THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

**EEX5362 Performance Modeling**

**Mini Project - Deliverable 01**

**Food Delivery Dispatch System Simulation**

**Name: A.R. Asrin Jumana**

**S-id: s22010084**

**Reg-num: 322515250**

1. **Overview of the scenario**

**Selected system: Food Delivery Dispatch System Simulation**

The selected system builds upon the previously analyzed case study and is enhanced to model a more complex, real-world scenario. In the modern food delivery industry, ensuring fast, reliable, and cost-efficient service is a major performance challenge. Delivery platforms must manage uncertain order arrivals, changing traffic conditions, and varying rider availability in real time. When rider availability is low, customers experience longer waiting times, while excessive rider allocation leads to idle resources and reduced efficiency. Achieving an optimal balance between customer satisfaction and resource utilization is therefore a central performance concern.

This mini-project models a complex and dynamic food delivery dispatch system using discrete-event simulation to evaluate how rider assignment strategies and traffic conditions affect overall system performance. The simulation captures the stochastic and time-dependent behavior of a real-world delivery process, providing insights into key performance trade-offs.

To reflect real-world operational complexity, the model incorporates two major enhancements:

* **Dynamic Rider Assignment Algorithm:** Each incoming order is assigned to the nearest available rider within a 10×10 km service region, replicating intelligent, location-based dispatching strategies used in modern platforms.
* **Traffic Variation Model:** Rider travel speeds fluctuate according to simulated time-of-day traffic patterns, such as peak lunch (12 – 2 PM) and dinner (6 – 8 PM) periods, directly influencing delivery durations and service reliability.

By integrating these mechanisms, the system behaves as a dynamic, queue-based environment where both demand and service conditions vary over time. This makes it an ideal scenario for performance modeling, enabling detailed analysis of waiting times, delivery efficiency, throughput, and resource utilization under diverse operating conditions.

**Key parameters and default values:**

* Number of riders: 4
* Mean order interval: 5 minutes
* Average delivery time: 10 minutes
* Simulation duration: 320 minutes
* Random seed: 42

**Performance Metrics Recorded:**

* Average wait time (from order to assignment)
* Average delivery time (from order to completion)
* Rider utilization (%)
* Throughput (orders completed per minute)
* Percentage of customers who waited vs. served immediately
* Maximum queue length

1. **High-Level Problem**

In real-world food delivery systems, maintaining fast and efficient service is difficult due to fluctuating customer demand, varying rider availability, and unpredictable traffic conditions. During peak periods, order volumes can exceed rider capacity, increasing waiting times, while excess riders during low-demand hours lead to underutilization and higher costs.

The main challenge is to balance rider allocation with dynamic demand and traffic variations to ensure timely deliveries and efficient resource use.

To analyze these challenges, the simulation evaluates system performance under different operating scenarios:

* **Baseline Scenario:** Normal operations under average demand and traffic.
* **Limited Rider Availability:** Fewer riders to represent high-demand periods.
* **More Riders Scenario:** Additional riders to improve service capacity.
* **Order Cancellation Scenario:** Variation in order arrival to reflect reduced demand.

These experiments help identify performance bottlenecks, evaluate resource utilization, and determine optimal rider configurations for improved service reliability and delivery efficiency.

1. **Performance Objective**

**Objective:** To **minimize the average customer waiting time** from order placement to rider assignment.

The main objective of this simulation study is to minimize the average waiting time customers experience before order assignment. This metric reflects the responsiveness and efficiency of the dispatch system. It is evaluated across multiple scenarios with varying rider availability, order arrival rates, and delivery conditions.

By analyzing the simulation outcomes across different scenarios varying rider numbers, order arrival rates, and delivery conditions, the study aims to identify key performance bottlenecks and propose strategies that enhance delivery speed, rider utilization, and service reliability while maintaining operational balance.

1. **Dataset**

The dataset used in this simulation is synthetically generated through the discrete-event simulation model. Each record represents a single food delivery order processed under varying operational conditions. The dataset contains both operational parameters and performance-related metrics, allowing for detailed evaluation of dispatch efficiency and system dynamics across multiple scenarios.

Dataset attributes:

* Scenario: The simulation scenario name (e.g., Baseline, Limited Rider Availability, More

Riders, Order Cancellation).

* order\_id: Unique identifier for each customer order.
* arrival\_time: Time at which the order arrives in the system (minutes).
* assign\_time: Time when a rider is assigned to the order.
* wait\_time: Time difference between order arrival and rider assignment.
* service\_time: Total delivery service duration (travel + drop-off).
* delivery\_time: Total time from order arrival to completion.
* rider\_id: Unique identifier of the rider assigned to the order.
* queue\_at\_arrival: Queue length at the time the order arrived.
* distance\_km: Distance (in km) between the rider and customer at dispatch time.
* speed\_kmh: Rider’s travel speed based on traffic conditions.
* peak\_hour: Indicates whether the order occurred during simulated peak traffic hours.

The dataset provides comprehensive insights into system behavior under different operational setups, enabling quantitative analysis of metrics such as average waiting time, delivery duration, rider utilization, throughput, and queue performance.

Git Repository link: <https://github.com/AsrinJumana712/EEX5362-Performance-Modelling_MiniProject/blob/main/Deliverable_01/simulation_data_all.csv>