ENHANCING COLLABORATION IN BUSINESS PROCESS MODELLING

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Abstract: Business process modelling is widely considered as the most critical task in the development of enterprise information systems that address the actual needs of a company. As business processes cross functional and sometimes company boundaries, the coordinated inclusion of diverse perspectives and knowledge sources is necessary. Towards this end, this paper presents an information systems framework that aims at the exploitation of personalised knowledge through a structured process of collaborative and argumentative business process model construction. By integrating an argumentation system that is specific to business process modelling with a discrete-event modelling simulation tool, we provide the appropriate infrastructure to increase the productivity and effectiveness of process design and re-engineering efforts. The paper presents the design rationale, the structure and the functionality of the proposed framework through a comprehensive example of collaborative work towards building a model of a typical business process in a manufacturing company.

1 INTRODUCTION

To respond to the e-business challenge, organizations need to gain a better understanding of their business models and the existing information technologies and applications. As noted in (Jayaweera *et al.*, 1999), new ways of working, new forms of organization and new business models are emerging to efficiently and effectively carry out e-business transactions. Intra- and inter-organizational collaboration is certainly an issue that needs to be carefully addressed in the above transformations. At the same time, information technologies are progressively getting more business-centric, in that they promote a more situational understanding of communication and organizational changes (Hirschheim *et al.*, 1995). The aim of these developments is to achieve an easier mapping of the business processes into an information system, while ensuring a rapid, reliable and low cost information supply.

Towards this end, the first and most critical step is to model the existing organisational processes with as much accuracy as possible. The modelling of business processes, however, is a highly complex task that has to clearly define, enable and manage sources of information from both within the organization as well as beyond its boundaries. In addition, it has to address the totality of related issues, such as process development and deployment, execution, administration, monitoring and reporting. Moreover, it has to reflect the organization's strategy and its relationships with other organizations by integrating entire business processes not only within the specific organization, but also with their customers, suppliers and business partners. Due to the above complexity, business process modelling needs to be supported by advanced information technology in its multiplicity of aspects, such as the collection and dissemination of information and knowledge produced by diverse sources, the evaluation of alternative schemes, the construction of shared meaning, and the feedback learning processes (Clases and Wehner, 2002; George *et al.*, 1992). Since most processes cross the boundaries of a single function, they can only be considered in their entirety by exploiting the collective cross-functional knowledge and experience through an apparent process of constructive discussion and collaboration among the parties (managers) involved, as well as through mechanisms that organize and maintain the shared context of the issue. Modelling is a decision-making process itself; as knowledge and experience reside in a diverse set of organizational assets (including employees, structure, culture and processes), a

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consistent approach for synthetic, problem-specific use of tacit and codified knowledge for its accomplishment is required. This advocates the synergy between the decision support and knowledge management processes of the organization. Decision-making processes generate new knowledge. For instance, the evidence that justifies or challenges an alternative to a specific business modelling problem, and the practices to be followed or avoided after the evaluation of the decision provide a refined understanding of the problem. On the other hand, knowledge management activities, such as knowledge elicitation, representation and distribution influence the creation of the decision model to be adopted, thus enhancing the decision making process (Bolloju *et al.*, 2002).

A series of methodologies and systems has been suggested in the literature to address the issue of collaborative business modelling. The majority of them concentrate on static, conceptual or activity, models for visualisation purposes (e.g. CM (Sierhuis and Selvin, 1996), or on how to combine simulation models developed by different parties (e.g. Sarjoughian *et al.*, 2000; Miller *et al.*, 2001). Only a limited number of efforts has been reported towards the collaborative development of business process simulation models, which pay particular attention on the collaboration process itself and its associated social and knowledge construction dynamics (Taylor, 2001).

The approach proposed in this paper extends the latter stream of research by presenting an IS framework for distributed and asynchronous collaborative process simulation modelling. It aims at strengthening the abovementioned synergy of knowledge management and decision making by the integration of argumentation and experimentation in the process of understanding how an organisation works and how it can be better supported by information technology. The need for argumentation is ubiquitous in most collaborative decision making problems that can be solved through debate and negotiation among a group of people. In such contexts, conflicts of interest are unavoidable and support for achieving consensus and compromise is required. Each decision maker may formulate and put forward his own (part of a) business model that fulfils some goals at a specific acceptance level. Moreover, he may have arguments in favour or against alternative solutions, as well as preferences and constraints imposed on them. Depending on the role and the goals of each decision maker, subjective estimates of the problem should be taken into consideration. Independently of the model used for the necessary decision making, argumentation is valuable in shaping a common understanding of a complex issue, such as a business process in its entirety. It provides the means to decide which parts of the information brought up by the decision makers are of any use or should be discarded. Furthermore, it has been shown that argumentation may stimulate the participation of decision makers and encourage constructive criticism (Karacapilidis and Papadias, 2001).

On the other hand, in-vitro experimentation is the missing part of many process design tools, not paying the necessary attention to the phase of process evaluation under different scenarios. In conjunction with a discourse-based decision support environment for business modelling, a simulation model can map organizational knowledge onto appropriate graphs, thus quantifying the problem under consideration and providing a clearer understanding of which alternative solution seems to be more prominent at the moment. Moreover, it can provide the means for an individual to conceptually define a proposition and perform experiments with (before asserting it as a dialogue item in the modelling process). Taking into account the current state of a discourse organized in an intelligent way, individuals may thoroughly contemplate on their next move to assure that it will have the best impact to the ongoing discussion.

The remainder of this paper describes the structure and operation of a platform that integrates simulation and argumentation into a knowledge-based tool for collaborative business process simulation modelling. The paper concentrates on the modelling phase. More specifically, Section 2 discusses related works highlighting their contributions on the business modelling area, while Section 3 illustrates the proposed integrated framework. Section 4 presents the features and functionalities of our approach by means of an illustrative example. Finally, Section 5 concludes the paper and outlines future work directions.

2 RELATED WORK

Real-life business process modelling may be undertaken by a group of people, who represent different units of the same or different organizations. In this way, the diversity of perspectives and the completeness of the model are augmented. However, different people usually have different and probably contradicting perspectives. Argumentative discourse provides the means to accommodate different views in the underlying process of considering, coordinating and evaluating activities. Reaching a high quality team decision requires thorough and accurate understanding of the problem, marshalling a realistic and acceptable range of alternatives and careful consideration of the positive and negative consequences that are associated with each alternative considered (Hirokawa, 1992). In addition to a well structured discourse output that clearly addresses "know-what", "know-why", "know-how" and "know-who" issues, the precautionary manipulation of competing or even conflicting problem interpretations, interests, objectives, priorities and constraints leads to the objective evaluation, synergy, stimulation and construction of new knowledge. In this respect, maximum exploitation and enhancement of the flow of the underlying organizational knowledge are two crucial requirements for efficient and effective decision making in building a business process model.

From the knowledge management perspective, we can distinguish two different strategies towards increasing the quality of business processing modelling. The first addresses the codification of knowledge by providing richer modelling formalisms, whereas the second is focused on the rigorous exploitation of personalised knowledge (Hansen *et al.*, 1999). In the context of the first perspective, approaches originating from the area of information systems development, such as the life-cycle and the structured paradigm, or even Prototyping and Rapid Application Development, have been extremely criticized in that they do not provide a sound understanding of business processes and organizational change. To remedy this, new methodologies emphasizing what people do while communicating, how they create a common reality by means of language and how communication brings about the coordination of their activities (van Reijswoud *et al.*, 1999), have been proposed. These have been basically founded on the Language/Action perspective (Dignum *et al.*, 1996) and the Speech Act Theory (Searle, 1969), and consider the utterance of various types of communicative actions as the backbone of the business process models.

More specifically, the Business Design Language (Medina-Mora *et al.*, 1992), based on the Conversation for Action theory (Winograd and Flores, 1986) that was conceptualized as an interplay of requests and commitments during a collaborative process, has as its basic modelling unit the so called four-step action workflow protocol. SAMPO (Auramäki *et al.*, 1988) views organizational activities as a series of speech acts that create, maintain, modify, report and terminate commitments, aiming at detecting the principles needed in the set-up and control of commitments, the inconsistencies in the coordination of commitments and the possibilities for organizational development that simplify communication and control mechanisms. Business Action Theory (Goldkuhl, 1996) has been proposed as a generic model of business communication that explains business processes as action and interaction, and can be used as an interpretative framework for business process reconstruction, evaluation and redesign. Finally, DEMO (Dynamic Essential Modelling of Organizations) provides a domain-independent theory that describes and explains the communicational dynamics of an organization together with a modelling facility based on it (van Reijswoud *et al.*, 1999). DEMO considers the business transaction as its key concept and views the functioning of an organization from three levels, namely the documental level, where the organization is considered as a system of operators producing, forwarding, storing and deleting documents, the informational level, where the organization is regarded as a system of processors that send, receive and transform information, and the essential level, where the organization is conceptualized as a network of interrelated business transactions, which in turn are composed of interrelated communicative acts.

The above methodologies concentrate on the representation of knowledge, but they do not consider the knowledge creation process which is a far more important issue. No matter how a richer modelling formalism is used, if the process-related knowledge is limited or incorrect, the model does not correctly represent the real process.

On the other hand, IS infrastructure to support people working in teams has been the subject of interest for quite a long time. Such systems are aiming at structuring group decision-making processes and helping group members in reaching a shared understanding of the issue by supporting knowledge elicitation, knowledge sharing and knowledge construction. Moreover, they exploit intranet or internet technologies to connect decision-makers in a way that encourages dialogue and stimulate the exchange of tacit knowledge. Representative systems falling in this category are QUESTMAP (Conklin, 1996), EUCLID (Smolensky *et al.*, 1987), JANUS (Fischer *et al.*, 1989), SEPIA (Streitz *et al.*, 1989), QOC (Shum *et al.*, 1993), SIBYL (Lee, 1990), and BELVEDERE (Suthers, 2001). One can also add here attempts to use Microsoft's Netmeeting as a platform for combining a chat-based dialogue with a simulation tool to facilitate developer-client interactions during the modelling process (Taylor, 2001), as well as attempts to use tools of this category in connection with static models (e.g. QUESTMAP in CM (Sierhuis and Selvin, 1996)).

With respect to business process modelling, all the above works provide limited knowledge management and decision-making support. Business process modelling is a social process, and as such it results in the formation of groups whose knowledge is clustered around specific views of the problem. Aiming at providing an integrated approach, this paper presents a web-based system that provides teams engaged in business process modelling with the appropriate means to collaborate towards the solution of the underlying issues. In addition to providing a platform for brainstorming and capturing organizational memory, our approach augments teamwork in terms of knowledge elicitation, sharing and construction, thus enhancing the quality of the resulting model. This is due to its structured model-specific language for conversation and its mechanism for evaluation of alternatives. Taking into account the input provided by the model builders, the system constructs an illustrative knowledge graph that is composed of the ideas expressed so far, as well as their influence connections. Moreover, through the integrated simulation environment, discussants are able to evaluate the model under construction by using different performance measures.

3 THE OVERALL FRAMEWORK

Adopting the general systems view of an organisational process, we consider *entities*, *activities*, *resources* and *decisions* as the basic building blocks used in collaborative business process modelling (BPM). The architecture of our framework is illustrated in Figure 1. The *Discourse-Based BPM Graph* module provides users with the appropriate structured and task-specific interface to express their beliefs towards the construction of a business process model in a modelling tool-independent way. More specifically, users are able to put forward *positions* regarding the activities that are to be considered, their topology, the decision points needed, and the resources involved. Discussion about activities may be further extended by placing positions conveying information regarding their *processing time*, *cost*, requirements for *queues* which may exist in front of them etc. In a similar way, discussions about resources may be further refined with the supply of information regarding their *type* (i.e., consumable or not), the activities they are *used in*, etc. For each of the above BPM objects, users may also provide *links* to related data and knowledge sources, such as MS Office or Adobe Acrobat documents, html or xml files, etc.

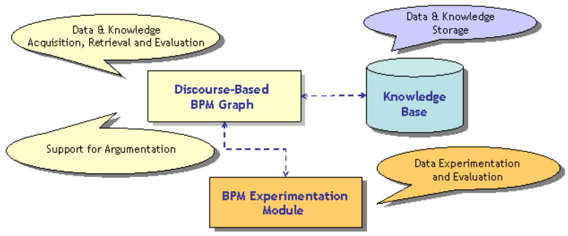

Figure 1: The proposed BPM framework.

For the graph items, users are able to assert arguments speaking in favour or against them. For instance, a user *x* may insert an argument that further validates his position about a certain decision point; the same user may also put forward an argument against an alternative decision point, which has been earlier submitted by a user *y*. Argumentation may be carried out in multiple levels, upon users' wish. The procedures that are responsible for the construction and maintenance of the discourse graph build on the functionalities of *Hermes* (Karacapilidis and Papadias, 2001), a fully implemented web-based system that supports argumentative discourse and decision making.

On the other hand, the *BPM Experimentation Module* builds on a commercial simulation tool, namely *Extend* (`www.imaginethatinc.com`), and provides users with the appropriate interface to see the progressive construction of the model. It should be noted here that other process modelling and simulation environments can be easily employed. The construction of the model is undertaken by a user (facilitator) who is proficient in the use of the specific modelling environment. He constructs the model by taking into account the current state of the argumentation (Discourse-Based BPM Graph). The other participants can load copies of the model and experiment with them at their own pace. This implicitly provides the means for data and knowledge acquisition at any instance of the overall process. Having considered the current status of the discourse graph, users may contemplate and shape their tacit or explicit knowledge according to the model built so far. Then, they may either directly "load" their input in the discourse or evaluate it further by using the integrated experimentation tool. In other words, users are able to make a series of experimentations by simultaneously considering the current status of the graph and the contributions they intend to make. By analyzing the corresponding results, they are able to explore the potential and the dynamics of their contribution before putting it in the graph and "share" it with their peers.

Obviously, the BPM Experimentation Module can be deployed at any time, thus enabling participants to get a quantified representation of the current outcome of the discussion. The module supports an extensive range of graphing and visualization features for a clear and easy reflection on the parameters of the model being considered.

The system's *Knowledge Base* keeps an archive of the position-based knowledge submitted so far during the design and re-engineering of the business process models of the company. Such knowledge integrates information about the objects of the business process model *per se* (i.e., activities, resources, topologies, processing costs, etc.) with information concerning the argumentative discourse and the experimentations carried out around them. This is handled through the definition of a specific BPM ontology. Due to space limitations, this issue is not comprehensively discussed in this paper. We only mention here that at the current stage of the system's implementation, the above information is stored in XML (eXtensible Markup Language). Since XML does not fully support ontology management issues, we are in the process of considering alternative solutions. Probably, the most promising one at the moment is BPML (Business Process Modelling Language), which is actually an XML Schema that provides a standard way to model business processes. BPML has been proven to enable the efficient handling of business process modelling issues such as business rules, security roles, distributed and compensating transactions, and exception handling (`www.bpmi.org/bpml.esp`).

The system's knowledge base is actually the place where the organizational knowledge regarding business processes of the company is developed and maintained, and serves storage and retrieval purposes. Storage of positions being asserted in the overall process takes place in an automatic way, that is upon their insertion in the Discourse-Based BPM Graph. On the other hand, retrieval of knowledge is performed through appropriate interfaces, which aid users explore the contents of the knowledge base and exploit previously stored or generated knowledge for their current needs. For instance, when a user intends to argue about the modelling of a particular process block, he may retrieve pieces of knowledge concerning the performance of this very block in an already constructed and validated business process model, thus further justifying his arguments.

4 AN EXAMPLE OF USE

This section presents the features and functionalities of the proposed BPM framework through an example concerning the modelling of a typical "order fulfilment" process. Three managers, namely the *Sales Manager*, the *Factory Manager* and the *Warehouse Manager*, are involved in the above task. The main window of Figure 2 (top left) illustrates an instance of the related BPM graph. As shown, managers have put forward their views (pieces of knowledge) concerning the activities, resources, topology, and decision points involved in the process under consideration, the aim being to "shape" the model that clearly represent the actual process of the company. Referring to the activities of the process, the Sales Manager had initially claimed that *"Order Processing"* and *"Dispatch from Warehouse"* are two necessary units; then, the Factory Manager added *"Production"* as a third one. The insertion of items related to the resources takes place in a similar fashion. In the instance shown in Figure 2, the resources proposed so far are *"Office Employee"*, *"Warehouse Employee"* and *"Fork Lift"*. Insertion of items related to the topology of the model is accomplished through an appropriately designed interface that keeps a dynamic list of the activities proposed so far and enables users to easily specify their order (i.e., to express knowledge of the form *"[activity_1] precedes [activity_2]"*). In the instance shown, the items *"[Order Processing] precedes [Dispatch from Warehouse]"* and *"[Order Processing] precedes [Production]"* have been submitted by the Sales Manager and the Factory Manager, respectively. Finally, insertion of items related to the required decision points is also performed through a user-friendly interface. In this case, users have to specify when a decision should be made. To do so, they "construct" an item by employing the temporal relations holding among activities (e.g., *after, before, in parallel*, etc.), as well as logical operators (e.g., *AND, OR, NOT*, etc.). The only such item submitted in our example declares that a decision point is needed after the *"Order Processing"* activity and before the activities *"Dispatch from Warehouse"* and *"Production"*.

As noted in Section 3, users are also able to argue in favour or against each graph item. Exploiting this feature, the Factory Manager has asserted the argument *"There are orders that cannot be fulfilled from stock"* to further justify his previously inserted position about the need of a *"Production"* activity. Note that the Sales Manager has also submitted the argument *"We do not produce to order; we group orders"*, which actually speaks against the need of inclusion of the *"Production"* activity in the model under construction. To defeat this last statement (and resolve the misunderstanding of the Sales Manager), the Factory Manager submits the argument *"The model should show how a SPECIFIC order is fulfilled"*. According to the underlying

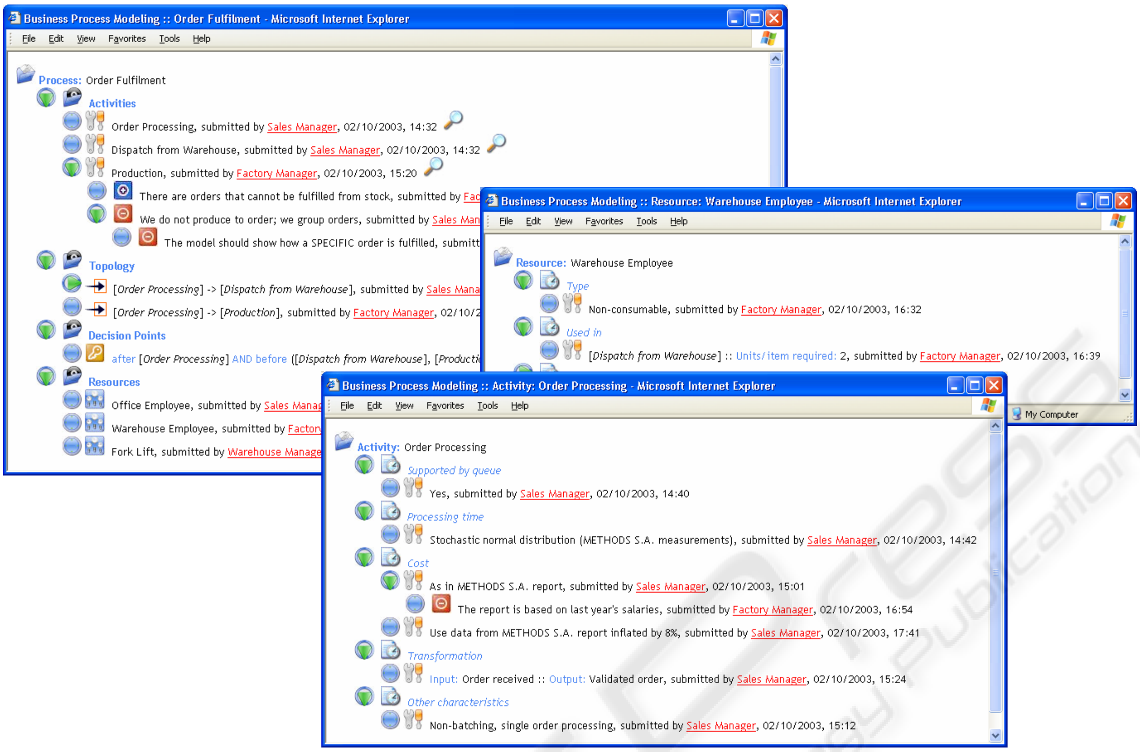

Figure 2: The interface of the discourse-based BPM graph.

argumentation's formal dialectics (for details, see (Karacapilidis and Papadias, 2001)), the argument *"We do not produce to order; we group orders"* is now defeated and it is consider as "inactive".

Graph items corresponding to activities and resources are accompanied (at the end) by a "magnifying glass" icon. By clicking on it, users may both view the existing (more detailed) information about the item and further refine it. For instance, by clicking on the icon of the *"Order Processing"* activity, the window appearing in the bottom part of Figure 2 pops up, where pieces of knowledge related to various characteristics of this activity, such as its cost and processing time, are shown. As in the main BPM graph, users may also submit here arguments and alternative positions. In the instance shown, the position *"As in METHODS S.A. report"* has been defeated by the argument *"The report is based on last year's salaries"*, thus the only position that stands for the activity's cost is to *"Use data from METHODS S.A. report inflated by 8%"*. Similar features and functionalities are provided for resources. The middle window of Figure 2 pops up when a user clicks on the "magnifying glass" icon of the resource *"Warehouse Employee"*.

The information layout in the windows provided by the BPM graph module can be modified upon a user's wish. There are buttons serving folding and unfolding purposes, thus enabling one to concentrate on the model's part that he is interested in. This is particularly useful in models of considerable length and complexity. In addition, information about when and by whom each graph item has been submitted can be either shown (as in Figure 2) or hidden.

Based on the outcome of the dialogue shown in Figure 2, the facilitator constructs the business process model in the experimentation environment (Figure 3). This model consists of the building blocks discussed in the BPM graph as well as of additional simulation-specific blocks, which may be the subject of additional dialoguing (e.g., what is the rate of order arrivals).

5 CONCLUSIONS

We have presented a framework for collaborative business process modelling that offers a series of argumentation and experimentation features to the users involved. Through the interfaces provided, users are able to deploy and share their knowledge, the aim being to design the business model that suits best to the requirements of the company. Experimentation and argumentation have been

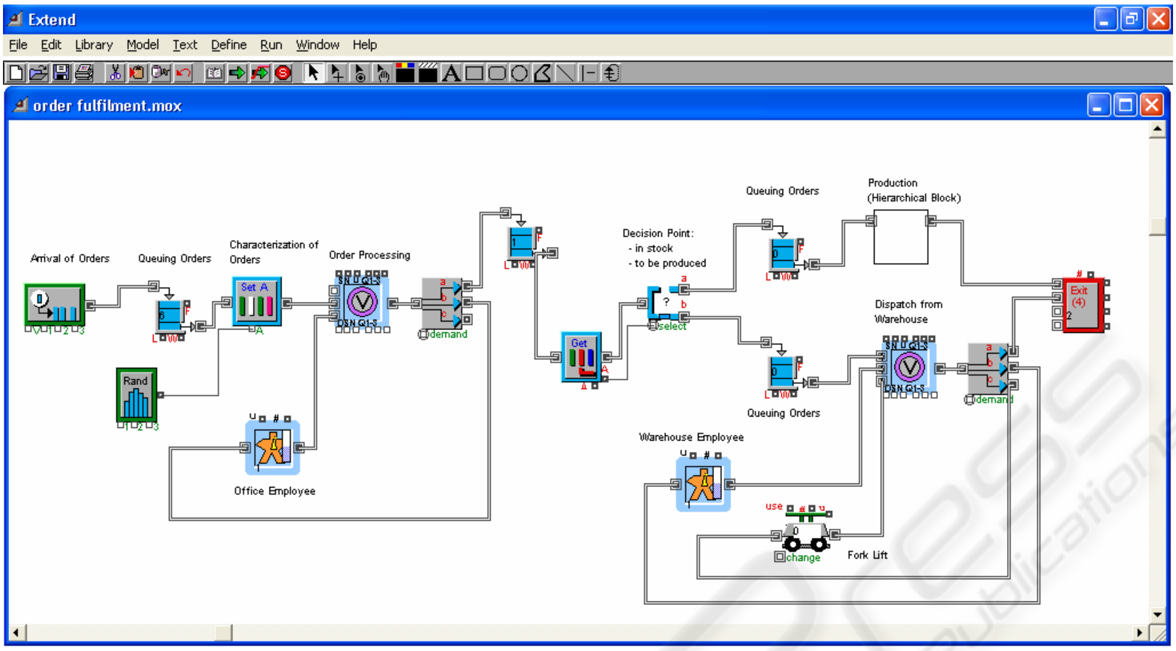

Figure 3: The BPM Experimentation module interface for the process shown in Figure 2.

considered as two complementary mental processes that increase the quality of organizational decision making while, at the same time, contribute to the creation and maintenance of organizational knowledge. We argue that the overall approach provides users with the appropriate means to overcome motivational (Davenport and Prusak, 1998) and cognitive (Huber, 2001) problems, which are ubiquitous in team work settings. The BPM graph and experimentation modules are easily conceived and motivate participants for creative knowledge sharing and evaluation.

The proposed framework is currently evaluated through a series of real cases of process design and re-engineering. Preliminary results show that its adoption aids participants to define, understand, document, analyze and improve business processes through the visual process representation diagrams. In addition, the interrelation of a business model's components is proven to be simple and easily comprehensible, while participants may also check their proposals for validity, correctness and completeness. More significant, the framework provides the means for effective communication on what is the current process and where improvements are possible, and enables all parties share a common understanding.

Future work is directed towards the automation of the inter-process communication (IPC) of the BPM graph and experimentation modules. This will be based on Extend's connectivity abilities through blocks that utilize the system's IPC functions, ODBC (Open DataBase Connectivity), embedded ActiveX or OLE (Object linking and Embedding) objects and DLL (Dynamic-Link Library).

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