AgentLink Technical Forum Group on

Multiagent Resource Allocation (TFG-MARA)

16th September 2005
Hotel Agro Panoráma, Budapest, Hungary

organised as part of
THE THIRD AGENTLINK III TECHNICAL FORUM (AL3-TF3)

Aims and Scope

Negotiation over the allocation of resources is widely regarded as one of the central research issues in the multiagent systems community. The AgentLink Technical Forum Group on Multiagent Resource Allocation (TFG-MARA) aims at providing a venue for the exchange of ideas in this area and puts special emphasis on the knowledge transfer between microeconomics and social choice theory on the one hand and computer science and AI on the other.

At the level of individual agents, TFG-MARA addresses the compact representation of preferences, building on both classical decision theory and recent advances in logic-based representation formalisms. At the system level, the overall performance of a multiagent system for resource allocation can be measured in terms of various notions of social welfare as studied in welfare economics. Here we are particularly interested in "non-standard" notions of social welfare, including those imposing different fairness constraints on allocations. Another focus of TFG-MARA is the complexity of multiagent resource allocation problems. This includes the computational complexity of relevant decision and optimisation problems, as well as issues in communication complexity (length of negotiation processes, amount of information exchanged between agents). The scope of this TFG includes both (combinatorial) auction-based resource allocation mechanisms and distributed negotiation schemes. Besides theoretical research questions, we are also interested in prototype implementations, which can inform theoretical research by providing empirical data and a test-bed for negotiation heuristics. In short, topics of interest include, but are not limited to:

- Compact representation of agent preferences
- Preference aggregation and notions of social welfare
- Resource allocation and fair division
- Complexity of negotiation
- Comparison of different negotiation topologies
- Protocol design for negotiation over resources
- Implementation, simulation, experimentation, heuristics

Promoters

- Yann Chevaleyre, LAMSADE, University of Paris-Dauphine
- Paul E. Dunne, Department of Computer Science, University of Liverpool
- Ulle Endriss (chair), ILLC, University of Amsterdam
- Jérôme Lang, IRIT, University Paul Sabatier, Toulouse
- Nicolas Maudet, LAMSADE, University of Paris-Dauphine
- Juan A. Rodríguez-Aguilar, Artificial Intelligence Research Institute (IIIA-CSIC), Barcelona

Contact

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

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

AgentLink

TFG-MARA is sponsored by AgentLink III, the premier Coordination Action for Agent-based Computing, funded by the European Commission's 6th Framework Programme. For more information, please visit the AgentLink website:

`http://www.agentlink.org/`

Programme

The second meeting of TFG-MARA will be held as part of the Third AgentLink III Technical Forum at the Hotel Agro Panoráma in Budapest, Hungary, and will be hosted by MTA SZTAKI, the Computer and Automation Research Institute of the Hungarian Academy of Sciences. The Technical Forum will run from the 15th until the 17th September 2005, while TFG-MARA will take place as a full-day meeting on Friday the 16th September 2005. For details of the venue, please refer to the AL3-TF2 programme, which is available at `http://www.agentlink.org/activities/al3-tf/tf3/`.

Friday, 16 September 2005

9.15–9.30	**Welcome**
9.30–11.00	**Session A** (Chair: Ulle Endriss)
9.30-10.00	Nicolas Maudet (LAMSADE, Paris-Dauphine) *Presentation of the MARA Survey: Issues in Multiagent Resource Allocation*
10.00-11.00	Discussion of the Survey and Short Presentations: – Paul E. Dunne (Liverpool) *Recent Complexity Results for Reachability Properties in Distributed Negotiation* – Peter Gradwell and Julian Padget (Bath) *Multiple Distributed Auctions for Allocating Grid Resources* – Patrick Storms (Y'all B.V., Waalwijk) *The COMBINED Project*
11.00–11.15	*Coffee Break*
11.15–13.00	**Session B** (Chair: Yann Chevaleyre)
11.15–11.50	Andrea Giovannucci (IIIA-CSIC, Barcelona) *Multi-unit Combinatorial Auctions with Transfomability Relationships among Goods*
11.50–12.25	Valentin Robu (CWI, Amsterdam) *Modeling Complex Multi-issue Negotiations Using Utility Graphs*
12.25–13.00	Sylvia Estivie (LAMSADE, Paris-Dauphine) *Optimal Outcomes of Distributed Negotiation in Utilitarian and Egalitarian Settings*
13.00-14.30	*Lunch Break*
14.30–16.00	**Session C** (Chair: Jérôme Lang) Invited Tutorial on Fairness and Uncertainty by Thibault Gajdos (EUREQua, Paris)
16.00–16.15	*Coffee Break*
16.15–18.15	**Session D** (Chair: Paul E. Dunne)
16.15–16.50	Eric Pacuit (ILLC, Amsterdam) *Some Recent Results on Adjusted Winner*
16.50–17.25	Marco Schmitt (TU Hamburg-Harburg) *Socionics: Blueprinting Multiagent Systems from Sociological Theory*
17.25–18.00	László Gulyás (AITIA Inc., Budapest) *Engineering Emergent Social Phenomena*
18.00–18.15	Final Discussion
18.15–18.30	*Break*
18.30–19.00	**Plenary Session** (Reports on MARA and other TFGs; Discussion)
19.10–	**Banquet Dinner**

Further information on the MARA Survey and the tutorial, as well as abstracts of the technical talks, are given on the following pages.

The MARA Survey

After the previous TFG-MARA meeting at the AgentLink Technical Forum in Ljubljana in February/March 2005, we have put together an extensive survey paper on Multiagent Resource Allocation, which is due to be published in the *Informatica* journal. This survey, which is also available at the TFG-MARA website, will be presented and discussed in Session A.

- Yann Chevaleyre, Paul E. Dunne, Ulle Endriss, Jérôme Lang, Michel Lemaître, Nicolas Maudet, Julian Padget, Steve Phelps, Juan A. Rodríguez-Aguilar, and Paulo Sousa.
  Issues in Multiagent Resource Allocation. *Informatica*. Accepted for publication.

  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 paper is a survey of some of the most salient issues in Multiagent Resource Allocation. In particular, we review various languages to represent the preferences of agents over alternative allocations of resources as well as different measures of social welfare to assess the overall quality of an allocation. We also discuss pertinent issues regarding allocation procedures and present important complexity results. Our presentation of theoretical issues is complemented by a discussion of software packages for the simulation of agent-based market places. We also introduce four major application areas for Multiagent Resource Allocation, namely industrial procurement, sharing of satellite resources, manufacturing control, and grid computing.

Session A will also include several short presentations, by various attendants, on either the survey itself or, more generally, the topics addressed by the survey.

Tutorial on Fairness and Uncertainty

At the first TFG-MARA meeting in Ljubljana earlier this year, we have identified fair division as a topic that is of particular interest to the community and that could greatly benefit from a closer interaction between computer scientists and economists. We are therefore delighted to be able to announce an invited tutorial on this topic:

- Thibault Gajdos (EUREQua, Paris)
  Tutorial on Fairness and Uncertainty

  Decision Theory (and especially decision theory under risk and uncertainty) and Social Choice are intimately connected, both at a conceptual and at a formal level. This tutorial aims at showing various connections between these two fields. In particular, we will try to show how decision theory may shed a useful light on resource allocation problems, and, more precisely, on the identification and implementation of fair allocations.

A "roadmap", summarising the main issues to be covered and providing a list of relevant references, is available at the TFG-MARA website.

Abstracts

- Paul E. Dunne (Liverpool)
  Recent Complexity Results for Reachability Properties in Distributed Negotiation

  Distributed negotiation schemes offer one approach to agreeing an allocation of resources among a set of individual agents. Such schemes attempt to agree a distribution via a sequence of locally agreed "deals" —reallocations of resources among the agents— ending when the result satisfies some accepted criteria. recent results show that some natural decision questions arising in such settings can be computationally significantly harder than questions related to optimal clearing strategies in combinatorial auctions. In particular the problem of deciding whether it is possible to progress from a given initial allocation to some desired final allocation via a sequence of "rational" steps has been shown to be PSPACE-complete.

- Sylvia Estivie (LAMSADE, Paris-Dauphine)
  Optimal Outcomes of Distributed Negotiation in Utilitarian and Egalitarian Settings

  In this talk, we report on preliminary experimental results regarding the outcomes of distributed negotiations over indivisible resources. While, under certain circumstances, we know *theoretically* that optimal outcomes will be reached eventually, here we focus instead on variants of the framework where no such guarantee can be proved, and set up an experimental framework. We present different results for a framework where agents negotiate only individually rational deals (*i.e.* deals that are beneficial to all the agents involved). These are known to be well adapted to utilitarian settings, *i.e.* with such deals we can always reach an allocation of resources with maximal utilitarian social welfare. Here we are interested in the effect such a negotiation regime has on the development of the egalitarian social welfare of allocations. Furthermore, in our experimental studies we restrict ourselves to the case where agents negotiate structurally simple (bilateral) deals only.

- Andrea Giovannucci (IIIA-CSIC, Barcelona)
  Multi-unit Combinatorial Auctions with Transfomability Relationships among Goods

  In this talk, we extend the notion of multi-unit combinatorial reverse auction by adding a new dimension to the goods on auction. In such a new type of combinatorial auction a buyer can express transformability relationships among goods: some goods can be transformed into others at a transformation cost. Transformability relationships allow a buyer to introduce his uncertainty as to whether it is more convenient to buy some goods or others.We introduce such information in the winner determination problem (WDP) so that not only does the auction help allocate the optimal set of offers —taking into account transformability relationships—, but also assess the transformability relationships that apply. In this way, the buyer finds out what goods to buy, from whom, and what transformations to apply to the acquired goods in order to obtain the initially required ones.

- Peter Gradwell and Julian Padget (Bath)
  Multiple Distributed Auctions for Allocating Grid Resources

  In [1] we wrote: "Grid computations will be enabled by participants trading resources in order to construct bundles of goods or services that together constitute experiments or solve problems in science, engineering and, now emerging, social sciences. A combinatorial auction (CA) is a natural choice for optimal allocation, but the space and time dimensions that characterise a Grid would appear to indicate they are incompatible. This paper proposes that an analogue of a physical commodities market seems more appropriate and that there remains a class of bundling problem whose complexity properties appear to make the utilisation of a CA impractical."

  Consequently we have begun investigating criteria to evaluate the appropriateness of resource allocation in MARA systems. The MARA survey also draws attention to this issue: "Such work comprises both positive results —e.g. algorithms with provably efficient performance characteristics, properties of restricted classes of allocation settings, etc.— and a large collection of negative results that suggest many naturally arising decision and optimisation problems are unlikely to admit generally applicable algorithmic solutions."

  Our first step in evaluating CAs and MDAs has been to compute a base line performance model of the currently available solvers, such as LPSolve (`http://www.geocities.com/lpsolve/`), CASS [2] and those implemented by Dang [3]. The results of this empirical analysis indicates that there are many problems for which CA can be quite fast, although many others cause CA to exhibit worst case behaviour. This supports our view that there is a class of problems for which CA is impractical if time and budget constraints are to be met.

  Our second step and current work, is comparing the performance of JASA (`http://www.csc.liv.ac.uk/~sphelps/jasa/`), Conoise-G (`http://www.conoise.org`) and our own

BrickWorld system to establish a performance model for distributed agent-based resource allocation.

[1] P. Gradwell and J. Padget. Distributed combinatorial resource scheduling. AAMAS SGT Workshop, 2005.

[2] K. Leyton-Brown. Resource allocation in competitive multiagent systems. PhD thesis, Stanford University, 2003.

[3] V. D. Dang and N. R. Jennings. Optimal clearing algorithms for multi-unit single-item and multi-unit combinatorial auctions with demand/supply function bidding. Proc. EC-2003, ACM Press, 2003.

- László Gulyás (AITIA Inc., Budapest)
  Engineering Emergent Social Phenomena

  Software today is not as it used to be. Systems are no longer monolithic, but they are typically part of a larger system consisting of many components. Software engineers are no longer in control of the entire system. Rather they design solutions that are intended to co-exist with other, cooperating or competing, components, in a way that ensures that the emerging behavior at the system level conforms with the stated goals. As a consequence, novel methods to design "complex software systems" are being sought.

  Agent-based social simulation (ABSS), on the other hand, deals with the scientific investigation of complex social systems, where many individuals (agents) interact, each pursuing its own agenda. This scientific endeavor seeks to explain global phenomena from (often relatively simple) local (individual-level) behavior. The practice of agent-based social simulation requires both programming skills and social science education. Therefore, ABSS is often carried out by collaborating teams of social scientists and software engineers.

  This talk will overview the practice of agent-based social simulation from the perspective of a software engineer. It will discuss the difference of this enterprise from that of developing AI-like multiagent systems. It will also point out special methodological considerations, which lead to particular implementation practices, tips and tricks. Finally, a glimpse will be provided at FABLES, a new generation agent-based simulation language currently under development.

- Eric Pacuit (ILLC, Amsterdam)
  Some Recent Results on Adjusted Winner

  Adjusted winner, invented by Steven Brams and Alan Taylor, is a procedure for dividing (divisible) goods fairly between two individuals. In this talk, I will present this algorithm and discuss some recent results. In particular, a geometric approach is introduced which allows us to give alternate proofs of some of the Brams-Taylor results and which gives some hope for understanding the many-agent case. Time permitting, some rather odd knowledge-theoretic properties of strategizing will be discussed as well as a proof that the final result is a continuous function of the valuations given by the two agents (provided the agents are allowed to use real numbers for their valuations). This is joint with Samer Salame and Rohit Parikh.

- Valentin Robu (CWI, Amsterdam)
  Modeling Complex Multi-issue Negotiations Using Utility Graphs

  Finding efficient negotiation techniques is an important, open problem in agent systems. We consider the problem of (bilateral) negotiation of multiple issues, through an alternating offers protocol. This type of negotiations is often referred to as a "win-win" negotiation, since it is often possible for the parties to make trade-offs that jointly improve their utility. The challenge is to do so without revealing any private preference information (other then implicit information from the offers and counter-offers).

Our work focuses on negotiations where the evaluations for the multiple issues are interdependent. More specifically, we discuss negotiations between agents with k-additive utility functions, identified as a hard problem in the existing literature.

First, we introduce the concept of utility graphs and show how can they be used to represent efficiently such k-additive functions. Next, we turn our attention to how these graphs can be used to learn the preferences of the negotiation opponent. Our main result is that, when some maximal structure of the utility graph of one of the parties (in our model the buyer) is assumed, then it is possible to reach agreements close to Pareto-efficiency with a limited number of negotiation steps. This allows our technique to be used in time-constrained negotiations and in negotiations where the impatience of one of the parties is a limiting factor.

We apply our approach in two settings: modeling negotiations over bundles of items in agent mediated e-commerce, and modeling complex negotiations over the distribution of tasks in transportation logistics. Finally, for the e-commerce setting, we present a method for learning the structure of the starting utility graph from past negotiation data, through a technique inspired from collaborative filtering.

- Marco Schmitt (TU Hamburg-Harburg)
  Socionics: Blueprinting Multiagent Systems from Sociological Theory

  The presentation will consist of three parts. The first part is dedicated to the basic ideas and aims of the socionic research program. How can sociology and MAS-Research, or more broadly Computer Science, profit from the mutual endeavour to construct MAS based on sociological theories. The second part will provide you with a glimpse at the variety of research projects working inside the socionic research framework. Thus, I will give a brief overview concerning the current research going on in each of the different projects. In the last part, I will show one project, the Communication-Oriented Modelling project, in a bit more detail. This project works on the simulation and visualization of patterns of communication based on the unfolding distribution of communicative attention.

- Patrick Storms (Y'all B.V., Waalwijk)
  The COMBINED Project

  The COMBINED research project is concerned with the improvement of the performance of large scale systems in chaotic and complex circumstances. The envisioned system features include early and improved situation awareness, decision making and action selection. This is achieved by making use of self-managing mechanisms and agent based techniques. A crisis scenario in the Rotterdam Harbor is used for evaluation and demonstration purposes

  One of the COMBINED workpackages deals with agent interaction, multiagent system organization and agent coordination mechanisms in dynamic environments. The problem we are trying to deal with is first-aid medic-casualty assignment. This "First Aid Case" is a Multiagent Resource Allocation problem that forms the basis of an experiment, in which we compare three main agent coordination mechanisms on their functional and non-functional system qualities. We are going to discuss the First Aid Case, the three agent coordination mechanisms and the current status of our research.

  See `http://combined.decis.nl` and `http://www.decis.nl` for details on the COMBINED project and the Decis lab.