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Towards Decision-Enabled Business Process Modelling Tools: from e-EPC to de-EPC

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Abstract

Business process- and decisions-modelling methodologies have developed largely independently and the existing lack of cross-discipline integration in the area of business modelling is not only counterproductive for future methodological advances, but also imposes unnecessary limits on the ability of the existing business modelling tools to adequately reflect the complex integrated nature of a business enterprise. This paper examines the relationship between business process-modelling methodology of Event-Driven Process Chains (EPCs) and a variety of decision-modelling methods originating from the field of Operations Research/ Management Science. A path towards integration of business process- and decision-modelling tools is proposed by enhancing the decision capabilities of EPCs with the aim of achieving a more comprehensive and flexible model of business enterprise and further development of both modelling methods.

Keywords

Business process modelling, Event-Driven Process Chains, ARIS, Operations Research/ Management Science, multiple criteria decision making

INTRODUCTION

Business-modelling defined by Nilsson *et al*. (1999) as "the use of models and methods to understand and change business operations together with information systems in organisations" has been the focus of extensive research effort within a variety of related disciplines such as process and information modelling, decision analysis, business dynamics and quantitative modelling (van der Aalst *et al*., 2000; Clemen *et al*., 2001; Nilsson *et al*., 1999; French, 1989; Santos *et al*., 2001; Sterman, 2000; Winston, 1994).

Over the past decade one of the advances in business modelling from the Information Systems (IS) perspective has been the development of an integrated process and information modelling tools such as event-process chain (EPC) and extended event process chain (e-EPC) introduced by Scheer (1999; 2000) as part of the Architecture of Integrated Information System (ARIS). The concept of e-EPC extends the functional flow process model of the EPC to include organisational, target, control, output, human and information flows and corresponding classes of objects such organisational units, goals, functions, events, messages, outputs, data and resources. The concept of views avoids the complexity of an "all-in-one" meta-business process model without the loss of information that would have been inevitable if the model was subdivided into simpler but separate sub-models events (Davis, 2001; Loos *et al*., 1998; Scheer, 1999). These process models have been applied extensively to describe business activities and to assist with the ERP and BPR projects (Davis, 2001; Loos *et al*., 1998; Nuttgens *et al*., 1998; Klaus *et al*., 2000).

At the same time, business modelling research in the area of Operations Research and Management Sciences (OR/ MS) that primarily concerns itself with business decision-modelling has been moving towards integration of highly prescriptive mathematical models aimed at finding feasible and/ or optimal solutions to a specific highly structured decision problem and more exploratory decision analysis methods aimed at assisting the decision maker to understand the context and structure of the decision (van der Aalst *et al*., 2000; Clemen *et al*., 2001; French, 1989; Rosenhead, 1989; Santos *et al*., 2001; Sterman, 2000;

Winston, 1994). These methods provide a framework for decision making by modelling decision objectives, alternatives and pathways using tools such as influence diagrams, feedback loops, stock and flow diagrams, mathematical/ statistical modelling and others. The strengths of these methods lie in their decision making capabilities, however a generally accepted weakness of these methods is their failure to model interactions between the decisions and other business processes required for a holistic solution (Elder, 1992; Rosenhead, 1989). On the other hand process models such as e-EPC provide a holistic view of business processes but have limited decision-enabling capabilities (Davis, 2001).

The complementary nature of the two methods is highlighted when one considers that both business process- and decision-modelling are aimed at achieving an efficient business outcome and are often concerned with the same business functions (van der Aalst *et al.*, 2000; Clemen *et al.*, 2001; French, 1989; Santos *et al.*, 2001; Sterman, 2000; Winston, 1994). Furthermore, decision models require enterprise wide information available within integrated business information systems while process models of IS nature require decision making capabilities of the OR/ MS type for efficient information management purposes.

In this paper we propose the way towards further integration of business modelling methods through consolidation of the their process- and decision-modelling components originating in the fields of IS and OR/ MS respectively. The need for integration of process- and decision-modelling approaches has been well recognised in the respective research communities (Ackerman *et al.*, 1999; Brans *et al.*, 1998; Khoong, 1996; Mehrotra, 1999; Nilsson *et al.*, 1999; Parker *et al.*, 1996; Rosemann, 2001; Santos *et al.*, 2001; Zeffane *et al.*, 1994), but due to the differences in basic concepts, terminology, development history, and methodologies of these areas, integration to date has been limited.

The objective of this paper is, therefore, two-fold. To reflect upon the issues of similarities and differences between business process- and decision-modelling methodologies and potential benefits of their integration; and to suggest practical ways for such integration by introducing a notion of a *decision enabled e-EPC (de-EPC)* that extends the decision-modelling power of a standard e-EPC based process-modelling approach.

This paper is organised as follows: in the next section the methodological origins of basic process- and decision-modelling tools are briefly described. This is followed by discussion of the relationship between the process- and decision-modelling; the presentation of a conceptual model that integrates the two approaches; a description of the implementation of the model leading to an introduction of a decision enabled e-EPC (de-EPC). Finally, a brief summary and conclusions are presented.

BUSINESS MODELLING PARADIGMS

Both process- and decision-modelling are concerned with the same underlying business operations. As discussed in the introduction, the differences between these two components of business modelling stem from the corresponding differences between the Information Systems (IS) and Operations Research/ Management Science (OR/ MS) paradigms from which these approaches have originated. In this section we provide a brief introduction to business modelling under the two paradigms.

In order to illustrate the discussion in this paper, we consider Human Resources (HR) planning and management – an essential component of any enterprise (Milkovich, 1991; Blain *et al.*, 1999; Scheer, 1998; Walker *et al.*, 2001). Numerous process (and other IS) models of HR describe HR operations through business process and information flows and corresponding objects (Blain *et al.*, 1999; Scheer, 1998; Cascio *et al.*, 1981; Gratton *et al.*, 1999; Gordon *et al.*, 1975). A typical HR process model includes recruitment, performance management, planning, administering payroll and other HR functions. Most of these functions have also been the subject of OR/ MS research resulting in a wealth of decision models developed to meet HR objectives (Bartholomew *et al.*, 1991; Gardiner *et al.*, 2000; Gass, 1991; Grinold *et al.*, 1977; Khoong, 1996; Winston, 1994; Zeffane *et al.*, 1994).

Information Systems (IS)

Iivary (1991:267) demonstrates that all IS schools "have quite similar assumptions, dominated by the view of information/ data as descriptive facts, ... a structural view of organizations, ...and values of IS research reflecting organizational and economic goals". These assumptions lead to descriptive business models presented in terms of business objects, activities or functions aimed at achieving organizational objectives, and business flows describing relationships between the model elements (Davis, 2001; Loos *et al.*, 1998; Scheer, 1999).

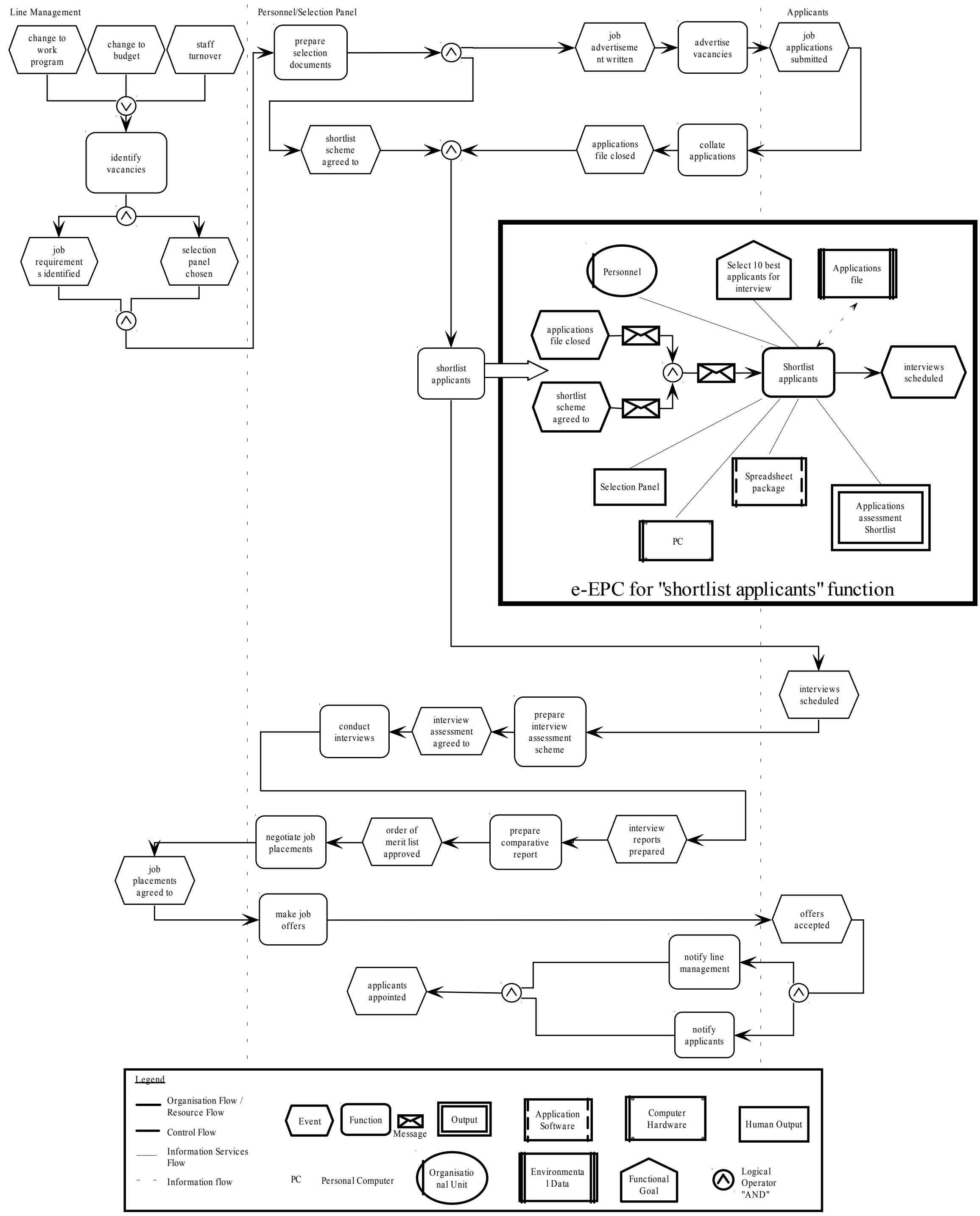

Figure 1: Recruitment EPC and e-EPC for the "shortlist applicants" function

Within the IS paradigm the organisational goals or objectives are defined in terms of objectives hierarchies originating in decision analysis (Clemen *et al.*, 2001). At the top of the objectives hierarchies are strategic (or fundamental) objectives such as "plan for organization's future needs", "structure human resources so they can best accomplish an organization's goals and mission", and "facilitate or optimise matching people to jobs"

(Schuler *et al*., 1991). As one moves down the hierarchy the fundamental objectives are eventually reduced to the specific functional goals (or means objectives) focusing on process outcomes and outputs such as “ensure sufficient job applications”, “shortlist 10 best applicants for interview”, “select the best applicant for the job”, etc.

An IS model supported, for example, by the ARIS House of Business Engineering concept (Scheer, 1999), uses the objectives hierarchy to drill down to specific processes (e.g. recruitment, training and development, manpower planning) describing functions (e.g. within the recruitment process the specific functions would be to advertise vacant positions, shortlist, select and appoint applicants, etc) aimed to achieve these objectives. An EPC describing the flow of functions within a recruitment process is provided in Figure 1.

By linking business processes and functions through business flows (such as information flows, resource flows, control flows) and describing associated business objects (such as people, organisational units, jobs, etc), a holistic business model is built (refer to e-EPC insert in Figure 1).

The e-EPC model, and IS models in general, provide decision support in so far as they allow the decision maker to identify the sequence of events and functions within a process, the functional inputs and outputs, and the decision making process’ stakeholders (Davis, 2001; Loos *et al*., 1998; Scheer, 1999; 2000). In some models information is used to describe the progress against key performance indicators derived from the objectives providing the decision maker with evaluation measures (Walker *et al*., 2001). However, the decision support capabilities of these models do not extend towards support of the decision in the OR/ MS sense, i.e. articulation of the decision objective, possible alternatives, and, most importantly, the methodology for the selection of the best alternative. In the recruitment process example illustrated in Figure 1, the model provides a comprehensive description of the steps involved in the process, but doesn’t on its own guarantee that the best applicant will be selected or that the selection process is conducted within legislative constraints such as equal opportunity employment. There is also no guarantee that the process is utilising resources efficiently. These limitations of the IS models simply reflect the fact that the process is only one dimension of the business. The users of IS modelling tools readily acknowledge this limitation, for example Davis (2001:138) notes that “complex project planning, tasks with multiple options and data driven systems don’t model well as processes, either because they can be better represented in other ways or because they use a high degree of human intelligence, design and planning in their implementation”. The Operations Research and Management Science paradigm is a complementary paradigm well suited to model the choice of alternatives in tasks with multiple options.

Operations Research/ Management Science (OR/ MS)

The OR/ MS paradigm is based on the traditional, quantitative, objectivist, scientific basis borrowed from the natural sciences (Elder, 1992; Hussey *et al*., 1997). Unlike an IS paradigm of a decision support model which is a descriptive or normative model of a business, an OR/ MS paradigm is a decision model based upon an algorithm or a program designed specifically to provide a feasible solution to the problem of making an optimal choice among possible alternatives in light of their possible consequences and subject to specified constraints (Clemen *et al*., 2001; Winston, 1994).

Due to the complex technical nature of mathematical modelling, the OR/ MS models (such as mathematical programming models, Markov models, decision trees, etc.) are often prescriptive addressing simplified decision problems with narrow decision objectives. These models, due to their highly conceptual nature, often remain in the domain of technical experts (Winston, 1994). In comparison, semi-conceptual nature of many IS models makes them easier to understand and apply in a business environment (Davis, 2001). More user-friendly OR/ MS methodologies dealing with the structure of and interactions between the decisions (e.g. decision analysis and system dynamics tools) provide a more holistic view of the decision situation at the expense of their ability to support specific decisions (Clemen *et al*., 2001; French, 1999; Sterman, 2000).

Within the OR/ MS paradigm, business functions are mostly described by the decision objectives and the decision models rather than as activities undertaken to achieve those objective. The focus on mathematical models within the OR/ MS paradigm results in information within this paradigm being considered primarily as an input of or an output from the model rather than part of the information flow interacting with other functions of the business.

As with the IS paradigm, the limitations of the OR/ MS paradigm are generally understood by those applying these methods to organisational planning and problem solving. In particular, Rosenhead (1989:10) states that "...optimal solutions to individual problems cannot be added to find an optimal solution to the whole mess: the behaviour of the mess will depend on how the solutions to its various parts interact."

Given the differences in the concepts, terminology, and objectives of the two paradigms it is not surprising that the process- and decision-modelling approaches are rarely integrated. However, as demonstrated in this paper, these two approaches complement each other and their integration can potentially increase the power of both modelling paradigms resulting in a more effective modelling tool. In the next section we demonstrate this by examining how the individual components of the two paradigms complement each other in the context of the HR recruitment process example.

RELATIONSHIP BETWEEN PROCESS- AND DECISION-MODELLING

In this section the "shortlist applicants function" is used to illustrate the relationship between process- and decision-modelling. As business objectives modelling is fundamental to both approaches, we begin by discussing the relationship between process objectives, functional goals and decision objectives.

Objectives and goals

It is interesting to note that business objectives at the strategic level are essentially the same irrespective of whether process- or decision-modelling approach is used. For example, consider HR strategic objectives such as "plan for organization's future needs", "structure human resources so they can best accomplish an organization's goals and mission", "facilitate or optimize matching people to jobs" (Schuler *et al*., 1991). These objectives are fundamental to both decision- and process-modelling methods and it is not possible to determine which method has been used to model the functions by simply examining the objectives. However, as objectives hierarchies are built to separate various levels of objectives the differences between methods begin to emerge.

For instance, consider "shortlist applicants" function in the context of the recruitment process. The recruitment process strategic objectives may include "cost-effective", "equitable", "select sufficient people to fill vacancies", "select people with the right skills", and "ensure timely recruitment". The specific objectives for the "shortlist applicants" function is most likely to be "select the best 10 applicants for interview". The terminology used for the functional process goal reflects the process approach focusing on the process outcomes and outputs. On the other hand, decision objectives for the same function would be concerned with the decision objectives often expressed as criteria and constraints (for example "relevant employment experience", "relevant academic qualifications" subject to the constraints of equal opportunity legislation, affirmative action practices, etc) or optimisation functions (for example "choose the candidate with the highest relevance value").

Due to the differences between methods and the differences in the language used to communicate functional goals and decision objectives, it appears that the two methods are addressing separate and independent goals and objectives. However, once these sets of goals and objectives are examined together, it becomes clear that they are interdependent and are addressing the same strategic objectives. For example, specific decision objectives such as "relevant employment experience" and "relevant academic qualifications" explain what is meant by the "best" in the functional goal. This is an example of a common relationship between the functional goals and decision objectives - with decision objectives being a subset of the functional goals (Agrell *et al.*, 2000). Process objectives, on the other hand, are often used as constraints for decision objectives, for example the process objective "ensure timely recruitment" would limit the amount of time that can be spend on arriving at a choice of applicants and therefore affecting the choice of a decision-modelling method to be used (Gardiner *et al*., 2000).

Linking functional goals, decision objectives and strategic objectives enriches one's understanding of both the process and the decision and ensures that the strategic objectives are met. Furthermore, identifying dependencies between objectives allows for dynamic and efficient updating of both models to reflect changes in circumstances. For example, by identifying dependency between the decision objectives of the "shortlist applicants" function and the objectives of the recruitment process, it can be ensured that changes in the recruitment requirements are immediately reflected in the shortlisting decision objectives avoiding time delays and misalignment between the two sets of objectives. This approach facilitates the development of a more holistic business model that can be dynamically updated to remain relevant and contemporary.

Once strategic objectives are defined, both modelling methods focus on the functions aimed at achieving these objectives. The relationships between decision and process views of the function are to be considered next.

Functions

Some functions do not have a non-trivial decision component (such as "compile a list of applicants"). These functions are included in the process model and are of no further interest for the purposes of this discussion. Functions that do have a non-trivial decision component (such as "shortlist applicants") have two dimensions – the process and the decision dimension.

A process model is concerned primarily with the "how" component of the business operations, in other words, the order of functions required to achieve specific process objectives. The process view is a "bird's eye" view of the function and functional flows. This view provides a description of the function, its inputs, outputs and resources in the context of the rest of the process. In a process model, the "shortlisting applicants" function will be one of a number of other functions linked together to form an event-driven process chain describing the sequence of steps in the recruitment process.

As discussed in the previous section, there is no shortage of HR process models. In Figure 1, a process model using an EPC (Scheer, 1999) is provided for the recruitment process. When complemented by the data, organisation and output views (as illustrated for the "shortlisting applicants" function) this model can be expanded into an e-EPC to provide an integrated business process model (Sheer, 1999).

A decision model, on the other hand, is concerned with the "what" component of business operations, that is, what choice to make among available alternatives in order to achieve the desired objective. This view of the function provides an internal or "x-ray" view of the function. A decision model for the "shortlisting applicants" function would be a prescriptive model, such as, for example, a multi criteria decision analysis model aimed to support the specific decision of shortlisting applicants by defining selection criteria, decision constraints, and the mathematical technique to be used to satisfy these criteria subject to the constraints (Bouyssou *et al*., 2000; Gardiner *et al*., 2000; Moshkovich *et al*., 1998; Olson, 1996). Examples of other decision modelling techniques within the HR context include, in particular, multi-knapsack and network flow methods used for team composition and assignment, multi criteria decision analysis used for HR selection, Markov chains and Dynamic programming used for HR planning (Bartholomew et al. 1991, Gardiner et al. 2000, Gass 1991, Grinold et al. 1977, Khoong 1996, Winston 1994, Zeffane *et al*., 1994).

By looking at the external and internal views in isolation (as is normally the case due to disciplinary and conceptual boundaries between the process- and decision-modelling methodologies) the fact that both views support the same objectives in a different but complementary way is easily overlooked resulting in an incomplete model of the business. Information provides the link between the two modelling methods essential for the effective operation of the business.

Information

Differences in modelling methodology lead to differences in the role information plays in the corresponding models. Transparency of information flows is one of the objectives of an extended process model of an e-EPC type. However, the links between information inputs and outputs are not apparent from a process model. A decision model, on the other hand, is primarily concerned with the transformation of existing information into new information with little reference to where the existing information is coming from or how the new information is going to be used. The information requirements of decision models are usually well defined and specific, however unless these requirements are incorporated into the process model there is no guarantee that this information is available as required. Similarly, unless the decision model is an integrated part of the process, it may not be generating information required by the process in order to fill its objectives. Gaps in the information or extraneous information resulting from the lack of communication between the models may cause process delays and costs to the business.

Motivation for integration

As can be seen from the above discussion, the strategic objectives of a real life business are not separated into decision and process objectives. However, currently available information models treat the two aspects independently failing to provide businesses with the functionality required to find optimal solutions to business problems within the overall business context (e.g. Rosenhead, 1989). Therefore integration of the two approaches will enable development of tools better suited to solve real-life business problems. Further arguments for integration of the decision- and process-modelling approaches are:

- As the two approaches represent the same operations from different perspectives, integration of these approaches will result in a more comprehensive model of business operations.
- As the two methods are complementary, integrating them has the potential for the weaknesses in one to be compensated by the strengths in the other contributing to the development of both methods. Later, we demonstrate that through the use of user-friendly semi-conceptual e-EPC to model interactions between decisions (as well as functions) the narrow focus of the decision-modelling tools and the lack of decision capability in process-modelling tools are addressed.

With this in mind, consider the model for integration of the decision- and process-modelling approaches that is proposed in the next section.

CONCEPTUAL MODEL

The conceptual model for integration presented in Figure 2 retains the ability of the process model to deliver a holistic business model through providing an external view of the business function. At the same time, the model is decision-enabled as it includes an internal view of the function with the focus on the decision objective. Information is included in the model in both external and internal views as it is the essential for successful integration (Ackerman *et al*., 1999).

The contribution of the model towards further integration of the two methods is in the links between the two views of the function demonstrating how the elements of each modelling approach described in previous sections are dependent on each other for the optimal outcome. Existing methods (discussed in the previous sections) that can be used to model dependencies and interactions between the elements are shown on each of the links. Each structural element of the model is numbered for easier reference. The structural links are referred to by the start and end elements of the link; for instance, the link between elements 1 and 2 is referred to as link 1-2. We continue to use the “shortlist applicants” function in the context of the recruitment process to illustrate the model.

Process view

The “shortlist applicants” function (element 1) is one of the functions in the recruitment process (Figure 1). The goals of this function are contained (link 1-4) within overall recruitment process objectives (element 4) such as “cost effective”, “equitable, enough people to fill vacancies”, “people with the right skills” and “timely recruitment”. Recruitment process objectives interact with each other and can be modelled with business dynamic tools (Sterman, 2000) once they are quantified (link 4-5) using available information (element 5). The flow of information between process functions (link 1-5) is modelled by the e-EPC (Scheer, 1999).

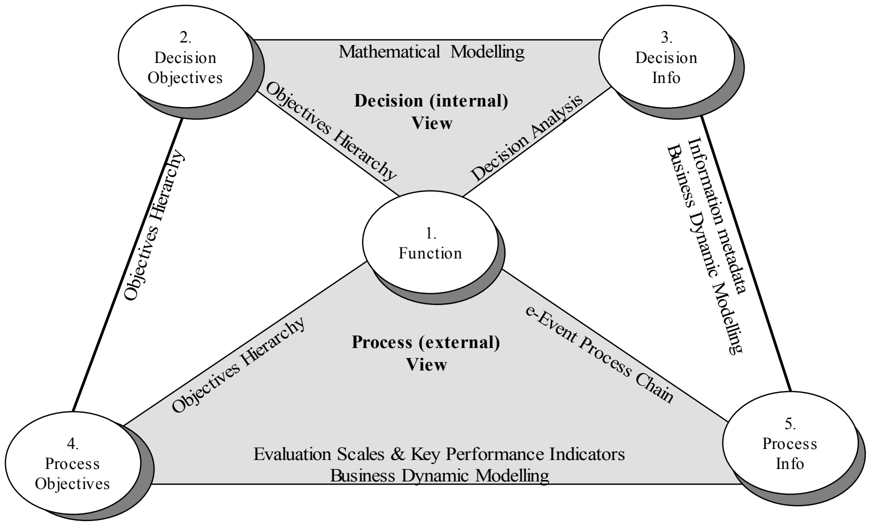

Figure 2: Conceptual model

Decision view

In this view, the functional goals are sub-divided (link 1-2) into specific decision objectives (element 2) such as “select applicants with relevant employment experience and relevant educational qualifications”. Decision variables (e.g. number of years in relevant employment, educational relevance scale, etc.) are populated by decision information (element 3) and are used by mathematical models (link 2-3) to provide solutions to decision objectives (Williams, 1997; Winston, 1994). Decision analysis tools (link 1-3) such as influence diagrams (Clemen *et al*., 2001) can be used to identify inputs and outputs of the decision.

Links between process and decision views: objectives (link 2-4)

Decision and process objectives can be linked via the objective hierarchy (Clemen *et al*., 2001). For example, the process objective of equitable recruitment could be expressed as a decision objective to use an objective method for shortlisting applicants.

Links between process and decision views: information (element 3-5)

As discussed in the previous section information inputs and outputs of a specific function are dependent on the information flows in the rest of the process and vice versa. In some cases a simple list of decision variables side by side with functional inputs and outputs sourced from the e-EPC will be sufficient to identify information gaps and unnecessary information. For more complex interactions, a system dynamics model (such as a feedback loop or stock and flow diagram) can be used to identify information dependencies (Sterman, 2001). Combinations of these tools will allow interactions between decision and process information to be identified and taken into account by the modeller.

For example, a system dynamics model that identifies the complexity of the shortlisting scheme will determine information requirements for the “shortlist applicants” function. The e-EPC information flow model indicates that the information for the “shortlist applicants” decision is sourced from written job applications. Once this connection is established, it becomes clear that the complexity of the shortlisting scheme and written applications requirements must be synchronised. In the recruitment process under consideration (Figure 1) this is achieved by determining selection criteria before the job is advertised and before the shortlisting scheme is determined.

The conceptual model presented in this section provides the framework for the integration of the process- and decision-modelling approaches. The next section suggests a possible approach for the implementation of this framework.

INTEGRATED MODELLING TOOL

The conceptual framework presented above establishes links between methods and suggests possible tools that can be used to model those links. However, it falls short of presenting a business modeler with a practical integrated alternative to the currently available tools. We start by examining the capabilities required from such a tool.

To enable the conceptual framework outlined in the previous section to be implemented, the modelling tool should:

- Include functions and their descriptions.
- Provide a static view of the functions including functional goals, resources that are used by the function to achieve these goals, and functional output.
- Provide a dynamic view of the functions presenting a coherent process that brings the functions together and ensures transparency across functional and information flows.
- Include decision objects such as decision objectives, mathematical models used to analyse the information and decision variables including decision constraints.
- Include reinforcement mechanisms for all the links.

As most of these requirements are satisfied by an existing, widely used business modelling tool (e-EPC), we suggest that additional requirements are incorporated into this tool to form a *decision-enabled extended event process chain* (de-EPC). Figure 3 illustrates how existing OR/ MS decision models (such as multi-criteria decision analysis, linear programming, network flow models, etc.) can be utilised to provide an e-EPC with decision modelling capabilities.

By identifying decision objectives as a subset of functional goals and process objectives and adding a *decision view* to the e-EPC, it is possible to apply appropriate quantitative modelling techniques to provide the decision maker with an optimal decision for a particular function within a wider business context.

For instance, in the context of the recruitment process, the “shortlist applicants” functional goal is to “select 10 best applicants for the interview”. However, in order to satisfy strategic objectives of the recruitment process, the functional goal should include decision objectives that can be expressed as “select 10 applicants according to a set of criteria (relevant employment, relevant education, etc) subject to a set of constraints (time, equity, etc)”. This decision objective is specific to the decision module in charge of its realisation (typically, one or more suitable OR/ MS models with corresponding objective(s)) and is formulated by utilising information about functional goals and process objectives.

The specific decision problem with respect to the shortlisting of applicants can be resolved using Multi Criteria Decision Analysis tools. The variables required for this decision are already available as part of the environmental data of the function (Figure 1 and Figure 3). By introducing a *Decision Module/ Object* (Figure 3), that includes the decision model and the decision objective, it is possible to link the mathematical programming based model to the function creating a de-EPC.

The functional goals in the de-EPC include decision objectives. These decision objectives together with the decision variables, that form part of the de-EPC information flows, provide inputs into a decision model. The output of the decision model provides the decision maker with an optimal path to satisfy the decision objective and if required contributes to the functional outputs which become available to the rest of the process.

In general, the power and flexibility of this integrated modelling tool is that it allows us to utilise the abundance of existing generic quantitative OR/ MS models as objects within the comprehensive process-modelling framework. According to the object-oriented methodology (Loos *et al.*, 1998; Scheer, 1999) this means that we are not confined to dealing with technical aspects of solving the quantitative models but rather treat them as “black boxes” with known sets of properties. This approach enhances the decision capabilities of process modelling by linking the "library" of OR/ MS models to the process-oriented view of the enterprise hence creating a more comprehensive and flexible model of a business enterprise.

Potential enhancements to this tool could incorporate:

- Constraint programming to provide opportunities to reinforce process constraints identified at the process level throughout the whole sequence of functions adding transparency at the constraint as well as objectives and information flow levels (Lusting et al., 2001).
- System dynamics models into the decision model if multiple functions are involved in the decision to describe interactions between functions within the context of the decision (Sterman, 2000).

By integrating existing tools, this approach for the development of an integrated modelling method brings together the elements of the conceptual model described in the previous section within a convenient and flexible modelling environment.

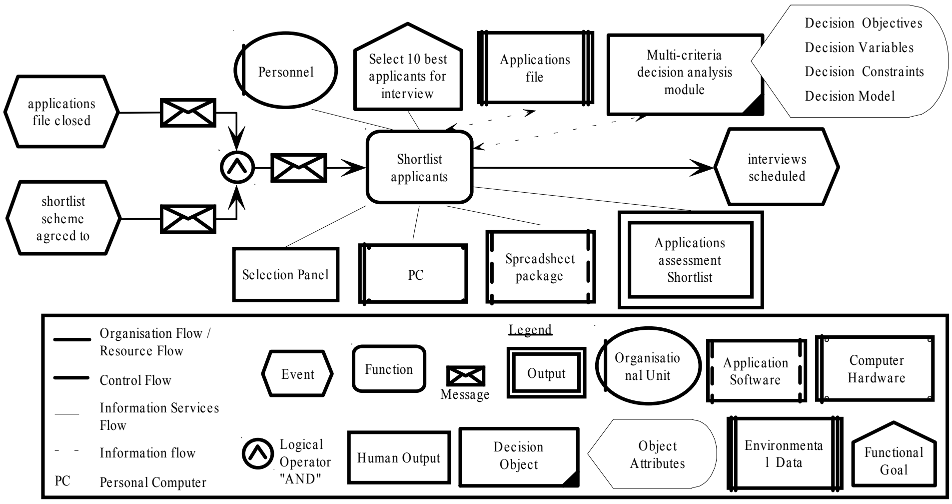

Figure 3: de-EPC of the "shortlist applicants" function

SUMMARY AND CONCLUSIONS

The discussion of the relationship between the two types of business-modelling tools has highlighted the duality currently existing in the field of business modelling. This duality can be formulated as follows: the more descriptive and contextual is the business model, the less decision enabled it is. Integration of the two paradigms results in a more complete picture of the whole business and a more powerful business model. This allows logical progression from the representation of the mental picture of the business to the precise and quantifiable knowledge enabling the best local decisions to be made in the context of the strategic objectives of the business. Although considerable future research effort (especially in the areas of reinforcement of links and application of the methodology to real life processes) is required to provide full integration of process- and decision- oriented modelling paradigms and corresponding modelling tools, it is believed that the concept of a de-EPC introduced in this paper, provides the solid basis for this effort.

REFERENCES

Ackerman, F., Walls, L., van der Meer R. and Borman M. (1999) Taking a strategic view of BPR to develop a multidisciplinary framework. Journal of Operational Research Society, 50, 195-204.

Agrell, P. J. and Steuer, R. E. (2000) ACADEA – a decision support system for faculty performance. Journal of Multi-Criteria Decision Analysis, 9, 191-204.

Bartholomew, D.J., Forbes, A.F. and McClean , S.I. (1991) Statistical techniques for manpower planning. 2nd Edition. John Wiley, Chichester.

Blain, J. and Dodd, B. (1999) Administering SAP R/3: the HR-human resources module. QUE, Indianapolis.

Bouyssou D., Marchant Th., Perny P., Pirlot M., Tsoukiàs A., and Vincke Ph. (2000) Evaluation and decision models: a critical perspective, Kluwer Academic, Dordrecht.

Brans, J. P., Macharis, C., Kunsch, P. L., Chevalier, A., and Schwaninger, M. (1998) Combining multicriteria decision aid and system dynamics for the control of socio-economic processes. An Iterative Real-Time Procedure. European Journal of Operational Research, 109, 428-441

Cascio, W. F. and Awad, E. M. (1981) Human resources management. Reston Publishing Company, Virginia.

Clemen, R. T. and Reilly, T. (2001) Making hard decisions with DecisionTools. 2nd rev. edn. Duxbury, USA.

Davis, R. (2001) Business process modelling with ARIS: a practical guide. Springer-Verlag, London Berlin Heidelberg (2001)

Elder, M. D. (1992) Visual interactive modelling: some guidelines for its implementation and some aspects of its potential impact on operational research. PhD Thesis, Department of Management Science, University of Strathclyde, Glasgow.

French, S. (1989) Readings in decision analysis. St Edmundsbury Press Limited, Suffolk.

Gardiner, L. R. and Armstrong-Wright, D. (2000) Employee selection under anti-discrimination law: implications for multi-criteria group decision support. Journal of Multi-Criteria Decision Analysis, 9, 99-109.

Gass, S. I. (1991) Military manpower planning models. Computers and Operations Research. 18:1, 65-73.

Gordon, L. A., Miller, D. and Mintzberg H. (1975) Normative models in managerial decision-making. National Association of Accountants, New York.

Gratton, L., Hope-Hailey, V., Stiles, P. and Truss, C. (1999) Linking individual performance to business strategy: the people process model. Human Resource Management, 38:1, 17-31.

Grinold, R.C. and Marshall, K.T. (1977) Manpower planning models. Elsevier North-Holland, New York.

Hussey, J. and Hussey, R. (1977) Business Research: a Practical Guide for Undergraduate and Postgraduate Students. Palgrave New York (1997)

Iivary, J. (1991) A paradigmatic analysis of contemporary schools of IS development. European Journal of Information Systems, 1:4, 249-272.

Khoong, C.M. (1996) An integrated system framework and analysis methodology for manpower planning. International Journal of Manpower, 17: 1, 26-46.

Klaus, H., Rosemann, M., and Gable, G. G. (2000) What is ERP? Information Systems Frontiers 2:2. Kluwer Academic Publishers, Netherlands.

Loos, P. and Allweyer, T. (1998) Object-orientation in business process modeling through applying event driven process chains (EPC) in UML. in C. Kobryn, C. Atkinson and Z. Milosevic (eds.) Enterprise Distributed Object Computing (2nd internationally Workshop EDOC'98, La Jolla, 3-5 November 1998, Piscataway), 102-112, IEEE.

Mehrotra, V. (1999) OR & IS: Scenes from a marriage. OR/MS Today, June, 12.

Milkovich, G. T. (1991) Human resource management. Richard D. Irwin, USA.

Moshkovich, H.M., Schellenberger, R. E. and Olson, D. L. (1998) Data influences the result more than preferences: some lessons from implementation of multiattribute techniques in a real decision task. Decision Support Systems, 22, 73-84.

Nilsson., A. G., Tolis, C. and Nellborn ,C. (1999) Perspectives on business modelling: understanding and changing organisation. Springer-Verlag, Berling, Heidelberg, New York.

Nuttgens, M., Field and T., Zimmerman, V. (1998) Business Process Modeling with EPC and UML: Transformation of Integration? in M. Schader and A. Korthaus (eds) The Unified Modelling Language – Technical Aspects and Applications, Proceedings (Mannheim, Oktober 1997), Heidelburg 250-261.

Olson, D. L. (1996) Decision aids for selection problems. Springer-Verlag.

Parker, B. and Caine, D. (1996) Holonic modelling: human resource planning and the two faces of Janus. International Journal of Manpower, 17:8, 30-45.

Rosemann, M. (2001) Integrated knowledge and process management. In B-HERT News, Business/Higher Education Round Table, Victoria, 11, 24-26.

Rosenhead, J. (1989) Rational analysis for a problematic world: problem structuring methods for complexity, uncertainty, and conflict. John Wiley & Sons, New York.

Santos, S. P., Belton, V. and Howick, S. (2001) Integrating system dynamics and multicriteria analysis: towards organisational learning for performance improvement. Proceedings of the 19th International Conference of the System Dynamics Society. July, Georgia, USA.

Scheer, A.-W. (1998) Business process engineering: reference models for industrial enterprises. Study edn. Springer-Verlag, Berlin, Heidelberg, New York.

Scheer, A.-W. (1999) ARIS – business process frameworks. 3rd edn. Springer-Verlag, Berlin Heidelberg.

Scheer, A.-W. (2000) ARIS – business process modeling. 3rd edn. Springer-Verlag, Berlin Heidelberg.

Schuler, R. S. and Walker, J.W. (1991) Managing HR in the information age. BNA Books, Washington.

Sterman, J. D. (2000) Business Dynamics: Systems Thinking and Modelling for a Complex World. The McGraw-Hill Companies, USA.

van der Aalst, W., Desel, J. and Oberweis, A. (2000) Business process management: models, techniques, and empirical studies. Springer-Verlag, Berlin, Heidelberg.

Walker, G. and MacDonald, J. R. (2001) Designing and implementing and HR scorecard. Human Resource Management, 40:4, 365-377.

Williams, H. P. (1997) Model building in mathematical programming. 3rd edn. John Wiley & Sons, New York.

Winston, W. L. (1994) Operations Research: Applications and Algorithms. Wadsworth, USA.

Zeffane, R. and Mayo, G. (1994) Planning for human resources in the 1990s: development of an operational model. International Journal of Manpower. 15:6, 36-56.

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