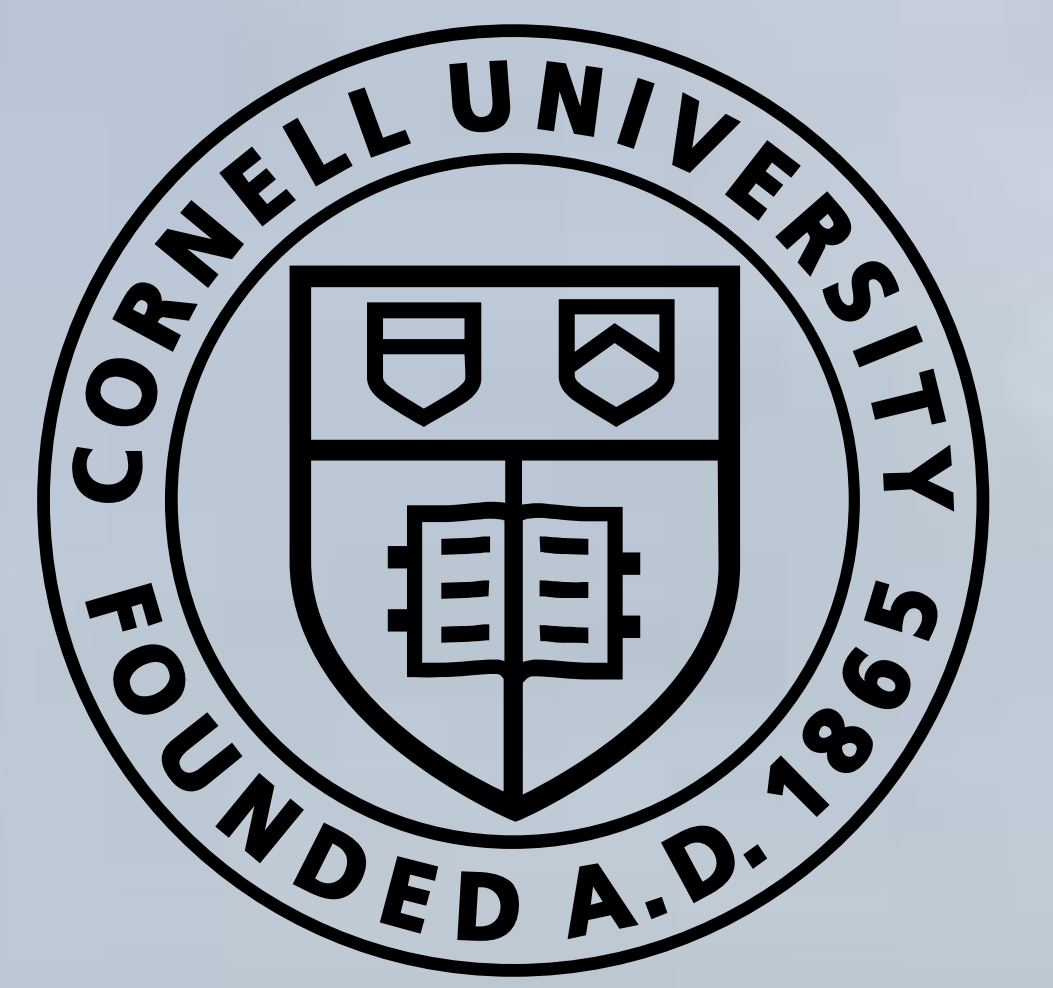


# WaterGuard: Toward Cheap Automated Irrigation Systems Powered by the Cloud and TV White Spaces

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## Introduction

- To sustainably feed a projected 10 billion people in 2050, we must:
- Reduce crop loss to environmental stresses by 20%
  - Increase water use efficiency by 50%
  - Increase farm productivity by 67%

### The promise of data-driven farming

- Agriculture constitutes approximately 70% of global water usage
- 50% of the irrigation water is wasted to over-watering
- Data-driven farming can reduce water intake

## Challenges & Related Work



- Inaccurate sensing due to soil variability
- Limited connectivity due to sparsely populated rural areas
- Irrigation schedules with limited foresight into weather forecasts

## Novel Approach

- Detecting drought stress via a plant MEMS sensor implant
- Leveraging free, farm wide connectivity with TV White Spaces (TVWS) and Long-range Radio (LoRa)
- Leveraging scalable, serverless compute in the cloud and optimally placed Raspberry Pis at the farm

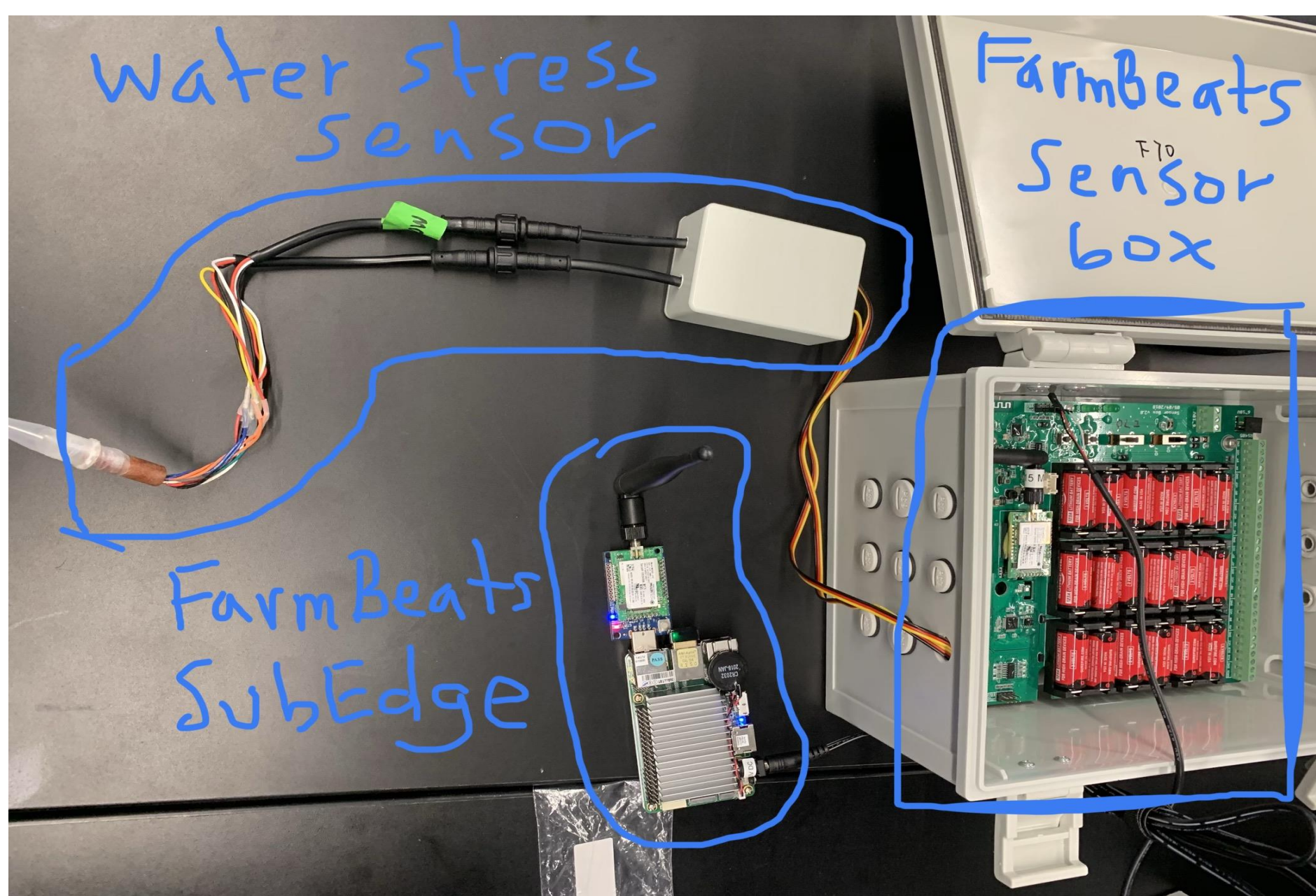
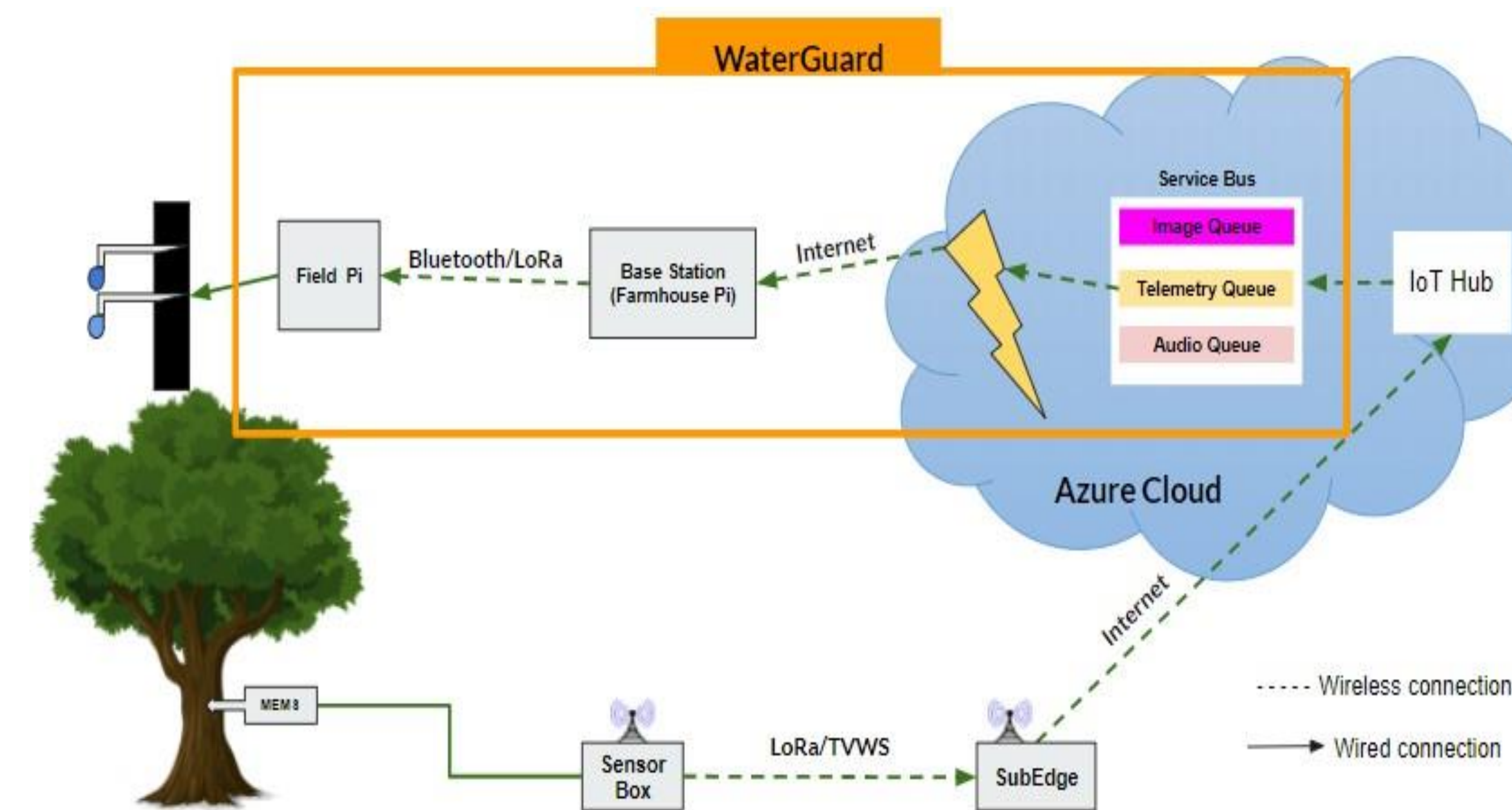


Figure 1 Sample FarmBeats Components including a sensor box, SubEdge, and LoRa Radio

## WaterGuard – Achieving Full Automation In Irrigation Systems

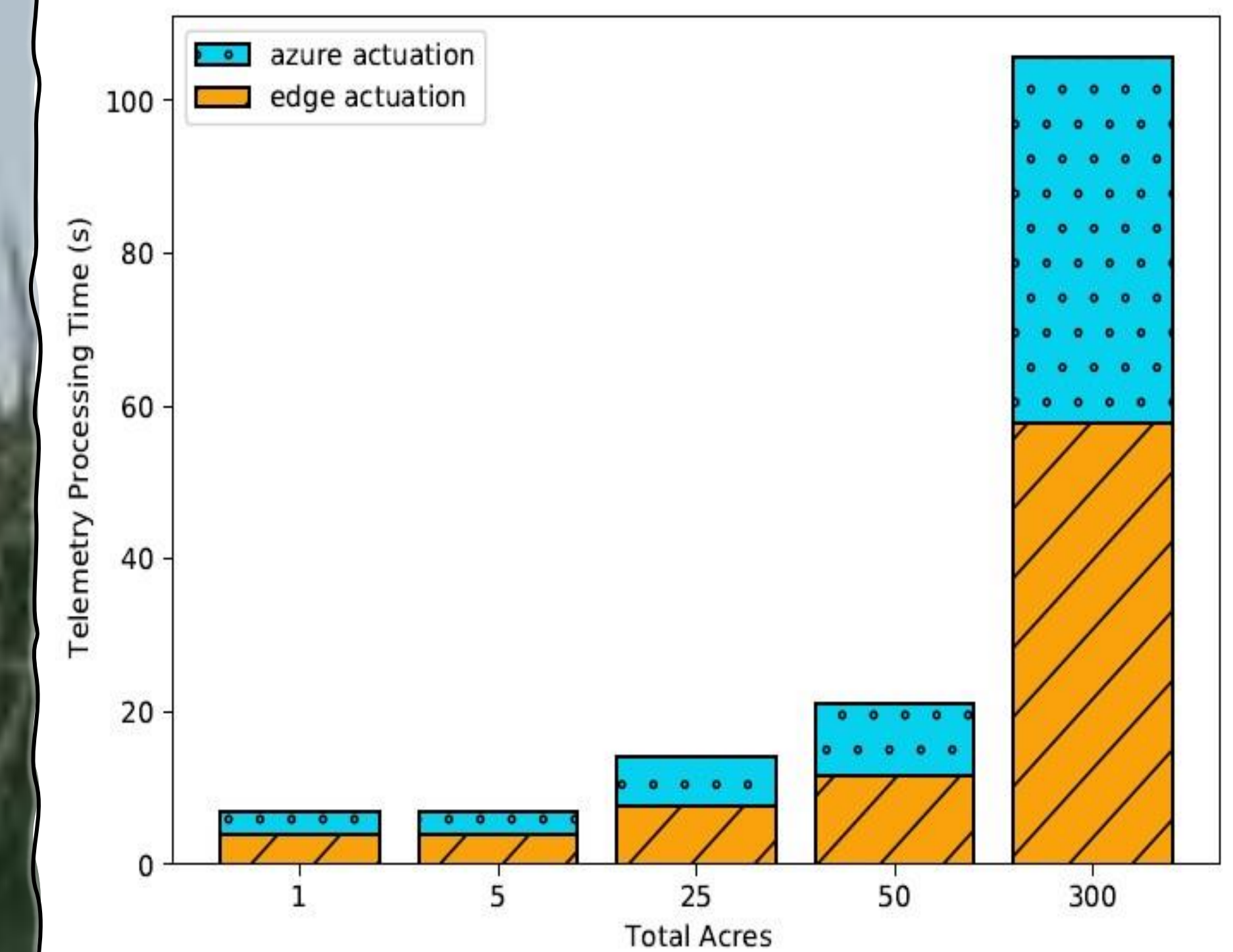


## Evaluation – Startup and Maintenance Costs

	Baseline	WaterGuard
Analog-to-digital (A2D) Converter	CR6 (\$1500)	Sensor Box (Approx. \$200)
Farmhouse Wi-Fi	Hologram Nova 3G Modem (\$69 up front cost, \$1.50 per device per month + 40 cents per MB transferred)	LoRa Radio (\$104) and SubEdge (\$225)
Raspberry Pi Kits	\$146 * 1 (\$146)	\$146 * 2 (\$292)
Analytics	Ubidots (\$49/month for IoT entrepreneur subscription)	Azure Functions (\$8 per month assuming 10 executions per hour)
Human Labor Costs	\$1920/month	\$0/month
Total Startup Cost	<b>\$1715</b>	<b>\$821</b>
Total Monthly Cost	<b>\$1971</b>	<b>\$52</b>

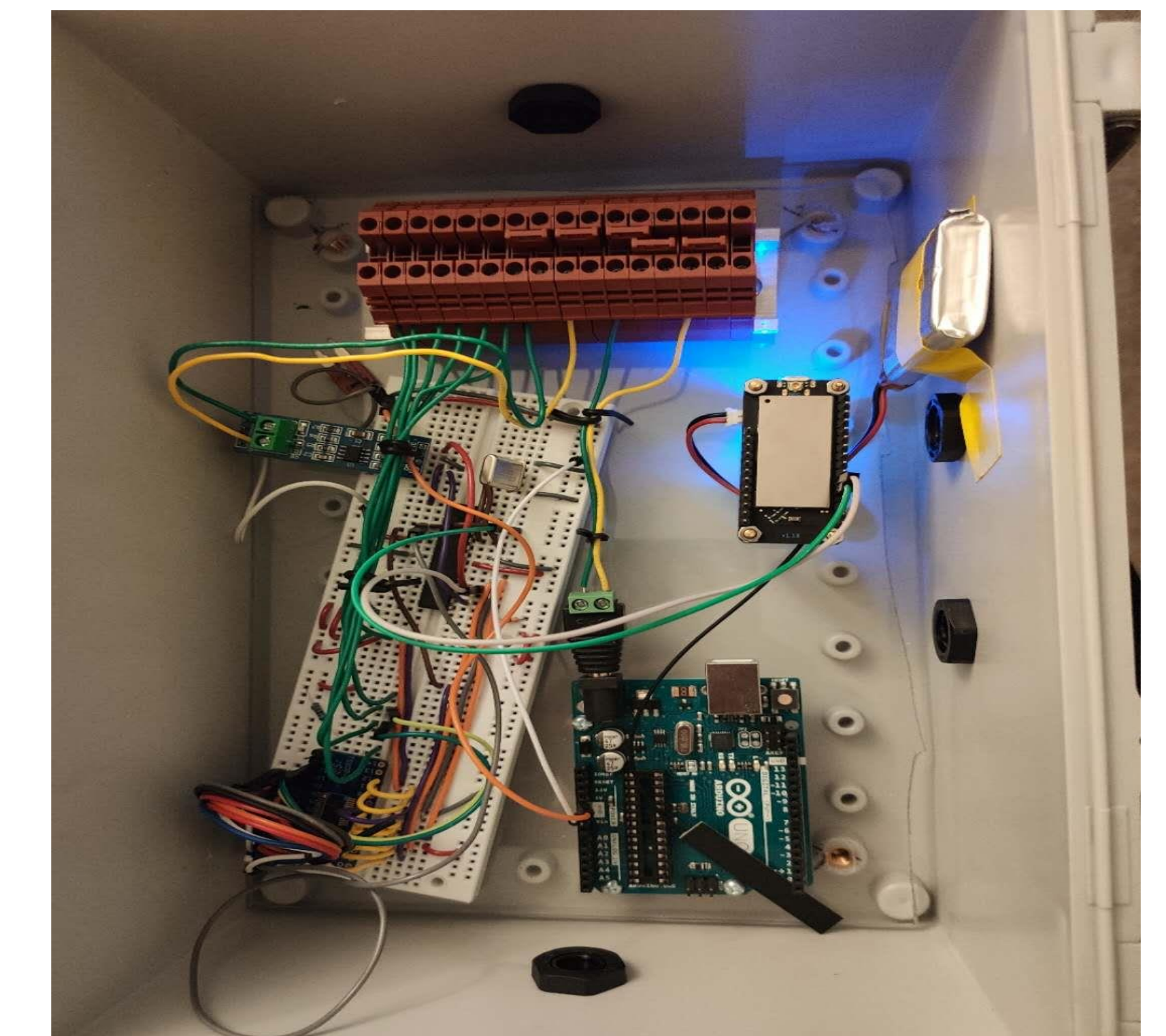
Table 1: Startup and maintenance costs for a 3G-based, baseline system and WaterGuard. The data transmission costs for the Hologram Nova modem assume 255-byte drought stress data transmitted every 6 minutes. The human labor costs for the baseline assume a \$16 per hour pay rate where the human operator performs water stress checks every 4 hours on Ubidots cloud dashboards.

## Scaling – Edge vs Remote Actuation



- Bringing the cloud locally with Azure IoT Edge
- Resilience in the face of network outages

## Future = Hardware Agnostic



- Soil variability? Model future plant drought stress
- No connectivity? Off-the-shelf network construction
- Limited forecast? Caching during better times

## Acknowledgments

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