How System Models Contributes to the Design of Information Systems

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ABSTRACT

Systemics is a discipline which has transdisciplinary characteristics; it shares its foundations with other scientific disciplines. This paper argues that the principles and methodologies of Systemics enrichs Information Systems Engineering (ISE). Thus ISE could be consider as a sub-domain of Systemics.

The most relevant ISE's objetive is to obtain succesful information systems (IS). Hence, it tries to improve analysis/design techniques. ISE's core is found in the models -or abstract representations of reality- and systemic modellization belongs to ISE's methodologies set. This modellization needs to be supported by robust theoretical foundations.

Based on that argument, this paper presents: *Bunge's system models* which are widely used to improve IS analysis/design modelling languages; and *Bunge's social ontology* which studies the social aspects of IS. These are two examples of how system models contributes to the design of IS.

Keywords: systems models, Information Systems Design, Bunge's ontology, BWW Model, systemic epistemology.

1. INTRODUCTION

The most relevant ISE's objetive is to obtain succesful information systems (IS). Hence, it tries to improve analysis/design techniques. ISE's core is found in the models -or abstract representations of reality- and systemic modellization belongs to ISE's methodologies set.

On the other hand, Systemics is a discipline that studies systems and systemic models. They constitute its study object. The authors carried out a disciplinary study of systemic based on Kuhn disciplinary matrix [1]. This proposal maintains that systemic models constitute one of the disciplinary basements of systemics.

This article maintains that *Systemic Models* are used to improve IS analysis and design. Two examples are presented. In one hand, the BWW model, widely used to improve IS analysis/design modelling languages. On the other hand, *Bunge's social ontology,* proposed by the authors as a model that would improve the design of IS social aspects.

At the same time in this Congress of International Federation for Systems Research the authors communicate the necessity and possibility of constructing a Systemic Epistemology as a *synthetic view of the Systems Sciences Foundations*.

This work procedes as follows. In item 2 the object of study of ISE is determined and its relationship with IS design. In Item 3 Systemics is presented as a scientific discipline and the rol played in it by systems modells. Item 4 makes reference to the contributions of the systems modells to the IS design. In item 5 proposed examples are presented: Bunge´s systemic ontology, BWW model and its use in IS design. Finally, in item 6, conclusions are presented.

2. INFORMATION SYSTEMS ENGINEERING AND IS DESIGN

Information Systems Engineering is an interdisciplinary approach and means to enable the realization of successful information systems [2]. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis, and system validation and deployment while considering the complete problem: Operations & Maintenance, Performance, Cost & Schedule, Test, Realization, Training & Support, Disposal, Social aspects.

There are at least three broad areas of knowledge that are needed for successful work in information systems engineering [3]:
- knowledge of information systems domains and applications,
- knowledge about methods, models and tools for business and systems analysis and design, deployment, and operations and maintenance,

- knowledge of technology needed for building systems and for integrating them with legacy components.

These three areas need to be founded with the generalizations and models of Systemics proposed in 3.

The main objects that conform the core of ISE were dealt with at the 1st Workshop on Philosophical Foundations of Information Systems Engineering, PHISE'05, Porto, Portugal, in June, 2005. Among them we find: logical theories, models, ontologies. Investigation methods of ISE and other matters referred to the SI design optimizations and social impacts were also discussed .

It is important to underline that ISE academics are stressing the objects that allow design optimization and SI construction: models [4, 5, 6].

3. SYSTEMICS AND SYSTEM MODELS

From Kuhn's epistemology, Systemics has been considered a scientific discipline which has its own symbolic generalizations, models and examplaries. Some of these Systemic's epistemology elements have been taken by ISE to justify its concepts and elementary methods.

Tabla 1. Disciplinary Matrix of Systemics.

SYMBOLIC GENERALIZATIONS
Systems General Theory, L. Von Bertalanffy. **Systems General Theory criticism** by R. García Cotarelo y M. Mesasovic. **Cybernetics: of first, second and third order**; Helmar G. Frank, **Systems Axiomatics** Mario Bunge. **Living Systems**, J. G. Miller. **Systems Theory Aplicate**, J. V. Gigch. **Systems Analysis**, S. Opter.
MODELS
Theory and Reality, **Treatise on Basic Philosophy**, Mario Bunge. **Theory and Experience**, W. Stegmuller. **Use of models in Sciences. Simulation and Emulation.**
Ontological Models
Concept of "system", "hierarchies transnivélicas", "synergy", "recursitivity ". Self-regulation y homeostat, Ashby. Black Box / traslucid / semi.
Heuristical Models
Types: closed / open; integrated / disperse; autopoiético.
EXEMPLARIES
Supply system / hydric elimination from a home. Exemplaries Rosnay: Ecology, Economy, City, Enterprise, Organism, Cell. Dynamic balance of populations (births, deaths). Automatic mechanism.

A disciplinary approximation to Systemics could be made using Kuhn's disciplinary matrix [7]. The authors Herrera-Tkachuk-Luna [1] identified the disciplinary elements of Systemics.

This disciplinary matrix allow the characterization of Systemics's nature. It (see table 1) is founded on bibliographic, hemerographic resources, publications, web-sites of worldwide relevance. These are supported by local (Galileo Galielei Institute,), national (Grupo de Estudio de Sistemas Integrados, Argentina) and international (IAS, Instituto Andino de Sistemas, ISSS, International Society for Systems Science, IFSR International Federation for Systems Research) groups which elaborate, discuss, communicate, difund and systematize the concepts, methods, applications and learning-teaching methods of Systemics.

4. SYSTEM MODELS CONTRIBUTIONS TO IS DESIGN

The essence of an IS is that it provides a representation of real world phenomena. Thus, the main concern of the members of the discipline should be how to build good representation of such phenomena. And, in order to build good representations, it is necessary to have good theories leading to the way in which real world phenomena are structured [8, 9].

There are ontological models of IS -abstract models- that supports the core of the ISE and contributes to the improvement of reality-modelling techniques. It is necesary to obtain an ontological model that lays the foundations for IS as technically implemented social systems. In this way there would be a contribution to the definition of the disciplinary basis core of ISE.

There are several proposals in the academic world on the use of systemic models for the optimization of IS design. One of the most recent ones is the Triune Coninuum Paradigm defined by Naumenko [5]. This is a complete theoretical base that can be used for building or for improvement of modern modeling frameworks that are employed for system modeling in different contexts, in particular in software development and in the engineering of enterprise IS.

The Mario Bunge´s systemic models are studied in this article as examples of system models that optimize the IS design. Thus this approximation is put in the field of systemic praxiology as the environment of systems practice applied to problem situations in social organizations [10].

5. OPTIMIZATION OF IS DESIGN FROM BUNGE'S MODELS

Within the various sistems models proposed, this paper deals with the models based on Bunge's ontology [6, 7], since it belongs to the scientific realism which requires a profound and detailed theoretical understanding of reality (peculiar of contemporary science). Bunge's ontological model (BS model), Wand and Weber's ontological model of Information Systems (BWW model) and Bunge's ontological model of Social Systems (BSS model) are presented.

Mario Bunge [11, 12, 13] assumes the universe is a world of interconnected systems (BS model).

Wand and Weber [8, 9] have investigated the branch of philosophy known as Ontology as a foundation for understanding the process in developing an information system. They have taken, and extended, Bunge's ontology and applied it to the modelling of information systems. They adapted and used Bunge's ontology to study information systems design and development tools. They proposed a formal abstract model called Bunge-Wand-Weber (BWW model).

In 1993 Mario Bunge proposed an ontological (formal) model of the social systems [14, 15]. Here it is called Bunge's Social System Model (or BSS model). He assumes that ignoring that society is a real system of concrete systems, rather than either a solid block or an unstructured aggregate of free individuals, precludes the understanding of its peculiar properties and processes.

5. 1. Bunge's Ontology

Mario Bunge [11, 12, 13] assumes the universe is a world of interconnected systems. His philosophical theories in his Treatise on Basic Philosophy [12, 13] are formulated in certain exact mathematical languages (definitions, axioms, corollaries), so that they are consistent with contemporary science. He presents the basic notions of substance, property, thing, possibility, change, space and time [12], as well as wholeness (or systemicity), variety, and change [13].

The primary concepts concerning Bunge's ontological model (BS model) are the following.

– An *object* can be concrete or conceptual. *Things* belong to the material world. *Concepts* are fictions.

– Other basic notions: *property, change, space, time*.

– *System*. A set of things is a system if, for any bipartitioning of the set, couplings exist among things in the two subsets. A system is itself a thing. Every system can be analyzed into its *composition* (collection of components), *environment* (things that are not in the system but interact with things in the system) and *structure* (collections of relations).

– *Systemicity*. The universe is a world of interconnected systems. Every thing is a system or component of a system.

– *Dynamics, development, history*. The fundamental property of a concrete system is the *transformation of its state*. An other characteristic of systemicity is history. Development is the qualitative change of a system patterned by laws.

– *Level*. The universe is enormously varied; its components can be grouped into a number of levels: physical, chemical, biological, social and technical.

– *Evolution*. There are mechanisms of qualitative novelty; new properties could emerge during a process; giving way to evolutions by which new systems emerge.

5. 2. BWW Model

Wand and Weber [8, 9] proposed a formal abstract model called Bunge-Wand-Weber (BWW model) [16]. This model consist of the representation model, the state-tracking model, and the good decomposition model [17]. The representation model defines a set of constructs that, at this time, are thought by the researchers to be necessary and sufficient to describe the structure and behavior of the real world. The essential constructs of the representation model (inherited from BS model) are: thing, property, class, kind, state, coupling, system, composition, environment. Properties can be: in general, in particular, intrinsic, mutual binding, emergent, etc.

In the state-tracking model, Wand and Weber identified necessary and sufficient conditions that must be satisfied by an IS. The good decomposition model focuses in how a decomposition transfers to the users the meaning of the real world system to be represented.

This work focus on the representation model since it has the main structures and relationships.

The BWW model is an adaptation of Bunge's ontology – related to the real world – to Information Systems. As an adaptation, it inherited important aspects that may cause positive as well as negative effects.
The BWW model has inherited the primary representational structures from Bunge's model: Thing

or entity, property and attribute, status, event, history, coupling, Type/kind, compound thing, system, composition, environment, structure, subsystem, inputs and outputs, properties (inheritance, emergency, intrinsic, mutual, generalizations, part of).

Being an adaptation of Bunge's model, the BWW model inherits its realistic (it assumes the existence of an external reality independent of the human experience) and also objective (it assumes that the world is made up of entities, properties and relations that may have a one-to-one correspondence with a set of technical symbols) ontology. This will lead to the criticisms related to the lack of consideration of non-formal cultural aspects.

5. 3. Social System Ontological Model

Mario Bunge proposed his BSS model. In this model, Bunge proposes definitions of the general concept of a system. Then he lays down some definitions and principles concerning Social Systems (SS). After that he proposes some methodological maxims concerning the systemic study of social facts. He starts from general systems concepts to formulates axioms on an SS and a society. He states and discusses general principles regarding SS. He also establishes methodological principles to deal with them [15].

The BSS model is formulated using basic hypotheses (axioms, postulates, principles) and their immediate consequences (corollaries). It has remarks and examples that make it easy to understand.

The main ontological structures of Bunge's social model related to the SS and society concepts are the following.

– Social system. It's a concrete system composed by animals that (a) share an environment and (b) act upon other members of the system, either directly or indirectly, in ways that are cooperative in at least one respect. A human SS is a social system composed of human beings and their artifacts. It can be natural (or spontaneous) if and only if it is self -organized -families, bands of hominids- or artificial (or formal or an organization) if and only if it is other-organized –schools, churches, business firms.
– Human society. It's a system composed by four subsystems: (i) the biological system, the members of which are held together by the relations of descent, sex, reproduction, child rearing, or friendship; (ii) the economic system, held together by relations or production and exchange; (iii) the political system, the specific function of which is to manage the social activities in the society; and (iv) the cultural system, the members of which are engaged in discovering or inventing, teaching or learning, designing or planning, and the like.
– Social process (or activity). It's a process involving at least two members of a SS (getting married or divorced, making friends or enemies).
– Social movement. It's a social process occurring in at least one artificial SS (or organization) and dragging a number of people not belonging to the latter (social reform movements, religious movements). SS principles derived from Bunge's proposals for concrete systems of any type –physical or chemical, biological or social- will be stated next. They constitute the core of a systemic and naturalistic world view or ontology.
– Every human being is a member of at least one SS. SS are held together by links of various kinds: biological, psychological, economic, political or cultural.
– A person's beliefs, preferences, expectations, choices and actions are socially conditioned as well as inner-directed.
– Every SS has a specific function. Every SS is engaged at all times in some process or other, continuous or discontinuous, of quantitative or qualitative change, causal, stochastic, or mixed.
– All of the members of a SS cooperate in some respects while competing in others.
Competition stimulates initiative and innovation, whereas cooperation favors efficiency and security.
– A SS emerges if and only if its existence contributes to meeting some of the needs or wants of some of its members. A SS breaks down if and only if it ceases to benefit most of its members, or if the intensity of conflicts in the system is greater than that of cooperation.
– Every social innovation benefits some members of a SS while harming others. Every social innovation is bound to be resisted by those who believe that the may be harmed by it. To minimize the conflicts generated by social innovation it is desirable to enhance the participation of all the stakeholders as well as the cooperation of experts in the design, planning and implementation of the innovations in question. Some of the methodological maxims concerning the systemic study of social facts are the following.
– Every SS can by analyzed into its composition (collection of persons and artifacts), environment (nature and society at large) and structure (collection of physical, biological, economic, political and cultural relations among the members of the systems and among they and members of other systems, social and nonsocial).
– Social science studies SS, such as families and factories.
– An adequate understanding of any SS involves the (empirical and theoretical) investigation of its composition, environment and structure. An adequate

understanding of any society involves investigation of its biological, economic, political, and cultural subsystems.
– The efficient management of SS involves the consideration of their composition (e.g., the personnel and management of a firm), environment (e.g. the market), and the structure (as represented by organization charts, schedules, budgets, etc.).

5. 4. Using Bunge's Modells in IS analyses and design

The BWW model has been widely used to improve IS analysis/design modeling languages. Bellow some of the works prepared by the SI academics are presented:

- Ontological Analysis of standard analysis and design languages object oriented using the BWW model [18]. Correct definition, integration and formalization of construction and modeling diagrams of UML and OML.

- Ontological Analysis of methods object oriented [19]. The E-R model has some BWW structures . The UML has most of the BWW structures.

- The frame for multi-perspective evaluation for requirement specification; structured analysis, object oriented analysis, phase analysis and points of view based analysis [20]. Extends the static basic structure of BWW model including conceptions and perspectives.

In spite of its great acceptance in the academic an professional world, the BWW model considers IS as a grapho of software components or useful modules to analyze the graphic properties such as coupling and good decomposition. It does not take into account the core and main components of IS based on non-formal definitions [21]. This criticism points out that IS are social systems that are technically implemented. They are social systems by nature, since their very existence depends on social institutions such as language, legitimization and energy control, and other ways of social influences and other norms of behavior. Data modelling deals with concepts like information, knowledge, meaning and language. Many of the IS design problems can be framed according to the beliefs and conceptions about the nature of social reality.

This IS conception grew stronger with Hirschheim [22]. The strength of his position is his effort to point out the relevance of social aspects of IS development, which are generally ignored by IS engineers, who consider their activity to be only technical. IS must not be reduced to technological aspects. Moreover, any technology that can change the way people live and work is necessarily a social and philosophical subject.

It is necessary to achieve an IS ontological model which may serve as a theoretical foundation for every kind of IS, hard as well as soft, with either strong technological or socio-cultural characteristics. For this purpose Herrera-Luna-Tkachuk-Palliotto [23] proposed to take the BWW model (based in Bunge's BS model) as a basis and incorporate social characteristics from Bunge's BSS model. In this way an integrated ontological model of IS would be obtained.

6. CONCLUSIONS

The very evolution of Bunge's philosophical thinking lends itself well to improve his ontological contribution to the IS foundations. His ontology has been consolidated from the 70s to his last proposition in 1993. His model has made progress towards the mastery of the social systems, their organizations and applications.

Systemics provides epistemological foundations to ISE. This article provided two cases that confirm the hypothesis. There would be no doubt that System Sciences are oriented towards epistemological foundations of the disciplines [24]. It is a crucial instance to realize a firmer epistemological reflection of System Sciences. This application, seen from a Systemic Epistemology, help to affirm that Systemic is meta-disciplinary. Thus, Systemic can work as trans-discipline in several knowledge fields, either in teaching and learning or in research.

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