IT Service Level Optimization: A Case Study

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Abstract

Over years, information technology (IT) has been a fundamental success factor by its contribution to the efficiency, profitability, and growth for enterprises. In time, IT has become a strategic partner of companies. As a consequence, the role of IT has evolved and organizations have become to see IT as a part of business rather than a separate unit. Thus, IT services have to function continually to make enterprises reach their business goals. However, IT services' working uninterruptedly is almost impossible due to many constraints (i.e. hardware and software requirements, budget etc.) and strict working conditions in the digitalized age (i.e. working 24 hours a day and 7 days a week, rapid change, complexity etc.). Therefore, there is a need for optimizing IT services' availability. This study suggests a new methodology to meet this requirement. For this aim, after preparing an efficient IT service catalog and determining right relationships between services, IT service level is optimized by means of a new mathematical model. Moreover, the proposed method is applied with both random instances and a real case study of a big Turkish IT company serving to a finance group. It is analyzed that the proposed method provides efficient service level.

Keywords
Information technology, service management, service level optimization, mathematical model, case study

1. Introduction
IT has been considered only as a provider of software applications until 1980's. Afterwards, the concept of IT services has appeared in the industry and IT Service Management (ITSM) has been introduced by the professionals. IT service is a means of enabling value to customers by facilitating outcomes that they want to achieve without the ownership of specific risks and costs (Van Bon and Van Selm 2008). Relevantly, ITSM is a set of activities performed by enterprises to provide IT services to their customers. It contains all activities and processes required to design, build, deliver, operate, and support IT services (Mesquida et al. 2012).

In recent years, different IT governance frameworks have been utilized within IT organizations (i.e. COBIT - Control Objectives for Information and Related Technology, ITIL - Information Technologies Infrastructure Library, Six Sigma, ISO/IEC - International Organization for Standardization/International Electro-Technical Commission standards and many more.) (Brooks 2006, Tan et al. 2009, McNaughton et al. 2010). Among these frameworks, ITIL is the most common known and accepted guidance of ITSM with the highest adoption rate of 24% (Marrone and Kolbe 2011). ITIL tries to align ITSM processes of organizations with their business requirements. According to ITIL, the lifecycle of IT consists of five stages as service strategy, service design, service transition, service operation, and continual service improvement.

Firstly, service strategy is the domain where the strategy to serve the customer is decided. This stage provides guidance on the ways of designing, developing, and implementing ITSM both as a strategic asset and an organizational capability. For this aim, customer requirements and market conditions are assessed, the service is defined, what the customer gets by this service (utility) is determined, how well the service is delivered to the customer and its impact in terms of availability, security, capacity and continuity (warranty) is analyzed in this stage. IT organizations work closely with business units to determine appropriate service strategies for short and long terms with the help of service strategy. Moreover, service strategy provides IT organization ability of thinking and acting strategically by means of its main processes which are strategy generation, service portfolio, demand, and financial management (Indounas 2009).

Secondly, service design is the step of designing new services with different aspects (i.e. technical and enterprise architecture, management and measurement systems etc.), changing and improving existing services for the live environment to meet business goals and support the lifecycle of the service. It is clear that the total cost of ownership is reduced by designing suitable services, processes, and technology. Furthermore, service and operational quality is improved by achieving better service alignment, performance, and governance by means of main processes of this stage which are service catalogue, service level, capacity, information security, supplier, service continuity, and availability management (Brocke et al. 2011).

Thirdly, new or modified services required by the customers are built, tested, and delivered in the service transition stage. Service transition ensures that changes in services and ITSM processes are fulfilled in an appropriate way. IT organizations mainly focus on the cost, quality, and time during the service transition. Main purposes of service transition are planning and managing resources needed for the deployment, assessing capability and risk of the service before it is deployed, providing efficient knowledge and information to speed up effective decisions related to the service transition. These goals and benefits are achieved by managing main processes (transition planning and support, change, assets and configuration, release and deploy, validation and testing, evaluation, knowledge) effectively (Kumaran et al. 2007).

Fourthly, the purpose of the service operation is to coordinate the processes and activities needed to provide services to customers at an agreed level. Thus, the value that the customer wants is realized in this stage. Service operation enables efficiency and effectiveness by delivering and supporting IT services with the help of main processes which are event, incident, request, problem, and access management (Punyateera et al. 2014).

Finally, the purpose of continual service improvement is to look for ways for the improvement of effectiveness and process efficiency by aligning IT services to changing business requirements. These improvement activities continue in all phases through service strategy, design, transition, and operation. In this phase, firstly, data is collected and trends are analyzed in comparison with business goals and service level agreements. Next, targets are set to improve efficiency, quality, and effectiveness. A service improvement plan is prepared by considering different requirements (i.e., business, technology, security, regulatory etc.) and improvements are implemented by fulfilling this plan (Long 2012).

ITIL is a mature, widely-used and practicable standard in IT organization management. However, it is limited in providing ways of measuring service level performance and it does not propose any analytical and optimization methods to maximize service performance. Besides, although there are many studies on IT performance management, most of them provide theoretical and qualitative approaches mainly focusing on only variable metrics. While ITIL and the other frameworks include many process metrics, they do not provide sufficient information how IT service performance can be measured and optimized practically (Lahtela et al. 2010).

This study suggests a novel systematic approach to optimize the performance of IT services. For this goal, firstly, preparing an efficient service catalog as a central source of information including current IT services is proposed in line with service design step of ITIL. Secondly, ways of determining right relationships between services are presented. Thirdly, a new mathematical model using service catalog and relationships between these services is proposed to optimize the performance of IT services.

Our contribution to the literature is integrating service design processes of ITIL and a new mathematical model to constitute IT service catalogue, define relationships between services, and optimize IT service performance by considering dependencies, significance level, and service level agreements negotiated with customers. Another great contribution of this study is applying proposed methodology to a real-life case study and finding efficient results achieving high service levels in an IT organization. Apparently, there is a need to optimize IT service performance in both academic and real cases. Therefore, our contribution to the literature and IT industry has tremendous importance. The remaining parts of the paper is as follows: The research related to IT performance measurement methods is presented in Section 2. Section 3 is dedicated to ways of preparing an efficient IT service catalog, determining right relationships between services, and IT service level optimization with the help of a novel mathematical model.

Experimental study on randomly generated problems and a real-life application of the proposed methodology in a big Turkish IT company are presented in Sections 4 and 5, respectively. Finally, conclusions and future studies are summarized in Section 6.

2. IT Performance Measurement Methods

IT provides enterprises many advantages (i.e. quality, customer satisfaction, agility, cost efficiency, competitive power, new business opportunities, innovative products etc.) (Nikoloski 2014). As importance of IT has increased for the enterprises to achieve their strategic and operational goals, organizations has enhanced IT investments. However, most of these investments conclude with undesirable results (Turban et al. 2001). Therefore, suitable methods of IT performance measurement are required in academic and professional life to evaluate IT contribution to the value chain of organizations (Lomerson and Tuten 2005). It is clear that, measuring IT performance is fundamental to monitor, control, and improve the performance of enterprises. For this reason, many performance measurement tools and methods have been used both in the academic and practical life. In fact, there are different performance measurement levels in IT organizations. These levels mainly can be categorized as organization, information systems, and service performance measurement levels from top to bottom.

Firstly, measuring organizational performance is an effectiveness assessment in the uppermost level (Henri 2004). Servqual (Parasuraman et al. 1985), Balanced Scorecard (BSC) (Kaplan and Norton 1992), and performance prism (Neely et al. 2002) are the most widely used organizational performance measurement techniques. Among these approaches, BSC can be considered as the most common performance management methodology in organizational level (Basar 2021). BSC method rests on four dimensions which are financial, customers, internal business processes, learning and growth. In this technique, the critical success factors (CSFs) support the realization of the company's vision and mission for each dimension. CSFs are measured with the help of key performance indicators (KPIs) (Kaplan and Norton 1992). Thus, performance metrics may easily be connected to organizational objectives. A survey conducted by Bain and Company (2017) with 1,200 respondents demonstrated that almost 53% of organizations use BSC approach to measure their organizational performance. It is widely used in many different theoretical and practical studies for a long time (Dobrovic et al. 2018, Alvarez et al. 2019, Rompho 2020, Basar 2021, Mauricio and Hinojosa 2021).

Secondly, evaluating the performance of information systems and IT functions is a continuous way to assess outcomes of all IT processes (Son et al. 2005). Different metrics are proposed in order to measure the performance of information systems in the literature. For example, productivity (Dedrick et al. 2003), quality (Chang and King 2005), effectiveness (Seddon et al. 2002), and the performance (Son et al. 2005, Marchand and Raymond 2008) are the most common criteria proposed for this aim. Saunders and Johns (1992) proposed Delphi method to evaluate the information systems function performance. Chang and King (2005) developed a theoretical input-output model for this purpose. They also emphasized the lack of empirical studies in the performance measurement of information systems due to the absence of validated performance metric.

Thirdly, measuring the service performance is a way of increasing the reliability of services and it is discussed in different studies. Suhairi and Gaol (2013) propose to measure service performance by Statistical Process Control. Veronica and Suryavan (2017) reviewed the literature on the service performance based on COBIT and ITIL frameworks. Suryavan and Veronica (2018) assess the service maturity of IT division in Binus University and evaluates IT service performance with the help of COBIT and ITIL frameworks.

Obviously, the practical studies about the IT service performance optimization is scarce, and the limitation on this area induce problems in different IT performance metrics (i.e., service quality, continuity, performance, cost, customer satisfaction etc.). Although IT service availability and achieving high performance level is fundamental in the digital age, to the best of our knowledge, there is no study proposing IT service optimization by integrating ITSM and ITIL perspective with mathematical models. Our study aims to optimize IT service level and apply the proposed approach in a big IT company.

3. Proposed Methodology

The proposed method optimizes IT service performance in a structured way. For this aim, firstly, an up-to-date service catalogue has to be available in IT organizations as it is addressed in the service design domain of ITIL. The service catalog concept was originally offered as one of the best practices in ITIL. It collects all services which IT company provides in a single place. It links the service request to the service fulfilment process. Thus, end users and customers can easily reach the required services. Although the content of the service catalog is customized for each IT company, it is fundamental to have a service catalogue including appropriate and sufficient information required to identify services. Basic components of an effective service catalogue are service name, service description, service availability, service criticality, who can order the service, ordering procedure, pricing, service level agreements, service owner, service representatives, and alternative services (Gartner 2018).

Secondly, dependencies between all services have to be determined after constructing the service catalogue. To this end, two questions are answered for each service to define dependencies between IT Services properly: i) which services have to be up in order to make this service available? and ii) the availability of which services are supported and affected by this service? These service relationships can be gathered with the help of systems and historic data. For instance, it is obvious that “active directory identity management”, “storage management”, “data storage” and “wide area network management” services affect “e-mail services” since it is not possible to receive and send an e-mail if these services do not work. Similarly, “all services” in an IT company are affected by “e-mail service”.

According to the literature review, while there are many studies related to ITSM frameworks and IT performance metrics, there is a shortcoming in ITSM performance optimization. Therefore, we propose a new mathematical model to meet this requirement. In IT, the criticality and importance of services can be varied according to the information included in the service catalogue and dependencies between services. Moreover, downtime or time to repair of each service have to be considered based on the agreements made with the customer of IT organization. Thus, a new mathematical model to optimize the performance of IT services is defined as follows: (See Table 1 for the notation).

Maximize $\sum_{t \in T} \sum_{i \in I} a_i y_{it}$

Subject to;

$$b_i y_{it} \geq \sum_{m \in K_i} y_{mt} \qquad \forall i \in I \;,\; \forall t \in T \qquad (1)$$

$$y_{jt} = 1 \qquad \forall j \in J \;,\; \forall t \in T \qquad (2)$$

$$\sum_{i \in I} y_{it} \geq d - e \qquad \forall t \in T \qquad (3)$$

$$\sum_{i \in I} a_i y_{it} \geq v \qquad \forall t \in T \qquad (4)$$

$$y_{it} + y_{i,t+c_i} \geq 1 \qquad \forall i \in I \;,\; \forall t \in T \qquad (5)$$

$$y_{it},\; y_{jt}, y_{mt} \in \{0,1\} \qquad \forall i, m \in I \;,\; \forall j \in J \,, \forall t \in T \qquad (6)$$

Table 1: Notation used in the model

Notation	Definition
<u>*Sets*</u>	
T	Set of working periods
I	Set of services provided by IT company
J	Set of critical services
K_i	Set of services affecting the availability of service i defined in set *I*
<u>*Indices*</u>	
t	Planning period (daily)
i	The service provided by the company
j	The critical service provided by the company
m	The service affecting the availability of other service

Parameters

a_i	The value of the service *i* as specified in the service catalogue
b_i	The number of services required to work for the availability of service *i*
c_i	The maximum time to repair service *i* when it is down (in hours)
d	Total number of services provided by the company
e	The maximum number of services which may be down in the same period
v	The minimum value of services working in the same period

Decision Variables

y_{it}	Binary variable which is 1 if service *i* works in period *t*, and 0 otherwise

The objective function is for maximizing the overall value of available services. The Constraints (1) indicate the dependencies between services. For instance, if the availability of service 5 depends on the availability of services 6, 7, and 8 ($b_5 = 3$); values of y_{6t}, y_{7t}, and y_{8t} must equal to 1 for service 5's availability to have $y_{5t} = 1$. The Constraints (2) show that the critical services affecting the availability of almost all other services must be working in each time. For example, storage, database, and security services can be considered critical in IT industry since any interruptions in these services cannot be tolerated. The Constraints (3) are used to guarantee at least a predetermined number of services ($d – e$) are working in each period due to the agreements made with the customers and workforce constraints which will be required when services are down. Constraints (4) show the total value of working services is at least a predetermined value (v) depending on the company strategies and customer expectations. The Constraints (5) guarantee the service availability in maximum time required to repair the service which is down. For instance, if the service 2 is interrupted at a time ($y_{2t} = 0$) and $c_2 = 4$ which means in maximum 4 hours the service must be working, then $y_{2,t+4}$ must be equal to 1. Constraints (6) indicate that decision variables are binary.

4. Experimental Study

Before applying the proposed methodology to a real life problem, the proposed mathematical model is tested based on randomly generated instances. For this aim, firstly, service catalogues are randomly generated including different number of services. We totally generated 50 random service catalogues by considering 10 catalogues each with 50, 100, 150, 200, and 250 services. It is clear that solving the mathematical problem in daily period by taking working period in the model (t) in days cannot provide sufficient continuity especially in digital channels which must be working 24 hours a day and 7 days a week. On the other hand, the complexity of the problem will highly increase if t is taken in minutes due to the increase in the number of binary variables. Therefore, t in the mathematical model is considered in hours and the problem is solved for each day separately. The value of each service (a_i) is assigned according to the 1-5 scale where 1 means "the least valuable" and 5 addresses "the most valuable" service. Moreover, dependencies between services are determined randomly. All parameters in the mathematical model (a_i, b_i, c_i, d, e, and f) are also generated for each catalogue and each service under the assumption that at least 10% of all services are critical which means that they must be working at any time, and the number of pair dependencies between services is at least 5 times the number of service in each case. Furthermore, it is assumed that the maximum number of services which may be down in the same period (e) is at most 10% of the number of services and the minimum value of services working in the same period (v) is 3 times (the average value in 1-5 scale) the number of service in each instance. We solved all problems with the last version of ILOG CPLEX. The results for 50 randomly generated instances are summarized in Table 2.

Table 2: Results of random instances

Catalogue	Number of services (d)	The number of critical services which must be working at any time	The number of pair dependencies between services	The maximum number of services which may be down in the same period (e)	The minimum value of services working in the same period (v)	Solution time (in seconds)
1	50	5	250	1	150	12.35
2	50	6	260	1	150	13.42
3	50	8	270	2	150	20.48
4	50	10	280	2	150	22.08
5	50	12	290	3	150	30.79

6	50	15	300	3	150	31.60
7	50	18	320	4	150	40.68
8	50	22	340	4	150	52.35
9	50	26	350	5	150	61.84
10	50	28	400	5	150	81.62
11	100	11	500	1	300	195.05
12	100	15	520	2	300	186.42
13	100	17	540	3	300	200.69
14	100	20	560	4	300	216.80
15	100	25	580	5	300	240.45
16	100	28	600	6	300	245.87
17	100	32	620	7	300	260.94
18	100	35	640	8	300	288.35
19	100	46	660	9	300	304.58
20	100	62	680	10	300	320.62
21	150	24	750	3	450	675.08
22	150	28	775	4	450	684.66
23	150	30	800	5	450	702.39
24	150	32	825	6	450	750.32
25	150	35	850	7	450	808.74
26	150	42	875	8	450	843.36
27	150	45	900	9	450	872.91
28	150	52	925	10	450	908.75
29	150	58	950	11	450	952.90
30	150	65	1,000	12	450	1,084.36
31	200	34	1,000	2	600	1,572.06
32	200	42	1,050	4	600	1,684.42
33	200	48	1,100	6	600	1,753.60
34	200	53	1,150	8	600	1,805.69
35	200	65	1,200	10	600	1,875.94
36	200	72	1,250	12	600	1,904.06
37	200	80	1,300	14	600	1,909.87
38	200	92	1,350	16	600	1,946.34
39	200	107	1,400	18	600	1,986.02
40	200	124	1,500	20	600	1,994.60
41	250	36	1,250	4	750	2,084.68
42	250	44	1,300	6	750	2,127.09
43	250	53	1,350	8	750	2,140.32
44	250	68	1,400	10	750	2,260.85
45	250	86	1,450	12	750	2,328.04
46	250	95	1,500	14	750	2,360.94
47	250	108	1,550	16	750	2,401.38
48	250	120	1,600	18	750	2,476.92
49	250	135	1,650	20	750	2,512.60
50	250	146	1,700	22	750	2,548.71

As it is seen in Table 2, optimal solution is obtained for all instances. However, when the number of services and the pair dependencies between services in the catalogue increase, the solution time also highly increases due to the problem complexity affected by the number of binary variables in the mathematical model. It is observed that the optimal solution is found in maximum 82 seconds for random companies which provide 50 different services to their customers. On the other hand, optimal solutions for random instances with 250 services are obtained in between 2,084 and 2,548 seconds (35 and 42 minutes). Thus, the solution time for all instances is found acceptable since the working period t in the mathematical model is considered in hours. Objective function values are also found reasonable and acceptable according to the size of instances, parameters, and assumptions.

5. A Case Study in an IT Company

The proposed method is applied for a real-life service level optimization problem of a large IT company in Turkey. The company provides IT services for a financial group which has participations and branches in 18 countries and more than 1,700 bank branches in Turkey. Main IT services provided by the company are application development including all financial products (i.e. core banking, internet-mobile applications, ATM, credit card etc.) IT infrastructure (data center, network management, central systems etc.), information security, and IT consultancy (e.g., project management, procurement etc.). The company tries to optimize the performance of its services to reach maximum service continuity with the minimum interruption. For this aim, firstly, the catalogue including all active services provided by the company is prepared with the help of all managers working in the company. Totally, the company provides 86 services (d in the proposed mathematical model) to all its customers. Secondly, dependencies between services are obtained with the help of continuity tests and experienced managers' judgments. Thus, the number of services required to work for the availability of service i (b_i) is determined for each service. Furthermore, the value of service i (a_i) is specified based on dependencies between services, the impact analysis, customers' feedback, and opinion of managers working in the company according to the 1-5 scale as in the experimental study with random instances. In connection with the value and criticality of service i (a_i), the maximum time to repair service i when it is down (in hours) (c_i) is specified according to the service level agreements made with the customers. Moreover, the maximum number of services which may be down in the same period (e) is determined based on agreements and the number of technical staff who will repair the interruptions. Finally, the minimum value of services working in the same period (v) is specified according to the company's strategies and customer expectations. Similar to the experimental study with random instances, working period (t) in the mathematical model is taken in hours and the service level optimization problem of the company is solved daily due to the same reasons. Finally, the results of the service level optimization problem of the company are given in Table 3. The name and the details of services in the catalogue cannot be presented openly due to the privacy and information security policies of the company. Therefore, services in the Table 3 are numbered from 1 to 86.

Table 3: Results of the case study

The service	The critical services which must be working at any time	The value of the service 1: "the least valuable" and 5: "the most valuable" (a_i)	Which other services' continuity affects the availability of this service?	The number of services required to work for the availability of this service (b_i)	The maximum time to repair service i when it is down (in hours) (c_i)
1		3	3, 13, 15, 18, 22, 34, 39, 45, 50, 57, 64, 82	12	1
2		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
3	X	5	13, 18, 22, 34, 39, 45, 50, 57, 64, 82	10	0
4		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
5		5	3, 13, 18, 22, 25, 28, 34, 39, 45, 50, 57, 64, 82, 85	14	0.25
6		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
7		4	3, 13, 18, 22, 30, 34, 39, 45, 50, 57, 64, 82	12	0.5
8		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
9		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.25
10		4	3, 10, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	12	0.5

11		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
12		4	3, 8, 13, 16, 18, 22, 34, 39, 45, 50, 57, 64, 82	13	0.5
13	X	5	3, 18, 22, 34, 39, 45, 50, 57, 64, 82	10	0
14		3	3, 6, 13, 18, 21, 22, 34, 39, 45, 50, 53, 57, 64, 69, 82	15	1
15		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
16		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.25
17		4	3, 13, 18, 22, 34, 39, 45, 50, 53, 57, 64, 82	12	0.5
18	X	5	3, 13, 22, 34, 39, 45, 50, 57, 64, 82	10	0
19		3	3, 13, 18, 22, 25, 29, 34, 39, 45, 50, 52, 57, 64, 82	14	1
20		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
21		1	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	2
22	X	5	3, 13, 18, 34, 39, 45, 50, 57, 64, 82	10	0
23		4	3, 13, 15, 18, 22, 34, 39, 45, 50, 57, 64, 82	12	0.5
24		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.25
25		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
26		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 60, 64, 75, 82	13	0.5
27		5	3, 13, 18, 22, 34, 39, 45, 50, 54, 57, 64, 82	12	0.25
28		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
29		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
30		5	3, 13, 18, 22, 34, 36, 39, 45, 50, 53, 57, 64, 82, 85	14	0.25
31		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 70, 82	12	0.25
32		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
33		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
34	X	5	3, 13, 18, 22, 39, 45, 50, 57, 64, 82	10	0
35		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
36		5	3, 13, 18, 22, 34, 39, 45, 48, 50, 57, 64, 70, 82	13	0.25
37		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1

38		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 68, 75, 82	13	0.25
39	X	5	3, 13, 18, 22, 34, 45, 50, 57, 64, 82	10	0
40		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.25
41		4	3, 13, 18, 22, 34, 39, 45, 50, 54, 57, 64, 82	12	0.5
42		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
43		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 69, 82	12	0.25
44		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82, 85	12	0.25
45	X	5	3, 13, 18, 22, 34, 39, 50, 57, 64, 82	10	0
46		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
47		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
48		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 67, 74, 82	13	1.5
49		5	3, 13, 18, 22, 34, 39, 45, 47, 50, 57, 64, 82	12	0.25
50	X	5	3, 13, 18, 22, 34, 39, 45, 57, 64, 82	10	0
51		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
52		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
53		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
54		4	3, 13, 18, 20, 22, 34, 39, 45, 50, 57, 64, 82	12	0.5
55		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 70, 82	12	0.5
56		5	3, 13, 18, 21, 22, 34, 39, 45, 50, 57, 60, 64, 82	13	0.25
57	X	5	3, 13, 18, 22, 34, 39, 45, 50, 64, 82	10	0
58		1	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	2
59		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
60		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 62, 64, 82	12	1.5
61		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
62		3	3, 13, 16, 18, 22, 29, 34, 39, 45, 50, 51, 57, 64, 68, 82	15	1
63		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
64	X	5	3, 13, 18, 22, 34, 39, 45, 50, 57, 82	10	0

65		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
66		4	3, 13, 18, 22, 34, 36, 39, 45, 50, 57, 64, 82	12	0.5
67		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
68		2	3, 13, 16, 18, 22, 34, 39, 45, 50, 57, 62, 64, 82	13	1.5
69		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
70		4	3, 13, 16, 18, 22, 34, 39, 45, 50, 57, 64, 82	12	0.5
71		2	3, 13, 18, 22, 28, 34, 39, 45, 50, 57, 64, 82	12	1.5
72		2	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1.5
73		4	3, 13, 18, 22, 29, 34, 39, 45, 50, 57, 60, 64, 82	13	0.5
74		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.25
75		3	3, 13, 18, 22, 34, 39, 45, 50, 54, 57, 64, 82	12	1
76		3	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	1
77		5	3, 13, 18, 22, 34, 39, 42, 45, 50, 57, 64, 68, 82	13	0.25
78		5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.25
79		3	3, 13, 18, 22, 34, 39, 45, 50, 52, 57, 64, 82	12	1
80		5	3, 13, 18, 22, 34, 38, 39, 45, 50, 52, 57, 64, 82	13	0.25
81		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
82	X	5	3, 13, 18, 22, 34, 39, 45, 50, 57, 64	10	0
83		4	3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82	11	0.5
84		3	3, 10, 13, 18, 22, 30, 34, 39, 45, 50, 57, 64, 82	13	1
85		2	3, 13, 18, 22, 30, 34, 39, 45, 50, 57, 64, 77, 82	13	1.5
86		2	3, 13, 18, 22, 34, 39, 45, 50, 55, 57, 64, 82	12	1.5

As it is presented in Table 3, there are 11 critical services which must be working at any time and affect other services' continuity (3, 13, 18, 22, 34, 39, 45, 50, 57, 64, 82). The value (a_i) of these services is "5" and the maximum time to repair these services when they are down (in hours) (c_i) is "0" since problems about their continuity cannot be tolerated. There are also 18 services evaluated as the most valuable ($a_i = 5$) although they are not critical (5, 9, 16, 24, 27, 30, 31, 36, 38, 40, 43, 44, 49, 56, 74, 77, 78, 80) and c_i values for these services are "0.25" hours. Moreover, there are 23 services with $a_i = 4$ and $c_i = 0.5$ hours, 18 services with $a_i = 3$ and $c_i = 1$ hour, 14 services with $a_i = 2$ and $c_i = 1.5$ hours, 2 services with $a_i = 1$ and $c_i = 2$ hours. The dependency between services are also presented in Table 3. Finally, service optimization problem of the company is solved with the same version of ILOG CPLEX as in the experimental study with random instances. The optimal solution for the case study is obtained in 1,173.90 seconds (almost in 20 minutes). As in the experimental study, the solution time for the case study is also found acceptable with the working period t considered in hours. Results representing availability of services (y_{it} values) are also appreciated by managers working in the company. Furthermore, the solution of the case study is found a valuable contribution to the service continuity problem of the company.

6. Conclusions and Further Research

This paper presents a new methodology to optimize the performance of IT services. The study proposes to prepare an efficient IT service catalog and determine right relationships between services as it is expected in service design area of ITIL which is the most popular and accepted IT service management framework. Moreover, this paper integrates ITIL requirements with a novel mathematical model to optimize IT service level. The proposed mathematical model provides IT professionals with fundamental opportunities such as considering the criticality, value, and downtime of each service based on agreements made with the customers.

It is surprising that although there are many ITSM frameworks and standards, IT organizations still have issues with measuring and optimizing service performance. Therefore, researchers and IT professionals need to find new ways of optimizing level of IT services. Although the studies about IT service management is rich, our contribution which is the performance optimization of IT services with the help of ITIL processes and mathematical modelling has not been studied in the literature. In this study, after applying our proposed methodology with 50 random instances, we implement it in a big Turkish IT company, and observe that the proposed method provides successful results. The results of both random instances and case study demonstrate that the solution time is acceptable with the working period of services considered in hours in the mathematical model. Results related to the availability of services in the case study are also appreciated by IT executives and top managers depending on the service continuity and strategy in the company.

Future studies may focus on solving the problem in shorter period of time (e.g. in minutes or seconds instead of hours) as an unavoidable fact in the digitalized age. In this case, the problem cannot be solved optimally in the reasonable time. Thus, we may need to develop an efficient metaheuristic to solve the same problem this time with higher number of variables.

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