THE OPEN UNIVERSITY OF SRI LANKA FACULTY OF ENGINEERING TECHNOLOGY

THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

EEX5362 Performance Modelling

Deliverable 01- Mini Project

Public Bus Transportation Network

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Introduction

Public transportation is a complex network laid down for the transportation of passengers, both urban and suburban, by buses, trains, or trams. In this paper, operations involving buses within the Colombo Metropolitan Region are focused on, particularly performance analysis along major routes such as:

Route 103 – Narahenpita → Fort

Route 144 - Rajagiriya → Fort

Route 171 – Koswatta → Fort

Every one of these routes has various stops along the way, each with different passenger demands at times of the day. Efficiency in the network is based on a number of factors including scheduling efficiency, passenger load, condition of the flow of traffic, and dwell times at every stop.

The selected system for this case study is the Public Bus Transportation Network operating in the Colombo Metropolitan Region, Sri Lanka. Being large-scale, complex, and dynamic, it is jointly managed by both public and private bus operators. The system consists of several routes passing through major cities, suburbs, and town centers, with a number of stops, depots, and terminals along each route, serving a fleet of buses that run at variable headways.

The structure of such a transportation network is characteristically dynamic, with interaction among several elements that include fluctuating passenger demand, efficiency in scheduling, road congestion, driver availability, and bus capacity. These interdependencies make the transportation network a very suitable candidate for performance modeling and analysis. Certain major measurable performance characteristics considered within the study include passenger waiting time, bus utilization, route throughput, and service reliability.

Problem Statement

While still the most affordable and publicly accessible mode of transportation within Colombo, public buses have continued to suffer from chronic inefficiencies that lead to passenger dissatisfaction and operational losses. The major issues include long waiting times during peak hours, uncertainties over the schedule of bus arrivals, delayed travel times on congested roads, and frequent overcrowding. These together deteriorate service quality, reduce system throughputs, and increase overall operational costs.

In this respect, it is of urgent necessity to have a structured performance evaluation methodology in place to quantify, analyze, and optimize system performance. Such models would be able to locate bottlenecks, test scalability for increased passengers, and perform optimizations in resource allocations to achieve reliability with efficiency.

Public bus systems in urban cities with a high population density face congestion, resulting in unpredictable delays, poor passenger distribution, and inefficient system scheduling. These would translate into protracted waits, overcrowding, and reduced passenger satisfaction. It is with this objective that this research effort is dedicated to the modeling and performance analysis of the public bus transport system in Colombo, focusing essentially on determining the critical bottlenecks, exploring opportunities for optimization in route scheduling as well as fleet utilization.

Performance Objectives

The major objectives of this research work include the assessment and improvement in the operational performance of the Colombo public bus transportation network using analytical and simulation-based modeling techniques. Important focus areas are the minimization of passengers' waiting times, improvement in the utilization of the fleet, headways, identification of systems bottlenecks, and optimization in passenger flow efficiency.

Minimize Average Passenger Waiting Time: Assess scheduling strategies that reduce waiting times at major stops.

Maximize Fleet Utilization: This ensures that the available buses are well distributed on high-demand routes.

Reduce Headway Variance - Keep the time between consecutive buses as consistent as possible to enhance service reliability.

Bottleneck Identification: Identify stops that have a congestion or high dwell time and will probably dent the performance of the route.

Improve Efficiency in Passenger Flow: Analyze the pattern of boarding and alighting to optimize the location and timing of bus stops.

Data Set

The dataset that will be used in this research is a simulated operational dataset of daily bus activity across selected routes, including temporal, spatial, and operational parameters required for modeling passenger flow, bus occupancy, and timetable adherence. Realistic conditions of the Colombo public transportation network are captured, and the dataset forms the basis for evaluating the performance of the system under different demand and traffic scenarios.

Field	Description
bus_id	Unique identifier for each bus
route_no	Bus route number (e.g., 103, 144, 171)
stop_name	Name of the bus stop
arrival_time	Time of bus arrival
departure_time	Time of bus departure
boarded	Number of passengers boarding
alighted	Number of passengers alighting
occupancy_after	Passenger count after leaving stop
dwell_time_s	Stop duration in seconds
headway_s	Time gap between two consecutive buses
is_timepoint	Whether the stop is a major timing checkpoint
is_peak	Whether the record belongs to peak hours

Expected Outcome

This research was done to visualize passenger flow, locate congestion points, and simulate various scheduling strategies through the modeling of a bus network using tools like SimPy, a Python discrete-event simulation. The resulting analysis will provide quantifiable performance metrics-including average trip time, bus occupancy ratio, and schedule adherence-that will support future route optimization and policy decisions.

The expected outcomes of the study are:

Quantitative Analysis: Results in clear numerical output for important performance metrics like passenger waiting times, system throughput, and fleet utilization.

Bottleneck identification involves the recognition of stops or routes that cause delays and decreased efficiency.

Resource Smoothing: Recommendations on the Optimum Number of Buses on a Route to Match Demand and Reduce Idle Time.

Scalability Insights: This will be used to evaluate how well the system can perform with increased passenger demand and expanded route coverage.

Visualization for Decision Making Generation of informative visualization outputs, such as bar charts, heatmaps, queue curves, aimed at interpretation and decision-making support.

Git Repository

https://github.com/kavindu9648/public-transport-performance-modeling.git

Conclusion

The present research work seeks to develop a performance modeling framework for the Colombo public bus transport network, which is one of the major means of urban mobility burdened with inefficiencies related to unpredictable delays, overcrowding, and inconsistent scheduling. This will be achieved through analytical and simulation modeling using tools such as SimPy in assessing and optimizing main performance parameters like waiting time, fleet utilization, headway variance, and route throughput.This paper proposes a structured approach to the identification of bottlenecks, analysis of resources allocation, and simulation of operational improvement options at various passenger demand scenarios. By quantifying measurable performance indicators and visualizing results through graphs and simulations, this study will facilitate informed decisions for transport planners and policy-makers in their pursuit of efficient and reliable improvements.

Ultimately, it is expected that these findings will improve the efficiency, scalability, and passenger orientation of the transport system in a way that will enable future integrations of intelligent scheduling, real-time monitoring, and data-driven optimization within Sri Lankan public bus services.