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A Formal Definition of Information Systems

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INTRODUCTION

Since its conceptualization in the 1960s (Adam & Fitzgerald, 2000), information systems (IS) has undertaken a hard effort to be recognized as a scientific discipline. Nowadays, indicators such as the existence of undergraduate, master, and doctoral programs; research centers focused on IS topics; specialized conferences and journals; and professional and academic associations suggest that the IS discipline is a scientific field that is independent from its root disciplines (e.g., computer science, management science, accounting, and behavioral sciences).

On the other hand, during this 50-year path, the discipline of information systems can be critiqued for the multiple self-identities perceived by the different stakeholders (e.g., IS researchers, IS practitioners, and IS users). Gelman, Mora, Forgionne, and Cervantes (2005) point out the following weaknesses IS exhibits, making it a still immature field:

i. the scarce utilization of deductive and formal (e.g., logical-mathematical) research models and methods (Farhoomand, 1987, p. 55);
ii. the lack of a formal and standard set of fundamental well-defined concepts used in the discipline (Banville & Landry, 1989, p. 56; Alter, 2001, p. 3; Wand & Weber; 1990, p. 1282); and
iii. the excessive number of availiable micro-theories (Barkhi & Sheetz, 2001, p. 11).

Additionally, the partial, disparate, and not consensual conceptualizations of what is the focus of study in IS is(Alter 2003; Benbazat & Zmud, 2003), along with the lack of integration of multiple research methodologies to cope with the complexity of the phenomena of study (Mingers, 2001), also suggest that the maturity-development process for the IS discipline still is an ongoing process.

Gelman et al. (2005), based on a profound study of the term *information system* (Mora, Cervantes, Mejia, & Weitzenfeld, 2002), confirmed that the fundamental concepts used in most IS research are based on few and misused core concepts from what is the Theory of Systems (Ackoff, 1960, 1971), and that the few proposals for formalization (Wand & Weber, 1990; Mentzas, 1994; Alter, 2001, 2003) are still incomplete. Furthermore, although Systems Science concepts were used in the two most comprehensive IS research frameworks reported in the IS literature (Ives, Hamilton, & Davis, 1980; Nolan & Wetherbe, 1980), a recent study also identified conceptual inconsistency and incompleteness in both frameworks from a formal systemic view (Mora, Gelman, Cano, Cervantes, & Forgionne, 2006). Hence, it can be inferred that the utilization of an informal, conflicting, and ambiguous communicational system in the IS discipline (Banville & Landry, 1989) and the lack of a comprehensive IS research framework have hindered the development of a cumulative research tradition and delayed the maturation of the field (Wand & Weber, 1990; Farhoomand, 1987).

As reported in Mora et al. (2002) and extended in Gelman et al. (2005), the formalization of the core concepts used in the IS discipline becomes a relevant and mandatory, as well as urgent, research purpose. This article furthers this purpose by utilizing the core principles from the Theory of Systems and a recent IS research framework (Mora et al., 2006) to extend and update the conceptualizations reported in previous studies. Formal definitions are updated and built upon the terms *system* (Ackoff, 1971; Gelman & Garcia, 1989), *organization, business process,* and *information system* (Mora et al., 2002; Gelman et al., 2005). Finally, this article examines the implications for IS research and practice.

BACKGROUND

The term *information system* has been defined in textbooks and research papers usually in non-formal terms. Table 1 shows a sample of the main definitions posed in the literature. An examination of these definitions suggests that the IS no-

Table 1. A sample of informal definitions of what an information system is

Definition	Reference
An IS is a system composed of subsystems of hardware, programs, files and procedures to get a shared goal.	Senn (1989, p. 23)
An IS is a system composed of application software, support software, hardware, documents and training materials, controls, job roles and people that uses the software application.	Hoffer, George, and Valachi (1996, p. 8)
An IS is a system composed of inputs, models, outputs, technology, data bases and controls.	Burch and Grudnitski (1989, p. 58)
A complete information system is a collection of subsystems defined by functional or organizational boundaries.	Ives et al. (1980, p. 910)
MIS is an integrated man-machine system for providing information to support the operation, management, and decision-making functions in an organization. The system utilizes computer software and software, manual procedures, management and decision models and a database.	Nolan and Wetherbe (1980, p. 3, quoting Davis, 1974)
We conceptualize the IT artifact as the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context(s).	Benbazat and Zmud (2003, p. 186)

tion: (i) lacks fundamental standardized and formal concepts (Alter, 2001); (ii) lacks competitive formal macro-structures to cumulate theories (Farohoomand & Drury, 2001, p. 14), and (iii) has an excessive variety of micro-theories (Barkhi & Sheetz, 2001).

There have been few, if any, efforts to formalize the the core concepts of IS. Despite attempts to reduce ambiguity, which have increased consequently the quality of the definitions, these proposals (Wand & Weber, 1990; Alter, 2001) have relied on partial views—for example, syntactical and structural perspectives that hide core semantic information—of the concept *system* formulated in the Systems Science literature (Sachs, 1976; Mora et al., 2002). Another study (Mentzas, 1994) offers a more articulated definition than exhibited in Table 1, by the identification of five subsystems and their functional properties. Nevertheless the resulting definition still lacks formalization and is based on a common-sense language that has been critiqued in the IS literature (Banville & Landry, 1989). Therefore, the concept *information system* still has multiple meanings. A systems-based research stream (Paton, 1997; Alter, 2001; Mora et al., 2002) combined with an ontological perspective (Wand & Weber, 1990) suggest that formal foundations from the Theory of Systems (Xu, 2000, p. 113) can reduce this ambiguity and strengthen the rigor that a scientific discipline requires to mature and simultaneously be relevant and useful for practitioners.

THE FORMALIZATION OF THE CONSTRUCT *INFORMATION SYSTEMS*

Formalization reported in this article is adapted and extended from previous definitions of the formal concepts of *system-I, system-II,* and *general system* (Gelman & Garcia, 1989). In turn, the concepts *organization* ***O(X)****, Information System* ***IS(X),*** and *envelop* ***EE(X)*** are updated from Mora et al. (2002), and the original concept of *environment* ***W(X)*** is replaced by the French term *entourage* ***ENT(X)***. To complete this set of formal definitions, Mora et al. (2006) also introduce the following concepts: *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)***. Updates are mainly based on ideas reported by Oliva and Lane (1998) on soft systems and originally developed by Checkland (2000). As in similar works from the authors and related literature (Wand & Weber, 1990; Wand & Woo, 1991), we follow a conceptual development based on an ontological path to define primitive concepts and postulates to derive the set of updated and new definitions.

Formal Definition 1

System-I: An object of study **X,** formalized as ***system-I*** and denoted as $\boldsymbol{S_I(X)}$**=<B(X),RB(X),E(X)>,** is a whole **X** that fulfills the following conditions: (I.1) it has a *conceptual structure* **§(X)** that defines its set of *attributes* **B(X)**, its set of *events* **E(X),** and its set of *range of attributes* **RB(X)**; (I.2) for any subset **B'(X)** of *attributes* of **B(X)**, the set of *events* **E(X)** associated with **B(X)** differs in at least one element from the set of *events* **E'(X)** associated with **B'(X).**

Therefore, to define a situation of study as a *system-I* implies to specify $\boldsymbol{S_I(X)}$ **= <§(X)> =<B(X), E(X), RB(X)>** and to fulfill condition I.2.

Formal Definition 2

System-II: An object of study **X,** formalized as ***system-II*** and denoted as $\boldsymbol{S_{II}(X)}$**=<**$\boldsymbol{C_X}$**,** $\boldsymbol{\Re_s(C_X')}$**>** is a whole **X** that fulfills