CHAPTER 1

Introduction

1.1 Rationale

Jakarta's high mobility needs, driven by the demands of work, school, and other daily activities, have led to significant road congestion and environmental issues. Public transportation options, such as the TransJakarta Bus and the Commuter Line (KRL), present efficient solutions to these problems by reducing the number of private vehicles on the road. However, challenges persist. Despite the high capacity of these services—KRL carrying approximately 1.4 million passengers daily and TransJakarta serving around 800,436 passengers per day overcrowding at certain stations, like Pasar Minggu Station, has been reported, particularly during the pandemic. This overcrowding affects passenger comfort and could potentially lead to a decline in public transportation use, driving more people back to private vehicles and worsening congestion.

Governor Anies Baswedan's Instruction (Ingub) Number 66 of 2019, issued on August 1, 2019, aims to address these issues by promoting public transportation use and enhancing walking conditions through accelerated infrastructure development. Despite these efforts, inefficiencies remain, with some transportation fleets operating with minimal passengers, contributing to higher operational costs and increased congestion. This situation necessitates a systematic approach to optimize public transportation use. Predictive models to estimate passenger numbers can assist in better fleet management and facility placement.

Several studies have focused on prediction problems in recent years, most of them focusing on rail transit. For example, [22] proposes a prediction of the density of inner-city trains based on auto fare collection (AFC) data. The framework performs a data-driven prediction of origination-destination (O-D) passenger flows using random forests and regression trees [15] proposed a Bayesian approach to predict passenger load on individual train cars at their current location based on APC data, where the passenger OD pattern is assumed to follow the previous distribution with parameters estimated from historical data. [24] and [12] both applied the long-short term memory (LSTM) method to predict train load based on temporal features (eg, day of the week, time of day) and load measurements from previous trains on the current day.

Advances in wireless communication technology such as the Global Positioning System (GPS) allow communication and collection of relevant information about the status and location of an object. However, the data generated from GPS has not been used optimally on this transportation fleet so that it can produce real-time information on the location of the transportation fleet. Spatial-temporal information generated from GPS is a key asset for developing intelligent transportation systems that can help optimize time and operational costs for the number of fleets that need to be spent [21]. Several studies on passenger density prediction systems have been conducted, including research for potential location recommendations [17], origin-destination pattern analysis [25][31] and road density estimation [29][32]. Most of these studies can answer the problems that arise in each background. However, with different route patterns and different rush hour patterns, problems in Indonesia require a special analysis that is in accordance with the mobility habits of the Indonesian people.

1.2 Theoretical Framework

The theoretical framework for this study integrates principles from urban mobility, transportation management, and data analytics. It encompasses theories related to capacity utilization, demand forecasting, and the use of advanced technologies for optimizing transportation systems. The framework underscores the importance of utilizing real-time data and predictive modeling to address inefficiencies and enhance public transportation effectiveness. The application of time series analysis for predicting passenger loads will be central to this study.

1.2.1 Transportation Planning Theory

Transportation planning theories provide the foundation for understanding how to optimize public transportation systems. The theory of transportation demand management (TDM) focuses on reducing travel demand during peak periods and promoting alternative modes of transportation. Concepts such as mode shift and multi-modal integration are key to developing effective transportation policies[19].

1.2.2 Forecasting Theory

Time series forecasting theories, particularly ARIMA models, are essential for predicting future trends based on historical data. ARIMA models are grounded in the theory of autoregressive processes and moving averages, providing a structured approach to forecasting time-dependent data [3].

The ARIMA model is particularly suitable for passenger load forecasting due to its ability to capture seasonality, trends, and stochastic components in time series data. Public transportation demand typically exhibits periodic patterns influenced by weekdays, weekends, holidays, and external disruptions. ARIMA has been successfully used in forecasting transportation demand, as demonstrated in studies like [8], where it effectively models fluctuations in passenger volumes. Additionally, ARIMA's interpretability and well-established statistical properties make it a reliable choice for policymakers and transit authorities aiming to optimize scheduling and capacity planning [1].

1.3 Conceptual Framework/Paradigm

The conceptual framework for this research involves the application of predictive modeling techniques to optimize public transportation systems. The study proposes using time series analysis, including ARIMA models to forecast passenger loads at KRL stations. The paradigm supports the notion that accurate prediction of passenger demand can lead to improved fleet management and operational efficiency. By integrating data from historical passenger data, the study aims to provide actionable insights for optimizing transportation services.

1.3.1 Forecasting Paradigm

1. **Objective:** To predict passenger loads at KRL stations using historical data.
2. **Approach:** Employ ARIMA models to analyze historical passenger data and generate forecasts for future passenger loads. This approach helps in identifying patterns, trends, and anomalies.

1.3.2 Recommendation Paradigm

1. **Objective:** To optimize the deployment of KRL trains and TransJakarta buses stop point based on forecasted passenger loads.
2. **Approach:** Utilize optimization models to determine the optimal number of vehicles and bus stops, ensuring efficient service coverage and minimizing operational costs. The optimization process considers constraints such as vehicle capacity, schedule frequencies, and service quality requirements.

1.4 Statement of the Problem

Despite the high capacity of Jakarta's public transportation systems, significant problems remain, including overcrowding at certain stations and inefficiencies in fleet operations. The overcrowding at stations like Pasar Minggu Station during peak times, exacerbated by the pandemic, affects passenger comfort and could lead to a decrease in public transportation use. Additionally, many transportation fleets operate with minimal passengers, leading to higher operational costs and congestion. There is a need for systematic analysis and predictive modeling to address these issues, optimize fleet management, and improve overall public transportation effectiveness.

Jakarta's public transportation system faces several critical issues:

1. **Overcrowding:** High passenger volumes at certain stations, such as Depok, lead to discomfort and decreased service quality.

2. **Underutilization:** Some transportation fleets operate with low passenger loads, contributing to inefficiencies.

3. **Operational Inefficiencies:** Inefficient deployment of transportation resources results in increased congestion and higher operational costs.

4. **Data Utilization:** There is a lack of real-time data integration and predictive analytics to guide transportation planning and management.

This study seeks to address these problems by forecasting passenger loads using ARIMA models and optimizing transportation services based on these forecasts. The illustration of this problem can be found in Figure 1.1.

Comfort is an important aspect of the train ride experience. With the increasing trend of aging population in many countries around the world, the proportion of elderly people among public transport users is increasing [10]. Elderly passengers are more concerned about comfort but less concerned about travel time compared to younger people. In this regard, the comfort of train travel is increasingly important today. Overcrowding in vehicles has a negative effect on passenger satisfaction and well-being which can hinder the transition from private to public transportation [27][16]. Therefore, careful calculation is needed so that the number of trips owned can be adjusted to the passenger load owned. Another problem is that the train fleet is quite limited, to overcome this, an additional TransJakarta bus fleet is needed to cover the shortage of the train fleet owned.

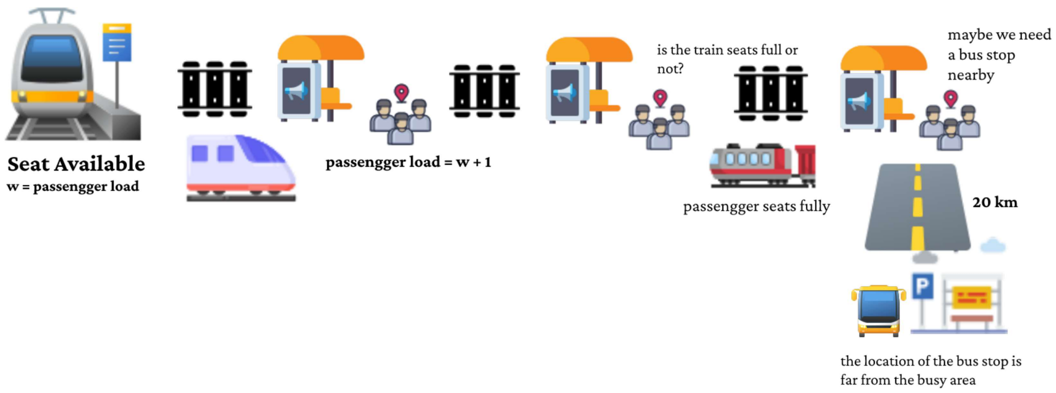

Figure 1.1: The illustration of passenger problems at the station.

1.5 Research Questions

This study seeks to address the following research questions:

1. How accurately can passenger loads at KRL stations be forecasted using ARIMA models?

2. What patterns and trends can be identified from historical passenger data regarding peak hours, station congestion, and underutilized services?

3. How can predictive passenger load data be utilized to optimize the deployment of KRL trains and TransJakarta buses?

4. What are the potential impacts of improved passenger load forecasting and fleet optimization on service efficiency, passenger comfort, and operational costs?

5. How can recommendations for train schedules and bus stop placements be developed based on forecasted passenger loads to address overcrowding and underutilization issues?

1.6 Objectives and Hypotheses

1.6.1 Objectives

1. **To Model Passenger Flow:** Develop an ARIMA model to forecast passenger loads at KRL stations on a specific line.

2. **To Optimize Transportation Services:** Propose strategies for optimizing the number of KRL trains and TransJakarta buses based on forecasted passenger loads.

3. **To Improve Service Efficiency:** Recommend adjustments to bus stop placements and train schedules to enhance overall service efficiency and passenger comfort.

1.6.2 Hypotheses

1. **Forecast Accuracy:** Time series analysis using ARIMA models predictions will provide accurate forecasts of passenger loads at KRL stations. Then provide recommendations for the construction of TransJakarta stop points if the station cannot accommodate number of passenger load.

2. **Recommendation Impact:** Recommendation the number of commuter trains trips needed and TransJakarta buses stop point based on forecasted data will lead to improved service efficiency and reduced congestion.

1.7 Assumption

1. **Data Availability:** Accurate and complete historical passenger data KRL is available.

2. **Model Stability:** The ARIMA model parameters will remain stable over the forecast period, allowing for reliable predictions.

3. **Operational Constraints:** There are defined operational constraints and resources available for implementing optimization recommendations.

4. **Data Accuracy:** Historical passenger data are accurate and reliable. The predictive models developed using ARIMA models will provide accurate forecasts of passenger loads.

5. **Implementation Feasibility:** Implementing the recommendations based on these predictions will be feasible within the current public transportation infrastructure.

1.8 Scope and Delimitation

The scope of this study is confined to public transportation systems in Jakarta, specifically focusing on the KRL and TransJakarta Bus. The research will not address other modes of transportation or cities beyond Jakarta. Delimitations include reliance on available data from public transportation operators and the Central Statistics Agency, which may limit the generalizability of the findings.

1.9 Significance of the Study

This study is significant for urban transportation management in Jakarta as it aims to enhance the efficiency of public transportation systems through predictive modeling. By providing accurate forecasts of passenger loads and optimizing fleet management, the study seeks to improve passenger comfort, reduce congestion, and increase the overall effectiveness of public transportation services. The findings will offer valuable insights for policymakers and transportation planners, contributing to more sustainable and effective urban mobility solutions.

The study holds significant implications for transportation planning and management in Jakarta:

1. **Improved Forecasting:** Enhancing the accuracy of passenger load forecasts will enable better planning and resource allocation.

2. **Operational Efficiency:** Optimizing the deployment of KRL trains and TransJakarta buses will reduce congestion and operational costs.

3. **Policy Recommendations:** The study will provide actionable recommendations for policymakers to improve public transportation services and address overcrowding issues.

4. **Public Comfort:** Enhancing service efficiency and reducing overcrowding will improve passenger comfort and satisfaction.

5. **Effective Recommendations:** Implementing a classification and recommendation system based on forecasted passenger loads will lead to more targeted and effective service improvements.

By addressing these issues, the study aims to contribute to more effective and efficient public transportation systems in Jakarta, ultimately benefiting both commuters and the city's overall transportation infrastructure.