Theory of Systems and Information Systems Research Frameworks

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Abstract

Information Systems (IS) discipline has been critiqued for being a fragmented discipline, and with little accumulative tradition. Consequently, several research frameworks have been proposed since the 1970s (Mason and Mitroff 1973; Ives, Hamilton and Davis 1980; Nolan and Wheterbe, 1980; Alter 2003) to help to organize, define and delimit such objects of study. However, despite the benefits reported to guide IS research to focus on the adequate objects of study, a formal systemic analysis of them reveals that these frameworks are still incomplete and have systemic inconsistencies. Then, this paper, based in the premise of the development of a more updated and comprehensive framework is required, reports a new one. Its completeness regarding previous frameworks is discussed as well as its potential utilization.

Keywords*:* Theory of Systems, IS Research Frameworks, Cybernetics Approach.

Context of the Research Problem and Related Works

Information Systems (IS) discipline has been critiqued for being a fragmented discipline (Banville and Landry, 1989), with: (i) a theoretical diversity that leads to a little accumulative tradition (Farhoomand and Drury, 2001), (ii) a main object of study still defined in multiple modes in the IS literature (Mora et al 2002), and (iii) a non integrated and unified perspective of the IS discipline and concept (Gelman et al 2005). Then, several research frameworks have been posited from the 1970s (Mason and Mitroff 1973; Ives, Hamilton and Davis 1980; Nolan and Wheterbe, 1980; Alter 2001) to help to organize, define and delimit such as objects of study. However, despite their efforts to organize the IS discipline, are incomplete under a formal systemic analysis.

This paper develops an updated and more comprehensive framework that integrates holistically all previous dimensions considered. The new IS research framework draws on

the contributions done by the two main proposals revised and previous conceptualizations from authors. The concepts of *system-I, system-II*, and *general-system* (Mora, Gelman et al , 2002; Gelman, Mora et al, 2005), are extended from original definitions (Gelman and Garcia, 1989). In turn, the concepts *organization O(X), Information System IS(X)* and *envelop* EE(X) are updated, the original *environment* concept is replaced by the French term *entourage ENT(X)*, and new ones introduced: *high-level business process HLBP(X)*, *low-level business process LLBP(X), socio-political business process SSBP(X)*, *supra-suprasystem SSS(X)*, *non-entourage NENT(X)* and *world W(X)*, All of them derived from the original concepts *organization* and *business process* from Mora, Gelman et al (2002) and ideas on Checkland's Soft Systems reported in Oliva and Lane (1998).

The Ives, Hamilton and Ives' IS research framework (1980) can be considered the first effort to develop a comprehensive one. According to Ives' et al (1980), the main shortcoming of the five previous frameworks studied is the dimensional incompleteness –*e.g*. a partial view of the IS field-. These ones do not take into account of the overall processes and environments to develop, operate and evolve the IS artifact, or are focused in specific types of IS or omit the organizational environment except by the type of managerial levels related with the IS artifact.

Then, Ives' et al (1980) IS research framework contributes with the integration of the dimensions posited in previous frameworks and with a structured -but not systemically correct- framework to organize and classify IS research, through the identification of five types of research generated by the single, two or three groups involved. Groups are: (a) environments with five categories, (a) process with three categories and (c) the IS artifact per se. Ives's et al (1980) framework fails in the correct systemic organization (*e.g.* the hierarchical definition of system, subsystems, environment and the conceptual differentiation of system's outcomes –despite it can be a system!- with systems elements in the model) of the seven categories of constructs proposed. Furthermore, the concept of <Organizational Environment> accounts for the attributes of a system –e.g. <Organization>-, which is not conceptualized in the model. From the exhibit 6 in the Ives' et al paper, the seven constructs are grouped as a system –without name- but its formal systemic articulation is failed.

Second most comprehensive IS research framework was reported also in the same year (Nolan and Wetherbe, 1980). It draws also on the same five IS research frameworks analyzed by Ives' et al (1980) and on a more fundamental conceptualization of the Theory of Systems (Boulding, 1956). Consequently, its elaboration is more refined and congruent with the formal concept of what is a system. Nolan and Wetherbe's framework is composed of: a <MIS Technology System> that is part of an < Organization> and it of its < Organizational Environment >. The <MIS Technology system> is conceptualized as a system composed of the following subsystems: <hardware>, <software>, <data base>, <personnel> and <procedures>. In turn, the <Organization> , as the wider system for the <MIS Technology system> is conceptualized in five subsystems: <goals and values>, <psychosocial>, <structural>, <technical> and <managerial>.

Then, this framework contributes to the discipline in making available a more systemic-based consistent scheme than previous ones and that accounts for almost all of the

categories of constructs related with IS research. However, it still has the following deficiencies: (i) the outputs of the <MIS Technology system> are only conceptualized in terms of types of IS, omitting other outcomes that it can generate such as <IT audits>, <IT proposal assessments> and <IT services> in general; (ii) the model does not conceptualize the interactions between the systems considered as wholes and the systems considered as a set of components – *e.g.* the *system type I* and *type II* views respectively defined in Gelman and García (1989) and updated in Mora, Gelman et al (2002)- and then influences like <IT suppliers>, <IT trends> or the conceptualization of an <Inter-organizational IS> cannot be modeled; and (iii) the time dimension that is critical for some of the 33 cases reported – *e.g.* on system's evolutions- is implicitly assumed and not related with the state _(t) of the system, subsystem or environment.

Hence, the two most comprehensive IS research frameworks posited, despite their theoretical and practical contributions to organize the discipline and guide toward relevant research present still limitations. Furthermore, systemic foundations are not totally supported by both models. Then, the development of an updated and more soundness framework that is able to integrate holistically all dimensions considered in past frameworks and the few dimensions omitted, is required.

The Systemic Framework for IS Research

By space limitations readers can consult the formal definitions of the concepts of *systems* in other works of authors (Mora, Gelman et al, 2002; Gelman, Mora et al, 2005a, 2005b). As a summary explanation, to define an object of study as a ***system-I*** implies to specify it as a whole composed by attributes, events and domains for attributes. For the case of ***system-II***, the formal definition offers the classic view of a *system* as a set of interrelated components.

Furthermore, the definition used here also considers the output/input relationships between any *subsystem* and the whole *system*. In turn, the auxiliary definitions help to support the expansionist systemic perspective that indicates that every *system* always belongs to another larger *system* (Ackoff, 1971). Hence, the following relationships are held: (i) ***SS(X)*** = ***X*** + ***ENT(X)***; (ii) ***EE(X)*** = ***ENT(SS(X))***; (iii) ***SSS(X)*** = ***SS(X)*** + ***EE(X)***; (iv) ***W(X)*** = ***ENT(X)*** + ***ENT(SS(X))*** + ***ENT(SSS(X))*** + ***NENT(SSS(X))***. It must be noted that NENT(X) is the set of all elements that are not part of the system X neither its *entourage ENT(X)*.

In Figure 1 –available upon request all formal definitions- are reported short and semi-informal definitions of the new concepts and In turn, Figure 2 exhibits a diagram of an *organization O(X)*.

An extended cybernetic-based paradigm is used here where S_{II}(X.1) and S_{II} (X.2) are conceptualized as a driving-org-subsystem and a driven-org-subsystem respectively, S_{II} (X.3) = *HLBP(X.3)* for a information-org-subsystem, and S_{II} (X.4) = *SSBP(X.4)* for a socio-political-org-subsystem. Interactions between subsystems are not showed. Figure 3

exhibits the systemic articulation of the concepts: <organization> and IS, as well as of its wider *systems* and *subsystems*.

Semi-Formal Definition of *Socio-Political Business Process* as *System*. An object of study X is called a ***socio-political business process*** and denoted as **SSBP(X) if it** can be defined as a *system-II* $S_{II}(X)=<C_X, \Re_S(C_X')>$ where $C_X=\{S_G(\text{Soc-SS}), S_G(\text{Pol-SS})\}$ are respectively called the social and the political subsystems.

Semi-Formal Definition of *Low-Level Business Process* as *System*. An object of study X is called a low-***level business process*** and denoted as **LLBP(X) if it** can be defined as a *system-II* $S_{II}(X)=<C_X, \Re_S(C_X')>$ where $C_X=\{S_G(\text{T-SS}), S_G(\text{P-SS}), S_G(\text{T\&I-SS}), S_G(\text{M\&P-SS}), \text{SSBP(LSP-SS)}\}$ are respectively called the task, people, tools&infrastructrure, methods&procedures and socio-political subsystems.

Semi-Formal Definition of *High-Level Business Process* as *System*. An object of study X is called a ***high-level business process*** and denoted as **HLBP(X) if it** can be defined as a *system-II* $S_{II}(X)=<C_X, \Re_S(C_X')>$ where $C_X=\{\text{LLBP(C-SS)}, \text{LLBP(O-SS)}, \text{LLBP(I-SS)}, \text{SSBP(HSP-SS)}\}$ are respectively called the control, operational, information and socio-political subsystems; IX.2) .

Semi-Formal Definition of *Organization* as a *System*. An object of study X is called an ***organization*** and denoted as **O(X)** if it can be defined as a *system-II* $S_{II}(X)=<C_X, \Re_S(C_X')>$ where $C_X=\{S_G(X.1), S_G(X.2), \ldots S_G(X.k)\}$ and for j=1,2, … , k either $S_G(X.j)=$ **HLBP(X.j), or** $S_G(X.j)=$ **SSBP(X.j)** or $S_G(X.j)=S_{II}(X.j)=<C_{X.j}, \Re_S(C_{X.j}')>$ where $C_{X.j}=\{BP(X.j.1), BP(X.j.2), \ldots BP(X.j.n)\}$ and $\Re_S(C_{X.j}')$ exists.

Semi-Formal Definition of *Information System* as *System*. An object of study X is called an ***Information System*** and denoted as **IS(X)** if it can be defined as either **IS(X) = HLBP(X.3)) of an O(X)** or **IS(X) = LLBP(I-SS)) of a HLBP(X.i) and O(X) holds** (e.g. the former view of an **IS(X)** corresponds to the general function of the organizational *Information System* and the latter to the specific view of an *Information System*.

Figure 1. Updated Definitions for *Organization*, *Information Systems* and Related terms

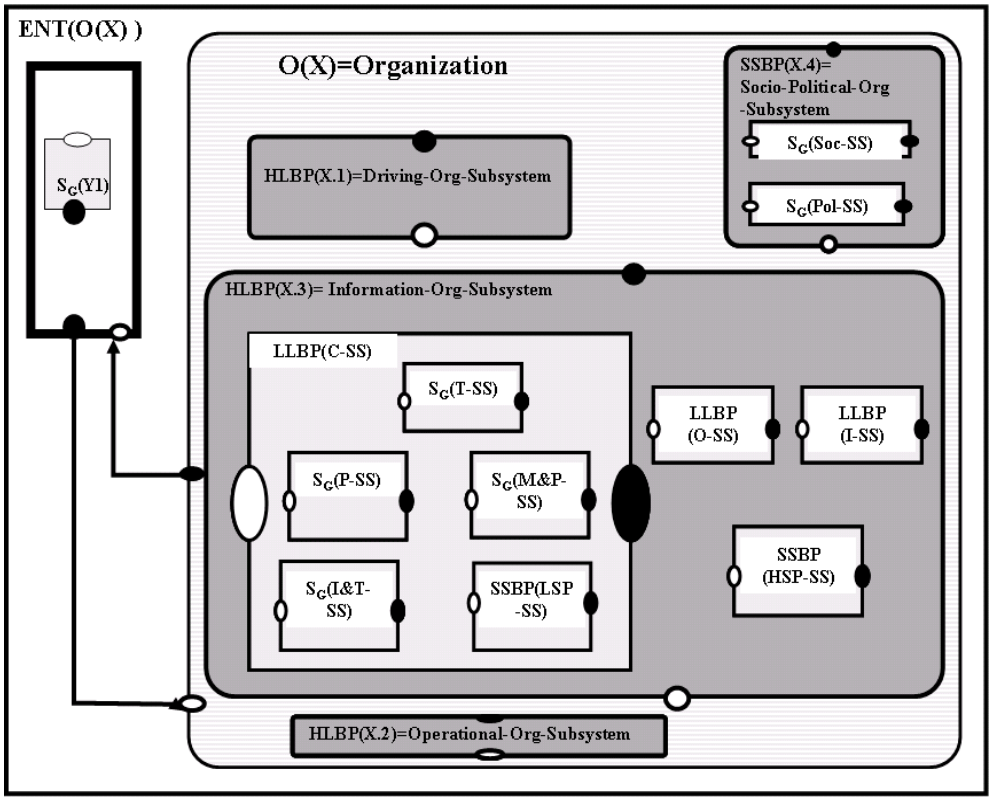

Figure 2. A schematic view of an *Organization* as a *system*

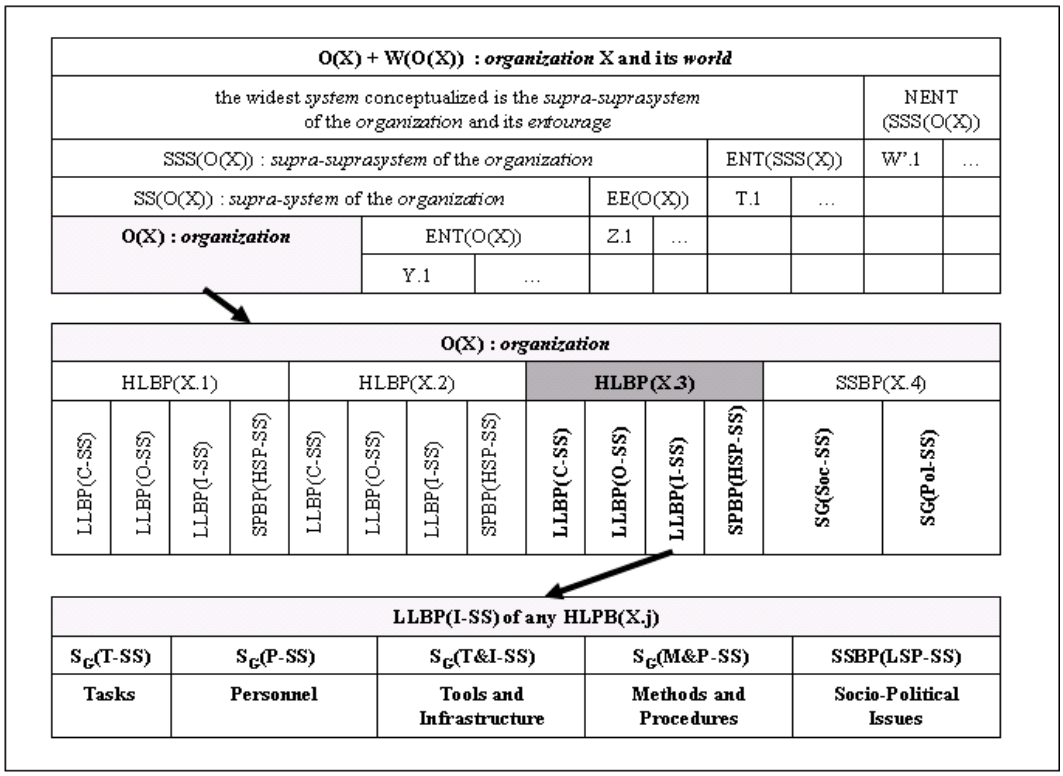

Figure 3. The Articulation of the Systemic Concepts of Organization and IS

Ives' et al Framework	Nolan and Wetherbe's Framework	Mora, Gelman et al's Framework
<external environment> : legal social, cultural, economic, educational, resource and industry/trade systems	**Not considered**	EE(O(X))
Not considered explicitly	<environment of the organization>: competitors, government, suppliers, customers, etc.	ENT(O(X))
The concept of <organizational environment> really considers organization's attributes such as: goals, tasks, structure, volatility and management philosophy/style	<organization>	O(X)
	The 5 subsystems of <organization>: goals and value SS, psychosocial SS, technical SS, managerial SS and structural SS	Goals & value SS and psychosocial SS are considered in the SSBP(X.4) and the SSBP(HSP-SS) for any HLBP(X.j). The same applies for the attributes posited by Ives' et al
<user environment> + <use process>	**<MIS Technology> :** **(hardware, software, data base, procedures and personnel)** (Development, operations and maintenance aspects are considered in this concept)	Any HLBP(X.j) and SSBP(X.4)
<IS development environment> + <IS development process>		LLBP(O-SS) and SSBP(X.4)
<IS operations environment> + <IS operations process>		HLBP(X.3) and SSBP(X.4)
<Information Subsystem> (attributes of content, presentation, time, etc)		**LLBP(I-SS) = SG(T-SS) + SG(P-SS) + SG(T&I-SS) + SG(M&P-SS) +SSBP(LSP-SS)**

Figure 4. Systemic map of the concepts for IS Research in the three Frameworks

Finally, Figure 5 exhibits a mapping of the concepts posited in previous two frameworks and the new one reported. From the formal definitions of *system-I*, *system-II* and *general system*, and the updated and new ones reported (*organization*, *suprasystem*, *supra-suprasystem*, *envelop*, *entourage* and *world*) can be inferred that previous frameworks failed in its effort to be comprehensive and its systemic articulation.

The new framework, in contrast: (i) is congruent with formal definitions of system; (ii) permits the modeling of all variables reported as sub-systems or attributes of sub-systems; (iii) includes the time variable if required through the consideration of the state of the system; (iv) and integrates both technical as socio-political perspectives.

Hence, despite a further and more detailed articulation of it is required, it can be concluded that new framework is more comprehensive and systemic correct than previous efforts. However, it must be considered a research start point rather than an end point.

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