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

LoRaWAN

• WAN
  • Wide area network

• Built ontop of LoRa
  • Easier to Manage for IoT
<table>
<thead>
<tr>
<th>Last seen</th>
<th>Device name</th>
<th>Device EUI</th>
<th>Device profile</th>
<th>Link margin</th>
<th>Battery</th>
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<tr>
<td>4 days ago</td>
<td>Sentinel</td>
<td>5015e20d72140c1a</td>
<td>device_profile_yaa</td>
<td>n/a</td>
<td>n/a</td>
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</table>
Our Robots

TurtleBot3

Burger
Related Works
## Related Works – Edge Computing

<table>
<thead>
<tr>
<th>HetroEdge</th>
<th>Previous Work of Saied</th>
<th>Optimizing computing resources (time/power/bandwidth/latency) across a diversified network</th>
</tr>
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<tbody>
<tr>
<td>Heindall</td>
<td></td>
<td>mobile GPU coordination for Deep Neural Networks</td>
</tr>
<tr>
<td>MASA</td>
<td></td>
<td>framework for memory and computing resources for multi-Deep Neural Networks applications</td>
</tr>
<tr>
<td>MAUI</td>
<td></td>
<td>automated system for allowing fine control of offloading of computing</td>
</tr>
<tr>
<td>BALB</td>
<td></td>
<td>(batch-aware latency-balanced) scheduling algorithm to drive object detection via images</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>Resource optimizing algorithms</td>
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</tbody>
</table>
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
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<th>Type</th>
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<td>46.8kb</td>
<td>png</td>
<td>TestFileDownload</td>
</tr>
<tr>
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<tr>
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<tr>
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<td>294kb</td>
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<td>Saeid Feature Extraction</td>
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<tr>
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<td>1.5mb</td>
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<td>Fire and Smoke Dataset</td>
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<tr>
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<td>2.04mb</td>
<td>24.5mb</td>
<td>jpg</td>
<td>Fire and Smoke Dataset</td>
</tr>
</tbody>
</table>
Dataset – 1A
Dataset – 2A, 2B, 2C
Dataset – 3A, 3B
Dataset – 4A, 4B
Results and Problems
Results
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
Acknowledgements
Acknowledgements

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• Center for Real-time Distributed Sensing and Autonomy Lab Members

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  • I have made memories and friends for a lifetime