Online Simulation for Logistics and Decision Making

Enrique Espinosa & Ernesto Pacheco

Abstract— **Traditional training for IT-professionals is substantially unsynchronized with that of a Business Process Management (BPM) professional, even though their respective fields of expertise are supposed to be placed along a continuum. This causes that the simulation, and later implementation, of dynamic supply chains, is not delivered in a realistic way, especially when business decisions are based on process optimization that features capabilities (what?) and orchestrations (how?), but the underlying structure and metrics are not in sync with business simulations. We present ongoing research that aims at covering the interactions between companies, emphasizing the interactions between methods typically associated with particular fields such as order fulfillment, parts and service support, or industrial packaging. We have developed an online Logistical Simulator (LOST) and have tested it with undergraduates and professionals in continuing education. We present the basic method for presenting and playing with variables and the preliminary conclusions of our work.**

Index Terms—**Simulation, Logistics, Decision-Making.**

I. Introduction

During the mid 20th century, Chester Barnard, author of the Functions of the Executive, coined the term "Decision Making" [1]. The introduction of this concept altered the way managers view their role inside the organization. Deciding means the end of *deliberation* and the beginning of *action*. For example, Jovanovich [2] states that a successful baseball player will become a superstar if he makes the right choice every 2 out of 3 times. The same applies to a manager. For these obvious reasons, decisions are key in every management process. On the other hand, global markets demand reductions in costs, which in turn foster new developments for worldwide logistics. As a result, adequate and sufficient training in financial planning, cost analysis, flow control and TI is becoming a commodity. As the disintegrated supply chain starts to come back together, links big between companies, governments, small and medium sized enterprises (SME's) are modified, so the very nature of decision-making is also transformed. New forms of training are thus required to provide all business actors with proper means to survive in the new economy.

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II. Inter-Disciplinary Training

Consider the automation of decision-making logistics. Currently, IT-professionals and business process managers view decision-making from an algorithmic or database point of view, while business administrators, entrepreneurs and managers view it from a strategic (i.e. action-based) point of view. In the IT-world, decision making is performed by models: data + behavior by machines, while in the business world decision making is performed by humans with the aid of machines. We may argue that the former and the latter experts are disjoint groups placed along a continuum, from *presence* to *enterprise integration*, as described in stage models that characterize a transition from organic (i.e. flat) organizational structures exhibited by Small and Medium Enterprises (SMEs), to more bureaucratic structures in large firms [3]. As companies place themselves on the continuum, they must address challenges in the shape of strategic, tactical and real-time decisions caused by uncertain scenarios and other types of exceptional cases during the execution of the supply chain. Business and IT-experts cannot possibly face all these challenges and be successful, especially for SME's, since they tend to lack complete knowledge about the business clusters and supply chains they belong to. In other words, they will not likely be able to visualize all the factors that play a role in unpredictable scenarios and events. The problem is evident when the SME is faced with dynamic supply-chains. *It must be solved in a truly inter-disciplinary fashion by acquiring global knowledge*. As a result, training on decision-making would benefit from addressing the problem in such a way that trainees acquire a global vision of the impact caused by the outcomes of their decisions, both within and outside their local corporate realms.

In this paper we present ongoing work that makes a contribution to education and training initiatives such as undergraduate and graduate courses, conferences, distance education courses, seminars and other types of continuing education, all of them in IT-supported Supply Chain

Management (SCM) specializing in logistical information systems, warehouse management, plus transportation and service logistics.

Our goal is to narrow the gap between domain knowledge the average business person considers relevant, and the actual skills the average graduate exhibits. Specifically, we target reducing criticisms by employers who argue learners do not obtain an integrated view of the organization. In other words, we propose a view of training that includes alignment of IT with decision-making and logistics knowledge.

III. Approaches to Logistics in Disarray

Logistics has been positioned as one way for firms to differentiate their product or service offerings by enabling them to serve selected customers better than their competitors do or to serve those customers at lower a price for the same service level [4].

In 1986, the Council of Logistics Management (CLM), the leading-edge professional organization in the logistics area, defined logistics as: "*The process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information flow from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements*" [5].

In the 90's, many of those academics and practitioners wrote, talked, and offered seminars about SCM. They used the terms Logistics and SCM as synonyms. However, SCM is a broader discipline than logistics when properly implemented. In fact, logistics could be seen as a sub-system of SCM.

In 1998, CLM announced a modified definition for logistics. In that definition, the CLM explicitly declares its position that logistics management is only a part of SCM, and that the two terms are not synonymous [6]. The revised definition for CLM's (1998) is:

"*Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements*".

Other definitions of supply chain management exist, for example, from the Council of Supply Chain Management. On this paper, however, we stick to the one by the CLM.

According to Boyson [7], and the CLM, logistics consists of a set of activities. This activities or areas are:

a) Traffic and transportation management
b) Warehousing and storage.
c) Industrial packaging.
d) Materials handling.
e) Inventory management and control.
f) Order fulfillment.
g) Demand forecasting.
h) Production planning and scheduling
i) Purchasing.
j) Customer service levels.
k) Plant and warehouse site location.
l) Returned goods handling.
m) Parts and service support.
n) Salvage and scrap disposal.

On the other hand, organizations with high performance standards recognize that the activities in the previous set are part of logistics and consider them not as isolated technical functions but as a strategically important set of activities, which can create competitive advantage [7].

As a result, experts in the field have developed techniques like Economic Order Quantity (EOQ) for inventory management, the Newsvendor Problem for profit assessment, a series of Stochastic Models, Dynamic Programming Algorithms such as the Warner-Within, the Silver-Meal for lot sizing, or the Center of Gravity Method for locating distribution centers, among others.

The problem is that these solutions are developed individually, without considering their potential links (i.e. their inter-disciplinary intersections). In other words, the authors believe it would be beneficial to bring together the solutions as a whole. For example, a function for calculating cost would contemplate a conjunction between methods for analyzing inventory control, transport of materials, acquisition costs, forecasting on demand variability, and decision-making over localization of distribution centers.

The challenge hereby posed implies handling a large number of [loosely connected] variables, while at the same time characterizing a number of diverse industries in such a way that their behavior may be portrayed homogeneously. On the IT world, this is being attempted as Service Oriented Architectures (SOA) [8], Enterprise Application Integration Products (EAI) [9], and Business Process Management (BPM) [10]. To our best knowledge, this challenge has not been solved yet. This paper presents a contribution on this direction.

IV. Business Simulations as Games to Foster Business Skills

We have developed a business game and published it online. Our goal is to guide our research for contributing to the goal stated in section III above. The focus of the game is to allow a player to handle a large number of variables in a systemic fashion within a business scenario that involves diverse actors within the supply chain.

The player, or trainee, experiments with a set of products as she is presented with a log showing the demand history per product. She may then analyze the log and infer a forecast on the future demand of a particular offering. Every product is manufactured using three distinct materials. Three distinct stations are used to assemble the product. Therefore, the products compete for raw material and for machine time while demand exists to satisfy for all products.

	Materia Prima A	Materia Prima B	Materia Prima C	Precio de Venta
Producto 1	400	1200	800	$74.00
Producto 2	800	800	1000	$52.00
Producto 3	600	600	1000	$63.00
Producto 4	500	800	900	$52.00
Producto 5	1000	500	800	$63.00
Producto 6	800	400	1000	$59.00
Producto 7	600	800	900	$64.00
Producto 8	1000	400	800	$57.00

Figure 1, Raw Material and Price per Product

	Máquina 1	Máquina 2	Máquina 3
Producto 1	3	5	4
Producto 2	5	0	4
Producto 3	4	3	3
Producto 4	6	5	0
Producto 5	4	4	4
Producto 6	2	6	3
Producto 7	6	0	4
Producto 8	1	3	6
Costo por hora de operación	$120.00	$150.00	$210.00

Figure 2, Cost: Machine Time per Product

Figures 1 and 2 show how this information is setup to the player. She may change values at all times.

In addition, the company has selected diverse providers of raw material required for the production process. These providers may exhibit different purchase and delivery costs, distribution (or delay) times, as well as quality control indexes on their products. Witness these variables on Figure 3.

Proveedor	Materia Prima	Precio (m^2)	Calidad	Tiempo de demora (semanas)	Costo de envío por pedido
A1	A	40	90	2	$600
A2	A	42	98	1	$700
A3	A	38	80	3	$500
B1	B	31	86	1	$400
B2	B	34	96	2	$500
B3	B	32	91	2	$500
C1	C	52	88	3	$800
C2	C	59	97	3	$900
C3	C	58	91	1	$1000

Figure 3, Provider Profiles

Under these conditions, every week the company must make three decisions.

First decision: The number of production units the plant must deliver. This must conform to weekly time and available raw material restrictions. Witness Figure 4.

	Producto 1	Producto 2	Producto 3	Producto 4
Unidades a fabricar	0	0	0	0
	Producto 5	Producto 6	Producto 7	Producto 8
Unidades a fabricar	0	0	0	0

Figure 4, Decision #1: Production Units

Second Decision: The number of raw material units each provider will use per weekly production run. Figure 5 shows this information.

	Proveedor 1	Proveedor 2	Proveedor 3
Materia Prima A	0	0	0
	Proveedor 1	Proveedor 2	Proveedor 3
Materia Prima B	0	0	0
	Proveedor 1	Proveedor 2	Proveedor 3
Materia Prima C	0	0	0

Figure 5, Decision #2: Raw Material Units

Third Decision: The actual amount ordered to each provider on every production run. Figure 6 shows this information.

	Proveedor 1A	Proveedor 2A	Proveedor 3A
Materia prima solicitada	0	0	0
	Proveedor 1B	Proveedor 2B	Proveedor 3B
Materia prima solicitada	0	0	0
	Proveedor 1C	Proveedor 2C	Proveedor 3C
Materia prima solicitada	0	0	0

Figure 6, Decision #3 Weekly Order to Provider

Please note that the amount of product delivered on a given production run is sent to the sales point at the end of the week. As a result, if the demand for a given product exceeds the current stock on the sales point, a net loss will be calculated. All orders are placed at the start of the week. Therefore, if the provider has a two-week delivery time and the order is taken on week one, the product will be available on the production run for week #3. Inventory control runs at the end of the week and reports on net sales and demand. It also checks-in net income for all sold products. The players must then make a deposit to all providers and company employees, and purchases all supplies required by the machines on the next production run. The latter are defined as operation costs. All net gains are sent to an investor account that offers an interest which is capitalized in a weekly fashion (considering a 52-week year).

The production run is played for a variable number of weeks, and the player with the highest net gain in her investor account is considered to be the head of the race.

After logging on to the web application, called Logistical Simulator (LOST), the user is faced with the set of widgets that allow her to define all the variables described in Figures 1-6 above. Figures 7-9 show decisions #1-#3 as seen within the game.

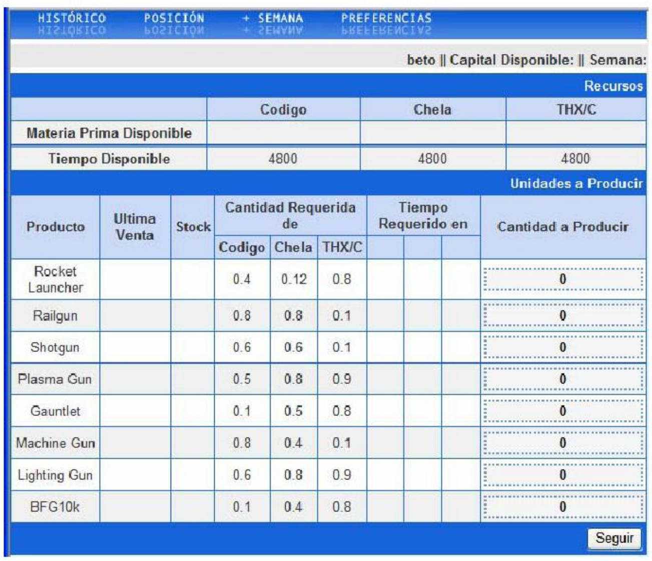

Figure 7, Actual View of the Game WebApp (1)

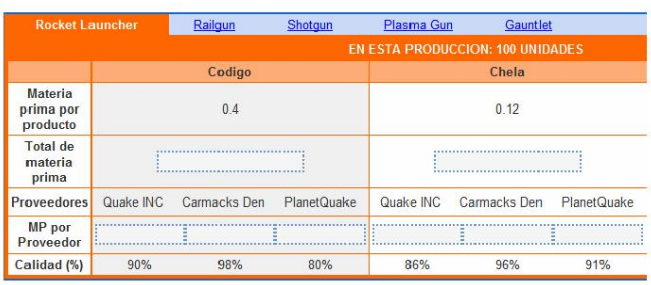

Figure 8, Actual View of the Game WebApp (2)

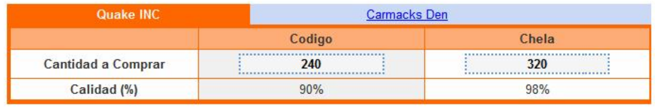

Figure 9, Actual View of the Game WebApp (3)

The game allows a number of players to define the names and profiles of all companies involved in the process. The production rounds are asynchronous, meaning that each company is responsible for its own production cycle. In practice, any company may play for a maximum of 52 weeks. In the current version, the game history persists over a number of sessions. The game administrator may revoke privileges and may erase player histories.

V. Relevance of our Project

Even though a number of business games have existed over the years, starting from the 1950's, the development of *management games* that involve diverse companies in a supply chain gaming simulation is still a development issue. For example, Industry Player [11] involves hundreds of manufacturing and [basic banking + investment] movements. However, in this and many other simulators, a holistic view of the steps involved in the process would constitute a key innovation.

Other business games are more sophisticated than ours and require the input of hundreds of decisions on every phase of the game [12,13,14]. Regularly, these games demand a greater teamwork effort and promote a broader view of the organization. However, given the complexity and number of decisions involved, each phase may take up a week or more to complete, so the number of movements performed by the trainee is limited, and restrict experimentation. Our solution is highly flexible and allows the player to experiment with a [possibly] large number of scenarios before she proceeds to the submission of her production run. This flexibility permits the player to devise gaming strategies. We define a strategy as sequences of events that handle a large number of [loosely connected] variables with the purpose of characterizing the behavior of a company or an industry. We hereby argue that a sufficient exposure to our gaming method by a trainee will offer her a ser of management skills, while at the same time showing her the bridge between strategic decision-making and technological decision-making. This makes of our tool a learning one.

As said in section 1 of this paper, on the IT world, this is being attempted as SOA, EAI, and BPM. The key contribution of our work is that our gaming method brings forward the strategic behavior that is generally not orchestrated in either of these IT's. In many corporations world-wide, BPM is currently undergoing a tough test when it comes to providing hard evidence of the impact or true benefits of the investment technology represents. Figure 10 shows how this bridge is attempted with the aid of LOST.

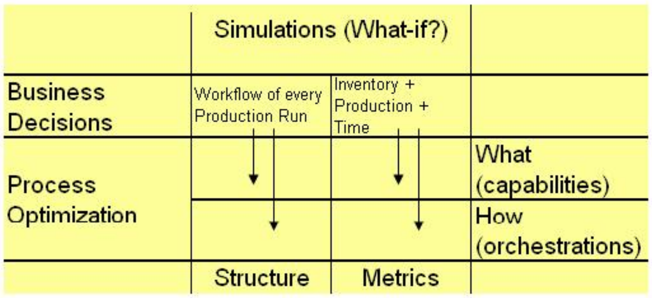

Figure 10, Bridge Between Business and IT Decision-Making

The workflow on every production run involves a number of business actors (i.e. the providers on Figures 3 and 8). The correct placement of these within the structure of the production run is a first step towards making a design of an orchestration in any commercial BPM product where documents will be delivered to actual provider firms. An IT professional will typically have to program metrics to calculate, for example, the best cost per product given a quality control factor and statistics on product delay. However, it is our experience that these metrics may not be correctly programmed, or not be known at all, because from the IT-side, this information is not available or not understood, because the IT staff has undergone an unrealistic training in business process, or supply chain, specification. Even though SOA contemplates a re-design of industrial tactics and strategies, the XML communication channels that underlie the orchestration process tend to ignore traditional forecasting procedures such as variance in demand history. In Order fulfillment, these statistics serve as criteria to decide whether the type of distribution will be uniform or will suffer variations. If a process designer can run this forecast, she will be able to tell, for example, whether the use of machines in the production cycle will be adequate, or not. This is an example of process optimization activities, where the focus is on capabilities (What can we do?). Proper tuning of capabilities will yield better orchestrations (How do we do it?), *but not the other way around*. The problem stems in traditional training for IT-professionals. Their focus is on orchestrations per se, *but not as a tool for implementing business strategies*. Our hypothesis is that trainees will have a broader understanding of the supply chain if they are able to introspect the concepts of structure and metrics as a result of careful planning of business scenarios when they are able to "play" with them in a dynamic fashion (what if?) using an online tool that lets them compare their own behavior with other peoples'.

VI. Implementation of the Online Game

LOST is implemented as a web application that adheres to the J2EE 1.4 specification. The architecture of the application is shown in Figure 11. The application serves concurrent sessions and updates a central database. Players access the application through the Internet using any standard web browser. The application was designed using standard design patterns such as Model View Controller (MVC), Intercepting Filter and Business Delegate, which conform to current best practices in web development.

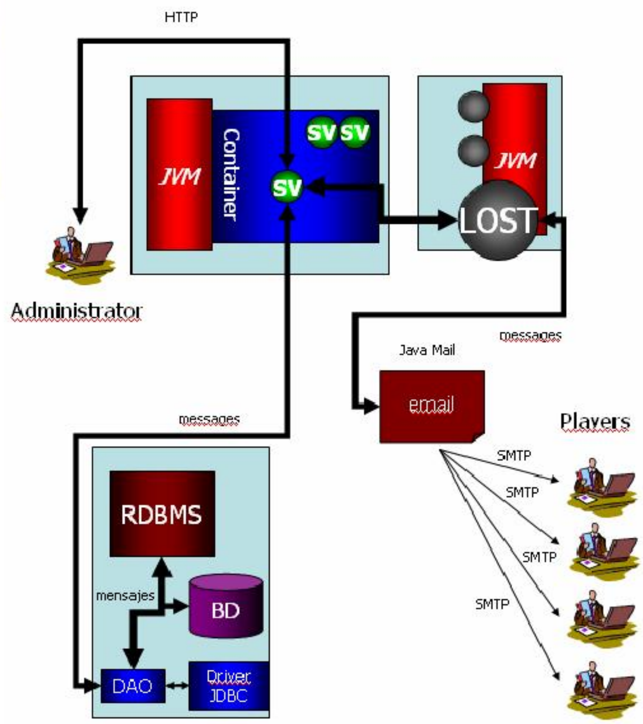

Figure 11, Architecture of the Web Application

VII. Conclusions and Further Work

We have presented a method, examples, and an IT tool, a web application. We have finished a first semester of tests for LOST on senior level college students. Our preliminary findings point out that these students have acquired a better understanding of dynamic programming and supply chain management. We still are in the process of testing the hypothesis on seasoned professionals with clear design goals. We are also on the process of acquiring data from the public use of the tool.

We may conclude that there exist no business games that contemplate actions on the whole spectrum of the supply chain, that is, there are few gaming or simulation initiatives for training that cover the interactions between companies in order to foster a better enactment of a whole supply chain. Even though a number of experts have recognized that barriers between companies tend to disappear, this message has not produced a bridge between the business and IT worlds, so specialist on both sectors lack a more complete training method. We hope to contribute in this area.

Currently, it is a hard problem to find optimum values and Nash equilibrium in moderns supply chains. By providing the means to play with "What-if" scenarios and then bridge this knowledge down to tasks related with process optimization: "what" and "how", we hope to make an impact on the implementation of structure and metrics on EAI and

SOA.

Down the road we plan to explicitly link this project with others that deal with workflow re-design and characterization from the point of view of dynamic, real-time changes, plus enactment of workflows that can re-configure themselves as they are enacted on a highly volatile business media. Such work has been previously published on [15].

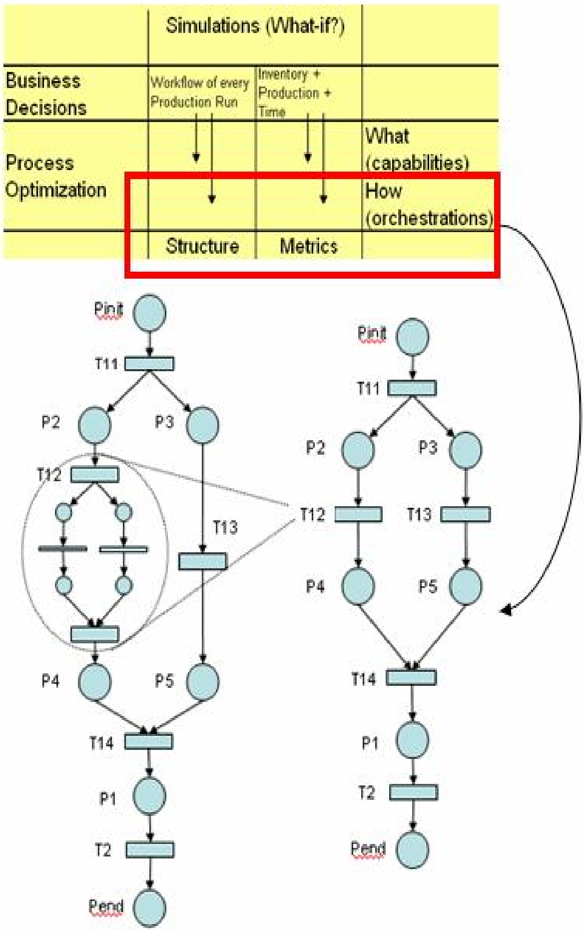

Figure 12, The Next Bridge: Business Simulation to Enactment

Figure 12 shows the path we will follow. On [15] we presented a method for achieving the dynamic construction of a workflow, featuring a set of states and transitions that represent activities, people, assets and infrastructure for defining the profile of the business model. However, the decision-making mechanisms that trigger the dynamic construction were unclear. Our training method promises to deliver behavior patterns and data that reinforce decision-making techniques viewed as a strategic set of activities. These will constitute our triggers for workflow re-configuration.

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