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Technology management methodologies and applications A literature review from 1995 to 2003

Shu-hsien Liao*

Department of Management Sciences and Decision Making, Tamkang University, No. 151, Yingjuan Road, Danshuei Jen, Taipei 251, Taiwan, ROC

Abstract

Technology management is a process, which includes planning, directing, control and coordination of the development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization. This paper surveys technology management (TM) development using a literature review and classification of articles from 1995 to 2003 with keyword index in order to explore how TM methodologies and applications have developed in this period. Based on the scope of 546 articles of technology management methodologies, this paper surveys and classifies TM methodologies using the eight categories of: TM framework, General and policy research, Information systems, Information and communication technology, Artificial intelligence/expert systems, Database technology, Modeling, and Statistics methodology, together with their applications for different research and problem domains. Discussion is presented indicating future development for technology management methodologies and applications as follows: (1) TM methodologies tend to develop towards expert orientation, and TM applications development is a problem-oriented domain. (2) Integration of qualitative and quantitative methods, and integration of TM technologies studies may broaden our horizons on this subject. (3) The ability to continually change and obtain new understanding is the power of TM methodologies and will be the subject of future work.

Keywords: Technology management; Technology management methodology; Technology management application; Literature survey

1. Introduction

Technology management is a process, which includes planning, directing, control and coordination of the development and implementation of technological capabilities to shape and accomplish the strategic and operational objectives of an organization (Task Force on Management of Technology, 1987). On the other hand, technology management includes: (1) planning for the development of technology capabilities; (2) identifying key technology and its related fields for development; (3) determining whether 'to buy' or 'to make', i.e. whether importation or self-development should be pursued; and (4) establishing institutional mechanisms for directing and coordinating the development of technology capabilities, and the design of policy measures for controls (Wang, 1993). Clearly, technology management should not only fulfill the management needs of a specific set of technologies within a domain and inter-domain relationship, but it should also develop the implementation strategies according to the available resources, current technologies, future markets, and socio-economic environment (Linn et al., 2000). Therefore, how to manage technology has become an important issue in the past few decades, and the technology management (TM) community has developed a wide range of methodologies and applications for both academic research and practical applications. In addition, TM has attracted much effort to explore its nature, concepts, frameworks, architectures, theories, systems, models, tools, functions, and real world implementations in order to demonstrate TM methodologies and their applications.

As a part of TM research, this paper focuses on surveying technology management development through a literature review and classification of articles from 1995 to 2002 in order to explore the TM methodologies and applications from that period. The reason for choosing this period is that the Internet was opened to general users in 1994 and this new era of information and communication

* Tel: +886-2-29472044; fax: +886-2-29453007.
E-mail address: Michael@mail.tku.edu.tw

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technology has played an important role not only in electronic commerce, but also in technology management. The literature survey is based on a search for the keyword index 'technology management' on the Elsevier SDOS online database, from which 9253 articles were found on 31 July 2003. After topic filtering, there were 1626 articles related to the keyword 'technology management application' and 546 of these were connected to the keyword 'technology management methodology'. Based on the scope of 546 articles on technology management methodology, this paper surveys and classifies TM methodologies using eight categories: TM framework, General and policy research, Information systems, Information and communication technology, Artificial intelligence/expert systems, Database technology, Modeling, and Statistics methodology, together with their applications on different research and problem domains.

The rest of the paper is organized as follows. Sections 2 to 9, present the survey results of TM methodologies and applications based on the above eight categories. Section 10 presents discussion, with suggestions for future development of technology methodologies and applications. Finally, Section 11 contains a brief conclusion.

2. Technology management framework and its applications

Since the 1980s, technology and the academic discipline management of technology, has received widespread attention from both practitioners of management and academics (Drejer, 1997). Researchers have developed a set of management definitions, concepts, activities, stages, circulations, and procedures, all directed towards dealing with objects in order to describe the framework of technology management as the TM methodology. Different TM working definitions, paradigms, frameworks, concepts, objects, propositions, perspectives, measurements, and impacts have been described for investigating the questions of: What is technology management? What are its methods and techniques? And what are its functions for supporting individual and organizations in managing the technology (Sarkis et al., 1995; Dey et al., 1996; Chan and Choi, 1997; Lopes and Flavell, 1998; Haas and Kleingeld, 1999; Garshnek et al., 2000; Pretorius and Wet, 2000; Sharratt and Choong, 2002; Wu, 2002; Hicks et al., 2002)?

For example, the methodology of enterprise engineering methodology is an integrated socio-technical framework that addresses organizational, cultural, process, and technological issues (Sarkis et al., 1995). In 1996, Dey et al., proposed a conceptual framework for project control through risk analysis, contingency allocation and hierarchical planning models. In their article, risk analysis has been carried out through the analytic hierarchy process (AHP) due to the subjective nature of risks in construction projects (Dey et al., 1996). From the business process reengineering perspective, the reasons for BPR failure have been categorized as the lack of understanding of and the inability to perform BPR; and new key concepts of BPR, such as fundamental, radical, dramatic, and process have been proposed as a conceptual and analytical framework (Chan and Choi, 1997). In addition, the methodology of project appraisal based on non-financial aspects of projects, has previously extended published guidance through interviews with a number of project-oriented organizations in the appraisal procedure (Lopes and Flavell, 1998). For strategy formulation and implementation, Haas and Kleingeld proposed a normative framework for multilevel design of diagnostic controls, i.e. performance measurement systems. Their framework is an attempt to synthesize a design theory from systems theory and cybernetics, using a composite of the goal-oriented model, the multiple-constituency model and the natural-systems model of organization (Haas and Kleingeld, 1999). In space technology, a scenario-based framework has been proposed to discuss and analyze the mitigation, management, and survivability of asteroid/ comet impact with earth (Garshnek et al., 2000). Furthermore, an assessment framework for new technology has been developed, providing suggestions for a 3-dimensional space structure of the business process in order to assess the relationship between technology and process on a manufacturing enterprise (Pretorius and Wet, 2000). In addition, the methodology of PERA (process environment risk assessment), has been presented for the assessment of business risks during the design of new processes. This methodology can be used as a project-centered risk assessment method that seeks potential problems along the overall supply chain (Sharratt and Choong, 2002). A framework for implementing an integrative approach based on a strategic perspective to business process reengineering has been discussed in an empirical study (Wu, 2002). On the other hand, a framework discusses data, information and knowledge, providing formal definitions and an understanding of the relations and limitations of these resources. This framework enables the development of better mechanisms and procedures for the capture and reuse of information and knowledge in engineering design (Hicks et al., 2002). In 2003, Liao presented a literature survey of knowledge management in order to explore the present and future development of KM (Liao, 2003). These methodologies offer technological frameworks and explore their content by broadening the research horizon with different perspectives on TM research issues.

Some applications have been implemented using a TM framework, including computer integrated manufacturing, construction project management, business process reengineering, project appraisal, product design, space disaster management, technology assessment, process design, and engineering design. The methodology of technology