Analysis of a Parallel MOEA Solving the Multi-objective Quadratic Assignment Problem

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The Quadratic Assignment Problem (QAP) is an NP-Complete problem [1]. The multiobjective Quadratic Assignment Problem (mQAP) is the multiobjective version of the QAP and was formalized in 2002 [2]. The QAP has had extensive research, but mQAP research is still in its infancy. The mQAP has been been used to optimize communication for formations of heterogenous unmanned aerial vehicles (UAVs) through the use of the Multi-Objective Messy Genetic Algorithm - II (MOMGA-II) [3]. This research extends that research by using a parallelized version of MOMGA-II and comparing the speedup and efficiency of the parallel results to the serial results.

The mQAP is defined in mathematical terms in equations 1 and 2

$$minimize\{C(\pi)\} = \{C^1(\pi), C^2(\pi), \ldots, C^m(\pi)\} \tag{1}$$

where

$$C^k(\pi) =_{\pi \in P(n)}^{min} \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} b^k_{\pi_i \pi_j}, k \in 1..m \tag{2}$$

and where n is the number of objects/locations, a_{ij} is the distance between location i and location j, b^k_{ij} is the kth flow from object i to object j, π_i gives the location of object i in permutation $\pi \in P(n)$, and *minimize* means to find all non-dominated points [2].

These experiments compared the parallel results with the serial results. The parallel model used in this research is the island model. See [3] for the environment the experiments were run.

The metrics used for the parallel experiments are speedup and efficiency. Speedup is chosen for its commonality throughout the literature and its ability to show how much faster or slower the parallel processing is compared to serial processing. Efficiency is used to show the amount of time the processing element is used vs. its idle time. Table 1 lists the results of the speedup and efficiency analysis. By using more processors, the speedup is increased enabling the runs to be done in a more efficient manner. The efficiency for each processor decreases as more processors are added. This means the processors are in idle mode more often and that scalability problems can occur as more processors are added.

Figure 1 shows a graph of the mean time to finish an experiment with set population sizes. This indicates that as more processors are added to search for

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Table 1. Speedup and Efficiency Results

Number of Processors	Speedup	Efficiency
2 Processors	1.842	0.9210
4 Processors	2.376	0.5941
8 Processors	3.431	0.4289

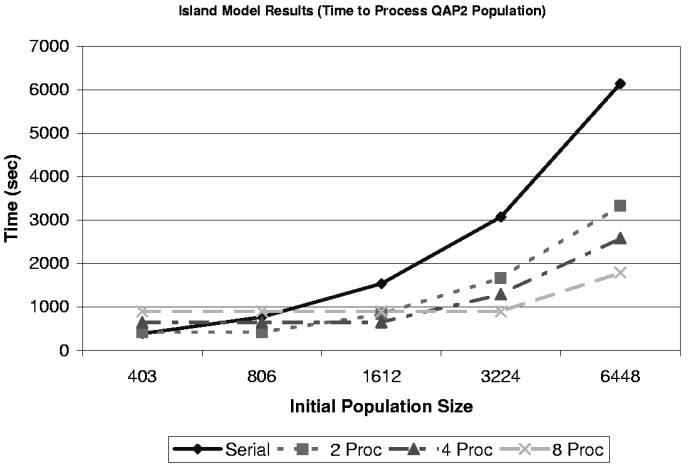

Fig. 1. Speedup results from running MOMGA-II on data set KC10-2fl-1uni.

solutions there is almost a linear speedup when compared to running the same number of searches in serial.

References

1. Çela, E.: The Quadratic Assignment Problem - Theory and Algorithms. Kluwer Academic Publishers, Boston, MA (1998)
2. Knowles, J., Corne, D.: Instance generators and test suites for the multiobjective quadratic assignment problem. In Fonseca, C., Fleming, P., Zitzler, E., Deb, K., Thiele, L., eds.: Evolutionary Multi-Criterion Optimization, Second International Conference, EMO 2003, Faro, Portugal, April 2003, Proceedings. Number 2632 in LNCS, Springer (2003) 295–310
3. Day, R.O., Kleeman, M.P., Lamont, G.B.: Solving the Multi-objective Quadratic Assignment Problem Using a fast messy Genetic Algorithm. In: Congress on Evolutionary Computation (CEC'2003). Volume 4., Piscataway, New Jersey, IEEE Service Center (2003) 2277–2283