Agent-Based Coordination Technologies in Disaster Management (Demo Paper)

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Categories and Subject Descriptors

I.6 [**Simulation and Modeling**]: General; H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Algorithms, Experimentation

Keywords

Coordination, Auction, Coalition Formation, Simulation, RoboCup Rescue

1. INTRODUCTION

Multi-agent systems (MAS) have been advocated as the natural solution to real-world problems that necessitate some form of decentralised control within dynamic and uncertain environments. Given this, a number of multi-agent coordination algorithms have been designed, ranging from auctions to coalition formation algorithms. These algorithms allow a number of agents to reconcile their constraints and preferences in order to maximise some global objective. An important domain where such algorithms can be applied is that of emergency response or disaster management.

Disaster management has become an important issue in the last few years due to the large number of disasters occurring such as hurricane Katrina or the London bombings in 2004. Disaster management involves coordinating a large number of emergency responders to rescue either people or infrastructure in possibly hazardous environments where uncertainty about events is predominant. In many cases, these responders have possibly conflicting preferences and need to resolve these conflicts in order to complete some tasks. For example, ambulance teams may belong to different ambulance companies that may want to minimise the number of resources they use in performing rescue tasks. Also, different ambulance teams may have different tools that may be useful to other teams in performing some tasks. To resolve such issues, it is important to develop new coordination algorithms that take into account the dynamic and uncertain nature of disasters and come up with good solutions that maximise the social welfare.

A number of research initiatives such as the RoboCup Rescue Simulation project[1], the DEFACTO System [4] or DrillSim[2] have attempted to simulate and evaluate potential agent-based solutions for disaster management [2]. While the RoboCupRescue Simulation project mainly aims at developing a simulation system and simple agent based coordination algorithms, the DEFACTO system targets human-agent fire brigade response strategies, and DrillSim mainly studies evacuation procedures. However, none of these systems specifically aim to benchmark and evaluate state of the art agent based coordination algorithms. It is important to do so in order to determine the issues that arise in applying these algorithms to real-world problems and to show how they improve upon the current solutions. To this end, we developed the ECSKernel as a demonstrator for coordination algorithms developed within the ALADDIN (Autonomous Learning Agents for Decentralised Data and Information Systems) project.[3] Using the demos run within the ECSKernel, we aim to show, in particular, how specific auction mechanisms and coalition formation algorithms could be applied to the disaster management problem. The rest of this paper is structured as follows. Section 2 summarises the algorithms that will be demonstrated and section 3 provides snapshots of the demos and a description of the events in those demos.

2. COORDINATION ALGORITHMS

The two main types of coordination algorithms that have been developed within the ALADDIN project involve auctions and coalition formation techniques which we discuss next.

2.1 Auctions

In environments where agents are selfish and rational, auctions have been shown to provide efficient solutions to coordination problems. This is because they allow agents to make their decisions locally while coordinating globally. In many cases, however, there may be multiple agents running several auctions trying to sell goods or tasks to multiple buyers. In the disaster management domain, this may happen when a number of ambulance companies are trying to subcontract ambulances from other ambulance companies which have an excess of ambulances to auction off. In such cases, agents need to adopt a strategy in order to bid in these multiple auctions at the same time. These strategies have been investigated in [1] and we aim to demonstrate this using the ECSKernel.

[1] `http://www.robocuprescue.org`.

[2] `http://www.ics.uci.edu/ projects/drillsim/`.

[3] The ALADDIN project (funded by EPSRC and BAE Systems) is a five-year project (currently in its third year) that aims to develop data fusion and coordination algorithms to solve disaster management problems. See `http://www.aladdinproject.org` for more details.

Cite as: Agent-Based Coordination Technologies in Disaster Management (Demo Paper), S. D. Ramchurn et *al.*, *Proc. of 7th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2008)*, Padgham, Parkes, Müller and Parsons (eds.), May, 12-16., 2008, Estoril, Portugal, pp. 1651-1652.

2.2 Coalition Formation

In order to coordinate a number of agents (e.g. ambulances or fire brigades) efficiently, it is important to distribute them in a number of efficient teams coalitions. Given N agents, the number of coalitions that could be generated is 2^N. Moreover, each coalition may have a value which represents how efficiently it can perform tasks. This may be due to differences in capabilities or constraints. Now, it is important to select the best coalitions and this problem is termed the coalition structure generation problem. In our demo we present a new anytime coalition structure generation algorithm was developed as part of the ALADDIN project [3].

3. DEMONSTRATION

The demonstrations will take the form of videos and interactive sessions. We first briefly describe the functionality of the ECSKernel and then go on to describe the specific demonstrations.

3.1 ECSKernel

The ECSKernel is a JAVA-based tool that plugs into the RoboCup Rescue simulation platform. It allows the user, amongst other things, to control the communication network used by agents launched within the system (i.e. reduce bandwidth, drop messages etc...), partition the map into distinct clusters, and control the agents' sensing abilities (e.g. up to what distance they can sense things in the environment). Using these capabilities, it is possible to evaluate the agents' decisions and impose constraints on their actions. Moreover, we developed viewers to allow the user to visualise the actions taken by the agents (see left part of figure 1).

3.2 Auction Demo

In this demo, a number of ambulance trusts in the United Kingdom (e.g. Surrey, Wiltshire, Hampshire) are responsible for different districts of a given country or city (shown by different coloured subsections of the map in figure 1). These ambulance trusts, have at their disposition a number of ambulances (denoted by the red crosses in the viewer and coloured squares on the map) in order to carry out a number of rescue tasks (denoted by the stick man icons in the viewer and green circles on the map). Each ambulance trust is selfish as it needs to pay for the maintenance of the ambulances and services provided out of its own budget. Given this, it aims to minimise its costs and maximise the amount of profit it can generate by selling off it services. In this demo, we demonstrate this through two different types of auctions:

1. A central auctioneer auctions off available ambulances to the highest paying ambulance trust. Once an ambulance has completed its rescue task, it is returned to the auctioneer to be auctioned off again. This is depicted in figure 1.

2. Decentralised auctions where each ambulance trust is initially assigned a number of ambulances and can either sell off its ambulances if it does not have any rescue tasks pending (or more ambulances than needed) or bid in auctions run by other trusts in order to get enough ambulances to rescue all civilians in its district.

We show the value of these approaches by comparing them with a case where there is no mechanism to re-allocate excess ambulances to other ambulance trusts and by having ambulance trusts failing and showing how the mechanisms can recover from such failures.

3.3 Coalition Formation Demo

In this demo, we provide a scenario similar to the one above except that we consider only a single ambulance trust that has a number of ambulances to allocate to different rescue tasks. In order to do so, the ambulance trust has to run a coalition structure generation algorithm to allocate ambulances to each task. The value of the coalition in this case is given by a function that takes in the time for the ambulances to travel to a given civilian, the amount of work that the team can perform, and the amount of work that needs to be completed to rescue the civilian. We aim to show the value of the approach by having different scenarios with different numbers of agents such that the algorithm may have to come up with solutions anytime in order to meet the short response times. Also, we aim to compare our algorithm with a simple ambulance allocation strategy that only tries to compute a reasonable solution.

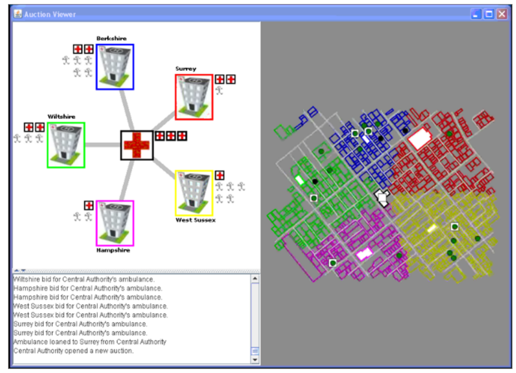

Figure 1: Snapshot of the centralised auction demo.

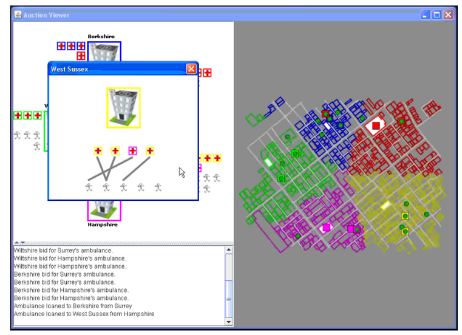

Figure 2: Snapshot of the coalition formation demo.

4. ACKNOWLEDGMENTS

This research was undertaken as part of the ALADDIN (Autonomous Learning Agents for Decentralised Data and Information Systems) project and is jointly funded by a BAE Systems and EPSRC (Engineering and Physical Research Council) strategic partnership (EP/C548051/1).

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