Faculty of Computer & Information Technology

Department of Computer Information Systems

Course: Decision Support System (CIS431)

ARENA PROJECT

Participants

NOOR ALHUDA MUSTAFA MAHMOUD JARADAT

JELAN AHMED ALI KHWEILEH

Supervised by:

PROFESSOR MOSTAFA Z.ALI

Part 1

Report part A

Introduction

We are trying to model a complex system composed of 4 press-drills each with its associated machines, the system has exponential interarrival times of packages and processing times and our model spans 10000 simulated minutes. The main objective is to check the system's performance under several conditions and to identify potential bottlenecks.

Methodology

We begin the simulation model by creating entities that represent packages, with interarrival times that follow an exponential distribution with a mean of 10 minutes. The following stage involves a decision-making procedure in which a decision module is used to classify the packages into three distinct types divided according to probabilities (type n way by chance). This classification is accomplished through the use of an assign module, which assigns each package type its own processing time, as detailed in the provided details. A sequential arrangement is also established for the assigned package types.

Following the classification and sequencing. The sequence of these processes was then arranged to follow a route with a transfer time of 3 minutes. The destination type, determined by sequence, guided the packages through various stations, each linked to processes labeled X, Y, Z, and W. All processes are linked through a common route before converging towards station 5, leading to the eventual disposal of the packages.

During the simulation, an error occurred, indicating that the number of entities exceeding the limit of 150.

To fix this error of having too many entities (more than 150) in the simulation, we made a new decision module (type 2 way by condition) where it checks if the total work-in-process (WIP) of all processes (W, X, Y, Z) is less than or equal to 140. If it is, the simulation continues; otherwise, the extra entities are disposed of, making sure that the total number of entities doesn't go beyond a set limit.

Analysis (when the capacity of y is 1)

Name	Type	Source	Average	Minimum	Maximum
Package 1	WIP	Entity	38.21384706	0	59
Package 2	WIP	Entity	37.41066368	0	59
Package 3	WIP	Entity	30.64683838	0	49
W.Queue	Number Waiting	Queue	0	0	0
W_machine	Instantaneous Utilization	Resource	0.212844875	0	1
W_machine	Number Busy	Resource	0.212844875	0	1
W_machine	Number Scheduled	Resource	1	1	1
X.Queue	Number Waiting	Queue	0.107068728	0	5

X_machine	Instantaneous Utilization	Resource	0.41775	0	1
X_machine	Number Busy	Resource	0.8355	0	2
X_machine	Number Scheduled	Resource	2	2	2
Y.Queue	Number Waiting	Queue	102.3406186	0	141
Y_machine	Instantaneous Utilization	Resource	0.998244875	0	1
Y_machine	Number Busy	Resource	0.998244875	0	1
Y_machine	Number Scheduled	Resource	1	1	1
Z.Queue	Number Waiting	Queue	0.292672051	0	5
Z_machine	Instantaneous Utilization	Resource	0.5793	0	1
Z_machine	Number Busy	Resource	0.5793	0	1
Z_machine	Number Scheduled	Resource	1	1	1

- All three package types show variations in WIP, with Package 3 having the lowest average WIP.
- The Y.Queue has a much higher average number of entities waiting compared to other queues, indicating a potential bottleneck or inefficiency in the Y process.
- The utilization of machines varies, with Y_machine operating at near maximum capacity. X_machine shows higher utilization, possibly due to its capacity of 2.
- Number of entities that have exited the system is 876

Recommendations:

- Monitor and optimize the processes causing longer waiting times in Y.Queue.
- Consider adjusting the scheduling of tasks for resources with high utilizations to avoid potential bottlenecks**.**

Analysis (when the capacity of y is 2)

Name	Type	Source	Average	Minimum	Maximum
Package 1	WIP	Entity	2.43603421	0	8
Package 2	WIP	Entity	2.148113792	0	8
Package 3	WIP	Entity	1.721664879	0	7
W.Queue	Number Waiting	Queue	0.042278741	0	2
W_machine	Instantaneous Utilization	Resource	0.33915	0	1
W_machine	Number Busy	Resource	0.33915	0	1
W_machine	Number Scheduled	Resource	1	1	1
X.Queue	Number Waiting	Queue	0.170655317	0	5
X_machine	Instantaneous Utilization	Resource	0.515	0	1

X_machine	Number Busy	Resource	1.03	0	2
X_machine	Number Scheduled	Resource	2	2	2
Y.Queue	Number Waiting	Queue	0.45995123	0	5
Y_machine	Instantaneous Utilization	Resource	0.739252859	0	1
Y_machine	Number Busy	Resource	1.478505718	0	2
Y_machine	Number Scheduled	Resource	2	2	2
Z.Queue	Number Waiting	Queue	0.820860439	0	7
Z_machine	Instantaneous Utilization	Resource	0.758005718	0	1
Z_machine	Number Busy	Resource	0.758005718	0	1
Z_machine	Number Scheduled	Resource	1	1	1

- All three package types show relatively low WIP, indicating efficient processing and minimal queuing.
- All queues have low average wait times, indicating efficient processing and little congestion.
- Machine utilization varies, with X and Y machines working at or near maximum capacity.
- Number of entities that have exited the system is 1002

Recommendations:

- Continue monitoring the queues and WIP for potential optimization opportunities.
- Consider adjusting the scheduling of tasks for resources with high utilizations to avoid potential bottlenecks.

Conclusion

The changes made to the simulation model, particularly the addition of another decision module to limit the overall number of entities, led to positive results. More modifications, particularly in resource capacity improved the system performance. The system is now more efficient, with lower average WIP and shorter queue wait times the overall simulation shows a more controlled and optimized manufacturing environment. These comparison findings highlight the iterative nature of simulation modeling and the ongoing need for improvement in order to attain optimal outcomes.

Report part B

Methodology

Same as part A only this time There were key changes including replacing all stations, except X_station, with the Enter module to release resources and using the Leave module (type route)

connected to processes via a TRIA(3, 5, 7) move time to seize resources. A new resource called "worker" has also been added to the model, with a capacity of 3.

Analysis b

Name	Type	Source	Average	Minimum	Maximum
Leave 1.Queue	Number Waiting	Queue	0.0491791	0	4
Package 1	WIP	Entity	32.727301	0	53
Package 2	WIP	Entity	37.37309	0	60
Package 3	WIP	Entity	35.133967	0	54
W.Queue	Number Waiting	Queue	0.0820573	0	2
W_machine	Instantaneous Utilization	Resource	0.2408633	0	1
W_machine	Number Busy	Resource	0.2408633	0	1
W_machine	Number Scheduled	Resource	1	1	1
X.Queue	Number Waiting	Queue	0.2198277	0	5
X_machine	Instantaneous Utilization	Resource	0.4275968	0	1
X_machine	Number Busy	Resource	0.8551937	0	2
X_machine	Number Scheduled	Resource	2	2	2
Y.Queue	Number Waiting	Queue	99.999881	0	142
Y_machine	Instantaneous Utilization	Resource	0.9988153	0	1
Y_machine	Number Busy	Resource	0.9988153	0	1
Y_machine	Number Scheduled	Resource	1	1	1
Z.Queue	Number Waiting	Queue	0.8119068	0	8
Z_machine	Instantaneous Utilization	Resource	0.5821155	0	1
Z_machine	Number Busy	Resource	0.5821155	0	1
Z_machine	Number Scheduled	Resource	1	1	1
worker	Instantaneous Utilization	Resource	0.3809714	0	1
worker	Number Busy	Resource	1.1429141	0	3
worker	Number Scheduled	Resource	3	3	3

- There is continued challenges in the Y.Queue, suggesting a persistent bottleneck or inefficiency in the Y process.
- Worker resource shows generally high utilization and is consistently busy, indicating a potential area for optimization or resource adjustment.
- Number of entities that have exited the system is 846

Recommendations

- Investigate and optimize the processes causing longer waiting times in queues, especially for Y.Queue.
- Monitor and adjust the workload on the worker resource to avoid potential overloading.

- Consider adjusting the scheduling of tasks for resources with high utilizations to avoid potential bottlenecks.

Report part C

Methodology

We extend our work from Part A by including the Transporter module (type forklift with number of units of 2) to show the transfer of processed packages between drill presses and the newly added exit station. We converted the forklifts speed from distribution with parameters (2, 4, 6) miles per hour to meters per hour to maintain unit consistency in the simulation. TRIA(3219, 6437, 9656) meters per hour is the triangle distribution for forklift speed.

Analysis c

Name	Type	Source	Average	Minimum	Maximum
Package 1	WIP	Entity	38.62217872	0	58
Package 2	WIP	Entity	39.52106429	0	63
Package 3	WIP	Entity	35.6110598	0	54
Request 1.Queue	Number Waiting	Queue	0.000640778	0	2
Transporter 1	Number Busy	Transporter	0.176327067	0	2
Transporter 1	Number Scheduled	Transporter	2	2	2
Transporter 1	Utilization	Transporter	0.088163534	0	1
W.Queue	Number Waiting	Queue	0	0	0
W_machine	Instantaneous Utilization	Resource	0.22575	0	1
W_machine	Number Busy	Resource	0.22575	0	1
W_machine	Number Scheduled	Resource	1	1	1
X.Queue	Number Waiting	Queue	0.116097475	0	6
X_machine	Instantaneous Utilization	Resource	0.421072336	0	1
X_machine	Number Busy	Resource	0.842144672	0	2
X_machine	Number Scheduled	Resource	2	2	2
Y.Queue	Number Waiting	Queue	110.2803082	0	141
Y_machine	Instantaneous Utilization	Resource	0.998560559	0	1
Y_machine	Number Busy	Resource	0.998560559	0	1
Y_machine	Number Scheduled	Resource	1	1	1
Z.Queue	Number Waiting	Queue	0.299000428	0	4
Z_machine	Instantaneous Utilization	Resource	0.570673613	0	1
Z_machine	Number Busy	Resource	0.570673613	0	1
Z_machine	Number Scheduled	Resource	1	1	1

- Queue waiting times vary significantly, with the longest queue observed in Y.Queue.
- Transporter 1 is utilized at 8.82% with 2 tasks scheduled.
- Resources W_machine, X_machine, Y_machine, and Z_machine have varying utilizations and scheduled tasks, indicating the workload on each resource.
- Number of entities that have exited the system is 881

Recommendations

- Further investigate and potentially optimize the processes causing longer waiting times in queues, especially for Y.Queue.
- Consider adjusting the scheduling of tasks for resources with high utilizations to avoid potential bottlenecks.
- Monitor and adjust the workload on Transporter 1 to maintain an optimal utilization level.

Part 2 report

Introduction

In this simulation using Arena software, we model a system comprising three independent conveyors converging onto a main conveyor. Conveyor #1 and #2 exhibit Poisson(5) and Poisson(10) package inter-arrival rates, respectively, while Conveyor #3 features uniformly distributed inter-arrival times between 0.07 and 0.15 minutes. Conveyors #1 and #2, both accumulating conveyors, are 15 and 20 feet long, running at 12 feet per minute. Conveyor #3, also an accumulating conveyor, spans 11 feet at a speed of 20 ft/min. The main conveyor, covering 20 feet, operates at 20 ft/min, disposing of packages at its end. Our goal is to simulate this system for 1000 minutes, estimating accessing times and the average number of packages waiting for the conveyors.

Methodology

In our Arena simulation model, we have created three distinct entities, named "Package 1," "Package 2," and "Package 3," each representing different types of packages. Each package type is associated with three different stations, and each station is linked to a specific conveyor. At the end of each conveyor, there is a connection to a station, indicating the exit point for the respective packages. These stations serve to mark the transition of packages from the conveyor to the storeroom. Additionally, we have connected the stations associated with each package type to a common station, signifying the convergence of packages in the storeroom. From this converging point, a main conveyor is created, connecting to another station. At the end of the main conveyor, there is a final station, indicating the point where the packages have completed their journey through the system and are ready for disposal.

Analysis

Name	Type	Source	Average	Minimum	Maximum
Access con1.Queue	Number Waiting	Queue	0.000333333	0	1
Access con2.Queue	Number Waiting	Queue	0	0	1
Access con3.Queue	Number Waiting	Queue	0.226572898	0	1
Access main con.Queue	Number Waiting	Queue	0.429033333	0	4
Conveyor 1	Length Accumulated	Conveyor	0	0	2
Conveyor 1	Utilization	Conveyor	0.015296875	0	0.125
Conveyor 2	Length Accumulated	Conveyor	0	0	1
Conveyor 2	Utilization	Conveyor	0.008492063	0	0.047619
Conveyor 3	Length Accumulated	Conveyor	0	0	4
Conveyor 3	Utilization	Conveyor	0.416933333	0	0.5833333
Pakages 1	WIP	Entity	0.44955	0	2
Pakages 2	WIP	Entity	0.29065	0	1
Pakages 3	WIP	Entity	14.7320229	0	19
main Conveyor	Length Accumulated	Conveyor	0	0	6

main Conveyor	Utilization	Conveyor	0.447142857	0	0.6666667

- Package 1 and Package 2 entities exhibit moderate to low WIP, indicating generally smooth processing.
- Package 3 entities experience high WIP, suggesting potential bottlenecks or increased demand.
- The queues associated with Conveyor 1 and Conveyor 2 generally maintain low to zero waiting times, indicating efficient processing. Consider evaluating the design and demand patterns to sustain this efficiency.
- Conveyor 1 and Conveyor 2 show low utilization and accumulation, indicating underutilization.
- Conveyor 3 shows high utilization, suggesting it is operating close to its capacity
- The main conveyor performs reasonably well with a balanced accumulation and utilization.

Recommendations:

- Investigate the causes of intermittent delays and bottlenecks in Conveyor 3 and queues to enhance overall system efficiency.
- Explore the possibility of increasing conveyor capacity or introducing dynamic adjustments to address varying demand conditions.
- Consider conducting sensitivity analysis to identify critical points in the system where small changes may have a significant impact on performance.