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IoT based Anti-Poaching System for Trees and Wildlife Monitoring System in Remote Area

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Abstract: ***These days we see a lot of news about how smuggling/theft of most important trees such as sandalwood, sagwan in forests, poses a serious threat to forest resources, and also brings about an economical damage as they are poached for their medicinal values. Even wildlife is endangered due to their differential cost in the wet markets. This project is based on IoT technology and also follows WSN principles to obtain a client-server model. A network of sensors is used in each node (also known as the client) to monitor the surrounding behavior of the trees which detects forest fires and anti-poaching. Each node connects to several other nodes via routing protocols communicating to each other and the status (data) of the sensors is constantly collected by the client. If the monitored data is above the threshold, it immediately sends a notification to the server which will send the message to inter-connected servers. This goes on until it reaches the concerned authority along with the node's location using a GPS module via the internet. A similar principle adheres to the Animal section. The health of the animal is monitored where, if the temperature of the animal goes beyond the threshold value, the connected node sends a notification to the server and so on until it reaches the concerned authority along with the RFID tag and location of the animal using RFID module and GPS module via the internet.***

Keywords: Anti-poaching, Wi-Fi module, WSN, GPS, DHT11, LM35, RFID.

I. INTRODUCTION

In recent, there are a lot of news flashings that talk about trees like sandalwood, sagwan (teak), being poached/smuggled for their importance in many fields of economy. These trees are also influenced by their medicinal values in the market[5]. Through these reasons, a lot of smugglers tend to keep a keen interest in them and engage in the illegal activity of theft. Poaching of trees and animals has been an issue for centuries. According to law, poaching is an act of illegal trapping, shooting of any living organism like plants and animals from private property or from areas where these acts are forbidden. It has been a massive threat to the wild organisms living in forest areas and is an immense benefactor to biodiversity loss. This issue is not only noticed in Indian society, but also takes place in other developed countries too. The Government has taken serious steps to control these activities and also bring about a safe environment around us. But to no avail, these actions of smugglers still take place[14]. There has been a surge in poaching of animals in the wake of lockdowns imposed in many countries[2]. These actions are also considered for the exceptional values in medicine and other artifact aspects that the animals pose. This motivates us to bring about a wireless system so that these acts can be put to a stop and let the ecosystem be peaceful. Due to today's technological advances, there are always fewer human efforts needed for any task assigned. With this citation, a lot of IoT based projects are in action to reduce human efforts. Several IoT based projects which include wireless sensor networks (WSN) has been proposed to avoid the poaching of trees. These techniques included an alarm system that would alert the forest officials when there would be a breach. Other methods were to make a network of the ZigBee modules that uses a mesh topology to pass the message and alert the officials[6].

Wireless Sensor Network (WSN) is been often termed as a technology under the Internet of Things (IoT). In IoT, we see that the sensors are directly connected to the internet so they can send information. WSN technology, these sensor nodes are connected to a central or master node through which the information is passed. In the introduced system, we use WSN technology to create a network of nodes that are connected to a master. For this paper's reference, we can denote a node as a client and the master as a server to design a client-server paradigm. A bunch of sensors that are mainly going to aid in reading the environmental condition is connected to a client. These would be fixed to the relevant trees and animals in the forest areas. The client acts as a station point for the incoming data from the sensors. This stationed client will be connected to a nearby server that acts as a master. After further processing by the client, an appropriate message for the end-user will be generated. This message will pass to the server nearby. The server itself would connect to other servers nearby, making the connecting server a client to the server network. This way a lot of these sensors are interconnected to each other, creating a vast network for message passing.

The main goal of creating a network of servers is to connect all the clients of the trees to at least one server. Also, since the system is being used in remote areas, there would be no active internet connection. Hence, to have the internet in the network, we end the network close by an internet tower. From this point, the message is given to the expected audience. For a proper messaging system, we have a lot of factors at hand. The cheapest way was to use a website called IFTTT to make web applets that would send an SMS directly to the forest officials through the internet. Finally, the authorities would receive a notification about any intrusion, so that a sudden action can take place to stop the illegal act.

II. LITERATURE REVIEW

Poaching has increased in recent years due to its exceptional cost in today's market. A survey[1] talks about how poaching of rhinos had risen drastically. The reasons were the differential cost for a rhino horn. Hence, it found that in the year 2016 that a rhino was killed every 8 hours in South Africa. Even animals like elephants also faced with an increasing poaching crisis. The same survey paper talks about anti-poaching technologies in terms of their requirement and also identifies challenges. According to the article[2], there has been an enormous rise in tree poaching activities. An estimated thousand trees have been poached according to an annual report submitted on May 11th, 2020. Besides this, there are numerous cases of forest fires that occurred in Australia recently and the Amazon forest fire in 2019[9]. A case study[3] also revealed the intentions behind tree poaching and how people tend to quit the crime. In this paper[8], the authors talk about a way to tackle poaching, the illegal trade, and come up with a method called SMART (Spatial Monitoring and Reporting Tool) approach. This approach provides a real-time monitoring tool like a cyber tracker, MIST to help is practical anti-poaching efforts. The most emerging technology for anti-poaching is the use of Wireless Sensor Network (WSN). A lot of development is been noticed in this technology for the said goal. This paper[4] talks about applying WSN for the theft detection system by continually monitoring the vibration produced while cutting of trees using MEMS. It also gives an insight into WSN technology as an application to overcome the barrier of communication module's capacity to transfer data, including the efficient method of managing battery power. In a more recent paper[5], we can see the use of WSN for designing an alarm system which is triggered when a certain threshold passes. It also made use of a temperature sensor to identify any distress like forest fires. Most of the WSN technology uses Zigbee modules[4][5][6] to implement a node for the system[6]. Here the data can be seen to have a centralized network to travel and share the information. The WSN technology is also employed to access any third party server to send or retrieve data over a communication interface like the internet.

III. PROPOSED SYSTEM

The introduced system is mainly dividing into two parts that act on two different real-world entities. These are the Tree section and the Animal section. The working of these two entities is almost the same, with the differentiation of having different sensor modules to evaluate the surroundings at the client-side. Both of these divisions work on the same technology, which is Wireless Sensor Network (WSN). The WSN is mainly applied in these sections to work on the sensor connection and data processing. For this system, we have made use of a cross-layer approach, which will help in reducing the amount of power used during computation[11]. For enabling this approach, we avoid mesh technology as it consumes too much power for the working. Instead, a star topology is applied where we connect several clients to a single server, and this server is connected to several other servers. The client performs the core processing of data and further sends the created message to the server for transmission.

A. Tree Section

In the tree section, we have many problems to look at to solve, which is the anti-smuggling of trees. Also, the wildfire that occurs due to lightning or sometimes due to spontaneous combustion of dry fuels, which ignite the dry leaves. The DHT11, which is both humidity and a temperature sensor, helps us to know the surrounding weather. DHT11 is a low-cost digital sensor that is worthwhile in our system with slight performance and accuracy issues. These issues are negligible for an application related to this paper. It is capable of reading temperature between 0 - 50℃ and humidity range of 20-80%[10]. The data read from a fire break rises to more than 50 C, which aids in figuring out if there is fire. Along with this, we have also embedded a flame sensor in the system which identifies any light source radiating infrared radiation. A forest fire is a good source of IR rays which aids the flame sensor to be suitable for the proposed system.

The primary task is to recognize if the tree is getting smuggled by the poachers. For this reason, we have a vibration and tilt sensor that will identify the motion in the tree caused during sawing and if there is any change in the axis of the tree while timbering it down. These sensors are very cheap and accurate in the working, such that the attached client module can receive the data as soon as possible to process it.

The client module is a NodeMCU, which has an in-built processor along with a TCP/IP stack to provide Wi-Fi accessibility. All the sensors have a connection to this module where the data received by the client can be processed to produce the appropriate message. Among the above sensors, we also placed a GPS module to detect the location of unrest. The GPS module only activates when there is a rise in temperature or humidity along with flame detected in the region. The GPS is also triggered when there is a difference in the axis of the tree along with vibration caused due to sawing it. Both these factors initiate the proceeding of further methods of calling in the authorities to the GPS location.

To carry the change in the forest to the officials, we have a chain of clients and servers situated in the vicinity. Each client node is attached to the trees of interest while adding the server to other nearby remote locations. The placement of servers is in such a manner that no one spots and removes them to create any disturbance in the associated network. After the client has produced the information, it will try to establish a connection with the nearest server. When the set up of the link is over, the transfer of the message initiates to that server. The server, which is an ESP-01, receives this information and processes it along with other earlier pieces of information. It will instruct the ESP-01 to take the necessary route for that particular message, which will lead to the authorities. This way, the server will collect the incoming information and processes it to find the proper path to reach the destination. The following fig 1 of flow diagram depicts the interaction between the sensors connected to the NodeMCU module, the server interactions, and the end of the system, the user.

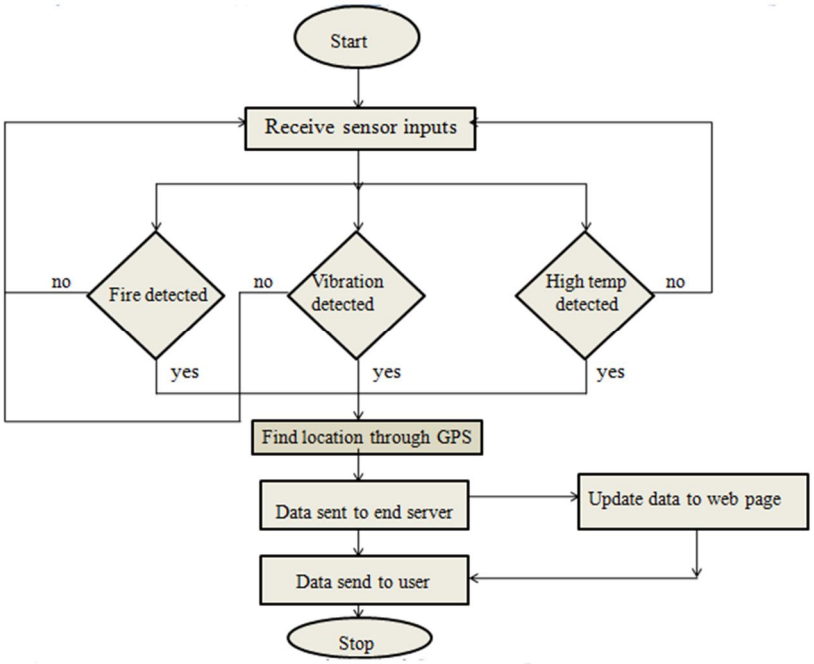

Fig 1: Flow Diagram of Tree Section

B. Animal Section

This section is very much similar to the working of the tree section with few distinctions. These distinctions are concerning the sensors used in the prevention of anti-poaching of wild animals. Also, the continuous monitoring of animal health was deemed necessary. To cover these issues, we have embedded sensors that are very small in size, given the animal has to wear the system. They include a temperature sensor, an RFID tag, and a GPS module, all connected to the NodeMCU module. The operating temperature sensor is an LM35, which is a precision integrated-circuit whose analog output voltage is directly proportional to the temperature. There is no need for any external calibration circuitry and gives an output in Celsius[13]. It also provides a very accurate and precise value of temperature for reading the health of the animals. The RFID tag is simple hardware that makes use of electromagnetic fields to identify and track the object that is attached to it. It consists of a tiny transponder, a radio transmitter, and a receiver that aids in continually communicating with the RFID reader. A unique tag is related to RFID, which is applied to identify the object it is attached to, in this case, the animals. Finally, the system employs a GPS module that helps in locating the animals and providing the entire whereabouts of it. The following flow diagram shows the course of data in the system until the point of reaching the user.

All the sensors connect to the NodeMCU module, where the data processing takes place and generates the message. The threshold, in this case, is for the temperature sensor and GPS module. For the temperature sensor, the focus is on animal health to determine whether it is feeling sick or if it is hyper activating in the state of being poached. Furthermore, there are possibilities to identify if the animal is dead or alive such that the authorities can aid them earlier. In the GPS module, setting up the threshold to be the boundary of the sanctuary, which will ensure animals stay within reach of the authorities. It also helps in learning the habitat of the animal and also creates a better understanding between humans and animals. These sensors interact with NodeMCU the data and using which an appropriate message is produced depending on the thresholds. After the creation of the information, the NodeMCU then establishes a connection with the nearest server and sends it. All this takes place in the vicinity of the client-side, where the end-user message gets generated for transmission.

After sending the data to the end-server in both cases, reaching the data to the authorities is the final task. The location of the end-server is necessarily close to an active internet. This way, the major part of the system, which is in the remote location and where the internet connectivity does not exist, can send the data to the end-server to reach the authorities. With the help of this network, the appropriate information that includes the message along with the GPS location of that particular position is sent to the concerned officers. This way, necessary actions can be taken immediately and keep the forest and wildlife protected

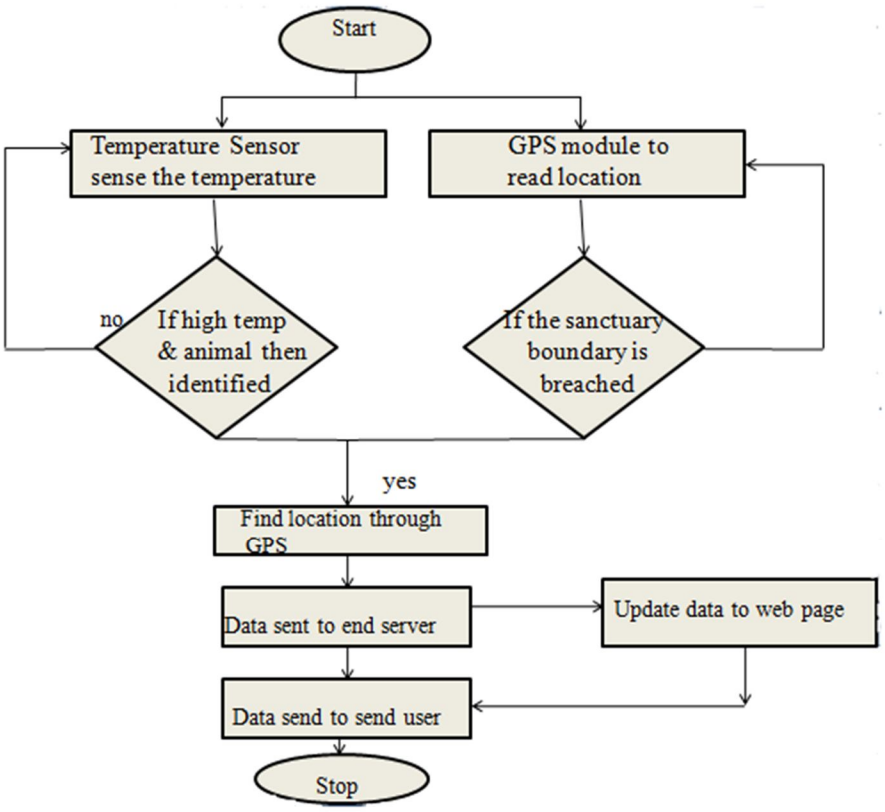

Fig 2: Flow Diagram of Animal Section

IV. RESULT

During the procedure of the project, there were many problems and rectifications made to get it working. The issue regarding the remote area because of which there would be no internet connectivity to the client-server location. The system solves it by making a network of the server, which will collect the data and transmit it to the server nearby an active internet connection. With this, there is a decrease in the cost required to provide the internet to each node. It also accounts for reduced data flowing into the network, avoiding the jamming of the communication channels. Since the sensors are continuously read and processing of the data at the client location, it helps in energy efficiency and easy maintenance at the client-side. The deep-sleep mode feature provided by the ESP8266 modules also accounts for the saving battery power. The system was found to encounter slight latency due to the establishment of connection by the interacting Wi-Fi modules.

The sensor data collected at each period are no longer necessary for any future processing; hence these data are thrown out, providing less memory to store the values. As the system uses tiny modules such as an ESP-01, Flame sensor, DHT11, GPS module, LM35, NodeMCU, and an RFID tag, it is easy to place at small locations and hides it from the world. At the end-server, the connection made to access the internet aids to pass the message into the cloud and finally using an applet to access it and send an SMS alert to the officials. The registration of the contact details of the officials is necessary to receive the warnings. The warnings include the message associated with the problem at hand and the location of the source and can directly lead the officials to the place of concern.

V. CONCLUSION

The proposed system in this paper endorses a system that is far more real-time in the given situation. Many ideas and attempts worked into the system to provide the sort of performance that verifies and validates it. The trees and animals are the main priority for the method and help everyone to get close to our nature. The sensors and modules aid at a reasonable cost for the process to work and will be very affordable to the authorities of the forest. Even though the system encounters a slight latency due to the establishment of connection every time the Wi-Fi modules receive the data, it is far effective than other proposed methods. This latency can also be negligible with further improvements and will bring about better sensor technology in the future. The battery power necessary to run the system is also negligible since the power-driven by the modules is in terms of milliamps. The process of sending SMS alerts to the officials can also be moved to better technology. With technology, we can also move to the betterment of the nature and surroundings around us to create a better place for everyone.

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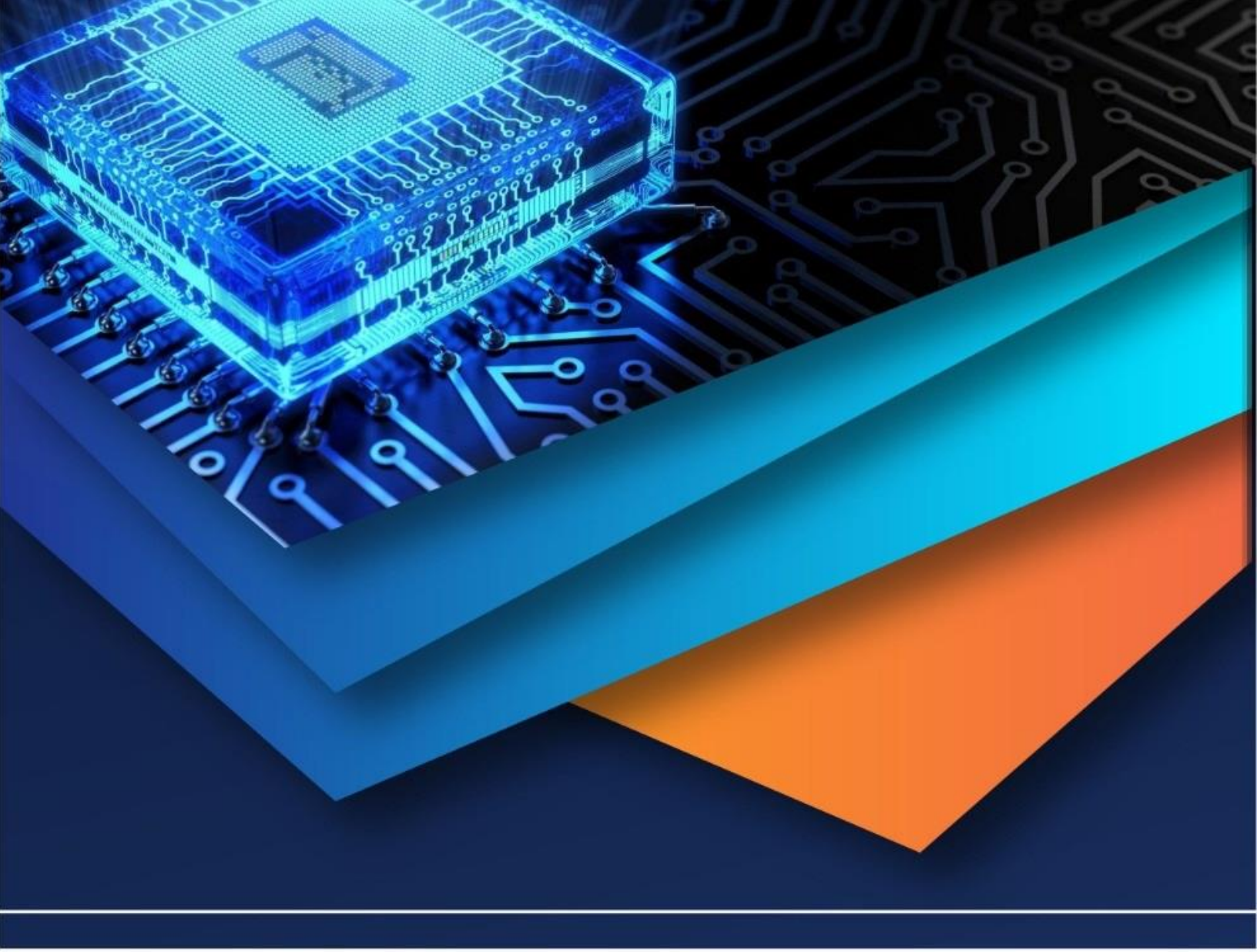

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