PLANET TEXAS 2050

The Conversion of a Multipoint Data Logging System into a Mesh-Based Observation Network: Implementation of a Mesh-Based Observation Network

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Project Collaborators

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- The University of Texas at Austin

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- The University of Minnesota
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 - The University of Texas at Austin

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LEAF (Logger for Ecological and Atmospheric Factors) v.1



Microcontrollers

• (4) Particle Electron (3G Cellular)

Data

- ThingSpeak (Mathworks)
- IFTT to Google Sheets

Features and Sensors

- Rain throughfall in a canopy
 - Tipping Bucket/Rain Gauge
- Branch Movement
 - Accelerometer/Gyroscope
- Ground water
 - Soil Moisture Sensors
- Atmospheric Conditions
 - Temperature/Relative Humidity/Pressure Sensors
- Stream Conditions
 - Temperature Probe
 - Pressure Sensor
- Sap Flux
 - Thermocouple



LEAF v.1 Construction & Installation



LEAF v.1 Lessons Learned



- Limited telemetry frequency
- Poor cable management
- Battery/Power issues
- Limited site access





Confluence of Events Towards LEAF v.1.2

Event	Date	Implication(s)
Particle (Gen. 3) Devices Released with Mesh	November 2018	 Multi-microcontroller sensor system with integrated and adaptive capabilities possible Reduced telemetry costs Standardization through FeatherWing form factor Reduced power requirements
UTexas @ Austin creates <i>UTexas-IoT</i> Wifi Network	December 2018	 No telemetry costs Increased sample frequency capability Reduced power requirements
Planet Texas 2050 DataX stands-up CHORDS Instance	December 2018	 Sample frequency capability increased to one (1) per second per device Increased sample frequency Data archival Direct/Automatic workflow capability

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Conversion to Particle Mesh Devices

Previous Particle Options

- Core WiFi
- Photon WiFi
- Electron Cellular



Particle Mesh Options

- Xenon Bluetooth/Mesh
- Argon WiFi/Bluetooth/Mesh
- Boron Cellular/Bluetooth/Mesh



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Note: *Particle IoT microcontrollers are named after elements of the periodic table.*

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Particle Mesh Options

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Mesh Network Topology



Reference: <u>https://blog.particle.io/2018/04/28/how-to-build-a-wireless-mesh-network/</u>



Conversion to Particle Mesh Devices (Continued)

Sensor Connections (No Initial Reductions)

- SPI (Serial Peripheral Interface)
 - SD Card Logger
- I2C (Inter-Integrated Circuit)
 - BME280
 - o 9DoF
- Analog
 - Soil Moisture
 - Pressure
 - Sap Flux
- Digital
- DS18B20
- Tipping Bucket
- DHT22



Communication (Telemetry)

- UTexas-IoT Wifi
- Mesh interconnection tested without issue

Telemetry Ingestion

- Switched to CHORDS
 - Increased collection frequency to 7 seconds

Form Factor Conversion

• Created custom PCB to match FeatherWing headers

Software Conversion

- Decreased time between telemetry streaming
 - $\circ~$ From every 30 minutes \rightarrow every 7 seconds
- No other changes required



LEAF v1.2 Initial Testing







LEAF v1.2 Build



LEAF v1.0 October 2018

LEAF v1.5 February 2018



Additional Changes:

- "PowerOn" and daily "SitRep" reports through Slack
- SD Card Datalogger replaced with Adalogger FeatherWing
- NTE997 Amplifier replaced with MAX3156 Thermocouple Sensor
- LSM9DS1 replaced with MPU9250
- DHT22 Removed
- HE13 5 Pin Circular Connector replaced with Glands
- 3.3v power rail reset controlled with a transistor



LEAF v1.2 Data in CHORDS



leaf-cypress-t	UT-Cypress-Waller	2038909	Data URLs
leaf-cypress-m	UT-Cypress-Waller	501321	Data URLs



// fulldata event Creation
String fulldata;
jsondata.printTo(fulldata);
Particle.publish("Full Data",fulldata);
delay(1500);

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Add a Nev	v Variable				
Short Name	Name	Units	Min/Max (Piot)	Measured Property	
bme_temp	BME280 Temperature	degree celsius Not Label: BME Temperature	171	Temperature	1
bme_ch	BME Relative Humidity	percent Plot Label: RH	1/1	Humidity Value	1
bme_pressure	BME280 Pressure	kilopescal Plot Label: Pressure	÷/÷	Air Pressure Value	1
bme_altitude	BME Atitude	meter Plot Label: Alt	+79	Altitude	1
ax	Acceleration X	meters per second Plot Label: Ax	÷ZB	Acceleration	1
ey	Acceleration Y	meters per second Plot Label: Ay	1/1	Acceleration	1
82	Acceleration Z	Meters per second Plot Label: Az	+7 +	Acceleration	Ţ
ga.	Gyroscope X	degree Plot Label: Gx	+2+	Relative Internal Position	1
0V	Gyroscope Y	degree Plot Label: Gy	÷73	Relative Internal Position	1
92	Gyroscope 2	degree Plot Label: Gz	1/1	Relative Internal Position	1
imu_temp	MPU9250 Temperature	degree celtius Plot Label: IMU-Temperature	578	Temperature	1
sapfluxmv	Sap Flux Thermocouple Voltage	millivolts Plot Label: Sap Flux Voltage	173	Power	1
rain_tip	Tipping Bucket	millimeter of water Plot Label: Tipping Bucket	173	Water Properties	1
sapfluxjc	Sap Flux Temperature	degree cersius	171	Temperature	1



LEAF v1.2 Mesh Testing

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LEAF v.2 - The Path Forward

Software

- Integration of **Mesh.publish()** and **Mesh.subscribe()** functionality for localized adaptive sensing triggered from weather events initially detected by other meshed devices
- Completion of object-oriented version of LEAF Firmware
- Creation of a LEAF Systems Library for distribution in the Particle Cloud
- LoRaWAN MQTT integration into the Things Network

Hardware

(Collaboration with UMN Electronics for Bioproducts and Biosystems Engineering Applications Course)

- Upgraded solar cells and modularized charging system for lower light areas in large-leaved trees
- Custom LEAF printed circuit board based on the FeatherWing form factor
- Fail-over Mesh gateway device support
- LoRa radio integration

PTDataX - CHORDS Wrapper

- Increased security and user permissions management
- POST request API support
- One-click integration into data formatting/parsing workflow
- One-click integration into model generation using PTDataX resources





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Thank you for your kind attention.



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LEAF GitHub: https://github.com/OpenInstrumentation/LEAF

PTDataX: https://ptdatax.tacc.utexas.edu/

Particle: https://www.particle.io/

CHORDS: http://ncar.github.io/chords/

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