Business-driven decision support for change management: planning and scheduling of changes

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Abstract. Moving from the results of a web survey we carried out in early 2006 we identified the main challenges in IT change management as *planning and scheduling of changes*; *high number of emergency changes* and *ill-definition or wrong scoping of request for changes*. In this paper we begin to address the problem of planning and scheduling changes taking business considerations into account, following a business-driven IT management (BDIM) methodology. We sketch a reference architecture which follows the principles of BDIM, comprising of a mathematical model linking IT availability metrics to business objectives (in our example: monetary loss due to availability service level violations). We present a numerical illustration of how the derived metrics may support change management decisions in order to plan and schedule changes to minimize adverse business impact.

Keywords. Information Technology Infrastructure Library (ITIL), change management, business-driven IT management, business metrics, modeling, performance evaluation, automation, probability of SLA violation, business impact, decision and negotitation support tools.

1. Introduction

IT management has become more user-centric and less service provider-dependent with the popularity of the practices recommended by the Information Technology Infrastructure Library – ITIL [3], which is used as the basis for the IT Service Management framework – ITSM [8]. ITSM defines a number of processes that are organized into 5 modules: security management; IT & communication infrastructure management; application management; service support (incident, problem, configuration, change and release management processes); and service delivery (service level, capacity, availability, continuity and financial management for IT services). Within the realm of ITSM, this paper focuses on the *change management* process.

ITSM expresses goals and gives guidelines to IT managers for ensuring smooth running of their IT service delivery and support. For instance, the mission of the change management process is defined as “to ensure that **standardized methods and procedures** are used for efficient and **prompt handling of all changes**, in order to **minimize the impact** of any related incidents upon service” [3]. However, it falls short of defining control objectives for IT. This shortcoming is addressed by the COBIT framework (Control Objectives for Information and related Technologies, [2]. In order to gauge the maturity and quality of the IT service delivery and support activities, COBIT introduces a number of key performance indicators (KPIs), KPIs drive the process goals, which in turn are measured by process key goal indicators (KGIs).

Examples of key performance indicators for the change management process are the number of emergency changes, or the number of changes that were rolled back, in a change management context. For activities in the service delivery scope, such as service level management, such metrics are taken into account as availability and reliability of the system.

The first wave of management software (from the early 90’s), concentrated on monitoring availability, resource consumptions levels, etc. In the last three or four years, software tools have appeared on the market that help with other activities of IT management, in particular with help desk and IT service support. These tools provide valuable help to IT managers in making informed decisions on the actions to take to ensure smooth running of IT processes.

However, just because the IT systems are running smoothly, it does not follow that the business that IT supports is best served by it. In order to ensure business-IT alignment, metrics should be taken into account which are more business-like in nature, such as cost, revenue or financial loss. This consideration is the basis for the Business–Driven IT Management (BDIM) discipline [6]. BDIM steers ITSM towards business alignment, i.e., to contribute to business results. This paper uses a BDIM approach to address change management challenges.

BDIM attempts to gauge the impact that IT has on the business and aims at rethinking IT management from this perspective. BDIM involves a new culture, tools and decision–making processes that should aim to *help the business*. A complete ITSM shift to BDIM requires IT personnel or automated tools to use business metrics to gauge the QoS offered to a business user. Although BDIM has been attracting mounting research efforts, attempts at investigating the feasibility and options of spreading BDIM applications to cover ITIL management processes are still scarce. Some recent applications include incident prioritization [1], capacity planning [5], and, an automatic change management process [4]. Embedding results of such efforts in tools for automating decision and negotiation support is at its very beginning. This is particularly true for the case of human assisted, change management processes. This paper proposes a BDIM approach which could be embedded in a tool to support decisions and negotiations in a more generic, ITSM–based change management process.

The remainder of the paper is organized into sections 2 through 7. Section 2 discusses current change management challenges as elicited by an early 2006 Web survey. Section 3 begins to address some of these challenges by describing a layered reference architecture for business-driven IT change management (BDIM-CM) solutions. Section 4 details how lower layer metrics for the BDIM-CM solution may be derived. Section 5 presents a numerical illustration on how the derived metrics may support change management decisions in order to minimize adverse business impact. Section 6 briefly examines competitive and related work, including the few tools available in the market. In section 7 we draw our conclusions and give a preview of our further work in this space.

2. Major challenges in change management

The change management process comprises four groups of activities:

- Request For Change (RFC) acceptance, classification and processing;
- approval and planning of changes;
- building, implementation, tests and reversal of changes;
- change evaluation.

Current state-of-the-practice solutions for in change management suffer from several acute problems, including the volume of changes, change complexity and inappropriate tools. It appears that the majority of and the most demanding challenges faced by technical personnel in charge of change management lie in carrying out the activities in the first two groups. ITIL recommends that change classification be done according to priority and category. Priority is set according to the business importance of an RFC relative to other RFCs; category is determined based on the availability of resources, risk to services and on the impact of the changes. Planning items include scheduling, allocation of resources, budgeting, sequencing of activities, back out plans, and, communication. According to results from a Web questionnaire posted by UFCG in the first quarter of 2006 [7], particular attention should be devoted to planning / scheduling issues. The questionnaire respondents were ITSM practitioners, all engaged in change management (some with over 10 years experience), from 21 companies worldwide. Seventeen of these companies already have change management processes in place (11 use ITIL and 6 adopt other practices); four are just starting to implement change management. Nine of the companies are in the business of providing IT services (including consulting), 4 are telecoms, 4 are in financial services and the others are either in government, health care or manufacturing. Seven companies have yearly revenues over US$ 1 billion; eight, make just under US$ 10 million annually. Questionnaire respondents who follow ITIL's *change management* process recommendations ranked the first 3 most important change management challenges as being (Figure 1):

1. scheduling/planning changes (with 47 points out of a maximum 55, or over 85%);
2. high number of emergency changes (43 points or 78%); and,
3. RFC scope ill-definition (40 points or 72%).

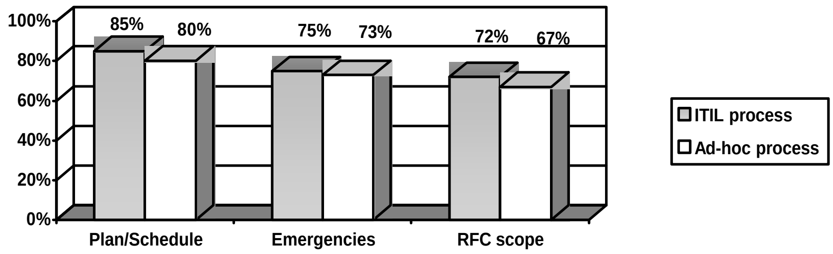

Fig. 1. Most frequent problems in Change Management

Interestingly, the survey also indicated that ad-hoc change management process adopters rank planning/scheduling as the most important challenge (80%) but now, together with "unauthorized changes" (that seems to be a consequence of an ad-hoc process); high number of emergency changes is ranked second (73%) together with "notification of people affected"; and, RFC scope mal-definition is also ranked third (67%), but together with "inconsistent CMDB" (again, a possibly symptom of an ad-hoc process). This paper contributes to addressing the most critical issues of change planning/scheduling to minimize negative impact to a service provider's business.

Properly addressing change planning / scheduling challenges is no trivial endeavor. As commented by one of the survey respondents, "scheduling is non-trivial due to people and process problems". Changes take place in a very dynamic environment. People become unavailable, business conditions vary and "urgent changes" may materialize. Hence, change plans and schedules have to be adjusted correspondingly. A change manager may have to build and consider several plans/schedules before a given plan is actually implemented. In an outsourcing environment, negotiating change windows with business clients is another complicating, human-dependent factor. Typically, outsourcing agreements do not provide explicit information on feasible time windows for scheduling changes that affect the associated service. Since no contractual binding exists, windows may be re-negotiated (and they are), causing re-planning and re-scheduling. The sheer volume of requests for change – RFCs – makes the scheduling exercise very complicated. As an example, the HP Managed Services organization handles 300 to 400 RFCs per weekend for a single customer. Therefore change classification and planning are currently driven by technical issues with little consideration for business needs or priorities. The solution for (re-) scheduling and elaborating such diverse plans that we begin to sketch in the next section would ease the lives of those responsible for the change management process.

3. Business-driven planning and scheduling of changes

In Figure 2 we sketch our reference architecture for BDIM solutions for change management, built upon a three-layer hierarchical model.

The bottom layer offers *business-IT linkage models* which describe change attributes and other related objects from the IT and business environments; on the IT side, this would include, for example, the Configuration Management Data Base –

CMDB or a Service Level Agreement (SLA). One may say that a SLA represents the "relationship" between the IT function or provider and the business proper or its units and as such, sits at the boundary between the two environments. From its formalized inputs, the lower layer produces IT-business linkage metrics in the sense defined in [6]: numerically evaluating relationships between IT causes and their effects on business results. Examples of such metrics are: risk of adversely affecting business operations if a change is not successful and the impact of an unsuccessful change (such as potential financial loss). As we will see in the worked examples in the next sections, these metrics require the derivation of the probability of violating an SLA, which in turn may depend on the change schedule. The solution discussed here adopts impact for linkage metric and uses the probability of SLA violation to estimate it.

Linkage metrics are then fed to the middle layer – labeled *decision support* **-** where decisions are made and used to steer activities of the change management process (to the left of Figure 2) and/or to prepare negotiators to negotiate change management process details with the IT client (at the top in the figure – *negotiation support*).

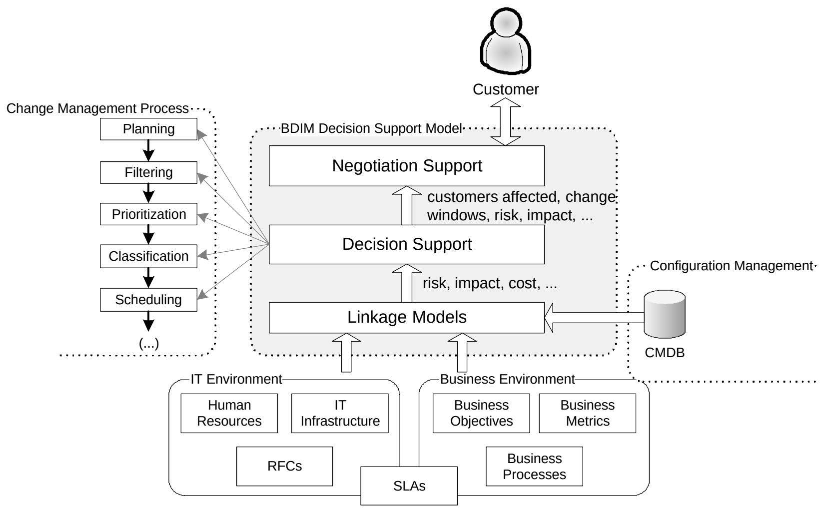

Fig. 2. A hierarchical model for business-driven change management solutions

We propose to use our reference architecture in a change management setting according to the following BDIM approach. By knowing details of a given RFC (such as affected configuration items), SLA violation history and its service level objectives (SLOs), at the linkage layer we can calculate the probability of violating a given SLA if the change is implemented at a given time. The business-IT linkage metrics used in this layer allow us to determine the expected monetary loss that will potentially result. This computation is basis for supporting the IT manager's determinations of what changes are to be implemented during a particular change window. Negotiations with the client are carried out to confirm the selected change window and in order for the client to take any precautions that are necessary – including requesting anticipation of the window, for instance (in which case the process must reiterate through the previous step). The business perspective introduced through the business-IT linkage model eases negotiations because arguments are presented to the client in familiar business terms (in this case, as potential financial loss).

4. Business-IT linkage model

This section captures the impact of changes on the business. Consider a scenario where a service organization provides support for IT services subject to SLAs including an SLO that states a minimum availability. The client organizations use the services to process "revenue-generating sessions" (an example of such a service could be an e-commerce site and sessions could be buying transactions from site visitors, for instance). The provider earns a fixed fee for each successfully completed session and pays a penalty whenever the associated SLA is violated. Whenever a service is down but the associated SLA is not violated, the provider stops collecting fees on that service since no session can be serviced. If the SLA is violated however, besides losing the contracted fees, the provider must pay a penalty to the client at the end of the SLA evaluation period

The business objective that we consider is to minimize the business loss.

- **Business loss**. Any loss (but usually financial in nature) incurred by a business due to malfunctions of supporting IT services. In our example, the episodes that can have an impact on the business loss are *violations of minimum availability SLO* and *system downtime* due to changes.

The episodes that can have an impact on the business objective above are *violations of availability SLO* and *system downtime* due to changes.

- **Violation of SLO on minimum availability.** Due to penalties included as SLA clauses and, more importantly, in order not to tarnish the service provider's image, SLA violation is frequently cited by change managers as a prime driver for decision making during change planning.
- **System downtime**. In our example, whenever the service is down and the availability SLA is not violated, the provider stops collecting fees since no session can be services. This has a direct impact on the business loss.

Next, we will estimate the likelihood and extent of impacting episodes due to requested changes (subsection 4.1), and derive their impact on the business loss (4.2).

4.1. Probability of SLA violation and extent of system downtime

We first consider a single IT service s_j from the provider's entire set of services, $S=\{s_1,...,s_{|S|}\}$ and assume that the associated Service Level Agreement (SLA) in force for s_j has a Service Level Objective (SLO) on *availability*, A_j^{min}.

Let the *mean service availability* for s_j be calculated over an evaluation period T [1], as determined by the associated SLA. This mean availability takes on a different value over each evaluation period and it is thus a random variable[2], denoted by $\tilde{A}_j$. We indicate the cumulative distribution of the service availability random variable with

[1]For simplicity we assume that all services have this same evaluation period.

$F_A(x) = \Pr[\tilde{A}_j \le x]$. Without loss of generality, let the current evaluation for availability start at time 0 and end at time T. Let us examine the situation at an arbitrary point in time, t, s.t. $0 \le t \le T$ during the current evaluation period. Let the availability over period (t_1, t_2) be $A_j(t_1, t_2)$. Thus, one has $\tilde{A}_j = A_j(0, T)$. One can also say that, over the time period $[0,t]$, the (past) mean availability is measured as $A_j(0, t)$. The future mean availability over time period $[t,T]$ is simply $A_j(t, T)$. Now, we ask: "At time t, what is the probability that the availability threshold, A_j^{min}, specified in the SLA will be violated by time T?" The mean availability, $A_j(0, T)$, over the whole evaluation period, $[0, T]$, can be calculated from the mean values of past and future availability by summing up the uptime over both time periods:

$$\tilde{A}_j = A_j(0,T) = \frac{uptime}{T} = \frac{A_j(0,t)t + A_j(t,T)(T-t)}{T} \quad \textbf{(1)}$$

Then the distribution for availability, given that time has reached t, follows:

$$\Pr\left[A_j(0,T) \le x \middle| t\right] = \Pr\left[A_j(t,T) \le \frac{xT - A_j(0,t)t}{T-t}\right] \quad \textbf{(2)}$$

Given that the probability distribution for availability is assumed to be the same over any time period in the interval $[0, T]$, we can now express $V_j(t, T, A_j^{min})$, the probability, at time t, of violating the availability SLO for service s_j by time T:

$$V_j(t,T,A_j^{\min}) = \Pr\left[A_j(0,T) \le A_j^{\min} \middle| t\right] = F_{A\,j}\left(\frac{A_j^{\min}T - A_j(0,t)t}{T-t}\right) \quad \textbf{(3)}$$

We now turn our attention to the impact of changes affecting service s_j. Let $C = \{c_1, \ldots, c_{|C|}\}$ be the set of all changes to be considered by the change manager; $[a,b]$ be the time interval beginning at time $t=a$ and ending at time $t=b$, where $a < b$; and $T_n^c = [a^n, b^n] \subseteq [0,T]$ be the time interval during which a given change c_n in C is performed. Notice that implementing c_n may or may not affect s_j. Let service s_j be provisioned with a set, I_j^s, of components (Configuration Items or CIs, in ITIL parlance). If we let $I=\{i_1,\ldots,i_{|I|}\}$ be the set of configuration items of the CMDB, then $I_j^s \subseteq I$. Each change is subject to a plan that specifies the time at which the change implementation will start, and a subset $I_n^c \subseteq I$ of the CIs that will be affected by change c_n.. The plan specifies which CIs will be brought down and when, so that one can calculate the time at which service will be brought down (if it is not already down) and the time at which it will be available again. The set of all intervals during which service s_j $\forall n \mid I_j^s \cap I_n^c \neq \varnothing$ becomes unavailable within T is given by the union of all s_j–affecting change intervals, T_n^c, i.e.,

$$T_j^s = \bigcup_{\forall n | I_j^s \cap I_n^c \neq \varnothing} T_n^c \quad \textbf{(4)}$$

Note that ΔT_j^s (a scalar) corresponds to the total time period during which s_j is unavailable, i.e., the interval algebra sum of the durations of all change intervals in T_j^s. Notice that all changes affecting service s_j will be implemented *after* the present moment (time t) so that any service downtime will need to be added to the "future" part of the evaluation period. Observing that the time period between $[t,T]$ but outside the service downtime called for in the change plan still obeys the same distribution of availability, we conclude that, with the changes planned for the current evaluation period, the probability of violating the s_j SLA is:

$$V_j(t,T,A_j^{\min}) = F_{A_j}\left(\frac{A_j^{\min}T - A_j(0,t)t}{T - t - \Delta T_j^s} \right) \quad (5)$$

In order to conclude the development, we need the cumulative probability distribution function, $F_A(x) = \Pr[\tilde{A}_j \bullet x]$. A result from reliability theory [9] states that, when the uptime (time-to-failure) and downtime (repair times) are exponentially distributed, availability follows the two parameter (a and b) Beta distribution. The mean value for availability is simply $E[\tilde{A}_j] = a/(a+b)$. a and b are chosen to match historical availability distribution data. Typical values are a = 7 and b = 0.03, yielding 99.57% availability averaged over several evaluation periods.

4.2. Impact of SLA violations on business loss

We now estimate the impact on the business loss minimization objective for a given SLA violation probability of a single service s_j. Table 1 summarizes the parameters of the provider's revenue model.

Table 1. Provider's parameters for service sj

Principal impact function variables	
$V_j(t,T,A_j^{\min})$	Probability of SLA violation at time t
ΔT_j^s	Service s_j unavailability period
Other impact function parameters	
p_j	Penalty ($) for service s_j SLA violation.
T	SLA evaluation period for s_j
g_j	Session throughput for service s_j.
s_j	Fixed fee ($) per successful session, for service s_j

In our model we assume that the provider schedules changes to be implemented during T which will bring service s_j down for a time interval, ΔT_j^s. At a given time, t, the provider's total financial loss expected for service s_j current evaluation period ending at time T is given by:

$$L_j^p(t,T) = V_j(t,T,A_j^{\min}) \cdot p_j + g_j \cdot \Delta T_j^s \cdot s_j \quad (6)$$

It is important to notice that the QoS history from the beginning of the SLA evaluation period up to time t is summarized in $A_j(0,t)$, the mean (past) availability up to t, and it affects the probability of violation and loss. Lastly, notice that loss is a function of time. At the beginning of the SLA evaluation period, the probability of SLA violation and hence, the expected loss, each has a given value. Both values change over time. As the change manager makes decisions at a time instant t, then both $V_j(t, T, A_j^{\min})$ and $L^p_j(t,T)$ must be functions of t.

In the case of multiple services $S=\{s_1,.s_j..,s_{|S|}\}$ supported by the provider and affected by multiple changes, the provider's total expected loss at time t is:

$$Loss_s(t,T) = \sum_{j=1}^{|s|} L_j^p(t,T) \tag{7}$$

5. Numerical illustration of BDIM support in change management

Consider a scenario where a service provider offers $S=\{s_1 s_2, s_3\}$ services: s_1 is a web auction service; s_2 an e-commerce service; and, s_3, a database service. Service s_1 is to be brought down due to two changes to two of its supporting CIs: an operating system (CI_1), whose change (c_1) is to be implemented in 3 hours; and, a Data Base Management System (CI_2), whose version upgrade (change c_2) is expected to last 2 hours. Services s_2 and s_3 share a firewall (CI_3) and run independently from CI_1 and CI_2. A firewall change (c_3) is expected to last 4 hours. Table 2 lists SLA parameters for these three services. T = 30 days (monthly evaluation).

Table 2. Service configuration

Input	Service s_1	Service s_2	Service s_3
g_j (session/s)	16	12	13
s_j	\$ 1.5	\$ 0.7	\$ 0.8
p_j	\$ 30,000.00	\$ 15,000.00	\$ 10,000.00
$A_j^{\min}$	0.99	0.99	0.99
A_j^{past} (on day 10)	0.998	0.992	0.9998

Due to staff limitations, the change manager cannot do both $\{c_1,c_2\}$ and $\{c_3\}$ simultaneously. He must choose which set of changes to implement first. Notice that there is no possible overlap between c_1 and c_2. Table 2 indicates that s_1 is the service with the greatest revenue stream (\$24/h) and from A_j^{past} at present time (t = day 10), the service with best SLA track record. The combined duration of the changes this service is to experience (3 + 2 = 5 hours) will not cause SLA violation (over its current, 30-day evaluation period). On the other hand, choosing to implement c_3 will cause s_2 SLA to be violated (making the provider pay a ten thousand dollars penalty), but not that of s_3. In an unlikely situation of disregarding all other change schedule influencing factors – such as political pressure from clients, provider's image concerns, change roll-back problems and the cost of not executing a given change – and of just analyzing SLA clauses and short-term past history (Table 4), one may be tempted to opt for implementing $\{c_1,c_2\}$, affecting s_1 (since this option is likely to yield a smaller loss).

The business-IT linkage metrics of the previous section offers the information in Figure 3. This figure shows that, at day 10, a better informed decision alternative is to select $\{c_3\}$ because this option yields a lower expected loss at day 10. Later on, however (around day 16), it is more advisable to select $\{c_1,c_2\}$ to implement first. Change management decisions are dynamic in nature and our business-IT linkage metrics captures this dynamic behavior.

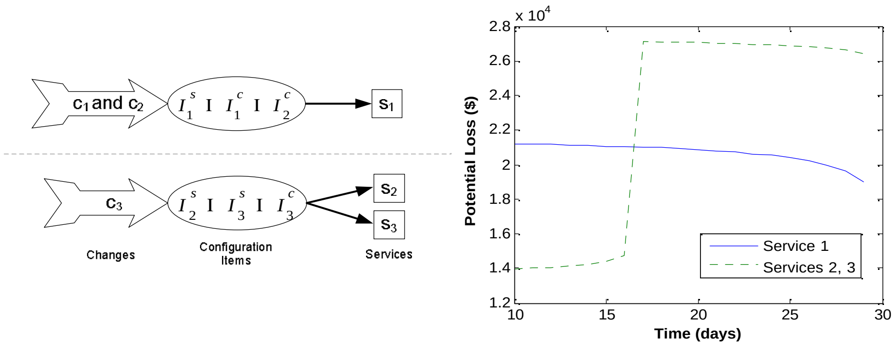

Fig. 3. Expected losses with changes in illustration scenario

6. Related work

IT management software tools available in the market (such as HP OpenView ServiceDesk and ServiceCenter and BMC Routes-to-Value Change and Configuration Management) provide administrative support to the change process by tracking a change in all phases of its lifecycle, coordinating its different activities, assigning activities to the appropriate people and monitoring its progress until it is closed. However, these tools provide no support to the decision-making process, and, although concepts such as *risk* and *impact* are present, their definition is rather ambiguous and their assessment is left to the tool user.

CHAMPS [4], a research prototype out of IBM Research, represents the state of the art in automation for change management, but it does not address aspects of project management of the changes such as scheduling activities that require human intervention. Further, it is assumed that business impact is an input parameter and the intended application is to an autonomic computing setting. The linkage model in our work helps to evaluate business impact. Our solution addresses change management challenges holistically: it considers all three components people, process and technology. Thus, our work may be seen as complementary to that of [4]. The work in

[1] brings ideas that could be adapted for prioritization / classification of RFCs, since RFCs are frequently related to incidents. Usage of utility functions is particularly attractive.

7. Conclusions and future work

From the results of a web survey we carried out in earlier 2006 [7], we identified the main challenges in IT change management as 1) planning/scheduling changes, 2) high number of emergency changes and 3) ill-definition or wrong scoping of request for changes. In this paper we have begun to address the problem of planning and scheduling changes taking business considerations into account, following a business-driven IT management (BDIM, [6]) methodology. We have sketched a reference architecture which follows the principles of BDIM, comprising of a mathematical model linking IT availability metrics to business objectives (in our example: monetary loss due to availability service level violations). We presented a numerical illustration of how the derived metrics may support change management decisions in order to plan and schedule changes to minimize adverse business impact.

The example we work here is the basis for the conception of an automated tool for decision support for planning and scheduling changes. We have received encouraging feedback from the respondents of our survey in [7], to whom we presented the scenario here exposed in a follow up interaction. The respondents agree that the information these metrics provide will definitely “add value to the decision process”. However, still much remains to be done, before we can embody the reasoning capabilities here described into a software tool that is complete enough for it to be of value for change managers in their tasks of decision making and negotiation with their outsourcing customers. The main contribution of this paper is remains the formalization of a sound base for supporting change scheduling and planning. Design and implementation of the decision support tool is the subject of the next phase of our research.

8. Acknowledgements

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