Multi-room Space Heater Temperature Control

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18500 ECE Capstone Proposal Presentation

Issues in off-campus student housing

- Old houses often lack reliable central heating, leading to inconsistent/insufficient heating across rooms
  - Thermostat in one room, but other rooms are far from the set temperature
  - Eg. This is the case for many off-campus student houses in Pittsburgh
- Residents are forced to use space heaters to provide heating for their homes.
  - Challenge to keep rooms at a desired temperature, especially while sleeping.
  - Too many space heaters turned on at once can lead to expensive electricity bills and blown fuses.
- Off-campus homes have also been restructured to fit many students
  - Have seen cases of anywhere in range 4-12 students a house
  - Even if central heating is present, there exists parties with many varying temperature preferences

Use Case

- We will create a remote controlled space heating system managed by a web application.
- The goal of this system is to provide temperature control via space heaters across multiple rooms.
- For these old wooden off-campus houses, the inefficient use of space heaters poses financial and a safety concern for home owners and student tenants.
    - Our system will limit energy waste and overloaded circuits by using motion sensors to track whether each room is occupied or not.
    - All of this will be easily controlled by the user through a web application, allowing custom temperature schedules and settings for each room.
- For newer houses that do have central heating and many tenants, this application would allow for more specific modification to individual personal spaces

Use Case Requirements

- A web application that is able to serve multiple separate users with their own personal space heaters and temperature preferences in different physical spaces for a given house
    - Backend will be able to support up to 50 different user accounts
- User can set a schedule for their personal temperature requirements, as well as a minimum temperature for when the room is vacant
- Ability to manage and select options for each room in the house
    - Supports multiple users simultaneously under one webpage
- Each user profile on the application will keep track total energy expended (watts)
- Web application will be running on a cloud-based server (Apache on an EC2 instance)
- User can input which outlets are on the same circuit
    - Heaters will never set off breakers assuming normal usage of electricity by other appliances

Technical Challenges

- Challenges with Web Application
  - Large number of customization options that will be time consuming to implement
- Challenges with Space Heaters
  - Ensuring thermostat is precise enough and communication is responsive enough to maintain +-1.5F requirement.
  - Requirement can be met by using a more precise thermostat and tightening threshold for turning on and off heater
- Challenges with Integration and Testing
  - Biggest challenge will be making sure all devices can communicate reliably
  - Mitigate problems by doing thorough research on our resources and leaving plenty of time for integration

User-side challenges

- Temperature preferences between different users
  - Multiple application users with varying preferences may live with close proximity within the house
  - Will be hard to regulate given unpredictable airflow, window locations
    - Hot air rising to higher floor levels, gaps of poor insulation within the house
  - Challenge to meet requirements with interconnected rooms/two users in the same room
- Option to decrease temperature
  - Space heaters can only increase the temperature at a desired rate
  - The rate in which temperature decrease will depend on the house structure, and insulation
- Housing power limitations
  - Total electrical output of old houses may vary
  - Usage may vary if many other electrical devices are being used
  - Mitigate risk by building project for low load capabilities

Additional Use Case Requirements From User-Side Challenges

- We will define a personal space of around 100 Sq. Ft.
- Sensors must be able to detect a physical presence in the personal space with >95% accuracy
- Each Space Heater must maintain a temperature within a +- 1.5F range
    - Under the assumption of an isolated personal space
- Heater should be able to increase temperature of an isolated personal space by 1 deg per minute
- Response time between devices within 100 milliseconds (may be faster depending on purchased resources)
- If requirement cannot be met due to different preferences, system will compromise for equity
    - Eg. two people are in the same room, the room will be much closer to the higher setting since space heaters can only increase temperate. Their personal spaces will be equally as close to their desired temperature.
- Goal to reduce average energy consumption by at least 15% through maintaining a constant temperature, temperature scheduling, and dealing with inefficiencies from users with different preferences
- Easy to set up project for user with instructions, just plug into the smart plug and easy wall installation for sensors
    - Additionally, minimal work from user connecting all components (pre-paired sensors and switch plugs)

Solution Approach

- Web Application will be operated by Apache on an AWS server using an EC2 instance
- Web Application will use Django to implement all the webpage requirements
- A smart thermostat to measure the temperature in the room.
    - Thermostat sends information to the backend web application to turn on or off the closest space heater if the temperature is out of the user's set range
- Space heater will be controlled using a remote, smart switch plug to automatically turn it on and off, controlled by Web App
- Algorithm to optimize a lower load on breaker and save energy
    - Infrared sensors will detect whether someone is in the room and turn the heaters on or off.
- when there is no one in the room, and the ability to create and select options for each room in the house.
- Web app will allow users to input which space heaters are under the same breaker, limiting the number of space heaters that can run on the same circuit.

Testing, Verification and Metrics

- Fulfilment of use-case requirements
  - To gauge the user satisfaction of our product we will demonstrate the usage of our product with 15+ different college students that live in off-campus housing
  - We will collect feedback with surveys
    - To gauge the demand and need for this product design
    - Tweak commonly mentioned differences to match intended user satisfaction
- Record power output and idle time of space heater to measure energy consumption
  - Will allow us to gauge the safely and financial benefits of the service

Testing, Verification and Metrics

- Testing of software
  - Individual load test will be administered to gauge the strength of strength of the web application server
  - Need to be able to support up to 50 different user accounts once server is on the cloud
    - Intermediate steps include
      - Local development database will be able to register, create, and sustain users & space heaters
      - Upload the web application onto an Apache Server within an online EC2 instance
- Testing of space heater temperature precision
  - Utilize infrared to measure temperature precision that is sustained by the space heater
    - At first one space heater
    - Then have multiple space heaters maintain the same temperature in different spaces
    - Finally have multiple space heaters maintain different temperatures in the same and different houses

Tasks and Division of Labor

Everyone will work together, but here our are following focuses

- Eric:
  - Will focus on hands-on tasks
  - Setting up space heaters, sensors, smart-switch, integration of physical devices with Web Application
- Jay
  - Will focus on the software elements of the project
  - Setting up of Web Application, hosting server on cloud instance
- Rong
  - Will work a more PM role, coordinating with Professors and TA for material and project requirements
  - Working in between and with Eric & Jay in the hands-on and software development

	Assigned	Progress
Design Experience		0%
▾ Space Heater Setup		0%
Research materials to meet requirements		0%
Procure Materials and setup in rooms		0%
Build/Setup infrared sensors		0%
▾ Web Application		0%
Set up webpage outline using html		0%
Use Django to develop the application		0%
Implement user customization features		0%
Add multi-user customization under one account		0%
Upload the application onto aws so it can run remotely ...		0%
▾ Integration and Testing		0%
Connect/test control of smart-switches to space heaters		0%
Test and optimize infrared sensors		0%
Connect infrared sensors to Web App		0%
Integrate web application with remote plugs		0%
Gather data from the sensors link it to the web app		0%
▾ Optimize switching for thermal airflow		0%
Thermal calculations to estimate temperature changes		0%
Test and optimize same-room different preferences		0%
Identify circuit usage and estimate average elec. loads		0%
Write algorithms to optimize circuit loads		0%
Identify energy inefficiencies in current algorithm		0%
Write algorithms to optimize energy consumption		0%
▾ Final steps		0%
Fine-tune project for presentation		0%
Test and integrate project in presentation form		0%
Work on final presentation		0%