**Modeling Project Report**

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**Introduction**

This project utilizes AnyLogic to model and simulate a dynamic stochastic system, emphasizing the identification and refinement of system components based on defined objectives. The subsequent construction of a computerized model integrates random variates, visualizations, and specifies key input and output variables. The final phase involves simulating and evaluating the system, estimating mean values for output parameters through multiple replications. Statistical analyses provide insights into the significance of system modifications and result confidence, contributing to a deeper understanding of system dynamics and the effectiveness of simulation in decision-making and optimization.

**System And Relations Between Components**

Our system in the project is a pizza shop. We have two different customers, one is the customers who come to the store, we can call them store customers, the other is the customers who order from home, we can call them remote customers. Remote customers are not directly in the system, instead they have couriers coming to pick up their pizzas from the shop. Couriers just wait for the pizza to be prepared, without queuing to order. Shop customers line up to order at the shop, but the pizza has a higher priority during preparation. Shop customers then queue up if there is not enough room to sit in the shop.

**A) System Components**

**Entity**

* Customer
* Courier
* Give order point
* Take order point

**Attribute**

* Pizza preparation speed
* Give order speed
* Order method
* Eating fast

**Activity**

* Waiting order queue
* Give Order
* Prepare pizza
* Waiting prepare queue
* Waiting desk queue

**Event**

* Waiting order queue
* Give order
* Prepare pizza
* Waiting prepare queue
* Waiting desk queue

**State Variable**

* Number of shop customer
* Number of remote customer
* Number of shop customer in order queue
* Number of shop customer in pizza prepare queue
* Number of coursier pizza prepare queue
* Number of shop customer in dest queue

**A)**

* Original Mean Value Estimation Process

| **Seed Value** | **Time of Shop Customer** | **Time of Remote Customer** | **Ordering End** | **# Shop Customer** | **# Remote Customer** |
| --- | --- | --- | --- | --- | --- |
| **1** | 114.25 | 40.75 | 10.67 | 148 | 82 |
| **2** | 108.75 | 35.77 | 5.96 | 143 | 93 |
| **3** | 140.95 | 39.54 | 11.06 | 153 | 80 |
| **4** | 110.05 | 26.23 | 6.76 | 86 | 147 |
| **5** | 164.81 | 40.36 | 30.08 | 162 | 88 |

\*It was run for 600 seconds.

* Alternative Mean Value Estimation Process

| **Seed Value** | **Time of Shop Customer** | **Time of Remote Customer** | **Time of Ordering End** | **Number of Shop Customer** | **Number of Remote Customer** |
| --- | --- | --- | --- | --- | --- |
| **1** | 187.3 | 154.15 | 27.29 | 152 | 84 |
| **2** | 194.83 | 147.27 | 11.64 | 140 | 88 |
| **3** | 175.29 | 146.62 | 6.73 | 145 | 77 |
| **4** | 179.14 | 150.53 | 4.86 | 143 | 77 |
| **5** | 213.88 | 160.85 | 33.49 | 165 | 77 |

\*It was run for 600 seconds.

**B) Confidence Intervals**

* Original confidence intervals (95%)

|  | **Lower Limit** | **Upper Limit** |
| --- | --- | --- |
| **Ordering Time** | 0.66 | 25.16 |
| **Shop Customer Time** | 98.11 | 156.21 |
| **Remote Customer Time** | 28.97 | 44.08 |
| **Number of Shop Customer** | 141.54 | 159.66 |
| **Number of Remote Customer** | 79.44 | 92.16 |

* Alternative Confidence Intervals (95%)

|  | **Lower Limit** | **Upper Limit** |
| --- | --- | --- |
| **Ordering Time** | 0.86 | 32.74 |
| **Shop Customer Time** | 171.10 | 209.07 |
| **Remote Customer Time** | 97.94 | 175.66 |
| **Number of Shop Customer** | 136.61 | 161.39 |
| **Number of Remote Customer** | 74.23 | 86.97 |

**C)10% CI Enhancement: Replication Estimate for Mean Outputs**

* Original

|  |  |
| --- | --- |
| **Ordering Time** | 1.42 |
| **Shop Customer Time** | 1.54 |
| **Remote Customer Time** | 1.54 |
| **Number of Shop Customer** | 1.54 |
| **Number of Remote Customer** | 0.04 |

* Alternative

|  |  |
| --- | --- |
| **Ordering Time** | 1.54 |
| **Shop Customer Time** | 1.54 |
| **Remote Customer Time** | 1.85 |
| **Number of Shop Customer** | 1.55 |
| **Number of Remote Customer** | 1.54 |

**D) 95% prediction intervals**

* Original

|  | **Lower Limit** | **Upper Limit** |
| --- | --- | --- |
| **Ordering Time** | 7.14 | 21.61 |
| **Shop Customer Time** | 110.62 | 147.29 |
| **Remote Customer Time** | 31.55 | 40.34 |
| **Number of Shop Customer** | 145.60 | 156.60 |
| **Number of Remote Customer** | 82.00 | 89.60 |

* Alternative

|  | **Lower Limit** | **Upper Limit** |
| --- | --- | --- |
| **Ordering Time** | 6.96 | 26.90 |
| **Shop Customer Time** | 179.23 | 202.35 |
| **Remote Customer Time** | 105.78 | 155.15 |
| **Number of Shop Customer** | 142.20 | 157.40 |
| **Number of Remote Customer** | 77.00 | 85.00 |

**Q/A**

1. **Difference Between Original and Alternative System**

Based on our performance analysis using confidence intervals, we can confidently say that our first system outperforms the alternative system in several ways. The confidence interval for “**Shop Customer Time**”, ranging from 98.11 to 156.21, is notably lower than the alternative system's range of 171.10 to 209.07. This indicates that our system is more efficient and completes tasks at a faster rate. Similarly, the confidence interval for “**Remote Customer Time**” varies greatly, with our first system's range being 28.97 to 44.08 compared to the alternative's 97.94 to 175.66. This illustrates our system's superior effectiveness in remote operations, providing quicker response times. In terms of the “**Number of Shop Customer**”, while the confidence interval for our first system (141.54 to 159.66) is comparable to that of the alternative system, it should be noted that our system still performs well within this range.