Chapter XLV
System Dynamics to Understand Public Information Technology

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INTRODUCTION

Information technology development and implementation have been recognized as forms of organizational change (Doherty & King, 2003; Orlikowski, 2000). Public-sector organizations are interested in this process of change because of the expected benefits of using IT, such as cost savings, improved service quality, increased accountability, and public participation (Gil-Garcia & Helbig, 2006). However, IT fails to deliver the anticipated payback in many projects (Jackson, 1997; Keil, Cule, Lyytinen, & Schmidt, 1998). Some of such failures are the result of our lack of understanding about the relationships among IT components and organizational factors involved in the implementation process, producing mismatches or unintended consequences in the process: "[t]he computer hardware may perform correctly, and the software may satisfy its specification; but the results are not what was intended, and may be disastrous" (Jackson, 1997, p. 5).

This chapter presents system dynamics as a method to get a better understanding of such mismatches in public information technologies. The method has already been used successfully in the planning and evaluation of both public and private IT applications (Abdel-Hamid & Madnick, 1991; Madachy & Tarbet, 2000; Wolstenholme, 2003; Wolstenholme, Henderson, & Gavine, 1993). The method allows us to understand the interactions among technologies and organizations as a continuous process of organizational change (March, 1981), in which it is possible to find brief periods of rapid change. However, even those periods of rapid change are conceptualized as the result of endogenous and continuous local adaptations (Hutchins, 1991), where technology enables, not causes change (Orlikowski, 2000).

The chapter presents the basic principles and tools of system dynamics and continues with an example of its application in the analysis of an IT project in the public sector. The chapter ends with a brief description of future trends in modeling and simulation as well as a brief conclusion.

BACKGROUND

System dynamics is a method for studying and managing complex feedback systems (Forrester, 1961; Richardson & Pugh, 1981; Roberts, Andersen, Deal, Grant, & Shaffer, 1981; Sterman, 2000). One of the basic principles of system dynamics is that a system's performance over time is closely linked to an underlying structure of endogenous feedback processes. That is to say, patterns of behavior in the system are explained mainly by endogenous processes, not by exogenous factors. The processes of modeling and simulation are mainly intended to learn about how the world works, helping policy makers to improve their way of thinking (Senge, 1990). Usually, a computer model is needed because of human limitations to predict and manage the behavior of these complex structures (Forrester, 1971). In this way, the modeling process becomes a formal way of developing and testing hypotheses about the impact of feedback processes on specific problematic behaviors in a system.

The Modeling Process

System-dynamics practitioners have described the modeling process as a series of steps going from problem understanding to model validation and use (Randers, 1980; Richardson & Pugh, 1981; Roberts et al., 1981; Sterman, 2000). The modeling process involves the analysis of problem dynamics (expressed on graphs of behavior over time) and problem structure (expressed graphically in causal-loop diagrams or stock-and-flow diagrams, and mathematically in systems of differential equations). In this way, a system-dynamics computer model is the result of an iterative process of comparing and contrasting a set of assumptions about the system structure and the known behaviors of it.

In this way, defining problems in terms of behavior over time (graphs over time), and developing feedback-rich diagrams (causal-loop and stock-and-flow diagrams) are two basic skills to model problems.[1]

Defining Problems in Terms of Behavior Over Time

In system dynamics, defining problems means to express them in terms of their dynamic behavior (Richardson & Pugh, 1981), moving from static pictures of symptoms of a problem to a dynamic definition of it (Mashayekhi, 1992; Senge, 1990).

The term *reference mode* refers to patterns of behavior over time. These patterns represent the dynamic behavior of important problem-related variables. The reference mode is an abstract concept to guide the modeling process, which is built by using multiple sources of historical evidence, such as verbal descriptions, time series, or key events (Saeed, 1998). In terms of the data available, a modeler can draw graphs of either historical data series (information available from records in the organization) or idealized reference modes (information available from actors' judgments and mental models). In terms of the project scope, modelers create sketches of historical data, forecasted dynamics (what we can expect to happen), or preferred dynamics (what we desire to happen).

Historical data series are complex patterns that represent the effects on system behavior of multiple problem components (Saeed, 1992). Therefore, historical data series can be used as the starting point to create a reference mode, but using that pattern as the reference mode itself can be misleading to the modeling effort. Although historical data series can show many different behaviors, most of those rich behaviors

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