QUEUE MANAGEMENT FOR PORT AUTHORITY OF THAILAND USING PRIORITY QUEUING AND BOOKING TECHNIQUE

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ABSTRACT

The aim of this study was to establish a process to manage vehicle queuing for the Port Authority of Thailand, which is currently facing heavy vehicle congestion problems at the terminals. The existing program based on a normal queuing technique (NQT), results a severe traffic congestion problem existed. In an attempt to reduce the number of waiting vehicle and the severity of the traffic congestion at the terminals, capacity service improvement of port management needed to be put into place, a Priority Queuing and Booking Technique (PQBT) is proposed. There are proposed techniques studied to address the queuing augmentation, terminals capacity, service time, and priority queue. The result showes that the combination of Priority Queuing and Booking Techniques are superior to NQT in terms of lower number of waiting vehicle and high capacity service.

KEY WORDS: PRIORITY QUEUING / QUEUE MANAGEMENT / PORT MANAGEMENT / QUEUE SIMULATION

72 pages.

การบริหารจัดการคิวของผู้ที่เข้ามาใช้บริการในการท่าเรือโดยใช้เทคนิคการจัดลำดับความสำคัญของคิวและการจองสิทธิ์

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บทคัดย่อ

ปัจจุบันนี้มีรถบรรทุกสินค้าเข้ามาใช้บริการปริมาณมาก ดังนี้จุดมุ่งหมายของงานวิจัยนี้มีความเกี่ยวข้องกับการบริหารจัดการรถบรรทุกที่เข้ามาในท่าเรือ โดยในงานวิจัยนี้นั้นจะใช้เทคนิคการจัดลำดับความสำคัญของคิวและการจองสิทธิ์ ทั้งนี้เพื่อที่จะลดความหนาแน่นและปัญหาการจราจรในบริเวณท่าเรือ ข้อมูลเดิมนั้นแสดงให้เห็นถึงปัญหาของการเข้าไปใช้บริการมีคิวและเสียเวลามาก การเทคนิคการจัดลำดับความสำคัญและการจองสิทธิ์นั้นช่วยให้ปริมาณรถที่เข้าไปรอรับบริการ และปัญหาการจราจรมีทิศทางที่ดีขึ้น ซึ่งปัจจัยหลักที่เกี่ยวข้องกับเทคนิคนี้มีด้วยกัน 3 ปัจจัย คือ ปริมาณที่สามารถให้ได้ ระยะเวลาในการให้บริการ และการจัดลำดับความสำคัญ ผลการทดลองนี้แสดงให้เห็นว่าการใช้เทคนิคการจัดลำดับความสำคัญและการจองสิทธิ์ดีกว่าการทำงานแบบเดิม โดยพิจารณาจากตัวเลขของรถบรรทุกที่เข้ามาใช้บริการมีปริมาณที่สูงขึ้นและปริมาณรถดังกล่าวนั้นใช้เวลาในท่าเรือลดลง

72 หน้า

CONTENTS

CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

CHAPTER I
INTRODUCTION

1.1 Background and problems

Transportation is the main factor that led to the production and productivity to the customers. The efficient transport and low cost transport are the elements that support economic development, and to increase the competitiveness of the country. The Government has a policy to focus on rail freight and sea freight.

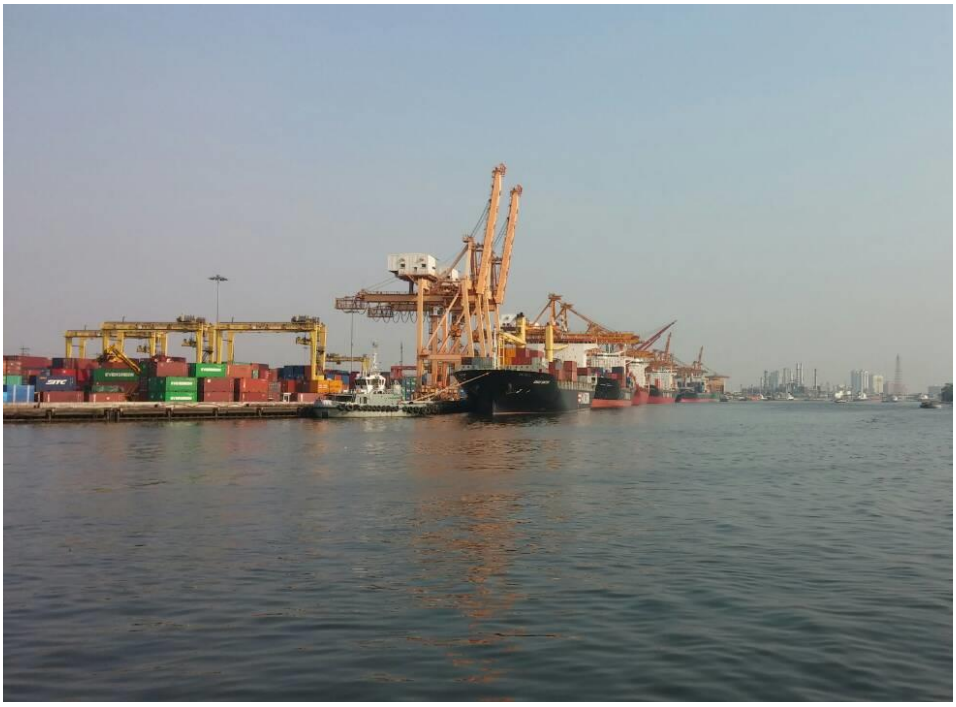


Figure 1.1 Bangkok port.

Port Authority of Thailand (PAT) is state enterprise. PAT has 5 ports which locate on Bangkok, Leam Chabang, Ronong, Chieng sean and Chieng Khon. Leam Chabang port is deep sea port where as the rests are river port [1]. The scope of this work is based on the Bangkok port, which can be seen in Figure 1.1. The Bangkok port is the oldest one among of these ports.

Every day a lot of vehicles come to the Bangkok port such as trucks, cars, etc., causing the port congestion problem. The trucks which park in front of the terminals make the trucks operator waste energy, money and time [1]. Vehicles inside the port have traffic problem which can model as is queue stacking problem. The pattern of the queue stacking forms as FIFO (First in First out) pattern.

Transportation cost mean expenses involved in moving products or assets to a different place, which are often passed on to consumers. The impact of the port congestion problem as follows:

- Freight cost and transportation cost increased Expenses : Shipping delays, as a turnover from approximately 7 days. To be increased to 3 weeks, the people involved in the business of international trade have been directly affected.
- Reduced production : Transportation of raw materials and products are delays.
- Trade volumes decreased : Bottlenecks in Logistics happened. Affect the volume of trade is unavoidable. Many manufacturers began trading with abroad declined. The loss of credibility due to the inability to transport products on time as scheduled.

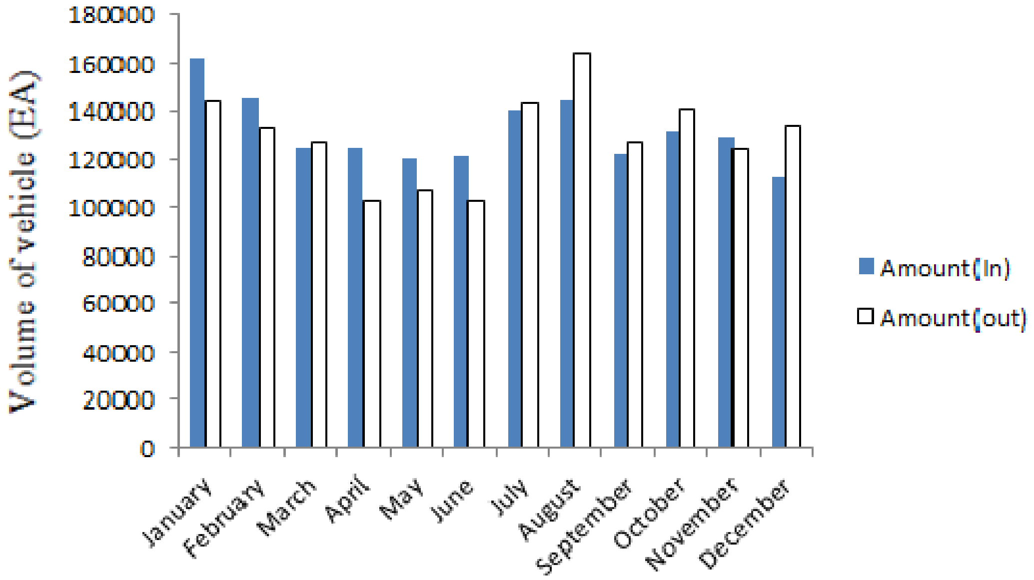


Figure 1.2 Volume of vehicle at the port 2013 (All types of vehicle).

According to Figure 1.2 shows volume of vehicle come into the Bangkok port in 2013. That means, a lot of problems in the port. There is a lot of research interested in queue problem. The researcher has been study about queue. Queuing algorithm base on mathematical theory. The basic queuing system can be extended into a queuing system of variety of queuing methods. Several researches applied queue system for solving problems,given as : Queuing and Priority Models to Improve Port Terminal Handling Service [2], Queue length dependent priority queues [3], Priority assignment in waiting line problems [4], Queue has strong impact to manage about service.

This work uses the historical data to implement and evaluate the proposed technique. Chapter 2, Queue theory approaches about queue system. The queue concept defined as specific attribute of the entities. Chapter 3 describes the problem and proposes of PAT. The model algorithm based on priority queue and booking. The simulation result are conduct in chapter 4. Conclusions are provided in chapter 5

1.2 Research objectives

1.2.1 The aim of this work is to study about priority queuing and booking models.

1.2.2 This work uses the historical data to implement and evaluate the proposed technique.

1.3 Scope of work

1.3.1 This research uses the historical daily data of the vehicle and service in the Bangkok port, in 2013.

1.3.2 This research uses the priority queuing and booking technique (PQBT) to find the appropriate model.

1.4 Expected outcomes and benefits

1.4.1 To study the queue theory.

1.4.2 The priority queuing and booking technique (PQBT) should improve port management to reduce number of waiting vehicle and the traffic in the terminal.

1.4.3 To employ use the thesis result as a tool in order to diagnose the port efficiently.

CHAPTER II
REVIEW OF RELATED LITERATURE AND RESEARCH

In Chapter 2, The review of related literature and research, which is a sequence of operations of this research. We will begin study with the basic queuing theory. And then we will consider the queue discipline concept. We will take these factors into simulation program, the simulation is creating or inventing a model (Model) for studies the behavior of naturally occurring phenomenon or any process. The main goal of the simulation problem is to use a component decisions.Then we will have to find the related literature and research. Finally, we will take the aforementioned techniques applied to this research. In chapter 2 topics following:

- Queuing theory;
- The queue discipline concept;
- Kendall Classification of Queuing Systems;
- Simulation;
- Related Researches.

2.1 Queuing theory

Queuing theory is the study of the mathematical theory and the methods of queuing systems. It is an important branch of operations research [5]. Basic queuing process of the queuing problem can be expressed in Figure 2.1.

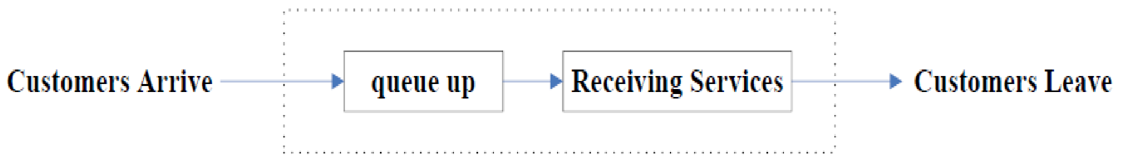


Figure 2.1 Queuing System.

The basic queuing system can be extended into a queuing system of variety of queuing methods e.g. single-team single desk system, multi-server single-team system, multi-server multi-team system, and multi-server tandem systems. Queuing system generally has three components: input process, queuing rules, and services.

Queues are characterized by a number of properties that represent the interrelationships among the entities involved in a queuing system. The arrival process, service duration, and queue discipline are among the most important properties of a queue[6]. In addition to these basic properties, the numbers of servers, capacity of the queue, and the population of entities to be served are some of the other properties of a queuing system. However, since information related to these latter properties are often provided as part of the project specifications (e.g. site layout and temporary route arrangement may dictate the number of dump trucks that can form a queue close to the loading area at any given time) or equipment manufacturers' catalogues (e.g. bucket capacity of an excavator can be used to determine how many dump trucks can be served within a certain time period), further onsite data collection and analysis regarding these properties do not contribute much to simulation model input data generation and thus are not the main focus of this study.

2.2 The queue discipline concept

Queuing discipline, it is easy for one to think of all queues operating, when an arrival occurs, it is added to the end of the queue and service is not performed on it until all of the arrivals that came before it are served in the order they arrived. Although this a very common method for queues to be handled, it is far from the only way. The method in which arrivals in a queue get processed is known as the queuing discipline. This particular example outlines a first-come-first-serve discipline(FCFS). Other possible disciplines include last-come-first-served (LCFS), and service in random order(SIRO). While the particular discipline chosen will likely greatly affect waiting times for particular customers (nobody wants to arrive early at an LCFS discipline), the discipline generally doesn’t affect important outcomes of the queue itself, since arrivals are constantly receiving service regardless[7].

Queue discipline is defined as a rule or set of rules based on a specific attribute of the entities. It determines the pattern (i.e. order) by which entities in the queue receive service. The choice of the queue discipline and the rules to be applied can significantly affect the number of entities waiting in a queue, the average waiting time, and the efficiency of the service facility. The most common queue discipline is the first in first out(FIFO) in which clients in line are served based on their chronological order of arrival. Although FIFO has been long used as a default queue discipline in modeling queuing systems [8], in many scenarios, it is equally likely that clients be served according to other service patterns.

For instance, the last-in-first-out(LIFO) discipline may be the case in situations where a heap or stack of clients (e.g. raw materials, prefabricated concrete segments, and steel sections) is waiting to be processed by a server. Other than FIFO and LIFO, the serving pattern of a queuing system can be characterized according to an intrinsic attribute of the entities in the system. This type of queue discipline is called priority queues (PRI). In the example of a queue of dump trucks waiting to be loaded by an excavator, priority might be given to those dump trucks with less fuel left. Sometimes, there may be no rule according to which clients receive service from the server, in which case the queue discipline is considered as service-in-random-order(SIRO). Figure 2.2 illustrates the concepts of FIFO, LIFO, and PRI queue disciplines. In this figure, clients are specified by letter C and the server is specified by letter S. Each of the three queues shows the client that should be drawn from the queue under the specified queue discipline.

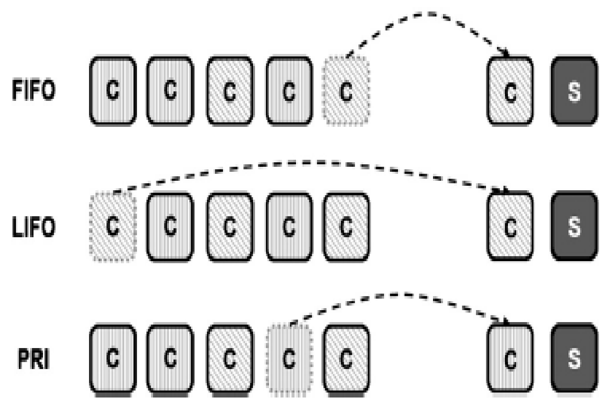


Figure 2.2 Demonstration of FIFO, LIFO, and PRI queue disciplines.

2.3 Kendall Classification of Queuing Systems

To explain every aspect of the queue will inevitably become a very wordy very simple notation can be used to describe the system. The notation Kendall Lee gave us six stands for the characteristics listed in order, separated by over a first and a second time to explain the process to arrive and services on the basis of probability distributions. For the first and second, M is distributed exponentially E refers to the distribution Erlang and G is the scattering characteristics of three, the number of servers working together at the same time that the number of servers in parallel, four. queue discipline was described by the acronym fifth highest number of clients that are allowed in the sixth the size of the pool of customers that can draw from.

The Kendall classification of queuing systems are available in several modifications. The classification uses 6 symbols:

$$A/B/s/q/c/p \tag{2.1}$$

where:

A is the arrival pattern (distribution of intervals between arrivals);

B is the service pattern (distribution of service duration);

s is the number of servers;

q is the queuing discipline (FIFO, LIFO, ...). Omitted for FIFO or if not specified;

c is the system capacity. Omitted for unlimited queues;

p is the population size (number of possible customers), omitted for open systems is used for arrival and service patterns;

M is the Poisson (Markovian) process with exponential distribution of intervals or service duration respectively;

Em is the Erlang distribution of intervals or service duration;

D is the symbol for deterministic (known) arrivals and constant service duration;

G is a general (any) distribution;

GI is a general (any) distribution with independent random values.

2.4 Simulation

Simulation is creating or inventing a model (Model) for studies the behavior of naturally occurring phenomenon or any process. The main goal of the simulation problem is to use a component decisions. In the analysis, systems, Process modeling problem sought to be realistic or. As close to reality possible [9].

Therefore, the replication process is divided into two parts: the simulation and implementation of the model used in the analysis. A great model that can help to understand. The real purpose of describing the behavior of the system and to improve the process.

Simulation Problem has been attention and awareness to implement solutions in the field. Various occupations apply a result of the advancement of the computer, which although. Simulation issue, it is very useful. However, the simulation results also have limitations, because of the models in engineering to check hypothesis for the explanation of the phenomenon. To develop a theorem or to predict what might happen in the future, we are. A common method of education, which can be summarized into simple images from Figure 2.3

According to Figure 2.3 the study groups are divided into two major groups, given as: Experiment with the actual system and experiment with a model of the system. Both of these are the advantages and disadvantages in itself may not be summarized. The engineer Or the researcher to choose the most appropriate solution to the problem being studied.

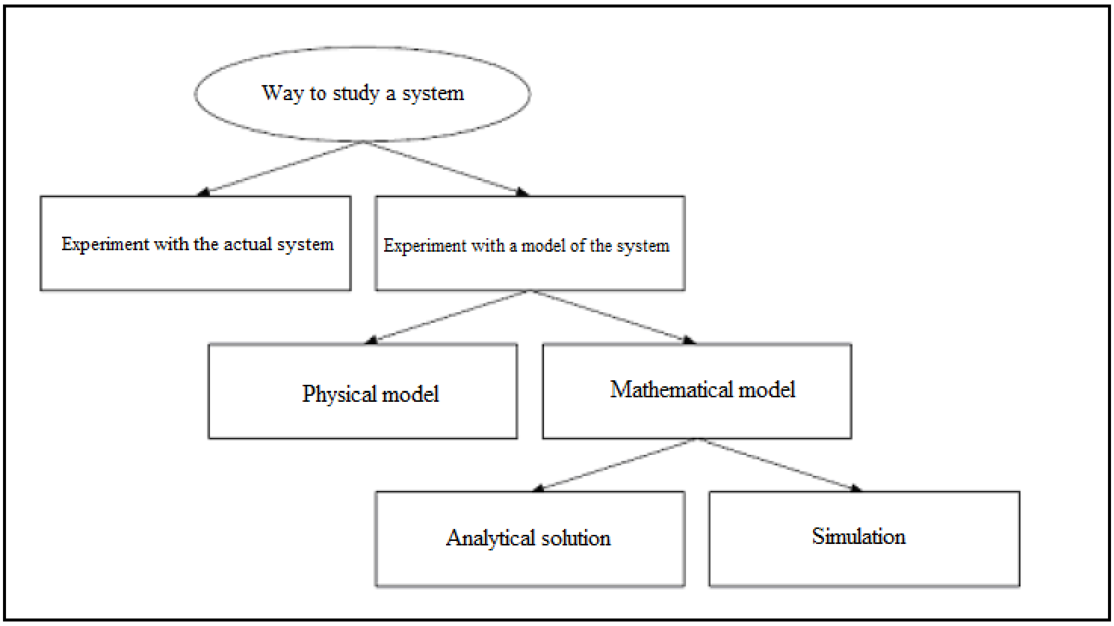


Figure 2.3 Study system flow.

A study of the experiment with the system actually makes the study was accurate and consistent information about the behavior of the factors associated with the system, which may be difficult to determine a mathematical model that takes into account the total. The system makes it possible to verify the level of realism of the study, however, the experimentation with the real cost, high uncertainty, which could pose a danger to life and property is not that. All problems can be experimented with and not always true. And not all problems can be studied from a model of the system.

A study of the experiment with the model of the system is a way for low-cost, safer and easier compared to experiment with the real system. The popular method can also be used in the training process. The trained a lot more comfortable than it has the major disadvantage. Complete truth or reality .

2.4.1 Creation of a simulation model

The model object or any of the concepts that are created to be used for education, with the ability to mimic the behavior of a phenomenon that occurs spontaneously or any human processes by computer modeling The research was conducted by applying the Arena program, which comprises an important component of the model by the model are as follows:

The model is used to describe the system components for our study and used to describe the relationship of the various stages of the system. The instructions are in the Block Diagram System. The views and values nature of the status of the entity.

Simulation problem is a method to predict the future solution. For use as components decision (Decision support) to analyze systems.

The design process model is divided into two parts as follows: the modeling and the implementation models for analysis. Great model must emulate the behavior.

Elements Simulation Model:

- Component;
- Variables and Parameters;
- Functional Relationships;
- Constraints;
- Objective Function multilayer.

2.4.2 The feature of the simulation

Simulation has features that distinguish it from other models.

To checked for accuracy. Simulation of any kind needs to be. Verify the correct first to avoid errors. Checking the logic and calculations are correct or not.

To rational to check that the results are not within the scope of the results. Prediction and modeling are working properly by then, the results can be analyzed.

To Reduce the deviation Using the similarly random variable to decrease and increase. Be compared with the different elements.

There is a way to simulate the real situation than the present situation.

It is characterized as described or predicted that would happen under different conditions.

The model is applied to the problem of high complexity.

2.4.3 Process of problem in simulation model

The problem and the definition of the system. Causes Problems And to conduct a study to scope limitations. And a measure

Modeling and defining characteristics to draw up a model It can describe the behavior of the system to be studied and define the characteristics of the system.

Data preparation Analysis and modeling of storage required.

2.4.4 Arena simulation

Arena software brings the power of modeling and simulation to the business. It is designed for analyzing the impact of changes involving significant and complex redesigns associated with supply chain, manufacturing, processes, logistics, distribution and warehousing, and service systems. Arena software provides the maximum flexibility and breadth of application coverage to model any desired level of detail and complexity [10].

Typical scenarios include:

- Detailed analysis of any type of manufacturing system, including material-handling components;
- Analysis of complex customer service and customer management systems;
- Analysis of global supply chains that include warehousing, transportation, and logistics systems;
- Predicting system performance based on key metrics such as costs, throughput, cycle times, and utilizations identifying process bottlenecks such as queue build ups and over-utilization of resources;
- Planning staff, equipment, or material requirements.

In addition to the Arena Professional Edition, Rockwell Software offers a full suite of products to provide enterprise-wide simulation, optimization, and 3D model animation.

2.4.5 Statistical Distributions in Arena

Arena contains a set of built-in functions for generating random numbers from the commonly used probability distributions. These distributions appear on pull-down menus in many Arena modules where they’re likely to be used. They also match the distributions in the Arena input analyzer. This appendix describes all of the Arena distributions.

Distribution		Parameter Values
Beta	(BETA)	Beta, Alpha
Continuous	(CONT)	Cum $_{P1}$ Val, … , Cum P_{∞} Val$_n$
Discrete	(DISC)	Cum $_{P1}$ Val, … , Cum P_{∞} Val$_n$
Erlang	(ERLA)	ExpoMean, k
Exponential	(EXPO)	Mean
Gamma	(GAMM)	Beta, Alpha
Johnson	(JOHN)	Gamma, Delta, Lamlxda, Xi
Lognormal	(LOGN)	LogMean, LogStd
Normal	(NORM)	Mean, StdDev
Poisson	(POIS)	Mean
Triangular	(TRIA)	Min, Mode, Max
Uniform	(UNIF)	Min, Max
Weibull	(WEIB)	Beta, Alpha

Figure 2.4 Summary of Probability Distributions.

Each of the distribution items in Arena, having one or more parameters associated with it, is shown in Figure 2.4. To define the fully distribution, we have to specify the parameters including the number, meaning, and order of the parameters.

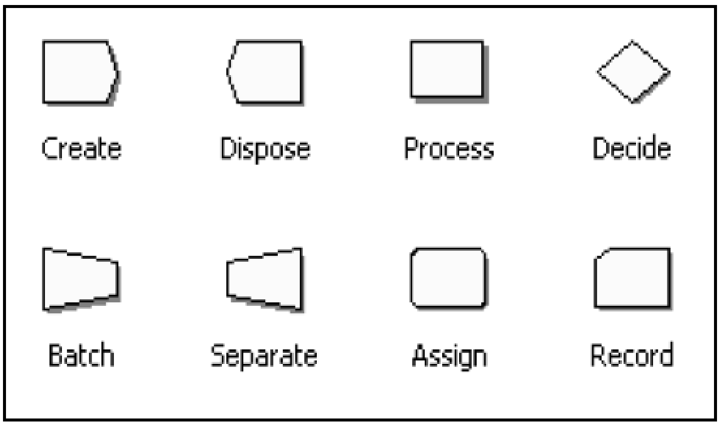


Figure 2.5 Flowchart module in basic process panel.

According to Figure 2.5. shown basic process panel. Create Module, Batch Module, Dispose Module, Separate Module, Process Module, Assign Module Decide Module and Record Module. This research explains about the basic process panel in the next point:

- Create: The beginning of process flow, enter the simulation data;
- Batch: Collect the volume of entities before the data continue processing;
- Dispose: The finish of process flow, removed from the simulation data;
- Separate: Duplicate entities for concurrent or parallel processing, or separating a previously established batch of entities;
- Process: An activity, usually performed by one or more resources and requiring some time to complete;
- Assign: Change the value of some parameter (during the simulation), such as the entity's type or a model variable;
- Decide: A branch in process flow. Only one branch is taken;
- Record: Collect a statistic, such as an entity count or cycle time.

2.4.6 Report of Arena simulation program

Report of the Arena simulation program related this research. the report show the performance of process. We can find the best solution to solve the problem. This research we just interested about number of waiting and wait time

Time:

- Wait Time;
- Total Time;
- Number In;
- Number Out.

Queue Report:

- Waiting Time;
- Number of Waiting.

2.5 Related Researches

Xu et al. [2] presented the basic principles of queuing theory and model of port management for solving the best service queuing system. Based on a one-dimensional established by scholars past, which would help to solve the minimal service cost. With additional forwarding of a two-dimensional, it was shown that both performance indexes obtained the minimal costs. Furthemore, the use of the Delphi Programming is to provide the proper management and to solve the excellent service.

Chen et al. [5] presented point-wise analysis model to estimate the static is proposed to analyze the car based on the queuing process with distributed service time random doors and yards of the station port model linear programming, convex be. development, which reduces the truck open and discomfort due to the shifting of the second stage optimization method is used to calculate the best first car models arriving for a photo. a desirable of tolls at different times, leading to the best arrived. Numerical experiments are conducted to test the computing performance and accuracy of the proposed model optimization.

Balachandran. [3] presented priority rules that are mixtures of pre-emption and postponable rules are analyzed. Whether a pre-emption occurs is made to depend on some factor in addition to priority class. A lower priority customer is pre-empted if and only if the queue length of higher priority customers is N, a decision parameter. The stochastic model (without priorities) is that of the M/G/1 queue. First moment expressions (e.g., expected number of customers in the system) in the steady state case are obtained for each priority class, using the concept of work conservation. A linear cost model is introduced which is a function of expected waiting time and expected number of pre-emptions. By considering a parametric class of rules determined by the decision parameter, the problem of finding an optimal rule is formulated.

Mohammed et al. [12] presented difficulties in estimating the time for the system to make it stable and if there is a queue outside the education system at the right time can lead to instability and the occurrence of the loss in time. this queuing system with a maximum length of the queue, and in this study were within the appropriate portions of the input and the specific distribution of time between the arrival follows the standard normal distribution.

Jenny et al. [11] presented the address a truck scheduling problem that arises in intermodal container transportation, where containers need to be transported between customers (shippers or receivers) and container terminals (rail or maritime) and vice versa. The transportation requests are handled by a trucking company which operates several depots and a fleet of homogeneous trucks that must be routed and scheduled to minimize the total truck operating time under hard time window constraints imposed by the customers and terminals. Empty containers are considered as transportation resources and are provided by the trucking company for freight transportation. The truck scheduling problem at hand is formulated as Full-Truckload Pickup and Delivery Problem with Time Windows (FTPDPTW) and is solved by a 2-stage heuristic solution approach. This solution method was specially designed for the truck scheduling problem but can be applied to other problems as well. We assess the quality of our solution approach on several computational experiments.

CHAPTER III
RESEARCH METHODOLOGY

The research methodology in this chapter, which is a sequence of operations of this research. We will begin with the basic infrastructure of the port. And then we will consider the factors which impact it. We will take these factors into priority, then we will have to find the maximum value of the port can be arranged services. Finally, we will take the aforementioned techniques applied to the sample data. The research will use the arena simulation program. In chapter 3 topics following:

- Existing Information;
- Classified priorities queue and booking;
- The most appropriate capacity of model;
- Using the priority queuing and booking to manage the queue;
- Methods and principles of the model with the program.

3.1 Existing Information

For the principles to be applied in the analysis, we need to know the basic information of port. That will be used to analyze them. For those who use the service in the Bangkok Port. The Bangkok port include 2 main terminals for used to ship goods to foreign countries.

The historical data of the Bangkok port is used in our study with permission. There are two terminal for PAT, i.e., terminal 1 and terminal 2. The terminal 1 is used for our study. Terminal 1 consists of terminal gates and terminal yards as shown in Figure. 3.1.

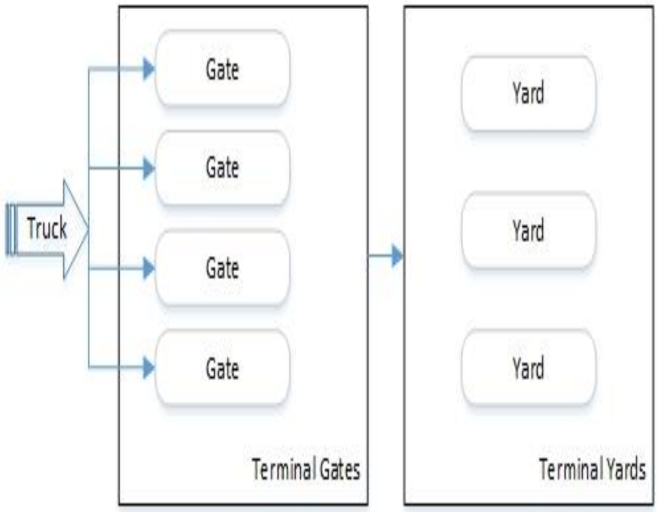


Figure 3.1 Queuing network in Terminal 1 of PAT.

Data collection will be used in this research. We will keep the period of service in the terminal gates and terminal yards, which are kept in units of minutes. And then we use the data collection to used in the analysis of the system queues.

The terminal gates and terminal yards have work flow as described following. When a vehicle comes to terminal gates with work order (W/O) and then goes to gate, the port officer and the custom officers check the document. After that the vehicle goes to terminal yards for load container. The work flow in the terminal is shown in Figure 3.2.

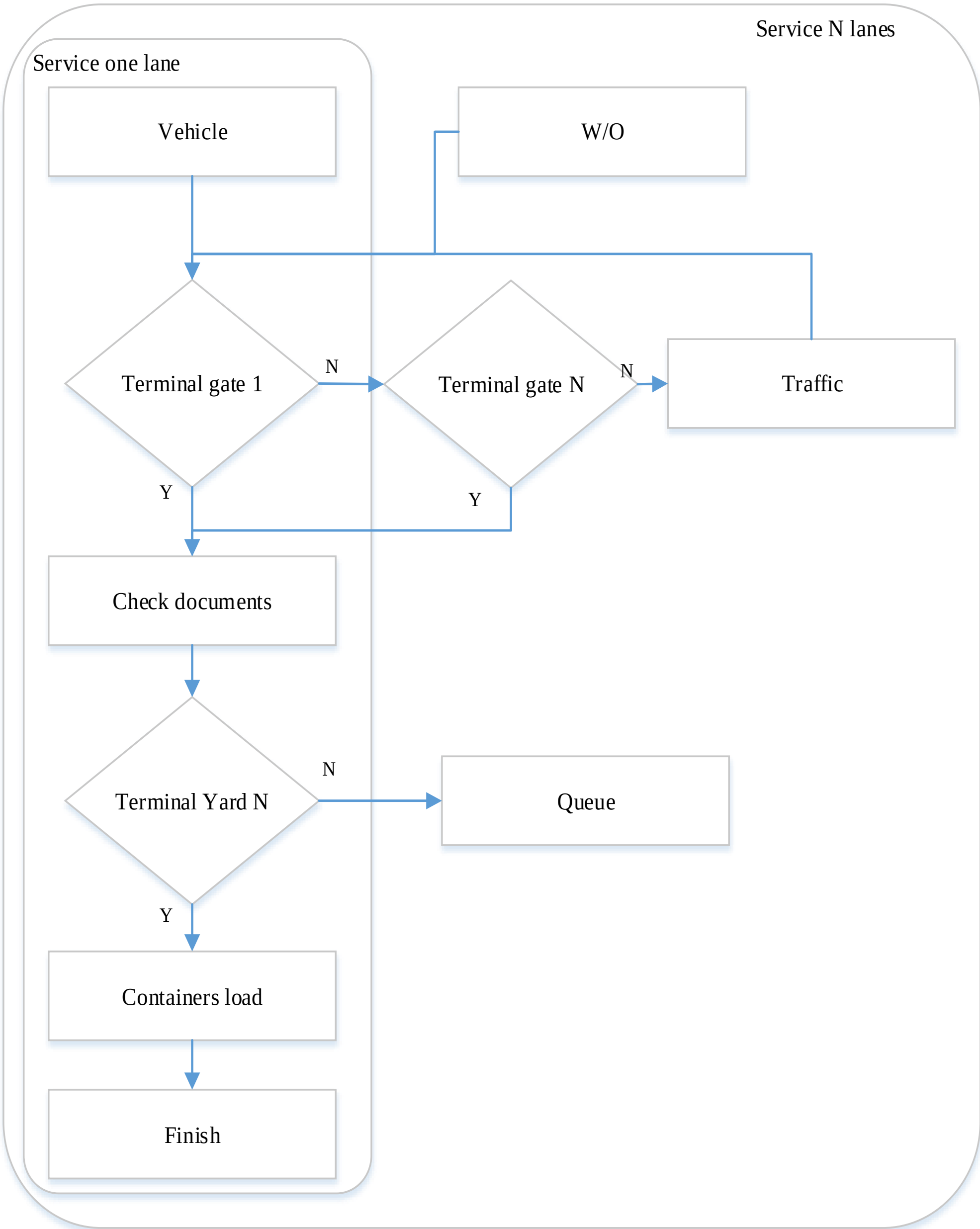


Figure 3.2 Work flow in terminal.

For each step in the process of getting services for customers who take the service in the port. There is a very important because each process does. There are factors or requirements vary at each point. Data collection in this research. We collected data for a specific service channels in the table, which according to Table 3.1.

3.2 The most appropriate capacity of model

Table 3.1 service time (minutes).

Gate 1	Gate 2	Gate …	Gate n	Yard 1	Yard 2	Yard …	Yard n
X1	Y1	…	Z1	A1	B1	…	C1
X2	Y2	…	Z2	A2	B2	…	C2
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
Xn	Yn	…	Zn	An	Bn	…	Cn

According to the data collect in Table 3.1. We collect each separate channel for the service. To know and understand the behavior of employees to provide services. Each channel. We use the information that is used to define the Capacity of service it not through the simulation program (Arena simulation program). Then we use the equation (3.1). To determine initial recognition of available capacity in the service.

$$C_T = \text{Min}\left(\frac{60}{T_G} \times N_G, \frac{60}{T_Y} \times N_Y\right) \qquad (3.1)$$

where:

C_T Capacity of terminal to give service per hour;

T_G Average service time of terminal gate;

N_G Number of terminal gate lane service;

T_Y Average service time of terminal yard;

N_Y Number of terminal yard lane service.

From this equation comes from considering the hour of service. Show that our customers take the appropriate service. We choose the smallest number that we can provide. So we cannot have a problem of bottle neck, which will cause problems queues and time consuming.

The capacity is setting on period. So find capacity in one day. The mean the capacity period + the capacity per period. So the equation is

$$C_D = \sum_{i=1}^{P} X_i \tag{3.2}$$

where:

C_D Capacity number of terminal to give service one day;

P Period time per day.

According to equation 3.1 and equation 3.2 gives us the ability to provide our services in both hourly and daily. Therefore we must know limit of port service for determine customer's priority. Which are discussed in the next step

3.3 Classified priorities queue and booking

There are a lot of customers doing business with Bangkok port. In this work, only the large capital companies are focused. These companies are very important customers (VIC). Figure 3.3. Depicts the sample of these companies.

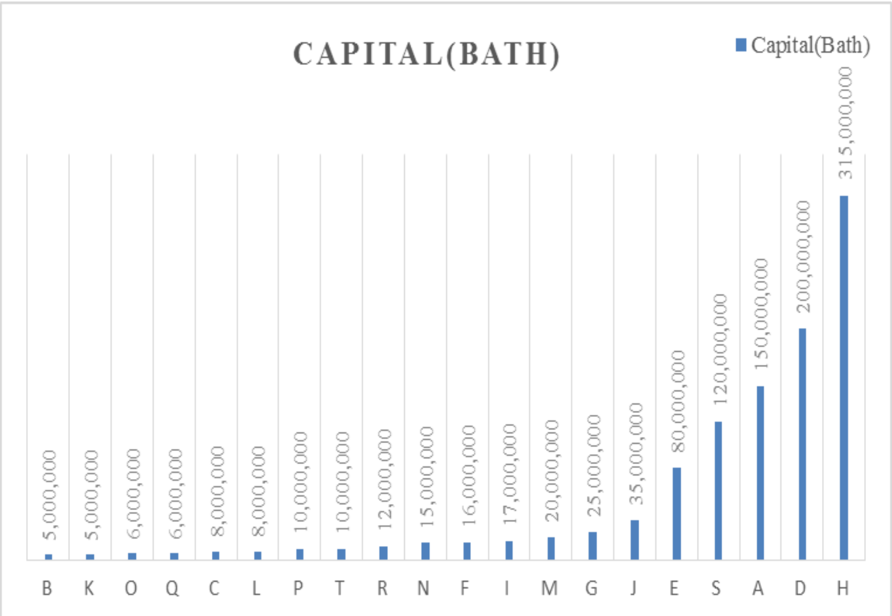


Figure 3.3 Sample companies contact with Bangkok port.

According to figure. 3.3, we can see that the larger capital company gives the higher benefit to the Bangkok port. Therefore the priority for high contact is important too. In the work, priority of the queue is set depending on the position of the company on of capitalization rank.

Rank consider the ability of the company to use the service port. This research consider the capital gain of companies and value of benefit port authority of Thailand to set priority rank, which can be seen in figure 3.4.

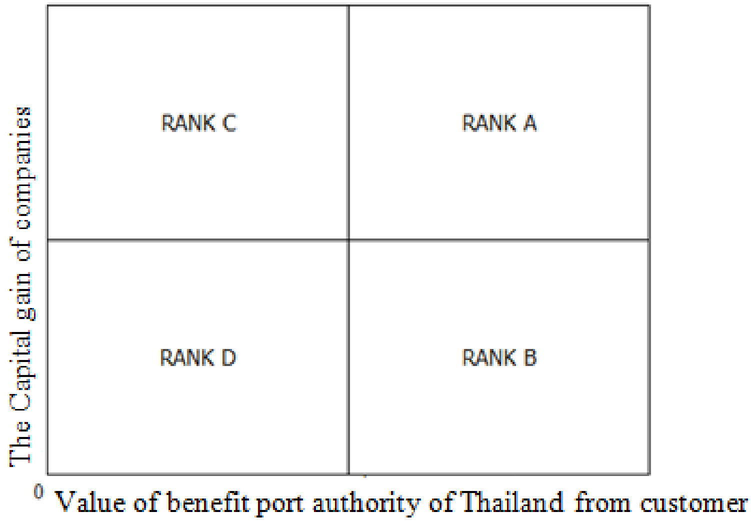


Figure 3.4 Classified priorities ranking.

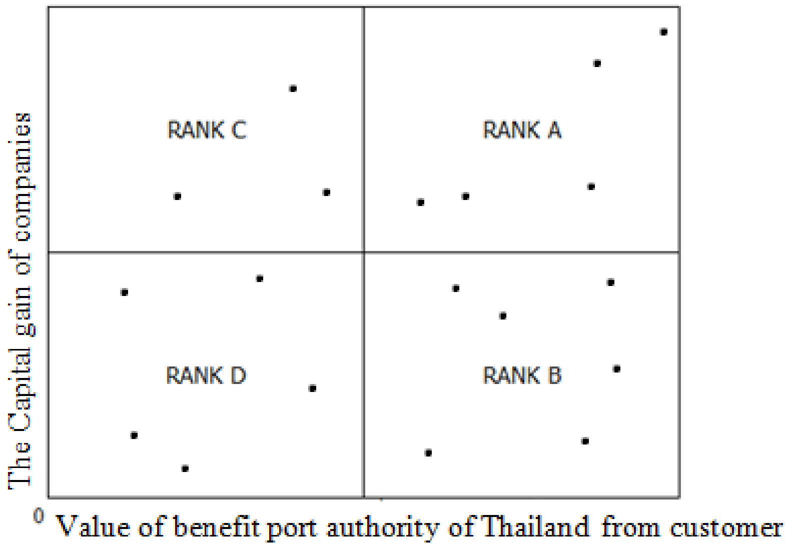


Figure 3.5 Sample Classified priorities ranking.

Figure 3.5 is an example of the information management group. We will point to each rank, which will contribute to our attention that a group of companies deal business with the Port. In a position the information in order to rank the priority rank.

3.4 Using the priority queuing and booking to manage the queue

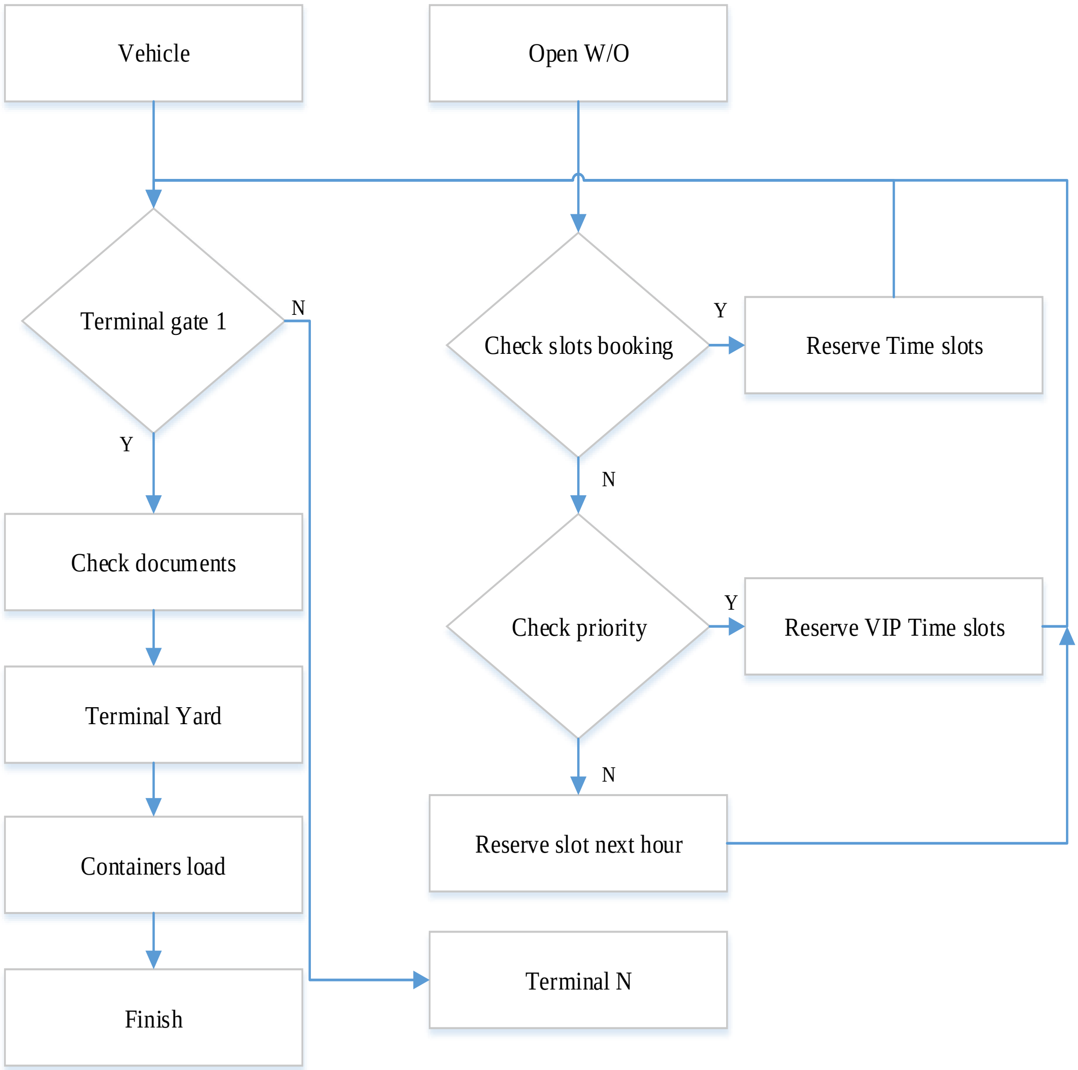


Figure 3.6 New work flow.

Figure 3.6 shows new work flow of priority queuing and booking technique. Before a truck comes to the port, the operator must book a time slot for the truck. The officer will check slot for truck. If a preferred time slot is available, the officer will book that time slot into the time table. Then the truck can come to the port depending on the booked time slot. If the slot is full, the officer will check rank of the company. If company is in rank A and 10% reserved for rank A is not full yet, the officer will book on the time table. After that the truck can come to port. The waiting time is dependent on rank definition.

Table 3.2 Actual service time (minutes)

Gate 1	Gate 2	Gate 3	Gate 4	yard	yard	yard
4.2	4.4	4.2	4	4.1	4.1	4.1
4.5	4.9	4.4	4.8	4.4	4.4	4.3
4.6	4.9	4.5	4	4.5	4.5	4.4
4.1	4.7	4.3	4.5	4.3	4.6	4.3
4.5	4.4	4.6	4.5	4.6	4.1	4.1
4.6	4.6	4.7	4.4	4.2	4	4.2
4.8	4.4	4.4	4.6	4.4	3.8	3.9
4.8	4.3	4.6	4.3	4.4	3.9	4
4.6	4.5	4.6	4.4	4.5	4	4
4.1	4.4	4.1	4.5	4.1	4.6	4.2
3.9	4.5	3.9	4.4	3.9	4.2	4.1
3.9	4.3	3.9	4.6	4	4.3	4.3
4.8	4.5	4.8	4.8	4.1	4.4	4.4
4.9	4.9	4.9	4.9	4.2	4.4	4.2
4.3	4.4	4.7	4	4.2	4.2	4.2
4.1	4.5	4.5	4.5	4.5	4.1	4.1
4	4.8	4	4.4	4.4	4	4.4
Average : 4.45				Average : 4.23		

From the record, the port capacity is actually. The model just finds max capacity per hour. According to the terminal gates information from Table 1, we can see that the average of processing time from start to finish is 4.45 minutes per vehicle. Therefore, the maximum capacity of gate is 60/4.45 =13.483 ≈ 14 vehicles/hr. The terminal gates have 4 gates for the Bangkok port. So the maximum capacity of the terminal gates is 14 x 4 = 56 vehicles / hr.

As same as the maximum capacity of terminal gates, the maximum capacity of the terminal yards can be determine as follows. According to the terminal yards information from Table 1, the average of processing time from start to finish is 4.23 minutes per vehicle. Thus, the maximum capacity of truck per gate per hour is 60/4.23 =14.184 ≈ 15 Vehicles/hr. Terminal yards has 3 zones. Therefore the maximum capacity of the terminal yards 15 x 3 = 45 vehicles / hr. Because the both parts, the terminal gates and the terminal yards, are connected in cascade manner, so the maximum throughput capacity is limited by the minimum of both terminal, which can be shown as table 3.1.

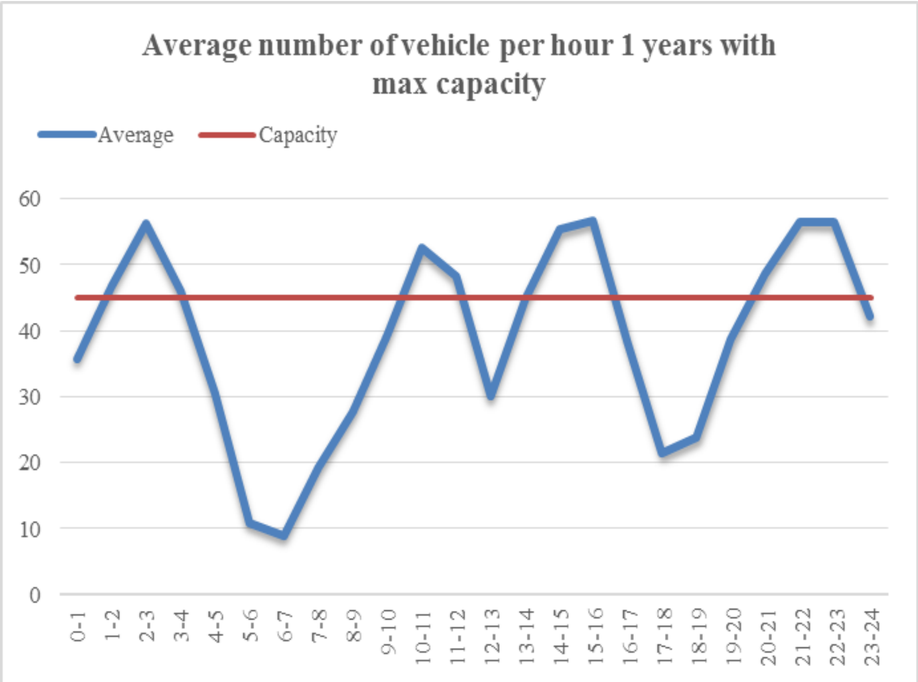


Figure 3.7 Average number of vehicle to take a service time in terminals Maximum capacity set on historical.

3.5 Methods and principles of the model with the program Arena

Arena is simulation program. Arena build form record or historical data, we need to put the variables involved in the situation. From the picture below is draft form process in arena.

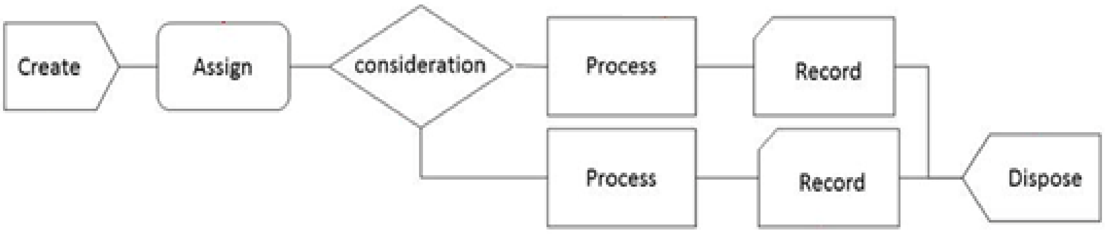


Figure 3.8 Method of arena.

Create: This module is built data in to process. The data record from time between data1 data2.

Assign: This module assign input data. The type of data is set in here such as sex, time.

Consideration: This module is set routing by condition or percentage.

Process: This module set the usage resource, time. The duration of the operation of each unit.

Record: Recording the data. Such as Volume of entity, time in process.

Dispose: Object out.

The next step we have to know the distribution of the data. The model is built using data with any distribution. The Arena program can make us aware of the notification by the program will select the type of notification related to the distribution of our precious little error as possible.

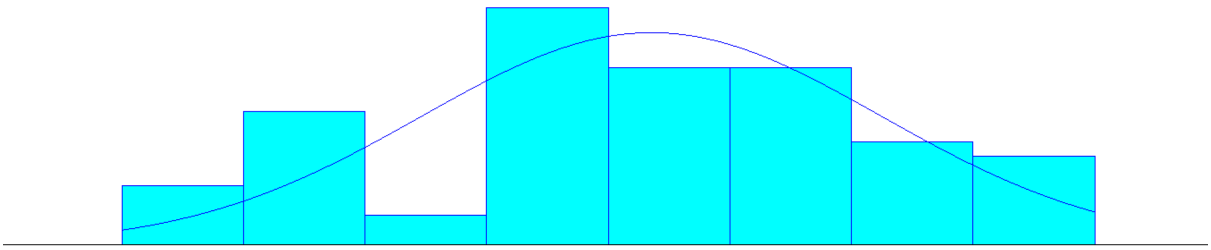


Figure 3.9 The normal distribution of the terminal gates.

Distribution Summary

Distribution: Normal
Expression: NORM(4.45, 0.284)
Square Error: 0.019666

Figure 3.10 Distribution Summary of terminal gates.

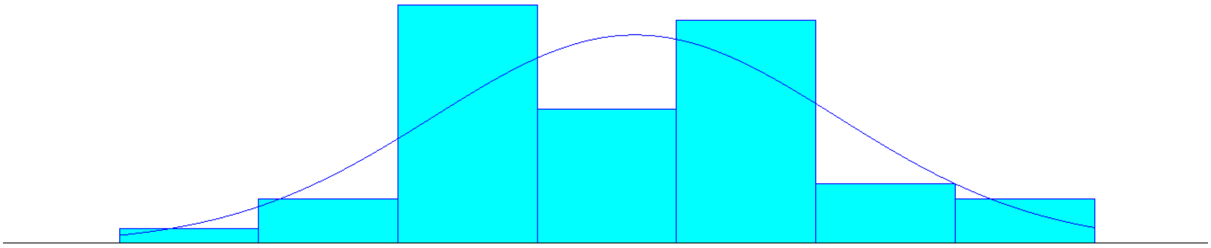


Figure 3.11 The normal distribution of the terminal yards.

Distribution Summary

Distribution: Normal
Expression: NORM(4.23, 0.199)
Square Error: 0.029966

Figure 3.12 Distribution Summary of terminal yards.

According to figure 3.9, 3.10, 3.11 and 3.12 shows that the data in this study is a normal distribution arena. The program can be used in the form of distributions and information used in the analysis. The information we have service time in the terminal yards and terminal gates.

CHAPTER IV
EXPERIMENTAL RESULTS AND DISCUSSION

In Chapter 4, we will discuss Experimental results, which is a sequence of operations of this research. We will begin with the basics of the Structure of the Port. And then we will consider the factors that affect it, we will take these factors into priority (priority), then we will have to find the maximum value of the port can be arranged. Finally, we will take the aforementioned techniques applied to the sample data. The research will use the arena simulation model to solve the problem. The topics following:

- Considering the results of the flow;
- Considering the results of the flow priority Queuing booking;
- Flow Compare.

The arena simulation program process data in Chapter 3 and further consideration, the assumption is true or false. We will consider the number of vehicles queued. And long waiting time.

4.1 Considering the results of the flow


Key Performance Indicators

System	Average
Number Out	903

Figure 4.1 Volume of number vehicle out.

According to Figure 4.1, the data we collected and processed. We know that this system is a truck out of 903 cars per day, but our data are simulated imports of trucks 1015 units in the table below, which can be seen in Figure 4.2. Shows that a residual information Wait for the service. This is caused by the time we process the final. A range of information are clustered. 02:00 – 03:00, 10:00 – 12:00, 13:00 – 16:00, and 20:00 - 23:00.

Number In	Value
Truck	1015.00

Number Out	Value
Truck	903.00

Figure 4.2 Volume of number vehicle in and out.

For this research, we are interested in the vehicle and the number of vehicles waiting in the queue. The simulation that we know is that it is highly concentrated at any point in the process, which can be seen in Figure 4.2.

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
One Stop Service.Queue	0.00	0.00	0.00
Terminal Gate1.Queue	0.1486	0.00	0.5823
Terminal Gate2.Queue	0.0905	0.00	0.5259
Terminal Gate3.Queue	0.2499	0.00	1.0058
Terminal Gate4.Queue	0.1375	0.00	0.6646
Terminal_Yard1.Queue	0.9237	0.00	2.2481
Terminal_Yard2.Queue	0.2218	0.00	0.7169
Terminal_Yard3.Queue	0.9106	0.00	2.1989

Figure 4.3 Summary waiting time result simulation arena program.

According to Figure 4.3, the table above, we know that. The amount of time that queuing Terminal gates each with an average waiting time of about 9 minutes and the average wait time of approximately 41 minutes, which channel is the channel waiting terminal gate 3 wait times up to 60 minutes.

For terminal yard, which is less than the amount of the channel terminal gates, but the management is very similar. As a result, the length of queues at this point is quite high. The average wait time in terminal yards is about 41 minutes, Channel 2 is the second time that a minimum waiting period. And the maximum waiting time of a table top channel terminal yard 1 terminal yard 3 is spent waiting for more than 120 minutes or 2 hours, which can be seen in Figure 4.4.

Number Waiting	Average	Minimum Value	Maximum Value
One Stop Service.Queue	0.00	0.00	0.00
Terminal Gate1.Queue	1.7118	0.00	11.0000
Terminal Gate2.Queue	0.9314	0.00	8.0000
Terminal Gate3.Queue	2.6407	0.00	14.0000
Terminal Gate4.Queue	1.5008	0.00	10.0000
Terminal_Yard1.Queue	13.6794	0.00	38.0000
Terminal_Yard2.Queue	2.8209	0.00	11.0000
Terminal_Yard3.Queue	12.2704	0.00	32.0000

Figure 4.4 Summary number waiting time result simulation arena program.

After that it will consider a number of cars waiting. According to Figure 4.4, we determine the amount of the average car comes into individual channels and queues in which the terminal gates, with the number of vehicles waiting an average of about 1.7613 or about 2 units. The maximum car at an average of about 11 units and the most number of vehicles waiting in the terminal gate 3 channels up to 14 units.

For terminal yards with less channels than terminal gates. The data is the bottleneck problem. The processing model in this arena is the average number of cars waiting to go in high terminal yard 1 13.67 units or 14 units and up to 38 units in the same lane.

One Stop Services	1015.00
terminal gate 1	259.00
terminal gate 2	246.00
terminal gate 3	234.00
terminal gate 4	243.00
terminal yard 1	311.00
terminal yard 2	297.00
terminal yard 3	298.00

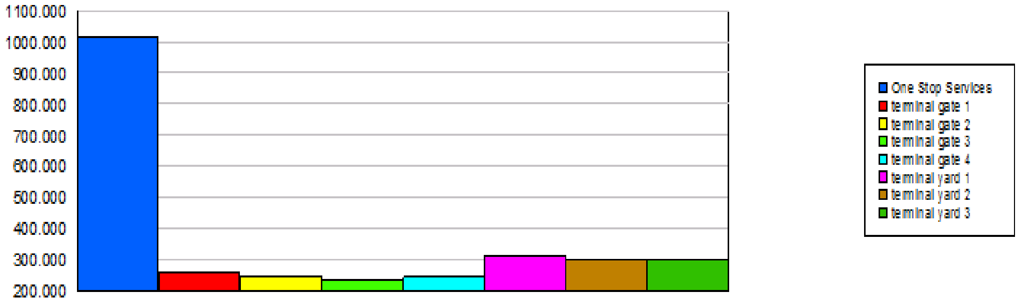


Figure 4.5 Summary result arena simulation program.

The number of vehicles to run on each process on this graph, we know the capabilities of each of the points of interest in traditional work patterns. In the diagram, we can see that there are customers who use the service in the One Stop Service 1015 units, the terminal gate 1 259 units, the terminal gate 2 246 units, the terminal gate3 234 units, the terminal gate4 243 units, the terminal yard 1 311 units the terminal yard 2 297 units and the terminal yard 3 298 units.

From the above figure, we have to be compared to the work in the priority queuing booking technique.

4.2 Considering the results of the flow priority Queuing booking

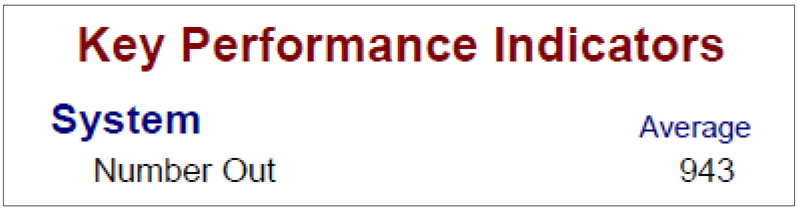


Figure 4.6 Volume of number vehicle out with priority rank.

According to Figure 4.6, the data we collected and processed. We know that this system is a truck out of 943 cars per day, but our data are simulated imports of trucks 1035 units in the table below, which can be seen in Figure 4.7. Priority booking for processing data, the number of trucks in and out is higher than the original system.

Number In	Value
Truck	1035.00

Number Out	Value
Truck	943.00

Figure 4.7 Volume of number vehicle out with priority rank.

According to Figure 4.7 the information we collect and calculate new processing. We know that this system is a truck out of 943 cars per day, but our data are simulated imports of trucks to 1035 units in the above table.

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
One stop service A 00_01.Queue	0.00	0.00	0.00
One stop service A 01_02.Queue	0.00102955	0.00	0.04015244
One stop service A 02_03.Queue	0.00	0.00	0.00
One stop service A 03_04.Queue	0.01160857	0.00	0.1047
One stop service A 04_05.Queue	0.02604317	0.00	0.1800
One stop service A 05_06.Queue	0.02985267	0.00	0.1832

Figure 4.8 Summary waiting time result simulation arena program with rank.

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
One stop service A 06_07.Queue	0.1683	0.00	0.3456
One stop service A 07_08.Queue	0.07996960	0.00	0.6411
One stop service A 08_09.Queue	0.02597394	0.00	0.2018
One stop service A 09_10.Queue	0.05219852	0.00	0.2417
One stop service A 10_11.Queue	0.1040	0.00	0.4693
One stop service A 11_12.Queue	0.06435062	0.00	0.2442
One stop service A 12_13.Queue	0.07832230	0.00	0.3931
One stop service A 13_14.Queue	0.2714	0.00	0.5439
One stop service A 14_15.Queue	0.4800	0.1317	0.8963
One stop service A 15_16.Queue	0.5856	0.00	1.0700
One stop service A 16_17.Queue	0.4891	0.04746003	0.9183
One stop service A 17_18.Queue	0.4367	0.00	1.0045
One stop service A 18_19.Queue	0.5130	0.05374547	0.8710
One stop service A 19_20.Queue	0.3821	0.00	0.9267
One stop service A 20_21.Queue	0.4748	0.01968078	0.8697
One stop service A 21_22.Queue	0.4977	0.1435	0.8928
One stop service A 22_23.Queue	0.5575	0.1819	1.1216
One stop service A 23_00.Queue	0.00235482	0.00	0.08692068

Figure 4.8 Summary waiting time result simulation arena program with rank (cont.).

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
One stop service A 10_11.Queue	0.1040	0.00	0.4693
One stop service A 11_12.Queue	0.06435062	0.00	0.2442
One stop service A 12_13.Queue	0.07832230	0.00	0.3931
One stop service A 13_14.Queue	0.2714	0.00	0.5439
One stop service A 14_15.Queue	0.4800	0.1317	0.8963
One stop service A 15_16.Queue	0.5856	0.00	1.0700
One stop service A 16_17.Queue	0.4891	0.04746003	0.9183
One stop service A 17_18.Queue	0.4367	0.00	1.0045
One stop service A 18_19.Queue	0.5130	0.05374547	0.8710
One stop service A 19_20.Queue	0.3821	0.00	0.9267
One stop service A 20_21.Queue	0.4748	0.01968078	0.8697
One stop service A 21_22.Queue	0.4977	0.1435	0.8928
One stop service A 22_23.Queue	0.5575	0.1819	1.1216
One stop service A 23_00.Queue	0.00235482	0.00	0.08692068

Figure 4.8 Summary waiting time result simulation arena program with rank (cont.).

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
One stop service C 00_01.Queue	0.00	0.00	0.00
One stop service C 01_02.Queue	0.00	0.00	0.00

Figure 4.8 Summary waiting time result simulation arena program with rank (cont.).

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
One stop service C 02_03.Queue	0.00	0.00	0.00
One stop service C 03_04.Queue	0.02773875	0.00	0.07989135
One stop service C 04_05.Queue	0.01331767	0.00	0.0932
One stop service C 05_06.Queue	0.03932661	0.00	0.1573
One stop service C 06_07.Queue	0.1328	0.00	0.2812
One stop service C 07_08.Queue	0.00	0.00	0.00
One stop service C 08_09.Queue	0.00	0.00	0.00
One stop service C 09_10.Queue	0.00	0.00	0.00
One stop service C 10_11.Queue	0.1783	0.00	0.4594
One stop service C 11_12.Queue	0.02628682	0.00	0.1418
One stop service C 12_13.Queue	0.1202	0.00	0.3990
One stop service C 13_14.Queue	0.3995	0.02962478	0.6045
One stop service C 14_15.Queue	0.6237	0.3120	0.9152
One stop service C 15_16.Queue	0.6211	0.2765	1.0324
One stop service C 16_17.Queue	0.5953	0.2797	0.8843
One stop service C 17_18.Queue	0.4289	0.05212204	0.7479
One stop service C 18_19.Queue	0.4475	0.1052	0.7969
One stop service C 19_20.Queue	0.5042	0.03112279	1.0534
One stop service C 20_21.Queue	0.4776	0.3923	0.6330
One stop service C 21_22.Queue	0.6008	0.3673	0.7747
One stop service C 22_23.Queue	0.5226	0.1958	0.8303
One stop service C 23_00.Queue	0.00352201	0.00	0.06691817

Figure 4.8 Summary waiting time result simulation arena program with rank (cont.).

Queue

Time

Waiting Time	Average	Minimum Value	Maximum Value
Terminal Gate1.Queue	0.2938	0.00	0.9220
Terminal Gate2.Queue	0.2845	0.00	1.0865
Terminal Gate3.Queue	0.3486	0.00	1.3116
Terminal Gate4.Queue	0.2795	0.00	0.8563
Terminal_Yard1.Queue	0.9076	0.00	1.6241
Terminal_Yard2.Queue	0.3721	0.00	1.2322
Terminal_Yard3.Queue	0.2470	0.00	0.8485

Figure 4.8 Summary waiting time result simulation arena program with rank (cont.).

According to Figure 4.8 the table above, we know that. The amount of time that queuing Terminal gates each with an average wait time of 18 minutes, which takes a long wait the old system. And the average wait time of approximately 60 minutes, which channel is the channel waiting terminal gate 3 wait times up to 78 minutes.

For terminal yard, which is less than the amount of the channel terminal gates, but the management is very similar. As a result, the length of queues at this point is quite high. The average wait time in terminal yards is about 30 minutes, the time to wait less than the original system. The terminal 3 is the second time that a minimum waiting period. And the maximum waiting time according table terminal yard 1 terminal yard 2 highest average wait time of approximately 64 minutes, which is less than the old system.

Number Waiting	Average	Minimum Value	Maximum Value
One stop service A 00_01.Queue	0.00	0.00	0.00
One stop service A 01_02.Queue	0.00167302	0.00	1.0000
One stop service A 02_03.Queue	0.00	0.00	0.00
One stop service A 03_04.Queue	0.01692916	0.00	6.0000
One stop service A 04_05.Queue	0.03038370	0.00	6.0000
One stop service A 05_06.Queue	0.02612109	0.00	4.0000
One stop service A 06_07.Queue	0.07011435	0.00	7.0000
One stop service A 07_08.Queue	0.08330166	0.00	7.0000
One stop service A 08_09.Queue	0.03896090	0.00	9.0000
One stop service A 09_10.Queue	0.07829777	0.00	13.0000
One stop service A 10_11.Queue	0.1603	0.00	15.0000
One stop service A 11_12.Queue	0.0992	0.00	15.0000
One stop service A 12_13.Queue	0.1142	0.00	14.0000
One stop service A 13_14.Queue	0.4524	0.00	37.0000
One stop service A 14_15.Queue	0.6400	0.00	32.0000
One stop service A 15_16.Queue	0.8541	0.00	32.0000
One stop service A 16_17.Queue	0.6725	0.00	33.0000
One stop service A 17_18.Queue	0.6550	0.00	34.0000
One stop service A 18_19.Queue	0.7908	0.00	37.0000
One stop service A 19_20.Queue	0.5732	0.00	29.0000
One stop service A 20_21.Queue	0.8112	0.00	40.0000
One stop service A 21_22.Queue	0.8087	0.00	39.0000
One stop service A 22_23.Queue	0.7898	0.00	34.0000
One stop service A 23_00.Queue	0.00706447	0.00	4.0000

Figure 4.9 Summary number waiting time result simulation arena program with priority.

Number Waiting	Average	Minimum Value	Maximum Value
One stop service C 00_01.Queue	0.00	0.00	0.00
One stop service C 01_02.Queue	0.00	0.00	0.00
One stop service C 02_03.Queue	0.00	0.00	0.00
One stop service C 03_04.Queue	0.00924625	0.00	4.0000
One stop service C 04_05.Queue	0.00388432	0.00	1.0000
One stop service C 05_06.Queue	0.00655444	0.00	1.0000
One stop service C 06_07.Queue	0.02766370	0.00	4.0000
One stop service C 07_08.Queue	0.00	0.00	0.00
One stop service C 08_09.Queue	0.00	0.00	0.00
One stop service C 09 10.Queue	0.00	0.00	0.00
One stop service C 10_11.Queue	0.05942067	0.00	4.0000
One stop service C 11_12.Queue	0.00876227	0.00	2.0000
One stop service C 12_13.Queue	0.04508263	0.00	4.0000
One stop service C 13_14.Queue	0.08322081	0.00	5.0000
One stop service C 14_15.Queue	0.3378	0.00	13.0000
One stop service C 15_16.Queue	0.2588	0.00	10.0000
One stop service C 16_17.Queue	0.2232	0.00	9.0000
One stop service C 17_18.Queue	0.1072	0.00	6.0000
One stop service C 18_19.Queue	0.1119	0.00	6.0000
One stop service C 19_20.Queue	0.1681	0.00	8.0000
One stop service C 20_21.Queue	0.07960109	0.00	4.0000
One stop service C 21_22.Queue	0.1502	0.00	6.0000
One stop service C 22_23.Queue	0.2395	0.00	11.0000
One stop service C 23_00.Queue	0.00278826	0.00	1.0000

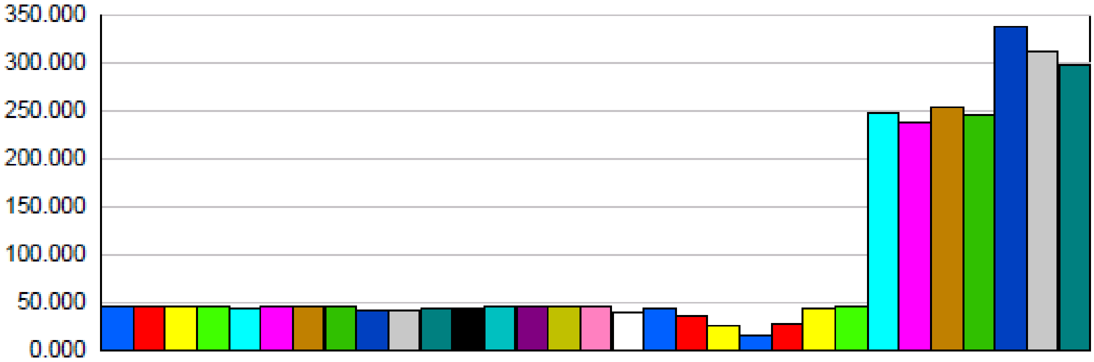
Figure 4.9 Summary number waiting time result simulation arena program with priority (cont.).

Number Waiting	Average	Minimum Value	Maximum Value
Terminal Gate1.Queue	2.9454	0.00	13.00
Terminal Gate2.Queue	2.7250	0.00	15.00
Terminal Gate3.Queue	3.6163	0.00	18.00
Terminal Gate4.Queue	2.7856	0.00	12.00
Terminal_Yard1.Queue	13.7812	0.00	32.00
Terminal_Yard2.Queue	4.9759	0.00	18.00
Terminal_Yard3.Queue	3.0495	0.00	10.00

Figure 4.9 Summary number waiting time result simulation arena program with priority (cont.).

After that it will consider a number of cars waiting. According to Figure 4.9, we determine the amount of the average car comes into individual channels and queues in which the terminal gates, with the number of vehicles waiting an average of about 3 units. The maximum car at an average of 15.33 units or about 16 units and the most number of vehicles waiting in the terminal gate 3 channels up to 18 units.

For terminal yards with less channels than terminal gates, the data implied the bottleneck problem. According to Figure 4.9, we determine the amount of the average car comes into individual channels and queues in which the terminal yards, with the number of vehicles waiting an average of about 7.268 units. The processing model in this arena is the average number of cars waiting to go in high terminal yard 1 13.78 units or 14 units and up to 32 units in the same lane.



One stop service 0_1	45.0000
One stop service 1_2	45.0000
One stop service 10_11	45.0000
One stop service 11_12	45.0000
One stop service 12_13	44.0000
One stop service 13_14	45.0000
One stop service 14_15	45.0000
One stop service 15_16	45.0000
One stop service 16_17	42.0000
One stop service 17_18	42.0000
One stop service 18_19	43.0000
One stop service 19_20	44.0000
One stop service 2_3	45.0000
One stop service 20_21	45.0000
One stop service 21_22	45.0000
One stop service 22_23	45.0000
One stop service 23_00	40.0000
One stop service 3_4	43.0000
One stop service 4_5	35.0000
One stop service 5_6	25.0000
One stop service 6_7	15.0000
One stop service 7_8	28.0000
One stop service 8_9	43.0000
One stop service 9_10	45.0000
terminal gate 1	247.00
terminal gate 2	238.00
terminal gate 3	254.00
terminal gate 4	245.00
terminal yard 1	337.00
terminal yard 2	312.00
terminal yard 3	297.00

Figure 4.10 Summary result arena simulation program with priority.

The number of vehicles to run on each process on this graph, which can be seen Figure 4.10. We know the capabilities of each of the interest points in the form of a new work. In the diagram, we can see that there are customers who use the service in the One Stop Service hourly earnings terminal gate 1 247 units, the terminal gate 2 238 units, the terminal gate3 254 units, the terminal gate4 245 units, the terminal yard 1 337 units, the terminal yard 2 312 units and the terminal yard 3 297 units.

According to the Figures 4.10, we have to be compared to the model works between priority queuing booking technique and old system that meets the target or not. From the analytical table of forms and patterns in priority is better than ever. Data entry and exit in a higher number. That means we can serve our customers even more and to generate profits to organizations for more. The possible side effect for driver knows the exact time. Able to manage time better, the driver can be able to make profit by drive the car.

4.3 Comparison of PQBT and NQT

The number of vehicle come to the port is set by using the collective data from Bangkok port. Then the proposed booking method is applied. This initial value is use for simulation. Then compare the result of proposed model and actual value. The service time is fixed 4.45 minutes, for all terminal gates and 4.23 minutes for all terminal yards. Form this simulation set service time to normal distribution. The vehicles which come in port have to book before come to load container. The capacity of each period cannot over the capacity of terminal, which can be seen in Figure 4.11.

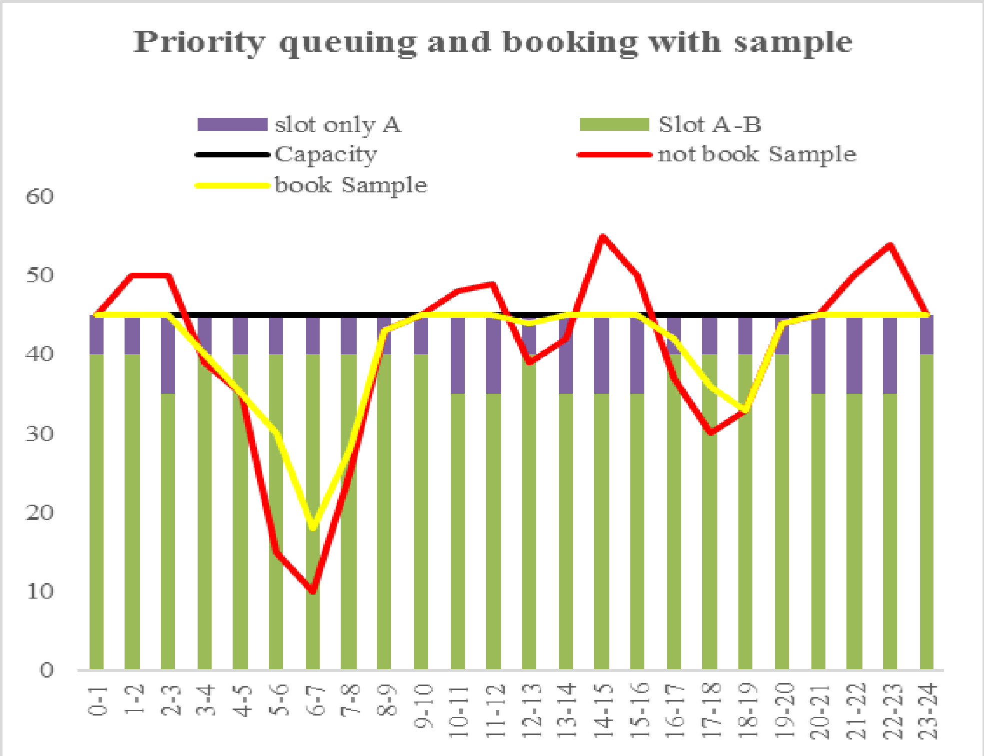


Figure 4.11 Priority queuing and booking with sample.

4.3.1 Result of PQBT

According to Figure 4.11 the experimental result show priority queuing and booking are better trend than normal queue. Not have a peak time. The data is distribution. The data spread wild. The combine of priority queuing and booking techniques can reduce the number of vehicle per hour to not over the capacity of the terminal. So the traffic inside the terminal can be improved. We can see that the customers in rank A and B will have less waiting times while the customers in rank C have book in next time slot if the preference period is peak period. However this problem is not big problem for them. They will manage their truck come to port in booking period. The accident is irrelevant factor. Overall of priority queuing and booking is better than normal queue.

CHAPTER V
CONCLUSION

The proposed priority queuing and booking technique can improve the queue management for PAT and customers. Time management so to helps business finish more jobs with less effort. By allotting a certain amount of time for each activity. Time management become more organized and time become more habitual than panic-driven. By making it a habit. As Aristotle said, we are what we repeatedly do. Excellence, then, is not an act, but a habit.

Work flows are importance for calculating the maximum capacity. The capacity can adjust other model. The data is distribution. The truck for each time slot should not over the maximum capacity. The mechanism of services, uncertainties related to the mechanism to provide a number of servers, the number of customers, the timing and style of service. Network of queue contains more than one management server in the series or parallel. Random variable that represents the number of servers and services when appropriate. If it is available for customers in their size can also be a random variable. With a capacity of customers waiting in the queue is an important factor for consideration. The waiting room is large, one can assume that all benefits are endless. The priority ranks are important. If priority is set properly, the results will have higher improvement. However, a vessel can impact to the queue management.

In the future, this model will should consider the irrelevant factors such as: service time for waiting load container, or cumulative number of queues.

REFERENCES

1 "Port Authority of Thailand". [Online]. Available: http://www.port.ac.th/

2 Xu Jingjing, Liu Dong (2012), "*Queuing Models to Improve Port Terminal Handling Service*", Systems Engineering Procedia 4 (2012) 345 – 351.

3 Balachandran KR, "*Queue length dependent priority queues*", Management Science 1971;17(7):463-471.

4 Cobham A, "*Priority assignment in waiting line problems*" Operations Research 1954;2:70-76.

5 Chen, X., Zhou, X., List, G. F. (2011), "*Using time-varying tolls to optimize truck arrivals at ports*", Transportation Research Part E: Logistics and Transportation Review, 47: 965-982.

6 R.B. Cooper, "*Introduction to queueing theory*", North Holland, New York, 1981.

7 L. Takács, "*Priority queues*", Oper. Res. 12 (1) (1964) 63–74 .

8 R.G. Miller, "*Priority queues*", Ann. Math. Stat. 31 (1) (1960) 86–103.

9 Pisit Methatham, "*Queue system of AIS service center by simulation with Arena*", faculty of engineering, Kasetsart University (2006-2007).

10 Rockwell software, "*Arena user's guide*", Publication ARENA-UM001B-EN-P - October 2005, Supercedes Publication ARENA-UM001A-EN-P.

11 Jenny Nossack, Erwin Pesch 2013 "*A truck scheduling problem arising in intermodal container Transportation*"

12. Mohammed Mohammed El Genidy , 2011. "*Maximal Queue Size with Standard Normal Distribution for Arrival Times*". Asian Journal of Mathematics & Statistics, 4: 161-167

13 Reza Akhavian, Amir H. Behzadan (2014), "*Evaluation of queuing systems for knowledge-based simulation of construction processes*", Automation in Construction 47 (2014) 37–49.

14 Balachandran KR, "*Parametric priority rules: an approach to optimization in priority queues*". Operations Research 1970;18(3).:526-540.

15 Xiaoju Zhang, Qingcheng Zeng, Wenhao Chen (2013), "*Optimization Model For Truck Appointment In Container Terminals*" Procedia - Social and Behavioral Sciences 96 (2013) 1938 – 1947.

16 Chen, G., Govindan, K., Yang, Z.Z. (2013), "*Managing truck arrivals with time windows to alleviate gate congestion at container terminals*", International Journal of Production Economics, 141(1): 179-188.

APPENDIX

DATA USED IN CREATE MODAL

Flowchart Modules

Create Module

Description

This module is intended as the starting point for entities in a simulation model. Entities are created using a schedule or based on a time between arrivals. Entities then leave the module to begin processing through the system. The entity type is specified in this module.

Typical uses

- The start of a part's production in a manufacturing line
- Document's arrival (e.g., order, check, application) into a business process
- The customer's arrival at a service process (e.g., retail store, restaurant, information desk)

Prompts

- Name: Unique module identifier displayed on the module shape.
- Entity: Type Name of the entity type to be generated.
- Type: Type of arrival stream to be generated. Types include Random (uses an exponential distribution, user specifies mean), Schedule (uses an exponential distribution, mean determined from the specified Schedule module), Constant (user specifies constant value; e.g., 100), or Expression (drop-down list of various distributions).
- Value: Determines the mean of the exponential distribution (if Random is used) or the constant value (if Constant is used) for the time between arrivals. Applies only when Type is Random or Constant.
- Schedule: Name identifies the name of the schedule to be used. The schedule defines the arrival pattern for entities arriving to the system. Applies only when Type is Schedule.

- Expression: Any distribution or value specifying the time between arrivals. Applies only when Type is Expression.
- Units: Time units used for inter-arrival and first creation times. Does not apply when Type is Schedule.
- Entities per Arrival: Number of entities that will enter the system at a given time with each arrival.
- Max Arrivals: Maximum number of entities that this module will generate. When this value is reached, the creation of new entities by this module ceases.
- First Creation: Starting time for the first entity to arrive into the system. Does not apply when Type is Schedule.

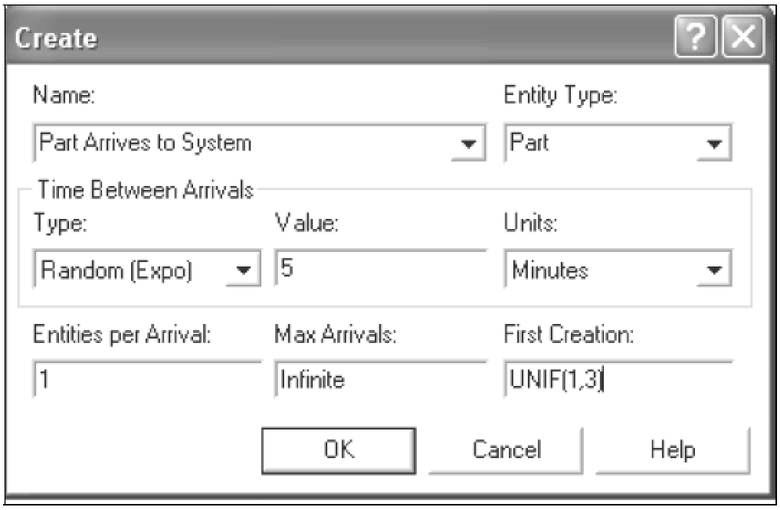


Figure 1 Creating a module with random exponential arrivals.

According to figure 1 shown module name is Part Arrives to System. The module create item name part come to this system by random (expo) time between first item and second item set uniform(1,3) per minutes.

Dispose Module

Description

This module is intended as the ending point for entities in a simulation model. Entity statistics may be recorded before the entity is disposed.

Typical uses

- Parts leaving the modeled facility
- The termination of a business process
- Customers departing the store

Prompts

- Name: Unique module identifier displayed on the module shape.
- Record Entity Statistics: Determines whether or not the incoming entity's statistics will be recorded. Statistics include value-added time, non-value-added time, wait time, transfer time, other time, total time, value-added cost, non-value added cost, wait cost, transfer cost, other cost, and total cost.

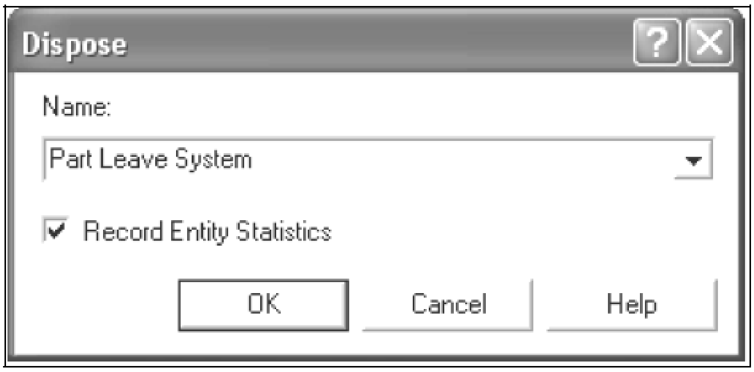


Figure 2 Dispose module.

Record Entity Statistics, which can be seen in figure 2 data corrected. This module can use the correct data to calculate for statistical, value added and waiting time.

Process module

Description

This module is intended as the main processing method in the simulation. Options for seizing and releasing resource constraints are available. Additionally, there is the option to use a "submodel" and specify hierarchical user-defined logic. The process time is allocated to the entity and may be considered to be value added, non-value added, transfer, wait, or other. The associated cost will be added to the appropriate category.

Typical uses

- Machining a part

- Reviewing a document for completeness
- Fulfilling orders
- Serving a customer

Prompts

- Name: Unique module identifier displayed on the module shape.
- Type: Method of specifying logic within the module. Standard processing signifies that all logic will be stored within the Process module and defined by a particular Action. Submodel indicates that the logic will be hierarchically defined in a "submodel" that can include any number of logic modules.
- Action: Type of processing that will occur within the module. Delay simply indicates that a process delay will be incurred with no resource constraints. Seize Delay indicates that a resource(s) will be allocated in this module and delay will occur, but that resource release will occur at a later time. Seize Delay Release indicates that a resource(s) will be allocated followed by a process delay and then the allocated resource(s) will be released. Delay Release indicates that a resource(s) has previously been allocated and that the entity will simply delay and release the specified resource(s). Applies only when Type is Standard.
- Priority: Priority value of the entity waiting at this module for the resource(s) specified if one or more entities are waiting for the same resource(s) anywhere in the model. Not visible when Action is Delay or Delay Release or when Type is sub-model.
- Resources Lists the resources or resource sets used for entity processing. Does not apply when Action is Delay, or when Type is sub-model.
- Delay: Type of distribution or method of specifying the delay parameters. Constant and Expression require single values, while Normal, Uniform, and Triangular require several parameters.
- Units: Time units for delay parameters.
- Allocation: Determines how the processing time and process costs will be allocated to the entity. The process may be considered to be Value Added, Non-Value Added, Transfer, Wait, or other and the associated cost will be added to the

appropriate category for the entity and process. Minimum Parameter field for specifying the minimum value for either a uniform or triangular distribution.

- Value: Parameter field for specifying the mean for a normal distribution, the value for a constant time delay, or the mode for a triangular distribution.
- Maximum Parameter field for specifying the maximum value for either a uniform or triangular distribution.
- Std Dev: Parameter field for specifying the standard deviation for a normal distribution.
- Expression: Parameter field for specifying an expression whose value is evaluated and used for the processing time delay.
- Report Statistics: Specifies whether or not statistics will be automatically collected and stored in the report database for this process.

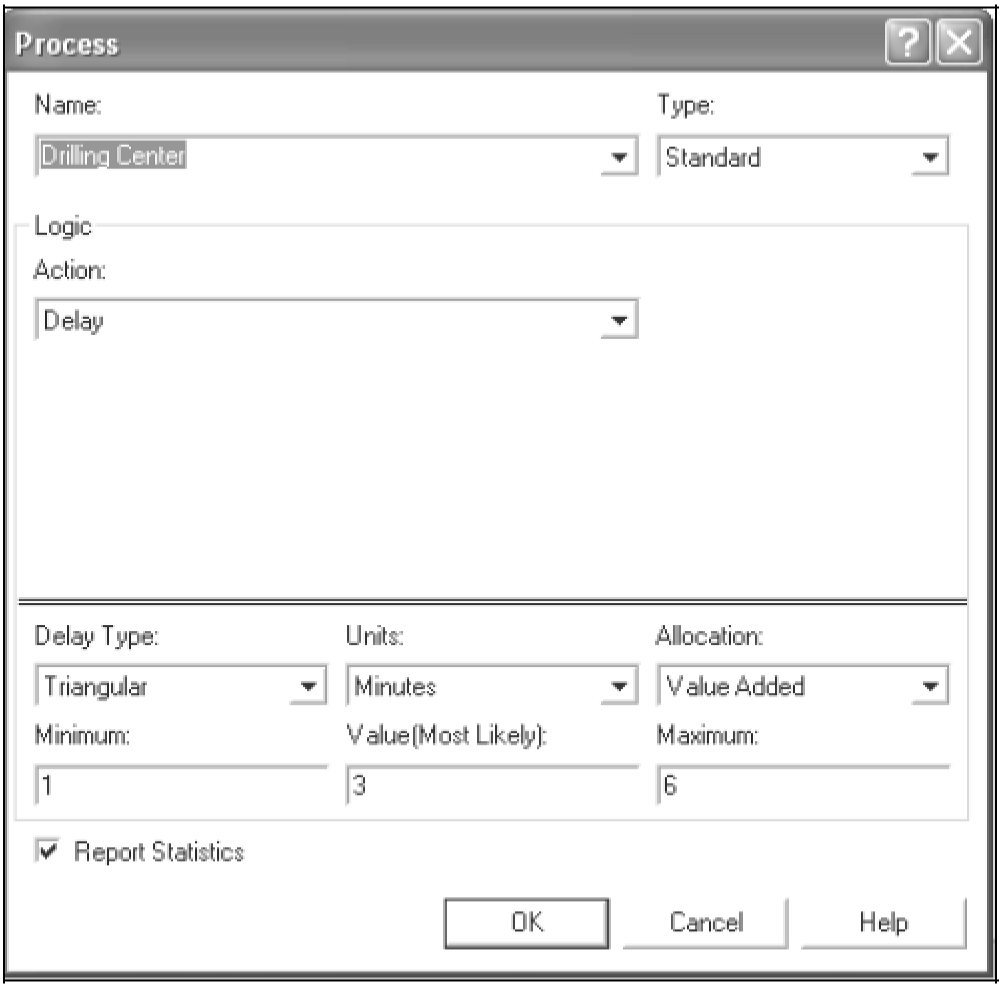


Figure 3 Dispose module.

According to figure. 3. Module name is Drilling Center. Module set action to Delay and no resource. So this process not have queue stack and distribution set to triangular.

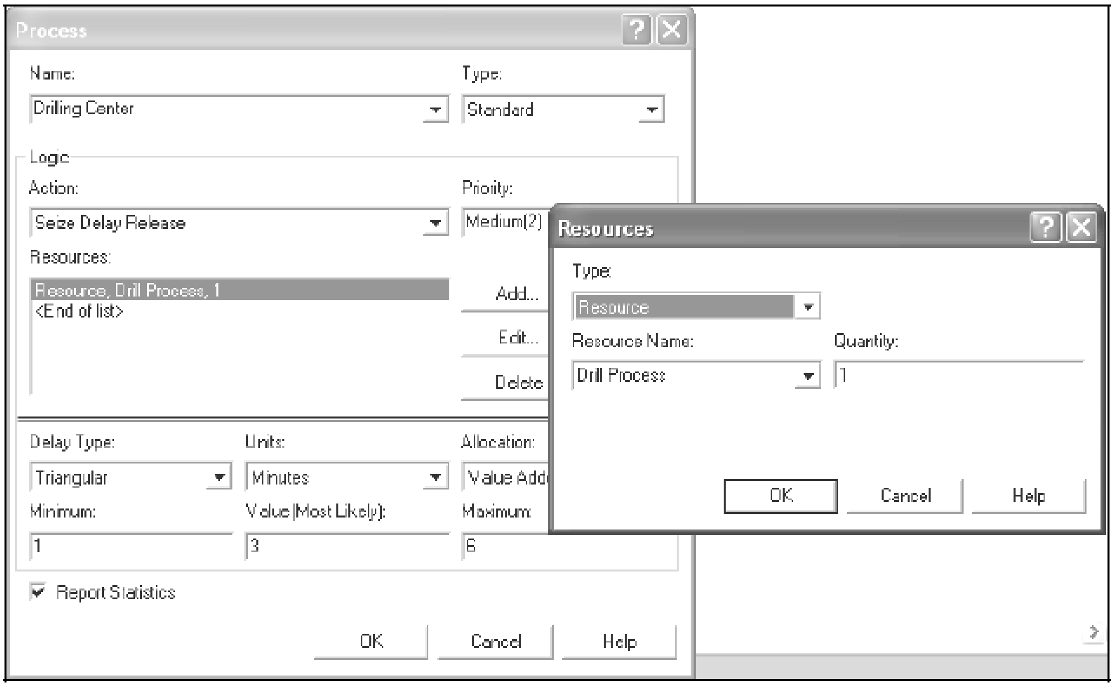


Figure 4 Process Module with Example for operation Seize Delay Release and set Resource Type.

According to figure 4 Module name is Drilling Center. Module set action to Seize Delay Release and use resource. The data distribution set to triangular between 1-6 minutes.

Assign Module

Description

This module is used for assigning new values to variables, entity attributes, entity types, entity pictures, or other system variables. Multiple assignments can be made with a single.

Typical uses

- Accumulate the number of subassemblies added to a part

- Change an entity's type to represent the customer copy of a multi-page form
- Establish a customer's priority

Prompts

- Name: Unique module identifier displayed on the module shape.
- Assignments: Specifies the one or more assignments that will be made when an entity executes the module.
- Type: Type of assignment to be made. Other can include system variables, such as resource capacity or simulation end time.
- Variable Name: Name of the variable that will be assigned a new value when an entity enters the module. Applies only when Type is Variable, Variable Array (1D), or Variable Array (2D).
- Row: Specifies the row index for a variable array.
- Column: Specifies the column index for a variable array.
- Attribute Name: Name of the entity attribute that will be assigned a new value when the entity enters the module. Applies only when Type is Attribute.
- Entity Type: New entity type that will be assigned to the entity when the entity enters the module. Applies only when Type is Entity Type.
- Entity Picture: New entity picture that will be assigned to the entity when the entity enters the module. Applies only when Type is Entity Picture.
- Other: Identifies the special system variable that will be assigned a new value when an entity enters the module. Applies only when Type is other.
- New Value: Assignment value of the attribute, variable, or other system variable. Does not apply when Type is Entity Type or Entity Picture.

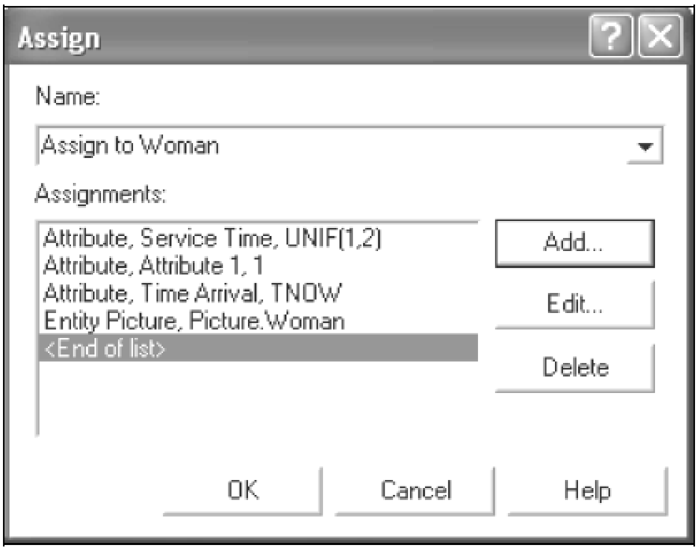


Figure 5 Assign module.

Record Module

Description

This module is used to collect statistics in the simulation model. Various types of observational statistics are available, including time between exits through the module, entity statistics (time, costing, etc.), general observations, and interval statistics (from some time stamp to the current simulation time). A count type of statistic is available as well. Tally and Counter sets can also be specified.

Typical uses

- Collect the number of jobs completed each hour
- Count how many orders have been late being fulfilled
- Record the time spent by priority customers in the main check-out line

Prompts

- Name: Unique module identifier displayed on the module shape.
- Type: Type of observational (tally) or count statistic to be generated. Count will increase or decrease the value of the named statistic by the specified value. Entity Statistics will generate general entity statistics, such as time and costing/duration information. Time Interval will calculate and record the difference between a specified attribute's value and current simulation time. Time Between will track and record the

time between entities entering the module. Expression will record the value of the specified expression.

- Attribute Name: Name of the attribute whose value will be used for the interval statistics. Applies only when Type is Interval.
- Value: Value that will be recorded to the observational statistic when Type is Expression or added to the counter when Type is Count.
- Tally Name: This field defines the symbol name of the tally into which the observation is to be recorded. Applies only when Type is Time Interval, Time Between, or Expression.
- Counter: This field defines the symbol name of the counter to Name increment/decrement. Applies only when Type is Counter.
- Record into : Set Check box to specify whether or not a tally or counter set will be used.
- Tally Set Name: Name of the tally set that will be used to record the observational-type statistic. Applies only when Type is Time Interval, Time Between, or Expression.
- Counter Set Name: Name of the counter set that will be used to record the count-type statistic. Applies only when Type is Count.
- Set Index: Index into the tally or counter set.

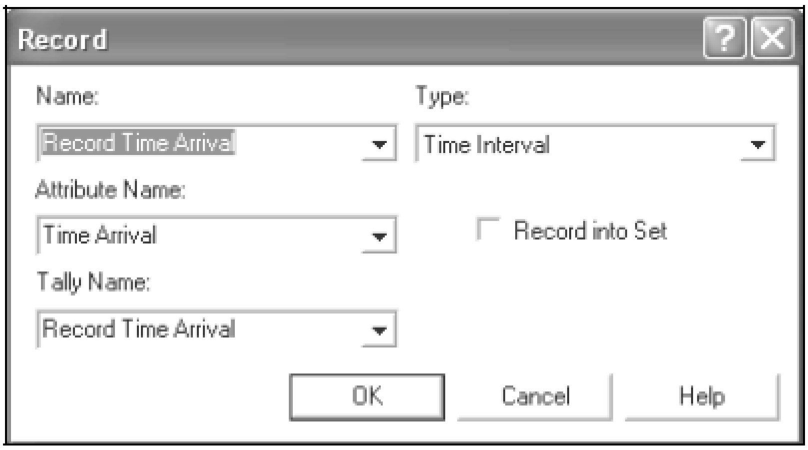


Figure 6 Record module.

According to figure 6 Record time arrival module. This module set to correct data. The data type is a time interval

Batch module

Description

This module is intended as the grouping mechanism within the simulation model. Batches can be permanently or temporarily grouped. Temporary batches must later be split using the Separate module.

Batches may be made with any specified number of entering entities or may be matched together based on an attribute. Entities arriving at the Batch module are placed in a queue until the required number of entities has accumulated. Once accumulated, a new representative entity is created.

Typical uses

- Collect a number of parts before starting processing
- Reassemble previously separated copies of a form
- Bring together a patient and his record before commencing an appointment

Prompts

- Name: Unique module identifier displayed on the module shape.
- Type: Method of batching entities together.
- Batch Size: Number of entities to be batched.
- Save Criterion: Method for assigning representative entity's user-defined attribute values.
- Rule: Determines how incoming entities will be batched. Any Entity will take the first "Batch Size" number of entities and put them together. By Attribute signifies that the values of the specified attribute must match for entities to be grouped. For example, if Attribute Name is Color, all entities must have the same Color value to be grouped; otherwise, they will wait at the module for additional incoming entities.
- Attribute Name: Name of the attribute whose value must match the value of the other incoming entities in order for a group to be made. Applies only when Rule is By Attribute.
- Representative Entity: The entity type for the representative entity.

Separate module

Description

This module can be used to either copy an incoming entity into multiple entities or to split a previously batched entity. Rules for allocating costs and times to the duplicate are also specified. Rules for attribute assignment to member entities are specified as well.

When splitting existing batches, the temporary representative entity that was formed is disposed and the original entities that formed the group are recovered. The entities proceed sequentially from the module in the same order in which they originally were added to the batch.

When duplicating entities, the specified number of copies is made and sent from the module. The original incoming entity also leaves the module.

Typical uses

- Send individual entities to represent boxes removed from a container
- Send an order both to fulfillment and billing for parallel processing
- Separate a previously batched set of documents

Prompts

- Name: Unique module identifier displayed on the module shape.
- Type: Method of separating the incoming entity. Duplicate Original will simply take the original entity and make some number of identical duplicates. Split Existing Batch requires that the incoming entity be a temporarily batched entity using the Batch module. The original entities from the batch will be split.
- Percent Cost to Duplicates: Allocation of costs and times of the incoming entity to the outgoing duplicates. This value is specified as a percentage of the original entity's costs and times (between 0-100). The percentage specified will be split evenly between the duplicates, while the original entity will retain any remaining cost/time percentage. Visible only when Type is Duplicate Original.
- # of Duplicates: Number of outgoing entities that will leave the module, in addition to the original incoming entity. Applies only when Type is Duplicate Original.
- Member Attributes: Method of determining how to assign the representative entity attribute values to the original entities. These options relate to six

of the special purpose attributes (Entity Type, Entity Picture, Entity Sequence, Entity Station, Entity Job step, and Entity Hold Cost Rate) and all user defined attributes. Applies only when Type is Split Existing Batch.

- Attribute Name: Name of representative entity attribute(s) that are assigned to original entities of the group. Applies only when Member Attributes is Take Specific Representative Values.

Create the vehicle arrives.

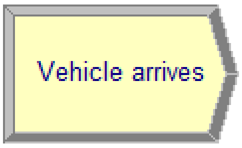


Figure 7 Vehicle arrives module.

From historical data. Styles of truck come in to port set by schedule. If we need to define the characteristics of data into a model based on time as well.

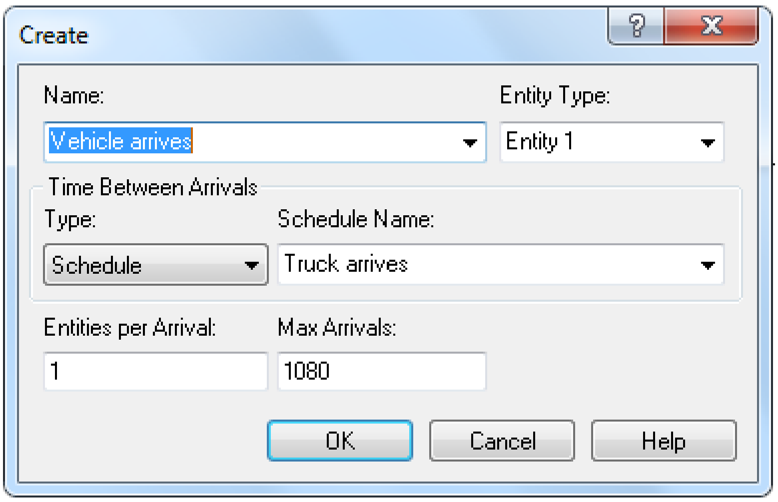


Figure 8 Creation of Vehicle arrives.

Consideration by work order document.

A survey of visitors to the car in the ports. Most of the truck that run regularly. Cause errors in dropping a few documents. But not yet and also articulated contract which did not run into a routine. Make some truck driver lost documents or documents into the dock. Thus wasting a lot the simulation model, we need to be made as well. According to the survey, the document has dropped about 5%.

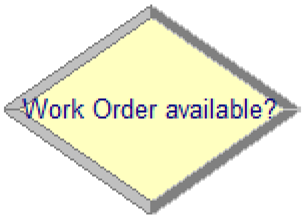


Figure 9 Decide Work Oder available module.

We will use functional decide with the most information.

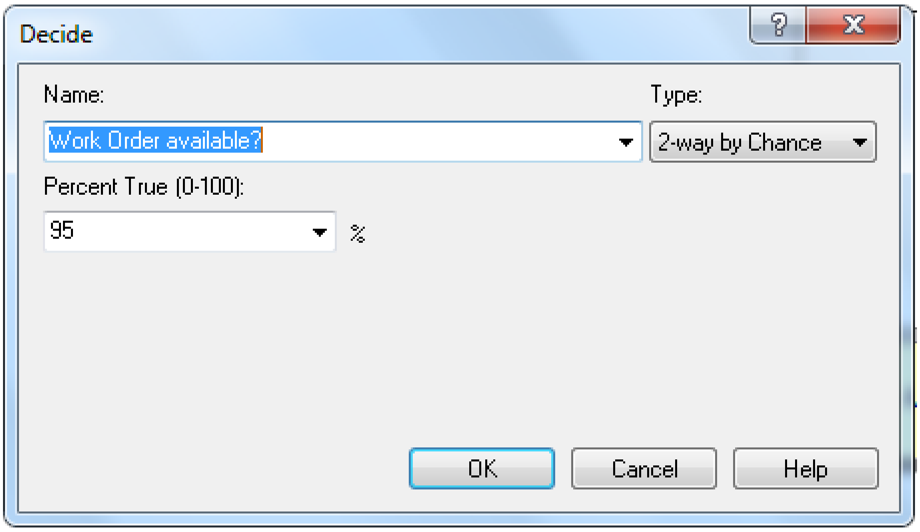


Figure 10 Decide Work Oder available.

Process in Terminal gates

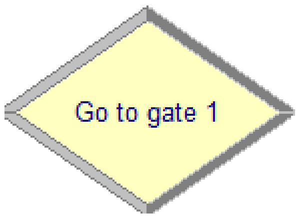


Figure 11 Vehicle decide go to gate module.

This procedure is the truck decided to go into the terminal gates at the terminal gates, in which it has 4 channels, the channels together into a truck that can be used in any way.

In modeling program we have used the function decide in this section, we will have to set it to truck through. Each channel of the same amount.

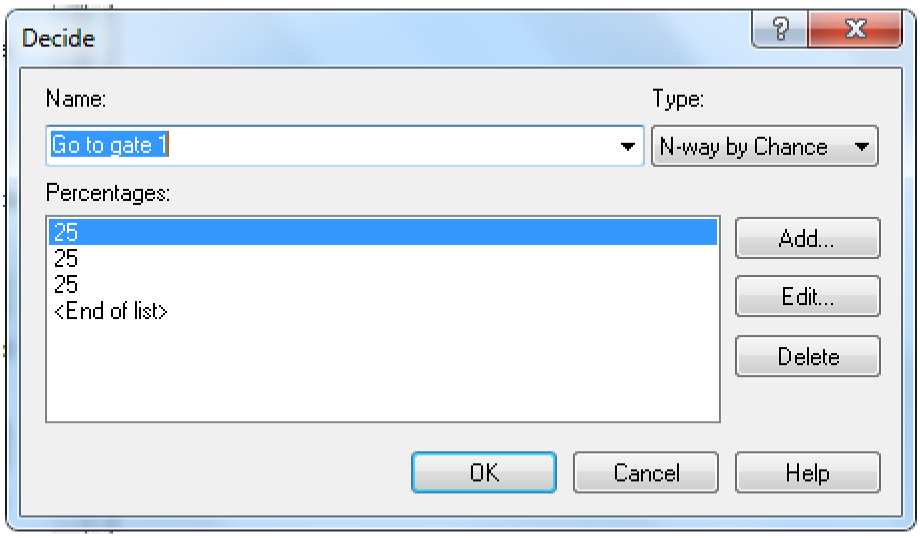


Figure 12 decide of Vehicle.

After that, we will set the process to work on terminal gates

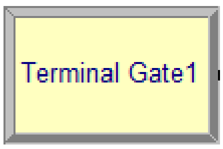


Figure 13 Terminal Gate module.

We are set on a terminal gate1 into 4 module, because we have 4 lanes in terminal gates.

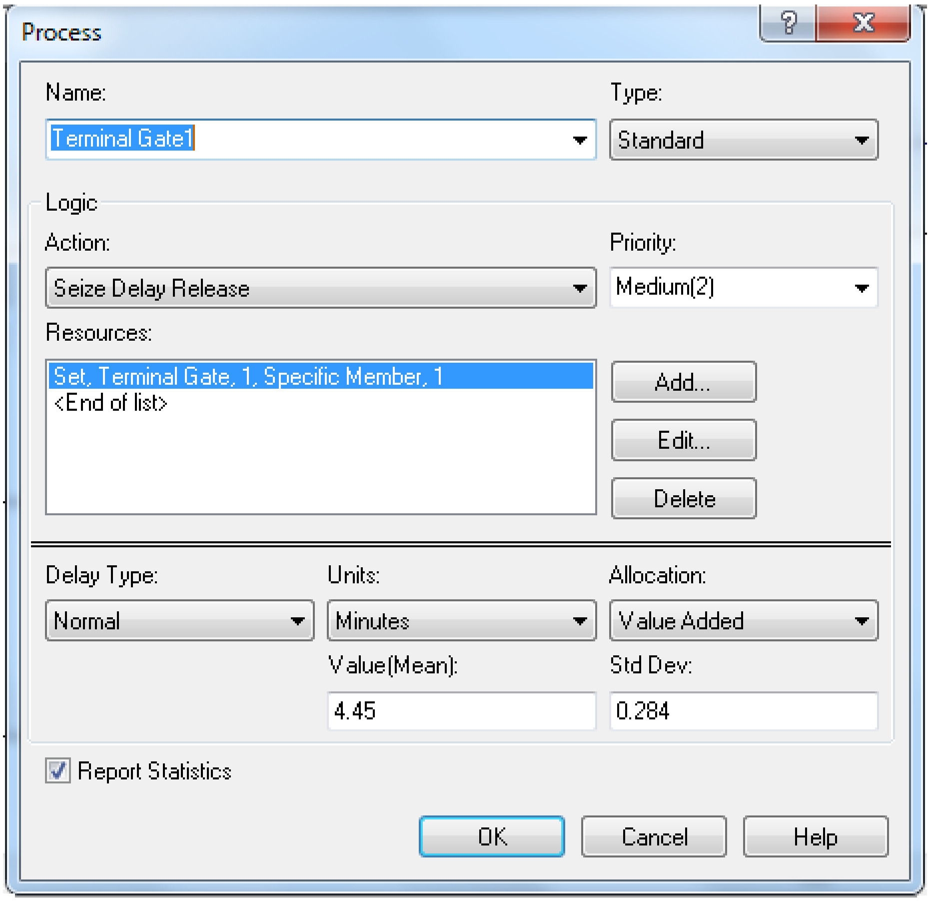


Figure 14 Process of Terminal Gate.

The data input is set to normal distribution. We tested prior to creating this module provided that we have to meet our data set. For precision processing modeling program.

Process in Terminal yards

In the process, we have set up in a manner similar to the terminal gates in terminal yards, but there were only 3 channels.

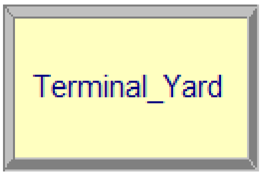


Figure 15 Terminal Yard module.

Data in the terminal yards are distribution normal. After that we set process depend on below picture.

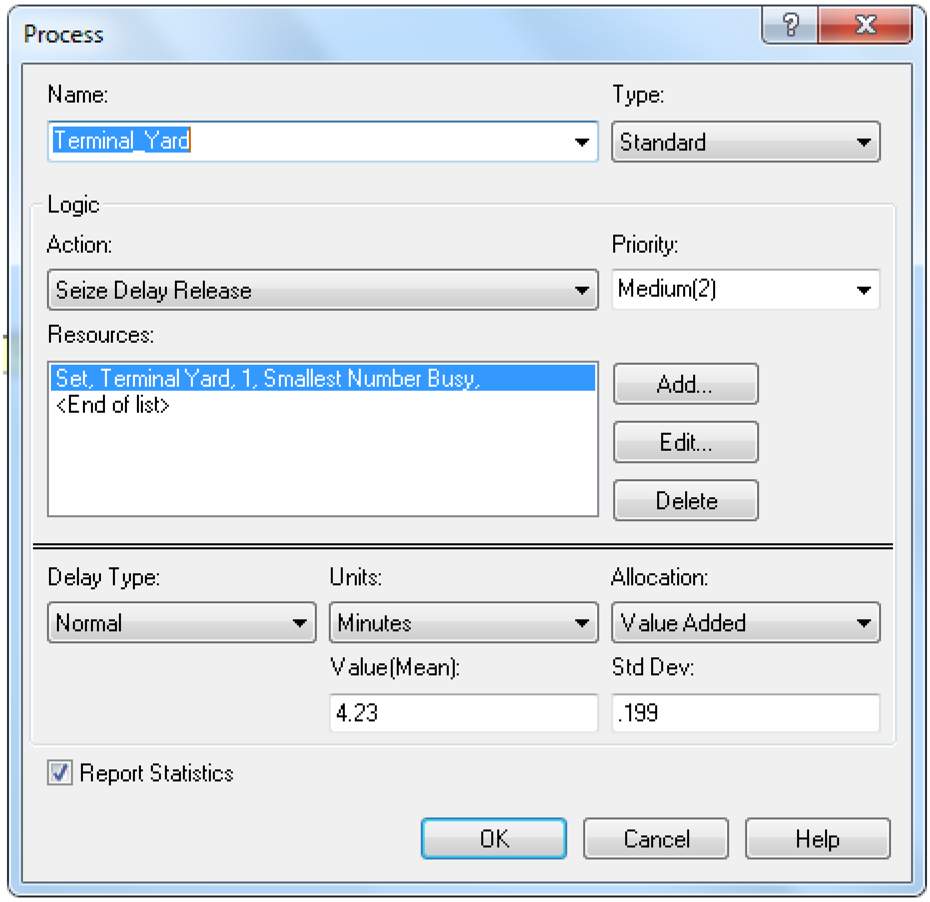


Figure 16 Process of Terminal Yard.

Dispose

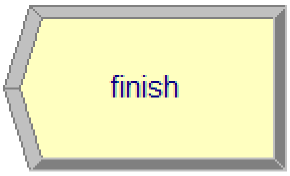


Figure 17 Dispose module.

Arena simulation model must be determined at this point, or it will not be processed.

Simulation with Arena for the Queuing booking.

Due to the structure of the arena for the replication of the data types are similar. For processing methods Queuing booking will have to step up a bit more. Based on New Work Flow this section shows how and principles used in the arena.

Schedule a reservation

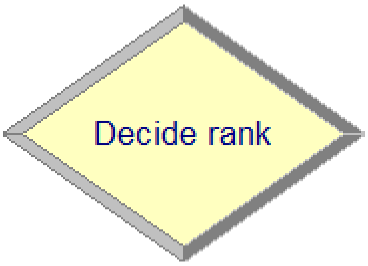


Figure 18 Dispose rank module.

For reservation, we use a set of. Value of Listed Company we are divided into two groups, we will take rank A rank b together because we have a sample of rank b just a single company. And the other one is the rank C.

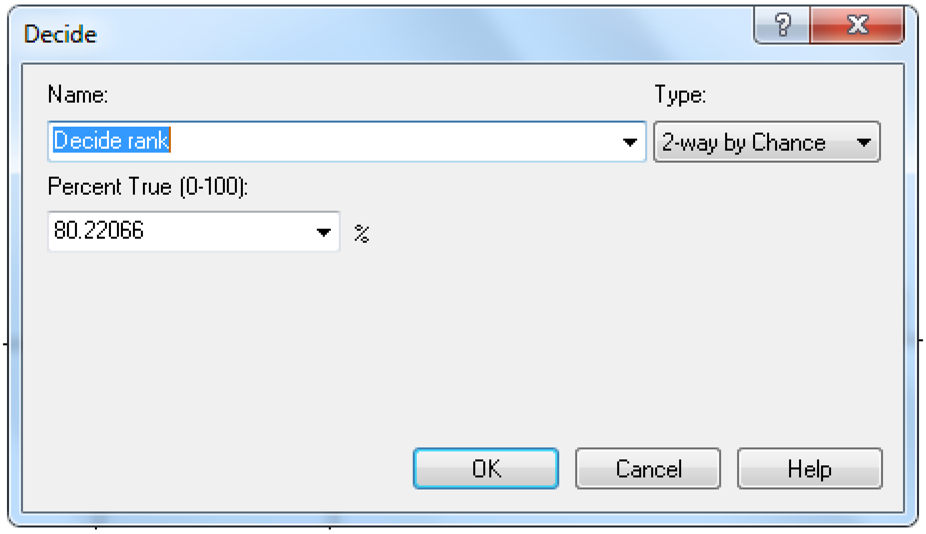


Figure 19 Dispose rank.

Priority booking module

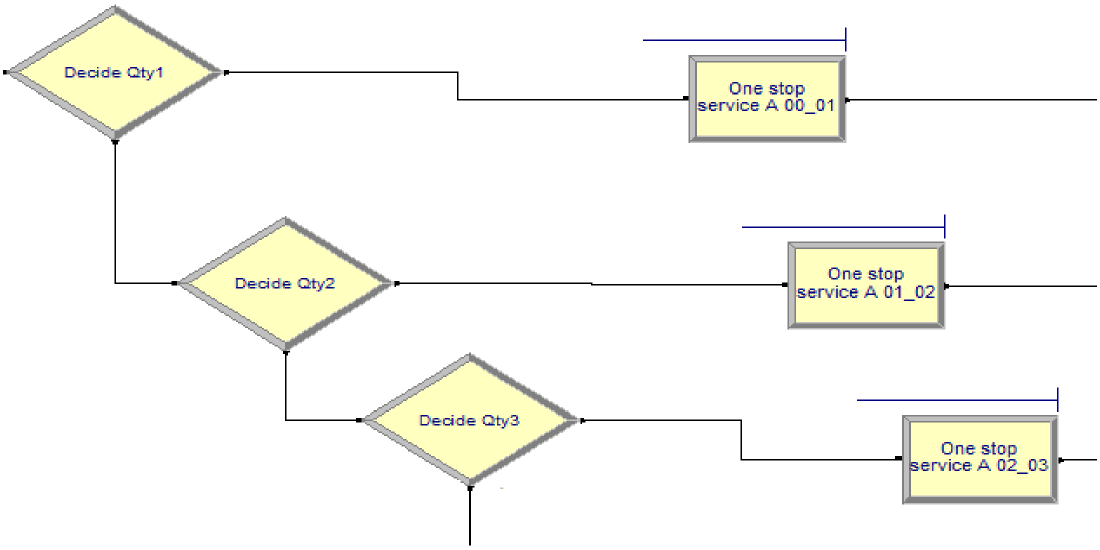


Figure 20 Priority booking module.

According to the hypothesis, we have to configure the service to a maximum of 45 cars per hour. According to this assumption, we need to be made in the loop indefinitely by the number script is not run the car into and beyond the capacity limit. The image below is an image we define the style set by the module This will be the subject of a one stop service Open work in the picture below will set the priority of rank a.

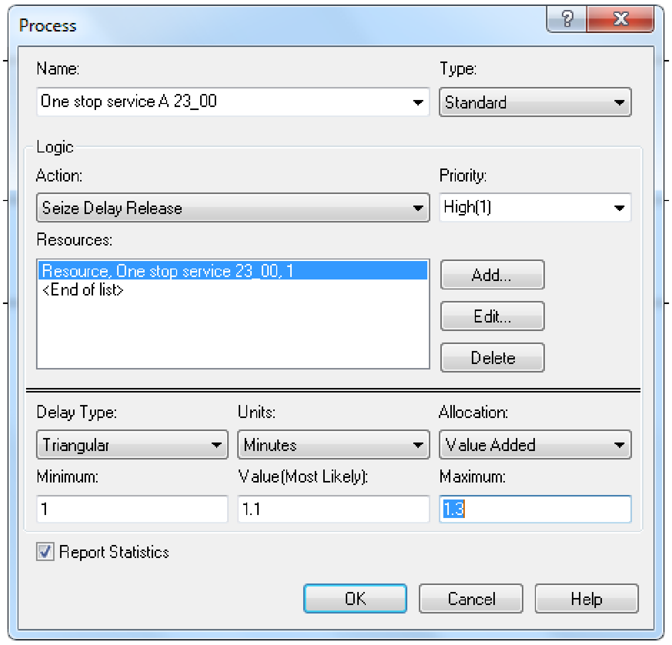


Figure 21 Processing of One stop service A.

The image below is an image we define the rank c and the time required for a one stop service in the manner we define the importance of a more rank a rank b.

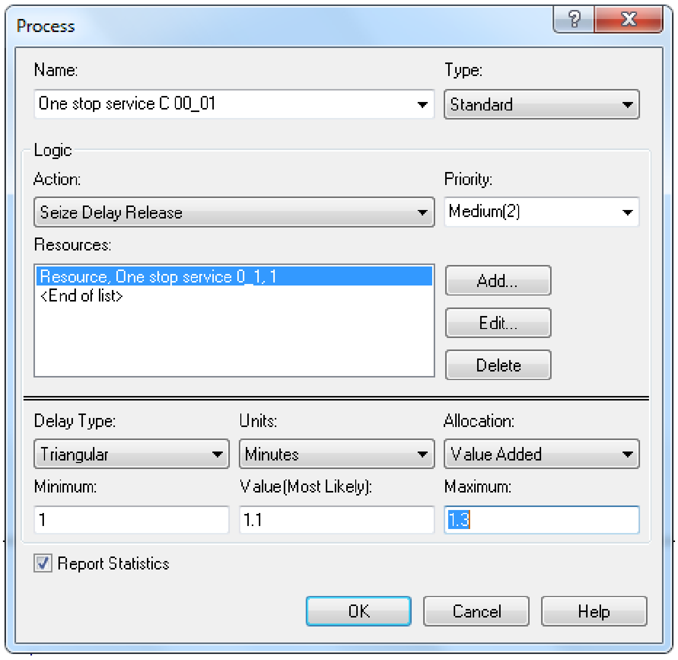


Figure 22 Processing of One stop service C.

Running time of one stop service possible in a triangular pattern, which is the setting of choice for most data.

QUEUE MANAGEMENT FOR PORT AUTHORITY OF THAILAND USING PRIORITY QUEUING AND BOOKING TECHNIQUE

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IT Management Program, Faculty of Engineering, Mahidol University

Management and Innovation Technology International Conference (MITiCON2014)
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QUEUE MANAGEMENT FOR PORT AUTHORITY OF THAILAND USING PRIORITY QUEUING AND BOOKING TECHNIQUE

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ABSTRACT

Abstract— The aim of this work is to manage vehicle queue in Port Authority of Thailand by using priority queuing and booking technique which is facing heavy vehicle congestion problem in the terminal now. The traffic data shows this problem based on normal queue technique. The proposed priority queuing and booking technique can improve port management to reduce number waiting vehicle and the traffic in the terminal. There are three dependent factors for the proposed technique which are terminals capacity, service time, and priority queue. The result shows that combining of priority queuing and booking superior to normal queue and average vehicles per hour increase.

Keywords-component; Priority queuing, Queue, Booking, Port management

1. INTRODUCTION

Port Authority of Thailand (PAT) is state enterprise. PAT has 5 ports which locate on Bangkok, Leam Chabang, Ronong, Chieng sean and Chieng Khon. Leam Chabang port is deep sea port while the others are river port [1]. The scope of this work is based on the Bangkok port.

The Bangkok port is the oldest one among of these ports. Every day a lot of vehicles come to the Bangkok port such as trucks, cars, etc., causing the port congestion problem. The trucks which park in front of the terminals make the trucks operator waste energy, money and time [1].

Vehicles inside the port have traffic problem which can model as is queue stacking problem. The pattern of the queue stacking forms as FIFO (First in First out) pattern.

There are a lot of research interested in queue problem. The researcher have been study about queue. Queuing algorithm base on mathematical theory. The basic queuing system can be extended into a queuing system of variety of queuing methods. A lot of researches applied queue system able to solve. Queuing Models to Improve Port Terminal Handling Service [2]. The priority have been used in to the model. Queue length dependent priority queues [3]. Priority assignment in waiting line problems [4]. They study in queue theory. Queue has strong impact to manage about service.

The aim of this work is to study about priority queuing and booking. This work uses the historical data to implement and evaluate the proposed technique. Section 2, Queue theory approaches about queue system. The queue concept defined as specific attribute of the entities. Section 3 describes the problem and proposes of PAT. The model algorithm based on priority queue and booking. The simulation result are conduct in section 4. Conclusions are provided in section 5

2. THEORIES RELATED

2.1. Queuing theory

Queuing theory is the study of the mathematical theory and the methods of queuing systems. It is an important branch of operations research [5]. Basic queuing process of the queuing problem can be expressed in Fig. 1.

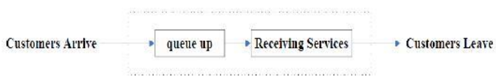

Fig. 1. Queuing System

The basic queuing system can be extended into a queuing system of variety of queuing methods e.g. single-team single desk system, multi-server single-team system, multi-server multi-team system, and multi-server tandem systems. Queuing system generally has three components: input process, queuing rules, and services.

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Pattaya, Thailand, December 17-19, 2014

Queues are characterized by a number of properties that represent the interrelationships between the entities involved in a queuing system. The arrival process, service duration, and queue discipline are among the most important properties of a queue [6]. In addition to these basic properties, the numbers of servers, capacity of the queue, and the population of entities to be served are some of the other properties of a queuing system. However, since information related to these latter properties are often provided as part of the project specifications (e.g. site layout and temporary route arrangement may dictate the number of dump trucks that can form a queue close to the loading area at any given time) or equipment manufacturers' catalogues (e.g. bucket capacity of an excavator can be used to determine how many dump trucks can be served within a certain time period), further onsite data collection and analysis regarding these properties do not contribute much to simulation model input data generation and thus are not the main focus of this study.

2.2. The queue discipline concept

Queue discipline is defined as a rule or set of rules based on a specific attribute of the entities. It determines the pattern (i.e. order) by which entities in the queue receive service. The choice of the queue discipline and the rules to be applied can significantly affect the number of entities waiting in a queue, the average waiting time, and the efficiency of the service facility [7]. The most common queue discipline is FIFO in which clients in line are served based on their chronological order of arrival. Although FIFO has been long used as a default queue discipline in modeling queuing systems [8], in many scenarios, it is equally likely that clients be served according to other service patterns.
For instance, the last-in-first-out or LIFO discipline may be the case in situations where a heap or stack of clients (e.g. raw materials, prefabricated concrete segments, and steel sections) is waiting to be processed by a server. Other than FIFO and LIFO, the serving pattern of a queuing system can be characterized according to an intrinsic attribute of the entities in the system. This type of queue discipline is called priority queues or PRI queue discipline. In the example of a queue of dump trucks waiting to be loaded by an excavator, priority might be given to those dump trucks with less fuel left. Sometimes, there may be no rule according to which clients receive service from the server, in which case the queue discipline is considered as service-in-random-order or SIRO. Fig. 2 illustrates the concepts of FIFO, LIFO, and PRI queue disciplines. In this figure, clients are specified by letter C and the server is specified by letter S. Each of the three queues shows the client that should be drawn from the queue under the specified queue discipline.

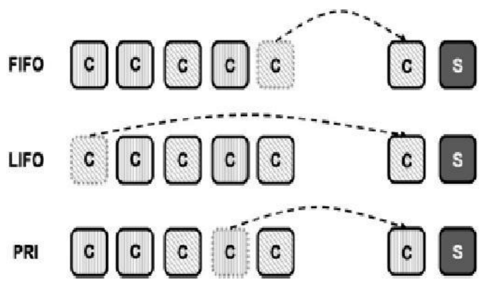

Fig. 2. Demonstration of FIFO, LIFO, and PRI queue disciplines.

3. METHODOLOGY

3.1. Existing Information

The historical data of the Bangkok port is used in our study with permission. There are two terminal for PAT, i.e., terminal 1 and terminal 2. The terminal 1 is used for our study. Terminal 1 consists of terminal gates and terminal yards as shown in Fig. 3.

The terminal gates and terminal yards have work flow as described following. When a vehicle comes to terminal gates with work order (W/O) and then goes to gate, the port officer and the custom officers check the document. After that the vehicle goes to terminal yards for load container. The work flow in the terminal is shown in Fig.4.

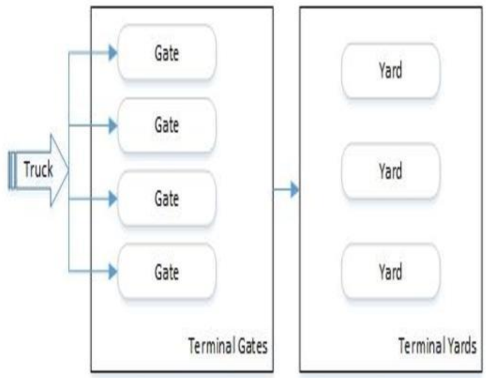

Fig. 3. Queuing network in Terminal 1 of PAT.

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Pattaya, Thailand, December 17-19, 2014

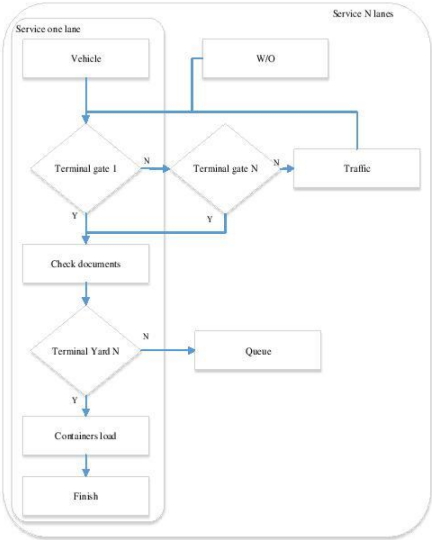

Fig. 4. Work flow in terminal

3.2. Maximun capacities

Table 1. Actual service time.

Gate 1	Gate 2	Gate 3	Gate 4	yard	yard	yard
4.2	4.4	4.2	4	4.1	4.1	4.1
4.5	4.9	4.4	4.8	4.4	4.4	4.3
4.6	4.9	4.5	4	4.5	4.5	4.4
4.1	4.7	4.3	4.5	4.3	4.6	4.3
4.5	4.4	4.6	4.5	4.6	4.1	4.1
4.6	4.6	4.7	4.4	4.2	4	4.2
4.8	4.4	4.4	4.6	4.4	3.8	3.9
4.8	4.3	4.6	4.3	4.4	3.9	4
4.6	4.5	4.6	4.4	4.5	4	4
4.1	4.4	4.1	4.5	4.1	4.6	4.2
3.9	4.5	3.9	4.4	3.9	4.2	4.1
3.9	4.3	3.9	4.6	4	4.3	4.3
4.8	4.5	4.8	4.8	4.1	4.4	4.4
4.9	4.9	4.9	4.9	4.2	4.4	4.2
4.3	4.4	4.7	4	4.2	4.2	4.2
4.1	4.5	4.5	4.5	4.5	4.1	4.1
4	4.8	4	4.4	4.4	4	4.4
	4.45				4.23	

From the record, the port capacity is actually. The model just finds max capacity per hour. According to the terminal gates information from Table 1, we can see that the average of processing time from start to finish is 4.45 minutes per vehicle. Therefore, the maximum capacity of gate is $\frac{60}{4.45}$ =13.483 ≈ 14 vehicles/hr. The terminal gates have 4 gates for the Bangkok port. So the maximum capacity of the terminal gates is 14 x 4 = 56 vehicles / hr.

As same as the maximum capacity of terminal gates, the maximum capacity of the terminal yards can be determine as follows. According to the terminal yards information from Table 1, the average of processing time from start to finish is 4.23 minutes per vehicle. Thus, the maximum capacity of truck per gate per hour is $\frac{60}{4.23}$ =14.184 ≈ 15 Vehicles/hr. Terminal yards has 3 zones. Therefore the maximum capacity of the terminal yards 15 x 3 = 45 vehicles / hr. Because the both parts, the terminal gates and the terminal yards, are connected in cascade manner, so the maximum throughput capacity is limited by the minimum of both terminal which can be shown as (1).

$$C_T = \text{Min}\left(\frac{60}{T_G} \times N_G, \frac{60}{T_Y} \times N_Y\right) \quad (1)$$

where:

C_T Capacity of terminal to give service per hour
T_G Service time of terminal gate
N_G Number of terminal gate lane service
T_Y Service time of terminal yard
N_Y Number of terminal yard lane service

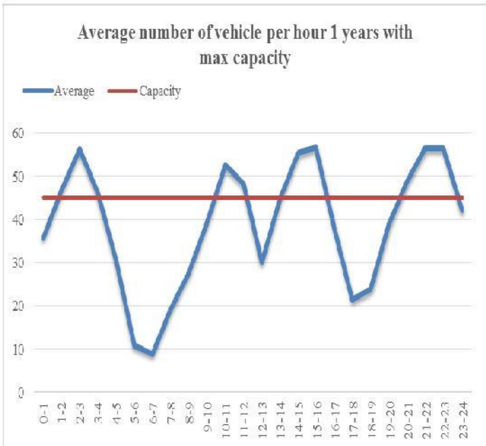

Fig. 5. Average number of vehicle to take a service time in terminals Maximum capacity set on historical

Management and Innovation Technology International Conference (MITiCON2014)
Pattaya, Thailand, December 17-19, 2014

The capacity is setting on period. So find capacity in one day. The mean the capacity period + the capacity per period. So the equation is

$$C_D = \sum_{i=1}^{P} X_i \tag{2}$$

where:

C_D Capacity number of terminal to give service one day

P Period time per day

3.3. Classified priorities queue and booking

There are a lot of customers doing business with Bangkok port. In this work, only the large capital companies are focused. These companies are very important customers (VIC). Fig.6. depicts the sample of these companies.

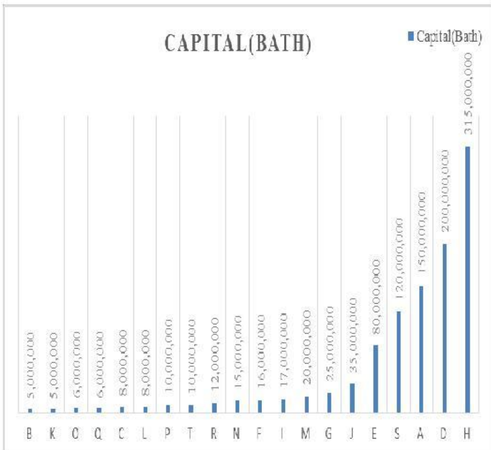

Fig. 6. Sample companies contact with Bangkok port

From Fig. 6, we can see that the larger capital company gives the higher benefit to the Bangkok port. Therefore, the priority for high contact is importance too. In the work, priority of the queue is set depending on the position of the company on of capitalization rank. Rank is performed as follows.

Rank A:	Capital >100,000,000 Baht
Rank B:	$50{,}000{,}000 \le$ Capital $\le 100{,}000{,}000$
Rank C:	$5{,}000{,}000 \le$ Capital $\le 50{,}000{,}000$

For the sample company in Fig. 6, we can classify these companies into ranking system as below

Rank A: S, A, D, H (4 companies)

Rank B: E (1 company)

Rank C : B,K,O,Q,C,L,P,T,R,N,F,I,M,G,J (15 companies)

After that we can set number of vehicles in each rake per hour by using weighting technique. That is

Rank A: $\frac{45}{20} \times 4 = 9$ vehicles per hour,

Rank B: $\frac{45}{20} \times 1 = 2.25 \approx 2$ vehicles per hour,

Rank C: $\frac{45}{20} \times 15 = 33.75 \approx 34$ vehicles per hour

$$\text{Rank } n_i = \frac{C_T}{N_R} \times n_{Rank\,n_i} \tag{3}$$

where:

Rank n_i: Rank calculate performed

C_T : Capacity number of terminal to give service per hour

N_R: Number of all companies are dealing in Bangkok port

$n_{Rank\,n_i}$: Number of all companies in Rank n_i

To simplify the system model, duration of time slot is set to 1 hour. In each time slot, the total number of vehicles should less than or equal to the capacity of the terminal. That is

$$C_T \ge \left(\frac{C_T}{N_R} \times n_{RankA}\right) + \left(\frac{C_T}{N_R} \times n_{RankB}\right) + \left(\frac{C_T}{N_R} \times n_{RankC}\right) + \ldots + \left(\frac{C_T}{N_R} \times n_{Rank\,n_i}\right). \tag{4}$$

The priority is set according to booking data before the truck come to the port. The operator just comes to select which period they should come. From Fig. 6, we can see that the peaking time slots are 02:00 – 03:00, 10:00 – 12:00, 13:00 – 16:00, and 20:00 - 23:00 depending on the office hour of each company. Using the proposed technique, the customers can book in any available time slot. When a time slot is full, the customers have to book the other time slot. In our system customers in any rank can book only 90% of time slot capacity. When this 90% is full, rank B and C cannot book in the remaining 10 %. This 10% of each time slot privileges for rank A. That means rank A can booking 100%. This priority queuing and booking is dependent definition of rank. On peaking time slots, the privileges for VIC are increased to 20%. (The privileges is calculate ratio of Rank companies based on percentile). In this case rank B set to rank A because rank B has only one company.

3.4. Using the priority queuing and booking to manage the queue

Fig. 7 shows new work flow of priority queuing and booking technique. Before a truck comes to the port, the operator must book a time slot for the truck. The officer will check slot for truck. If a preferred time slot is available, the officer will book that time slot into the time table. Then the truck can come to the port depending on the booked time slot. If the slot is full, the officer will check rank of the company. If company is in rank A and 10% reserved for rank A is not full yet, the officer will book on the time table. After that the truck can come to port. The waiting time is dependent on rank definition.

Management and Innovation Technology International Conference (MITiCON2014)
Pattaya, Thailand, December 17-19, 2014

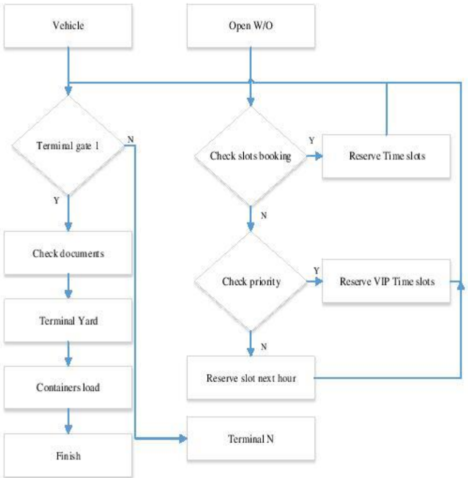

Fig. 7. New work flow

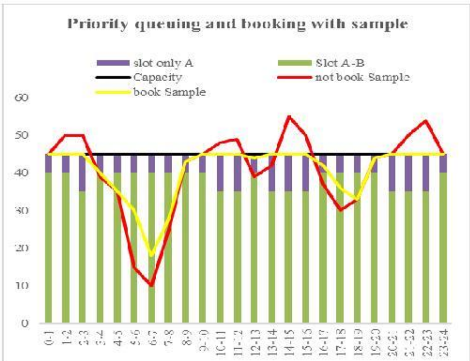

Fig. 8. Priority queuing and booking with sample

4. SIMULATION RESULTS

The number of vehicle come to the port is set by using the collective data from Bangkok port. Then the proposed booking method is applied. This initial value is use for simulation. Then compare the result of proposed model and actual value. The service time is fixed 4.45 minutes, for all terminal gates and 4.23 minutes for all terminal yards. The vehicles which come in port have to book before come to load container. The capacity of each period cannot over the capacity of terminal.

From the Fig. 8, the experimental result show priority queuing and booking are better trend than normal queue. Not have a peak time. The data is distribution. The data spread wild. The combine of priority queuing and booking techniques can reduce the number of vehicle per hour to not over the capacity of the terminal. So the traffic inside the terminal can be improved. We can see that the customers in rank A and B will have less waiting times while the customers in rank C have book in next time slot if the preference period is peak period. However this problem is not big problem for them. They will manage their truck come to port in booking period. The accident is irrelevant factor. Overall of priority queuing and booking is better than normal queue.

5. CONCLUSION

The proposed priority queuing and booking technique can improve the queue management for PAT and customers. Work flows are importance for calculating the maximum capacity. The capacity can adjust other model. The data is distribution. The truck for each time slot should not over the maximum capacity. The priority ranks are importance. If priority is set properly, the results will have higher improvement. However a vessel can impact to the queue management. In the future this model will should consider this factor and other irrelevant factors such as service time to wait load container, or cumulative number of queues.

6. REFERENCES

[1] Port Authority of Thailand <http://www.port.ac.th/> (accessed 27/08/14)

[2] Xu Jingjing, Liu Dong (2012). Queuing Models to Improve Port Terminal Handling Service. Systems Engineering Procedia 4 (2012) 345 – 351

[3] Balachandran KR. Queue length dependent priority queues. Management Science 1971;17(7):463-471.

[4] Cobham A. Priority assignment in waiting line problems. Operations Research 1954;2:70-76.

[5] Chen, X., Zhou, X., List, G. F. (2011). Using time-varying tolls to optimize truck arrivals at ports. Transportation Research Part E: Logistics and Transportation Review, 47: 965-982.

[6] R.B. Cooper, Introduction to queueing theory, North Holland, New York, 1981.

[7] L. Takács, Priority queues, Oper. Res. 12 (1) (1964) 63–74.

[8] R.G. Miller, Priority queues, Ann. Math. Stat. 31 (1) (1960) 86–103.

[9] Xiaoju Zhang, Qingcheng Zeng, Wenhao Chen (2013). Optimization Model For Truck Appointment In Container Terminals. Procedia - Social and Behavioral Sciences 96 (2013) 1938 – 1947.

[10] Chen, G., Govindan, K., Yang, Z.Z. (2013). Managing truck arrivals with time windows to alleviate gate congestion at container terminals, International Journal of Production Economics, 141(1): 179-188.

[11] Reza Akhavian, Amir H. Behzadan (2014) Evaluation of queuing systems for knowledge-based simulation of construction processes, Automation in Construction 47 (2014) 37–49.

[12] Balachandran KR. Parametric priority rules: an approach to optimization in priority queues. Operations Research 1970;18(3).:526-540.

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