Management, Complexity and Perdurability: An Experience for a Laboratory for Modeling and Simulation in Colombia

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***Abstract*—This paper presents a novelty in the structure, philosophy and works of a school of management. It is about the creation of the Modeling and Simulating Laboratory at the Management and Business School at Rosario University, Bogotá, Colombia, by which it is intended to both model and simulate the behaviors and patterns not only of companies and enterprises but also and foremost of strategic sectors. The theoretical frame of the laboratory is the theory of complexity, and the basis for its research is the perdurability of the companies, enterprises and firms.**

***Index Terms*—Modeling, simulation, organizations, complex systems, living systems.**

I. Introduction

The relationship between management and complexity can be taken in at least two main ways. First, it can be viewed as the study of management in a complex world and, therefore, how to manage or handle a complex world. Such is notoriously the perspective of the best achieved studies about it [5]. Secondly, it can be taken as the way in which complexity sciences can contribute to both studying and acting and deciding in the world, vis-à-vis the instabilities and crises the world is facing currently. In this sense the use of computational tools is considered of high value [8].

The Management and Business School at Rosario University, located in Bogota, has undergone a large-scale research project based on the study of perdurability, i.e. the companies, enterprises, firms and corporations' life span in the social and economic contexts. As a consequence, complexity appears as a necessary and useful ground and frame. In accordance, a laboratory for modeling and simulating the companies´ life has been recently set up in order to study organization´s complex behavior. Here we introduce the laboratory, its goals and philosophy.

II. A Laboratory to Work with Complexity within the Frame of Management

In the laboratory, a cross-disciplinary team is currently working, thus: a philosopher with expertise in the sciences of complexity and non-classical logics, several computer systems engineers with proficiency in modeling and simulation who works as programmers, a statistician, a mathematician, and a physicist.

The basic philosophy of the Management School at Rosario University is that it shall be possible to understand and work with organizations when understood as living organisms, leaving aside any mechanical, physical or engineering-like comprehension of the former. This perspective is inherited from classical authors such as Fayol, Ford, Taylor, and even Drucker or Porter.

It is well known that living beings, whether natural or artificial, are clearly the most complex systems in the universe and on earth. As a consequence it is necessary to fully grasp the complexity of companies as living beings, for example their dynamic or structural, their thermodynamic and physiological complexity. We believe firmly that a modeling and simulation laboratory will be a highly valuable stance by which the School can contribute to strengthen the links between University and companies, University and public sector as well as University and society, namely civil society.

The creation of the Modeling and Simulation Laboratory (MSL) is aimed at both doing research and supporting the ongoing research projects within the School of Management through complexity science and non-linear mathematic modeling. The laboratory studies own models as well as others provided by local researchers in the School, to be subsequently translated into innovative computing-oriented consultancy tools. The first real outcomes are expected to be achieved by mid 2009.

Thanks to MSL, methodological and experimental developments by the School's research groups are being implemented through modeling and simulation. A new approach based on non-classical logics (modal, diffuse, paraconsistent and quantum logic, among others) leads the group to produce subsequently innovative tools with the appropriate rigor in the context of dynamical systems modeled after organizations. These contributions are intended to be tools specifically designed for the Colombian corporate sector and, specifically for environments that generate decision-making processes. Nonetheless, it is well known that concerning the possibilities of a practical use of non classical logics, fuzzy logic has been the most used and valuable tool for studying for example control systems and non-linearity in management. A good case is presented by Grint [6].

The setting of the MSL is closely related with the whole research structure of the School of Management at RU (Fig.1). This structure encompasses the Center for Business Studies on Perdurability (CEEP in its Spanish acronym) articulated in three stances: the Research Group for Corporate Perdurability (GIPE in Spanish), the Epidemiological Companies Observatory (OEE in Spanish) and the Modeling and Simulation Laboratory (MSL). The main task of the GIPE is to do research and produce books with outstanding quality; the Observatory´s

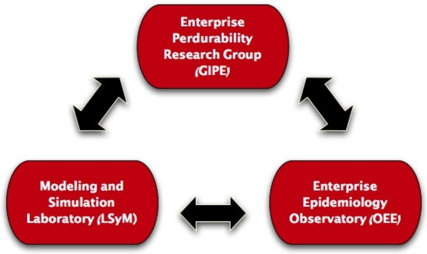

Figure 1. CEEP's structure

main task is to gather information and monitor the companies´ health, large and small. Finally, the Laboratory is aimed at modeling and simulating the findings of the Group and the Observatory. All in all, the CEEP will become a think tank at the core of the School.

As a consequence, the works and processes among the CEEP, the OEE and the MSL are fundamentally cooperative. The Group's contribution to the Laboratory is twofold, not only providing information on the business environment (from which non-evident correlations are inferred starting from research-obtained databases for example), but also contributes with new theories about the business environment. In the same way, the Laboratory supports the Group by proposing models used to test hypotheses and to achieve results through non-linear techniques that lead researchers outside the laboratory to find innovative approaches to the problems of organizations.

Similarly, the Laboratory supports the OEE with new techniques for monitoring business phenomena in order to complement proposals of epidemiology applied to business. Reciprocally, the OEE provides information as databases in order to implement the models that describe companies' behaviors studied companies.

As for the MSL, it aims to develop computational and mathematical methodologies and products, under the perspective of the sciences of complexity having as the main concern private organizations. More particularly, we are firmly convinced that complexity sciences will be the tool for the diagnosis and the generation of strategies in the context of high uncertainty in which national companies are immerse, always having in mind the guiding directive of increasing these companies´ levels of perdurability. As first step to the target firstly aimed at, the laboratory is implementing a data warehouse for strategic sectors in Colombia, so that any research project conducted at the UR School of Management can be supported by a robust set of data. Later on, this warehouse will also be available as a consulting tool for the private and public sectors.

In the short term, the laboratory expects an impact in the social context aiming at developing a series of consulting informational tools on the basis of the input received from Colombian companies. However, on the long run, other projects must be produced to support the internal methodologies achieved within the laboratory, always having in mind the projection onto the local corporative environment throughout research papers.

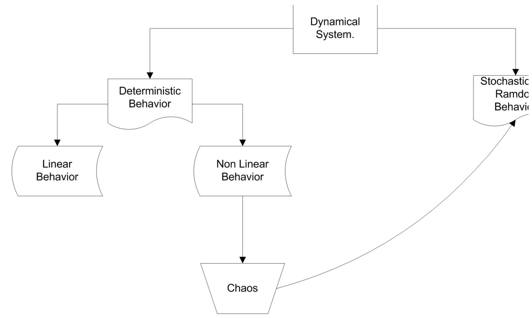

Figure 2. A shift of paradigm from Linear to Chaotically driven models [10]

III. CONCEPTUAL STRUCTURE AND FRAMEWORK

The diagram bellow gives a basic idea of the concept of dynamic systems, as they are to be addressed by the MSL:

A dynamical system can be characterized in very different fields, whether economic, social, biological, chemical, physical, mathematical, or others [1]. This type of system is described by one or more properties or variables that change over time. These systems can be classified according to the behavior of the solutions (namely, the values of variables in a given time in the future) for a fixed set of inputs: some systems exhibit a deterministic behavior when the variables state can be exactly reproduced under identical initial conditions in the context of several experiments. Linear dynamical systems can be solved using simple functions, given the proportionality of each variable with itself at moments in the future. This character is not shared by the variables in nonlinear systems.

If the behavior is reproducible to a certain level, the dynamical system although not deterministic, can be modeled by methods that can bring a very approximate solution. Such systems are known as stochastic dynamical systems. This kind of systems is prone to the effects of noise by the large number of variables involved, which may lead to non-trivial outcomes as the appearance of deterministic transitions between equilibrium states called attractors.

Some nonlinear systems can exhibit a completely unpredictable behavior, which even though appear to be deterministic are truly random. This chaotic or aperiodic behavior is extremely sensitive to initial conditions, taking very different paths when the former vary slightly. Chaotic systems could be modeled with some success using other systems partially equivalent (in terms of behavior) of the stochastic type. The main concern here consists in working with unpredictability and uncertainty.

There is, however, another possible form of classification for dynamical systems depending on whether the time domain is measured using real or integer numbers. The scheme in Fig. 3 shows an example of a deterministic dynamic model where time is considered in continuous and discrete terms.

Being as it might be, it is necessary to point out that the MSL was created in order to study this type of systems, stressing and focusing especially on those modeled from the organizations and their interactions, and seeking innovation in the sense of perdurability as a consequence

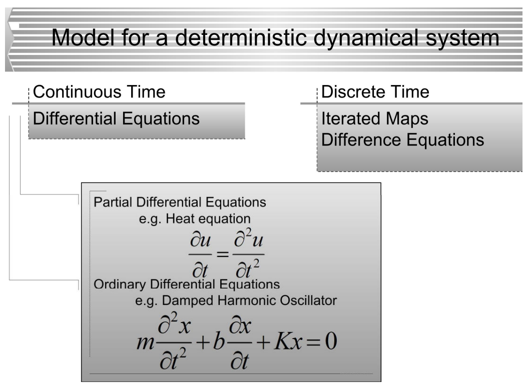

Figure 3. A classification for dynamical systems based on time measurement [10]

of a good management. The two primary tools for achieving this goal are modeling and simulation of business environments in three major conceptual fronts, namely: mathematics, logics and computation. These three lines of attack have in common the non-conventional or traditional approach under the context of complex systems.

The front of logics relies on the application of a set of non-classical logics to serve the qualitative analysis and modeling of a system to study. Among the non-classical logics considered by the MSL are: modal logic, fuzzy logic, quantum logic, time logic, many-valued logics, epistemic logic, paraconsistent and relevant logics.

The mathematical front's main objective is to match the theoretical results obtained by several researchers of the School to the standards of rigor, generality and simplicity governing modern mathematics. The idea is to find appropriate mathematical tools that are suited to the type of problems studied in the School.

Finally, the computational front seeks to abstract the traditional component to business models and simulations. While the nontraditional component will be reflected in the use of Genetic Algorithms, Cellular Automata, Neural Networks, Expert Systems, Artificial Life and Swarm Intelligence. The specific objective of this front is the implementation of simulation models to obtain qualitative and quantitative results that can be analyzed and contrasted with reality.

We believe that much of the work to be done will be focused on problems of topology (particularly structural topology), dynamical systems and the change in approach from P problems P to N-P problems. These tools are aimed towards making quantitative and qualitative analysis and modeling of the systems under scrutiny.

In general, the focus will be on N-P problems seen from the non classical logic perspective, computationally materialized with the approach of natural computing, to fulfill the requirements of a world whose complexity increases gradually, also marked by instabilities and turbulence, uncertainty and risk. The laboratory´s aim is to study emergent properties and systems, self-organized patterns, the presence of power-law structures and dynamics as well as the various networks implied in the life of organizations, companies and firms. A summary of the scope we have is given in Fig. 4.

IV. TECHNOLOGICAL STRUCTURE

The technological structure discriminates the different environments, on which the productive activity of the laboratory will be performed from the perspective of software construction. Within this structure, the following components can be found: a code repository, a database server, an application server and a web server.

The code repository is the system where the incremental versions of source code for various projects are stored and managed. This repository will guarantee the access only to members of the laboratory and its contents can be viewed as an industrial secret. Taking into account an initial exploration of the problems, the following

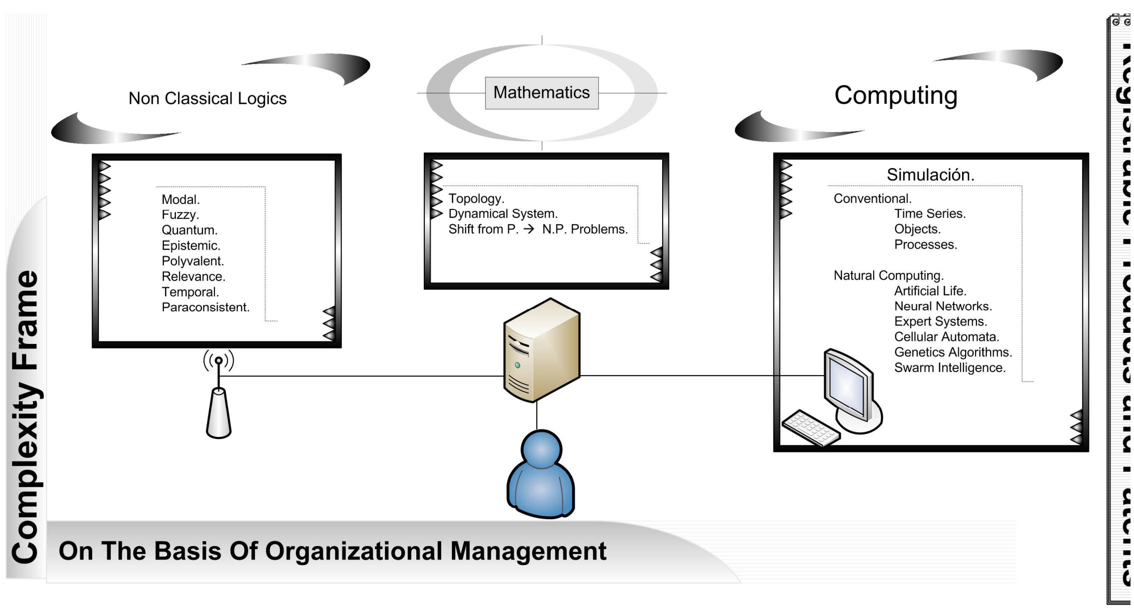

Figure 4. The scope of the research in the laboratory

languages were chosen to address them: Java, C++ and

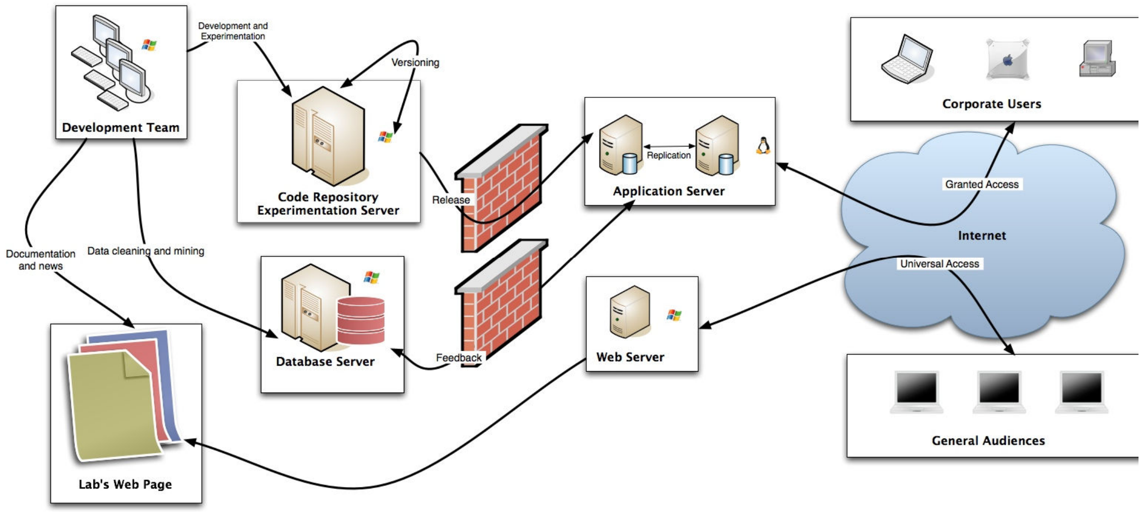

Figure 5. an overview of the laboratory´s technological platform

Lisp, and supporting experimentation MATLAB, Mathematica and R.

While applications are aimed at improving levels of perdurability, the necessity of an orderly and systematic compilation of relevant information about companies' activities and their relationship with the environment arises. The problem of designing a structure to store this information is being addressed as one of the first goals. Here a joint research with other universities is being seriously considered. It was decided to implement this compilation in a traditional manner using a free distribution RDBMS (Relational Database Management System) namely PostgreSQL.

Moreover, the paradigm of web-based applications, that imposes itself as a dominant form in which users relate to information processing, will be the guide for the developments. This is a ubiquitous paradigm nowadays and promotes the ease of distribution of information through networks. Following this trend, the construction of a single information store run by the University is seek, so any actor in the business sector must be referred to this store.

Finally, there is a clear need to report on MSL progresses and publications. Also its structure and research lines are to be posted in a web page. Guidelines for the use of the tools produced by the Laboratory will also be published here. This website will be linked to the website of the School.

V. CONCLUSION

Technological developments produced at MSL constitute the scientific advance that embodies the intentions of the Management and Business School at the University of Rosario. This contribution focuses on the provision of alternative tools to those linear ones currently used by researchers in the field of management. The use of developments achieved by the laboratory will be an alternative to the traditional observation of the phenomena of business that presently are being analyzed from a linear perspective.

In addition to the instrumental contributions already mentioned, the MSL has the ability to contribute with research proposals with their respective disclosure which will be eventually evaluated by the scientific community.

Both practical and conceptual advances are the building material for new academic content, as well as for the training of future managers and directors of companies.

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