Smart bus transportation for tracking system: A study case in Indonesia

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Abstract. The current public transportation system must improve the quality of its services so that they can go hand in hand with technological advancements. Transportation, as a supporter of economic progress and development of the country, is expected to be able to answer the high mobility of the community of transportation needs by utilising the expansion of existing technology. Tracking and monitoring bus locations as public transportation is now an important issue that needs attention, but there is no bus tracking system based on mobile that can provide real-time locations. The research aimed to design a wireless sensor network that automatically identified and provided accurate information about travel routes and the movement of public transport buses in real-time. By using Global Positioning Systems (GPS) as vehicle tracking systems and sensor that support, this application provided bus position information and the nearest bus route recommendations to users in real-time. Thus contributing to the time management of public transport users in their activities.

Keywords: tracking system, bus transportation, mobile application

1. Introduction

Along with the advancement of information technology today, the public transportation system continues to innovate in order to improve the quality of its services to the community. With an 2.35% increase in the development of bus use from the total population of Indonesia, which now reaches 266.91 million people, this certainly presents an important challenge for public transport service provider authorities on how to take advantage of existing information technology advancements, in order to support the high mobility of the public towards the use of public transportation facilities [1]. This is also supported by its rapid development online-based transportation in Indonesia[2].

Public transportation which currently has good access and makes it easy for the public is a bus because it has affordability rates for long and near distances. And usually, public transportation systems such as buses, estimate the arrival time of a bus manually based on the time of departure of the bus from the starting point to the endpoint where the bus arrives[3].

Bus transportation modes can experience various obstacles in the form of late arrivals and non-conformities with the estimated arrival time [4]. The problem of bus delays is an important problem because it involves issues of time efficiency and the effectiveness of using these modes of transportation. Many factors can cause bus delays, including weather, traffic jams, and so on[3].

It is necessary to develop a system of tracking and monitoring the actual location of the bus, so that it can inform about the estimated time of arrival of the bus, the location where the bus is located and can
recommend the nearest travel route to the user's destination. In addition, information systems are clearly a key element of the success of public transportation, because quality public transportation can provide accurate bus arrival information, bus position information and travel time required[5].

The design of the bus transportation system for tracking and monitoring bus locations requires IoT (internet of things) technology to connect various devices in real-time, combining Global Positioning System (GPS) technology and Open Source Radio Frequency Identification (microcontroller) technology RFID and Arduino, proving that real-time bus tracking for better transportation management is possible [3]. Because bus tracking via GPS can provide location accurately and effectively, then the use of microcontroller devices functions to connect various devices with the internet.

From these problems, the research tries to design a real information system for tracking and monitoring bus transportation by focusing on developing mobile-based applications that can track and display bus locations in real-time, as well as information about the nearest route to the user's destination mode of bus transportation.

2. Literature review

The public transportation system is an important part of urban transportation, which is useful to meet the basic needs of citizens' trips[6], the basic travel needs of citizens can be met if the mode of public transportation is designed as well as possible to answer the high mobility of the community.

With the development of technology, the public transportation system refers to an intelligent system [4][7], which is proven to have significantly increased the level of public transportation services and the level of user satisfaction, namely by increasing the utilization of transportation resources and reducing passenger travel time [6][8].

The smart public transportation system, utilizing internet support, known as IoT that can be applied in various fields of research. IoT is concerned with building a network of devices that support the internet to develop an intelligent environment[9]. As with the use of mobile devices, which can provide the concept of bus movement in real-time [6][7][10], so that it can overcome the problem of tracking and monitoring buses manually. Bus tracking and monitoring are one of the main problems in the public transportation sector [3][6]. Bus tracking and monitoring using mobile devices can also be designed using smartcard-based ticket modules for transaction purposes [11], the bus arrival time is usually estimated from the passenger ride time at the station, so that the lack of data can create difficulties in estimating the bus arrival time [12]. Traffic density as one of the factors inhibiting bus movement through tracking and monitoring has also been discussed in other studies, using temporal-spatial correlation in Long Short-term Memory (LSTM) networks to make reliable estimation results [13].

With IoT, the bus transportation system can utilize the mobile platform as a sensor to be able to increase network coverage of bus movement information from each platform [14]. In addition, a combination of technologies such as Global Positioning Systems (GPS) and mobile devices as part of IoT, can help passengers when traveling on public transportation [3][6]. A bus transportation tracking system using GPS technology is needed to overcome bus tracking manually because manual bus tracking is prone to errors.

Several studies have discussed the problem of using IoT in bus transportation mode, in the form of optimization problems using RFID as well as other technologies related to IoT, system performance analysis, use of cable, and sensor networks [6].

In addition, several studies combine GPS tracking with mobile applications to get the exact location of the bus to be more accurate, but do not provide recommendations on the nearest bus route [3]. Using a smart ticket device that contains dynamic routes according to the bus terminal, by utilizing GSM and GPS technology[11], and analyse the attractiveness of routes to form an optimal bus route network in suburban areas, based on the passenger distribution function [15].

Advanced data collection techniques on research in order to obtain accurate and reliable information to users of bus transportation modes, such as monitoring vehicle locations automatically to improve operations and management [7]. Requires accuracy of data to obtain definitive information, in order to predict bus arrival. Bus arrival time predictions are collected from selected detection points [4].
Wireless sensor network design at each stop and tags in each bus transportation mode will identify and provide bus movement information in real-time[3].

Based on previous studies, the research focuses on designing tracking systems and monitoring bus transportation by utilizing mobile devices and GPS to determine the exact bus location and inform about travel routes that can be taken as a contribution in achieving ease and management real-time bus usage time.

3. Proposed method
The design of mobile applications based on Internet of Things (IoT) illustrates the paradigm of the concept of evolution brought about by the presence of internet technology [16]. The smart bus is a tangible proof of an intelligent transportation system using IoT [17]. With the problem of efficiency in urban mobility, it is necessary to monitor the transportation system and design solutions to improve the quality of the system [8]. For this reason, designing applications for smart buses in real-time automatic bus tracking and route recommendation using mobile applications is very much needed.

Figure 1 presents a picture of the proposed system architecture.

Figure 1. Architecture Design of the Smart Bus Transportation System

Figure 1 explains that the system design focuses on how to know the actual location or position of the bus, this is related to the IoT concept and the use of a number of sensors to read data from each bus unit. Each Bus unit is equipped with Global Positioning System (GPS). IoT includes the use of Global Positioning Systems (GPS) allowing users to find out where the desired bus location is [18][19]. Besides observing the actual position of the bus is also available through GPS data[20][21].

In the proposed method, a cellular application is designed to be able to capture and send bus location or position data from GPS to the web system which then accesses the server or database, which will automatically transfer data that has been visually accessed through the Google Maps display where the bus location is. When the user accesses the proposed application system, the GPS on the cellphone must be activated, so that when there is a request position of the bus on the server, it helps the users easily to find out the location of the bus in real-time. Likewise, with GPS that has been installed on the bus will give the coordinates of the bus where the bus is currently located. Sensors installed in the GPS can provide information related to the vehicle location, travel route, vehicle time/speed and other information needed.

Because the location or position of the bus is clearly displayed via GPS to find out the coordinates or the point where the bus is located, and access to information owned is based on the server. So, the system manager is also needed to help provide clear and targeted information.
4. Results and discussion
The design of a mobile application system to find out the actual position or location of the bus can show accurate results, where the system used is the use of sensors embedded on each bus, and the accuracy of GPS as a reader of data or information can provide detailed tracking of bus location and position with the use of the mobile application, can successfully access the bus’s whereabouts, departure position, and when the bus arrives at the intended location. When the bus is experiencing problems, the bus position will read as stopped at a location point. An overview of the proposed application design can be seen in the Figure 2.

![Proposed Application Design](image1.jpg)

**Figure 2. Proposed Application Design**

In Figure 2, the first display proposal is the start menu when the application is opened. Before the user enters the destination of the trip, the GPS that has been installed on the bus before will give a signal where the bus is on the server which is then accessed and forwarded to the user through the application with a display such as maps with points where the bus is located.

In addition, the duration of the trip from the existing bus and information on the origin and destination of the vehicle can also be seen by the user. This, of course, makes it easy for bus vehicle users to determine which buses can be boarded to save travel time.

The second display is a proposed application that requires the user to fill in the destination location and current location of the user. After filling in the destination location, a third display will appear where the existing system provides route recommendations, which can be selected by the user. After selecting one of the routes suggested by the system, a map of the trip route will appear which provides direction for the user to reach the destination of the trip.

5. Conclusion
System design to track the location or position of the bus makes a positive contribution to the wider community, especially users of bus transportation modes in managing travel time. With the existing mobile application and system design, it is also an appropriate contribution to support the improvement of public transportation services through technology development to get to smart bus transportation.

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