Computers in Industry 92 (2017) 161–177

Contents lists available at ScienceDirect

Computers in Industry

journal homepage: www.elsevier.com/locate/compind

A decision model and system for planning and adapting the configuration of enterprise information systems

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ARTICLE INFO

Article history:
Received 7 April 2017
Received in revised form 19 July 2017
Accepted 10 August 2017
Available online xxx

Keywords:
Enterprise modelling
Decision-making model
Risk management
Computer-supported investment planning
ERP systems
CRM systems

ABSTRACT

The decision to invest in an enterprise information system is usually made without taking into account the different types of subsequent decisions and without understanding the hidden implications of making them. This paper presents a decision-making model named DecISIonAl used to evaluate and manage implementation risks on ERP and CRM projects before the actual investment is made. This model was implemented into a web-based system to facilitate configuring, comparing, and selecting implementation plans by evaluating their impact in terms of cost, time, benefits, human resources capabilities, and risks. We apply our decision model to investment case studies in two enterprises. The results show a level of compliance between 80% and 83% when comparing the implications estimated by simulated scenarios and the actual investments.

1. Introduction

Information technology (IT) investments have become vital to deal with the changing and competitive organizational environment. Most companies invest on enterprise information systems (EIS) such as enterprise resource planning (ERP) and customer relationship management (CRM) systems. These EIS investments support several transactional, informational, and strategic capabilities expected in an IT portfolio [1].

The decision to invest on these EIS seems evident, however this decision entails implications that are not always considered by decision makers when planning the investment: high and hidden costs in implementation, time required for aligning the EIS generic data and processes with organizational-specific needs [2], specific human capabilities required in configuration, implementation and deployment risks, among others. Even when two companies face an EIS implementation within similar conditions, the way each one faces the risks of the implementation process is determinant to assure the success or failure of the project [3]. For example, some companies adopt open source platforms to tackle financial issues. Unawareness of the subsequent decisions associated with an EIS investment (*e.g.*, target platform, implementation model, maintenance model) increases the issues and uncertainty in the implementation and management of the investment. Naturally, the subsequent decisions and implications appear once the investment has already been made and then it is too difficult and expensive to change them.

Moreover, the following challenges have been identified recently as the next generation of Enterprise Information Systems. The enterprise design (business and IT models) must be continuously adjusted according to changes in the business strategy or to changes in IT capabilities. These models must support automated processing operations for decision making on potential risks and opportunities due to enterprise change [4]. In addition, faster, better, and smarter decisions on enterprise automation require representing and analyzing a large amount of environmental and operational information on enterprise models to achieve sustainable enterprise systems [5]. Despite this challenge refer to EIS design and operation, it also applies for planning the adoption and configuration of EIS which require representing and analyzing a large amount of information for decision-making (*e.g.*, product information, implementations risks, and decisions made by multiple stakeholders). This amount of asymmetric information increases the complexity to support decision-making by IT managers [6]. Therefore, modelling tools and systems for model analysis are required for designing and adapting EIS before they are actually changed [4]. We illustrate these challenges by presenting a detailed discussion of open issues found in literature review (see Section 2).

We aim to provide a suitable and comprehensive approach to perform an ex-ante evaluation of the implications related to an EIS investment project. This paper presents the design, implementation,

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http://dx.doi.org/10.1016/j.compind.2017.08.004
0166-3615/

and evaluation of three artefacts to plan and adapt investments in new EIS (see Section 3). First, we create a metamodel to abstract and support the implementation of model instances related to the IT investment planning domain (see Section 4.1). Second, we create a decision model instance which defines and relates 12 decision models or types (*e.g.*, EIS modules, EIS implementation type, EIS deployment model) representing common characteristics to configure and justify investment scenarios (see Section 4.2). Each decision type contains decision alternatives or options representing the variable characteristics for a decision-making process on ERP and CRM systems. The model defines, for each decision option, a set of decision criteria or implications as a reference value evaluated for a specific dimension (*i.e., costs, time, human resources, and risks*) in terms of a specific business activity (*e.g.*, maintenance, implementation, integration). This decision model also incorporates EIS business drivers, EIS-specific risks, and IT investment-generic risks as additional decision criteria to analyze the impact of an investment scenario. Finally, we develop a web-based Decision-Support System (DSS) to enact the instantiated model (see Section 5). The DSS allows multiple stakeholders to configure different EIS decision scenarios by selecting decision options for each of the decision models representing an EIS investment/implementation plan. Then, the predefined model constraints turn subsequent decisions mandatory or unavailable and the resulting implications (*e.g.*, EIS-specific risks) are presented to decision makers to enrich the impact analysis and decision-making capabilities. The DSS also allows to automatically combine multiple EIS configurations defined for a common investment into an optimal configuration. To achieve this, we have defined in previous works [7–9] a program synthesis to specify configuration constraints (*e.g.*, optimization functions, hard limit constraints) for general-purpose domain models and to automate their processing by using constraint programming.

An ex-ante evaluation of the implications at the planning stage of an EIS investment, allows the organization to identify and allocate needed resources, to understand and manage risks, and to manage uncertainty before an EIS implementation. We used the proposed model to analyze the EIS investments performed by two companies. The results show a level of compliance between 80% and 83% when comparing the implications estimated by simulated scenarios and the actual implications obtained when the investments were made (see Section 6). We conclude by discussing the capabilities of the decision model to be extended and reused, and also directions for future work (see Section 7).

2. Preliminaries and motivation

2.1. Core concepts

An *EIS* is a system that integrates different modules required by a company to support the execution of multiple business processes in an efficient manner [1]. Two of the main subsystems that compose an EIS are ERP and CRM systems. Some of the modules considered by an ERP are the finance asset management, production, project management, sales, human resources, among others [10]. The CRM integrates different business processes and stakeholders, which are usually related to marketing, sales, and customers management [11]. Sometimes, CRM is seen as an additional module of an ERP solution [1], however given its complexity we define it as an independent system.

Usually, the selection of a particular module or capability within an EIS requires IT support in order to organize and explore concerning information models. A *DSS* is a system that supports a set of tasks in a decision process by processing input information (*i.e.*, requirements from a user) according to stored knowledge, in order to present a result or decision as outcome [12]. A DSS entails productivity, agility, innovation, or satisfaction when deriving a particular outcome. A DSS is useful and necessary when selecting a particular decision in a complex domain, such is the case of a business context for investing in IT where variables like functional

Table 1
Gaps and solutions for planning the configuration of EIS.

	Approaches	Gaps	Scope of our approach
MCDM	Tsai et al. [13] Kahraman et al. [14] Karaarslan et al. [15] Sarkis et al. [16] Teltumbde [18]	• Decision models are bounded for an individual decision type at a time. • Most approaches do not consider risk attributes as decision criteria. • Management of ephemeral models representing both functional and non-functional criteria.	• A decision model integrating 12 MCDM decision models (types) considered during an ex-ante EIS investment evaluation. • Cross-model analysis of adaptive and persistent decision criteria and its metadata (reference values) related to decision alternatives. • Modelling of risks as relevant decision criteria within each alternative for searching a suitable option. • A metamodel for configuring decision models by defining decision types, decision alternatives, and decision criteria for selecting them. • Tools for verifying the consistency of decision models. • Semi-automated configuration of decision scenarios performed by stakeholders for planning EIS investments. • A DSS for searching optimal configurations (quantitative and qualitative analysis) among multiple decision scenarios. • Tools for identifying conflicts among decision scenarios.
Analytical	Apostolopoulos et al. [19] Gunasekaran et al. [20] Haddara et al. [21] Benaroch [22] Leiblein et al. [23] Wu et al. [24]	• Lack of a semi-automated approach to search suitable EIS investment alternatives. • Missing mechanisms to support decision scenarios with multiple stakeholders. • Decision-making models for planning IT investments but few specific to EIS. • Lack of risk analysis mechanisms in EIS decision scenarios.	
Other	Daneshgar et al. [17] Renkema et al. [25] Jukic et al. [26] Daneva et al. [27] Berghout et al. [28] Mukherji et al. [29]	• Informative sources without further risk analysis. • Lack of quantitative considerations related to decision criteria. • Models to effectively use an EIS, but not to effectively plan its investment.	