**EEX5362 – PERFORMANCE MODELLING**

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**Academic Year – 2024/2025**

**Deliverable 1**

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**Smart Bus Transportation Network**

1. **System Description**

Public transportation is a critical part of urban mobility, particularly in growing cities where traffic congestion and travel delays are common. The **Smart Bus Transportation Network** is designed to improve the efficiency and reliability of bus operations through intelligent scheduling, dynamic routing, and real-time passenger data integration.

This system models the performance of a city bus network by analyzing passenger demand, bus frequency, route congestion, and waiting time. Using IoT sensors, GPS tracking, and automated scheduling algorithms, the Smart Bus Network collects real-time data on bus arrivals, passenger counts, and traffic flow.

The goal of this study is to create a **performance model** that captures the system’s behavior under different operational conditions such as peak vs. off-peak hours and identifies potential bottlenecks in the network.

1. **Problem Statement**

Traditional bus networks often suffer from unpredictable arrival times, route congestion, and inefficient bus utilization, leading to long passenger waiting times and overcrowding.

This mini project aims to address these issues by modeling and analyzing the Smart Bus Transportation System to identify performance bottlenecks and optimize resource allocation.

1. **System Components and Flow**
2. **Bus Fleet:** Multiple buses operating across fixed routes with variable frequency.
3. **Bus Stops:** Designated stops where passengers queue and board buses.
4. **Central Monitoring System:** Tracks bus locations and passenger loads in real time.
5. **Passenger Application (Optional Simulation):** Provides estimated arrival times and demand forecasts.
6. **Data Flow:**

* Passenger arrival → Queue formation → Bus arrival → Boarding and departure → Next stop
* System continuously collects and processes data on travel time, waiting time, and capacity utilization.

1. **Performance Objectives**

The project focuses on analyzing and improving the following performance metrics:

|  |  |  |
| --- | --- | --- |
| Performance Objective | Description | Expected Outcome |
| 1. Minimize Passenger Waiting Time | Measure and reduce average passenger waiting time at each stop. | Increased passenger satisfaction and reduced queue length. |
| 2. Optimize Bus Utilization | Evaluate how efficiently buses are allocated and used during different time intervals. | Balanced load distribution and fewer idle vehicles. |
| 3. Improve Route Throughput | Determine how many passengers are successfully transported per route per hour. | Higher throughput and smoother passenger flow. |
| 4. Identify Bottlenecks and Delays | Detect stops or routes causing congestion or slow service. | Actionable insights for schedule redesign or route optimization. |
| 5. Analyze Scalability | Test how system performance changes with increased passenger demand or additional routes. | Recommendations for capacity planning and network expansion. |

1. **Dataset Description**

Since this is a modeling study, a **synthetic dataset** will be generated or simulated to represent real-world conditions.

The dataset may include the following variables:

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Description | Type | Example Value |
| Bus\_ID | Unique identifier for each bus | Categorical | B101, B102 |
| Route\_ID | Assigned route number | Categorical | R01, R02 |
| Stop\_ID | Bus stop identifier | Categorical | S001, S002 |
| Passenger\_Arrival\_Rate | Number of passengers arriving per minute at each stop | Numeric | 4.2 |
| Bus\_Arrival\_Time | Time of bus arrival at the stop | Timestamp | 08:15:00 |
| Waiting\_Time | Average waiting time of passengers | Numeric (mins) | 6.8 |
| Travel\_Time | Time taken between stops | Numeric (mins) | 12.5 |
| Occupancy\_Rate | Percentage of bus capacity utilized | Numeric (%) | 78 |
| Delay | Difference between scheduled and actual arrival time | Numeric (mins) | 3.0 |
| Traffic\_Level | Road traffic density indicator | Categorical | Low / Medium / High |

1. **Expected Deliverables (Future Stages)**
2. Performance analysis charts (waiting time vs. load, throughput vs. route)
3. Identification of bottlenecks through data visualization
4. Optimization recommendations (e.g., increase frequency, redistribute buses)
5. Final performance model report
6. **Conclusion**

This deliverable introduces the Smart Bus Transportation Network as a complex, data-driven system suitable for performance modeling and evaluation.

By analyzing bus frequency, passenger flow, and route performance under varying load conditions, the study aims to propose practical solutions to enhance public transportation efficiency and reliability.