A knowledge centred framework for collaborative business process modelling

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Abstract

Purpose – The paper aims to present the design rationale, the structure and the use of a web-based information systems framework for collaborative business process modelling.

Design/methodology/approach – By viewing process modelling as a "problematic situation" that entails a considerable amount of social and knowledge activity in order to be resolved, a novel process modelling construct has been developed and a participative problem-structuring methodology adapted to the specific domain. The framework presented is the result of an action research study for process improvement and has been introduced in a real organizational setting as a pilot application.

Findings – Experiences from the use of the framework presented indicate that it stimulates interaction and makes participants more accountable for their modelling contributions, as well as aiding them to define, understand, document, analyze and improve business processes in a holistic manner by interacting with one another and with the model under construction.

Research limitations/implications – Currently, the application of the framework is limited by and depends on the availability and the technical abilities of a technical facilitator, but work is under way towards automating the inter-process communication between the system implementing the problem-structuring methodology and the modelling environment.

Practical implications – The framework presented can be used in distributed organizational settings for business process management through a structured modelling process.

Originality/value – The paper presents an IS framework for business process management that integrates a problem-structuring methodology, a Knowledge Management System and a modelling/simulation environment in a consistent way.

Keywords Business process re-engineering, Knowledge management, Problem solving, Modelling

Paper type Research paper

Introduction

As new ways of working, new forms of organizing, and new business models are emerging to efficiently and effectively carry out transactions in e-business environments, organizations are in a greater need to gain a better understanding of their existing organizational structures and be able to design new ones which are in better fit with their environment. Although the "re-engineering movement" has fainted with the turn of the century, it has left the notion of the process as the prevailing unit of organizational analysis, operational performance measurement, and management decision (Melão and Pidd, 2000), as far as business models are concerned. Moreover, the importance of business processes has been amplified by being in the centre of late technological inputs in the form of ERP and workflow systems that aim at increasing

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productivity and functional interconnectivity by automating internal and external transactions.

As a result of the interest in the systematization of the different forms of intervention in business processes, over the last 15 years a large number of different change methodologies, techniques and tools has been proposed and used (Kettinger *et al.* 1997; Valiris and Glykas, 1999). Modelling has always been in the kernel of processes management activities and methodologies, independent of their focus and objectives; process models have always been used in improvement, re-engineering, certification and IT implementation initiatives. Consequently, there has been a considerable amount of discussion with respect to the characteristics and suitability of the different modelling formalisms. Surveys, however, indicate that little attention has been given to the modelling process *per se* as a socio-cognitive process, that is, to the process of managing the interaction of different knowledge sources and information artefacts for producing a valid and useful business model (e.g., Melão and Pidd, 2000; Lin *et al.*, 2002; Barber *et al.*, 2003). The value of this process cannot be solely assessed in purely teleological terms (the production of an acceptable model) (Dean *et al.*, 2000), but, more importantly, it has to be seen as a collective learning exercise that augments the organizational knowledge base of the firm, the model serving as a "transitional object" for mental models (Morecroft, 2004).

In the modern diversified and multi-sited enterprise, different stakeholders with personal, functional and professional idiosyncrasies shape different mental models and assign different meanings to organizational knowledge constructs. Therefore, the modelling of business processes, as a knowledge and social activity, entails a great complexity. This complexity is further increased by the fact that the creation of the model is contingent to the organization's strategy and is influenced by its relationships with other organizations, as strategies and operations of customers, suppliers and business partners have to be taken into account. From the systems perspective, reductionist process management approaches cannot deal with this complexity effectively and are always likely to fail because they lack a holistic view (Ackoff, 1999). But holism implies a procedural complexity as participants with different, even coercive, views should be involved (Jackson, 2003). However, systems methodologies that deal with this sort of problems, such as the soft systems methodology (Checkland and Scholes, 1990), strategic assumption surfacing and testing (SAST) (Mason and Mitroff, 1981) and strategic options development and analysis (SODA) (Eden and Ackermann, 1998), and associated software tools (e.g., *Group Explorer* (Eden and Ackermann, 1998) and *IBIS* (Conklin, 1996)) put an asymmetric emphasis on the intervention-through-modelling process compared to the means of representation (modelling formalism). They primarily use models to structure problems/issues by generating debate and insight about the organization rather than to represent the organization (Pidd, 2004). Hence, they rely on rather loose and generic modelling formalisms which cannot provide any basis for experimentation and quantitative evaluation. On the other hand, approaches to collaborative model building that rely on more formal and quantitative formalisms, seem to be rather poor as far as the systemicity of the associated modelling process is concerned (Vennix, 1996), or limited in participation by their lack of technology support (Robinson, 2001). In both cases, the interaction among participants is through process facilitation and is restricted with respect to both time and place.

The role of modern information and communication technologies (ICT) in overcoming the above limitations has already been emphasized (George *et al.* 1992; Dean *et al.*, 1995; Vreede and Dickson, 2000; Clases and Wehner, 2002) and a number of information technology-based methodologies and systems have been suggested to address the issue of collaborative business modelling. However, the majority of them concentrate on static, either conceptual or activity (e.g. IDEF0), models for visualization and quantitative analysis purposes (e.g. *CM* (Sierhuis and Selvin, 1996) and *Activity Modeller* (Dennis *et al.*, 1999; Dean *et al.*, 1995), or on how to combine simulation models developed by different parties (e.g. (Sarjoughian *et al.*, 2000; Miller *et al.*, 2001)), in both cases according to a pre-defined mode of collaboration. Furthermore, a limited number of efforts has been reported towards ICT-based tools for the collaborative development of business process simulation models (e.g. Taylor, 2001), which pay little attention to the collaboration process itself and its associated social and knowledge-construction dynamics.

The approach proposed in this paper adopts a socio-cognitive perspective to process modelling and, thus, extends the latter stream of research by integrating features present in the others. By viewing process modelling, in the logic of "soft OR" as a "problematic situation" that entails a considerable amount of social and knowledge activity in order to be resolved, we have relied on structuration theory (Giddens, 1984) for developing an enhanced process modelling construct (EPMC) and an associated business process modelling methodology. The EPMC integrates and implements not only the semantics of business process representation, but also the semantics of the collaborative modelling process. The former are based on traditional discrete-event simulation logic, whereas the latter have been developed adopting the agoric logic of the group model building by selection and argumentation (G-MoBSA) methodology (Adamides and Karacapilidis, 2003; Adamides and Karacapilidis, 2006). After a review of related work, we present the theory, the design rationale and the structure of an IS framework that implements the above construct into a web-based system that is used in a participative business process modelling and simulation methodology. In addition, we briefly describe the action research study that triggered the development of the framework and we explain the framework's functionalities through a simple use case in the same organizational setting. Finally, accounts of the pilot application of the framework are provided.

Collaborative business process modelling

From the organizational knowledge management point of view, in a collaborative modelling session, a group member (otherwise called a subject matter expert (SME)) participates into four interrelated activities with respect to the model (the transitional object), or part of it: construction, presentation and understanding, critique, and intervention on the model. Model construction is a creative activity synonymous with the externalization phase of the knowledge creation spiral (Nonaka, 1994). The model construction activity involves an intensive interaction between the modeller's world and its knowledge base in the one hand, and the situation context on the other. It is a process of knowledge transformation from tacit to more codified forms. In the process of codification, pieces of knowledge are critically reviewed, associated and receive new meaning. The construction of the model indirectly defines the space of possibilities that the participant sees and is a proposal for action.

The presentation and understanding activity results in the re-organization of a modeller's knowledge base. In trying to interpret another participant's modelling proposals, the modeller either deletes elements and associations from its own knowledge, or strengthens his views by associating different facts and different (new) meanings. This is a more personal and tacit process (knowledge internalisation) compared to the critique and intervention activities which involve, as in model construction, externalisation and association of knowledge.

Based on the above, we can distinguish two different strategies towards increasing the quality of business process modelling. They lie in the two sides across the "knowledge"/"knowing" dichotomy. The first addresses the codification of knowledge by providing richer modelling formalisms (i.e. concentrates on "knowledge"), whereas the second is focused on the modellers' interaction as a means of elicitation and rigorous exploitation of personalized knowledge (i.e. concentrates on "knowing") (Hansen *et al.*, 1999). In the context of the first perspective, the majority of approaches has been originating from the areas of "hard" operational research, industrial engineering and information systems development, including formalisms from Artificial Intelligence. Surveys of usage, however, have criticized them in that they do not rely on a sound understanding of business processes as human activity systems, and in that undermine the fact that organizational change is a social process that includes modelling (Melão and Pidd, 2000; Barber *et al.*, 2003; Lin *et al.*, 2002).

To remedy this, new formalisms based on what people do while acting and communicating have been proposed (van Reijswoud *et al.*, 1999). These representation schemes have been founded along two directions: on the one hand, on the human activity systems models of Checkland's soft systems methodology (Checkland and Scholes, 1990) to accommodate the "softness" of organizational life, and on the other, on the language/action perspective (Dignum *et al.*, 1996) and the speech act theory (Searle, 1969) to emphasize the conversational nature of human-centred organizational activity. The latter consider the utterance of various types of communicative actions as the backbone of the business process models (Medina-Mora *et al.*, 1992; Winograd and Flores, 1986). In both cases, related structures and methodologies concentrate on the representation of knowledge (content), but they barely consider knowledge creation through interaction (despite Checkland's own emphasis on the process, most reported uses of SSM on process management are restricted to human activity modelling (Galliers, 1994; Chan and Choi, 1997)).

As far as interaction is concerned, ICT infrastructure to support people working in teams has been the subject of interest for quite a long time (Fjermestad and Hiltz, 2000). Such systems are aiming at facilitating group decision-making processes by providing forums for expression of opinions, as well as qualitative and quantitative tools for aggregating proposals and evaluating their impact on the issue in hand (Bose, 2003; Dennis *et al.*, 2003; Cummings, 2004). Current systems exploit intranet or internet technologies to connect decision-makers in a way that encourages dialogue and stimulate the exchange of knowledge (enhancing "knowing" rather than "knowledge"). In the same line, the more recent computer-based knowledge management systems (KMS) intend at providing a corporate memory, that is, an explicit, disembodied and persistent representation of the knowledge and information in an organization, as well as mechanisms that improve the sharing and dissemination of knowledge by facilitating interaction and collaboration among the parties involved (Bolloju *et al.*

2002; Taylor, 2001). Compared to problem-structuring methodologies and tools, they lack a concrete theoretical basis, as well as any methodological support with respect to social interaction. The connection of this sort of systems to business process modelling and simulation is apparent along three directions: in attempts of using Microsoft's *Netmeeting* as a platform for combining a chat-based dialogue with a simulation tool for facilitating developer-client interactions during the modelling process (Taylor, 2001), in projects of using general-purpose groupware tools for scheduling and managing synchronous BPR meetings (Dennis *et al.*, 2003), and in systems for constructing static activity models according to pre-determined procedures (e.g., *Activity Modeler* (Dennis *et al.*, 1999; Dean *et al.*, 1995) and *Questmap* in *CM* (Sierhuis and Selvin, 1996)).

In reality, however, supporting collective model building implies providing an infrastructure that augments the work of a group of people beyond technological or facilitation constraints, whose function and dynamics depend significantly on what they know (individually and collectively). Business process modelling is a social process that principally involves spontaneous and multidirectional interaction. It is this interaction that requires explicit technological support in its structuring and management (Smoliar, 2003). And, it is this interaction that requires methodological support and whose explicit embedment is missing in the systems proposed so far. Although they provide concurrent model development capabilities, the modelling process is structured along simple top-down, bottom-up, or hybrid, heavily facilitated divisions of labour (Dean *et al.*, 2000). Driven by the single-dimensional objective to increase the productivity of the model building process, they lack in the provision of an environment for a structured discourse space that augments team learning and group creativity, which are the principal requirements of a modelling session (Fülscher and Powell, 1999). Overall, the approaches mentioned above in this section, as well as in the previous one, can be organised into four distinct categories with complementary characteristics as far as the "knowledge"/"knowing" orientation and related attributes are concerned. These are summarised in Table I.

By viewing group model building more as a problematic situation whose resolution entails an organizational learning and capability building process, we have developed the IS framework described in the following sections. In addition to providing a platform for brainstorming and for capturing organizational memory, our approach based on the G-MoBSA methodology it provides the means for a structured but not procedurally constrained debate to get insight about the world (organization) using a language that facilitates the subsequent representation of the organizational processes. As such, its features and functionalities extend over all four categories of Table I. To present our approach in the following section, we first place participative business process modelling in the framework of the G-MoBSA methodology, we then concentrate on the EPMC and its associated argumentation schema, before we give the technical characteristics and the functionalities of the proposed framework.

The proposed framework

The G-MoBSA methodology in the context of business process modelling

The group model building by selection and argumentation (G-MoBSA) methodology is a systemic general problem-resolution methodology implemented, in its generic form, in the *Knowledge Breeder* software environment (Adamides and Karacapilidis, 2006).

Table I.
Models, modelling and ICT support for process management

	Focus	Modelling formalism	Knowledge management orientation	Mode of process	Knowledge elicitation and recombination	Contribution and main shortcoming w.r.t. to process modelling and management
Groupware and KMS	ICT	Informal	Knowing	Mostly synchronous, but can be asynchronous	Unstructured	Structured discussion forums about process management issues Not explicit process modelling-related formalism used
Problem-structuring methodologies and tools	Methodological problem-structuring	Soft	Knowing	Mostly synchronous	Structured	Through soft modelling can facilitate shared understanding and result in agreed process interventions Not explicit process modelling-related formalism used
Process modelling formalisms	Representation	Hard Rigorous	Knowledge	N/A	Unstructured	Can provide rich process representations and support experimentation Absence of methodology for facilitating shared understanding and resulting in agreed process interventions
Group model building tools and procedures	ICT and representation	Hard Rigorous	Knowledge	Mostly synchronous, but can be asynchronous	Structured	Allow different people to contribute to model building Procedurally constrained and theoretically shallow w.r.t. knowledge and social dynamics

G-MoBSA belongs to the “soft” stream of operational research and adheres to its philosophical and epistemological foundations, as they have been clarified by Checkland and Holwell (1998a). Consequently, business process modelling is viewed as a systemic process of accommodation of different stakeholders’ perceptions regarding a business process’s purpose, structure and functionality. The objective is not to model in the best possible way a process that exists in the organization “out there”, but to reach an accommodated view, through better mutual understanding, of what the stakeholders of the process think the (existing or the future) process may look like in a specific modelling formalism. G-MoBSA supports this task through the systemisation of the stakeholders’ interactions according to a formal argumentation schema.

Figure 1 shows the G-MoBSA methodology in the context of business process modelling. In a modelling session, using the EPMC, connected SMEs propose, refine, argue for, or argue against, models or parts of models, providing their complete supporting rationale in a logically organised way. This is a continuous, asynchronous, and recursive process, at each instance of which, the supporting information system, using a formal argumentation schema and a quantitative evaluation algorithm (Karacapilidis *et al.*, 2003), resolves conflicts and assesses the acceptability of each alternative (model or part of it), respectively. At specific time instances, a facilitator, proficient in the use of a specific simulation modelling environment, using system-produced discussion summaries, constructs the model in a graphical form and runs simulations (technical, or “chauffeured”, facilitation). Model acceptability and simulation outputs are fed back to the SMEs (process stakeholders).

In effect, business process modelling within the framework of the G-MoBSA methodology follows the interpretive sociological paradigm, according to which social action is based on personal and collective *Sense Making* (Giddens, 1984; Vickers, 1984). Consequently, standards and criteria concerning the “goodness” of a model under construction are not given from outside, but are based on the group’s acceptability of the current state of the model as it is compared to the collectively perceived reality of the process to be modelled. Actions and proposals are directed towards improving and, finally, stabilising this relationship. As participants are exposed to more information and get involved into more focused debates, convergence of the perceptions and opinions takes place (Leonard and Sensiper, 1998; Fuchs, 2003; Schwarz, 2003) and support for a specific model structure is increased, improving and stabilising the relationship. The specific model is selected as being in a better fit with the collective perception of the process. It should be noted that the quantitative results of the evaluation algorithm and the outcome of the application of the rules of the argumentation schema are only indicative. The final selection depends on the group’s roles and power structure as defined in the context of the specific modelling and process management project. In the trend and objectives of problem-structuring methodologies, the objective is to resolve an issue rather than solve it. In addition, the philosophy of the G-MoBSA methodology is to support the group’s dynamics rather than enforcing specific procedures.

The enhanced process modelling construct

The EPMC is an object-oriented modelling formalism that, in addition to a data structure for representing real-world organizational entities, includes the operations required for its construction in a participative manner. The EPMC was developed for

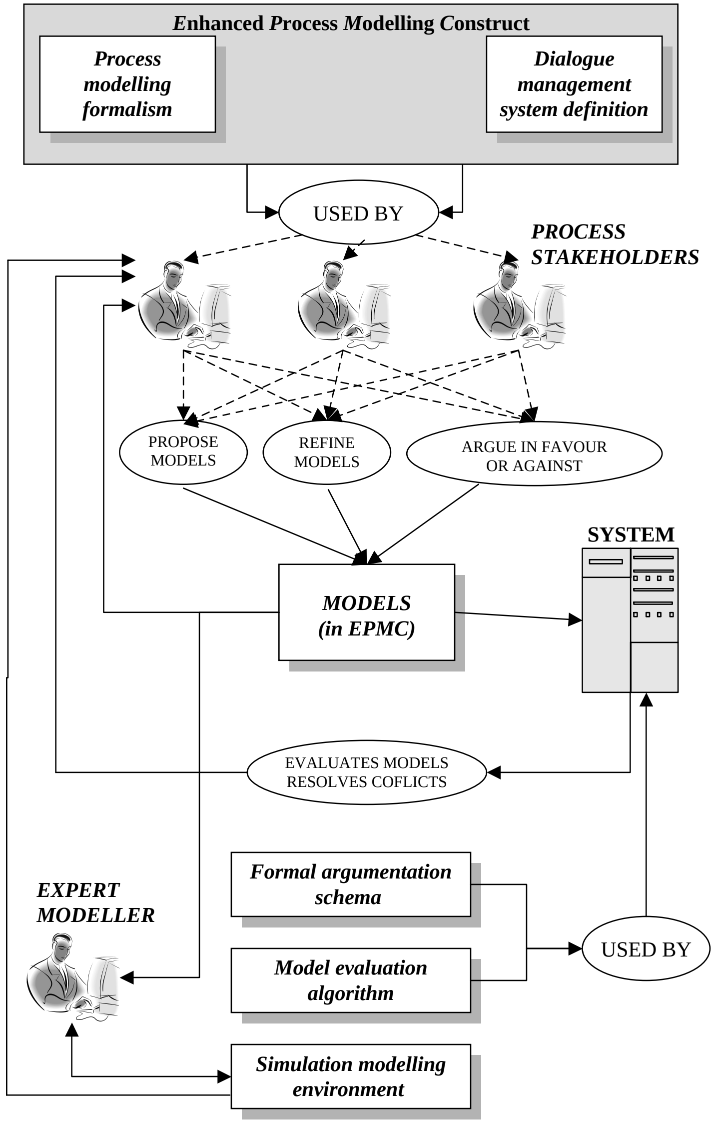

Figure 1.
The G-MoBSA methodology in the business process modelling context

explicitly addressing the social dynamics of the modelling process. It is based on Gidden's structuration theory (Giddens, 1984), according to which social interaction is viewed in a three-dimensional space. In the first dimension, signification implies what things mean subjectively. In the other two dimensions, domination is about understanding who has authority, while legitimation signifies what is acceptable.

The social space of collective model development is structured along the above three dimensions through EPMC by, first, providing a common language of representation (unifies signification) and then a structured language for developing complex representations collectively (structures domination and signification). Process representation is by means of activities, resources, decision points and their topology. Activity is the main unit of recursion, that is, an activity in a high-level model may represent a lower-level process and so on. Each element contains attributes for describing its individual characteristics (e.g., processing time, costs, etc.) The collective construction of the model is accomplished by employing the generic operations:

- place position (with respect to each of the data elements (activities and other discrete-event modelling constructs) and their characteristics (e.g. cost));
- argue for a position (asserting a supporting position);
- argue against a position (asserting an opposing position); and
- *resolve conflict* of positions using an argumentation schema (and power structure).

The exact meaning and the way that these operations are implemented and employed in the modelling process are given in the following subsections.

The argumentation schema

The current implementation of our system uses the formal argumentation schema (set of rules) of the *logical propedeutic of the Erlangen school* (van Eemeren *et al.*, 1996). The system operates on the logical connectives that exist in single arguments/positions and among their connected arguments. The argumentation schema provides the rules for conducting the dialogue among participants and for resolving conflicts (which argument or clause holds and which is defeated). Its role within the framework of the methodology is more consultative than imposing. It consists of a starting rule which indicates that the participant who asserts a position, or thesis, is the proponent who starts the dialogue. The participants that defend the thesis as a whole, or some of its elements, are the opponents, while those who support it are the supporters. In a specific dialogue instance, a supporter may become proponent as a different participant challenges her argument(s). The general dialogue rule indicates that, at any instance, a proponent can attack one of the statements put forward by an opponent, or defend herself against an opponent's attack. The opponent, in turn, can attack the statement made by the proponent in a preceding move or defend herself against the proponent's attack in the preceding move. The winning rules indicate the procedure and outcome of successive argumentations on combined (connected with logical connectives) statements. "Ultimate victory" in conflicted cases results from the successful defence of elementary statements on which the argumentation has been exercised. The specific set of winning rules of the argumentation schema used can be found in (van Eemeren *et al.*, 1996) and in (Adamides and Karacapilidis, 2006).

Technical characteristics and functionality

The IS architecture of our framework is shown in Figure 2. Its main constituent parts are the "discourse-based BPM graph module" that maintains the argumentative dialogues with the users/modellers and the "BPM experimentation module" that, in effect, is an "off the shelf" discrete-event simulation environment (Imagine That Inc.'s Extend Industry Suite). The framework's Model Base is a database of Extend's models that can be accessed by context and version, while the framework's Knowledge Base is

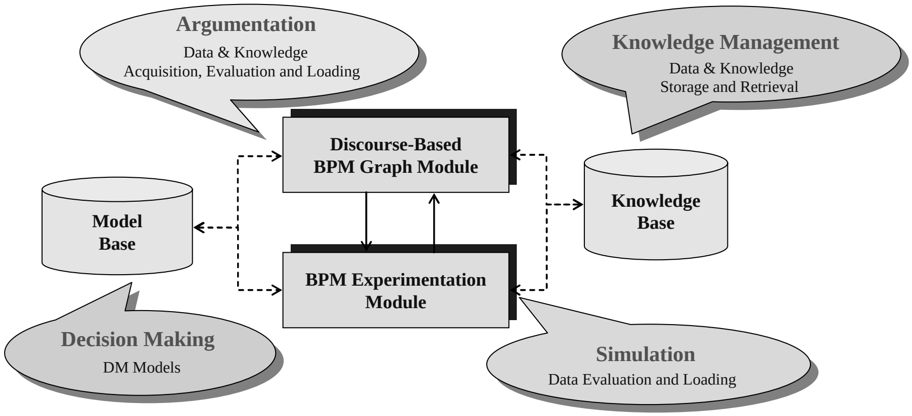

Figure 2.
The proposed BPM framework

a database of model construction dialogues (discourse graphs) with supporting information artefacts (multimedia documents) and links to models in the Model Base. In other words, the Knowledge Base keeps an archive of the position-based knowledge submitted so far during the development of the business process models of the company. Such knowledge integrates information about the elements 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. Decision-making issues about the acceptability of alternative models proposed for a specific problem are handled through two different model evaluation algorithms (Karacapilidis *et al.*, 2003).

The discourse-based BPM graph module provides users with an appropriately structured, task-specific interface for expressing their views on the construction of a business process model in a modelling-tool-independent way. The participants of the modelling process are able to put forward positions regarding the activities that are to be considered, their topology, the decision points needed, and the resources involved. Positions concerning topology are of the type "activity a precedes (or follows) activity b", while those concerning the inclusion of a decision point in the business process model under consideration are of the type "after activities $a_1, \ldots, a_n$ and before activities $b_1, \ldots, b_m$". Activities may be further enriched by placing positions conveying information regarding their processing time, cost, requirements for queues, transformation type ("what is the input and output of the activity"), and other characteristics (where any other information a user believes that it should be considered during the construction of the model can be placed). In a similar way, resources may be further refined with positions supplying information regarding each resource's type (i.e., consumable or not), the activities they are used in, and other characteristics (this serves exactly the purpose discussed above for the activities). For each of the above graph items, users may also provide links to related data and knowledge sources, such as MS Office or Adobe Acrobat documents, html or xml files, etc.

Users are also able to assert arguments speaking in favour or against each graph item. 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 modelling entity, 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 provides users with the appropriate interface to evaluate the progressive construction of the model. Other process modelling and simulation environments can easily be employed. The construction of the model is undertaken by a facilitator. He constructs the model by taking into account the summary of the current state of the dialogue (discourse-based BPM graph). Participants can then load copies of the model (through a web connection) and experiment with them at their own pace. Having considered the current status of the discourse graph, users may contemplate further interventions on the model built so far. Following, they may either directly deploy their positions in the ongoing discourse or evaluate them further by using the integrated experimentation tool. In other words, users are able to conduct a series of simulations by simultaneously considering the current status of the graph/model 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 "sharing" it with their peers.

The development and use of the framework

The development of the proposed framework through action research

The development of the collaborative model building framework described above has been initiated by a modelling and simulation project for improving the empty bottle recollection process in a major brewery in Greece. The objective was to re-design this process so that the supply of used and new bottles to the production process was smoothed out. The underlying goal was to synchronise the collection and production processes for the two major and three minor brands of the company. Empty bottle recollection has always been the responsibility of the regional distributors and it was quite difficult for the factory management to forecast their rate of arrival at the production site.

A core team of four production management personnel was given the responsibility for looking into the problem. They were already familiar with the use of discrete event modelling and simulation for representing and assessing industrial processes through a series of seminars organised by one of the authors. The factory manager led the modelling and intervention effort with the help of a technical facilitator (simulation expert). During the first meeting it became clear that the team's range of work responsibility was limited with respect to representing the entire recollection-production process. Other managers, employees, as well as external partners (sales, purchasing, logistics, as well as regional distributors) were required to provide their knowledge and perspectives. Some of these people were site resident, but their availability to same time same place meetings was problematic. Others were situated in remote places throughout the country and it would be extremely difficult to get them involved actively in meetings. Nevertheless, it was decided to start the modelling process with the core team, and each time a piece of information would be required the team would note it and ask for clarification/enrichment at a later stage via e-mail or by phone. In the process, it was found that, in addition to the problem of getting answers in a timely manner, each time a question was put forward, the response resulted into a different model, which again required more information and the views of stakeholders who had already contributed. In the presence of different perspectives, the latter frequently changed their original input and so on. Faced with these problems, the team decided to distribute a memo asking the combined process stakeholders to draw a sketch of the process or part of it providing the necessary data. A simple modelling convention based on flowchart notations was distributed to them. In this way, the modelling process became a long one as incorrect, inconsistent and contradicting responses were difficult to deal with. Contradicting responses were initiating "investigation" procedures for finding the correct view. Overall, the modelling project became extremely inefficient and inevitably the intervention was driven solely by the views and interests of the factory personnel.

The experience of this project initiated the interest to develop a more efficient framework for carrying out similar projects. During the development of the framework presented in the previous sections, the empty bottle recollection process modelling project was completed, inevitably below initial expectations and its outcome was not taken into account in the proposals for the re-design of the process. However, the lessons learned out of this project were invaluable in tuning the new framework through the action research cycle (Checkland and Holwell, 1998b) (as shown in Figure 3).

The requirements for the new IS framework were summarised as follows:

- to allow remote and asynchronous participation using an ICT infrastructure;
- to provide a language for communication between process modellers, which lies between the technical language of modelling and that of operations management;
- to provide a syntax for lean expression of opinions and views which nevertheless could be gradually refined and justified "on demand";
- to provide a formal argumentation system for clarifying issues and giving guidance for the resolution of conflicting issues and views; and
- to allow for the model to be developed in phases, as technical facilitators may not be available at any time, i.e. discussion about the process model and the intervention may take place independently of the actual modelling and simulation activity.

A prototype of the software system was developed and used in a pilot application of the overall framework in the modelling of the "order fulfilment process" in the same company. After an initial training, the same group of managers from the main factory with the addition of personnel from the company's headquarters (three additional middle managers) were involved in the application. The first observation, in comparison to the previous modelling effort, was that participants became more accountable to what information they were providing, as it was now stored and available to all. In addition, the dialogue syntax limited rhetoric performances and the placement of vague statements. As a consequence, the information placed was more accurate and contributing to the modelling objective. The presence of the formal argumentation system made participants to be more explicit in their views providing

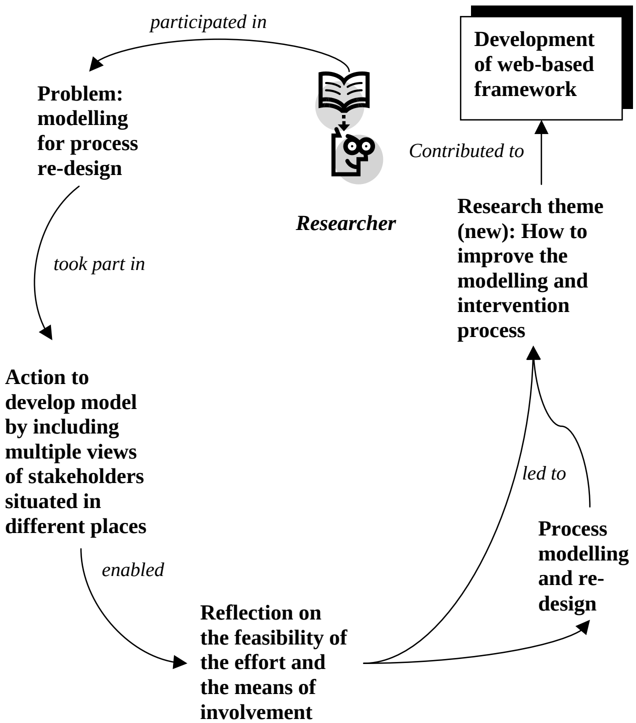

Figure 3.
The action research cycle that resulted in the development of the IS framework

explicit supporting evidence. Moreover, the absence of a strict meeting schedule and agenda allowed them to think independently, come back and enrich the model at different times by adding new positions or refining their previously asserted ones.

From the start of the project, voluntary contribution improved but not at the level that the project demanded. Inherent group dynamics worked again, and the immediate process stakeholders proved to be more active and willing to contribute than others whose function was at the boundaries of the process. The roles of the project leader and the technical facilitator were vital at this stage of the project for keeping it going. Gradually, however, the managers that were more interested in the project started to act as agents for gathering information from other less-interested participants to enrich and support their views, or to argue more concretely against others. This provided an internal dynamic division of labour, and the supporting mechanism for the project to be completed. This behaviour justified the underlying Darwinian-like philosophy of the G-MoBSA methodology, according to which tasks are attracted dynamically by the "fittest" (more interested) participants to accomplish them (rather than imposed through facilitation). Users found of particular interest the independent conflict resolution feature of the software which, as it was observed, was tested extensively by even providing artificially conflicting arguments. It should be noted that the pilot use of the framework was concentrated on modelling, as participants were less familiar with the process and technicalities of simulation.

An example of use

This section illustrates the features and functionalities of the proposed system through a specific episode of the "coarse-grain" modelling process of the "order fulfilment" process in the organization of the previous section. Three managers (sales manager, factory manager and warehouse manager), are involved in the modelling task. The top left window of Figure 4 shows an instance of the related BPM graph. Using EPMC, the managers have put forward their views with respect to the activities, resources, topology, and decision points involved in the process under consideration. Insertion of activities is performed through the window shown in the top right part of Figure 4 (similar windows serve the insertion of the other entries of the graph). Referring to the activities of the process, the sales manager had previously 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 4, 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 and enables users to easily specify their order. 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. The insertion of items related to the required decision points is also accomplished through a similar interface. Users "construct" decision items by using the temporal relations holding among activities (e.g., after, before, in parallel, etc.), as well as logical operators (e.g., AND, OR, NOT, etc.). As shown in Figure 4, a decision item has been placed after the "Order Processing" activity and before the activities "Dispatch from Warehouse" and "Production".

The implementation of EPMC allows users 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. 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 argumentation's formal dialectics (for details, see (Karacapilidis and Papadias, 2001; Adamides and Karacapilidis, 2006)), the argument "we do not produce to order; we group orders" is now defeated and considered as "inactive". The corresponding position is evaluated accordingly.

In the system's interface, graph items corresponding to activities and resources are accompanied (at the end) by a "magnifying glass" icon. By clicking on it, users may 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 left part of Figure 4 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 higher-level BPM graph, users may submit arguments and

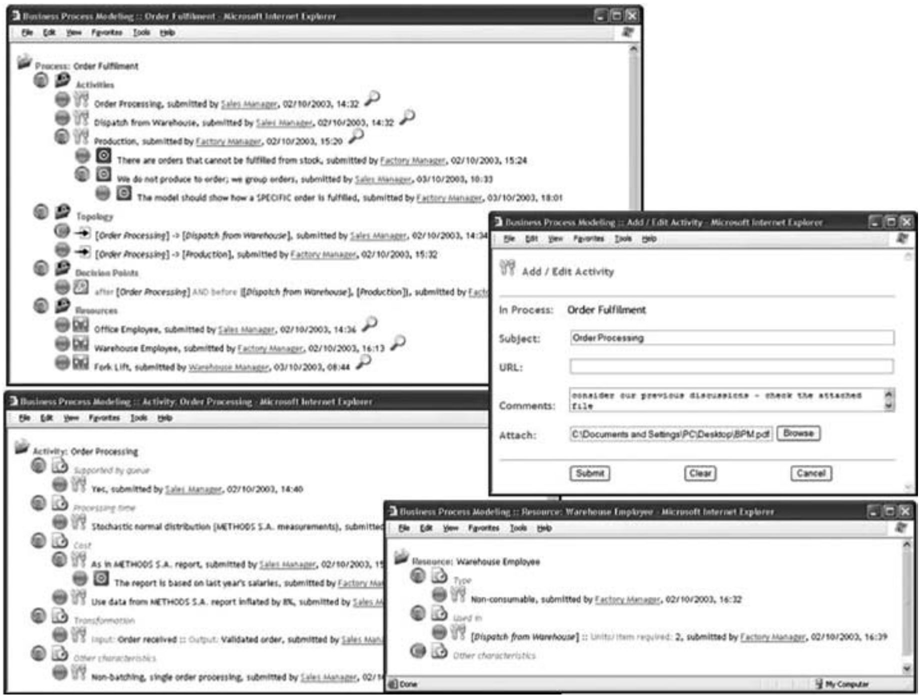

Figure 4.
The interface of the discourse-based BPM graph

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 per cent". Similar features and functionalities are provided for resources. After clicking on the "magnifying glass" icon of the resource "Warehouse Employee", the window shown in the bottom right part of Figure 4 pops up.

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 part of the model 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 4) or hidden.

Based on the outcome of the dialogue shown in Figure 4, the facilitator has constructed the business process model in the experimentation environment (Figure 5). 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).

Conclusions

This paper has introduced a knowledge-centred perspective into business process modelling by directly addressing the dynamics of its process. Process modelling, and more generally representation, is an organizational competence that can be augmented

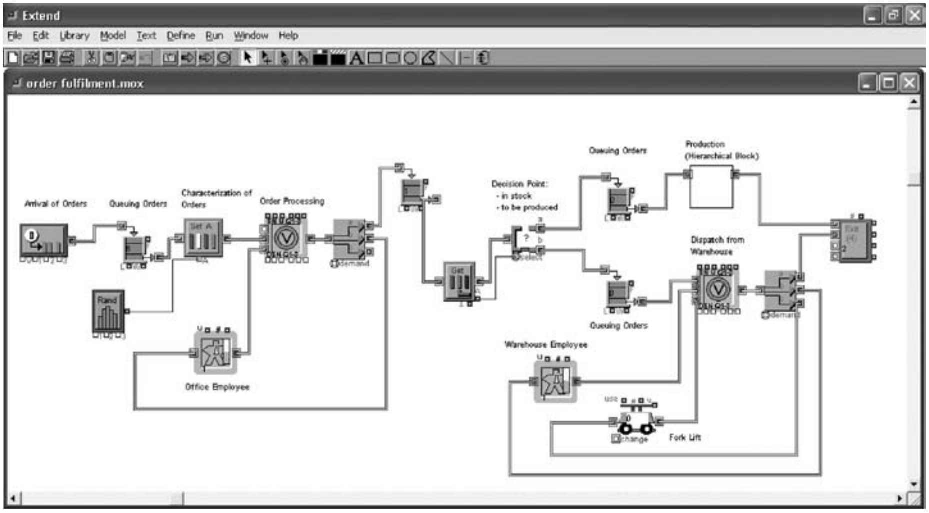

Figure 5.
The BPM experimentation module interface for the process shown in Figure 4

by including as many perspectives as possible. However, the systemic incorporation of multiple perspectives into the modelling process requires the management of interaction of those expressing them with the model under construction, as well as with each other. This is a knowledge creation process, as modellers do not only shape the model according to their perspectives, but also the model and the modelling process influences their beliefs.

Technology has a role to play in the management of the interactions if it is used methodologically taking into account the social dynamics of the modelling team. Information and communication technology can improve participation, as well as enhance the effectiveness and efficiency of interaction by providing a structured forum for expression of opinions, argumentation and negotiation. Towards this end, in this paper, we have presented a web-based information systems framework for distributed and asynchronous collaborative business process simulation modelling. By viewing process modelling as a "problematic situation" that entails a considerable amount of social and knowledge activity in order to be resolved, we have relied on structuration theory for developing the enhanced process modelling construct (EPMC) and for adapting a participative problem-resolution methodology (G-MoBSA) to the specific domain.

The proposed framework is the result of an action research study for process improvement and has been introduced in a real organizational setting as a pilot application regarding the modelling process only (not simulation). Preliminary results show that it stimulates interaction and makes participants more accountable for their contributions, as well as aiding them to define, understand, document, analyze and improve business processes in a holistic manner through interacting with each other and with the model under construction. Currently, the application of the framework is limited by and depends heavily on the availability and the technical abilities of the technical facilitator, but work is underway towards the automation of the inter-process communication (IPC) between the system implementing the specific mode of the

G-MoBSA methodology (the dialogue and argumentation system) and the simulation modelling tool.

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