Animal Tracking System using LoRa Technology

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Abstract— **In rural areas, it is difficult for farmers to keep track of individual animals in their farms. During grazing, some animals would go missing. It is a tedious process to find the missing animal manually. Animals can be tracked individually with the use of available technologies. Several technologies like RFID, Wireless sensor networks, Low Power Wide Area Network (LPWAN) have been used in tracking applications. RFID technology gives a very good battery usage which long last for upto 15 years but gives the location of the RFID reader and not the RFID tag. Hence, the real time tracking is lost. In Wireless sensor network, it sends the information through sensor node but the power consumption is very high and every node has to have a GSM module and must be recharged along with battery. Thus, a low power and long range system is necessary which can be achieved by using LPWAN. LoRa is a wireless technology developed for low power wide area networks. This technology is an exciting development of low power, long-range wireless transmissions. The proposed project uses the LoRa technology to create low-weight and low-cost tracking devices that can be safely deployed on animals. LoRa modulation is using a chirp (Compressed High Intensity Radar Pulse) spread spectrum (CSS) technique which offer resilience to interference, great communication link budget, performance at low power while being resistant to multipath propagation fading and doppler effect. The main aim of this project is to present the solution implemented to track the animals and to measure its surrounding temperature using LoRaWAN technology. LoRa end node transmits the GPS data and temperature value to the user through server via gateway. User can track the animal and monitor its surrounding temperature using android application.**

1] INTRODUCTION

Study and monitoring of animals has always been a subject of great interest. Studying the behavior of animals is a difficult task due to the difficulties of tracking and classifying their actions. Nowadays, technology allows designing low-cost systems that make these tasks easier to carry out, and some of these systems produce good results; however, none of them obtains a high-accuracy classification because of the lack of information. Monitoring the behavior of animals is a hard technological task to implement. There are some commercial devices that can track animals using GPS and obtain some vital signs through sensors. The information given consists only of raw data without processing, thus, these solutions are not able to recognize animal patterns with the data obtained from its attached sensors. In the conventional system GPS provides the data of the animal location and is transmitted using GSM network. But this system is power consuming and battery life would be very small and the sim deployed in every end node need to be recharged at regular intervals. A low-cost device enabling geo-positioning with a long battery lifetime would be useful for securing successful tracking. Long Range Wireless Area Network (LoRaWAN) presents interesting features, so it becomes a powerful technology in geo-location applications. LoRaWAN is an open source technology; communications and other relevant features. The LoRaWAN protocol is defined and standardized by the LoRa Alliance. A single gateway or base station can cover entire cities or hundreds of square kilometers. Range highly depends on the environment
or obstructions in a given location, but LoRa and LoRaWAN have a link budget greater than any other standardized communication technology. Spread Factor (SF), Bandwidth are the parameters that decides the coverage and efficiency of LoRaWAN.

Internet of Things, has been growing over the last few years in multiple applications and due to the extensive use of GPS for tracking capabilities, an innovative opportunity arises. Currently, there are affordable GPS receivers available in the market, but their main problem is the battery lifetime and need to be recharged every few days. The current consumption of a GPS receiver is about 30-50 mA, which is considerably more required to in most low power IoT devices. There is always a compromise between the power consumption and range achievable; for example, the passive RFID technology [1] can give a less power consumption but area coverage cannot be met, where as, the LoRaWAN module in 868 MHz band consumes 2.8 mA, in the on state, 38.9 mA transmitting data and 14.2 mA receiving data and coverage is also good compared to the other standardized communication. Motivation of this work arises from the need of designing a low-power consumption system and achieve a considerably good range.

Objective of this paper is to present the solution implemented to track the animals using LoRaWAN technology in the wide land, and also to obtain the environmental conditions surrounding the animal, the temperature. End node tied to the collar of animal transmits the information to the server through gateway. Data is stored in the cloud and is accessed by any third party application.

2] Related works

Various works have been carried out on the animal tracking system. Due to rapid advancement in technologies, animal tracking system can be achieved using one of these different technologies.

RFID Technology: So-Hyeon Kim et al. [1] described the system with the technology of sensor, RFID, and GPS. Researches have been carried out on monitoring animal behaviour and its interaction with environment. L Catarinucci et al. [2] proposed an RFID technology, which uses Ultra high frequency Passive RFID tags for animal tracking. The tag has a life for about 15 years and power supply is not needed. The transmitter section is attached to each animal. The Receiver section is an integrated system of RFID reader, a controller unit and GPS chip. The major drawback of this system is range. The RFID reader has the ability to read the tags within the range of 30m. So there needed many receiver sections to be deployed in the area which would be more expensive.

WSN technology: J P Dominguez Morales et al. [3] used Wireless Sensor Network (WSN) to track animals. The WSN consists of gateway and sensor nodes, also termed as end nodes which collect various data such as temperature, humidity and localisation. In this work, WSN was installed in Donana National Park, information about animals behaviours using the end nodes was collected. Once a behaviour was detected, the information was redirected by network to the server through the gateway. This method can reduce power consumption and facilitate animals behaviour.

LoRa Technology: Mariano Pulpito et al. [4] focused on a specific Low power wide area network technology, namely Long Range Wireless Area Network (LoRaWAN), which offers noticeable features such as wide coverage areas, low power consumption, bandwidth optimisation and reconfigurability. This study describes a prototype in which the sensor end nodes collect the data and sends to the server through the gateway using LoRaWAN protocol. Third party

application is used for user interface. An experimental campaign carried out on the prototype resulted in best coverage range of 3 km and packet loss ratio of 15 percent. Jerrin George James et al. [5] proposed an alternative to the conventional public transport tracking systems which uses GPS. LoRa wireless transmission is used to communicate between the bus stops and a base station. RF transmitters are installed in buses, which sends data regarding the bus identity continuously. RF receivers placed in the bus stop, detects this bus when it is in range, and relays this information to the base station instantly through LoRa communication. Alexandru Lavric [6] describes a review of the challenges and the obstacles of IoT concept with the significance of the LoRa technology. A LoRaWAN network is of the LPWAN type and has battery powered devices, which ensures bidirectional communication. The main contribution is the evaluation of the LoRa technology with the requirements of IoT. U Raza et al. [7] presented the design goals and the techniques, which different LPWAN technologies exploit to offer wide-area coverage to low power devices at the expense of low data rates. Alexandru Lavric et al. [8] presented the performance evaluation and sustainability analysis of LoRa technology which offer flexibility to interference, performance at low power while being resistant to multipath propagation fading and doppler effect.

Amongst various technologies described above, LoRa technology is more suitable to track the animals. Because it offers long range, low power and optimized bandwidth.

3] System Overview

A. Long Range Technology

Long Range (LoRa) Technology is wireless communication system, promoted by the LoRa Alliance. The LoRaWAN protocol designed by the LoRa Alliance is as shown in the Figure 3.1. The protocol refers to three distinct layers:

Implementation of LoRa modulation is done in physical layer, LoRaWAN technology is implemented in Medium access control (MAC) layer, the Application layer, which is a bridge between the end-nodes and the internet

LoRa Network Architecture : The basic architecture of LoRaWAN network consists of end nodes, gateway and network server. End node consists of LoRa shield with Arduino Uno board, which can be interfaced with different kind of sensors and can acquire GPS values, having GPS module within the node. End nodes communicate with gateways using LoRaWAN protocol. Gateways transmit the packets to network server over back haul interface using internet connection.

LoRa Physical Layer: LoRa is a chirp spread spectrum modulation, uses frequency chirps in order to encode information. Because of the linearity of the chirp pulses, frequency offsets between the receiver and the transmitter are equivalent to timing offsets, easily eliminated in the decoder.

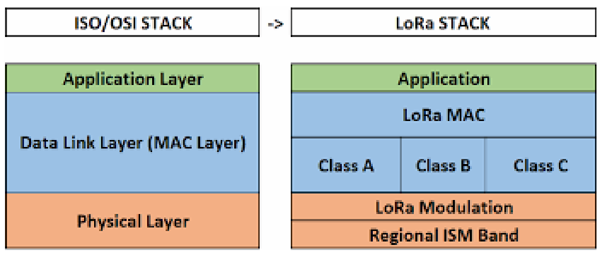

Figure 3.1: LoRaWAN protocol

B. Proposed System

The block diagram of the proposed system is as shown in Figure 3.2. The system mainly aims at tracking the animal and measuring its surrounding temperature. The proposed system has LoRa GPS shield with a DHT-11 sensor, a gateway, TTN server and an android application.

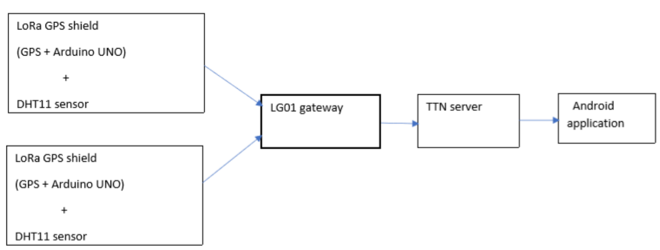

Figure 3.2: Block diagram.

LoRa GPS Shield: The LoRa GPS Shield consists of Arduino as controller and a DHT-11 sensor to measure the surrounding temperature and an embedded GPS module to send the location data. This LoRa device transmits the location data and the temperature value to the gateway using LoRaWAN protocol.These devices are also known as end nodes.

LG01 Gateway: The LG01 Gateway is configured in WiFi client mode. It acts as a bridge between the LoRa devices and the TTN server. The gateway forwards the data packets coming from the LoRa device to the server using single packet forwarder using internet.

TTN server: The packets sent by the devices are decoded in the server. The Things Network is about sanctionative low power devices to use long range gateways so that it can get attached to localized network to exchange information with applications. The data flow from end node to android app through TTN network server is shown in Figure 3.3.

Figure 3.3: TTN overview.

Android Application: This android application retrieves the data from "The Things network" using the uniquely designed keys such as App session key, Network Session key and Device EUI, later the data is decoded and accordingly it is mapped in real time. The developed android app overview is shown in Figure 3.4 which consists of two buttons indicating the two end nodes which shows the location of the animal in Google Maps and also displays the surrounding temperature of the animal respectively.

Figure 3.4: App overview

4] Implementation

The Implementation of entire system is categorized in terms of Hardware and Software. Once the hardware part is assembled, i.e Interfacing DHT-11 sensor to LoRa (LONG RANGE) module integrated with GPS , comes the software part. Initially configuration between gateway and end node is carried out, end node as client and gateway as server. After configuration, coding is done in Arduino for obtaining GPS values. Communication between gateway and cloud server is established, to store the received data from gateway in the server. Android app is developed using Android studio.

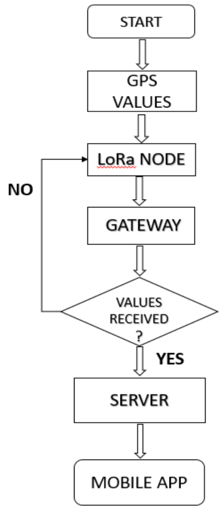

Fig 4.1: Flow chart for Animal Tracking System using LoRa

Gateway device is connected to "THE THINGS NETWORK" (TTN), which is a LoRaWAN Iot Server. Gateway receives the data from end node and forward it to TTN server. The gateway is registered in TTN console using the MAC address of the device. Once the gateway is registered in console, Arduino sketch is uploaded to Linux system. After uploading the sketch, configuration of LoRaWAN server is carried out. Mobile app is built in Android studio using Java programming. Fig 4.1 illustrates the sequence of activities in Animal tracking system. When the power supply is given to end node, it will start acquiring GPS values from the satellite. Lora node then sends these values to gateway. Gateway then forwards the packets received to server. If values are not received, it resends the data to gateway after some back-off time. Location of animal can be tracked in app using the GPS values, which is stored in server.

5] RESULTS

The LoRa end node, tied to the animal shown in Figure 5.1 sends the location information and temperature values to the server via gateway. The end node consists a rechargeable

Figure 5.1: LoRa end node tied to the animal

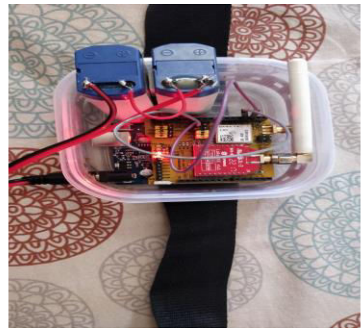

Figure 5.2: End node.

Experiment was carried out to check the range and measure the surrounding temperature. During the experiment, the gateway was kept at certain height of a building and end node was moved away from gateway keeping Spreading Factor (SF) value fixed at a time. Various range values for different spreading factors with delays are depicted in Table 7.1; from the test cases it was conferred that as SF increases the range increases and also a delay increases. In this project SF value of 7 is used as it has the minimum delay of 1 minute.

Sl. No.	Spreading Factor(SF)	Range(m)	Delay(min)
1	7	100	1
2	8	150	2
3	9	200	2.50
4	10	250	4

Table 7.1: Range for different Spreading Factors

The Android app displaying the location and temperature of the animals is shown in Figure 5.3. The location gets updated when the animal moves to other location as well as temperature also gets updated. The experiment results for different locations are shown in Figures 5.4, 5.5. Practically, it was observed from the test cases that in urban area, when the gateway was kept at nearly 30 m above the ground, total range of 250 m radius was achieved with maximum delay of 4 minutes.

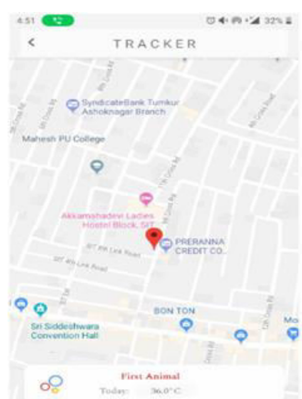

Figure 5.3: Android App displaying the location and

temperature of the animal.

Figure 5.4: Location 1

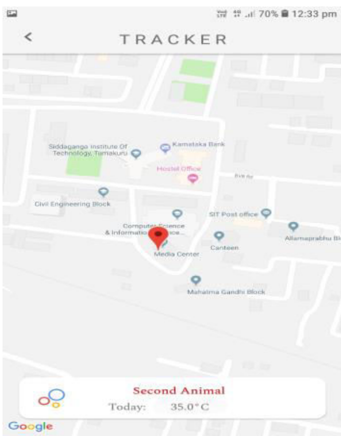

Figure 5.5: Location 2.

6] CONCLUSION

A study is carried out on existing animal tracking system based on various technologies such as RFID, Wi-Fi and implemented the system using low power and long range technology (LoRa). The designed system is able to send the sensor data to the remote user and user can in turn track the animals, locate it within the range up-to 5 km. The DHT-11 sensor is also used to measure the temperature surrounding the animal. System is able to implement the LoRa technology which sends the information of the end user nodes to the server through gateway with low power of 40 mA and high range of communication approximately of 250 m radius.

7] Future scope

The system can use the mesh network topology for the nodes and gateways which can increase the physical range of communication by connecting the node which is nearby to it, so that the information is not lost. It can also be used for the finding patients suffering from Alzheimer's disease. It can use the sensor like gyroscope to detect the movements of the animal (sitting, standing, sleeping, walking) to know the activeness of the animal. Further GPS less system can be achieved using TDOA algorithms that gets the location.

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