

ECE 480 Design Team 2

AHEAD

Accessible Home Energy Audio Dashboard

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Design Issues

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Introduction

The AHEAD project is a home automation device that will provide a universally designed interface for consumers to be informed about power consumption and have the ability to control appliances from one module. Through a simulated smart meter and power line carrier signals the AHEAD module will accomplish its functionality. The underlying task of universal design is done mostly through software. Both aspects of the project have been taking design issues into account. The main issues considered were product life management, environmental issues, and universal design.

Product Life Management

Instead of merely focusing on short-term improvements and basic functionality, a successful company must take into account the entire lifespan of their products. Without taking heed of reliability issues and actual performance metrics, it is nearly impossible to maintain good standing in product reputation. With this in mind, it is crucial to back up the fundamental product design with sound product life management principles (PLM). Typically, product life management develops along through the following stages:

- Design
- Production
- Distribution
- Consumption
- End-of-Life

Unlike traditional product development, each step should feedback information to the other steps, streamlining cost and allowing more agile responses to design flaws.

One of the most compelling design features in our product with regards to PLM is the smart grid data link. Since it is tethered to a smart meter which communicates with a utility provider, there is a permanently established communication channel open to the device. By cooperating with the utility, the manufacturer can gather as much real-time performance data as needed, and can provide software upgrades with ease. This integral feature of our design allows us to extend the life of our product and have better control over unanticipated issues that may present themselves over time.

The production phase of this product should be similar to most advanced consumer electronics on the market. A key design issue with our prototype is the reliance on a high-level device (PC) to run the control functionality. This equates to unnecessary components and reliance on proprietary software. In future iterations, it would be desirable to develop a more pared-down embedded system, lowering the software cost and economizing the material use necessary for production. By simplifying both hardware and software, we can implement software/firmware that uses less CPU, and thus requires less power to run, and we can reduce the amount of components required, which makes production more reliable and potentially produces less e-waste. Less power combined with fewer industrial byproducts helps reduce the environmental footprint of the device, the primary goal of producing it in the first place.

The distribution of our device is most likely to be done through traditional retail supply chains. Since electricity usage in the US is essentially universal, anyone who purchases power from a utility is a potential customer. Our primary market is geared towards people with disabilities. In the US, there are approximately 32 million adults with disabilities, enough to justify mass production of this device. Furthermore the use of our device is not limited to just those with disabilities, widening the potential consumer base even more. In terms of cost, a production ready iteration of our prototype could be made smaller, which would allow overland shipping costs to decrease substantially per unit.

When a customer takes AHEAD into their home, they should be able to use it right out of the box with little prompting. The configuration menus are designed to be simple and “shallow”, allowing the user to view most of the customizable options very quickly. Assuming the customer is hooked up to the smart grid, the device should be able to communicate with the smart meter and receive alerts from the power company, as well as software updates from the manufacturer. Any software or hardware faults can be detected easily and reported through the communication channel. Since our team did not receive an actual smart meter to interface with our device, we could only simulate this very roughly. A key area of investigation in the future would be to figure out how the customer tethers their AHEAD device to their smart meter.

AHEAD's device control functionality currently depends on PLC (power line communication), provided by X10 modules. Since this is a widely used commercial standard, our product is able to control X10 devices right out of the box, and is thus already usable as a home automation device. With the X10, however, there are limitations on complex operations involving appliance settings, such as air conditioning or water heater temperature. In order to achieve this, a communication protocol between AHEAD and other appliances is needed. A possible candidate for this is the OpenHAN standard, which is currently under development. Paired with ZigBee, this standard would allow smart grid signals to facilitate appliance control given certain conditions, such as energy cost. Currently, such devices are simply not widely available, but once the national power grid becomes smart-meter enabled, they will more than likely become more common. Since our device already uses XBee transceivers which are capable of using the ZigBee communication stack, implementation of OpenHAN standards with ZigBee devices should prove to be very straightforward in the future.

End-of-life considerations for this device parallel those made with regards to personal computers. Upgrading software for both should be quite flexible. Having a communication link to the manufacturer allows this for AHEAD. Unlike the PC, however, increasing hardware requirements should not be as big of an issue, since the feature set of our device has a much more limited scope. Despite this, the hardware will eventually fail, and

replacement and disposal on some scale is inevitable. Since the components of AHEAD are quite similar to a PC, an e-waste disposal program similar to that of Dell would do much to alleviate the environmental impact, and be consistent with our product's overall mission: to promote environmentally friendly practices in the home.

Environmental Issues

Most of the nation's electricity is produced by coal-fired plants. The amount of carbon dioxide gas that is emitted from burning fossil fuels, especially coal, accounts for 75% of today's net emission of this gas. Moreover, coal produces double the amount of carbon dioxide that is produced by natural gas, and 33% more carbon dioxide than oil per watt. According to the latest data, the atmospheric concentration of carbon dioxide has increased from 280 parts per million to 381 parts per million in the last century. It is predicted that this concentration will double by around the middle of the next century, and will continue to increase. This will have negative effects on people's lives as it might cause diseases and death as well as increase in the temperature of earth and contribution to the global warming effect.

Our project, AHEAD, will provide the means for power utilities to manage the power that is being consumed by the customers' home appliances. Through power consumption information and alerts from the smart meter, our device will display the amount of power that is being consumed by the appliances and will have the ability to turn on/off pre-selected devices during peak and low demand periods. If our project is implemented in each home, the power that is being generated by the plants will be greatly reduced. As a result, a cleaner environment will be achieved.

Universal Design Principles

The Principles of Universal Design present guidelines for designing products or environments in a way that is usable by all, to the greatest extent possible. This means to allow different groups of people regardless of disabilities to be able to use the same device. The seven principles follow as: equitable use, flexibility in use, simple and intuitive to use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use. The AHEAD project takes all of these principles into account for the design, but focuses primarily on principle four; communicating perceptible information regardless of the user's sensory abilities.

In designing the project, the aim was to make the device accessible to people with diverse abilities. Universal design principles guided this project to make it a multisensory device, using sight, touch, and hearing for interaction and communication of important information. For instance, a user who cannot depend on sight to use the device must rely on other senses to interact effectively. The AHEAD device achieves this by using touch and hearing for user interaction through touch gestures and text to speech audio. A user does not need to know where on the dashboard a button or option is located but merely has to swipe a finger or some type of similar gesture and with the text-to-speech feature it will communicate to them where their current selection is. This provides equitable use in that you do not need to see the display to operate and it also has the added benefit of introducing a function that enhances the experience for all. Similarly, for someone who is hearing impaired, light emitting diodes (LED's) are used to catch the attention of the user without the need of periodically checking the display. A quick glance at the device from across a room can provide important information without having to read directly from the display. Finally, for someone with motoric disabilities the entire interface had to be designed around the ability to navigate and allow for complete functionality with only one button, commonly known as single-switch-scanning.

One aspect to improve the usability of the dashboard by all would be to incorporate speech recognition. With many of today's cell phones and electronic devices having this kind of technology, users no longer have to physically type information into a device. Being able to speak and have the device interpret the meaning expands on what can be done in only a few commands. This type of accessibility would benefit nearly all users helping to hone in the universal design.

Conclusion

The process of designing a new product will always present challenges that must be overcome if that product to be successful in the marketplace. The AHEAD module inevitably faced a few problems of its own. The first being product life management issues, where many different aspects of the project had to be considered to take this into account. Secondly, the environmental issues were considered. Lastly and most importantly, universal design principles were a main concern, and in the end governed a lot of how the project was designed. After everything was taken into consideration, the AHEAD device has overcome different design issues to become a very strong product marketplace.

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