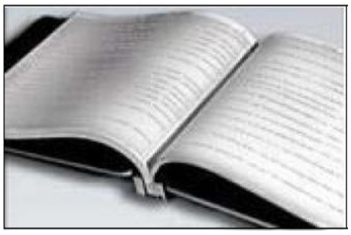

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DETERMINING INCOME OF ROAD PASSENGER TRANSPORTATION USING DISCRETE EVENT SIMULATION

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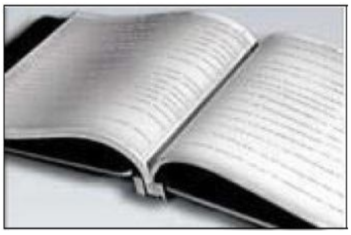
Abstract: Simulation is one of the most powerful analysis tools available to those responsible for the design and operation of complex processes or systems. In this study; it is investigated that the income variety of road transportation company according to month, day, bus and expedition. A discrete event simulation model is developed to determine the income for the next year trips. The model can be used by decision makers for the other aims as well. The model is developed in Arena Software and MS Excel.

Key Words: Discrete Event Simulation, Road Passenger Transportation, Determining Income, Arena Software, MS Excel

KESİKLİ OLAY BENZETİMİ YAKLAŞIMI İLE KARAYOLU YOLCU TAŞIMACIĞINDA GELİR BELİRLENMESİ

Özet: Karmaşık sistemlerin yönetiminde ve tasarımında benzetim tekniği en güçlü araçlardan birisidir. Bu çalışmada, karayolu yolcu taşımacılığında faaliyet gösteren bir firmanın ay, gün otobüs ve sefer bazında elde etmiş olduğu geliri incelenmiş ve gelecek dönemdeki ay, gün otobüs ve sefer bazında beklenen gekir değerlerini belirlemek amacıyla Arena paket programında benzetim modeli geliştirilmiştir. MS Excel'de geliştirilen diğer modelden elde edilen sonuçlar ile karşılaştırma yapılmıştır.

Anahtar Kelimeler: Kesikli Olay Benzetimi, Karayolu Yolcu Taşımacılığı, Gelir Belirleme, Arena Paket Programı, MS Excel



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1. INTRODUCTION

Simulation and optimization techniques are commonly applied in tandem to study many types of real world problems. A simulation is the imitation of the operation of a real-world system over time. Simulation modeling has become an extremely important tool in analyzing dynamic and complex systems. Simulation is the attempt to duplicate the features, appearance and characteristics of a real system.

The idea behind simulation is threefold:

1) To imitate a real world situation mathematically,
2) Then to study its properties and operation characteristics and,
3) Finally, to draw conclusions and make action decisions based on the results of the simulation (Heizer & Render, 2000: 851).

Simulation modeling and analysis the process of creating and experimenting with a computerized mathematical model of a physical system. Although many different types of system can be simulated, the majority of the system that are considered are manufacturing, service or transportation related.

Transportation system examples include;

- Airport operations
- Port shipping operation
- Train and bus transportation
- Distribution and logistics (Chung, 2004: 2).

Road transport sector and also private companies are one of the main users of computer simulation technique for planning, scheduling and developing new traffic systems (Sezen & Günal, 2009).

2. LITERATURE REVIEW

Padilla, Torres, Villamizar, Isaza & Polo(2013) consider the stochastic version of the location-routing problem in which transportation cost and vehicle travel speeds are both stochastic. A hybrid solution procedure based on Ant Colony Optimization (ACO) and Discrete-Event Simulation (DES) is proposed. Rensburg, He & Kleywegth (2005), describe a computer simulation model of ocean container carrier operations. The simulation is called SimSea which is developed in C#. SimSea simulates the transport of containers by container vessels. Kenyon & Morton (2003), consider stochastic vehicle routing problem as random service and random arrival time. Estimated arrival time minimization is provided according to the proposed model. Goldsman, Pernet, & Kang (2002), calculate expected transportation time of goods in container vessel using Arena. Song, Zhang, Carter, & Field (2005), use simulation to calculate cost-efficiency of the global container shipping network. Sajedinejad, Mardani, Hasannayebi, Reza, Mohammadi & Kabirian (2011), presented an event-driven simulation-based optimization method for solving the train timetabling problem to minimize the total traveling time in the hybrid single and double track railway networks based on integration of a discrete event simulation and GA meta-heuristic algorithm to generate near optimal train timetable. Bush, Biles & DePuy (2003), describe an iterative technique between optimization and simulation models used to determine solutions to optimization problems and ensure that the solutions are feasible for real world operations using Arena software. The technique allows for the development of separate optimization and simulation models with varying levels of detail in each model.

3. METHODOLOGY

Simulation is one of the most powerful analysis tools available to those responsible for the design and operation of complex process or systems. In an increasingly competitive world, simulation has become a very powerful tool for the planning, design, and control of systems (Pegden, 1990). The majority of modern computer simulation tools implement a paradigm, called discrete-event simulation (DES). This paradigm is so general and powerful that it provides an implementation framework for most simulation languages, regardless of the user worldview supported by them (Altiok & Melamed, 2007: 11).

In a discrete model, though, change can occur only at separated points in time, such as a manufacturing system with parts arriving and leaving at specific times, machines going down and coming back up at specific times, and breaks for workers (Kelton & Sadowski,2004: 9).

The simulation event list is a means of keeping track of the different things that occur during a simulation run (Law & Kelton, 2000). Anything that occurs during the simulation run that can affect the state of the system is defined as an event. Typical events in a simple simulation include entity arrivals to the queue, the beginning of service times for entities, and the ending of service times for entities. These events change the state of the system because they can increase or decrease the number of entities in the system or queue or change the state of the resources between idle and busy. The event list is controlled by advances in the simulation clock. In our basic simulation model, the simulation clock advances in discrete jumps to each event on the event list. This type of model is called a discrete event simulation (Chung 2004: 10).

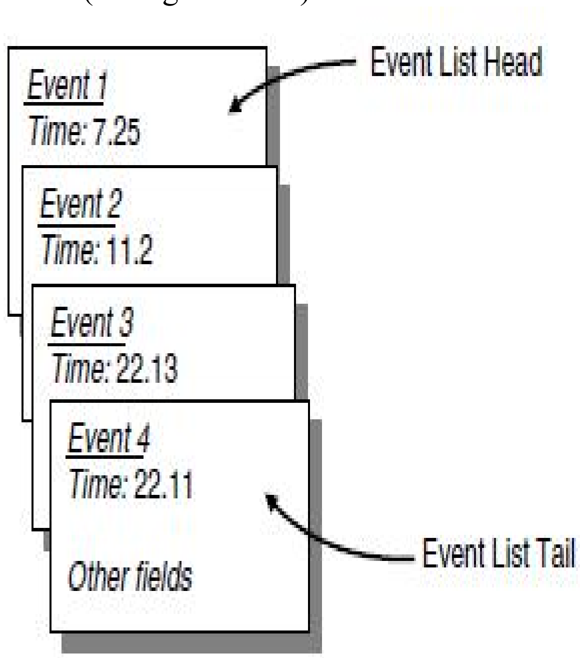

Figure 1: Structure of a Discrete Event Simulation Event List

A Discrete Event Simulation simulator executes the following algorithm:

1. Set the simulation clock to an initial time (usually 0), and then generate one or more initial events and schedule them.
2. If the event list is empty, terminate the simulation run. Otherwise, find the most imminent event and unlink it from the event list.
3. Advance the simulation clock to the time of the most imminent event, and execute it (the event may stop the simulation).
4. Loop back to Step 2 (Altiok & Melamed, 2007: 12).

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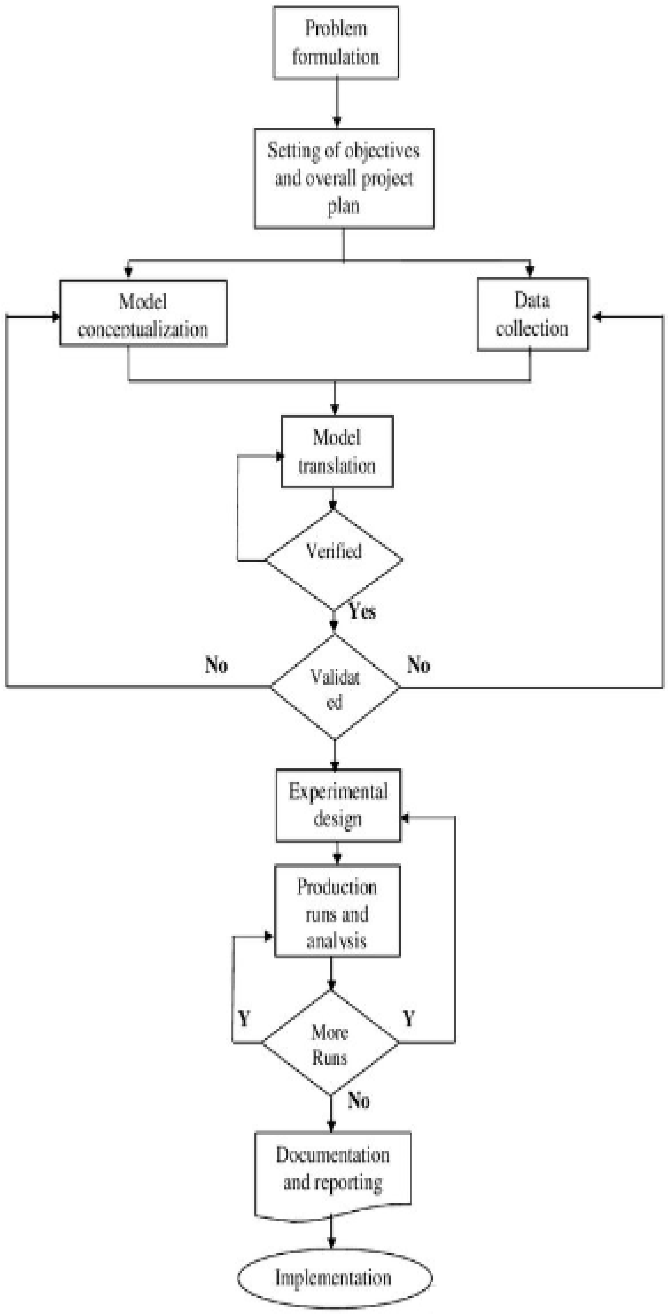
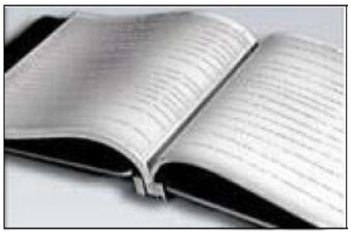


Figure 2: Flow Diagram Of Discrete Event Simulation



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4. APPLICATION

Interested system consists of three main station; namely Ankara, Çanakkale and Bursa. Each bus has the same route: initial station is Ankara, second station is Çanakkale and third station is Bursa. When bus returns to Ankara the route will be terminated. Each bus must wait departure times as shown Figure 1 for every station. Therefore four buses are allocated for this route system.

Destinations		Departure Time	Departure Time	Duration (Hour)
From	To			
Ankara	Çanakkale	21:00	22:30	10
Çanakkale	Bursa	15:00	16:00	4,5
Bursa	Ankara	00:00	01:00	5,5

Table 1: Departure Time and Durations

4.1. Assumptions

Following assumptions are accepted while developing the simulation model:

1. At the beginning of simulation (when tnow = 0), the buses are in Ankara. The buses wait until their departure time.

2. Each month is assumed to consist of 30 days.

3. 88% of the tickets are assumed to be sold at the ticket sales office, and 12% of the ticket are assumed to be sold on internet.

4. The number of passenger is 60 person for special days (For only one bus).

5. The velocity of the bus is 90 km/hour.

6. Simulation will run for a year (8760 hours).

7. The special days include New Year 's Day, Feast of Ramadan, Festival of Sacrifices.

The simulation model was developed in Arena 3.0. The ticket prices and the percentage of ticket sales type of each links are shown at Table 2. 88% of the tickets are sold at the ticket sales office, and 12% of the ticket are sold on internet. Price of tickets are shown on the Table 2 are used to calculate income level for the simulation model.

Tour	Ticket Sales Office		Online Ticket	
	Price (TL)	%	Price(TL)	%
Ankara- Çanakkale	50	88	45	12
Çanakkale -Bursa	30	88	27	12

Bursa -Ankara	30	88	27	12

Table 2: The Ticket Prices And The Percantage of Ticket Sales Type

The distributions of passenger for each expedition, which are called A-Ç 21:00, A-Ç 22:30, Ç-B 15:00, Ç-B 16:00, B-A 00:00, B-A 01:00, are determined with Input Analyzer in Arena.

The distributions of passenger are observed to behave normal distribution based on annual data.

Branch block are used to provide number of passenger always positive. If a none positive value is assigned for number of passenger, branch block doesn't accept the assignment and a new assignment occurs.

Therefore the number of passenger are always assigned positive value($y \geq 0$). Table 3 shows the distributions of expedition based on annual and monthly data.

	A - Ç 21:00	**A - Ç 22:30**	**Ç-B 15:00**	**Ç-B 16:00**	**B-A 0:00**	**B-A 01:00**
Annual	Norm(47.8,11)	Norm(37.1,9.8)	Norm(33.4,14.6)	Norm(36.2,15.1)	Norm(27.2,12.4)	Norm(26.1,7.17)
January	Norm(44.5,12.5)	Norm(36.4,9.77)	Norm(32.3,12.5)	Norm(26.7,11.9)	Norm(28.7,14.1)	Norm(24.3,9.3)
February	Norm(44.6,7.93)	Norm(36.1,7.56)	Norm(17.1,6.96)	Norm(23.0,10.2)	Norm(25,10.7)	Norm(23.2,7.19)

....	....	....	....	....	....	....
December	Norm(41,12.2)	Norm(25.7,8.79)	Norm(33.9,11.4)	Norm(34,11.1)	Norm(19.7,10.9)	Norm(23.9,8.99)

Tablo 3: Distribution of Expeditions

Figure 3 shows the interactive visual simulation model which is developed in Arena package program. The simulation model includes 25 different variables.

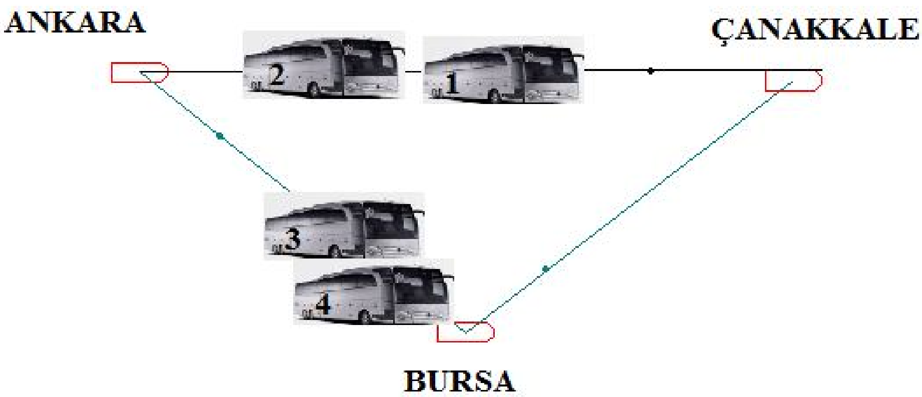

Figure 3: Expression of the Visual Simulation Model

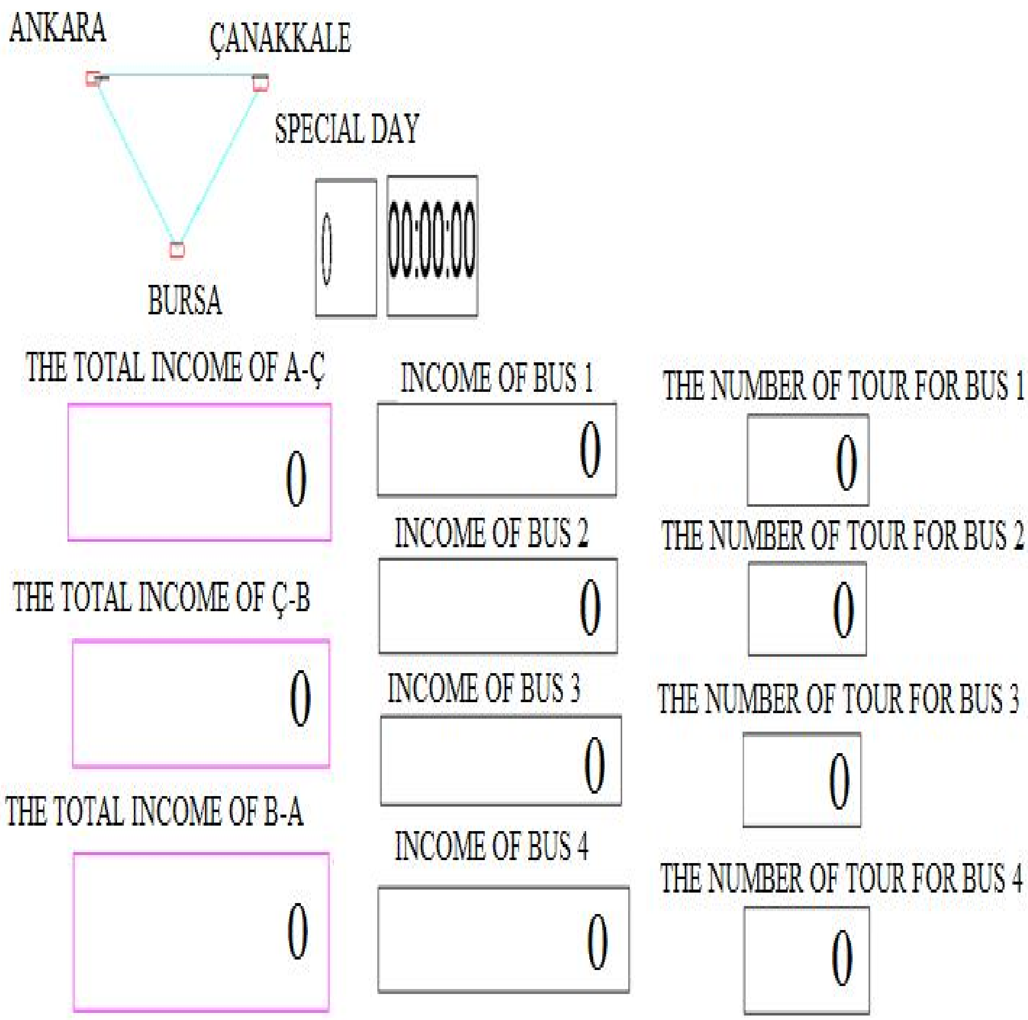

Figure 4: Simulation Model in Arena Software

Figure 4 shows the visual interactive model before simulation model runs. Simulation model runs for 8760 hours (for one year).

Flow diagram for expedition of Çanakkale-Bursa is shown in Figure 5. The flow diagrams for other expeditions can be created similarly.

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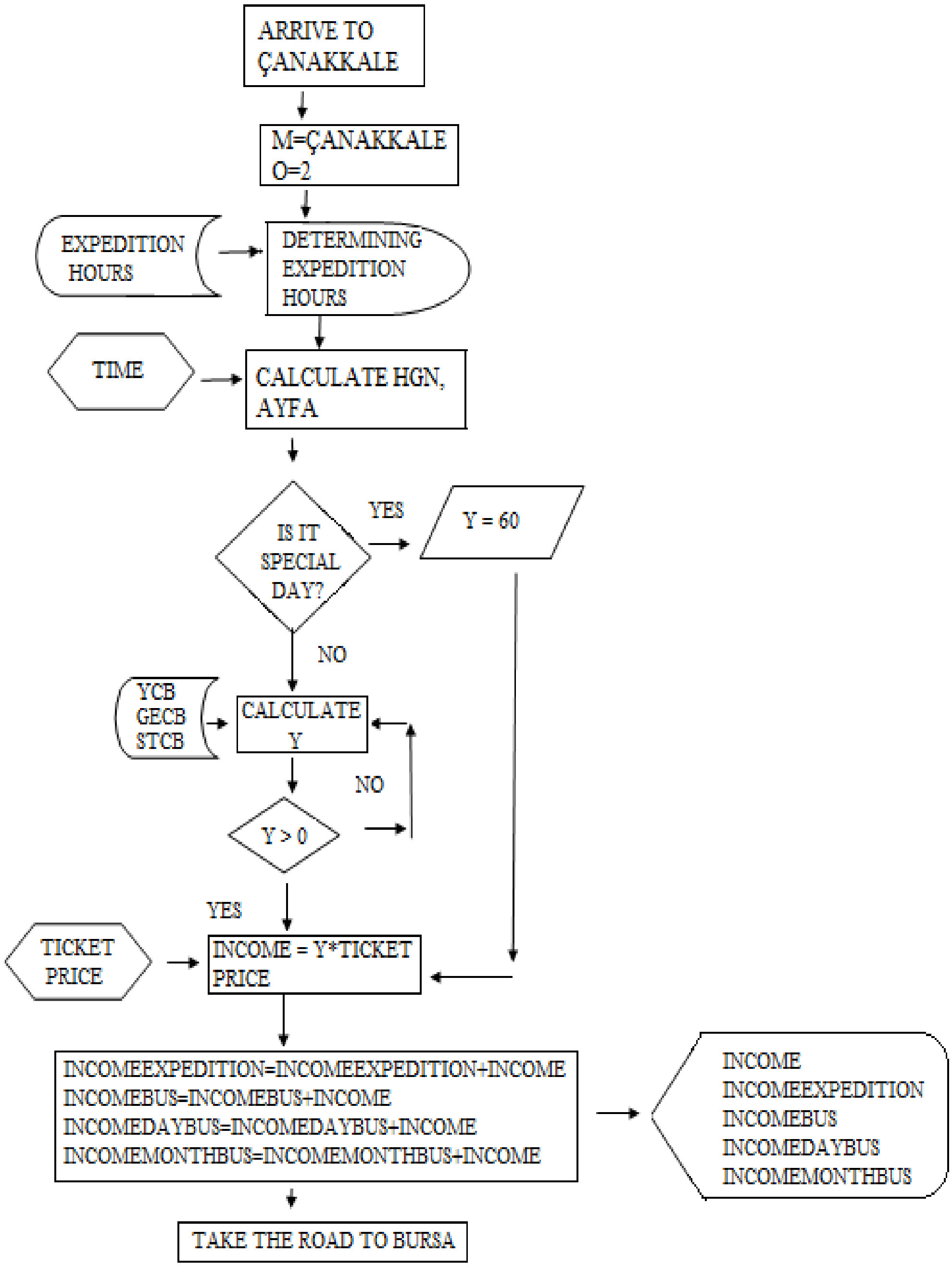

Figure 5: Flow Diagram For Expedition of Çanakkale-Bursa

The special days include New Year 's Day, Feast of Ramadan, Festival of Sacrifices. If it is a special day, simulation model shows 1 in special days table then number of passenger is assumed to be sixty(y=60). By time pass (tnow), total income for each expedition, number of expedition, total income for each bus (1, 2, 3, 4) are shown on the visual interactive simulation model.

The visual interactive simulation model after running 8760 hours (1 year) is shown as Figure 6.

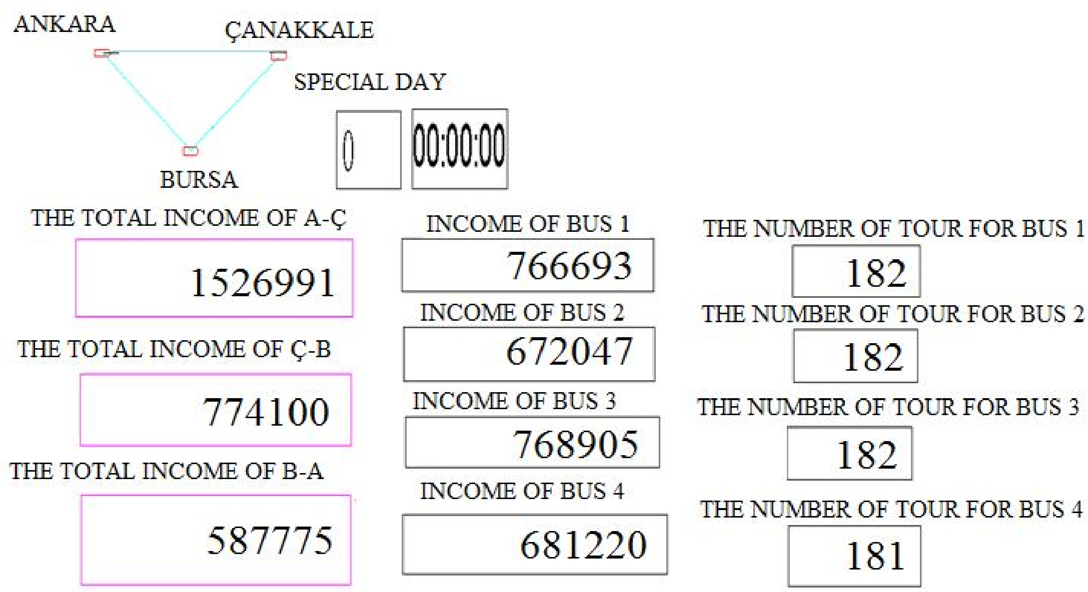

Figure 6:_The Image Obtained After Simulation Model Runs For 8760 Hours

After running 8760 hours (1 year), the number of tours is 182 for bus 1, 2, 3 and 181 for bus 4. It's observed that the total income of Ankara - Çanakkale' s expedition is 1526991 TL, the total income of Çanakkale-Bursa's expedition is 774100 TL and the total income of Bursa-Ankara's expedition is 587775 TL.

Income value for each buses are calculated respectively 766693TL, 672047TL, 768905 TL, 681220 TL. Monthly incomes for each bus are determined in simulation model.

Monthly incomes for each bus are shown on Figure 7.

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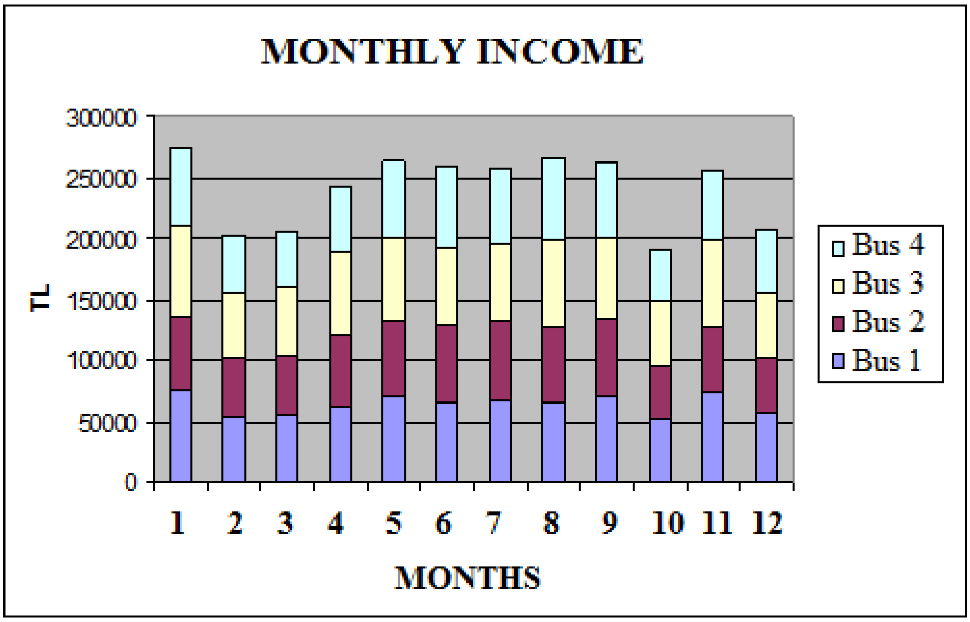

Figure 7: Monthly Income For Each Buses

Daily incomes for each bus are determined in simulation model. Daily incomes for each bus are shown on Figure 8.

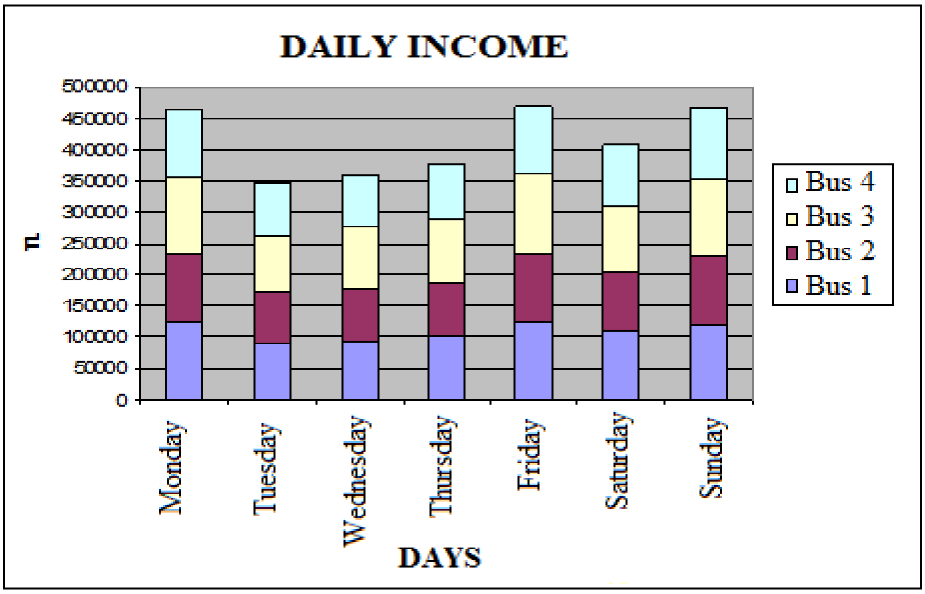

Figure 8: Daily Income For Each Buses

According to the result of simulation model, the highest total revenue is provided by bus 3. And the revenue of Ankara - Çanakkale' s expedition is higher than the other expeditions.

Monthly income values are listed below respectively, l273464, 202967,206480, 243465, 263044, 258342, 257206, 265574, 262368, 191566, 256170, 208197 TL. The highest total revenue is observed in January.

4.2. Verification and Validation

Chi-Square test (99% confidence level) is applied for testing verification of model.

Hypothesis:

H_0 : There is no significant difference between the model output and observed values.

H_1: There is significant difference between the model output and observed values.

For each expedition that we have calculated chi-square value is less than the chi-square table value, consequently, H_0 hypothesis can't be rejected. Thus, the simulation model represents the actual system.

4.3. Simulation in Excel

Discrete event simulation and Monte Carlo simulation can sometimes be done in Spreadsheet such as Excel. If the problem of interest is not too complex. In this regard, Excel provides a random number generator from some basic probability distribution. (Law, 2007: 74).

Spreadsheet simulations are widely used for performing risk analysis in application areas such as finance, manufacturing, Project management and oil-gas discovery (Law, 2007: 75).

The problem is solved also in Excel Spreadsheet with the same assumptions. The simulation model is running for a year (8760 hours). Model results are shown in Figure 9, Figure 10 and Figure 11.

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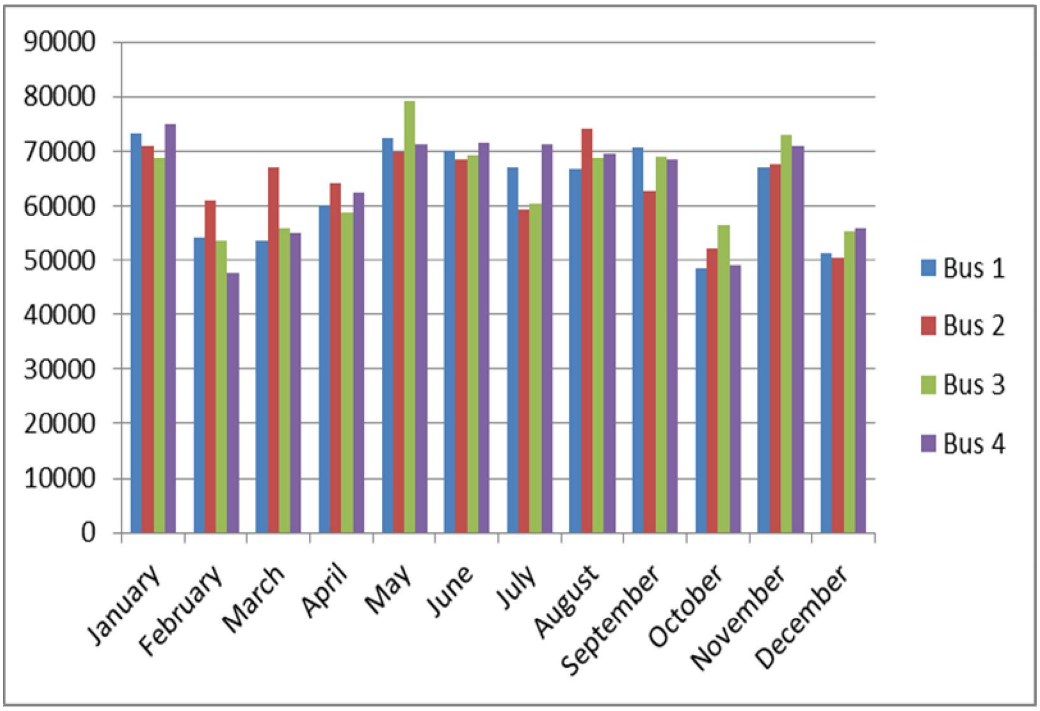

Figure 9: Monthly Income For Each Buses

Figure 9 shows that maximum income value is observed in May by bus 3. And minimum income value is observed in February by bus 4.

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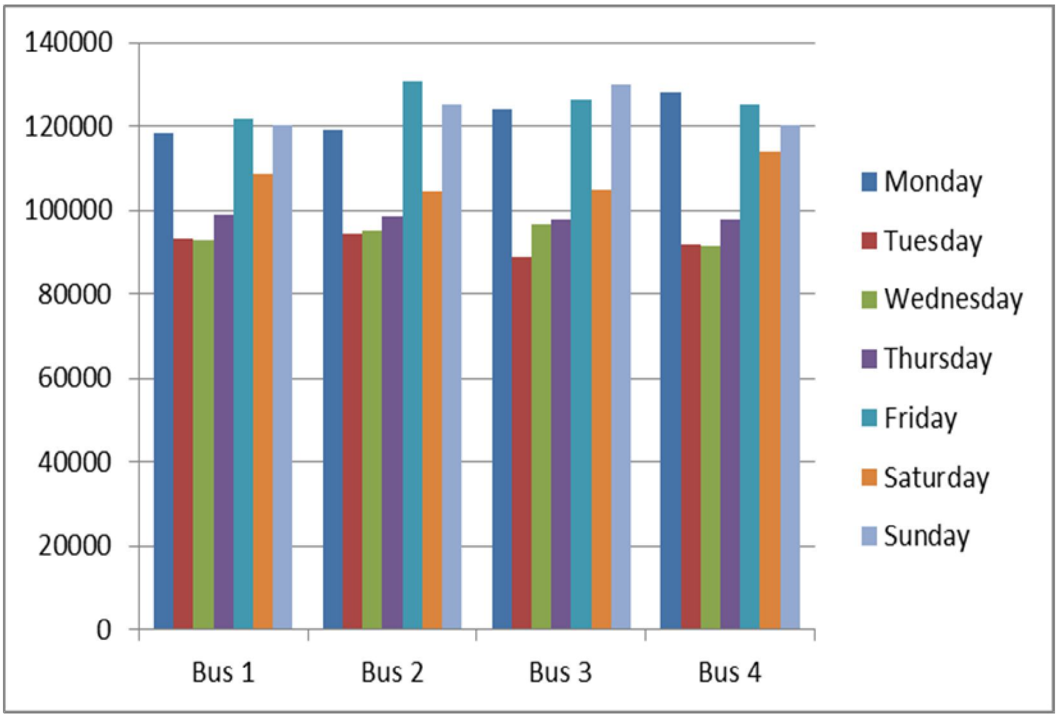

Figure 10: Daily Income For Each Bus

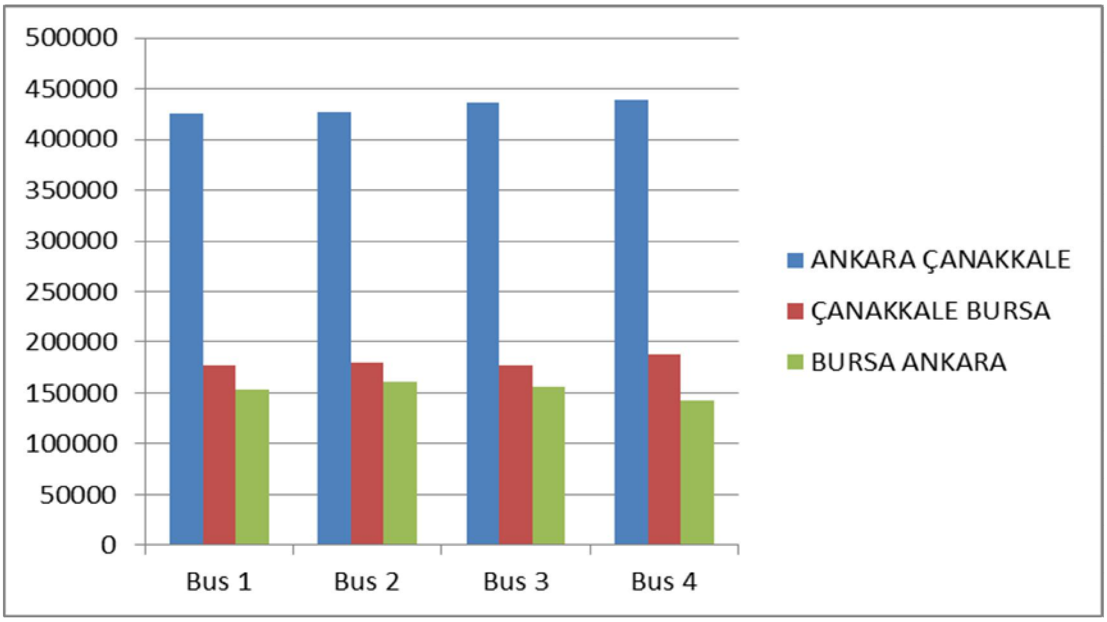

Figure 11: Income For Each Expedition

5. CONCLUSION

Results that are obtained from model developed in Arena software are consistent with the results that are obtained from model developed in Excel Spreadsheet.

In accordance to the results obtained from the models, calculated on a monthly basis of the total revenue increase is observed during the summer times. In addition, a monthly revenue rise in the months of January and November was observed due to special day such as Christmas and religious holidays.

As will be seen from Table 4; the income value obtained in the month of February, March, April, October and December, are lower compared to other months. Company specific to this month can run a number of marketing strategies to increase the number of passengers or it can reduce number of expedition in order to minimize cost.

As can be seen in table 5, for daily income Mondays, Fridays and Sundays' revenues are higher compared to other days' income. Company can seek a marketing strategy to increase number of passengers for Tuesday, Wednesday, and Thursday.

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