INTEGRATING RISKS IN BUSINESS PROCESS MODELS WITH VALUE FOCUSED PROCESS ENGINEERING

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Abstract

As enterprise systems develop, the integration of various business management dimensions becomes increasingly important. However, historical disciplinary boundaries between information systems and management sciences can obstruct this path to integration. For example, risk management is generally considered as a business process within process engineering, while in the context of management sciences risk is treated as a threat to business objectives that needs to be minimized. Both views are essential for a complete approach to identifying, understanding and managing risks in order to optimally meet business requirements. In this paper, we address the need for a holistic business view of risk management in the enterprise systems space by drawing on the strengths of the respective disciplines and identifying links between their complementary views of risk, which enables us to integrate these apparently diverging views. Through the application of value-focused process engineering principles to risk management models, we develop a framework that extends the capabilities of existing enterprise systems and enables risk-oriented process management which incorporates a multi-disciplinary view of risk. The proposed framework is illustrated in the context of a critical administrative process in a university to demonstrate the practical application of and the resulting benefits from the use of this framework.

Keywords: risk, process, value-focused, enterprise, systems.

1 INTRODUCTION

Yu, Hwang and Huang (1999, p. 401) note that an "operational system is normally or typically constituted by hardware, software, and human operation. Errors or failures in any of these components may cause a system to break down."

A business process as defined by Davenport (1993, p. 5) is a structured, measured set of activities across time and place, with a beginning, an end, and clearly identified inputs and outputs which are designed to produce a specified output for a particular customer or market. Business processes are subject to errors in each of the components discussed by Yu, Hwang and Huang (1999) above. Accordingly, to enable the successful completion of a business process it is important to understand and manage the risks associated with each process activity and with the process overall.

Within the context of decision and management sciences, risk issues are traditionally separated from operational concerns of the business (e.g. Campbell & Stamp 2004, iSixSigma 2005, March & Shapira 1987). In these disciplines, risk is typically characterized as "the probability of occurrence of loss/gain multiplied by its respective magnitude" (Jaafari 2001). In the context of business processes, the representation and analysis of risk is linked directly to the individual activities and the order of these activities, often without sufficient links to quantitative risk models (Scott & Vessey 2000).

While the importance of understanding process-related risks in the context of business process management increases due to legislative requirements (e.g. the Sarbanes-Oxley Act of 2002), this topic has only recently become a focal point of study in the academic community (e.g. zur Muehlen & Rosemann 2005; Yu, Hwang & Huang 1999, iSixSigma 2005). Otherwise, the two views of risk and process modeling methodologies and tools remain largely independent of each other. As a result of these research silos, the progress towards an integrated risk-aware approach for process management is still in its infancy.

The aim of this paper is to propose a new conceptual framework that bridges the gap between the risk management and process management disciplines to provide business process analysts a foundation for their decisions regarding different process design scenarios. This framework builds on the concept of risk-oriented process management proposed by zur Muehlen and Rosemann (2005) and is aimed at increasing the capabilities of existing process modeling approaches in terms of risk modeling. The theoretical basis of the framework is the concept of value-focused process engineering which was introduced by Neiger and Churilov (2003, 2004, 2006) and is reviewed briefly in the next section. This section is followed by a step-by-step guide towards the integration of risk management and process management modeling techniques in Section 3. The application of the conceptual model is illustrated with an intuitive example in Section 4 in the context of an administrative process in the academic domain. The paper ends with a discussion of the proposed framework, future research directions and opportunities to extend the proposed framework in this field.

2 BACKGROUND

Value-focused process engineering creates links between business processes and business objectives at the operational and strategic levels as illustrated in figure 1 (Neiger 2005, p. 212). Values of an organization are reflected in fundamental objectives that are defined by Keeney (1994, p. 34) "as a statement of something that one wants to strive toward". These objectives are then decomposed into means objectives, which are defined by Keeney (1994, p. 34) as "methods to achieve ends" which correspond to process objectives (at the higher levels of the business process hierarchy) or functional objectives (at the lower levels of the business process hierarchy).

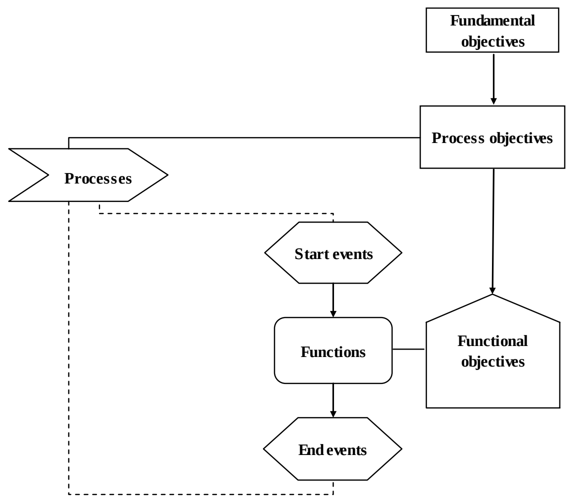

Figure 1. *Overview of value-focused process engineering.*

As shown in figure 1, business processes and objectives are identified simultaneously and synchronized in order to establish a clear relationship between the process and objectives structures in the context of value-focused process engineering. The implementation model for identification and linking business processes and objectives structures is provided in figure 2 (Neiger & Churilov 2004).

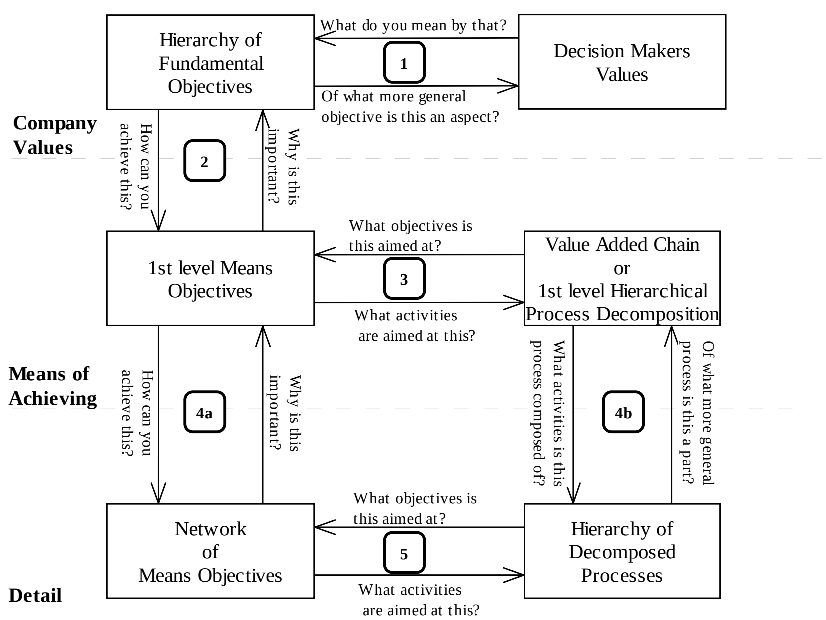

Figure 2. *Implementation steps for value-focused process engineering.*

Once the identification process is complete, the objectives structure can be used to quantify and evaluate objectives using existing decision modeling tools. This enables the identification and comparison of alternative process structures during the process engineering stage (so called build time) as well as the assessment of attainment of objectives during the process execution stage (runtime).

As a result of links between existing business process modeling techniques such as Event-driven Process Chains or the Business Process Modeling Notation and the decision-based objectives models established within the value-focused process engineering framework, risk management tools developed within decision sciences can easily be integrated with existing process modeling frameworks. In this paper, we illustrate how one such model (Multiple Attribute Utility Theory) can be used to address the need to document process-related risks and their relationships with goals, other risks, and other processes.

Multiple attribute utility theory (MAUT) is based on the hypothesis that "in any decision problem, there exists a real valued function U defined on the set of feasible alternatives which a decision maker wishes, consciously, or not, to maximize" (Olson 1996, p. 20). While MAUT can cater for complex value functions, trade-offs, and measurement mechanisms, in its simplest form it consists of the following steps:

1. identification of objectives and corresponding measures;
2. identification of alternatives that are defined as vectors of allowable objectives values;
3. definition of the utility as a function of objectives and their relative importance to express the relative value of each alternative to the decision-maker. As the utility function is expressed in terms of value to the decision maker, the alternative with the largest utility function is considered the best among the evaluated alternatives.

In the context of MAUT, risk is usually expressed as a set of one or more objectives that are to be minimized and measured in units of probability.

3 A CONCEPTUAL MODEL FOR THE INTEGRATION OF RISK INTO BUSINESS PROCESS MODELS

Both the value-focused process engineering framework and the risk-oriented process management approach discussed in the introduction rely on the Event-driven Process Chain (EPC) notation and its extensions within the widely accepted Architecture of Integrated Information Systems (ARIS) (Scheer 1999, 2000). The EPC and ARIS have been chosen to visualize the ideas on the basis that using a popular methodology such as ARIS is beneficial for the dissemination of our suggestions without unnecessarily limiting the application of the proposed framework (zur Muehlen & Rosemann 2005). This approach is also adopted for the discussion of the conceptual model in this section and the illustration of the conceptual model in the following section.

One of the objectives of risk-oriented process management is to facilitate more "risk-aware" decision making processes when it comes to the design of future process scenarios (process configurations). In other words, when comparing two process configurations, with all other things being equal, the business process analyst should choose the configuration which is exposed to less risk.

To ensure that risk minimization is taken into account in the context of other business values and objectives and does not dominate the choice of process configuration, the need for risk minimization should be expressed as one of the objectives contributing to the overall success of the relevant business process as well as the business as a whole. The expression of risks as business objectives is a common practice (e.g. Olson 1996) in the field of decision analysis and modeling. Since the value-focused process engineering framework integrates decision and process models, treating risks as business objectives allows for the direct application of the value-focused process engineering framework to the task of integration of risk and process management.

Following the steps in figure 2, this integration can be achieved as follows.

Step 1. Business values and fundamental objectives are decomposed (drill-down) to identify relevant process risks (top-down approach to risk identification). To ensure that risk objectives are taken into account we suggest that a higher level objective of "minimizing risk of process failure" is identified as part of the fundamental objectives hierarchy. In addition, each business activity can be examined in order to identify any further risks relevant to that activity (bottom-up approach to risk identification).

Step 2. Concepts of value-focused thinking and principles of synchronized decomposition summarized in figure 2 (also refer to Neiger 2005, Neiger and Churilov 2006) are used to identify specific risks and determine which processes and which functions within these processes contribute to these risks. As highlighted by Keeney (1992), the articulation of links between business activities and risk related objectives facilitates the identification of alternative process configurations that may have been overlooked in the initial analysis. As a result of this step, an objectives structure linked to the process flow is constructed.

Step 3. Alternative process configurations constitute alternative solutions to identifying the best process structure that meets the business objectives. Since the risk minimization objective is often in conflict with other business objectives (such as cost minimization or profit maximization) a process configuration that minimizes the risk may be sub-optimal. To enable a more holistic assessment of risk in the context of other business objectives, an overall objective function should be developed and used to compare alternative configurations using MAUT. While the MAUT model is a quantitative model, verbal decision and simulation models can be used at this stage when business preferences and values cannot be easily measured or quantified exactly (e.g. Larichev & Moskovich 1997, Ragsdale 2004).

Step 4. Results of the comparison of alternative configurations in Step 3 enable the choice of optimal process configuration that meets risk minimization objectives in the context of the overall business requirements.

The four-step process discussed in this section is summarized in Figure 3 using EPC notation. This diagram shows the events (hexagons), functions/activities (rectangles with rounded corners), the control flow (arrows between events and functions), and the control flow logic (with exclusive OR represented as XOR).

4 ILLUSTRATION

The following example will be used to provide insights into the actual application of the proposed framework. The selected process scenario is based on an actual occurrence and was introduced by zur Muehlen and Rosemann (2005) to illustrate the concepts of risk-oriented process management:

> In June 2005, the payroll process of a large educational institution failed. More than 4,000 employees were not paid on schedule, but on the following day instead. This unanticipated delay resulted in bounced checks, rejected automatic bill payments and declined check card purchases by staff and faculty, who did not receive information about this delay in time. A hastily installed mediation procedure allowed employees to receive their compensation as a cash payout, which was then deducted from their following month's paycheck, depleting cash reserves of the university.
>
> An investigation of the problem revealed that the cause for the delay was a data entry mistake made by a staff member who entered the wrong payroll date in one step of the payroll process. Two administrators signed off on the scheduled payroll run and did not notice the wrong date. The payroll run order was transmitted to the university's bank for processing and when the error was discovered it was too late to re-schedule the payroll run.

zur Muehlen and Rosemann (2005) concluded that "the organization was not sufficiently aware of the impact of this risk" and suggested that if the risks were articulated in the process documentation, the organization would have been in a better position to respond to the single data entry mistake. Specifically, two risks were identified by zur Muehlen and Rosemann (2005) as relevant to the error described: process structural risk, expressed as the possibility of the data entry mistake, and organizational risk, expressed as a possible violation of the separation of duties principle. It is likely that the identification of these risks during process analysis of the (re)-engineering stage would lead the process engineer to consider alternative process configurations that are less likely to result in process failure such as the one outlined above or that would provide better mechanisms for error mitigation once a failure occurred. For example, an alternative configuration could include a double entry of the payroll information as well the approval by two administrators. The framework introduced in the previous section helps answer the question as to which of the alternative process configurations should be accepted once all relevant factors have been taken into account.

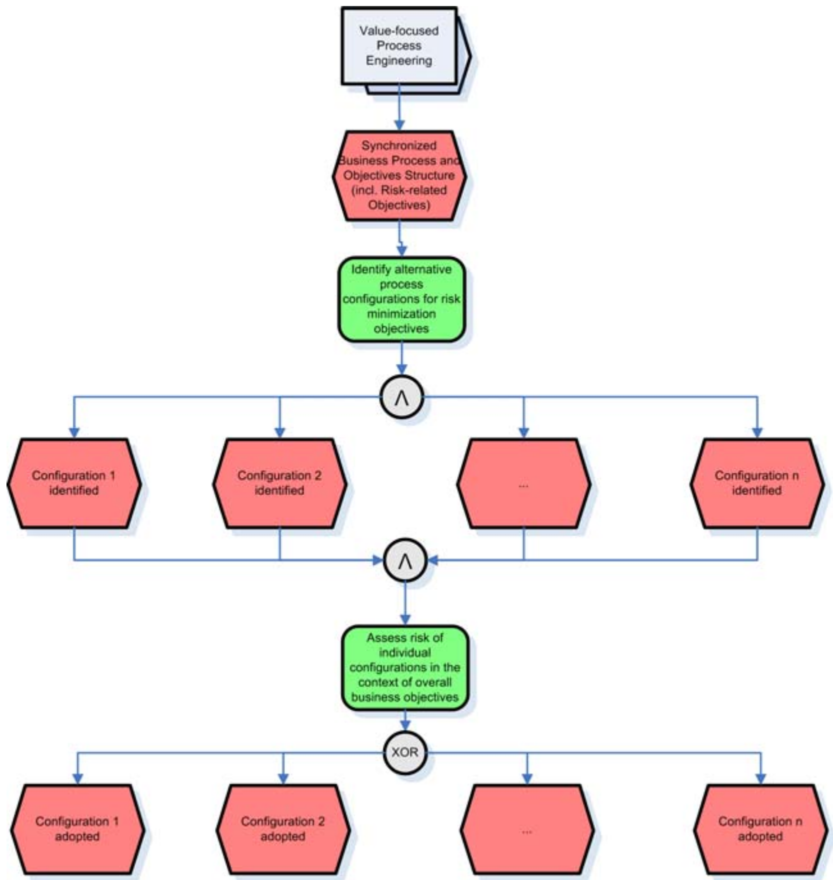

Figure 3. *Process management and risk assessment linking process.*

The first step towards this decision is the application of value-focused thinking to derive a synchronized process and objectives structure that includes risk-related objectives. Figure 2 can be used to guide the development and synchronization of process and objectives structures in accordance with organizational values. For the purposes of illustration, assume that the fundamental HR objectives of the university include 1) *maximizing efficiency and effectiveness of the HR process* and 2) *providing employees with fair and flexible pay conditions*. By asking the question of how we can achieve this in the context of the payroll process, two means objectives can be derived – *minimizing payroll administration costs* and *minimizing risk of payroll mistakes*.

The payroll run component of the payroll process has been described by zur Muehlen and Rosemann (2005) and can be used to derive lower level means objectives, as illustrated in Figure 4. For example, by asking the question of what a specific function is designed to achieve and by reconciling the answer with higher level means objectives, the final objectives of the “enter payroll run information” function can be expressed as maximizing accuracy and minimizing costs of data entry. Similarly, the objectives of the “approve payroll run” function can be expressed as maximizing accuracy and minimizing costs of the approval.

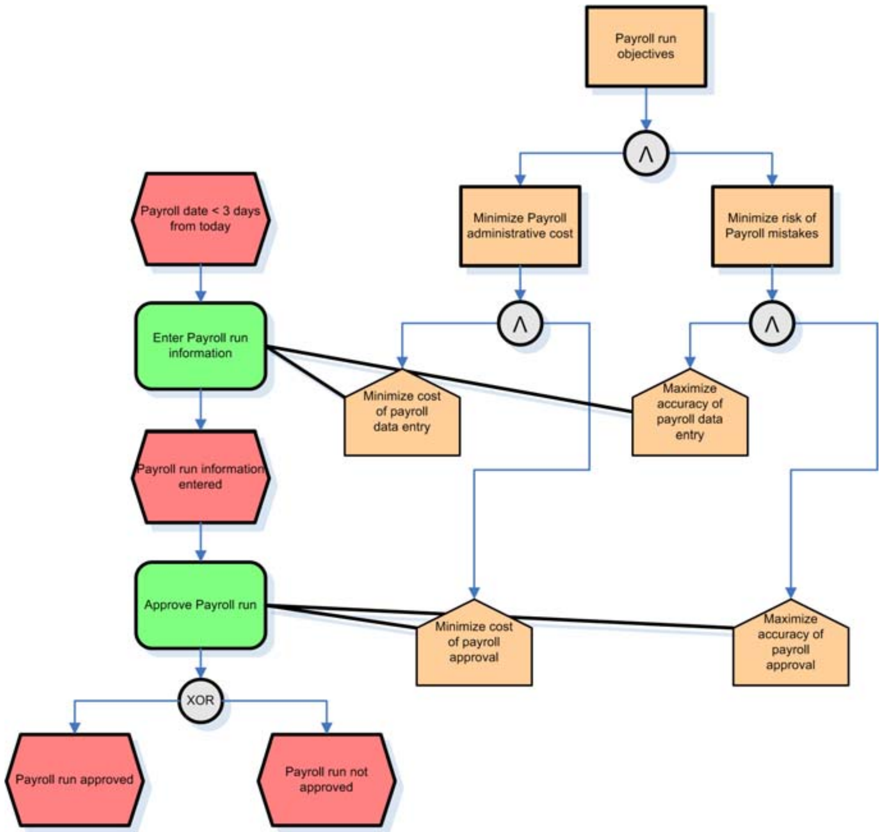

Figure 4. *Synchronized process and objectives structures for payroll example.*

For the purposes of the example, four alternative configurations are considered:

Alternative 1: single entry, single approval

Alternative 2: double entry, single approval

Alternative 3: single entry, double approval ("as is" configuration)

Alternative 4: double entry, double approval

In order to assess the relative merits of the four configurations, measurement units are determined for each of the objectives that contribute to the process objectives. Subsequently, a value function is constructed that reflects the decision maker's preferences and values and allows for the calculation of each configuration's utility. In order to keep the example intuitive, a simplified utility function is assumed, which expresses the relative value of the alternatives as the inverse of the total cost of a payroll run. Such a function can be expressed as:

$$Utility=-(run\_cost + approval\_cost + pr(combined\_risk)*rectification\_cost) \qquad (1)$$

where

- all cost are measured in dollars and reflect the cost involved in a single payroll run;
- data entry cost for each payroll run are estimated to be $1000;
- the cost of the payroll approval is estimated to be $500 for each payroll run (note this cost includes error rectification if the error is found during the approval process);
- rectification cost are estimated to be approximately $250,000 taking into account additional staff time, lost interest on the university's cash reserve and loss of good will of the university staff and faculty;

- risk is measured as a probability and by using past history was estimated as a 5% chance of incorrect data entry and as a 30% chance of the data entry error not being picked up by an administrator during the approval process;
- where activities are duplicated (e.g. double entry) the probability of error are assumed to be independent between the duplicate activities.

The utility calculations for each alternative are summarized in Table 1.

			Probability				
Alternative	Entry cost	Approval cost	Incorrect data entry	Error missed during approval process	Combined risk	Rectification costs	Utility
1. single entry, single approval	$1,000	$500	0.05	0.3	0.015	$250,000	-$5,250
2. double entry, single approval	$2,000	$500	0.0025	0.3	0.00075	$250,000	-$2,688
3. single entry, double approval	$1,000	$1,000	0.05	0.09	0.0045	$250,000	-$3,125
4. double entry, double approval	$2,000	$1,000	0.0025	0.09	0.000225	$250,000	-$3,056

Table 1. Utility table for payroll example.

As discussed in the previous section, the configuration with the largest value of the utility function (corresponding to the lowest cost) will provide the best outcome given the organizational objectives and risks involved. Based on the analysis in this section, the *double entry, single approval* configuration would result in the best overall utility out of the four configurations considered. This analysis also indicates that the adopted configuration (alternative 3) is the second worst alternative and that from a risk management viewpoint a revision of the current process structure is recommended.

Sensitivity analysis can be used to establish the extent of change in the input values that would require a change to configuration or to evaluate “what if” scenarios (e.g. which configuration would be best if the data entry error rate was to double). Sensitivity analysis is also useful when the exact probabilities of risk are unknown. In table 2, results of a two-way sensitivity analysis for a range of risk probabilities are provided. As can be seen from Table 2, the *single entry, single approval* alternative should only be used if the probability of incorrect data entry is less than 5% and the probability of the error being missing during the approval process is less than 30%. The second alternative configuration (*double entry, single approval*) is suitable when the probability of incorrect data entry is low while the probability of the error being missed during the approval process is high. Inversely, if the probability of the error being missed during the approval process is very low, the third configuration (*single entry, double approval*) is recommended. Not surprisingly, given the high rectification costs of the payroll error not being detected in time and comparatively low operational costs, the fourth configuration (*double entry, double approval*) results in the best utility in most cases. Such a sensitivity analysis could be implemented as an ongoing risk and process monitoring tool, which would trigger risk-aware process adoptions.

More complex utility functions developed for risk/cost trade-off situations (e.g. Olson 1996) can also be easily substituted in the above example if required. Furthermore, once a full objectives structure is developed that includes all relevant business processes, risk dependencies from other processes can be easily identified and added into the utility function as appropriate.

Alternative with The best utility		Probability of error being missed during the approval process								
		0.1	*0.2*	*0.3*	*0.4*	*0.5*	*0.6*	*0.7*	*0.8*	*0.9*
Probability of data entry error	*0.01*	alt 1	alt 1	alt 3	alt 3	alt 2	alt 2	alt 2	alt 2	alt 2
	0.05	alt 3	alt 3	alt 2	alt 2	alt 2	alt 2	alt 2	alt 2	alt 2
	0.1	alt 3	alt 2	alt 4	alt 4	alt 4	alt 4	alt 4	alt 2	alt 2
	0.15	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.2	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.25	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.3	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.35	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.4	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.45	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.5	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.7	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4
	0.9	alt 3	alt 3	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4	alt 4

Table 2. Two-way sensitivity analysis for payroll example

Application of the proposed framework in this section provides an informal illustration of the four steps and benefits of integration of risk into business process models. A formal evaluation using action research methodology is planned in order to validate the proposed approach and to formally assess the benefits.

5 DISCUSSION AND FUTURE DIRECTIONS

The framework proposed in this paper is motivated by an apparent need to integrate risk management practices into current business process management practices and methodologies. This consolidation is required in order to provide a more risk-aware support for process configuration-related decisions. To ensure congruency between organizational values, actions, and risks that would characterize such framework, both decision and process models should be capable of representing various organizational perspectives. For a decision model, this includes the ability to consider a broader organizational context, whilst for a process model, this must incorporate the ability to identify and quantify objectives that business activities are aimed at as well as risks that threaten the achievement of these objectives.

The value-focused process engineering approach resulted from the integration of existing goal modeling and process modeling approaches and is therefore easily extended to include a multi-disciplinary view of risk. While acknowledging that the framework proposed in this paper is neither the only possible nor a universally applicable approach towards risk-aware process engineering, it provides one possible way towards bringing the complementary views of risk and process management closer together.

The key advantage of the proposed framework is that it preserves the strengths of both the process engineering and decision sciences approaches to risk management whilst overcoming their respective shortcomings to enable quantitative evaluation of risk in the context of broader business concerns thus facilitating:

1. identification and representation of risks in a holistic business framework;
2. articulation of the links between risk issues, business goals and business activities;

3. quantification and analysis of risk within the context of overall business objectives to facilitate "eyes-open" process design and evaluation.

The conceptual framework provides a necessary first step towards risk-aware process engineering. To further progress the ideas discussed in this paper, our future research directions include an empirical evaluation of the proposed framework using action research. First promising conversations with leading Australian banks have already indicated strong interest in and support for this type of research.

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