

WIRELESS SENSOR NETWORKS, REACTJS AND FUNCTIONAL PROGRAMMING FOR MONITORING OF WILD ANIMALS IN PUERTO VALLARTA, JALISCO, MEXICO

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ABSTRACT

In the city of Puerto Vallarta, in Mexico, there are wild crocodiles living near to human settlements This work describes and gives the background of the problem, It is proposed to monitor the location of each crocodile. es proposed the use of functional programming, clojure/clojurescript and reagent to create reactjs app and seize the advantages of functional programming in Design of Graphical interfaces, also the design proposal of a network of wireless sensors for the monitoring of crocodiles is carried out. The use of a LORA network is proposed, 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 visualisation 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.

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.

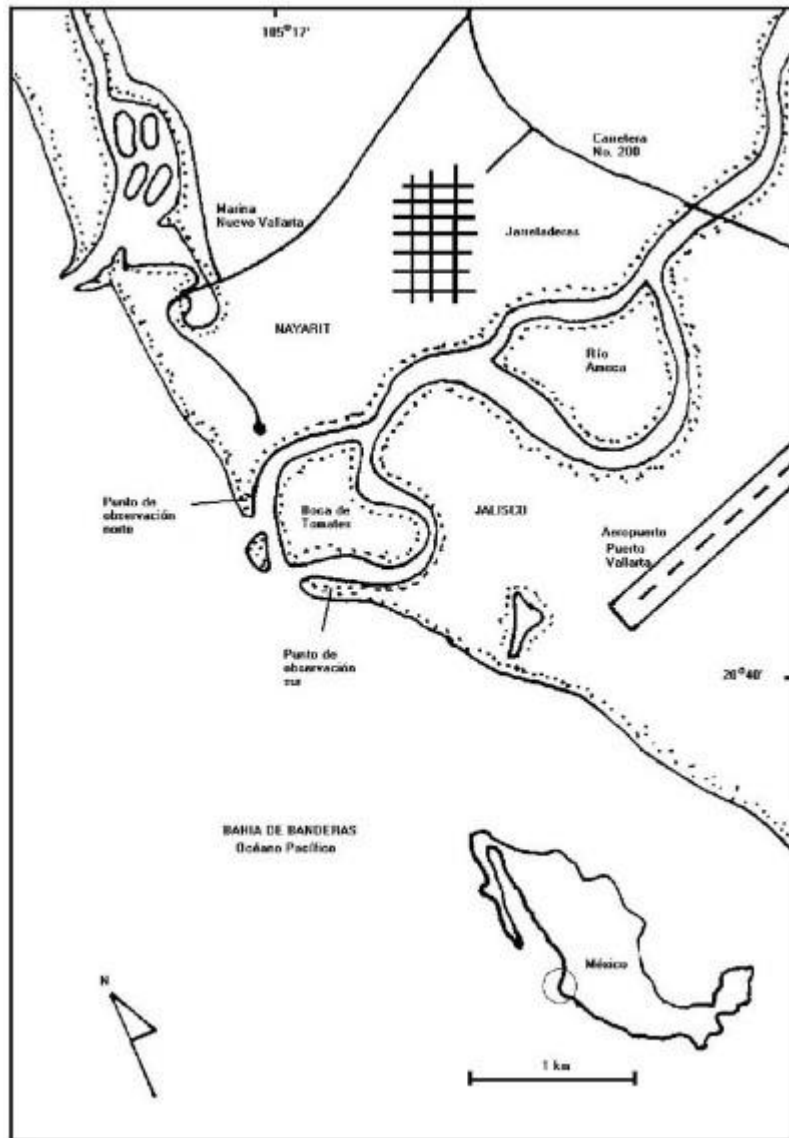


Fig 1. The Boca Negra Estuary on the north coast of Jalisco, flanked by the Puerto Vallarta airport and the mouth of the Ameca River (Boca de Tomates) [2].

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 spaces where the reptile lives, among others [1]

Despite this outlook, there is no crocodile management plan in the region. It is also known, due to information from the University of Guadalajara (U de G), that there are only 45 adult crocodiles in the area that measure more than two meters. Regarding the number of nests, they do not exceed a dozen, which also represents a low quantity. Also, there are about 100 young

crocodiles. It is estimated that one crocodile for every 100 reaches adulthood, although this figure could be lower in the area, he stressed and qualified that there should also be no exponential growth of the species.

“In the last thirteen years we have had more than 15 dead crocodiles, all of them greater than two and a half meters. They have died run over, machetes, or captured with hooks made with construction rods”, and some have even been shot.

In the words of Hernández Hurtado (biologist from the U of G) he explained that this region is an area of crocodiles, whose name of said species is "river crocodile" (*Crocodylus acutus*), which is the most abundant species in the region. and in the Mexican Pacific. The academic and researcher commented that they have worked with around 120 newborn individuals, which were marked, released into the ecosystem and it was known where they were. In five months "85 percent of the population had been lost," he denounced. He explained that there are various factors that prevent crocodiles from reaching their adult stage, such as natural predators: crabs, birds, fish, dogs, badgers, among others; In addition, infrastructure development has fragmented their transit and habitat sites. Regarding human pressure, he explained: “We have found nests where people, in a syndrome of madness and destruction, arrive and kill everyone. We have found a whole clutch, about 35 squashed crocodiles.”

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 [10] 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 [11] 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 [12], 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 [13] at Australia Zoo, the University of Queensland and Queensland Parks and Wildlife undertook a project to monitor the movements and behaviour 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 travelled 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.

1.3. Clojure, Clojurescript, Reagent and Functional Programming

Clojure

Clojure is an effort in pragmatic dynamic language design in this context. It endeavours to be a general-purpose language suitable in those areas where Java is suitable. It reflects the reality that, for the concurrent programming future, pervasive, unmoderated mutation simply has to go. Clojure meets its goals by: embracing an industry-standard, open platform - the JVM; modernizing a venerable language - Lisp; fostering functional programming with immutable persistent data structures; and providing built-in concurrency support via software transactional memory and asynchronous agents. The result is robust, practical, and fast [14].

Clojurescript

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Advantages of clojurescript

Performance

Because of Google Closure compatible code, apps written in ClojureScript tend to be more efficient concerning the size of the codebase and unused libraries than ones in JavaScript. In addition to this, using immutable data structures gives ClojureScript a great advantage when it comes to comparison of data. The equality comparison of immutable data structures is faster than comparison of mutable ones since shallow comparison is enough to determine if there have been changes [16].

Scaling and modularity

Since pure functions do not have side effects and they only take in data and then return data, they are easily reusable

Better code organisation

Clojure/clojurescript provides better language constructs for organising software correctly (without causing undue pain for the working programmer) in comparison with C, C++, Objective-C, Java, JavaScript, Python, Ruby [17].

Faster development

Clojure is expressive, its code is clear, concise, and easy to understand. This can make it easier to write code quickly and efficiently, and consequently launch your product faster [18]

Less error prone

Clojures expressiveness helps reduce the risk of errors and bugs. It also has on average 10 times fewer lines of code than a traditional language like Java and typically fewer lines of code is directly proportional to the number of bugs. Hence, developing in Clojure will save you (lots of) work in the long run [18]. Most of our source code can be understood locally, any given pure function, by understanding its outputs for any set of inputs. There is rarely a need to reason or recreate the internal state of objects. Information moves through the system in a consistent and immutable way, making it easy to compose and inspect (without encapsulating it) [19].

Functional code is much easier to test. That gives some companies the confidence to implement an average of 50+ changes per day per microservice.[19].

Better Retention of code

it has such strong fundamentals and design, that if you build a product built in Clojure, you will rarely have a need to go back and remove old lines of code. Instead, you can focus on adding new lines of code and keep scaling the product. [18] Clojure has simple constructs that allow us to focus on the problem we are solving. Thus making system evolution an incremental challenge: it gets easier over time[19]

High learning Curve

This could have been taken as a disadvantage, because Clojure does take longer to learn than a more traditional programming language, it is not a language that typically attracts beginner developers. It is known for attracting people with genuine interest in technology and science, after that knowledge is gained, it will allow your team to operate faster and with fewer errors. [18]

Reagent

Reagent ,is a ClojureScript wrapper for Facebook React, brings another key feature in the ClojureScript ecosystem. Reagent also abstracts difficult concepts from React and brings its own version of reactive programming to you.[20]

Reagent uses Hiccup data structure, explained in detail in chapter 3 (3.1.2 Components), to create HTML by using nested Clojure vectors as HTML elements (10). It makes it possible to write UI code almost only with ClojureScript functions. Reagent components are essentially pure or almost pure ClojureScript functions that take parameters as basic Clojure data types. Reagent

components re-render only when their data changes, which together with ClojureScript optimising enhances the software performance to a point where one rarely has to think about it [16].

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 [21] 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.

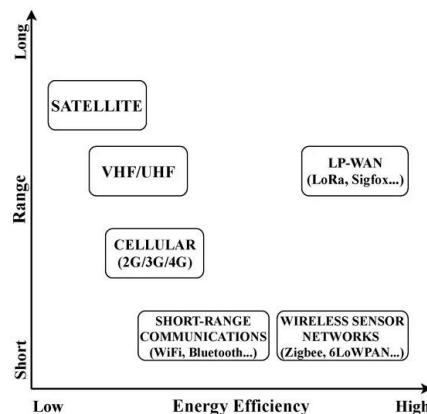


Fig 3. Comparison of transmission range and power efficiency provided by different communication technologies used in maritime scenarios[22]

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. [22]

How Reagent works

It is mandatory add reagent as dependency in project manager preference, leiningen, boot, clj, shadow-cljs, exist templates that have a common configuration for por web apps in clojurescript or clojure, such include reagent and re-frame by default.

In a main clojure file, typically core.cljs, is mandatory import reagent.core. To do that in clojure/clojurescript is using the “require” function.

```
1 (ns test.app
2   (:require
3     ["expo" :as ex]
4     ["react-native" :as rn]
5     ["react" :as react]
6     [reagent.core :as r]
7     [shadow.expo :as expo]
8     ;[cljs-http.client :as http]
9     [react-native-elements :as el]
10    [re-frame.core :as rf]
11    [reagent.core :as rt]
12    [reagent.coercion :as rc]
13    [reagent.coercion.spec :as rss]
14    [reagent.frontend :as rtf]
15    [reagent.frontend.controllers :as rfc]
16    [reagent.frontend.easy :as rfe]))
17
```

fig Requiring reagent [23]

On line 2 is calling require function and in line 6 is indicating the need for reagent.core with an alias “r” for short to create a component in reagent There are three ways [24] Ordered by increasing complexity, they are:

- via a simple render function - data in as parameters, and it returns HTML.
- via a function which returns the render function - the returned function is the render function.
- via a map of functions, one of which is to render the rest of the functions are React lifecycle methods which allow for some more advanced interventions.

The most common is number 1 and almost always is the only way is indeed.

```
(defn greet
  [name] ;; data coming in is a string
  [:div "Hello " name]) ;; returns Hiccup (HTML)
```

fig. form 1 of Creation of componente in reagent [24]

Actually the component is only a clojure function that return the last line of code Hiccup uses vectors to represent HTML elements, and maps to represent an element's attributes. [24]

So this clojurescript data structure:

```
[:div {:style {:background "blue"}} "hello " "there"]
```

is simply a clojurescript vector, containing a keyword, map and two strings. But when processed as hiccup, this data structure will produce the HTML: <div style="background:blue;">hello there</div> you can create complex Components to define better Graphical interfaces

```
(:require [reagent.core :as r]
          [reagent.dom :as rdom]
          [clojure.string :as str]))

(defonce timer (r/atom (js/Date.)))

(defonce time-color (r/atom "#f34"))

(defonce time-updater (js/setInterval
                      #(reset! timer (js/Date.)) 1000))

(defn greeting [message]
  [:h1 message])

(defn clock []
  (let [time-str (-> @timer .toTimeString (str/split " ") first)]
    [:div.example-clock
     {:style {:color @time-color}}
     time-str]))

(defn color-input []
  [:div.color-input
   "Time color: "
   [:input {:type "text"
            :value @time-color
            :on-change #(reset! time-color (-> % .-target .-value))}]]])

(defn simple-example []
  [:div
   [greeting "Hello world, it is now"]
   [clock]
   [color-input]])
```

fig Code of Digital Clock web App [25]



fig Visual Result of Code of Digital Clock web App [25]

Creating Reagent "Components" from React Components

The function `reagent/adapt-react-class` will turn a React Component into something that can be placed into the first position of a Hiccup form, as if it were a Reagent function. There is also a convenience mechanism `>` (colon greater-than) that shortens the use of a react component and avoid some parenthesis. [26]

```
(defn top-articles [articles]
  [:> FlipMove
   {:duration 750
    :easing "ease-out"}
   articles])
```

fig Creation of a Reagent "Components" from React Components [26]

```
const TopArticles = ({ articles }) => (
  <FlipMove duration={750} easing="ease-out">
    {articles}
  </FlipMove>
);
```

fig javascript version of custom component using react component [26]

reagent and react-native with reagent we also can create react-native components [25] the syntax is similar to reactjs component

```
[:>ReactComponent Props]
```

is what you would typically do. There are a few caveats you should be aware of: If the react component calls any callback handler you might have specified in props, the data you receive in your fn is a JS object. [27]

Using Reagent with React Native can provide several benefits. Reagent allows you to write React Native apps using ClojureScript. This means you can take advantage of the features of ClojureScript, such as its powerful macro system, immutable data structures, and functional programming paradigm. Additionally, Reagent provides a simple and intuitive way to manage state and create reactive components, making it easier to build complex user interfaces. [32]

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:

Características:

- Microcontrolador: SAMD1 Cortex –M0+ 32bit Low Power ARM
- Módulo LoRa: Murata CMWX1ZZABZ
- Voltaje de alimentación (USB/Vin): 5V
- Baterías soportadas: 2 AA o AAA 3.7V 700mAh (mínimo)
- Voltaje de operación lógico (pines): 3.3V
- Pines digitales I/O: 8



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:

$$Duration (hours) = \frac{0.7 * Battery\ capacity (mAh)}{I\ average\ consumed (mA)} \quad (1)$$

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 μA 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 . [28]



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.[29]] 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.

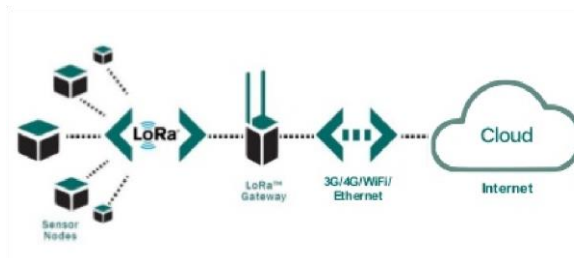


Fig 6.-Star topology with a single gateway

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[30]. 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[31], 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 analysing 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.

Using Reagent with React Native can provide several benefits. Reagent allows you to write React Native apps using ClojureScript. This means you can take advantage of the features of ClojureScript, such as its powerful macro system, immutable data structures, and functional programming paradigm. Additionally, Reagent provides a simple and intuitive way to manage state and create reactive components, making it easier to build complex user interfaces

5. CONCLUSIONS

In this work is analysed alternative to javascript to develop mobile app using the reactjs framework this give the possibility to continue in 2 possible ways, user apache cordova to show the reagent web app in mobile devices with a webview or go for the native version o reactjs, react native, to get a better performance, both option are multi platform. Also this work marks 2 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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