Department of Computer Science and Engineering

Islamic University of Technology (IUT)
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Final Report

Car Manufacturing System

Simulation and Modeling
CSE 4550

Name: Wasswa Lutufi Sebbanja
Student ID: 200041156
Section: 1B

Name: Mahajabin Tabassum
Student ID: 200041132
Section: 1B

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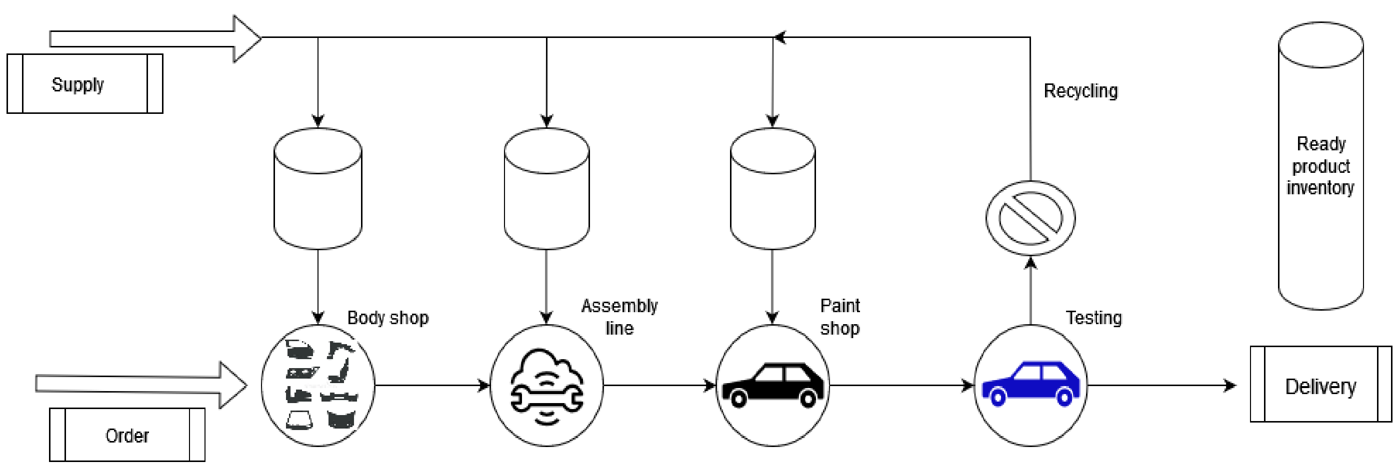
Abstraction
The Car Manufacturing System simulation holds significant importance by encapsulating the intricate operations of an industry vital to global economies. Chosen for its complexity and real-world implications, simulating this system allows us to delve into the optimization of production processes, resource utilization, inventory management, customer satisfaction and overall operational efficiency. As cars represent a ubiquitous commodity with a diverse range of components and intricate assembly procedures, the simulation becomes a robust tool for understanding and enhancing the dynamics of a high-stakes manufacturing environment. Through this simulation, we aim to glean insights that can inform strategic decisions, improve system performance, and contribute to the broader discourse on operational excellence in the automotive industry.

Problem Statement
- Car manufacture system simulation
- An order arrives and the manufacturing starts
- There are 4 workstations
- Each server maintains an inventory of its own
- Car that have failed quality test are recycled
- Runs until 500 orders are met

Motivation and aims
1. Optimize Production Efficiency:
2. Minimize Resource Idle Time to improves resource utilization
3. Assess the effectiveness of inventory management at each workstation.
4. Enhance Quality Control Processes
5. Optimize the allocation of space to workstations based on task requirements.
6. Minimize Delivery time

System Diagram:



Input variables

- Inter arrival time of orders: exponentially distributed
- Size of each order: normally distributed
- Complexity of an order
- Inventory restocking time: exponentially distributed

Output variables

- Average waiting time of each customer
- Average queueing delay of the orders
- Average time each server stays idle
- Optimum queue length for each server to avoid bottleneck

State variables

Xi (*t*) = Server State {Busy, Idle}

Qi (*t*) = Queue Length {0,1,...,MAX}

Li (*t*) = Inventory Level (0,1,..,Threshold,..,MAX}

State equations

Server state

$$Xi(t^{+}) = \begin{cases} x(t) == 0?x(t)+1 : x(t) & ifarrivaloccursattimet \\ q(t) = 0?x(t)-1 : x(t) & ifdepartureoccursattimet \\ x(t) & otherwise \end{cases}$$

Queue length

$$qi(t^{+}) = \begin{cases} x(t) > 0?q(t)+1 : q(t) & ifarrivaloccursattimet \\ q(t) > 0?q(t)-1) : q(t) & ifdepartureoccursattimet \\ q(t) & otherwise \end{cases}$$

Flow Charts:

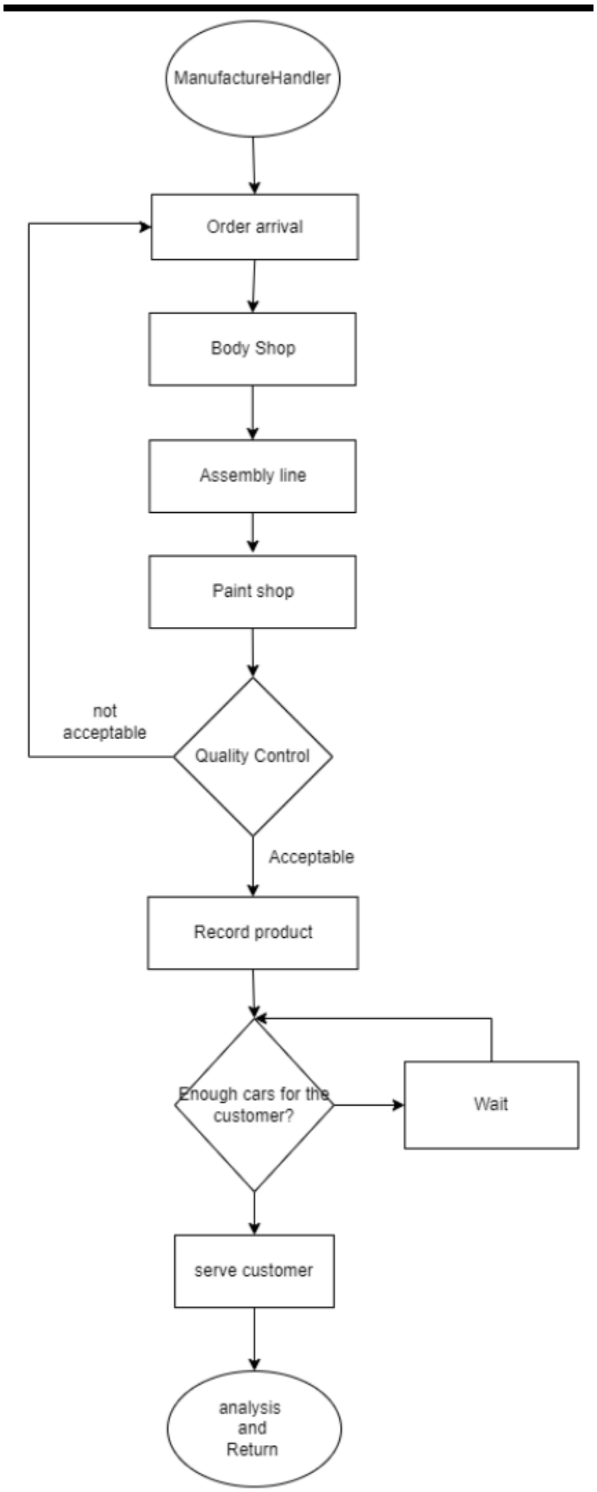


Fig: Overall Flow

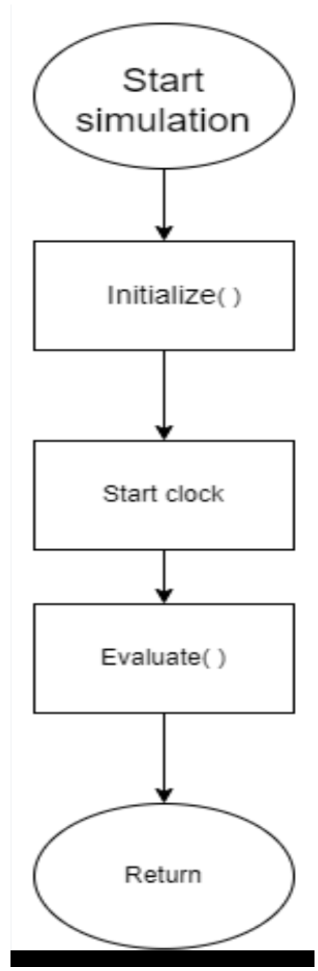


Fig: Start Event

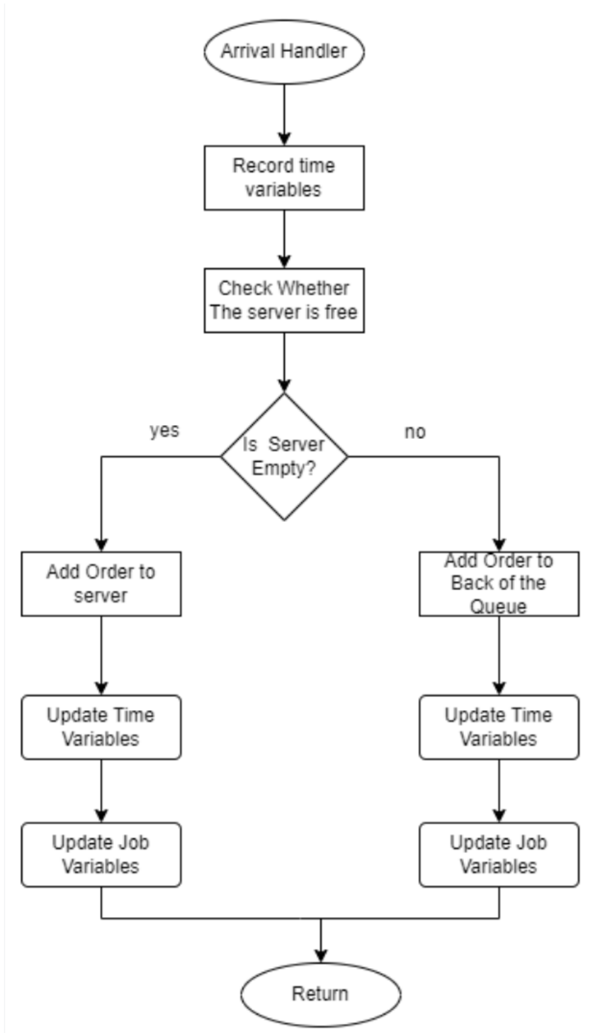


Fig: Order Arrival Event

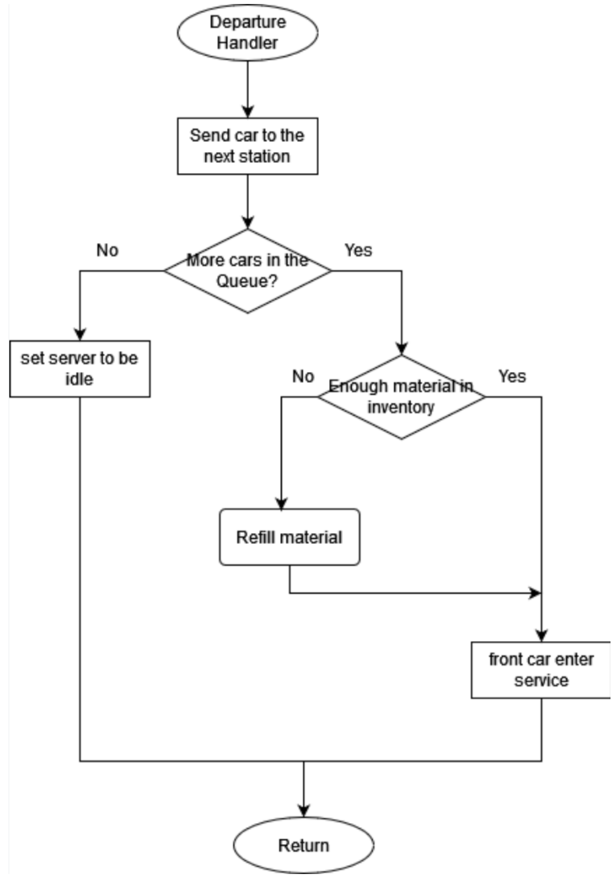


Fig: Departure Event

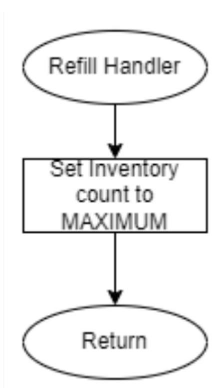


Fig: Refill Handler

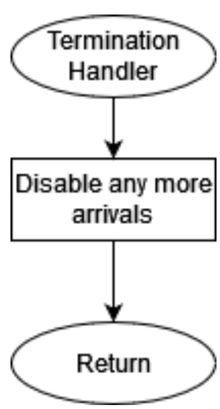
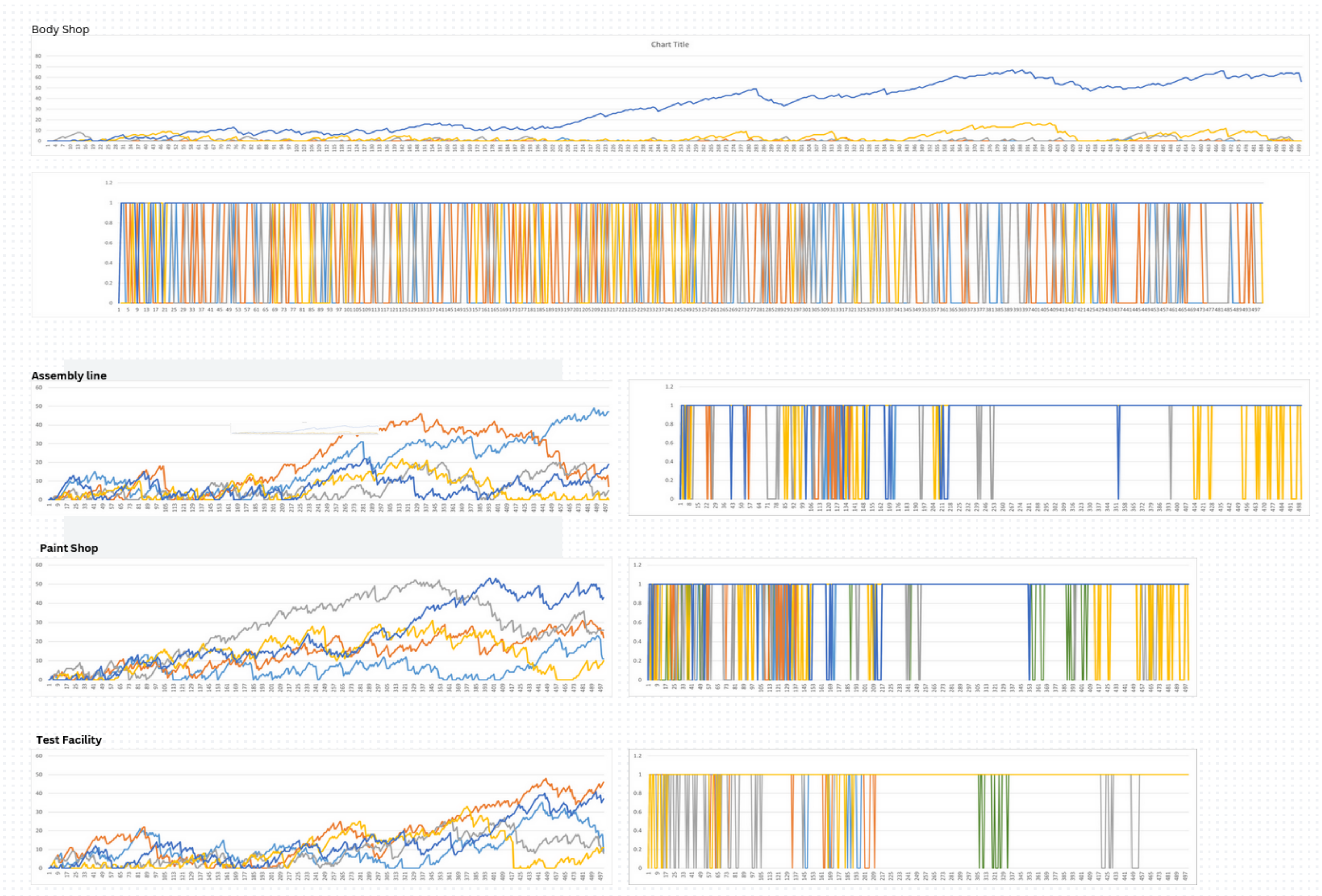


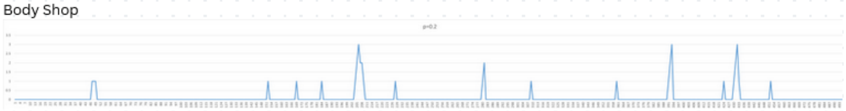
Fig: Termination Event

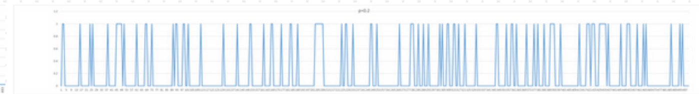


Figures: Input data analysis

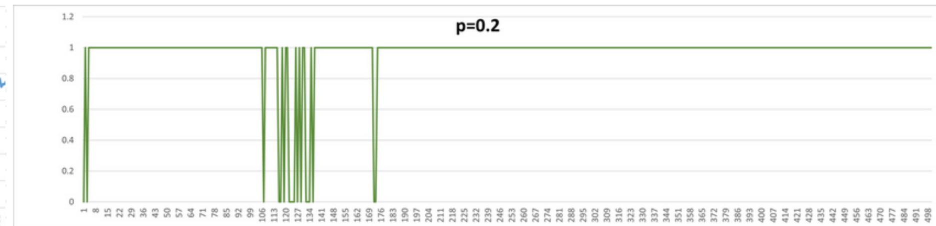
ArrivalMean/DepartureMean = 0.2

Body Shop

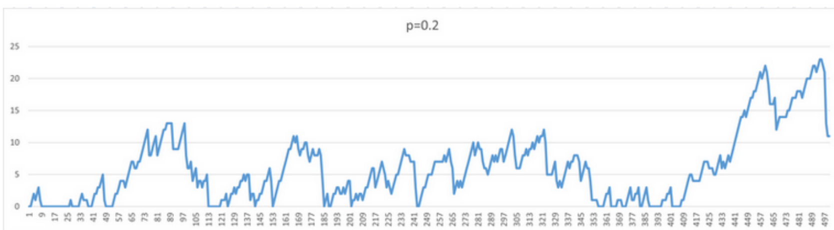


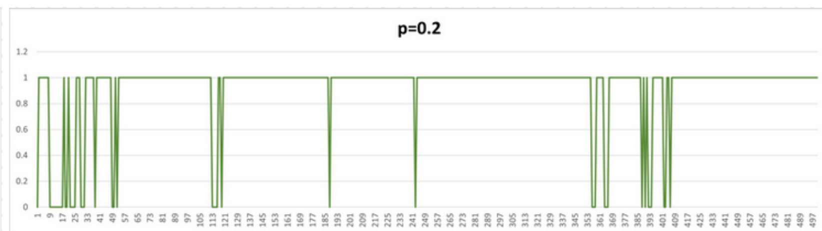


Assembly line

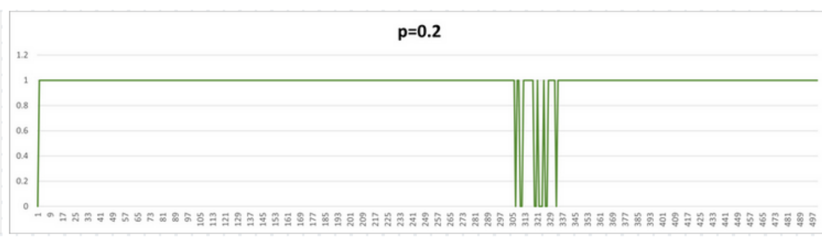


Paint Shop





Test Facility



ArrivalMean/DepartureMean = 0.4

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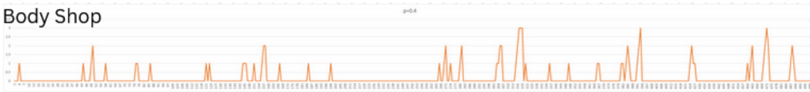

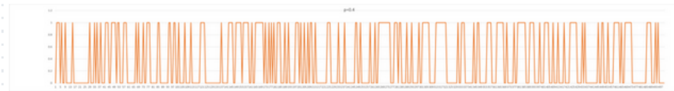

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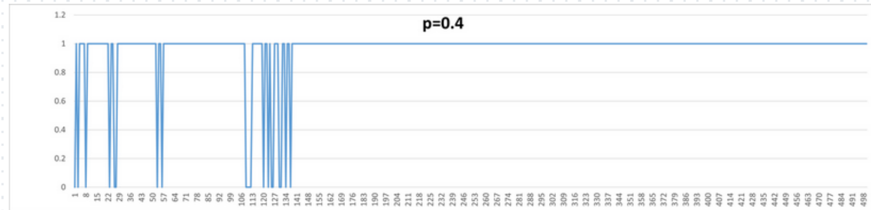

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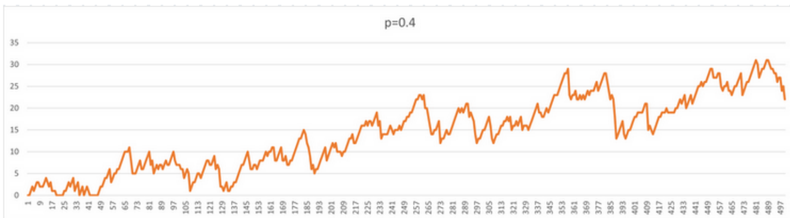

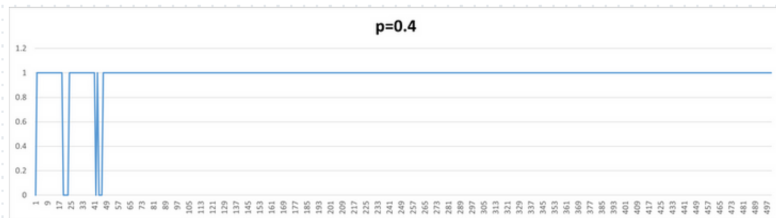

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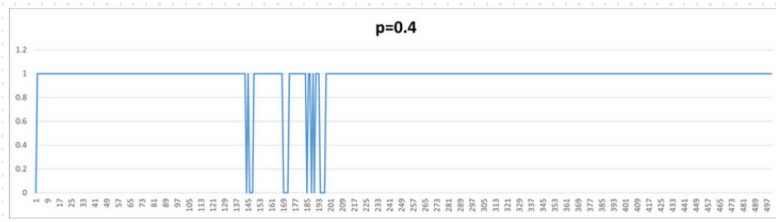
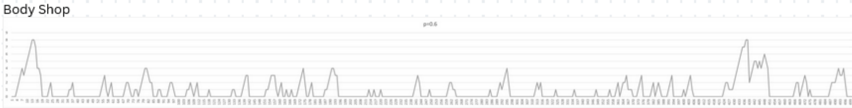


ArrivalMean/DepartureMean = 0.6

Body Shop



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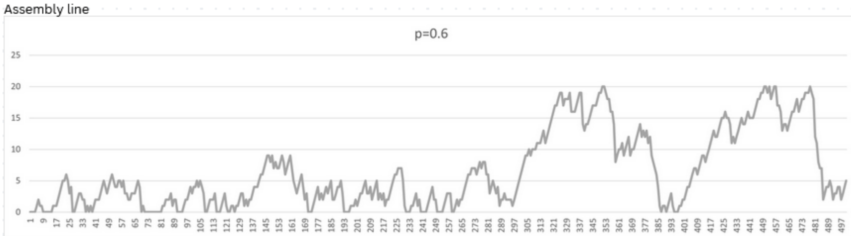

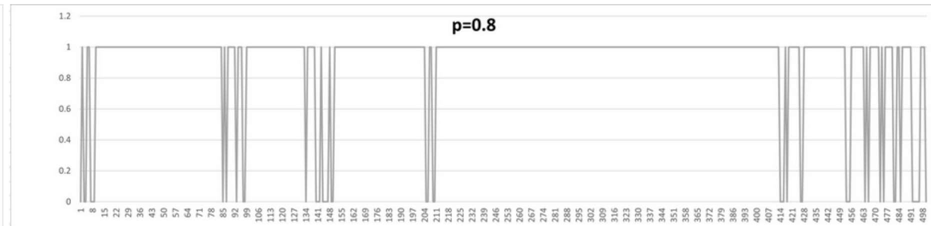

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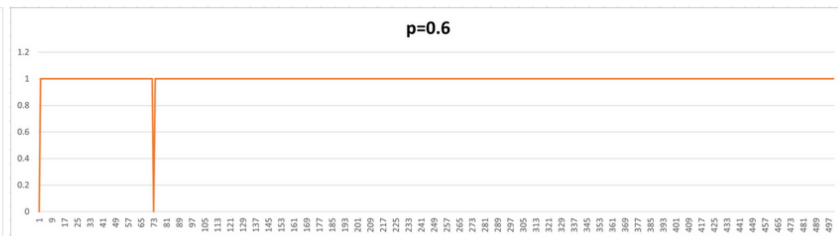

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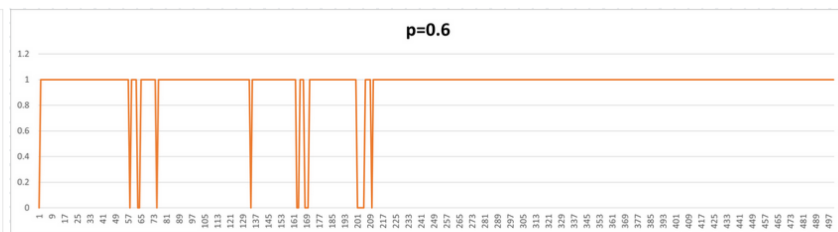

ArrivalMean/DepartureMean = 0.8

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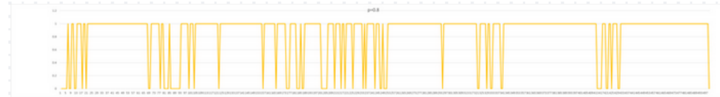

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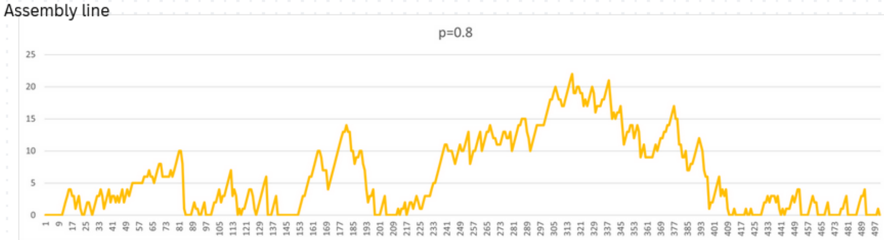

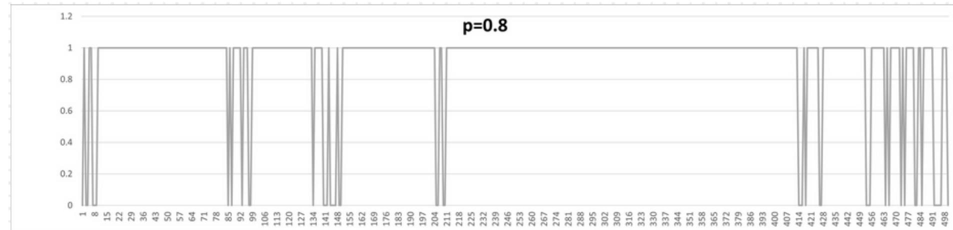

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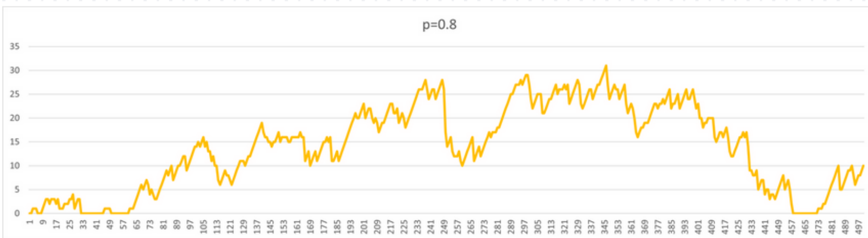

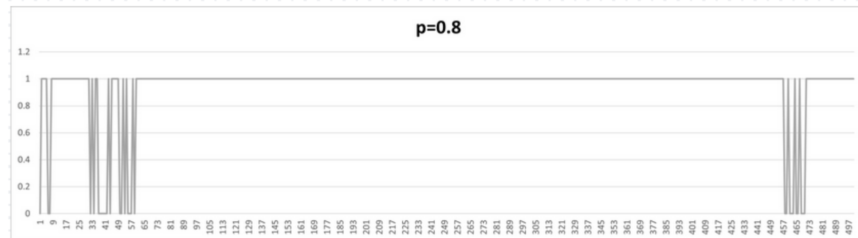

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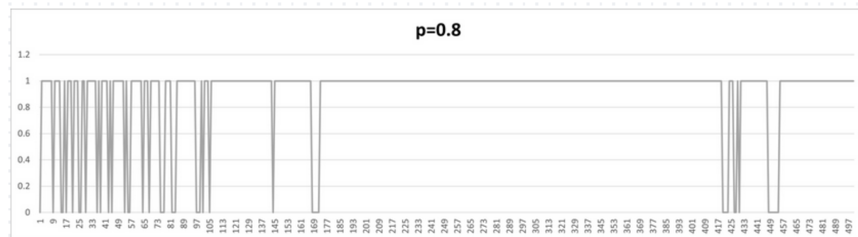
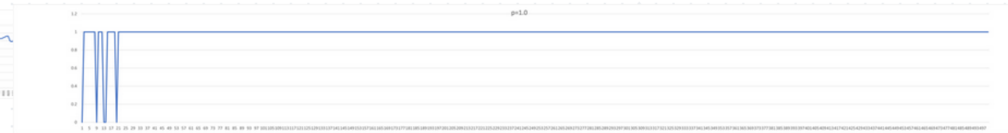


ArrivalMean/DepartureMean = 1.0

Body Shop



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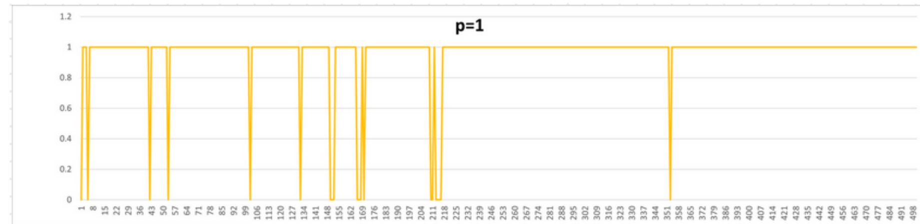

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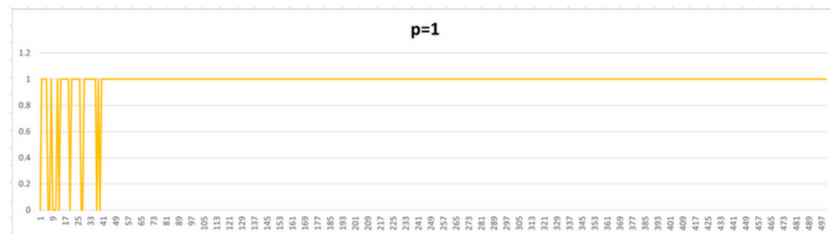

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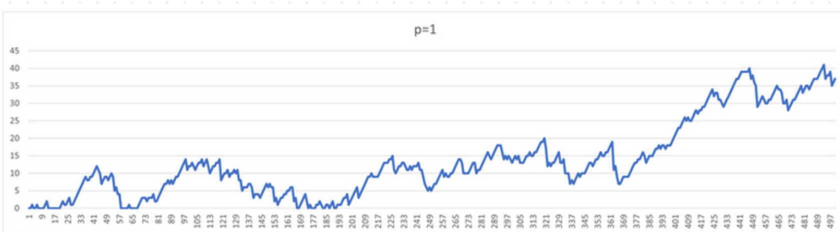

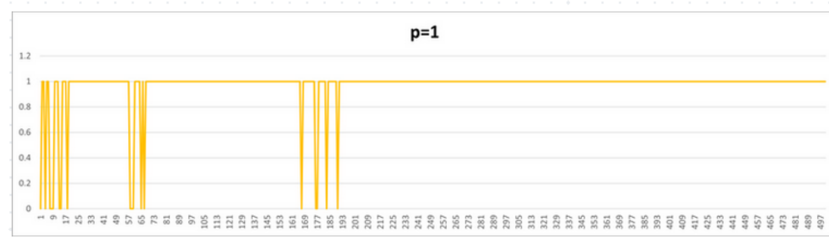

Results:

1. Minimize bottleneck by trying to set (Arrival Mean/Departure Mean) p=1
   - Higher Customer satisfaction because of slow increase in queue length
   - Minimum delay time
   - Server Utilization is highest
   - Best trade off between customer satisfaction and server utilization
2. the maximum queue length at every station
   - for 500 orders, we take the average maximum queue length
   - observed optimum queue length is 63

Conclutions:

The Car Manufacturing System Simulation strategically set the Arrival Mean to Departure Mean ratio (p=1), minimizing bottlenecks, leading to increased server utilization and customer satisfaction. Optimizing for an observed queue length of 63 showcased a balanced trade-off between operational efficiency and customer expectations. The average maximum queue length underscores the system's resilience. These findings provide actionable insights, informing strategic decision-making and establishing a robust foundation for operational efficiency and customer satisfaction in the manufacturing process.

Challenges Faced:

During the simulation, a significant hurdle arose in precisely adjusting the system's parameters to mirror real-world complexities. Achieving an accurate representation of factors like fluctuating production rates, intricacies in quality control, and varying customer demands necessitated meticulous fine-tuning. Striking the correct balance between model simplicity and capturing detailed manufacturing dynamics proved challenging, demanding iterative adjustments to ensure a realistic simulation outcome. Despite this challenge, the process emphasized the criticality of fidelity in modeling and highlighted the delicate equilibrium required between realism and computational efficiency.