

ECE 480 Design Team 2

AHEAD

Accessible Home Energy Audio Dashboard

Team members:

Ahmad Al-Qudaihi

Dennis Wey

Joey Grover

Jason Grimes

Facilitator: Fathi Salem

Sponsored By:



RCPD

*Maximizing
Ability & Opportunity*

**Final Proposal
February 19, 2010**

Executive Summary:

The demand of electricity is constantly at a growing rate. The overall demand can be brought down by giving consumers a way to be able to monitor the current cost of electricity. The informed consumer has been shown to limit their use of electronic devices when the cost of electricity rises due to peak demand. Team 2 purposes to make a device that would make it easy for consumers to be able to monitor the cost of electricity and to control their appliances from one device. The other component of the project will be to develop a device that addresses the needs of people with disabilities. Since most products that are new to the market do not include accessibility features, team 2 hopes to introduce their AHEAD device with the features that people with disabilities need and create a new standard in the product development process.

Table of Contents

1. Introduction	2
2. Background	2
2.1 The AHEAD Project	2
2.2 Consumers Energy	3
2.3 X10 Home Automation	3
2.4 Text To Speech	4
2.5 Wireless Communications and power consumption	4
3. Design Specifications	5
3.1 Managing Energy Consumption	5
3.2 Accessibility	6
3.3 Portability	6
3.4 Cost	6
3.5 Heat	6
3.6 Design Criteria Matrix	7
3.7 FAST Diagram	7
4. Conceptual Design	8
4.1 Netbook PC	8
4.2 Touch Screen	9
4.3 Microcontroller	9
4.4 Wireless I/O support	9
4.5 X10 Home Automation	9
5. Proposed Design Solution	10
6. Risk Analysis	11
7. Project Management Plan.....	11
8. Budget	12
9. References	13

1. Introduction

As the world becomes more energy efficient, personal responsibility to monitor energy consumption in the home becomes more important. Reducing our impact on the environment can be achieved by eliminating wasteful electricity practices, especially those of consumers. One benefit of implementing smart grids is the ability to assist electricity providers in regulating demand during peak hours. By controlling how much energy consumers use, power companies do not need to install new power plants to relieve stress on the current power grid. Also, the electricity provider needs to interact with consumers in a manner that is universal for all users including those with disabilities. An energy monitoring device that can be placed in a consumer's home needs to have accessibility features such that visual, hearing, and motoric impaired persons can operate.

2. Background

2.1 The AHEAD Project

The AHEAD project has not been worked on previously to this semester. The Ahead is a central, universally accessible device that receives and responds to smart meter signals to provide consumers with the ability to control in-home devices. The team is working from ideas and customer needs to a finished product. The team researched devices that essentially performed a similar task. The results provided several methods of implementation to address the need to control appliances in the home, but not many took into account the needs of those with disabilities. The AHEAD project will address these shortcomings and be its main focus.

2.2 Consumers Energy

A few of the team members went to the Consumers Energy Smart Home in Jackson, MI. The members observed how the new Smart Grid technology was able to function with appliances. The house demonstrated existing technologies with human machine interfaces for accessing the smart grid; however, all were lacking in accessibility options for people with disabilities.

Few of the appliances they had on display actually were smart grid ready. These devices could be controlled by the smart grid itself. However, the amount of appliances that are smart grid ready is very limited at this time.

2.3 X10 Home Automation

One of the options researched was a system that sent signals through existing power lines in a home. The modules only needed to connect to a wall outlet. Software could be used with the devices to control them from a computer, or a user could implement switches instead. These systems have been proven to function well at its basic job; however, for someone with disabilities it may be difficult to use. Also, it would be required to have computer access in the home, or the ability to install switches. The AHEAD module would be a stand alone system that could interact with the modules without having a separate computer or the need for other devices.

The interaction between the modules can be done through a transceiver that hooks up via universal serial bus. The transceiver then sends a radio signal to a receiver plugged into an outlet somewhere in the home. Through that communication, appliances within the home can be controlled with the addition of X10 modules.

2.4 Text To Speech

Text to Speech is the ability to turn text into an audible form. The options for text to speech are broken into hardware and software. After hearing some of the examples that the hardware modules would provide, it became obvious that software is a far better choice. This is an important part to the AHEAD project as it adds accessibility for the blind and also can give all users an added benefit.

2.5 Wireless Communications and power consumption

The user will not have to go through the pain of connecting wires or replacing the batteries every short period of time. Communication between the smart grid system components are currently set to be enabled via Zigbee wireless technology. A Zigbee network will remotely control and connect the user's appliances to the power utility for improving power efficiency and managing peak/low demand. There are many advantages and disadvantages of using Zigbee over other standard wireless technologies such as Bluetooth and Wi-Fi. It has the following characteristics:

- A Zigbee device consumes much less power compared to the other wireless technologies. In fact, if it is a battery powered device, the batteries last for months to years.
- When in sleep mode, a Zigbee device draws a very small amount of current. Also, in this mode the device will not lose its association with the network.
- Easy implantation.
- Low data rate.
- Support of up to 65,000 nodes connected to the network.
- Low cost.
- Small packet usage.
- Automatic establishment of the network.
- High Security.

Below is a brief comparison of Zigbee with other popular wireless standards:

	Wi-Fi	Bluetooth	Zigbee
Battery life (days)	.1-5	1-7	100-7,000
Nodes per network	30	7	65,000
Data rate	2-100 Mbps	1 Mbps	20-250 Kbps
Range (meters)	1-100	1-10	1-75
Standby current	20 mA	200 μ A	3 μ A

Table 1. Zigbee vs Wi-Fi vs Bluetooth

3. Design Specifications

It is important to consider the following specifications when we design AHEAD:

3.1 Managing Energy Consumption

Our device will receive and interpret power consumption information from a simulated smart meter, which is controlled and monitored by the power utility. The device will display this data as a readable text on its screen. This information could include the amount of power that is consumed by the user's appliances in the unit of kilowatts per hour or if the user prefers, the current cost of that power in the unit of dollars per hour and the estimated bill. Moreover, the device can be set up to automatically or manually. When one of the automatic modes are activated then the AHEAD device will turn off pre-selected appliances that consume most of the power (such as the air conditioner and the water heater) during peak demand periods and turn them on during low demand periods. However, if the user wanted these devices on they would be able to do so through manual overrides. Power consumption of the device itself also needs to be kept low so it does not cancel out the benefits of the appliance control power savings.

3.2 Accessibility

The most critical aspect of this design and the primary purpose of our device is to provide easy accessibility to people with disabilities. Our device will provide several methods to achieve this purpose. For people with visual disabilities, the device will have an option of converting what is being displayed on the screen into a voice output via text-to-speech software. These people can have access to the control features of this device through the multi-touch screen. There will be a built in flashing LED that will notify the people with hearing disabilities of the status. This device could also be accessible to people with motoric disabilities through an optional sip and puff system.

3.3 Portability

Technically, the device will be mounted to the wall, but the relatively small size and light weight will allow it to be portable. To make this feature more feasible, the device could be powered using batteries.

3.4 Cost

The device will be affordable considering the built in features and parts. Table 3.1 shows the rankings of the above parameters based on their importance to the customer.

3.5 Heat

In order to ensure stable operation, heat created by the device must be monitored and controlled.

3.6 Design Criteria Matrix

Parameter	Importance
Information from the utility company	6
Automatic Control	5
Accessibility	7 (most important)
Cost	4
Portability	1 (least important)
Power Consumption	3
Heat	2

Table 3.1 Design Criteria Matrix

3.7 FAST Diagram

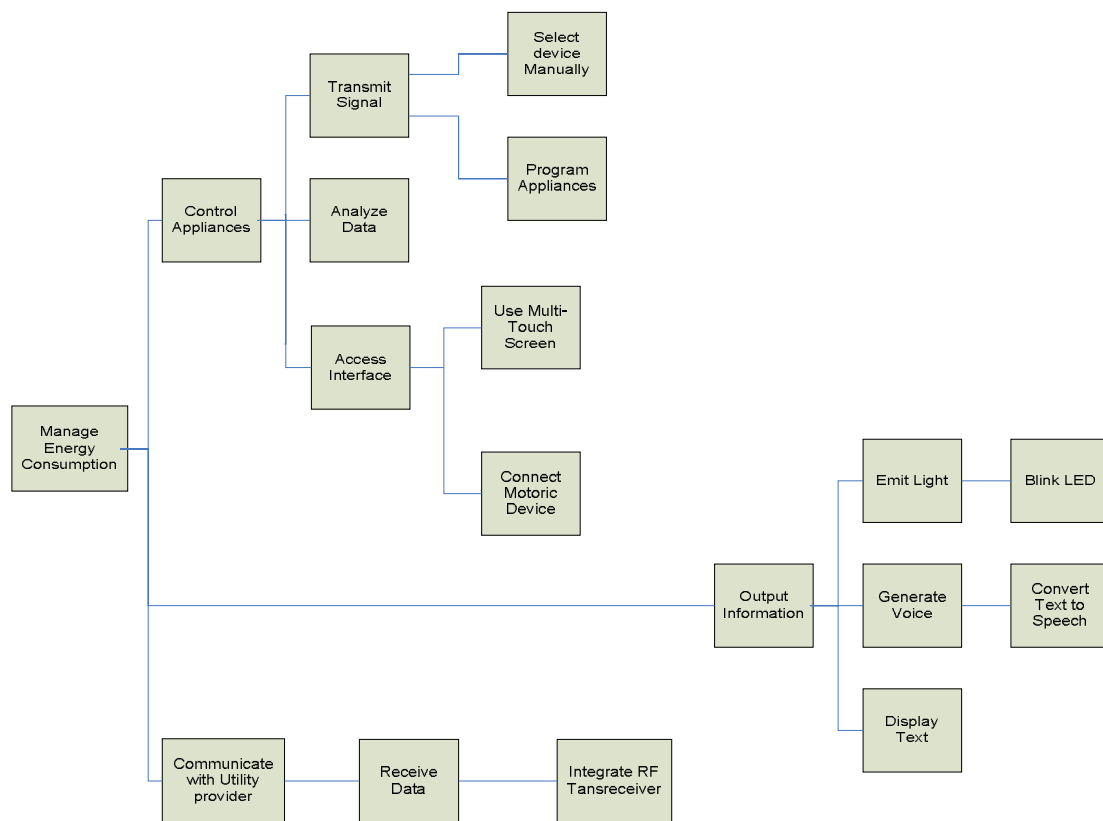


Figure 3.1 FAST Diagram

4. Conceptual Design Description

Design Criteria	Weight	CPU		Tactile Interface		Wireless Communication		LED		Accessibility Input Device		Audio Playback	
		Embedded System Board	PC	Touch Pad	Touch Screen	Zigbee	RF Module (Stand Alone)	w/o LED	w/ LED	w/o Input	w/ Input	IC	Software
Communication with Utility Company	5	3	3	5	5	5	4	2	4	1	2	2	3
Accessibility	5	2	2	3	5	1	1	3	4	2	5	4	5
Automatic Control	4	5	5	2	2	3	3	1	1	2	2	1	1
Cost	3	4	5	3	2	2	5	1	1	3	3	3	2
Portability	2	4	4	3	3	4	4	5	5	2	2	1	1
Heat	1	4	5	4	4	3	3	5	5	1	1	2	2
Power Consumption	2	3	3	3	4	4	4	5	5	3	2	2	2
Score		75	79	73	82	67	71	57	72	43	61	51	58

Table 4.1 Decision Matrix

4.1 Netbook PC

The netbook PC will run an operating system and serve as a platform for a high-level programming language, such as Visual Basic. This simplifies the programming of the graphical user interface for the touch screen. This will also control the audio feedback required for visually-impaired users to interact with this device. The netbook will be incorporated into the product itself.

4.2 Touch Screen

The touch screen will act as the main input method for our device as well as displaying real-time data from the smart meter. The touch screen will enable users to interact with notifications from the power company and configure the power-saving settings of appliances around the home.

4.3 Microcontroller

The microcontroller will serve to control LEDs. It will receive data from the PC and convert into a series of on/offs to visually display a code that gives intuitive visual feedback to the user. Additionally, hardware switches on the device will be fed into the microcontroller in order to toggle accessibility features on or off.

4.4 Wireless I/O support

The device will be able to receive data coming from our simulated smart meter to display power consumption data. The device will also be capable of sending data to Zigbee receivers connected to household appliances in order to control power usage. Also, radio frequency signals will be used for appliances communication.

4.5 X10 Home Automation

Appliances connected to X10-compatible receivers will be able to receive commands from the device in order to enact power saving policies as defined by the user. This will enable appliances that aren't Smart Grid ready to be able to still be controlled by the user.

5. Proposed Design Solution

A personal computer will serve as the platform to run the required software. This also makes programming the user interface simpler when using Microsoft Visual Basic. A netbook will be ordered from the internet. To help with budget issues a refurbished Asus model will be purchased. A touch screen overlay will provide the touch screen interface, made by Hoda, will also be ordered from the internet. The X10 modules that are needed for the AHEAD device will be ordered from the internet as well, however, a receiver and transceiver were donated to the project from the Resource Center for People with Disabilities at MSU. The entire system will be packaged into an enclosure. Figure 4.1 shows how the system will be connected to all of its components.

Testing and simulation will be done with a simulated program being sent to the device giving price and usage. Success of the project will be determined on how well the device can be operated by someone with a physical handicap.

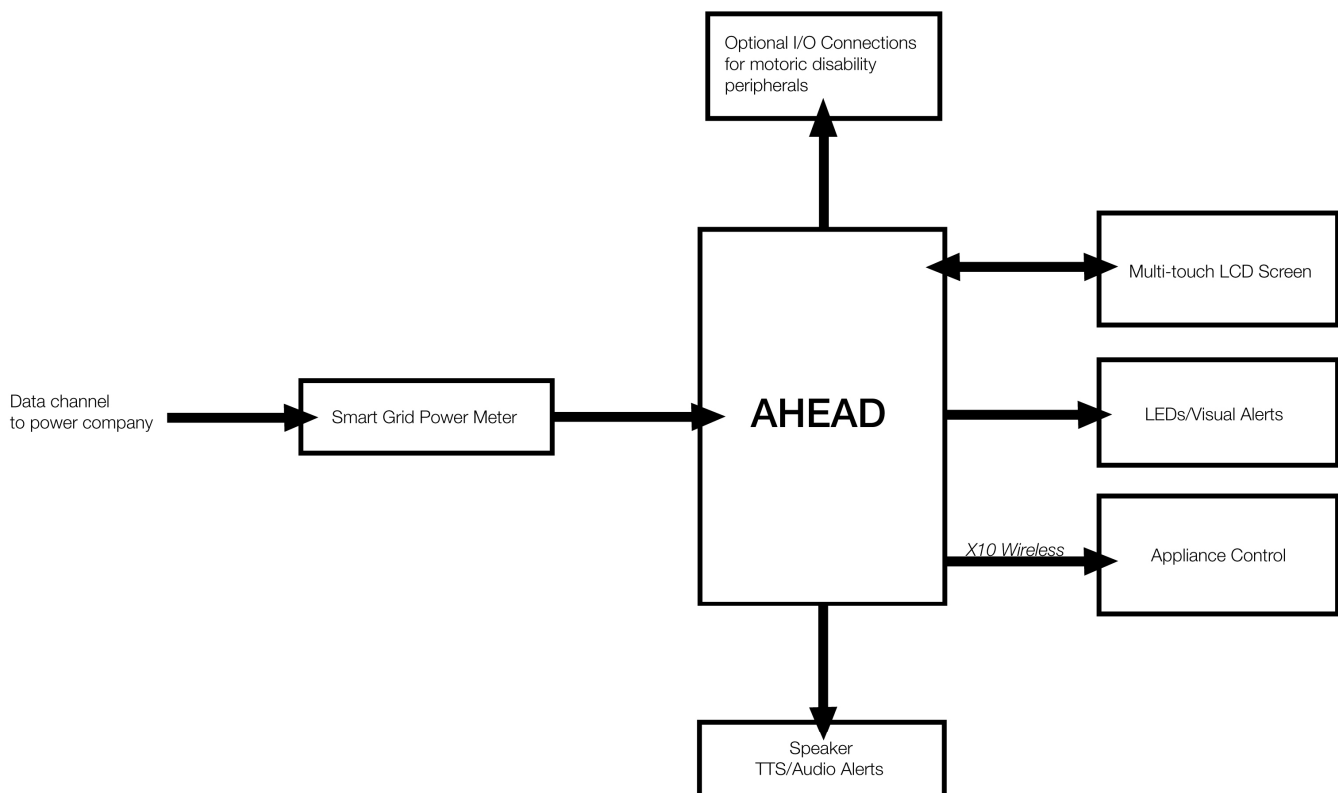


Figure 4.1 Block diagram of conceptual design

6. Risk Analysis

One of the main risks of this project is to balance functionality with robustness and cost. This device is meant to streamline energy-saving/cost-saving policies regarding power consumption, and if the device is too expensive or consumes too much power by itself there would be little point in using it in the first place. Likewise, making sure the accessibility features included are actually effective and allow users with disabilities to easily interact with device is a key concern. Additionally, the touch screen component and Zigbee transceivers are relatively expensive and harder to obtain than most of the other components of this project. Any faults with these parts would put a large strain on our budget and jeopardize the project.

7. Project Management Plan

7.1 Technical Roles and Balanced Division

Ahmad Al-Qudaihi

Appliance Wireless Communication & Microcontroller Applications - Management

Ahmad is in charge of researching and developing the wireless communication between the AHEAD device and the appliances that are to be controlled. This will involve both hardware and software implementations. Ahmad will also develop microcontroller based applications, such as LED notifications and temperature control.

Dennis Wey

Touch Screen Implementation- Website

Dennis Wey is responsible for making the main interface part of the project. Through a screen overlay, Dennis will provide the AHEAD device with a touch-screen interface. Dennis will give support to the text to speech and software portions of the project. In addition, he will also be adding the hardware for audio output support to the device.

Joey Grover

Text to Speech and Software - Document Preparation

Joey Grover is the only computer engineer so it is his responsibility to oversee most of the programming that will be involved in the project. Joey's main focus will be to give the AHEAD device the ability to relay messages through the audio system. This will be done through text-to-speech software either developed or purchased if the right package is available. Joey will also be support to the touch screen and microcontrollers.

Jason Grimes

Smart Meter Wireless Communication - Presentation Organization

Jason Grimes will be head of the wireless communication between the smart meter and the AHEAD device. In lieu of an actual Zigbee enabled smart meter, incoming information from the utility company will be simulated, using measurements from a wattmeter and preprogrammed rate information. Jason will ensure that the AHEAD device sends data messages in a manner as consistent as possible with current smart meters standards.

8. Budget

Part	Cost
Netbook PC	\$220
Touch Screen Overlay	\$85
X10 USB Module	\$10
X10 Receivers(4)	\$80
Microcontroller	\$0
Packaging	\$30
RF Modules	\$60
Watt-meter	\$20
Total:	\$505

9. References

Elahi, Ata and Adam Gschwender. *ZigBee wireless sensor and control network*. Upper Saddle River, NJ : Prentice Hall, 2009.

"TEXAS INSTRUMENTS - CC2430ZDK - CC2430 ZigBee Development Kit." Newark. 2008. 17 Feb. 2010. <<http://www.newark.com/jsp/search/productdetail.jsp?SKU=36M3768&CMP=AFC-GB100000001>>.

"Department of Energy - Smart Grid." United States Department of Energy. 2006. United States Government. 1 Feb. 2010. <<http://www.oe.energy.gov/smartgrid.htm>>.

"GE Energy Services; GE Smart Grid Technologies Build Sustainable 21st Century Cities." *Energy & Ecology* 26 Feb. 2010: Sciences Module, ProQuest. Web. 18 Feb. 2010.

Farkas, Suzanne. "Access by design: interview with Pam Cluff, FRAIC, FRIBA, OAA, pioneer in the movement for accessibility by design." *WE International*. 1 Jan. 1999: Research Library Core, ProQuest. Web. 24 Jan. 2010.

Rigg, Sarah A. "AMI technology a foundation of smart grid, helps consumers cut bills" Mlive.com. 2009 17 Feb 2010. <http://www.mlive.com/business/ann-arbor/index.ssf/2009/03/ami_technology_a_foundation_of.html>