

# CprE 388 Embedded Android Labs

Design Document - May 15-20

Final Version

Angela Borgman, Ben Turbes, Alex Jensen, Ryan Dincher

## **Index**

1. Project Definition
2. Goals
3. Deliverables
4. System Level Design
  - a. System Components
  - b. System Requirements
  - c. System Analysis
5. Functional Decomposition
6. Detailed Descriptions
  - a. Hardware Specifications
  - b. Software Specifications
  - c. Lab Specifications
  - d. Implementation Problems
  - e. Testing

# Project Definition

This project was designed to add embedded systems programming to the CprE 388 Android Programming class. As the class currently stands, there is only one lab that uses hardware and it does not require students to do any programming directly to or from this hardware. Our goal was to find hardware that would work well with the Arduino to create interactive and exciting labs for students to use.

## Goals

1. Develop a setup design that can be easily replicated so that it can be setup at every lab station.
2. Develop labs that will be difficult enough to be beneficial, but will not take more than 2-4 hours.
3. The labs created will be interesting and show a practical need for this type of programming.
4. We use hardware that is interesting to students and will be flexible enough that there is room for several labs to be done.

## Deliverables

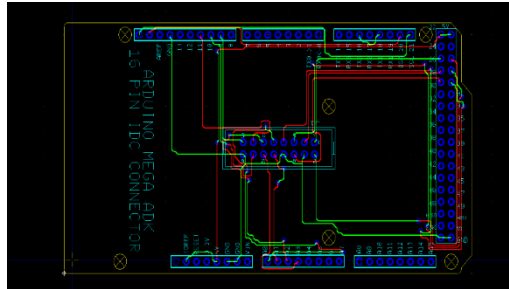
1. A lab setup that can be easily replicated
  - 1.1. Arduino Mega ADK and LED board are simple to replace or get more.
  - 1.2. A setup guide that can be used by either CSG or students to install all necessary software and drivers.
  - 1.3. Shield for the Arduino Mega ADK that will allow simple connection between Arduino and LED board.
2. Labs designed for the appropriate amount of time using the Nexus 7 tablet and extra hardware
  - 2.1. Labs will take 2 to 4 hours to complete.
  - 2.2. Must use both external hardware and the Nexus 7 tablet
  - 2.3. Labs will challenge students each week with new material and clear learning objectives.
  - 2.4. Lab write-ups should be clear, easy to follow and give students a clear understanding of what they are required to do.

## System Level Design

### System Components

1. Nexus 7 Tablet

- 1.1. Used for all the UI controlling
- 1.2. Sends signals to the Arduino in order to power correct pins for lighting up specific pieces of the LED board.
2. Arduino Board
  - 2.1. Connected to the Nexus 7 using USB to MicroUSB
  - 2.2. Connected to LED board using a PCB shield
    - 2.2.1. Shield Design



- 2.3. Controls signals to LED board and other hardware
3. LED Board
  - 3.1. Receives signals from the Arduino board in order to light up correct LEDs with correct colors
4. Foscam Wireless IP Camera
  - 4.1. Allows multiple students to connect at once and view video stream
  - 4.2. Moves on a motorized base so students can control it using the Nexus 7 tablet.

## System Requirements

- Functional Requirements
  - Labs must help the student to learn concepts related to embedded systems
  - Must use external hardware in some form
  - Should require students to learn and use new concepts
- Non-Functional Requirements
  - Labs are fun and interesting
  - Labs are relatable to real world problems
  - Will take approximately 2-4 hours on average to complete
  - Setup for labs must be easy to replicate with provided setup guide.

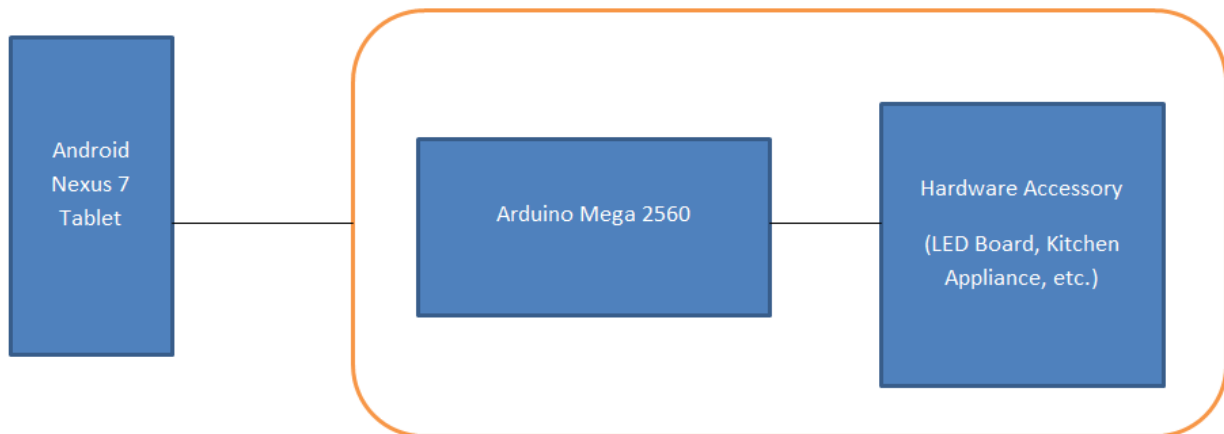
## System Analysis

1. Scope Definition
  - 1.1. LED Board is used to aid in the viewing of lab results for the various labs created. Some viewing of results is also done on the Nexus 7 tablet.
  - 1.2. The Arduino and Nexus provide a way to examine different aspects of embedded systems

- 1.3. The Goals for the System are that it helps students to learn more about embedded components and smart devices
2. Problem Analysis
  - 2.1. First challenge was establishing communication between the Nexus 7 tablet and the Arduino board. This was done by creating a simple application that would blink an LED on the Arduino.
  - 2.2. Connecting the LED board to the Arduino required a ribbon cable to be cut and then each wire connected to the correct pin. This was something that would not work in a lab situation so a shield was created.
  - 2.3. Choosing labs that could be developed to meet all of our requirements was a big challenge that we encountered. This was solved by brainstorming ideas that would be interesting to us as students and researching hardware that could be used.
3. Decision Analysis
  - 3.1. Other boards considered
    - 3.1.1 Green Bean board by GE
    - 3.1.2 Google ADK board
    - 3.1.3 Arduino Mega ADK – this board was chosen because of the large community and the wide range of possible hardware that could be connected.
  - 3.2. External Hardware
    - 3.2.1 LED board – provides good resources for communication with Arduino boards.
    - 3.2.2 Foscam Wireless IP Camera – needed to be portable, low energy draw, and connect to the internet

## Functional Decomposition

In labs, students will be creating Android USB accessories using the Arduino Mega 2560 board as a controller for various additional hardware components. The LED board is one such component. The Arduino board and the LED board will together be an Android USB accessory. When connected via USB, the Android device will launch the students' app on the device, allowing data to be read to/from the accessory controlled by the arduino.



## Detailed Design

Since CprE 388 is a hybrid of implementing software into hardware for specific applications, the following specifications for the hardware and software will be utilized per person in a lab:

### Hardware Specifications

1. A computer with:
  - a. Windows, Mac, or Linux
  - b. A USB port
    - i. To communicate with the Arduino device
2. Arduino Mega 2560
  - a. Device to interface with the LED board and receive commands from Nexus 7
  - b. Communicates with Nexus 7 and any additional hardware via USB
  - c. Must have a shield for easy connection to the LED board.
3. Nexus 7
  - a. To be programmed by students to talk to the Arduino for the various labs
  - b. Will communicate with the arduino via USB
4. RGB LED Panel - 32x32 (COM-12584)
  - a. A great visual device for learning as students can see the commands they send with a Nexus 7 to an Arduino for any sort of project they may encounter
5. Power Supply
  - a. Needs to run between 3.3-5vdc @ up to 2.5 amps to power the LED panel
  - b. Created these using a Hard Disk external power supply that can be soldered to the power cord that comes with the LED board. This is a cheap and effective solution.
6. Foscam Wireless IP Camera
  - a. Need 1 to 2 cameras for the lab so students can connect the Nexus 7's to them

## Software Specifications

1. Arduino IDE
  - a. Will be used by students to program the Arduino
  - b. LED board used provides a library with some functions to aid in the communication between the arduino and the board.
2. Eclipse with Android SDK
  - a. To be able to write Android Applications that can be sent to the Nexus 7 to interface with the Arduino

## Lab Specifications

1. Morse Code Lab
  - a. Provide code for basic application that toggles an LED on the Arduino board (this will allow students to test their setup before beginning to code).
  - b. Provide outline for Morse Code application including code which converts a string into an array of bytes representing that string in Morse Code.
  - c. Students will be responsible for designing an interface for this lab, which allows the user to enter a string, convert it to Morse Code, and then transmit that to the Arduino board.
  - d. Students will be responsible for writing Arduino code to interpret the Morse Code and toggling the LED for the appropriate lengths of time.
2. SketchPad Lab
  - a. Provide outline for SketchPad application including a user interface which will be used to control individual LEDs on the LED board.
  - b. The first week of lab requires students to create a user interface where they can enter the specific coordinates and RGB values they want. The second week requires they create a grid of buttons so they can “draw” the image.
  - c. Provide libraries which students can use to assist in updating LED board.
  - d. Students will be responsible for updating the LED board based on the signal they sent.
3. SpyCam Lab
  - a. Provide skeleton code with some pre-finished methods.
  - b. Students will be required to finish their own user interface with three components.
  - c. Students must stream video from an IP camera and control its movement.

## Implementation Problems

1. For device safety and ease of use, we will have to come up with a “shield” for the Arduino to connect the necessary pins into a connector that sits on top of the Arduino.
2. After working with ETG, a method of allowing any tablet to use the same drivers was developed. This allows students to work on any machine in the lab instead of just one.

## Testing

1. Initial testing is to have a working version of each of our proposed labs. This requires that we test the communication between the Nexus 7 tablet, the Arduino and any other external hardware.
2. An experimental class, CprE 276X, was created with the purpose of allowing our team to test our labs. The class consisted of four labs from the previous 388 lab list and the four weeks of labs we developed. Once students finished each lab, they were required to fill out an evaluation from detailing how much time it took, what they liked and didn't like as well as anything they would like to see improved.
3. Once the class was complete, the feedback forms were analyzed. The lab manuals were then edited to reflect this feedback and any other observations we made during lab time were updated.