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Using simulation-based optimization in the context of IT service management change process

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ABSTRACT

Today's IT systems and IT processes must be ready to handle change in an efficient and responsive manner to allow businesses to both evolve and adapt to a changing world. In this paper we describe an approach that consists of using *simulation based multi-objective optimization* to select optimal ITIL change management process strategies that help IT managers achieve process efficiency as a Critical Success Factor (CSF). A multi-method simulation model, which is based on agent-based and discrete-event simulation paradigms, has been built to simulate the whole process lifecycle, since the change initiation until its closure. As most engineering problems, assuring an efficient delivery of the *change management process* requires optimizing simultaneously the corresponding Key Performance Indicators (KPIs) in which the process-efficiency CSF can be rolled down. In this paper, we show the results of applying two well-known Multi-Objective Evolutionary Algorithms, namely NSGA-II and SPEA2, to obtain a set of optimal solutions for the KPIs associated with delivering process efficiency as a CSF. We also compare the results obtained with the output from the single-objective optimization algorithm provided by the simulation tool. The experimental work included shows how the approach can provide the IT manager with a wide range of high quality solutions to support them in their decision-making towards CSF achievement.

1. Introduction

In our current digital world, Information Technology (IT) plays a crucial role to help organizations succeed in delivering value to their customers. In response to this growing dependence on technology, today's IT organizations need to be both effective and efficient in transforming resources into valuable services. IT Service Management (ITSM) is defined as the strategic approach to the design, delivery, management, and improvement of the way in which IT is used within an organization.

Since technology and the IT infrastructure are constantly changing and advancing in today's world, organizations such as IT service providers must be ready and able to adapt themselves to evolving conditions if they want to remain competitive and innovative. To this end, the different ITSM guides and standards provide guidance about how to manage change in a productive way, ensuring that new or modified IT services evolve along their lifecycle under a controlled and well-organized manner that keeps these services compliant with the business requirements.

There are different ITSM best-practice guides and standards that help organizations implement an ITSM strategy. A 2017 report, based on a survey of 261 IT leaders in large organizations around the world [18], shows that the top five most used ITSM approaches are: Information Technology Infrastructure Library (ITIL) (47%) [3], Business Process Framework (eTOM) (36%) [48], Control Objectives for Information and Related Technologies (COBIT) (36%) [20], Microsoft Operations Framework (MOF) (34%) [33] and ISO/IEC 20000 (29%) [21].

Among all the existing ITSM guides, we focus in this work on the ITIL proposal, the most widely used one. In fact, it is regarded by many as the de-facto standard for ITSM and its terminology is widely understood and used. ITIL follows a process-driven approach that is grounded in business experience. It offers a set of best practices for IT service management and delivery under an ITSM approach. The ITIL framework comprises the definition of 26 process areas used to describe how IT services evolve through the five main stages of their lifecycle. ITIL consists of five core publications, namely, (i) Service Strategy, (ii) Service Design, (iii) Service Transition, (iv) Service Operation, and (v) Continual Service Improvement, each one dedicated to describe in depth each of the five stages of an IT service lifecycle.

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The ITIL service transition stage is precisely aimed at helping organizations plan and manage the change of state of services in their lifecycle, in a controlled manner, minimizing the risks and ensuring that the services meet the customer's expectations and the business requirements [36]. One of the critical processes within service transition is change management. According to ITIL, "the purpose of the change management process is to control the lifecycle of all changes, enabling beneficial changes to be made with minimum disruption to IT services" [36]. The scope of change management covers changes to service assets and configuration items across the whole service lifecycle. The process addresses all changes at all levels: strategic, tactical and operational.

Today's organizations demand service changes to be performed in less and less time without compromising efficiency. Thus, efficient change management is essential, since the consequences associated with process inefficiency reach the customer. Low quality service changes often lead to new incidents that result in customer dissatisfaction.

Change management needs the involvement of several types of resources, with their corresponding costs. Among them, human resources are crucial for the outcomes of the process. These resources are commonly structured in IT support groups. Each one plays a different role in the process such as change initiators, developers, deployers, and can be part of the IT staff or work for third-party organizations. In practice, all these factors are combined to make the entire change process highly unpredictable, where outcomes depend on complex interactions between different changes, people and groups, each of which, have their own priorities and objectives. Although ITIL and other ITSM frameworks provide important guidance, managing change in real organizations is a very complex process. Also, change management often requires optimizing several objectives simultaneously, such as maximizing the percentage of changes completed on time and minimizing the change duration ratio and the number of resources used.

Therefore, change management is a complex problem that organizations need to handle in an effective way when coping with service transition processes. The goal is to perform the changes with the lowest impact on the Quality of Experience (QoE) perceived (as service disruption, incidents with other live services, or any other issue that might affect customers' satisfaction), but also with the lowest effort for the organization (as minimizing the cost of the change or the resources required). Often, the interests of organization and customers are in conflict, e.g., reducing the time required for the change management process leads to a cost rise for the organization. Optimization techniques can be very valuable tools used to both find high quality solutions to support decision-making and to ensure an efficient change management delivery.

Particularly, multi-objective optimization algorithms can effectively handle the optimization of different conflicting objectives simultaneously, offering a wide and diverse range of trade-off solutions to the problem, helping the IT manager to make the most appropriate decisions. In order to guide the search towards high-quality solutions for such a complex problem involving a large number of processes, interactions among them, and uncertainties, these algorithms must rely on accurate simulations. This approach is explicitly proposed in frameworks to improve decision-making in the ITSM scope, such as the Sim4ITSM framework, which includes activities of simulation optimization in the experimentation phase of the method [39].

The main contribution of this work is a novel application of the multi-objective simulation optimization approach for the IT change management process problem aimed at supporting effective decision making. To this end, we introduce a simulation approach that relies on both the agent-based and discrete event simulation paradigms to model the ITIL change process. We define the problem of optimizing process efficiency according to three main goals: 1) the size of the staff to perform the changes, 2) the change duration ratio, and 3) the percentage of changes completed, which are optimized simultaneously. The problem is tackled with two well-known Multi-Objective Evolutionary Algorithms (MOEAs), NSGA-II and SPEA2. The MOEAs outperform the reference result provided by the single-objective optimization obtained from the simulation software used to build the simulation model. This research represents pioneering work related to the use of multi-objective approaches in simulation-based optimization in the context of ITSM.

The structure of the paper is organized as follows. Section 2 summarizes the works related to our proposal. Section 3 describes the simulation model built for the ITIL change process. Section 4 introduces the MOEAs used in this study and the coupling structure followed to integrate the simulation software with the multi-objective optimization framework. Section 5 describes the experimental work performed. Finally, Section 6 outlines the conclusions and our further work.

2. Related work

In this section, we cover the most relevant works related to our study. Section 2.1 addresses contributions focusing on the design of ITSM simulators. We present the results of a systematic search in the literature of simulation-based optimization in the context of ITSM in Section 2.2.

2.1. Simulation in ITSM

Simulators have been demonstrated to be very useful tools for decision support systems to help decision makers in their activity. We can find many examples in the literature, with different fields of application as logistics [17], planning [41], economics [52,8], or supply chains [19], among many others. The use of simulation modeling to address ITSM problems has been an active topic of research in the last years. The most relevant works in the scope of the service change management process are reviewed next, and we refer the reader to the work by Orta et al. [39] for a more comprehensive literature review.

In [32], the authors describe a System Dynamics model to address the problem of low-performing IT operation by adopting and sustaining IT change and access controls. The simulation model built helped to validate *"underlying observations that change and access controls simultaneously reduce the security risk and increase the efficiency and effectiveness of IT management and operations"*.

Planning and scheduling of changes were identified among the main challenges in IT change management according to the results of a survey carried out by Hewlett Packard in 2006 [40]. The topic of the efficient management of a set of application changes under possible scheduling conflicts was addressed by Luo et al. [31]. The authors use graph and queue modeling to simulate different scheduling heuristics and find their impact on the change completion time and the change capacity of the system. The work finds the limit values for the degree of the scheduling conflicts and the cross-training of executing personnel that help keep the average change delay in the lowest level. In addition to an efficient scheduling of changes, it is also very important to estimate the business impact of operational risk resulting from changes. One proposal that quantifies this impact in terms of financial loss was described by Setzer et al. [42]. In this work, a probabilistic model for analyzing the business impact of changes in a network of services is introduced together with a decision model for service changes scheduling with the aim of reducing the total expected change-related costs. The proposal is then evaluated by using discrete event simulations of different scenarios.

Silva and Yaix [44] propose process simulation as a key element to guide the CIO and CEO in strategic business and IT alignment. They show the benefits of their proposal by simulating the incident and problem management process from the COBIT framework (which are sub-processes of the change management process in the ITIL framework). In this case, the simulation model is built using ADOIT®, which uses its own modeling language and provides basic simulation analysis