OPEnS Hub - A Real-Time Decentralized Internet Portal, Connecting Field Sensors to Google Sheets

Thomas DeBell[1], Luke Goertzen[2], Chet Udell[3], and John Selker[4]

[1]Oregon State University, OPEnS lab, First Author
[2]Oregon State University
[3]OPEnS Lab
[4]Oregon State University, OPEnS Lab

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Abstract

Advancements in sensing technology have sparked a new age of data acquisition and transmission that continue to change the way we understand the world around us. In earth science, we often must move and store tremendous amounts of data from remote locations. Present options are limited to costly propriety devices, which are rigid in structure and have numerous expenses associated with their use. The solution developed in the Openly Published Environmental Sensing Lab (OPEnS) at Oregon State University, was to employ a new methodology using low-power, open-source hardware, and software, to achieve near-real-time data logging from the field to the web. This new approach simultaneously lowers the cost of experimentation and data collection and breaks down traditional technical barriers. Data can be collected remotely from nearly anywhere on Earth using a decentralized OPEnS Hub which can utilize a host of low bandwidth transmission protocols and modes of communication, such as: 900 MHz Long Range Radio (LoRa) with a transmission distance of up to 25 km, the Global System for Mobile communications (GSM) using well established cell network infrastructure, Wi-Fi for high bandwidth applications, and Ethernet where LAN connections are available. It is notable that LoRa technology is still developing and has been expanded to transmit to an ever-growing constellation of satellites, making this technology truly global in its applicability. The OPEnS-Hub is capable of mesh networking with other nodes and will parse and back up the data to an onboard microSD card. By first exploiting a free open-sourced Application Programming Interface (API), PushingBox, acting as a data broker, and secondly, a customized Google App script, the OPEnS-Hub was able to achieve a dynamic, low latency portal connecting to google sheets. These methods working in tandem allowed for near real-time data logging of over a dozen devices each with unique sensor suites to form valuable time series data. This poster details our methods and evaluates the application and development of PushingBox's API, Google App Script, Adafruit's open-hardware Feather development boards, the Hypertext Transfer Protocol (HTTP) and various modes of data communication used to collect nearly half a million data points dispersed across remotes sites in the state of Oregon to date.

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Introducing the OPEnS HUB 2.0

-A Versatile, In situ, Remote, Sensor Hub

THOMAS DEBELL[1]; LUKE GOERTZEN[2]; DR. JOHN SELKER[3] PHD ; DR. CHET UDELL[3] PHD

1&3[COLLEGE OF ENGINEERING/COLLEGE OF AG. SCIENCE, SCHOOL OF ECOLOGICAL & BIOLOGICAL ENGINEERING], 2[COLLEGE OF ENGINEERING, SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE]

ABSTRACT: NEW METHODS OF REMOTE DATA RETRIEVAL

Research in geoscience often requires transmission of significant amounts of data from remote locations. The emergence of microcontrollers and open-source sensors are allowing connectivity to affordable, distributed in-situ monitoring. This report describes the OPEnS Hub, a modular data hub orders of magnitude cheaper than commercial dataloggers when scaled to multiple nodes. The test Hub has achieved consistent transmission up to one fourth of a mile in a densely forested basin and pushed nearly half a million data points from a network of open-source weather stations and soil probes as a real-time stream to Google Sheets. The Hub can process 12 variables from each device, and telemetry options range from LoRa, nRF, GSM, and wired ethernet. The inherently modular nature of the Hub means the user can adapt the transmission protocol to suit the unique context of each deployment.

PURPOSE: DATA AT ANYTIME FROM ANYWHERE

For as long as humans have tried to understand the natural world, they have attempted to take measurements to help deduce something significant about the world around them. Thankfully sensor technology has become cheaper and smaller over the years - enabling scientists to create networks of multitudes of sensors to be distributed in an environment. This would not be feasible to do if a researcher has to physically collect data from each sensor device out in the field. To make a distributed sensor network viable, one needs a way to wirelessly send data to a central hub, which is then saved in different formats (e.g. SD flash and in a spreadsheet online). This not only eliminates the requirement to travel to the field to collect data from each sensor, but online reporting of data can enable the researcher to determine of all devices in operation are working properly without having to physically observe each one.. The implications of such a technology allows researchers and scientists to form new data driven empirical models faster, and more cost efficiently than ever before.

Left Dr Chet Udell and right Tom DeBell running signal strength diagnostics between the transmitter and receiver hub.

Image Depicting the Average GSM traffic across the globe in 2017

Contact Information

Presenter: Tom DeBell (debellt@oregonstate.edu)

Lab Director: Chet Udell (udellc@oregonstate.edu)

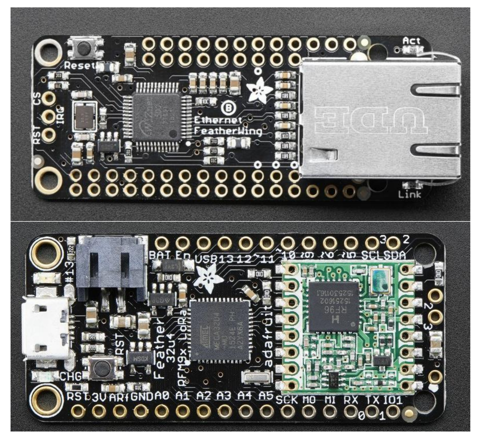
Website/Projects: (http://www.open-sensing.org/)

CHECK OUT OUR CODE ON GITHUB: https://tinyurl.com/OPEnSLab

Scan Me to See to Our Project Page!

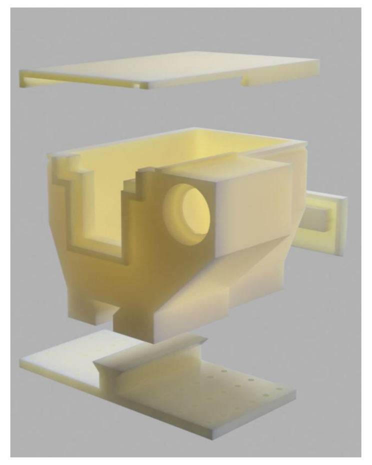
HUB COMPONENT BREAKDOWN

- Adafruit Feather 32u4 LoRa Radio (RFM9x) – Integrated Microcontroller.
- Adafruit Ethernet Featherwing – Ethernet Shield for LAN connectivity.
- Adafruit MicroSD card breakout board+ – Back-up data storage.
- 900Mhz Antenna Kit – Increase radio transmission distance.
- Adafruit Fona GSM module – Cell tower connectivity from remote locations
- Custom 3D Printed enclosure- Weather-proof and modular for future development

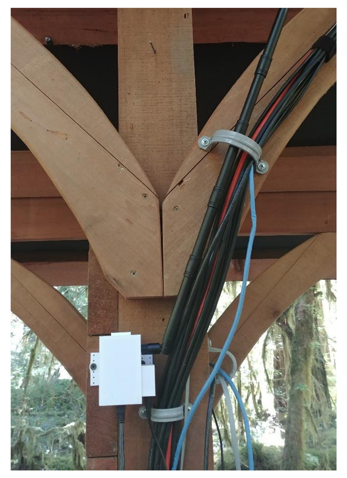


Above, Ethernet Featherwing Below, The 32u4 LoRa Radio

Fona GSM Breakout for most remote locations



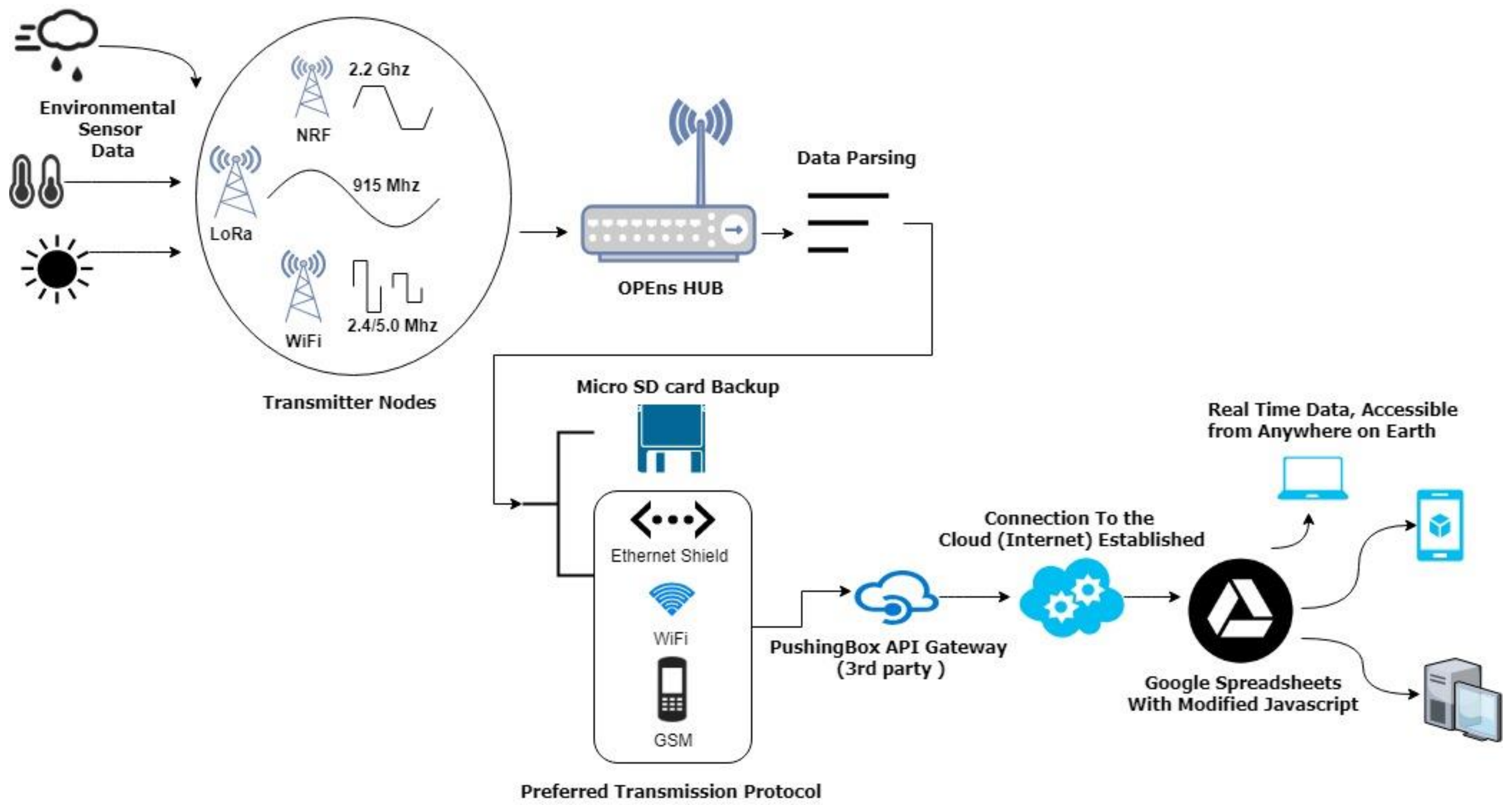
Fusion 360 Rendering of the ABS 3D printed HUB enclosure



Fully assembled receiver hub located in the HJ Andrews Experimental forest.

METHODS: FLOW OF DATA

The largest hurdle to overcome with any remote sensing project is the availability of the data being collected. This approach is unique because instead of having to physically go collect the data or retrieve memory banks at the site of collection the data is dynamically transmitted, compiled and uploaded to a google spreadsheet in 5 minute intervals. In the figure below, a diagram of the transmission protocol is outlined.



The first step in this process was modifying the Google Application script in such a way that it would agree with the comma delimited values that our hub would be parsing. After deploying this new modified spreadsheet, it was necessary to set up a third party Application Programming Interface as a middle man between our HTTP Ethernet transmitted data and the Google compliant HTTPS encrypted data. This handshake protocol was done through a API service called *PushingBox*. This GET/POST service was especially helpful because it allowed very small packets of data to be transmitted through the Ethernet LAN connection as a HTTP request and then compiled, separated and organized all in the cloud instead of on the microprocessors themselves.

TESTING: A MULTI-NODE APPROACH

For this study, two micro-scale weather stations (OPEnS Evaporometers) and three soil moisture probes were connected to a Hub at Lewis Brown Farms in Corvallis, Oregon and five Evaporometers were deployed in the H.J. Andrews Research Forest in Blue River, Oregon.

A Evaporometer Weather Station.

A Wireless Transmitting Soil Moisture probe (Above)
A LoRa Radio Strength "Sniffer" Rover (Below)

Figure depicting the locations of in-suti sensors relative to the data hub at the HJ Andrews Forest (Left) and Lewis Brown Farms (Right).

RESULTS: DATA RECEIVED

- Reliable Data Transmissions from up to 2km away in heavy wooded conditions for LoRa, and GSM reporting from remote rural sites.
- Nearly 500,000 data points collected over the lifetime of the experiment
- 5 minute update interval gave near "real-time" updates

Design Phase	Location	Device(s)	Time of Deployment	Variables Collected	Collection Interval	Data Points
Field Test 1	HJ Andrews Experimental Forest, Blue River OR	1 Open Source Weather Station	07/24/2017-09/21/2017	Temperature, Humidity, Light Intensity, Change in Mass (Rain)	5 minutes	106,274
Field Test 2	Lewis Brown Farms, Corvallis OR	3 Soil Moisture Devices & 2 Open Source Weather Stations	04/17/2018-08/14/2018	Soil Conductivity, Soil Temperature, Temperature, Humidity, Change in Mass (Rain)	15 minutes	334,961
Field Test 3	HJ Andrews Experimental Forest, Blue River OR	5 Open Source Weather Stations	08/28/2018-9/15/2018	Temperature, Humidity, Albedo, Light Intensity (Full spectrum and IR), Change in Mass (Rain).	8 minutes	41,615
				Total Data Points Collected:		482,850

Summary Table of Field Test Results.

CONCLUSIONS: FUTURE DIRECTION

The need to develop wireless communication and networked data hubs are essential for expanding the viability and functionality of distributed sensor networks. Recent developments on the Norwegian microsatellite NORSAT-2 have proven the ability to transmit LoRa signals to low-orbit satellites, implicating tremendous potential for this remote data logging strategy in the future.

The OPEnS Lab also plans to develop a graphical user interface for the Hub to enable end-use by researchers without any programming experience. This project is at the core of the lab's Internet of Agriculture initiative, aiming to break down technical barriers and put environmental monitoring into the hands of farmers, hobbyists, and beginning researchers. **This technology is currently being utilized by Kwame Nkrumah University of Science and Technology in Ghana!**

ACKNOWLEDGMENTS

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I am grateful to all of those with whom I have had the pleasure to work during this and other related projects. Each of the members of OPEnS Lab team, Dr. John Selker, Manuel Lopez, Lars Larson and have aided to this project significantly and in my professional development teaching me a great deal about both scientific research and life in general.
Finally, nobody has been more important to me in the pursuit of this project than the members of my family. I would like to thank my parents, whose love and guidance are with me in whatever I pursue. Lastly, I thank my teachers, professors, and peers for helping foster a love for science that has brought me to where I'm now.