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Developing a Smart Integrated Animal Tracking System Using Smart Sensors to Effectively Localize Humans(Students) for Various Applied Purposes

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INTRODUCTION

What is animal tracking?

It is basically tracking or navigating the location of animals moving in groups or individually. The data allows us to better understand and keep track of their movements while the animals move within communities, migrate across seas and continents, and adapt over generations. This data is being utilised to address environmental issues such as climate and land use change, biodiversity loss, invasive species, animal trafficking, and disease spread.

What is IoT?

The Internet of Things, or IoT, is changing our way of life, from how we react to how we act. IoT is a system for linking computing devices, machines, any technological objects, animals, and humans who are outfitted with RFIDs for unique identifiers by transmitting data in a network without requiring human-to-human or human-to-computer interaction. Air conditioners that we can manage with our phones, smart autos, and smartwatches that track our everyday activities are just a few examples. The Internet of Things (IoT) is a vast network of interconnected devices. These gadgets collect and communicate information on how they're utilized and the environment they're in, IoT smartphone sensors, which are incorporated in every physical device, are used to do this. It might be our cellphones, electrical appliances, barcode sensors, traffic lights, and anything else we encounter in our daily lives.

These sensors continuously output data regarding the state of devices' operation, but the key concern is how they communicate data, particularly large amounts of data, and where do we place it. To our advantage, the Internet of Things provides a single platform for all of these devices to dump their data and a common language for them to speak with one another. The data collected by various sensors are forwarded to the IoT Inter-Integrated Platform. IoT platform integrates data acquired from multiple sensors, does further analyses on the data, and extracts important information as needed. This data is shared with other devices to improve the user experience, automate processes, and increase efficiencies. Any person with a heart monitor implant, any animal with a biochip transponder, and any vehicle with built-in sensors for warning the driver can all benefit from the Internet of Things.

How IOT helps in animal tracking

It helps with tracking and navigating the real-time location of cattle by using various technological devices such as IoT cattle collars, ear tags, or even other location-tracking devices with GPS and geolocation capabilities.

IoT gives the ability to access information from anywhere, at any point of time on any device and improves communication between connected electronic devices. It can also transfer data over a connection by saving time and money. IoT automates tasks, which helps to improve the quality of business services and reduces the need for human intervention.

Due to the above-mentioned reasons, IOT is proven to be very helpful for animal tracking.

TECHNOLOGIES USED:

1)LORA:

- Lora is an abbreviation of Long-range.
- It is a low-power wide-area network modulation technique.
- Lora is based on spread-spectrum modulation (derived from CSS technology).
- Lora is a proprietary radio modulation technology owned by Semtech and deals with only the Physical layer of the stack.
- LoRa nodes are devices with the LoRa radio modulation capability along with sensors and microcontrollers.
- The LoRa nodes to gateway connection are in the form of a star network and the nodes cannot talk to each other directly.
- Also, the communication between the gateway and the nodes is bidirectional, so that we can also get the nodes to perform some actions like turning on some status lights and so on.
- Each node can transmit to multiple gateways and the network server removes the duplicates and forwards the appropriate data from the node to the correct application server.

2) CELLULAR DATA:

- Cellular standards use complex radio systems to transmit information between mobile devices within the cellular network.
- The name 'cellular' describes the pattern of small geographical area radio “cells” created around towers or antennae

3) NB-IoT:

- The NB in NB-IoT stands for Narrow Band and utilizes radio waves, which enable particularly large area coverage.
- At the same time, they can penetrate thick concrete walls and thus reach even remote corners of a building.
- NB-IoT is perfectly designed for constrained devices that usually transmit small data packets only once an hour or a day for making them perfect to run on batteries over a very long period.
- LTE-M however delivers higher bandwidths with lower latencies than NB-IoT but comes with slightly higher energy consumption.

4) BLUETOOTH/ WIFI:

- Bluetooth is an open wireless technology with various applications in consumer as well as Industrial devices and practices.
- It is based on a frequency-hopping spread spectrum and uses a master-slave structure for establishing a connection. One master can connect to seven slaves at a time forming a piconet network.
- Wi-Fi is a wireless technology based on the IEEE 802.11 standards and is synonymous with Wireless Local Area Network (WLAN).
- Wi-Fi uses the same radio frequencies as that of Bluetooth but requires more power for operation and thereby provides higher bit rates and a better range of communication.

5)RFID:

- RFID (radio-frequency identification) is a technology that uses radio waves to capture digital data recorded in RFID tags or smart labels.
- RFID is comparable to barcoding in that data from a tag or label is acquired by a device that records the data in a database.
- It is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person.

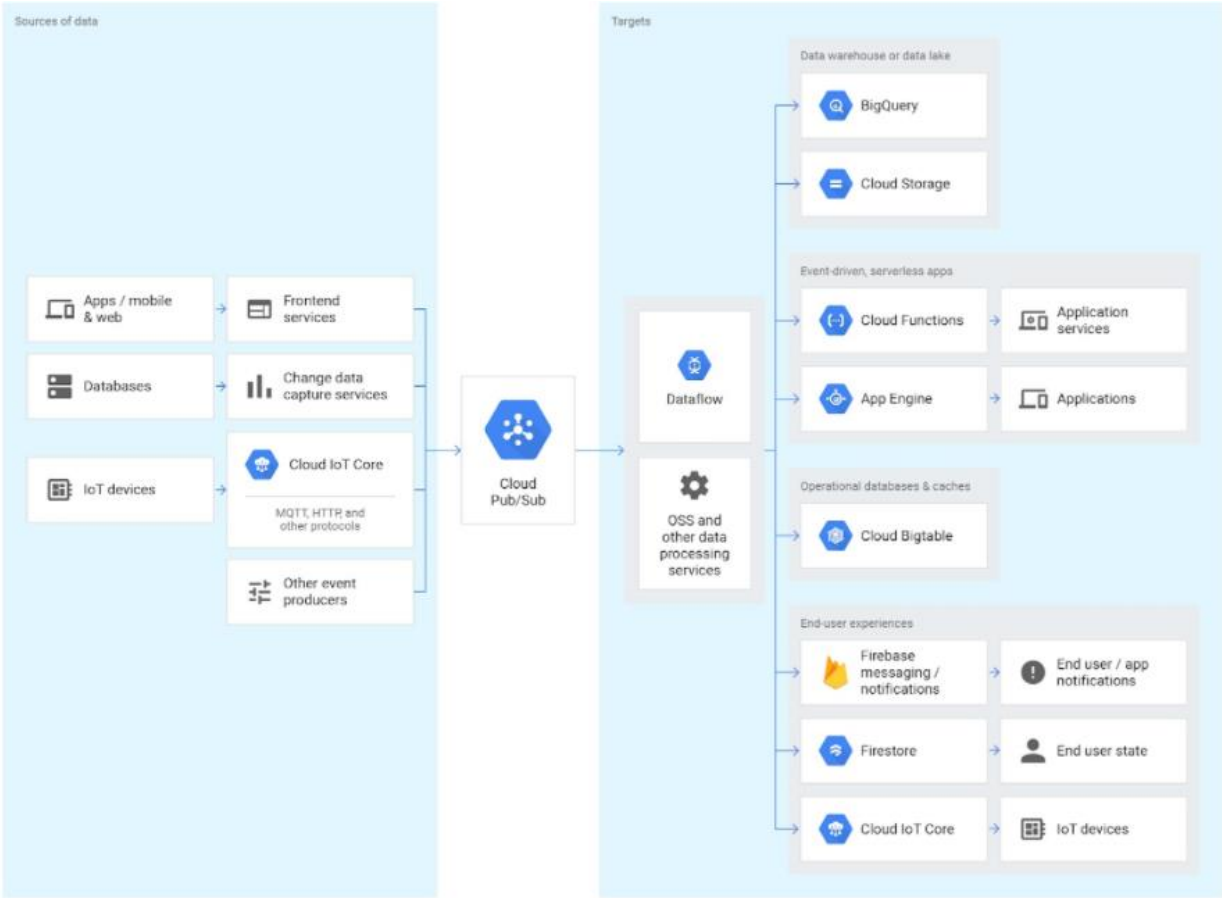
6) SERIAL COMMUNICATION:

- Serial communication is needed for long-haul communications, where synchronizations in parallel communications can be a challenge.

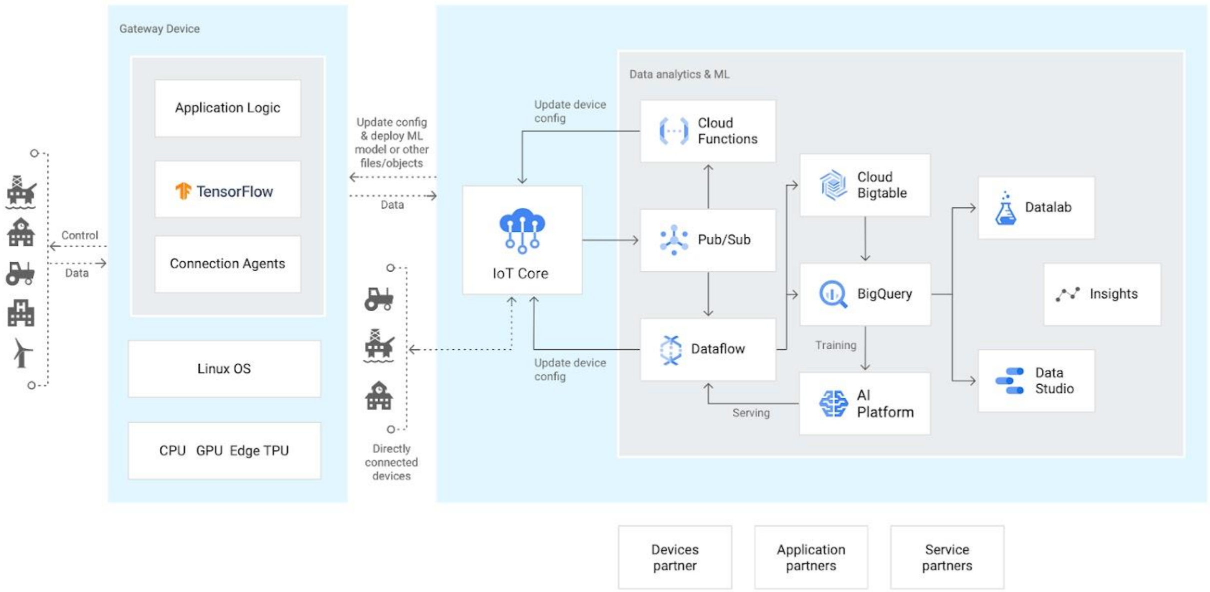
- Serial communication is a form of communication in which data is sent one bit at a time through a communication channel in a sequential manner.
- The transmission modes in serial communication are, simplex, half-duplex, full-duplex.
- And this mode of communication follows three types of protocols, that are, UART, SPI, I2C.
    - UART - Universal Asynchronous Receiver Transmitter
    - SPI - Serial Peripheral Interface
    - I2C- Inter Integrated Circuit

Integration of IoT in the Google Cloud

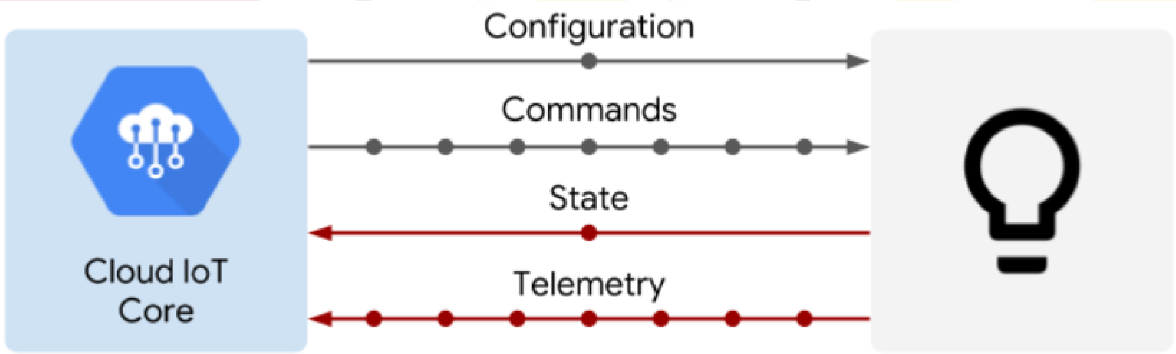
Google Internet of Things services, as previously said, are diverse and have a lot to offer for the creation of every layer of an IoT system. Device deployment, communication, and administration, end-to-end security, full edge and cloud intelligence, and more are all possible with the platform's features.



The Google IoT development platform provides a wealth of AI materials and tools for incorporating machine intelligence into digital systems. It's no secret that machine learning and other AI technologies help data-intensive IoT applications a lot. Integrating machine intelligence into your apps becomes easier and more cost-effective using Google services.



The above-given tools offered by google cloud can be used for various features ranging from IoT, been visualize performance to advance analytics



We must map state changes to messages that we may send to the device. The following message types are supported by Cloud IoT Core:

Configuration: Up to one message per second is sent from the cloud to the device. The delivery of configuration messages to the device is ensured.

Send up to 100 messages per second from the cloud to the device using commands. If the gadget is connected to the internet, commands will be transmitted.

State: Up to one message per second is sent from the device to the cloud. Active Pub/Sub subscribers get state updates, and recent updates are saved in Cloud IoT Core.

Send up to 100 messages per second from the device to the cloud with telemetry. Only active Pub/Sub subscribers get telemetry events.

```
functions.firestore.document('device-configs/{device}').onWrite(
  async (change, context) => {
    const deviceId = context.params.device;
    const config = change.after.data();
    ...
    // Create a new Cloud IoT client
    const client = google.cloudiot({
      version: 'v1',
      auth: auth
    });
    // Update IoT Core configuration
    const parent =
      'projects/my-project/locations/us-central1';
    const devicePath = `${parent}/registries/my-registry`;
    const request = {
      name: `${devicePath}/devices/${deviceId}`,
      binaryData: Buffer.from(JSON.stringify(config))
        .toString("base64"),
    };
    await client.projects.locations.registries.devices
      .modifyCloudToDeviceConfig(request);
  });
```

The message is published to a Cloud Pub/Sub topic that we pick when the device returns its state back to IoT Core. The changed state may then be written to Firestore using another function that captures those messages.

```
functions.pubsub.topic('device-events').onPublish(
    async (message) => {
      const deviceId = message.attributes.deviceId;
```

```
// Write the device state into Firestore
const deviceRef = firestore.doc(`devices/${deviceId}`);
try {
    await deviceRef.update({
        'state': message.json,
        'online': true
    });
    console.log(`State updated for ${deviceId}`);
} catch (error) {
    console.error(error);
}
});
```

Our devices may provide this information as status updates or telemetry events, with the code behaving in the same way. We don't require IoT Core to achieve the same thing because Firestore takes care of storing device state in our cloud service. As a result, having the device communicate data via telemetry events makes the most sense.

Only authenticated users have authorization to see and handle the devices they own, thanks to security rules that specify access control for the data stored in Firestore. The following controls are defined by the rule set below:

Users who really are listed as the owner of a device can read, modify, or remove it.

Users will be unable to add a new device entry (this will be handled by device provisioning)

A pending device entry can be created directly by users (part of device provisioning).

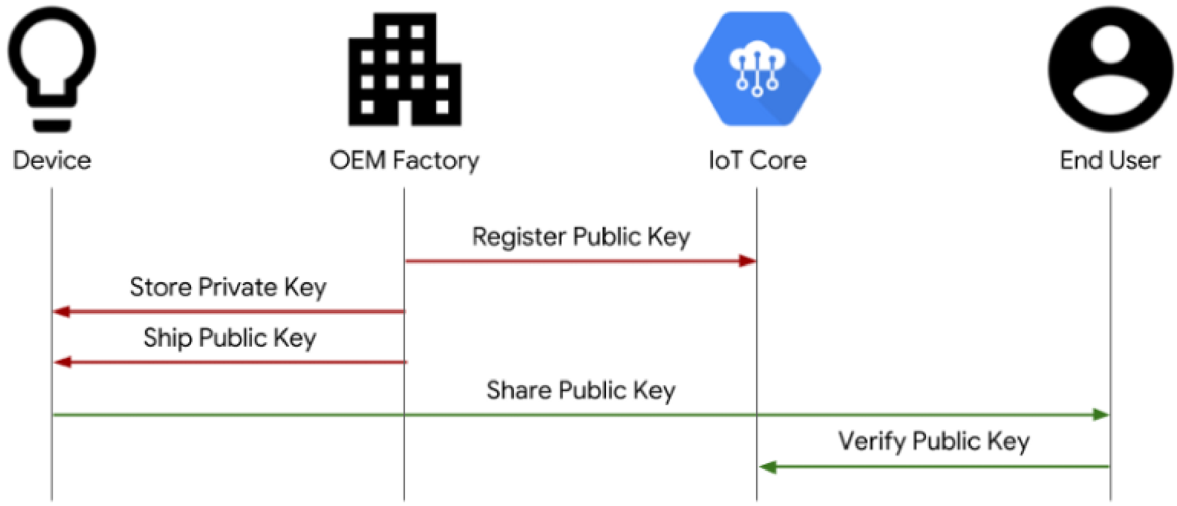
```
service cloud.firestore {
  match /databases/{database}/documents {
    match /devices/{deviceid} {
      allow read, update, delete:
       if request.auth.uid == resource.data.owner;
    }

    match /device-configs/{deviceid} {
      allow read, update, delete:
       if request.auth.uid == resource.data.owner;
    }

    match /pending/{deviceid} {
      allow read, write:
        if request.auth.uid == resource.data.owner;
      allow create:
        if request.auth.uid != null;
    }
  }
}
```

Client apps only need to interact with the Firebase SDK to authenticate users and manage devices because Firestore is the source of truth for device data. Users can see their devices by looking through the documents in the devices collection whose owner field matches their account. Using the FlutterFire plugin, the following Dart code lists the documents for the current user's devices.

Each user command that alters the device's state updates the device-configs collection's related document. Using the cloud function mentioned in the previous section, an update to the device's IoT Core configuration is initiated.

Device Provisioning

Cloud IoT Core uses public/private key pairs to authenticate devices. We won't discuss the process in detail here, but see device security for more information on how it works. For consumer devices, we will split the provisioning process into two stages: factory provisioning and end-user provisioning.



The public key and device metadata are bound to a location that the user can access from their mobile device during the device registration process. The user application writes this data into Firestore as a pending device registration, which triggers a cloud function to verify that the public key from the physical device matches the value provisioned in Cloud IoT Core for the corresponding device identifier and that the device is not already registered to a different account.

The data from RFID sensors may be transferred to RFID middlewares using an Arduino Wi-Fi module.

The data might then be sent to GCP using these middlewares. One thing to keep in mind is that RFID sensors generate a big amount of data, which need some forethought in order to store them cost-effectively.

We could just store them in cloud storage buckets for simplicity, but for an application that serves a large number of users, we should look at other possibilities such as cold-line, near-line, and so on.

We could utilize BigQuery to examine the data (it can handle petabytes of data in a couple of seconds). One advantage is that you only pay for what you use. It is undeniably cost-effective.

APPLICATION SCENARIO OF VARIOUS TECHNOLOGIES:

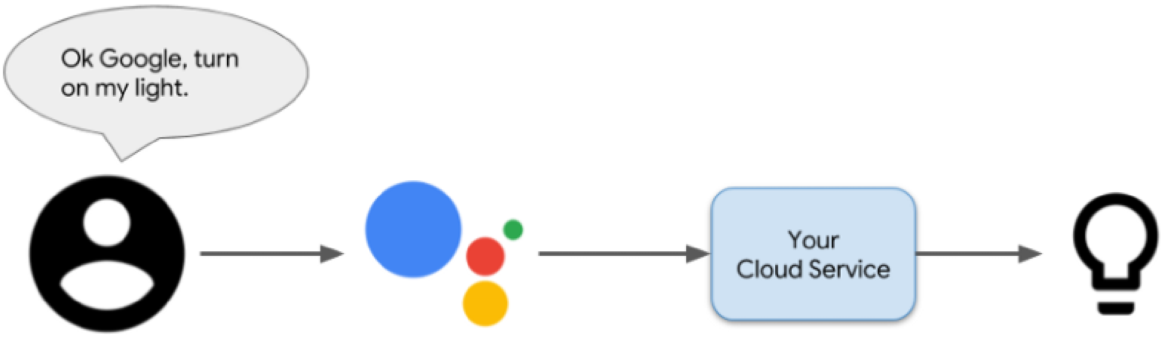


Figure 1: Assistant Communication Flow

NB-IoT

- Smart metering (electricity, gas, and water)
- Facility management services
- Intruder and fire alarms for homes & commercial properties
- Connected personal appliances measuring health parameters
- Tracking of persons, animals or objects
- Smart city infrastructures such as street lamps or dustbins
- Connected industrial appliances such as welding machines or air compressors.

SERIAL COMMUNICATION

Protocol used for serial communication is SPI protocol which stands for Serial peripheral interfaces

- These are used in MMC and SD cards, as well as SDIO variants.
- The SPI interface is used to communicate with a wide range of peripherals, including sensors such

as temperature and pressure, analogue to digital converters (ADC), and digital to analogue converters (DAC).

- It is found in audio and video codecs, as well as digital potentiometers.
- It's found in flash and EEPROM memory.
- It is used in cameras as a Canon EF lens mount.
- It's found in real-time clocks.
- It is used in LCD and LED displays.
- It's also in video games.
- It's used in protocols including Ethernet, USB, USART, CAN, IEEE 802.15.4, and IEEE 802.11.

RFID

- Usage of RFID Sensor in Smart Navigation System
- As soon as the animals are inspected, they are branded with an RFID tag (the detection is done by an IR sensor).
- The RFID tag then transmits a signal to Arduino, which is then received by the RFID reader. It also provides a unique ID that may be used to identify the animal.
- After that, the sensor may log that information (along with other data such as the length of their stay, their present position, and their behaviour, which can be tracked using other sensors).
- One can gather data based on their needs to protect the safety of the animals in the sanctuary) and save it in a database for later use.
- Finally, when the animal changes the location (This is detected by other sensors).

WIFI/ BLUETOOTH

- WiFi can be used to build basic wireless connections from one location to another. This is beneficial for connecting two places that are difficult to access by wire, such as two company buildings.
- Employees can do inventory using smartphone or tablet PCs that have a WiFi connection and are recorded in real time in the company's database.
- One of WiFi's most promising features is its capacity to manage digital audio transmissions.When VoIP (Voice over Internet Protocol) is used on a wireless network, it is frequently referred to as VoWIP (the "W" stands for Wireless), but the technology is the same. VoWIP

providers already provide phones that connect to the network through WiFi.

LORA

- Smart buildings which include property and facility management implementing LoRa-based smart building .
- Smart Electricity Metering ,with the rise of low power, wide area networking (LPWAN) technologies.
- Smart Supply chain and logistics, LoRa technology's long range and low power consumption qualities makes it easier to monitor large geographical regions.

<u>Overall Architecture</u>

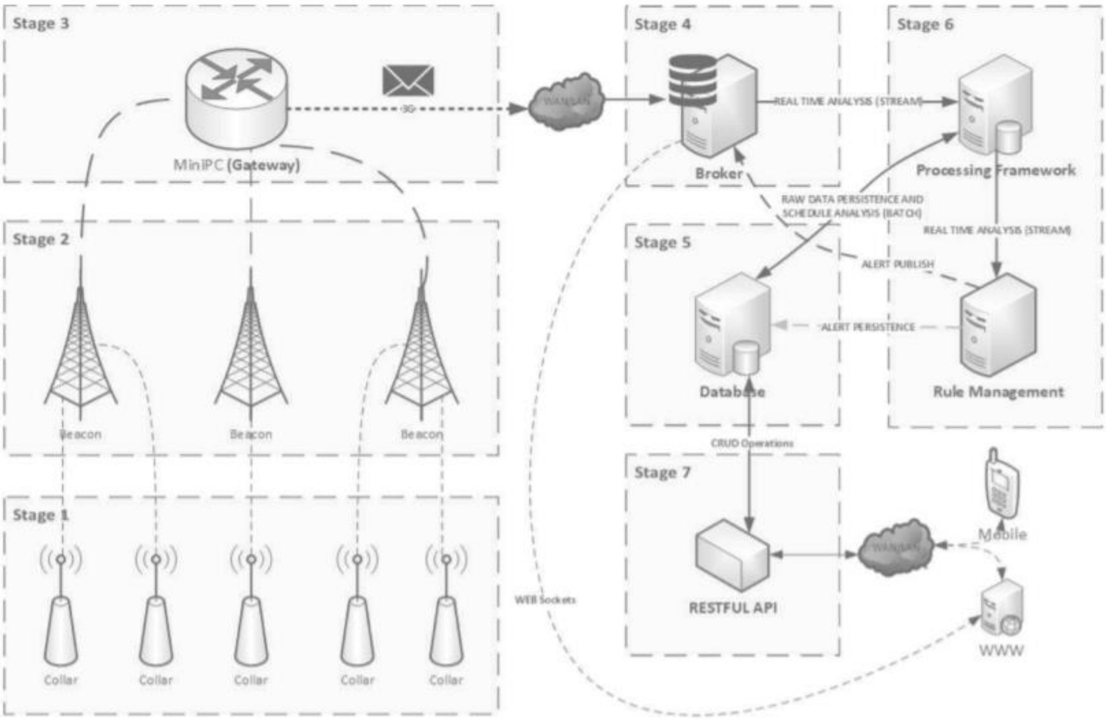
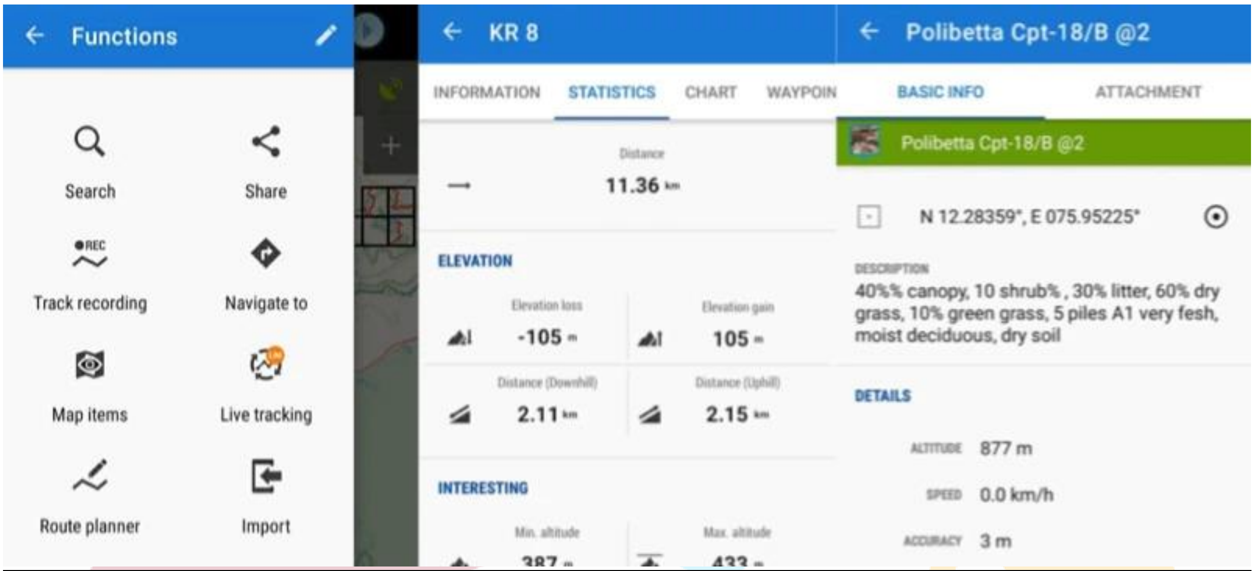


Fig. 1: Overall architecture

Remote monitoring of animal behavior in the environment can aid in the management of both the animal and its impact on the environment. Researchers can monitor both animal behavior and interactions with the environment using GPS collars that record animal locations with high temporal frequency. To better understand animal-landscape interactions, these ground-based sensors can be combined with remotely sensed satellite images. Communication methods such as wireless sensor networks are crucial in combining these technologies (WSNs). We investigate this concept using a case study from a large cattle enterprise in northern Australia and show how GPS collars and satellite images can be combined in a WSN to monitor cattle behavioral preferences and social behavior.

PROPOSED APP DEMONSTRATION:



The proposed app contains various features including tracking , track record, navigation to the location through which authorities can reach the animal along with a route plan of the animal with additional import option to import live data into the system.

Learnings from Google Cloud

The goal of employing IoT devices will not be realised unless and until the data generated throughout the process is correctly stored, managed, and transmitted. As a result, we learned how to link IoT devices to the Google Cloud in order to take advantage of the benefits of IoT devices. Cloud IoT Core is a service or API on the Google Cloud Platform that allows us to connect various IoT devices to the cloud. As a result, we learnt how to utilise this API to save data from the numerous sensors we used in our project.

Learnings from RFID

We began by learning what RFID is and how it works, as well as the ideas that underpin it, its uses, flaws, and benefits. RFID, we discovered, is a type of wireless communication. on radio frequency, electromagnetic or electrostatic coupling is used. To uniquely identify an object, a component of the electromagnetic spectrum is used as an object. We also learned about RFID's three major components. A scanning antenna, a transceiver, and a transponder are the three components. Then we moved on to talk about the several types of RFID tags, such as Low Frequency, Medium Frequency, and High-Frequency tags. RFID tags with a high frequency, a UHF frequency, or a microwave frequency. Following a dive into the ,IoTscience behind RFID

We also spoke about the issues that RFID presents in its applications.

We learned about the man in the middle security attack as part of this project, which is a very prevalent assault in the networking industry in which an attacker intercepts data being transferred, decodes it, duplicates it, and then utilises the data to access encrypted information. In the case of an RFID system, the most simple way of an MITM assault necessitates a battery-operated hardware device positioned just above the RFID tag's real reader. We learned about the specifics of this type of assault and discussed how to avoid it.

Learnings from LoRa technology

This project made a significant contribution to the fundamental understanding of IoT, Lora, distributed computing, and the implementation of the same. While working on the job, we were first introduced to the Internet of Things (IoT) and its various applications and uses. We figured out how it has made our lives easier and better in the new year's by making even the tiniest of details more dazzling and superior to the norm. The primary goal of structuring the meeting with strangers was to bring us closer together in order to form a relationship with people we didn't know. Learning about the many sensors and devices used in Lora, as well as how the cloud works.

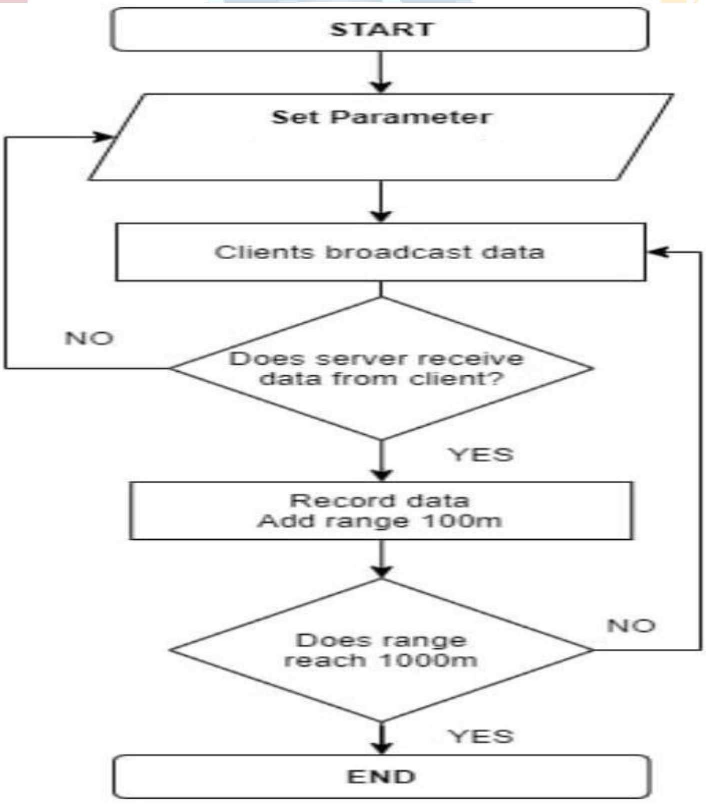
FUTURE SCOPE:

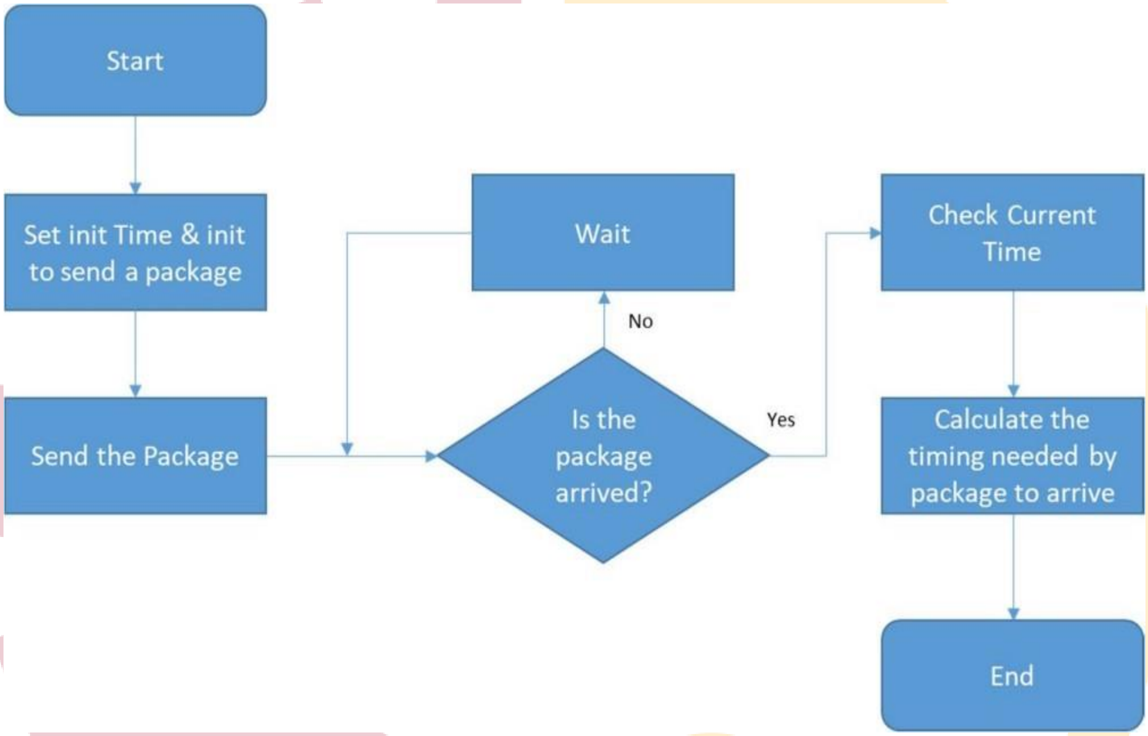
A key use case of the Animal IT project, namely the identification of instances when the animal engages in various behaviors that may involve risk factors such as hunters who get unauthorized access to smuggle or even kill the animal for personal gain, demonstrates the platform's potential.

By using the existing platform, a data set consisting of collar sensor data was produced and maintained, and each entry can be manually classified. As a consequence, machine learning techniques were evaluated in order to identify the platform's capabilities. Although all algorithms had about the same accuracy, the results obtained by each approach were simple to read.

Future study will entail evaluating the platform's adaptability and effectiveness in a sanctuary with a greater number of animals, as well as additional examples of fear, sickness, mobility patterns, resting spots, food preferences, and other behavior tendencies.

The smart sensors are equipped with signal conditioning, embedded algorithms and digital interfaces. Transducers, amplifiers, excitation control, analog filters, and compensation are some of the other components that may be found in a smart sensor.




Start
Set init Time & init to send a package
Send the Package
Wait
No
Is the package arrived?
Yes
Check Current Time
Calculate the timing needed by package to arrive
End