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Improvement of Process and Staff Utilization in a Maintenance Service by Using Simulation

Verbesserung der Prozess-und Personalplanung in der Instandhaltung mit Hilfe der Simulation

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Abstract: The telecommunication service providers brought services to their customers continuously and rapidly with a minimum level of cost during the last a couple of decades almost all around the World. Furthermore, quality level of maintenance processes of a telecommunication supplier is very important to guarantee customer satisfaction. The number and qualification of staff working in a maintenance team and organizational structure of the service provider affect the cost of maintenance. Therefore, process and staff planning become important issues in the maintenance processes of telecommunication sector.

The purpose of the current study is to investigate maintenance processes of a telecommunication system in Turkey by using simulation method. The system performance indicators which are the number of customers served, waiting times and resource utilization rates are the main interest to be forecasted by collecting data from a local maintenance unit which has four teams of a telecommunication company in Turkey. First, an initial simulation model is developed to analyze the current status of the maintenance process. The questions to be answered are the structure of the current breakdown occurrences, the resource utilization rates and the number of defects repaired in a time interval. Then, three alternative models have been developed and simulated to evaluate the same performance parameters for the process improvement and staff planning. The simulation results suggest that a new staff structure is necessary in maintenance teams to improve customer satisfaction.

1 Introduction

The telecommunication service providers brought services to their customers continuously and rapidly with a minimum level of cost during the last a couple of decades almost all around the World. Furthermore, quality level of maintenance processes of a telecommunication supplier is very important to guarantee customer satisfaction. The number and qualification of staff working in a maintenance team and organizational structure of the service provider affect the cost of maintenance. Therefore, process and staff planning become important issues in the maintenance processes of telecommunication sector.

Staff costs, economic stability and customer requirements are affected from the structure of maintenance services in companies directly. Alternatives in the different number of maintenance teams in companies have an effect on the utilization of members of maintenance teams. Qualifications of workers and working hours play an important role to construct the number of teams.

In this point, the customer demands for a telecommunication company can be grouped as Asymmetric Digital Subscriber Line (ADSL) problems, cable problems, connection line problems and new line connections. A simulation study is used to determine the parameters of a telecommunication system for maintenance in this paper.

Mainly, the queuing problems are discussed to reduce waiting time, total time per entity etc. Cost, time and quality are placed as primary components for manufacturing and service systems to be optimized. The combination of the working staff is related with the organizational structure of the system, utilization of resources, flexibility and environmental conditions. Furthermore, the simulation methods help to complex systems in decision making processes for cost and time related issues. Thus, different alternatives and strategies could be developed by using simulation.

This paper deals with improvements in the maintenance processes of a local area telecommunication system which serves to a population of 60,000 people supported from Turk Telecom (TT) Company. A real system with collected data is simulated and evaluated by using ARENA 7.1 simulation software. In conclusion, different organizational concepts are developed as alternatives for process and staff planning for analyzing the queue waiting times, utilization rates and outputs.

2 Background

In the literature, the simulation studies for the staff planning and measurement of service efficiency have presented in production systems, health service systems, shopping centers, education and finance facilities, traffic systems etc. in service systems (GIRGINER, SAHIN 2007).

Some research has been presented for staff or workforce planning with alternative structures of simulation models and performance measures, especially working hours are evaluated (ZÜLCH et al. 2002). A personnel-oriented simulation tool has been developed, and integrated as ESPE for modeling human reliability in production systems. They tested effectiveness of the new methods for quality-oriented assignments of staff to functions and workplaces (ZÜLCH et al. 2003). In automatic control engineering, a simulation model has been developed by using ARENA for electronic components to improve production processes. Three scenarios for working sequences are simulated and the mean process time per order and the mean quantity per order are compared. Consequently, the different allocation of resources and the best distribution of staff have been found for the individual scenarios (SCHULZ, BECKER 2008).

A practical discrete event simulation based policy has been developed as an analysis tool for maintenance of bridges. The significant improvements have been provided in the network conditions (DEVULAPALLI et al. 2002). In service systems, staffing problems arise and widely are used in applications. A staffing problem has been presented for telecommunications industry in a trouble diagnosis and repair system by using simulation to find effective performance visualizations and optimal staffing allocations. The results are evaluated by the analytic mean value analysis (BOYER, AMASON 2002). About preventive maintenance, another study at a distribution warehouse has been presented for a conveyor system. The integrating predictive maintenance strategies with production planning strategies have been used to reduce of downtime for the management of equipment breakdown and failure conditions by simulation with ARENA. For instance, the downtime was reduced more than 50 % and work in process inventory was reduced more than 65 % (CONTRERAS et al. 2002). The selection of the preventive maintenance schedule has been proposed by a multi criteria decision making approach. A simulation model has been developed by ARENA for production line utilization rate of a packing line process selection. The conceptual approach has occurred with multi criteria decision making analysis tool by using simulation modeling for this process (ALTUGER, CHASSAPIS 2009). An optimized maintenance design has been implemented to analyze the capability of an auto part manufacturing production system by using simulation. The maintenance scheduling procedures and their effects have been presented for the overall system performance. The results have been validated through real-life applications and this study has been demonstrated to help for manufacturing performance improvement (ALI et al. 2008).

3 The Case Study: Analysis of Maintenance Service by Simulation

In this study, a telecommunication system is examined in a local area with a population of 60,000 people by supporting Turk-Telecom (TT) Company. The purpose of this study is to investigate maintenance process of TT by using the ARENA simulation software that is based on mechanisms of event-oriented simulation. The feature of event-oriented simulation is that each planned event has a time of occurrence and its occurrence causes a certain transition of status.

3.1 The Workflow of Maintenance Process in a Telecommunication System

A telecommunication system is analyzed systematically. Then, a maintenance process workflow for a telecommunication system is presented. The customer requests and/or complaints are summarized in Figure 1. Figure 1 represents the sources of problems which are automatic arrivals from telecommunication lines and different requests of customers. In this point, some problems are solved with phone interviews. Remaining problems are transferred to maintenance teams. Four different groups of maintenance teams are placed in the system as follows:

- The ADSL Teams: Any ADSL problems and breakdowns are solved and replied to customer requirements.
- The Master Cable Teams: The team works on master communication lines as fiber optical lines.
- The Phone Line Teams: The team works for telephone lines only.
- The New Line Teams: The team works for new telephone line connections only.

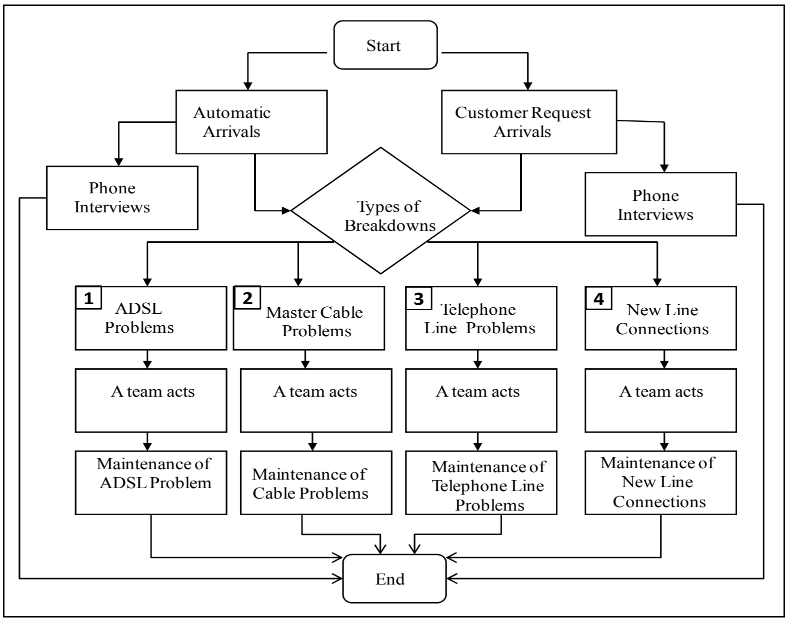

Figure 1: *The Workflow Diagram for a Telecommunication Maintenance Unit*

3.2 Initial and Alternative Staff Structures in Maintenance Processes

In this section, three different scenarios other than the current situation are developed and evaluated for customer requirements. The team structures of all alternatives which are the initial situation (A0) and alternatives (A1, A2, and A3) are given in Table 1.

In the initial situation (A0); the ADSL line group which has one team with two persons, the phone line group has four teams with two persons in each team, the new phone line connection group has one team with two persons and the master cable line group which has one team with two persons. The entities are classified in two classes which are breakdown types and telephone connections. The percentage of arrivals to the system has a uniform distribution with parameters of 3 and 12 minutes, UNIF(3,12) minutes, for all departments. 32 % of arrivals are classified as

ADSL problem, 6 % of arrivals are classified as cable problems, 19 % of arrivals are classified as new phone line connections, 42 % of arrivals are classified as phone line problems and 1 % of arrivals are classified as other types of problems which are solved with phone interviews.

	A0	A1	A2	A3
The ADSL Teams	Team1	Team1	Team1 Team2	Team1
The Master Cable Teams	Team1	Team1 Team2	Team1 Team2	Team1 Team2
The Phone Line Teams	Team1 Team2 Team3 Team4	Team1 Team2 Team3 Team4	Team1 Team2 Team3 Team4	Team1 Team2 Team3 Team4
The New Line Teams	Team1	Team1	Team1	

Table 1: *The Initial Situation (A0) and Alternative Staff Structures (A1, A2, A3)*

The service time distribution parameters are given in Table 2 with details. In model-A1, the Team4 in PLT is allocated as a new team to MCT Group. In addition to A1, a new team is joined to ADSL Team in model-A2. Then, in the alternative structure A3 model, team4 in PLT is placed from PLT to MCT and team1 in New Line Team Group is placed into PLT as team4. Thus, the all of the staff of Phone Line Team has been assumed as the same qualification for phone line problems and new phone line connection (NLT) process. Process times are determined in two different ways. If an entity is arrived as a type in PLT, then its processing time is assigned as TRIA(5,25,35) minutes. If an entity is arrived as type in NLT, then it is assigned as EXPO(8) minutes in A4.

Team Name	Distribution Type (min)
The ADSL Teams	Uniform; UNIF (5,15)
The Master Cable Teams (MCT)	Triangle; TRIA (25,70,150)
The Phone Line Teams (PLT)	Triangle; TRIA (5,25,35)
The New Line Teams (NLT)	Exponential; EXPO (8)

Table 2: *Service Time Distribution*

The initial and alternative models are simulated for a month by collecting the data of the study in ARENA 7.1.

4 Experimental Results

In the beginning, the initial model (A0) is simulated and then the alternative scenarios are developed to find the better performance levels of staff allocations and qualifications. The results are evaluated to reduce waiting times in queues, and to increase the number of replies as outputs and better utilization rates in all three alternative scenarios.

The alternative one (A1) has been developed from A0 by adding a team to phone line problems group. Its results are examined and then the alternative model (A2) has been obtained by adding a team to ADSL group of A1. Some structural changes are provided for personnel qualifications of maintenance units to have A3. The phone line and the new line groups are combined with four teams and one team is assigned to the ADSL group and two teams are allocated to the master cable group to form the alternative three (A3). The alternatives are included personnel planning. The simulation results are given in Table 3 for all four alternatives.

Simulation Results			Outputs				Queuing Waiting Times (min)				Personnel Utilization Rates			
	Arrive Time	Process Time	A0	A1	A2	A3	A0	A1	A2	A3	A0	A1	A2	A3
ADSL Team	UNIF(3,12)	UNIF(5,15)												
		Team 1	653	662	407	660	44,36	72,20	10,82	60,03	0,98	0,99	0,61	0,98
		Team 2			395				8,72				0,59	
Master Cable Team	UNIF(3,12)	TRIA(25,70,150)												
		Team 1	117	69	81	63	154,03	22,30	21,59	14,00	0,93	0,55	0,65	0,48
		Team 2		68	71	68		11,30	14,50	15,85		0,52	0,52	0,51
Phone Line Team	UNIF(3,12)	TRIA(5,25,35)												
		Team 1	222	288	337	327	14,92	24,00	27,11	17,72	0,57	0,72	0,83	0,69
		Team 2	201	290	344	276	7,50	13,98	31,50	12,20	0,49	0,72	0,86	0,58
		Team 3	214	299	347	310	9,91	15,66	34,11	9,85	0,54	0,75	0,84	0,66
		Team 4	205			320	7,63			14,20	0,5			0,69
New Line Team	UNIF(3,12)	EXPO(8)												
		Team 1	386	409	486		6,28	7,27	9,95		0,49	0,54	0,65	

Table 3*: The Simulation Results*

The simulation models answered the questions that arisen in the beginning of the study. The all three alternative models are run for predefined simulation times. The results are given in Figure 2 to compare alternative models. These results can be summarized as follows:

- **The number of Outputs:** The number of outputs of the alternative A2 is better than A0 24 % in average. Therefore, more problems are solved and more new phone lines are connected in A2.
- **Queue waiting times:** Queue waiting times for A2 model is 19.79 minutes which is 43.4 % better than in alternative A0, which is 34.95 minutes in average. The average waiting time is 20.55 for all alternatives. The waiting time is 154.03 minutes, 29.85 minutes, 14.00 minutes and 15.85 minutes for alternatives A0, A1, A2, A3 respectively, for the cable problems group.
- **Resource utilization rates:** The utilization rates of phone line problems group in A0 are lower than the utilization rates of alternative A2. The difference is about 22 %. The other groups have sufficient rates for the study goals. The personnel utilization rates reduced from 93% in A0 to 48% in A2 and to 51% in A3 for the cable defects.

The simulation results show that some improvements are necessary to have better efficiency of the actual maintenance system for waiting times, utilization rates, and qualification of the staff for processes of the telecommunication system.

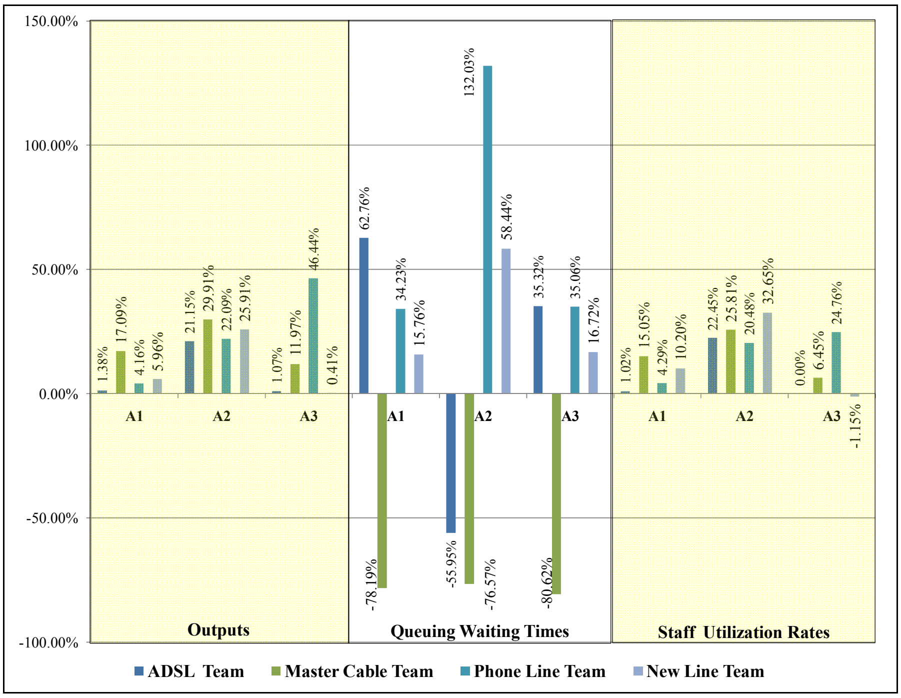

Figure 2: *The Comparison of the Results of Alternative*

5 Summary and Conclusion

The simulation models provide some opportunities to analyze the current situation of systems for improving system parameters with the performance measures. Some scenarios are analyzed before purchases of expensive equipments. Therefore, the better organizational structures are designed for the systems with many organizational goals as higher level of customer satisfaction.

A maintenance unit of a telecommunication system in Turkey is investigated with initial model and alternative models for evaluating queue waiting times and outputs of the performance measures first time in this study.

The results are discussed with the management of Kuşadası TT Company. This study has noticed them to start works on a new organizational development process. The further research can be assessment of working hours and cost analysis of staff with simulation method.

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