ELSEVIER

Knowledge-Based Systems 16 (2003) 149–160

Knowledge-Based SYSTEMS

www.elsevier.com/locate/knosys

Knowledge-based process management—an approach to handling adaptive workflow

P.W.H. Chung[a,*], L. Cheung[a], J. Stader[b], P. Jarvis[b], J. Moore[a], A. Macintosh[b]

[a]*Department of Computer Science, Loughborough University, Leicestershire LE11 3TU, UK*
[b]*AI Applications Institute, University of Edinburgh, UK*

Received 12 December 2001; revised 20 September 2002; accepted 17 October 2002

Abstract

In recent years, many organisations have found enterprise modelling, especially business process modelling, to be an effective tool for managing organisational change. The application of business processing modelling has brought benefits to many organisations, but the models developed tend to be used for reference during business operations and re-engineering activities; they rarely play an active role in supporting the day-to-day execution of the processes.

While workflow management systems are widely used for the streamlined management of 'administrative' business processes, current systems are unable to cope with the more dynamic situations encountered in ad hoc and collaborative processes [1]. A system that supports complex and dynamically changing processes is required.

There is increasing interest in making workflow systems more adaptive [8,18] and using knowledge-based techniques to provide more flexible process management support than is possible using current workflow systems [4,19].

This paper describes the results of a collaborative project between Loughborough University and the University of Edinburgh. ICI and Unilever were industrial partners on the project, providing real business requirements in the application domain. The project investigated the use of ontologies, agents and knowledge based planning techniques to provide support for adaptive workflow or flexible workflow management, especially in the area of new product development within the chemical industries.

Keywords: Workflow management; Adaptive workflow; Knowledge-based process management; Process modelling; Agent selection

1. Introduction

Enterprise modelling, especially business process modelling, is an effective tool for managing organisational change. Business processing modelling has brought benefits to many organizations. Organisations and their processes undergo changes from time to time, and in some cases changes are continual. Organisations change either through proactive efforts to become more competitive or in response to a need to maintain competitiveness in a changing environment.

Workflow systems are designed to support business processes. These systems embody explicit process models that will need to be modified to reflect the changes in the organisation. A major limitation of workflow systems is that they can, typically, only support simple, predicable processes, but not the dynamically changing and complex processes that are present in many organisations.

van der Aalst et al. [23] point out that existing tools that support collaborative work are typically in one of two extremes: unstructured, information centric approaches (CSCW) and structured, process centric ones (product workflow). "Adaptive workflow aims at providing process support like normal workflow systems do, but in such a way that the system is able to deal with certain changes. These changes may range from ad hoc changes such as changing the order of two tasks for an individual case to the redesign of a workflow process …"

The Task Based Process Management (TBPM) project aims to support the management of change in business organisations with the help of intelligent task management and coordination technologies. The area of new product development (NPD) within the chemicals industries was

* Corresponding author. Tel.: +44-1-509-222-543; fax: +44-1-509-211-586.
E-mail address: p.w.h.chung@lboro.ac.uk (P.W.H. Chung).

0950-7051/03/$ - see front matter © 2003 Elsevier Science B.V. All rights reserved.
PII: S0950-7051(02)00080-1

chosen as the application focus for generating and testing ideas. The reason is that the NPD process, like many other engineering activities, has characteristics that pose significant challenges for workflow systems:

- It is a highly interdisciplinary process, requiring the coordination of individuals from different engineering and business specialities.
- Many ad hoc processes occur, which nonetheless are activities requiring a significant amount of time, specific technical and business skills and other resources to perform, thus needing careful management.
- The structure of the process is highly flexible, which vary from one project to the next.
- The process is information-intensive, where a significant amount of technical information of different types is generated and must be distributed to interested parties reliably and efficiently.

These characteristics make conventional workflow systems unsuitable for handling NPD processes ([1,7,11]). However, if such support could be provided, there are potential benefits to be gained by:

- providing a single computing framework allowing the planning, execution and monitoring of processes. This ensures that planned processes are followed faithfully and allows the inspection of information about the current status of the process.
- permitting flexibility in process modelling and planning, so that process plans may be revised in the light of events and experiences gained during the process.
- improving the quality of decision-making because of the effective management of information and its dissemination to interested parties as it becomes available (for example, technical difficulties or discoveries which may have an impact on the business case for the product being developed).

Because of these and other related potential advantages, there is increasing interest in making workflow more adaptive [8,18] and in using knowledge-based techniques to allow workflow to cope with complex and dynamically changing processes [5,19].

The TBPM project extends the application scope of current workflow system by incorporating knowledge about processes in general, and about the domain in which the system is deployed in particular. Such knowledge enables the system to reason about processes within those domains, providing the necessary power and flexibility for computer support.

The industrial partners on the project provided the scale-up process within NPD as a test-case application to elucidate the requirements for an intelligent process management support tool from a particular real-world standpoint.

2. The scale-up process

Scale-up typically occurs at a point during NPD when a promising product has been identified, preliminary marketing investigation has been done, and a potential chemical process for manufacturing the product has been proposed, but not yet fully investigated. There is a series of experiments to be performed at gradually increasing scale, starting in the laboratory and ending (if all proves satisfactory) with a working pilot plant in order to investigate the behaviour of the proposed chemical process, and the nature of the engineering necessary to implement it at the intended scale of production.

A scale-up project tends to be long-term, typically 6–24 months, and involves a very large number of interacting and ad hoc processes that are the province of a number of different disciplines and departments, including R&D, Engineering, Marketing, Finance, Safety Health and Environment and General Management. Failure to achieve good communication, collaboration between disciplines and effective implementation of the necessary processes can have a range of undesirable consequences, from a failed product [2], with associated financial consequences for the business, to an incompletely studied chemical process, with potentially disastrous consequences for health, safety or for the environment.

Cooper [3] suggests that improper management of the NPD process contributes to a large proportion of new product failures. He presents a canonical process model for effective NPD, in which it consists of a series of 'go/no-go' decisions, separated by activities intended both to develop the design of the product itself and to improve the business and marketing case for its introduction. The scale-up process straddles one of these decision points—the decision of whether or not to proceed by sanctioning the construction of a pilot plant, which usually represents a major capital outlay.

3. Requirements

In considering the scale-up process, extensive interviews were carried out with our industrial partners to identify the key characteristics of the process and to elucidate the key requirements of a support system. A number of challenges were identified which are not addressed by current commercial workflow systems, and which must be addressed by a system if it is to succeed in supporting complex and dynamic scale-up processes. These requirements are discussed below.

3.1. Flexibility

There are almost no fixed rules for process management in scale-up even though a number of canonical process models exist. The complexity of the domain,