LoRaWAN

FINAL EVALS

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agenda

PROBLEM STATEMENT

Objective it to make a **DOG TRACKER** using LoRa and LoRaWAN protocol .

We also tried to LOCALISE it using a basic triangulation method by calculating linear distances calculated using RSSI.

LoRa AND LORAWAN

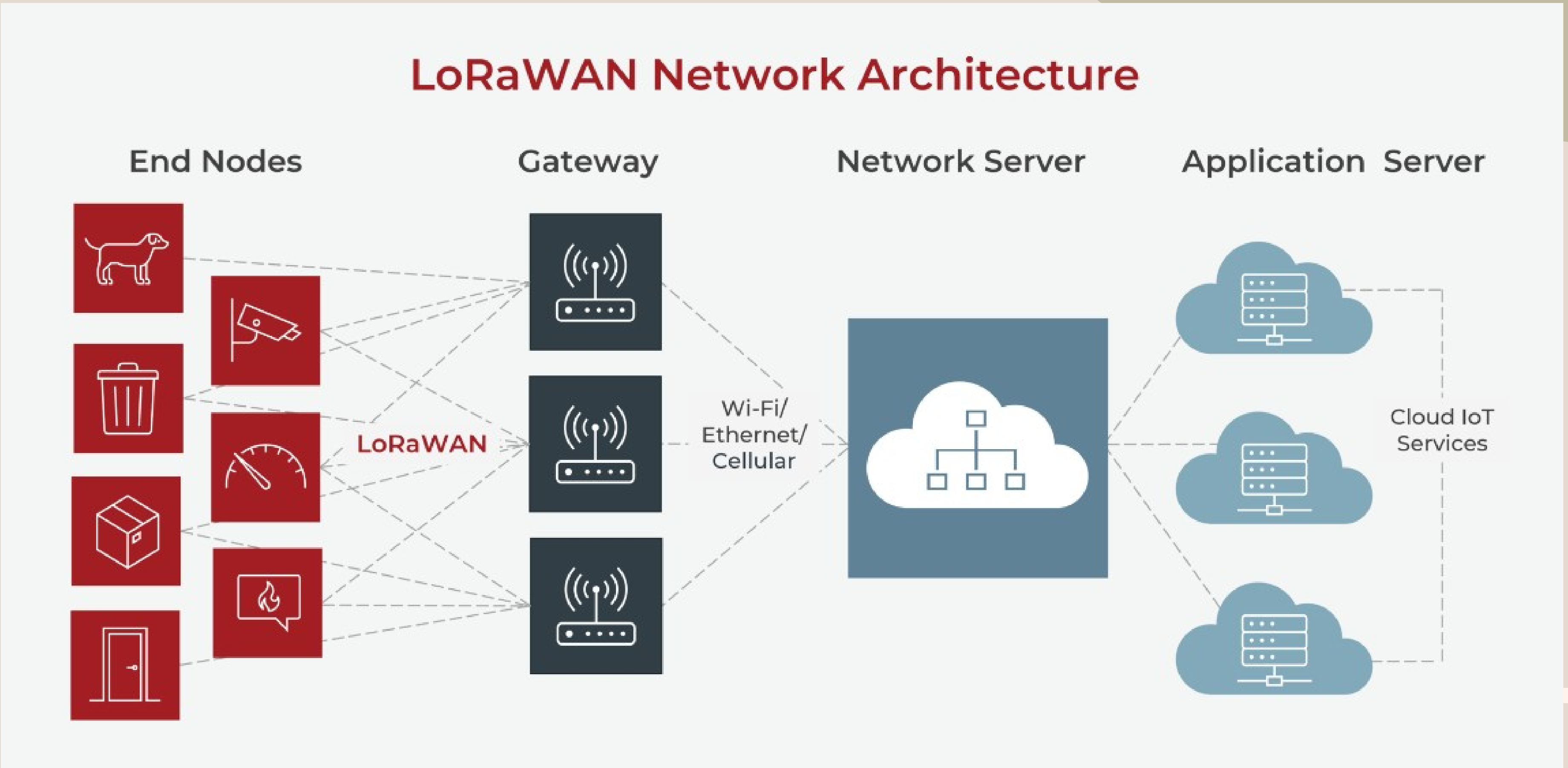
LoRa and LoRaWAN

LoRa - which stands for **long range**, is a wireless technology widely acknowledged for its ability to send small amount of data over wide distances .

LoRaWAN is the network protocol that links the lora signal (sensor data) to the application.

To put it simply, LoRa is the radio signal that carries the data, and LoRaWAN is the communication protocol that controls and defines how that data is communicated across the network.

Working of LoRaWAN



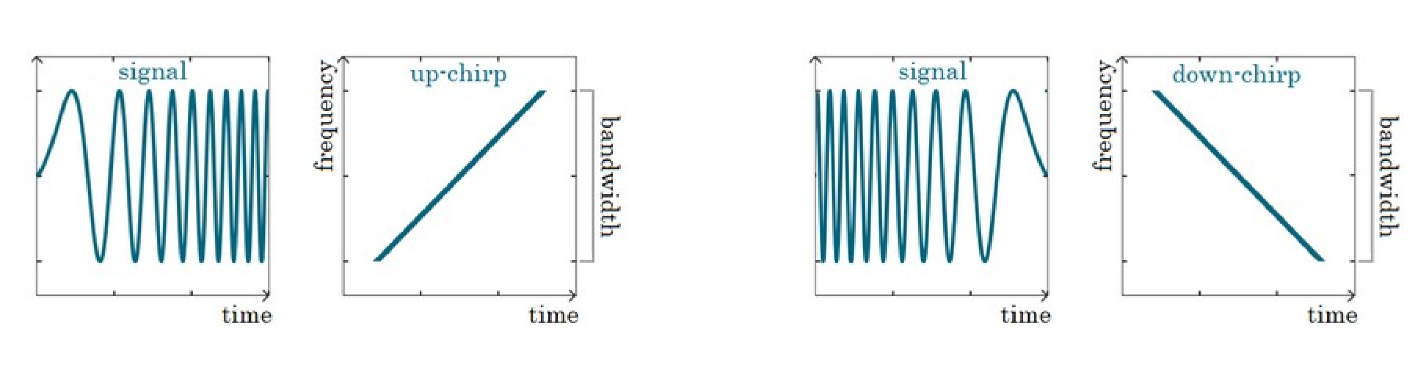
CHIRP SPREAD SPECTRUM

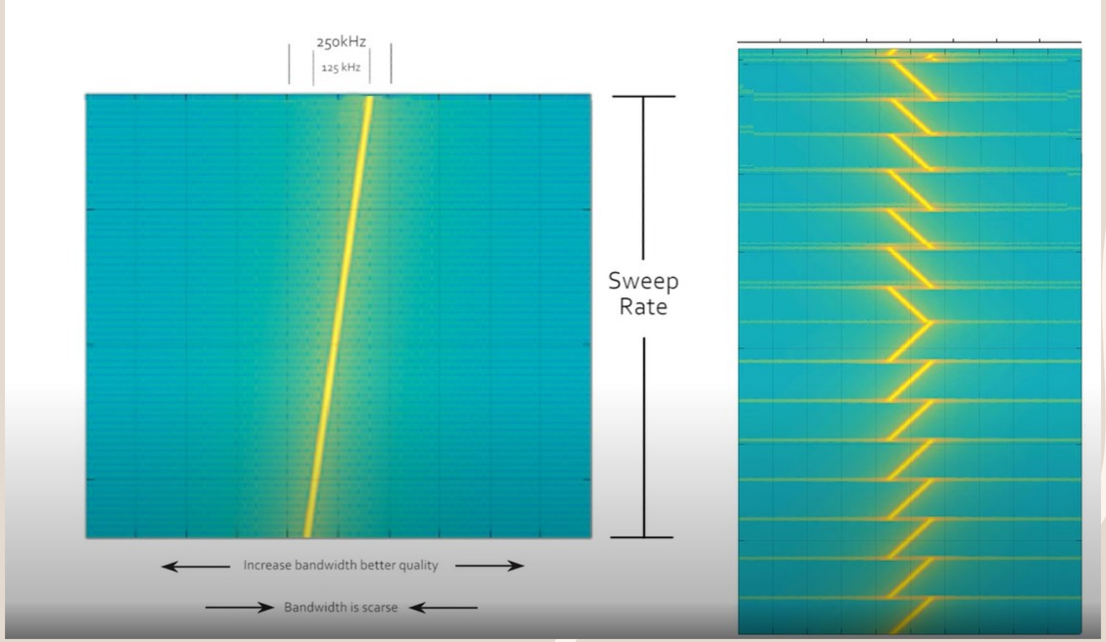
1. Uses up-chirp and down –chirp to send data.

2.Different bits are send by altering the **sweep rate** and the range in which it sweeps (Bandwidth)

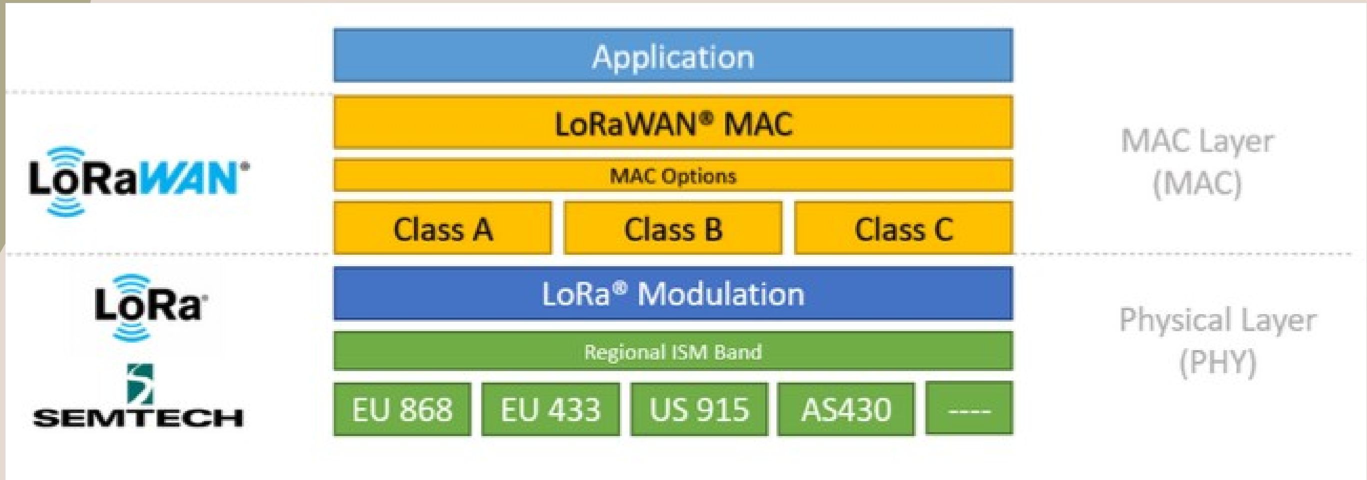
3.Also , LoRa devices follow **Aloha protocol** (Just wake up and communicate)

4. **Orthogonality** of the SF signals





TECHNOLOGY STACK



1 . **LoRa** is the physical (PHY) layer, i.e., the wireless modulation used to create the long-range communication link.

2. **LoRaWAN** is an open networking protocol that delivers secure bi-directional communication, mobility, and localization services standardized and maintained by the LoRa Alliance.

WHY LoRa ? LoRa MODULATION vs FSK

Transceiver	Modulation	Max sensitivity according to the datasheet	Data rate	RX- bandwidth
CC1020	FSK	-118 dBm	2.4 kBit/s	12.5 kHz
CC1101	FSK	-116 dBm	0.6 kBit/s	58 kHz
SX1261	FSK	-125 dBm	0.6 kBit/s	4 kHz
SX1261	LoRa	-149.2 dBm	0.02 kBit/s	8 kHz

1. LoRa achieves at least a **24dB** better maximum sensitivity than with the best FSK transceiver (SX1261) .
2. It is also noticeable that the maximum LoRa sensitivity is achieved with an extremely slow data rate of **only 0.02 kbit / s.**

RSSI

Instead of using GPS to locate the position of a beacon , we use RSSI method .

Received Signal Strength Indicator (RSSI) is one of the range-based techniques in localization. The longer distance resulted in the signals travel with greater attenuation .

The linear distance can be obtained from RSSI using the below formula

$$d = 10^{(A - \mathrm{RSSI})/10n}.$$

1.A is the standard RSSI value I.e, value corresponding to 1m distance
2.RSSI is the received RSSI value from the beacon
3. 10n in the denominator is the environmental factor .

COMPONENTS AND REQUIREMENTS

COMPONENTS REQUIRED

SR NO	COMPONENT	APPLICATION
1	esp32	It's a part of tracker and is used to connect to internet
2	rfm95	It's the LoRa module and is a part of both tracker and beacon
3	Arduino nano	To control the signal the transmitter sends and its timing
4	9V | 600 mAh battery	To power the beacon up .

BEACON

rfm95 + Arduino nano + 9V|600 mAh battery+ antenna

TRACKER

rfm95 + esp32 + Powered by mains

WORKING OF COMPONENTS

1 . BEACON :

It goes on the dog collar which pings to the receiver every **5 secs** which is further transmitted to the gateway .

The pinging of beacon to receiver – **LoRa MODULATION**

Consists of rfm95 and arduino nano which is powered by a 9V battery .

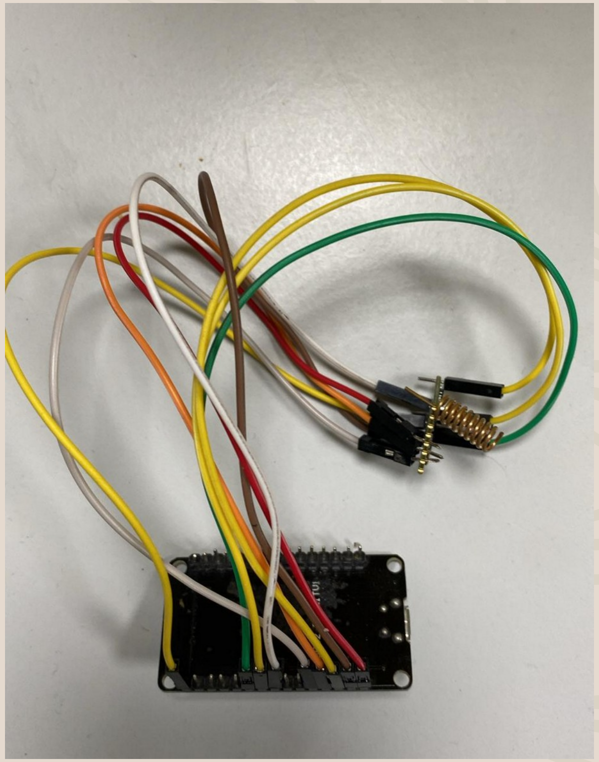
It is shielded by a 3D modelling box which is compact enough to fit all the components and still be less than our **palm size !!**

This makes it **compact and robust .**

WORKING OF COMPONENTS

2 . TRACKER :

Shown on the right is the stationary tracker which pings to the gateway **every 10** secs using **LORaWAN .**



Consists of rfm95 and esp32 which is powered by mains and can be placed anywhere within the range of the dog beacon.

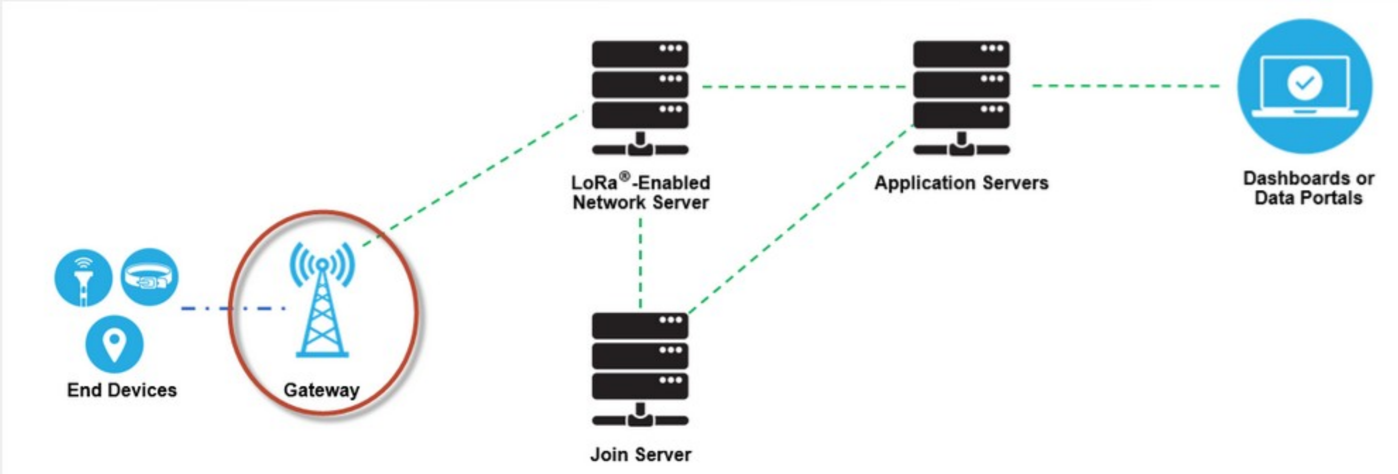
It receives the RSSI value of the beacon and sends that to the gateway by changing the **sendjob** and **payload formatting .**

```
function decodeUplink(input) {
  // Convert bytes to string
  const byteToString = input.bytes.reduce((acc, byte) => acc + String.fromCharCode(byte), '');

  return {
    data: {
      // bytes: input.bytes,
      // byteString: byteToString // Add the byte to string representation
      rssi: -input.bytes[1]

    },
    warnings: [],
    errors: []
  };
}
```

WORKING OF COMPONENTS

3. GATEWAY :

A LoRaWAN gateway receives LoRa modulated RF messages from any end device in hearing distance and forwards these data messages to the LoRaWAN network server (LNS), which is connected through an IP backbone.



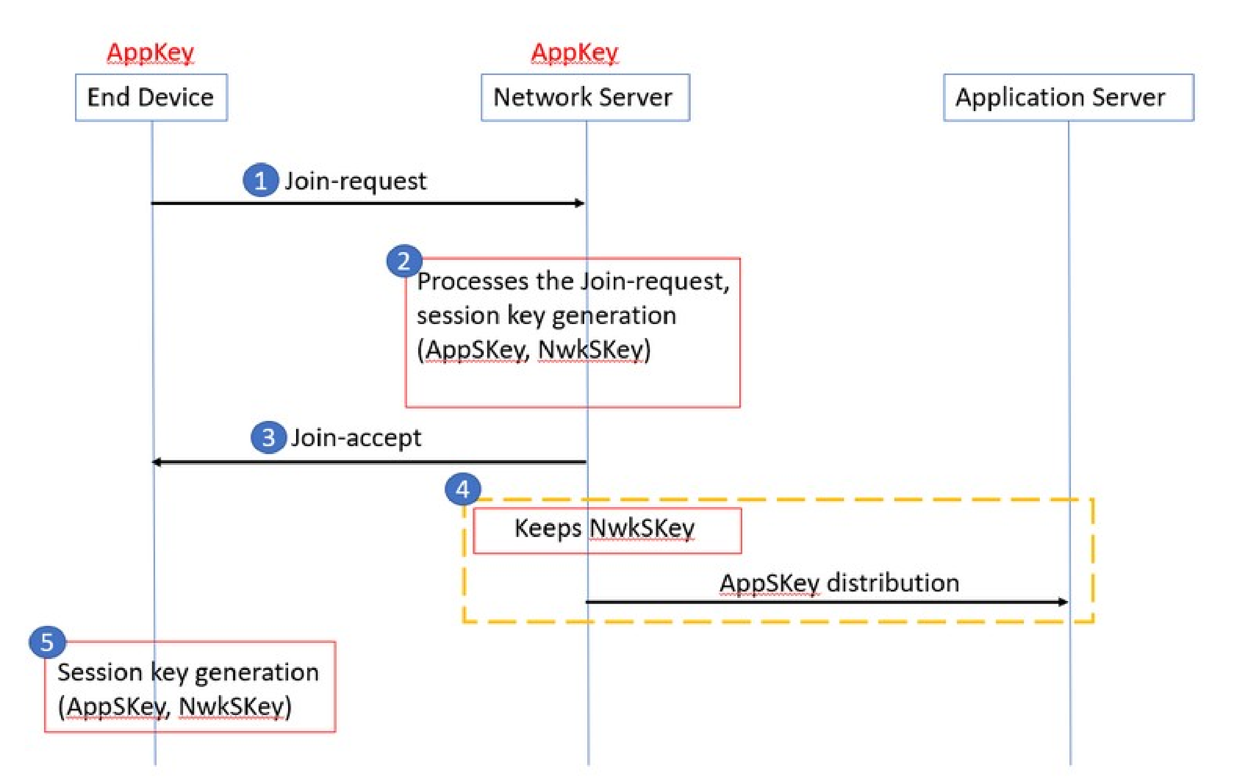
JOIN PROCEDURE and CLASSES

LoRaWAN – OTAA vs ABP

Over-The-Air-Activation (OTAA) - .
1.Devices perform a join procedure with the network, during which a dynamic device address is assigned and security keys are negotiated with the device.

Activation By Personalization (ABP)
1.Requires hardcoding the keys and address .

2.ABP is less secure than OTAA



LoRaWAN – JOIN PROCEDURE

The join procedure requires two MAC messages to be exchanged between the end device and the Network Server:

Join-request - from end device to the Network Server

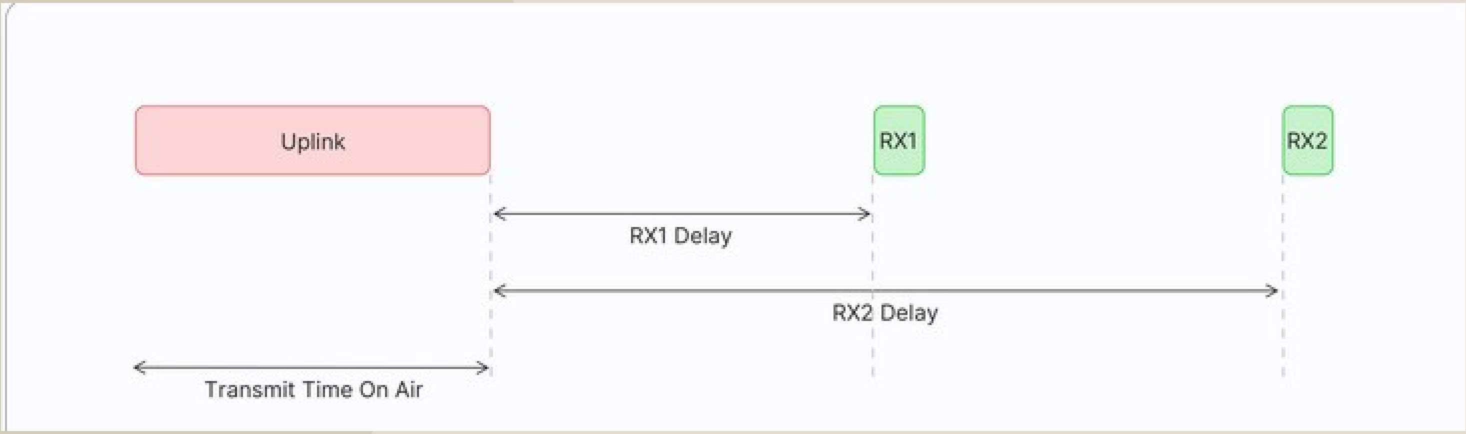
Join-accept - from Network Server to the end device

1.Before activation, the **AppEUI, DevEUI, and AppKey** should be stored in the end device.

2.The **AppKey is an AES-128** bit secret key known as the root key.

3.The AppEUI and DevEUI are not secret and are visible to everyone

CLASS – A DEVICES



1.Once the uplink transmission is completed, the device opens two short receive windows for receiving downlink messages from the network.

2.There is a delay between the end of the uplink transmission and the start of each receive window, known as **RX1 Delay and RX2 Delay**, respectively

3. If the network server does not respond during these two receive windows, the next downlink will be scheduled immediately after the next uplink transmission.

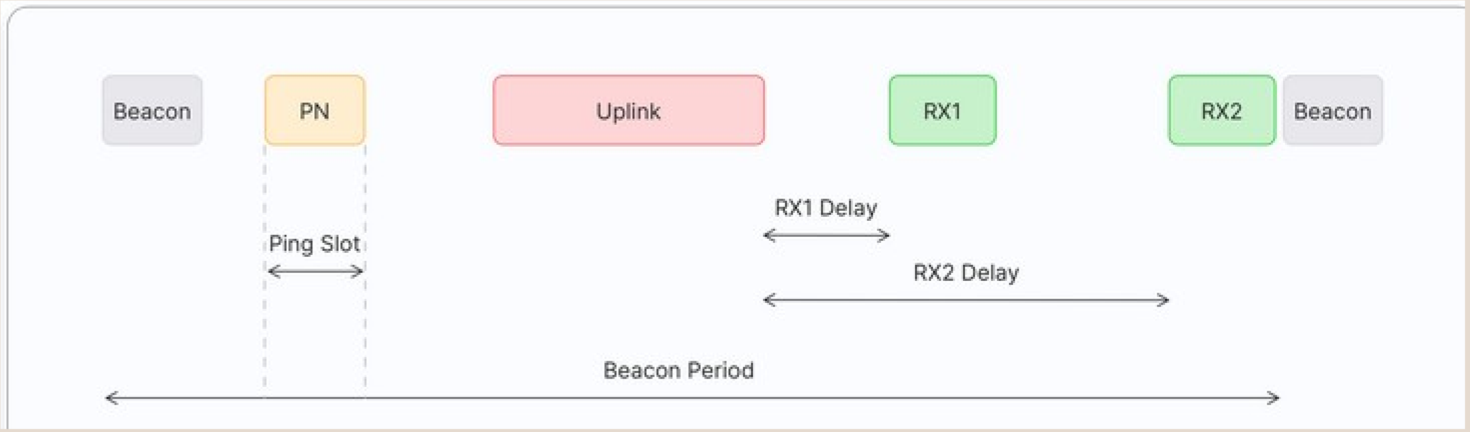
WHY CLASS – A ?

1.Class A end devices have very **low power consumption**. Therefore, they can operate with battery power. T

2.They spend **most of their time in sleep mode** and usually have long intervals between uplinks.

3.Additionally, Class A devices have **high downlink latency**, as they require sending an uplink to receive a downlink.

CLASS – B



1. Class B devices periodically opens a receive windows called **ping slots** to receive downlink messages.

2.The network broadcasts a time-synchronized beacon periodically through the gateways, which is received by the end devices. These **beacons provide a timing** reference for the end devices, allowing them to align their internal clocks with the network

3.The time between two beacons is known as the **beacon period.**

CLASS – A vs CLASS -B

1.Class B end devices have **low latency for downlinks** compared to Class A end devices because they periodically open ping slots.

2. Class B devices are often battery powered.

3.The **battery life is shorter in Class B** compared to Class A because the devices spend more time in active mode due to receiving beacons and having open ping slots.

4.Because of the low latency for downlinks, Class B mode can be used in devices that require medium-level critical actuation, such as utility meters.

PROGRESS SINCE MIDEVALS

1 . Setting up tracker using esp32 and connecting to gateway .

2 . 3D modelling and making the beacon robust .

3 . Sending the beacon’s RSSI by changing sendjob and payload formatting .

4 .Localisation using triangular formulation .

5 . DEPLOYMENT

LOCALISATION

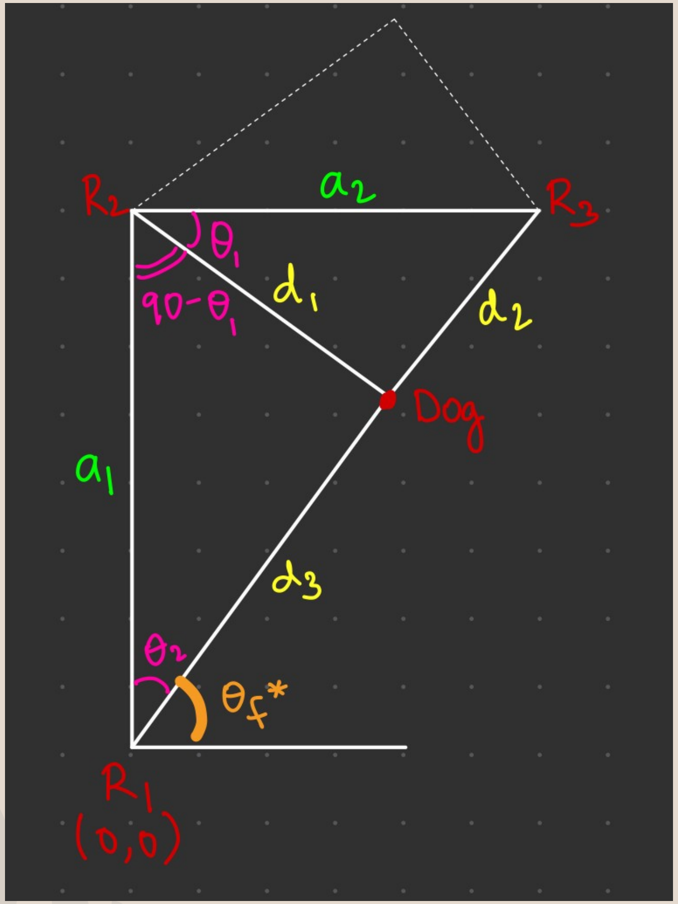
1. The distances a1 and a2 are predetermined as they represent the placement of the receivers, which is determined according to our preferences .

2. The distance d1 , d2 and d3 are found using the RSSI value send by the beacon which can be used to find the linear distance as discussed in the RSSI slide .

3. We calculate θ_1 to know the position of the dog i.e which side is the dog on (the dotted or the marked position).

4. We can calculate θ_f using the cosine rule (all the sides of the triangle are known) and then find $\theta_f = 90 - \theta_2$

5. The corresponding (x,y) can be found using this θ_f value .



GETTING DATA FROM GATEWAY

b'{"end_device_ids":{"device_id":"eui-70b3d57ed0067545","application_ids":{"application_id":"test-lora-3"},"dev_eui":"70B3D57ED0067545","jo
in_eui":"0000000000000420","dev_addr":"260B7B26"},"correlation_ids":["gs:uplink:01HXBN6ME5C7DD6YXF979Z26RB"],"received_at":"2024-05-08T08:3
0:29.524936116Z","uplink_message":{"session_key_id":"AY9XKmZ82e+kHscdE/5e7w==","f_port":1,"f_cnt":104,"frm_payload":"AEI=","decoded_payload
":{"rssi":-66},"rx_metadata":[{"gateway_ids":{"gateway_id":"multitech-conduit-246a-us-eu-gb","eui":"00800000A00030E8"},"time":"2024-05-08T0
8:30:28.980983972Z","timestamp":581235780,"rssi":-92,"channel_rssi":-92,"snr":-5.5,"uplink_token":"Ci0KKwofbXVsdGl0ZWNoLWNvbmR1aXQtMjQ2YS11
cy1ldS1nYhIIAIAAAKAAMOgQxOiTlQIaDAil8OyxBhCTysaXASCg0+ii9Y0B","received_at":"2024-05-08T08:30:29.059079443Z"}],"settings":{"data_rate":{"lo
ra":{"bandwidth":125000,"spreading_factor":7,"coding_rate":"4/5"}},"frequency":"866385000","timestamp":581235780,"time":"2024-05-08T08:30:2
8.980983972Z"},"received_at":"2024-05-08T08:30:29.318327961Z","consumed_airtime":"0.046336s","network_ids":{"net_id":"000013","ns_id":"EC65
6E0000000181","tenant_id":"ttn","cluster_id":"eu1","cluster_address":"eu1.cloud.thethings.network"}}}'

1.We used a nodejs script to obtain data from the gateway as shown above .

2 . We can obtain the RSSI value from these and compute the distance and then localise it accordingly .

PROBLEMS FACED and FIXES

We faced multiple problems along the course of the project but listed below are a few major ones :

1.Difference in the size of the pins of MC’s and the rfm95 : We addressed the size difference between MC's pins and the RFM95 by carefully soldering and fitting them closely together, ensuring the wires didn't touch.

2.We encountered **significant temperature sensitivity with the RFM** module during soldering. To prevent any adverse effects on its functionality, we regularly monitored and regulated the soldering temperature throughout the process.

3. SIZE OF THE BEACON : Even after the addition of the 9V battery , our goal was to keep the beacon as compact as possible which resulted in soldering and placing each component over an other and still make sure it works .

CONCLUSIONS and FUTURE SCOPE

1. We were able to implement the LoRa and LoRa modualation using rfm95 and microcontrollers and connect to the gateway .

2. For future scope : we wanted to improve our localisation method by considering error in the distance calculation while estimating the location – LLS - Linear Least Square .

3. We can also set up more receiver and future expand the network and locate the dog with much more precision .
4.

THANK YOU !!