Object Oriented Modeling Frameworks for the Social Systems

Manuel Ignacio Balaguera[*1], Jenny Paola Lis[#2], Mercedes Gaitán[#3], Amelec Viloria[+4], Paula VivanaRobayo Acuña[#5]

[*]School of Mathematics and Engineering, FundaciónUniversitaria Konrad Lorenz, Bogota, Colombia

[#]School of Business, FundaciónUniversitaria Konrad Lorenz, Bogota, Colombia

[+]Universidad de la Costa, Barranquilla, Colombia

Abstract

In the present paper an object oriented approach and modeling framework is proposed for the construction of synthetic, computational models of social systems. The conventional approach to model and study social systemswill be reviewed and outlined, indicating its limitations to deal with their associated complex turbulent phenomena. The proposed object oriented integrative modeling will be explained emphasizing its advantages compared to reductionist methods when dealing with complex systems. Finally, the main architecture of the UTOPIAcomputational modeling framework, an ongoing developmentis shown and described.

Turbulent, UTOPIA, reductionist methods, computational models, modeling framework.

1. *Introduction*

In recent years, global change has gone beyond climatological and environmental contexts: both economy and society show signs of increasing turbulent behavior, manifested in the inadequacy of statistics and traditional econometric methods to predict even short term behaviors: collapses in the global financial markets emerge more frequently, political polarization and social instability are widespread conditions.

Despite humankind founds in those events clear signs and strong arguments to accept the inadequacy of determinist and reductionist focus of modern science to deal with real, complex phenomena such as found in biological, physiological, psychological, social, ecological, geological and environmental systems; our world continues functioning under these obsolete epistemological paradigms retarding crucial changes and decisions, approaching humankind to conditions in which no human social life is possible, even more, conditions in which no individual human life could be possible (Rees, 2003). New paradigms for the construction, integration and use of knowledge are required and that is the task currently being undertaken by the science and the engineering of complex systems (Anderson, 1999) (Castellani & William, 2009). In order to support these reflections and new proposals, a quick review on the evolution of science paradigms is presented.

2. *Science, Reductionism and complexity*

Let's begin by stating that the essential feature of we, human beings, is our rationality: our actions are based upon our decisions and these decisions are the result of individual and social processes: thinking, imagination, reflection, dialogue, submission, etc., all of them based on knowledge, hope, faith, myth, or caprice, actually, almost always in a combination of them.

Generally, but in particular when dealing with the physical world, once a decision has been taken and an action has been realized, a set of events and processes are triggeredleading, in agreement with the second law of thermodynamics, to irreversible changes in the states of the world and in the multiplicity of its components, Some of them are taken into account, some of themare despised or ignored, it is impossible to predict all of them and, which is worst, to predict or prognostic their consequences: this is what we call "risk".

In order to make decisions with restricted or controlled risk, scientific knowledge is the universally accepted resource by human organizations. Scientific knowledge is supported by the Scientific Method which sets empirical or measurable evidence as the referee for assign the degree of scientific validity to a system of concepts, principles and hypothesis: a theory or in the contemporary language: a model (Godfrey-Smith, 2003).

Nowhere in the scientific method reductionism is stated as an imperative need: to reduce a theory to a small system of mathematical equations.However, since the Newtonian revolution of science, reductionism and the physics style in the formulation of theories has been imposed as a de facto rule, even in the human and social sciences, possibly motivated for the high precision and exactitude of the predictions that mathematical models allow about the future behavior of a system. Of course, the logic coherence of mathematics is desired in the formulation of a theory but fortunately complexity sets up a radical gap between social systems and the physical world.To precise the term"reductionism", The Oxford Companion to Philosophy (Bynum & Porter, 2005) suggests a three part division:

1. Ontological reductionism: a belief that the whole of reality consists of a minimal number of parts
2. Methodological reductionism: the scientific attempt to provide explanation in terms of ever smaller entities
3. Theory reductionism: the suggestion that a newer theory does not replace or absorb the old, but reduces it to more basic terms.

These perspectives of reductionism are in strong opposition (if not in contradiction) to the observed evidence of complexity in our reality: individual subjective, natural objective or socially constructed. Despite in the moment there is not agreement in the definition of "complexity", there is an unanimous agreement in the fact that a "complex system" is essentially different from a "complicated system" and about the inadequateness of the reductionist perspective to deal with the main features of a complex systems: its hierarchical organization, the absence of knowledge that allow causal connections between events and processes occurring at the diverse levels of organization in these hierarchies, nonlinearity, emergence and contingency (NEMICHE, 2017).

Complex systems and as such, the social systems, cannot be globally modeled by an enumerable set of deterministic laws expressed by mathematical functions, therefore, the idea of a single set of governing equations (algebraic, differential, integral or a combination of them) is not satisfactory for social systems modeling.

In the early stages of dealing with social systems under the paradigms of complex systems science, statistical physics has been used as an alternative: econophysics and sociophysics. However, this approach still being inadequate because in Statistical Physics the probability functions associated to the states of the system under studyare relevant for its mathematical modeling and they are possible only the hypothesis of an ergodic system.If a system is ergodic its dynamical behavior can be derived from optimization rules of a single objective function as, for example in physics, the energy associated with a given state (Slanina, 2014).

In the case of a system having autonomous agents, such as humans and organizations in social systems, their autonomy produces an ergodicity breaking making inappropriate the hypothesis that they may be considered as identical particles and consequently to associate the probability of their dynamical states with a single objective function.As an example, in the case of biological cells, their autonomy stems in the fact that each cell have a redundant set of “programs”, its genotype, which codifies a corresponding set of possible adaptation, regulation or response behaviors. Depending on the values of many factors: physical and chemical conditions globally called “epigenome”, the cell will execute just one program which will trigger the production of one specific protein and consequently, realizing just one specific behavior .

Given this nondeterministic nature of complex social systems, there isn’t a single response to each of the many research questions involved in a given social situation such as in a war or in a financial collapse. This diversity of possible ways of actions forces us to design strategies based upon the prognostic of a complex system behavior in response to a multiplicity of inputs and scenarios.

3. *Object Oriented frameworks and Integrative modeling of complex systems*

As Brian Epstein states in his TEDx Stanford 2015 Talk (Stanford University, 2015), the origin of the reductionism limitations is in the nature of its central question: "how the system behaves" which englobes the working hypothesis that the systems always evolves following behavior patterns, sometimes complicated and intricated but always with a regularity pattern representable by a mathematical structure or"law".In the talk, Epstein suggest implicitly the epistemic focus of object orientation by stating as an alternative the question: "what is it", meaning that instead of representing the global behavior of the system in terms of variables characterizing the behavior patterns which possibly will never be repeated, what must be represented is the complete integrated identity of the system without destroying by generalization the very own identity of its components, most of them being autonomous in the case o complex systems, and their integrative connections and associations. The approach implied by this question privileges the creation of virtual digital worlds in computers with overwhelming representative and predictive superiority over the chimera of reduce a system's identity to a model written in paper and pencil.

Computer integrative modeling arises as an ideal complement to mathematical modeling. Computer integrative modeling is intended as the creation of a holistic system model by the interconnection of their component models in a single computational environment or platform ("framework"). Thanks to the facilities and features of Object Oriented technology (Booch, et al., 2007), these component models may correspond to diverse modeling paradigms such as deterministic mathematical modeling, stochastic modeling and artificial intelligence methods such as cellular automata, genetic algorithms, neural networks and expert systems.Thanks to the main features of object orientation: classification, encapsulation, composition, inheritance and polymorphism, it is possible to automatically create and assemble a huge number of component objects coming from a diversity of classes whose definition may encapsulate specific and particular properties and sets of behavior rules.

Classification refers to the abstraction and generalization of objects having a common ontological description in terms of theirattributes and behaviors under the concept of a "class". With the construction of a class not only generalization is attained but also a tool to automatically produce many different objects belonging to the same category: instances, by assigning different values to their common ontological identifiers.**Encapsulation**guarantees the autonomy of an object by restricting the access to its attributes and behaviors and in this way to be able to adapt and give selective responses included in its own repertory of behaviors.**Composition**allows the inclusion of objects as components of other objects and in this way to create model hierarchies resembling the hierarchical structure of the represented entities. **Inheritance**, also called specializationconsist in the possibility to create new classes from existing classes by adding new attributes and behaviors. This feature facilitates the representation of evolutionary and adaptive behaviors. Finally, **polymorphism** gives to objects the capacity to implement the same behavior in different ways, as an example, the behavior "translate" is implemented in different ways between a dog and a fish.

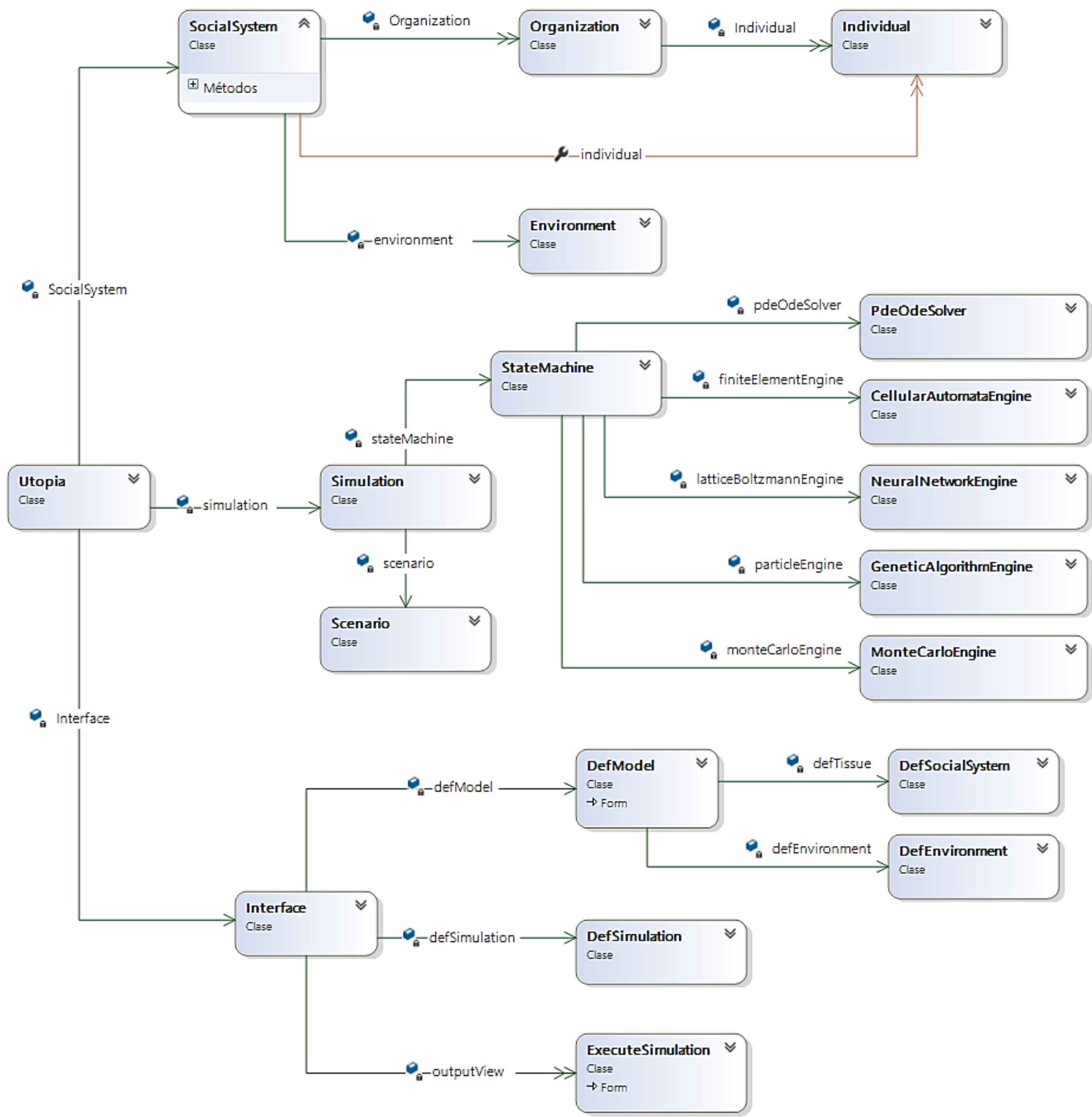

Figure 1

In object oriented integrative modeling the starting point is the analysis of the system to be modeled beginning with a hierarchical decomposition into different levels of structural categories, represented by the concept of "class" in the object oriented approximation.

Figure 1 shows an UML (Unified Modeling Language) Class Diagram (Parunak & Odell, 2002) (Rumbaugh, Jacobson, & Booch, 1999). A class diagram displays the different categories of objects, classes, composing a complex system and its relations, in this case, composition relations. The figure 1 class diagram corresponds to the planned structure for the "UTOPIA"social systemsmodeling and simulation systemunder development at the present, designed to allow simulation experiments using diverse modeling paradigms (hybrid modeling) and simulation engines .

In agreement with the diagram in order to create the class experiment it will be necessary to create three composing objects, each one belonging to one of the three classes: social system, simulation system and interfaces system. Notice that the double tipped arrows indicate an array of components.

The social system will be a composition of social organization, which is composed by individuals, single individuals and an external environment.

The simulation system component is composed by a simulation scenario which defines the external agents, social system boundary and initial conditions for the simulation.

The simulation class is also equipped with a set of mathematical engines necessary to process the time evolution of each component and the complete system: a Monte Carlo (Metropolis) engine used to simulate all stochastic processes involved in the simulated process. Depending upon the problem, a specific simulation engine is chosen.

Finally, regarding the figure 1 class diagram, it is necessary to include a user interface composed by an input interface for information source specification and a simulation output interface which may be a set of 2D x-y like plots or a 3D structure and fields visualizator.

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