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

- Boston Data
- MBTA API
- BestTime API
- Open Weather Map API
- WiFi
- Android Application
- Mobile Device
- Bluetooth
- Microcontroller
- WiFi Module
- Bluetooth Module
- SPI
- LED Display
- SPI
- LEDs
- LEGO Map
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

1/2in

Outside Wall / Border

LEGO Plate

Base Mounting Plate

1/2in

LED (To Scale)

Bottom View of LED Series
LEGO MBTA Map Wiring Diagram

*LED and Wire Size not to scale
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
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, i.e., 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 user 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
MapModes: Train Mode

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

EPILEPSY WARNING
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 intensity
  - Weather
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 LEGO pieces 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
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Questions?