ECE 480 Team 3
Final Design Proposal

Home Automation Control Panel

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Executive Summary:

Home automation system is an emerging trend that will soon become standard in all modern houses. In order to help Texas Instruments anticipate and take advantage of this trend, our team is going to design a sophisticated but yet very intuitive and low-cost home automation control panel system based on Texas Instruments' latest OMAP3 processor. We are going to create an interactive user interface that will allow our users to obtain and utilize real-time information collected from different devices in their house. We aim to make the interface look very presentable, aesthetic and efficient. Our design will be expandable and capable of handling different frequently used household devices such as a video door bell and a climate control system. This will all be done on a low-cost Beagle Board, which incorporates the TI OMAP3530 processor. With the help of software-hardware interfacing devices, all these various electronic modules will be working on the control panel concurrently. In addition, our system will automate the control process by applying an input-driven feedback system. For example, devices such as climate control will be controlled by our system automatically, based on current temperature in the house. All the information one needs to see and manipulate in the household can be done with just the touch of a button.

Our system will demonstrate the TI OMAP3 processor's capabilities as a potential industry leader in the field of home automation due to its low cost and high performance.

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Introduction:

An emerging trend in modern households is to have a sophisticated centralized control panel to manage all frequently used electronic modules within the house, such as climate control, security system, and lighting. While such control panels aren't a commonplace yet, they may become customary in the near future. Texas Instruments has commissioned us to develop a demonstration to show that their OMAP3 series processors are a capable, fast and cost-effective platform on which one could run such highly integrated control panels. This demonstration will allow the end users to manipulate a fully interactive display which gives information on the household's status, controls devices such as a programmable feedback driven thermostat and even uses a video camera to monitor a visitor at the front door.

Objective:

Our primary objective for this project is to implement a powerful, aesthetic and user friendly interface that gives the user complete freedom to explore various functionalities provided by Texas Instruments' OMAP3 series processor. In order to do this, we will be developing our product on a platform called the Beagle Board. With the great expandability and versatility of the Beagle Board and OMAP3 processor, we will be able to interface many external devices and create a system that is capable of collecting, processing, displaying, and controlling all of the information at your fingertips just with a touch of a button.

FAST Diagram:

F-A-S-T (Function Analysis System Technique) Diagram is a diagram that we use to identify some basic functions that our system will contain.

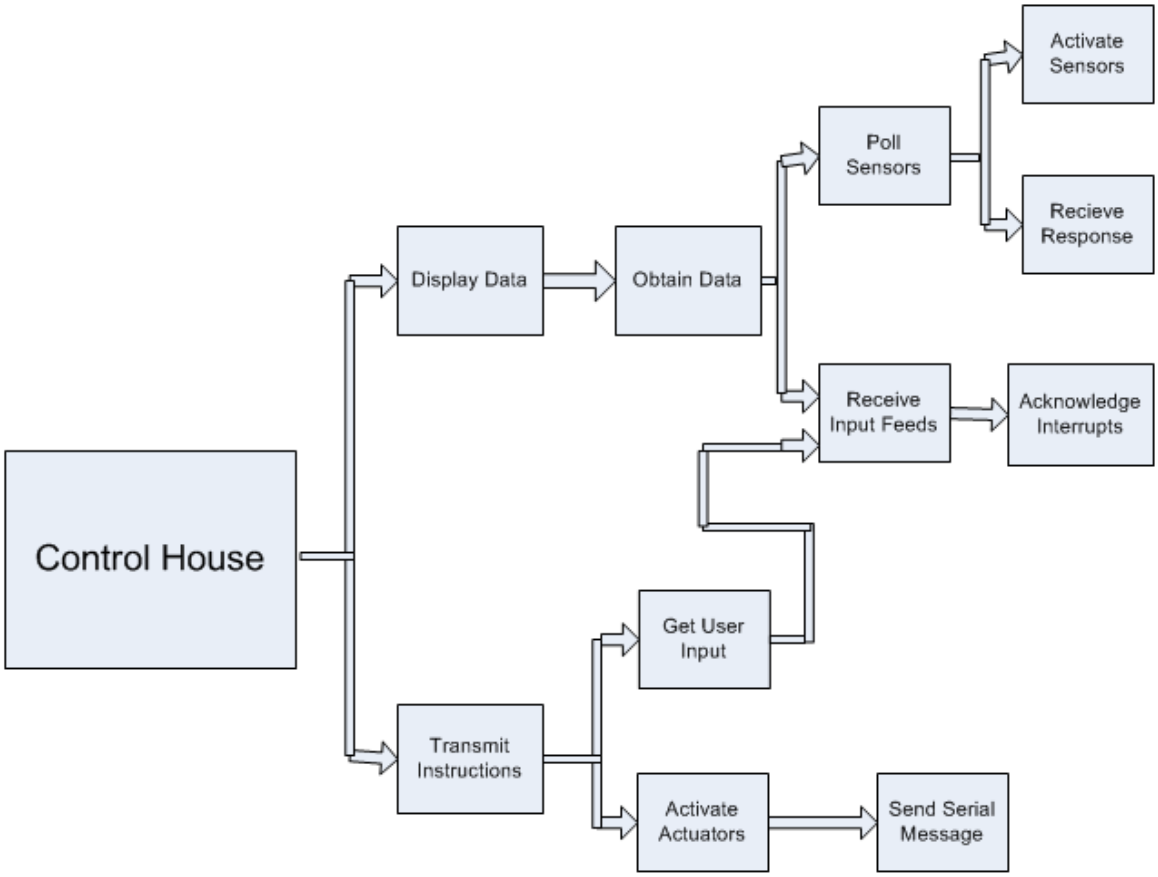

Figure 1: F-A-S-T Diagram

Conceptual Designs:

There is a vast array of devices we could connect to our system, some more important than others. These devices include:

Touchscreen:

This would allow users to interact with the panel with only a single input/output peripheral, rather than using a mouse.

Standard DVI Monitor:

Cheaper than a touchscreen, this output device easily displays menus and data.

Mouse:

A commonplace input device, a mouse would allow users to click on buttons and sliders.

Keyboard:

This input device would allow us to expand the possible uses of the control panel by allowing the user to enter text and numbers.

SD Memory Card:

SD cards are mass storage devices, which would allow the user to store media such as pictures, videos, and music. SD memory is available up to a maximum capacity of 32GB.

Stereo Speakers:

We could use speakers to provide audio feedback to the user, like adding sound effects to button presses, alerting the user to errors, or even warning the user of a dangerous weather condition.

Lighting Demo:

This would represent the user's household lights, which would be turned on or off using the control panel. We would have to design an external power system, as the Beagle Board can't supply enough power to turn on a large lightbulb.

Security Demo:

This would represent a basic home security system, also controllable with the control panel. The hardware would consist of one or more motion sensors attached to the board through a USB hub. When the system is armed, and a motion sensor is tripped, the alarm would go off.

Climate Control Demo:

This system consists of a digital thermometer, and a fan. The thermometer takes the home temperature and compares it with the user's setting of where it should be. If heating or cooling is needed, the fan turns on.

Weather Band Radio Receiver:

Using the National Weather Service's radio broadcast network, we can pick up local weather information using a basic radio receiver and a signal decoder. We can then display this local forecast to the user.

Video Doorbell:

By connecting a USB camera, we can allow the user to monitor someone at the front door without having to open the door. This camera could be always on, activated by a doorbell use, or activated with a motion sensor. The video could also be captured and stored on the SD card.

Wi-Fi Adapter:

A Wi-Fi adapter would allow the system to connect to the internet. We could then allow the user to browse the internet or even use it as an alternate source for weather information.

Conceptual Design Rankings:

I/O Devices:

	Easy to use	Intuitive	Portability	Feasibility	Compatibility	Performance Improvement	Score
Importance	5	2	4	1	6	3	
Touchscreen	4	6	6	1	1	5	78
DVI Monitor	5	5	3	4	3	3	78
Mouse	6	4	2	5	4	2	81
Keyboard	2	2	1	3	2	1	36
SD Card	1	1	5	6	6	6	87
Speakers	3	3	4	2	5	4	81

Figure 2: Input/Output Device Design Rankings

Home System Demos:

	Sponsor Importance	Ease of Implementation	Processor Overhead	Memory Requirement	Usefulness	User Appeal	Cost of Devices	Score
Importance	5	1	4	3	7	6	2	
Lighting	2	1	5	6	4	2	4	97
Security	3	3	6	4	2	5	3	104
Climate Control	4	6	4	5	1	1	6	82
Weather	5	4	3	3	5	3	1	105
Video	6	5	2	1	6	6	2	128
Wi-Fi	1	2	1	2	3	4	5	72

Figure 3: Sub-Systems Design Ranking

Suggested Solution:

We envision that the system will be used as a platform to organize and utilize information gathered from the aforementioned devices. The challenge in this project is that we have to mainly involve collecting and presenting this information to the user. In order to manage all the communications with the peripheral devices and interact effectively with the user, we are going to use the Beagle Board. This board features a Texas Instrument OMAP 3530 microprocessor, on-board memory, and several input/output ports to which we will connect our peripheral devices.

Information Collection

In order to collect useful information, we will need to interface different external devices with the Beagle Board. To configure the hardware and make it work on Beagle Board will be a real challenge due to lack of support from most hardware vendors. As our time is confined, we will expect Texas Instruments to provide us with most of these external devices with supporting driver. Our task will be to utilize these devices to collect data, decode the information we get, and present it to user in a way they can easily understand and manage.

Information Display

The information we get will be wrapped into a Graphical User Interface (GUI) that we will need to design with the help of graphical icons and visual indicators. The display will provide basic controls, such as buttons, tabs, and sliders, which will allow the user to manipulate commands in order to change the state of the control panel, activate household features, and request for more information. The OMAP3 processor will then retrieve that information from the appropriate external device and display them to the user in an organized and conceivable manner.

We will use a two phase approach to design and implement the project. The break down of our tasks is as follows:

Design Phase 1:

In this phase we make sure that the information that is gathered is decoded and displayed in an extremely presentable and organized appearance.

GUI Design:

The GUI (Graphical User Interface) design is one of our most important priorities. Since appearance is the first thing that attracts a customer to any product, we aim on designing an interface that is both easy to use and looks impressive to potential customers.

Install Operating System:

Having a correctly configured, flexible and usable operating system on the Beagle Board is the starting point for this project. We decided to install Angstrom Linux after careful review and comparison of its functionalities and cost with other embedded operating systems.

Configure development environment:

We need to set up an easy-to-use and efficient developing environment for the project. Excellent Java IDEs like Eclipse from IBM and Netbeans from Sun Microsystem are our potential choices. A version control system like CVS or SVN will also help us manage and organize our code and ensure timely delivery of project.

Initial GUI layout:

This will provide the pictorial view of how and what kinds of data will be displayed on the screen for every application that we build for our demo.

Implementation of GUI:

After we gather all the GUI design specifications and the GUI layout, we will implement the GUI design using the Java programming language. Java will allow us to both design the user interface to our specifications and specify how the user interface will respond to user commands. This will truly make the applications interactive and get things working.

Design Phase 2:

This phase deals with installing the video device and manipulating various feedback driven modules using relay switches and motion sensors.

Interface the video device:

Texas Instruments will provide us with the drivers to interact with the video camera. Our goal is to figure out a way to display and control the video captured by the camera and display it within a GUI element created using Java.

Incorporate the video into GUI:

Upon successful completion of embedding video into GUI element. We will integrate that application into our design. If time permits, we would even try and activate the camera automatically when it detects any motion.

Decode the weather band:

We will be able to receive the National Weather Band's radio frequency using a radio receiver. Then, with the help of Si4707 chip, developed by Silicon Labs, we can decode the signal's tones into usable and understandable information, which we can then transmit to the display.

Incorporate weather information:

Displaying weather information is an important feature of our demo. After gathering weather information from the National Weather Band, we will format the information in the way that fits in with the rest of the GUI.

Add Demonstrative HVAC system:

We want to demonstrate the functionality of our climate control system, so we will connect a USB fan that will turn on whenever heating or cooling is needed in the home.

Design Specification:

As mentioned before, our central platform for handling the software and external devices is the Beagle Board. In order to get all of our software to run, we will install Angstrom Linux with Kernel version 2.6.28 and Java Virtual Machine to handle the operating system and GUI interface roles of the control panel. Using the Java Virtual Machine, we will design and implement our user interface and program the various devices we will connect to the Beagle Board. These devices include the video doorbell, a radio receiver/decoder to receive weather data from the National Weather Service, and a thermostat system.

The control panel will feature a monitor, which allows us to display information to the user, and a computer mouse, which will provide an intuitive input mechanism. If time permits, we will port the mouse-based input mechanism to a touchscreen-based input system. In addition, we will add a stereo speaker system, which will allow the option of adding sound effects.

Risk Analysis:

Touchscreen Support: Our initial development stage involves the GUI display and control on a monitor screen. We have to make sure that as soon as the GUI design is finalized, conversion from monitor screen to touch screen is accomplished without any complications. Unfortunately, restrictions and complications during this transition are inevitable.

Weather Band Receiver: Synchronization with the Beagle Board on Angstrom Linux is a big challenge. Silicon Labs provides C8051F321 microcontroller to form a USB radio using Si470x products. The current driver for this product is Linux kernel version 2.6, which is same as Angstrom Linux. However, the chance of incompatibility with Angstrom Linux may exist.

Video Camera: We assume that the video camera that we are going to use for the security system will be provided by TI. We also anticipate that the hardware driver for our Beagle Board will be shipped with the camera. Our task is to embed the video output into our GUI.

Java Virtual Machine: The Java Virtual Machine that we are going to use in this project is JamVM. JamVM is a compact and open source implementation of Sun Microsystem's Java Runtime Environment. It is designed to use GNU Classpath Java class library. Due to incomplete compatibility of the GNU Classpath, there might be some function calls that we intend to use that won't be fully supported by JamVM.

	Conform to Specification	Cost	Crucial to Project	Difficulty	Alternative
Touch Screen	**Low**	**High**	**Medium:** We can use Keyboard and Mouse instead.	**High:** Depend on weather driver will be provided by the vendor.	Mouse and Keyboard
Weather Band Receiver	**High**	**Medium**	**Medium**	**High**	Get weather information from Internet
Video Camera	**High**	**Low:** Will be provide by TI	**High**	**Medium**	None
JamVM	**High**	**Low:** Freely available online.	**High:** Foundation to our software implementation	**Low**	Cacao, OpenJDK

Project Management Plan:

To ensure our project stays organized and well on track, we decided on using different tools to manage and control our work. We created a Gantt chart(See Appendix) to lay out time-line for all development stages that we can anticipate. To make sure we have a fully working code at any point of time we decided to use SVN, an open source Version Control System, to manage our code.

Individual Technical Assignment:

Rituraj Behera: - Presentation Preparation

Rituraj will work together with Sam on the GUI design and implementation using the java programming language. Also, he will develop code with the C programming language for the system level calls. So, mostly, he will deal with software development and testing.

Samuel Flynn: - Management

Sam Flynn will be heavily involved with the GUI design. He will start by working closely with the other team members to establish a conceptual design, with a general idea of where the controls should fit together. Once the conceptual design is established, he will be in charge of developing the graphics that will be placed over the Java template icons, placing them correctly using Java, and ensuring that no graphics overlap or conflict with each other.

Da Ke: - Webmaster

Da Ke will be working on installing and configuring the operating system on the Beagle Board. After successful setup of the operating system, he will work with Sam and other team members to make a general layout of the GUI and create a initial prototype of the GUI. He will also be involved in implementation of the GUI. He will interface different control components on the GUI with actual function calls. He will do a extensive testing on each milestone release of the software.

Sungsoo Kim: - Lab Coordinator

Sungsoo will do research on hardware devices that are needed for the project. He is also in charge of purchase these devices. He will be mainly focus on researching about communication between the Beagle Board and other external devices. He will conduct hardware testing to ensure they are working properly. He will also work on GUI implementation using Java.

Eric Myers: - Document Preparation

Eric will be in charge of designing control circuits for the household device demonstrations. He will work with Sungsoo to research the communication protocols and design the proper analysis hardware to convert the signals into ones the Beagle Board can use. He will also work with Rituaj and Da to then configure the Java code to properly request, receive, and handle information from these devices.

Budget:

Beagle Board	$ 149.00
SD Card (8G)	$ 14.59
SD Card Reader	$ 7.99
USB 2.0 3-Port Hub with Ethernet Adapter	$ 40.99
USB to 5.5mm Barrel Jack Adapter	$ 2.95
Acrylic Case for Beagle rev B5	$ 29.00
Monitor Cable(HDMI A to DVI-D)	$ 8.00
USB Std-A-Female to mini-A-Male Adapter	$ 9.00
DB9M to 1DC10F AT/Everex Serial Adapter	$ 2.00
DVI-D 7" Touch Screen Monitor	$ 399.00
Total	**$ 662.52**

Conclusion:

In order to stay ahead of this emerging trend of home automation, we need to develop a prototype that will establish the OMAP3 series processor as an optimal platform for a control panel. We will develop a full GUI and configure a subset of representative peripherals to demonstrate the processor's capabilities as a potential industry leader in the field of home automation.

Reference:

BeagleBoard.org
Information and support on the features and operation of the Beagle Board
<http://www.beagleboard.org>

Beagle Board Shopping List - Google Code
List of items needed to configure and run the Beagle Board
<http://code.google.com/p/beagleboard/wiki/BeagleBoardShoppingList>

CVS (Concurrent Version System)
<http://www.nongnu.org/cvs/ >

Angstrom Linux operating system
More info on Angstrom Linux
<www.angstrom-distribution.org/>

Eclipse IDE
<http://www.eclipse.org/ >

Netbeans IDE
<http://www.netbeans.org/ >

SVN
<http://subversion.tigris.org/ >

SI474X Weather Band Receiver Linux Driver Information:

<http://ftp.gnu.org/tmp/linux-libre-fsf2_2.6.28/linux-2.6.28/Documentation/video4linux/si470x.txt>