

USE CASE

[Problem]

Search/explore an unknown area without functioning networking infrastructure.

[Product]

Small wheeled robots autonomously explore region, build network, and relay data back to fixed station.

[MVP scope]

- > Ad-hoc networking
- > Robot chassis
- > Localization

[North-star scope]

- > Vision processing
- > Obstacle avoidance
- > Navigation

USE CASE

[Crawler]

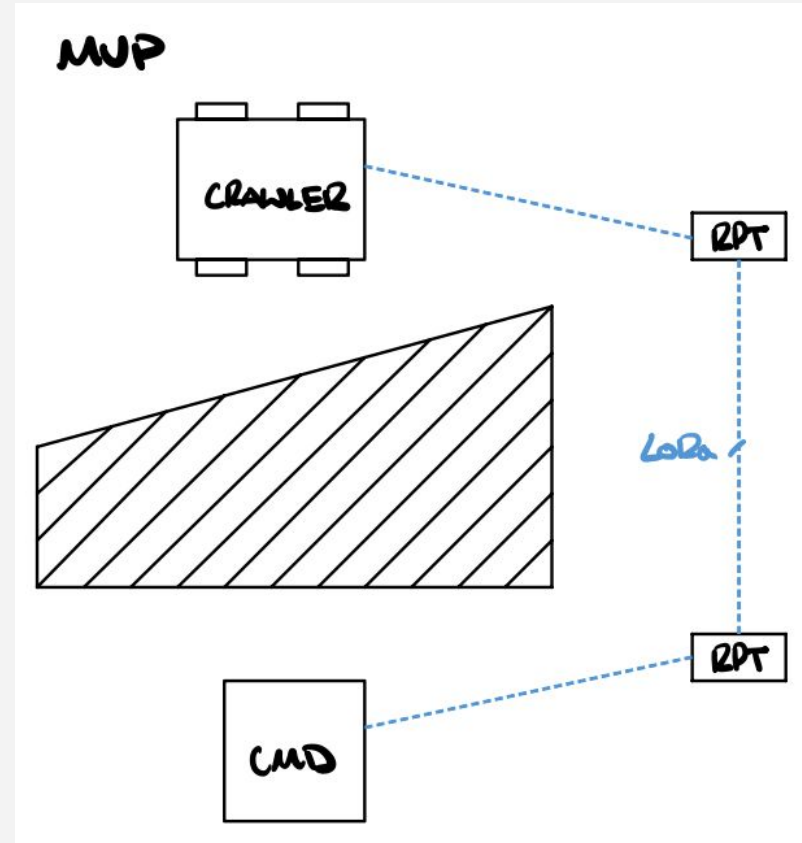
Autonomously explores the environment and captures data.

[Repeater]

Unactuated node carried by crawlers to extend the network.

[Commander]

Unactuated node with vision processing capabilities; sends fleet-level commands.



REQUIREMENTS: CRAWLER

[Localization]

Crawler must be able to navigate to known home location, both indoors and outdoors.

- > Localization accuracy: < 20m (GPS, monocular vSLAM)
- > Outdoor localization domain: > 5km (GPS)

[Traversal]

- > Speed: > 1.5 m/s
- > Battery life: > 30 min

[Video]

- > Resolution: > 512x512, grayscale, monocular
- > Framerate: > 60 fps

REQUIREMENTS: NETWORKING

[Capacity]

Network should be able to support arbitrary expansion.

- > Theoretical num max participants: > 64

[Link Protocol]

Agnostic to underlying link protocol.

- > Min supported links: LoRa, Wi-Fi

[Path Resolution]

Dynamic path resolution should occur quickly as crawlers move.

- > Path rediscovery latency: < 30s

TECHNICAL CHALLENGES: CRAWLER

[Electronics]

- > vSLAM is computationally expensive
- > High-fps camera will stress disk writing
- > Compute and drive have different power requirements

[Traversal]

- > Drive needs to handle variety of terrain

[Localization]

- > GPS suffers in urban/indoor zones
- > vSLAM requires time-synchronized IMU fusion

TECHNICAL CHALLENGES: NETWORK

[Path Discovery]

- > Endpoints needs to be robust to movement, new path discovery must be fast
- > It is difficult to incorporate multiple protocols in one network

[WiFi]

- > Routers need to broadcast hotspot + connected to upstream
- > More devices will congest more bandwidth
- > Interference/hidden terminal problem

[LoRa]

- > Lora very susceptible to attenuation + low bandwidth

SOLUTION APPROACH: CRAWLER

[Electronics]

- > RPI 5: runs vSLAM, networking stack, motor driving
- > T-Beam: runs LoRa driver, GPS driver, IMU driver
- > Compute battery: powers RPI 5, T-Beam
- > Drive battery: powers motors
- > Global shutter camera: data capture

[Traversal]

- > 2x BLDC planetary: skid-steer drive

[Localization]

- > GPS: outdoors localization
- > vSLAM+IMU: indoors localization

SOLUTION APPROACH: NETWORK

[Path Discovery]

Uses Reticulum to discover paths and transmit data.

- > No IP Address
- > Protocol-agnostic pathing
- > Multi hop

[WiFi]

Algorithm to select upstream parent WiFi AP to bind to.

- > AP-STA mode
- > Single parent, multiple children

[LoRa]

Test communication stability and goodput within Reticulum.

TESTING: CRAWLER

[Traversal]

- > Velocity/accel: test traversal in various scenarios
- > Battery life: exhaustive drive battery test

[Video Capture]

- > Lighting: auto-exposure in various lighting conditions
- > Motion blur: severity during turning
- > Storage: stable capture to disk, on-board compression

[Localization]

- > GPS: test performance in application scenario (outdoors)
- > vSLAM: test performance in application scenario (indoors)

TESTING: NETWORK

[Protocol agnosticism]

Test that mixed-protocol paths are discovered and stable:

```
> 3 node E2E: a <WiFi> b <LoRa> c
```

[Path rediscovery]

Test that as nodes move around, paths are re-discovered:

```
> 2 node E2E close: a <WiFi> b
```

```
> 2 node E2E far:    a <LoRa> b
```

[Data transmission]

Test target data transmission over paths:

```
> Pure WiFi path: compressed video streaming
```

```
> Multicast: fleet-level coordination commands
```

Division of Work

Ben	- reticulum - crawler - GPS - vision processing
Ethan	- reticulum - repeater - robotics software stack
Alden	- IMU - vSLAM

Schedule

Task Name	Status	September					October				November					Buffer
		2	6	13	20	27	4	11	18	25	1	8	15	22	29	
BEN'S TASKS — HARDWARE																
design Crawler	In Progress ▾		█	█	█	→										
build Crawler	Not Started ▾				█	█	█	↶								
test Crawler	Not Started ▾					█	█	↶								
intergrate repeater	Not Started ▾						█	█								
Test GPS	Completed ▾	█	█	→												
Integrate GPS	Not Started ▾			█	█											
vision processing	Not Started ▾									█	█					
ALDEN'S TASKS — LOCALIZATION																
test IMU	Not Started ▾			█	█	→										
integrate IMU	Not Started ▾				█	█	↶									
test SLAM	Not Started ▾			█	█	→										
integrate SLAM	Not Started ▾				█	█	↶									
combine IMU with SLAM	Not Started ▾					█	█									
ETHAN'S TASKS — SOFTWARE & COMMS																
develop repeater software	In Progress ▾	█	█	█	█	↶										
test repeater software	Not Started ▾			█	█	█	↶									
build pub sub abstraction layer	In Progress ▾			█	█	█	█	↶								
GROUP TASKS — INTEGRATION & MILESTONES																
Reticulum work	In Progress ▾	█	█	█	█	█	█	█	█	█	█	█				
SLAM/GPS + driving crawler	Not Started ▾						█	█	█	↶						
Reticulum + driving crawler	Not Started ▾						█	█	█	↶						
Reticulum + driving crawler + repeater	Not Started ▾							█	█	↶						
Reticulum + driving crawler + repeater + SLAM/GPS	Not Started ▾								█	█	█	█				
Reticulum + driving crawler + repeater + SLAM/GPS + vision proc	Not Started ▾										█	█	█			
North-star: multi-robot (week of 11/8) + buffer	Not Started ▾											█	█	█	█	

AI Usage

- > Gemini to help with schedule chart
- > Used AI heavily for brainstorming + testing