SUITABILITY OF PROCESS MAPS FOR BUSINESS PROCESS SIMULATION IN BUSINESS PROCESS RENOVATION PROJECTS

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ABSTRACT

Many different methods and techniques can be used for modelling business processes within business process renovation (BPR) projects. There are several techniques and tools that attempt to effectively represent all modelling perspectives and fulfil all goals and objectives but as such generate complex models that are hard to understand and reduce their ease of use. One of widely used techniques for process modelling is process maps. They are based on flowcharts and one of their most important advantages, that is extremely important in early phases of BPR projects, is that models are easily understandable to all members of a project group. It is believed that this technique can provide only basic facilities in representing processes and is inappropriate for simulation. The main objective of this paper is to show that enhanced process maps have all elements required for simulation, they can serve as a foundation for IS modelling, and they are very suitable for business renovation. However, a single technique cannot cope with a variety of different aspects related to modelling without becoming too complex and thus less useful in phases where communication of models is very important.

1. INTRODUCTION

Business process modelling has emerged as an important research and application area within organizational and information system design. Business process models can be used to serve a wide number of applications, for example to drive a strategic organizational analysis, to renovate existing processes as a part of business renovation, to derive requirements and specifications for information systems design, or to support (semi)automated execution of processes or so called work flows (Paul et al. 1999). Curtis et al. (1992) had identified several modelling goals and objectives: facilitate human understanding and communication, support process improvement, support process management, automated guidance in performing process, and automated execution support.

The focus of this paper is on process modelling with the purpose of business process renovation. This is a re-engineering strategy that critically examines current business policies, practices and procedures, rethinks them and then redesigns the mission-critical products, processes, and services (Prasad 1999). The objectives of modelling during business renovation projects are usually to fulfil the first two of the above-mentioned goals.

Models of business processes play an important role in different phases of business process (re)design regardless of the methodology used (Desel and Erwin 2000). Several definitions of business processes can be found in literature but, as observed by (Giaglis et al. 1999), all of them have something in common. Most authors agree that processes have internal or external customers and have to produce an output for them. Business processes are decomposed into a number of more elementary steps (activities) that are being executed according to certain rules. During their execution, activities have to be coordinated (Desel and Erwin 2000). Resources have to be provided where needed for the execution of activities. A process has to be described in a way specifying which activities have to be executed in what order and what resources are needed for the execution of these activities.

The need to deal with business processes has caused an increased need for suitable techniques and tools for their identification, modelling and analysis. The increasing popularity of business process modelling results in a rapidly growing number of modelling techniques and tools. Kettinger et al. (1997) report about at least 72 techniques and 102 tools, while Hommes' (2001) survey revealed about approximately 350 business process modelling tools. No single technique or approach can capture the whole spectrum of requirements posed by different people and applications. The choice of a modelling technique for a particular project should be based on matching the

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virtues and limitations of various techniques with the objectives of the project (Paul et al. 1999). Giaglis (2001) proposed an evaluation framework and a taxonomy of modelling techniques.

There are several techniques and tools that attempt to effectively represent all modelling perspectives and fulfil all goals and objectives. As already observed in (Curtis at al. 1992) such modelling techniques generate complex models and reduce the ease of use for any single particular application. On the basis of our involvement in some business renovation projects we came to a conclusion that complex models are a big obstacle especially in early phases of such projects when the focus is on human understanding and communication.

On the other hand, processes need to be analysed and different scenarios have to be evaluated to support their improvement. The methods of business renovation, which combine business process modelling with analysis of process performance are one of the possible approaches that can be used for the analysis of the existing processes and for the evaluation of redesigned processes. Simulation can provide a valuable mechanism for addressing the problem of quantitative and qualitative evaluation of business processes. It can facilitate experimentation with and study of multiple perspectives of organizations, thus contributing toward increasing the quality of change decisions.

Flowcharting is one of the first graphical modelling techniques. Nowadays flowcharts are very useful as a simple, graphic means of communication, intended to support understandable descriptions of processes (Giaglis 2001).

The paper is structured as follows: In the next section simulation modelling of business processes is discussed. Section 3 describes process maps modelling techniques and illustrates a case. Process maps suitability for simulation modelling in BPR projects is analysed in section 4. Conclusion remarks and some further research directions are the content of the last section.

2. BUSINESS PROCESS SIMULATION MODELLING

Business process modelling and the evaluation of different alternative scenarios for improvement are usually the driving factors of the business renovation process (Bosilj-Vuksic et al. 2003). Techniques that enable modelling business processes, evaluation of their performance, experimenting with alternative configurations and process layouts, and comparing between diverse proposals for change, are highly suitable for organizational design. Computer based simulation models of business processes can help overcome the inherent complexities of studying and analyzing organizations and therefore contribute to a higher level of understanding and designing organizational structures (Giaglis et al. 1999). Simulation of business processes creates added value in understanding, analysing, and designing processes by introducing dynamic aspects. It enables the migration from a static towards a dynamic process model (Aguilar and Rautert 1999).

Simulation is generally defined as a set of numerical and programming techniques for representing stochastic models and conducting sampling experiments on those models using a digital computer (Seila et al. 2003). It is important to note that simulation is a set of techniques belonging to analysis methodology. It is not a specific type of model, as would be implied by the often-used term simulation model. Instead, simulation involves methodology for extracting information from a model by “observing” the behaviour of the model with the use of a digital computer. The term simulation model actually means a model that has been adapted to be analyzed with the use of simulation.

There are some modelling requirements specific to simulation-assisted business renovation modelling (Giaglis and Paul 1996):

- Processes need to be formally modelled and documented.
- Modelling should take stochastic nature of business processes into account, especially the way in which they are triggered by external factors.
- There is a need to quantitatively evaluate the value of proposed alternatives.
- The evaluation is highly dependent on the objectives of the particular study.
- Modelling tools should be easy to use to allow users of the processes to be involved in the modelling process.

Simulation can serve as a tool for deriving new knowledge on current business processes, such as additional in-depth understanding of how the process is executed and the identification of the sources of the problems observed during the process execution (Bosilj-Vuksic et al. 2003). A first phase of business renovation project usually consists of identifying, describing and mapping (modelling) the processes of a company. The results have to be communicated carefully so that everybody in the company understands the concept of process orientation and the mapping results. By introducing dynamic parameters of the process, like times, volumes, capacities and costs simulation fundamentally enhances process performance analysis. It provides a much better picture of bottlenecks, hand-over times and dynamic performance than a static analysis. In order to detect weak points and opportunities for improvement process performance is evaluated and benchmarked (Aguilar and Rautert 1999).

The main impact of simulation is directed towards performance analysis and design of future processes as illustrated in Figure 1 (Aguilar and Rautert 1999). With a help of process simulation tools we normally assign values to activities and then run a number of cases to see how the business process will respond (Harmon 2003). Thus, simulation has also an important role in analyzing the activities before changes are introduced, since it enables quantitative estimations to be made on the influence of the redesigned process on system performances (Bhaskar et al. 1994). Any envisaged change in process design can be anticipated and evaluated by simulation. The experimentation results can significantly contribute to the decisions about future process design.

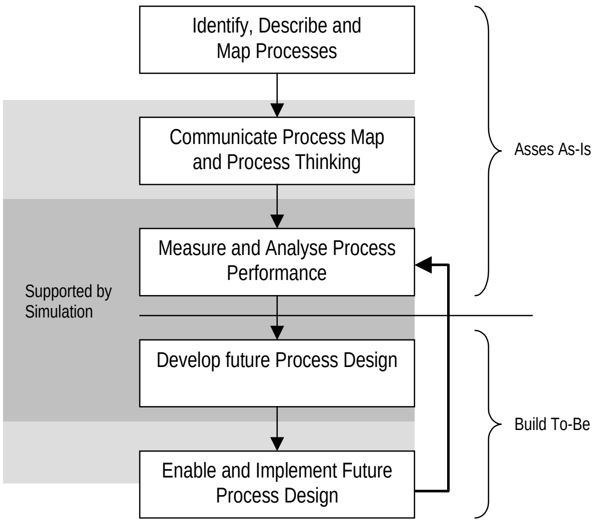


Figure 1: The main impact of simulation in BPR (Aguilar and Rautert 1999)

Simulation further supports the communication and implementation steps illustrated by the light grey areas in Figure 1. Modelling and simulation of entire process helps all participants adapt a process perspective, understand their contribution to the process result and reflect about the interactions with others in the process. Therefore simulation facilitates communication and redirects people to the most important objective: improving process performance (Aguilar and Rautert 1999).

Thus, simulation is a technique that uses a model to make predictions about a system or process (Harmon 2003). There are different types of simulation, some more informal and some more formal. The technique that is the most suitable for simulation of business processes and is also implemented in the majority of simulation software is the discrete-event simulation - DES (Seila et al. 2003). Discrete simulations allow system quantities to change only at discrete points in time that are called events (for example arrival of a new customer). Computer-based discrete-event simulation relates to a symbolic representation of processes in ways that can be made persistent, replayed, dynamically analyzed, and reconfigured into alternative scenarios (Paul et al. 1999).

Simulation offers a wide range of possibilities for analysing time/cost/resources aspect of a business process. In the context of other process improvement methodologies, there are two general areas to which simulation modelling may contribute uniquely. These areas dynamically measure activity utilization and system workload. There is a need for integrating component simulation results obtained from alternative process design considerations (Paul et al. 1999). Simulation can aid business decision makers in prioritizing improvement actions and resource allocation decisions. Simulation in BPR can be used not only for modelling the As-Is and To-Be processes but also for marketing, communication, educational, and benchmarking purposes (Bhaskar et al. 1994). Mature process companies will maintain simulations and routinely use them for process improvement projects (Harmon 2003).

There are many techniques and tools that support them for simulation modelling of business processes. Since our focus is on modelling to support human understanding and communication and to support process improvement, it is very important that a model is understandable, because communication between members of a project team is extremely important (Kawalek and Kueng 1997). Visual interactive simulation (VIS) meets this request. The basic features of VIS can be summarised as the ability to build and modify simulation models on-screen, execute graphic simulation models, animate models as they execute, present simulation output graphically, and interact with the model during execution (Seila et al. 2003). It can contribute to communication of process thinking and to the acceptance of simulation results.

Simulation of business processes is very useful in many areas and many tools for its implementation are available. Besides simulation usefulness and tools availability there are still many open issues around to which practitioners and researchers have been devoting their attention. Among these issues there are data collection issues (many data have to be collected for running simulation, which is sometimes very time demanding), hierarchical decomposition modelling issues and granularity issues (the level of details has to be balanced with project goals). Some of these issues are discussed in next sections and can be overcome by a suitable process modelling technique and tool selection.

3. PROCESS MAPS

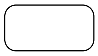
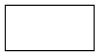
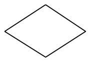
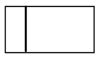
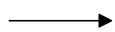
Processes can be modelled with different techniques – most of them are graphical. One of the most popular is process maps. Process maps are a proven analytical, communication and management tool intended to help process participants understand real business processes, make improvements to them or to implement a new process-driven structure in order to renovate business processes (Hunt 1998). They were initially developed and implemented by General Electric as part of their integrated strategy to significantly improve their bottom-line business performance (Boehringer 2003).

Process maps are based on flowcharts. A flowchart is a graphic representation of all major steps in a process. It is used to provide understanding of processes, help in identifying critical stages of processes, locate problem areas and show relationships between different steps in a process. By reviewing articles in the fields of business process renovation and business process management a set of standard flowchart symbols most commonly used to model business processes can be identified (see symbols 1 – 3 in table 1). Many authors address flowcharts and process maps as synonyms. Some advanced flowcharts might show some of the inputs, but rarely take into account all of the process information. Enhanced process maps (EPM) on the other hand, provide additional process information opposite to simple process maps (van Ackere et al. 1993). EPM consider information as time, resources (personnel, material and equipment), environment (functions or departments), outputs, etc. For each step in the flowchart we add the EPM information and thus have a real understanding of the process. Each graphic symbol (see table 1) can be additionally described in a structured text format and for the purpose of simulation tools usually enable associating these information to graphic symbols. Association of information to graphic symbols is usually not seen on the model graphic.

The authors of this paper understand EPM as a technique for graphic representation of logical steps in a process by considering activities (including duration, resources, constraints and costs), resources (types, number and costs), process delays, hierarchical decomposition and organizational structure (e.g. departments). Modelling elements (symbols) are connected with links that describe the process flow. EPM are described by activities placed in one or more departments (e.g. organizational units performing these activities). A process can be broken down into sub-processes to get a more detailed view (the level of detail is defined by the goal of the model). Delays are clearly noted in order to ease fast spotting of potential "bottleneck" areas in the process. At the stage of simulation model execution VIS can be carried out.

Figure 2 shows an example of using the EPM technique, an EPM model of a renovated process that was previously presented in (Jaklic et al. 2003). The figure also shows sample details collected for an activity.

Table 1: EPM symbols

	Symbol	Indicates	Examples
1		Start / finish	Receive sales report Customer arrives
2		Activity	Check merchandise Prepare customer invoice
3		Decision point	Approve / Disapprove Accept / Reject
4		Delay	Waiting for customer's response
5		Sub process	Ship merchandise
6		Organisational unit	Sales department Marketing
7		Process flow	

Over the past years, several new software tools have been developed specifically for modelling business processes and their simulation. Most of these tools define business processes using graphical symbols. Special characteristics of each process or activity may then be attached as attributes of the process. Many of these tools also allow for some type of activity-based costing or simulation analysis depending on the sophistication of the underlying modelling technique. Boehringer (2003) divides process mapping tools into three general categories: flow diagramming tools (e.g. ABC Flowcharter, EasyFlow, Flowcharting), CASE tools (e.g. Design/IDEF and Workflow Analyzer, Action Workflow) and simulation tools (e.g. PROMODEL, SimProcess, Simul and iGrafx/Optima!).

4. ANALYSIS OF THE PROCESS MAPS SUITABILITY

As discussed before, business process modelling has several modelling goals and objectives which result in different requirements for modelling techniques. Curtis et al. (1992) proposed five different goals and objectives presented in table 2.

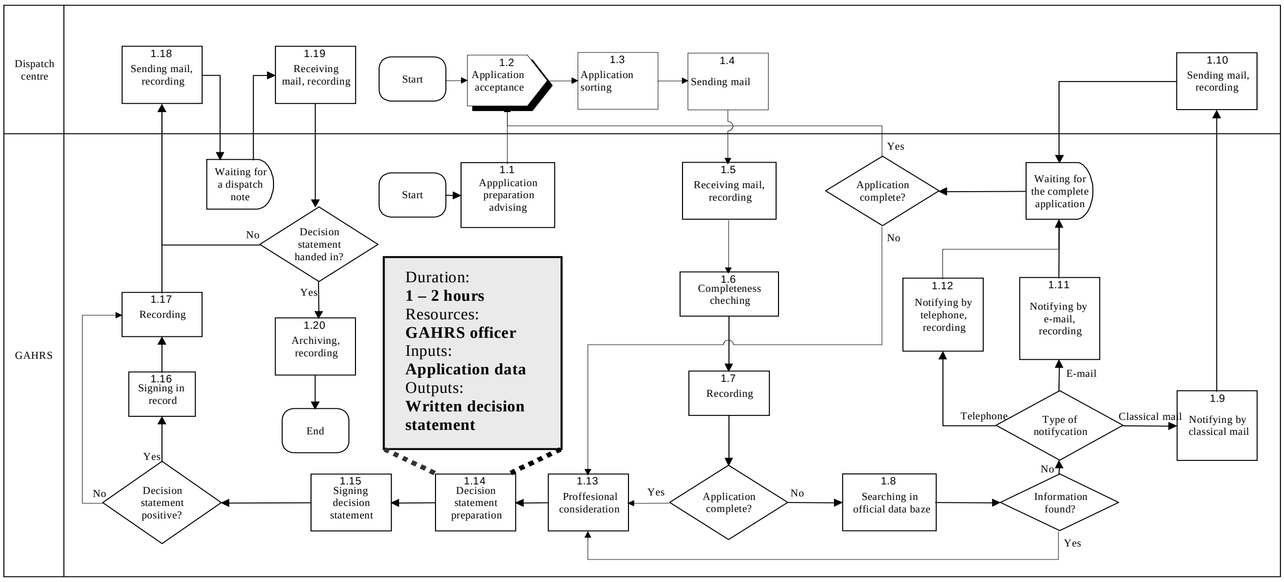


Figure 2: Renovated process Promotion of employees in education to a higher educational title

In BPR projects process modelling mostly addresses the first two goals, i.e. support human understanding and communication and support process improvement. Overlooking communication is identified as one of four most damaging practices in reengineering work (Bhaskar at al. 1994). Therefore the first requirement or criteria for selecting a technique in a BPR project would be clarity for the intended users.

Table 2: Goals and objectives of business process modelling (Curtis et al. 1992; Giaglis 2001)

Modelling Goals and Objectives	Requirements for Modelling Techniques
Support human understanding and communication	Comprehensibility, communicability
Support process improvement	Model process components, reusability, measurability, comparability, support technology selection and incorporation, support process evolution
Support process management	Support reasoning, forecasting, measurement, monitoring, management, and coordination
Support process development	Integrate with development environments, support for process documentation, reusability
Support process execution	Automate process tasks, support co-operative work, automate performance measurement, check process integrity

In Guidelines of Modelling Becker et al. (2000) stressed six principles that are important for business process modelling: correctness, relevance, economic efficiency, clarity, comparability, and systematic design. Guideline of clarity is extremely subjective and postulates that the model is understood by the model user. Clarity of models is especially important when the objective of business process modelling is to facilitate human understanding and communication or to support process improvement. Although several different graphic notations are used to present process maps, it has to be observed that in the analysis and design phase it is important to use a notation which is easily understandable to the process participants. The actual notation used is of secondary importance; it is more important that the process team feels comfortable (Kawalek and Kueng 1997).

As suggested by Harmon (2003), many different groups are involved in business process modelling. Predictably, different groups use different types of diagrams. The key thing to think about in selecting any notation is who is going to use it. As the main target audience of the process models in BPR projects are people who perform processes and other members of BPR team it is clear that the elements of the process models that are only used to describe software conventions should be omitted. Without a readable, understandable, useful model all other efforts become obsolete.

To accommodate the objectives and goals of BPR, a model must be capable of providing various elements to its users. Such elements include, for example, what activities constitute the process, who performs these activities, when and where the activities are performed, how and why they are executed, and what data elements they manipulate (Giaglis 2001). For the business process analysis in BPR projects the data about who performs activities, other required resources, duration etc. are important regardless of the fact if simulation is going to be used as an analysis technique or not.

The EPM technique enables modelling of business processes in a way that is as easy to understand as possible, while it is still possible to describe (Harmon 2003) all of the basics that need to be described for the intended purpose i.e. process analysis for BPR and communication. Process maps can be very effective communication tools that facilitate, across internal and external organizational boundaries, in a very simple visual format, transmission of ideas concerning what is actually happening in business and ways to improve the business.

As follows from the work of Curtis et al. (1992), the second criteria for selecting a modelling technique for BPR projects is the possibility to model process components, measurability, compare different scenarios etc. The static model description models the components that make up the system, but it does not tell how they interact (Seila et al. 2003). A complete model description must also include the system dynamics. The dynamic model description provides a set of rules telling how the components interact as time advances.

The process view represents system dynamics by joining a sequence of events and activities to follow the progress of a temporary entity through the system. A process consists of a routine that describes the sequence of related events (where the system state changes) and activities (the interaction between different entities over a specific length of time) for the entity - permanent or temporary (Seila et al. 2003). Giaglis et al. (1999) define process from the simulation point of view as a time-ordered sequence of interrelated events (activities) which describes the entire experience of an entity as it flows through a system. From these definitions one can see that a simulation is just a way in which one can analyze a business process. In other words, simulation modelling techniques are by nature process-oriented (Giaglis et al. 1999).

The main required elements for a DES simulation model are therefore: events, activities, time, permanent (resources) and temporary (tokens) entities, and sequence (flow). Harrel and Field (1996) argue that much of the process definition used in a simulation model is contained in a process map, yet insufficient data are provided in a process map for running simulation. Therefore additional information has to be manually added on the simulation side. Giaglis et al. (1999) state that several attempts of integrating process mapping and simulation have been made, although with not very successful results. In their opinion this is due largely to incompatibilities in both purpose and paradigm. On the other hand Srinivasan and Jayaraman (1997) stated that activity (function) and entity (information) models contain all the information needed for developing DES simulation models of an enterprise. Van Ackere et al. (1993) argue that *simple* process maps do not typically provide sufficient understanding of the process to know what to change. Van der Aalst (1992) suggests that the intended analysis dictates the type of modelling that is done. The goals of a reengineering effort are most often related to business improvement measures. The process maps helps to understand the problem, but to help in knowing what to change, the process map must be supplemented with quantitative analysis.

Our experience on BPR projects shows that for a detailed analysis of existing business processes, required by process renovation, more elements of the process model than just activities and process flow are required. A complete viewpoint may be difficult to establish using only fixed-process map descriptions. They address aspects of processes for which static activity and data modelling are inadequately suited, because they cannot cope with the impact of resource flow. Resources (permanent entities) and their costs, organizational structure, duration of activities and waiting times, events and their frequency are the necessary elements of a carefully prepared process model for a process (organizational) analysis. Process maps provide detailed information about observed processes, usually presented on separate sheets that are filled in as the process map is developed. This brings to the conclusion that a properly designed process map model contain all the necessary information for DES analysis of a business process.

The only element of simulation that is not fully supported by process maps is an explicit definition (presentation) of events. In a certain other more structured modelling techniques, such as eEPC (extended Event-Driven process Chain) each activity is triggered by an event and the result of each activity is an event. With process maps this is not a case, however we do not consider this as a weak point of the process maps technique considering the purpose of modelling in our case, i.e. process analysis and renovation which requires a great deal of communication and therefore comprehensibility. Also, from the formal point of view an activity consists of a starting event followed by an ending event that is scheduled by the staring even (Seila et al. 2003), which implies that it is not necessary to model events separately. We found more formal technique regarding modelling of events as less understandable.

Another important issue in process modelling and simulation is the support for hierarchical decomposition and design modularity (MacArthur et al. 1994), which is also enabled by the EPM technique. Today many tools for process maps modelling support process decomposition, and appropriate simulation decomposition.

Advances in software technology support integration of technologies such as process mapping and simulation that previously functioned only as stand-alone applications (Giaglis and Paul 1996). The fact is that today many of the more powerful business process tools offer simulation. While a certain amount of expertise is required to build models with most simulation languages, process modelling solutions usually offer a possibility for an easy to use appropriate simulation performance measurement in the assessment of alternative designs for BPR.

Bhaskar et al. (1994) proposed a set of requirements that should be met by tools used for modelling and simulation of business processes. These requirements can be divided into five groups: process documentation, process redesign, performance measurement, communication, and institutional learning. Based on our analysis and our experience from BPR case studies we believe that EPM based tools meet these requirements.

Hommes and van Reijswoud (2000) have developed a framework for the evaluation of business process modelling techniques. They propose eight evaluation criteria which can be divided into two groups: one related to the conceptual modelling in general and another group related to the business process modelling in particular. They refer to the quality of the way of modelling and the way of working of a modelling technique respectively. These criteria are:

- Expressiveness - the degree to which a given modelling technique is capable of denoting the models of any number and kinds of application domains;
- Arbitrariness - the degree of freedom one has when modelling one and the same domain;
- Suitability - the degree to which a given modelling technique is specifically tailored for a specific kind of application domain.
- Comprehensibility - the ease with which the way of working and way of modelling are understood by the participants;
- Coherence - the degree to which the individual submodels of a way of modelling constitute a whole;
- Completeness - the degree to which all necessary concepts of the application domain are represented in the way of modelling;
- Efficiency - the degree to which the modelling process utilises resources such as time and people;
- Effectiveness - the degree to which the modelling process achieves its goal.

It has to be observed that the properties are not orthogonal. For example, van der Aalst (1993) suggests that the complexity and detail are essential to sound analysis, however excessive complexity and detail can impede human understanding of the process.

Using theoretical findings from the reviewed literature and our own experience from several BPR projects we have evaluated the EPM technique based on these criteria. Additionally, we have to evaluate for each criteria/property the importance for the purpose of modelling which is in our case business process renovation.

As seen from the table 3 our estimation is that the EPM technique performs well for the criteria that are of high importance for the BPR projects.

Table 3: Evaluation of the EPM technique

Criteria	Importance	Score
Expressiveness	Low	Poor
Arbitrariness	Medium	Good
Suitability	High	Good
Comprehensibility	High	Good
Coherence	Low	Good
Completeness	Medium	Limited
Efficiency	Medium	Good
Effectiveness	High	Good

Levas et al. (1995) discuss some of business process simulation issues (such as problem definition, data collection, socio-political issues, hierarchical and modular modelling, granularity, integration, and multi-perspective issues) needing attention in BPR projects. We found the EPM technique very suitable for solving socio-political issues (by enhancing communication and understanding in a project group), hierarchical issues (by providing hierarchical (de)composition features), and granularity issues (by easily allowing modelling at different levels of details).

5. CONCLUSION

Simulation modelling has many benefits for BPR projects for analysing the existing processes and evaluation for alternative scenarios of their improvement. In the paper we have analysed suitability of the process maps technique for simulation based process analysis.

From the literature review and our own research work we can conclude that flowcharts and simple process maps do not have all the required elements for simulation modelling. However, enhanced process maps as defined in the paper have all modelling elements formally required for simulation. With additional benefits, such as clarity of models, tools based on this technique can be very efficient for the first two modelling goals that are related to BPR projects.

Process models built by using EPM technique can serve as a base for identifying information requirements and planning of information system development projects. They are also very suitable for the introduction of workflow management system. Therefore, enhanced process maps can serve as a foundation for IS modelling. However, a single technique cannot capture all different aspects of modelling without becoming too complex and as a consequence less useful for early phases of BPR where communication of models is very important. Research on bridging the gap between business process and IS modelling is left for our future work.

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