A Group Selection Pattern Optimizing Job Scheduling in Decentralized Grid Markets

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Abstract. Decentralized economic models are being considered as scalable coordination mechanism for the management of service allocations to clients. However, decentralization incorporates further dynamicity and unpredictability into the system, degrading its performance. In this paper, a solution based on a self-organized and emergent Group Selection mechanism is proposed. Dynamic congregations evolve Grid Markets participants (c and service providers) into optimized market segments, maximizing utility outcomes for system-wide performance. We provide evaluation by simulation of the Group Selection mechanism performance in a market-based resource management and job scheduling scenario for Grid computing, compared with alternative scheduling strategies such as economic in a flat population (not using groups), random and least loaded resource selection.

1. Group Selection mechanism

Group Selection refers to a process of natural selection that favors characteristics in individuals that increase the fitness of the group the individuals belong relative to other groups. This implies that every member of the group depends on a group characteristic that is not isolated in a single individual [Wilson, 1975]. The Group Selection process has been proposed as a means of understanding processes such as the evolution of capitalist economies and of human cooperation. Exploiting group structure in multiagent systems (MAS) has also been proposed in coalition formation literature. Major limitations of these algorithms are a high computational complexity, and unrealistic assumptions regarding the availability of information [Shehory, 2004]. Congregations [Brooks, 2002] are a static solutions and agents can trade in just a specified number of subgroups. In contrary, Group Selection approaches do not imply costly computations, and enable for a dynamic view of the system.

Figure 1 shows the solution proposed. Buyers (Clients) interact preferentially with sellers (Services) belonging to the same group, which due to the operation of Group Selection tend to be closer to them in negotiation characteristics and goals, hence increasing the probability of successful allocations.

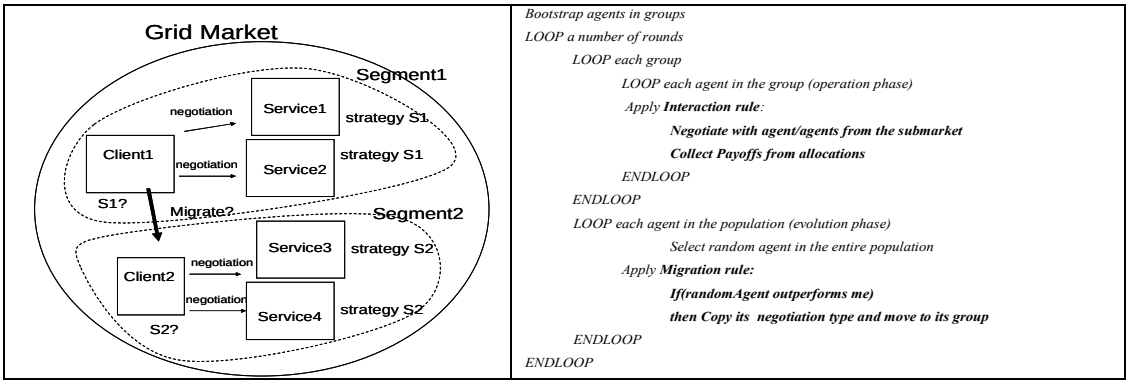

Figure 1: Segmented Grid Market (left), algorithmic realization of Group Selection pattern (right)

2. Optimizing Decentralized Grid Markets trough Group Selection

We have used as decentralized economic agents an implementation of the Contract-Net protocol, standardized by FIPA [FIPA, 2007]. Buyers groupcast call for proposals (CFP) to sellers, which submit proposals in response; finally buyers select the best ones. In top of this protocol, we apply a simple offer/demand-based economic algorithm: If the CFP does not meet seller requirements, it will lower its expectations and decrease the selling price. As for the buyers, if a seller rejects the CFP, then it will lower its expectation by increasing the offer in the next CFP. Both the buyers and the sellers will increase their expectations in case of receiving offers/bids which meet their expectations. The price updating is done at fixed small price steps. Prices evolve by offer and demand, bounded by the dependence on the limited buyer budget and the limited resources which can be sold by sellers.

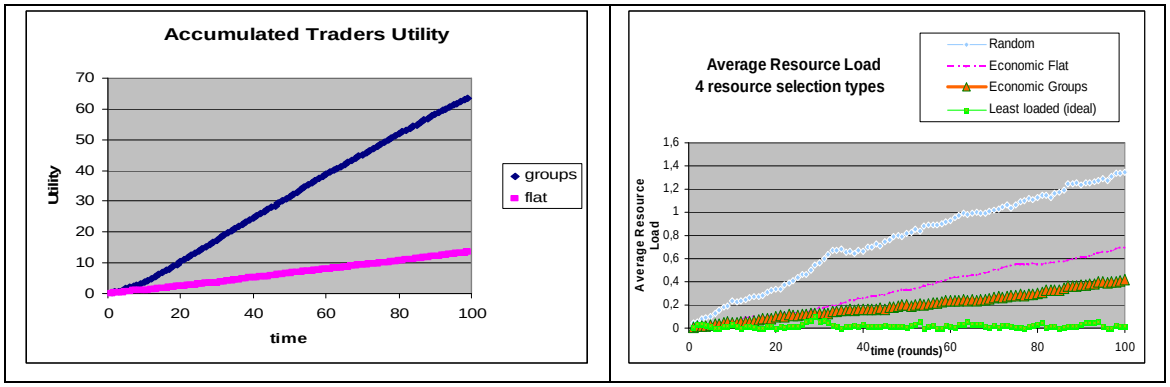

Figure 2. Setup: 100 agents (50 buyers and 50 sellers): left: 5 different "types of negotiation". Group Selection increases allocation utility; (right) Job submission, 4 selection mechanism compared.

The experiments are conducted in an open source, generic agent-based Grid simulator specifically built for developing agent coordination mechanism on top of Grids [AgentGridSim, 2007].

The results of experiment in Figure 2(left) show accumulated utility of traders after 100 rounds of resource allocation in both flat markets and markets segmented in groups. The utility U is calculated as follows, being nt1 and nt2 the negotiation type of buyer and seller respectively:
U = 1/(nt1 –nt2), with U=1 when nt1 = nt2 and a value between 0 and 1 in the rest of cases.
Market segments evolve, grouping traders with compatible negotiation types. The decentralized economic algorithm in a flat population is optimized applying the Group Selection mechanism.

The results in experiment from Figure 2(right) compare the performance of flat economic-based selection, group selection, and two other strategies from the state of the art: random selection, a baseline selection type which balances load in a worst case scenario; and least loaded selection, which achieves optimal scheduling (supposing perfect updated information on resources states). The resource load is calculated for each resource as the total queue length divided by the resource capacity. Group Selection outperforms alternatives, scoring the closest to the ideal least loaded selection.

The Group Selection mechanism optimizes the performance of market-based resource managers by grouping and evolving the agent's population. Deployment in a realistic, asynchronous environment is possible, since no synchronization step is required to update agent's strategies and group memberships.

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