Towards Unified Conceptual Modeling and Integrated Analysis in Joint Applications of Project Management, Business Process Management and Simulation

Kienbaum, G. S., PhD; Augusto Neto, A., PhD
Lab. Associado de Comp. e Matemática Aplicadas (LAC)
Instituto Nacional de Pesquisas Espaciais (INPE)
São José dos Campos, SP, Brasil
kienbaum@uol.com.br

dos Santos, C.A.M.B.; Durán, A. N. P.; Fernandez, R.; Fornari, C. I.
Departamento de Engenharia e Tecnologia Espaciais (ETE)
Instituto Nacional de Pesquisas Espaciais (INPE)
São José dos Campos, SP, Brasil
carlos.ambsantos@gmail.com

Abstract—**This work proposes a systematic approach for model building and analysis of the product lifecycle processes of complex systems development, products and/or services, making use of Project Management, Business Process Management and Simulation techniques in an integrated and unified way. The modeling process targets the creation of a unified reference model right from the start, making use of multifaceted and cross consistent representations, aiming at the achievement of the complementary benefits resulting from the application of these diverse views and disciplines. The approach is demonstrated making use of an academic model, describing an online Bookshop, but it envisages real systems applications and its use in Product Lifecycle Management in general.**

Keywords-unified conceptual/communicative modeling; product lifecycle management, business process management; project management; process simulation; process science and technology

I. INTRODUCTION

Process Science and Technology (PROST) is a designation given by the authors [10] to an emerging transdisciplinary science that addresses the integration and unification of concepts and techniques, which were originated and are traditionally used in several autonomous scientific areas, such as: Systems (Concurrent) Engineering (SE), Project Management (PM), Business Process Management (BPM) and Simulation.

The research scope of this emerging unified study area is the complete lifecycle of complex products and services: modeling, building, simulating, automating, managing and continuously improving the system´s concurrent engineering process, described as the integration of product development and organization management processes, by means of creating a unified methodology and its supporting tools.

This unified methodology for conducting a PROST study consists in the building and the application of theoretical and practical integrated and unified–transdisciplinary-knowledge and techniques to a complex discrete event process problem. The main focus is on the development of a unified conceptual/communicative process model of the system (product and organization) under consideration and on its use to implement different applications, according to various disciplines, for its integrated analysis, building, operation, management and continuous improvement.

The present work describes and illustrates a part of the PROST modeling methodology, especially those aspects related with the Product Lifecycle Management (PLM) by the manufacturing organization. The SE aspect, product engineering, is not addressed in the article. The objective is to perform PLM making simultaneous use of PM, BPM and Simulation techniques and achieving the complementary benefits of their joint application.

II. UNIFIED CONCEPTUAL MODELING FOR JOINT PM, BPM AND SIMULATION APPLICATIONS

Figure 1 shows the unified conceptual modeling approach for joint applications of the disciplines or dimensions of PM, BPM and Simulation proposed by the authors.
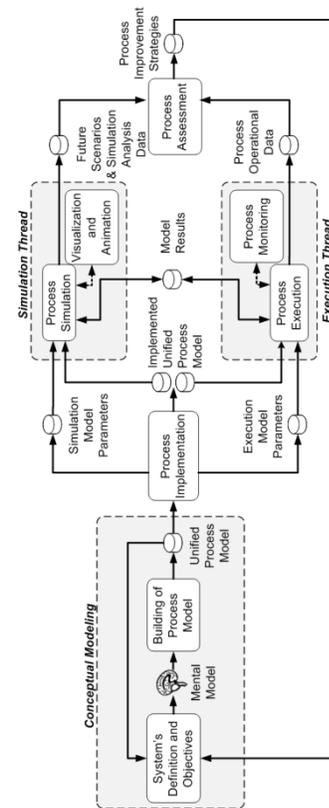

Figure 1. - The Unified Approach for PM, BPM and Simulation [11].

The rounded rectangles are the transformation processes and the cylinders stand for the model knowledge content (databases with the model description) at a specific point in time. The Unified Implemented Process Model is the model created by the Unified Conceptual Modeling and the Model Implementation phases, and it might be represented by various diagrams, textual descriptions and applications developed, as suggested in Onggo [5], each one related with a specific discipline or model view.

In the proposed approach, simulation lays in the core of the process model lifecycle, differently from traditional Plan-Do-Check-Act (PDCA) procedures, as for example in Naidoo and Muehlen [3], which puts simulation as an independent and accessory procedure, to be carried out independently and near the end of the model lifecycle, in support of the phases of model assessment, validation and improvement.

In the proposed unified approach the PM, BPM and simulation models are just different views of the same artifact, the reference model; PM, BPM and Simulation are just different phases or modeling perspectives belonging to a unified procedure. Model's analysis and revision are conducted according to each one of these modeling perspectives, aiming at a more complete analysis and achievement of the complementary benefits from the joint application of these study areas, usually considered as autonomous disciplines.

The cycle starts with the definition of the system and of the study's objectives, which determine the scope of the model to be built. The specification of the logical structure of the product lifecycle model together with the organization's management process (the unified system´s) model according to the study's objectives is the main product of this phase: the mental or conceptual unified model, together with the system's boundaries, the model control parameters and eventual additional premises and restraints.

The mental or conceptual unified model is a concept that needs to be understood as the logical content of the system's operation taking into account the study's objectives. The concept of mental model is similar to the one presented in Nance's conical methodology for building the conceptual or logical model [4], defined separately and prior to the creation of the communicative process model.

Besides the idea of a unified conceptual model for both product´s development and organization´s management processes (system´s unified processes), another important difference in relation to Onggo´s [5] formulation of multifaceted modeling is that all these representations must be kept consistent with a single reference model that is created at the very start of the modeling process.

The reference model is created making use of ULMD (Unified Lifecycle Modeling Diagrams), a notation based on an extension of ACDs (Activity Cycle Diagrams) [8] and PERT-like diagrams, originally proposed in Travassos with the denomination of USMD (Unified Simulation Modeling Diagrams) [12]. The use of ULMD is a corner stone of the methodology, in order to assure the unified conceptual and communicative modeling processes and the cross consistence of the other communicative models to be created later using several kinds of notations.

The next step is building the various system´s unified processes communicative models, by transforming the conceptual/communicative model from ULMD into different formats, such as workflow charts and all other sorts of diagramming techniques, as exemplified by PERT (Project Evaluation and Review Technique) diagrams, UML activity diagrams or Petri-Net diagrams, BPD (Business Process Diagrams), etc.

The communicative process models undergo a third step of transformation, the implementation or model programming, yielding the implemented 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 business process and project management facilities, and the other one for simulation with design 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 consistency and validity in regard to the unified system's specifications. Data collected during real system's operation are used as input data for simulation model execution, making validation easier and future scenarios projections more reliable.

The results from the two threads of execution (process execution and monitoring, simulation visualization) provide information for the next phase of process analysis and assessment. The process analysis and assessment step shall be carried out according to the diverse views and disciplines, making use of the appropriate metrics, with the aim of continuous process model improvement, by restarting the cycle.

III. THE ONLINE BOOKSHOP PROBLEM

The study case selected to demonstrate the application of the methodology proposed in this work is one of a hypothetical online Bookshop, as presented in Aalst [1].

The process model of the virtual Bookshop might be decomposed in three different sub-processes, each one corresponding to a different class of entity or participant of the process: the Clients or Customers, the online Bookshop itself and the Publisher(s).

The clients access the Bookshop´s site online via the Web. Initially the client places an order for a book filling out a form and his order and personal data are registered by the system. The Bookshop then sends the client´s request to a Publisher, who will check if the book exists in store. The publisher sends a message with the information requested and, if the book is not available, the bookshop online communicates this fact to the client and the process ends. If the book is available, the online Bookshop informs the client and pays in advance the publisher, who sends the book directly to the client and notifies the Bookshop of the fact. The Bookshop sends the invoice to the client, who then pays the Bookshop and the complete process is finished.

The reference model is created at the start of the modeling process, making use of the ULMD notation, and it is used to maintain the consistency of the PM, BPM and the Simulation models, to be created later, making use of the appropriate tools. Figure 2 shows the reference model of the online Bookshop problem.
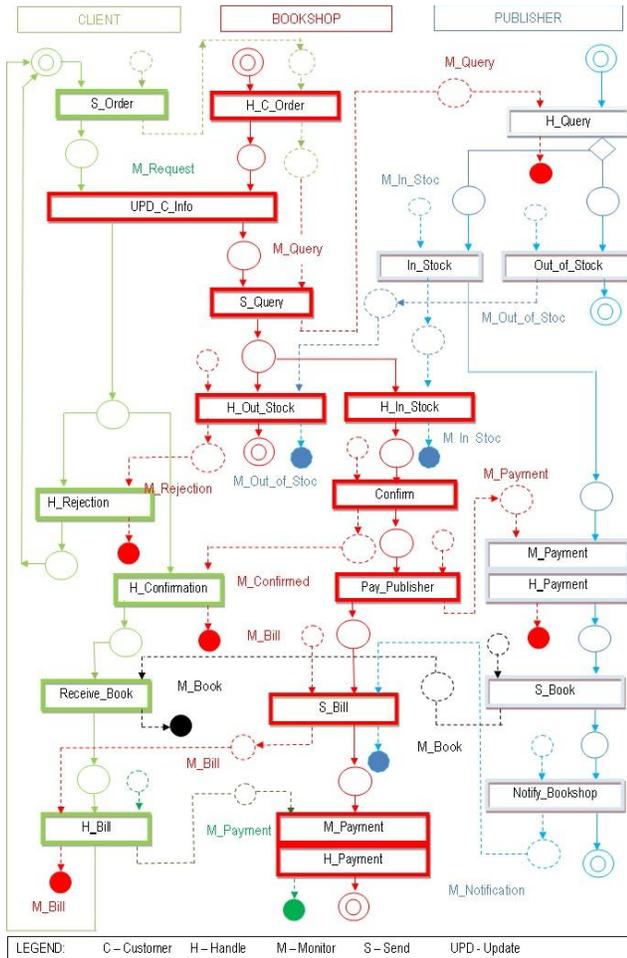

Figure 2.   The Online Bookshop´s Reference Model.

The colors green, red and blue are associated with the main entities involved: the Customers, the Bookshop and the Publisher, respectively. The squares are the macro processes or single activities (transformations that require real time to be executed) and the circles stand for the queues or actual location in which each of the entities (or token representing the control flow) stay along their pathway in their process lifecycles. Actually, one could think of these locations as databases or knowledge contents carried by the entity at a specific point of its path and the complete set of these databases as the descriptive (structural) model, whereas the process map shows the dynamical model associated with the product evolution along its lifecycle. If a complex product is under construction, one could think that a complete

representation (including functional aspects of the product, using for example SYSML notation) could be an artifact produced by a transformation activity in some point in time along the workflow of the product development process.

This type of diagram shows important aspects of the model logic, such as: the main entities which are involved, the flow of control and how the individual processes communicate with each other, the queues in the system, and which resource is responsible for the execution of each activity. In the case of Customers, just one individual at a time is responsible for the activity being executed in his process lifecycle, but the other entity lifecycles could have many resources associated with them, which would mean that several instances of an order or other kind of entity flowing through the process map could be processed simultaneously. The resources are part of the organization´s asset and they might have an associated utilization cost, as well as their availability could be established according to a schedule varying with daytime or weekday, for example. The quantity of resources of each kind can be fixed based on some kind of cost consideration or the throughput of the system can be chosen as the primary control variable for process optimization purposes, and the workload and number of resources necessary could be derived – making use of simulation modeling and performance analysis.

V.   THE PROJECT MANAGEMENT MODEL AND ITS IMPLEMENTATION

The traditional way to describe a project is by representing it as a sequenced network of activities, by means of diagrams known as PERT (Program Evaluation and Review Technique), a renowned and well documented technique, used for management of engineering projects, be it a service provided by an enterprise or an industrial product, aiming at their planning and execution control [8].

A project is traditionally seen as "a single enterprise, of limited time duration, formally organized, which aggregates and applies resources aiming at the fulfillment of precisely pre-established objectives" [7]. This "single enterprise" way of viewing projects might be the reason why projects have been traditionally treated in the literature of the area and by computer systems developers as a matter completely dissociated from business process management and industrial serial processes.

The analogies between these study areas and their particular types of problems become evident, however, when one considers a project not as a single process, but as a serial one or, equivalently, when one looks at it as a multi-project, made by the repetition, in parallel and possibly with some delay between each start, of its basic single process. The objective of a project management study could then be seen as the determination of the ideal basic process descriptive of the project, corresponding to the optimized distribution of all allocated resources to achieve the best performance both in terms of total process time and cost through all stages or phases of the project execution.

The PM model in PROST studies consists of the implementation of the ULMD diagram that describes the concise systems process model and all its essential

functionalities in PM systems. These models are then used for the analysis and management of the project under development, including the identification of the critical path, the balancing of resources for shortening partial cycle times of model´s components, making use of simulation facilities existing in these systems, or by implementing the simulation model as a separate analysis artifact.

VI. THE BPM MODEL AND ITS IMPLEMENTATION

A business process occurs when different entities (individuals and/or organizations) interact to achieve a common business goal. The business process model is described by a workflow of activities, that is, how the entities interact to perform certain tasks in order to meet the business goals. The jobs under execution flow among them and each entity performs the part of the business process he/she is responsible for.

The BPM study area requires process model building in BPMN as a means for the creation of representative models of the product´s or services´ development processes provided by an organization, in order to better understand them and to allow their continuous improvement.

Figure 3 shows the transformation of the ULMD reference model into the BPMN representation using the Bizagi´s Process Modeler graphical editor.

Bizagi is a Business Process Management System (BPMS), a system used for implementation of solutions in order to model, analyze, manage and improve performance of an organization´s business process [2].

Bizagi provides a graphical user interface for business process design based on the BPMN notation – called Process Modeler – and a Suite Bizagi, an environment with many functionalities, for the implementation and the deployment of applications to help real system´s operation, automation, management and control, the monitoring of results and the analysis of performance, in order to continuously improving the organization´s business process.

Graphical editors like Process Modeler allow model building of business process operations making use of a network of graphical objects, constituted mainly by the activities, the routing and the synchronization gates, and the lines showing the flow of control - the activities´ sequence of execution. A BPMS like Bizagi provides several functionalities to help the development of automatic BPM applications, such as:

• Model building, workflow application generation, execution, control, management, automation and simulation of business processes;
• Real time monitoring;
• Communication and quality improvement of business processes;
• Increasing of efficiency and productivity;
• Fast results and good ROI.
• Optimization and continuous improvement of business processes at low cost;

The editor presents a drag and drop menu with the BPMN elements for rapid prototyping of new models, as well as the maintenance or reuse of existing ones or parts thereof. Each component can be individually entered and

configured, making use of the templates representative of the BPMN elements and of context sensitive help, allowing the user to speed up model construction.
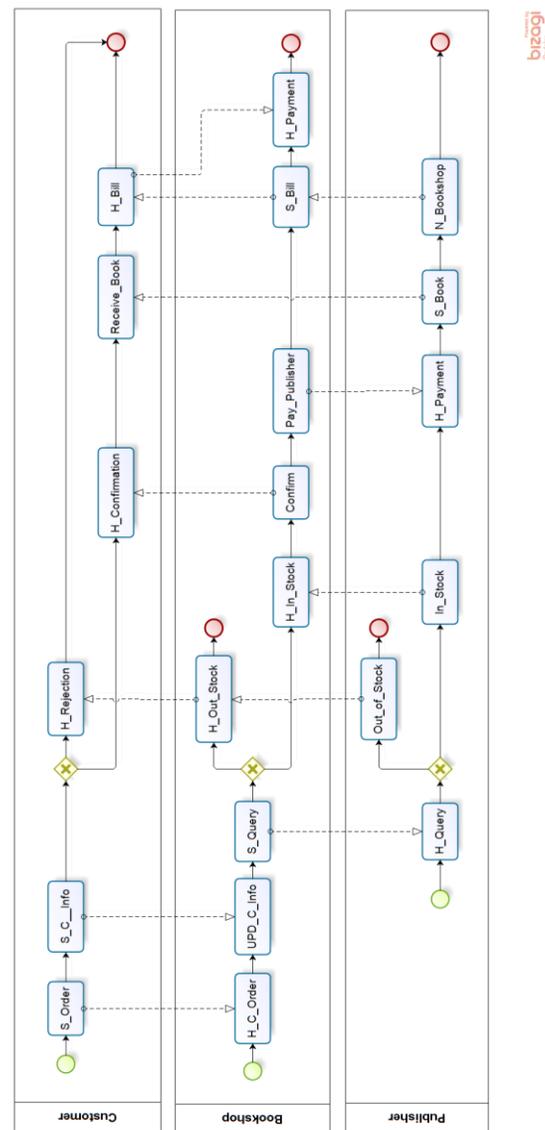

Figure 3. BizAgi´s Model of the Bookshop Online.

The Customer, Bookshop and Publisher processes shown in the reference model were transformed into pools in the business process model and a one-to-one correspondence of each entity´s activities was kept in the BPMN representation format, as well as were kept the control and messages flows connecting the activities in each pool representing the entity´s process cycle.

An interesting remark shall be made in relation to the apparent duplication of the UPD_C_Info activity, which was originally depicted as a single activity under responsibility of the bookshop agent executed in cooperation with the Customer agent in the ULMD model, and now is depicted as a send-receive message pair in the BPMN representation.

Actually, this kind of coupled or synchronized activities shown in the ULMD model is very common and they have been already explicitly represented in other parts of the model, such as the pairs (S_Query/H_Query), (In_Stock/ H_In_Stock), (Out_of_Stock /H_Out_of_Stock), (Confirm/ H_Confirmation), (Pay_Publisher/H_Payment) and (S_Bill/ H_Bill). These coupled activities can either be represented as joint tasks performed under the responsibility of a single agent or split in different pools, in which case they are represented as pair of send/receive sequential activities linked by messages. They are executed in a synchronized way, in the sense their agents interact during their execution and are liberated to continue their individual lifecycle processes after these activities are finished. Both kinds of representations reflect a similar logical construct and they were used interchangeably in the implementations of the BPD (Business Process Diagram) described in this section and in the simulation model to be described in section VII of this article.

The initial BPMN model description built with Process Modeler can be later developed into a fully operational application making use of the BizAgi Suite module. For example, certain activities might require a form for data input by the user. These forms can be designed by the application developer and local and global variables can be defined for model parameterization and flow of control description. Databases can also be used linked to the model operation. There are several objects which might be configured for expressing different prebuilt tasks and a report mechanism linked to the databases helps the management and analysis of model operation.

The BizAgi Suite functionalities allow the model to be deployed and put into operation. The use of this additional module allows the deployment of the model in the form of a Web application accessible by usual Web browsers. A workflow execution engine provides the control for the workflow of activities to be performed by the agents in the application created for support of the management of the real system.

VII. THE SIMULATION MODEL AND ITS IMPLEMENTATION

Similar to the BPMN model representation created with the BPMS BizAgi, a simulation model is built based on the reference model. In the absence of automatic mechanisms for model transformation and verification, this procedure requires the modeler to check himself model fidelity with the reference model and its overall consistency. The transformation from the ULMD notation into a workflow of activities to be implemented using the graphical elements of Simprocess is done in a very straightforward way. One can keep the one-to-one correspondence of activities, as mentioned in the case of the BPD shown in section VI, but the representation chosen was in the form of macro or coupled activities, as a way to emphasize their equivalence. Figure 4 illustrates the online Bookshop model implemented with the GUI interface of the Simprocess simulation system.

Simprocess is a tool for hierarchical process simulation modeling that combines workflow modeling with discrete event simulation capabilities and Activity Based Cost (ABC)

analysis in a single environment with a friendly Graphical User Interface (GUI) [9] for process model design.
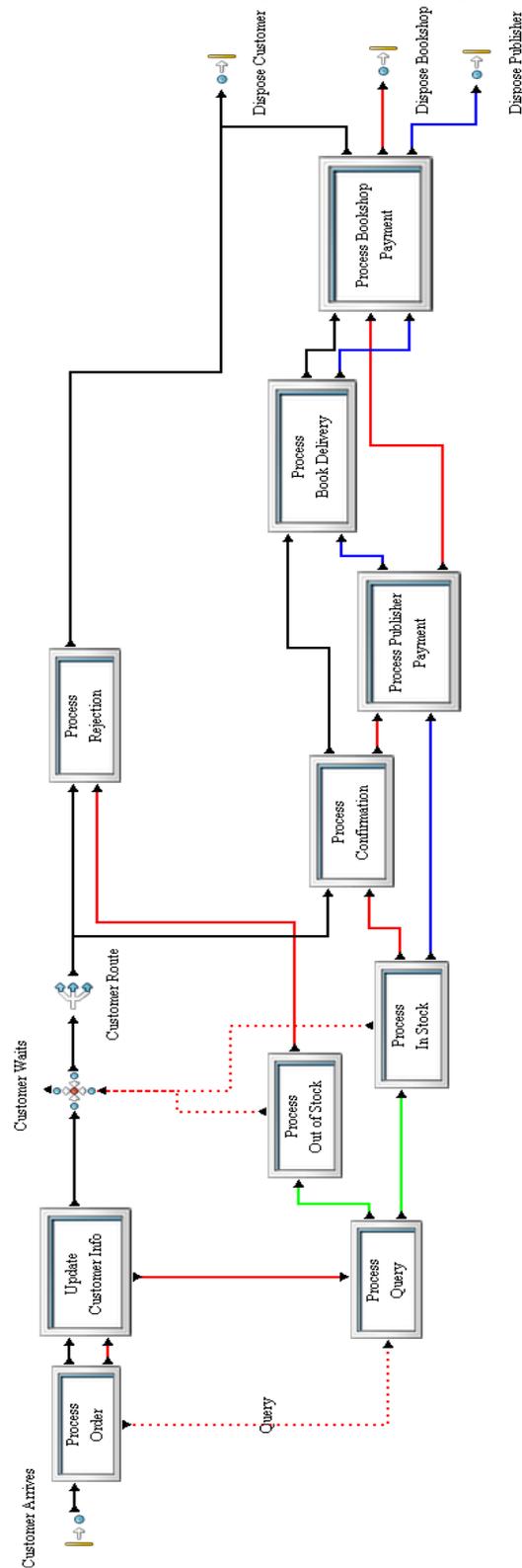

Figure 4.   Simprocess Online Bookshop Model.

BizAgi and Simprocess have no special integration mechanisms, except for import/export using XPDL model formats, which are not fully compatible. The integration of these kinds of systems is a trend though and Simprocess´ manufacturers advertise on the existence of integration facilities with Ultimus BPMS and with MS Project, which makes it an interesting choice for exploring the unified conceptual modeling concepts proposed in this work.

The most updated version of BizAgi Process Modeler, Version 2.5, presents also some functionalities for the execution of simulation runs, but these functionalities do not substitute the use of a simulation system like Simprocess, because the last one has prebuilt facilities for the creation of more complex models, for making them more faithful to the real system and for allowing project of experiments and an adequate performance analysis, making use of scenarios.

The model built using Simprocess shown in Figure 4 has six types of entities defined, namely: Customer, Bookshop, Publisher, Message, Book and Payment. The entities Customer, Bookshop and Publisher are the same defined in the ULMD model. The color legend used is the following: Black for the Customer, Red for the Bookshop and Blue for the Publisher. The continuous lines represent the flow of control or the pathway of the entities and the dotted lines stand for the message exchange between the processes. The colors shown by the dotted lines are associated with the class of the entity which generated the message. The Green continuous lines indicate pathways of more than one class of entity, for the sake of simplifying the graphical model representation, although these entity flows could be duplicated and differentiated by their original colors, if preferred.

The entity instances of class Message are created or have their type transformed whenever a process needs to send a certain kind of message, for example at the moment the client enters the system and fills out a form (book order), when the bookshop sends this order further to the Publisher (query) and when the Publisher answers the request for information (book in or out of stock). The entities Book and Payment have a similar nature to the Message entity and they were created to represent the pathway of the Book and of the Payment followed in the system, respectively. Additionally to these entities there were two types of resources created, called Bookshop Resource and Publisher Resource, to allow multiple executions of the activities performed under the responsibility of the entities Bookshop and Publisher.

The system was tested for gradual workload increase and determination of warm up period. The warm up period, the time necessary for the system to reach the steady state, was determined based on the quantity of clients being processed in the system. Some prebuilt standard graphical displays can be activated in Simprocess to help performing these kinds of analysis.

The system maximum workload was determined by varying the quantity of available resources of each type in different simulation runs. Initially the resources were defined independently for each activity and just one instance of each type was made available. The quantity of available resources was gradually increased until there were no more entities waiting for resources in the queues in front of each activity and the maximum total number of occupied resources was reached. Based on these numbers new simulation runs were executed with just two kinds of resources defined, as previously described: Bookshop Resource and Publisher Resource.

The total number of resources needed in this last case is a bit lower than the total sum of the individual resources previously found. This is due the fact that when two types of resources are used they can be assigned in different points of the process lifecycles of the entities being served, freeing some bottlenecks. The use of individual resources in each activity might result in an oversupply, because individual resources cannot be allocated elsewhere in the process lifecycle of the entities, helping the process overall throughput.

Many other predefined variables for model assessment maybe used, besides the total number of clients in the system, such as the quantity of clients being processed or waiting in specific points in their process flow (activities or queues, respectively), as well as the total number of busy resources and the percentage of the time they have been busy.

VIII. INTEGRATED ANALYSIS AND ASSESSMENT OF RESULTS

A. Domain of Applicability and Limits of the Approach

The domain of applicability of the proposed approach for Unified Conceptual Modeling and its application in PLM of complex product and service development is given by the discrete event systems which can adequately be represented by the ULMD representation, which is a hybrid creation from ACDs and a workflow or PERT-like network of activities. This problem class tends to be very large because a network of activities, as well as its particular form known as ACDs, is a good representation of processes executed in discrete event systems in general. An additional remark to this point is that the use of this kind of diagram in PROST studies is solely intended for the product´s lifecycle process modeling, whereas other kinds of diagrams, such as SysML, are kept for other static and dynamical product descriptions, making the overall modeling procedure very powerful.

ULMD is essentially a sub-set of BPMN, but it is necessary as a unified conceptual/communicative modeling notation because its level of abstraction is much higher, aiming at allowing flexible modeling with the minimum number of elements. The kind of problems that might be represented by the ULMD notation includes even discrete event systems with a cyclical nature, such as a serial production processes. The transformation from a cyclical nature into PERT-like networks is possible and demonstrated in [12], since the main path and its ramifications do not need to correspond to one of the real entities processed by the model. It might be described by a virtual entity "execution orders or flows of control" that splits for branches that are executed in parallel or return for recycling in case it proves necessary, in the same way one can use BPMN for describing complex processes.

The application of the methodology and tools derived from the project management area is based on the idea that the complete production process or its segment currently under analysis can be seen as a single project. The successive cycles representing the different batches of products are dealt with by replicating the basic process, which might be restarted any number of times, with or without a time delay, creating a network of activities whose graphical representation is drawn and executed sequentially from left to right or top to bottom.

Serialized production processes are therefore represented as equivalent to a complex process/project of a multi-project nature, made of several instances of the single process, each instance initialized with a different start time.

There is no need to consider multi-projects with a high number of identical processes, because the finish time of the first process would limit the number of total processes which would be simultaneously active in the system. The system's steady state behavior would thus depend only on the number of simultaneous processes being carried out in it at any one moment.

In some cases it might be necessary to repeat some parts of a process to create its complete graphical representation, if the same entity needs to repeat a sequence of activities for a fixed number of times, differently of the treatment described above for cycles that are originated from the processing of successive jobs or entities.

A problem arises when the number of times a segment must be repeated is dependent on a variable attribute for different instances of a class of entities being processed in the model. In this case the process cannot be described in this level of detail as a fixed PERT-like network of activities that needs to be traversed only once by that entity class or transaction existing in the model.

In these cases the problem may only be described as a PERT-like network of activities if the level of detail is reduced, that is, if the problem is modeled in a higher hierarchical form, with some details being encapsulated into a macro activity that has to be considered as a single activity for the purpose of complementary time and cost analysis proposed by the approach.

B. Benefits of the Methodology and its Tools

The idea is to take advantage from the joint application of several modeling and analysis techniques in support of the Product Lifecycle Management of complex products´ and services´ development processes, in order to benefit from the complementary aspects for which each kind of these techniques is especially stronger.

From the project manager standpoint, it is expected that the application of BPM and simulation into PM will complement the benefits from the isolated application of the PM technique. BPM applications can be built to automate and help the management process. Project assessment will be made by a combination of the normal procedures used in project management with the addition of the simulation technique, with the aim of enhancing the understanding of the factors and strategies which significantly affect project execution.

The analysis, using simulation, of multi-projects made by several single projects of identical nature, will produce a better understanding of its characteristic single project or process and allow the improvement of its descriptive process, by optimizing resources allocation and shortening the complete process or segments execution times, while keeping control of activities costs.

The optimization will be based on the dissociation of the time delay incurred by the entities staying in the queues in front of each activity from the proper duration of these activities, what is treated as an aggregated estimation in the project management current studies, based on conservative estimative. The reduction of these waiting times by increasing the number of resources allocated, while keeping control of their relative costs, shall produce on its own a major gain of productivity in the execution of single projects.

The gain in productivity will be even greater when one considers the scaling factor, existing in systems in which real multi-projects or multi-processes need to be carried out, with their start time shifted only by a certain delay and their processes being executed in parallel, by big work teams divided in classes by their specialities.

The lack of this kind of analysis in project management studies actually performed is explained by the fact that the existing software tools used in this study area have no capabilities for experimentation of alternative forms for the modeling of their processes, for the animation of the passage of time, and for the testing of its dynamical resources allocation in the case of multi-projects. These are clear deficiencies of these systems, when they are compared to the existing simulation systems. These mechanisms will be an essential part of the hybrid PM, BPM and simulation environment here proposed.

Simulation studies performed with this hybrid environment will keep track of the complete map of dependences and sequencing of all activities, as well as of the resources allocated in the model. Experimentation and simulation model assessment will be improved and productivity will be enhanced in some segments or in the overall project´s lifecycle, through the optimization of resources allocation and the minimization of completion times, subject to costs constraints.

This result can be achieved by creating pre-built mechanisms that are independent from the specific model under consideration, allowing model assessment for project enhanced productivity to become part of the normal objectives of simulation systems. These model independent mechanisms may be developed by using existing functionalities, or may be newly created if these functionalities are still not available, in an integrated PM, BPM and simulation environment.

C. Actual State and Future Goals of the Research

The ULMD model of the online Bookshop was implemented both in BizAgi and the Simprocess simulation systems. These implementations were conducted by groups of research students as final simulation course projects. The choice of the application systems above was made solely due to their availability as course material, but any existing PM,

BPM and process simulation software available in the market can be used for this exploratory phase of the methodology development.

Concepts such as the identification of idle times of entities staying in queues in front of activities and dynamical resources allocation via the use of simulation were applied to reduce segments or overall process completion times and costs in the model. Concepts such as critical paths and completion time for a segment of the process, typical of project management technique, were not applied in the study, since the course´s objective was the joint application of BPM and Simulation techniques only. Efforts in this direction can be proposed for future research, with the goal of yielding greater productivity and a thorough analysis of possible strategies for system's operation.

As expected, the tools chosen for implementation showed their deficiencies in dealing with some aspects of the modeling, such as replicating the processes and allowing the conduction of experiments with multiple processes in the case of simulation and with making activity duration dependent upon the quantity of resources of each class allocated in the model, in the case of the BPM tool.

IX. CONCLUSION

The joint use of PM, BPM and simulation in process modeling and analysis reveals that they have a complementary nature. The first two of these procedures allow for a better understanding of the logic and strategies for managing the lifecycle of the entities flowing through the system. The last one allows for the analysis of the dynamics of their processes, including optimization of resources allocation, a better evaluation of completion time of partial or complete production cycles, as well as their cost assessment. The combination of these techniques is therefore very promising, but the advantages of their joint use have not been exploited, as far as the authors are aware, for two main reasons: (1) first and more importantly, because there is no unified conceptual modeling methodology, capable of unifying the modeling procedure prior to the application of these individual techniques; (2) second, because they have been designed with different purposes and knowledge basis in mind, without considering their complementary nature.

The first aspect can be dealt with by developing a unified/integrated conceptual modeling methodology, for which one hopes this work may have contributed, but the dream of achieving the full benefits of a unified methodology shall only come totally true if one undertakes the design and the building of a hybrid PM, BPM and simulation environment to deal simultaneously in a unified and integrated way with all issues involved in these autonomous and complementary study areas.

This work addresses the identification of the similarities and differences between model representation formats used in the different disciplines dealing with process modeling and the formulation of concepts and procedures for their integration. An initial conceptual PROST framework has been proposed, which one hopes that will lead to the development of a complete methodology and its supporting tools to deal with the issue of improving PLM procedures.

The application of PM, BPM and simulation performed illustrated further the use of the methodology under construction. The continuation of the development and application of the methodology will require the use of existing PM, BPM and simulation systems to perform several case studies, as well as the creation of a new hybrid simulation environment, which on its turn will require quite a lot of software development effort.

REFERENCES

[1] Aalst, W. van der; Weske, M; Witrz, G. Advanced Topics in Workflow Management. Journal of Integrated Design and Process Science march 2003, Vol. 7, No. 1, pp. 58.

[2] Bizagi Process Modeler User Guide 2013. Avaiable from: http://help.bizagi.com/processmodeler/en/ Accessed on June 18, 2013.

[3] Naidoo, T.; Muehlen, M. Z. The state of standards and their practical. AIIM CONFERENCE AND EXPOSITION, Phialdelphia, n. 1, 2005.

[4] Nance, R. E. The conical methodology and the evolution of simulation model development. Ann Opns Res, n. 53, p. 1-45, 1994.

[5] Onggo, S. B. Towards a unified conceptual model representation: a case study in health care. Journal of Simulation, 3, n. 1, 2009. 40-49.

[6] Pidd, M. "Computer Simulation in Management Science". John Wiley & Sons, Chichester, UK, 1992, 3rd Edition.

[7] PMI. A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition. 5. ed. Newton Square: Project Management Institute, 2013.

[8] Prado, Darci. "Administração de Projetos com PERT/CPM". Rio de Janeiro: LTC, 1984.

[9] Simprocess - Product Overview. CACI, 2011. Disponivel em: <http://simprocess.com/products/products.html>. Acessed on: March 17, 2011.

[10] Silva, L. A.; Kienbaum, G. S.; Loureiro, G.; Tanik, M. M. (2011). A Process Science and Technology Study Applied to the Laboratory of Integration and Testing of the National Space Research Institute (LIT/INPE). In: Society for Design and Process Science 2011, 2011, Jeju Island South Korea. SDPS Conference Proceedings, 2011.

[11] Silva, L, A. Uma abordagem unificada para modelagem, simulação e gestão por processos e sua aplicação aos serviços de integração e testes de produtos complexos. versão: 2013-03-05. 160 p. Dissertação (Mestrado em Engenharia e Gerenciamento de Sistemas Espaciais) - Instituto Nacional de Pesquisas Espaciais (INPE), São José dos Campos, 20130205. Available (Portuguese) in: <http://urlib.net/ 8JMKD3MGP7W/3DBGB82>. Accessed on June 10, 2013.

[12] Travassos, P R N (2007) An Integrated Approach for Business Process Management and System Simulation and its Application in Project Management. 176 p. (INPE-14819-TDI/1259). PhD Thesis (Computer Science) – National Space Research Institute. São José dos Campos. Available (Portuguese) in: <http://urlib.net/sid.inpe.br/mtc-m17@80/2007/06.12.18.51>. Accessed on June 7, 2013.