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An Improvement Using Global Positioning System (GPS) and Cloud Firestore for Integration of Information System in Surabaya Public Transportation

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ABSTRACT
Surabaya is a developing city which has a significant growth in trades and services, thus requiring facilities and access in the field of transportation infrastructure. Surabaya has been fulfilled by adequate urban infrastructure. Therefore, not need to worry to reach all corners of Surabaya. Public transportation consists of share taxis, city buses, bus rapid transit, and commuter trains. There are many transportation modes in Surabaya, but there is no integrated information system of it. This study is to help passengers feel ease to access and choose any public transportation in Surabaya. The system provides recommendation best route, cheap ticket price, monitoring vehicle position, visualization on the map and arrival time while using public transportation in Surabaya. The practice has proved that the system has good usability and strong real-time. A positioning device is installed on every public transportation, where it will send the vehicle's position to the server. The integrated information system is based on Android with minimum Jelly Bean version. This research has two android mobile applications, they are naik.in for passenger which runs in user side and naik.in for driver which runs in vehicle side. The database used is cloud firestore.

Keywords: Mobile Application, Global Positioning System, Google Map APIs, Cloud Firestore, Hierarchical Data

INTRODUCTION

The transportation system is a basic element of infrastructure that have an impact on urban development. Transportation development has an important role in government policies and programs. Infrastructure development in transportation sector ultimately creates high costs. With the Surabaya's economic power, Surabaya has a strategic and crucial role in determining the direction of East Java Province's

policy. Surabaya has grown rapidly as a city of culture, education, tourism, maritime, industry and trade (Siti Aminah, 2007).

In recent years, smart public transportation is being developed in big cities include Surabaya. Public transportation in Surabaya leads to mass transportation. There will be people transport clusters that are integrated with various supporting facilities in Surabaya. Such as park and ride, it's one of the facilities being prepared to support this concept. Mayjen Sungkono's Park and Ride has functioned now. It's not only as a private vehicle parking building, in due course, the park and ride will be the location of integrated mass transit. Surabaya has been fulfilled by adequate urban infrastructure. Therefore, people not need to worry to reach all corners of Surabaya.

Public transportation currently available is share taxis, city buses, bus rapid transit, and commuter trains. But there is no integrated information system of it for passengers. Until now, there is only one mobile application that provides information on public transportation, which is GOBIS. The Transportation Department of Surabaya City created this Android-based mobile application and published it at Google Play Store to help passengers monitor Suroboyo Buses' movement between stops and their arrival and departing schedule at each stop (Dishub Surabaya City, 2019). This mobile application requires an internet connection to access real-time information on active Suroboyo Buses. The drawback of this application is that it is not integrated with other public transportation systems, which limit the users in determining the best way to reach their destinations.

Previous related research developed a mobile application on Android using Google Maps to give detail of route of particular chosen share taxi by a user. However, the app only provides limited information on which share taxi to use without other vital information such as the current position of the share taxi or the estimated charge for the trip (A. Noertjahyana, G. S. Budhi, and A. D. Andilolo, 2015).

Another related research is determining nearest bus stop search system and facilitating passenger in utilization of BRT (Bus Rapid Transit) using A* algorithm. Which is this algorithm a Best First Search algorithm that combines Uniform Cost Search and Greedy Best-First Search. However, the application only provides bus stops searching toward passenger. There is no tracking of public transportation, then the passenger can't know the current position of public transportation, then can't make sure the estimated arrival time (A. C. Pramudhita, Muljono, 2018). And also previous related research is guiding of hospital search using location based service with android platform in Semarang city. The research using Google Maps API and Global Positioning System (GPS). the application immediately shows the nearest route to hospital from user (M. Udka, R. R. Isnanto, R. Kridalukmana, 2015).

This study is to help passengers feel ease to access and choose any public transportation in Surabaya. The system provides recommendation best route, cheap ticket price, monitoring vehicle position, visualization on the map and arrival time while using public transportation in Surabaya. The practice has proved that the system has good usability and strong real-time. A positioning device is installed on every public transportation, where it will send the vehicle's position to the server. The integrated information system is based on Android. This research has two android mobile applications, they are naik.in for passenger which runs in user side and naik.in for driver which runs in vehicle side. The database is used cloud firestore. It's a flexible, scalable database for mobile from firebase and google cloud Platform.

METHOD

Stages of research development are consisting of few stages as shown in Figure 1, such as problem definition, determine purpose of research, review references, survey data, design system, design user interface, develop system at user side, develop system at vehicle side, user side testing system, vehicle side testing system, testing overall, conclusion discussion, and upload at play store.

Accurately describing the problem is important, such as in this study, problem definition is needed to looking for solutions. The research problem indicates the area of concern. Then the next stage is determining purpose of research, why the study is being conducted. The purpose is generated from the research problem and clearly focuses the development of the study.

Review related paper references step is carefully identifying and synthesize relevant literature to evaluate a specific research question, substantive domain, theoretical approach, or methodology and thereby provide readers with a state-of-the-art understanding of the research topic.

Data surveys are conducted to determine the location of bus stops, terminals, stations, and each public transportation routes. Every stop station with longitude and latitude provided is marked. If the stop station is unfamiliar, a survey directly to the location is needed to ensure the position of stop station. Table 1 shows sample of data survey, the variable taken are bus stop name, plus code on map, latitude point, and longitude point.

The design of system as shown in Figure 2, so far is for prototype. This prototype utilize firebase as data base server. Each data written such moving location will write into cloud. If there are so many movement, it needs a lot of storage and we limited the access just for three usages of each sample of vehicle. The limitation is based on free usage of Firebase provided by Google.

The GPS will be installed on the public transportations where the GPS is used to send the current position to the cloud. The GPS is available on driver's smartphone. The data recorded is vehicle position data such as longitude and

latitude. From the recorded data, user can monitor vehicle positions and visualize it on the map.

Specification of application for passenger side shown in Table 2 which require minimum OS version of android, target OS version of android, size of application, and supported screens. Table 3 shows the permissions of application which include access fine location, foreground service, access network state, and access coarse location. And also Table 3 shows features of application that contain faketouch and location.

Specification of application for driver side shown in Table 4 which require minimum OS version of android, target OS version of android, size of application, and supported screens. Table 5 shows the permissions of application which include access fine location, foreground service, access network state, and internet. And also Table 5 shows features of application that contain faketouch and location.

Fig. 1 Stages of Research Development

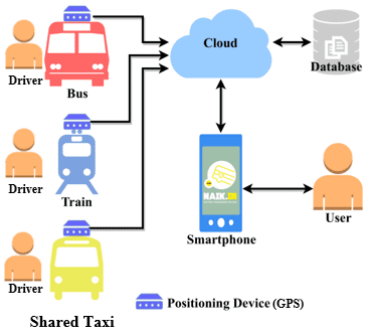


Fig. 2 Design of System

Table 1 - Bus Stop Data Survey.

Bus Stop	Plus Code	Latitude	Longitude
Taman Pelangi	MPJJ+9X Surabaya	-7.319051	112.7236953
RS Bhayangkara	MPGJ+6Q Surabaya	-7.3244322	112.7297488
UBHARA	MPHM+C3 Surabaya	-7.3214322	112.7304988

Table 2 - Application Details for Passenger Side.

Item	Name
Minimum OS Version	Jelly Bean 4.1, 4.1.1
Target OS Version	Pie 9.0
Size	15.31 MB
Supported Screens	Small, Normal, Large, Xlarge

Table 3 - Features and Permissions for Passenger Side.

Item
android.permission.ACCESS_FINE_LOCATION
android.permission.FOREGROUND_SERVICE
android.permission.ACCESS_COARSE_LOCATION
android.permission.ACCESS_NETWORK_STATE
android.hardware.faketouch
android.hardware.location

Table 4 - Application Details for Driver Side.

Item	Name
Minimum OS Version	KitKat 4.4
Target OS Version	Pie 9.0
Size	5.51 MB
Supported Screens	Small, Normal, Large, Xlarge

Table 5 - Features and Permissions for Driver Side.

Item
android.permission.ACCESS_FINE_LOCATION
android.permission.FOREGROUND_SERVICE
android.permission.ACCESS_NETWORK_STATE
android.permission.INTERNET
android.hardware.faketouch
android.hardware.location

UML

Figure 3 shows the usecase diagram of the research. There are two actors in the diagram; passenger and driver. Naik.in application on passenger side provide

information about the trip route, estimated trip charge, vehicle schedule, and vehicle position. Naik.in application on driver side provide a button to start and stop sharing vehicle position.

Naik.in activity diagram of Passenger Side shown in Figure 4. If passenger click icon naik.in on the desktop of android mobile device, then the application will show flashscreen. After display flashscreen, the application will show map with current position and main menus on the bottom. Main menu contains information about vehicle preference. The passenger can choose bus or share taxi or train button to know more about schedule or operational time, ticket price, tracking vehicle, routes, and estimated arrival time.

Naik.in activity diagram of Driver Side shown in Figure 5. If driver click icon naik.in for driver on the desktop of android mobile device, the application will show the labels and text fields about transportation type, transportation route, and transportation id. Also start button can send current position to be stored in database server. The start button can switch to be a stop button.

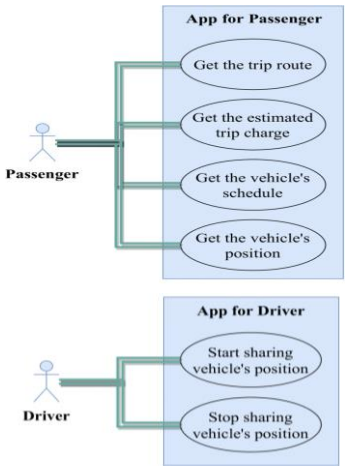


Fig. 3 Usecase Diagram

Location Based Service (LBS) and Global Positioning System (GPS)

Location Based Service (LBS) is an information services that can be accessed by mobile device via mobile network, which is capable to utilize location of mobile device (Aljufri Fatimah, 2012). LBS provides the possibility of two-way communication. Therefore, the user tells the service provider to get the information needed, by reference to the user's position. LBS are in the presence of three technologies, namely Geographic Information System (GIS), Internet Services, and Mobile Devices.

Android's location-based services manage technologies like GPS and Google's cell-based location technology to determine the device's current position. These services enforce an abstraction from specific location-detecting technology and let you specify minimum requirements rather than choosing a particular

technology. It means that your location-based applications will work no matter what technology the host handset supports. To combine maps with locations, Android includes an API for forward and reverse geocoding that let you find map coordinates for an address and the address of a map position (Reto Meier, 2009). Figure 6 shows location based service architecture.

Global Positioning System (GPS) is a satellite navigation system used to determine the ground position of an object. GPS system includes 24 satellites deployed in space about 12,000 miles (19,300 kilometers) above the earth's surface. GPS technology was first used by the United States military in the 1960s and expanded into civilian use over the next few decades. Today, GPS receivers are included in many commercial products, such as automobiles, smartphones, exercise watches, and GIS devices (Global Positioning System, 2019). The Android SDK includes APIs for location-based hardware such as GPS.

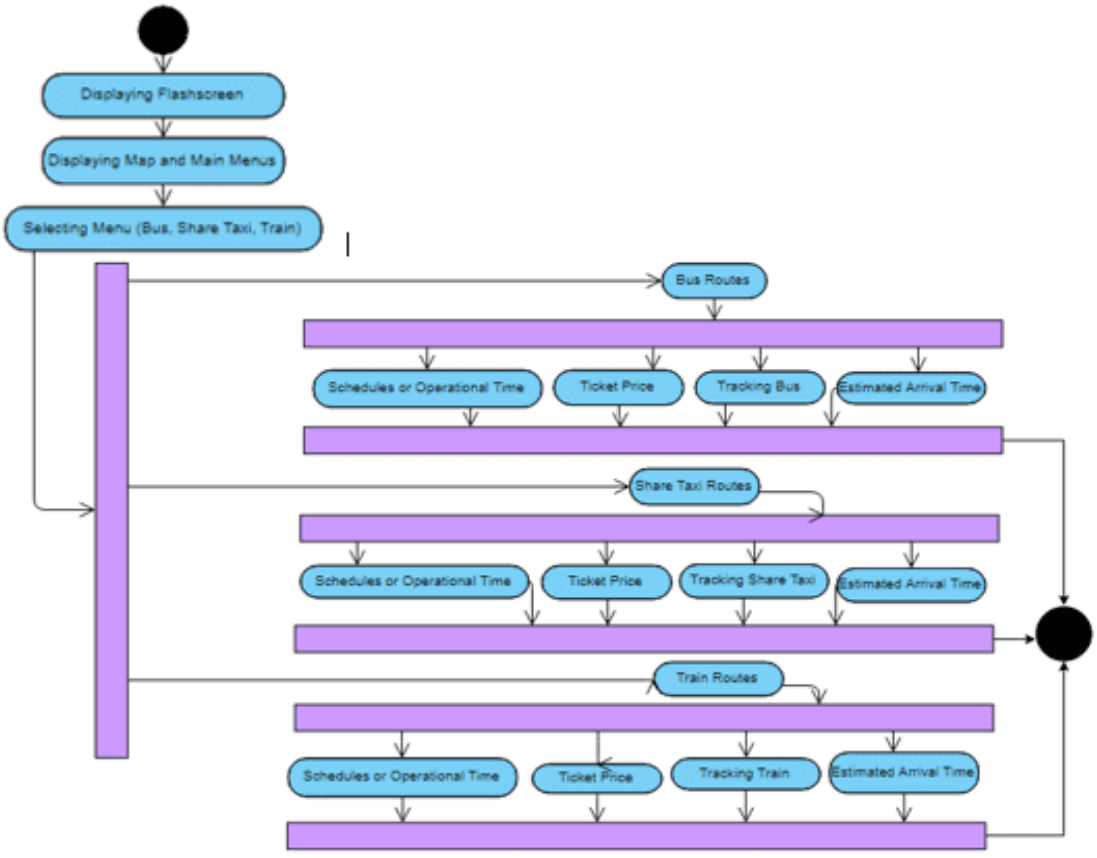


Fig. 4 Naik.In Activity Diagram of Passenger Side

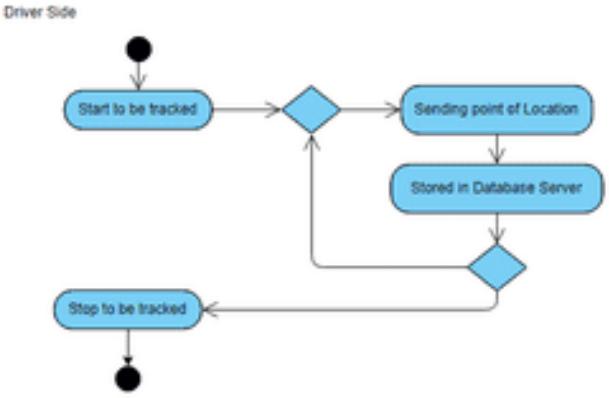


Fig. 5 Naik.In Activity Diagram of Driver Side

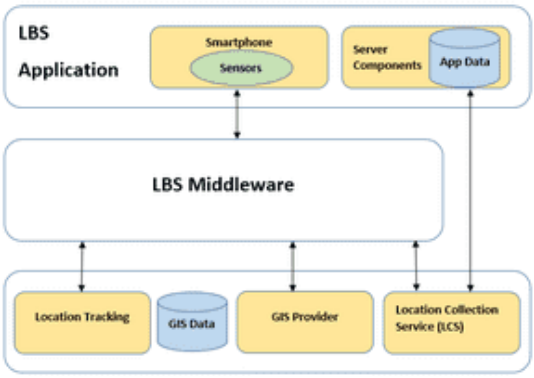


Fig. 6 LBS Architecture

Google Maps APIs

Google Maps is a free Google service that is quite popular. Developers can add Google Maps features in an Android application with the Google Maps application programming interfaces (APIs). By using the Google Maps APIs, developers can save time and costs of building a reliable digital map application and can focus more on the data.

To use Google Maps APIs, we first login to the Google Console. A new project is required to get an API key from the Google Console. The example of a retrieved Google API key. These keys were then added to our server so the Google Map can be integrated into the mobile application.

Database

Firebase is used as a realtime database platform to make it easier for android application developers to develop their applications without having a big effort. The Firebase feature is available for Android, iOS and the Web. In Firebase there is a Firebase Console which is a web front end for managing Firebase developer projects.

This study uses cloud firestore from firebase. Cloud Firestore is a flexible, scalable database for mobile, web, and server development from Firebase and

Google Cloud Platform. Like Firebase Realtime Database, it keeps data in sync across client apps through realtime listeners and offers offline support for mobile and web so developer can build responsive apps that work regardless of network latency or Internet connectivity. Cloud Firestore also offers seamless integration with other Firebase and Google Cloud Platform products, including Cloud Functions (Firebase Official, 2019).

The Cloud Firestore data model supports flexible, hierarchical data structures. Store your data in documents, organized into collections. Documents can contain complex nested objects in addition to subcollections. Like Realtime Database, Cloud Firestore uses data synchronization to update data on any connected device. However, it's also designed to make simple, one-time fetch queries efficiently.

This research uses hierarchical data in Figure 7. Transport has SBY_BUS, SBY_SHARED_TAXI, and SBY_TRAIN. Each SBY_BUS has many routes, one of the example is PUR_JMP. Each SBY_SHARED_TAXI has many routes, one of the example is KM_SDY. Each SBY_TRAIN has many routes, one of the example is SUB_PRG.

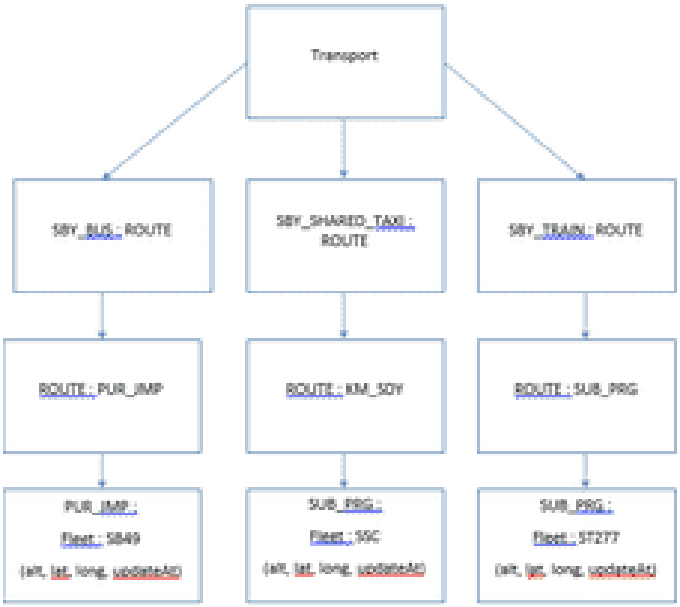


Fig. 7 Hierarchical Data

RESULTS AND DISCUSSION

This section explains the results of the research. It includes User Interface (UI), Cloud Firestore, and Software Testing.

User Interface (UI)

User interface is made by android studio which provides variety of UI components, UI controls, and UI modules. Making it easier for developers to make user interface for their mobile application. Table 6 shows the list of features on the

research. Developer makes two user interface for passenger and for driver. This naik.in mobile application use Indonesian Language in hope many people from various ages can access it easily.

Figure 8 shows User Interface of Naik.in For Passenger. From those page, passenger can select which one of public transportation will be used. Those page also shows the current location of passenger.

If the bus button is selected, then the list of bus routes will appears as shown in Figure 9 (a). From those page, passenger can select which one of bus will be used. Those page also shows the operational time and ticket info as shown in Figure 9 (b). If passenger select one of bus route, it will show the location of the bus so the passengers can track the bus in real time. It will also show the bus stop which passed by the bus. Red line as shown in Figure 9 (c) is to represent the routes traversed. If passenger click the bus icon on the map, it will show the name of bus stop as shown in Figure 9 (d). These schemes go on the same for the shared taxi button on Figure 10 (a) – (e) and train button on Figure 11 (a) – (c).

Table 6 - List of Features.

Application Name	Features	Sub-Feature	Details
Naik.in For Passenger	Display Map		
	Set Current Position		
	Bus	Display Bus Stop	
		Display Bus Routes	Represented by red line on map
		Schedule/OperatingTime	
		Ticket Price	
		Bus Tracking (show the bus position)	
	Share Taxi	Display Share Taxi Stop	Represented by yellow line on map
		Display Share Taxi Routes	
		Schedule/OperatingTime	
		Ticket Price	
		Share Taxi Tracking (show the share taxi position)	
	Train	Display Station	Represented by blue line on map
		Display Train Routes	
		Schedule/OperatingTime	
		Ticket Price	
		Train Tracking (show the bus position)	

Naik.in For Driver	Stop	Disable to share position
	Start	Enable to share position

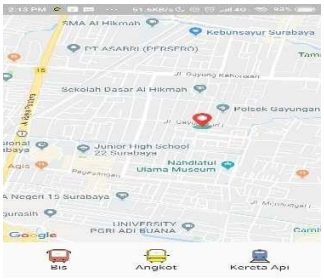
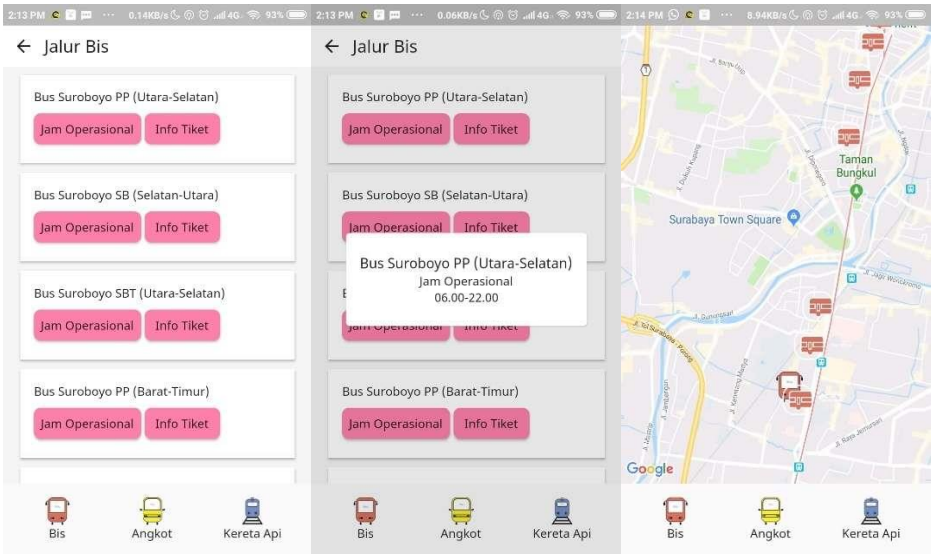
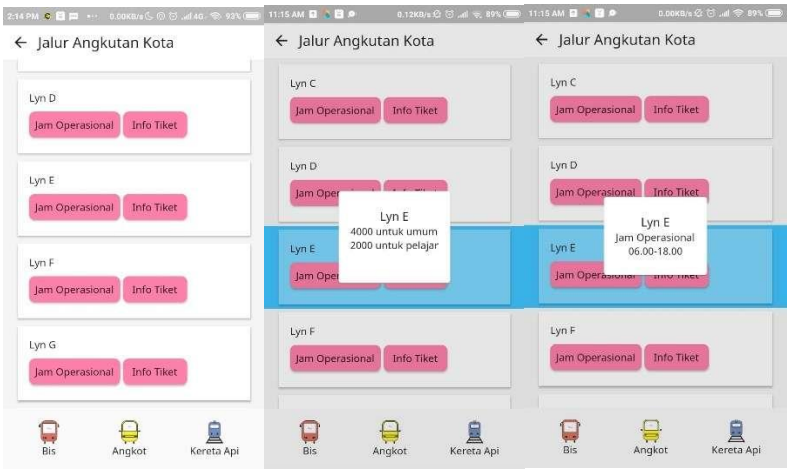


Fig. 8 Main Menu of Naik.in for Passenger

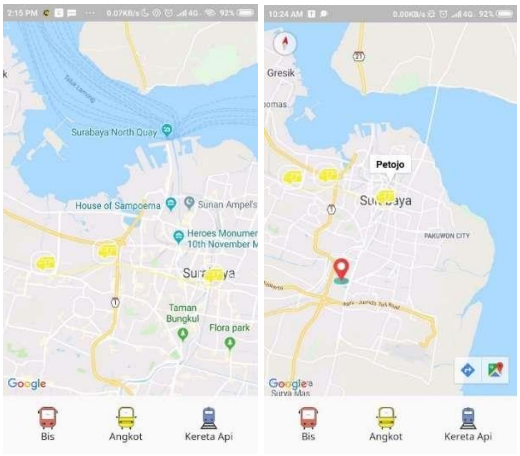


(a) (b) (c)

Fig. 9 Naik.in for Passenger (Bis Selected)

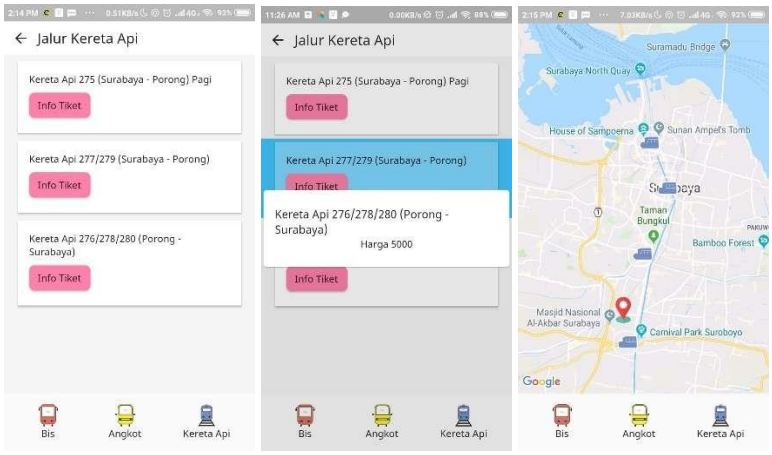


(a) (b) (c)



(a) (b)

Fig. 10 Naik.in for Passenger (Shared Taxi Selected)



(a) (b) (c)

Fig. 11 Naik.in for Passenger (Shared Taxi Selected)

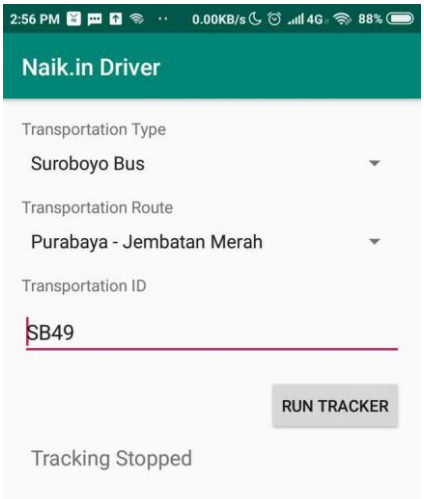


Fig. 12 Naik.in for Driver (State : Tracking Stopped)

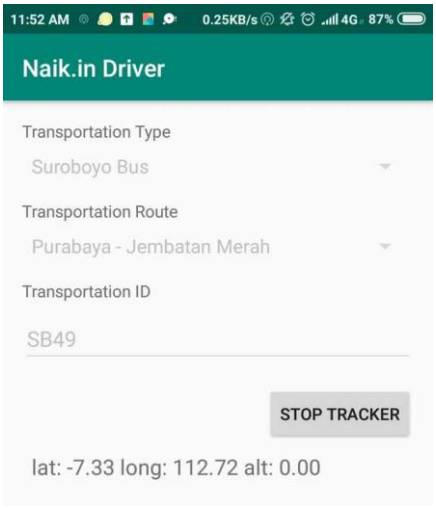


Fig. 13 Naik.in for Driver (State : Tracking Started)

Fig. 14 Buses Movement

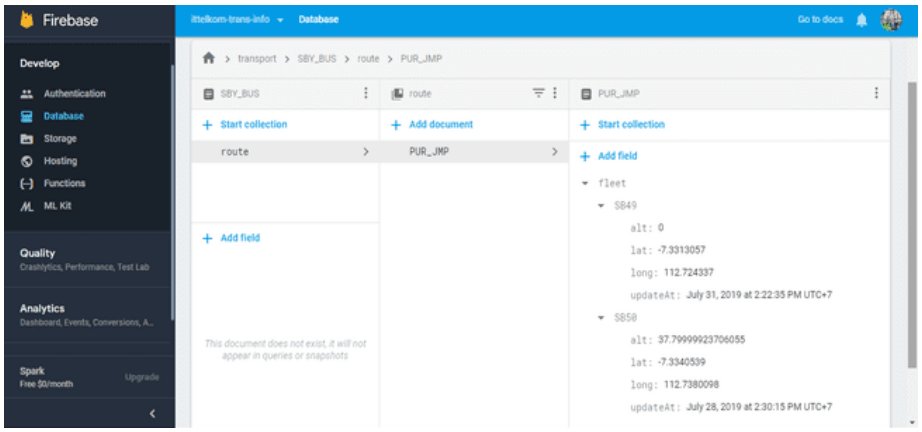


Fig. 15 Dashboard Firestore Database

```
rules_version = '2';
service cloud.firestore {
  match /databases/{database}/documents {
    match /{document=**} {
      allow read, write: if true;
    }
  }
}
```

Fig. 16 Rules of Database

Figure 12 shows User Interface of Naik.in For Driver. From this page, driver can choose transportation type and transportation route from the vehicle being driven. Then, filling in the edit box of transportation id. After that, the driver can select run tracker button to enable sharing location so the passenger can track the movement of the vehicle. If the driver won't to share the vehicle location because of operational time has finished, the driver can click stop tracker button as shown in Figure 13. This user interface is also show the current location of the vehicle by giving latitude, longitude, and all updated location in every 5 seconds. For example the bus movement as shown in Figure 14.

Cloud Firestore

Cloud firestore as services belonging to the google cloud platform where provided SDK to be able to use firestore via firebase (Kenji A, Hendrawan A, C. Pikerling, 2020).

This research uses cloud firestore as database to save the data movement of vehicles. Figure 7 shows the hierarchical data. Implementation of data, documents, and collection shown in Figure 15.

The database is divided into small part using collection as the outer part. Inside the collection there are documents which have many data used in each field. For example, this research has "fleet" collection which has various data as shown in Figure 15. Documents within the same collection can have different fields or can store different types of data in the fields.

This research uses database rules as shown in Figure 16. Cloud Firestore Security Rules allow developer to control access to documents and collections in our own database. The flexible rules of syntax allow developer to create rules that match with anything, from writing the entire database to operating on a specific document.

Software Testing

Testing on an application aims to check whether a program is running properly so that the program created will be a program that has good quality (Fadhila C. N, Dandi S, Sita A, Handika A, dan Aries S, 2020).

Software testing is one of the stages in life cycle of software development (Egia R.S, Danang W.U, 2016). Software testing is a process for look for errors in any software item, record the results, evaluate every aspect on each component (system) and evaluate the facilities of the software to be developed (Desy I. P, Misbahul A, Arvianti Y. M, Nindy I, Sandy G. P, Seria R. D. A, Nadia W. N, 2020) (Agus Pamuji, 2018).

In this section, this step is explained a process to evaluate the functionality of each features on this application. This step is important to know software bugs. Based on Table 7 and Table 8, all of features on application is already succeed.

Table 7 - List of Naik.In Passenger Features.

Item	Name
Features Name	Testing Result
Display Map	Succeed
Set Current Position	Succeed
Display Bus Stop	Succeed
Display Station	Succeed
Schedule/OperatingTime	Succeed

Table 8 - List o Naik.In Driver Features.

Features Name	Testing Result
Filter of Transportation Type	Succeed
Filter of Transportation Route	Succeed
Filter of Transportation Id	Succeed
Start Button	Succeed
Show the movement position	Succeed
Stop Button	Succeed

Discussion

This research was tested with a limited number of users. For the future, it can be tested with more users (as passenger or driver) so that the performance can be seen from both the mobile application and the server.

The results of the trials that have been carried out have resulted in the conclusion that the application and server have a fairly good performance where the server can serve user requests with a small number of users.

CONCLUSION

The system currently use GPS to determine position, Google Map APIs, and firebase cloud firestore to store data in real-time. It enables passengers to track the public transport vehicle in real-time. Passengers can choose their preferred means of public transportation, schedule and the travel expands. The vehicle's position can also be monitored in real-time through the app, originating from the positioning device installed on each vehicle. The future works include employing an independent database and integrate it with the current application.

This system is always use GPS to show the position or to share the position; therefore, this application needs battery as source of energy. It’s recommended to charge smartphone during sharing position.

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