Analysis of estimated buses arrival time on public transportation using real-time monitoring

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Abstract. The purpose of this study is to create a system that can inform the bus position and provide information about the arrival time of the bus. We propose real time monitoring of the position and estimated time of arrival of Damri buses using the Haversine formula. GPS devices that are applied to each bus are monitored by utilizing passengers’ cellular applications. The results show information about the position of the bus and estimated time of arrival of the bus at each stop. This research can help estimate the arrival time, especially in providing information about the certainty of bus arrival to prospective passengers who are waiting at each stop according to the bus destination.

1. Introduction

To realize infrastructure development in urban areas, it is necessary to create a reliable transportation system for the entire community. Damri Bus is one of the public transportation vehicles in Indonesia, mainly used in the city of Bandung. With this, Damri is expected to be able to meet the needs of community movements and overcome congestion by combining several urban transportation routes into Damri bus transportation routes. However, the level of Damri bus transportation services is still considered not optimal at this time. In some cases there are complaints with public transport performance, including frequent overload, inadequate vehicle quality, and slow travel speeds [1].

It was found that based on the results of score analysis [1], the value of user perceptions of time travel performance stated that it was sometimes late Damri bus AC at 88.10 which shows a negative value of 11.90%, with the value of this variable getting a score of 1 or unsatisfactory performance. Whereas for Damri non-AC bus transportation there is no difference with AC Damri bus transportation, with a perception value of a delay performance of 67.24%, which shows a negative value of 32.76%, with this variable gain score 1 or unsatisfactory performance.

This shows that the travel time for Damri AC and Non AC buses is no different [2]. The second type of bus from Damri buses has very poor or unsatisfactory performance. The poor performance of travel time is greatly influenced by road routes that have high activity and are often jammed, also caused by the behaviour of vehicle crews who often drop passengers in any place. In addition to traffic jams in the middle of the road, this is also because Damri buses do not have their own lanes like Jakarta Busway which already has its own lanes.

To overcome the problem of unexpected travel times from Damri buses and to help Damri passengers know the arrival time of Damri buses is easy; a reliable method of estimating travel time is needed [3]. We propose using REMOT (Real-Time Monitoring) to determine the location of Damri buses. By
utilizing a GPS device that is applied to each bus and then the data will be processed in such a way that it can be monitored by utilizing a cellular application by the passenger. With this system, it is expected to help provide information about bus arrivals to prospective passengers waiting at each stop to the destination bus.

2. Methods
The research location is in the Bandung city area and uses Damri buses as the object of study where the route studied is Ledeng-Leuwipanjang. The process of research methods carried out can be seen in the following diagram.

![Flowchart of research method.](image)

The source of research data is obtained through observation and interview. The observation process is done by making direct observations to observe the conditions in several Damri stops. Observations were made, namely at the bus stop that passed the Damri Ledeng-Leuwi Panjang bus route. While a direct survey by conducting an interview process at the Damri stop on the Ledeng-Leuw Panjang route. Interviews were conducted with officers and prospective passengers. Interviews conducted to bus stop staff are about conditions at the bus stop and problems faced by bus stop staff. Interviews conducted with prospective passengers are about their waiting time and satisfaction in using Damri buses.

Real-time monitoring of Damri buses uses GPS technology which consists of several stages. The stage starts from GPS satellites that send data to the GPS module, then the system will receive data and parse data to obtain latitude, longitude and speed data. Data will be displayed on a special application for vehicle tracking.

3. Results and discussion
In this research, our tracking process uses GPS Tracker TK110 and to see the bus position in real-time we use the android and web applications that can be used free of charge by any GPS device, namely IDTrack and [http://server-gps.com](http://server-gps.com). The tracking process can only be done in real-time, information
obtained from the GPS server application is the coordinates of the vehicle's position, the speed of the vehicle's speed, and the address of the position of the vehicle's position located.

Figure 2. GPS tracked TK110.

Figure 3. IDTrack application for tracking process.

Figure 4. Tracking process with web http://server-gps.com.
Data collection was carried out by physical measurements, namely taking latitude and longitude coordinates from the stop location on the Damri Ledeng-Leuwi Panjang bus route, namely the distance between stops, estimated travel time data, and average bus speed obtained from direct survey results in the field. Latitude and longitude, shown in Table 1.

| Bus Stop       | Latitude | Longitude   |
|----------------|----------|-------------|
| Ledeng         | -6.85961 | 107.59515   |
| Setiabudhi     | -6.874403| 107.59613   |
| Sukajadi       | -6.881009| 107.5964    |
| RSHS           | -6.898963| 107.59752   |
| Braga          | -6.914474| 107.60906   |
| Otto Iskandar Dinata | -6.933925| 107.60328   |
| Leuwi Panjang  | -6.85961 | 107.59515   |

After seven tracking processes are carried out on Damri buses, the average Damri bus travel time is obtained from one stop to another. This process can be seen in Table 2.

### Table 2. Average of destination time.

| Departure Stop       | Destination Stop       | Time Passed of Bus | Average of Destination Time (Minutes) |
|----------------------|------------------------|--------------------|---------------------------------------|
| Ledeng               | Setiabudhi             | 10 12 15 13 11 10 11 | 11.71                                 |
| Setiabudhi           | Sukajadi               | 3 3 2 2 2 5 1 | 2.57                                  |
| Sukajadi             | RSHS                   | 7 9 11 8 13 19 | 12.14                                 |
| RSHS                 | Braga                  | 9 13 10 9 12 15 12 | 11.43                                 |
| Braga                | Otto Iskandar Dinata   | 14 11 12 7 19 19 19 | 14.43                                 |
| Otto Iskandar Dinata | Leuwi Panjang          | 17 10 14 14 13 14 13 | 13.57                                 |

Table 2 shows that the average travel time for Damri buses has been obtained from one bus stop to another. Data can be used as a prediction to determine the estimated bus arrival time for each event, to find out the bus arrival time.

Before getting an estimated bus arrival time at each stop, we need to know the distance from one stop to another using the Haversine method. The distance calculation process using the Haversine method is shown in Table 3. Haversine is a method for determining the distance between two points by considering that the earth is not a flat plane but a plane that has a degree of curvature. The Haversine method calculates the distance between two points based on a long straight line between two points at latitude and longitude [4,5].

Haversine method is formulated as follows.

\[
\Delta lat = (lat_2 - lat_1)
\]
\[
\Delta long = (long_2 - long_1)
\]
\[
a = \sin^2\left(\frac{\Delta lat}{2}\right) + \cos(lat_1) \cdot \cos(lat_2) \cdot \sin^2\left(\frac{\Delta long}{2}\right)
\]
\[
c = 2 \cdot \tan \cdot 2\left(\sqrt{a}, \sqrt{1-a}\right)
\]
\[
d = c \cdot R
\]
With the following caption:
\( \Delta Lat = \) The amount of change in latitude
\( \Delta Long = \) The amount of change in longitude
\( D = \) Distance (km)
\( R = \) Earth radius = 6371 km
\( 1 \) degree = 0.0174532925 radians
\( c = \) Calculation axes intersect

### Table 3. Calculation of distances based on the Haversine method.

| Departure stop | Latitude 1 | Longitude 1 | Destination stop | \( d \) (°) | \( d \) (km) |
|----------------|------------|-------------|------------------|------------|------------|
| Ledeng         | -6.85961   | 107.59515   | Setiabudhi       | 94.39065419| 1.6474276  |
| Setiabudhi     | -6.874403  | 107.59613   | Sukajadi         | 42.1116636 | 0.7349872  |
| Sukajadi       | -6.881009  | 107.5964    | RSHS             | 114.5355623| 1.9990226  |
| RSHS           | -6.898963  | 107.59752   | Braga            | 115.4467029| 2.014925   |
| Braga          | -6.914474  | 107.60906   | Otto Iskandar Dinata | 127.3932698| 2.2234319  |
| Otto Iskandar Dinata | -6.933925 | 107.60328  | Leuwi Panjang   | 87.36354528| 1.5247815  |

**Total of Distance** 10.144576

After getting the distance from one stop to another, we can calculate to find the estimated bus arrival time based on the distance known as the haversine method and the average speed obtained from the average speed of Damri buses every day. Estimated bus arrival times based on the haversine method are shown in Table 4.

### Table 4. The travel time of bus based on the Haversine method.

| Departure Stop      | Destination Stop       | Bus Travel Time (Minutes) |
|---------------------|------------------------|----------------------------|
| Ledeng              | Setiabudhi             | 9.6                        |
| Setiabudhi          | Sukajadi               | 4.2                        |
| Sukajadi            | RSHS                   | 12                         |
| RSHS                | Braga                  | 12                         |
| Braga               | Otto Iskandar Dinata   | 13.2                       |
| Otto Iskandar Dinata| Leuwi Panjang          | 9                          |

Table 5 shows two bus trip time results obtained based on the tracking process and based on distance calculation using the Haversine method. From Table 5, it can be seen when there are differences in Damri bus trips at each stop. This happens because in the process of tracking data obtained in the process of tracking direct trips through the route that is indeed passed by Damri buses. While the results of calculating the bus travel time using the Haversine method depends on the results of distance calculations, while drawing a straight line from one stop to another to get the distance. But on the route, the Damri bus route is winding, a straight line cannot be drawn to find out the actual distance.
Table 5. The travel time of the bus based on the tracking process and based on distance calculations using the Haversine method.

| Departure Stop | Destination Stop         | Bus Travel Time (Minutes) | Time Difference (Minutes) |
|----------------|--------------------------|---------------------------|---------------------------|
|                |                          | Tracking Process          | Haversine Method          |                          |
| Ledeng         | Setiabudhi               | 11.71                     | 9.6                       | 2.11                     |
| Setiabudhi     | Sukajadi                 | 2.57                      | 4.2                       | 1.63                     |
| Sukajadi       | RSHS                     | 12.14                     | 12                        | 0.14                     |
| RSHS           | Braga                    | 11.43                     | 12                        | 0.57                     |
| Braga          | Otto Iskandar            | 14.43                     | 13.2                      | 1.23                     |
| Otto Iskandar  | Dinata                   |                           |                           |                          |
| Dinata         | LeuwI Panjang            | 13.57                     | 9                         | 4.57                     |

From the two research processes conducted above, we have obtained data on Damri bus travel times from one bus stop to another. Based on the Damri bus travel time, we can make it as a prediction to determine the estimated arrival time of the bus. Thus, we can find out the position of the bus directly by using the IDTrack application, while knowing the estimated arrival time of the bus can be adjusted to the process of tracking bus trips through the IDTrack application that can be seen in real-time.

4. Conclusion

Average travel time in the research table can be used as a prediction of bus arrival time at each stop. The expected results of research on analyzing the estimated arrival time of Damri buses in real-time is to be able to provide information to the public about the whereabouts of the bus through the application and find out travel time from one stop to another and to find out the estimated time of arrival of the bus. The results of this study are expected to be a reference for further research in order to display predictions of bus arrival times in an application.

References

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