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	MAKALE ADI	SAYFA
1	SOSYAL AĞ'DA GÜÇLÜ BAĞLAR GELİŞTİRME VE İLİŞKİSEL PSİKOLOJİK SÖZLEŞME İLİŞKİSİ, AKADEMİSYENLER ÜZERİNE BİR ÇALIŞMA Yavuz KORKMAZYÜREK	1-23
2	ÖRGÜTSEL ADALET ALGISI VE ÖRGÜTSEL BAĞLILIĞA ETKİSİ: KAMU ÇALIŞANLARI ÜZERİNE BİR ARAŞTIRMA Prof. Dr. İlker Hüseyin ÇARIKÇI, Dr. Öğr. Üyesi Ercan KÜÇÜKEŞMEN	24-44
3	TÜRKİYE'DE DÖVİZ KURUNUN DIŞ TİCARET ÜZERİNE ETKİLERİ (2005-2015) Habibe YAMAN	45-69
4	İNSAN KAYNAKLARI YÖNETİMİNİN BAĞLAMSAL (CONTEXTUAL) MODELE GÖRE STRATEJİKLEŞMESİ VE KALİTE ANLAYIŞININ AKTÖRLER ARASI İLİŞKİLERE ETKİSİ Ertan Cem GÜL	70-83
5	DECISION MAKING BY SIMULATION- A CASE STUDY Dr. Güney GÜRSEL	84-97
6	ÖĞRENCİLERİN KARİYER ALTERNATİFLERİNİ ETKİLEYEN FAKTÖRLER VE GİRİŞİMCİLİK EĞİTİMİ Doç. Dr. Hatice Hicret ÖZKOÇ, Prof. Dr. Mehmet MARANGOZ, Ali Emre AYDIN	98-119
7	THE RESPONSE OF SHIPBUILDING ACTIVITIES TO FREIGHT MARKET Doç. Dr. Sadık Özlen BAŞER, Abdullah AÇIK	120-136
8	MUHASEBECİLERİN MESLEKİ GELECEKLERİ İLE İLGİLİ DÜŞÜNCELERİ: BİR ARAŞTIRMA Doç. Dr. Osman AKIN, Doç. Dr. Osman Kürşat ONAT, Fatma Özge ÖZGEN	137-159
9	KIRSAL TURİZM BÖLGELERİNDEKİ RESTORANLARA YÖNELİK ÇEVRİMİÇİ MÜŞTERİ DEĞERLENDİRMELERİNİN ANALİZİ: EĞİRDİR ÖRNEĞİ Doç. Dr. Murat ÇUHADAR, Öykü İmge GÜNEY	160-175

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SİMÜLASYON YÖNTEMİ İLE KARAR VERME- BİR PİLOT ÇALIŞMA

Güney GÜRSEL*

ÖZ: *Karar verme çok önemli bir çalışma alanıdır. Veri çağında güçlü araçlar kullanarak veri işleme çabaları yoğunlaşmaktadır. Zamanında ve doğru karar verebilmek için kaliteli veriye ve kaliteli işleme araçlarına ihtiyaç vardır. Simulasyon gerçek dünyadaki senaryoların sanal ortamda modellenmesidir. Deneme yanılma ile yapılması mümkün olmayan, maliyeti yüksek ya da tehlikeli olan senaryoların sanal olarak gerçekleştirilmesine olanak verir. Bu çalışma bir donanım bakım kısmının modellendiği bir simülasyon çalışmasıdır. Çalışmanın amacı, yöneticiler için, sistemin tıkanan yerleri tespit edip bu tıkanma için çözüm yolları bulunmasına imkân veren simülasyonun, bir karar destek aracı olarak ne kadar önemli olduğunu göstermektir. Çalışmada uzun tamirat sürelerinden müzdarip olan bir hastanenin donanım bakım ünitesi modellenmiştir. Gerekli veriler hastane bilgi sisteminden alınmıştır. Sonuçlar sorunun bakım firmasından kaynaklandığını ve personel artırımı ile çözülebileceğini göstermektedir.*

Anahtar Kelimeler: *Karar verme, Simülasyon, Modelleme, Performans optimizasyonu.*
Jel Sınıflandırması: M15, M16, M51, M54
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DECISION MAKING BY SIMULATION- A CASE STUDY

ABSTRACT: *Decision making is a very important area of research. In the era of data, the efforts to support decision making by powerful data processing tools are becoming intense. True and in-time decision is of great importance. For this, decision makers need qualified data and qualified processing. Simulation is the reconstruction of real world scenarios in the virtual environment. It makes possible to analyze the different scenarios that is hard or dangerous to accomplish with a trial and error method. This is a simulation case study in which a hardware maintenance service is the subject. The aim of the study is to illustrate how simulation can be used as a valuable decision support tool for managers and directors by first detecting the bottleneck and then find a solution by applying different scenarios. In this study, a hardware maintenance unit of a hospital, which is suffering for long fixing times, is modelled. Data are collected from the system that the hospital uses. Results show that there is a problem in the firm service unit and it can be overcome by increasing the number of personnel.*

Key Words: *Decision making, Simulation, Modeling, Performance Optimization.*
Jel Classification: M15, M16, M51, M54
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1. INTRODUCTION

Decision making is the problem of today's world. Managers, physicians, politicians, directors make very important and critical decisions every day. The more people and money affected by the decision, the more critical it becomes. That is why the decision makers need qualified support, no matter how qualified themselves are. They need true, up-to-date and reliable data, in addition, they need powerful tools and techniques to process that data, to make right and in-time decisions.

Soft Computing (SC) methodologies, Data Mining, Big Data Processing, Simulation studies are all in the objective of decision support. SC is a collection of different well-known methods providing flexible information processing capability for handling real life ambiguous situations (Yardimci, 2009). Decision Trees (DTs), Artificial Neural Networks (ANNs), Probabilistic Reasoning methods, Genetic Algorithms (GA), Fuzzy Logic (FL) can be given as the components of SC. Artificial Neural Network (ANN) is the model that tries to emulate human nerve system into computer applications (Amato, López, Peña-Méndez, Vaňhara, Hampl, & Havel, 2013). Genetic Algorithms approach is the effort to emulate natural evaluation into computer applications. The idea behind GAs is building a better solution by combining the good parts of other solutions just like nature does by combining the DNA of living beings (Jain & Srivastava, 2013). Regression and Correlation methods (such as Logistic Regression) evaluates the strength of a relationship where regression is a predictive method of future values by fitting the current available values into a curve and correlation is a descriptive method used to examine the degree of similarity (Jiawei & Kamber, 2001). Bayesian Network is a statistical multivariate model for a set of variables which is defined in terms of two components, a qualitative component, a directed acyclic graph (DAG), and a quantitative component, a conditional distribution of each variable in the graph (Jensen & Nielsen, 2007). Support Vector Machines are manly used for classification. It is a type of supervised machine learning method. The method is presented with a set of labeled data instances and the SVM training algorithm aims to find a hyper plane separating the given dataset into a discrete predefined number of classes consistent with the training set (Mountrakis, Im & Ogole, 2011). Similarity Measures are used for measuring the similarities in big data. Nearest Neighbor Method, Manhattan distance, Euclidean distance is the most known forms of similarity measures. Decision Tree (DT) is a structure where each node denotes a test on an attribute value, each branch represents an outcome of the test and tree leaves represent classes or class distribution, it is a predictive model used for classification commonly (Jain & Srivastava, 2013).

The most fundamental challenge about Big Data is to explore the large volumes of data and extract useful information or knowledge for future use (Wu, Zhu, Wu, & Ding, 2014). Data mining is one of the techniques to utilize this valuable healthcare data. There are many different definitions available in the literature. Drawing from the literature, we can define data mining as the process of analyzing data and discovering knowledge, patterns, associations, rules, anomalies, sequences that are non-trivial, implicit, previously unknown and potentially useful from databases. For business decisions in organizations, data mining utilizes data to discover examples and connections inside the data (Sharma, Sharma, & Pandey, 2018).

Simulation is another powerful tool for decision support. It is commonly used for modelling in engineering research, business analysis, manufacturing planning, and biological science experimentation etc. (Purniya, & Rai, 2018). It is an important tool for emulating the real performance of the systems. Applying different scenarios with different resources can only be possible by the help of simulation. Without simulation, trial and error method becomes very costly for some applications (i.e. pilot training), impossible for most applications such as war scenarios. Improvement of existing systems' performances with different parameters in advance can only be made with the use of simulation. That is why it is an indispensable tool for managers.

Literature are very well interested in simulation researches. Since 1990, there has been a huge increase in the number of articles being published on simulation, that can be numbered as thousands (Rohleder, Lewkonia, Bischak, Duffy, & Hendijani, 2011). One can find thousands of simulation studies in the literature. Some examples may be healthcare education (Rogers, 2011), team-based training (Eppich, Howard, Vozenilek & Curran, 2011), study of the human and system performance (LeBlanc, Manser, Weinger, Musson, Kutzin, Howard, 2011), adverse surgical outcomes (Slakey, Simms, Rennie, Garstka, & Korndorffer, 2014). As understood from the examples, there is no area of limitation for the usage of simulation in research. Every problem can be modelled and different scenarios can be analyzed with low cost and no danger.

A simulation model is the abstraction of the actual process, it captures the resources and various inputs needed to perform the process (Laguna & Marklund, 2013). Simulation and optimization should not be confused. Simulation is an evaluation tool for the different scenarios whereas optimization is used for tuning the system (Laguna & Marklund, 2013).

By determining the weak or congested parts of the system, managers or directors can make more powerful decisions. Simulation is a big decision support tool for determining these weak and congested parts. In this study, a simulation case study is given by modeling hardware maintenance section of information systems department. The purpose of the study is to illustrate how simulation can be used as a valuable decision support tool for managers and directors.

2. BACKGROUND

Hardware Maintenance is a considerable cost item for the institutions. Number of personnel employed is a main issue for this cost. The number of technical personnel should be so optimal that neither it would be less to tackle with the upcoming problems nor more than required. Then the question arises: What is the optimum number and how can we determine it? Here, there is a decision to make. These kinds of questions can only be answered by modelling a good simulation project. In this simulation project, we try to find the bottleneck of the hardware maintenance department to shorten the hardware repair time, called as through time. In this study, hardware maintenance department of a hospital is modelled. The model is called as "system" throughout the paper.

2.1. System description

In the hospital, there is a great number of hardware and there are four technicians to tackle with this hardware. Everyday 30-50 hardware failure complains are received. When the distance of the defected hardware location is considered, a repair takes 20 minutes to two days. The system work flow is given in Figure 1.

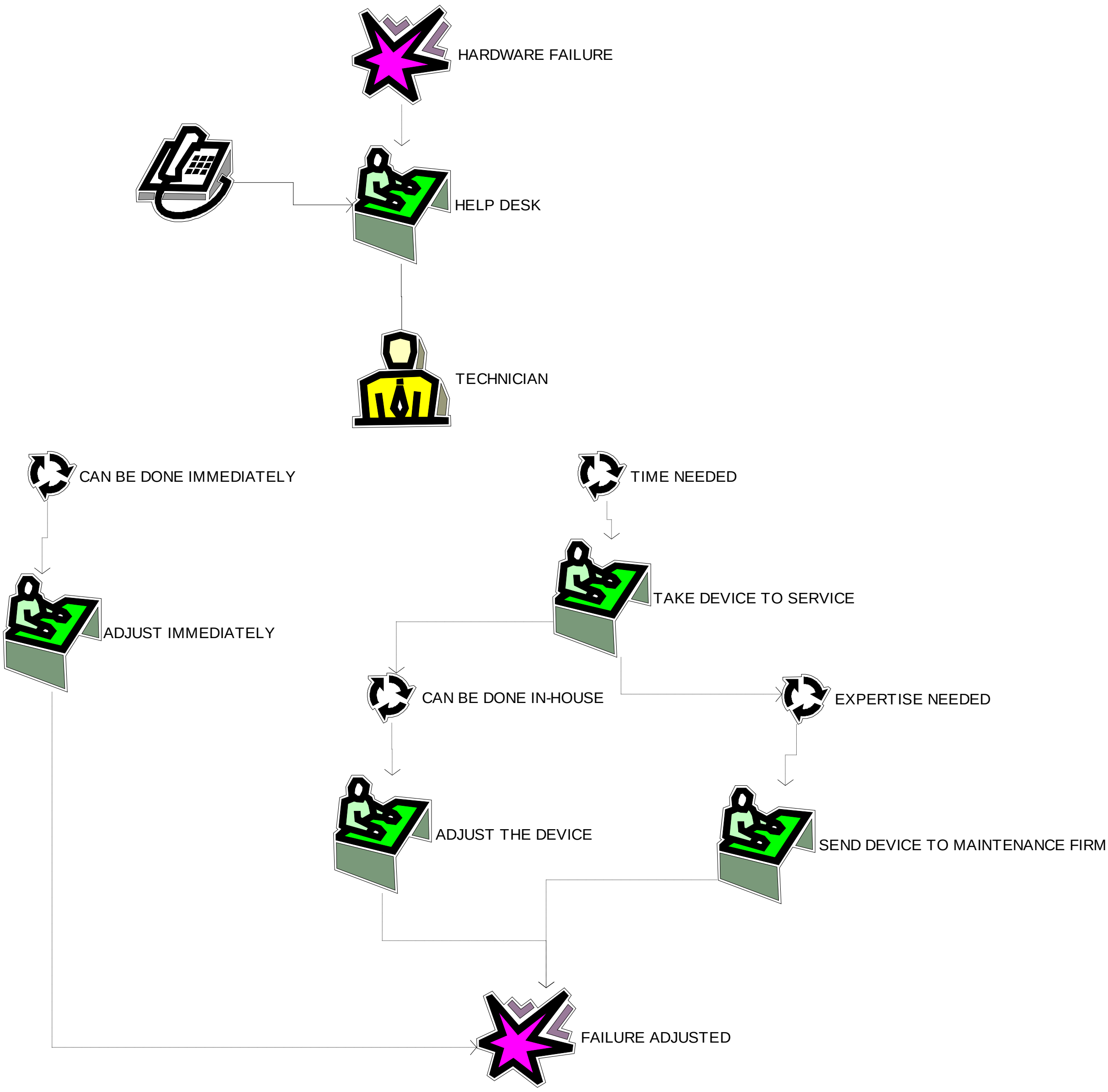

Figure 1. Hardware maintenance work flow

2.2. How the system works

The hardware failure complain is received by a phone call from the user. After recording the complain, it is queued for examination. In the in-site examination, it is determined if it can be repaired in the location of the hardware, or it needs in-house service care or vendor service care. If it needs any service care, the hardware is taken to the related service. After the hardware is repaired, it is taken back to its own place. The problem is the increase in time duration of this cylce. The users experience trouble because of the absence of the hardware during the repair time.

2.3. System boundaries

The system includes all the hardware failure complains. The time to determine whether the hardware can be repaired immediately, by in-house maintenance department or by vendor is neglected because it takes a very short time (within seconds). The time needed to access to the problem area, time to repair in maintenance departments (in-house or vendor), time to send the harware to its location after the repair are included. Time for a technician to access to the defected hardware location is assumed as one to ten minutes constantly.

2.4. Data

Data for the simulation model are captured from the maintenance module of the Healthcare Information System(HCIS). It is observed that monthly incoming hardware failure complains are not changing throughout a year and approximately the same. For this reason, last three months of data is captured and used to construct the model.

3. MATERIALS AND METHODS

A simulation model is made up of entities, events, states, activities/processes. The entity is an object or component of the system that is explicitly represented in the model; a state can be defined as the collection of variables necessary to describe the system at any time, depending on the objectives of the study; these variables are called state variables, while an event is an instantaneous occurrence that may change the state of the system (Zuniga, Mujica Mota, & Herrera García, 2016).

Model is constructed using ARENA simulation software. The simulation model components are given below.

3.1. Entities

Hardware

Technicians

Vendor workers

3.2. States

The states of the hardware:

Waiting to be determined its problem;

Waiting in the in-house service for repair;

Waiting in the vendor service for repair;

Being repaired;

Repaired;

The states of the technicians:

Busy

Idle

The states of the firm workers:

Busy

Idle

3.3. Events

Arrival of hardware failure complain

Arrival of hardware to the maintenance department(in-house)

Arrival of hardware to the vendor service department

Exit of hardware from the maintenance department (in-house)

Exit of hardware from the vendor service department

3.4. Processes

Hardware failure complain admission process

Failure examination process

In-place hardware repair process

Taking hardware to service process

In-house hardware repair process

Vendor hardware repair process

Relocating hardware process

3.5. Simulation Outcomes

Average in-house service repairing time

Average vendor service repairing time

Overall hardware repair through time

Average number of busy technicians

Average number of busy vendor workers

Average number of hardware waiting for examination

Average number hardware waiting in in-house service for repairing

Average number of hardware waiting in vendor service for repairing

3.6. Input Analysis

Using Input analyzer of the ARENA tool, by means of the available data, distributions of the arrival time of the hardware failure complains, service time for in-house service, service time in the vendor, service time in the place of hardware are determined. The distributions are:

- arrival time of the hardware failure complains : -0.001 + WEIB(7.36, 0.494)
- service time in the place of hardware : -0.5+6*BETA(0.197, 0.362)
- service time for in-house service : 5 + LOGN(21.2, 37.9)
- service time in vendor : NORM(117, 53.9)

4. RESULTS

4.1. Running the Pilot Model

After the determination of the distributions of the needed inputs, the pilot model can be run to determine the length of one batch size. The pilot run is performed with the below parameters:

- 1 replication and 7200 time units that correspond to 120 hours of work.
- arrival time of the hardware failure complains :-0.001 + WEIB(7.36, 0.494)
- service time in the place of hardware :-0.5 + 6 * BETA(0.197, 0.362)
- service time for in-house service : 5 + LOGN(21.2, 37.9)
- service time in vendor : NORM(117, 53.9)

The result of the pilot run gave us 37150 time unit as the length one batch.

When 5 batches are run and then 95% confidence interval is constructed, the number of batches are found as 13 and warm-up period as 5500.

For 13 batches;

One long simulation run length = 5500 (warm-up) + 13 * 37150 = 488450

4.2. Running the Final Model

When the final model is run with the parameters founded in pilot model, results given in Table 1 and Table2 are founded.

Variable	**Average**
through_Time	187.29
in-house_service_time	26.429
firm_service_time	717.15

Table 1. variables of time

Variable	**Average**
number of works	1.12
waiting services in in-house services	0.02
waiting services in vendor	9.35
waiting after reporting	0.12
busy vendor workers	1.83

Table 2. variables of resources

In Table 1, it is seen that overall through time is 187 minutes, while in-house service department average is 26 minutes and vendor average is 717 minutes. According to Table 2, there is no waiting repair work in the in-house department (the number of hardware waiting in in-house department is 0.02). The number of busy vendor workers is 1.83, that is, almost all the time all of the workers are busy. The average number in queue in the vendor is 9.35, whereas in in-house department, it is 0.02. It's clear in the situation that the vendor increases the average through time. The bottleneck is in the vendor services.

As seen in the final model, the bottleneck is determined. It is in the vendor service. Now the model is revised to find a solution to the problem. If the number of workers in the vendor is increased and the final model is run again, the results in Table 3 and Table 4 are founded.

Variable	**Average**
through_Time	47.59
in-house_service_time	26.94
vendor_service_time	121.65

Table 3. Second scenario results according to variables of time

Variable	**Average**
number of works	1.13
waiting hardware in house services	0.01
waiting hardware in vendor	0.07
waiting after reporting	0.14
busy vendor workers	1.79

Table 4. Second scenario results according to variables of resources

It is seen that average time decreased from 717 to 121. The number of waiting works decreased to 0.07 from 9.35. The number of busy workers is 1.79.

5. DISCUSSION

This is a case study in a maintenance department of the hospital having problems with the repair time of the HCIS hardware. The purpose of the study is to prove the help of simulation as a valuable decision support tool for managers and directors. We use simulation model to help detect the problem and find ways to solve it with low cost ad zero danger. With the help of running different scenarios, managers can make right decisions.

After having the right settings such as input distribution fits, number of batches and length of a batch, by running the final model the bottleneck and reason of it is detected. Everybody including the managers and the end users thought that the number of in-house workers were not sufficient and the number of technicians should be increased. If the work flow had not been simulated and the number of the technicians had been increased, it would have been a mistake, the problem would have continued, the money and the resources would have been wasted. That would have been a wrong decision.

In this study, it is seen that problem determination is very important for decision making. After determining the problem, as a solution, the number of vendor workers are increased, and the model is run again. With this action, it is seen that the service time decreased to 121 from 717 unit time (83.2%). The number of busy workers is 1.79 when the total number is 5. It seems that this is not the optimum number. There are idle workers. We can decrease the number and run the final model again, until consistent, acceptable firm servicing time is founded and almost all the workers become busy.

Before making the simulation, every end user in the hospital thinks that the number of technicians in the in-house services is not enough. The simulation showed this comment is partly true. The striking outcome became; the queue in firm cause the average throughout time increase.

The study has proven that with the right model, work flow-based problems can be detected and solved with little effort and no danger. This study can be a proof that Simulation is a good tool for managers and directors for decision making, to keep the costs in optimum level and help them optimize their sources.

In the literature there is some ambiguity in defining what is a simulation and what is a game (Costin, O'Brien, & Slattery, 2018). Simulation is a replica of reality and actual events, and the outcomes are used for the decisions to be made within a given context (Costin, O'Brien, & Slattery, 2018). To encourage the development of entrepreneurial skills such as decision-making, risk management, problem solving, communication, and teamwork, simulation is increasingly being used in both academia and business (Costin, O'Brien, & Slattery, 2018). These skills are very important to start one's own business (Garalis & Strazdiene, 2007)

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