“CANOPY”

Low-Power, Long-Range Automated Wireless Sensor Network for a Rainforest Environment

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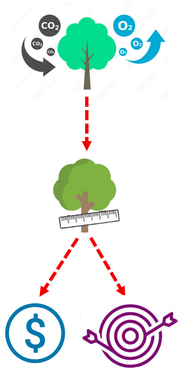
Project Purpose

Data Collection for Carbon Capture:
The purpose of the project is to provide a method of collecting and aggregating tree measurement data, which will be used to estimate the carbon mass sequestered by tree-planting projects in the Bolivian Amazon rainforest.



Reduce Cost and Improve Accuracy:
Existing data collection approaches include manual measurement and LiDAR images taken by drones flying overhead. These methods lack accuracy and/or require expensive physical labour. With the carbon sequestration industry growing, it is increasingly important for the data to be affordable and reliable. Novel methods are needed to achieve this objective.

Scope and Requirements

Automated Wireless Sensor Network

The project seeks to address the issue through design of a wireless sensor network for automated, continuous collection and aggregation of tree measurement data.

Components: We were tasked with designing and assembling the wireless node hardware, a power system, and all firmware needed to collect, aggregate, and send data to the satellite link device.

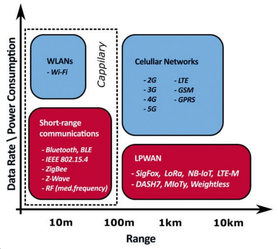
Scale: The fully scaled system is intended to collect data from tree samples spread over an area of 50,000 acres. Our solution is intended to use subnetworks of 255 measurement nodes, each covering an area of around 50 acres (38,000 trees).

Performance: The network will operate in the rainforest unmanned for at least 3 years. Thus, the system needs to be highly robust and have low power consumption.

Major Design Considerations

Scalability: We aimed for a solution that would be affordable when scaled to include hundreds of devices communicating over a wide area. Our firmware was designed to work reliably with a network of this size spread over several acres..

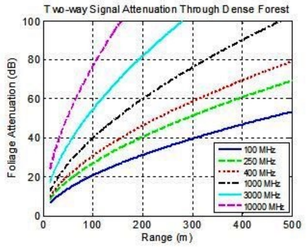
Power Constraints:
To contend with the limited available power in an unmanned system, we considered:

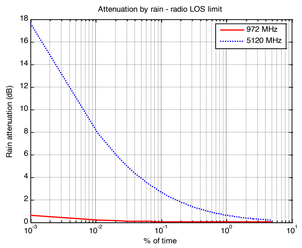


- Solar power
- Low-power network stacks
- Low-power microcontrollers
- Custom built low-power PCBs
- Batteries with high capacity and long lifespan
- Firmware written to reduce power consumption

Dynamic Path Obstructions: To contend with the dense tree-packing and changes in the environment, we considered:

- Sub-GHz transmission frequencies
- Physical layers with high resistance to interference
- Network stacks offering high Quality of Service
- Hopping capability to further extend range
- Ability to reroute signals
- Timing of transmissions to avoid rain and ensure maximum signal strength





RF attenuation and scattering by foliage and rain

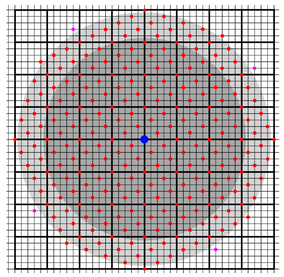
Solution

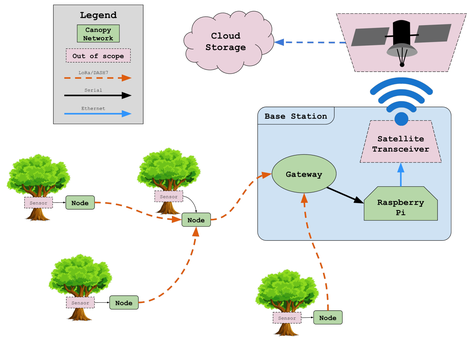
Network Stack:
- LoRa physical layer, 915 MHz: Compliant with international regulations, high resistance to interference, low power usage, long range, suitable data rate for application
- DASH7 Alliance Protocol network stack: Ad-hoc synchronization, high quality of service, ability to reprogram behaviour of the deployed network

Firmware:
- Sub-IoT framework: Flexible open-source implementation of DASH7 network stack
- Custom application implements up to two hops, allows rerouting, and manages selection of repeaters to balance load across the network

Power System:
- Monocrystalline solar panel: Affordable, easy to install, suitable for diffuse sunlight under canopy. Sized based on analysis of available solar resource on site
- Lithium-ion battery: Long lifespan, high energy capacity and low maintenance
- BMS: Manages the complexity of charging

Supporting Hardware:
- IP67 dust- and water-resistant enclosure to keep electronics safe from harsh environment
- Raspberry Pi to interface between central node and satellite link device
- Custom designed PCB with low-power MCU





References

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3. N. Schizas, A. Karras, C. Karras, and S. Sioutas, Figure 17. Comparison of Network Protocols. 2022.

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