Modular LED Wall Panels Project Proposal

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1 Introduction

1.1 Problem

In recent years, LED decorations and the IoT marketplace have grown immensely in popularity. However, many of the commercially available products are either overpriced or provide very little customizability. Currently, most LEDs are only available as strips, with the few purchasable modular LED panels unable to display text or images. The linearity of LED strips hinders the user's ability to create 2-D displays tailored to their specific room dimensions. On the other hand, the lack of text and images on current modular LED panels restricts the possibilities for dynamic displays that can provide useful information.

1.2 Solution

We will design and implement multiple modular LED panels that are capable of displaying customizable text or images. The modular design allows for the user to connect together as many panels as desired, in relatively any shape (excluding diagonally). For example, with four tiles, the user can create either a 2x2 square, a 4x1 line, or an "L" shape.

The design is focused around a "core panel" containing the main control unit, which can then be connected to "expansion panels" in the manner described above. Each panel will contain an array of 8x8 serially addressable LEDs which can be illuminated in any color. Utilizing a smartphone, the user will be able to choose what image, text, or dynamic display will be shown on the panels. At all times, the central panel will recognize the overall configuration, updating the display to fit within the set boundaries.

1.3 Visual Aid

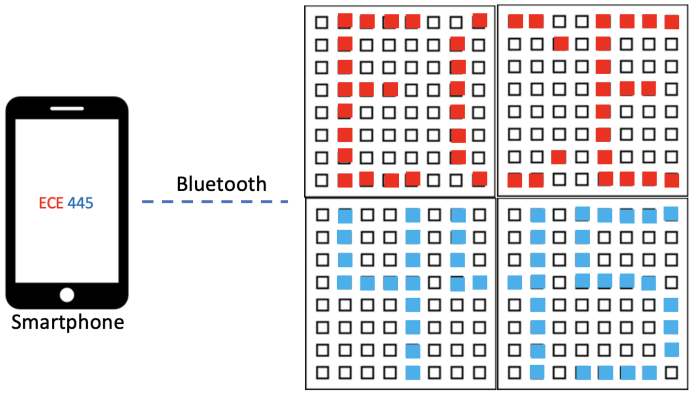

Figure 1: Configuration example 1 of four panels

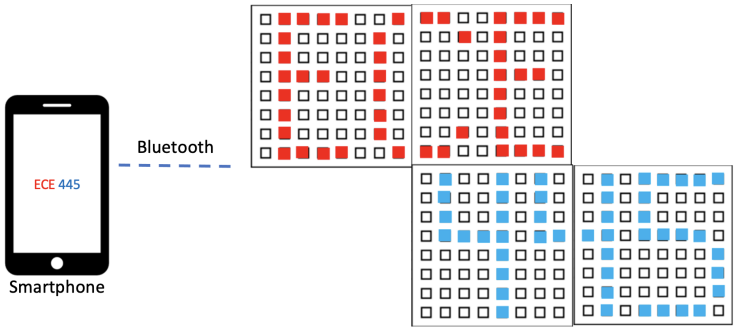

Figure 2: Configuration example 2 of four panels

1.4 High-level Requirements

- The panels must be able to display text, images, and dynamic effects that can adapt to current configuration.
- "Core panel" must automatically recognize any change to the configuration of expansion tiles, updating the display output to each tile to fit within the new boundaries in under 1 second.
- Panels must be able to be controlled through Bluetooth by a smartphone or other external device.

2 Design

2.1 Block Diagram

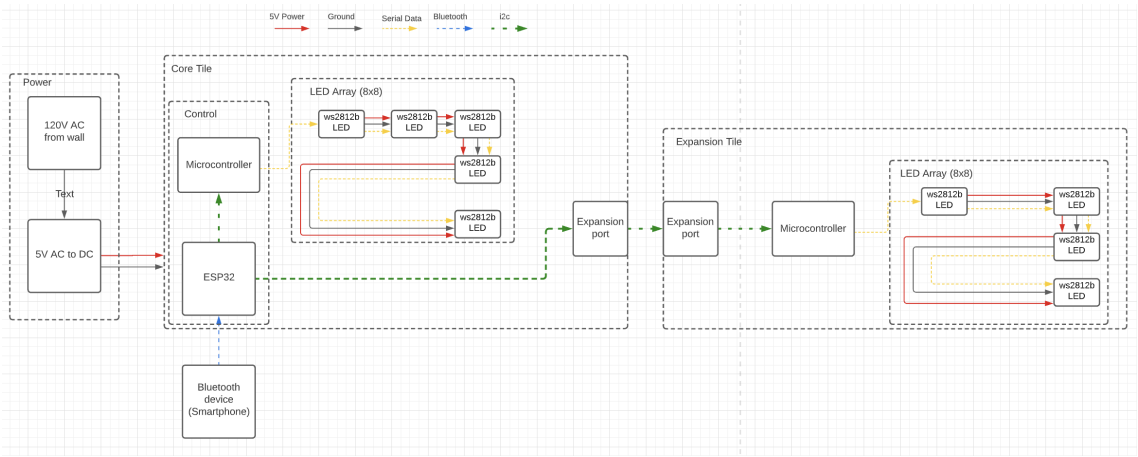

Figure 3: Block Diagram

2.2 Subsystem Overview

2.2.1 Power

The power subsystem will be plugged into a standard North American outlet which outputs 120 V AC rated at 15 A. Utilizing a power adapter we will step down the 120 V to a 5 V DC supply.

Requirement 1: AC - DC converter must be able to output $5V \pm 0.1\ V$

2.2.2 Main Tile: ESP32

The ESP32 will control the overall image being displayed on the panels. Through I2C, it will send packets of data to each microcontroller, containing the data that is to be displayed. Additionally, the ESP32 will poll the microcontrollers on the secondary panels to determine the current configuration of all panels, adjusting the image output accordingly. Finally, this chip will facilitate the Bluetooth connection between our product and the user's smartphone.

Requirement 1: Must be able to establish Bluetooth connection with smartphone in under 5-7 seconds.
Requirement 2: Must be able to process algorithm to determine overall configuration of all panels.

2.2.3 Expansion Tile Microcontroller

Each expansion panel's microcontroller will receive a stream of packets through I2C from either the main tile or previous expansion tiles. Each tile will parse through the data stream and display its image on the LEDs, and forward other tiles' packets to subsequent expansion tiles.

Requirement 1: Each microcontroller must receive a packet stream, and forward packets to other panels on the appropriate pin.
Requirement 2: Each microcontroller must parse its packet and update the LED array attatched to the expansion panel.

2.2.4 LED Array

The LED Array will be composed of an 8x8 array of WS2812B LEDs. These are serially addressable LEDs that are controlled by sending a bitstream indicating what color each LED should be illuminated as. The microcontroller only has to interface with the first LED, with each LED sending the bitstream to its subsequent neighbor.

Requirement 1: Each LED must display correct color and brightness as indicated by the user.

2.2.5 Expansion Port

The expansion port is essentially a connector that will transfer both voltage, ground, and data signals between each panel. The data will be transferred through the I2C protocol.

Requirement 1: Must be able to stay connected without any human assistance
Requirement 2: Must be flush with all adjacent panels ($\leq$ 5mm)

2.3 Tolerance Analysis

A significant part of our design will be the successful illumination of the LEDs as specified by the user. If the algorithm and control units that describe how the LEDs should be lit up are incorrect, this would pose a significant risk to the successful completion of our project. Furthermore, not delivering adequate power to the LEDs could result in diminished brightness, or even prevent them from turning on. As more panels are added to the system, we want all LEDs to remain bright without needing an additional power supply.

Individual LED power usage: 3V, 20mA (at full brightness)
Panel size: 8x8; 64 LEDs per panel
$3V * 60mA = 180mW$
$180mW * 64 = 11.52W$

Based on our calculations, each panel will draw 11.5W of power at peak usage. We plan on using a power adapter with a supply of at least 30W. With this adapter we can have around 3 panels connected before a noticeable brightness decrease.

3 Ethics and Safety

3.1 Ethics

While there is not an excessive amount of ethical issues that arise with our project, we still must take into consideration a few key ethical standards. Code I.1 of the 7.8 IEEE Code of Ethics states that we must "protect the privacy of others" [1]. With users of our product potentially entering in sensitive information to be displayed on the LED panels (e.g., text messages) we must take measures to ensure the privacy of this information. Since we don't plan on storing any user data, we must inform the user of this, but also ensure the user knows of the potential risk of sharing any private information.

Additionally, during the development of our project we must make sure to be honest and trustworthy with our teammates and any others who provide us with assistance. As Section 1.3 of the ACM Code of Ethics states, we must be "honest about [our] qualifications, and about any limitations in [our] competence to complete a task" [2]. This is a crucial standard to follow during development, for designing anything that is outside of our qualifications could lead to potential failure and harm. It is essential for us as teammates to communicate with each other and understand each person's area of expertise.

3.2 Safey

Issues of safety will mostly arise during our time in the lab. We should "never work in the laboratory alone" and will always "clean up after [ourselves]" [3]

as stated by the ECE 445 lab rules. Working in the lab alone could lead to potentially dangerous situations if something happens and no TA or professor is present. Also, it is important to clean up after ourselves, for students who use the lab after us may or may not know the potential risks of any equipment we were previously using. Lastly, we will likely be soldering in the lab, so we must always keep to best practices while doing any soldering work.

References

[1] IEEE Policies, Section 7.8 Code of Ethics, Standard I.1, [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. June 2020.

[2] ACM Code of Ethics and Professional Conduct, Section 1.3. [Online]. Available: https://www.acm.org/code-of-ethics. June 2018.

[3] ECE 445 Lab Rules. [Online]. Available: https://courses.engr.illinois.edu/ece445/lab/