Smart Laundry

PROJECT PLAN

Team 21

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Contents

List of Figures

1 Introduction

The following gives a basic summary of the project and our goals for it.

1.1 Project statement

The goal of this project is to bring clothing washers and dryers into the Internet of Things at an affordable cost of less than $30/machine. Our approach is to make a device that senses on/off states upon attachment to a broad range of laundry machines. The data gathered from the device will be accessible via a mobile application. This enables owners to bring their machines into the Internet of Things and along with them, many more benefits (e.g. increased throughput, money savings, etc.). Ultimately, our solution will increase the efficiency for all machine owners - both residential and commercial. Users benefit from the data provided in the mobile app while machine owners benefit from easy commercial implementation and improved analytics.

1.2 purpose

The goal of this project is to bring increased throughput to the owners and users of laundry machines. By allowing many existing or new laundry machines to be brought into the Internet of Things there are many benefits. On a commercial level, owners can enhance their outdated machines. By attaching our internet connected sensing unit to existing machines, customers can efficiently plan their machine access because they will know the availability in nearby stores.. On top of this, other commercial businesses, such as hotels and laundromats, can track when their machines are being run and how many resources they utilize[1]. This provides a valuable opportunity for big companies to further analyze the expenses and efficiency of their operation[2].

The smart device that we are creating allows anyone with internet access and a laundry machine to be able to track their laundry. This can be used to notify them when laundry is done as well as how much water and electricity is being used. This gives anyone the ability to become better informed about their efficiency, and at the same time improve it.

1.3 Goals

- Develop a machine state sensor that is easily attachable to laundry machines
- Have the developed device easily connect to the internet and send data to a server
- Store each sensor's data(e.g. machine on/off status, machine location, machine start time) in a database
- Have a mobile app that can pull data from the database and display it in a user friendly way that can easily be understood and used for the user to interpret the information
- Incorporate machine learning to be able to predict availability of laundry machines

2 Deliverables

- Device(s)
    - The delivered device(s) will be easily attachable to washers and dryers with the capability to sense a broad range of machines in order to tell if they are on or off. The sensing device will also be easily configured to use local wifi.
- Configured database
    - The delivered database will store various laundromats, machines, and users of the smart laundry app. Data will be sent and received from this database based on the users needs and the needs of the laundromat owner.
- Configured server
    - The delivered server will be able to gather information from nearby machine state sensing devices and then store it into the delivered database.
- Functioning android mobile app
    - The delivered mobile app will allow for users of it to easily access specific stores and their machine availability.

3 Design

Diagrams that break down the structure of the devised solution can be found in the Appendix. Specifically figures 9.1, 9.2, and 9.3.

3.1 Previous work/literature

It has been discovered there are accessories such as z-wave[3] devices on the market that can track to see if a laundry machine is on or off based on vibrations or power consumption. These devices notify a phone for example only when something specific happens such as a machine turns off. It is apparent that the devices from z-wave are meant for in home personal use and are not meant to function in a large scale environment. They provide only an on/off functionality for a few users.

3.2 Proposed System Block diagram

In figure 3.1 below, overall system flow can be seen. The proposed design has a machine state sensing device that is attached to the outside of the a machine. This device will be developed so that it can reliably measure the vibrations of the machine it's mounted on in order to know if it is in use or not. Our sensing mechanism will then be able to communicate to a local server within close proximity of the laundry machine. This will allow for the state of machines to be sent to that local server to analyze the data. When the local server runs the data through an algorithm that we develop, it will be able to determine if specific machines are running or not. The results will then be sent and stored into a central database containing all of the machines and stores using a smart laundry sensor. This database allows for the mobile app to query it and relay store/machine information to a user pertaining to a user specified store and machine.

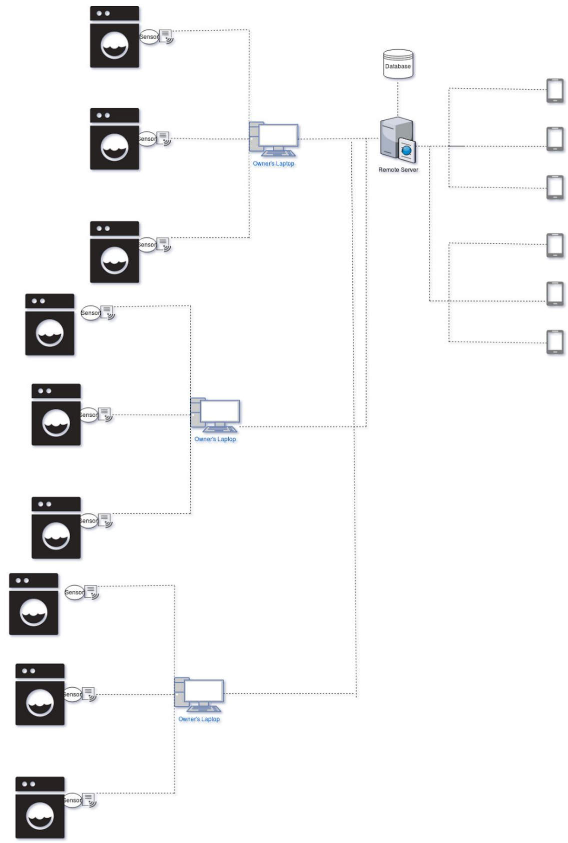

Figure 3.1 .: This diagram illustrates the system in its most basic form.

3.3 Operating Environment

The operating environment that needs to be considered is that of which the laundry machine sensing device will be used in. This device will be where washers and dryers are every minute of every day once attached to a machine. The nature of the attachment to a laundry machine means the sensing device will be in warm and possibly damp conditions. With the described conditions in mind, the device must be able to withstand more than room temperature heat, not let any perspiration into its required housing, and will also have to remain attached to a vibrating/shaking machine.

3.4 Intended Users and Use

The people envisioned to buy the laundry machine sensing devices own a large amount of machines due to having a commercial business of some sort (such as apartment, hotel, laundromat, etc). The owners of the sensing device would attach the device to their machines and connect it to their internet. The owners would then be able to see machine statistics per machine, site, or sites.

The actual users of the laundry machines would be able to download a mobile application to be able to see various information about the machines they want to use. The mobile app users would be able to see the availability, predicted availability, and location of any machine that is connected to the network from anywhere.

3.5 Assessment of Proposed methods

When initially thinking about the different approaches we could take when trying to develop a smart solution for the problem at hand, many ideas were taken into consideration. The first thing we thought about was the device. The device needed to be attachable to a laundry machine, be able to receive power, sense if the machine is on/off, and be connected to the internet. The actual approach we decided to take for the device is one that is plugged in for power, has wifi for internet connectivity, has a plastic outer casing, uses a vibration sensor, and is adhesively mounted to a machine. The advantages and disadvantages for the chosen solution versus other possible solutions are as follows:

- Power
  - Advantages
    - Guaranteed continuous power supply
  - Disadvantages
    - Has to be plugged in
- Internet Connectivity
  - Advantages
    - Does not require many cords from many devices
  - Disadvantages
    - Has to be configured on each device
- Mounting
  - Advantages
    - Non-invasive to the machine
  - Disadvantages
    - Could fall off after extended time
- Protection
  - Advantages
    - Cheap, withstands assumed conditions, lightweight
  - Disadvantages
    - Breakable
- Sensing
  - Advantages
    - Cheap, easily interpretable data
  - Disadvantages
    - Comparably may not end not being the most reliable type of sensor we could use

The advantages this has is that the power is never brought into question, as long as the building has power, the device does. With the wifi connectivity, it allows for many of these devices to be in the same environment without the need of many cords running to a router from many devices.

3.4 Validation

In order to know that the solution that is implemented does indeed work, there are multiple criteria that can be looked at. First, the device must be able to sense a broad range of laundry machine vibrations. The device must also be easily attachable to many laundry machines, have power supplied to it for long durations, and be able to easily interface with the owners internet for communication with the owners local server.

The owners local server must be able to receive data that is collected by all nearby devices. The local server then needs to be capable of processing the data and producing results that accurately reflect the correct state of each nearby machine. The results must then be sent to the database and stored within the appropriate table.

Beyond the device and local server, a database will be set up in such a way that many stores with many machines could be added to it. Scalability is critical as many devices from many locations will be feeding data into the database. A well designed database would also be able to handle queries from the mobile application that is developed to obtain specific information about different machines in different locations. Data will be pushed to the database from the local store servers, and pulled from users of the mobile app whenever data has been flagged as changed in the database.

The overall system of the solution must also be real time. The user of the mobile app must be able to see current states of laundry machines in order to be useful. On top of this, the delivered mobile app must be able to see machine information from any store the user desires. After being functionally validated, the resulting solution must also be cost effective in order to be valuable to the intended customers for the product.

4 Project Requirements/Specifications

This section covers requirements that were set forth by our team for the solution in mind.

4.1 FUNCTIONAL

- There must be a Physical Device that
  - is mountable
  - has sensors on it
  - is able to connect to internet
  - is set up to be able to interface with a router/local server on site
- There must be a Database that
  - is a central database
  - stores sensor information
  - interfaces with the local server and the mobile app
- There must be a local server server that
  - interfaces with the database
  - receives data from local devices
  - sends information to the database
- There must be a mobile app that
  - is used by users of the laundry facilities
  - receives information from the database
  - sends post requests to the database

- sends get requests to the database

4.2 Non-functional

- Machine learning (predictive scheduling)
- The system must track how many loads of laundry are completed
- Battery backup
- Live feed
- Live map
- Database GUI
- Extra Database tables
- Social media plugins
- Outage reporting
- The app is responsive
- Tracks water used
- Tracks electricity used
- Tracks detergent used
- UI for breaking down machine/location(s) statistics

4.3 Standards

Our team is following a couple standards when developing a solution to the stated problem we are solving. The device that is being made uses IEEE standard wifi(802.11 b/g/n) to communicate with a nearby server. As the mobile application is developed, it will follow a MVC like coding architectural standard. The way the architecture is set up is to be a dependency injected model view controller. With this code structure it allows for "black box" development. It makes development go smoother and gives the application as a whole an easy to understand architecture. With this standard, the database does not need to be implemented right away in order to develop a functioning app.

The database that will be used for storage of all information will be a "Firebase Realtime Database". Firebase is a cloud hosted database that stores data in JSON format. The local server and mobile application use the Firebase API protocols in order to communicate with the database.

5 Challenges

Below is the list of challenges that may affect the progress with respect to the project plan.

- Ordering hardware takes time as it needs approval from multiple people then there is additional time after parts are ordered. This will only slow progress slightly but can be combatted by ordering parts before they are needed (being proactive with part ordering instead of reactive).
- Nobody on our team as much experience with backend development. This imposes a learning curve to the backend team as they develop a local server and database. In order to keep progressing during hard times, we are aiming to talk to people with more experience in order to gain more insight and knowledge of how to complete certain goals we have.

- Machine learning is something no one on the team has worked with before. In order to combat this lack previous experience, we will try to consult others with experience to know what solutions to look at/towards.

6 Timeline

This section outlines the major activities and milestones.

6.1 First Semester

The timeline corresponding to the major development for first semester is shown in table 6.1 below.

September	**October**	**November**	**December**
Hardware: Find and order parts. Start implementation of client side server. **Backend**: Brainstorm database relations and implement at least one table. **Mobile**: Develop underlying architecture and start development of activities without the need of database.	**Hardware**: Start developing firmware for the hardware and connect components together. Re-order parts if necessary. **Backend**: Receive and send data from mobile and also hardware if hardware is ready. **Mobile**: Start the connection of mobile to database, figure out what/how. Finish database connection from mobile to database for activities that are done.	**Hardware**: Have hardware components and client-side server communicate with each other. **Backend**: Research machine learning and identify areas of application, maintain/update database as needed. **Mobile**: Then work on finishing any more activities that need to be implemented.	**Hardware**: Finish up breadboard prototype and set up plan for testing sensing device's functionality. Finalize the design of machine sensor. **Backend**: Continue research and implementation of machine learning algorithms. Set up plan for testing database functionality. Finalize the overall database design, no more change of structure should be needed. **Mobile**: Research and start implementation on interactive store map. Set up plan for testing app functionality. Finish the complete design, UI pages should not be changed past this point. -------- At this point we should be able to collect data from a single sensing device and reflect the results within the mobile app.

Table 6.1 .: The first semester timeline consists mainly of research and development for all areas of our project.

6.2 Second Semester

The timeline corresponding to the major development for second semester is shown in table 6.2 below. The granularity is at a level of month, however, we expect a finer granularity s the project evolves.

January	February	March	April
Hardware: Research materials and how to use AutoCAD. Research signal processing for data from sensor to determine on/off state. **Backend**: Develop data pipeline for machine learning implementation to allow for auto-training on new data collection. **Mobile**: Finish interactive store map implementation. -------- At this point we should be able to collect data from multiple sensing devices and reflect the results within the mobile app.	**Hardware**: Develop protected sensor box. Develop algorithm to sense state of machines. **Backend**: Develop API documentation for server interface. **Mobile**: Implement machine learning inference model push on app update. -------- At this point we should be able to collect data from multiple sensing devices at multiple locations and reflect the results within the mobile app.	**Hardware**: Add more sensors to the network and client side server. **Backend**: Test and refine tables upon additional sensors. **Mobile**: Test and refine mobile app to handle multiple sensors/stores.	Testing and finalizing

Table 6.2 .: The second semester timeline consists mainly of finishing up development, testing, and finalizing our deliverable products.

7 Conclusions

Laundry machines that are available to consumers are either outdated due to no internet connectivity, or too expensive due to internet connectivity. Laundry machines that are not connected to the internet are behind the times and should be brought into the Internet of Things at an affordable and easy to implement way. Our plan is to create a device that can reliably broadcast information about the current state of a laundry machine to a scalable database. The created database would be able to receive information from many sensing devices at many locations and then be able to respond to queries from the mobile phone application. The mobile phone application that is developed will be easy to use, but at the same time be able to convey an abundance of useful information to the user. By bringing laundry machines into the Internet of Things, the efficiency of those who own or operate the machine will be increased.

8 References

[1] Benjamin, Jonathan. "Improving Hotel Laundry with the Internet of Things." *Improving Hotel Laundry with the Internet of Things*, IoT Evolution, 11 Oct. 2016, www.iotevolutionworld.com/m2m/articles/425997-improving-hotel-laundry-with-internet-things.htm.

[2] Xeros. "IoT Improves Sustainability in Laundry Operations." *Xeros Polymer Laundry Bead Cleaning*, 14 Dec. 2015, www.xeroscleaning.com/blog/iot-improves-sustainability-in-laundry-operations-part-1-of-2.

[3] "Z-Wave the Smartest Choice for Your Smart Home." *Z-Wave*, www.z-wave.com/.

9 Appendix

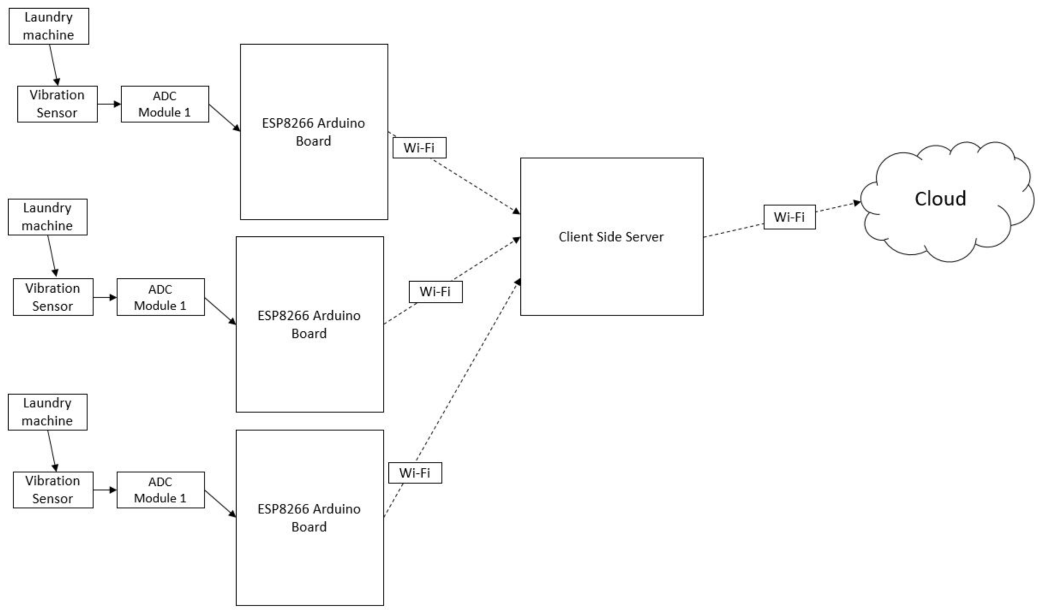

Figure 9.1.: Above is an example of how our components within a store would communicate with each other. The figure shows that multiple laundry machines will have an arduino board mounted onto them in order to sense their on/off state. The data is then transmitted to the client side server which will communicate with the cloud.

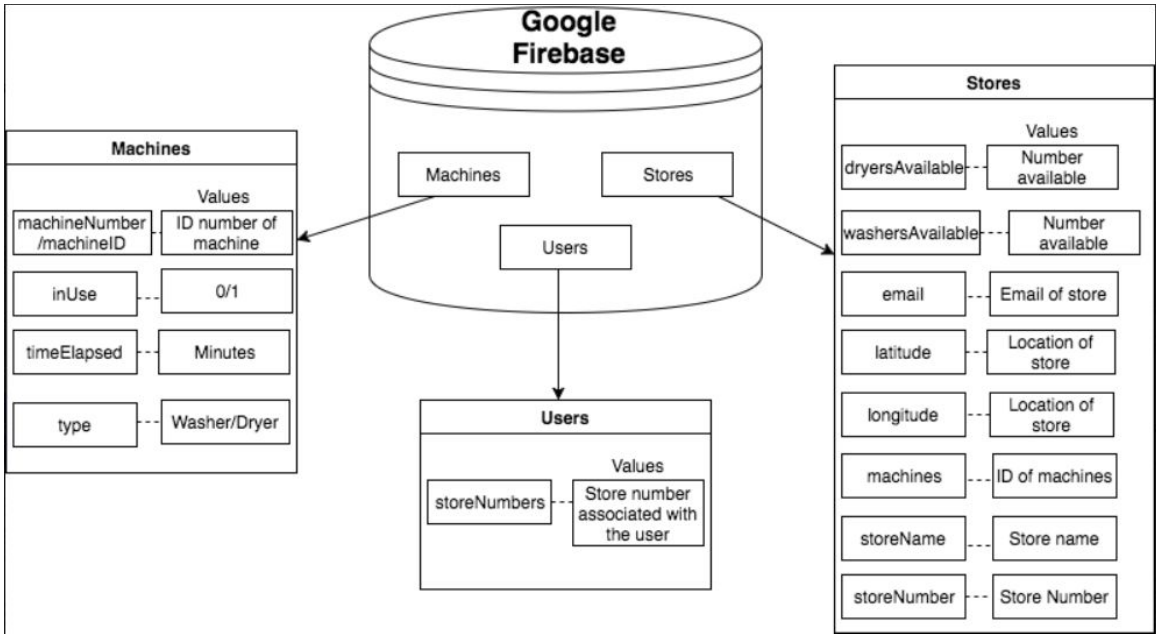

Figure 9.2 .: Above is the representation of the database with its various tables and their relationships.

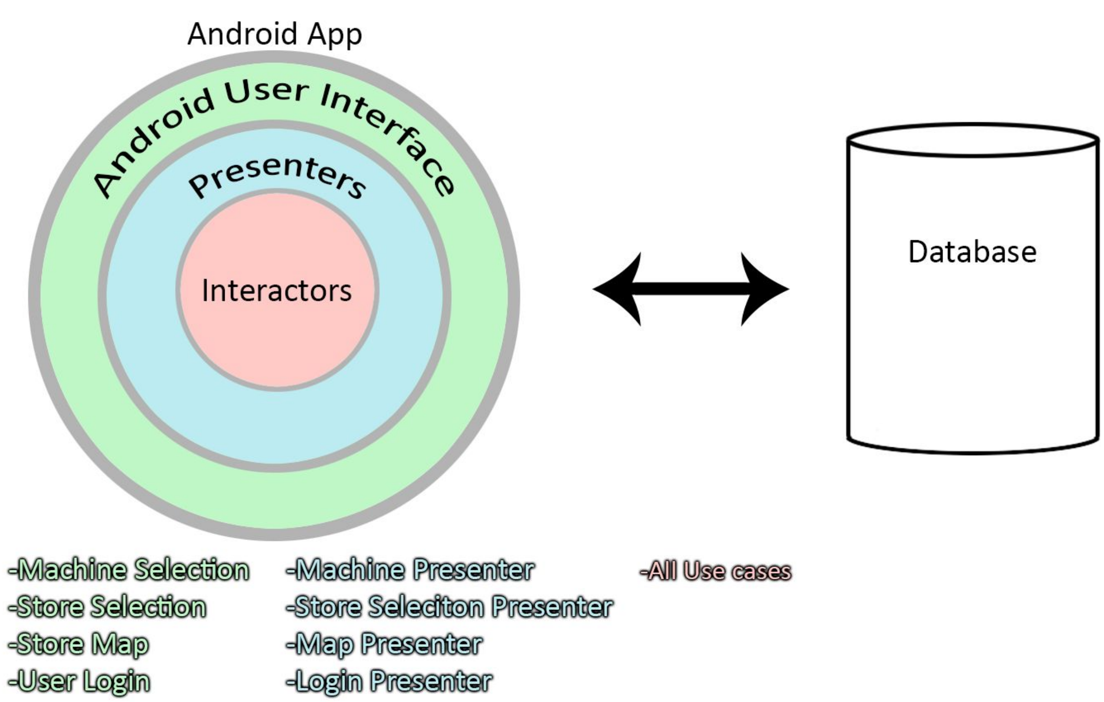

Figure 9.3 .: Above is the depiction of the mobile app architecture