Smart Campus Energy Lab Environmental Sensor Network Nodes

Students: Joslyn Hamada (496), Jennifer Chun (496), Emily Lum (396)

Project Advisor: Dr. Anthony Kuh

Smart Campus Energy Lab - Renewable Energy and Island Sustainability

University of Hawai'i Mānoa — College of Engineering, University of Hawai'i at Mānoa

Vertically Integrated Projects

REIS — Renewable Energy & Island Sustainability, Smart Campus Energy Lab, University of Hawai'i at Manoa

Introduction & Motivation

- In 2012, the University of Hawaii at Manoa (UHM) paid $35 million for their electricity bill. Despite the implementation of energy efficient measures, UHM paid $34.3 million for their electricity bill in 2014. This is due to the fact that the price of electricity per kilowatt hour has increased greatly.
- SCEL is in the process of creating a wireless environmental sensor network to collect data used to forecast solar irradiation patterns and determine optimal places to install renewable energy sources on the UHM campus.

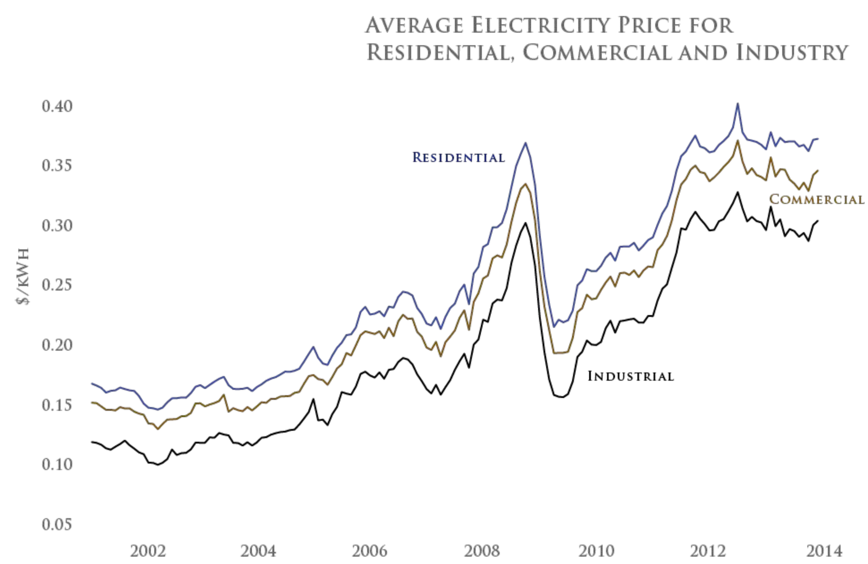

Figure 1: Electricity prices in Hawaii
Source: University of Hawaii Economic Research Organization

Project Description

Objective: Design and build a low cost, low power consumption sensor module that collects data on various weather characteristics, such as solar irradiation, temperature, humidity, and pressure.

- Improve the hardware of the third generation weatherbox modules by increasing functionality, data reliability, and ease of use
- Modify sensor modules to include GPS and Real Time Clock
- Design weatherproof housing for sensor node
- Deploy the sensor modules on rooftops of buildings around the UHM campus
- Collect and store data in real time in a database on a local server and use it to predict solar irradiance patterns around campus

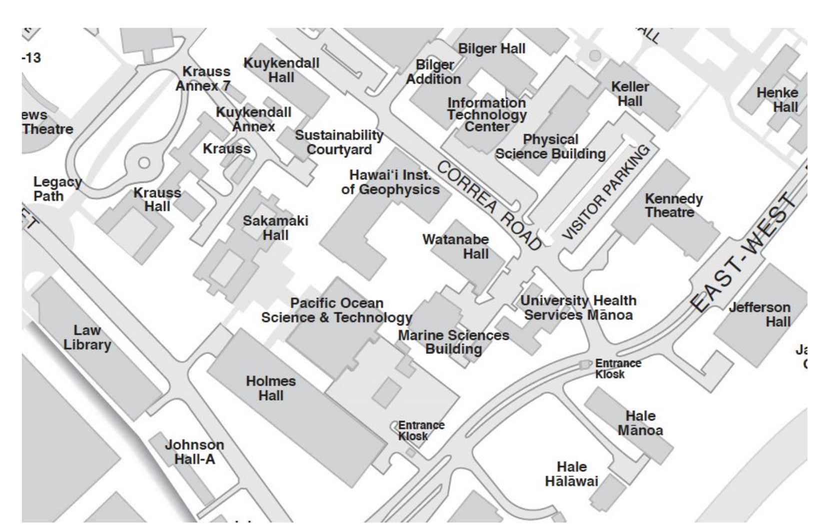

Figure 2: Planned sensor module deployments on the upper UHM campus buildings: Holmes, Sakamaki, MSB, HIG, and Kuykendall

Design

Hardware Methods

Power Management
- Incorporate solar panel and rechargeable battery
- Utilize solar charging chip for self-sufficiency

Low Cost
- Design own sensor circuit using Eagle
- Print 3D Housing

Increased Functionality
- Utilize GPS for future data tracking purposes
- Include Real Time Clock separate from GPS to timestamp data and provide lower power consumption

Communication
- Transmit sensor and diagnostic data using an XBee Pro S2B, which has a maximum range of 1 mile
- Use smaller relay nodes to extend the range of the sensor network

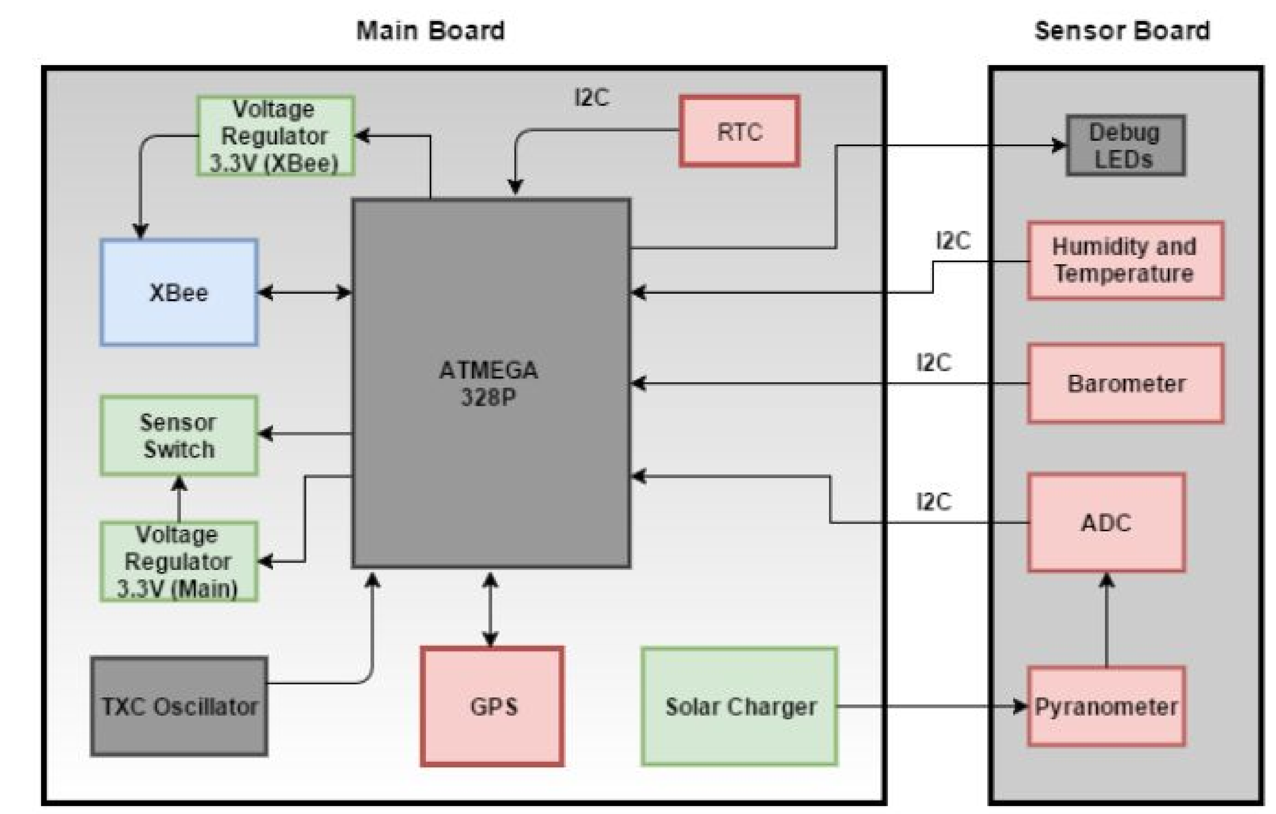

Figure 3: Hardware block diagram

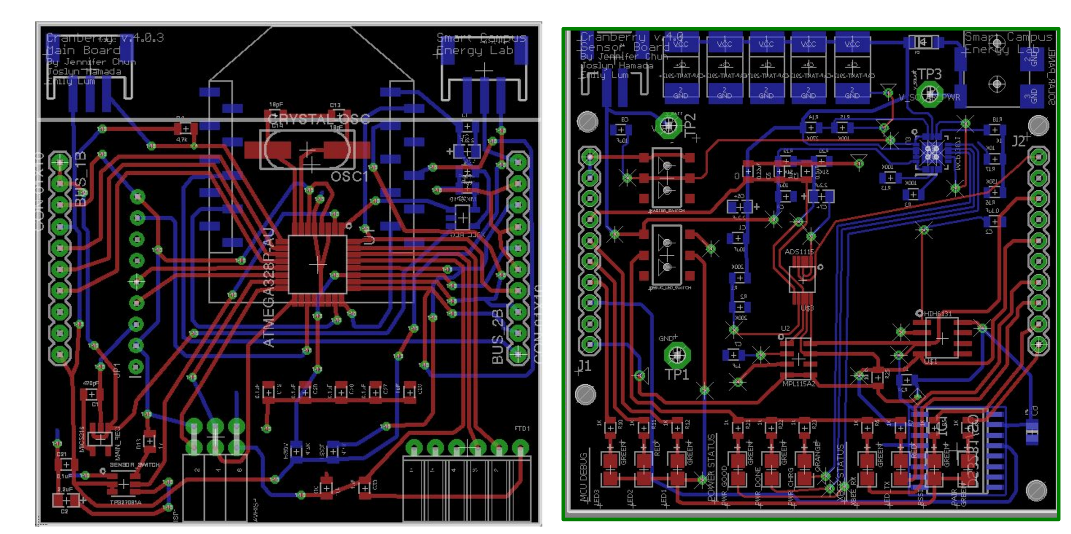

Figure 5: Cranberry 4.0 PCB (2.375'' by 2.375'')

Firmware Methods

Data Encoding
- Heartbeat packet contains diagnostic data
- Data packet contains sensor data

Data Collection
- Gather diagnostic data and sensor data
- Different sampling rates for different data packets

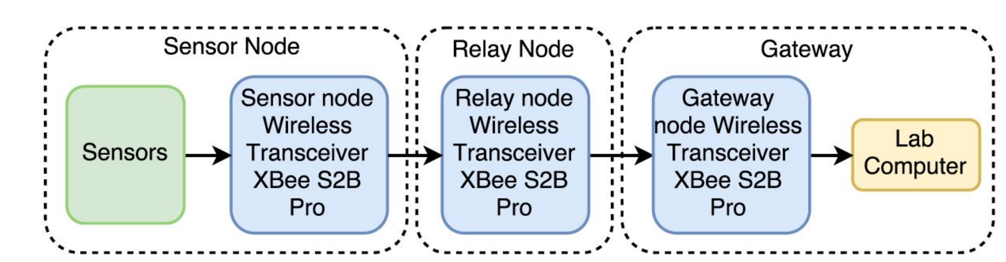

Figure 4: Relay node block diagram

Results

- Populated and programmed two Cranberry 4.0 boards
- Found and fixed several Cranberry 4.0 PCB design issues
- Simulated and measured energy consumption and battery runtime
- Design weatherproof housing for sensor node

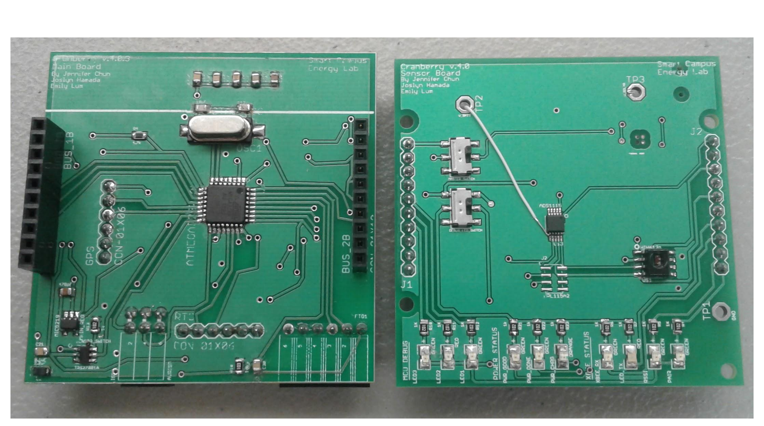

Figure 7: Populated Cranberry 4.0

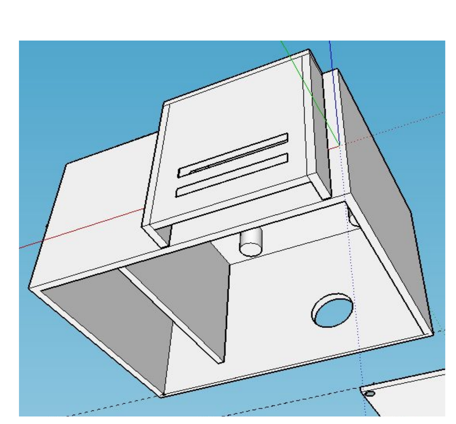

Figure 8: 3D Housing Design

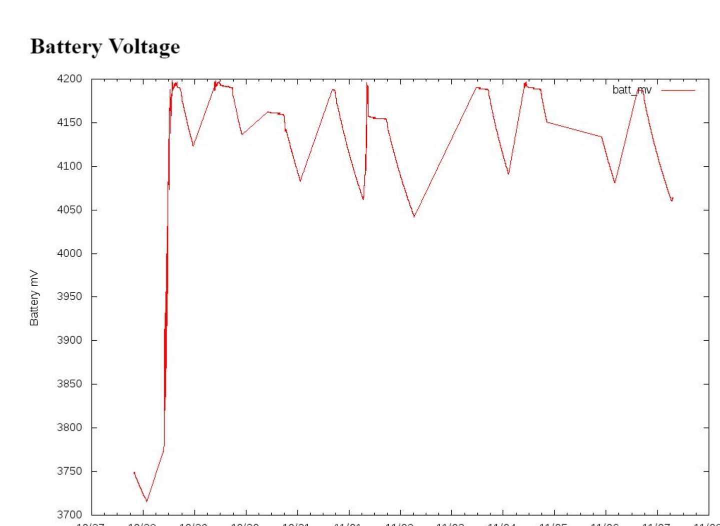

Figure 8: Battery voltage data for the 3rd generation sensor module

Conclusion

Key Work
- Populated and debugged two Cranberry 4.0 boards
- Completed PCB design of Cranberry 4.1 using Eagle
  - Improved placement of components for a cleaner PCB layout
  - Changed real time clock to a surface mount device

Future Work
- Implement firmware for real time clock and GPS

Figure 10: Deployed Cranberry v3.5

Acknowledgments

Dr. Anthony Kuh, UHM College of Engineering and the Department of Electrical Engineering

Industry Sponsors: Johnson Controls, National Science Foundation, Raytheon