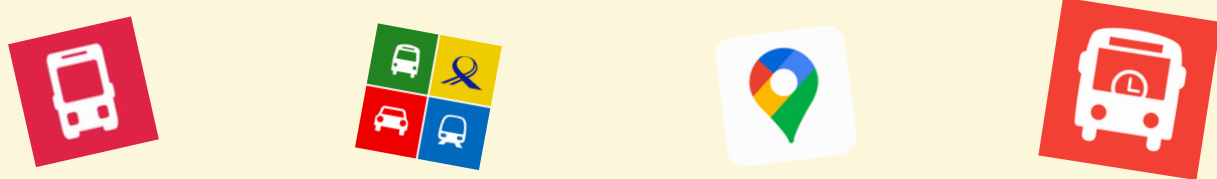


# How Good Are Bus Timing Apps In Singapore?



## RATIONALE

We will investigate on four main apps, namely:

- Google Maps** - The most widely used Maps globally. We used this app aids us in our comparison of an international benchmark in Singapore's context.
- MyTransport** - The official Bus Timing App backed by the Land Transport Authority. We used this app as it represents the government standard for information on bus arrival.
- Busleh** - Award winning local Bus Timing App (Land Transport Excellence Awards 2016), We used this app to verify if wide consumption does indeed align with accurate and consistent information.
- Singabus** - A less widely used app. We used this app as a control set up to examine the performance of less popular apps.

The best app is defined as by its performance which demonstrates **accuracy** with **consistency**.



## INTRODUCTION

Have you ever wondered how accurate are the distinct bus arrival timing apps? You are not alone, many of us do too! With the ever-growing number of bus arrival apps today, it can be confusing for a user to choose between all the choices.

Knowing the exact bus arrival timing is highly essential, as it enables you to predict the **estimated time of arrival** (ETA) for your destinations, and can also help you make more accurate travel plans.

Therefore, this statistics research project focuses on finding out which bus arrival timing app is the **most accurate and consistent** in terms of predicting the arrival timing for each bus at every bus stop. We hope to find the "best" bus app once and for all, so that commuters can make the best decision for themselves, not to be stressed by the number of options available for them.

**Purpose:** Through data collection and thorough analysis via various methods, we want to promote the usage of the application which is the best at predicting bus arrival timings, so as to enable public transport users to plan their bus trips more accurately.

**Motivation:** As school going students, we commute using public buses frequently. Sometimes, we ended up significantly overestimating or underestimating the time taken to travel to and from school. As such, we realised the need for using an accurate bus arrival timing app, which is why we have embarked on this statistics project to investigate!

## RESEARCH QUESTION

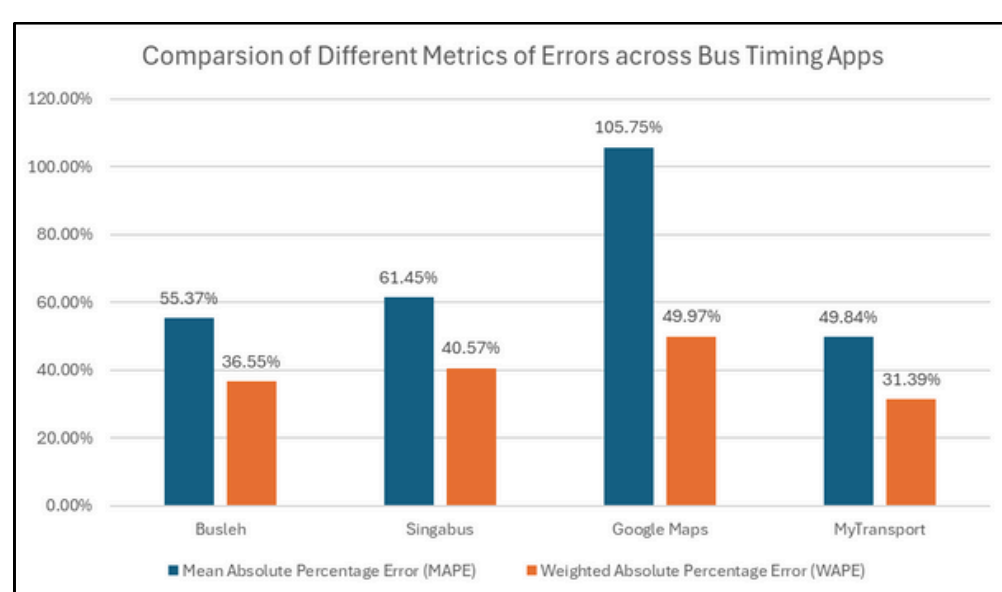
We wanted to determine **which commonly used bus timing app had the best overall performance**. We also were interested in investigating **if the performance of the bus arrival apps are affected by different periods of the day, specifically if they differ between day and night hours**.

Performance of the bus timing apps are measured in terms of **consistency and accuracy**.

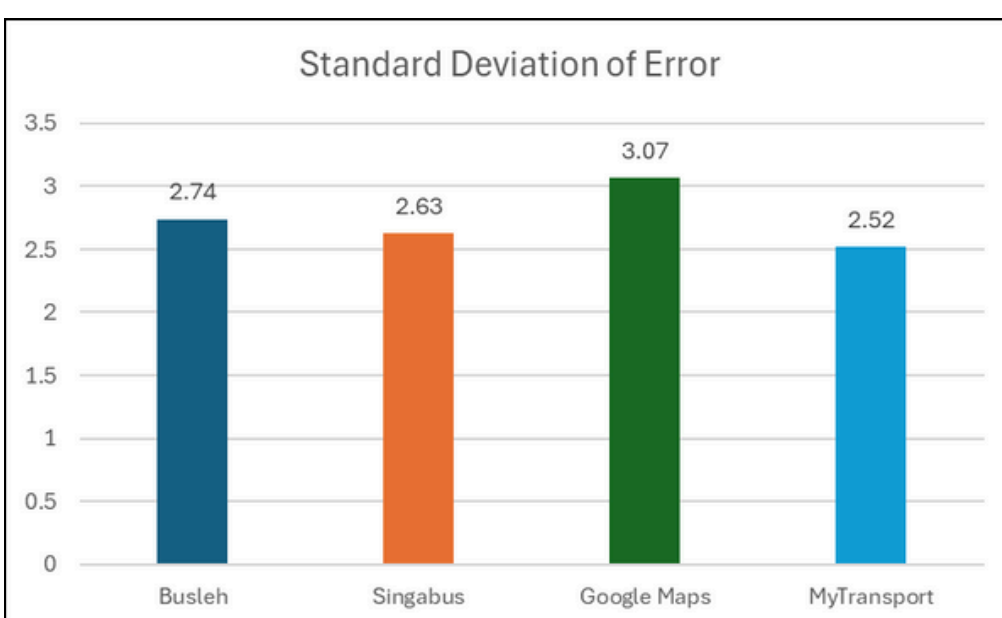
## ANALYSIS (RESEARCH QUESTION 1)

Among the four ETA applications, MyTransport recorded the **smallest magnitude of errors** across all three Error metrics, (MAPE: 49.84%, WAPE: 31.39%, SDE: 2.52), suggesting that it provided the **most accurate and consistent** estimates.

On the other hand, Google Maps recorded the **largest magnitude of errors** across all three Error metrics (MAPE: 105.75%, WAPE: 49.97%, SDE: 3.07), which suggests that it provided the **least accurate and consistent** estimates, with larger prediction errors and more extreme deviations. Moreover, it is important to note that an error of more than 100% will translate to the bus taking more than double the time of the estimated time arrival.



Graph 4: Mean and Weighted Absolute Percentage Error



Graph 5: Standard Deviation of Error

Focusing on the other 2 apps, Singabus and Busleh, careful analysis of the error metrics is needed to distinguish the differences in performance of these ETA apps. Busleh records a lower MAPE of 55.37% and WAPE of 36.55% than Singabus (61.45% and 40.57% respectively). This shows that Busleh's estimates are **more accurate** and tend to align more closely to the actual bus arrival timings on average.

On the other hand, Singabus obtained a lower SDE of 2.63 compared to 2.74 for Busleh. The error suggests Singabus has **more consistent** estimates as compared to Busleh. Hence, we can conclude that although Singabus is **less accurate** on average, it is **more consistent** as compared to Busleh.

## CONCLUSION

Hypothesis 1 is **not rejected**. This is because **MyTransport** consistently shows to be the **most accurate and consistent in scoring the lowest across various error metrics**.

Our **key findings** are

- My Transport is the **most accurate, and consistent** overall
- Google Maps is the **least accurate, and consistent** overall
- Busleh is **more accurate**, but **less consistent** than Singabus

MyTransport is thus the **most recommended app** to use to best plan your bus trips accurately. Followed by which come the apps, Singabus and Busleh respectively, and Google Maps comes in last place. This may be due to several reasons. Firstly, Google Maps gives the most inaccurate timings, because it is **not specialized to Singapore** for the **sole purpose of tracking** bus arrival timings. Moreover, it is not a locally developed app while the others are, which is also why inconsistencies tend to be more prevalent. Moreover, MyTransport is the official app of the LTA and receives its data directly from the API, unlike third party apps.

Hypothesis 2 is **not rejected**. This is because **majority** (3 of 4 apps) are **more accurate at night**, coupled with the fact that the app that is more accurate in the day (Google Maps), is the same app that gives the most inaccurate timings out of the 4 apps, a finding we obtained from research question 1. At the same time, exactly half the number of apps is more consistent at night while the other two are more consistent in the day. Hence, the overall performance of the apps is greater at night than in the day, with **more apps showing greater consistency or accuracy during the night than the day**. This can be explained by the fact that day hours are **more prone to unpredictable congestion** than night hours.<sup>(7)</sup>

Our **key findings** are

- Singabus is the **most accurate, and consistent** overall in the **day** (6-8am).
- Google Maps is **more accurate in the day** while Singabus, BusLeh, MyTransport are **more accurate in the night**.
- Singabus and Google Maps are **more consistent in the day** while BusLeh and MyTransport are **more consistent in the night**.
- Generally, **most apps show greater performance in the night**.

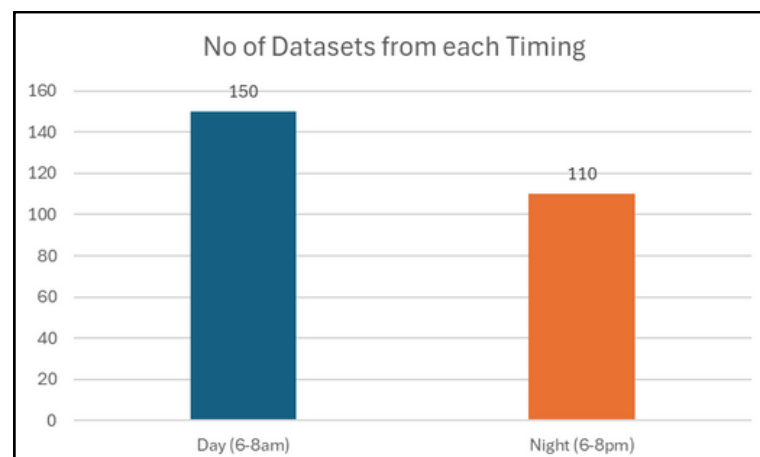
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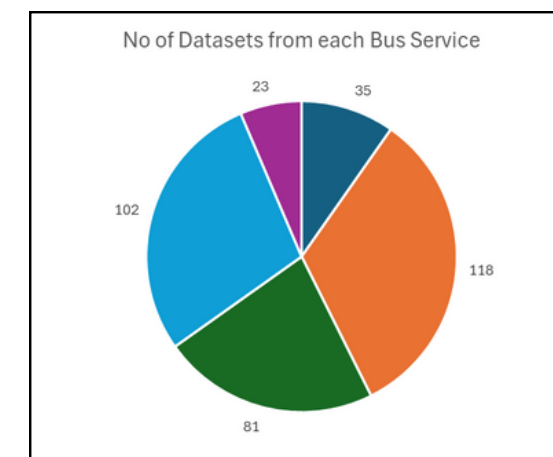
## METHODOLOGY

To collect a dataset everytime we commute, we will first open all the bus arrival apps (Google Maps, MyTransport, Busleh and SingaBus) and take a screenshot on the respective bus apps. We also start the stopwatch simultaneously. When the bus arrives and comes to a halt, we will stop the stopwatch. Lastly, we key in the data collected into a Microsoft Forms so that we can access the data conveniently for analysis. Through this data collection method, we obtained a total of **358 data samples**, from **104 bus trips**.

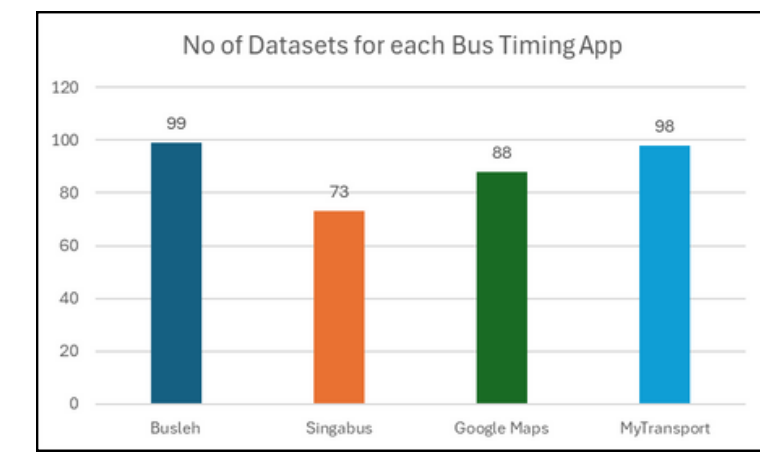
To answer the 2nd research question, we have chosen to analyse the data between the **day (6-8am)** and **night (6-8pm)** timings as both are during peak-hours. Peak hour is used as a controlled variable here to ensure that the difference in accuracy is only affected by the timing itself, due to the crowdedness of the stations or number of commuters.



Graph 1: Datasets from respective timings



Graph 2: Datasets from respective Bus Services



Graph 3: Datasets from respective Bus Timing Apps

With **similar amounts of data** for both day and evening timings, we are able to compare the effectiveness of the apps in the aspect of timings.

From Graph 2, we can see that the datasets are **split relatively equally** between the different bus services. This ensures that our dataset remains diverse and representative of the average bus in Singapore. Furthermore, as seen in Graph 3, we have collected a **large no. of samples** (>70) for each application, to ensure that any differences in accuracy and consistency are more likely **due to the capabilities of the apps** rather than **due to chance alone**.

## METRICS

**Mean Absolute Percentage Error (MAPE):** Gives the raw error percentage for each dataset. MAPE is good to make intuitive comparisons, but becomes **biased** when  $A_i$  is small.

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left| \frac{A_i - E_i}{A_i} \right| \times 100\%$$

**Weighted Absolute Percentage Error (WAPE):** Gives the weighted average of the errors. WAPE allows for a fairer comparison, as compared to MAPE as it **weights the data point** to the absolute value, reducing deviation due to small denominators and giving a more balanced value.

$$WAPE = \frac{\sum_{i=1}^n |A_i - E_i|}{\sum_{i=1}^n A_i} \times 100\%$$

**Standard Deviation of Error (SDE):** SDE accounts for how spread out the data points are away from the mean. A lower SDE indicates greater consistency. Typically, the SDE formula uses the value of n for the denominator. However, in our analysis, the value of n-1 is used instead. This is known as **Bessel's Correction**, and it accounts for the fact that the data collected represents only a small sample of all buses in Singapore. Using n-1 instead of n, offsets the bias that happens when estimating variability from limited data. Hence, the SDE determined reflects the variation of prediction errors more accurately in a wider population.

$$SDE = \sqrt{\frac{\sum_{i=1}^n (e_i - e_{mean})^2}{n - 1}}$$

**Legend:**

- A - Actual value
- E - Estimated value
- e - error

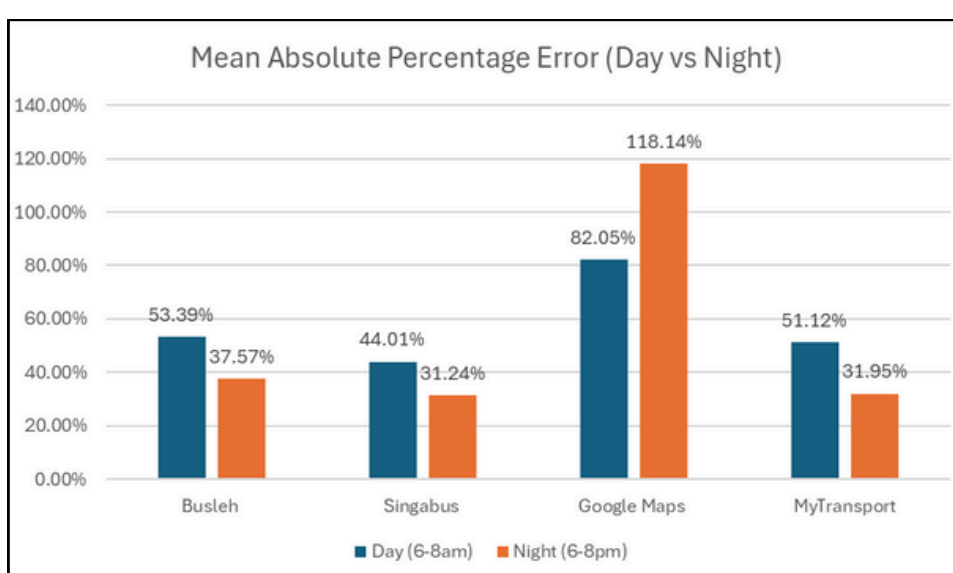
## HYPOTHESIS

**Background Information:** Maps functions globally using an open data format called GTFS Realtime, which primarily collects information from local transit agencies, specifically the LTA (Land transport authority in Singapore). Essentially all the four apps access their arrival data through LTA DataMall API, with Singbus, Busleh and MyTransport specialised to a local context. However, the performance of these apps differs due to factors such as Data Retrieval Frequency, processing algorithms, deviations in rounding, interpolation and user interface refresh rates.

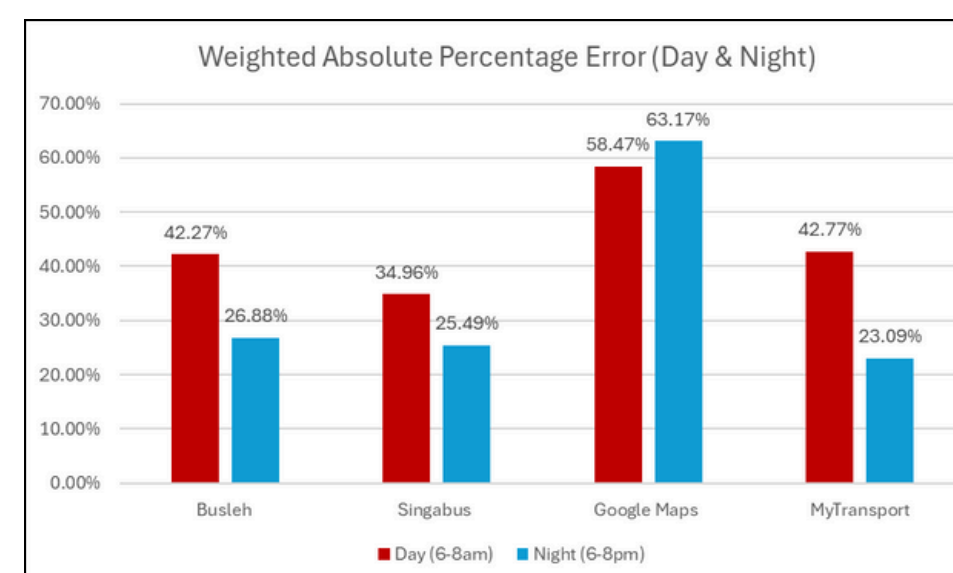
**Hypothesis 1:** We believe that **MyTransport** will be the **most accurate and consistent** Bus Timing App as it is the **Official App** maintained by the Land Transport Authority, (LTA) whom handle the data and real-time positions of buses directly. Hence, this app would most likely have the **highest Data Retrieval Frequency** out of the four apps.

**Hypothesis 2:** We believe that Apps achieve **greater overall performance at night** than as traffic patterns are often **more stable and consistent** compared to the day, as day hours are more prone to **unpredictable congestion** such as traffic jams and records **higher traffic volumes**, leading to greater variation in the actual duration for bus time arrivals.<sup>(7)</sup>

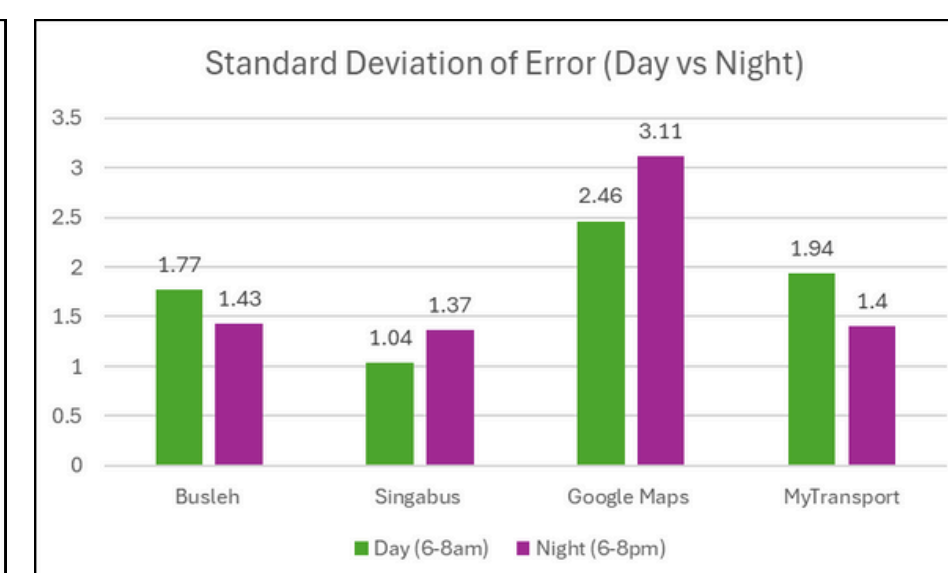
## ANALYSIS (RESEARCH QUESTION 2)



Graph 6: Mean Absolute Percentage Error at different times of the day



Graph 7: Weighted Absolute Percentage Error at different times of the day

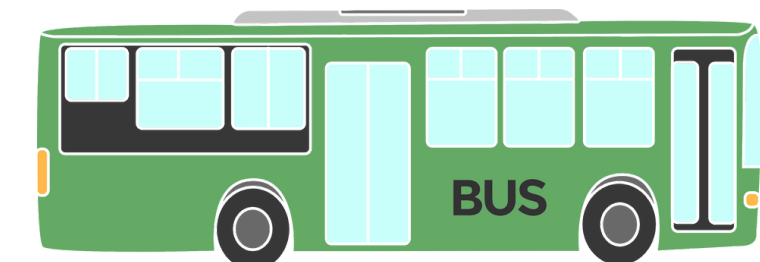


Graph 8: Standard Deviation of Error at different times of the day

To answer Our Second Research Question, Graph 6 & 7 shows that the Mean and Weighted Absolute Percentage Errors are lower at night than in the day for Busleh, Singabus and MyTransport. This means that on average, Bus Timing Apps like Busleh, Singabus and MyTransport are **more accurate at night**. However, it is important to note that Google Maps has a higher MAPE and WAPE at night (118.14% and 63.17% respectively) than in the day (82.05% and 58.47% respectively), which means that it is **less accurate at night**, unlike all the other bus apps.

In addition, from Graph 8, we can see that Singabus and Google Maps are **more consistent in the day** (6-8am) as it has a lower Standard Deviation of Error during the time period, while Busleh and MyTransport are **more consistent at night** (6-8pm) with a lower standard deviation of error during then.

Lastly, an interesting note is that Singabus has it has the lowest MAPE (44.01%), WAPE (34.96%) and Standard Deviation of Error (1.04) in the Day, making it the **most accurate and consistent** bus timing app in the **day** (6-8am).



## FUTURE STUDIES

**Limitations:** The dataset used for analysis only encompasses the trips that we took ourselves. Our data also lacked variations generally and in terms of the bus stops as the data we collected only had abundant readings at two bus stops for a bus 189 which were part of our daily route to and from school. Hence, the data collected is skewed towards the bus services that was studied. Moreover, the dataset we obtained does not represent all the bus trips but only a mild fraction of all bus trips around Singapore. This is also accompanied by the fact that the **sample size is limited**, as we had a **limited timeframe** for data collection.

**Future work:** In the future, we could try to have a more extensive data collection method, involving more people to collect data whenever they commute, and extend to significantly more bus routes, buses and bus stops. And this data collection can be conducted over a **longer time period** to increase the sample size, which would hopefully introduce a greater variation of . This will allow us to be able to come to a more accurate conclusion that is representative of the average user experience when using these Bus Arrival Timing Apps.

In addition, the research can be extended on whether the performance of these apps is affected by the **relative region** of Singapore, along with determining which app is the most accurate in this region. This can be done by sampling data from the 5 main regions of Singapore (North, South, East, West, Central) and analyzing them by the methods shown above, to see if there is any notable difference in accuracy depending on the region. Moreover, we can analyse if the performance different between **peak hour or non peak hour**, days of the week (**weekday or weekend**), and **does shorter time of arrival or larger time of arrival** affect the prediction accuracy and deviation in predictions by the apps.