Group 36: **The Occupancy Project**

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Project Statement

Recently, homes and offices around the country are rapidly becoming connected to the web via the Internet of Things, providing people with previously unknown information that can offer a wide variety of benefits. We want to provide these benefits to Iowa State University, as well, by making its lecture halls, classrooms, and offices “smart.” Our project makes use of IoT data to reveal classroom availability information to both Iowa State students and staff.

Rooms around the university will report their current occupancy status via an occupancy sensor to a user-friendly web application. With this new room occupancy information, students can make informed choices about where to study and meet, and the university can make informed decisions using our application’s analytics about classroom usage (room popularity, energy consumption, etc). Because of Iowa State’s continued growth in enrollment, managing classroom usage effectively is more important than ever. The Occupancy Project will help Iowa State get the most out of their current buildings and be at the forefront of smart and sustainable technologies.

Project Requirements

Project Requirements:

- Be able to detect room status (occupied/non-occupied)
- Cannot cut any wires or modify existing devices in classrooms
- Must cost under $30/device when produced commercially
- Must have way for users to access information about which rooms are occupied

Our project has two main components, the device (hardware) and the app or website (software) associated with the data the devices are collecting.

Possible Device Solutions:

- Create our own occupancy sensor to trigger states
- Use LED feedback from existing occupancy sensors to monitor state

- Send state data over cellular network
- Send state data over wi-fi network

- Use batteries to power the device
- Use solar panels and supercapacitors to power device

Possible Web Solutions:

- Create mobile app
- Create Desktop Site
- Create Mobile-Friendly Site

Assessment of Proposed Solutions

Regarding Detecting Occupancy

When it comes to monitoring the occupancy, the nice thing about creating our own occupancy sensor would be that we can install it in rooms that don't already have a sensor installed. The downsides of using our own sensor is that we miss out on the decades of research and tweaking that commercial sensors are already integrating so our sensor would be substantially less reliable. It would also cost more to create the entire sensor from scratch.

If we were to use the existing sensor LED states, we couldn't install our device in rooms without sensors, but we would have substantially more accurate readings as well as lower costs.

Regarding transmitting data over the cellular network vs. Wifi network

If we were to transmit state data over the cellular network, we could install our devices anywhere there is cell phone reception, the downside is that it would require a 3g/4g modem which would substantially increase the initial device cost as well as recurring costs associated with the data plan. It would also make the device much more bulky.

If we used wifi, it would limit us to buildings that have wifi networks, the buildings would have to let our device connect to their network which could cause more security issues than the cellular data transmission. The nice thing about using wifi would be the reduced cost and size of our device, as well as not having any recurring costs.

Regarding Power Supply

Batteries would be a more consistent supply of power, but of course that power could run out. Finding long lasting batteries that would need to be changed very rarely could drive up costs or maintenance costs. Ideally our device would be something you could install and forget about.

WIth solar and supercapacitors, our device could require more power than the solar panels could generate. Having a lot of solar panels to power our device may add a lot of bulkiness to the device and make it look ridiculous.

Regarding the Web Application

If it was a mobile app, the only way to access the information would be through downloading the app and loading it, it may turn away some users who would rather just go to a website or have it saved on their work computer. A nice thing about an app is we could send notifications for when a room becomes available. Using an app would also have the fastest load times on a mobile device.

If it was a desktop site, we could display a wide variety of information and have large interactive floor maps and save a lot of time compared to making a mobile or mobile-friendly site. With the larger screen size, UI becomes much easier to work with. There would be no push-notifications with a desktop site.

A mobile-friendly site would allow users to access the data on their desktop computers or mobile phones. A mobile-friendly site would take much more time to code than just a regular desktop site. A mobile-friendly site would take longer to load than a native mobile app and could not send notifications to a user's phone.

Our Solution
We decided to start off our solution as an add-on to an existing device, we figured that rooms that should be monitored most likely already have a device in them or that the organization would be willing to first install a regular occupancy sensor before using ours.

Since our main target market is going to be universities and corporations, we figured that they would have their own wifi enabled network that we could access. Security will need to be looked into more, but since we won't be required to access their internal wifi networks, it should be manageable.

We realized we could combine both batteries and solar panels for maximum power supply. We'd rely as much as possible on solar panels, but if we needed to, we could resort to the battery on occasion to keep the device functioning.

For displaying the data, we thought a mobile site would be a great place to start. People can access it on both their smartphones and their desktop computer. Once we have a mobile-friendly site, it should be relatively easy to turn that into an app as well.

Validation and Acceptance Testing

Requirement	**Testing**
Be able to detect room status (occupied / non-occupied)	Have someone walk into room and see if state is updated Have someone in room 20 feet away turn around and see if change is detected
Can not cut any wires or modify existing devices in classrooms	Note if any existing devices were modified
Must cost under $30/device when produced commercially	Observe budget and scaling notes to note that end device would cost under $30
Must have way for users to access information about which rooms are occupied	Have someone with an internet connection look at the state changes

Design Specification and Technical Approach

At the core of our hardware, we will use an Adafruit HUZZAH ESP8266 breakout WiFi microcontroller to connect to the ISU network and transmit the sensor data. For occupancy detection we will use photoresistors to determine light status from the LEDs on existing devices. We will use the Arduino IDE and C to program the hardware. We will use Parse to manage the data received from the hardware. The user interface will consist of both a web application utilizing the Materialize framework (CSS/JavaScript/HTML) and a mobile application utilizing the Ionic framework.

Using the sensor hardware we built, we will be able to report the current occupancy status of a room to a user-friendly web application. This will be done in real-time, so all students or faculty have to do is go to our website, select a building, and we'll show them the occupancy status of classrooms on that part of campus! As an added bonus, this hardware can also indicate whether the lights in a room are on or off. These features allow the university to view informative analytics provided by our application about classroom usage, popularity, and energy consumption.

Process Details

While we plan on using a photoresistor to initially detect motion by relying on existing sensor's LED lights, it would be great to later on be able to incorporate our board directly into existing sensors so it would look like one solid package that can be powered by the existing sensor.

We also plan on taking our mobile-friendly site and making it into both an iOS and Android App, there are a couple of web frameworks we have considered using that will allow us to create our mobile app directly from our mobile site more or less.

Test Plan

What we have finished already is connecting the photoresistor to our breakout board and sending the sensor data over ISU's wifi network. We can then view that data in our database and on a primitive webpage. We have functionally tested what we have now by connecting our prototype to an installed motion detector. When we move about the room, the photoresistor picks up the LED change and sends the data to our database.

Our test plan for the future will be very similar, but will have tests for different room/lighting conditions as well as tests for breaks in activity and subtle movements. Our website will also have tests to make sure data from our database is read properly.

Project Schedule

The project timeline below will help us monitor the rate of progress we are making on completing The Occupancy Project. By making sure we meet the following deadlines and begin tasks at the specified time, we can be sure that we make headway at an appropriate rate to complete our expected deliverables.

First, we hope to have a fully-functional prototype of a room occupancy sensor pinging our web application. By demoing with this device, we will pitch our product to be used in a live demo environment (hopefully throughout Coover Hall) to test its capability and functionality in the real world. We will install multiple devices within this demo environment and gain insight about improvements through functional testing and feedback from users of our application. This live demo environment will also provide us with data to use in developing our analytics functionalities. This real-world case study will give us strong leverage in our pitch to install devices all throughout Iowa State University in the spring.

Date	**Tasks**
9/18/15	● Attend HackISU to build initial prototype. ● Have a basic web interface establishing connection between hardware & software completed.
10/15/15	● Web-app prototype completed. ● Begin expanding our web-app to mobile with the Ionic framework.
11/1/15	● Have a functioning device correctly pinging our web app. (Full demo functionality complete). ● Have a budget created with plans to get funding in place (from GSB or the business pitch competition). ● Compile a database of all classrooms and their amenities.
12/1/15	● Final design for device with enclosure complete. ● Prepare pitch to install devices in a live demo environment.
12/14/15	● Demo our project's functionality to other groups. ● Begin creating additional devices for the live demo environment. ● Pitch to put the product in a live demo environment complete. ● Evaluate current progress in order to adjust second semester plans.
1/1/15	● Begin installing devices in a live demo environment throughout this month. ● Begin work on analytics functionality within the web application.
2/1/15	● Pitch for additional funding from GSB.

	● Make improvements/modifications to our product based on results and feedback from the demo environment.
3/1/15	● Pitch for funding at Iowa State's Innovation Pitch Competition. ● Tailor analytics to express specific business needs before presenting to Iowa State.
4/1/15	● Pitch the full project to Iowa State University.
5/1/15	● Compete in the ISU Pappajohn Business Plan Competition
5/16/15	● Final demonstration to other Senior Design groups.

Risks and Feasibility Assessment

We have made sure the project can be done by looking at what existing projects and technologies are out there. We have seen many projects do different parts of what we are trying to accomplish so we think combining them all together should be feasible. One of the main risks is the cost of the device. The board and photoresistors cost a little under half of our proposed budget which leaves about $8-$18 for a power supply and casing. While there are a lot of low cost power systems that can work for our device, we may find through testing that we need to spend more money for a reliable power system that will meet our other project goals of low maintenance.

The other possible feasibility issue is scaling. We would like to scale this to classrooms across Coover Hall and the University. The university could shut us down and not go along with the project which would be really unfortunate. We think we could partner with other local businesses such as Workiva or the ISU Research Park as a contingency plan.

In terms of the website, everything is completely feasible and we have the skills on our team to make a great site over the course of a year and hopefully expand much more than that.

Cost Considerations

We're targeting our prototype version of the occupancy sensor in the $20-30 range. Depending on the scale we reach, this number could fluctuate. An estimated cost for production of occupancy sensors for each room (using Coover Hall as our initial base) would be around $1000. This number could fluctuate based on how much of a markup we charge for profit as well as any unforeseen production issues. If we plan to scale to the entire campus or potentially an even larger scale, we might have to reassess our design and components to see where we can cut costs.

Market Survey

Before starting our project, we performed extensive research to ensure that our idea hadn't already been created in any way. Luckily, we didn't find any IoT occupancy sensors being commercially produced. The only similarities we saw were hacks or DIY projects that others had posted online. The current state of occupancy detection devices is very "1995." Most devices we saw were very simplistic, simply controlling the status of lights. Other devices that reported the exact number of people in the room were more advanced with some having internet connectivity. Overall, we saw that this market hadn't been utilized and that a need was there to better visualize and understand room usage. This is where our product can shine and fill the gap in the market.

For example, a company called Kadtronix offers a somewhat similar, but outdated product called a Wi-Fi Sensor System. The applications given for this product include monitoring of meeting rooms, employee attendance, security systems, elder-care assistance, and inventory tracking. This product uses a WS-1000 controller coupled with an RF receiver and antenna, paired with sensors and the WSS online host software. Unfortunately no pricing information is given, you must request a quote for a specific package.

D-Link also offers a Wifi Smart Motion Sensor. This device detects motion up to 26 feet away and connects with Mydlink smart plugs and cameras to turn on/off devices or start video recording. It also includes the functionality of being able to receive push notifications via mobile app. This device connects to existing networks with 2.4 GHz Wifi. Priced at $35, this device would definitely be a competitor. However, online reviews express much frustration with lack of reliability and the push notifications not working.

We also found a hobbyist's "bathroom occupancy detection" system to help employees at a company know when it was open. Although it was just a fun hobby project and not a commercially available product, we can learn from this implementation.

Conclusion

We are confident that our project will provide Iowa State University's students and staff with extremely valuable analytics on room occupancy. We are enthusiastic that the information we provide will be utilized in a way that will provide many benefits. Whether students are using it to find an open study location or the university's building staff is using it to make sure that a building is being used in the most energy-efficient way, we are adamant that our product will make a positive impact.

By implementing a user-friendly website and mobile application, we will make sure the data our hardware generates is easily accessible and usable by as many people as possible, while also allowing us to showcase the strong software background we have built during our education at Iowa State. We will also strive to deliver hardware that not only works as described, but also is

packaged compactly and efficiently, with intent for it to become a scalable, market-viable device. In combination with the diverse hardware and software skills we will be utilizing throughout this project, we will continue to learn and practice business skills such as negotiation, pitching, marketing, and product adaption to customer needs, all of which will be extremely valuable in our future careers.

In conclusion, we look forward to developing together as a team and delivering this exciting project to successful completion.