**ETA analysis based on NTU bus fleet and existing schedules**

Let’s analyze the number of **ETA requests per month** for the case where **8 buses operate 2 times a day**, and **2 buses operate 2 additional times per day** under different request intervals (1, 2, and 3 minutes):

**Scenario Overview:**

* **8 buses operate twice a day** (morning and evening).
* **2 buses operate an additional two times per day** (for a total of 4 trips per day).

We will analyze for **1-minute**, **2-minute**, and **3-minute** intervals.

**Assumptions:**

* Each trip lasts **2 hours** (120 minutes).
* The number of days buses operate: **5 days per week**.
* A month is roughly **4 weeks**.

**1. ETA Requests with a 1-Minute Interval:**

**Step 1: Requests per Trip**

* **For each trip (2 hours)**, with a 1-minute interval:  
  [  
  120 , \text{minutes} \div 1 = 120 , \text{requests per trip}  
  ]

**Step 2: Requests per Day for Buses:**

* **8 buses** running **2 trips per day**:  
  [  
  120 , \text{requests per trip} \times 2 , \text{trips per day} = 240 , \text{requests per day per bus}  
  ]
  + For all **8 buses**:  
    [  
    240 \times 8 = 1,920 , \text{requests per day for 8 buses}  
    ]
* **2 buses** running **4 trips per day**:  
  [  
  120 , \text{requests per trip} \times 4 , \text{trips per day} = 480 , \text{requests per day per bus}  
  ]
  + For the **2 buses**:  
    [  
    480 \times 2 = 960 , \text{requests per day for 2 buses}  
    ]
* **Total requests per day for all buses**:  
  [  
  1,920 + 960 = 2,880 , \text{requests per day for all buses}  
  ]

**Step 3: Requests per Month:**

* **5 days per week** over **4 weeks**:  
  [  
  2,880 \times 5 , \text{days per week} \times 4 , \text{weeks per month} = 57,600 , \text{requests per month}  
  ]

**2. ETA Requests with a 2-Minute Interval:**

**Step 1: Requests per Trip**

* **For each trip (2 hours)**, with a 2-minute interval:  
  [  
  120 , \text{minutes} \div 2 = 60 , \text{requests per trip}  
  ]

**Step 2: Requests per Day for Buses:**

* **8 buses** running **2 trips per day**:  
  [  
  60 , \text{requests per trip} \times 2 , \text{trips per day} = 120 , \text{requests per day per bus}  
  ]
  + For all **8 buses**:  
    [  
    120 \times 8 = 960 , \text{requests per day for 8 buses}  
    ]
* **2 buses** running **4 trips per day**:  
  [  
  60 , \text{requests per trip} \times 4 , \text{trips per day} = 240 , \text{requests per day per bus}  
  ]
  + For the **2 buses**:  
    [  
    240 \times 2 = 480 , \text{requests per day for 2 buses}  
    ]
* **Total requests per day for all buses**:  
  [  
  960 + 480 = 1,440 , \text{requests per day for all buses}  
  ]

**Step 3: Requests per Month:**

* **5 days per week** over **4 weeks**:  
  [  
  1,440 \times 5 , \text{days per week} \times 4 , \text{weeks per month} = 28,800 , \text{requests per month}  
  ]

**3. ETA Requests with a 3-Minute Interval:**

**Step 1: Requests per Trip**

* **For each trip (2 hours)**, with a 3-minute interval:  
  [  
  120 , \text{minutes} \div 3 = 40 , \text{requests per trip}  
  ]

**Step 2: Requests per Day for Buses:**

* **8 buses** running **2 trips per day**:  
  [  
  40 , \text{requests per trip} \times 2 , \text{trips per day} = 80 , \text{requests per day per bus}  
  ]
  + For all **8 buses**:  
    [  
    80 \times 8 = 640 , \text{requests per day for 8 buses}  
    ]
* **2 buses** running **4 trips per day**:  
  [  
  40 , \text{requests per trip} \times 4 , \text{trips per day} = 160 , \text{requests per day per bus}  
  ]
  + For the **2 buses**:  
    [  
    160 \times 2 = 320 , \text{requests per day for 2 buses}  
    ]
* **Total requests per day for all buses**:  
  [  
  640 + 320 = 960 , \text{requests per day for all buses}  
  ]

**Step 3: Requests per Month:**

* **5 days per week** over **4 weeks**:  
  [  
  960 \times 5 , \text{days per week} \times 4 , \text{weeks per month} = 19,200 , \text{requests per month}  
  ]

**Summary of Requests:**

* **1-minute interval**: **57,600 requests per month**.
* **2-minute interval**: **28,800 requests per month**.
* **3-minute interval**: **19,200 requests per month**.

**Google map vs Mapbox**

Here’s a **comparison between Mapbox and Google Maps** based on your project needs, considering features like **map SDKs for Android and web**, **geofencing**, and **ETA calculation with traffic**.

**1. Map SDK for Android and Web**

**Mapbox:**

* **Platforms**: Provides **SDKs for both Android and web**. You can create custom maps and implement features like offline maps, real-time updates, and custom styling via **Mapbox Studio**.
* **Customization**: Highly customizable. You can adjust map styles, layers, markers, and more. This is useful for tailoring maps to match your project’s specific design or needs.
* **Offline Support**: Offers **offline maps** for mobile, which can be useful if your buses operate in areas with limited connectivity.
* **Pricing**: Mapbox offers **50,000 free map loads per month**. Once you exceed the free tier, it costs **$5 per 1,000 additional map loads**.
* **Best for**: If you need full control over map design, customization, and **cost-effective map loads**.

**Google Maps:**

* **Platforms**: Also offers **SDKs for Android and web** but with a familiar, more standardized interface.
* **Customization**: While Google Maps offers some customization, it is more limited compared to Mapbox. You can’t change map styles as flexibly as in Mapbox.
* **Offline Support**: Does not provide **offline maps** by default in its API (for general use), so this can be a limitation for areas with poor connectivity.
* **Pricing**: Google Maps gives **28,000 free map loads per month**, with additional costs of **$7 per 1,000 map loads** beyond that.
* **Best for**: If you need familiar maps with **built-in data layers** like traffic, transit, and points of interest.

**Winner: Mapbox offers better customization and a more generous free tier, making it ideal for your needs with map customization and offline capabilities. However, if you prefer familiarity and rich data layers like transit and points of interest, Google Maps may still be appealing.**

**2. Geofencing**

**Mapbox (with Turf.js):**

* **Geospatial Analysis**: Mapbox does not have built-in geofencing, but you can easily integrate **Turf.js**, an open-source geospatial analysis library. With Turf.js, you can create **polygons, buffers, and distance checks** to determine whether a bus is within a defined geofence or deviating from the route.
* **Customization**: Full control over **geofence setup** and monitoring, giving you flexibility to define areas, bus routes, and alerts.
* **Pricing**: No extra cost beyond the standard **map loads**, making this solution more cost-effective.
* **Cons**: Requires **custom code** and integration with Turf.js, but this gives you more control over geofencing behaviors.

**Google Maps Geofencing API:**

* **Built-in Geofencing**: Google Maps offers a **built-in geofencing API**, making it easier to implement without external libraries. You can define geofences around areas or routes and get **notifications** when buses enter or exit these zones.
* **Real-time Monitoring**: Google provides a robust monitoring system for multiple geofences, with minimal configuration required.
* **Pricing**: Geofencing uses map loads, and the higher usage costs of Google Maps can make this more expensive in the long run compared to Mapbox.
* **Cons**: The **cost per request** can increase if you frequently monitor multiple geofences.

**Winner: Mapbox with Turf.js is the better option for cost control and customization. If you need out-of-the-box geofencing, Google Maps is simpler to implement but at a higher cost.**

**3. ETA Calculation with Traffic**

**Mapbox Directions API:**

* **ETA Calculation**: Mapbox provides a **Directions API** that allows you to calculate ETA for each stop along a predefined route. It can handle **waypoints**, offering accurate time predictions.
* **Traffic Consideration**: **Mapbox Directions API does not have the same rich traffic data as Google Maps**. Traffic prediction is based on less detailed data, which might result in less accurate ETA predictions in high-traffic areas.
* **Pricing**: The **free tier** offers **100,000 free requests per month**. After that, it’s **$2 per 1,000 additional requests**, which makes it much more cost-effective than Google.
* **Best for**: If your primary concern is **cost-effective** ETA calculations for predefined routes, especially where traffic data isn’t crucial.

**Google Maps Directions API (Advanced):**

* **ETA Calculation**: Google’s Directions API offers **highly accurate ETA calculations** with real-time **traffic data**. If the departure\_time=now parameter is used, the ETA is adjusted dynamically based on current traffic conditions.
* **Traffic Consideration**: Google Maps has one of the most comprehensive traffic datasets, providing accurate traffic-aware ETA predictions, which is a major advantage if you’re working in urban or traffic-heavy environments.
* **Pricing**: For **traffic-based ETAs**, Google Maps charges under the **Advanced SKU**, which gives **40,000 free requests per month**, after which it costs **$10 per 1,000 requests**. This can become costly if your request volume is high.
* **Best for**: If you need **real-time traffic data** for highly accurate ETAs, especially in areas where traffic plays a major role.

**Winner: For basic ETA calculations (without complex traffic considerations), Mapbox Directions API is the better choice due to cost savings and a larger free tier. If real-time traffic is crucial for your ETA calculations, Google Maps Directions API is more accurate but more expensive.**

**Final Recommendation:**

* **Map SDK**: **Mapbox** wins for its **flexibility**, **customization**, and **generous free tier**, especially for Android and web.
* **Geofencing**: **Mapbox with Turf.js** is the more **cost-effective** and **flexible** solution for geofencing. Google Maps’ built-in geofencing is simpler to set up but at a higher cost.
* **ETA Calculation**: If **real-time traffic** isn’t a deal-breaker, **Mapbox Directions API** is the better, more affordable option. However, if **traffic data is essential** for accurate ETAs, Google Maps **Advanced Directions API** is superior.

In conclusion, **Mapbox** offers more value across your requirements with **cost-effective solutions** and **flexibility** in customization. However, if you absolutely need **real-time traffic data** for ETA predictions, you’ll need to use **Google Maps Directions API (Advanced)**.