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Integrating AI planning techniques with workflow management system

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Abstract

There is a variety of applications that can benefit from the ability to find optimal or good solutions to a proposed problem, automatically. The artificial intelligent (AI) community has been actively involved in efficient problem-solving in complex domains such as military or spacecraft problems with successful results. In this paper, we describe the integration of AI planning techniques with an existing workflow management system. We show how these techniques can improve the overall system functionality and help automate the definition of business processes. The work is based on a short study carried out at BT research laboratories as part of a larger programme that aims to provide technologies for a new generation of business support systems.

Keywords: AI Planning techniques; Workflow Management Systems; Contingent planners

1. Introduction

Every organisation tries to shape its processes to optimally suit the market and offer the best service to the customer. When an organisation is analysed with the purpose of identifying possibilities for optimising its routines and procedures, three basic facets are outlined:

- A task or activity describes what should be done.
- An organisation model describes who should do something.
- An information model describes which information is needed to perform an activity.

From a historical perspective, the first issue that companies focused on was the design of organisational units. In the years to come, control logic (when should something be done) is set to play a central role in connection with optimisation of business processes.

Numerous issues need to be considered when designing business processes [6,18] and implementing them in IT systems. These include: reusability of past processes, accessibility from the different agents, consistency of usage, and selection of the right model.

In recent years, a new class of software infrastructure product to support business processes has emerged: workflow management systems (WfMS) [4,17,25]. A WfMS can provide active support to a business process by controlling the routing of work around the organisation automatically. This is done based on input describing the flow, the decisions, the exceptions, the resource to be used, etc. It co-ordinates user and system participants, together with the appropriate data resources, which may be accessible directly by the system or off-line to achieve defined goals by set deadlines. The co-ordination involves passing tasks to participants' agents in correct sequence, and ensuring that all complete their tasks successfully. In case of exceptions, actions to resolve the problem can be triggered, or human operators alerted.

Prior to WfMS, many enterprises created special-purpose bespoke applications to support their processes. The advantage of WfMS-based solutions is that the workflow representation is explicit, and separate from the application code. This means that a WfMS can be customised quickly to support a new business or process, and that workflows are relatively easy to modify, should a process change. However, current WfMS do not address all aspects of the problem. Specifically, they do not deal with scheduling or resource management/allocation. Similarly, while they provide means of generating exception events when things go wrong they do not have a built-in re-planning function. They do, however, provide interfaces so that application-specific modules performing these functions can be integrated.

Recently, there has been considerable interest in the application of artificial intelligence (AI) techniques to WfMS. The lack of maturity that the area of workflow management presents due to its short history can be

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addressed by introducing techniques from other fields. Some researchers have seen the advantages of the integration of this approach, as shown by the existence of a technical co-ordination unit of the European research network on planning and scheduling, PLANET [28], on applications of planning and scheduling to workflow. This has lead to some exploratory work reflected in a roadmap and some published papers [16,21,23,26]. Although the MILOS project [7] of the AI Group at the University of Kaiserslautern and the software process support group at the University of Calgary or the AI group at Edinburgh University in the TBPM project [15,31] have addressed the problem, to date very few tools have been developed using these ideas [24].

In this paper we highlight the improvements that a legacy system can gain by incorporating AI planning techniques into its day-to-day operation. We first introduce the phases that both systems have in common. After this, Customer Orientated System for the Management Of Special Services (COSMOSS), a purpose-built legacy workflow application in use at BT is described. Then we review contingent planners, an AI technology that addresses issues found in the COSMOSS application. After this, the similarities between both workflow management and planning are presented. We conclude with an example, based on a COSMOSS scenario that illustrates how ideas from the two fields may be merged.

2. Phases

To provide a frame of reference, we identify four stages in workflow systems as in Ref. [26], although some authors only identify three since the monitoring phase is included in the enactment phase [14,30].

- *Process modelling*. The stage where the user designs, models, optimises, simulate the organisation's processes. We include in this stage design of the process templates that can be instantiated and enacted by a workflow system.
- *Process planning*. The stage where the activities required to achieve a user goals are instantiated in a determined order, resources assigned, and preliminary scheduling performed.
- *Enactment/execution*. In this stage, the agents (software and humans) carry out the activities with the workflow system co-ordinating execution.
- *Monitoring*. This is conducted concurrently with enactment/execution. The system enacting the workflow is monitored, with status information being made available to human operators. Exceptions, such as deviation from the plan, and subsidiary processes initiated to rectify problems.

In AI planning systems, the following phases can be identified.

- *Domain modelling*. In this phase the user introduces the knowledge to the system, that is, the operators, the initial conditions and goals. Each planner has its own syntax although lately it has been an effort to unify the syntax in a unique language: the Planning Domain Definition Language 2.1 (PDDL2.1) [22].
- *Process planning*. The plan is outlined as a set of instantiated actions in a determined order. Commonly, plans do not contain information about resources, so in some problems planning and scheduling can be separated. In other cases, this idea has to be abandoned and mechanisms to treat resources through constraining equations must be integrated to solve the problem as in O-plan [8].
- *Execution*. This stage is concerned with the actions' execution.
- *Monitoring*. The results of the actions execution can differ from the actions expected results, so monitoring must take place to anticipate events or re-plan if the initial plan cannot be achieved.

3. A legacy workflow system

COSMOSS [5] provides support for progressing orders concerning provision of private lines. It was built at the beginning of 1990s and it handles about a dozen main product families divided into digital and analogue categories.

The business processes start with a customer contacting a call centre to place an order. The representative in the call centre gathers information from the caller about the customer and the service required in the form of a service order. This is passed automatically to COSMOSS for completion where it becomes a job. The job is decomposed into activities by matching against a set of job templates. Target times are then derived for these activities based on information stored in the job and activity templates and the customer requirements. These activities, with target start and completion dates, are passed to other OSSs,[1] where they are allocated and enacted. Progress is reported back to COSMOSS.

The main COSMOSS modules are:

- Order taking module.
- *Product register*. This interface to the portfolio database—PDB—which holds information on 90% of BT's product range. This is also used by other systems.
- *Customer and site database*. This holds information on customers and their premises, and is basically specific to the COSMOSS system.
- An engineering database.
- Job management module.

All information that COSMOSS can handle is organised in templates. Each time new products are introduced, new templates are created. The process modelling stage

[1] Operational support systems.