12f Mip in Agent Systems: Algorithmic Collaboration or the Lack Thereof
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Historically, process optimization has focused on two primary

areas of research: development of optimization algorithms and

development of problem formulations. Both of these areas focus

primarily on the single-threaded optimization of a single problem

using a single computer processor. In contrast, the emerging standard

for high-performance computing is the distributed computing cluster.

While clusters excel at both high-throughput single-threaded batch

processing and large-scale parallel computations, general optimization

does not lend itself well to either of these approaches. Instead, we

propose the use of collaborative agent-based systems and parallelism

at the method level as a promising third approach for leveraging

parallel resources for general optimization.

In previous work, we demonstrated how combining rigorous,

stochastic, and heuristic algorithms in a collaborative environment

could solve single [1] and multi-objective [2] optimization problems

that none of the individual algorithms could solve in isolation. We

further showed how to combine multiple problem formulations through an

extension to the collaborative system we termed, "Polymorphic

Optimization" [3,4]. In these systems, diverse sets of transient

algorithms interact asynchronously by sharing intermediate and final

solutions to the problem through a centralized database of problem

information. Through this interaction, the system as a whole

substantially outperforms any of the individual algorithms working in

isolation. However, these applications were all linked by the absence

of a single algorithm that could provide a guarantee of optimality,

and consequently, the multi-agent optimization system was unable to

provide a guarantee of optimality.

 In this work, we address the integration of branch-and-bound

optimization algorithms into a collaborative optimization system.

These algorithms can provide a guaranteed optimal solution and require

a fundamentally different collaborative structure compared to the

transient local optimization and stochastic search algorithms used in

our previous work. We present a candidate collaborative structure and

illustrate its application to both synthetic mixed-integer linear

(MILP) and general batch scheduling problems. Our results indicate

that, while the collaborative multi-agent system is able to identify

the optimal solution significantly faster, there are instances where

standard off-the-shelf MILP solvers can take significantly longer to

prove the solution optimality. This suggests new directions for

developing improved branch-and-bound algorithms designed explicitly to

operate in collaborative environments.

References:

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