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A Framework for Managing Complexity in Information Systems

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ABSTRACT

A particularly difficult, but important, challenge in the design and development of contemporary information systems is dealing with complexity. Although complexity has been richly discussed from various perspectives in the literature, there is limited guidance on how to address complexity in information systems design. This research analyzes different approaches to handling complexity and finds that there exists a plurality of ways in which to address complexity that are dependent upon the given situation. This analysis results in the derivation of a framework for addressing complexity in information systems. The framework explicitly recognizes implications and limitations of decomposition, inner-outer environments, abstractions, and decentralization, and the role of Ontology. Application of the framework is intended to enable information researchers to identify and adapt applicable strategies for managing complexity in any domain.

KEYWORDS

Abstraction, Chaos Theory, Complex Adaptive Systems, Complexity, Decomposition, Inner Environment, Ontology, Outer Environment

INTRODUCTION

An information system is a representation of a real world system (Wand & Weber, 1995). Today's information systems operate in a complex business environment driven by rapid changes in technology and a highly competitive business setting. Information systems must be developed quickly and accurately. Challenges in designing and developing information systems involve understanding what to include or exclude in a design, as well as dealing with the complexity of systems development efforts. The latter involves identifying and deciding how information can be captured and represented (Clarke, Burton-Jones, & Weber, 2013; Hadar, Soffer, & Kenzi, 2014). To be practically useful, of course, an information system must consistently and accurately model applications (Choi, Song, & Han, 2006).

There have been a number of approaches to dealing with complexity in information systems. Notably, are Wand and Weber's (1993) work on decomposition and Simon's (1996) notion of inner and outer environment. These approaches are, generally, based upon the notion of abstraction, although they have not been presented as such. There is, thus, a need to understand and synthesize

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these different approaches in an effort to provide clarification and guidance on their use when dealing with complexity.

The objective of this research is to analyze the work that has been carried out to deal with the notion of information systems complexity, identifying the appropriate use of different approaches for a given situation. The overall contribution is to provide suggestions and guidelines for addressing complexity in designing information systems. Our research proposes that employing various notions of abstraction is useful for this purpose.

The following tasks are involved in carrying out this research.

1. Analyze complexity from the perspective of using abstractions and ontologically-based decomposition.
2. Propose a framework for positioning and conducting research centered on concepts and tradeoffs involved when dealing with complexity from an abstraction perspective (where abstraction is considered a specific mechanism associated with decomposition).
3. Identify existing approaches, both in information systems and other domains (e.g., biology and physics), to addressing complexity. From this we populate our proposed framework for understanding complexity and suggesting when to use a specific approach or a combination of approaches.
4. Illustrate the use of the framework by showing how it can help information systems developers identify and select strategies for managing complexity.

The remainder of the paper is organized as follows. The following section reviews related research. The section, Framework for Complexity in Designing Information Systems, proposes an abstraction-based framework for dealing with complexity. The fourth section discusses the results of doing so. The final section concludes the paper, and proposes areas for future research.

RELATED RESEARCH

The notion of complexity has been richly examined in the literature from a variety of perspectives, including algorithmic complexity (in the form of mathematical complexity theory and information theory), deterministic complexity (in the form of chaos theory and composite theory), and aggregate complexity (Manson, 2001). Algorithmic complexity is primarily concerned with the problem of complexity that makes it difficult to describe systems' characteristics. In the form of mathematical complexity theories, algorithmic complexity calculates the effort required to solve complex problems within information theory (Chaitin, 1992). Complexity is addressed through the simplest computation that can reproduce system behavior. Deterministic complexity posits that the interaction of a few variables creates largely stable systems that are prone to sudden discontinuities (Manson, 2001). Aggregate complexity finds holism and synergies resulting from the interaction of system components. In this form of complexity, the properties of the whole system are different than the sum of the constituent parts; therefore, such systems have emergent qualities that are not separable from the properties of the components (Baas & Emmeche, 1997) .

This section first defines complexity with respect to designing information systems. It then examines complexity from the different perspectives found in the literature. First, though, the main concepts of complexity, emergence, and abstraction are defined and described.

It is, generally, not easy to explain complexity, although a great deal of work has been carried out to try to specify the characteristics of a complex system (Ladyman, Lambert, & Wiesner, 2013). For the purpose of this paper, our definition is limited to the context of designing and developing information systems. The definition proposed by Simon fits this context well: "Roughly, by a complex system I mean one made up of a large number of parts that have many interaction. …, in such systems

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