Online E-commerce Order Processing System

TMA

EEX5362 - Performance Modeling

Bachelor of Software Engineering

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1. **System Overview:**

The selected system for performance modeling is an Online E-commerce Order Processing System. This system represents how incoming customer orders are processed from submission to delivery.

Key components and resources include:

- Customer orders with diverse products, quantities, and priorities.

- Front-end order management system that receives and validates orders.

- Inventory management and warehouse systems that prepare items for shipment.

- Payment processing system that verifies transactions.

- Delivery scheduling system coordinating shipping and logistics.

- Monitoring and routing policies that influence order prioritization and fulfillment.

Due to dynamic order arrivals and finite resources, the system exhibits queueing, resource contention (inventory, packaging, shipping), and variable processing times.

2. **High-Level Problem Definition:**

E-commerce platforms must process customer orders efficiently to meet delivery timelines and maintain customer satisfaction. However, unpredictable order volumes, stock limitations, and logistical constraints often create bottlenecks, increasing order fulfillment time, reducing throughput, and risking SLA violations.

Problem Statement:

To model and analyze the performance of an Online E-commerce Order Processing System to identify bottlenecks, measure order processing time and resource utilization, and evaluate optimization strategies such as improved inventory allocation, order prioritization, and dynamic workforce scheduling.

2. Dataset Description:

Simulation and analysis use synthetic or real traces with the following attributes:

Attribute	Description
Order_ID	Unique identifier for each customer order
Order_Time	Time the order is placed
Product_Type	Type of product in the order (electronics, clothing, etc.)
Priority	Priority of order (High, Medium, Low)
Processing_Time	Duration required to pick, pack, and ship the order
Queue_Wait_Time	Time waiting before processing begins
Assigned_Warehouse	Warehouse or fulfillment center handling the order
Payment_Status	Payment verification status
Inventory_Usage	Stock allocated to fulfill the order
Completion_Time	Time when the order is shipped/delivered
Order_Response_Time	Completion_Time − Order_Time

These attributes allow quantitative measurement of average processing time, throughput, queue length, warehouse utilization, and order fulfillment efficiency.

3. Performance Objectives:

The main objectives of the Online E-commerce Order Processing System are to evaluate and improve order processing efficiency.

Focus areas include:

- **Minimizing order processing time:** Reduce time from order submission to delivery.

- **Maximizing throughput:** Increase the total number of orders processed in a given period.

- **Identifying bottlenecks:** Detect overloaded warehouses, delayed payments, or logistics constraints.

- **Optimizing resource allocation:** Balance inventory, workforce, and delivery resources.

- **Improving scalability:** Assess system performance under varying order volumes and peak shopping periods.

- **Enhancing flexibility:** Evaluate how processing adapts to sudden demand spikes or stock limitations.

5. Tools and Techniques:

Recommended modeling and analysis stack:

- **Python (SimPy):** Discrete-event simulation of order arrivals, queues, and fulfillment processes.

- **NumPy:** Random variate generation and statistical analysis.

- **Pandas:** Data capture and post-processing.

- **Matplotlib:** Visualization (order completion time distributions, queue length over time, warehouse utilization).

- **Tabulate:** Table formatting for console output.

- **Queueing Theory (M/M/c, M/G/c approximations):** Analytical baselines for validation.

- **Optional:** Cost modeling for staffing and shipping optimization.

6. Expected Outcomes:

By modeling the Online E-commerce Order Processing System, the project aims to:

- Quantify order processing time vs. load relationships and identify capacity limits.

- Evaluate order prioritization and fulfillment policies to balance cost, SLA compliance, and efficiency.

- Identify bottlenecks (warehouse, inventory, payment verification) and suggest mitigations.

- Recommend optimal resource allocation for warehouses, workforce, and logistics.

- Provide visualizations (processing time distributions, throughput plots, queue lengths) for decision-making.