The 3rd MARA Get-Together:

Workshop on Multiagent Resource Allocation

5th & 6th June 2008
Institute for Logic, Language and Computation
University of Amsterdam

supported by
COST ACTION IC0602 ON ALGORITHMIC DECISION THEORY

The 3rd MARA Get-Together

Multiagent Resource Allocation (MARA), the allocation of resources within a system of autonomous agents that not only have preferences over alternative allocations of resources but also actively participate in computing an allocation, is an exciting area of research at the interface of computer science and economics.

The 3rd MARA Get-Together is an informal workshop on Multiagent Resource Allocation, hosted by the Institute for Logic, Language and Computation at the University of Amsterdam with financial support from the European COST Action IC0602 on Algorithmic Decision Theory. The meeting continues the tradition of the AgentLink Technical Forum Group on Multiagent Resource Allocation (TFG-MARA), with previous meetings in Ljubljana and Budapest.

The MARA workshops are aimed at bringing together researchers working on different aspects of MARA. Topics of interest include languages for modelling agent preferences in resource allocation applications; the study of algorithms for resource allocation (including combinatorial auctions and distributed negotiation schemes); complexity issues; simulation and experiments; and connections to work in social choice theory and fair division.

Practicalities

Unless specifically indicated otherwise, all activities take place in Room P.017 on the ground floor of the Euclides Building, Plantage Muidergracht 24, Amsterdam. | You can use the student computer labs on the first floor to check your email (ask the local organisers for a temporary account). | There are several places for getting lunch in the neighbourhood (the organisers can provide a map with suggestions). | All participants are invited to make a contribution to the *rump session* on Friday afternoon. You may talk on any MARA-related topic you wish. Speaking time will be around five minutes. | Directly after the workshop there will be the ILLC Beth Lecture by Dov Samet, in the same building. You are cordially invited to attend the lecture and the reception afterwards.

MARA Survey

In 2006 the group has published the MARA Survey:

- Yann Chevaleyre, Paul E. Dunne, Ulle Endriss, Jérôme Lang, Michel Lemaître, Nicolas Maudet, Julian Padget, Steve Phelps, Juan Antonio Rodríguez-Aguilar and Paulo Sousa. Issues in Multiagent Resource Allocation. *Informatica*, 30:3–31, 2006.

The paper reviews languages for representing preferences, concepts for assessing social welfare and the overall quality of an allocation, different allocation procedures, and important complexity results. It also includes a discussion of software packages for the simulation of agent-based market places. Finally, the survey presents four major application areas for MARA, namely industrial procurement, sharing of satellite resources, manufacturing control, and grid computing.

MARA Website

For all enquiries regarding the MARA workshops, please contact Ulle Endriss (`ulle@illc.uva.nl`). For up-to-date information on the activities of the group, please visit the MARA website:

`http://www.illc.uva.nl/~ulle/MARA/`

COST Action IC0602

This meeting is sponsored by the European COST Action IC0602 on Algorithmic Decision Theory, an interdisciplinary network of scientists coming from the areas of Decision Analysis and Artificial Intelligence. For more information, please visit the website of the network:

`http://www.algodec.org/`

Programme

Thursday, 5 June 2008

8:30–9:00	**Welcome, Registration, Coffee**
9:00–10:30	**Tutorial 1** (Chair: Ulle Endriss) Nicolas Maudet (LAMSADE, Paris-Dauphine) *Tutorial on Distributed Resource Allocation*
10:30–11:00	*Coffee Break*
11:00–12:30	**Talks: Graphs etc.** (Chair: Sylvain Bouveret)
11:00–11:45	Mathijs de Weerdt (TU Delft) *Resource Allocation in Social Networks*
11:45–12:30	Yann Chevaleyre (LAMSADE, Paris-Dauphine) *Resource Allocation in Graphs*
12:30-14:00	*Lunch Break*
14:00–15:30	**Talks: Auctions etc.** (Chair: Yann Chevaleyre)
14:00–14:45	Juan Antonio Rodríguez-Aguilar (IIIA-CSIC, Barcelona) *Mixed Multi-Unit Combinatorial Auctions for Supply Chain Automation*
14:45–15:30	Joel Uckelman (ILLC, Amsterdam) *Winner Determination for Bidding Languages using Weighted Formulas*
15:30–16:00	*Coffee Break*
16:00–17:30	**Systems Session** (Chair: Ulle Endriss)
16:00–16:15	Jesús Cerquides (Barcelona) *A Graphical Framework for the Analysis of Mixed Multi-Unit Combinatorial Auctions*
16:15–16:30	Philippe Mathieu and Antoine Nongaillard (LIFL-USTL, Lille and Concordia Univ.) *Utilitarian Welfare Negotiation*
16:30–16:45	Gijs Kruitbosch and Nadya Peek (Amsterdam) *MADRAS: Multiagent Distributed Resource Allocation Simulator*
16:45–17:30	System Demonstrations (over more coffee)
20.00–	**Workshop Dinner** Restaurant Savvas, Eerste van Swindenstraat 40, Amsterdam

Friday, 6 June 2008

9:00–10:30	**Tutorial 2** (Chair: Juan Antonio Rodríguez-Aguilar) Kevin Leyton-Brown (British Columbia) *Tutorial on Empirical Hardness Models (from CATS to SAT)*
10:30–11:00	*Coffee Break*
11:00–12:30	**Talks: Fairness etc.** (Chair: Nicolas Maudet)
11:00–11:45	Sylvain Bouveret (ONERA, Toulouse) *Fair Allocation of Indivisible Goods: Modelling, Representation, Complexity*
11:45–12:30	Flip Klijn (IEA-CSIC, Barcelona) *Smith and Rawls Share a Room: Stability and Medians*
12:30-14:00	*Lunch Break*
14:00–15:00	**Rump Session** (Chair: Ulle Endriss) *Give a 5 minute talk on anything you like (sign up before lunch)!*
15:00–15:30	*Coffee Break*
15:30–17:00	**ILLC Beth Lecture by Dov Samet** (Room P.227)
17:00–18:30	**Reception** (3rd Floor Lobby)

Tutorials

- Nicolas Maudet (LAMSADE, Univ. Paris-Dauphine)
  Tutorial on Distributed Resource Allocation

  This tutorial is intended to give an overview of mechanisms that seek to allocate in a distributed manner indivisible goods among a set of agents. In this approach, agents negotiate autonomously and locally the reallocation of (some of) their resources with fellow agents, in order to improve their well-being. Such mechanisms are appropriate when no central authority is at hand to do the job of an auctioneer. I will introduce many issues that occur in such systems, in particular as opposed to centralized approaches (e.g. combinatorial auctions). These include a mixture of the following: assumptions regarding agent rationality/preferences, topological/protocol constraints on agent interactions, guarantee of convergence towards optimal allocations, and communication/computational complexity issues. I will conclude by mentioning a bunch of open problems.

  The tutorial will be introductory, and will be illustrated with many examples. Some issues introduced will be investigated further by other talks of the workshop.

- Kevin Leyton-Brown (University of British Columbia)
  Tutorial on Empirical Hardness Models — From CATS to SAT: Modeling Empirical Hardness to Understand and Solve Hard Computational Problems

  From combinatorial auctions to supply chains and beyond, researchers in multiagent resource allocation frequently find themselves confronted with hard computational problems. This tutorial will focus on empirical hardness models, a machine learning methodology that can be used to predict how long an algorithm will take to solve a problem before it is run. My coauthors and I first developed this line of research in our work on the Combinatorial Auction Test Suite (CATS), when investigating whether "realistic" combinatorial auction problems were always computationally easier than the hardest artificial distributions. We did eventually figure out how to tune our instance generators to create harder instances. Along the way, however, we also developed a host of other methods that I will survey in this tutorial. These included ways of accurately predicting an algorithm's runtime on an unseen instance, determining which instance properties most affect an algorithm's performance, and building algorithm portfolios that can dramatically outperform their constituent algorithms.

  After satisfying ourselves that empirical hardness models are a useful way of tackling combinatorial auction problems, we sought to demonstrate their effectiveness on a more widely-studied NP-complete problem, and hence turned to SAT. I will also describe some of the techniques we developed for this second problem domain, including the direct prediction of satisfiability status, the construction of hierarchical models, and the inclusion of incomplete local search algorithms. I will conclude by describing SATzilla, an algorithm portfolio constructed from 19 state-of-the-art complete and incomplete SAT solvers, which won 5 medals at the 2007 SAT competition.

Talks

- Mathijs de Weerdt (Delft University of Technology)
  Resource Allocation in Social Networks

  This talk is on a variant of the resource allocation problem, where agents owning resources and/or tasks are connected by a social network. A connection between two agents represents the possibility to allocate resources of one of the agents to a task of the other.

  First we introduce an efficient algorithm for a cooperative setting, based on the contract-net protocol. This algorithm is completely distributed, and it assumes that agents have only local knowledge about tasks and resources.

  We conduct a set of experiments to evaluate the performance and scalability of the proposed algorithm in terms of solution quality and computation time. Three different types of networks, namely small-world, random and scale-free, are used to represent various social relationships among agents in realistic applications.

  In the final part of the talk we look at the same problem from a mechanism design perspective, assuming that the agents that own the resources are rational, but may strategize to increase their utility. We propose a modification of the distributed protocol to be used in an incentive compatible allocation mechanism.

- Yann Chevaleyre (LAMSADE, Univ. Paris-Dauphine)
  Resource Allocation in Graphs

  In societies of agents sharing resources, allowing all agents to communicate with each other is a common but quite unrealistic assumption. Instead, one can assume there are communication restrictions which can be modelled by a graph in the following way: each vertex would represent an agent, and the neighbourhood of that vertex would represent the agents with which it is allowed to negotiate. Unfortunately, most of the guarantees do not hold anymore in this setting. In this talk, we will show how this restriction affects the negotiation process in many ways. We will show that the trajectories of resources inside the graph can be related to the welfare of the society, and thus to various notions of optimality. Finally, we will present simple myopic strategies by which agents improve the negotiation process.

- Juan Antonio Rodríguez-Aguilar (IIIA-CSIC, Barcelona)
  Mixed Multi-Unit Combinatorial Auctions for Supply Chain Automation

  In this talk we present a novel combinatorial auction, the so-called Mixed Multi-unit Combinatorial Auction (MMUCA), which automates the process of collaborative supply chain network formation. MMUCAs offer a high potential to be employed for the automated assembly of supply chains of agents offering goods and services. Its winner determination problem (WDP) is an NP-hard problem that can be mapped into an integer program. While this provides a first algorithmic solution to the WDP, its computational cost hinders the application of MMUCAs to realistic scenarios. Recent contributions on computationally efficient WDP solvers for different auction types agree on and defend that a careful, formal analysis of the structure of WDPs can provide guidance for developing efficient winner determination solvers. Along these lines, we provide a computationally efficient solver for the MMUCA WDP based on a formal analysis of its topological structure. Furthermore, we provide empirical evidence showing that the new IP allows to cope with much larger supply chain formation scenarios.

- Joel Uckelman (ILLC, University of Amsterdam)
  Winner Determination for Bidding Languages using Weighted Formulas

  Weighted formulas have been much-studied recently for representing cardinal preferences. In particular, sets of weighted formulas can be used for specifying bids for combinatorial auctions. In this talk, I will focus on two methods for finding exact solutions of the Winner Determination

Problem in a single-unit combinatorial auction where the bidders give their valuations using weighted formulas: branch and bound (B&B), and integer programming (IP). In the B&B approach, we attempt to exploit features of the bidding language (e.g., what formulas are permitted) in order to rapidly calculate an upper bound. Experimental results will be shown for several different languages. For the IP approach we give an IP formulation of the problem (a general one, and also formulations specialized for a few languages) which can be used as input for an IP solver.

- Sylvain Bouveret (ONERA, Toulouse)
  Fair Allocation of Indivisible Goods:
  Modelling, Compact Representation using Logic, and Complexity

  Many real-world problems can be modelled as resource allocation problems implying indivisible goods to distribute among a set of agents. Many of these problems, implying human agents expressing some preferences on the set of objects to allocate, have also in common the notion of social fairness, that is, the fact that the collective decision must reflect the individual preferences. This notion of individual preference representation is also crucial in resource allocation problems: since many of these problems require the expression of non-additive preferences, one may introduce a compact language for expressing preferences, to avoid falling in the combinatorial trap.

  In this talk we will focus first on the modelling of fair resource allocation problems, borrowing the notion of fairness from microeconomics. We will then introduce a compact representation language based on propositional logic for representing these resource allocation problems, and analyze the impact of compact representation on the complexity of finding a fair allocation, for the notions of fairness introduced in the first part.

- Flip Klijn (Institute for Economic Analysis, CSIC, Barcelona)
  Smith and Rawls Share a Room: Stability and Medians

  We consider one-to-one, one-sided matching (roommate) problems in which agents can either be matched as pairs or remain single. We introduce a so-called bi-choice graph for each pair of stable matchings and characterize its structure. Exploiting this structure we obtain as a corollary the "lonely wolf" theorem and a decomposability result. The latter result together with transitivity of blocking leads to an elementary proof of the so-called stable median matching theorem, showing how the often incompatible concepts of stability (represented by the political economist Adam Smith) and fairness (represented by the political philosopher John Rawls) can be reconciled for roommate problems. Finally, we extend our results to two-sided matching problems.

System Demonstrations

- Jesús Cerquides (University of Barcelona)
  A Graphical Framework for the Analysis of Mixed Multi-Unit Combinatorial Auctions

  In this demo we present the Mixed Multi-unit Combinatorial Auctions Platform (MMUCAP). MMUCAP is a platform for visualising, analysing, and implementing Mixed Multi-unit Combinatorial Auctions (MMUCAs). MMUCAs offer a high potential to be employed for the automated assembly of supply chains of agents offering goods and services. Their winner determination problem is an NP-hard problem that can be mapped into an integer program. By means of MMUCAP it is possible to visualise the process underlying the automatic formation of the supply chain. Once formed a supply chain, MMUCAP also allows to visualise the dynamics of its execution and implementation.

- Philippe Mathieu and Antoine Nongaillard (LIFL-USTL, Lille and Concordia University)
  Utilitarian Welfare Negotiation

  The multi-agent resource allocation problem corresponds to the negotiation of m resources among n autonomous agents in order to maximize a social welfare. Contrary to some former studies, the purpose is neither here to simply determine a socially optimal resource allocation nor to prove the existence of a transaction sequence leading to this optimum, but to find a practical transaction sequence among agents, based on any type of graph. With this intention, we study various agent behaviors in order to identify which one leads to the optimal resource allocation required. During MARA-3 we propose a system presentation of an interesting transaction type that we call "social gift" which leads to the utilitarian social welfare as a global emergent phenomenon in the resource allocation problem.

- Gijs Kruitbosch and Nadya Peek (AI Programme, University of Amsterdam)
  MADRAS: Multiagent Distributed Resource Allocation Simulator

  MADRAS is a simulation platform developed to study the effects of different negotiation policies in the context distributed multiagent resource allocation problems. The system can generate scenarios which describe different societies of agents with individual valuation functions for resources. It can simulate the negotiation between these agents to find out whether or not negotiation leads to an improvement with respect to different types of social welfare. Finally, it can visualize any of the results obtained. MADRAS is available at `http://madras.infosyncratic.nl`.