



UNIVERSITAS INDONESIA



UNIVERSITÉ D'ARTOIS

**SIMULASI MODEL CROSS-DOCK
DENGAN MENGGUNAKAN SOFTWARE ARENA**

TESIS

ALANG SUNDING

0906579115

**FAKULTAS TEKNIK
PROGRAM STUDI TEKNIK MESIN
DEPOK
JUNI 2011**



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**Diajukan sebagai salah satu syarat untuk mendapatkan gelar Magister
Teknik**

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PROGRAM STUDI TEKNIK MESIN
DEPOK
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HALAMAN PERNYATAAN ORISINALITAS

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Telah berhasil dipertahankan dihadapan dewan penguji dan diterima sebagai bagian persyaratan yang diperlukan untuk memperoleh gelar Master 2 Université d'Artois (Perancis) dan Magister Teknik Progran Studi Teknik Mesin, Fakultas Teknik, Universitas Indonesia

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4. Teman-teman DDIP-2010 atas segala kerjasama dan dukungannya

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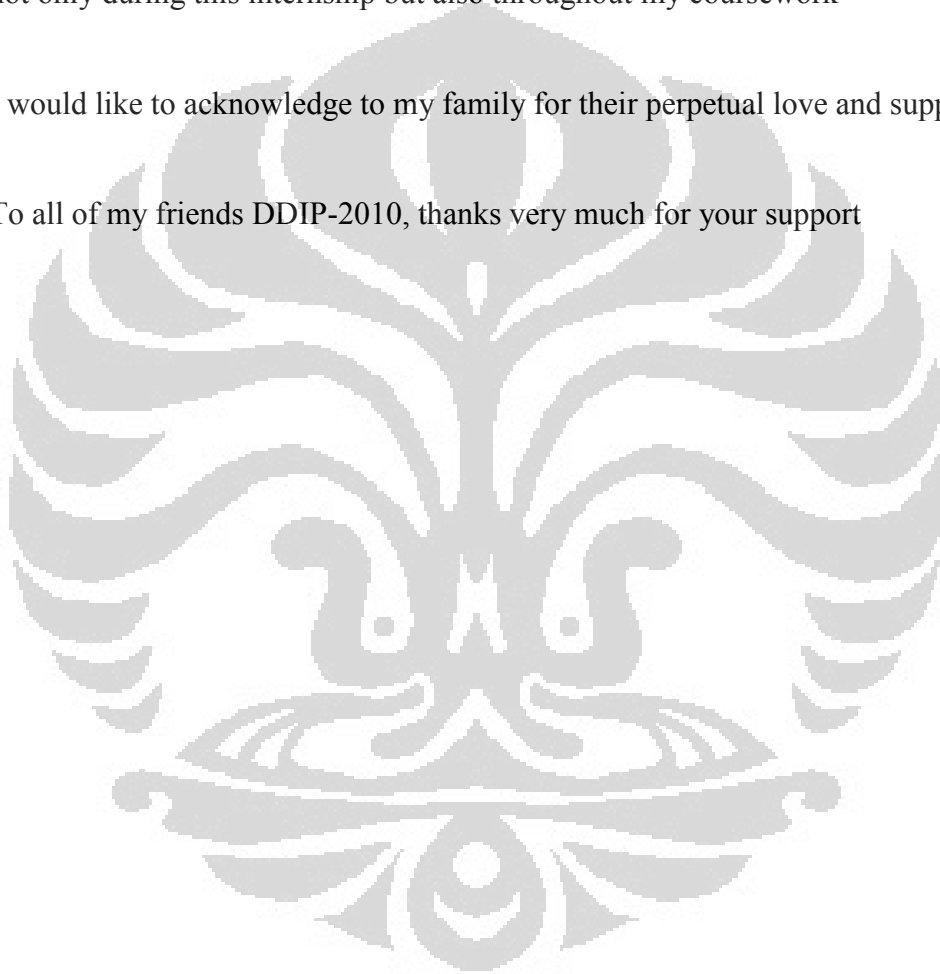
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To all of my friends DDIP-2010, thanks very much for your support



**HALAMAN PERNYATAAN PERSETUJUAN PUBLIKASI
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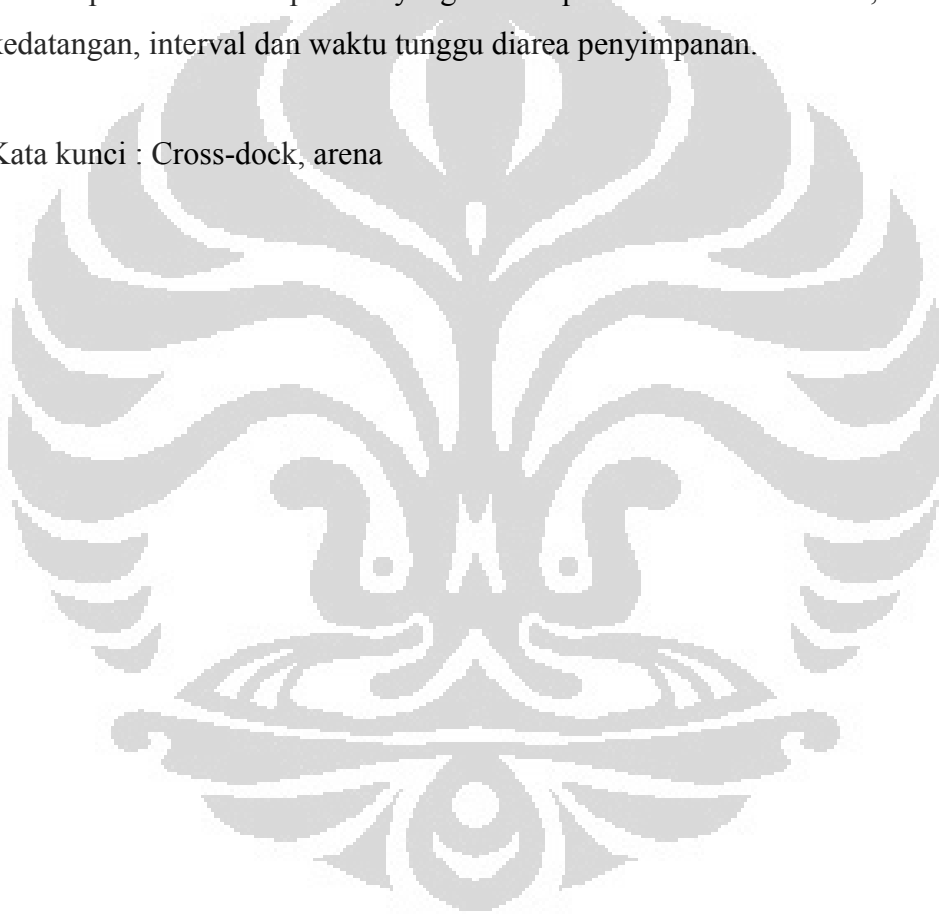


Alang Sunding

ABSTRAK

Laporan ini berisi simulasi cross-dock dengan menggunakan software Arena. Dalam simulasi ada empat tahapan yang dilakukan dalam melakukan analisa cross-dock, yaitu: Membuat model, menjalankan model, melakukan simulasi dan menganalisa hasil simulasi. Ada tiga scenario yang akan dimodelkan, disimulasikan dan dibandingkan untuk mendapatkan scenario terbaik. Analisa system cross-dock focus pada pusat aktifitas cross-dock dengan melakukan analisa pada : Jumlah produk yang keluar pada sistem cross-dock, waktu antar kedatangan, interval dan waktu tunggu diarea penyimpanan.

Kata kunci : Cross-dock, arena



ABSTRACT

This report consist of simulation cross dock using the arena simulation software. The cross-docking project that analyzed in this work is made up of four steps: Create a basic model, refine the model, simulate the model, and analyze simulation results. There are three cross-dock scenarios to be modeled, simulated and compared to determine the best model. The analysis will be conducted focusing on the cross dock center with four measurement parameters are: number of products out of the cross dock, time between arrival, time interval, and waiting time in staging area.

Keywords: Cross-dock, Arena simulation

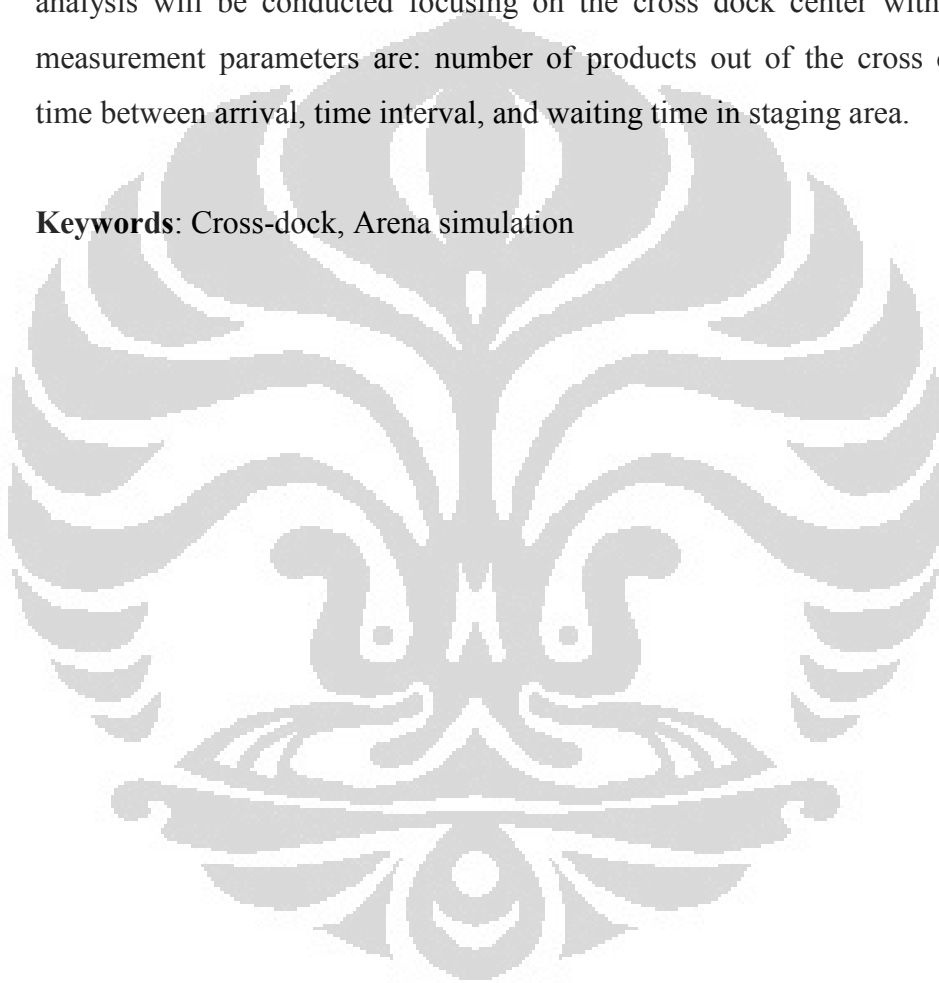
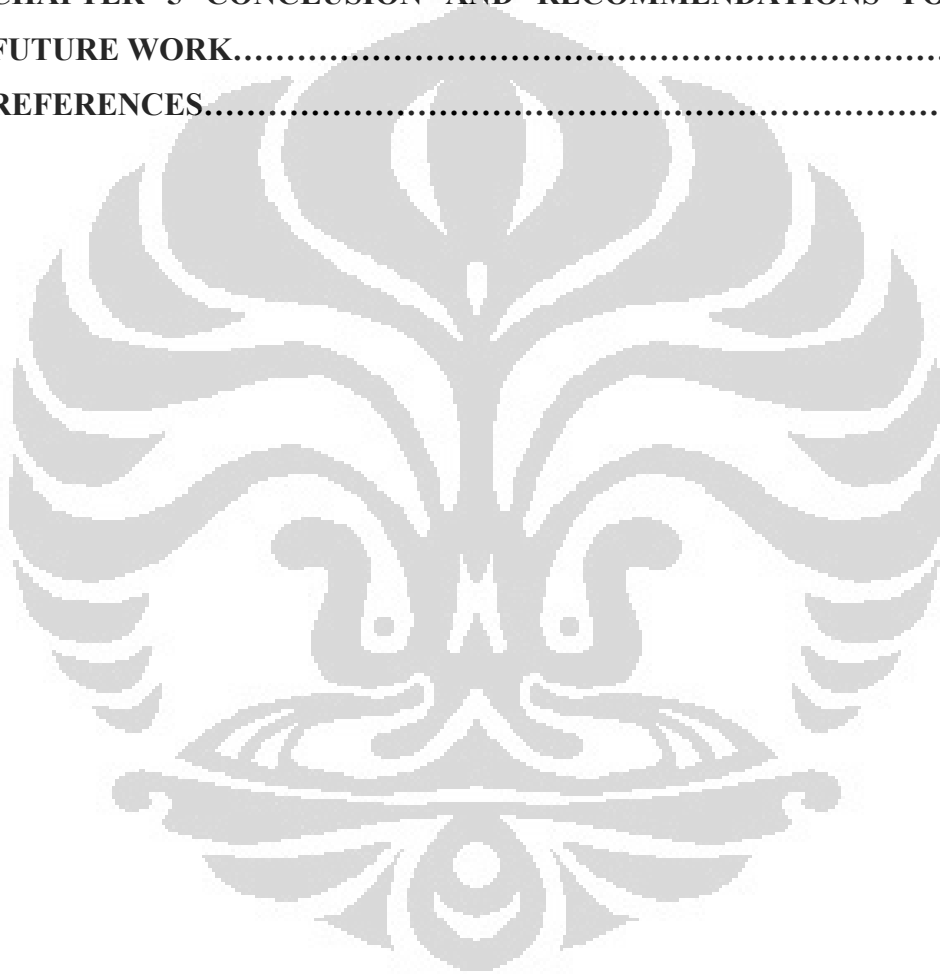


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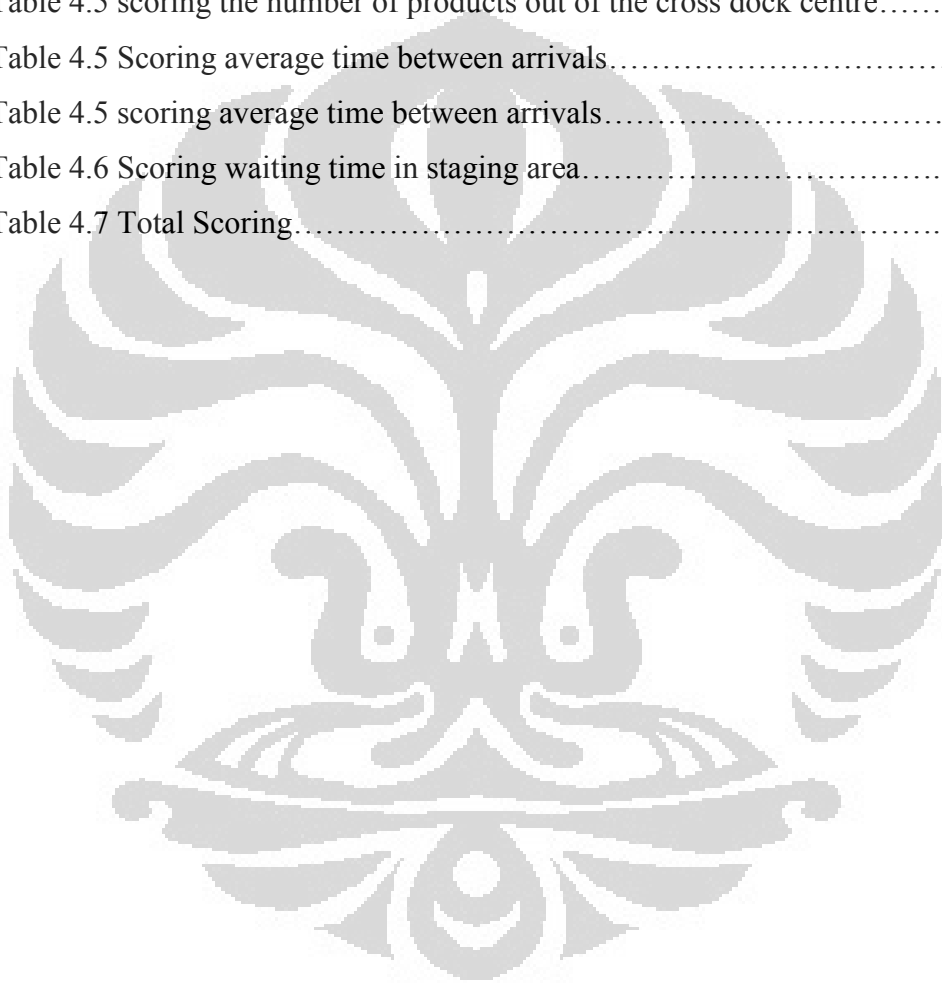
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CHAPTER 1

INTRODUCTION

1.1 Background

Good distribution centers have criteria (objectives) as follows: The First, cost efficiency, in terms of not storing stuff in a long time, the distribution of goods at the right time, transportation within and outside the warehouse that is easy, and well documented. Second, time efficiency, which is easily accessed, retrieved, and recognizable, and there are not rearranging stuff.

Cross docking (also referred to as just-in-time distribution) is a relatively new Logistics technique that has been successfully applied by several retail chains a cross dock is a transshipment facility in which incoming shipments (possibly originating from several manufacturers) are sorted, consolidated with other products and transferred directly to outgoing trailers without intermediate storage (G. Ghiani: 2004).

Arena simulation software can show the power of modeling and simulation to business process improvement. It is designed primarily for newcomers to simulation and serves as an introductory. Typically, any process that can be described by means of a flowchart can be simulated with it.

Arena simulation software is most effective when analyzing business, service, simple manufacturing processes or flows of material such as cross dock distribution strategy. Typical scenario include: Documenting, visualizing, and demonstrating the dynamics of a process with animation.

1.2 Methodology

Methodologies are needed to facilitate in solving problems, to guide the construct of models and to analyze of simulation and scenarios.

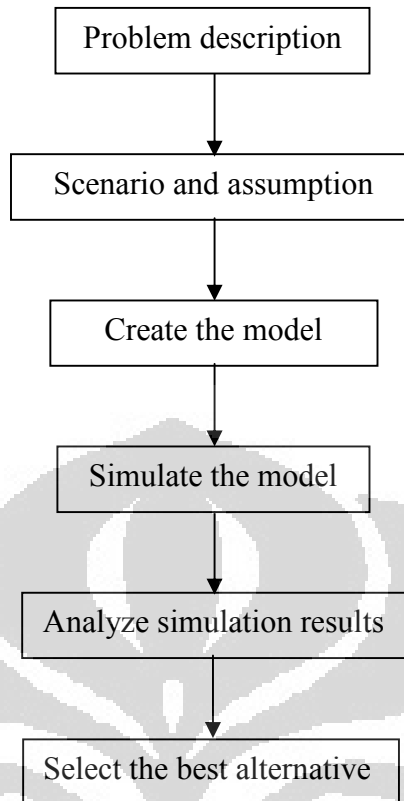


Figure 1.2 the steps of process

1.3 Objectives

- Modeling the cross-dock system by Arena Simulation Software.
- Analyzing visually on the model (scenario) and the assumptions
- Analyzing time interval in cross docking centre.
- Analyzing time between in cross docking centre.
- Analyzing waiting time in staging area
- Comparing each scenario to obtain the best solution.

1.4 Internship Period

Internship period starting from 4 April until 4 July at Laboratoire Genie Informatique et Automatique de l'Artois (LGI2A) in Bethuné-France

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution Strategy

Inventory and transportation policies are intertwined. When distributing a product, three main strategies can be used: direct shipment, warehousing, cross docking (G. Ghiani: 2004).

Direct shipment strategy is used to ship directly from the manufacturer to the end-user (the retailers in the case of retail goods) direct shipments eliminate the expenses of operating a distribution centre and reduce lead times. On the other hand, if a typical customer shipment size is small and customers are dispersed over a wide geographic area, a large fleet of small trucks may be required. As a result, direct shipment is common when fully loaded trucks are required by customers or when perishable goods have to be delivered timely.

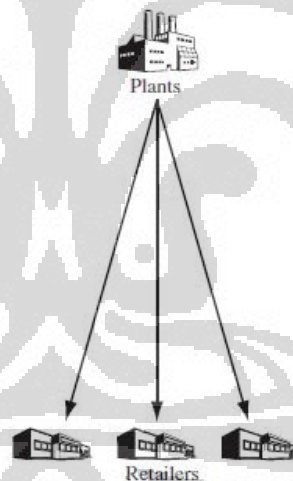


Figure 2.1 Direct shipment strategies

Warehousing is a traditional approach in which goods are received by warehouses and stored in tanks, pallet racks or on shelves. When an order arrives, items are retrieved, packed and shipped to the customer. Warehousing consists of four major functions: reception of the incoming goods, storage, order picking and shipping. Out of these four functions, storage and order picking are the most expensive because of inventory holding costs and labor costs, respectively.

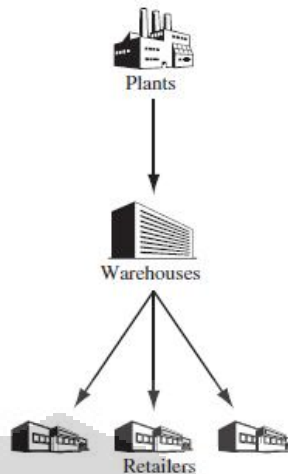


Figure 2.2 Warehousing

Cross docking (also referred to as just-in-time distribution) is a relatively new Logistics technique that has been successfully applied by several retail chains. A cross dock is a transshipment facility in which incoming shipments (possibly originating from several manufacturers) are sorted, consolidated with other products and transferred directly to outgoing trailers without intermediate storage or order picking. As a result, shipments spend just a few hours at the facility. Cross docking requires high volume and low variability of demand (otherwise it is difficult to match supply and demand) as well as easy-to-handle products. Moreover, a suitable information system is needed to coordinate inbound and outbound flows.

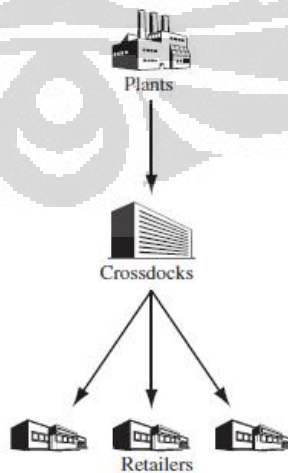


Figure 2.3 Cross docking

2.2 Cross dock

Cross docking is a logistics technique that eliminates the storage and order picking functions of a warehouse while still allowing it to serve its receiving and shipping functions. The idea is to transfer shipments directly from inbound to outbound trailers without storage in between. Shipments typically spend less than 24 hours in a cross dock, sometimes less than an hour. Cross docking is an important logistics strategy for many firms in the retail, grocery, and other distribution industries. (John J. Bartholdi: 2004).

Cross-docking is a practice in logistics of unloading materials from an incoming truck or rail car and loading these materials directly into outbound trucks, trailers, or rail cars, with little or no storage in between (Baker,P:2008)

Cross-docking is a special warehousing policy moving goods directly from inbound trucks (ITs) to outbound trucks (OTs) without storage or with just temporary storage. In a typical logistics distribution network, products are sent to a warehousing facility for storing, retrieving, sorting and reconsolidating (Sunil, C. and P. Meindl: 2002)

Problems relating to cross-dock facilities can be categorized into two groups (Boysen: 2010):

- a. problems that consider the facility as a node within a larger transportation network
- b. problems that focus on the operations of the facility

2.3 The Advantage of Cross dock

(Yan Liu, Soemon Takakuwa: 2010) The primary objective of cross-docking is to **eliminate storage**, excessive handling, and lead time while minimizing transportation and storage costs and maintaining a high level of customer service.

Cross-docking's impact to supply chain is to make it more **responsive** to customer demand (Zhengping Li *et.al* :2007). Cross-docking has some obvious advantages. First cross-docking eliminates two cost- and labor-intensive functions: storage and order picking of a traditional warehouse, while still allowing it to serve receiving and shipping functions. Second, the speed of

material movement is faster because products arrive in inbound dock has their destination. Third, inventory is much lower and the throughput is higher in cross-docking compared to traditional warehousing. In addition, when timing is well coordinated, products can be made available in shorter time windows, thus reducing cycle times.

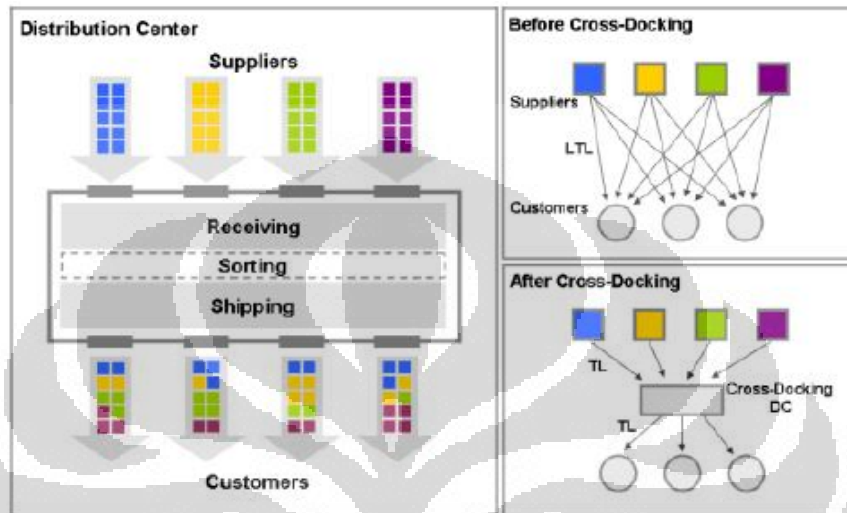


Figure 2.2 Before and after Cross dock distribution

2.4 Arena Simulation

Arena is a simulation environment consisting of module templates, built around SIMAN language constructs and other facilities, and augmented by a visual front end (Tayfur: 2007).

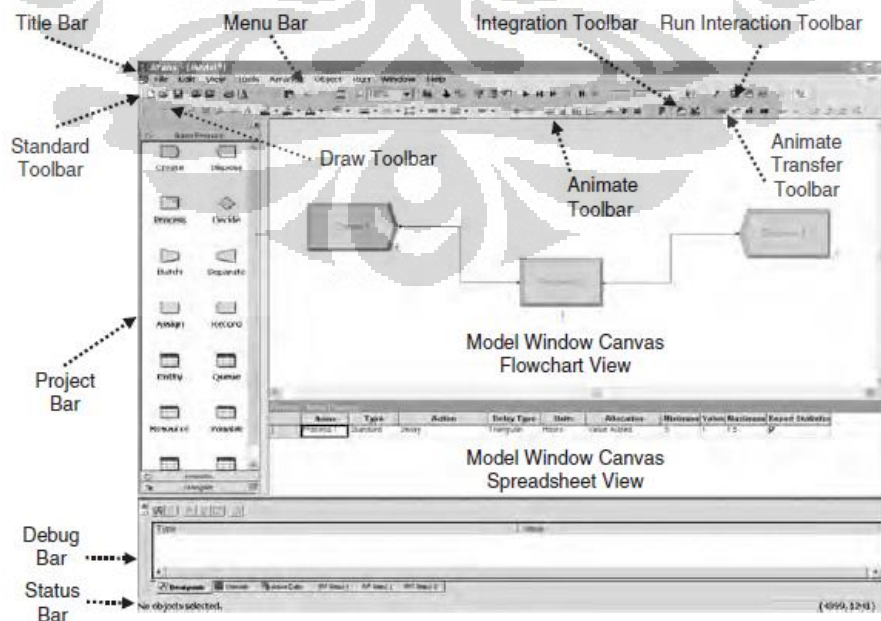


Figure 2.5 The arena home screen

SIMAN consists of two classes of objects: blocks and elements. More specifically, blocks are basic logic constructs that represent operations; for example, a SEIZE block models the seizing of a service facility by a transaction (referred to in Arena as “entity”), while a RELEASE block releases the facility for use by other transactions. Elements are objects that represent facilities, such as RESOURCES and QUEUES, or other components, such as DSTATS and TALLIES, used for statistics collection.

Arena's fundamental modeling components, called modules, are selected from template panels, such as Basic Process, Advanced Process, and Advanced Transfer, and placed on a canvas in the course of model construction. A module is a high-level construct, composed of SIMAN blocks and/or elements. For example, a Process module models the processing of an entity, and internally consists of such blocks as ASSIGN, QUEUE, SEIZE, DELAY, and RELEASE. Arena also supports other modules, such as Statistic, Variable, and Output among many others.

Five easy steps with Arena:

1. Create a basic model.

Arena provides an intuitive, flowchart-style environment for building an "as-is" model of your process. Simply drag Arena's modules — the shapes in the flowchart — into the model window and connect them to define process flow.

2. Refine the model.

Add real-world data (e.g., process times, resource requirements, and staff levels) to your model by double-clicking on modules and adding information to Arena's data forms. To create a more realistic picture of your system, replace the animation icons that Arena automatically supplies with graphics of your own (e.g., from ClipArt or other drawing packages).

3. Simulate the model.

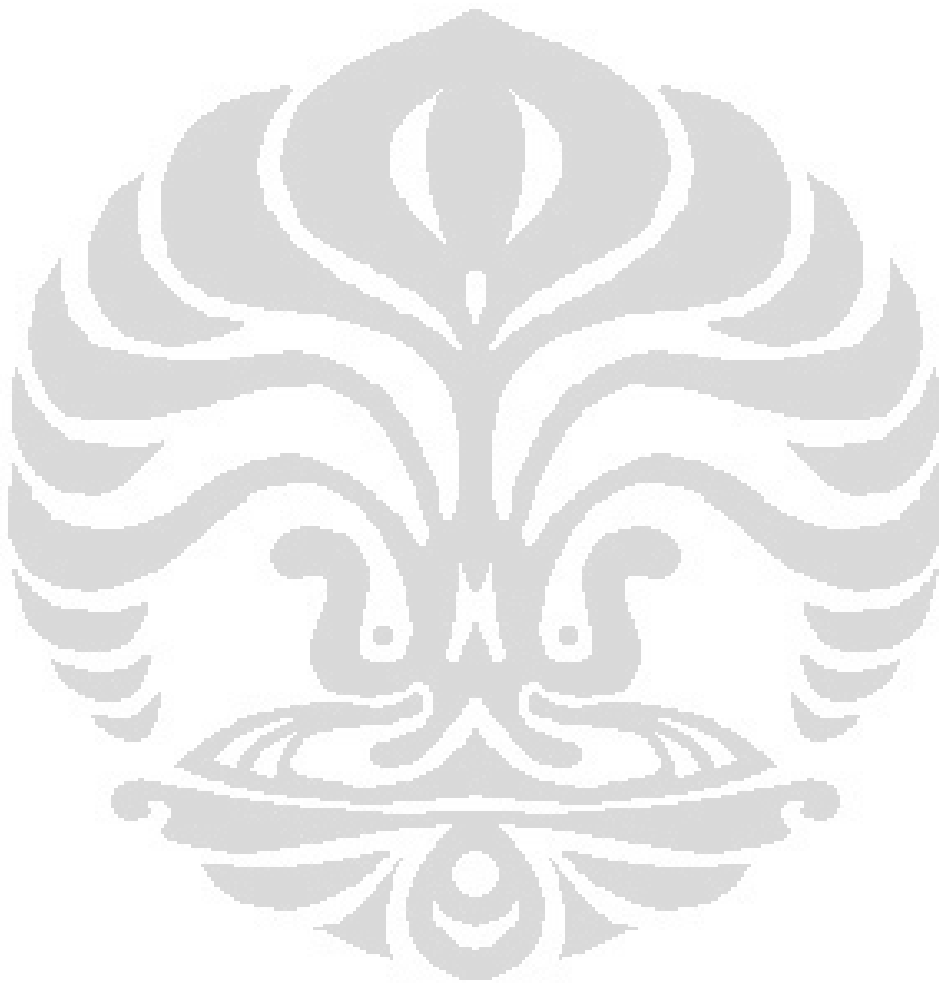
Run the simulation to verify that the model properly reflects the actual system. Identify bottlenecks and communicate with others through the dynamics of Arena's graphical animation

4. Analyze simulation results.

Arena provides automatic reports on common decision criteria, such as resource utilization and waiting times. Augment the built-in statistics with your own, so that Arena reports what's important for your decision-making needs

5. Select the best alternative

Make changes to the model to capture the possible scenarios you want to investigate, and then compare the results to find the best "to-be" solution.



CHAPTER 3

MODEL APPROACH AND ASUMPTIONS

3.1 Problem Description

There are two categories of problems in cross dock (Boysen: 2010), one of them is the problems that focus on the operations of the facility. Base on that, case studies that will solve, that is: how to regulate the flow of products in the cross dock centre start from unloading dock until the loading dock.

In this case, we considered a simplified cross docking terminal with three docks of unloading and three docks of loading. The model is based on a common cross-docking layout.

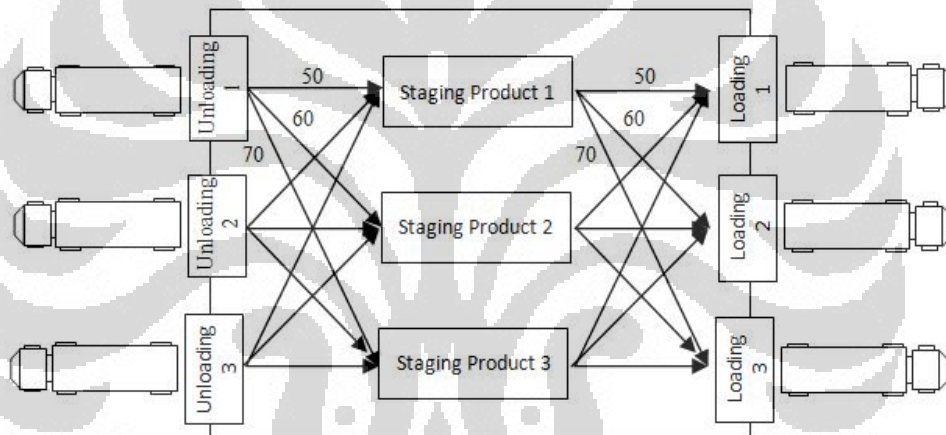


Figure 3.1 Model of cross-dock centre

3.2 Scenario and Assumption

There are three scenarios modeling the flow of incoming products to cross dock and outflow of products to customer that will be modeled, simulated and analyzed.

3.2.1 Scenario 1

Each truck carrying three kinds of products to the center of cross dock and each truck will deliver one kind of product to customers

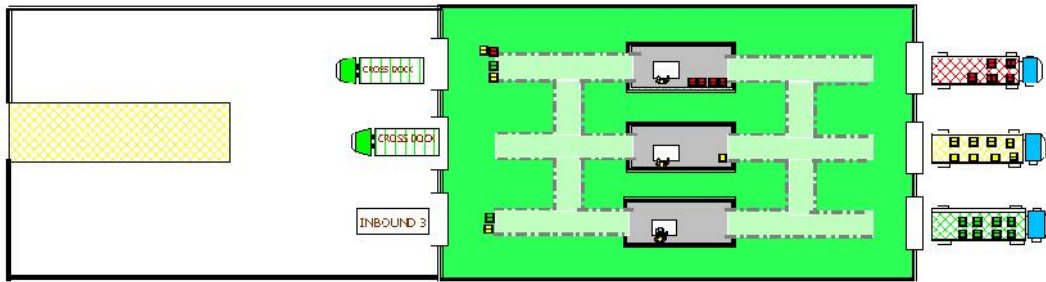


Figure 3.2 Animation of scenario 1

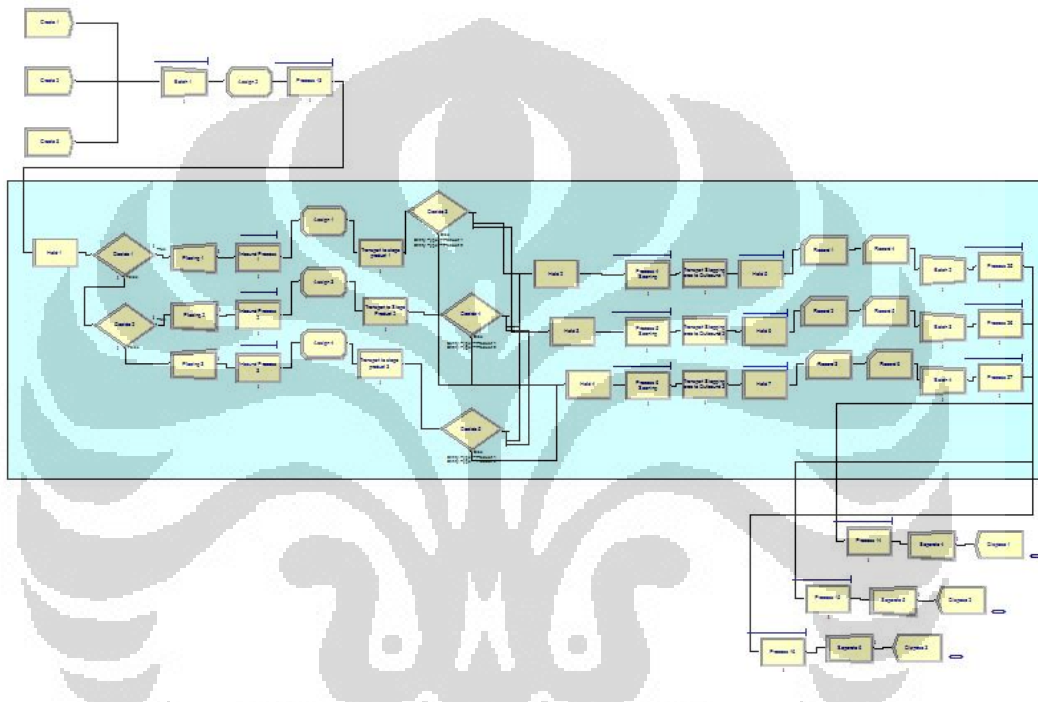


Figure 3.3 Model logic scenario 1

3.2.2 Scenario 2

Each truck carrying one kind of products to the center of cross dock and each truck will deliver one kind of product to customers

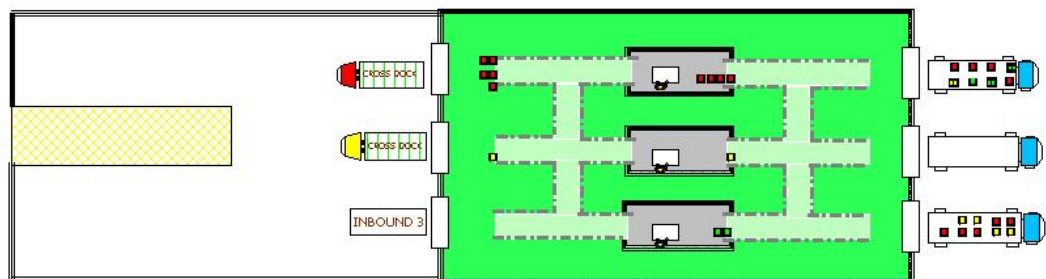


Figure 3.4 Animation of scenario 2

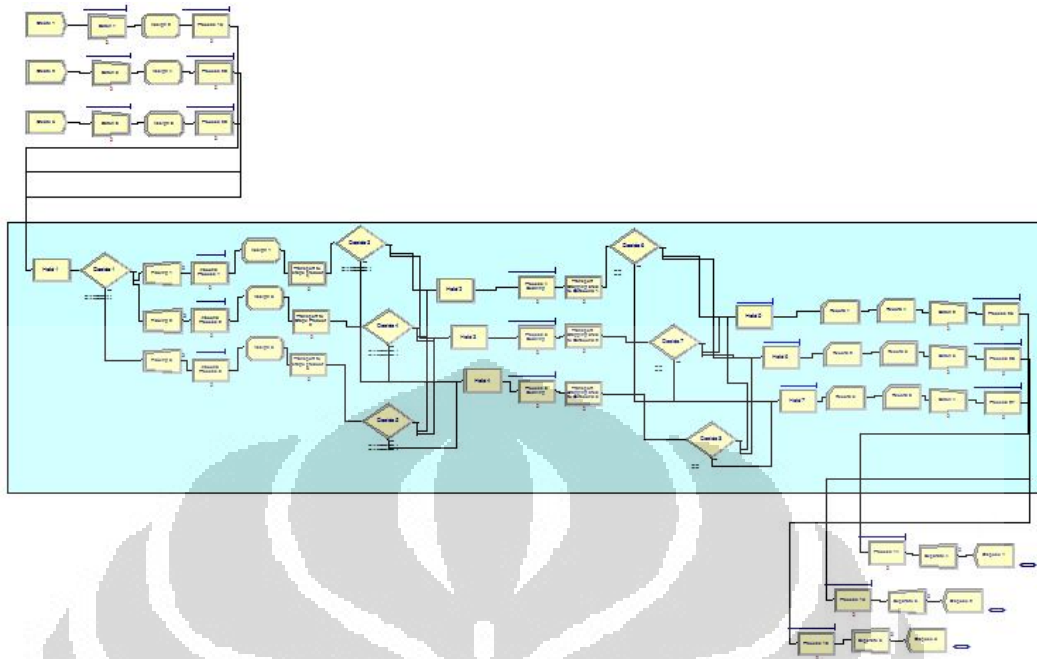


Figure 3.5 Model logic scenario 2

3.2.3 Scenario 3

Each truck carrying three kinds of products to the center of cross dock and each truck will deliver one kinds of product to customers



Figure 3.6 Animation of scenario 3

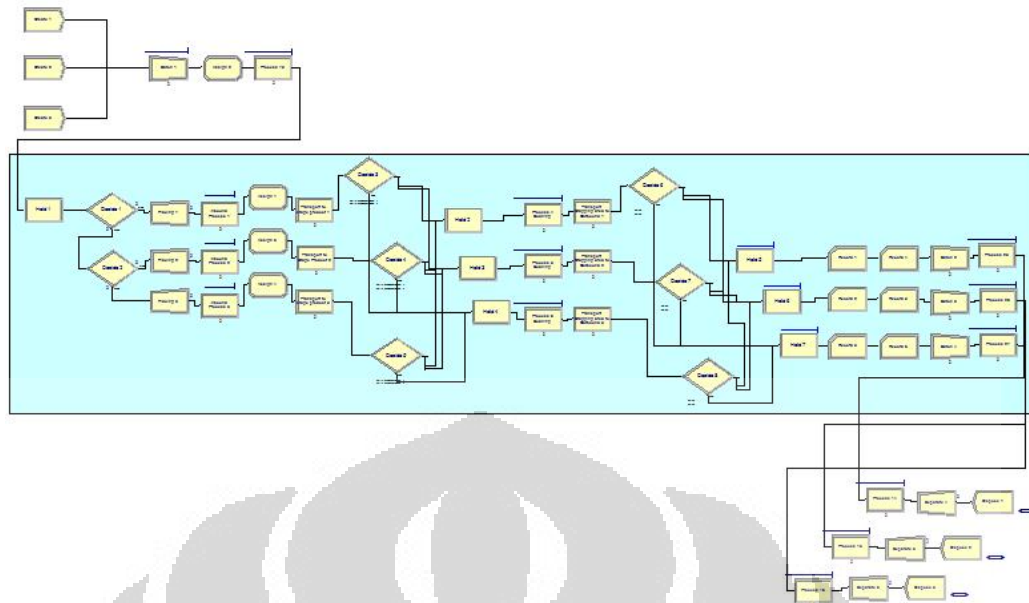


Figure 3.7 Model logic of scenario 3

At this cross-docking center, there are five operator groups. There are loading, transporting to stage area, scanning, transporting to loading dock. Time Activities, assumption and parameter of the model that will be simulated as follow:

Table 3.1 Activities and parameter of the model

| Activities | | Parameter |
|-------------------------|----------------------------|-------------------------------------|
| Supplier to Cross dock | Producing product 1 | Every 5 minutes |
| | Producing product 2 | Every 5 minutes |
| | Producing product 3 | Every 5 minutes |
| | Collecting product | Every 10 products |
| | Truck Arrival | Every 15minutes |
| Cross Dock | Unloading | 20 minutes |
| | Transporting to stage area | Depending on the distance and speed |
| | Scanning | 10 second |
| | Transporting to load area | Depending on the distance and speed |
| Loading | 20 minutes | |
| Cross Dock to Suppliers | Delivering | Every 20 minutes |

The cross dock model operates around the clock. Models approach from supplier to customer is as follows:

- Each truck carries 10 products
- The arrival of trucks every 15 minutes
- Each product will be unloaded 2 minutes each product
- Each product will be transported by forklift to the staging area in accordance with the type of product
- In the staging area will be scanned and ready to be transported to the loading dock by forklift
- Each truck will carry 10 products to customer

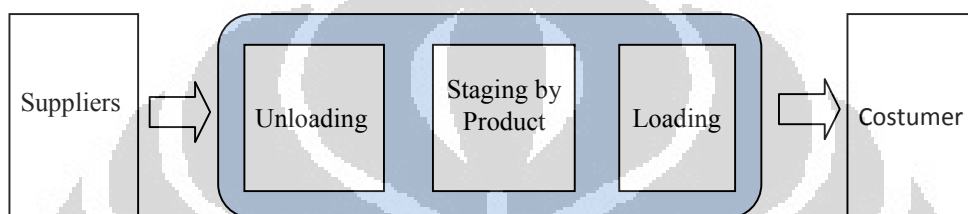


Figure 3.8 Operation flow of the cross-docking

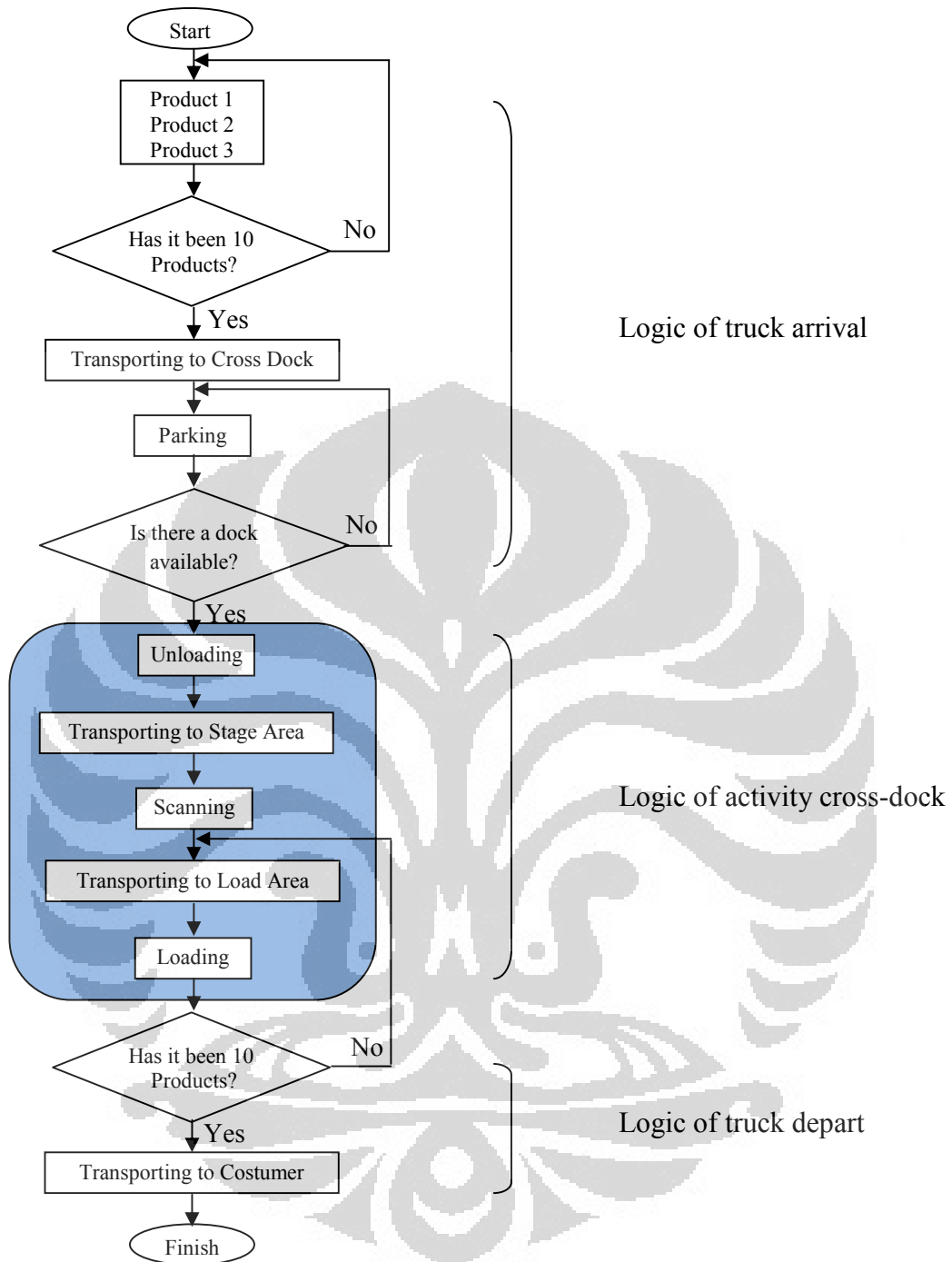


Figure 3.9 Flow chart operations

3.3 Create the model

Arena implements a programming paradigm that combines visual and textual programming. A typical Arena session involves the following activities, as follows:

1. Selecting module/block icons from a template panel, and placing them on a graphical model canvas (by drag and drop).

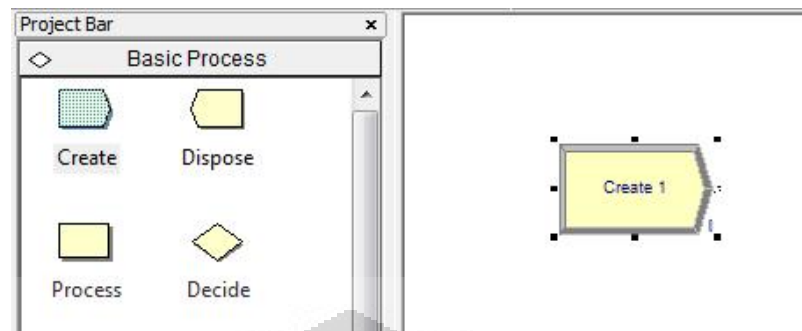


Figure 3.10 Create module

2. Connecting modules graphically to indicate physical flow paths of transactions and/or logical flow paths of control.

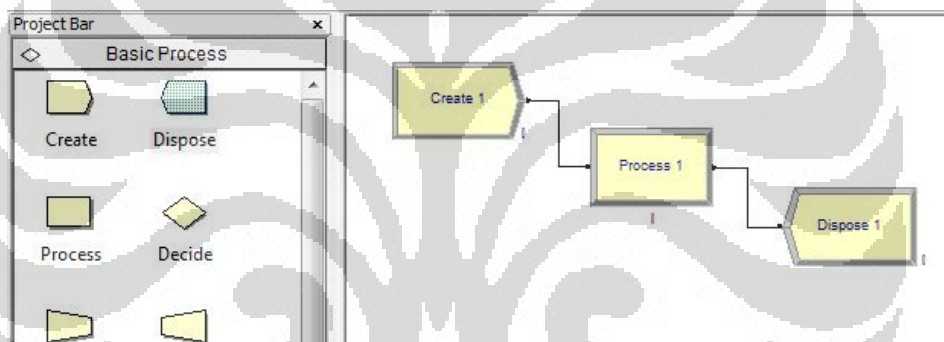


Figure 3.11 Interconnecting module

3. Parameterization of modules or elements using a text editor.

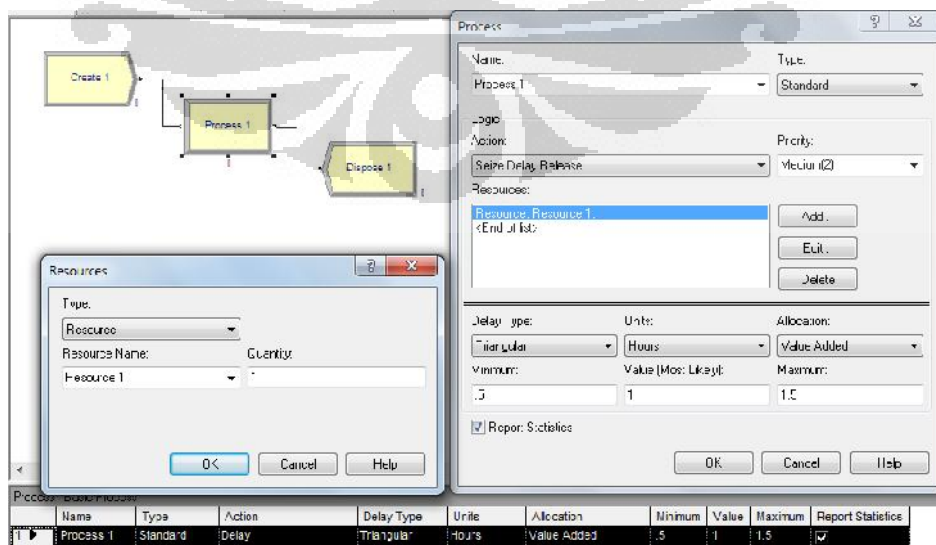


Figure 3.12 Parameterization of modules

3.4 Running the model

Simulation modeling is a common paradigm for analyzing complex model. In a nutshell, this module creates a simplified representation of a system under study. The model then proceeds by running for simulating model.

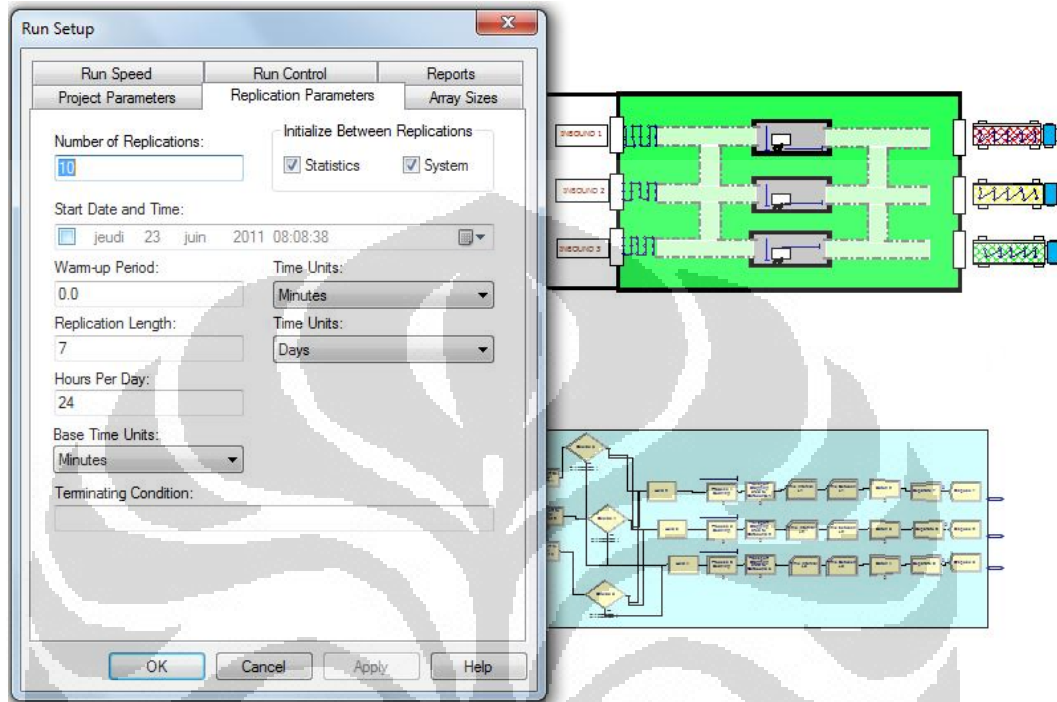
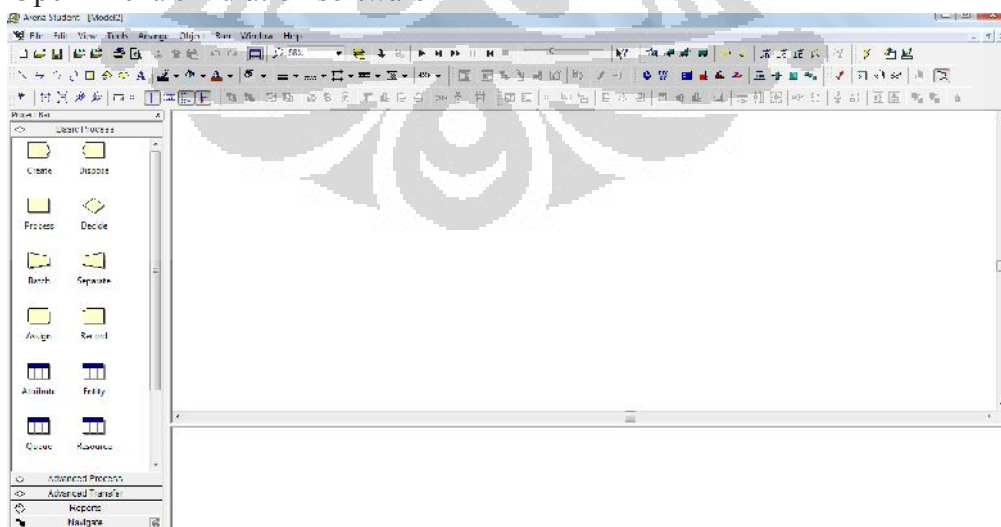


Figure 3.13 Run setup the model

3.5 Building the model step by step

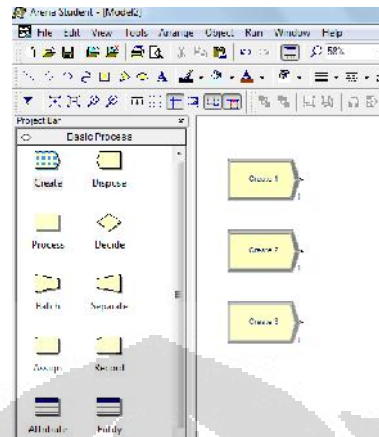
Create the model (scenario 1)

1. Open Arena simulation software



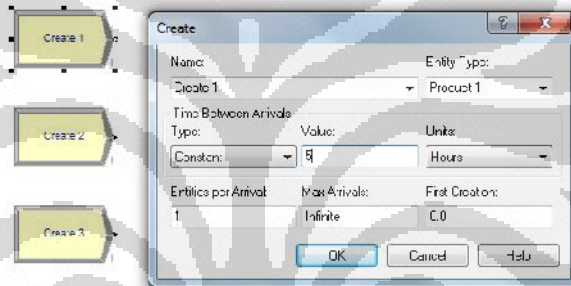
3.14 Building the model step 1

2. Drag the 3 **Create** modules from the Basic Process panel into the model window



3.15 Building the model step 2

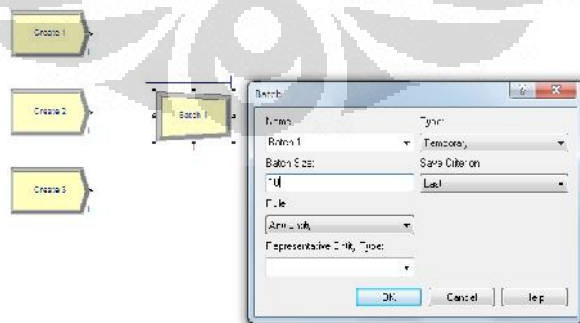
3. Double click create 1 and type



3.16 Building the model step 3

And then click OK, Do it again to create other modules to fill the entity with the product 2 and product 3

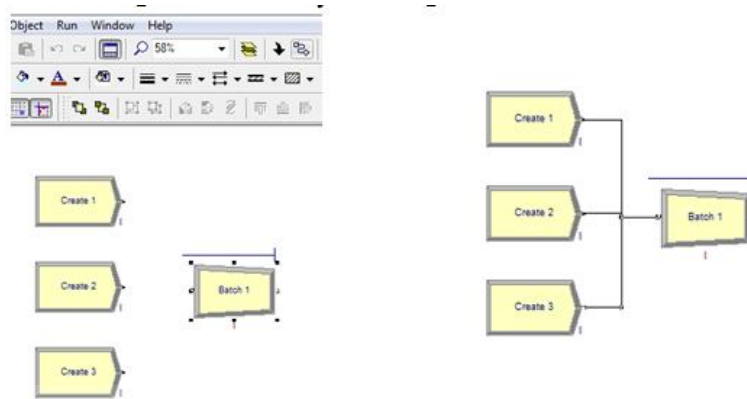
4. Click and drag **batch** module into the model window, double click it and type like figure below



3.17 Building the model step 4

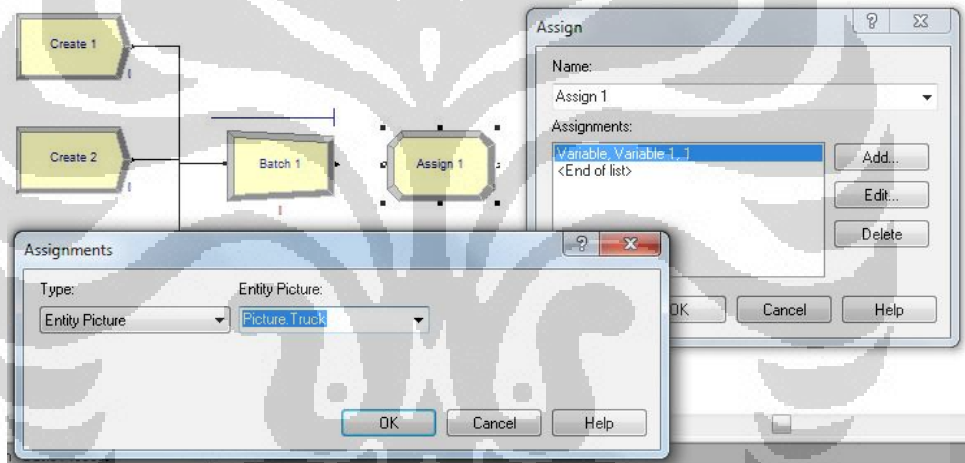
Click Ok

5. Connecting the module by clicking **connect**



3.18 Building the model step 5

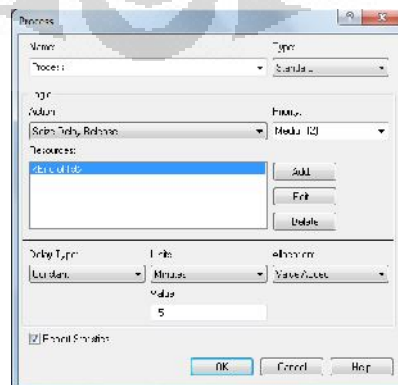
6. Click and drag **Assign** module into the model window, double click it, click **add** in dialog box and fill it



3.19 Building the model step 6

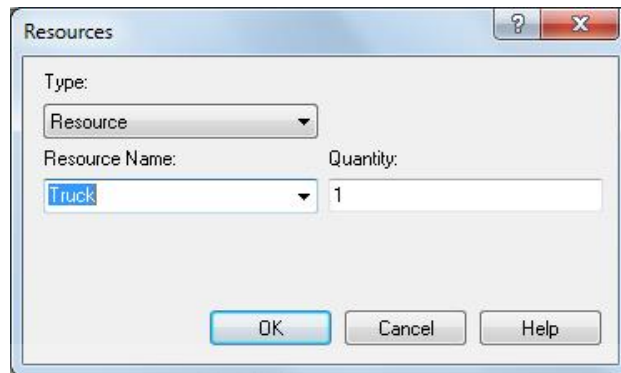
OK

7. Click and drag **Process** module into the model window, double click it, click **action delay release**,



3.20 Building the model step 7a

Click **add**

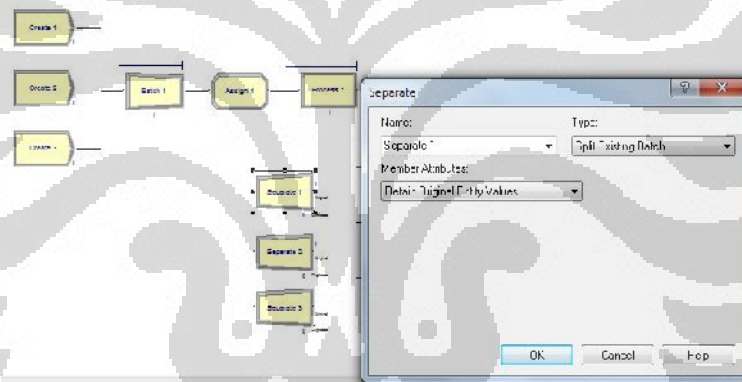


3.21 Building the model step 7a

OK

We have completed the logic of suppliers and then we have to continue the logic of cross dock.

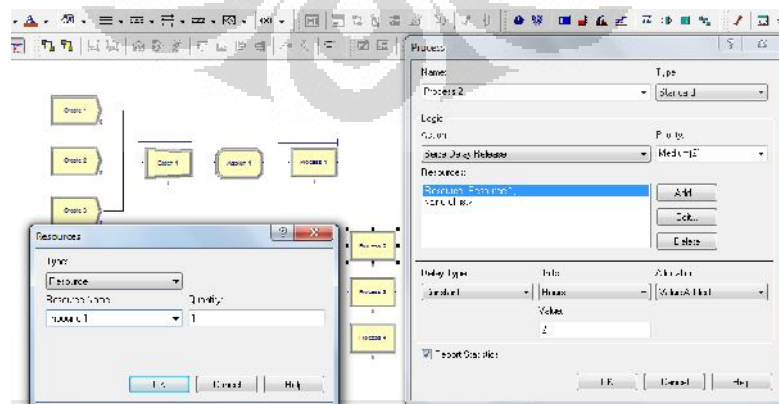
8. Click and drag 3 **Separate** modules into the model window, it addressed for unloading product one by one, double click it.



3.22 Building the model step 8

Ok,

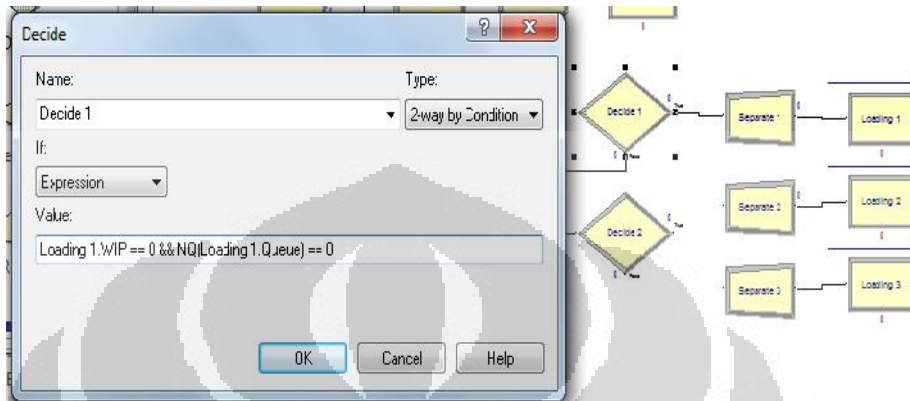
9. Click and drag 3 **Process** modules into the model window (3 unloading docks), double click it.



3.23 Building the model step 9

Click OK, now we have 3 inbound docks, and then we have to make regulation how to enter the dock.

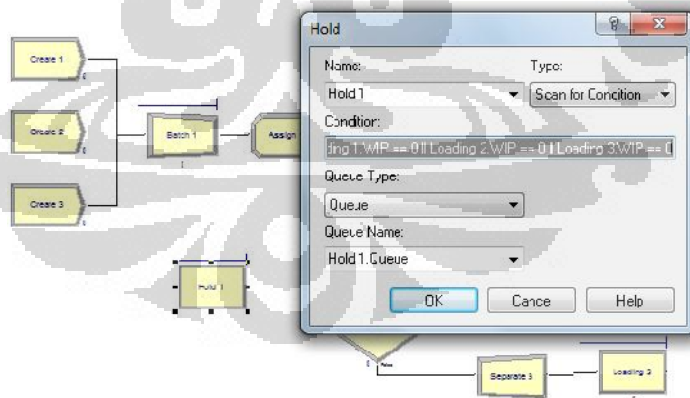
- Click and drag 2 **Decide** modules into the model window for regulating the truck enter to the dock.



3.24 Building the model step 10

Expression “Loading 1.WIP == 0 && NQ>Loading 1.Queue) == 0” mean truck will go to loading dock 1 if there is no process and no queue in the first dock. If there is process or queue in that, it will go to loading dock 2. OK

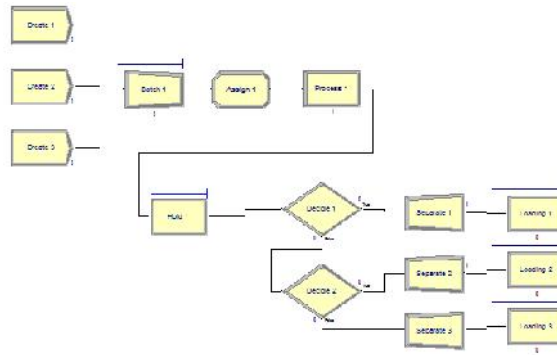
- Do it for the other **Decide** module with expression “Loading 2.WIP == 0 && NQ>Loading 2.Queue) == 0” OK
- Now, Now we have to park the truck if all the loading dock full. Click and drag **Hold** module (advance process) into the model window.



3.25 Building the model step 12

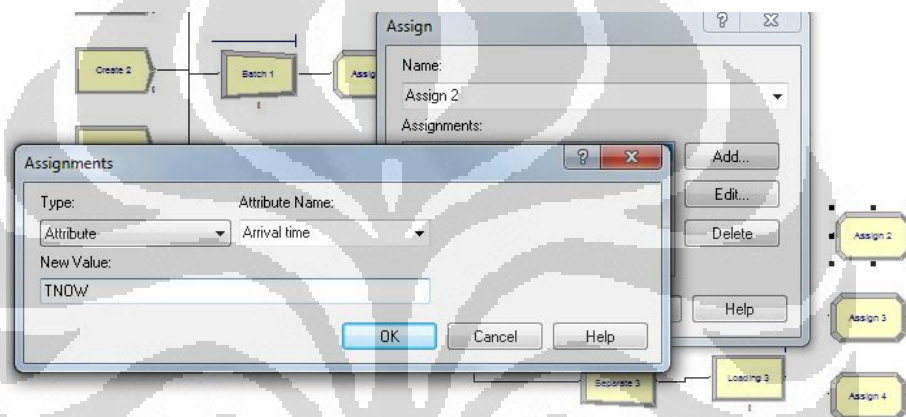
Condition “Loading 1.WIP == 0 || Loading 2.WIP == 0 || Loading 3.WIP == 0” mean truck will park if all of the dock is full

- Connect each module as follows



3.26 Building the model step 13

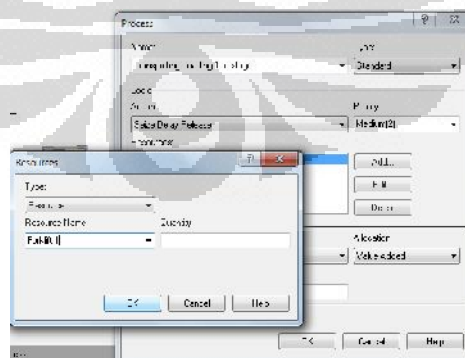
- Click and drag 3 **Assign** modules into the model window for assigning the product.



3.27 Building the model step 14

Click OK, TNOW mean time now. So, we will count the entry time start from this module.

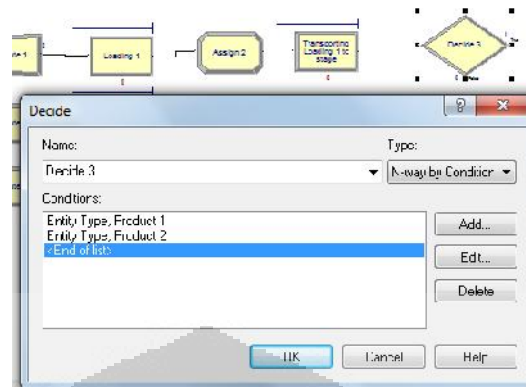
- Click and drag 3 **Process** modules into the model window for transporting the product to staging area.



3.28 Building the model step 15

Resource name Forklift 1, OK, Delay type constant, 4.8 minutes. Do the same thing for the others **Process** module

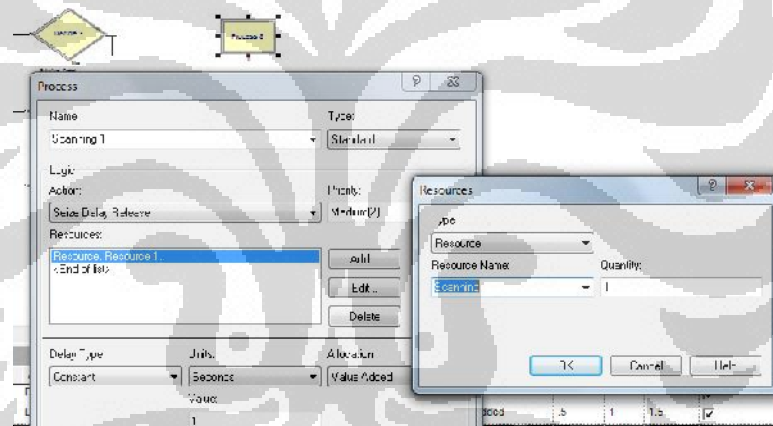
16. Click and drag 3 **Decide** modules into the model window for driving the product to staging area, double click the module and doing like this



3.29 Building the model step 16

OK, Do the same thing for the others **Decide** module

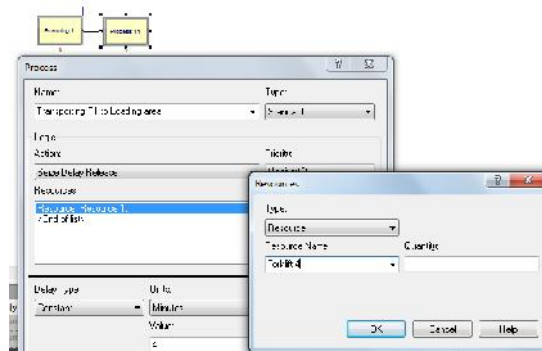
17. Click and drag 3 **Process** modules into the model window for scanning the product in staging area



3.30 Building the model step 17

Do the same thing for the others **Process** module with different name and different resources

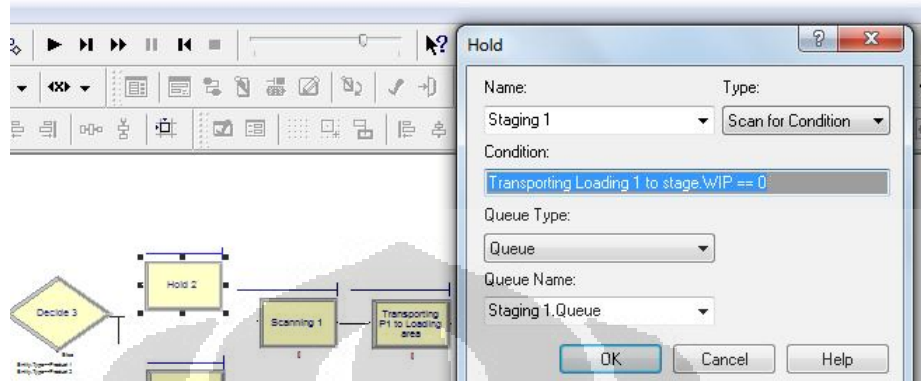
18. Click and drag 3 **Process** modules into the model window for transporting the product to loading area



3.32 Building the model step 18

Do the same thing for the others **Process** module with different name and different resources

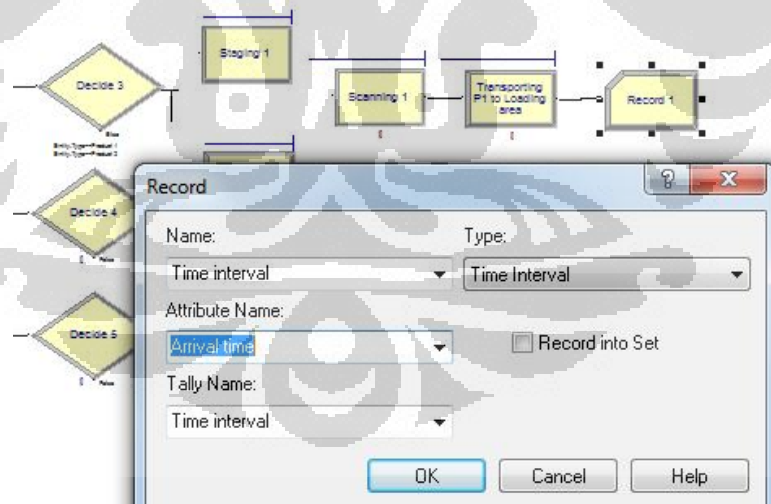
19. Click and drag 3 **Hold** modules into the model window for staging the product in staging area. Placing before scanning process



3.32 Building the model step 19

Condition “Transporting Loading 1 to stage.WIP == 0” means product will be released from staging area when there is no process in “Transporting Loading 1 to stage”. OK and do the same thing for the others **Hold** module with different name and different condition

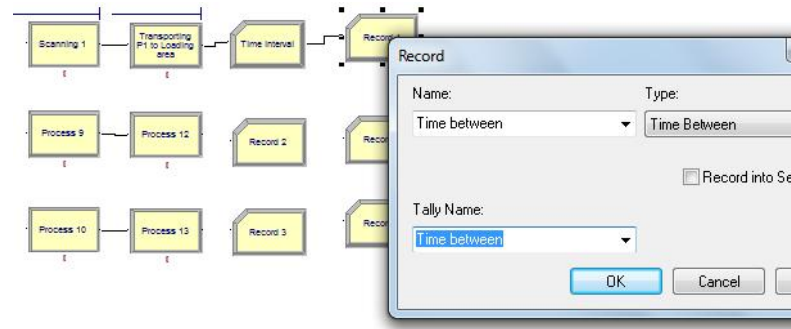
20. Click and drag 3 **Record** modules into the model window for counting “time interval” the product out of cross dock centre



3.33 Building the model step 20

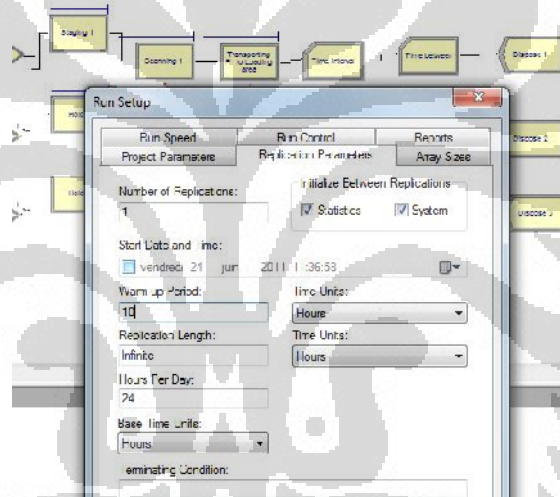
Do the same thing for the others **Record** module

21. Click and drag 3 **Record** modules into the model window for counting “time between arrival” the product out of cross dock centre



3.34 Building the model step 21

22. Click and drag 3 **Dispose** modules into the model window for ending the model
23. For running the model, click run, setup



3.35 Building the model step 23

3.6 Analyze simulation result

The result of simulating the model is set of requisite statistics, such as mean waiting times, buffer size probabilities, and so on. These will be referred to as run results. Arena provides a considerable number of default statistics in a report, automatically generated at the end of a simulation run. Additional statistics can be obtained by adding statistics collection modules to the model, such as Record (Basic Process template panel) and Statistic (Advanced Process template panel)

Model 1

SIMAN Run Controller.
 41.6 Minutes>

ARENA Simulation Results
 User - License: STUDENT

Summary for Replication 1 of 10

Project: Cross dock scenario 1
 Analyst: Alang and Faizal

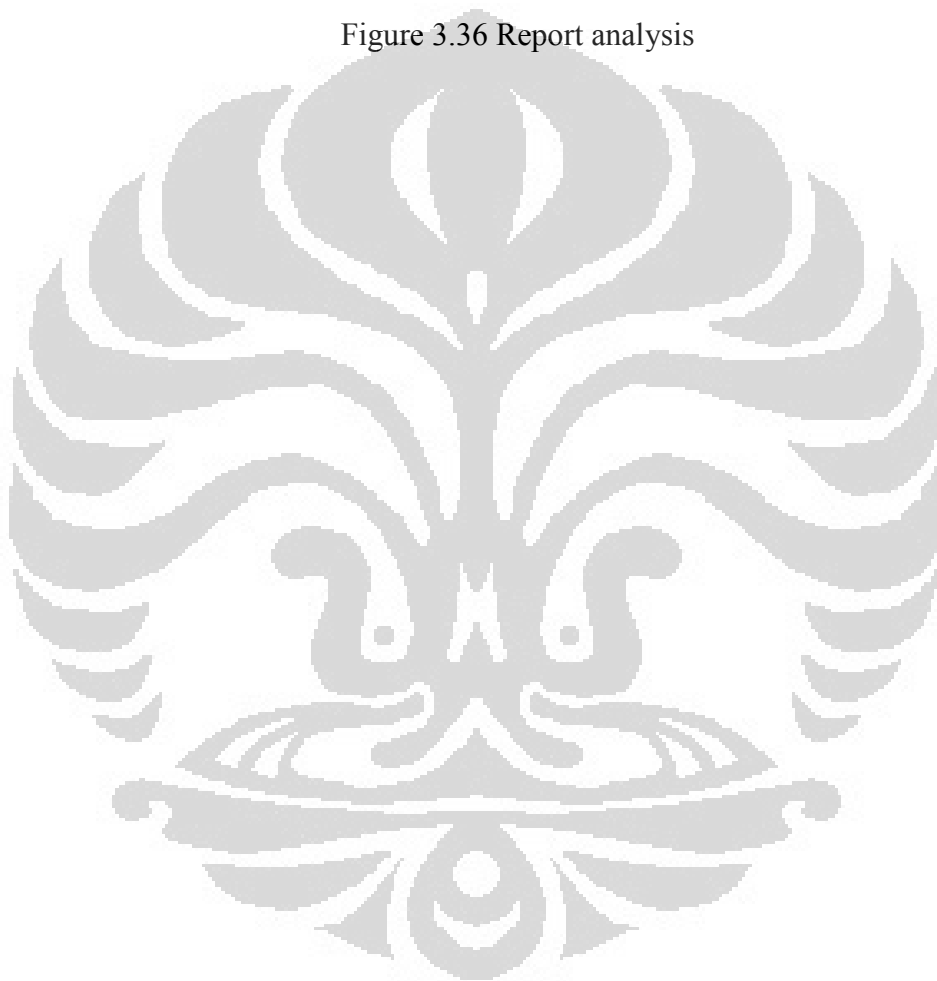
Run execution date : 6/22/2011
 Model revision date: 6/22/2011

Replication ended at time : 10080.0 Minutes
 Base Time Units: Minutes

TALLY VARIABLES

| Identifier | Average | Half Width | Minimum | Maximum | Observations |
|------------|---------|------------|---------|---------|--------------|
|------------|---------|------------|---------|---------|--------------|

Figure 3.36 Report analysis



CHAPTER 4 SIMULATION AND ANALYSIS

4.1 Simulation Model

Simulation models are built by placing modules in a model window, providing data for these modules, and specifying the flow of entities through modules. A module defines the underlying logic that is applied when an entity is directed to the module, as well as the associated graphical animation, to depict the module's activities during a simulation run

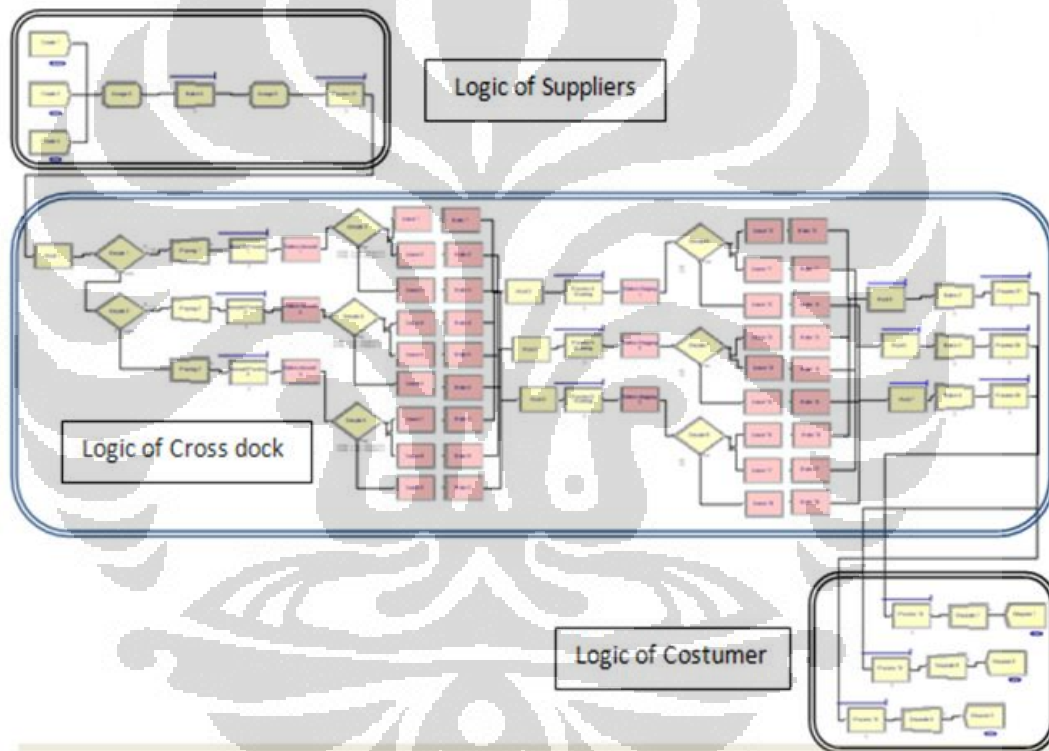


Figure 4.1 Model Logic

4.1.1 Model logic of supplier

There are three suppliers that product one kind of product each supplier, each products will be collected in the module batch. Every 10 products will be trucked to the cross dock center with a time of arrival of the truck every 15 minutes.

4.1.2 Model Logic of cross dock centre

Every truck that comes will go to parking area; they will see a dock that is available. The first, the truck will go to dock 1, if there is not available it will be to dock 2 and so on.

In the cross dock center of each product will be unloaded with a time of 2 minutes each product by the resources of each dock and then they will be transported to staging area by forklift accordance with the type of product with the time base on distance and speed.

Products, in the staging area, will be scanning and sorting by the resource 10 seconds of each product and then ready to be moved to the loading area with a forklift to serve each staging area.

4.1.3 Model logic of costumer

The product that comes out of the cross dock centre will be collected every 10 products and then put into trucks to transport to the customer.

4.2 Enhance the Visualization Process

To be more understood the processes involved in the cross dock centre, it will be displayed in animated form as in figure 4.1. We can embellish the graphical animation to gain further insight into the process dynamics. Animation also can be of great benefit to improve the process in cross dock.

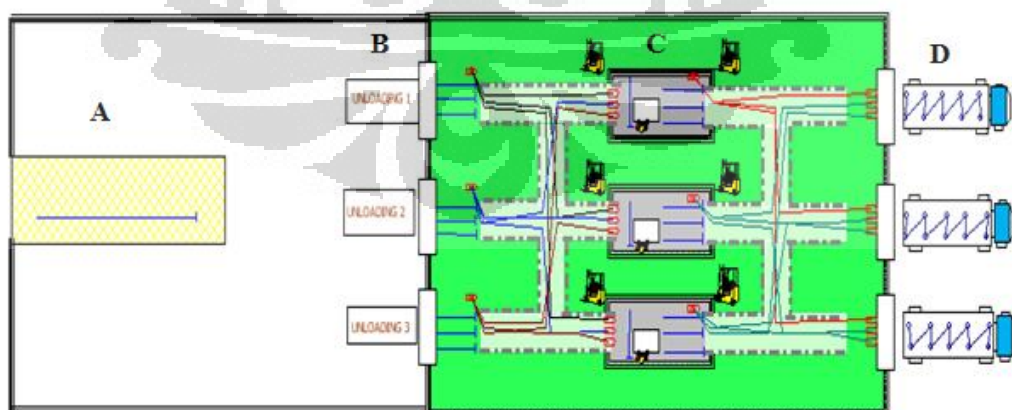


Figure 4.2 Animation model of cross dock process

- A. Parking area
- B. Unloading area

- C. Staging area
- D. Loading area

4.3 Analysis

The analysis focus on activities within the cross dock centre, to find some values that can affect cross-dock system. Each model will run for 7 days, 24 hours in day with 1 time replication. The data that will be analyzed from the simulation results, as follows:

4.3.1 The number of products out of the cross dock centre

The number of products out of the CD is calculated without considering the time factor of transportation to the customer.

Table 4.1 the number of products out of the cross dock centre

| Scenario | the number of products out |
|------------|----------------------------|
| Scenario 1 | 6016 |
| Scenario 2 | 5991 |
| Scenario 3 | 6006 |

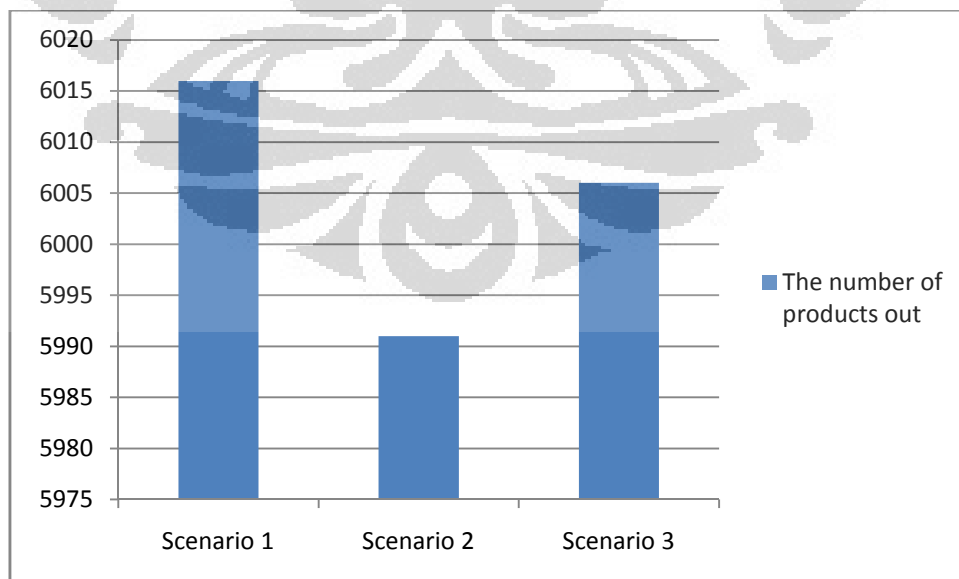


Figure 4.3 the number of products out of the cross dock centre

4.3.2 Average time between arrivals

Time between arrivals is time between arrivals the product and the next product.

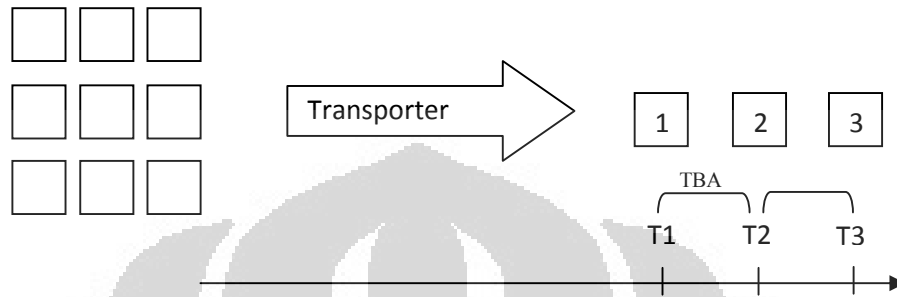


Figure 4.4 Time between arrivals

Table 4.2 Average time between arrivals (minutes)

| Scenario | Loading dock 1 | Loading dock 2 | Loading dock 3 | Average |
|------------|----------------|----------------|----------------|---------|
| Scenario 1 | 5 | 5 | 5 | 5 |
| Scenario 2 | 4.84 | 5.12 | 5.07 | 5.01 |
| Scenario 3 | 4.84 | 5.12 | 5.07 | 5.01 |

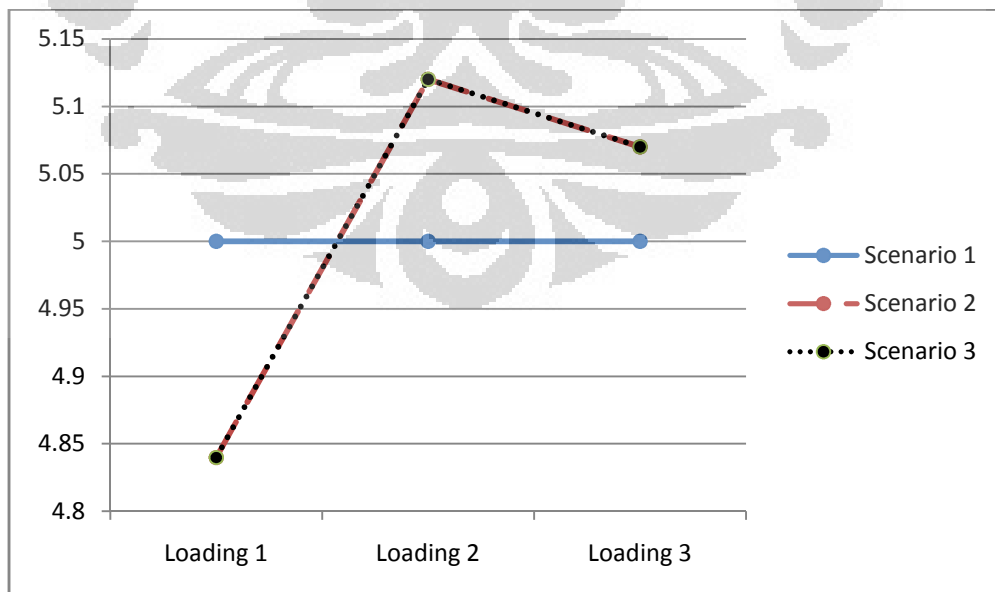


Figure 4.5 Average time between arrivals graphic

4.3.3 Average time interval

Time interval is the difference between the current simulation times (TNOW) and the time product out from the cross dock (loading).

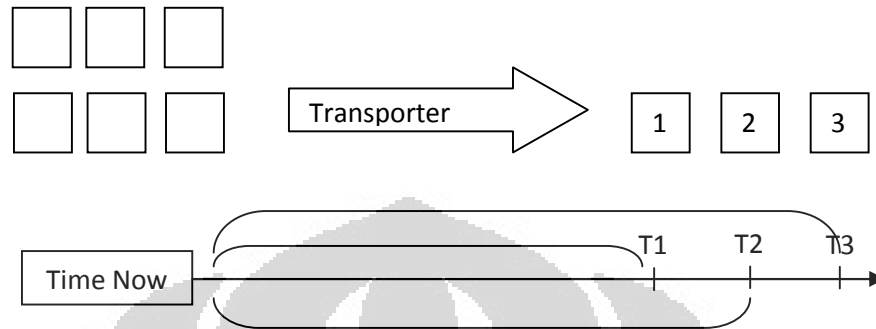


Figure 4.6 Time interval

Table 4.3 Average time interval (minutes)

| Scenario | Loading 1 | Loading 2 | Loading 3 | Average |
|------------|-----------|-----------|-----------|---------|
| Scenario 1 | 37.09 | 37.12 | 37.15 | 37.12 |
| Scenario 2 | 49.37 | 47.53 | 46.90 | 47.93 |
| Scenario 3 | 43.27 | 43.17 | 40.49 | 42.31 |

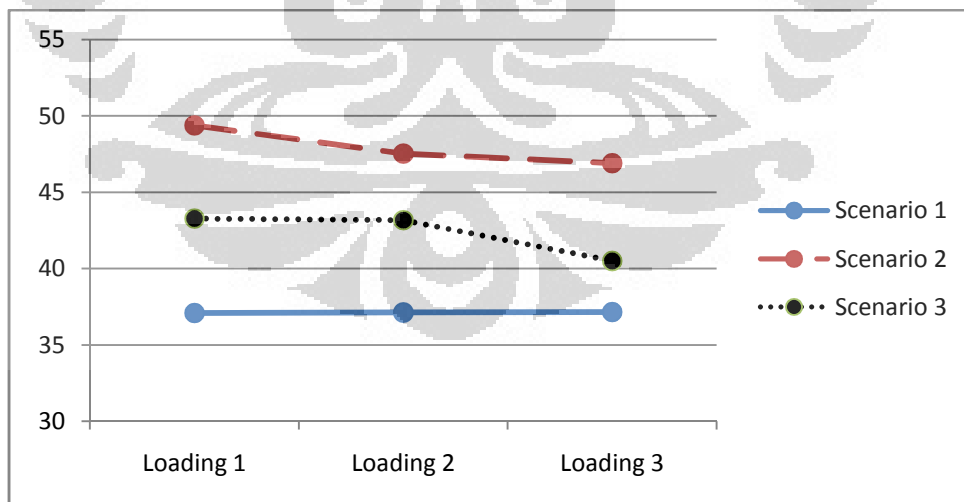


Figure 4.7 Average time interval graphic

4.3.4 Average waiting time in staging area

Table 4.4 Average waiting time in staging area

| Scenario | Staging 1 | Staging 2 | Staging 3 | Average |
|------------|-----------|-----------|-----------|---------|
| Scenario 1 | 2 | 1.97 | 1.97 | 1.99 |
| Scenario 2 | 5.40 | 2.96 | 6.57 | 4.97 |
| Scenario 3 | 3.46 | 3.56 | 3.44 | 3.48 |

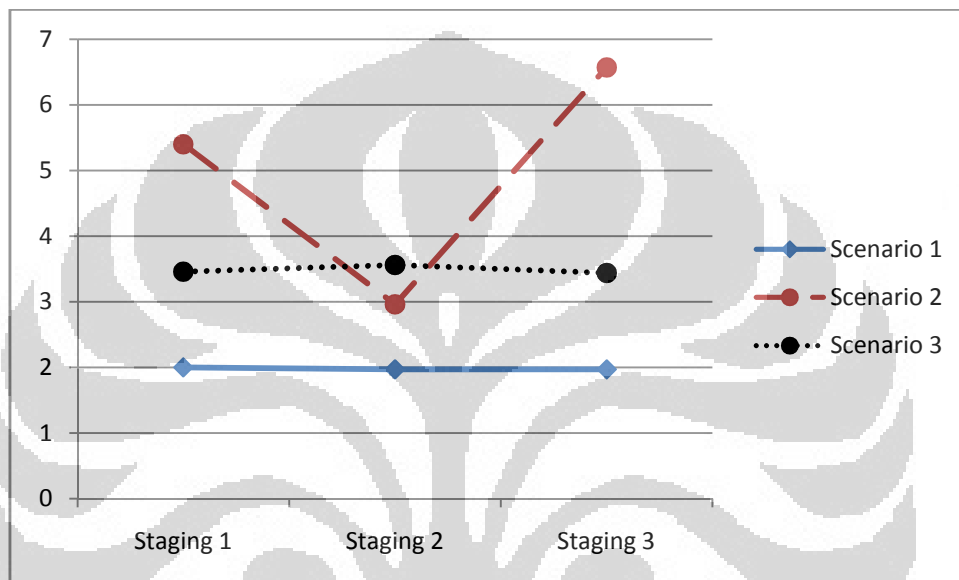


Figure 4.8 Average waiting time in staging area graphic

4.4 Scoring

Selection of the best scenario is based on an assessment of three factors that have been analyzed. Assessment carried out by using the point, the best will get point 3, the best 2 will get the point 2, and the best 3 will get the point 1. The data will be used for scoring and it will be counted the total of point each scenario.

4.4.1 Scoring the number of products out of the cross dock centre

For giving score, we have to recognize the characteristics of the parameters to be assessed, for the amount of product out the highest valuation given to the largest number of products

Table 4.5 scoring the number of products out of the cross dock centre

| Scenario | Average | Score |
|------------|---------|-------|
| Scenario 1 | 6016 | 3 |
| Scenario 2 | 5991 | 1 |
| Scenario 3 | 6010 | 2 |

4.4.2 Scoring average time between arrivals

For giving score to average waiting time in staging area, the smallest average will get the highest score

Table 4.5 Scoring average time between arrivals

| Scenario | Average | Score |
|------------|---------|-------|
| Scenario 1 | 5 | 3 |
| Scenario 2 | 5.01 | 2 |
| Scenario 3 | 5.01 | 2 |

4.4.3 Scoring average time interval

For giving score to average time interval, the smallest average will get the highest score.

Table 4.5 scoring average time between arrivals

| Scenario | Average | Score |
|------------|---------|-------|
| Scenario 1 | 37.12 | 3 |
| Scenario 2 | 47.93 | 1 |
| Scenario 3 | 42.31 | 2 |

4.4.4 Scoring waiting time in staging area

For giving score to average time interval, the smallest average will get the highest score.

Table 4.6 Scoring waiting time in staging area

| Scenario | Average | Score |
|------------|---------|-------|
| Scenario 1 | 1.99 | 3 |
| Scenario 2 | 4.97 | 1 |
| Scenario 3 | 3.48 | 2 |

Table 4.7 Total Scoring

| Assessment | Scenario 1 | Scenario 2 | Scenario 3 |
|--------------------------------------|------------|------------|------------|
| The number of products out | 3 | 1 | 2 |
| Average time between arrival | 3 | 2 | 2 |
| Average time interval | 3 | 1 | 2 |
| Average waiting time in staging area | 3 | 1 | 2 |
| Total of point | 12 | 5 | 8 |

, the best solution is scenario 1

CHAPTER 5

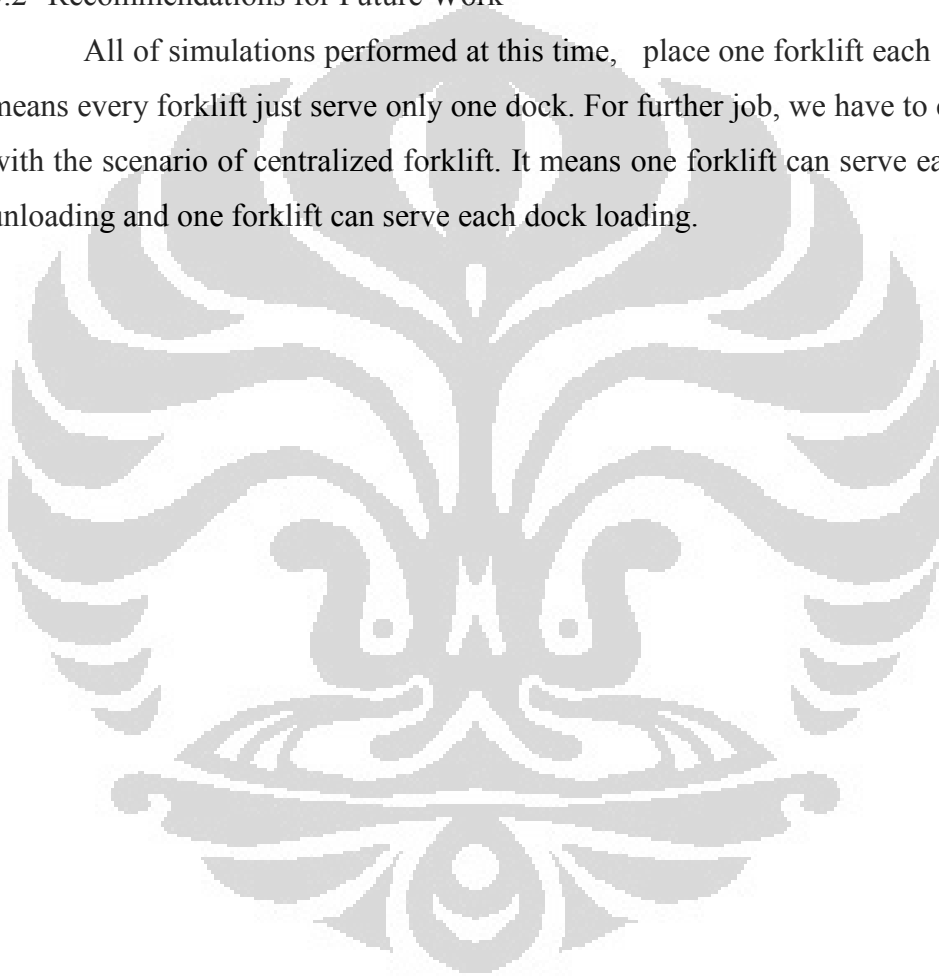
CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

5.1 Conclusion

Based on the results of analysis of three scenarios with four measurement parameters, it can be concluded that the best is scenario 1.

5.2 Recommendations for Future Work

All of simulations performed at this time, place one forklift each dock. It means every forklift just serve only one dock. For further job, we have to compare with the scenario of centralized forklift. It means one forklift can serve each dock unloading and one forklift can serve each dock loading.



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