# Engineering Distributed Protocols for Multi-Agent Interactions using Game Theory

Rajdeep K. Dash
School of Electronics and Computer Science, University of Southampton, Southampton, SO17 1BJ, UK
rkd02r@ecs.soton.ac.uk

## Categories and Subject Descriptors

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Algorithms, Design, Economics

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## ABSTRACT

This thesis considers engineering both protocols and strategies in multi-agent systems comprised of selfish, rational autonomous agents. Mechanisms dealing with failures as well as aspects of decentralisation are designed and applied to a multi-sensor network scenario. A model for designing strategies is also proposed and a risk-based strategy for a continuous double auctions designed.

## 1. MAIN

Multi-agent systems are an important new software paradigm that views large, complex systems as a collection of autonomous, interacting, decision making entities (termed agents) [5]. These agents typically represent distinct stakeholders with different aims and objectives. In such multi-agent systems (MAS), there are two fundamental design issues that need to be addressed. First, there is a need to specify the *protocols* that govern the interactions. These cover issues such as how the actions of the agents translate into an outcome, what range of actions are available to the participants, and whether the interactions occur over a series of steps or are one-shot. Second, given the prevailing protocol, there is a need to define the *strategy* (mapping from state history to action) for each agent.

Stated in this way, it is obvious that microeconomics — the study of the decision-making behaviour of self-interested agents as they interact with their environment — has been advocated as a useful tool in the design and study of multi-agent systems[7, 2].

Two important issues, generally overlooked when designing protocols in traditional MD, which a MAS designer should consider are failures and decentralisation. In this thesis, we first propose a mechanism for dealing with failures to complete a task. We incorporate the notion of trust in order to deal with varying levels of confidence agents may have on other agents in successfully fulfilling a desired task [3, 1]. We then deal with decentralisation of information and decentralisation of computation. Decentralisation of information is concerned with the situation where an agents forms its valuation based on the observation of other agents and is more commonly known as interdependent valuations. We extend the mechanism proposed by Krishna in order to deal with multiple items having combinatorial valuations [4]. Decentralisation of computation is concerned with distributing the computational load when computing the outcome whilst ensuring that the selfish agents follow the distributed computation protocol faithfully. In order to do so, we modify an existing cooperative algorithm namely OPTApo[6], and find the cost the system incurs as a result of selfishness.

In the second part, we concentrate on the design of strategies when we have a pre-specified protocol, in this case the continuous double auction. We show how incorporating of adaptiveness based on risk enables the strategy to perform significantly better than current state of the art strategies and achieves a higher level of efficiency in the market [8].


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