



Performance Analysis of Heterogeneous Networks for Robotic Navigation

By Hersch Nathan

Problem Statement:

In the absence of WiFi network, LoRaWAN is a potential candidate to transmit data. However, the data transmission can be impacted due to low bandwidth. We analyze the performance of LoRa to observe the delay. We compare the same with WiFi.

In short: Is LoRaWAN a viable option for data transmission in the absence of WiFi?

Road Map

- Premise of Research & Background Information
- Related Works
- Methodology
- Results and Problems
- Conclusions
- Skills and Research Experience
- Acknowledgements

Premise of Research & Background Information

Research Premise - Environment

Large Scale Disasters cause:

- Hazards
 - Collapsed Buildings
 - Hazardous Materials
 - Flooding
- Destruction of Infrastructure
 - Roads
 - Powerlines
 - Wireless networks





Research Premise - Need

- Danger to deploy humans
- Ought to use robots
 - Navigate hostile terrains
 - Autonomously make application-oriented decisions
 - Send data to human personnel for decision-making
- Need for **easily deployable**, **long range**, and **low-cost** wireless communication





Research Premise – Problem 1

- Humans are smart
 - Can synthesis environments
 - Effective communicate via vocal radios
- Robots are dumb
 - Long time/high power to process environments
 - High wireless bandwidth to send data
- Lack of Infrastructure
 - Damaged/Destroyed

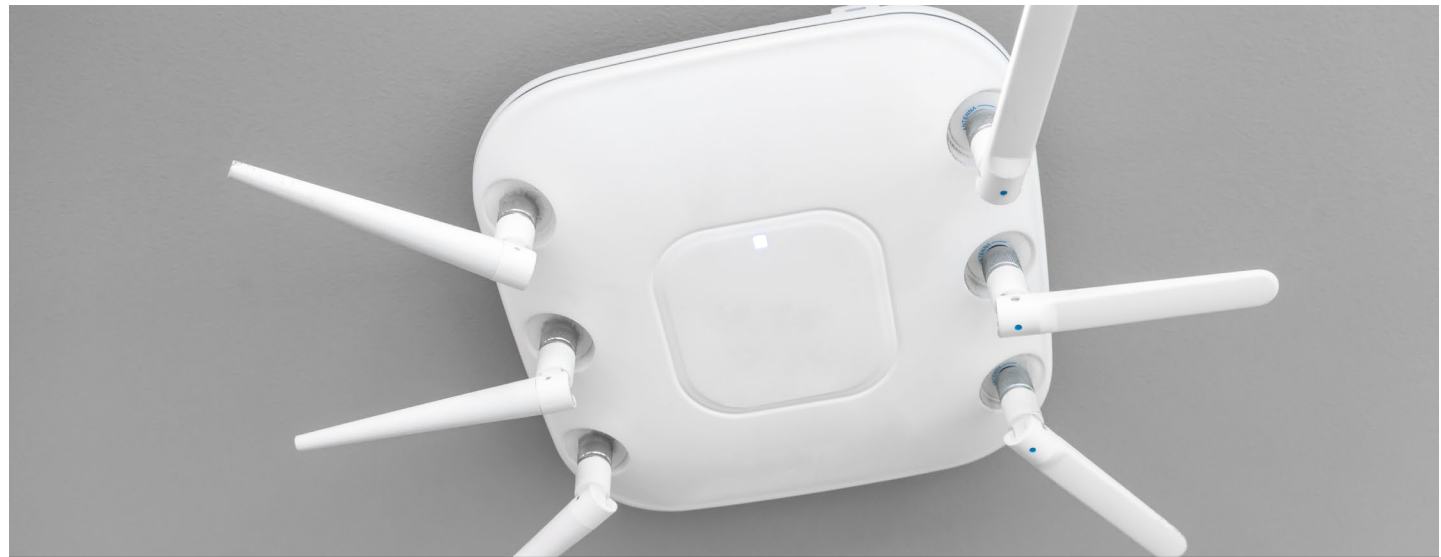
Research Premise – Wireless Options: WiFi


Wi-Fi

- Common place (i.e., pre-existing integrations with our robots)
- Short effective range (~50 meters)
- Need for much infrastructure

MQTT

- lightweight, publish-subscribe, machine to machine network protocol for message queue/message queuing service





Research Premise – Wireless Options: Satellite-Based

Satellite-Base Communication (i.e.,
LTE, 4G, 5G, Starlink, OneWeb,
etc.)

- Easy to integrate via a tunnel
- Long Range
 - Covers mass regions of the earth
- High Cost
 - Satellite and End Node

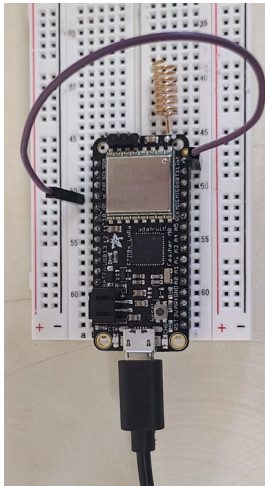
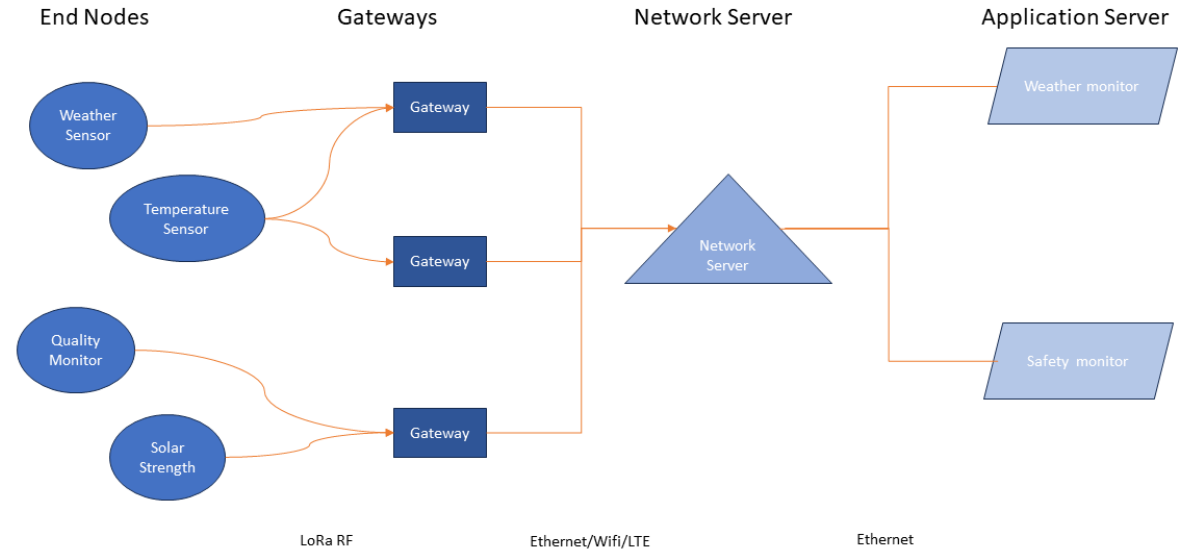
Research Premise – Wireless Options: LoRa and LoRaWAN

LoRa

- Created for IoT applications
 - Long Range/Low Bandwidth
 - Leverage Chirp Spread Spectrum (CSS) technology
- Power efficient
 - Small chirps of data over Long Range
 - To sustain their battery life



Nominal LoRaWAN setup



LoRaWAN

- WAN
 - Wide area network
- Built ontop of LoRa
 - Easier to Manage for IoT

ChirpStack Application Server x +

Not secure | 192.168.141.5:8080/#/organizations/1/applications/5

ChirpStack Search organization, application, gateway or device admin

- Dashboard
- Network-servers
- Gateway-profiles
- Organizations
- All users
- API keys

chirpstack

- Org. dashboard
- Org. users
- Org. API keys
- Service-profiles
- Device-profiles
- Gateways
- Applications
- Multicast-groups

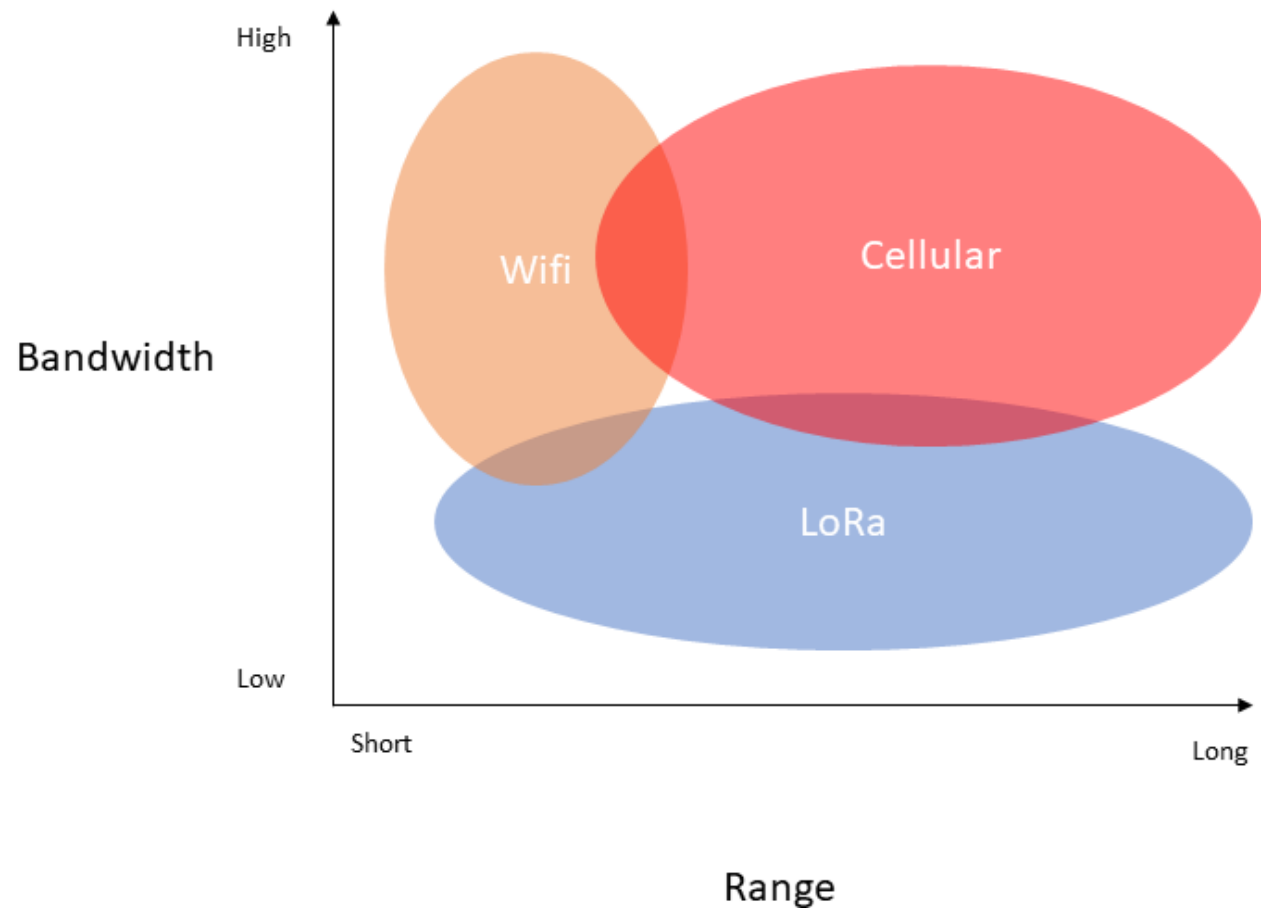
Applications / ImageTrans

DEVICES APPLICATION CONFIGURATION INTEGRATIONS FUOTA

+ CREATE

Last seen	Device name	Device EUI	Device profile	Link margin	Battery
4 days ago	Sentinel	f015e20d72f40c1a	device_profile_otaa	n/a	n/a

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Research
Premise –
Wireless
Options:
Summary

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Our Robots



TurtleBot3
Burger



Related Works

Related Works – Edge Computing



HetroEdge

Previous Work of Saied

Optimizing computing resources (time/power/bandwidth/latency) across a diversified network



Heindall

mobile GPU coordination for Deep Neural Networks



MASA

framework for memory and computing resources for multi-Deep Neural Networks applications



MAUI

automated system for allowing fine control of offloading of computing



BALB

(batch-aware latency-balanced) scheduling algorithm to drive object detection via images



Others

Resource optimizing algorithms



Related Works – LoRa and LoRaWAN

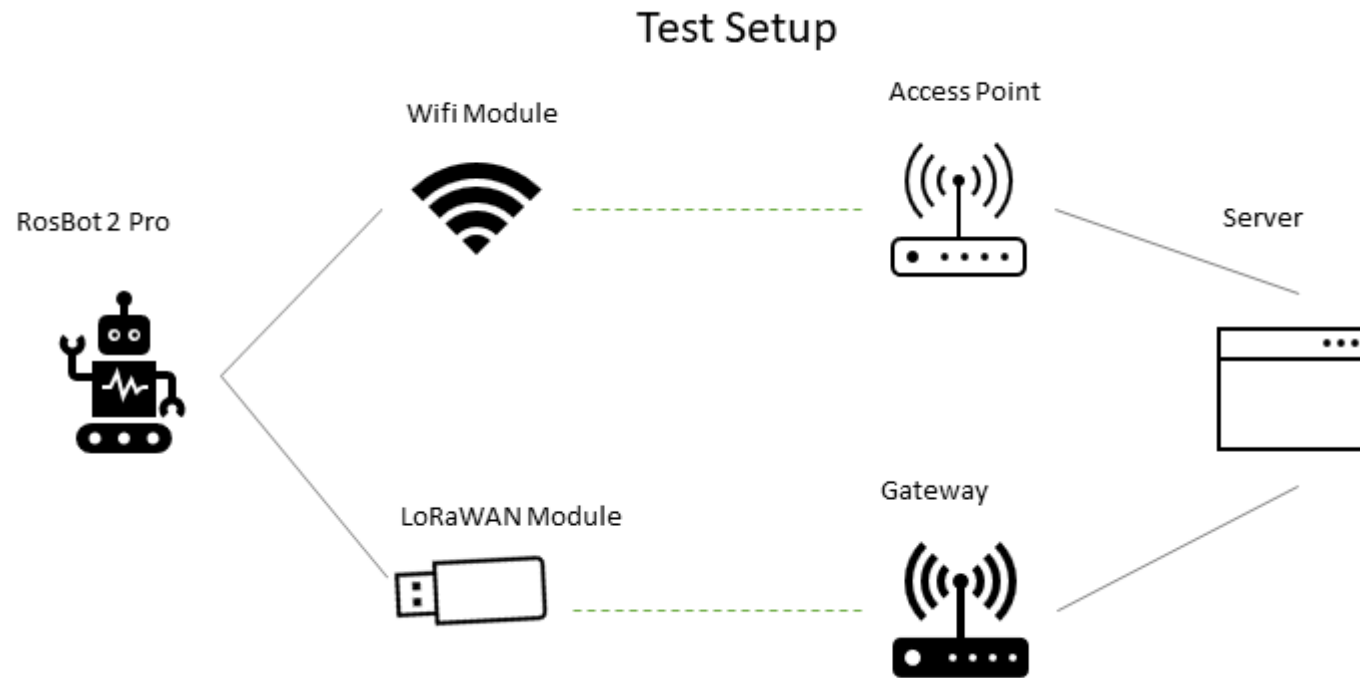
- Search and Rescue Case Study proposes X-IoCA (Internet of Cooperative Agents Architecture)
 - Framework for integrating heterogeneous sensor networks, heterogeneous robotic networks, multiedge computing, and 5G communications in cooperative field applications

Methodology

Testing Premise

What is the latency (time) to send unprocessed images across WiFi (MQTT) and LoRaWAN?

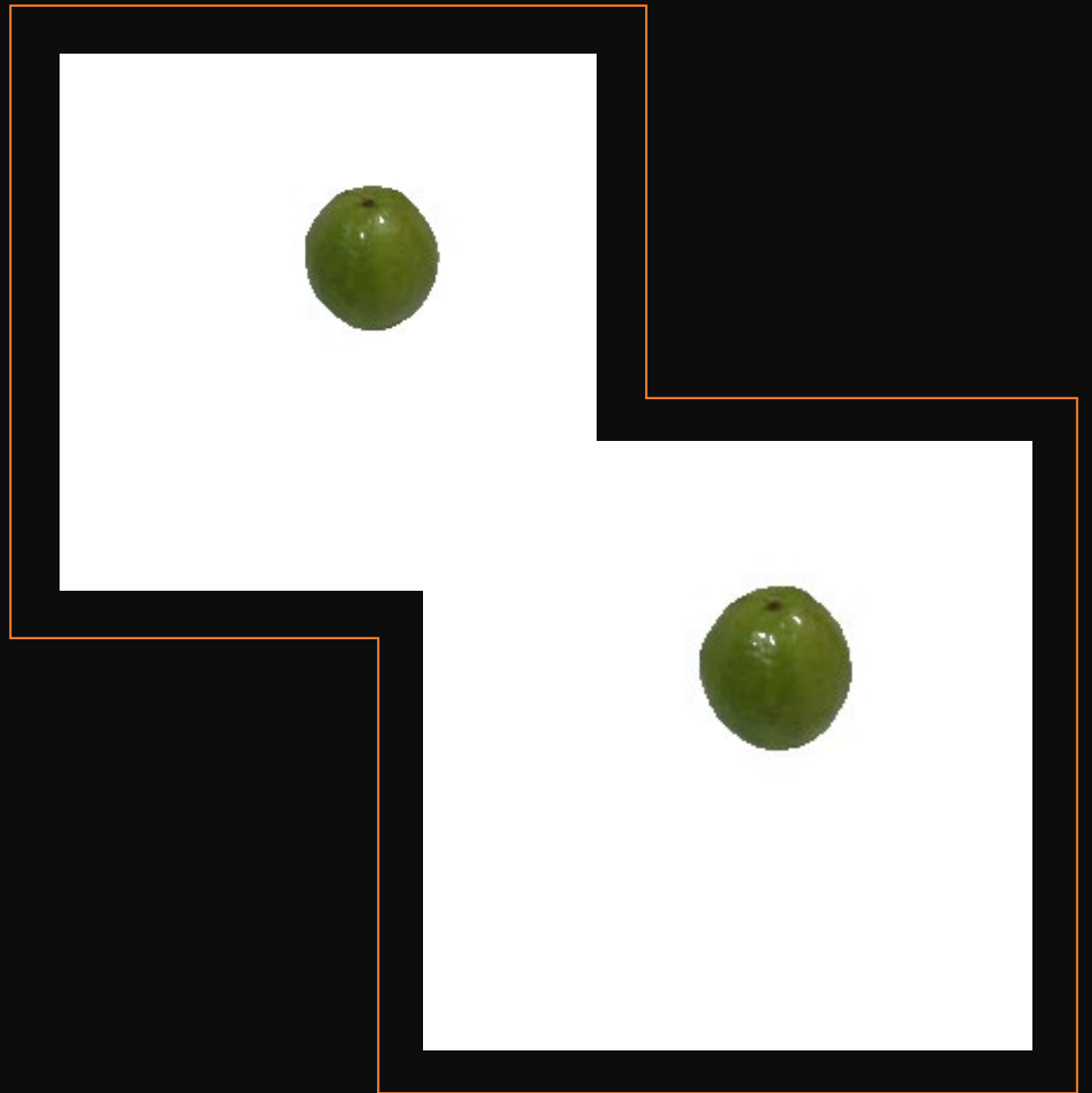
Test Setup – Overview



Name	Type	Count	Average Size	Total Size	File Type	From
1A	Small Images	6	7.8kb	46.8kb	png	TestFileDownload
2A	Extra Small	6	2.31kb	13.9kb	jpg	bounding_box_test
2B	Extra Small	12	2.29kb	27.5kb	jpg	bounding_box_test
2C	Extra Small	24	2.18kb	52.5kb	jpg	bounding_box_test
3A	Medium	6	49kb	294kb	jpg	Saeid Feature Extraction
3B	Medium	12	55.7kb	668.8kb	jpg	Saeid Feature Extraction
4A	Large	6	0.25mb	1.5mb	jpg	Fire and Smoke Dataset
4B	Large	12	2.04mb	24.5mb	jpg	Fire and Smoke Dataset

Datasets

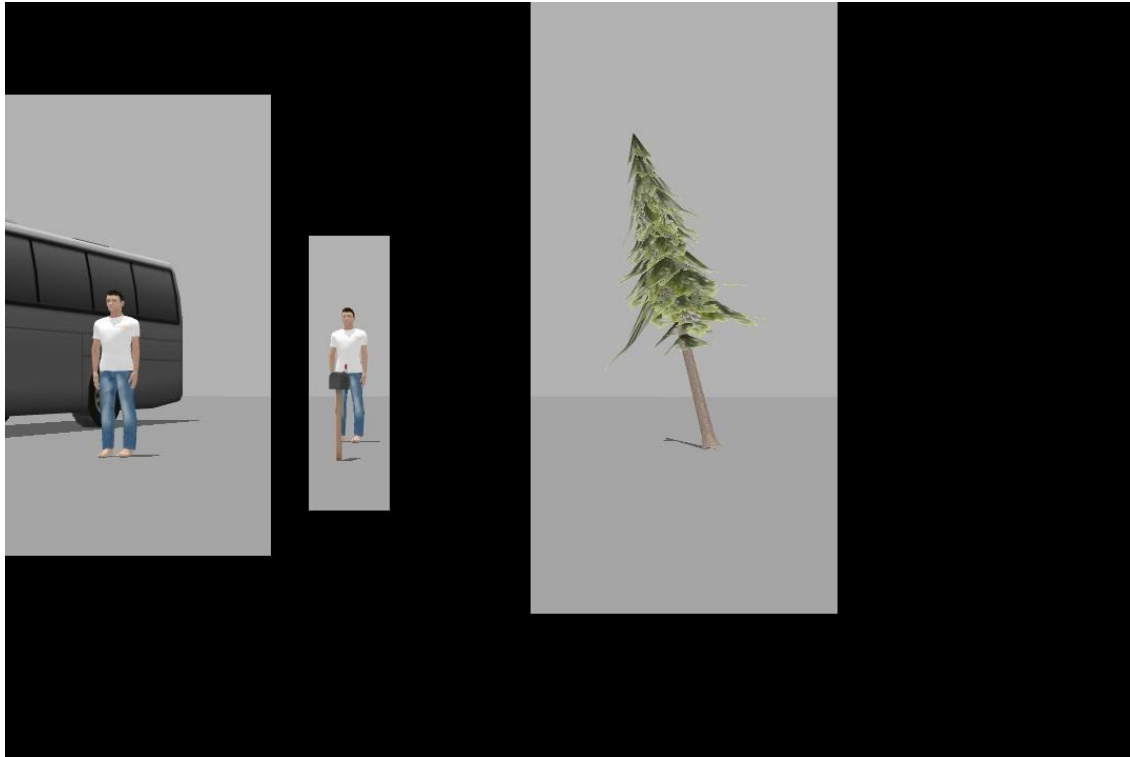
Dataset – 1A



Dataset – 2A,
2B, 2C



Dataset – 3A, 3B





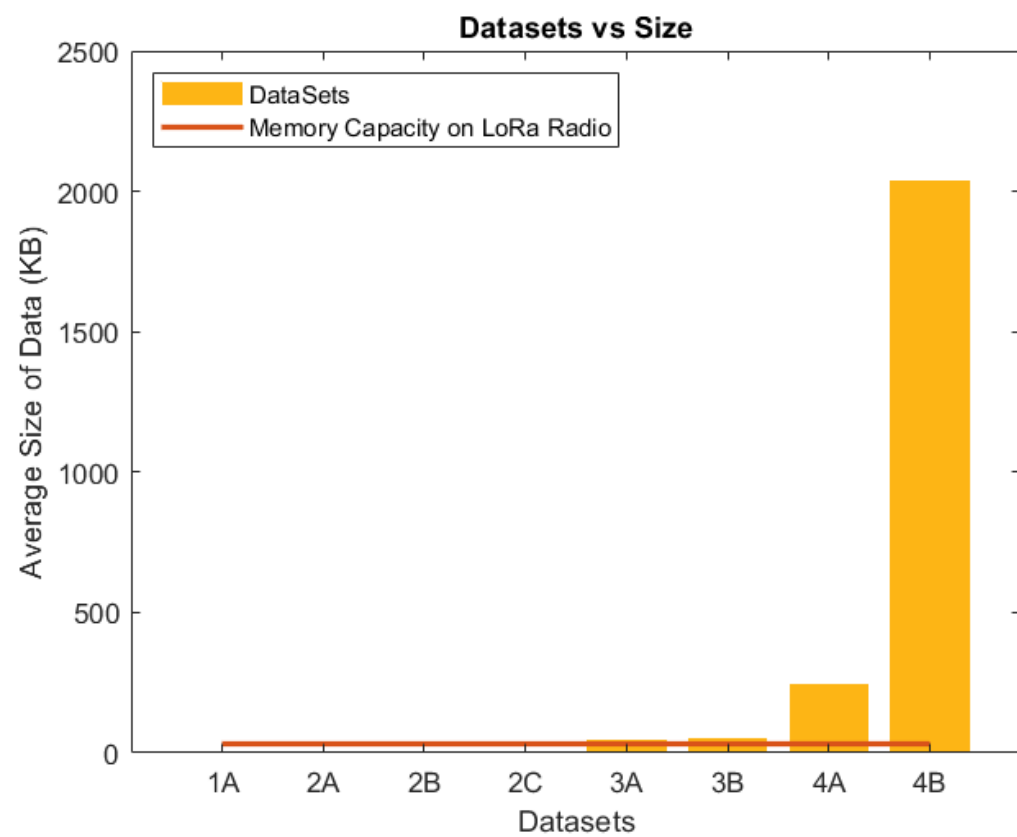
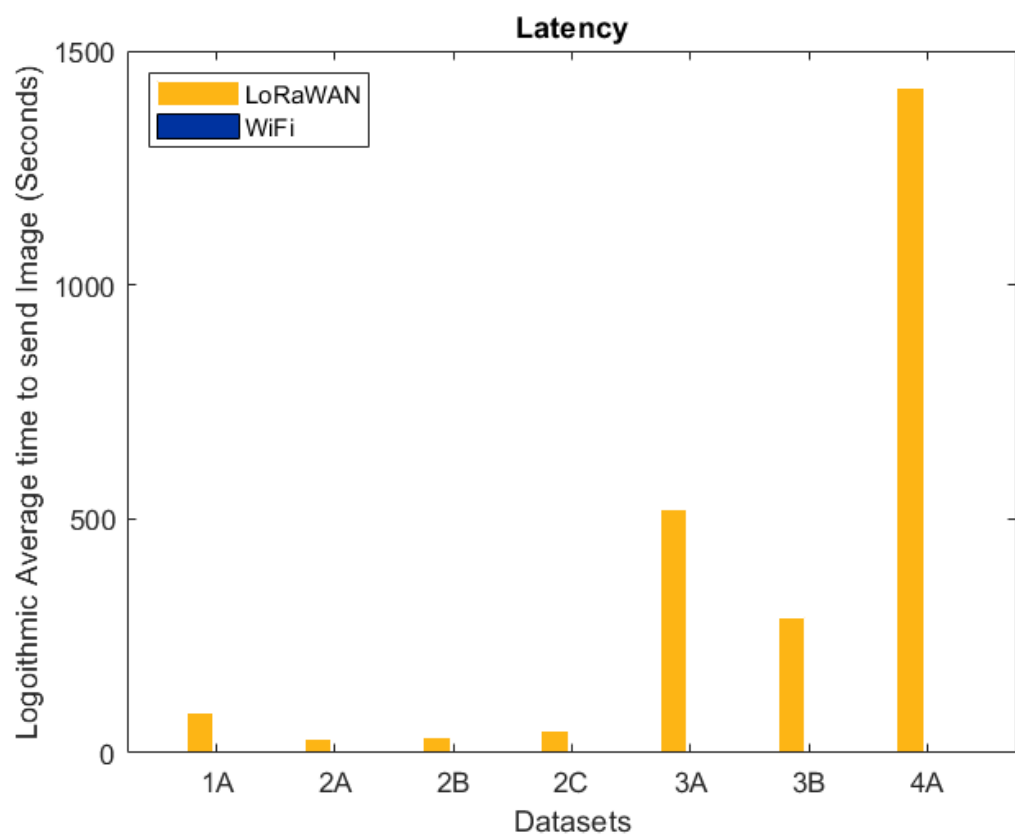
Dataset –
4A, 4B



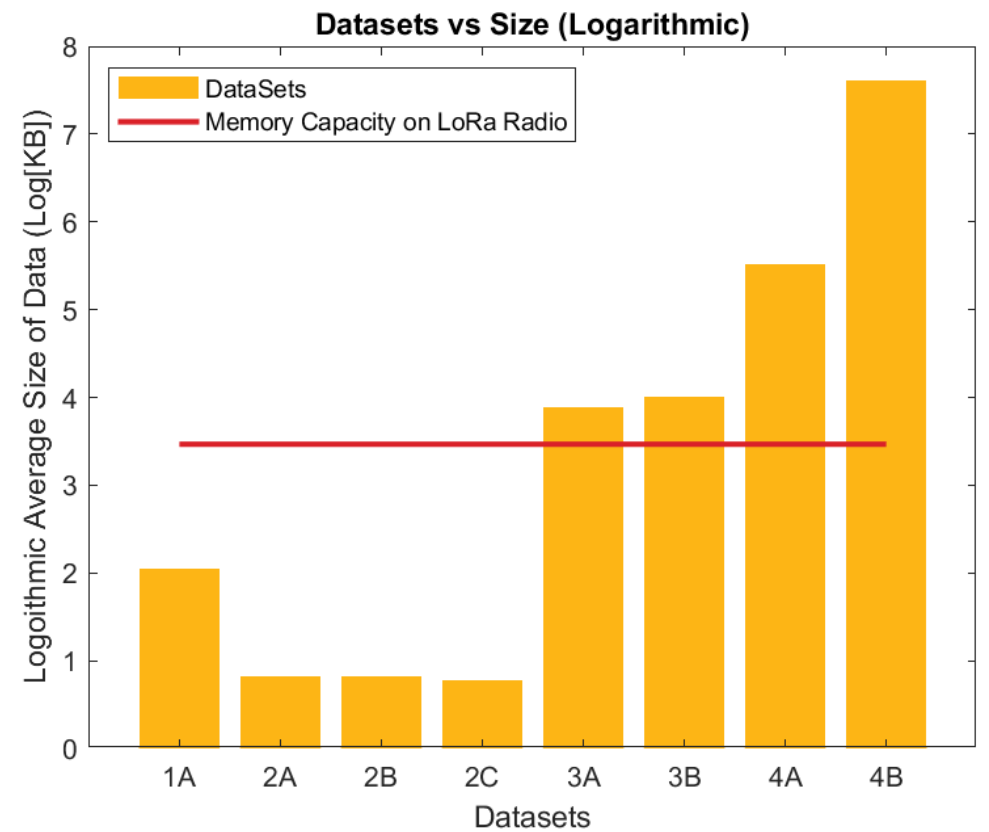
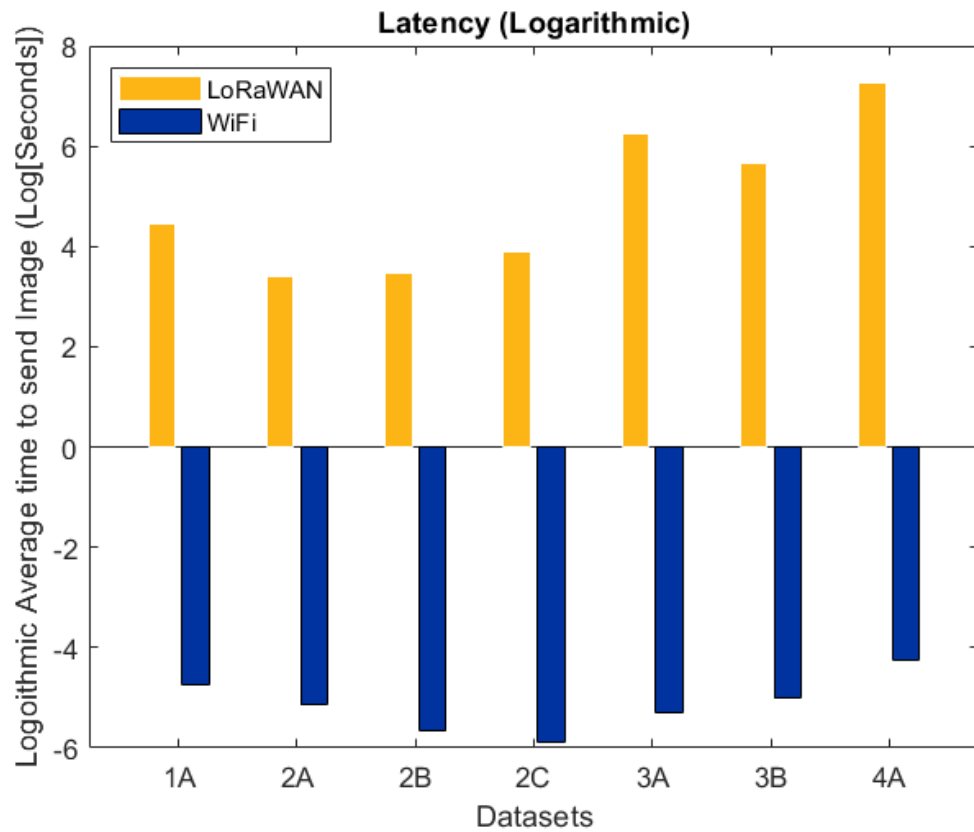
Results and Problems

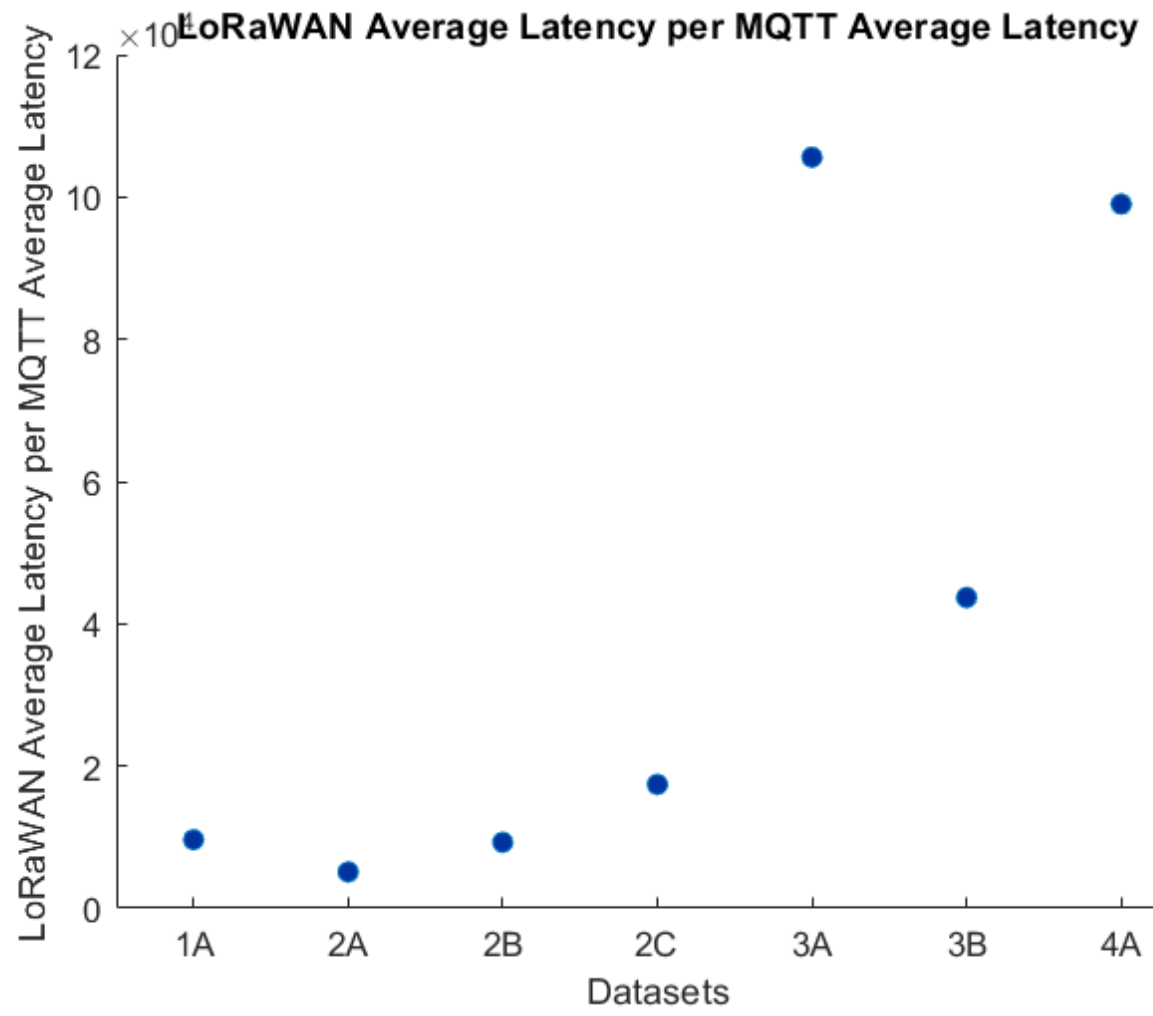


Results



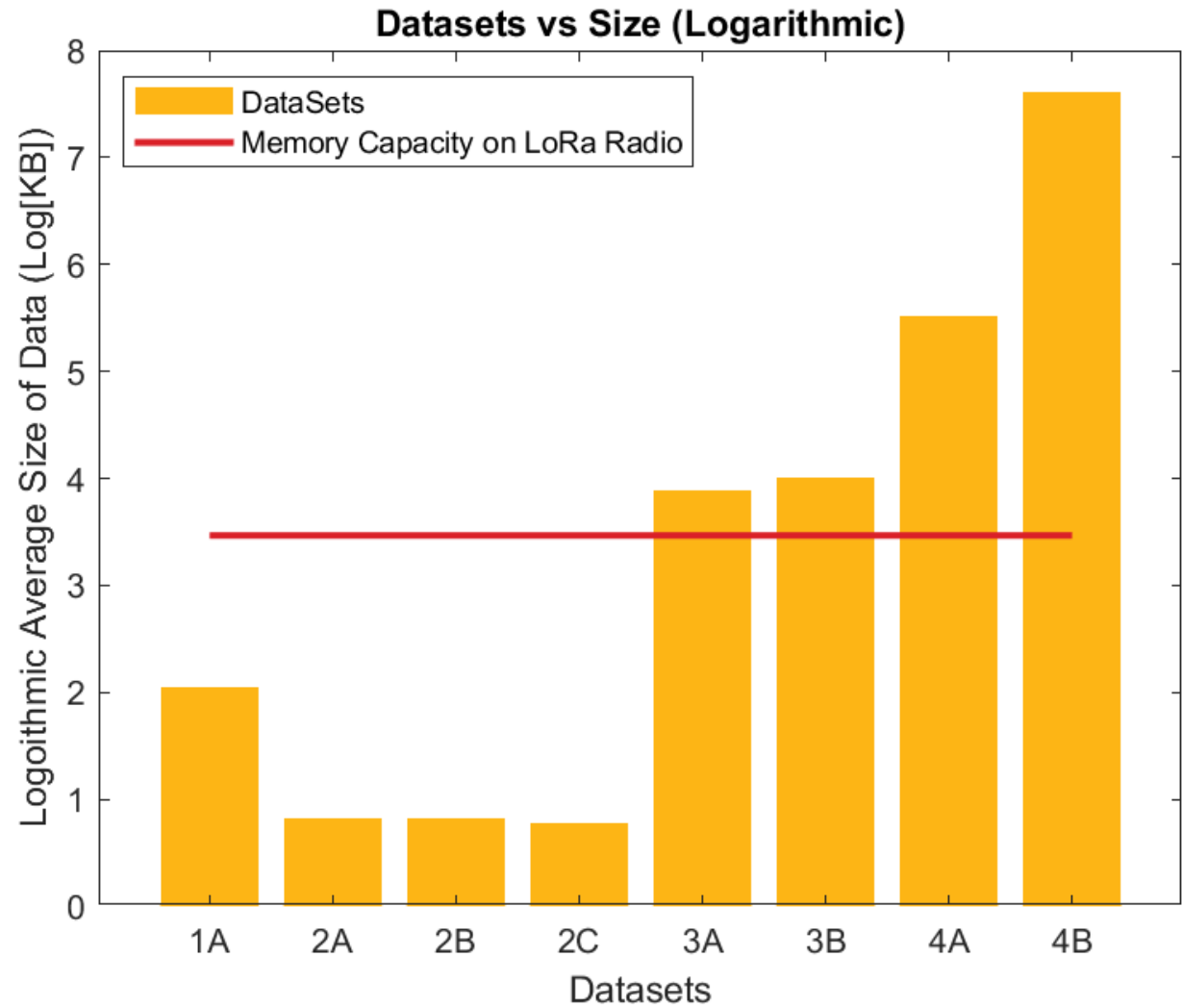
Data (Log)





Problems – Memory of Radio

- Our radio based on Arudino M0
- 32Kb of flash
- Can't fill a full glass with more water



Conclusions

Conclusions



Viable option

We can send large amounts of data using
LoRaWAN



LoRaWAN preformed as expectedly

Orders of magnitude longer than WiFi



Need further research

Some sort of data compression is needed
Needs to balance latency with computational time



Skills and Research Experience



Skills

- Embedded Development
- MQTT networking
- Multi-layer Networking
- Python
- Dockers
- LaTeX
- Modal AI Drone Deployment
- Data Analysis



Research Experience

- Independently Explore Problems
- Read and Understand Academic Works
- Contribute to an ongoing project



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