A Dynamic Organization in Distributed Constraint Satisfaction

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Abstract

We present a novel dynamic organization to solve DCSP(Distributed Constraint Satisfaction Problem). DCSP provides a formal framework for studying cooperative distributed problem solving[Yokoo 92]. To solve DCSP, we have developed a simple algorithm using iterative improvement. This technique has had great success on certain CSP(Constraint Satisfaction Problems)[Minton 90][Selman 92]. In our algorithm each agent performs iterative improvement and also plural agents can do in parallel. However, one drawback of this technique is the possibility of getting caught in local minima(which are defined specifically in our algorithm). LMO is a technique for escaping from local minima. It is summarized as follows:

When an agent(A1) gets caught in a local minimum,
(*step 1*) A1 sends its CSP(variables, domains and constraints) to an agent(A2). A1 selects A2 such that it shares violated constraints at that time. Ties are broken randomly.
(*step 2*) A2 puts its CSP and A1's CSP together and searches for all possible assignments with simple backtracking. After that, A2 performs iterative improvement.

Besides escaping from local minima, LMO prevents agents from getting caught in the same local minima as before. Therefore our algorithm for DCSP is complete.

LMO is also the algorithm for a dynamic organization since agents reassign the responsibilities of solving CSP based on a developing view of the problem. As a dynamic organization, LMO is characterized by grouping in response to the conflicts(i.e., local minima) that arise during problem solving. This produces the effect that the organization with LMO(we call it the LMO organization) makes groups depending on the number of local minima. That is, when there are few local minima in a problem, the LMO organization solves it in a distributed manner, and when there are many, it does in a centralized manner.

To evaluate the performance of LMO, we have compared the LMO organization with the following ones.

1. Distributed organization: This organization always solves problems in a distributed manner. In this organization each agent performs iterative improvement. When one agent gets caught in a local minimum, all agents change their assignments randomly and continue to perform iterative improvement.
2. Centralized organization: This organization always solves problems in a centralized manner. In this organization, to begin with agents have to solve the leader election problem. Then all agents(but the leader) send their CSP to the leader. Finally the leader searches for one solution with simple backtraking(the method used in LMO). Note that agents solve the leader election problem and send their CSP regardless of the possibility of distributed problem solving.

In our experiments, for the problems with few local minima the LMO organization solves them faster than the Centralized organization(because the cost of leader election exceeds that of distributed problem solving), and for the problems with many local minima it solves them faster than the Distributed organization.

Finally, in LMO, we use backtracking as a method to help iterative improvement. We believe that this approach will be applicable to non-distributed CSP. That will be our future work.

References

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