On Frameworks and Architectures for Intelligent Decision-Making Support Systems

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INTRODUCTION

Making organizational decisions is a critical and central activity to successful operations of profit and nonprofit-based organizations (Huber, 1990; Simon, 1997). Organizational paradigm evolution from the paternalistic/political and accountability/bureaucratic organizational paradigms toward process-oriented and decisional views (Huber & McDaniel, 1986) has also fostered the organizational relevance of such processes. Some studies suggest that decision-making ineffectiveness is the main cause for top executive firings in large corporations (Rowe & Davis, 1996). Others state the need to find possible solutions/decisions to the new critical and complex world problems (such as pollution, poverty or corruption) (McCosh & Correa-Perez, 2006) and make better strategic business managerial decisions (Savolein & Liu, 1995). Consequently, how to do so becomes a relevant research stream for academicians and has strong practical implications for decision-makers.

Simultaneously, to study, understand, and improve the individual, team-based, and organizational decision-making process (DMP) through computerized system tools has been academically recognized in Management Science (Huber & McDaniel, 1986; Little, 1986; Scott-Morton, 1971), Operations Research (Simon et al., 1987), and Artificial Intelligence (Goul, Henderson, & Tonge, 1992). Such computerized tools (called decision-making support systems (DMSS)), include decision support systems (DSS), executive information systems (EIS), expert or knowledge-based systems (ES/KBS), and other stand-alone or integrated systems (Forgionne, Mora, Gupta, & Gelman, 2005). When AI-based mechanisms and intelligent services are deployed within the DMSS to serve tasks that demand intelligence, such systems are identified as intelligent DMSS (i-DMSS) (Mora, Forgionne, Gupta, Cervantes, & Gelman, 2005). These i-DMSS are designed to enhance DMSS by incorporating more complete representations for data, information, and knowledge models and to provide intelligent processing algorithms or heuristics than traditional systems (Bonczek, Holsapple, & Whinston, 1981; Holsapple & Whinston, 1996; Jacob, Moore, & Whinston, 1988; Liang, 1988; Little, 1986; Simon, 1987; Simon et al., 1987).

According to Mora, Forgionne, Cervantes, Garrido, Gupta, and Gelman (2005, p. 323) a missing knowledge piece in the i-DMSS research stream has been the lack of an integrated framework (architecture or component model) that supports a standardized design and evaluation process from a Decision-making Process and a Computational Mechanism perspective. This failure has occurred even though AI researchers have long suggested that the design of intelligent systems must separate the analysis of tasks from their implementation computational mechanisms.(Chandrasekaran, 1986, 1990; Chandrasekaran, Johnson, & Smith, 1992; Clancey, 1985; McDermott, 1988; Newell, 1981; Steels, 1990). As a result, the i-DMSS concept has not been implemented widely.

This article, then, reviews five of the several general design frameworks and architectures for developing intelligent decision-making support systems (i-DMSS) posed in the DMSS literature. Few studies have addressed such research issues or offer a combined view for a better understanding of an i-DMSS design. A conceptual research method with a descriptive approach (Glass, Ramesh, & Vessey, 2004; Mora, 2004) is used to guide the analysis. First, an overview of the generic decision-making process is developed, followed by the description and analysis of the five frameworks and architectures. By using the last generic architecture as the broadest container, the limitations and contributions of such frameworks and architectures are discussed. The article ends with a brief but substantial discussion on the research and practical challenges for advancing this stream of research.

BACKGROUND

The Decision-Making Process

Most models of a general decision-making process (DMP) reported in the literature are based on the seminal work of Herbert A. Simon (Simon, 1960, 1997). These DMP models originate from problem-solving (Huber,

Table 1. General decision-making process models

<table>
<tr><th>Simon's DMP Model</th><th colspan="2">Huber's (1980) DMP Model</th><th colspan="2">Sage's (1981) DMP Model</th><th colspan="2">Howard's (1988) DMP Model</th><th colspan="2">Turban & Watson (1994), Forgionne's (1991) DMP Model DMP Model</th></tr>
<tr><td rowspan="3">Intelligence</td><td rowspan="3">Analysis</td><td>Problem Identification</td><td rowspan="3">Formulation</td><td>Problem Definition</td><td rowspan="3" colspan="2">"Real Decision Problem"</td><td rowspan="3">Intelligence</td><td>Problem Recognition</td></tr>
<tr><td>Problem Definition</td><td>Value System Design</td><td>Data Gathering</td></tr>
<tr><td>Problem Diagnosis</td><td>Systems Synthesis</td><td>Objectives</td></tr>
<tr><td rowspan="3">Design</td><td rowspan="3">Generation</td><td rowspan="2">Generation of Alternatives, Criterions and Scenarios</td><td rowspan="3">Analysis</td><td rowspan="2">Systems Modeling</td><td rowspan="3">Formulation</td><td>Choices</td><td rowspan="3">Design</td><td>Design of Criteria</td></tr>
<tr><td>Models</td><td>Design of Choices</td></tr>
<tr><td>Model Behavior Design</td><td>Optimization</td><td>Preferences</td><td>Design of Model</td></tr>
<tr><td rowspan="4">Choice</td><td rowspan="4">Election</td><td rowspan="2">Evaluation</td><td rowspan="6">Interpretation</td><td rowspan="2">Evaluation</td><td rowspan="2">Evalua-</td><td>Evaluation Procedures</td><td rowspan="4">Choice</td><td>Model Solution (Evaluation)</td></tr>
<tr><td>Prioritizing</td><td>Sensitivity Analysis</td></tr>
<tr><td rowspan="2">Selection</td><td rowspan="2">Selection</td><td rowspan="2">Appraisal</td><td>Sensitivity Analysis</td><td rowspan="2">Selection</td></tr>
<tr><td>Re-Prioritizing</td></tr>
<tr><td rowspan="2">Implementation (added)</td><td rowspan="2">Implementation</td><td>Decision Planning</td><td rowspan="2">Planning for Action</td><td rowspan="2" colspan="2">"Real Action"</td><td rowspan="2" colspan="2">Planning for Implementation</td></tr>
<tr><td>Decision Execution</td></tr>
<tr><td rowspan="2">Learning (added)</td><td rowspan="2">Control</td><td>Monitoring & Control</td><td rowspan="2" colspan="2"></td><td rowspan="2" colspan="2"></td><td rowspan="2" colspan="2"></td></tr>
<tr><td>Verification</td></tr>
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