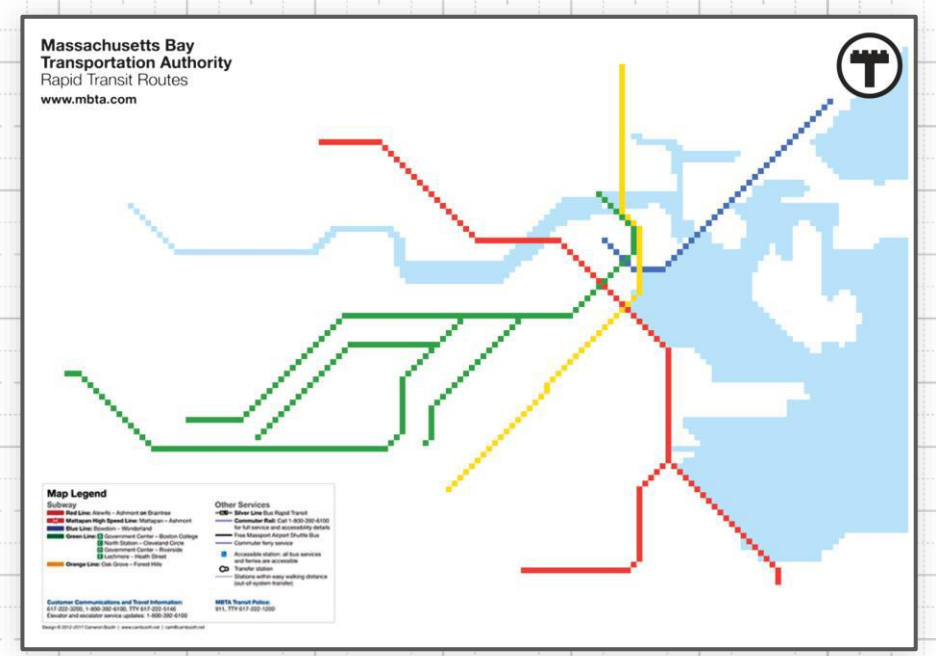

# 2024 Winter Quarter Design Presentation

# Project Description

- Create captivating LEGO art piece depicting Massachusetts Bay Transportation Authority (MBTA) map
- Provide real-time information of the subway system through LEDs
  - Precise locations of trains within the MBTA network
  - Status of each train station
- Offer commuters and enthusiasts an interactive and informative way to experience public transit



# Development Team

**Jake Greenbaum**
(Team Lead)

Android App Development, LED Display Integration

**Chris Fisher**

PCB Design, LED Display Integration

**Zachary Richards**

Map Design & Construction

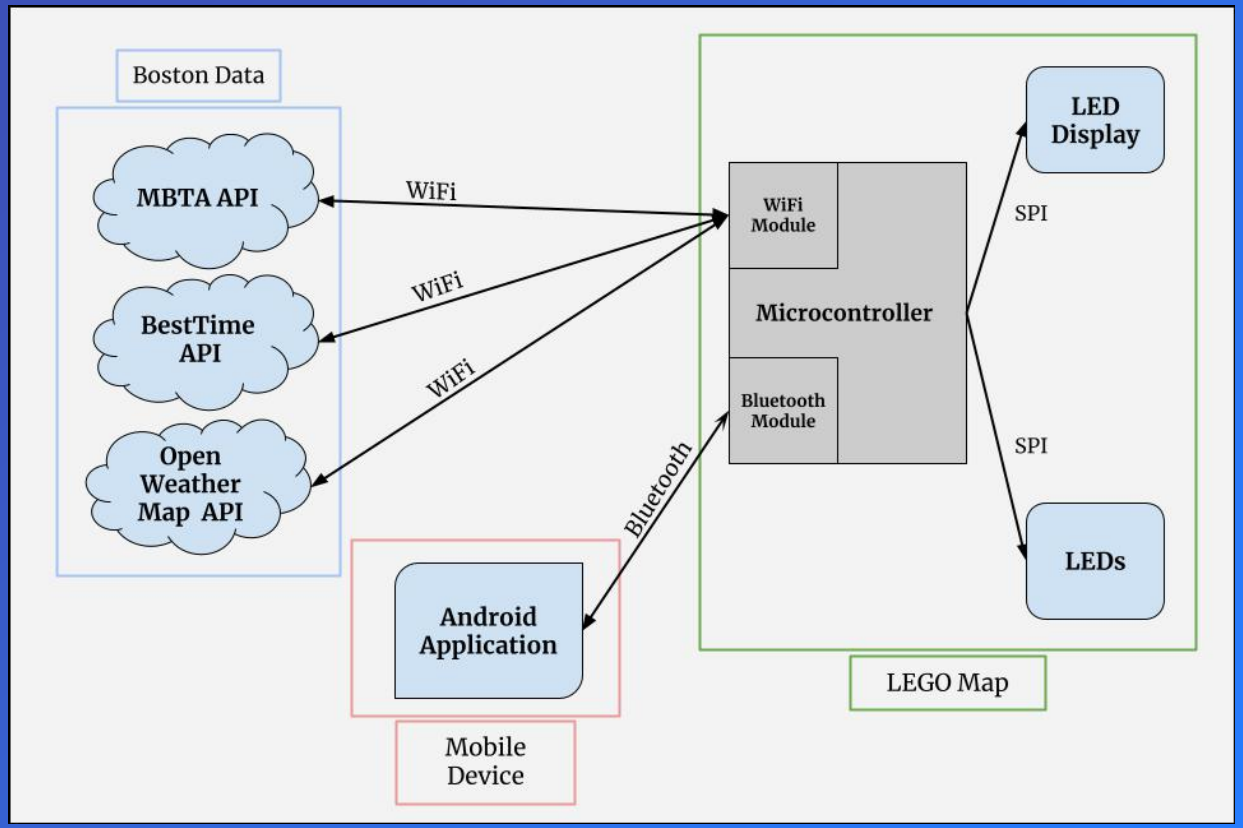
**Jack Shoemaker**

WiFi Module Control, API, and Data Parsing

**Sam Ng**

LED Programming

# Block Diagram



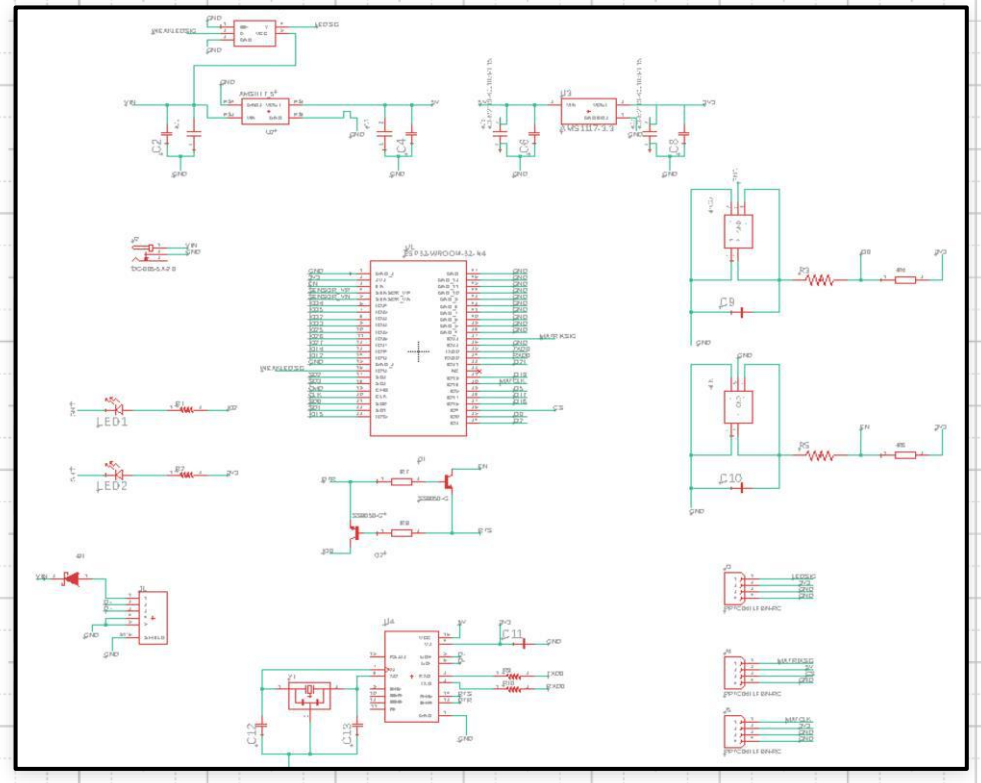
# Components

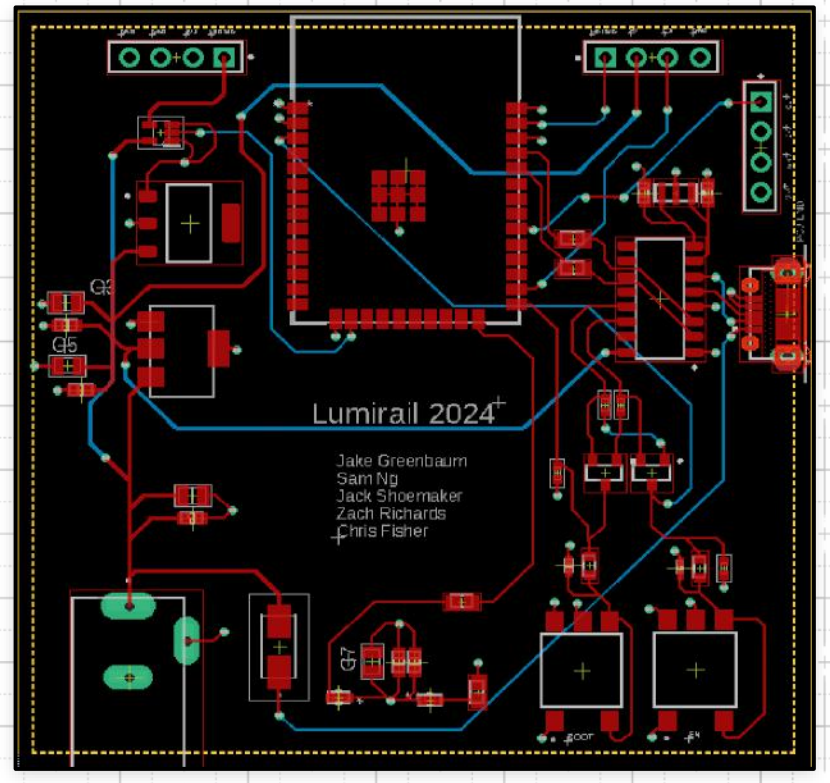
- ESP32-WROOM-32-N4, Microcontroller


- PL2983 Addressable LEDs, Train Station Markers

- Max7219 Dot Matrix, LED Display

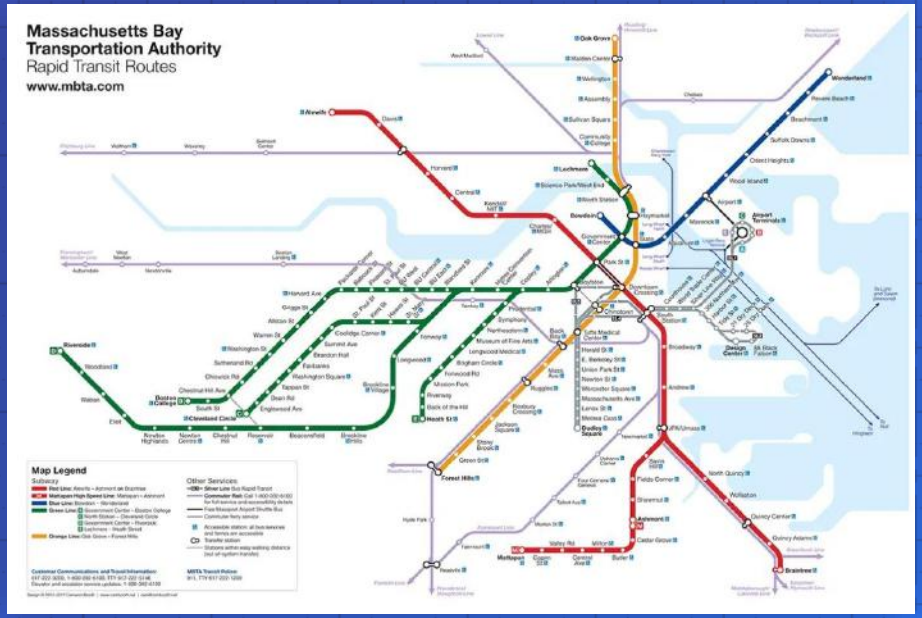
# PCB Schematic and Layout

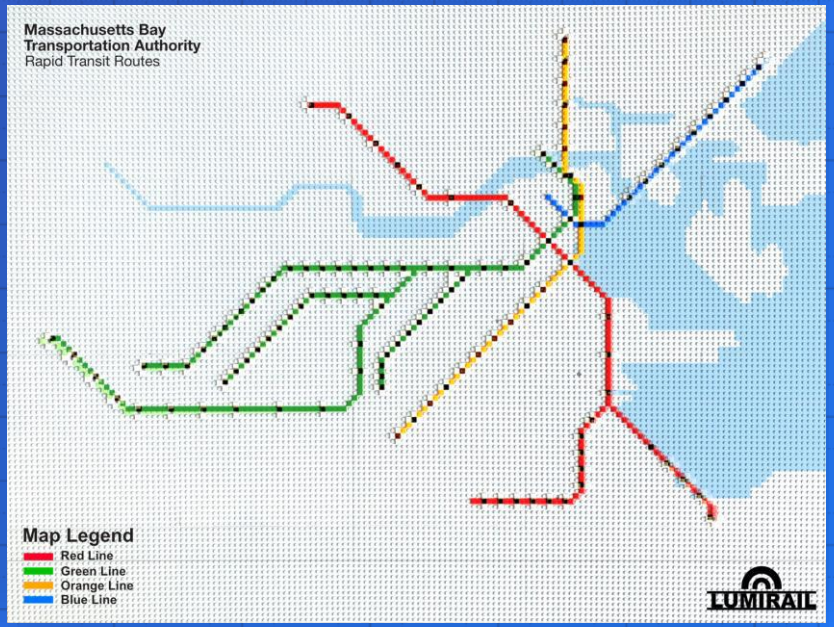




# Physical Map Design And Construction

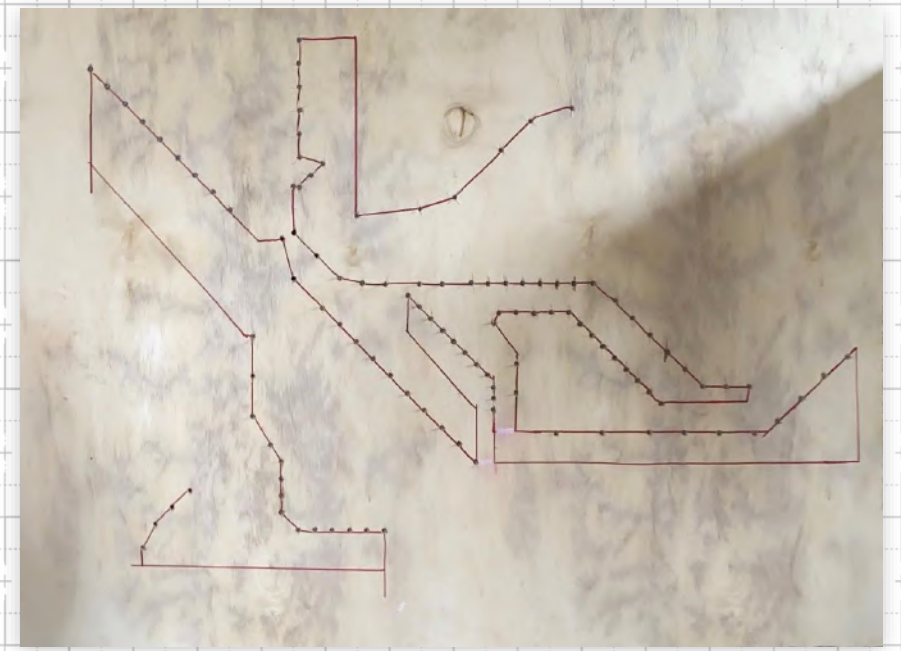
# MBTA Map Layout

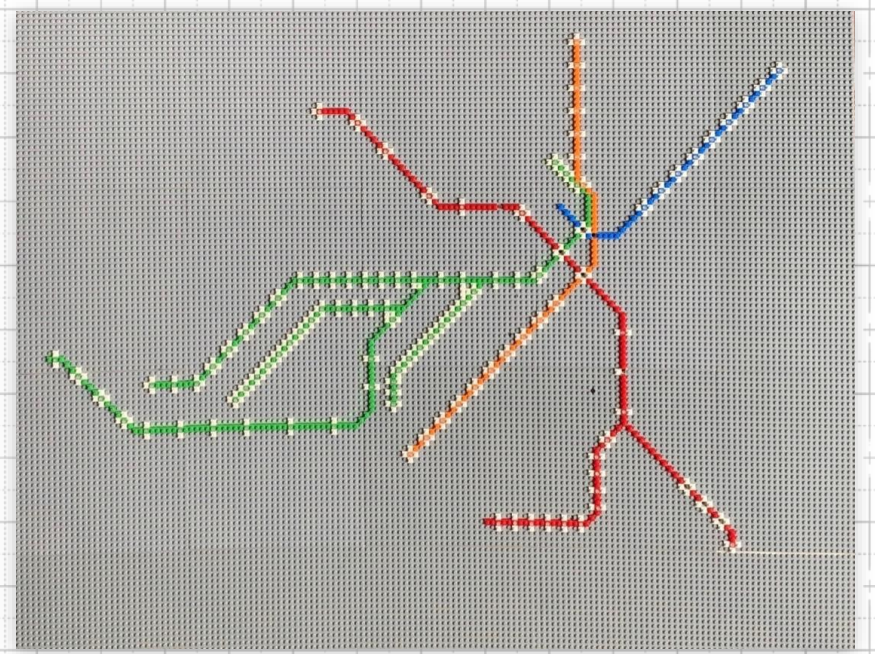


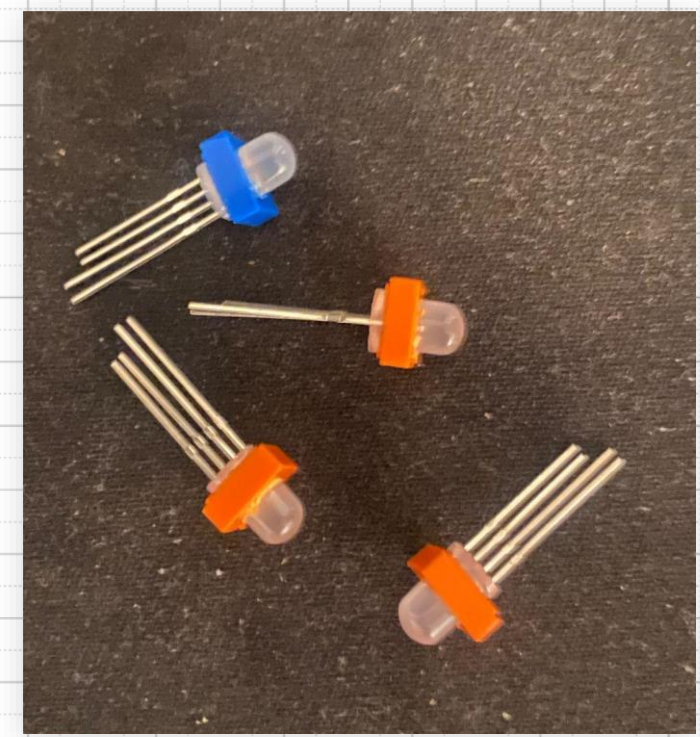

(48in x 36in)

# Map Construction Progress

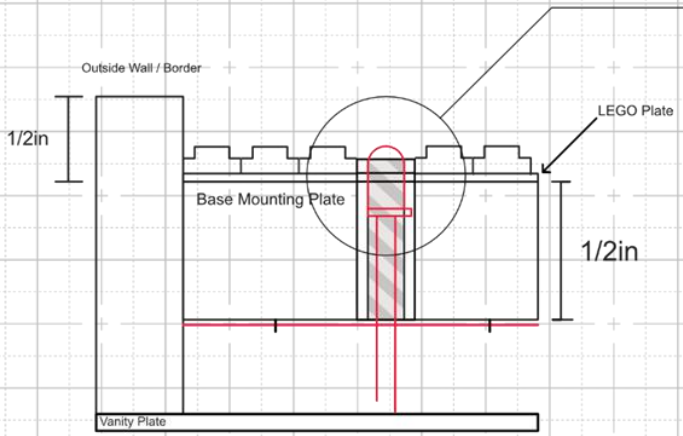




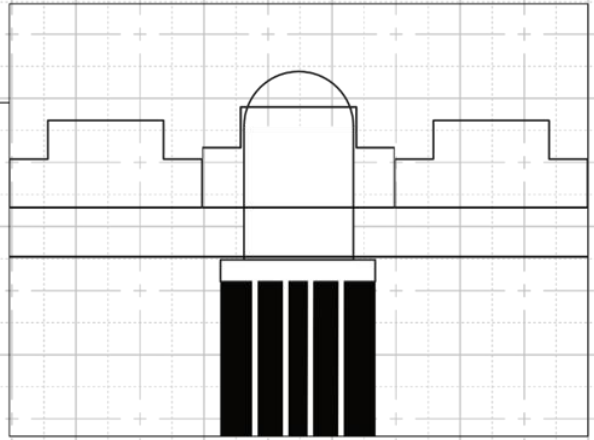
# LED Mounting



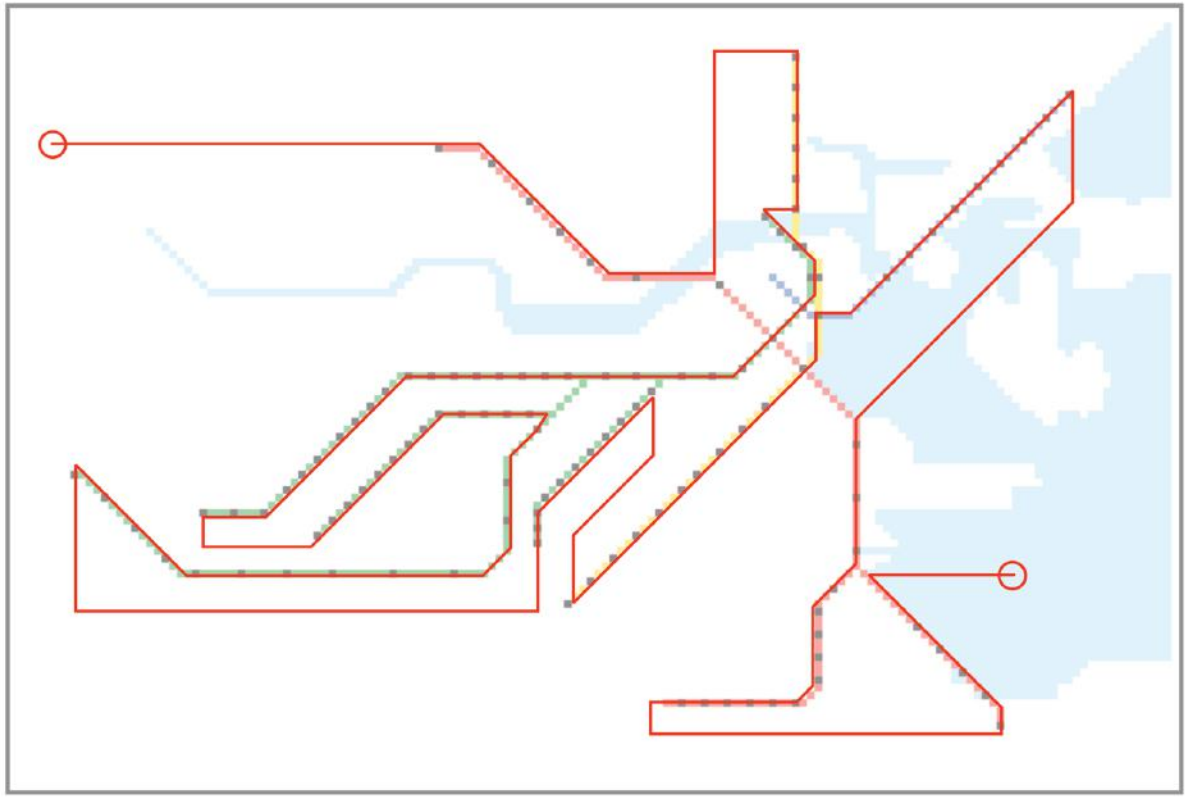
# LED Mounting Schematics


Blown up LED Mounting Side View



Bottom View of LED Series



# LEGO MBTA Map Wiring Diagram

*LED and Wire Size not to scale

GND
LED
POWER
SIGNAL

# WiFi Connection and Data Sources

# ESP32 Integrated WiFi Module

- 802.11b/g/n capable WiFi Module
- ESP32 connects to local WiFi network using login information provided via user input, then sends HTTPS requests to corresponding APIs receiving transmitted data


# MBTA API

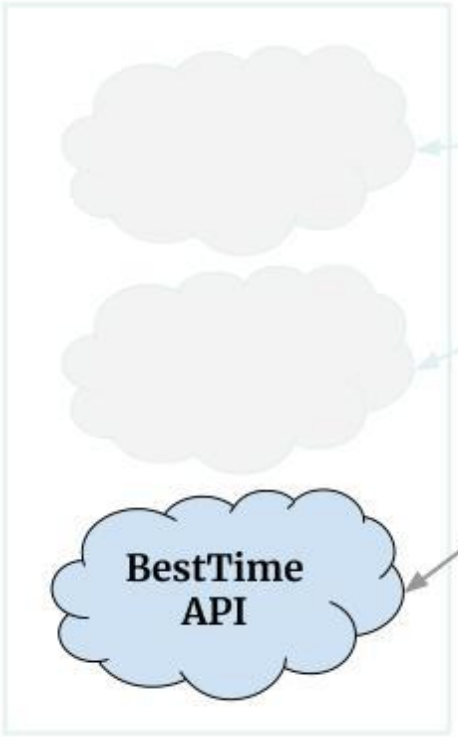

- The MBTA API contains all the live information about the rail and public transit network in the Boston area
- We will filter the live vehicle information to contain only the positions and directions of the train and subway system which will be displayed on the LEDs when the user selects train mode
- Also information about the chosen stop, ie next train arrival time, will be extracted and displayed on the LED matrix display

# OpenWeather API


- Offers real time weather information

- Weather information will be displayed on the LED matrix when chosen to in the app

# BestTime API



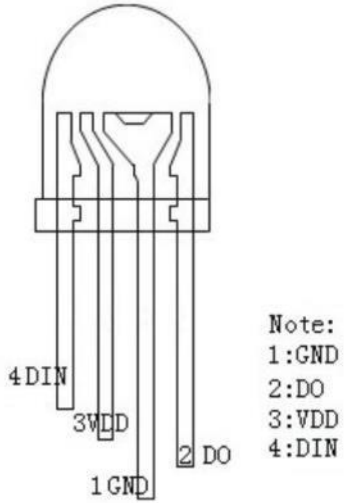

- Offers information about the current busyness levels at businesses

- This API will be used to capture the busyness level of all the stops in the Boston subway and rail system which will be displayed when the use selects station mode

# Train Station LEDs

# LEDs

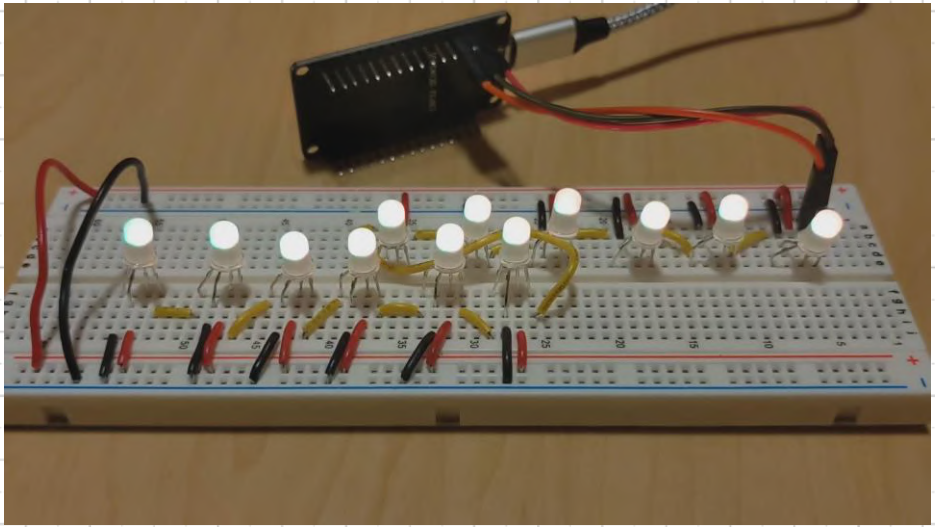
- PL9823
  - Addressable RGB LED
- Use similar protocol to WS2818
  - Using datasheet as reference
- Communicate to using SPI
  - Each bit of data represented by 3 bits in SPI
    - High = 110
    - Low = 100
  - Each color takes one byte of data, leading to each color being represented by 3 bytes in SPI



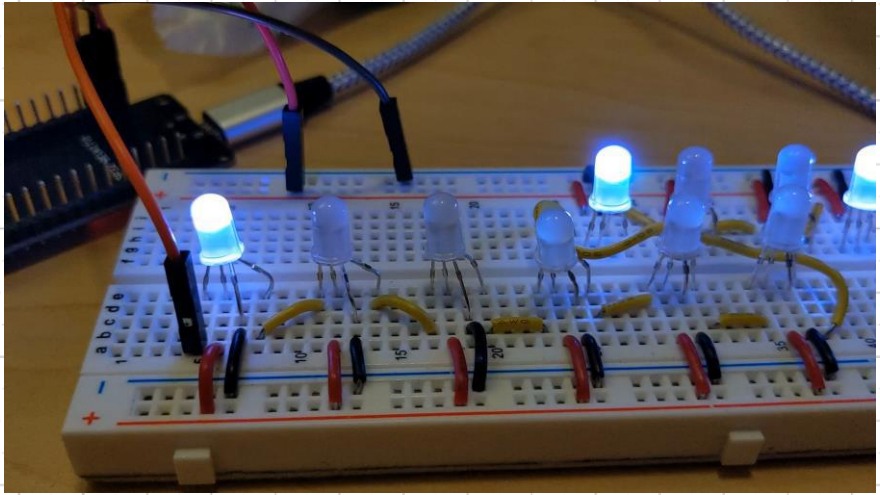
# Map Modes: Connecting

Loading action while waiting for internet connection:

- Not connected → pulse orange
- Connected → flash green



# Map Modes: Train Mode



**EPILEPSY WARNING**

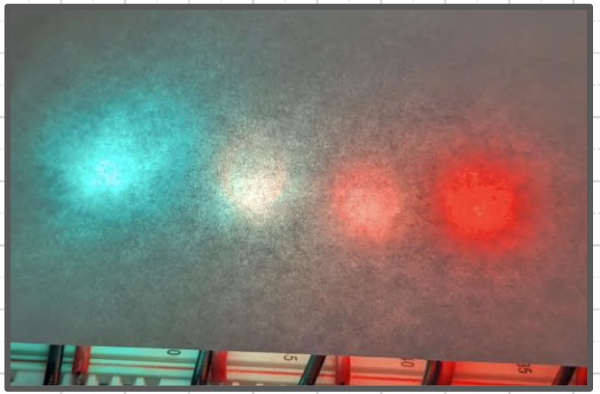
LEDs are lit up according to where trains currently are and where they are going:

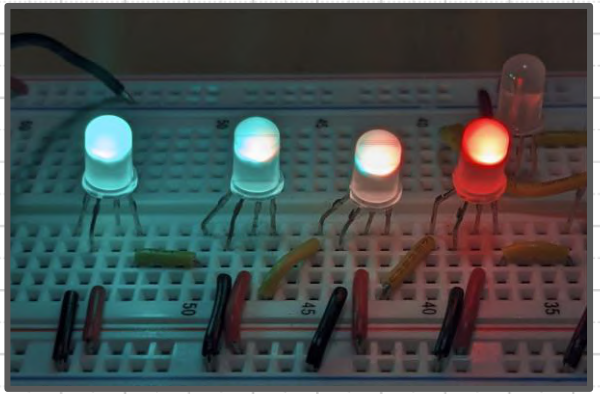
- Steady light → train at station
- Fast blinking light → train just departed
- Slow blinking light → train about to arrive
- No light → no train currently at station, or no train immediately arriving at/departing from station

# Map Modes: Busyness Mode

LEDs lit up according to traffic around station

- Green = light traffic
- Yellow = light-medium traffic
- Orange = medium-heavy traffic
- Red = severe traffic

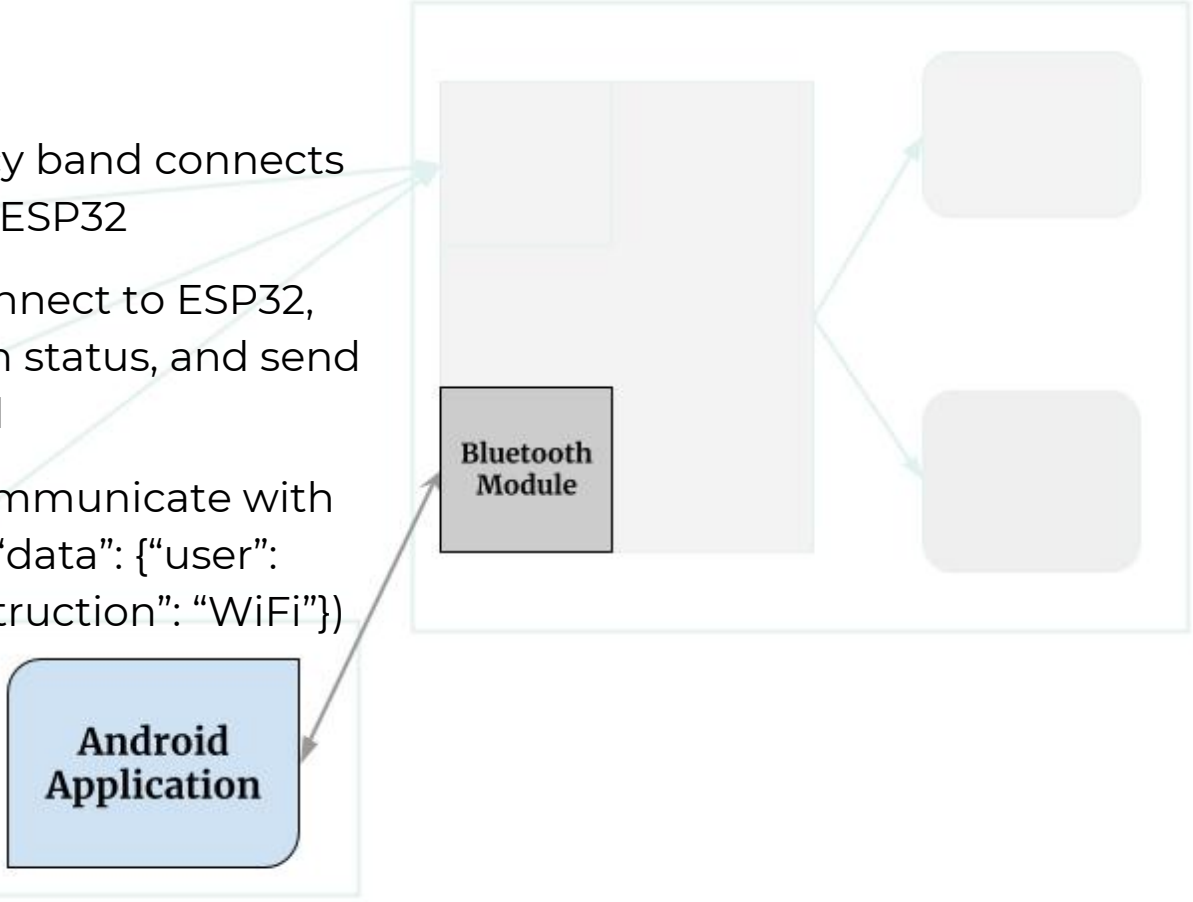




# Android Application

# The Application

- BLE on 2.4GHz frequency band connects Android smartphone to ESP32
- Application is able to connect to ESP32, maintain the connection status, and send commands to the board
- Uses JSON strings to communicate with and control the board ({“data”: {“user”: “bob”, “pass”: “abc”}, “instruction”: “WiFi”})

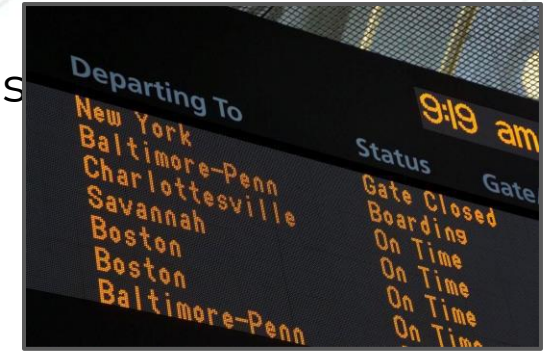


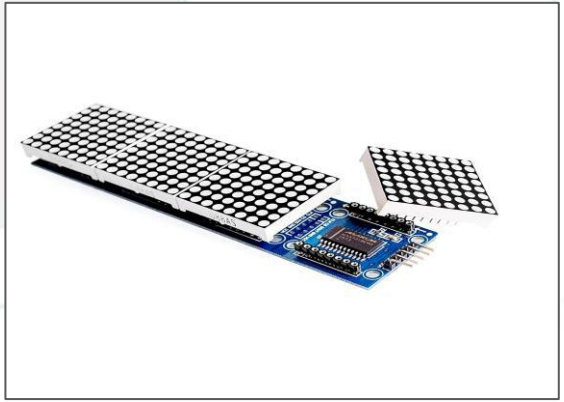
# Application Demo

# LED Display

# MAX7219 LED Matrix Display

- 8x8 Dot Matrices daisy-chained into a long display
- Serially interfaced via SPI
- Used to display information related to the Boston transit system:
  - Arrival/Departure times for specific trains
  - Traffic intens
  - Weather



# Risk Analysis

- Mounting the final LEGO map to the wall (ensuring it is sturdy while also being visually appealing)
- Poor soldering can lead to LED outages since we will only have a single line for data
- Ensuring the LEGOS remain planted to the baseplate after LED modification
- Software does not break on edge cases where API calls fail or return unexpected data

# Progress and Timeline

## Winter Progress

WiFi, Bluetooth, and API connectivity programming completed

Final board construction in progress

Basic LED display functionality (time, weather display, etc)

## End of Spring Quarter

Map is fully integrated with all functionality (train tracking/station capacity) and LED display fully developed

Customization options added to Android App and implemented

Finishing touches and polishing

# Acknowledgements

Dr. Yogananda Isukapalli

Eric Hsieh

Dr. Haewon Jeong

# Questions?