SDPS-2011
Printed in the United States of America, June, 2011

A PROCESS SCIENCE AND TECHNOLOGY STUDY APPLIED TO THE LABORATORY OF INTEGRATION AND TESTING OF THE NATIONAL SPACE RESEARCH INSTITUTE (LIT/INPE)

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ABSTRACT

Process Science and Technology and Design and Process Science are used as synonyms in this work to designate an innovative and transdisciplinary study and research branch that consists of the integration of concepts, methods, and tools used for modeling, simulation, automation and management of processes, and of their application to solve business process problems in general. This work proposes a unified approach for conducting a Process Science and Technology study based on the integrated use of three techniques: Unified Conceptual Modeling, Process Simulation, and Business Process Management. The approach covers the development of the whole process model life cycle and its potentialities are demonstrated by its application on a real case study, the Laboratory of Integration and Testing of the National Space Research Institute, Brazil.

INTRODUCTION

Modern organizations are constantly required to discover solutions for complex problems and to adapt their business processes accordingly, as they strive to satisfy a highly demanding and competitive market.

The organizations must also be very efficient in the use of their resources of all types, energy or capital, human or material, in order to keep themselves economically viable while seeking to fulfill their clients' changing demands and facing the new challenges posed to them.

In the never-ending search to attend these objectives, the organizations are increasingly relying on advanced technological resources to improve the management of their processes, such as Process Simulation and Business Process Management Systems (BPMS).

Process Simulation is a valuable technique towards this goal, since it provides a way to emulate the systems behavior and to assess its performance without the need to interfere with the real system's operation. This characteristic brings great advantages in many real case studies, such as in the services provided by hospitals, which are not allowed to alter or halt its activities just to collect data for analysis and a later improvement of its business processes. The same happens in the case of expensive or risky plant operations, such as a nuclear or hydraulic power plant, whose "production line" cannot be stopped at any time for the sake of testing the implementation of new procedures. These have always been seen as the main arguments in favor of the use of the simulation technique for conducting studies of systems of a complex, risky and/or expensive nature.

Business Process Management (BPM) acts as a management philosophy in process theory. Its main objective is to provide the correct information elements for the adequate allocation of the organization's resources by its directors and managers. This increases its efficiency and revenues, by means of a systematic management of the of its business processes. The technological solution in support of this management philosophy is known as BPMS.

The BPMS work throughout the whole development process of the model life cycle of business process studies: modeling, implementation, execution, automation, monitoring, analysis and continuous improvement of the system. They provide an environment for the complete development and deployment of an application that will act as part of the mechanisms used in the operation of the real system, playing a major role in aspects regarding its execution, its monitoring and control, and contributing for its continuous improvement.

Process Science and Technology and Design and Process Science are used in this work as synonyms to designate an innovative and transdisciplinary study and research branch, consisting of the integration and application of methods, techniques and tools originated in diverse autonomous process study and research branches, such as Project Management, Process (Re) Engineering, Business Process Management and System Simulation. Process Science and Technology covers the whole process model development life cycle, aiming at the modeling, execution, analysis and improvement of process models for the study and solution of complex process problems in general. The original denomination is due to the Society for Design and Process Science and her founders (SDPS, 2011), whereas the new one is a free alternative interpretation of the original term scope and meaning made by the authors of this article, who wanted to stress the development of software products, especially those related with business process models for producing and managing the development of complex products and services in general.

This work presents a unified approach for conducting a Process Science and Technology study applied to a system of the spatial area. Initially one tries to identify and organize the basic concepts related with the Process Science and Technology itself, which is a knowledge area still under development, in order to contribute with its consolidation. In the following a study case is presented, involving the commercial services provided by the Laboratory of Integration and Testing (LIT) of the National Space Research Institute (INPE), Brazil, for a demonstration of the potential of the techniques and tools proposed. The models and applications developed aim at supporting the decision taking about the real system, regarding its execution, its automation, its performance assessment and monitoring capacities, as well as its continuous process improvement.

This article is structured in the following way: section 1 consists of this introduction; section 2 presents the authors' motivation; section 3 presents its objectives; section 4 defines Unified Conceptual Modeling; section 5 describes the meaning of the Unified Approach for Modeling, Simulation and Business Process Management used in this work; section 6 describes the problem used as the case study, the Laboratory of Integration and Testing of the National Space Research Institute, Brazil; section 7 presents the software tools used in the research; section 8 reports on the development of the study and its actual status; section 9 performs the analysis of the results and draws some conclusions.

MOTIVATION

LIT's staff finds it hard to assure an efficient management of the services processes performed by the laboratory, especially when the activities related with the space missions occur simultaneously with those related with the accomplishment of external clients commercial service orders. This happens because there is a great diversity and quantity of resources allocated to LIT's services processes, such as: human resources, constituted by its engineers and technicians; material resources, constituted by its climatic chambers, thermo-vacuum chambers, vibrators, anechoic chambers, warehousing sites, offices, meeting rooms, among others.

Additionally there is the fact that the quantity of the services provided, as a sum of the activities originated from the space missions and those from the commercial services orders, has been growing steadily (LIT, 2009), which leads to even greater problem forecasts for the future of the organization.

In the search for mechanisms to support addressing these problems and finding a solution for them, the authors identified in the concepts and techniques described in this work, such as Unified Conceptual Modeling and the Unified Approach for Modeling, Simulation and Business Process Management, a solid basis for developing a a complete and unified approach, covering the development of the whole process model life cycle, for conducting Process Science and Technology studies applied to support decision taking about systems of the spatial area.

OBJECTIVES

This work aims at the creation and consolidation of concepts, methods and techniques to be used in Process Science and Technology and, based on them, at the development of a complete study of the process model life cycle of LIT/INPE, focusing on the commercial services provided by it for the Brazilian industrial sector, but taking also into account their interface with the activities originated from INPE's spatial program.

The general objective is to contribute with the extension and solidification of Process Science and Technology body of knowledge itself, involving both methodological and technological aspects related with the development of its supporting environments; the specific objective is to create an operational process model of the commercial services processes provided by LIT, in order to help decision taking about the system, involving the aspects of modeling, execution, performance assessment and capacities for control and monitoring, as well as of analysis and of continuous improvement of its component processes.

UNIFIED CONCEPTUAL MODELING

Conceptual modeling is the first step of the abstraction exercise performed by the analyst for building a model of a real system. This abstraction process results – in the majority of cases – in a simplified logical version of the real system, otherwise it would be impossible to work with the model efficiently. It constitutes the most important (and difficult) phase in the development life cycle of models of all areas of interest of process studies, not only those made for simulation purposes.

There are many important aspects that are affected by this initial phase of the model development life cycle of process studies. Among the influences of the modeling on the subsequent phases of a process study, one can list: (1) input requirements; (2) the total effort and time span required for model development; (3) the validity of the model, that is, its capacity to represent faithfully the real system; (4) the project of experiment; (5) the degree of confidence on model's results.

One observes, nevertheless, that this is one of the most unknown and informally treated aspects in the model life cycle of process studies in general. This is a good reason to direct efforts to research and develop concepts and methods to assure a thorough understanding of the conceptual modeling process by everybody involved in these studies, be it users, technicians or managers. Some recent works in this area proposes the use of a multifaceted representation for creating an Unified Conceptual Modeling procedure and advocates that this is one of the most important and beneficial issues in a system simulation study (Onggo, 2009), what might be extended to other kind of process studies in general.

In this work it is adopted, for greater simplicity and clarity, the graphical notation BPMN (Business Process Modeling Notation) for the description of the logical structure of the business processes and the ACDs (Activity Cycle Diagrams) for a synthesis of the dynamic behavior of the model, to allow its rapid implementation both in the BPMS and process simulation tools.

AUNIFIED APPROACH FOR MODELING, SIMULATION AND BUSINESS PROCESS MANAGEMENT

Figure 1 shows the complete process model life cycle according to the Unified Approach for Modeling, Simulation and BPM proposed in this work. The rounded rectangles represent the macro activities and the cylinders represent databases with the model's different types of representations. In this approach, simulation is at the core of a unified model development life cycle, differently from traditional PDCAs, in which the simulation model is created near the end of the business process model life cycle, as an additional and independent construction, in support to the its phase of model analysis and improvement. In the Unified Approach for Modeling, Simulation and Business Process Management, the process model and the simulation model are the same, Simulation and BPM are two variants of a unified procedure, aimed at conducting a thorough analysis and understanding of the system from different viewpoints. The cycle starts with the definition of the system and of the study's objectives, equivalent to the requirements' specification phase of systems engineering, which determines the scope of the model to be built. The specification of the logical structure of the organization's model and of the study's objectives is the main product of this phase: the unified conceptual model, together with the system's boundaries, the model control parameters and eventual additional premises and restraints. One important remark that needs to be made is that the unified conceptual model is understood as the logical content of the system and of the study's objective, any kind of graphics and diagramming technique used thereafter belongs to the next phase described below, the building of the communicative model.

The next step is the building of the communicative process model, for representation of the unified conceptual model making use of different formats, such as workflow charts and all other sorts of diagramming techniques, as exemplified by BPMN, UML, ACDs or Petri-Net diagrams. The entities and resources involved and their interaction to perform the chain of activities (model's dynamic) are described explicitly in this phase.

The communicative model undergoes a third phase of transformation, the implementation or model programming, yielding the programmed model or model's applications, which might be seen as different software systems or the same system that can be executed according to two different threads, one for process enactment in production mode, with management facilities, and the other one for the simulation of the process with built in project of experiments, the building of scenarios and visualizations facilities embedded. Both threads are fed by the unified process model, produced from the a set of communicative models and, in case of different implementations, verified to assess its consistence and validity in regard to system's specifications.

Data collected during real system's operation are used as input data for simulation model execution as well. This way the process simulation is more faithful to reality and future scenarios projections are more reliable.

The results from these two threads of execution, corresponding to the process execution and monitoring and to the process simulation and visualization, provide information for the next phase of process analysis and assessment.

The process analysis and assessment phase uses appropriate metrics and results for process model improvement, restarting the cycle.

THE LIT COMPLEX AND ITS LAB UNITS

The LIT complex is composed by several small laboratory units located in the same building, conceived for mounting, integrating and testing spatial devices for the Brazilian Space Program (LIT, 2011). The main Brazilian satellites and some satellites developed in cooperation with foreign partners, such as China, Argentine and USA, have been built and tested in this plant.

LIT's lab units are equipped with advanced technological devices and is staffed with highly specialized personnel (technicians and engineers) and they perform, to a certain extent, autonomous and complementary activities, to attend INPE's spatial mission and commercial service orders from the external industrial sector. Some of these labs are:

- Antennae Laboratory

- EMI/EMC Measurements Laboratory
- Mass Properties Measurements Laboratory
- Metrological Laboratory
- Components Qualification Laboratory
- Thermal Vacuum Laboratory
- Vibration and Shock/Vibroacoustic Laboratory

THE SERVICE PROCESSES OF LIT

The main activities developed by LIT are related with the fulfillment of the Brazilian Spatial Program, conducted by INPE. LIT's interface with the spatial program is carried out by a senior member of the staff, usually an engineer with participation in former spatial missions. Usually there is a different member of the team responsible for each mission. The way LIT communicates with the spatial mission is by means of Gantt charts, showing resources allocation and the timetable for all activities of the individual labs.

Besides the activities related with the spatial program, LIT provides services to the industrial sector, offering the know-how acquired by its participation in the Brazilian Space Program to support the development of the national industry. These activities occur simultaneously with those of the spatial program, the last of them receiving a higher priority, whenever there is a conflict or competition for resources.

There is a special sector of LIT called PAC – Planning, Analysis and Costs – which is in charge of the communication with the commercial client, dealing with the proposal's assessment (for generation of a service order), as well as the messaging regarding acceptance and invoicing. Another sector, called Warehousing, is responsible for the reception, the storage and the return of all equipment sent for testing by the commercial clients. A third important sector deals with the filing and control of all documentation generated by the processes or received from the external world.

The commercial services processes are the focus of this article and they are described in (LIT, 2005) which has been summarized grouped below in three phases, each one addressing a part of the model life cycle of the system, from the proposal reception, passing by the execution of the service order, to the final phase of payment and the issuing of invoice and receipt for the services provided.

The Proposal Elaboration Phase

The client sends some sort of service request – by telephone, e-mail or fax – to LIT's Commercial Sector. A member of the staff decomposes and register the service request in an online form, in which every kind of service provided by LIT is listed.

After the form is completed it generates a number, called process number, to be used as reference for following up purposes of the progress of the service order through the system.

Each service order needs to be assessed by the technical staff and a record is generated, containing the start date, the number of working hours necessary for service execution, and its conclusion date.

The system helps the data input and the elaboration of the answers from the individual labs, by maintaining a database with all scheduled activities (a chronogram) of each lab, by suggesting the number of hours needed for execution of the service and by making a forecast of its conclusion's date. The answers from the individual labs are further reviewed and aggregated by the system and they are made available to the Commercial Sector for preparation of the commercial proposal to be sent to the customer.

The Technical Area is notified about the requests generated by the Commercial Sector in order to be able to answer them and the Commercial Sector is notified about the answers given by the Technical Sector to these requests. The system warns both the Commercial Sector and the Technical Area if a certain request is not answered within predefined time duration.

The Commercial Sector elaborates the commercial proposal and sends it for approval by the management.

Once approved by the management, the Commercial Sector sends the proposal to the client via mail, fax or e-mail, and registers this information in the system.

If the finish date of the proposal's validity is approaching, the Commercial Sector is notified by the system in order to contact the customer and to request an answer whether the proposal was accepted or rejected. The acceptation or rejection of the proposal is registered in the system.

If there is a confirmation of acceptation from the client, the Technical Area is notified by the system. If no confirmation is received from the client until the proposal expires, both the Commercial Sector and the Technical Area are notified by the system.

The Execution Phase

When the services involve the testing of equipments, the Warehousing Sector receives the external client's device in the Storage Room and, in case of service orders from internal clients, the device is sent directly to the lab, where it is filed and registered in the system. The commercial proposal associated with the equipment received is located in the system using its reference number.

If the equipment was received without any formal service request or previously to the issuing and/or acceptation of a commercial proposal by the client, the Storage Sector notifies the Commercial Sector for it to take the necessary measures to deal with that exception.

When the arrival of equipment is registered, the system notifies the Technical and the Commercial Areas.

Once in possession of the equipment, the area opens a service order and this service order is constantly updated during service execution. Even services that do not involve equipment need to have a service order issued for them.

After service is completed, the area registers in the system its conclusion, by closing the service order. When applicable, the equipment is sent to the Storage Room, to be picked up by the external customer. The internal customers withdraw the equipment directly from the lab.

The documents generated (certificates, reports and others) are sent to the Commercial Sector, where they are registered and a copy is sent to the customers. Another copy is sent to the Documentation Sector, which is responsible to complete the registering data, such as storage location, for example.

The digitalized data are input to the system by each area and the Commercial Sector is notified by the system in order to register them and to send them to the clients. After registering by the Commercial Sector, the Documentation Sector is notified about them as well.

When a service is not finished by its due date according to its service order, the system warns the Technical Area.

When the equipment arrives at the Storage Sector the delivery term (partial or complete) is issued via the system. The Storage Sector waits until the client withdraws the equipment, holding it in the Storage Room (external clients) or in the lab (internal clients). Once the equipment is withdrawn, the information is registered in the system.

The Invoice Issuing Phase

The Commercial Sector, using the system, generates the necessary data for the elaboration of the tax invoice and receipt and sends them to the Foundation responsible for issuing these documents and for receiving the payment from the client. The Foundation sends the tax invoice and receipt back to the Commercial Sector, who registers the data and send them forward to the client.

The Commercial Sector awaits the client's payment and, once it is done, updates the system with this information.

THE APPLICATION TOOLS

The Simulation and Business Process models of the system were implemented using the BPMS Bizagi® (BizAgi 2011) and the SIMPROCESS® (SIMPROCESS 2011) simulation systems, chosen among other COTS systems due to their diversity of functionalities, friendliness of use and the existence of academic licenses, gently made available to INPE by their suppliers in support for the development of this study in an academic environment with teaching and researching objectives.

BPMS BizAgi ®

A Business Process model can be superficially seen as the evolution of the workflow model of a process, that is, a structured set of activities to be executed, consecutively or in parallel, by individuals, machines or applications, in order to reach a given objective. A Business Process Model, nevertheless, extends far beyond this simple definition of the dynamic behavior and the interaction of the process resources. It encompasses the organizations business rules, the strategic guidelines and politics of the enterprise, the exceptions handling mechanisms, information databases and other kinds of elements, which might undergo continuous modification.

BizAgi ® is a BPMS, an environment used to support the building of applications to automate complex business processes in a rapid and flexible way. It helps the users throughout all the development phases of the model life cycle, shortening system's development and deployment times and leading up to the continuous improvement of the organization's critical processes.

Bizagi applications are built progressively, starting with a process model of a workflow type, built in BPMN notation using a process modeler, and finishing with a Web application that executes as an embedded software component of the real system, automating, integrating and orchestrating all activities and resources involved in its operation.

BizAgi assures the efficient and adequate execution of all sequence of activities involved in the Business Process, by the correct person or resource, according to the enterprises' objectives and rules, allowing for the monitoring and the control of the process to be performed in real time.

BizAgi extracts the information related with process performance automatically and presents it to the right organization's personnel, helping improving the processes and increasing their efficiency. It offers an incomparable level of flexibility for modifying the Business Process in a simple, intuitive and consistent manner.

SIMPROCESS® Simulation System

SIMPROCESS is a tool for hierarchical modeling which combines the power of Process Mapping, Discrete Event Simulation and Activity Based Costing (ABC) in one friendly Graphical User Interface.

SIMPROCESS can be used equivalently to a Decision Support System for analysis and decision taking about complex process systems, centered on the use of Modeling and Simulation techniques for process model building, execution and control, analysis, monitoring, and continuous model improvement.

SIMPROCESS comes with a library of predefined components for the rapid creation of dynamic business process models, while an incorporated script language allows experienced programmers to add logic to the more complicated business process. SIMPROCESS is indicated for organizations which want to reduce the risks associated with dramatic changes in their processes. The tool allows the users, in a fast and easy way, to analyze different what-if scenarios and to make use of Java and XML technologies to attend the needs of their organizations for developing powerful and flexible process models.

The main characteristics of SIMPROCESS are: hierarchical Process Mapping; Object Oriented Methodology; Activity-Based Costing; animation; reports and graphical analysis through interfacing with MS-Access®; development by drag-and-drop procedures; reusable process models; realistic activities estimates; resources and consumable goods costs evaluation; dynamic visualization of the process and its bottlenecks; customizable reports, future scenarios and what-if analysis.

RESEARCH PROGRESS AND CURRENT STATUS

The development of a Process Science and Technology study is an exercise of directly building and applying integrated and unified knowledge and techniques (transdisciplinarity) to the solution of a complex process problem.

The alternative is to treat the same problem making use of n different and usually independent knowledge areas and techniques (multidisciplinarity) for achieving a variety of insights and results and, since they are treated as independent coordinates, putting them together to build the full n-dimensional picture of the solution.

In the Process Science and Technology case study presented in this work, the three different knowledge areas and techniques identified and the way they are used in the solution of the problem are:

- Project Management: the requests for testing and the scheduling of activities built based on them, which represent the demand for LIT's services linked to the spatial missions, as well as the resulting scheduling from the accepted proposals from clients of the commercial services, are described by Gantt graphics, created by software tools such as MSProject.
- Business Process Management: BMPS are used in support of the modeling, execution and management of the processes. The data generated by real system operated by the embedded BPMS application will further be used as the main source of data for input in the simulation modeling process, as well as the definition of the process simulation model control parameters, project of experiment, analysis and the validation of the simulation.
- Process Simulation: The process models are built, implemented and executed making use of Unified Conceptual Modeling and of a Unified approach for Modeling, Simulation and Business Process Management concepts, that is, trying to keep a unified view of the process model throughout its complete life cycle, from modeling to their different implementations, trying to assure consistency and equivalence through their different representation formats.

To keep the model simple and gain the necessary skill with the modeling and the application of the different software tools, the LIT process model was created initially containing only a limited set of processes, namely the commercial services processes, which have been simplified and represented using only macro components and a reduced number of laboratory units and resources.

In future versions of the model, as the research progresses, the interface with the spatial mission processes and the complete set of laboratory units will be added, as well as a more detailed representation of the process model components involved, what can be done hierarchically, both in SIMPROCESS and Bizagi.

The modeling process started by making use of Bizagi Process Modeler to build the BPMN description of the system. In this model two macro processes have been defined (pools), namely the client and the LIT processes, the last one divided into lanes, represented by the Commercial Sector, the Documentation Sector, the Head Office, the Laboratory (an aggregate of unit labs) and the Storage Room.

In parallel, the process model built in BPMN was also used to guide the elaboration of the simulation model to be implemented in SIMPROCESS, together with the model representation made using Activity Cycle Diagrams, containing a better description of the network of queues and activities involved in the process. The ACDs diagrams define also the interaction of the resources for the accomplishment of the set of processes representative of the commercial services provided by LIT.

The model building using SIMPROCESS Graphical User Interface has benefited from the fact that the same icons used in the description of the commercial services could be imported into the simulation system and could be used to describe the hierarchical structure of the system, making the model more familiar and easy to understand to all participants of the project.

The next step was to determine the statistical distributions to be used to represent the duration of each activity, what was again facilitated by the use of the application ExpertFit. This tool comes together with SIMPROCESS simulation system and it allowed that data from the operation of the real system, extracted from LIT's information system (eLIT), could be used to find the best distribution which fits each activity duration.

BPMS Suite BizAgi was used to create a preliminary executable version of the system from the BPMN description of the model created using the Process Modeler, but the original BPMN model has to be altered and complemented for this to be accomplished.

The products yielded by the research so far were: a simplified process model of the commercial services provided by LIT (industrial sector supporting activities), modeled in BPMN and ACDs notations; the corresponding simplified model implementations, both in the BPMS Suite Bizagi and in the SIMPROCESS simulation system; some facilities for experimenting with the simulation model, such as the curves distribution fits for the duration of each activity; and a technical report written summarizing all analysis and conclusions about the problem drawn until now.

ANALYSIS AND CONCLUSIONS

The unified approach devised to conduct a study of Process Science and Technology applied to LIT's services processes shown in this work was based on two methodological fundamentals: the use of Unified Conceptual Modeling principles for building the process model representations of the system and the use of a Unified Approach for Modeling, Simulation and Management to implement these models. Each of these fundamentals covers a part of the process model development and together they cover all aspects of its whole process model life cycle.

The choice of the two representation formats, BPMN and ACD Diagrams, was made due to their ease of understanding and the fact that they are patterns traditionally used in its respective knowledge area and, in the case of BPMN, widely supported and maintained.

The case study conducted on a real problem, the commercial services provided by LIT in support to the Brazilian industrial sector, demonstrated the potentialities of the approach. These potentialities include:

- Different views of the model are created: the BPMN model shows its logical structural aspects and the ACD representation and simulation model show its dynamic behavior and the interaction between the system's resources for the accomplishment of the processes;
- The use of a multifaceted modeling aids to a better visualization and communication of the model among the participants, as well as in the documentation of the model;
- The essentials aspects of the model are identified in the beginning of the modeling process, but these aspects need (and ought to) be enhanced during the next steps performed by the analyst, while he implements the models in the BPM and simulation systems.
- As a consequence and a synthesis of the above mentioned, a better understanding of the problem is achieved and there is a considerable speed up in the complete model's development life cycle;

SIMPROCESS turned out to be a very versatile tool, offering a diversity of functionalities and resources. Among them, one shall remark:

- Customizable icons, which allowed the creation of a more communicative and familiar model to the team of developers;
- The creation of scripts, which allowed the customization of the tool and the introduction of specific logical aspects of the model;
- The plotting of graphical results during model execution, which enhances model understanding and analysis;
- The ExpertFit tool, which allowed the use of formal statistical distributions to represent essential characteristics of the model, exploiting to the best the use of the data collected from the operation of the real system.

The simulation study of the model produced a series of preliminary results, which were consistent with those of the real system, helping to understand better the commercial services processes provided by LIT and to identify some of their deficiencies. A list of suggestions is made below for the improvements of the model and of the services provided, even though some of them might impact considerably on model structure and complexity:

- Discrimination of resources used in the Laboratory, classifying them into Engineers and Technicians;
- Discrimination of resources used in the Commercial Sector, classifying them into Administrative Assistant, Commercial Manager and Responsible for Invoicing;
- Discrimination of the types of Services provided (there are approximately 50 different types);
- Identification of exceptions and devising mechanisms for handling them;
- Inclusion of the space missions processes: mounting, integration and testing of spatial systems.

The non-existence of a completely integrated and unified environment for simulation and BPM was overcome by the independent modeling using BPMN and ACDs and the independent application of SIMPROCESS and BIZAGI as well. This naturally sends one back to the multidisciplinarity reality of the achieved solution, as opposed to the transdisciplinarity promise of the proposed approach.

Each of the techniques used handled one dimension of the model analysis, being the point of view of the production engineer (the operational approach) dealt with by the simulation modeling and the point of view of the business manager (the BPM approach) dealt with by the BPMS application.

This drawback resulting from the independent use of the different techniques, namely simulation modeling and BPM, to cover different phases of the process model life cycle - modeling (BPMN/ACD) and implementation (BizAgi/SIMPROCESS) – turned out to be a very expensive procedure in regard to maintaining model consistency and compatibility.

This handicap will be treated in more detail in the continuation of this work, which will target the improvement of the models and the creation of verification formal procedures and software mechanisms to improve the LIT's services process model consistency and compatibility.

The authors advocate, however, that a more encompassing and definitive solution for this problem can only be achieved through the development of a unified methodology and its supporting environment for the development of Process Science and Technology studies in general.

Each step taken on the way to improve the achieved solution and to apply the same methodology on other study cases will also represent a step forward in the evolution path of an adequate framework to conduct the development of Process Science and Technology studies in general.

This framework can be defined as the combination of three elements: a structure with the representation of the knowledge on processes, the implementation method and its supporting tools. This framework, which would implement what could be called a Unified Methodology for Process Science and Technology, shall be based on the integrated use of consecrated pattern(s), verification mechanisms, communication interfaces, and applications to perform model transcriptions, in order to assure consistency and compatibility across different model formats and the complete interoperability of its component tools.

The main applications might be chosen among existing tools, with additional interfaces built for their integration or, alternatively, one can endeavor the development of an original integrated and unified environment, composed by a set of tools designed from scratch to support the conduction of studies of Process Science and Technology in general.

ACKNOWLEGMENTS

The authors thank the LIT's information systems development team, for the elaboration of the documents which describe its commercial services processes.

Special thanks are also given to the former students of the Simulation and BPM Course, taught by professor Dr. Germano Kienbaum at INPE in 2010- Luiz Alexandre da Silva, Ana Claudia de Paula Silva, Expedito Pinto de Paula Junior e Leonardo Leite Oliva –for the development of LIT's commercial services process model as the course's final project, whose results are incorporated in this article, and whose evolution resulted in the MSc Research Project currently under development by the first author.

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FIGURES

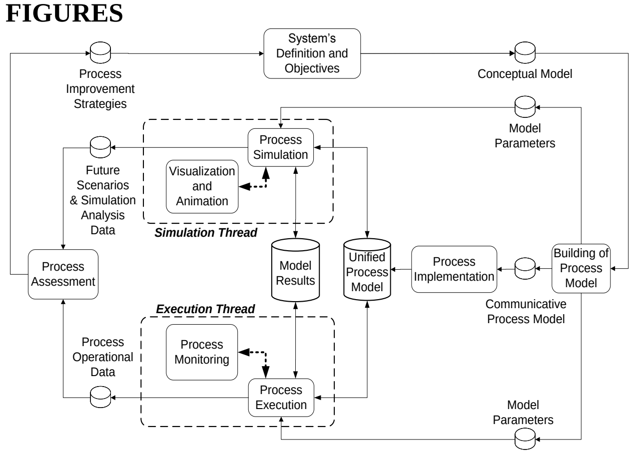

Figure 1: The Unified Approach for Modeling, Simulation and Business Process Management (Source: Travassos et al., 2007, modified by the authors)