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Development of a web-based system for engineering change management

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Abstract

Engineering changes (ECs) are changes and/or modifications in forms, fits, functions, materials, dimensions, etc., of products and constituent components. ECs usually induce a series of downstream changes. Multiple disciplines and responsibilities are therefore involved in managing ECs. Previous investigations conducted by the authors and other researchers have shown that paper-based and standalone computerised EC management (ECM) systems have limited support for such intensive teamwork and close communication. This paper proposes to establish a web-based framework that supports ECM procedures and activities. A web-based ECM system is able to provide better information sharing, simultaneous data access and processing and more prompt communication and feedback. The amount of paperwork and the throughput time of managing ECs are significantly reduced while the effectiveness and the efficiency are substantially improved. This paper focuses on discussing the issues of design, development, and implementation of this prototype web-based ECM system. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Engineering change management; Web/Internet/Intranet; Configuration management

1. Introduction

The ability to manage changes efficiently and effectively reflects the agility of an enterprise. Engineering changes (ECs) are one kind of changes and/or modifications in forms, fits, functions, materials, dimensions, etc., of products and constituent components. The management of ECs directly affects the agility of the product development process of the enterprise. Recent investigations have revealed that the number of ECs active at any one time in a noticeable number of manufacturing companies reaches a level that is too difficult to manage with a paper-based system and by an ad hoc procedure. In the meanwhile, it has been found that computer aids have not been utilised to facilitate EC management (ECM) activities although sophisticated systems with comprehensive functionality are available in the market. Standalone computer-aided systems are limited in supporting the multi-disciplinary teamwork in ECM, especially when they are distributed in terms of location and time.

The aim of this paper is to develop a web-based ECM framework for facilitating information sharing between various parties that are dispersed at different geographical locations and for achieving simultaneous data access and processing. It is hoped that the proposed framework is capable of overcoming the time and geographical limitations in the paper-based and standalone ECM systems so that the effectiveness and the efficiency in managing ECs are enhanced dramatically. Parties are able to use open standard web browsers to access such systems regardless of where they are and when they start.

The work reported in this paper is only one main part of a research project. The overall research methodology is as follows. The first round of investigation involves the examination of current ECM practices through a comprehensive literature review, a comprehensive industrial survey [1–3], and a review of existing ECM technologies such as computer-aided configuration management and product data management where ECM is usually a subset [4]. This is followed by a second round of investigation to establish a theoretical ECM framework to extract good practice elements and to overcome limitations identified from the review [5–7]. The third round of investigation is mainly concerned with the development of the web-based ECM platform that incorporates the

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theoretical model. The loop of investigation is closed by illustrative case studies for further investigations. This paper is mainly concerned with the third round of investigation of system development.

ECM is a complicated issue. It usually has impacts on other business activities/decisions that are usually addressed in decision support systems such as computer-aided design (CAD), computer-aided process planning (CAPP), product data management (PDM), and enterprise resource planning (ERP). It should be emphasized here that this paper only focuses on ECM activities.

This paper is organised in six sections including the introductory and concluding sections. Section 2 reviews the ECM literature in order to give a brief overview of ECM and the web technology. Section 3 proposes the web-based ECM framework. Main components included in the framework are described. A detailed discussion on how the proposed system is deployed and implemented in the web-based environment is presented at Section 4. Then, the main facilities provided by the system for managing ECs are described at Section 5. Lastly, a discussion summarises the key issues in this paper and highlights the main directions for future work.

2. Literature review

A comprehensive literature review has been conducted on ECM and is still continued. A number of major CD-ROM databases in the libraries were searched for relevant publications. To our surprise, the engineering change (EC) literature is extremely scarce in contrast with other topics such as concurrent engineering (CE) and total quality control/management (TQC/M). Only one volume of monograph was found to cover this topic systematically [8]. Other comprehensive coverage of the topic includes standards such as American MIL-STD-973. A few design and manufacture texts were found to include some coverage of the ECM topic as a chapter [9]. So far, the review by Wright [10] is probably the most comprehensive literature review which is based on some 15 relevant papers.

In total, around three dozens of articles have been retrieved and subsequently obtained. Some of them only contribute briefly to the discussion of the topic in 2 or 3 pages in awareness magazines rather than research journals. Some articles discuss the topic in reasonable depth. They can be divided into four general categories. The first category includes survey and review articles [11,12]. The second category includes those articles reporting on industrial case studies [21,8,1,6,22]. The size of the third category, articles providing implementation frameworks, is relatively small [13,14]. Finally, the fourth category involves strategic conceptual guidelines [15–17].

Boznak [12] has reported on a 1988 international survey conducted among American and European companies (e.g., aerospace, defence, textiles, electronics, consumer products, construction, utility, ship repair, and foundry). It has been found that the cost of change experienced in these companies underscored their difficulty in reducing product costs. The range of company responses has been from two to 1000 monthly changes with an average of 330 design changes per month. Administrative processing costs, from small firms to FORTUNE 500 companies, average US$1400 per change. This corresponds to an annual administrative processing cost ranging from US$3.4 million to US$7.7 million.

There have been a number of industrial case studies on the ECM subject. Saeed et al. [18] have conducted an intensive case study within an American FORTUNE 500 manufacturing company. Hegde et al. [19] have carried out a field investigation on the impact of engineering change orders (ECOs) on completion time of jobs in repetitive manufacturing environments. Balcerak and Dale [20] have examined ECM in an automotive manufacturer and made a number of specific suggestions on EC classification and prioritisation, and effectivity analysis. Harhalakis [14] has carried out industrial case studies on engineering change management for made-to-order products. Watts [21] has told his experience in reengineering the EC control process in an electronic product manufacturer. Perhaps, Dale's early work in 1982 was among one of the best papers that provided a comprehensive framework and yet specific good practice guidelines [13]. Based on his company case studies, Harhalakis [14] also outlined an ECM system. These contributions not only identified ECM activities, but also described responsibilities.

Although scarce, the literature has highlighted a clear message that EC is a serious issue that cannot be underestimated and ECM is of major concern to most companies that design and manufacture products. This has been confirmed in a survey conducted by the authors within the UK manufacturing industries [1]. In addition, the limited number of references has also highlighted that ECM is, in general, under researched and ECM deserves much more attention, compared with its extent of severity as highlighted in the literature.

Most of the efforts reported in the literature have been based on paper-based ECM systems. Although some companies seem to have well-structured comprehensive ECM documents, paper-based systems generally fail to manage ECs with sufficient effectiveness and efficiency. For example, the systematic procedures clearly defined in a document may not be necessarily followed in practice. Some companies adopt such a system that the paper-based EC packages are circulated according to the flowchart indicated on the cover page. When one function finishes with processing the EC package, it is passed onto

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