Publications

1. Benito Mendoza and José M. Vidal. Approximate bidding algorithms for a distributed combinatorial auction (short paper). In Padgham, Parkes, Müller, and Parsons, editors, *Proceedings of the 7th International Conference on Autonomous Agents and Multiagent Systems*, Estoril, Portugal, May 2008.

2. Benito Mendoza and José M. Vidal. Bidding algorithms for a distributed combinatorial auction. In *Proceedings of the Autonomous Agents and Multi-Agent Systems Conference*, 2007.

3. Hrishikesh J. Goradia and José M. Vidal. An equal excess negotiation algorithm for coalition formation. In *Proceedings of the Autonomous Agents and Multi-Agent Systems Conference*, 2007.

4. Muralidhar V. Narumanchi and José M. Vidal. Algorithms for distributed winner determination in combinatorial auctions. In *LNAI volume of AMEC/TADA*. Springer, 2006.

5. José M. Vidal, Paul Buhler, and Christian Stahl. Multiagent systems with workflows. *IEEE Internet Computing*, 8(1):76–82, January/February 2004. `doi:10.1109/MIC.2004.1260707`.

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Faculty

José M. Vidal is an expert on multiagent systems, web applications, and applied game theory. He has many publications and is working on a textbook called *"Fundamentals of Multiagent Systems"*. You can find his blog at `www.multiagent.com`

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Negotiation Networks, Combinatorial Auctions, Web Services

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Negotiation Networks

Our research lab develops solution concepts and algorithms for analyzing and implementing networks of negotiating agents. These problems, which we call **negotiation networks** can arise in any environment where a network of autonomous agents needs to arrive at a set of mutually consistent agreements but, while the network itself can be arbitrarily large, each agent only needs to negotiate with a small subset of other agents. For example, consider the case of multiple companies, each one of which is looking to fill a limited set of contracts, say for custom software, and a large number of software consultants each one of which is interested landing a few contracts but limits his negotiations to a few companies which he deems are most likely to hire him. In this scenario each consultant negotiates with a small set of companies. All agents are selfish and thus wish to maximize their respective utilities. The main constraints are that each consultant can only handle very few contracts at the same time and the companies have a limited budget for all their projects. We then ask:

- what is a good allocation of resources?
- how do we define “good” in this scenario?
- how do we build automated negotiation mechanism that arrive at one of these “good” solutions?

This problem is a distributed variation of the characteristic form game where we are trying to find a solution via bargaining. Indeed, our research fully utilizes existing results from *game theory*, as well as *Sociology* and *Economics*, as the basis for forming our computational solutions to this problem. We note, however, that most of the existing solutions are axiomatic, while our research instead aims at generating distributed incentive-compatible algorithms for realizing these solutions, or variations thereof, using automated agents. That is, we design algorithms for automated negotiation in social networks and implement simulations that demonstrate the average case performance of our algorithms under various scenarios. Wherever possible we also provide formal proof of the correctness and worst-case behavior of our algorithms.

Application Areas

Our research has applications that range from supply chain automation to network protocol design and even has some utility to social scientists.

One direct application of negotiation networks is one that can best be summarized as a **distributed combinatorial eBay**—a Web 2.0 variation on this idea is known as *zBay*. For example, imagine that PC component manufacturers develop agents which advertise their particular goods for sale. PC manufacturers can then place combinatorial bids on the components they wish to buy at the time. The manufacturers receive these combinatorial bids and must then negotiate with the other manufacturers named in these bids so as to clear them and make a sale—they thus form a negotiation network with links defined by the combinatorial bids submitted by the buyers. Note that this approach has the advantage that it distributes the computational problem of finding an allocation—an NP-complete problem—among the sellers, who have a clear financial incentive to perform this computation.

Thus, we distribute the computation among those agents that want to find a solution to the problem. The negotiation network builds an **automated supply chain** which connects consumers directly to manufactures via a network of automated negotiating agents, thereby minimizing transaction costs and market inefficiencies. We have already developed some initial algorithms for these type of distributed combinatorial auctions as well as developed simulations of a dynamic supply chain, by extending the original beer game to arbitrary topologies, in joint work with researchers from the school of business.

Another application area is in the development of **incentive-compatible routing mechanisms** for the Internet. The routers and cables that make up the backbone of the Internet are owned by a number of companies. These companies establish contracts between them whereby they agree on how much traffic, and which kind, they will carry for each other. For example, an ISP that specializes in end-users might be willing to pay a lot to get traffic from the rest of the Internet into its network but will probably not need a lot of upstream bandwidth. Also, a network that has high speed (direct) connections to a lot of popular servers will be able to demand more money for its bandwidth someone else who has only direct access to very unpopular servers. Currently, human representatives from these companies meet to negotiate over these contracts. As such, new contracts are relatively rare and perhaps too simple, as they must be simple enough for humans to negotiate over.

We envision instead that each company (or even, each router) is represented by an agent. These agents exist in a negotiation network with identical topology to the Internet. We have formalized this problem as the **multiply-owned network allocation problem** and verified that it is a special instance of the more general negotiation network problem presented here. Thus, our algorithms for negotiation networks will allow agents to constantly re-negotiate routing contracts even as demand for various servers fluctuates. The end result promises to be a much more efficient allocation of the bandwidth which takes into account the utility, in the form of their willingness to pay, derived by all users. Again, our research would remove inefficiencies from the bandwidth market and thus increase overall welfare. These research results would also be directly applicable to routing problems in some ad-hoc wireless networks and distributed sensor networks.

Finally, our research will also provide a tool for research and learning across the social sciences. Specifically, negotiation networks are an extension of those studied in **network exchange theory**. The goal there, as in **behavioral economics**, is to develop models of human behavior, focusing on that behavior which is not utility maximizing as defined in classical Economics and game theory. That is, it focuses on instances where people take actions which are inconsistent with a utility theory interpretation. For example, studies show that, in a negotiation where two people must decide how to divide a pot of money or get nothing if they fail to reach agreement (the ultimatum game), people will often rather get no money than get a small fraction of the pot—they deem it “unfair” that the other should get nearly everything. This decision is irrational under utility. Our research uses these models to implement bounded rational agents and also builds large simulations of these negotiating agents which might be used by social scientists studying large **social networks**.