Simulation Optimization for Transportation System: A Real Case Application

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***Abstract* – Simulation applications help decision makers to give right decisions to eliminate some problems such as: create a new firm, need some changes inside a factory; improve the process of a hospital etc. In this engineering simulation study, there are two points which are used by students to arrive at the University. Initial point is the train station and the final point is the arrival point. Students' transportation is provided with buses. The main problem is to decide the number of buses by taking number of student into consideration. To be able to solve this real-life application PROMODEL pack software is used.**

***Keywords* – Simulation, optimization, real life application, decision maker.**

1. Introduction

Preference of simulation packages not limited to planning and training to methodical researches are very common in many engineering studies [1]. In these branches, bus transportation simulations are one of the major researches in transportation engineering and decision making projects. Bus transportation structure has a notably composite nature and it includes many elements such as scattered and connected entities [2-4].

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Simulation or the system has three essential parameters in order to give the right decisions. One of these factors is input. This parameter is the number of entities which are embedded intoto the system. Following this parameter, the second one is service. This is the service area for the entities. The last one and the final one is called output. This is the last phase of a system. In this process entities enter the system and get service, and then these entities change into outputs. This is a summary about a system. Inside the simulation optimization, a simulation model can be thought of as a mechanism that changes input parameters into output performance measures. [5] To be able to understand this system and simulation optimization an extensive review is provided. [6, 7]
Entities have much more importance when compared to outputs. The reason is that entities must be correctly chosento be able to have right outputs. Moreover, if these entities are inaccurately accepted, this may result with costly situations as well as undesired activities.

Second part of the system is about service area [8]. This place also has importance for the simulation. The entities get service in this part and it may be transportation, surgery, packaging etc. This process also must be taken into consideration in order to provide the right service to the right entities.

The last phase of the simulation is the output procedure [9]. Thus far, entities attend the system and they get service. Afterwards, entities change into output and leave from the system. In order to make all these system parameters and procedure more clear; carton raw material can be taken as an example. This material can be used for a milk package. First process of this material is the cutting process. Afterwards, labelling process comes as second and the milk will be poured inside this cut carton as the last step of the production line processes The carton raw material leaves the system having full of milk in it. Here the raw material is called entity, pouring the milk inside of the carton is service area. Lastly, the final situation which is ready to sell it is called output [10].

Simulation models are widely preferred for operating systems and developing current decision making methodologies [11]. In order to model construction operations, productivity level predictions and cycled planning duties, activity cycle diagrams are chosen extensively [12]. This method is derived from Cyclone methodology with the improvement of Stroboscope technique [13, 14]. One of the generally used and multiple purpose simulation system is PROMODEL and it is regularly practiced for its easy and user friendly environment [15]. A PROMODEL work includes resources, entities and locations in a 2D interface and, modeling tools which are used while modeling the logical and the physical elements (Table 1.) of the simulation system [16].

Table 1. PROMODEL Modeling Elements [17]

Modeling Elements	Functionalities
Entities	Entities are the items processed in the system. Entities of the same type or of different types may be consolidated into a single entity, separated into two or more additional
Resources	Agents used to process and move entities. Resources may be either static or assigned to a path network for dynamic movement.
Path networks	Aisles and pathways along which entities and resources traverse.
Routing (Processing)	Processing defines the routing of entities within the system and what operations take place for each entity at each location. The operation or service times at locations, resource requirements, processing logic, input/output relationship, routing conditions, and move times or requirements can be described.
Locations	The places where entities are processed or held. Processing locations may have a capacity greater than one and may have periodic downtimes as a function of clock time (e.g. shift changes), usage time (e.g. tool wear), usage frequency (e.g. change a dispenser after every n cycles), change of material (e.g. machine setup) or based on some user defined conditions.
Arrivals	Arrivals define the entry of entities into the system such as inter arrival times and quantities.
Shifts	Shifts define custom work and break schedules.
Variables	Variables are used for decision making and statistical reporting.
Attributes	Attributes can be defined for entities and locations.

PROMODEL simulation methodology is practiced as per afore mentioned reasons. In this study a real life application is mentioned and in the second part, problem definition will be given with real data. For the third part, application steps and solving methodology is going to be explained as well as the used simulation pack program. As for the fourth part, conclusions of this study will be shared.

2. Problem Definition

There are two stops which are referred as initial and final. Initial point is for students, they come there by train and their aim is to reach their University by using buses. Between these two points the travel time is almost fifteen minutes. The main aim is to decide the number of the buses and how to solve these problems with other methods.

In regard to the first initial point, there is a train station and the students are commonly using this vehicle in order to reach initial point. There are three ways to be able to reach the University. First preferences are University buses. The second number is 750 buses which belong to the municipality. The last number is 850 which is under the control of the municipality. Students must decide on one of the three options in order to reach University but in this project, the main aim is to optimize the number of University buses since municipality buses are not only preferred by students. The initial point is shown in Fig. 1.

Figure 1. View of the Initial Point

As mentioned in the previous paragraph, the main point is to decide the right transportation vehicle for the students. The reason is that if the University buses are full, they may be late to their classes. This may result with backfire. Besides, the distance between the two points is almost 10 kilometres. As for the final station, it is showed in fig. 2.

Figure 2. View of Final Point

3. Application

To be able to solve the mentioned problem, a simulation program will be used and the results will be shared in the next part. Here the main aim is to mention the application steps and share the solving methodology. To be able to optimize this problem, the number of students must be known and for this, some measurements must be taken into consideration.

Number of University students is known as normally but some of them are using their own cars in order to reach the University. Thus there is unknown and unpredicted situation. For this, some observations must be done on the initial point in order to collect real data as numerical. If statistical data is correct, simulation program gives you the best result. Starting from this definition, the data is collected from the initial point in different days of the weeks and different hours of the day. The collected data is shown below (Table 2.).

Table 2. Collected Data on Friday

Observations	**Bus Departure Time**	**Bus Arrival Time**	**Passenger No**	**Bus Line 750**	**Bus Line 850**	**Train North Line**	**Train** South **Line**	**Student No. Left**
1		9:29	77				9:27	17
2			None			9:34		
3	9:38	9:34	62				9:35	
4	9:48	9:45	49				9:42	
5		9:48				9:47		
6	9:58		52				9:54	

As shown in Table 2., the number of observations and the number of students which use University buses are presented clearly. In addition to this information, the arrival times of trains are also shared. To be able to collect more data, the collection method has been changed and decided to start observation between minutes. These observations are given in Table 3.

Table 3. Collected Data's on Monday

Student Transportation Preference Numbers			
University Buses		Bus Line 850	Bus Line 750
08:50-08:52	46		
08:51-08:52		5	
09:00-09:02			15
09:01-09:04	66		
09:10-09:12	38		
09:15-09:16		12	
09:20-09:22	65		
09:30-09:31	54		
09:40-09:43	77		
09:41-09:42			10
09:54-09:55	53		
10:00-10:03	32		
10:15-10:17	87		
10:20-10:21		9	
10:21-10:22			12
10:30-10:31	51		
10:45-10:47	72		
11:00-11:02			17
11:15-11:17	35		
11:30-11:33	58		
11:42-11:43			7
11:45-11:47	28		
12:00-12:02	49		

As shown in Table 3., the University buses and other buses are providing transportation between the University and the initial point. In order to collect data, observation time is decided as 08:50. In that time, the number of students which come to the initial point is 46. They preferred to choose the University bus to reach the final point. Between 08:51 – 08:52, 5 students arrived to the initial point and they decided to reach the University with bus number 850. This transportation system was observed until 12:02 o'clock. At the end of this observation it was possible to say that most of the students prefer to use University buses rather than number 850 and 750. Meanwhile, there is also much more collected data but just two of them are shared in this study.

After all this data was collected, the type of the statistical distribution is decided with using PROMODEL pack program. Then, to be able to analyse the problem, simulation model was created as shown in Figure 3. Here the main point is student queue as well as the University bus queue. This place can be considered as waiting line for students. They wait there until any of the vehicles reaches this place. The road is the way between the initial point and the University and it is almost 10 kilometres far away as mentioned before. The final point is shown below (Figure 3.).

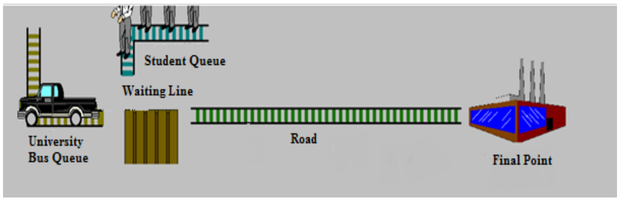

Figure 3. Simulation Model of Transportation System

4. Conclusion

In this part, the results of this study will be shared in respect to the simulation model outputs as shown in Figure 4.

General Report (Normal Run - Rep. 1)

General | Locations | Location States Multi | Location States Single | Failed Arrivals | Entity Activity | Entity States | Variables

(Normal Run - Rep.)

Name	Scheduled Time (HR)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
Uni. Bus Queue	24,00	999999,00	148,00	1,37	0,14	4,00	0,00	0,00
Student Queue	24,00	999999,00	3655,00	749,75	1903,02	3507,00	3506,00	0,19
Waiting Line	24,00	1,00	149,00	9,61	0,99	1,00	1,00	99,48
Road	24,00	999999,00	148,00	0,39	0,04	1,00	1,00	0,00
Final Point	24,00	1,00	147,00	2,24	0,23	1,00	0,00	22,88

Figure 4. Simulation Model Outputs

The main aim of this project was to decide the number of buses and optimize this transportation system. In order to analyze the system, simulation optimization is used. Some observation happened in order to collect real data.

As simulation program output (Table 3), the number of capacities are 99% for the University bus queue, student queue and road while the utilization of the waiting line is 99.48%. Total entities of the University bus queue are estimated at 148 while student queue total entity is 3655. Another important output is the time a student spends in the waiting line. It is estimated at 1, 37 minutes per entity. This time is rather rational for a waiting time.

In addition to these results, during the observations the student queue was optimal since the number of student is much more than the University buses' capacity as well as numbers 750 and 850 were absent in the initial point. Another observed point is the number of students who preferred to choose the University buses instead of numbers 850 and 750. The reason is that these buses were also travelling to another places while going to the final station. This causes much more time delay when compared to the University buses.

In the general summary of this study, instead of increasing the number of University buses, the shape of the University buses could be increased in regards to these results. This new shape might be articulated by buses which have higher capacity rather than the normal buses. Another solution methodology might be the new schedule of class's starting time. In general, lessons start at 09:00 o'clock and the students are late due to the mentioned results. If the lessons started at 09:30 or 10:00, this problem will be solved, as another solution methodology. For the future work, this study may be enlarged with adding additional governmental buses to the system with making new observations.

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