A Web-based What-If Scenario Analysis Tool for Performance Improvement of IT Support Organizations

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***Abstract*—IT support organizations are in charge of restoring normal operations after IT service disruptions and can be complex systems. Thire performance assessment and optimization is an extremely challenging task that requires considering organization-specific structure, behavior, and business-level objectives. This paper presents Symian-Web, a decision support tool that enables IT managers to assess and improve IT support organization performance. Symian-Web features advanced information visualization concepts and metaphors, allowing for precise and timely assessment of IT support organization performance, and facilitating their re-design.**

***Keywords*—Decision support tools, IT service management, incident management.**

I. INTRODUCTION

IT support organizations are a fundamental pillar of IT service management, as they are responsible for dealing with service disruptions. Among other things, IT support organizations are in charge of the *Incident Management* process, which the IT Infrastructure Library (ITIL) [1] [2] defines as the process for "… *restoring normal service operation after a disruption, as quickly as possible and with minimum impact on the business*".

IT support organizations can be very large systems, composed of a network of interacting support groups, each comprising of a set of operators with specific skills and work schedules. IT support organizations implement complex organizational, structural, and behavioral processes according to the strategic objectives defined at the business management level.

The complexity of IT support organizations makes their performance assessment an extremely challenging task, requiring deep behavioral analysis at both the system level and the level of single components, the support groups. In addition, the process of incident management needs setting objectives that are organization-specific and defined by the business.

Improving the performance of IT support organizations is an even harder task, requiring the evaluation of possible improvements brought by alternative structures and policies. The space of possible operations is very large, including actions such as support group merging, splitting, or re-staffing (increasing, cutting, or transferring operators between support groups, possibly on retraining) and the implementation of different policies for incident assignment and prioritization. Alternative organization structures and incident management strategies need to be carefully evaluated before putting them in practice, as implementing corrective measures is usually extremely expensive and time-consuming.

Traditional software tools provide a somewhat limited support for IT managers dealing with the performance assessment and optimization of the support organization. In fact, they usually focus on the analysis of transactional data collected from logging tools and do not allow to evaluate the performance of different organization configurations.

Existing research techniques are also lacking. Generic approaches aim at improving business processes through the collection of metrics and the inferences over the acquired data [3] or the exploitation of simulation methods [4], but are designed for complex process descriptions are either overkill or unapplicable to simple business processes taking place in a complex organization such as incident management. IT-specific approaches instead focus on specific aspects of IT business process optimization, e.g., optimizing labor cost and business value of IT services through the analysis of process complexity [5] [6] or the ticket routing in IT support organizations through machine learning techniques [7] [8].

IT managers need comprehensive decision support tools enabling them to analyze incident management operations, both at the whole organization level and at the single support group level, verify the effectiveness of the current structural organization, and assess how it would perform under different loads. The tools should also enable IT managers to evaluate possible alternative organizations and policies when the business-level objectives are not met, assisting and guiding the users along the entire performance optimization process.

This paper presents Symian-Web, a decision support tool for the performance and business impact analysis, and the assisted re-design of IT support organizations. Symian-Web enables IT managers to assess the IT support organization performance, and assists them in its re-design for performance optimization. Symian-Web builds on a well-tested state-of-the-art IT support organization model, which we developed in the context of the Symian research project [9] [10]. To enable an immediate and comprehensive information visualization, Symian-Web represents IT support organizations as a network of support groups, leveraging on visualization concepts typical of social network analysis [11] and applying them to the IT support organization performance optimization domain.

Our preliminary evaluation demonstrates that Symian-Web provides a much deeper insight into the structure and the dynamics of an IT support organization than is currently available through state-of-the-art software such as HP IT Analytics, or similar software by other management vendors.

II. SYMIAN-WEB

Symian-Web is a decision support tool for IT performance analysis, business impact analysis and assisted design of an IT support organization. Symian-Web adopts a what-if scenario analysis approach based on simulation, a technique that enables the behavioral analysis of complex real-life systems under alternative working conditions [10]. Symian-Web exploits a discrete event simulator to reproduce in detail the behavior of IT support organizations and to evaluate their performance in managing incidents. The simulation approach is particularly appropriate given that the scale and the complexity of real-life organizations make it extremely difficult to devise an analytical model.

The what-if scenario analysis implemented by Symian-Web enables an iterative performance optimization process, in which users can incrementally specify the set of changes to apply to the current organization model in order to define an alternative configuration that will be tested on a set of performance metrics.

The Symian-Web architecture follows the Model-View-Controller architectural pattern, that enables separation of concerns with regards to the 3 essential functions of IT support organization modeling, performance information representation, and the response to user interactions.

Symian-Web allows creating realistic models of real-life IT support organizations and using them to understand the impact of IT processes, strategies and tactics on the organizations' performance. The Symian-Web model of IT support organizations is based on an open queueing network and is particularly well-suited for modeling the incident management process. In fact, open queueing networks it can easily measure IT support organization dynamics in terms of throughput, queue lengths, response times, and utilization, both at the system level and at the single support group level [10]. Symian-Web leverages on techniques and tools designed to build accurate models of real-life IT support organizations through the statistical analysis of their incident transaction logs [12].

The user interface is another essential component of Symian-Web. Symian-Web proposes an innovative interface that displays IT support organization structural and performance data simultaneously, thus enabling a deep insight into the organization dynamics. The Symian-Web interface features high-density visualization mechanisms that provide immediately accessible information at different aggregation levels. At the same time, Symian-Web enables users to change the IT support organization configuration directly from the performance visualization interface, guiding them through the available set of reconfiguration options.

Management of user interactions is also a complex and delicate task. Symian-Web needs to prevent user actions that may leave it in an inconsistent state, and needs to manage simulation runs efficiently and reliably.

III. MODEL: CAPTURING AND RE-ENACTING THE IT SUPPORT ORGANIZATIONS' BEHAVIOR

Symian-Web's model of IT support organizations is very sophisticated and highly configurable. Creating a new organization model therefore requires a very good knowledge of the open queuing network model realized in Symian-Web as well as of the processes in place within the real-life IT support organization. This challenging task is likely to be carried out by specialized personnel. However, in order to facilitate the creation of new organization models, Symian-Web provides users with specific tools, e.g., for the statistical analysis of incident transaction logs from real-life organizations [12]. Symian-Web also lets users check whether the model reproduces the IT support organization baseline behavior by feeding it with historical data and inspecting critical configuration parameters through ad-hoc visuals.

In Symian-Web each IT support organization can have many *configurations*, representing different working conditions, for examplea higher incident load for stress testing purposes. When a new IT support organization model is created, it is in a *default configuration*. New configurations can be created by cloning an existing one and changing the desired parameters. This differential specification – that is, the definition of a new configuration with respect to a preexisting one – represents a very convenient way to create a new IT support organization configuration.

Once an IT support organization configuration is finalized, Symian-Web re-enacts it through a series of simulations and lets the user assess its performance by applying a set of predefined metrics to the simulation outcomes. Symian-Web also allows users to define custom metrics through a dedicated scripting language. This enables to fully customize the process of performance assessment according to the specific needs and characteristic of the IT support organization – an essential feature in order to enable business impact-driven performance analysis.

Symian-Web also enables users to compare the performance of different configurations for the same IT support organization, and verify which one represents the best alignment to the business objectives.

IV. VIEW: THE IT SUPPORT ORGANIZATION PERFORMANCE VISUALIZATION AND RECONFIGURATION INTERFACE

The IT support organization performance Visualization and Reconfiguration (VR) interface represents the main interface to the functions provided by Symian-Web. The VR interface leverages on several *metaphors*, some of which were introduced in a previous work [13], to facilitate digesting information, and proposes a streamlined interface designed to keep all the functions always easily accessible. Because of the extremely high density of information that it conveys, the VR interface is the ideal starting point for the performance analysis and assisted optimization (re-design) of IT support organizations.

A. Metaphors for Information Visualization

The main view of Symian-Web is a map of the support groups of the IT support organization, as shown in Fig. 1. Symian-Web adopts a graph-based representation to provide simultaneously structural and performance-related information about the IT support organization. More specifically, each node in the graph represents a support group of the IT support organization and each edge represents the presence of ticket escalations between the corresponding support groups.

Within the context of the graph-based IT support organization representation, the VR interface adopts several metaphors to facilitate information communication:

Metaphor 1: *node proximity represents the interaction between the corresponding support groups*. The VR interface lays out support groups according to inter-group communication dynamics: support groups that communicate often – i.e. redirect tickets from one another – are depicted next to each other while support groups that do not interact are depicted far from each other. To this end, the VR interface leverages on a force-directed node placement algorithm [14]. Force-directed graph representations are often proposed to visualize social networks, where entities that are marked as "friend" are placed in close proximity.

Metaphor 2: *node size represents the amount of work* that the corresponding support group performs. A prominent feature of the VR interface visualization is that the size of the node is proportional to the number of tickets that the workgroups process. In this way, users can immediately recognize the support groups visited by the largest number of tickets.

Metaphor 3: *edge size represents the flow of tickets between corresponding support groups*. The thickness of the edges connecting nodes is used to represent the ticket throughput between the workgroups, with thicker edges indicating a larger flow of incidents. In this representation, edges come to represent "information highways", thus enabling users to immediately detect the most important paths that incidents take through the organization.

Metaphor 4: *node border represents the number of tickets closed by the corresponding support group*. This enables user to see which support groups are most effective in finalizing the service restoration process.

Metaphor 5: *node color represents the amount of work that the corresponding support group performs*. When information about the level of support (Help Desk, first line of support, second of support etc…) of each support group is available, coloring is used to represent it.

B. Customizable and Interactive Visualization

The mapping of visual features to metrics for support group dynamics in the VR interface is highly customizable. For example a user may want the dimension of the node to indicate the staffing level of the workgroup, or the coloring to indicate the geography that the workgroup belongs to.

For IT support organization with a very large number of support groups (a large IT support organization can have several thousands), users can switch the VR interface configuration to represent the IT support organization using a hyperbolic tree instead of a graph. Hyperbolic trees render the out-of-focus regions of the map with lesser details, and represent a lower-density information visualization method.

The VR interface enables interactive data visualization. Nodes can be moved (by drag and drop), the view on the graph can be zoomed in or out, etc. The VR interface also presents additional contextual information, such as secondary attributes of support groups and their dynamics, at the bottom of the graph-based IT support organization representation.

C. IT Support Organization Reconfiguration

Using the VR interface, users can trigger what-if scenario analyses guiding them in the assisted organization design step.

Symian-Web gives several options to optimize the performance of IT support organizations. Some of the operations available to IT managers, such as support group removal, support group creation, merging of two support groups, and splitting of a support group, have a major impact on the IT support organization and trigger the redefinition of the transition matrix.

Other operations, such as support group re-staffing, work shift redefinition, incident prioritization and/or operator assignment policy modification, are also available via a lower-level interface. For the complete list of operations, we point the reader to reference [10].

Upon the organization reconfiguration, the VR interface notifies the user that the current configuration is out of date. The user can then choose to run a new simulation to assess the performance of the new IT support organization configuration. When a new simulation is launched, no more changes to the IT support organization configuration are allowed. At the end of the simulation, the VR interface updates the graph based representation with data collected from the simulation.

D. Data Analysis and Visualization of Simulation Outcomes

At the end of each simulation, Symian-Web calculates both Key Performance Indicators (KPIs) and the IT metrics that are of crucial importance in understanding the IT support organization performance.

Users can then analyze the collected performance data using the Symian-Web reporting functions. Symian-Web enables the visualization of available data on the dynamics of the IT support organization, as well as of each support group, according to different dimensions. For example, a user may be interested in a specific time period, incident category or severity. Symian-Web supports several plot types, as well as tabular representations, for performance information visualization.

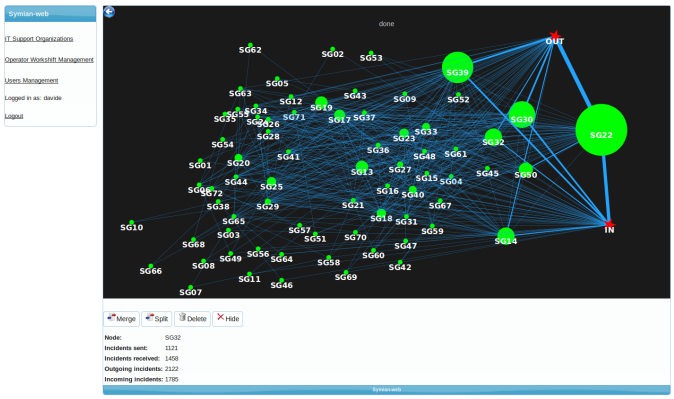

Figure 1. The Symian-Web Visualization and Reconfiguration Interface .

V. CONTROLLER: THE SIMULATION CONTROLLER

Symian-Web's Simulation Controller keeps track of the state of each IT support organization configuration, preventing operations that could leave the system in an inconsistent state. The Simulation Controller is also in charge of managing simulation runs in the cloud.

An IT support organization configuration can transition through several states during its lifecycle. When created, an IT support organization configuration is in the "Configurable" state. In this state, users cannot immediately access performance information, but they can change the IT support organization configuration. Any attempt by the user to visualize performance result will automatically trigger a simulation run and a switch of the IT support organization configuration state to "Running". In the "Running" state, users cannot perform any reconfiguration or visualize performance results. However, they can keep working on cloned copies of the current IT support organization configuration. When the simulations terminate, the IT support organization configuration state becomes "Assessed", and performance information is finally accessible. In this state, any IT support organization configuration reconfiguration will bring it back to the "Configurable" state.

The Simulation Controller runs simulations, which can take several minutes to complete, asynchronously with respect to the user interactions with the Symian-Web interface. When a user triggers a new simulation run, the Simulation Controller marks the IT support organization configuration state as "Running", creates a job for each simulation to run, and puts the jobs in the waiting-to-run queue. Jobs will be later processed and run. Symian-Web attempts to run multiple simulations in parallel according to its configuration and the available computational capabilities in the cloud. When the simulations are over and the outcome data is ready to display, the Simulation Controller notifies the user and marks the IT support organization configuration state as "Assessed".

Finally, the Simulation Controller exposes a ReST-based API [15] [16] that makes Symian-Web remotely controllable.

VI. IMPLEMENTATION

Symian-Web is realized as a cloud computing-based Web application, adopting a Software-as-a-Service (SaaS) approach and adopts a layered architecture.

The top layer takes care of common presentation functions, interfacing with lower-layer components to provide access to all the Symian-Web functions. The middle layer contains components that implement the main Symian-Web functions. It provides reporting functions on IT support organization, keeps track of each IT support organization configuration state, manages simulation runs, and provides support tools for the creation of IT support organization models.

Finally, the lowest layer provides common functions for the upper layer components. It is in charge of supervising the execution of simulations in the cloud, of dealing with to store, retrieve and compare IT support organization configurations and the related simulation parameters. It also implements caching and post-processing.

Symian-Web is implemented as a Ruby on Rails application [17] [18] and uses the JavaScript InfoVis Toolkit (*http://thejit.org/*) to realize the graph- and tree-based IT support organization representations implemented by the VR interface. Symian-Web also integrates with the R statistics framework (*http://www.r-project.org/*) to realize the complex statistical data analysis functions and high quality plots.

VII. CONCLUSIONS AND FUTURE WORK

This paper presented Symian-Web, a decision support tool enabling the interactive performance optimization of IT support organizations through what-if scenario analysis.

The most innovative aspect of Symian-Web is that it provides a comprehensive set of tools that assist users along every step of the IT support organization performance optimization process, from the creation of a virtual organization model, to its performance evaluation, and finally to its reconfiguration. In addition, the Symian-Web interface can deliver a much higher insight into the structure and the dynamics of an IT support organization than is currently available through the ones proposed by state-of-the-art commercial software.

We are planning to extend and improve the set of functions and tools that Symian-Web provides to its users. We are especially interested in the development of inference methods for multi-server multi-priority queues and of higher-density information visualization methods for IT support organization performance data. We are also considering further evaluations of Symian-Web, involving interested researchers and practitioners as well as IT managers and collecting their feedback to improve the feature set and usability of the tool.

REFERENCES

[1] Office of Government Commerce, "Service Strategy Book", The Stationery Office, Norwich , 2007.

[2] Office of Government Commerce, "Service Operation Book", The Stationery Office, Norwich, 2007.

[3] F. Casati, M. Castellanos, U. Dayal, M.C. Shan, "A Metric Definition, Computation, and Reporting Model for Business Operation Analysis", in *Proc. of Advances in Database Technology - EDBT 2006, 10th International Conference on Extending Database Technology*, Munich, Germany, March 26-31, 2006.

[4] K. Tumay, "Business process simulation", in *Proc. Winter Simulation Conference 1995*, 3-6 December 1995.

[5] Y. Diao, A. Keller, S. Parekh, V. Marinov, "Predicting Labor Cost through IT Management Complexity Metrics" in *Proceedings of the 10th IEEE/IFIP Symposium on Integrated Management (IM 2007),* Munich. Germany.

[6] Y. Diao, K. Bhattacharya, "Estimating Business Value of IT Services through Process Complexity Analysis", *in Proceedings of the 11th IEEE/IFIP Network Operation and Management Symposium (NOMS 2008)*, Salvador de Bahia, Brazil.

[7] Q. Shao, Y. Chen, S. Tao, X. Yan, N. Anerousis, "Efficient Ticket Routing by Resolution Sequence Mining", in *Proceedings of 14th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD'08)*, Las Vegas, NV, USA, 24-27 August 2008.

[8] Q. Shao, Y. Chen, S. Tao, X. Yan, N. Anerousis, "EasyTicket: A Ticket Routing Recommendation Engine for Enterprise Problem Resolution", in *Proceedings of 34th International Conference on Very Large Data Bases (VLDB'08)*, Auckland, New Zealand, 23-28 August 2008.

[9] C. Bartolini, C. Stefanelli, M. Tortonesi, "SYMIAN: a Simulation Tool for the Optimization of the IT Incident Management Process", in *Proceedings of 19th IFIP/IEEE International Workshop on Distributed Systems: Operations and Management (DSOM 2008)*, 25-26 September 2008, Pythagorion, Samos Island, Greece.

[10] C. Bartolini, C.Stefanelli, M. Tortonesi, "SYMIAN: Analysis and Performance Improvement of the IT Incident Management Process", *IEEE Transactions on Network and Service Management*, Vol. 7, No. 3, pp. 132-144, September 2010.

[11] L. Freeman, "Visualizing Social Networks", *Journal of Social Structure*, Vol. 1, No. 1, 2000.

[12] C. Bartolini, C. Stefanelli, M. Tortonesi, "Modeling IT Support Organizations from Transactional Logs", in *Proceedings of the 12th IEEE/IFIP Network Operations and Management Symposium (NOMS 2010)*, pp. 256-263, 19-23 April 2010, Osaka, Japan.

[13] C. Bartolini, "IT Incident Management as a Collaborative Process: A Visualization Tool Inspired to Social Networks", in *Proceedings of 4th ACM International Conference on Collaborative Computing: Networking, Applications and Worksharing (CollaborateCom 08)*, 13-16 November 2008, Orlando, FL. USA.

[14] T. Fruchterman, E. Reingold, "Graph Drawing by Force-Directed Placement", *Software – Practice & Experience*, Vol. 21, No. 11, pp. 1129–1164, 1991.

[15] R. Fielding, R. Taylor, "Principled Design of the Modern Web Architecture", *ACM Transactions on Internet Technology*, Vol. 2, No. 2, pp. 115–150, May 2002.

[16] L. Richardson, S. Ruby, "RESTful Web Services", O'Reilly, 2007.

[17] I. Vosloo, D. Kourie, "Server-Centric Web Frameworks: An Overview", *ACM Computing Surveys*, Vol. 40, No. 2, Article 4, April 2008.

[18] M. Bachle, P. Kirchberg, "Ruby on Rails", *IEEE Software*, Vol. 24, No. 6, pp. 105-108, 2007.