Intelligent Fleet Cargo Scheduling

Magenta Technology and Tankers International
A Case Study

1 Introduction

In this document we present a case study involving the development of an application using agent and agent-related technologies; in particular, Magenta Technology's Agent Technology platform [1]. The application presented is that of the Ocean i-Scheduler, an intelligent scheduler for cargo fleets at the Tankers International organisation [2]. It helps the human schedulers at Tankers International to plan and re-plan which cargoes are to be assigned to which vessels in their fleet. This document is based on interviews conducted in London between Magenta Technology, Tankers International, and the authors of this document in December 2004.

The document is formatted as follows. Section 2 gives an overview of the requirements of the Ocean i-Scheduler. Section 3 gives an overview of the agent platform on which the application is developed. Section 4 provides an insight into some of the development decisions that were made.

2 Tankers International

Tankers International is one of the world's largest Very Large Crude Carrier (VLCC) oil tanker pools. Based in London, Tankers International has a 46-strong VLCC fleet, which operates all over the world.

2.1 Problems facing Tankers International's Schedulers

Vessel scheduling at Tankers International was being performed manually by human schedulers with no automated support. This was causing two major problems:

1. The vast amount of information that must be considered to schedule such a large fleet of vessels in a dynamic environment meant that the complexity was high, potentially leading to costly mistakes. Reducing the frequency of such mistakes improves fleet utilisation, allowing the company to increase their profits while using the same resources.

2. Each time a scheduler employee leaves the company, all the expertise that they have learnt about scheduling leaves with them, and new employees must start from the beginning.

2.2 Why is the Scheduling so Complex?

At first glance, it may seem like a simple problem to schedule vessels to cargo. However, there are many considerations that need to be taken into account.

For starters, each vessel, cargo, and port has its own constraints that may prevent certain schedules (e.g. a vessel may be too big for a port, or a cargo too big for a vessel). Such constraints are known as hard constraints. That is, they are the constraints that cannot be broken when scheduling.

But there are many other contracts that need to be taken into consideration that are known as soft constraints. These are constraints that the scheduler can break only if there are no other reasonable solutions available. Examples of soft constraints are such things as:

- Reducing the amount of time that a vessel travels without cargo. After a delivery, a vessel must travel to its next load port. If a vessel can collect cargo on the way to this port, then it can recover more of its travel costs.

- Particular stevedoring companies may have a preference to not load or unload cargo on weekends because they have to pay their workers higher wages. However, agreeing to a contract that will not profit the company but may increase their chances of future

contracts for the vessel could be beneficial in the long term.

Both hard and soft constraints can be either global, meaning that they apply to the entire system, or they may be specific to a particular vessel/cargo/port or type of vessel/cargo/port. These constraints may also change over time, for example, a port may upgrade their facilities.

In addition to these constraints, the environment is dynamic, in that the cargo is changing constantly, and the vessels may fail, rendering them out of service for a period, and requiring a reschedule for their cargo over that time. These complexities led Tankers International to search for a system that provides decision support for its scheduling employees.

3 Magenta Technology's Agent Technology

Magenta Technology are located in London, with a software development centre in Russia. In 2002 they launched the commercial aspects of their business with the aim of providing multi-agent technology to companies to run their applications in a commerical environment.

Magenta Technology's agent technology is used to build and run the Ocean i-Scheduler presented in this paper. This agent technology has two main components:

- Ontology Management Toolkit: This toolkit is used to create ontologies for a specific business domain.

- Virtual Market Engine: This is used to build, run, and monitor agent systems that use the ontology defined in the Ontology Management Toolkit.

Magenta Technology's agent technology is built on Sun's Java 2 Enterprise Edition (J2EE), thus providing an enterprise ready platform on which the above two components can run.

For more details regarding Magenta Technology's agent technology, see [1] and [3].

3.1 Ontology Management Toolkit

An ontology is a computer processable model of business concepts that also records the attributes of, instances of and relationships between these concepts, therefore providing a model of business knowledge. In addition, having an ontology provides a suitable set of terms for agent communication, ensuring that when one agent uses a particular term, the other agents in the system share the same meaning of that term.

Magenta Technology's ontology toolkit allows developers to define an ontology using a graphical user interface. The ontology is modelled as a graph,with the nodes in the graph representing a concept or instance, and the edges in the graph representing the relationship between two concepts/instances, as shown below.

Magenta Technology's ontology toolkit also provides automatic translation of ontologies into other formats, such as J2EE with method stubs, and XML. This translation provides an excellent means to take an ontology as a static document, and put it to use in a running system.
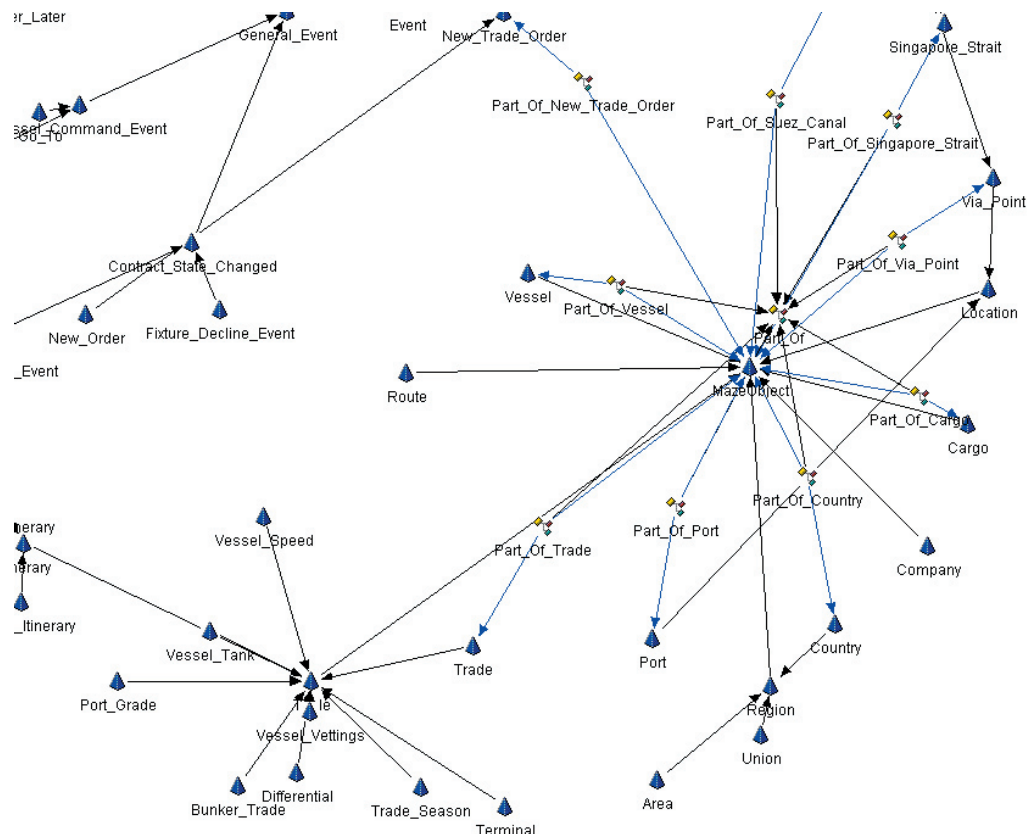
3.2 Virtual Marketplace Engine

Magenta Technology's Virtual Marketplace Engine is a component for building, running, and monitoring multiagent systems.

Once an ontology has been agreed upon and developed using the Ontology Management Toolkit, the developers define the types of roles that will be in the system, and how an agent fulfilling each role will make decisions using the knowledge in the ontology.

The Virtual Marketplace Engine provides support for principles and components that are common in multiagent systems. For example, it provides a convenient way for sending messages between agents to save the developers from implementing such functionality. In addition, the platform provides utilities to monitor and debug agent applications at runtime.

4 Agent Technology in the Ocean i-Scheduler

The Tankers International application was built using Magenta Technology's agent technology using the multiagent paradigm. Tankers International's original idea for an application was an online system that allows people to book their cargo to be transported. However, after being introduced to Magenta Technology and their agent technology, Tankers International decided that this technology may allow the development of a a much more useful system. A proof of concept application developed by Magenta Technology convinced Tankers International to invest in such a system.

Tankers International were first impressed by the way that, using agent technology, applications could change behaviour without having to shut down the system or introduce new code, by editing the ontology at runtime. They were also impressed by how well the agent system itself could handle changes to cargo, vessels, and ports.

Tankers International envisaged two benefits to implementing their system using Magenta Technology's agent technology:

1. the system would provide support for scheduling to its employees, therefore reducing the probability of costly mistakes; and

2. the ontology would provide a formal model of the business knowledge needed to schedule fleets, therefore when scheduling employees leave, the knowledge lost is greatly reduced.

In the development of the system, Tankers International together with Magenta Technology developers used the agent paradigm as a design tool. Each cargo, vessel, port, etc., was modelled as a real-world role. For example, the role of vessel was designed, taking into account the responsibilities and rights that a vessel has. Then, for each vessel in the Tankers International fleet, a vessel agent was created. The developers claim that this lead to a simplified design when compared to one they would have developed using other software engineering techniques.

Estimating the cost of developing the application is difficult. Firstly, Magenta Technology's original agent platform required the use of Delphi instead of J2EE. The first version of the Tankers International application was developed using this Delphi version, and after Magenta Technology's change to J2EE, Tankers International re-implemented the system using the new version. Secondly, the development was split over over the two companies.

Magenta Technology estimate that the second version of the application used approximately 10 000 person hours at Magenta Technology alone. Tankers International estimate that this version used an additional 4000 person hours of their time. However, we must take into account that a Delphi version had already been implemented. This gave developers from both companies experience not only in building multiagent systems, but also meant that they had already solved many application-specific problems prior to developing the J2EE version, therefore reducing development time.

5 Discussion

From meetings with the developers regarding the design and implementation of the system, it seems as though agent technology has provided them with a means of developing flexible systems that can sufficiently handle changes in the environment. Tankers International are clearly impressed with both the agent paradigm, and Magenta Technology's agent technology. The Ocean i-Scheduler is currently in the beta stage of testing, so Tankers International could not provide us with any quantitative data showing an improvement in the scheduling of their vessels, although they are convinced that their application will benefit their business in the long term.

In any busy industrial enterprise, there are always difficulties in integrating new working practices, and training and familiarisation must play a vital role in the adoption of any new technology, and Tankers International are facing this problem with the Ocean i-Scheduler. Even though the system has impressed Tankers International management, they admit that there is still an effort to be made in training and familiarising the scheduling staff to use and trust the output of the system. The human schedulers working at Tankers International have a great deal of experience in their area, and for them to accept and trust the recommendations produced by the scheduling software, a period of familiarisation and day-to-day interaction with the system will be necessary.

From a development perspective, we have noted the following:

1. The developers did not use current agent standards for such things as agent communication, and have developed their own languages and protocols.
2. Agent technology not developed by Magenta Technology did not appear to play any role in the development.

These design and development choices reflect the closed nature of the agent system. In other words, standardized methodologies and communications languages were not important since the system does not inter-operate with other agents systems.
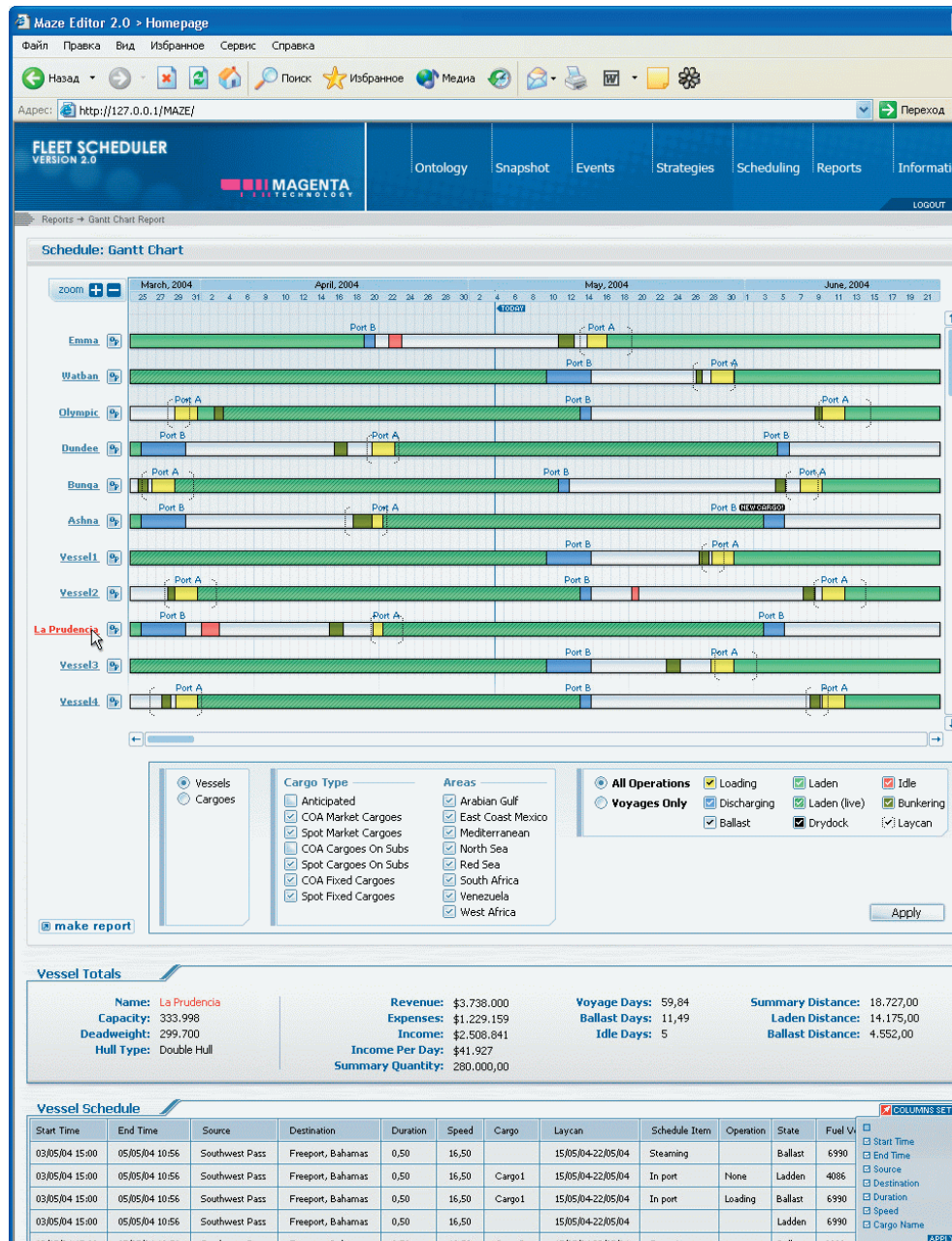
As part of Magenta Technology's commitment to further developing the Ocean i-Scheduler to improve the features and functionality, Magenta Technology is releasing Ocean i-Scheduler v2.1 in Spring 2005. This will also benefit from new platform software to increase agent interactions and performance. Features of the new release will include real-time scheduling, web-based multi-user environment with powerful visualizations such as interactive maps, Gantt-

charts, user specific dashboards, KPI charts, additional reports, and a simple manual rework facility to allow the user to take full control.

Magenta Technology are also building related i-Scheduler software for truck logistics and project management. Many others are possible beyond these as well.

References

[1] Magenta Technology, http://www.magenta-technology.com

[2] Tankers International, http://www.tankersinternational.com

[3] Michael Wooldridge. Responding to real-world complexity: Introduction to multi-agent technology. Magenta white paper, August 2004. Available from http://www.magenta-technology.com/library/whitepapers.shtml.

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