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Improving the performance of warehouse loading and unloading system using simulation

Setareh Abedinzadeh[1*], Hamid Reza Erfanian[2], AmirhosseinMostofi[1], ParisaTavafi[1]

[1] *Department of Industrial Engineering, University of Science and Culture, Tehran, Iran*
[2] *Department of Mathematics, University of Science and Culture, Tehran, Iran*

Abstract: *In a warehouse, all the processes in the loading and unloading systems are run simultaneously. Due to the voluminous transportation of cargoes in different industries, simulation of a warehouse of an automotive company in Tehran, Iran is performed in this paper. The main goal of this study is to define strategies to decrease average waiting time of personnel. First, conceptual model is provided. Then, model is simulated in ARENA 13.5 simulation software and results are analyzed. Simulation results demonstrate bottle-necks in miscellaneous parts of the warehouse which lead to long waiting time for personnel. Finally, some strategies are introduced to reduce the average waiting time and ameliorate the performance of warehouse loading and unloading system.*

Keywords*:* *Warehouse, Loading, Unloading, ARENA simulation software.*

I. Introduction

Warehouse is an important distribution center. Receiving and delivering are the interface of a warehouse for incoming
and outgoing material flow. Incoming shipments are brought to the warehouse, unloaded at the receiving docks, and put into storage. Orders are picked from storage, prepared, and shipped to customers through docks by using van, lorry, truck and ship. The examples of receiving and delivering operations are the assignment of trucks to docks and the scheduling of loading and unloading activities [3]. In a warehouse, all the processes in the loading and unloading systems are run simultaneously [5]. Due to the voluminous transportation of cargoes in warehouses of different industries, long waiting time of personnel is predictable. One of the most concern in any warehouse is the deduction of waiting time of personnel. To overcome this issue, approaches such as simulation have been applied. The results of analyzing this kind of issues can be used to improve the performance of warehouse loading and unloading systems. There have been fruitful efforts in developing simulation models to ameliorate the performance of warehouse loading and unloading system. According to Van den Berg, topics such as planning and controlling in warehouse management have been studied by researchers in both the arts and the sciences. Nevertheless, a good basic theory for design methodology of warehouse is still lacking [9]. In order to provide a characterization of the warehouse, three different angles from which a warehouse may be viewed have to be considered: processes, resources, and organization [7]. Products arriving at a warehouse will go through a number of steps called processes. Resources refer to all tools, equipment and personnel needed to operate a warehouse. Finally, organization includes all aspects of planning and the control procedures used to run the warehouse system. A product is defined as a type of goods, for example shampoo of a certain brand in the study. An individual bottle is called an item and the combination of several items of several products requested by a customer is called customer order.

Rockwell ARENA is a simulation and automation software from Rockwell Automation, Inc. It uses the SIMAN simulation language as the underlying building block and the current version is version 12.0. In ARENA, a simulation model can be built by putting together predefined modules, which represents processes or logic. Connector lines are used to connect modules and designate the flow of entities. Statistical data, such as cycle time and waiting time are recorded and displayed automatically as reports by ARENA. ARENA has been widely used in simulating business processes and various kinds of discrete event operations. Large firms that use ARENA include GM, UPS, IBM, Nike, XEROX, Lufthansa, Ford, Lucent and Sony. ARENA is used in Na et al. to model and simulate the terminal operation processes which involve ship arrival, loading, unloading and other related discrete events [6]. Tahar and Hussain used ARENA to model and simulate the seaport operations at the Malaysian Kelangport [8]. Deshpande et al. used ARENA to model and analyze truckload terminal operations in order to experiment withalternative dock assignment scenarios [1]. Greasley gave a good account on the usage of simulation modelling in the manufacturing sector, and stresses that most are for the analysis of production planning and for control purposes. Greasley used ARENA simulation to investigate the effect of conveyor breakdowns on the performance of a continuous operations process [4]. In relation to simulation of loading and unloading systems, Na et al. used ARENA to model and simulate the terminal operation processes which involve ship arrival, loading, unloading and other related discrete events. The paper also gave an overview of the methodology in using ARENA to model the system and explains that ARENA provides extendable simulation environments through graphical and animation modeling facilities. The simulation model was calibrated and verified with actual operation records from 15 different container terminals [6]. Tahar and Hussain used ARENA to model and simulate the seaport operations at the Malaysian Kelang port in the context of commercial activities. The main aim of the work was the improvement of the logistics processes at the port. The simulation model were carried out using the ARENA package because of "its flexibility in modeling many scheduling and planning problems and its user-friendly modeling environment". Fitting of inter arrival times of ships was done using the ARENA input tool which fits probability distributions to the real data collected. The models also involved the assignments of berth, crane and prime movers in the port operation [8]. In 2014, Emami et al. performed a simulation study in a loading and unloading system using ARENA. The aim of the study was to obtain a strategy for optimizing the time of truck loading and unloading system. The study dealt with worker recruitment and waiting time in various processes until dissolve problems. Declining the processing time and the long queues in the loading and unloading are the considerable results of the research [2].

In this paper, we simulate a warehouse loading and unloading system in an automotive company in Tehran, Iran. The main goal is to propose strategies to lower the average waiting time of the personnel. After providing the conceptual model, it is performed in ARENA13.5simulation software and the results are analyzed. Simulation results demonstrate the bottlenecks in different parts of the warehouse which leads to long waiting time for personnel. Finally, some strategies are proposed to decline the average waiting time and improve the performance of warehouse loading and unloading system.

This paper is organized as follows. In Section 2, description of a warehouse loading and unloading system is presented; the methodology adopted for modeling and simulation is explained in Section 3; Section 4 includes simulation results and discussion; Section 5 proposes strategies for improving the performance of warehouse loading and unloading system. Finally, conclusion is presented in Section 6.

II. System description

In this study, reception department, warehouses and empty pallets department of an automotive industry in Tehran, Iran have been considered. The relationship between the departments is shown in Fig 1.

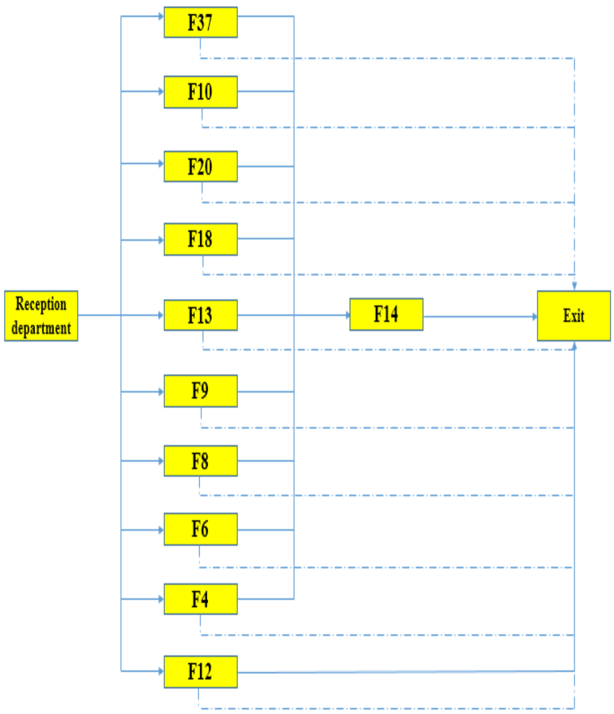

Fig. 1: Relation between reception department, warehouses and empty pallets department

The three main components which enter to reception department are as follows:

1) Receiving CKD

2) Receiving internal parts

3) Receiving raw materials

Arriving at the complex follows a logic process as depicted in Fig 2. Vehicle waits after entering to the reception department until service starts. This Service includes registration of information on the vehicle load and checking the situation of quality card. After accomplishing the service in reception department, the destination warehouses are determined. Code target warehouse is evident in Table 1.

Table 1: Coding of destination warehouses

No	Code	Name	No	Code	Name
1	F40	Entrance door	8	F37	Warehouse of chemical material
2	F11	Reception department	9	F13	Warehouse of motive power
3	F14	Empty pallets department	10	F9	Warehouse of chassis
4	F18	First warehouse of raw material	11	F8	Warehouse of temporary reception
5	F10	Second warehouse of raw material	12	F12	Warehouse of iron and sheet
6	F20	Warehouse of pressing parts	13	F6	Warehouse of repack
7	F4	Warehouse of raw material of Van	14	F40	Exit

If a queue exists in destination warehouse the vehicle should wait until its cargo unloaded in that relevant warehouse. The percentage of vehicle should return to manufacturer.So after unloading at the warehouse, they go to the empty pallets department as there are empty pallets to be loaded. Upon completion all these stages, vehicles leave the complex.

Most of the time, long lines are observed in miscellaneous parts of the complex (i.e. reception department, destination ware houses and empty pallets department). The goal is to recognize the bottlenecks and ameliorate the performance of the whole complex.

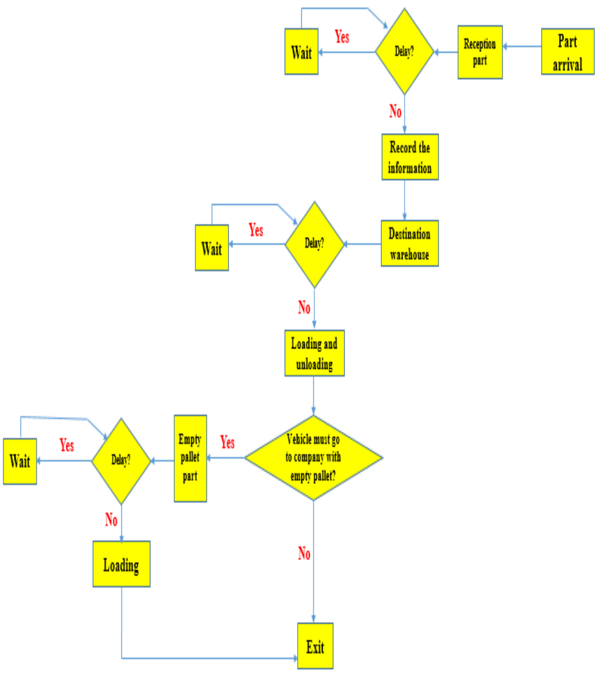

Fig. 2: Conceptual model of the warehouse loading and unloading system of an automotive company

III. Methodology

In this study, the goal is to improve the performance of warehouse loading and unloading system by reducing waiting times. There are two main steps to achieve the target of the present study. Data collection and developing a data bank are included in the first step. Then model is implemented in ARENA simulation software.

3.1. Collecting data and developing a databank

First, the required data of simulation including arrival rate and different service times should be gathered and stored in a databank. Then, statistical distributions can be developed using ARENA input analyser. Table 2 delineates the statistical distributions of different parts of the complex.

Table 2: Statistical distributions of different destinations

Destination	Statistical distribution
F14	5.5+LOGN(3.16, 2)
F10	4.5+7*BETA(0.858, 1.18)
F12	TRIA(5, 7, 10)
F13	4.5+WEIB(2.96, 1.57)
F18	5.5+LOGN(1.91, 1.89)
F20	4.5+ERLA(1.1, 3)
F37	POIS(7.06)
F4	4.5+LOGN(2.83, 2.43)
F6	4.5+WEIB(2.86, 1.6)
F8	POIS(6.75)
F9	4.5+WEIB(3.52, 1.73)

3.2. Implementation of model in ARENA software

After making a databank, the next step is implementing the model in ARENA simulation software. According to the explained process in Section 2, the following modules are used for simulation of different parts of complex. Fig 3, Fig 4 and Fig 5 depict the applied modules in reception department, warehouses and empty pallets department, respectively.

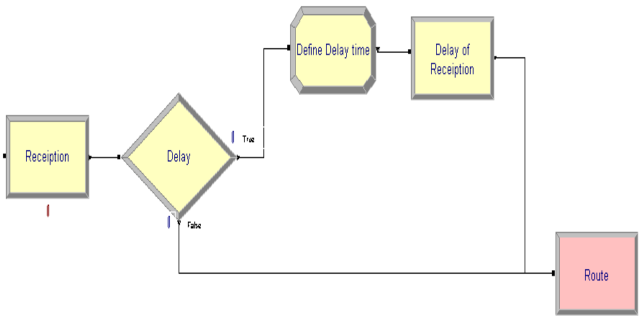

Fig. 3: Applied modules in reception department

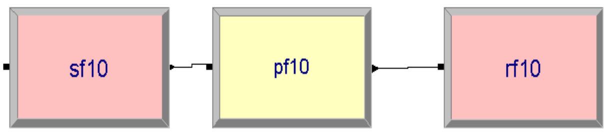

Fig. 4: Applied modules in warehouses

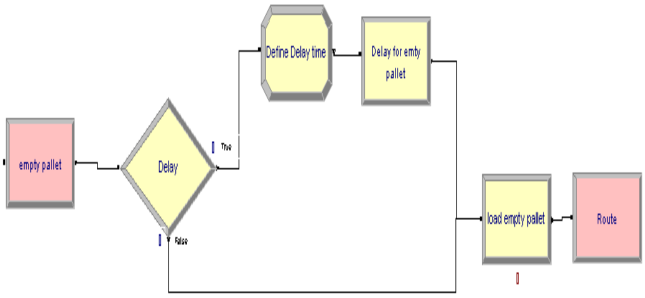

Fig. 5: Applied modules in empty pallets department

IV. Simulation results

After implementation of model in ARENA software, the model was run for 6 days and these initial results attained:

1) The average number of vehicles entered the complex at the end of the day were 438.

2) The average number of vehicles left the complex at the end of the day were 364.

The average number of vehicles transport cargoes during a day and the maximum number of vehicles wait for loading in miscellaneous destinations are shown in Fig 6 and Fig 7.

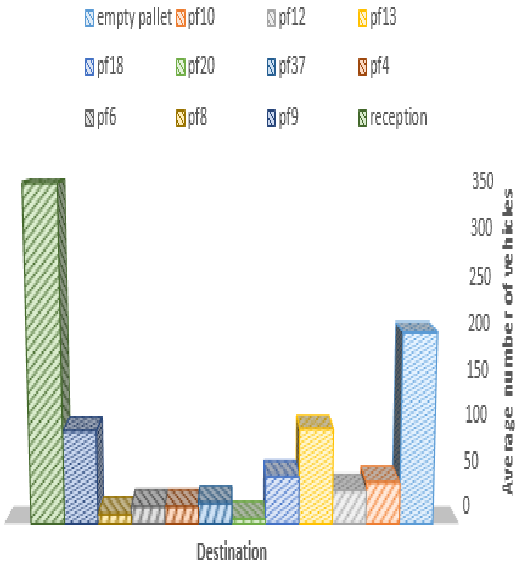

Fig. 6: The average number of vehicles transport cargoes to different destinations during a day

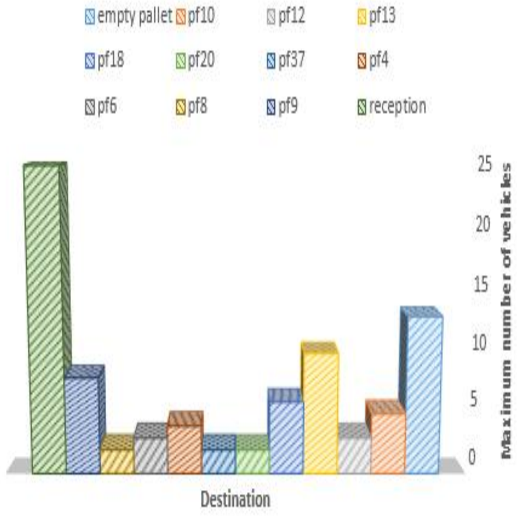

Fig. 7: The maximum number of vehicles wait for loading in different destinations during a day

The followings are concluded from Fig 6 and Fig 7:

1) Reception department has the most number of entered vehicles to the complex, because of its centrality.

2) Department of empty pallets with 44% places in the next level.

3) Warehouse of motive power (F13) with 29% has the third place.

V. Improvement of system performance

In this Section, after analysis of the results of each department, some alternatives are proposed to improve the performance of system.

5.1. Analysis of reception department

One of the most important concerns in this department is incoordination between the scheduling problem of reception department and warehouses. This causes lots of problems (i.e. overcrowding the warehouses and long queues of loading and unloading). Fig 8 depicts the situation of loading and unloading in reception department of the complex in one day.

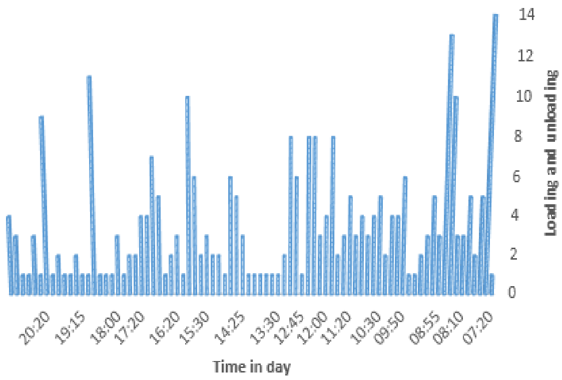

Fig. 8: Situation of loading and unloading in reception department in one day

Though the peak hours are 7:20 to 9:30, 12:30 to 13:30 and 15:30 to 20:20, loading and unloading perform slowly during these hours. The following strategies are proposed to overcome the problem:

1) Making two parallel stations in reception department decreases the waiting time of personnel and facilitates service level.

2) Only 83% of cargoes have quality card and the rest does not have. Separating the queues of checking the quality card is considered as another strategy.

3) Employing personnel in pick hours in a way that loading and unloading are always performed, is regarded as an improving strategy.

Fig 9 depicts the average waiting time in current situation and proposed strategies. As it is obvious the average waiting time is declined when the proposed strategies are performed.

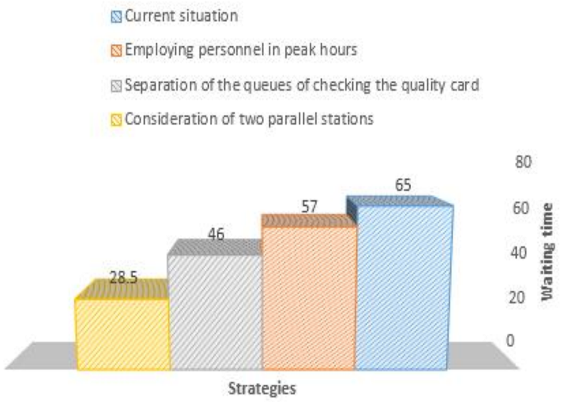

Fig. 9: Comparison between the average waiting time of different strategies

5.2. Analysis of warehouses

Delivery of cargoes from suppliers to the complex does not follow a monotonous scheduling. On average, most of the cargoes are received from suppliers in 10 last days of the month. This is due to the fact that there is not a specified scheduling plan when the contract with suppliers is made. Considering a unique scheduling plan to deliver cargoes during a month is proposed to overcome the difficulty in warehouses.

Fig 10 compares the average number of waiting cargoes with consideration of the current situation and propose strategy. It is clear from the Fig 10 that the average number of waiting cargoes is lowered when the proposed strategy is performed.

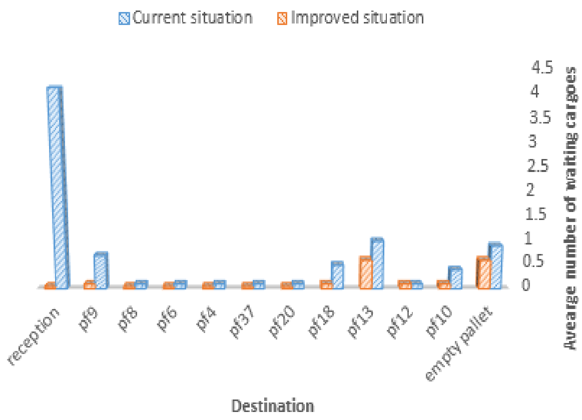

Fig. 10: Comparison between the average number of waiting cargoes in different situations

5.3. Analysis of empty pallets department

On average, 45% of the vehicles refer to the empty pallets department. Due to the lack of empty pallets in this department, vehicles wait 2 to 7 hours per day which leads to long queues. Fig 11 delineates the percentage of referring vehicles to empty pallets department which wait due to the lack of empty pallets.

The following strategy is proposed to overcome the problem:

Collecting system of pallets are often modeled based on the structure of vehicle routing problem with backhauls. In these systems, pallet producer companies rent their pallets to the companies which have long queues in their empty pallets department. These companies put their cargoes on rented empty pallets and send them to their distributors. Then, pallet producer companies collect thee empty pallets from distributors and prepare them for next times.

By considering this strategy, the average waiting time of personnel in empty pallets department is reduced intensively.

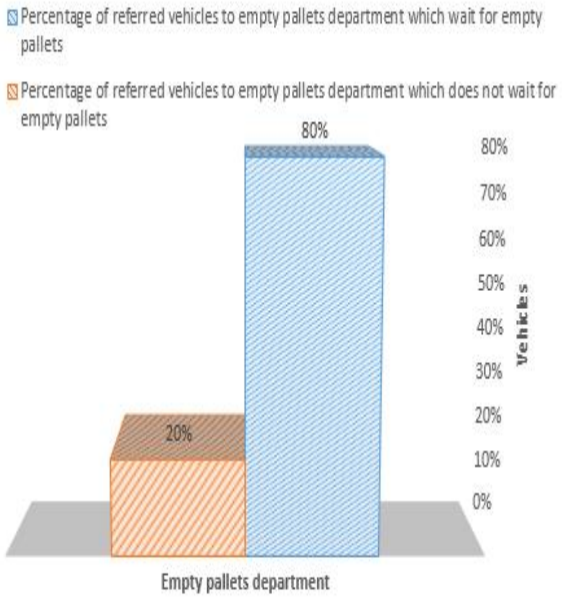

Fig. 11: Percentage of vehicles refer to empty pallets department

VI. Conclusion

Computer simulation consists of miscellaneous methods to study the models of real systems, using numerical evaluation by the software to emulate system operation and characteristics. From a scientific point of view, simulation, process design and create computer models of real or proposed systems to conduct numerical experiments to better comprehension of the systems used in different situations. Although this technique can also be used to study a simple system, but when the main power appears while studying of complex systems. Although simulation is not the only tool to study but for the most of the time is the best option. The reason is that if we really want to describe a real system and have to build a complex model, we can still use simulation analysis. While in other methods may be we have to consider more assumptions to the model that it would be overthrown the model of credit.

Due to the voluminous transportation of cargoes in warehouses of different industries, simulation of a warehouse of an automotive company in Tehran, Iran is performed in this paper. First, conceptual model is provided. Then, model is run in ARENA13.5simulation software and results are analyzed. Simulation results demonstrates the bottlenecks in different parts of the warehouse which lead to long waiting time for personnel. Finally, some strategies are proposed to decline the average waiting time and improve the performance of warehouse loading and unloading system.

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