Viability Analysis of Wireless Communication Hardware for Multi-rotor Swarm Integration

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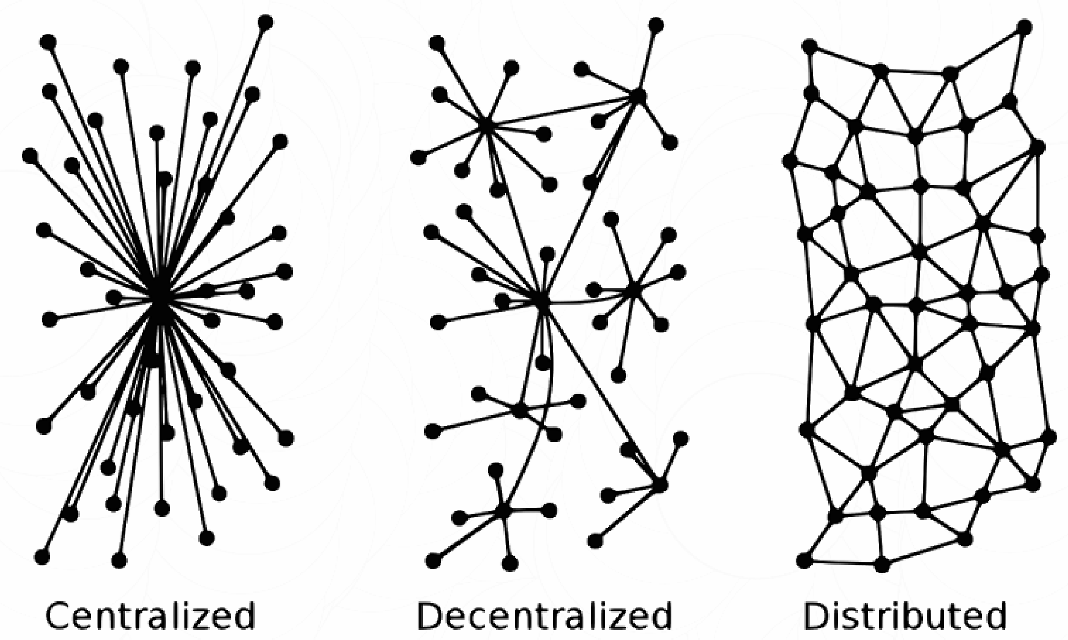

Figure 1: These are examples of centralized, decentralized, and distributed communication networks.

INTRODUCTION

- In a swarm robotics system, information transmission between robots is important. With communication, robots can share information for coordination, conflict avoidance, and to accomplish complex tasks [1].
- The communication techniques are shown in Figure 1, have previously been demonstrated. However, the communication needs to implement a theoretical multi-agent hierarchical decentralized controller has not been established [2].

GOAL

We seek to evaluate the operational performance and viability of Wi-Fi and XBee field radio-based communication (see Figure 2) for the implementation of the novel controller.

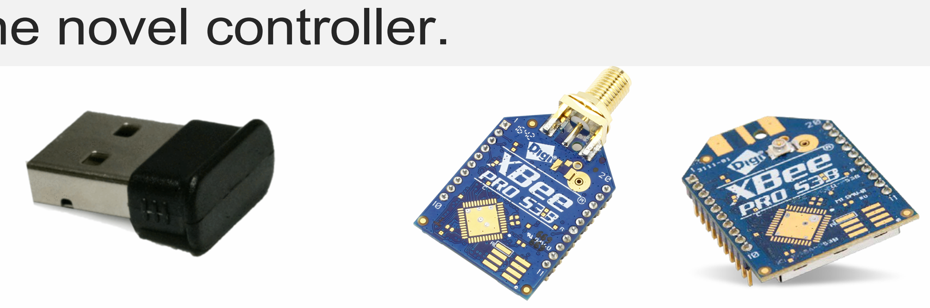

Figure 2: (*Left*) Wi-Fi Dongle Hardware, (*right*) Xbee SB3 Hardware.

APPROACH

Field Experiments:

Docker v20.10.7, which containerizes software to run independently of system architecture, was identified as a viable software deployment mechanism for the hierarchical approach. We ran a series of field experiments with increasing Docker patch sizes being sent over Wi-Fi dongle and Xbee field radio. This allowed us to measure the range and duration of round trip transmission concerning docker patch size. We test at intervals α, β, ε, φ, ψ (see Figure 3).

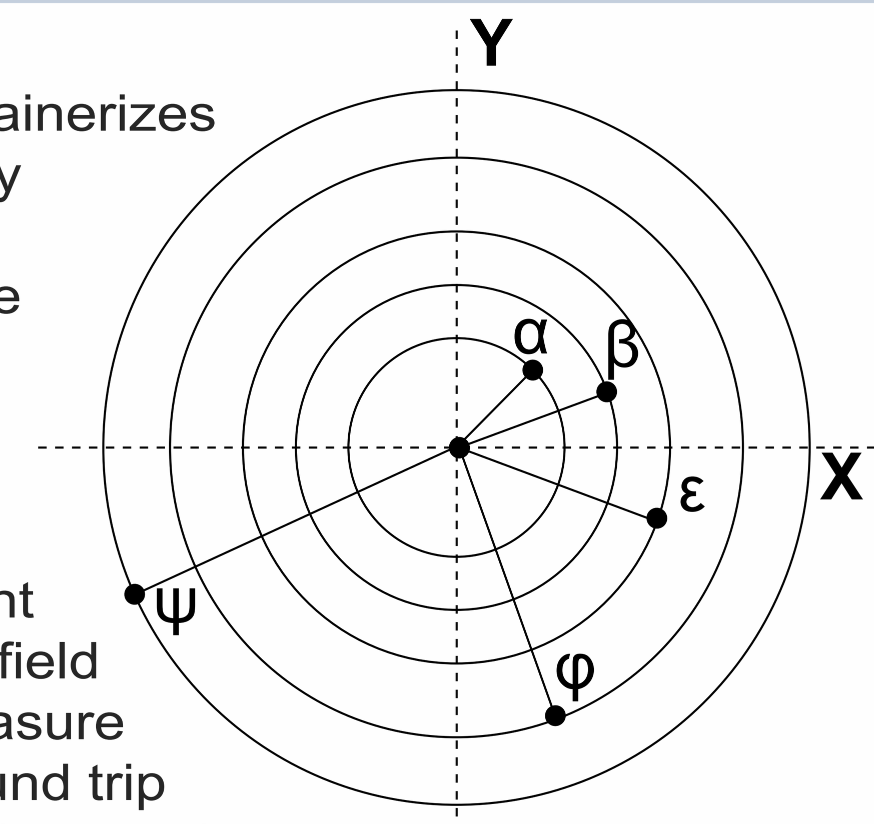

Figure 3: Test intervals α = 10m, β = 15m, ε = 20m, φ = 30m, ψ = 40m

Wi-Fi Patch Transmission:

When testing Wi-Fi communication, we utilized the Edimax EW-7811Un USB Wi-Fi dongle operating at 2.4GHz connected to an Odroid-XU4 single board computer configured as a swarm agent. We used a laptop's native Intel AC 7265 Wi-Fi module as a centralized wireless router.

XBee Patch Transmission:

When testing Xbee field radio communication, we utilized the Xbee Pro S3B modules operating between 902-928MHz with the Zigbee 802.15.4 protocol. We first configured and paired the set in XBee Configuration Testing Utility (XCTU).

RESULTS

Wi-Fi Dongle:

- As we can see in Figure 4, patch size and round trip transmission time are directly related, which is an expected result.
- The variance increases with patch size and distance to the wireless router. This may be related to the relatively high operating frequency of 2.4GHz.

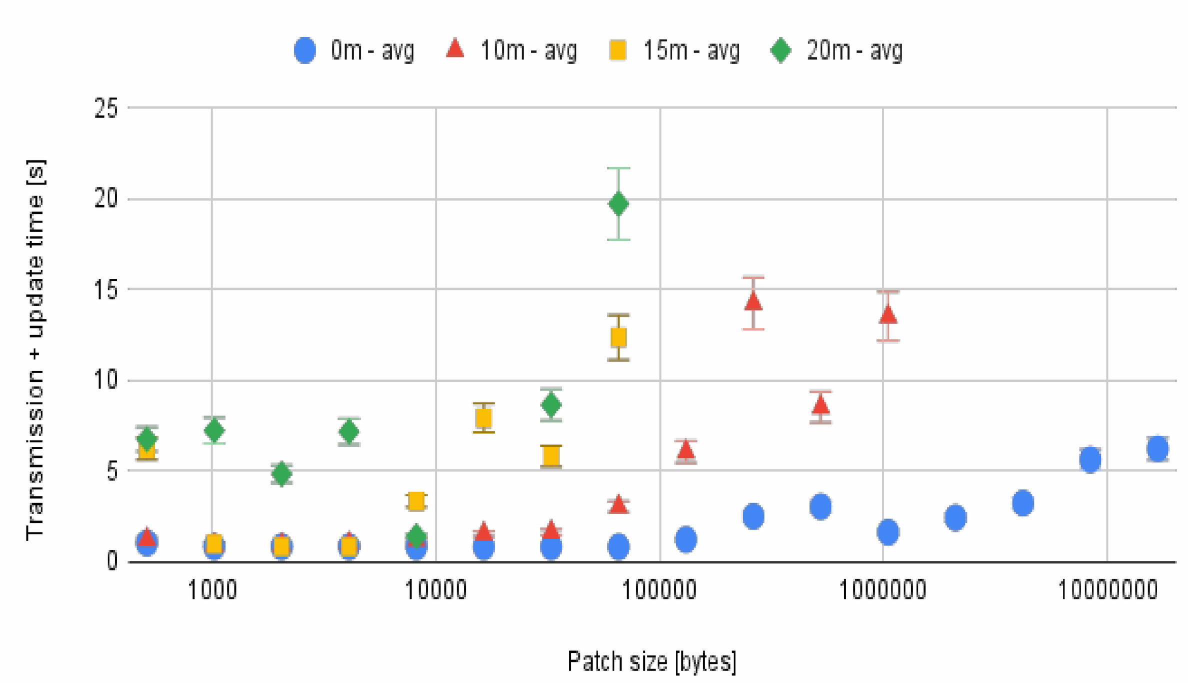

Figure 4: Increasing Docker patch size and round trip transmission time with respect to distance for the Wi-Fi dongle hardware.

Xbee Hardware:

- Similar to the Wi-Fi dongle, patch size and round trip transmission time are directly related, which is an expected result shown in Figure 5.
- There is less variance with patch size and distance to the centrally paired radio with respect to the Wi-Fi dongle. This may be due to the lower transmission frequency of ~900MHz.

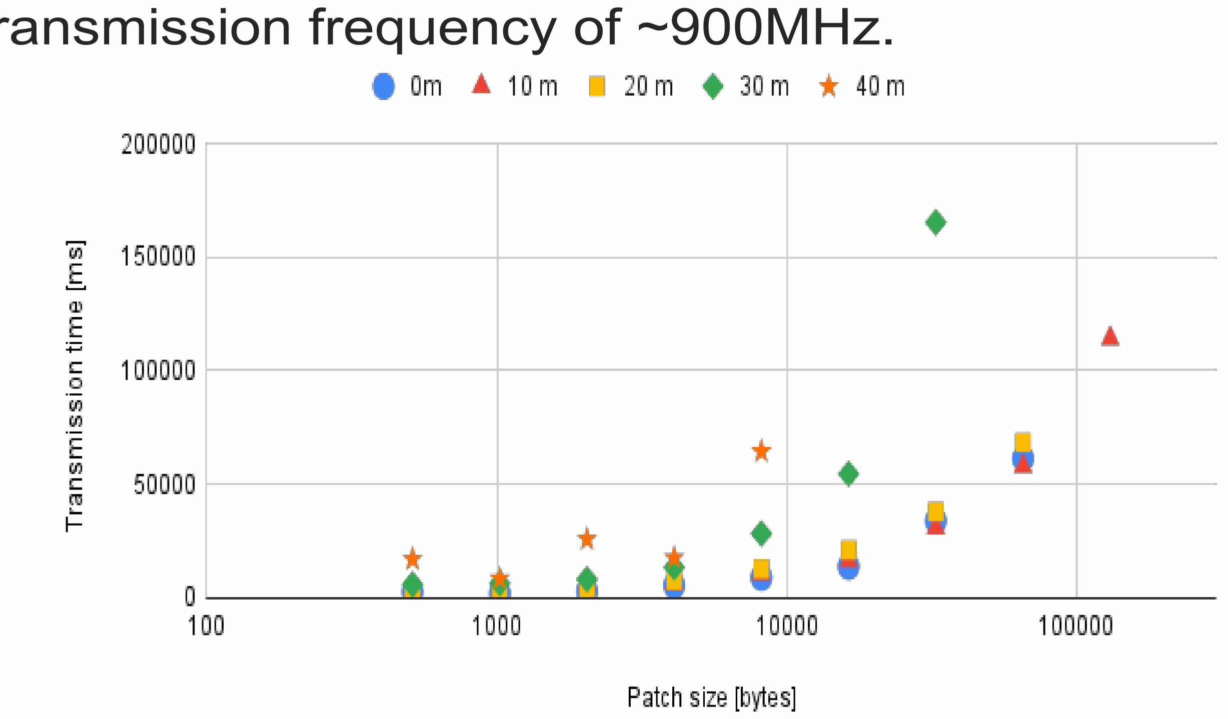

Figure 5: Increasing Docker patch size and round trip transmission time with respect to distance for the Xbee S3B hardware.

DISCUSSION

- By taking these two sets of communication hardware to the field and running our experiments we found that transmission times were lower for the Wi-Fi dongle with respect to the Xbee, but only viable at transmission distances less than 20m before timing out.
- For relatively large Docker patch sizes Wi-Fi dongles are more capable. However, for small Docker patches over distances >20m the Xbee field radios are more viable. We recommend the fusion of these wireless communication systems to cover the widest range of distance and patch sizes.

FUTURE WORK

- For more in-depth evaluation we will run experiments in the field to analyze Bit Error Rate (BER) and Received Signal Strength Indicator (RSSI) in dBm.
- Implement swarm algorithms to improve over-the-air (OTA) communication to reduce BER and increase RSSI.

REFERENCES

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[2] H. Bai, J. George, and A. Chakrabortty, "Hierarchical Control of Multi-Agent Systems using Online Reinforcement Learning," in *2020 American Control Conference (ACC)*, July 2020, pp. 340–345, iSSN: 2378-5861.

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