IOT NETWORK PROPOSAL FOR THE IDENTIFICATION, MONITORING AND LOCATION OF CROCODILES IN THE ESTUARY OF PUERTO VALLARTA, JALISCO, MEXICO

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ABSTRACT

In the city of Puerto Vallarta, in Mexico, there are crocodiles, distributed in the Bahía de Banderas area, between the states of Nayarit and Jalisco. Man invaded their habitat, forcing them to look for those spaces they naturally occupied, generating confrontations. This work describes and gives the background of the problem, as well as a possible way to mitigate the situation, the use of IOT technology is proposed to monitor the location of each crocodile and the definition of risk zones to warn of possible dangerous situations. Therefore, the design proposal of a network of wireless sensors for the monitoring of crocodiles that are found in the area of the estuary and the Marina, which is an area surrounded by commercial and residential areas, is carried out. The use of a LORA network is proposed, since the coverage of the Coast, mangrove swamp and Marina is around 8 km. Also, a star topology with a single hub and a gateway node was chosen to send the data to a server. A NoSQL database service such as Firebase and data visualization software using React Native are proposed. The data of interest for the project will only be the latitude and longitude provided by the GPS and that will be decoded through an mkr 1300 development card. With the application of the project it is possible to know the behavior of the reptiles, act quickly in case that the crocodiles are outside their natural area and notify Civil Protection.

KEYWORDS

IoT, Wireless Sensor Networks (WSN), react native, LoRa WAN, animal monitoring.

1. INTRODUCTION

1.1. Description of the Problem

It was 1861, the date on which a whaling ship docked in its waters documented in its log the occurrence and abundance of reptiles in the Bahia de Banderas area in Mexico [1], where the city of Puerto Vallarta is located today.

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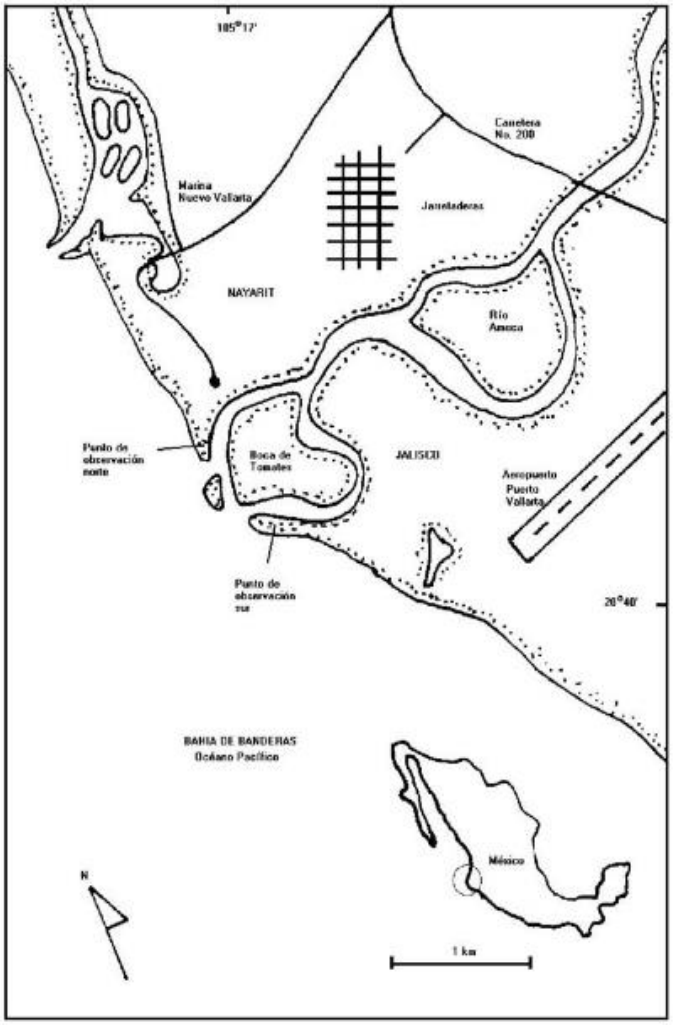

Fig 1. The Boca Negra Estuary on the north coast of Jalisco, flanked by the Puerto Vallarta airport and the mouth of the Ameca River (Boca de Tomates) [2].

In 1930, the commercial exploitation of furs for export began, but in 1970 the ban was decreed by the Mexican government. In the sixties of the 20th century, the region experienced an explosive growth of massive influx of local and foreign tourism, pollution of rivers and streams as well as expansion of the urban sprawl. This increases the chances of people and reptiles coming into contact and generating situations of conflict or attacks, mainly in urban areas near rivers, streams, estuaries, and ponds[1].

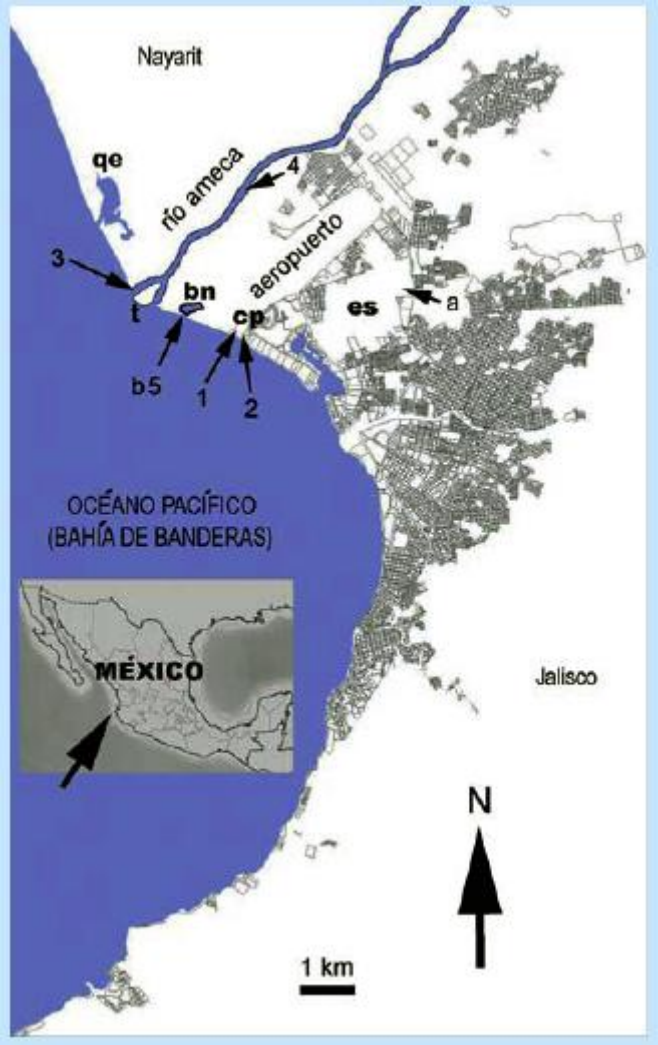

Fig 2. Location in Mexico and location of the urban sprawl in Puerto Vallarta, Jalisco, on the Pacific Ocean coast (Bahía de Banderas)[1].

For a period of 49 years (1958-2007) between 25 and 26 crocodile attacks have been documented on the Jalisco coast, three of them with fatal consequences, two attacks occurred during the reproductive season of the species; nine in hatching season; in six incidents, the victim fished with the water level at or above his waist and, in three of these nine events, the fisherman was holding onto the fish[1].

some studies argue that the recovery of crocodile populations is directly related to the increase in conflicts between man and crocodile; In addition, it highlights that this risk increases due to the loss of habitat experienced by the species, due to the occurrence of large-sized specimens, due to forced conditioning of the crocodile by feeding it in natural spaces (imprinting), due to the recklessness and trust of people when making use of of spaces where the reptile lives, among others [1]

When taking into account the maximum counts of animals obtained in various studies [2] Conducted in the El Salado, Boca Negra, Boca de Tomates, El Quelele-Chino estuaries and golf course water traps, there are about 250 specimens in the entire Banderas Bay, between Nayarit and Jalisco, of which 35 are adults , 15 females and 20 males, in addition to the fact that the

percentage of development is very low, it has been built on its habitat, thereby reducing its possibility of reproduction and growth, forcing it to look for those spaces that it naturally occupied.

Based on [2]and [1] , they propose that the increase in conflicts between man and crocodilians is, in part, a product of the growth of reptile populations, modifications to their habitat, the increase in the human population and recreational activities near the water, among others. There have been 5 cases of crocodile attacks in Puerto Vallarta documented on golf courses and within the estuary, resulting in people being affected and in more serious cases amputations of a limb.

In [1] 5 crocodile attacks on humans are documented that occurred between 2007 and 2010, however, sightings and captures of at least three more have been reported in local and national newspapers between the years 2018 and 2022 [3],[4],[5]y[6].

According to [7] Among the variables that can be measured in wildlife, the position in space and time is one of the most important, since it allows inferring the relationship of individuals with their environment.

Given the difficulty of obtaining information on the positions of individuals in wildlife populations, the most viable alternative is to deploy a wireless sensor network (Wireless Sensor Networks). WSNs are a collection of sensors, with their own power supply, wireless communication, as well as data storage and processing capabilities.

One of the main advantages of WSNs is that they do not require direct intervention to establish communication between network nodes and send data. Working together, a network can provide spatial location information using global positioning systems (GPS) [7], using different standards and protocols, for example WiFi, Bluetooth, ZigBee, LoRa, etc. Within the same Network we can use a combination of wireless technologies and different topologies for the distribution of nodes [8]. According to [9] WSNs are star, tree and mesh or hybrid topologies, in this way a star topology in which the outdoor gateway is in the center of the WSN, so that the received data can be sent to the internet or some other communication system.

The importance of the project lies in the fact that some specimens of this species often leave the limits of their natural habitat, recording sightings in various places and being dangerous for other smaller-scale animals such as dogs, cats or even attacks on humans by these predators. Obtaining the approximate location where the crocodiles are found helps reduce some accidents or scares for tourism that visits the Puerto Vallarta marina area and monitor the behavior of these reptiles.

The data of interest for the project will only be the latitude and longitude provided by the GPS.

The final user interface contemplates a mobile application that can be intuitive and easy to use for the Department of Civil Protection, generating alarms and reports every so often, to know the behavior of reptiles, act quickly in case crocodiles They are outside their natural area and notify Civil Protection specialists for their reincorporation into their habitat. Furthermore, it should not only be used as a monitoring method but also to safeguard this species and predict its behavior in its natural state.

1.2. Background of the WSN

There are several companies dedicated to monitoring wild animals such as penguins, birds, sharks, whales, rhinos, among many others. One of the most important examples of this type of tracking company is WildLife Computers [12] developing specific technology with UHF/VHF

for its Argos, Fastlock and GPS units modules. Its operation is focused on sending data by UHF/VHF through of the GSM/GPRS protocol and the monitoring costs will be applied according to the number of data sent per day to your server and database.

On the other hand, Wireless Wildlife [13]expresses importance of South Africa in animal monitoring applies the development of sensor nodes with UHF and GPS technology, receiving the data periodically manually or automatically, like the previously mentioned company charging for tracking It implies the number of messages that are sent daily, so if an animal is monitored in short periods of time, the cost of the application increases considerably.

Also many projects have been developed to monitor animals for livestock use such as cows, goats, sheep, among other specimens. One is developed by [10], which is a wireless electronic system to monitor and control livestock in real time through a website. The system comprises two main blocks, the first for acquisition-processing and the other for communication. The prototype was an intelligent collar that allows monitoring the state of the livestock, by means of the MLX-90614 infrared sensor information on body/environment temperature is obtained, the NEO-7M GPS acquires speed and location values. The HC-SR04 ultrasonic sensor provides distance values that are necessary for decision-making in the detection of the estrous stage of livestock, while the GSM/GPRS SIM900 module allows the connection for sending and receiving information processed by means of a Arduino Micro to a cell phone and a database hosted on a web server.

Another one is [11]at Australia Zoo, the University of Queensland and Queensland Parks and Wildlife undertook a project to monitor the movements and behavior of estuarine crocodiles in Lakefield National Park. The aim of the study was to provide better information on how adult estuarine crocodiles interact within a river system, allowing informed decisions on how to manage crocodile populations. To monitor their movements in the wild, novel technology was used that uses implanted transmitters and remote listening stations. A total of 27 adult estuarine crocodiles between 2.1 and 4.86 meters in length were taken along the Kennedy River and adjacent tributaries. A miniature electronic device was implanted under the skin that transmitted a sonic pulse containing information about animal identification, body temperature, and diving data. Underwater listening receivers were deployed along the Kennedy River and these continuously listened to the devices carried by the crocodile. The receivers had a limited range and only collected the data when the crocodile was swimming within 100 metres.

The transmitters, which were implanted in the crocodiles, had a one-year battery life and vast amounts of data were generated from the 27 tagged crocodiles. Of the 19 males that were tagged, some maintained a small home range of only a few kilometers of river, while others traveled back and forth along the entire stretch of the river. They could travel more than 60 km in a single night and stay at sea for a few weeks before returning to the river.

2. METHODS

For this project, interviews were conducted with personnel related to the Department of Ecology, as well as Civil Protection and related authorities; following the proposal of life stories of [14]a type of empirical research based on field work, this perspective focuses on what is called the category of situation, that is, strategies, suggestions and recommendations for the protection of both the crocodiles like human beings. The interviews were conducted during April and May 2021 in Puerto Vallarta, based on a semi-structured script that was adapted according to each interviewee. The subjects were selected based on their relationship with the protection of fauna and Civil Society in Puerto Vallarta, analyzing the needs of the system.

As the needs and demands of the system were expressed, in terms of telecommunications and protocols, a comparison was made with other technologies such as Zigbee and SigFox, so LoRa was chosen for coverage, cost, energy savings and architecture used. It was decided to propose a LoRa network, since it is a transmission technology that allows long communications of more than 15 kilometers with a reduced power consumption that allows a battery life of approximately up to 10 years, depending on the use.

Comparison of range and power efficiency with respect to other technologies is shown in Fig 3.

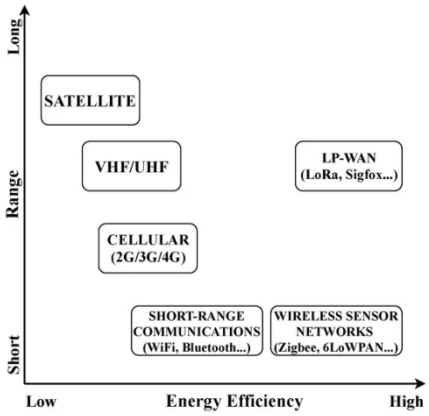

Fig 3. Comparison of transmission range and power efficiency provided by different communication technologies used in maritime scenarios[15]

Animal monitoring fits perfectly to the main precepts of IoT systems: (i) need for long-range transmissions; (ii) reduced use of bandwidth per message; (iii) limited number of messages per node per day; (iv) a large number of end devices connected simultaneously, and (v) low-cost end devices. [15]

3. RESULTS

3.1. Network Design Proposal WSN

For the nodes that the adult reptiles will carry within the Puerto Vallarta marina, the use of an Arduino MKR 1300 that combines the MKR Zero and LoRa connectivity functionality is proposed. This open source board can be connected to: the Arduino IoT Cloud, your own LoRa network using the Arduino LoRa PRO Gateway, LoRaWAN ™ infrastructure like The Things Network, or even other boards using direct connectivity mode. Some of its characteristics are shown below in Fig 4:

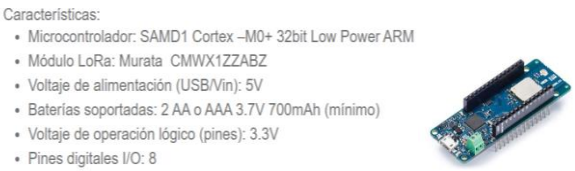

Fig 4- Characteristics of MKR 1300

One of the characteristics for which LoRa was chosen as the communication protocol for this project was because of the coverage area, since it is around 8 km from the coast, therefore, since

the murata modules can communicate up to 15 km in line of sight, they are feasible for use. Fig 5 shows the area to be monitored from the estuary on the Ameca River to the Vallarta Marina.

Fig 5.- Area to be monitored with the project

For the transmission of latitude and longitude data, the GPS module was used in its GY-GPS6MV2 model. In fig. 6 shows the GPS module used:

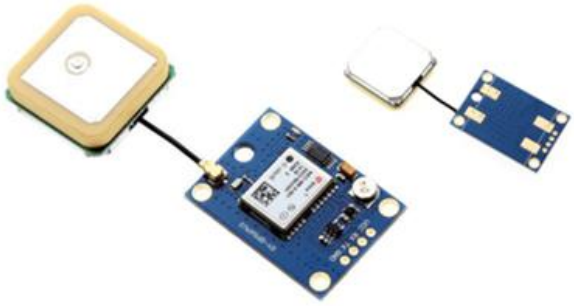

Fig 6.- GPS NEO 6M

Therefore, each of the sensor node modules will be made up of an MKR1300, a GPS module and a 3000 mAh battery, in such a way that using the configuration in deep sleep the MKR 1300 can last about a year sending data to the gateway correctly. This is defined by equation 1:

$$Duration\ (hours) = \frac{0.7 * Batterycapacity\ (mAh)}{Iaverageconsumed\ (mA)} \qquad (1)$$

Equation 1.- Average lifetime of a sensor node

Being the average current equal to the consumption at rest (deep sleep) plus the consumption when the MK1300 module is activated, the tests carried out found that in deep sleep mode it consumes 30 $\mu A$and in active state around 60 mA. Assuming a 3000 mAh battery, it would have a lasting capacity of 437 days.

To receive data from adult reptiles, the gateway DLOS8 LoRaWAN Open source outdoor It allows you to connect LoRa wireless network to IP network via WiFi or Ethernet, which can be used as a gateway for TTN or can communicate with ABP LoRaWAN server LoRaWAN. The system integrator can use it to integrate with their existing IoT service without setting up their own LoRaWAN or using a LoRaWAN . [16]

Fig 5 .- Dragino DLO 58 Gateway

In a LoRaWAN , the end devices, which have one or more sensors or actuators connected to them, are the so-called nodes that connect to gateways and these in turn send all the information they receive to a server, which, through an application interface or API, in turn delivers the data to a final application for the user. We can therefore distinguish the following elements in a LoRaWAN: end nodes, gateways, network servers and application servers.[17]] The typical network architecture is a Star Network network, so that the first star is made up of the end devices and the gateways, and the second star is made up of the gateways and a central network server. In this case the gateways are a transparent bridge between the end devices and the central network server.

Fig 6.-Star topology with a single gateway

The following objectives were set: to maintain a history of the censused data, high-speed data updating and offline mode access. Based on this, Firebase was chosen as the database for storing the collected data. One of Firebase's tools is real-time databases[18]. These are hosted in the cloud, are No SQL and store data in a JSON-like format. They allow the data and information of the application to be stored and available in real time, keeping them updated even if the user does not perform any action.

Firebase automatically sends events to applications when data changes, it stores the new data on disk. Even if there was no connection for a user, their data would be available to the rest and the changes made are synchronized once the connection is re-established.

Among the objectives of the use of React are: cross-platform visualization: mobile, web and desktop and code reuse on different platforms. Based on this, react native was chosen as the application development framework to notify and visualize data. React Native is a JavaScript framework to create real native applications for iOS and Android[19], which can run directly on native mobile platforms, in this case iOS and Android. What you end up with as a result is a real application that is native, and can run on a web platform.

4. DISCUSSION

As mentioned above, there are international precedents, from private companies, in particular 2. The proposal of this work has several advantages, the main difference with similar projects such as livestock monitoring, is that related state-of-the-art technologies are used. to IOT environments, Cloud Computing, WSN networks and mobile applications in the generation of a WSN network that does not increase the cost per message sent by each of the nodes, that is, a free network which is not limited by the number of messages sent as it can be with GSM or SigFox, a low energy consumption due to the type of reptile that is being monitored, a scalable network according to the needs of the project and a necessary scope to cover the entire area. One of the most important disadvantages would be the 1-year battery life, however there is the possibility of innovating in the form of energy generation or storage for mobile devices, which would allow the maintenance period to be extended

The duration of the battery is an aspect with possibilities of improvement, to increase its duration, possibly analyzing the possibility that the signal emission is intermittent, and seeking to find the most efficient intermittency periods to consume less energy and continue providing the proper date.

5. CONCLUSIONS

It is considered that this work pays in 2 important aspects, the protection of the inhabitants and tourists in the area, as well as the protection and control of the crocodiles themselves. The proposal is designed to provide the corresponding authorities with a tool that allows them to be alert, have updated information in real time, and make decisions and take action in a timely manner to reduce or prevent attacks.

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