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
- Bluetooth Control

Chris Fisher
- PCB Design, LED Display Integration

Zachary Richards
- Map Design & Construction

Jack Shoemaker
- WiFi Control, API Control and Data Parsing

Sam Ng
- LED Programming
Block Diagram
Components

- ESP32-WROOM-32-N4, Microcontroller
- PL9823 Addressable LEDs, Train Station Markers
- Max7219 Dot Matrix, LED Display
PCB

PCB Dimensions:
2.5” x 2.5”

On/Off Switch

DC Power Jack

Microprocessor

Headers

Micro USB Port

Buttons
Physical Map Design and Construction
MBTA Map Layout

(48in x 36in)
Map Construction
LED Mounting
LED Mounting Schematics

Blown up LED Mounting Side View

LED (To Scale)

Outside Wall / Border

LEGO Plate

Base Mounting Plate

1/2in

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
- Provides live vehicle information in Boston
- Filtered to only contain positions and directions of the train and subway system (displayed on LEDs in train mode)
- Information about next train arrival at chosen stop extracted (displayed on LED matrix display)
BestTime API

- Provides information about the current busyness levels at businesses
- Busyness info displayed when selected on Android application
OpenWeatherMap API

- Provides real time weather information
- Weather information will be displayed on the LED matrix when chosen to in the app
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 → orange pulse
- Unable to connect → red
- Connected, getting WiFi data → green pulse
Map Modes: Train Mode

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

- **White light** → train at station
- **Green light** → train arriving at station
- **No light** → no train currently at station, or no train immediately arriving at/departing from station
LEDs are 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": {"ssid": "abc", "user": "bob", "pass": "def"}, "instruction": "WiFi"}})
Application Demo
LED Display
MAX7219 LED Matrix Display

- LED Dot Matrices daisy-chained into a longer and wider display
- Serially interfaced via SPI
- Used to display information related to the Boston transit system:
  - Arrival/Departure times for specific trains
  - Traffic intensity at specific stations
  - Weather
Challenges Faced

- FreeRTOS task scheduling library
- Power and data wire layout
- Board design and construction
- Custom app design and development
- API edge cases
- Incoming data management
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Questions?