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A Systemic Framework for Business Process Modeling Combining Soft Systems Methodology and UML

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ABSTRACT

Business process analysis and modeling is a crucial step in formulating information systems user requirements. The practice of information technology (IT) development does not indicate a lack of problems in spite of the growing number of modeling techniques. This article gives an action research account of formulating and applying a new business process modeling framework to manufacturing processes to guide software development. It is based on a combination of soft systems methodology (SSM) and the Unified Modeling Language (UML) business process modeling extensions suggested by Eriksson and Penker. SSM has been linked to information systems provision in the past. The examination of prior research shows that there is no underlying reasoning about the justification from a methodological point of view of the combination of SSM and UML. This article justifies the mixing of SSM and Eriksson and Penker's UML extensions using the ideas of Mingers' Multimethodology. The latter helps to overcome the ontological complexities of combining soft and hard techniques in a single intervention. The proposed framework was applied to modeling the production process in an aluminum rolling plant as a step in the development of a new information system for it. The reflections on the intervention give details on how actual learning and appreciation is facilitated using SSM, leading to better UML models in this complex problem.

Keywords: action research; business process modeling; conceptual design; information requirements analysis; manufacturing; process improvement; soft systems methodology; systems analysis; UML

INTRODUCTION

Alter (2006) points out the fact that techno-centric analysis of business and information technology problems is one of the many causes that contribute to the poor results in information systems development. This underlines the need to bridge the description of business problem contexts with information systems (IS) modeling. In calling for greater application of systems thinking in information systems, Alter (2006) also emphasizes the dangers of promoting single non-systemic approaches, among them business process re-engineering as a panacea for implementation problems. The theoretical motivations for the work on process modeling reported here are of a somewhat similar nature. A recent example of addressing just one aspect of complex problems like enterprise system implementation is a thought-provoking paper by Sommer (2002, p. 20). It recognizes that many enterprise resource planning (ERP) implementation failures can be attributed to overzealous implementation cycles, a lack of top management support, traditional scope creep, inadequate requirements definition and a host of other factors but focuses only on the role of middle management in the implementation process. The resulting research model is interesting but it is impossible in our opinion to determine whether middle management or inadequate requirements definition can be taken independently from the other factors affecting IS success. It is hard to ignore the interdependencies between all factors involved. Hence, in line with Alter's (2006) ideas, we conclude that there is a fundamental need for systemic ways of capturing the richness of business processes and expressing their models more adequately for the purposes of building enterprise information systems.

The practical reason for the research discussed here emanated from the needs of the employer of the first author at the time the project took place, an aluminium rolling and extrusion company. In the late 1990s, it grappled with understanding the complexities influencing the design of business processes. It is widely accepted that the notion of a business process (see Hammer & Champy, 1993; Kumar & Hillegersberg, 2000, pp. 23-25) is central to organisational change and IT development initiatives. In other words, the business process serves as the unit of design and the unit of evaluation in change programs. A fundamental activity of all these process-improvement initiatives is business analysis and modeling.

The aluminium semi-fabricator needed to support the complex manufacturing process with suitable information systems and had failed to deliver successful information systems projects using traditional approaches on a number of occasions. The company was looking for better ways of linking process modeling with the development of its information systems. It had already decided on using the Eriksson and Penker (2000) UML business modeling extensions to model business processes that had appeared in an Object Management Group (OMG) Press book publication. There was, however, no agreement on how to conceptualise the context of the business situation. Some authors working in business process modeling had suggested the use of soft systems methodology (SSM) to enhance business process analysis and modeling (see Ackermann Walls, Meer, & Borman, 1999, p. 202, and others). The general theme amongst these researchers seems to be that SSM is advocated in complex management problems because its process provides a rich inquiry process, a problem structuring process, a goal formulation process, or sense making devices (Galliers, 1994, p. 165; Mingers, 1995, p. 21; Nuseibeh & Easterbrook, 2000, p. 43; Ormerod, 1995, p. 292). Intuitively, SSM seemed to be a suitable technique to employ in assisting with understanding the problem situation before modeling business processes, but it was unclear at the time, when the practical need for this project emerged (around 2000), how to combine it effectively with UML in practice in spite of a few publications like Lane (1998).

The aim of the article is to present an innovative systemic framework for modeling business processes, mixing SSM and Eriksson and Penker's (2000) business modeling extensions. Such a combination had not been applied in the same intervention and is not described in the literature before to the best of our knowledge. The contribution of the paper to the field of information systems is in the formulation and justification of the proposed framework following Mingers' (2001) multimethodology concepts and other advances in systems thinking. The proposed framework is applicable with other variants of UML that are currently being developed to improve business modeling. The reflections on the implementation of the framework are another contribution of the article. The research had a direct practical contribution through the development of a model of the process of delivery of essential product information to the shop floor during the production process. That helped to resolve subsequently major stumbling blocks in the modeling of the business processes and the development of information systems at the aluminium company.

The following section reviews the problem situation associated with finding more effective techniques to define and communicate information system requirements at the aluminium semi-fabricator. Following this are an overview of business process modeling and a review of the work done in the area of combining SSM with information systems modeling techniques. This is followed by the formulation of the proposed framework combining SSM and UML in the modeling of the production processes, by a brief description how it was applied, and by reflections on its implementation. The conclusion summarises the results of this paper and provides a few directions for future research.

AN OVERVIEW OF THE SITUATION OF CONCERN

The aluminium semi-fabricator, located in South Africa, had embarked on an expansion and transformation of its manufacturing and information systems capabilities in the late 1990s. Prior efforts to meet production information systems requirements with standard ERP packages were unsuccessful. After several attempts, the ERP approach was abandoned, and the company opted to pursue customised development. The semi-fabricator had a combination of manual and automated machinery. It aimed at integrating in a better way shop floor automation with its plant production planning systems. The plant was also unique in that it manufactured diverse products, which were ordered in many specific sizes and features.

Such a flexible business strategy is threatened by fluctuating process conditions and is dependant on constantly having the manufacturing process under control. The most urgent business priority facing the semi-fabricator at the time of this project was eliminating customer complaints. Customers were not satisfied with the erratic quality being supplied. A key factor causing the production of poor products was that operators were not receiving adequate information to set up, control, and monitor the machine. The operators and the traditional manual mechanisms of assimilating new product knowledge gradually became a constraint for the business to continue with its flexible manufacturing strategy. According to management, the challenge was to get the right elements of information to the shop floor at the right time without flooding the operator with excessive details, but making sure the operator gets the critical information that is needed.

Management at the aluminium semi-fabricator had tried in the past to improve the situation through the introduction of technology using traditional approaches to systems analysis and design. According to the plant engineering manager, these attempts were not successful for the following reasons (Torr, personal communication, 2001):

1. There was a tendency to focus on optimization and automation (technical issues) instead of first measuring, then understanding, and finally controlling through IT (learning).
2. There has always been a tendency to be more sophisticated than the users could appreciate or the business was ready to support.
3. Point solutions introduced at particular machine centers were poorly integrated with the remainder of the plant systems and slowly fell into disuse.

In this project, we focused particularly on an important production management problem: modeling the process of delivery of essential product information to the shop floor during execution of a customer's order. This process was crucial for improvement of production quality in the plant. The difficulties that the plant was experiencing were related to the distortion of the information by the time it reached the shop floor and were similar to the concerns about the role of middle management discussed in Sommer (2002). The specific problem was that the existing situation of concern was not captured well through a well-defined and acceptable human activity system that took into consideration the major issues identified by the stakeholders. Hence, there was no starting point to begin thinking about better implementation of information systems to serve the production process.

Mingers (1995, p. 19), along with other researchers, argues that related types of failures can ultimately be seen as failures in expectation, that is, the final information system does not in some way meet the legitimate expectations of the stakeholders. Mingers further states that information system failures ultimately occur as a result of the limitations in conventional (hard) information system analysis and design methodologies. Traditional approaches to information systems design have been attracting a considerable amount of criticism recently because of their lack of attention to social, political, and cultural issues. In spite of the fact that some of that criticism appeared about a decade ago (see Stowell, 1995), there is still very little practical progress to date in the IT field on this issue. Through our work, we realized that the positivist, objectivist assumptions with which traditional approaches were underpinned made them inappropriate for the analysis or modeling of production systems at the aluminium semi-fabricator, where there were many stakeholders with potentially divergent interests. Hence, we needed to apply relevant interpretive methods together with other existing IS approaches to capture the existing diverse perspectives for modeling the business processes. The latter are briefly reviewed in the next section.

A BRIEF OVERVIEW OF BUSINESS PROCESS RESEARCH

Many business modeling methods have been proposed in the literature. The most important approach that has been receiving attention in recent years is the "process-driven modeling" technique, in which the business is analysed in terms of main business processes (Herzum & Sims, 2000, p. 428). Despite all the effort in this area, business modeling is a poorly understood research area, according to Osterwalder, Pigneur, and Tucci (2005). They suggest the following definition for business models:

A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams (Osterwalder et al., 2005).

The emphasis on business models being conceptual tools is an interesting, innovative concept that we adopted as one of the starting points in our work.

Our literature review shows that business process modeling research is reported along three themes. The first theme focuses on the symbology and objective recording of reality as symbols and relationships to other symbols following the stated rules that accompany the symbology. Work done on flow charting, UML modeling, IDEFIX, Petri nets, and so forth can be classified as methods belonging to this first theme (see Kettinger, 1997; Peppard & Rowland, 1995; Osterwalder et al., 2005, and others). It is done typically from a functionalist point of view even if the complexity of the problem is acknowledged as by Edwards, Braganza, and Lambert (2000). The second theme focuses on using modeling for learning about a problematic situation as a social setting. This is the major feature characterizing the application of soft systems thinking (e.g., see Checkland & Holwell, 1998; Checkland & Scholes, 1999, and others). The third theme focuses on preceding methods from the first theme with methods from the second theme (see Galliers, 1994; Lane, 1998; Mingers, 1992; Mingers, 1995; and the extensive review in Mathiassen & Nielsen, 2000).

Among the methods suggested in the first group, an important contribution is the work by Eriksson and Penker (2000). Eriksson and Penker built on the momentum established by the use of UML in software systems design and proposed their extensions with the goal of enabling business modeling with a language that has been used mainly for software systems design. The result is not ground-breaking in terms of business modeling but presents a synthesis of concepts relevant for modeling business processes that are integrated in a UML model, and for this reason we found it of interest while working on this project.

Analyzing previous attempts at combining different methods from diverse methodologies in the same operations research intervention, Munro and Mingers (2002) outline a common weakness in them: the combination of these approaches in practice was performed in an ad-hoc manner with no consideration of their theoretical basis linked to interpretive and positivist paradigms. The need to define a business process modeling approach that combines the power of methods from different paradigms and avoids the above criticism was another motivation for our work. The following section gives a review of literature on SSM being linked to information systems methodologies.

ON LINKING OF SOFT SYSTEMS METHODOLOGY WITH OTHER INFORMATION SYSTEMS METHODS

Work on Comparing the Foundations of SSM and IS Methods

Publications in the area of information systems show that many researchers have tried to use SSM to improve the requirements determination process in IS development (see Al-Humaidan and Rossiter, 2004; Mingers, 1995; Lopes & Bryant, 2004; Stowell, 1995; Stowell, 1997; Wilson, 1990, and others). These and other sources discuss the benefits and the concerns about how the techniques from two philosophical backgrounds are linked without compromising the advantages the individual techniques provide (see Mingers, 1992). Mingers (1995, p. 45) acknowledges that SSM and information systems analysis and design are philosophically incompatible but also indicates that he does not see how the incompatibility is a serious problem because there must be a path toward greater concreteness, which can result in action being taken. The same author states that although a final design is then used to take action, the design can change through the design process to accommodate new or changed needs. Mingers (1995, p. 45) also explains that, by embedding hard elements into the process, there are advantages to be gained from using SSM as the guiding process for the entire project. According to Mingers, SSM has several advantages over IS approaches because the entire development cycle is based on learning, which is the strength of SSM. In addition to the attempts to improve information systems delivery, SSM has also been used to enhance business improvement programs (Ackermann et al., 1999, p. 202).

Broad participation is essential to soft systems thinking philosophically because it provides justification for the objectivity of the results and practically because it generates creativity and ensures acceptance of the proposed system. Although this is recognised by SSM, the processes entailed by SSM do not prescribe a method of encouraging broad participation. Jackson (2003) argues that soft systems thinkers believe in a consensual social world because they take the possibility of participation for granted and see it as a remedy for so many organisation problems. Perhaps because of its significance, soft systems thinkers play down the obstacles to full and effective participation. Although comparing the system model with the reality helps illuminate the assumptions of the participants, there is little in SSM to guide the participants toward taking action, and hence there is a need to combine it with other methods to initiate taking action.

The information systems modeling techniques discussed in the IS literature analyse and describe the technical features of information systems instead of the required business architecture, goals, resources, rules, and actual work required by the business. A notable exception is the emerging body of knowledge on the work systems method (see Alter, 2006). Therefore, neither structured IS approaches nor object oriented analysis methods like Eriksson and Penker's (2000) business modeling extensions appear to provide on their own a comprehensive business modeling approach, allowing them to establish a suitable platform to support the delivery of information systems.

Aspects of linking SSM with information systems development are discussed in Doyle, Wood and Wood-Harper (1993), Mathiassen and Nielsen (2000), Petkov, Petkova, Nepal, and Andrew (2006), Petkova and Roode (1999), and others. Although there are different perceptions of the research into ways of linking SSM with information systems analysis and design, the critics do not think the linking is unnecessary or a bad idea (Mingers, 1995, p. 48). The critics appear to be more concerned with the question of how the techniques are combined. According to the survey by Munro and Mingers (2002), that has happened in most cases without a consideration for the methodological justification of such combinations, and this was another motivation behind this research. The next sub-section deals with past attempts at combining SSM and UML leading to a further justification for the approach we propose in this paper.

On Prior Research on SSM and UML Combinations

Bustard, He, and Wilke (2000) present an argument that links SSM with use case analysis. There is no clear distinction in their paper between architectural modeling, analysis models, and design models. The authors do not emphasize the difference in the ontological assumptions between SSM and use case analysis. This is precisely the concern this article attempts to treat.

Lopes and Bryant (2004) show that there is a connection between patterns, enterprise architecture, and SSM. According to them, these techniques aid in unearthing a context to support decisions on further action. Lopes and Bryant (2004) state also that during a particular case study, rich pictures were represented as UML diagrams. This implies, however, that UML diagrams were considered to be sufficiently expressive to be used as rich pictures, and in our opinion such an approach prevents the utilization of SSM as a learning framework. Lopes and Bryant (2004) do not offer further comments on what specific UML views were produced. The value of the article is in the assertion that more work is required on looking at enterprise architecture as a human activity system.

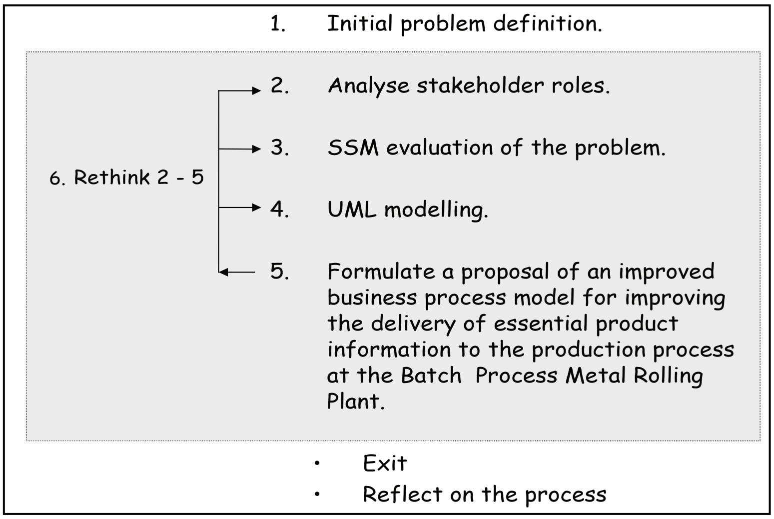
Al-Humaidan and Rossiter (2004) recognize the importance of the ontological challenge in integrating soft (SSM) and hard (UML) techniques. These authors also highlight the potential problems in using the solution proposed by Bustard et al. (2000). Similar to the approach presented in this article, Al-Humaidan & Rossiter (2004) propose the conceptual primary task model (CPTM). The approach to map each activity from the CPTM directly to a use case is perhaps eradicating the value that business modeling or architectural approaches imply. The research reported in this paper assumes that a use case is a specific use of a system that is part of a business process. A CPTM is more likely to map to a business process than a specific use of the system. Al-Humaidan and Rossier (2004) state that the UML modeling takes place within SSM, but there are no further details provided about how this idea is implemented or formalized. No reasoning is provided on how an SSM analysis is reduced to a CPTM and use case model. Again, as with the effort by Bustard et al. (2000) the real benefit provided by SSM is hard to locate.

Prior research on linking SSM and UML modeling gives the impression that the reasoning and feasibility in merging the two methodologies is being judged primarily on the level of continuity offered by moving from SSM to symbolising the desired business process and concepts. If SSM is used for business modelling there is a high probability that the concepts are new to the business and that the software development process has to continue with exploring the needs through the use of exploratory prototyping, evolutionary prototyping or incremental development. It is very unlikely that software development will follow a waterfall-like process as implied by the approaches discussed above (Al-Humaidan & Rossiter, 2004; Bustard et al., 2000). Developers today are more likely to follow an agile approach (Ambler, 2005; Cockburn, 2002a, 2002b; Jacobson, 2002). An SSM application should not be trivialised to symbolic representation of objective realities. A lack of underlying theory like multimethodology (see Mingers, 2001) gives a false sense of linearity, sequence, and order, and trivialises the application of SSM. If this happens, then the true benefits of using SSM are not being realised. The following section presents the proposed combination of SSM and UML modeling and its methodological justification.

THE PROPOSED SYSTEMIC FRAMEWORK FOR BUSINESS PROCESS MODELING

The proposed framework was defined following the foundations of multimethodology, a recent strand in systems thinking that justifies the mixing of methods from different paradigms. Mingers (2001, p. 251) emphasises that multimethodology is a regulatory approach guiding suitable combinations of methods in the same managerial intervention. The multi-method approach is being used in this research project to ensure that consideration is given to the range of factors that can influence the situation and to critically evaluate the extent to which the proposed techniques add to the richness and validity of results. The decisions on the nature of the framework and the techniques to include were taken by the authors after several meetings with the company managers.

Figure 1. Proposed framework for mixing of SSM and UML for a systemic business process modeling (Based on a generic action research methodology following Checkland and Holwell, 1998, p. 27)



The proposed systemic framework for improved business process modeling is comprised of SSM (which is used as the overall guiding methodology in the role of a problem sense making tool) and UML business modeling extensions, included for its expressive power in formulating the resulting business processes. The combination of SSM and UML business modeling is structured within the broader scheme of conducting action research suggested by Checkland and Holwell (1998, p. 27). The action research approach was justified by the nature of the problem and by the extensive long work experience of the first author with the company. He was directly involved both as a facilitator and as a middle manager who is affected by the results of the project during the implementation of the framework. Figure 1 shows the proposed framework that was used. As illustrated in Figure 1, an analysis of the stakeholders takes place first. The stakeholder analysis is followed by an SSM evaluation of the problem. Once there is agreement on the human activity that will improve the situation, the next step involves the UML modeling, using Ericsson and Penker extensions.

Our framework for mixing SSM and UML is different from past attempts of combining methods from the two areas as it is better justified methodologically from the point of view of the underlying current theory on multi-method research in systems thinking and operations research (see Jackson, 2003, and Mingers, 2001). It is also different because it is formulated as an action research approach, which is a more likely mode of operation of the systems analyst in the process of uncovering the inherent complexities of business modeling. It is also different because other research has not attempted combinations of SSM with Ericsson and Penker's extensions to UML for business process modeling

Due to the fact that SSM plays an organizing role in the proposed framework, we can identify such a combination of methods as methodology enhancement within the typology of multimethodology possibilities discussed by Mingers and Brocklesby (1997, p. 491).

Mingers (2001, p. 245) states that any intervention or research is never a discrete event but is a process that has phases requiring different types of activities. Mingers (2001, p. 245) identifies the following four generic phases that comprise a research process:

1. **Appreciation** is concerned with understanding why the problematic situation exists, who the actors are, accepting that the researchers' access to the situation and prior experience will influence what is appreciated or observed;
2. **Analysis** is concerned with understanding and explaining the reasons for the information gathered during appreciation;
3. **Assessment** is concerned with evaluating alternatives and assessing the results; and
4. **Action** is concerned with reporting the research results in order to bring about change.

Following the above generic model, the steps in our framework for mixing SSM and UML can be formulated in more detail also as shown in Table 1. The SSM evaluation of the problem in our framework (see Figure 1) corresponds to the first three stages listed in Table 1 (for details on SSM, see Checkland and Scholes, 1999). These equate to the appreciation step, analysis step, and assessment step of the problem solving intervention (formulation of a particular business process in our case), as defined by Mingers (2001, p. 245). A known limitation of SSM is the lack of techniques required to initiate taking action. This limitation is overcome in our approach by the use of UML business modeling extensions proposed by Eriksson and Penker (2000). This step equates to the action stage identified by Mingers (2001, p. 246). Thus we have shown here that our framework satisfies the generic process of a managerial intervention suggested by Mingers (2001).

UML business modeling is initiated by taking the finally agreed conceptual model of human activities that will bring about im-

Table 1. The steps and related methods in the proposed framework for mixing SSM and UML business process modeling extensions

1. Express the problem situation as experienced, using rich pictures and technical analyses, cultural, and political analysis;
2. Model the relevant conceptual systems (holons) using CATWOE analysis, root definitions, and conceptual models;
3. Compare the models and real world to arrive at an action that is acceptable to all stakeholders and bring about improvement in the situation. It is defined as an agreed conceptual model of the human activities that will bring about improvement
4. UML business modeling: - expand the conceptual model into a detailed conceptual data flow diagram, - complete a goal model to show goal hierarchy for the production process improvement, - model the important concepts required to improve the production process using a conceptual view (domain class diagram with associations and multiplicity), and - produce the business process view, assembly line diagrams and state transition diagram for sub processes and important business concepts (see Eriksson & Penker, 2000).

provement and expanding them into a detailed conceptual data flow diagram. The latter and the SSM analysis are used as the basis for the UML models. These included business process views and assembly line diagrams (see Eriksson and Penker, 2000). This approach of arriving at the conceptual data flow diagram from the conceptual model is somewhat similar to the steps in the standard seven stages SSM approach (see Checkland and Holwell, 1998).

The Eriksson and Penker (2000) UML business modeling extensions are not discussed here in detail for space reasons. The *goal model* shows goal and sub goal dependencies. The goal model also gives the process model context because it describes the goals that the process model is trying to achieve. The *assembly line diagram* (see Eriksson and Penker, 2000, p. 420) focuses on the connection between the business processes and the domain classes (business objects). According to the same authors, it is the point of connection between the world of business modeling and the world of software engineering. The assembly diagram sets the scene for detailed design of information systems support. A *state machine or state-chart diagram* shows the state's transitions of core business objects. If changes result to the goal model, then the changes will have to ripple through the process model, assembly line diagram, domain class diagram, and state-machine diagram. Change is seldom linear but iterative.

The theoretical difficulties of working across paradigms were resolved through the same integrative approach addressing the issue of paradigm incommensurability, reported in Petkov et al. (2006) and hence will not be discussed here for space reasons.

The cognitive difficulties expressed by Mingers (2001, p. 248) that can be experienced working between paradigms are avoided through the separation of the activities within the SSM and the UML parts of the framework. However the results from one stage continuously were used to feed the next stage in this action research project involving a number of stakeholders from the plant. This basically means that the SSM evaluation of the problem will be at the back of the facilitator's and participants' minds throughout the UML modeling process. This is in line with the ideas for interaction between the various methods involved in a systemic intervention within the actual process as suggested by Jackson (2003) and not at a meta-level. The following section discusses the reflections on the application of the framework to model one of the most important production processes in the plant.

HOW THE FRAMEWORK WAS IMPLEMENTED IN FORMULATING A PROCESS FOR DELIVERY OF ESSENTIAL PRODUCT INFORMATION AT EVERY STAGE OF THE PRODUCTION PROCESS

How SSM was Applied

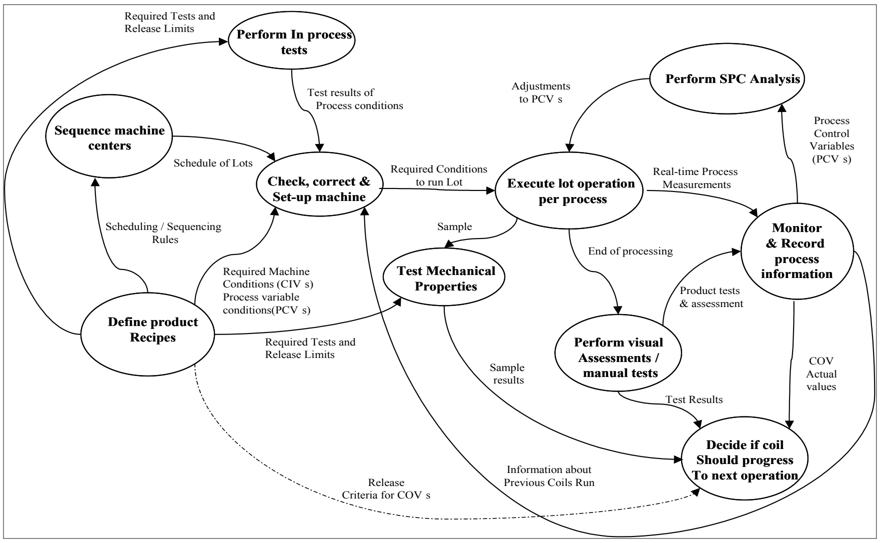
The issue of delivery of essential product information to every stage on the shop floor during the execution of customer orders is extremely complex. The complexity is due to the diverse stakeholders involved at various levels of management, the varying degrees of automation that could be adopted, and the varying levels of expertise and cultural backgrounds of operational staff. In practice, their interests were not always aligned with the overall goal of the company, nor were each other's perspectives clearly articulated. The communication channels were ineffective and burdened by the traditional organizational structures within the plant. Improving that process was seen as a key to improvement of product quality.

The intervention started after careful planning with the assistance of the chief production manager. The SSM sessions involved brainstorming and rich picture building sessions with different groups of stakeholders in the problem of concern. For each of the recommendations that followed, root definitions were compiled to answer three questions: What to do, how to do it, and why to do it. These were accompanied by corresponding CATWOE analysis from several viewpoints in order to capture the multiple perspectives of the various stakeholders (see Checkland and Scholes, 1999).

A number of root definitions emerged through the iterations. At the end, a root definition was accepted by all stakeholders as a reflection of their integrated views. It was fleshed out into the conceptual model for the desired business process. Both are shown in Figure 2.

<u>Root definition</u>: *A system is required to present essential product information to operators*

Figure 2. A root definition and a conceptual model of the business process for the delivery of essential product information to the shop floor in fulfilling customer orders



and sequencers when requested, in the right context without overloading them, to support the sequencers to plan a batch of lots on a specific machine, help the operator create the right conditions before running a product, and assist operators in the set-up, control, and final releasing of a specific lot to ensure the quality requirements specific to the operation being performed on the product are achieved.

The model in Figure 2 is comprised of activities and flows of information and influences between the activities. This makes the conceptual model a closer representation to a dataflow diagram. A similar approach is proposed by Prior (as quoted in Mingers, 1992, p. 83).

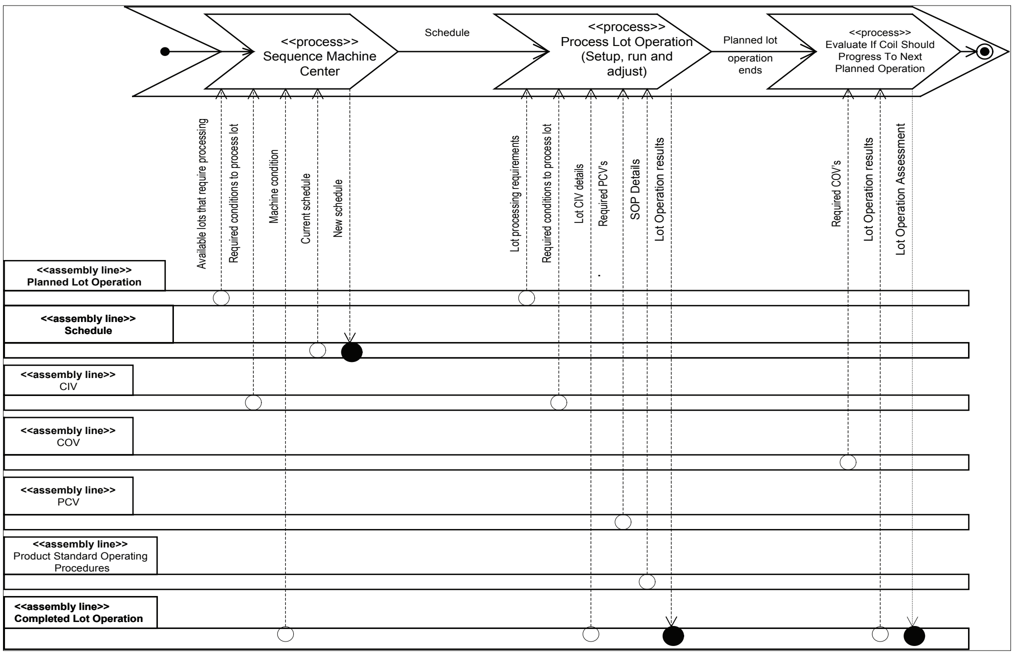
According to Checkland (1999), the formal aim of this kind of thinking prior to building a model is to ensure that there is clarity of thought about the purposeful activity. In summary, we used SSM to develop a rich understanding of the issues surrounding the problem of delivery essential information to the shop floor during the production of a customer order and to reach agreement on the activities and concepts that future information systems will need to support.

How UML was Used for Modeling of the Business Processes

Modeling the business process requirements was the fourth activity of the methodology defined in Figure 1 and Table 1. These models were necessary to communicate the information systems requirements to the software developers to initiate subsequently use-case definitions. The UML views were formulated from the conceptual model and the rich understanding the action researcher acquired. In addition to the SSM workshops, further workshops were needed to clarify detailed aspects of the conceptual and business process views. The subsequent reviews were all done in the spirit of progressive elaboration.

The language and concepts of the Eriksson and Penker (2000) business process modeling

Figure 3. Assembly line diagram of "process lot operation" activity of the production process



extensions provided guidelines for constructing the business process view. It shows primary processes and support processes with dependencies. In addition to sequence and sub-process dependencies, the business process view also indicates inputs, outputs and control information. The structuring of the production-process-business-process view was achieved through the application of the process layer supply and process layer control patterns suggested by Eriksson and Penker (2000, pp. 315-328). The process layer supply pattern assisted in organising the business processes into primary and support processes. The process layer control pattern helped layer the processes to show how certain processes control other processes. The business process view gives a detailed description of the production process activities that are required. A more detailed business process view that also shows the interactions between the processes and concepts of the production process is presented in the assembly line view (following Eriksson and Penker, 2000) that is discussed below. Figure 3 shows the assembly line view of the "process lot operation" activity of the production process.

An assembly line diagram was produced for each activity in the business process view. The expanded view has to show information and other resources that are referred to and created during the life cycle of the activity. The interaction is shown using lines drawn from the activity to the resource with an indication of whether the resource is referenced, consumed, or created. The dark shaded circles indicate a write while the empty, unfilled circles indicate a read operation. Each read or write operation is described by the type of information that is read or written. Eriksson and Penker (2000, p. 116) propose that the assembly line diagrams provide the connection between business modeling and software requirements modeling with use-cases. This view provided a starting point to begin use case analysis. The developers appreciated the benefit of being able to see in the assembly line view the total set of use-cases that needed to be supported by corresponding information systems.

Once the business analysis and modeling phase was done, we typically had the business process model, data architecture model, and domain class model. Once these were in place, then the development of the software proceeded in iterations. We focused on delivery of the use-cases in an input, process, and output development order. The assembly line diagram guided choices. No sequence diagrams or extensive explicit modeling was done during the design unless the interaction was complex or a novice developer was working on the project.

REFLECTIONS ON THE APPLICATION OF THE FRAMEWORK

On the Role of SSM in the Development of Understanding of the Problem Situation

The application of the proposed framework afforded the action researcher a deeper understanding of the situation of concern, as experienced by each of the stakeholders. Besides rich pictures we used CATWOE analysis which helps describe the problem from a particular stakeholder perspectiveby elaborating on: customers; actors; transformation; worldview; owners; and environment. We found these dimensions of a system description to be crucial in providing a meaningful multifaceted description of the system pursuing purposeful action. The emerging rich understanding of the problem allowed the first author in his role of an action researcher to facilitate the recommendation of a proposed human activity system for delivery of essential product information in every step of the production process. It captured the composite needs of all stakeholders in the overall company drive to improve its operations and information systems.

The use of the SSM techniques was made possible delving into sensitive areas of the situation of concern. Although the devices allowed articulation of complex perceptions, many iterations were necessary to get to the real interests, world views, and expectations each of the stakeholders were consciously latching onto or unknowingly biased by. The iterations perhaps made the stakeholders conscious of the values they were enacting through the stances they were taking. This is perhaps what Checkland refers to as clarity of thought and learning.

Although now we may conclude that the SSM process was used at first somewhat mechanistically during the initial iteration in applying the framework, it is necessary to reiterate that subsequently the action researcher internalized the questioning and manoeuvred the process to address those areas that were directly affecting progress to allow greater learning. Learning took also the tangible form of preparing each of the stakeholders for tolerance of the proposed solution using the sense-making devices of SSM. Since the first author has left the company in the second half of 2005, one might expect that the use of SSM there might not be so strongly supported as before, but the established ways of consultation between the stakeholders and for questioning the aspects of a problem situation along the principles of SSM are most likely to be sustained as they became part of the standard work practices at the company.

Several factors were influencing the sanction of the proposed human activity system, but the use of the SSM sense-making devices compelled the stakeholders to consider each perception logically. In a way, acceptance of the solution became so compelling that the stakeholders saw this as an emergent property of the process.

Refelections on the Value of UML Modeling in Our Framework

Through the various views, developers were able to understand how the goals of the surrounding business context were being realised. Developers felt that the UML business process views gave more information about the business than business process descriptions they had received previously when structured analysis techniques were used for business analysis and modeling.

Generally, the software developers felt that the business rules in the derived UML models were more apparent, and the requirements were defined more precisely. They assessed the models as being capable of guiding them toward the development of required information systems. The response from developers to the results of this project provides supporting evidence to the claims made by Eriksson and Penker (2000, pp. 66-130) about the advantages in having a common language for both the business process model and software models. Those claims are in line with what we achieved in this intervention according to the company management.

Within the project team we knew we were not conforming to the step-by-step waterfall process and were still delivering adequate quality. We did not use the agile terms to describe what we did, but the nature of our activities could be well captured by the concepts raised by the agilest community. However, we had to have architectural business models within our project prior to any development starting. It was so architectural-centric we did not even begin any iterations until we knew what the architecture was that needed supporting.

Although the Eriksson and Penker UML modeling extensions were used in this case, the framework can accommodate other types of IS modeling methods, provided the business process, the interactions with resources and the goals of the models can be represented in the chosen symbology and SSM is used as the integrated sense-making mechanism. Since the essence of the proposed framework is not dependent methodologically on the particular UML models, it will be applicable with other emerging variants of UML that aim at improving the business modeling phase.

Lessons Learned from the Application of the Framework for Mixing SSM and UML

If we had to redo this project again, we would try to use SSM more widely but less explicitly as a method from the very begining. A less-explicit use will make use of the CATWOE and root definitions to accompany each business process model. Using SSM in that way would clarify the value business processes are designed to yield and would also make goals and purpose assumptions more clear. These would also give direction to more detailed requirements definition and design stages. If SSM is easily interleaved with the typical software techniques and is less of a mechanistic step, then there is more of likelihood that the technique will be used continuously.

We would also spend more time delving into the areas of disagreement between the individual stakeholders to see where these disagreements originated from. The resulting information may point to elements of the business process that are candidates for redesign.

We would also like to support the use of the UML standard by trying to use the standard diagrams. Promoting a single modeling standard is important for overall improvement of systems analysis activities. Since the project at the aluminium plant took place, UML has matured significantly, and there has been more acceptance of the activity diagram view to model business processes. The assembly line diagram proposed by Ericsson and Penker (2000), however, does not have a matching standard UML view. This view of domain object interaction with business activities is useful according to our experience. In structured analysis techniques, the data flow diagram served this purpose. The above discussion can be summarised in the following conclusion.

CONCLUSION

The world of business is imprecise and often characterised by conflicting views of the various stakeholders. On the other side, developers need a view of the world that is precise, consistent, and represented by a single model. These differences in assumptions result in information systems delivery being dependant on several types of modelling. This is difficult to achieve in practice following the existing methods for information systems development. This becomes especially obvious when trying to define models suitable for unique situations like the manufacturing process of the aluminium semi-fabricator discussed in this article. The motivation for this research project emerged from the limitations of current business process modeling practices. The paper has presented a systemic integrated framework to business analysis, and modeling involving SSM and UML extensions which was not demonstrated before. Its value was demonstrated through the application of our approach to define and model the important process of delivering essential product information at every production stage related a particular customer order in an aluminium semi-fabricator plant.

Our lessons showed that SSM could be used slightly less mechanistically from the start of the project, something that is a typical initial weakness that disappears with more experience of the stakeholders in applying it.Nevertheless, the action research approach adopted in this study provided a continuity between the interpretive paradigm of SSM and the functionalist nature of UML. The richness of the appreciation through SSM was not lost. Potential theoretical omissions, implicit assumptions, and natural biases can be made explicit and taken into consideration in a practical business modeling activity through the use of our multimethodology framework. The experimental implementation of the framework on a complex production process within the action research reported here provided evidence of the potential benefits that can result from its application.

The practical contribution of this research is that it helped an aluminium semi-fabricator define the required production process activities that will allow shop floor operators to receive sufficient quality information, at the right time, and in the right context to enable them to ensure consistent product quality. Another important practical outcome of this research project is the resulting UML definition of the required specific business process. Its purpose is to allow the software developers to pursue the detailed analysis, design construction, and implementation of suitable information systems. The management at the aluminium semi-fabricator accepted the solution as a sound approach to guide the subsequent implementation of the various components of the plant production management system. The developers were pleased that the resulting modeling artifacts provided continuity to the subsequent software development activities.

Further work is possible on the verification of the framework in other business settings and for refinement of some of its elements. On the theoretical side, recent developments like the work systems model (Alter, 2006) may require future investigation for possible exploration of incorporating work system modeling analysis techniques in our approach in the strive to enhance business process modeling for information systems analysis and design.

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