

Idaho Incubation Fund Program

Final Report Form

Proposal No. IF14-008
Name: Gang-Ryung Uh
Name of Institution: Boise State University
Project Title: Self-organizing Air VEnt (SAVE) System

Information to be reported in your final report is as follows:

1. Provide a summary of overall project accomplishments to include goals/milestones met, any barriers encountered, and how the barriers were overcome:

Electrical/Firmware:

- Implemented basic radio protocol for system testing and design.
- Added a small LCD display for debugging.
 - **Barriers:** Initial system debugging was being performed by status LEDs on the board, but proved slower to debug and work with in a practical sense. Added the LCD display to provide more useful information, increasing our test/debug cycle time and interface capability.
- Implemented the base firmware architecture.
 - **Barriers:** Initial firmware architecture was not utilizing abstraction and modular design, making any future transitions to different parts or boards cumbersome. Reworked the firmware to incorporate abstraction layers and a modular design, thereby reducing impact of hardware related changes on firmware design. This also makes firmware debug much more manageable as issues can be tracked quicker to their respective domains.
- Created a fully assembled and functionally complete prototype board.
 - **Barriers:** First revision had issues encountered with antenna design impacting transmit range. Resolved issues with second revision, where third revision optimized layout design and utilized 3rd party manufacturing of entire board.

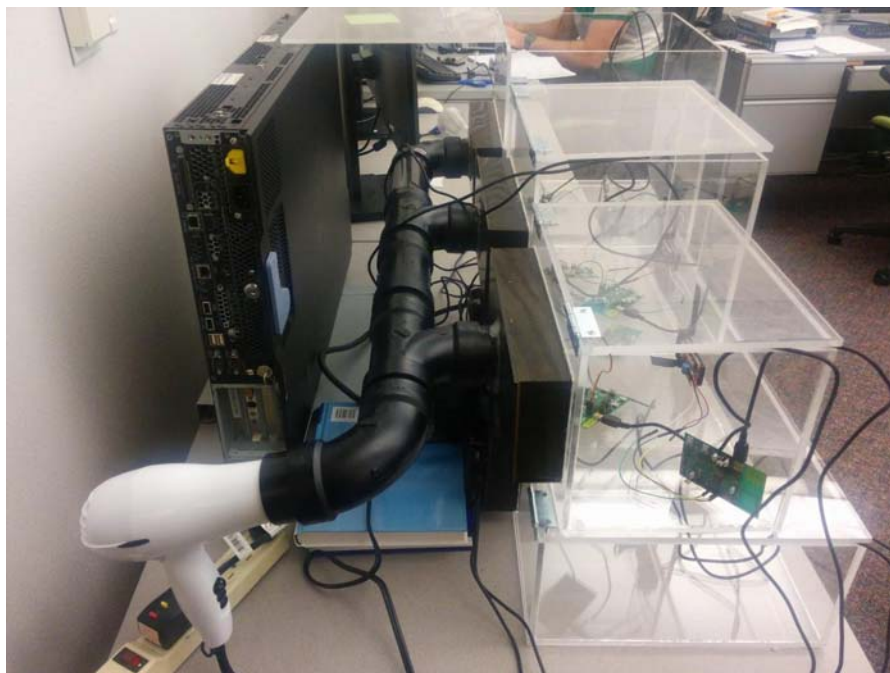


Fully Populated Prototype Board Revision 3

- Implemented generic temperature balancing algorithm.
- Verified basic system functionality in simulated house environment to validate system concept.

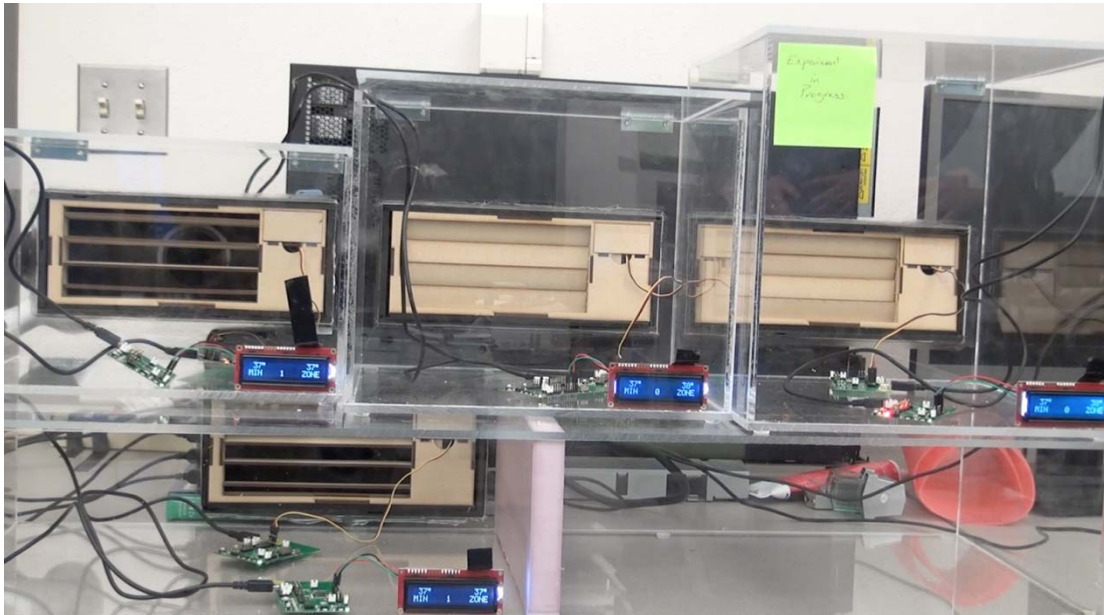
Mechanical:

- Created a prototype environment for system level testing.
- Created a simplified venting system driven by a hair driver to simulate HVAC heating cycles.



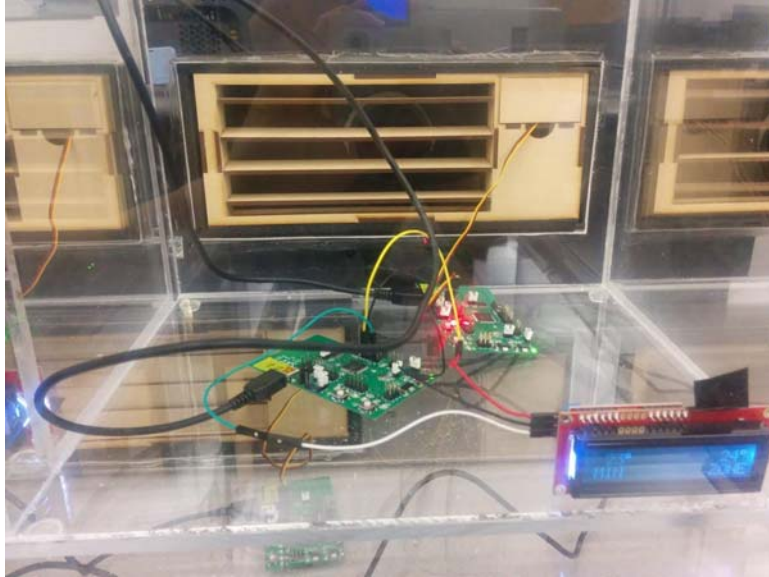
Ventilation Setup for Simulating HVAC Heating Cycles

- Designed a small scale testing chamber for system level testing of HVAC heating cycles.



Testing Chamber for System Level Debug and Data Metrics

- Created a register prototype near final product dimensions.
 - **Barriers:** Initial register prototype design was much larger, making it difficult to approximate effects in a realistic environment. We revised and compressed the prototype into a smaller scale that more closely resembles the desired final product, enabling us to perform more realistic system level testing.



New Thin Prototype Register with Zone/Register Controllers and Debug LCD

2. Describe the current state of the technology and related product/service:

We are currently still in the prototyping and design phase where we are working to optimize our product. We are beginning to move from the prototyping phase into a more commercialized application by working with industry HVAC manufacturing partner FAMCO. We have verified in testing that the **SAVE** system works, and are now towards improving our plan on how to best penetrate the market.

3. List the number of faculty and student participants as a result of funding:

Gang Ryung-Uh – PI

Kyle Schwab (Graduate Research Assistant)

Jared Law (Graduate Teaching Assistant)

Gregory Cook (Graduate Teaching Assistant)

Kyle Hoff (Undergraduate Research Assistant)

Adam Carrillo (Undergraduate Research Assistant)

4. What are the potential economic benefits:

There are several significant ways in which **SAVE** will positively affect the economy of Idaho. First, the **SAVE** system can be supported by the State Legislatures for

energy efficiency, and it can be supported by Idaho local utility companies as a consumer commodity for the same reason. Second, as long as the **SAVE** system implementation, testing and market acceptance look promising, it can easily augment various HVAC products from the Nest, Lennox, Activent, Airflow and other suppliers, which will help U.S households save cooling and heating bills. By approaching existing manufacturers with enhanced and working versions of their own products by the **SAVE** system, we can make it easy for them to visualize the **SAVE** system's Intellectual Properties (IPs) in their product line. Third, a provisional/non-provisional patents for the **SAVE** system also gives Boise State University a sellable piece of IP.

5. Description future plans for project continuation or expansion:

There are **THREE KEY COMMERCIALIZATION CHALLENGES** of the **SAVE** system which we encountered during the HERC FY 2014 that we would like to address during project continuation and expansion:

- i. How to reduce the liability of icing HVAC (air-compressor) coils?
- ii. How to measure the HVAC airflow rate and detect overall HVAC system health?
- iii. How to prolong **SAVE** battery life and energy efficiency through the use of energy harvesting and enhanced wireless communication protocols?

6. Please provide a final expenditure report (attached) and include any comments here:

7. List invention disclosures, patent, copyright and PVP applications filed, technology licenses/options signed, start-up businesses created, and industry involvement:

We are working with Martin Artis, the president of **FAMCO**

(<http://www.famcomfg.com/>) as a commercialization partner. In particular, Martin

Artis and his engineering team director (David Davis) will help us (1) design and

implement a safe (as a consumer product) and energy efficient mechanical

prototypes of the **SAVE** system and (2) commercialize the **SAVE** system as a consumer HVAC supplement.

8. Any other pertinent information:

In August of 2014, the **SAVE** team was awarded a second round of funding from the HERC Idaho incubation found program for FY 2015. The **SAVE** team will be looking to capitalize on the project continuation and expansion objectives listed in section 5.

FINAL EXPENDITURE REPORT

A. FACULTY AND STAFF		
Name/Title	\$ Amount Requested	Actual \$ Spent
Dr. Gang-Ryung Uh	\$12,818	\$12,818.88
B. VISITING PROFESSORS		
Name/Title	\$ Amount Requested	Actual \$ Spent
C. POST DOCTORAL ASSOCIATES/OTHER PROFESSIONALS		
Name/Title	\$ Amount Requested	Actual \$ Spent
D. GRADUATE/UNDERGRADUATE STUDENTS		
Name/Title	\$ Amount Requested	Actual \$ Spent
Kyle Schwab – Graduate Research Assistant	\$19,883 for Grads	\$13,430
Gregory Cook – Graduate Research Assistant		\$1,384.62
Adam Carrillo – Undergraduate Research Assistant		\$1,927.50
Kyle Hoff – Undergraduate Research Assistant		\$2,529.50
E. FRINGE BENEFITS		
Rate of Fringe (%)	\$ Amount Requested	Actual \$ Spent
Dr. Gang-Ryung Uh – 30.7%	\$3,930	\$3,066.52
Kyle Schwab – 3.3%	\$442	\$257.91
Gregory Cook – 3.3%	\$43	\$114.47
Adam Carrillo – 3.3%	\$60	\$11.31
Kyle Hoff – 3.3%	\$115	\$160.13
PERSONNEL SUBTOTAL:	\$37,291	\$35,700.84
F. EQUIPMENT: (List each item with a cost in excess of \$1000)		
Item/Description	\$ Amount Requested	Actual \$ Spent
1.	0	0

2.		
3.		
4.		
EQUIPMENT SUBTOTAL:		
G. TRAVEL		
Description	\$ Amount Requested	Actual \$ Spent
1.Kyle Schwab to UKC conference in Newark, NJ	\$1,798	\$1,798.40
2.		
3		
TRAVEL SUBTOTAL:		\$1,798.40

H. PARTICIPANT SUPPORT COSTS:			
Description		\$ Amount Requested	Actual \$ Spent
1.			
2.			
3.			
PARTICIPANT SUPPORT COSTS SUBTOTAL:		0	0
I. OTHER DIRECT COSTS:			
Description		\$ Amount Requested	Actual \$ Spent
1. Materials and Supplies < \$1,000		\$6,711	\$6,711.33
2.			
3.			
OTHER DIRECT COSTS SUBTOTAL:		\$6,711	\$6,711.33
TOTAL COSTS (Add Subtotals):		\$45,800	\$44,210.57
TOTAL AMOUNT REQUESTED:			\$45,800
TOTAL AMOUNT SPENT:			\$44,210.57