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A performance study on multi improvement neighborhood search strategy

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Abstract

Among the methods to deal with optimization tasks, parallel metaheuristics have been used in many real-world and scientific applications to efficiently solve these kind of problems. This paper presents a novel Multi Improvement strategy for dealing with the Minimum Latency Problem (MLP), an extension the classic Traveling Salesman Problem. This strategy is embedded in a Graphics Processing Unit (GPU) local search procedure, in order to take advantage of the highly parallel processors from this architecture. In order to explore multiple neighborhoods simultaneously in a CPU/GPU heterogenous and distributed environment, a variant of the classic Variable Neighborhood Descent (VND) is also proposed, named Distributed VND (DVND). The DVND was inspired by a randomized version of the VND (called RVND) and a comparison was made, achieving competitive results in terms of solution quality. The variant of the DVND using two processes succeeded in achieving superlinear speedups up to 2.85, demonstrating that the DVND scalability and capability to explore both GPUs and CPUs. Finally, experiments demonstrate that the Multi Improvement is capable of finding better quality solutions in shorter computational times, when compared the classic Best Improvement strategy, motivating

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future applications in other hard optimization problems.

Keywords: DVND, GPU, neighborhood search, multi improvement, minimum latency problem

1 Introduction

Transportation problems are still some of the most challenging tasks in the Combinatorial Optimization field, although many recent advances in heuristic search techniques and, specially, in metaheuristics (general purpose heuristic frameworks), have been developed. Furthermore, the practical applications of these problems in industry and science are becoming increasingly large and complex, requiring more computational power and specialized methods for a scalable solution. One of such problems is the Minimum Latency Problem (MLP), that has many important applications in business and industry, which consists in finding a tour such that the total accumulated costs (or waiting time) is minimum [2].

In order to solve the MLP and to provide a scalable solution, all computational power available should be explored. In this direction, the Graphics Processing Units (GPUs) have emerged as an alternative high computational power, provided by its massively parallel architecture (manycore) and attractive cost/benefit trade-off for high performance systems [6]. However, integrating GPUs and multicore CPUs is not a trivial task. The CPUs are designed to provide fast response times for a wide range of sequential applications resulting in a more complex device, in which concentrate almost all of the current heuristic techniques. On the other hand, GPUs focus on applications with high data parallelism level, where each processor performs the same task on different pieces of data. As result, GPUs trade single-thread performance by parallel processing power [3], while CPUs should explore task parallelism [7]. Therefore, to fully benefit from CPU/GPU heterogeneous platforms, metaheuristics should properly explore the parallel resources available in those systems seeking to achieve a good trade-off on both data and task parallelism.

The current best results for the MLP have been achieved by means of

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