve as leaders within the livestock group. Animals that aren't typically sink nodes use multi-hop and short-range communication to send data to the ones that are. Since 3G/4G cellular communication proved feasible in the lab, that's what the nodes utilized to send information to the cloud. 3G module served as the experiment's gateway node, which was connected to the sink node.

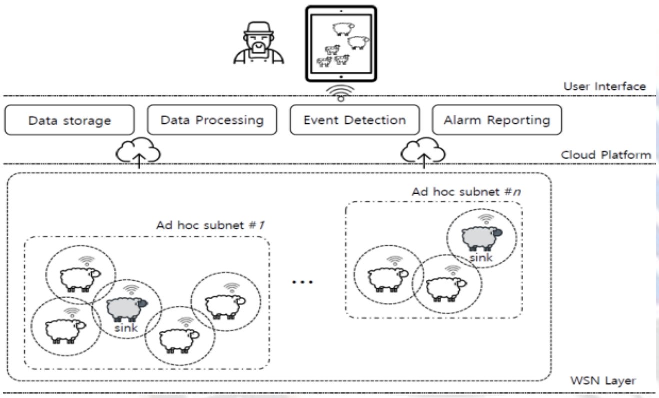


Fig.4: A System for Tracking Animals in the Cloud

Animals on the farm like to congregate in small groups based on shared traits, so it's more accurate to say that there are multiple groups than one. A break in communication with the sink node may result from this. A 3G connection module was attached to each animal's necklace in order to address this issue. When the primary sink node is unavailable, temporary nodes can step in to fill the role. This approach allows the node-collected data to be safely communicated to the cloud over the modified sink node. To manage data from numerous nodes, WSN configurations might be complicated. But this is something that cloud platforms can handle. In terms of real manufacturing costs, nodes that can simplify things are preferable. The node structure is illustrated schematically in Figure 5. With its 3G module, you can connect to the cloud, and its wireless module, you can communicate over short distances.

The nodes shown in Figure 5 were implemented using the MSP430F2274 MCU. Texas Instruments' MCU is a popular low-power microcontroller with 16 bits of memory [25]. The UART communication module makes programming and debugging the MCU a breeze. The eZ430-RF2500 development kit with MSP430F2274 was utilized for the rapid implementation of the nodes.

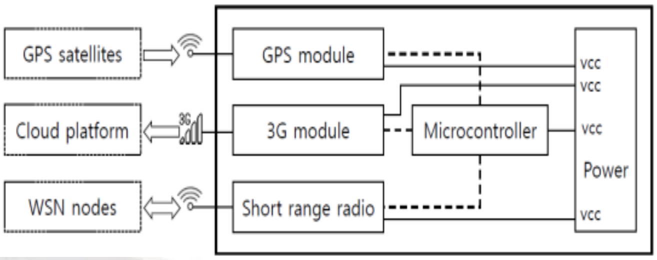
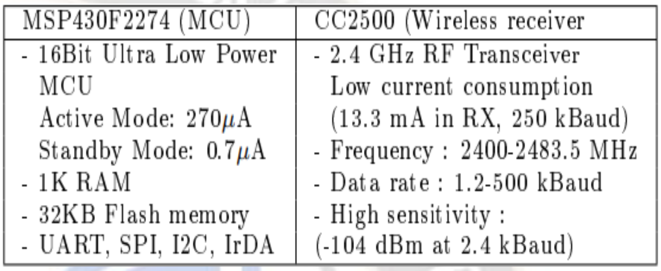


Fig.5: Structured nodes diagram

Table 1: Details regarding the microcontroller unit and wireless receiver.



MSP430F2274 (MCU)	CC2500 (Wireless receiver
- 16Bit Ultra Low Power MCU Active Mode: 270μA Standby Mode: 0.7μA - 1K RAM - 32KB Flash memory - UART, SPI, I2C, IrDA	- 2.4 GHz RF Transceiver Low current consumption (13.3 mA in RX, 250 kBaud) - Frequency : 2400-2483.5 MHz - Data rate : 1.2-500 kBaud - High sensitivity : (-104 dBm at 2.4 kBaud)

A battery pack, a USB debugging interface, two ez430-RF2500T boards with MCUs, and one more board are all part of the development kit. Along with the microcontroller unit (MCU), the motherboard also has the CC2500 short-range communication module.

For localized data transmissions, Texas Instruments offers the CC2500 wireless transceiver, which is similar to the MSP430F2274 microcontroller unit (MCU). Designed for usage in the scientific, medical, & industrial fields, this module typically operates between 2400 & 2483.5 MHz. The CC2250 wireless receiver & MSP430F2274 microcontroller unit are described in depth in Table 1. The actual experiment's nodes are shown in Figure 6. A node collar is shown on a cow in Figure 7.

Fig.6: The experiment's node module.

3.2 Cloud Platform

For the purposes of this research, cloud computing was taken for granted as the WSN back-end infrastructure. Applications, data storage, & processing power are all made available through cloud computing platforms. With the use of sink nodes as gateways, WSN can skip base stations altogether and send information direct to the cloud. Cloud eliminates the need for complex back-end environments to be a concern for farm management.

Fig.7: A cow covered with a node collars

For this article, we relied on Amazon Web Services (AWS) on the cloud. AWS is a multi-tiered platform that provides a wide range of services. The AWS layers are illustrated in Figure 8. The communication between the sink node & cloud platform begins at the highest service layer. The system in the cloud undergoes periodic chores performed by the listener layer. For instance, if we tracked the daily mileage of all the animals and added it up on a 24-hour basis, we could find out how far they traveled. Steps to execute different system tasks are analyzed and processed by the business layer. The sink node is responsible for converting the raw measurement data into JSON representation. The receiving lower layer just inserts the GPS data into the database after processing the JSON-type input. The business tier oversees the database tier, which utilizes the PostgreSQL relational database server.

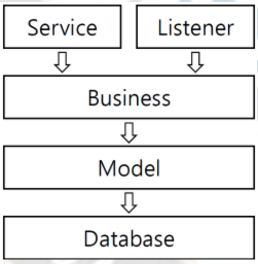
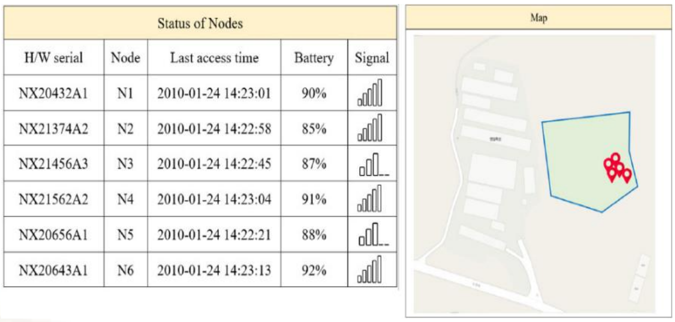


Fig.8: Layers of Cloud Platform.

3.3 User Interface

We stored the data that was gathered from the WSN nodes in the cloud. On the graphical user interface page, you can view the positions of the nodes on the map and their status reports. You may see the signals, battery life, latest data delivered, hardware serial number, and node number in the node status information. Presently, the user interface is made up of web apps that follow the Model-View-Controller (MVC) pattern. In order to facilitate communication between the cloud infrastructure and online applications, we employed the JSON data format. You can see the web page that allows you to track the animal's whereabouts in Figure 9. Every three minutes, the administration web page is automatically renewed, & administrator also has the option to manually refresh it.



Status of Nodes

H/W serial	Node	Last access time	Battery	Signal
NX20432A1	N1	2010-01-24 14:23:01	90%	▂▄▆█
NX21374A2	N2	2010-01-24 14:22:58	85%	▂▄▆█
NX21456A3	N3	2010-01-24 14:22:45	87%	▂▄▆
NX21562A2	N4	2010-01-24 14:23:04	91%	▂▄▆█
NX20656A1	N5	2010-01-24 14:22:21	88%	▂▄▆
NX20643A1	N6	2010-01-24 14:23:13	92%	▂▄▆█

Fig.9: Animal monitoring webpage.

IV. RESULTS

Three primary methods were utilized to conduct the experiment. The primary objective was to assess the wireless receiver's fundamental performance by measuring the value of RSI over distance. The second analyzed the cloud platform's performance by measuring the transmission & processing of messages. Third, by setting up nodes on the real farm, we were able to track the animal's trip battery usage.

4.1 Rationale of Data Gathering

The primary objective of the first experiment was to validate the behavior based on WSN. The experiment verified the node's ability to receive location data on a regular basis or accurately transfer that data to the network. A large number of generic nodes disseminate location data across the network; these nodes relay the data they've gathered to the central sink node. During the first trial, the node's GPS receiver was programmed to activate every 30 seconds in order to gather location data. In addition to receiving data from regular nodes, nodes can also be configured to act as sink nodes. We used a monitoring PC to overlay the data received by the sink node onto a real-time map and confirm its accuracy. The SIM808 receiver module, which the node utilized, enabled accurate location reception, allowing it to accomplish this. There is a 50 to 60 m measuring range that can be achieved, as stated in the chip description. Nevertheless, a plethora of outliers beyond 20 m were introduced by the device's actual experimentation use, rendering all data unreliable outside of that range.

The experiment collecting location data using a node lasted for fifteen minutes and thirty data points were acquired. Over the course of the trial, the WSN node maintained its motion within a rectangular region of 500 m. Due to the near closeness of the normal node & sink node, which was roughly 10 m, there was no packet loss that occurred during transmission. In order for Google Maps to make use of the GPS data received from the node, NMEA 0183 format was employed for data storage. In Figure 10, the actual map created from the data collected at the nodes.

Fig.10: Actual map including GPS data

4.2 Confirmation of CC2500 Wireless Receiver

Ad hoc communication between WSN layer nodes is crucial to the suggested system. This is why we looked at how well the CC2500 transceiver worked. When choosing a wireless transceiver for a WSN, the communicator's communication range is crucial. Which is why we decided to test the CC2200 transceiver's transmission range first. When two transceivers were physically separated, researchers studied the RSSI (Received Signal Strength Indication) variation as a function of distance. The goal of this experiment is to find out how far data can be reliably carried between transceivers. For the experiment, we set up two nodes: one to act as the master node and another as the slave node. For data & RSSI information verification, the sink node wirelessly connects to the laptop. An open, unobstructed space was used to conduct the node experiment. The animal's height was taken into account while setting the node to 1 m in height. The experiment involved moving the general node to positions 1, 2, 4, 8, and 16 m while fixing the sink node. Each 5sec, the general node sends packets to the sink node using all of its available supply.

As our application showed the RSSI data collected through the serial connection, we verified that the packet had reached the sink node. Each destination received ten packets from the node. Upon receipt of the tenth packet, the sink node documented the RSSI data. There is a plot of the RSSI values versus distance in Figure 11. One approach to lessen the burden on the network or its power consumption is to decrease the number of wireless nodes that utilize energy. In unit experiments, receiving data was frequently lost and the node's power consumption increased by 25% over distances greater than 20 m.

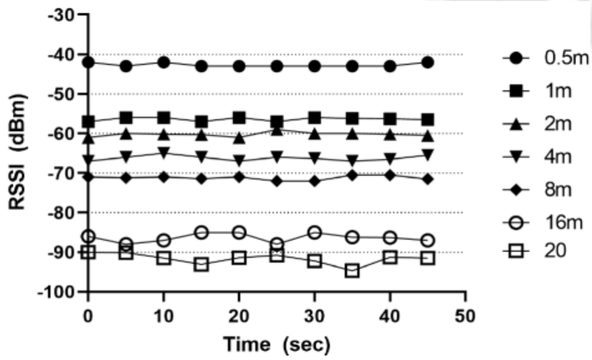


Fig.11: RSSI value as a function of distance

4.3 Confirmation of Cloud Platform

The present method was developed with the intention of serving as a model for animal tracking. This is why numerous animals are not yet having their data sent to a cloud server in real time. Eventually, we plan to utilize a prototype to gather extensive data about animals and their locations, and then we'll use a cloud platform to analyze all sorts of information about them. The details pertain to the routines of creatures that have been uncovered by scientific investigation. We can forecast the animals' health conditions if we gather the data. As a free cloud platform for testing, we utilized Amazon Elastic Compute Cloud (EC2) for this project. With an increase in the amount of messages received from nodes, we monitored the cloud platform's status. We looked at message delay in the cloud experiment. The time it takes for a message to travel from its source to EC2 and then be processed by the platform itself is called the delay time. The data was sent to the EC2 cloud server using socket communication using the Amazon API Gateway. Ten, one hundred, thousand, ten thousand, and one hundred thousand messages were sent to the server by the task. We ran five separate experiments to get a good feel for how long it took to process each message, and then we averaged & standard deviationd the data. The amount of messages delivered and the time it took to process them are displayed in Figure 12. Just like any other server, the ec2 server has a linear increase in processing time in relation to the number of messages transferred. To put it simply, the amount of messages in the server's message queue increases in direct proportion to the number of messages transmitted. This explains why there is a significant lag between the timestamps of the first and last messages that arrived. Consequently, there is a significant amount of variation in the message processing delay. Nevertheless, for better speed, the messages in the queue are processed simultaneously rather than sequentially. Although messages are being handled in parallel, there may be some processing delays due to the restricted performance of the servers.

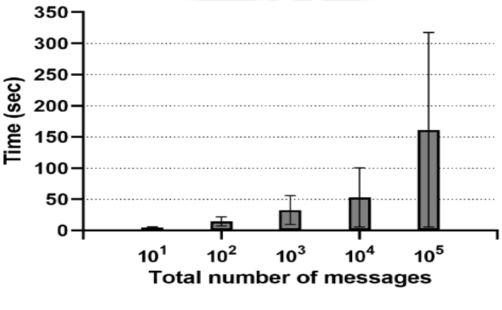


Fig.12: Data processing latency is a mean value following message transmission.

4.4 Livestock Farm

Livestock farms in the vicinity of the school were the sites of studies to validate the suggested system. Roughly thirty cows spent their days grazing and their nights in the barn as part of the experiment. When livestock are grazing outdoors, it is important for farm managers to keep an eye on them. 2 sink nodes and three normal nodes made up the 5-node configuration employed in the initial experiment. With the assistance of a farmer, we chose a herd of five cows and fitted them with neck collars. The location of actual experiment can be shown in Figure 13.

Fig.13: Environment of livestock farm.

Figure 6 shows the nodes that were attached to the cows' necks in order to keep an eye on them while they were in the farm. We were able to gather data on battery life and GPS coordinates utilizing those nodes. The data was sent each 15 min to tracking the cow's movements & keep the batteries from dying. Two out of five nodes in the farm experiment were able to accommodate 3G/4G modules acting as sink nodes. While the sink node was down, the other three nodes continued to function normally & served as a buffer for the data that had been acquired. Taking the battery into account, this experiment lasted for three days. The 4G module was not sleeping & battery consumption was considerable, so the transmission frequency was fixed to 15 minutes.

The use of WSN infrastructure is crucial for the tracking of specific farm animals. In order to confirm this, we monitored the WSN nodes' battery consumption & connection times. First, while the nodes were running, we changed the connection time. It is common practice to divide cattle into many groups for grazing during the day. In the meantime, the cows head back to the barn to spend the night. Reason being, the CC2500 wireless receiver module is presumptively located within the proximity of all cows, and the sink node & typical data-collecting node are presumed to maintain a connection for the vast majority of this time. This is confirmed every 30 minutes when the normal node transmits data acquired to the sink node. At this moment, connections to the sink node can be established either with a single hop or with numerous hops. Figure 14 shows the results of this science experiment. There was a total of 12 hours of data utilized to analyse the connection rate among nodes; 6 hours were utilized during the day & 6 hours were used at night. Approximately 342 minutes, or almost 95% of the 360 minutes, were spent maintaining connections to sink nodes by hourly nodes throughout the day. The CC2500 communication module can only transmit and receive signals up to 20 meters in distance, as demonstrated in experiment 4.2. Cows, it seems, spend a lot of time frolicking in herds.

This is critical to identify the actual energy usage of the wireless nodes when operating a wireless tracking system on a farms. We followed 2 sink & 3 mesh nodes to find out how much power each one used. The consumption of energy node during a 24-hour period is displayed in Figure 15. Preliminary testing confirmed the notion that energy consumption is higher for sink nodes compared to mesh nodes. This is due to the fact that the mesh node obtains GPS data, measures battery life, and communicates with the cloud, whereas the sink node serves two purposes. The real power consumption of the nodes reveals, however, that there is little difference in power consumption between the mesh & sink node. The reason the sink node transferred 80 to 430 mA of current to the cloud platform during data transfers that lasting only a few seconds, despite the significantly shorter real transfer duration, may be understood by analysing it. The 3G/4G modules used 20 mA while they weren't in use. Node power consumption is high because the GPS module takes a lot of current (approx. 78mA), it gets accurately GPS data from the devices.

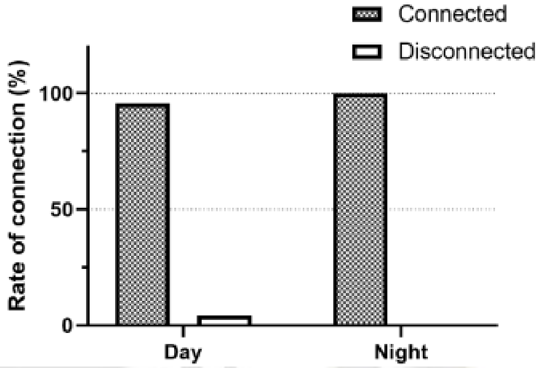


Fig.14: Sink node to mesh node connection rate

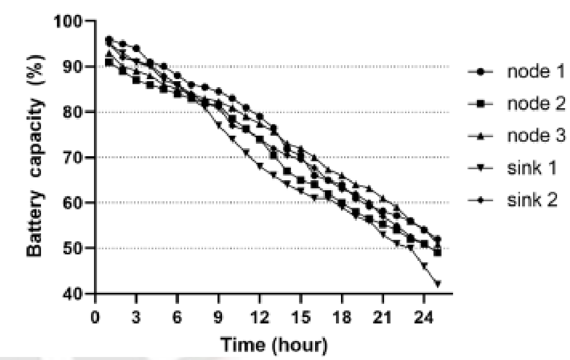


Fig.15: Nodes' battery consumption.

V. CONCLUSIONS

We presented a WSN system for monitoring farm animals in this work, which is based on a cloud platform. The proposed system constructed a WSN using its own protocol to transmit the measured data from all data nodes to the sink node. Through the use of communication technology, the data acquired by the sink node was sent to the cloud platform. The data from every node was saved by the cloud platform, which also created a webpage that managers could view in real-time. Through a web portal, the farm manager may monitor the health of every animal & study their collective behavior. We were able to put the suggested technology into action and do trials with live animals. The testing proved that data transmission & reception were functioning normally. The web page provided the administrator with up-to-the-minute animal status updates & map showing their exact position. Our long-term goal is to create a system that can analyze animal data over time and make predictions about their health. In order for the WSN model to be able to track a large number of animals, we will also make it more robust.

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