EEX5362 Performance Modelling Mini Project

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**System Details and Performance Objectives**

**System Overview**

System Title: **Multi-Stop Bus Transportation System**

An efficient public bus transportation system operates along a linear route connecting multiple stops across urban and suburban areas. Each stop serves as both a boarding and alighting point for passengers, depending on the time of day and the direction of travel. The system functions according to a fixed timetable, but in real life, it is continuously affected by traffic congestion, fluctuating passenger demand, and environmental factors.

In a typical day, buses begin their routes from the main terminal or depot, where they are refueled and checked for maintenance before departure. Each bus follows a predetermined route, stopping at all major bus stops to pick up and drop off passengers. During peak hours, such as morning and evening rush periods, the number of passengers increases dramatically, especially at residential and business area stops. This leads to longer queues, crowded buses, and extended boarding times.

Passengers arrive at bus stops at irregular intervals influenced by work hours, school schedules, and connecting transport availability. When a bus arrives, passengers waiting at the stop board in order, while those reaching their destination disembark. The duration of each stop depends on several factors, including the number of passengers boarding or alighting, payment method, and accessibility needs. Elderly passengers or those carrying luggage may take longer, slightly delaying the bus.

Buses must also deal with road traffic variations, such as traffic lights, congestion near intersections, or accidents, which cause unpredictable delays. As a result, even though buses are meant to maintain a fixed headway, real-world conditions often lead to bunching, where two or more buses arrive close together after a delay, disrupting the smooth flow of service.

To ensure service reliability, bus controllers or schedulers monitor the movement of each bus using GPS or route logs. If one bus is delayed, adjustments are made such as short-turning or deploying an additional bus to balance demand.

Buses have limited seating and standing capacity, so once a bus becomes full, new passengers at upcoming stops must wait for the next bus. This can cause queue build-up, especially at busy terminals or markets. To handle these fluctuations, operators may increase bus frequency during rush hours and reduce it during off-peak times to save fuel and operational costs.

Overall, this real-world multi-stop bus system represents a dynamic, interdependent process involving passenger behavior, vehicle movement, and traffic conditions. Maintaining efficiency requires balancing frequency, capacity, punctuality, and passenger comfort, ensuring that buses run on time while minimizing overcrowding and long waiting times.

**Performance Objective**

Primary Objective: **Optimizing Resource Allocation**

The goal of the simulation is to identify how to best allocate limited resources, buses, and routes to maximize system efficiency. This includes determining:

* How many buses are needed to meet passenger demand without excess idle time?
* How does changing the number of buses affect waiting times and occupancy?
* How to balance resource allocation among stops with uneven passenger flows.

**Optimizing resource allocation helps achieve:**

* Reduced average waiting time for passengers.
* Increased bus utilization (occupancy).
* Improved throughput and service quality.
* Better environmental efficiency by reducing underutilized trips.

**Data set**

**Data set:** <https://github.com/Ameerasra/Multi-Stop-Bus-Transportation-System.git>