Project Plan

Acknowledgements

Throughout the development process, several people have been key to the success of this project. We would like to thank Dr. Mani Mina for his advice and guidance throughout this project. Additionally, our team would like to thank Dr. David Ringholz, the liaison to Freescale Semiconductor, who has not only helped us communicate with our client, but also offered us his design expertise. We would especially like to thank the Industrial Design teams that did the initial field and market research and concept art for this project. Lastly, we would like to thank Freescale Semiconductor and the Electrical and Computer Engineering department at Iowa State for their funding and for helping us achieve our goals.

Problem Statement

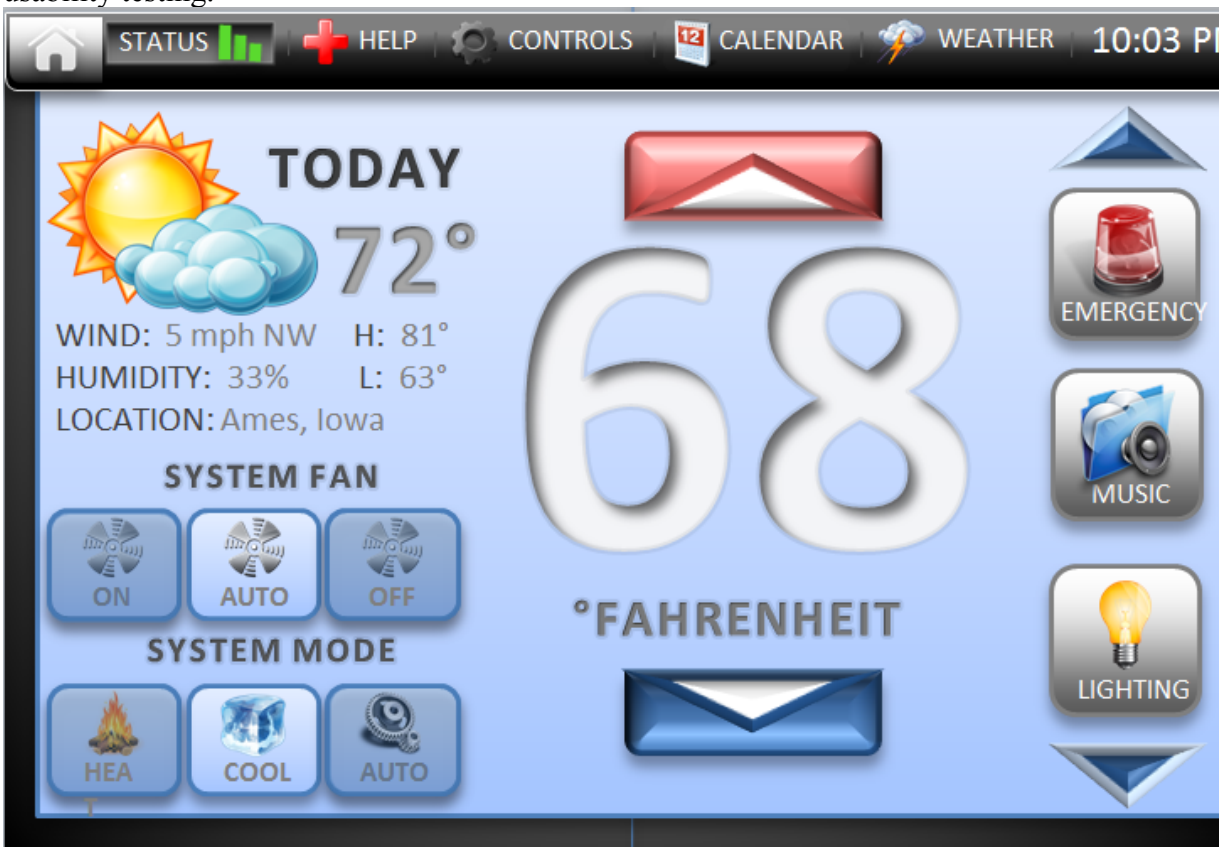
With the advent of smart devices, customers are expecting a richer experience out of the appliances they interact with daily. Freescale, in conjunction with Iowa State University's Industrial Design Department, has noticed a market opportunity to use touchscreen interfaces for interaction with home appliances. During the course of this market research, the need for an interactive touchscreen prototype was discovered.

Our goal as an engineering senior design group was to provide a prototype platform for use in research to measure reactions to a home appliance touchscreen interface. The approach
that our group took was to interpret the compiled research and develop prototype appliance interfaces to be used on an Android tablet for continued testing and development. In order to fit the project's time constraints, the appliance interfaces that we chose to simulate are for a washing machine and Heating Ventilation Air Conditioning (HVAC/thermostat) Controller.

Preliminary Research and Design

An industrial design class performed market and consumer research for a new line of appliances that would feature touch screen interfaces. They determined the current opportunities within the market and obtained user preferences regarding appliance features and component placement. Their consumer research consisted of conducting surveys about desired appliance features, menu setup, the placement of the touchscreen on the appliance, and the size and shape of the touchscreen. From their research they constructed menu designs and layouts, flowcharts, and wire charts for the home appliance applications. Their final designs were then passed on to us, the engineering team, so that a prototype could be created for

usability testing.



Mockup of the HVAC Main Screen, created by Industrial Design

Mockup of the Washer Main Screen, created by Industrial Design

Standards

The standards adhered to throughout this project can be divided into two distinct categories.

Android Design Recommendations

Android also does not force users to follow the guide on the Design website, http://developer.android.com/design/index.html, but these guidelines give the user a consistent android-style and make the interface intuitive. Some examples we used are:

- Utilizing Android's themes like Holo Dark for consistency
- Providing haptic feedback for clicked buttons
- Use of the Roboto typography family, made for high-resolution screens

- Creating multi-view layouts, specifically with fragments

UI Heuristics

Finally, there are heuristics in place that aim to make the interface intuitive, easy to use, and aesthetically appealing. The heuristics that we focused on most were:

- Visibility of system status
- Match between system and the real world
- Minimalist design
- Help documentation

Project Timeline

- Pre Semester 1
  - Prior to our group receiving this project, initial market research and prototype mock up was completed by Iowa State Industrial Design student teams.
- Semester 1
  - January
    - Project introduction and definition
    - Initial meeting with client liaison
    - Determined development platform
  - February
    - Established regular meeting schedule
    - Commonality and Variability planning
    - Decided on two appliance interfaces
    - Module design
    - Android research
  - March
    - Met with Industrial Design teams to discuss prototypes and workflows
    - Development started
    - James, Andy, Tamara - HVAC
    - Kat - Washer
    - Documentation (Design document and project plan)
  - April
    - Development continues
    - James - Weather
    - Andy - Scheduler
    - Kat - Washer backend
    - Tamara - HVAC
    - Hardware requirements reconsidered
- Semester 2
  - September
    - Development progress
    - Andy - Scheduler backend
    - James - Weather fragments
    - Kat - Dial interface and Program Customization
    - Tamara - Energy efficiency

- October
  - Testing instrument/script developed
  - Development progress
  - Andy - Scheduler views, Events
  - James - Washer progress bar, HVAC button groups, layout improvements
  - Kat - Washer Stain and Maintenance guides database, front and backend
  - Tamara - Energy efficiency
- November
  - Usability testing
  - Testing results tabulation
  - Development revisions from testing
  - Documentation
  - Finalize code
- December
  - Present project deliverables

Work Break-Down

Phases of Implementation

Throughout the course of the two semester of Senior Design, we stepped through the design process, starting at concept art and ending with a working application for our client. Our work can be broken down into a few key segments: Design, Initial Development, Progress and Schedule Analysis, Secondary Development, Testing, and Final Development.

Design

This stage was the beginning of our project. In it, we began by familiarizing ourselves with the project, the client, and their goals. We met the Industrial Design teams that had designed home appliance controls and worked to understand their goals of their project. In this phase, we narrowed the scope to designing an HVAC/thermostat application and a washer application. Next, we decided on some designs and basic layouts, workflows, and features for these two applications.

Initial Development

After the initial design stage, we moved into primary development. We began to create the two applications, using older Archos tablets that ran Android version 2.2. We developed two rudimentary applications that both had similarities to our final applications. Both applications had a menu bar at the top. The washer had a painted dial as well as skeletons for stain and maintenance guides; the HVAC had the large temperature display and some state buttons. At this point in the spring semester, our first semester of Senior Design was finished.

Progress and Schedule Analysis

When we returned for our fall semester to resume our Senior Design project, we needed to analyze where we sat and where we believed we could go with only one semester left. First, we met with our advisor and our client to discuss possibilities with them. Then we analyzed the features we created in the previous semester, the worth of them to the project, and the difficulty of implementing each of them. We weighed this information, and created a prioritized list of features, and an accompanying schedule for developing these.

Secondary Development

This stage involved rapid development, along with a repository choice change. We chose to move our code to Github for ease of use. In addition, we moved to using Nexus 7 tablets that ran Android 4.1.Throughout this phase, we met as a team to do group development; we reviewed our goals, and we analyzed our modules, identifying risks as we went.

Upon returning to development, we realized that the weather module had stopped working. The Google weather API that we had utilized was shut down without warning so we switched to a different API from WeatherUnderground.com. This API shift actually provided richer features and weather data, which we were able to incorporate into our weather module. Additionally, the initial design for the HVAC's schedule feature was not viable. The font sizes were too small to read, and we needed to redesign the module with accessibility in mind.

In the Washer application, the original dial lacked the aesthetic we wanted for our final application, so the dial design was reworked using a rotating dial image. Other program options were also added to the main screen to allow the user to further customize their basic wash programs.

In order to complete the Stain and Maintenance guides on the Washer, databases needed to be populated to show the capabilities of the modules. The maintenance instruction items were populated by hand from various sources on the internet. The stain removal instructions were all gathered from the same source, the University of Illinois (uiuc.edu) Extension's "Stain Solutions" website. There were too many items in the database to copy by hand, so we wrote a web-crawler to parse and collect the data.

Testing

After this secondary stage of development, we moved into a brief period of user testing. This stage was important in its ability to give us new insight to the work we had been doing. Using our tablets and testing documents we administered tests to a wide range of users. This gave us outsider's perspectives on the usability of our app and provided us with information about improvements that could or should be made.

Final Development and Wrap-up

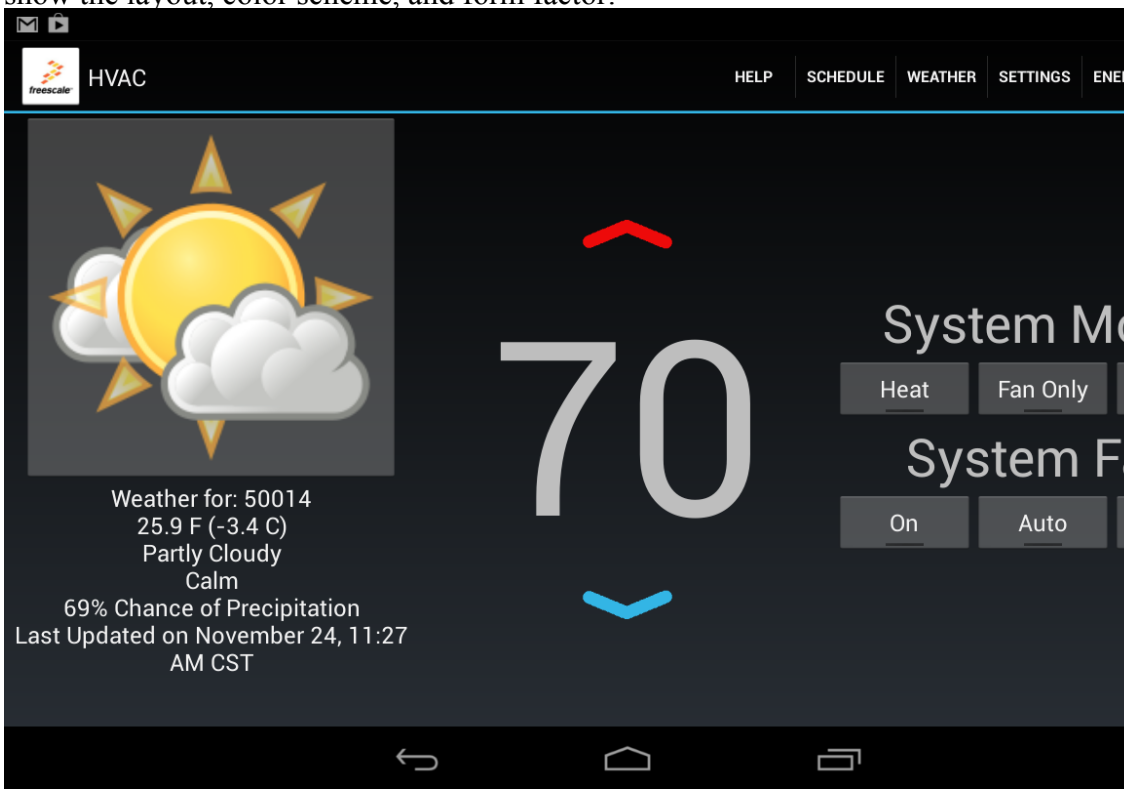
Finally, we began a period of quick development, fixing or altering issues identified in testing. This very quick iteration provided us with more intuitive applications. Improvements made in this

iteration included adding clearer button icons and labels, fail-safe internet for weather access, larger font sizes, and sound-based feedback for the dial interface. In addition, we wrapped up the semester by creating our final documentation on the progress we made throughout our senior design project.

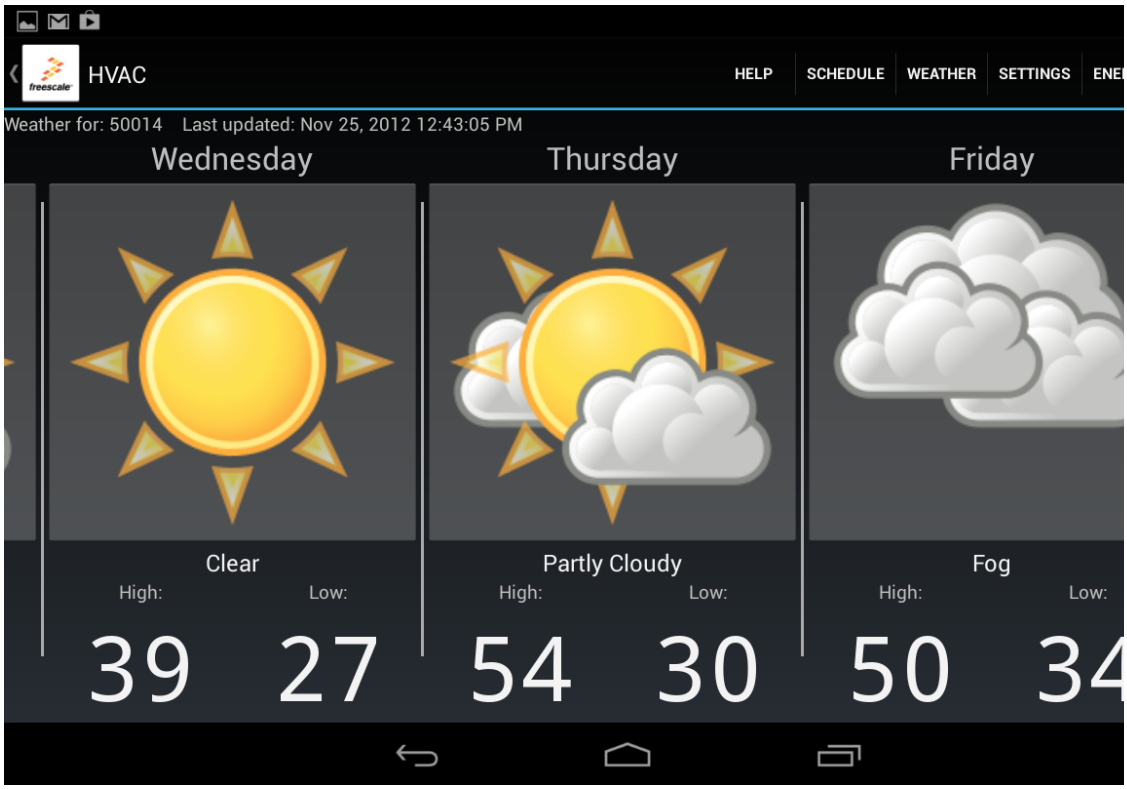
Design

The design methodology for this project was to make the applications as intuitive and aesthetically pleasing as possible. We developed workflows and features that would complement our methodology.

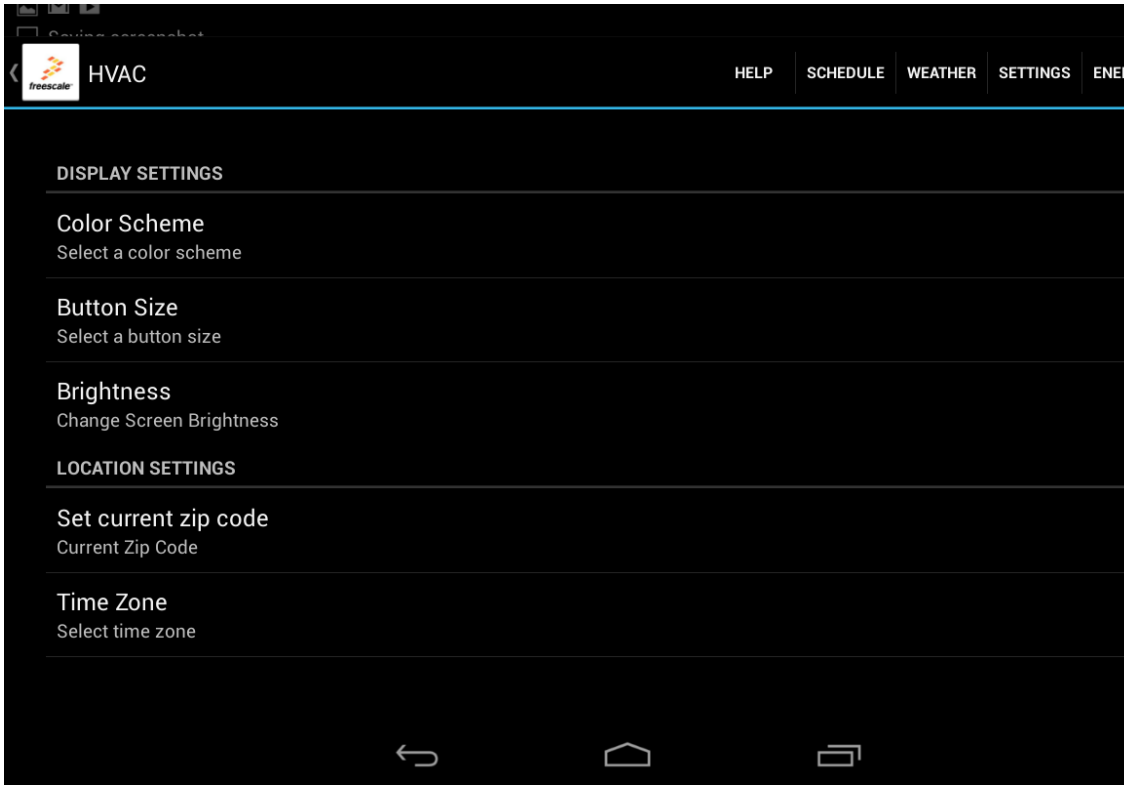
The modules for HVAC are: Home, Weather, Settings, Calendar and Energy Efficiency. We have the following screenshots to show the layout, color scheme, and form factor:



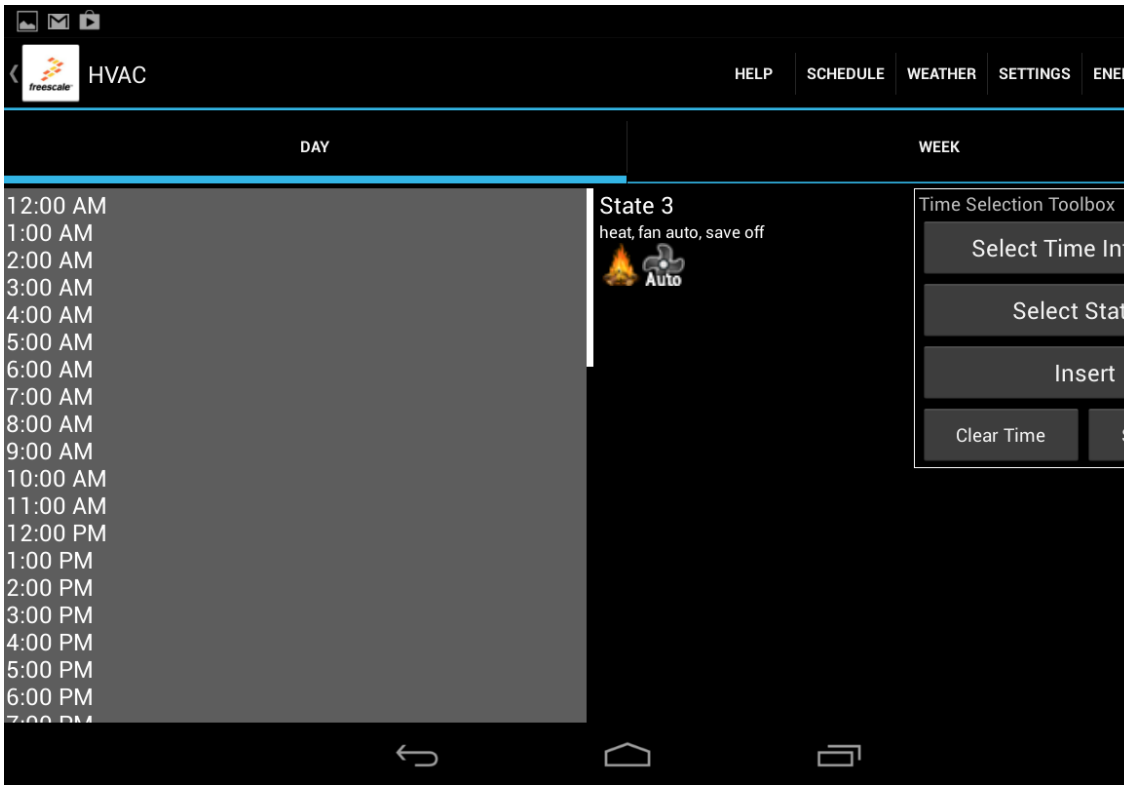
HVAC Main Screen



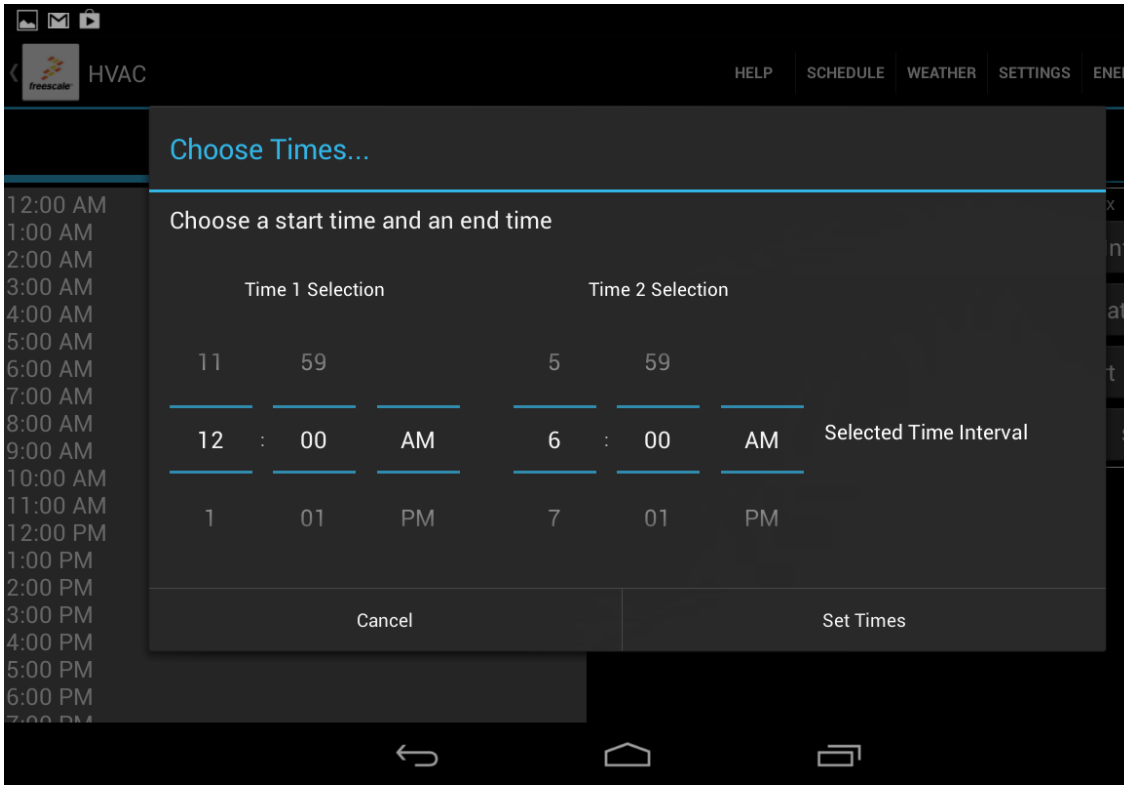
HVAC Weather Screen



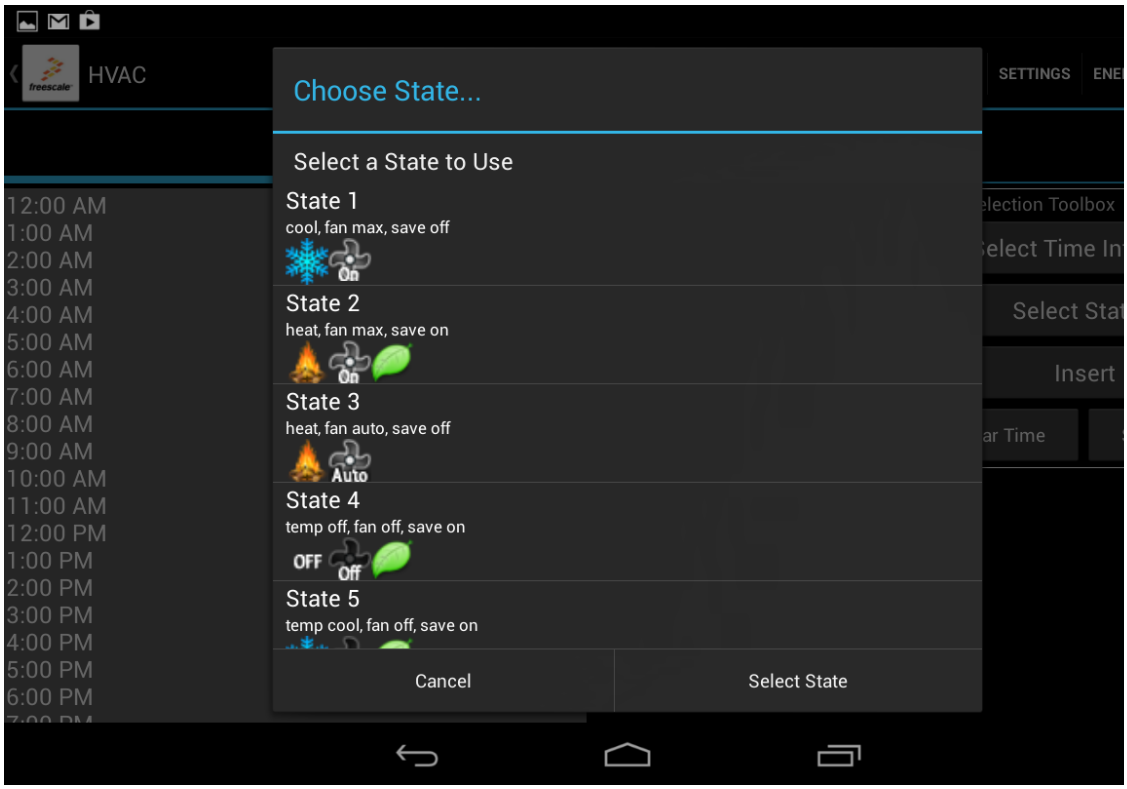
HVAC Setting Screen



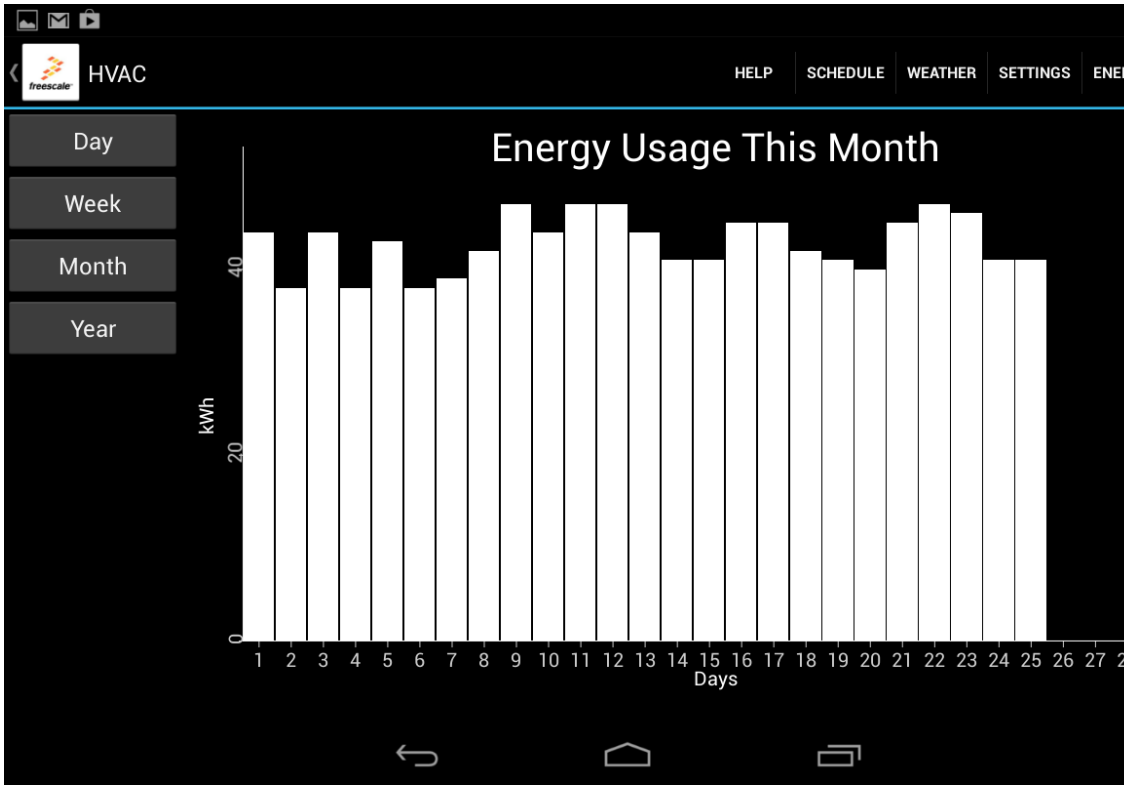
HVAC Schedule Screen



Calendar Screen: Time Selection

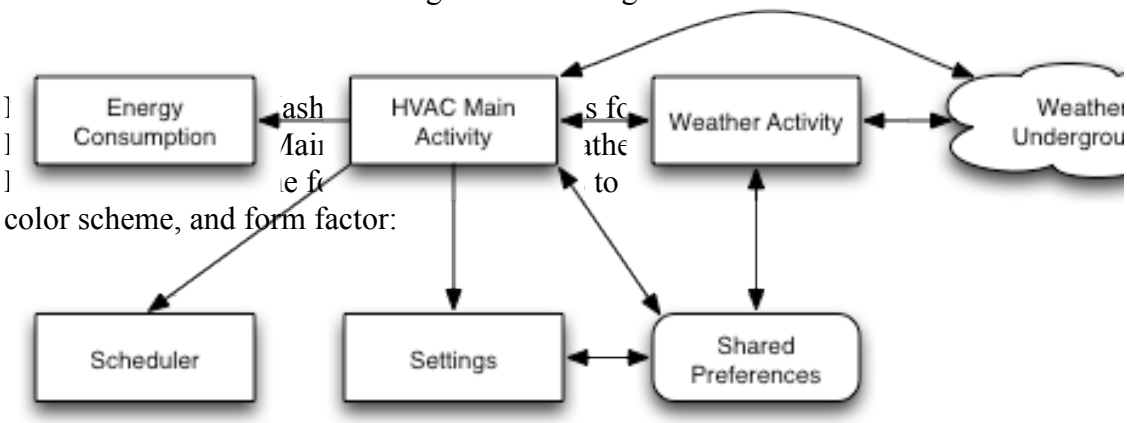


Calendar Screen: Mode Selection

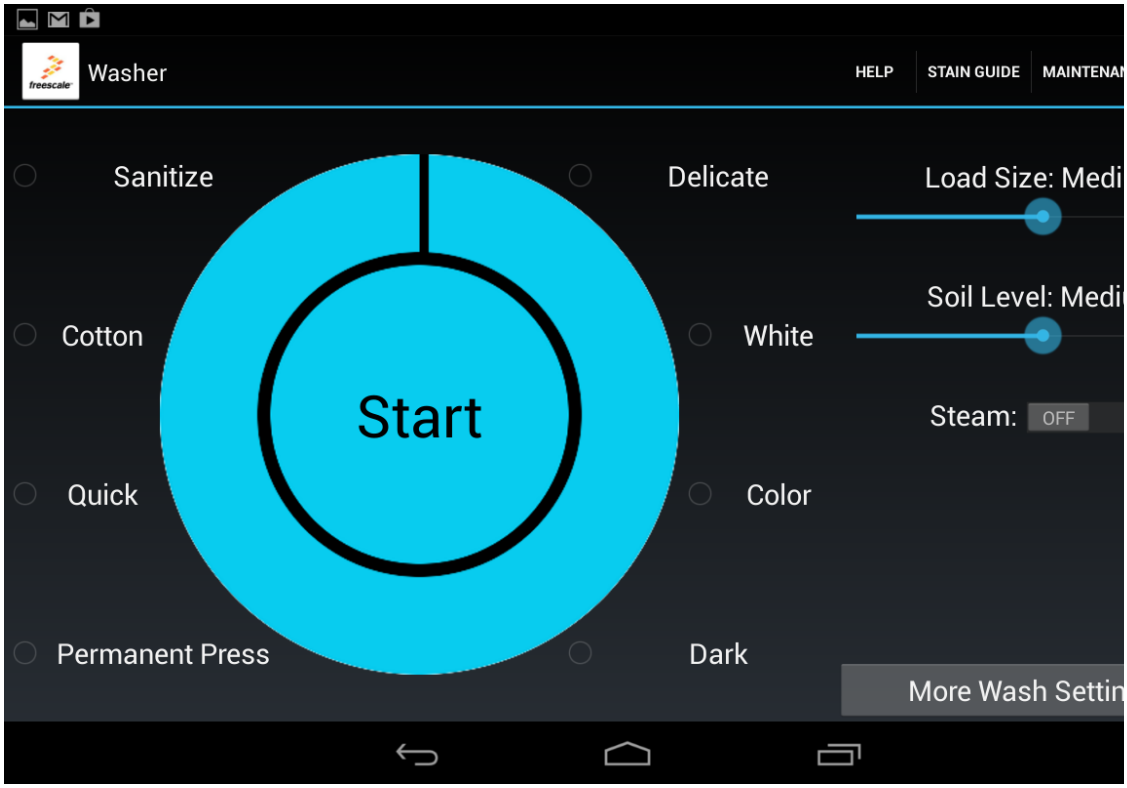


Energy Screen: Monthly Energy Usage

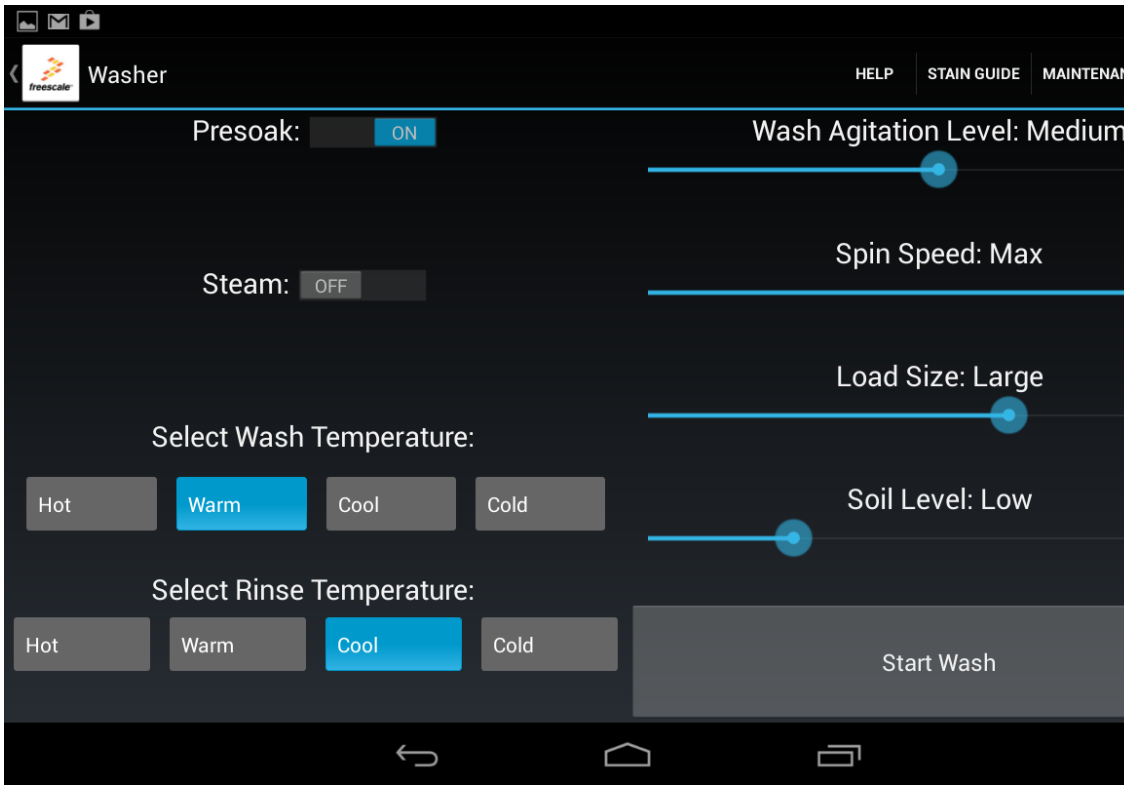
The HVAC also has the following workflow diagram:



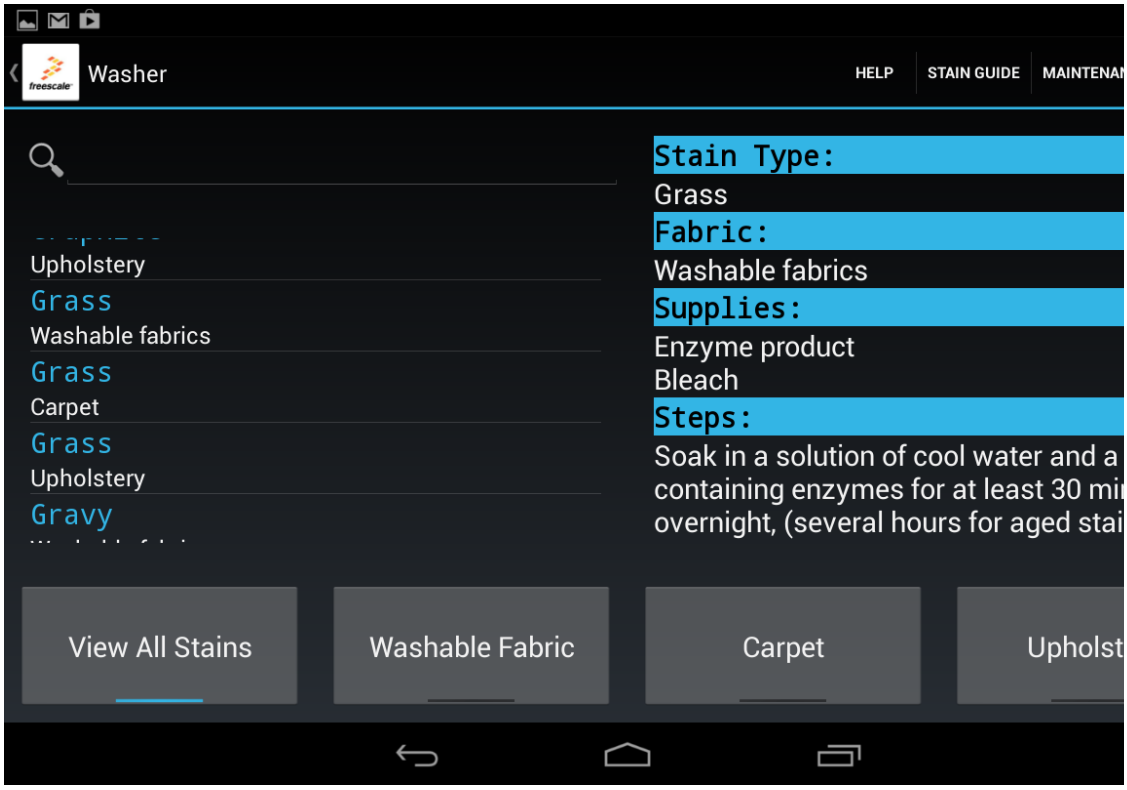
color scheme, and form factor:



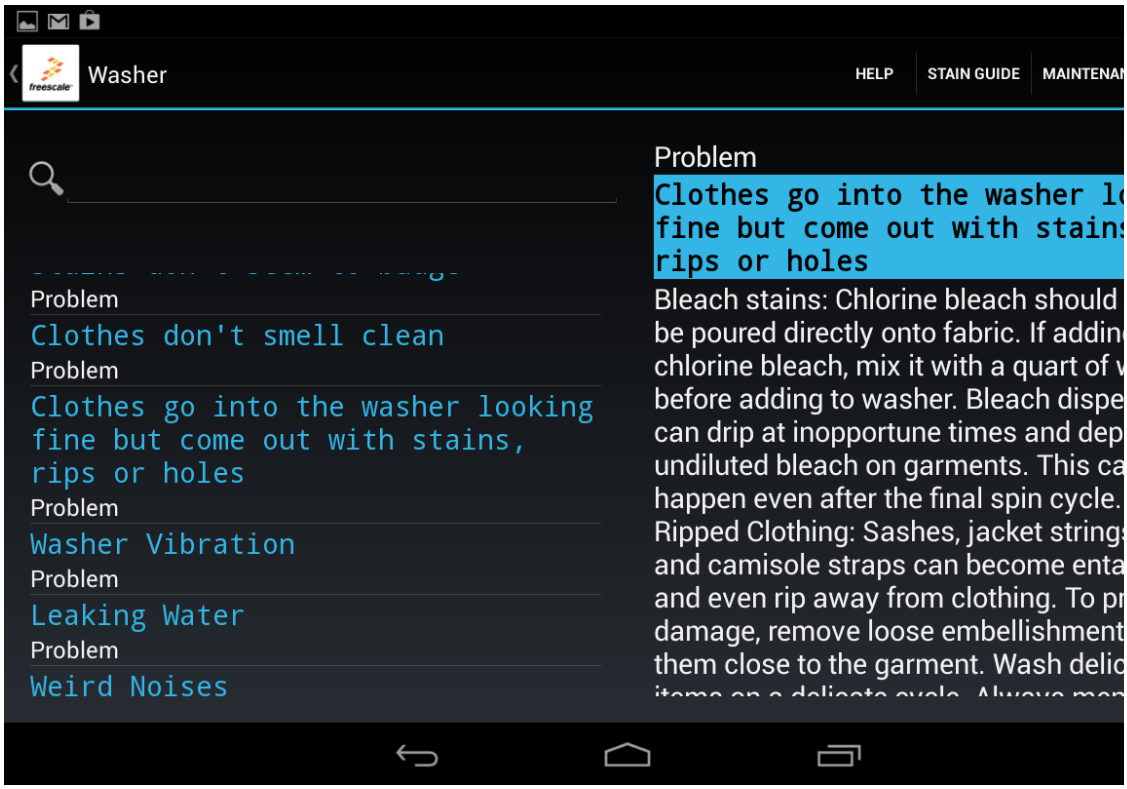
Washer Home Screen



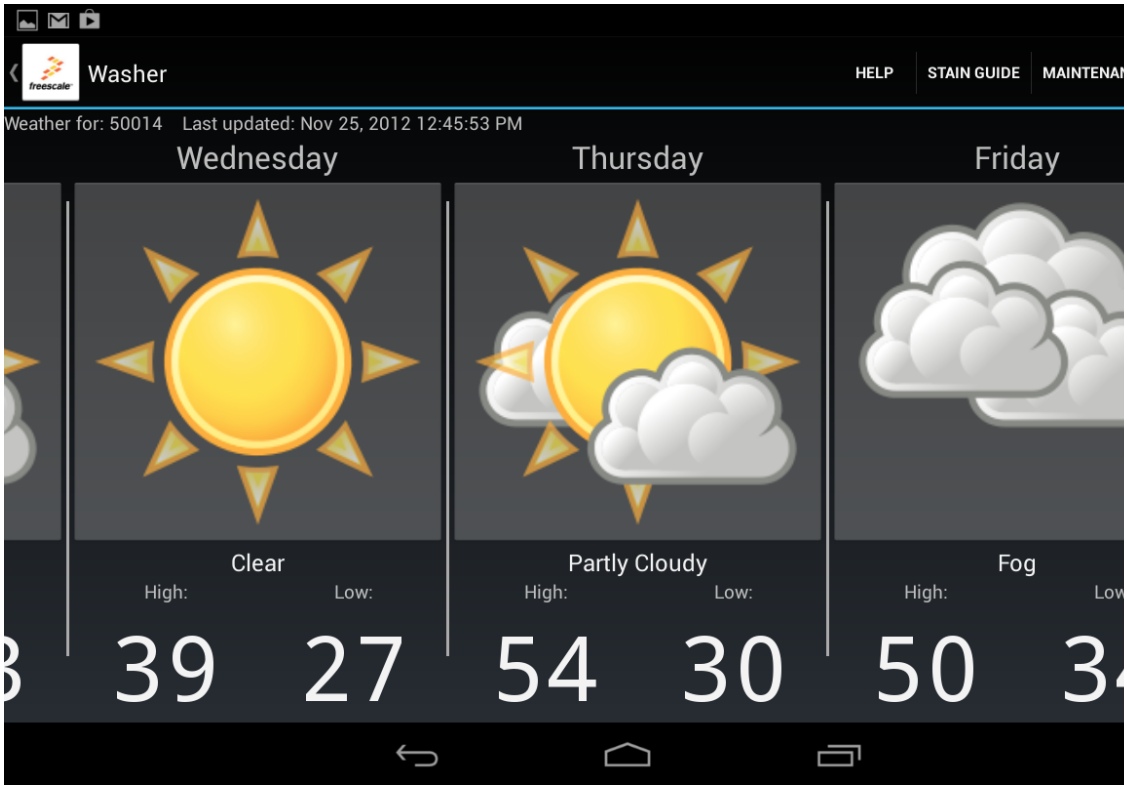
Washer "Customize Wash" Screen



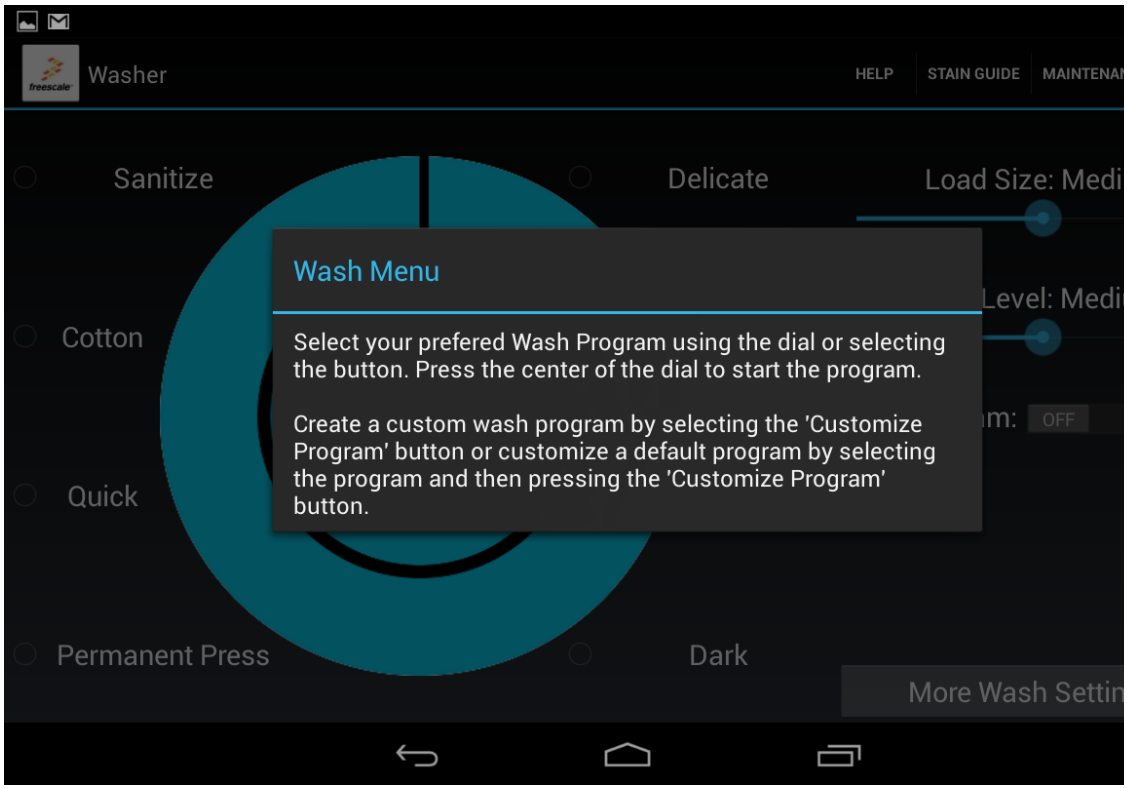
Washer Stain Guide



Washer Maintenance Guide

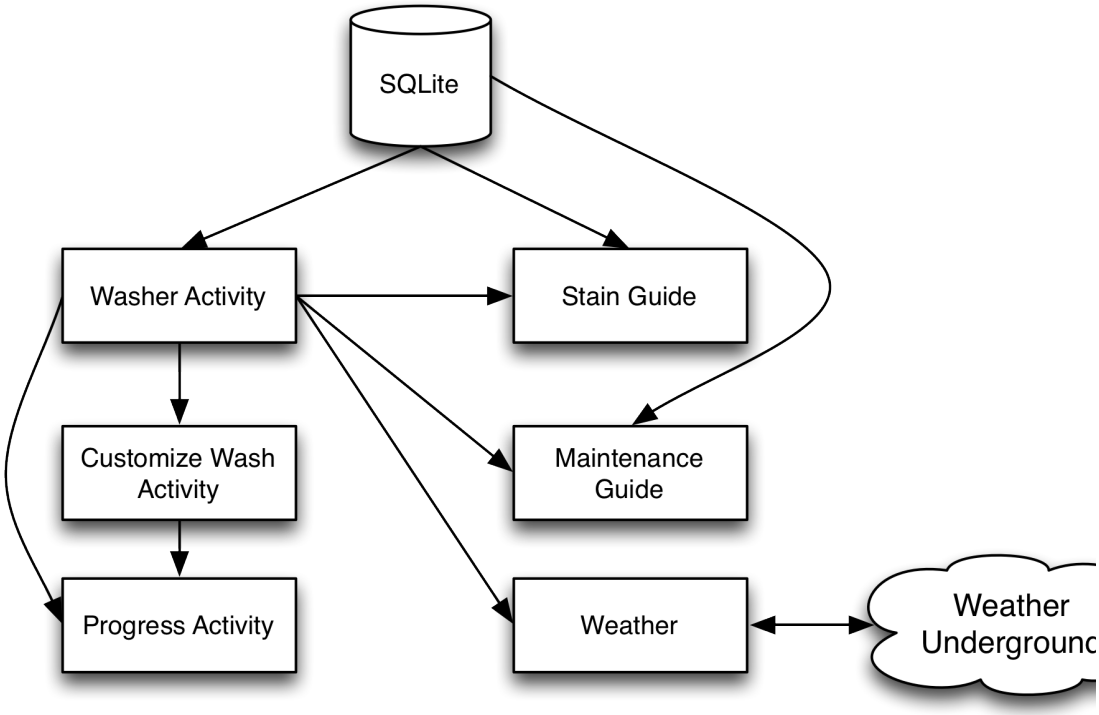


Washer Weather Screen



Sample Washer Help Screen

The architecture of the Washer application is as follows:



Washer Architecture Diagram

Risks

This project carried a number of risks. While not all risks would lead to the project's failure, some of them created time sinks which, if not properly managed, would lead to an incomplete project. The biggest risk this project had was its size and scope. We could have chosen more than two appliances, but then we ran the risk of poorly implementing each device. Another risk is lack of communication, since our advisor and client have very busy work schedules. While we were concerned about the consequences of poor communication, we were able to maintain good communication with both our advisor and client.

To keep the scope of the project manageable, our team relied on a number of external resources. However, we ran the risk of discontinued support for these libraries and APIs, or incompatibility of resources due to version updates. In our project, one of these risks came to fruition; support of the Google weather API we had been accessing to provide weather data was discontinued. We overcame this by shifting to WeatherUnderground's API. While an initial setback cost us some time to redevelop, we ended up with a richer weather module.

The industrial design team invested a number of hours in researching and designing mockups for the touch screen applications. In interpreting their designs, we ran the risk of our implementations falling short of their expectations. We mitigated this risk by consulting Dr. David Ringholz who provided his design insight for our project.

Testing Process

Once we had created the initial version of the prototypes, we designed a usability test process. With Dr. Ringholz's guidance, we first created a testing instrument for each application. These instruments, inspired by an industrial design practices, described tasks that each user would perform and denoted fields for data collection. The data we sought was both quantitative and qualitative. The quantitative data collected was the time to accomplish each task, number of false starts, and help guide usage. These data provided us with metrics we used to improve our programs. The qualitative data we collected focused on general feedback, layout opinions, and user frustration. We also created a testing script to make sure that each user was taken through the same testing process. After creating all of the test documents, we performed the tests with users from a variety of age groups and backgrounds. These test documents and their findings can be found in Usability Testing Results.

Summary

In the past two semesters, our senior design group gained experience with interdisciplinary collaboration, project planning and documentation, and design and implementation of a product. The design and implementation

of the HVAC and Washer prototypes went through the following cycle: Planning, Development, User Testing, and Revision. Initial collaboration with the industrial design teams provided us with ideas and market research used in planning our project. Once we reviewed the research, we decided to focus on the HVAC and Washer appliances. We then identified requirements and chose which features to implement. Development started with concept drawings, and progressed to crude prototypes with few features, to a testable user interface, finally we incorporated user-feedback to create a deliverable prototype.