Business Process Simulation: An Alternative Modelling Technique for the Information System Development Process

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ABSTRACT

This paper discusses the idea that even though information systems development (ISD) approaches have long advocated the use of integrated organisational views, the modelling techniques used have not been adapted accordingly and remain focused on the automated information system (IS) solution. Existing research provides evidence that business process simulation (BPS) can be used at different points in the ISD process to provide better integrated organisational views that aid the design of appropriate IS solutions. Despite this fact, research in this area is not extensive; suggesting that the potential of using BPS for the ISD process is not yet well understood. The paper uses the findings from three different case studies to illustrate the ways BPS has been used at different points in the ISD process. It compares the results against IS modelling techniques, highlighting the advantages and disadvantages that BPS has over the latter. The research necessary to develop appropriate BPS tools and give guidance on their use in the ISD process is discussed.

KEYWORDS

Business Process Simulation, IS modelling, BP and IS integration, IS evaluation, IS requirements validation, IS requirements gathering.

1. INTRODUCTION

This paper looks at Information Systems Development (ISD) and examines the potential role of simulation techniques within the Information System (IS) developer's toolkit. Since the inception of business data processing in the 1950s ISD has remained a complex and unreliable process with the research repeatedly reporting high levels of "failed" projects (Standish Group, 1999).

Early approaches to discipline ISD focused on treating it as a production process and gave rise to the linear, or waterfall, Systems Development Life Cycle (SDLC). This was perceived to have three advantages: a) it follows a series of specific and sequential phases from the beginning of the project until its end; b) it advocates the use of techniques and tools to formulate, step by step, the detailed design and implement the IS, and c) it introduces the use of project management tools to control the overall process.

Despite the initial success of the linear SDLC, it did not deliver a dramatic reduction in the project failure rate and a number of limitations were identified. For example, it is argued that instead of meeting organisational objectives, the traditional or linear SDLC aims to design an IS to help to solve low-level operational tasks (Avison and Fitzgerald, 2003). In addition, it is claimed that the traditional SDLC focuses on "automating" processes, rather than proposing innovative integrated solutions (Rhodes, 1998). It is important to recognise that in parallel with the adoption of more rigorous ISD techniques there has also been a progressive demand for IS to deal with more complex and wide ranging business processes.

In trying to address some of these limitations IS practitioners have proposed a wide range of alternative ISD approaches by emphasising different aspects of the development process. For instance, some methodologies claim that organisational objectives can be better met by stressing the analysis of the organisational processes. Examples of these are structured analysis and design of IS (STRADIS), SSADM (OGC, 2000) and Yourdon Systems Method (YSM). Others, such as information engineering (IE), claim that organisational goals can be better addressed by placing more emphasis on the analysis of the data. Finally, there are those approaches, like Merise, that considers both processes and data with equal importance (Vessey and Glass, 1998). Most of the approaches above stress a scientific or functionalist approach by breaking-up a complex system into its constituent parts. However, there are other approaches, like soft systems methodology (SSM) (Checkland and Scholes, 1999), that suggest that the properties of the whole system cannot be explained in terms of the properties of its constituent parts, but can be better understood when looked at from a holistic perspective. A key issue is the dichotomy between methodologies, like SSM, that see the human actors and decision makers as part of "the system" and those that focus on the automated all programmed elements as "the system". The former wider view introduces complex socio-technological issues, which are avoided in the latter narrower perspective.

Even though ISD approaches have long advocated the use of integrated organisational views, appropriate modelling techniques have not been adopted and practice remains focused on the automated IS solution. For example, well defined IS modelling techniques are available to understand the overall function of the system in question, to understand IS data structures, or to model the processes involved in the IS software (see Table 1). There is, however, very little indication of modelling techniques for examining organisational views that explicitly integrate automated software and human activities (Giaglis et al., 2004).

Stage/Aspects addressed	Overall	Data	Process
Strategy	Rich Pictures		
Investigation &Analysis	Rich Pictures Objects Martices Strcuture diagrams Use Cases	Entity Modelling Class Diagrams	Data Flow Diagrams Entity Life Cycle Decision Trees Decision Tables Action Diagrams Root Definitions Conceptual Models (UML)
Logical design	Objects Matrices Structure diagrams	Normalisation Entity Modelling Class Diagrams	Decision Trees Decision Tables Action Diagrams
Implementation	Objects Matrices Structure diagrams	Normalisation	Decision Trees Decision Tables Action Diagrams

Table 1 Classification of Modeling Techniques adapted from Avison and Fitzgerald (2003)

To address this problem it is proposed that Business Process Simulation (BPS) can be used at different points in the ISD process to better integrate the organisational views and thereby to aid the design of appropriate IS solutions. To this end, the paper is structured in the following way. In order to illustrate the advantages of using BPS for the ISD process, section 2 describes the underlying principles behind BPS. To provide a reference point for this critique, sections 3 to 6 describe the objectives pursued in the main phases of the linear SDLC. In addition, a critique of the modelling techniques used in these phases is provided together with a description of how BPS has been used in ISD projects to address some of the limitations found in the critique. The linear SDLC paradigm (as described by Avison and Fitzgerald (2003)) was chosen as the reference point because it can be seen as a generalisation of the variety of IS methodologies available in the field. Arguably, iterative, star and spiral SDLC models modify rather than escape from this basic linear model. Advocates of specific ISD approaches can all refer back to the linear model, and the way BPS is useable in each phase of a linear SDLC can be related to the corresponding phases of particular ISD approaches. Section 7 is a discussion of the implications of this approach and the research needed to establish the use of BPS within the ISD toolkit. Finally, section 8 draws general conclusions from this paper and points at future research in the area.

2. BUSINESS PROCESS SIMULATION

Business Process Simulation (BPS) can be defined as:

> "*the process of designing a model of a real system and conducting experiments with this model for the purpose, either of understanding the behaviour of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system*" (Shannon, 1975).

Simulation can be used to understand the behaviour of the existing business system, to identifying problematic tasks and to experiment with alternative scenarios (Hlupic and Robinson, 1998; Vreede, 1998). Business process practitioners have long recognised this advantage and have been using this technique in process innovation projects. In particular BPS has been used to:

- evaluate process and information systems (Paul et al., 1998)
- allow multidisciplinary teams to understand the system under investigation and enforce communication amongst the stakeholders (Vreede and Verbraeck, 1996; Paul et al., 1998)
- understand analyse and improve business processes (Pegden et al., 1995).
- provide quantitative information related to the system performance, hence to take better decisions (Pegden et al., 1995; Sierhuis et al., 2003).
- evaluate different system alternatives (Levas et al., 1995; Giaglis, 1999).

Subsequent sections of this paper will use this information to show that BPS is a modelling technique that can, in principle, be used to model many of the aspects needed for different stages of the ISD process. In particular this paper concentrates to demonstrate that BPS can be used within the Feasibility Study, System Investigation, System Analysis and System Design phases of the linear SDLC.

3. FEASIBILITY STUDY PHASE

The purpose of the feasibility study phase is simply to answer the question: "is this system worth building?" A feasibility study will review analysis and design issues in sufficient detail to answer this question but it will not go further. It is therefore a preview of the analysis and design process but conducted at low-cost within a short timescale. As soon as the question can be answered the project will go through a full management review and the decision on whether to make the necessary investment is taken.

Because this phase focuses on capturing general aspects of the present system, the modelling techniques used in this phase are mainly holistic and process oriented. Rich pictures, root definitions, conceptual, models and cognitive mapping are some of the techniques used in this phase to help to understand the problem situation being investigated by the analysts. Rich pictures are particularly useful as a way to understanding the general problem situation at the beginning of the project. Root definitions help the analysts to identify the organisational context the system has to deal with, in particular human activity systems. Conceptual models show how the various activities in the human activity system relate to each other.

It can be argued that the aforementioned IS modelling techniques are capable of modelling the information required in this phase with few, if any, limitations. The following section, though, describes the way BPS can be used to obtain other information that these traditional IS techniques cannot expose.

3.1 BPS for the Feasibility Study Phase

The different reasons for using simulation in process innovation projects and the information obtained from simulation models (see section 2) does not differ much from the information collected in a feasibility study. Thus, BPS is a technique that could be used to get most of the results needed for the feasibility study.

The major advantage that BPS has is related to its dynamic properties. Traditional techniques can be used to understand the problem situation, to identify the organisational context (people, resources, processes, etc) and extract system requirements. However, these models are static in the way that they represent a particular moment during the operation of the system. On the other hand BPS can be used not only as a graphical representation of the system but also to simulate the operation of the system as it evolves over time (Paul et al., 1998). This feature allows practitioners to gain a better understanding of the behaviour of the system because the analyst can observe the way the system operates without the need to interrupt the organisation's operations or the need to be in the organisation's premises. The quantitative data provided by simulation runs, such as queuing times, processing, time, resource utilisation, and so on, can also be used to complement the qualitative information derived from the graphical interface, providing more information to take better decisions (Pegden et al., 1995; Sierhuis et al., 2003). These metrics can also be used for evaluating different system alternatives (Levas et al., 1995; Giaglis, 1999).

Recent research provides evidence that BPS has already successfully been used in IS projects for similar purposes. For example, Eatock et al (2002) used BPS to assess the impact that the insertion of new IT may have on the organisational process. The authors argue that the performance measurements provided by the BPS model helped them to gain a better understanding of the current system. This in turn, allowed IS practitioners to propose alternative IS solutions that better fit the identified problems.

The proposed alternatives were also modelled using BPS so performance measurements could be compared.

Similar to this research, Giaglis et al (2004) used BPS to assess the expected operational benefits of Electronic Data Interchange (EDI) in the textile/clothing sector in Greece. The main purpose of the simulation exercise was to provide quantitative measures of the supposed ability of EDI to facilitate inventory reduction in the organisations that use this technology as part of their ordering and logistics processes. The study showed that the process of developing, validating and using simulation models for the design of BP and IS was a very useful learning exercise for all participants in the study. It generated greater awareness of both the specifications of the proposed system and the conditions of the business operations under which the system can produce the desired results.

4. SYSTEMS INVESTIGATION PHASE

This phase is an extension of the work performed in the previous phase but in much more detail. This phase usually looks at:

- Functional requirements of the existing system and whether these requirements are being achieved
- The requirements of the new system
- Any constraints imposed
- Range of data types and volumes to be processed
- Exception conditions
- Problems of present working methods

The modelling techniques used in this phase are the same used in the feasibility phase, namely Rich pictures, root definitions, conceptual, models and cognitive mapping. The major difference is that the models developed in previous phases are elaborated in much more detail. Thus, there is the need to collect detailed information about the system. This phase, therefore, uses other techniques for gathering information. Amongst the most popular ones are the five-fact finding techniques: observation, interviewing, questionnaires, searching records and documentation and sampling.

The advantages and disadvantages of IS modelling techniques used in this phase were already discussed in section 3. In relation to the five-fact finding techniques the following disadvantages can be listed (Bennett et al., 1999):

- Written documents do not match reality, for instance company reports can be biased and out of date
- Lack of access to required people
- Interviews are time consuming and can be the most costly form of data gathering
- The interviewee may be trying to please and saying what they think the interviewer wants to hear
- Most people do not like being observed and are likely to behave differently from the way in which they would normally behave.
- Questionnaires are easier to ignore and hence suffer from low response rates.
- Good questionnaires are difficult to design.

4.1 BPS for the Systems Investigation Phase

The main difference between the investigation phase and the feasibility phase is related to the depth in which the system is analysed in the former. Thus, the uses of BPS illustrated in the feasibility phase apply also to the systems investigation phase, where the distinction lies on the depth in which the models are constructed.

Apart from the advantages already described in section 3, Paul and Serrano (2004) provide evidence that BPS can also be used as a requirements gathering technique. Paul and Serrano reported that the analysis of BPS models had helped IS analysts to identify IS requirements, in particular non-functional requirements, that were overlooked by traditional IS techniques. Based on the results derived from a case study, the authors reported that in order to reduce the time to complete an order (identified as a system requirement) the system depended on one particular factor: the number of backorders produced by the system. Hence, a non-functional requirement that was previously overlooked and that was derived from the analysis of the BPS model is related to the reduction of backorders. Moreover, the results provided by the simulation model suggested that in order to deliver orders within the period of time set by the organisation (24 hrs) the system should produce no more than 5% of backorders. This information was obtained because the BPS model produced performance measurements of the whole operational processes including those supported by the proposed IS solution. In this way analysts were able to identify system requirements that were related to performance and also provide specific metrics for those requirements. Therefore, BPS can be used to complement the information derived from traditional gathering techniques.

BPS can also help to overcome some of the limitations found in the five-fact finding techniques. It is argued that a simulation exercise can engage staff in the process because it presents a dynamic and visual impression of the system or process (Hlupic and Vreede, 2004). By engaging staff, problems related to unambiguous or biased information can be reduced.

5. SYSTEMS ANALYSIS PHASE

In this phase the efforts concentrate on understanding the information gathered in the previous phase. It seeks to describe all aspects of the present system, the reasons it was developed as it is, and eventually, proposing alternative solutions for the creation of a new system. The analysis of the present system is usually done by asking the following questions:

- Why do the problems exist?
- Why were certain methods of work adopted?
- Are there alternative methods?

Apart from the modelling techniques used in previous stages, in this phase analysts count on other modelling techniques to capture more specific information. For example, to model the data used, produced and manipulated by the system, data techniques such as Entity modelling and Class Diagrams are used. Similarly, process oriented techniques, such as Data Flow Diagrams, Entity Life Cycle, Decision Trees, Decision Tables, Action Diagrams, are also employed as basic techniques for functional decomposition. This is, to break down the problem into more and more detail in a disciplined way.

Entity modelling and class diagrams are designed to identify specific issues related to the data that the system uses and manipulates and they have been proved very reliable to achieve this aim. Thus little criticism can be made in this respect. This is not the case, though, for process techniques.

Once again, the main disadvantage that traditional IS modelling techniques have is related to their static nature. The main questions posed in this phase, such as identifying the reasons of why problems exists and if there are alternative methods of work, are very difficult to answer with static models (Pidd, 1998; Robinson, 1994). IS analysts rely much on their experience and expertise to answer such questions since these techniques are mainly used to portray the analyst perspective and they rarely provide more information to the analysts to make better decisions.

5.1 BPS for the Systems Analysis Phase

BPS has been proved an excellent tool for functional decomposition and systems analysis. It has been said that simulation models can be regarded as problem understanding rather than problem solving tools (Hlupic and Vreede, 2004). Therefore, BPS can be used to answer the questions *Why do the problems exist?* and *Why were certain methods of work adopted?*.

A major difference between BPS and traditional IS techniques is that the former is capable of conducting "what if" analysis whereas the latter cannot. Once a BPS model is build and validated, changes to system variables and processes can be done to test alternative scenarios. According to Giaglis (2004), there are two main sets of variables to be studied by decision makers: the configuration of the proposed information system (IS functionality) and the organisational arrangement regarding the structures and operations that surround it (business processes). By measuring the performance of the business processes with and without the use of IT, decisions makers can collect the quantitative information needed to conduct further investment appraisal and IS design using established methods (Giaglis et al., 2004).

Paul and Serrano (2004) have used BPS to analyse five different process solutions for the case study reported in their research. The experiments' results provided more information, such as performance measurements, that helped on the selection of the scenario that better matched the organisational needs. More importantly, prior to the experimentation with BPS models, the scenario that included the use of IT was thought to be the most appropriate one for the organisation. The analysis of the simulation results indicated that the scenario that included the insertion of IT did not improve, in a significant manner, the overall system's performance. It was identified that one of the main problems with the system was due to the way processes were organised rather than the lack of adequate IT infrastructure to support them. Similar to this work, Giaglis et al (2004) have used BPS to assess different solutions in an IS development project. The main objective of the simulation study was specified to provide a measure of the efficiency gains that could be achieved in inventory control within the textile/clothing value chain. The simulation exercise was also aimed to explore the possible benefits of the insertion of EDI in inventory reduction. To this end the authors developed two simulation models, one to portray the organisation's operations as they are and one that included an Electronic Data Interchange (EDI) solution. The results provided evidence that indicated that all inventory levels were reduced after the introduction of EDI. Materials inventory, for example, were reported to be reduced by up to a 46% whereas the product inventory by up to a 27%.

6. SYSTEMS DESIGN PHASE

This stage involves the design of the system. To achieve this aim, analysts use the information gathered during previous phases to produce the documentation that portrays the functionality of the new system. Many parts of these documents can be seen in the form of models. Models used in previous phases can be used to derive more detailed models of the way the system will operate. For example, *Use Cases* is a modelling technique that can be used in the first stages of an ISD process to capture the functionality of the system. At the systems design phase, the information depicted in Use Cases is commonly used to design collaboration, sequence and activity or state diagrams. These models provide detailed information about how the system will function at particular points in time. For example, they can provide information about how the system will perform a specific transaction and how it will interact with the user to achieve this aim. Traditional IS techniques, however, cannot be used to assess how different workloads may affect the performance of such transactions. More importantly, they cannot be used to assess the impact that this new way of operating will have on the system as a whole.

6.1 BPS for the Systems Design Phase

It is argued that misinterpretation of user requirements is one of the main factors that contribute to IS failure (Vessey and Conger, 1994). Therefore, one of the challenges faced by analysts in this phase is to ensure that the functionality proposed for the new system matches, in the best possible way, user requirements. Because misinterpretation of user requirements may cause significant changes on the system's design, hence adding unexpected time delays and/or expenses, validation of requirements should be done prior the implementation phase. Validation of user requirements is frequently done iteratively throughout previous phases of the ISD process. The techniques used to validate requirements are usually those employed to capture user requirements. For example, *Use Case* is one modelling technique that is commonly used to capture user requirements. Once requirements are captured and translated into Use Cases, these models are taken to the users to validate that their requirements are well represented in such models.

Traditional IS techniques such as Use Cases, however, cannot provide information on whether the functionality proposed in such models will improve the performance of the system as a whole or to provide predictive metrics of such performance. Use Case models cannot provide information related to what could be the benefits of implementing the functionality described considering the organisational context. In other words, traditional IS techniques cannot be used to answer questions such as:

What is the performance of the proposed IS functionality? or What would be the impact that the proposed system will have on other processes?

When asked to validate requirements models users typically focus on items of detail rather than the impact of system on general working practices. The experience of using the system is not the same as reading about using it. Users will be able to perceive the impact of the system on their individual tasks but not know how these effects combine to change the behaviour of the organisation as a whole. Long-term systemic impacts will often remain hidden.

Researchers in this area argue that BPS can be used in this phase to verify that the functionality proposed for the new system matches global or systemic requirements. Paul and Serrano (2004) and Giaglis et al (2004) have proposed alternative ways of using BPS to simulate the effects that a proposed IS functionality will have on the business processes and vice versa. Paul and Serrano (2004) proposed a BPS modelling approach that uses the specifications derived from IS models, such as Use Cases, collaboration and activity diagrams to represent the IS functionality within a BPS model. In this way, analysts can obtain metrics of a) the performance of the IS as it evolves over time (known as non-functional requirements), and b) the impact that the functionality proposed by the IS would have in the business processes. More importantly, Paul and Serrano (2004) report that the use of BPS models helped analysts to identify flaws in system design and thus, redesign the proposed IS functionality. With the aid of the BPS model, the authors observed that the IS functionality proposed for their organisational case study would not improve, in a significant manner, the overall system's performance. They observed that in order to take full advantage of the proposed information system, changes to other processes were also required. This helped them to redesign the system's functionality so it better meets the organisational targets.

Prototyping is a method that has long been used by the IS community to ensure that the proposed IS functionality meets user requirements. Software engineers use the term prototype, or prototyping, to reflect a variety of different activities. In this paper we will concentrate on the conventional engineering sense of prototyping. This is the production of a partial system (interface, a key algorithm, etc) for the purpose of evaluating or selecting an element of the design. Such prototypes are not of adequate quality or sufficiently complete to be regarded as early deliverable versions of the system (Oxford-University-Press, 2002).

A traditional prototyping process consists of designing and building a scaled-down usable model of the proposed system and then demonstrate the working model to the user with the purpose of obtaining feedback on its suitability and effectiveness. Developers then take the feedback and make corresponding changes on the design. This process is repeated until the users agree that the prototype is satisfactory (Boar, 1984; Arthur, 1992) .

There are some cases, however, where prototypes, all pilot systems, may not be appropriate. Organisational processes and their supporting information system(s) require input from users at different points in time. The time between these points may range from seconds, minutes or hours to days, months or even years depending on the organisational processes. For example, an arbitration process can take more than one year to be completed, having several users' input information at different times during this period. Similarly, insurance processes can take months to be completed. Prototype systems need to wait for the processes and related transactions to be completed in real time to obtain user feedback. Thus, when processes take long periods of time, prototyping methods cannot provide the desired results within acceptable limits.

Ongoing research in the School of Information Systems and Computing at Brunel University (Elliman and Eatock, in press) claim that BPS can be used to validate user requirements in cases where long term processes are involved. The authors propose a modelling approach that combines prototyping with simulation techniques, specifically with BPS. The approach is composed of two main models: a BPS model that simulates the organisational processes and an IS prototype that simulates the functionality of the proposed information system. The business process simulation will model the behaviour of actors within, or even without, the organisation. It will generate "work" for the organisation and play out the way actors respond to information from the proposed new IS. Thus the link between the two components in this prototyping experiment is:

- signals of events that are recorded by the information system
- outputs from the information system which change the behaviour of actors

Note that the level of implementation required is well below that of a completed information system. For example, the system has no user interfaces nor data that affects the state of the information held in such a way as to change the subsequent behaviour of actors. For example, it is not necessary to work out whether a particular arbitration case requires the use of an expert. In the simulation one can simply assign a probability to this necessity and ensure that, at random, an appropriate number of cases are tagged as needing an expert witness. The IS implementation simply carries this tag rather than a full set of name, address, etc. describing the witness. Upon interrogation the IS can confirm the involvement of the expert and provide the tag value as a sufficient identifier.

Because this approach simulates the interactions between the system's components, namely actors, IS and processes, analysts were able to test the way the system would behave without the need to wait for long periods of time. Processes that take long periods of time, for example months, were now simulated by the BPS model in minutes.

7. DISCUSSION

Previous sections provide evidence that Business Process Simulation (BPS) is a modelling technique that can be used effectively in different phases of the IS development process paradigm and, more importantly, that it can be used to overcome some of the limitations identified in traditional IS modelling techniques. To this end, section 3.2, 4.2 and 5.2 discuss the ability that BPS has to provide the information required for the *Feasibility*, *Systems Investigation* and *Systems Analysis* phases of the SDLC. More importantly, that it provides other information that traditional IS techniques cannot provide, such as performance metrics of the system as it evolves over time.

Although this suggestion of simulation, as an ISD technique, has a long history it has not been developed as a routine tool in the analysts' armoury. To achieve the potential value set out in this paper two areas of ongoing research are necessary. First, there is the need to develop business process simulation tools and techniques that can be rapidly applied. Second, there is the need to develop awareness and acceptance of the techniques.

The development of a model in the E-Arbitration-T project (Elliman and Eatock, in press) involved significant technical effort that could have been reduced if appropriate tools were available off the shelf. This project suggested a need for three lines of tool development research. The most important part of a combined information system and business process model is a representation of the IS itself, and its interface to the discrete event simulation of human activity. The point of the IS is to inform the human actors and enable them to change their behaviour appropriately. It is also necessary for the simulated actors to update the IS. Thus the IS component is unlike any other element in the discrete event model. For the simulation to be constructed rapidly and effectively this component needs to be easily configured and integrated within the model. As described above much of a conventional IS need not be constructed because the simulation requires no Graphical User Interface (GUI) and no long-term data storage. The necessary component only needs to focus on data entity or class identity and some form of entity or system state model. The details of such an IS prototype, however, requires further research to create it as a generic component in BPS packages.

The second area of technical development is the need to provide other pre-built business process elements. Almost all simulation packages provide pre-built elements for modelling manufacturing systems – machine tools, stores, conveyors and transport devices. The availability of business elements is less frequent and more basic. Although packages may have elements like call centres they do not deal with higher levels of knowledge worker behaviour (Kidd, 1994; Elliman and Hayman, 1999). Research to formulate and develop these components is also necessary (Elliman et al., 2005). The last area of technical development concerns the generation of "work" for the simulated business. The demands for information or knowledge services are much more variable than those experienced in general manufacturing. Thus there is a need to enhance the case or work generation capabilities of most simulation packages so that they can handle complex case of generation efficiently. With the increasing use of mass customisation and flexible manufacturing improved “work” generation, tools may incidentally have benefits for manufacturing systems simulation.

These three tool development areas are not independent and research is needed not only to develop models for each of these tools but also to establish the relationships between them and the different ISD phases. Given the time and cost limits on a feasibility study, the time and cost of setting up current simulation packages could be inappropriate for most IS projects, at least for this phase. BPS practitioners argue, however, that it is possible to create broad-brush models with only limited detail but with enough information to determine whether the synergies exist to deliver the expected benefits or whether the reorganised system contains negative interactions that could undermine the anticipated benefits. Furthermore, the information captured from models developed during the first phase of the SDLC is frequently used to design models for subsequent phases. This suggests that IS analysts could use the simplified version of the BPS model designed in the first phase and gradually modify the level of detail according to the requirements needed for each phase.

In conventional engineering, simulation is an accepted and standard element of design practice. The use of models in wind tunnels or model ships in a wave tanks are examples of tried and trusted simulation techniques. Engineers understand the limitations of these models and their relationship to the final product. Similarly, discrete event simulation of physical production plant is an accepted methodology (Siemer et al., 1995). In ISD these relationships are less well defined and understood, and thus there is a reluctance to accept simulation in this context. Further research is needed to refine the techniques and present them to practitioners. These lines of research are intimately tied up with building a bridge between objective technology and subjective evaluations or perceptions. Developing appropriate guidelines for their use will be important.

The knowledge required to construct adequate BPS models for many elements of the Feasibility Study, System Investigation and System Analysis phases is relatively simple. IS developers can refer to the simulation steps found in the literature such as those suggested by Banks et al (2000) or Robinson (1994). However, in order to answer deeper questions about performance measurements of both BPS and IS functionality, particularly in the Design Phase (see section 6.2), developers need significant modifications to the way traditional BPS models are constructed as described above.

8. CONCLUSIONS

This paper argues that BPS models are able to provide the same and more information than traditional IS modelling techniques, thus, they are suitable to address the modelling needs required at different points in the ISD process. Evidence to sustain this argument has been presented in the following ways:

a) BPS has been successfully used in the business process innovation domain to obtain very similar information to that required in different phases of the SDLC paradigm, and
b) BPS models have already been used within the IS domain for similar purposes

The main advantage that BPS provides over traditional BPS modelling techniques is its ability to simulate the dynamic behaviour of the system as it evolves over time. In particular it provides models that better integrate the dynamics of human activity and the automated IS. It has been discussed that the quantitative metrics provided by BPS models can be used by IS analysts to:

- better understand the operation of the current system

- identify possible system bottlenecks
- evaluate different system alternatives
- obtain performance measurements of the system's behaviour for both processes and IS

To justify these arguments, three different case studies that employ BPS in IS projects are used: Paul and Serrano (2004), Giaglis et al (2004), and Elliman and Eatock (in press).

The evidence presented in this paper strongly suggests that BPS models are able to provide more information than traditional IS techniques and that this information can be very useful to design better IS solutions. Thus, the authors of this paper advocate the idea that practitioners in this domain should routinely consider the use of BPS as an alternative tool to support different stages of the ISD process. Moreover, section 7 argues that BPS models can be used to simulate proposed IS functionality and the effect that it may have on the organisation as a whole. The development of such models, however, is more complicated than the way traditional BPS models are designed. Thus, further research in this area is needed to improve the BPS toolkit and demonstrate its effectiveness in various ISD scenarios.

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