UNDERSTANDING THE DYNAMIC INTERACTIONS BETWEEN BP AND IT USING SIMULATION

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ABSTRACT

Business Process (BP) design approaches claim that Information Technology (IT) is a major enabler of business process, a view also shared by the Information Systems (IS) community. Despite this fact, approaches in these domains do not provide clear indication of which modelling techniques could be used to detect IT opportunities within a business process context. This paper examines the advantages and limitations of a simulation framework used in a research project, namely ASSESS-IT, that aimed to depict relationships between BP and IT. It provides evidence that for some cases the relationships between BP and IT can be viewed by focusing in the relationship between BP and IS alone and assess the feasibility of using an alternative framework, namely BPISS, to address this relationship. Finally, this paper provides evidence that the BPISS framework could help BP and IS analyst to assess the benefits, or constraints, that the functionality of a given IS design may bring to the BP.

INTRODUCTION

Business processes became the focus of continuous improvement efforts in the mid-40's (Davenport and Stoddard, 1994). It is argued, however, that process analysis started far before in 1911, when Frederick Taylor first advocated the systematic study of work procedures. From that time, the concept of process became very important. For example, process control and process techniques have been outlined in the quality movement (Juran, 1964; Garvin, 1988). Process skills and process consultancy have been very important in human relations and management of change schools (Schein, 1969). Operations management is concerned with the management of processes, people, technology, and other resources in the production of goods and services (Armistead et al., 1995).

It was at the beginning of the 1990's when the process movement became stronger. Business Process Reengineering also named Process Redesign, or Process Innovation is today one of the most popular concepts in business management (Davenport, 1993; Hammer and Champy, 1993). The study of business processes, however, is not isolated and has always been related to Information Technology. IT is considered one of the most important enablers of process change. For example, in one of the first articles about BPR, Davenport and Short (1990) argue that together, processes and information technology can be seen as a new industrial engineering that may revolutionise the way in which organisations operate. Similarly, Hammer and Champy (1993) claim, in one of the most renowned books on BPR, that IT is part of any reengineering effort, and they position IT as "an essential enabler".

Most of the advocators of the business process reengineering movement highlight the importance of the role that IT plays in the reengineering process. Many argue that IT should be seen as an enabler of organisational change rather than as a tool to implement business processes (Davenport, 1993). Childe et al. (1994), for example, state that the initiative to move towards BPR in many cases originates from the IT departments. In one of the first empirical studies on IT-enabled BPR, Grover et al. (1994) claim that the success of IT to enable BPR lies in IS-strategy integration. They contend that the success of IT-enabled BPR efforts will succeed only if they are directed through a strong integration with strategy. This relationship, however, is not fully explored in most of the existing business process methodologies nor in the IT domain. Trying to address this problem the ASSESS-IT project propose a simulation framework that aim to depict the interaction between BP and IT. The following section describes the ASSESS-IT framework, it analyses its advantages and limitations and provides the basis to propose an alternative framework to address the limitations found.

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THE ASSESS-IT PROJECT

The ASSESS-IT project assumed that the relationship between BP and IT could be seen as a three layered structure, namely Business Process, Information Systems and Computer Networks (CN). Business processes usually rely on the support provided by the information systems to perform many of the activities. Similarly, the information systems that support these processes also depend on the underlying communications infrastructure, namely computer network (see Figure 1).

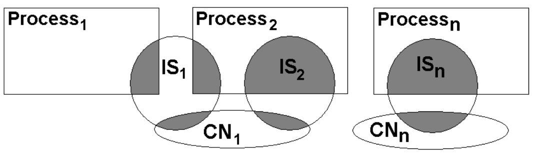

Figure 1 Business Process/IT Relationship

Figure 1 depicts the relationship between processes and IT domains. The rectangles represent the various processes that may be found in any organisation, the circles represent the information systems that support those processes and the ovals represent the computer network infrastructure.

Figure 1 suggests that the relationships between processes, information systems and computer networks are complex and that changes in any domain may have an impact on the others. Figure 1 also suggests that particular attention must be paid to the IS domain since it is the "connection" layer between the business processes and computer network layers. Because of this, changes to the business process may have a direct impact on the information systems, affecting indirectly the network infrastructure. Likewise, changes to the computer network infrastructure may have a direct impact on the information systems, affecting indirectly the process layer. Finally, changes to the information systems may have an impact on both the process and network layers. Thus, processes, information systems, and computer networks may be viewed in terms of two relationships, namely BP-IS and IS-CN, which are related by the information system layer. Recognising the complexity of these relationships creates difficulties in assessing the impact that changes to any of these domains may have to the others before implementing them.

ASSESS-IT aimed to provide practical solutions to support the process of change in organisations by providing on the expected impact of IT investments on business performance. The ASSESS-IT project proposed the use of an alternative simulation framework and tests it using a case study. The following is a résumé of the case study together with the simulation framework proposed in this project.

The Case Study

The case study presented in ASSESS-IT consisted of two collaborating organisations in Greece. One company is a branch of a major multinational pharmaceuticals organisation (we will refer to this company as Org-A), while the other is a small-sized regional distributor of Org-A's products (we will refer to this company as 'Org-B').

The case study was carried out within a single business unit, which deals with hospital consumables. The business unit imports products from other Org-A production sites across Europe. The goods are stored in a warehouse that operates as a central despatch point for all products, which are then distributed to the company's customers via a collaborating distributor, namely Org-B. Org-B responsibilities include:

a) Maintaining an adequate inventory of products to fulfil the orders.

b) Distributing the ordered products to customer premises.

Org-B has to operate within rigorous deadlines. The agreement between the companies, stipulates that each order has to be fulfilled within 24 hours for products delivered within the city of Thessaloniki, or within 48 hours for the rest of northern Greece. Org-A management noted, however, that these targets are rarely met in practice. A brief analysis by the companies seemed to attribute the problems to some inefficiencies within the ordering system as well as difficulties being experienced by Org-B in maintaining their inventory at an optimal level. The effects that these inefficiencies caused were seen as a major source of customer dissatisfaction, so an in-depth analysis of the problem was commissioned. The main objectives of this study were:

a) To examine the existing business processes that were felt to be responsible for long lead times for order fulfilment.

b) To determine the sources of problems and propose alternative solutions.

c) To evaluate the potential of introducing appropriate IT to improve communication between the two companies.

The ASSESS-IT Framework

The basic idea behind the ASSESS-IT framework is simple. Changes to business processes usually involve changes to the information systems. Similarly, modifications to the information system architecture or the insertion of a completely new software application increases or decreases the network traffic load. Consequently, depending on the network infrastructure, changes at the network traffic level may affect the communications between the network components along the network (nodes, serves, routers, communication lines etc). This affects the performance of the software applications that run over the network, including the information systems that support the business process under analysis, which in turn, may have unexpected consequences in the business process performance. The ASSESS-IT project investigated the suitability of using discrete event simulation models to assess the impact of the insertion of an IS in Org-A and Org-B. To this end, two discrete event simulation techniques were selected to model both business process and IT: Business Process Simulation (BPS) and Computer Network Simulation (CNS).

In order to calculate the business effects of changing the underlying IT, the ASSESS-IT framework developed a computer network model, including IS design, it then identify the information that may be relevant to the BPS model and incorporate it in the latter (see Figure 2). That is, if a computer network model of the proposed IT system is built, the outputs from this model can be directly fed into the business process model, thus, reflecting the changes that the new IT would produce at the BP level. The ASSESS-IT framework is based on the steps for a simulation study suggested in (Banks et al., 2000). The steps proposed in the ASSESS-IT framework are depicted in Figure 2 and summarised next:

1. The problem formulation and setting of objectives and overall project plan should be performed together for both business process and computer network models.

2. Model conceptualisation and data collection steps should be performed separately for both BP and CN models.

3. A new step, BP/IT model conceptualisation is introduced. The aim of this step is to co-ordinate the conceptualisation of the BP with the CN models and vice versa so they reflect both process and information technology.

4. Before undertaking the experimental design step, the BP modeller should wait for the input from the CN model results (e.g. transmission times over specific network conditions). This information needs to be considered for the experimentation design phase in the business process model.

A complete description of the ASSESS-IT framework and analysis of the results can be found in (Eatock et al., 2001).

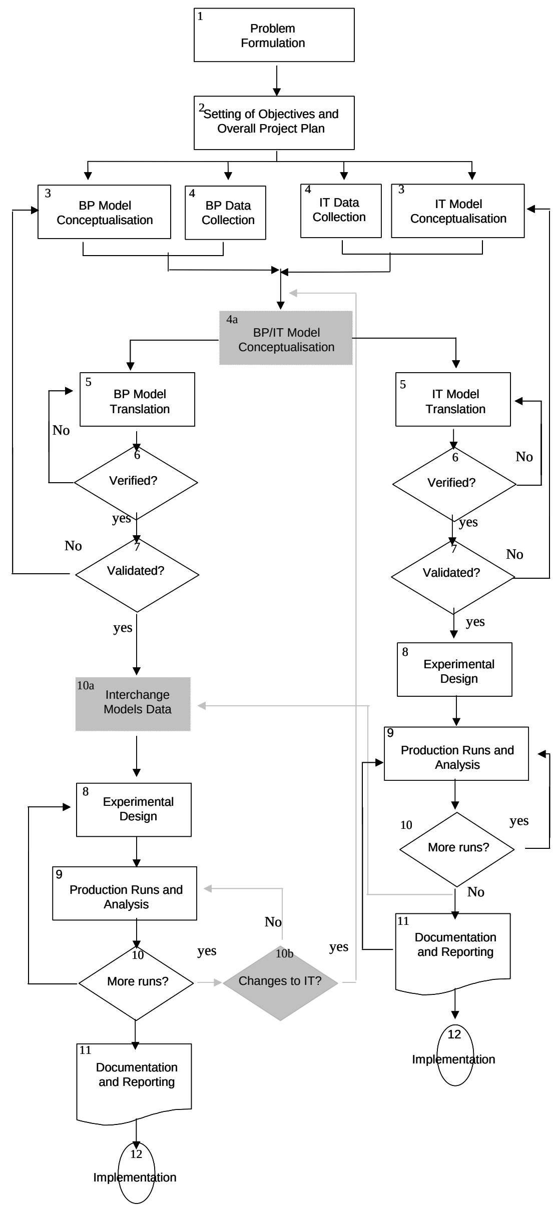

Figure 2 ASSESS-IT Framework

Experimentation and Results

The ASSESS-IT framework is divided into two major phases. The first phase develops the Computer Network Simulation model. The second phase develops the Business Process Simulation Model and uses the outputs of the CNS model to reflect the impact of the IT in the BP. This section presents a resume of the results obtained in each phase.

Phase One. The CNS Model

Once the computer network model was designed and verified a number of pilot runs were performed. The results showed that the time taken to complete an order was a maximum of 3.6 seconds and an average of 2.3 seconds. The fact that the figure was significantly low led to rethink the way the model was designed. The model represented the traffic flow generated by a single IS which in turn produces on average an order every 24 minutes. Thus, the traffic flow was considerably low. It was thought that in reality the traffic in a computer network would be composed of a series of applications. The fact that a number of IS applications run over a computer network will increase the network traffic which in turn may have a greater effect on the transmission times in the IS. Therefore, it was decided to experiment with a series of different network traffic utilisation levels. The computer network model was run using varying degrees of network utilisation, which correspond to different levels of underlying IT capability to support the business process workload imposed on the network. The network response times were recorded for each run.

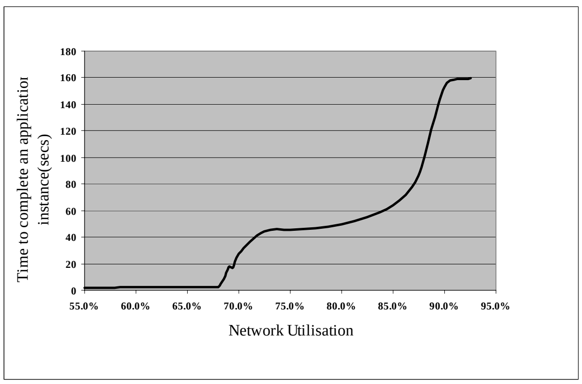

Figure 3 Application Instance Completion Time with Varying Degrees of Network Utilisation

From Figure 3 it can be seen that until network utilisation reaches a critical point (around 67%) application instance duration are relatively steady and utilise the network for about 2 seconds per application instance (number of transactions produced by a given node within the network); a response time that can be considered as acceptable from the end-user viewpoint. As network utilisation increases, however, it can be observed a considerable increase in application instance completion times, rising to almost 45 seconds for high network workloads (67 to 79%), to 60 seconds for very high network workloads (79% to 85%), followed by an extremely sharp rise as utilisation rises to 92% (indicating network congestion at such high utilisation).

Phase Two. The BPS Model

Three scenarios that would possibly alleviate the problems with backorders were considered. These are described in the following list.

1. Faxing backorders. It was proposed to fax the backorders to Org-A, instead of sending them by post.

2. Org-B sends the backorder list twice a week. Instead of waiting until Friday to send the backorder list, this is sent Tuesday and Friday evenings.

3. A final scenario that included the use of an IS was designed. The two companies share the same database to allow Org-A to have up-to-date information on stock levels at Org-B, and hence adjust replenishment shipments accordingly. The backorder list is generated automatically so Org-A knows the real-time stock levels in Org-B warehouse.

The results obtained from running scenario 1 showed some interesting results. Although the time taken to send the back orders by mail was reduced from 2 days to a matter of minutes, the reduction in time taken to deliver the entire order was reduced by only 1 hour for orders and remained almost the same for backorders. After a more thorough analysis, it was found that this situation was due to two major reasons. Firstly, due to the system’s business rules, orders were retained until Friday afternoon to be faxed. Despite the fact orders arrived in a matter of minutes to their destination, employees take about 8 hours to process an order list. Therefore, orders send by fax on Friday afternoon did not have enough time to be processed on the same day and they have to wait until Monday. In the original scenario, orders took two days to arrive at its destination by normal mail. Considering that the mail works on Saturdays, the backorder list also arrived on Monday. Hence, both scenarios process the list almost at the same time. The second, and most important reason, is that there is only one employee working in the warehouse of Org-B, who, is busy nearly 97% of his/her working time. Consequently, an extra experiment was performed adding one more warehouse employee, resulting in an 11 hours decrease for orders. Backorders, however, remained the same.

The second scenario was to schedule the replenishment shipments to be sent twice a week instead of once. This resulted in a reduction in delivery times for backorders, but it was much smaller than anticipated (11 hours for back orders). This was due to the same problem identified in scenario 1 related to the warehouse employee. When the time was measured combining the scenarios of having two employees, faxing backorders twice a week, ordering times were showed an 11 hours reduction and backorders a 40 hours reduction.

Scenario 3 addressed the only real IT-based solution, in which, both companies share a database. Following the ASSESS-IT framework guidelines, transmission times (to send an electronic order) had to be obtained from the computer network model. Subsequently, transmission times were used in the business process model. The network reported that to send an electronic order, or backorder, could be done in less than 30 seconds.

Sharing a database gives Org-A a better idea of the replenishment requirements of Org-B. The results did not show a noticeable reduction in the delivery times for the orders that had in-stock products, on the contrary, an increase of 29 hours was noticed for orders. The problem, as in the previous scenarios, was due to warehouse employee workload. It was reported that he/she was busy 99% of his/her working time. The increase of utilisation (more than 2%) was due to he/she had to deal with a slightly higher number of backorders. Those products that required back orders, however, showed a substantial reduction of nearly 74 hours. This was mainly because the backorder list would no longer need to be created, as it would be generated in conjunction with the normal replenishment shipment. A final experiment was created which combined the results from scenario 3 with an extra warehouse employee. The results were as expected, since there was a reduction of 10 hours for orders and 82 for backorders. The times reached in this scenario were the best in comparison to the as-is scenario, though, they were still distant from Org-A and Org-B targets.

ASSESS-IT Limitations

The results from the computer network-modelling phase showed that the impact that the computer network infrastructure may have on the information systems strongly depends on time. These results also demonstrated that due to current network technologies, the information systems that could suffer from changes to network architecture are those that depend on time. The type of systems that the ASSESS-IT approach aims to address, however, do not fit within this category. The experiments showed that changes to the network infrastructure and to network traffic did not have a considerable effect on IS performance, and consequently, did not affect the BP performance. Similar results were found in the business process-modelling phase. The experiments did not show a significant improvement on business process performance despite the fact that the time for those activities that were aided by the IS was dramatically reduced. A deeper analysis of this situation suggested that the problem was due to the fact the ASSESS-IT approach concentrated on depicting the way IT affects processing time, but not in the way IT affects process performance.

Business process modelling experiments showed that time was not a parameter that could affect process performance. The experiments showed, however, that there are other IS parameters that affect BP performance. For example, once it was detected that the backordering process was a major system bottleneck, it was proposed to use of an IS to alleviate this problem. Therefore, the IS was designed, amongst other things, to reduce the number of backorders. This information, though, could not be reflected in the business process model because the BP model was designed to represent the percentage of backorders statically (as a fixed number) and not dynamically. Reducing the backorders percentage manually (from 30% to 5%) demonstrated that the reduction of backorders would reduce the overall processing time. This figure was directly related to the way the IS would handle the backordering process.

Two conclusions can be obtained from the ASSESS-IT approach exercise.

1. The computer network infrastructure does not affect the performance of information systems used to support organisational processes. Consequently, the overall business processes performance is not affected, in a significant way, by changes to the CN infrastructure. Therefore, the use of a computer network model is, in the context of the ASSESS-IT approach, unnecessary.

2. The experimentation with different BP scenarios provided evidence that suggests that in order to portray the benefits that the use of an IS may bring to the business processes, it is necessary to obtain measurements of the way the IS behaves over time.

It can be derived from these conclusions that in order to provide a modelling approach that depicts the relationships and interactions between BP and IT, it is necessary to focus on the relationship between BP and IS alone. Furthermore, the insights gained from the experiments with different BP scenarios imply that the parameters that govern the relationship between business processes and information technology are not those that are related to time constraints but are instead those that are related to IS performance measurements. It was observed that time reduction on certain activities of the ordering process did not improve business process performance. On the other hand, IS performance measurements, such as the reduction of the number of backorders produced by the IS, improved the overall process performance.

These facts lead us to think that a new BP/IT integrated approach is needed. According to the results and conclusions presented here, the approach should focus on the relationship between BP and IS, and more importantly, should depict IS behaviour measurements. This means, it is necessary to investigate more about how to model IS performance. IS performance measurements are also known as information system's non-functional requirements. Most IS modelling techniques, however, aim to depict functional requirements. Non-Functional Requirements (NFR), on the other hand, are not easy to represent in a measurable way, thus, a limited number of techniques and approaches can be found.

The results rendered by the ASSESS-IT approach highlighted the importance to portray the dynamic behaviour of the IS as it evolves over time. The problem, though, is that the ASSESS-IT approach, as it stands now, cannot provide such information. The following section presents the rationale for an alternative framework, namely BPISS, that proposes a new approach that can be used to identify NFR that affect IS performance and to model the behaviour of the IS and the BP as they evolve over time.

THE BPISS FRAMEWORK

The results derived from the ASSESS-IT framework suggest that the relationship between BP and IT can be described as the relationship between business processes and the information system that support those processes, and not as a three layered structured (BP, IS and CN) as it was thought in the ASSESS-IT framework. Furthermore, the results from the ASSESS-IT framework found that in order to depict the interactions between BP and IS it is necessary to portray IS non-functional requirements, in particular IS performance requirements. This section describes a new simulation framework, namely BPISS, to develop simulation models that depict business process and information systems performance. The BPISS framework is summarised as follows and is depicted in Figure 4.

1. Develop BPS model and identify possible IS scenarios. The framework uses a BPS model to represent current processes, identify process bottlenecks and propose possible IS solutions.

2. Identify IS functional and non-functional requirements. Once IS solutions are proposed, its functionality is described using current IS modelling techniques. Non-functional requirements are described and identified in two ways. First, current IS modelling techniques are used to derive a list of IS performance requirements. Second, the list is complemented using the BPS model to investigate other parameters that may affect BP performance and that are related to the proposed IS.

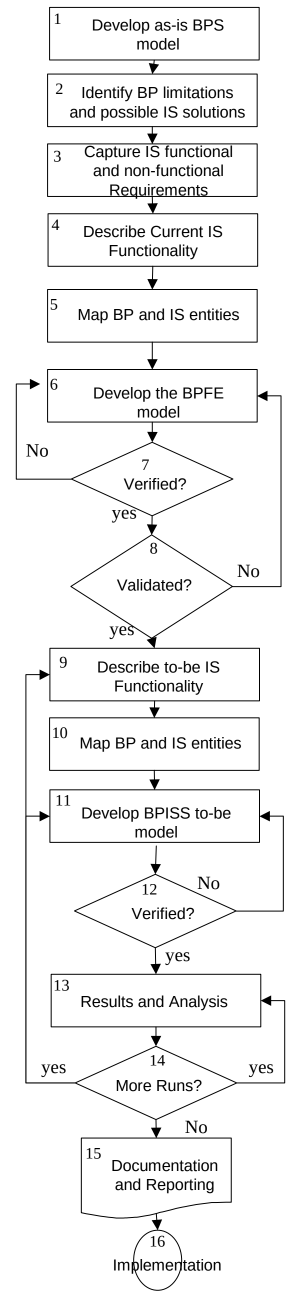

Figure 4 BPISS Framwork

3. Develop the BPISS model. To develop a model that reflects both process and IS performance, the BPISS framework uses a preliminary model, namely BPFE to validate the model against the original BPS model. The BPFE model aims to portray the way current business processes behave considering the changes that the functionality of the current system

(automated or manual) produce on the model. The BPFE model identifies those business entities, namely Record Entities (RE), that are used in the business process model and that are affected by the system. To reflect the way the system affects RE, the BPISS decomposes the RE into Field Entities (FE), which in turn represent the information contained in the RE. FE should describe the information used by the system to trigger events or to produce changes on business entities. Based on the BPFE, a new model is created so it reflects the functionality of the new IS (the BPISS model).

Experimentation and Results

Because the ASSESS-IT had already developed a BPS model this was used in Step One of the BPISS framework. Similarly, the IS proposed in ASSESS-IT was used in the BPISS framework. The proposed IS should accomplish the aims described in the following list.

- The IS should automatically update inventory levels so a real-time inventory level could be monitored by both organisations.
- The IS should automatically produce a backorder whenever a given product is out of stock.
- When a backorder is produced or the inventory level of a given product is below the figures established by the organisations, the IS should request the replenishment of this product.
- When a replenishment cargo is delivered, the inventory levels should be updated and reflected in real-time.

Two IS non-functional requirements related with performance measurements were identified for the proposed IS. The first and most important requirement was requested by Org-A and establishes that the overall delivery time, including backorders, should be 24 hours, for products delivered within the city of Thessaloniki, or within 48 hours for the rest of northern Greece. This means that it is expected that the introduction of the new IS would reduce current delivery times so they fit the requirements previously mentioned. The second requirement was obtained during experimentation of the BPS model. It was detected that the backordering process was a major system bottleneck, and that delivery times depended on this process. It was demonstrated that when reducing the backorders percentage from 30% to 5%, the overall processing time was significantly reduced. Therefore, a performance requirement that was not identified before is related to the percentage of backorders produced by the IS. The following paragraphs describe the results obtained from the BPISS model.

The results of the BPISS model reported a significant reduction in the totality of lead times, in particular, backorder lead times. Table 1 shows that backorder lead-time for both, Thessaloniki and Northern Greece were reduced in more than 80%.

Table 1 Table 1 BPISS Model Results

	BPFE Model	BPS/ISS Model	Difference	Difference (in %)
Orders (Thessaloniki) in hrs.	29.605	23.659	-5.946	-20.0844452
Orders (Northern Greece) in hrs.	44.344	44.127	-0.217	-0.489355944
Backorders (Thessaloniki) in hrs.	276.971	39.998	-236.973	-85.55877691
Backorders (Northern Greece) in hrs.	279.147	46.498	-232.649	-83.34282654
Total (Thessaloniki) in hrs.	87.136	36.102	-51.034	-58.5682152
Total (Northern Greece) in hrs.	97.407	52.885	-44.522	-45.70718737
Number of orders produced	3097.333	3166	68.667	2.216971827
Number of backorders produced	801.333	1125.667	324.334	40.47430968
% of backorders	25.87170963	35.55486418	9.683154553	

The reductions on lead-time, however, were still below the organisational targets. An interesting observation in Table 1 is that the percentage of backorders produced by the BPISS model reported an increase of nearly 10%, a situation that contradicts the assumptions made in Step Two. A possible reason that causes this situation is that the minimum product stock level used in the model (10 products) produces a greater number of backorders. This event, though, does not affect backorder lead-time because the new system schedules delivery times in a more accurate manner than the manual system. Experimenting with the BPISS model showed that a possible way of reducing backorders and consequently lead time is to increment the minimum stock level for each product. The results suggested a minimum stock level of 100 items for each product reduced the number of backorders having only 5% of backorders.

CONCLUSIONS AND FURTHER RESEARCH

This paper provided evidence that despite the fact BP and IT interact in practice, existing BP and IS design approaches and modelling techniques do not provide a clear guidance of how to address the relationship between BP and IT. Trying to address this problem, the ASSESS-IT framework proposes the use of BPS and CNS to coordinate the design of business process and IT simulation models and depict the effect that changes on any of these domains may have on the others.

The results derived from the ASSESS-IT framework suggest that the relationship between BP and IT can be described as the relationship between business processes and the information system that support those processes, and not as a three layered structured (BP, IS and CN). Furthermore, the results from the ASSESS-IT framework found that in order to depict the interactions between BP and IS it is necessary to portray IS non-functional requirements, in particular IS performance requirements.

This paper used this knowledge to propose and test a new simulation framework, namely BPISS, to develop simulation models that depict business process and information systems performance.

The BPISS simulation results demonstrated that it is possible to obtain performance measurements of the IS and depict the way the insertion of IS affects BP performance. For example, the model provided quantifiable metrics of the IS, such as the number of backorders that the IS produces over a given period of time given a particular organisational context. These measurements helped to investigate the way IS may affect process performance. For example, new backordering delivery lead times that considered the effects that the IS has on the backordering process were obtained.

The experiment showed that depicting the behaviour of the IS and the effects that the latter would have on the processes is feasible, however, this was not and easy task. Despite the simplicity of the case study used to test this framework the development of the model proved to be complex. It is thought that the higher the complexity of the IS the harder the construction of the simulation model. Regardless of these drawbacks, the results of the experiment provided alternative information to assess the impact of IS on process performance. Furthermore, It was noticed that process and IS functionality are intrinsically related and further research is needed to analyse this relationship in more detail.

Finally, one of the major constraints when developing the simulation models was due to the fact that the discrete-event simulation tool used in the project was designed to simulate business process, hence it offered limited capabilities to simulate the information system functionality. Further research in this area is also needed in order to identify simulation tools that offer better capabilities to model the elements required to simulate the IS functionality.

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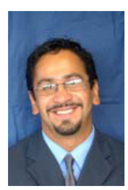
BIOGRAPHY



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