

Computer Simulation Improving the IT Helpdesk Problem Management: A Systematic Literature Review

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Abstract: Now a days, many information systems users are non-technical professionals. Therefore, many of them find it difficult to use the systems at their disposal. To overcome this problem many organization have conceived and deployed IT helpdesks services. However, managing a helpdesk is no easy task. The difficulties that users face are varied, involving the use of software and hardware and business procedures and regulations. Moreover, information tends to change with the passage of time. As a result, not all use questions can be answered as soon as they are formulated, making problem management a critical function in helpdesk management. In this scenario, computer simulation has emerged as a tool that allows improvements in helpdesk services to be tested before they have to be deployed. This study performs a systematic literature review on the use of simulation to develop helpdesk services. It aims at creating a roadmap that shows how this technology has been used in the context of helpdesk services to facilitate the use of formation systems. As a result, it is a source of information leading to future research and development.

Key words: Simulators tools, problem management, helpdesk, call-center, road map

INTRODUCTION

In the highly competitive and technological world we live in, companies have been turning to IT as a source of innovation and competitive advantage at an increasing pace. As a result, IT systems currently permeate all business functions, providing prompt reliable information for decision-making (Alencar *et al.*, 2012).

Moreover, many business functions depend heavily on the information provided by IT systems to carry out the tasks for which they are responsible. For instance, it is becoming increasingly commonplace that sales, operations and logistics cannot be properly run without the support of IT systems (Andriole, 2008).

Nevertheless, many system users are non-technical professionals. Despite the skills and experience that they may have, non-technical users frequently face difficulties in interacting with computer-based systems (Alencar *et al.*, 2012).

It is the case that system interfaces may not be as intuitive as their designers had hoped. This tends to generate questions on how to obtain the information that users' need. In addition, reading, understanding and analyzing this information may require additional support,

that frequently are not made available on the system interface. Finally, computer systems may not work properly in all circumstances, putting users under unnecessary pressure to deliver, especially when a deadline is coming up (Andriole, 2008).

Therefore, not surprisingly, helpdesk services have become an integrated part of the regular IT services that are available in a large variety of organizations. It provides a single point of contact for users, offers guidance on the use of software and hardware, renders assistance in troubleshooting and gives answers to questions. All of this has made the IT help desk services a point of concern for managers. Therefore, helpdesk services require recurrent capital investment for training, improvement and expansion that may not be available at all times (Stegeman *et al.*, 2012).

As a result, many models, frameworks and approaches have been presented to analyze and improve helpdesk services, keeping its cost under control. Besides, these tries can be tested at no cost while deficit changes could cost real money in the real world. Within helpdesk industry, the staff cost represents about 70% of the total. Thus, almost free-cost simulations can be very useful checking out how staff scheduling alternatives

would perform. In this scenario, computer simulation tends to play an important role, as it allows managers to identify bottlenecks more easily and try out possible improvements before they are fully implemented (Bartolini *et al.*, 2010).

This study performs a Systematic Literature Review (SLR) based on (Fink, 2013; Kitchenham, 2004) of the use of computer simulation to improve helpdesk services. The SLR focuses on problem management, as it is a critical part of helpdesk management. This study aims to provide a road map for academics and practitioners that may lead to future research and development.

Presentation: The aim of this study is to review existing research on simulation on Helpdesks and to identify areas and opportunities for future research. There are temporal limitations for this review with contributions from January 2006 until end of June, 2015. We utilize researches of verified quality, which means that they only address articles in peer-review journals and from reputable conferences. We researched on the databases in repositories.

Repositories:

- Google scholar
- IEEExplore
- Capes perodicals
- Spring link
- Science direct
- Engineering village
- Wiley online library
- Scopus
- Web of science

Motivation: There is extensive literature on the use of simulators in incident management processes focusing on call volumes but less attention was dedicated to the quality of the problem management process. In order to achieve the research objectives we examined academic study, best practice, master and doctors' degree thesis and books and discovered that computer simulation tool is an emerging technology relevant not only to Callcenter but to helpdesks as well.

Researchers as Bouzada (2009a, b) (Bartolini *et al.*, 2012) have performed extensive research on the use of simulation and we intend to further develop their research.

Background: In the last few years computer-based simulation models and software have been more and more used in call-center environments. The main reason for this can be traced to the advantages of simulation which become even more prevalent as price performance ratio of

outsourced call-centers has changed the way we work in this area. Computer simulation enables helpdesks to perform better most parts of IT operation processes and is already widely used in call-center environments.

The importance of integrating IT to business is mandatory to the success of Information Technology management. In this new Helpdesk scenario the implementation of Information Technology Infrastructure Library (ITIL) processes using simulation is a key element to reduce spending and provide quality services for clients.

MATERIALS AND METHODS

This study is a literature review based on Fink and Kitchenham methodology. The main objectives for this review are: to identify and summarize existing research on problem management implementation using simulation in Helpdesks. We will present the research questions and analyze the articles in two: process and simulators. Finally, we identify areas and opportunities for future research (Fink, 2013); Kitchenham, 2004).

SLR methodology adapted to IS: SLR is an important part of research projects that provides robust up-to-date information on the subject under consideration. SLR follows a well-defined sequence of steps leading to the identification, analysis and synthesis of relevant information that helps to answer those questions (21). This study follows the ideas of Fink (2013) and Kitchenham (2004), adapted to the IS environment by Okoli and Schabram (2010). Okoli uses Fink's definition that "a Systematic literature review " must be systematic in following a methodological approach, explicit in explaining the procedures by which it was conducted, comprehensive in its scope of including all relevant material and hence reproducible by others who would follow the same approach in reviewing the topic" (Fink, 2013). Okoli has adapted Fink research to IS and detailed his own methodology based on the eight steps that will be followed on the next chapters (Okoli and Schabram, 2010) shown in Table 1.

Purpose of the literature review: Research questions: In a complex and changing IT environment the need of fast and accurate user support is a key issue. There is an increase need in solving problems fast and with quality in order to prevent new problems from recurring. Motivated by these facts, this thesis focus is on presenting a revolutionary perspective on problem management. In addition to the conceptual perspective it will show how computer simulator can help decision taking and assure

Table 1: The detailed methodology produced by Okoli and Schabram (2010)

| Steps | Objective |
|---|---|
| Purpose of the literature review | Identify the purpose and intended goals of the review |
| Protocol and training: | Define a procedure to be followed |
| Searching for the literature | Detailing of the literature search |
| Practical screen (screening for inclusion) | Why studies were considered for review and which ones were eliminated |
| Quality appraisal (screening for exclusion) | Explicitly spell out the criteria for judging which articles are of insufficient quality |
| Data extraction | Extract the applicable information from each study |
| Synthesis of studies (analysis) | Combining the facts using appropriate techniques, whether quantitative, qualitative or both |
| Writing the review | The process of a systematic literature review needs to be reported in sufficient detail and can be independently reproduced |

processes changes to achieve targeted objectives. From this perspective the question to be investigated was formulated as a research question. How to improve IT Helpdesk problem management using computer simulation? The research questions specifically addressed by this study can be detailed as follows:

- RQ1: How computer simulation has been used to support helpdesk?
- RQ2: What are the main benefits provided by computer simulation to problem management in helpdesk operation?
- RQ3: Which studys propose the use of simulation methods to support problem management?

Protocol and training: The research process: The research was organized according the guidelines found by Kitchenham (2004).

The research process has used the keywords: problem management, simulation and helpdesk or service desk and their synonyms: (“problem management” or “issue management” or “problem solving” or “issue solving”) and (“simulation” or simulator) and (“contact center” or “callcenter” or “call center” or “call-center” or “Helpdesk” or “service desk”).

According to Kitchenham, the search string was based on the PICO (Population, Intervention, Compare and Outcome) criteria. The population criteria used was: Helpdesk. The Intervention was: problem management; The comparison was: callcenter and helpdesks and the Outcome was: simulation (Kitchenham, 2004). The research logic is based on the Venn diagram where the intersection is the objective of the study as shown in Fig. 1.

Searching for the literature: Our goal was to identify articles presenting research of validated quality. As major contributions are likely to be in quality journals, we started by searching articles in a Google academics’ and moved forward by using: CAPES, IEEE, Springer Link, Science direct and Engineering Village (Table 2).

Practical screening: Identification and selection of studies: The studies considered for this review are extracted on the repositories and cataloged using a tool called Zotero, the articles were scored by quality

Table 2: repositories and hits

| Repositories of scientific information | Hits | Internet address |
|--|------|-----------------------------|
| Google scholar | 1120 | www.scholar.google.com |
| IEEE xplore | 604 | www.ieeexplore.ieee.org |
| Capes periodicals | 201 | www.periodicos.capes.gov.br |
| Springer link | 31 | www.link.springer.com |
| Science direct | 14 | www.sciencedirect.com |
| Engineering village | 4 | www.engineeringvillage.com/ |
| Wiley online library | 2 | www.onlinelibrary.wiley.com |
| ACM digital library | 2 | www.dl.acm.org |
| Scopus | 1 | www.scopus.com |
| Web of science | 0 | www.webofscience.com |

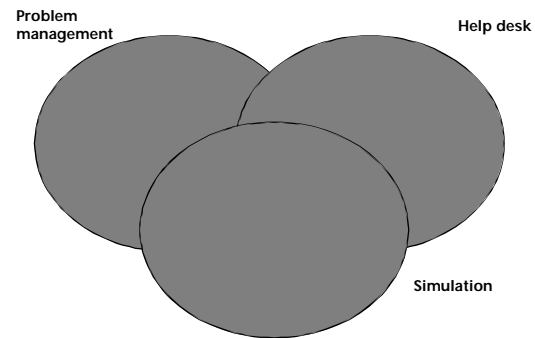


Fig. 1: Research logic

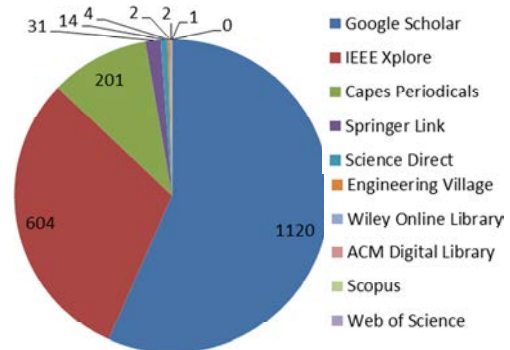


Fig. 2: Amount of selected studys grouped by repository

concerning authors, journals and the information they provided. As a result of using the composite term as a filter for the works stored in the repositories, 1445 studys were put aside for further analysis. Figure 2 shows the amount of selected studys grouped by repository of scientific and technical work.

Table 4: Articles reviewed and research questions answered by them

| ID | Article title | RQ1 | RQ2 | RQ3 |
|------|--|-----|-----|-----|
| [3] | “Scenario analysis within a call center using simulation” | - | X | X |
| [4] | “SYMIAN: Analysis and Performance Improvement of the IT Incident Management Process” | - | X | X |
| [6] | “A Tutorial on modelling Call centres using Discrete Event Simulation” | X | - | - |
| [7] | “Implementing IT service management: a systematic literature review” | X | - | - |
| [8] | “Simulation Environment for IT Service Support Processes: Supporting Service Providers in Estimating Service Levels for Incident Management” | X | X | X |
| [9] | “Compliance Analysis in IT Service Management Systems” | - | X | X |
| [10] | “Designing an evaluation framework for IT service management.” | X | - | - |
| [11] | “IT Service Management Case Based Simulation Analysis Design: Systems Dynamics Approach” | X | X | - |
| [12] | “Decision-Making in {IT} Service Management: A Simulation based Approach” | - | X | - |
| [13] | “O setor de callcenter e métodos quantitativos: uma aplicação de simulação” | - | X | X |
| [14] | “Managing Trade-Offs in Call Center Agent Scheduling: Methodology and Case Study” | - | X | - |
| [15] | “A simulation approach to restructuring call centers” | - | X | - |
| [18] | “A simulation tool for the optimization of the IT incident management process” | - | X | - |
| [21] | “Using simulation in call centers” | - | X | - |
| [22] | “O uso de ferramentas quantitativas em call centers: o caso Contax” | X | X | X |
| [23] | “Adding clicks to bricks: A study of the consequences on customer loyalty in a service context” | - | X | - |
| [24] | “Optimizing daily agent scheduling in a multiskill call center” | - | X | - |
| [25] | “Dimensioning a Call Center: Simulation or Queue Theory” | - | X | X |

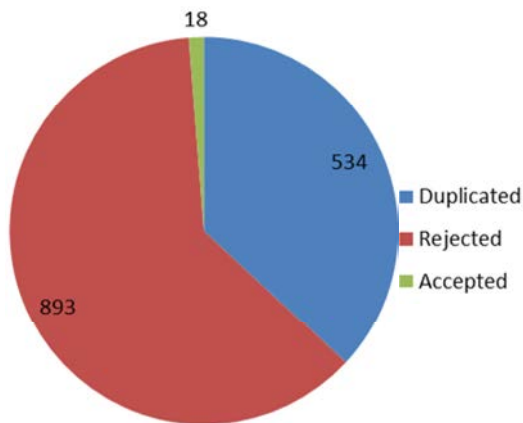


Fig. 3: The result of applying the initial selection criteria

Quality appraisal: Inclusion and exclusion criteria: In this section the selected articles were explicit and the elimination criteria detailed. All included articles were scored for their quality and insufficient quality and duplicated articles were excluded. Articles from laboratories and companies white studys that have not been presented on Conferences and Journals were rejected. The review targeted peer reviewed articles on the implementation of non-analytical Helpdesk projects and simulation published between January 1, 2006 and June 30, 2015. Only articles in English and Portuguese were included. The titles and abstracts were analyzed and a total of 16 articles were selected, categorized and summarized to be used on the literature review.

The inclusion criteria were defined to include processes that do not use ITIL but other business processes we include other problem management synonyms. To include simulators from other areas we include the term Call-center and not only an IT Call-center

usually called Helpdesk. The quality control included articles on ITIL implementation, Helpdesk-incident and problem management processes and simulation used in Call-centers (Fig. 3).

RESULTS AND DISCUSSION

The objective of this chapter is to identify the relevant studies and the subjects that existing research has covered so far. We will present the research questions and the findings from the articles reviewed related to each research question.

Data extraction (selected articles): This SLR followed the advice of Knopf (2006) and consolidated the studies that have a direct bearing on the central focus of this review about simulators and service management processes. Overall 18 relevant studies were identified and the researchers have focused on the aspects that are relevant. Some articles and master thesis cover all research questions while others focus on simulation or process. A complete list of the articles is given on References. Researchers at HP and USA Universities have been especially active; they are involved in 5 of the 18 studies (Table 3). Table 3 helped to identify individual studies and the research questions that has been addressed by them.

Theoretical referential: main concepts used

Simulation in incident management: As studied by (Saltzman and Mehrotra, 2007) the use of simulation is essential to analyze Service Level Agreement (SLA) sensitivity to critical variable changes. Simulators are also used in Helpdesks and a range of computer programs are available for simulation as: SYMIAN, ARENA CONTACT CENTER, CASSIS and VENSIM.

Extensive research was performed by HP and published by Bartolini *et al.* (2010) and in Brazil (Bouzada 2009a, b) realized extensive tests with Arena Contact Center on Contax Helpdeks publishing several articles. Bouzada thesis produced in Brazil has also performed a literature review on the use of simulators in Callcenters and participated actively on the research giving advice for incident management.

Simulation methodology: The methodologies for simulation modeling are based on a generically system development methodology with some specificities as running an initial simulation run and running what-if scenarios. One methodology is the Service Model SW, a complete model with animation capabilities where a set of initial simulation runs were conducted and the output results from this base model taken as a baseline result. The scenarios were implemented either by model data updates or by model logic changes. Each scenario generated a unique set of results summarized and additional simulation runs were determined as needed. Ideally these findings drive changes in the client's systems and processes as a result of the study simulation. Lam and Lau (2004), Barash *et al.* (2007) has also created a methodology to analyze performance using simulation. It consists on the steps: define business objectives, built workflows for scenarios, manage data availability, analyze measures and perform data mining, built a model for process analysis, create analysis flux visualization. In this work the methodology used will be Lam and Lau's because it is more simplified although data mining and other complex methodologies may be used with these model if available (Lam and Lau, 2004). The eight step methodology to help developing the simulator.

Eight step methodology

- Define scope, requirements and data availability
- Prepare project proposal
- Develop functional specification with process flow and modeling assumptions, data and planned scenarios
- Model development, collect data, analyze data , verify validity
- Redefine model with client
- Conduct simulation runs build the baseline result
- Implement scenarios, summarize results and run additional simulations scenarios
- Drive changes in systems and processes

Simulation techniques: There are several simulation techniques: sensitivity analyses, state-based models,

discrete event simulation, dynamics systems, agent based simulation, petri nets, queue based models, Monte Carlo, probabilistic and mathematical models. (Orta *et al.*, 2014) For managing incidents the simulation model selected by all researchers (Bartolini *et al.*, 2010; Orta *et al.*, 2014; Bouzada (2009b)

Simulations can be classified in relation to the state change of the system they model. They can be continuous/discrete, dynamic/static or stochastic/deterministic.

Discrete systems are characterized by the fact that the state variables change instantaneously at different points of time. In contrast, state variables in continuous systems change continuously with respect to the time (Bartsch *et al.* 2010). Additionally, Bartsch *et al.* (2010) identifies that if the number and escalation paths were modeled the simulation should be a combination of discrete and continuous but if only call volume is analyzed it may be discrete.

Most modeling methods limit themselves to the representation of static states of business process. Also, a number of dynamic modeling methodologies and tools such as Petri nets, Systems Dynamics and Continuous and Discrete Simulation have been developed (Lee *et al.*, 2007).

When the values of all parameters of the simulated scenario are known, the simulation is considered to be deterministic. On the other hand, when some of them must be represented by a probability distribution, the simulation is considered to be stochastic.

Research questions: We want to identify the subjects covered by existing research as well as catalog key questions that research has sought to answer. The research questions sorts itself into the process and simulation category. Within the process category, the popular research question is related to factors for achieving successful implementations, which overall is the most frequently asked question. Within the simulation category, 16 articles have addressed simulation applicability while 6 articles have investigated the applicability of simulation to address changes in Callcenters and helpdesks. Two master theses include primary studies and a case study of simulation implementation. In some articles there is also reference to all subjects researched.

Research question 1: The first research question is: RQ1: How computer simulation has been used to support Hekpdesk operations?

In a conceptual perspective the usefulness of simulators are detailed mainly in call-center and helpdesk operation where simulation has been used to analyze call volumes in complex environments but there are other uses that will be detailed.

The first use of computer simulation is on shaping the interaction between calls, routes and agents. Through the use of simulation, managers and analysts can translate call-centers gross data (call forecast, distribution of the handling times ,schedule hours, agents abilities, call route vectors, etc.) in handling information about service levels, clients abandonment, use of agents, costs and other important performance measures (Bouzada, 2009b).

Secondly, simulation is able to explore processes in such a way as to identify alternative solutions to the threat of potential conflicts and operating risks, analyzing the dynamic behavior of systems under conditions of uncertainty (Lee *et al.*, 2007). The simulation of the incident management process is detailed on the simulations analyzed on the HP helpdesk and there was the identification of critical variables that affect the SLA accorded (Bartolini *et al.*, 2010).

Additionally, simulation can also support service providers in identifying feasible levels for IT service support processes. Extensive research on uses of simulation and SLA changes supporting the use of priori estimation for example based on simulation in order to reduce risks (Bartsch *et al.*, 2010). Most of the time the use of the Queue Theory for its modeling, including: generic distribution for the handling time, time-varying arrival rates, temporary overflows and abandonment is not enough (Bouzada, 2009b). On Contax (Bouzada, 2009a) have used simulation to compare the performance of three different calls programming approaches (heuristic, daily batches optimization and dynamic optimization), revealing opportunities for improving the outbound call-center process. The model has provided a way to check the system performance compared to the management goals. There is evidence that simulation analysis may be validated in a real Helpdesk operation and they are only valid if a “as is scenario” is included and the simulation has at least one year run. As most vendors are including simulation in their call management systems the use of commercial products not previously tested with the call management system must be avoided (Bartsch *et al.*, 2010; Lee *et al.*, 2007).

Concluding, there is increased importance of using simulation because some call-center characteristics make it difficult to apply analytical formulas. The articles selected concluded that simulation has a primary advantage of exploring process; identify improvements opportunities and analyses how measurers and SLA should be achieved.

Research question 2: The second research question is: What are the main benefits provided by computer simulation to problem management in helpdesk operation?

The use of Simulation in call-centers help on defining: agent scheduling, skills, technology, call management algorithms and techniques, consequently allows having processes explicitly defined and tested. Simulation can also help on identifying bottlenecks rarely identified by Work Flow Management (WFM) and collecting data from Call Management Systems (CMS) to determine the best problem management process (Orta *et al.*, 2014; Avramidisa *et al.*, 2010).

Another benefit of simulation is to support call-center decision management in visualizing future processes, preview impacts and test implementation scenarios. The main reasons to use simulation would be to address complexity not identified by analytical methods and cope with complex call-center environments. Additionally decisions concerning escalation procedures and problem periodization can be analyzed and their impact on the quality of managing the problem reduced. (Bartolini *et al.*, 2010; Lam and Lau, 2004). The third usefulness of simulation in a call-center is to allow a fast and accurate understanding of how the operational performance will work when facing specific scenarios as the adoption of a new technology, a new business strategy or the increase of the amount of work. Furthermore, the analysis can be done before any change in the process is effectively made and do not interfering on the call center’s operation and impacting the SLA targeted (Saltzman and Mehrotra, 2007; Sabiote and Roman, 2012; Bouzada 2009a).

Research question 3: The third research question is: Which studies propose the use of simulation software to support problem management?

There are three lines of research in simulation in ITIL: HP laboratory, COPPEAD-UFRJ and Sofia University in Bulgaria (Bartolini *et al.*, 2010; Bouzada, 2009a; Ilkov, 2004). Some articles presented a methodology to work with simulation in other contexts and to use simulation in problem management for helpdesk an adaptation will be necessary. A variety of software is presented in the academic and commercial area with its unique characteristics and specific design.

Some software used for simulation in helpdesks and call-center environment presented are used in more than one line of research, for example : CASSIS uses simulation with analysis and optimization mode (Bartsch *et al.*, 2010) Arena Contact Center is used to evaluate incident management and call volumes (Ilkov, 2004). HP laboratories developed a series of theories and experiments in simulation using a tool called SYMIAN

(SYMulation for Incident Analysis) (Bartolini *et al.*, 2010). Some call management systems as TIVOLY has simulation capabilities included and some simulation methodologies as service model SW also offer a simulation SW as part of the methodology.

There is extensive literature on the capabilities of SYMIAN as expected from a commercial sw. SYMIAN is said to be a decision support tool for the performance analysis and optimization of the incident management function in IT support organizations allowing what-if scenario analysis. The software enables its users to build an accurate model of real life IT supports organizations, to evaluate their performance using a discrete event simulator to reproduce in detail the behavior of IT support organizations and to evaluate their performance in managing incidents. HP researchers go on explaining how SYMIAN analyzes simulation outcomes to locate potential performance bottlenecks in IT support organizations. To this end, it uses a set of redefined IT performance metrics that were designed to consider both routing effectiveness and support group efficiency. (Bartolini *et al.*, 2010). In the incident process detailed problem management is included and the escalation and prioritization procedures detailed but additional work should be done to map more complex problem management processes.

A very powerful call management software that has simulation capabilities, IBM TIVOLY (MAXIMO) is presented on Baier (2010). The article stresses the importance of using simulation in Call-centers and in any reengineering activities. Their simulation capabilities are detailed on theory but only IBM internal information is available about implementation projects.

The third commercial software researched is CASSIS. It uses simulation with analysis and optimization mode using continuous simulation to track incident tickets or discrete simulation if the number of tickets is the area of interest (Bartsch *et al.*, 2010).

In the academic area Arena Contact Center is the predominant software and there are a series of thesis, dissertations and cases implemented in ITIL using this software. Unfortunately, there are not much information about it easily accessible and the scientists articles, thesis and dissertations say more about the cases than about the software.

Concluding, simulation technology is emerging as the best analysis tool to manage change within an increasingly complex environment and a variety of software is available. Table 6 shows the main simulation

systems and Call Management Systems (CMS) with simulation capabilities that were used in call-center projects.

Simulation solutions:

- IBM Tivoly (Maximo)
- Symian (Symulation for Incident Analysis)
- Arena Contact Center
- Cassis
- Service Model sw

Analysis: This chapter presents the findings, claims, thoughts and arguments can be drawn from existing research. The articles and research questions will be summarized and analyzed in order to draw conclusions on central issues based on the MIT 90. (Robson, 1994; Perlson and Saunders, 2009). The MIT 90 can be used to align strategy, organization, IT and process. This framework offers a perfect way of analyzing the use of simulators in problem management for helpdesks and in this analysis help to group the findings in IT, process and people.

The summaries of the various issues may serve as guidelines for IT managers who are planning to adopt or already are adopting IT management projects using simulation to help on helpdesks projects implementation. This study also contributes to decision making in any Helpdesk project where executives and IT managers would benefit from our review. The review and the search process based on Kitchenham (2004), Fink (2013) and Okoli and Schabram (2010). Let us confident that our review is thoroughly conducted. However, the selection of key words, sources, inclusion and exclusion criteria and time frame is based on our own judgment and our choice has limitations. We could have added more key words for our search; for example: various names for incident and problem management and more technical elements of simulation.

First of all we concluded that simulation is a key element on decision making for Helpdesks projects (Bartolini *et al.*, 2012; Avramidisa *et al.*, 2010). Secondly, the selection of a software tool and the interaction with the workflow management is mandatory (Barash *et al.*, 2007). Finally, it is crucial to consider the importance of what if scenarios to analyze with processes changes the impact on metrics targeted (Lee *et al.* 2007; Bouzada 2009b).

Based on the MIT 90 adapted from Robson (1994) and Perlson and Saunders (2009), we will present the articles conclusions in two areas: IT (simulation) and process (organization) to have a complete analysis of the use of simulation in helpdesk.

Analyzing computer simulation: In recent years computer simulations has emerged as a powerful approach that can improve help desk related services considerably. Simulation has been successfully used to improve complex helpdesks and call-center processes. In order to do this deeper analysis in complex helpdesks we should also use other tools and methods that help decision support. Bartolini *et al.* (2010) explains the use of a simulation tool for the performance analysis and optimization of helpdesks using simulation and what if scenarios. Bouzada (2009b) defended that simulation allows a fast and accurate understanding of how the operational performance of a call-center will work with a new technology, business strategy or increased amount of work.

Secondly, the simulation system should be developed using both discrete and continuous simulation. The selection of a software tools is a key element as well as the level of integration and analysis with real data from the workflow management. There is evidence that simulation analysis may be validated in a real helpdesk operation and that the use of commercial products not previously tested with the call management system must be analyzed carefully (Bartsch *et al.*, 2010; Lee *et al.*, 2007).

The selection type of the simulation selected depends upon the objective targeted. If the intention is to analyze the tracking of incident tickets from one stage of the IT service desk to another is simulated using continuous simulation. If the number of incident tickets in one stage is rather of interest, the system might be modeled discrete. If both the tracking and the number are relevant, then the system might even be modeled as a combined discrete-continuous simulation. The use a mix of continuous and discrete simulation on future research in helpdesk is recommended to model complex problem management (Bartsch *et al.*, 2010).

The software selection should consider prior integration with CMS, the time and resources available. Commercial and academic software selection is not the objective of this article but the main characteristics that should be considered are a good start point for comparing them. In the academic research some attention should be done to the limits of Arena Contact Center academic regarding scenarios and simulation runs and in the commercial area the importance of having a full package integrated with the call management system should be considered (Orta *et al.*, 2014).

The use of customizable and scalable products is recommended because they make it easier to derive benefit from simulation. Similarly, there is a complementary upward trend of customers demanding

that Work Flow Management (WFM) vendors include simulation in their analysis methodologies while configuring WFM systems to suit the unique needs of their call center. The combination of these trends is a measure of the growing level of acceptance of simulation in call-center technology (Bapat and Pruitte Jr., 1998).

Finally the question is when use simulation and not the traditional analytical tools. Simulation modeling is often used when random events cause significant impact on performance (Lam and Lau, 2004). There is great importance to integrate other techniques to simulation to analyze impacts and complexity (Bouzada, 2009a). Yonamine is identified that the performance of simulation tools is usually good but certain setups have fault tolerance and cause loops. The main facts that promote efficiency gains on predictive dialing are simultaneous calls and complete call index and that this may be validated accordingly.

Analyzing process and ITIL problem management: There are a variety of reasons why Call-centers are adopting ITIL, a question of legal compliance, marketing or satisfying customers. Most ITIL processes uses the problem management process and among the many activities that are part of a good IT helpdesk service management, problem solving is regarded as central to the quality of helpdesk service. The problem management process helps by documenting and eliminating errors, reducing the number of incidents and mainly providing permanent solutions to the problems in the IT infrastructure (Bartolini *et al.*, 2010) goes on saying that to have a clear picture of organization's performance one must really define metrics that look inside the support organization and describe its inner working at a much finer grain level of detail. It is essential to goes forward the incident management level and deeply analyses the problem management process.

The importance of problem management is evident but the need to have powerful tools to design the process and achieve the targeted metrics is a new area of growing interest. Case studies have mainly asked why companies are implementing incident and problem management processes but the use of process design as a requirement to use simulation to model and test a process is a grey area on the research. Additionally, analyzing the processes area in incident and problem management we concluded that further attention may be given to evaluate the company readiness to implement ITIL (Baier, 2010). In this way ITIL is strongly influenced by quality management and business process mapping. Without process management, it is not likely that ITIL will succeed

beyond its initial implementation and that a simulation project will be implemented accordingly (Iden and Eikebrook, 2013).

CONCLUSION

This systematic review of published research articles explains how simulation can be used in ITIL implementation projects. Significant contributions were summarized which provide the current status of this emergent research field and will ease researchers to target relevant studies. First of all the information about the use of simulation is complete and accurate detailed. Second, through a deep analysis, potential areas and approaches for future studies were proposed.

Some articles describe real cases conducted and it shows that different simulation approaches are extensively used to help complex Helpdesk projects and that it is imperative to select a customizable simulator and integrate the simulation tool with the CMS. Additionally, the use of a system development methodology adapted to simulation and the use of what if scenarios and a mix of discrete and continuous simulation helps the implementation success. Finally, managers should consider the importance of a process management culture to design processes and simulate in a way that will help on achieving the metrics targeted.

The review concludes that the use of simulation in call-center is widely accepted and in helpdesks the ITIL implementation is the predominant model, how projects are measured are the most dominant topics in current research (Bartolini *et al.*, 2012; Baier, 2010). The review shows that there is only limited research on implementation on simulators in helpdesks problem management and that they are rarely been measured accordingly (Bouzada, 2006). Articles researched show methods for implementing simulators in helpdesks but their use in simulation of problem management needs attention. There is an agreement on the use of non-analytical tools to manage helpdesks but the reports are inconclusive on how to use simulation and other non-analytical software to achieve user satisfaction. (Barash *et al.*, 2007). There is no evidence of a systematic use of both Information Technology System Management (ITSM) frameworks and simulation model development methodologies in helpdesks (Orta *et al.*, 2014). The set of success factors has not yet been tested and validated but the use of what if scenarios to analyze client focused measures should be more systematic and is an area of future research.

There are extensive opportunities on researching the use of simulation that goes beyond inbound call volumes

and study problem management. There is great importance as future work to investigate whether IT functions that implement ITIL also employ process management. Concerning process maturity, more research is needed in order to assess whether firms should implement the entire ITIL package or can improve service support independently using simulation. The function or process design IT being organized by department or process need further attention, more research is needed on implementation maturity in firms and the company readiness to work with process driven mindsets. Future studies could also address strategies for ITIL implementation and analyze of companies priorities when they are selecting processes for implementation.

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