Developing Telemetry Systems for Stations in the Hydroclimate Network

CW3E Summer Internship 2021

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Overview:
My project this summer was to assist the Center for Western Weather and Water Extremes (CW3E) Field Team in developing a telemetry system for stations in the Hydroclimate Network. Telemetry is the automatic recording and transmission of data from remote sites to a database. In this case that database will be CW3E's server, Skyriver. The telemetry system consists of the following components: the data logger (DL4-Met), a microcontroller (Raspberry Pi), and a cell modem. The DL4-Met data logger can be found within an enclosure at the Hydroclimate stations located in the Sierra Hydroclimate Network transect. The data logger records the data coming in from various sensors for every minute of the day. The Raspberry Pi will boot up at the top of the hour and automatically flush out all of the data recorded in the past hour using a python script. That same script will read and write all the data from the serial port of the data logger, and save it onto a file. On completion, the script will then use cellular service to access the internet and upload the saved file up to WebDAV (web Distributed Authoring and versioning). The file will then be accessible from a web browser where it can be retrieved and then uploaded to Skyriver.

Hydroclimate Network:
The Hydroclimate Network is located in the California Sierra Nevada and was started by Dan Cayan in 2002 [1]. The Sierra Hydroclimate Network is composed of a transect of stations along California Highway 120 (Fig. 1 stations marked in orange) and spans 5 watersheds (green areas). Data recorded at these sites include: pressure, temperature, soil moisture, solar radiation, wind speed, air humidity, and rain.

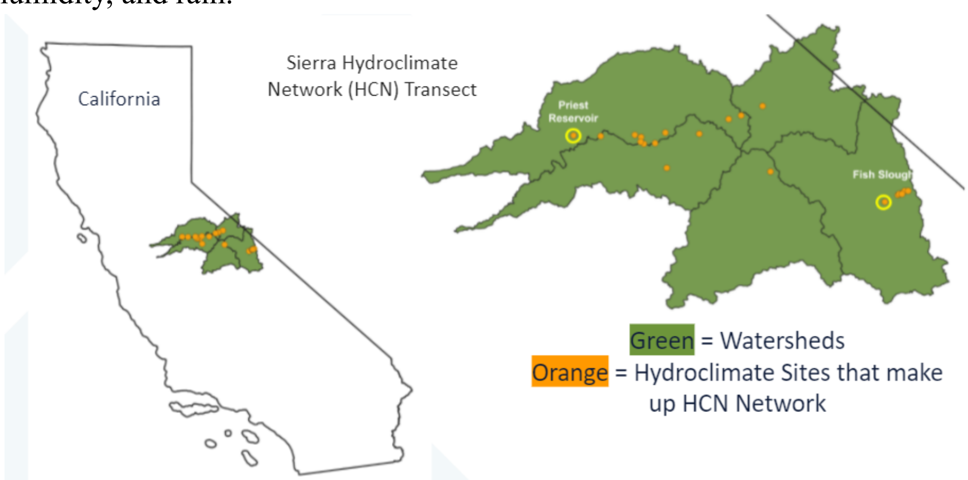

Figure 1: Location of the Hydroclimate Network in California.

DL4-Met:
The DL4-Met data logger used in my project was a development logger that would be used for testing [2], and developing a telemetry system (Figure 2 left). A typical data logger would be found with an enclosure along with a setup as shown in Figure 2 right. The data logger includes an integrated GPS that can pinpoint the location of the station as well as record the exact time and date. This information will be included with the data that is being recorded from each of the sensors found at the stations. The DL4-Met data logger also includes a Standard Digital (SD) card slot that will save all that data that is being collected and will serve as a backup in case of loss of communication with the station. It is also important to note that the data logger is

low-powered as it is continuously recording data every minute of every day, and must be energy efficient to operate.

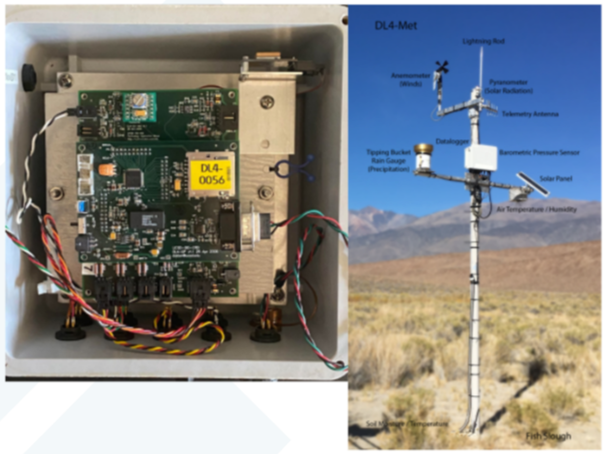

Figure 3: DL4-Met Data Logger

Figure 2: DL4- Met Data Logger (Left). Full Hydroclimate Station with DL4-Met Data Logger (Right).

Raspberry Pi:
The Raspberry Pi is a microcontroller with a Linux operating system that will be connected to the DL4-Met data logger to flush out all the data that was recorded [3]. The raspberry pi is a very capable microcontroller with bluetooth and wifi capabilities, that has a desktop interface and gives access to using a powerful programming language in Python. The first step to this project consisted of getting familiar with the Raspberry Pi. The Raspberry Pi is very easy to set-up and configure. In this case, packages were downloaded from the Terminal that would be used throughout the development of the project. A few packages include Secure Shell Protocol (SSH), X2Go, and Lighttpd (pronounced lighty). Using a SSH gave an easy and convenient access to the Pi's terminal from another Linux operating device (e.g. my laptop). X2Go also can be used to gain remote access if not in close proximity. Lighttpd will allow for creating the configuration and setting up a web server such as WebDAV directly from the Raspberry Pi. Additionally, Python 3 was also downloaded to develop a script that will instantaneously run when the Raspberry Pi boots up.The Raspberry Pi will be connected to the DL4-Met data logger radio output port which requires a keyspan USB to Serial adapter that will plug directly into one the Raspberry Pi's USB ports.

Python Script, bits and bytes:
My biggest challenge throughout this project was getting familiar with Python. I have a basic understanding of Python, but this was a bit beyond my general knowledge. Luckily, Python has multiple libraries along with forums that assisted me with developing a working script. Using the Serial library allowed me to set the configurations needed to open the serial port from the data logger, and read in all of the data [4]. This data will also be written onto a file and saved.

Another obstacle in reading the data was converting the bytes coming in via the serial port to hexadecimal. The reason for this is that the radio output port packs the data into human unreadable characters. The data logger is a low-powered data logger so it becomes much more energy efficient to send the data written in human unreadable characters, and then allow the Raspberry Pi to run a script that will decode the data into hexadecimal [5]. Once the data is converted from hexadecimal into an ASCII string that is readable, it is saved onto a file that can then be uploaded to the web server, WebDAV.

Lighttpd and WebDAV:
Using Lighttpd, an open source web server [6], I was able to write a configuration directly on the Raspberry Pi that will create the WebDAV server. WebDAV is an extension of the hypertext transfer protocol (HTTP), and allows authorized users to upload and edit files [7]. The files saved on the raspberry pi will be automatically uploaded to WebDAV. The files will then be available by accessing WebDAV from the internet browser. Coming full circle, the files can then be retrieved safely, and uploaded to Skyriver.

Conclusions and next steps:
The developed telemetry system will allow sites with cellular service to transmit data to Skyriver in near real-time. This will make data more immediately available to researchers and partners who can use the data for forecasting and modeling efforts. Near real-time data availability will also help the Field Team in identifying issues with the station and its sensors more immediately. One limitation of the system is the requirement of cellular service which is only available at five of the Hydroclimate stations (out of the 12 stations on the CA-120 transect). Prior to field viability tests, the Field Team and I will finalize the scripts for data collection and transfer and test the connection to a cellular modem. Then the full telemetry system can be tested and deployed across the Hydroclimate Network.

Bibliography

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