SIMULATION AND INFORMATION SYSTEMS MODELLING: A FRAMEWORK FOR BUSINESS PROCESS CHANGE

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ABSTRACT

Many different methods and techniques can be used for modelling business processes in order to give an understanding of possible scenarios for improvement. The simulation modelling shows the process as a whole, drawbacks of the existing process, bottlenecks in the process execution and provides critical insight into process execution. The results of the simulation modelling represent a good foundation for a business process reengineering as a next step towards e-business introduction. The main goal of the paper is to present and discuss the level of information system modelling and simulation modelling methods and tools integration in the conditions of dynamic e-business environment. The paper also stressed the necessity for integrating simulation modelling and information system modelling. The examples of business process modelling and simulation tools are also presented.

INTRODUCTION

The nineties of the last century had a focus on changing the business processes hand in hand with the introduction of new information technology. In the 90s, BPR focused on internal benefits such as cost reduction, the downsizing of a company and operational efficiency, which are more tactical than strategically focused. Nowadays, e-business renovation (BR) strategies focus on the processes between business partners and the applications supporting these processes. These strategies are designed to address different types of processes with the emphasis on different aspects (Kalakota and Robinson, 2001): customer relationship management, supply chain management, selling-chain management, and enterprise resource planning.

Many authors have shown that the awareness of IT capabilities and information systems modelling techniques influenced the design of business processes (Davenport, 1993; Gigalis, 2001; Grant, 2002; Arora and Kumar, 2000). In addition to investing in information technology, a new type of information systems models has to be designed. The dynamic structure of information systems demands the implementation of process-oriented methods and tools. Since prior to business process change, companies need to assess the costs of business process change and to compare it with the expected benefits, simulation modelling has an important role in the projects of business process reengineering.

The main objective of this paper is to present and discuss the level of information system modelling and simulation modelling methods and tools integration in the conditions of dynamic e-business environment. The paper is structured as follows. Following a brief overview of business renovation strategies, the main characteristics of simulation modelling methods and tools are summarized. A relationship between simulation modelling and information system modelling is described. Finally, the main findings of this research are discussed and concluding remarks are provided.

THE OVERWIEW OF BUSINESS PROCESS CHANGE

The emphasis on business process change has gone through a number of phases in the last 15 years. First, there was the Total Quality Management that refers to programs and initiatives to emphasize incremental improvement in work processes and outputs over an open-ended period of time (Davenport and Beers, 1995). In the early 1990s BPR has become one of the most popular topics in organizational management, creating new ways of doing business (Tumay, 1995). Since improving the business performance was not achieved by automating existing business activities, many leading organizations have conducted BPR in order to gain competitive advantage. The first wave of BPR was focused on internal business processes radical change. Furthermore, it was particularly suggested that TQM should be integrated with BPR (Al-Mashari and Zairi, 1999).

The second wave of BPR began in 1996 when the Internet and World Wide Web phenomenon took of and provided IT internetworked infrastructure that enabled electronic business and new forms of Web-based business processes (El Sawy, 2001). To meet customer demand, companies depend on close cooperation with

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customers and suppliers. BPR driven by e-business could not be based only on radical redesign of intra-organisational processes, but should be extended to the entire business network (internal and external).

An online partnership must extend far beyond presenting promotional and pre-sales activities on companies' Web sites. It has to drill deep into a company's processes in order to create totally different business models. Therefore, most companies need to re-evaluate and Web-enable core processes to strengthen customer service operations, streamline supply chains and reach new customers. Traditional companies are forced to change their current business models and create new ones. The use of the Web and supply chain management has opened up the opportunities for exchanging information and managing knowledge around the new processes.

BUSINESS PROCESS CHANGE THROUGH SIMULATION MODELLING

Business process change involves changes in people, processes and technology. As these changes happen over time, simulation appears to be a suitable process modelling method. The list of the available business process modelling tools supporting simulation is as long as over 50 names (Hommes, 2001). Simulation is often called a technique of last resort because it is used when the system to be modelled is too complex for analytical models (Oakshot, 1997). The interaction of people with processes and technology results in an infinite number of possible scenarios and outcomes that are not possible to predict and evaluate using widely popular static process modelling methods. Kettinger et al. (1997) mention simulation as one of the modelling methods in their survey on business process modelling methods.

The reasons for the introduction of simulation modelling into process modelling can be summarized as follows (Pidd, 1996):

- **Dynamic** – process behaviour varies over time.
- **Interactive** – processes consist of a number of components which interact with one another.
- **Complicated** – the process consist of many interacting and dynamic objects.

The main advantage of simulation modelling is in its' integration of following functions: **analysis and assessment** of business processes, either in quantitative or qualitative terms; **development of "to-be" models** in order to examine "what-if" scenarios and **export to implementation platforms**, such as workflow management and enterprise resource planning systems. Modern simulation software tools are able to model dynamics of the processes and show it visually, which then can enhance generating the creative ideas on how to redesign the existing business processes. Such tools include graphic user interface (GUI) that enables process animation and graphical display of simulation results.

Several authors (Denis et al, 2000; Greasly, 2000, Giaglis and Paul, 1996) have reported the application of simulation for business process redesign. Despite the numerous advantages of simulation software, it is apparent that some user requirements are still not adequately met. The survey on the use of simulation software tools conducted by Hlupic (Hlupic, 2000) revealed that the main positive features are ease of model development and visual facilities, while main problems were lack of links with other packages (software compatibility) and lack of interfaces for data input.

BUSINESS PROCESS MODELLING METHODS AND TOOLS

Business process modelling projects can have different goals and similarly those creating the models could use different methods and tools (Table 1). Methods and tools for business process reengineering do not adhere to one particular business process modelling standard, but it must be pointed out that most modelling techniques used in business today have been developed for industrial engineering, software engineering or information systems modelling environment.

Table 1: Focus of different BPR methods/tools

Focus of BPR methods/tools	Example
Strategic planning	Balanced Scorecard - BSC, Benchmarking
Accounting techniques	Activity Based Costing Analysis – ABC, Return on Investment – ROI
Continuous improvement	Total Quality Management – TQM, ISO Standard
Static process modelling or functional decomposition modelling	Data Flow Diagrams - DFD, IDEF0
Action coordination modelling	Action Workflow modelling method
Dynamic process modelling (simulation)	Petri Nets

Over the last three decades, a well-established procedure for modelling information systems was based on two complementary aspects of analysis: data modelling (entity-relationship modelling) and function modelling (data-flow diagramming). Since events which trigger a response in an information system come from within the organisation or from the external environment, it is obvious that a third representational framework is effectively a business process view (Scheer, 1994).

Giaglis (Gigalis, 2001) developed a Taxonomy of Business Process Modelling techniques where the modelling techniques are classified by the purpose that they would have when used in business process modelling projects. According to this taxonomy, modelling techniques could have informational (data), organisational (where, who), behavioural (when, how) and functional (what) focus, and can be used to fulfil different objectives: understanding & communicating, process improvement, process management, process development and process execution. It is obvious that there does not exist a single process modelling technique that covers all aspects of process modelling, specially the aspect of process dynamics.

Except the simulation that has been discussed in Section 3, there have been three generic approaches to solving the problem of system dynamics (El Sawy, 2001). One approach is to extend functional decomposition methods with event triggers in order to introduce task interdependence into the model. The example of this approach is the ARIS methodology.

The second approach is to extend action coordination methods with added workflow structure through Petri net activity representation, like it was done in the Role Activity Diagramming method or UML Activity Diagram.

The third approach is to develop new process modelling methods that are focused on process flow and process dynamics, such as IDEF3 and Activity Decision Flow diagrams.

A FRAMEWORK FOR BUSINESS PROCESS CHANGE

Process modelling is one of the most cost-effective and rewarding ideas to come along in years. On the other hand, the successful development of information systems requires an integrated approach, which includes modelling of business processes, as well as, information systems modelling and development. Therefore a rapid growing number of frameworks and modelling tools have been developed for an integrated modelling of the entire enterprise with the focus to both organisational modelling and information systems modelling (Hommes, van Reijswound, 2000).

Simulation Modelling and Information Systems Modelling: The Need for Integration

Nowadays, the ability to develop and deploy simulation models quickly and effectively is far more important than ever before. As process modelling is very much a business rather than technical role, a modelling tool must be simple to use by a non-technical business user. However, a number of factors such as inefficient data collection, lengthy model documentation and poorly planned experimentation prevent frequent deployment of simulation models (Perera and Liyanage, 2001). In the majority of cases, the analysis of business process models is based on hand entered parameters such as time required to execute a given function, waiting time, availability and utilization of resources, etc. In cases where the business processes are supported by information systems, there is a transaction base which contains data on the processes, and it is necessary to develop an interface for the business process database, and to develop components with the task of exporting data from the production databases of a given information system and importing that data into the analytical bases, that is, to give parameters to the business process database.

The need for integration of simulation modelling and information systems modelling methods is evident in many cases. A flexible data collection link to a company's enterprise resource planning (ERP) database will undoubtedly improve the efficiency of model maintenance. Therefore, the methodology for rapid identification and collection of data structure for simulation modelling is developed by Perera and Liyanage (2001). It provides the link between the data conveniently stored in a database and the simulation model. This approach supports also the need for detailed model documentation via the use of standard modules from the functional model (IDEF0) library. Moreover, recent advances in simulation software (integration via VBA) afford the automatic creation of the entire simulation model.

Despite attempts to become user-friendly, dynamic discrete event modelling lends itself most readily to specific, single dimensional problems. Since the business practice has shown that there was no ideal simulation or business process modelling technique, the interfaces for automatic translation and integration of different techniques were developed. The examples are the software tools used for translation of IDEF diagrams into Petri nets: Design/IDEF, Design/CPN, WorkFlow Analyser, Service Model and WITNESS (Pinci and Shapiro, 1991; Shapiro, 1994). IDEF3 based descriptions were used to automatically generate WITNESS simulation code in the target language using ProSim (Painter et al, 1996).

Several frameworks have been developed which attempt to provide an open modelling architecture for general

models, but most of them deal effectively with non-dynamic modelling issues whilst dynamic modelling issues have traditionally only been addressed at the operational level. These include IDEF, CAM-I, GIM, ARIS, IEM, the ISO Reference Model, CIMOSA and GERAM (Vernadat, 1996; O'Sullivan, 1994). Therefore, the efforts are focused to apply simulation modelling in the enterprise modelling frameworks (Dewhurst et al, 2002).

The developers of the Unified Modelling Language (UML) have recognized the need for modelling methods which allow process modelling. Therefore diagrams like the use case diagram and the activity diagram have found their way into the UML (Lieberman, 2001). Activity diagrams combine the various approaches of different technique such as event diagrams of Jim Odell, state diagrams and Petri nets. The Event-Driven Process Chain (EPC) method was developed at the Institute for Information Systems (IWi) of the University of Saarland, Germany, in collaboration with SAP AG (Loos and Allweyer, 1998). As the key component of SAP R/3's modelling concepts for business engineering and customizing, it is based on the concepts of stochastic networks and Petri nets.

The above examples from business practice have shown the existence of large market space to improve BPM tools with the components for dynamic modelling and measuring the performance of the processes, and to integrate it with tools for developing information systems, which substantially decrease the time required to create the company's information system. According to the trends recognized from current business practice and literature, the typical features of integrated BPM tool could be summarized as follows (Table 2):

Table 2: Features of integrated BPM tool

Feature	**Description**
Data Modelling	Providing the function of entity modelling, used to create logical data model to support business processes
Static Process Modelling	Used to build a "top-down" understanding of processes and to analyse an enterprise process model static analysis (i.e. direct calculation of critical measures – number of resources required, total process time, cost being incurred)
Dynamic Process Modelling	Used to design and communicate end-to-end business processes (a static process model can be modelling transferred easily into its corresponding dynamic model by entering time-related data)
Data and process modelling interface	Mapping business processes to logical data, describing relationships between processes, applications and organizations
Repository	Used to manage objects and models, enables multi-user working and sharing of object between different views
Publisher	Automatically documenting and publishing process and system changes in order to train the staff and to enable communicating the new business practice

The Examples of Integrated BPM Tools

ARIS (IDS Scheer) and CorporateModeler (Casewise) software tools are used in this Section to explain the basic ideas underlying business process modelling and simulation modelling. These tools are selected on the base of authors' participation in Croatian and Slovenian BPR projects and the great number of large companies using these tools. While ARIS is used to present the example of different BPR methods/tools integrated in the system (as explained in the Table 1), the description of CorporateModeler presents the key building blocks of an integrated BPM tool (as stated in the Table 2).

The **ARIS Toolset** (Architecture of Integrated Information System) version 6.1 of IDS Scheer stands for a group of systems, the essential feature of which consists in the functions of documenting, analyzing, changing, implementing and optimizing business processes. ARIS integrates business processes database and disposes of a browser enabled Front-End. This means platform independence for users, worldwide availability, high scalability and low administration costs (Scheer, 2002; IDS Scheer, 2000). Knowledge about company processes is stored in the ARIS database objects. Using the ARIS Toolset the enterprise business processes are analyzed and described. Each object is defined through different perspectives: **organization, function, data and process view** and attributes which could be used as the input parameters for **ARIS Simulation**, **ARIS ABC** (Activity Based Costing), and **ARIS BSC** (Balanced Scorecard) tool. Since ARIS Simulation is fully integrated in the ARIS Toolset, the data relating to the processes, recorded in the ARIS Toolset could be used as a basis for the simulation of business processes. This simulation supplies information about the executability of processes, process weak points and resource bottlenecks. There is also the **interface toward Workflow management tools**, **CASE tools** (ORACLE Designer 6i) and **project**

management tools. **ARIS Process Performance Manager** (ARIS PPM) automatically identifies performance data from company processes, especially those which span systems, and thus makes it possible to analyze them. This information can be gathered from software systems, for example, for ERP, SCM, CRM, e-Business, or workflow management.

Another BPM tool to be presented in this paper is **Corporate Modeler 8e**. It supports six core diagram types. **Hierarchy Modeler** provides an overall picture of the business. Starting at the highest level, users can drill-down into the lowest level of detail for all object types. **Process Dynamics Modeler and Simulator** uses dynamics modelling to model activities and their dependencies within the end-to-end business process. It shows business events that trigger the process, the process flow, roles, and responsibilities mapped as swim lanes, which illustrate which department is responsible for each process step. Process models can be simulated to produce statistical analysis of resource utilisation, throughput times, costs, and overall performance. **Generic Modeler** allows the creation of user-defined notation style and symbology, which enables users to create their own diagram templates to model application architecture, EPC (SAP) Diagrams, and Use Case Diagrams. Work level procedures, such as flowcharts and Activity-Based Modelling (ABM) diagrams can also be modelled. **Data Flow Modeler** depicts the information flow between processes, external entities, and data stores. **Entity Modeler:** Enables users to design the data structure by defining tables, fields, and their properties. This is used to create an entity relationship diagram. **Matrix Manager:** Defines the relationships between processes, entities, locations, application technologies, organisations, and so on. The integration of the models to external applications is provided, including Sybase's PowerDesigner, Rational Rose, Staffware, Oracle Designer, ERwin, Telelogic, and Visio. Corporate Modeler 8e provides tight integration allowing processes to be transferred to a workflow application. It has an XML import/export capability that follows the standards established by the Workflow Management Coalition (WfMC).

Integrated BPM Tools in Practice

There are about 40 Croatian and Slovenian large companies using ARIS in business process modelling projects, most of them from banking, financial, telecommunication and government sector. Similarly, Corporate Modeler is used in the Croatian Ministries (i.e. Ministry of Transport) and the telecommunication company. Both of the tools are used by organisations across the world to understand complex operations and optimize performance through improvement projects. Only two examples are briefly presented here.

Efficient usage of ARIS in Slovenian insurance company **Slovenica** is reported in Divic-Mihaljevic (2002) where simulation modeling was used in order to implement integrated information system. The aim was not only to graphically present business processes, but also to support them thoroughly with an appropriate IT solution. The project started in 1999, when Slovenica's gross written premium climbed for 22.4% and Board of Management decided to build an integrated information system to support business processes. Besides that the main goals ware improved market position and acquisition of a larger market share, improved portfolio quality and improved financial strength and increased profit. They did not only perform the optimization of processes but prepared them for IT implementation.

In the case study of Croatian insurance company (Ivandic-Vidovic and Bosilj-Vuksic, 2003) ARIS Toolset was used to establish a single repository of business processes. A model of the company organizational structure was created, as were models of the business processes of the company at 5 levels. A comprehensive database of the company's business processes was created and used in the project of information system development and redesign. Following this, a system of managing business processes was implemented, namely, metrics and analysis were conducted on those processes. The parameterized model was transformed into simulation model, which was used by the process owners and managers to find the best solution for business process change.

Discussion

According to the overview of the actual state of the art in the "business process modelling" field and the experiences from Croatian and Slovenian companies the advantages and disadvantages of integrated business process modelling tools could be summarized and discussed. The aim of using business modelling is to develop a **framework** that:

- interrelates several business process modeling methods and techniques,
- is easy to design and understand,
- encourages standardization,
- provides a single business process repository and the use of a common process vocabulary,
- is able to tune and optimize the processes of a company
- provides model analysis, validation and testing
- is formal enough to serve for software development purposes.

Most of integrated BPM tools meet these requirements and therefore are used in BPR projects, but the authors have also observed some difficulties in using these tools.

Very serious problem is **the inability to translate business models** into information (workflow) models. Except the potential benefits from process improvements, and maximization of process performance via implementing process change, the key goals of companies' projects are to model enterprise applications, integrate and interconnect different applications, providing an effective business environment that meets customers' performance demands. While business models should act as a basis for creating suitable information systems and defining engineering requirements, BPM tools should enable the export of business process models to implementation platforms, such as workflow management and enterprise resource planning systems. To support the transition between the business process modelling and the information system (IS) modelling, the direct mapping and transition of all entities and activities defined during business process modelling should be enabled. Although the software interfaces between process modelling and IS modelling are developed, these interfaces might provide some syntactical translation but they cannot bridge the semantic gap between business processes and IS models. Here the manual revision of IS models is often more efficient and useful than the use of interfaces, but the problem is expected to be solved by the producers of BPM tools using the appropriate rule-transformation approach and introducing the rule repository.

Rule repository is the core of a development environment providing appropriate tools for process, workflow, data and organisation modelling, process refinement, as well as import and export capabilities. It can also be regarded as an integration link between business modelling and IS modelling. The motivation to develop a rule repository is to establish an environment in which business rules can be traced from their origin in the business environment through to their implementation in information systems. This provides the information necessary for rapid information system maintenance and adaptations to changes in the business environment. Its purpose is to describe the activities that must be undertaken to achieve an explicit goal and establish a clear link between business process modelling and IS modelling.

Another problem noticed in Croatian and Slovenian companies was **the risk of over-analyzing** existing business processes which led to the long period of modelling (1-2 years), producing a huge documentation on "as-is" business processes and getting stuck in the business process analysis phase of the project (e.g., analysis paralysis) from which they were never able to move on. Therefore, the volume of business process models (i.e. number of models, number of diagrams and their levels) must be defined and strictly limited to the scope of the project.

CONCLUSIONS

To realize the business process change, most of companies use different methods and tools, which integrate components for static and dynamic modelling and measuring the performance of the processes. Simulation modelling is used to benchmark the current, "As-Is" process, to verify model set-up and metrics and to test 'to-be' scenarios when re-designing business processes or supply chains. Changes can be easily and inexpensively examined and graphical presentations can be used to gain organizational commitment to change.

The integrated BPM tools combine formerly diverse areas of business process, IT, resource and financial modelling, enabling the companies to form a complete view of their operations and providing a framework for efficient development of a robust and complete enterprise architecture. Furthermore, the numerous interfaces are developed to enable the connection with tools for developing information systems, which substantially decrease the time required to create the company's information system and to permit fast and simple tracking of operations.

These possibilities are shown in this research with the example of the ARIS and the Corporate Modeler toolset. Since nowadays, the majority of Croatian and Slovenian companies are involved in the projects of business process change and ERP systems development, this research could serve to adopt a process centric approach introducing business process modelling standards and rules and developing information systems modelling standards based on integration with dynamic business process modelling tools and techniques.

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