**EEX5362 Performance Modelling**

**Mini Project**

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**1. System Overview: Manufacturing/Logistics Pipeline**

This system represents a smart manufacturing and logistics pipeline that handles the flow of goods from raw materials to final delivery. The process involves multiple interconnected stages such as procurement, production, quality inspection, packaging, warehousing, and distribution.

Each stage depends on resources such as machines, human labor, and transportation units. Data is collected from IoT sensors and ERP systems to monitor real-time performance, including production rate, queue length, and transportation delays.

The pipeline can be modeled as a sequence of dependent processes where the overall performance depends on the efficiency of each stage. Bottlenecks in any stage (e.g., limited machine capacity, transport delays, or inspection slowdowns) can significantly affect total throughput and delivery time.

**2. Problem Definition**

Currently, the manufacturing/logistics pipeline suffers from uneven resource utilization and delayed order fulfillment due to inefficient scheduling, unpredictable delays in transportation, and limited visibility into bottlenecks.

As a result:

* Some machines or production lines remain idle while others are overloaded.
* Finished goods wait in queues for packaging or shipment.
* Customer deliveries are delayed due to poor synchronization between production and logistics.

The goal of this study is to analyze system performance using key metrics, identify bottlenecks, and propose optimization strategies that can improve the overall throughput and minimize delays.

**3. Data Set Description**

A simulated dataset (or collected factory data) can include the following attributes

|  |  |
| --- | --- |
| **Attribute** | **Description** |
| Order\_ID | Unique ID for each order |
| Stage | Process stage (Procurement, Production, Inspection, Packaging, Shipping) |
| Start\_Time | Timestamp when the stage begins |
| End\_Time | Timestamp when the stage completes |
| Processing\_Time | Duration taken for that stage |
| Machine\_ID | Identifier for the machine used |
| Resource\_Utilization (%) | Percentage of resource usage |
| Queue\_Length | Number of items waiting before processing |
| Delay\_Time | Waiting time before stage start |
| Throughput\_Rate | Units processed per hour |
| Transport\_Delay | Time lost during delivery between stages |

4**. Performance Objectives**

The main performance objectives are:

1. Minimize Processing Delays:  
   Reduce average time per stage to increase overall production speed.
2. Maximize Throughput:  
   Ensure that the number of completed goods per hour/day is as high as possible.
3. Optimize Resource Utilization:  
   Balance workloads across machines and human operators to avoid idle or overloaded resources.
4. Reduce Queue Lengths:  
   Improve scheduling and resource distribution to prevent congestion at specific stages.
5. Minimize Transportation Delays:  
   Optimize routing and coordination between production and delivery to ensure timely dispatch.
6. Identify Bottlenecks:  
   Locate stages where delays or inefficiencies cause the largest impact on system performance.