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A viewpoint analysis reference model for Concurrent Engineering

Martin Hanneghan *, Madjid Merabti, Gary Colquhoun

School of Computing and Mathematical Sciences, Liverpool John Moores University, James Parsons Building, Byrom Street, Liverpool, L3 3AF, UK

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Abstract

Requirements analysis is a complex task. All too often, information systems that do not fulfil users' requirements are built and delivered. In software engineering, viewpoint analysis has been proposed as a means of successfully capturing user requirements for complex systems. Viewpoint analysis is a process that produces a synthesis of requirements from a number of disparate and distinct perspectives. This paper describes such a viewpoint analysis that has been applied to the field of Concurrent Engineering. A viewpoint reference model is proposed which draws on the experiences of a number of existing models from fields such as manufacturing, information systems and distributed computing. This new reference model, the CE-RM, has been designed using object-oriented methods and has been used as a basis for building a Concurrent Engineering support environment. A description of the implementation of this new support environment is given, outlining its supporting computer systems architecture and information system model. The CE-RM is discussed and compared with a number of existing models that have been proposed to capture requirements in the manufacturing and engineering domains in order to validate the viewpoint analysis approach.

Keywords: Concurrent engineering; Viewpoints; Open distributed processing; Object-oriented reference model; Support environment

1. Introduction

Concurrent Engineering (CE) is a manufacturing philosophy that has emerged in the last decade in response to growing pressures to reduce costs and lead times while improving product quality. For the purposes of this research, CE is defined as a systematic approach to parallel development of all product life-cycle activities, from initial conception through design, planning, production and disposal. It presupposes an enriched communication infrastructure which is unconstrained by geographical location and encourages right-first-time methods through cross-functional team working and consensus [24].

In the design of systems, a viewpoint is a self-contained and complete perspective of a person or system that is directly affected by the system under investigation. From an object-oriented perspective, Kotonya and Sommerville [34] describe a viewpoint as ''an external entity that interacts with the system being analysed, but one which can exist without the presence of the system.'' In modelling the requirements of any new system, multiple ideas and perspectives must be analysed and resolved. Invariably, conflicts of opinion and omissions cause requirements specifications to incompletely capture a system's proposed behaviour [22]. Finkelstein et al. [16]

* Corresponding author. Tel.: +44-151-231-2578; fax: +44-151-207-4594; e-mail: m.hanneghan@livjm.ac.uk

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endorse viewpoint analysis as a means for formulating requirements definitions for large and complex systems. In CE projects, we find what has been termed 'the multiple perspective problem' [13] with many actors, sundry representation schemes, diverse domain knowledge and differing development strategies. Smith [47] supports this point stating that co-operation of multiple competing perspectives and the integration of complementary engineering expertise are requirements for systems that intend to support CE. This research contends that viewpoint analysis can therefore be used to help design the complex environments necessary to support CE.

This paper begins, in Section 2, by describing the background for this research which has its basis in architectures and reference models from fields such as Manufacturing, Engineering and Open Distributed Processing. It then goes on, in Section 3, to describe a viewpoint analysis model that has been devised for CE and Section 4 describes a computer systems architecture and environment that has been developed using this model. This is followed in Section 5 by an evaluation of the new model in relation to other initiatives and research, and discusses how the technique of viewpoint analysis can be applied to these existing approaches to help overcome some of their inherent limitations. Finally some conclusions about the viewpoint approach are drawn in Section 6.

2. Background

Over the last decade the concept of manufacturing architectures has evolved to provide structure for the analysis and design of manufacturing enterprises. Early examples include the European ESPRIT phase I-CIM project [52] which provided flowcharts and text descriptions of the generic activities that comprise the machining sector of manufacturing. It is claimed to provide ''a European Computer Integrated Manufacturing (CIM) architecture against which IT vendors could fashion CIM products.'' Subsequently, much of the European ESPRIT phase II research was aimed at developing open-systems CIM architectures and communications to support multi-vendor environments [31,32,37]. In the USA the ICAM architecture [50] was taking a hierarchical architectural approach to do the same thing. The development of the ISO Manufacturing Automation Protocol (MAP) grew from a proposal [29] to ''create a multi-dimensional, open ended reference architecture and provide a basis for long-range planning and standardisation through the identification of interfaces and their characteristics, electrical, mechanical, man-machine, information, procedural language, etc.'' Large manufacturing system vendors have also proposed architectures [28] as frameworks to develop computer-based manufacturing.

The scope of the proposed architectures is limited, in the case of ISO to 'discrete parts manufacture.' The ESPRIT CIM project was specifically aimed at mechanical engineering and machining operations ''because there are more manufacturing organisations within Europe involved in machining operations than any other single type of manufacturing and machining represents the largest market for CIM system vendors'' [52]. The GRAI architecture [12] is restricted to production management systems. Subsequently many 'architectures' have been proposed [8,11,21,31,33,36,45,51,53] for manufacturing enterprise applications.

A common thread to these architectures is that they use graphical models to represent the various aspects of manufacturing such as processes or functions and the logic or sequence of information flow (documents, verbal or data) that link and control them. Such modelling methods are characterised by a formal syntax and structured diagramming techniques and are based on concepts from General Systems Theory and software development methods. In practice this means that models claim to describe a complex manufacturing system (consisting of people, machines, material, products, data, etc.) in easily understood, related elements using a series of diagrams. A model can then be used as a common understanding of a complex situation, for gaining insight, for system design or as the basis of quantitative analysis. However, in the models described above it would appear that no single model sufficiently addresses all the needs of CE, forcing the designers of CE support environments to use multiple, separate, and sometimes contrasting models to achieve their goal. When using multiple models, there is the risk that information from a particular model might be missed or misinterpreted in a following model when that information is transcribed. The