

# Coordinating Specialized Robots with a Market-based Approach

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## Introduction

This paper describes an experiment we performed to evaluate the nature of specialization in a multi-robot coordination task governed by a market-based architecture. First we will discuss the background and motivation for the experiment; then, we will explain our experimental hypothesis; next, we will describe the experiment; and finally, we will present our results and discuss them.

### **Background: The Market-Based Approach**

There are many situations in which it is important to coordinate multiple robots. Players on a robot soccer team must work together; a set of agricultural robots need to communicate with each other so that all the land is watered or harvested correctly; and a team of planetary rovers should coordinate so that they don't all explore the same territory.

There are a number of different approaches to coordinating multiple robots. One set of methods uses centralized planning to coordinate the robots. All the robots communicate sensor data to the central "leader," who calculates an optimal plan and sends commands out to the rest of the robots. The advantage of these approaches is that robots can be coordinated very efficiently. Unfortunately, this planning is extremely computationally intensive (and slow), this requires a very high communication load, and if the "leader" fails, the whole system breaks down. Another way to coordinate robots is to use a decentralized approach. In these systems, each robot is free to make its own decisions based on the information that it senses locally. The advantage of decentralized systems is that they are very robust—if one robot fails, the rest of the system keeps working—they can respond quickly to changing environments, and they don't require much computation or communication. The major disadvantage is that the resulting "plans" are often highly sub-optimal, with very little real coordination going on.

As a response to these problems, researchers proposed a market-based approach to multi-robot coordination (Dias 2001). This approach is based on the economic idea of a free market: robots work to maximize their individual profit by maximizing revenue (gained by completing tasks successfully) and minimizing cost (reducing time taken or distance traveled). Robots are free to negotiate with each other to complete tasks. If one robot can complete a task more efficiently than another robot, it can bid for the right to complete the task. If the bid is higher than what the other robot would have profited by completing the task itself, it can auction off the task, the result being that the more efficient robot ends up doing the work. The net result of this system is that by acting at a local level to maximize profit, the robots create a solution that is globally very efficient. This approach has the